European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

4th International Workshop *EuNetAir* on

Innovations and Challenges for Air Quality Control Sensors

FFG - Austrian Research Promotion Agency - Austrian COST Association

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AIR-QUALITY MODELLING AT DIFFERENT SCALES

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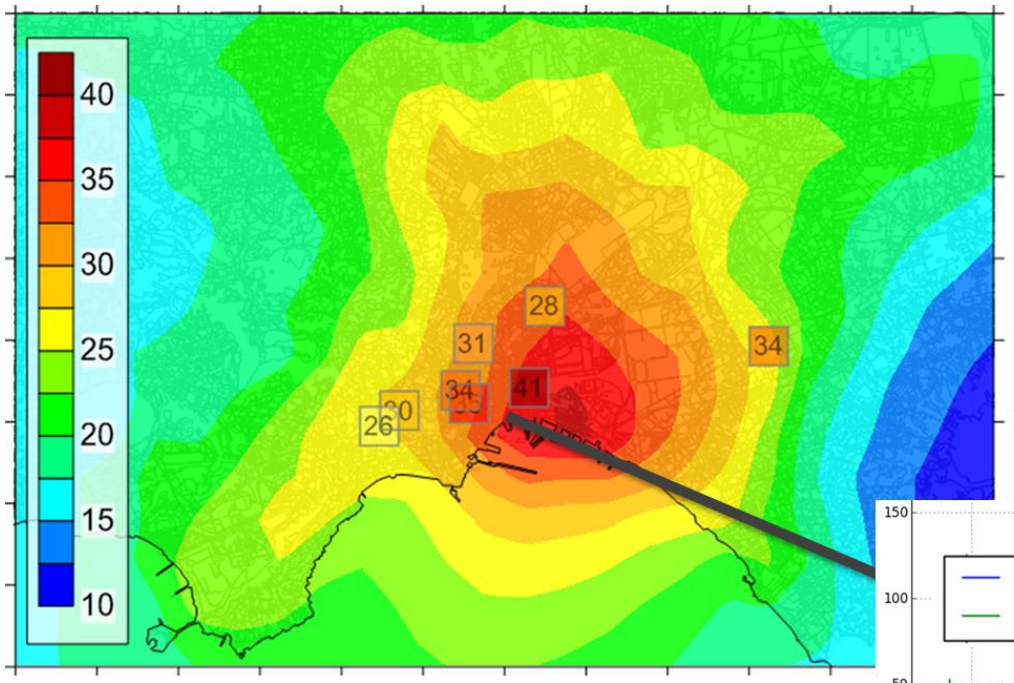
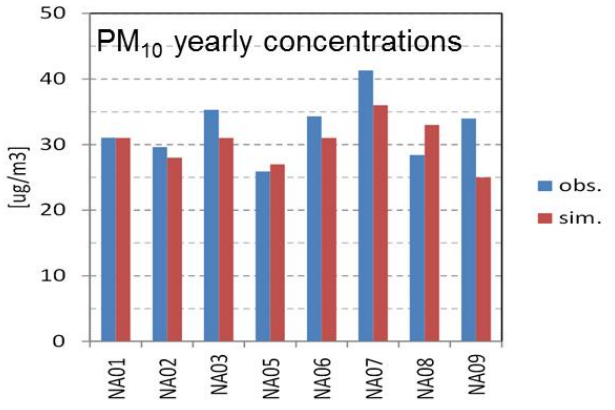
OUTLINE

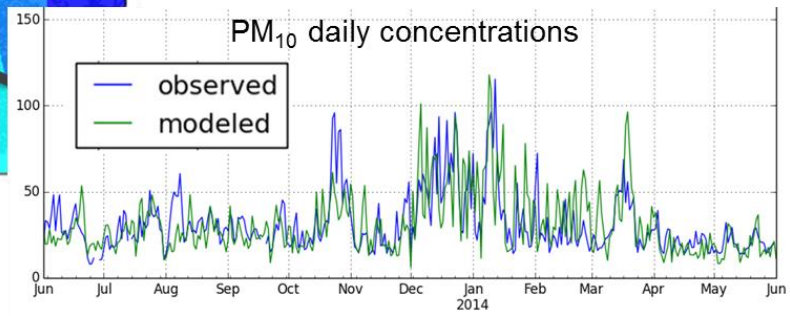
- The integration of dispersion models and low-cost sensors observations is a challenging issue
- Potential for low-cost sensor technologies with respect to dispersion modelling
- Current research activities of ARIANET
- Conclusions

Scientific context and objectives in the Action

- integration of dispersion models and low-cost sensors observations is a challenging issue
  - ✓ The deployment of a large amount of sensors in urban, road traffic, rural or remote sites, permits *to evaluate the behaviour of dispersion models in different real-world situations*



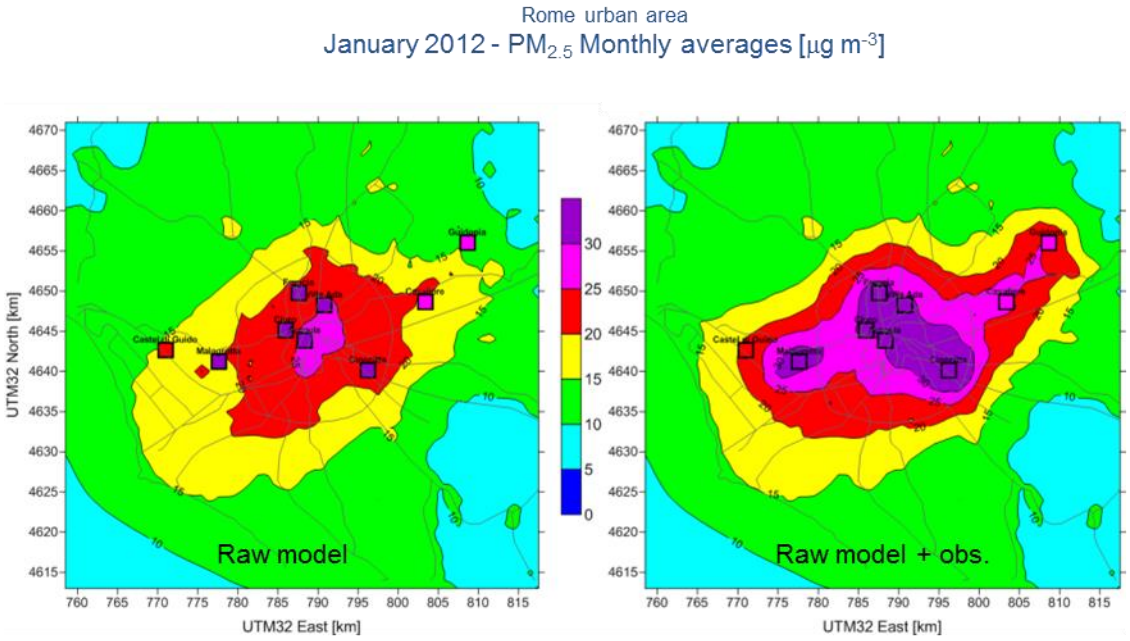


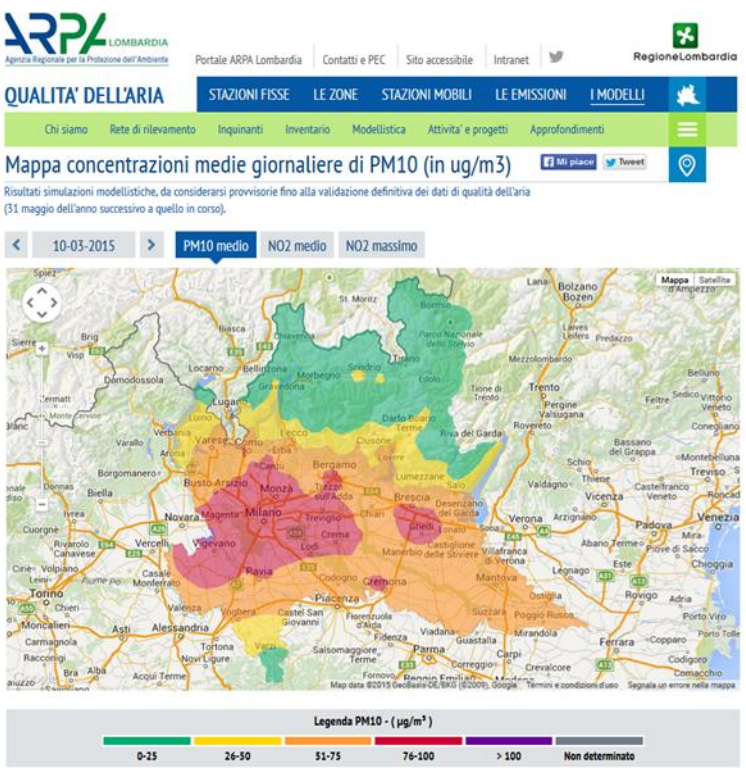


Scientific context and objectives in the Action

- integration of dispersion models and low-cost sensors observations is a challenging issue
  - ✓ *data assimilation/fusion techniques* permit to obtain more realistic air quality maps and to better estimate the exposure of population

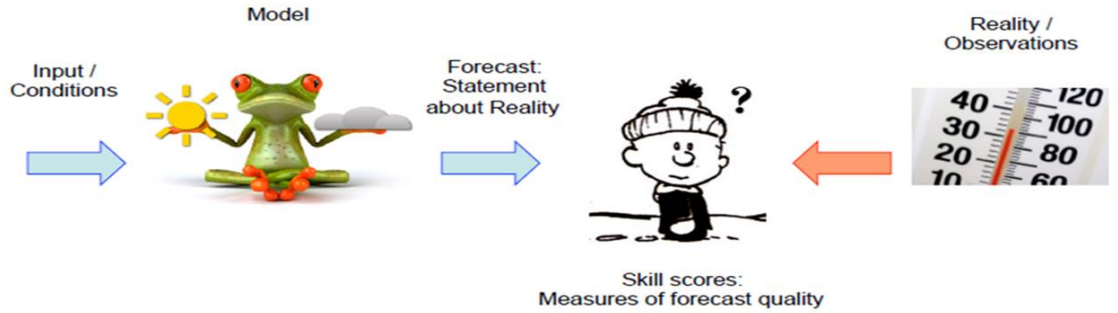
Data fusion & assimilation



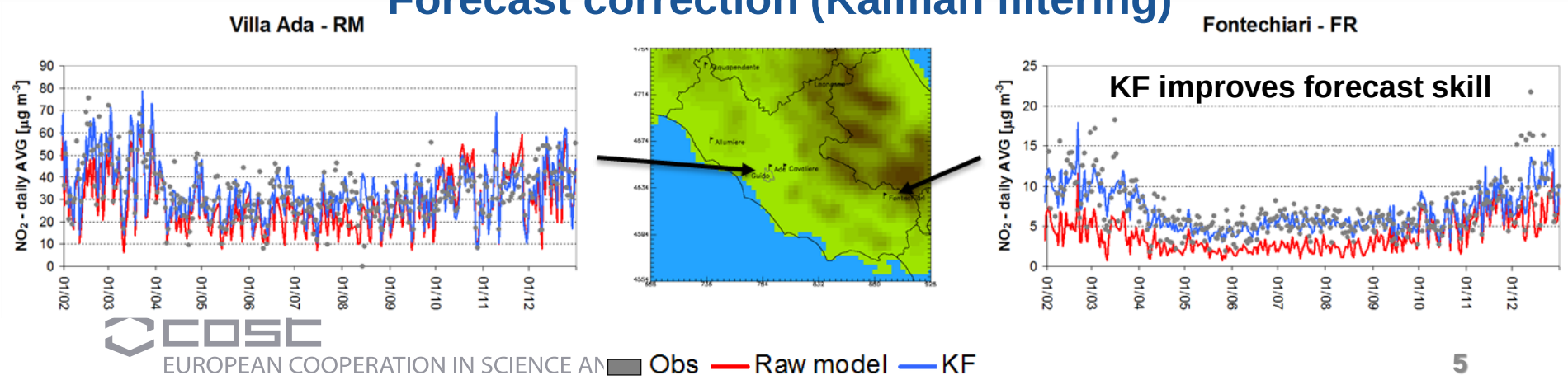


Scientific context and objectives in the Action

- integration of dispersion models and low-cost sensors observations is a challenging issue
  - ✓ Bias-adjustment techniques, using recent past forecasts and observations, can be effectively applied to remove the systematic errors in predictions and *to improve the accuracy of air quality forecast systems (AQFS)*



Forecast correction (Kalman filtering)



Scientific context and objectives in the Action

- potential for low-cost sensor technologies with respect to dispersion modelling
  - ✓ To establish source-receptor relationships and to estimate emission fluxes from known/unknown sources

Definitions:

- Trajectories: the paths of infinitesimally small particles of air as they move through time and space.

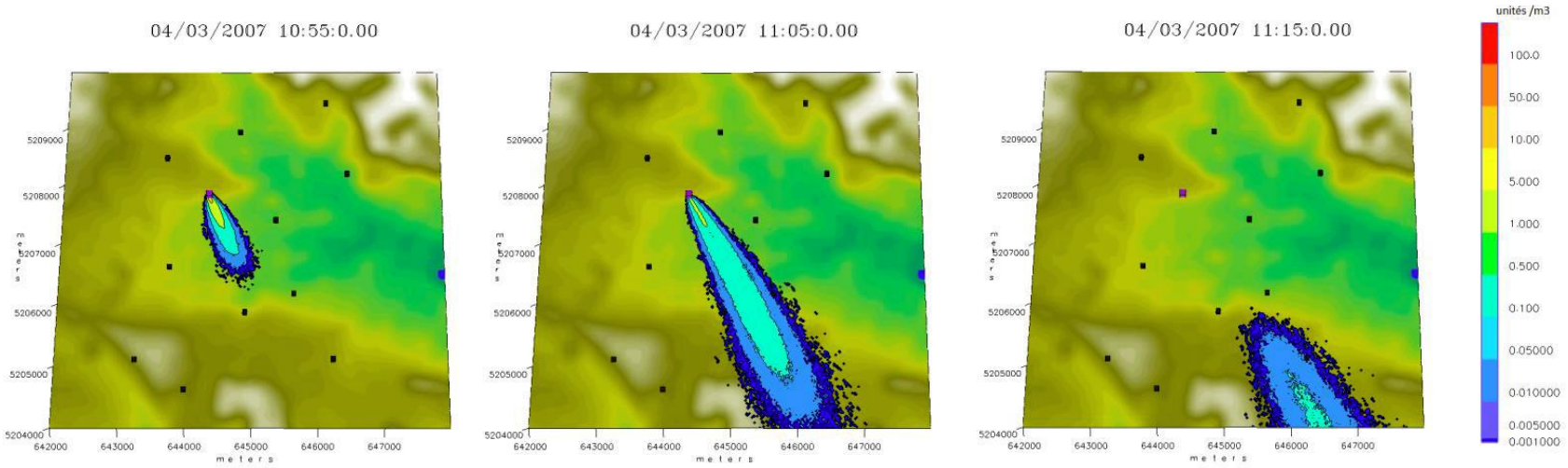
- Such fluid particles, ‘marked’ at a certain point in space at a given time, can be traced ***forward*** or ***backward*** in time along their trajectory:

  - **Forward trajectories**: indicate the future path of a particle

  - **Backward (back) trajectories**: indicate the past path of a particle

Scientific context and objectives in the Action

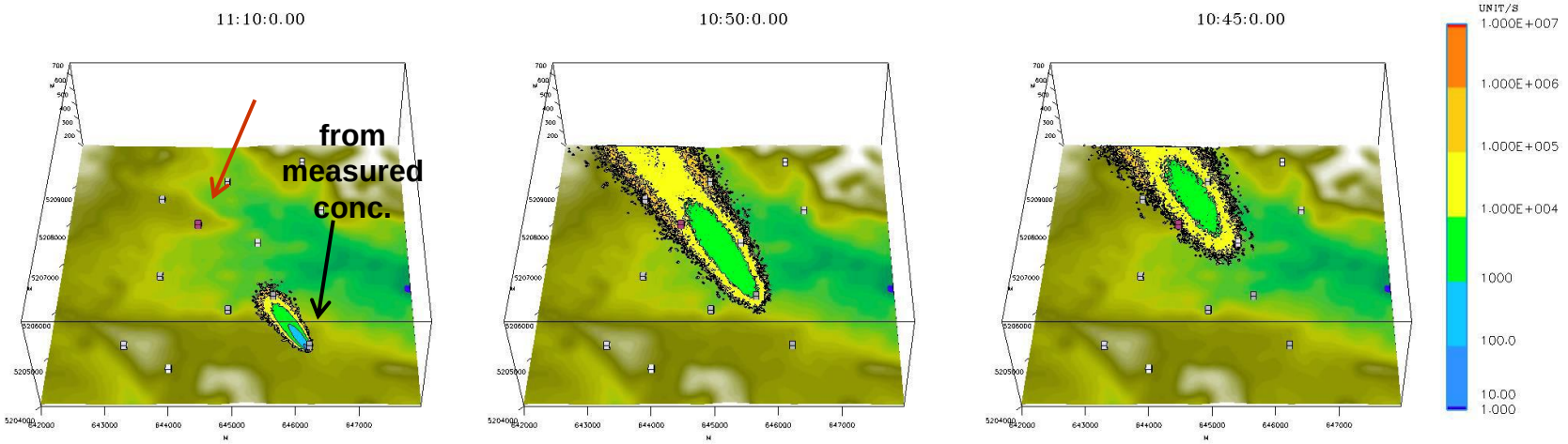
Forward Lagrangian particle simulation (from **source** to **receptors**)



Ground level concentrations [μg m^{-3}] from a source at ground that emits from 10:00 to 10:20 ($Q(t)=10^5$ μg s^{-1}).

- **source**
- **receptors**

Backward Lagrangian particle simulation (from 1 **receptor** to **source**)

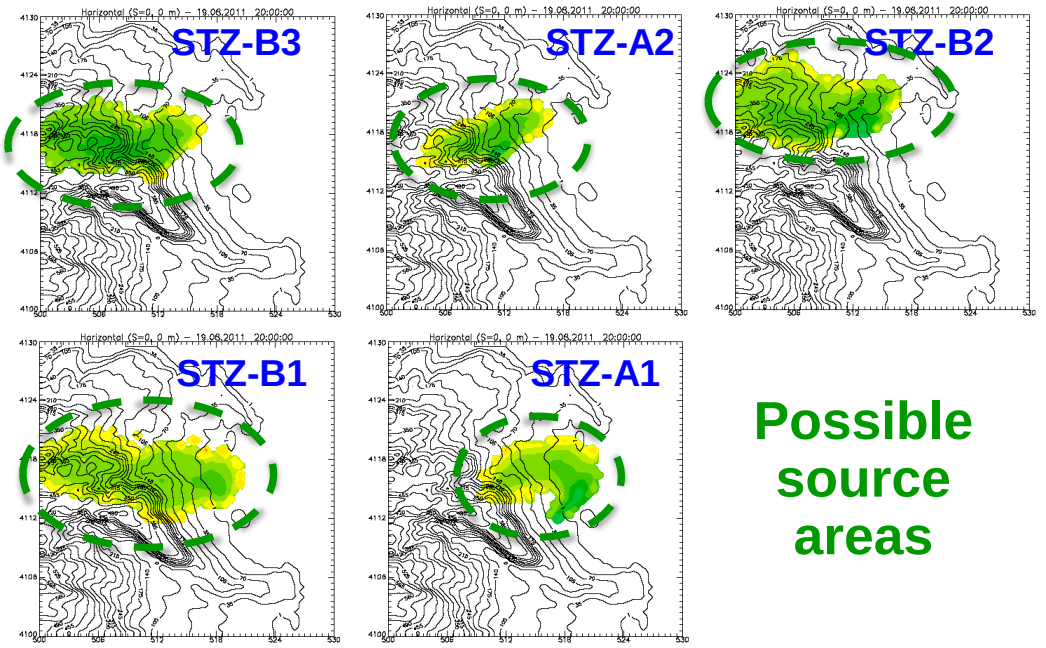


The emission flux close to source is correctly estimated (about 10^5 μg s^{-1}).

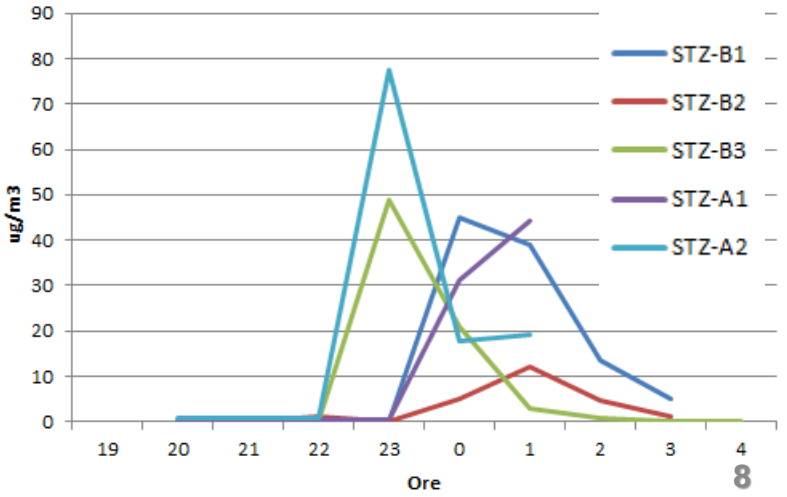
Scientific context and objectives in the Action

Odoriferous emissions estimates

Backward Lagrangian particle simulations (from 5 receptors to source)



Possible source areas

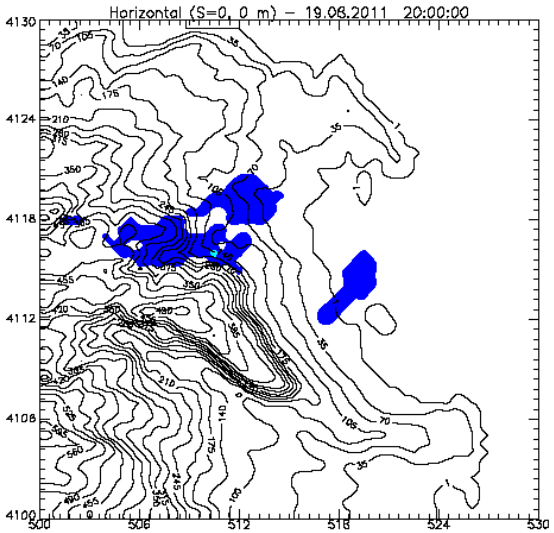


Scientific context and objectives in the Action

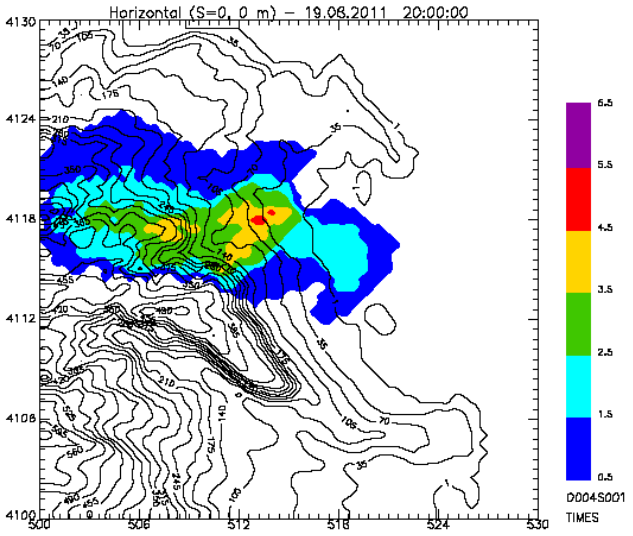
Odoriferous emissions estimates

At each grid point it is possible to determine the number of events below defined thresholds

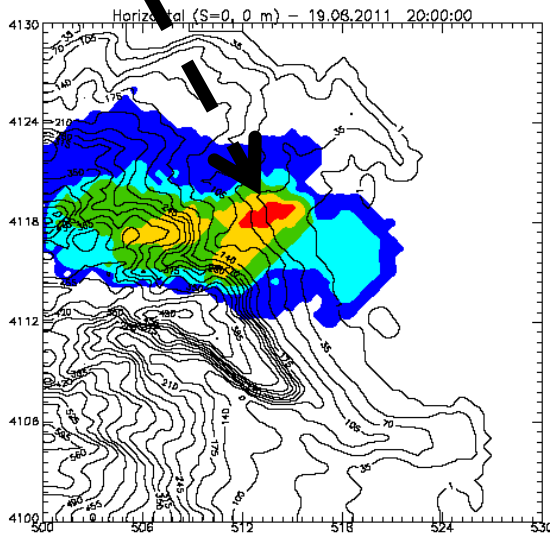
The different simulations evidence «overlapping zones» from which the odoriferous substances could be emitted. For these zones it is also possible to estimate the intensity of emissions.



# of events < 1 g/s



# of events < 100 g/s



# of events < 1000 g/s

Scientific context and objectives in the Action

- potential for low-cost sensor technologies with respect to dispersion modelling
  - ✓ set-up *of alert systems*, based on dispersion models and sensors deployed around hazardous facilities, would provide important information regarding the danger to public safety in case of accidents

Risk Assessment and Emergency Response

The legislation prescribe that hazardous facilities have **to *identify possible accident situations*** and **to perform dispersion simulations** in order to:

- ➢ *identify risk areas*
- ➢ *categorise the areas with respect to the possible effects of contaminants on population*

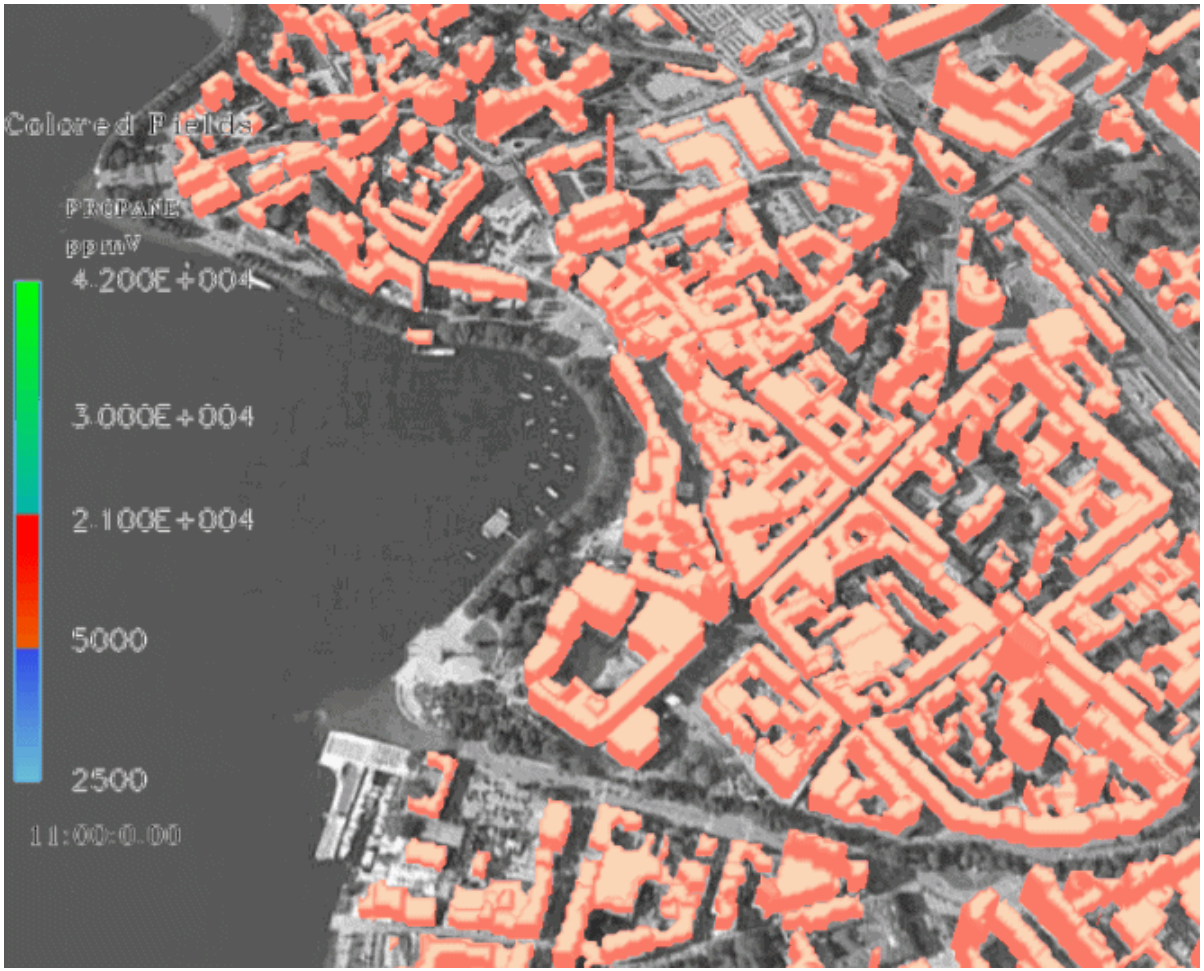
Scientific context and objectives in the Action

Ground level propane concentrations 1 min after an accident involving a LPG tank truck

Upper Explosion limit (UEL)

Potential Explosion area

Lower Explosion limit (LEL)

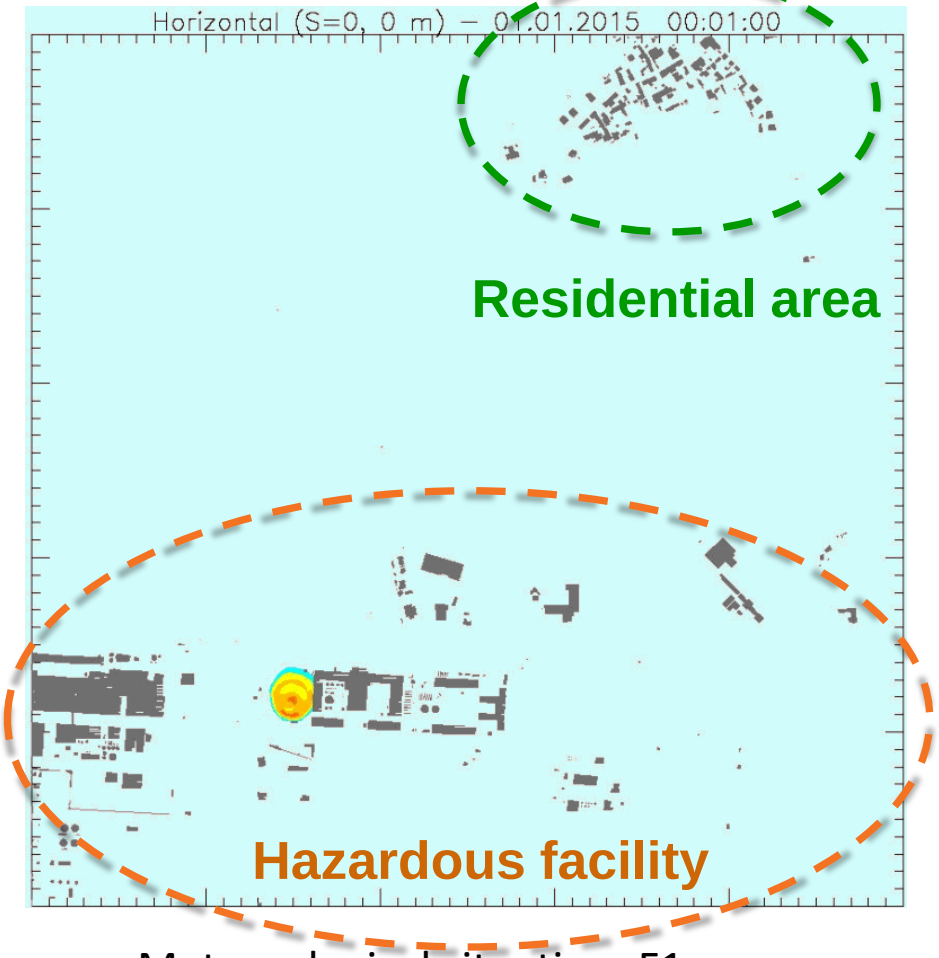


Scientific context and objectives in the Action

Dense gas emission from an hazardous facility

- the simulation of significant **meteorological situations** and **potential releases** provide recommendation for low-cost sensors placement

- the set-up of alert systems, based on dispersion models and well located sensors, permits to promptly respond to an acute ACCIDENTAL release



Meteorological situation: F1

dense gas emission: 15’ simulation period: 60’, Animation freq.:1’

Current research activities of ARIANET

- establishing consensus on the 'state-of-the-art' in local (micro) scale airborne hazards modelling
- providing common means, tools and data for rigorously testing and evaluating models
- providing guidance for reliable use of models in the context of local-scale emergency response
- develop and test strategies and methodologies for new advanced modelling approaches

http://www.elizas.eu/index.php/documents-of-the-action

Current research activities of ARIANET

Open burning impact on air quality and health

The **F**ire **In**ventory from **N**CAR model (***FINN version 1***) provides:

- high resolution, global emission estimates from **open burning** at a horizontal resolution of 1 km^2;
- input needed for modelling atmospheric chemistry and air quality based on a new compilation of biomass burning emission factors; a large number of species are considered and speciation profiles of the NMOC emissions are provided for following chemical mechanisms: MOZART, SAPRC99 and GEOS-CHEM.

Geosci. Model Dev., 4, 625–641, 2011
www.geosci-model-dev.net/4/625/2011/
doi:10.5194/gmd-4-625-2011

Geoscientific Model Development

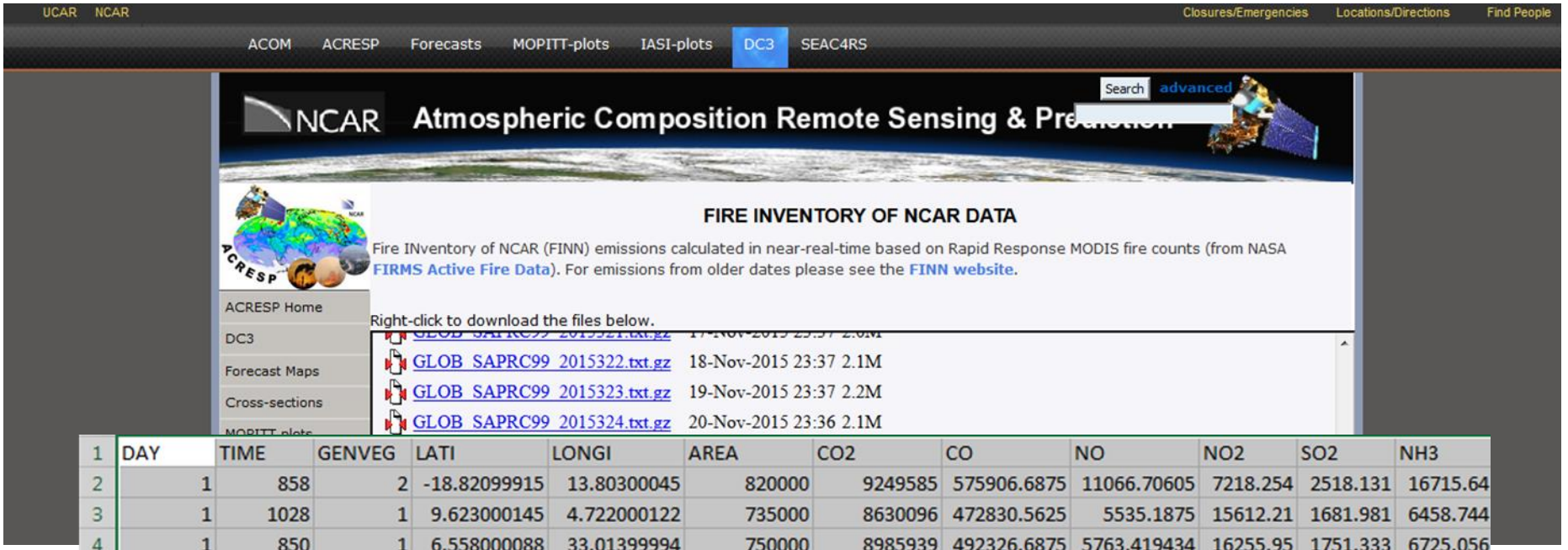
The Fire INventory from NCAR (FINN): a high resolution global model to estimate the emissions from open burning

C. Wiedinmyer[1], S. K. Akagi[2], R. J. Yokelson[2], L. K. Emmons[1], J. A. Al-Saadi[3], J. J. Orlando[1], and A. J. Soja[4]

[1]National Center for Atmospheric Research, Boulder, CO, USA
[2]University of Montana, Department of Chemistry, Missoula, MT, USA
[3]NASA Headquarters, Washington DC, USA
[4]National Institute of Aerospace, NASA Langley Research Center, Hampton, VA, USA

Current research activities of ARIANET

FINN data availability

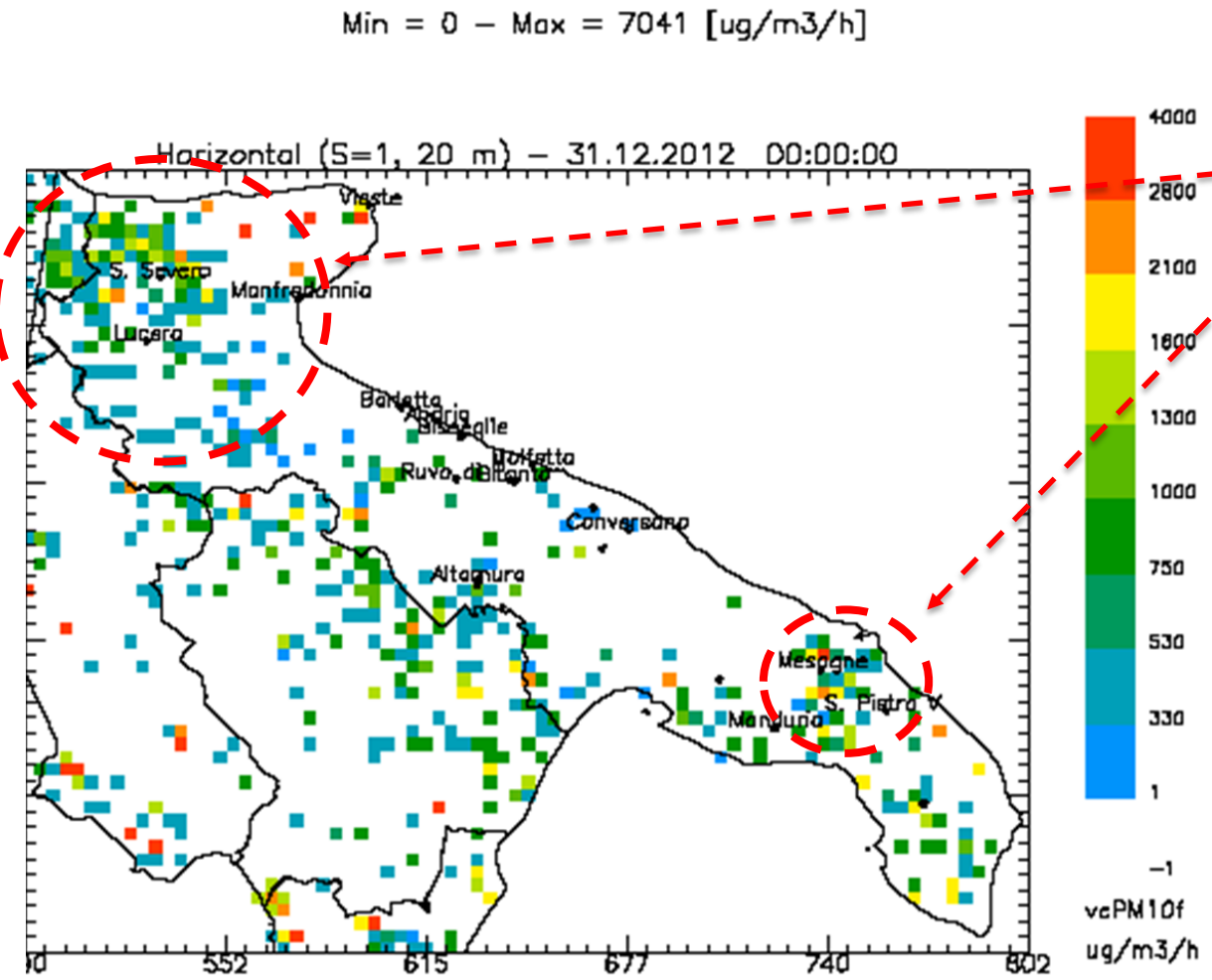


	DAY	TIME	GENVEG	LATI	LONGI	AREA	CO2	CO	NO	NO2	SO2	NH3
2	1	858	2	-18.82099915	13.80300045	820000	9249585	575906.6875	11066.70605	7218.254	2518.131	16715.64
3	1	1028	1	9.623000145	4.722000122	735000	8630096	472830.5625	5535.1875	15612.21	1681.981	6458.744
4	1	850	1	6.558000088	33.01399994	750000	8985939	492326.6875	5763.419434	16255.95	1751.333	6725.056
5	1	1028	1	10.2840004	1.567999959	720000	8281440.5	453728.1875	5311.566406	14981.48	1614.029	6197.811
6	1	1028	1	10.89900017	5.228000164	719072.1875	8260111.5	452559.6563	5297.886719	14942.89	1609.872	6181.848
7	1	850	1	6.56099987	32.99399948	750000	8985939	492326.6875	5763.419434	16255.95	1751.333	6725.056
8	1	1029	1	8.736000061	2.267999888	750000	8985939	492326.6875	5763.419434	16255.95	1751.333	6725.056
9	1	2352	3	-35.09799957	150.3619995	1000000	125612112	11051469	102028.3125	263266.5	21009.63	262773.9
10	1	850	2	6.550000191	25.70299912	1000000	27237328	1695877	32588.2168	21255.65	7415.16	49222.67
11	1	2116	2	6.940000057	23.59199905	1000000	12151199	756569.875	14538.35449	9482.635	3308.074	21959.37
12	1	850	1	6.8660								725.056
13	1	858	2	-18.820								17749.8

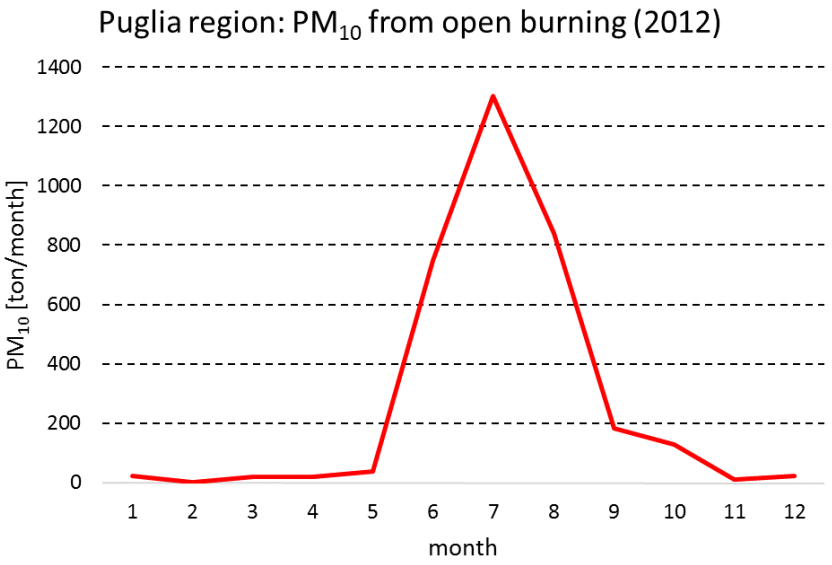
http://www.acom.ucar.edu/acresp/dc3/AMADEUS/finn/emis/

Current research activities of ARIANET

PM_{10} emissions from open burning in Southern Italy

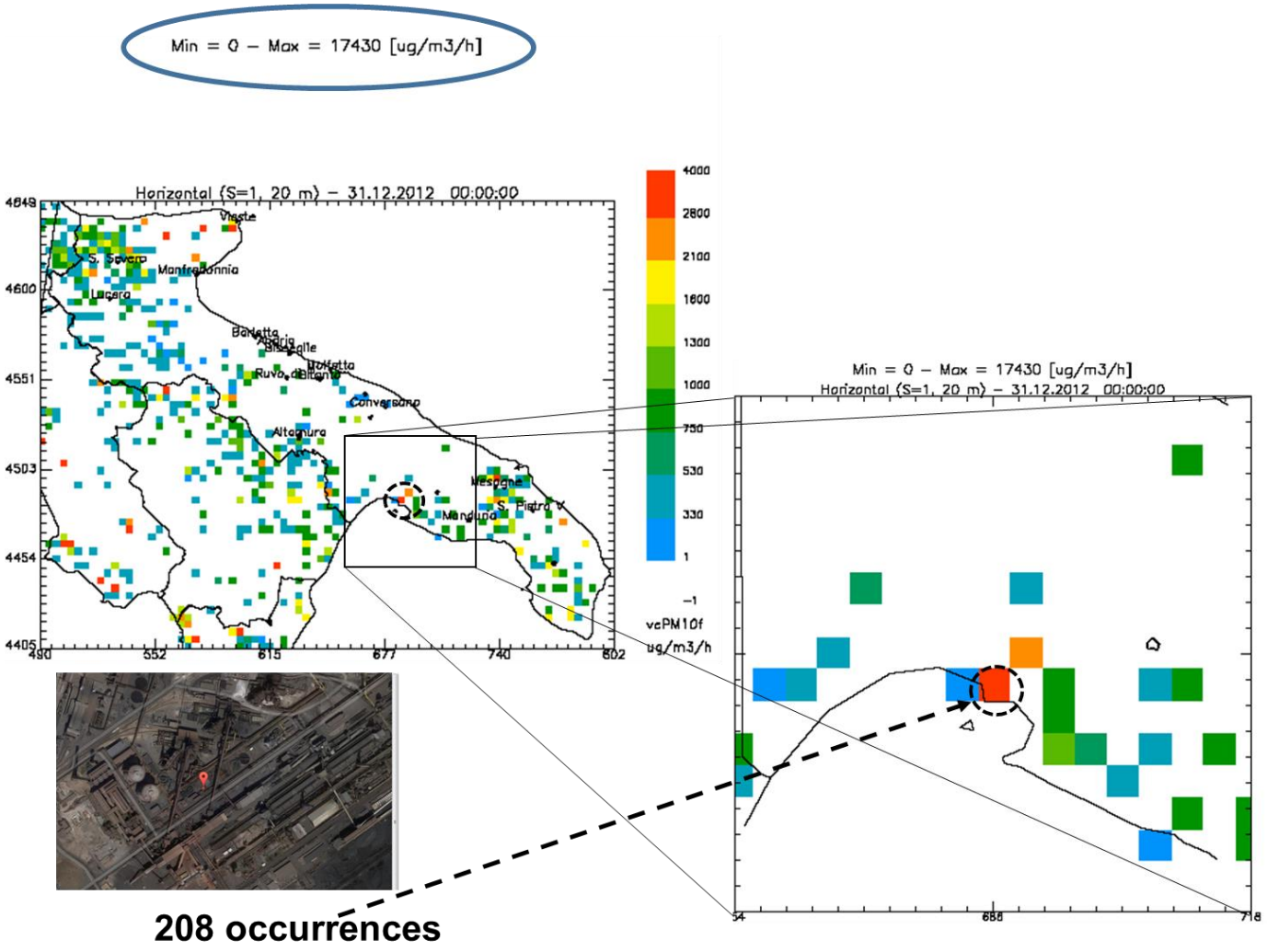


These areas (burning of residues from agriculture) could be monitored by low-cost sensors to check the actual impact of open burning emission on air quality and health



Current research activities of ARIANET

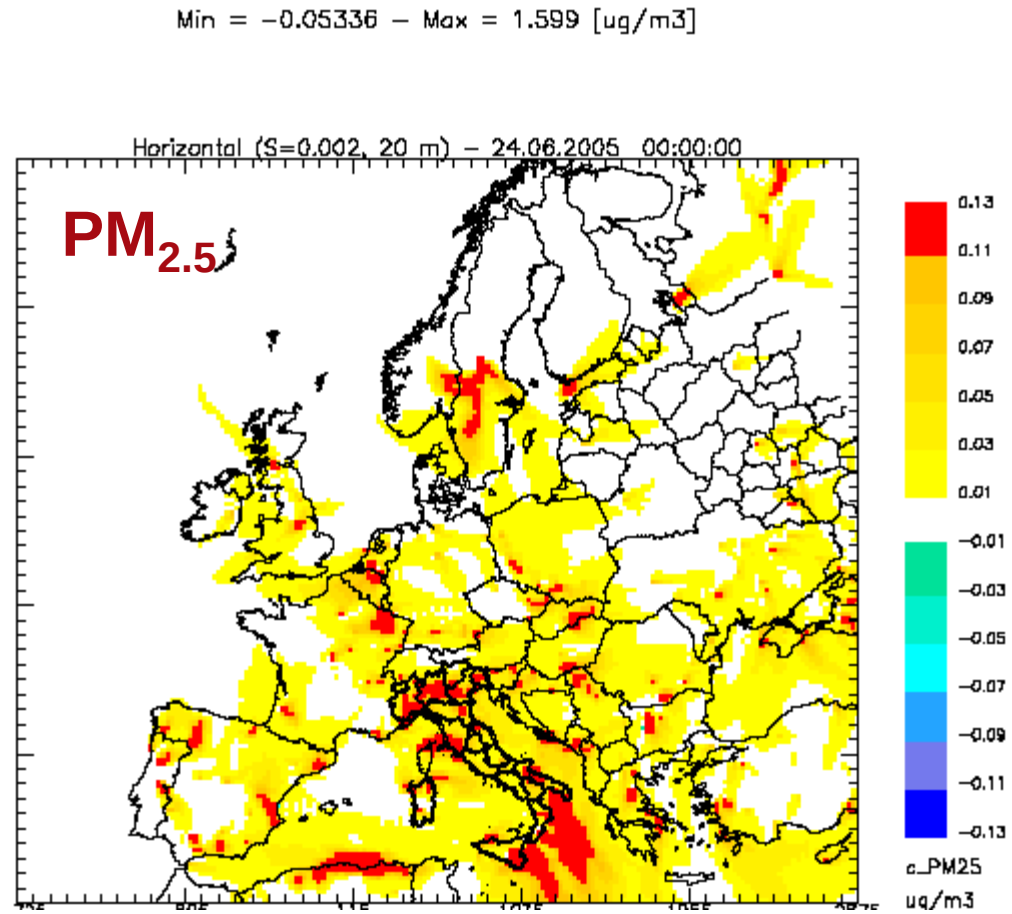
Pre-analysis of FINN data is needed !!!

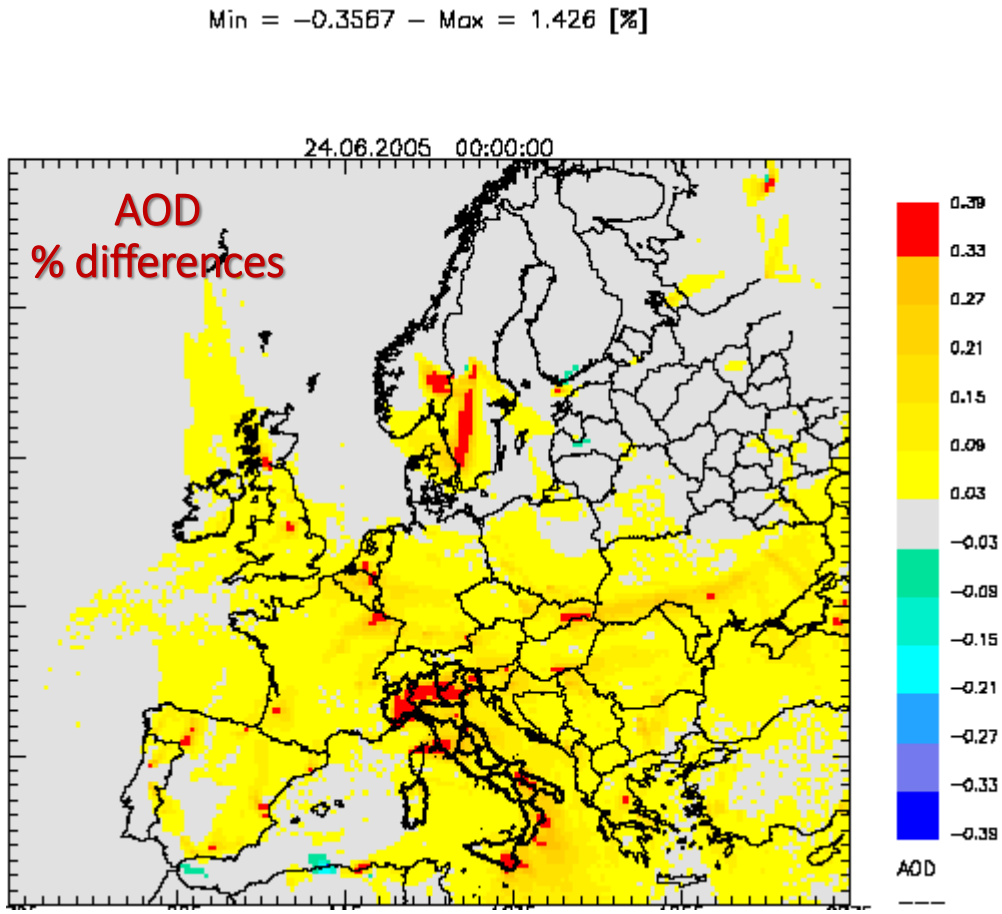


"false fires" from an area in which the largest steel plant in Europe is located

Current research activities of ARIANET

Open burning impact on air quality and visibility





CONCLUSIONS

- integration of dispersion models and low-cost sensors observations is a challenging issue for:
  - Model evaluation;
  - air quality assessment (data fusion);
  - forecast (bias-adjustment techniques);

- dispersion model results provide guidance for sensors placement

- potential of new sensing technologies:
  - to deploy a large number of sensors possibly measuring a wider range of pollutants;
  - to establish source-receptor relationships and to estimate emission fluxes from unknown sources by means of backward trajectory models;
  - set-up of alert systems to support emergency management and response

Acknowledgments

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Arianet S.r.l. and Aria Technologies S.A.

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Thank you for your attention !!!