



IMPORTANCE OF MULTISCALE INTERACTIONS FOR PREDICTING AND FORECASTING URBAN AIR QUALITY - EXPERIENCE FROM WMO/GURME

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Hertfordshire



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- Shanghai Meteorological Service (Tan Jianguo)

WMO/GAW Urban Research Meteorology and Environment Project (GURME)

Created under WMO Global Atmospheric Watch in 1995

Global focus on urban air quality and meteorology research

Overarching aims of GURME:

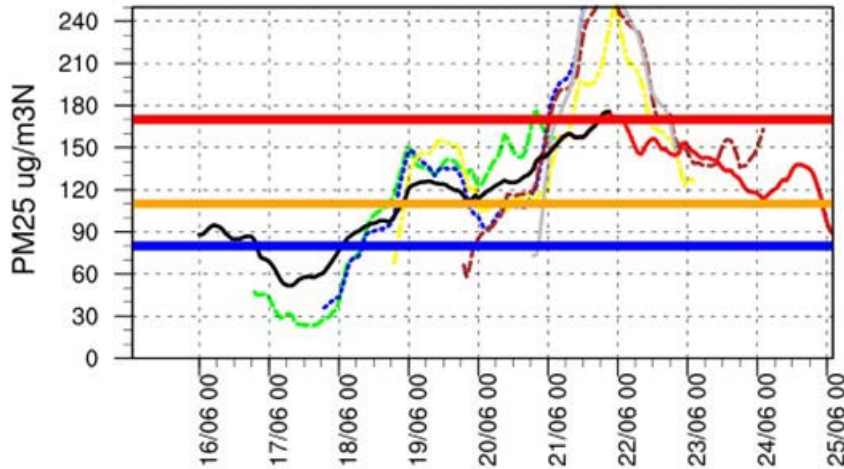
1. To initiate and exploit **new scientific advances** in **meteorology** and **atmospheric composition** by engaging proactively with the wider community for **improving air quality** in urban areas within a regional context
2. To provide **strategic research direction** and highlight future **scientific challenges** relevant to urban air quality and meteorology

Specific objectives

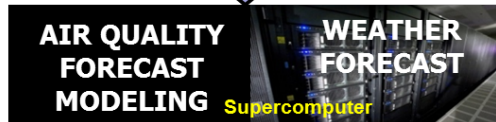
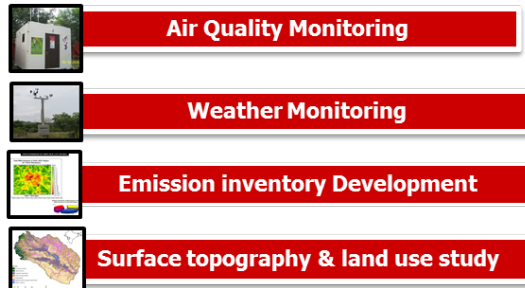
- (i) Advancing modelling
- (ii) Representing urban processes
- (iii) Understanding scale interactions
- (iv) Integrating observations and modelling
- (v) Science for impact assessment, mitigation and adaptation
- (vi) Promoting dissemination, outreach and training

WMO/GAW Urban Research Meteorology and Environment Project (GURME)

Emergency in Santiago

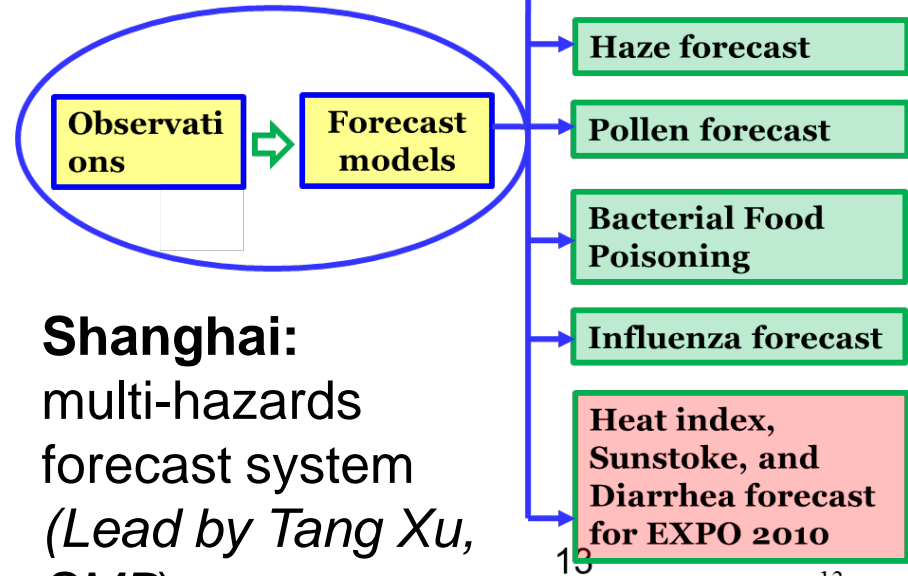


SAFAR



Projects affiliated to GURME

- PROMOTE (NERC/MOES) – Delhi AQ
- Paris Olympics 2024 – AQ forecasting
- SAFAR - 1st AQ Forecasting System in India (Beig, IITM)



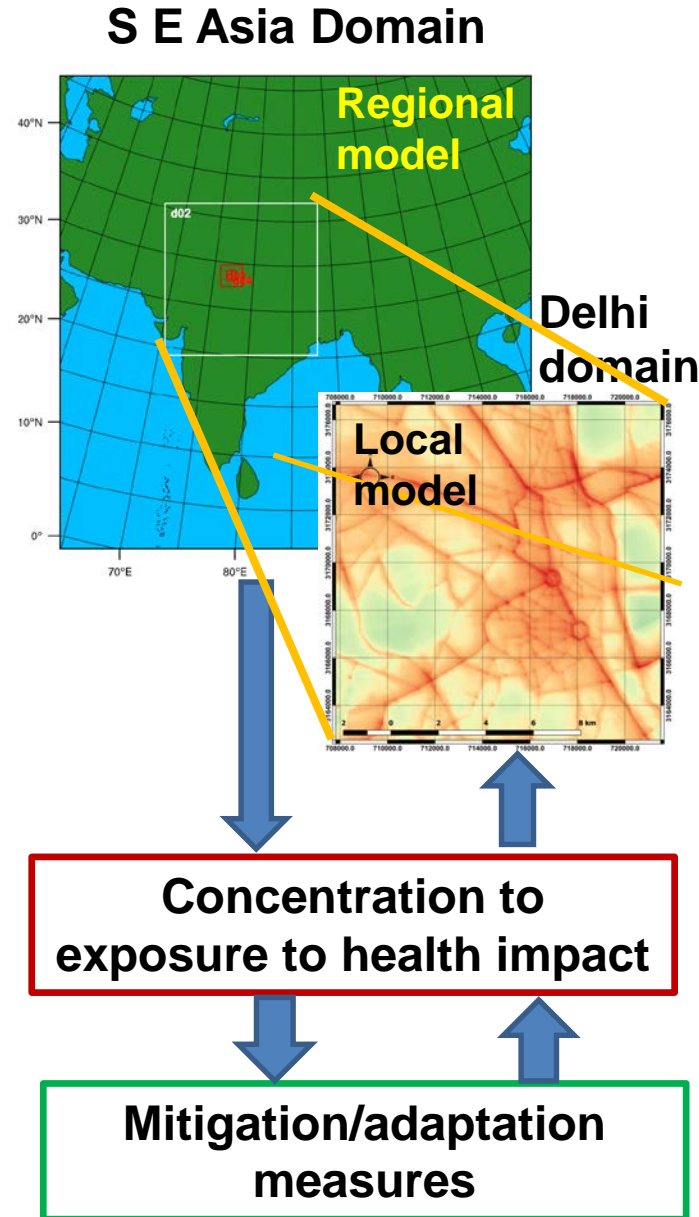
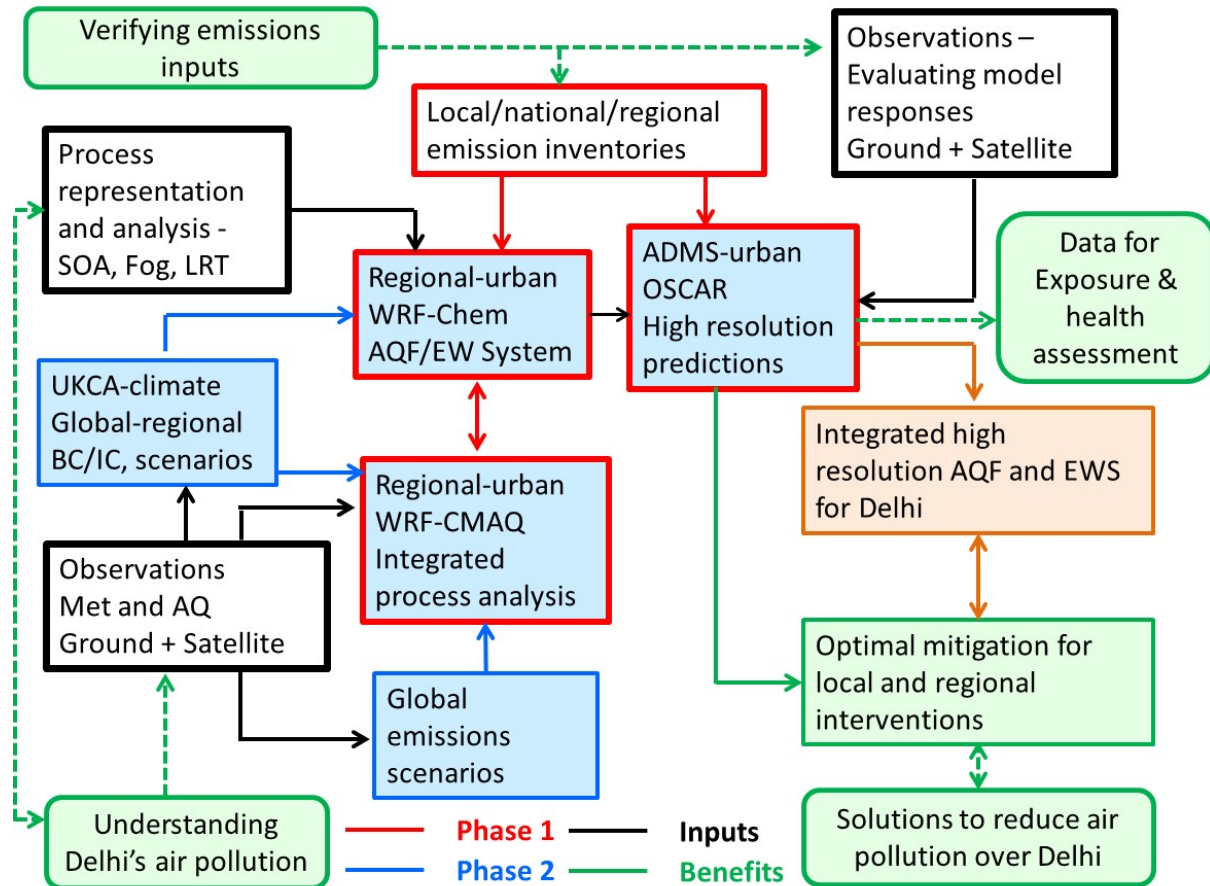
Shanghai:
multi-hazards
forecast system
(Lead by Tang Xu,
SMB)

Latin American cities

- Mexico City, Sao Paulo, Santiago...

Linking scales – downscaling for cities

Integrating air quality, climate, health across scales



Challenges – consistency of emissions, meteorology, chemistry coupling/interfaces

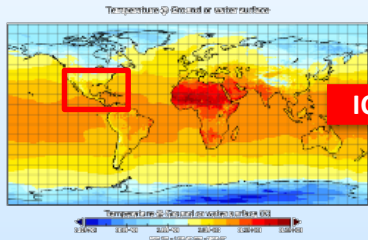
Source: NERC/MOES PROMOTE



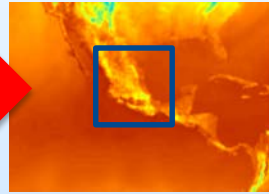
Linkages within the operational system (Mexico City)

Downscaling

METEOROLOGICAL MODEL (WRF)

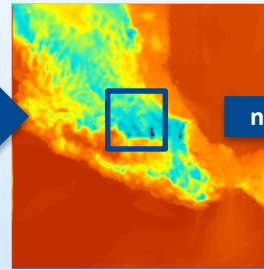


NCEP GFS
0.25° x 0.25°



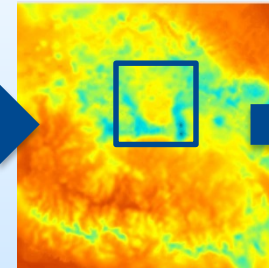
WRF-ARW
27 km x 27 km

nesting



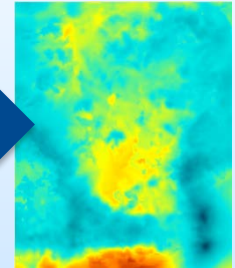
WRF-ARW
9 km x 9 km

nesting



WRF-ARW
3 km x 3 km

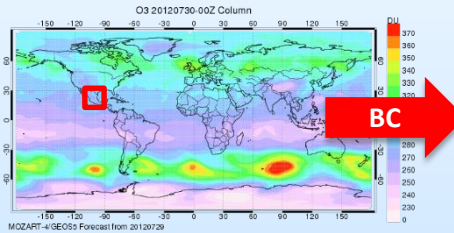
nesting



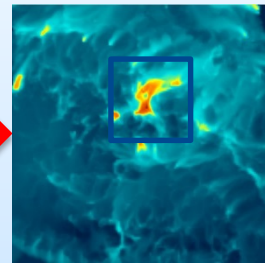
WRF-ARW
1 km x 1 km

Meteo

AIR QUALITY MODEL (CMAQ)

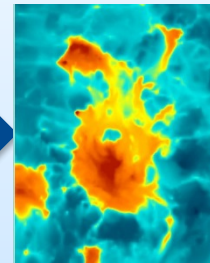


UCAR MOZART4
1.9° x 2.5°



CMAQ
3 km x 3 km

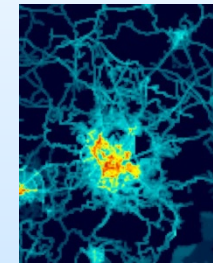
nesting



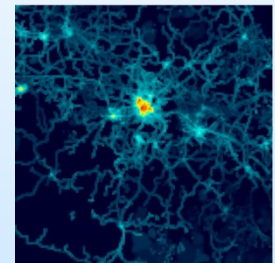
CMAQ
1 km x 1 km

Emis

EMISSION MODEL (HERMES-Mex)

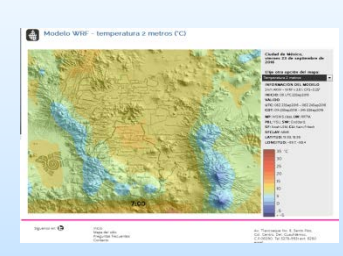
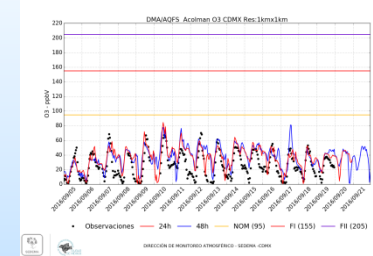
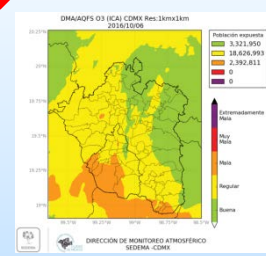
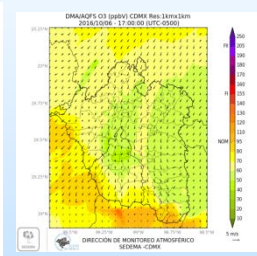
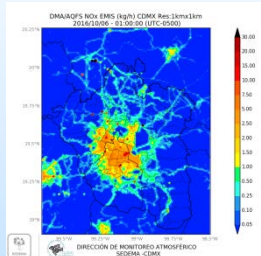


HERMES-Mex
1 km x 1 km



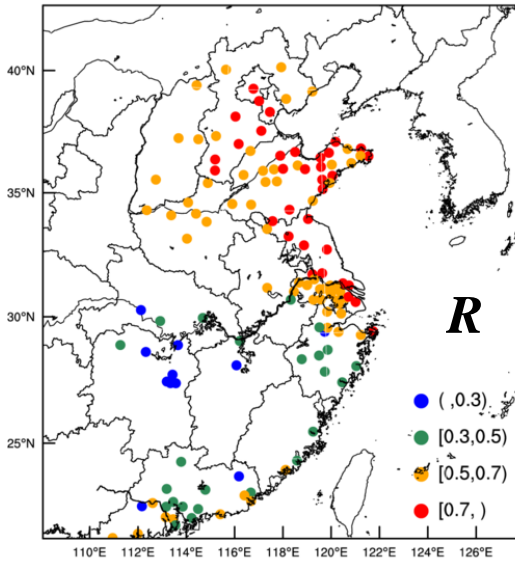
Post-procesos

PRODUCTS



Shanghai – WRF-Chem performance distribution of PM_{2.5} (131 cities) and O₃-8h (130 cities)

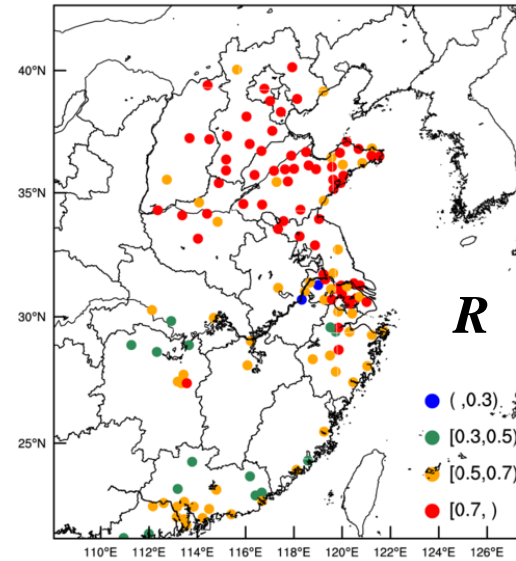
Correlation Coefficient of PM_{2.5} 48h Forecast



PM_{2.5}

**71 city ≥ 0.6 ,
34 ≥ 0.7 ;
better in
north**

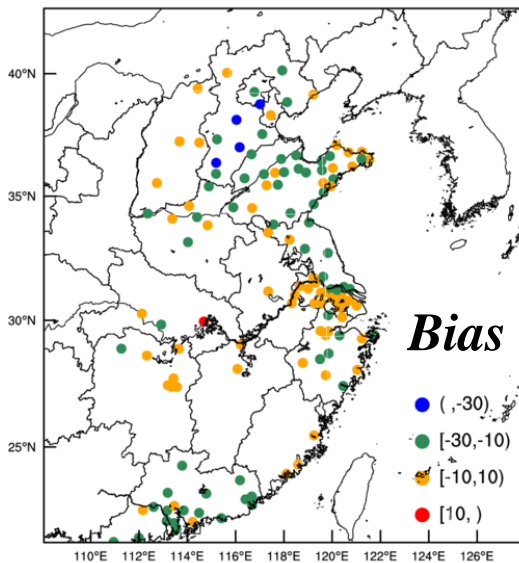
Correlation Coefficient of O₃-8h 48h Forecast



O₃ – 8h

**62 city ≥ 0.7 ,
18 ≥ 0.8 ;
Better in
north**

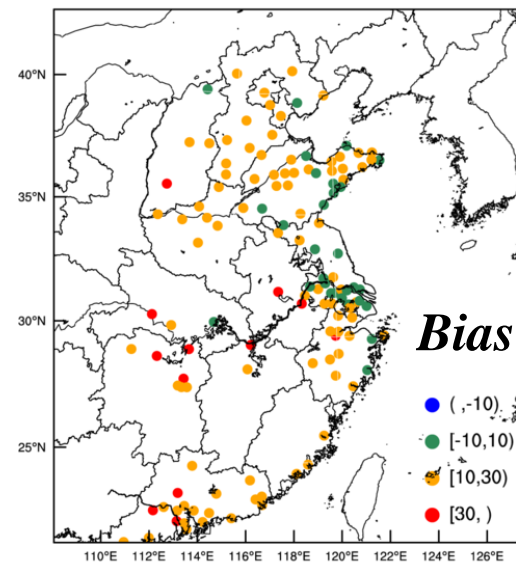
Mean Bias (ug/m³) of PM_{2.5} 48h Forecast



PM_{2.5}

**109 city < 0 ;
Worse in
north**

Mean Bias (ppb) of O₃-8h 48h Forecast

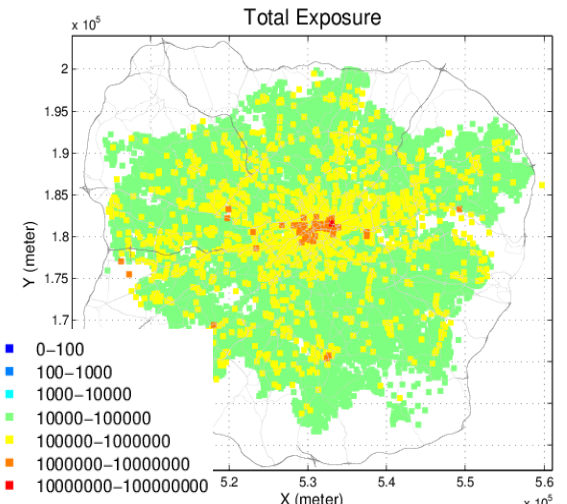
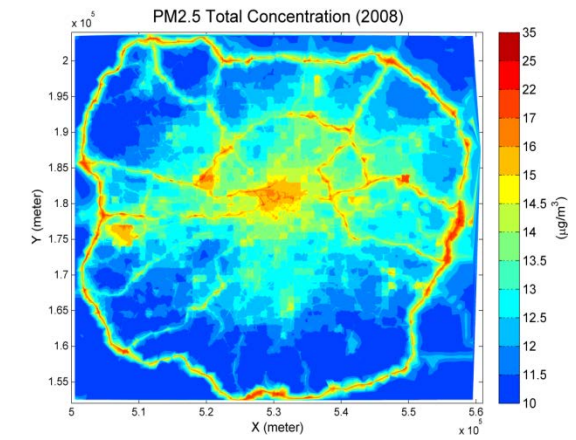
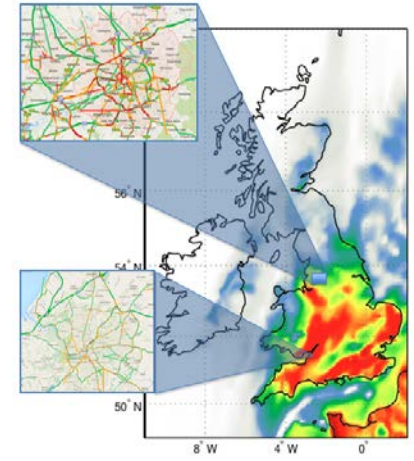
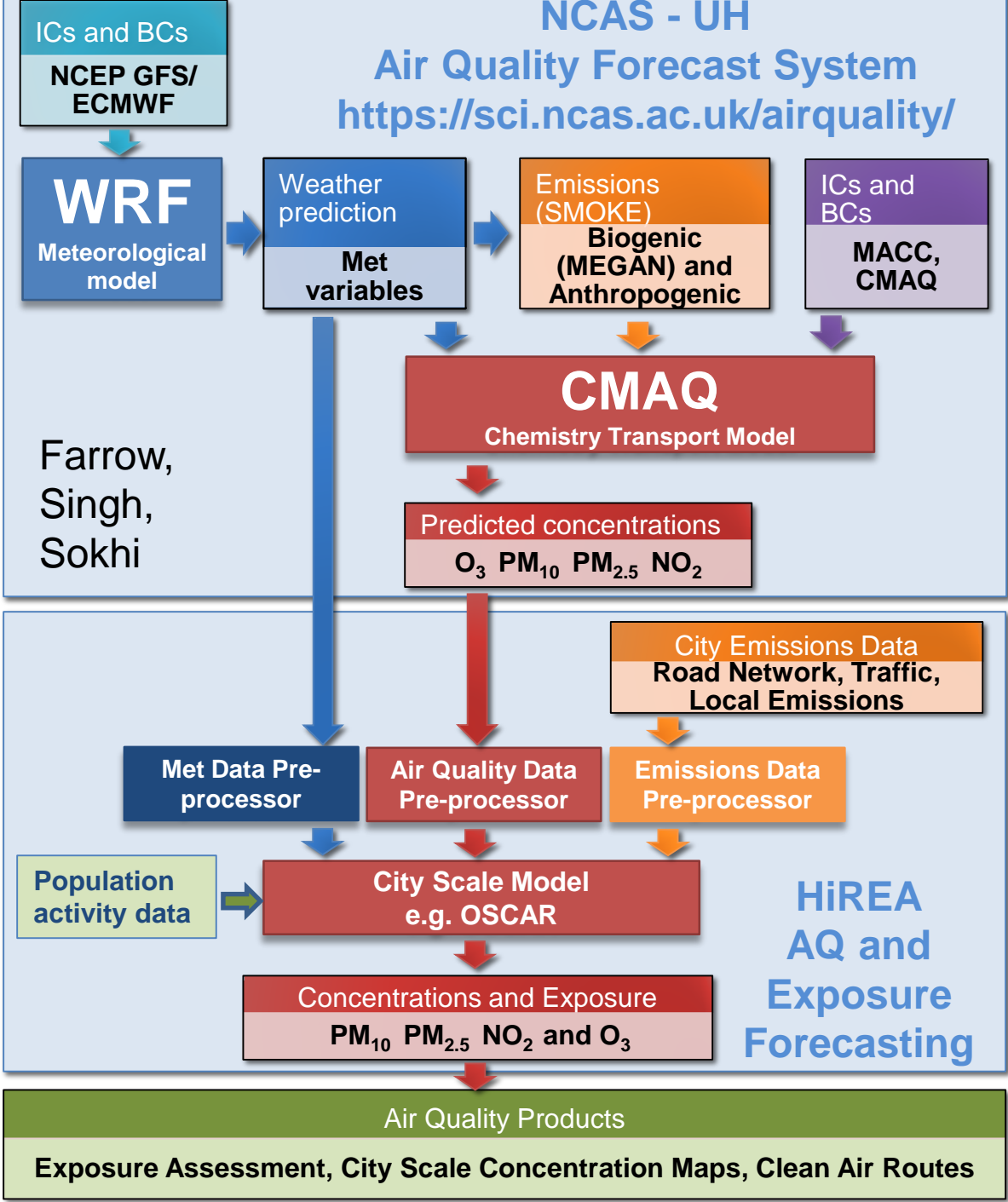


O₃ – 8h

**Almost > 0 ;
Better near
coast**

NCAS - UH Air Quality Forecast System

<https://sci.ncas.ac.uk/airquality/>



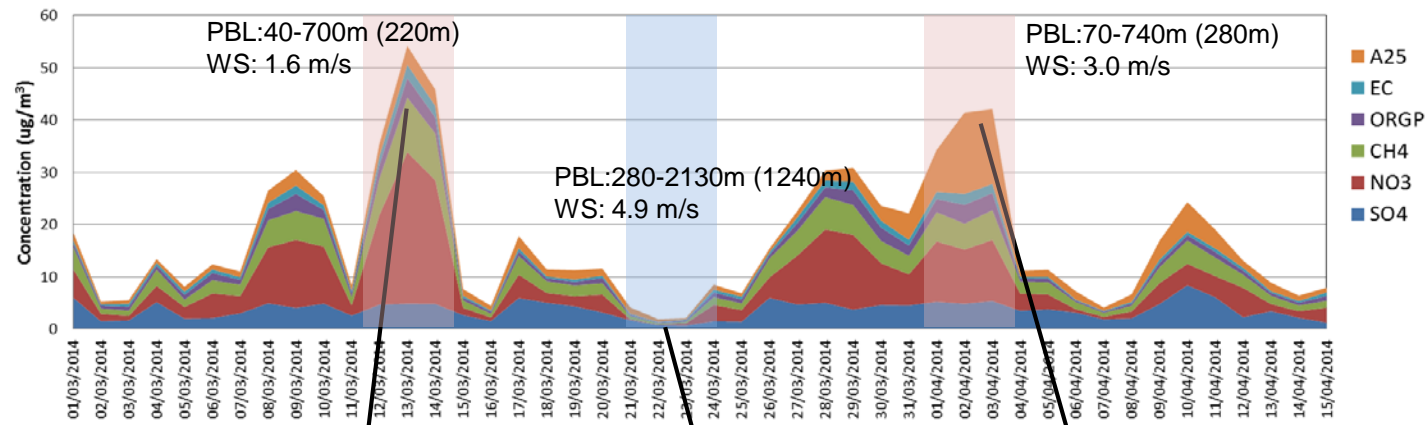


NCAS-UH Air Quality Forecast

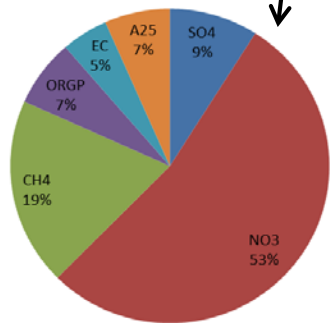
Analysing causes of high air pollution

PM2.5 episode over the UK (March – April 2014)

Composition of PM2.5 at Rural Site (HAR)

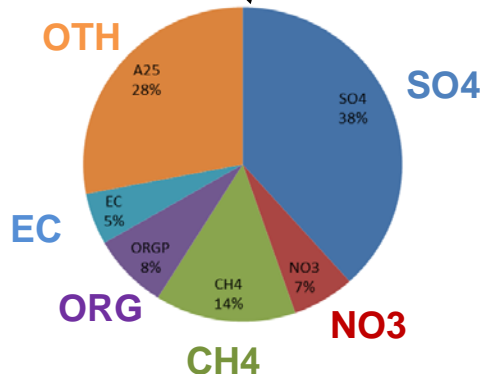


13 March 2014

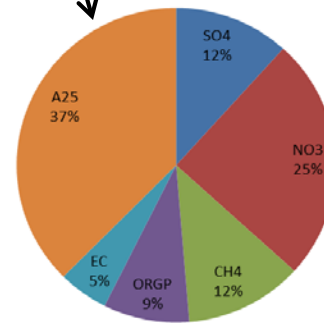


Nitrate dominated

22 March 2014



2 April 2014

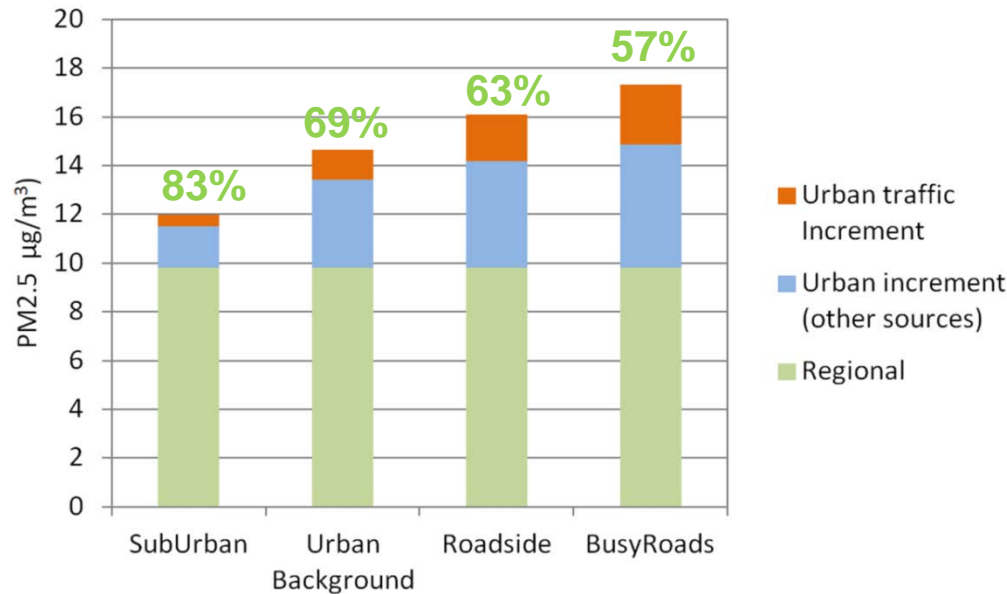


Mixed - Nitrate and Dust



Importance of regional contribution (source apportionment)

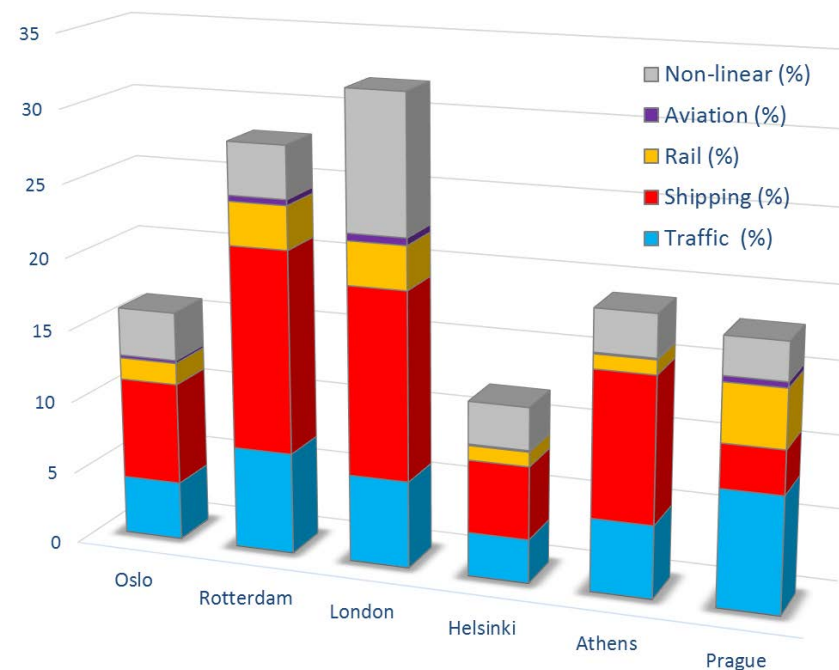
Regional contributions to PM2.5 in London (Annual)



Singh et al (2014) JAWMA

Make up of regional PM2.5 contributing to European cities

Regional background source contribution to PM2.5 at target cities



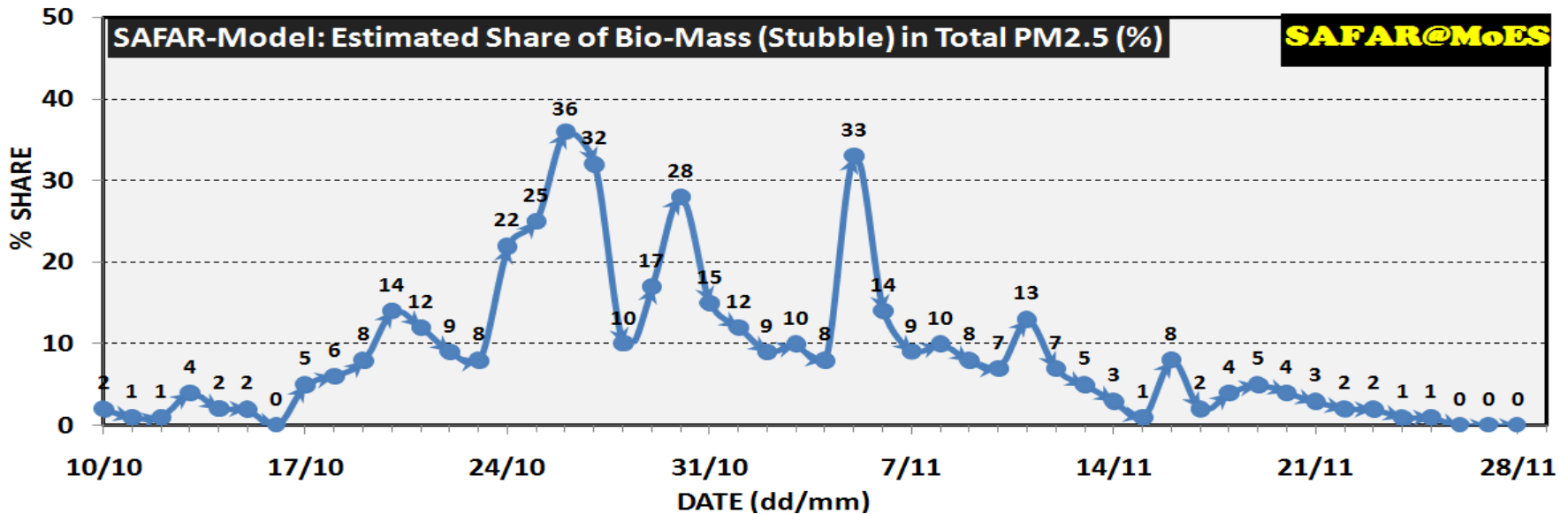
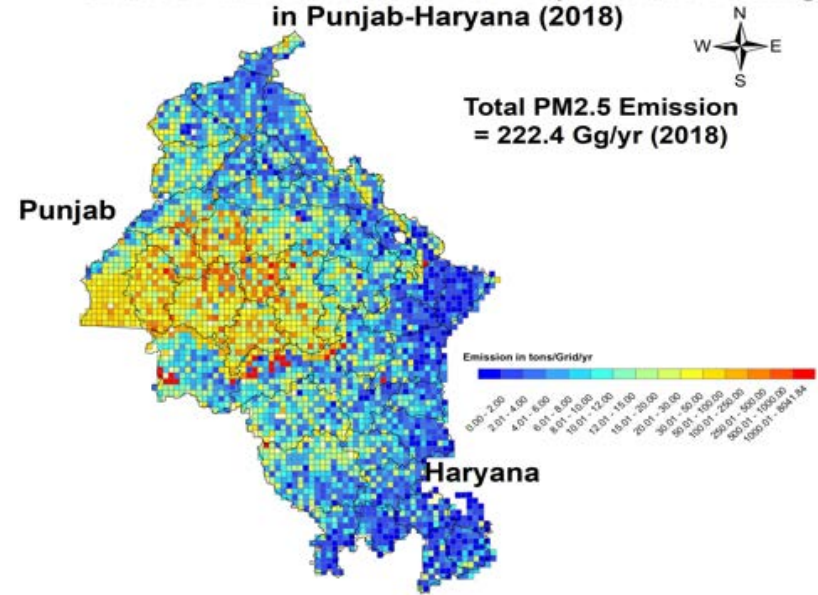
Source: TRANSPHORM Project

SAFAR-DELHI: LONG RANGE TRANSPORT OF POLLUTANTS (CROP RESIDUE BURNING IMPACT)



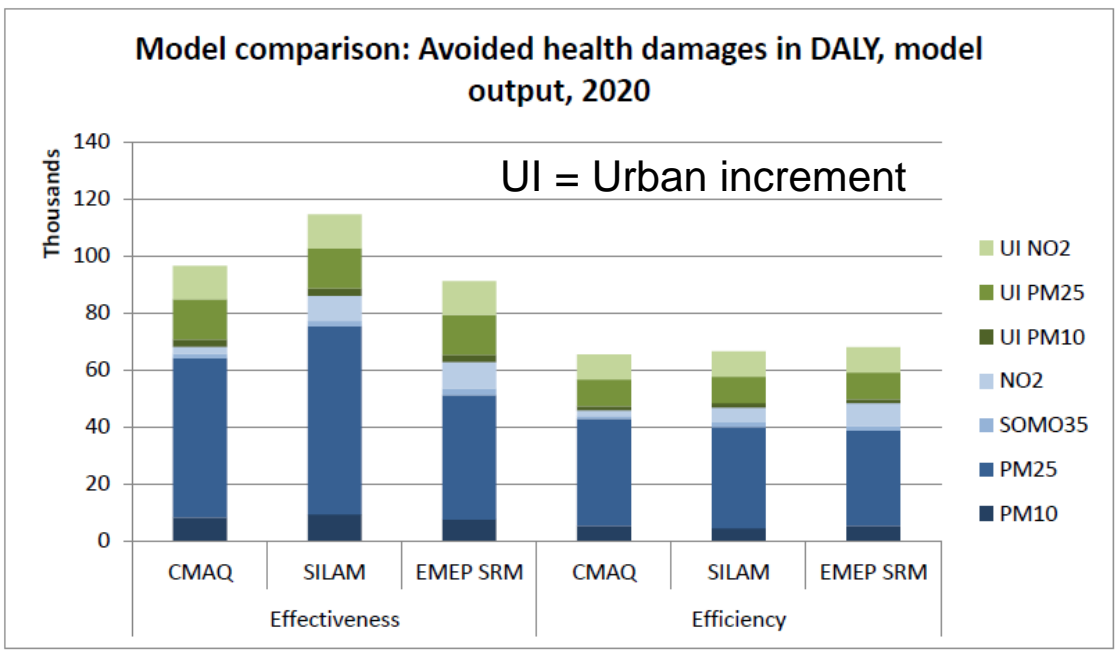
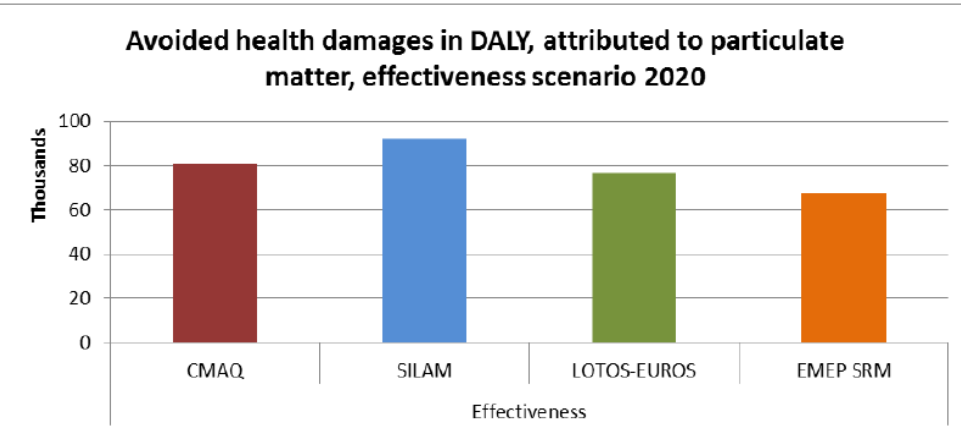
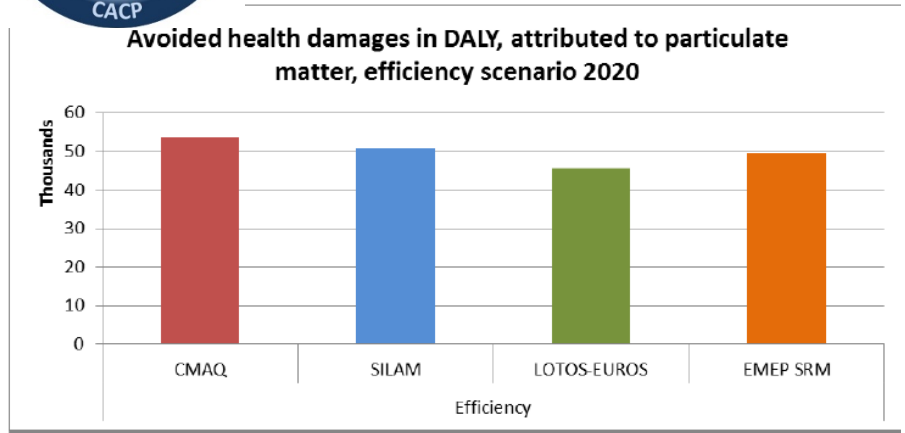
Development of GRIDDED Emission Inventory of Kharif Stubble burning of Punjab-Haryana and simulated its % share in Delhi's Air Quality (PM2.5) using SAFAR-Model

Gridded PM2.5 Emission from Crop Residue Burning in Punjab-Haryana (2018)



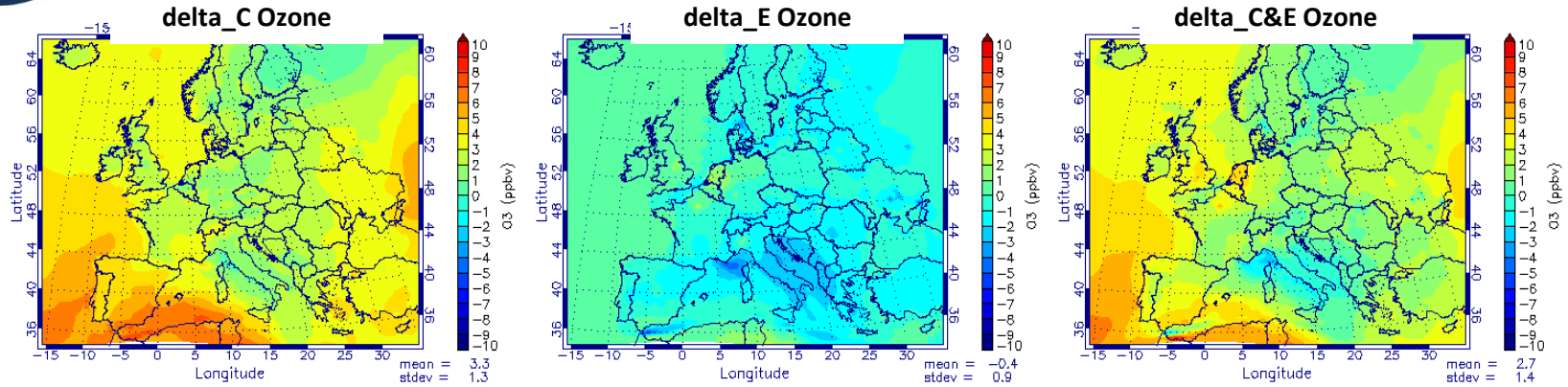


Multimodel Health Impact Assessment for Europe



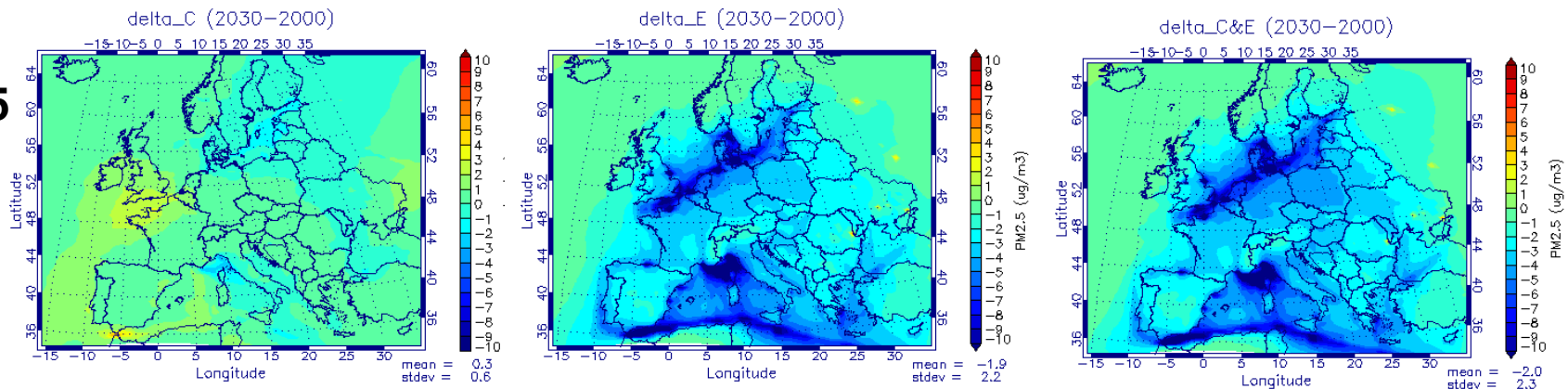
How will future climate and emissions affect air pollution over Europe (2030)?

O3



Delta_C is relatively large for ozone compared with delta_E. The combined effects could lead to an increase of 1-6 ppbv ozone over most of Europe by 2030s

PM2.5



Delta_C for regional PM2.5 over Europe is less than delta_E, but substantial spatial variations across Europe and climate influences may be relatively more important in the future



- **Scale issues** are critical to reach end goal of air quality improvement
- **Regional models coupled with street scale models** offer a process-based assessments of air quality and its impacts
- **Suitability** – complex terrain, dynamics, chemical transformations; complex source distributions; detailed processes based analysis; linking sources - distributions – impacts on multiple scales
- **Complementarity** of approaches to get the right solutions and increase confidence
- **WMO-GURME**
 - Urban focus within a regional context – experience in many global cities
 - Prediction, forecasting, observations for mitigation and training
 - Science to support Integrated Assessment for city and regional scales