

法規名稱：IMPLEMENTING ARRANGEMENT #21 DEVELOPMENT OF A HIGH-RESOLUTION QUANTITATIVE PRECIPITATION ESTIMATION AND QUANTITATIVE PRECIPITATION FORECAST (HRQ2) SYSTEM PURSUANT TO THE AGREEMENT BETWEEN THE TAIPEI ECONOMIC AND CULTURAL REPRESENTATIVE OFFICE IN THE UNITED STATES AND THE AMERICAN INSTITUTE IN TAIWAN FOR TECHNICAL COOPERATION IN METEOROLOGY AND FORECAST SYSTEM DEVELOPMENT

簽訂日期：民國 98 年 07 月 13 日

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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 the Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO), and AIT's designated representative, NOAA/ESRL/ GSD. This Implementing Arrangement is of mutual interest to both TECRO and AIT, hereafter referred to as the parties. The products of this Implementing Arrangement 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 Taipei Economic and

Cultural Representative Office in the United States and the American Institute in Taiwan for Technical Cooperation in Meteorology and Forecast Systems Development (TECRO-AIT Agreement), and any subsequent revision as agreed to by the parties. This Implementing Arrangement is the twenty first such arrangement under a succession of umbrella agreements between TECRO and AIT.

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

Article III - Services

During the period of Implementing Arrangement #21, TECRO's and AIT's designated representatives respectively, the CWB and NOAA/ESRL/GSD joint team, will focus on four tasks: (1) the HRQ2 (Highresolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) advanced 3DVAR data assimilation implementation and verification, (2) the HRQ2 (High-resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) applications improvement, (3) continuing interaction on earlier cooperative projects, and (4) GPS Radio Occultation satellite data assimilation using the NCEP/ JCSDA Gridpoint Statistical Interpolation (GSI) analysis system. Tasks under this Implementing Arrangement 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 four tasks:

Task #1 - HRQ2 (High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) advanced 3DVAR data assimilation implementation and verification

In the past 15 years, the statistical analysis approach such as standard 3DVAR or ensemble Kalman filter has been the focal point for data assimilation. Even though many researches have been done in these areas, there is no clear evidence that this analysis technique has been improved significantly under an operational environment. For example, with the same datasets, it has not been shown that the statistical approaches are superior to a traditional objective analysis.

STMAS (Space and Time Multi-scale Analysis System) merges the advantages of objective analysis and modern variational analysis into a unified data assimilation system and removes the limitations of these data assimilation schemes. For example, without an accurate error covariance, STMAS can extract the resolvable information from all observation datasets, including radar and satellite datasets, whereas a standard 3DVAR or 4DVAR may have problems because an accurate error covariance is difficult to compute. STMAS handles remotely sensed observation datasets through a variational minimization process with appropriate constraints dynamically; where traditional objective analysis has to treat these constraints as post processes with possibilities of losing useful information.

STMAS is a new and advanced data assimilation technique with a superior analysis advantage. TECRO's designated representative, CWB, could benefit from using this system for its operational applications and from participating in system development and improvement. During Implementing Arrangement #21, two STMAS tasks will be performed by AIT's designated representative, NOAA/ESRL/GSD; one is the STMAS surface analysis, and the other is the STMAS 3D system implementation. The surface analysis is mainly used for CWB weather reanalysis to provide the ground-truth for establishing a climatology statistics. The STMAS 3D system can further improve CWB weather reanalysis using

upper air datasets to overcome the complex terrain effect.

Under the STMAS surface analysis task, the software package will be modified to improve the efficiency to meet the application requirement for TECRO's designated representative, CWB. Also the STMAS analysis will be improved with more sophisticated background effect, water-land interaction, quality control mechanism, and a complex terrain factor.

With support of AIT's designated representative, NOAA/ ESRL/GSD, TECRO's designated representative, CWB, will perform a whole year of reanalysis with calibrated parameters for STMAS, such as length-scale, multigrid levels, smoothing and penalty function for various reanalysis fields such as P, T, Td, U, V and precipitation. For a longer-term reanalysis, a careful verification is required to examine each of the reanalysis fields and to build up climatology verification statistics. These verification statistics can provide valuable evidence for further improvement of STMAS surface analysis in the future.

Under the STMAS 3D system implementing task, TECRO's designated representative, CWB, will apply it for the upper air reanalysis to overcome the complex terrain effect and to use other upper air data sources such as radar datasets. CWB will also use STMAS 3D to initialize CWB regional models for improving short range forecasts. CWB and AIT's designated representative, NOAA/ESRL/GSD, will collaborate on the verification and model initialization of the STMAS 3D system.

AIT's designated representative, NOAA/ESRL/GSD, and TECRO's designated representative, CWB, will set up an analysis domain and examine the STMAS 3D analysis against the observations, in-situ or remotely sensed data and calibrate the parameters for the CWB analysis domain. NOAA/ESRL/GSD and CWB will perform quality control over the CWB datasets and develop some automated

QC schemes if needed. With proper dynamical constraints, NOAA/ESRL/ GSD and CWB will check the analysis balance for our applications. CWB and NOAA/ESRL/GSD will perform a short range of reanalysis using CWB datasets and accumulate statistical information to compare to the STMAS surface analysis. NOAA/ESRL/GSD and CWB will initialize a CWB regional model (WRF-ARW) using STMAS and compare it with other initialization methods, such as LAPS, and to further improve STMAS 3D analysis.

AIT's designated representative, NOAA/ESRL/GSD, has provided a comprehensive training on the evaluation and calibration of short-range Probabilistic Quantitative Precipitation Forecasts (PQPF) in 2008. This training covered ensemble system configuration, evaluation of QPF and PQPF, CWB case studies and applications. During Implementing Arrangement #21, NOAA/ESRL/ GSD will provide the graphic programs for PQPF products, and the program for PQPF verification and technical support on ensemble post processing schemes such as calibration artificial neural network and linear regression. This task will benefit TECRO's designated representative, CWB, in transferring the research program of PQPF into their evaluation phase before operational use.

Task #2 - HRQ2 (High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) applications improvement

AIT's designated representative, NOAA/ESRL/GSD, understands that the National Severe Storms Laboratory (NSSL) will continue research towards the refinement, development, and maintenance of HRQ2 applications required for TECRO's designated representatives, the Central Weather Bureau (CWB), Water Resources Agency (WRA) and the Soil and Water Conservation Bureau (SWCB) operations. 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.

During Implementing Arrangement #21, AIT's designated representative, NOAA/ESRL/GSD understands that the National Severe Storms Laboratory (NSSL) will continue to improve the HRQ2 system through research towards the 0-2 hour typhoon QPF (Quantitative Precipitation Forecast). This task will include the QPF performance assessment and any new development to improve typhoon QPF based on the assessment from the current 0-2 hours QPF performance during typhoon cases. This task will implement an enhanced sea clutter algorithm to improve radar data quality control. This task will improve the short term QPF during a typhoon heavy rainfall situation and eliminate precipitation uncertainty due to sea clutter. TECRO's designated representatives, CWB and WRA/ SWCB, will benefit from receiving a more reliable and higher quality product of precipitation forecasts for the 0-2 hour period.

Two brand new C-band dual-polarization (dual-pol) radars now been installed in Taiwan (RCMK at Makung and RCKK at Ching Chung Kung). These radars will add new capability to measure rainfall and discriminate hydrometer types. These two radars and a CWB radar at Chi-Kuo will have excellent area coverage over the west side of Taiwan. This new observation network will increase CWB's capability for short-term precipitation prediction during severe weather. It can help government emergency agencies to increase the lead time to issue necessary warnings to protect the public. This task will ingest and evaluate these new C-band radar data for the HRQ2 system. NSSL will release the software source code for the HRQ2 web verification system and the radar data ingest source code. In addition, four progress reports will be provided as part of this task.

Task #3 - 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 the facility of TECRO's designated representative, CWB. AIT's designated representative, NOAA/ESRL/GSD, development activities in these areas will continue, and further NOAA/ESRL/GSD-CWB interaction is important to keep CWB staff up-to-date on current developments. This task will directly improve and update CWB's current forecast assistant and decision making system at an appropriate level, including new AWIPS and relevant forecast assistant application software releases and available documents.

AIT's designated representative, NOAA/ESRL/GSD, released the latest AWIPS OB 8.3.1 and necessary test datasets to TECRO's designated representative, CWB, near the end of 2008. This version is the one currently used by NOAA/NWS. This version is ready to accept dual-pol radar products and has the capability to integrate radar data with environment sampling of temperature, relative humidity, wind, equivalent potential temperature, wet-bulb temperature, and pressure at the height of the radar beam. CWB will access data from two new dual-pol radars soon, so this new radar product display capability will be extremely useful for its forecast and decision making operation. NOAA/ESRL/GSD will continue to make the latest AWIPS build software available, if applicable, during Implementing Arrangement #21.

NOAA/NWS has awarded a contract in 2005 to Raytheon Technical Services Company for the development of the next generation of AWIPS, called AWIPS II. AWIPS II is based on Service Oriented Architecture (SOA). AIT's designated representative, NOAA/ESRL/GSD, is tasked to perform an Independent Validation and Verification (IV&V) for each task order released by Raytheon. NOAA/ESRL/GSD plans to share some experience of AWIPS

II in the area of SOA, EDEX (Environmental Data Exchange handles data ingest, storage and communication) and CAVE (Common AWIPS Visualization Environment is the graphical user interface) with CWB, if appropriate, during Implementing Arrangement #21.

AIT's designated representative, NOAA/ESRL/GSD, has a long history in supporting research and operational weather forecasting by developing advanced prototype workstation display systems. We have an ongoing ALPS (AWIPS Linux Prototype System) development, which is an evolution change to AWIPS, and FXC (FXCollaborate) development which is an Internet-based system for displaying data from AWIPS with additional drawing and briefing tools. CWB has adopted FXC as an addition to its capability of drawing tools in 2008. AIT's designated representative, NOAA/ESRL/GSD, has provided in-depth training on GFE/Text Formatter and GHG (Graphical Hazards Generator) to support TECRO's designated representative, CWB, development of FIES (Forecast Information Editing System) in 2008. CWB has a plan to implement such a graphical editing capability and a Chinese text generator as part of their forecast assistant tool for township weather forecasts including severe weather warning products of a few kilometers space resolution. NOAA/ESRL/GSD will continue to provide interaction support including software update, available documents of ALPS, FXC, and GFE training, if applicable.

For the data feed support, AIT's designated representative, NOAA/ESRL/GSD, will continue to provide the NOAAPORT data feed for CWB's data assimilation purposes during Implementing Arrangement #21. NOAA/ESRL/GSD will also continue to calculate IPW (Integrated Precipitable Water) values using CWB's ground-based Global Positioning System (GPS) with some additional sites and will transfer IPW values to CWB for application use during Implementing Arrangement #21. NOAA/ESRL/GSD will continue develop Google Maps based user

interface to allow easy visualization of IPW values and other meteorological variables for validation and verification by CWB users.

This continuing interaction task will benefit TECRO's designated representative, CWB, with the updated knowledge of the forecast assistant and decision making system developed at NOAA. This task also provides the important data feed of NOAAPORT and GPS/IPW for CWB's daily operation needs. Finally, AIT's designated representative, NOAA/ESRL/GSD, will provide necessary visitor training, exchange of visits, copies of papers and reports, and e-mail interactions, if applicable.

Task # 4 - GPS Radio Occultation satellite data assimilation using the NCEP/JCSDA Gridpoint Statistical Interpolation (GSI) analysis system

As part of the COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) mission, TECRO's designated representative, the Central Weather Bureau, will support the inclusion of GPS Radio Occultation (RO) observations from the COSMIC mission into the NCEP's regional system to implement the Gridpoint Statistical Interpolation (GSI) data assimilation of GPS radio occultation data under the joint collaboration project between NOAA/NASA/DoD JCSDA and the Central Weather Bureau (CWB). NCEP is the National Centers for Environmental Prediction under NOAA's National Weather Service (NWS). JCSDA (Joint Center for Satellite Data Assimilation) is a multi-agency research center tasked with improving the use of satellite data for analyzing and predicting the weather, the ocean, the climate and the environment. JCSDA partner agencies are NASA (National Aeronautics and Space Administration), NOAA/ NESDIS (National Environmental Satellite, Data, and Information Service) and DoD (Department of Defense). The main objectives of this collaborative project are to tune and test the assimilation of

GPS RO data in the NCEP regional system and to accelerate and enhance the use of GPS RO data in global numerical weather prediction at CWB. Currently, TECRO's designated representative, CWB, is performing global numerical weather prediction using its own global model and an older version of the NCEP data assimilation system, the Spectral Statistical Interpolation (SSI). Through this collaboration, CWB would like to enhance their global data assimilation system and to make optimal use of satellite data, including COSMIC/FORMOSAT-3. Accordingly, CWB would like to migrate from SSI to GSI, and to initialize the CWE global model with an analysis generated by GSI. This task will cover the use of GSI in both global and regional capabilities. In exchange, CWB will contribute to the tuning and testing of the GPS RO assimilation in the regional model.

Article IV - Responsibilities of TECRO

In addition to participation in the joint project team, TECRO through its designated representative, CWB shall:

- A. Provide overall coordination project activities at the CWB facility;
- B. 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
- C. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #21.

Article V - Responsibilities of AIT

In addition to participation in the joint project team, AIT, through its designated representative, NOAA/ESRL/ GSD shall:

- A. Provide overall coordination project activities at the NOAA/ESRL/GSD facility in Boulder, Colorado;

- B. Provide administrative support for preparing reports for delivery to TECRO's designated representative, CWB, in accordance with this Implementing Arrangement;
- C. 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
- D. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #21.

Article VI - Financial Provisions

In accordance with the TECRO-AIT Agreement, 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. \$680,000. TECRO agrees to transfer fifty percent of the funds to AIT 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 performance by AIT's designated representative 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 AIT's designated representative's, NOAA/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 and the termination date of this Implementing Arrangement is December 31, 2009.

Ta-Tung J. Chang
Deputy Representative
Date:
July 13, 2009

Barbara J. Schrage
Managing Director
Date:
May 8, 2009