cost

Off-line model integration:

EU practices, interfaces and possible strategies for harmonisation

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Outline Part I

1. **overview: European model systems**
   main systems, applications

2. **coupling issues**
   input data, downscaling/nesting, modularity

3. **model harmonisation – integrated model systems**

COST728 Working Group 2: Integrated systems of MetM and CTM/ADM: strategy, interfaces and module unification

2.1 Coupling of off-line models (Barbara Fay, DWD, Germany)

D2.1 Overview of existing integrated (off-line and on-line) mesoscale systems.

1. Overview of existing integrated (off-line and on-line) mesoscale systems

- a tentative state-of-the-art inventory on existing methodologies, approaches, models and practice in different countries for building the integrated (off-line and on-line) MetM and CTM mesoscale systems.

- **COST728/732 Model Inventory (http://www.mi.uni-hamburg.de/index.php?id=539)**

- in Europe + WRF + US EPA + York University, Canada
- sampled from COST728 members through questionnaire

→ as provided, patchy, only active COST countries

- edited, but no rankings, represents knowledge and opinions of individual authors

	Meteorology	Chemistry & transport	Met & chem. & transport
Mi Cro-Scale COST 732	MITRAS	AERMOD MICTM	AERMOD, AERMOD_Urban MICTM Chensi M-SYS MERCURE Meso-NH MIMO RCG VADIS
Meso-Scale **COST 728**	ALADIN, ALADIN/A, ALADIN/PL ARPS CALGRID, CLM FVM, GEM/LAM GESIMA, GME GRAMM, Hirlam, HRM COSMO Lokalmodell aLMo, LAMI, LME, LMK COSMO Lokalmodell LME_MH LAPS, MC2 MEMO (UoA-GR), (UoA-PT) MERCURE, MESO_NH METRAS MINERVE MM5 (UoA-GR) MM5 (UoA-PT), (UoH-UK),(GKSS) NHHIRLAM, RAMS SAIMM, TAMOS TRAMPER , UM WRF_ARW	ADMS-Urban AERMOD ALADIN-CAMx AURORA CALGRID CAMx CHIMERE, CHIMERE (ARPA) CMAQ, CMAQ(GKSS) EMEP ENVIRO-HIRLAM EPISODE FARM FLEXPART, FLEXPART/A FVM GEM/LAM-AQ GEOS-CHEM GRAMM HYSPLIT LOTOS-EUROS LPDM MARS (UoT-GR), (UoA-PT) MATCH MECTM MOCAGE MUSE NAME III OFIS RCG SILAM SPRAY 3 TAMOS TCAM TREX UAM-V	BOLCHEM CALMET/CALPUFF CALMET/CAMx ENVIRO-HIRLAM GEM/LAM-AQ M-SYS MC2-AQ COSMO-LM-ART COSMO-LM-MUSCAT MCCM MEMO (UoT-GR) MERCURE Meso-NH RCG TAPM
Macro-scale	GEM GMElam HIRLAM TAMOS	CAM-CHEM CHIMERE, CHIMERE (ARPA-IT) EMEP FLEXPART, FLEXPART/A GEOS-Chem IMPACT LPDM MATCH MOCAGE NAME III SILAM STOCHEM TAMOS TCAM	ENVIRO-HIRLAM GEM_AQ

MetMs and CTMs from COST 728 model inven-tory (WG4)

Model systems covered in
- 16 countries / 38 institutions / > 25 systems

Main model systems MetMs:

MM5	COSMO LM	HIR-LAM	ECM WF	ALA -DIN	GME DWD	UM	RAMS	CAL-MET	ECHAM	NCEP	WRF
11	9	6	6	3	3	3	3	3	2	2	1

CTMs:

CAMx	Chimere	CAL-GRID	CMAQ	Match	MEMO
5	4	3	3	2	2

Model applications

- **Diagnostic / climatologic**

  Transport, AQ assessment + impact scenarios, episodes, source apportionment

- **Forecasting: transport + chemistry, AQ (UAQ, coastal and industrial AQ), management:** gases incl. ozone, PM, pollen grains

- **radioactivity (and environment) emergency forecasting**

On-line coupled MetM - CTMs

BOLCHEM (CNR/ISAC, Bologna)
ENVIRO-HIRLAM (DMI)
COSMO LM_ART (FZ Karlsruhe)
COSMO LM-MUSCAT (IfT Leipzig)
MCCM (Inst.Environm. Atmos.Research FZ Karlsruhe, Garmisch-Partenkirchen, Germany)
MESSy: ECHAM5(and planned: LM) (MPI-C Mainz , Uni Bonn)
MC2-AQ (York Univ, Toronto, Warsaw Univ.)
GEM/LAM-AQ (York Univ, Toronto, Warsaw Univ.)
OPANA = MEMO +CBM IV + SMVGear (Univ. Madrid)
ECMWF (passive prognostic stratos. ozone tracer, GEMS chenistry)
GME (DWD, passive prognostic stratos. ozone tracer)

On-line coupled models

Model name	*On-line coupled chemistry*	*Time step for coupling*	*Feedback*
BOLCHEM	Ozone as prognostic chemically active tracer		None
ENVIRO-HIRLAM	Gas phase, aerosol and heterogeneous chemistry	Each HIRLAM time step	Yes
WRF	RADM+Carbon Bond, Madronich+Fast-J photolysis, modal+sectional aerosol	Each model time step	Yes
COSMO LM-ART	Gas phase chem (58 variables), aerosol physics (102 variables), pollen grains	each LM time step	Yes
COSMO LM-MUSCAT	Several gas phase mechanisms, aerosol physics	Each time step or time step multiple	Yes
MCCM	RADM and RACM,photolysis (Madronich), modal aerosol	Each model time step	(Yes)
MESSy: ECHAM5	Gases and aerosols		Yes
MESSy: ECHAM5-COSMO LM (planned)	Gases and aerosols		Yes
MC2-AQ	Gas phase: 47 species, 98 chemical reactions and 16 photolysis reactions	each model time step	None
GEM/LAM-AQ	Gas phase, aerosol and heterogeneous chemistry	Set up by user – in most cases every time step	None
GME	Progn. stratos ozone passive tracer		
ECMWF model (IFS)	Prog. stratos O3, GEMS chemistry	Each model time step	Yes
OPANA=MEMO+CBMIV			

2. Coupling issues and problems

2.1 Input data

- **measurements -> pre-processors: point measurements to 3D**
  Only diagnostic,possible advantage: no divergence from obs
- **models**
  - **input *format***
    - **GRIB (majority?)**
    - **netCDF**
  - **coupling *time step***
    - **15 min: COSMO LMK 2.8km, UM (4km)**
    - **1 h (majority)**
    - **3h (6h)**

2.2 Downscaling / nesting

- **requirements: higher resolution**
  - **- improved vertical turbulence**
  - **- suitable heterogeneous surface characteristics, fluxes**
  - **- subgrid-scale orography,**
  - **- urban structures,**
  - **- local emission sources + transformations**
  - **- local circulations (sea breeze, mountain-valley winds)**
  - **- improved chemical boundary conditions**
- **achieved through (self-) nesting of MetMs and CTMs**

  2-way interactive nesting for *MetMs* MM5, RAMS, (COSMO-LM)

2.3 Modularity

Requirements:

- **high modularity**
- **high compatibility, e.g. no COMMON blocks but direct parameter passing**
- **flexible IO strategies**

2.4 Interfaces -> part II, Sandro

3. Model harmonisation - integrated model systems

- **COST710 (1994-1998): Harmonisation in the pre-processing of met data for dispersion modelling**
  - including harmonisation questionnaire
- **COST715 (1998-2004): Met applied to urban air pollution problems**

- **regular conferences on Harmonisation for regulatory modelling**
  - **harmonised local-scale model evaluation:**
    - Model Evaluation Kit
    - American Standard Evaluation Tool
    COST728, WG4: harmonised evaluation

3. Integrated model systems

- **PRISM (FP5): Earth system modelling, software infrastructure**
- **PRISM support: COSMOS, OASIS coupler**
- **ENSEMBLES (FP6): climate change ensemble prediction system for Earth system models**
- **ENES European system for Earth system modelling including PRISM, ENSEMBLES …**
- **ESMF Earth system modeling framework (US)**
- **FLUME flexible Unified Model Eenvironment (UK MetOffice)**
- **CURATOR info on earth system/climate models, intercomparison projects and IPCC assessments (US)**
- **GEMS global+reginal Earth system monitoring using satellites and in-situ data, ECMWF, data assimil. and forecasting**
- **GENIE Grid ENabled integrated Earth system model (UK)**
- **GO-ESSP global orga of Earth system science portal (UK,NOAA,NASA...):access to obs and simulated data**

Off-line model integration: EU practices, interfaces and possible strategies for harmonisation

Part II

Interfaces between meteorological and air quality models

Sandro Finardi

Copenhagen, 21-23 May 2007

Why should we care about interfaces ?

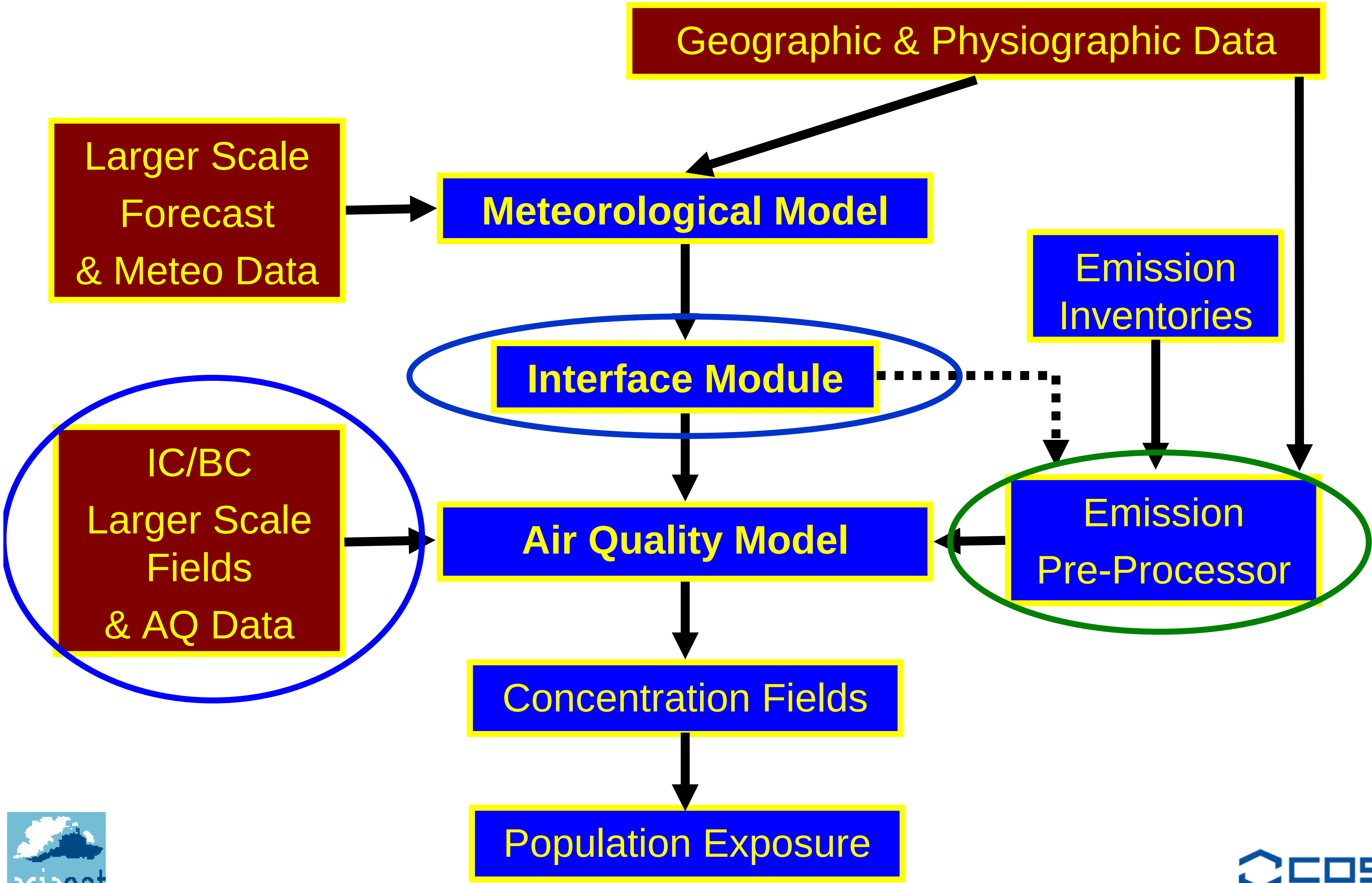
In principle, interfaces should be simple pieces of software connecting Met. Models outputs and AQ Models inputs with minimum influence on results, but:

- Often MetM and AQM have been built separately and are applied on different grids at different space scales
- Often MetM cannot provide all the variables required by AQM or some fields can be estimated by parameterisations and algorithms not compatible with modelling methods implemented in AQM
- Some AQ models need to rely on "standard" meteorological products, e.g. average met. variables while turbulence, atmospheric stability, mixing height, and dispersion coefficients are diagnostically estimated.
- Sometimes re-computation or "filtering" of dispersion parameters can guarantee AQ modelling robustness for practical applications.

The communication between off-line coupled meteorological and AQ models is a problem of often underestimated importance:

- Interfaces can limit the possibility of AQ models to access and exploit all the information provided by new generation mesoscale meteorological models, and can make difficult model intercomparison,
- Interfaces can be used to improve boundary layer low description

AQ Modelling System Conceptual Scheme



Common interface tasks :

- **Interpolation of Met. data to match grid differences (geographic projections, vertical grid system, resolution)**
- **downscaling of meteorological data**
- **Estimation of boundary layer scaling parameters, mixing height and eddy diffusivities (or σ_i and T_L for Lagrangian models)**
- **Emissions related computations (e.g. biogenic VOC emission, wind blown dust).**
- **Enhancement of physiographic data and parameterisations (e.g. urbanisation)**
- **Air quality fields and data treatment for AQ models IC/BC**

COST728/732 Inventory - Coupled Models involved:

MetMs:

EU Met. Services: LM, ALADIN, HIRLAM, UM

Other EU: METRAS, MEMO

US Community: MM5, RAMS, ARPS, WRF

CTM/AQMs:

EU Met. Services: LPDM, TRAJEK, NAME III, MATCH, SILAM, DERMA, ARGOS

Other EU: TCAM, FARM, SPRAY3, CHIMERE, AirQUIS, FLEXPART, AURORA, EURAD, MECTM, MARS, MATCH, AUSTAL, MISKAM, HYSPLIT, SCIPUFF

US Community: CAMx, UAM-V, CMAQ, REM-CALGRID, CALPUFF

Three main practises :

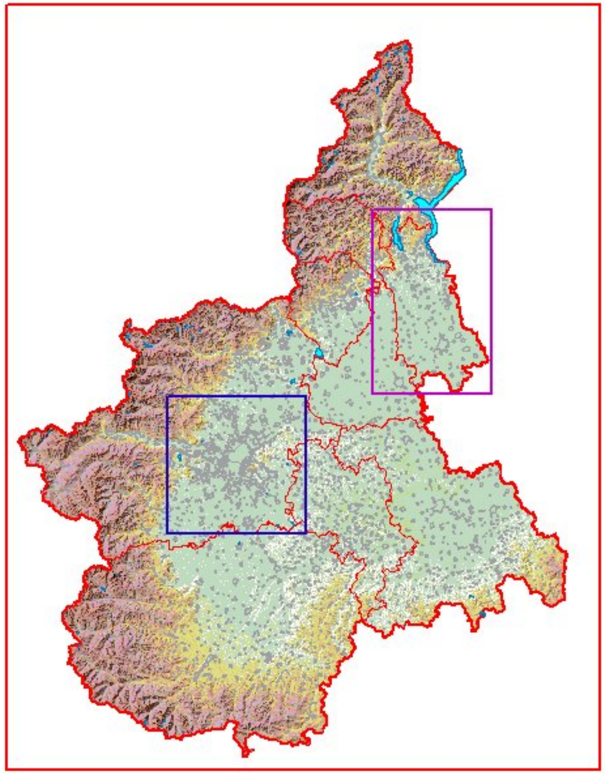
- **Development of integrated systems (mainly Met services)**
  - **Interfaces built on specific model features and needs**
- **Use/Customisation of US Community modelling systems**
  - **MM5+CAMx, MM5+UAM-V, MM5/WRF+CMAQ**
  - **Customisation of available interfaces (e.g. MCIP)**
- **Interfacing of self developed AQ models with EU Met Services and US Community Met. Models**
  - **Development of model specific or general purpose interfaces**

Different choices possible effects :

Some interface choices can have relevant effects on the AQ simulation results and mask actual meteorological and air quality model results, examples:

- Minimum K_Z value effect
- Reconstruction or direct use of modelled surface fluxes
- Air quality initial conditions effects

Examples from AQ simulations in Torino and Roma



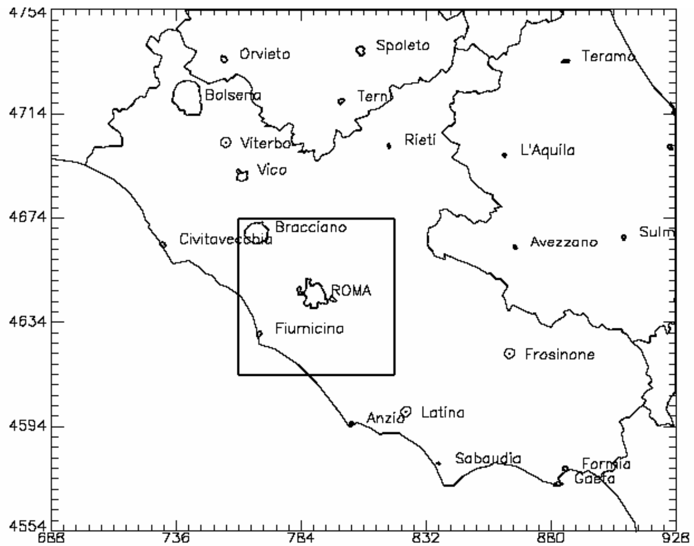
Meteorological driver:
- Roma: RAMS
- Torino: RAMS, LAMI

Air Quality Model:
- FARM (Chemical Transport Model)

Interface Module:
- GAP/SurfPRO: fields interpolation and meteo processing

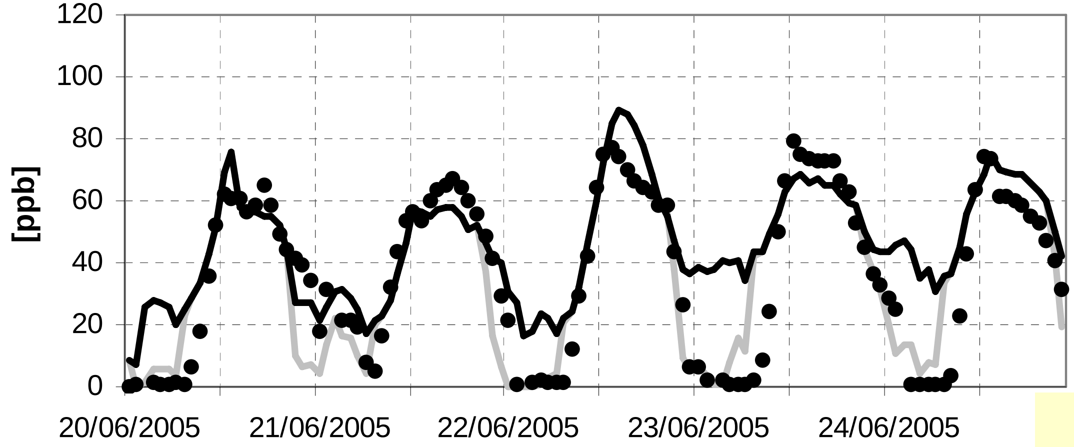
Finardi et al., 2007, Env. Mod. and Sof.

Gariazzo et al., 2007, Atm. Env.1h

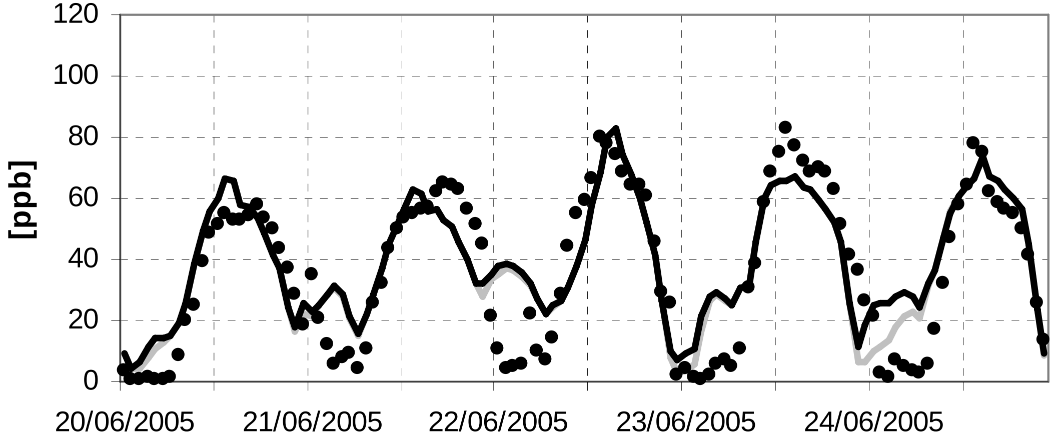


Minimum K_Z effect: O_3

Villa Ada: urban



Cavaliere: rural

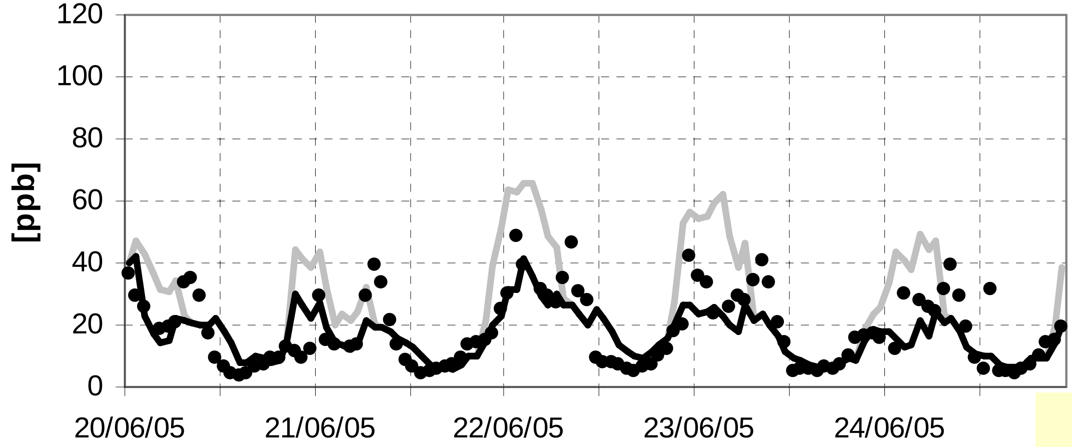


Computed (Roma, dust, Kzurb=0.1) Computed (Roma, dust)

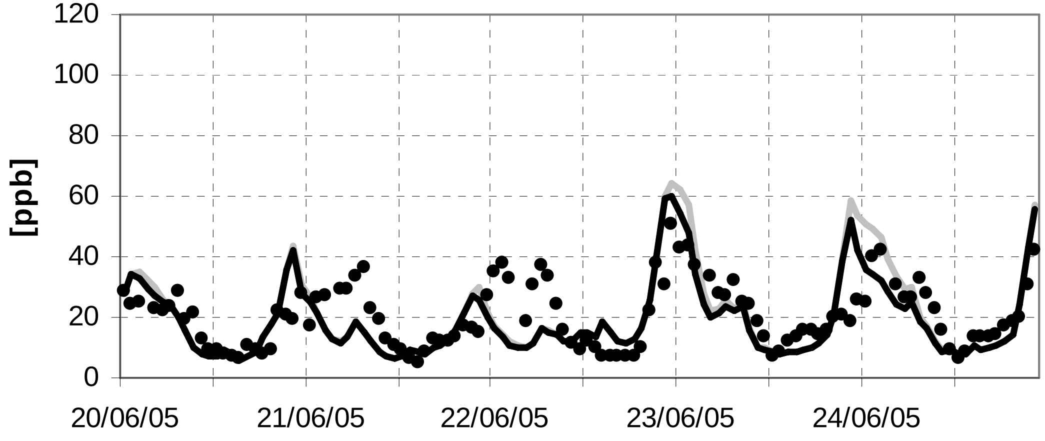
Measured

Minimum K_Z effect: NO_2

Villa Ada: urban

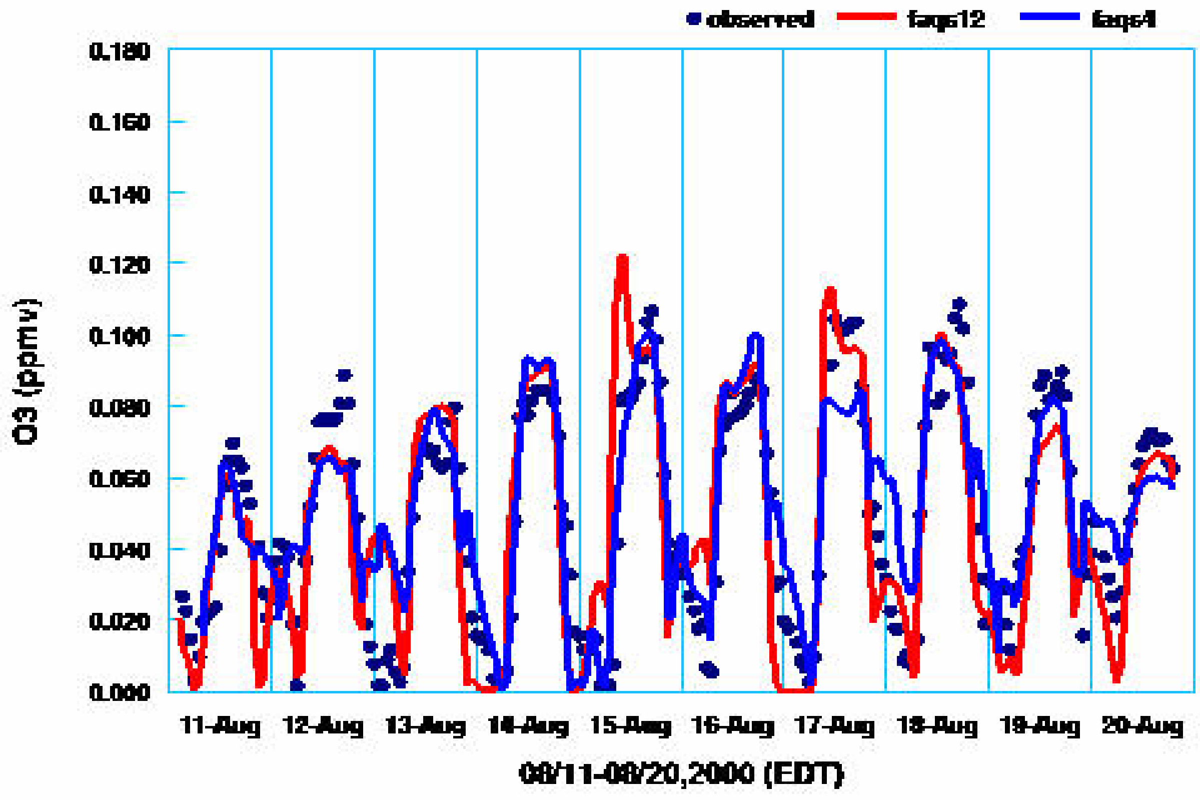


Cavaliere: rural



Computed (Roma, dust, Kzurb=0.1) Computed (Roma, dust)
Measured

Minimum K_Z effect: other experiences

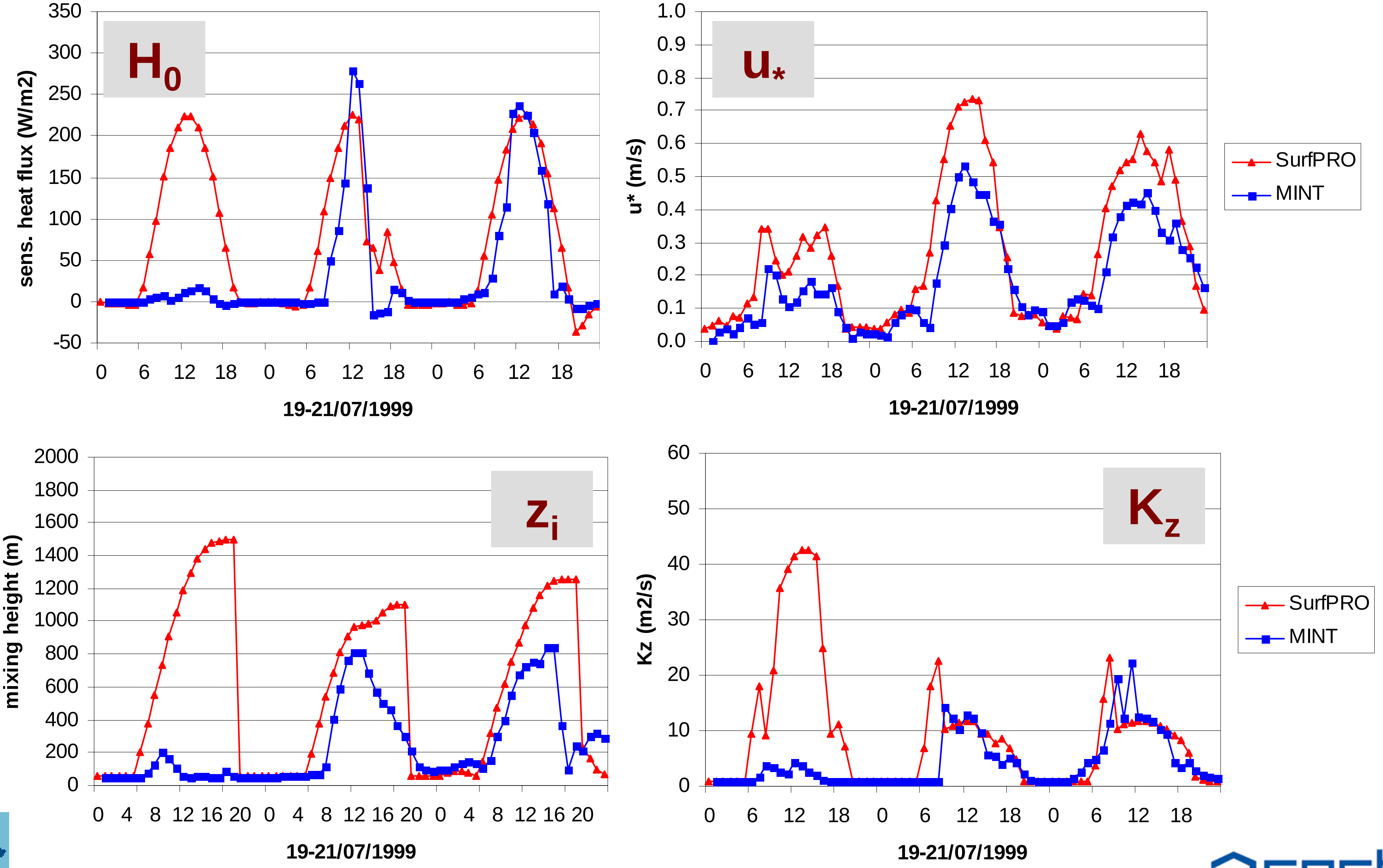


Time Series Plot of Simulated and Observed Surface Ozone Concentrations in Columbus, GA, the Minimum Vertical Eddy Difusivity of $10^{-4}m^2/s$ was used in CMAQ.

Ted Russell, 2003, "Air Pollutant Transport, Control and Modeling Issues in the Eastern United States", Georgia Inst. of Technology

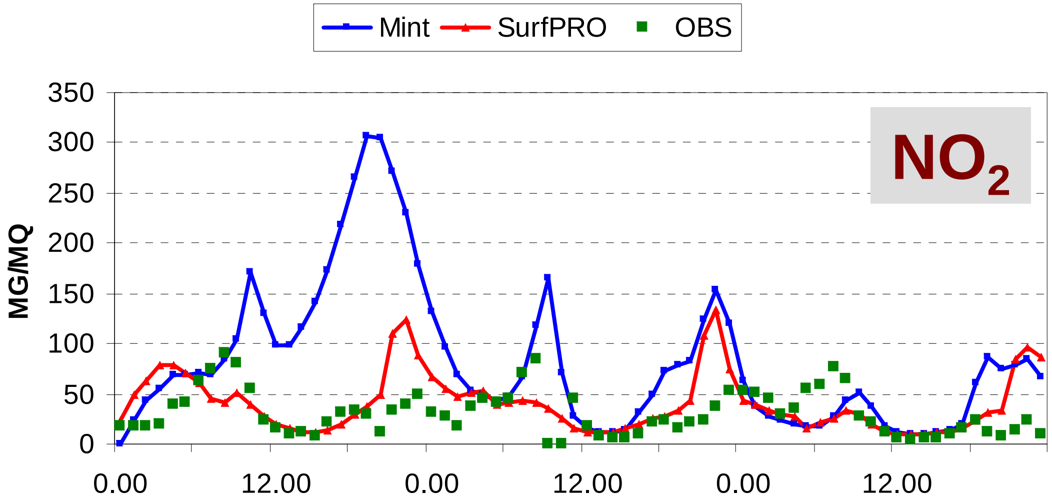
Direct use or reconstruction of surface fluxes

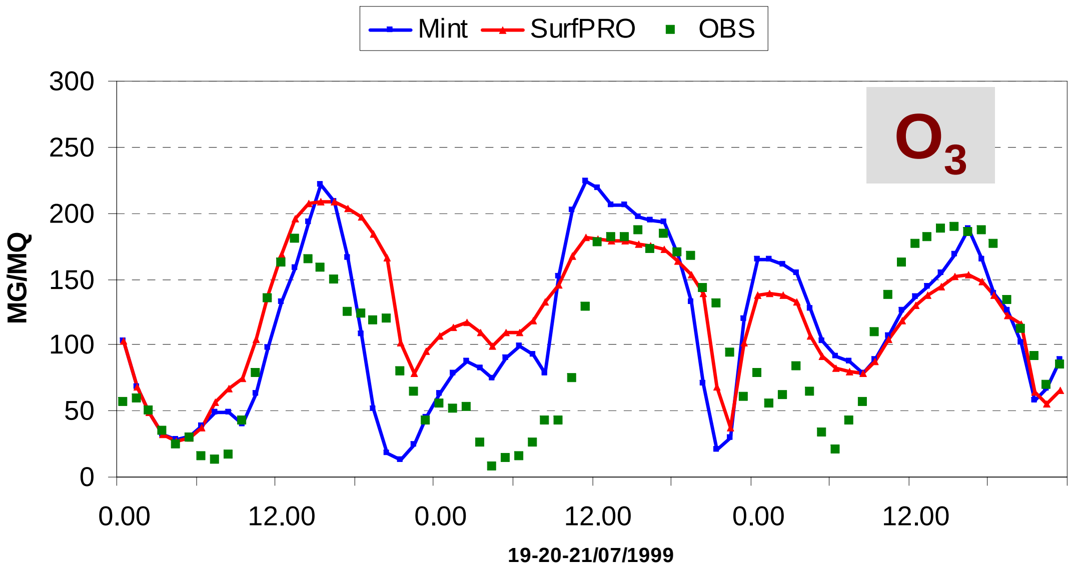
Torino – Lingotto: surf. fluxes and disperion parameters



Direct use or reconstruction of surface fluxes

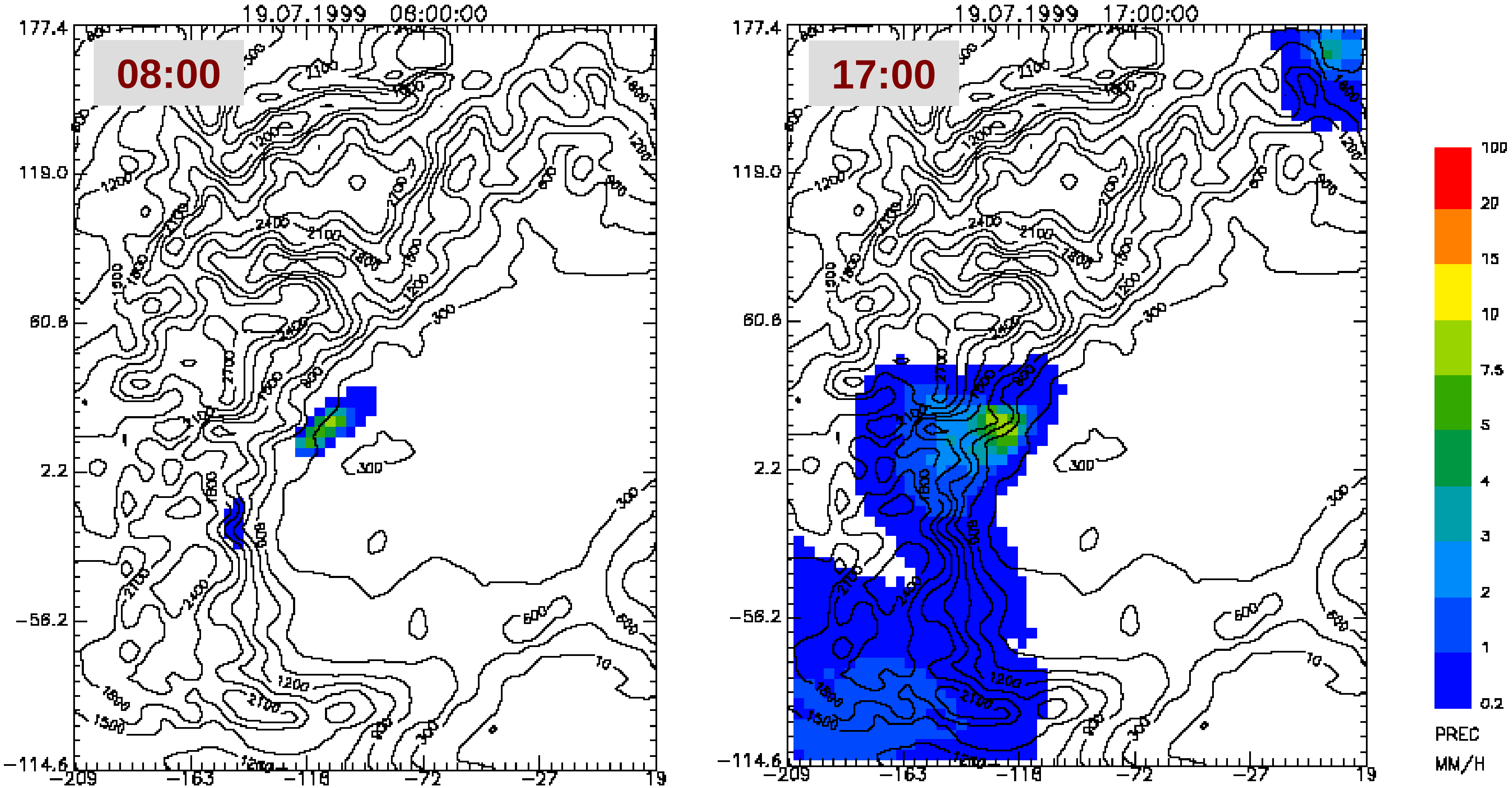
Torino – Lingotto: effects on concentrations



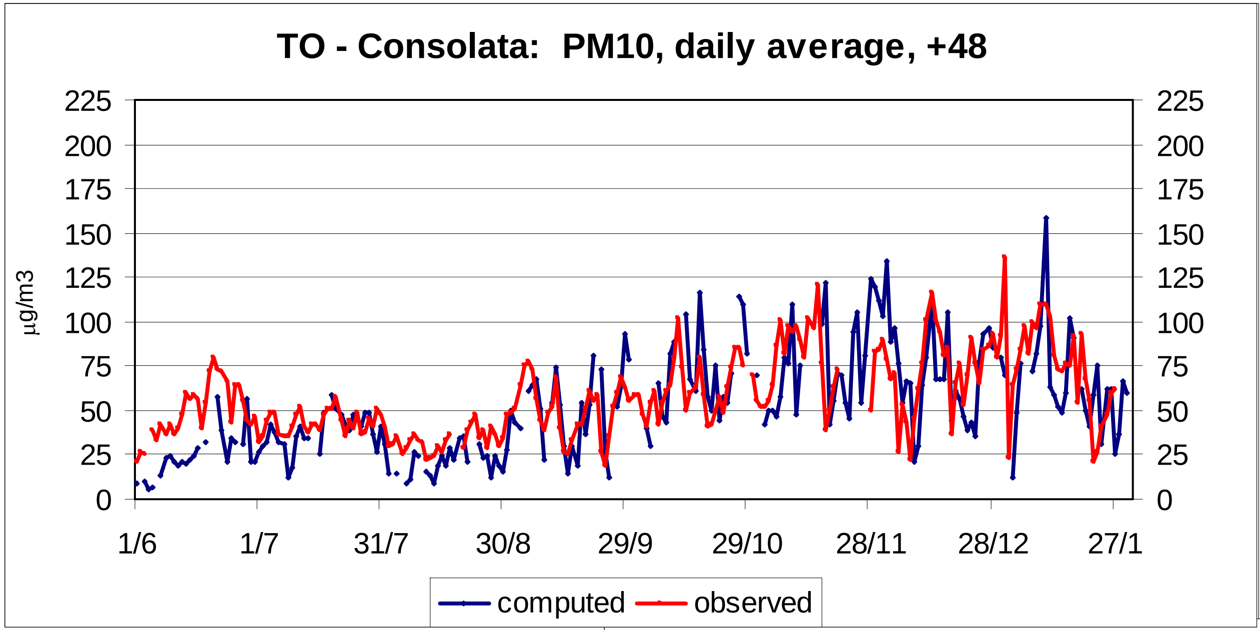


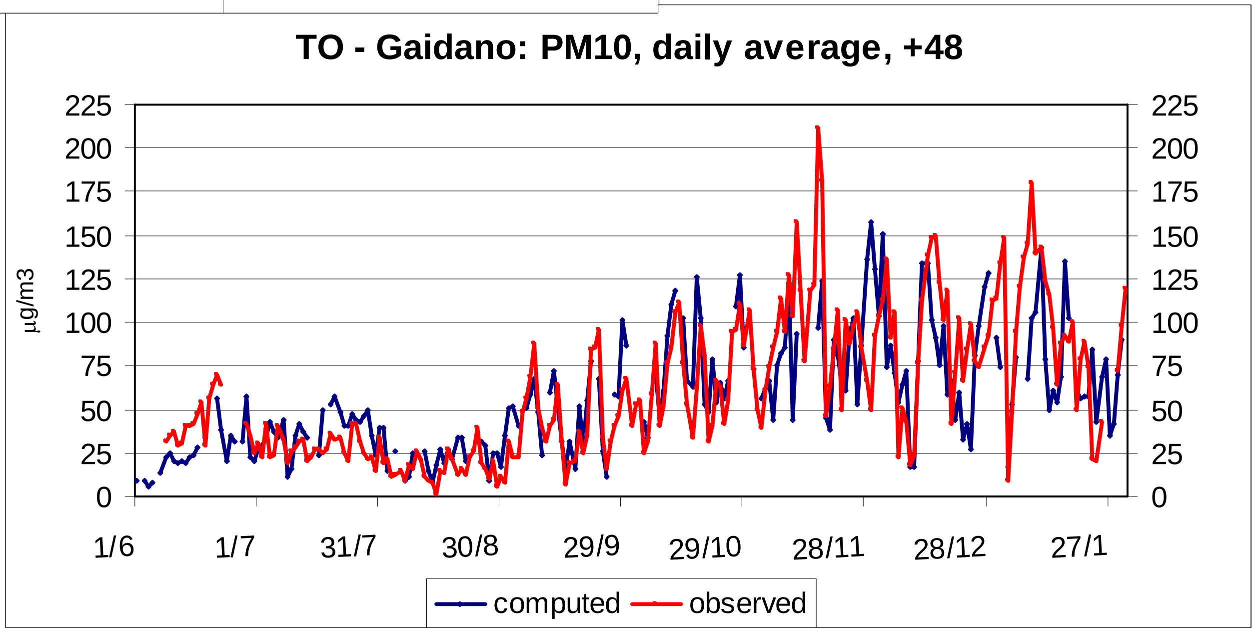
Direct use or reconstruction of surface fluxes

Cause: mountain foot thunderstorms



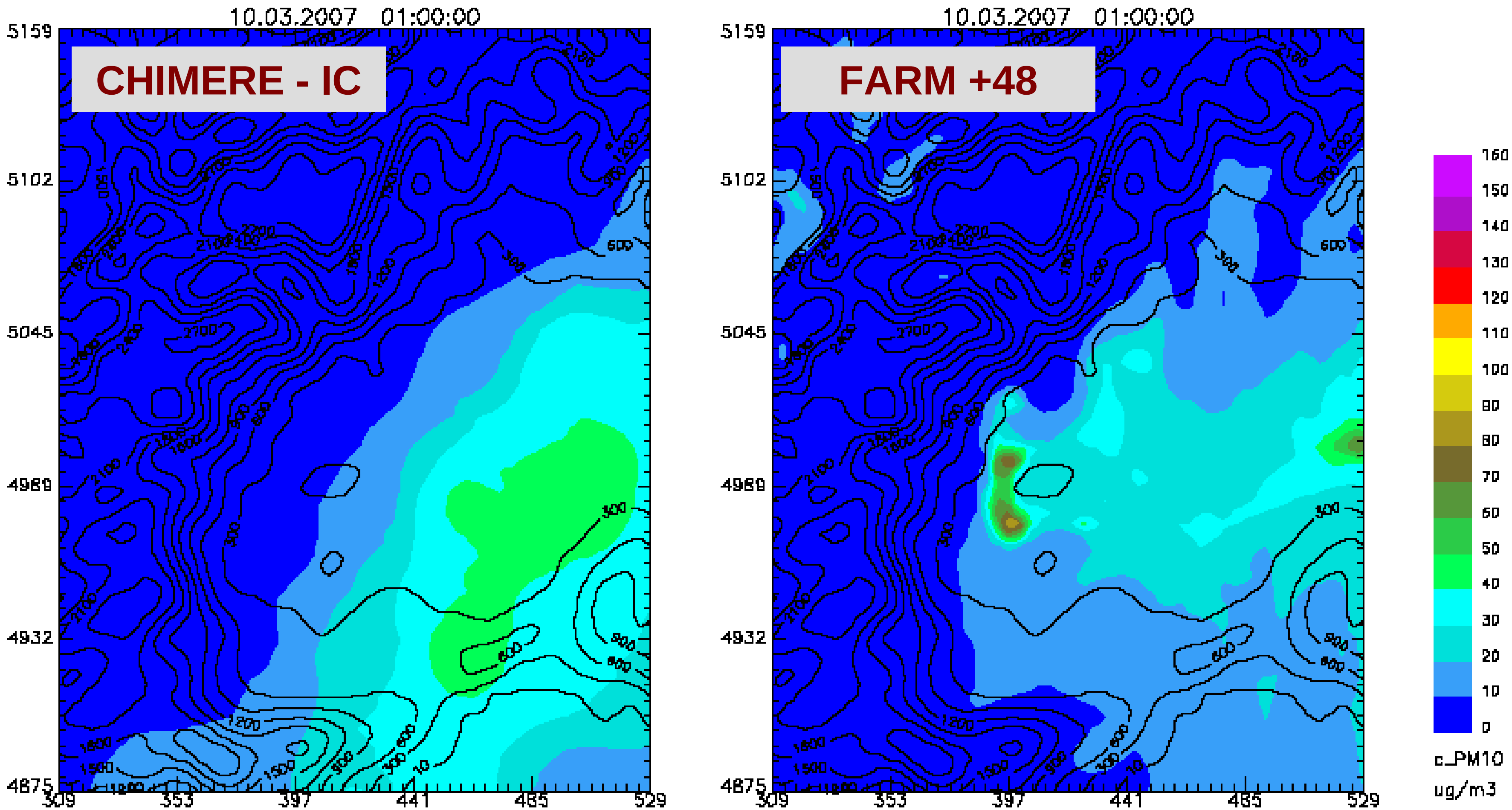
Nesting effects through IC/BC:





Nesting effects through IC/BC:

Torino is out of the Po valley for CHIMERE topography, causing initial concentration underestimation



Discussion and Conclusions (1)

- A large variety of air quality modelling systems are developed and applied for research, operational forecast and air quality assessment over Europe.
- The use of different meteorological drivers, air quality models and interface modules can be considered a scientific richness but creates problems of model result inter-comparison and make difficult stakeholders choices for practical applications.
- Difficulties in model development collaboration in Europe are evident and can limit an effective exploitation of scientific advance.
- Model harmonisation remains an important issue despite earlier efforts, e.g. COST710 (1994-1998) which are continued in the regular Harmonisation conferences and recent COST Actions (728, ES0602).
- Development of community models can foster scientific cooperation, state-of-the-art knowledge dissemination and tools harmonisation (US experience), but it seems still hardly feasible in Europe.

Discussion and Conclusions (2)

Some basic steps to help harmonisation are desirable and feasible:

- **Definition of agreed guidelines for off-line and on-line integrated modelling**
- **Modular modelling, flexible IO strategies to permit different model use and testing**
- **Definition of standards for the distribution of meteorological fields for air quality applications (weather forecast standards are not suitable)**
- **Continental scale air quality fields distribution harmonisation**
- **Definition of guidelines for interfaces development and application.**
- **Volunteer sharing of software implementing parameterisations for interfaces ?**