Lessons learned from using MACC boundary conditions in downstream applications

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Outline

- Use of MACC BC in China Forecast systems
  - ❖ Wuhan Region in China- Hubei
  - ❖ Norwegian Cities - Bedre Byluft forecasts
- Use of MACC BC for scenario analysis – Hindcasts
- MACC BC in Uncertweb project – Ensemble forecasts
- Main lessons learned

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The Hubei project (EuropeAid)

The objective of the project was to establish an up-to-date air quality (AQ) information system for 9 cities in Hubei

➢ provide more accurate and adequate AQ information to the public
➢ develop an air quality forecast demonstration case for Wuhan,
➢ enhance the awareness of AQ status among the public for protecting human health.

Duration: 24 month 项目为期2年
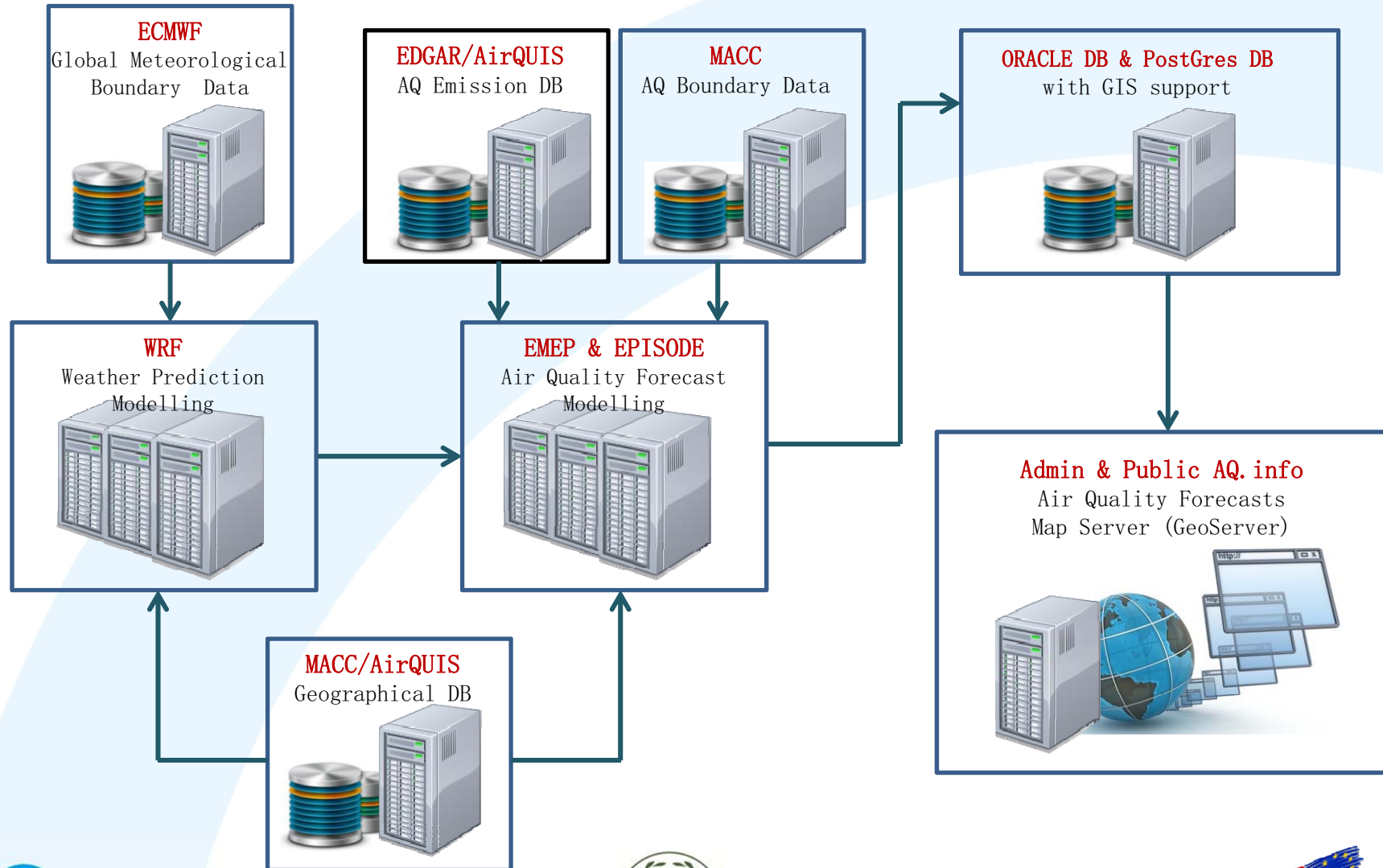Period: 1/12/2012- 1/12/2014

"十二五"重点区域规划范围
CITY CLUSTERS AND KEY AREAS IN CHINA

Hubei

Wuhan "1+8" City Cluster
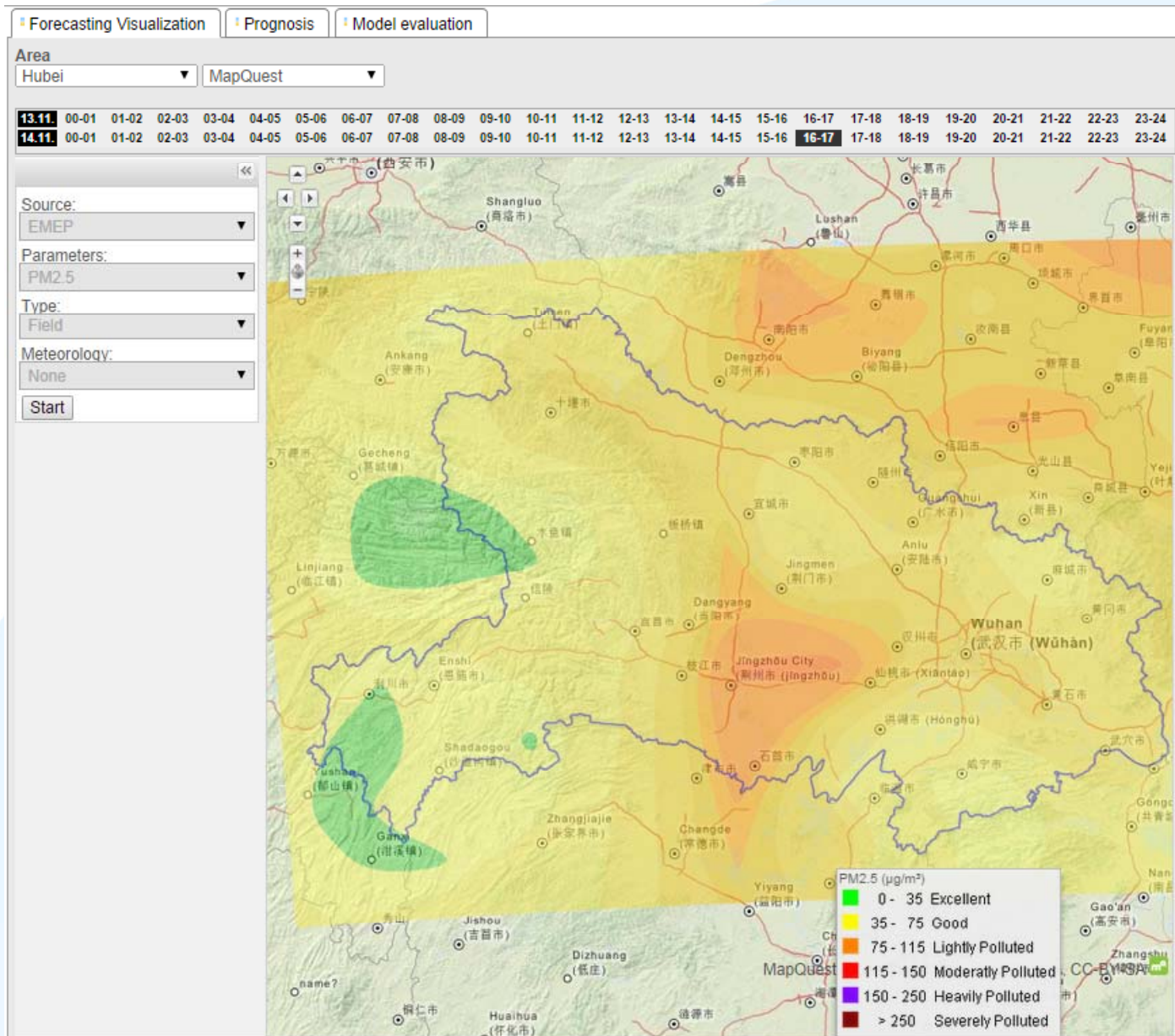
WRF-EMEP Domain（WRF-EMEP模型区域）

WRF-EMEP model domains: two nests (0.5° and 0.1° resolution)

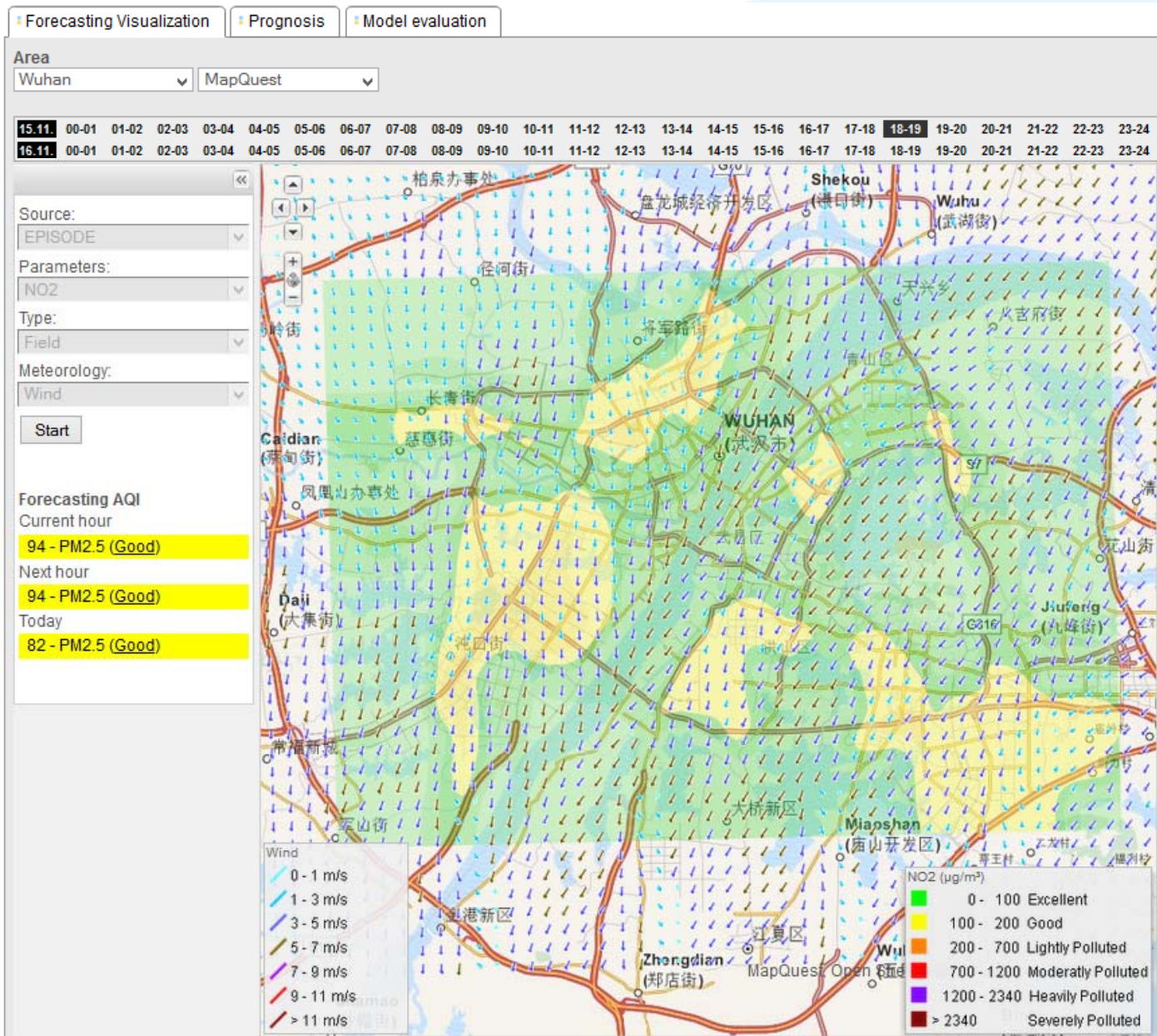*WRF-EPISODE model domains: domains (5km and 1km)*

HB-AQINFO: Hardware and Data Flow Overview

Visualization of forecasting results

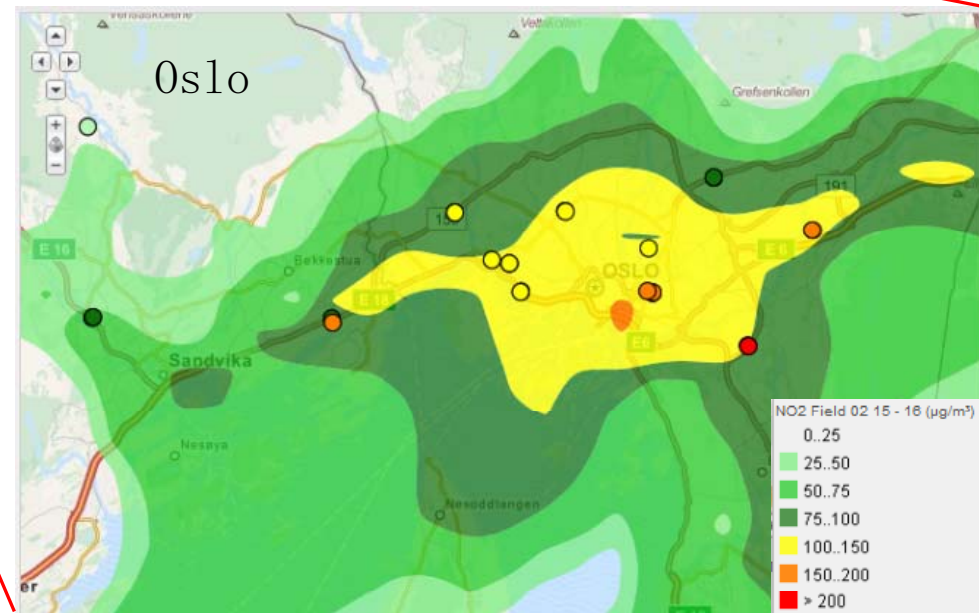# Visualization of forecasting results
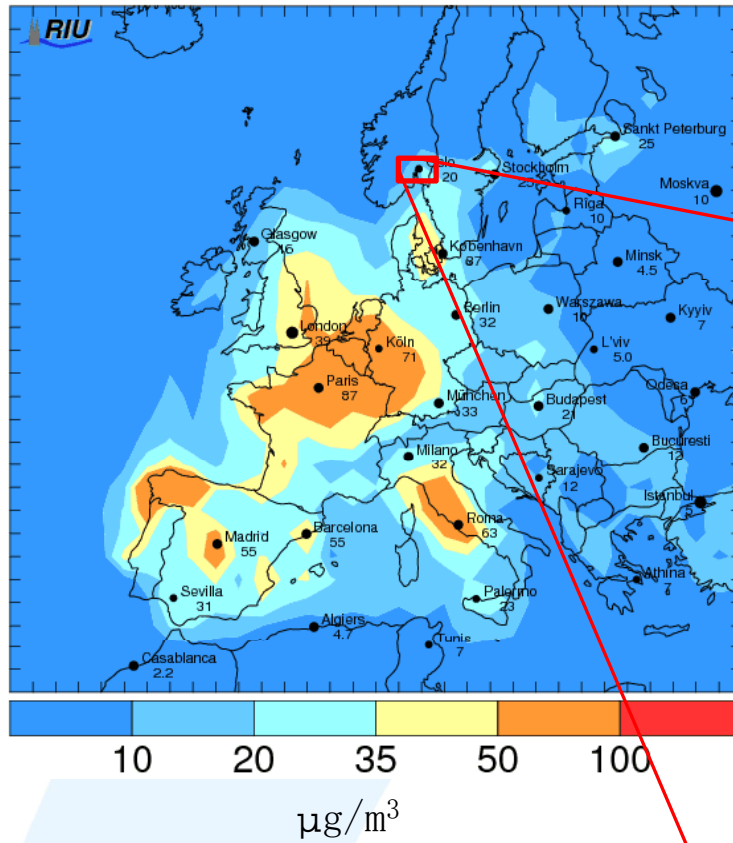
BC from MACC for Hubei project

- Global MACC forecast used as BC for EMEP-WRF 3-day forecasts

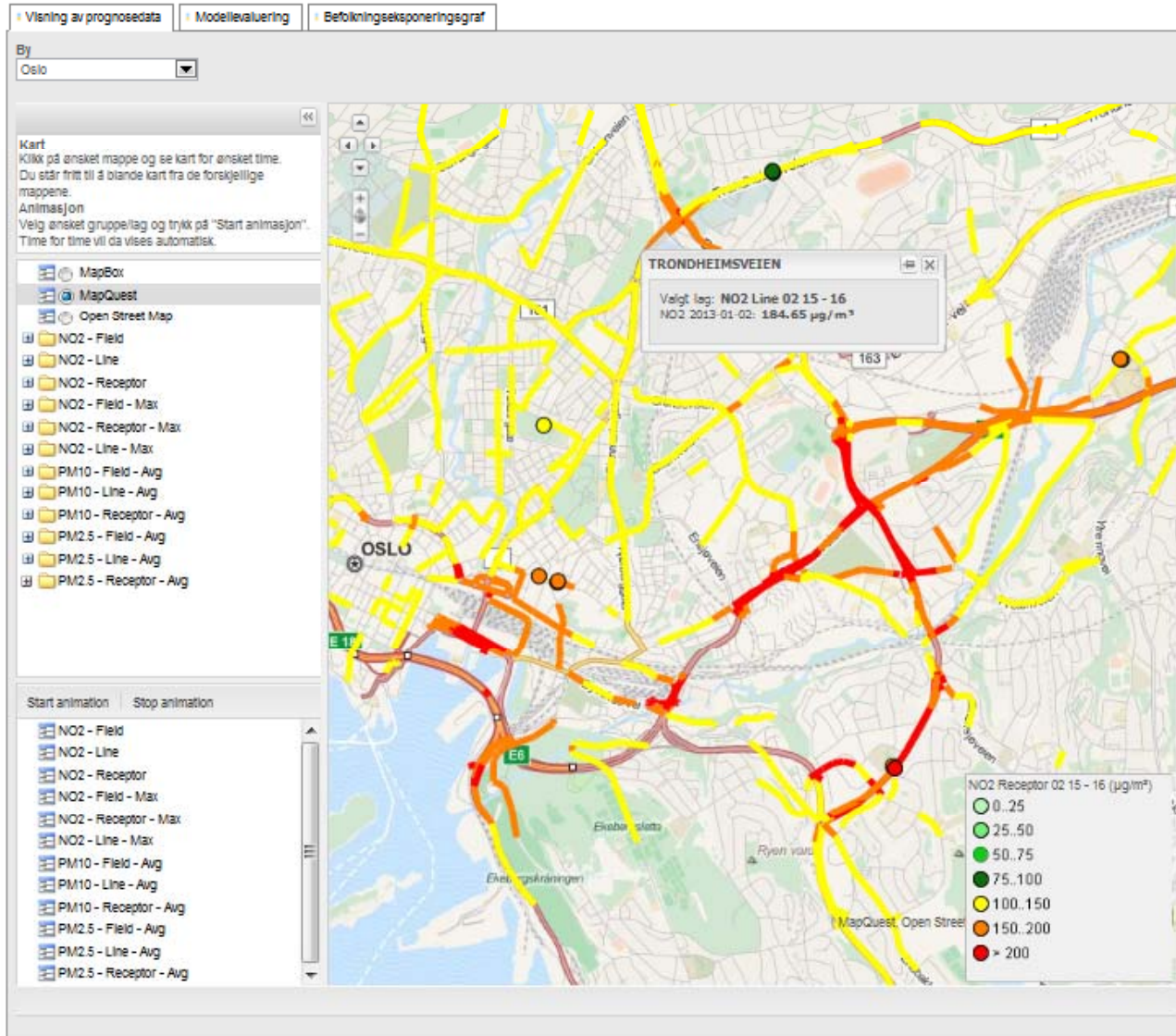|	
Server:	Juelich
Model:	MOZART-3.5 (global MACC forecast)
Timeliness:	Files with 3-hourly output (5 days)
Vertical res.:	47 vertical levels (pressure weighted linear interpolation)
Horizontal res.:	$1.1°$ x$1.1°$ (lon: 73-133; lat: 20-54) -> EMEP in $0.5°$x$0.5°$ -> EPISODE in 1x1 km
	(distance weighted 4-point bilinear interpolation)
Variables:	Concentrations in MMR and VMR of OC, BC, OC, PAN, O_3, CH_2O, C_2H_6, ISOP, CO, HNO_3, NO_2, NO, CH_4, SO_2, dust (3 bins), seasalt (3 bins), SO_4

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Better City Air - Bedre Byluft: Norwegian AQ Forecast

Downscaling from:

MACC: Regional AQ forecast to
AirQUIS/EPISODE urban forecast
http://www.gmes-atmosphere.eu

Better City Air

Presentation of the AQ forecast made through our Web portal

Example:

Zooming AQ at receptor points and main road network

BC from MACC in the Bedre Byluft project

- Use of Regional MACC forecasts used as BC for 72h forecasts

Server:	MeteoFrance
Model:	MACC RAQ ensemble
Timeliness:	Hourly output (3-day forecasts)
Vertical res.:	8 levels (0, 50, 250, 500, 1000, 2000 meters) ->
	11 levels (0, 20, 50, 100, 200, 400, 700, 1100, 1700, 2500, 3500 meters) by using a linear interpolation
Horizontal res.:	700x400 grids (0.1°x0.1°=5.6x11km)
	-> EPISODE 1x1km (distance weighted 4-point bilinear interpolation)
Variables:	Concentrations µg/m3 of CO, NO2, O3, PM10, PM2.5, SO2 - We don't need CO and SO2 in EPISODE
	- We would like to have also NOx or NO, now available

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Chart of the interpolation code

1 Reads MACC static data: lon, lat, level

Loop through time:

2 Defines EPISODE domain in MACC

3 Calculates the horizontal interpolation weights

4 Reads MACC data: height above ground

5 Reads MACC data: time dependent variables

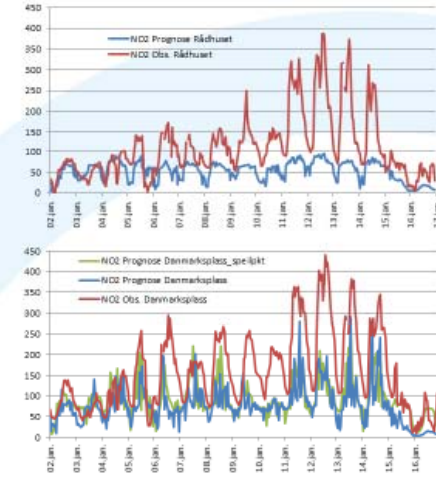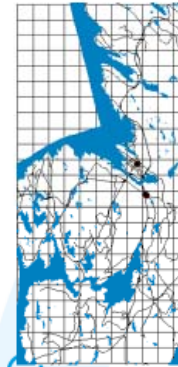**6** For each time dependent variable → Horizontal interpolation / Vertical interpolation

7 Writes to output files the interpolated concentrations
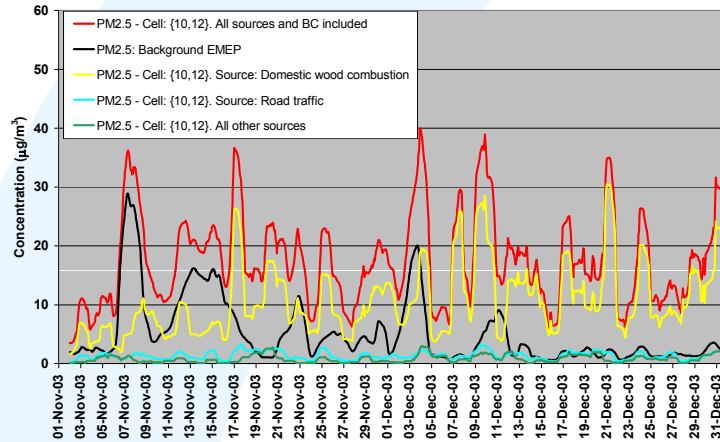
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MACC BC introduced after episodes in 2010

Use of MACC BC directly in the urban scale applications in BedreByluft

Ozone from MACC-BC compared to observation at background station outside Oslo

The effect of MACC Boundary conditions on PM₁₀ results in Oslo area
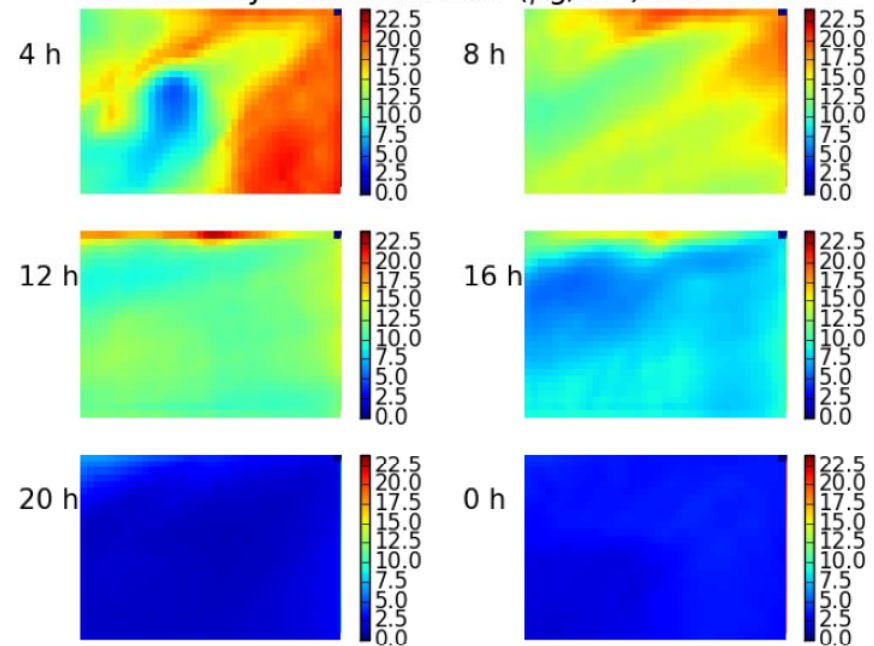
Uncertweb project

Ensemble probabilistic forecasts at street and urban scale (1 km) are made with 51 ensemble members

Ensemble inputs:

- **Meteorology:** ECMWF ensemble forecasts

- **Background concentrations:** MACC regional scale 'ensemble of models' air quality forecasts

- **Emissions:** Sampling of emission probability distributions

Models used:

- **Meteorology:** TAPM for dynamic downscaling of ECMWF forecasts (1 km)

- **Dispersion:** EPISODE air quality model for calculating dispersion and chemistry of the pollutants

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Meteorological downscaling of ECMWF ensembles using TAPM

TAPM is a combined meteorological/dispersion model from CSIRO, Australia www.cmar.csiro.au/research/tapm

Oslo

Rotterdam

Grids per domain
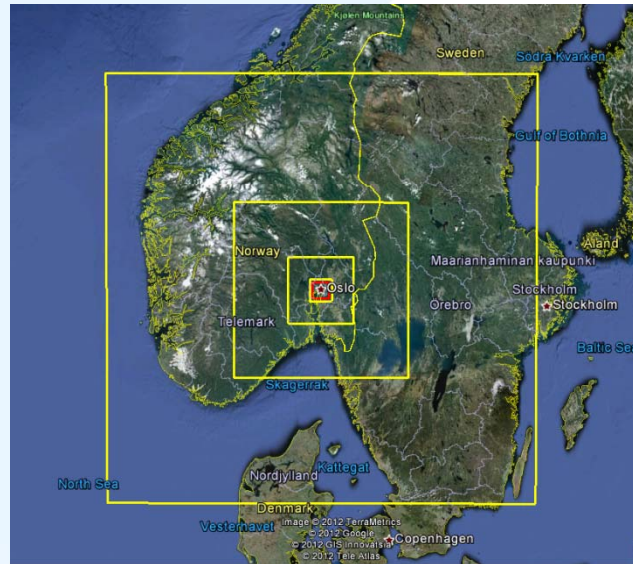40 x 40

Nested domains
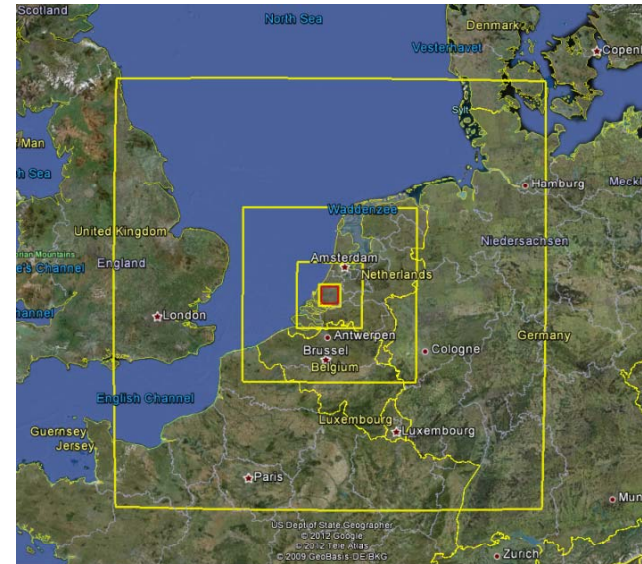800 km
320 km
120 km
40 km

25 levels
From 10 m up to 8 km

MACC regional background ensembles of NO_2 and PM_{10}

Regional background concentrations for both Oslo and Rotterdam are based on the GEMS/MACC regional scale atmospheric model ensemble

- CHIMERE; EMEP; EURAD; LOTOS-EUROS; MATCH; MOCAGE; SILAM

A PDF of the model ensemble is made using a cube-root transformation. Uncertainties in background concentration are considered to be normally distributed with mean and SD set to ensemble mean and SD

Other uncertainty contributions are defined using stochastically perturbed emissions and ECMWF meteorology ensembles.
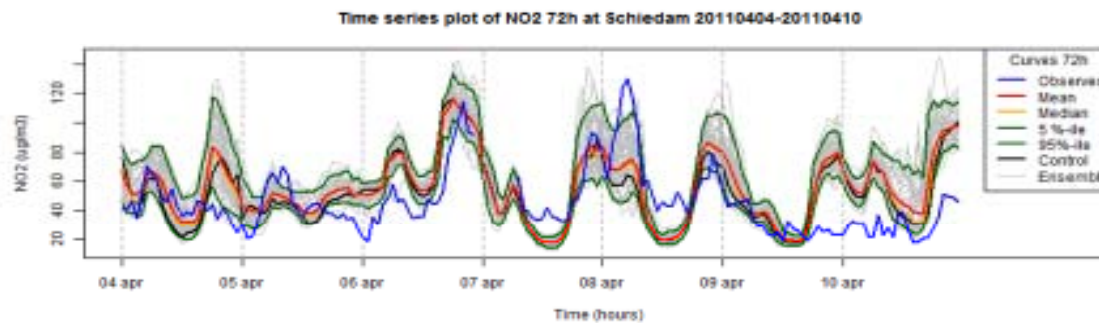
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BC from MACC for Uncertweb project

- Probabilistic air quality forecasting system for Oslo and Rotterdam.

Server: Direct contact with MeteoFrance for data extraction

Model: CHIMERE; EMEP; EURAD; LOTOS-EUROS; MATCH; MOCAGE; SILAM

Timeliness: Hourly (3 days forecasts)

Vertical res.: Not considered

Horizontal res.: One location at the surface for each city from each model. Used to calculate the MACC ensemble mean and standard deviation. To represent uncertainty contribution from the BC the MACC ensemble mean is stochastically perturbed (standard deviation is used as primary information of uncertainty) to produce a set of realizations.
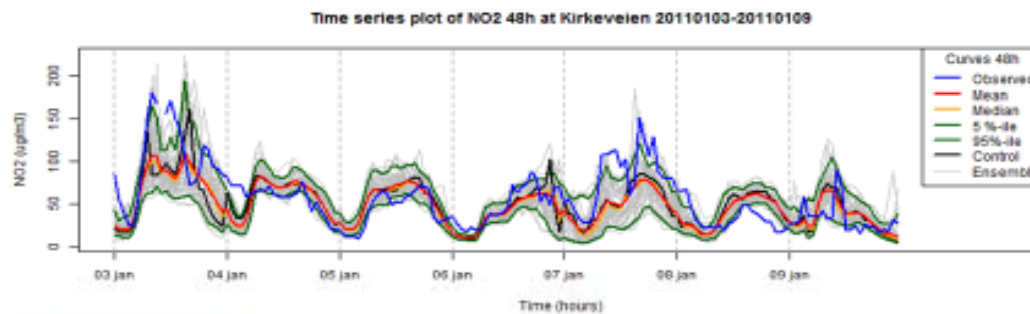
Variables: NO2 and PM10

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Results from the Uncertweb project

Schiedam: NO2 concentration 3rd day forecasts 4 Apr – 10 Apr 2011

Rotterdam

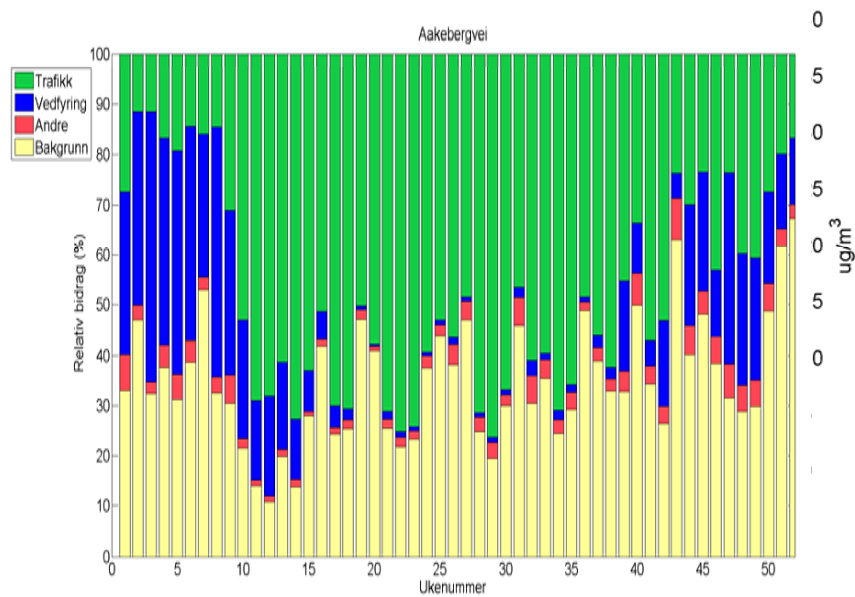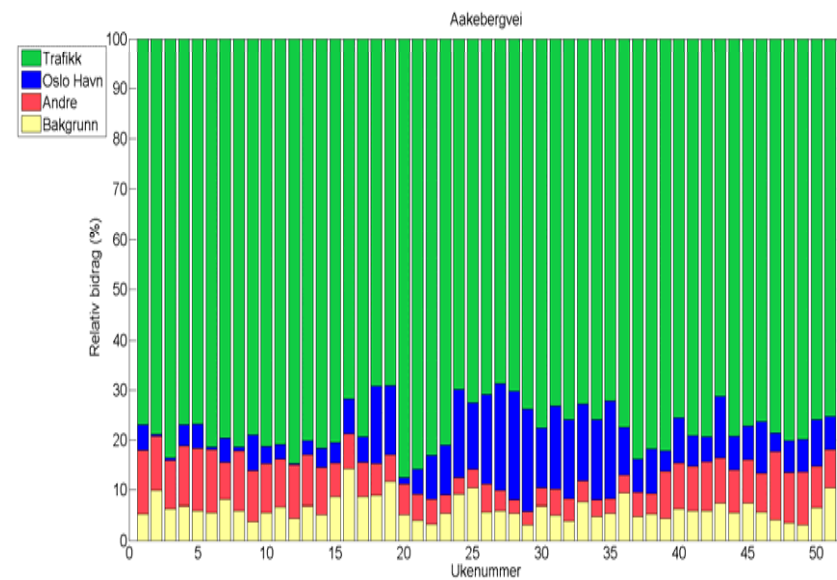Kirkeveien: NO2 concentration 2nd day forecasts 3 Jan – 9 Jan 2011

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Scenario analysis – Oslo 2020

Evaluation of AQ control measures in Oslo

PM₁₀ in 2020 BAU

Source allocation

NO₂ in 2020 BAU

Source allocation

BC from MACC for Scenario Analysis

- MACC Regional ensemble used for Hindcast calculations.

Server: Direct contact with MeteoFrance for data extraction

Model: MACC RAQ ensemble

Timeliness: Hourly (3 days forecasts)

Vertical res.:   4 levels (0, 500, 1000, 3000 meters) -> 11 levels (0, 20, 50, 100, 200, 400, 700, 1100, 1700, 2500, 3500 meters) using linear interpolation

Horizontal res.: 122x130 grids (0.1°x0.1°= 5.6x11km) -> EPISODE 1x1km (distance weighted 4-point horizontal bilinear interpolation)

Variables: Concentrations µg/m3 of CO, NO2, O3, PM10, PM2.5, SO2
- We don't need CO and SO2 in EPISODE

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Main lessons learnt

➢ Regional scale concentrations are a major element of PM_{10} in urban areas and PM2.5 and to some extent are also relevant for NO2 through O3. As a result BC and regional forecast uncertainty can be important for urban scale.

➢ The use of boundary conditions needs to be fit for purpose. In Norwegian cities, we use MACC BC without further nesting. This approach is only valid under Norwegian urban emitter island emissions. It is not valid in Wuhan.

➢ Caution is advised in the interpretation of the results, in particular with respect to source allocation and the influence of LRT in urban results

➢ Welcome improvements in the retrieval of MACC data to select the relevant region (min/max lat/lon) for downstream applications and reduce the number of NetCDF files to be downloaded

➢ For hindcast applications, it would be useful to have access also to reanalysis data for e.g. scenario analysis

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For more information, www.nilu.no

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