

Regional Air Quality Model Intercomparison and Validation in GEMS Project

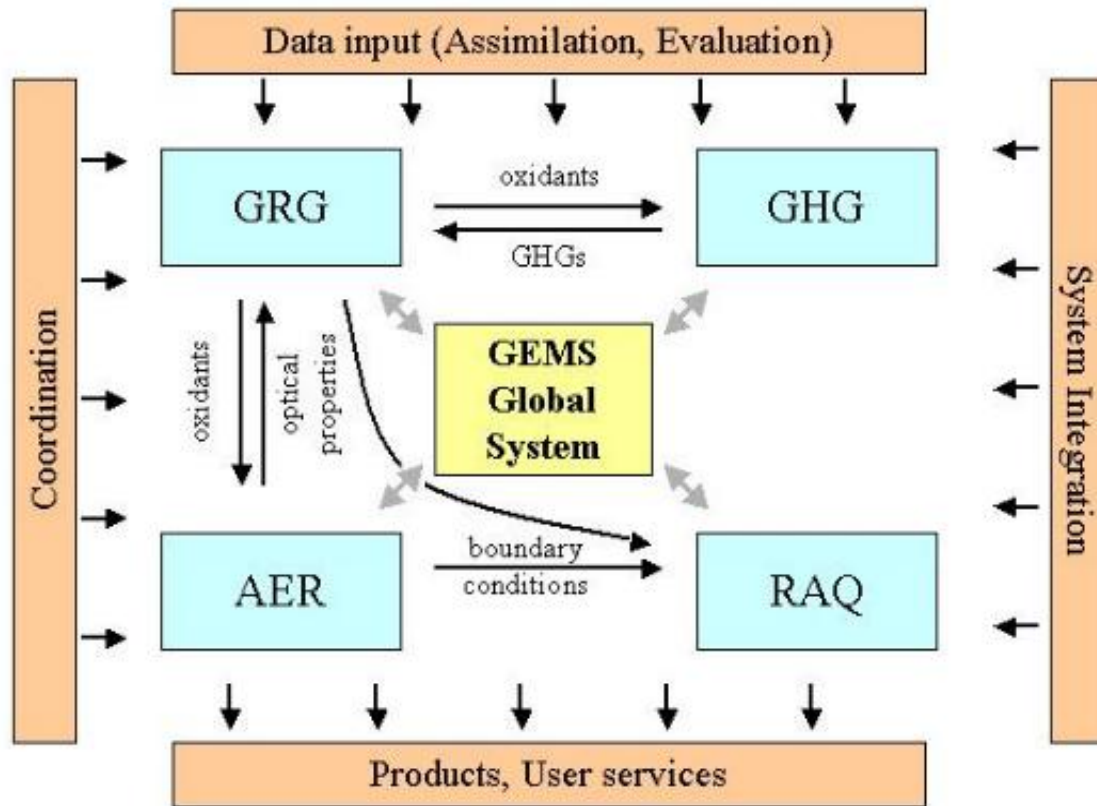
Miha Razinger <miha.razinger@ecmwf.int>

ICAP Workshop on Aerosol Verification, Oxford, 30. 9. – 1. 10. 2010

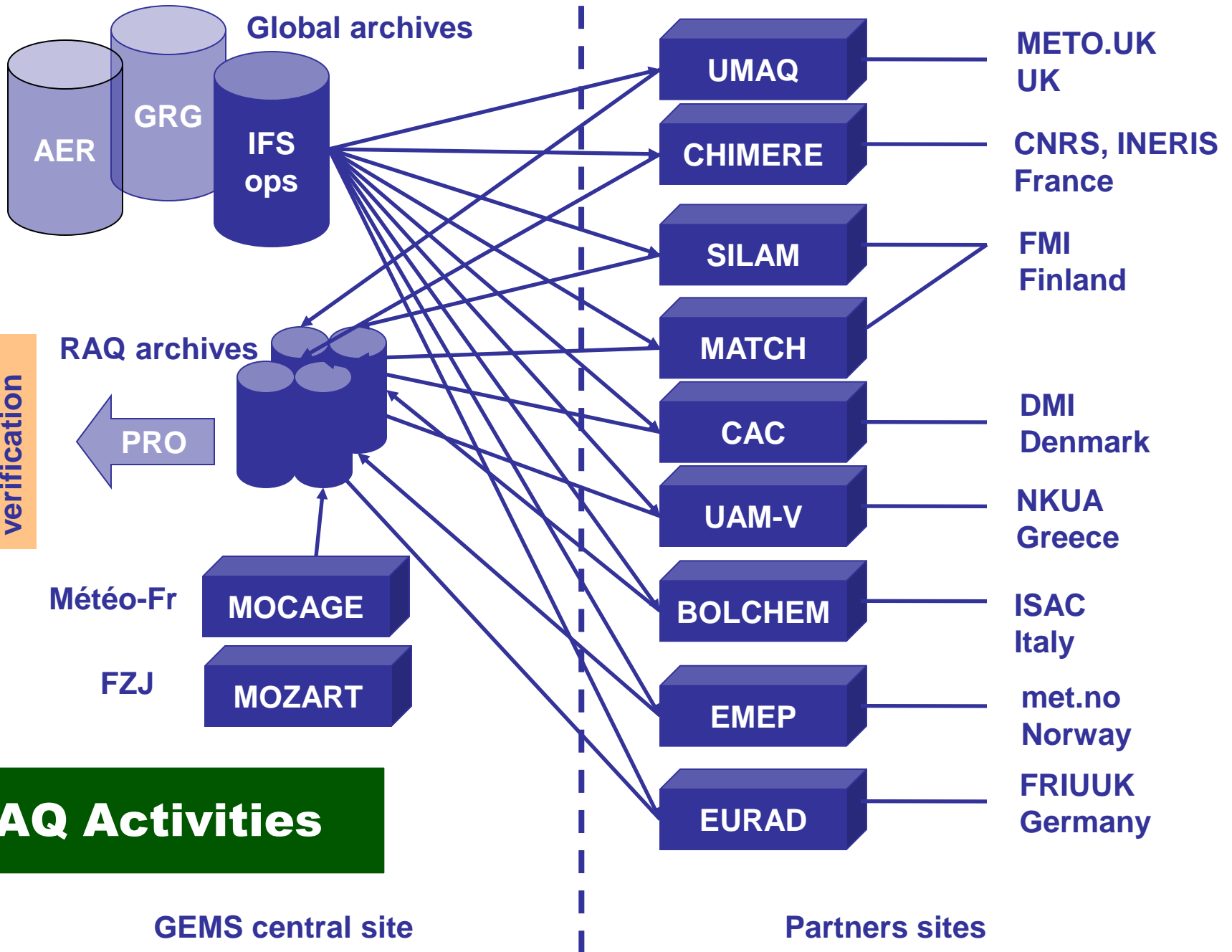


GEMS Project (2005-2009)

- An EU FP7 funded project
- Monitoring the global distributions of atmospheric constituents important for climate, air quality and UV radiation
- MACC – a follow-on and extension of GEMS activities



courtesy of Vincent-Henri Peuch



GEMS RAQ products & verification

PRO

RAQ Activities

GEMS central site

Partners sites

RAQ operational verification system FAQ

Why?

- Track performance changes
- Quickly spot and fix problems
- Understand differences between models
- Learn about models' strengths and weaknesses
- (feedback to data providers)

What?

- Regional air quality models:
 - common geographical area (but different resolution)
 - same list of parameters
 - same emissions and meteorological boundary conditions
 - common data format

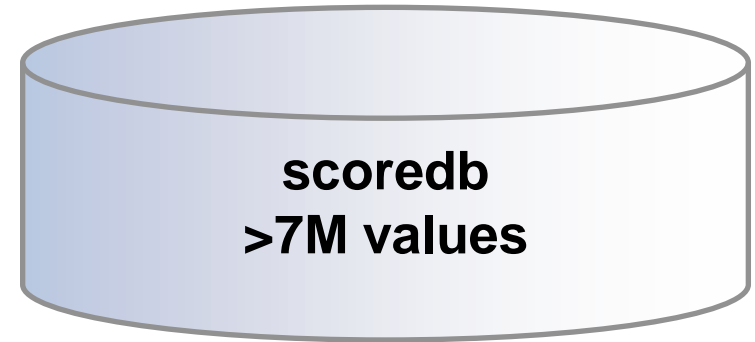
How?

- Paul's talk
- P Agnew et al.: Evaluation of GEMS Regional Air Quality Forecasts

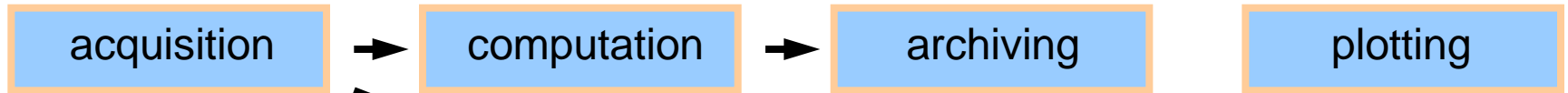
<http://gems.ecmwf.int/do/get/PublicDocuments/1533/1402?showfile=true>

observations

surface obs from BE*
DE DK ES* FI FR GR
IT NL* NO PL SE* UK
(120.000 observations
daily)



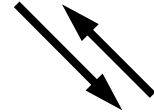
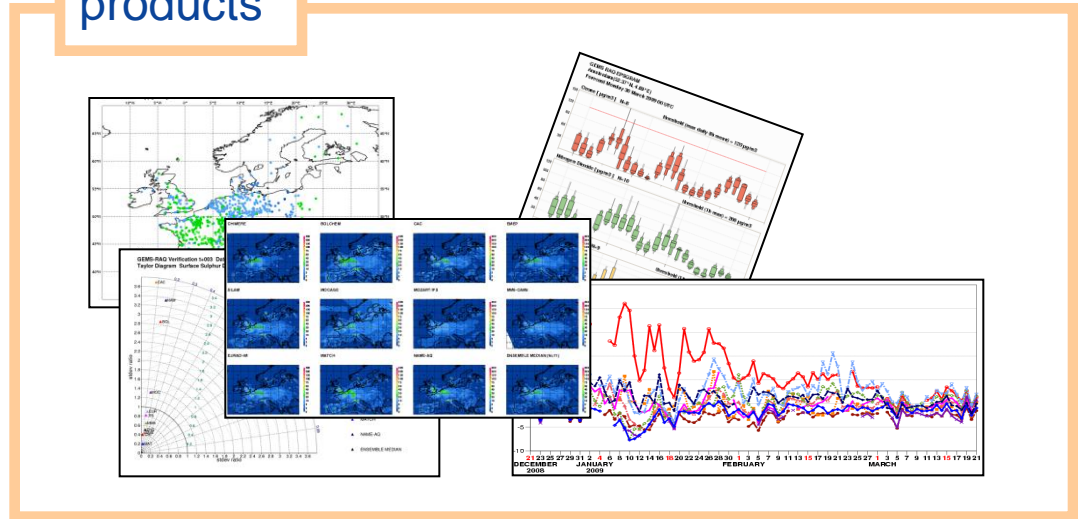
How does it work?



forecasts

10 regional models from
DE DK FI FR GR IT NO
SE* UK + 1 global model
+ RAQ ensemble
median

products



What is computed?

- scores: bias, root mean square error, modified mean bias, fractional gross error, correlation coefficient, ratio of standard deviations
- parameters: O₃, NO₂, SO₂, CO, PM₁₀
- forecast steps: 0 to 72 by 3
- models: 10 regional + 1 global model + median of RAQ ensemble
- all stations used (simple error checking)
- ~ 9000 scores computed daily

Forecast Intercomparison Products

RAQ Forecasts

MOCAGE

- Model**
- [EURAD](#)
 - [MOCAGE](#)
 - [NAME-AQ](#)
 - [MATCH](#)
 - [MM5-CAMx](#)
 - [SILAM](#)
 - [BOLCHEM](#)
 - [CAC](#)
 - [EMEP](#)
 - [CHIMERE](#)
 - [MOZART/IFS](#)

- Parameter**
- [Ozone](#)
 - [Nitrogen Monoxide](#)
 - [Nitrogen Dioxide](#)

- Level**
- [Surface](#)
 - [500m](#)
 - [1000m](#)
 - [3000m](#)

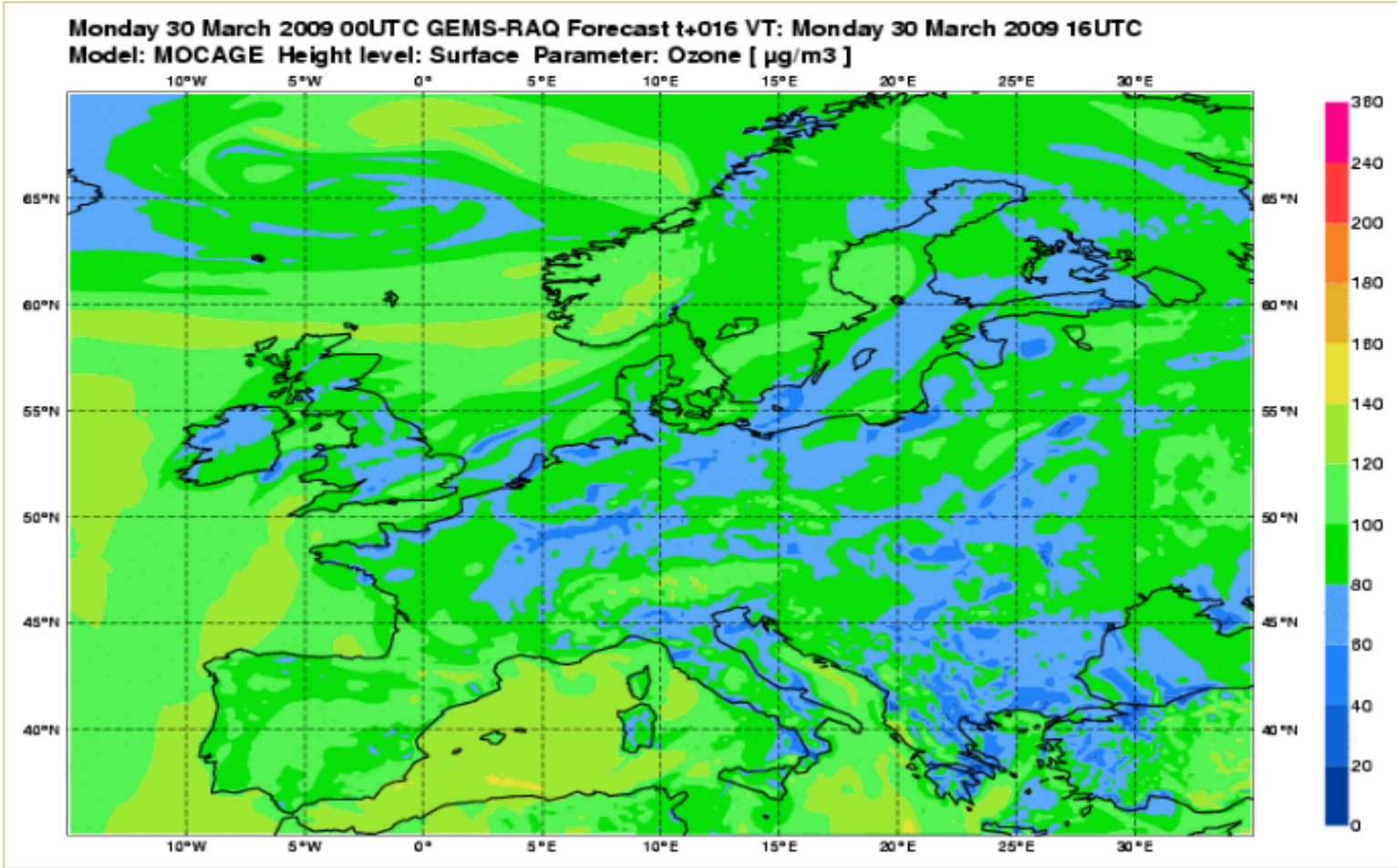
Base time finder

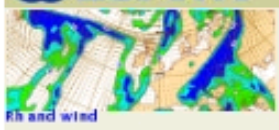
Forecast base times with forecast valid for the displayed valid time: **Mon 30 Mar 16UTC**

[Mon 30 Mar 00UTC](#)

Step (-> valid time)
[16 \(Mon 30 Mar 2009 16UTC\)](#)

Forecast base time
[Mon 30 Mar 2009 00UTC](#)





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Nitrogen Dioxide

Ensemble Forecasts
[Ensemble Fields](#)
[Epsgrams](#)

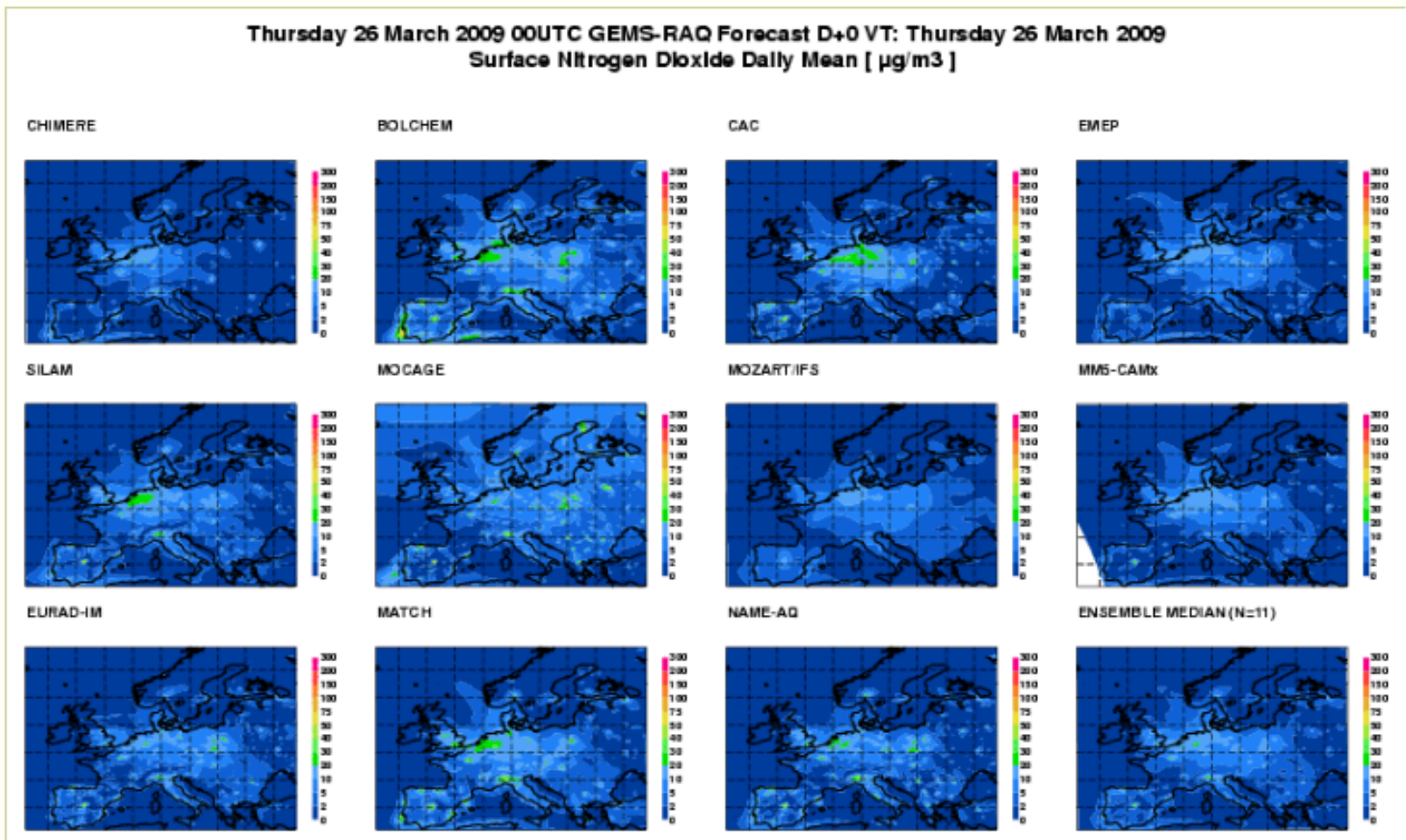
Day Forecast base time
Day 0 Thu 26 Mar 2009 00UTC

RAQ Ensemble

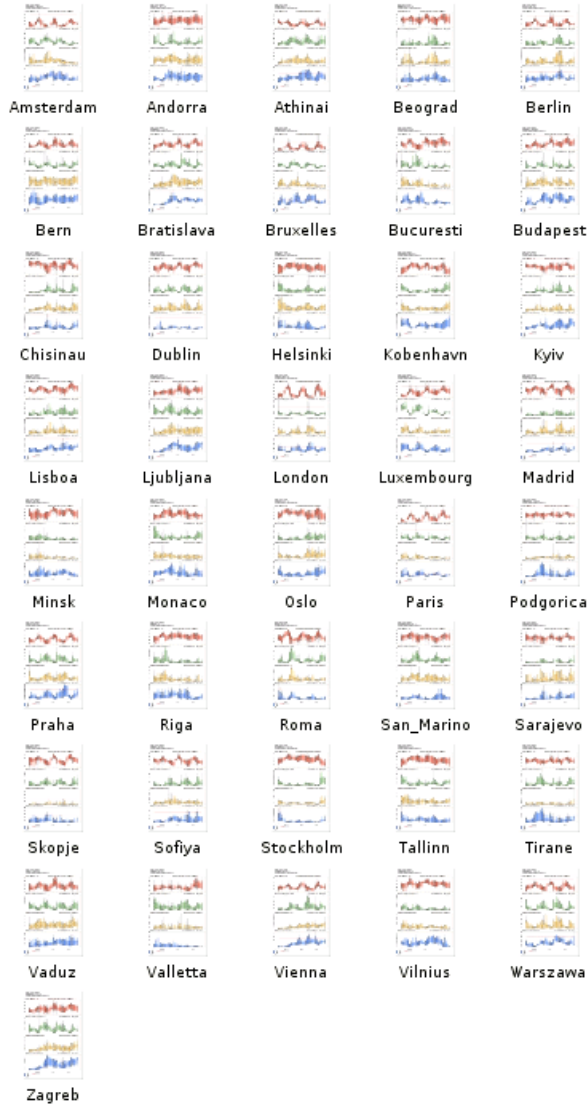
Ensemble Fields
[Ozone](#)
[Nitrogen Dioxide](#)
[Sulphur Dioxide](#)
[Carbon Monoxide](#)
[PM10 Aerosol](#)
[Air Quality Index](#)

Model
[All](#)
[Ensemble Median](#)
[CHIMERE](#)
[BOLCHEM](#)
[CAC](#)
[EMEP](#)
[SILAM](#)
[MOCAGE](#)
[MOZART/IFS](#)
[MM5-CAMx](#)
[EURAD-IM](#)
[MATCH](#)
[NAME-AQ](#)

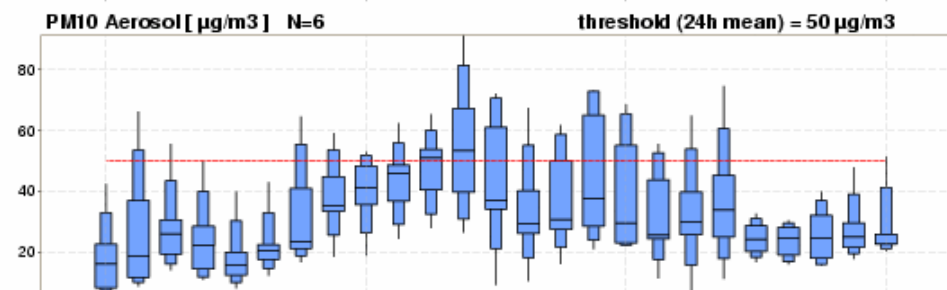
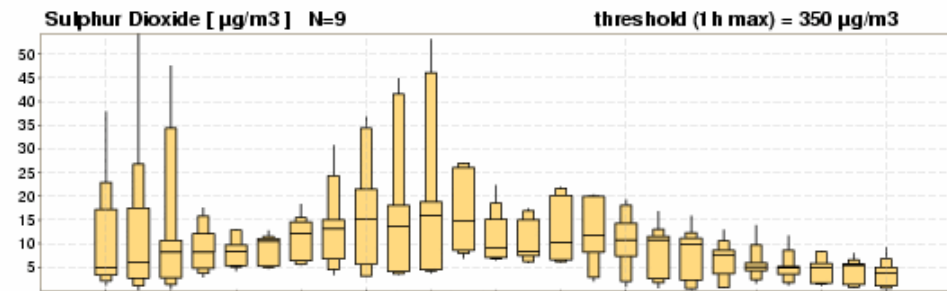
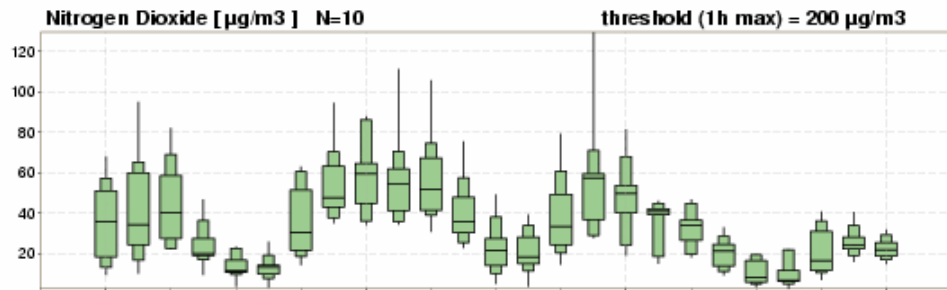
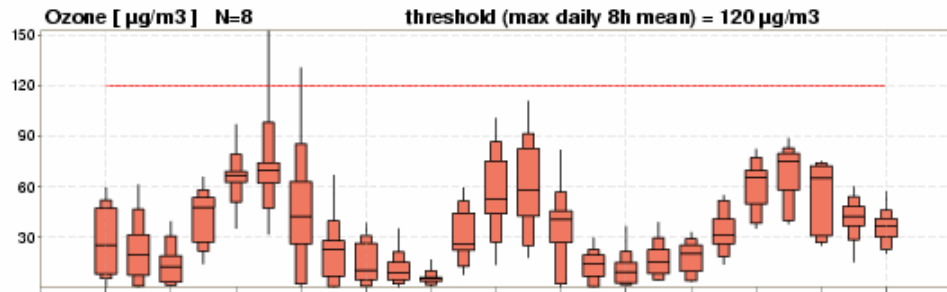
Parameter
[Daily Mean](#)
[Daily Maximum](#)



RAQ Epsgrams



GEMS RAQ EPSGRAM
 Amsterdam(52.37° N, 4.89° E)
 Forecast Monday 30 March 2009 00 UTC



Forecast Validation Products

Sulphur Dioxide

Observation and Model Values

Type

- [Mean Scores](#)
- [Timeseries](#)
- [Taylor Diagrams](#)
- [Observations vs Forecasts](#)
- [OMI NO2 Total Columns](#)

Parameter

- [Ozone](#)
- [Nitrogen Dioxide](#)
- [Sulphur Dioxide](#)
- [Carbon Monoxide](#)
- [PM10](#)

Model

- [CHIMERE](#)
- [BOLCHEM](#)
- [CAC](#)
- [EMEP](#)
- [SILAM](#)
- [MOCAGE](#)
- [MM5-CAMx](#)
- [EURAD-IM](#)
- [MATCH](#)
- [NAME-AQ](#)

Your Room

- [Add this product](#)

Show overview

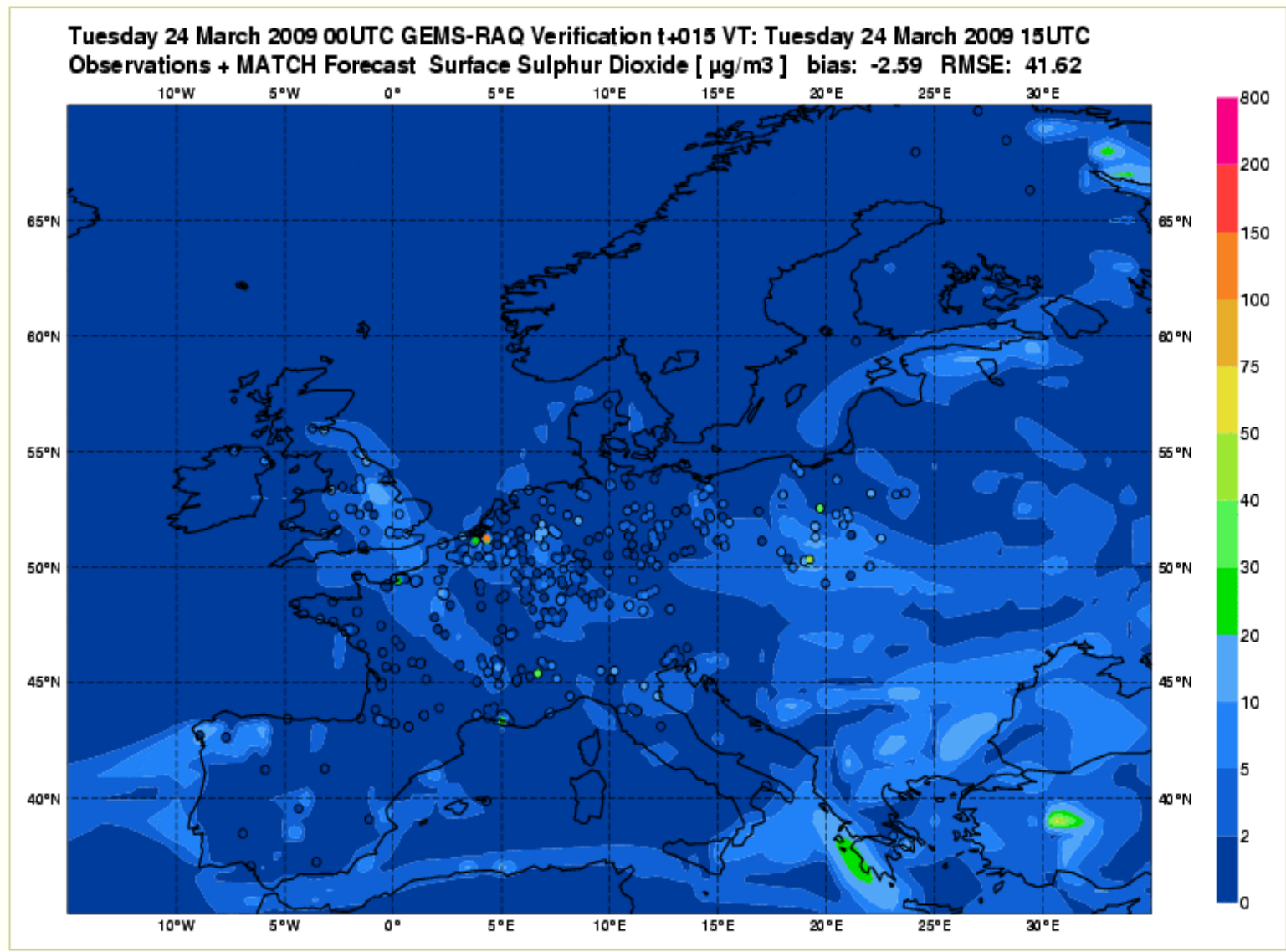
- [Model](#)

Time

Forecast base time

15

Tue 24 Mar 2009 00UTC



Type

- [Mean Scores](#)
- [Timeseries](#)
- [Taylor Diagrams](#)
- [Observations vs Forecasts](#)
- [OMI NO2 Total Columns](#)

Forecast base time

Sun 29 Mar 2009 00UTC

Parameter

- [Ozone](#)
- [Nitrogen Dioxide](#)
- [Sulphur Dioxide](#)
- [Carbon Monoxide](#)
- [PM10 Aerosol](#)

Score

- [Bias](#)
- [Modified Mean Bias](#)
- [Root Mean Square Error](#)
- [Fractional Gross Error](#)

Forecast step

3

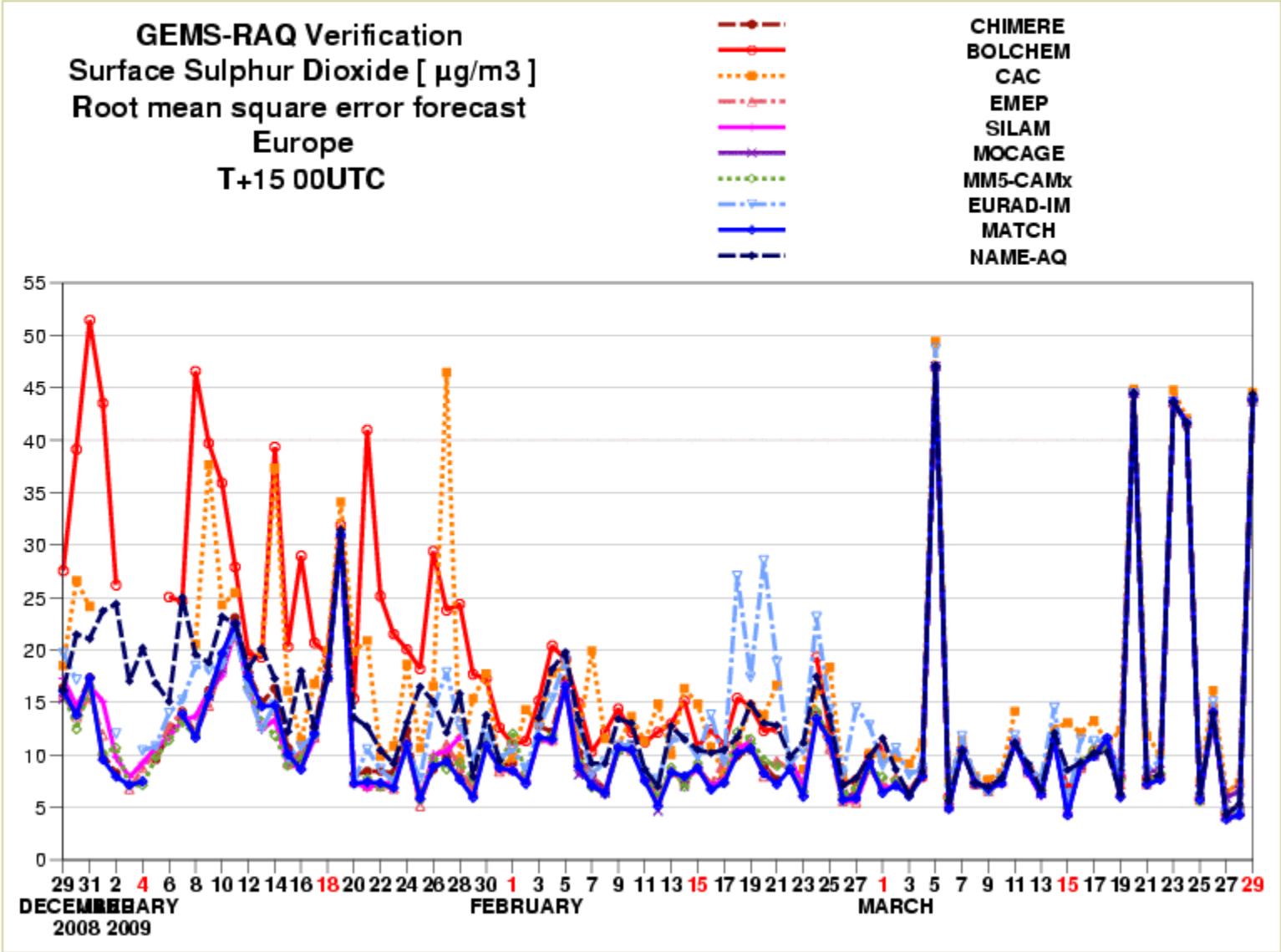
15

Period

- [Last Week](#)
- [Last Three Months](#)

Your Room

[Add this product](#)



Mean Scores

Mean Scores

Type

[Mean Scores](#)

[Timeseries](#)

[Taylor Diagrams](#)

[Observations vs Forecasts](#)

[OMI NO2 Total Columns](#)

Parameter

[Ozone](#)

[Nitrogen Dioxide](#)

[Sulphur Dioxide](#)

[Carbon Monoxide](#)

[PM10 Aerosol](#)

Score

[Bias](#)

[Modified Mean Bias](#)

[Bias](#)

[Root Mean Square Error](#)

[Fractional Gross Error](#)

Period

[Last Week](#)

[Last Three Months](#)

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Show overview

[Parameter](#)

[Score](#)

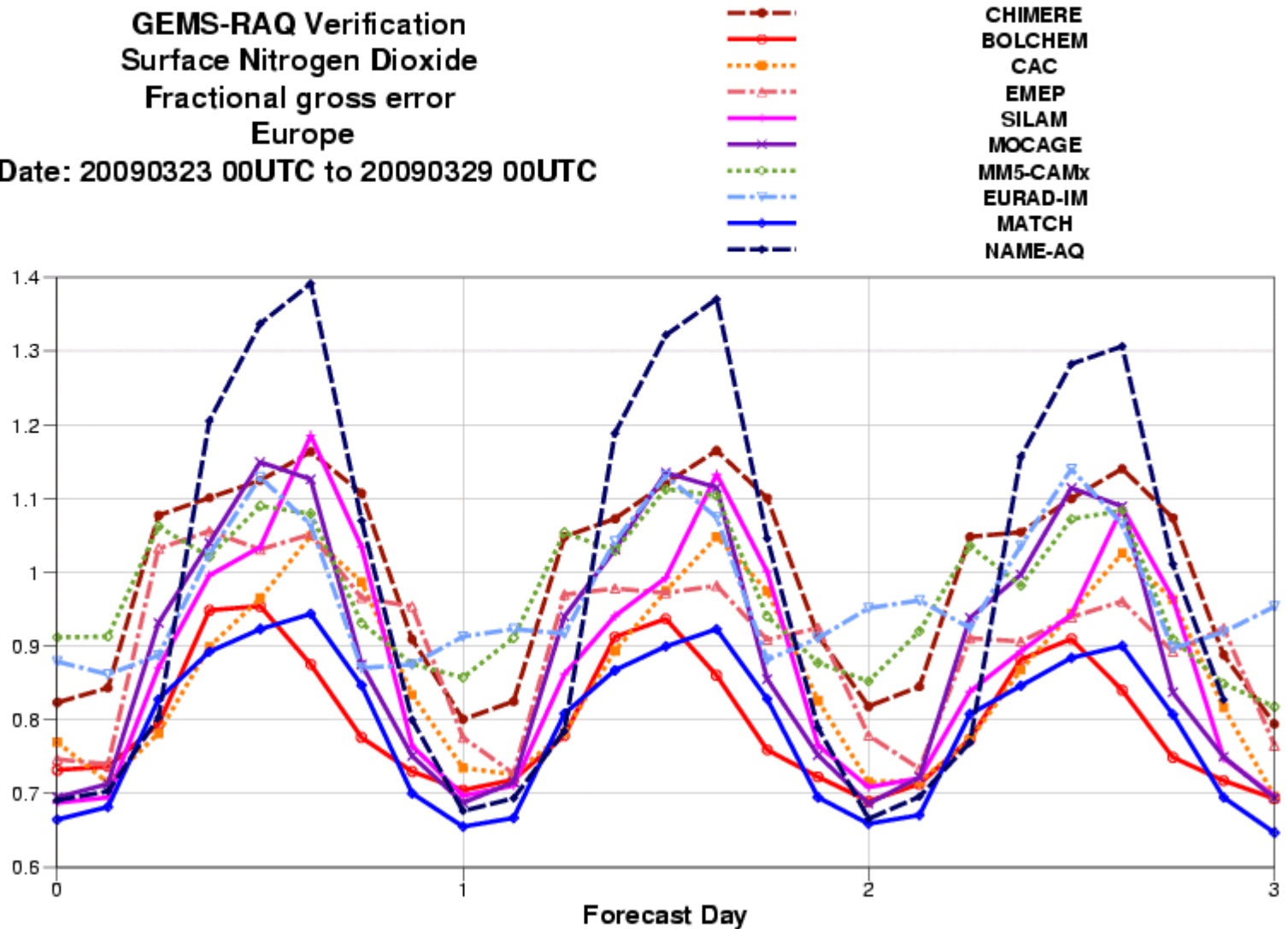
Forecast base

time

Sun 29 Mar 2009 00UTC

GEMS-RAQ Verification Surface Nitrogen Dioxide Fractional gross error Europe

Date: 20090323 00UTC to 20090329 00UTC



Taylor Diagrams

Taylor Diagrams

- Type
- [Mean Scores](#)
 - [Timeseries](#)
 - [Taylor Diagrams](#)
 - [Observations vs Forecasts](#)
 - [OMI NO2 Total Columns](#)

- Parameter
- [Ozone](#)
 - [Nitrogen Dioxide](#)
 - [Sulphur Dioxide](#)
 - [Carbon Monoxide](#)
 - [PM10 Aerosol](#)

- Period
- [Last Day](#)
 - [Last Week](#)
 - [Last Three Months](#)

Base time finder

Forecast base times with forecast valid for the displayed valid time: **Thu 26 Mar 15UTC**

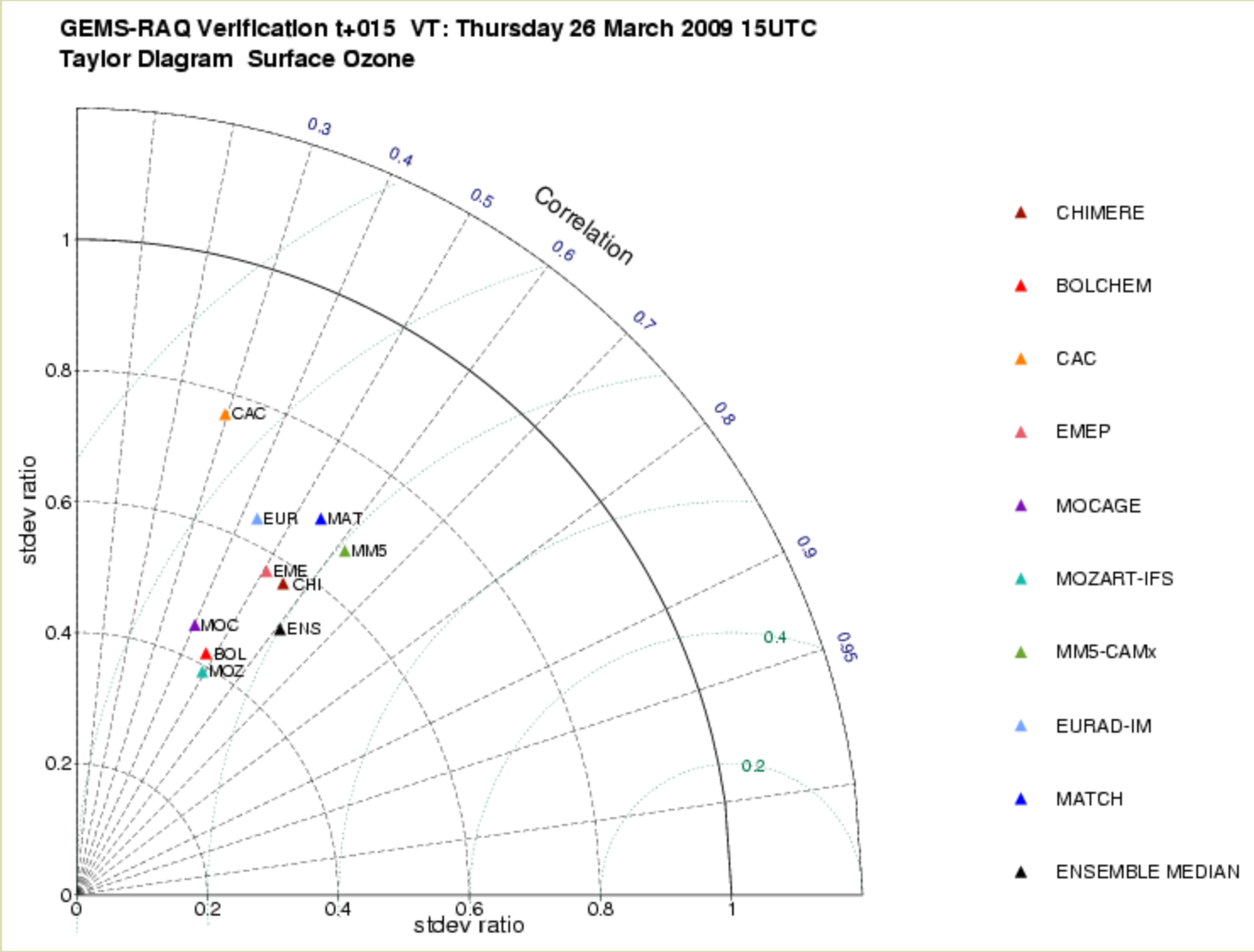
Thu 26 Mar 00UTC

Open in new window

Your Room

Step (-> valid time) [▲▼▼] Forecast base time [▲▼▼]

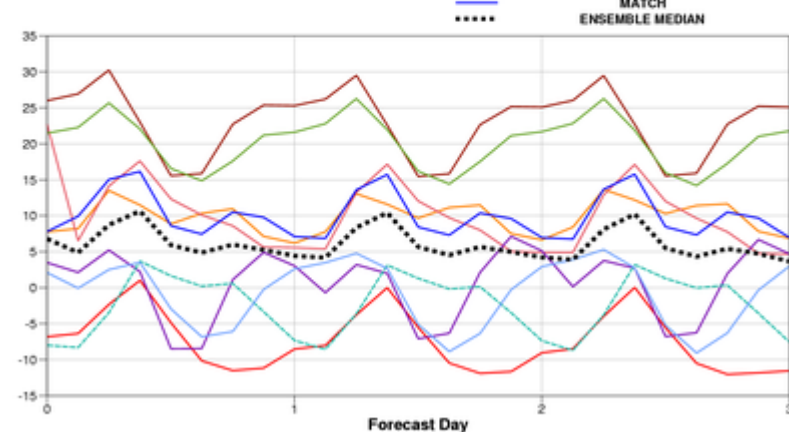
15 (Thu 26 Mar 2009 15UTC) [▼] Thu 26 Mar 2009 00UTC [▼]



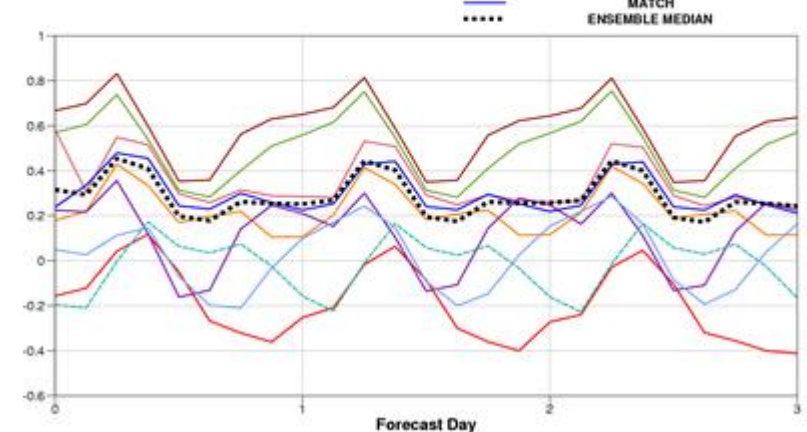
A Sample of Overall Scores

Mean plots - Ozone

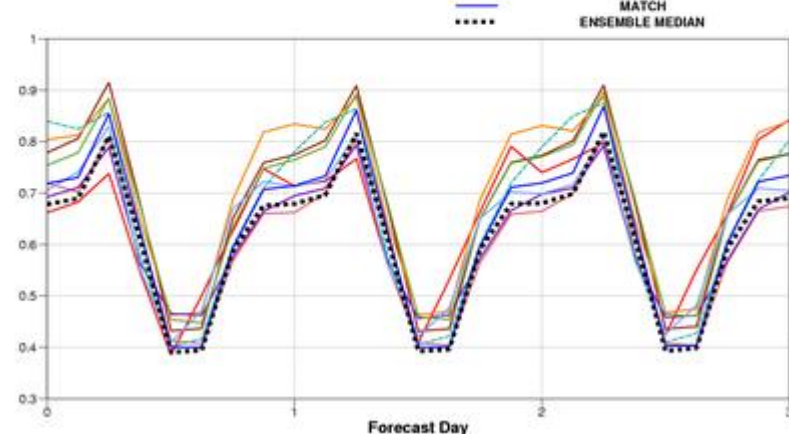
GEMS-RAQ Verification
Surface Ozone [$\mu\text{g}/\text{m}^3$]
Mean error forecast
Europe
 Date: 20080611 00UTC to 20090325 00UTC



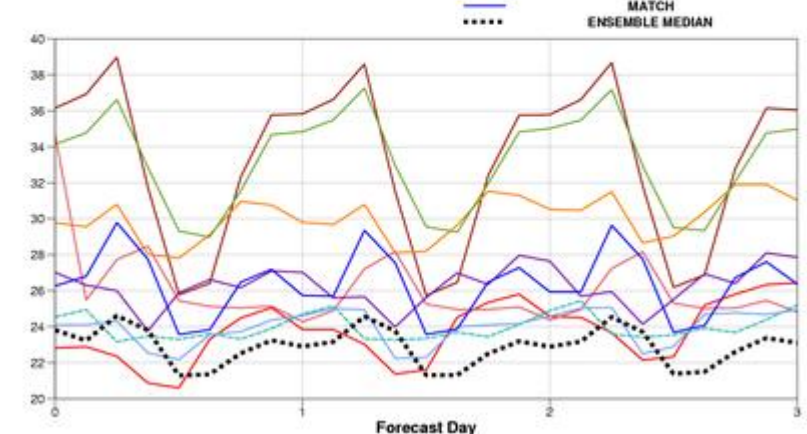
GEMS-RAQ Verification
Surface Ozone
Modified mean bias
Europe
 Date: 20080611 00UTC to 20090325 00UTC



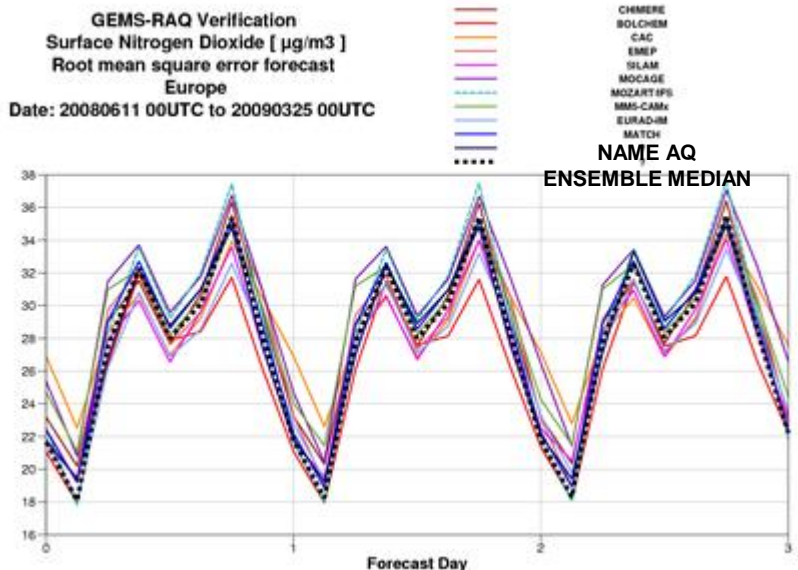
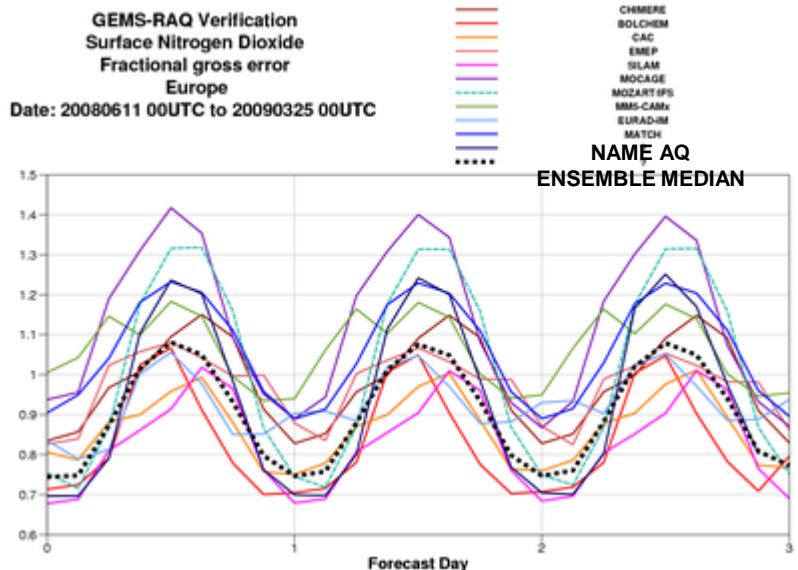
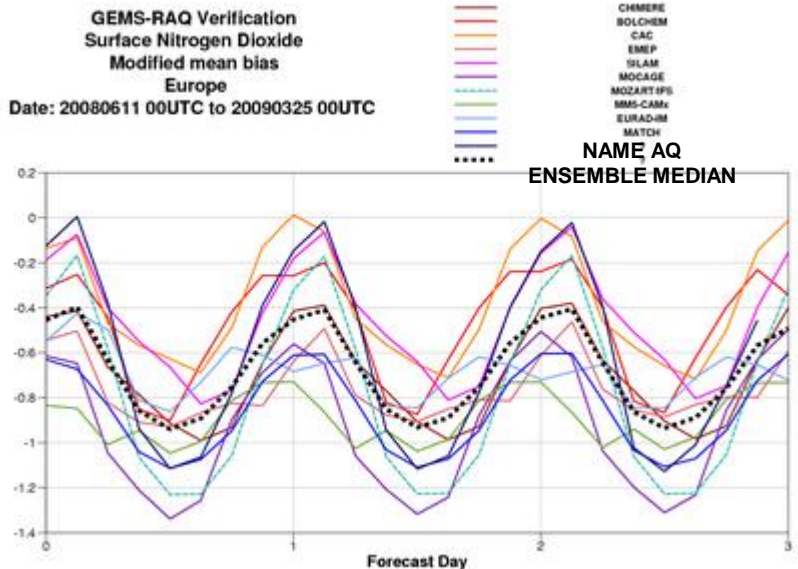
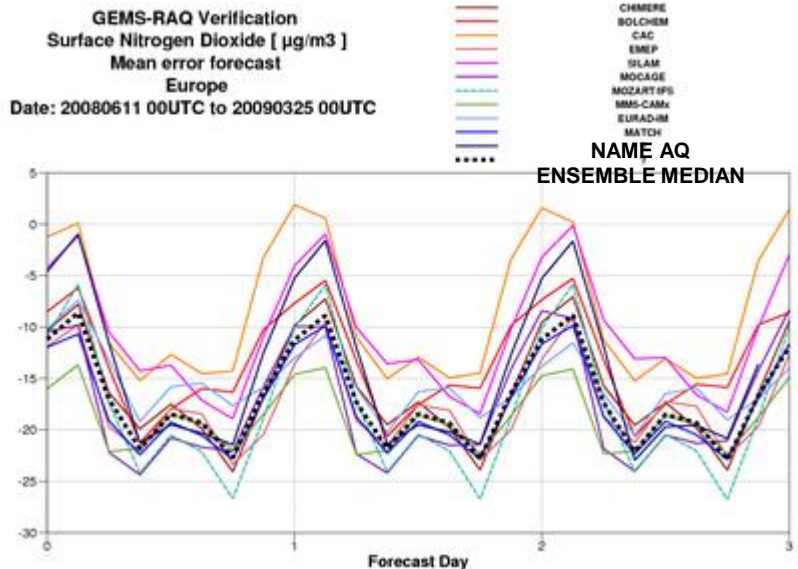
GEMS-RAQ Verification
Surface Ozone
Fractional gross error
Europe
 Date: 20080611 00UTC to 20090325 00UTC



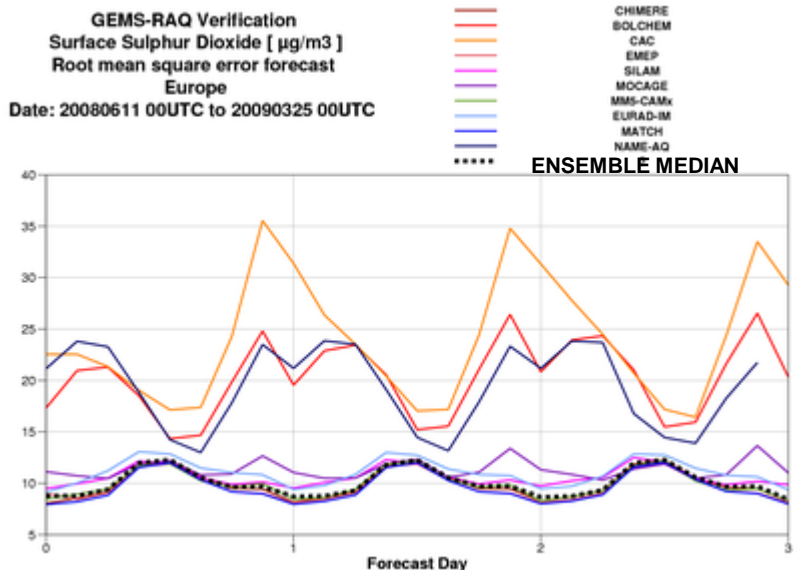
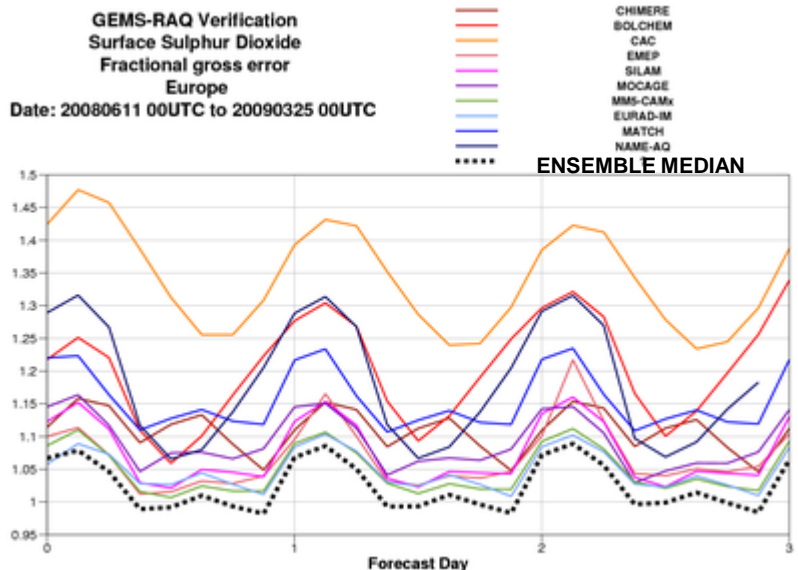
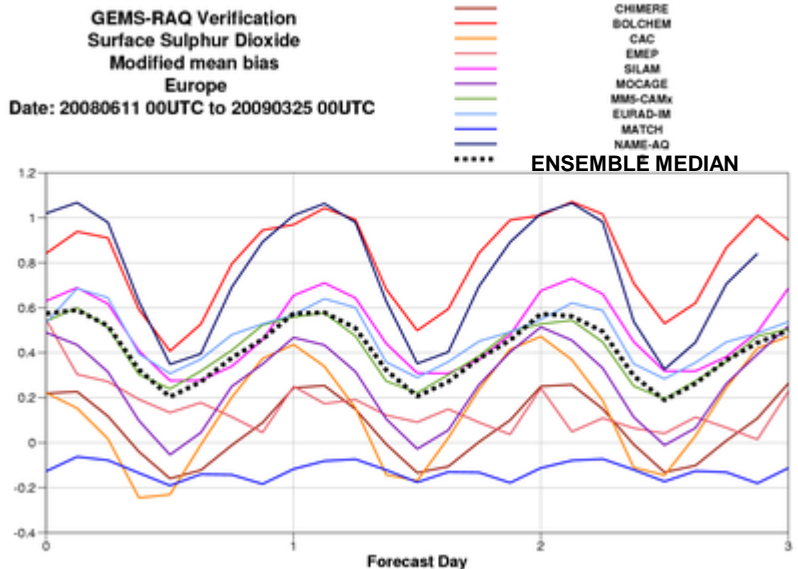
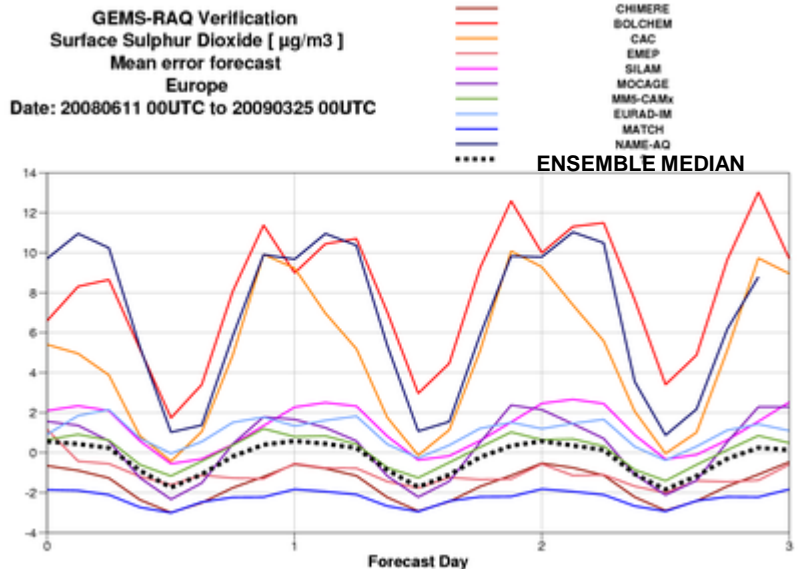
GEMS-RAQ Verification
Surface Ozone [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
 Date: 20080611 00UTC to 20090325 00UTC



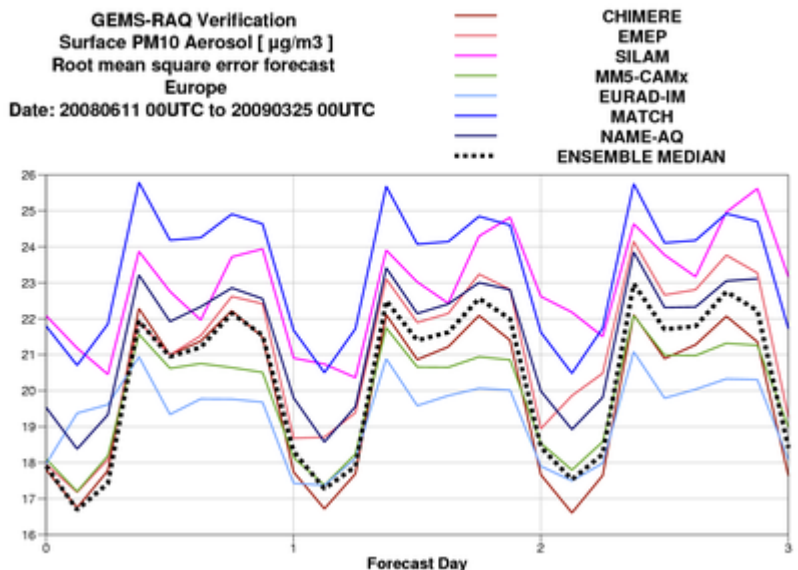
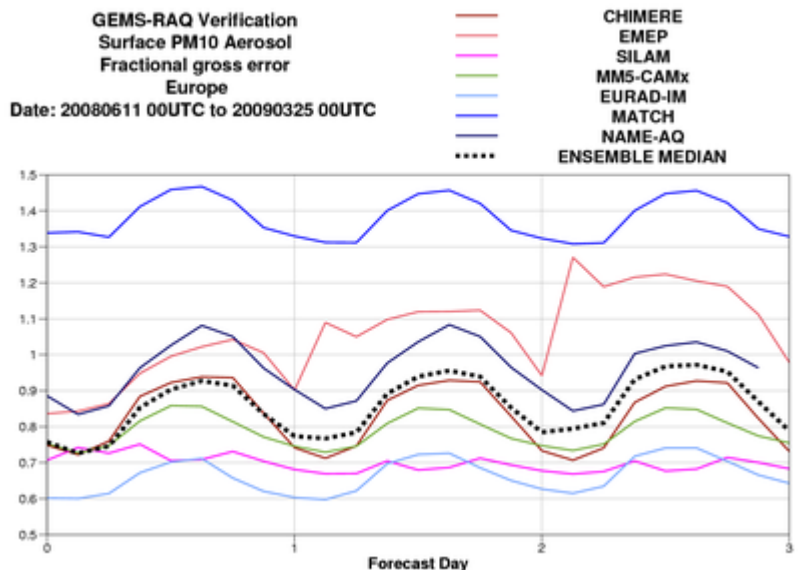
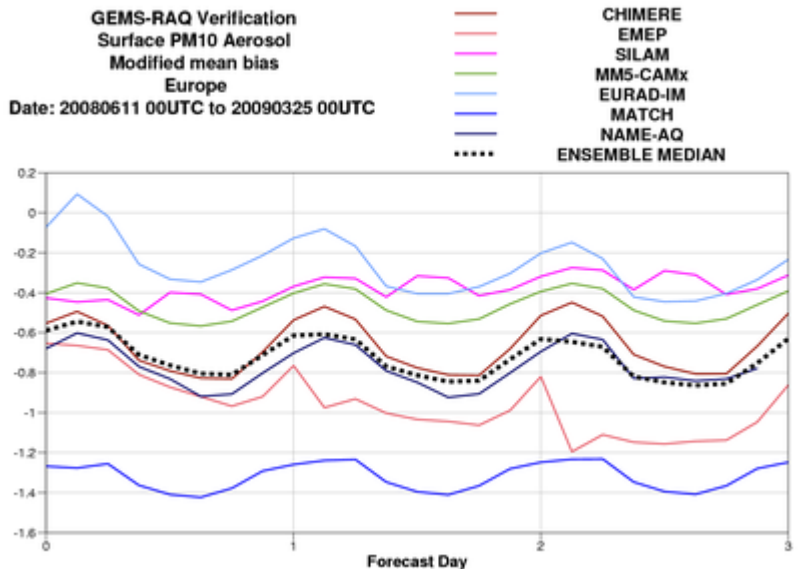
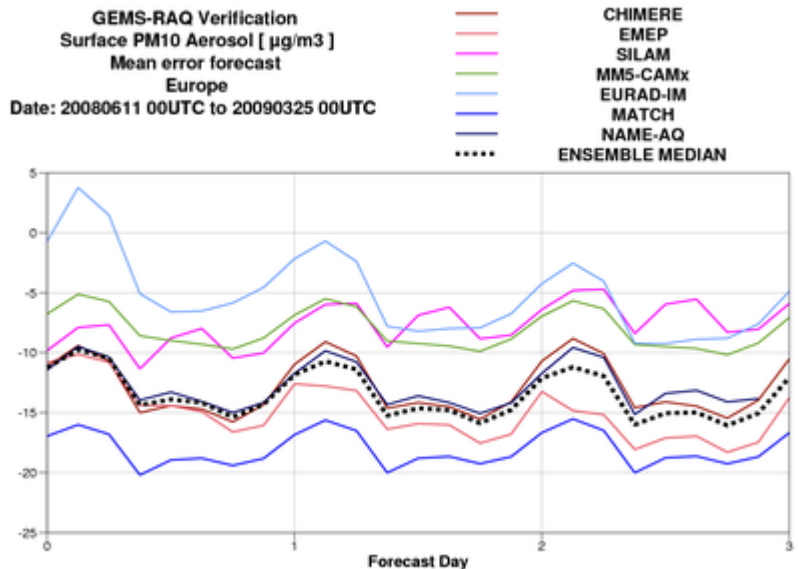
Mean plots – Nitrogen Dioxide



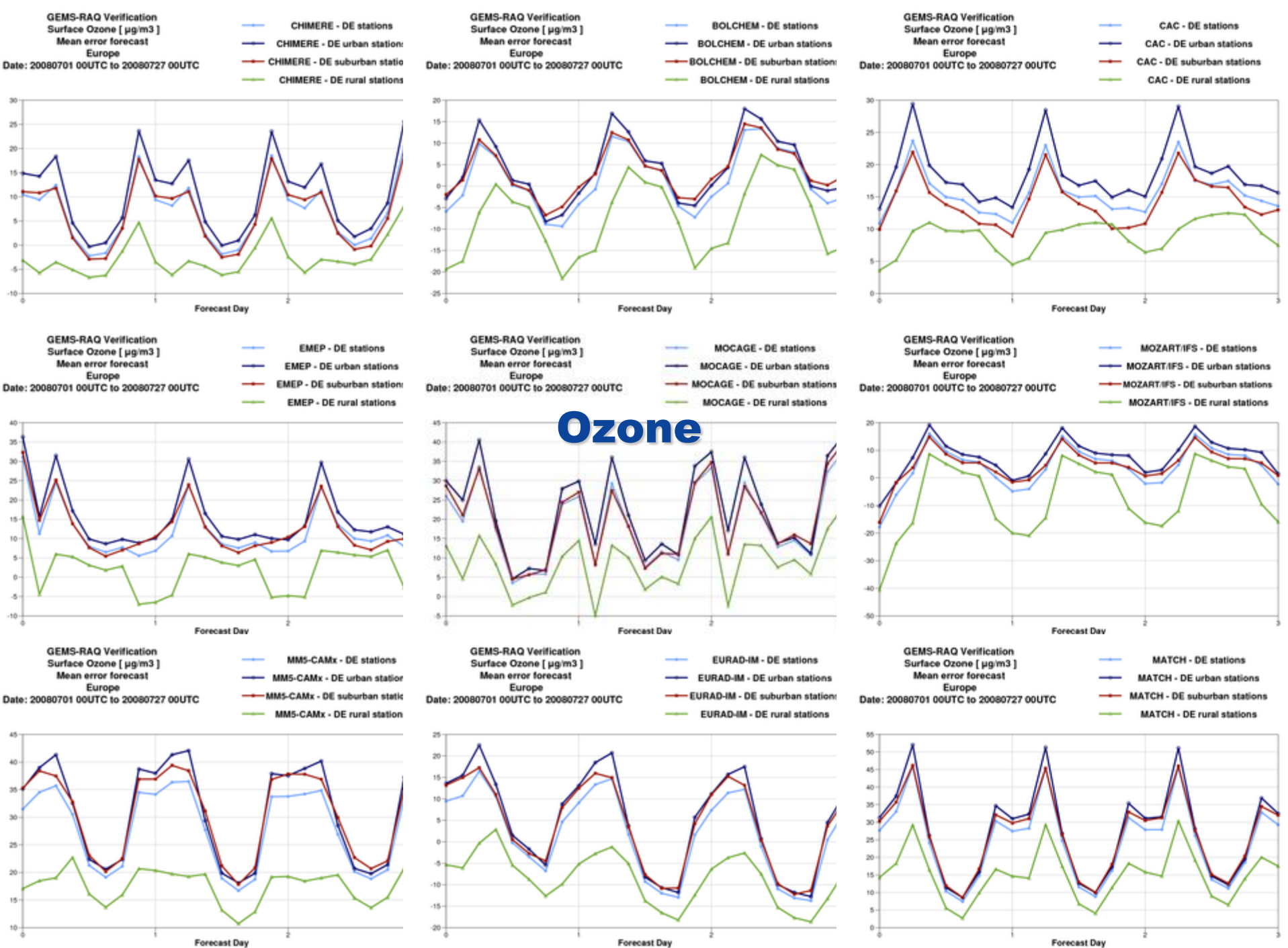
Mean plots – Sulphur Dioxide



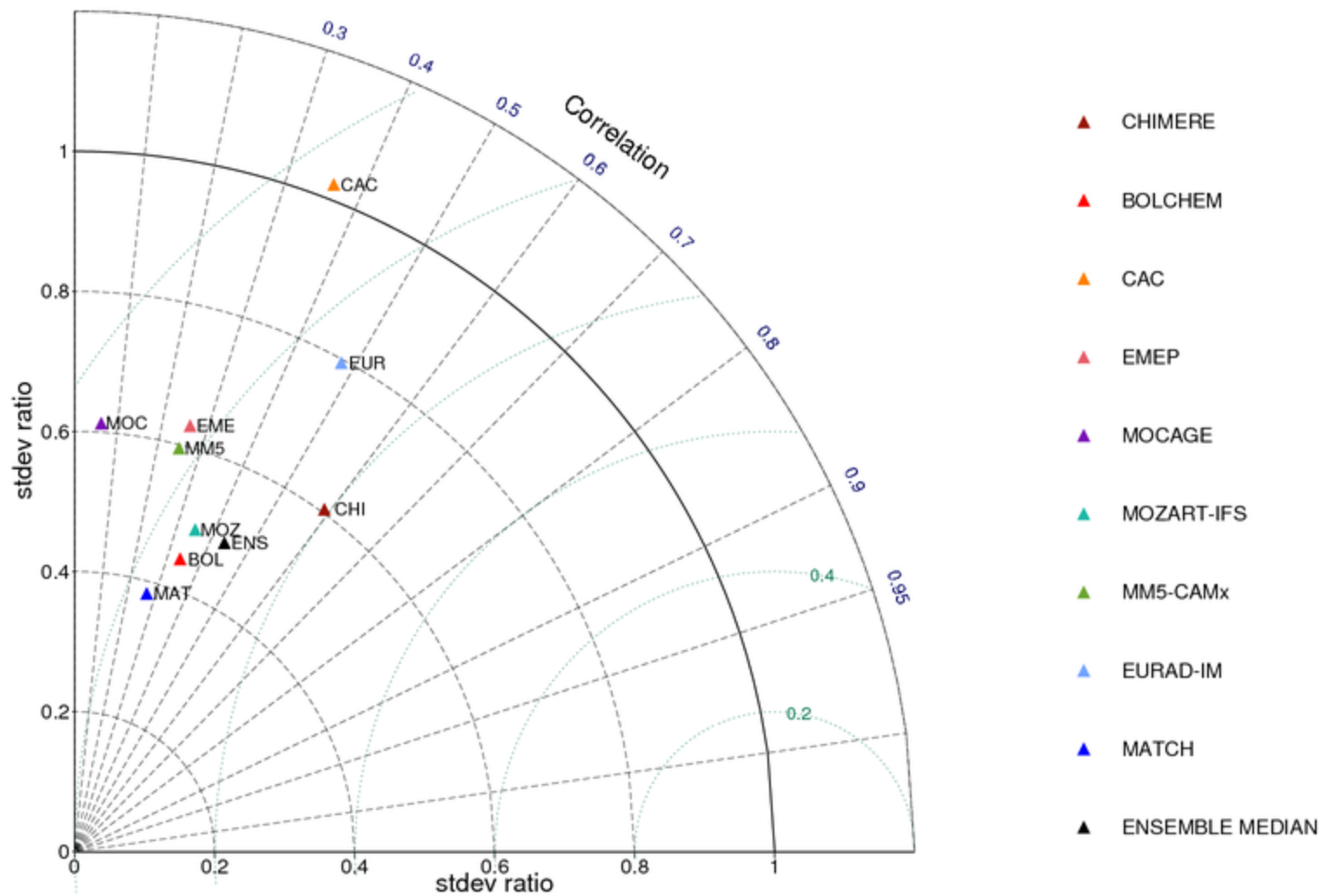
Mean plots – PM₁₀ Aerosol



Scores by Area Type

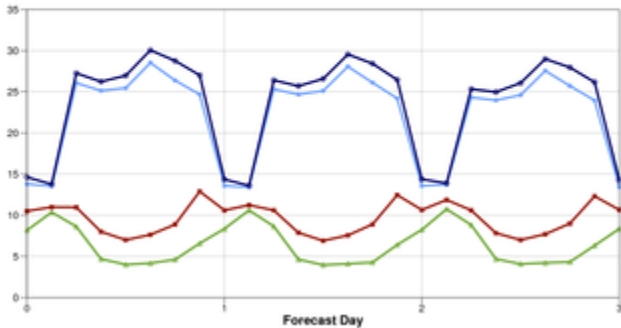


GEMS-RAQ Verification t+015 Date: 20080701 00UTC to 20080727 00UTC
 Taylor Diagram Surface Ozone rural stations



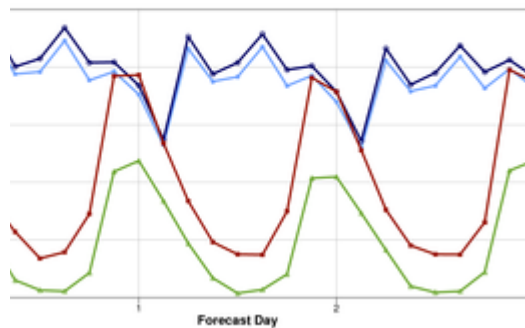
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- CHIMERE - DE stations
- CHIMERE - DE urban stations
- CHIMERE - DE suburban stations
- CHIMERE - DE rural stations



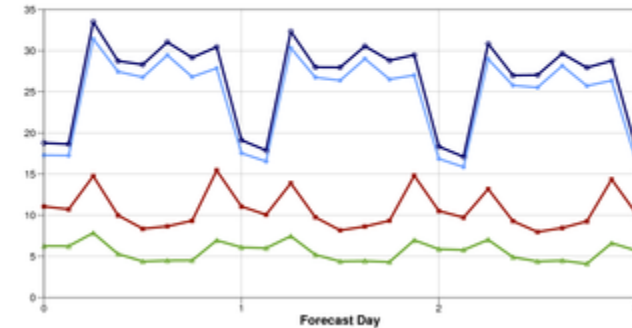
S-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
in square error forecast
Europe
1 00UTC to 20080727 00UTC

- CAC - DE stations
- CAC - DE urban stations
- CAC - DE suburban stations
- CAC - DE rural stations



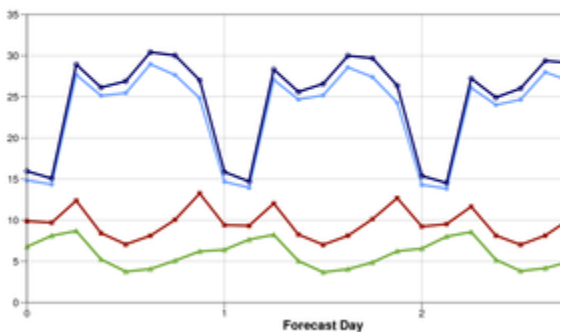
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- EMEP - DE stations
- EMEP - DE urban stations
- EMEP - DE suburban stations
- EMEP - DE rural stations



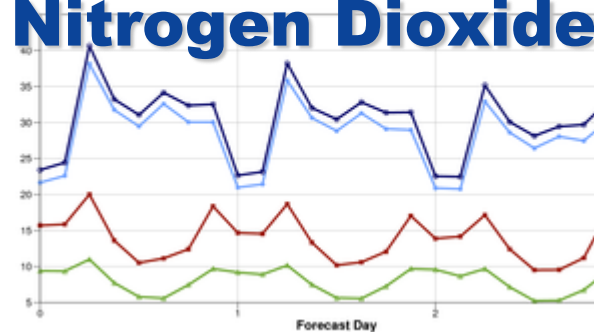
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- SILAM - DE station
- SILAM - DE urban stat
- SILAM - DE suburban st
- SILAM - DE rural stati



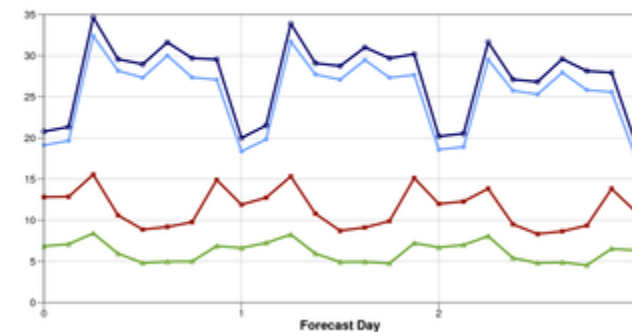
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- MOCAGE - DE stations
- MOCAGE - DE urban station
- MOCAGE - DE suburban station
- MOCAGE - DE rural station



GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

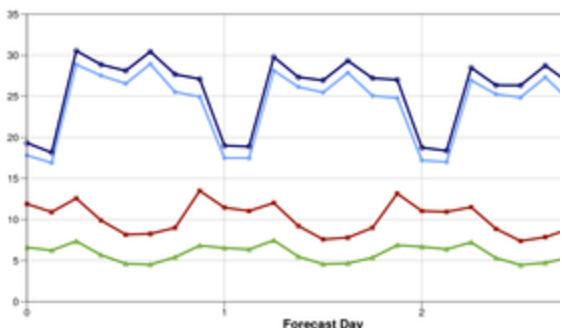
- MMS-CAMx - DE stations
- MMS-CAMx - DE urban stations
- MMS-CAMx - DE suburban stations
- MMS-CAMx - DE rural stations



Nitrogen Dioxide

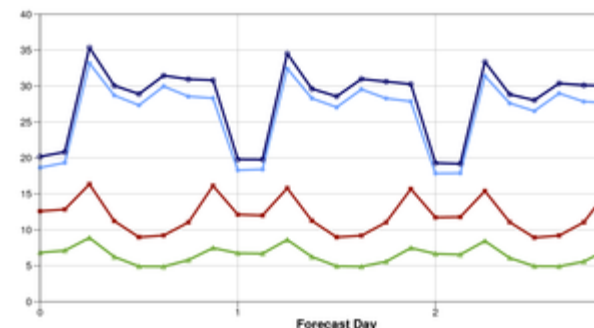
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- EURAD-IM - DE statk
- EURAD-IM - DE urban st
- EURAD-IM - DE suburban
- EURAD-IM - DE rural sti



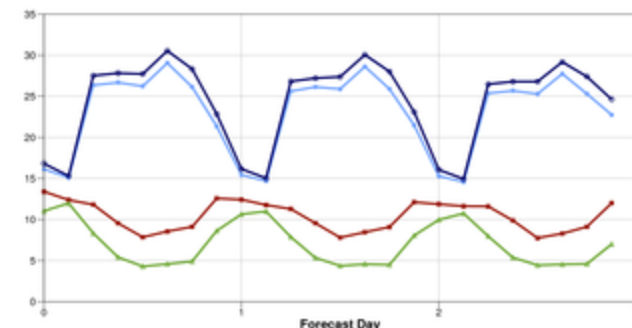
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- MATCH - DE stations
- MATCH - DE urban station
- MATCH - DE suburban station
- MATCH - DE rural stations

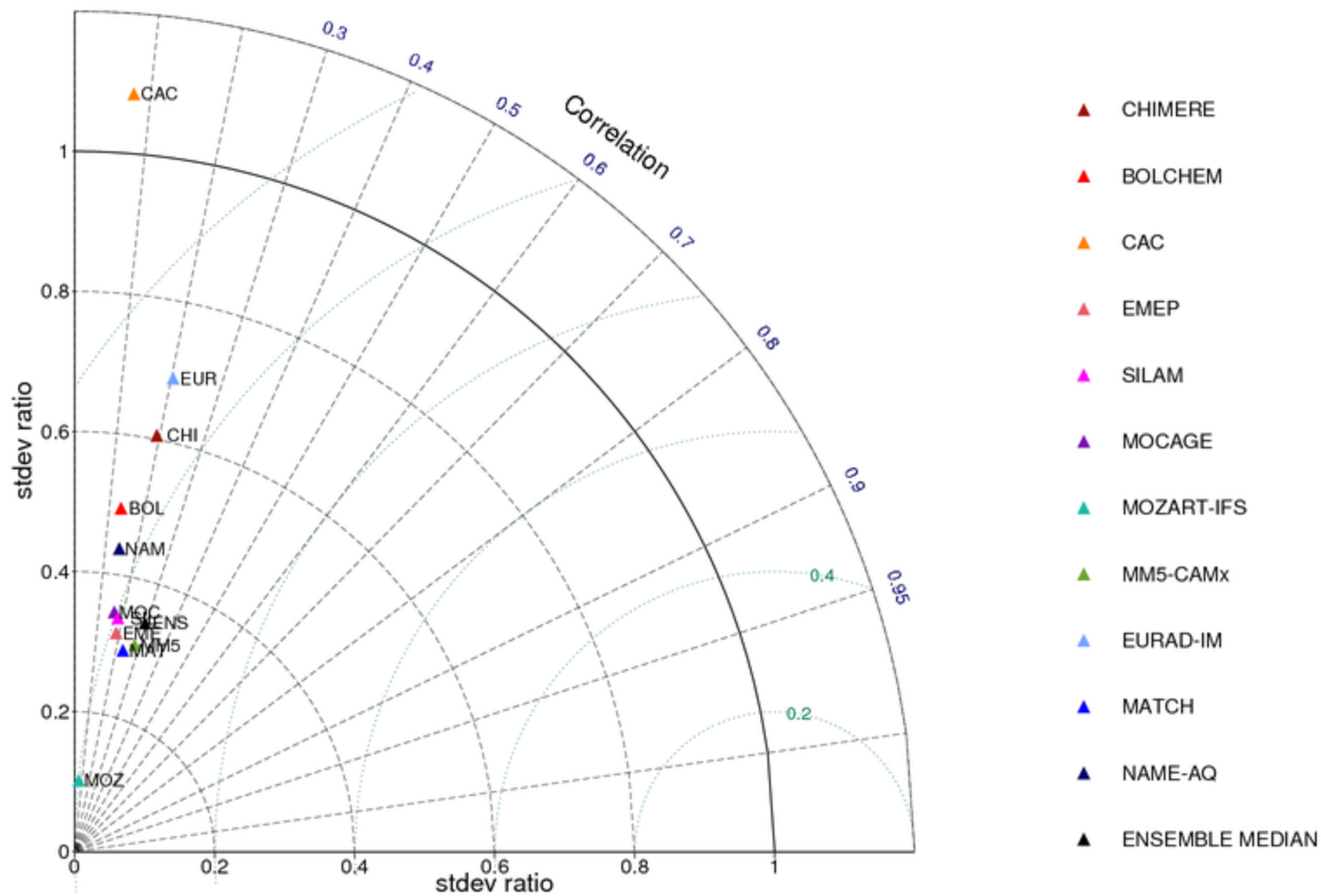


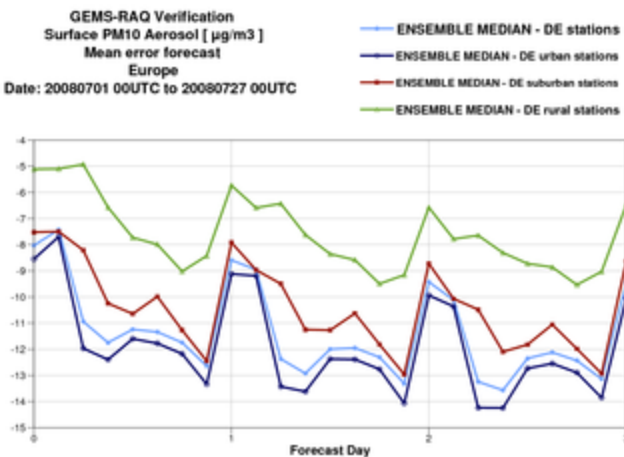
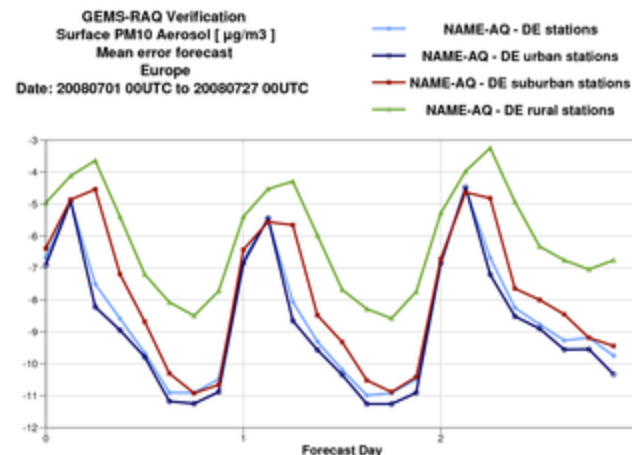
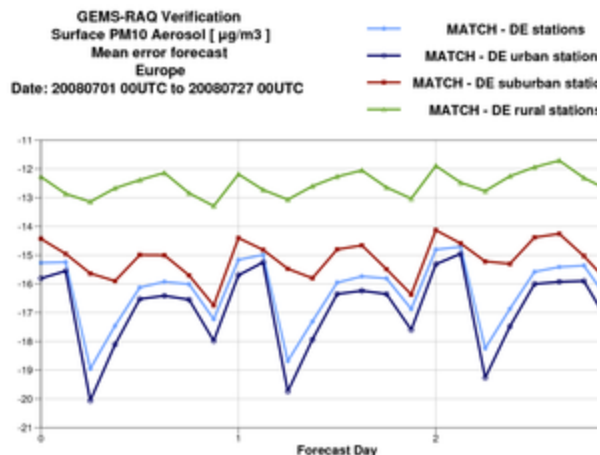
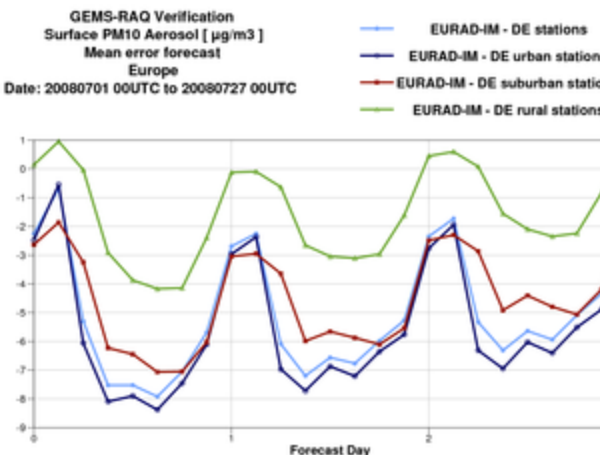
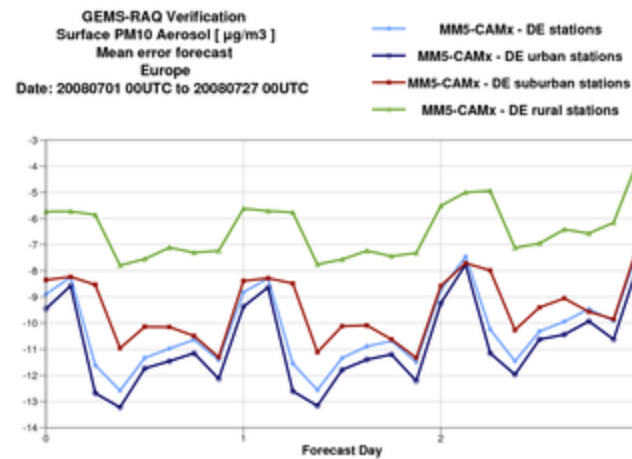
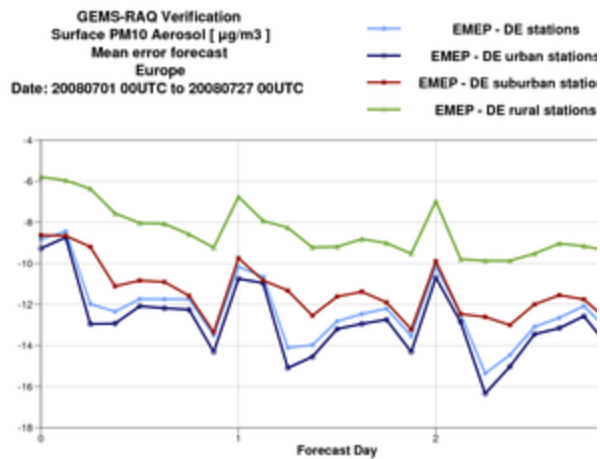
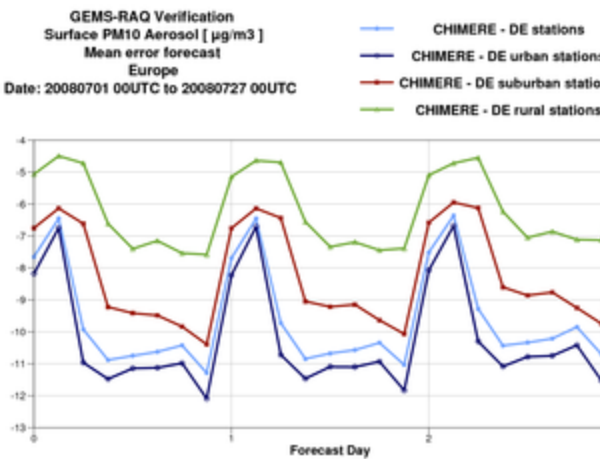
GEMS-RAQ Verification
Surface Nitrogen Dioxide [$\mu\text{g}/\text{m}^3$]
Root mean square error forecast
Europe
Date: 20080701 00UTC to 20080727 00UTC

- NAME-AQ - DE stations
- NAME-AQ - DE urban stations
- NAME-AQ - DE suburban stations
- NAME-AQ - DE rural stations

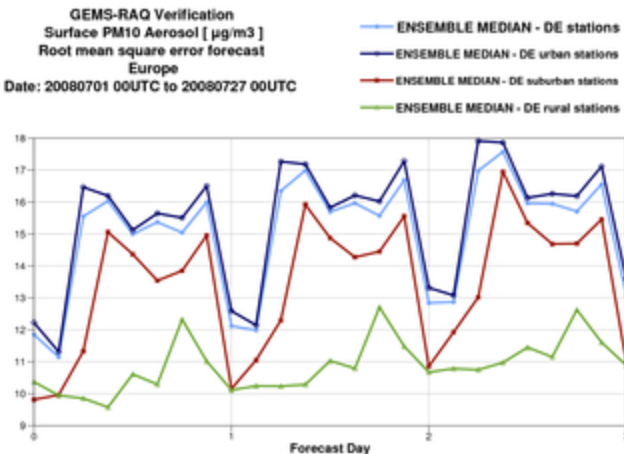
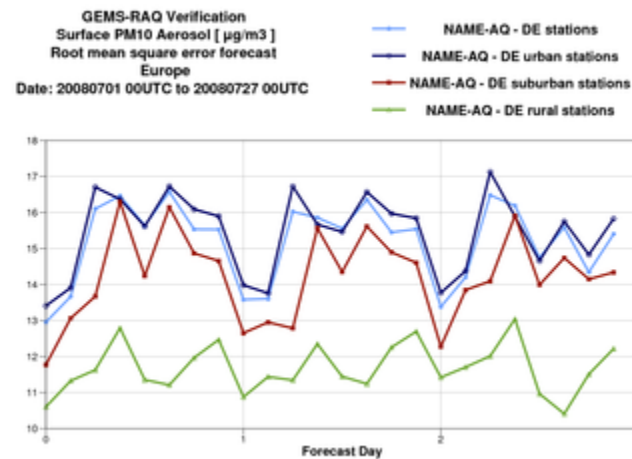
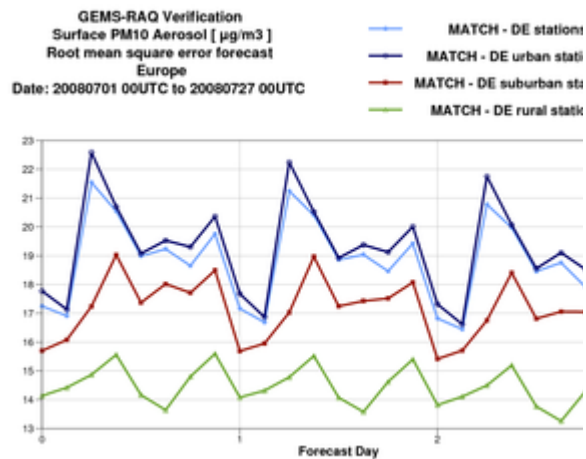
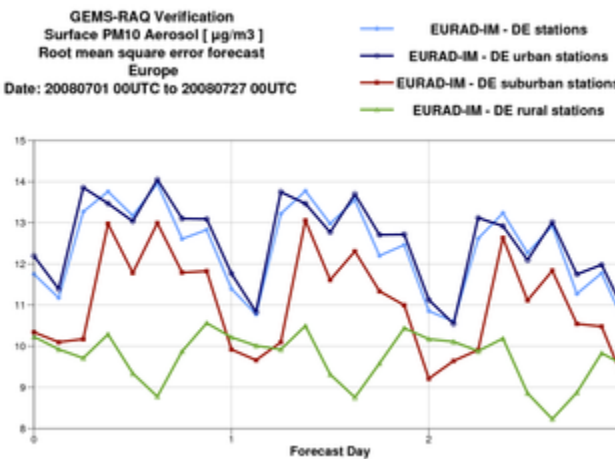
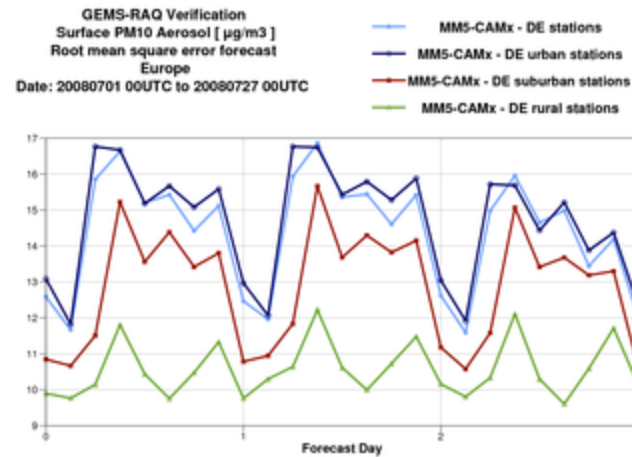
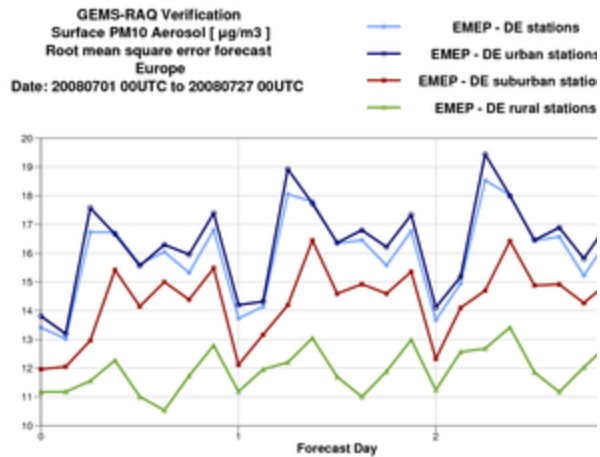
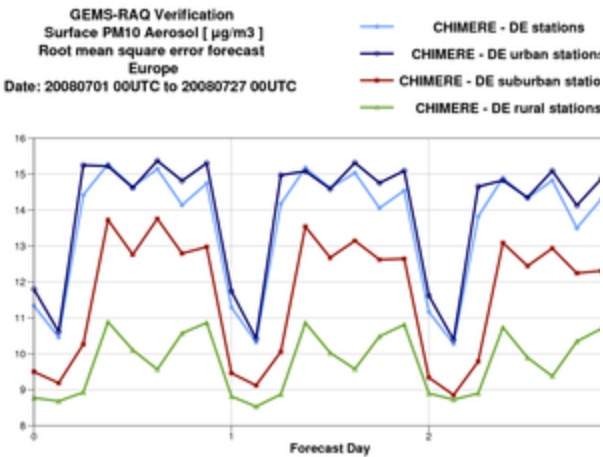


GEMS-RAQ Verification t+015 Date: 20080701 00UTC to 20080727 00UTC
 Taylor Diagram Surface Nitrogen Dioxide rural stations



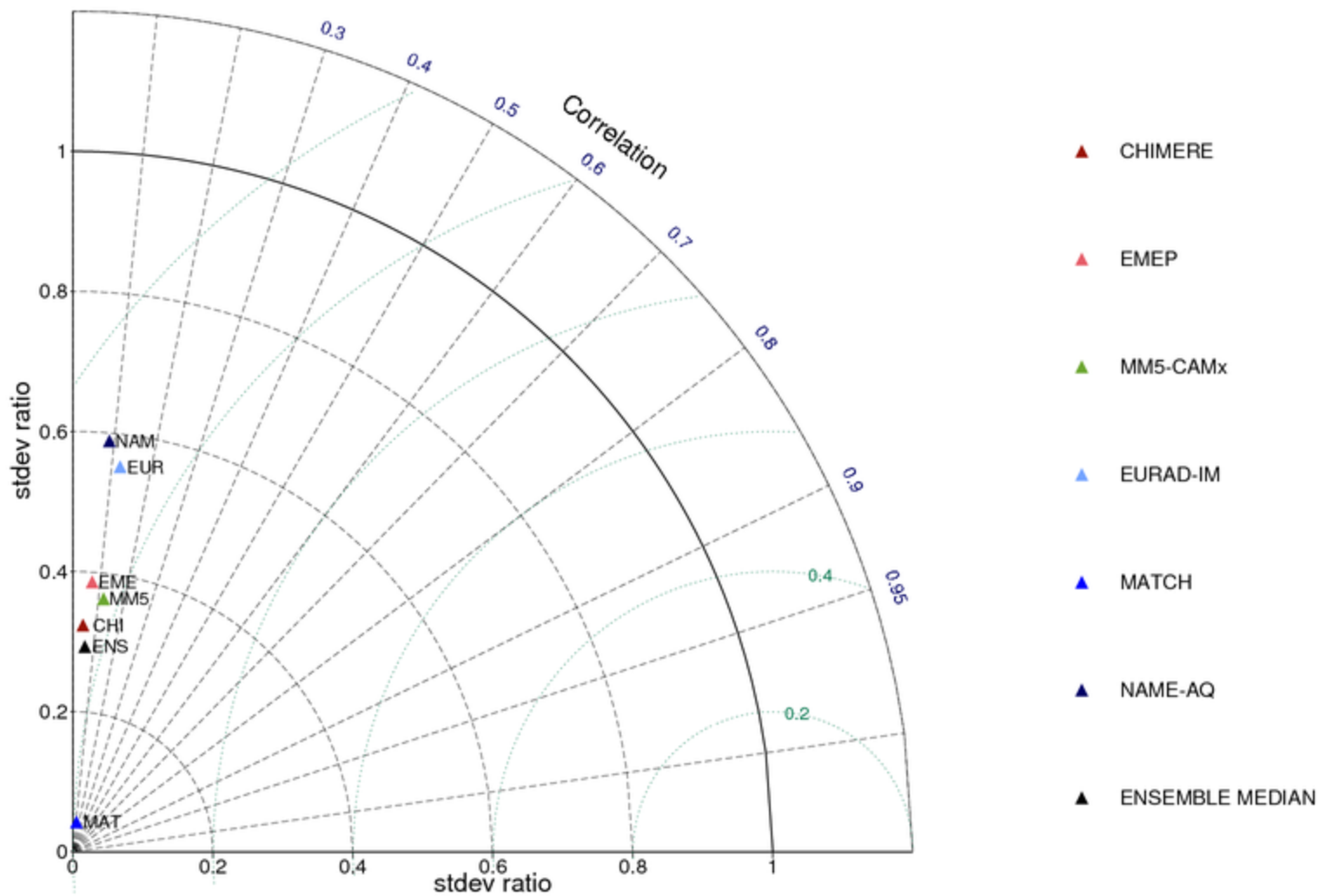


PM₁₀ aerosol bias



PM₁₀ aerosol RMSE

GEMS-RAQ Verification t+015 Date: 20080701 00UTC to 20080727 00UTC
Taylor Diagram Surface PM10 Aerosol rural stations



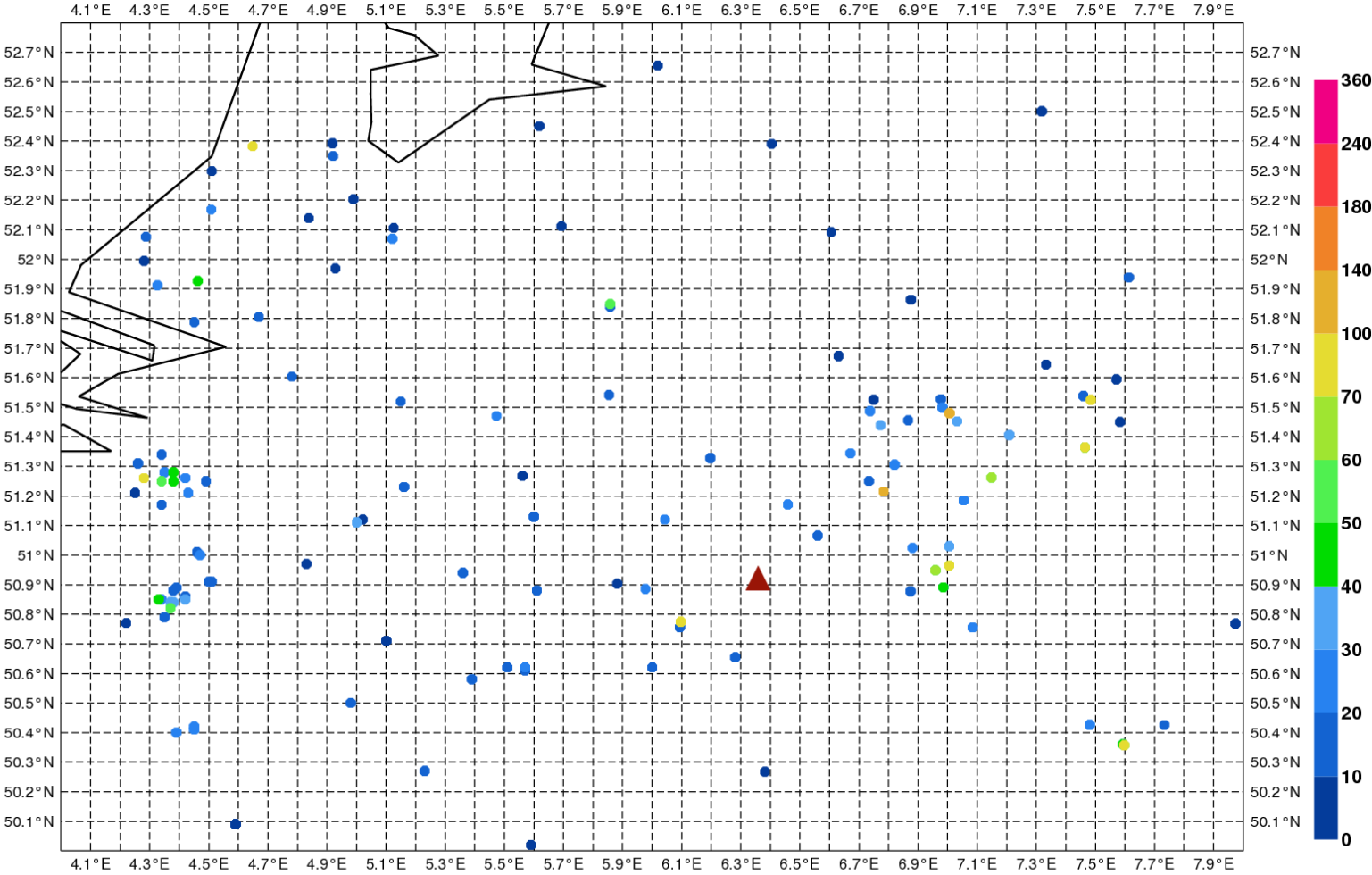
Open questions

- Data is not validated -> normalised scores?
- Scores sensitivity experiments
- Use of suburban and rural stations for some parameters?
- Uneven geographical density distribution -> gridded obs?
- E-suites/parallel runs verification

Observation Density

GEMS-RAQ Observations VT: Tuesday 24 March 2009 15UTC

Surface NO2 [$\mu\text{g}/\text{m}^3$]



Conclusions

- Restrictive observation data policy hindered system development
 - testing bugs fixes
 - computation of some types of scores
 - hindcasts rescoring experiments
 - building station climatologies
- Benefit of common formats
- Useful tool for modellers to track updates and spot problems

GEMS website

<http://gems.ecmwf.int/>

MACC website

<http://www.gmes-atmosphere.eu/>