Proponente:

Ministero delle Infrastrutture e dei Trasporti

ENAC ENTE NAZIONALE PER L'AVIAZIONE CIVILE

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Procedimento:

Verifica di assoggettabilità a V.I.A.
art. 20 D.lgs. 152/2006 ss.mm.ii.

MASTERPLAN 2014-2028
Aeroporto Internazionale G. Galilei - Pisa

Oggetto: Integrazioni volontarie al procedimento

Relazione di controdeduzione richiesta chiarimenti ARPAT

Titolo: Relazione con documentazione allegata: verbale e manuale sw

Scala:

Cod. Elab.: 40_AMB_ATM_R02_INT

REV.	DATA	FILE	OGGETTO	Elaborato N°:
00	Lug. 15	Controdeduzioni.pdf	Richiesta chiarimenti ARPAT	**01**

Cod. progetto:	Redatto:	Verificato:	Approvato:
...			

Relazione di controdeduzione richiesta chiarimenti ARPAT

R2015.09

Luglio 2015

Autori: A. Nanni, C. Pozzi, P. Radice

INDICE

1 Introduzione

Nell'ambito della procedura di verifica di assoggettabilità a VIA dell'espansione dell'aeroporto Galileo Galilei di Pisa all'anno 2028 secondo il Piano di Sviluppo Aeroportuale (Masterplan) approvato da ENAC nel maggio 2014, ARIANET aggiornava uno precedente studio d'impatto atmosferico relativo allo stato 2014 estendendone l'orizzonte temporale al 2028.

Avendo il Ministero dell'Ambiente acquisito il parere della Regione Toscana su tale procedimento, redatto anche sulla base del parere di ARPAT (nota prot. n. 2015/0002837 del 16.1.2015), ha fatto sue le osservazioni di ARPAT che riguardano anche lo studio d'impatto atmosferico e richiesto altri approfondimenti.

Con il presente documento (R2015.09) che si rifà in molte parti a un parallelo documento R2015.08 ARIANET intende rispondere alle richieste del Ministero, qui con particolare riferimento alle osservazioni di ARPAT.

Richiamando il verbale dell'incontro tecnico svolto presso gli uffici ARPAT di Firenze il 24.2.2015 (fornito in allegato), in sostanza le 10 osservazioni ARPAT possono essere riassunte come segue:

1. Si precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso l'effetto building downwash determinato dal complesso degli edifici in cui è articolato lo scalo, con particolare riferimento a quelli prossimi o sottostanti le emissioni convogliate dalle centrali termiche. Nel caso non sia stato incluso è necessario che le simulazioni siano ripetute includendo tale effetto. Le eventuali simulazioni aggiuntive devono offrire elementi tecnici utili ad orientare la progettazione della quota dei camini delle emissioni convogliate (che potrebbe essere oggetto di eventuale prescrizione a conclusione del procedimento).

2. Si precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso il contributo delleemissioni dovute ai movimenti degli aeromobili dell'aviazione generale e militare. Nel caso non sia stato incluso è necessario che le simulazioni siano ripetute includendo tale contributo (in particolare quello dell'aviazione generale).

3. Siano precisati i motivi per i quali non si è ritenuto di adeguare i TIM delle fasi di rullaggio (taxi in/idle e taxi out/idle) rispetto allo studio condotto nel 2008, tenuto conto del nuovo assetto al 2028 caratterizzato dall'arretramento di 400 m del punto di stacco degli aeromobili in fase di decollo verso la città. Nel caso in cui i TIM nel nuovo assetto fossero diversi da quelli fin qui adottati è necessario che le simulazioni siano ripetute con i nuovi TIM.

4. Sia presentato il quadro emissivo delle emissioni convogliate dalle centrali termiche (includendo portata, velocità di uscita dei fumi, concentrazioni al camino o ratei emissivi per ciascun inquinante emesso), sia nello stato attuale sia in quello futuro (anno 2028) dopo la dismissione degli impianti obsoleti e l'attivazione dei nuovi sistemi di produzione del calore e dell'energia.

5. Sia presentato il quadro completo dei GSE di cui sono state stimate le emissioni, compresi i fattori di emissione adottati".

6. Si precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso il contributi degli APU. Nel caso non sia stato incluso, chiarisca le motivazioni di tale scelta; se altrimenti all'anno 2028 si ipotizza che siano ancora attivi APU che comportano emissioni in atmosfera è necessario che le simulazioni siano ripetute includendone il contributo".

7. Si precisi, per quanto concerne i dati meteorologici utilizzati nelle simulazioni con il codice ARIA IMPACT, sia il metodo di assegnazione ad ogni ora della classe di stabilità atmosferica sia i dati di profilo verticale utilizzati per la stima dello spessore di rimescolamento".

8. Siano effettuate nuovamente le stime con il codice ARIA IMPACT per un'intera annualità, superando l'impostazione adottata nella documentazione esaminata (in cui le stime sono state condotte per due mesi invernali e quattro estivi), al fine di ottenere per tutti i punti di griglia gli indicatori statistici delle distribuzioni delle concentrazioni fissati dal DLgs 155/2010 per i diversi inquinanti considerati".

9. Una volta stimate le concentrazioni orarie in aria ambiente di NOx con il codice ARIA IMPACT, siano stimate le relative concentrazioni di NO2 impiegando il metodo ARM2 adottato da US-EPA e, successivamente, calcolando per tutti i punti di griglia gli indicatori statistici delle distribuzioni delle concentrazioni fissati dal DLgs 155/2010.

10. Sia effettuato il confronto delle stime ottenute con gli standard di qualità dell'aria fissati dal DLgs 155/2010 tenendo conto dei valori di fondo desumibili dai dati di qualità dell'aria caratteristici della zona, come rilevati da ARPAT con le campagne effettuate con laboratorio mobile e/o come rilevati presso la stazione Pisa-Passi facente parte della rete regionale di qualità dell'aria. Tale confronto dovrà essere effettuato in forma tabellare presso 10 punti recettori interni ed esterni al sedime aeroportuale, con preferenza per quelli prossimi ad edifici residenziali o adibiti ad attività ricettive, scolastiche, sanitarie"; nell'effettuare il confronto si dovrà tenere conto anche delle indicazioni formulate da UK-Environment Agency ("Conversion ratios for NOx and NO2": http://persona.uk.com/kings_lynn/Core_docs/Q/Q11.pdf).

Nel seguito, punto a punto, le risposte alle richieste ARPAT.

Osservazione 1. Si precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso l'effetto building downwash determinato dal complesso degli edifici in cui è articolato lo scalo, con particolare riferimento a quelli prossimi o sottostanti le emissioni convogliate dalle centrali termiche. Nel caso non sia stato incluso è necessario che le simulazioni siano ripetute includendo tale effetto. Le eventuali simulazioni aggiuntive devono offrire elementi tecnici utili ad orientare la progettazione della quota dei camini delle emissioni convogliate (che potrebbe essere oggetto di eventuale prescrizione a conclusione del procedimento).

Il software modellistico ARIA Impact, di cui è fornito in allegato il manuale d'uso per completezza, include la possibilità di eseguire simulazioni di dispersione di due tipi:

- Utilizzando il modello AIM che include l'algoritmo gaussiano classico conforme al modello EPA ISCST3 nelle situazioni di avvezione (velocità del vento uguali o superiori a 1m/s) e un modello gaussiano a puff (dunque non stazionario) simile al modello EPA CALPUFF nelle situazioni di calma di vento;
- Utilizzando direttamente il modello EPA AERMOD che però consente di simulare solo situazioni avvettive (v>=1m/s).

AERMOD consente alternativamente di scartare nelle statistiche le ore con calma di vento oppure in quelle situazioni mantiene valido il dato di direzione del vento e forza la velocità a 1m/s.

AERMOD ha in più rispetto ad AIM anche la possibilità di considerare nelle simulazioni l'effetto sulla dispersione atmosferica della presenza di ostacoli ("building downwash") che consiste essenzialmente in una correzione dell'altezza del pennacchio se la geometria degli ostacoli limitrofi al camino di emissione (e la geometria del camino stesso) portano a concludere che una interazione tra pennacchio e scie aerodinamiche degli ostacoli è possibile. In questo caso, tuttavia, l'ipotesi di stazionarietà della soluzione gaussiana s'indebolisce e il rischio, documentato anche nel sito ufficiale SCRAM di EPA (http://www.epa.gov/scram001/10thmodconf/presentations/3-3-EPA10thConferenceAQModeling-BuildingDownwash_SchulmanScire.pdf), è quello di ottenere forti sovrastime.

Dunque, tra la possibilità di simulare più correttamente le situazioni di calma di vento, non infrequenti nei rilevamenti presso l'aeroporto, e quella di considerare l'effetto della presenza degli edifici aeroportuali sulla dispersione dai camini delle centrali termiche è stata scelta la prima.

In risposta all'osservazione ARPAT è di seguito mostrata una analisi di sensitività dell'algoritmo di "building downwash" in AERMOD applicato al caso dell'aeroporto di Pisa. Trattandosi di un modello diverso rispetto ad AIM applicato nello studio è mostrata per chiarezza anche la differenza tra i due modelli.

La Figura 1. chiarisce posizione, posizione relativa, funzione e altezza di edifici e sorgenti puntiformi considerati nell'analisi. Tra gli edifici, sono da segnalare come rilevanti soprattutto:

- l'hotel in progetto, edificio 36, altezza max 45m, come il più alto dei considerati;
- gli uffici del Cargo Village così come sarà ampliato al 2028, n. 22 e 33 PSA e originale, altezza massima 19m, come quello che maggiormente interagisce con il pennacchio della centrale di cogenerazione (COGE in figura).
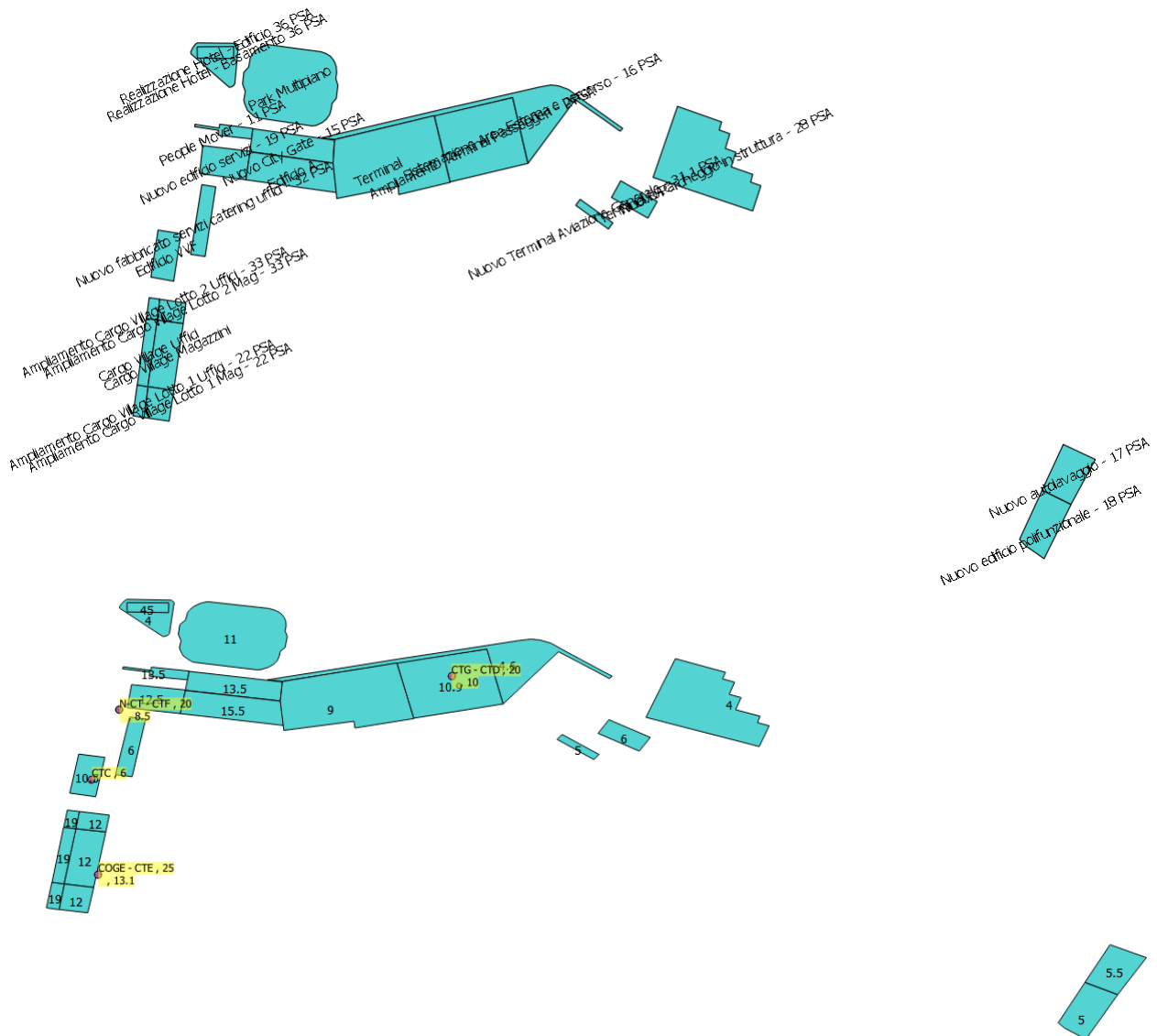
Figura 1. Posizione, funzione e altezza (m) di edifici e camini delle centrali termiche considerate nell'analisi

Poiché l'effetto di downwash legato agli ostacoli è generalmente molto locale e si esaurisce entro brevi distanze, le simulazioni in questo caso, rispetto a quelle generali presentate nello studio d'impatto atmosferico, hanno riguardato un dominio meno esteso, di 3 x 2 km di lato, ma con maggiore risoluzione (50m). Sono state considerate inoltre in queste simulazioni solo le sorgenti influenzate dall'effetto degli ostacoli (sorgenti puntiformi dotate di inerzia verticale dinamica e termica), dunque solo le centrali termiche, nello scenario 2028. Con maggiore approfondimento rispetto a quanto richiesto, le simulazioni hanno riguardato l'intero periodo annuale, consentendo il calcolo dello standard di legge percentile 99.8 delle concentrazioni orarie di NO_X, parametro su cui generalmente le sorgenti puntiformi influiscono di più, per via del tipo d'impatto intermittente, rispetto alle sorgenti diffuse (lineari, areali e volumetriche).

In Tabella 1. sono indicati i valori massimi di dominio calcolati dai modelli utilizzati con algoritmo di building downwash attivato / disattivato. Nel caso del confronto di AERMOD con AIM (simulazioni 2a e 2b) sono state considerate solo le situazioni di velocità del vento superiore o uguale a 1m/s in quanto AIM non contempla la possibilità di gestire le calme di vento alzando la velocità a 1m/s. Questa possibilità è invece presente in AERMOD ed è stata quindi utilizzata nell'analisi di sensibilità di AERMOD all'algoritmo di building downwash (simulazioni 1a e 1b).

Dalla Figura 2. Alla Figura 3. Sono presentate le mappe d'impatto ottenute come percentile annuale 99.8 delle concentrazioni medie orarie di NO_X.

Nonostante, in termini di massimo di dominio, l'incremento d'impatto dato dall'utilizzo in AERMOD dell'algoritmo di building downwash sia piuttosto consistente e ottenuto considerando una risoluzione di calcolo più elevata rispetto alle simulazioni generali, esso rimane in termini assoluti ben al di sotto dei massimi calcolati nello studio d'impatto atmosferico ($136.9\mu g/m^3$).

Inoltre, AIM si dimostra più conservativo di AERMOD anche trascurando i casi di calma di vento, che vanno ad alzare il massimo di ricaduta di AIM e non influenzerebbero in ogni caso i massimi della simulazione di AERMOD con building downwash in quanto l'effetto di disturbo degli edifici è tanto maggiore quanto minore è l'altezza del pennacchio e dunque, a parità di condizioni di stabilità, quanto maggiore è la velocità del vento.

L'edificio che maggiormente influenza la dispersione è il già segnalato Cargo Village 2028 (parte uffici), che tende ad alzare i massimi d'impatto della centrale di cogenerazione. Livelli superiori a $10\mu g/m^3$ (5% del limite di legge del solo NO_2) sono calcolati solamente entro il sedime aeroportuale tranne verso ovest della COGE ma solo su un'area di limitatissime dimensioni.

I risultati ottenuti già in questa configurazione progettuale non giustificano ulteriori approfondimenti di altre più cautelative ipotesi di altezza dei camini.

Tabella 1. Posizione, funzione e altezza (m) di edifici e camini delle centrali termiche considerate nell'analisi

Rif.	Modello	Building Downwash	Valore max di dominio ($\mu g/m^3$)
1a	AERMOD	S	23.2
1b	AERMOD	N	3.4
2a	AERMOD (solo v>=1m/s)	N	3.4
2b	AIM (solo v>=1m/s)	N	10.0
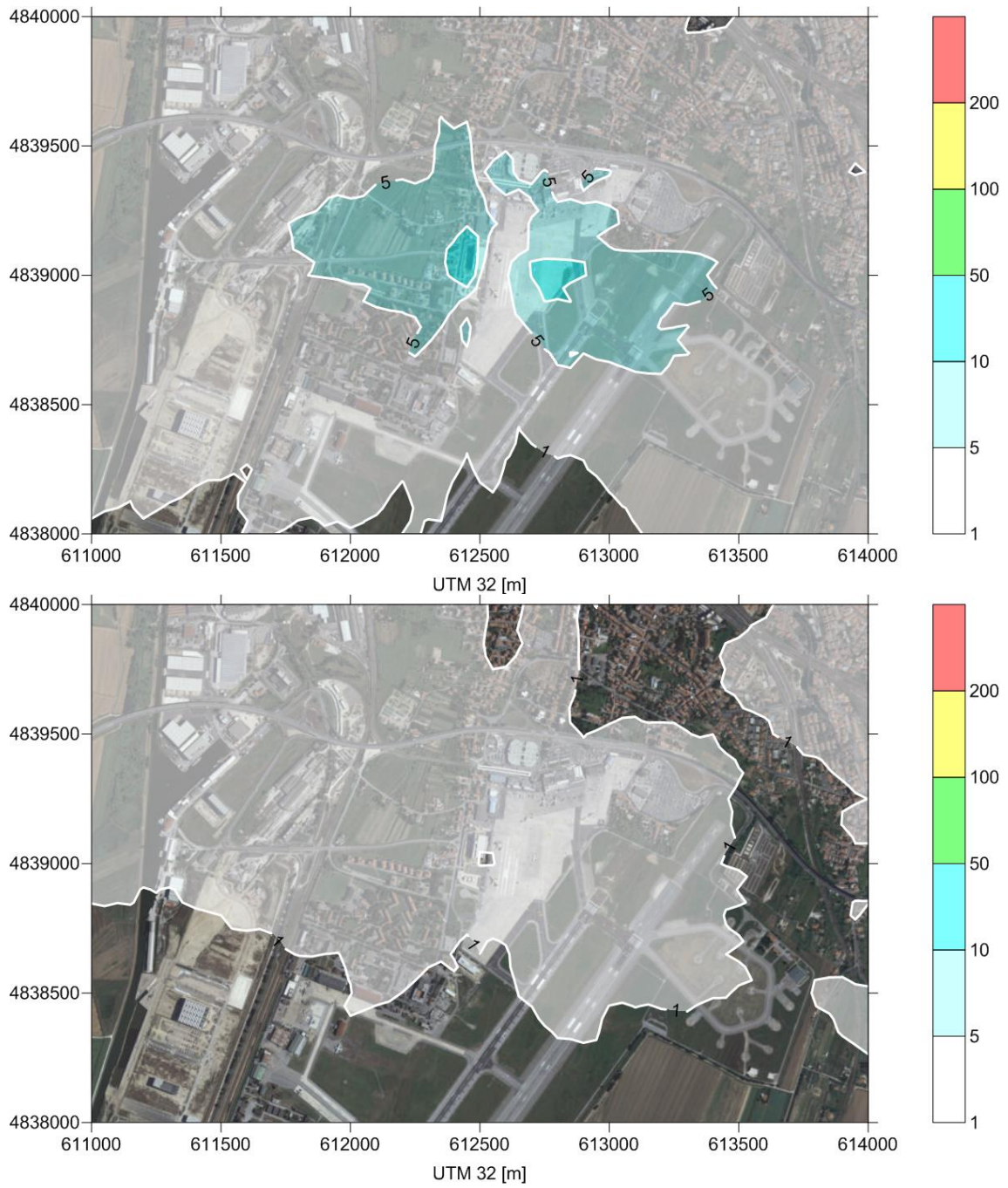
Figura 2. Modello AERMOD, percentile annuale 99.8 delle concentrazioni medie orarie di NO$_X$ – confronto risultati considerando (sopra) e non considerando (sotto) l'effetto di "building downwash".
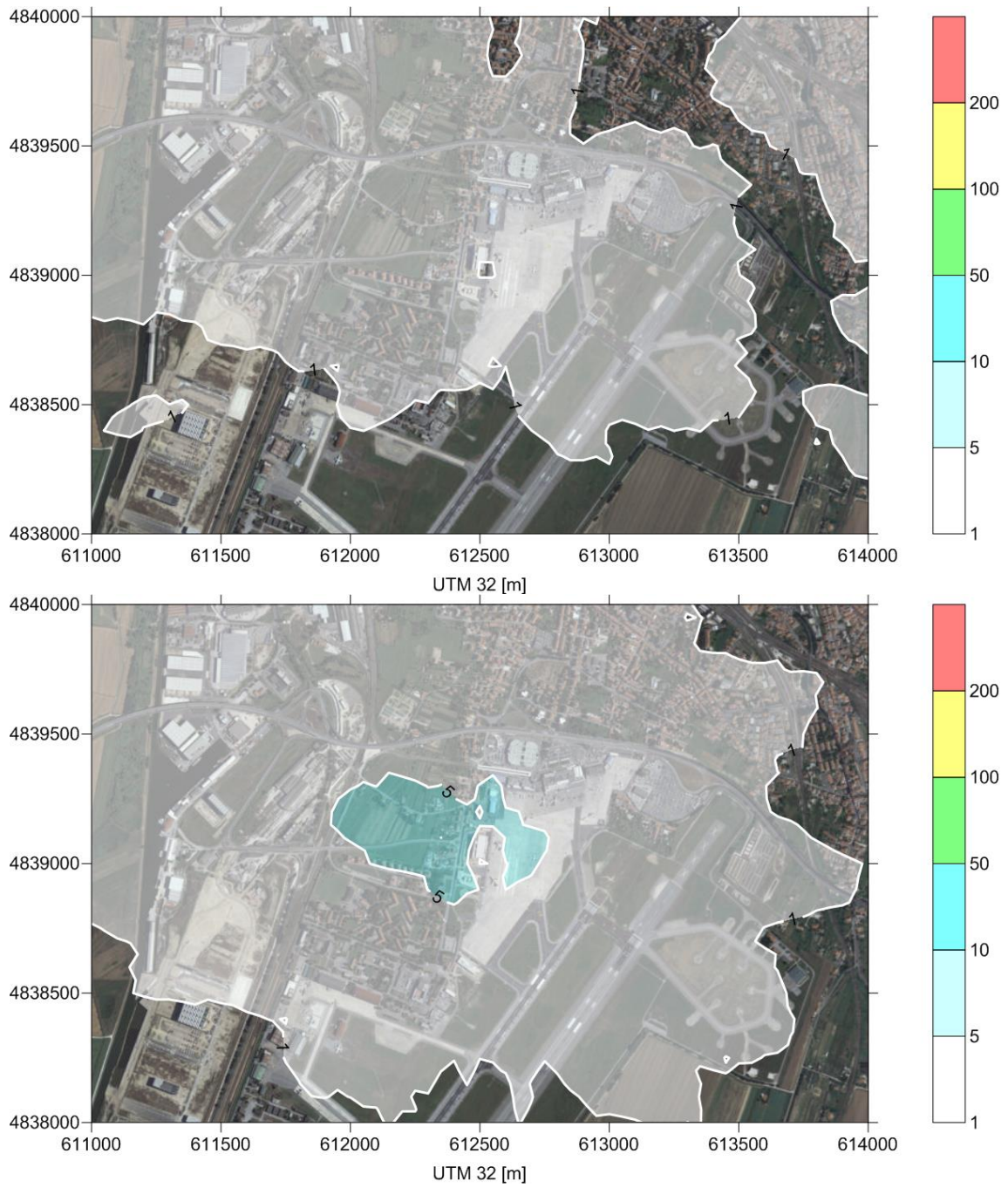
Figura 3. Percentile annuale 99.8 delle concentrazioni medie orarie di NO_X – confronto risultati tra i modelli AERMOD (sopra) e AIM (sotto) nelle situazioni di avvezione (vv>1m/s).

Osservazione 2.   Si precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso il contributo delle emissioni dovute ai movimenti degli aeromobili dell'aviazione generale e militare. Nel caso non sia stato incluso è necessario che le simulazioni siano ripetute includendo tale contributo (in particolare quello dell'aviazione generale).

Le emissioni dell'aviazione generale sono incluse nei conteggi e nella composizione della flotta mentre per quanto riguarda gli aerei militari non erano disponibili informazioni.

(par. "7.2: Attività aeroportuale di Pisa San Giusto" nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028")

Osservazione 3. Siano precisati i motivi per i quali non si è ritenuto di adeguare i TIM delle fasi di rullaggio (taxi in/idle e taxi out/idle) rispetto allo studio condotto nel 2008, tenuto conto del nuovo assetto al 2028 caratterizzato dall'arretramento di 400 m del punto di stacco degli aeromobili in fase di decollo verso la città. Nel caso in cui i TIM nel nuovo assetto fossero diversi da quelli fin qui adottati è necessario che le simulazioni siano ripetute con i nuovi TIM.

Rispetto al 2014, nel 2028 l'assetto sarà caratterizzato da un arretramento di 400m del punto di avvio della fase di decollo degli aeromobili; in fase di taxi precedente al decollo verso la città, pertanto, il tempo di IDLE OUT04R in tale direzione aumenterà di 21 secondi (per un tempo complessivo di 501 secondi). I risultati dello studio complementare di approfondimento consegnato insieme al presente includono questa tempistica di fase aggiornata.

(par. "7.3 Tempi caratteristici di fase (TIM)" nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028")

Osservazione 4.   Sia presentato il quadro emissivo delle emissioni convogliate dalle centrali termiche (includendo portata, velocità di uscita dei fumi, concentrazioni al camino o ratei emissivi per ciascun inquinante emesso), sia nello stato attuale sia in quello futuro (anno 2028) dopo la dismissione degli impianti obsoleti e l'attivazione dei nuovi sistemi di produzione del calore e dell'energia.

Anno 2014:

	rif.	Utenza	Altezza (m)	Diametro (m)	Temp (K)	Vel (m/sec)	Pot. Termica Nom. Installata (kW)	Consumo Metano (m3/anno)	NOX (t/anno)	CO (t/anno)	PM10 (t/anno)
1	CTA	Aerostazione					2224	5 540	6.7E-03	4.8E-03	3.8E-02
2	CTB	Ex Merci					930	-			
3	CTC	Officina Mezzi	6	0.25	409	0.06	105	19 000	2.3E-02	1.6E-02	1.3E-01
4	CTD	Catering	5	0.2	373	0.16	190	7 000	8.4E-03	6.0E-03	4.8E-02
5	CTE	Edificio A	20	0.15	373	8.01187	1000	3 081	3.7E-03	2.7E-03	2.1E-02
6	CTF	VV.F	8.5	0.3	373	0.12	291	20 000	2.4E-02	1.7E-02	1.4E-01
7	CTG	Cargo	20	0.3	373	0.86	2250	34 200	4.1E-02	3.0E-02	2.4E-01
8	COGE	Cogeneratore	25	0.3	373	11.91799	2855	2 450 000	1.9E+00	1.7E+00	1.2E-03
9	NCT	Ampl+ Aerost	20	0.3	373	0.9	0	-			
		totale						2 538 821	2.05	1.77	0.61

Anno 2028:

	rif.	Utenza	Altezza (m)	Diametro (m)	Temp (K)	Vel (m/sec)	Pot. Termica Nom. Installata (kW)	Consumo Metano (m3/anno)	Fattore di utilizzo rispetto a 2014	NOX (t/anno)	CO (t/anno)	PM10 (t/anno)
1	CTA	Aerostazione					-	-	0.00			
2	CTB	Ex Merci					-	-	0.00			
3	CTC	Officina Mezzi	6	0.25	409	0.06	105	13300	0.70	1.6E-02	1.1E-02	9.2E-02
4	CTD	Catering	5	0.2	373	0.16	190	4900	0.70	5.9E-03	4.2E-03	3.4E-02
5	CTE	Edificio A	20	0.15	373	8.01187	1000	3081	1.00	3.7E-03	2.7E-03	2.1E-02
6	CTF	VV.F	8.5	0.3	373	0.12	291	14000	0.70	1.7E-02	1.2E-02	9.7E-02
7	CTG	Cargo	20	0.3	373	0.86	2250	61560	1.80	7.4E-02	5.3E-02	4.3E-01
8	COGE	Cogeneratore	25	0.3	373	11.91799	2855	2450000	1.00	1.9E+00	1.7E+00	1.2E-03
9	NCT	Ampl+ Aerost	20	0.3	373	0.9	5100	290000		3.5E-01	2.5E-01	2.0E+00
		totale						2836841		2.41	2.03	2.67

(par. "7.8.2 Centrali termiche" nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028")

Osservazione 5. Sia presentato il quadro completo dei GSE di cui sono state stimate le emissioni, compresi i fattori di emissione adottati".

Per l'elenco dei GSE considerati si rimanda all'ALLEGATO B - GSE 2014.pdf; la stima emissiva ha riguardato esclusivamente i soli mezzi alimentati a gasolio o a benzina, elencati insieme a tutti gli altri veicoli e dettagliati per tipo, marca, modello e alimentazione.

Di seguito si riportano i fattori di emissione utilizzati.

YEAR	TYPE	FUEL	CO_G_HPHR	HC_G_HPHR	NOX_G_HPHR	PM_G_HPHR
2028	Air Conditioner	D	0.09804	0.132078	0.282132	0.010376
2028	Air Start	D	0.136769	0.134336	0.520154	0.018438
2028	Aircraft Tractor	D	0.147063	0.134237	0.365537	0.016832
2028	Baggage Tractor	D	0.39206	0.132072	0.282788	0.010204
2028	Belt Loader	D	0.263914	0.132094	0.293613	0.010707
2028	Bobtail	D	0.160983	0.133156	0.333877	0.016556
2028	Cabin Service Truck	D	0.131317	0.132194	0.180902	0.011556
2028	Cargo Loader	D	0.258942	0.134666	0.319316	0.01642
2028	Cargo Tractor	D	0.623988	0.144188	0.585134	0.047646
2028	Cart	D	0	0	0	0
2028	Catering Truck	D	0.131317	0.132194	0.180902	0.011556
2028	Deicer	D	0	0	0	0
2028	Fork Lift	D	0.384912	0.16236	0.584476	0.052399
2028	Fuel Truck	D	0.130274	0.131992	0.180819	0.011283
2028	Hydrant Truck	D	0.147609	0.135945	0.246115	0.012224
2028	Lavatory Truck	D	0.139811	0.134146	0.211357	0.011787
2028	Lift	D	0.383688	0.162145	0.582147	0.052189
2028	Other	D	0.156893	0.132835	0.324419	0.015331
2028	Passenger Stand	D	0.147521	0.135924	0.245669	0.012214
2028	Service Truck	D	0.13228	0.132435	0.184907	0.011399
2028	Sweeper	D	0.623875	0.144181	0.585524	0.047963

(par. "*7.8.1 Ground Support Equipment (GSE)*" nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028")

Osservazione 6.   Si precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso il contributi degli APU. Nel caso non sia stato incluso, chiarisca le motivazioni di tale scelta; se altrimenti all'anno 2028 si ipotizza che siano ancora attivi APU che comportano emissioni in atmosfera è necessario che le simulazioni siano ripetute includendone il contributo".

Le unità di potenza ausiliaria (APU, Auxiliary Power Unit) non sono considerate nel calcolo delle emissioni al 2028 in quanto completamente elettrificate.

(par. "*7.8 Sorgenti emissive diverse dagli aeromobili*" nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028")

Osservazione 7. Si precisi, per quanto concerne i dati meteorologici utilizzati nelle simulazioni con il codice ARIA IMPACT, sia il metodo di assegnazione ad ogni ora della classe di stabilità atmosferica sia i dati di profilo verticale utilizzati per la stima dello spessore di rimescolamento".

Per approfondimenti circa lo schema di calcolo delle categorie di stabilità atmosferica si rimanda al manuale utente di ARIA Impact.

Il metodo di stima dei profili verticali di velocità del vento e temperatura sono descritti nel manuale utente di ARIA Impact (par. 5.8, p. 129).

Il metodo di calcolo dello spessore dello strato rimescolato è descritto nella relazione di approfondimento ARIANET R2015.08 che riprende quanto scritto con maggiore approfondimento nel manuale utente di ARIA Impact (par. 5.9, p. 132).

Osservazione 8.   Siano effettuate nuovamente le stime con il codice ARIA IMPACT per un'intera annualità, superando l'impostazione adottata nella documentazione esaminata (in cui le stime sono state condotte per due mesi invernali e quattro estivi), al fine di ottenere per tutti i punti di griglia gli indicatori statistici delle distribuzioni delle concentrazioni fissati dal DLgs 155/2010 per i diversi inquinanti considerati".

Per la descrizione dei risultati delle simulazioni effettuate considerando un'intera annualità meteorologica si rimanda al documento degli approfondimenti allo studio d'impatto atmosferico consegnato insieme al presente e di cui il presente costituisce un allegato

(capitolo."8 Simulazioni modellistiche di dispersione "nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028")

Osservazione 9. Una volta stimate le concentrazioni orarie in aria ambiente di NOx con il codice ARIA IMPACT, siano stimate le relative concentrazioni di NO2 impiegando il metodo ARM2 adottato da US-EPA e, successivamente, calcolando per tutti i punti di griglia gli indicatori statistici delle distribuzioni delle concentrazioni fissati dal DLgs 155/2010.

Si rimanda al documento di approfondimento di cui il presente costituisce un allegato.

(par."5.3 Relazione semiempirica tra le concentrazioni in aria di NOX e NO2 "nel documento: "Aggiornamento Relazione simulazioni impatto atmosferico scenario 2028" e successivi capitoli)

Osservazione 10.   Sia effettuato il confronto delle stime ottenute con gli standard di qualità dell'aria fissati dal DLgs 155/2010 tenendo conto dei valori di fondo desumibili dai dati di qualità dell'aria caratteristici della zona, come rilevati da ARPAT con le campagne effettuate con laboratorio mobile e/o come rilevati presso la stazione Pisa-Passi facente parte della rete regionale di qualità dell'aria. Tale confronto dovrà essere effettuato in forma tabellare presso 10 punti recettori interni ed esterni al sedime aeroportuale, con preferenza per quelli prossimi ad edifici residenziali o adibiti ad attività ricettive, scolastiche, sanitarie"; nell'effettuare il confronto si dovrà tenere conto anche delle indicazioni formulate da UK-Environment Agency ("Conversion ratios for NOx and NO2": http://persona.uk.com/kings_lynn/Core_docs/Q/Q11.pdf)

Si risponde qui all'osservazione solo in maniera parziale, per il resto si rimanda al documento di approfondimento di cui il presente costituisce un allegato.

Di seguito sono presentate le distribuzioni cumulate dei valori di concentrazione ottenuti, per i vari inquinanti e gli standard di legge, sulla griglia di calcolo sommando il valore calcolato modellisticamente come contributo del sistema aeroportuale al valore di fondo ottenuto, come descritto altrove, tramite applicazione di tecniche di "data fusion" tra i dati misurati presso le stazioni della rete regionale di rilevamento in continuo e quelli calcolati dal modello nazionale MINNI di riferimento presso il Ministero dell'Ambiente.

Inoltre, le tabelle seguenti riassumono la valutazione oggettiva nel caso specifico così come suggerito dal documento di UK-EPA citato nell'osservazione. Secondo questo criterio, fissato l'inquinante, lo standard statistico e un valore di riferimento (per es.: NO_2, media annuale e limite di legge – 40µg/m^3) la valutazione dell'impatto di una sorgente inquinante, espressa come somma del contributo calcolato modellisticamente più il fondo ambientale (nel nostro caso derivato sul dominio di calcolo tramite applicazione di tecniche di data-fusion) due sono i limiti da non superare:

- uno, denominato "long term relevant background concentration" corrisponde al valore di riferimento e deve essere soddisfatto dal 100% dei valori calcolati (modello + fondo);
- l'altro, "short term relevant background concentration", corrisponde al doppio del valore di riferimento e deve essere soddisfatto da almeno il 50% dei valori calcolati.

Se uno dei limiti non è soddisfatto allora la valutazione dell'impatto richiede più del livello di "screening" e si deve considerare un livello di approfondimento superiore "worse case"; se anche i limiti per questo livello superiore di approfondimento sono superati (rispettivamente 70% e 35% dei casi) allora l'approfondimento deve spingersi a un livello ancora superiore ("case specific scenario") che, si sottolinea, è quello comunque adottato da subito per lo studio dell'impatto atmosferico del masterplan 2028 dell'aeroporto.

L'ambito di applicazione di questo criterio di selezione dell'approfondimento della valutazione può essere interpretato come sia spaziale (mappa delle concentrazioni calcolate sul territorio a tempo fisso) sia temporale (serie delle concentrazioni calcolate ora per ora in un punto fisso); nel primo caso, la tabella seguente mostra che il massimo livello di approfondimento adottato ("case specific scenario") è richiesto solo dal fatto che non è soddisfatto il criterio "long term" sul percentile del

PM10, in quanto le concentrazioni calcolate, sommate al rilevante fondo ambientale, risultano inferiori al limite di legge in percentuale inferiore al 35% (20.5%).

Tabella 2. Posizione, funzione e altezza (m) di edifici e camini delle centrali termiche considerate nell'analisi

Inquinante / standard di legge	Limite di legge (µg/m³)	Criterio "long term" (percentuale di valori inferiore al valore di riferimento)	Criterio "short term" (percentuale di valori inferiore a 2 volte il valore di riferimento)
NO₂ / media annuale	40	100%	100%
NO₂ / percentile annuale 99.8	200	100%	100%
PM10 / media annuale	40	100%	100%
PM10 / percentile annuale 90.4	50	**20.5%**	100%
CO / massimo annuale della concentrazione 8-oraria	10000	100%	100%
C₆H₆ / media annuale	5	100%	100%

Figura 4. Distribuzione di frequenza cumulata della concentrazione media annuale di NO₂ ottenuta sul dominio di calcolo come somma del differenziale d'impatto 2028-2014 del sistema aeroportuale calcolato modellisticamente più il fondo ambientale.

Figura 5. Distribuzione di frequenza cumulata del percentile 99.8 delle concentrazioni medie orarie di NO_2 ottenuta sul dominio di calcolo come somma del differenziale d'impatto 2028-2014 del sistema aeroportuale calcolato modellisticamente più il fondo ambientale.
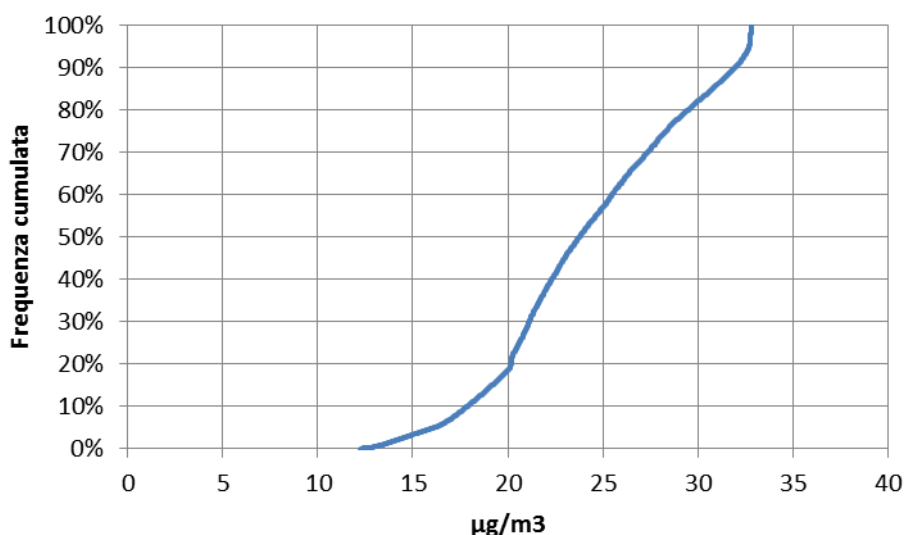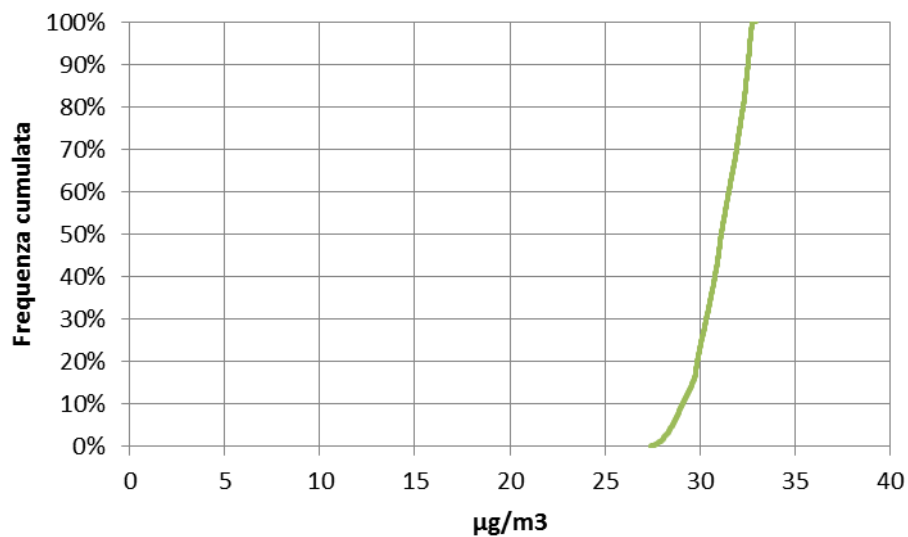

Figura 6. Distribuzione di frequenza cumulata della concentrazione media annuale di PM10 ottenuta sul dominio di calcolo come somma del differenziale d'impatto 2028-2014 del sistema aeroportuale calcolato modellisticamente più il fondo ambientale.
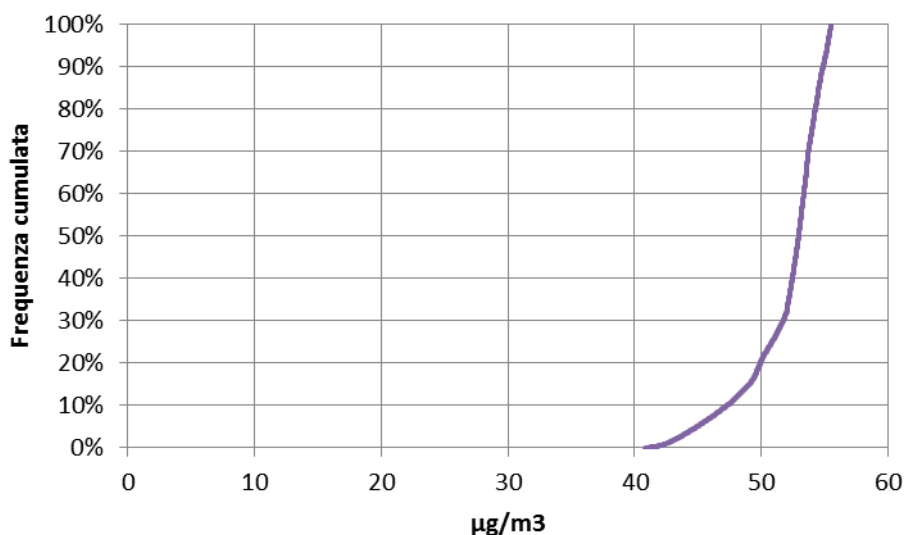
Figura 7. Distribuzione di frequenza cumulata del percentile annuale 90.4 della concentrazione media giornaliera di PM10 ottenuta sul dominio di calcolo come somma del differenziale d'impatto 2028-2014 del sistema aeroportuale calcolato modellisticamente più il fondo ambientale.

Figura 8. Distribuzione di frequenza cumulata del massimo della concentrazione media 8-oraria di CO ottenuta sul dominio di calcolo come somma del differenziale d'impatto 2028-2014 del sistema aeroportuale calcolato modellisticamente più il fondo ambientale.
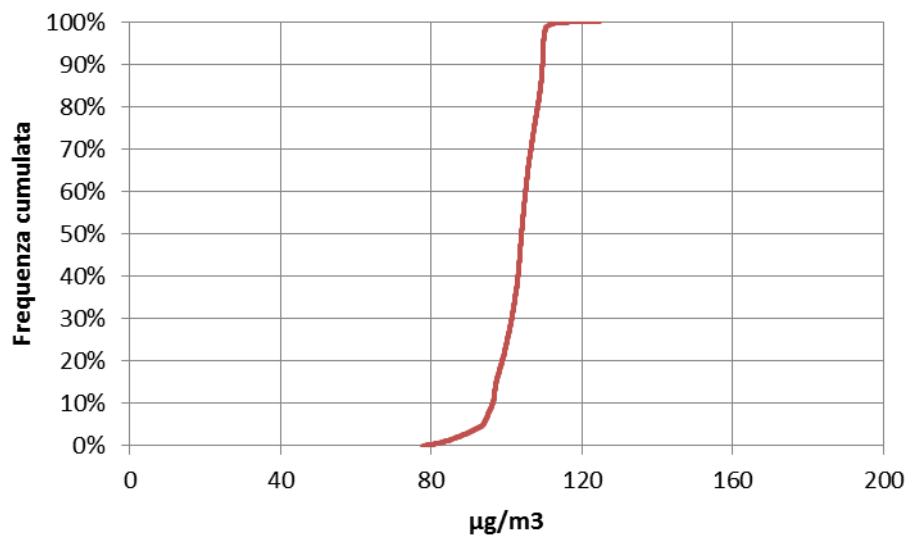
Figura 9. Distribuzione di frequenza cumulata della concentrazione media annuale di C_6H_6 ottenuta sul dominio di calcolo come somma del differenziale d'impatto 2028-2014 del sistema aeroportuale calcolato modellisticamente più il fondo ambientale.
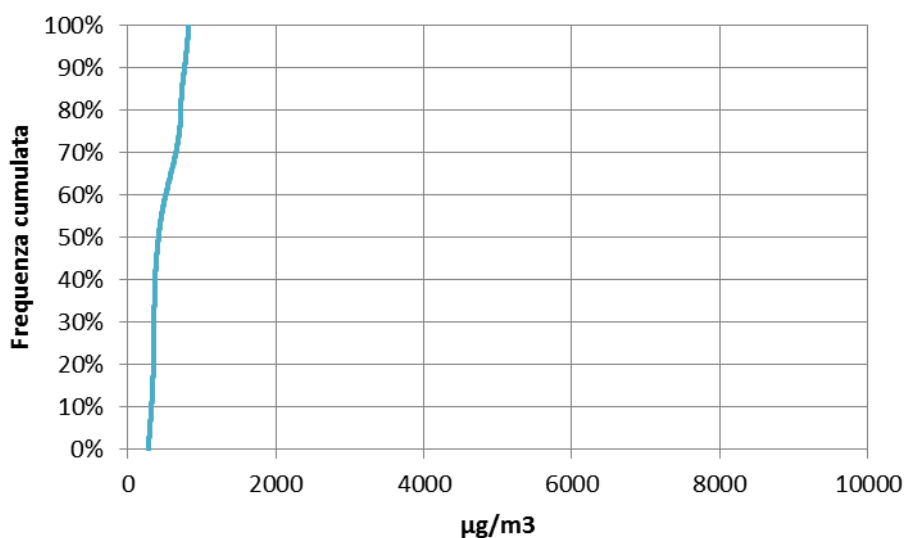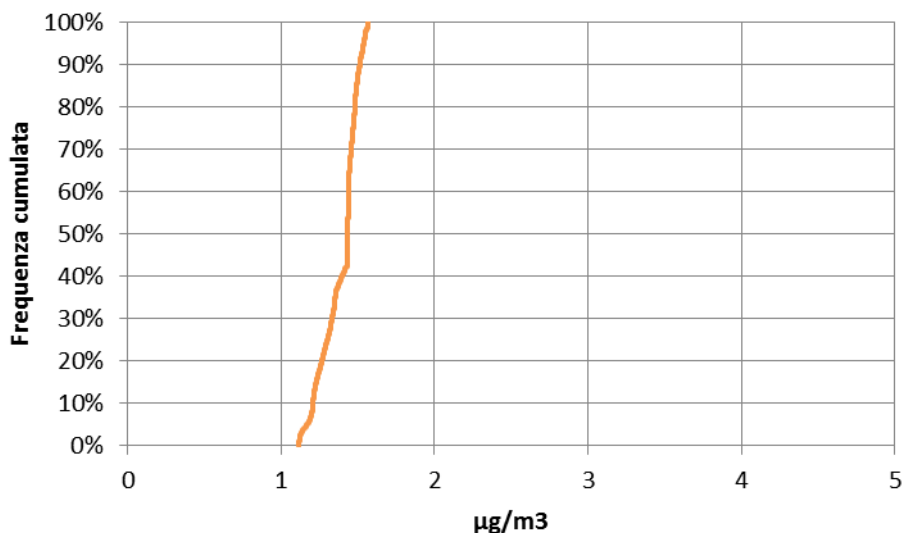
Nel caso l'ambito di applicazione sia invece temporale, si riporta nelle tabelle seguenti l'elaborazione relativa al recettore "P59" risultato dall'analisi presentata nella relazione di approfondimento come il più interferito dall'aeroporto in termini di media annuale di NO_2. Questa elaborazione è da ritenersi a rigore conservativa in quanto il valore calcolato come fondo include, nei pressi dell'aeroporto, il contributo dell'aeroporto stesso allo stato attuale.

Come si osserva dalle tabelle, la valutazione del PEC di short term porta a richiedere sempre il livello di approfondimento più elevato (quello comunque adottato da subito nello studio del masterplan 2028) perché già la concentrazione rilevante di background supera il limite di legge. Considerando invece la valutazione del PEC di long term, il livello di approfondimento richiesto sarebbe il secondo, "worse case scenario" in particolare a causa del superamento del limite da parte del percentile 100 delle concentrazioni orarie di NO_X

Tabella 3. Metodo oggettivo per la selezione del livello di approccio per la valutazione d'impatto – Inquinante NOx – recettore P59 (PEC = contributo calcolato + concentrazione rilevante di background). Limite di legge per la media annuale: 40µg/m^3.

Percentile concentrazioni orarie	Contributo calcolato – masterplan 2028 (µg/m^3)	Media annuale di fondo	Concentrazione rilevante di background – long term	Concentrazione rilevante di background – short term	PEC
100	13.2		31.6		**44.8**
70	0.8	31.6			32.4
50	0.3			62.4	**62.7**
35	0.2				**62.6**

Tabella 4. Metodo oggettivo per la selezione del livello di approccio per la valutazione d'impatto – Inquinante PM10 – recettore P59 (PEC = contributo calcolato + concentrazione rilevante di background). Limite di legge per la media annuale: 40µg/m^3.

Percentile concentrazioni giornaliere	Contributo calcolato – masterplan 2028 (µg/m^3)	Media annuale di fondo	Concentrazione rilevante di background – long term	Concentrazione rilevante di background – short term	PEC
100	0.79		32.20		32.99
70	0.04	32.20			32.24
50	0.02			**64.4**	**64.42**
35	0.01				**64.41**

Allegato 1

Si allega il documento "Verbale_SAT_20150224_finale.pdf", verbale dell' incontro tecnico relativo al procedimento di verifica di assoggettabilità a VIA per il Master plan 2014-2018 dell'aeroporto "Galileo Galilei" svoltosi presso gli uffici ARPAT in via Porpora 22, Firenze, in data 24.2.2015.

Allegato 2

Si allega il documento "Impact_1.8_utilisateur_eng.pdf", manuale utente del software modellistico ARIA Impact utilizzato per le simulazioni di dispersione atmosferica.

Verbale sommario
Incontro tecnico relativo al procedimento di verifica di assoggettabilità a VIA
per il Master plan 2014-2018 dell'aeroporto "Galileo Galilei"

L'incontro, richiesto dalla società di gestione dello scalo "Galileo Galilei" SAT S.p.A., si è svolto presso gli uffici ARPAT in via Porpora 22, Firenze, in data 24.2.2015. Presenti:
- per SAT: Ing. Tirotta;
- per ARPAT (Settore Modellistica previsionale): Dott. Barbaro.

Sono altresì presenti i consulenti SAT per la redazione della documentazione depositata nel procedimento:
- Arch. Mancino e Dott. Nanni.

SAT chiarisce che il procedimento relativo all'opera in questione (verifica di assoggettabilità a VIA ex art. 20, di competenza statale ex art. 7 e Allegato II alla Parte Seconda, del DLgs 152/2006) è ancora in corso presso il Ministero dell'Ambiente (http://www.va.minambiente.it/it-IT/Oggetti/Info/1505); su tale procedimento il Ministero dell'Ambiente è tenuto ad acquisire il parere della Regione Toscana (ex art. 25 del DLgs 152/2006), alla quale ARPAT ha già fornito il proprio parere con nota prot. n. 2015/0002837 del 16.1.2015.

Al fine di abbreviare i tempi di predisposizione dell'eventuale documentazione integrativa, SAT ha assunto l'iniziativa di acquisire (tramite "accesso agli atti" presso la Regione Toscana) i diversi pareri espressi per la Regione dagli Enti tenuti ad esprimersi: tra cui il citato parere ARPAT del 16.1.2015. Il quale riprende, allegandolo integralmente, il contributo istruttorio redatto dal Settore Modellistica previsionale di ARPAT del 13.1.2015, nel quale sono esaminati e valutati gli elementi inclusi nella documentazione depositata da SAT relativi all'impatto sulla "componente atmosfera".

La riunione perciò si focalizza sulle indicazioni espresse nel parere ARPAT del 16.1.2015 ("componente atmosfera", pagg. 1-2) ed in particolare nel contributo istruttorio del Settore Modellistica previsionale del 13.1.2015 (cui ARPAT rinvia per tutti i dettagli qui non riportati), con l'obiettivo di chiarire natura (richiesta di integrazione o richiesta di chiarimento) e finalità tecniche delle 10 richieste al proponente.

1. "Precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso l'effetto *building downwash* determinato dal complesso degli edifici in cui è articolato lo scalo, con particolare riferimento a quelli prossimi o sottostanti le emissioni convogliate dalle centrali termiche. Nel caso non sia stato incluso è necessario che le simulazioni siano ripetute includendo tale effetto". ARPAT precisa che la natura della richiesta è in parte di chiarimento ed in parte di integrazione, e che le eventuali simulazioni aggiuntive devono offrire elementi tecnici utili ad orientare la progettazione della quota dei camini delle emissioni convogliate (che potrebbe essere oggetto di eventuale prescrizione a conclusione del procedimento). SAT chiarisce che nel codice di calcolo ARIA IMPACT non è stato attivato l'effetto *building downwash* e si impegna a:
    a. esplicitare questa circostanza nella risposta;
    b. allegare il manuale d'uso e/o una descrizione degli algoritmi implementati nel codice di calcolo ARIA IMPACT (di cui al momento è disponibile solo una brochure di sintesi: http://www.aria-net.it/front/IT/codici/files/11.pdf);
    c. allegare planimetrie e sezioni dei corpi di fabbrica che, in relazione alle emissioni convogliate, possono determinare l'innesco dell'effetto *building downwash*;
    d. predisporre una o più simulazioni semplificate (riferite all'inquinante più critico ed effettuate con idoneo codice di calcolo, anche diverso da ARIA IMPACT) finalizzate a stimare l'impatto delle emissioni convogliate in diverse ipotesi di altezza dei camini, al fine di individuare l'altezza ottimale, compatibilmente con eventuali vincoli di natura aeronautica e/o paesaggistica.
2. "Precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso il contributo delle emissioni dovute ai movimenti degli aeromobili dell'aviazione generale e militare. Nel caso non

ARIA Impact

General Design
and
User's Manual
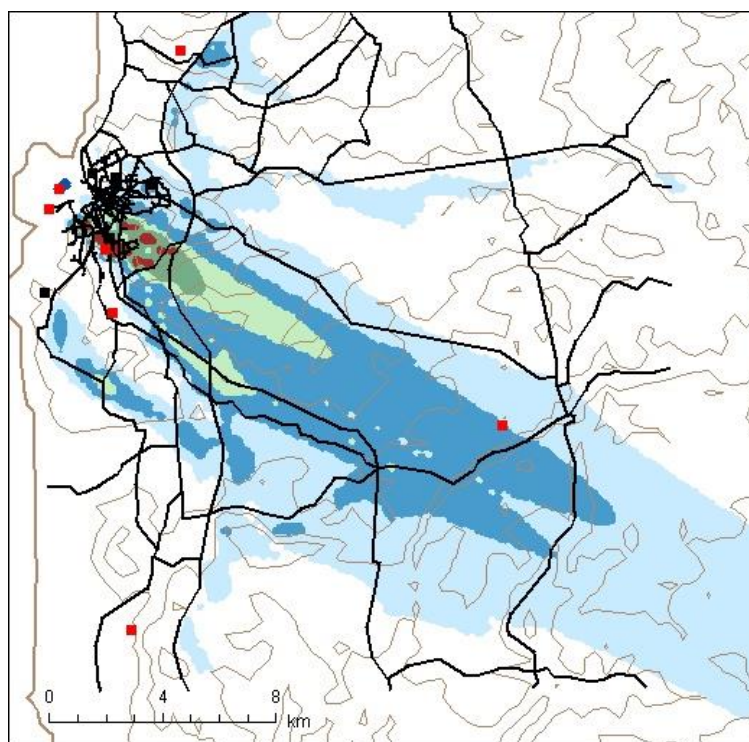
ARIA Impact General Design and User's Manual

Version: 1.8
Document: ARIA/2013.070
Last update: November 2013

CONTENTS

Table of illustrations

1. BACKGROUND

ARIA Impact is user-friendly software adapted to meet the needs of industry, consulting agencies and air quality monitoring associations.

The program is consistent with regulations on air quality and provides the basic elements for assessing human health risks and olfactory nuisance.

The model calculates the long-term impact of air pollutants (gaseous or particulate) from different type of emission sources and yields pollutant concentration and deposition (dry and wet) expressed as annual averages or percentiles. It has a special module for reproducing dispersion during calm winds and it can account for different phenomena such as reflection of gas plumes by the mixing layer.

2. INSTALLING ARIA IMPACT

2.1 INSTALLATION

ARIA Impact is delivered on a CD-ROM. Minimal hardware configuration required for optimum operation of the software includes:
- Processor: Pentium IV or equivalent
- Memory: 512 Mb
- Operating system: Windows 2000, XP or seven.
- Screen display: 1024 x 768 pixels

To install ARIA Impact, first insert the CD-ROM in the drive. The installation procedure is launched automatically; if not, double click on `setup.exe` located in the main directory of the CD-ROM.

During setup, the user will be asked to enter the name of the directory where the software should be installed. The directory name must not contain any spaces. It's recommended to install the software on the C: or D: hard disc drive. At the end of setup, the user will be asked to restart the computer to complete the setup.

2.2 SOFTWARE PROTECTION

The ARIA Impact software is protected against illegal copying. A license number is required in order to use the model.

Before running the model, the user should therefore register with ARIA Technologies (by email, fax, or letter) by supplying the volume series of the C: disc on the computer where ARIA Impact is/will be installed. To find out the volume series, go to the MS-DOS window and type:

```
vol C:
```

At the reception of this information, ARIA Technologies will in return send a file named adso.lic including the user's license number. This file should be copied to the directory:

IMPACT1.8\LICENSE,

that was created at the installation of the software.

Protection is limited to the computer on which the software is installed. Installation on another machine will require a new registration key.

3. PRINCIPLE OF USE

The ARIA Impact program is designed to:
- Generate statistical output of meteorological data at a specific site, allowing analysis of the atmospheric dispersion conditions at the site;
- Simulate the dispersion of atmospheric pollutants from one or several emission sources based on Gaussian equation formulations.

Several types of modelling calculations are possible with ARIA Impact:
- <u>Academic calculation</u>: calculates the dispersion of air pollutants for specific meteorological conditions defined by the user.
- <u>Calculation from a wind rose</u>: calculates the dispersion of air pollutants by taking into account the distribution of winds based on a wind rose. This option enables to calculate annual averages, 100 percentiles or the frequency of threshold exceedances.
- <u>Statistical calculation</u>: calculates the dispersion of air pollutants by taking into account a time-series of meteorological data for one or several years. In this case a calculation is performed for each individual hour in the meteorological database. Based on these results, statistical post processing allows obtaining annual averages, percentiles (98, 99.5 ... etc.) or frequencies of threshold exceedance.

ARIA impact allows simulating the dispersion of:
- gaseous pollutants (NOx, SO_2 ...)
- particulates (PM10, heavy metals, dioxins ...)
- odour,
- radioactive pollutants.

The model can account for emissions from different types of sources including:
- point sources
- line sources
- area sources
- volume sources

The ARIA Impact software is not limited in number of pollutants, or number of sources. Different type of sources and pollutants may be taken into account simultaneously in the same calculation.

4. DESCRIPTION OF USER INTERFACE

4.1 MAIN PANEL

The figure below presents the main window of ARIA Impact:
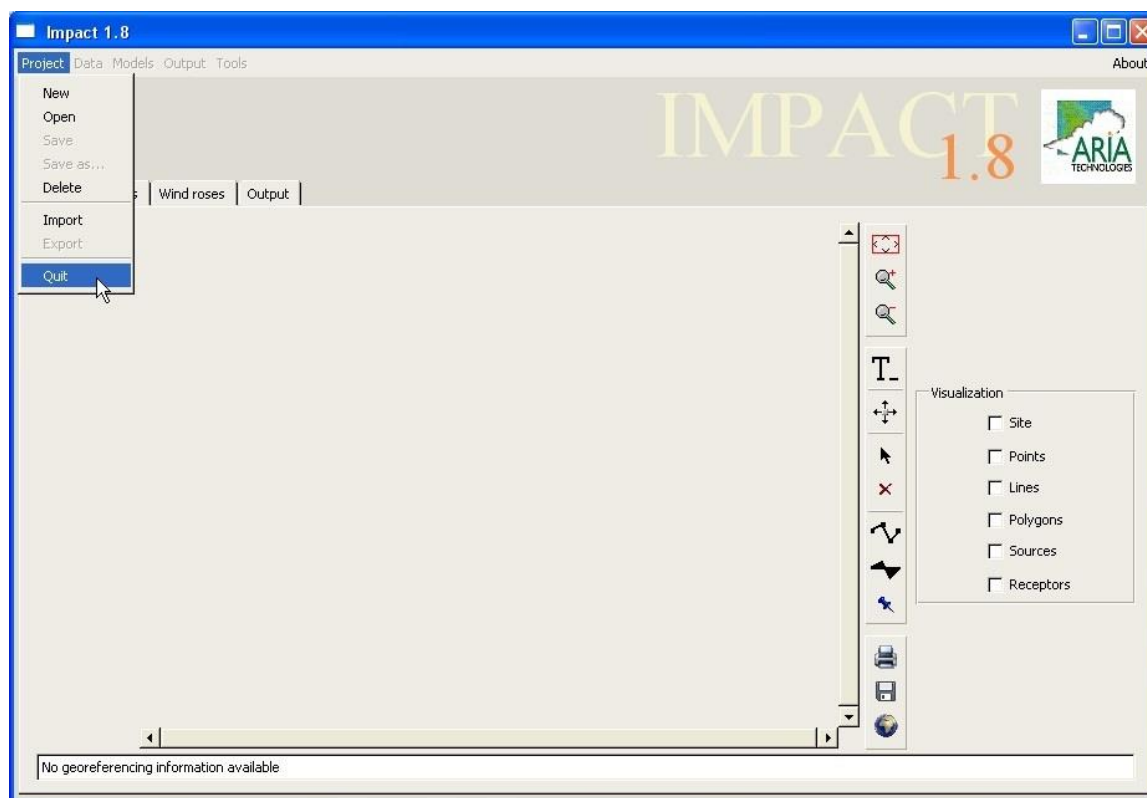
Figure 1: Main panel with Project pull down menu

Before using the interface to access program functionality, the user needs to either create a new project or to select an existing project. A project is a set of files linked to a particular site, which are created by the user of the software. The Project menu allows the user to manage a particular project by choosing between the following options:

4.2 PROJECT MENU

A project is a list of files created by the software or given by the user, related to the study of a particular site.

The Project menu contains the different tools for managing project files.

4.2.1 Project - New

Creates a new project containing default files. The default files are copied to the working directory (SCRATCH). When the user gives a name for the new project, a subdirectory with

the project name is created in the "PROJECT" directory. The site definition windows appears (see 4.3.1.1)

4.2.2 Project - Open

Allows the user to load an existing project. Click Open to display a list of existing projects and select one of them (Figure 2). The project files are copied to the active directory, and the project name is updated. If another project is already open, the user will first be asked if the active project should be saved before loading the new one.
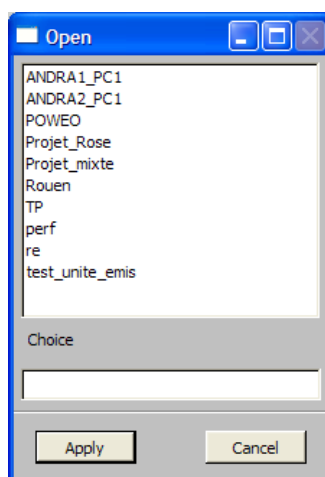
Figure 2: Window for the Project - Open option.

4.2.3 Project - Save

Saves the active project.

4.2.4 Project - Save As

Saves the active project under another name. Clicking on Save As displays a window with a list of existing projects and a bar for specifying a new name. The working files in the SCRATCH directory are then copied to a subdirectory PROJECT with the name given by the user. The project is saved and can be reloaded for a future run.

4.2.5 Project - Delete

Removes a project from the disk. Clicking on Delete displays a Window with a list of existing projects from which the user selects the one to be deleted. The subdirectory containing the files to be deleted is removed from the disk.

4.2.6 Project - Import

Allows the user to load an existing project from a different directory (other than the default directory: ARIA\IMPACT1.8\PROJECT).

4.2.7 Project - Export

Allows the user to save the current project in a different directory.

4.2.8 Project - Quit

Allows the user to close ARIA Impact. If the active project has not been saved, the user will be asked if it should first be saved.

4.3 DATA MENU
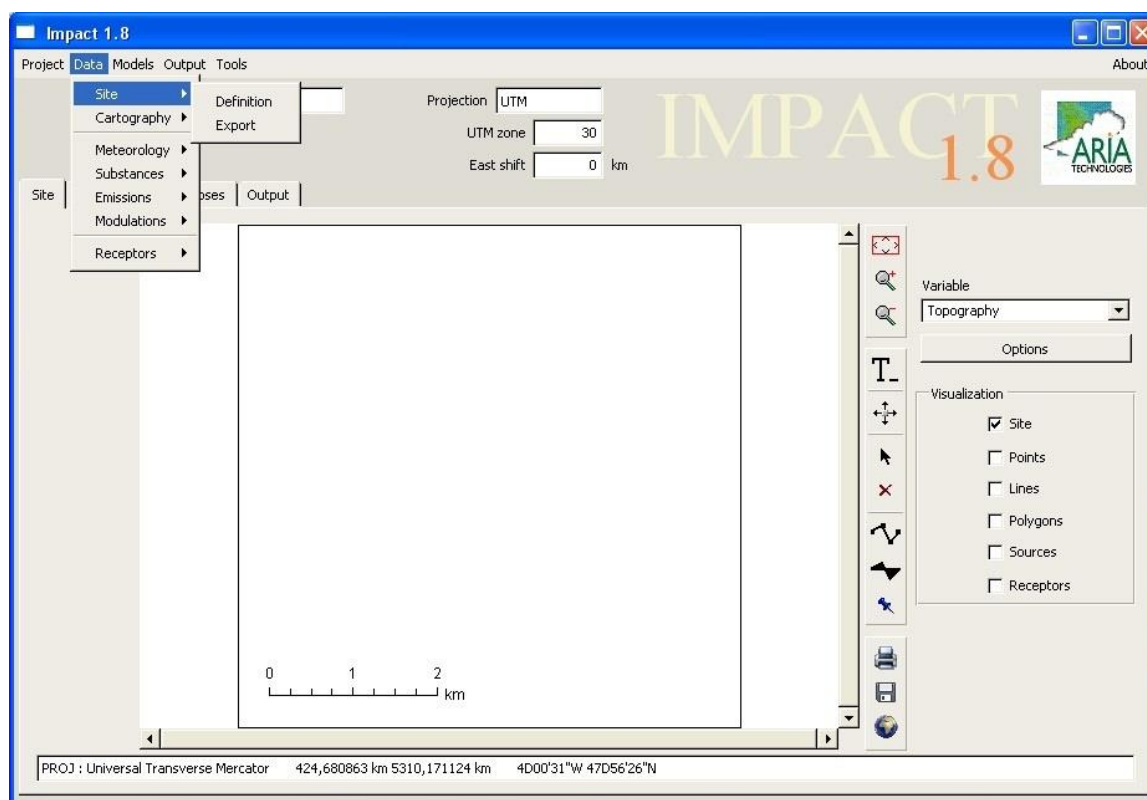
Figure 3: Main window with Data pull down menu.

The Data menu directs the user to the following input data options:
- Site
- Cartography
- Meteorology
- Substances
- Emissions
- Modulations
- Receptors

4.3.1 Data - Site

The Site submenu allows the user to define or export a site (study domain).

4.3.1.1 Define

Clicking on the Define option opens the Site definition window. Two options are available; either the software assumes flat topography or it uses a topographic file created according to the format presented in section 7.1.
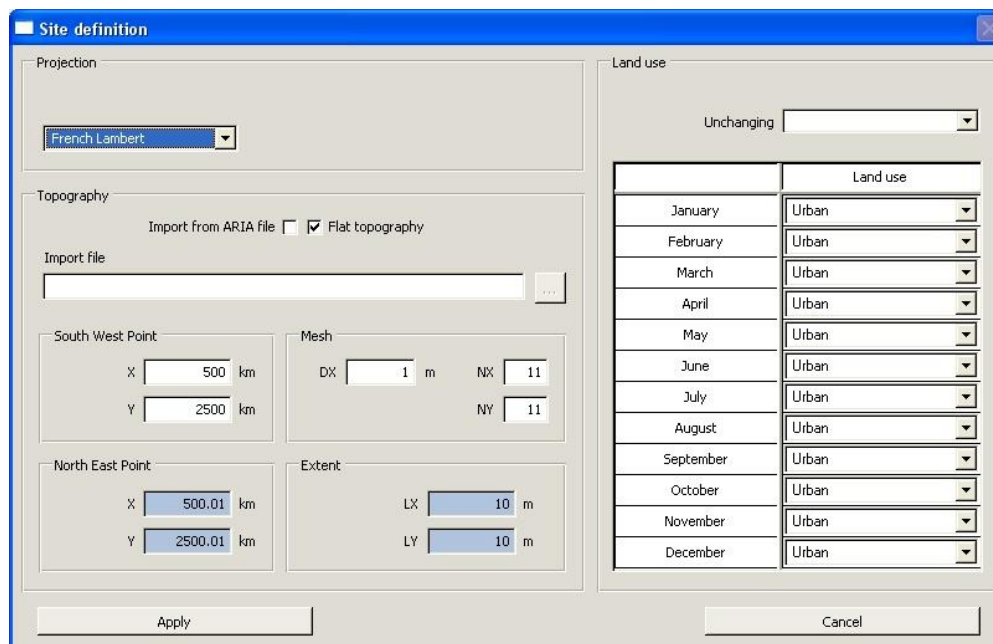
Figure 4: Site definition panel

1) Without topographic file

The upper bar is used for selecting the type of coordinate system to use in the project, given the following alternatives:

- French Lambert II
- UTM
- French Lambert 93

- **French Lambert** - Lambert II and Lambert 93 coordinates are plane coordinates used in France. Site characteristics are defined by filling the following fields: x and y coordinates (km) of the southwest point of the domain, grid size (DX) in meters, and the number of points along the x (NX) and y (NY) axes.

- **UTM** - UTM (Universal Transverse Mercator) coordinates are plane coordinates. The UTM zone must also be indicated (see Figure 5). Site characteristics are defined by filling the following fields: x and y coordinates (km) of the southwest point of the domain, grid size (DX) in meters, and the number of points along the x (NX) and y (NY) axes.
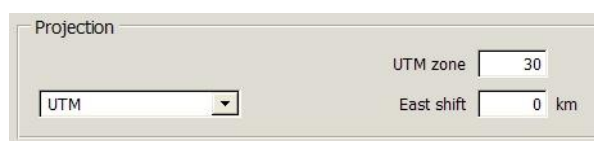
Figure 5: Indication of UTM zone

When all the fields have been filled in, click Apply to display the domain.

2) With topographic file

Select the check box Import from ARIA file on the Site definition panel. Browse by clicking on the [...] button and select the required file. The topographic file has to be prepared in advance according to the specification in example 1 of section 7.1. Once the terrain file has been selected, the other fields (coordinate type, southwest point coordinates, grid size, and number of points) are filled automatically.
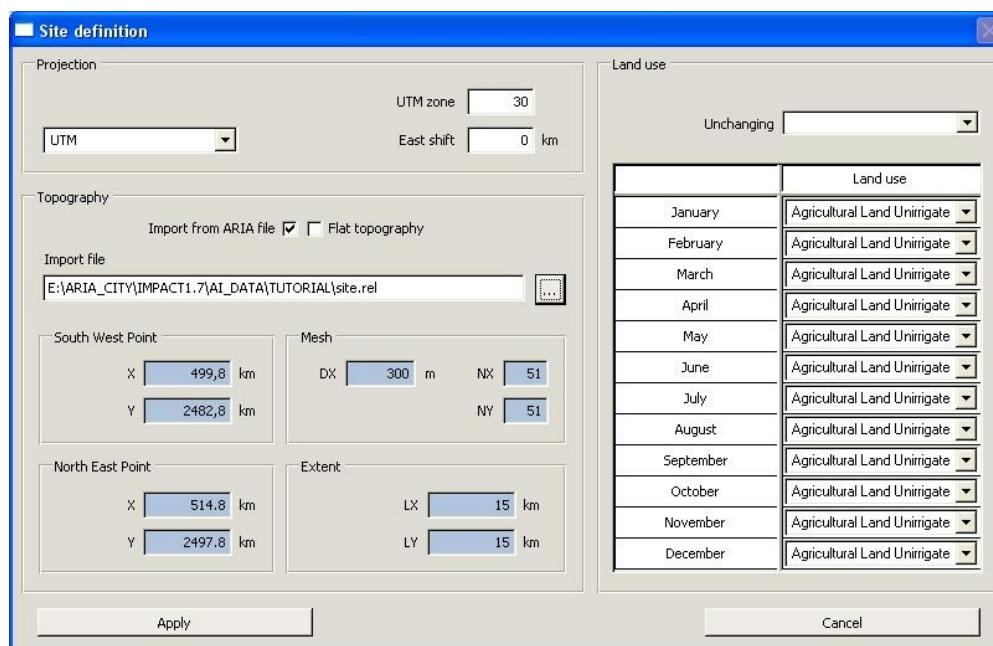
Figure 6: Selection of topographic file.

In the example of the figure, the domain is defined by the following characteristics:
- *Southwest point (499.8 ; 2482.8) km in French Lambert II coordinates*
- *Grid size: 51 x 51 grids with a resolution of 300 m*

The topographic file can be changed by clicking once again on the [...] button and selecting a new file.

3) Definition of land cover

The right part of the « Site definition » window is reserved to the definition of the land cover. The user has the choice between different types of land cover to which are associated a value corresponding to the roughness, albedo, and Bowen ratio:

- the roughness characterizes of the ground surface (buildings, forest, water)
- the albedo is the part of incoming solar radiation that is reflected by the ground surface. It is a value between 0 and 1.
- the Bowen ratio is a value that compares the quantity of energy being used for heating the air to the quantity of energy used for evaporation (H/LE). It is a value between 0.01 and 10.

These parameters allow the calculation of the height of the mixing layer.

The different types of land cover that the user can choose are listed in the table below:

LAND (category)	ZRUGOS (roughness in metre)	ALBEDO (no unit)	BOWENR (no unit)
Urban fabric			
1	1.00	0.18	4.00
Industrial or commercial units			
2	1.00	0.18	4.00
Airports			
3	1.00	0.18	4.00
Mine, dump and construction sites			
4	1.00	0.18	4.00
Non-irrigated arable land			
5	0.05	0.18	2.00
Rice fields			
6	0.03	0.18	0.20
Permanent crops			
7	0.10	0.20	2.00
Pastures			
8	0.10	0.20	2.00
Heterogeneous agricultural areas			
9	0.20	0.18	1.80
Broad-leaved forest			
10	0.80	0.12	2.00
Coniferous forest			
11	1.30	0.12	1.50
Mixed forest			
12	1.00	0.12	1.50
Natural grassland			
13	0.02	0.20	2.00
Shrubs			
14	0.20	0.15	0.40
Beaches, dunes, and sand plains			
15	0.05	0.30	6.00
Bare rock			
16	0.10	0.25	10.00
Sparsely vegetated areas			
17	0.04	0.20	1.80
Glaciers and perpetual snow			
18	0.01	0.70	0.50
Inland wetlands			
19	0.03	0.14	0.20
Maritime wetlands			
20	0.03	0.14	0.20
Water bodies			
21	0.0001	0.14	0.10

The user can define different types of land cover for different months of the year.

To confirm the selection, click Apply. If a topographic file has been chosen it will be automatically displayed in the main window. To exit the site definition panel, click Cancel.

Warning!
The site definition is essential for the subsequent calculations.
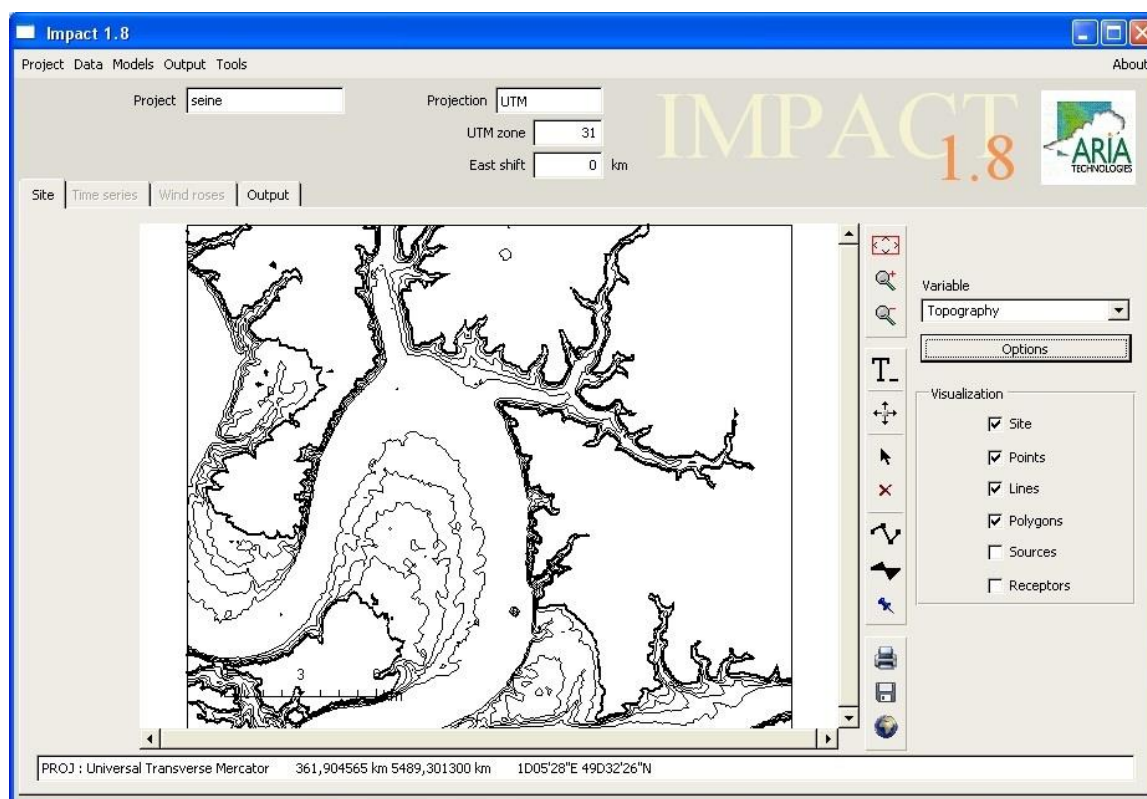
Figure 7: Display of a topography file.

4.3.1.2 Export

If the domain has been created by the user, it can be exported by clicking on Export. The topography will be exported in a file with the ARIA Relief format (.rel).

The user should select a directory and give a name to the output file. The extension .rel is added by the program.
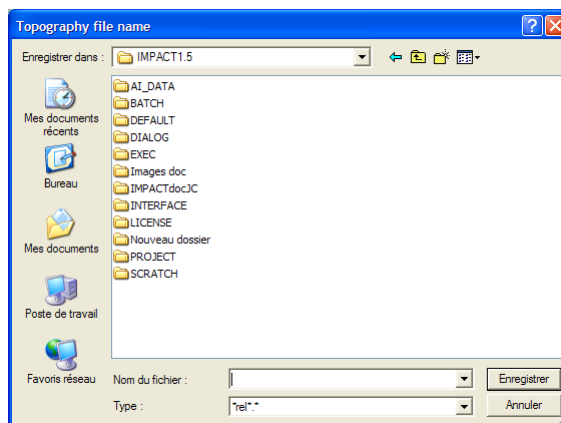
Figure 8: Save As box for saving topographic file.

4.3.2 Data - Cartography

After defining the site characteristics, the user can input map (cartographic) objects by:

- importing a file
- defining the map objects manually on the screen

4.3.2.1 Import
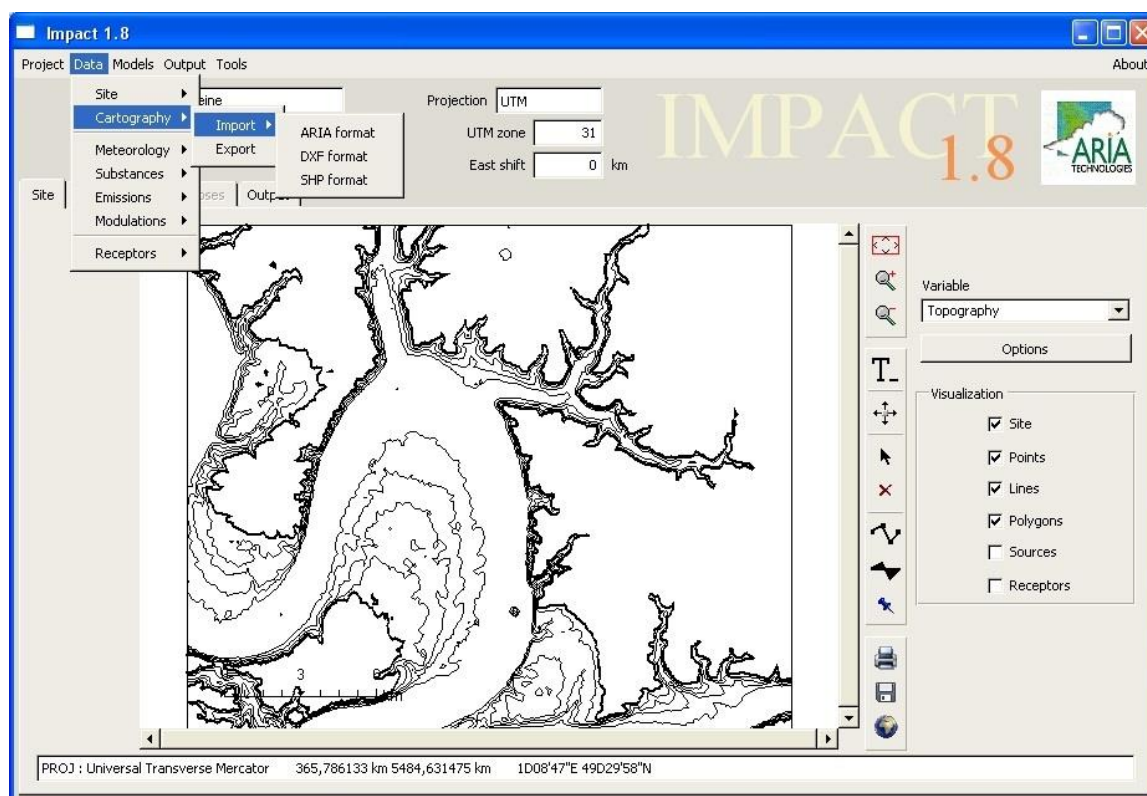
Figure 9: Main window showing options of Import menu.

Three formats can be used for importing cartographic files:
- ARIA format
- DXF format
- SHP format (ESRI shapefile)

In all cases, a file in the selected format must exist. An example of a file in ARIA format is presented in section 7.2 (example 2). Selection of format from the Import submenu opens the Look Up box (Figure 10).
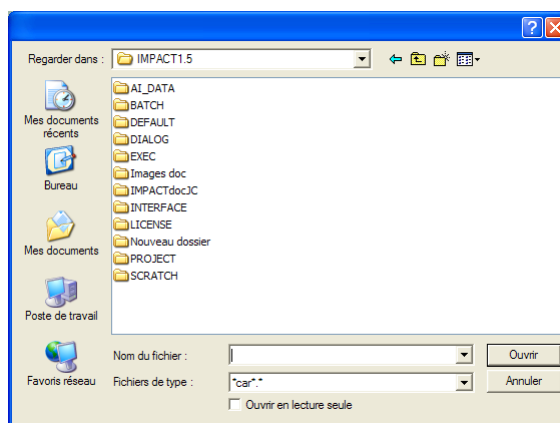
Figure 10: Look up box for importing cartography files.

The map file is then displayed on the main panel.

4.3.2.2 Export

In the case where the cartographic elements have been created manually, it is possible to export them by activating the button Export. It is also possible to save the map objects in ARIA format (file extension .car) which can further be imported in another ARIA Impact Project.

4.3.3 Data - Meteorology
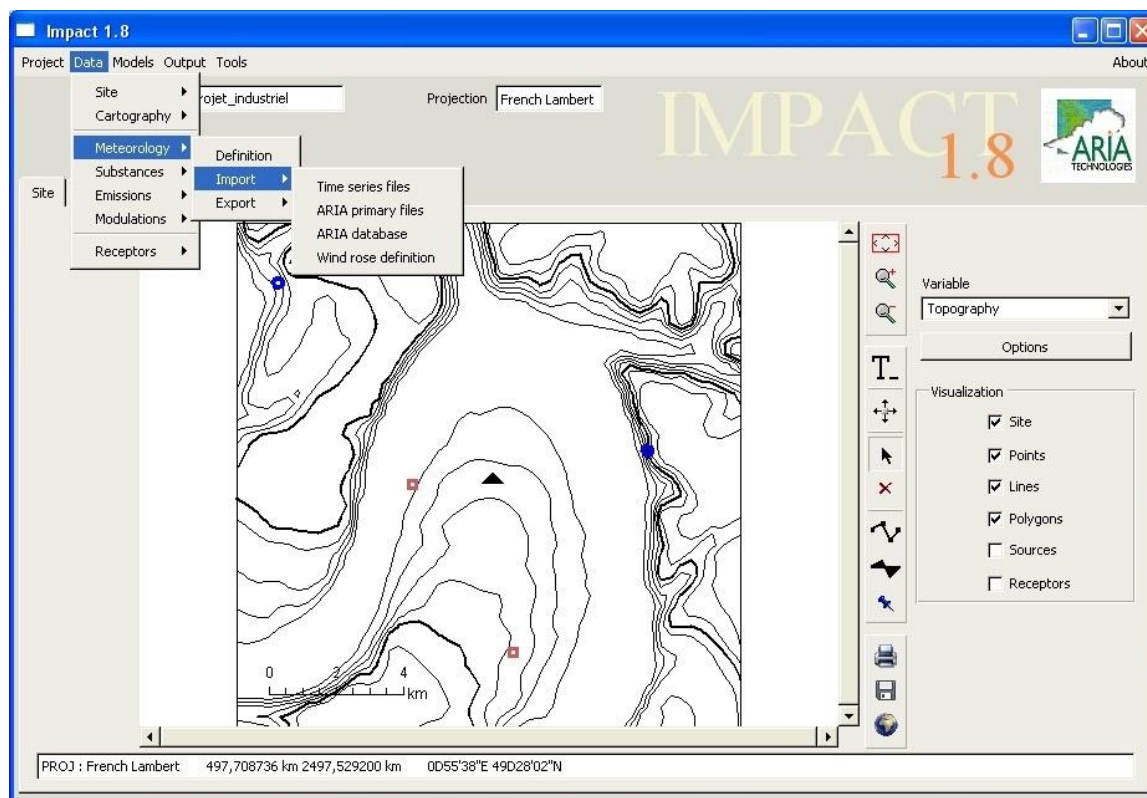
Figure 11: Main panel with Meteorology pull down menu.

The Meteorology menu directs the user to the following options:

- Define meteorology data for a specific case
- Import a file with time series of meteorological data
- Import **ARIA "primary" files**
- Import an ARIA **"adso" database**
- Define a table of wind speed/direction based on a wind rose
- Export meteorology file

4.3.3.1 Define

This option allows the user to define the meteorological data required to run an academic simulation for a specific meteorological situation.

Figure 12: Window for defining meteorological data for a specific case

The following parameters should be input:

- Calculation Date. The accepted formats are DD-MM-YYYY HH:MN:SS and DD/MM/YYYY HH:MN:SS.

For example, if the simulation date and time is June 20, 2000 at 12 p.m., the data is input as follows:

20-06-2000 12:0:0 or 20/06/2000 12:00:00

- Station Name and Position. Station name (8 ch), x and y coordinates (km) of station, altitude z (m).
- Meteorological parameters. Wind, temperature, cloud cover...

The following parameters are mandatory:

- wind direction and speed
- temperature
- height of the anemometer
- a parameter for computing the <u>stability class</u> (see section 5.4), by choosing one of the variables:
  - net or global radiation
  - cloud cover
  - temperature gradient
  - sigma direction
  - temperature gradient and humidity
  - Pasquill or Briggs class, defined in ARIA Impact as follows:
    - 1 for class A
    - 2 for class B
    - 3 for class C
    - 4 for class D
    - 5 for class E
    - 6 for class F
  - Brookhaven class, defined in ARIA Impact as follows:
    - 1 for class A
    - 2 for class B2
    - 3 for class B1
    - 4 for class C
    - 5 for class D
  - Doury class, defined in ARIA Impact as follows:
    - 1 for class DF
    - 2 for class DN

Once all the parameters have been input, click Apply to validate data. Clicking Close shuts the window.

4.3.3.2 Import - Time Series files

The Time series import menu allows the user to import a time series of real meteorological measurement data from a file. The file must conform to one of the formats presented in section 7.3.

Selecting Import Time series files opens the import panel containing two tabs: Sensor and Station.

1) Sensor tab

The Sensor panel is presented in the Figure 13. In this window the meteorological parameters measured by the sensor(s) are defined.
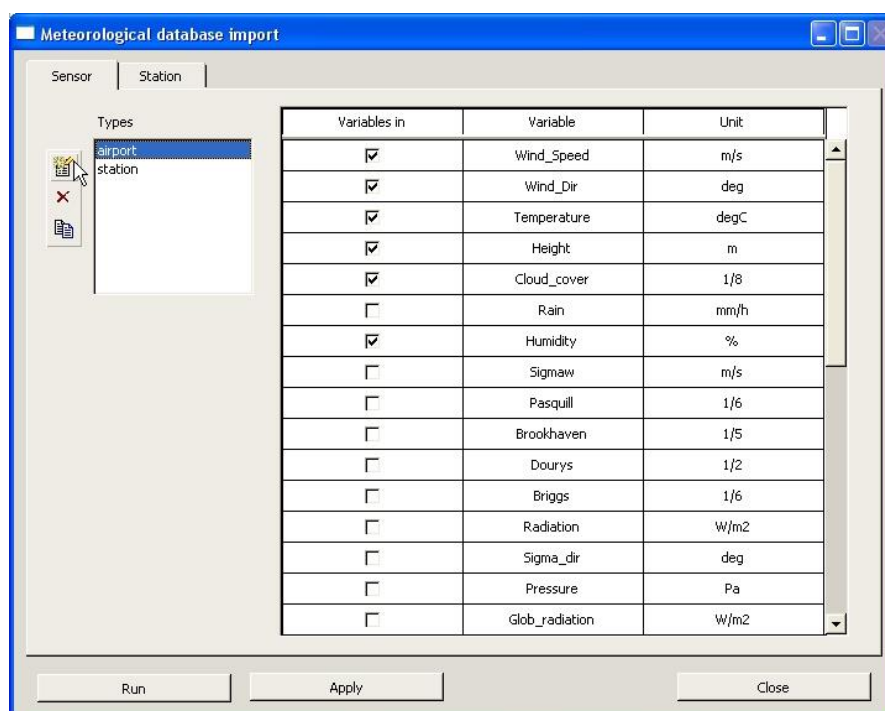
Figure 13: Sensor tab of time series import window

> **Warning!**
> It is recommended to define different sensor types for ground stations and for profile stations.

Click on the button 📝 « Add a new sensor type ». Give the sensor a name and select the variables connected to it. The variables should be chosen from the list of meteorological parameters presented in the table. In the left column of the data table, the parameter «height» is already selected by default (obligatory parameter).

In the example above, a sensor called «airport» has been created, containing measurements of wind speed, wind direction, temperature, cloud cover and humidity.

If parameters necessary to import are not present in the list (for example measurements of ambient air quality), the user can define new variables with the help of the `Dictionary Editor` in the `Tools` menu (see section 4.6).

A station type can be copied with 📋 button and deleted with the ✖ button.

2) **Station tab**

This tab allows:
- defining the different meteorological stations and specifying the type of sensor associated with the station(s)
- defining the format of the meteorological file(s) to import

First, the user should create a meteorological station by clicking on the button 📝 and giving a name to the station. The following window appears:

Figure 14: Station tab in time series import menu

The Start and End date fields allow defining the time period (dates) during which the data import will be carried out. The year should be given in four digits.
For example, if the data covers 3-hourly data from the period January 1, 1995 12 a.m. to December 31, 1999 9 p.m., the information should be input as:
>   *Start Date: 01/01/1995*
>   *End Date: 31/12/1999*
>   *Time Step (s): 10800*

The **"Stations"** frame specifies the position and sensor type for each station.

- First select the Station `Type` by selecting from the list of sensors that has been created earlier (see "sensor tab")
- Station coordinates are entered in the columns `X`, `Y`, and `Z` according to the coordinate system defined in the site menu. The following units are used:
    - decimal degrees for longitude/latitude coordinates
    - kilometers for UTM and French Lambert coordinates (meters for z)
    - meters for altitude Z
- the `Time step` column specifies the time resolution (in seconds) of the meteorological data in the import file.

Warning!
Performing a statistical calculation with AERMOD requires that the time step of wind data must be of 3600 seconds (hourly data).

If there are several stations to import, containing complementary data (different measuring periods or meteorological parameters, measurements on different heights above ground, etc.), use the buttons to the left:

      📝 adds a new station
      📋 copies a station
      ✖ deletes a station

The lower part of the tab "Files for the station" is used for defining the format of the meteorological data file for each station. The 🗋 button "Add an import file" will add a file to the data import list. Up to 10 files can be imported at the same time.
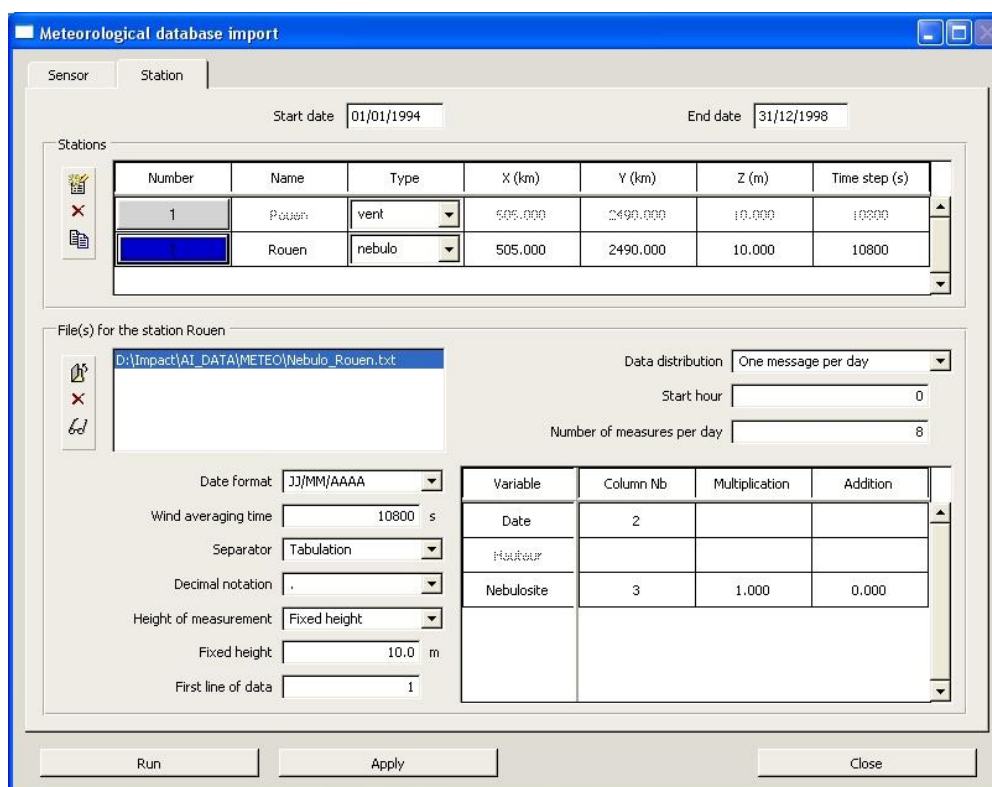
Figure 15: Station tab in time series import menu

The following information should be entered for each imported file:

- Date Format - Right click on Date Format and hold for a list of available formats (Figure 16).

Figure 16: List of available date formats.

Note: This list is not exhaustive; other formats can be defined manually.

- Wind averaging time - This parameter specifies the average time (in seconds) during which wind measurements have been carried out (a value needs to be indicated but it will not be used in the modeling with ARIA Impact).

  For example:
  Data from the French meteorological service:
  Wind speed and wind direction measurements correspond to 10 minute-averages
  => avg. wind = 600 sec

- Separator - The separator used in the file can be a semicolon, comma, or tabulation mark.

- Decimal notation - The decimal notation for real numbers in the meteorological file can be either a decimal point or a comma.

- Height of measurement - The measurement height is
  - either constant, in which case the height above ground should be indicated
  - or it is given for several vertical levels, in which case the heights are read from the meteorological file

- First line of data - This parameter indicates the number of the first line of measurements. If the first line of the file carries a heading, the number of the first line of measurements is 2.

- Data distribution - This parameter specifies whether the meteorological data are defined:
  - per day (all data for one day given on the same line): "1 message/day", or
  - per date (1 time step per line): "1 message/time step" (see section 7.3.1)

- Start Hour - Specifies the time when the meteorological file starts; it is entered only for a "One message per day" periodicity.
- Number of measures per day - The parameter gives the number of messages for 1 day; it is entered only for a message/day periodicity.
  For data every 3 hours: 8 messages/day
  For data every 30 minutes: 48 messages/day

The lower right half of the tab contains a table to indicate in which column of the meteorological file the different parameters are located.

Variable	Column Nb	Multiplication	Addition	
Date				
Wind_Speed				
Wind_Dir				
Temperature				
Height				
Cloud_cover				

Figure 17: Table in Import Files screen.

The first column of the table (Variable) lists the parameters defined in the sensor tab, which should be imported from the meteorological file. In the second column (Column Nb) the user should specify where in the meteorological file (in which column) the parameter to import is located.

Examples:
- *In example 5 of section 7.3.1, the positions of parameters for each line are as follows:*
  date: column 1
  wind speed: column 4
  wind direction: column 5
  temperature: column 3
  cloud cover: column 6
- *In example 5 of section 7.3.1, the positions of parameters for each line are as follows:*
  date: column 2
  wind speed: column 19
  wind direction: column 11
  temperature: column 3
  cloud cover: column 26

The next two columns can be used for multiplying the values in the data file by a factor (Multiplication) and/or adding a constant value (Addition). This can sometimes be necessary in order to respect the units required for import of meteorological data as indicated in the sensor tab (Figure 13).

Example: If the wind direction values in the meteorological file are given between (0 − 36), they should be multiplied by 10 in order to achieve final values between (0 - 360). Multiplication factor = 10 and addition factor = 0.

The procedure is the same for each meteorological station to import.

When all file information has been filled, click on Save.

Click on inspect button ✍, to verify that the import definition is accepted by the software. If yes, the following message (Figure 18) appears on the screen with a summary of the operation (filepath, number of lines, start and end dates, maximum and minimum frequency, number of vertical levels and corresponding heights).
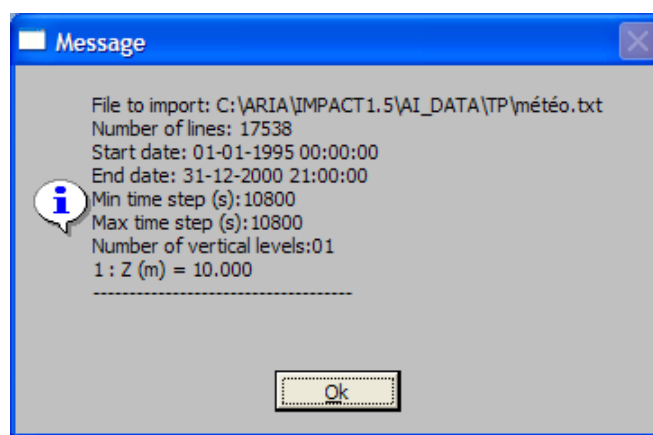
Figure 18: Inspect message box for meteorological file.

Finally, click Run to activate the import of data. The program then verifies the validity limits of each parameter and creates a meteorological database. Clicking Close closes the window.

> Warning!
> It should be observed that the wind speed, wind direction and temperature parameters are necessary to import in order to be able to carry out dispersion simulations later on.

4.3.3.3 Import - ARIA database

This option allows to import a file containing a meteorological database in ARIA format also called "Adso database" (.adb) exported from another ARIA Impact project.

4.3.3.4 Import - Wind Rose definition

If a wind rose is the only meteorological data available, it can be defined by selecting Wind Rose definition in the Meteorology Import menu. This opens a window as illustrated in Figure 19.

Figure 19: Meteorological statistics (wind rose) definition panel.

Under Station, the user specifies the Name of the station for the wind rose as well as the X, Y, Z coordinates of the location of the station.

Under Definition, the user specifies:
- The number of wind speed classes and their values
- The number of wind direction classes and the First wind direction (degrees)
- The method (formula) for calculating atmospheric stability class

Method for stability classes
The following equations are available in ARIA Impact (section 4.6):
- Pasquill
- Doury
- Briggs
- Brookhaven

Number of wind speed classes
Enter the number of wind speed classes in the corresponding box and press the Enter key. The number of lines that will be displayed in the table below is based on this number. The minimum number of classes is 2.

In the example in Figure 19, the number of classes selected is 3 and the corresponding values are: 3, 6, 8.

Number of wind direction classes and First wind direction (deg)
Enter the number of wind direction classes in the corresponding box and press the Enter key. The number of columns that will be displayed in the table below is based on this number. Indicate the value of the first wind direction (in degrees).

In the example in Figure 19, the number of classes selected is 18 and the first wind direction is 20°.

The Update button reinitializes the wind rose table located below the input bars. It is now configured with the selected number of wind speed (rows) and wind direction (columns) classes. Each wind speed class is further associated with a corresponding stability class.

Wind (m/s)	Class	20.0 deg	40.0 deg	60.0 deg	80.0 deg	100.0 deg	120.0 deg	140.0 deg	160.0 deg	180.0 deg
3.0	A	0	0	0	0	0	0	0	0	0
3.0	B	0	0	0	0	0	0	0	0	0
3.0	C	0	0	0	0	0	0	0	0	0
3.0	D	512	731	702	497	351	190	190	307	643
3.0	E	0	0	0	0	0	0	0	0	0
3.0	F	0	0	0	0	0	0	0	0	0
6.0	A	0	0	0	0	0	0	0	0	0
6.0	B	0	0	0	0	0	0	0	0	0
6.0	C	0	0	0	0	0	0	0	0	0
6.0	D	190	278	351	175	73	29	29	58	132

Figure 20: Table of wind rose values on Meteorological statistics panel

In the table that is displayed, fill in the number of observations recorded for a particular wind direction, wind speed class, and stability class. A cell without a value is treated as 0.

The last column and last row give the total number of observations for each class.

It is possible to directly fill the table by importing a file in csv format (text file, data separated by semicolon ";")

Click Apply to confirm data input. To exit the panel click Cancel.

4.3.3.5 Export

To export the meteorological database containing the data from the imported file(s), click Export in the Meteorology menu.

There are two different export options:

- ARIA database export: In the Look Up box that opens, select the directory to which the database will be exported; the file extension is .adb. This file could eventually be imported in another ARIA Impact project by using the "Import > ARIA database" option.
- EWB meteorological export: Allows creating a file that can be visualized with the 3D graphical software EWB (also called Savi3D). Except for the meteorological data, this file also contains the topography of the study domain.

4.3.4 Data - Substances

The Substances menu allows the user to define the characteristics of the different substances to be accounted for in the calculations. It has three options:
- Define substances (with the user interface)
- Import substance file (.csv format)
- Export substance file

The user can import a substance file in Excel .csv format (see paragraph 7.5), or enter the substance data manually with the user interface.

Important warning in the case of a calculation with AERMOD!
To perform a statistical calculation with AERMOD requires that species names do not contain "_" character (8 key on the keyboard).
The names of substance "PM25, PM2.5, PM 25, PM-2.5" are names reserved by AERMOD that imposes either the calculation corresponding to the U.S. regulations, either the inter-annual average of annual daily maximum concentrations. So, it is not possible with AERMOD to calculate an annual average on an hourly basis, for example. To correct this problem, it is necessary to rename PM2.5 in a name other than those reserved by AERMOD.

4.3.4.1 Define

Clicking on Definition displays the Substance panel (Figure 21).
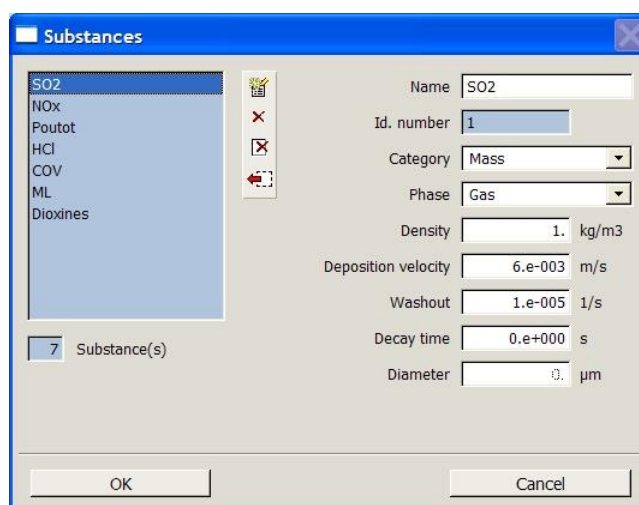
Figure 21: Substance panel

If an emission substance file (a so called PEMPSE file) already exists in the project, the panel displays the list of substances. To select a substance, click on its name in the list to the left of the window. The characteristics related to each substance are then activated and can be modified if necessary.
The user can either import a file containing substances specifications (see paragraphs 4.3.4.2 and 4.3.4.3), or enter the characteristics manually in the "Substances" panel (Figure 21):

To create a substance, use the New button .

To delete a substance, select the substance in the list and click "Delete" ✖. To delete all the substances, click "Delete all" ☒.

To save the modifications of the substance definition, the button ⬅ should be pressed.

The steps necessary for defining a new substance are described below:
1. Click the New button 📝
2. Enter the substance name (e.g., NOx). The substance is attributed a number that cannot be changed.
3. Choose substance category from the drop down list. Three options are available:
    - Mass (for gaseous and particulate substances)
    - Activity (for radioactive substances)
    - Odour (for odorous substances)
4. Select the substance phase from the drop down list:
    - Gas
    - Particulate matter
    - Heavy gas (inactive in this version)
    - Droplets (inactive in this version)
5. Enter substance density (kg/m^3)
6. Enter dry deposition rate (m/s) (optional parameter, used for calculating dry deposition)
7. Enter washout coefficient (s^{-1}), (optional parameter, used for calculating wet deposition if rain fall data is available in the meteorological data base)
8. Enter time to half-life (s), (optional, used for radioactive substances)
9. Enter diameter (μm) (only for particulate matter)
10. Save the characteristics with the button: ⬅

To account for pollutant washout by rain, ARIA Impact calculates the ability of each pollutant to be washed out by water droplets falling towards the ground. Particulates, having a significant diameter, are more likely to be washed out than gases. Wet deposition is calculated independently of dry deposition. Wet deposition is a function of pollutant characteristics (washout ratio[1]) and rainfall derived from the meteorological data file.

When all the substances have been described, the input is confirmed by clicking the OK button. To exit the panel without saving the modifications, click Cancel.

The table below includes values recommended for different substance parameters used in the calculation of dry and wet deposition.

---

[1] The washout ratio represents the proportion of the pollutant washed out by the rain during a second.

Pollutant	Substance phase	Particle diameter	Dry deposition rate (cm/s)	Washout coefficient (s^{-1})	Reference
NOx	Gas	-	0	1.10^{-5}	-
SO$_2$	Gas	-	0,6	1.10^{-5}	[1]
PM10	Particulate	10 μm	1	4.10^{-4}	[3]
PM2.5	Particulate	2,5 μm	0,4	8.10^{-5}	[3]
CO	Gas	-	0	1.10^{-5}	[1]
HCl	Gas	-	2,45	1.10^{-5}	[4]
HF	Gas	-	4	1.10^{-5}	[1]
NH$_3$	Gas	-	0,8	1.10^{-5}	[4]
PCDD/F	Particulate	1,3 μm	0,05	1.10^{-5}	[2]
HAPs	Particulate	1,3 μm	0,05	1.10^{-5}	[2]
Métaux lourds	Particulate	2 μm	0,1	5.10^{-5}	[5]

[1] « Empirical atmospheric deposition parameters – a survey », T.A. McMahon, P. J. Denison, Atmospheric Environment Vol 13 (1979), 571-585.

[2] "Atmospheric particle size distributions of polychlorinated dibenzo-ρ-dioxins and dibenzofurans (PCDD/Fs) and polycyclic aromatic hydrocarbons (PAHs) and their implications for wet and dry deposition", Heike Kaupp, Mickael S. McLachlan, Atmospheric Environment Vol 33 (1999), 85-95

[3] Underwood, AEA Technology, Harwell, 2001 : Review of Deposition Velocity and washout coefficient

[4] "Seasonal and annual deposition rates of sulphur, nitrogen and chloride species to an oak forest in north-eastern austria" (wolkersdorf, 240 m a.s.l.), Hans Puxbaum and Martin Gregori, Atmospheric Environment Vol 32 (1998), 3557-3568

[5] WGE RIVM report n° 259101011/2002 :Preliminary modelling and mapping of critical loads for cadmium and lead in Europe JP Hettelingh, J. Slootweg, M. Posch (eds.) S. Dutchak, I Ilyin

4.3.4.2 Import

Use this option to import a list of substances from a file. The selected file can be either in:

- Excel .csv format (text file, data separated by semicolon ";")
- ARIA format (default file extension.spe.).

The description of these two formats is presented in paragraph 7.5.

Note: If the substances file is imported with ARIA format (file .spe) it only lists the « Mass » substance category (odour and radioactivity is not included in this file).

> Warning!
> If the project already contains a list of substances, it will be replaced by the list read in the imported file.

4.3.4.3 Import the substance database

ARIA Impact is delivered with a substance database containing thirty pollutants with predefined values of the characteristics necessary for dispersion calculations. To import this substance database, proceed as in Section 4.3.4.2 by importing the file Base_produits_sp.csv that can be found in the directory: ARIA\IMPACT1.8\PROJECT\AI_DATA.

Once the file has been imported, all the 30 substances are displayed in the window with their default characteristics. The user can thereafter remove species from the list and/or change the characteristics of the different pollutants if necessary.

The user can also save its own substance database by exporting pollutants present in the Substances panel as presented in section 4.3.4.4.

The characteristics of the pollutants are taken from scientific references mentioned in Section 4.3.4.1. These values vary depending on bibliographic sources consulted. ARIA Technologies give these values as a recommendation but cannot be held responsible for the choice made by the user.

4.3.4.4 Export

The substance data that have been entered can be saved by clicking Export in the Substance pull down menu. The user should choose between the two formats:
- Excel .csv format (text file, data separated by semicolon ";")
- ARIA format (default file extension .spe.)

In the Look Up box that opens, select the directory to which the data should be exported.

Note: If the substances file is exported to ARIA format (file .spe) it only lists the « Mass » substance category (odour and radioactivity is not included in this file).

These two formats can further be re-imported in other ARIA Impact projects.

4.3.5 Data - Emissions

The Emissions submenu offers two options:
- Import emission file
- Export emission file
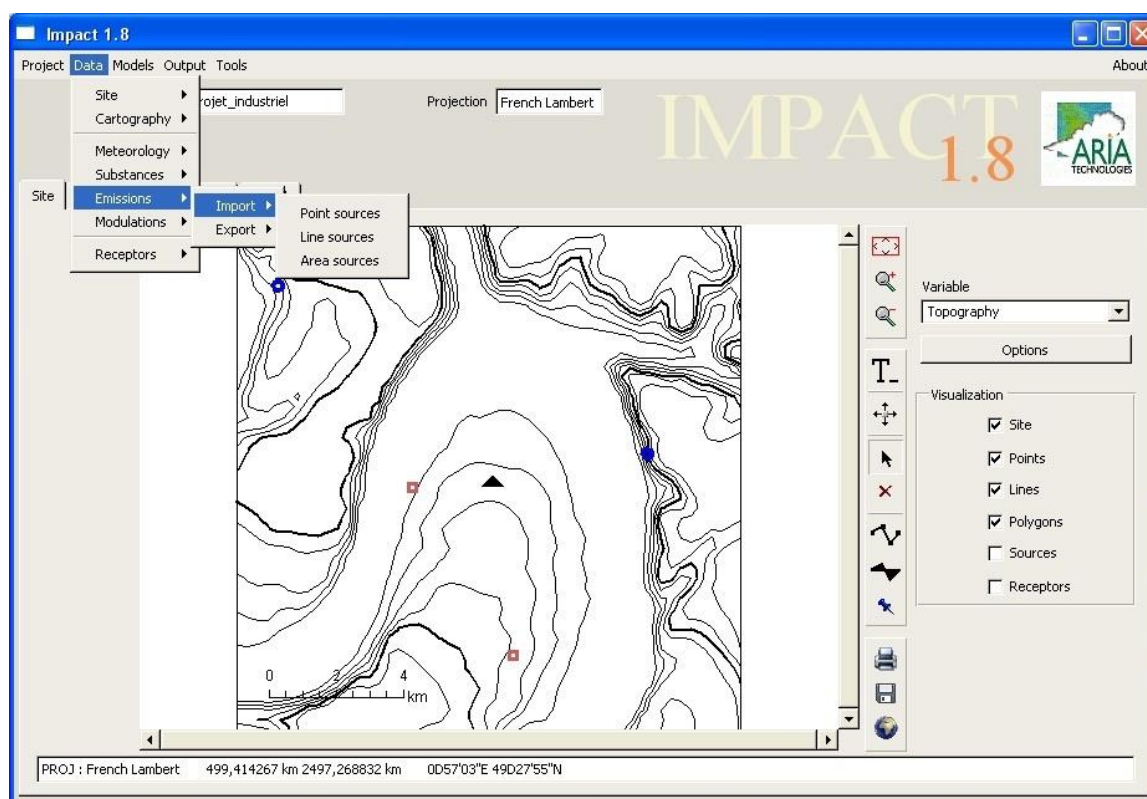
Figure 22: Main window with Emission pull down menus.

If there are only a few sources to account for, it might be easier to manually define the sources by using the toolbar on the right side of the Site tab (section 4.7.5). If there are many emission sources to include in the study, it's however recommended to prepare an emission file with Excel (.csv format) to import to ARIA Impact.

4.3.5.1 Import

Selecting Import opens a menu listing three source types:
- Point
- Line
- Area

Selecting a source type opens a Look Up window to search for a file to import. The file should conform to the formats presented in section 7.6.

To display the sources on the screen, select Emitters situated on the right side of the main window.

4.3.5.2 Export

If the sources are manually defined (section 4.11), the data can be saved by clicking Export in the Emissions menu. There are two export formats available:

- "Client file": it is an Excel csv format file (text file, data separated by semicolon ";"). This format is described in section 7.6. Three files, (one file per source type) will be created at the export. These files can be imported to another ARIA Impact project later on.
- "ARIA" format: also called «pemtim» format: this file is compatible with other ARIA Technologies models (ARIA Regional, ARIA Industry…). It is described in section 7.6.3. If the user selects to export to an «ARIA» format file, the following window will appear:

Figure 23: Export panel of a source file to ARIA format

The user should give the following information:
- Start and end date of emissions
- The coordinates of the south west point of the grid,
- The grid resolution
- The number of points in X and Y direction
- The name of the export file «pemtim», select name and directory with the button

The user can also choose to project the line sources on the above defined grid by checking the option "Line projection on mesh". If this option is not chosen, the line sources are defined as bi-point segments. When all the information has been filled, click the button Run to export the file.

4.3.6 Data - Modulations

The Modulations submenu allows importing, exporting and editing modulation files. The time modulation allows for example to take into account stops or variations in plant operation over a period of time or to describe daily patterns of traffic flow. Time-based modulation of emissions can be integrated for all type of sources (point, line, and area sources).

Time modulation is set by defining a multiplier which is varying with time (hour, day or month of the year). The emissions accounted for during each time step of the dispersion calculation, corresponds to the product of the reference emission (mass per time unit) and the multiplier defined for each time step.

The definition of these factors is contained in three files (also called " Modulations profiles) with extension:

- .heu, modulations related to the 24 hours of the day;
- .jou, modulations related to the 7 days of the week;
- .moi, modulations related to the 12 months of the year.

Two other files are needed:

- .par, to assign a modulation to a particular source;
- .def, to assign a modulation to a particular emission activity (for example SNAP code).
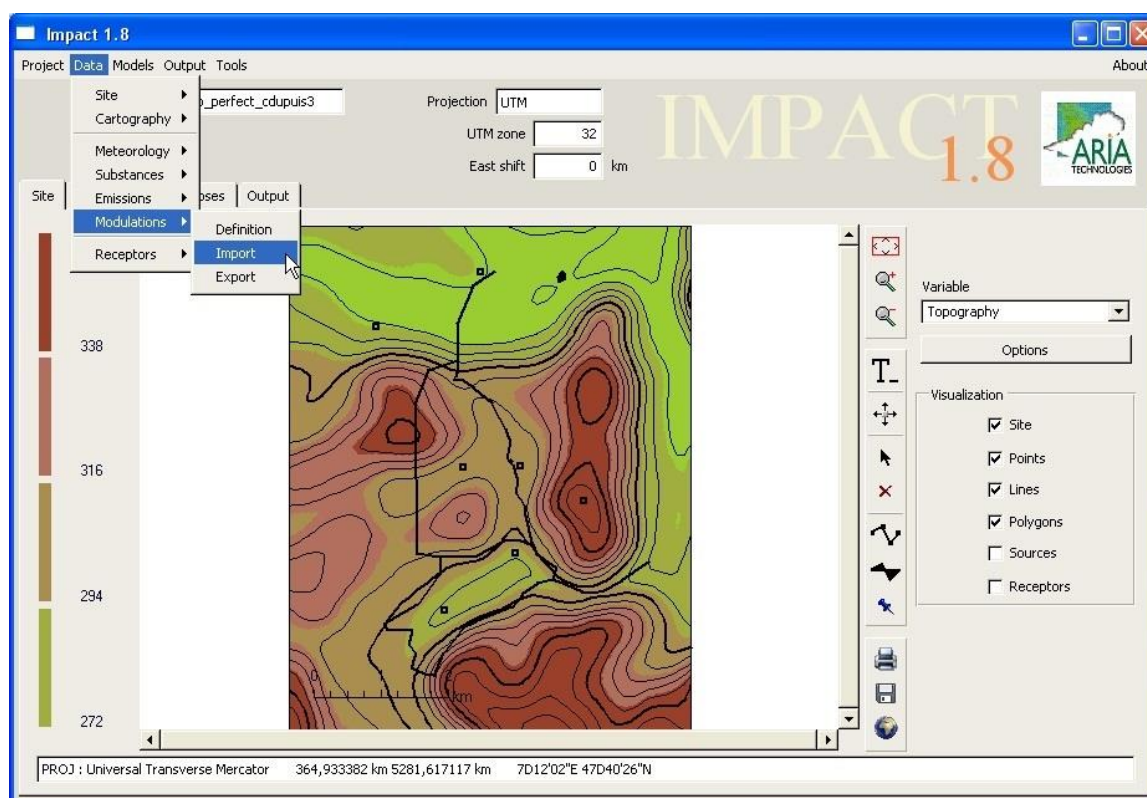
Figure 24: Modulation pull-down menu.

4.3.6.1 Import

Selecting `Import` opens a Look Up window for selecting the required file. The user can thereafter select the file. ".par". The software automatically imports files ".moi" ".jou" and ".heu" of the same name, located in the same directory. The modulation files must conform to the formats presented in paragraph 7.6.5.

> **Warning!**
> If the project contains modulation profiles, they will be lost and replaced by the imported ones.

4.3.6.2 Export

To export a modulation file that has been created, click `Export` in the `Modulation` submenu. In the Look Up box that opens, select the directory to which the file will be exported.

4.3.6.3 Define

This option opens the "Modulation editor" panel.

The editor contains four tabs:
- `Day` tab: to define hourly modulations of emissions
- `Week` tab: to define daily modulations of emissions
- `Year` tab: to define monthly modulations of emissions
- `Modulation drawing` tab: to plot the resulting modulation (hourly, daily and monthly).

The modulations are accounted for in the following manner:
- D_{ref} the pollutant flux considered as reference flux
- F_1 hourly modulation factor
- F_2 daily modulation factor
- F_3 monthly modulation factor

During each time step of the meteorological data base, ARIA Impact reads the date, hour and the meteorological data. Based on the factors F_1, F_2 et F_3, associated to each date and hour, the emission rate will be calculated as the product of: $D_{ref} \times F_1 \times F_2 \times F_3$. If no modulation has been defined, the values of the three factors (F1 to F3) are set to 1.

Several profiles with different set of factors (F1 to F3) can be defined and each profile can be applied to more than one source in the project.

1) Hourly modulation

The `Day` tab (Figure 25) is used for defining hourly modulations. A set of 24 multiplying factors is applied to the emission rate (defined in the `Display` tab) as a function of the hour of the day. The multipliers can be both higher and lower than 1.

The profile can either be specified directly with the user interface or be prepared in a .csv file which can be imported to ARIA Impact.

> **Warning!**
> The hours correspond to UTC time (Coordinated Universal Time/Greenwich mean time). In France, during summer time, the local time is 2 hours in advance compared to UTC and in wintertime, local time is 1 hour in advance compared to UTC.
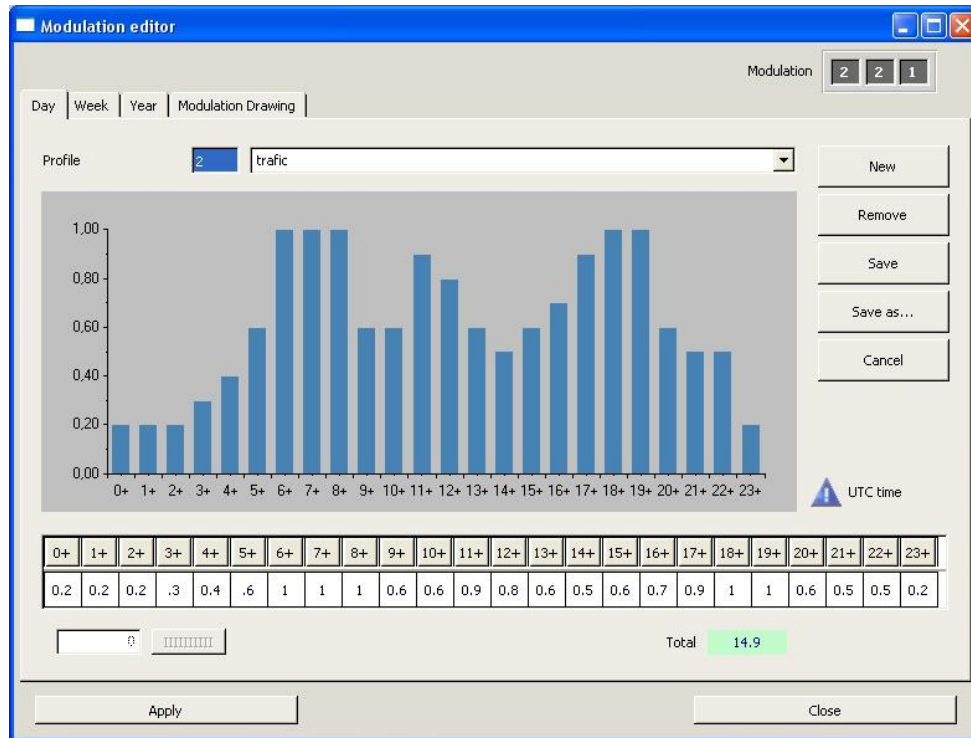
Figure 25: Hourly modulation panel (Day tab).

Example
In Figure 25, an industry operates at half capacity between 12:00 and 14:00 and is closed at night from 20:00 in the evening to 06:00 the next morning.

To introduce the hourly modulation:

- Select a profile

  Use the ▾ button, and select an existing profile to modify. It also is possible to create a new profile with the "New" button.

  Note: In "PROFIL_1, all modulations are set to 1. This profile is the default profile. It is recommended not to change this profile because it will change the default profile for all sources of the project.

- Modify the profile

  The x-axis corresponds to the hours of the day. The factors can be modified in the table situated under the graph.

If the same multiplier should be applied to each hour of the day, enter the required multiplier in the box situated below the hourly values and click the button to the right. All the hourly values will thereby be set to number defined in the box.

The "Total" box indicates the total modulation value for the whole day.

- Save modifications

  Click Apply once all the changes have been made.
  To remove an entire profile, click Remove.
  To save a profile that has been created, click Save.
  To rename a profile by saving it under a new name, click Save as.

2) Daily modulation

The Week tab (Figure 26) is used for modulating the emission rate during the different days of the week by following the same steps as described above.
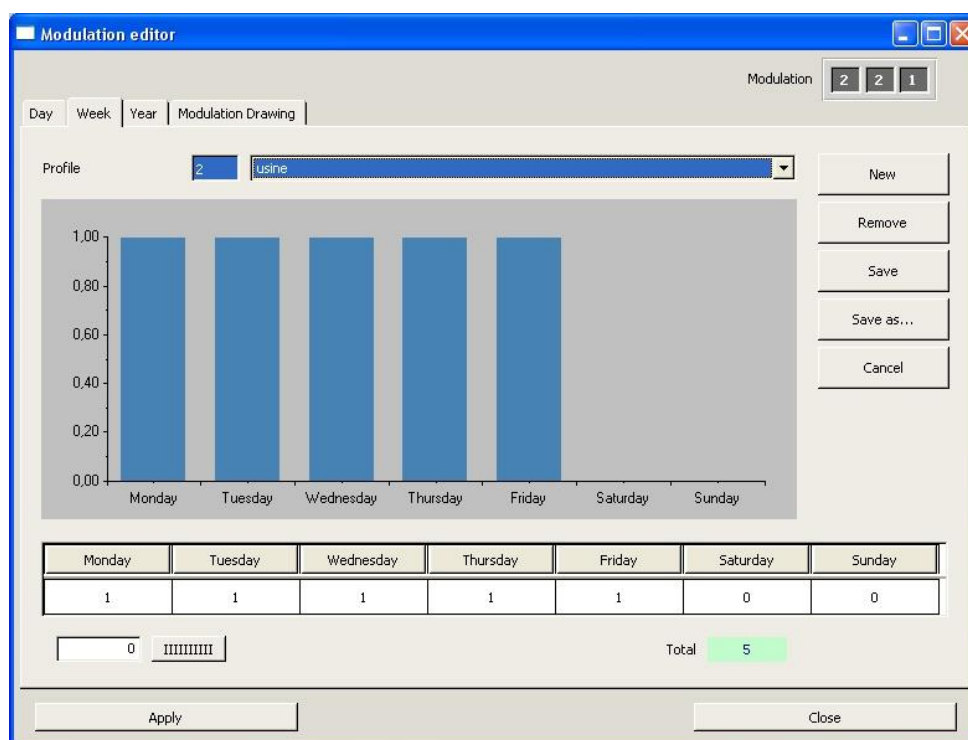
Figure 26: Daily modulation panel (Week tab).

A set of 7 multiplying factors is applied to the emission rate (defined in the Display tab) as a function of the day of the week. The multipliers can be both higher and lower than 1.

The profile can either be specified directly with the user interface or be prepared in a .csv file which can be imported to ARIA Impact.

3) Monthly modulation

The Year tab (Figure 27) is used for modulating the emission rate throughout one or more months, by following the same steps as described above.
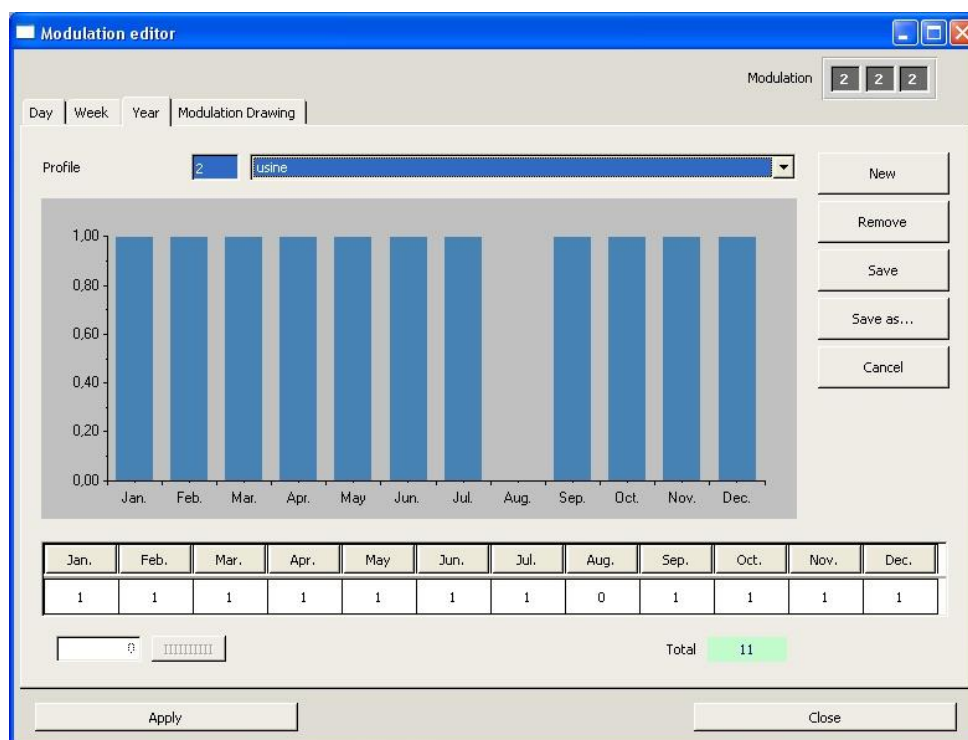
Figure 27: Monthly modulation panel (Year tab)

A set of 12 multiplying factors is applied to the emission rate (defined in the Display tab) as a function of the month of the year. The multipliers can be both higher and lower than 1.

The profile can either be specified directly with the user interface or be prepared in a .csv file which can be imported to ARIA Impact.

4) Modulation drawing

The modulations entered in the Day, Week, and Year tabs are combined and plotted in graphical format.
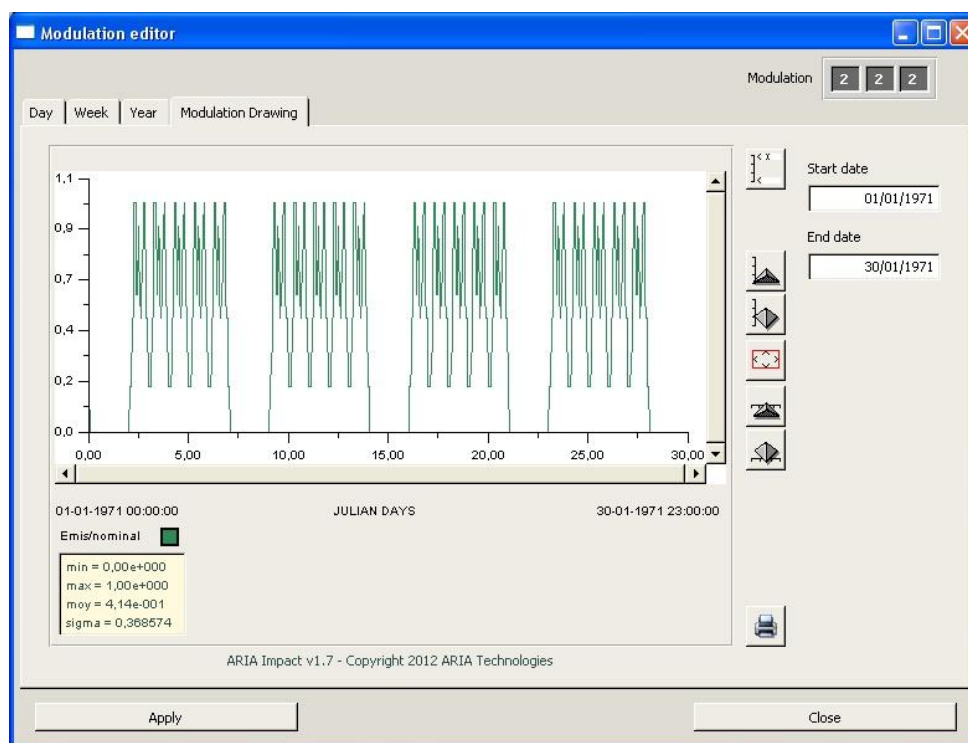
Figure 28: Modulation drawing tab

The `Start` and `End dates` of the modulation drawing can be modified by entering a new date as follows: dd/mm/yyyy.

The x-axis represents the time scale and the y-axis the modulation value.

The graphic can be shrunk (⬙) or stretched (⬛) along the x-axis. And it can be shrunk (⬙) or stretched (⬛) along the y-axis. To return to the original size, click on the ⬚ button. Clicking on the ⬚ button opens a `Scale editor` window (Figure 80) for the y-axis.

4.3.7   Data - Receptors

Cartographic elements defined as "Receptor" (for which the concentration at a given point is calculated) can be imported and exported using the `Receptors` menu.
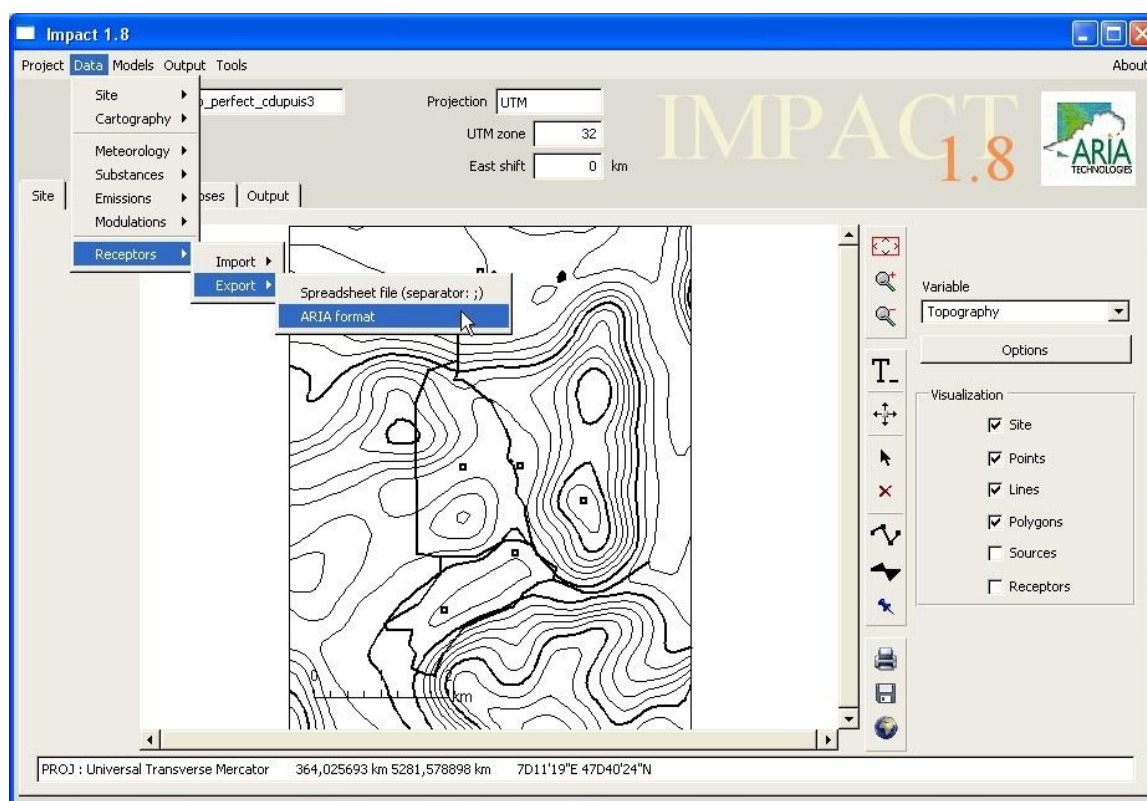
Figure 29: Receptors pull down menu

4.3.7.1 Import

The user can choose between two different receptor file formats to import:

- Excel csv format (text file, data separated by semicolon ";")
- ARIA format file also called « donpos »; this file is compatible with different ARIA Technologies models.

Selecting Import opens a Look Up window for searching and selecting the required file. The file format is described in paragraph 7.7.

4.3.7.2 Export

The user can choose between two different receptor file formats to export:

- Excel csv format (text file, data separated by semicolon ";")
- ARIA format file also called « donpos »; this file is compatible with different ARIA Technologies models.

In the Look Up box that opens, select the directory to which the file should be exported. This file can further be imported to another ARIA Impact project later on. The file format is described in paragraph 7.7.

4.4 MODELS MENU

The Models menu offers four options:
- Meteorological statistics
- Specific case run
- Statistical run
- Wind rose run

Two models are available for statistical calculation: AIM developed by ARIA Technologies and AERMOD from US-EPA.
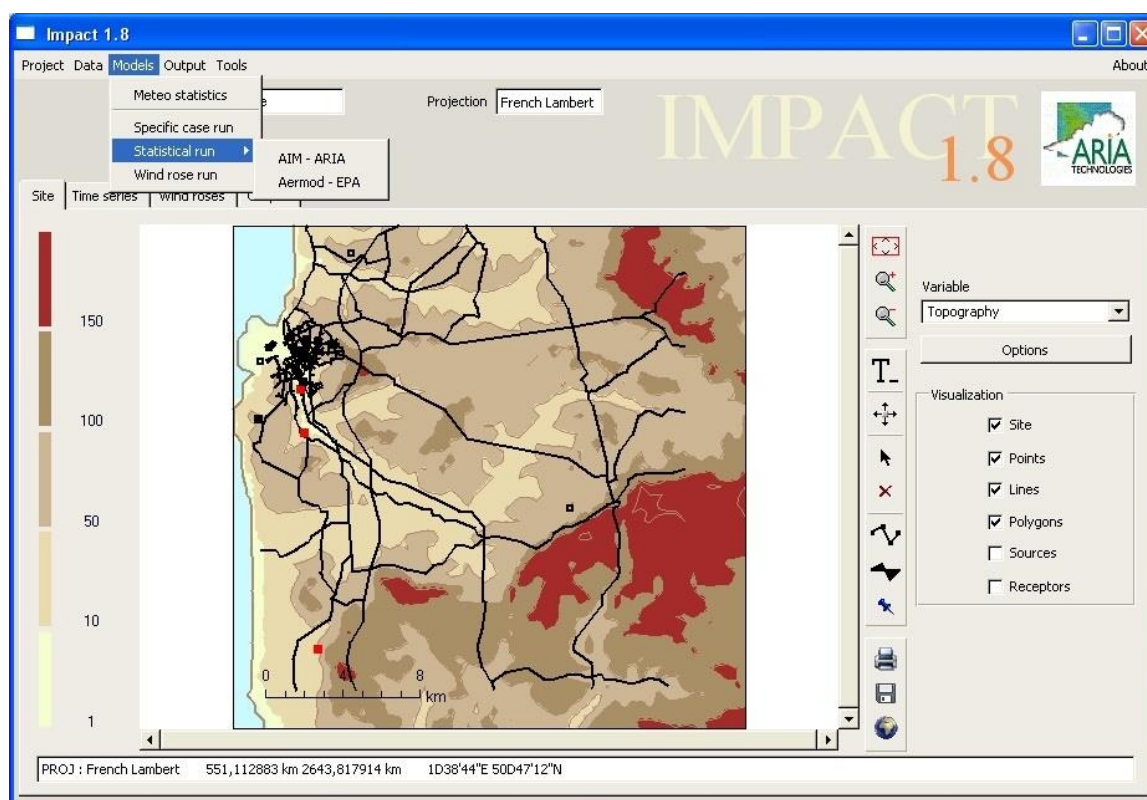
Figure 30: Main panel with Models pull-down menu.

4.4.1   Models - Meteorological statistics

Clicking on Meteorological Statistics opens a window for statistical analysis and calculation of wind roses based on the meteorological data available.

Figure 31: Meteorological statistics panel.

The window showed in the figure above is used for:
- specifying the calculation period
- defining the output parameters to be considered
- selecting the formats for output results
- accounting for precipitation if the imported meteorological file includes precipitation data

In the Wind section, the user should specify the station that contains the wind measurements for which the wind roses should be calculated.

In the Stability section, the user should specify the station that contains the parameters allowing estimating the atmospheric stability class. This variable is estimated from available data in the meteorological data file. The user selects the method for computing the stability class from the pull-down list (Figure 32). Active options are those including parameters that can be found in the meteorological database.
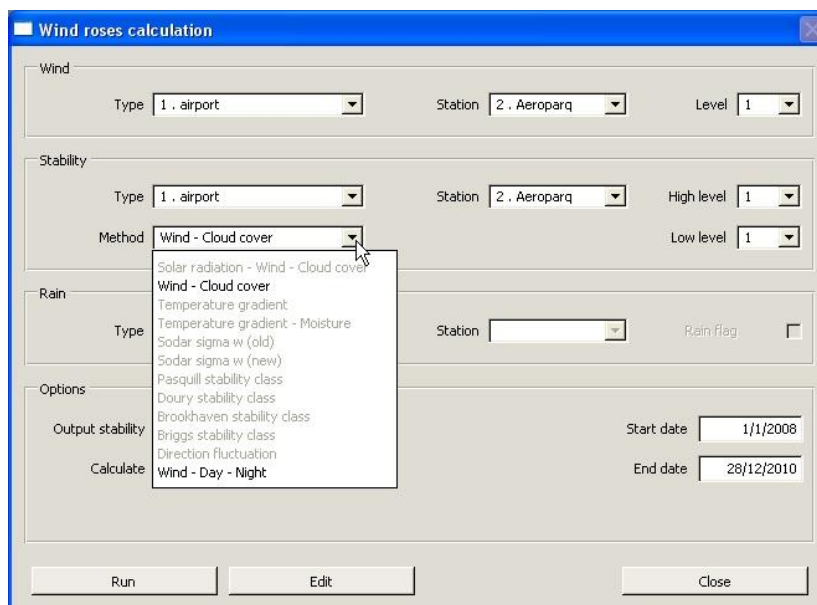
Figure 32: Meteorological statistics - Methods for computing atmospheric stability

The methods available in ARIA Impact generally relate to the Pasquill equation. For the other methods, a correspondence between the classes is used (Section 4.4).

The Rain section allows separating wind rose calculations with and without rain respectively if rainfall data is available for the meteorological station. It is not mandatory to complete this section.

The Start and End dates are by default the dates indicated in the imported meteorological file. These dates can be altered to make the calculation for a shorter time period.

Output stability - the user selects one of the formulas from the pull-down list:
- Pasquill
- Doury
- Briggs
- Brookhaven

Calculate - the user defines the output format:
- Frequency: The <u>frequency</u> of observations is calculated (in % or ‰, depending on the selected option)
- Occurrence: <u>Number</u> of observations is calculated
- Both: Both type of statistics are calculated

Run starts the statistical calculation and Close shuts the window.

Edit opens the SCRATCH.STA file in an editor window; it contains a list of tables with the computed statistics.

The resulting wind roses can also be visualized in graphical format in the tab "Wind roses" of the main menu.

4.4.2 Models - Specific case run

Once the data related to meteorology, topography, emissions and substance characteristics have been defined; the user can compute pollutant concentration for a specific configuration by selecting Specific case run (Figure 33) in the Models menu.
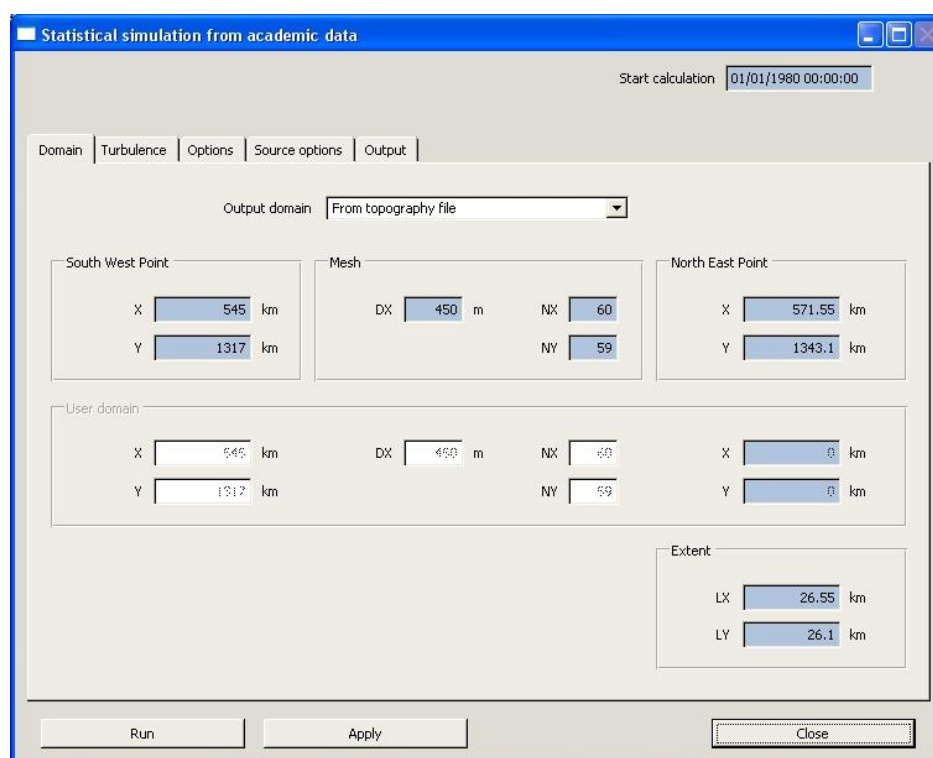
Figure 33: Specific case run panel showing the Domain tab

The top part of the window contains the Start calculation date field, by default equal to the date defined for meteorological data.

The lower part of the screen contains five tabs:
- Domain
- Turbulence
- Options
- Source options
- Output

4.4.2.1 Domain

Displays the characteristics of the calculation domain. The domain can either be set equal to the area defined by the « Topography » file or it can be defined manually for a smaller area.

The user has two options:
- **From topography file** – automatically displays the domain definition already set in the "Site" menu option from the topographic file (southwest corner coordinates, grid size, number of grid points along x and y axes).
- **User defined** - the user can manually specify the domain.

Click **Apply** once the domain has been defined.

4.4.2.2 Turbulence

This tab (Figure 34) allows selecting the station containing the measurements for wind, temperature and stability (for specific case run, the station is defined as "Academic" since the met. data correspond to an academic meteorological situation.
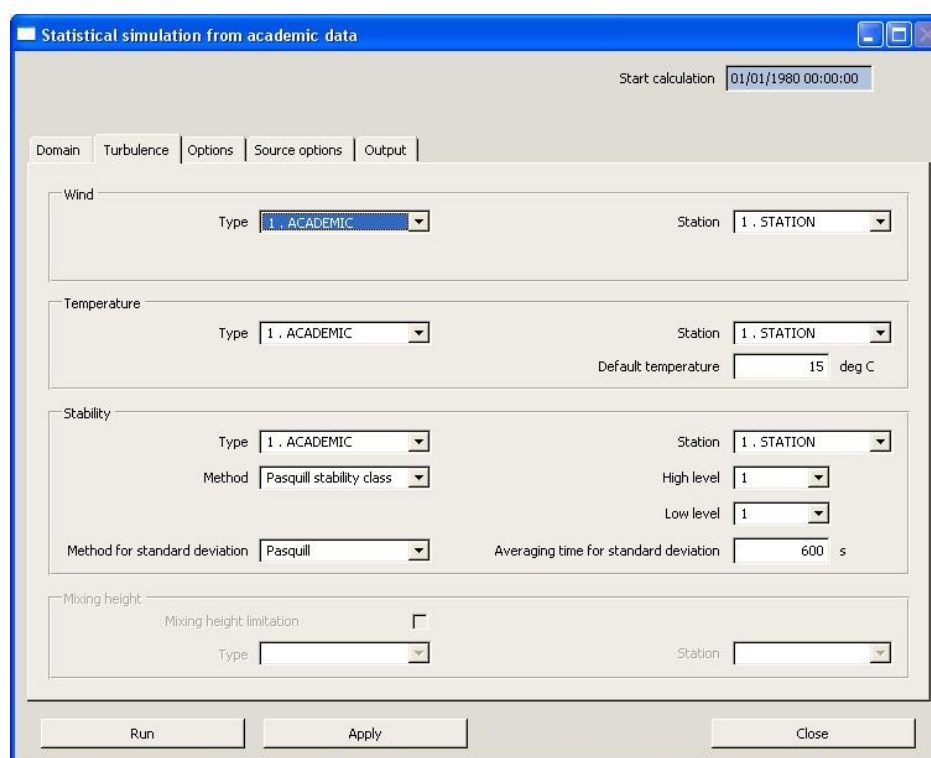
Figure 34: Specific case run panel showing the Turbulence tab

The **Default temperature** should be given by the user. This value will be taken into account if the temperature has not been specified during the definition of meteorological data.

In the "Stability" frame the user should specify the formula for stability class computation, and the method and averaging time for standard deviation (section 4.4.3.2).

Averaging time for standard deviation : This parameter concerns pollutant concentration (and not meteorological data): It is related to the average time over which a concentration should be calculated in order to equal the average time of measurements (i.e. it defines whether the concentrations calculated should correspond to 5 min, 15 min, 60 min averages, etc…).

Example:
If you want to compare the model output to concentrations measured as hourly mean values, you should choose an average time of 3600s (1 hour).

This parameter is involved in the calculation of the sigma values and determines to what extent the Gaussian plume is diluted around the central axis in the calculations. By default, the standard deviation formulation of Pasquill is a concentration averaged over 10 minutes. As a consequence, if the average time is higher, the standard deviations increase, the plume becomes wider and the concentrations close to the central axis are reduced.

Warning!
Don't confuse this term with the "time step" between measurements of concentration that corresponds to the interval between 2 measurements.

Click Apply once the parameters are selected.

4.4.2.3 Options

This module displays the different options that can be selected if it is necessary to account for:
- the terrain (a topographic file prepared in advance is incorporated)
- calm wind conditions
- radioactive decay (for substance category « Activity »)
- NO/NO_2 conversion for traffic emissions (see calculation method in paragraph 5.15)
- plume rise
- downwash of the gas plume due to turbulence around the chimney (« chimney downwash effect », (see. 5.16)
- mixing layer limitation
- generation of a wind profile (calculation of wind speed at stack height to be used in the dispersion calculation)
- generation of temperature profile (calculation of temperature at stack height to be used in the dispersion calculation)
- precipitation, allowing to take into account the washout by rain if precipitation has been selected among the meteorological parameters and for the substances for which a washout ratio has been defined.
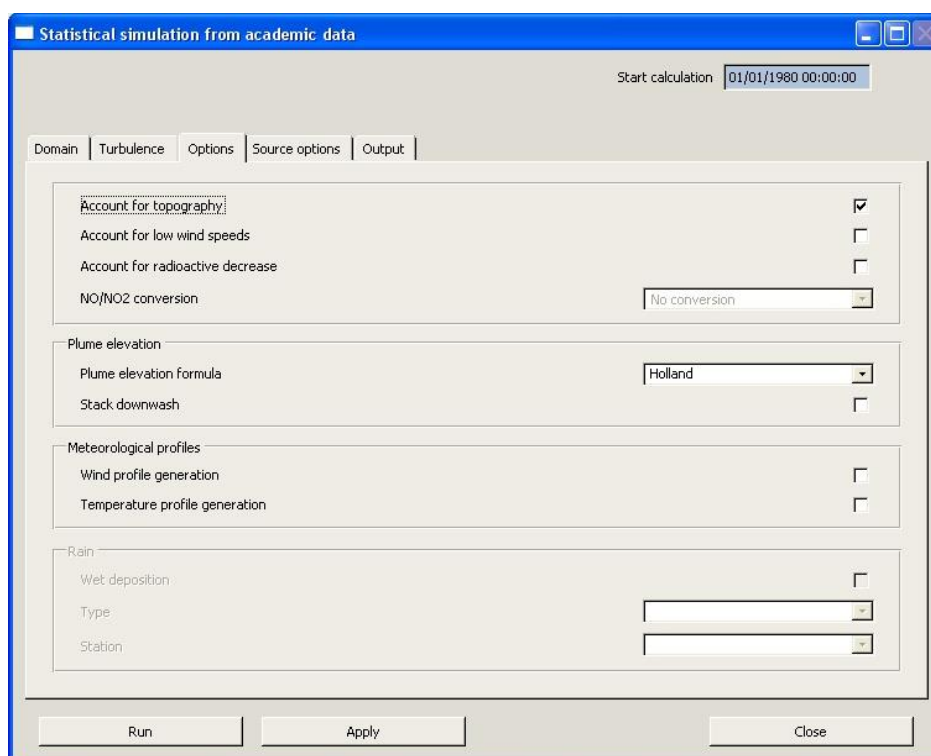
Figure 35: Specific case run panel showing the Options tab

Click Apply once all the Options have been selected.

4.4.2.4 Source options

This tab (see Figure 36) contains two sections:

- The upper part « Source chronology » can only be used in the statistical run (is not used in the specific case run) ;
- The lower part « Line source projection » allows the user to choose method for projecting line sources (road traffic…) on the calculation grid. The different projection methods are explained in paragraph 0.
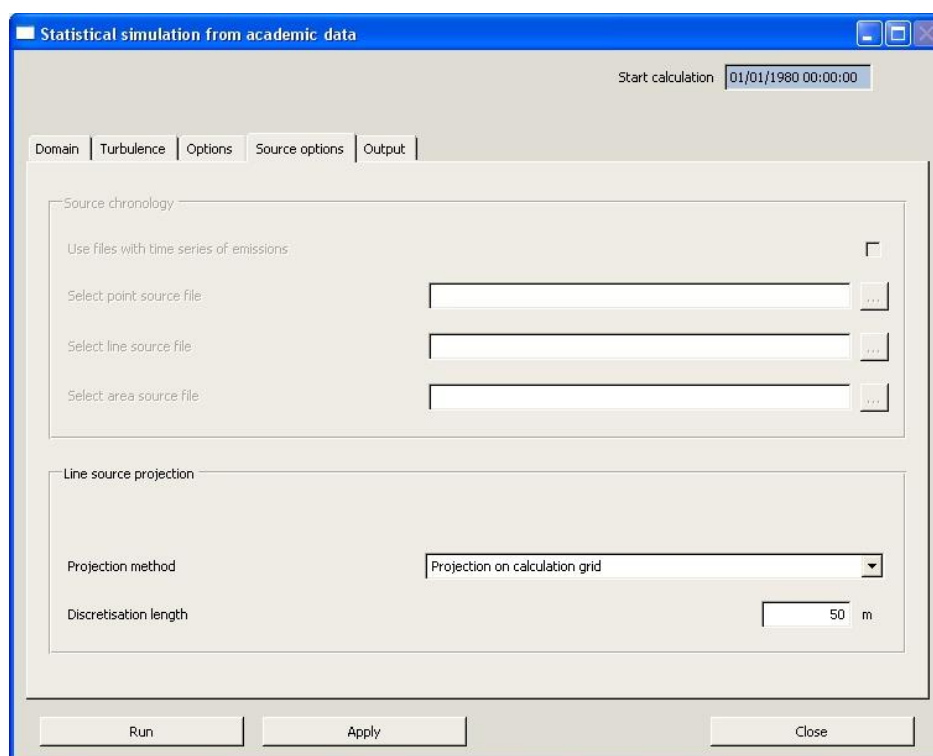
Figure 36: Specific case run panel showing the Source options tab

4.4.2.5 Output

This tab defines the substances that are to be included in the calculation. Clicking the All button displays all the substances defined earlier. Check or uncheck the box in the Calculate column to select or unselect a substance.

In the Calculation basis column, the user enters the calculation average time (in seconds) required by the regulations on ambient air quality.

For example (French air quality guidelines for SO_2):
- 99.7 percentile of <u>hourly</u> average values => mean time length = 3600s
- 99.2 percentile of <u>daily</u> average values => mean time length = 86400s (24 hours)

The user has the possibility to either manually define a value related to the Background concentration for each pollutant or to read the background concentration from a data base corresponding to measurements of ambient air quality (section 4.4.3.5).

The Units of the output results for the different pollutants should be given. For substances defined as « Mass » the user has the choice between the following units: $\mu g/m^3$, ng/m^3, pg/m^3, fg/m^3. For substances defined as « Activity », the output results will be given in Bq/m^3 and for the category « Odour », they will be given in ou/m^3 (odour unit).

Click Apply once all the fields are entered.
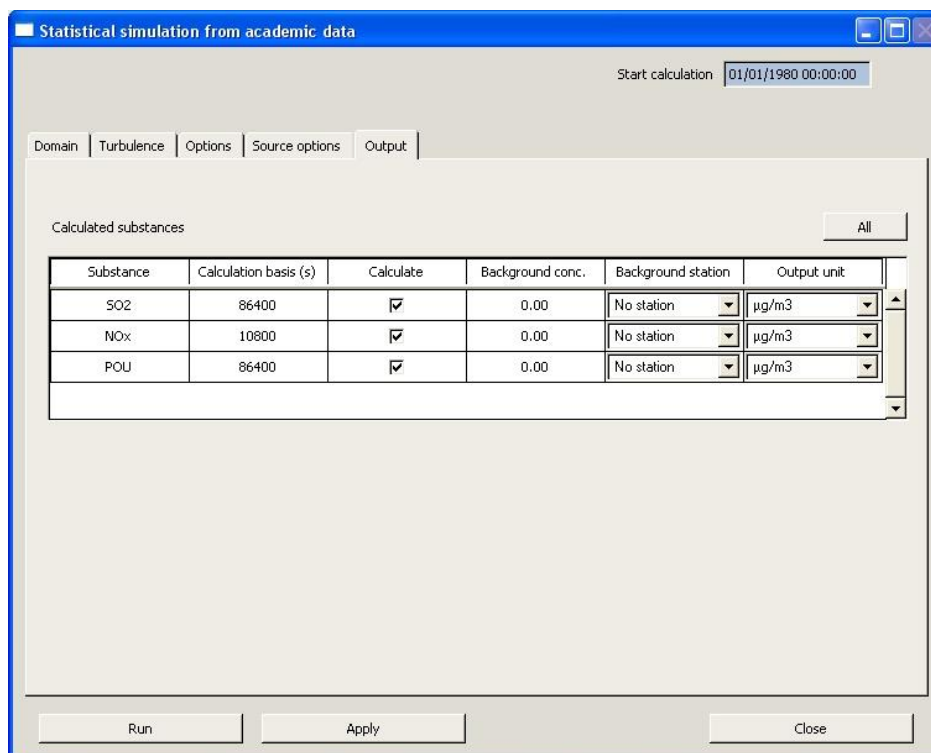
Figure 37: Specific case run panel showing the Output tab

Once all the data in the five tabs of the specific case calculation window has been validated, click Run to start the computation. The window below appears on the screen, showing the progress of the calculation. The user has the possibility to interrupt the calculation at any moment by clicking the button « Kill ».
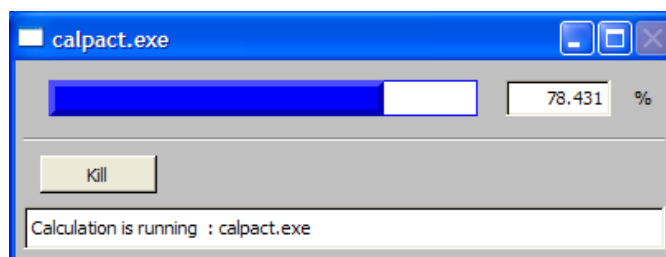
At the end of the calculation the following message appears on the screen.
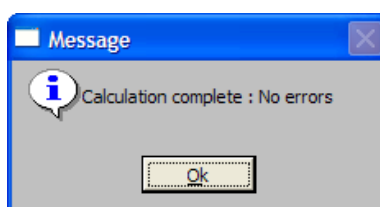
To exit the window, click Close.

4.4.3   Models - Statistical run - AIM

The Statistical run function performs computations of long-term impact of atmospheric pollution using AIM model, based on a meteorological file containing several years of data (e.g., five years of measurements). This function can be activated once all the parameters related to meteorology (time-series for a longer period), topography, emissions, substances, etc. have been defined.
The window is shown Figure 38.

The top part of the window has two text fields: Start and End calculation dates.
The dates indicated here should be confined within the period of data included in the meteorological database.

For example, for a calculation covering five years (from 0:0:0 on 01/01/2000 to 21:0:0 on 31/12/2004), enter "01-01-2000 0:0:0" or "1-1-2000 00:00:00" in the Start calculation field and "31-12-2004 21:0:0" or "31-12-2004 21:00:00" in the End calculation field
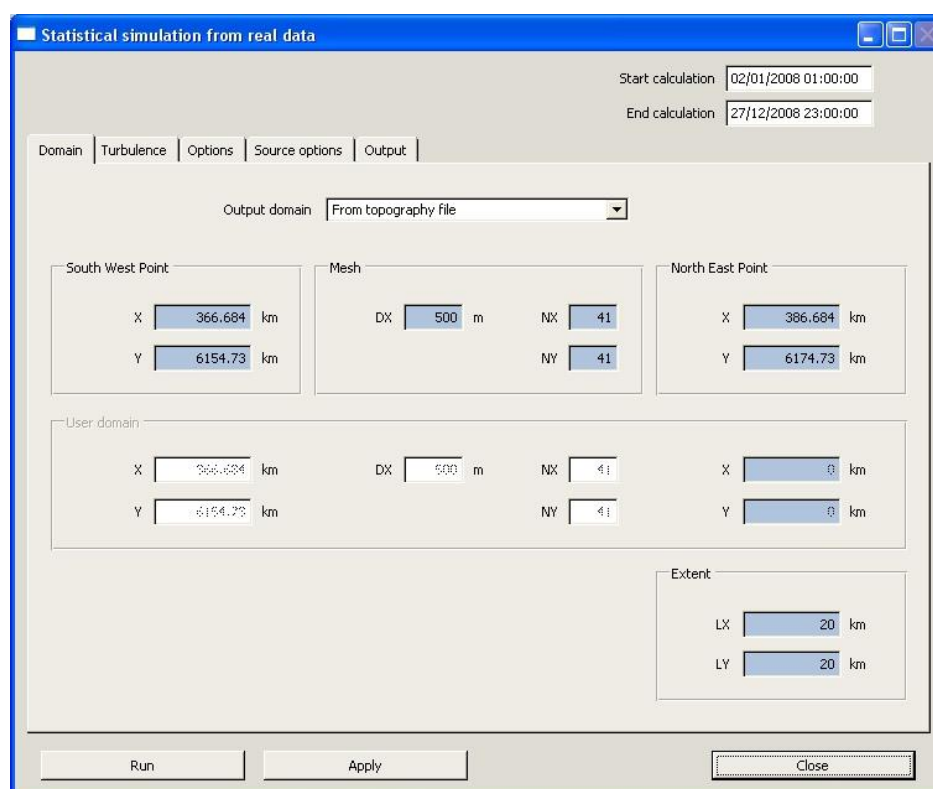
Figure 38: Statistical run panel showing the Domain tab

The lower part of the window contains five tabs:
- Domain
- Turbulence
- Options
- Source options
- Output

4.4.3.1 Domain

Displays the characteristics of the calculation domain. The domain can either be set as specified in the « Topography » file or it can be defined for a smaller area.

The user has two options:
- From topography file – automatically displays the domain definition already set in the "Site" menu option from the topographic file (southwest corner coordinates, grid size, number of grid points along x and y axes).
- User defined - the user can manually specify the domain.

Click Apply once the domain has been defined.

4.4.3.2 Turbulence

After defining the domain, options for taking turbulence into account should be selected. In order to do this, the different sections of the Turbulence tab should be filled.
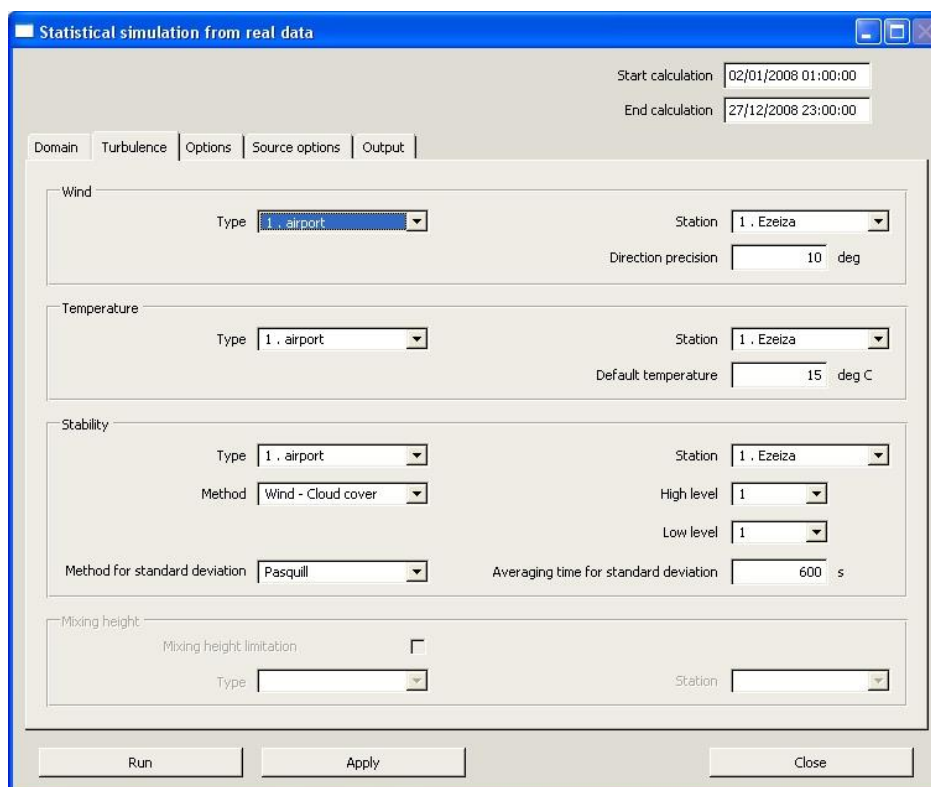
Figure 39: Statistical run panel showing the Turbulence tab

1) Wind section

In the wind section, the user should specify the station that contains the wind measurements. Moreover, based on the degree of accuracy of the wind direction measurements, the user should specify the precision of the wind direction (given in degrees).

For example: If the wind direction in a meteorological file is rounded off to the nearest 10 degrees, the user should set the precision to 5 degrees, to take into account all possible directions of wind. The software will thereafter use a random value of the direction plus or minus 5 degrees around the values read in the file.

2) Temperature section

In the temperature section, the user should specify the station containing the measurements of temperature. It could be the same station as for the wind measurements, but not necessarily. A Default temperature should also be given by the user. This value will be applied for the dates in the meteorological data file for which the temperature is invalid.

3) Stability section

In the stability section, the user should specify the station that contains the parameters allowing to compute the atmospheric stability class. This variable is estimated from available data in the meteorological data file. The user selects the method for computing the stability class from the Method pull-down list (Figure 40). Active options are those including parameters that can be found in the meteorological database.

In the example below, the file with meteorological data contains measurements of wind and cloud cover. AIM therefore proposes to calculate stability class with the methods « wind-could cover », or « wind-day-night ». The latter formula is however normally only selected when there is no other choice (i.e. no meteorological parameter available allowing to calculate atmospheric stability class).

Figure 40: Methods for calculating stability class

Also, formula for calculating the standard deviations of dispersion (σ_y, σ_z), (see chapter 5.6) should be selected. The user can choose among 4 type of formulas.

With Method for standard deviation, the user selects one of the formulas from the pull-down list:
- Pasquill
- Doury
- Briggs
- Brookhaven

Averaging time for standard deviation (given in seconds): This parameter concerns concentration data (and not meteorological data in the database): It is related to the average time over which concentrations should be calculated in order to equal the average time of measurements (i.e. it defines whether the concentrations corresponds to 5 min, 15 min, 60 min averages, etc…).

This parameter is involved in the calculation of the sigma values and determines to what extent the Gaussian plume is diluted around the central axis in the calculations. By default, the Pasquill formulation for the standard deviation is a concentration averaged over 10 minutes. As a consequence, if the average time is higher, the standard deviations increase, the plume becomes wider and the concentrations close to the central axis are reduced).

Note**: Don't confuse this term with the "time step" between measurements of** concentration that corresponds to the interval between two measurements.

Example:
If you want to compare the model output to concentrations measured as hourly mean values, you should choose an average time of 3600s (1 hour).

4) Mixing layer section

If the mixing height has been calculated (see 5.9), it is possible to account for the reflection of the gas plume at the height of the mixing layer by activating the Mixing height limitation check box and thereafter defining the meteorological station containing this variable.

Click Apply to save the options.

4.4.3.3 Options

This module displays the different options that can be selected if it is necessary to account for:
- the terrain (a topographic file prepared in advance is incorporated)
- calm wind conditions
- radioactive decay (for substance category « Activity »)
- NO/NO$_2$ conversion for traffic emissions (see calculation method in section 5.15)
- plume rise
- downwash of the gas plume due to turbulence around the chimney (« chimney downwash effect », cf. 5.16
- mixing layer limitation
- generation of a wind profile (calculation of wind speed at stack height to be used in the dispersion calculation)
- generation of temperature profile (calculation of temperature at height to be used in the dispersion calculation)
- precipitation allowing to take into account the washout by rain if precipitation has been selected among the meteorological parameters and for the substances for which a washout ratio has been defined.
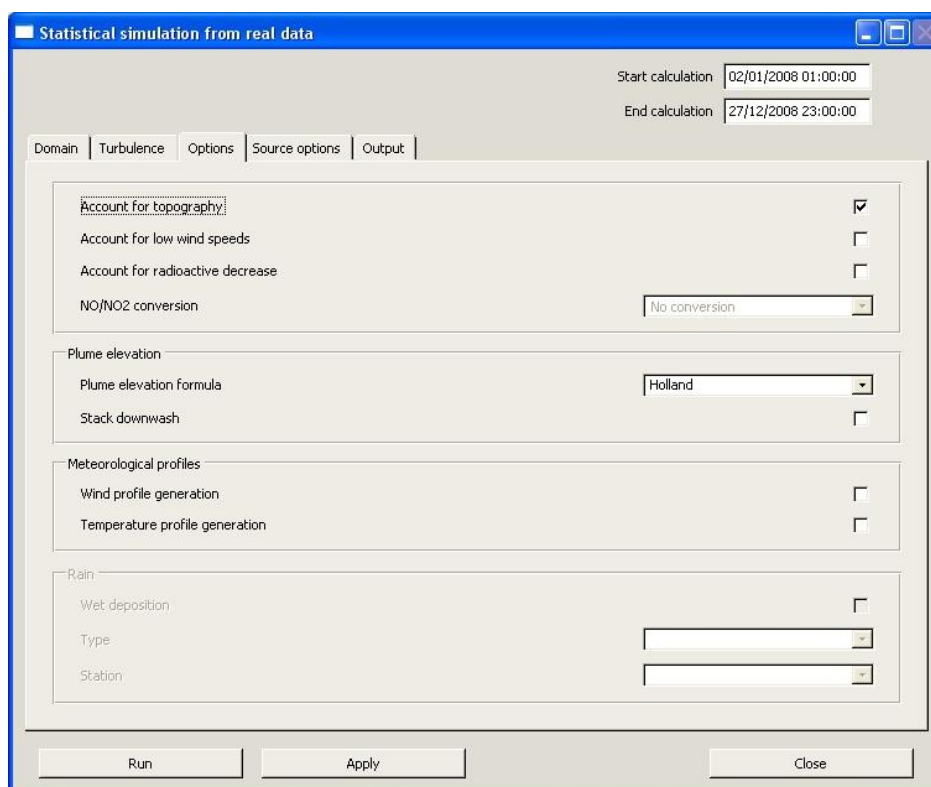
Figure 41: Statistical run panel showing the Options tab

Click **Apply** once all the **Options** data have been entered.

4.4.3.4 Source options

This window (see Figure 42) contains two sections:

1) Source chronology

This part allows importing files containing time series of emission data for one or several particular periods. These files are optional and complementary to the definition of emissions sources made in menu "Data > Emissions" and "Data > Modulations". The description of these files is presented in paragraph 7.6.6.

2) Line source projection

The lower part allows the user to choose a method for projecting line sources (road traffic…) on the calculation grid. The different projection methods are explained in paragraph 0.
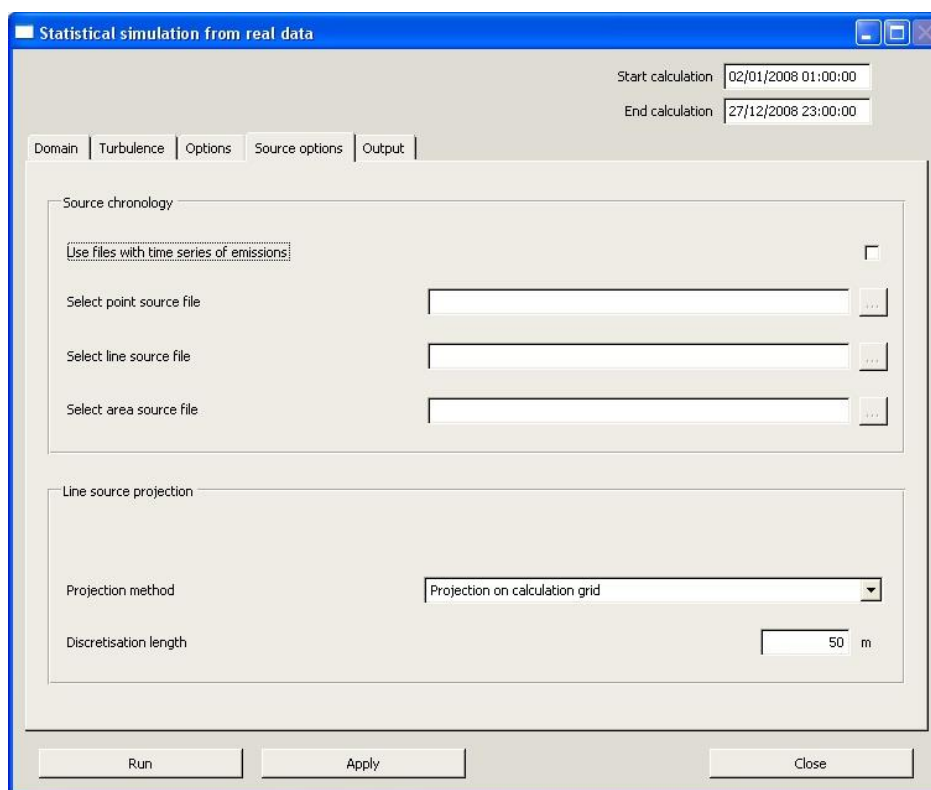
Figure 42: Statistical run panel showing the Source options tab

4.4.3.5 Output

This tab defines the substances and the statistical results that are to be included in the calculation.

The minimum acceptable percentage of valid data for the calculation should be defined. It is commonly set to 80%.

The user selects the substances to be calculated. Clicking the All button selects all the substances defined earlier. Check or uncheck the Calculate column to select or unselect a substance.
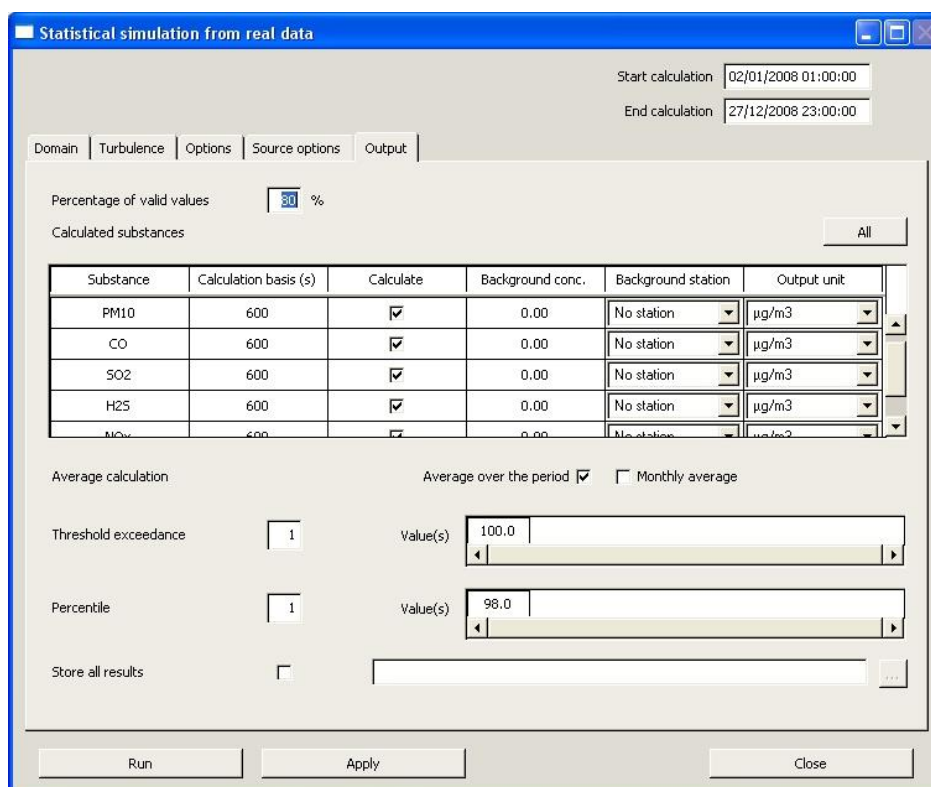
Figure 43: Statistical run panel showing the Output tab

In the `Calculation basis` column, the user enters the calculation average time (in seconds) required by the regulations on ambient air quality. For the calculation of percentiles, these values are very important.

For example (French air quality guidelines for SO$_2$):
-99.7 percentile of hourly average values => mean time length = 3600s
-99.2 percentile of daily average values => mean time length = 86400s (24 hours)

The `Units` of the output results for the different pollutants should be given. For substances defined as « Mass » the user has the choice between the following units: µg/m^3, ng/m^3, pg/m^3, fg/m^3. For substances defined as « Activity », the output results will be given in Bq/m^3 and for the category « Odour », they'll be given in ou/m^3 (odour unit).

`Background concentration` (in µg/m^3) corresponds to background pollution not accounted for by the emission sources included in the dispersion calculation. The user has the possibility to either manually define a constant value of background concentration for each pollutant or to read data from a file containing time series of measurements of ambient air quality which can be considered as background concentration in the dispersion simulation (section 4.4.3.5). In the second case, the procedure to follow is:

1. Go to the menu "Tools > Dictionary editor", and define an additional variable(s) for each substance for which background concentration should be accounted. The new variables should have the same name as the substances defined under "Data > Substances" and the variable type should be set to « Concentration ».

2. Create a data file of background concentration by following the same file format standard as for meteorological data files (including date and hour associated to each measurement of pollutant concentration). An example of such a file is presented in paragraph 7.4.

3. Import the file containing the background concentration data in the same manner as when importing meteorological data files, (see menu "Data > Meteorology > Import > Time series files").

4. Finally, in the calculation output tab, choose the station corresponding to the background data by selecting from the pull-down list (see Figure 43)

AIM can perform the following statistical calculations:

- annual average (check the corresponding box)
- monthly average (check the corresponding box)
- frequency of exceeding a given threshold (enter the number of thresholds and corresponding values)
- percentiles (enter the number of percentiles to be computed and the corresponding statistical values)

It is possible to store the results from each calculation time step, in binary format. This file can further be visualised with the 3D graphical software EWB (also called SAVI3D) after having been converted to a so called .MeRAF file (see section 7.8.2). The results in this file are stored for each time step in the meteorological data file and for each substance included in the calculation. In order to create a binary file, check the corresponding box "Store all results" and select the file directory by clicking on the look up button ⬚ .

Click Apply once all the parameters are entered.

Once all the data in the five tabs of the Statistical run window have been validated, click Run to start the computation. The window below appears on the screen, showing the progress of the calculation. The user has the possibility to interrupt the calculation at any moment by clicking the button « Kill ».
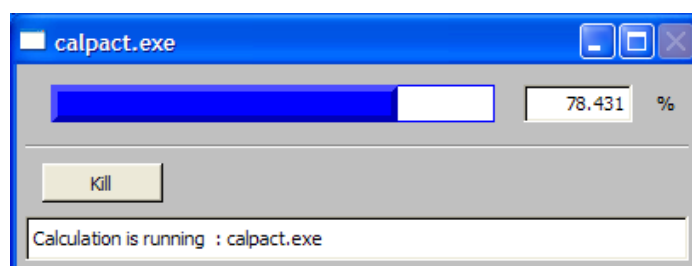
At the end of the calculation the following message appears on the screen.
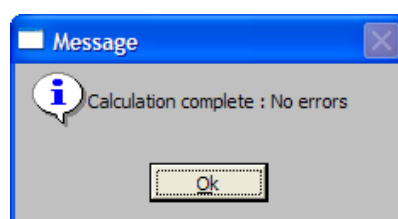
To exit the window, click Close.

4.4.4 Models - Statistical run – AERMOD -EPA

The Statistical run function performs computations of long-term impact of atmospheric pollution using US-EPA AERMOD model, based on a meteorological file containing several years of data (e.g., five years of measurements). This model has been developed by the AERMIC (American Meteorological Society (AMS)/United States Environmental Protection Agency (EPA) Regulatory Model Improvement Committee), a collaborative working group of scientists from the AMS and the EPA.
The version of AERMOD and its preprocessors taken as reference is the latest version available on the website of the U.S. EPA in July 2011.

More information on this model can be found on the EPA web site:
http://www.epa.gov/scram001/7thconf/aermod/aermod_mfd.pdf

This function can be activated once all the parameters related to meteorology (time-series for a longer period), topography, emissions, substances, etc. have been defined.

The window is shown Figure 44.

> **Warning!**
> To have access to the AERMOD model, the ARIA Impact project must be using UTM coordinates. It is also necessary to have a meteorological chronic at hourly intervals for modeling the dispersion of pollutants with AERMOD.
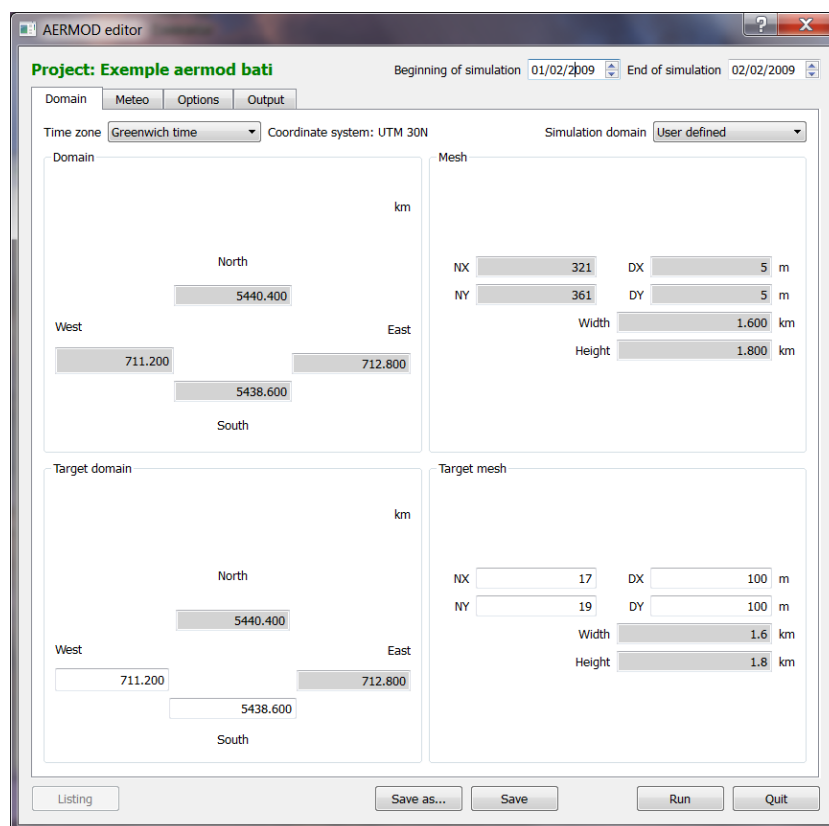
Figure 44 : AERMOD statistical model – Domain tab

The aspect and functioning are the same as for IMPACT panel. When a parameter is invalid, its field is turned to a red background. The user has no access to the other tabs unless he has corrected the field.

First the user must select the beginning and ending dates for the simulation.
Dans un premier temps, l'utilisateur doit remplir les champs « Début de la simulation» et «Fin de la simulation». By default, the dates listed at the top of the window are those defined in the definition of meteorological data.

The Save button saves the xml parameter file in the directory of the original project.
The Save As button allows you to save it to another folder.
The Quit button closes the window of AERMOD statistical calculation.
The Run button launches the calculation.
The Listing button gives access to the listing file when it becomes available.

Four tabs appear on the main window:
- Domain;
- Meteorology;
- Options;
- Output.

4.4.4.1 Domain

The « Domain » tab gives the coordinates of the study domain, the size of the mesh and the number of grid points in the topography file of the project (See. Figure 44).

The user can choose between two options to define his study domain:
- Read in the topography file;
- User defined.

If the user selects the option "Read in the topography file", the characteristics of the domain (coordinates of the southwest, mesh size and number of points on X and Y) are filled up with the dimensions of the topography.

If the user selects the type "User Defined", then it is possible to change the definition of the domain to a run a simulation on an area smaller than the topography. For this, the user must give the coordinates of the southwest, the mesh size and the number of points on X and Y.

The user must also specify the time difference between the project location and the UTC. This time difference is defined as a function of the position (East or West) compared with the Greenwich meridian.

4.4.4.2 Meteorology

Once the domain is set, one must give the meteorological data used by AERMOD calculation.

The user can import model aermod meteorological files (.SFC and .PFL files). In this case, it is necessary to check the box relative to the use of this type of file, then to import files ⬚.
The user also has to specify the height of the meteorological profile, which represents the height of the bottom of the temperature profile of the file AERMOD.
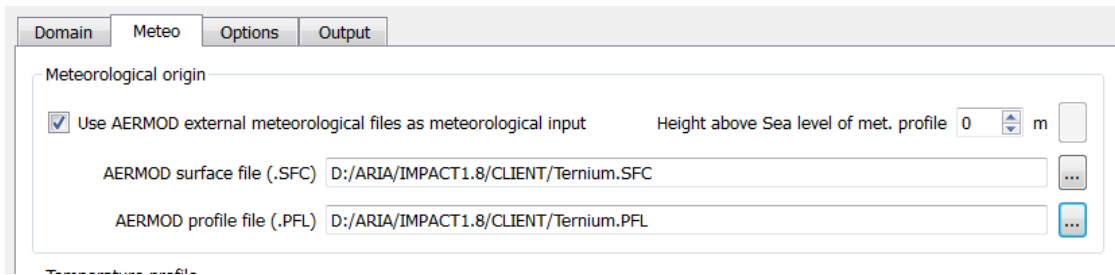
If the user does not possess meteorological AERMOD files, the software uses the meteorological data imported previously (cf. 4.3.3.2). In tis case, the user must define the sensor and the station he wishes to use for each type of weather data (temperature profile, rain, wind ...).
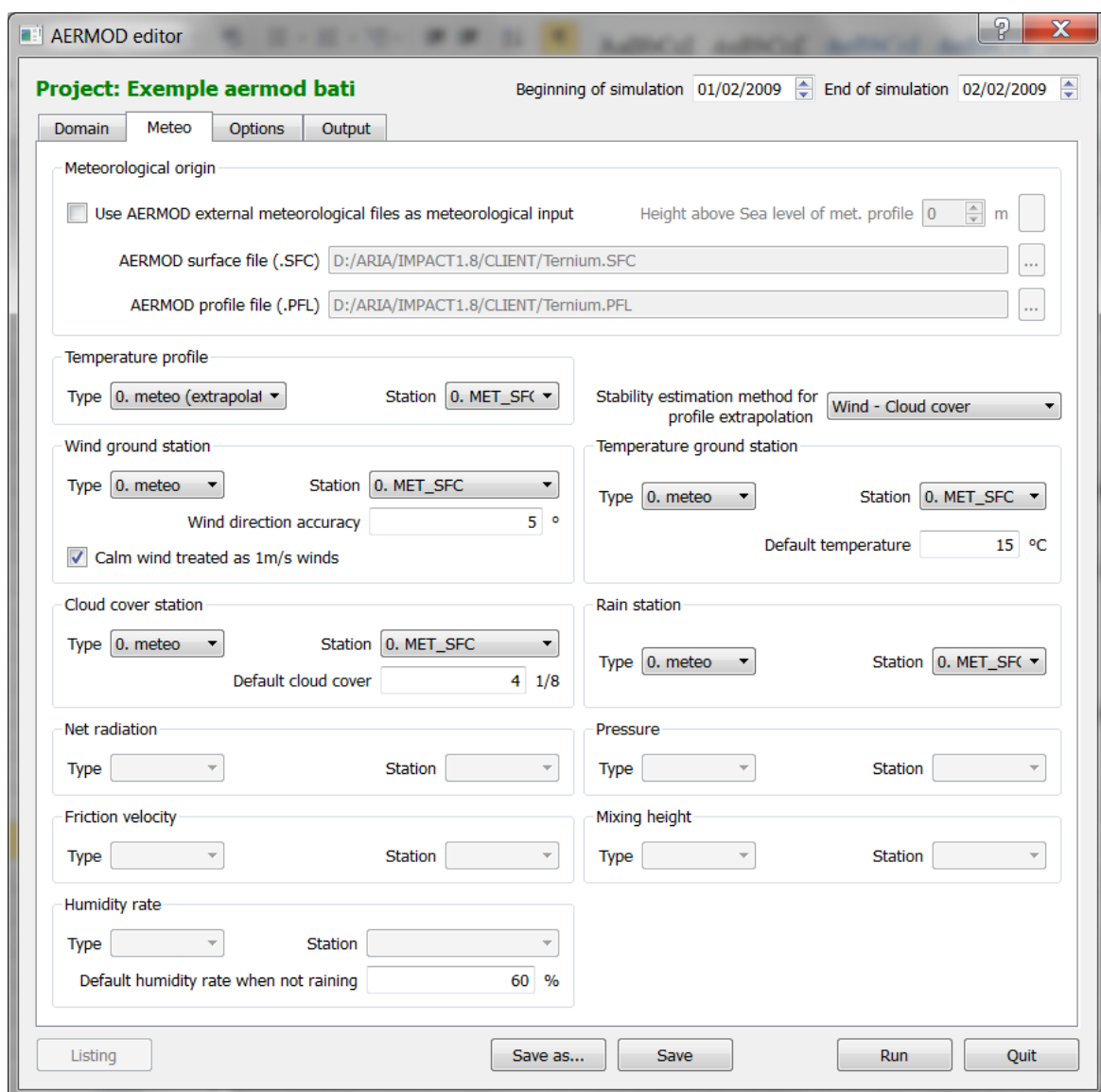
Figure 45 : AERMOD statistical model – Meteorology tab

1. Temperature profile

In the "temperature profile" section, the user must define the sensor and the station that contains the temperature profile data used for calculation.

The user must also define the "method of estimating the stability for the extrapolation of the profile" to use in the absence of temperature profile data. This method is chosen based on weather data provided by the meteorological data file (see Figure 46).
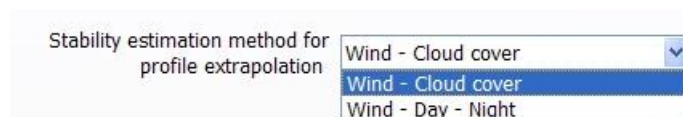
Figure 46: Method for calculating the stability

In our example, the meteorological data file includes wind and cloud cover measurements. Thus, the software can calculate stability class using the method "Wind – Cloud cover". The default method "Wind - Day - Night" is also available. The latter method is used as a last resort when no other method is possible (absence of parameter for the calculation of a stability class).

Generally, methods for determining the stability, available in the software, are described in the Pasquill formulation. Regarding to other formulations, the correspondences between classes are used (see §).

2. Wind ground station

In the "Wind ground station" section, the user must define the sensor and the station that contains wind data at ground level to use for the calculation.

The "Wind direction accuracy" allows the user to specify the fluctuation of wind direction for its calculation, depending on the accuracy of wind direction data in the meteorological file. This data must be expressed in degrees.

For example: In a weather file, the data of wind direction can be rounded so as to have data every 10 degrees. To take into account in the calculations all possible wind directions, the user must enter a precision of 5 ° in direction. The software will then take a random direction to within 5 ° from the value read in the weather file

3. Temperature ground station

In the "Temperature ground station" section, the user must define the sensor and the station that contains the temperature data at ground level to use for the calculation.

The "Default temperature" allows the user to set the value to be considered in cases where temperature read in the meteorological file is invalid.

4. *Cloud cover station*

In the "Cloud cover" section, the user must define the sensor and the station that contains cloud cover data to be used for computing.

The "Default cloud cover" allows the user to specify the value of cloud cover to use by default when the cloud cover data are invalid or unavailable. This data must be expressed in multiples of 1/8.

5. *Rain station*

In the "Rain" section, the user must define the sensor and the station that contains the data of pluviometry to use for the calculation.

Note: taking into account of rain in AERMOD is not enabled in version 1.8 of ARIA Impact. The calculation of wet deposition is not currently possible.

6. *Net radiation*

In the "Net radiation" section, the user must define the sensor and the station that contains the data of net radiation to use for the calculation.

7. *Pressure*

In the "Pressure" section, the user must define the sensor and the station that contains the data of pressure to use for the calculation.

8. *Friction velocity*

In the "Friction velocity" section, the user must define the sensor and the station that contains the data of friction velocity to use for the calculation.

9. *Mixing height*

In the "Mixing height" section, the user must define the sensor and the station that contains the data of mixing height to use for the calculation.

10. *Humidity*

In the part "humidity rate", the user has to define the sensor and the station which contain the humidity. If not available, it is necessary to fix a value of humidity, proposed by default at 60%.

4.4.4.3 Options

This tab allows selecting the options for calculations (see. Figure 47).
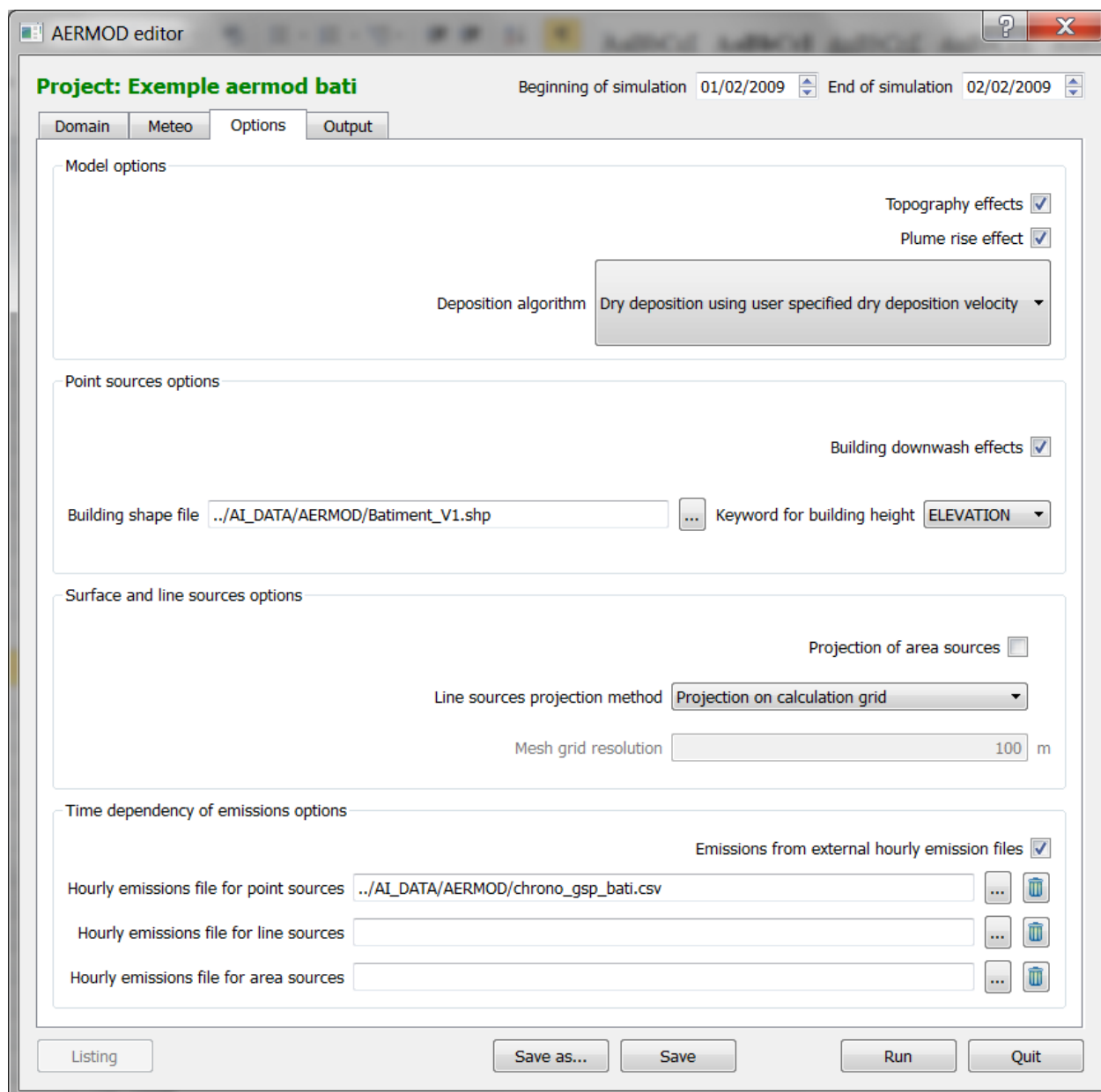
Figure 47: AERMOD statistical model – Options tab

1. *Model options*

In the "Model Options" section, the user may choose to take into account the relief (in this case it is necessary to have previously integrated a topographic file) and the plume rise effect in the calculation.

In addition, the user must choose the deposition method used in AERMOD calculation. Two options are available:

- No wet and dry deposition,
- Dry deposition using the dry deposition velocity.

2. *Point sources options*

In the "Point sources options", the user may choose to consider the effects of downwash of the plume due to the presence of buildings. When this option is set, the user must give the path to the shapefile containing the obstacles and the "Keyword for building height" corresponding to the field of the shapefile containing building heights.

3. *Surface and line sources options*

AERMOD cannot manage surface sources as such, two solutions are thus possible:
- Projection AIM like, considering AERMOD sources as volume sources with a horizontal deviation;
- No projection and use of native AERMOD algorithm for surface sources.

In the "Surface and line sources options" section, the user can choose to project the surface sources using the algorithm of AIM (option "projection of area sources" on) or the AERMOD algorithm (option "projection of surface sources" off).

Using the algorithm of AIM allows the user to choose the method of projection of line sources on the mesh. Four methods are selectable:
- Projection on calculation grid;
- Projection prorata on calculation grid;
- Segment discretization;
- Projection on fixed grid.

These different projection methods are detailed in paragraph 0.

4. *Time dependency of emissions options*

The section "Time dependency of emissions" allow importing a file describing the chronic of emission sources on one or more time periods. This file comes in addition to emissions integrated into the model when describing sources (See § 4.3.5). The description of these files is presented in paragraph 7.6.6.

4.4.4.4 Output

This window allows the user to define the calculations he wants to perform.
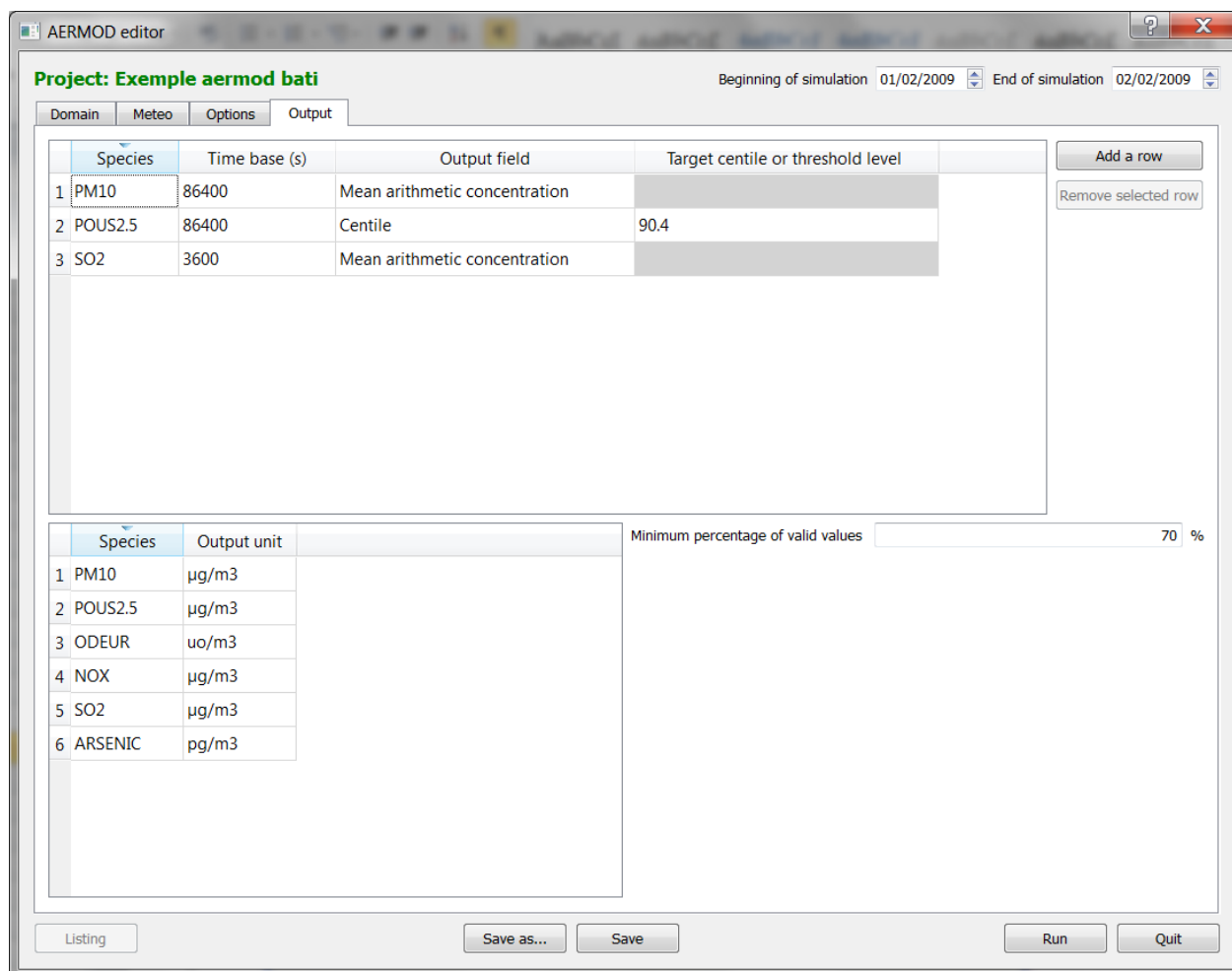
Figure 48: AERMOD statistical model – Output tab

The top table allows the user to define the variables to calculate. For each field the user must select the species, the time base for calculating the statistics, the type of variable to calculate and the percentile or the value of threshold if necessary.

The fields "Species" and "Output Field" can be changed by double clicking on the item you want to edit (double click on "NO2" or "Mean concentration" in the example in Figure 49): a drop-down list is activated allowing the user to choose the different elements available (see Figure 49).
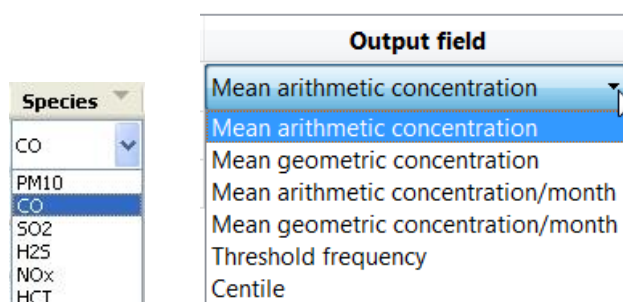
Figure 49: AERMOD statistical model– "Species" and "Output field" menus

The fields "Time base (s)" and "Target centile or threshold level" are also editable on double click of the user that can manually set the desired value.

The same pollutant can be repeated several times in this list with different parameters. The user can add or remove rows to this table using the two buttons on its right. The delete button is only available if one or more lines have been selected by clicking on the line number.

The table at the bottom left is used to manage output units. It contains all the species available in the project.

The user must also define the acceptable percentage of valid data for the statistics calculation, the current value is 80%.

Once all the data in the five tabs of the have been validated, click Run to start the computation. The window below appears on the screen, showing the progress of the calculation. The user has the possibility to interrupt the calculation at any moment by clicking the « Kill » button.
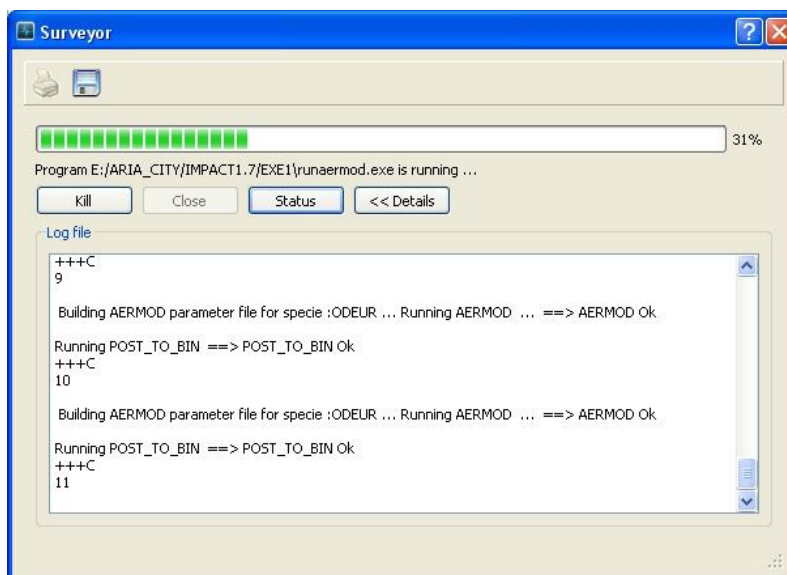
At the end of the calculation the following message appears on the screen.

4.4.5   Models - Wind rose run

The Wind rose run (Figure 50) function is used for performing a calculation based on a meteorological wind rose. Once topography, emission sources, and wind rose data have been defined, concentration levels can be determined using this calculation.
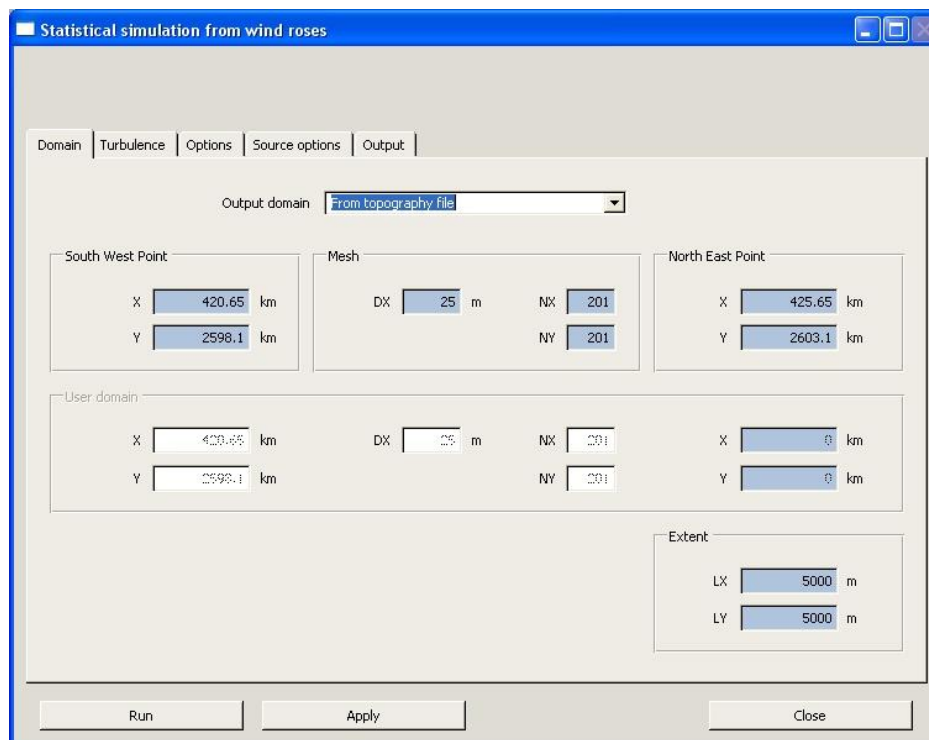
Figure 50: Wind rose run panel showing the Domain tab

4.4.5.1 Domain

Displays the characteristics of the calculation domain. The domain can either be set as specified in the « Topography » file or it can be defined for a smaller area.

The user has two options:
- From topography file – automatically displays the domain definition already set in the "Site" menu option from the topographic file (southwest corner coordinates, grid size, number of grid points along x and y axes).
- User defined - the user can manually specify the domain.

Click Apply once the domain has been defined.

4.4.5.2 Turbulence

After defining the domain, options for taking turbulence into account should be selected. In order to do this, the different sections of the Turbulence tab should be filled (see chapter 4.4.3.2).

4.4.5.3 Options

This module displays the different options that can be selected if it is necessary to account for:
- the terrain (a topographic file prepared in advance is incorporated)
- calm wind conditions
- radioactive decay (for substance category « Activity »)
- NO/NO_2 conversion for traffic emissions (see calculation method in paragraph 5.15)
- plume rise
- downwash of the gas plume due to turbulence around the chimney (« chimney downwash effect », cf. 5.16
- mixing layer limitation
- generation of a wind profile (calculation of wind speed at stack height to be used in the dispersion calculation)
- generation of temperature profile (calculation of temperature at height to be used in the dispersion calculation)
- precipitation allowing to take into account the washout by rain if precipitation has been selected among the meteorological parameters and for the substances for which a washout ratio has been defined.

Click Apply once all the Options data have been entered.

4.4.5.4 Source options

This window contains two sections:
- The upper part « Source chronology » can only be used in the statistical run (this option is not available in the wind rose run)
- The lower part « Line source projection » allows the user to choose method for projecting line sources (road traffic…) on the calculation grid. The different projection methods are explained in paragraph 0.

4.4.5.5 Output
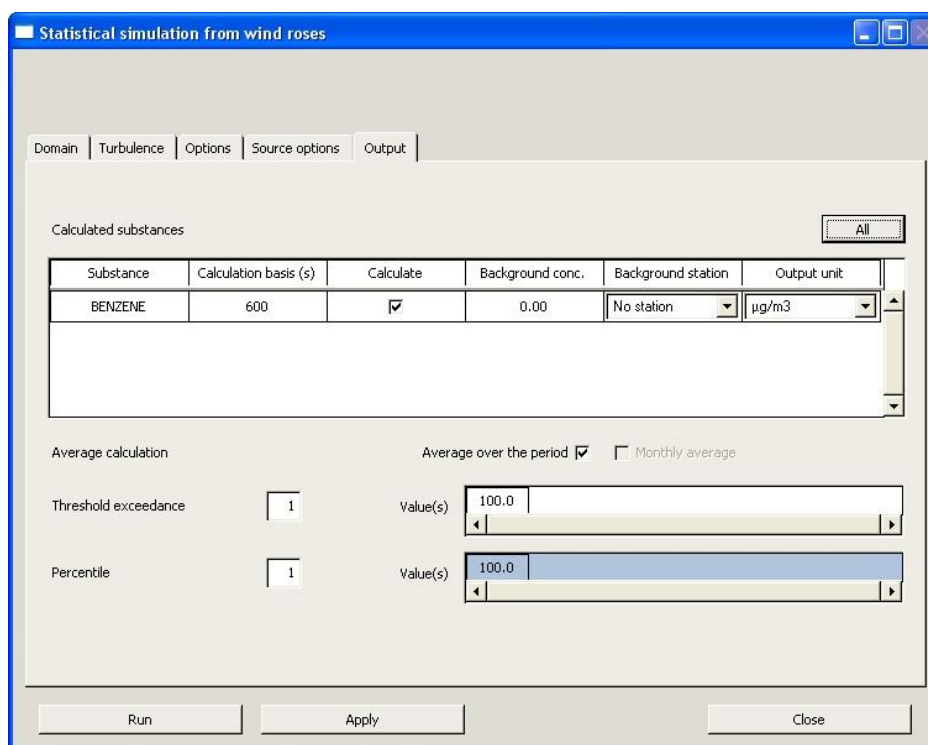
Figure 51: Wind rose run panel showing the Output tab

This window defines the substances that are to be included in the calculation. Clicking the All button displays all the substances defined earlier. Check or uncheck this box in the Calculate column to select or unselect a substance.

In the Calculation basis column, the user enters the calculation average time (in seconds) required by the regulations on ambient air quality. For the calculation of percentiles, this value is very important.

For example (French air quality guidelines for SO$_2$):
-99.7 percentile of hourly average values => mean time length = 3600s
-99.2 percentile of daily average values => mean time length = 86400s (24 hours)

The user also has the possibility to define a constant value related to the Background concentration for each pollutant.

Dispersion modeling based on a wind rose, yields the following statistical measures:
- annual average (check the corresponding box)
- frequency of exceeding a given threshold (enter the number of thresholds and corresponding values)
- the 100 percentile

The units of the output results for the different pollutants should be given. For substances defined as « Mass » the user has the choice between the following units: $\mu g/m^3$, ng/m^3, pg/m^3, fg/m^3. For substances defined as « Activity », the output results will be given in Bq/m^3 and for the category « Odour », they'll be given in ou/m^3 (odour unit).

Once all the data in the five tabs of the Wind rose run window has been validated, click Run to start the computation. The window below appears on the screen, showing the progress of the calculation. The user has the possibility to interrupt the calculation at any moment by clicking the button « Kill ».
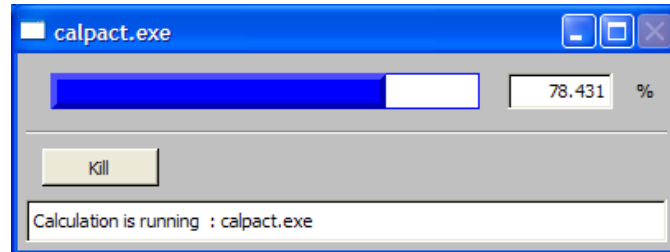
At the end of the calculation the following message appears on the screen.
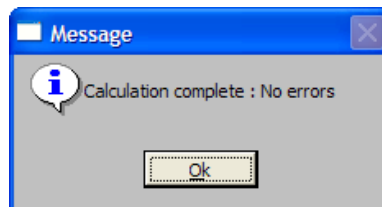
To exit the window, click Close.

4.5 OUTPUT MENU

Once the concentration calculation is completed, the user can look at the results by clicking the Output menu, which offers four options:
- Export EWB (Savi3D)
- Export Ascii
- Control file (log file)
- Listing
- Plume axis results
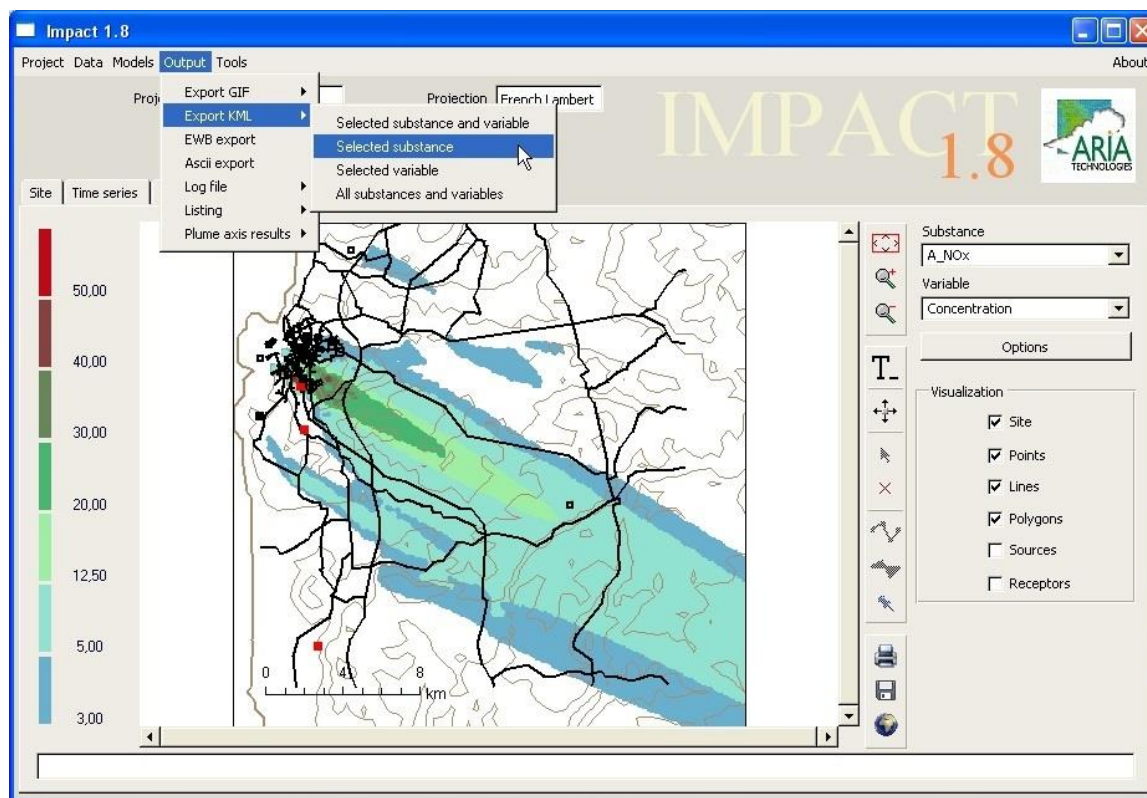
Figure 52: Main panel with Output pull-down menu.

4.5.1 Output – EWB export (Savi 3D)

EWB export (Figure 53) allows the user to save results under Savi 3D,[2] the postprocessor for 3D visualization.
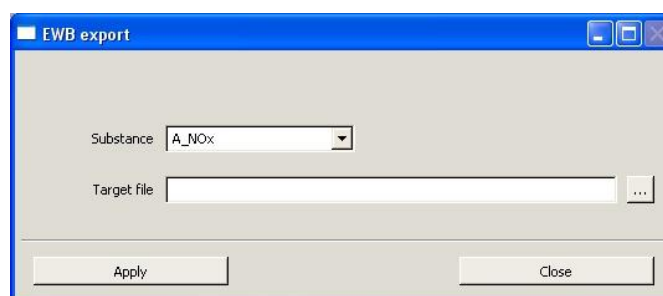
Figure 53: EWB export window

Select the substance to export in the menu of calculated substances.

Then click on the ⎯ button and enter the Savi 3D output file name (without file extension) for the selected substance. Click Apply. A file with the extension MRF (Meraf) is created and all the data concerning the substance can be viewed under Savi 3D.

Warning!

---
[2] User Guide: Savi 3D Environmental WorkBench.

> For an export to EWB, the file name including the complete path should be given without using space or accented characters.

To exit, click Close.

4.5.2 Output – Export Ascii

The results can also be exported in ASCII format (Figure 54). Export files can be specified by selecting substance, parameter (average concentrations, percentiles, deposition) and by output format. Six different output formats can be defined:
- Arc Info
- Map Info
- CSV (data separated by semicolon ";")
- Surfer DAT
- Surfer GRD
- Shapefile
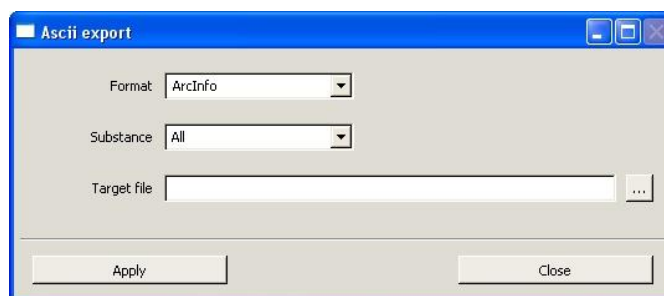
Figure 54: ASCII export window

Select the output format and the substance whose results are to be exported.

Then, enter the name of the output file (without the file extension) by clicking on the [...] button.

Click Apply to validate the output specifications. An ASCII file is then created.

To exit, click Close.

4.5.2.1 Example of an Arc Info export file

The Arc Info file contains the following variables:
- NCOLS: number of columns
- NROWS: number of rows
- XLLCORNER and YLLCORNER: coordinates of the southwest corner in meters
- CELLSIZE: size of grid in meters
- matrix of values

Example of export of an « Arc Info » file:

```
ncols                   51
nrows                   51
xllcorner        627500.0
yllcorner        1740500.
cellsize         300.0000
NDATA_value      -9999
 1.9585066E-21   8.7044735E-22   1.9585066E-21   1.9947751E-21   6.2071185E-21
 0.0000000E+00   1.3471210E-21   2.1761185E-21   8.1656265E-21   8.7044735E-22
 0.0000000E+00   0.0000000E+00   0.0000000E+00   1.5958201E-21   2.6597003E-21
 8.7044735E-22   1.0880593E-21   4.3522370E-21   9.3643978E-02   8.3157278E-18
 0.0000000E+00   0.0000000E+00   1.1787828E-18   0.0000000E+00   1.3495188E-13
 0.0000000E+00   4.3522370E-21   0.0000000E+00   4.3522370E-21   0.0000000E+00
 0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00   2.1761185E-21
 1.0880592E-20   0.0000000E+00   0.0000000E+00   0.0000000E+00   4.3522370E-21
 0.0000000E+00   2.1761185E-21   2.1761185E-21   0.0000000E+00   0.0000000E+00
           0.0000000E+00      0.0000000E+00      1.4507455E-21      2.1761185E-21
       2.1761185E-21
```

4.5.2.2 Example of a Map Info export file:

By choosing this option, ARIA Impact exports the results directly to format mif/mid, which is a format compatible with a number of GIS software on the market (Mapinfo, Arcview, Arcinfo …). This function can equally be used for calculating and producing health risk maps based on concentration and deposition of pollutants.

The .mif file contains the whole set of geographical data, i.e. all the points setting up the calculation grid net. It is built up of a header including different data information:

- the version used
- the set of characters (*Charset*)
- the *delimiter* separating data
- the parameter *CoordSys* allowing the specification of the system coordinates used
- the parameter *Transform* to convert the coordinates according to the North-West square
- the parameter *Columns* that describes the tabular data format in the associated .mid file

Example of .mif file:

```
Version 300
 Charset "WindowsLatin1"
 Delimiter ";"
CoordSys Earth Projection 3, 1002, "m", 0, 46.8,45.898918964419,
47.696014502038, 600000, 2200000 Bounds (-113967455.417, -106367759.649)
(115167455.417, 122767151.185)
 Columns            4
   MAILLE Integer
   Maille_X Integer
   Maille_Y Integer
   CONCAN Float
 Data
```

A section of data, introduced by the parameter DATA alone on a line, follows the header. It contains the whole set of geographical data, each object associated to a line in the .mid file. In our case, the map is solely defined by rectangles, each rectangle being defined by its

coordinates. Finally, the optional parameters (in parenthesis) allow indicating the format of the object.

```
Rect    x1      y1      x2      y2
 Pen (thickness, frame, color)
 Brush (frame, foreground color, background color)
```

Example of .mid file:

The tabulated data are data with separators, each record occupying a line separated by a carriage return and/or an end of line indication. On each line, the data related to a grid are separated by a semicolon:
- grid number
- X grid number
- Y grid number
- concentration.

```
1;1;1;2.331057
2;2;1;2.390733
3;3;1;2.443805
4;4;1;2.484447
5;5;1;2.505343
6;6;1;2.513320
```

4.5.2.3 Example of a « CSV » export file

The « CSV » output file is contains the following parameters:
1. X coordinate (abscissa)
2. Y coordinate (ordinate)
3. concentrations at point (X,Y) in µg/m^3 (CONCAN_mcg/m3)

Example of a « CSV » output file:

```
X;Y;CONCAN_mcg/m3
506000.0;1884000.;2.9292705E-03;
506100.0;1884000.;3.1245092E-03;
506200.0;1884000.;3.3228211E-03;
506300.0;1884000.;3.4017684E-03;
506400.0;1884000.;3.4886936E-03;
506500.0;1884000.;3.5696689E-03;
506600.0;1884000.;3.5980716E-03;
506700.0;1884000.;3.5991054E-03;
506800.0;1884000.;3.5959887E-03;
506900.0;1884000.;3.5967981E-03;
507000.0;1884000.;3.6025250E-03;
507100.0;1884000.;3.6123605E-03;
507200.0;1884000.;3.6251661E-03;
```

4.5.2.4 Example of a « Surfer (dat) » export file

This format can be used as an input to SURFER software. It is an X, Y, V type separated by spaces. The file may contain multiple values side by side.

Example of a "Surfer DAT" file:

```
X Y  REL_M   CONCAN_mcg /m3  DEPAN_mcg _m2
   546.8000        1317.000        1.000000        9.6921504E-02   7.7705871E-04
   547.2500        1317.000        2.000000        9.4637647E-02   7.5977581E-04
   547.7000        1317.000        11.00000        9.4522826E-02   7.5984147E-04
   548.1500        1317.000        15.00000        9.4436511E-02   7.6119904E-04
   548.6000        1317.000        26.00000        9.4128937E-02   7.6166174E-04
   549.0500        1317.000        22.00000        9.5140330E-02   7.8000478E-04
   549.5000        1317.000        73.00000        0.1022972       8.3330629E-04
   549.9500        1317.000        70.00000        0.1134650       9.1613882E-04
   550.4000        1317.000        77.00000        0.1294802       1.0420078E-03
   550.8500        1317.000        91.000…
```

4.5.2.5 Example of a « Surfer (grd) » export file

This export format is used for display of dispersion modelling results with the SURFER software.

Example of a "Surfer GRD" file:

```
DSAA
        151            151
  813.5000        828.5000
  2382.000        2397.000
  3.6412004E-08   9.1964124E-05
  4.9830899E-08   5.0241930E-08   5.0646914E-08   5.0598636E-08   4.9895707E-08
  4.8720668E-08   4.7054414E-08   4.4797943E-08   4.1976673E-08   3.9104290E-08
  3.7055241E-08   3.6412004E-08   3.7581287E-08   4.0750027E-08   4.5489557E-08
  5.1048964E-08   5.7054770E-08   6.3557543E-08   6.9826790E-08   7.4122219E-08
  7.6403524E-08   7.8193892E-08   8.0141845E-08   8.2109423E-08   8.3692086E-08
  8.4561307E-08   8.5829136E-08   8.8625384E-08   9.1573511E-08   9.3613295E-08
  9.5793588E-08   9.8596672E-08   1.0058724E-07   1.0110856E-07   1.0216462E-07
  1.0307629E-07   1.0397184E-07   1.0495348E-07   1.0574728E-07   1.0683196E-07
  1.0811152E-07   1.1033510E-07   1.1281588E-07   1.14…
```

4.5.2.6 Example of a « shapefile » export file

This output is used to visualize the results with the ArcView (ESRI) software. The shapefile format is also recognized by a large number of software.

By choosing this option, ARIA Impact creates three files with extensions: .shp, .shx and .dbf.

4.5.3 Output – Log file
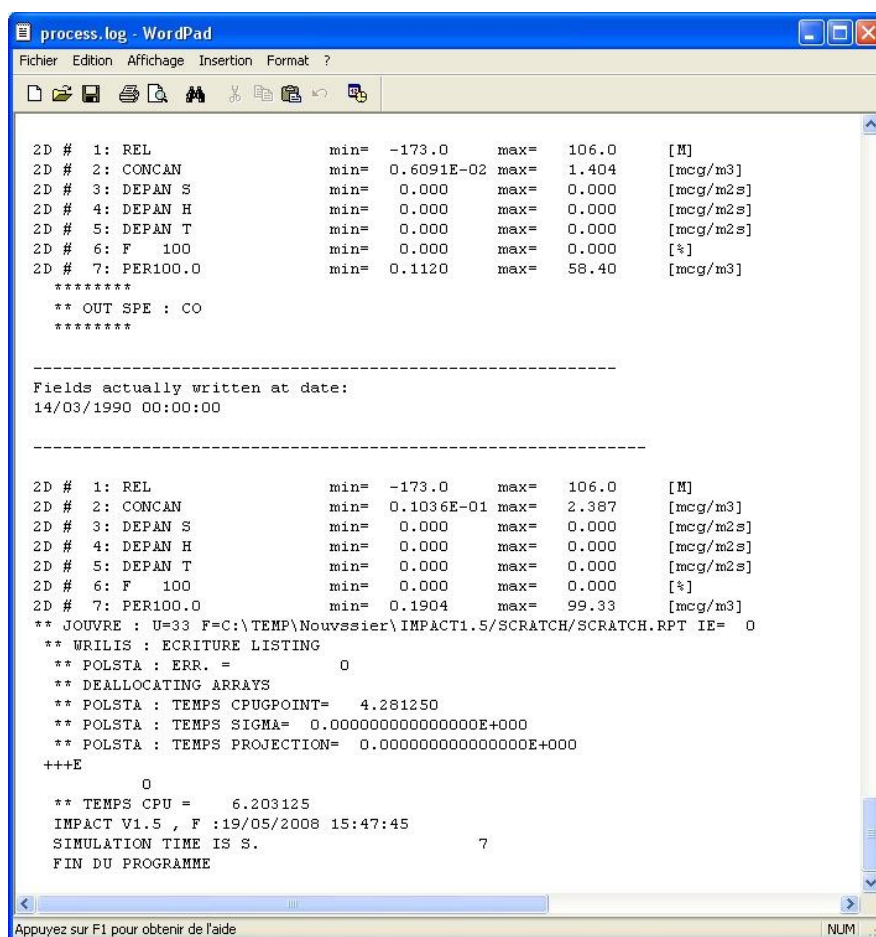
The control file is a file containing the set of messages that the software is producing during the calculation process. It allows verifying that the calculation has been carried out correctly.

By clicking on the menu log file, the user can choose to:
* Show the log file
* Export the log file

4.5.3.1 Show

Opens an editor window (Figure 55) that displays the content of the log file:

Figure 55: Example of log file (editor: WordPad)

4.5.3.2 Export

Opens the window in Figure 56. The user selects the file name he wants to export. The file will be created with the extension ".log".
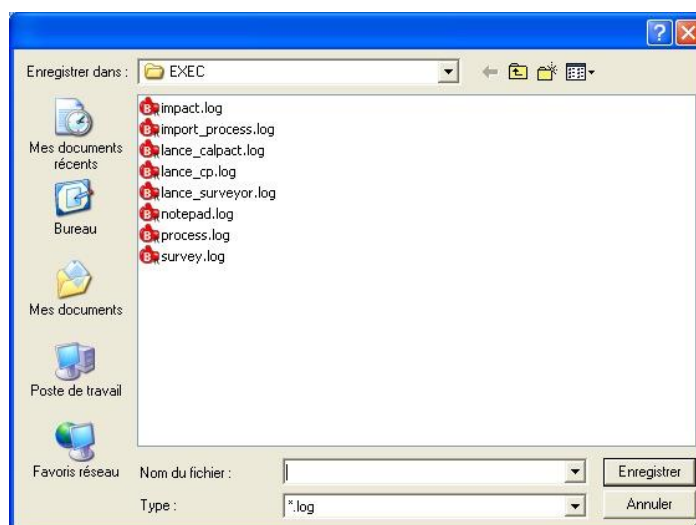
Figure 56: Log file export window

4.5.4 Output - Listing

The listing file is a file containing a summary of the whole set of parameters and data used in the calculation as well as the results obtained.

The Listing menu offers two options:
- Show list of results
- Export output file

4.5.4.1 Show

Opens an editor window (Figure 57) that displays the following information:
- calculation date
- grid characteristics
- calculation options
- output options
- substance characteristics
- emission characteristics
- maximum values

Figure 57: Example of listing file (editor: Notepad).

Example of a listing file:

```
----------------------------
----------------------------
                SIMULATION LISTING
                   D===>26. 6. 0
PROJECT NAME: perpignan


               --------------------------------
          CALCULATION  BASED ON SPECIFC CASE DATA
               --------------------------------


START OF SIMULATION: 1/ 1/1995  0: 0: 0
END OF SIMULATION: 31/12/1999 21: 0: 0
DATABASE START DATE: 31/12/94
DATABASE END DATE: 31/12/99

 STATION NAME:
  perpignan
 POSITION OF MEASUREMENT STATION (KM):
  X:    638.0000     Y:   1749.000


GRID CHARACTERISTICS:
---------------------------------------
     Xor. =  627 500 km           Yor. = 1740 500 km
     DX =  300 000 m          DY  =  300 000 m
     NX =  51                 NY  =  51


COMPUTATION OPTIONS:
--------------------
   - SIMPLE TERRAIN
   - CALM WINDS ARE INVALID
```

```
   - WIND DIRECTION PRECISION, AMPLITUDE (DEG.):  10.00
   - AVERAGING PERIOD FOR UNIT CONCENTRATION (S): 10800
   - PERCENTAGE OF VALID DATA REQUIRED FOR COMPUTING AVERAGES: 80.00
   - NO RECONSTITUTION OF WIND PROFILES
   - NO RECONSTITUTION OF TEMPERATURE
   - BOUNDARY LAYER CONSIDERED
   - PLUME RISE MODEL FOR POINT SOURCES: HOLLAND
   - STABILITY CLASS COMPUTATION BASED ON WIND AND CLOUD COVER


OUTPUT OPTIONS:
-------------------
   - COMPUTATION OF CONCENTRATION IN ANNUAL AVERAGES


SPECIES CHARACTERISTICS :
----------------------------
SPECIES FLAG: 4
  NAME: NOX
  DRY DEPOSITION RATE(M/S): 0.0000
  WASHOUT COEFFICIENT (1/S): 0.0000
  TIME TO HALF LIFE (S): 0.0000
  GRAVITATIONAL FALL SPEED (M/S): 0.0000
  AVERAGE CONCENTRATION PERIOD (S): 3600


EMISSION CHARACTERISTICS:
-----------------------------
SOURCE NUMBER: 1
 - NAME : NIL
 - MODULATED SOURCE, NOMINAL RATE (MCG/M3):
 NOX       ==>   0.546E+04 MCG/M3
 - POSITION OF SOURCE (X, Y IN KM):   635.60   1748.97
 - STACK HEIGHT (M): 38.0000
 - STACK DIAMETER (M): 1.5000
 - EXIT SPEED (M/S): 15.0000
 - GAS EXIT TEMPERATURE (DEG.C.):  140.0000


-----------------------
 CONCENTRATION IN MCG/M3
 -----------------------

  - MAXIMUM NOX VALUES
  ***************************
DATE                 I    J      X KM        Y KM         NOX
18/ 4/1997 15: 0: 0  26   37    635.00      1751.30     0.179E+03
30/ 3/1998  9: 0: 0  13   23    631.10      1747.10     0.150E+03
19/ 8/1996 21: 0: 0  16   36    632.00      1751.00     0.147E+03
25/10/1995 15: 0: 0  14   25    631.40      1747.70     0.128E+03
 5/ 7/1999  6: 0: 0  14   25    631.40      1747.70     0.119E+03
25/ 6/1997 21: 0: 0  25   37    634.70      1751.30     0.959E+02
 8/ 9/1999 12: 0: 0  16   36    632.00      1751.00     0.890E+02
26/ 4/1999 18: 0: 0  13   24    631.10      1747.40     0.776E+02
23/ 8/1999 12: 0: 0  14   25    631.40      1747.70     0.767E+02
20/ 6/1995 12: 0: 0  14   25    631.40      1747.70     0.719E+02


  ----------------
 DEPOSITION IN MCG/M2
 ----------------


  - MAXIMUM NOX VALUES
  ***************************
DATE                 I    J      X KM        Y KM         NOX
31/12/1994 24: 0: 0   1    1    627.50      1740.50     0.000E+00
```

```
1/ 1/1995  3: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995  6: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995  9: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995 12: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995 15: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995 18: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995 21: 0: 0    1    1       627.50      1740.50      0.000E+00
1/ 1/1995 24: 0: 0    1    1       627.50      1740.50      0.000E+00
2/ 1/1995  3: 0: 0    1    1       627.50      1740.50      0.000E+00
```

4.5.4.2 Export

The user chooses a name for the output file as in section 4.5.3.2. The file will be created with the extension ".lis".

4.5.5 Output - Plume axis results

This menu is only activated in the case of a specific case calculation and carried out for one or several point sources. It yields the results of concentration under the plume axis at ground level.

The Plume axis results menu offers two options:
- Show list of results
- Export plume axis results file

4.5.5.1 Show

Opens an editor window (Figure 58) that displays the following information

Figure 58: Plume axis results panel

Example of .axe concentration file (ASCII)

```
Source:;-999             ;
Species:POU
Position/origin of domain (X,Y):; 9900.02; 9649.90;m
Height with plume rise:  60.17;m
Stabilisation distance:;   565.69;m
Maximum concentration:;   0.278E+00;mcg /m3
Maximum deposition rate  :;.2230E-02;mcg /m2s
Downwind distance         :;  1319.9;m
Rate                     :;   0.722E+05;mcg /s
Number of gridpoints along axis   :;  55
Distance from source (m);Concentration;Deposition;
  0.0000000E+00;  0.0000000E+00;  0.0000000E+00
   188.5618   ;  1.7019030E-08;  1.3630430E-10
   377.1236   ;  1.1184542E-03;  8.9576270E-06
   565.6854   ;  4.1468967E-02;  3.3212223E-04
   754.2473   ;  0.1411593   ;  1.1305355E-03
   942.8091   ;  0.2264733   ;  1.8138096E-03
   1131.371   ;  0.2691569   ;  2.1556604E-03
   1319.933   ;  0.2784379   ;  2.2299911E-03
   1508.495   ;  0.2685221   ;  2.1505763E-03
   1697.056   ;  0.2494591   ;  1.9979014E-03
   1885.618   ;  0.2258142   ;  1.8085313E-03
   2074.180   ;  0.2031778   ;  1.6272377E-03
   2262.742   ;  0.1828244   ;  1.4642285E-03
   2451.303   ;  0.1646819   ;  1.3189266E-03
   2639.865   ;  0.1485756   ;  1.1899325E-03
   2828.427   ;  0.1342969   ;  1.0755751E-03
   3016.989   ;  0.1216358   ;  9.7417342E-04
   3205.551   ;  0.1103962   ;  8.8415592E-04
   3394.113   ;  0.1004013   ;  8.0410752E-04
   3582.675   ;  9.1495089E-02;  7.3277822E-04
   3771.236   ;  8.3541356E-02;  6.6907721E-04
   3959.798   ;  7.6421857E-02;  6.1205769E-04
   4148.360   ;  7.0034362E-02;  5.6090066E-04
   4336.922   ;  6.4290442E-02;  5.1489793E-04
   4525.483   ;  5.9113666E-02;  4.7343748E-04
   4714.045   ;  5.4437909E-02;  4.3598964E-04
   4902.607   ;  5.0205797E-02;  4.0209494E-04
   5091.169   ;  4.6367485E-02;  3.7135417E-04
   5279.731   ;  4.2879615E-02;  3.4342002E-04
   5468.292   ;  3.9704286E-02;  3.1798900E-04
   5656.854   ;  3.6808368E-02;  2.9479581E-04
   5845.416   ;  3.4162804E-02;  2.7360767E-04
   6033.978   ;  3.1742010E-02;  2.5421969E-04
   6222.540   ;  2.9523471E-02;  2.3645155E-04
   6411.102   ;  2.7487280E-02;  2.2014382E-04
   6599.664   ;  2.5615796E-02;  2.0515524E-04
   6788.225   ;  2.3893379E-02;  1.9136051E-04
   6976.787   ;  2.2306090E-02;  1.7864803E-04
   7165.349   ;  2.0841533E-02;  1.6691847E-04
   7353.911   ;  1.9488607E-02;  1.5608297E-04
   7542.473   ;  1.8237380E-02;  1.4606198E-04
etc.
```

4.5.5.2 Export

The user chooses a name for the output file as in section 4.5.3.2. The file will be created with the extension ".axe".

4.6 TOOLS MENU

The **Tools** menu (Figure 59) is used for changing mapping parameters. The **Tools** menu offers two options:
- Cartography display
- Dictionary editor,

and a sub-menu allowing to select the text editor used in ARIA Impact.
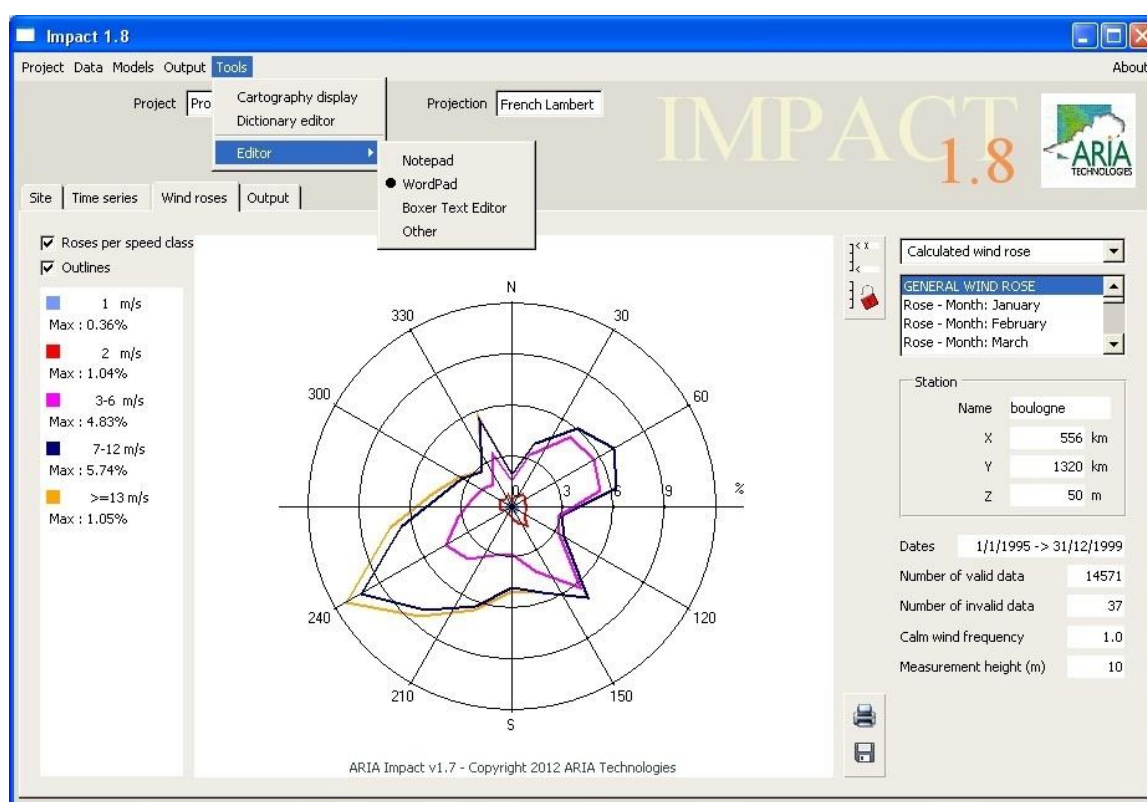
Figure 59: Main panel with Tools pull-down menu

4.6.1 Tools - Cartography display

Selecting **Cartography display** in the **Tools** menu opens the window in Figure 60, which can be used for changing map objects.
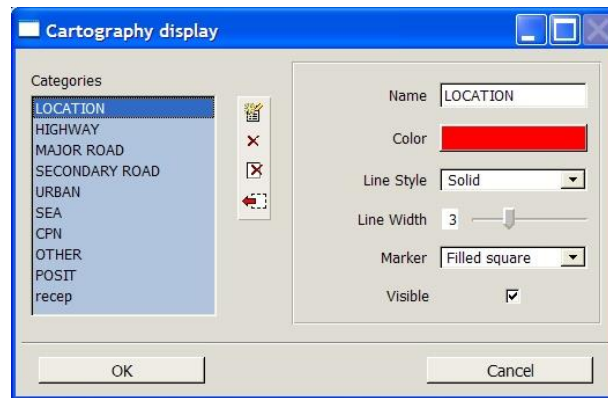
Figure 60: Cartography display panel

The display of map objects can be chosen from a pre-defined list, but the user can also add a new or modify an existing display category.

To create a new display type, click 📝 and give a new name.

To remove a display type, select it in the list and click ✖. To remove all types, click ⊠.

The sources can be represented by different symbols of various shape and colour to be assigned by the user. Check the Visible box to display the objects.

The colour of each source symbol can be defined by clicking the coloured rectangle. This pops up the Colour editor (see section 4.12.1).

To select the shape of the source symbol, scroll the pull-down list of shapes and select one from the following:
- square
- diamond
- circle
- cross
- plus
- filled square
- filled circle
- filled diamond
- triangle
- filled triangle

Note: Each category that has been modified or added should be validated by clicking the button ◂⌐.

Once Site and Map characteristics have been defined, click OK to save and quit. To close without saving, the window click Cancel.

4.6.2   Tools - Dictionary editor

When selecting Dictionary editor, the following window appears.
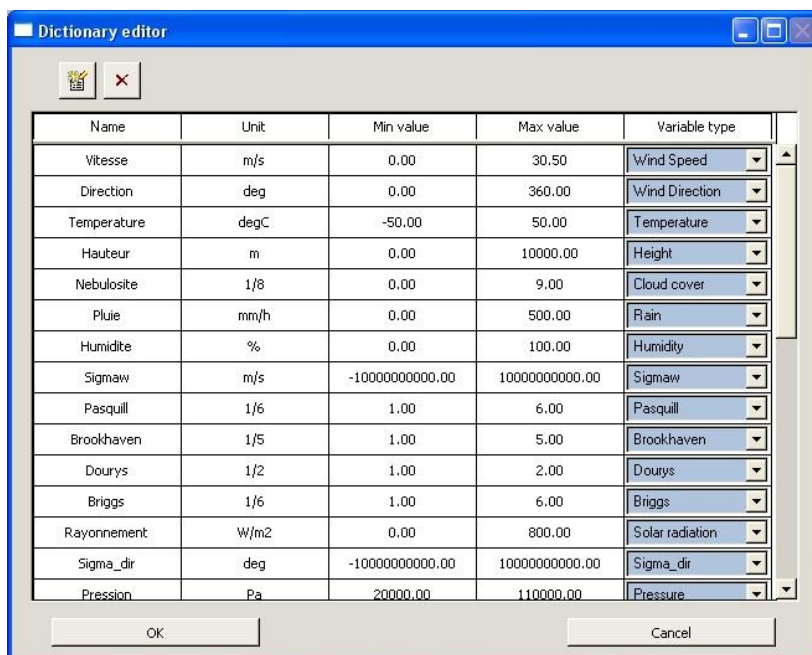
Figure 61: Dictionary editor panel

This window contains all the parameters that can be used in the project (meteorological and others) specifying the min. and max. value for each of them.
The default variables cannot be changed. The fields are inactive and the "Variable type" appears on a blue background.

However, it is also possible to add new variables not existing in the default list.
This can be done by clicking on the ⬚ button. A new line appears at the end of the list.
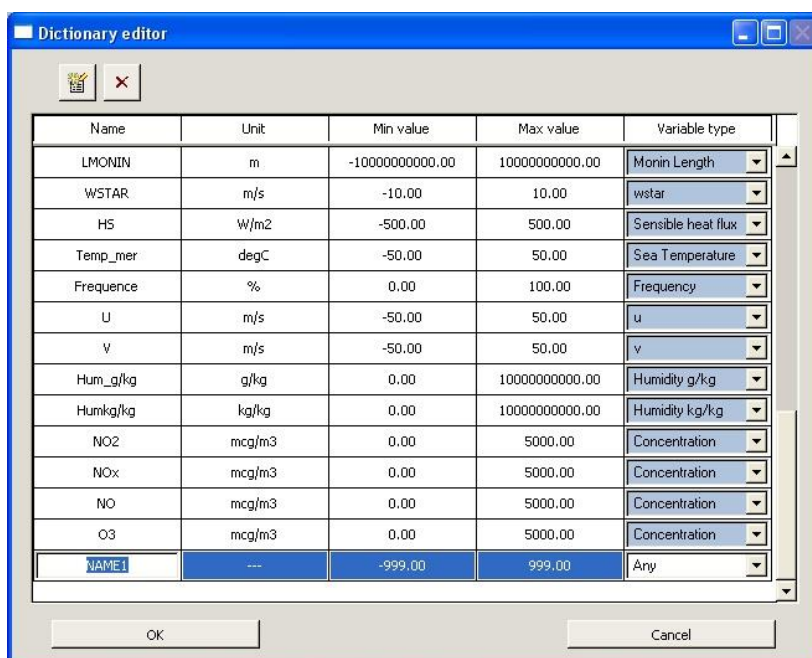
Figure 62: Dictionary editor panel - add variable

The user should thereafter fill in the different fields allowing characterizing the new variable.
- Name: variable name
- Unit: variable unit
- Min value and Max value: Minimum and maximum of the variable
- Variable type

In this way, a new variable can be integrated in the data base (e.g. the potential temperature).

Once the variable has been defined, just click OK. This new variable is thereafter included in the parameter list and can be selected at the import of meteorological data (section 4.3.3.2).

The user can also remove a variable by clicking on the ✖ button.

4.7 SITE TAB

Once the topography has been defined, it is displayed in the window of the Site tab (Figure 63).
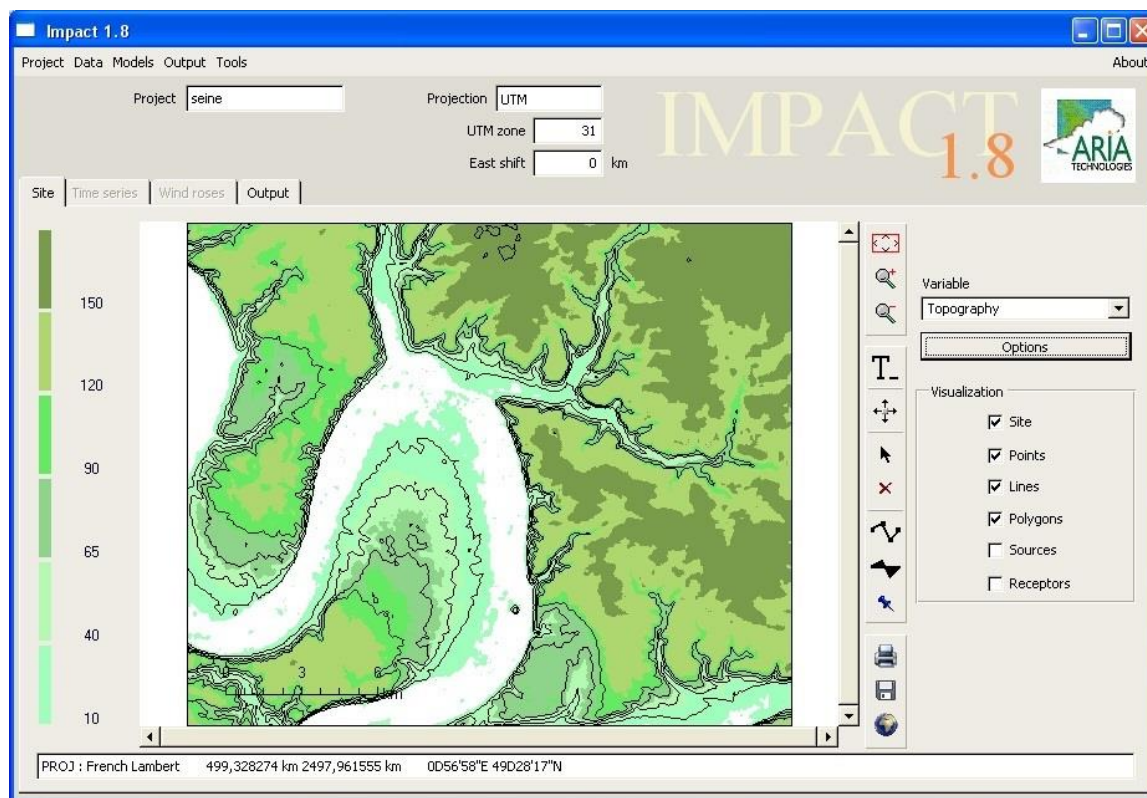
Figure 63: Site tab on the main ARIA Impact window

4.7.1 Description

The central part of the Site tab contains a graphic display. A color scale can be found on the left side of the window (when the 2D field is displayed with color shades).

The buttons on the right are used for the following functions:

⬚ : restore original domain size

🔍⁺ : zoom in on domain

🔍⁻ : zoom out of domain

T₋ : write text

✛ : move domain

↖ : select an object

✕ : delete an object

⋁ : creation of a line object (road…)

▼ : creation of an area object

📍 : creation of a point object (receptor, point source)

🖨 : print the current page

💾 : export to an image file (gif)

🌐 : export to a Google Earth file (kml).

At the bottom of the window, a status bar gives the geographical projection, the position of the cursor and the value under the cursor of the 2D field displayed.

4.7.2   Visualization

The part to the right of the window called Visualization box allows selecting objects to display on the screen.
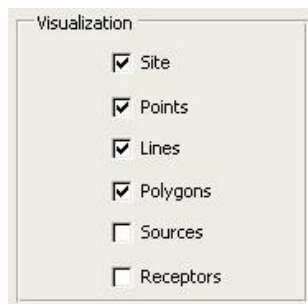
Figure 64: Visualization box

4.7.3   Display of topography

The site tab displays the topography of the site.
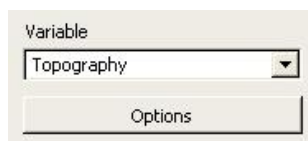
Click the button « Options » for opening the window below.
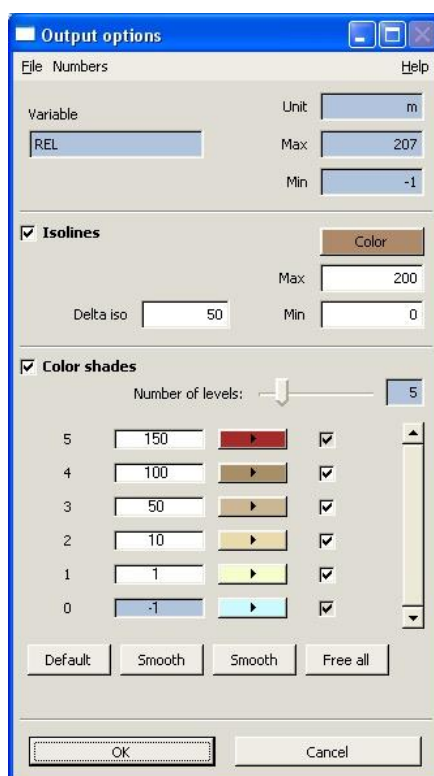
Figure 65: Output options panel

Three distinct parts can be observed:
- Information about the topography
- Definition of isolines
- Definition of coloured zones

The upper part gives information about the topography: min and max terrain values on the domain, and unit. These values are read from the topography file and cannot be modified.

Isolines

Check the box "Isolines" to represent the terrain with iso-lines of topography. It is possible to modify; the Min (minimum isoline) and Max (maximum isoline) values and the interval between isolines (Delta iso field). The colour can also be selected with the Color button.

Colour shades

Check the "Colour shades" box to represent the topography with colours.

In this part, the user can edit the colours:
- choose the number of colours using the slider;
- choose the threshold values (validate with <Enter> after changing each value). The thresholds represent the lower value for each color zone.
- select the colours (click on the button to the right of the threshold values to modify colour). The "Color chooser" window appears (see section 4.12.1);

- select the "fixed" levels (check the corresponding box to the right of the colour buttons). This option allows the user to define a limited number of fixed levels of topography and colours; intermediate levels will thereafter be interpolated by the software by clicking on the Smooth buttons.

The "Default" button restores a default range of colours.

The "Smooth" buttons interpolates values for topography and colours. Intermediate values are calculated between the fixed levels (max/min topography levels and levels for which the checkbox has been activated).

The "Free all" button releases the check boxes of all intermediate levels.

The "File-Open" from the menu bar allows to read a file containing a range of colours.

The "File-Save" option allows to save the colour range in a specific file.

The "Numbers" option can change the display of numbers: Switching on/off scientific format and allowing decimal precision.

A click on a colour button pops up the Color selector window described section 4.12.1.

If the user has chosen to display colour shades, a colour scale appears in the "Site" tab to the left of the graphics. By clicking directly on this scale, the "Output options" window opens.

Once all the Output options data have been entered (maximum/minimum, isoline, colour), click OK to validate the selections. Click Cancel to close the Options window without modifications.

4.7.4 Output

Two types of output are proposed:
- Export
- Print

The "Export" button exports the image in GIF format. An example is shown on Figure 66.
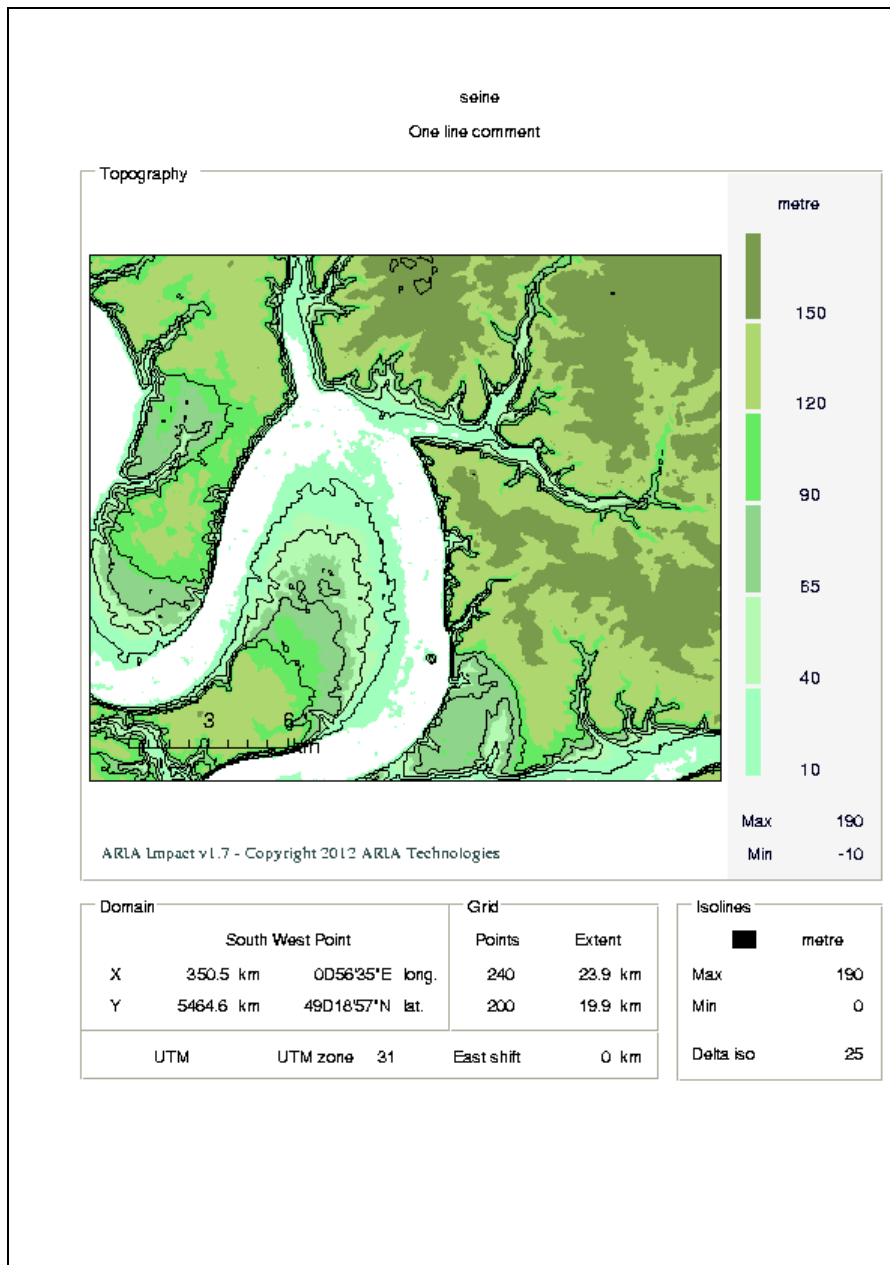
Figure 66: Export of the site tab

The "Print" button 🖶 prints the data that appear on the screen. The user selects the printer from the list of printers connected.

4.7.5   Objects and source management

The Site tab allows the user to manage map objects and sources manually. Those actions are described in section 4.11.

4.8 TIME SERIES TAB

The Time series tab is used for viewing variations in meteorological parameters over time in graphical format.

Four lists are shown next to the plot window; the lists are initially blank:

- **Type** - list of station types in the database; the default term is ARIAMET
- **Station** - list of name of stations; in order to activate the list of station names, first click on a station type
- **Variable** - list of names of meteorological parameters in the database; the list is updated when clicking on a Station name
- **Sensor level** - vertical level (height) of the sensor (if there are several); select the level to plot in the list

The **Plot** button ▨ is used for plotting the time series in the display window for the period defined by the Begin and End dates.
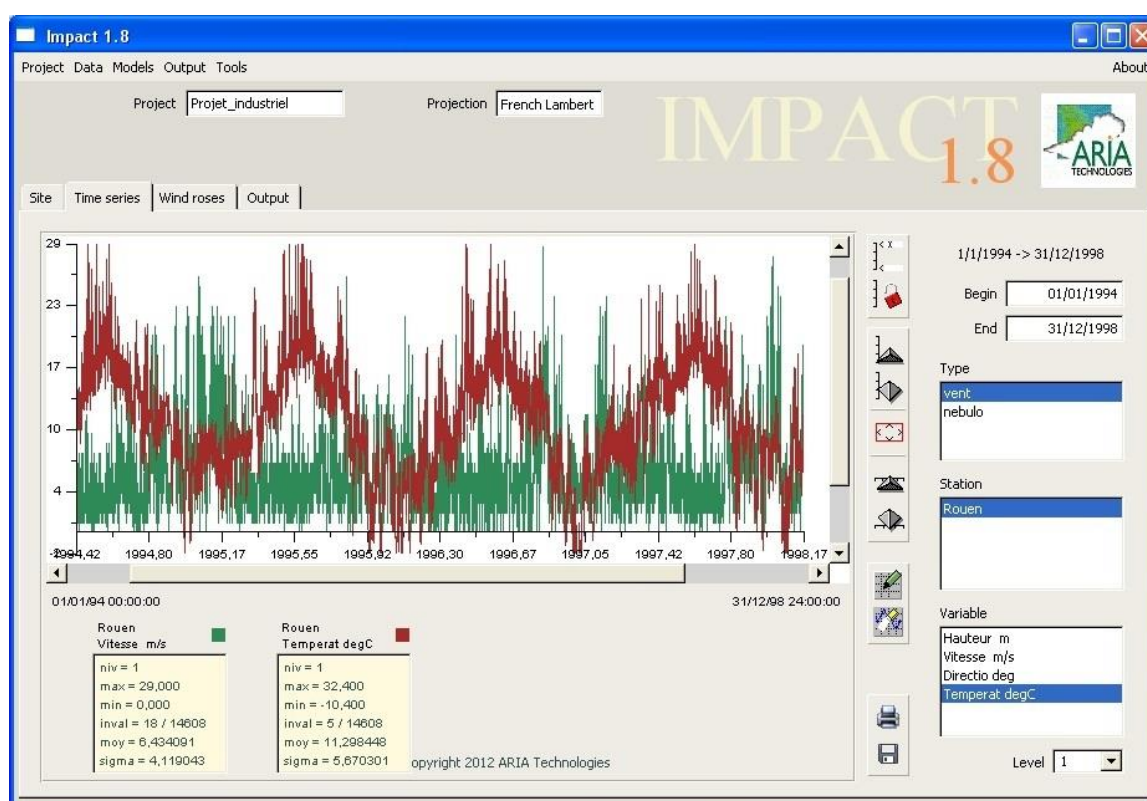
Figure 67: Time series tab

It is possible to plot up to four stations/variables at the same time. Use the **Clear** button ▨ to clear the entire graph.

The graph box is made up of the following parts:

- A graphical section where the graphs are plotted.

- Five buttons for: zooming in ⬛ and zooming out ⬛ along the y axis; zooming in ⬛ and zooming out ⬛ along the x axis; and adjusting the graph to the view ⬛.

- Two buttons Lock ⬛ and Scale editor ⬛ with the same functionality as for the wind roses (see section 4.12.2).

Below the graph, there is a space reserved for the legend of the plotted station (name of the station, a square showing the colour of the graph for the station):

For each station/variable a box is displayd indicating the following parameters:
- vertical level
- maximum of the variable during the selected period
- minimum of the variable during the selected period
- number of invalid data compared to total number of data
- arithmetic average of the variable
- standard deviation of the variable

Click on the coloured square to select the type, colour, and thickness of the line for plotting each graph. The user can also position the selected variable on top or behind the other variables.

The Print button ⬛ is used for printing the graphic on the printer selected by the user, the Export button ⬛ for saving the graph in GIF format,

4.9 WIND ROSES TAB

The Wind roses tab (Figure 68) allows the user to plot all or a part of the met statistics in the meteorological database.

The user can choose between different type of wind roses:
- <u>annual</u> wind rose showing the distribution of winds over the entire period of available data, based on:
  - all observations
  - rainfall (with or without), if data on precipitation is available
- <u>monthly</u> wind roses (one for each month) to show the seasonal variations, based on:
  - all observations
  - rainfall (with or without), if data on precipitation is available
- <u>hourly</u> wind roses (one for each hour) to show typical daily variations, based on:
  - all observations
  - rainfall (with or without), if data on precipitation is available
- wind roses for each <u>stability class</u> to show the relation between atmospheric stability, based on:
  - all observations
  - rainfall (with or without), if data on precipitation is available
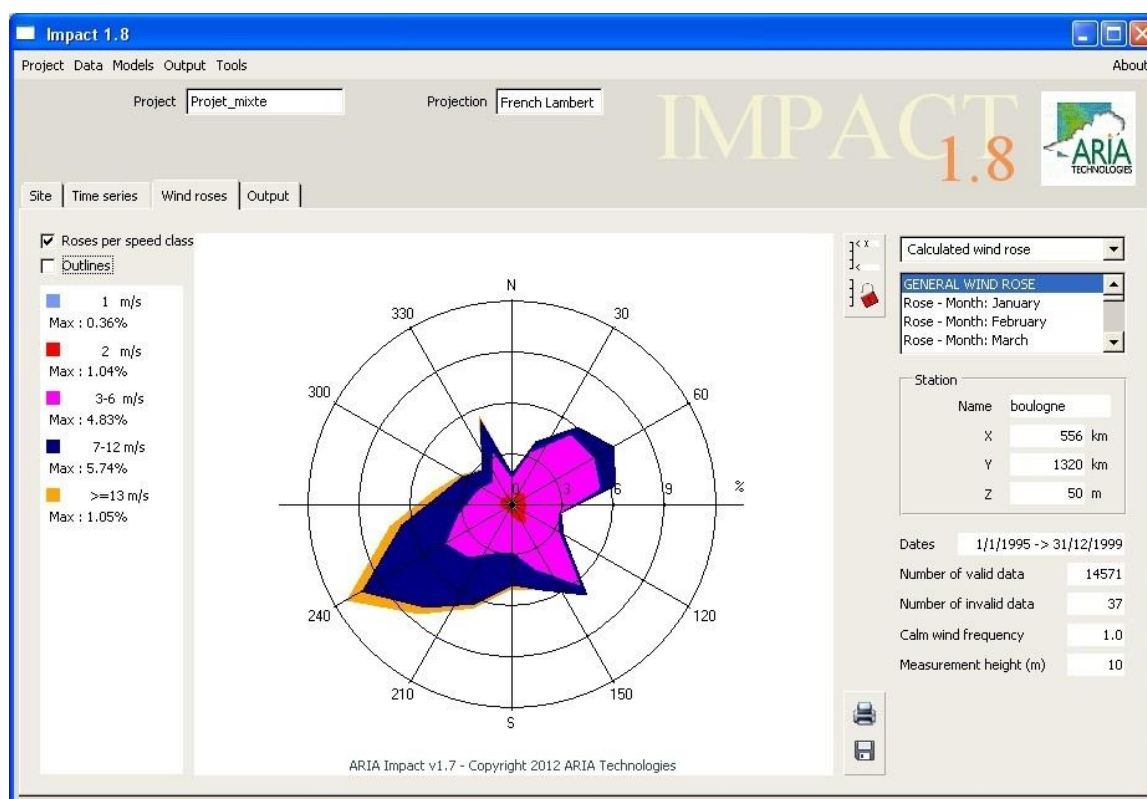
Figure 68: Wind roses tab

When taking precipitation into account in the calculations, the wind roses are divided into three sub groups:

- wind rose (based on <u>all</u> observations)
- wind rose rain 0 (based on observations without rainfall)
- wind rose rain 1 (based on observations with rainfall)

The window is divided into several parts:

- A legend area (right) showing:
    - name and position of the station
    - sampling period
    - number of valid and invalid data for the period
    - frequency of calm winds,
    - measurement height (a.g.l)

- A list of wind rose types displayed in the upper right of the window, (select from the drop down list)
- A menu to indicate if the wind rose is computed from a time series of measurement data or based on an academic case
- A graphical section in which the wind roses are plotted. An option for displaying wind roses divided into different wind speed classes, can be activated by checking the corresponding box. Each colored line in the wind rose represents the occurrence of winds with regards to the direction from where it blows. The direction (in degrees related to the North) is indicated along the outer circle. The inner circles represent the frequency of occurrence expressed in % (values indicated along the horizontal axis).
- Two checkbox options (upper left): wind rose by speed and details of legends
- A section for the legend showing colored squares corresponding to different wind speeds and, if Details is checked, the maximum computed frequency. Click and hold on the colored square to select the type, color, and thickness of the line in the graph.
- The ![lock] button locks the scale; if the option is selected (closed lock), the scale is retained for all wind roses. The option can also be activated through the Scale editor by clicking the "Edit scale" button ![icon] (see section 4.12.2).

The Print button is used for printing the wind rose on the printer selected by the user and the Export button for saving the wind rose in GIF format.
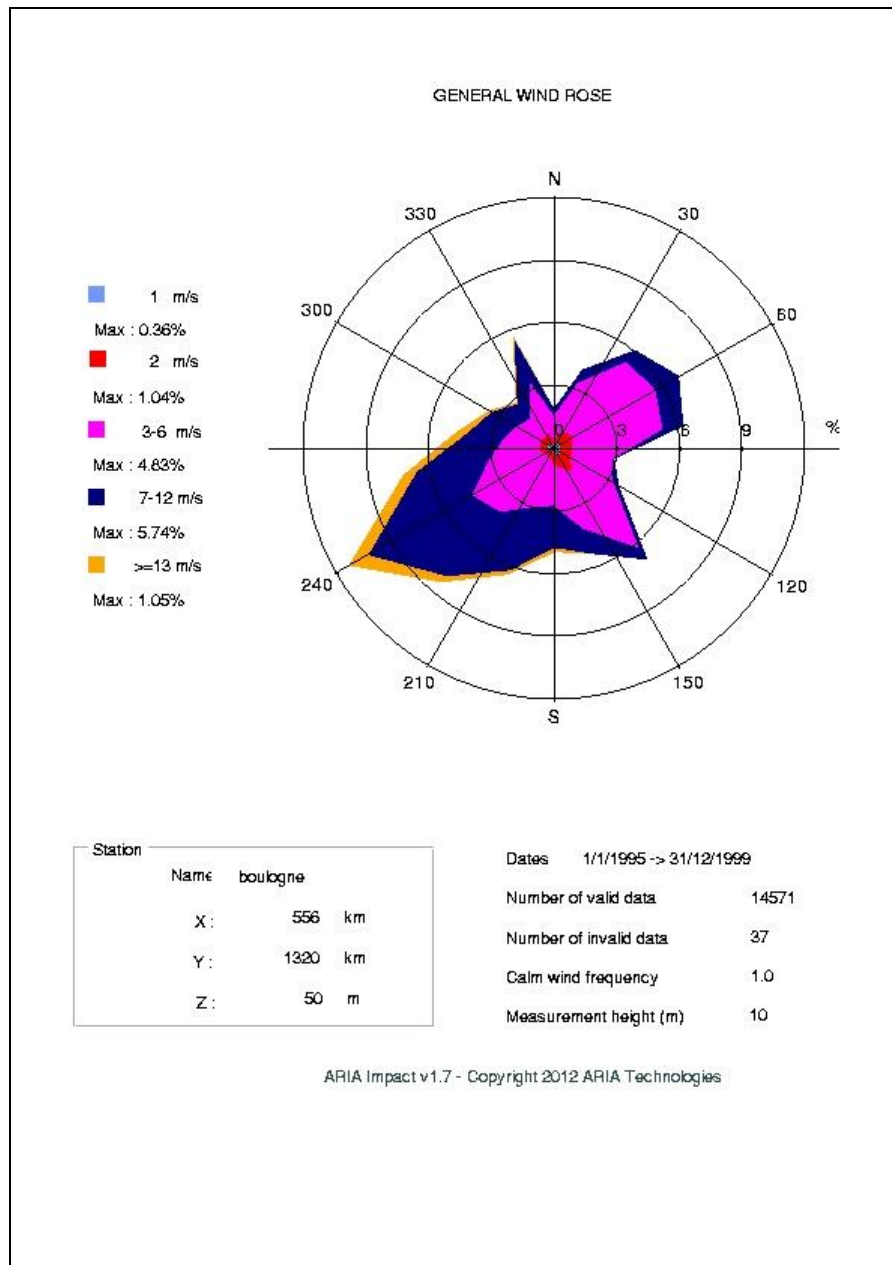
Figure 69: Export of the Wind roses tab

4.10 OUTPUT TAB

The Output tab (Figure 70) is used for viewing concentration maps.
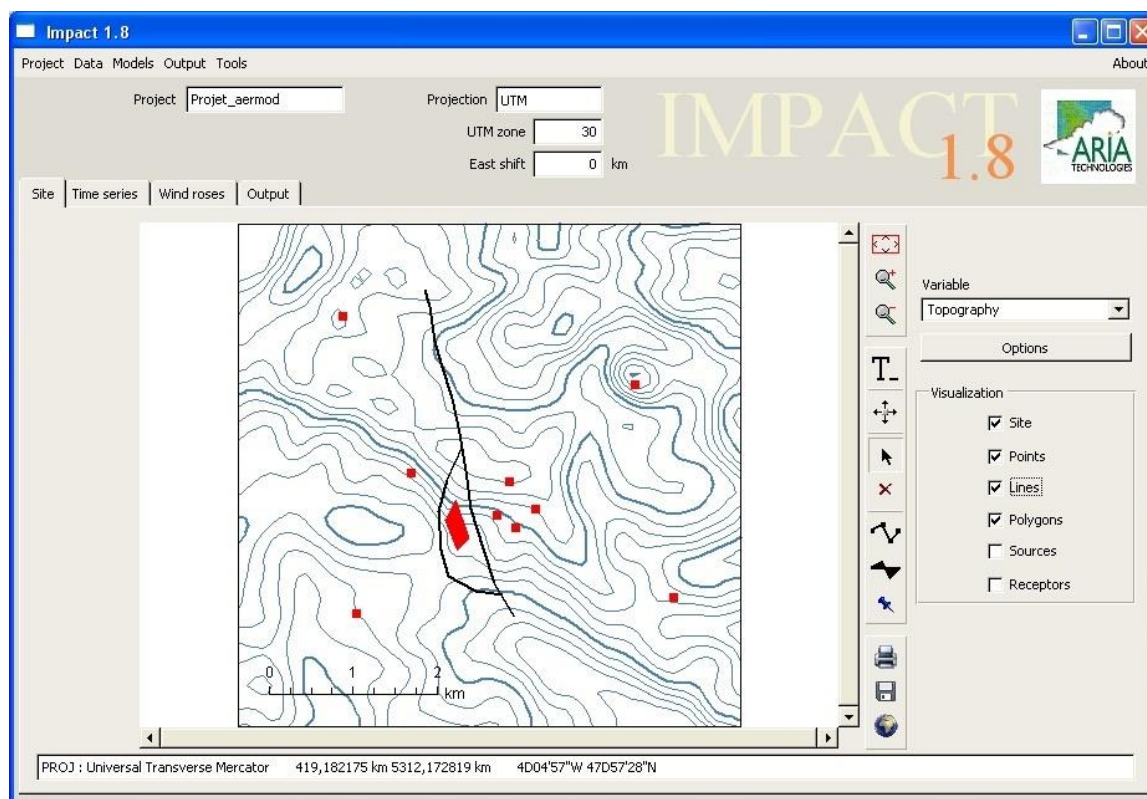
Figure 70: Output tab.

The different pollutants for which the calculated concentration can be viewed are displayed in the upper right part of the window:

- For an academic calculation, the output is indicated by A_xxx
- For a wind rose calculation, the output is indicated by R_xxx
- For a statistical calculation, the output is indicated by xxx

xxx stands for the name of the pollutant.

The user selects the substance from the pull-down list to the right. The type of results (second pull-down list) to be viewed must also be selected:

- concentration (annual average, percentile, etc.)
- frequency of value exceeded, if this option has been included in the simulation
- ground deposition: dry, wet and total deposition (« DEPOT S », « DEPOT H ») and « DEPOT T » respectively)

The Options button displays the Output options window (Figure 71). Minimum and Maximum concentration values are already shown and cannot be modified.
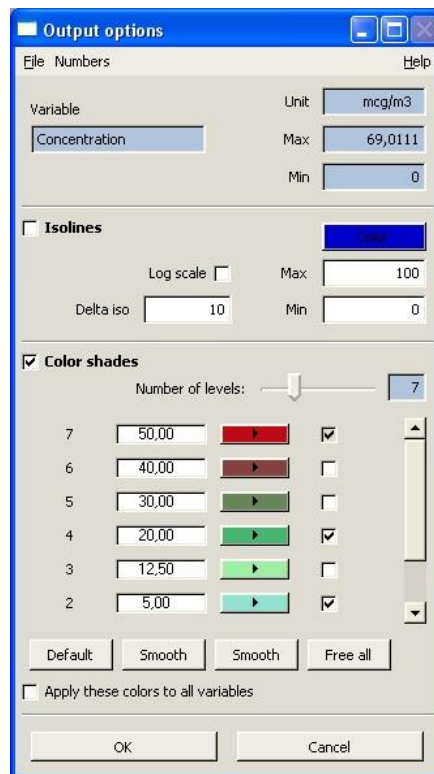
Figure 71: Output options window

Check the Isolines box to modify its Minimum and Maximum values and the Interval between isolines.

To start with, the user can choose the number of colored levels that should be displayed; this is done by moving the cursor

Check the Colour shades box to show the variable with colours.

Click on a coloured button, to change its colour with the colour selector described section 4.12.1.

It is also possible to define a scale with nuances of a colour shaded off into each other. Select the check box corresponding to the highest and lowest level, the check boxes for the other levels should not be checked. Choose the colours for the highest and lowest levels, for example light blue and dark blue respectively. By clicking on « Smooth » the colours as well as the value of the levels between the max/min levels are modified.

The button «Free all» unchecks the levels between max and min levels. With the button « Default » the colours can be reset to initial values.

The colour settings can be saved by clicking on File - Save. In the same manner, the user can load files containing predefined colour settings with File – Open.

Once the Colour options have been defined, click Validate. The modifications appear in the main window of ARIA Impact with the colour scale shown to the left (Figure 72).

The Options window can be closed by clicking Cancel.
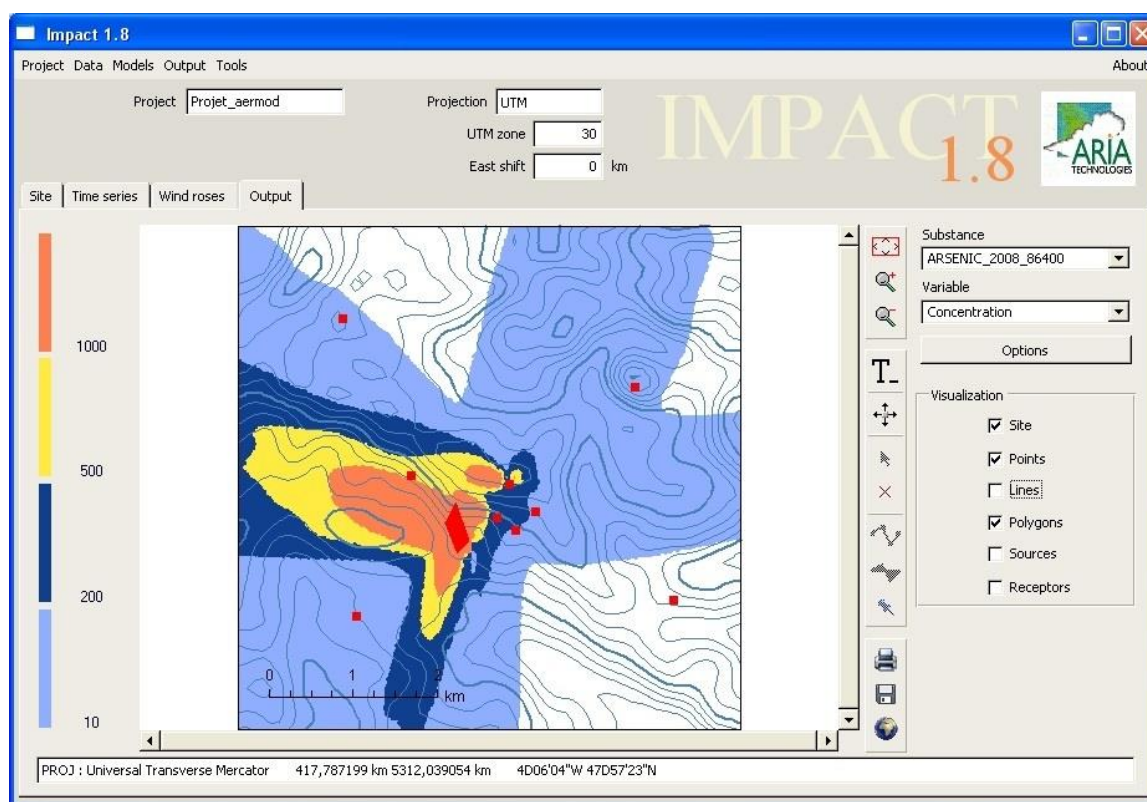
Figure 72: Display of a concentration map

At the bottom of the screen the X and Y coordinates as well as the concentration at the point of the cursor are indicated.

The Print button is used for printing the concentration map on the printer selected by the user and Export for saving the map in GIF format.

4.11 EMISSION MANAGEMENT

The management of emission sources is found in the "Site" tab. The user can choose between the tools:

      ↖ : Select an object;
      ✕ : Delete an object;

      〽 : Create a linear (road ...);

      ◤ : Create a surface;

      ⚲ : Create a point (receptor, source).

To create an emission source, you must first create a map object and then identify it as an emission source. It is also possible to modify the characteristics of sources already defined or imported from an emission file in .csv format.

4.11.1 Creation of a map object

4.11.1.1 Point object

To define a point object on the domain, the user must first change to "Creation" mode by clicking the button . An object can be created by clicking somewhere in the map area, a square thereby appears on the screen. The user can create several points by clicking several times. When the definition of objects is finished, the "Creation" mode should be deactivated by clicking one more time on the button . The other buttons thereby become available.

The objects can further be modified using the object map editor described in paragraph 4.11.2.

4.11.1.2 Linear object

To define a polyline object on the domain, the user must first change to "Creation" mode by clicking the button . The user can draw a polyline in the map area by defining the different points setting up the line segments of the polyline . When the definition of objects is finished, the "Creation" mode should be deactivated by clicking one more time on the button . The other buttons thereby become available.

The objects can further be modified using the object map editor described in paragraph 4.11.2.

4.11.1.3 Surface object (polygon)

To define a polygon object into the domain, the user must first change to "Creation" mode by clicking the button . The user can draw a polygon in the map area by defining the different points setting up the border of the polygon. When the definition of objects is finished, the "Creation" mode should be deactivated by clicking one more time on the button . The other buttons thereby become available.

The objects can further be modified using the object map editor described in paragraph 4.11.2.

4.11.2 Object editor

This editor allows you to modify the characteristics of map objects, imported from a .csv file or created manually with the user interface. To access the object editor, first change to the "Selection" mode by activating the button, click on an object to select it and then open the editor by clicking on the right button of the mouse.
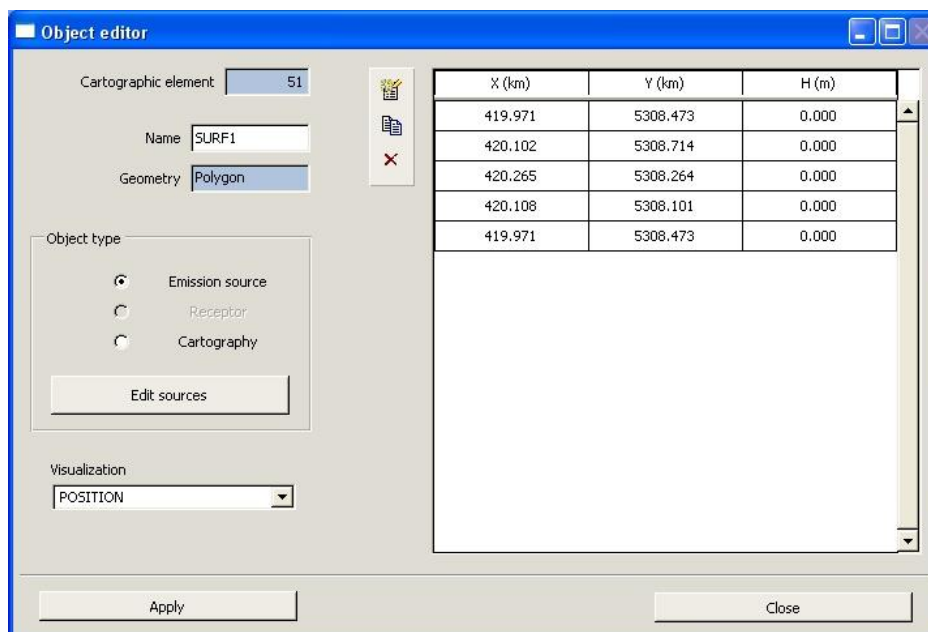
Figure 73: Object editor panel

The field "Name" is the name of the map object to which one or more emission sources can be linked. This name corresponds to the column NAMGP2 in the emission source file (see 7.6).

The object can be renamed and its position can be changed. The shape of polylines and polygons can be modified by adding or removing lines. To change the position of a point, enter the values of the coordinates in the fields X and Y, then press the "Enter" key to validate. The coordinates are expressed in km.

It is possible to specify whether an object is a "Receptor" or an "Emission Source".

Note: Use 'Emission Source' to declare the object as a source. The emission source can further be edited by using the **button "Edit sources".**

A receptor corresponds to a particular point (such as a measurement station, a school e.t.c...) for which it would be interesting to know the concentration.

The display options for an object can be selected from the drop down list in the "Visualization" menu. For a source imported from a file, the type of display is given in the column NAMGP1 of the emission file. The list reflects the display types that have been defined earlier in the window "Cartography display" (see section 4.6.1):
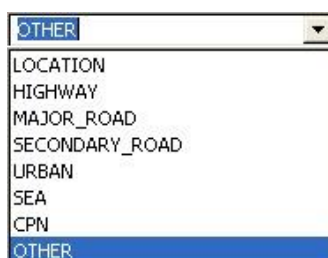
Click **Apply** to validate the modifications. Click **Close** to go back to the main window without modifications.

4.11.3 Source editor

Sources can be imported from an emission file (see Section 4.3.5.1) or defined manually with the user interface.

To create a new source with the user interface, a point, line or area map object should first have been created, as described in paragraph 4.11.1. The object should thereafter be declared as an emission source (see section 4.11.2).

> **Warning!**
> Several sources may be associated with the same map object.

4.11.3.1 Point source

When the **Source editor** is open (Click on the **"Edit sources"** button of the object editor), the window in Figure 66 appears on the screen. In this window the characteristics of the emission sources can be defined.

Figure 74: Sources editor – Point source

The field in the upper right of the window gives the list of emission sources associated to a particular map object. The user should first select a source to edit from this list.

The name of the source is given in "Source Name" and corresponds to the column NAMGP3 in the emission source file (see 7.6). This name can be changed.

The following point source characteristics should be filled in the Emission source characteristics fields:
- stack height (m)
- internal stack diameter (m)
- gas exit temperature (° C)
- gas exit velocity (m/s)

In the Unit column, select the unit of the emission rate from the pull-down list:

- For pollutants of category « Mass »:
  - tons/year
  - tons/day
  - kg/hour
  - micrograms/second
  - nanograms/second
- For pollutants of category « Activity »:
  - Becquerel/second
  - Curie[(3)]/second
- For pollutants of category « Odour »:
  - Odour unit/hour

The value of the emission rate for each substance is entered in the Emission column (refer to the Substances panel where the substance was defined earlier).

It is also possible to apply time modulations on the emissions. They are defined in the Modulation profiles menus. For more information on these tabs, see paragraph 4.3.6.3.

Click Apply once all the data are entered. To exit, click on the button "Close".

4.11.3.2 Line source

The Editor is the same as for point sources (see paragraph 4.11.3.1).

The emissions from line sources occur at ground level. The " Emission source characteristics" fields are not accessible.

4.11.3.3 Area source

The Editor is the same as for point sources (see paragraph 4.11.3.1).

In the «Emission source characteristics" fields, only Height is accessible. By default, the other parameters are set to zero. The height of the area source should correspond to a value equal to or higher than 0 m. When the height is higher than 0 m is commonly referred to as a volume source.

---

[3] 1 Curie = $3,7.10^{10}$ Becquerel

In the "Emission type" menu, the two options "Emission Modulation" and "Passive source" exist for defining the source emission rate:

a) Emission Modulation: Source with emission rate identified

As for point sources (see paragraph 4.11.3.1), the user can choose the unit of the flow of pollutants, then enters the flow for each pollutant in the list.

A volume source can be defined by indicating the source height.

Time modulations emissions can also be introduced (see paragraph 4.11.4).

b) Passive source: Calculation of dust emissions rates

This option allows the user to calculate dust emissions by estimating the erosion potential (quantity of dust likely to be eroded by the wind) of a surface based on wind speed. Dust emission calculations apply only to particulate matter and area sources (e.g., coal pile from which fine dust is blown away by strong winds). The user should therefore make sure to have defined a particulate substance in order to use this option. See section 0 for a technical explanation of dust emission calculation.

To compute dust emissions, select Passive source instead of Emission modulation in the Emission type menu (Figure 75).
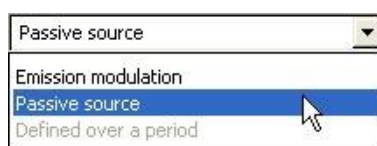
Figure 75: Emission type menu for Passive source

The type of dust must then be characterized from the pull-down list in the second menu (Figure 76):
- fine coal dust on concrete pad
- scraper tracks on coal pile
- uncrusted coal pile
- ground coal (surrounding coal pile)
- scoria (roadbed material)
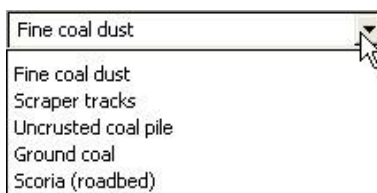
Figure 76: Pull-down list of different dust types.

Click Apply once all the data are entered. Click Close to exit the window.

4.11.4 Modulation of emissions

It is possible to apply time modulations to the emissions of each source (point, line and area sources)

To access the source editor, you must first swap to "Selection" mode by turning the ⬉ button in the "Site" tab, select an item with the left mouse button and then open the "Object editor" by clicking the right button. If this object is an emitter, the "Edit sources" provides access to the Source editor.

The Modulation profile frame of the source editor is composed of three menus containing the profiles defined in the modulation editor (see Section 4.3.6.3 Modulations):

- Day - allows you to choose the hourly modulations of emissions;
- Week - allows you to choose the daily modulations of emissions;
- Year - allows you choose the monthly modulations of emissions.
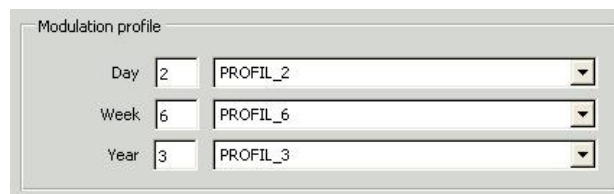
Figure 77: Selection of modulation profiles

Thus, a profile once created in the editor of modulations, can be applied to one or more sources.

The model takes into account the modulations by making the product of day, week and year modulation factors and applying the result to the nominal flow of the source.

4.12 OTHER TOOLS

4.12.1 Colour selector

The first menu allows the user to define a colour using:

- RGB: red (R)
      green (G)
      blue (B)

- HSV: hue (H)
      saturation (S)
      value (V)
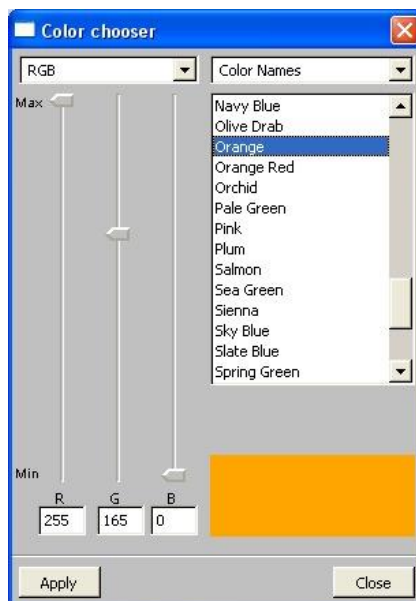
Figure 78: Window for selecting Colour

The user can enter specific values for RGB or HSV in the fields, or use the corresponding sliders.

The second menu offers two alternatives to select a colour:
- Color names: It is possible to choose the colour from a predefined list of names. The colour appears at the bottom right of the window.

- Color disk: This type is presented in Figure 71. It is possible to change the colour by moving the black square on the circle and the black triangle located below.
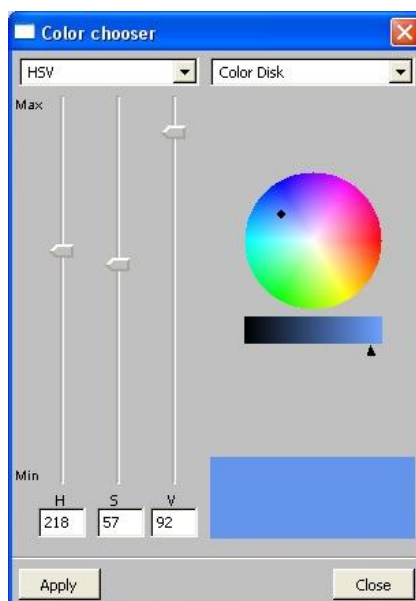
Figure 79: Colour chooser, showing the Colour chart option

Click Apply when the colour has been selected or Close the window to return to the previous window

4.12.2 Scale editor

The Scale editor allows the user to modify the parameters of a vertical scale(min and max values, number of steps and precision).

It can be accessed by clicking on the "Edit scale" button .
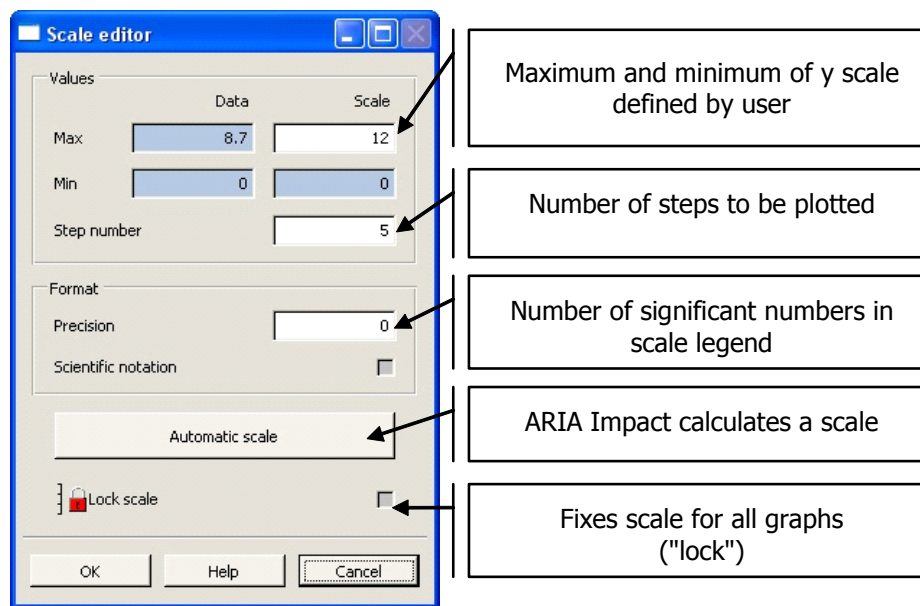
Figure 80: Scale editor

To lock the scale, click and the icon changes to .

Clicking OK applies the modification to the scale and closes the window.

5. MATHEMATICAL MODELS

AIM computes ground deposition for two types of pollutants:

- chemically non-reactive gases
- particulate matter subject to sedimentation and deposition

Individual calculations are carried out for each source (point, line, area), where after the pollutant contribution of all sources is added up for each substance separately. The program also accounts for the decrease of plume concentration and plume tilt over time due to sedimentation of particles, in dividing particles into 10 classes according to size. In addition, for situations with low wind speeds, a Gaussian puff model computes pollutant concentration at ground level.

The model calculations are based on certain hypotheses that the user should keep in mind when applying the program:

- turbulence is uniform in the lower layers of the atmosphere
- site measurements are representative for the entire calculation domain
- pollutant density is close to that of air
- the vertical wind component is negligible compared to the horizontal component
- steady-state regime, i.e. the plume is considered to instantly reach the steady-state configuration for each in a series of meteorological conditions to which the dispersion calculation is applied

These hypotheses can generally lead to somewhat overestimated concentrations of the pollutants, nevertheless, they allow the user to rapidly visualize pollution parameters for domains ranging from (1 km x 1 km) to (30 km x 30 km).

The relevant parameters and procedures for air pollution modeling with ARIA Impact are described in the following sections.

5.1 TOPOGRAPHY

Even though AIM is a 2D model it can account for topography in simple terrain. For terrain configuration, the plume axis is adjusted according to the procedure below:

- If the plume axis (h) rises above terrain height (h_t), $h_t < h$, then
  - ⇨ in a neutral or unstable atmosphere, adjusted plume axis height is ($h + h_t/2$)
  - ⇨ in a stable atmosphere, plume axis height does not change

- If the plume axis falls below terrain height, $h_t > h$, then
  - ⇨ in a neutral or unstable atmosphere, adjusted plume axis height is ($h_t + h/2$),
  - ⇨ in a stable atmosphere, adjusted plume axis height is fixed at a threshold value of 10 m.

This formulation tends to overestimate pollution concentration at stable atmospheric conditions.

5.2 DOMAIN

The domain should be sufficiently large so that

- obstacles (e.g., buildings, trees) can be merged into terrain roughness,
- calculated plumes are contained within the domain.

If there are several stacks in the domain, plumes are computed individually. Concentrations are calculated for each grid point of the domain, by adding up the contribution of each stack. As possible interference between the plumes is not accounted for, plume rise can be underestimated thus leading to higher pollutant concentration values at ground level.

5.3 STATIONARY METEOROLOGY

The rectilinear Gaussian formulation simulates steady-state conditions. It should be pointed out that a stationary regime yields higher concentration values compared with a non-stationary regime.

Variations in meteorological data should be sufficiently slow in time compared to the dispersion of the plume. A simple method for estimating the time period during which meteorological data to be considered constant is:

$$T \approx L/U$$

where L is the size of the domain and U is wind speed.

5.4 ATMOSPHERIC TURBULENCE

It is assumed that the plume spreads across a uniform atmospheric layer, starting from the ground and reaching sufficiently high to allow vertical expansion of the plume.

Turbulence is represented by the calculation of standard deviations (parameterizing vertical and horizontal dimensions of the plume). This parameterization is a mathematical description of the vertical and horizontal dimensions of the plume. Likewise, temperature inversion starting from the ground and covering the entire plume corresponds to stable or very stable atmosphere (Pasquill class E or F).

As turbulence is cause by either thermal or mechanical forcing, the following meteorological data are required:

- wind measurements, in order to evaluate the mechanical turbulence
- information on radiation (solar and infrared) including astronomic position of the sun (date/hour in the year) and cloud cover (1/8), in order to evaluate thermally induced turbulence

Mechanical turbulence is induced by high wind speeds and tends to make the atmosphere well mixed and thermally neutral. Thermally related turbulence causes strong vertical instability

and occurs when the sun heats the ground and wind speeds are low enough to gives rise to natural free convection, i.e. formation of thermals.

For manual initialization of meteorological data, the stability class is either specified by the user or deduced from available meteorological input data. When manually specified wind roses are used, the, initial data are taken from a meteorological data file containing several years of measurements, which are used for determining the stability class.

The methods available with AIM for determining atmospheric stability are based on the Pasquill formula. For the other formulations, a stability class corresponding to Pasquill is calculated as summarized in the table below.

Formula	Classes					
Pasquill	A	B	C	D	E	F
Briggs	A	B	C	D	E	F
Doury	DN	DN	DN	DN	DF	DF
Brookhaven	A	B2	B1	C	D	D

In AIM, the stability classes are not represented by a letter but by a number. The numbers equivalent to the letters for the different formulas are given below.

Pasquill and Briggs classes:

A	B	C	D	E	F
1	2	3	4	5	6

Doury classes:

DF	DN
1	2

Brookhaven classes:

A	B2	B1	C	D
1	2	3	4	5

5.4.1 Radiation-wind method

The radiation–wind method for determining the stability class uses net radiation during the day and cloud cover at night. The method is recommended by the International Atomic

Energy Agency (IAEA) and can be found in their safety guidelines. If cloud cover data are not available, the sky is assumed to be clear (N <=3/8).

Wind speed	DAY			NIGHT		
	Net radiation (W/m²)			Radiation = 0, cloud cover N(1/8)		
m/s	>600	>300	<=300	3/8<N<8	N<=3/8	N=8
< 1	A	A	B	F	F	D
1-2	A	B	B	E	F	D
2-4	A	B	C	E	F	D
4-6	B	C	C	D	E	D
6-7	C	C	D	D	D	D
>=7	C	D	D	D	D	D

5.4.2 Temperature gradient method

This method requires the knowledge of the temperature at two different heights in order to calculate the vertical temperature gradient. The stability class corresponding to the computed temperature gradient can be established from the following table.

Temperature gradient (degree/100 m)	Stability class
G < -1.9	A
-1.9 < G < -1.7	B
-1.7 < G < -1.5	C
-1.5 < G < -0.55	D
-0.55 < G < 1.5	E
1.5 < G	F

5.4.3 Sigma direction method

The sigma direction method is based on the standard deviation of the fluctuation in wind direction (frequently referred to as sigma-theta). The stability classes corresponding to the different standard deviations are given in the following table.

Standard deviation (degree)	Stability class
Sd < 5	F
5 < Sd < 10	E
10 < Sd < 15	D
15 < Sd < 20	C
20 < Sd < 25	B
25 < Sd	A

5.4.4 Day-night method

The day–night method is useful when the two methods mentioned above can not be applied due to lack of data. The stability class can be determined even when radiation and cloud cover data are not available. The method uses a classification based on day and night values in combination with wind speed as shown in the following table.

Wind speed (m/s)	Day	Night
< 5	C	E
5–6	D	E
>6	D	D

5.4.5 Temperature gradient and humidity method

The consideration of relative humidity (RH) in the atmosphere can have an importance when determining the stability class. The following method is proposed in this case:

1- Si U < 10 %

$G \leq -1,13°C/100m$	=>	A
$-1,13 < G \leq -1,03°C/100m$	=>	B
$-1,03 < G \leq -0,91°C/100m$	=>	C
$-0,91 < G \leq -0,37°C/100m$	=>	D
$-0,37 < G \leq +0,78°C/100m$	=>	E
$+0,78°C/100m < G$	=>	F

2- Si 10 <= U < 20 %

$G \leq -1,18°C/100m$	=>	A
$-1,18 < G \leq -1,05°C/100m$	=>	B
$-1,05 < G \leq -0,91°C/100m$	=>	C
$-0,91 < G \leq -0,22°C/100m$	=>	D
$-0,22 < G \leq +1,12°C/100m$	=>	E
$+1,12°C/100m < G$	=>	F

3- Si 20 <= U < 30 %

$G \leq -1,39°C/100m$	=>	A
$-1,39 < G \leq -1,18°C/100m$	=>	B
$-1,18 < G \leq -0,97°C/100m$	=>	C
$-0,97 < G \leq -0,16°C/100m$	=>	D
$-0,16 < G \leq +1,25°C/100m$	=>	E
$+1,25°C/100m < G$	=>	F

4- Si 30 <= U < 40 %

$G \leq -1,61°C/100m$	=>	A
$-1,61 < G \leq -1,33°C/100m$	=>	B
$-1,33 < G \leq -1,00°C/100m$	=>	C
$-1,00 < G \leq -0,10°C/100m$	=>	D
$-0,10 < G \leq +1,32°C/100m$	=>	E
$+1,32°C/100m < G$	=>	F

5- Si 40 <= U < 50 %

$G \leq -1,82°C/100m$	=>	A
$-1,82 < G \leq -1,48°C/100m$	=>	B

$$-1,48 <G <= -1,04°C/100m \quad => \quad C$$
$$-1,04 <G <= -0,04°C/100m \quad => \quad D$$
$$-0,04 <G <= +1,39°C/100m \quad => \quad E$$
$$+1,39°C/100m <G \quad => \quad F$$

6- Si 50 <= U < 60 %

$$G <= -1,62°C/100m \quad => \quad B$$
$$-1,62 <G <= -1,00°C/100m \quad => \quad C$$
$$-1,00 <G <= +0,02°C/100m \quad => \quad D$$
$$-0,02 <G <= +1,46°C/100m \quad => \quad E$$
$$+1,46°C/100m <G \quad => \quad F$$

7- Si 60 <= U < 70 %

$$G <= -1,77°C/100m \quad => \quad B$$
$$-1,77 <G <= -1,16°C/100m \quad => \quad C$$
$$-1,16 <G <= +0,08°C/100m \quad => \quad D$$
$$+0,08°C/100m <G \quad => \quad E$$

8- Si 70 <= U < 80 %

$$G <= -1,25C/100m \quad => \quad C$$
$$-1,25°C/100m <G \quad => \quad D$$

9- Si 80 <= U < 100 %

$$G <= -1,40 C/100m \quad => \quad C$$
$$-1,40°C/100m <G \quad => \quad D$$

10- Si U=100% \qquad => \qquad D

Cloud cover and wind method

This is a method commonly used since cloud cover (or a corresponding index) is a parameter that generally can be supplied by the National Meteorological Institutes. The stability is calculated based on wind speed and cloud cover according to the following method:
Determination of a parameter (Iv) characterizing mechanical effects by using wind measurements at 11 meters:

Wind speed (m/s)	0<V≤0,5	0,5<V≤1,5	1,5<V≤3,5	3,5<V≤5,5	5,5<V≤6,5	6,5<V
Iv	1	2	3	4	5	6

2) Determination of a radiation parameter (R) which characterizes thermal effects using the sun elevation H (as a function of day in year and hour in day) and the cloud cover (N):

Sun elevation "H": Cloud cover "N":	Night	0≤H<15°	15°≤H<35°	35°≤H<60°	60°≤H≤90°
N=0	R=5	R=5	R=3	R=2	R=1
N=1	R=5	R=5	R=3	R=2	R=1
N=2	R=5	R=5	R=3	R=2	R=1
N=3	R=5	R=5	R=3	R=2	R=1
N=4	R=5	R=4	R=6	R=2	R=1
N=5	R=4	R=4	R=6	R=3	R=2
N=6	R=4	R=4	R=6	R=3	R=2
N=7	R=4	R=4	R=6	R=3	R=2
N=8	R=6	R=6	R=6	R=6	R=3

Then, both parameters (Iv and R) are combined to obtain the PASQUILL class:

	DAY			NIGHT or cloudy day (R = 6)		
	R=1	R=2	R=3	R=4	R=5	R=6
Iv=1	A	A	B	F	F	D
Iv=2	A	B	B	E	F	D
Iv=3	A	B	C	E	F	D
Iv=4	B	C	C	D	E	D
Iv=5	C	C	D	D	D	D
Iv=6	C	D	D	D	D	D

The assumptions made in this method, are:

at high wind speeds the atmosphere is well mixed and neutral (D)
at low wind speeds and if thermal energy near the ground is available (heating of ground by the sun), natural convection can exist (A, B or C)
the default atmospheric stability is E or F (stable)

It should be specified that this method gives a general estimation of the atmospheric stability. However, it does not permit to get a detailed description of the vertical atmospheric structure. To obtain this information, (altitude and thickness of stable layers or inversions), specific instrumentation at the site is required, that most meteorological stations are not equipped with.

5.5 CLASSIFICATION OF ATMOSPHERIC PARAMETERS

All meteorological parameters are categorized into different classes. These classes allow the calculation of frequency distributions of the different parameters, and serve as a basis for the creation of wind roses. The classes recognized by AIM are described below.

5.5.1 Wind speed classes

Wind speed measurements should:
- be expressed in m/s,
- range between 0 and 150 m/s,
- represent an average period of 10 min.

Class description	Lower speed limit, included (m/s)	Upper speed limit, excluded (m/s)
Calm winds	0	0,5
0,9≤V<1,0	0,5	0,9
1,0≤V<2,0	0,9	1,5
2,0≤V<3,0	1,5	2,5
3,0≤V<6,0	2,5	6,5
6,0≤V<13,0	6,5	12,5
V≥13,0	12,5	99,0
Invalidated value	-999	-999

Table 1: Wind speed classes

5.5.2 Wind direction classes

Wind direction measurements should
- be expressed in degrees,
- range between 0 and 360 degrees,
- represent an average period of 10 minutes.

Wind direction is divided into sectors of 20 degrees. It indicates the direction from which the wind blows, and the angle is counted clockwise starting from the North. Thus:
- 0 or 360° represents the North,
- 90° represents the East,
- 180° represents the South,
- 270° represents the West.

Inclusion or exclusion of limit values varies, depending on the practice followed by the individual meteorological office.

Class description	Lower limit, excluded (°)	Upper limit, included (°)
0 or 360 (North)	350	10
20	10	30
40	30	50
60	50	70
80	70	90
100	90	110
120	110	130
140	130	150
160	150	170
180 (South)	170	190
200	190	210
220	210	230
240	230	250
260	250	270
280	270	290
300	290	310
320	310	330
340	330	350
Calm winds	0	0
Invalidated value	-999.	-999.

Table 2: Wind direction classes

5.5.3 Time and date classes

For time and date specification:

- the year is expressed in four digits to be able to separate between the years 1900 and 2000. Two-digit year indications can, however, be read, and they are interpreted accordingly:
  - 00–29 as 2000–2029
  - 31–99 as 1931–1999
- the month in 1 or 2 digits (1 to 12)
- the day in 1 or 2 digits (1 to 31)
- time in hours (0 to 23), minutes (0 to 59), and seconds (0 to 59)

The second is the smallest time unit. The hours of the day are grouped in threes (0–3 h, etc.).

5.5.4 Rainfall intensity classes

Rainfall intensity is expressed in mm/h. It represents the quantity of water that precipitates in 1h. Rainfall is divided into two classes:

- class with nil precipitation rate

class including all meteorological observations for which the precipitation rate is available

5.6 STANDARD DEVIATIONS

ARIA Impact uses the same equations for the gas and particle models to compute standard deviations of dispersion (σ_y, σ_z). The user can select among several types of formulas for σ_y and σ_z.

Standard deviations must be determined for evaluating turbulent diffusion around the main trajectory. The Gaussian distributions of pollutants are characterized by horizontal and vertical standard deviations.

The choice of standard deviations, parameters that drive the plume dispersion, is a delicate problem that includes empirical considerations of relative importance. The parameters should be adapted to the site studied. In order to decide the values of the standard deviations, the following points should be taken into account:

- an uneven surface and the presence of obstacles increase roughness;
- high roughness increases turbulence (meteorological conditions being the same);
- strong turbulence increases the standard deviations;
- large standard deviations accelerate plume dispersion and touchdown (for elevated sources).

The following formulas can be used for computing standard deviations of plume dispersion:
(1) **PASQUILL – TURNER**, standard formula
- (2)**BRIGGS OPEN COUNTRY**, for sites in rolling terrain
(3) **BRIGGS URBAN**, for urban sites with very strong vertical mixing
- (4)**DOURY**, formula used by the French atomic energy commission (CEA)
- (5)**BROOKHAVEN**, formula of the Brookhaven National Laboratory, USA

The formulas have been established for sampling periods of 10 min, depending on the downwind distance from emissions and stability class. Average concentrations for up to 3 hours can be extrapolated from the 10-minute sampling periods. The standard deviations on the sampling time T are then calculated as follows:

$$\sigma_T = \sigma_{10mn} \, (T/10)^{0,25}$$

The significant variables are:
x = downwind distance from source

σ_y = horizontal standard deviation, perpendicular to the plume axis
σ_z = vertical standard deviation, perpendicular to the plume axis

5.6.1 Pasquill - Turner

For x < 1 km:

Class	σ_y	σ_z
A	$0{,}215\, x^{0,858}$	$0{,}01 + 0{,}467\, x^{1,89}$
B	$0{,}155\, x^{0,889}$	$0{,}103\, x^{1,11}$
C	$0{,}105\, x^{0,903}$	$0{,}066\, x^{0,915}$
D	$0{,}068\, x^{0,908}$	$0{,}0315\, x^{0,822}$
E	$0{,}050\, x^{0,914}$	$0{,}0232\, x^{0,745}$
F	$0{,}034\, x^{0,908}$	$0{,}0144\, x^{0,727}$

For x > 1 km, the values of the standard deviations differ for classes E and F:

Class	σ_y	σ_z
E	$0{,}050\, x^{0,914}$	$- 0{,}126 + 0{,}1480\, x^{0,150}$
F	$0{,}034\, x^{0,908}$	$- 0{,}017 + 0{,}0312\, x^{0,306}$

5.6.2 Briggs

There are two formulas for Briggs standard deviations:
- BRIGGS OPEN COUNTRY: Country for rolling terrain
- BRIGGS URBAN: for urban sites with a high degree of vertical mixing

The selection of one of these formulas is determined by the roughness at the site:
- Briggs Open Country when roughness is <u>lower</u> than 0.5 m
- Briggs Urban when roughness is <u>higher</u> than 0.5 m

5.6.2.1 Briggs Open Country

Class	σ_y	σ_z
A	$0{,}22\, x\, (1 + 0{,}0001\, x)^{-1/2}$	$0{,}20\, x$
B	$0{,}16\, x\, (1 + 0{,}0001\, x)^{-1/2}$	$0{,}12\, x$
C	$0{,}11\, x\, (1 + 0{,}0001\, x)^{-1/2}$	$0{,}08\, x\, (1 + 0{,}0002\, x)^{-1/2}$
D	$0{,}08\, x\, (1 + 0{,}0001\, x)^{-1/2}$	$0{,}06\, x\, (1 + 0{,}0015\, x)^{-1/2}$
E	$0{,}06\, x\, (1 + 0{,}0001\, x)^{-1/2}$	$0{,}03\, x\, (1 + 0{,}0003\, x)^{-1}$
F	$0{,}04\, x\, (1 + 0{,}0001\, x)^{-1/2}$	$0{,}016\, x\, (1 + 0{,}0003\, x)^{-1}$

5.6.2.2 Briggs Urban

Class	σ_y	σ_z
A - B	$0.32 \, x \, (1 + 0.0004 \, x)^{-1/2}$	$0.024 \, x \, (1 + 0.001 \, x)^{-1/2}$
C	$0.22 \, x \, (1 + 0.0004 \, x)^{-1/2}$	$0.20 \, x$
D	$0.16 \, x \, (1 + 0.0004 \, x)^{-1/2}$	$0.14 \, x \, (1 + 0.0003 \, x)^{-1/2}$
E - F	$0.11 \, x \, (1 + 0.0004 \, x)^{-1/2}$	$0.08 \, x \, (1 + 0.0015 \, x)^{-1/2}$

5.6.3 Doury

The Doury formula is based not on plume distance from the source, but on the time taken for the plume to be transported from the source. For a rectilinear Gaussian plume, distance and time are linked to wind speed. The formula is based on two classes: low diffusion and normal diffusion.

- **Standard deviations for the low-diffusion class**

Time	σ_y	σ_z
0-240 sec	$0.405 \, t^{0.859}$	$0.2 \, t^{0.5}$
240-97000 sec	$0.135 \, t^{1.130}$	$0.2 \, t^{0.5}$
97000-508000 sec	$0.463 \, t$	$0.2 \, t^{0.5}$
508000-1300000 sec	$0.65 \, t^{0.824}$	$0.2 \, t^{0.5}$
>1300000 sec	$200000 \, t^{0.5}$	$0.2 \, t^{0.5}$

- **Standard deviations for the normal diffusion class:**

Time	σ_y	σ_z
0-240 sec	$0.405 \, t^{0.859}$	$0.42 \, t^{0.814}$
240-3280 sec	$0.135 \, t^{1.130}$	$1.0 \, t^{0.685}$
3280-97000 sec	$0.135 \, t^{1.130}$	$20 \, t^{0.5}$
97000-508000 sec	$0.463 \, t$	$20 \, t^{0.5}$
508000-1300000 sec	$6.5 \, t^{0.824}$	$20 \, t^{0.5}$
>1300000 sec	$200000 \, t^{0.5}$	$20 \, t^{0.5}$

5.6.4 Brookhaven

Class	σ_y	σ_z
A - B1	$0.40 \, x^{0.91}$	$0.41 \, x^{0.91}$
B2	$0.36 \, x^{0.86}$	$0.33 \, x^{0.86}$
C	$0.32 \, x^{0.78}$	$0.22 \, x^{0.78}$

| D | $0.31 \text{ x}^{0.71}$ | $0.06 \text{ x}^{0.71}$ |

Gaussian distribution models commonly use Pasquill[4] standard deviations. They depend on the distance covered by the pollutant from the source and atmospheric stability. The laws governing plume evolution are illustrated in the Figures 1 and 2.

The figures show that evolution of the magnitude of the horizontal and vertical standard deviations is more rapid for the high-diffusion (Pasquill class A) than for the low-diffusion (Pasquill class F) class, as the class A curve is situated above the class F curve (diagrams with logarithmic scales).
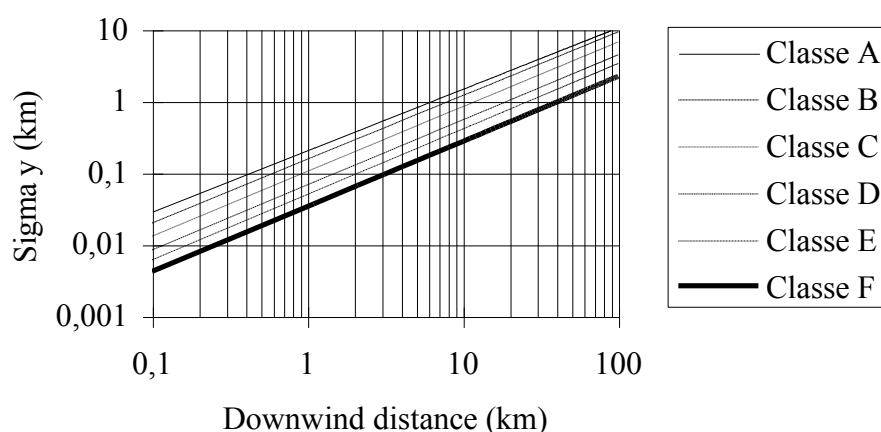
Figure a: Horizontal standard deviations depending on the distance covered from the source for each Pasquill stability class.
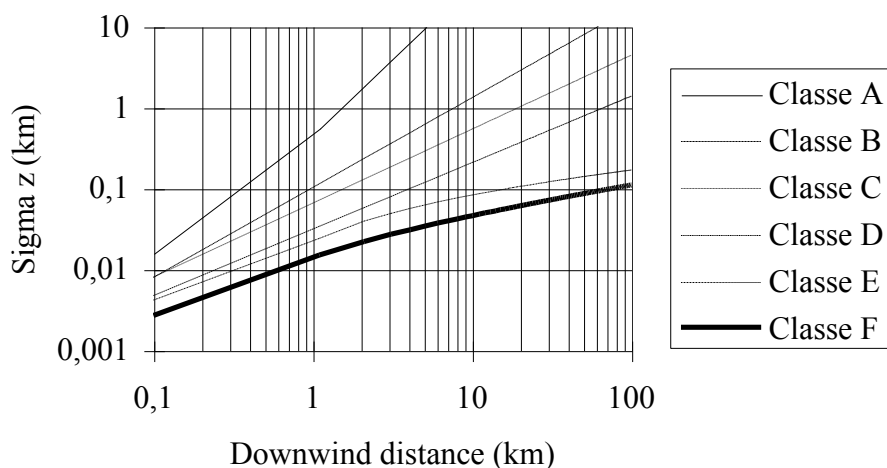
Figure b: Vertical standard deviations depending on the distance covered from the source for each Pasquill stability class.

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[4] Guide sûreté de l'Agence Internationale de l'Énergie Atomique. P 50

5.7 PLUME RISE EQUATION

The stack top is the starting point of pollutant trajectories. Plume rise is taken into account when stack exit temperature and/or velocity of the gas plume is high. The emissions from the combustion will continue to rise above the stack until the effects from the initial gas exit velocity and difference in air/gas density (due to temperature difference) are no longer significant. Emission height accounted by the model is therefore the actual emission height (stack height) plus plume rise due to gas emission conditions. ARIA Impact accounts for both temperature-driven and dynamic plume rise.

The intermediary phase between stack exit and transport–diffusion, where there is a merging of the thermodynamic characteristics of the plume and ambient air, cannot be taken into account in a rapid estimation. In simulations, the actual source S is replaced by a virtual point source S'. The horizontal distance between S and S' is negligible compared with the distance from S or S' to the computation point. The effective stack height and the distance at which the plume attains this height should therefore be determined.
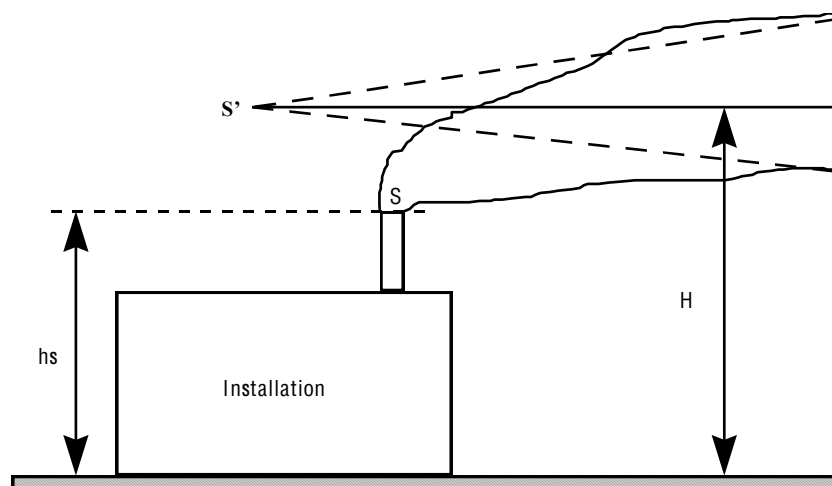
Effective height H is the sum of the real stack height (h_S) of the source and the plume rise (Δh), so that

$$H = h_S + \Delta H$$

For plume rise calculations, ARIA Impact offers a choice of formulas: Briggs, Anfossi, Holland, Stumke, Concawe, and Cude.

The significant variables are:

Variable	Description	Unit
Cp	specific heat of air at constant pressure	j/kg/K
D	internal stack diameter	m
Fb	buoyancy flux	m^4/s^3
Fm	initial momentum flux	m^4/s^2
g	acceleration due to gravity	m/s^2
Q	emission strength	Watt
ρ_a	air density	kg/m^3
ρ_n	density of gas exhaust	kg/m^3
s	measure of atmospheric thermal stability (square of Brunt-Vaisala frequency)	$1/s^2$
$\theta(z)$	potential temperature profile	K
Ta	ambient air temperature	K
Tp	stack exit temperature	K
U	wind speed	m/s
Vp	exit gas velocity	m/s
x	downwind distance from source	m
x*	distance of plume stabilization	m
z	plume height above ground	m
z_{init}	source height above ground	m
Dc	critical deviation of temperature (selection criterion of thermal effect/dynamic effect)	K
DH	effective height	m
DHb	rise due to buoyancy effects	m
DHm	rise due to dynamic effects	m

5.7.1 Concawe formula

The Concawe equation is valid only for wind speeds above 1 m/s. Otherwise, the user should apply the Briggs formula.

- Computation of calorie rate in calories per second:

$$D = 226,19.V_p.d.\pi.(T_p - T_a).0,25$$

- Computation of plume rise:

$$DH = 0,175.\frac{\sqrt{D}}{U^{0,75}}$$

5.7.2 Briggs formula

The Briggs formula serves as a criterion (EPA 86) for distinguishing a jet from a hot plume. The formula compares the temperature difference between the plume and air with a critical deviation beyond which plumes are dominated by buoyancy forces.

Buoyancy flux:

$$Fb = \frac{gQ}{\pi \rho_\alpha C_p T_a} \approx \frac{gd^2(T_p - T_a)V_p}{4T_p}$$

Initial momentum flux:

$$Fm = \frac{\rho_n}{\rho_\alpha}V_p U \approx VpU$$

Atmospheric thermal stability:

$$s = \frac{g}{T_p}\frac{\partial \theta}{\partial z}$$

Computation of deviation from critical temperature Dc
- Neutral or unstable atmosphere

$$Fb < 55\,m^4/s^3 \qquad Dc = \frac{0,0297T_p V_p^{1/3}}{d^{2/3}}$$

$$Fb \geq 55\,m^4/s^3 \qquad Dc = \frac{0,00575T_p V_p^{2/3}}{d^{1/3}}$$

- Stable atmosphere

$$Dc = 0,01958T_a V_p s^{1/2}$$

If $Dc > (T_p - T_a)$, the plume is dominated by buoyancy forces.

Distance of stabilization:
- Neutral or unstable atmosphere
  - Dominant buoyancy forces

$$Fb > 55\,m^4\!/s^3 \qquad x^* = 119Fb^{2/5}$$
$$Fb \le 55\,m^4\!/s^3 \qquad x^* = 49Fb^{5/8}$$

  - Dominant dynamic forces

$$x^* = \frac{4d(V_p + 3U)^2}{V_p U}$$

- Stable atmosphere
  - Dominant buoyancy forces

$$x^* = \frac{\pi U}{\sqrt{s}}$$

  - Dominant dynamic forces

$$x^* = \frac{\pi U}{2\sqrt{s}}$$

Plume rise formulation:
- Neutral or unstable atmosphere
  - Dominant buoyancy forces

$$DHb_{(x)} = 1{,}6\,\frac{Fb^{1/3}\min(x, x^*)^{2/3}}{U}$$

  - Dominant dynamic forces

$$DHm_{(x)} = 2\,\frac{Fm^{1/3}\min(x, x^*)^{1/3}}{U^{2/3}}$$

The threshold value is:

$$DH_{max} = 400\,\frac{Fb}{U^3}$$

In the case of unstable or neutral atmosphere, the plume rise equation corresponds to the minimum between the threshold value and plume rise:

$$DH = \min(DH_{max}, DH)$$

- Stable atmosphere
  - Dominant buoyancy forces

$$DHb_{(x)} = 2{,}6\left(\frac{Fb}{sU}\left(1 - \cos\left(\frac{\sqrt{s}\min(x, x^*)}{U}\right)\right)\right)^{1/3}$$

  - Dominant dynamic forces

$$DHm_{(x)} = 2,6 \left(\frac{Fm}{\sqrt{s}U} \left(\sin\left(\frac{\sqrt{s}\min(x, x^*)}{U} \right) \right) \right)^{1/3}$$

The function 'min' signifies the smaller of the two parameters in brackets.

The sum of cubes accounts for cumulative buoyancy and dynamic effects:

$$DH(x) = \sqrt[3]{DHb_{(x)}^3 + DHm_{(x)}^3}$$

5.7.3 Anfossi formula

Buoyancy flux (same as Briggs):

$$Fb = \frac{gQ}{\pi \rho_\alpha C_p T_a} \approx \frac{g(T_p - T_a)V_p}{T_p}$$

Measure of atmospheric thermal stability:

$$s = \frac{g}{T_p} \frac{\partial \theta}{\partial z}$$

Plume rise formula:

$$DH_{(x)} = 2,6 \frac{Fb^{1/3}x^{2/3}}{U} (\frac{x^2 s}{V^2} - 4.3)^{-1/3}$$

5.7.4 Holland formula

$$DH = 1,5\frac{d\,V_p}{U} + 2,7\frac{V_p d^2}{U}\frac{T_p - T_a}{T_p}$$

Holland's formula only accounts for the capacity of plume rise and/or dynamic bent over of plumes. It does not account for atmospheric stability.

5.7.5 Stumke formula

The Stumke formula is valid only for wind speeds above 1 m/s. Otherwise, the user should apply the Briggs formula:

$$DH = 1,5.d.\frac{V_p}{U} + \frac{\Omega}{U} \text{ with}$$

$$\Omega = 118.d^{1,5}.(1 + \frac{T_p + T_a}{T_p})^{0,25}$$

5.7.6 Cude formula

The Cude formula, like that of Briggs, is used to account for plume rise as a function of distance from source. It also computes the tilting of plumes for heavy gases. When this option is selected, gravitational fall speed is determined with the Cude formula instead of Stoke's equation (see 2.11). This method is particularly relevant for wind speeds above or equal to 2 m/s.

- Maximum plume rise due to dynamic emission effects:

$$DH\max = \frac{V_p d}{0,32U}(\frac{\rho_g}{\rho_a})^{0,5}$$

where:

ρ_g is the gas density at stack exit temperature; it is derived from density under normal temperature and pressure conditions supplied by the user in the emission description

ρ_a is air density

Plume rise is the smallest value between 2*(distance from the source) and maximum plume rise, DHmax. Maximum plume rise is reached at a distance (DHmax/2) from the source.

- Inclination of the plume due to gravity effects on the gas:

The plume inclination angle θ in relation to the horizontal axis is determined by the following formula:

$$tg(\theta) = -\frac{AF_1(x_1)}{t_1}$$

where:

A is a time-dependent parameter: $A = 9,42 \frac{gN(\rho_g - \rho_a)}{\rho_g U^4}$ with g as the gravity constant, and N the emission rate

- t_1 is a time constant, arbitrarily set as 200 sec

$F_1(x_1)$ is a function given by the following table where $x_1 = \frac{t_1}{A}$

x_1	$x_1 \times 10^{-3}$	$x_1 \times 10^{-2}$	$x_1 \times 10^{-1}$	x_1	$x_1 \times 10$	$x_1 \times 10^2$	$x_1 \times 10^3$
1	0.0059	0.0323	0.170	0.767	2.33	4.50	6.79
1.2	0.0067	0.0370	0.193	0.852	2.49	4.68	6.97
1.4	0.0075	0.0414	0.215	0.930	2.64	4.83	7.13
1.6	0.0083	0.0456	0.235	1.00	2.75	4.97	7.26
1.8	0.0091	0.0497	0.255	1.07	2.86	5.08	7.38
2.0	0.0098	0.0537	0.274	1.13	2 .95	5.19	7.48

2.5	0.0116	0.0632	0.319	1.27	3.16	5.41	7.71
3.0	0.0133	0.0721	0.360	1.39	3 .33	5.59	7.89
3.5	0.0149	0.0806	0.398	1.50	3.48	5.74	8.04
4.0	0.0164	0.0887	0.434	1.59	3.61	5.88	8.18
4.5	0.0179	0.0965	0.469	1.68	3.72	5.99	8.29
5.0	0.0194	0.104	0.501	1 .76	3.82	6.10	8.40
6.0	0.0222	0.119	0.532	1.90	4.00	6.28	8.58
7.0	0.0249	0.132	0.619	2.03	4.15	6.43	8.74
8.0	0.0274	0.145	0.671	2.14	4.28	6.57	8.87
9.0	0.0299	0.158	0.720	2.24	4.40	6.69	8.99
10.0	0.323	0.170	0.767	2.33	4.50	6.79	9.09

For $x_1 < 10^{-3}$, $F_1(x_1) = 1,054 x_1^{0,75}$

For $x_1 > 10^3$, $F_1(x_1) = Log(x_1) - 0,12$

5.7.7 Validity of different formulas

Formula	Type of installation	Atmosph. stability	Wind speed	Remark
Holland	Chimneys Low thermal flux	No	-	Under estimates the plume rise in neutral atm. conditions Good results in stable conditions
Briggs	-	Yes	-	Standard EPA formulation
Anfossi	-	Yes	-	Over estimates the plume rise in instable atm. conditions
Concawe	Power/heating plants (1 - 10 MW) Thermal flux. signif.	No	> 1 m/s	Briggs formula, adjusted by CNRS Italy
Stumke	Chimneys Low thermal flux	No	> 1 m/s	International organism in the energy sector
Cude	Chimneys Low thermal flux	No	≥ 2 m/s	Formulation used for german nuclear power plants, recommended by IAEA*

* International Atomic Energy Agency

5.8 VERTICAL PROFILES

5.8.1 Vertical wind profiles

One of the parameters used in the calculation of plume rise is the wind speed. The value of the wind speed is taken directly from the database of meteorological data. These data normally corresponds to wind measurements made near the ground, more exactly at a height

of 10 meters above ground level. However, the wind speed observed at the top of a chimney varies with the height of the chimney; the higher the chimney the higher the wind speed at the level of gas exhaust.

In order to take into account this vertical variation of wind speed in the dispersion calculation, ARIA Impact can compute vertical profiles of wind speed based on wind measurements made at ground level as well as on atmospheric turbulence
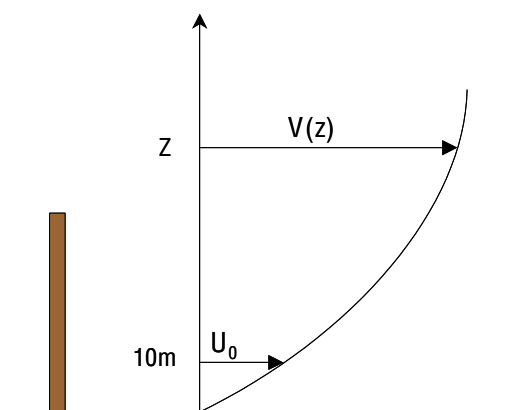
The wind at altitude Z is calculated according to the Irwin law (power-law profile):

$$V(Z) = U_0 \left(\frac{Z}{Z_0} \right)^b$$

where:

V(Z): wind at altitude Z
U_0: wind at altitude Z_0 (Z_0 is a standard reference height commonly equal to 10 meters)
b: coefficient calculated as a function of land cover (surface roughness) and atmospheric stability

The values of coefficient b are given in the table below:

	Pasquill class					
	A	B	C	D	E	F
Zone urbaine	0.15	0.15	0.20	0.25	0.40	0.60
Zone rural	0.07	0.07	0.10	0.15	0.35	0.35

This formula can be applied in the lowest 200 meters above the ground. Above this level the wind speed is considered constant with height.

The figures below illustrate the variation of wind speed as a function of altitude for different stability classes. In this example, the speed at 10 meters has been set to 3 m/s.
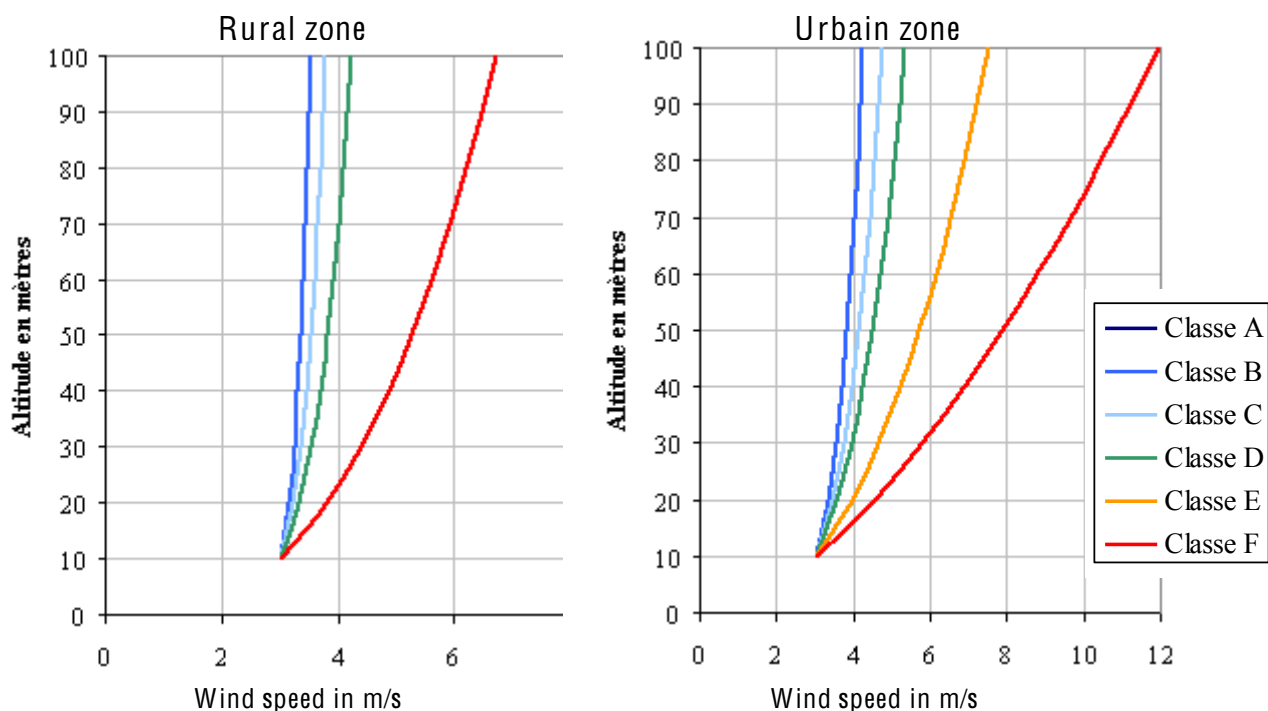
Figure 81: Variation of wind speed as a function of altitude

5.8.2 Vertical temperature profiles

In the same way as for the wind speed, the temperature varies as a function and of altitude and of atmospheric stability. The vertical profiles are therefore calculated based on the gradient of temperature and atmospheric stability.

1.1.1.1 Pasquill class

	A Very unstable	B Unstable	C Slightly unstable	D Neutral	E Stable	F Very stable
Thermal gradient in °C/100m	- 2,1	- 1,8	- 1,6	- 1,0	1,0	2,0

1.1.1.2 Doury class

	DN Normal diffusion	DF Weak diffusion
Thermal gradient in °C/100m	- 1	0

1.1.1.3   Brookhaven class

	A Very unstable	B1 Unstable	B2 Slightly unstable	C Neutral	D Stable
Thermal gradient in °C/100m	- 2,1	- 1,8	- 1,6	- 1,0	1,5

The figures below illustrate the variation of temperature as a function of altitude for different stability classes. In this example, the ground temperature has been set to 15 °C.
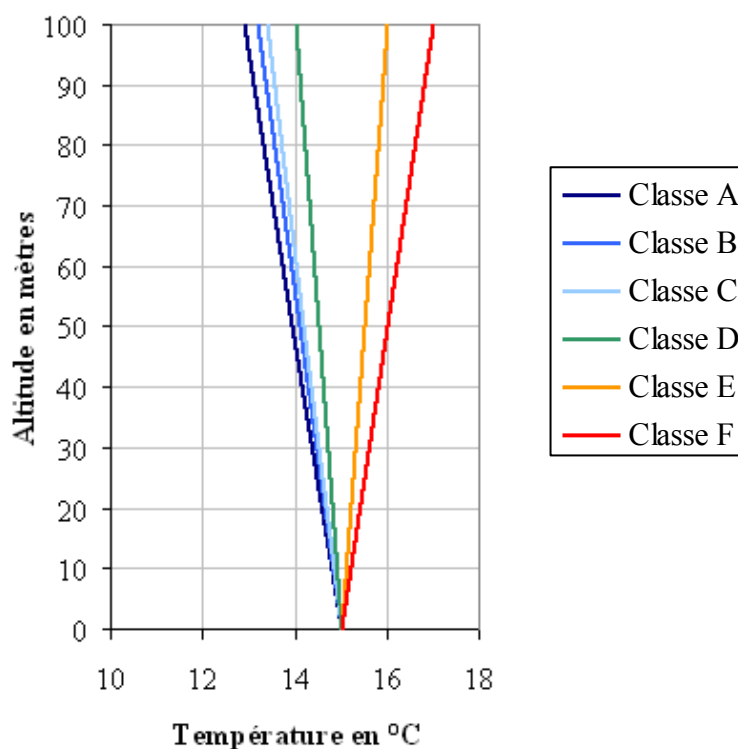
Figure 82: Variation of temperature as a function of altitude

5.9 MIXING LAYER COMPUTATION

The height of the mixing layer is an important factor for computations of ground-level concentrations. In fact, the plume is reflected by the ground as it is by the mixing layer which serves as an impermeable boundary between a turbulent and a non-turbulent layer. Pollutant concentrations below the mixing layer are therefore much higher if the layer is taken into account.

Mixing layer height is determined mainly by the preprocessor METPRO (Paine 1988) developed by the Environmental Protection Agency (EPA), United States. The principle and formulas used for this computation are described in the following sections.

5.9.1 Principle

During daytime hours, net radiation of heat is divided into sensible heat flux, latent heat, and ground heat flux (see Figure 83).

The energy balance is given in a simple equation:

$$R_n = H + LE + G$$

where:

        R_n is net radiation
        H is heat flux at the surface
        LE is latent heat flux
        G is the heat flux at ground level
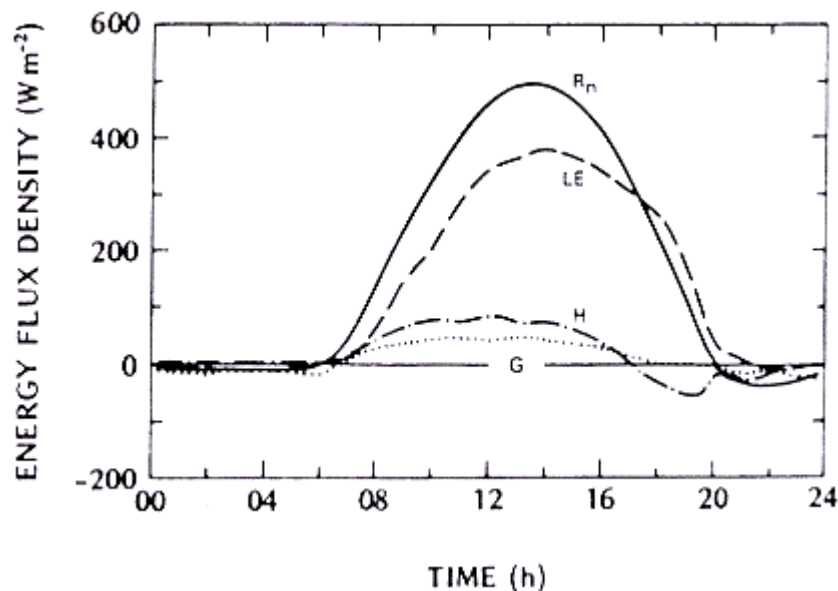
Figure 83: Distribution of energy components (Oke 1978).

Sensible heat flux is proportional to the turbulence intensity in the surface layer and to the depth of the boundary level. The height of the mixing layer during convective periods is determined from calculations of hourly sensible heat. Nocturnal descending heat flux is estimated from wind speed and cloud cover data.

For unstable conditions, the energy balance (see above equation) and wind measurements at 10 m are used for estimating sensible heat flux, friction velocity, and Monin-Obukhov length, L_{mo}, (Holstag and Van Ulden 1983). For stable conditions, friction velocity u_* and Monin-Obukhov length, L_{mo}, are determined by the Venkatraman formula (1980).

5.9.2   Determination of the mixing layer during convective periods

Positive heat flux at ground level (insolation conditions) combined with winds lead to both mechanical and convective turbulence. The turbulent energy balance shows that mechanically driven energy decreases rapidly with altitude as it is proportional to wind shear. Inversely, heat convection varies slowly with altitude. The top of the boundary layer is therefore determined by heat convection parameters, particularly heat flux at ground level.

A simple equation for z_i in convection conditions can be derived from the heat energy balance equation (first law of thermodynamics). Vertical distribution before sunrise (time t_0) is shown by the inversion of curve AB in Figure 5.
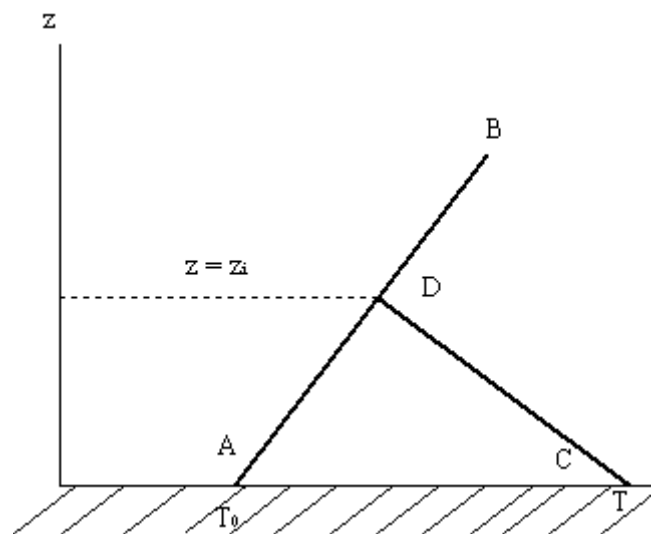
Figure 84: Illustration of inversion height (Panofsky and Dutton).

Curve AB represents the temperature profile before sunrise and curve CDB, the profile after heating of the near-ground atmospheric layers..

The assumption is that heating gives rise to an adiabatic layer Dc from the ground up to altitude zi at time t. If T_0 is the initial surface temperature then T is the surface temperature at time t. The figure geometry leads to:

$$\gamma_d - \gamma = \frac{T - T_0}{h} \qquad (1)$$

where:

γ and γ_d are the vertical temperature gradient at sunrise and the adiabatic gradient, respectively.

If H is the surface heat flux, conservation of heat energy is represented by:

$$\int_{t_0}^{t} H dt = \frac{c_p \rho h (T - T_0)}{2} \qquad (2)$$

Equations [1] and [2] give the following equation (Panofsky and Dutton 1984):

$$h = \left(\frac{2 \int_{t_0}^{t} H dt}{c_p \rho (\gamma_d - \gamma)} \right)^{1/2} \qquad (3)$$

where:

c_p is specific heat at constant pressure (around 1000 J deg^{-1} kg^{-1}) and ρ, air density.

5.9.3   Determination of nocturnal mixing layer

For nocturnal or high atmospheric stability periods, the boundary layer is modeled using a formula developed by Nieuwstadt (1981) based on the work of Zilitinkevich (1972):

$$\frac{h}{L_{mo}} = \frac{\dfrac{0.3 u_*}{f L_{mo}}}{\left(1 + 1.9 \dfrac{h}{L_{mo}} \right)}$$

where:

f is the Coriolis parameter ($f \sim 10^{-4}$ s^{-1}).

For strongly neutral conditions (very high L_{mo}), the commonly used formula is therefore:

$$h = \frac{0.3 u_*}{f L_{mo}}$$

5.9.4   Use of ground parameters

As indicated earlier, magnitudes characterizing the surface layer (L_{mo}, u_*, mixing layer height) are determined from the following ground parameters:

- Roughness Length, z_0,
- Bowen ratio,
- Albedo.

The Bowen ratio is the ratio between sensible heat flux and latent heat flux at the surface. It is therefore lower above wet surfaces where a large proportion of the energy is lost by evaporation; it is higher above dry surfaces where a large proportion of the energy is lost as sensible heat. Typical values vary around 5 or more above semiarid regions (Stull 1988), 0.5

above prairies and forests, 0.2 above irrigated croplands, 0.1 above the sea; they are sometimes even negative over oases.

The albedo is the ratio between reflected solar radiation and incident solar radiation. Albedo values vary from about 0.95 for snow, 0.1 for forests, up to 0.05 for black and wet soils.

The three parameters (roughness length z0, Bowen ratio, albedo) are derived from the land use matrix. Land use data are presented by a two-dimensional land use matrix, which attributes a numeric value for each existing class at all grid points. For example, in a domain with five types of land use, the numerical values for the existing classes is as follows:

presence of water:	1
forest:	2
prairie:	3
cropped land:	4
urban habitat:	5

The Bowen ratio, albedo, and roughness length values, presented together as a two-dimensional matrix, can be computed from a correspondence table. This requires data on land use at each grid point for the simulation period. In the above example, the Bowen ratio, albedo, and roughness height values are attributed as follows:

landuse	bowen-ratio	albedo	z_0
1	0.1	0.12	0.0001
2	0.7	0.12	1.3
3	0.4	0.18	0.05
4	0.5	0.16	0.3
5	1	0.14	0.6

High values of the Bowen ratio are observed in urban areas, of albedo in prairies, and of roughness height in forest areas.

Mixing layer height is systematically determined at each import of meteorological data once data are available for temperature and atmospheric stability (net radiation, global radiation, or cloud cover). The following parameters are then stored: mixing layer height (called ZI), Monin length (LMONIN), and friction velocity (named USTAR).

5.10 PARTICLE SIZE

Stokes law for computing the speed of gravitational fall is applicable only when the particle diameter lies between 5 μm and 200 μm.

5.11 GASES

ARIA Impact assumes that pollutant gases are chemically non-reactive.

5.12 CALCULATION OF GROUND CONCENTRATION AND DEPOSTION

5.12.1 Concentration and deposition for wind speeds above 1 m/s

Pollutant concentration at ground level is determined according to several parameters defined in this manual including, among others, standard deviations, particle size, wind speed, and stack height.

Taking into account the assumptions described in this document, the transport–diffusion equation for gas pollutants is as follows:

$$C(x, y, z = 0) = \frac{Q}{\pi \sigma_y \sigma_z U} Exp\left[-0.5\left(\frac{y}{\sigma_y}\right)^2\right] \times V \quad [4]$$

où : $V = Exp\left[-0.5\left(\frac{H}{\sigma_z}\right)^2\right]$

        C(x, y, 0) is the pollutant concentration (g/m^3)
        (x, y, 0)   are the coordinates of a grid point in a system of coordinates starting from source projection on the ground, and whose x-axis is oriented in the direction of the wind (m)
        U   is the horizontal wind speed (m/s)
        Q   is the source strength (g/s)
        σ_y, σ_z are standard deviations of horizontal and vertical dispersion (m)
        H   is the effective stack height (m.a.g.l)

For dispersion and deposition calculations of particulate matter, ground-level concentration is calculated as the sum of contributions of N particle size classes. It thus takes particle size (10 classes) into account to reduce the concentration of particles in the plume over time. The values are determined by the following equations:

$$C(x, y, z = 0) = \sum_{j=1}^{j=N} C_j(x, y, 0)$$

and

$$C_j(x, y, 0) = \frac{Q_j}{\pi \sigma_y \sigma_z U} Exp\left[-0,5\left(\frac{y}{\sigma_y}\right)^2\right] \times Exp\left[-0,5\left(\frac{H_j}{\sigma_z}\right)^2\right]$$

where:

      N   is the number of particle size classes

      Q_j is the source strength for class j (g/s)

      H_j is the effective plume height for class j (m.a.g.l.)

Height (H_j) corresponding to plume height for particle j is calculated as a function of the distance (x) from source and horizontal wind speed U, using the following formula:

$$H_j = H - V_{gj}\frac{x}{U}$$

V_{gj} (in m/s) is the gravitational fall speed of particles of type j (size class):

$$V_{gj} = \frac{d_j^2 g(\rho_p - \rho_a)}{18\mu}$$

where:

      d_j is the diameter of class j particles (m)

      g   is acceleration due to gravity (m/s²)

      ρ_p is particle density (kg/m^3)

      ρ_a is air density (kg/m^3)

      μ is the dynamic viscosity of air = $1.8\ 10^{-5}$ kg/m/s

The gravitational fall speed has a sedimentary effect on the particles and thereby causes the plume axis to tilt towards the ground.

Q_j (g/s) is a source term, which is can be reduced by deposition and radioactive decay between the source and the calculation point. Q_j (x) is thus discretized along x-axis parallel to the wind in a series of $Q_{j,i}$ values corresponding to the distance interval indexed by i.

The quantity of pollutant thus depends on the following phenomena:
- dry deposition to the ground
- washout of pollutants by rain
- radioactive decay

The value of Q_j at distance i is:

$$Q_{j,i} = Q_{j,\,i-1} - Ds_{j,\,i-1} - Dh_{j,\,i-1} - Dr_{j,\,i-}$$

$Ds_{j,\,i-1}$ is the dry deposition to ground of particles of class j up to distance (i-1).

It is calculated as follows:

$$Ds_{j,i-1} = \int_{i-1}^{i} \sqrt{2\pi}\, \sigma_y V_{gj}\, C_{j,i-1}\ dx$$

$Dh_{j,i-1}$ is the wet deposition to ground of particles of class j up to distance (i-1). It is related to washout of particles removed from the atmosphere by being incorporated into falling raindrops. The wet deposition is calculated as follows:

$$Dh_{j,i-1} = \frac{\Lambda\, Q_{j,i-1}}{U}\, dx$$

where: $\Lambda = \lambda \dfrac{R}{R_1}$

or

Λ	Washout ratio (s^{-1})
λ	Washout coefficient (s^{-1})
R	Precipitation intensity (mm/h)
R_1	Reference precipitation intensity = 1mm/h

Some reference values for λ:

Pollutant	λ values
SO_2	1.10^{-4}
NOx	0
HNO_3	6.10^{-5}
NO_3^-	3.10^{-5}

$Dr_{j,i-1}$ is the quantity of pollutant lost in radioactive decay. This radioactive decay is characterized by the half-life of the substance i.e. the time necessary for the quantity of the substance to be divided by two. The decay is described be the following equation :

$$Dr_{j,i-1} = Q_{j,i-1}\, \frac{\log 2}{UT}\, dx$$

where T is the half life of the substance

Influence of mixing layer height:

When taking the mixing layer height into account in the calculations, it is assumed that the plume is reflected by the mixing layer in the same way as it is by the ground. Term V thus takes on additional terms:

$$V = Exp\left[-0,5\left(\frac{H}{\sigma_z}\right)^2\right] + \sum_{i=1}^{\infty}\left(Exp\left[-0,5\left(\frac{2iz_i + H}{\sigma_z}\right)^2\right] + Exp\left[-0,5\left(\frac{2iz_i - H}{\sigma_z}\right)^2\right]\right)$$

where z_i is the mixing layer height.

5.12.2 Concentration and deposition during calm wind conditions

In the case of low wind speeds, a Gaussian puff model (DIFFUS) is used for computing ground concentrations. DIFFUS models pollutant transport and dispersion through two distinct functions:

- computation of pollutant trajectory (transport by wind)
- computation of pollutant dispersion around the trajectory and pollutant impact at different grid points

In the dispersion simulation, the emission is fragmented into a large number of puffs. Plume continuity is maintained because of the low puff emission interval (some tens of seconds) and by a computation method that integrates concentration between two consecutive puffs. Plume trajectory is represented by the movement of the puff center over time. The puffs are driven, every second, by the wind.

Horizontal speed of the pollutant cloud is that of the wind at the point where the puff is located. The speed of vertical pollutant movement is that of the wind plus the fall speed v_g. Fall speed v_g simulates the gravity effect on pollutant particles and tends to tilt the plume downwards (Figure 3).

Vg :gravitational fall speed

Vg
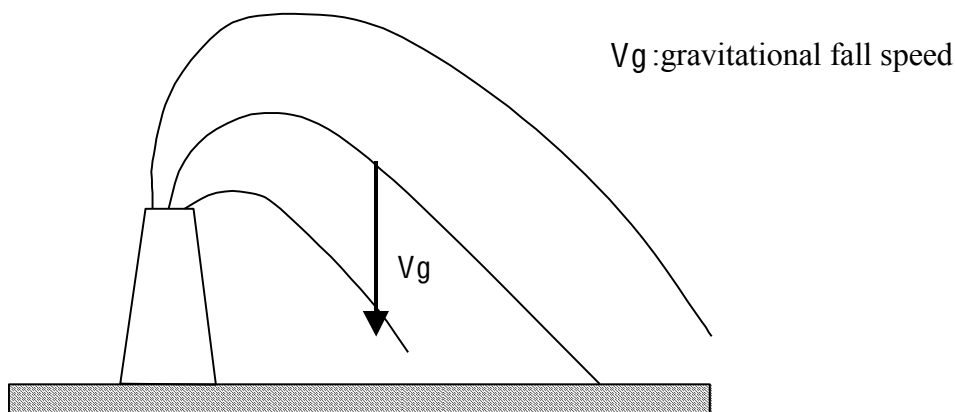
Diagram showing the influence of fall speed on the axis of a pollutant plume.

Transport of a pollutant to a grid point, (x, y, z), at a given time, t, for a time interval, dt, is driven by the following equations:

$$\left.\begin{aligned} dx &= u(x, y, z, t)\,dt \\ dy &= v(x, y, z, t)\,dt \\ dz &= \left[w(x, y, z, t) - Vg\right]dt \end{aligned}\right\} (1)$$

where:
- *dx, dy, dz* define the movement of the puff along three axes of the domain during time interval, dt.

- $u(x,y,z,t)$, $v(x,y,z,t)$, $w(x,y,z,t)$ are the three wind components at point (x,y,z) of the domain at the time of computation

- V_g is the fall speed of the pollutant (relevant for large particles)

Fall speed for gases is nil; for dust, it depends on particle size and density. The model uses Stocke's[5] theorem to calculate fall speed of dust according to particle size:

$$Vg = \frac{2\,r^2\,g\rho_p}{9\mu}$$

where:

- μ is air viscosity ($= 1.8.10^{-4}$ g/s/cm)

- ρ_p is particle density

- r is particle radius

- g is the gravity constant ($= 9.81$ m/s²)

The stack top is the starting point of pollutant trajectories. Plume rise is taken into account when stack exit temperature and/or velocity of the gas plume is high.

In the dispersion simulation, the emission is fragmented into a large number of elementary puffs. Puff size evolves over time depending on the distance of the puff from the source and atmospheric stability. The puff canter of mass is a point on the pollutant trajectory. Around this point, concentration is assumed to follow a Gaussian distribution (more pollutant at the center of the puff than at the edge).

The Gaussian distribution of pollutants is characterized by horizontal and vertical standard deviations, which evolve over time to model plume dispersion in ambient air. The puff evolution law is based on the Pasquill formula[6], which is normally used in Gaussian dispersion models. Puff growth is based on the distance travelled by the puff since its exit from the source and on the atmospheric stability.

This type of puff modeling is identical to standard Gaussian modeling, and it assumes uniform wind over the entire domain (without vertical wind speed), flat terrain, and constant flow.

To each puff is attributed the concentration (or mass) of pollutants as a function of the stack exit emission of the puff. Ground impact (concentration or deposition) is the sum of the contribution of each puff.

If $[x_i.\ y_i.\ z_i.\ (t - t_e)_i.\ M_i]$ are the characteristics of puff, i, at time, t, the Gaussian formula giving the concentration at any point (x, y, z) due to the puff is:

$$C = \frac{M_i}{(2\pi)^{\frac{3}{2}}\sigma_{hi}{}^2\sigma_{vi}} \exp\left[-\frac{(x-x_i)^2 + (y-y_i)^2}{2\sigma_{hi}{}^2} - \frac{(z-z_i)^2}{2\sigma_{vi}{}^2}\right]$$

---

[5] Hannah, R. Handbook on Atmospheric Dispersion, p. 67
[6] Guide sûreté de l'Agence Internationale de l'Énergie Atomique. P 50

Total concentration is the sum of the contribution of each puff along the trajectories. For a spot concentration at time, t, the first puff of age $(t-t_e)_i \geq t_e$ is taken from each trajectory released before t. Linked together, the puffs form the emission line.

Computation time is longer for sites dominated by calm winds.

5.13 IMPACT OF DUST EMISSIONS

This section explains the approach adopted by ARIA Impact for modeling dust emissions. These calculations can, however, be applied only to particulate matter and for area sources.

To compute the suspended particle potential (quantity of dust likely to be suspended by wind), the user must first determine the maximum wind speed for a gust winds. According to the manual of the US-EPA, this gust wind speed corresponds to a period of 1–4 minutes. To determine the speed of a 1-minute gust wind (maximum speed), the user should apply a factor of 1.12 to the average wind speed supplied by the national meteorological office.

The suspension of particulates from a surface can be induced by several parameters, the most important being the wind speed. The most relevant factors include:
- wind speed near the surface, which depends on wind direction (at 10 m) and roughness;
- humidity of ambient air.

Dust emissions are quantified in three steps:

1. calculation of the equivalent friction velocity
2. calculation of suspended particle potential
3. calculation of suspended particulate surface material

5.13.1 Calculation of the equivalent friction velocity

The equivalent friction velocity, u^*, at 25 cm above the surface is derived from the following equation:

$$u^* = \frac{K_a u_s^+}{\ln(\frac{0,25}{z_0})}$$

where
u_s^+ is wind speed at 25 cm above a coal pile
z_0 is roughness expressed in m (see Table 3)
K_a is the Von Karman constant (= 0.4)

Roughness is related to the surface material as seen from Table 3.

Table 3: Surface roughness (m) corresponding to different surface materials.

Material	Roughness (m)
Scoria (roadbed material)	0.05
Ground coal (surrounding coal pile)	0.04
Uncrusted coal pile	0.03
Scraper tracks on coal pile	0.02
Fine coal dust on concrete pad	0.01

Surface wind speed is:

$$u_s^+ = \left(\frac{u_s}{u_r}\right) u_{10}^+$$

where u_{10}^+ is the wind gust coefficient at 10 m

The US-EPA guide gives three characteristic values for the ratio $\dfrac{u_s}{u_r}$: 0.2, 0.6, and 0.9.

5.13.2 Calculation of suspended particle potential

The suspended particulate potential (in g/m^2) is computed by the following equation:

$$\begin{cases} P = 58(u^* - u_t^*)^2 + 25(u^* - u_t^*) & \text{if } u^* \geq u_t^* \\ P = 0 & \text{if } u^* < u_t^* \end{cases}$$

where
- u^*: friction velocity (m/s)
- u_t^*: threshold friction velocity (m/s)

In the US-EPA method for modeling dust emissions the threshold friction velocities (u_t^*) for different types of materials is listed (Table 4).

Table 4: Threshold friction velocity by type of materiel.

Material	Threshold friction velocity (m/s)
Scoria (roadbed material)	1.33
Ground coal (surrounding coal pile)	0.55
Uncrusted coal pile	1.12
Scraper tracks on coal pile	0.62
Fine coal dust on concrete pad	0.54

5.13.3 Calculation of suspended particulate surface material

The total quantity of material likely to be suspended at a given wind speed is the sum of calculations for the three different values of the ratio $\left(\dfrac{u_s}{u_r}\right)$: 0.2, 0.6, and 0.9. A percentage of total area is assigned to each value (Table 5).

Table 5: Percentage of total area assigned to three different values of $\left(\dfrac{u_s}{u_r}\right)$

$\dfrac{u_s}{u_r}$ values	Percentage of total area (%)
0.2	36
0.6	50
0.9	14

By multiplying the emission factors for each value of $(\dfrac{u_s}{u_r})$ with the corresponding percentage area, the suspended particulate matter is attained. The emission factor is equal to the suspended particle potential multiplied by a coefficient k, which is a function of particle size.

Thus, for a given wind speed, the emissions are determined by:

$$E = \sum_{subarea} kPS$$

where:

   E   represents emissions of suspended particulate matter (g)
   k   is the multiplier coefficient related to particle size
   P   is the dust removal potential (g/m^3)
   S   is the subarea (m^2)

The US-EPA guide provides the values of k as a function of particle size (Table 6).

Table 6: Value of coefficient k as a function of particle size.

Particle size	> 30 μm	< 15 μm	< 10 μm	< 2.5 μm
Coefficient k	1	0.6	0.5	0.2

5.14 PROJECTION OF DIFFUSE SOURCES

The following table shows the difference in treatment of line, surface and volume sources in AIM and AERMOD.

Source type	Treatment in AIM	Treatment in AERMOD
Line	They are projected on a regular grid or on the segments with a user-selected resolution. Point sources thus generated have a horizontal standard deviation based on the projection resolution (see § 5.14.1).	AERMOD does not manage the line sources as such, the lines are projected using the same projection methods as AIM using the same projection parameters. To specify horizontal deviations, the projected sources are considered as "VOLUME" sources with a height of 0.5 m above the ground.
Surface	The sources are projected onto a grid whose resolution is specified by the user. As for the line sources, the sources have a projected standard deviation based on the horizontal projection resolution (see § 5.14.2).	AERMOD managing the native surface sources, two solutions are possible: - Projection AIM like considering AERMOD sources as volume sources with a horizontal deviation - No projection and use of the native algorithm of AERMOD for surface sources
Volume	The volume sources are treated as surface sources but with a height of ejection initialized to the half height of the volume (see § 5.14.3).	The volume sources are projected as the surface sources and their height is set to the height of the volume. It is then AERMOD which manages the effective height of emission.

5.14.1 Projection methods for line sources

Several methods for projecting line sources on the calculation grid net are possible:
- « initial method »
- « new method »
- « discrete segment method »
- « projection on fixed grid method »

5.14.1.1 Initial method

This first method is the one that has been applied in earlier version of ARIA Impact (no other options were possible). It consists in projecting the emissions in the grid cells intersected by the line.

The method consists in distributing the line emissions uniformly over the grid cells intersected by the line source. Each grid cell will thus emit the same pollutant quantity.

Each grid cell is further considered as a point source on the ground (H = 0 meters) with the initial diffusion Y equal to:

$$\sigma_0 = \frac{dX}{2,15} \qquad \text{(US-EPA method)}$$

where dX = grid size
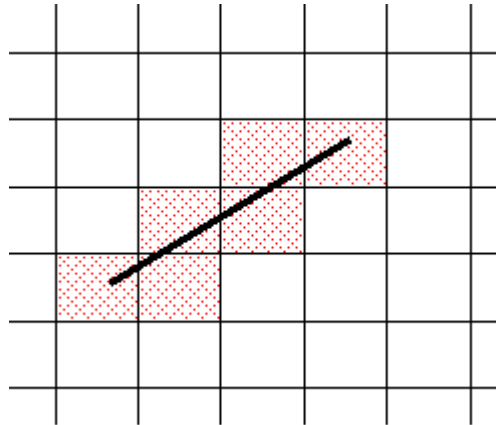
Figure 85: « Initial method » for projecting line sources

5.14.1.2 New method

This method consists in projecting the line source emissions proportionally to the length of the line segment in each grid cell. Each grid cell will therefore not emit the same pollutant quantity as in the method previously described.

Each grid cell is further considered as a point source on the ground (H = 0 meters) with the initial diffusion Y equal to:

$$\sigma_0 = \frac{dX}{2,15} \qquad \text{(US-EPA method)}$$

where dX = grid size
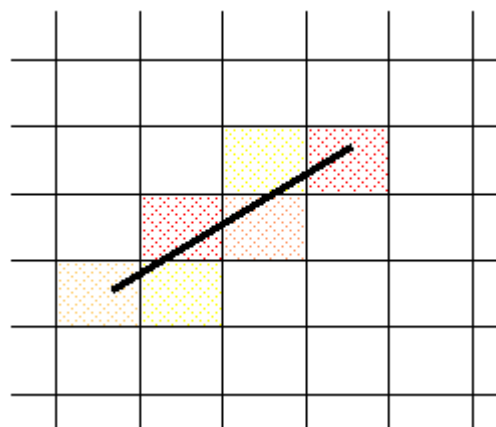
Figure 86: « New method » for projecting line sources

5.14.1.3 « Discrete segment method   »

This method consists in dividing the line sources into small segments of identical length each emitting the same pollutant quantity. The length of the segments is defined by the user in the box « Discretisation length » found in the Source options tab of the calculation windows. By default, the length of the segments is set to 50 meters.

Each segment is further considered as a point source on the ground (H = 0 meters) with the initial diffusion Y equal to:

$$\sigma_0 = \frac{dX}{2{,}15} \qquad \text{(US-EPA method)}$$

where dX = grid size

This method will result in a much larger amount of sources to account for and thus a calculation time which is monger than the two first methods.
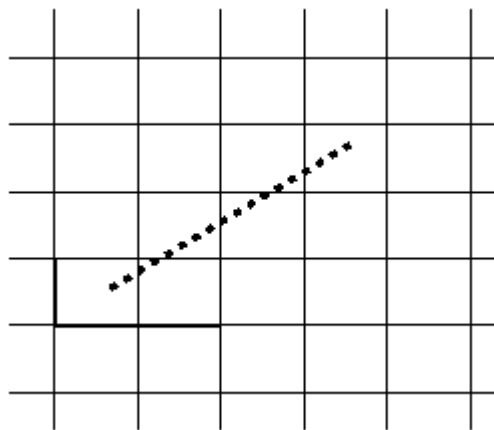
Figure 87: « Discrete segments » method for projecting line sources

5.14.1.4 « Projection on fixed grid method»

This method consists in projecting the line emissions on a grid with a higher resolution than the initial grid.

A finer grid is defined around the line sources. The size of the grid cells is defined by the user in the box « Discretisation length » found in the Source options tab of the calculation windows. By default, the size of the grid cells is set to 50 meters. The emissions of the line source are thereafter distributed uniformly in each grid cell of the finer grid.

Each grid cell is further considered as a point source on the ground (H = 0 meters) with the initial diffusion Y equal to:

$$\sigma_0 = \frac{dX}{2{,}15} \qquad \text{(US-EPA method)}$$

where dX = grid size
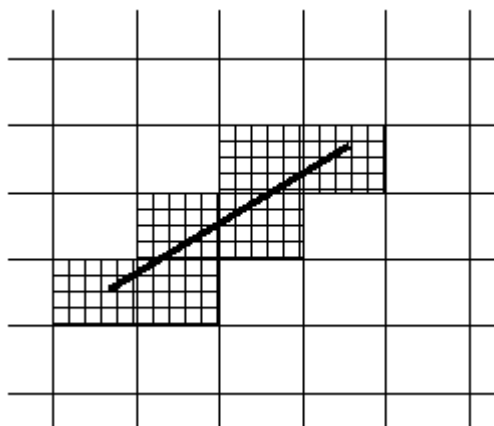
Figure 88: « Projection on fixed grid » method for projecting line sources

5.14.2 Projection methods for area sources

This method consists in projecting the emissions in the grid cells overlapped (partly or entirely) by the area source.

The area source emissions are distributed proportionally to the surface of the area source in each grid cell. Each grid cell will thus not emit the same pollutant quantity.

Each grid cell is further considered as a point source on the ground (H = 0 meters) with the initial diffusion Y equal to:

$$\sigma_0 = \frac{dX}{2{,}15} \qquad \text{(US-EPA method)}$$

where dX = grid size
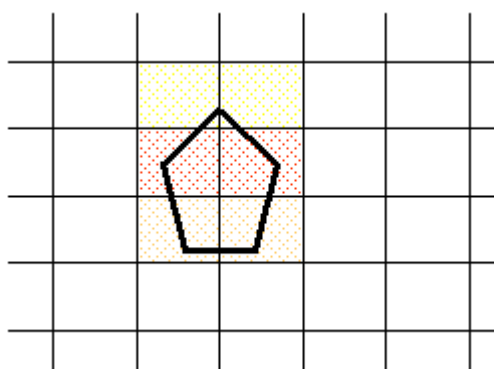
Figure 89: Method for projecting area sources

5.14.3 Projection methods for volume sources

This projection method is the same as for area sources (see above).

Each grid cell is further considered as a point source with emissions at height H = h/2 meters (h is the height of the volume source as defined by the user with the interface of ARIA Impact).

The initial diffusion Y is equal to:
$$\sigma_0 = \frac{dX}{2,15} \qquad \text{(US-EPA method)}$$

where dX = grid size

5.15 METHOD FOR CONVERTING NOx TO NO/NO$_2$

It is possible to convert the results of nitrogen oxides (NOx) to nitrogen monoxide and (NO) nitrogen dinoxide (NO$_2$). This method is recommended by MIDDLETON[7] and allows estimating the concentrations of NO and NO$_2$ based on the concentration of NOx.

$$\begin{cases} [NO_2] = 2,166 - [NOx](1,236-3,348\,A+1,933\,A^2-0,326\,A^3) \quad \text{and} \quad A = \log([NOx]) \\ [NO] = [NOx] - [NO_2] \end{cases}$$

where :

[NO$_2$] : concentration of NO$_2$ in ppb
[NOx] : concentration of NOx in ppb
[NO] : concentration of NO in ppb

This formula is only valid for traffic sources in urban environment and for calculations carried out for hourly averages of concentrations.

To use this option in ARIA Impact, first define the 3 substances NOx, NO$_2$ and NO. The emission of NO$_2$ and NO should be set to zero, only the emissions of NOx should be non-zero. In order to activate the option, check the box NO/NO$_2$ conversion in the tab « Options » of the calculation window.

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[7] "An empirical function for the ratio NO$_2$/NOx", Middleton, 1996

5.16 PLUME DOWNWASH EFFECT

Low pressure in the wake of the stack may cause the plume to be drawn downward behind the stack. Downwash can be effectively prevented by maintaining the efflux velocity (w_0) at a magnitude greater than the crosswind velocity (u). The fact that the downwash will not occur for w_0/u less than 1.5 (Briggs (1973)), suggests that the distance (h_d) that the plume downwashes below the top of the stack can be obtained by the following formula[8]:

$$h_d = 2 \times \left(\frac{w_0}{u} - 1,5 \right) \times D$$

where :

   h_d is the distance that the plume downwashes below the top of the stack
   w_0 is the vertical speed of the gas at the exit of the stack
   u is the crosswind (horizontal) speed
   D is the internal diameter of the stack
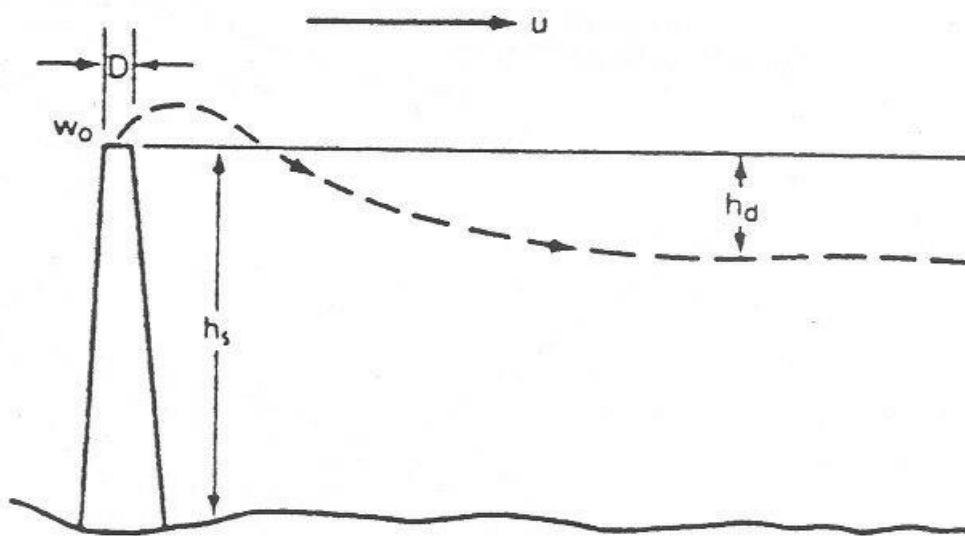
Figure 90: Downwash effect

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[8] « Handbook on atmospheric diffusion », Stevent R. Hanna, Gary A. Briggs, Rayford P. Hosker, Jr., Technical Information Center, U.S. Department of Energy, 1982

6. SOFTWARE

6.1 BASIC FEATURES

The input files of the ARIA Impact system are compatible with other **ARIA Technologies** systems and are listed and described in detail in section 3.4. Output is either in the form of tables in a printable text file or graphics that can be saved as GIF files to be inserted in a text file or printed directly.

The program scans user data files and builds an internal database by computing the values required for a run (e.g., stability classes). During this phase, it tests the parameter ranges in the user file and invalidates those outside the range.

6.2 SOFTWARE STRUCTURE

The ARIA Impact program is located in a directory, whose name is provided by the user (e.g., /IMPACT1.8). This is the root directory. Several subdirectories are installed: PROJECT, INTERFACE, SCRATCH,… and EXEC.

For each new test site, a subdirectory with the name of the project is created in /IMPACT1.8/PROJECT. It contains input and output files related to the computation run.

An intermediary directory named SCRATCH contains a copy of the files related to the ongoing project. The user has the option to save or not save changes when moving to another site or quitting an application.

ARIA Impact cannot be used simultaneously by two users working on different workstations on the same file network.

Warning!
Do not copy anything in the SCRATCH directory, which is emptied automatically.

Example:
/my documents/data/meteo/lyon.txt ⇒ space in directory name my documents ⇒ incorrect path

/Studies/Lyon_site/ARIA_impact/data/meteo/meteo_lyon.txt ⇒ 56 characters for path (> 50 characters) ⇒ incorrect path

/Studies/Lyon/impact/data/meteo/lyon.txt ⇒ correct path

6.3 CARTOGRAPHY AND COORDINATE SYSTEM

Dispersion computations superimposed on cartographic or topographic digital data require a simple and well-defined coordinate system. The cartographic coordinate system used in ARIA Impact is a system of kilometric coordinates derived from a local projection of the earth's sphere on a mapping plane. Such systems are generally established and used by national geographic organizations and serve as reference systems that can be directly integrated with the model.

One of the kilometric coordinate systems used by the French national geographic institute, IGN, is the extended French Lambert II coordinate system, which is a conic secant projection along two latitudes enclosing the study area. This system has been replaced by French Lambert 93.

The Universal Transverse Mercator (UTM) system, which is valid for the entire globe, can also be used. There are 60 UTM zones of 6° width centred on a meridian. The projection is made on a cylinder wrapped around the globe tangent to a meridian and whose axis passes through the two poles.

In both cases, the x-axis is oriented West-East and the y axis North-South.

7. EXTERNAL FILES

ARIA Impact can import external files from various sources to carry out the simulations. These files include:

- a topography file derived from a digital terrain model
- a cartography file
- a meteorological data file generally supplied by a national organization
- a substance file
- an emission file

These files should be specified according to certain formats (described below) in order to be integrated by the software.

7.1 TERRAIN FILE

The terrain file should comply with specifications established by ARIA Technologies for digital terrain models so that it can be used by most applications developed by ARIA Technologies. The specifications include georeferencing of the site described by the file and description of the terrain grid.

The terrain file is a self-descriptive ASCII file with the following structure:
- heading with file description, georeferencing, and grid definition
- terrain height data based on specified grid
- subgrid variance data based on specified grid
- reference points

The last two sections of the file are not used by the software, but they should be present to ensure compatibility with other ARIA Technologies software. The file can be generated by the utility "Relief" supplied with the software.

Example 1. Example of a terrain file

```
FILE:
/WORKIEV/ORIGNY/DATA/dannes.rel
  SITE:
dannes
  DATE OF CREATION:
3   5   0
  AUTHOR:
LD
  SOURCE FILE:
DANNES    100m IGN
 TYPE OF FILTER ON TOPOGRAHY:
NO FILTER
  SOUTHWEST POINT OF WINDOW-
  X, Y COORDINATES ROUNDED OFF BY DEFAULT:
544.3000
2611.7002
```

```
   LONGITUDE (+/- = EAST/WEST GREENWICH) AND LATITUDE OF SW POINT:
1.5538
50.4976
   FLAGS FOR SOUTHWEST POINT IN ORIGINAL SOURCE FILE:
11
46
 NORTHEAST POINT OF WINDOW-
 X, Y COORDINATES ROUNDED OFF BY DEFAULT:
564.4000
2631.8000
 LONGITUDE (+/- = EAST/WEST GREENWICH) AND LATITUDE OF NE POINT:
1.8347
50.6794
 FLAGS FOR NE POINT IN ORIGINAL SOURCE FILE:
212
247
 EXTENT OF WINDOW (X, Y   KM) :
20.1000   20.1000
 NUMBER OF POINTS ALONG X, Y / MIN TERRAIN H (M) / MAX TERRAIN H (M)
68  68     -1.    206.
 GRID SIZE (X, Y   KM) :
0.3000
 COORDINATES ALONG X AXIS (W-E DIRECTION):
0.000 0.300 0.600 0.900 1.200 1.500 1.800 2.100 2.400 2.700
3.000 3.300 3.600 3.900 4.200 4.500 4.800 5.100 5.400 5.700
6.000 6.300 6.600 6.900 7.200 7.500 7.800 8.100 8.400 8.700
9.000 9.300 9.600 9.900 10.200 10.500 10.800 11.100 11.400 11.700
12.000 12.300 12.600 12.900 13.200 13.500 13.800 14.100 14.400 14.700
15.000 15.300 15.600 15.900 16.200 16.500 16.800 17.100 17.400 17.700
18.000  18.300  18.600  18.900  19.200  19.500  19.800  20.100
 COORDINATES ALONG Y AXIS (S-N DIRECTION):
0.000 0.300 0.600 0.900 1.200 1.500 1.800 2.100 2.400 2.700
3.000 3.300 3.600 3.900 4.200 4.500 4.800 5.100 5.400 5.700
6.000 6.300 6.600 6.900 7.200 7.500 7.800 8.100 8.400 8.700
9.000 9.300 9.600 9.900 10.200 10.500 10.800 11.100 11.400 11.700
12.000 12.300 12.600 12.900 13.200 13.500 13.800 14.100 14.400 14.700
15.000 15.300 15.600 15.900 16.200 16.500 16.800 17.100 17.400 17.700
18.000 18.300 18.600 18.900 19.200 19.500 19.800 20.100


 TERRAIN ALTITUDE (M) - 1ST POINTS
 LINED FROM N-W TO N-E; LAST POINTS LINED FROM S-W TO S-E:
-1.000 -1.000 -1.000 -1.000 18.000 64.000 63.000 88.000
94.000 85.000 41.000 52.000 88.000 87.000 97.000 97.000
111.000 71.000 39.000 11.000 7.000 8.000 19.000 44.000
34.000 29.000 54.000 58.000 41.000 46.000 64.000 68.000
63.000 87.000 109.000 88.000 84.000 73.000 82.000 103.000
94.000 76.000 69.000 55.000 48.000 68.000 69.000 67.000
61.000 43.000 32.000 24.000 29.000 34.000 42.000 48.000
59.000 67.000 67.000 79.000 67.000 56.000 48.000 54.000
80.000 82.000 74.000 79.000
-1.000 -1.000 -1.000 -1.000 3.000 62.000 77.000 78.000
93.000 63.000 66.000 88.000 76.000 105.000 106.000 110.000
102.000 95.000 52.000 13.000 16.000 8.000 7.000 15.000
16.000 40.000 52.000 35.000 44.000 61.000 60.000 47.000
71.000 93.000 80.000 65.000 70.000 70.000 99.000 115.000
96.000 92.000 86.000 65.000 59.000 42.000 64.000 65.000
56.000 36.000 25.000 27.000 39.000 44.000 47.000 51.000
57.000 65.000 83.000 85.000 72.000 74.000 58.000 61.000
57.000 61.000 70.000 76.000
……
STANDARD DEVIATION OF SUBGRID (M)
```

```
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000
......
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000

 NUMER OF REFERENCE POINTS, FOLLOWED BY:
 SITE NAME / X (KM) / Y (KM) / DEFAULT FLAGS I, J / ALTITUDE (M)
0

 ALBEDO FLAG =
0
```

7.2 CARTOGRAPHY FILE

The cartography file should comply with specifications set by ARIA Technologies. It is an ASCII file with the following structure:

1. Version number: IVENUM 201
2. Number of points
3. Number of lines and maximum number of points on the line
4. Number of polygons and maximum number of points per polygon
5. Site name
6. Type of projection
   0 = Lambert II
   NN = UTM
   93 = Lambert 93
   99 = Latitude–Longitude
   For UTM coordinates, the zone is indicated by XDECAL.

7. Site name
8. Selection of unit
   0 = kilometre
   1 = metre
   99 = degrees

9. Specification of numbers
   2 = 2 digits considered
   4 = 4 digits considered

10. Selection of coordinates
       0 = absolute
       1 = relative

11. Selection of height
       1 = above-ground height
       0 = altitude
       –999 = none

12. Southwest point coordinates

13. Domain size

14. Standard point specifications

Example of point specification (PTS):

```
ELT. TYPE   =   PTS.
ELT.    NUM. / OBJ. :     10     10
POSIT    POINT
501.0000   2485.0000
```

A number is indicated for identification of each point. When the number is repeated twice on the same line, it cannot be used again for another point. The coordinates defining the position of the point is indicated by using the projection and unit previously defined.

15. Standard line specifications

Example of line specification (FIL)

```
ELT. TYPE   =   FIL.
ELT.    NUM. / OBJ. :      4      4
ROUTENAT LINE
12(1)    4(2)
502.5411   2497.6917     501.7886   2496.6692     503.2123   2496.1868
504.6909   2495.5132
505.5246   2493.2295     506.5469   2492.2886     508.2405   2491.5623
507.9992   2489.2500
507.6481   2487.3677     506.6281   2485.8364     505.7133   2484.4392
504.8271   2483.0681
```

A number is indicated for identification of each line. When the number is repeated twice on the same line, it cannot be used again for another line. Next, the user adds a comment on the line name representing:

- the number of points on the line
- the number of coordinate couples on each line

The coordinate couples of the different points setting up the line are indicated at the end.

16. Standard polygon specifications

Example of polygon specification (POL)

```
ELT. TYPE   =   POL.
ELT.    NUM. / OBJ. :      6      6
CPN      ZONE IND
7(3)     4(4)
506.0907   2494.2495     507.0581   2493.4971     507.9706   2494.3044
507.7843   2494.8420
507.1919   2494.8420     506.7356   2495.0305     506.1695   2494.3569
```

A number is indicated for identification of each polygon. When the number is repeated twice on the same line, it cannot be used again for another polygon. Next, the user adds a comment on the polygon name representing:

- the number of points on the polygon
- the number of coordinate couples of each polygon

The coordinate couples corresponding to the different points setting up the polygon are indicated at the end.

Example 2. Example of a cartography file in ARIA format

```
* IVENUM
        201
 * NB. PTS
          5
 * NB. FIL - NB. MAX PTS/FIL.
          3           13
 * NB. POL - NB. MAX PTS/POL.
          3           46
 * ------------------------------------------------------------------
 *  CARTOG . SIT.
 * ------------------------------------------------------------------
 *******************************************************************
 *  SIT. NOM.
          NOWHERE
 * ELT. PROJ =>ICOGEO=0:LII =NN:UTM ZONE =99:LATLONG
    ICOGEO   XDECAL: X SHIFT
          0      0.0000
 * ELT. UNIT  =  0:KM  1:M  99:DEG
          0
 * ELT. PRECISION  2=F11.2  4=F11.4
          4
 * ELT. RELAT. FOR LINES AND POLYGONS =
 *      0=ABSOLUTE  1:RELATIVE TO SW PT
          0
 * ELT. HEIGHT TYPE =1:HEIGHT/GROUND, =0:ALTITUDE, =-999: NO HEIGHT
    -999
    COORD. X - Y S-W KM
          0.0000
          0.0000
    DIM.  X - Y     KM
          0.0000          0.0000
 * ELT. TYPE   =
    PTS.
    ELT.    NUM. / OBJ. :     10      10
    POSIT    POINT
          501.0000   2485.0000
    ELT.    NUM. / OBJ. :      1       1
    POSIT    RECEPT2
          509.0407   2493.8481
    ELT.    NUM. / OBJ. :      2       2
    POSIT    POINT
          504.6192   2492.1785
    ELT.    NUM. / OBJ. :      3       3
    POSIT    POINT
          510.2924   2491.5168
```

```
     ELT.    NUM. / OBJ. :      11      11
     POSIT    POINT
          514.2266   2490.3345
 * ELT. TYPE   =
     FIL.
     ELT.    NUM. / OBJ. :       4       4
     ROUTENAT LINE
          12    4
502.5411 2497.6917 501.7886 2496.6692 503.2123 2496.1868 504.6909 2495.5132
505.5246 2493.2295 506.5469 2492.2886 508.2405 2491.5623 507.9992 2489.2500
507.6481 2487.3677 506.6281 2485.8364 505.7133 2484.4392 504.8271 2483.0681
     ELT.    NUM. / OBJ. :       5       5
     ROUTEDEP LINE
           9    4
514.6924 2493.3894 513.9399 2493.7119 512.7838 2494.0083 511.3052 2494.2783
510.3115 2493.7671 509.3704 2492.6636 508.9117 2491.6697 508.3743 2491.6147
508.2405 2491.5359
     ELT.    NUM. / OBJ. :       9       9
     ROUTEDEP RD134
          13    4
500.3912 2493.6475 500.9860 2492.2168 502.2759 2490.7524 503.6709 2490.5779
505.4505 2489.8447 506.2173 2488.5190 507.9276 2488.3447 509.2175 2488.6599
510.7176 2488.9036 511.9048 2487.8572 512.5665 2486.6367 513.9280 2486.4265
514.3460 2486.8110
 * ELT. TYPE   =
     POL.
     ELT.    NUM. / OBJ. :       6       6
     CPN      ZONE IND
           7    4
506.0907 2494.2495 507.0581 2493.4971 507.9706 2494.3044 507.7843 2494.8420
507.1919 2494.8420 506.7356 2495.0305 506.1695 2494.3569
     ELT.    NUM. / OBJ. :       7       7
     VILLE    POLYG
           6    4
512.0577 2492.5845 512.6214 2490.9985 514.1549 2491.2922 513.8325 2492.4485
512.5688 2492.8784 511.8976 2493.0408
     ELT.    NUM. / OBJ. :       8       8
     VILLE    POLYG
          46    4
506.4251 2491.6626 506.1456 2491.3472 505.7610 2490.7524 505.5150 2489.6704
505.5150 2489.1807 505.4816 2488.6553 505.4816 2488.1296 505.6559 2487.8167
505.7610 2487.5708 506.0764 2487.3606 506.2841 2487.1167 506.5995 2486.8374
506.9506 2486.6272 507.1584 2486.5220 507.8942 2486.3118 508.0685 2486.3118
508.3146 2486.3118 508.6275 2486.3813 509.1530 2486.8015 509.3274 2487.0476
509.3967 2487.5015 509.5017 2488.5142 509.5734 2488.6909 509.6427 2489.0398
509.7478 2489.4243 509.8171 2489.7729 509.8171 2489.9832 509.6761 2490.3679
509.2581 2490.6140 509.0837 2490.7524 508.8735 2491.0320 508.8735 2491.2087
508.9428 2491.5933 508.9786 2491.7317 508.7684 2492.1165 508.4173 2492.3625
508.0327 2492.3625 507.6839 2492.5728 507.3686 2492.7112 506.8455 2492.8162
506.5995 2492.7805 506.3200 2492.5010 506.2507 2492.2573 506.3893 2492.0112
506.4609 2491.9063 506.4251 2491.7317
```

7.3 METEOROLOGY FILE

7.3.1 Imported files

The statistical module accepts any input file having the following separators: «; « », »or tabs. A blank character separator is not accepted. Excel spreadsheet files can also be imported.

Missing or invalid data are either represented by a blank (there are two consecutive separators) or invalidated by the code –999.

Data must carry date and time information. Hours are expressed in U units. Several date formats are available, for which the following specifications must be given:

- Day: number of D characters (DD for 2-characer code),
- Month: number of M characters,
- Year: number of Y characters,
- Hour: number of H characters,
- Minute: minutes are indicated by MN.

The year can be expressed in 2 or 4 characters. Input is converted as follows for a 2-character code:

- year $\in [00,29] \rightarrow$ year $= 2000 +$ year
- year $\in [30$-$99[\rightarrow$ year $= 1900 +$ year

Meteorological data can be presented in two ways:

- one message per day: all meteorological parameters for each day (made up of several time steps) are supplied after the date on the same line.

  Example 1:
  1 day of 3-hourly data on wind direction (8 data/day)
  01/01/93 180 190 200 190 170 210 200 180

- one message per time step: meteorological parameters for each time step are supplied after the date on the same line.

  Example 2:
  1 day of 3-hourly data on wind direction (8 data/day)
  ```
  01/01/93   00   180
  01/01/93   03   190
  01/01/93   06   200
  01/01/93   09   190
  01/01/93   12   170
  01/01/93   15   210
  01/01/93   18   200
  01/01/93   21   180
  ```

Examples of different meteorological input files are given on the following pages.

Example 3. Ground station providing temperature, wind speed, wind direction, cloud cover data (3-hourly data, one message per time step)

```
01/01/98;0;14;2;121;3
01/01/98;3;14;2;127;5
01/01/98;6;17;5;130;7
01/01/98;9;16;6;139;7
01/01/98;12;17;5;149;8
01/01/98;15;18;5;143;7
01/01/98;18;19;3;135;7
01/01/98;21;18;6;123;7
02/01/98;0;18;3;125;7
02/01/98;3;18;3;129;8
02/01/98;6;22;2;130;7
02/01/98;9;24;2;135;7
02/01/98;12;24;3;135;7
02/01/98;15;22;5;130;8
02/01/98;18;29;3;115;6
02/01/98;21;36;9;88;0
03/01/98;0;4;3;86;0
03/01/98;3;4;3;96;0
03/01/98;6;6;5;79;1
03/01/98;9;2;5;102;5
03/01/98;12;2;2;138;2
03/01/98;15;36;3;138;5
03/01/98;18;3;1;119;3
03/01/98;21;0;0;99;6
```

Example 4. Ground station providing station number, temperature, wind direction, wind speed, cloud cover (3-hourly data, one message per day)

```
95527001;19940101;3.9;3.0;3.5;4.1;6.9;6.7;6.1;5.4;270;260;270;240;230;21
0;200;180;3.0;4.0;5.0;3.0;6.0;3.0;6.0;6.0;2;2;5;1;3;5;7;8;
95527001;19940102;5.2;6.2;10.2;10.0;10.5;10.6;9.6;7.8;170;190;240;240;25
0;260;240;240;11.0;10.0;7.0;8.0;8.0;9.0;6.0;5.0;8;8;7;6;6;7;6;1;
95527001;19940103;7.2;7.0;7.2;7.7;9.2;11.3;9.9;8.3;230;200;190;140;180;2
30;230;240;5.0;4.0;5.0;4.0;9.0;13.0;8.0;8.0;4;7;7;7;8;8;4;4;
95527001;19940104;6.9;6.1;6.4;7.0;8.7;8.5;6.1;6.9;220;200;200;200;220;22
0;220;240;6.0;8.0;10.0;10.0;13.0;11.0;8.0;10.0;2;5;3;7;7;5;5;6;
95527001;19940105;6.1;6.2;6.8;8.6;8.6;8.6;7.6;6.5;230;200;180;200;210;22
0;190;180;7.0;7.0;11.0;13.0;14.0;10.0;8.0;8.0;6;7;8;8;8;6;6;6;
95527001;19940106;7.3;7.3;7.7;7.5;7.2;6.8;6.2;5.7;180;200;180;180;180;19
0;200;250;12.0;9.0;9.0;9.0;7.0;5.0;7.0;4.0;7;7;8;8;8;8;7;7;
95527001;19940107;4.4;3.6;3.7;3.3;5.0;5.6;5.0;3.4;220;130;220;260;280;14
0;180;200;3.0;2.0;2.0;1.0;1.0;3.0;3.0;3.0;7;7;7;8;7;7;7;0;
95527001;19940108;1.6;1.5;0.7;1.1;2.5;2.5;1.9;2.1;200;160;170;150;170;15
0;140;140;3.0;4.0;4.0;4.0;6.0;7.0;8.0;5.0;0;0;7;8;8;8;8;8;
95527001;19940109;2.2;2.1;2.3;3.1;4.4;5.5;5.9;5.7;150;160;150;140;160;15
0;130;130;6.0;4.0;5.0;6.0;5.0;6.0;8.0;6.0;8;5;7;7;8;7;7;5;
95527001;19940110;5.5;5.8;6.4;6.2;6.7;7.2;6.8;6.4;140;120;160;150;170;15
0;190;200;5.0;6.0;4.0;4.0;2.0;4.0;3.0;3.0;5;8;8;8;8;8;8;6;
95527001;19940111;5.2;4.4;2.7;3.7;4.7;5.7;6.0;7.3;200;210;200;210;190;19
0;170;200;2.0;3.0;3.0;4.0;5.0;5.0;6.0;7.0;2;3;7;8;8;8;7;8;
95527001;19940112;7.6;7.8;8.4;9.3;10.9;13.1;12.9;13.3;190;180;170;200;22
0;220;220;210;5.0;6.0;5.0;8.0;11.0;10.0;11.0;12.0;8;8;8;8;8;8;8;8;
95527001;19940113;12.8;10.0;10.1;10.0;11.2;11.0;10.5;9.7;210;270;240;230
;230;220;220;240;12.0;13.0;7.0;7.0;9.0;7.0;7.0;9.0;8;8;8;6;6;7;7;7;
```

Example 5. Sodar file of Valduc station, France, providing meteorological data for different heights (one message per time step)

```
VA,9302221500,100,344,1.9,,0001,0.5,1168,1,
VA,9302221500,150,313,3.4,,,0.4,0735,1,
VA,9302221500,200,328,6.8,,0003,0.4,0545,1,
VA,9302221520,050,323,2.9,,0001,0.4,1925,,
VA,9302221520,100,327,2.6,,,0.1,1474,,
VA,9302221520,150,,,,,0.4,0813,,
VA,9302221600,050,,,,,0.2,1449,1,
VA,9302221600,100,359,5.1,,,,,1,
VA,9302221600,150,347,5.8,,,0.7,0585,1,
VA,9302221600,200,350,8.3,,,,,1,
VA,9302221600,250,346,8.3,,,,,1,
VA,9302221600,300,343,9.1,,,,,1,
VA,9302221600,350,339,8.6,,,,,1,
VA,9302221900,100,294,3.9,,,0.2,0980,,
VA,9302222100,050,,,,,0.0,1487,1,
VA,9302222100,100,332,5.5,,,0.4,0679,1,
VA,9302222100,150,340,5.4,,,,,1,
VA,9302222100,200,346,7.3,,,0.6,0652,1,
VA,9302222100,250,345,7.2,,,0.4,0740,1,
VA,9302222100,300,350,8.7,,,,,1,
```

Example 6. Valduc ground station file (one message per time step)

```
VA,9306101500,000,0.0,20.1,085,954.1,,,0.0,1
VA,9306101600,262,4.7,18.8,089,954.3,,,0.0,1
VA,9306101700,209,3.4,20.2,086,954.1,,,0.0,1
VA,9306101800,191,3.1,18.8,093,954.3,,,0.0,1
VA,9306101900,189,3.6,17.2,085,954.2,,,0.2,1
VA,9306102000,196,3.8,16.5,088,953.8,,,0.0,1
VA,9306102100,224,3.8,15.2,096,954.8,,,0.0,1
VA,9306102200,225,2.4,14.5,100,954.6,,,0.0,1
VA,9306102300,228,3.2,14.1,100,954.8,,,0.0,1
VA,9306110000,234,4.3,14.1,093,955.1,,,0.0,1
VA,9306110100,247,4.0,13.6,098,955.2,,,0.0,1
VA,9306110200,217,3.2,13.0,100,955.3,,,0.0,1
VA,9306110300,201,2.8,12.7,100,955.7,,,0.2,1
VA,9306110400,238,5.9,12.6,097,955.7,,,0.0,1
VA,9306110500,240,6.1,12.9,092,956.4,,,0.0,1
VA,9306110600,239,6.2,12.8,088,956.7,,,0.0,1
VA,9306110700,235,6.0,13.3,086,957.3,,,0.0,1
VA,9306110800,232,6.2,13.3,086,957.7,,,0.0,1
```

7.3.2 Exported files

Export files are in standard table format. The heading comprises the station name, wind rose type, statistical computation period, and the number of valid and invalid values.

The file indicates, for each type of wind rose, the frequency distribution or the number of wind speed (entered on the top line of the table) and wind direction classes (left column).

The values entered in the table indicate either the number or percentage of observed cases for each wind speed and wind direction class (see example for the Marseille station).

```
X:   846.00KM  Y: 1815.00KM Z:   10. M
 ST :         MARSEILLE
GENERAL WIND ROSE
 D:  1/ 1/1993 -> 31/12/1997




 ** Nbr total :   14237 valid
 ** Nbr total :     371 invalid

 ** Table of occurrences  / Valid data
 ********************************************************************************************
 *         *<0.9 m/s*  1 m/s*   2 m/s* 3-6 m/s*7-12 m/s*>=13 m/s*Calm m/s*  Tot.  *VMOY m/s*
 ********************************************************************************************
 * 20  Deg*    0 *  169 *  161 *  262 *   25 *    0 *    0 *  617 *  2.8  *
 * 40  Deg*    0 *   83 *   49 *   31 *    1 *    0 *    0 *  164 *  1.8  *
 * 60  Deg*    0 *  105 *   79 *   48 *    0 *    0 *    0 *  232 *  1.8  *
 * 80  Deg*    0 *  307 *  522 *  290 *    2 *    0 *    0 * 1121 *  2.0  *
 * 100 Deg*    0 *  319 *  610 *  308 *    6 *    0 *    0 * 1243 *  2.1  *
 * 120 Deg*    0 *  278 *  399 *  667 *  214 *    0 *    0 * 1558 *  3.6  *
 * 140 Deg*    0 *  147 *  161 *  440 *  138 *    0 *    0 *  886 *  4.0  *
 * 160 Deg*    0 *   78 *   78 *  244 *   24 *    0 *    0 *  424 *  3.4  *
 * 180 Deg*    0 *   36 *   67 *  216 *   12 *    0 *    0 *  331 *  3.4  *
 * 200 Deg*    0 *   38 *   69 *  130 *    0 *    0 *    0 *  237 *  2.7  *
 * 220 Deg*    0 *   58 *   65 *  142 *    1 *    0 *    0 *  266 *  2.7  *
 * 240 Deg*    0 *   48 *   60 *   76 *    0 *    0 *    0 *  184 *  2.4  *
 * 260 Deg*    0 *   78 *   92 *  172 *    1 *    0 *    0 *  343 *  2.6  *
 * 280 Deg*    0 *   74 *  174 *  382 *   19 *    0 *    0 *  649 *  3.1  *
 * 300 Deg*    0 *  115 *  265 *  583 *   32 *    0 *    0 *  995 *  3.2  *
 * 320 Deg*    0 *  175 *  349 *  733 *   94 *    0 *    0 * 1351 *  3.4  *
 * 340 Deg*    0 *  259 *  351 *  935 *  143 *    0 *    0 * 1688 *  3.6  *
 * 360 Deg*    0 *  196 *  295 *  617 *   74 *    0 *    0 * 1182 *  3.3  *
 *Calm Deg*    0 *    0 *    0 *    0 *    0 *    0 *  766 *  766 *  0.0  *
 ********************************************************************************************
 *Tot.    *    0 * 2563 * 3846 * 6276 *  786 *    0 *  766 * 14237 *  2.9  *
 ********************************************************************************************
```

7.4 BACKGROUND CONCENTRATION FILE

The statistical module accepts any input file having the following separators: " ; ", " , " or tabs. A blank character separator is not accepted. Excel spreadsheet files saved under .csv format (separator ;), can also be imported.

Missing or invalid data are either represented by a blank (there are two consecutive separators) or invalidated by the code –999.

Data must carry date and time information. Hours are expressed as UTC (Universal Time Conversion/Greenwich mean time). Several date formats are available, for which the following specifications must be given:

- Day: number of D characters (DD for 2-characer code),
- Month: number of M characters,
- Year: number of Y characters,
- Hour: number of H characters,
- Minute: minutes are indicated by MN.

The year can be expressed in 2 or 4 characters. Input is converted as follows for a 2-character code:

- year $\in$ [00,29[➜ year = 2000 + year
- year $\in$ [30-99[➜ year = 1900 + year

The data in these files can be stored in two different ways:

- one message per day: (composed by several time steps), all data related to each <u>day</u> is listed on one line.

  Exemple : 1 day of three-hourly data of NOx concentration (8 measurements / day)

  01/01/93 22 24 30 32 29 25 20 15

- one message per date (time step) : all data related to each <u>time step</u> is listed on one line.

  Example : 1 day of three-hourly data of NOx concentration (8 measurements/day)

  ```
  01/01/93  00  22
  01/01/93  03  24
  01/01/93  06  30
  01/01/93  09  32
  01/01/93  12  29
  01/01/93  15  25
  01/01/93  18  20
  01/01/93  21  15
  ```

The files of background concentration thus have the same format as the files of meteorological data. A file can include data for several substances (the substances should first be defined in the « Dictionary editor » - found in menu « Tools »).

7.5 SUBSTANCE FILE

There are two different formats possible for the substance files:

- Excel csv format (separator ;)
- Format ARIA

7.5.1 Excel .csv format (separator ;)

This is an ASCII file (text format) with data separated with semicolon « ; ». It contains several columns describing the characteristics of the substance. Each line corresponds to one substance.

Description of file format :

SPEID :	Index of substance
NAMSPE :	Name of substance (max 8 characters)
IRASPE :	Flag for link to another database (e.g., gas characteristics, toxicity) etc…). 1 = radioactive element 0 = no radioactive element *This indicator is not used by ARIA Impact*
CATEG :	Substance category: 0 = Category « Mass » 1 = Category « Activity » (for radioactive pollutants) 2 = Category « Odour » (for a set of pollutants integrated to one « odour » substance)
ITYSPE :	Substance phase: 0 = « Gas » phase 1 = « Particulate » phase
VDEPOS :	Substance dry deposition velocity (m/s)
RWASHC :	Substance washout ratio (s^{-1})
TDECAY :	Substance decay (half-life) (sec)
DENSPE :	Substance masse volume (kg/m^3)
DIAMSO :	Substance particule diameter (µm) (if « Particulate » phase

Example of substance file :
```
SPEID;NAMSPE;IRASPE;CATEG;ITYSPE;VDEPOS;RWASHC;TDECAY;DENSPE;DIAMSO
1;Nox;0;0;0;0;0;0;1;0;
2;PM10;0;0;1;0.001;1e-005;0;5000;10;
3;odour;0;2;0;0;0;0;1;0;
4;uranium;0;1;0;0;0;86400;1;0;
5;PM50;0;0;1;0.001;1e-005;0;5000;50;
```

This file can be created with MS-Excel, by saving it in .csv format (separator ;).

	A	B	C	D	E	F	G	H	I	J
1	SPEID	NAMSPE	IRASPE	CATEG	ITYSPE	VDEPOS	RWASHC	TDECAY	DENSPE	DIAMSO
2	1	Nox	0	0	0	0	0	0	1	0
3	2	PM10	0	0	1	0.001	1.00E-05	0	5000	10
4	3	odeur	0	2	0	0	0	0	1	0
5	4	uranium	0	1	0	0	0	86400	1	0
6	5	PM50	0	0	1	0.001	1.00E-05	0	5000	50

7.5.2 ARIA format: PEMSPE

ARIA ASCII format file also called « PEMSPE » ; this file is compatible with different ARIA Technologies models.

> **Warning!**
> This file doesn't contain any information about pollutant category. All pollutants in this file are considered to be category « Mass ».

Description of parameters:

NLAACT	Arbitrary value (a value should be defined but it is not used)
NDPUTI	Total number of defined substances
IP	Substance index (from 1 to NDPUTI)
NAMSPE	Substance name (8 characters)
IND	Substance code
IL – IL = 0 – IL = 1	Flag for link to another database (e.g., gas characteristics, toxicity) – no radioactive element – radioactive element
DIAM	Diameter (µm) if substance belongs to a size class (particulates)
IT – IT = 0 – IT = 1 – IT = 2 – IT = 3 – IT < 0	Substance type – gas – aerosol – heavy gas – droplet class - ignored → gas
DENS	Density (kg/m³) of emitted material – gas density for gases – dry aerosol density for solid aerosols – liquid aerosol density for aerosols – DENS < 0: ignored
VDEP	Dry deposition velocity of element (m/s)
RWASH	Washout coefficient (/sec)
TDECAY	Decay time (half-life, dry) – TEDECAY< 0: ignored – IL = 1: ignored

An example of a PEMSPE file is presented below.

Example of an ARIA format file:

```
***********************************************************************
* NLAACT* = TOTAL NUMBER OF LANGUAGES ACTIVATED IN THE LIST.
*----------------------------------------------------------------------
       0
*----------------------------------------------------------------------
* NDPUTI * = TOTAL NUMBER of SUBSTANCES
*----------------------------------------------------------------------
       5
*----------------------------------------------------------------------
*IP* NAMSPE * IND*IL*  VDEP * RWASH   * TDECAY   *    DENS * DIAM * IT*
*  *  (8.C) *    *  *   M/S * SEC-1   * SEC      * KG/M3   * MIC. * --*
*----------------------------------------------------------------------
  1*Nox     *   1* 0*0.00000* 0.00E+00* 0.000E+00*0.100E+01*   0.*  0*
  2*PM10    *   2* 0*0.00100* 0.10E-04* 0.000E+00*0.500E+04*  10.*  1*
  3*odour   *   3* 0*0.00000* 0.00E+00* 0.000E+00*0.100E+01*   0.*  0*
  4*uranium *   4* 0*0.00000* 0.00E+00* 0.864E+05*0.100E+01*   0.*  0*
  5*PM50    *   5* 0*0.00100* 0.10E-04* 0.000E+00*0.500E+04*  50.*  1*
* ----------------------------
```

7.6 EMISSION FILES ("CLIENT" FORMAT)

7.6.1 Organization of emission files

The emissions are described by defining different files:

- **Mandatory** file describing constant parameters also called « **Time independent emission files** » ;

- **Optional** files describing variation of emissions in time. These variations can be defined in 2 different ways, either by defining the emissions during specific periods (dates) called « **Time dependent emission files** », or by describing the typical hourly, daily and monthly variation of emissions called « **Modulation files** ».

As the parameters are not identical for describing the different source types, three different file formats can be distinguished:
- Point sources (LPS)
- Line sources (LIN)
- Area sources (SRF)

7.6.2 General remarks

- The files are **compatible with MS-Excel** (.CSV files) with a header indicating the position of the different fields

- The headers can be enclosed by inverted commas (")

- The **characters** authorized for character parameters include: lower case letters from "a" to "z", upper case letters from "A" to "Z", numbers 0 to 9, the character "_", and space " ". Inverted commas (") cannot be used

- The **decimal** separator must be a point "."

- The **character separating different parameters** must be a semicolon ";"

- Some fields are **mandatory** whereas others are **optional**. A column corresponding to an optional field can be deleted from the file, however if it remains in the file, it must be filled with valid values. For each field, a default value is given, if there is no default value the character « - » will be used

- The letter « V » and « C » in the tables describing the different fields, indicate if a parameter is time dependant (« V ») or not (« C »). The time dependant parameters can appear in the time dependant emission files.

- When defining the name of the pollutants only the characters « a » to « z » or « A » to « Z » are accepted. The characters will be automatically transformed to lower case letters

The description of different file formats in the paragraphs below, is made in the following manner:

Background color:
- fields with a red background correspond to main source parameters
- fields with a cyan blue background correspond to classification and naming of sources
- fields with a light blue background correspond to SNAP classification
- fields with a green background correspond to geographical fields
- fields with a yellow background correspond to physical parameters of the source
- fields with a light pink background correspond to substance data.

Text style
- fields with italic text are optional
- fields in bold text are mandatory

Other

The `classification` of emission generating activities is the same for all point sources and must correspond to that used for other source types. Different classifications cannot be combined. The default classifications are SNAP97 and SCC. A user-defined classification can also be applied.

The `projection type` is the same for all point sources and must correspond to that used for area and line sources.

If a `reference point` is defined, it must be the same for all point sources.

7.6.3   ARIA format: PEMTIM

Below is an example of an ARIA export format with projection of line sources on the grid:

Example		

900
  3   0
MCG.
    1
 0.0000000E+00 0.0000000E+00
     25 6 1 12 0 0
		Header

1#NULL   #NULL   #<u>POINT</u>   #
    2#
# 1# 1# 0# 0# 	
      # 505000.#2490960.# 80.#   1#   0# 0.15E+03#
       #   0.#   0.# 0.# 0.20E+01# 0.00# 0.00# 0.15E+02#
  1#NOX   #0.150E+12# 1#
  2#PM   #0.500E+11# 2#
	1st hour	Point sources

# 2# 1# 0# 0# 	
  1#NOX   #0.150E+12# 1#
  2#PM   #0.500E+11# 2#
	2nd hour	

1#NULL #NULL #<u>LINE</u> # 2#	1st hour	Line sources

Example		

# 1# 1# 0# 0# 	
  # 501450.#2483550.# 0.# 1# 0# 0.00E+00#
  # 140.# 140.# 0.# 0.00E+00# 0.00# 0.00# 0.00E+00#
 1#NOX #0.786E+10# 1#
 2#PM #0.393E+10# 2#		

# 2# 1# 0# 0# 1#NOX #0.786E+10# 1# 2#PM #0.393E+10# 2#	2nd hour	
1#NULL #NULL #<u>P O L Y G</u> # 2#	1st hour	Area sources

# 1# 1# 0# 0# 	
  # 507450.#2490150.# 0.# 1# 0# 0.00E+00#
  # 300.# 300.# 0.# 0.00E+00# 0.00# 0.00# 0.00E+00#
 1#NOX #0.360E+11# 1#
 2#PM #0.180E+11# 2#		

# 2# 1# 0# 0# 1#NOX #0.360E+11# 1# 2#PM #0.180E+11# 2#	2nd hour	

<table>
<tr><td colspan="6" align="center">**Details**</td><td rowspan="10">HEADER</td></tr>
<tr><td colspan="6">Number of PEMTIM version</td></tr>
<tr><td colspan="3">Number of Sources</td><td colspan="3">Number of classification levels</td></tr>
<tr><td colspan="6">Unit</td></tr>
<tr><td colspan="6">Type of emission (1=mass 2=activity)</td></tr>
<tr><td colspan="3">Origo (absolute) of X positions (km)</td><td colspan="3">Origo (absolute) of Y positions (km)</td></tr>
<tr><td colspan="6">Start date and hour of the of file, DD MM YY HH MN SS</td></tr>
<tr><td>Source number</td><td>NAME 1</td><td>NAME 2</td><td colspan="3">NAME 3: source type (POINT, LINE, POLYG)</td></tr>
<tr><td colspan="6">Total number of periods</td></tr>
<tr><td colspan="2">Period number</td><td>Time length of period, HH</td><td colspan="2">Time length of period, MN</td><td>Time length of period, SS</td></tr>
</table>

Pos.X (m)	Pos.Y (m)	Height/ground (m)	N° of poly-objects belonging to the source (0 if not a poly-object)	Type of source (0,1,2,3,30 and 31)	Temperature (°C)
Dimension of the source in X direction (m)	Dimension of the source in Y direction (m)	Dimension of the source in Z direction (m)	Diameter of the source (m)	Horizontal speed of emission in x direction (m/s)	Horizontal speed of emission in y direction (m/s)	Vertical speed of emission (m/s)
Number of substance		Name of substance		Quantity emitted during the period	Substance index

If the user wants to export a source file to ARIA format without projecting the line sources on the grid, the format of the exported file will instead be:

Pos.X P1 (m)	Pos.Y P1 (m)	Height / ground P1 (m)	N° of poly-objects belonging to the source (0 if not a poly-object)	Type of source (0,1,2,3,30 and 31)	Temperature (°C)
Pos.X P2 (m)	Pos.Y P2 (m)	Height / ground P2 (m)	N° predecessor	N° successor	3rd neighbour	4th neighbour
Dimension of the source in X direction (m)	Dimension of the source in Y direction (m)	Dimension of the source in Z direction (m)	Diameter of the source (m)	Horizontal speed of emission in x direction (m/s)	Horizontal speed of emission in y direction (m/s)	Vertical speed of emission (m/s)
Number of substance		Name of substance		Quantity emitted during the period	Substance index

7.6.4   Time independent emission files

For area and line sources, two types of files are possible for describing the sources:

•   A simplified file where sources are described as segments or quadrangle

•   A more complex approach with two files: the first one describing the general information of the sources and the second one, a DXF file, describing the geographical objects corresponding to the sources (this file can be prepared with a GIS such as MapInfo, ArcWiew, AutoCad etc..). The two files are linked by the IDGEOM flag for each line source.

7.6.4.1 Point sources (LPS)

Parameter	Description	Type	Default value	Status	Time dependency
SRCEID	Absolute indicator of the point source, used for identifying a given source. Each value is unique.	Integer	-	!	C, V
IDADM1	Administrative code corresponding to the highest administrative territorial unit (e.g., country, county, province, or state code) where the point source is located. The default is –999	Integer	-999	Optional	C
IDADM2	Administrative code corresponding to a lower administrative territorial unit where the point source is located. For example, if IDADM1 is the country code, IDADM2 could be the administrative code for the county or city. The default is –999.	Integer	-999	Optional	C
NAMADM	Name of the territorial unit where the source is located (e.g., county, state, district). The default is NULL.	20 char.	NULL	Optional	C
NAMGP1	First level of point source ID (name of the map visualization attributes in the GUI) The default is NULL	8 char.	NULL	!	C
NAMGP2	Second level of point source ID (name of the graphic object in the GUI). The default is NULL.	8 char.	NULL	!	C
NAMGP3	Third level of point source ID	16	NULL	!	C

	(name of the source in the GUI). The default is NULL.	char.			
IDCLA1	First classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the first classification level, 01, corresponds to "Combustion activities in energy and transformation industries"). The default is −999.	Integer	-999	!	C
IDCLA2	Second classification level for emission generating activity (e.g. in the case of the SNAP97 methodology, the second classification level, 01, corresponds to "Public power"). The default is −999.	Integer	-999	!	C
IDCLA3	Third classification level for emission generating activity (e.g. in the case of the SNAP97 methodology, the third classification level, 05, corresponds to "Electricity production−stationary engines"). The default is −999.	Integer	-999	!	C
IDCLA4	Fourth classification level for emission generating activity. The default is −999.	Integer	-999	!	C
IDCLA5	Fifth classification level for emission generating activity. The default is −999.	Integer	-999	!	C
IDPROJ	Type of projection selected for coordinates defining point source positions and the reference point: 0 = Lambert Conformal Conic 1 to 60 = Transverse Mercator (Gauss-Krüger) 99 = longitude/latitude The default is 0.	Integer	-	!	C
SHIFTX	Shift of x-axis of origin in Transverse Mercator system, (UTM zone). To be entered only if Transverse Mercator is selected. The default is 0.	Real	0	!	C
ORIGX	X coordinate of reference point that serves as the origin for positioning the point source:	Real	0.	!	C

	– in meters – in decimal degrees if IDPROJ = 99 (longitude/latitude) If a value is entered, the position of the point source (POSX and POSY) is given in relation to this point. POSX and POSY are absolute coordinates if ORIGX = 0 and ORIGY = 0. The default is 0.				
ORIGY	Y coordinate of reference point that serves as the origin for positioning the point source: – in meters – in decimal degrees if IDPROJ = 99 (longitude/latitude) If a value is entered, the position of the point source (POSX and POSY) is given in relation to this point. POSX and POSY are absolute coordinates if ORIGX = 0 and ORIGY = 0. The default is 0.	Real	0.	!	C
POSX	X coordinate of point source position: – in meters – in decimal degrees if IDPROJ = 99 (longitude/latitude) POSX must be given in relation to the reference point (if ORIGX and ORIGY are other than 0) according to the selected projection system (IDPROJ). Otherwise, POSX represents the absolute x coordinate in the selected projection system.	Real	-	!	V
POSY	Y coordinate of point source position: – in meters – in decimal degrees if IDPROJ = 99 (longitude/latitude) POSY must be given in relation to the reference point (if ORIGX and ORIGY are other than 0) according to the selected projection system (IDPROJ).	Real	-	!	V

	Otherwise, POSY represents the absolute y coordinate in the selected projection system.				
HEIGHT	Height (m.a.g.l) of gas exhaust. In the case of a stack, HEIGHT is equal to the stack height. The value is either positive or 0.	Real	-	!	V
DIAMET	Diameter (in meters) of point source. In the case of a stack, DIAMET is equal to the stack diameter. The value is either positive or 0.	Real	-	!	V
TEMPER	Emission temperature (degrees Kevin). In the case of a stack, TEMPER is equal to the gas exit temperature. If the entered value is –999, the computation will consider ambient temperature. Otherwise, the value is positive.	Real	-	!	V
SPEEDX	Gas exhaust velocity (m/s) along X axis. In the case of a stack, SPEED is equal to the stack exit velocity.	Real	-	!	V
SPEEDY	Gas exhaust velocity (m/s) along Y axis.	Real	-	!	V
SPEEDZ	Gas exhaust velocity (m/s) along Z axis.	Real	-	!	V
IDUNIT_i	Unit in which emission rate (parameter Q_i) is expressed. Available options: see. 7.6.7	Integer	-	!	C
Q_i	Emission rate expressed in selected unit (IDUNIT). The value is either positive or 0.	Real	-	!	V

Example :

In the example below, 3 point sources have been documented. The names of the 23 first fields is consistent with the table above. Four substances have been listed: NOx, odour, uranium and PM10. The units and the names of the fields follow the nomenclature « IDUNIT_ » + name of substance and « Q_ » + name of substance.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	SRCEID	IDADM1	IDADM2	NAMADM	NAMGP1	NAMGP2	NAMGP3	IDCLA1	IDCLA2	IDCLA3	IDCLA4	IDCLA5	IDPROJ	SHIFTX	ORIGX	ORIGY	POSX
2	1	1	1	NULL	four1	NULL	NULL	-999	-999	-999	-999	-999	0	0	0	0	788150
3	2	1	1	NULL	four2	NULL	NULL	-999	-999	-999	-999	-999	0	0	0	0	790500
4	3	1	1	NULL	chaudiere	NULL	NULL	-999	-999	-999	-999	-999	0	0	0	0	794364

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	POSX	POSY	HEIGHT	DIAMET	TEMPER	SPEED	IDUNIT_NOx	Q_NOx	IDUNIT_odeur	Q_odeur	IDUNIT_uranium	Q_uranium	IDUNIT_PM10	Q_PM10
2	788150	1956500	30	2	373.15	15	1	800	6	8000	7	70000	3	50
3	790500	1965250	20	1.2	423.15	12	1	500	6	7000	7	50000	3	20
4	794364	1952648	15	1	353.15	8	1	300	6	10000	7	20000	3	10

7.6.4.2 Simplified line sources (LIN)

In this file, the sources are described as line segments set up by two points

Parameter	Description	Type	Default value	Status	Time dependency
SRCEID	Absolute indicator of the line source, used for identifying a given source. Each value is unique.	Integer	-	!	C
IDADM1	Administrative code attributed by the highest administrative authority of the territorial unit (e.g., country, county, province, or state code) where the line source is located.	Integer	-999	Optional	C
IDADM2	Administrative code of the lowest administrative authority of the territorial unit where the line source is located. For example, if IDADM1 is the country code, IDADM2 is the code for the following territorial unit. The default is –999	Integer	-999	Optional	C
NAMADM	Name of the territorial unit where the source is located (e.g., county, state, district). The default is NULL.	20 ch	NULL	Optional	C
NAMGP1	First level of line source ID (name of the map visualization attributes in the GUI). The default is NULL	8 ch	NULL	!	C
NAMGP2	Second level of line source ID (name of the graphic object in the GUI). The default is NULL.	8 ch	NULL	!	C
NAMGP3	Third level of line source ID (name of the source in the GUI). The default is NULL.	16 ch	-	!	C
IDCLA1	First classification level for emission generating activity (e.g. in the case of the SNAP97 methodology, the first classification level, 07, corresponds to "road transportation". The default is –999.	Integer	-999	!	C
IDCLA2	Second classification level for	Integer	-999	!	C

	emission generating activity (e.g. in the case of the SNAP97 methodology, the second classification level, 01 corresponds to "passenger cars"). The default is −999.				
IDCLA3	Third classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the third classification level, 03, corresponds to "urban transport"). The default is −999.	Integer	-999	!	C
IDCLA4	Fourth classification level for emission generating activity. The default is −999..	Integer	-999	!	C
IDCLA5	Fifth classification level for emission generating activity. The default is −999.	Integer	-999	!	C
IDPROJ	Type of projection selected for coordinates of points defining the contours of the line source (see section geographical object file): 0 = Lambert II 1 to 60 = UTM 99 = longitude/latitude Default is 0.	Integer	-	!	C
SHIFTX	Shift of x axis of origin in Transverse Mercator system, (UTM zone). To be entered only if Transverse Mercator is selected. The default is 0.	Real	0.	!	C
ORIGX	X coordinate of reference point that serves as the origin for positioning the line source: - in meters - in decimal degree if IDPROJ=99 (longitude/latitude) If a value is entered, the position of the line source (POSX and POSY) is given in relation to this point. POSX and POSY chare absolute coordinates if ORIGX = 0 and ORIGY = 0. The default is 0.	Real	0.	!	C
ORIGY	Y coordinate of reference point that serves as the origin for	Real	0.	!	C

	positioning the line source: - in <u>meters</u> - in <u>decimal degree</u> if IDPROJ=99 (longitude/latitude) If a value is entered, the position of the line source (POSX and POSY) is given in relation to this point. POSX and POSY chare absolute coordinates if ORIGX = 0 and ORIGY = 0. The default is 0.				
IDZH	Reference height used for the sources : 0: height above sea level 1: height above ground In AIM, this value should always be set to 1.	Real	-	!	C
X1	X coordinate of the first point of the line: - in <u>meters</u> in <u>decimal degree</u> if IDPROJ=99 (longitude/latitude) If a reference point has been defined (i.e. if ORIGX et ORIGY are not equal to 0), the value of X1 corresponds to the X coordinate <u>relative</u> to this reference point. Otherwise, X1 represents the <u>absolute</u> value of the X coordinate.	Real	-	!	V
Y1	Y coordinate of the first point of the line: - in <u>meters</u> if IDPROJ=0 (Lambert II) or if IDPROJ=1-60 (UTM) - in <u>decimal degree</u> if IDPROJ=99 (longitude/latitude) If a reference point has been defined (i.e. if ORIGX et ORIGY are not equal to 0), the value of X1 corresponds to the Y coordinate <u>relative</u> to this reference point. Otherwise, X1 represents the <u>absolute</u> value of the Y coordinate.	Real	-	!	V
ZH1	Height (in metres) at which emission occurs. ZH1 represents height above sea	Real	-	!	V

	level or above ground according to IDZH value. The value is either positive or 0.				
X2	Same as X1 for the second segment point.	Real	-	!	V
Y2	Same as Y1 for the last segment point .	Real	-	!	V
ZH2	Same as ZH1 for the last segment point.	Real	-	!	V
SLOPE	Slope (%) of the line source in forward direction (X1, Y1 → X2, Y2) (direction in which vehicles move on roadway). The sign of the slope indicates if it is upward (positive) or downward (negative).	Real	-999	Optional	V
WIDTH	Width (in metres) of line source	Real	-999	Optional	V
IDCANYON	Canyon Key	Integer	-1	Optional	C
SPEEDX	Gas exhaust velocity (m/s) along X axis.	Real	-	!	V
SPEEDY	Gas exhaust velocity (m/s) along Y axis.	Real	-	!	V
SPEEDZ	Gas exhaust velocity (m/s) along Z axis.	Real	-	!	V
IDUNIT_i	Unit in which emission rate (parameter Q_i) is expressed. Available options: see. 7.6.7	Integer	-	!	C
Q_i	Emission rate expressed in selected unit (IDUNIT). The value is either positive or 0.	Real	-	!	V

7.6.4.3 Complex line source file

Two different files are required for complex line source definition. The first one describing the general information of the sources and the second one, a DXF file, describing the geographical objects corresponding to the line sources (this file can be prepared with a GIS such as MapInfo, ArcWiew, AutoCad etc..). The two files are linked by the IDGEOM flag for each line source.

> Warning!
> It is strongly recommended to either use simple or complex line source files in one same project. However, if the user wants to apply the two different type of files in one same project, first make sure that the values of parameter IDGEOM and SRCEID don't occur in doubles in the two files.

General information file:

Parameter	Description	Type	Default value	Status	Time dependency
SRCEID	Absolute indicator of the line source, used for identifying a given source. Each value is unique.	Integer	-	!	C
IDGEOM	Absolute indicator of administrative zone. It is also used for identifying a given geographical object zone in the corresponding DXF file. Each value should correspond to a single object.	Integer	-	!	C
IDADM1	Administrative code attributed by the highest administrative authority of the territorial unit (e.g., country, county, province, or state code) where the line source is located.	Integer	-999	Optional	C
IDADM2	Administrative code of the lowest administrative authority of the territorial unit where the line source is located. For example, if IDADM1 is the country code, IDADM2 is the code for the following territorial unit. The default is –999	Integer	-999	Optional	C
NAMADM	Name of the territorial unit where the source is located (e.g., county, state, district). The default is NULL.	20 ch	NULL	Optional	C
NAMGP1	First level of line source ID (name of the map visualization attributes in the GUI). The default is NULL	8 ch	NULL	!	C
NAMGP2	Second level of line source ID (name of the graphic object in the GUI). The default is NULL.	8 ch	NULL	!	C
NAMGP3	Third level of line source ID (name of the source in the GUI). The default is NULL.	16 ch	-	!	C
IDCLA1	First classification level for emission generating activity (e.g. in the case of the SNAP97 methodology, the first classification level, 07,	Integer	-999	!	C

	corresponds to "road transportation". The default is −999.				
IDCLA2	Second classification level for emission generating activity (e.g. in the case of the SNAP97 methodology, the second classification level, 01 corresponds to "passenger cars"). The default is −999.	Integer	-999	!	C
IDCLA3	Third classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the third classification level, 03, corresponds to "urban transport"). The default is −999.	Integer	-999	!	C
IDCLA4	Fourth classification level for emission generating activity. The default is −999.	Integer	-999	!	C
IDCLA5	Fifth classification level for emission generating activity. The default is −999.	Integer	-999	!	C
IDPROJ	Type of projection selected for coordinates of points defining the contours of the line source (see section geographical object file): 0 = Lambert II 1 to 60 = UTM 99 = longitude/latitude Default is 0.	Integer	-	!	C
SHIFTX	Shift of x axis of origin in Transverse Mercator system, (UTM zone). To be entered only if Transverse Mercator is selected. The default is 0.	Real	0.	!	C
SLOPE	Slope (%) of the line source in forward direction (X1, Y1 $\rightarrow$ X2, Y2) (direction in which vehicles move on roadway). The sign of the slope indicates if it is upward (positive) or downward (negative).	Real	-999	Optional	V
WIDTH	Width (in metres) of line source	Real	-999	Optional	V
IDCANYON	Canyon Key	Integer	-1	Optional	C
IDUNIT_i	Unit in which emission rate (parameter Q_i) is expressed. Available options: see. 7.6.7	Integer	-	!	C

Q_i	Emission rate expressed in selected unit (IDUNIT). The value is either positive or 0.	Real	-	!	V

Geographical line source file (.dxf file):

In addition to the general information file, the user must supply a DXF file defining the polylines that set up the line sources. The geographical object file is linked to the general information file by the IDGEOM flag for the source. Each line source must be associated to a geographical object in the DXF file. Coordinate points setting up the polylines are indicated according to the projection system selected with IDPROJ.

7.6.4.4 Simplified area source file (SRF)

In this file, the sources are described as polygons set up by four points.

Parameter	Description	Type	Default value	Status	Time dependence
SRCEID	Absolute indicator of the area source, used for identifying a given source. Each value should be unique.	Integer	-	!	C, V
IDADM1	Administrative code corresponding to the highest administrative territorial unit (e.g., country, county, province, or state code) where the area source is located. The default is –999.	Integer	-999	Optional	C
IDADM2	Administrative code corresponding to a lower administrative territorial unit where the area source is located. For example, if IDADM1 is the country code, IDADM2 could be the administrative code for the county or city. The default is –999.	Integer	-999	Optional	C
NAMADM	Name of the territorial unit where the source is located (e.g., county, state, district). The default is NULL.	20 char.	NULL	Optional	C
NAMGP1	First level of area source ID (name of the map visualization attributes in the GUI). The default is NULL.	8 char.	NULL	!	C
NAMGP2	Second level of area source ID (name of the graphic object in the GUI). The default is NULL.	8 char.	NULL	!	C
NAMGP3	Third level of area source ID (name of the source in the GUI). The default is NULL.	16 char.	NULL	!	C
IDCLA1	First classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the first classification level, 02, corresponds to "Non-industrial combustion plants"). The default is –999.	Integer	-999	!	C

IDCLA2	Second classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the first classification level, 02, corresponds to "Residential"). The default is –999.	Integer	-999	!	C
IDCLA3	Third classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the third classification level, 03, corresponds to " Gas turbines"). The default is –999.	Integer	-999	!	C
IDCLA4	Fourth classification level for emission generating activity. The default is –999.	Integer	-999	!	C
IDCLA5	Fifth classification level for emission generating activity. The default is –999.	Integer	-999	!	C
IDPROJ	Type of projection selected for coordinates of points defining the contours of the area source (see section geographical object file): 0 = Lambert II 1 to 60 = UTM 99 = longitude/latitude Default is 0.	Integer	-	!	C
SHIFTX	Shift of x-axis of origin in Transverse Mercator system, (UTM zone). To be entered only if Transverse Mercator is selected. The default is 0.	Real	0	!	C
ORIGX	X coordinate of reference point that serves as the origin for positioning the area source: - in meters - in decimal degree if IDPROJ=99 (longitude/latitude) If a value is entered, the position of the area source (POSX and POSY) is given in relation to this point. POSX and POSY chare absolute coordinates if ORIGX = 0 and ORIGY = 0. The default is 0.	Real	0.	!	C
ORIGY	Y coordinate of reference point that serves as the origin for	Real	0.	!	C

	positioning the area source: - in meters - in decimal degree if IDPROJ=99 (longitude/latitude) If a value is entered, the position of the area source (POSX and POSY) is given in relation to this point. POSX and POSY chare absolute coordinates if ORIGX = 0 and ORIGY = 0. The default is 0.				
IDZH	Reference height used for the sources : - 0: height above sea level - 1: height above ground In AIM, this value should always be set to 1.	Real	-	!	C
X1	X coordinate of the first point of the polygon: - in meters - in decimal degree if IDPROJ=99 (longitude/latitude) If a reference point has been defined (i.e. if ORIGX et ORIGY are not equal to 0), the value of X1 corresponds to the X coordinate relative to this reference point. Otherwise, X1 represents the absolute value of the X coordinate.	Real	-	!	V
Y1	Y coordinate of the first point of the polygon: - in meters - in decimal degree if IDPROJ=99 (longitude/latitude) If a reference point has been defined (i.e. if ORIGX et ORIGY are not equal to 0), the value of X1 corresponds to the Y coordinate relative to this reference point. Otherwise, X1 represents the absolute value of the Y coordinate.	Real	-	!	V
ZH1	Height (in metres) at which emission occurs. ZH1 represents height above sea level or above ground according to IDZH	Real	-	!	V

	value. The value is either positive or 0.				
X2	Same as X1 for the second polygon point	Real	-	!	V
Y2	Same as Y1 for the second polygon point	Real	-	!	V
ZH2	Same as ZH1 for the second polygon point	Real	-	!	V
X3	Same as X1 for the third polygon point	Real	-	!	V
Y3	Same as Y1 for the third polygon point	Real	-	!	V
ZH3	Same as ZH1 for the third polygon point	Real	-	!	V
X4	Same as X1 for the fourth polygon point	Real	-	!	V
Y4	Same as Y1 for the fourth polygon point	Real	-	!	V
ZH4	Same as ZH1 for the fourth polygon point	Real	-	!	V
SPEEDX	Gas exhaust velocity (m/s) along X axis.	Real	-	!	V
SPEEDY	Gas exhaust velocity (m/s) along Y axis.	Real	-	!	V
SPEEDZ	Gas exhaust velocity (m/s) along Z axis.	Real	-	!	V
IDUNIT_i	Unit in which emission rate (parameter Q_i) is expressed. Available options: see. 7.6.7	Integer	-	!	C
Q_i	Emission rate expressed in selected unit (IDUNIT). The value is either positive or 0.	Real	-	!	V

7.6.4.5 2.Complex area source file

Two different files are required for complex area source definition. The first one describes the general information of the sources and the second one, a DXF file, defines the contours of the geographical zones of the area sources (this file can be prepared with a GIS such as MapInfo, ArcWiew, AutoCad etc..). The two files are linked by the IDGEOM flag for each area source.

> **Warning!**
> It is strongly recommended to either use simple or complex area source files in one same project. However, if the user wants to apply the two different type of files in one same project, first make sure that the values of parameter IDGEOM and SRCEID don't occur in doubles in the two files.

General information file:

Parameter	Description	Type	Default value	Status	Time dependency
SRCEID	Absolute indicator of the area source, used for identifying a given source. Each value is unique.	Integer	-	!	C,V
IDGEOM	Absolute indicator of administrative zone. It is also used for identifying a given geographical object zone in the corresponding DXF file. Each value should correspond to a single object.	Integer	-	!	C
IDADM1	Administrative code corresponding to the highest administrative territorial unit (e.g., country, county, province, or state code) where the area source is located. The default is –999.	Integer	-999	Optional	C
IDADM2	Administrative code corresponding to a lower administrative territorial unit where the area source is located. For example, if IDADM1 is the country code, IDADM2 could be the administrative code for the county or city. The default is –999.	Integer	-999	Optional	C
NAMADM	Name of the territorial unit where the source is located (e.g., county, state, district). The	20 ch	NULL	Optional	C

	default is NULL.				
NAMGP1	First level of area source ID (name of the map visualization attributes in the GUI). The default is NULL.	8 ch	NULL	!	C
NAMGP2	Second level of area source ID (name of the graphic object in the GUI). The default is NULL.	8 ch	NULL	!	C
NAMGP3	Third level of area source ID (name of the source in the GUI). The default is NULL.	16 ch	-	!	C
IDCLA1	First classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the first classification level, 02, corresponds to "Non-industrial combustion plants"). The default is –999.	Integer	-999	!	C
IDCLA2	Second classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the first classification level, 02, corresponds to "Residential"). The default is –999.	Integer	-999	!	C
IDCLA3	Third classification level for emission generating activity (e.g., in the case of the SNAP97 methodology, the third classification level, 03, corresponds to " Gas turbines"). The default is –999.	Integer	-999	!	C
IDCLA4	Fourth classification level for emission generating activity. The default is –999.	Integer	-999	!	C
IDCLA5	Fifth classification level for emission generating activity. The default is –999.	Integer	-999	!	C
IDPROJ	Type of projection selected for coordinates of points defining the contours of the area source (see section geographical object file): 0 = Lambert II 1 to 60 = UTM 99 = longitude/latitude Default is 0.	Integer	-	!	C
SHIFTX	Shift of x-axis of origin in	Real	0.	!	C

	Transverse Mercator system, (UTM zone). To be entered only if Transverse Mercator is selected. The default is 0.				
IDUNIT_i	Unit in which emission rate (parameter Q_i) is expressed. Available options: see. 7.6.7	Integer	-	!	C
Q_i	Emission rate expressed in selected unit (IDUNIT). The value is either positive or 0.	Real	-	!	V

Geographical area source file (.dxf file):

In addition to the general information file, the user must supply a DXF file defining the polygons that set up the area sources. The geographical object file is linked to the general information file by the IDGEOM flag for the source. Each area source must be associated to a geographic object in the DXF file. Coordinate points at the boundaries of the polygons are indicated according to the projection system selected with IDPROJ.

7.6.5 Emission modulation files

As discussed earlier, the time variation of emissions can be represented by two type of files:

1. **Modulation files** describing the way the emission rate varies according to the hour in the day, the day of the week and the month of the year
2. **Time dependent emission files** defining the emissions during specific time intervals (dates) for each source

7.6.5.1 Modulation files

There are five types of emission modulation files, all of them are mandatory. This modulations only affects the emission rates.

7.6.5.2 General profile file

Example:

IDSRCE	TYP_OBJET	NOM_PROFIL	ID_PRF_M	ID_PRF_J	ID_PRF_H
1	0	EDF_TR1_2	1	1	13
2	0	EDF_TR4	1	1	24
3	0	TOT_Cent1	1	1	35
4	0	TOT_D11	1	1	46
5	0	TOT_Chaud11	1	1	57
6	0	TOT_RegeCR4	1	1	68
7	0	TOT_Chaud12	1	1	79
8	0	TOT_Chaud13	1	1	90

IDSRCE　　　　source number

TYP_OBJET　　flag for object type (0 = point, – 2 = line, – 3 = area)

NOM_PROFIL　name given to profile (selected by user, limited to 16 characters)

ID_PRF_M　　monthly profile number ID

ID_PRF_J　　daily profile number ID

ID_PRF_H　　hourly profile number ID

The fields in this file are separated by a semicolon ";". The file should not contain more than one blank line at the end. The file extension is ".par".

7.6.5.3 SNAP profile file

Emission sources can be classified into SNAP corresponding to different types of emission generating activities (SNAP - Selected Nomenclature for Air Pollution) categories. The sources taken into account are defined as combinations of several subcategories related to the activities and fuels used, as well as other subdivisions based on criteria such as type of process, abatement technology equipment, operation conditions, etc.

Example:

ID_CLA1	ID_CLA2	ID_CLA3	ID_CLA4	ID_CLA5	NOM_PROFIL	ID_PRF_M	ID_PRF_J	ID_PRF_H
1	1	1	0	0	SNAP_111	1	1	1
1	1	2	0	0	SNAP_112	1	1	1
1	1	3	0	0	SNAP_113	1	1	1
1	1	4	0	0	SNAP_114	1	1	1
1	1	5	0	0	SNAP_115	1	1	1
1	2	1	0	0	SNAP_121	2	1	1
1	2	2	0	0	SNAP_122	2	1	1
1	2	3	0	0	SNAP_123	2	1	1
1	2	4	0	0	SNAP_124	2	1	1
1	2	5	0	0	SNAP_125	2	1	1
1	3	1	0	0	SNAP_131	3	2	2
1	3	2	0	0	SNAP_132	3	2	2
1	3	3	0	0	SNAP_133	3	2	2

ID_CLA1 1st level classification number

ID_CLA2 2nd level classification number

ID_CLA3 3rd level classification number

ID_CLA4 4th level classification number

ID_CLA5 5th level classification number

NOM_PROFIL   name given to profile

ID_PRF_M   monthly profile number ID

ID_PRF_J   daily profile number ID

ID_PRF_H   hourly profile number ID

The fields in this file are separated by a semicolon ";". The file should not contain more than one blank line at the end. The file extension is ".def".

7.6.5.4 Monthly modulation profiles file

Example :

ID_PRF	NOM_PROFIL	PRF_1	PRF_2	PRF_3	PRF_4	PRF_5	PRF_6	PRF_7	PRF_8	PRF_9	PRF_10	PRF_11	PRF_12	TOTAL
1	AIRPARIF01	1.10	1.10	1.10	1.00	0.90	0.90	0.90	0.90	0.90	1.00	1.10	1.10	12.00
2	F(1/T)	2.49	1.14	1.32	0.77	0.56	0.47	0.36	0.40	0.57	0.54	1.22	2.16	12.00
3	365J/A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	12.00
4	AIRPARIF02	1.55	1.55	1.55	1.00	0.45	0.45	0.45	0.45	0.45	1.00	1.55	1.55	12.00
5	AIRPARIF03	1.10	1.12	1.12	1.12	1.00	1.00	0.91	0.70	0.98	1.00	1.00	0.95	12.00
6	AOUT=	1.09	1.09	1.09	1.09	1.09	1.09	1.09	0.00	1.09	1.09	1.09	1.09	12.00
7	50%_AOUT	1.04	1.04	1.04	1.04	1.04	1.04	1.04	0.52	1.04	1.04	1.04	1.04	12.00
8	INDUS_PAPIER	1.35	1.41	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	1.01	1.28	12.00
9	F(T)	0.28	0.60	0.52	0.89	1.23	1.45	1.93	1.73	1.20	1.27	0.57	0.32	12.00
10	AIRPARIF06	0.60	0.70	0.80	1.00	1.30	1.40	1.40	1.20	1.30	1.00	0.70	0.60	12.00
11	AEROPORT	0.97	0.88	0.98	1.01	1.07	1.04	1.07	1.04	1.04	1.03	0.94	0.92	12.00
12	6MOIS/12	0.50	0.50	0.50	1.50	1.50	1.50	1.50	1.50	1.50	0.50	0.50	0.50	12.00

ID_PRF   profile number ID

NOM_PROFIL   name given to profile (selected by user, limited to16 characters)

PRF_1   multiplier applied to average yearly emission rate during January

PRF_2   multiplier applied to average yearly emission rate during February

PRF_3   multiplier applied to average yearly emission rate during March

PRF_4   multiplier applied to average yearly emission rate during April

PRF_5   multiplier applied to average yearly emission rate during May

PRF_6   multiplier applied to average yearly emission rate during June

PRF_7   multiplier applied to average yearly emission rate during July

PRF_8   multiplier applied to average yearly emission rate during August

PRF_9   multiplier applied to average yearly emission rate during September

PRF_10   multiplier applied to average yearly emission rate during October

PRF_11   multiplier applied to average yearly emission rate during November

PRF_12   multiplier applied to average yearly emission rate during December

TOTAL   total of factors (should be equal to 12)

The fields in this file are separated by a semicolon ";". The file must not contain more than one blank line at the end. The file extension is ".moi".

7.6.5.5 Daily modulation profiles file

Example:

ID_PRF   profile number ID

NOM_PROFIL name given to profile (selected by user, limited to 16 characters)

PRF_1   multiplier applied to average yearly emission rate during day 1 (can be any day)

PRF_2   multiplier applied to average yearly emission rate during day 2

PRF_3   multiplier applied to average yearly emission rate during day 3

PRF_4   multiplier applied to average yearly emission rate during day 4

PRF_5   multiplier applied to average yearly emission rate during day 5

PRF_6   multiplier applied to average yearly emission rate during day 6

PRF_7   multiplier applied to average rate during day 7

TOTAL   total of factors (should be equal to 7)

The fields in this file are separated by a semicolon ";". The file should not contain more than one blank line at the end. The file extension is ".jou".

7.6.5.6 Hourly modulation profiles file

Example :

ID_PRF	NOM_PROFIL	PRF_23	PRF_24	PRF_1	PRF_2	PRF_3	PRF_4	PRF_5	PRF_6	PRF_7	PRF_8	PRF_9	PRF_10	PRF_11	PRF_12	PRF_13	PRF_14	PRF_15	PRF_16	PRF_17
1	AIRPARIF01	0.90	0.90	0.90	0.90	0.90	0.90	1.00	1.00	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.00
2	24H/ 24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	AIRP02_1H	0.50	0.50	0.50	0.50	0.50	1.00	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.00	1.00
4	6H-22H_MAX	0.27	0.27	0.27	0.27	0.27	0.27	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
5	8H-20H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
6	TRAFIC	0.11	0.06	0.05	0.09	0.22	0.59	1.53	1.74	1.32	1.22	1.31	1.48	1.44	1.49	1.45	1.74	1.98	1.88	1.62
7	AIRPARIF06	0.80	0.80	0.80	0.80	0.80	0.80	1.00	1.00	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.00
8	F(T)	0.75	0.71	0.69	0.66	0.64	0.68	0.80	0.91	1.01	1.10	1.17	1.22	1.25	1.28	1.29	1.29	1.27	1.23	1.17

ID_PRF   profile number ID

NOM_PROFIL   name given to profile (selected by user, limited to 16 characters)

PRF_1   multiplier applied to average yearly emission rate at 0100

PRF_2   multiplier applied to average yearly emission rate at 0200

PRF_3   multiplier applied to average yearly emission rate at 0300

PRF_4   multiplier applied to average yearly emission rate at 0400

PRF_5   multiplier applied to average yearly emission rate at 0500

PRF_6   multiplier applied to average yearly emission rate at 0600

PRF_7   multiplier applied to average yearly emission rate at 0700

PRF_8   multiplier applied to average yearly emission rate at 0800

PRF_9   multiplier applied to average yearly emission rate at 0900

PRF_10   multiplier applied to average yearly emission rate at 1000

PRF_11   multiplier applied to average yearly emission rate at 1100

PRF_12   multiplier applied to average yearly emission rate at 1200

PRF_13   multiplier applied to average yearly emission rate at 1300

PRF_14   multiplier applied to average yearly emission rate at 1400

PRF_15   multiplier applied to average yearly emission rate at 1500

PRF_16   multiplier applied to average yearly emission rate at 1600

PRF_17   multiplier applied to average yearly emission rate at 1700

PRF_18   multiplier applied to average yearly emission rate at 1800

PRF_19   multiplier applied to average yearly emission rate at 1900

PRF_20   multiplier applied to average yearly emission rate at 2000

PRF_21   multiplier applied to average yearly emission rate at 2100

PRF_22   multiplier applied to average yearly emission rate at 2200

PRF_23   multiplier applied to average yearly emission rate at 2300

PRF_24   multiplier applied to average emission rate at 0000

TOTAL   total of factors (should be equal to 24)

The fields in this file are separated by a semicolon ";". The file should not contain more than one blank line at the end. The file extension is ".heu".

> Warning!
> The hours correspond to UTC time (Coordinated Universal Time/Greenwich mean time)In France, during summer time, the local time is 2 hours in advance compared to UTC and in winter time, local time is 1 hour in advance compared to UTC.

The root of the five file names must be the same. For example, if the root is "test", the five file names are:

- test.heu
- test.jou
- test.moi
- test.par
- test.def

The user then launches "test" to activate the modulations. All five files must be located in the same directory and on the same disk as the ARIA Impact software.

7.6.6 Time dependent emission files

Time dependent emission files define the emissions during specific time intervals (dates) for each source. Emission rates are represented by a constant value between two dates: DATEDEB, the beginning of the time interval, DATEFIN, the end of the time interval.

The rules described in paragraph 7.6.2 are applicable for these files. The following additional rules must be respected:
- Dates should be defined in format : DD-MM-YYYY HH:MN:SS where DD is the day, MM the month, YYYY the year, HH the hour, MN the minute and SS the second. For example, the 2004,1st April at 12 should be written as: 01-04-2004 12:00:00.
- The dates in the file should be in chronological order.
- If a source is not present at a given time, the emissions will be calculated by the corresponding modulated rates if modulation files exist, if not, the nominal rate given by the time independent emission file is applied. The position will be given by the time independent emission file.
- All the fields for a given source and a given time must be filled with a valid value.
- Only fields with a "V" value in the "time dependency" column can be present in the time independent emission file.
- Emissions rates for a given substance are given using the corresponding IDUNIT in the time independent emission file.

Example of a time series file for a point source (LPS) :

SRCEID	DATEDEB	DATEFIN	Q_NOx
1	01-04-2004 12:00:00:00	01-04-2004 15:00:00	1000.
2	01-04-2004 12:00:00:00	01-04-2004 14:00:00:00	2000.
2	01-04-2004 14:00:00:00	01-04-2004 16:00:00	1500.
1	01-04-2004 15:00:00:00	01-04-2004 16:00:00	1500.

The names of the substances should be identical to those already defined in the ARIA Impact project to which they will be imported. Please notice that the substance names will be in upper case letters when importing the file.

As for time independent files, there should be one file for each type of source (LPS, LIN and AREA).

7.6.7 Units for defining emission rates

IDUNIT	Definition	Type	Conversion Factor
1	tons/year	Mass	$3.169 \ 10^4$ µg/s
2	tons/day	Mass	$1.157 \ 10^7$ µg/s
3	kg/h	Mass	$2.778 \ 10^5$ µg/s
4	µg/s	Mass	1 µg/s
5	ng/s	Mass	$1. \ 10^{-3}$ µg/s
6	uo/h	Odeur	-
7	Bq/s	Activity	-
8	Ci/s	Activity	$3,7.10^{10}$ Bq/s

7.7 RECEPTOR FILE

Two formats exist for import/export of the definition of receptor points:

- Excel .csv format (separator ;)
- ARIA format

7.7.1 Excel .csv format (separator ;)

This file is an ASCII file that can be prepared with MS-Excel by saving it in .csv format with data separated by semicolon ";". This file can be directly imported to ARIA Impact.

Description of variable in the file:

R_INDEX :   Index of receptor point
R_NAME :   Name of receptor point (user's choice, max 8 characters)
R_X :   X-coordinate of receptor point
R_Y :   Y-coordinate of receptor point
R_ALTI :   Altitude of receptor point

Exemple :

```
R_INDEX;R_NAME;R_X;R_Y;R_ALTI
2;Stadium;794.443;1964.43;0
3;Hospital;796.936;1955.01;0
4;School;789.684;1955.24;0
5;Daycare;789.73;1959.72;0
```

7.7.2 ARIA format

ARIA format file also called « donpos » ; this file is compatible with different ARIA Technologies models.

The first 13 lines explain the file.

Description of variable in the file:

NUMBER OF REFERENCE SITES :   Number of receptor points in the file
NUMPOS :   Index of receptor point
NOMPOS :   Name of receptor point (user's choice, max 8 characters)
XPOS :   X-coordinate of receptor point
YPOS :   Y-coordinate of receptor point
ZPOS :   Altitude of receptor point

The star symbols (*) in the « table» defining the receptor points should vertically lined up.

Example :

```
$$$$   DONPOS
 * ----------------------------------------------------------------------
 * POSITION OF REFERENCE SITES
 * ----------------------------------------------------------------------
 * NUMPOS  : SITE CODE NUMBER
 * NOMPOS  : SITE NAME
 * XPOS    : X COORDINATE (KM)
 * YPOS    : Y COORDINATE (KM)
 * ZPOS    : SITE HEIGHT A.S.L.(METERS)
 * ----------------------------------------------------------------------
 **********************************************************************
 * NUMBER OF REFERENCE SITES.
 **********************************************************************
 *     4*
 ****************************************************
 * NUMPOS * NOMPOS *   XPOS    *   YPOS    *  ZPOS  *
 ****************************************************
 *       2*Stadium *  794.4425* 1964.4337*     0.*
 *       3*Hospital*  796.9363* 1955.0126*     0.*
 *       4*School  *  789.6842* 1955.2419*     0.*
 *       5*Daycare *  789.7296* 1959.7231*     0.*
```

7.8 SAVING RESULTS FOR EACH CALCULATION TIME STEP

ARIA Impact has the possibility to store the results calculated at each meteorological time step. This option is only possible when carrying out a statistical calculation based on a time series of meteorological data. Two output formats are possible for storing the results obtained for each calculation time step:

- ASCII format (results given only for receptor points)
- Binary format (.BIN)

7.8.1 ASCII file format

If the user has defined receptor points before executing a statistical calculation with ARIA Impact, an ASCII file (text file) is automatically created containing the results of concentration and deposition for each substance and for each calculation time step.

The output ASCII file can be found in the PROJECT directory under ARIA Impact and the file has the extension .AXE. For example, a statistical calculation is carried out for a project called « DEMO », containing receptor points. The output file containing the results for the receptor points can be found under:

/IMPACT1.8/PROJECT/DEMO/demo.axe

This file can further be opened with Excel (separator ;).

The variables in this file are:

SPECIES : Substance for which the results are given
DATE : Date and hour of the calculation time step
SPEED : Wind speed at time step DATE
DIREC : Wind direction at time step DATE
STAB : Atmospheric stability at time step DATE :
        1 = Pasquill class A
        2 = Pasquill class B
        3 = Pasquill class C
        4 = Pasquill class D
        5 = Pasquill class E
        6 = Pasquill class F
POINTX : Results for the receptor point POINTX

In the example below the results at four receptor points are presented (Stadium, Hospital, School, Day care center) for the period 01/01/2000 03:00:00 to 01/01/2000 18:00:00 for the 3 substance NOx, odour and PM10.

Example :

```
SPECIE;DATE;SPEED;DIREC.;STAB.;Stadium;Hospital;School;Daycare;
NOx     ;1/1/2000 3:0:0;    2.00;   234.15;   5;    0.0000;    0.0000;    0.0000;    0.0000;
odour   ;1/1/2000 3:0:0;    2.00;   234.15;   5;    0.0000;    0.0000;    0.0000;    0.0000;
PM10    ;1/1/2000 3:0:0;    2.00;   234.15;   5;    0.0000;    0.0000;    0.0000;    0.0000;
NOx     ;1/1/2000 6:0:0;    3.00;   225.23;   5;    2.5975;    0.0000;    0.0000;    0.0000;
odour   ;1/1/2000 6:0:0;    3.00;   225.23;   5;    0.0337;    0.0000;    0.0000;    0.0000;
PM10    ;1/1/2000 6:0:0;    3.00;   225.23;   5;    0.7102;    0.0000;    0.0000;    0.0000;
NOx     ;1/1/2000 9:0:0;    3.00;   258.38;   4;    0.0000;    0.0000;    0.0000;    0.0000;
odour   ;1/1/2000 9:0:0;    3.00;   258.38;   4;    0.0000;    0.0000;    0.0000;    0.0000;
PM10    ;1/1/2000 9:0:0;    3.00;   258.38;   4;    0.0000;    0.0000;    0.0000;    0.0000;
NOx     ;1/1/2000 12:0:0;    3.00;   262.04;   4;    0.0000;    0.0000;    0.0000;    0.0000;
odour   ;1/1/2000 12:0:0;    3.00;   262.04;   4;    0.0000;    0.0000;    0.0000;    0.0000;
PM10    ;1/1/2000 12:0:0;    3.00;   262.04;   4;    0.0000;    0.0000;    0.0000;    0.0000;
NOx     ;1/1/2000 15:0:0;    2.00;   262.16;   5;    0.0000;    0.0000;    0.0000;    0.0000;
odour   ;1/1/2000 15:0:0;    2.00;   262.16;   5;    0.0000;    0.0000;    0.0000;    0.0000;
PM10    ;1/1/2000 15:0:0;    2.00;   262.16;   5;    0.0000;    0.0000;    0.0000;    0.0000;
NOx     ;1/1/2000 18:0:0;    2.00;   263.44;   5;    0.0000;    0.0000;    0.0000;    0.0000;
odour   ;1/1/2000 18:0:0;    2.00;   263.44;   5;    0.0000;    0.0000;    0.0000;    0.0000;
PM10    ;1/1/2000 18:0:0;    2.00;   263.44;   5;    0.0000;    0.0000;    0.0000;    0.0000;
```

7.8.2   Binary file .BIN format

It is possible to store the results from each calculation time step, in binary format (format .BIN). This file can further be visualised with the 3D graphical software EWB (also called SAVI3D) after having been converted to a so called .MeRAF file. The results in this file are stored for each time step in the meteorological data file and for each substance included in the calculation.

In order to create a binary file, check the corresponding box "store all results" and select the file directory by clicking on the look up button .

If this option is activated, several files with the nomenclature MMYYYY_SUB.BIN will be created. MM corresponds to the month stored, YYYY to the year and SUB to the substance. In these files, the results of concentration and deposition of substance SUB is stored for each grid cell.

> **Warning!**
> These files can rapidly become very large. Make sure to first verify that there is enough space available on the disk. For information, a binary file including one substance and one month corresponds to about 23 Mb with a calculation grid of 7500 grid cells (75 x 100 cells for example).

8. RUNNING CALCULATIONS IN BATCH MODE

It is possible to launch a series of projects prepared with the interface ARIA Impact from a MS-DOS window. The way to proceed is described below:

    1- preparation of ARIA Impact projects
    2- preparation of a batch file for executing the different projects
    3- execution of calculations from an MS-DOS window

8.1 PREPARATION OF IMPACT PROJECTS

First, use the interface of ARIA Impact in order to prepare the different projects to launch. For each project, define:

- the site (grid and relief if necessary)
- the substances to include
- the meteorology (academic case, wind rose or file with times series of meteorological data)
- the sources and the emissions associated to each source
- the receptors if necessary
- the calculation options (e.g. : calm winds, standard deviation formula, stability method…)
- the calculation period
- the output statistics (average concentration, percentiles, exceeding's frequency…).

Once the definition of projects has been completed and saved, close ARIA Impact.

8.2 PREPARATION OF A BATCH FILE

Thereafter a program should be prepared for running the different projects. With the help of a text editor (Bloc-notes, WordPad…) define the execution of ARIA Impact in batch mode as follows:

For execution of an academic case calculation:

```
AI_ROOT\EXEC\calpact.exe  projectX 0
```

For execution of a statistical calculation:

```
AI_ROOT\EXEC\calpact.exe projectX 1
```

For execution of a wind rose calculation:

```
AI_ROOT\EXEC\calpact.exe projectX 2
```

Where:

The flag in red indicates the type of calculation:

      0 = academic case calculation
      1 = statistical calculation
      2 = wind rose calculation

The parameters in blue should be modified by the user:
      AI_ROOT represents the directory where the ARIA Impact software is installed (for example D:\ARIA\IMPACT1.8)
      projectX is the name of ARIA Impact project to execute

Each line corresponds to the execution of a project by ARIA Impact. There's no limit to how many consecutive projects that can be launched.

The example below shows a batch program which will successively launch an academic case calculation for the project « TIR », a statistical calculation for the project « MEAN_AN » (annual mean) a statistical calculation for the project « NOx_00 » (NOx percentile for year 2000), and a wind rose calculation for the project « ROSE ». In this example, the software ARIA Impact is running under the directory c:/IMPACT.

Example:

```
d:\ARIA\IMPACT1.8\EXEC\calpact.exe  TIR 0
d:\ARIA\IMPACT1.8\EXEC\calpact.exe  MEAN_AN 1
d:\ARIA\IMPACT1.8\EXEC\calpact.exe  NOx_00 1
d:\ARIA\IMPACT1.8\EXEC\calpact.exe  ROSE 2
```

The calculation results are stored under the corresponding project directories.
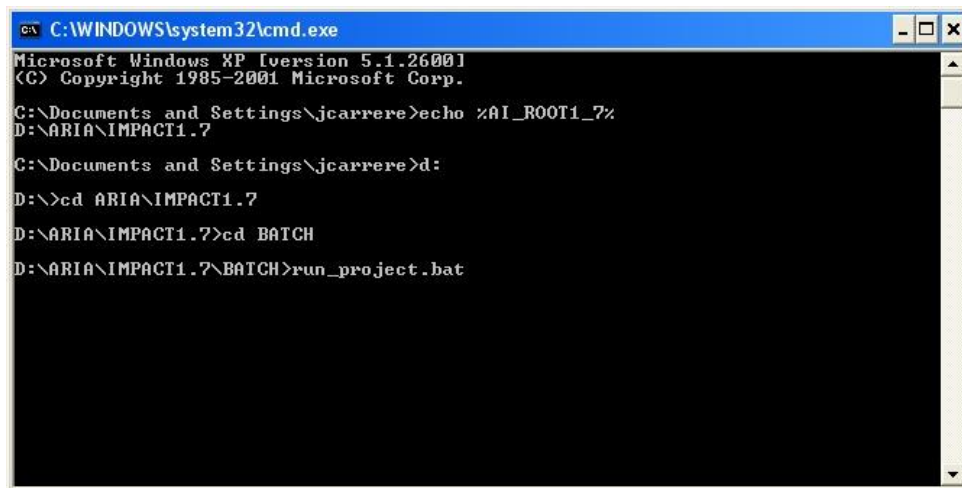
Once the program has been prepared, save the file. The file can have any name but the file extension should be « .bat », e.g "lance_projects.bat".

8.3 RUNNING THE BATCH FILE

Copy the batch file to directory « BATCH » under ARIA Impact.

Open an MS-DOS window. This command can be found in the Start menu on your computer by selecting /Programs/Accessories/ MS-DOS.

In the MS-DOS window, first go to the directory where the batch file has been copied and thereafter type the name of the batch file followed by « ENTER »,

Figure 91: DOS window to run batch

The progress of the calculation can be seen on the screen. At the end of the calculation of each project, the message « erreur = 0 » is displayed on the screen and the consecutive project is automatically started.

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sia stato incluso è necessario che le simulazioni siano ripetute includendo tale contributo (in particolare quello dell'aviazione generale)".

ARPAT precisa che la natura della richiesta è in parte di chiarimento ed in parte di integrazione. SAT si impegna a verificare se le stime effettuate circa il numero di movimenti degli aeromobili al 2028 e quindi sulle conseguenti emissioni abbiano incluso o meno quelli dell'aviazione generale e militare; nel caso non siano stati inclusi, SAT si impegna ad effettuare nuove simulazioni includendo tale contributo, qualora siano disponibili i dati (per i movimenti dell'aviazione militare potrebbero esservi difficoltà a precisare questa informazione).

3. "Precisi i motivi per i quali non ha ritenuto di adeguare i TIM delle fasi di rullaggio (*taxi in*/*idle* e *taxi out*/*idle*) rispetto allo studio condotto nel 2008, tenuto conto del nuovo assetto al 2028 caratterizzato dall'arretramento di 400 m del punto di stacco degli aeromobili in fase di decollo verso la città. Nel caso in cui i TIM nel nuovo assetto fossero diversi da quelli fin qui adottati è necessario che le simulazioni siano ripetute con i nuovi TIM".

ARPAT precisa che la natura della richiesta è in parte di chiarimento ed in parte di integrazione, e che le eventuali simulazioni aggiuntive (in termini di concentrazioni in aria ambiente o almeno di emissioni) devono offrire elementi tecnici utili a comprendere l'effetto sulla qualità dell'aria dell'unica modifica *air side* inclusa nel Master plan 2014-2028. SAT precisa che la modifica *air side* in questione può incidere esclusivamente sulla fase *taxi out* e comunque in misura modesta; si impegna tuttavia a presentare le stime aggiornate dei TIM nel nuovo assetto dell'infrastruttura ed un quadro emissivo aggiornato con tali valori dei TIM, integrando le simulazioni condotte con ARIA IMPACT.

4. "Presenti il quadro emissivo delle emissioni convogliate dalle centrali termiche (includendo portata, velocità di uscita dei fumi, concentrazioni al camino o ratei emissivi per ciascun inquinante emesso), sia nello stato attuale sia in quello futuro (anno 2028) dopo la dismissione degli impianti obsoleti e l'attivazione dei nuovi sistemi di produzione del calore e dell'energia".

ARPAT precisa che la natura della richiesta è di chiarimento. SAT si impegna a presentare il quadro emissivo completo delle emissioni convogliate, sia nella configurazione attuale che in quella futura.

5. "Presenti il quadro completo dei GSE di cui sono state stimate le emissioni, compresi i fattori di emissione adottati".

ARPAT precisa che la natura della richiesta è di chiarimento. SAT si impegna a presentare il quadro completo dei GSE, comprensivo dei fattori di emissione utilizzati nelle simulazioni.

6. "Precisi se nelle stime condotte con il codice ARIA IMPACT è stato incluso il contributi degli APU. Nel caso non sia stato incluso, chiarisca le motivazioni di tale scelta; se altrimenti all'anno 2028 si ipotizza che siano ancora attivi APU che comportano emissioni in atmosfera è necessario che le simulazioni siano ripetute includendone il contributo".

ARPAT precisa che la natura della richiesta è in parte di chiarimento ed in parte di integrazione; inoltre precisa che il testo del proprio parere reca un refuso, giacché ci si intende riferire non solo agli APU, ma anche e soprattutto ai GPU. SAT si impegna a verificare gli input forniti al codice di calcolo ARIA IMPACT in materia di APU e GPU ed a fornire il chiarimento e l'integrazione richiesta.

7. "Precisi, per quanto concerne i dati meteorologici utilizzati nelle simulazioni con il codice ARIA IMPACT, sia il metodo di assegnazione ad ogni ora della classe di stabilità atmosferica sia i dati di profilo verticale utilizzati per la stima dello spessore di rimescolamento".

ARPAT precisa che la natura della richiesta è di chiarimento. SAT afferma che la stima dello spessore di rimescolamento è stata effettuata avendo come riferimento il modello di Carson; comunque si impegna a chiarire questo aspetto, allegando il manuale d'uso e/o una descrizione degli algoritmi implementati nel codice di calcolo ARIA IMPACT, con particolare riferimento alla stima dei dati meteo in quota e/o dello spessore di rimescolamento.

8. "Effettui nuovamente le stime con il codice ARIA IMPACT per un'intera annualità, superando l'impostazione adottata nella documentazione esaminata (in cui le stime sono state condotte per

due mesi invernali e quattro estivi), al fine di ottenere per tutti i punti di griglia gli indicatori statistici delle distribuzioni delle concentrazioni fissati dal DLgs 155/2010 per i diversi inquinanti considerati".

ARPAT precisa che la natura della richiesta è di integrazione, giacché il riferimento per la valutazione della qualità dell'aria sono gli indicatori statistici delle distribuzioni delle concentrazioni degli inquinanti fissati dal DLgs 155/2010, pressoché tutti su base annuale. SAT precisa che le simulazioni condotte con ARIA IMPACT sono state limitate a 6 mesi dell'anno 2007 per omogeneità con lo studio presentato a completamento della precedente procedura di VIA conclusa nel 2002; in ogni caso - essendo in possesso dei dati meteorologici rilevati a Pisa per l'intero anno 2007 - si impegna ad integrare le simulazioni al fine di ottenere le stime sull'intera annualità

9. "Una volta stimate le concentrazioni orarie in aria ambiente di NOx con il codice ARIA IMPACT, stimi le relative concentrazioni di NO_2 impiegando il metodo ARM2 adottato da US-EPA e, successivamente, calcolando per tutti i punti di griglia gli indicatori statistici delle distribuzioni delle concentrazioni fissati dal DLgs 155/2010".

ARPAT precisa che la natura della richiesta è di integrazione, giacché il metodo ARM2 (recentemente adottato da US-EPA)[1] risulta più corretto rispetto al metodo di Derwent-Middleton-Dixon (con riferimento alla stima del 99.8° pecentile annuo delle concentrazioni orarie) utilizzato nella documentazione depositata da SAT. SAT si impegna ad effettuare l'integrazione richiesta.

10. "Effettui il confronto delle stime ottenute con gli standard di qualità dell'aria fissati dal DLgs 155/2010 tenendo conto dei valori di fondo desumibili dai dati di qualità dell'aria caratteristici della zona, come rilevati da ARPAT con le campagne effettuate con laboratorio mobile e/o come rilevati presso la stazione Pisa-Passi facente parte della rete regionale di qualità dell'aria. Tale confronto dovrà essere effettuato in forma tabellare presso 10 punti recettori interni ed esterni al sedime aeroportuale, con preferenza per quelli prossimi ad edifici residenziali o adibiti ad attività ricettive, scolastiche, sanitarie".

ARPAT precisa che la natura della richiesta è di integrazione, giacché gli standard di qualità dell'aria fissati dal DLgs 155/2010 sono riferiti all'insieme dei contributi emissivi presenti in una data area, mentre nella documentazione depositata da SAT il confronto è stato effettuato solo tenendo conto del contributo delle sorgenti emissive riferite all'attività aeroportuale; nell'effettuare il confronto SAT dovrà tenere conto delle indicazioni formulate da UK-Environment Agency[2], nonché dei dati di qualità dell'aria rilevati localmente presso la stazione Pisa-Passi[3] o presso l'aeroporto "Galileo Galilei" mediante laboratorio mobile[4]. SAT si impegna ad effettuare l'integrazione richiesta.

---

[1] Si veda:
- "Ambient Ratio Method Version 2 (ARM2) for use with AERMOD for 1-hr NO_2 Modeling - Development and Evaluation Report", API e RTP, 2013 (http://www.epa.gov/ttn/scram/models/aermod/ARM2_Development_and_Evaluation_Report-September_20_2013.pdf);
- "Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard", Memoradum US-EPA, 30 settembre 2014 (http://www.epa.gov/ttn/scram/guidance/clarification/NO2_Clarification_Memo-20140930.pdf).
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[4] ARPAT, "Campagna di rilevamento della qualità dell'aria con laboratorio mobile a Pisa (PI) – anno 2009": http://www.arpat.toscana.it/documentazione/report/campagna-di-rilevamento-della-qualita-dellaria-con-laboratorio-mobile-a-pisa-pi-anno-2009.

In sintesi, oltre agli elementi di chiarimento sopra citati, SAT integrerà lo studio di dispersione degli inquinanti emessi in atmosfera con una nuova simulazione effettuata con ARIA IMPACT nello scenario emissivo al 2028 in cui:

- saranno aggiunte le emissioni dovute ai movimenti dell'aviazione generale (e militare, qualora i dati siano disponibili), se non incluse nella documentazione depositata;
- saranno corretti i TIM (ed in particolare il tempo della fase *taxi out*) qualora - per effetto dell'allungamento del percorso di rullaggio in uscita - si stimi un significativo aumento dei tempi nel ciclo LTO;
- saranno inclusi i contributi emissivi degli APU e GPU con emissioni in atmosfera, qualora non inclusi nella documentazione depositata;
- saranno stimate le concentrazioni in aria ambiente dei diversi inquinanti emessi per un'intera annualità, utilizzando i dati meteo rilevati localmente nel 2007;
- le concentrazioni orarie in aria ambiente di NO_2 saranno stimate - a partire da quelle di NOx fornite dal codice ARIA IMPACT - utilizzando il metodo ARM2 di US-EPA.

I valori delle concentrazioni in aria ambiente dei diversi inquinanti emessi, stimati con il codice ARIA IMPACT, dovranno essere confrontati con gli standard di qualità dell'aria fissati dal DLgs 155/2010 aggiungendo opportunamente la "concentrazione di fondo" dovuta alle altre sorgenti non connesse con l'attività aeroportuale (ricavabile dalle misure ARPAT effettuate *in situ*), limitatamente a 10 punti recettori significativi collocati presso abitazioni o altri recettori "sensibili" presenti nell'intorno.

Per quanto riguarda l'altezza delle emissioni convogliate, SAT presenterà contestualmente uno studio speditivo a parte, effettuato con altro codice di calcolo, finalizzato ad individuare l'altezza ottimale dei camini, al fine di minimizzare l'impatto delle emissioni nell'intorno.

Infine, ARPAT richiama l'attenzione di SAT sulle prescrizioni relative alla fase di cantiere ipotizzate nel parere del 16.1.2015 (pag. 3), finalizzate a mitigarne l'impatto sull'atmosfera, suggerendo che SAT le valuti con attenzione e presenti una propria ipotesi aggiornata ed onnicomprensiva delle misure che intende adottare, anche alla luce del citato parere.

Verbale letto e condiviso dai partecipanti