FAIRMODE CT9

Chair: Alexandra Monteiro (Univ. of Aveiro)

Co-chair: Bertrand Bessagnet (JRC)

Core JRC team :

Kees Cuvelier, Alexander de Meij (METCLIM), Enrico Pisoni and Philippe Thunis

Active modelling participants (11 groups)

- ***Alexander de Meij***;*Joint Research Centre / METCLIM*
- ***Angelos Violaris, Jonilda Kushta***; *The Cyprus Institute, Climate and Atmosphere Research Center, Cyprus*
- ***Bruce R. Denby, Qing Mu, Eivind G***. *Wærsted; Norwegian Meteorological Institute, Norway*
- ***Marta García Vivanco, Mark R. Theobald, Victoria Gil;*** *Atmospheric Modelling Unit. Environment Department, CIEMAT, Spain*
- ***Ranjeet S Sokhi, Kester Momoh, Ummugulsum Alyuz, Rajasree VPM, Saurabh Kumar***; *Centre for Climate Change Research (C3R) and Centre for Atmospheric and Climate Physics (CACP), Department of Physics, Astronomy and Mathematics, University of Hertfordshire, United Kingdom*
- ***Elissavet Bossioli, Georgia Methymaki***; *Department of Physics, Sector of Environmental Physics & Meteorology, National and Kapodistrian University of Athens, Greece*
- ***Arineh Cholakian, Romain Pennel, Sylvain Mailler, Laurent Menut***; *Laboratoire de Météorologie Dynamique (LMD), Ecole Polytechnique, IPSL Research University, Ecole Normale Supérieure, Université Paris-Saclay, Sorbonne Universités, UPMC Univ Paris 06, CNRS, France*
- ***Gino Briganti, Mihaela Mircea***; *ENEA – National Agency for New Technologies, Energy and Sustainable Economic Development, Italy*
- ***Claudia Flandorfer, Kathrin Baumann-Stanzer***; *Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Austria*
- ***Virginie Hutsemékers, Elke Trimpeneers***; *Belgian Interregional Environment Agency, Belgium*
- ***Darijo Brzoja, Velimir Milić***; *Croatian Meteorological and Hydrological Service, Croatia*

FAIRMODE CT9 OBJECTIVES

- For a given mitigation scenario, models provide different absolute results C_{scen}^{M}

- **BUT, HOW DO THEY BEHAVE ON DELTAS?**

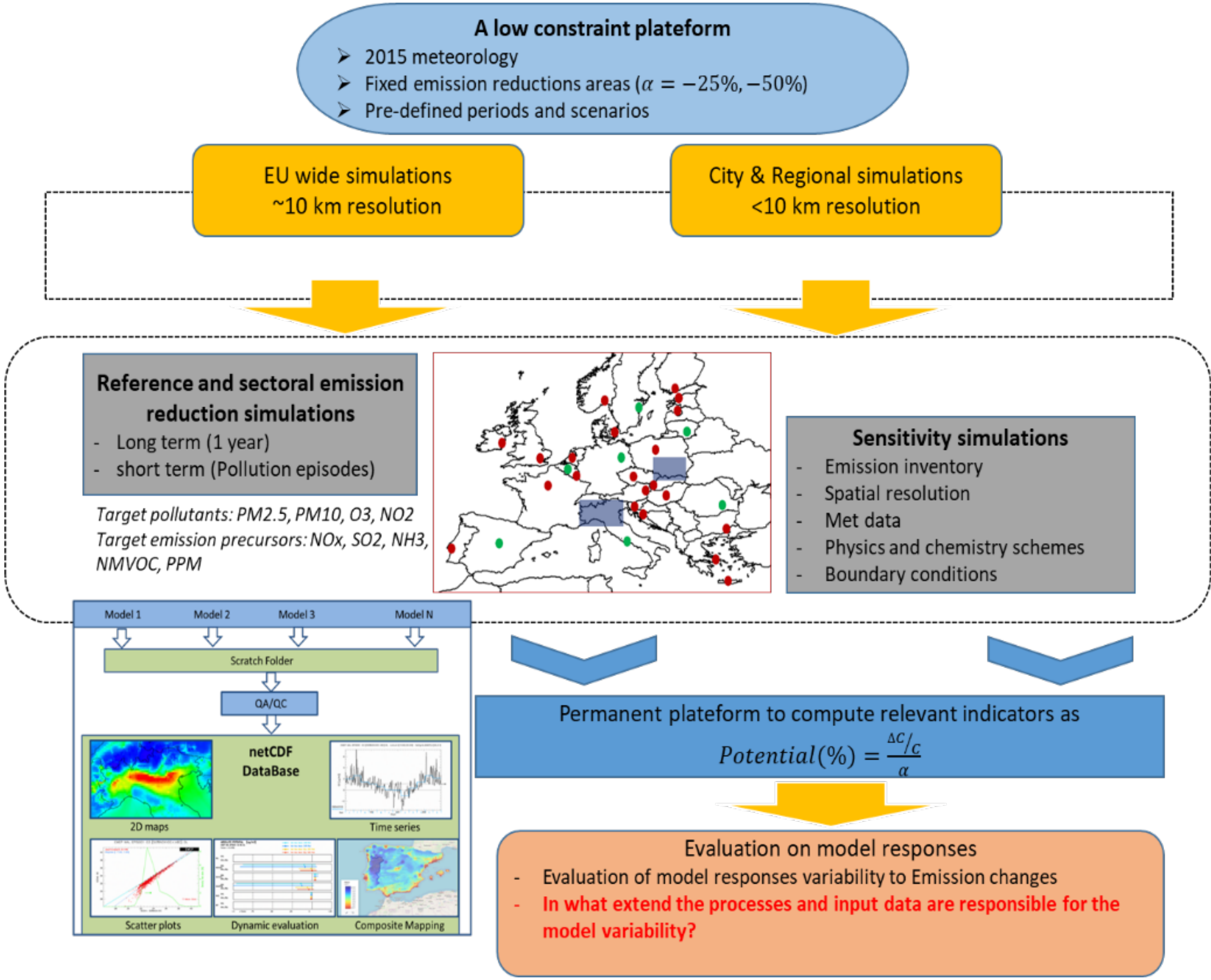
$$\Delta = C_{scen}^{M} - C_{bc}^{M}$$

- 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?

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

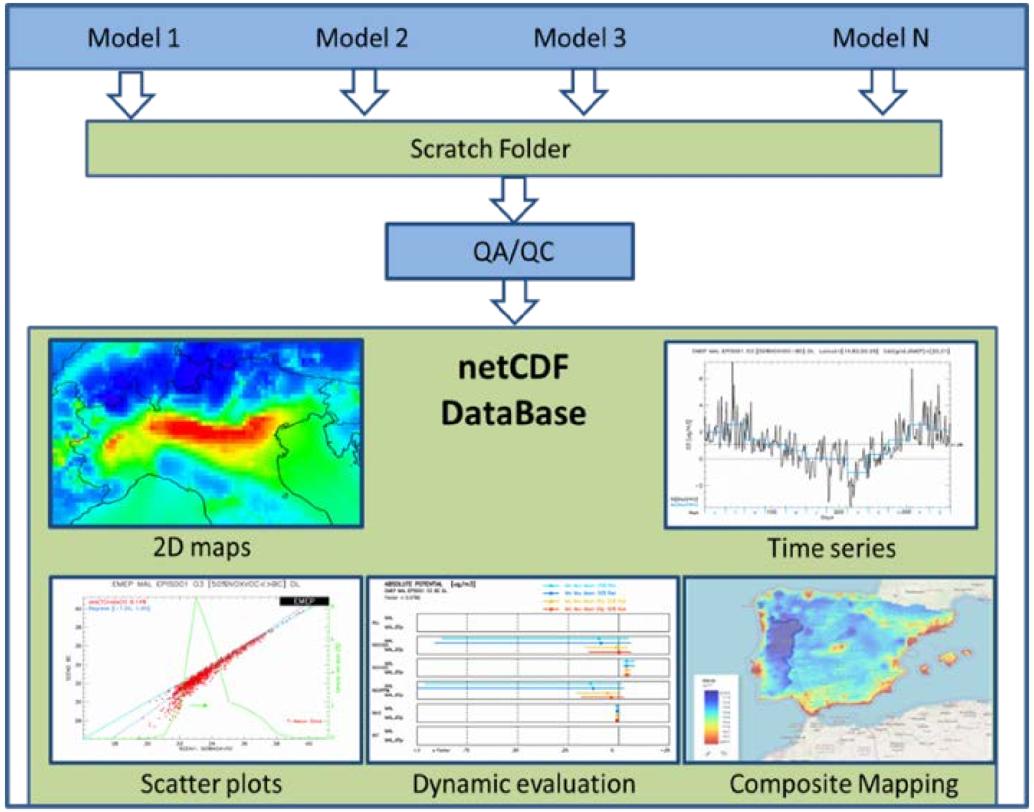
Models and teams involved - Overview

Team name - Country		Model Name
JRC	(EU)	EMEP
JRC	(EU)	EMEP
JRC	(EU)	EMEP
JRC	(EU)	EMEP
JRC	(EU)	WRF-Chem
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



A Tool to explore the simulations

- Common netcdf formatting of outputs delivered by modellers
- 2D Maps & Time Series: For visualization of 2D maps of Concentrations (mean values over the episode period) and Emissions.
- Dynamic evaluation
- Model Compliance Test



The overall framework

Set-up

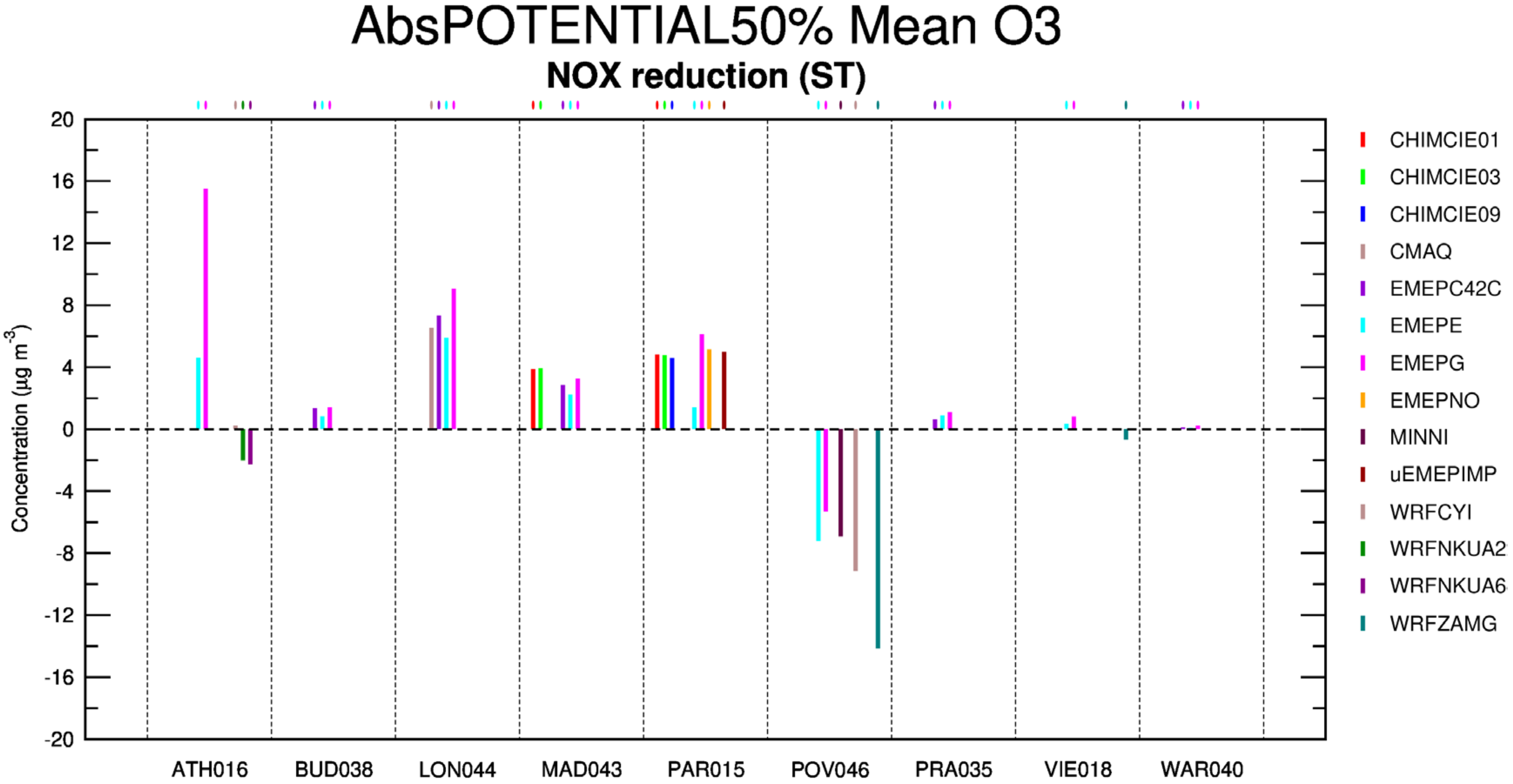
- Short term (ST) on episodes (PM10, O3)
  - *Emissions reduced only during 2015 episodes from 00:00 to 23:00*
- Long term (LT) simulations (PM10, O3)
  - *Emissions reduced the whole year 2015*
- Two reductions so far:
  - 25% and 50% from a base case (BC)
- Reduced species depends on target pollutants
  - *PM10: PPM, NOx, VOC, NH3, SO2,* ***ALL***
  - *Ozone: NOx, VOC,* ***ALL***
  - *All together or separately*

The overall framework

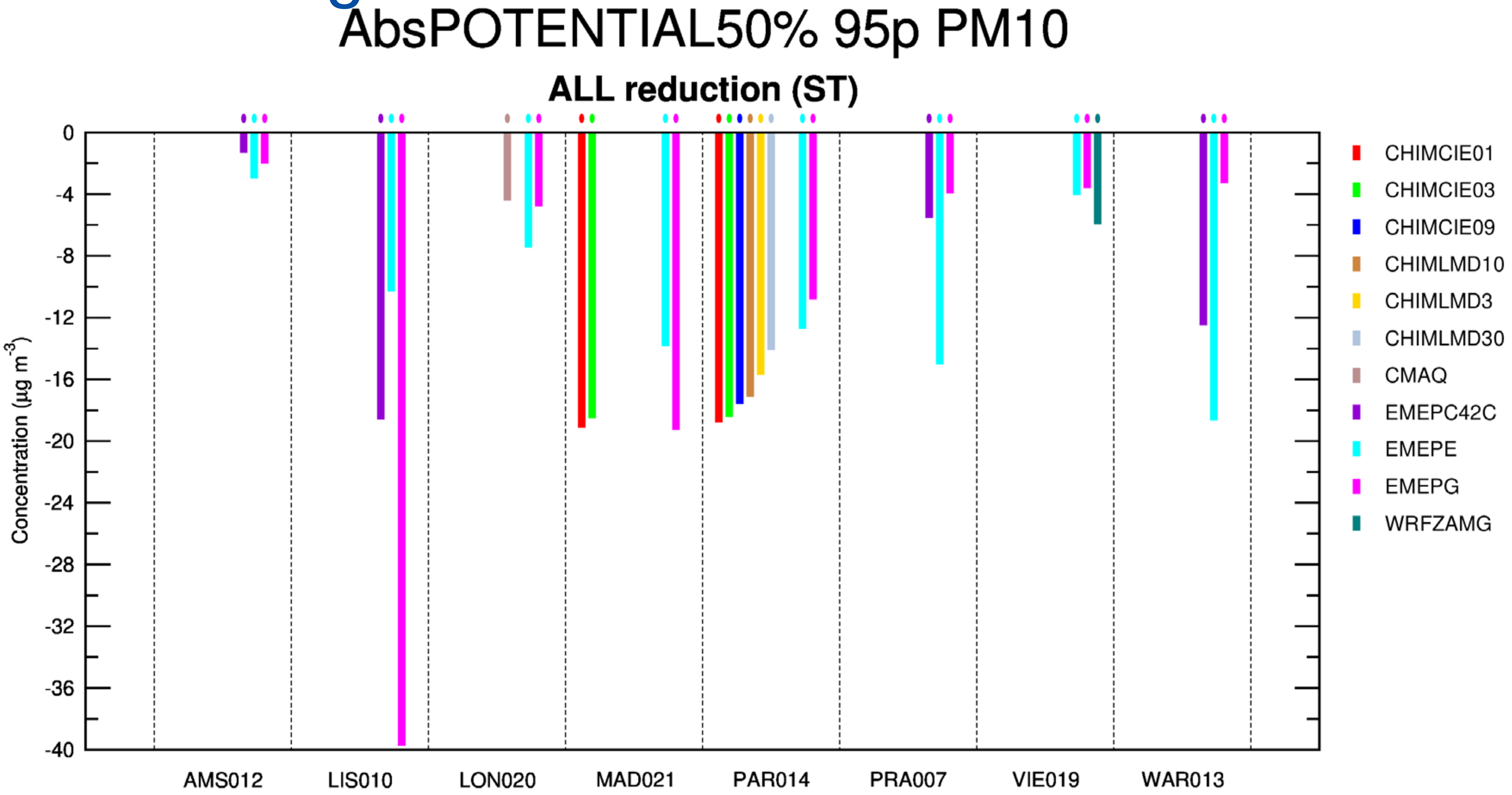
Basis Indicators

- The Absolute Potential is defined as the reduction in µg/m^3 scaled by the reduction $\boldsymbol{\alpha}$ of the scenario (25 or 50%) of a precursor from base case BC
  - $\boldsymbol{APl} = \left(\boldsymbol{C} \quad - \boldsymbol{C^{BC}}\right)/(\boldsymbol{\alpha} \quad)$ ($\boldsymbol{APl} \times \boldsymbol{\alpha}$ is the delta of concentrations)
- The Relative Potential is defined as the reduction in % scaled by the reduction $\boldsymbol{\alpha}$ of the scenario (25 or 50%) of precursor *n* from base case BC and by the BC concentrations.
  - $\boldsymbol{RPl} = \left(\boldsymbol{C} \quad - \boldsymbol{C^{BC}}\right)/(\boldsymbol{\alpha} \quad \times \boldsymbol{C^{BC}})$
- The Absolute Potency in µg/m^3/(ton/day) is 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)
  - $\boldsymbol{APy} = \left(\boldsymbol{C} \quad - \boldsymbol{C^{BC}}\right)/(\boldsymbol{\alpha} \quad \times \boldsymbol{E^{BC}})$

Absolute Potential for O3 with NOx reduction



Absolute Potential for PM10 with ALL reduction together



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**

$$100 \times \left(\frac{APl50\% - APl25\%}{APl25\%}\right)$$

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

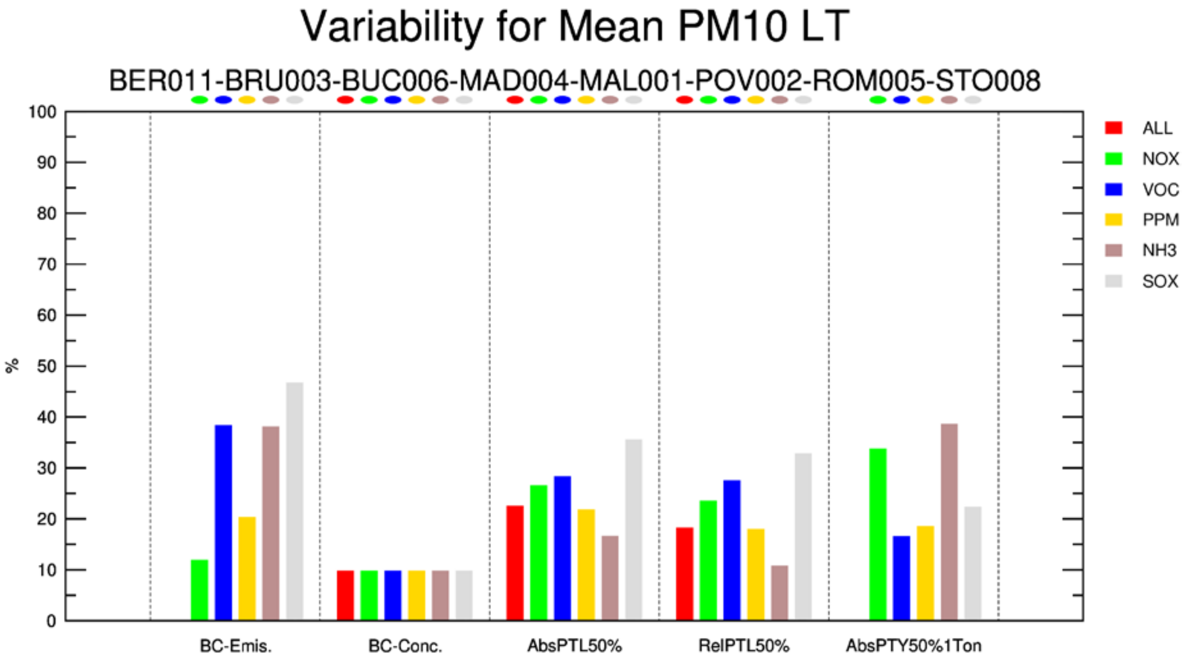
$$100 \times \left(\frac{APl_{ADD} - APl_{ALL}}{APl_{ALL}}\right)$$

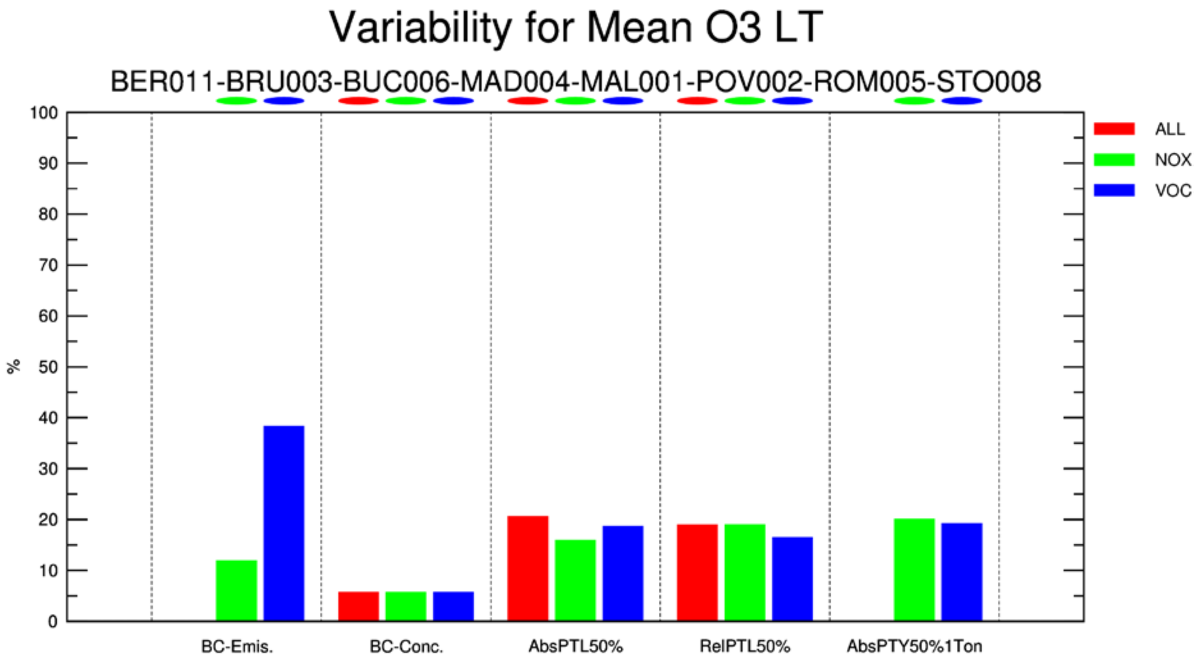
Results on variability - LT

- Less variability on O3 BC Mean than PM10 BC Mean
  - 4 versus 8 %
- Variability of RPI << API (less clear for O3)
  - 10 to 25% depending on the indicator

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

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



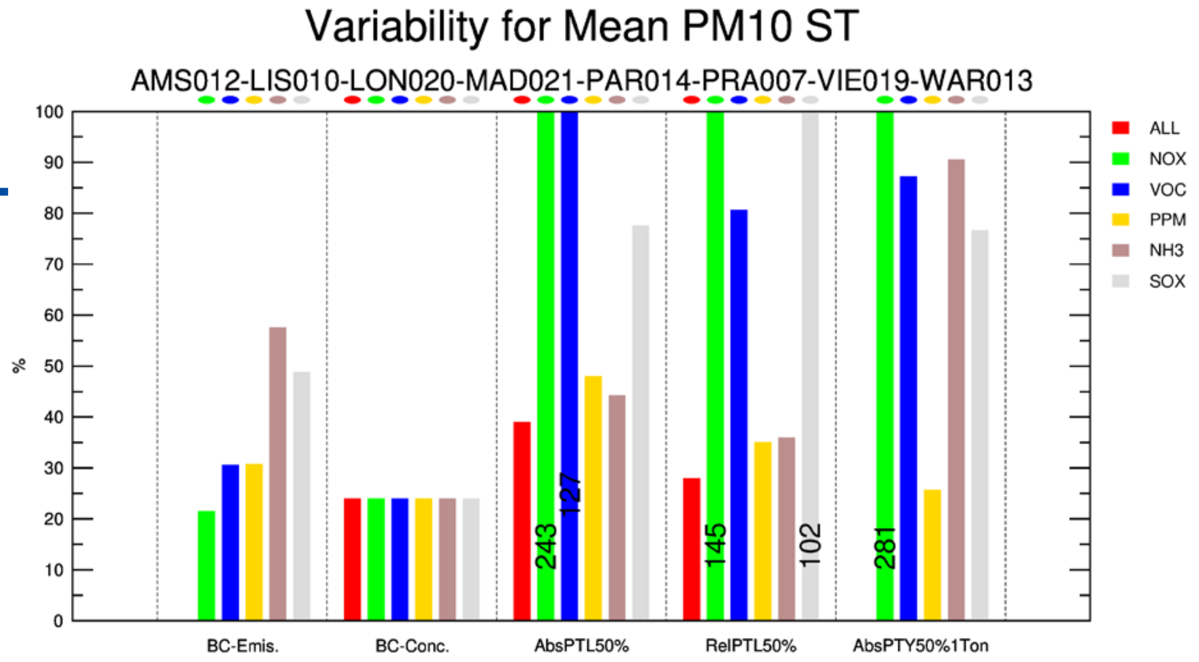


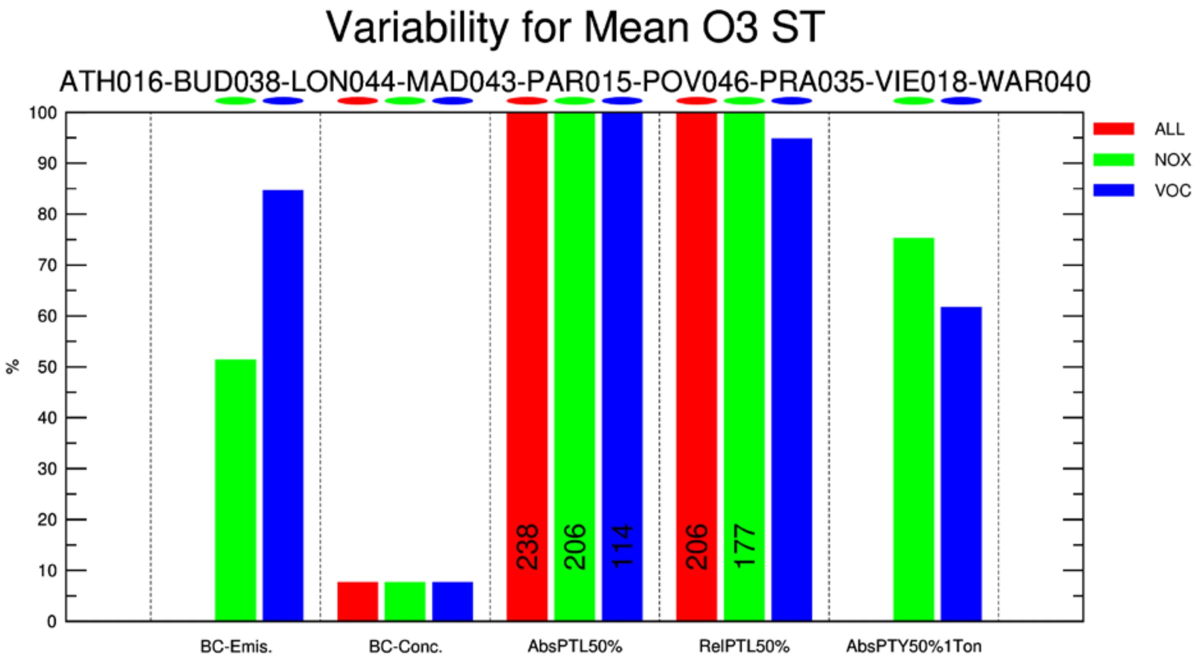
Results on variability - ST

- Less variability on O3 BC Mean than PM10 BC Mean
  - 6 versus 22%
- Variability of indicators
  - Very high, depending on the indicator

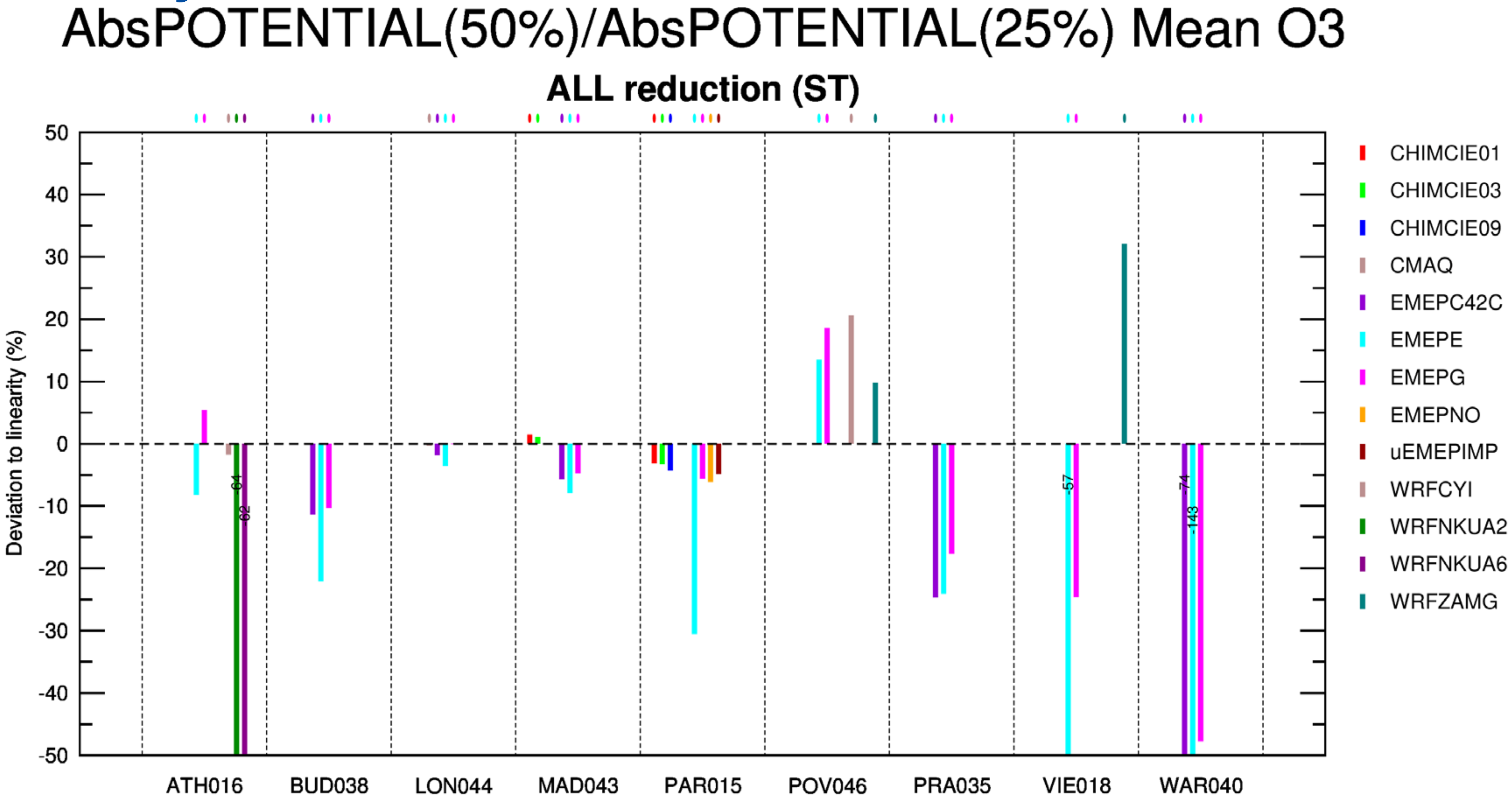
Variability from models M assessed by Norm. Std. Dev.

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





Linearity on O3

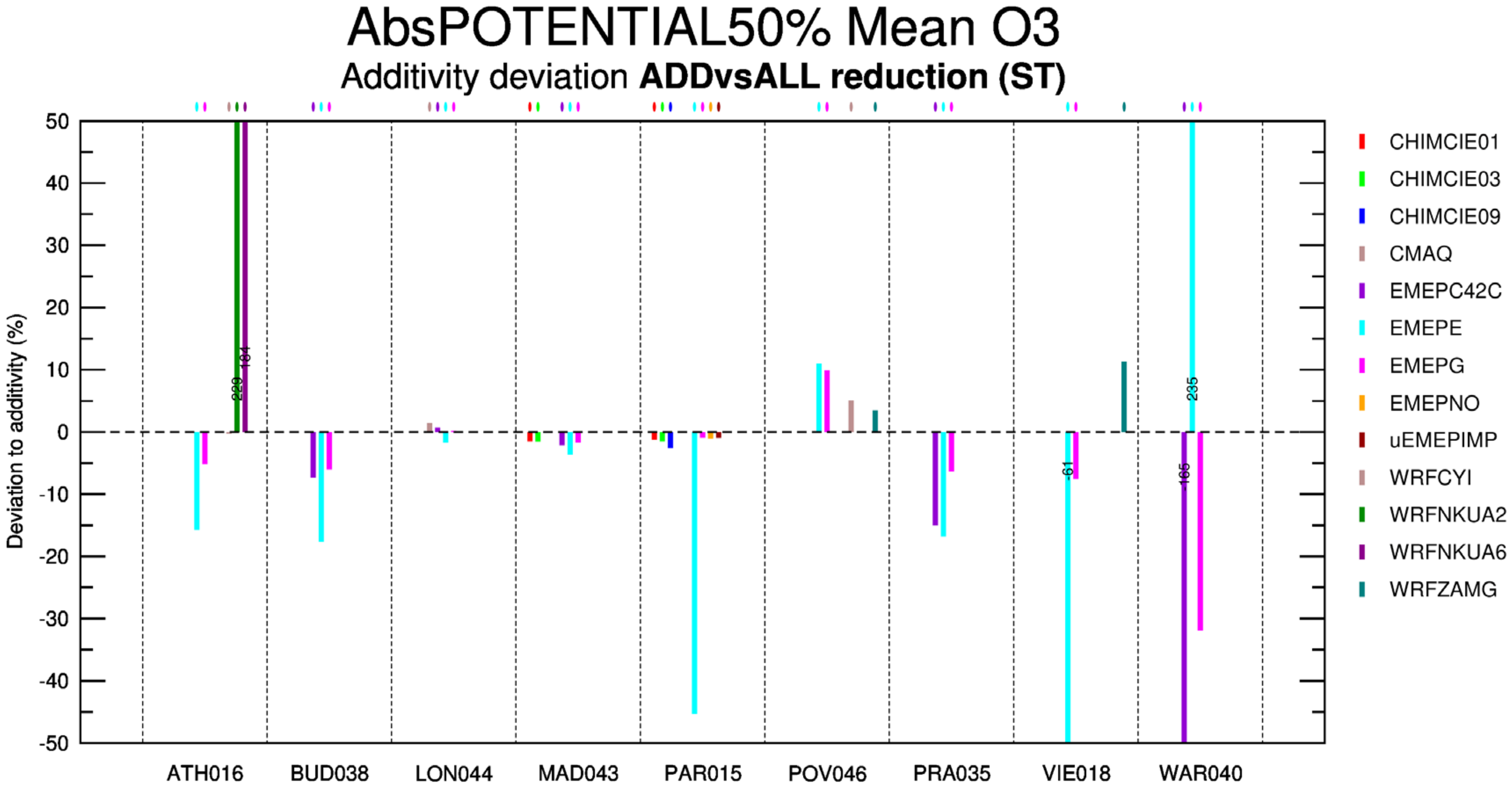


Conclusions

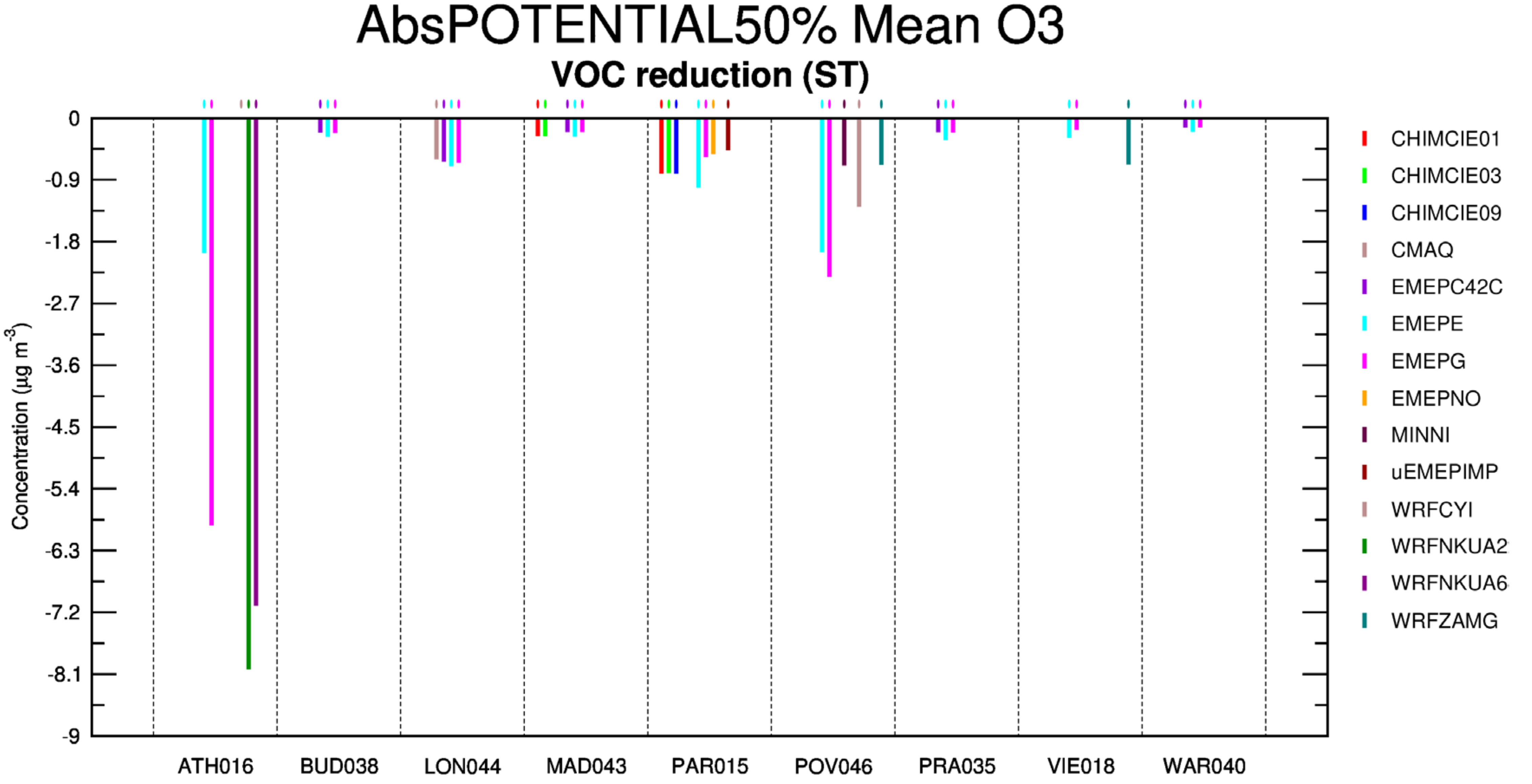
- ➢ High variability of indicators observed in our first results
- ➢ Next steps
  - ✓ Rough analyses and paper I (presentation of the exercize)
  - ✓ In depth work in sub groups on the impact of:
    - *Resolution (CIEMAT, LMD, NKUA, CACP-UH)*
    - *Chemistry (CIEMAT, NKUA)*
    - *Emissions (Alexander de Meij – METCLIM/JRC)*
  - ✓ Possible extention investigating the impact on threshold exceedances using observations
    - Impact at stations applying an absolute or relative delta

END

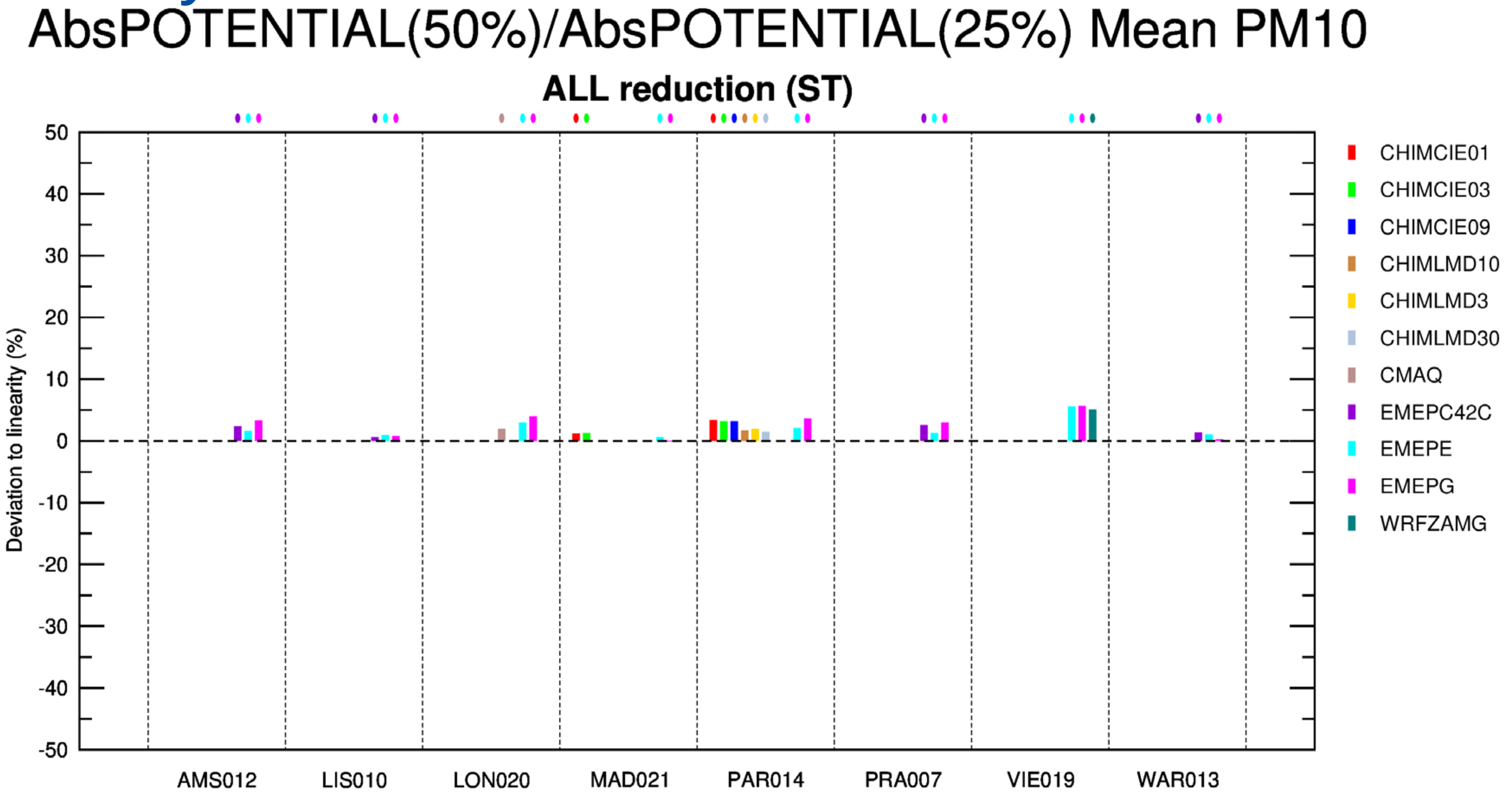
Additivity on O3



Absolute Potential for O3 with VOC reduction



Linearity on PM



FAIRMODE CT9 CONTEXT

- 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 sacle
- **Need to have a long term inter-comparison platform 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?): $C_{scen} = C_{obs} + \left(C^{M}_{scen} - C^{M}_{bc}\right)$
  - 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***