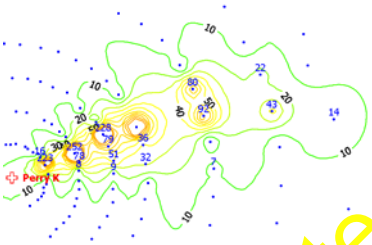
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

A VALIDATION EXERCISE ON THE SAFE-AIR VIEW SOFTWARE

F. D'Alberti [1], F. d'Amati [1], E. Canepa [2], G. Triacchini [3]

[1] Joint Research Centre – NDFM – Ispra, Italy
[2] CNR – INFM – CNISM – Department of Physics, University of Genova, Italy
[3] Catholic University of Brescia, Italy

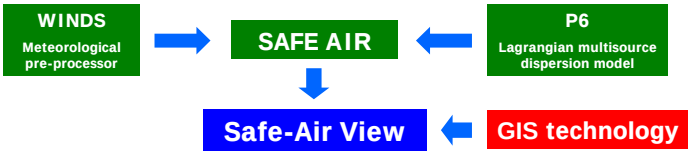


EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

WHAT IS *SAFE-AIR VIEW*?

- **Safe-Air View** is a software for the prediction of the air and ground contamination following an accidental release of radionuclides into the atmosphere.
- **Safe-Air View** integrates the SAFE AIR code with GIS technology.
- **Safe-Air View** can provide a graphic output of the air and ground contamination patterns on the region around the JRC Ispra site.
- **Safe-Air View** is used as decision aid tool for the JRC Ispra off-site nuclear emergency planning and management.



JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

WHY PERFORM A VALIDATION EXERCISE ON THE *SAFE-AIR VIEW* SOFTWARE?

SAFE AIR
Wide range of functions

- 4 different σ-functions
- Briggs, Moore or Turner plume rise computing methods
- 4 plume – thermal discontinuities interaction dynamics
- etc...

SAFE AIR CODE IMPLEMENTATION →

Safe-Air View
Restricted set of functions

- Brookhaven σ-function
- Briggs plume rise
- No interaction between plume and thermal discontinuities
- etc...

The present exercise aims to validate the **SAFE AIR** code as implemented within the **Safe-Air View** software.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

METHODS AND INSTRUMENTS

- **Model Validation Kit (Olesen, 1994)**
  - ⇨ Quantitative analysis
    - Model Validation Kit's performance indices: FB, NMSE, FA2...
    - Other two indices: WNNR and NNR
  - ⇨ Qualitative analysis
    - Box Plot diagrams
- **Copenhagen, Indianapolis and Kincaid tracer experiments**
- **Simulations carried out for different Safe-Air View configurations**

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

SAFE-AIR VIEW CONFIGURATIONS

configuration used at the JRC Ispra

(A) Suggested mixing height

(B) Observed mixing height

and → Wind data from only one meteorological station

(C) Observed mixing height

(D) Observed mixing height
Wind profile

and → Wind data from two meteorological stations

The remaining input data (wind direction and velocity, Pasquill stability class, etc...) are common to all configurations.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

TRACER EXPERIMENT COPENHAGEN

- Residential site
- About 2 hours release/monitoring cycles
- Constant meteorological conditions
- Neutral or unstable stability classes
- Negligible plume rise
- Two Safe-Air View configurations: (A) and (B)

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULT COPENHAGEN

	MEAN	SIGMA	BIAS	NMSE	COR	FA2	FB	FS	WNNR	NNR
Ideal values	632.66	450.25	0.00	0.00	1.000	1.000	0.000	0.000	0.00	0.00
Safe-Air View (A)	784.22	537.07	-151.56	0.38	0.672	0.783	-0.214	-0.176	0.45	0.25
Safe-Air View (B)	786.12	535.39	-153.47	0.37	0.682	0.783	-0.216	-0.173	0.43	0.25
HPDM	358.23	268.09	274.42	0.61	0.874	0.652	0.554	0.507	0.62	0.36
IFDM	551.87	345.27	80.79	0.19	0.843	0.870	0.136	0.264	0.21	0.11
INPUFF	560.55	352.65	72.10	0.50	0.490	0.739	0.121	0.243	0.58	0.25
OML	283.61	251.05	349.05	1.12	0.823	0.217	0.762	0.5[illegible]	[illegible]12	0.73
UK-ADMS	177.12	138.48	455.53	2.84	0.891	0.043	1.12[illegible]	1.[illegible]59	2.84	1.74

Normalized arcwise maxima concentrations (10^{-9} s m^{-3})

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULTS COPENHAGEN

	MEAN	SIGMA	BIAS	NMSE	COR	FA2	FB	FS	WNNR	NNR
Ideal values	448.70	239.29	0.00	0.00	1.000	1.000	0.000	0.000	0.00	0.00
Safe-Air View (A)	414.09	179.61	34.61	0.24	0.529	0.957	0.080	0.285	0.28	0.11
Safe-Air View (B)	416.30	178.88	32.39	0.22	0.567	0.957	0.075	0.289	0.26	0.10
HPDM	382.32	161.62	66.37	0.16	0.778	1.000	0.160	0.387	0.17	0.09
IFDM	443.26	193.38	5.43	0.16	0.681	0.957	0.012	0.212	0.13	0.08
INPUFF	339.59	180.43	109.10	0.46	0.361	0.696	0.277	0.280	0.52	0.26
OML	249.17	131.70	199.52	0.52	0.893	0.565	0.572	0.580	0.52	0.36
UK-ADMS	207.05	110.68	241.64	0.86	0.912	0.348	0.737	0.735	0.86	0.60

Normalized crosswind integrated concentrations (10^{-6} s m^{-2})

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

TRACER EXPERIMENT INDIANAPOLIS

- Urban site
- Nine or eight hours release/monitoring cycles
- Variable meteorological conditions
- Unstable, neutral or stable stability classes
- Buoyant plume
- Three Safe-Air View configurations: (A), (B) and (C)

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULTS INDIANAPOLIS

	MEAN	SIGMA	BIAS	NMSE	COR	FA2	FB	FS	WNNR	NNR
Ideal values	353.81	221.25	0.00	0.00	1.000	1.000	0.000	0.000	0.00	0.00
Safe-Air View (A)	237.60	248.75	116.21	1.15	0.248	0.340	0.393	-0.117	1.68	1.39
Safe-Air View (B)	237.94	248.67	115.87	1.15	0.248	0.340	0.392	-0.117	1.68	1.39
Safe-Air View (C)	210.61	225.84	143.20	1.39	0.166	0.347	0.507	-0.021	2.00	1.54

Normalized arcwise maxima concentrations (10^{-9} s m^{-3})

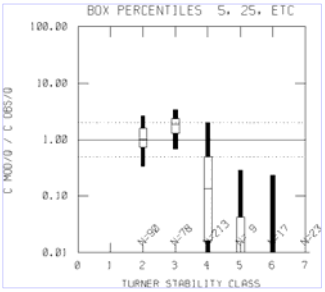
	MEAN	SIGMA	BIAS	NMSE	COR	FA2	FB	FS	WNNR	NNR
Ideal values	1194.51	862.33	0.00	0.00	1.000	1.000	0.000	0.000	0.00	0.00
Safe-Air View (A)	615.42	678.46	579.09	1.30	0.500	0.362	0.640	0.239	1.60	1.47
Safe-Air View (B)	630.77	741.32	563.73	1.28	0.506	0.365	0.618	0.151	1.60	1.47
Safe-Air View (C)	599.21	1054.78	595.30	2.50	0.231	0.327	0.664	-0.201	2.06	1.67

Normalized crosswind integrated concentrations (10^{-6} s m^{-2})

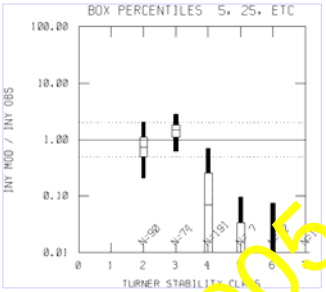
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULTS INDIANAPOLIS



Arcwise maxima concentrations



Crosswind integrated concentration

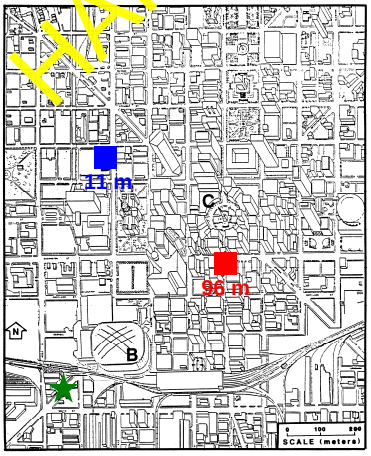
Tendency to underestimation under atmospheric stable classes!

➡ Another σ–function, such as Briggs Urban, should by used under these conditions.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULTS INDIANAPOLIS



Caution in choosing the meteorological sites!

- "★" Emission source
- "■" Surface meteorological site
- "■" Bank tower meteorological site

We cannot be sure that model performances are improved by introducing wind data from two or more meteorological stations.

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

TRACER EXPERIMENT KINCAID

- Rural site
- From three to nine hours release/monitoring cycles
- Variable meteorological conditions
- Unstable, neutral conditions
- Very buoyant plume
- Four Safe-Air View configurations: (A), (B), (C) and (D)

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULTS KINCAID

	MAN	SIGMA	BIAS	NMSE	COR	FA2	FB	FS	WNNR	NNR
Ideal values	54.34	40.25	0.00	0.00	1.000	1.000	0.000	0.000	0.00	0.00
Safe-Air View (A)	34.89	31.50	19.45	1.52	0.044	0.385	0.436	0.244	2.19	0.99
Safe-Air View (B)	36.33	32.27	18.00	1.47	0.035	0.408	0.397	0.220	2.10	0.94
Safe-Air View (C)	43.74	40.82	10.59	1.52	-0.064	0.382	0.216	-0.014	2.25	1.16
Safe-Air View (D)	39.67	41.22	14.66	1.59	0.033	0.343	0.312	-0.024	2.46	1.35
HPDM	44.84	38.55	9.50	0.75	0.441	0.565	0.192	0.043	0.80	0.49
IFDM	29.42	26.03	24.92	2.00	-0.132	0.423	0.595	0.429	-	-
INPUFF	34.61	26.76	19.72	1.29	0.140	0.497	0.443	0.403	1.74	0.80
OML	47.45	45.48	6.89	1.24	0.146	0.547	0.135	-0.122	1.47	0.64
UK-ADMS	86.32	103.78	-31.99	2.45	0.228	0.518	-0.455	-0.882	1.59	0.87

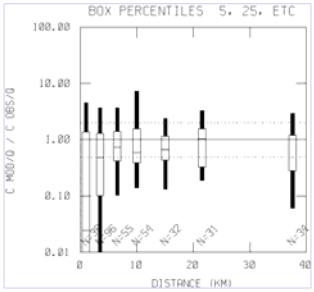
Normalized arcwise maxima concentrations (10^{-9} s m^{-3})

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

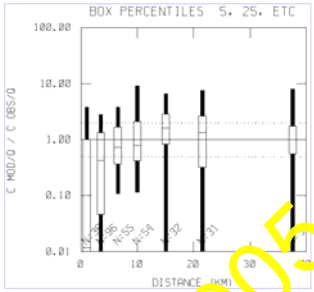
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

VALIDATION AND RESULTS KINCAID



(B) Configuration



(C) Configuration

Tendency to underestimation close to the emission source!

➡ A different plume rise calculation method, such as Moore's one, should be used if the plume is very buoyant.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

SUM OF THE VALIDATION EXERCISE RESULTS

- Scenarios like Copenhagen are well simulated by Safe-Air View.
- Scenarios like Indianapolis and Kincaid are not as well simulated by Safe-Air View: an underestimation of the observed concentrations should be expected.
- Type (B) configuration gives better performances, but the difference of performance with respect of type (A) configuration is reduced.
- (C) and (D) configurations give the worst performances.

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

CONCLUSIONS

- **Mixing height**
  - ⇨ It is not a critical parameter under the current SAFE AIR implementation.
- **Atmospheric dispersion**
  - ⇨ Safe-Air View faces difficulties in predicting the exact ground concentrations under stable conditions (Indianapolis tracer experiment).
- **Plume rise**
  - ⇨ Safe-Air View may underestimate the concentrations close to the emission source (Kincaid tracer experiment).
- **Plume – thermal discontinuity interaction**
  - ⇨ No interaction assumption can bring an underestimation of the observed concentrations if the thermal discontinuity is strong enough to confine the contaminants under the mixing height.
- **Wind field**
  - ⇨ Interpolation of wind data from two meteorological stations can affect negatively the Safe-Air View performances.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

CONCLUSIONS

The present validation exercise suggests that an optimization of the Safe-Air View software may be possible.

Atmospheric dispersion and **plume rise**: more options on these processes can be included in the software by implementing all **σ–functions** and **plume rise computing methods** from the SAFE AIR code.

⇨ The experience from this exercise can help the user to set the best parameterization.

Plume – thermal discontinuity interaction: more options on this process can be included in the software by implementing all **plume – thermal discontinuity interaction dynamics** that the SAFE AIR code can handle: mixing layer total, partial or no penetration.

⇨ However, how to estimate the thermal inversion strength? Further meteorological pre-processing is required.

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

THANK YOU FOR YOUR ATTENTION!

francesco.d'amati@cec.eu.int

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

WNNR AND NNR PERFORMANCE INDICES

- WNNR – Weighted Normalized mean square error of the Normalized Ratios.
  - ⇨ It attributes more weight to model errors concerning the estimates of the highest measured concentrations.
- NNR – Normalized mean square error of the distribution of Normalized Ratios.
  - ⇨ It attributes the same weight to all model errors.
  - ⇨ It is independent of the data set.
  - ⇨ With FA2, it is the only performance index that can be used to compare performances from different data sets.

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

WINDS

(Wind-fiels Interpolation by Non Divergent Schemes)

- **Mass-consistent model**
- **Different initialisation schemes:**
  - ⇨ **ground station data**
  - ⇨ **geostrophic wind**
  - ⇨ **observed vertical profiles**
- **Conformal coordinates**
- **It considers:**
  - ⇨ **complex orography**
  - ⇨ **roughness effects**
  - ⇨ **roughness changes**
  - ⇨ **Coriolis force**

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

P6

(Program Plotting Path of Pollutant Puffs and Plumes)

- **Lagrangian model based on a Gaussian formula.**
- **The emitted pollutant is divided into a sequence of segments and/or puffs which are connected together:**
  - ⇨ **Plume segments during transport conditions;**
  - ⇨ **Puffs during diffusion conditions caused by calm or low wind situation.**
- **It can perform numerical simulations of both non stationary and inhomogeneous situations.**

JRC – NDFM – 10th Conf. on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes. Sissi, Crete (EL), 17-20 September 2005