WRAP UP

CT9 FAIRMODE

JRC, Ispra, IT

FAIRMODE CT9

- Models provide different absolute results C^M_{scen}

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

$$\Delta = C^M_{scen} - C^M_{bc}$$

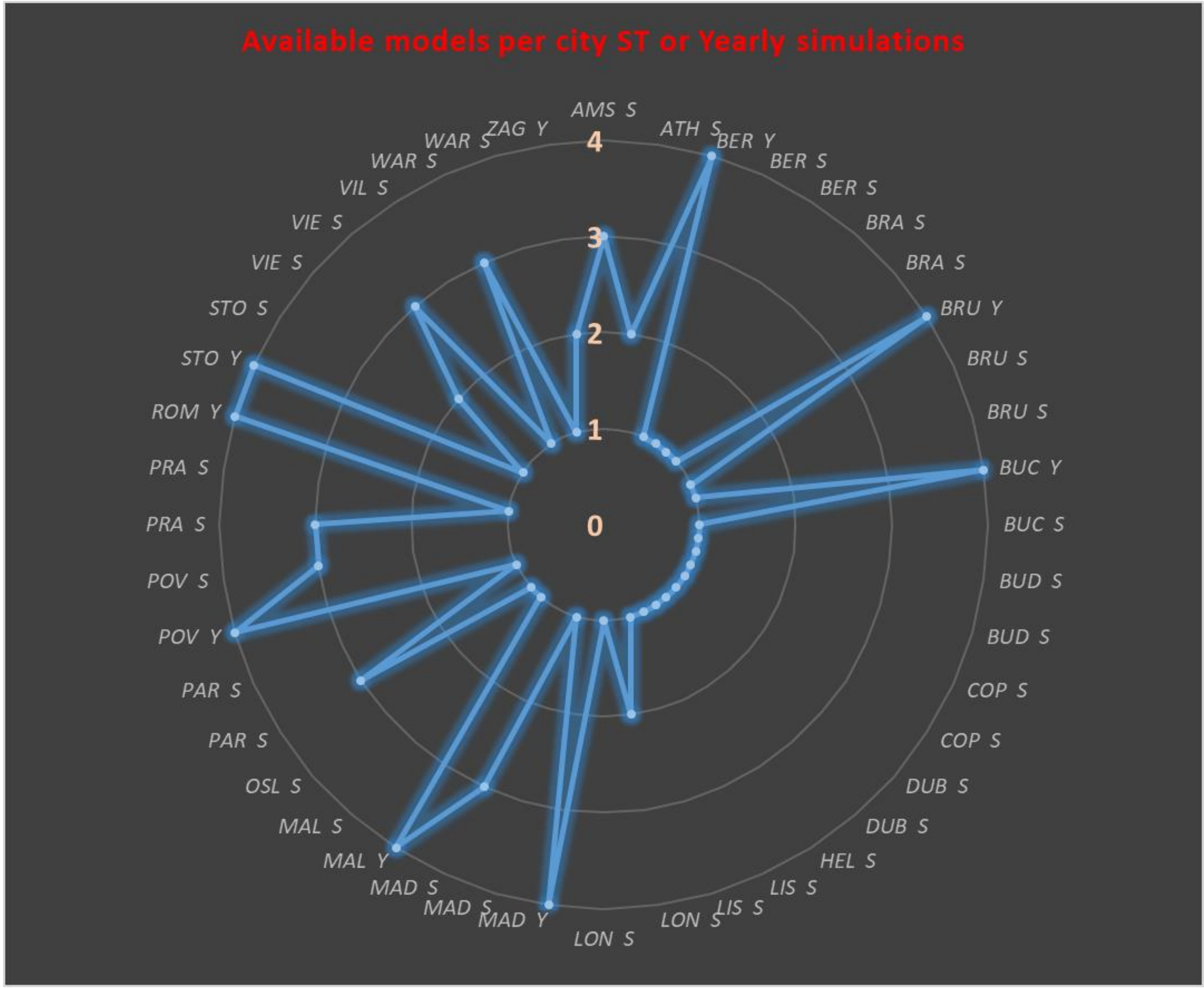
- What is the order of magnitude of differences? How to evaluate these differences? Which indicators?
- Can we explain the differences, what are the main drivers?

CT9 Database

- JRC box
  - 10 Participants
  - 15 Models

  - Many cities and regions are covered by one or more models
  - Number of DBMC (Concentration) files > 5000, Resol: HL, DL, YL
  - Number of DBME (Emissions) files = 170, Resol: YL, ML

- Box will be moved to an other place this month
- Access: Contact coordinators

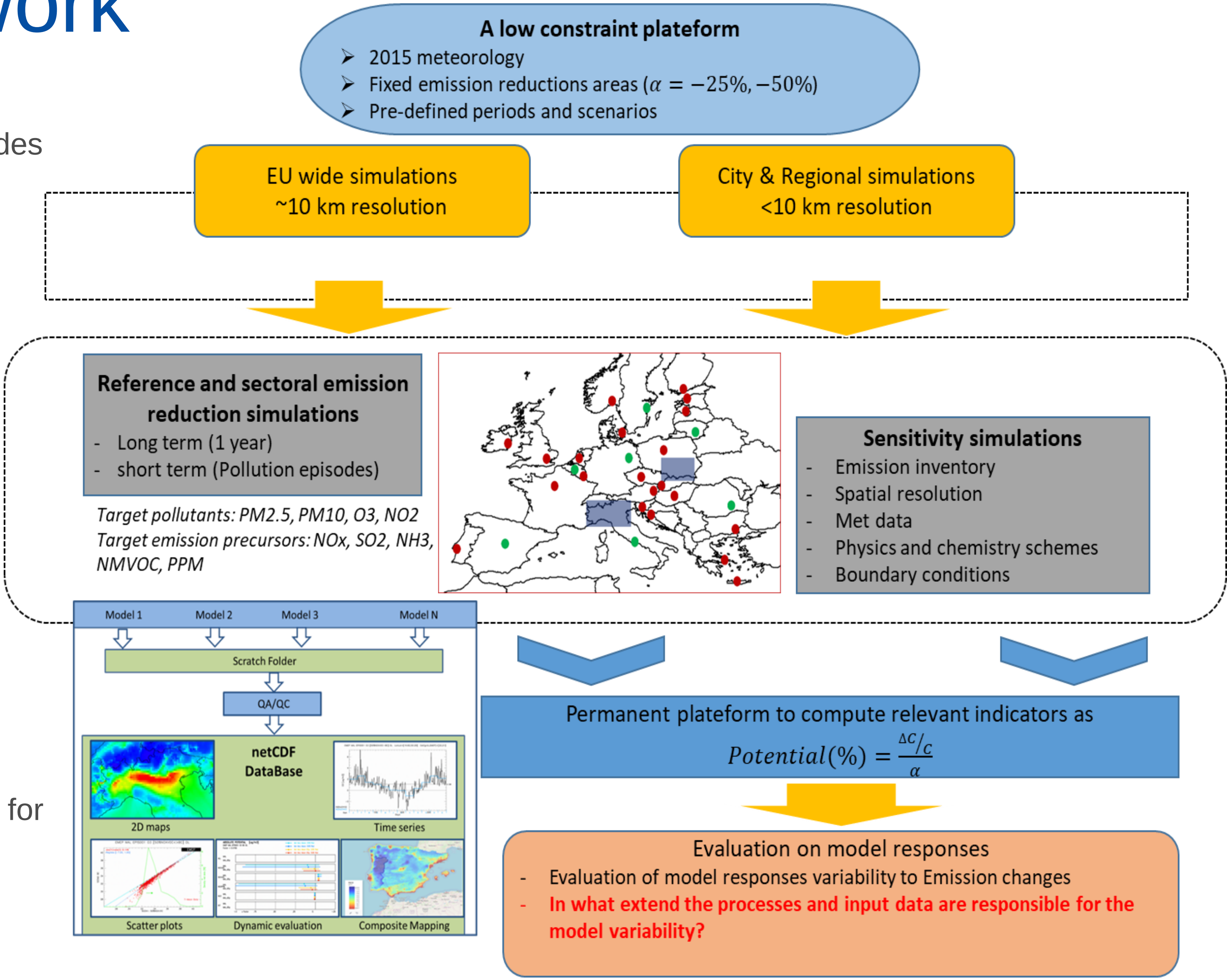


Models and teams involved

Team name - Country		Model Name	Emission Inventory, resolution, date
JRC	(EU)	EMEP	EDGAR V5.0, 2015
JRC	(EU)	EMEP	CAMS V2.2.1, 2015
JRC	(EU)	EMEP	EMEP - GNFR, 2015
JRC	(EU)	EMEP	CAMS REG V4.2 + Condensables 2015
JRC	(EU)	WRF-Chem	EDGAR V5.0, 2015
ZAMG	(AT)	WRF-Chem	CAMS-REG 2015
Met Norway	(NO)	EMEP	EMEP, 0.1x0.1, 2015
Met Norway	(NO)	EMEP + uEMEP	EMEP, 0.1x0.1, 2015
CyI	(CY)	WRF-Chem	EDGAR V5.0, 0.1° x 0.1°, 2015
NKUA	(GR)	WRF-Chem	EDGAR HTAP, 2010
DHMZ	(HR)	ADMS-Urban	Croatian National Emission Inventory for Zagreb
DHMZ	(HR)	LOTOS-EUROS	CAMS-AP-v2.2.1 2015
LMD/IPSL	(FR)	WRF-CHIMEREv2020r1	CAMS REG V4.2 2015
UH-CACP	(UK)	WRF-CMAQ	EDGAR V5.0, 2015
CIEMAT	(ES)	IFS-CHIMEREv2017r4	EMEP + NEI, 2015
ENEA	(IT)	WRF-MINNI	ISPRA Italian national inventory 2015
UNIBS	(IT)	WRF-CAMx	INEMAR 2015+EMEP
IRCELINE	(BE)	CHIMERE + RIO + ATMOSTREET	Local inventories

The overall framework

- Short term (ST) on episodes (PM, O3)
  - Emissions reduced only during the episodes from 00:00 to 23:00
- Long term (LT) simulations (PM, O3)
  - Emissions reduced the whole year
- 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
- Notation:
  - **POL#PRE**: Pollutant concentrations POL for an emission reduction of precursor PRE
  - Ex. **PAR014** : Paris episode 014



Modelling teams presentations - **METCLIM**

- Major contributor for the analysis
- Two models EMEP and WRF-chem
- 5 configurations mostly based on emission changes
- Long term simulations
- Alexander shared some technical issues particularly with the restart and the management of Boundary Conditions
  - Important to check init files and intermediary files
  - Reminder of potential inconsistencies with domain management

Modelling teams presentations - **LMD**

- Three nested domains 30 > 10 > 3 km over Paris
- Wintertime episode
- Coherence of emission reductions
- Evaluation against observations (good correlations, negative bias for most species but slight)
- All scenarios done + Impact of coupling effect
- Effect of resolution:
    - Decrease of impact by increasing resolution

Modelling teams presentations - **CIEMAT**

- Ozone episode in Madrid begin of July
- CHIMERE + IFS
- Four nested domains from 27 to 1km
- Effects:
  - Mixed effects on ozone by reducing NOx (increase within the study, decrease outside)
  - Weak effect on VOC emission reductions
- Underestimation compared to observations (NO_2 and O_3)
- Peak observed at night for O_3 due to wind effect
- Effect of spatial resolution on O_3
  - Clear effect from 27 to 9 but less after up to 1km
- Next steps: Other episode , model version, full year 2015

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Modelling teams presentations – **UH CACP**

- PM episode in March 2015 (ammonium nitrate episode)
- Three nested domains 25km/5km/1km
- CMAQ + WRF
- Evaluation of model performances
  - Negative bias on ws
  - Very good performance on PM, less on NO2

- Next steps:
  - Finish emission reduction scenarios
  - Use new inventories to improve performance on NO2

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Modelling teams presentations - **IRCELINE**

- RIO system based on model interpolation of CHIMERE simulation using a trend
- Simulation of -50% done for Brussels
- The parent domain is not affected by the reduction
- Increase of O3 for NOx reductions
    - Weak impact of resolution for Ozone delta

Modelling teams presentations – **Met.NO**

- EMEP (0.1°) + uEMEP (250m) framework
  - Gaussian plume modelling
  - NOx-O3 chemistry from During scheme, no VOC in uEMEP chemistry

- All cities can be covered
  - Emissions are refined by proxies
- Techniques applied to avoid double counting
  - Tagging for primary species
- Secondary species not affected by the scenarios
- Consistent approach between brute force and tag approach on NO2 concentration delta

Preliminary results

Indicators I/II

- Indicators defined for a single pollutant reductions
- The **Absolute Potential** is defined as the reduction in µg/m³ scaled by the reduction $\boldsymbol{\alpha}$ of the scenario (25 or 50%) of a precursor from base case BC
  - $API = \left(C - C^{BC}\right)/(\alpha)$ ($API \times \alpha$ 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.
  - $RPI = \left(C - C^{BC}\right)/(\alpha \times C^{BC})$
- The **Absolute Potency** in µg/m³/(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)
  - $APy = \left(C - C^{BC}\right)/(\alpha \times E^{BC})$

Clappier et al. 2016

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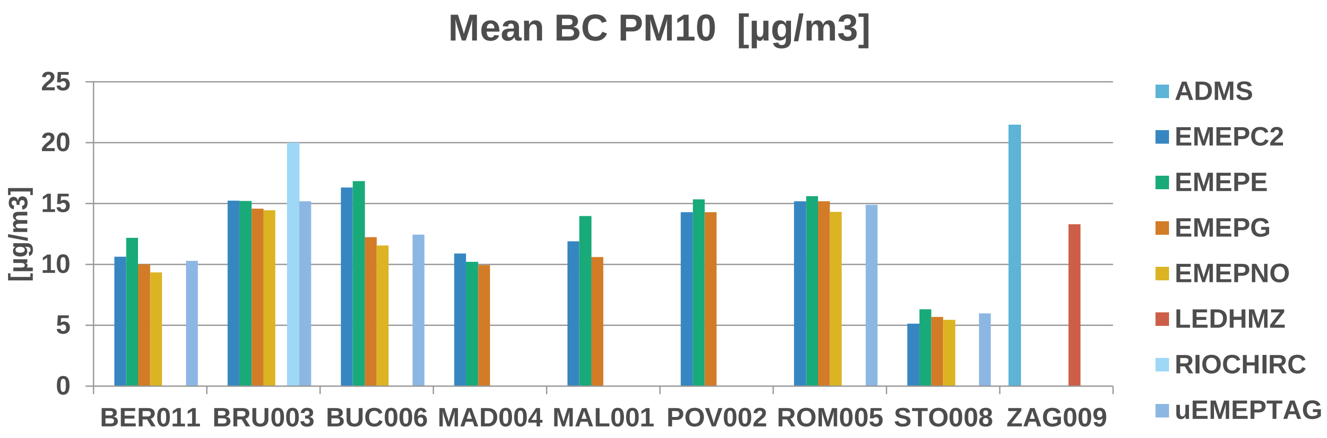
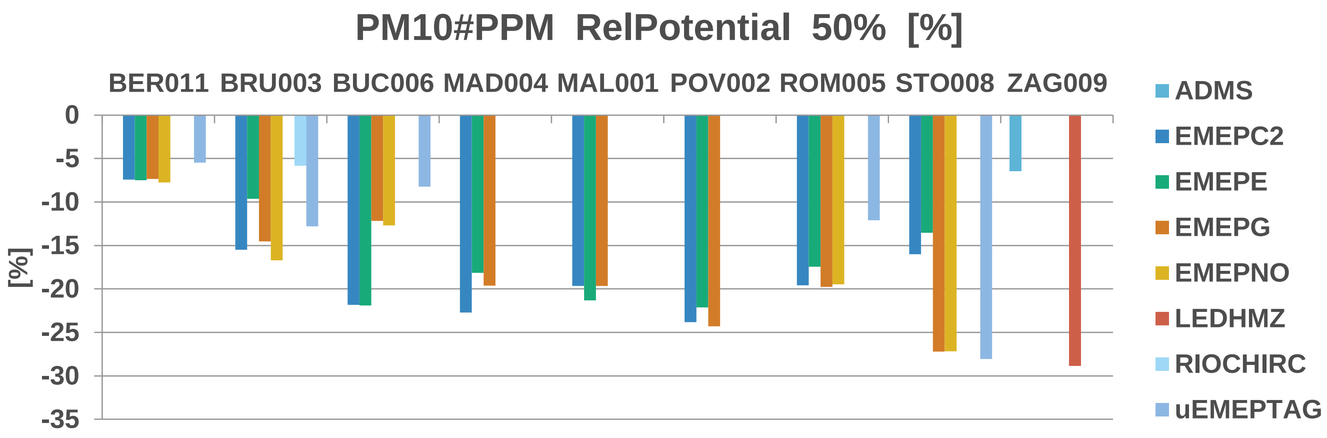
Assessing the variability of indicators

- The Normalized Standard Deviation (NSD) is adapted
  - IND can be calculated for:
    - Concentration value (Mean, Tcenter, P95) over the Target area:
      - **Mean** : average over time and Target domain of all concentrations
      - Tcenter (**TC**): center of the domain
      - **P95**: averaged values over percentile 95^{th}
  - For a given indicator : $NSD_{IND} = \sqrt{\frac{\sum_M (IND_M - \overline{IND})^2}{(\overline{IND})^2}}$
    - For the list of models M in a given city/region
    - $\overline{IND}$ the average value for all models $\overline{IND} = \frac{1}{N}\sum_M IND_M$

Yearly mean RPI – PM10

- Reduction of variability
- But still important in STO, a factor of 2





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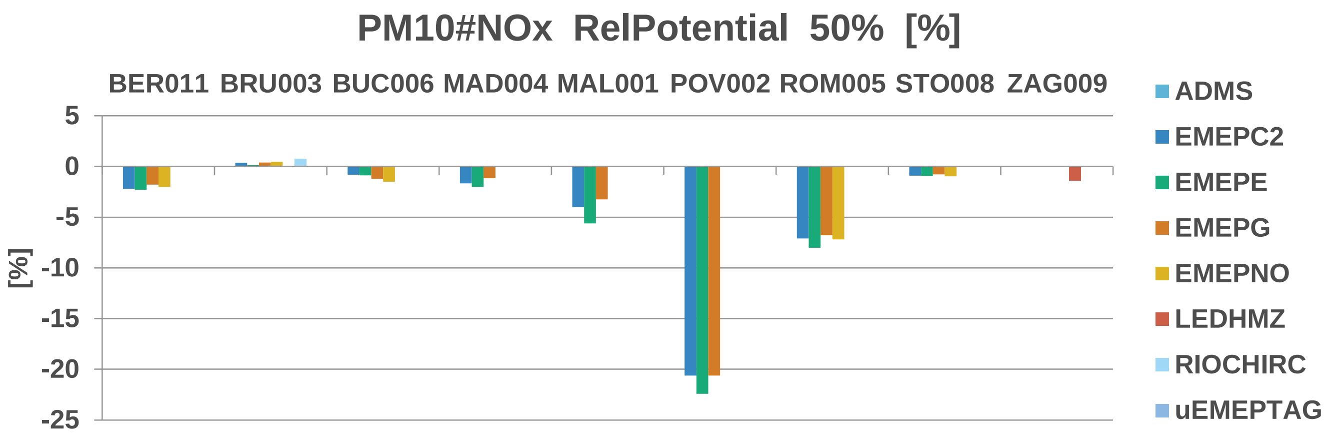
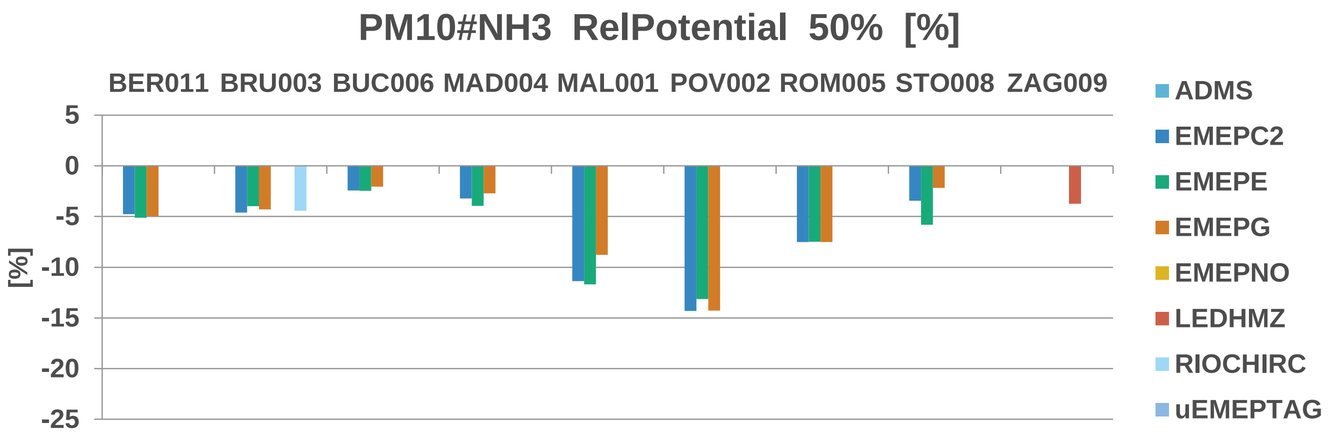
Yearly mean RPI – PM10 (NOx versus NH3 emissions)

- Slight increase of PM10 over Brussel for NOx emissions reductions
- Large reduction over POV
- In general low variability
- Large variability over STO for NH3 emission reductions





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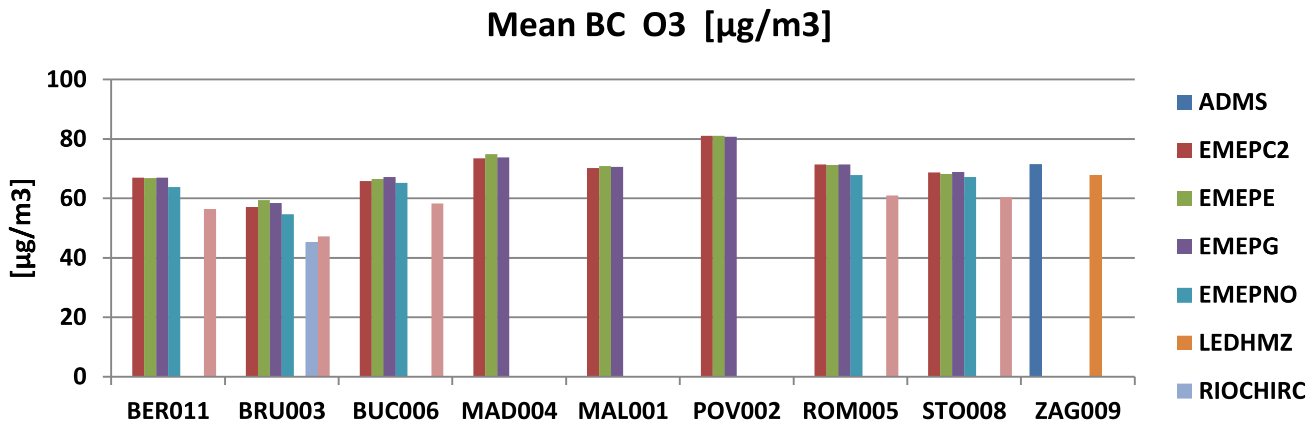
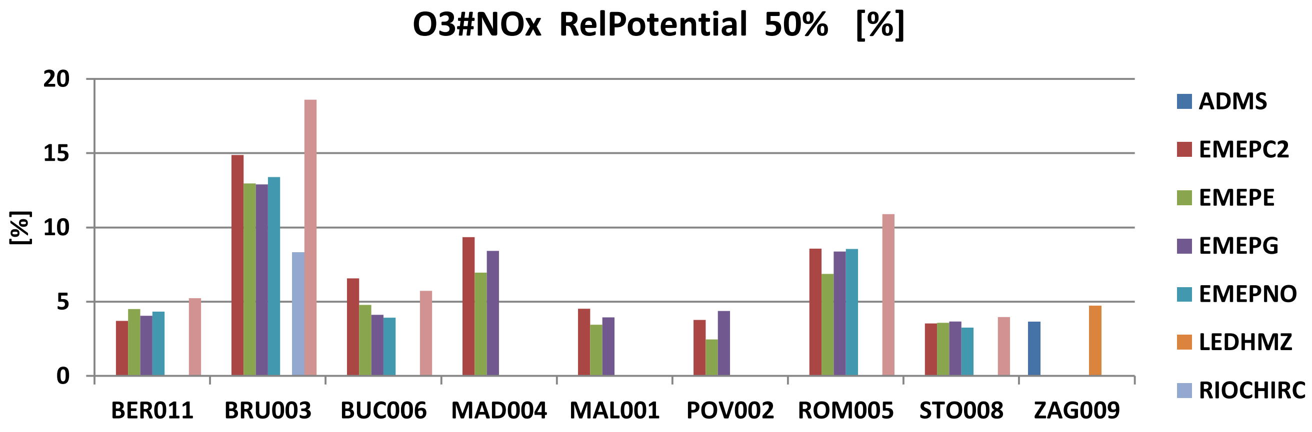
Yearly mean RPI – O3

- Low variability on mean concentrations





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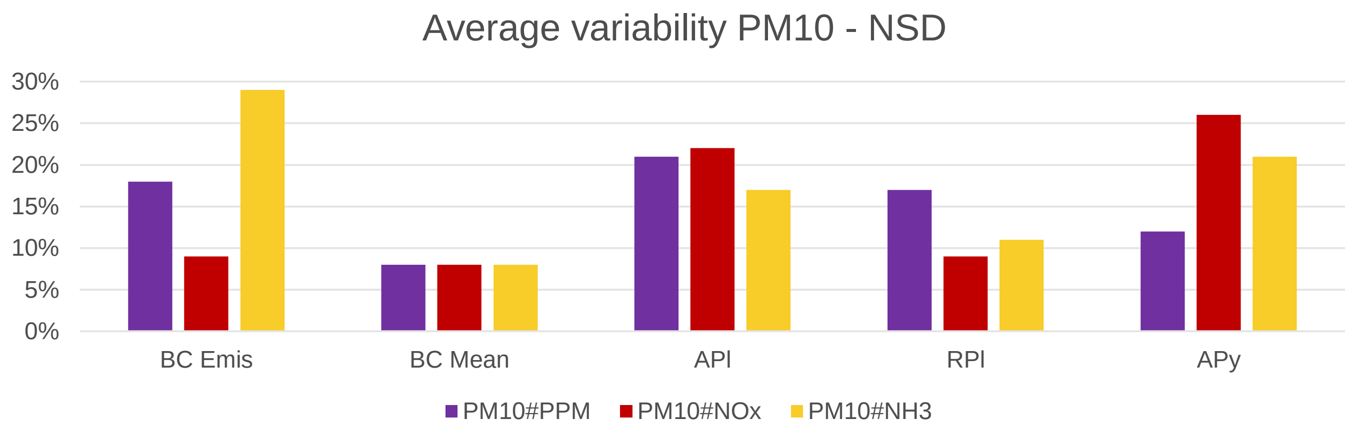
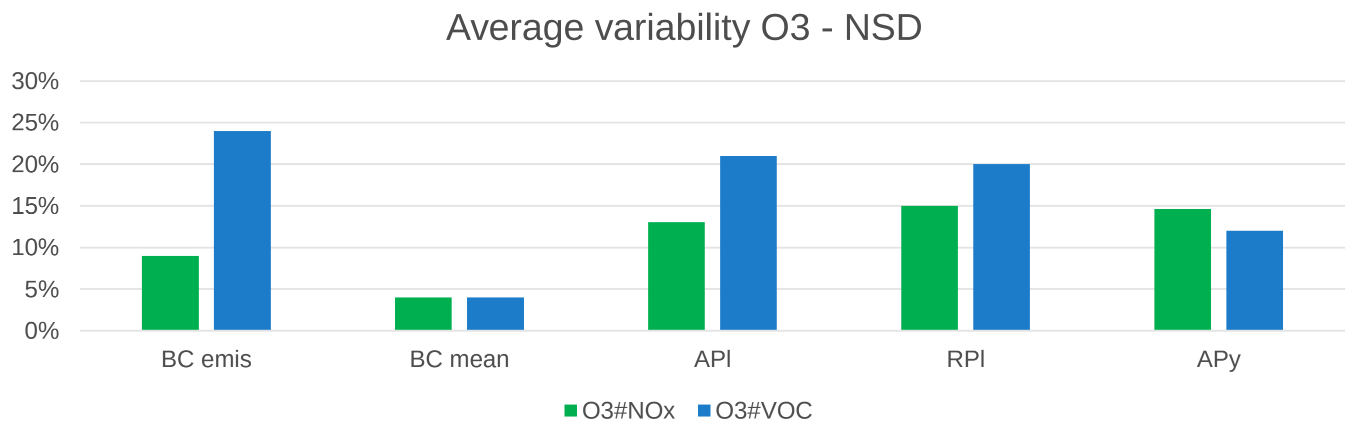
Summary of variability

- 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

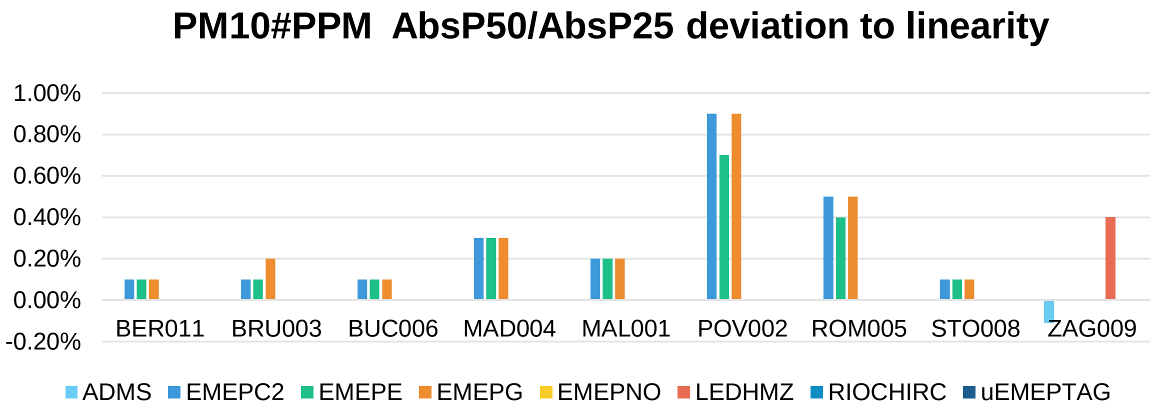
$$NSD_{IND} = \sqrt{\frac{\sum_{m=1}^{M}(IND - \overline{IND})^2}{(\overline{IND})^2}}$$

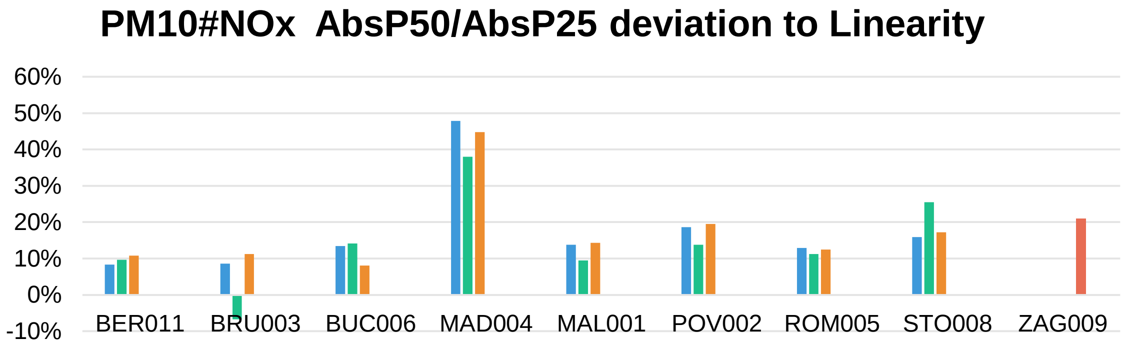


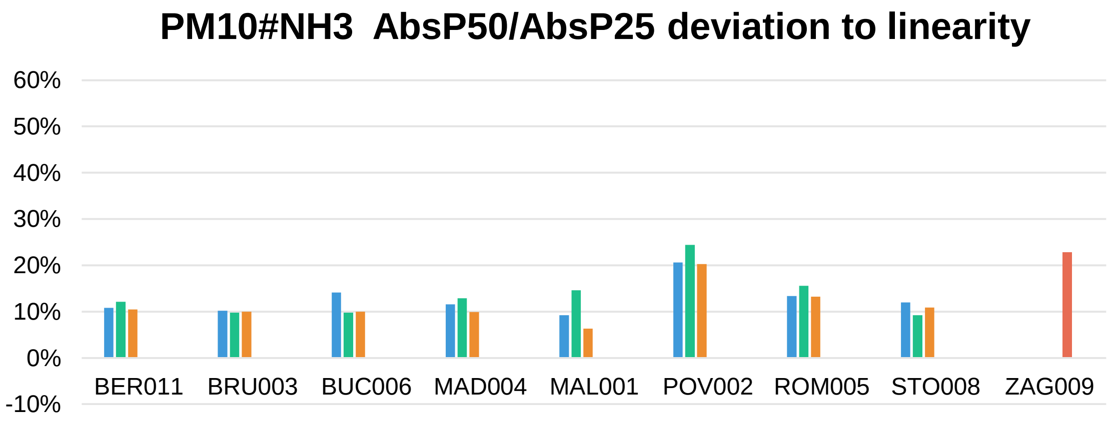


Linearities (PM10)

- Deviation % to linearity:
  - *as (AbsP50/AbsP25 - 1)x100*
  - *“0%” means perfect linearity*
- Perfect linearity for PPM, as it is considered as chemically inert (deviation < 1%)
- Usually higher efficiency when NOx or NH3 are reduced by 50% compared to 25%
  - *NH3 or NOx becoming no longer on average in excess and then being limiting in nitrate formation*







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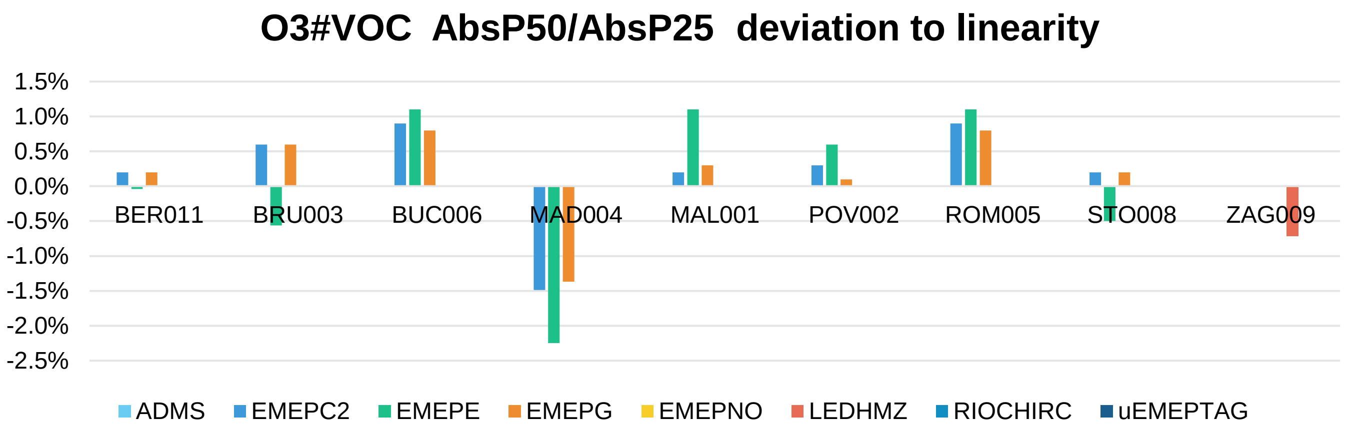
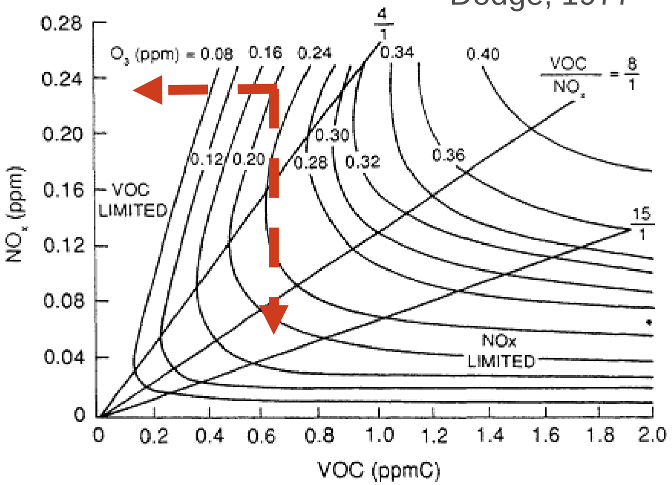
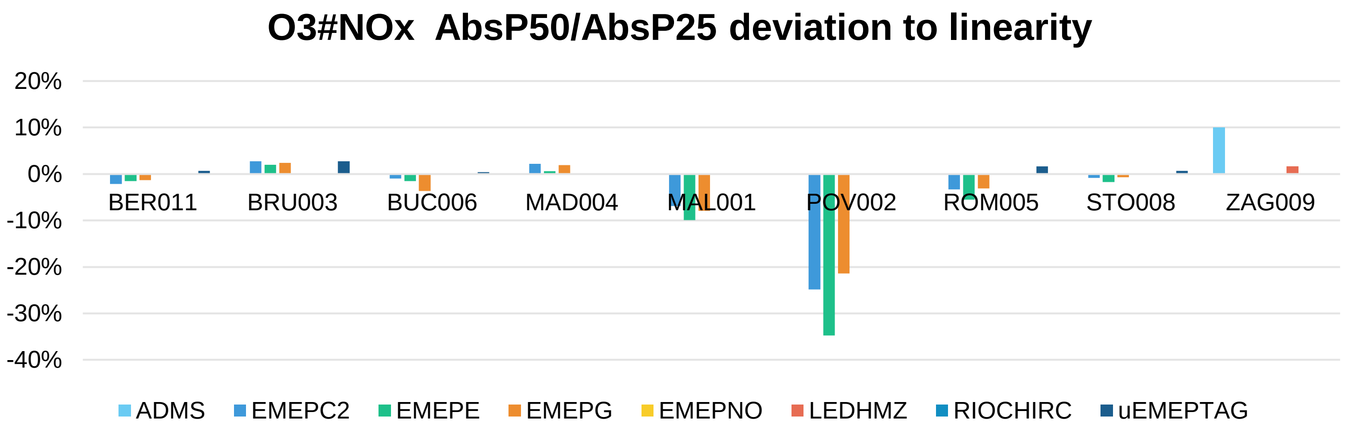
Linearities (O3)

- Linearity for VOC emission reduction
- More or less linear in urban areas (VOC limited)
- Non linear for large regions (POV and MAL)



Dodge, 1977





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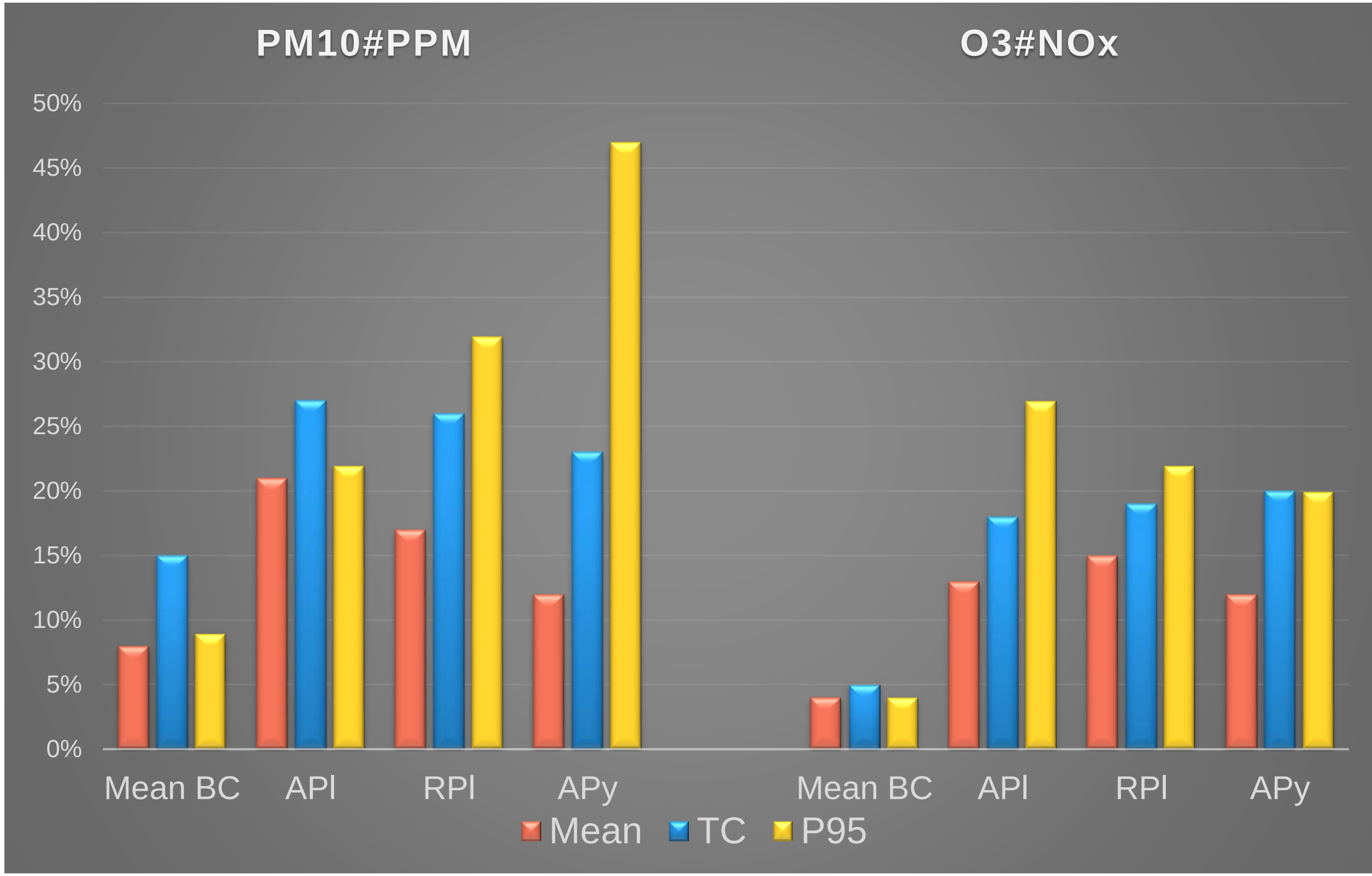
Variability change **Mean** *versus* **TC** *versus* **P95**

- Clear increase of variability of indicator scaled by concentrations or emissions



Concluding remarks

- A sufficient database to play with but we need more scenarios on Short Term and more emission reductions
- Indicators: API, RPI, APy
- Many simulations remains to be performed particularly for episodes
- Variability based on NSD:
  - Less variability on O3 Mean than PM10 Mean (4 versus 8 % on average for LT)
  - Variability of RPI << API (less clear for O3) - 10 to 25% depending on the indicator
  - Extent of the target domain where emissions are reduced could be important
  - More variability looking at specific location (TC) and shorter timeframe (ST)
- Indicators are sensitive to seasons
- Non linearity effects clearly highlighted for secondary species
- **Open exercize: other modelling teams are still welcome** ☺

Ideas for the next steps (I/II)

- **Continue to populate the database**
  - Yearly simulation for variability assessment and seasonality
  - Short term simulations for variability analysis and prepare next phases
- More data will be necessary to analyse the ST simulations (more hourly concentrations for many species at least at the first level)

- *Other indicators to calculate?*

- *APl, RPl, APy, NSD for variability of indicator: Other?*

- *Are taking the mean, TC, P95 adapted?*

Ideas for the next steps (II/II)

If a team performed all requested simulations for this first step then prepare the next phase to understand the delta of concentrations

- Creation of sub-groups to understand this large variability with Short Term simulations over episodes
  - One or several models change only one setting (on a target area) that could be:
    1. Emissions (including the impact of vertical profile distribution, biogenic emissions: NO and VOC)
    2. Horizontal resolution
    3. Physics and chemistry schemes
    4. Lateral and boundary conditions (link with vertical diffusion schemes) particularly for O3
    5. General model setting (Domain nesting strategy, numerical schemes)

    ✓ **Other?**
  - **We need leaders to frame each activity (i, ii, iii, iv, v,…)**

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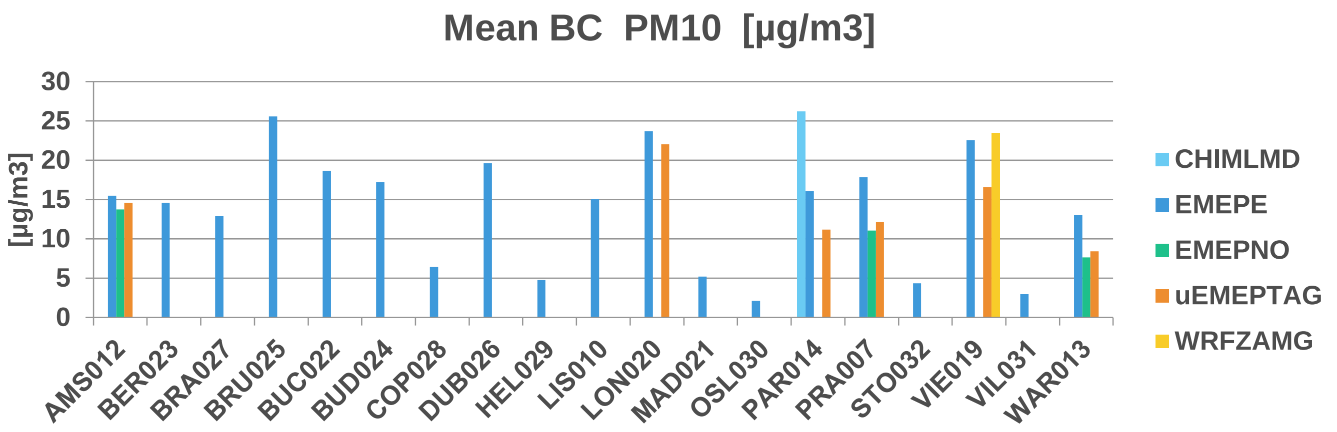
Feadback from morning session

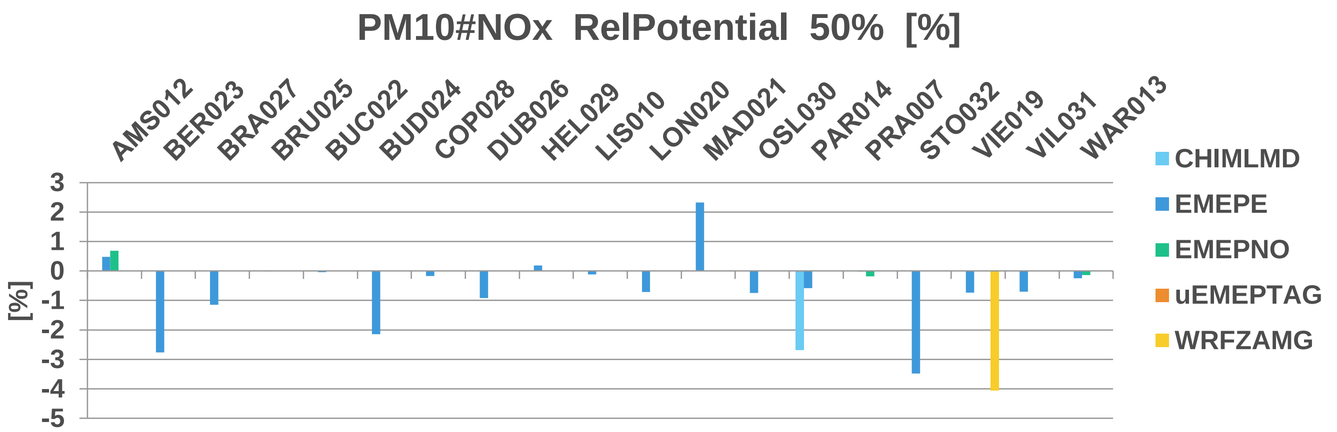
- Optimize the request to modellers who are able to provide results on multiple cities
  - We will propose with Kees a plan to prioritize the simulations based on what is existing so far: **next week**
  - Deadline to end the first phase for output delivery: **End of November**
  - **From end of november:** analysis and paper to show the variability based on the current indicators
- Focus on episodes and perform all requested simulations
- CAPC group in UK will update the results by end of November on London with a new inventory, possible yearly simulations at 0.1° to complement simulation on all EU capitals
- Joanna from PL mentioned that 2015 Polish emissions are far from the current reality … and it is true. However we reminded the CT9 initialtive is not to evaluate air quality plans but focus on (i) identifying the variability on model response to emission changes, and (ii) try to explain it in a next phase

The end

A look at short term

- So far 0 city with at least 3 different model settings for a PPM emission reductions





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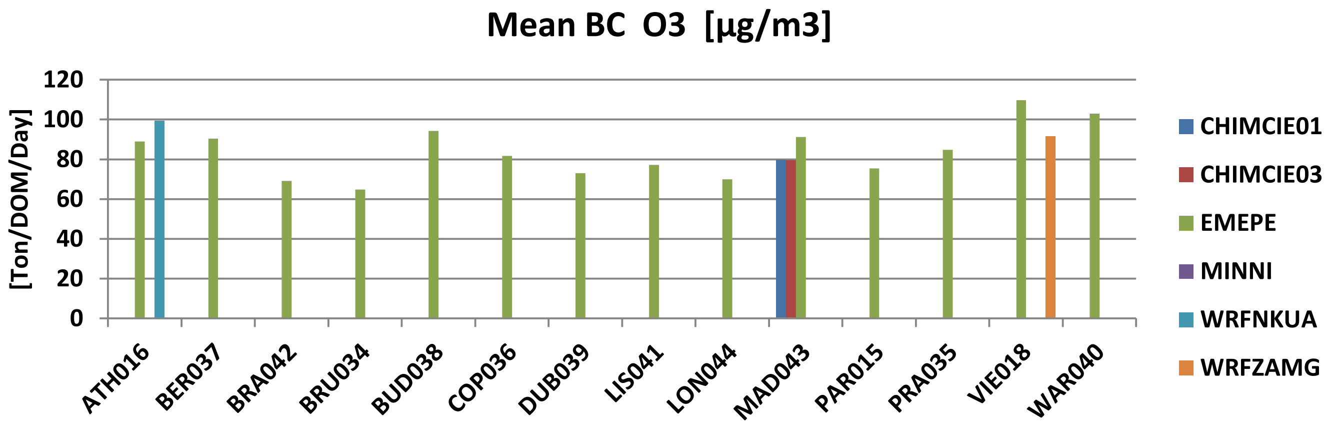
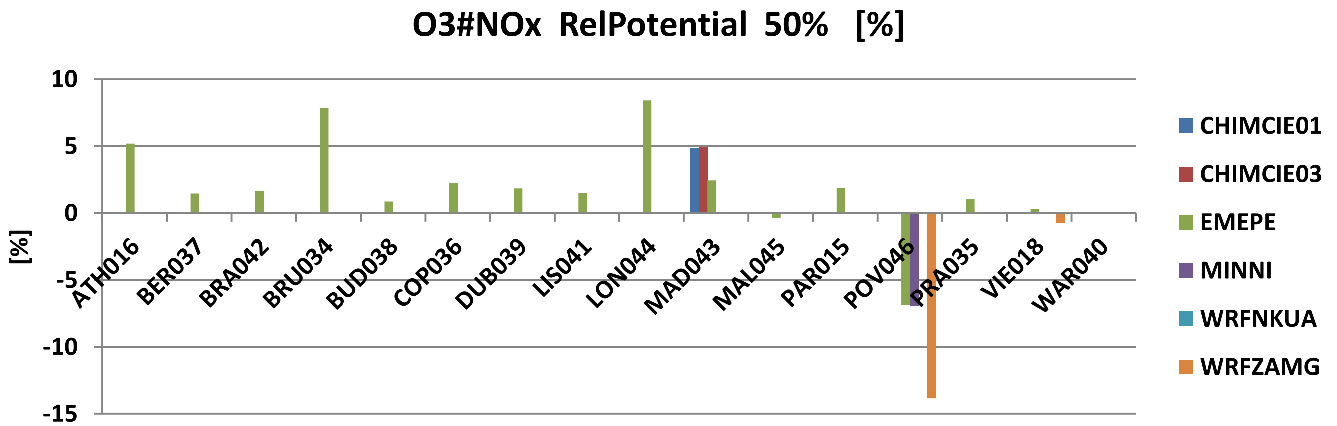
A look at short term for O3 episodes

- Weak impact of resolution in Madrid case with a slight increase of the RPI from 1 to 3km
- Increase everywhere except over the Po Valley





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