Brief Overview of GURME Shanghai Project and WMO Shanghai IUWCS

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1 Milestone and goals

- Jan 2007, Accepted by WMO;
- Feb 2007, Start ceremony;
- Aug 2007, 1st SSC meeting, Shanghai, China;
- Jan 2008, 2nd SSC meeting, Phoenix, Arizona, USA;
- May 2008, Spring school of atmospheric chemistry;
- Oct 2010, 3rd SSC meeting, Shanghai, China
- Dec 2011, GURME Workshop (reviewed)
Main goals to achieve

(1) To investigate the physical and chemical mechanism during the transportation and transformation process of atmospheric pollutants in Shanghai megacity;

(2) To better understand the impact of air pollutants on the low-visibility episodes (such as fog, haze, etc.);

(3) To establish the chemical weather forecasting system to improve the capacity of prediction, warning and regulation for urban and regional air quality;

(4) To understand the impact of weather and environment on human health to develop the adaptive technique.
2 Practice and behavior

(1) Established the integrated observation system for atmospheric physics and chemistry in urban planetary boundary layer (PBL), as well as the data analysis, diagnose and fusion platform.

(2) Developed the Numerical Weather Prediction systems extend from hours to weeks without time-gapping, includes Rapid Update Cycle (RUC), Meso-scale Ensemble System, and integrated regional model for both physics and chemistry by WRF/CHEM.

(3) Carried out forecast, warning and service of urban and environment meteorology: AQ, emergency response, haze ...

(4) Developed impact forecast and service: weather and environment on health, to achieve healthy city development.
PBL observation: Physics & Chemistry

- AWS: 220
- Doppler radar: 1+1
- Wind profile: 8 + 1
- Lightening position: 6
- GPS/Met :18
- Tower: 13
- Mobile: 3+1+1
- Total sky imager: 16

Physics instruments: in-situ OBS. & remote sensing

Chemistry instruments: Sampling & remote sensing

Physics + Chemistry

Atmospheric chemistry: 10
Key point: horizontal measurement

(1) Representative in different environments

(2) Layout at different scale

Shanghai megacity
~ hundred of kilometers

Shanghai downtown
~ tens kilometers

Expo garden
~ kilometers
Key point: vertical measurement

(1) Extend from the surface to the top of the Earth

~100m ~3000m ~6000m ~10000m ~30000m the Earth top

(2) Integrated observation including dynamical, thermal and chemical
Numerical Weather Prediction
----Urban meteorology and chemistry aspect

- Met data assimilation (ADAS)
- SMB-WARMS (9km)
- WRF/DUST (24km)
- WRF/CMAQ (9km/3km, off-line)
- WRF/CHEM (6km, on-line)

- Chemical data assimilation (GSI)

- HYSPLIT/CFD
  - Trajectory, emergency response

- Highly-impacted chemical weather & health (O3, PM, haze, et al.)
- dust
Products sampling:

Chemical weather

Sandstorm

PM2.5 & Ozone

Haze level
Dispersion

Specific & emergency response

Trajectory

CFD

16:00 UT of 7 Apr - CFD Forecast initialization
3 Scientific result and achievement

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

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Diurnal, daily and season variation of surface O₃ (left) and NOₓ (right) in Shanghai

Ran, et al., 2008, JGR

Impact of NOₓ and NMOC on maximum daily ozone

Impact of AOD on surface ozone
Clear weekend effect of ozone

Tang, et al., 2008

Ozone ISOPLETH in Shanghai (left) and YZD (right) region


Ozone measurements by aircraft
The impact of synoptic pattern on surface ozone in Shanghai by WRF/CHEM

*Tie, et al., 2009, Atmospheric Environment*
Wind rose

Aerosol scattering coefficient & Wind

Xu, et al., 2010

AOD & Wind

Aerosol transportation and dispersion
Haze determination by Lidar measurements

Pan, et al., 2010
4 Summary

Through WMO-shanghai GURME Pilot Project, we:

(1) Greatly extended the understanding and knowledge of atmospheric physics and chemistry issues in the megacity such as the typical phenomena of “urban oven” and “urban chimney”.

(2) Significantly enhanced the capacity building on PBL observation, Numerical Chemical Weather Prediction and healthy-meteorology forecasting, which played an import role in the 2010 Shanghai EXPO service and social service.

(3) Notably promoted the team construction and expert training for persistently development of scientific activities and operational practice in the field of urban environment and meteorology.
Improvement in Numerical Environmental Meteorology Forecasting after GURME
The system development in brief

2006
- Introduction of WRF-Chem

2008
- experiments/test system
- evaluation
- framework determination

2009
- the real-time system (YRD region)
- guidance for API forecast over SH

2012/2013
- operational system
- guidance for AQI&Haze forecast over EC
- products website

2014-
- Update in Anthro. Emiss.
- Sharing Platform of East China
Flow chart/framework of the operational system

- Resolution of 6km
- 96h forecasts starts at 12UTC
- Dust BC from WRF-Dust
- Chemical BC from climatic MOZART simulation
- Land use update;
- Eastern China
- Authorized by CMA in 2013
The sharing platform

http://222.66.83.21:8086
Performance distribution of PM2.5

- Correlation Coefficient of PM$_{2.5}$ 48h Forecast
- Mean Bias (ug/m$^3$) of PM$_{2.5}$ 48h Forecast
- RMSE (ug/m$^3$) of PM$_{2.5}$ 48h Forecast

Bar graphs showing:
- Correlation coefficient: Fraction (%) for ranges -0.3 to 0.7
- Mean bias: Fraction (%) for ranges -20 to 20
- RMSE: Fraction (%) for ranges -20 to 20
Performance distribution of $O_3$-8h
WMO Shanghai IUWCS Overview
Background

Challenges
- On-going urbanization
- Expected increase of weather and climate extremes

Experiences
- MHEWS
- WENS
- GURME
- TLFDP

Why Establishing Shanghai IUWCS

Objectives
- Observation design and practices
- Forecasting and warnings across all time scales
- Impact based weather forecasts and multi-hazard risk analysis and reduction
- Urban framework for climate services

WMO CAS, CBS Priorities, GFCS
Background

★ Megacity of Shanghai: high exposure and vulnerability

4 centers
Strategic Positioning
Financial, Trade, Transportation, and Shipping Center of China

- 24+ million Population
- 2+ million Civil vehicles
- Productive economic activities.

Critical locations
Downtown, bund, airports, ports, etc. are highly sensitive to weather events.
Proposal

Objectives & Development Plan

Identification of end user needs, hazards and partners

- Weather Service
- Climate Service

Assessment

Impact-based Forecast and Risk Warning

Numerical Forecast R & D and Application

Urban Integrated Meteorological Observation and Application
Main task of Shanghai Integrated Urban Weather and Climate Service: Two integrations

1. Integration of weather forecast and climate prediction

- Fined nowcasting for 0-12h
- Extended range forecast and short-term climate prediction
- Urban Meteorological Integrated Observation
- High resolution regional weather forecasting systems

2. Integration of weather forecast and risk management

- Impact-based Forecasting and Warning
- Urban climate services
- Early-warning triggered service for decision making and department response
Main task: seamless forecast
Impact-based Forecasting and Warning: urban flooding

- The threshold for Flooding risk warning is docked with community four-level response and linkage standards.
- Flooding Risk products released to the public, community manager and shared with flood control sector.
- Cooperation with the Civil Affairs Department and flood control sector.

Rainstorm waterlogging simulation (50mm/h)
Impact-based Forecasting and Warning: Human health

- SMS Issues impacts forecasts for respiratory diseases, such as common cold, children’s asthma and COPD (Chronic Obstructive Pulmonary Disease) in cooperation with Shanghai municipal center for disease control and prevention.

- WeChat ‘jiankangqixiang’ is used to release health forecasting service. It has over 70,000 followers till now.

![](image)

The influence of PM2.5 on the sensitivity of primary pollutants in different age groups.
Impact-based Forecasting and Warning: environment

- Jointly issue the AQI prediction and warning with Shanghai Environment Protection Bureau.

- Extend the air quality forecast to 10 days for emergent emission reduction to mitigate severe air pollution events.

- Evaluate the cost effect of local clean air action plan to support the decision making for emission control.

AQI forecast in Shanghai

Regional PM$_{2.5}$ numerical prediction

Source area for emission control derived by air pathway analysis
The WMO Coastal Inundation Forecast Demonstration Project – Shanghai Subproject (CIFDP-S) is being implemented as national sub-project since 2013.

Cooperation with Hydrology (Shanghai Water Authority), Oceanography (East China Sea Branch of State Oceanic Administration), Emergency Management (Shanghai Emergency Response Center) and Coastal Planning (Shanghai Maritime Safety Administration).

**Impact-based Forecasting and Warning: ocean meteorology**

- Ensemble forecast from meso-scale ensemble system (EnWARMS) and ECMWF Ensemble system.
- Wave Models (WIII and SWAN), Radar QPE & Ensemble QPF, Storm Surge Model.
- Joint Probability of Inundation occurrence and intensity (Bayes’ theorem).
- Inundation forecast Decision Making System.
Impact-based Forecasting and Warning: traffic meteorology

- Cooperation with Shanghai Metro to carry out the risk warning forecast of rail transport
- Cooperative development of rail transport impact forecast and risk warning platform
- According to the risk warning products, line 16 and line 2 suspend operations during the period of typhoon ‘chan-hom’ in Shanghai.

The gust risk warning of Metro Line 16 during typhoon’ Chan-Hom’ attacking Shanghai
Impact-based Forecasting and Warning: aviation meteorology

- Preliminary aviation weather service is issued to support east China ATMB and east China Airlines etc.
- Based on high resolution numerical weather prediction model, aviation index including icing and clear air turbulence has been developed.
- Developed high impacted weather analysis and forecast platform for aviation integrated MET and ATM information.
Urban climate service: climate change risk assessment
Urban climate service: the climate feasibility studies

- The climate feasibility studies on large infrastructure construction projects.
- Shanghai Disney resort, Pudong international airport, Shanghai stadium
Urban climate service: climate environmental effect

- Numerical simulation of climate environmental effects of the ecosystem network planning
Technical progress: Enhancement of the Urban Integrated Meteorological Observation

- Experimental studies on adaptive layout of the synoptic network in Yangtze River Delta.
- Establishment of the integrated meteorological observation system, enhance the city's meteorological disaster monitoring, early warning

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic station</td>
<td>256</td>
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<tr>
<td>radar</td>
<td>2</td>
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<tr>
<td>Wind profiler</td>
<td>10</td>
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<tr>
<td>Gradient observation station</td>
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<td>L band sounding</td>
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<tr>
<td>Lightning location</td>
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<tr>
<td>GPS/Met</td>
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<td>Satellite remote sensing</td>
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<td>Atmospheric composition</td>
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<tr>
<td>Real monitor</td>
<td>27</td>
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<tr>
<td>Mobile observation car</td>
<td>5</td>
</tr>
</tbody>
</table>
Technical progress: High Resolution Regional Weather Forecasting Technology

- Rapid updated cycling analysis and forecasting system (SMS-WARR2.0). Assimilate multi-source observational data and add additional meso-scale and micro-scale weather information in the initial fields.

- Tropical cyclone modeling system. Assimilate multi-source observational data and optimize the NCEP vortex initialization technique.

- Air quality forecasting system. Improve Chemical transformation process of pollutants and optimizing gas phase chemistry and aerosol schemes.

- Ocean modeling system. Achieve high resolution forecasts in key areas.
Thank you for your attention