

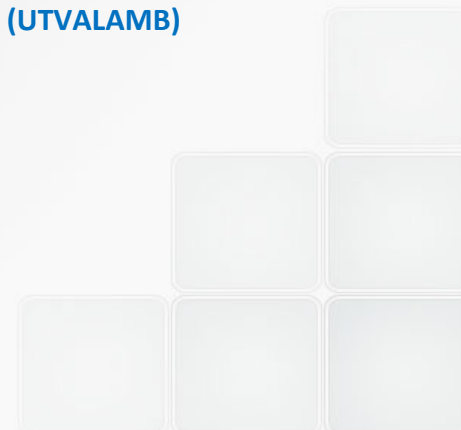


Air quality assessment over Italy, Europe and Middle East using Copernicus data

*Gabriele Zanini, Luisella Ciancarella, Massimo D'Isidoro
and colleagues from the Air Quality LAB.*

National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)
Technical Unit Models, Methods and Technologies for the Environmental Assessment (UTVALAMB)

Gabriele.zanini@enea.it

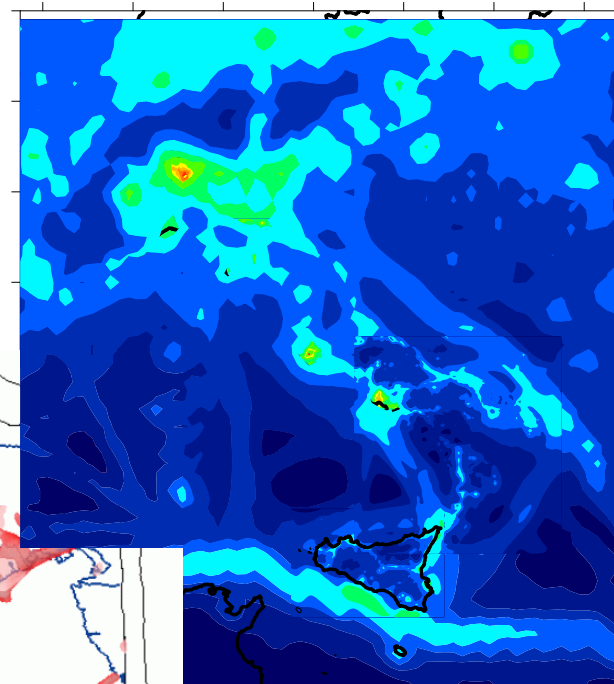
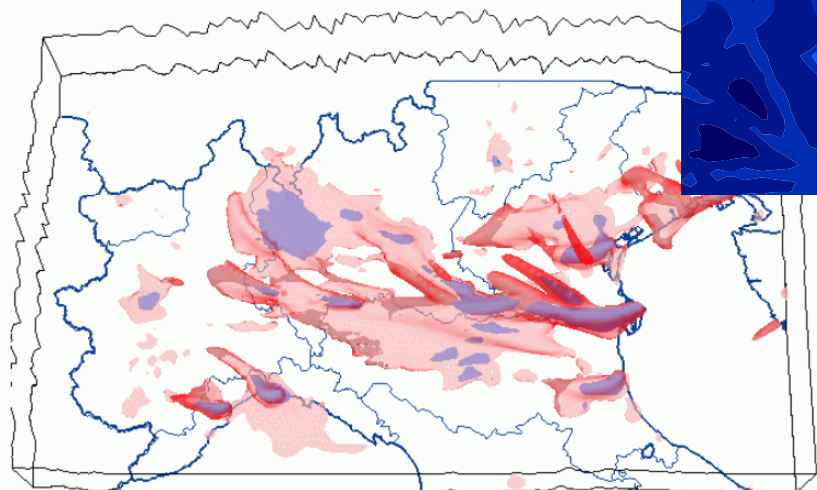


MINNI National Air Quality Assessment System

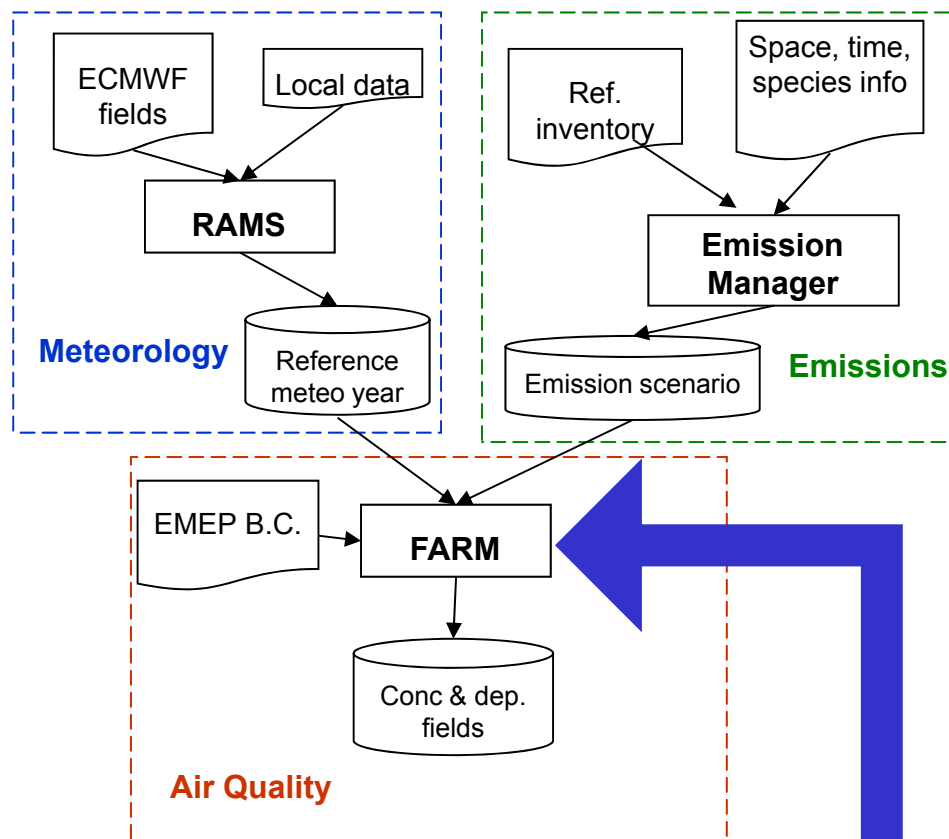


- ➔ Support to international negotiations on air pollution.
- ➔ Integrated assessment of national and regional air quality plans.

WWW.MINNI.ORG



AMS-MINNI Atmospheric Modelling System



FARM Main features:

- ✓ **Emission** of pollutants from area and point sources, with plume rise calculation and mass assignment to vertical grid cells
- ✓ **3D dispersion** by advection and turbulent diffusion
- ✓ Flexible **gas-phase mechanism** (SAPRC-99, **POPs-Hg**) through **KPP** (Kinetic Pre-Processor: Damian *et al.*, 2002).
- ✓ Treatment of **PM₁₀** and **PM_{2.5}** (*aero3* modal aerosol module)
- ✓ **Dry removal** of pollutants dependent on local meteorology and land-use
- ✓ Removal through **precipitation scavenging** processes

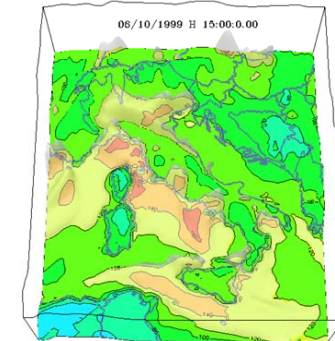
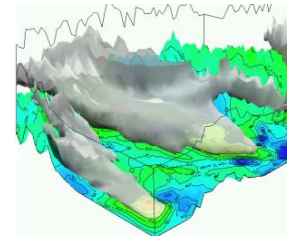
Free Download:
<https://hpc-forge.cineca.it>

FARM (Flexible Air quality Regional Model)



Multigrid Eulerian grid model for dispersion, transformation and deposition of inert and **reactive pollutants** (photochemistry and aerosols)

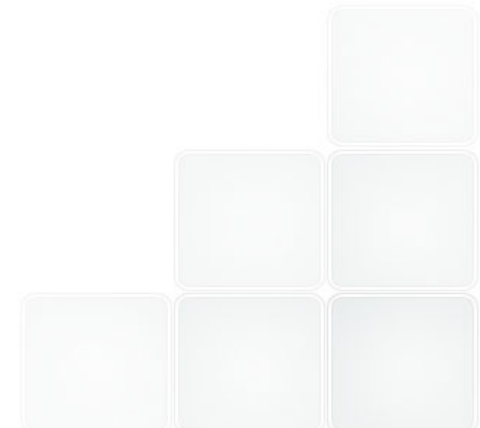
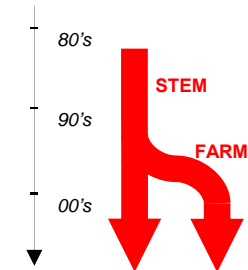
- From urban to national to continental scale
- Multiple nested grids, on- and off-line
- Observational data assimilation
- Time frame: episodic / long-term
- Reactive / tracers
- Fully parallelized



Initially derived from **STEM** prof. G.R. Carmichael *et al.*, CGRER (Center for Global and Regional Environmental Research, U. of Iowa)

OPEN FOR MODELERS COMMUNITY AND FREE.
Continuously improved by **ARIANET & technical partners.**

Registered in European Environmental Agency Model Documentation System(MDS):
<http://pandora.meng.auth.gr/mds/showlong.php?id=130>



MODEL SIMULATIONS

SIMULATED YEARS: assessment (1999, 2003, 2005*, 2007, 2010**) scenarios (different projections at 2015, 2020, 2030)

* includes HM and POPs at 20 km horizontal resolution

** includes HM and POPs at 4 and 20 km horizontal resolutions

METEOROLOGY:

1999, 2005:

20km res. RAMS (nudging)

4km res. LAPS (diagnostic)

2003, 2007, 2010:

RAMS (nudging) at 20km and 4km res.

EMISSIONS:

EMEP + National Inventory (ISPRA)
(top-down approach)+ Regional
Inventories (GAINS methodology)

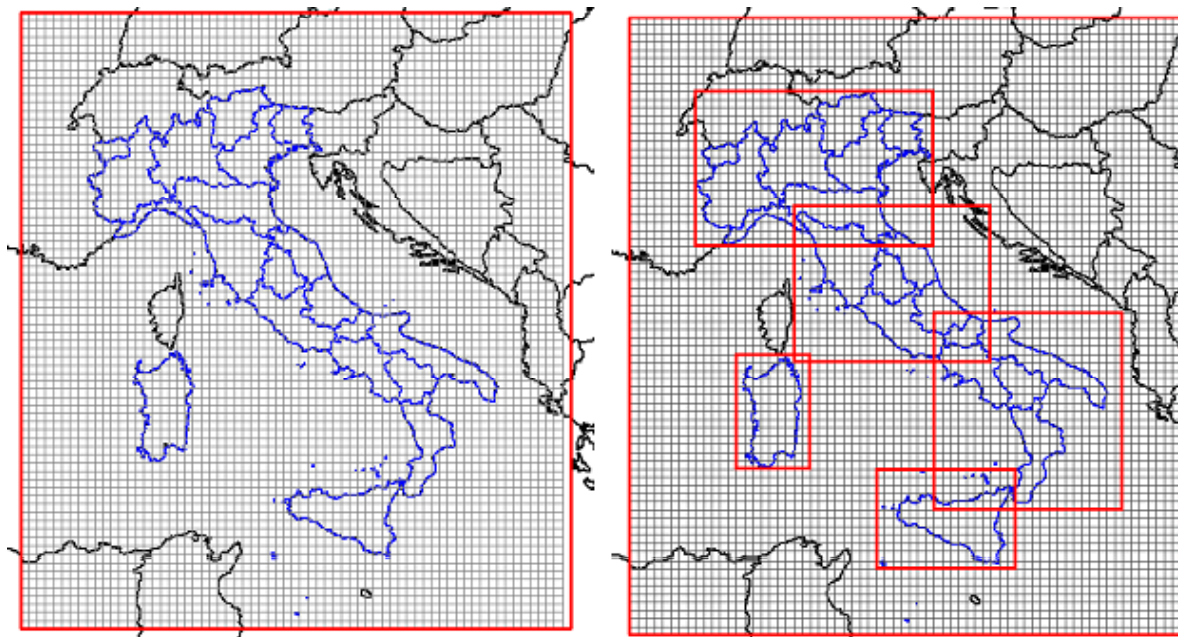
IC/BC:

EMEP/MSC-W output at 3 hour time
resolution for gases and aerosol species;
EMEP W/MSC-E output at 6 hour time
resolution for HM and POPs

AIR QUALITY:

20km and 4 km res. FARM

One-way nested



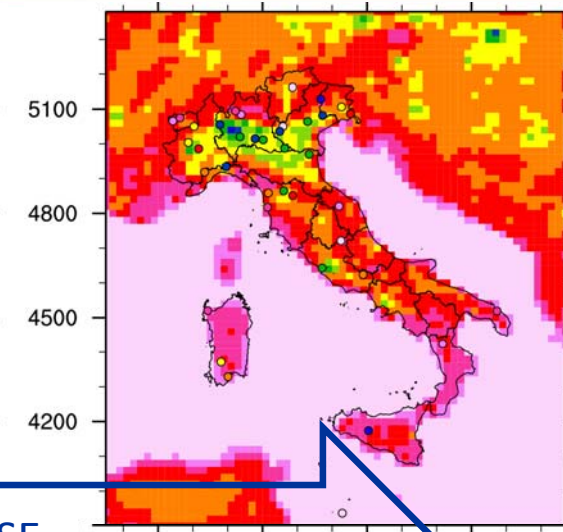
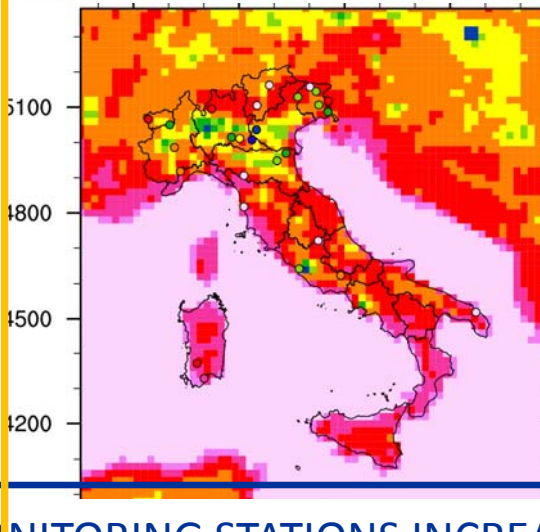
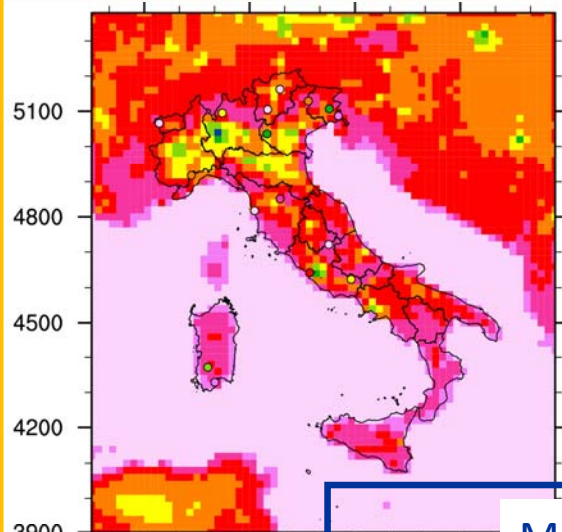
Ozone (O₃): background stations



2003

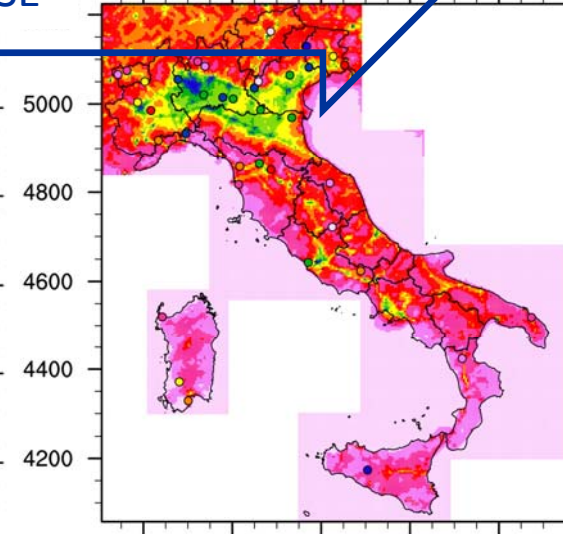
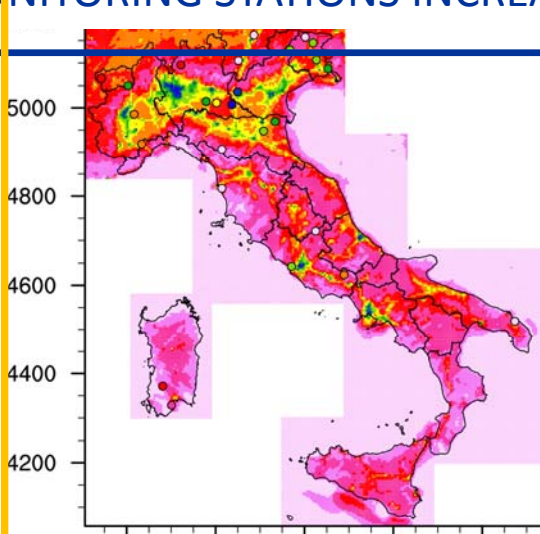
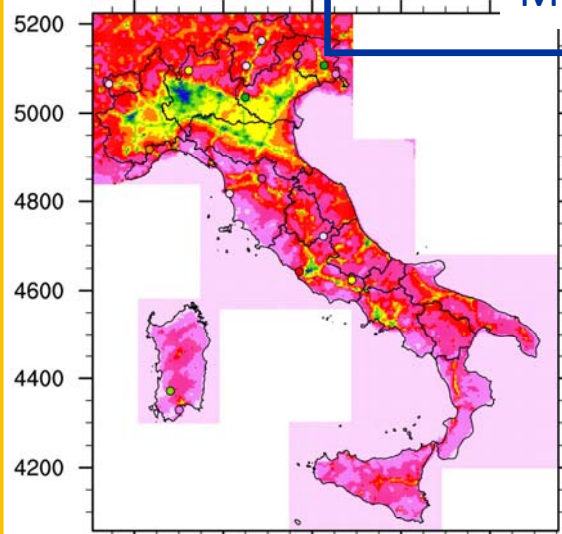
2005

2007

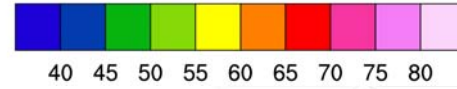
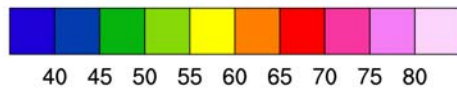
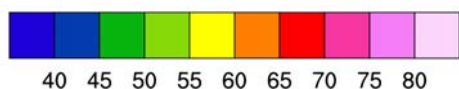


20 km

MONITORING STATIONS INCREASE



4 km



$\mu\text{g}/\text{m}^3$

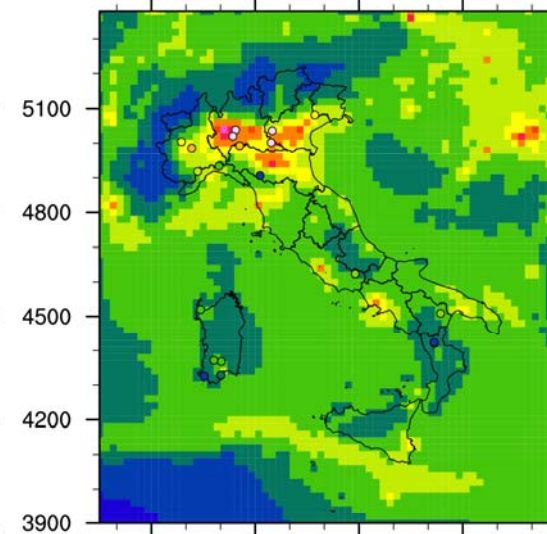
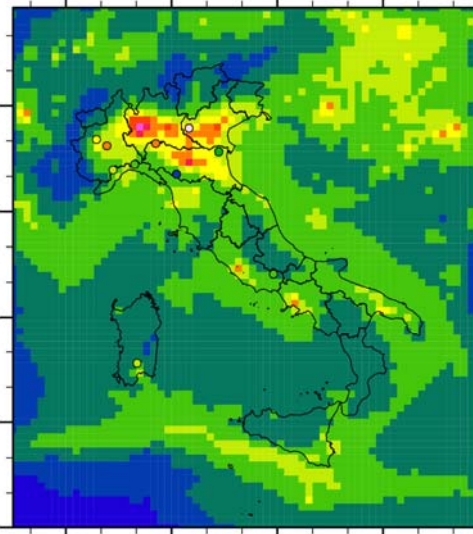
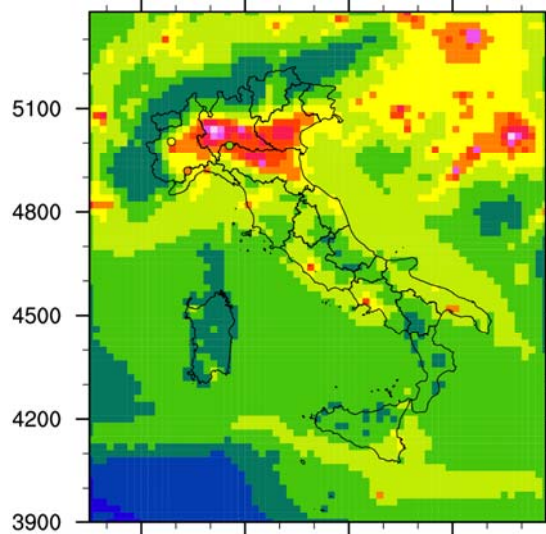
PM10: background stations



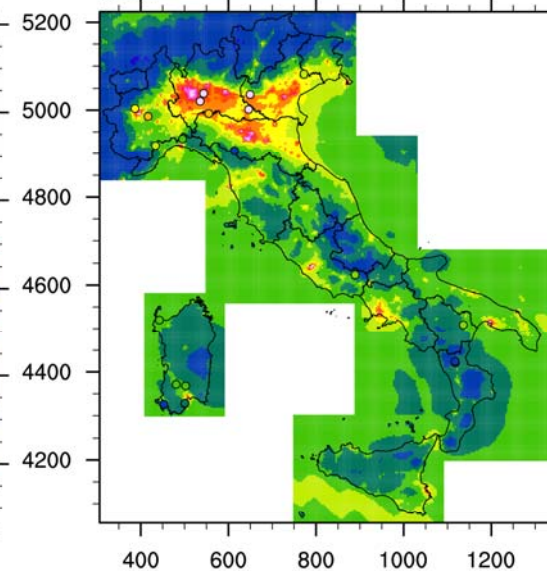
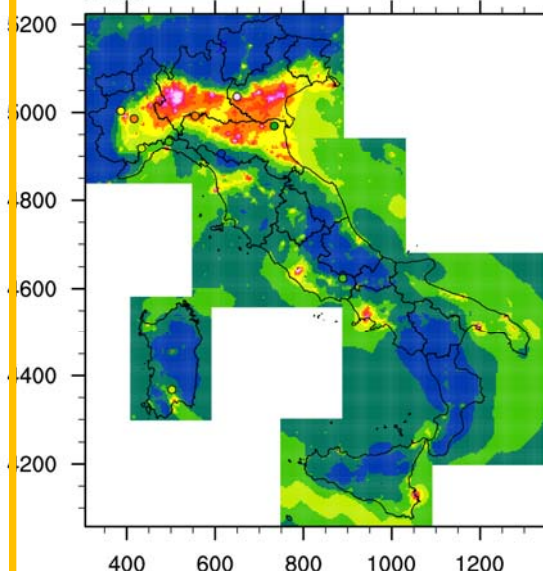
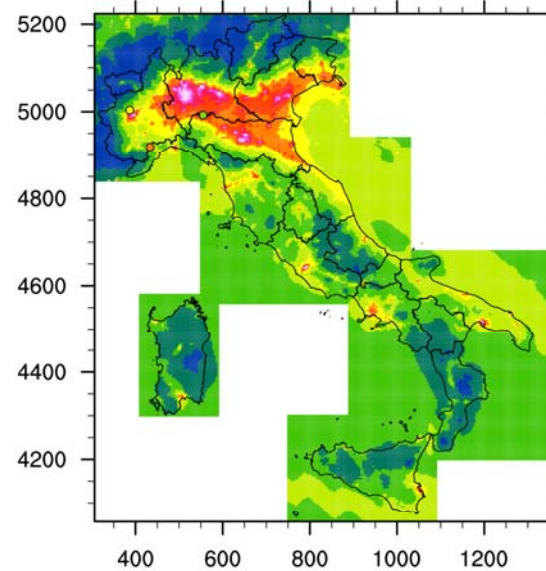
2003

2005

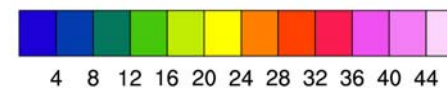
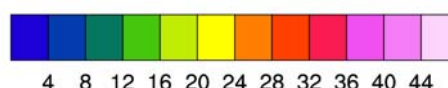
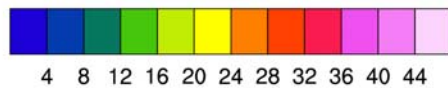
2007



20 km



4 km



$\mu\text{g}/\text{m}^3$

MODEL VALIDATION



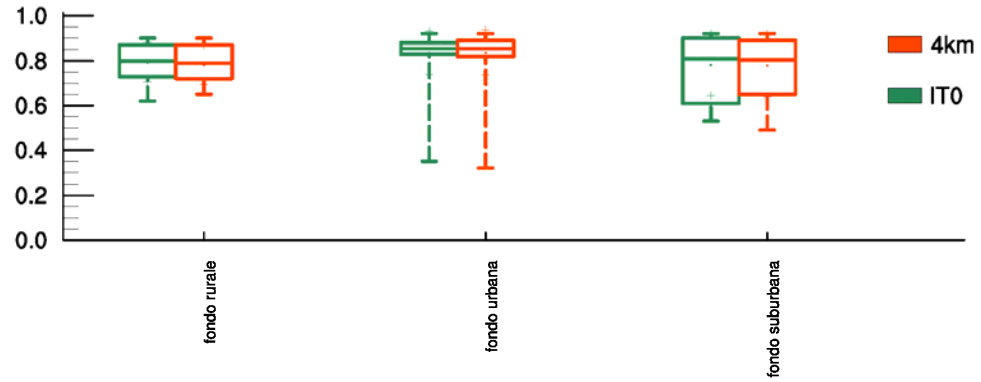
For standard validation of AMS results, we run a set of procedures:

- extraction of monitoring stations data: from national repository (conducted by ISPRA, which collects data from Regional agencies)
- comparison with simulated data at stations sites: calculation of scores following EU-FAIRMODE guidelines
 - **e.g., requirements on data capture for calculating a yearly average:**
 - ✓ valid days: > 75% of valid hourly records in 1 day
 - ✓ valid months: > 90% of valid days in 1 month
 - ✓ valid seasons: > 75% of valid records in 1 season
 - ✓ valid year: > 90% of valid records in 1 year (O3: > 75% of valid data both in summer and in winter 6 months)

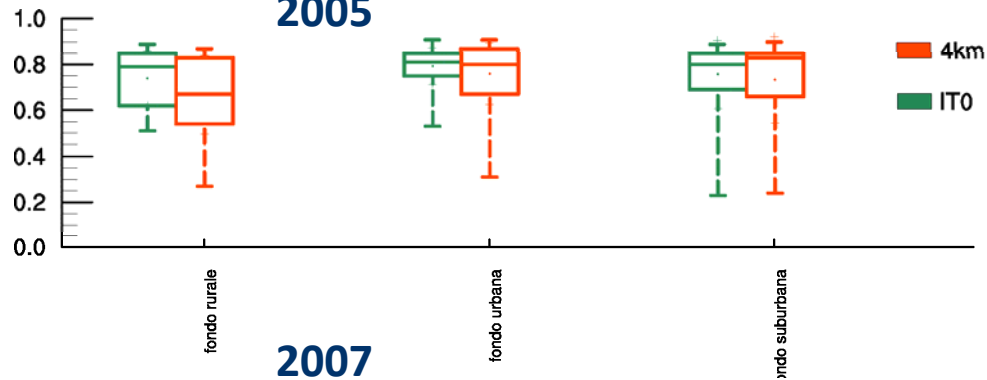
Mircea, M., Ciancarella, L., Briganti, G., Calori, G., Cappelletti, A., Cionni, I., Costa, M., Cremona, G., D'Isidoro, M., Finardi, S., Pace, G., Piersanti, A., Righini, G., Silibello, C., Vitali, L., and Zanini, G., (2014). Assessment of the AMS-MINNI system capabilities to predict air quality over Italy for the calendar year 2005. Atmospheric Environment, Vol. 84, February 2014, Pages 178–188

O₃: correlation

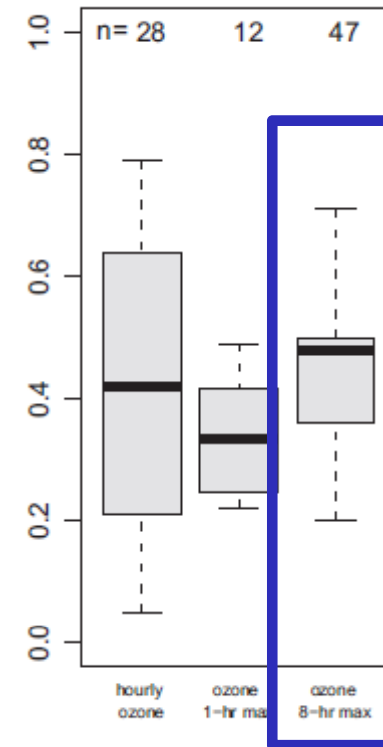
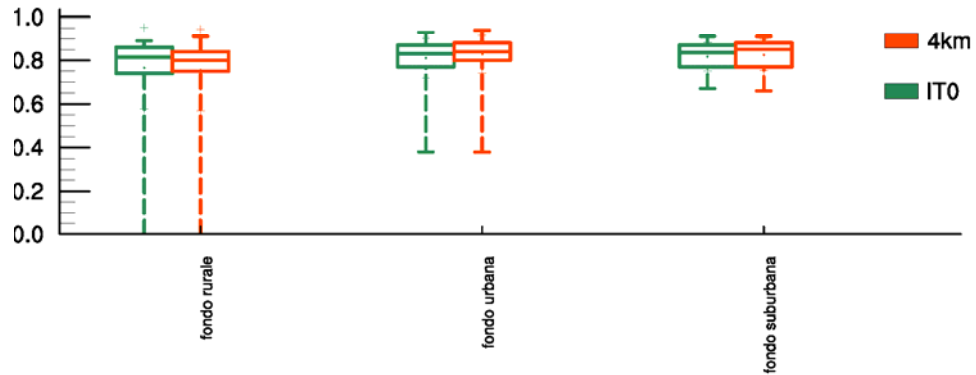
2003



2005

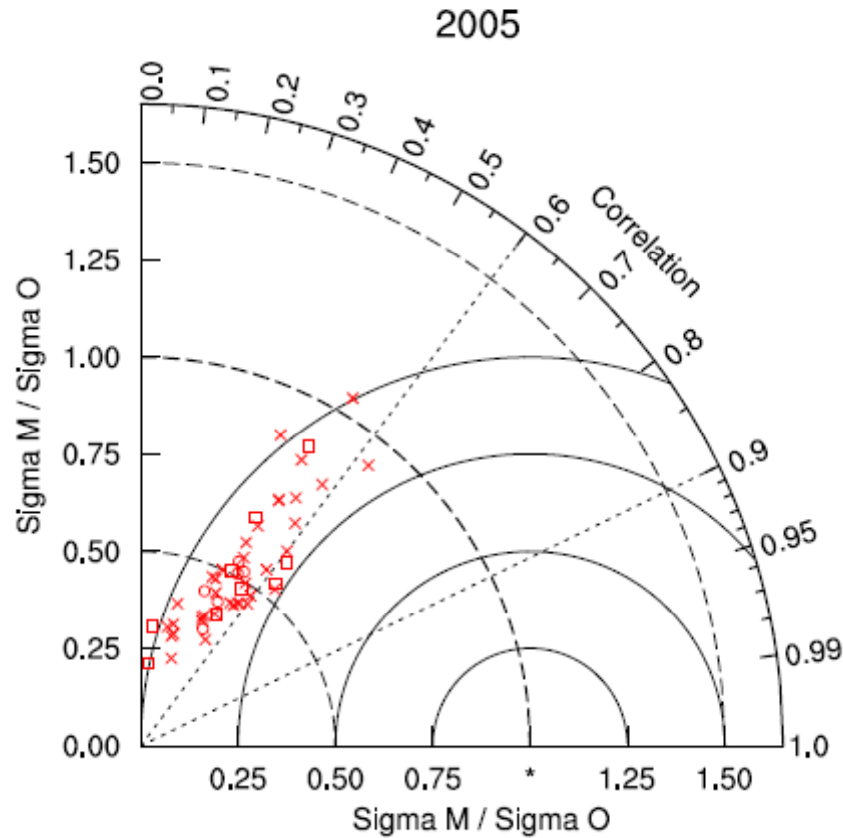


2007



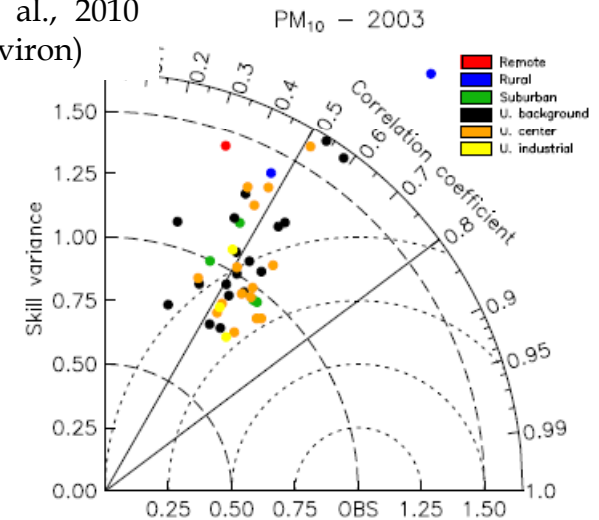
Simon et al., 2012
(Atmos. Environ)

PM10: Taylor diagram

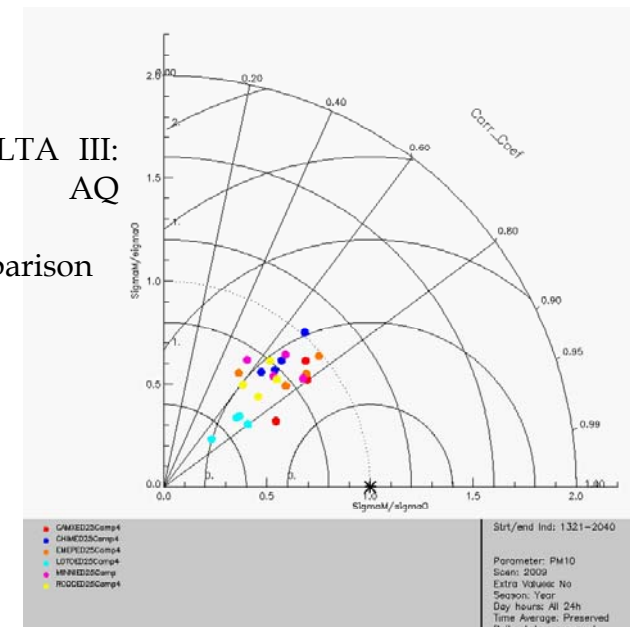


Circles: background stations
 Crosses : urban stations
 Squares: suburban stations

Chemel et al., 2010
 (Atmos. Environ)



EURODELTA III:
 European models
 intercomparison



Start/end Ind: 1321-2040
 Parameter: PM10
 Size: 2009
 Extra Values: No
 Season: Year
 Day hours: All 24h
 Time Average: Preserved
 Daily stats: preserved

DATA ASSIMILATION



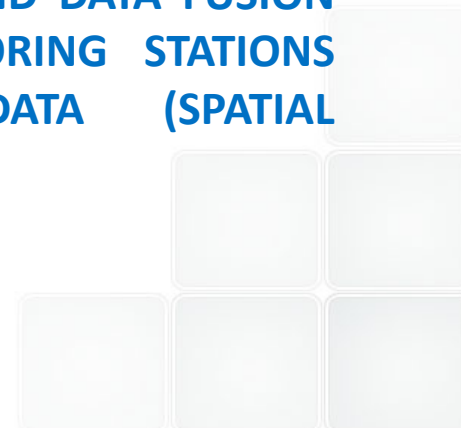
DATA ASSIMILATION ALGORITHM ARE IMPLEMENTED IN FARM MODEL.

THREE DIFFERENT ALGORITHMS ARE IMPLEMENTED: NUDGING, SCM (SUCCESSIVE CORRECTION METHOD), AND OI (OPTIMAL INTERPOLATION)

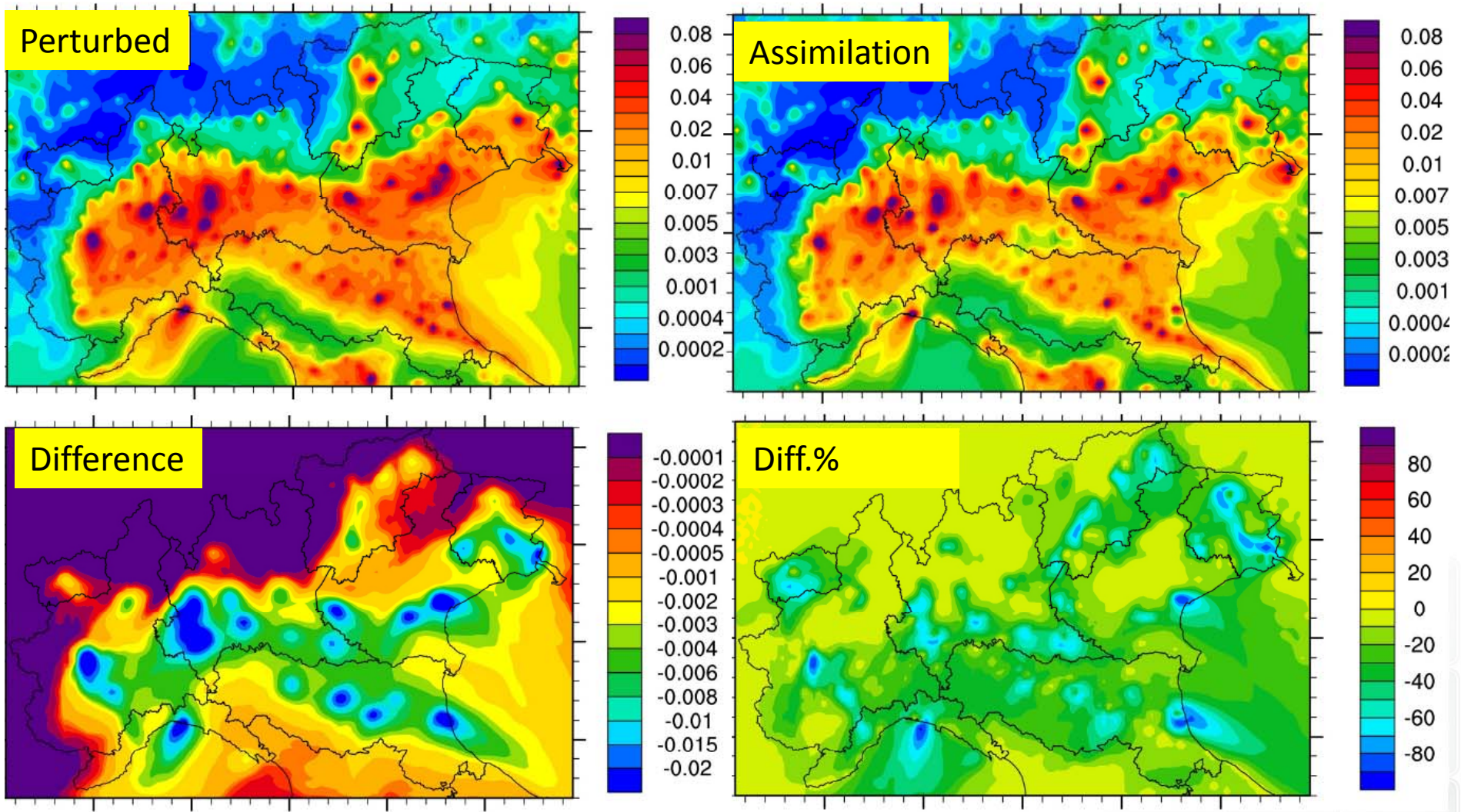
Silibello, C., A. Bolignano, R. Sozzi, C. Gariazzo "Application of a chemical transport model and optimized data assimilation methods to improve air quality assessment". 2014. Air. Qual. Atmos. Health, 7(3), 283-296

ENEA IS NOW DEVELOPING AN ALGORITHM TO ASSIMILATE HMs AND POPs

TESTING ARE UNDERWAY BOTH ON DATA ASSIMILATION AND DATA FUSION TECHNIQUES, USING AREAS OF INFLUENCE OF MONITORING STATIONS CALCULATED ON TIME SERIES OF MODEL DATA (SPATIAL REPRESENTATIVENESS).



OSSE (Observing System Simulation Experiment) data assimilation experiment : B(a)P (average in january 2005)



MINNI SERVICES AT NATIONAL SCALE- 1



1. BOUNDARY CONDITIONS FOR LOCAL PUBLIC AUTHORITIES AIR QUALITY MODELS

- ✓ TOSCANA REGION
- ✓ LIGURIA REGION
- ✓ CALABRIA REGION
- ✓ BOLZANO PROVINCE

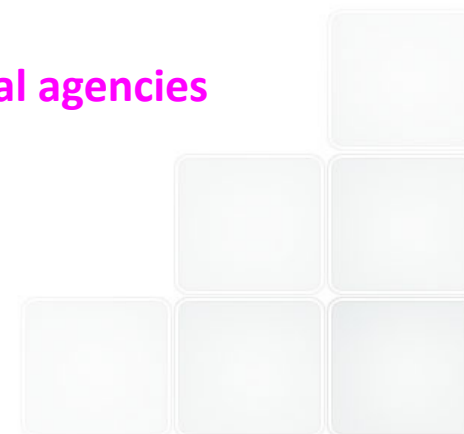
2. METEOROLOGICAL FIELDS AND/OR GRID DISAGGREGATED EMISSIONS AND/OR TEMPORAL DISTRIBUTED EMISSIONS ON GRID FOR LOCAL PUBLIC AUTHORITIES APPLICATIONS

3D METEOROLOGICAL FIELDS

- ✓ Piemonte Region, Veneto Region/ARPAV
- ✓ Torino Province
- ✓ Valle d'Aosta, Friuli Venezia Giulia, Lazio, Puglia, Bolzano regional agencies
- ✓ Magistrato alle Acque di Venezia

2D EMISSIONS

- ✓ TOSCANA REGION, LIGURIA REGION, UMBRIA REGION

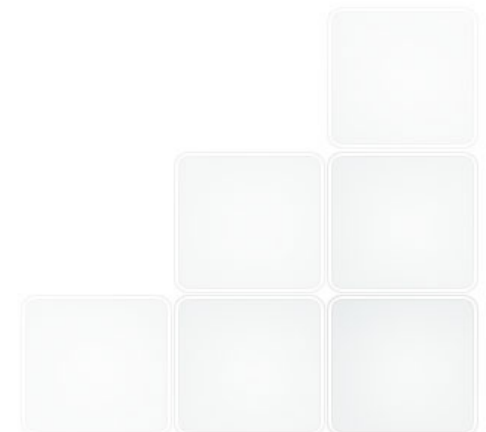


MINNI SERVICES AT NATIONAL SCALE- 2



3. PRIVATE COMPANIES IN CHARGE OF ENVIRONMENTAL IMPACT STUDIES

- ✓ **STEAM Sistemi Energetici Ambientali – Power Plant, Pianopoli (CZ)**
- ✓ **SPEA – Ingegneria Europea – several domains for new highways**
- ✓ **AECOM Italy – “Offshore Adriatico” project**
- ✓ **Associazione Industriale Bresciana**
- ✓ **Consultants for environmental impact assessment**

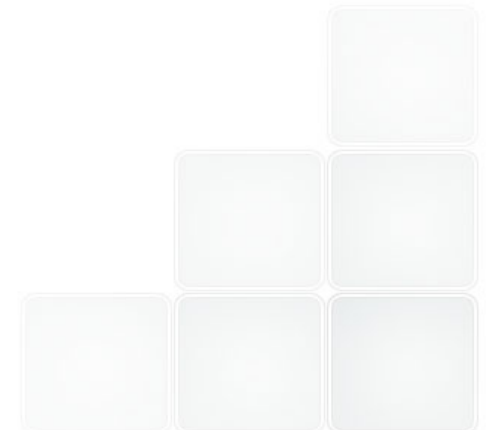


The national model as reference



Since MINNI provides the national “system” (Ministry, Regional Agencies, Private Companies) with scenarios, data, alternatives related costs we have pledged to keep the model validated by a wider and upper level “system”:

- Fairmode model performance tools and indicators.
- International models comparison exercises.
- An endless research on model physics and chemistry.
- Experimental campaigns.



EURODELTA III exercise in support of EMEP Task Force on Measurements and Monitoring



Phase A: Evaluation on the EMEP field campaigns

2006: 01/06 - 30/06
2007: 08/01 - 04/02
2008: 17/09 - 15/10
2009: 25/02 - 26/03

Phase B: Retrospective analysis 1990-2000-2010

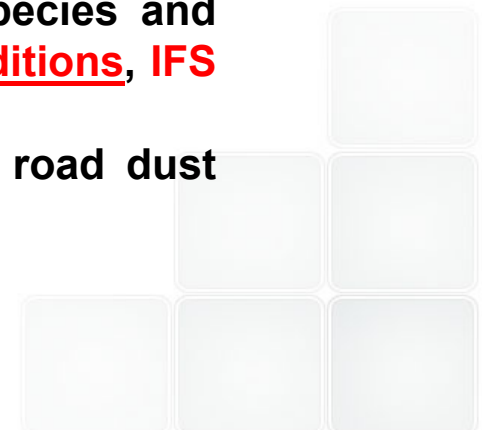
Phase A: Models & Institutions

Met.No – UNECE (EMEP)
TNO – NL (LOTOS-EUROS)
INERIS – FR (CHIMERE)
FUB – DE (RCG)
ENEA/Arianet - IT (MINNI)
HZG - DE (CMAQ)
PSI/RSE –CH/IT (CAMX)

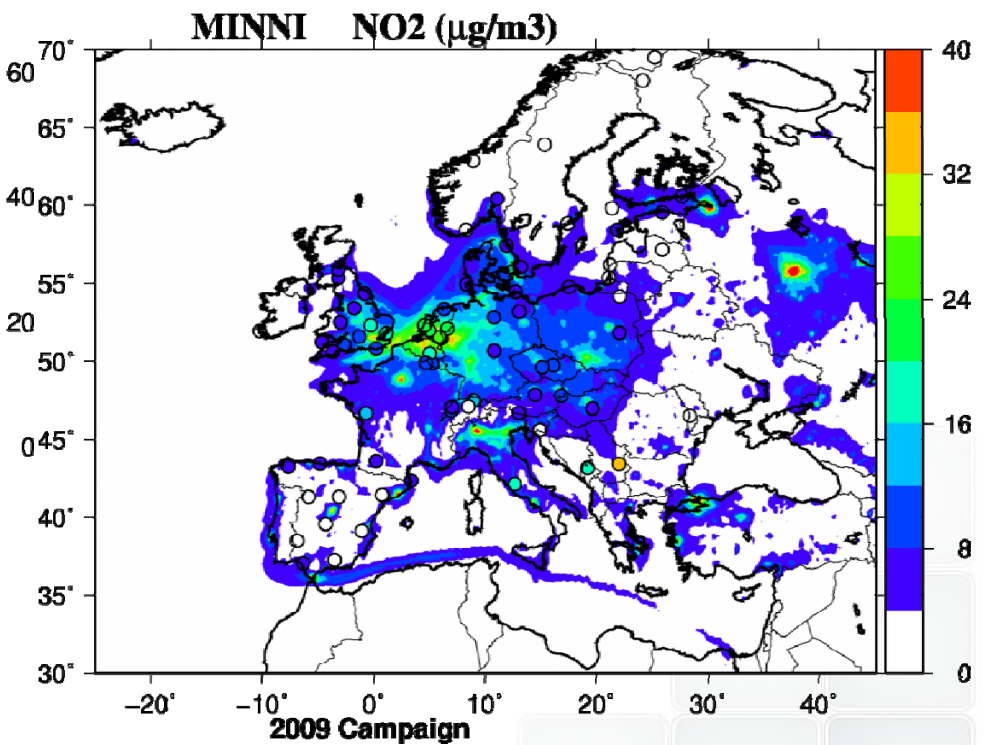
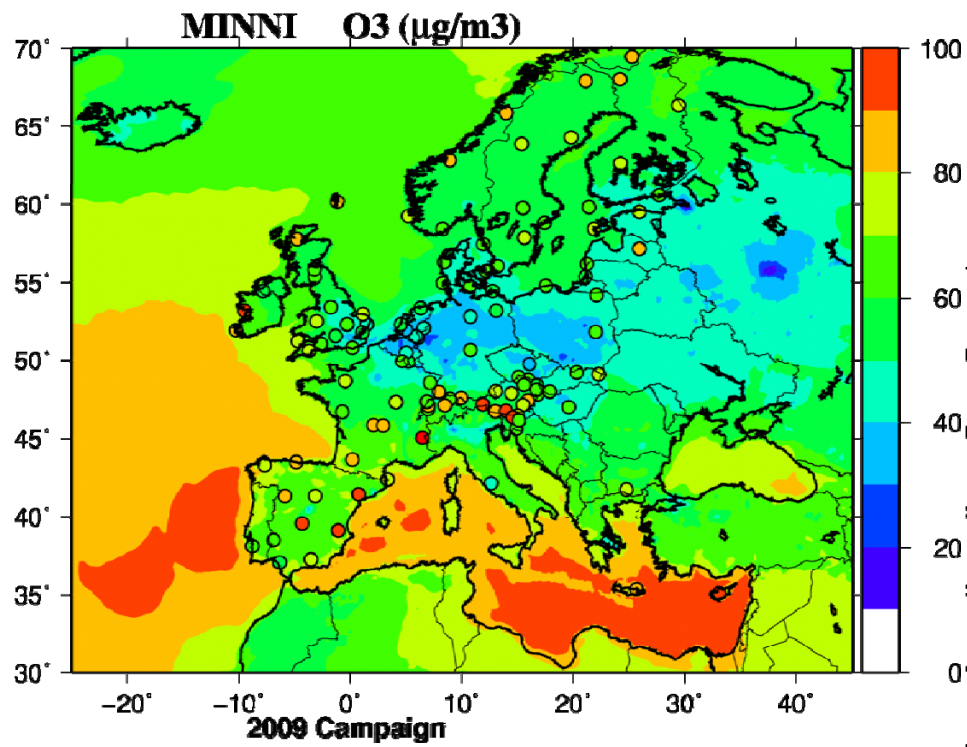
Phase A: Simulations setup

Same domain, emission dataset for anthropogenic species and wildfires, grid resolution (25 km), **MACC boundary conditions, IFS meteorology.**

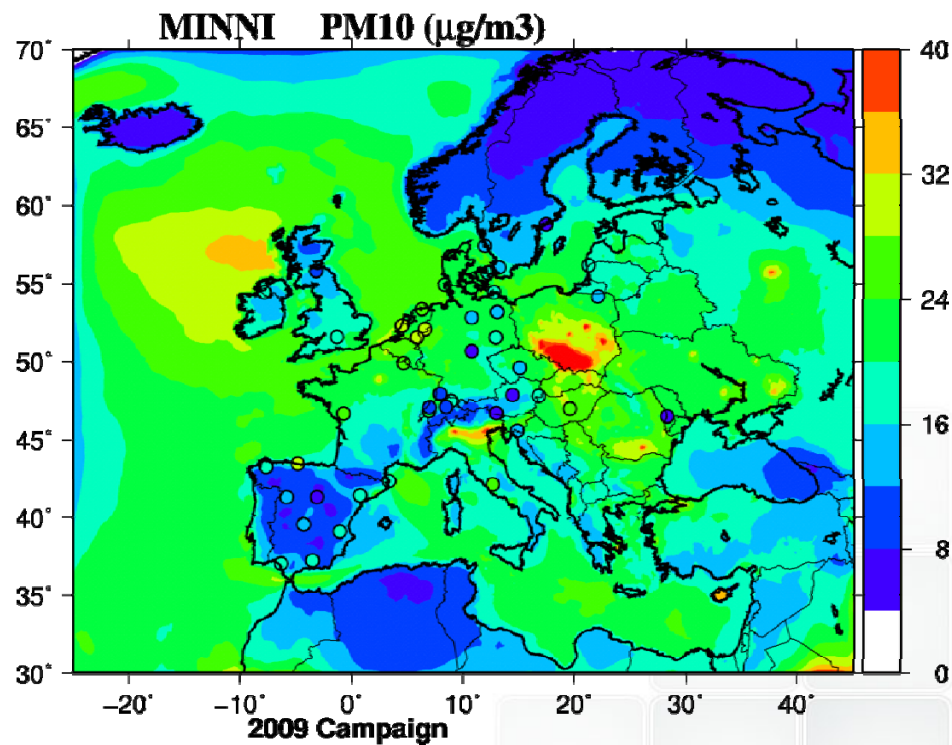
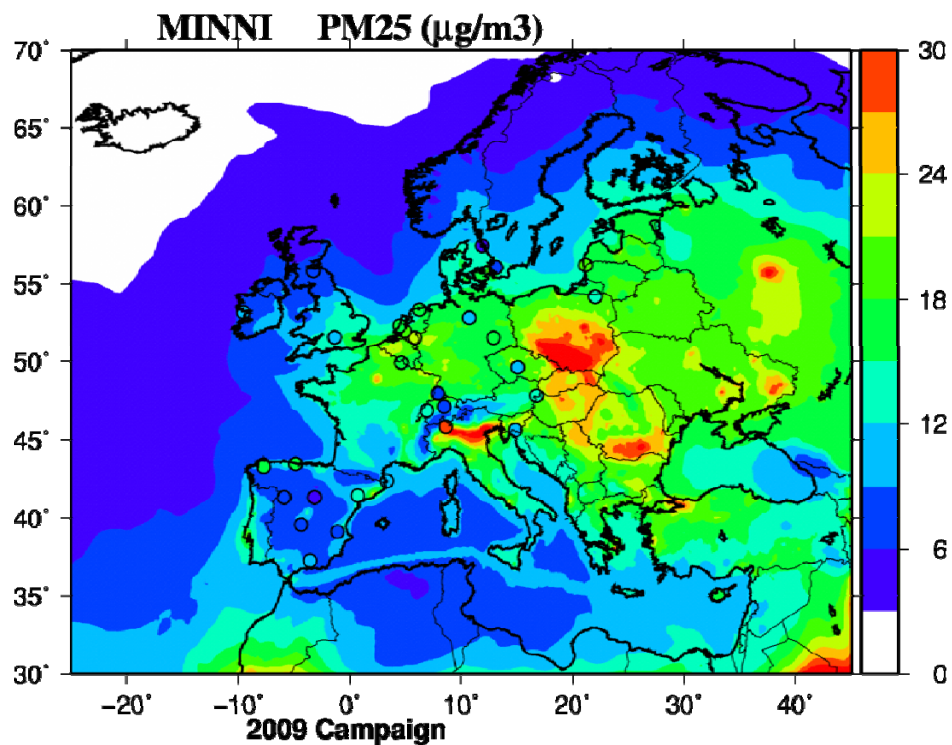
Free: biogenic emissions (free), NO & VOC; landuse, road dust resuspension, wind blown dust.



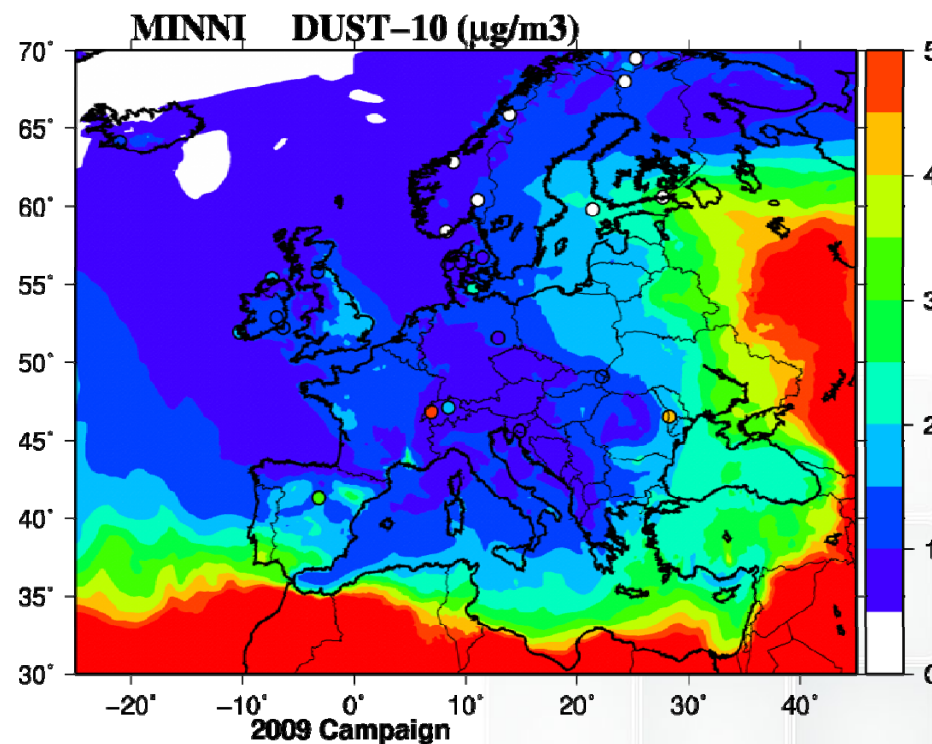
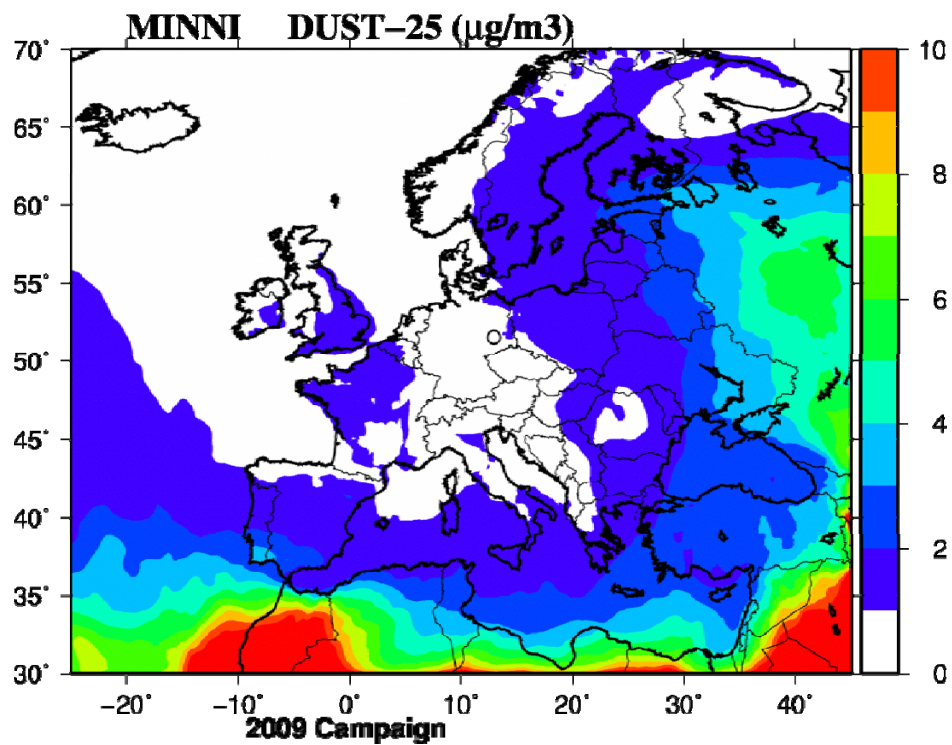
2009 EMEP field campaign



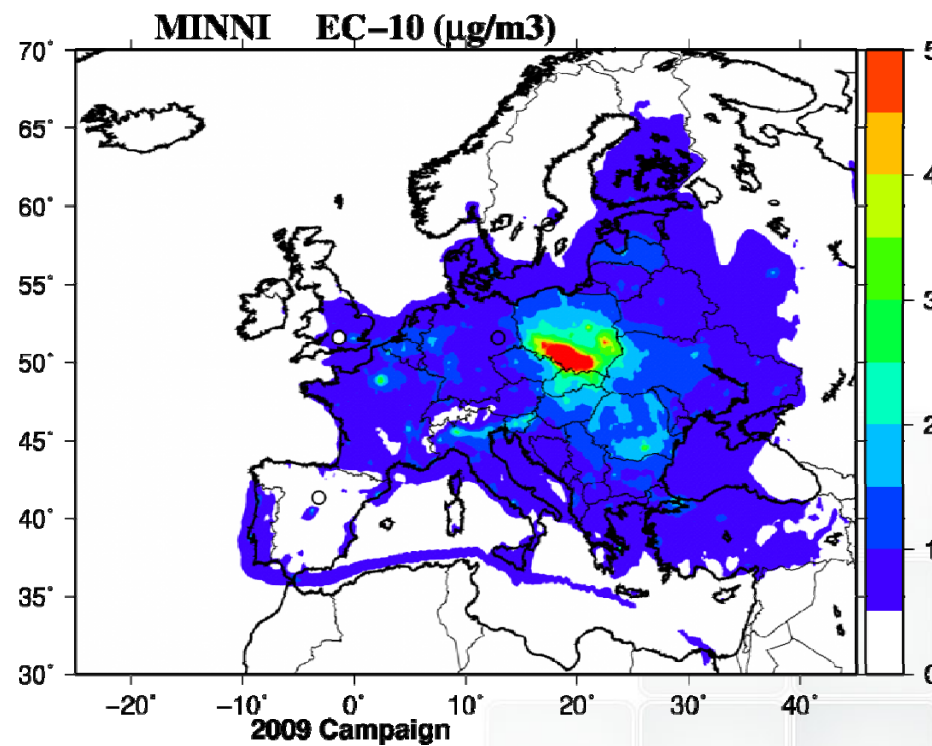
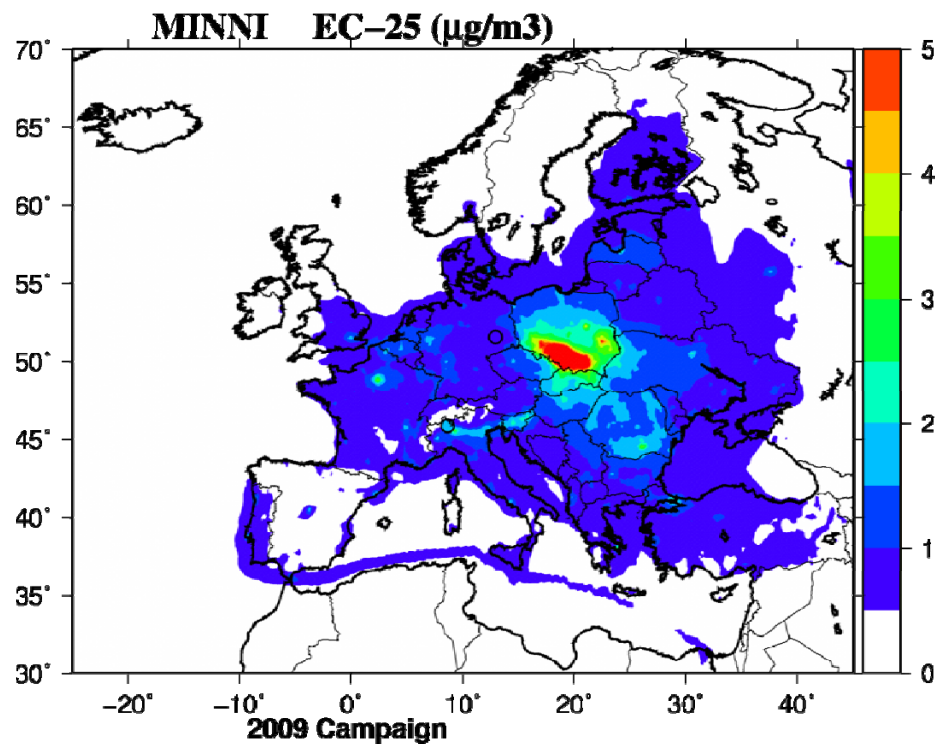
2009 EMEP field campaign



2009 EMEP field campaign



2009 EMEP field campaign



Main results of the Eurodelta 3 exercise Phase I on criteria pollutants

Bertrand BESSAGNET (INERIS) on behalf of the EURODELTA team

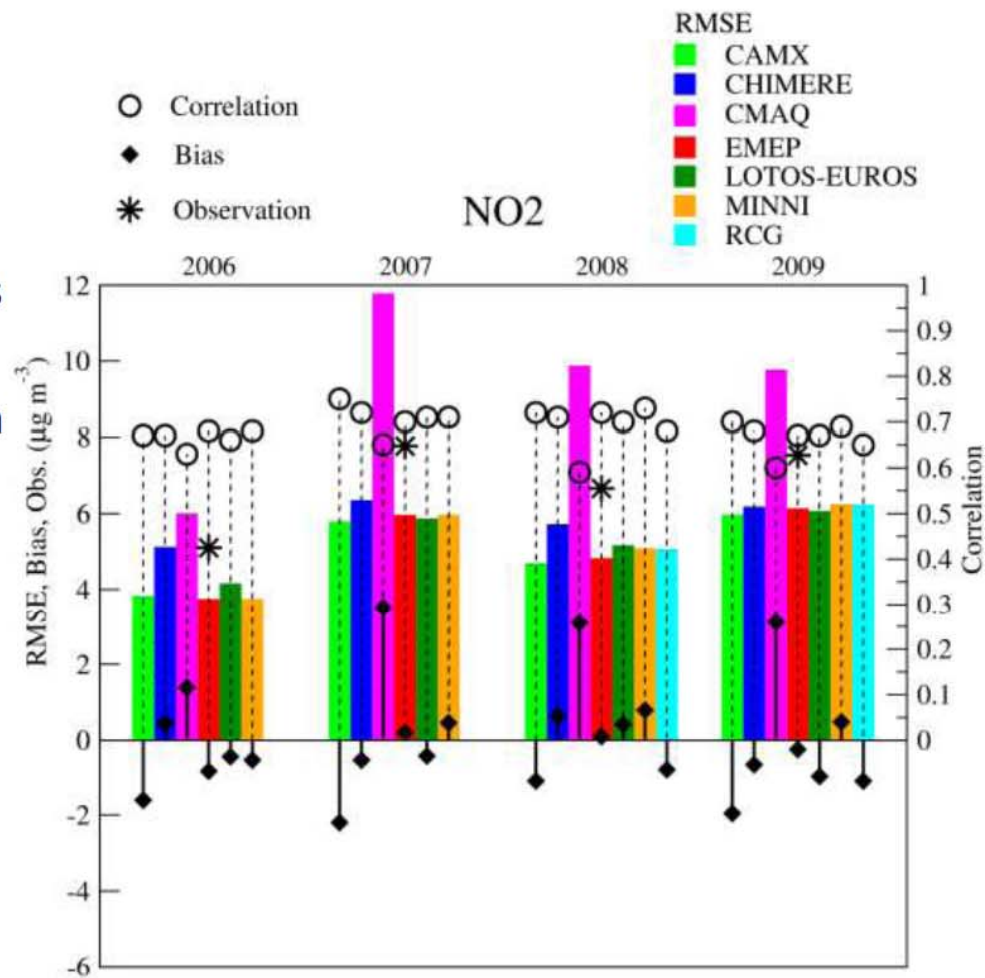
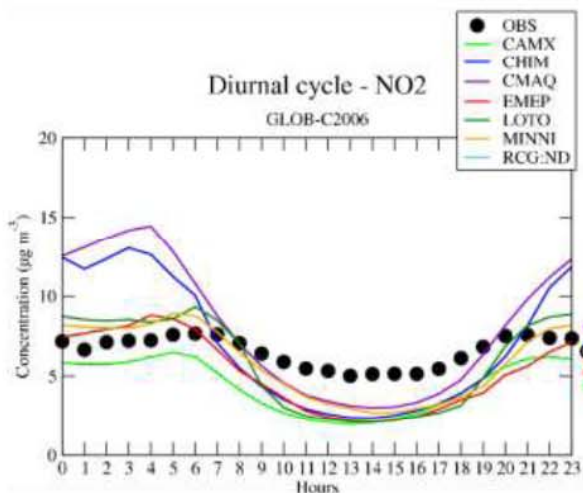
CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION
16th Task Force on Measurement and Modelling Meeting:
5 - 8 May 2015 in Krakow



NO₂ MODELS PERFORMANCES IN EURODELTA 3



- Similar correlations (0.6-0.7)
- CMAQ overestimates the concentrations
- CAMX systematically underestimate the concentrations
- CMAQ & CHIMERE overshoot at night, all models underestimate in the afternoon



Source: B. Bessagnet

AIR QUALITY MODELLING OBJECTIVES

- Demonstrate to Ministry of Environment (MoE) and stakeholders the usefulness of AQ modelling as a tool for addressing air quality policy, design air quality network, and provide baseline scenario.
- Take into account the complexity of the atmospheric processes by means of state of the art chemical transport model (photochemical reactions and secondary PM)
- Take on board all the emissions both natural and anthropogenic; possible extension to long range desert dust.
- Provide responses on effectiveness of new emissions scenario:
 - simulate air quality following changes of Emission Limit Values for the various sources,
 - assess the impact of the planned power plants transformation,
 - assess the impact of future offshore drilling activities
- Provide MoE with a baseline for ambient air quality to be used by the consultants for the preparation of Environmental Impact Assessment (EIA) studies, namely for the assessment of cumulative impact on air quality of new sources.
- Ensemble prediction: collaboration with USJ team (model to model intercomparison to assure robust predictions...waiting for ambient air quality data).

BOUNDARY & INITIAL CONDITIONS



Boundary/Initial Conditions were extracted from both MACC-IFS-MOZART (for chemical gaseous species) and MACC-IFS (for aerosols) reanalysis archives (global air quality services, <http://www.gmes-atmosphere.eu/>).

The fields from the two MACC archives needed to be regridded and remapped, in order to match both the chemical mechanism SAPRC-99 and the aerosol AERO3 model. The used map is shown below.

Gas		Aerosol	
O3	→	O3	
NO	→	NO	
NO2	→	NO2	
HNO3	→	HNO3	
HO2NO2	→	HNO4	
OH	→	OH	
H2O2	→	HO2H	
CH4	→	CH4	
CH2O	→	HCHO	
CO	→	CO	
C2H6	→	ALK1	
CH3CHO	→	CCHO	
PAN	→	PAN	
BIGENE	→	OLE2	
BIGALK	→	50% ALK4	
	→	50 % ALK5	
ISOP	→	ISOP	
TOLUENE	→	ARO1	
SO2	→	SO2	
		var1 Sea Salt (0.03-0.5 μm)	→ 100% ASEASJ
		var2 Sea Salt (0.5-5.0 μm)	→ 70% ASEAS
		var3 Sea Salt (5.0-20 μm)	→ 25% ASEAS
		var4 Desert Dust (0.03-0.55 μm)	→ 100% ASOILJ
		var5 Desert Dust (0.55-0.9 μm)	→ 100% ASOILJ
		var6 Desert Dust (0.9-20 μm)	→ 30% ASOILJ
			→ 70% ASOIL
		var8 Organic matter	→ 50% SOA (5% AORAI, 95% AORAJ), → 50% POA (5% AORPAI, 95% AORPAJ)
		var 10 Black carbon	→ 100% EC (5% AECl, 95% AECJ)
		var 11 Sulfate	→ 100% ASO4 (5% ASO4I, 95% ASO4J)

Computational domain.

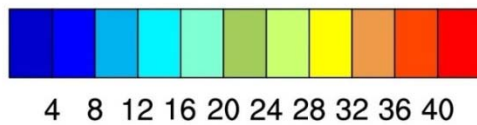
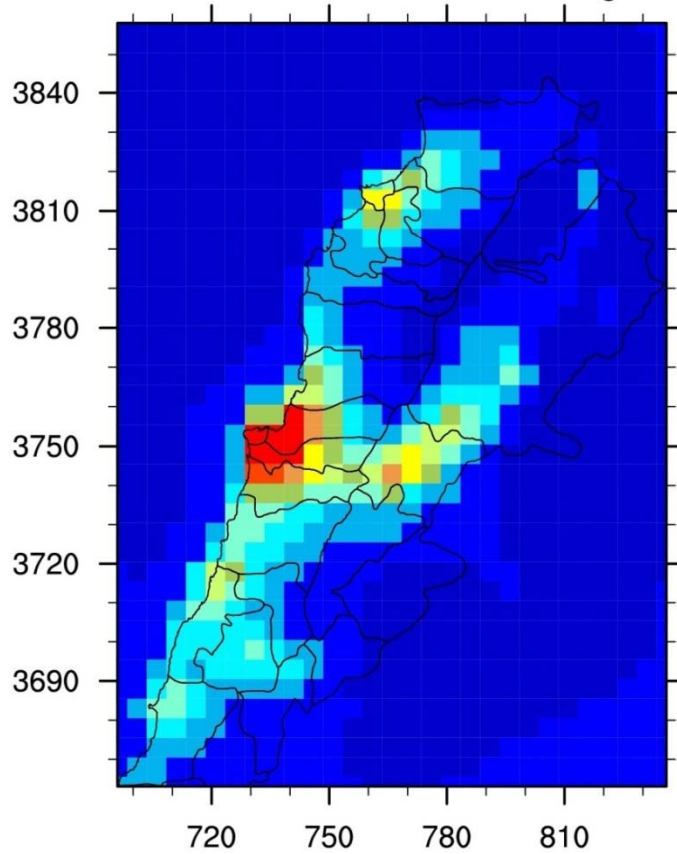
grid cell sizes (x, y) : (5, 5) km
 coord. of SW corner : (696, 3663) km
 coord. of NE corner : (836, 3858) km
 UTM 36 coordinates

16 vertical levels, from 20 to 10000 meters

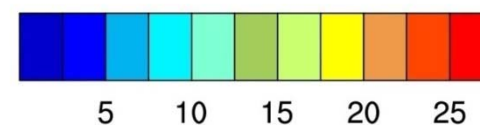
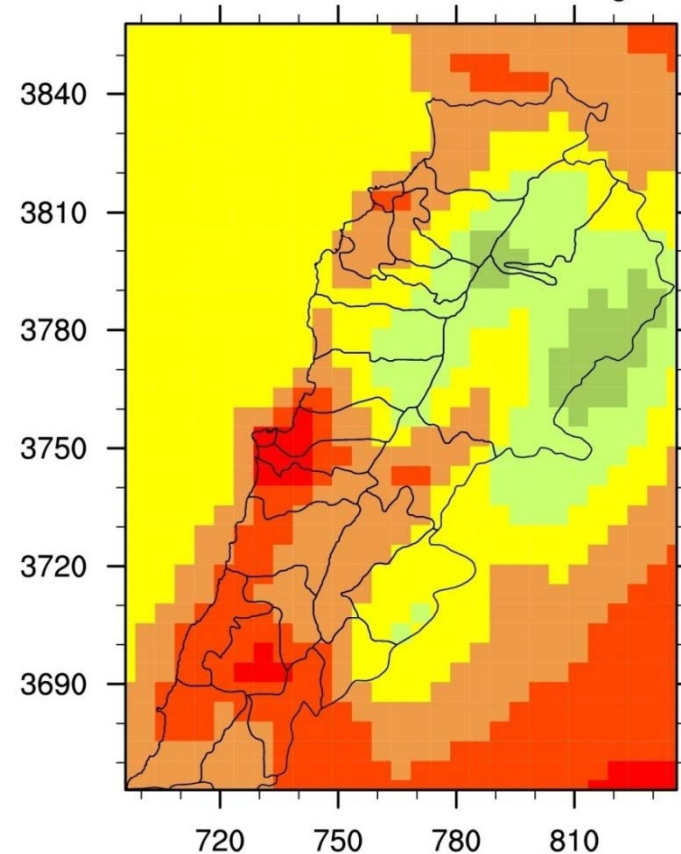
AIR QUALITY MODELLING OVER LEBANON



NO₂: LH0, period: 2011010100-2011123123
ug/m³



PM_{2.5}: LH0, period: 2011010100-2011123123
ug/m³

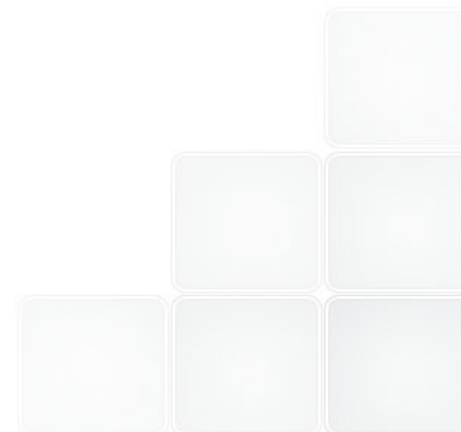


REQUIREMENTS ON MACC-III PRODUCTS



...as said in Vienna...

- **MAKE AVAILABLE MORE AEROSOLS SPECIES (NO_3^- , NH_4^+)**
- **MAKE AVAILABLE EMISSIONS, METEOROLOGY AND MONITORING DATA ACCOMPANYING THE AIR POLLUTION DATA IN ORDER TO ALLOW OTHER MODELS, NOT INCLUDED IN MACC, TO RE-CREATE THE ATMOSPHERIC CHEMISTRY**
- **MAKE AVAILABLE ENSEMBLE AND REANALYSIS DATA**



Thank you for your attention.

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