The FAIRMODE WG9 platform

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FAIRMODE WG9 OBJECTIVES

- For a given mitigation scenario (**scen**) and a base case (**BC**), models (**M**) provide different absolute results $\boldsymbol{C_{scen}^{M}}$
- **BUT, HOW MODELS BEHAVE ON DELTAS?**

$$\Delta = C_{scen}^{M} - C_{BC}^{M}$$

- What is the order of magnitude of differences? How to evaluate these differences? Which indicators?
- Can we explain the differences, what are the main drivers?

Policy Implication:

It is important to assess the robustness of deltas for urban air quality policies!

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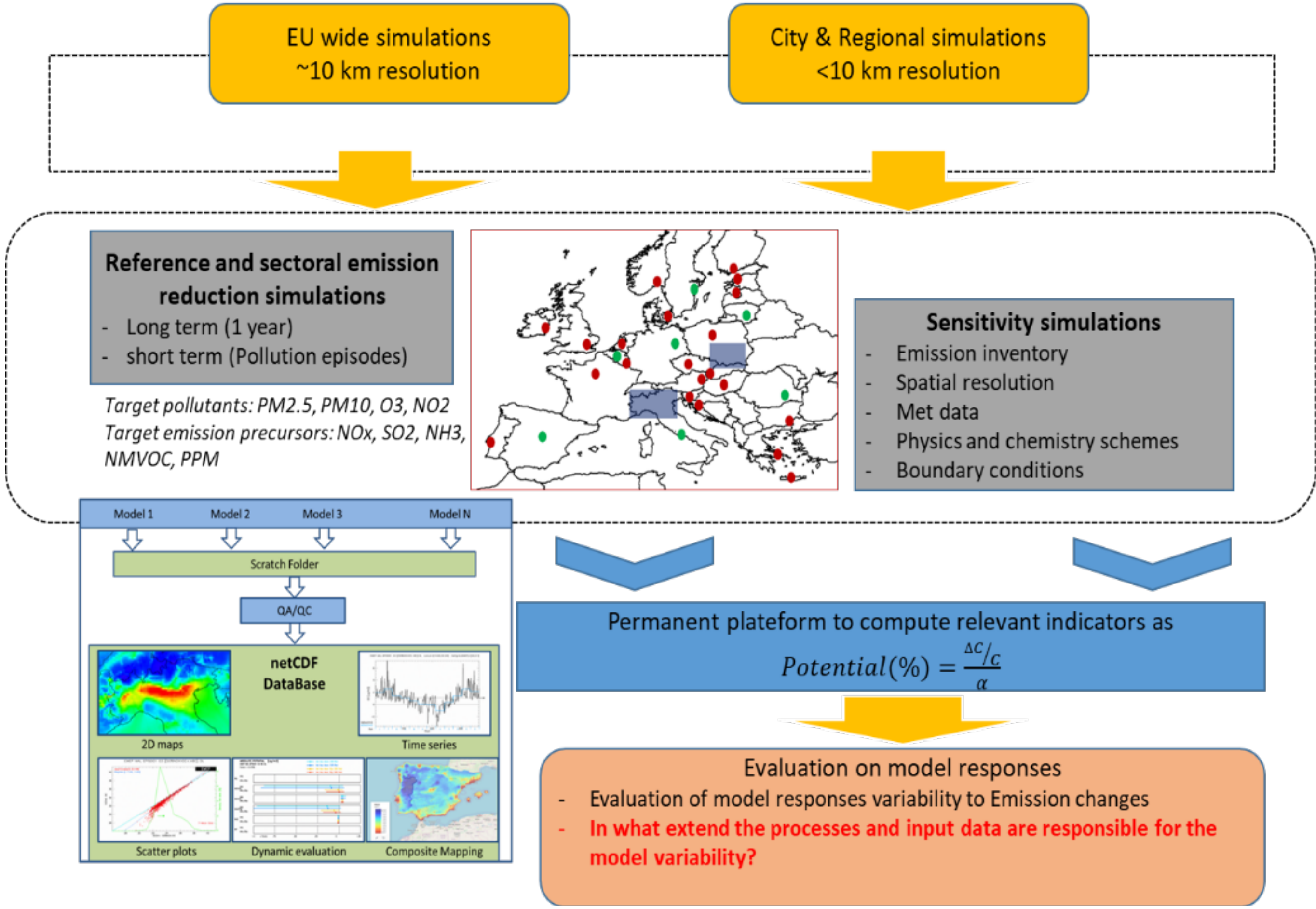
Models and teams involved - Overview

Constraints:
-Meteorology 2015
-Emission reductions 25 and 50%
-Target domains, periods (episodes)

Team name - Country		Model Name
JRC	(EU)	EMEP
ZAMG	(AT)	WRF-Chem
Met Norway	(NO)	EMEP
Met Norway	(NO)	EMEP + uEMEP
CyI	(CY)	WRF-Chem
NKUA	(GR)	WRF-Chem
DHMZ	(HR)	ADMS-Urban
DHMZ	(HR)	LOTOS-EUROS
LMD/IPSL	(FR)	WRF-CHIMEREv2020r1
UH-CACP	(UK)	WRF-CMAQ
CIEMAT	(ES)	IFS-CHIMEREv2017r4
ENEA	(IT)	WRF-MINNI
IRCELINE	(BE)	CHIMERE + RIO + ATMOSTREET



Two papers under review

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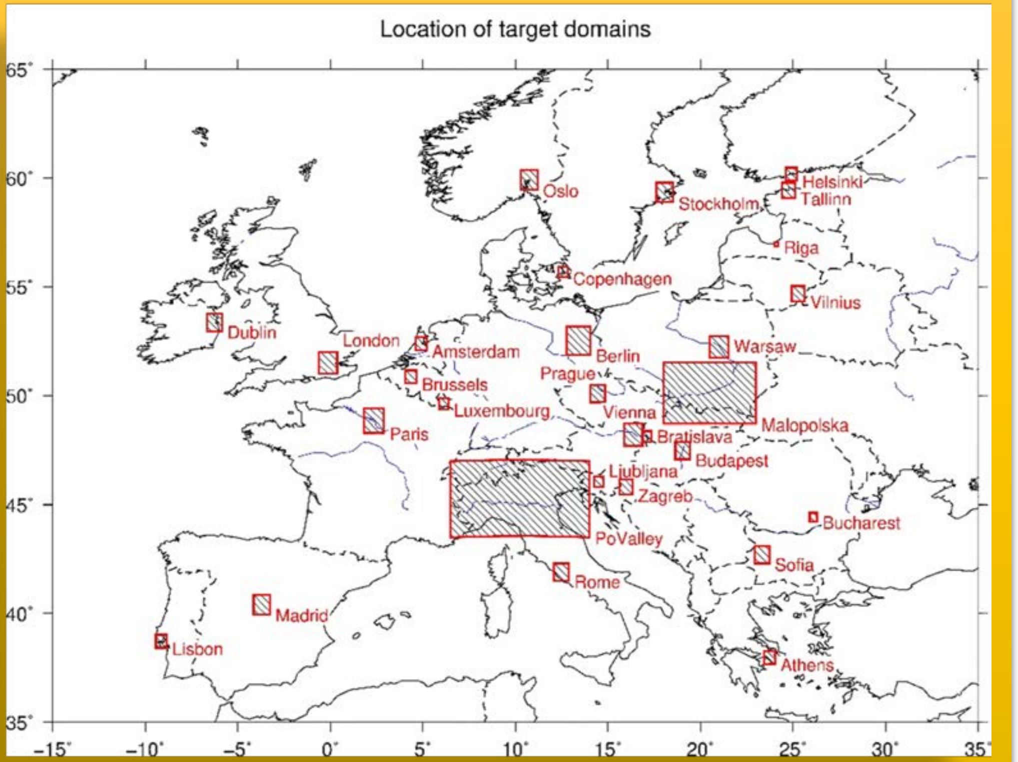
The overall framework

Set-up

- Short term (ST) on episodes
  - *Emissions reduced only during 2015 episodes*
    from 00:00 to 23:00
- Long term (LT) simulations
  - *Emissions reduced for the whole year 2015*
- Two reductions so far:
  - 25% and 50% from a base case (BC)
- Reduced species depends on target pollutants
  - ***PM10**: PPM, NOx, VOC, NH3, SO2, **ALL** (All together)*
  - ***Ozone**: NOx, VOC, **ALL** (All together)*

Domains of emission reductions



The overall framework

Basis Indicators

- **Absolute Potential** defined as the reduction in µg/m^3 scaled by the reduction α of the scenario (25 or 50%) of a precursor from base case BC
  - $APl = (C_{SCEN} - C_{BC})/(\alpha\ )$ ($APl \times \alpha$ is the delta of concentrations)
- **Relative Potential** defined as the reduction in % scaled by the reduction α of the scenario (25 or 50%) of precursor *n* from base case BC and by the BC concentrations.
  - $RPl = (C_{SCEN} - C_{BC})/(\alpha\ \times C_{BC})$
- **Absolute Potency** in µg/m^3/(ton/day) defined as the derivative of the concentration with respect to the emissions density E of a precursor or in other words the rate with which the concentrations (*C*) will change as a result of an emission density E)
  - $APy = (C_{SCEN} - C_{BC})/(\alpha\ \times E_{BC})$

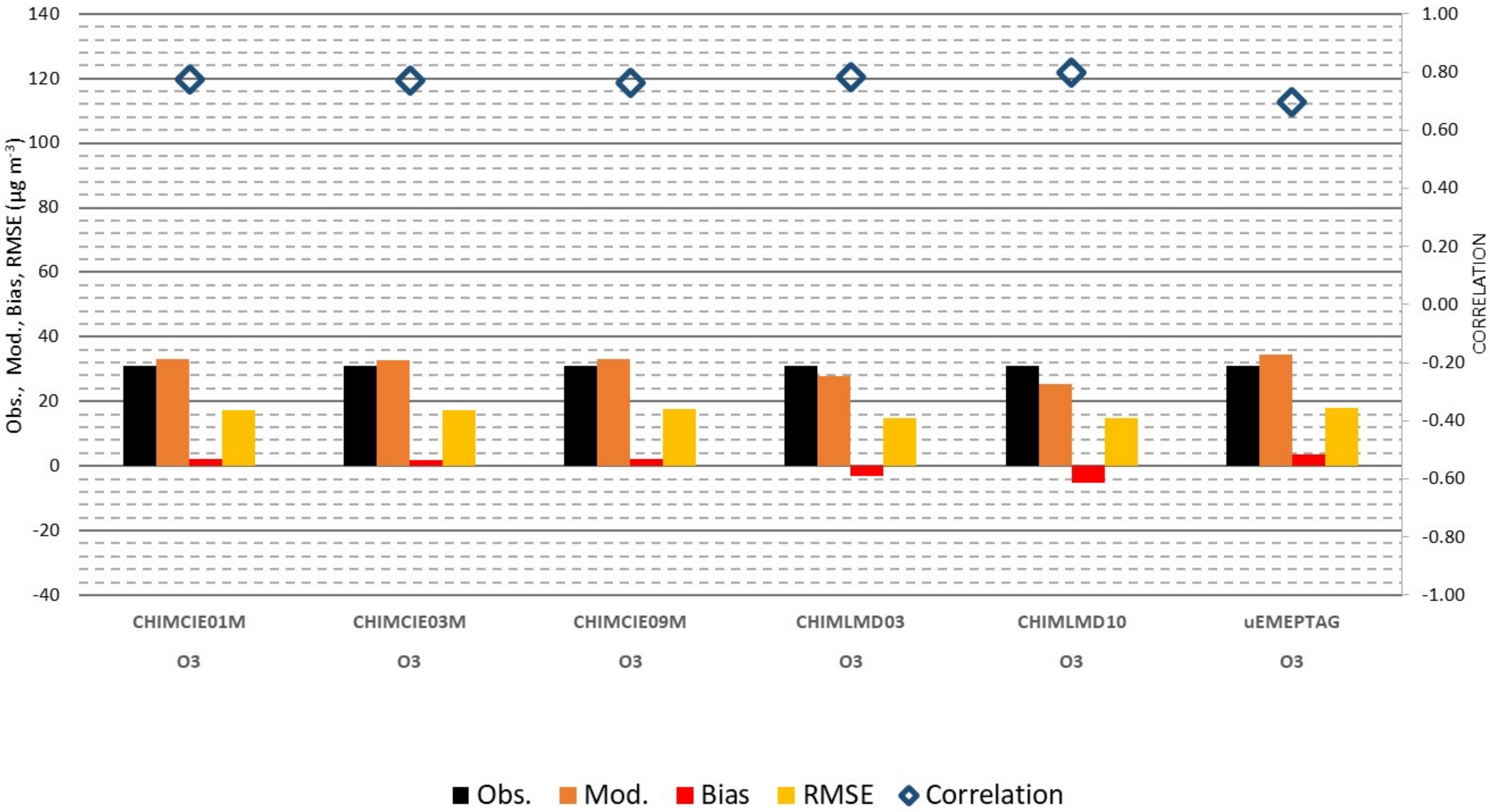
Main conclusions of our paper (I)

- The evaluation of model outputs show a large variability of model performances for the base case, **a high spatial resolution does not automatically improved the model performances** even for pollutants influenced by local emissions like NO_2;
- The variability of model responses using delta-based indicators is **higher for PM_{10} than for Ozone**;
- The variability of **model responses is higher than the variability of base case concentrations** and emissions;

Main conclusions (II)

- Relative indicators like the Relative Potential (normalized by the concentration) and the **Absolute Potency** (normalized by the emission reductions) **have a lower variability compared** with the Absolute Potential (which is proportional to the delta of concentrations);
- For **ozone**, the analysis of linearity and additivity of model responses show a clear impact of **non-linear chemistry processes**, which produce a large deviation to linearity and additivity of emission reductions;
- **For PM, the response is in general more linear** and additive particularly, as expected, when reducing the primary emissions of particles which weakly perturb the chemical and physical processes involved in the PM formation;
- One should remain cautious in the interpretation of these **indicators**, because they are built on averages and ratio of values that can be **very low** with **different signs**.

Evaluation over Paris (PM episode) – O3



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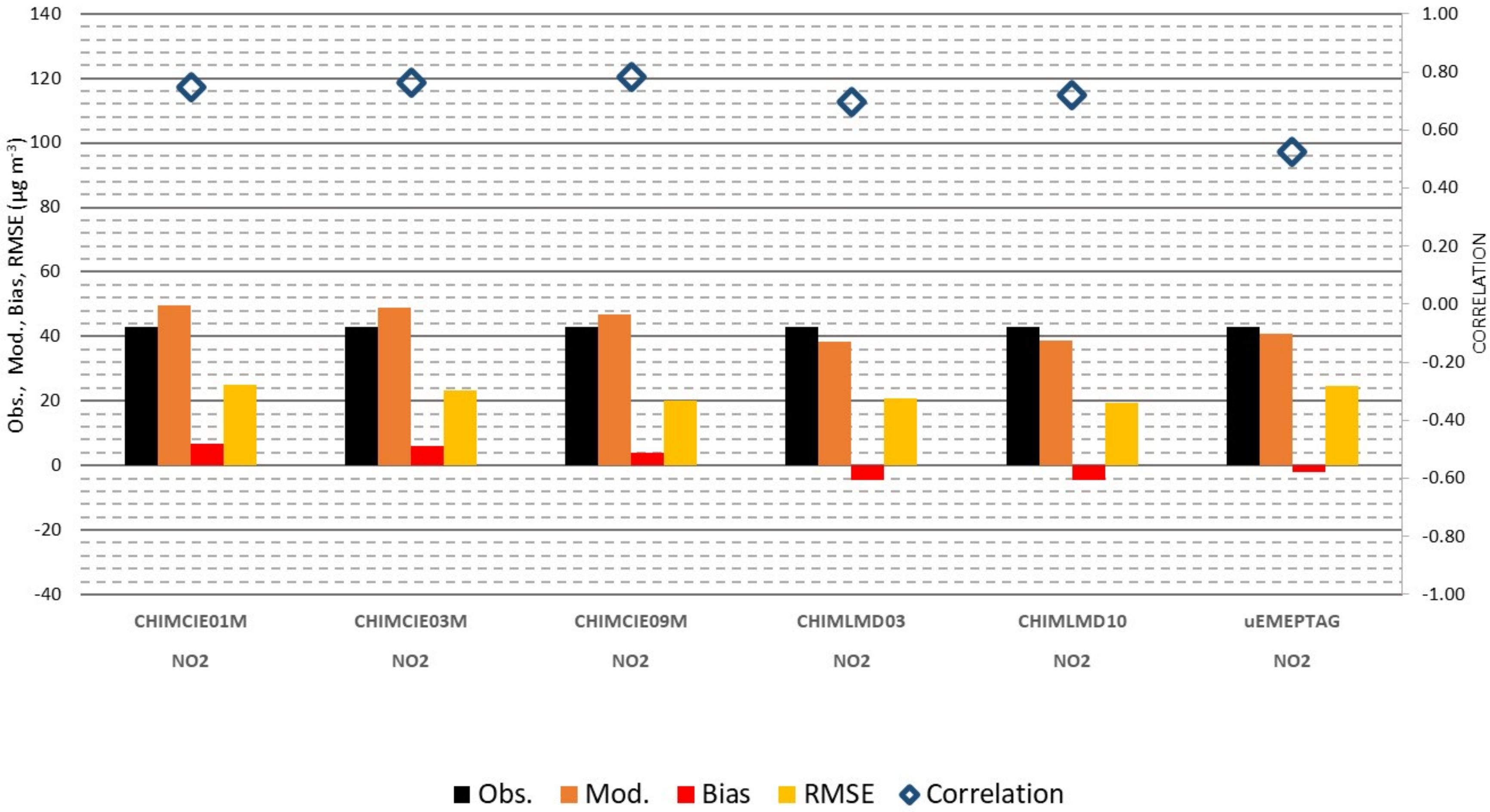
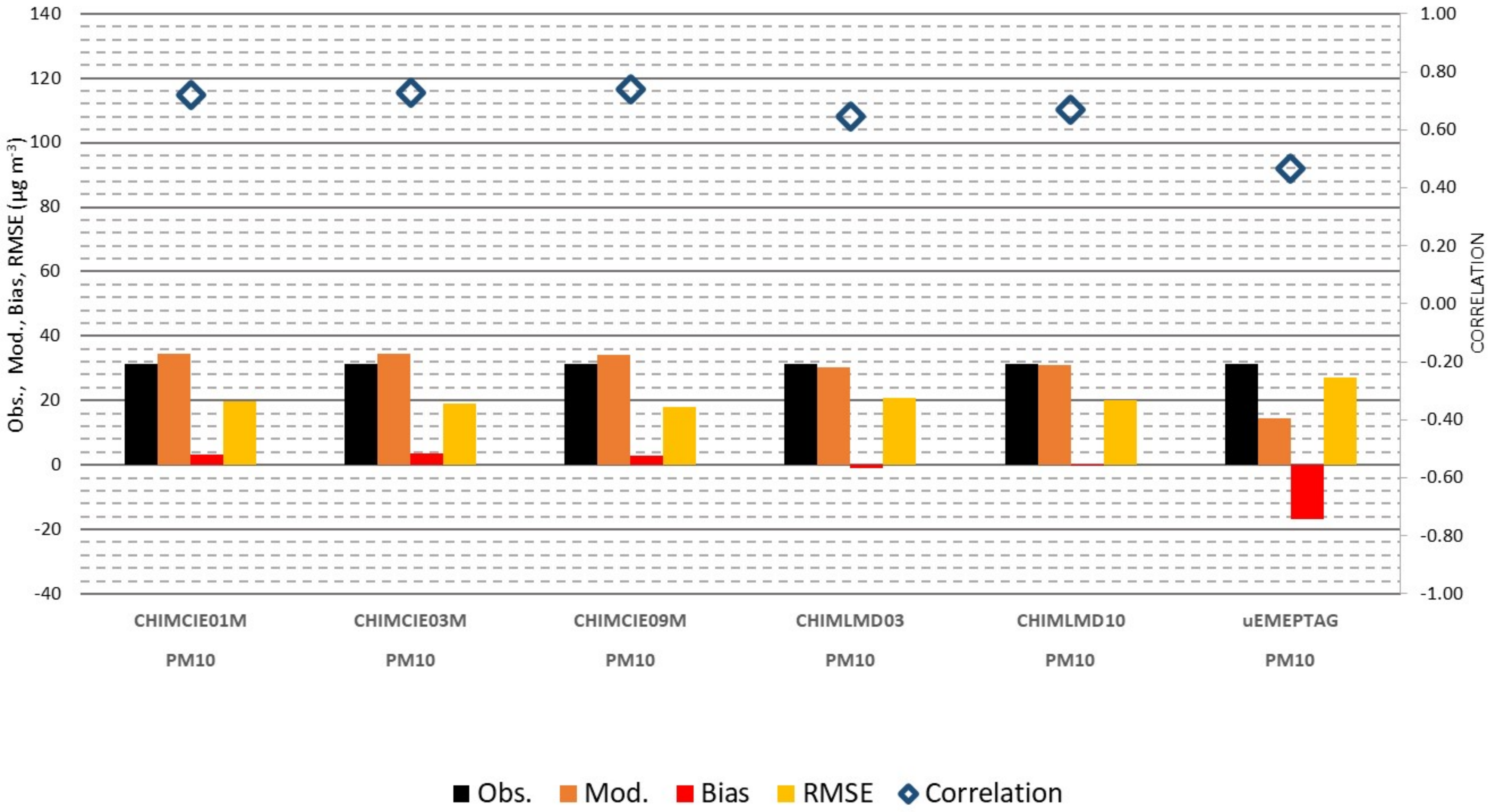
Evaluation over Paris (PM episode) – NO2



Evaluation over Paris (PM episode) – PM10



Relative Potential for O3 for NOx and VOC reduction

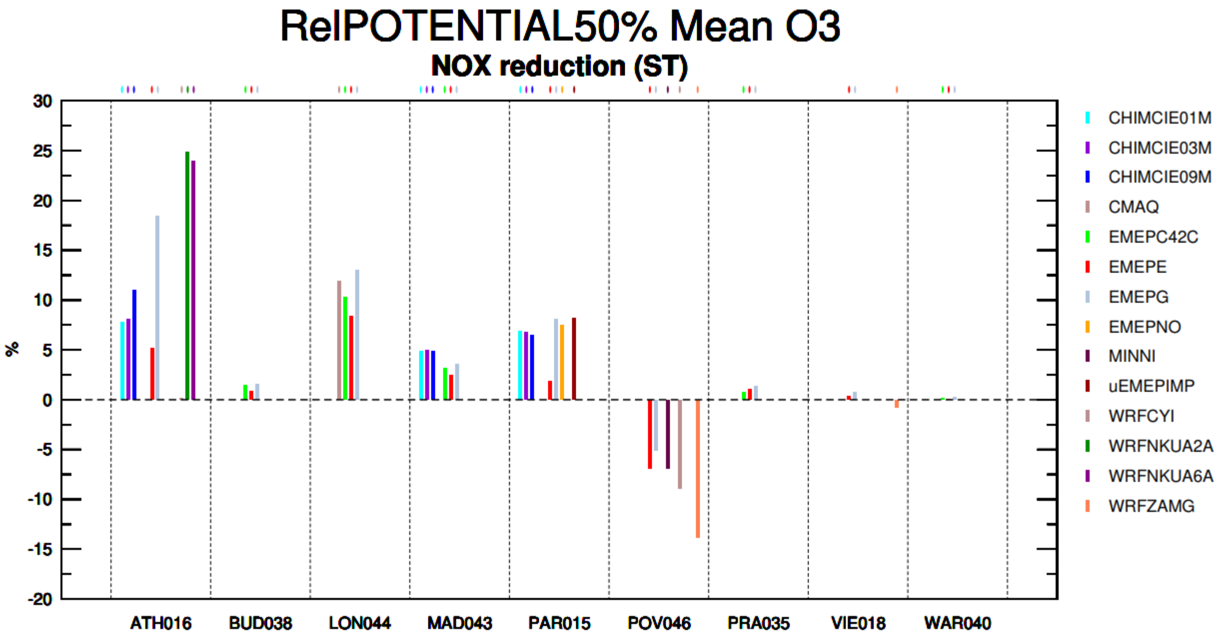


Figure S41: RelPOTENTIAL50% for Short-Term Mean O3 applying a reduction on NOX precursor

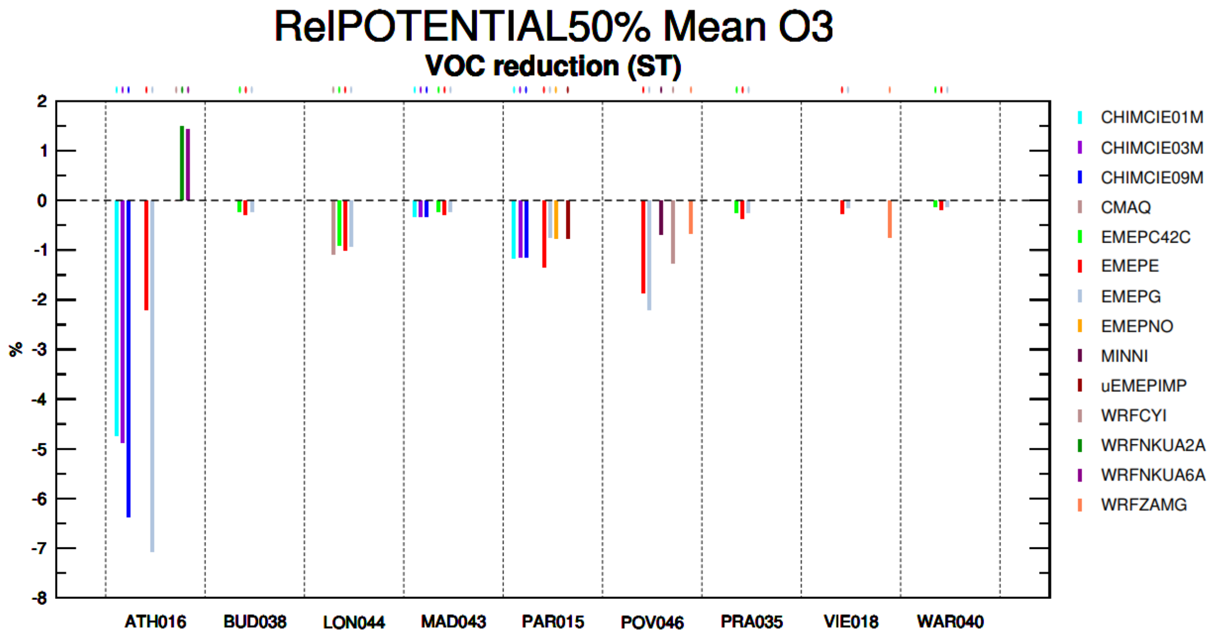


Figure S63: RelPOTENTIAL50% for Short-Term Mean O3 applying a reduction on VOC precursor

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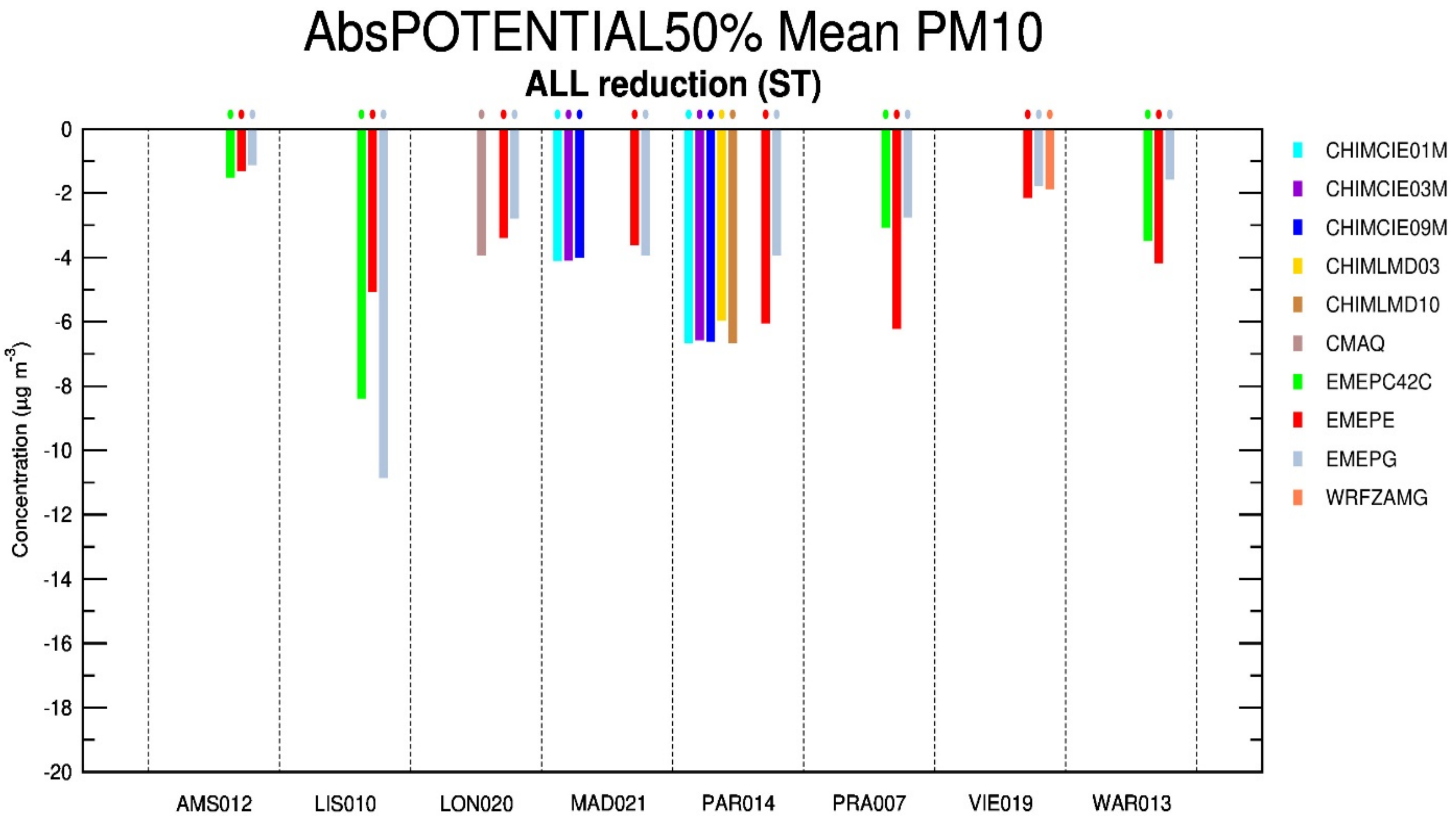
Absolute Potential for PM10 with ALL pollutant reductions



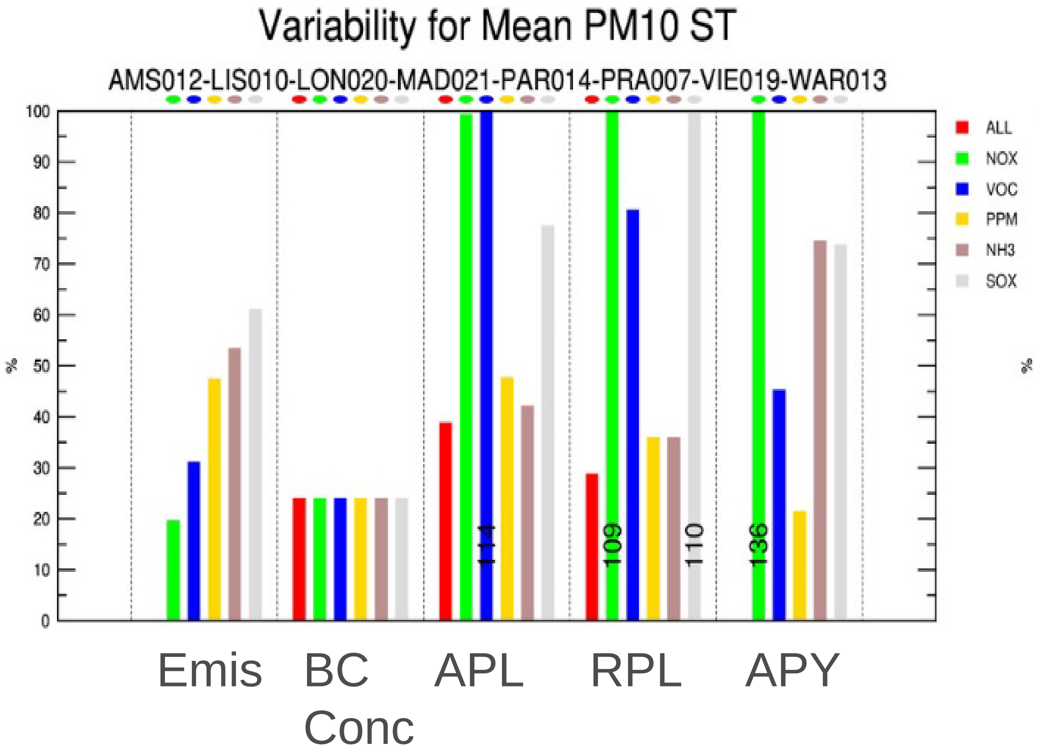
Other indicators

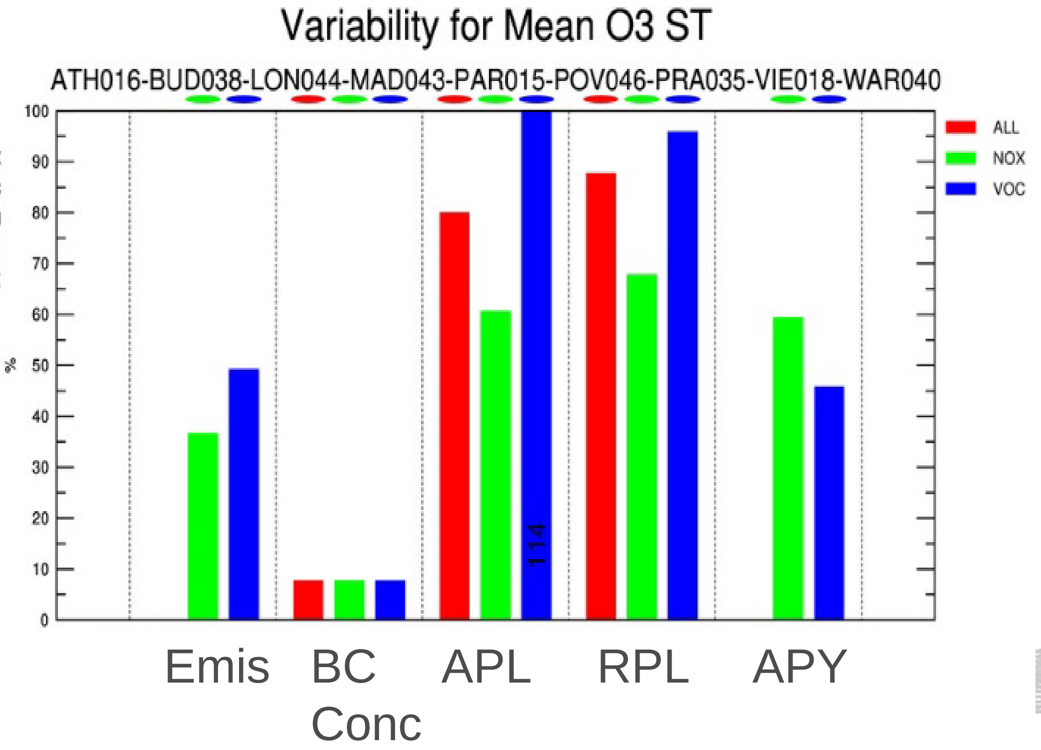
- **Variability** for each indicator
  - IND = APL, RPL, APY

Variability from models M assessed by Norm. Std. Dev.

$$VAR_{IND} = \sqrt{\frac{\sum_{m=1}^{M}(IND_m - \overline{IND})^2}{(\overline{IND})^2}}$$

-50% scenario





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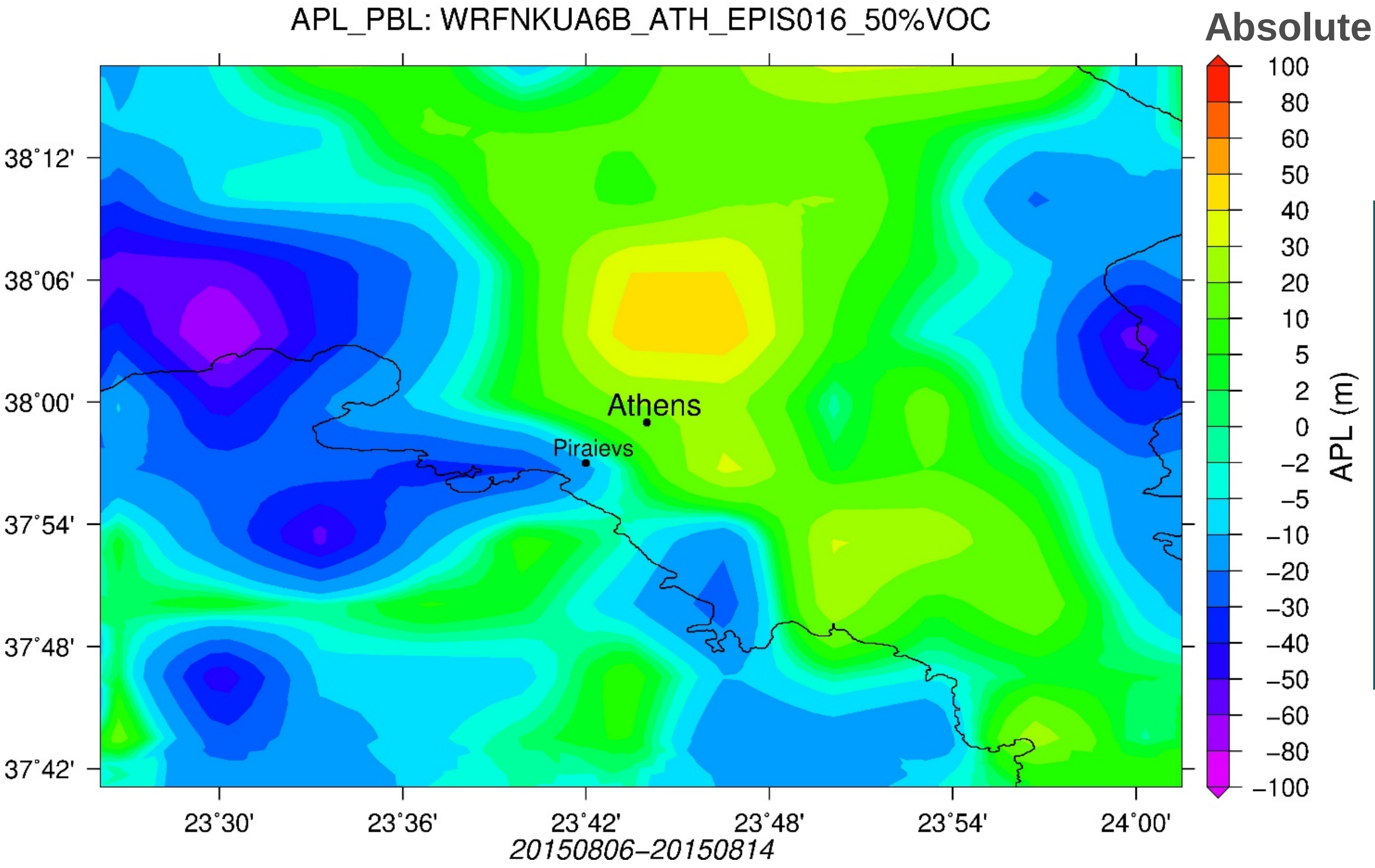
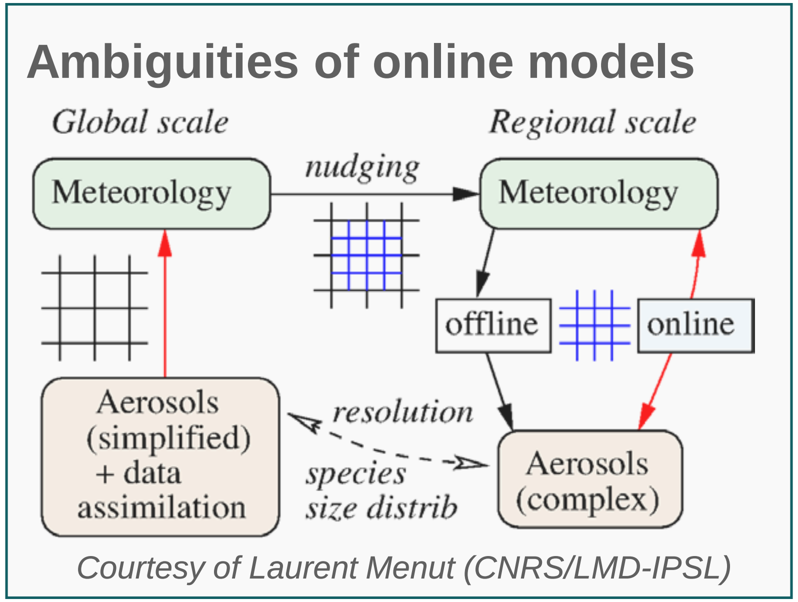
WRF online radiative feedbacks

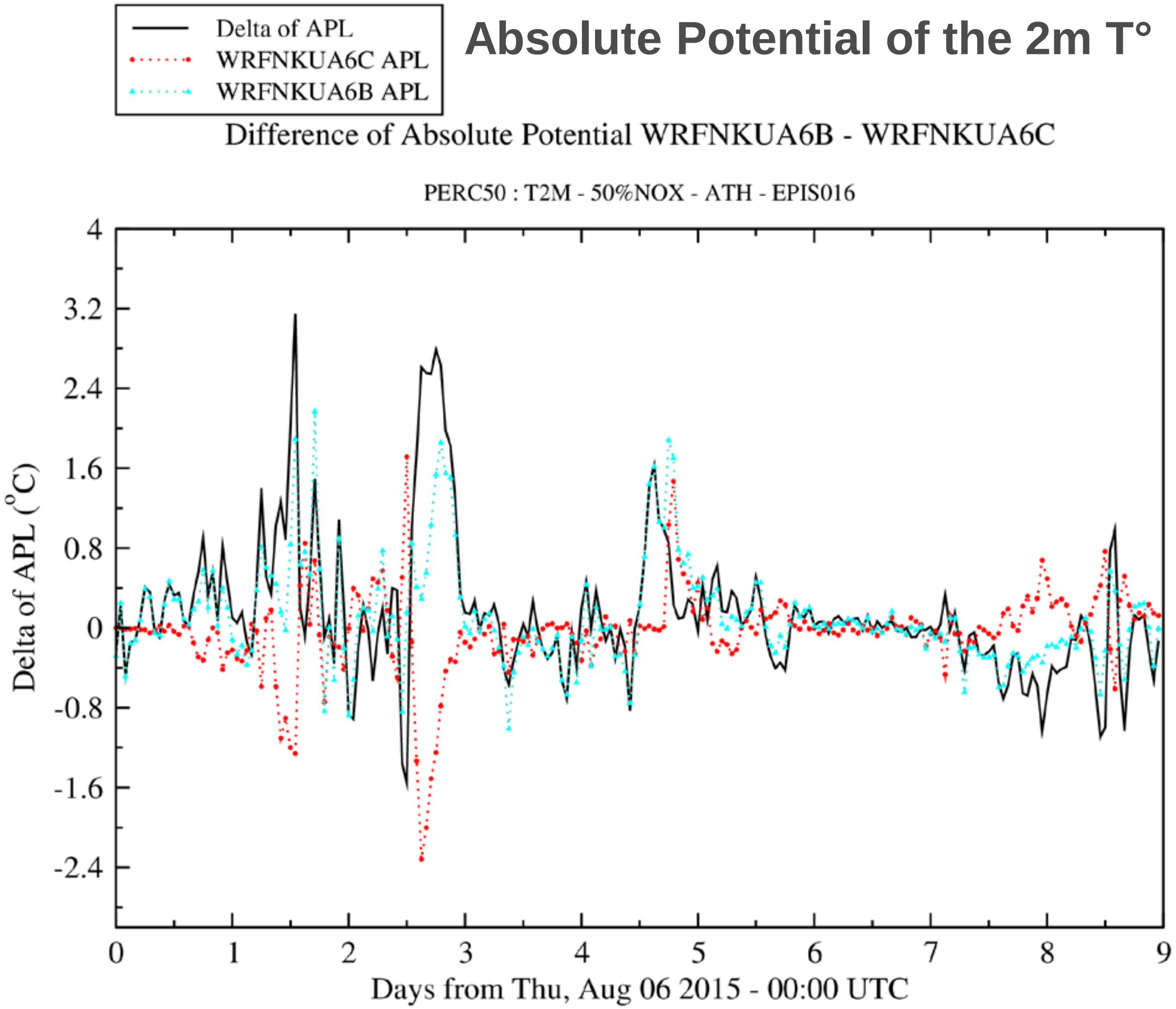
Absolute Potential of the PBL



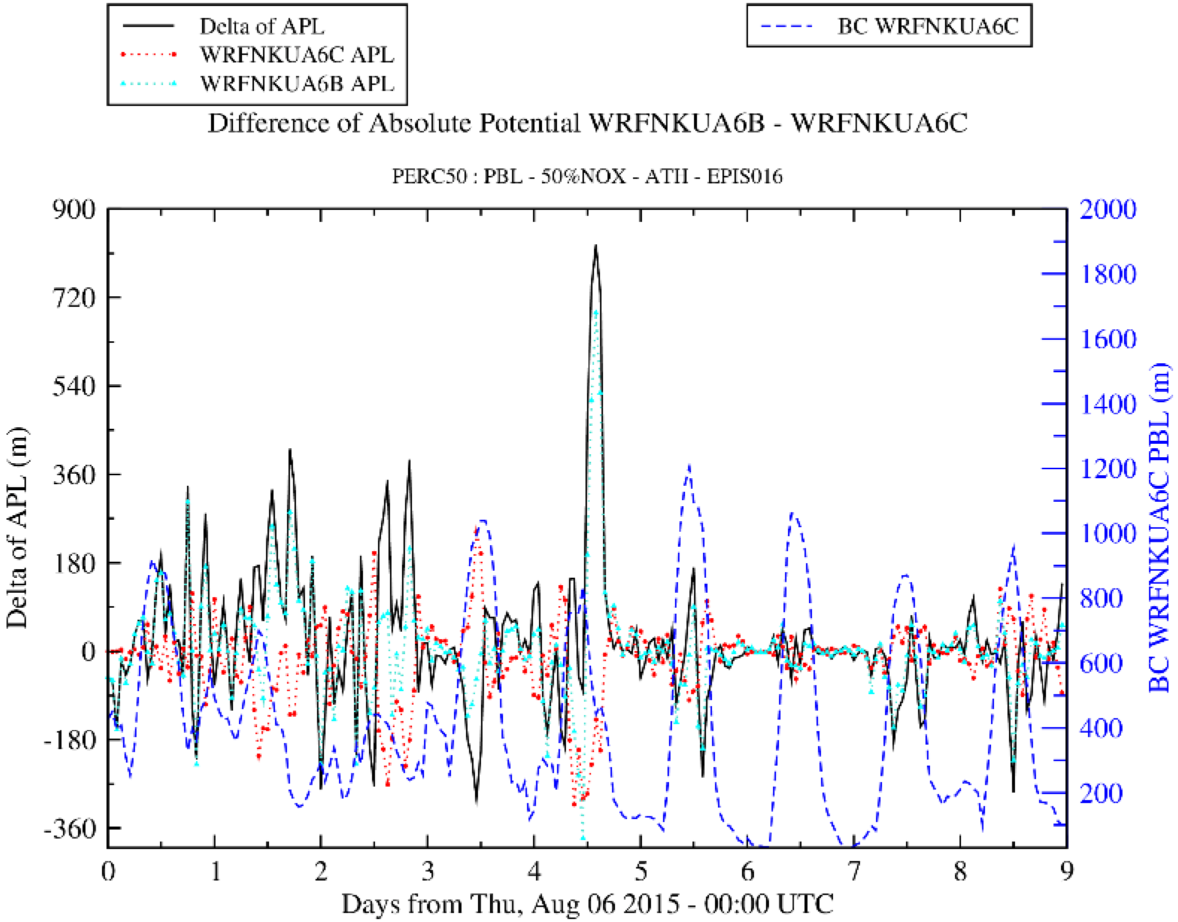


WRF online radiative feedbacks

Absolute Potential of the 2m T°



Absolute Potential of the PBL



B and C are two different chemical schemes

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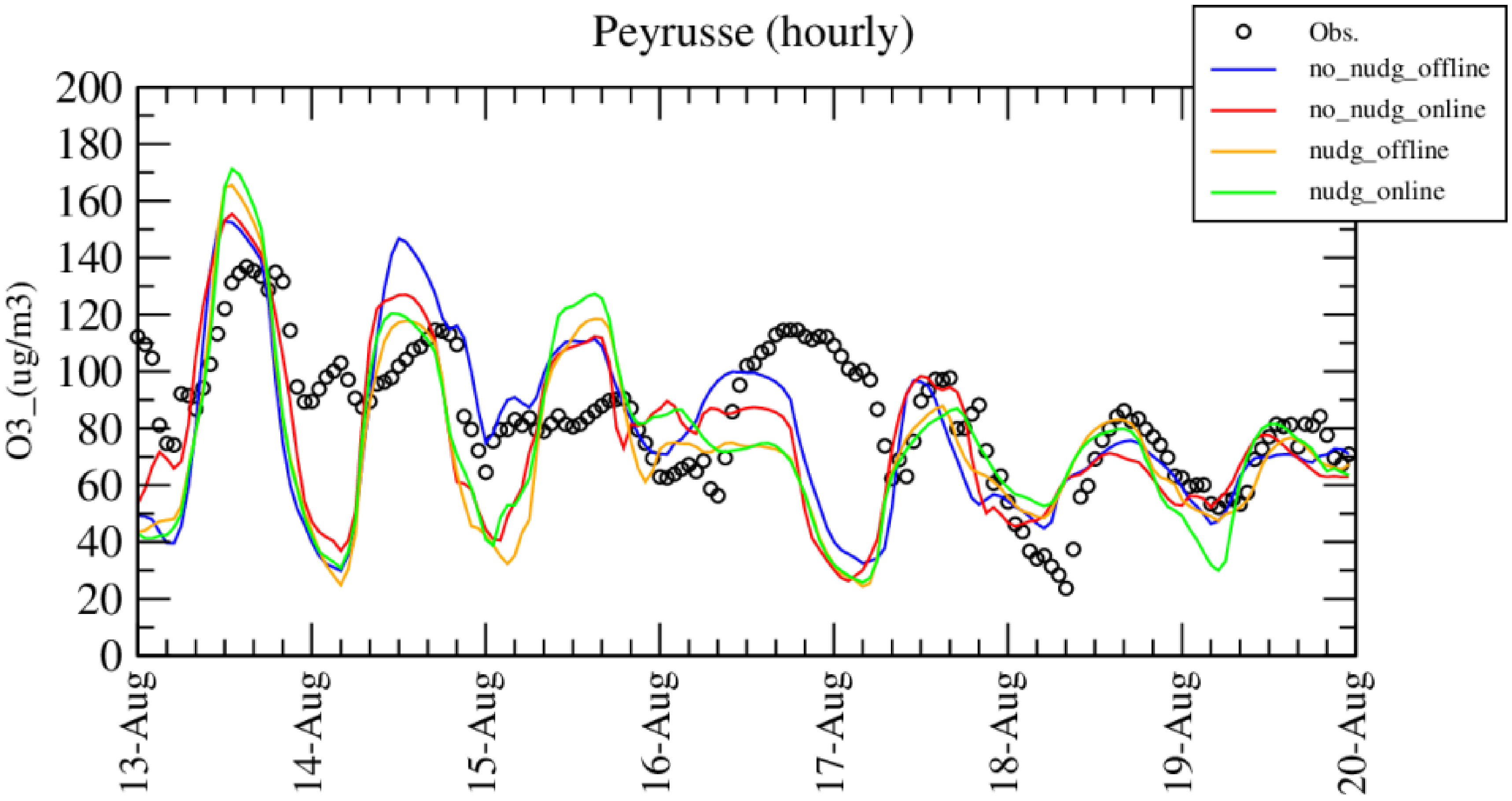
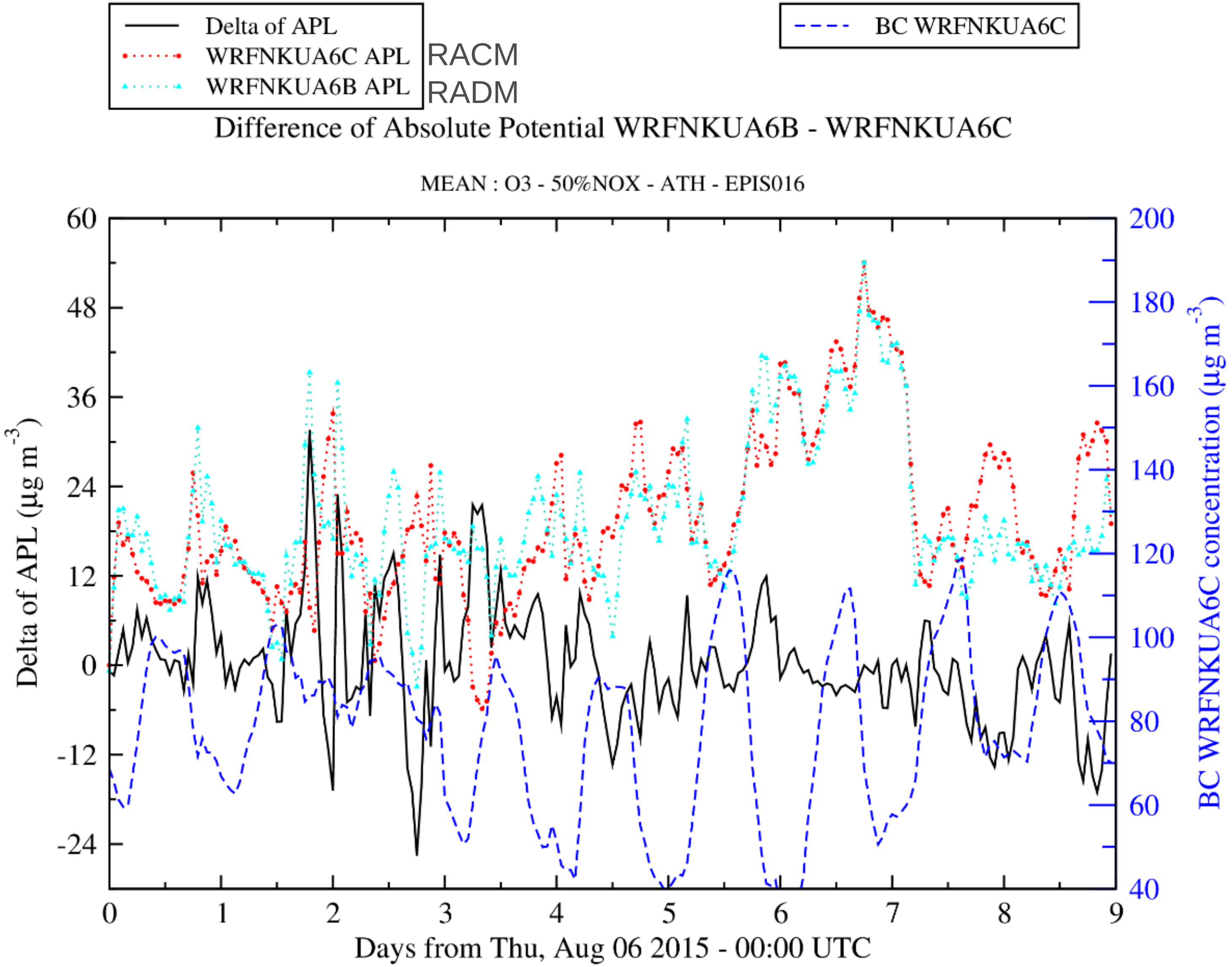
Online coupling with or without nudging in CHIMERE-WRF on a base case



Courtesy of Laurent Menut (CNRS/LMD-IPSL)

Impact of the chemistry (RACM vs RADM) over Athens



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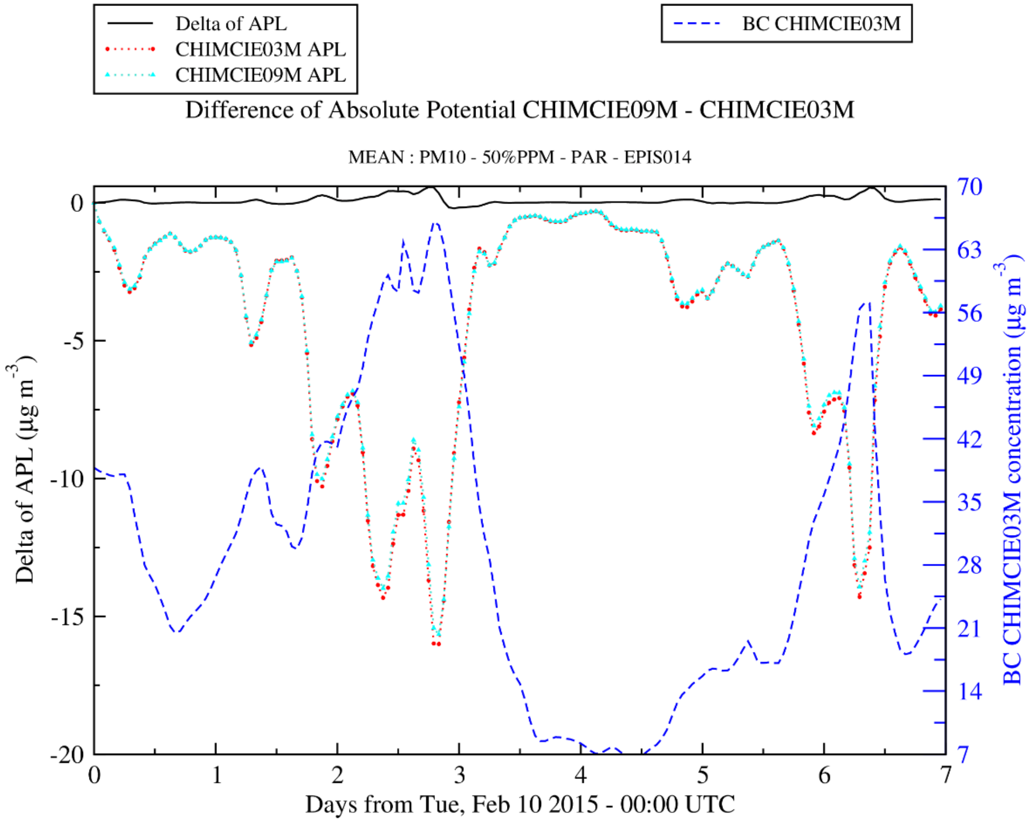
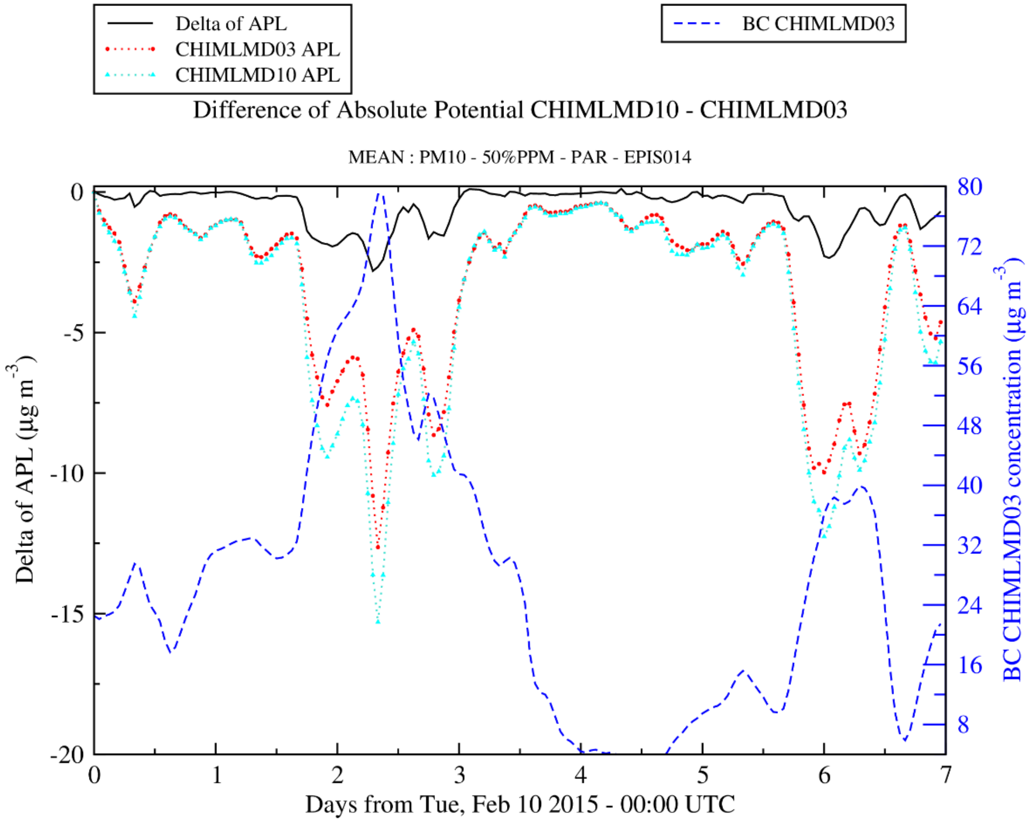
Impact of the resolution: CHIMERE over Paris (PM episode) – From 3 to 10km

PM10

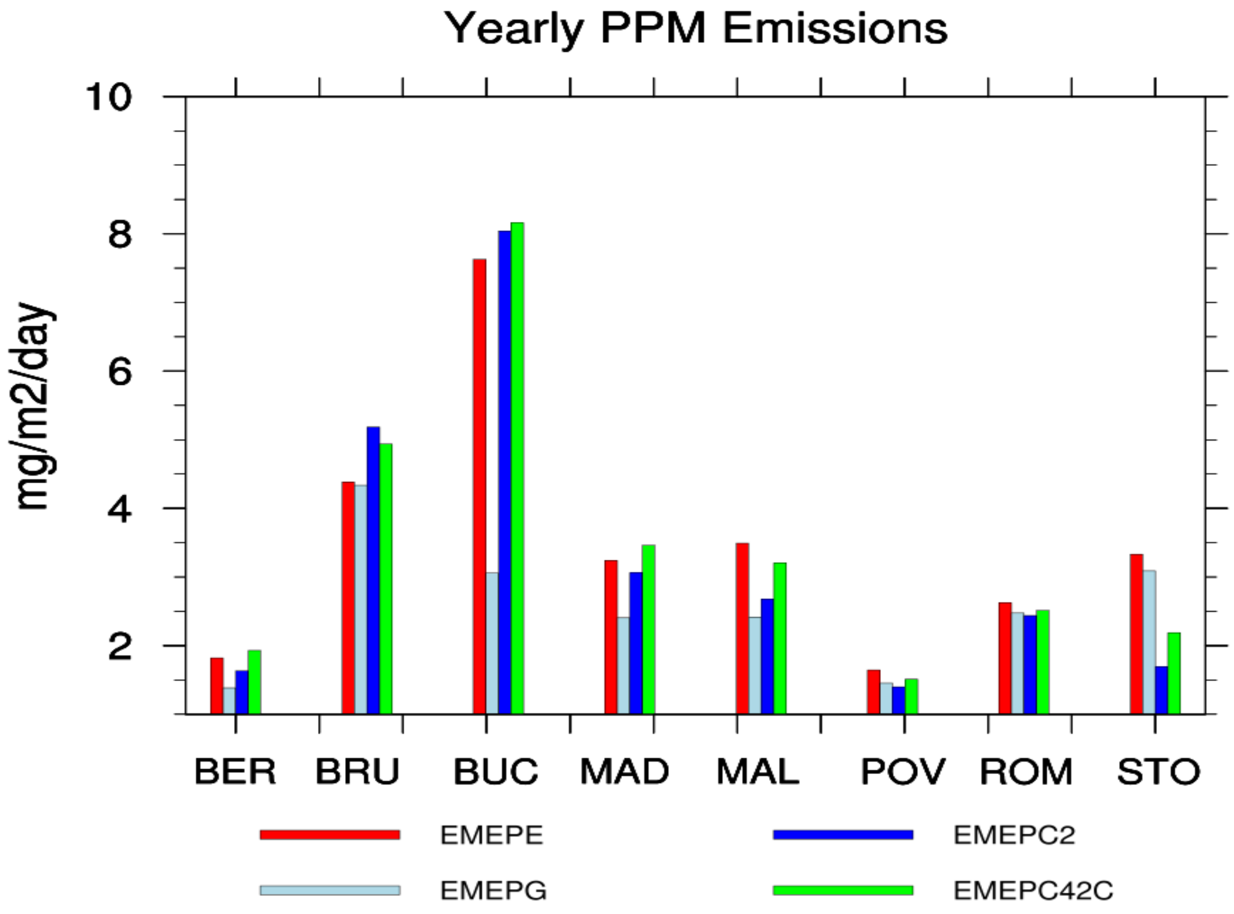


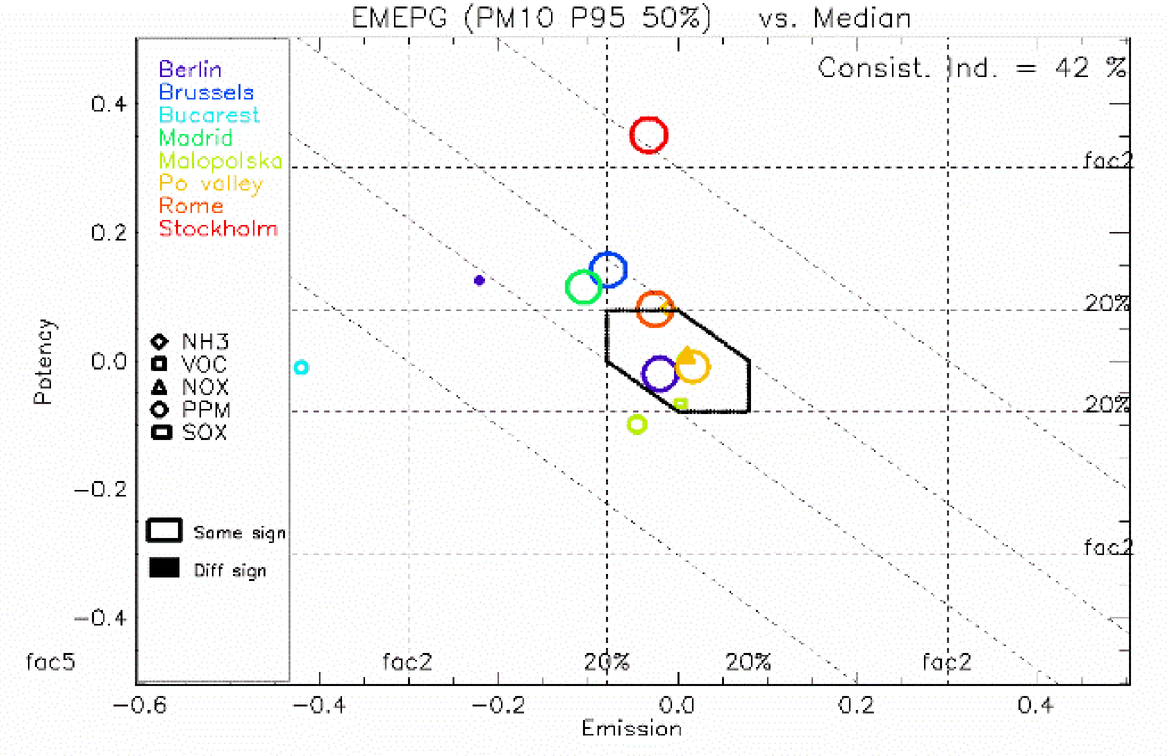
CIEMAT



LMD

Impact of emissions on the Potency





De Meij, A. et al. 2023 submitted

Conclusions

- A good plateform to experiment the impact of emission reductions on delta
- Study on the relevance of indicators
- Development of a visualization plateform
- A first flavor of variability is provided with some conclusions (impact of processes, emissions, resolutions)
- An opportunity for modellers to challenge their set-up (bug detection thanks to dynamic evaluation)
- Two papers under review

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Next steps to be discussed

- Are the teams still interested to go on feeding the database?
- Add more constraints (for instance same emissions)?
- Cut emissions by sectors and pollutants to be more realistic?
- Simulation of episodes (less costly)?
- Make use of observations?
- A modelling team could change one setting flags at a time to generate a new model member (vertical distribution of emission, vertical mixing scheme, vertical resolution ….)
- **Make use of SHERPA as a reference for LT?**
- Development of an online version of the visualization tool (> Kees)

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END

Thank you for your attention

Other indicators

- **Variability** for each indicator
  - IND = API, RPI, APY

Variability from models M assessed by Norm. Std. Dev.

$$VAR_{IND} = \sqrt{\frac{\sum_{m=1}^{M}(IND_m - \overline{IND})^2}{(\overline{IND})^2}}$$

- Test of linearity using the 50% and 25% runs. **Deviation to linearity for API**

$$100 \times \left(\frac{API50\% - API25\%}{API25\%}\right)$$

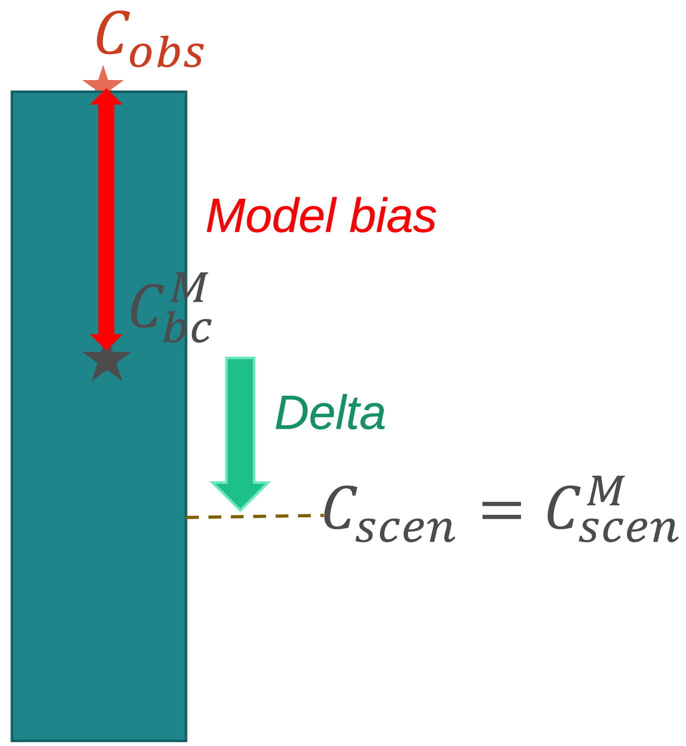
- Test of additivity using the ALL scenarios and "ADD" as the sum of individual precursors reductions. **Deviation to additivity for API, RPI**

$$100 \times \left(\frac{IND_{ADD} - IND_{ALL}}{IND_{ALL}}\right)$$

FAIRMODE CT9 CONTEXT ➡ TOPIC 2

- Many inter-comparison exercises of air quality models
- No recent exercises to assess the capacity of models to simulate “delta” (Formerly CityDelta, EURODELTA) particularly at more local scale
- **Need to have a long term inter-comparison platform to continually assess model responses**

Mod. only based method



FAIRMODE CT9 CONTEXT ➡ TOPIC 2

- Many inter-comparison exercises of air quality models
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- **Need to have a long term inter-comparison <u>platform</u> to continually assess model responses**

- A Model Concentration Delta can be applied to an observation C_{obs} to evaluate a scenarios based on '*bc*' reference and '*scen*' simulations:
  - Absolute (for O3?): $C_{scen} = C_{obs} + \overbrace{\left(C^{M}_{scen} - C^{M}_{bc}\right)}^{delta}$
  - Relative (for NO2 or PM?): $C_{scen} = C_{obs} \times \left(C^{M}_{scen} - C^{M}_{bc}\right)/C^{M}_{bc}$
  - ***Techniques often used but rarely assessed***

Mod.+obs only based method