Brief Overview of GURME Shanghai Project and WMO Shanghai IUWCS

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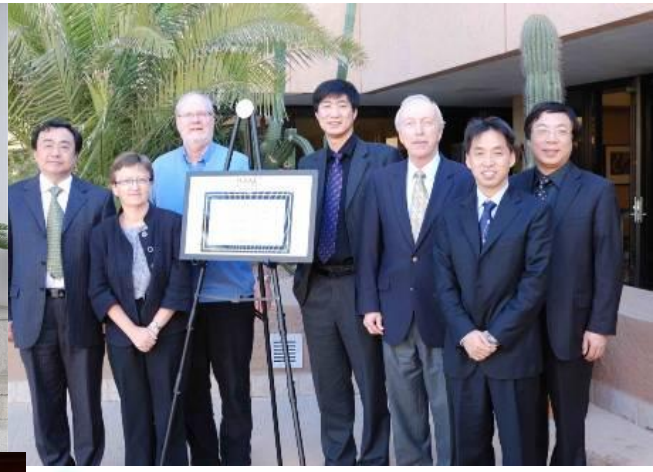
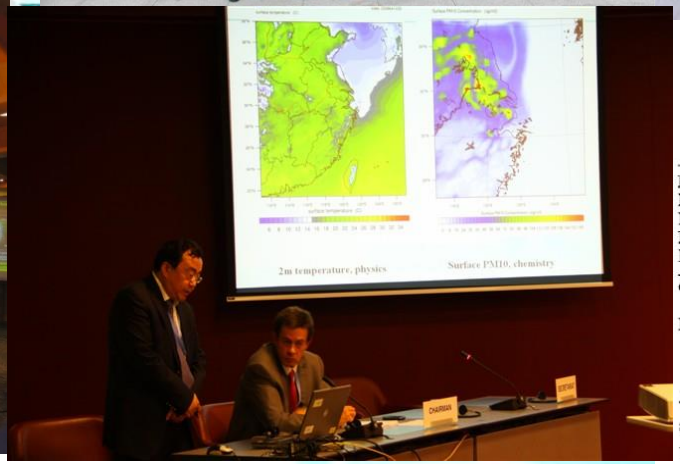
Shanghai Institute of Meteorological Science

Shanghai Meteorological Service

8. April, 2017

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)

中 国 气 象 局

CHINA METEOROLOGICAL ADMINISTRATION

46 Zhongguancun Nandajie, Beijing 100081, China

Date: 24 January 2007
From: Dr. Qin Dahe, Permanent Representative of China with WMO
For the attention of: Mr. M. Jarraud, Secretary-General, WMO
Fax No.: 0041 22 730 8181
Number of pages including this one: 1

Our Ref.: 07- 012 /F1/CMA

Dear Mr. M. Jarraud,

I have pleasure to acknowledge the receipt of your letter dated 11 January 2007 (ref: AREP/GURME-Shanghai) concerning WMO's acceptance of the GURME-Shanghai Project Proposal. I fully appreciate WMO's acceptance of the above-mentioned project proposal as a GURME pilot project.

Taking this opportunity, I wish to reassure you that CMA and specifically the Shanghai Regional Meteorological Center will make good use of this opportunity to contribute to WMO's programs and activities in the field of urban meteorology. We are looking forward to close collaboration with WMO Secretariat in carrying out the pilot project.

With my best personal regards,

Yours Sincerely,

Qin Dahe

(Qin Dahe)
Permanent Representative
of China with WMO

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

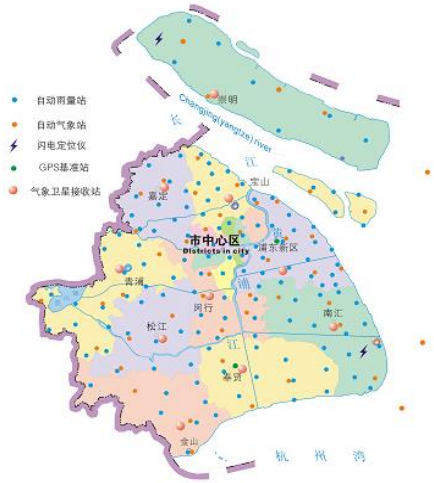
(1) Established the integrated observation system for atmospheric physics and chemistry in urban planetary boundary layer (PBL), as well as the data analysis, diagnose and fusion platform.

(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

- Atmospheric chemistry: 10

Physics + Chemistry

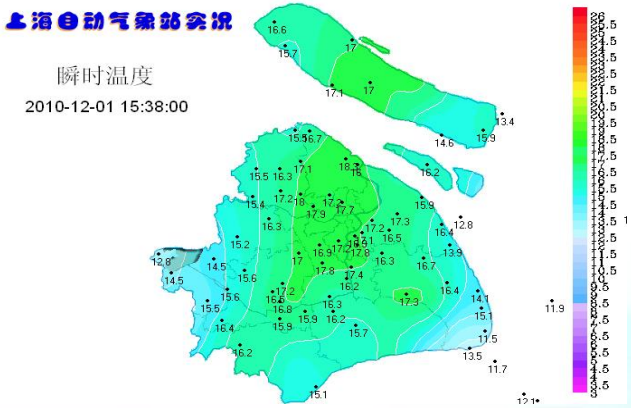
Physics instruments: in-situ OBS. & remote sensing

Chemistry instruments: Sampling & remote sensing

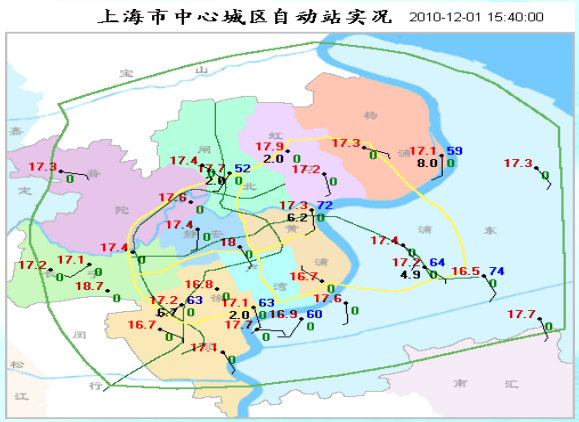
Key point: horizontal measurement

(1) Representative in different environments

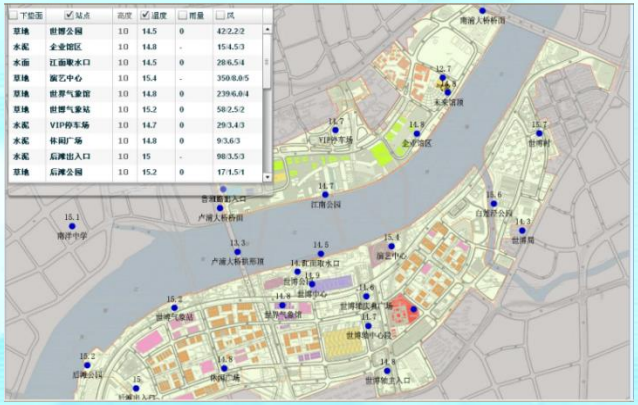
(2) Layout at different scale



Shanghai megacity
~ hundred of kilometers



Shanghai downtown
~ tens kilometers



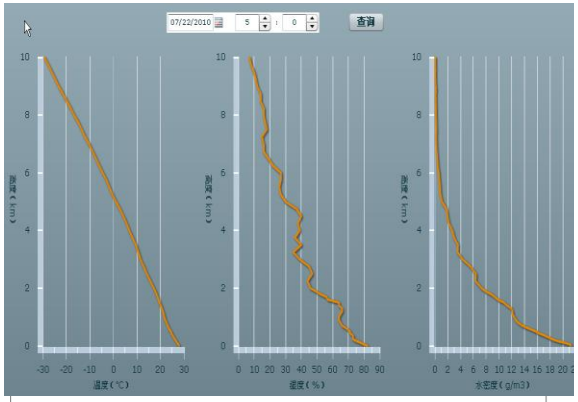
Expo garden
~ kilometers

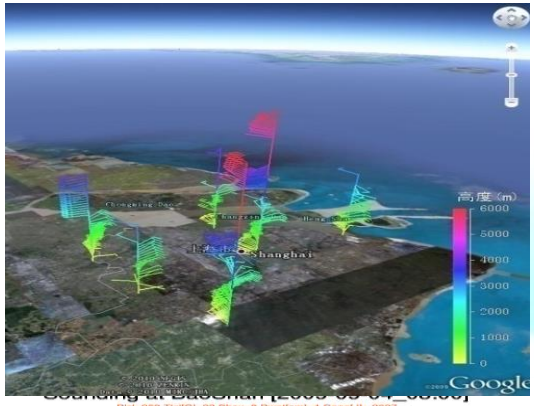
Key point: vertical measurement

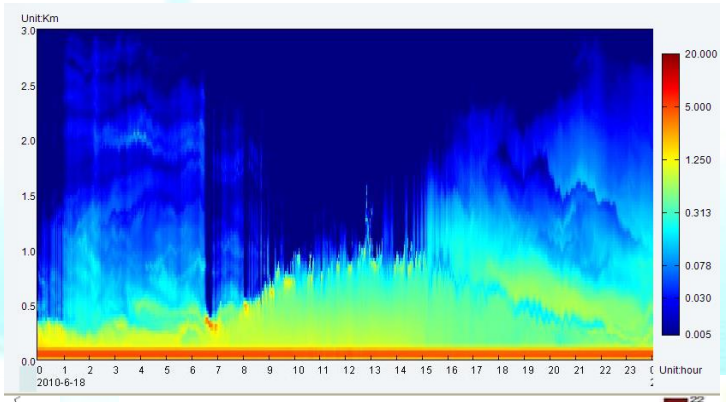
(1) Extend from the surface to the top of the Earth

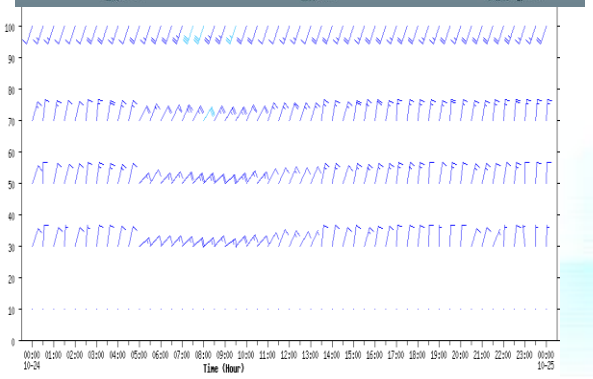
~100m ~3000m ~6000m ~10000m ~30000m the Earth top

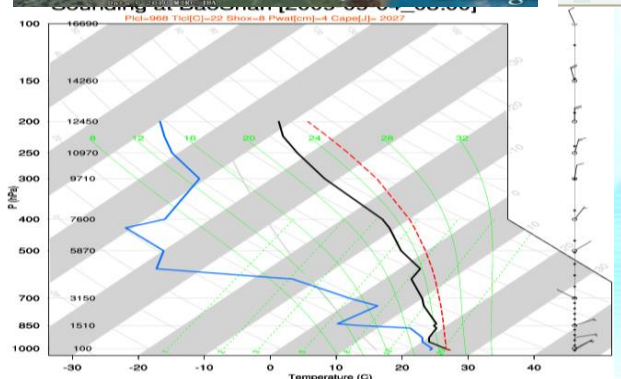
(2) Integrated observation including dynamical, thermal and chemical

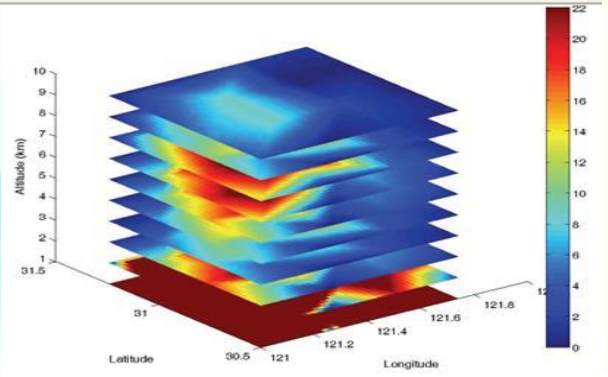




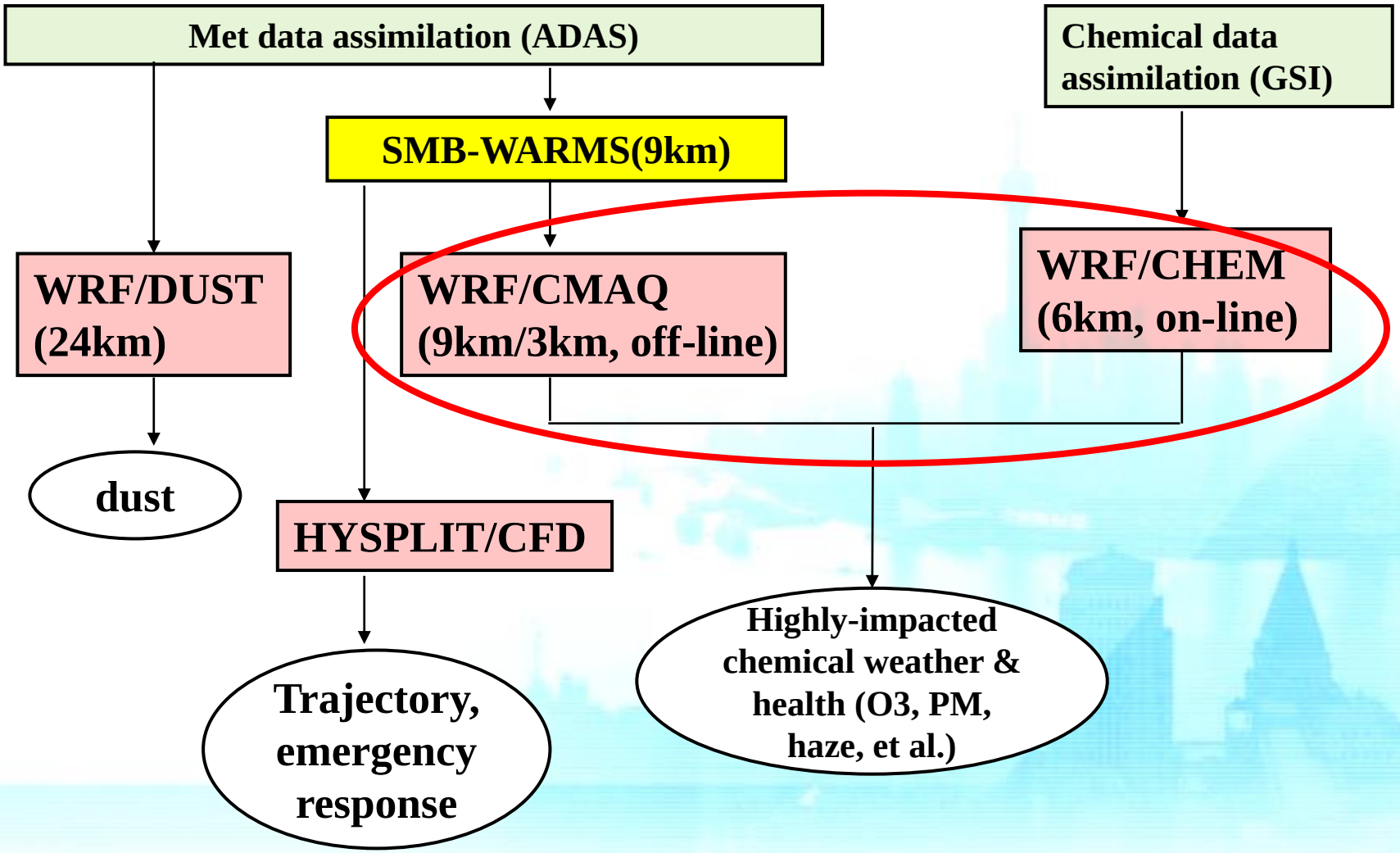






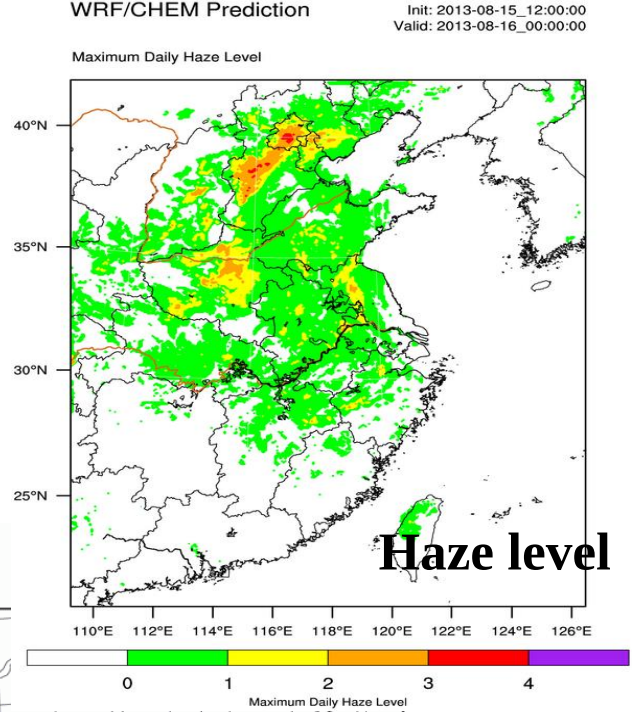


Numerical Weather Prediction
----Urban meteorology and chemistry aspect

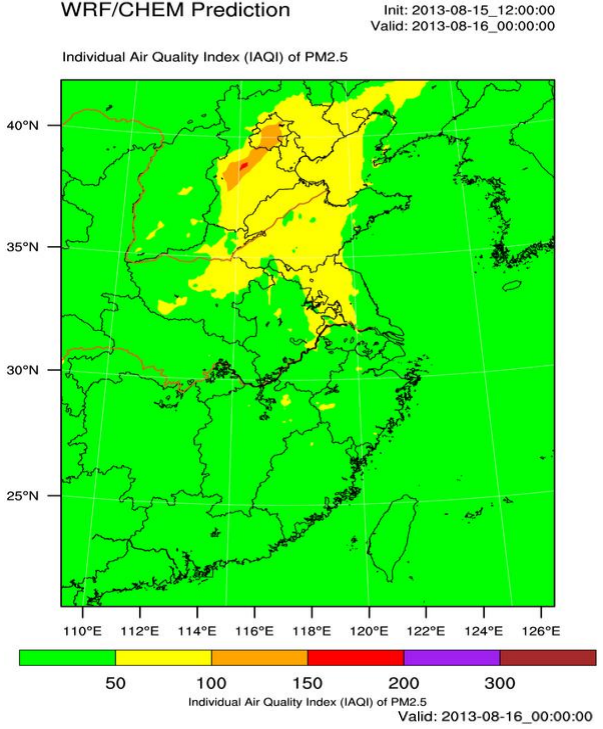


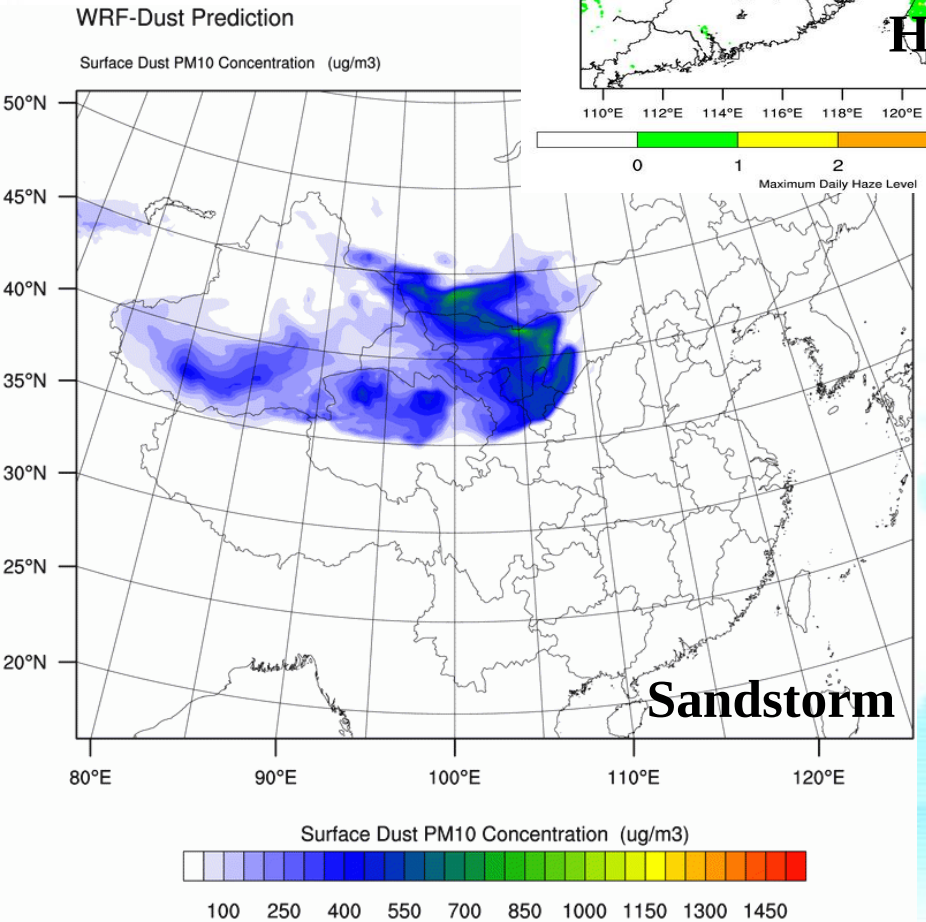
Products sampling:

Chemical weather



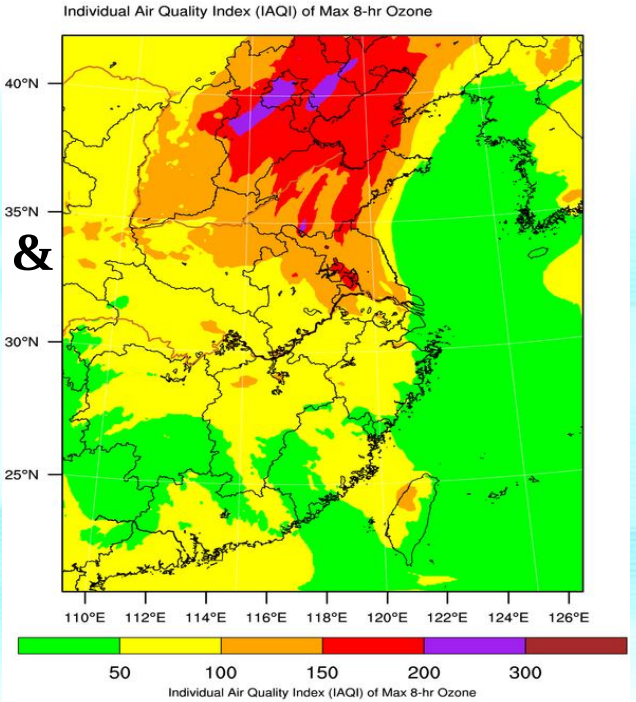
Haze level

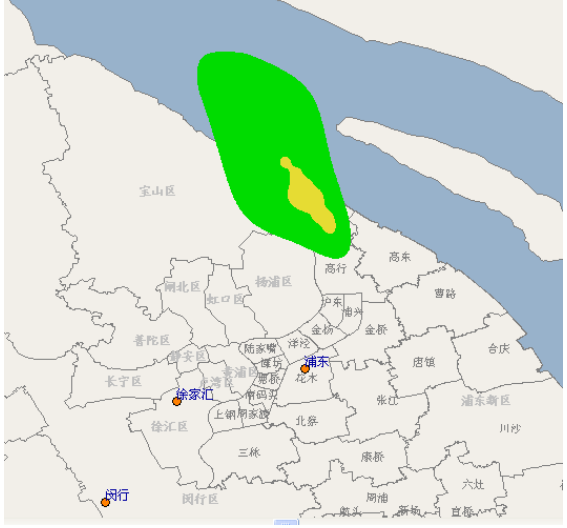




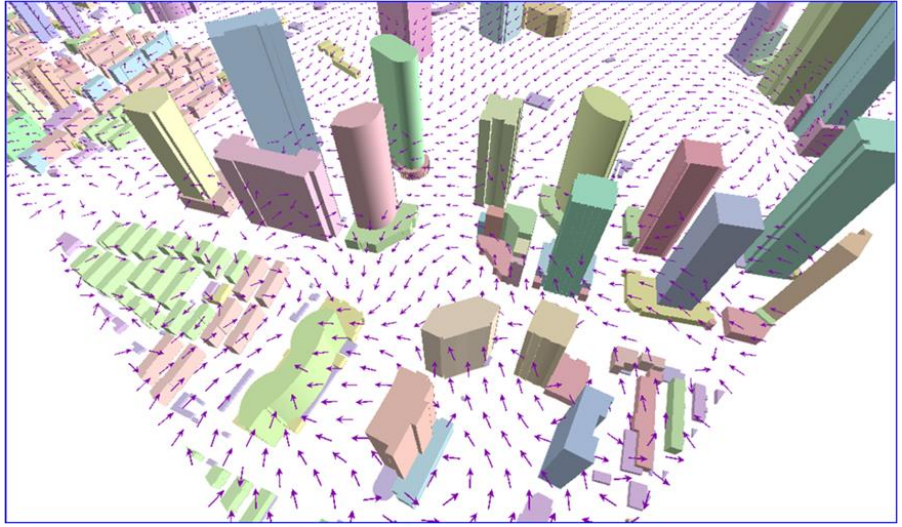
Sandstorm

PM2.5 & Ozone



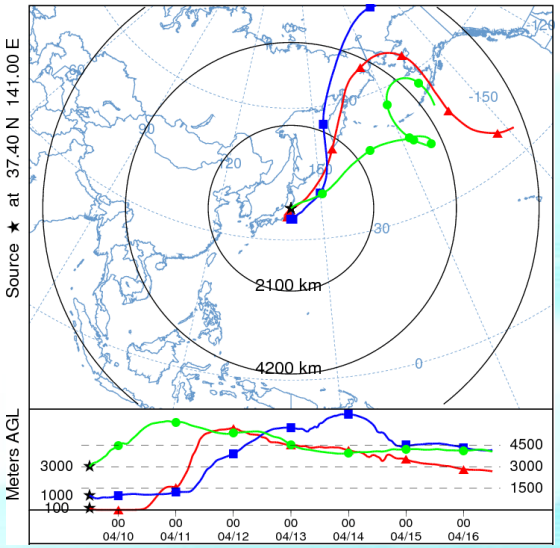


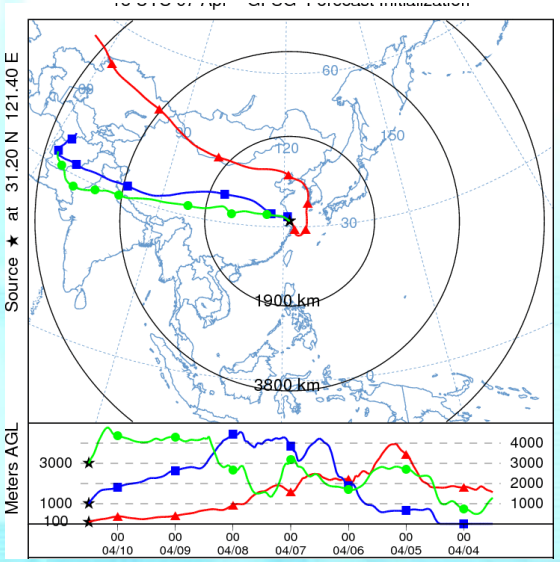
Dispersion



CFD

Specific & emergency response





Trajectory

3 Scientific result and achievement

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 Yangtze 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

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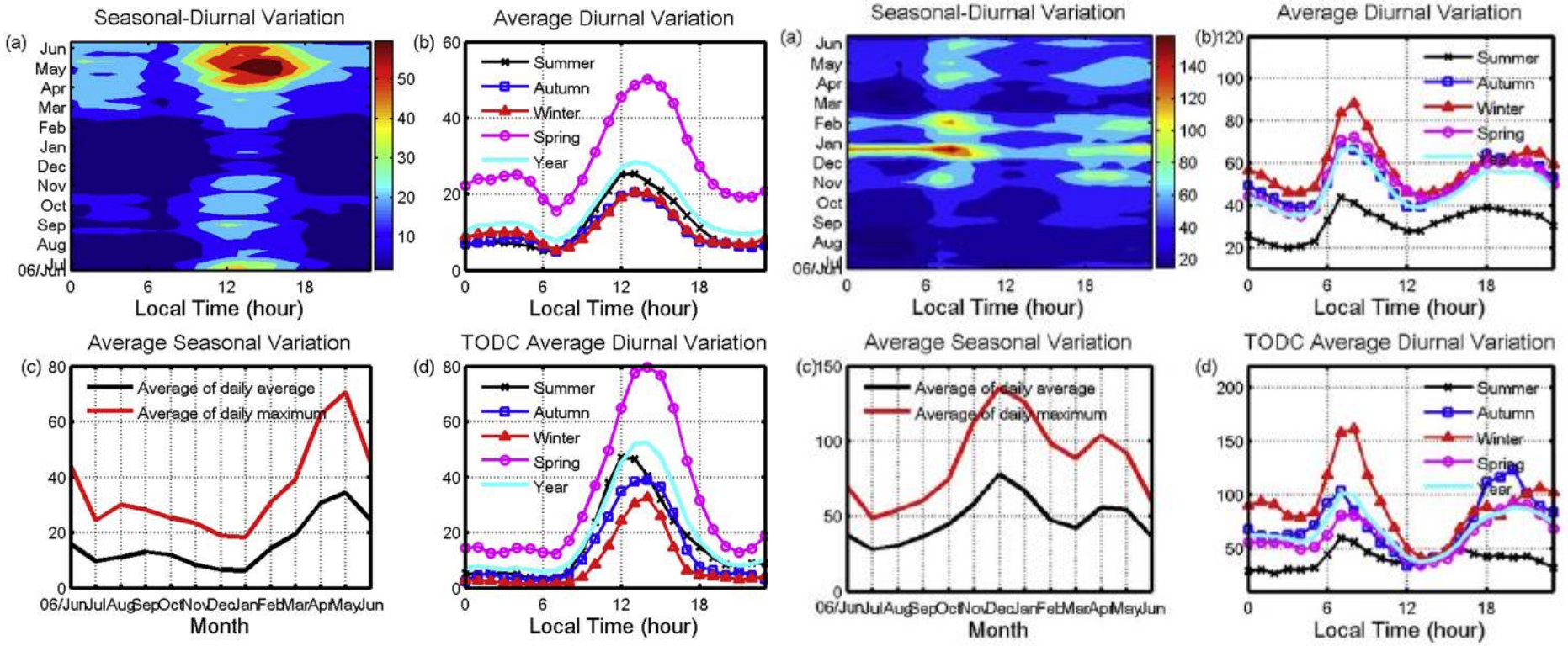
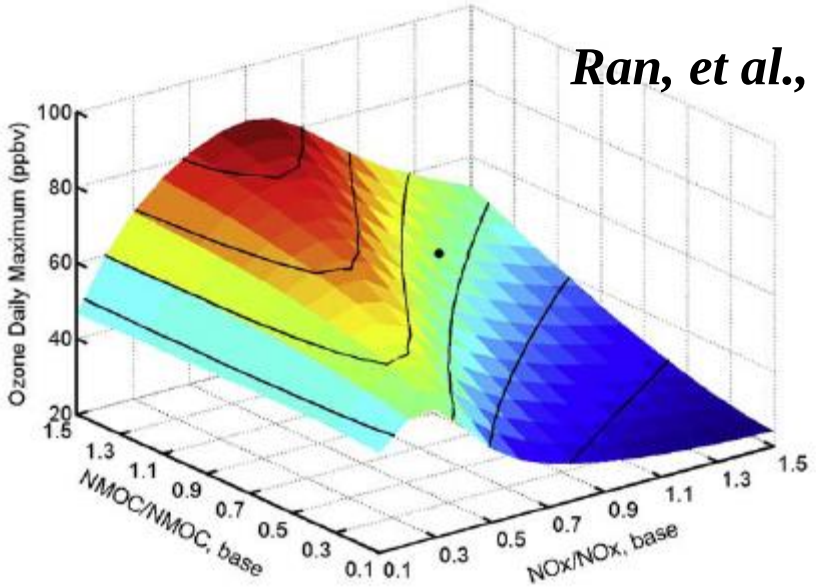
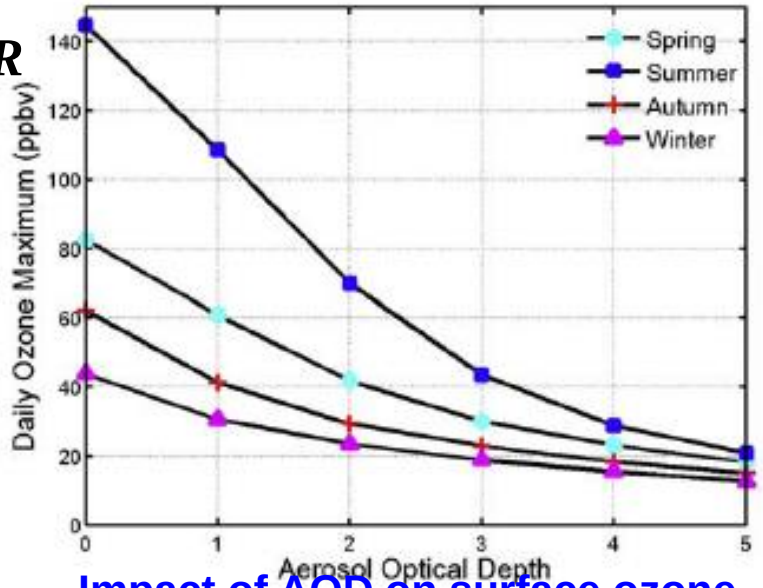


Diurnal, daily and season variation of surface O3 (left) and NOx (right) in Shanghai

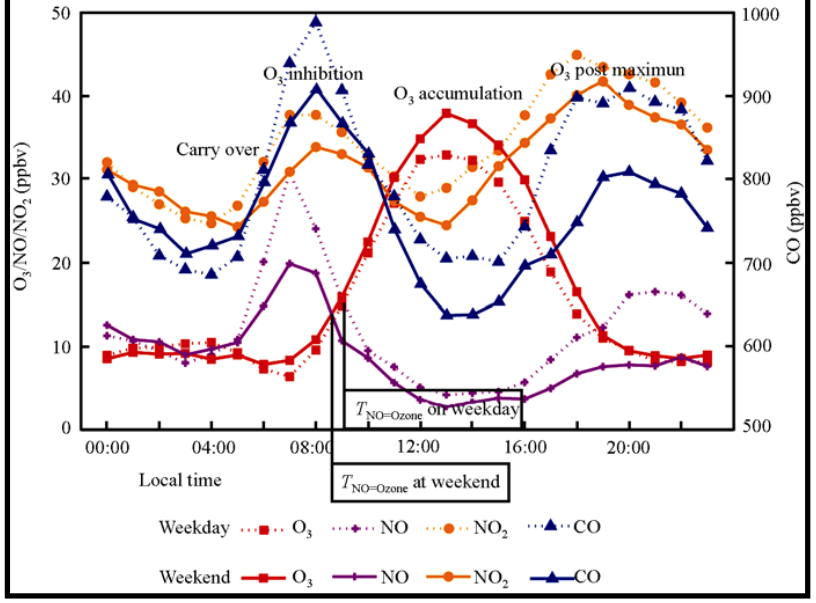
Ran, et al., 2008, JGR



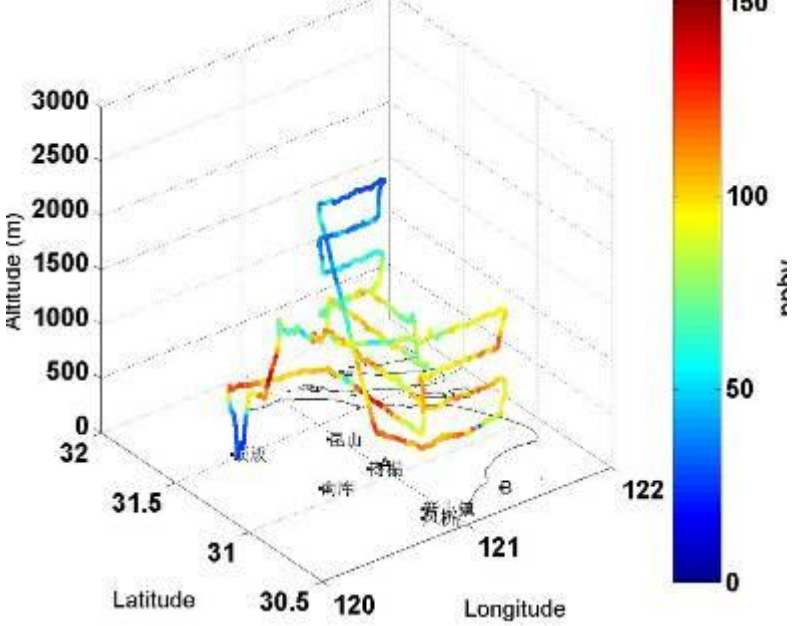
Impact of NOx and NMOC on maximum daily ozone



Impact of AOD on surface ozone

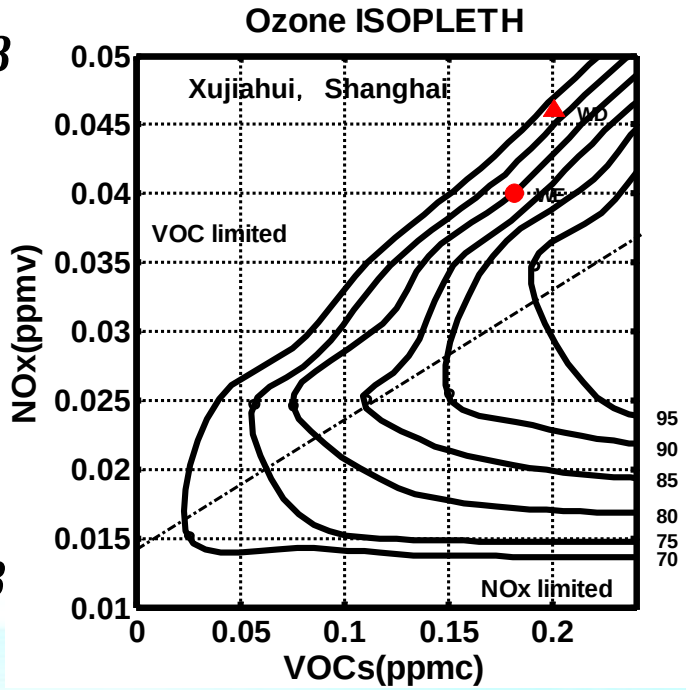


Clear weekend effect of ozone

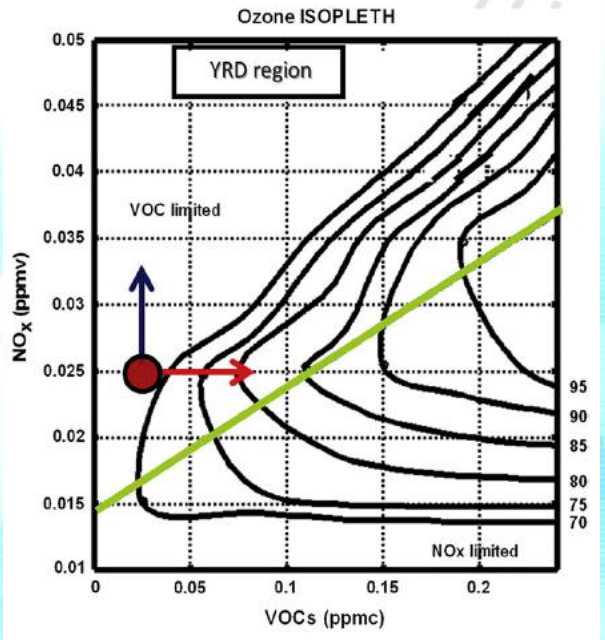


Ozone measurements by aircraft

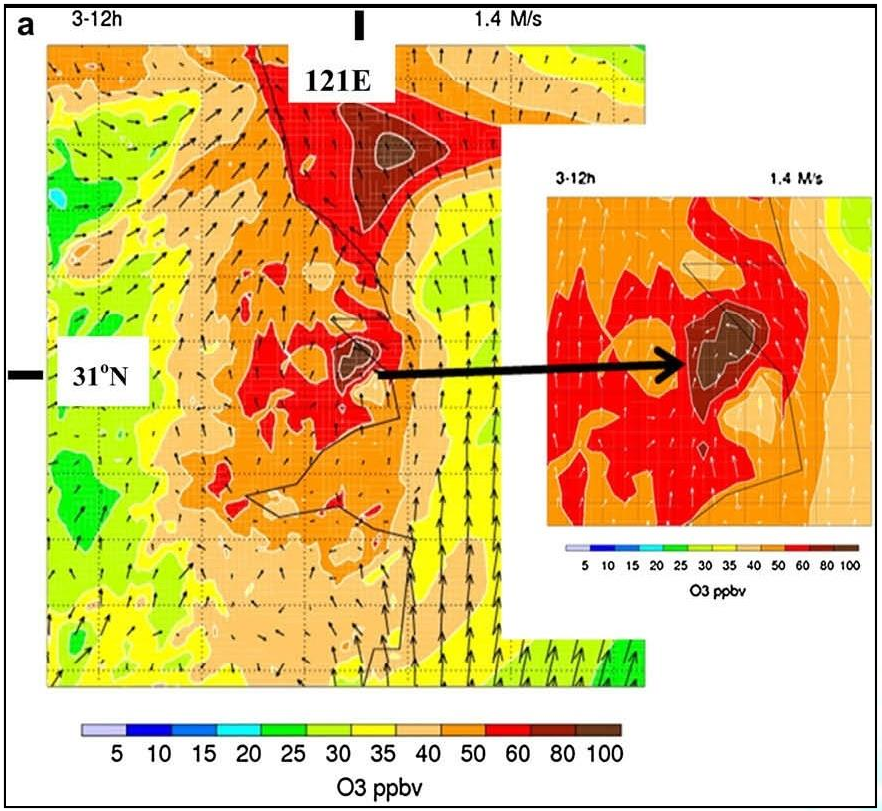
Tang, et al., 2008

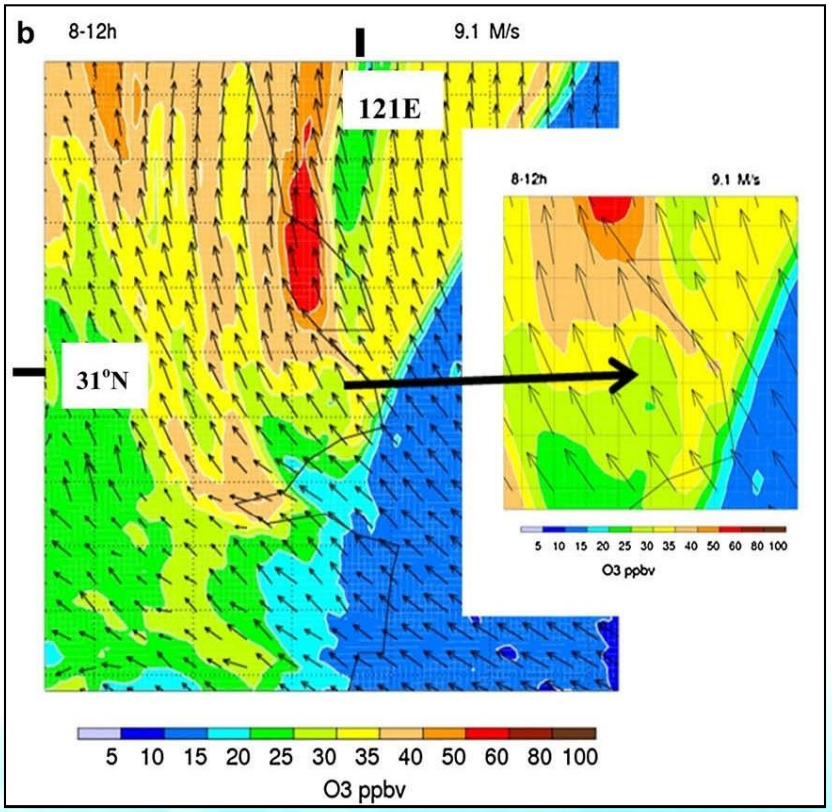


Geng, et al, 2008



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



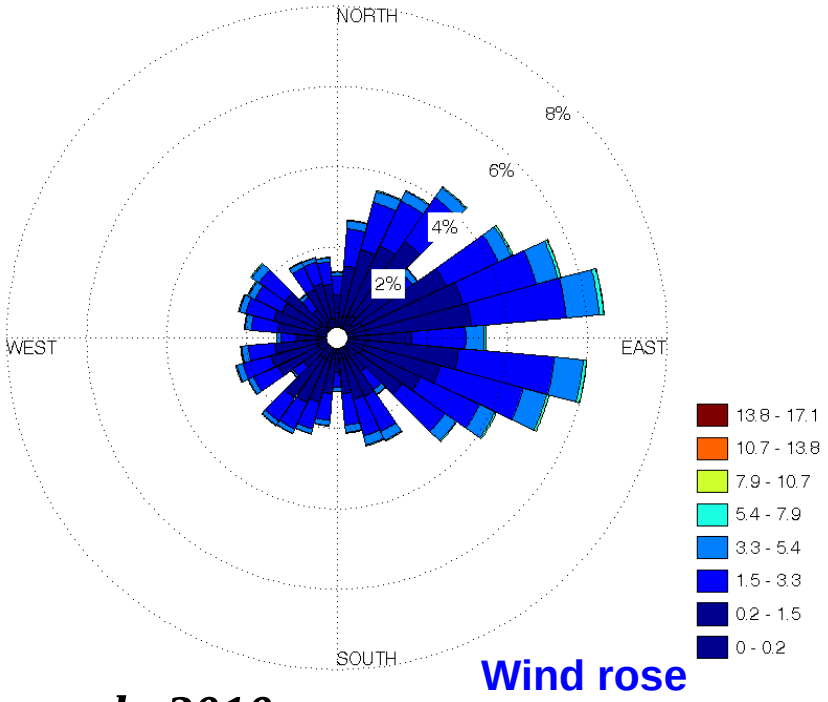


Stable weather condition

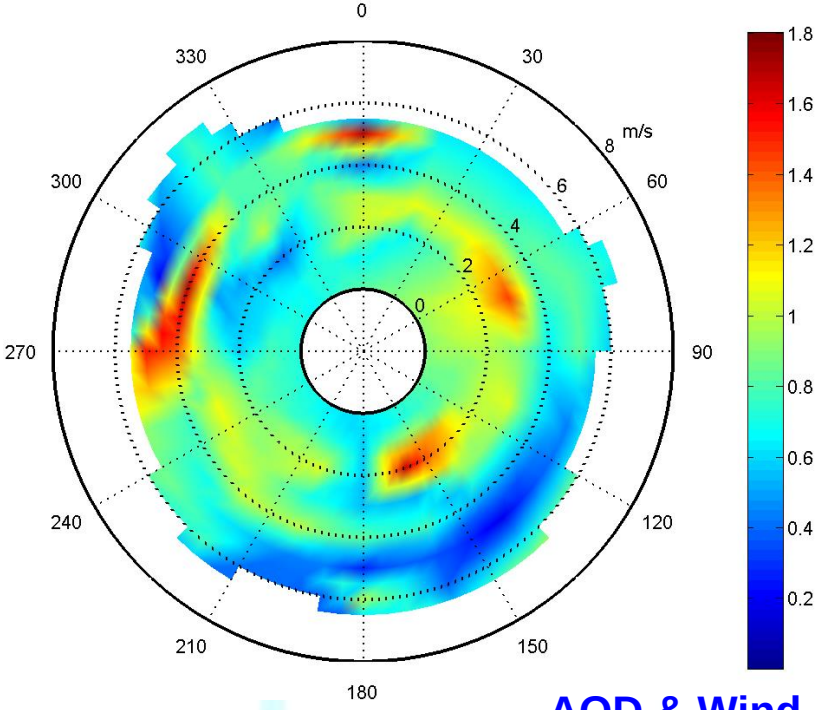
High pressure control

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

Tie, et al., 2009, Atmospheric Environment

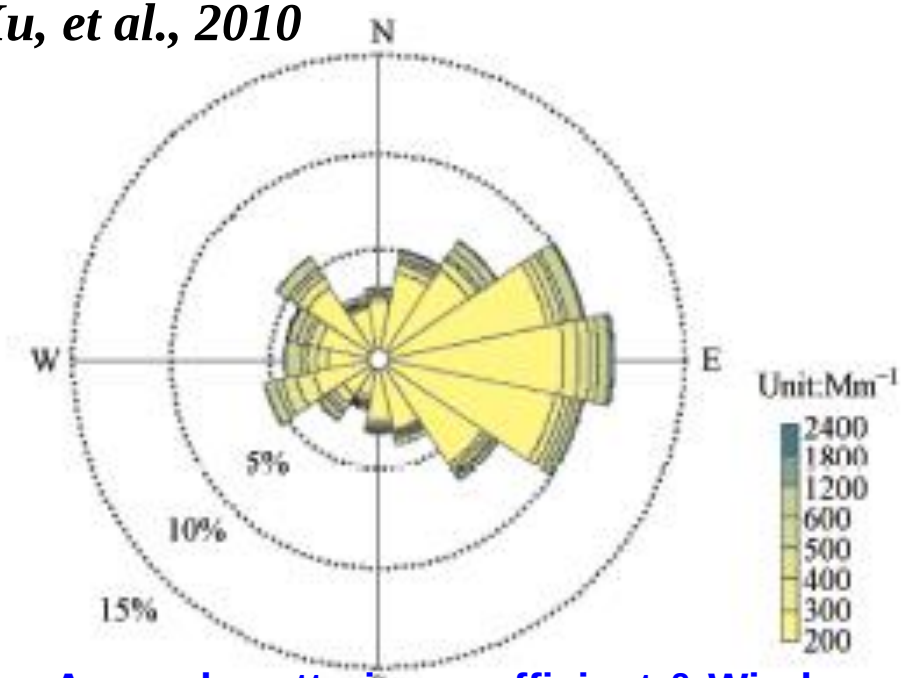


Wind rose

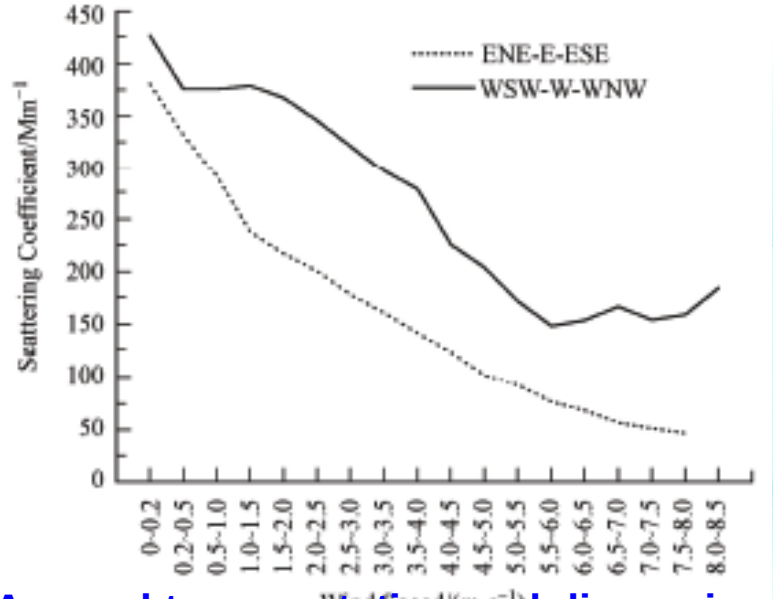


AOD & Wind

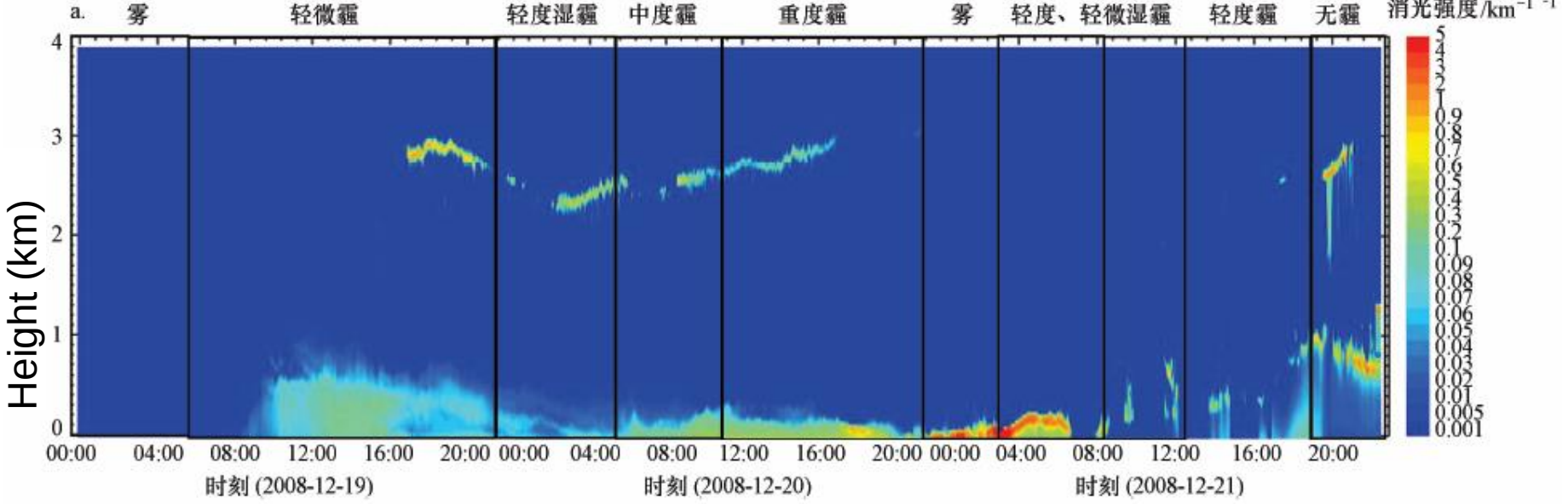
Xu, et al., 2010



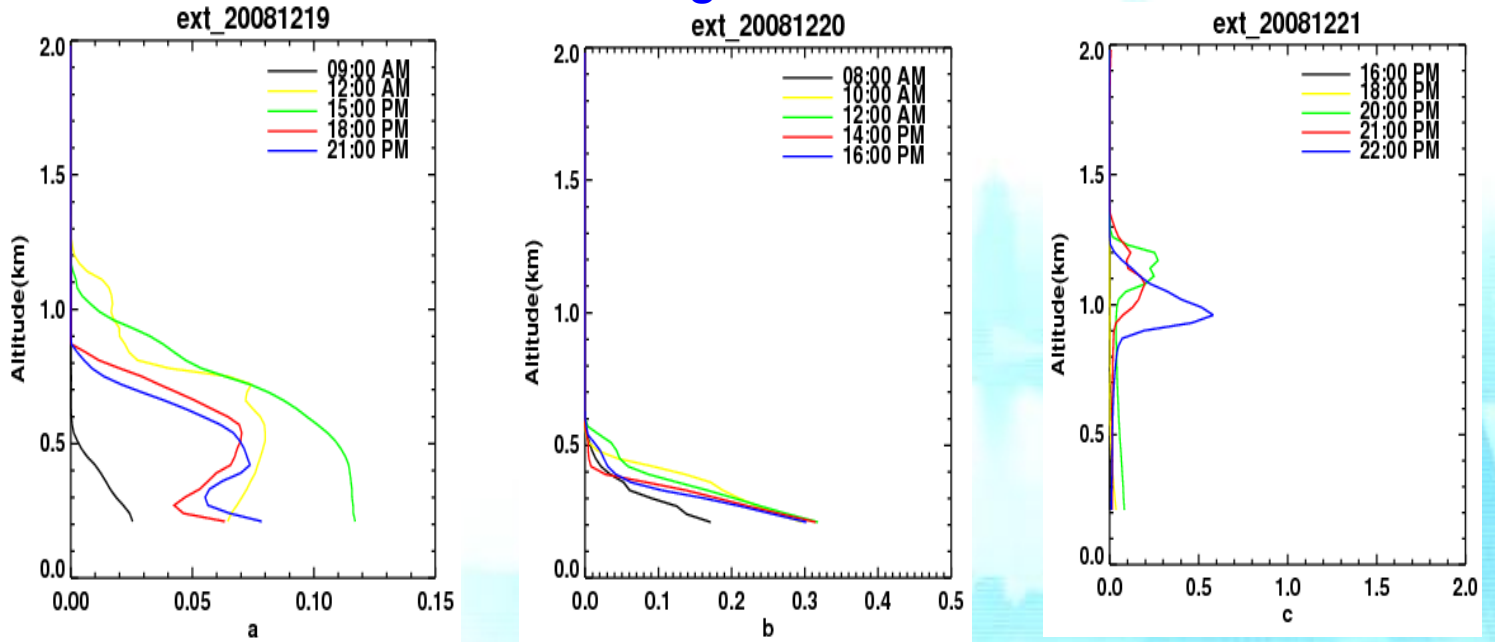
Aerosol scattering coefficient & Wind



Aerosol transportation and dispersion



PBL height variation



Vertical aerosol extinction coefficient

Pan, et al., 2010

Haze determination by Lidar measurements

4 Summary

Through WMO-shanghai GURME Pilot Project, we:

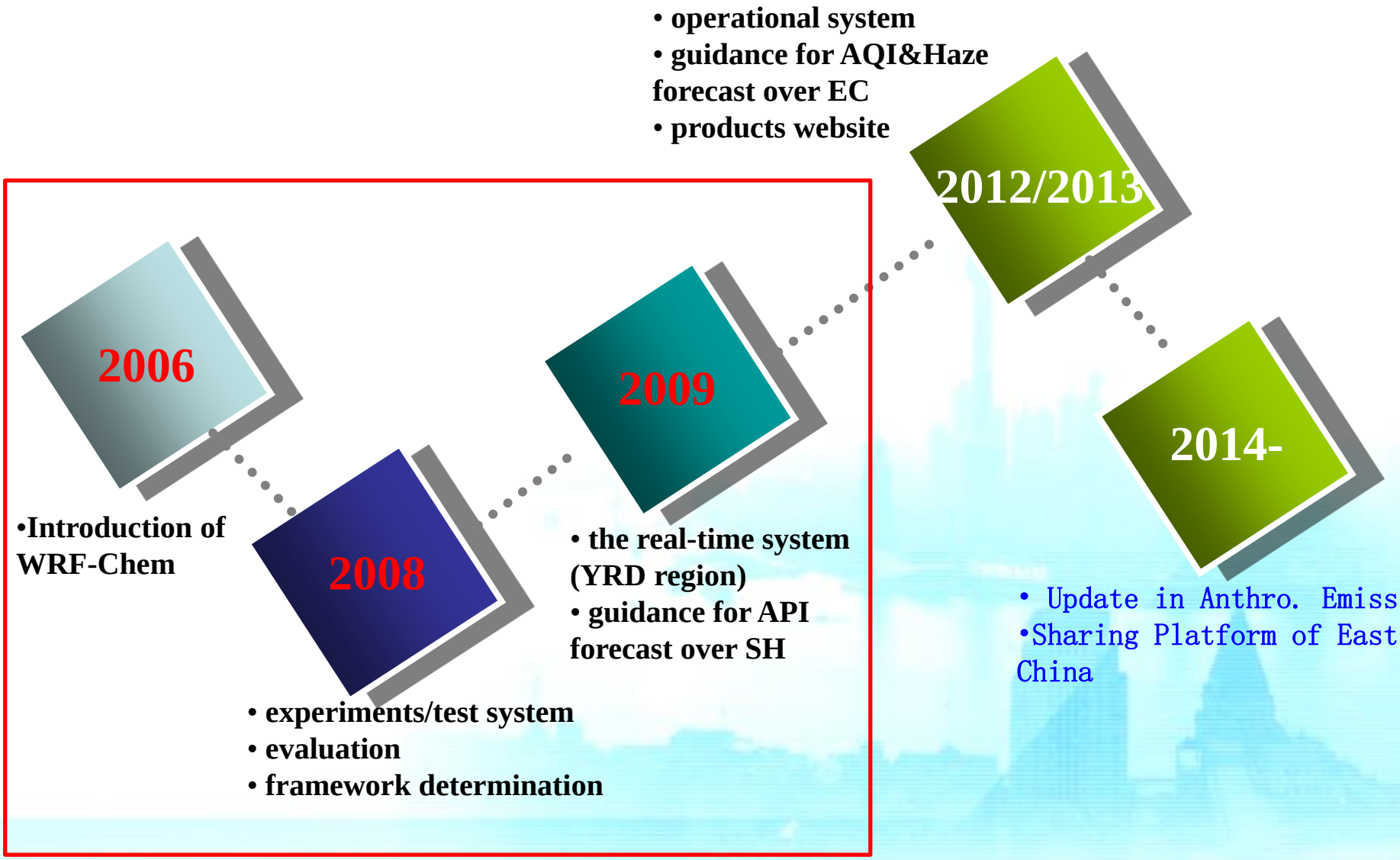
(1) Greatly extended the understanding and knowledge of atmospheric physics and chemistry issues in the megacity such as the typical phenomena of “urban oven” and “urban chimney”.

(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.

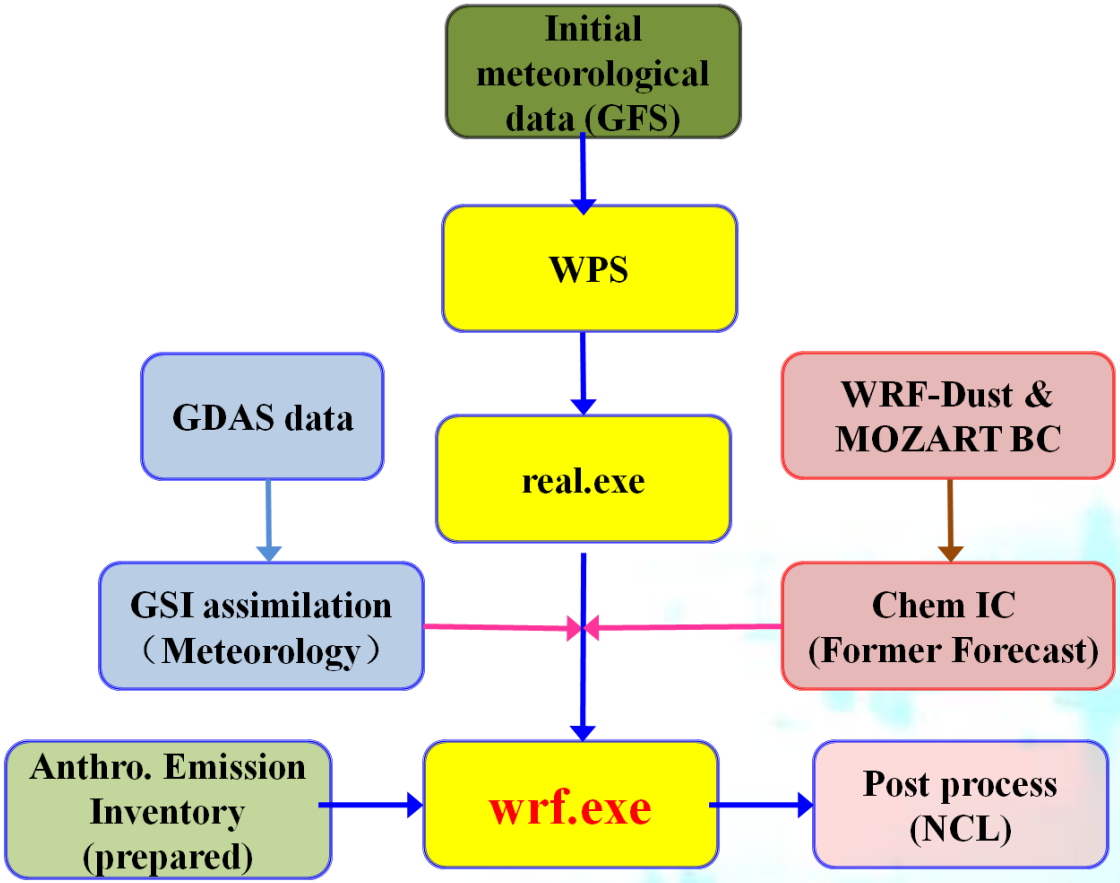
(3) Notably promoted the team construction and expert training for persistently development of scientific activities and operational practice in the field of urban environment and meteorology .

Improvement in Numerical Environmental Meteorology Forecasting after GURME

The system development in brief



Flow chart/framework of the operational system

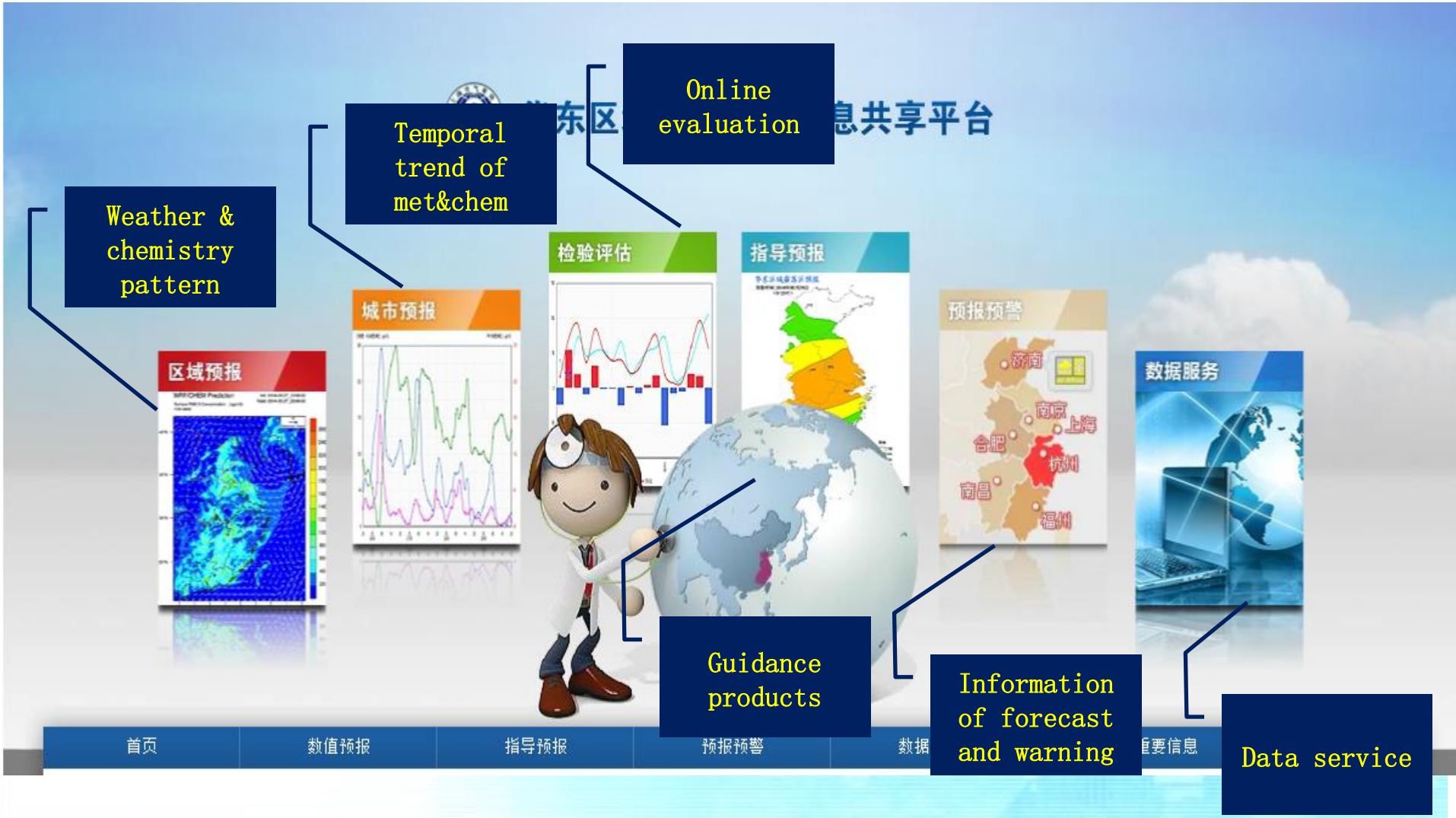


- **Resolution of 6km**
- **96h forecasts starts at 12UTC**
- **Dust BC form WRF-Dust**
- **Chemical BC from climatic MOZART simulation**
- **Land use update;**
- **Eastern China**

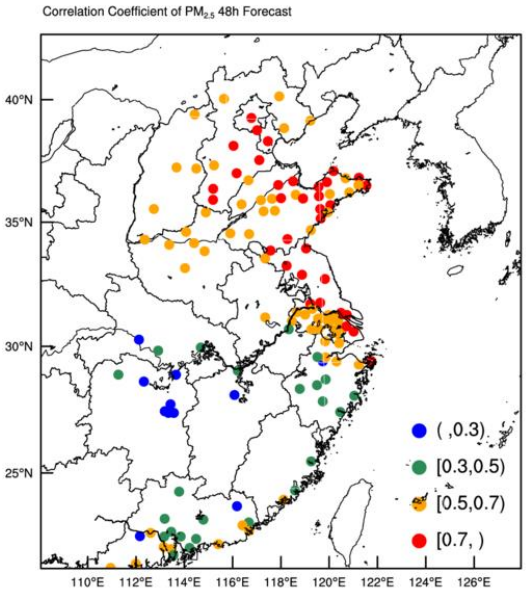
- **Authorized by CMA in 2013**

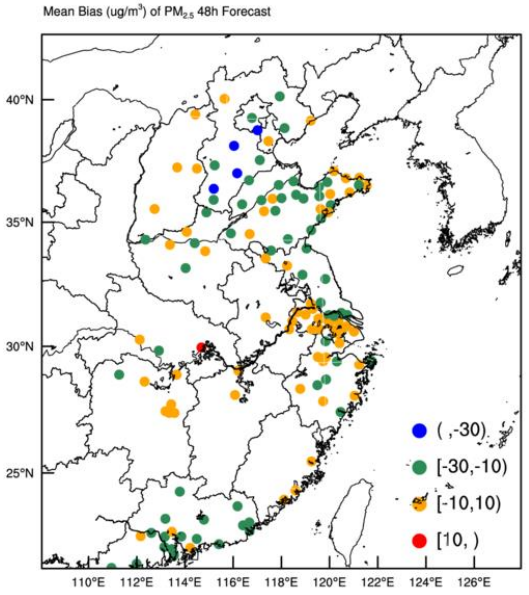
The sharing platform

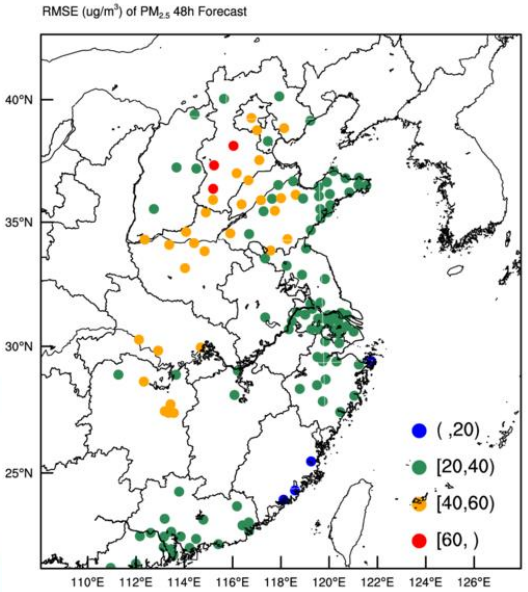
http://222.66.83.21:8086

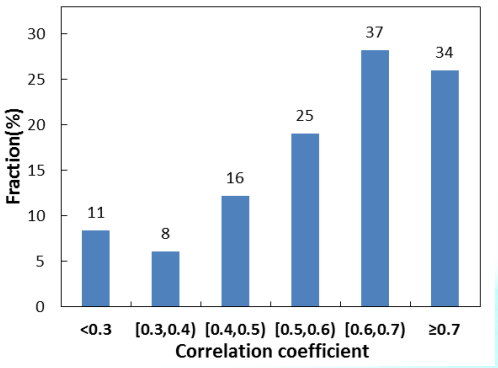


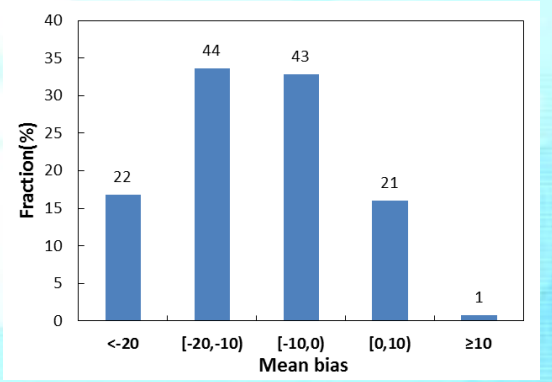
Performance distribution of PM2.5



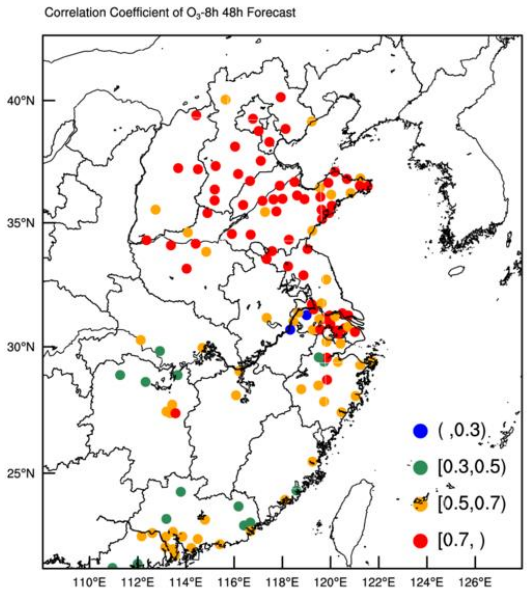


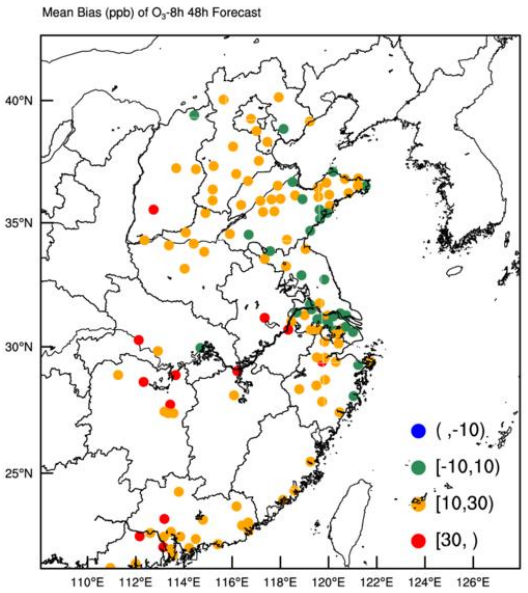


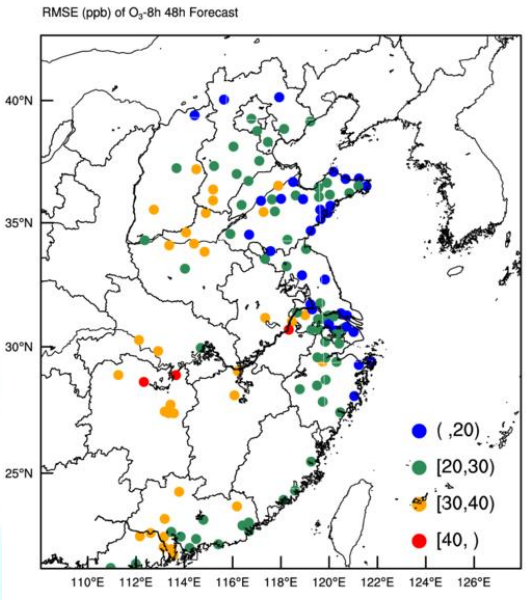


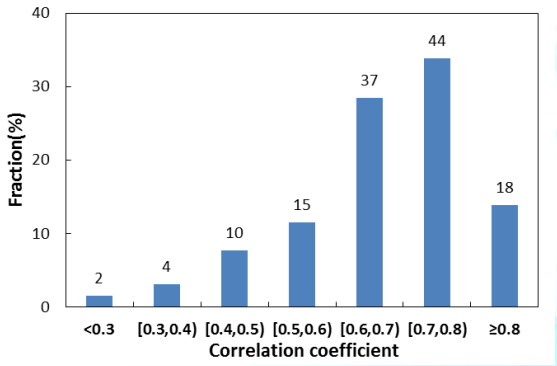


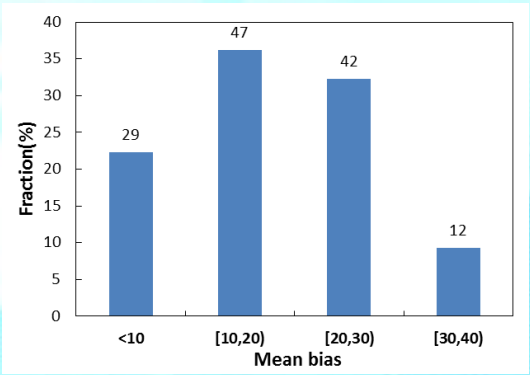
Performance distribution of O_3-8h







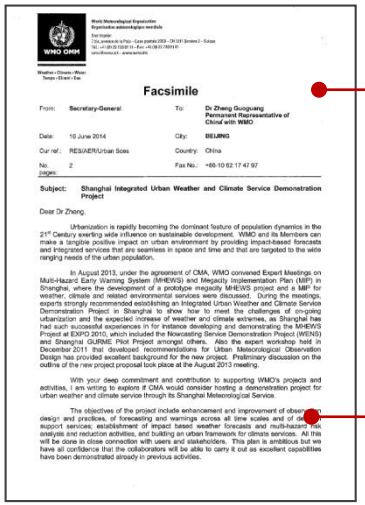




WMO Shanghai IUWCS

Overview

Background



Facsimile

From: Secretary-General To: Dr Zheng Guoguang, Permanent Representative of China with WMO

Date: 16 June 2014 City: BEIJING

Our ref.: RES/AER/Urban Sces Country: China

No. pages: 2 Fax No.: +86-10 62 17 47 97

Subject: Shanghai Integrated Urban Weather and Climate Service Demonstration Project

Dear Dr Zheng,

Urbanization is rapidly becoming the dominant feature of population dynamics in the 21st Century exerting wide influence on sustainable development. WMO and its Members can make a tangible positive impact on urban environment by providing impact-based forecasts and integrated services that are seamless in space and time and that are targeted to the wide ranging needs of the urban population.

In August 2013, under the agreement of CMA, WMO convened Expert Meetings on Multi-Hazard Early Warning System (MHEWS) and Megacity Implementation Plan (MIP) in Shanghai, where the development of a prototype megacity MHEWS project and a MIP for weather, climate and related environmental services were discussed. During the meetings, experts strongly recommended establishing an Integrated Urban Weather and Climate Service Demonstration Project in Shanghai to show how to meet the challenges of on-going urbanization and the expected increase of weather and climate extremes, as Shanghai has had such successful experiences in for instance developing and demonstrating the MHEWS Project at EXPO 2010, which included the Nowcasting Service Demonstration Project (WENS) and Shanghai GURME Pilot Project amongst others. Also the expert workshop held in December 2011 that developed recommendations for Urban Meteorological Observation Design has provided excellent background for the new project. Preliminary discussion on the outline of the new project proposal took place at the August 2013 meeting.

With your deep commitment and contribution to supporting WMO's projects and activities, I am writing to explore if CMA would consider hosting a demonstration project for urban weather and climate service through its Shanghai Meteorological Service.

The objectives of the project include enhancement and improvement of observation design and practices, of forecasting and warnings across all time scales and of decision support services; establishment of impact based weather forecasts and multi-hazard risk analysis and reduction activities, and building an urban framework for climate services. All this will be done in close connection with users and stakeholders. This plan is ambitious but we have all confidence that the collaborators will be able to carry it out as excellent capabilities have been demonstrated already in previous activities.

Why Establishing Shanghai IUWCS

Challenges

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

Experiences

- MHEWS
- WENS
- GURME
- TLFDP

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

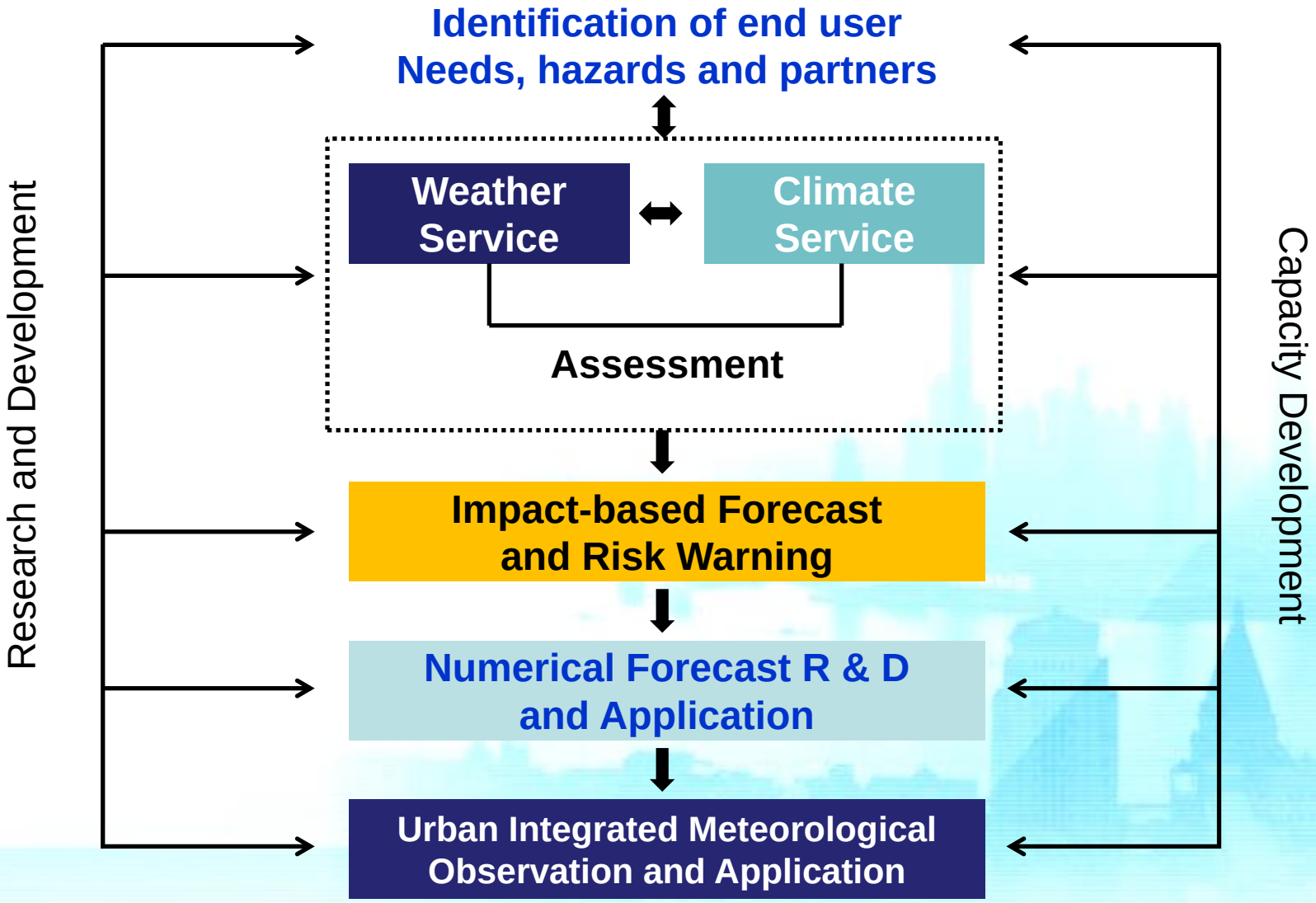
- 24+ million
Population
- 2+ million
Civil vehicles
- Productive
economic activities.

Critical locations

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

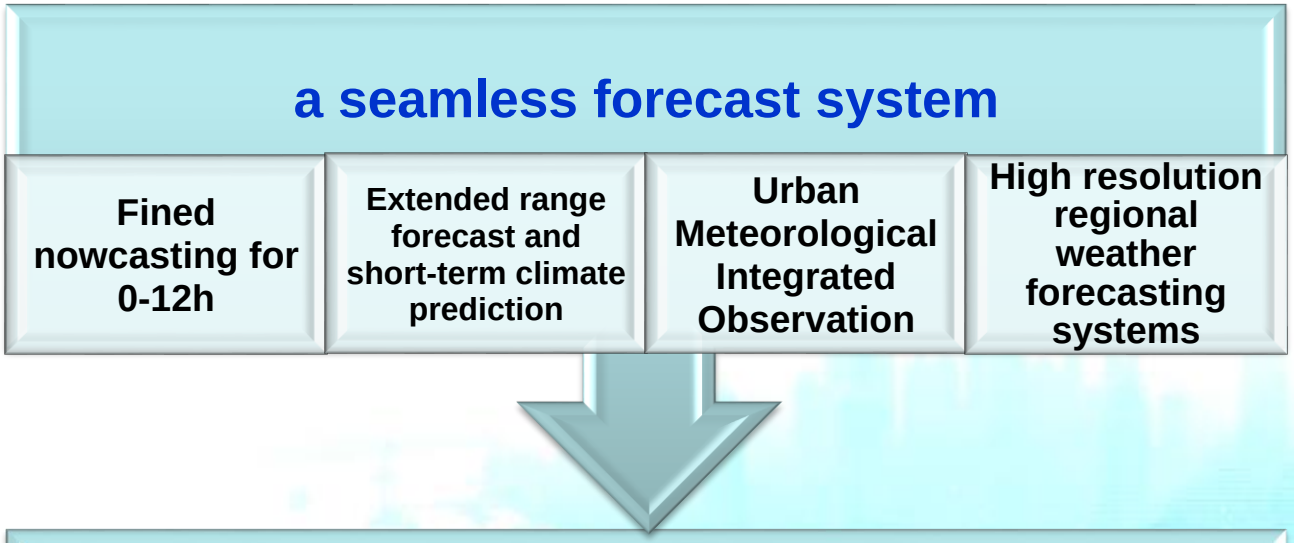
Proposal

Objectives & Development Plan



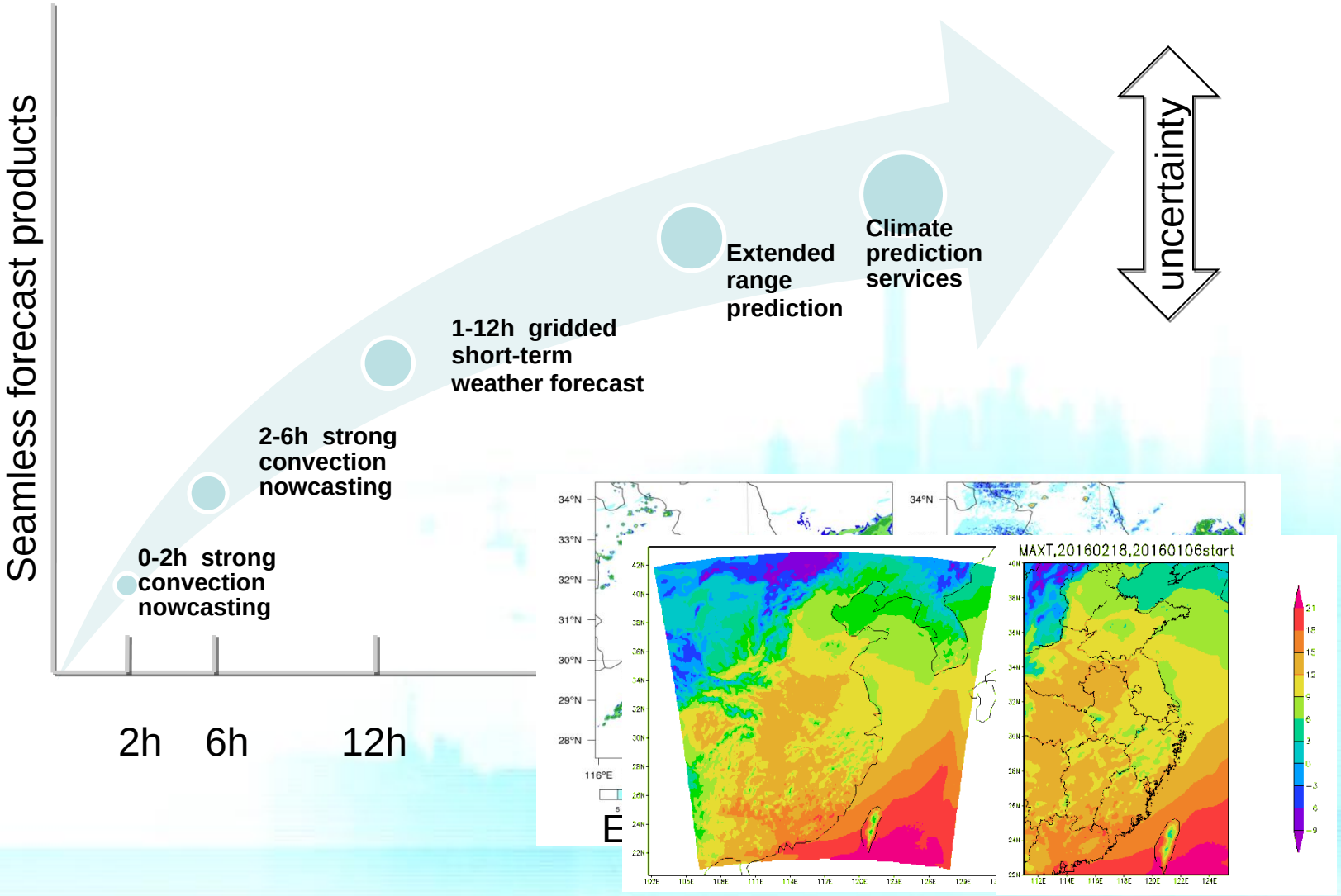
Main task of Shanghai Integrated Urban Weather and Climate Service :Two integrations

1. Integration of weather forecast and climate prediction



2. Integration of weather forecast and risk management

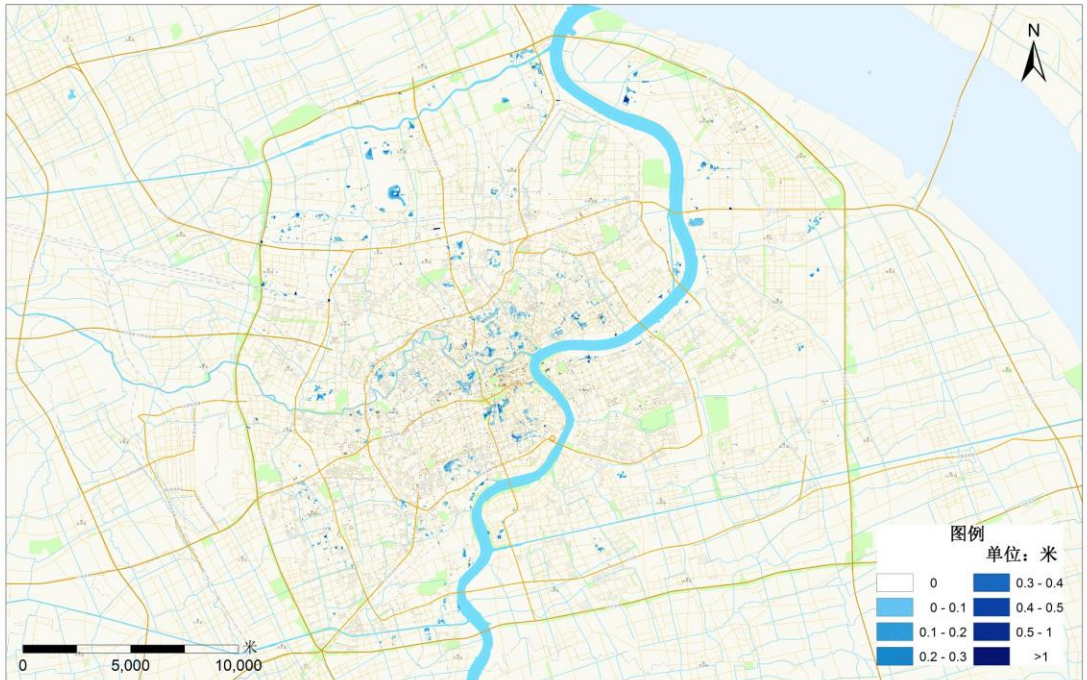
Main task: seamless forecast



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

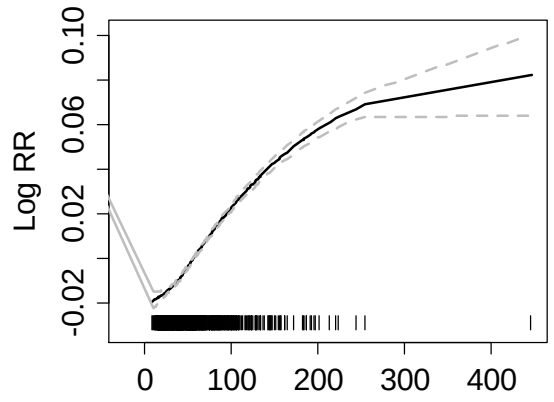
Rainstorm waterlogging simulation （50mm/h）



flood risk warning in Songjiang district

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.



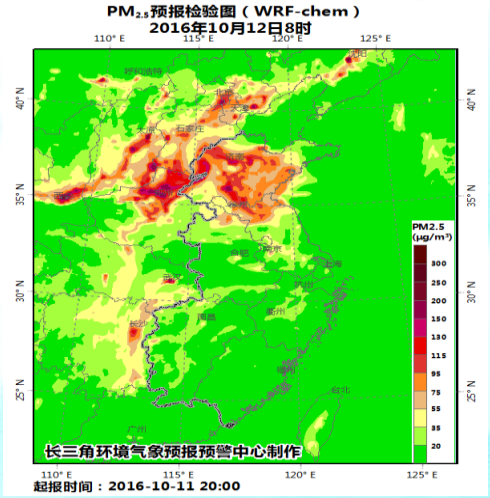
the influence of PM2.5 on the sensitivity of primary pollutants in different age groups

health forecast in hospitals

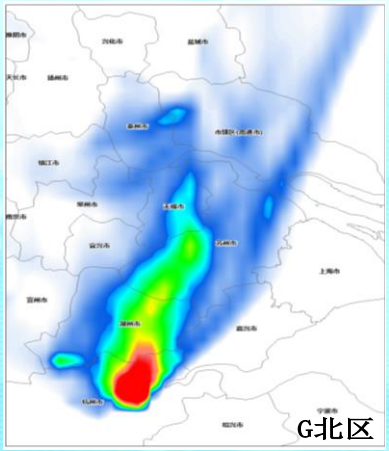
Impact-based Forecasting and Warning : environment

- Jointly issue the AQI prediction and waring with Shanghai Environment Protection Bureau.
- Extend the air quality forecast to 10d 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



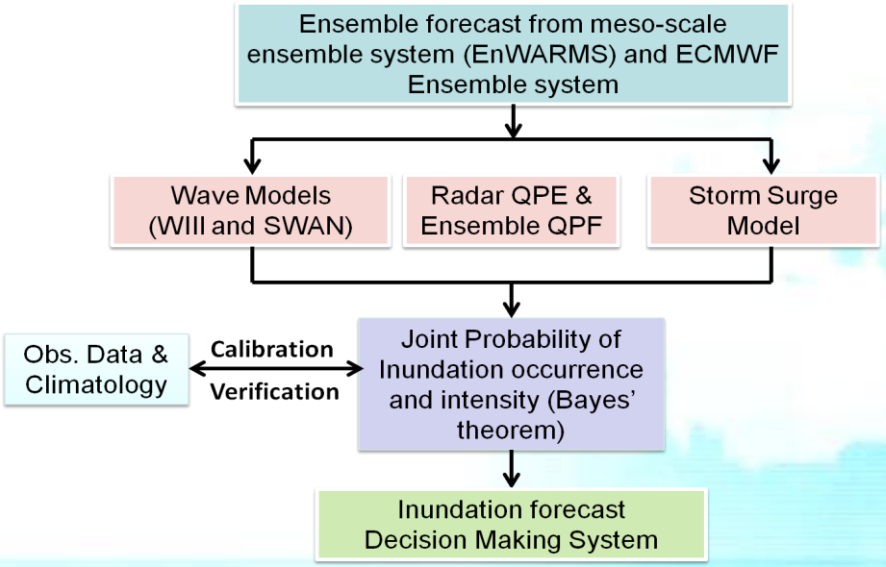
Regional $PM_{2.5}$ numerical prediction



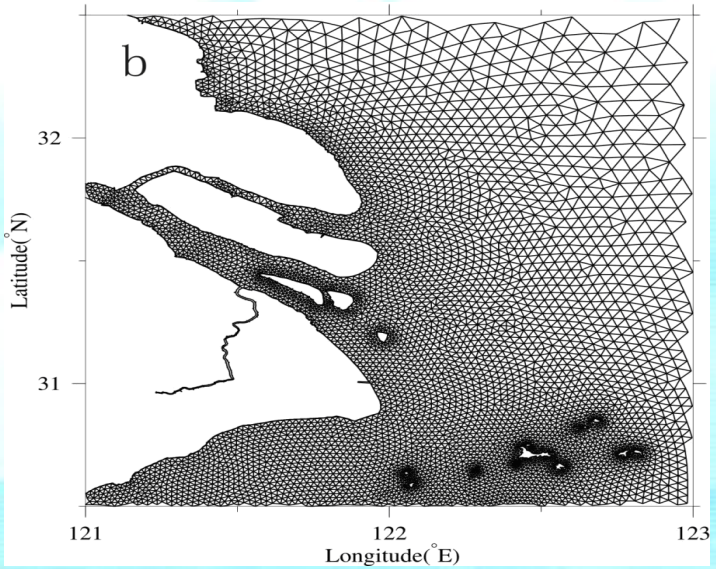
Source area for emission control derived by air pathway analysis

Impact-based Forecasting and Warning : ocean meteorology

- 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).



Technical Approach



Finite-Volume Coastal Ocean Model for Shanghai Coastal Area

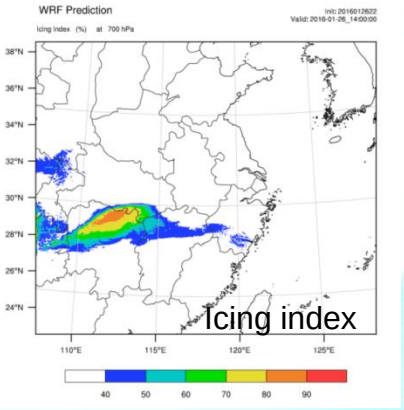
Impact-based Forecasting and Warning : traffic meteorology

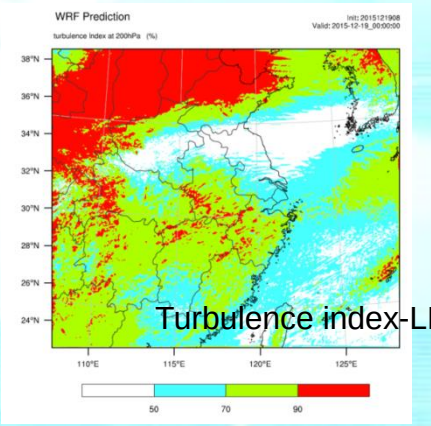
- Cooperation with Shanghai Metro to carry out the risk warning forecast of rail transport
- Cooperative development of rail transport impact forecast and risk warning platform
- According to the risk warning products, line 16 and line 2 suspend operations during the period of typhoon ‘chan-hom’ in Shanghai.

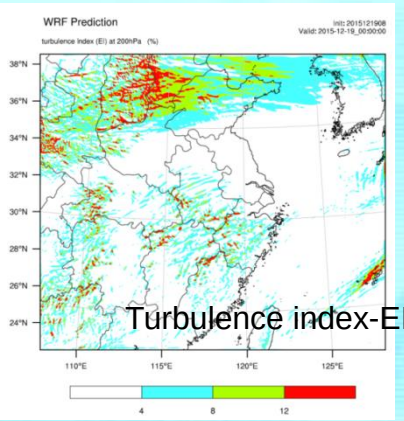
The gust risk warning of Metro Line 16 during typhoon’ Chan-Hom’ attacting Shanghai

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 .



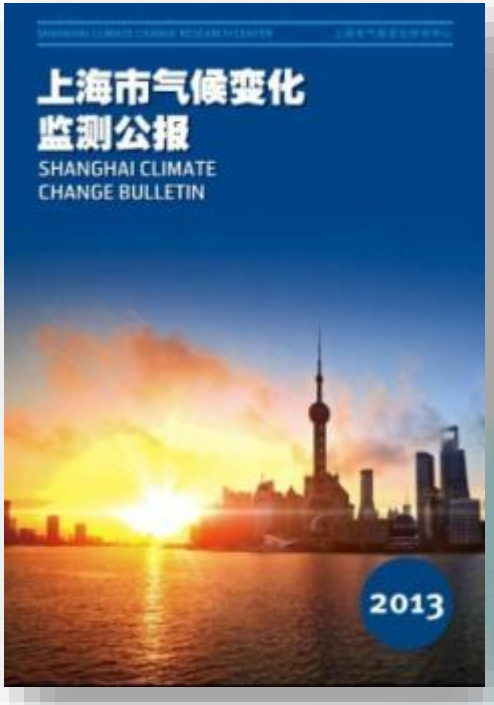




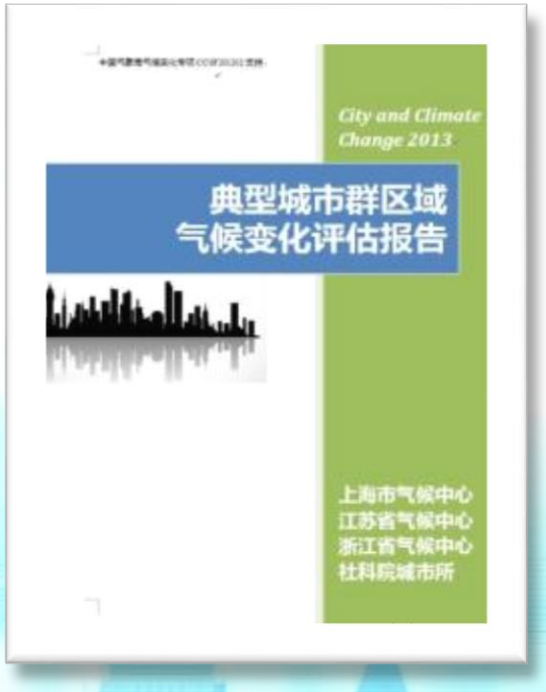
Aviation Meteorology

Urban climate service : climate change risk assessment

1st Assessment Report of Climate Change in East China and summary for Policy Makers



Shanghai Climate Change Observation & Monitoring Report



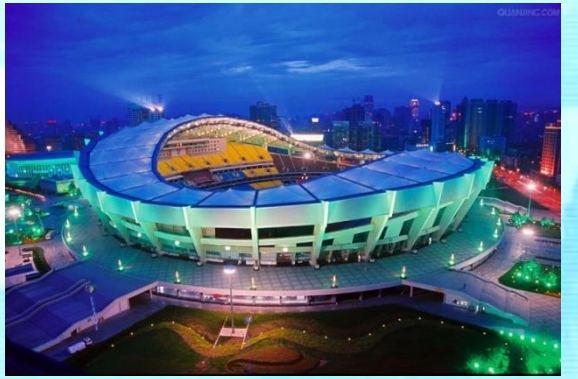
Assessment Report of Climate change in the Yangtze River Delta City Cluster

Urban climate service: the climate feasibility studies

- The climate feasibility studies on large infrastructure construction projects.
- Shanghai Disney resort , Pudong international airport , Shanghai stadium

Shanghai Disney Resort

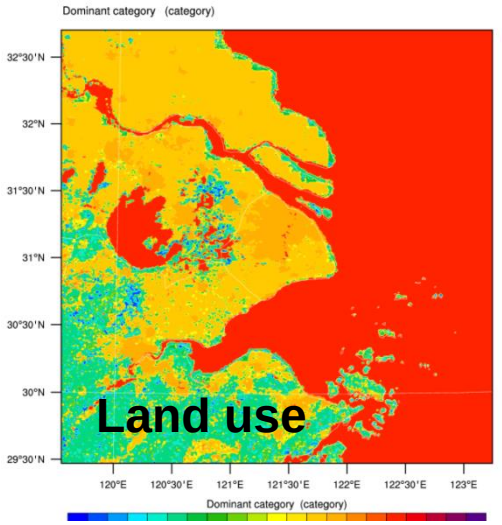
Pudong International Airport

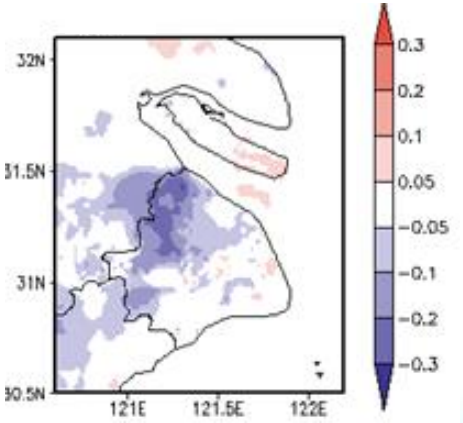


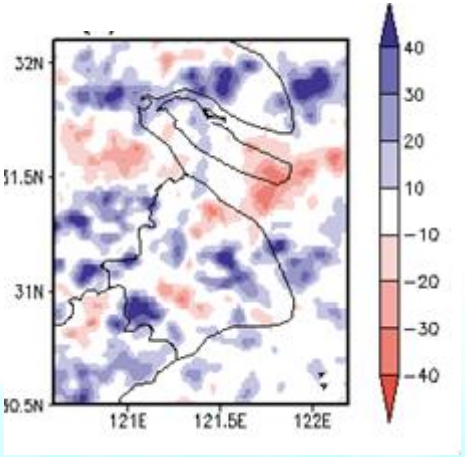
Shanghai Stadium

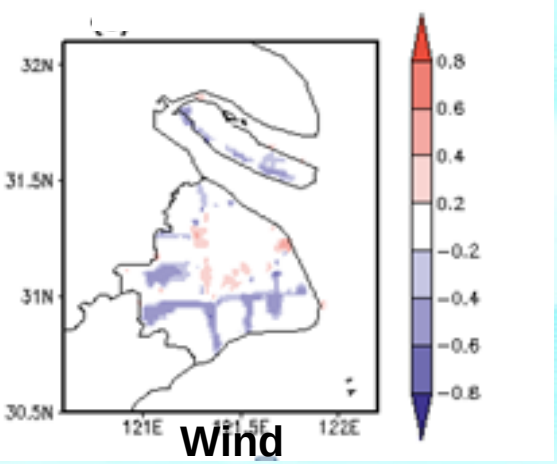
Urban climate service : climate environmental effect

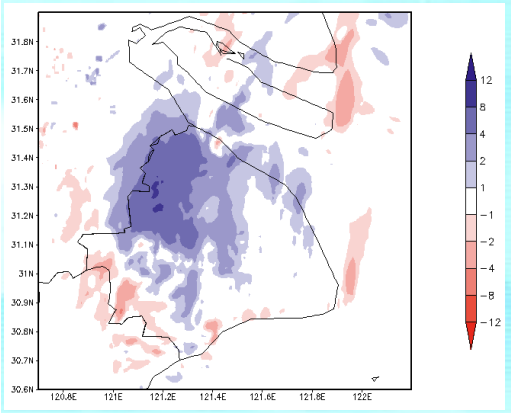
- Numerical simulation of climate environmental effects of the ecosystem network planning











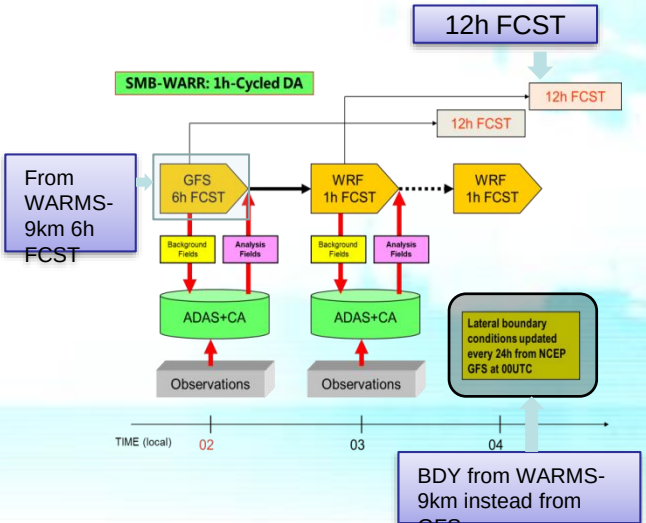
Technical progress: Enhancement of the Urban Integrated Meteorological Observation

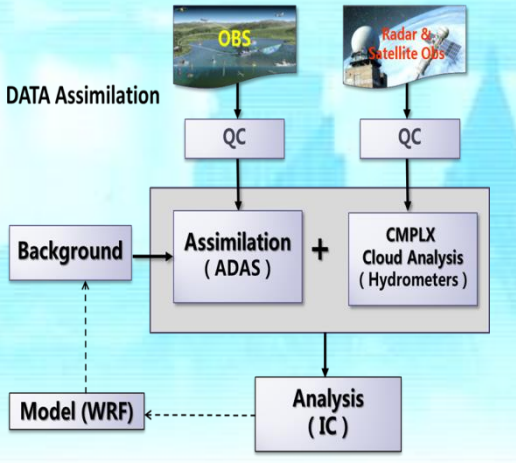
- Experimental studies on adaptive layout of the synoptic network in Yangtze River Delta.
- Establishment of the integrated meteorological observation system, enhance the city's meteorological disaster monitoring, early warning

Automatic station	256
radar	2
Wind profiler	10
Gradient observation station	13
L band sounding	1
Lightning location	7
GPS/Met	31
Satellite remote sensing	9
Atmospheric composition	10
Real monitor	27
Mobile observation car	5

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