

IMPLEMENTING ARRANGEMENT #18

Development of a High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) System

Pursuant to the Agreement Between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office In the United States

for Technical Cooperation in Meteorology and Forecast Systems Development

Article I - Scope

This Implementing Arrangement describes the scientific and technical activities to be undertaken by the American Institute in Taiwan (AIT), through its designated representative, the Global System Division (GSD), (formally the Forecast Systems Laboratory) of the Earth System Research Laboratory (ESRL) of the National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce. It provides for continuing development of the forecast system being developed by the Joint Forecast Systems Project. This project is a cooperative effort between AIT's designated representative, NOAA/ESRL/GSD, and the Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO). This agreement is of mutual interest to both parties. The products of this agreement will provide substantial value through development of new and upgraded capabilities and applications that can be integrated into other NOAA/ESRL/GSD systems.

Article II - Authorities

The activities described in this Implementing Arrangement will be carried out under the general terms and conditions established by the Agreement between the National Oceanic and Atmospheric Administration, United States Department of Commerce, and the American Institute in Taiwan for Technical Cooperation in Meteorology and Forecast Systems Development (NOAA-AIT Agreement), and any subsequent revision as agreed to by the parties. This Implementing Arrangement is the eighteenth such arrangement under a succession of umbrella agreements between NOAA and AIT.

NOAA has authority to participate in the meteorology and forecast systems development project with AIT under:

- A. 15 U.S.C. 1525, the DOC Joint Project Authority, which provides that DOC may enter into joint projects with nonprofit, research, or public organizations on matters of mutual interest, the cost of which is equitably apportioned;
- B. 22 U.S.C. 3301 et seq., the Taiwan Relation Act of April 10, 1979, Public Law 96-8, which authorizes agencies of the United States Government to perform services for, and

to accept funds in payment from AIT;

- C. 15 U.S.C. 313, the Weather Service Organic Act, which authorizes the Secretary to perform meteorological services;
- D. 49 U.S.C. 44720(b), the Federal Aviation Act, which authorizes the Department of Commerce to promote safety and efficiency in air navigation; and
- E. An agreement between AIT and the Taipei Economic and Cultural Representative Office in the United States (TECRO), which authorizes AIT to provide technical assistance from a designated agency to an agency designated by TECRO. AIT has designated NOAA to provide technical assistance in meteorology and forecast systems development. TECRO has designated the Central Weather Bureau (CWB) of Taiwan to receive such technical assistance.

This Implementing Arrangement is hereby attached to that Agreement and becomes part of the Agreement.

Article III - Services

During the period of Implementing Arrangement #18 the ESRL/GSD-CWB joint team will focus on two tasks: (1) the development of a High-resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) System, and (2) continuing integration on earlier cooperative projects. Tasks under this Agreement range from full scale developmental collaboration to system upgrades and support that allow systems to operate with the latest technical and scientific capabilities and specifications. These ongoing activities, described in more detail in the Statement of Work, will include the following two tasks:

Task #1 - High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) System

During Implementing Arrangement #17, GSD and CWB continued to improve the LAPS data ingest of radar data and the cloud scheme. GSD and CWB added WRF (Weather Research and Forecast) to the modeling suite and established a LAPS/MMS-WRF hot start shadowing system at GSD. The state variable verification system for point verification of precipitation and for gridded verification of model QPF with LAPS QPE was also improved. In addition, the computer resources and technical guidance to one CWB visiting scientist to do his cases study of LAPS analysis with different background models was provided.

During Implementing Arrangement #18, GSD and CWB will focus on the Quantitative Precipitation Forecast (QPF) for water accumulation and debris flow based on a new advanced 3D variational (3DVAR) data assimilation scheme as GSD's part of the HRQ2 task. This new task will support the operational needs from threats from flash flood, debris flow and landslide. One candidate is to adopt the STMAS (Space and Time Mesoscale Analysis System) for surface observations and other remote sensing data such as radar data. STMAS is an extended 3DVAR and provides multiscale analysis using

inhomogeneous observation distribution. Another candidate is the GSI (Gridpoint Statistical Interpolation) analysis system used operationally by NOAA/NCEP (National Centers for Environmental Prediction). GSD and CWB will upgrade the LAPS analysis to LAPS III to improve cloud scheme and microphysical recovery. A 1D version of the host model's microphysics scheme will be used instead of the current one. LAPS III utilizes situational error covariances from an ensemble with the 3DVAR analysis driver. GSD and CWB will adopt full WRF (NMM and ARW) for hot start. This will mean adding the WRF-NMM to the CWB modeling suite. NMM and ARW are different versions of WRF, the NMM was developed by NOAA's NCEP and NCAR (National Center for Atmospheric Research) respectively. GSD and CWB will continue to upgrade the state variable verification system for the HRQ2 system.

During Implementing Arrangement #18, the National Severe Storms Laboratory (NSSL) will continue research towards the refinement and development of applications and algorithms required for the CWB and the WRA (Water Resources Agency) and the Soil and Water Conservation Bureau (SWCB) operations as NSSL's part of the HRQ2 task. The NSSL research is directed towards improving the monitoring and prediction of flash floods and severe storm identification and short-term forecasting for the Taiwan environment. The NSSL research and development for IA#18 will focus on three core areas: 1) quality control, 2) 0-1 hour Quantitative Precipitation Forecast (QPF) and its application toward debris and flash floods, and 3) verification and assessment of application performance. During IA#18, NSSL will conduct research and present findings, algorithm documentation and source code where appropriate for system maintenance.

Task #2 - Continuing Interaction on Earlier Cooperative Projects

Several earlier cooperative tasks have been completed. Technology has been transferred successfully and is beginning to be used operationally at CWB. ESRL/GSD's development activities in these areas continue, and further ESRL/GSD-CWB interaction is important to keep CWB staff up-to-date on current developments. This task will allow continuing interaction at an appropriate level, including new software releases of the forecast information system including the internet-based forecast workstation (FX-C) with advanced drawing capability, NOAA data support, visitors training, exchange of visits, copying papers and reports, and e-mail interaction.

Article IV - Responsibilities of NOAA/ESRL/GSD

In addition to participation in the joint project team, NOAA/ESRL/GSD shall:

- A. Provide overall coordination of the joint project activities at the GSD facility in Boulder, Colorado;
- B. Provide administrative support for preparing reports for delivery to AIT, in accordance with this Implementing Arrangement;
- C. Work under the guidance of AIT and consult with representatives of the CWB and other agencies designated by AIT;

- D. Assign appropriate staff to perform the activities defined in this Implementing Arrangement and provide support in accordance with the terms of the umbrella agreement; and
- E. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #18.

Article V - Responsibilities of AIT

The AIT shall:

- A. Provide guidance to NOAA/ESRL/GSD regarding consultations with representatives of TECRO, CWB, and other agencies as necessary;
- B. Coordinate the appropriate transfer of funds to NOAA for reimbursable activities, as mutually agreed; and
- C. Accept the delivery of reports and specifications from NOAA/ESRL/GSD and make distribution as appropriate.

Article VI - Financial Provisions

In accordance with the Agreement, NOAA/ESRL/GSD is undertaking this work as the designated representative of AIT. TECRO is required to reimburse AIT for all costs incurred by AIT's designated representative, NOAA/ESRL/GSD, in association with the project covered by this Implementing Arrangement. AIT shall transfer to NOAA/ESRL/GSD all payments made by TECRO to AIT for costs incurred by NOAA/ESRL/GSD in association with this Implementing Arrangement.

The total cost for activities described in this Implementing Arrangement is mutually agreed to be U.S. \$740,000.00. AIT agrees to transfer fifty percent of the funds to NOAA in advance, with the remaining fifty percent to be transferred upon completion of the year's activities, to the extent that funds for this purpose have been provided by TECRO.

The funding arrangement represents an equitable apportionment of project costs. NOAA's performance of activities under this Implementing Arrangement is subject to the availability of funds.

Article VII - Intellectual Property Considerations


No intellectual property considerations are expected to arise in conjunction with activities described in this Implementing Arrangement. Existing system designs and computer software of the ESRL/GSD Forecast System are in the public domain. Reports, specifications, and computer software prepared under this Implementing Arrangement also will be in the public domain once NOAA and CWB have approved them in final form.

Article VIII - Effective Date, Amendment, and Termination

This Implementing Arrangement is effective on the date of the last signature hereto. This Implementing Arrangement may be amended and/or terminated in accordance with the terms of the Agreement. The estimated completion date for the activities described in this Implementing Arrangement is June 30, 2007.

Additionally, this approval of this Implementing Arrangement extends the termination date of the underlying agreement to September 30, 2007. The underlying agreement titled, Agreement between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office in the United States for Technical Cooperation in Meteorology and Forecast Systems Development, signed by the parties June 20, 2001.

**FOR THE AMERICAN INSTITUTE
IN TAIWAN**

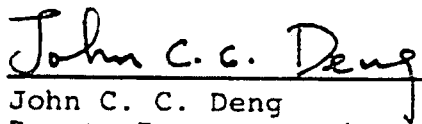


Barbara Schrage
Managing Director

9/12/06

Date

**FOR THE TAIPEI ECONOMIC AND
CULTURAL REPRESENTATIVE
OFFICE IN THE UNITED STATES**



John C. C. Deng
Deputy Representative

9/26/2006

Date

Statement of Work
For Implementing Arrangement #18
Development of a High-Resolution Quantitative Precipitation
Estimation and Quantitative Precipitation Forecast (HRQ2) System

Between the American Institute in Taiwan
And the
Taipei Economic and Cultural Representative Office in the United States

1.0 - Background and Objectives

This Statement of Work addresses tasks that will be undertaken by the joint team of the Global Systems Division (GSD) of the Earth System Research Laboratory, (ESRL) and CWB personnel in accordance with the terms of Implementing Arrangement #18 of the Agreement Between the American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Representative Office in the United States (TECRO) for Technical Cooperation in Meteorology and Forecast Systems Development, which provides for technical cooperation between AIT's designated representative, the U.S. National Oceanic and Atmospheric Administration's Global Systems Division (NOAA/ESRL/GSD), and TECRO's designated representative, the Taiwan Central Weather Bureau (CWB). The two designated representatives cooperate on the development of meteorology and forecast systems.

The WFO-Advanced system currently under development at the NOAA's GSD of the ESRL in Boulder, Colorado, has been deployed as an essential part of the AWIPS (Advanced Weather Interactive Processing System) for the U.S. National Weather Service (NWS). The WFO-Advanced system development has been a very important cooperative activity between GSD and CWB.

The WFO-Advanced system is a realization of the generic FX-Advanced (GSD X-window Advanced) system. Figure 1 illustrates the WFO-Advanced components:

- National and local data feeds
- GSD's Local Analysis and Prediction System (LAPS)
- Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPE-SUMS)
- Geographical Information System (GIS) data
- The interactive display system (D2D)
- The AWIPS Forecast Preparation System (AFPS)
- 3-D visualization
- Hydrological applications developed at the NWS Office of Hydrology
- A component that contains General X applications
- Local Data Acquisition and Dissemination System (LDAD)

Two tasks are included in the Statement of Work: (1) the development of a High-

resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) System, (2) continuing integration on earlier cooperative projects, such as data support and forecast workstation upgrade.

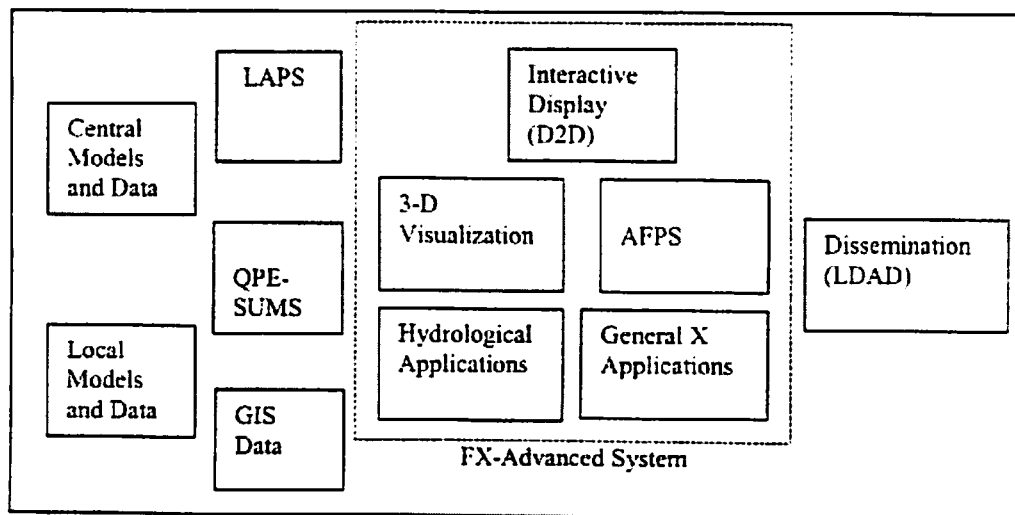


Figure 1 WFO-Advanced

The tasks will be undertaken by the GSD-CWB Joint Team working at the GSD facility in Boulder, Colorado, the NSSL-CWB Joint Team working at the NSSL facility in Norman, Oklahoma and by CWB staff at the CWB facility in Taipei, Taiwan, as appropriate. This Statement of Work addresses only tasks that will be undertaken by the GSD-CWB Joint Team and the NSSL-CWB Joint Team under the terms of Implementing Arrangement #18. It describes the performance period, deliverables, and resource requirements.

2.0 - Task Descriptions

In terms of the overall program schedule, the following two tasks have been identified as being critical during the January 1 to December 31, 2006, time period. These are listed below, along with the estimated proportion of resources that is to be allocated to each task.

- Task #1 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) System (68%)
- Task #2 - Continuing interaction on earlier cooperative projects (32%)

These two tasks are described in more detail below.

Task #1 - High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) System

During Implementing Arrangement #17, GSD and CWB continued to improve the LAPS data ingest of radar data and the cloud scheme. GSD and CWB added WRF (Weather Research and Forecast) to the modeling suite and established a LAPS/MM5-WRF hot start shadowing system at GSD. The state variable verification system for point verification of precipitation and for gridded verification of model QPF with LAPS QPE were also improved. In addition, computer resources and technical guidance to one CWB visiting scientist to do his cases study of LAPS analysis with different background models were provided.

During Implementing Arrangement #18, GSD and CWB will focus on the Quantitative Precipitation Forecast (QPF) for water accumulation and debris flow based on a new advanced 3D variational (3DVAR) data assimilation scheme as GSD's part of HRQ2 task. This new task will support the operational needs from threats from flash flood, debris flow and landslide. One candidate is to adopt the STMAS (Space and Time Mesoscale Analysis System) for surface observations and other remote sensing data such as radar data. STMAS is an extended 3DVAR and provide multiscale analysis using inhomogeneous observation distribution. Another candidate is the GSI (Gridpoint Statistical Interpolation) analysis system used operationally by NOAA/NCEP (National Centers for Environmental Prediction). GSD and CWB will upgrade the LAPS analysis to LAPS III to improve cloud scheme and microphysical recovery. A 1D version of the host model's microphysics scheme will be used instead of the current one. LAPS III utilizes situational error covariances from an ensemble with the 3DVAR analysis driver. GSD and CWB will adopt full WRF (NMM and ARW) for hot start. This will mean adding the WRF-NMM to the CWB modeling suite. NMM and ARW are different versions of WRF, the NMM developed by NOAA's NCEP and NCAR (National Center for Atmospheric Research) respectively. GSD and CWB will continue to upgrade state variable verification system for HRQ2 system.

The following summarizes the schedule and resources required for the GSD part for Task #1:

<u>Resources Required:</u>	34% GSD/CWB
<u>Deliverables and Schedule:</u>	
1. STMAS 3DVAR (or GSI) data assimilation software (on-line version)	05/31/06
2. Implement WRF-NMM as a new model	05/31/06
3. Implement WRF-ARW and WRF-NMM ensemble	11/30/06
4. Provide basic probabilistic QPF products	11/30/06
5. HRQ2 verification system for QPF	11/30/06

During Implementing Arrangement #18, the National Severe Storms Laboratory (NSSL) will continue research towards the refinement and development of applications and algorithms required for the CWB and the WRA (Water Resources Agency) and the Soil and Water Conservation Bureau (SWCB) operations as NSSL's part of the HRQ2 task. The NSSL research is directed towards improving the monitoring and prediction of flash floods and severe storm identification and short-term forecasting for the Taiwan environment. The NSSL research and development for IA#18 will focus on three core areas: 1) quality control, 2) 0-1 hour Quantitative Precipitation Forecast (QPF) and its application toward debris and flash flood, and 3) verification and assessment of application performance. During IA#18, NSSL will conduct research and present findings, algorithm documentation and source code where appropriate for system maintenance.

The following summarizes the schedule and resources required for the NSSL part of Task #1:

Resources Required: 34% NSSL/CWB

Deliverables and Schedule:

- | | |
|--|-------------------------------------|
| 1. Document of HRQ2 QC performance on Taiwan 'challenge' cases | 3/31/06 |
| 2. Source code and libraries for HRQ2 QPF (0-1 hr) | 3/31/06 |
| 3. Initial enhancements to HRQ2 QC applications for the Taiwan environment | 6/30/06 |
| 4. Case study analysis and recommendations to improve typhoon QPE and QPF (0-1 hr) | 9/30/06 |
| 5. Further enhancement to HRQ2 QC applications for the Taiwan environment | 11/30/06 |
| 6. Quarterly progress reports & annual review | 3/31/06, 6/30/06, 9/30/06, 11/30/06 |

Task #2 - Continuing Interaction on Earlier Cooperative Projects

Several earlier cooperative tasks have been completed. Technology has been transferred successfully and is beginning to be used operationally at CWB. ESRL/GSD's development activities in these areas continue, and further ESRL/GSD-CWB interaction is important to keep CWB staff up-to-date on current developments. This task will allow continuing interaction at an appropriate level, including new software releases of the forecast information system including the internet-based forecast workstation (FX-C) with advanced drawing capability, NOAA data support, visitors training, exchange of visits.

copying papers and reports, and e-mail interaction.

The following summarizes the schedule and resources required for Task #2:

Resources Required: 32% GSD/CWB

Deliverables:

- | | |
|---|-------------|
| 1. Relevant documents, reports and electronic information | (as needed) |
| 2. AWIPS upgrade software and support | 11/30/06 |
| 3. FX-C software with enhanced drawing capability | 06/30/06 |
| 4. NOAAPORT data support | 11/30/06 |
| 5. D3D upgrade software | 06/30/06 |
| 6. Visitors support including necessary training and travel | 11/30/06 |

3.0 - Schedule

<u>Functions</u>	<u>Milestones</u>
1. Provide initial HRQ2 with 3DVAR system	12/06
2. Provide improved HRQ2 QC system, QPE and 0-1 hr QPF	12/06
3. Provide AWIPS update, WarnGen and SCAN technical support, D3D software and FX-C software	12/06
4. Provide technical support of FX-C, NOAAPORT data transmission relevant document and technical support on WINS II with AWIPS functions	12/06

Schedule by Month

<u>TASKS</u>	<u>1/1</u>	<u>2/1</u>	<u>3/1</u>	<u>4/1</u>	<u>5/1</u>	<u>6/1</u>	<u>7/1</u>	<u>8/1</u>	<u>9/1</u>	<u>10/1</u>	<u>11/1</u>	<u>12/1</u>
<u>Task 1 (GSD)</u>												
STMAS3DVAR (or GSI) data Assimilation (on-line version)	x	x	x	x	x	x						
Implement WRF-NMM model	x	x	x	x	x	x						
Implement WRF-ARW and WRF-NMM ensemble	x	x	x	x	x	x	x	x	x	x	x	x
Provide basic probabilistic QPF products	x	x	x	x	x	x	x	x	x	x	x	x
HRQ2 verification for QPF	x	x	x	x	x	x	x	x	x	x	x	x

Task 1 (NSSL)

HRQ2 QC performance documentation	x	x	x									
HRQ2 QPF (0-1 hr)	x	x	x	x	x	x						
HRQ2 QC initial enhancement	x	x	x	x	x	x	x	x	x	x	x	x
Case study and QPE and QPF improvement	x	x	x	x	x	x	x	x	x	x	x	x
HRQ2 QC further enhancement	x	x	x	x	x	x	x	x	x	x	x	x
Quarterly progress reports & annual review				x		x			x			x
<u>Task 2 (interaction on earlier projects)</u>												
Provide relevant documents and information	x	x	x	x	x	x	x	x	x	x	x	x
AWIPS upgrade software, AWIPS technical support, and D3D software	x	x	x	x	x	x						
FX-C software with enhanced capabilities	x	x	x	x	x							
Support CWB visitors		x	x	x	x	x	x	x	x	x		

4.0 - Budget

The following are the estimated costs for Implementing Arrangement #18

Tasks	Personnel	Travel/Training	Total
Task #1 (GSD)	\$ 235,000	\$ 15,000	\$ 250,000
Task #1 (NSSL)	\$ 235,000	\$ 15,000	\$ 250,000
Task #2	\$ 210,000	\$ 30,000	\$ 240,000
Total	\$ 680,000	\$ 60,000	\$ 740,000

As stated in Implementing Arrangement #18, the funds available from CWB, the WRA (Water Resources Agency) and the Soil and Water Conservation Bureau (SWCB) to support the tasks, traveling and meeting expenses described in this Statement of Work, will be a total of US\$ 740,000, of which US\$ 390,000 will be provided by CWB, US\$ 250,000 by WRA and US\$ 100,000 by SWCB. All budget figures are estimates. Actual amounts will be accrued for purposes of fulfilling the financial arrangements described in the Implementing Arrangement, in accordance with the terms of the Agreement.

All programs within the Global Systems Division (GSD) use the same budget procedures, whether they are base-funded programs or externally-funded programs. Beginning in FY91, a facility charge has been applied to all programs to cover management and administrative costs as well as the use of the GSD facility and all associated equipment and data.

GSD and NSSL staff time is charged at the employee's salary plus the normal NOAA benefit, leave, and overhead charges. GSD and NSSL professional staff people are primarily in the civil service grade scales of GS-11 to GS-14. Contract staff is in equivalent categories.

5.0 - CWB Joint Team Assignments at GSD

Several tasks encourage CWB staff in residence at GSD or NSSL. The primary effort of CWB staff at GSD during the Implementing Arrangement #18 period will be directed toward developing the HRQ2 task. It is important that CWB staff be available to work at GSD facilities during the period. Specific assignments will be made to most efficiently use the available personnel resources. Assignments for the CWB staff members would be as follows:

- Development of a high-resolution QPE and QPF system for the Taiwan area (at GSD).