World Meteorological Organization

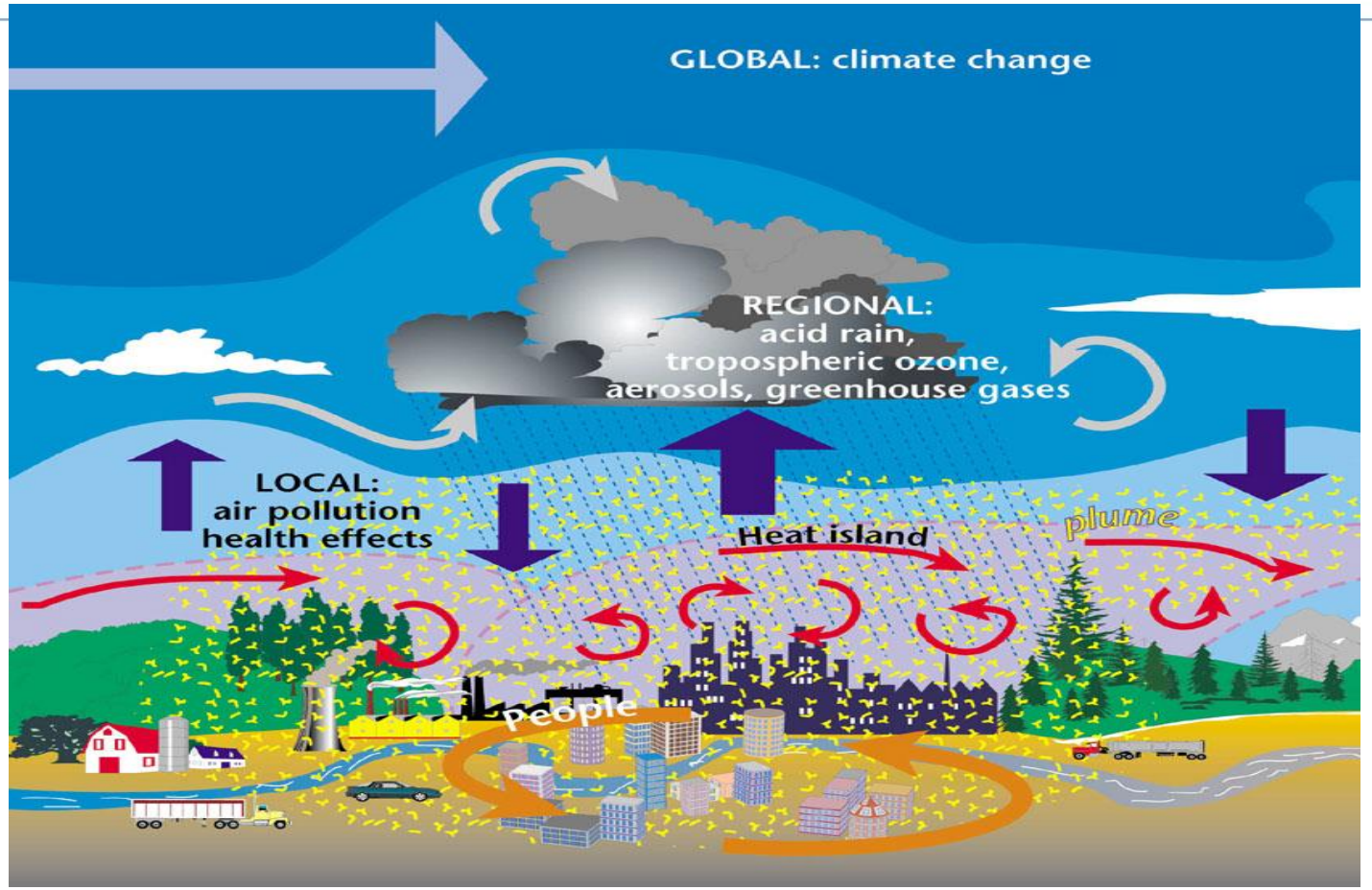
Working together in weather, climate and water

# WMO GURME overview

**Liisa Jalkanen, WMO, Switzerland**

The WMO GAW Urban Research Meteorology and Environment Project

# GAW ⇨ GAW Urban Research Meteorology and Environment (GURME)




Need to consider all scales

# GURME Tasks For The Strategic Planning Period 2008-2015

**Observational Needs**
- Chemical
- Meteorological

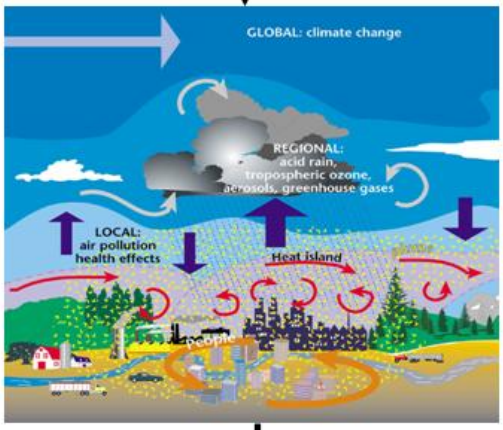
*(Tasks: 3,6,17)*

**Assimilation**

**Modeling Needs**
- Weather prediction
- Chemical weather and air quality prediction

*(Tasks: 8,11,13,15)*

**Demonstration**




**Coordination**

**Capacity Building**
- Workshops
- Training

*(Tasks: 2,4)*

**Users**
- Health
- Agriculture
- Environmental
- Public
- Emergency Response

*(Tasks: 9,14,16,18)*

**Education**

**Air Quality & Related Products**
- Improved Forecasts
- Guidelines
- Pilot Projects

*(Tasks: 1,5,7,12)*

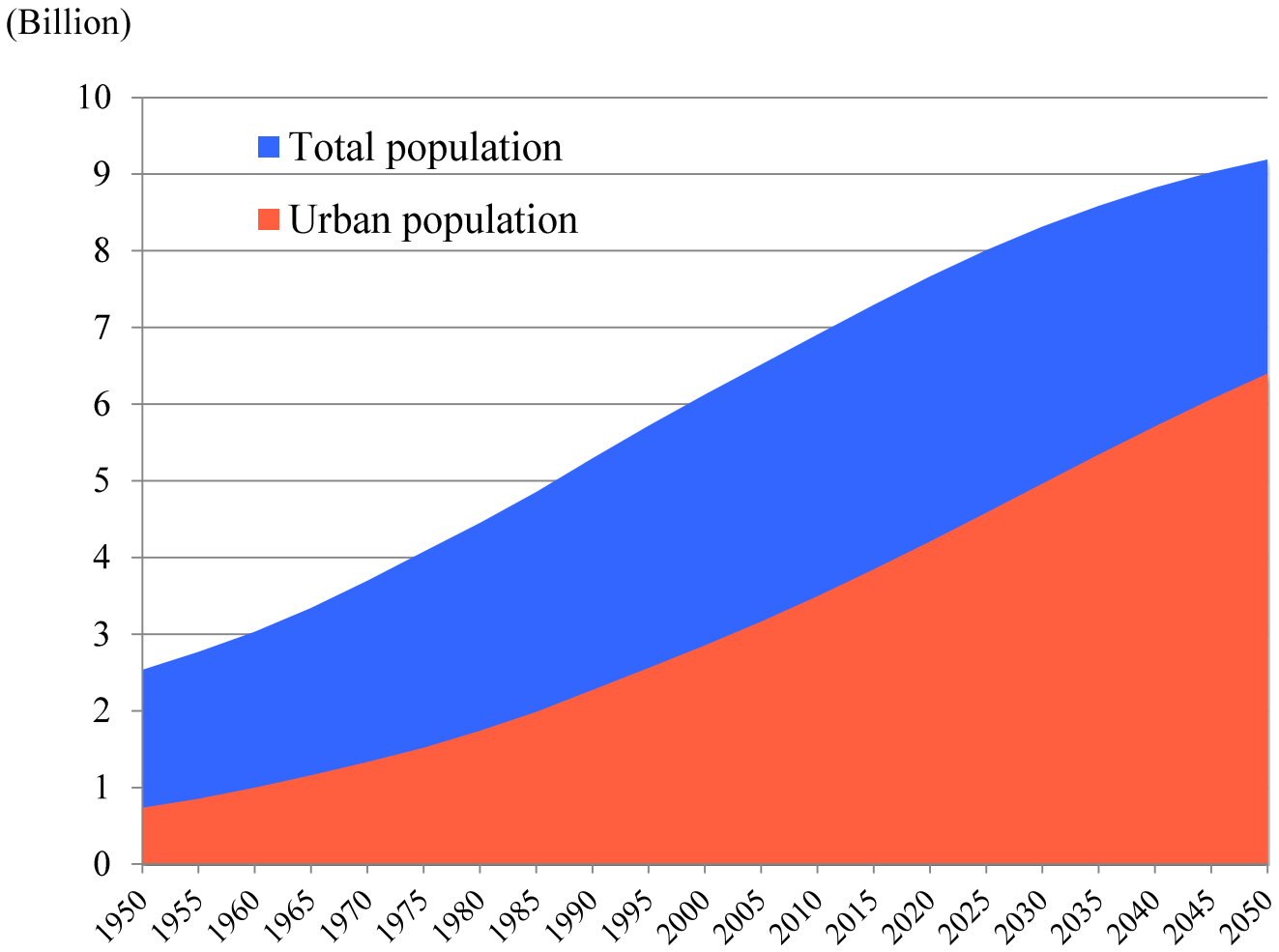
**Dissemination**

# CAS President:

The significant technical, social and environmental stressors driving the demand for more accurate and user friendly environmental assessments and predictions:

- ⇨ Climate Change
- ⇨ Population Growth
- ⇨ Urbanization

# Growing Urban Population



# Urban population growth

- Currently about 50% urban dwellers in cities of 100 000 to 500 000 inhabitants, 10 % in megacities (number will grow from current 23 to 37 by 2025).
- There are 633 cities >750 000 inhabitants
- By 2050 urban population will double: 3.5 to 6.3 bill
- Almost all growth in developing countries
- In high-income countries urban population will stay largely the same, growth comes mainly from legal and illegal immigration

Megacities *and* large urban complexes!

# Urban Areas: Unique Challenging Environments …

- Urban morphology: street canyons, roughness, rainwater and used water drainage, transport infrastructure, near shore locations, major contrast with surrounding habitats, etc…
- Very high population density.
- High concentration of industrial activities.
- From 1 m scale to 100 km scale.

# …that pose unique challenges to modeling and monitoring …

- Highly contrasting albedoes
- Highly contrasting fluxes of heat, momentum
- Turbulent flows at small scales, coupling to more laminar in canyons and outside areas
- Chemical weather situation from transport, heating, industrial activities
- Air sea interactions if near shore

# …and create a unique multi-disciplinary spectrum of potential threats.

- Local wind storms through channeling
- Heat wave amplification
- In city flooding from overflow of aqueducts
- Water contamination issues
- Impacts on traffic flow, and industrial activity
- Health issues (food, illnesses …)
- Amplification of impact of sea level rise and storm surges
- Increased and severe bad air quality episodes
- And more…

# Health and air pollution

Air pollution causes about 3.3 mill deaths annually worldwide, of these 1.3 mill are due to *outdoor* urban air pollution.

(WHO)

# WMO increasing focus: Megacities and large urban complexes

Need focus on large urban areas both for meteorological and air quality

research → applications → services

Activities should be aimed at:

(i) development of strategies for megacities to deal with weather, climate and environmental problems and improvement of related services;

(ii) enhancement of environmental monitoring and modelling capabilities; and

(iii) establishment of case studies for understanding air pollution, health and climate connections in different types of megacities.

# GURME projects and collaboration

# Example of GURME project: Latin American Cities

Sao Paulo, Brazil

Mexico City, Mexico

Santiago, Chile

**Improvement of AQ forecasting in Latin American cities through capacity building**

- First Air Quality Forecasting Workshop for the Latin American Cities October, 2003, Santiago, Chile;
- Workshop on application of WRF/Chem Model and Use of Remote sensing, 2006, Sao Paulo
- Training Workshop on AQF for Latin American countries, 2006, Lima
- Air Quality Modeling for Latin America, August 2009, Mexico City
- Workshop on SLCFs for Latin America, Sept 2011, Mexico City

**NMHSs - Universities - Environmental Agencies**

GURME
The WMO GAW Urban Research Meteorology and Environment Project

# India

# SYSTEM OF AIR QUALITY FORECASTING & RESEARCH

# (SAFAR-CWG-2010)



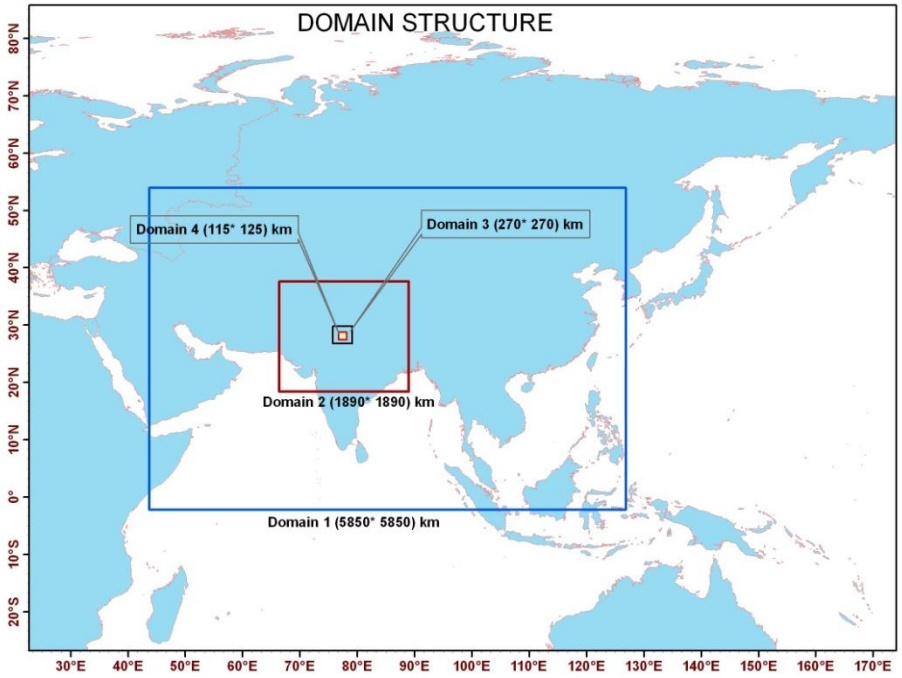
DELHI 2010
XIX COMMONWEALTH GAMES

# SAFAR Components for CWG

The SAFAR project involved 4 components to facilitate the current and 24h to 48h advance forecasting, namely,

- (1) The development of high resolution emission inventory of air pollutants and defining air quality index for India.
- (2) Network of eleven Air Quality Monitoring Stations (AQMS) equipped with instruments to provide near real time air quality information. (CO,CO2,O3,NO,NOx,NO2, BTX,O3,PM2.5,PM10,BC)
- (3) The 3-D atmospheric chemistry transport forecasting modeling coupled with weather forecasting model to provide forecast of air pollutant levels.
- (4) (a) Display the information on LED and LCD screens located at 20 different locations in Delhi in a public friendly format and

  (b) displaying the online detailed information through the Web portal developed for CWG as: http://safar.tropmet.res.in/.




# AIR QUALITY FORECAST

- 4 Nested Domains in our System
- 2-Ensembled Forecasting Systems

1. REMO/WRF-CMAQ
2. WRF-Chem-Interactive (with feedbacks)

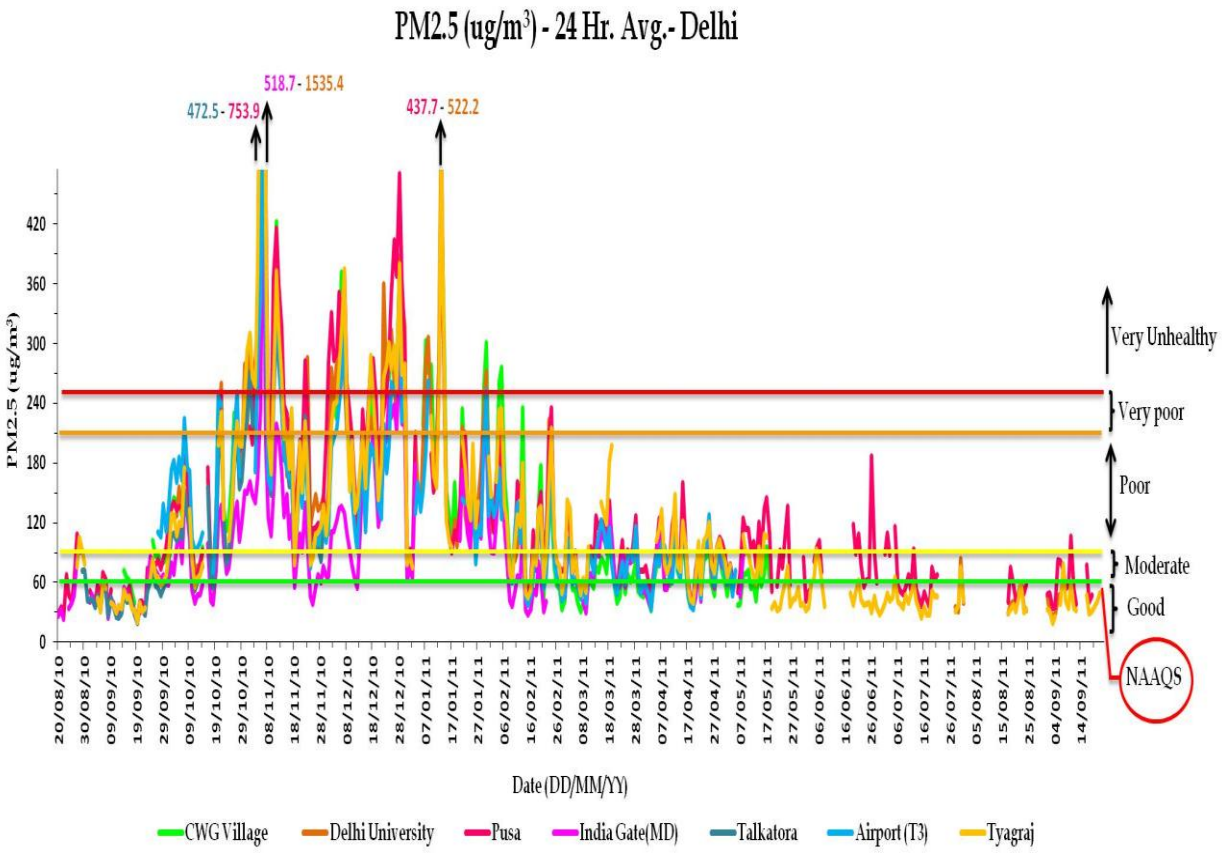
Boundary Conditions (Outermost Domain):

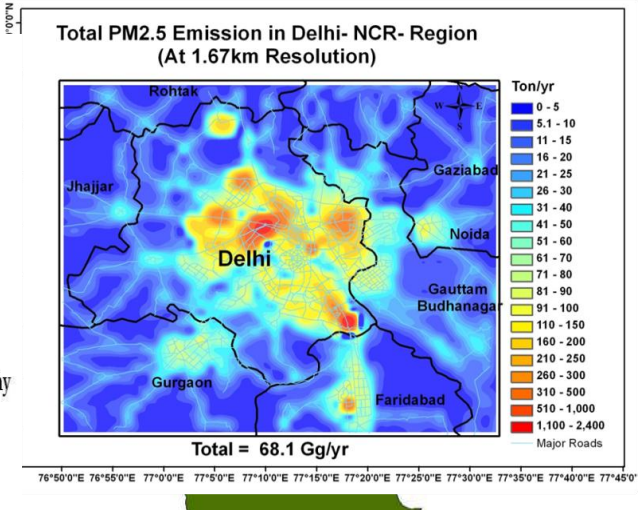
Chemicals:
• MACC-GMES
(24-hourly forecast)

Weather:
• GFS –NCEP Reanalysis
(Global forecast)

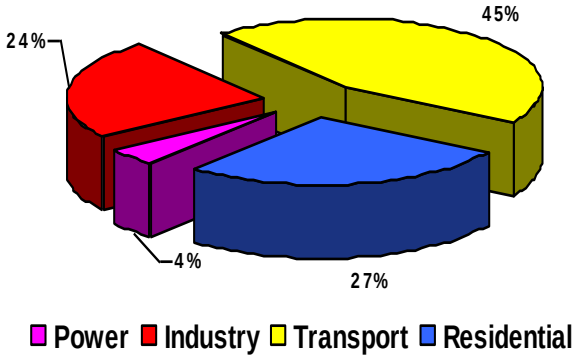
| Domains | Latitude | Longitude | Number of Grid Points | Domain Area (Square Km) | Resolution (Km) |
|---|---|---|---|---|---|
| Domain - 1 | 2.93°S to 53.21°N | 43.73°E to 126.84° E | 131*131 | 5850*5850 | 45 |
| Domain - 2 | 18.41°N to 37.60°N | 66.43°E to 88.99°E | 127*127 | 1890*1890 | 15 |
| Domain | 26.79°N | 75.75°E | | | |

# Improving Predictions through Developing and Evaluating New Emission Estimates and Establishing New Monitoring Systems




**Relative Contribution of PM2.5 Emission from Different Sectors in Delhi-NCR-Regions**

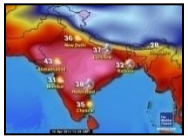



*SAFAR Delhi Commonwealth Games – Beig et al.*

*Sahu et al., AE 2011.*

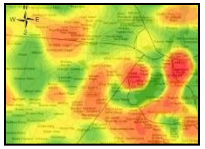
# METROPOLITAN AIR QUALITY AND WEATHER FORECASTING SERVICES

AIR-Now & AIR-Tomorrow

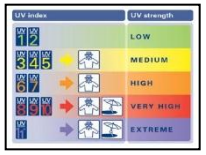


Weather -Now & -Tomorrow

Health Advisories



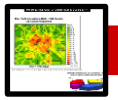
City Pollution Maps



UV Index- Skin Advisory

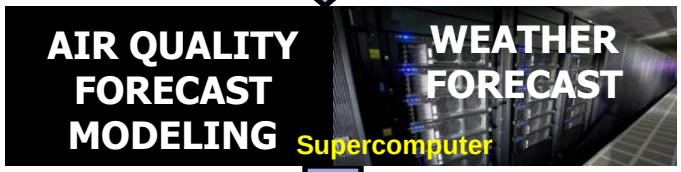
Air Quality Monitoring

Weather Monitoring



Emission inventory Development

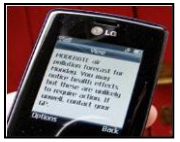
Surface topography & land use study




PRODUCTS ⇔ Translate Science to Public ⇔ SERVICES

Web Portal

E-mail Alerts



SMS Alerts

Digital Display


TV /Radio

## BENEFIT TO END -USER

- Protecting Human Health
- Agricultural yield Benefits to Farmers
- Awareness of impact of AQ & Weather
- Basis for mitigation strategies

## RESEARCH

- Explore Chemical-Weather
- Improve Weather & AQ Forecasting Skill
- Development of Emission scenario
- Short Term Climate Change


AIR QUALITY-NOW
10-10-2010 17:13
AQI
CWG Village
PM2.5 225
PM10 279
North-East

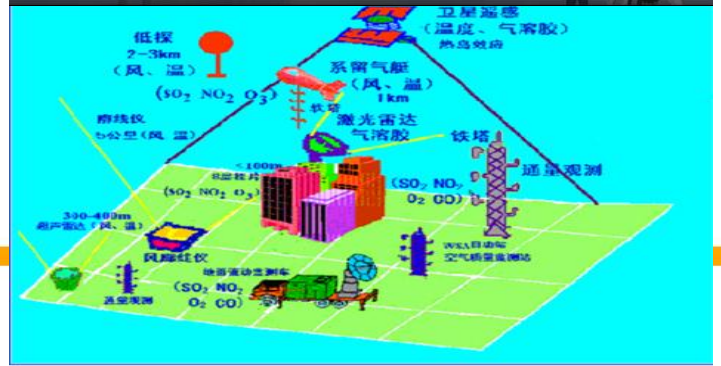

AIR QUALITY
FORECAST (TOMORROW)
10-10-2010 12:14
AQI
I.G.Sports Cmplx
Ozone 93
Nitrogen Oxide 35
Good Moderate Poor V.Poor
:ction:South.
*Major C


AIR QUALITY
FORECAST (TOMORROW)
10-10-2010 12:15
AQI
I.G.Sports Cmplx
PM10
Good Moderate Poor V.Poor
:Moderate,PM2.5:Poor,P


वायु गुणवत्ता-अभी
08-10-2010 19:02
AQI
कार्बन मोनो ऑक्साइड 93
पी.एम2.5 261
उत्तम सामान्य
h, Wind Direction:South-I
08/10/2010


पी.एम.10 (PM10) प्रदूषण (आज)
तुलनात्मक चार्ट
48
43
47
236
48
48
61
09/10/2010

# GURME Pilot Project (MHEWS Shanghai) (EXPO-2010)

- ✓Enhanced observing system
- ✓Enhanced air quality & weather forecasting (& heat waves)
- ✓Field experiment (joint with NCAR)
- ✓Workshop activities

Operation ozone prediction and warning based on WRF-CHEM modified version and one hour refresh assimilation and 3km resolution technique based on WRF3.0

**(1) Information system**

Forecast dynamics (NCEP)

Emissions of air pollutants

Initial and boundary conditions
(Meteorology - NCEP)
(Chemistry - MOZART)

Land surface data

Pre-process system (WRF-SI)
(integrating data)

**(2) Physical and chemical system**

Dynamical model (WRF) – forecast dynamical parameters
winds, temperature, clouds, rain, PBL….

Chemical/aerosol model (Chem) – forecast O3, NOx, aerosols…….

Radiation model (TUV) – forecast UV, Photolysis ……

On-line coupled dynamics-chemistry-aerosols-radiation (WRF-Chem)

**(3) Products**

Data analysis system
Visual display
Ozone analysis

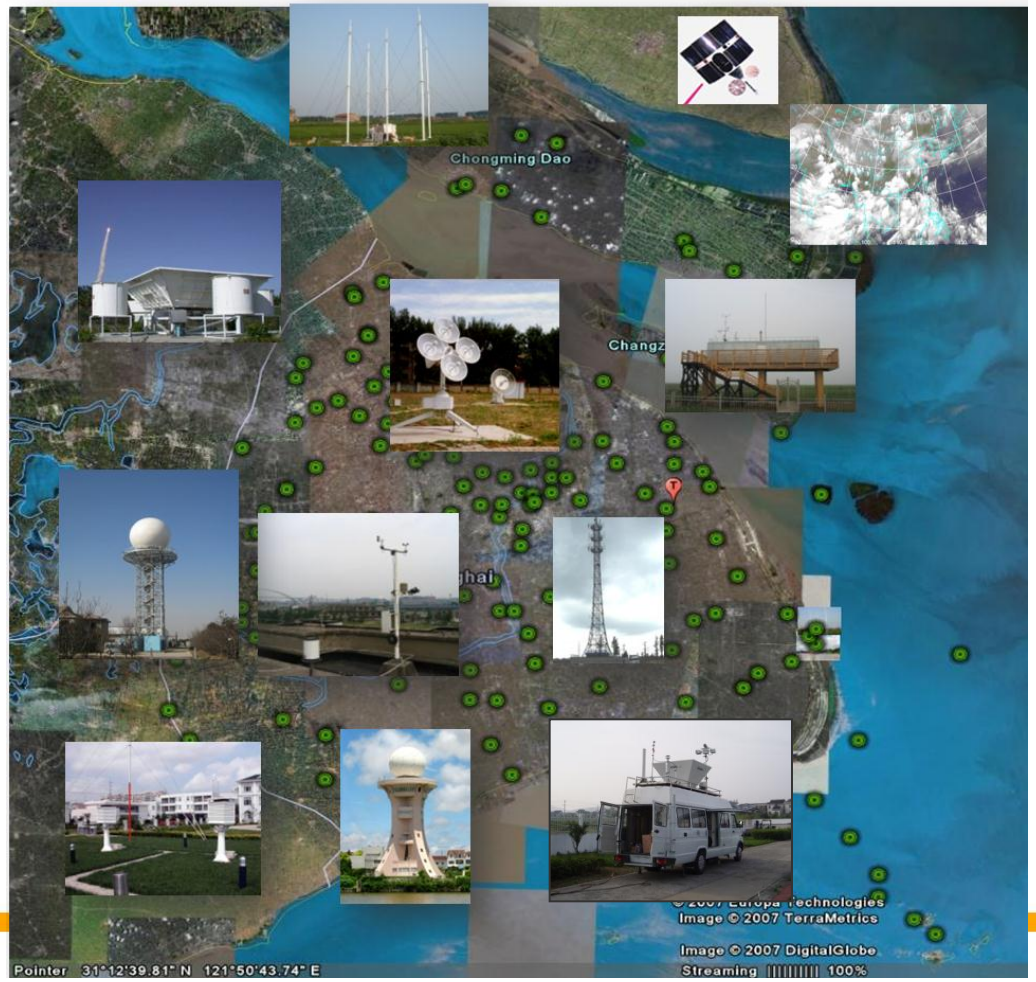
Impact model
Effect of O3 on health
Effect of O3 on vegetation

Alert system
Distribute the early warning results

Reduction strategy
Providing possible methods to reduce O3

# Practices for environmental meteorology in Shanghai - Monitoring

## Current integrated dynamic, thermal and chemical system for Shanghai urban PBL monitoring.




| Ground-based: | |
|---|---|
| AWS | 256 |
| Wind profiler | 10 |
| Gradient stations | 13 |
| Lidar | 2 |
| Ceilometer | 2 |
| Microwave radiometer | 1 |
| GPS/MET | 31 |
| Satellite receivers | 9 |
| Radiosonde | 1 |
| Atmospheric chemistry | 12 |
| Mobile | 5 |

# Papers and Research Outcomes


1. Geng F.H., C.S. Zhao, X. Tang, et al., 2007: Analysis of ozone and VOCs measured in Shanghai: A case study. *Atmospheric Environment*, 41, 989–1001.
2. Geng F.H., X.X Tie, J.M. Xu, et al., 2008: Characterizations of ozone, NOx, and VOCs measured in Shanghai, China. *Atmospheric Environment*, 42, 6873–6883.
3. Ran L, C.S. Zhao, F.H. Geng, et al., 2009: Ozone photochemical production in urban Shanghai, China: Analysis based on ground level observations, J Geophys Res, vol. 114, D15301
4. Huang W., J.G.Tan, H.D. Kan, et al., 2009: Visibility, air quality and daily mortality in Shanghai, China, *Science of the Total Environment*, 407, 3295-3300
5. Tie X. , F.H. Geng, L. Peng, et al., 2009: Measurement and modeling of O3 variability in Shanghai, China: Application of the WRF-Chem model, *Atmospheric Environment*, 43(28), 4289–4302
6. Geng F.H., Q. Zhang, X.X. Tie, et al., 2009: Aircraft measurements of O3,NOx,CO,VOCs,and SO2 in the Yangze River Delta region, *Atmospheric Environment*, 43, 4289-4302
7. Cai C.J., F.H. Geng, X.X. Tie, et al., 2010: Characteristics of Ambient Volatile Organic Compounds (VOCs) Measured in Shanghai, China, *Sensors,* 7843-7862;
8. Geng F.H., C.J. Cai, X.X. Tie, et al., 2010: Analysis of VOCs emissions using PCA/APCS receptor model at city of Shanghai, China, *Journal of Atmospheric Chemistry*, 62, 229-247
9. J. Xu, C. Li, H. Shi, Q. He, and L. Pan, 2011: Analysis on the impact of aerosol optical depth on surface solar radiation in the Shanghai megacity, China, Atmos. Chem. Phys., 11, 3281–3289


……

# 中国气象局-国际气象组织
# 城市气象和环境研究示范项目
## A CMA-WMO GURME Pilot Project

# NRT Data Application to Air Quality Forecasts

# Objectives - 1

- **Develop and establish a NRT chemical data transfer system to collect and process both ground based and satellite observations, based on the WMO data transfer protocols for conventional weather data;**

- **Develop an AQ forecasting system and integrate it with the NRT system to illustrate the capacity of NRT data to enhance the accuracy of AQ forecasts in China;**

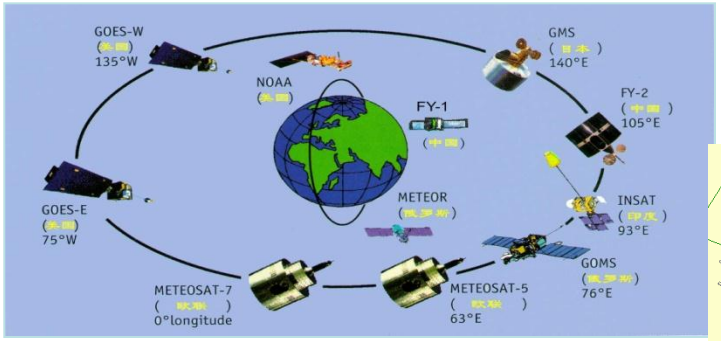
# Objectives - 2

- Develop an emission estimating system using the NRT data and inverse modeling methodology;

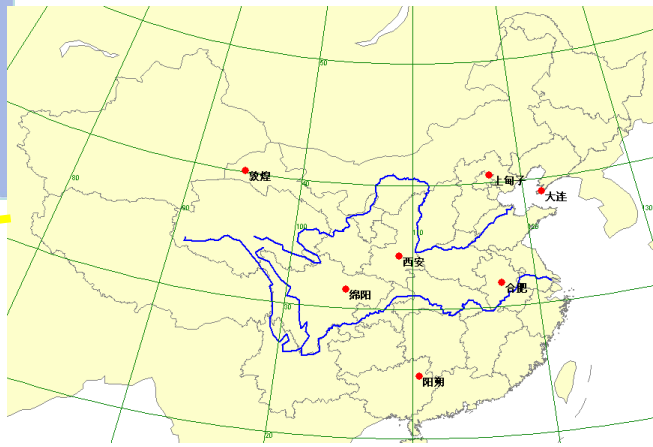
- Exchange and transfer research results with other national and international agencies.

# Dust Storm: CUACE/Dust

Satellite
FY-2c




lidar

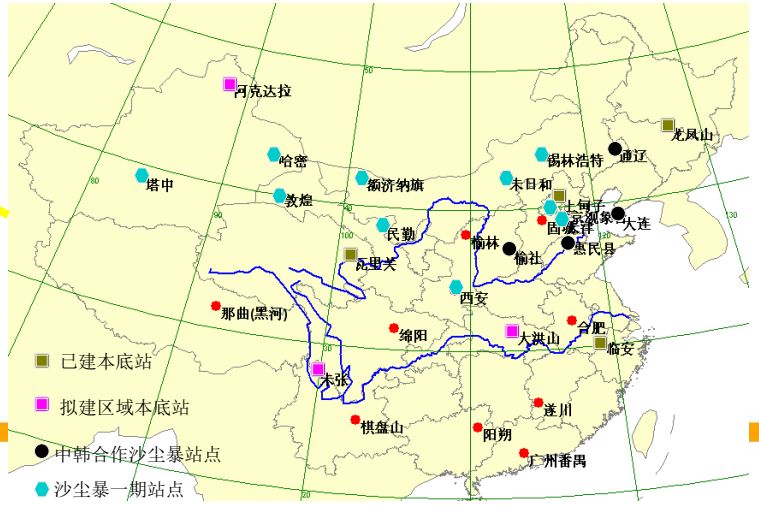



SDS
Observations

Data
Assimilation

CUACE/Dust

Ground Obs.




Gong and Zhang 2007, ACP

# Weather and air quality forecasting

## Guidance from WMO-CAS XV

**Near-real time delivery of air chemistry observations for use in weather and environmental forecasting**

# NRT in GAW

- GAW WIS WIGOS Pilot Project on Ozone and Aerosol observations in NRT
- Data delivered to large, integrating projects, such as MACC; MACC has also delivered data for GAW (Antarctic Ozone Bulletin)
- GAW Expert Team on NRT CDT, Chair Vincent-Henri Peuch, ECMWF
- Operational NRT ceilometer and lidar network being established (Thomas Werner)

# New focus: Integrated approach combining physical, chemical and biological weather

**There is a need to design and implement public information and warning levels for biological weather (examples: European COST project ES0602, Shanghai).**

**In addition to separate impacts, the three need to be considered together and research is needed to improve the coupling of these, to understand exposure and improve modelling and forecasting.**

# EU, COST, IGAC, GEO collaboration

- MEGAPOLI Project, MACC (GEMS)
- COST Actions

  728 Mesoscale for AP and Dispersion Applications:

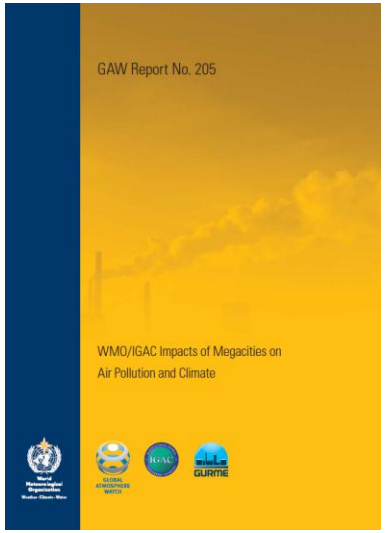
  0602 Chemical weather; 0603 Allergenic pollen

  1004 European framework for online integrated air quality and meteorology modelling (EuMetChem)
- IGAC: Megacity Report, biomass burning
- GEO Global Urban Observation and Info Task

# GAW publications available from:

http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html

**Including the IGAC/WMO Impacts of Megacities on Air Pollution and Climate**



The WMO GAW Urban Research Meteorology and Environment Project

# 4th International Workshop on Air Quality Forecasting IWAQFR

## 12-14 December
## WMO Secretariat
## Geneva, Switzerland

# Collaboration critical for success!