Shanghai World EXPO 2010 Nowcasting Service Demonstration Project (WENS)

Project Implementation Plan

Developed by the WENS Science Steering Group

World Meteorological Organization   China Meteorological Administration

November 2008, Shanghai

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Executive Summary

The first meeting of the Science Steering Group (SSG) of the World EXPO 2010 Nowcast Services Demonstration Project (WENS) was convened in Shanghai from 26 to 29 November 2008. The SSG meeting was preceded by a two-day meeting of the Interim SSG to prepare for the full meeting. The WENS structure was based on a concept document developed by the Public Weather Services Implementation and Coordination Team (PWS-ICT) at their meeting in Shanghai (May 2008).

The WENS SSG is composed of representatives of the WMO PWS Open Programme Area Group, representatives of the China Meteorological Administration (CMA), representatives of the WMO Members who propose to provide nowcasting systems in support of WENS, capacity building leads, and socio-economic leads. The SSG developed a Project Implementation Plan (PIP) which incorporates the following:

- **The Goals and Objectives of the project;**
    - *The Goals are*:
        - In the context of multi-hazard early warning services (MHEWS), to demonstrate how Nowcasting applications can enhance short-range forecasts of high-impact weather using the opportunity afforded by the World EXPO 2010; and
        - Promote the understanding and enhance the capability, as appropriate, of WMO Members in nowcasting services.
    - *The Objectives are*:
        - Provide *advanced* high impact weather and precipitation nowcasting products and services in the context of the World EXPO 2010;
        - Enhance the capacity of the SMB in MHEWS to:
            i) Address the problem of urban inundation;
            ii) Provide improved heavy precipitation warnings;
            iii) Evaluate the contribution of QPE/QPF to the overall effectiveness in the risk assessment process;
            iv) Effectively present the information to the decision makers and the public.
        - Demonstrate the introduction, optimal implementation, and training in use (technology transfer) of advanced nowcasting systems in operational forecasting and in the generation of enhanced products and services;
        - Evaluate the impact of the implementation of operationally focused nowcasting on the quality of high impact weather and precipitation forecasts, on forecasters and on end-users of a local meteorological service;
        - Promote the implementation of nowcasting services in the Shanghai region initially and ultimately for the benefit of WMO Members, especially those in East Asia.

- **The Nowcasting Service Product Providers (NSPPs) who will contribute to WENS**;
  - o China Meteorological Administration (CMA);
  - o Australian Government Bureau of Meteorology (BOM);
  - o Hong Kong Observatory (HKO);
  - o The Terms of Reference of NSPPs are as follows:
    - ➢ To provide nowcasting services products or systems in support of the World EXPO 2010 on a functional real-time basis;
    - ➢ To assist in the customisation, support, maintenance and interfacing of their systems to operational data feeds and information / dissemination systems as agreed for implementation in Shanghai;
    - ➢ Offer consultancy and advisory support and undertake agreed interface and capacity-building activities.

- **International Collaboration**

Several representative experienced groups, including those from Australia and Asia, will participate in WENS. This implementation plan is developed in response to the requirements of the World EXPO 2010, and to the needs of better understanding and improved nowcasting services of high impact weather events. Collaboration among the participants will contribute to advances in basic knowledge and new nowcasting techniques, to the improvement of nowcasting systems and services, and to the fulfillment of the nowcasting service demonstration project.

The activities to be carried out under WENS, in addition to supporting the essential public weather services delivery goals of the project, contribute to the work of the World Weather Research Programme and the Data Processing and Forecasting Services of WMO activities for disaster reduction, and efforts to strengthen the role and operation of National Meteorological and Hydrological Services

- **The Expected Outcome of the project is**;
  - o Through international collaboration to build, demonstrate and quantify the benefits, during the World EXPO 2010 period, of an end-to-end nowcasting weather service focused on high impact weather and based on the latest science and technology.

- **The structure of WENS, including Terms of Reference**:
  - o *Science Steering Group (SSG) – ToRs as follows:*
    - ➢ To develop a strategy for the provision of enhanced products and services deriving from the integration of advanced nowcasting systems into the forecast process at the Shanghai Meteorological Bureau (SMB) in the context of the World Expo 2010;
    - ➢ To set milestones that need to be reached for this strategy for enhanced services to be realised;
    - ➢ To oversee the coordination of the work of NSPPs with the forecast processes and systems of SMB;

- To provide guidance to the WENS Management Group (WENS-MG) on the scientific and technical aspects of the project as required;

- To develop strategies to optimise the dissemination and communication of WENS-related products and services;

- To review and approve plans for the evaluation of the impact of WENS on the stakeholder/user community and enhanced products and services of SMB;

- To develop a framework for training and capacity-building activities to be held in conjunction with the project;

- To monitor reports of the progress of WENS implementation as provided by the WENS-MG;

- To prepare and disseminate regular reports, to the sponsoring agencies, on the scientific and services aspects of WENS;

- To prepare a final evaluation report at the conclusion of the project;

- Based on the experience gained over the course of WENS, to prepare guidance on the applications of nowcasting for the benefit of other NMHSs.

o **WENS Management Group (WENS-MG) – ToRs as follows**:

- To facilitate and prioritise the activities of the WENS project to realise the strategies as defined by the Scientific Steering Group;

- To provide specific scientific guidance for the implementation of the tasks of the WENS project;

- To establish dialogue with the stakeholder / user community with a view to assessing their requirements;

- To identify the enhanced products and services to meet the requirements of the stakeholder / user community;

- To facilitate the exchange of information among scientists participating in the project and relevant scientific institutions and agencies, at the national and international levels;

- To collaborate, as appropriate, with academia, users of forecast products and other partners, relevant groups of the WMO PWSP and the WWRP as well as other international scientific programmes, including the WWRP/WGNE Working Group on Forecast Verification and the WWRP Advisory Group on Societal and Economic Impacts;

- To facilitate capacity-building activities over the course of the project as defined by the SSG;

- To monitor and evaluate the impact of the WENS on the stakeholder / user community;

- To make arrangements for the archiving of selected data collected during WENS with a view to providing a resource for future research and capacity-building activities;

- To establish Working Teams and their Terms of Reference;

      ➢ To report on the progress of the project to the WENS SSG.

    o **Management Group Working Teams (MG-WT).**

- **Operational aspects of the project**:
  - o To support the operation of WENS systems CMA will provide the necessary hardware, data and operational environment. Products from the WENS systems will be integrated. Products will be provided to end-users.
- **Impact Assessment plan**:
  - o The process by which the societal and economic impacts of WENS would be assessed were determined:
    - ➢ Risk assessments of user groups to be undertaken;
    - ➢ Baseline surveys to be conducted in advance of operations;
    - ➢ Public surveys to be conducted during EXPO;
    - ➢ Post-operational survey of specialized users.
- **Capacity Building and Training plan**:
  - o Five different levels of training and capacity building were defined and plans were drawn up on how best to address each of these.
- **Project Resource plan**:
  - o The provision of resources and division of responsibilities among all the sponsoring agencies were defined.
- **Project Implementation schedule**:
  - o The schedule of WENS as agreed by the SSG is summarized in the table below:

Year\Month	January - May	June	July	August	September	October - December
2008		WENS Concept Document	Consultation with JONAS SC	Official invitations to participate in WENS		WENS Interim SSG and first WENS SSG meeting. Preparation of Project Implementation Plan
2009	Preparation of first trial run, end-user survey	First trial run		Assessment by WENS Management Group of initial trial; adjustments as appropriate.		Interim Review Meeting
2010	Fine-tuning of systems and development of services and products.	WENS Full Operation (May to November) Post-project survey to assess impact of WENS				Post-project survey to assess the impact of WENS
2011	Post-project survey to assess impact of WENS	Final Review Meeting and Report Preparation	Capacity Building Workshop. Publication of Guidelines.			

1.   Introduction

The Shanghai World EXPO 2010 is to be conducted from May to October 2010. It is a major international event in which weather can have a significant impact. Weather services are required to support planning and coordination of the EXPO activities. During the EXPO period, precipitation and thunderstorms occur frequently, together with some high impact weather (HIW) that includes heavy rain, squalls, hails, lightning, and tropical cyclones may bring weather-related disasters. Important issues concern the weather effects on individual exhibition pavilions and potential impacts associated with the outdoor exposure of a large number of people and a large extent of property. Nowcasting is defined as Very Short-Range (0-6 hour) forecasts, and nowcasts of HIW are particularly important components of the World EXPO 2010 weather service requirement. The Shanghai Meteorological Bureau (SMB) of China Meteorological Administration (CMA) is the provider of the EXPO weather services. In case of thunderstorms and other severe weather being forecast, severe weather outlooks (0-12 hour) will be normally issued at 6 hour intervals for the EXPO site, and special early warning information will be issued through the Dissemination Platform of the Shanghai Multi-Hazards Early Warning System (MHEWS) in a timely manner.

At the recommendation of WMO Implementation and Coordination Team on Public Weather Services, WENS should focus on the "services" rather than the "systems", in particular, the translation of nowcasting system outputs to timely, relevant and user friendly products for decision makers and stakeholders. WENS products will be made available to local weather forecasters on duty. A post-project review will be conducted to assess the impact of WENS. This will be followed by the publication of guidelines on the provision of nowcasting services reflecting experience gained from WENS, and the conduct of capacity building workshops for WMO Members.

The WENS will be conducted over four years (2008-2011). Baseline evaluation of stakeholder / user communities will take place during the first half of 2009. The trial demonstration phase will start in June 2009. The primary aims of this trial will be to test logistical and infrastructure support, tune algorithms and systems, and gain experience with the specific forecast problems of the Shanghai region. The formal WENS will be conducted over the period 1 March to 31 October 2010. This encompasses both the World EXPO 2010 and its preparation period.

Procedures and approaches to be tested in this Demonstration Project are expected to have general international applicability.

WENS will be conducted by the China Meteorological Administration (CMA) and international participating groups with active support from the World Meteorological Organization. This project will be conducted in the framework of the "Learning through Doing" concept as developed by PWS Programme Experts.

2.   Goal and Objectives

The goals of WENS are as follows:

- In the context of multi-hazard early warning services (MHEWS), to demonstrate how Nowcasting applications can enhance short-range forecasts of severe weather using the opportunity afforded by the Shanghai World EXPO 2010; and

- Promote the understanding and enhance the capability, as appropriate, of WMO

Members in nowcasting services.

Emphasis is to be placed on 0-6 hour forecast and services with a particular interest on HIW, which are the primary challenges during the World EXPO. Latest forecast generation and production techniques will be employed to optimise decision making and product generation. A comprehensive user evaluation process will be developed and applied to all WENS products and services by the WENS Working Group.

The objectives of WENS are as follows:

- Provide *advanced* high impact weather and precipitation nowcasting products and services in the context of the World EXPO 2010;
- Enhance the capacity of the SMB in MHEWS to:
    i)   Address the problem of urban inundation;
    ii) Provide improved heavy precipitation warnings;
    iii) Evaluate the contribution of QPE/QPF to the overall effectiveness in the risk assessment process;
    iv) Effectively present the information to the decision makers and the public.
- Demonstrate the introduction, optimal implementation, and training in use (technology transfer) of advanced nowcasting systems in operational forecasting and in the generation of enhanced products and services;
- Evaluate the impact of the implementation of operationally focused nowcasting on the quality of high impact weather and precipitation forecasts, on forecasters and on end-users of a local meteorological service;
- Promote the implementation of nowcasting services in the Shanghai region initially and ultimately for the benefit of WMO Members, especially those in East Asia.

3. General Approach, including relationships and collaborations with other relevant projects

a) International Collaboration

Several representative experienced groups, including those from Australia and Asia, will participate in WENS. This implementation plan is developed in response to the requirements of the World EXPO 2010, and to the needs of better understanding and improved nowcasting services of high impact weather events. Collaboration among the participants will contribute to advances in basic knowledge and new nowcasting techniques, to the improvement of nowcasting systems and services, and to the fulfillment of the nowcasting service demonstration project.

The activities to be carried out under WENS, in addition to support the essential public weather services delivery goals,contribute to the work of the World Weather Research Programme and the Data Processing and Forecasting Services of WMO activities for disaster reduction, and efforts to strengthen the role and operation of National Meteorological and Hydrological Services.

b) Expected Outcome

Through international collaboration to build, demonstrate and quantify the benefits during the World EXPO 2010 period of an end-to-end nowcasting weather service focused

on high impact weather and based on the latest science and technology.

4.   Shanghai's Environment and Climatology

Shanghai, located in 31°N and 121°E, is washed by the East China Sea to the east and Hangzhou Bay to the south. North of the city the Yangtze River pours into the East China Sea and so Shanghai occupies a central location along China's coastline (Fig.1). Except for a few hills lying in the southwest corner, most parts of the Shanghai area are flat and belong to the alluvial plain of the Yangtze River Delta. The average sea level elevation is about 4 m. Dotted with many rivers and lakes, the Shanghai area is known for its rich water resources. Topography, surface features and the urban heat island all play important roles in Shanghai's weather.

Shanghai receives an average annual rainfall of *1,200* **mm**; nearly 60% of the precipitation comes during the April-September warm season. During July and September, strong thunderstorms with lightning strikes, heavy rain, hail and damaging winds (squalls) become frequent. Abnormal rainfall events can occur during this period, e.g. on 25th August 2008, the precipitation recorded over one hour exceeded 100mm. On average there are *15* rainy days and *8* thunderstorm days per month in the S10 period. According to the record, 2-3 tropical cyclones per year may impact on Shanghai. The summer of Shanghai is hot and humid. July and August are Shanghai's hottest months with average highs of *32.4*°C. Humidity is high (daytime average *75%*).

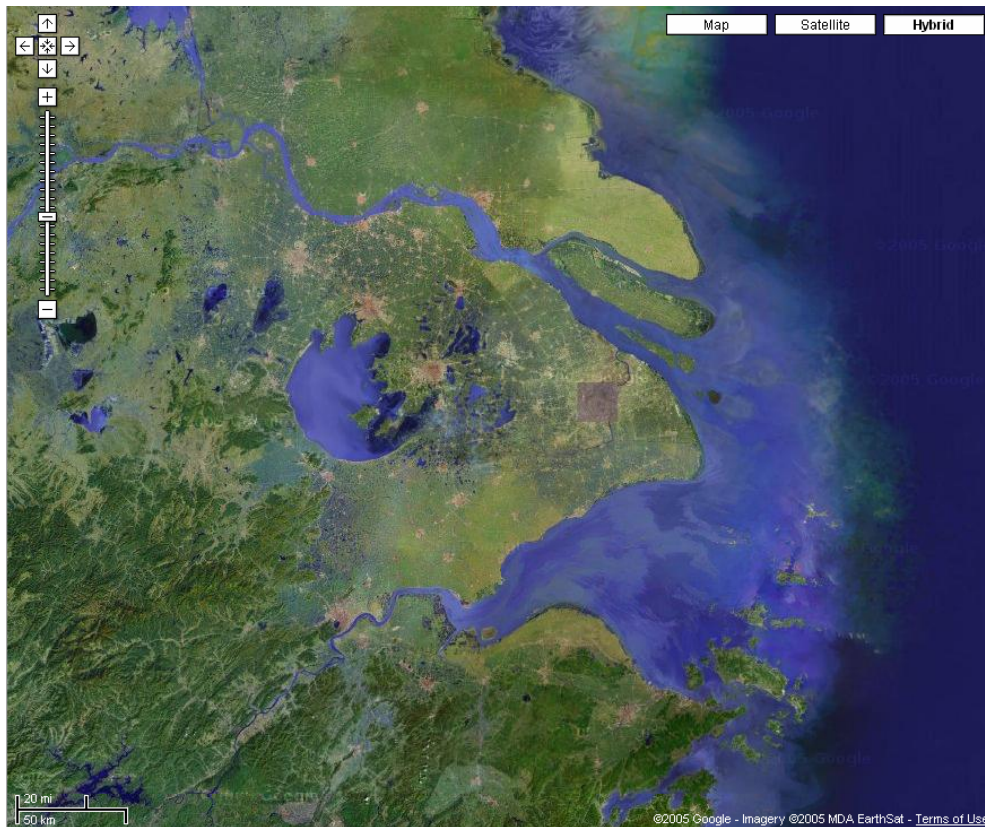Fig.1 Topography in Shanghai and the Yangtze River Delta

5.   Strategy to identify and target stakeholder / user communities

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and their individual requirements.

Following the practice of Beijing 2008 FDP, the target stakeholder / user communities of the WENS are defined as below:

- SMB forecasters; the forecasters in neighbouring weather offices and other relevant agencies;
- End users:
  - **World EXPO 2010 organizers and participants;**
  - Relevant government departments, especially the emergency response agencies;
  - Special users, particularly those in the transport and energy sectors;
  - Public (including visitors to the World EXPO).

Forecasters:

The major primary users of the WENS Systems Products are the weather forecasters of the host city's Meteorological Bureau – SMB. SMB has a 24-hour shift for very short range forecasting / nowcasting. The SMB forecasters are responsible for monitoring weather, analysing mesoscale weather conditions, and the issue of severe weather nowcasts and warnings. WENS systems will provide a range of operational products to the SMB forecasters. These operational nowcast products for professional forecasters include some primary products, e.g. radar reflectivity nowcast and convective index forecast, and some warning-related products, e.g., quantitative precipitation forecast, probability forecast of the threat of severe weather, etc. The primary users also include the forecasters of the neighbouring weather forecast offices, e.g., Hangzhou, Ninbo, and Jiaxing in Zhejiang Province, and Nanjing, Wuxi, and Suzhou in Jiangsu Province, and the forecasters in Shanghai's two international airports and the Yangshan Deep-sea harbour.

End users fall into 4 categories:

1) The first category of end user includes the World EXPO 2010 organization committee and its departments and participants. Final nowcasts and warnings for severe weather will be directly disseminated to the World EXPO 2010 organizers by SMB forecasters on duty. They will organize and adjust the EXPO activities according to SMB's nowcasts and warnings as necessary.

2) In the second category of the end users, there are some relevant government departments including the Shanghai Water Bureau (SWB), the Shanghai Emergency Response Centre (SERC), and some key service units. These second category end-users need to have some meteorological background or to be trained in the use of WENS products before the EXPO. The operational nowcasting products for category two indirect end users provided by WENS are generally regular operational nowcast products, such as those for rainfall or severe weather, and some primary products, according to the users' needs that will be determined in a service survey before the beginning of the EXPO. On receiving a warning of heavy rain and flooding, the Water Bureau will instigate urban flood risk management. If severe weather warnings are issued, the Emergency Response Centre will start relevant preparedness activities.**3)** Category Three end-users are the specialised users such as media, transport and energy sectors; for example the Shanghai Yatong Co. Ltd which provides river transportation services in Shanghai.

4) The Category Four end users are generally the public (local citizens and visitors to the World EXPO 2010), some public or private agencies or companies, and those organizations or agencies that just want to use the final nowcasting products. The products will inform the users of the immanent occurrence of severe or hazardous weather, and what its impact might be. Category Four end users will typically not have a meteorological background. They will receive severe weather warnings via a range of means, such as cell phone message, TV, radio, internet, and the public electronic screens in streets, buildings, buses, metros, schools, and social communities.

A series of WENS Services and Products will be designed and developed to meet the specific needs of each of the specialist end-users. Typical products might include:

- Outlook
- Watch
- Warning
- Nowcasting for some key occasions and activities

6. Mode of Operation

Based on the experience of successful implementation of Beijing 2008 FDP, a number of nowcasting systems will be engaged in the operational phase of WENS to provide comprehensive nowcasting service products.

Nowcasting service products providers(NSPPs) will provide operational nowcasting system(s) in support of WENS on a real-time basis. Operational systems will be set up to generate real-time products and to disseminate these to users for the duration of the World EXPO 2010 with a range of training and capacity building initiatives.

Terms and conditions for the involvement of NSPPs are to be discussed between SMB/CMA and the NSPP host organizations and will be the subject of a formal agreement

Conditions for use of systems in WENS, subsequent rights to employ systems, and IP ownership will be mutually agreed prior to involvement of NSPPs in WENS.

To facilitate the liaison between the WENS project and all end-users, the WENS Management Group will establish Working Teams of WENS personnel and representatives of the end-users for this purpose.

7. Programme Management

The WENS project will be managed through the following structure:

Science Steering Group (SSG)

The members of the SSG will be as follows:

- Dr TANG Xu (SMB) – Co-Chair
- Mr Gerald FLEMING (Chair OPAG on PWS) – Co-Chair

- Ms Haleh KOOTVAL (WMO Secretariat)
- ???(CMA)
- Dr Tom KEENAN (Co-Chair of JONAS)
- Mr Hon-Gor WAI (Co-Chair of JONAS; NSPP, HKO)
- Dr Alan SEED (NSPP, BOM Australia)
- Prof WANG Yingchun (NSPP, BMB)
- Dr YUAN Zhaohong (NSPP, SMB and Chair, WENS Working Group)
- Mr Brian MILLS, Socio-Economic Lead (Canada) (Chair, WWRP-SERA Working Group
- Prof LI Lianshui, Socio-Economic Lead (China)
- Dr LEI Zhaochong, Capacity-building Lead (China)
- Dr DAI Jianhua – Secretary to SSG (China)

The Terms of Reference (TORs) of the SSG are as follows:

a) To develop a strategy for the provision of enhanced products and services deriving from the integration of advanced nowcasting systems into the forecast process at the Shanghai Meteorological Bureau (SMB) in the context of the World Expo 2010;

b) To set milestones that need to be reached for this strategy for enhanced services to be realised;

c) To oversee the coordination of the work of NSPPs with the forecast processes and systems of SMB;

d) To provide guidance to the WENS Management Group (WENS-MG) on the scientific and technical aspects of the project as required;

e) To develop strategies to optimise the dissemination and communication of WENS-related products and services;

f) To review and approve plans for the evaluation of the impact of WENS on the stakeholder/user community and enhanced products and services of SMB;

g) To develop a framework for training and capacity-building activities to be held in conjunction with the project;

h) To monitor reports of the progress of WENS implementation as provided by the WENS WG;

i) To prepare and disseminate regular reports, to the sponsoring agencies, on the scientific and services aspects of WENS;

j) To prepare a final evaluation report at the conclusion of the project;

k) Based on the experience gained over the course of WENS, to prepare guidance on the applications of nowcasting for the benefit of other NMHSs.

WENS Management Group (WENS-MG)

The members of the WENS-MG will be as follows: *(to be reviewed)*

- Dr YUAN Zhaohong (SMB) – Chair
- Mr WANG Yubin (NSPP, BMB) – Co-Chair
- Mr Edwin ST LAI (NSPP, HKO)
- Dr Alan SEED (NSPP, BOM Australia)
- Mr CHEN Mingxuan (NSPP, BMB)
- Dr LEI Zhaochong, Capacity-building Lead (China)
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The Terms of Reference (TORs) of the WENS-MG are as follows:

a) To facilitate and prioritise the activities of the WENS project to realise the strategies as defined by the Scientific Steering Group;

b) To provide specific scientific guidance for the implementation of the tasks of the WENS project;

c) To establish dialogue with the stakeholder / user community with a view to assessing their requirements;

d) To identify the enhanced products and services to meet the requirements of the stakeholder / user community;

e) To facilitate the exchange of information among scientists participating in the project and relevant scientific institutions and agencies, at the national and international levels;

f) To collaborate, as appropriate, with academia, users of forecast products and other partners, relevant groups of the WMO PWSP and the WWRP as well as other international scientific programmes, including the WWRP/WGNE Working Group on Forecast Verification and the WWRP Advisory Group on Societal and Economic Impacts;

g) To facilitate capacity-building activities over the course of the project as defined by the SSG;

h) To monitor and evaluate the impact of the WENS on the stakeholder / user community;

i) To make arrangements for the archiving of selected data collected during WENS with a view to providing a resource for future research and capacity-building activities;

j) To establish Working Teams and their Terms of Reference;

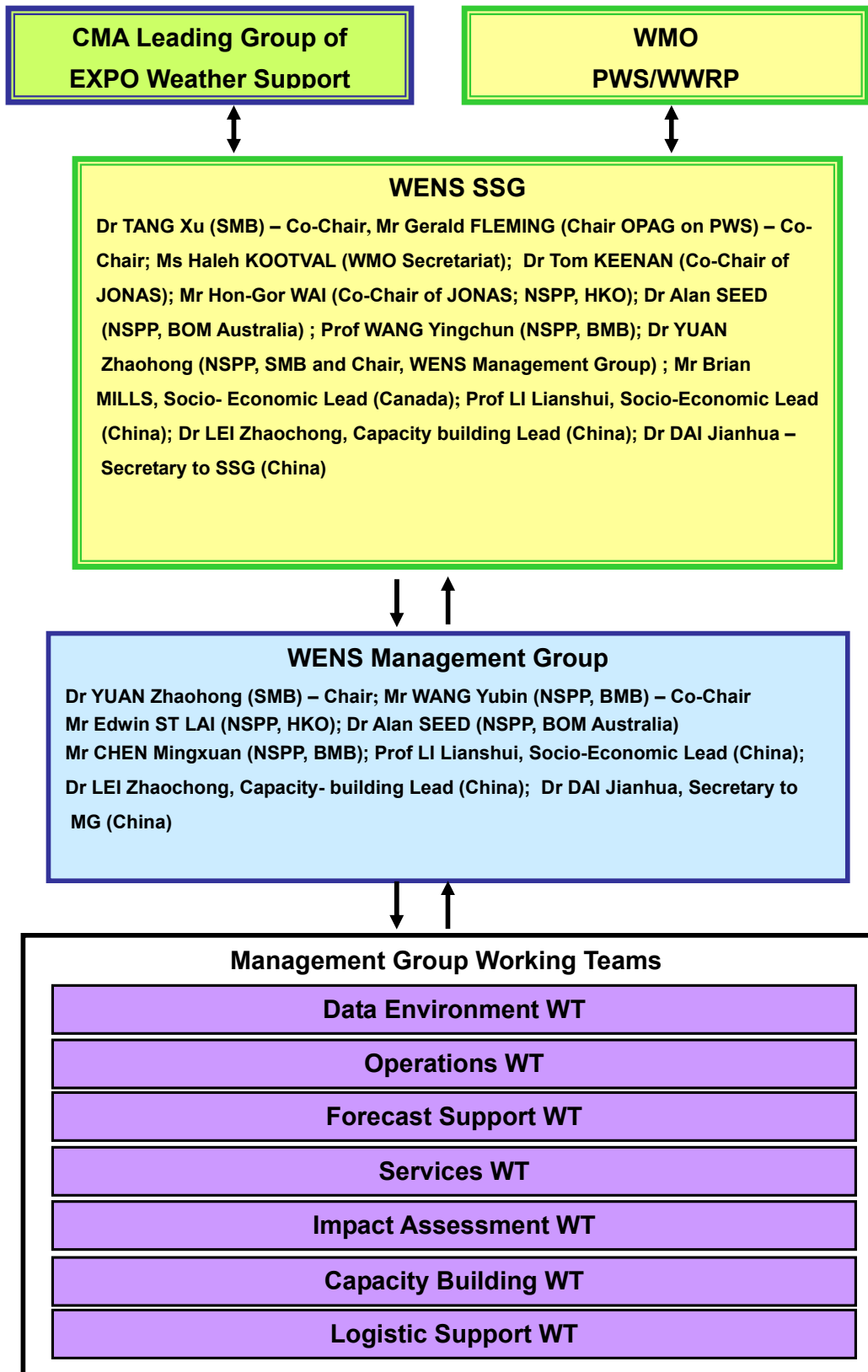k) To report on the progress of the project to the WENS SSG.

The **nowcasting service product providers** for WENS project which have been confirmed are as follows:

- China Meteorological Administration (CMA);

- Australian Bureau of Meteorology (BOM);

- Hong Kong Observatory (HKO)

The participating nowcasting systems are described in Appendix A. The WENS is open for other nowcasting service product providers. If additional systems wish to provide nowcasting service products for Shanghai World EXPO 2010 and join WENS, the resource implications should first be discussed with SMB and a proposal then submitted to the SSG for approval. Participating nowcasting systems need to join WENS before the end March 2009.

The Terms of Reference for NSPPs are as follows:

a) To provide nowcasting services products or systems in support of the World EXPO 2010 on a functional real-time basis;

b) To assist in the customisation, support, maintenance and interfacing of their systems to operational data feeds and information / dissemination systems as agreed for implementation in Shanghai;

c) Offer consultancy and advisory support and undertake agreed interface and capacity-building activities.

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│      CMA Leading Group of   │      │           WMO               │
│      EXPO Weather Support   │      │         PWS/WWRP            │
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Management Group Working Teams

Data Environment WT

Operations WT

Forecast Support WT

Services WT

Impact Assessment WT

Capacity Building WT

Logistic Support WT

Organization of WENS

8.   Operational Aspects

(a) CMA Observational Network

Surface observational network

There are 120 automatic weather stations (AWSs) and 200 rain gauges in the Shanghai area. The spatial resolutions of the AWS network and the rain gauge network are about 8 km and 5 km, respectively. The temporal resolution of these two observational systems is 1 min. An auto-fog-observing system is set along the shoreline of the Huangpu River. All data are communicated in real-time using the GPRS/CDMA.
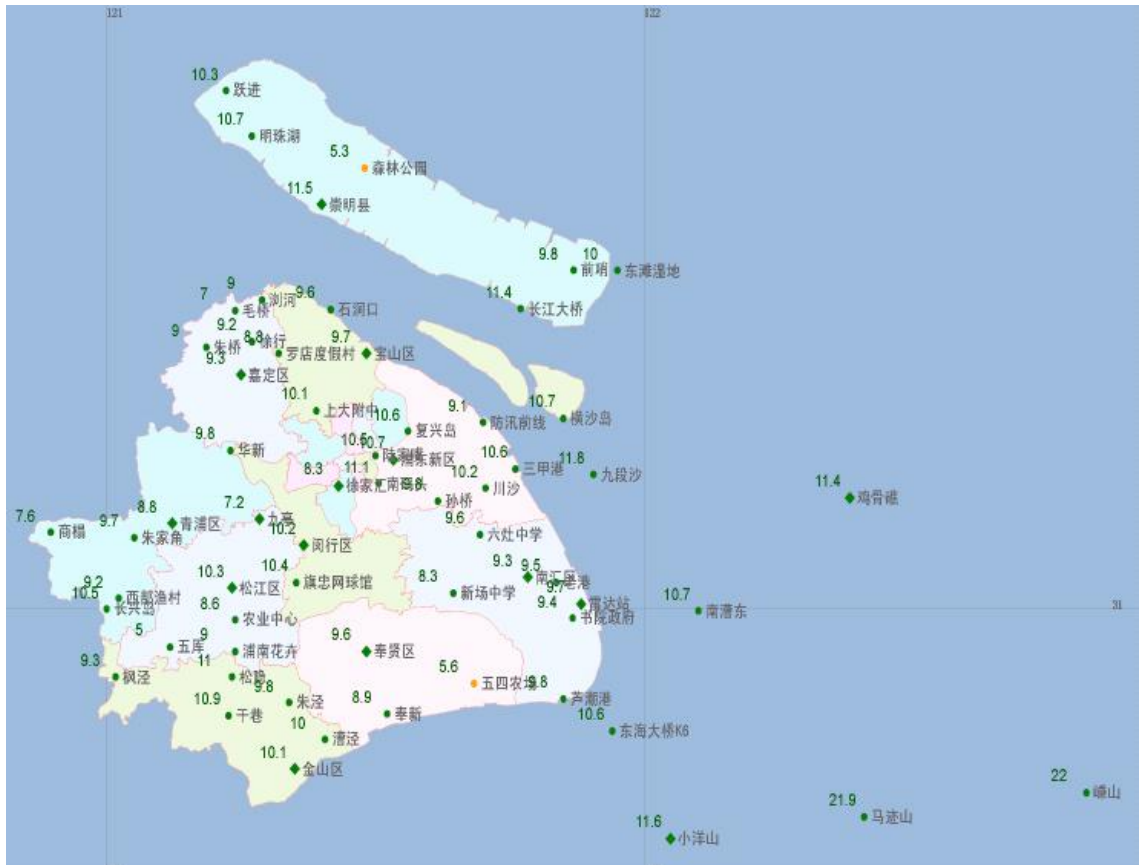
Surface-based remote sensing observational system

Doppler weather radar

A WSR-88D Doppler weather radar was introduced in 1997. It operates 24 hours a day and 365 days a year. It has a volume scan each 6 minutes and provides 3 types of base data: reflectivity, radial velocity, and spectrum width, and more than 70 derived radar products for weather forecasting and research work of the SMB. The application software of the radar system is updated to keep pace with those of the WSR-88Ds in the United States. With the CINRADs at Zhoushan, Ningbo, Nantong and Hangzhou, a Doppler weather radar

network over the Yangtze River Delta provides weather information in real time. By end of 2009, 2 Doppler weather radars which are at Changzhou and Qinpu will put into operation.

SMB employed a mobile Dual-polarization & Doppler weather radar in the late 2007. This radar can be used optionally, and in some research programs, such as the local severe storm observing program and the typhoon tracking program.

Wind profiler

Three LAP-3000 boundary layer wind profilers in Shanghai provide vertical wind and temperature profiles up to an altitude of 3 km above the ground. The spatial resolution of the profiles is 60 m in the vertical direction, and the temporal resolution is 30 min.

Lightning Detection Network

A lightning detection network of 3 SAFIR 3000 sensors was established in Shanghai in 2003. The system detects total lightning that includes Intra-Cloud (IC) lightning and Cloud to Ground (CG) lightning. The data are transported with the CDMA technique to the central station in real time. In 2008, this network was updated by adding one total lightning detection sensor and 3 CG lightning detection sensors.
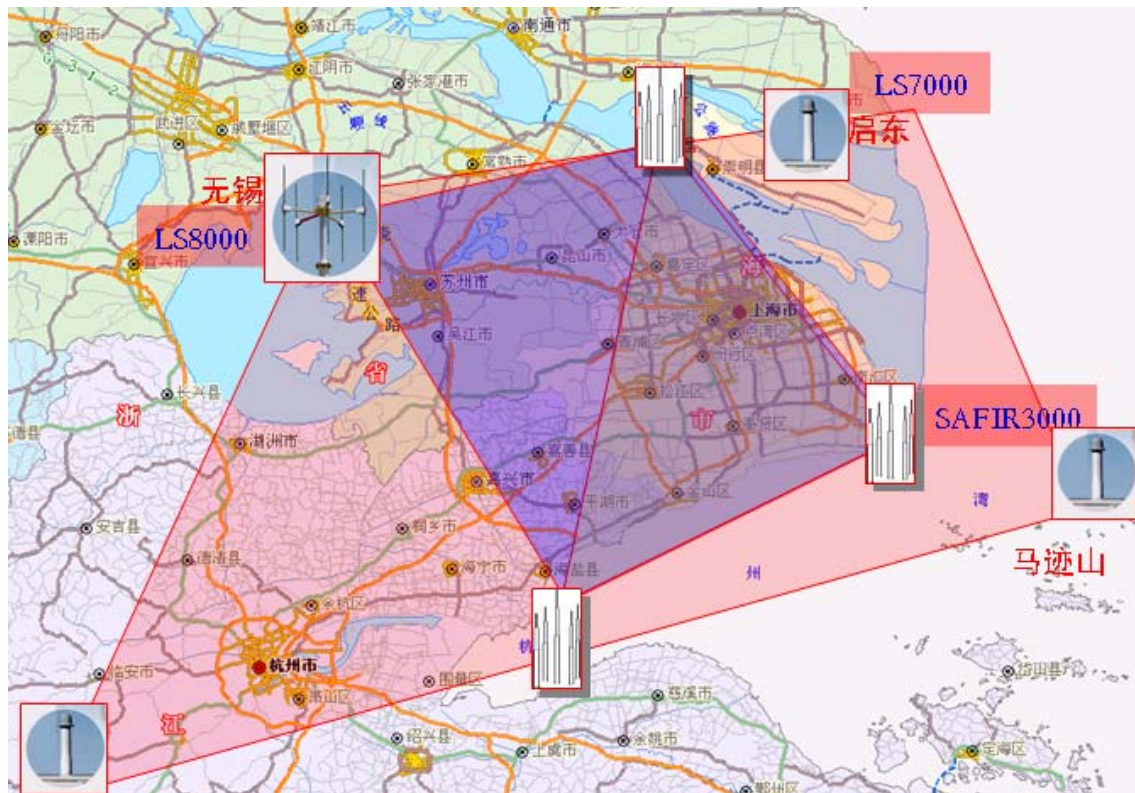
GPS network

There are 50 GPS stations in the Yangtze River Delta. Perceptible water vapour (PWV) data are obtained every 30 min.

Mobile observation

The CMA/SMB is equipped with 4 observational vehicles for tracking hazardous weather observing temperature, humidity, pressure, precipitation, wind (speed and direction), and radiation. The mobile system communicates with the Shanghai Meteorological Center by the GPRS/CDMA technique in real time.

Meteorological observation in the offshore area

Ten automatic weather stations (AWS) have been setup in the islands about 10 km off shore. These stations provide information of temperature, humidity, pressure, wind (speed and direction) and visibility. The data are transported to and shown in the Shanghai Meteorological Center based on the GPRS technique in real time.

Radiosonde

The regular observation of the radiosonde of the SMB is conducted twice a day. In the intensive observational period, the observation is four times a day. It is planned to set up an integrated aerological sounding system at the Baoshan meteorological station of the SMB. Along with the same sounding systems at Sheyang, Nanjing and Hangzhou, an integrated aerological sounding network will be constituted in the Yangtze River Delta.

Satellite observation

The receivers in the SMB can obtain information from a series of satellites including polar-orbiting satellites (e.g., FY-1, FY-3, the NOAA series, MODIS, and so on), Geostationary satellites (e.g., FY-2, the MTSAT, and so on).

By 2010, some new observing equipments and systems will be added in the observational network, which include some new surface observational network, some special observing systems, such as perpetual ice (snow) and road surface temperature detection systems. The network of GPS/Met will be extended by adding 15 GPS receivers.

Observation System and Data Transfer Tasks

CMA Enhanced Data Sources (scheduled)

In this regard, the following approaches and standards are:

- Format to transfer data and products should be NetCDF CF andXML;

- Each participant should be able to view each other's products as soon as possible after they are generated;
- Radiosonde launch frequency in Shanghai and surrounding areas will be increased from twice daily at present to 4 times daily during the WENS demonstration period.

Data Transfer Alternatives

- Conventional observation data and supplemental radiosonde will be transferred via GTS;
- Other non-conventional observation data (data not currently available in GTS), such as Doppler radar volume scan radial wind data and reflectivity data, automatic weather station data, wind profile data, land-based GPS data etc., will be placed on ftp server in SMB, and these data will be available for transfer to ftp servers in all participants' home institutions.

Detailed Data Types to be Made Available to All Participants

- Shanghai, Nantong, Hangzhou, and Ningbo Doppler radar volume scan level-2 data.
- Geostationary Satellite digital data.
- Shanghai, Jiangsu, and Zhejiang climate station data, every 10 minutes.
- All real-time AWS and lightning location data in Shanghai, Jiangsu, and Zhejiang.
- Shanghai, Jiangsu, and Zhejiang radiosonde data.
- The enhanced observational period will be from March to October 2010.

(b) Computational Environment Requirement

SMB/CMA will offer its super-computer (IBM) to support the WENS project. It will have the following capability:

- Floating point operation capacity: peak speed 4T.
- Computing node number: 34
- Node communication : HPS(IBM standard)
- Hard disk storage: 20T.
- Software supported: Fortran90-95, MPI, OpenMP, NetCDF, C/C++, etc.
- System monitoring and maintenance: 2-3 operators.

Requirement of Shanghai Meteorological Bureau Display

- Display platform: 1G.
- Bit rate of network card: 1G.
- Memory: 2G.
- Hard disk storage: 100G.
- Software support: software for display and file, software for system management, etc.
- Two servers: for observation data and Numerical Weather Prediction products (60 min)
- Hot spare systems for product and data servers
- Web server for webpage display
- PC Operation System: Linux
- VPN access through firewall

Network Environment Requirement

Network communication requirements of Shanghai Meteorological Bureau:

- Network bandwidth: 1000M.
- Network communication time: 24 consecutive hours.

Network communication requirements of Shanghai Meteorological Bureau and other participants by internet.

- Network bandwidth: 12M.
- Network communication time: 24 hours.

Network communication requirements of Shanghai Meteorological Bureau and the end users by dedicated line

- Network bandwidth: 2M-8M.
- Network communication time: 24 hours.

(c) Systems Description

A comprehensive description of each system is given in Appendix XXX, together with a listing of the data requirements, system products, IT aspects, and integration needs. The two tables below summarize the respective data requirements and system products.

WENS Nowcasting Systems – Data Required

System / Data		STEPS AND RAINFIELDS	SWIRLS	SWAN	BJANCS	NoCAWS	STI -WARR
Radar Raw Data or R, V, SW PPI products		√	√	√	√	√	√
Gridded radar products	1-18 km mutli-level reflectivity CAPPI		√			√	
	1-2 km VIL; 1-5 km VIL; 1-18 km VIL		√				
	10-dBZ and 60-dBZ echo top		√				
	QPE: 6 minute radar rainfall field	√				√	
AWS	5-min rainfall accumulatio n	√	√	√	√	√	
	1-sec or 3-sec (time		√				

	averaged) wind speed						
	all other standard weather elements		√	√	√	√	√
Lightning : cloud-cloud and cloud-ground lightning strikes information, including lat, lon, height, time, current, etc			√			√	
Radiosonde			√	√	√	√	√
Wind Profiler			√	√	√	√	√
GIS : all available data types as provided in B08FDP, including high-resolution coast lines, administrative boundaries, major roads, rivers, water bodies, important landmarks, etc.			√	√	√	√	
Satellite : all channels from FY2C or MTSAT			√	√	√	√	√
NWP	5-km resolution grid-point data on standard pressure levels		√	√	√	√	
	hourly or better NWP surface rainfall forecasts	√				√	

WENS Nowcasting Systems – Products

System / Products		STEPS AND RAINFIELDS	SWIRLS	SWAN	BJANC	NoCAWS	STI-WARR
QPE		√	√	√	√	√	
	QPF (radar)		√	√	√	√	

QPF	Every 6 minutes: Probability of exceeding thresholds in the next hour; Ensemble mean 30,60,90 minute accumulation forecast	√					
	Every hour (or 30 minutes): Probability of exceeding thresholds for each hour for 1 to 6 hours ahead.	√					
	Deterministic 6 min forecasts for 0 to 6 hours lead time	√					
Storm track and properties			√	√	√	√	
Nowcast ellipses of cloud to ground lightning; downburst, hail; rainstorms			√				
Probability of Lightning			√	√		√	
Severe weather alerts or Warnings			√	√		√	
Mesoscale analysis fields			√				
Reflectivity mosaic			√	√	√	√	
Storm tracking and extrapolation			√	√	√	√	
TREC wind			√	√		√	
Forecasts of storm reflectivity			√	√	√	√	
Forecasts of storm evolution trend					√	√	
Conventional hourly updates of current conditions (analyses) and short-range forecasts							√
Special products such as visibility, ceiling, wind shear etc.							√

						√
Satellite-like or radar-like products through post-processing based on radiative transfer model or radar simulator						

(d) Integration of System Products

Nowcasting products

Nowcast products provided by the participants may include:

- 0-6h QPF;
- 0-6h echo reflectivity: such as 25 dBZ, 40 dBZ, and 50 dBZ
- Severe weather or high impact weather event.

Service products

Service products to be provided include:

- QPE
- Severe weather outlook
- Severe weather warning

Mesoscale NWP model (STI WARR) outputs

STI-WARR stands for "Shanghai Typhoon Institute – WRF ADAS-3dvar Rapid Refresh" The system is comprised primarily of 1) a numerical forecast model (WRF3) and 2) an analysis/assimilation system to generate refreshed analysis fields and to initialize the model. Currently an one-hour assimilation cycle is running.

The mesoscale NWP model outputs will include:

- Conventional hourly updates of current conditions (analyses) and short-range forecasts;
- Special products such as visibility, ceiling, wind shear etc.;
- Satellite-like or radar-like products through post-processing based on radiative transfer model or radar simulator.
- Surface Rainfall
- Convective indices, such as CAPE, convective inhibition, lifted Index, etc.

Summary Table

The following table shows the production information more clearly:

| Category	Products
Nowcasting Products	0-6h precipitation, 0-6h echo reflectivity, severe weather of HIW event; …
Service Products	Severe weather outlook, severe weather warning;…
Mesoscale NWP Models	Surface Rainfall, CAPE, convective inhibition, lifted Index, etc..

VIPS (Very short-range Interactive Prediction System)

For integration of individual system products it is suggested to build upon the BMB VIPS system. This is similar to the Australian TIFS system that was used for integrating the B08FDP nowcasting systems. VIPS can display all the products from participating systems and allow the forecaster to make final decisions based on these products. However, one of the primary findings from the B08FDP experience indicated that this integration process must contain, as a first guess, automated method for combining the individual systems that takes account of the weather regime and the strengths and weaknesses of the individual systems for that particular regime. Also it is essential that the forecaster have the ability to influence the integration procedure. A missing component during the B08FDP was a method to account for initiation, growth and decay tailored to Beijing. Thus for EXPO2010 it is important to include this critical component for Shanghai. A technical working group needs to be assembled early on to define procedures for: 1) determining forecast rules for specific weather situations, 2) evaluating the strengths of each system for specific weather situations, and 3) specifying the required software.This working group would be comprised of Shanghai forecasters and scientists who participated in the B08FDP. This working group is encouraged to meet early in 2009 to initiate the above three tasks.

(e) Dissemination of end-user Products

End-user products are operational products which the forecasters on duty will produce based on integration of WENS systems output. They include nowcasting, watch and outlook products in graphical or text formats. Selected nowcasting products will also be disseminated directly to end-users.

End-user products will be distributed by SMB's early-warning information dissemination platform, a key component of MHEWS, which will be built before the EXPO. This platform includes Issuance & Response Standards; operational procedures; dissemination systems and a management platform. Some important end-users, such as the Flooding Prevention Office of Shanghai, have established a joint-warning and response mechanism with SMB which will maximize the value of end-user products. The dissemination system includes the nine main communication channels used by SMB to distribute various kinds of weather information. These are Telephone, FAX, TV, Radio, Cell Phone, Hotline, Website, Electronic Screen and Tower Lights.
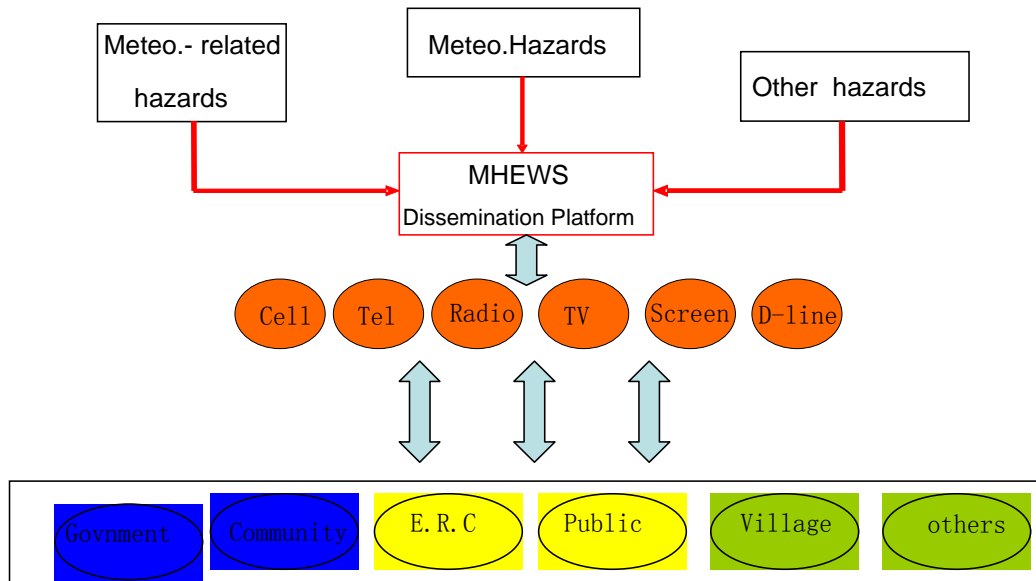
Operational Flow Chart of MHEWS Dissemination Platform

For the cell phone dissemination platform, SMB has applied a user-classified distribution mechanism. Following this mechanism, all stakeholders (users) are divided as 3 levels: (i) City-level, which comprises Municipal Emergency Response Committee members; (ii) Department-level, which includes 50+ governmental agencies, 8000+ community heads, nearly 2000 school principals and 300 agricultural units, and (iii) Public-level with more than 500,000 subscribers. SMB is working with the local telecommunication companies to realize an area-specific targeted cell phone dissemination mechanism, and plans to complete this in early 2009.

Public electronic display screens will also act as an important means to disseminate end-user products; at present SMB can distribute weather information through 23,000+ screens which are situated all over Shanghai.

Based on close cooperation with the relevant government authorities, a number of initiatives have been launched. The Urban Grid Weather Disaster Messenger Mechanism, the Agricultural Meteorological Disaster Distribution Platform, and the Community Safe Program have been set up and put into operation; these represent new approaches to the provision of a better weather service for targeted users.

9. Application of new technology to products and services

Nowcasting techniques enable the provision of high precision forecast of high impact weather in terms of space, time and severity. Typical products would include:

Nowcast products

- Last 0-1 h QPE
- 0-6h QPF (10-15 min interval)
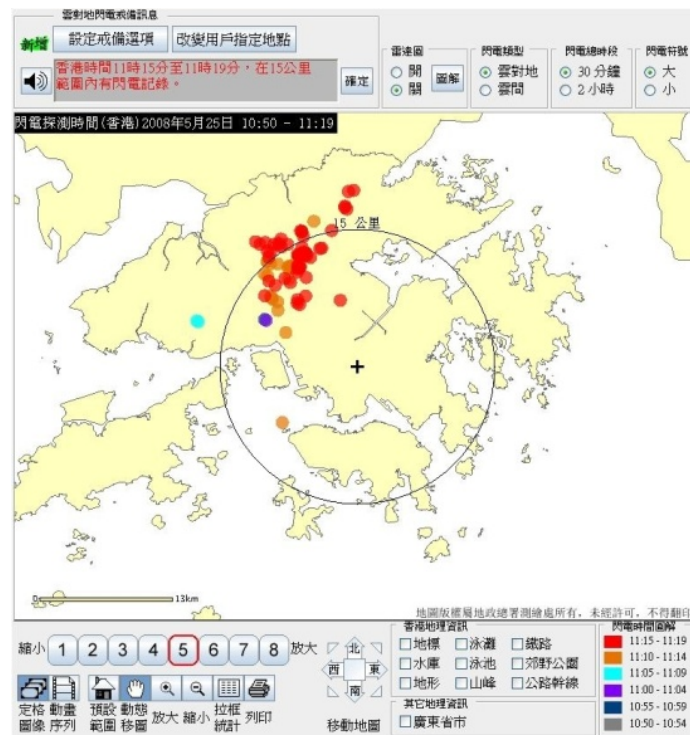- Lightning
- Squalls
- Hail
- etc

Service products

- Severe weather outlook
- Severe weather warning
- Nowcast products for all end users

Rainstorm warnings may be devised by reference to pre-determined rainfall thresholds recorded or forecast over specific regions. Such warnings may be color coded such that they require little communication bandwidth for their dissemination.

For most users, information on current position and intensity of the HIW, coupled with an indication of its future development, is sufficient for their operation. The dissemination of such information is most effective through maps or graphics; these are most conveniently communicated via the web. A few examples are given below.

Lightning locations over the past 30 minutes may be displayed in different colors so as to give the user an idea of their movement. The following display enables the users to monitor the threat of lightning at their specific location. An alarm may be set by users online such that they may be alerted to approaching thunderstorms. For special users, color coded warnings for specific locations, based on lightning probability derived from nowcasting algorithms, may also be developed.

The combination of nowcast rainfall or lightning locations with GIS technology enables the user to overlay the HIW information with other geographical information in support of their operations.
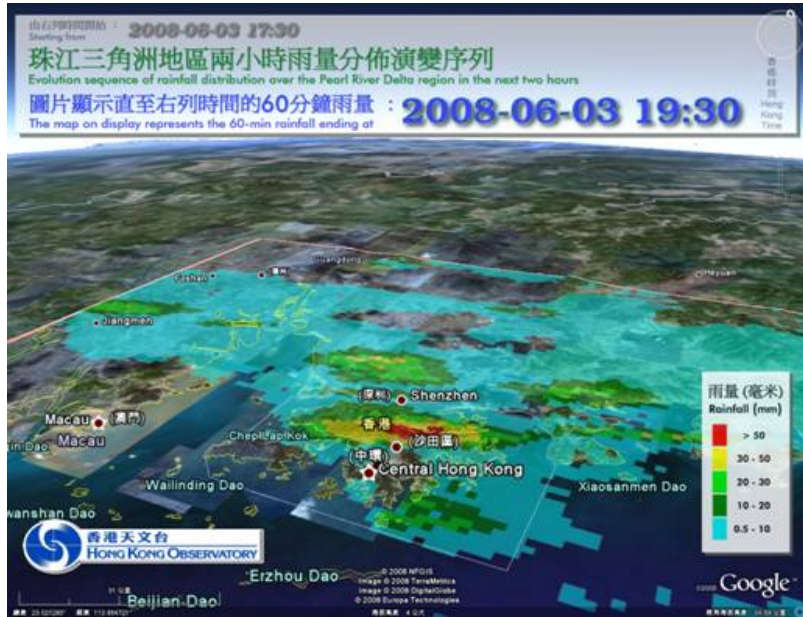
3-D lightning location

10. Data Archive

The SMB will arrange for an archive of data relating to interesting case studies; these will be made available after the conclusion of the operational phase of the project for research, training and capacity-building activities.

The system will archive the following data types: Raw radar volume, NWP, soundings, lightning, AWS and rain-gauge, GPS/Pwv, wind profile. Consideration will be given to providing an archive of the relevant products.

Access to the archive can be arranged through contact with SMB.

11. Capacity building and training plan

The training and capacity building inherent in WENS will operate at different levels:

a) The NSPPs will need to provide training in their systems to the SMB forecast staff in the use of their systems and the interpretation of the new information.

b) The SMB forecasters and related staff will need to provide training to end users in the interpretation and application of the enhanced services and products including probabilistic forecast such that nowcasting information may contribute positively to their operational response to HIW.

c) Forecasters from other countries may work alongside SMB forecasters on attachment in order to gain familiarity with nowcasting systems and services.

d) International Workshops will be organized in Nanjing University of Information Science and Technology for participants from WMO Members, in particular, from developing countries and least developed countries.

e) Guidelines on the provision of nowcasting services, reflecting the experience gained from WENS, to be prepared by the SSG, published, and distributed to WMO Members by the WMO Secretariat in 2011/12.

12. Impact Assessment

The goal of the Impact Assessment activity is to critically evaluate the benefits of nowcasting information services produced through, or as an indirect result of, the WENS FDP project. While a comprehensive quantitative assessment is beyond the scope and resources available to the Team, similar efforts in the past (e.g., Sydney 2000 and Beijing 2008 Olympic Games FDPs) have demonstrated the efficacy of combining qualitative analysis with selected quantified case studies of user-specific and societal benefits[1]; this will be the general approach applied in the WENS Impact Assessment.

The beneficiaries of the WENS project include 6 primary sets of users. In general, these user groups may be distinguished by their familiarity with and experience in applying weather information in their decision-making:

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[1] See Anderson-Berry, L. et al. 2004. The societal, social, and economic impacts of the World Weather Research Programme Sydney 2000 Forecast Demonstration Project (WWRP S2000 FDP), Weather and Forecasting, 19:168-178.

- Operational meteorologists employed by the SMB and other CMA centres (include other meteorologists in media, etc., who are responsible for adapting, explaining and communicating hydrometeorological information?);
- EXPO 2010 organizers responsible for scheduling and managing events, visitor services, and transportation;
- Public agencies responsible for mitigating hydrometeorologic hazards and risks, including the Shanghai Emergency Response Centre (SERC) and Shanghai Water Bureau (SWB);
- Public and private agencies or enterprises that manage critical infrastructure including transportation (surface, air, and marine), energy (electricity distribution), water (domestic supply and treatment, wastewater treatment), and health/safety (hospitals, clinics, ambulance, fire, police);
- Local Shanghai population with emphasis on vulnerable subpopulations (elderly, young, infirm, etc.);
- Visiting tourist population and hospitality industry representatives (e.g., 50,000 member official tourist guiding community, hotels, major attractions).

Three primary areas of benefit are anticipated to be realized through the WENS project:
- Improvements in the existing observation network and in the skill of existing forecast products and services provided by the SMB. The additional NSPPs are expected to have direct impacts on the accuracy, precision, and timeliness of current QPF and other nowcasting products and services provided by SMB.
- Development and application of new and/or integrated products and services. WENS will facilitate the creation of new products, services and delivery mechanisms that are targeted to user-specific requirements. In general they may be issued more frequently, have improved spatial and temporal resolution, and communicated in several formats through multiple media.
- New knowledge and understanding obtained through greater interaction and exchanges among participants and users. WENS training and capacity-building activities will provide several opportunities to enhance understanding between NSPP scientists and SMB forecasters (meteorological knowledge); SMB forecasters and users (risk, impact, and decision process knowledge), and different sets of users (knowledge concerning relative roles, responsibilities and response capacities). Though difficult to quantify, these indirect benefits are often the most substantive and long-term and often lead to considerable innovation.

Measuring the impact of WENS will involve the development and implementation of an evaluation framework and timeline. This plan will be provided by the Impact Assessment WT to the WENS Management Group by the end of May 2009. Specific methods, techniques, and data requirements will need to be defined commensurate with available financial, infrastructural, data and human resources. In addition, the plan will include descriptions of linkages with other teams, especially those associated with capacity building.

The framework will be executed in 3 sequential stages—pre-EXPO (January 2009-March 2010), EXPO (April-October 2010), and post-EXPO (November 2010-April 2011). Contemplated tasks are defined below with an emphasis on the first stage. Subsequent stages will be expanded and adapted according to baseline results and reported in the evaluation plan.

Pre-EXPO 2010 Baseline Evaluation

The baseline evaluation is a critical component of the impact assessment as it

provides a common foundation from which to determine the relative contribution of WENS to the user and forecast communities. Reviews of available literature, reports and other documentation will be supplemented with informal interviews, a workshop, and a public survey to establish the following profile for each user category:

- Overview of agency size, scope and operations
- Primary goals, objectives or mandate and key outcomes
- Decision sensitivities to weather-related risks
- Capacity to monitor, model, adjust and respond to weather-related risks/impacts
- Current application of weather information in decision-making
- Required and desired variables; precision, accuracy, certainty, frequency; communication format/media; training
- Impacts of current use of nowcasting scale products and services
-

Case studies will be conceived for selected users that provide sufficient socio-economic data to permit formal empirical baseline risk and sensitivity analysis (e.g., traffic-weather relationships).

A parallel activity will solicit input from SMB forecasters, primarily through interviews during the Summer 2009 NSPP workshop, and involve the following:

- Self-rated effectiveness/quality of current products and services
- Comparable standard verification of a sample of products and services
- Identification of expected forecast benefits associated with WENS
- Measurement of the knowledge of user sensitivities, needs, and decision-making context as defined above

EXPO 2010 Continuous Evaluation

Continuous evaluation of the products and services provided through WENS and SMB will occur for both user and forecaster communities throughout World EXPO 2010. Public and visitor populations will be surveyed, most likely using web-based questionnaires and personal interviews. Other users will be consulted using personal, telephone or web-delivered surveys a minimum of once per month during the World EXPO 2010 period. Summary results from these surveys will be made available to NSPPs and WENS SSG on a regular basis. Furthermore, the evaluation process will also include the forecaster's assessment of the products provided by WENS Systems. Each day, as part of the forecasters' activities, a summary log will be produced providing an assessment of the WENS products. These subjective interpretations will provide ongoing feedback to the forecasters and the WENS participants on the performance of each system and their associated products. Standard verification measures will also be developed to complement the subjective interpretations.

Post-EXPO Evaluation

The final stage will essentially involve repeating the first stage tasks with the added task of drawing qualitative and quantitative comparisons between pre- and post-EXPO results. A final workshop bringing together representatives from the user groups and forecasters is recommended to review and discuss impact assessment results.

13. Resource Plan

13.1 Principle

The Project will be jointly supported by SMB/CMA, WMO, and the Participating System Owners (NSPPs).

13.2 CMA's Support

SMB/CMA will provide local logistical support and coordination as required, and will also provide resources for local travel/per diem for NSPP personnel to participate in agreed activities.

13.3 WMO's Support

WMO will provide resources for international travel/per diem for NSPPs, and for publications and training events.

13.4 Participant's Support

NSPPs will use their own resources to support the development and maintenance of their participating systems. SMB/CMA will second development staff to NSPPs to assist in customization, support, maintenance and interfacing of systems to the operational data feeds, and to the information/dissemination systems as agreed for implementation in Shanghai for World EXPO 2010. SMB/CMA may accept attachment of staff from other WMO Members to its facilities for the purposes of capacity building and technology transfer. The support for such staff will be arranged by mutual agreement.

It is anticipated the SMB/CMA may second development staff to specific NSPP organizations, as mutually agreed, to assist in customization, support, maintenance and interfacing of system(s) to operational data feeds, and to information/dissemination systems as agreed for implementation in Shanghai for World EXPO 2010. It is expected that SMB/CMA will provide resources as mutually agreed for travel/per diem support for NSPP personnel to participate in agreed activities. NSPPs, using their own resources, will support their systems, offer consultancy / advisory support, and undertake agreed interface and capacity building activities. Stationing of NSPP personnel at World EXPO 2010 will be required over a mutually agreed period, which is expected to be primarily for a short duration before and at the beginning of the World EXPO 2010. CMA/SMB may consider deploying staff to operate the participating systems during the rest of the World EXPO 2010 duration. NSPPs will provide off-site support for such operation.

14. Product Implementation Schedule

14.1 Action Plan

a) Production of WENS concept document, as a key starting document, highlighting its relationship to the overall MHEWS project. The document will include components such as objectives, governance structure, resources, links between contributors, timetable, respective obligations. An inventory of target user sectors is of primary importance including the initial identification of user requirements, proposed approaches to impacts assessment etc. (SMB/CMA). Completed by end of June 2008. *Completed.*

b) Consultation with JONAS SC to decide on scope of engagement with WENS (JONAS SC co-chairs). Completed by end July 2008. *Completed.*

c) Official invitations to participate in WENS (WMO PWS Secretariat). Completed by end August 2008. *Completed*

d) Establishment of WENS Scientific Steering Group and WENSWG by interim SSG who will also provide draft TORs and draft business plan for WENS. (Interim SSG). December 2008. *Meeting held in Shanghai, November 2008.*

e) SSG Planning Meeting to finalise TORs and WENS Business Plan on project scope, duration, milestones and deliverables as well as funding arrangements (SSG) Meet by mid December 2008. *Meeting held in Shanghai, November 2008.*

f) Implementation of the WENS Project Implementation Plan e.g. benchmark survey to assess baseline impact of nowcast products to target user sectors, system integration, product development, capacity building including experience sharing workshop etc. (SMB/CMA, WENSWG, NSPPs). Identification of suitable case-studies and preparation of data sets. November 2008 - May 2009.

g) First trial run (WENSWG) commencement. June / July 2009.

h) Interim Review Meeting. Review objectives, undertake validation and performance assessment of systems taking part in trial run; engage key stakeholders/users to provide feedback on products; adjust Project Implementation Plan, if appropriate (SSG). October 2009.

i) Fine-tuning of systems and further development of services and products. November 2009 – April 2010.

j) WENS Full Operation (WENSWG). May-November 2010

k) Post-project survey to assess impact of WENS (WENSWG). December-February 2011

l) Final Review Meeting and Report Preparation (SSG). To be completed by end of March 2011

m) Publication of Guidelines on provision of nowcasting services reflecting experience gained from WENS, to be followed by a Capacity Building Workshop for WMO Members (SSG, Secretariat). To be completed by end of 2011

14.2 Schedule

Year\Month	January - May	June	July	August	September	October - December
2008		WENS Concept Document	Consultation with JONAS SC	Official invitations to participate in WENS		WENS Interim SSG and first WENS SSG meeting. Preparation of Project Implementation Plan
2009	Preparation of first trial run, end-user survey First trial run	Assessment by WENS Management Group of initial trial; adjustments as appropriate.				Interim Review Meeting
2010	Fine-tuning of systems and development of services and products.	WENS Full Operation (May to November)				Post-project survey to assess impact of WENS

2011	Post-project survey to assess impact of WENS	Final Review Meeting and Report Preparation	Capacity Building Workshop. Publication of Guidelines.

Appendix A

Agenda for WENS Interim SSG (24-25) and First WENS Meeting 26-29 November) Shanghai, China

	Monday 24	Tuesday 25	Wednesday 26	Thursday 27	Friday 28	Saturday 29
0900 1045	**1.** Opening remarks **2.** Review of the Project Implementation Structure	**6.** Discussion on Stakeholder (user) Survey	**1.** Opening ceremony **2.** Opening remarks by CMA/SMB, WMO **3.** Group Photo **4.** Presentation on EXPO 2010	**10.**WENS stakeholder session	**16.** Trial run implementation	**18.** Finalize the SSG Implementation Plan drafted by Interim SSG
1115 1245	**3.** Review and confirmation of TORs for SSG **4.** Nominating members of S	**6.** Continue with item 6	**5.** Review and Approval of the agenda **6.** Overview of B08FDP **7.** WENS SSG, WENS MG, PSO membership and TORs	**11.** Initial Discussions of WENS Plan **12.**WENS Management Group.	17. Study tour organized by SMB	**18.** Continue with item 18 **19.** Meteoworld pavilion and IABM / broadcasting discussions.
	Lunch	Lunch	Lunch	Lunch	Lunch	
1400 1530	**5.** Drafting TORs of WENS Working Group based on outline in the Concept Document	**7.** Initial Draft of SSG Implementation Plan	**8.** Tour of SMB facilities **9.** Overview of participating systems	**12.** continue with item 12. **13.** WENS data, communication and computer support	**17.** Continue with item 17	**20.** Final review and preparation of meeting report.
1600 1730	**5.** Continue with item 5	**7.** Continue with item 7. **8.** Conclusion of SSG Interim meeting	**9.** Continue with item 9	**14.** WENS social impact **15.** WENS capacity building plan plan	**17.** Continue with item 17	**21.** Closing remarks

Appendix B

LIST OF PARTICIPANTS

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NSPPs System Description:

SWAN – China Meteorological Administration

WENS Nowcasting Systems – basic information

System: <u>SWAN</u>

Overall Description:
SWAN, short for the Severe Weather Automatic Nowcast system, is newly developed by CMA, aiming at providing an integrated, state-of-the-art and swift severe weather nowcast platform that is suitable to operational applications. SWAN ingests data from China's new generation radars, automatic weather station, satellite, and mesoscale numerical weather prediction model. It offers a platform for severe weather monitoring, analysis, warning and prediction. The current version of SWAN system provides a software package that integrates a series of algorithms and functions. In 2009, SWAN will provide more useful algorithms and functions in its next version.
Data Required:
Radar raw data and products, total lightning data, AWS data, satellite data, GPS/Pwv data, wind profiler data, mesoscale NWP model outputs (including wind, rainfall, and some convective indices), and radiosonde data.
Products:
3-D radar reflectivity mosaic, storm identification and tracking, radar precipitation estimate, very-short-range radar echo extrapolation forecast, 0-1 hour quantitative precipitation forecast, strong-echo-area identification and warning, derived radar reflectivity displacement vector (COTREC wind), and real time severe weather warning of various kinds.
Communications and IT support:
Local Area Network support, Windows Operating System support;
Integration into the Shanghai system; staffing, resource and financial requirements:
SWAN needs about 2 local staffs to support SWAN's installation and trial run, and 2 PC computers to run the system and its server.

Short Term Ensemble Prediction System (STEPS) - BOM

STEPS generates ensembles of rainfall forecasts in the 0-6 hour lead time by blending the radar based extrapolation nowcast with the Numerical Weather Prediction (NWP) rainfall forecasts and then perturbing the blend with a statistical model of the forecast error. The life time of a storm generally increases with the size of the storm, therefore large rain areas in the radar image can be predicted with greater accuracy than smaller rain areas. STEPS models this behaviour by decomposing an observed rainfall field into a range of scales and then estimating the error in the advection forecast as a function of scale and lead time. Errors in the NWP also decrease as the size of the storms increases, so STEPS calculates the skill of the NWP as a function of scale and then blends the advection nowcast with the NWP forecasts at each scale according to their relative skills. The ensemble of forecasts is generated by perturbing the blended forecast by

means of a model for the forecast error in a manner that preserves the observed statistical characteristics of the rain fields.

STEPS is used to generate nowcast 30 member ensembles over the UK radar network, a domain of approximately 1500 km x 1000 km, at 2 km, 15 minute resolution out to 6 hours and updated hourly. The same system is used in Australia to generate ensembles of nowcasts over a 200 km domain out to 90 minutes, updated every 10 minutes but with no NWP blending and nowcasts over a 400 km domain out to 6 hours at 2 km, 10 minute resolution. These ensembles are used to calculate the probability that rainfall will exceed a range of thresholds and are being tested as drivers of hydrological models so as to calculate the probability that river levels will exceed certain critical thresholds.

The code is written in C++ and has been compiled and run on a number of platforms. The 0-6 hour ensembles are generated on an SX 6 NEC super-computer and currently the 0-90 minute ensembles are generated on a LINUX workstation. The 0-6 hour ensembles could be generated on a fast workstation with multiple CPUs or on the IBM super computer currently installed in SMB, whichever is more convenient.

WENS Nowcasting Systems – basic information

System: STEPS

Overall Description:
Radar QPE 6-minute rainfall fields, gauge + radar blended rainfall fields
Deterministic forecasts and probabilities for either 0-90 minutes or 0-6 hours
Data Required: 1. Radar volume scans   2. Rain gauge observations   3. Hourly or better NWP surface rainfall forecasts
Products: 1. 6 minute radar rainfall QPE based on a mosaic of 5 radars   2. 30,60 minute rainfall accumulations based on radar rainfall, updated every 6 minutes   3. 30,60,120,180 minute and daily rainfall accumulations based on a blend of the radar rainfall and the gauge data   4. probability of rain exceeding certain thresholds (eg 1,5,10,20,50 mm) in each hour for the next 6 hours, updated every hour.   5. 6-minute deterministic rainfall forecast for the next 6 hours, updated every hour   6. forecast rainfall accumulation for the next 30,60,90 minutes, updated every 6 minutes   7. 6-minute deterministic rainfall forecast for the next 90 minutes, updated every 6 minutes
Communications and IT support: 1. 2x Intel quad core CPU with 2.66 GHz or better and16 GByte of RAM, RAID 3TByte disk storage, Red Hat Enterprise Linux 32 bit OS   2. Linux cluster with 4x blade server each with a quad core and 8 GByte of RAM OR access to the IBM   3. If using the IBM: Need local IT support to write the scripts to schedule the tasks and to get the data on and off the IBM. Need c++ programmer support to assist with the port, especially converting to run as a parallel application.
Integration into the Shanghai system; staffing, resource and financial requirements: 1. SMB staff to visit Australia for 8 weeks to assist with radar QPE set up tasks (costs to be covered by SMB)   2. Airfare and travel allowance while in China for Bureau staff; 2 people to travel to Shanghai for two weeks each to set up rainfields and STEPS

3. Licence to use STEPS in Shanghai- will check with the Met Office

Short-range Warning of Intense Rainstorms in Localized Systems (SWIRLS) - HKO

The Hong Kong Observatory (HKO) nowcasting system SWIRLS (abbreviation for) has been in operation since 1999. The second-generation version (referred to as SWIRLS-2) has been under development and real-time testing in Hong Kong since 2007. A special version of SWIRLS-2 was implemented for Beijing and run during the WMO/WWRP B08FDP operation period (July to September 2008) to support the Beijing Olympics.

SWIRLS-2 comprises a set of nowcasting sub-systems, responsible for the ingestion of observation data, execution of nowcasting algorithms, as well as product generation and visualization.

WENS Nowcasting Systems – basic information

System: Short- range warning of Intense Rainstorms in Localized Systems (SWIRLS)

Overall Description:

The Hong Kong Observatory (HKO) nowcasting system SWIRLS has been in operation since 1999. Its second-generation (referred to as SWIRLS-2) version has been under development and real-time testing in Hong Kong since 2007. SWIRLS-2 comprises a set of nowcasting sub-systems, responsible for the ingestion of observation data, execution of nowcasting algorithms, as well as product generation and visualization.

Data Required:

Radar : volume scan raw data of reflectivity, radial velocity and spectral width

Gridded radar products:

2-km	level	reflectivity	CAPPI;
3-km	level	reflectivity	CAPPI;

1-18 km multi-level reflectivity CAPPI;

1-2 km VIL; 1-5 km VIL; 1-18 km VIL;

10-dBZ echo TOP; 60-dBZ echo TOP;

data grid size is 480x480 in azimuthal equidistant projection, covering a square area of 512x512 km

all radar products to be generated from mosaic of time-synchronized quality-controlled raw data of all available radars;

Lightning : cloud-cloud and cloud-ground lightning strikes information, including lat, lon, height, time, current, etc

AWS :

5-min rainfall accumulation;

1-sec or 3-sec (time averaged) wind speed alternative : the maximum wind speed and time records deduced from the 1-sec or 3-sec wind speed data;

all other standard weather elements

Radiosonde : high temporal resolution (preferably at 2-sec intervals)

Wind profiler : standard requirements

GIS : all available data types as provided in B08FDP, including high-resolution coast lines, administrative boundaries, major roads, rivers, water bodies, important landmarks, etc.

Satellite : all channels from FY2C or MTSAT

NWP : 5-km resolution grid-point data on standard pressure levels

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Products:

QPF (radar)

Storm track and properties

Nowcast ellipses of cloud to ground lightning; downburst, hail; rainstorms

Alert for severe wind gust (maximum possible) over warning area

Probability of Lightning (in 1, 2, 3 hours)

Rainfall maps, severe weather maps, echo motion fields, Tephigram and stability indices

Severe weather alerts as deduced according to user-defined warning criteria

Rainfall maps and actual lightning locations, overlaid on public and user-supplied GIS layers

Mesoscale analysis fields

QPE

Reflectivity mosaic

Communications and IT support:

CPU cores (3.6 GHz Intel Xeon or faster) : 10

RAM : 16 GB

Local hard disk : 2.2 TB

RAID-5 Shared storage : 2 TB (for 3 month's data)

Operating system : Enterprise Red Hat / Scientific Linux

Compilers / development tools: Intel Fortran and C compilers; Java JDK v1.4 or above; Perl v 5.8; Google Earth API

Integration into the Shanghai system; staffing, resource and financial requirements:

To implement SWIRLS-2 for WENS, the major technical supports required from SMB include:

- provision of all the required computing facilities and installation of all the software above;
- generation and conversion of CINRAD radar products to the format required by SWIRLS-2 ;
- generation and conversion of other local data to the corresponding B08FDP formats ;
- adaption of various computer programs for the WENS forecast domain;
- customization of various nowcasting algorithms for the weather warning criteria in Shanghai;
- provision of past data and algorithm tuning for the local severe weather climate; and
- conversion of SWIRLS-2 products to WENS output formats, if required.

HKO will be responsible for training up development staff seconded from SMB and the necessary system tunings on-site in Shanghai.

Depending on the progress, 2-3 trips of 1 scientist and 1 system expert to Shanghai for about 1 week each trip may be required. Flight, accommodation and subsistence have to be provided by SMB.

BJANC – Beijing Meteorological Bureau

BJANC is the fruit of an international collaborative project between China and U.S.A. It is formed through cooperative research, and the further development of NCAR's nowcasting system for convective storms at the Beijing Meteorological Bureau (BMB) and Beijing Institute of Urban Meteorology of CMA (IUM). BJANC was focused on severe convective storm analysis and nowcast in support of the 2008 Olympics, and convective weather warning in Beijing area.

BJANC is an automated nowcasting system that produces 0-1 hr forecasts of convective storm location and intensity with optional human enhancement to forecasts by entering the boundary layer convergence line or modifying focused forecast areas. Severe storm extrapolation from the system can also be extended to 2 hrs. BJANC combines meteorological observations, high-resolution low-level thermodynamic structure analysis based on a 4D-Var technique, rapid-updating Meso-NWP outputs and several storm feature detection and tracking algorithms, as well as local data analysis algorithms, to provide routine nowcasts of position, intensification and evolution of convective storms. Observational data used in the system include those from CINRAD radars, geostationary satellites (FY2C and FY2D), Auto Weather Stations (AWSs), and enhanced rawinsondes. A data integration technique based on fuzzy logic is used to combine the

predictor fields calculated through various analysis and detection algorithms in the system. The resultant nowcasts of storm initiation, growth, and decay can be used as guidance by the forecasters or nowcasters. BJANC can also produce quantitative precipitation estimates (QPE) based on the three-dimensional reflectivity mosaic data and local Z-R relationship, and convective quantitative precipitation forecast (QPF) based on the severe storm reflectivity forecasts and local Z-R relationship.

BJANC demonstrated ease and reliability of use, and produced real-time analysis and nowcasts of more than 40 convective storm events within its 500km by 500km domain centered on urban Beijing during summer 2008. BJANC was also one of eight international nowcasting systems that participated in WWRP's B08FDP in Beijing during the Olympic and Paralympic periods.

The following products expected from the system will be available from BJANC

Product Type	Product Description
Reflectivity mosaic	3-D and composite, 6-min interval and 1-km resolution
Storm tracking and extrapolation	Detection, tracking and 30-, 60- and 120-min extrapolation of 35dBZ reflectivity, 6-min interval
TREC wind	TREC wind vectors from radar reflectivity, 6-min interval and 1-km resolution
Forecasts of storm evolution trend	30- and 60-min forecasts of storm evolution trend (growth, steady, decay, initiation), 6-min interval and 1-km resolution
Forecasts of storm reflectivity	30- and 60-min forecasts of storm reflectivity, 6-min interval and 1-km resolution
QPE	6-min, 30-min, 60-min, 3-h and 6-h quantitative precipitation estimates (QPE) based on reflectivity mosaic and a local Z-R relation, 6-min interval, 1-km resolution
QPF	30- and 60-min quantitative precipitation forecast (QPF) based on storm reflectivity forecasts and a local Z-R relation, 6-min interval, 1-km resolution

WENS Nowcasting Systems – basic information

System: <u>BJANC</u>

Overall Description:

BJANC is an automated nowcasting system that produces 0-1 hr forecasts of convective storm location and intensity with optional human enhancement to forecasts by entering boundary layer convergence line or modifying focused forecast areas. Also severe storm extrapolation from the system can be extended to 2 hrs. BJANC combines meteorological observations, high-resolution low-level thermodynamic structure analysis based on a 4D-Var technique, rapid-updating Meso-NWP outputs and several storm feature detection and tracking algorithms, as well as local data analysis algorithms, to provide routine nowcasts of position, intensification and evolution of convective storm. A data integration technique based on fuzzy logic is used to combine the predictor fields calculated through various analysis and detection algorithms in the system. The resultant nowcasts of storm initiation, growth, and decay can be used as guidance by the forecasters or nowcasters. BJANC can also produce quantitative precipitation estimates (QPE) based on the three-dimensional reflectivity mosaic data and local Z-R relationship, and convective quantitative precipitation forecast (QPF) based on the severe storm reflectivity forecasts and local Z-R relationship.

Data Required:

Observational data used in BJANC include those from CINRAD radars, geostationary satellites (FY2C and FY2D), Auto Weather Stations (AWSs), enhanced rawinsondes, and Meso-NWP outputs. CINRAD radar data are necessary and synchronization is expected if multiple radars are used.

Products:

The following products expected from BJANC will be available for WENS:

(1) Reflectivity mosaic → 3-D and composite, 6-min interval and 1-km resolution;
(2) Storm tracking and extrapolation → Detection, tracking and 30-, 60- and 120-min extrapolation of 35dBZ reflectivity, 6-min interval;
(3) TREC wind → TREC wind vectors from radar reflectivity, 6-min interval and 1-km resolution;
(4) Forecasts of storm evolution trend → 30- and 60-min forecasts of storm evolution trend (growth, steady, decay, initiation), 6-min interval and 1-km resolution;
(5) Forecasts of storm reflectivity → 30- and 60-min forecasts of storm reflectivity, 6-min interval and 1-km resolution;
(6) QPE → 6-min, 30-min, 60-min, 3-h and 6-h quantitative precipitation estimates (QPE) based on reflectivity mosaic and a local Z-R relation, 6-min interval, 1-km resolution;
(7) QPF → 30- and 60-min quantitative precipitation forecast (QPF) based on storm reflectivity forecasts and a local Z-R relation, 6-min interval, 1-km resolution.

Communications and IT support:

(1) 4~5 DELL workstations or servers for system installation and running;
(2) With one or two 500 Gb SCSI disk(s), 4 Gb EMS memory and two network cards for each computer;
(3) Over 100 Mb local network connections for getting data and transferring products in real-time;
(4) An internet setup expected for remote access of each computers of the system;
(5) An UPS power expected for running the system.

Detailed IT and communications to be needed from IUM's software engineer of nowcast research group.

NoCAWS is an operational system for severe weather very-short range forecasting and nowcasting. NoCAWS has the following functions: Data Process and Management, GIS-based Integrated Display, Severe Weather Automatic Alert, Nowcasting Methods and Products, Analysis Functions (sounding and 3-D lightning), and Nowcasting and Warning Products Generation. NoCAWS uses some relevant techniques in the system, such as Radar Data Pre-Processing technique, Severe Weather Outlook technique, Regional Severe Weather Watch technique, Nowcasting (CO-TREC) technique, Quantitative Precipitation Estimate (QPE) technique, Quantitative Precipitation Forecast (QPF) technique, Storm Life-Cycle Analysis & Estimate technique, and Lightning Prediction technique. Using this system, forecasters can monitor weather changes, make mesoscale weather analyses, analyze storm environments, diagnose storm structures and life cycles, and interactively make nowcasting and warning products.

Based on NoCAWS, some service products can be generated automatically, or interactively by the forecasters. The service products that are relevant to the WENS project are the severe weather outlook (0-12h) for the Yangtze River Delta (YRD) region and Shanghai city, severe weather watch (0-6h) for the YRD region, severe weather warning (0-2h) for Shanghai city and end users. Moreover, some special service products, such as QPE and QPF for a certain period, thunderstorm/lightning threat, and severe weather type forecast, will be provided for all WENS end users based on their requirements.

NoCAWS is written using Visual C++ and works within the Windows Operating System. The Operating System of the NoCAWS server is Windows 2003 Server. The methods of nowcasting and warning are written using both Visual C++ and Fortran 90.

WENS Nowcasting Systems – basic information

System: <u>NoCAWS</u>

Overall Description:
NowCAsting and Warning System (NoCAWS) is an operational system for severe weather very-short range forecasting and nowcasting. NoCAWS has the following functions: Data Process and Management, GIS-based Integrated Display, Severe Weather Automatic Alert, Nowcasting Methods and Products, Analysis Functions (sounding analysis), and Nowcasting and Warning Products Generation. Using this system, forecasters can monitor weather change, make mesoscale weather analyses, analyze storm environment, diagnose storm structure and life cycle, and interactively make nowcasting and warning products. Based on NoCAWS, some service products can be generated automatically or interactively with forecasters. Moreover, some special service products will be provided for all WENS end users based on their requirements.
Data Required:
Radar raw data and products, total lightning data, AWS data, satellite data, GPS/Pwv data, wind profiler data, mesoscale NWP model outputs (including some convective indices), and conventional weather data (including radiosonde data, upper air data, and surface data) .
Products:
3-D radar mosaic (after quality control), 0-1h QPE, 0-3h QPE;
0-2h echo nowcast, 0-2h QPF, 0-2h lightning nowcast, and all these nowcasts for individual end user;
0-6h QPF, 0-6h lightning probability, 0-6h severe weather probability, 0-6h severe weather watch;
0-36h convection probability outlook;

Communications and IT support:
Local Area Network support, Windows Operating System and Windows 2003 Server support;
Integration into the Shanghai system; staffing, resource and financial requirements:
N/A.