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

COST Action TD1105

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Modelling for Air-Pollution Monitoring

Institute for Environment and Development - IDAD

Aveiro, Portugal, 14 - 15 October 2014

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 3: 2014-15 (*Ongoing Action*)

AIR QUALITY MODELLING IN SLOVENIA: STUDYING SENSITIVITY OF WRF/CHEM FORECAST

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Function in the Action: MC Member, WG3 Member

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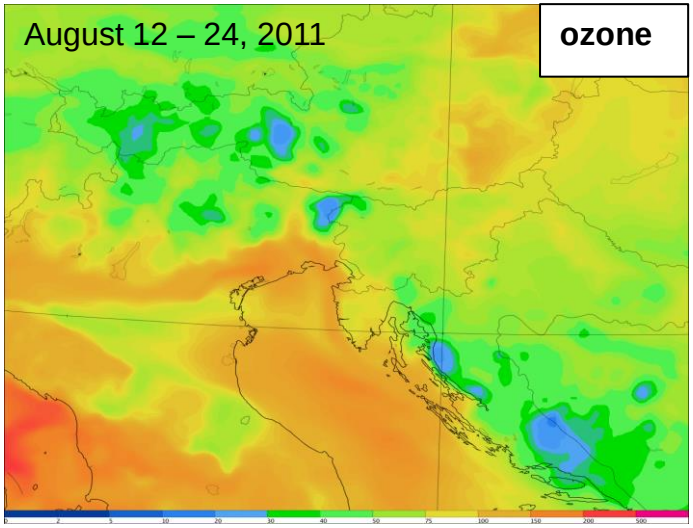
COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Background



Air quality models:

- complete coverage of air quality (time&space)
- provide an improved understanding of the sources, causes and processes
- can be applied prognostically
- important tool for decisions about effective abatement strategies and for environmental assessments during planning stage
- …

Challenges:

- require extensive input data (limited accuracy of inputs)
- many uncertainties in input data and model representation
- extensive validations and sensitivity analyses needed
- must be used together with measurements

AQ modelling at UL

Models:

- WRF/Chem model
- ALADIN/CAMx model
- statistical model for O_3 daily maximum forecasting

EuNetAir WG3: Environmental measurements and air-pollution modelling

Objectives:

- Report on chemical weather forecasting at global area and hot-spot case-studies;
- Assessment of air-quality modelling with data assimilation from integrated AQC gas sensors;
- …

Facilities: WRF/Chem model

On-line coupled

For past air pollution episode studies:

- model setup depends on purpose and area of interest

Computer cluster at UL

For participation in international initiatives, actions:

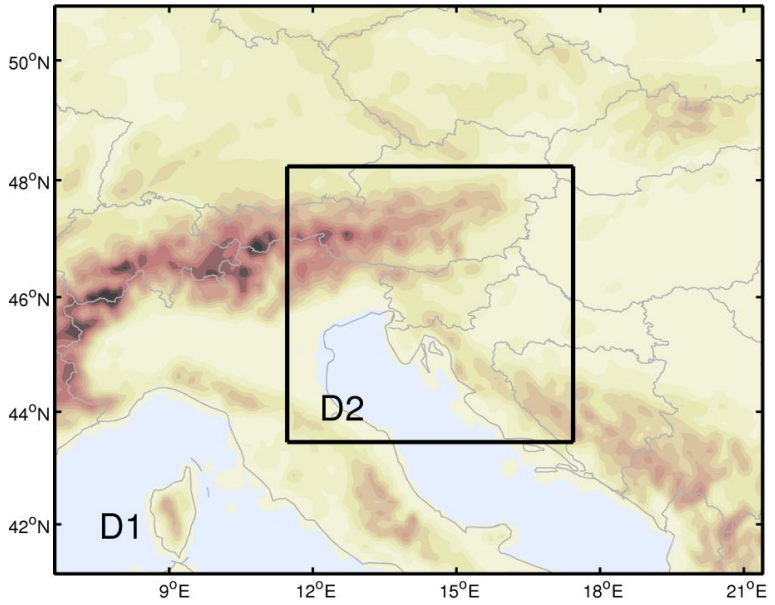
- AQMEII, COST action activities…

For operational AQ forecast in Slovenia:

- running since summer 2013
- available online:

http://meteo.fmf.uni-lj.si/onesnazenje

- the basis for further scientific research



Modelling domains used in WRF/Chem operational forecast for Slovenia running at UL

Facilities: Models running at SEA

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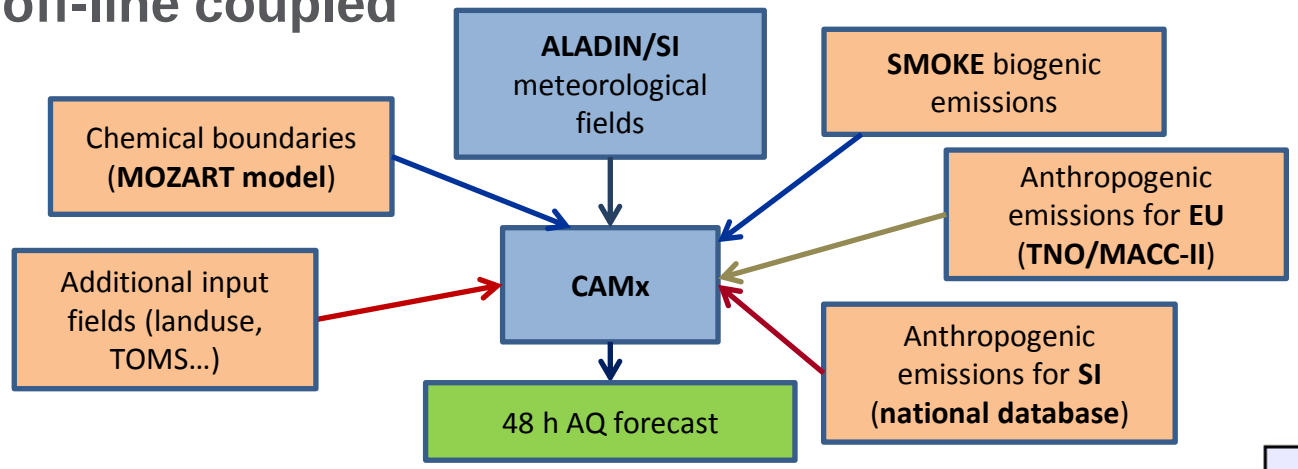
ALADIN/CAMX:

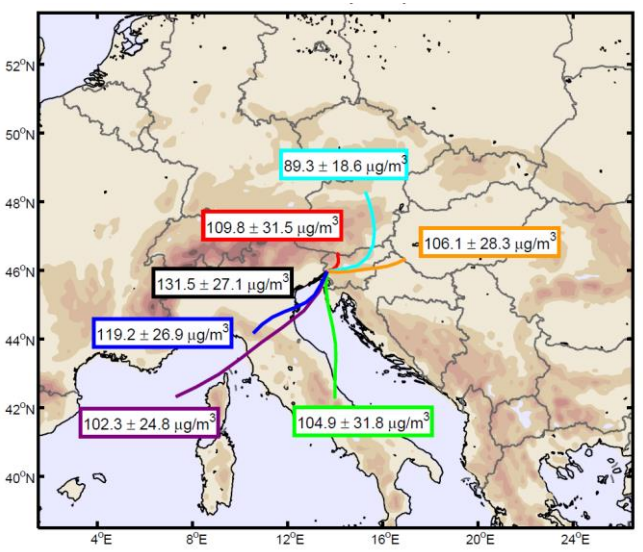
- running operationally at Slovenian Environment Agency
- off-line coupled



Copmuter cluster at SEA

Statistical model for O_3 daily maximum forecast:

- Regression type model based on measured data, meteorological forecast and predicted trajectories



Anthropogenic emissions

AGENCIJA RS ZA OKOLJE

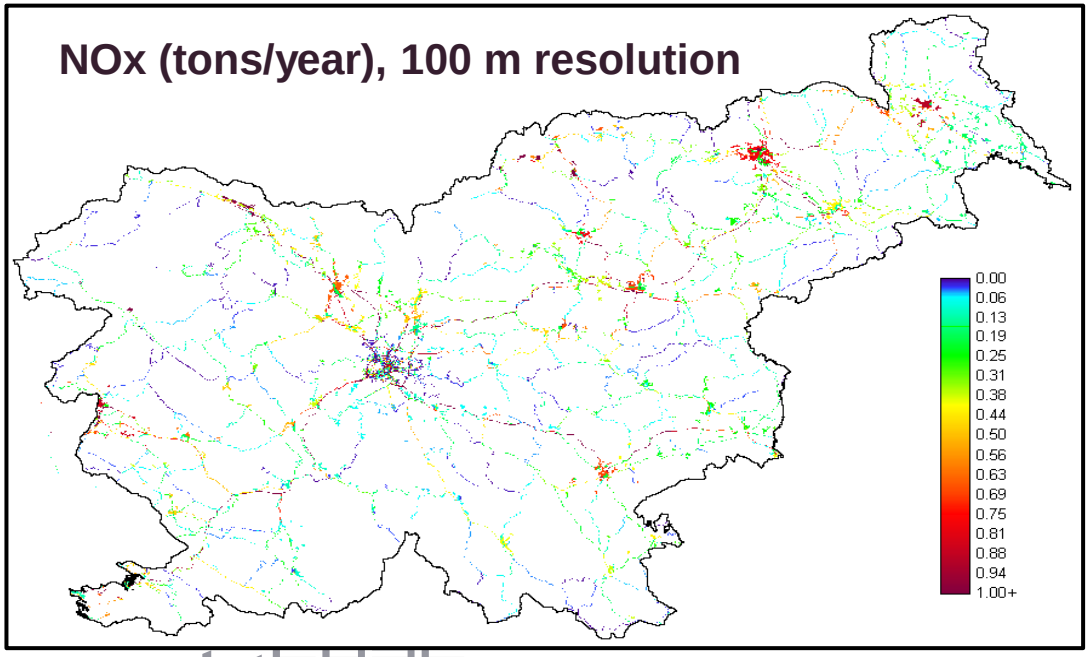
For Slovenia:

a) Detailed database for year 2009 (currently used)

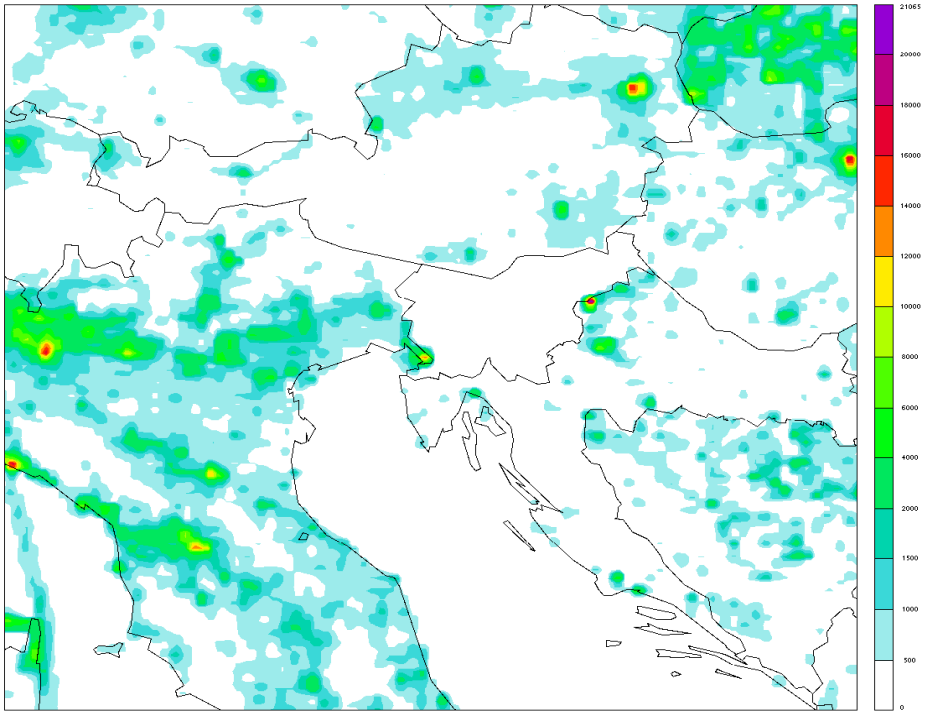
b) Detailed database for year 2011 (new, not yet implemented)

Outside Slovenia:

TNO/MACC-II for year 2009



TNO/MACC II: PM2.5 (g/hour)



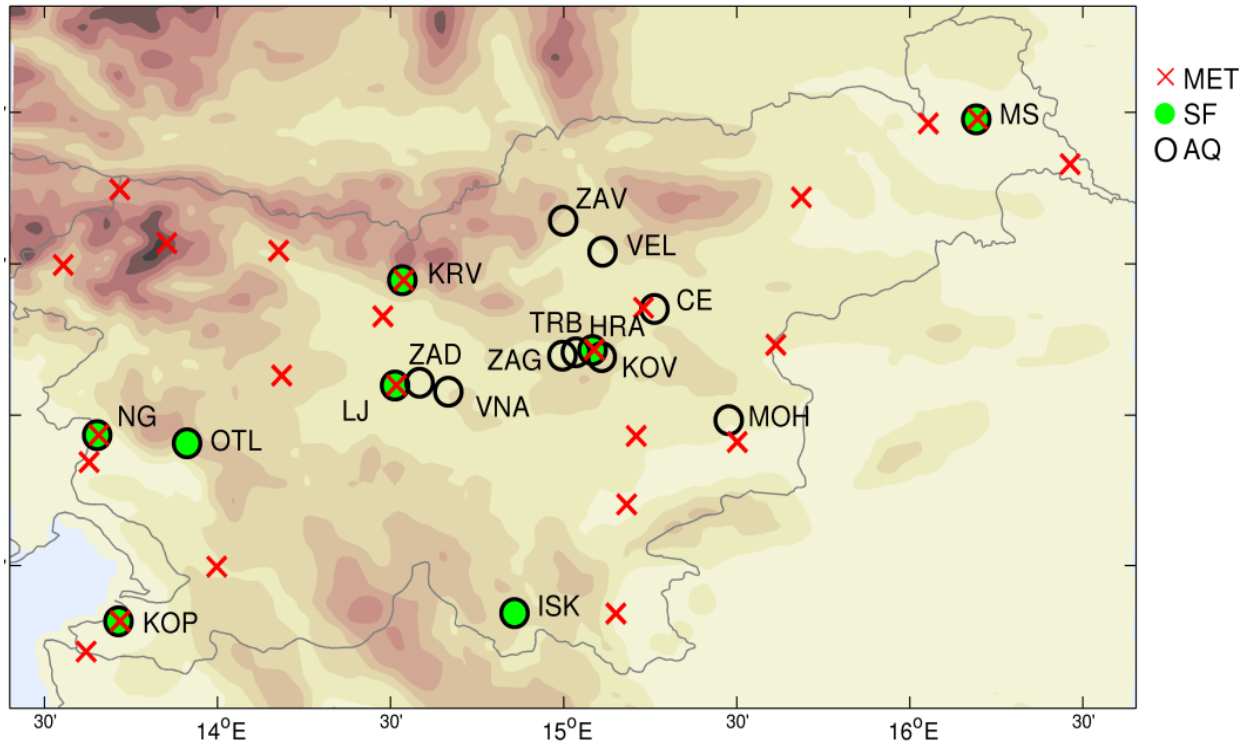
AQ measurements

National network: 17 AQ stations, most of them monitoring O_3, PM10; some of them: NOx, SO_2, PM25, CO, heavy metals, benzene, benzo(a)pirene

Supplement network: 19 AQ stations monitoring SO_2; some of them: O_3, NOx, PM10

17 AQ stations used in our analyses:

KOP – urban
NG – urban
OTL – rural
LJ – urban
ISK – rural
KRV – rural
HRA – urban
TRB – suburban
CE – urban
MS – rural
ZAG – urban
ZAD – rural
VNA – rural
KOV – rural
ZAV – rural
VEL – urban
MOH – rural



Current activities

- EuMetChem COST: studying the importance of aerosol feedbacks with unified WRF/Chem model. Participated in international AQMEII exercise.
- EuNetAir COST: oportunity for exploring possibilities for combination of modeling with observational data to produce a most probable representation of the state of the variables (off-line data assimilation).
- Support to Slovenian Environment Agency (statistical model and ALADIN/CAMx modelling system)
- Studies on operational WRF/Chem forecasting system

  -> to identify and estimate the impact of model uncertainties

  -> focus on sources of uncertainties with highest impact

  -> to improve model performance

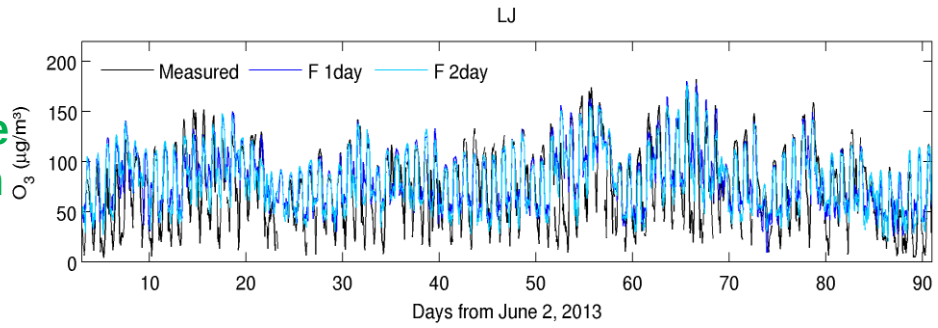
Scientific questions

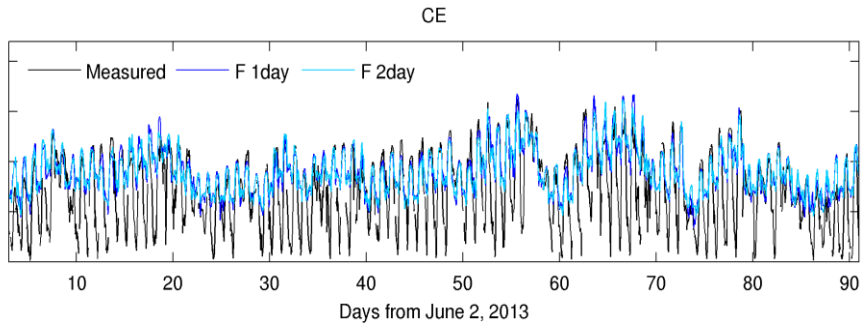
Coupled Chemistry Meteorology Model (CCMM) – WRF/Chem:

- Can an integrated model (considering many uncertainties) produce a good climatology of the most important chemical species?
- Is such model able to beat persistence or statistical forecast of these species?
- What is the impact of aerosol feedbacks on weather and AQ forecast?
- What is the added value of high resolution modelling (running forecast in 3.7 km resolution is computationally very demanding)?
- What is the sensitivity of WRF/Chem forecast to using detailed anthropogenic emission database for Slovenia (considering that Slovenia is a small country)?

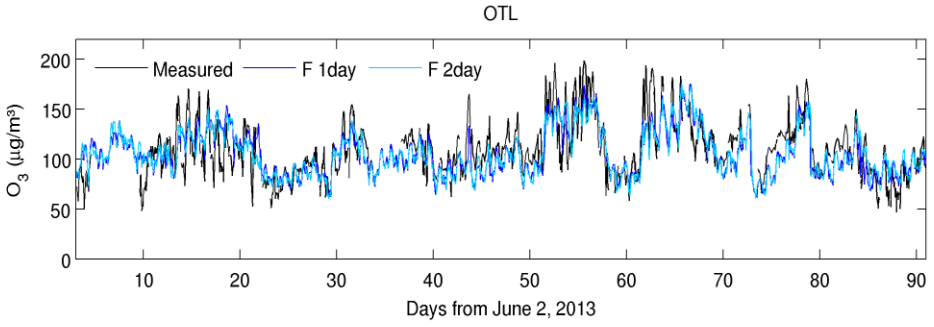
Evaluation of O_3, NO_2 and PM10 WRF/Chem predictions

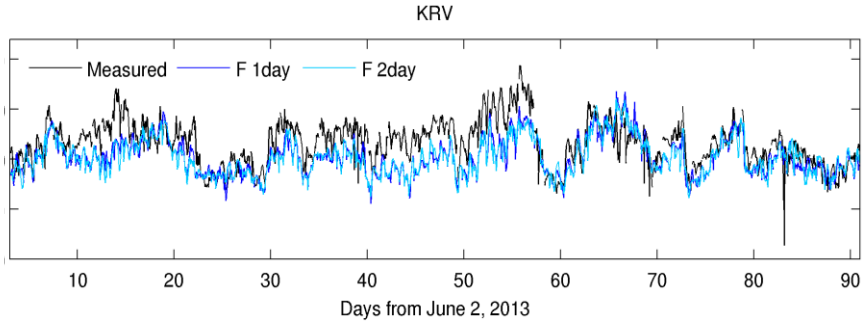
ozone urban



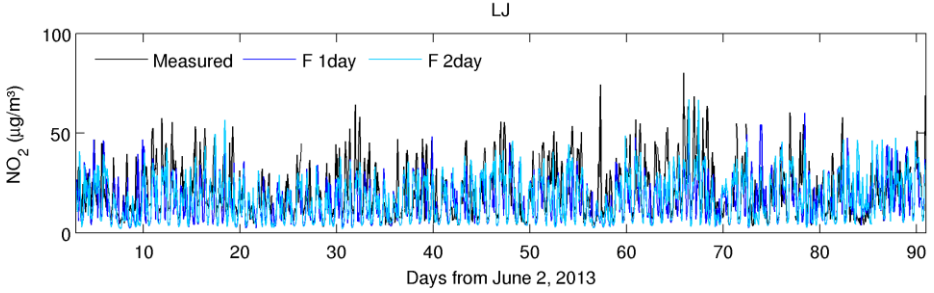


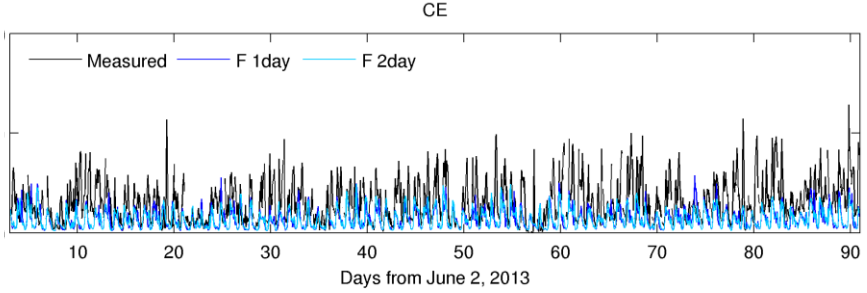
ozone rural



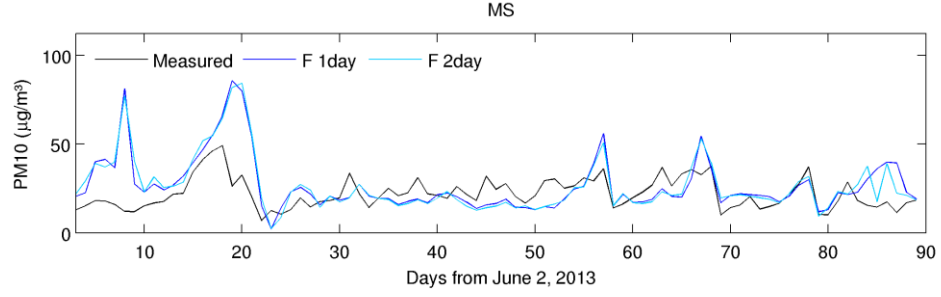


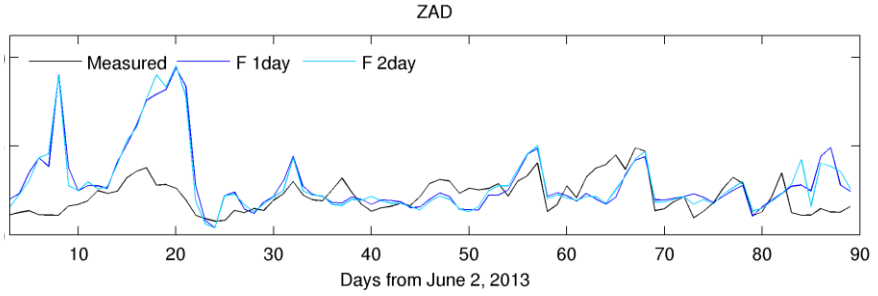
NO_2 urban





PM10 rural

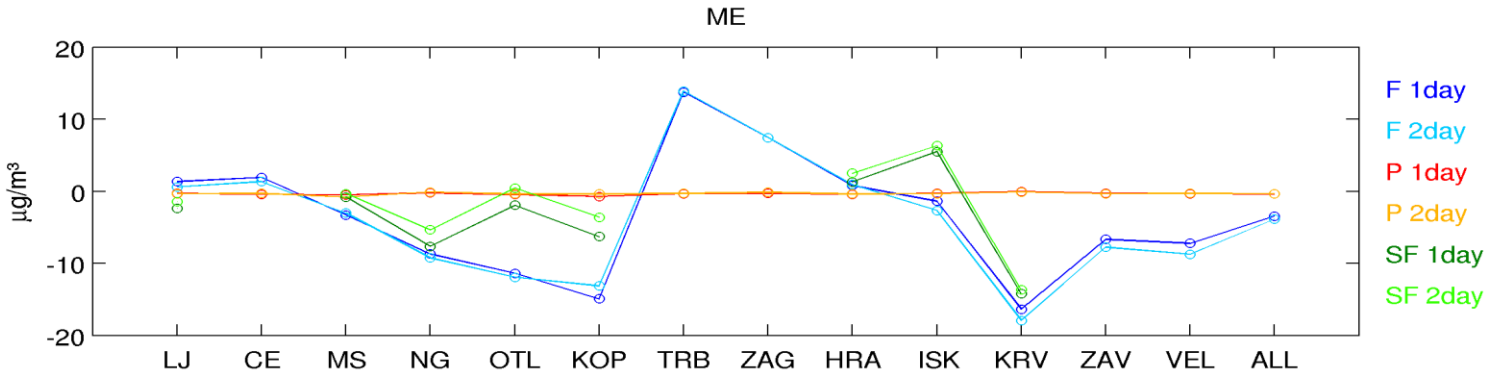




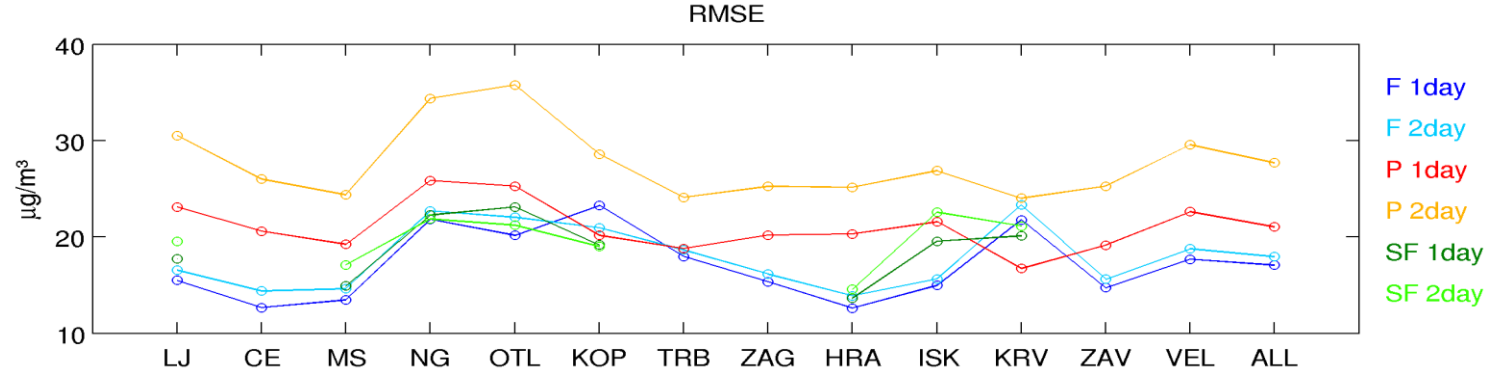
WRF/Chem, statistical forecast, persistence

Summer 2013, ozone daily maximum:

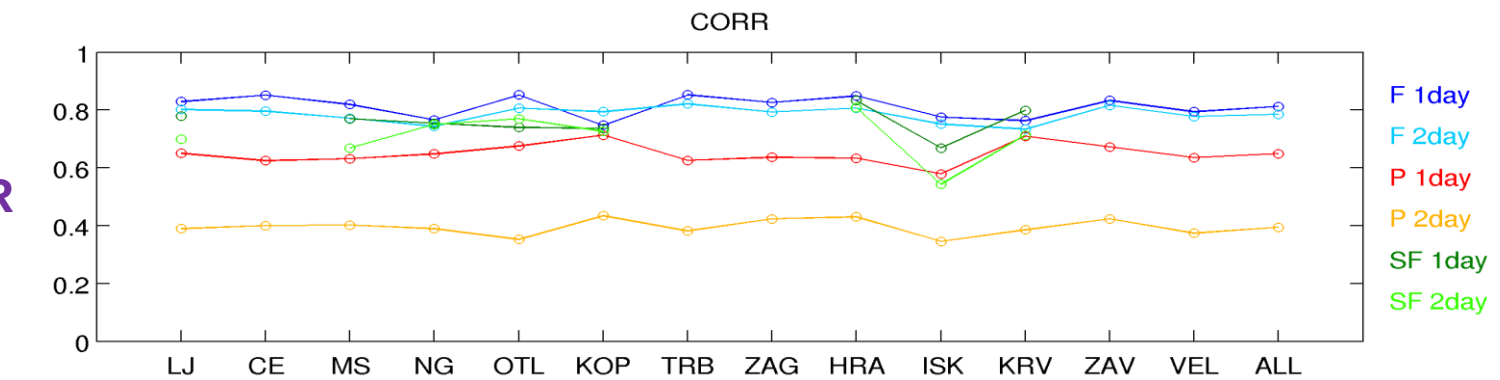
BIAS



RMSE



CORR



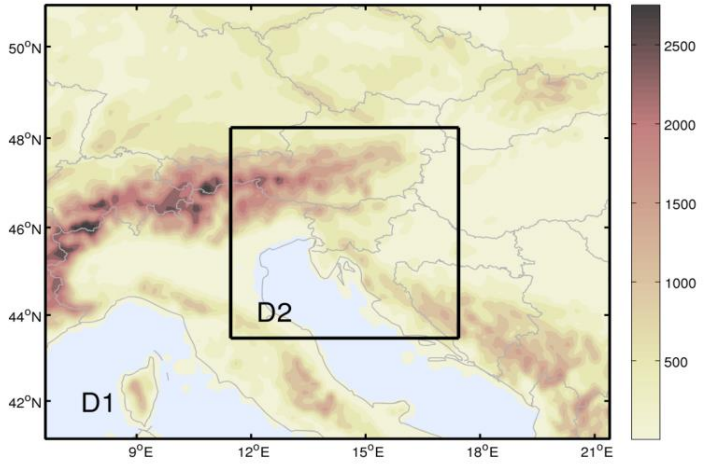
SF, SF:
statistical forecast

P, P:
persistence

F, F :
WRF/Chem forecast

M:
measurements

Sensitivity experiments



5 model predictions for summer 2013:

1. **OPER** – operational forecast
   - 1st day and 2nd day forecast for June-August 2013
   - WRF-Chem model, selected parameterization schemes
   - 2 nested domains, the resolution of the inner domain (D2) 3.7 km
   - detailed anthropogenic emissions for Slovenia, TNO/MACC-II for EU
   - aerosol effects on radiation processes taken into account (but not impacts on microphysical processes)

2. **RES** – lower horizontal resolution
   - Predictions on the outer domain (D1) with 11 km resolution

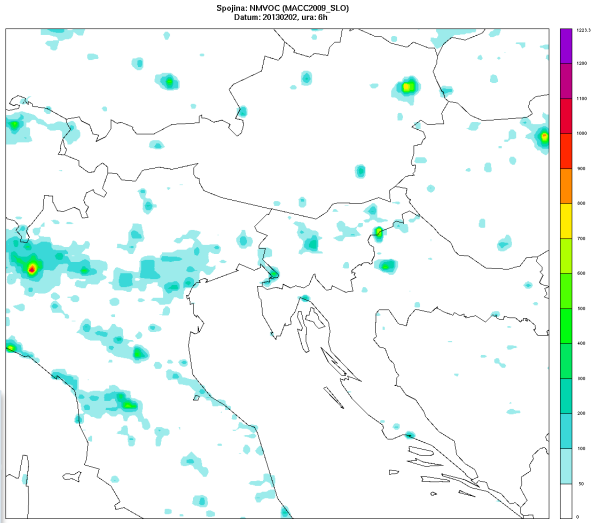
Sensitivity experiments

3. NOE – no aerosol effects on radiation processes

- Zero aerosol concentrations considered in radiation schemes -> reduced scattering of solar radiation or absorbtion (e.g. black carbon) ...
- subsequent changes in temperature, boundary layer height, relative humidity, clouds,…

4. EMIS – different anthr. emissions for Slovenia

- TNO/MACC-II emissions everywhere
- Resolution: 1/8° × 1/16° , top-down approach



units: tones	CO	NH_3	NMVOC	NOx	PM10	PM25	SO_2
TNO/MACC	**124635**	**17794**	**31692**	**45259**	**16326**	**13255**	**11569**
SLO 2009	**94004**	**13681**	**13578**	**34693**	**14634**	**10453**	**8423**
SLO 2011	140135	650	20654	40480	14586	14024	8399

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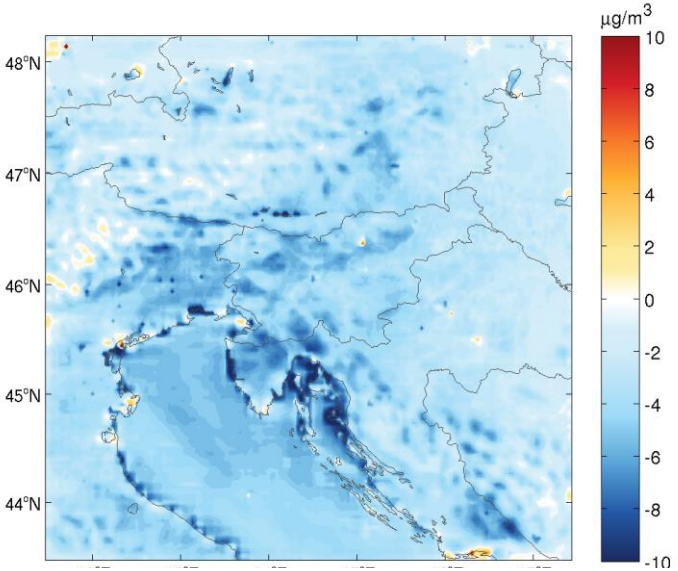
5. PER – persistence (pollutant level today and tomorrow the same as yesterday)

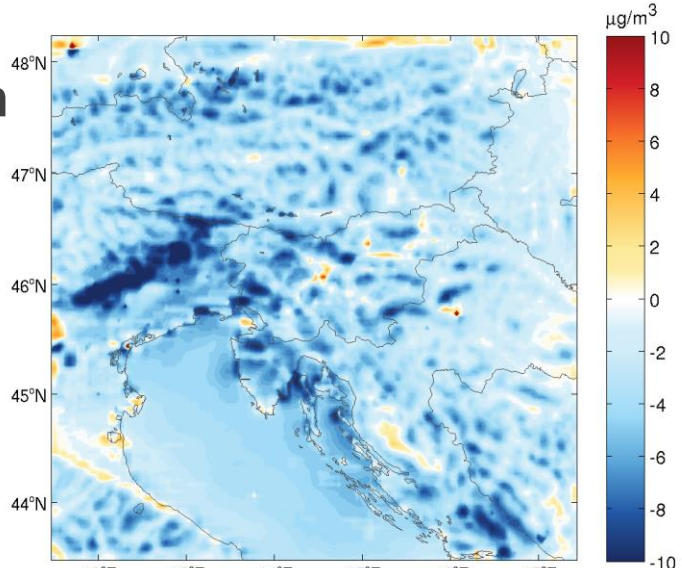
Impact of model resolution

Mean for summer 2013

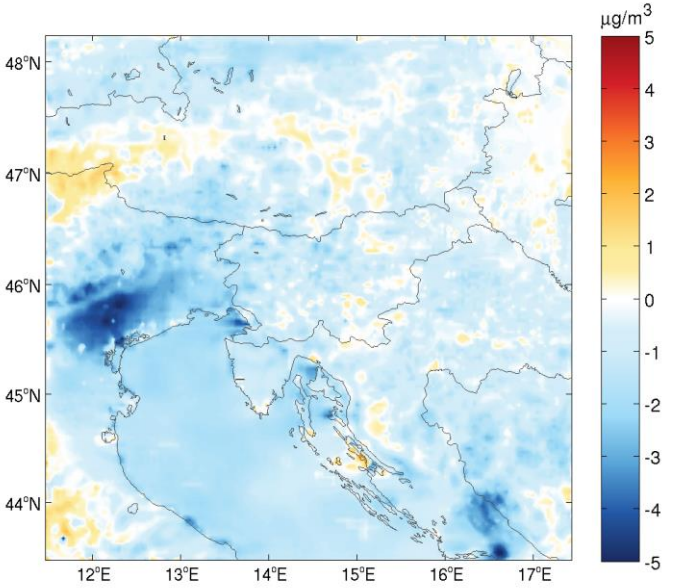
DIFF in O_3 daily max



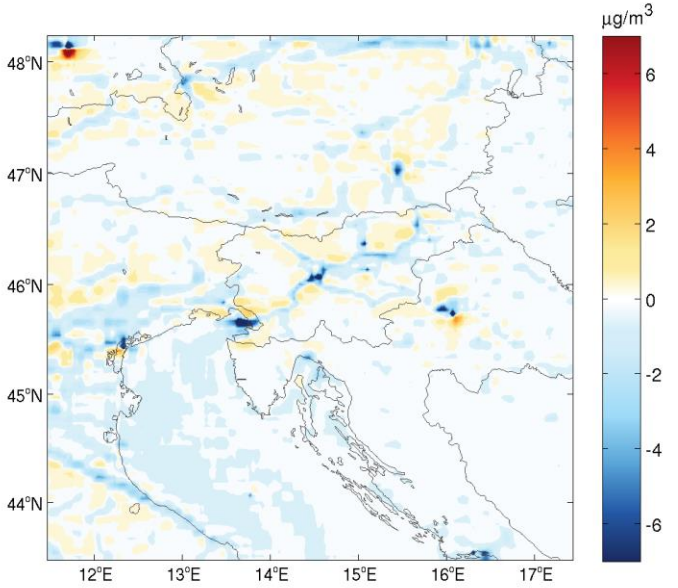
DIFF in O_3



DIFF in PM10



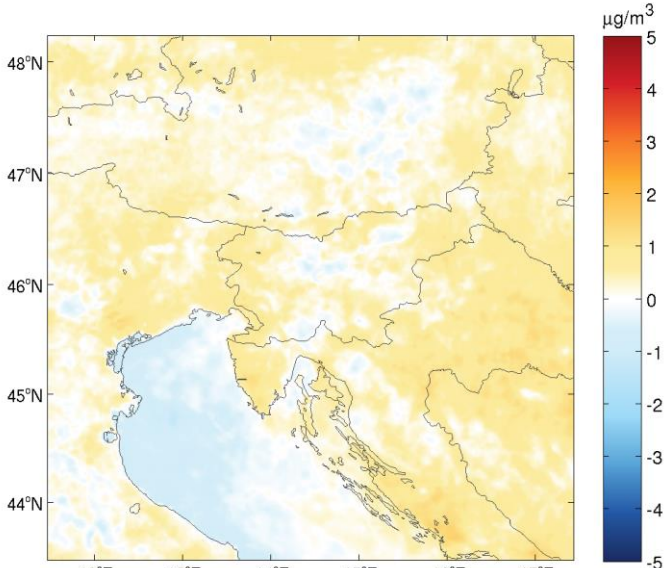
DIFF in NO_2



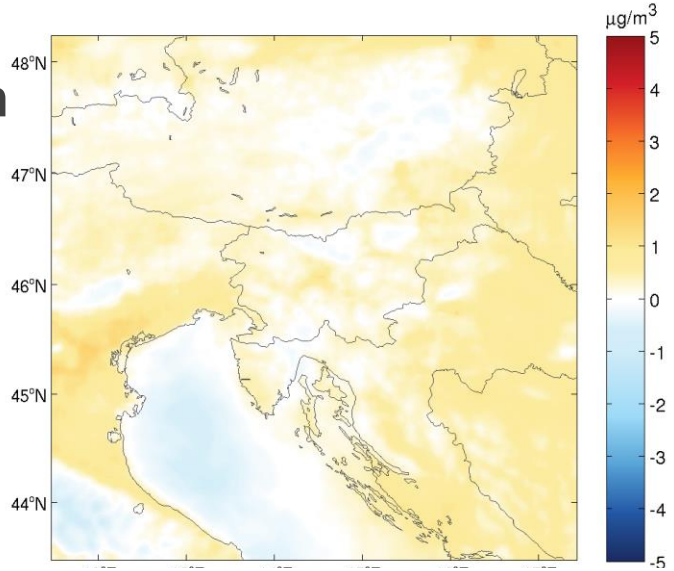
Impact of no aerosol direct effects

Mean for summer 2013

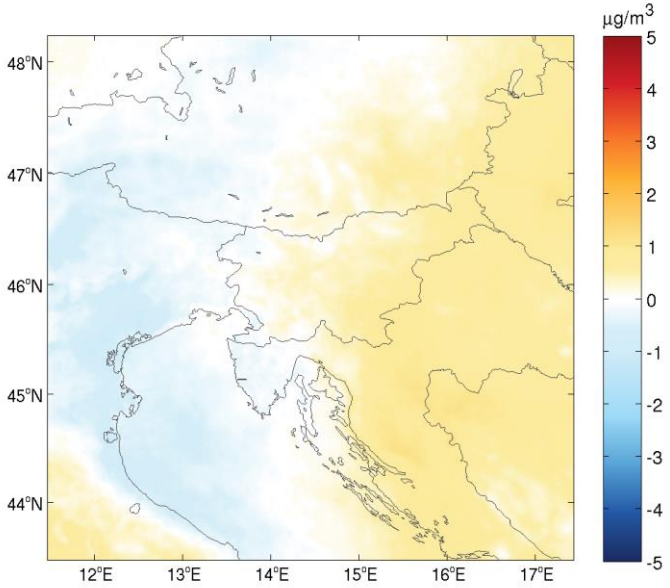
DIFF in O_3 daily max



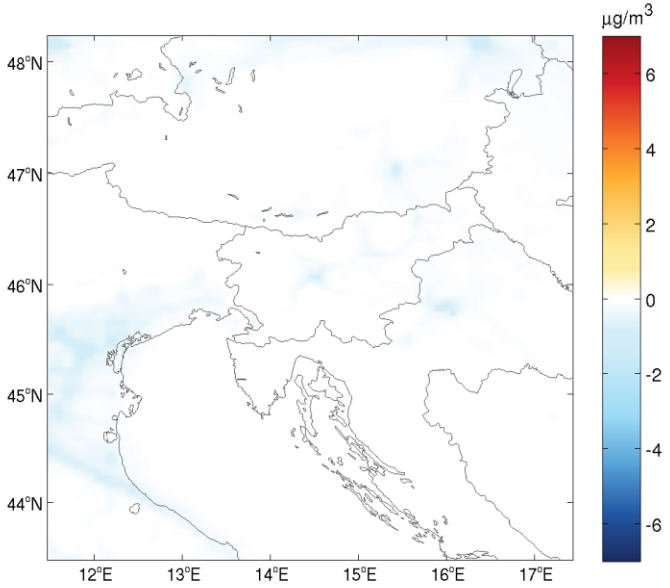
DIFF in O_3



DIFF in PM10



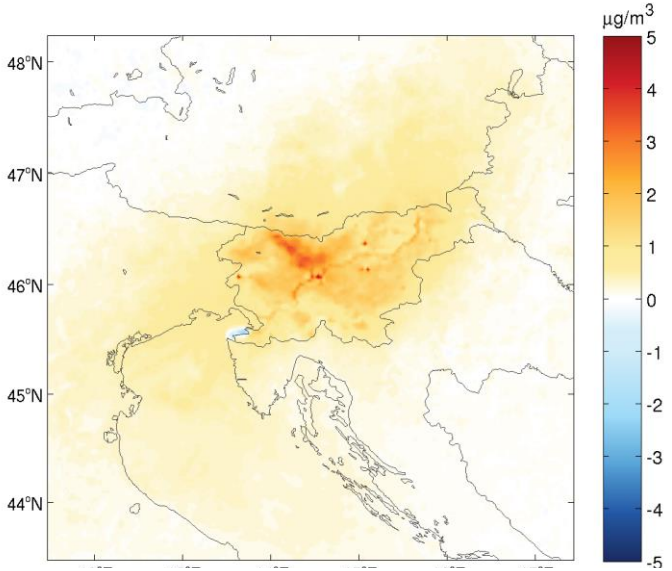
DIFF in NO_2



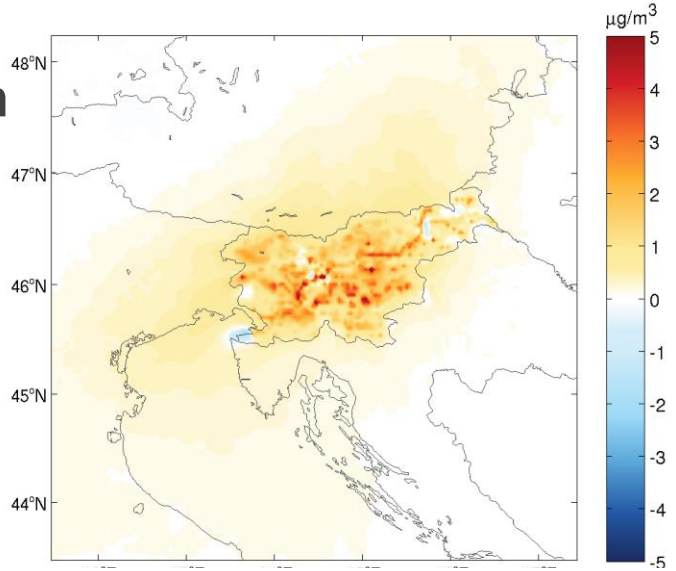
Impact of TNO/MACC emissions for Slovenia

Mean for summer 2013

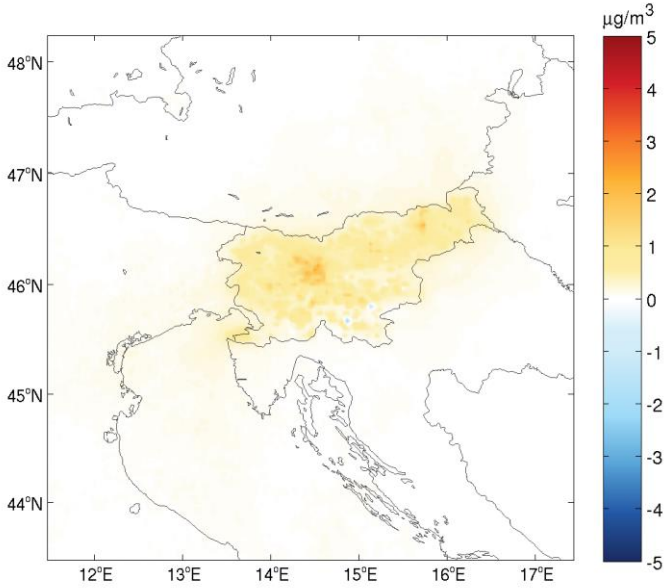
DIFF in O_3 daily max



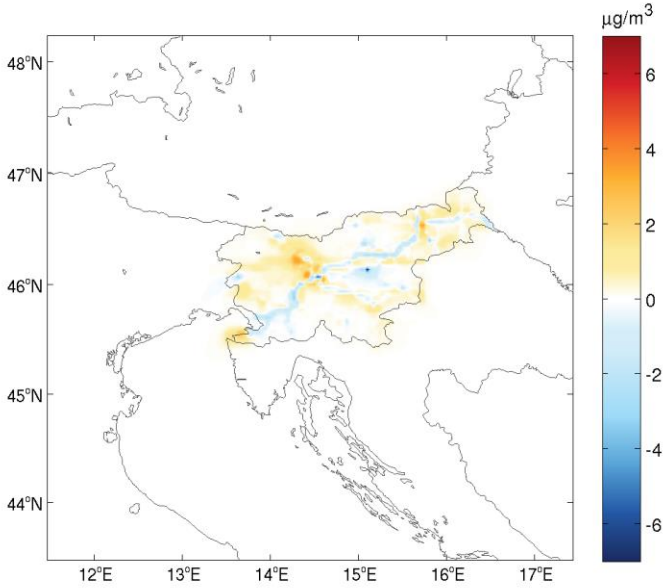
DIFF in O_3



DIFF in PM10



DIFF in NO_2



WRF/Chem, statistical forecast, persistence

Summer 2013, ozone daily maximum:

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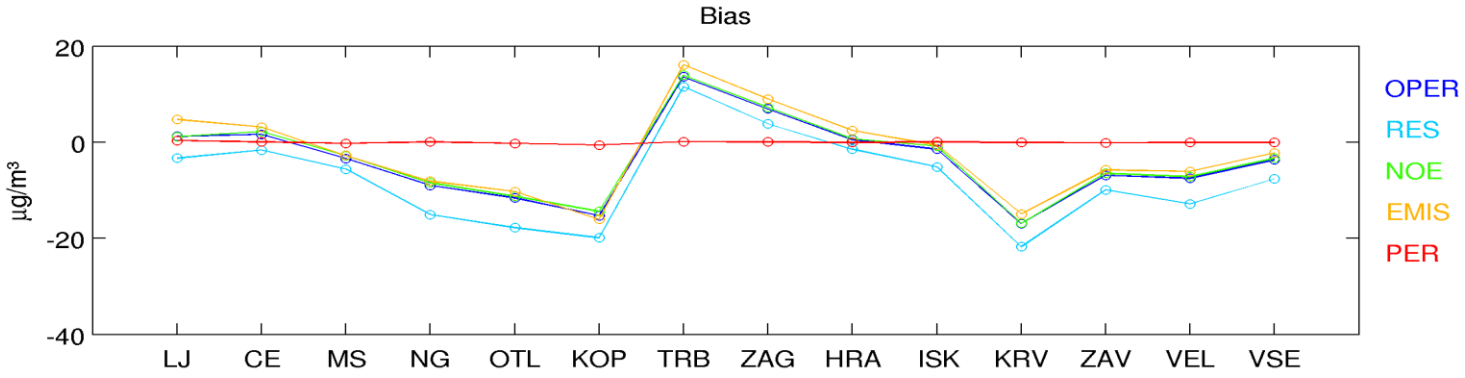
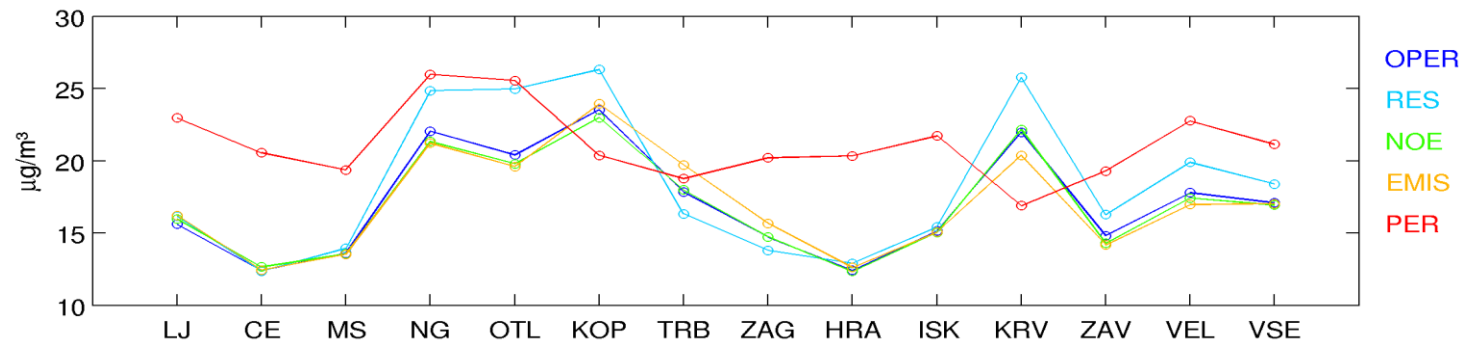


RMSE



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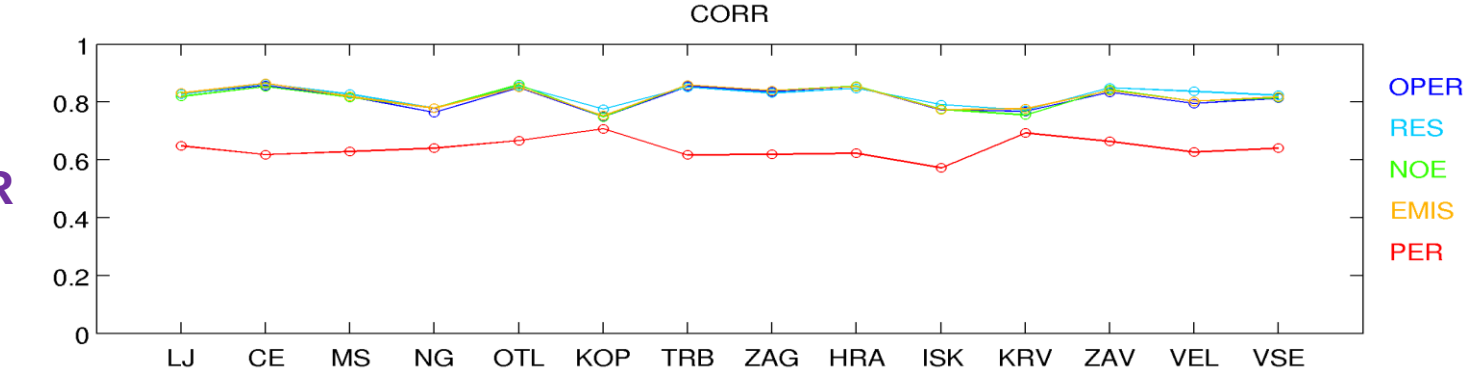


OPER - operational forecast

RES - 11 km resolution

NOE - no aerosol effects

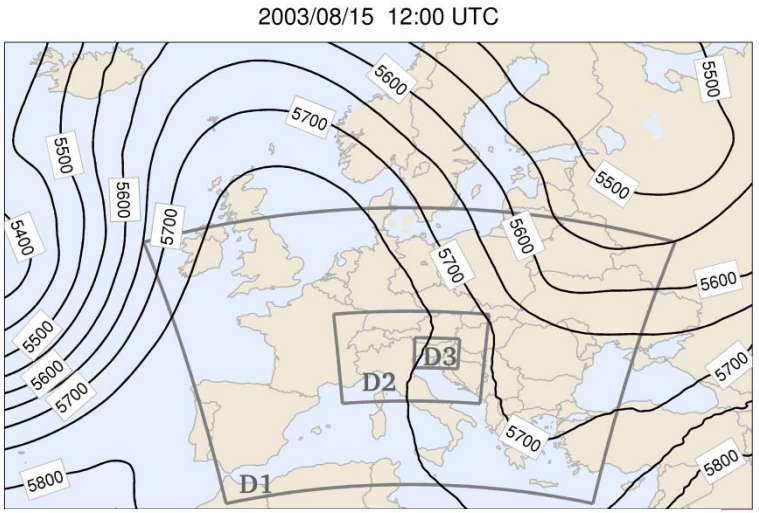
EMIS - TNO/MACC-II for Slovenia

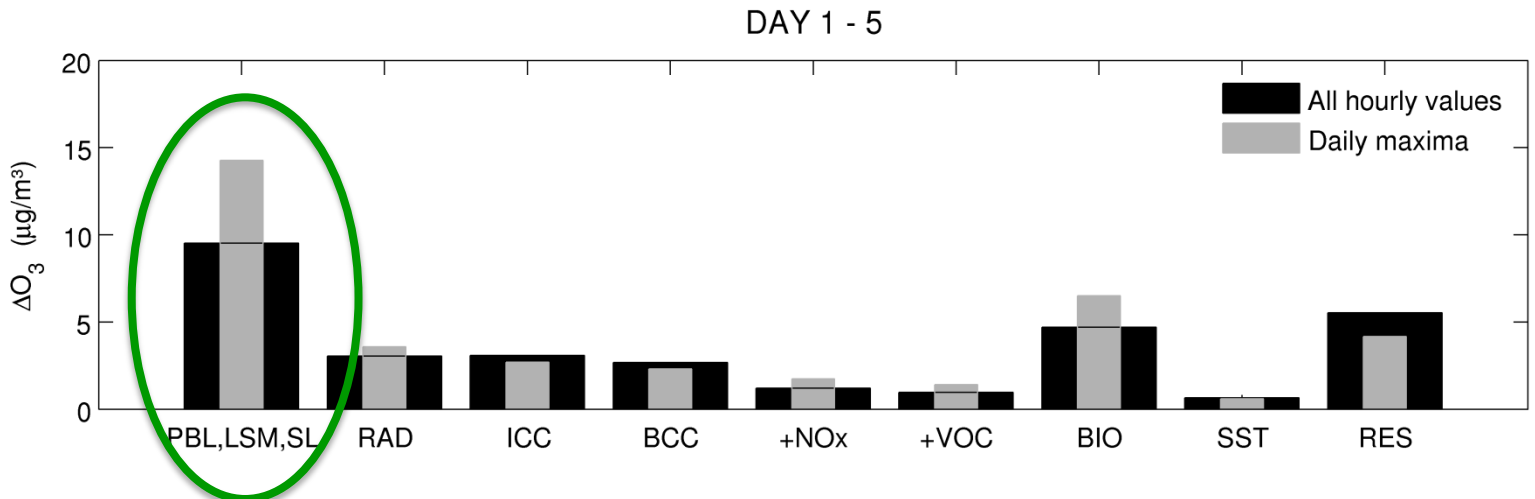
PER - persistence

Impact of model parameterization schemes

- WRF-Chem model sensitivity study
- August 2003 episode, 51 ensemble simulations
- Compared impacts on simulated **ozone** concentrations for varying:

PBL,LSM,SL - model physics parameterization options
RAD - radiation schemes
ICC - chemical initial conditions
BCC - chemical boundary conditions
+NOx, +VOC - anthropogenic emissions (+30%)
BIO - biogenic emissions
RES - model domain setup and resolution





Data assimilation

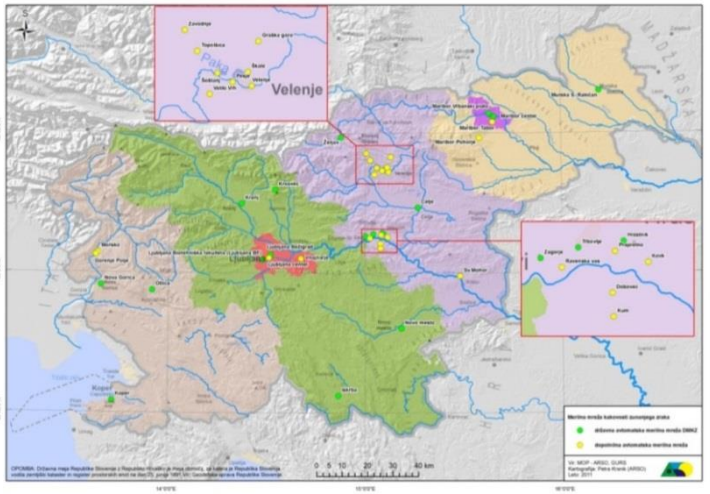
Models:

- WRF/Chem model (online)
- ALADIN/CAMx model (offline)
- statistical model for O_3 daily maximum forecasting

Challenges related to chemical data assimilation (Bocuet et al., 2014):

- major limitation for chemical data assimilation in models is likely to be the limited availability of data, particularly in near-real-time
- On-line chemical data assimilation in coupled chemistry meteorology models is still in its infancy
- …

Off-line data assimilation techniques (data fusion)



National and supplement network of AQ monitoring stations in Slovenia

Conclusions

- Depending on station and statistical measure applied WRF/Chem model can beat persistence or statistical model predictions (for ozone daily maximum)
- Further improvements of WRF-Chem forecasting skill could be obtained by applying one of the bias-correction methods in order to account for unresolved topographical effects and emission patterns.
- Data assimilation in on-line coupled models still in its infancy: only a few application of data assimilation in coupled meteorology-chemistry models, many potential difficulties
- Can EuNetAir Cost action help to make steps towards data fusion to produce a most probable representation of the state of the variables by combining model outputs and measurements

Thank you!

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