THE THIRD PHASE OF AQMEII: EVALUATION STRATEGY AND MULTI-MODEL PERFORMANCE ANALYSIS

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AQMEII 3: phase 3 of the Air Quality Model Evaluation International Initiative
Coordinated by EC/JRC and US-EPA

Regional program of the HTAP2 exercise (Hemispheric Trasp. Of Air Pollution)

European Commission

AQMEII is a two-continent regional scale **model evaluation** exercise

Collection of model and monitoring data for **North America and Europe**

Organizing the information into a centralised database with high level of harmonization

Model evaluation against measurements and **ensemble modelling**

Joint Research Centre

AQMEII is now running its third phase

Modelling systems	Simulating air quality over Europe and North America for the year 2010	Evaluation against observations
WRF-CMAQ	gas phase	**Ozone**: Hourly time series from 2190 (EU) and 1767 (NA) surface stations
ECMWF-SILAM	aerosol	
ECMWF-L.-EUROS	precipitation chemistry	
WRF-CMAQ	ozonesondes	
WRF-WRF/Chem	meteorology	**PM**: Hourly time series from 1837 (EU) and 1749 (NA) surface stations
WRF-CAMx	AERONET	
Cosmo CLM-CMAQ	AERONET PROFILES	
WRF-WRF/Chem	MOZAIC	
WRF-CMAQ	map concentration	
WRF-DEHM	map deposition	
ECMWF-Chimere	map emissions	
WRF-CMAQ		
CCLM-CMAQ		
WRF-CMAQ		
WRF-CAMx		

Error Apportionment

Model evaluation: Does the **model provides the correct response for the right reason?**

Operational metrics (error, associativity, variability) have little or no impact on model improvement as they:
- do not target the source of the modelling error and
- do not discriminate between the reasons for appropriate or inappropriate performance

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New model evaluation paradigm

- **moving away from metrics**
- **more focused on the quality of the error**
- **targeting the time-scale of the error, allowing better identification of the cause**
- **sensitivity analysis to identify the contribution of external inputs (emissions, boundary conditions) to model bias**

Diagnostic of the error

$$MSE = bias^2 + variance + covariance$$

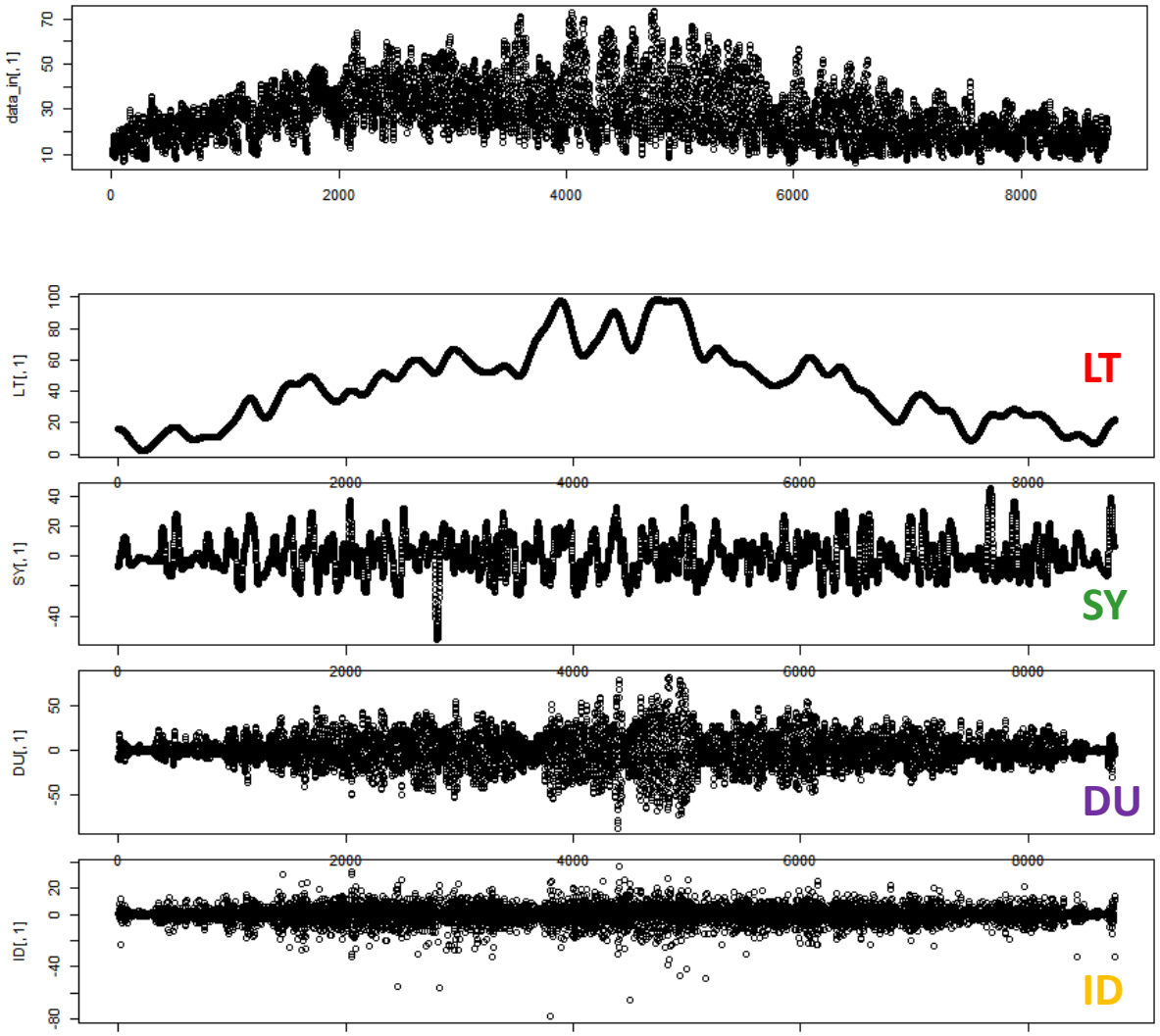
$$MSE = \underbrace{\left(\overline{mod} - \overline{obs}\right)^2 + \left(\sigma_{mod} - r\sigma_{obs}\right)^2}_{reducible} + \underbrace{mMSE}_{unexplained}$$

$$mMSE = \sigma_{obs}^2(1 - r^2)$$

MSE -> 0 in the case of 'perfect' model: unbiased and r-> 1

Solazzo, E., Galmarini, S.: Error apportionment for atmospheric chemistry-transport models: a new approach to model evaluation, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-15, 2016

Spectral decomposition



Spectral decomposition of time series of pollutants derived from power spectrum analysis

Four components ID, DU, SY, LT

LT : Long term (processes > 21d)

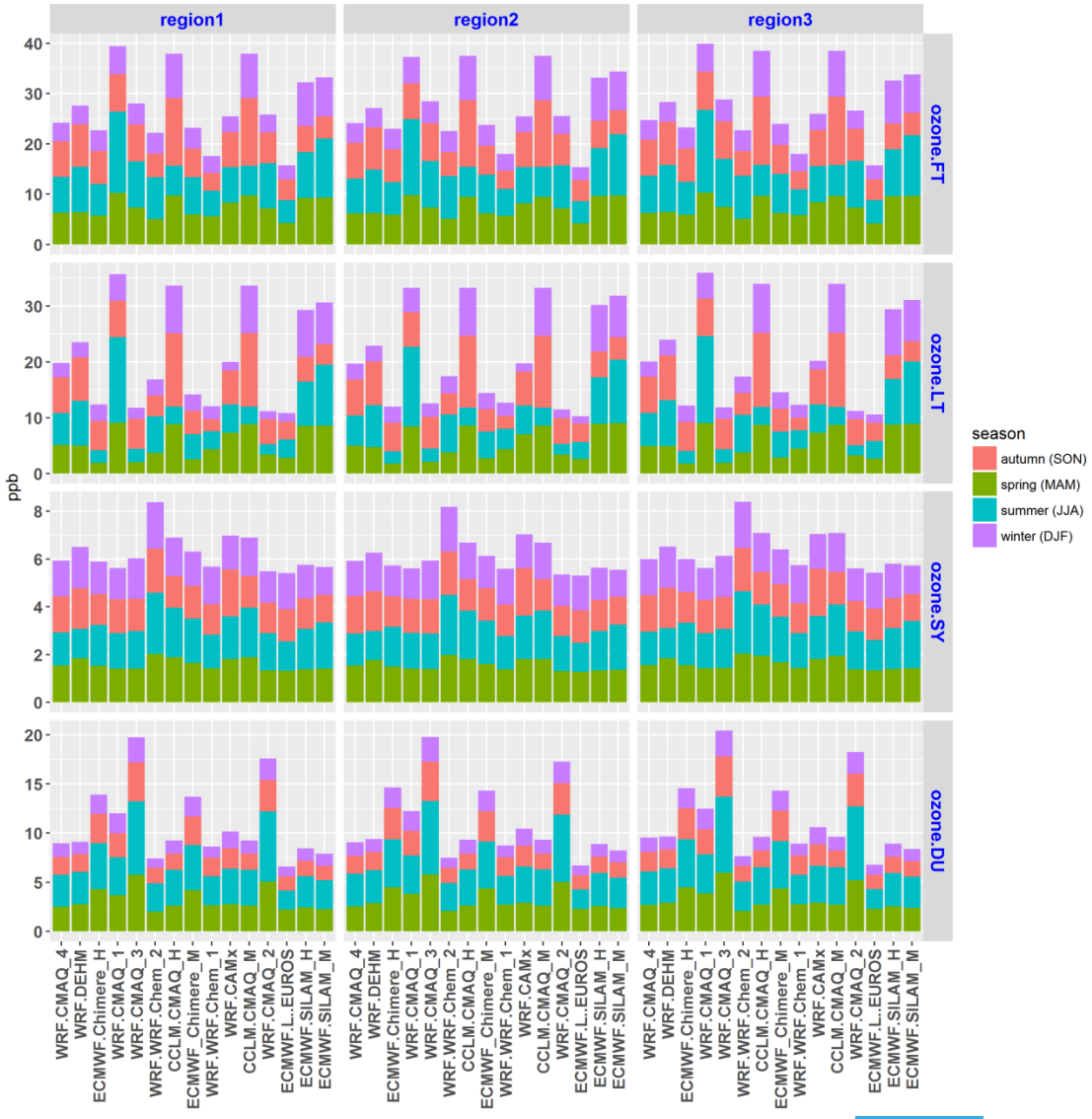
SY : Synoptic (weather [2.5d;21d]

DU: diurnal (day/night [12h; 2.5d]

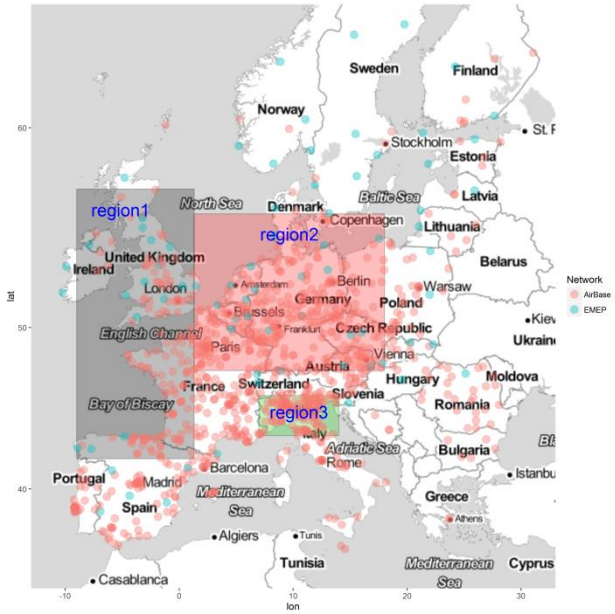
ID : intra-day (fast-acting < 12h)

LT is the base line, the other components are obtained using the filter as band-pass and have zero mean

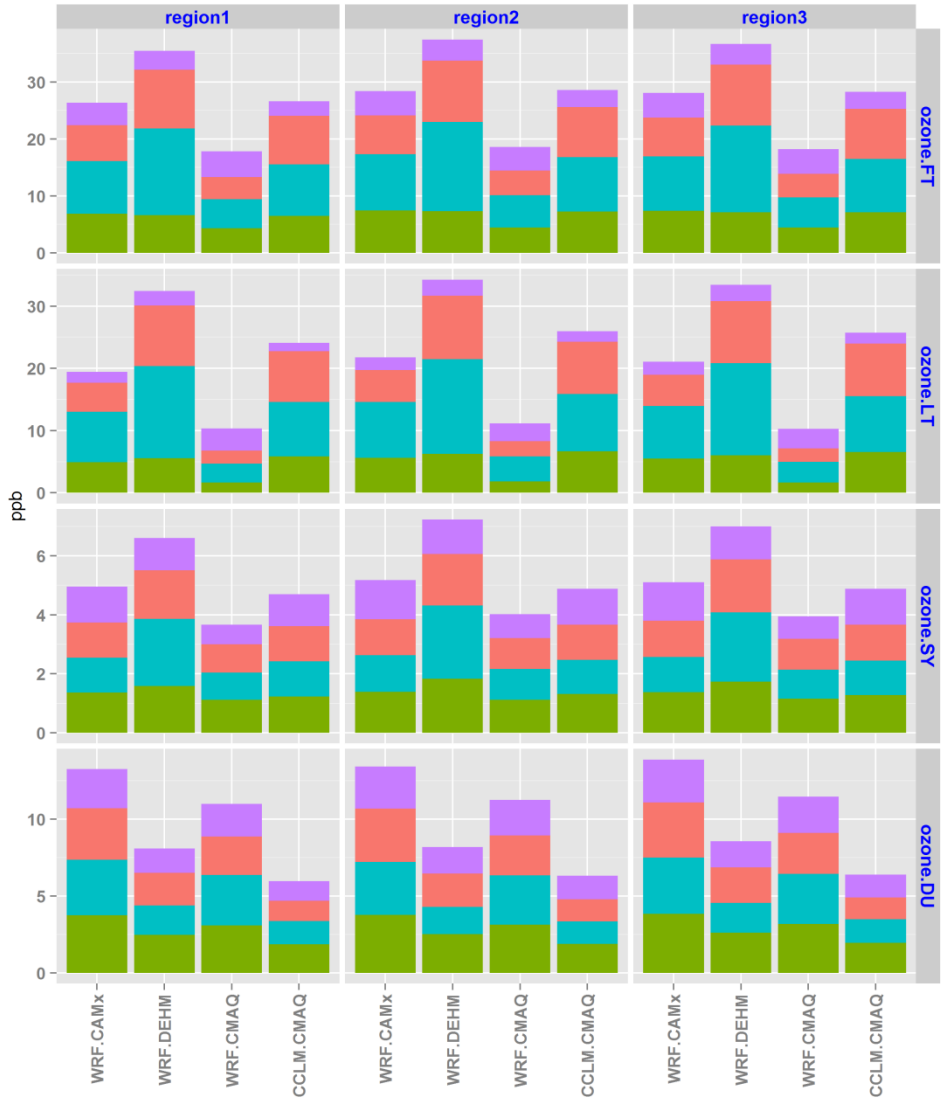
Ozone - Europe



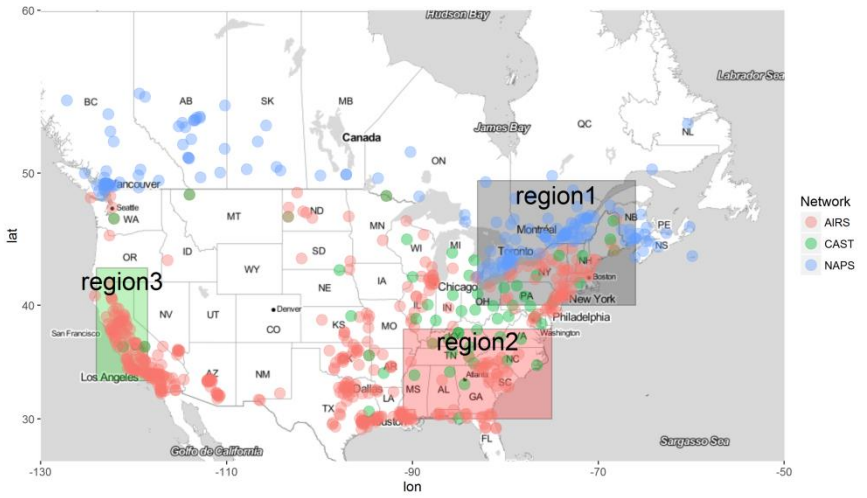
RMSE for ozone in Europe by season and spectral component

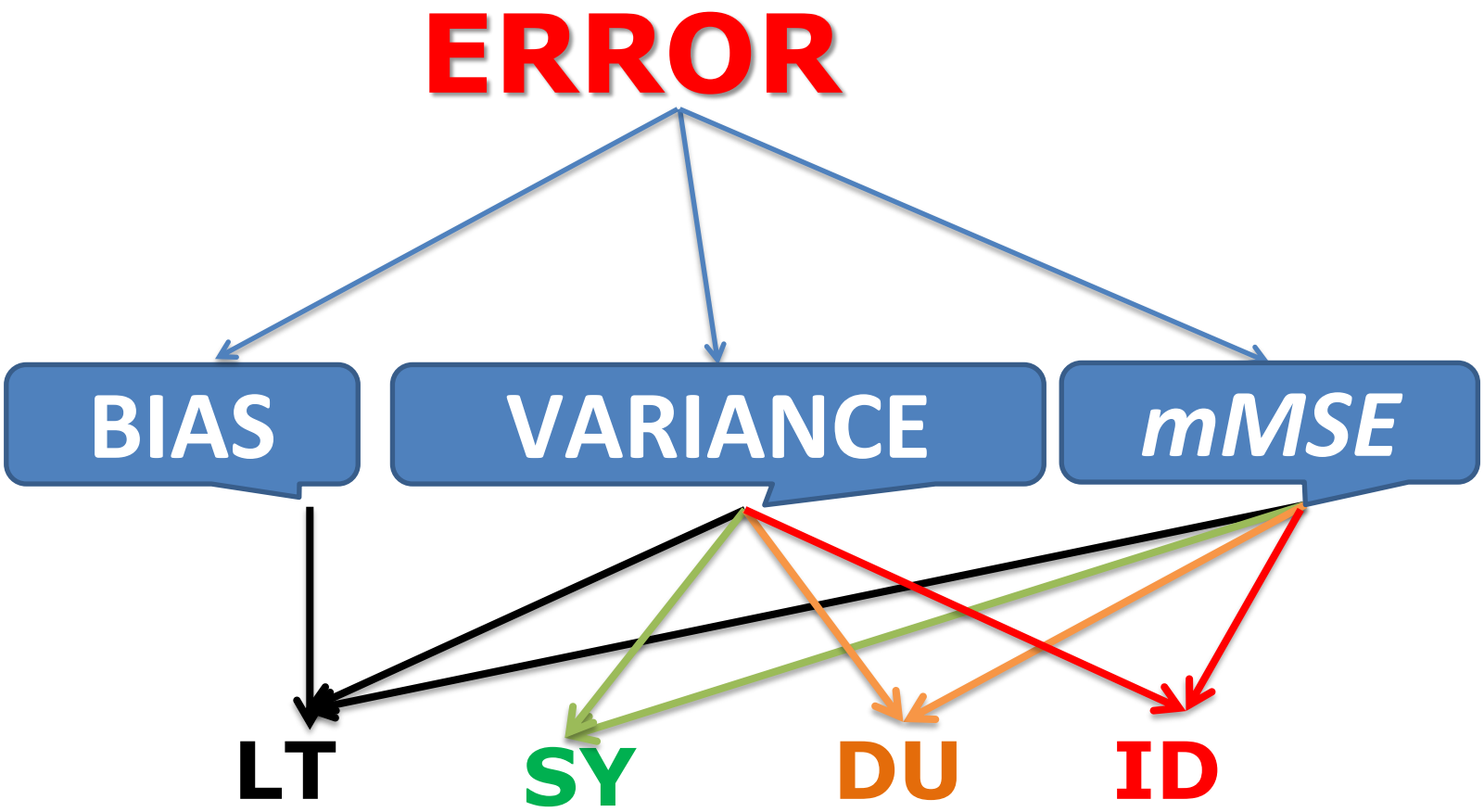


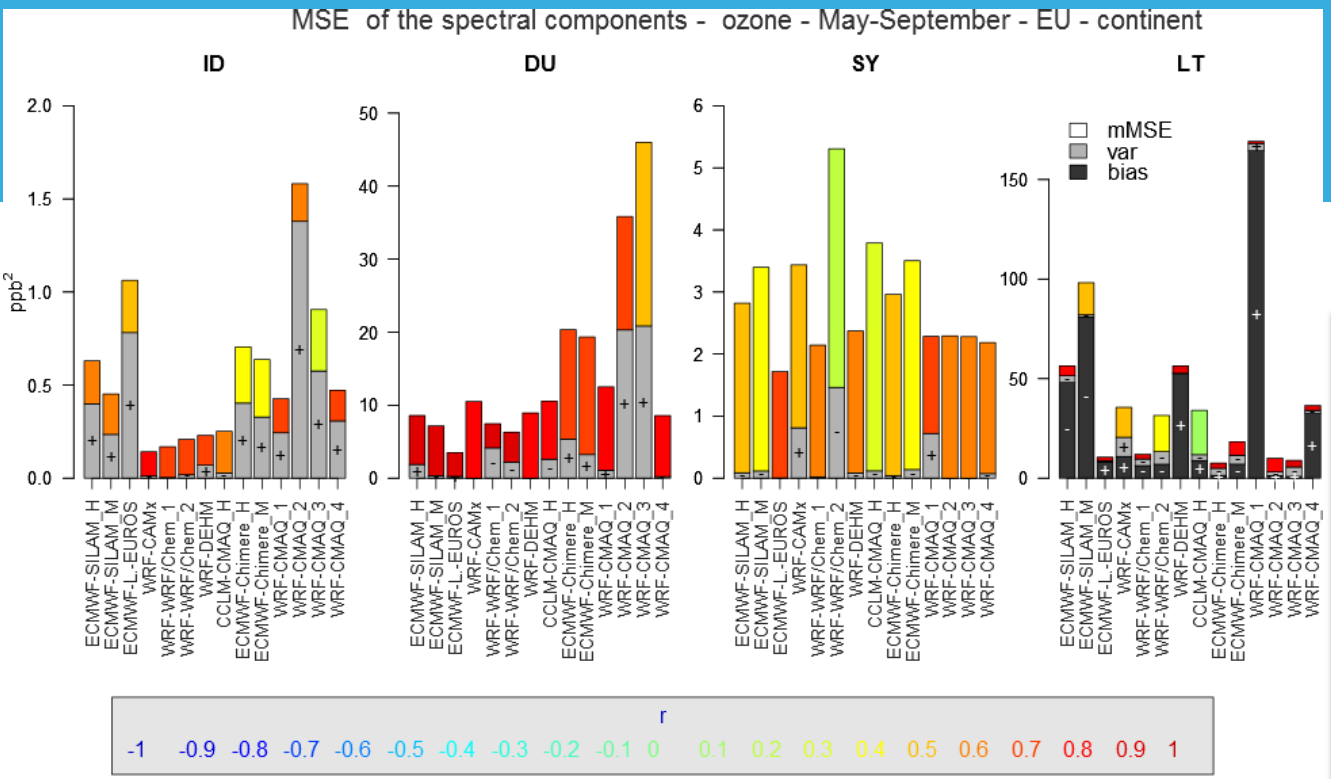
Ozone – North America



RMSE for ozone in North America by season and spectral component




ERROR
BIAS
VARIANCE
mMSE
LT
SY
DU
ID



The LT contains all the bias

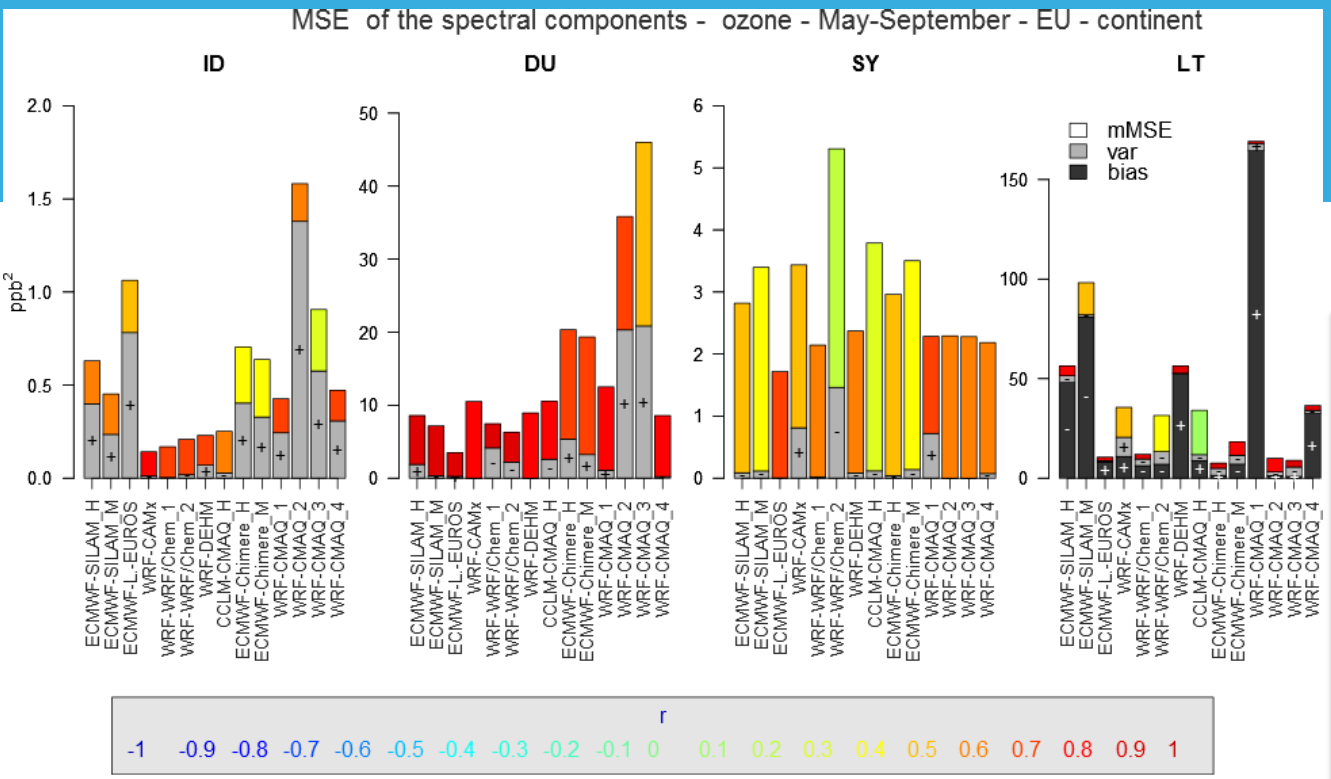
The signs indicate model underprediction (-) or overprediction (+) of bias and variance.

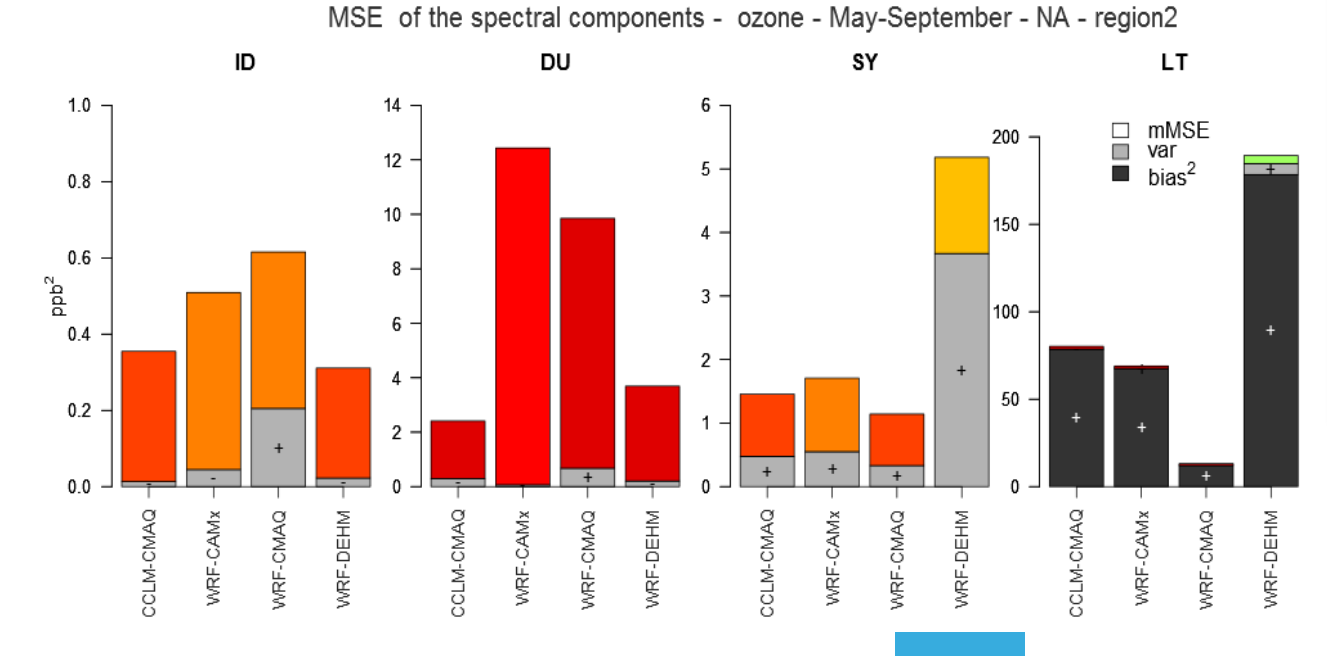
The color scale indicates the correlation coefficient

bias $=(\text{mod}-\text{obs})^2$

var $= (\sigma_{mod} - r\,\sigma_{obs})^2$

$mMSE = \sigma_{obs}^2(1-r^2)$





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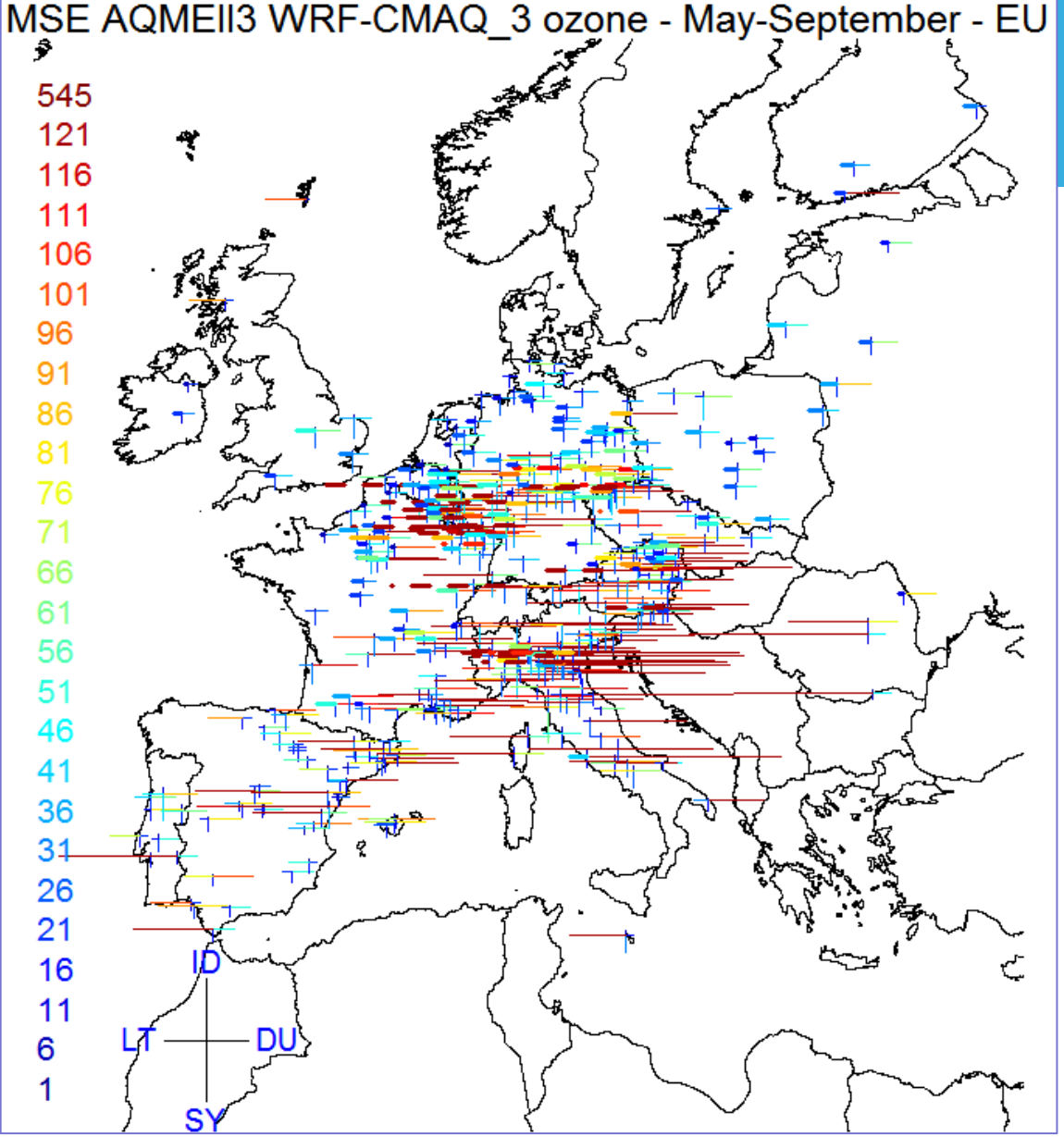
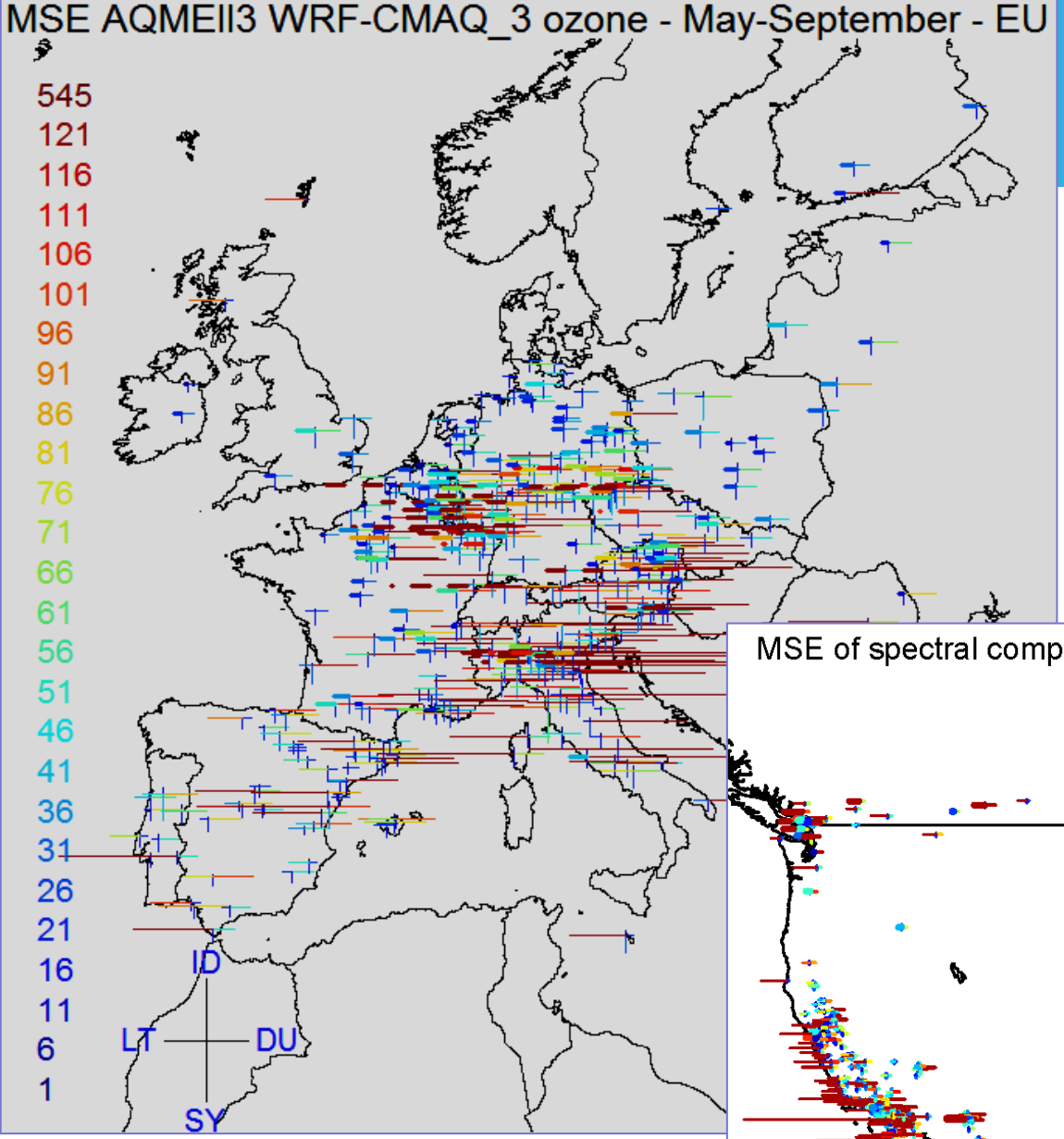
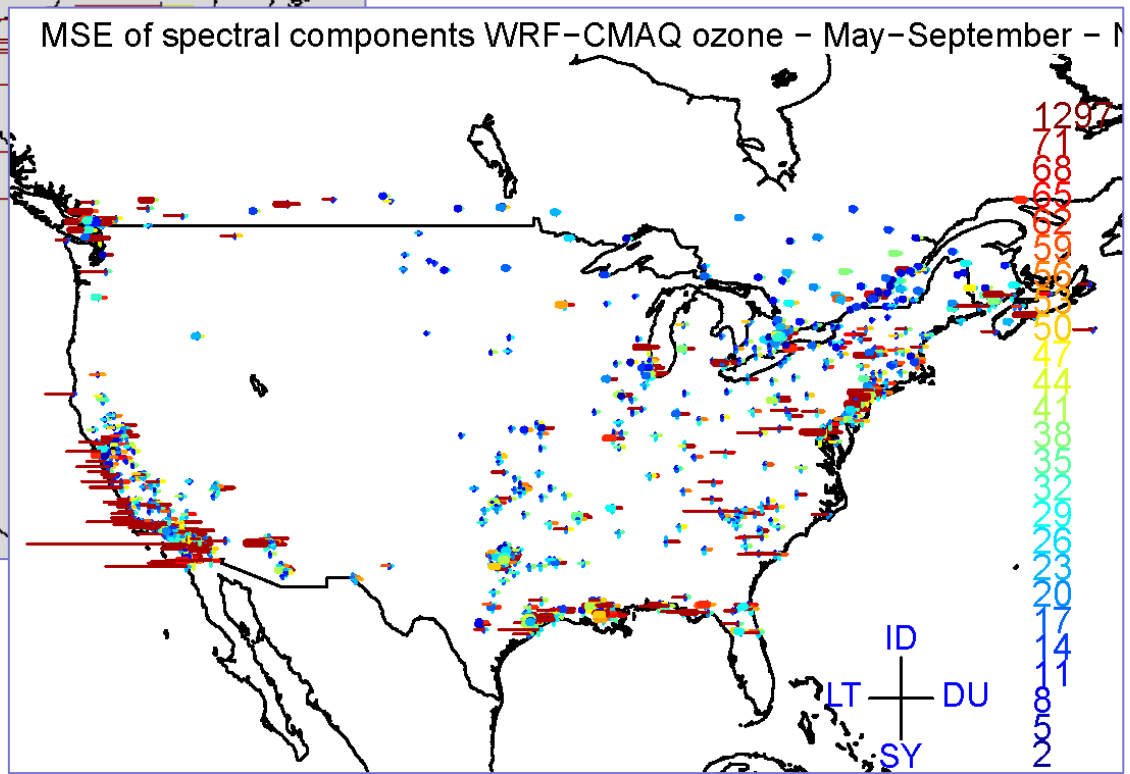


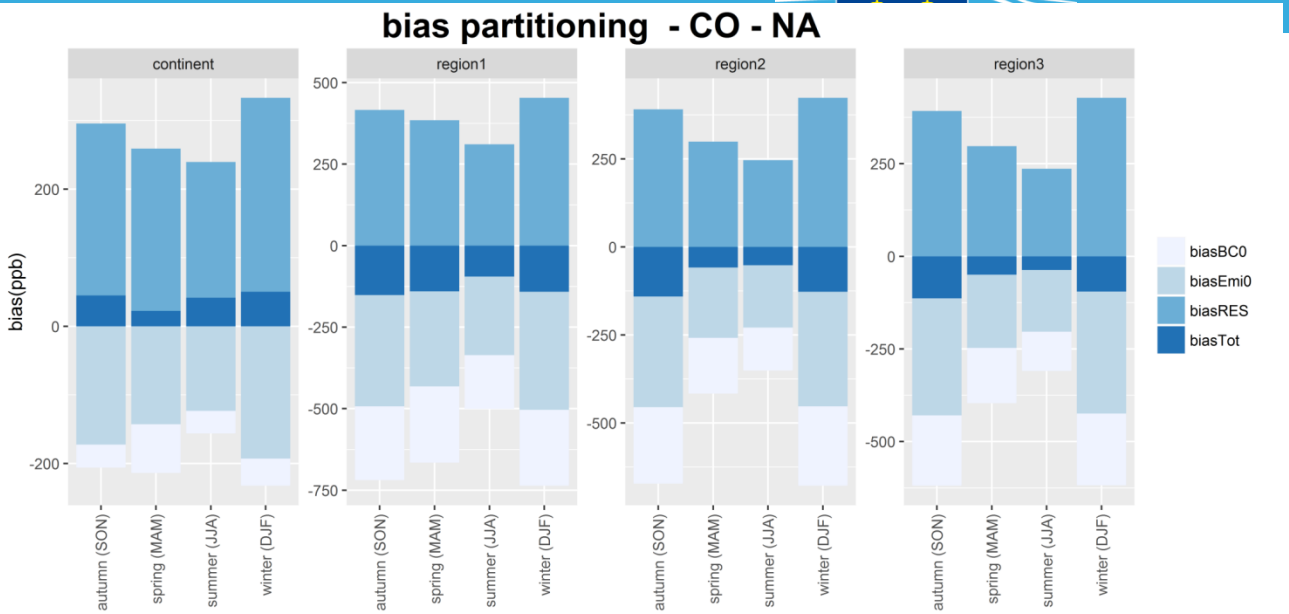
Spatial distribution of the error for winter and May-September for ozone.

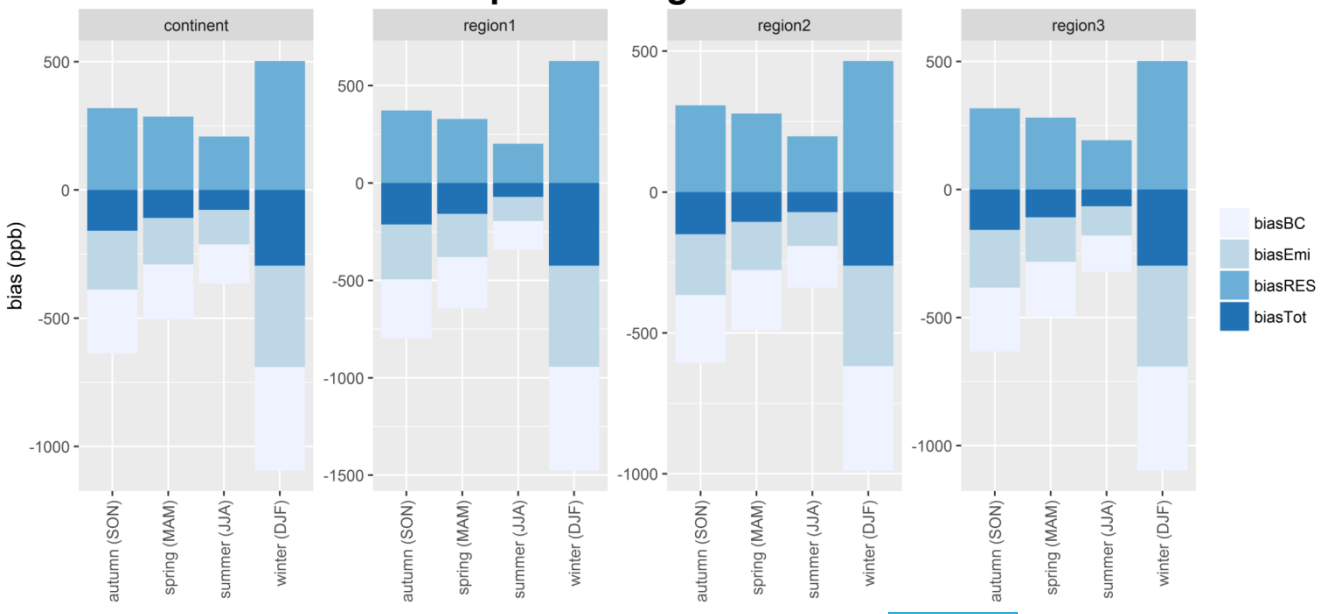
The influence of the BCs on the bias is more marked in winter, in all the continent



Spatial distribution of the error for May-September by components.







Sensitivity runs for the partitioning of the bias for CO

External bias: due to external factors (emission and boundary conditions)

Internal model bias: due to model error (chemistry, deposition, transport, etc.)

Summary

- The complexity of air quality modelling systems is such that the simple scoring of performance is not sufficient to inform about the causes of the error;
- AQMEII promotes the model evaluation as a stage of model development and presents a method to interpret the model's error, qualitatively other than quantitatively;
- The application to the spectral decomposition help identifying the nature of the error, and the components that contribute the most to the error;
- The spatial representation helps identify the possible sources of the error;
- Currently, work is underway to further decompose the error into process specific components for a clearer identification of its cause.

E.Solazzo et al. Evaluation and error apportionment of an ensemble of atmospheric chemistry transport modelling systems: multi-variable temporal and spatial breakdown. In preparation for submission to ACP journal

ACKNOWLEDGEMENTS

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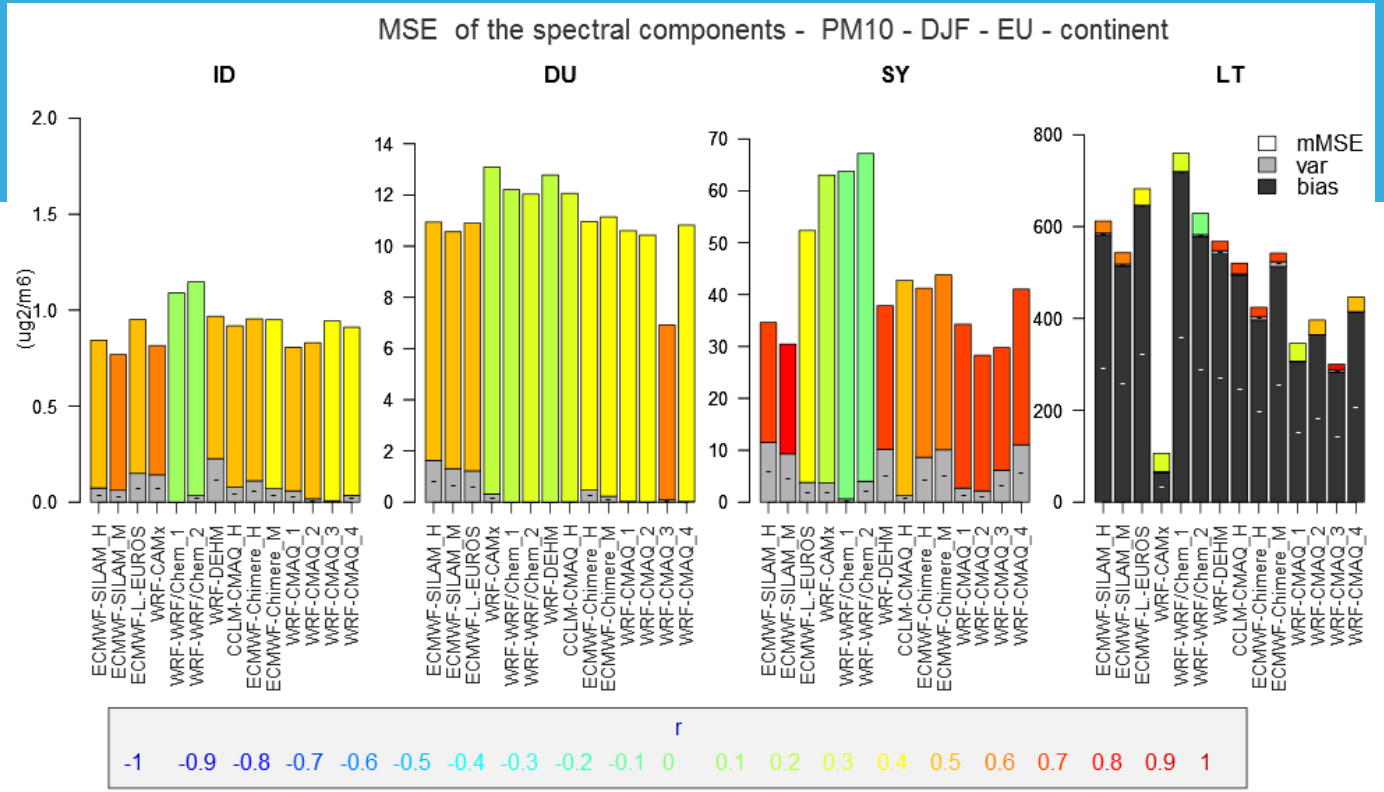
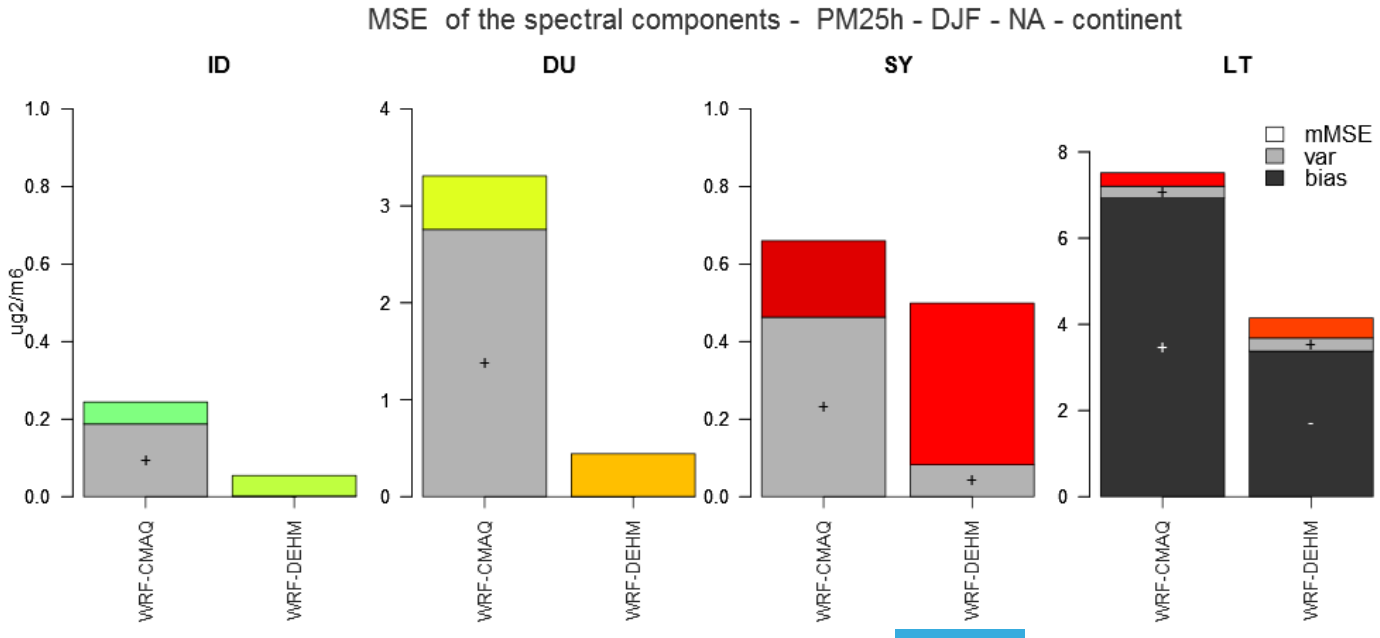

MSE of the spectral components - PM10 - DJF - EU - continent
ID
DU
SY
LT
mMSE
var
bias
(ug2/m6)
ECMWF-SILAM_H
ECMWF-SILAM_M
ECMWF-L-EUROS
WRF-CAMx
WRF-WRF/Chem_1
WRF-WRF/Chem_2
WRF-DEHM
CCLM-CMAQ_H
ECMWF-Chimere_H
ECMWF-Chimere_M
WRF-CMAQ_1
WRF-CMAQ_2
WRF-CMAQ_3
WRF-CMAQ_4
r
-1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1


MSE of the spectral components - PM25h - DJF - NA - continent
ID
DU
SY
LT
mMSE
var
bias
ug2/m6
WRF-CMAQ
WRF-DEHM