

Implementing Arrangement #25

Development of a hazardous weather monitoring and forecast 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 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 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), signed by all parties as of March 06, 2012, and any subsequent revision as agreed to by the parties. This Implementing Arrangement is the twenty-fifth 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 #25, TECRO's and AIT's designated representatives respectively, the Taiwan Central Weather Bureau (CWB) and NOAA/ESRL/GSD, has started a new phase V program on hazardous weather monitoring and forecasting. Therefore the CWB-NOAA/ESRL/GSD joint team will expand work to address this

hazardous weather theme. Eight tasks are identified: (1) Development and improvement of satellite products for tropical storm monitoring and prediction; (2) Real-time Analysis and Forecasting with the Advanced Regional Prediction System (ARPS); (3) Improvement and verification of short-range forecasting using Space-Time Mesoscale Analysis System (STMAS) with remote sensing data; (4) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement; (5) Enhancement of Nowcasting Decision Assistance Tools; (6) Development of High-Resolution Product Generation Assistance Tools; (7) Development of intra-seasonal to inter-annual climate monitoring and forecast; and (8) Continuing interaction on earlier cooperative projects. 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 eight tasks:

Task #1 Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction

In 2012, STAR/SMCD (Center for Satellite Applications and Research/Satellite Meteorology and Climatology Division) has been supported by the GOES-R (Geostationary Operational Environmental Satellite R-Series) and JPSS (Joint Polar Satellite System) proving ground program to develop a satellite data assimilation system for HWRF (Hurricane Weather Research and Forecasting model) applications.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that STAR/SMCD will lead this task. STAR/SMCD will continue providing NOAA satellite data from heritage instruments on board NOAA-18, -19 and METOP-A satellites, continue providing geostationary satellite precipitation products from MTSAT (Multi-functional Transport Satellite), and develop an HWRF satellite data assimilation system for CWB to improve typhoon prediction and precipitation forecasts. After the NPP launch, microwave products have been updated with the Advanced Technology Microwave Sounder (ATMS) soundings that are unique for hurricane and typhoon monitoring and forecasting due to their improved horizontal and vertical sounding resolution. The Microwave Integrated Retrieval System (MIRS) is being updated with ATMS data for all temperature and moisture profiles. The operational version of ATMS products will be developed and the ATMS products will be generated.

Task #2 Real-time Analysis and Forecast with ARPS

The principal goal of Task #2 is to configure, demonstrate, and deploy a real-time forecasting system at convection-allowing resolution (2.5 km grid spacing) for TECRO's designated representative, CWB, in order to obtain accurate 0-4 hour heavy precipitation forecasts. The forecast system uses the Advanced Regional Prediction System (ARPS) developed at the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma. ARPS is a comprehensive regional-to-storm-scale atmospheric modeling system. It is a complete system that includes a real-time data analysis and assimilation system, a forward prediction model, and a post-analysis package. The assimilation of radar and other high-resolution observations for convective-scale forecasting is a noted strength of ARPS. The 3DVAR/Cloud Analysis package

of ARPS is computationally efficient for producing convective-scale initial conditions, including radar data.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that CAPS at the University of Oklahoma will lead this task. For IA #25, CAPS will focus on three main task areas: 1) to upgrade ARPS system to the newest version with CWB added capability; 2) to test partial cycling that includes several assimilation cycles for each forecast cycle, evaluate its performance relative to single analysis cycle, make necessary adjustments to cloud analysis, and make recommendations for real-time implementation; and 3) to investigate and report on maintaining initial convection and avoiding quick dissipation.

These tasks will benefit CWB by improving its very-short-range forecasting capabilities, in particular those related to 0-4 hour heavy precipitation forecasts.

Task #3 – Improvement and Verification of Short-range Forecast Using Variational LAPS (STMAS) with Remote Sensing Data

STMAS (Space and Time Multi-scale Analysis System) is a new and advanced data assimilation technique with a superior analysis advantage. STMAS combines the advantages of objective analysis and modern variational analysis into a unified data assimilation system and removes the limitations of these data assimilation schemes. NOAA/ESRL/GSD is starting to use variational LAPS for STMAS in order to replace the traditional LAPS analysis by STMAS as a default analysis system. During the past few years, TECRO's designated representative, CWB, has demonstrated its benefit from using STMAS for its operational applications especially for surface analysis and verification against observation data.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, will further improve STMAS 3D analysis for CWB short-range forecasts. Further improvements have also been identified, such as assimilating new datasets (derived radar wind velocity, GPS and satellite data) and developing a variational cloud analysis. For IA #25, there are two main task areas: 1) testing variational LAPS analysis of AMSU-B (Advanced Microwave Sounding Unit-B) data in real time; 2) assimilating GPS-Met (Global Positioning System Meteorology) TPW (total precipitable water) observations.

In the previous IA #24, AIT designated representative, NOAA/ESRL/GSD tested variational analysis of AMSU-B data using the Morakot Typhoon as a case study. It has been done as standalone software. In IA #25, NOAA/ESRL/GSD will integrate this standalone software into the variational LAPS analysis. It requires connecting the analysis variables to CRTM (Community Radiative Transfer Model) for real analysis. This involves selecting consistent control variables with the variational analysis, checking the convergence rate and evaluating the analysis and its forecasts with colleagues at TECRO's designated representative, CWB. Based on previous experiments, some AMSU-B channel data results in slow minimization convergence. Effort has been spent investigating this and some improvement strategies have been considered. In this year's task, one of these strategies may be implemented when integrating the standalone software into variational LAPS system. If successful, this will lead to the implementation of CRTM in real-time analysis.

There are 15 or more GPS-Met receivers available to CWB. The current variational LAPS analysis has not assimilated these data yet. In last year's task, effort was put into developing a variational humidity analysis. These GPS-Met data would benefit the analysis by constraining the humidity analysis and reducing its humidity bias. This task would require modifying the current humidity analysis to accommodate the GPS-Met data constraints. To use radar reflectivity data to improve humidity analysis, reflectivity data has been used to derive a humidity low bound estimate for humidifying the analysis. When GPS-Met TPW (total precipitable water) observations are available, an adjustment is required to relax the humidity low bound derived from radar reflectivity. Instead of assuming humidity low bounds, both temperature and humidity will be adjusted to satisfy certain saturation, that is, to relax humidity adjustment and let temperature adjustment in so that both adjustments will meet the saturation. Therefore, humidity can have the freedom to meet the GPS-Met TPW requirements. Thus, this task involves two major efforts. First, modify the humidity low bound to full temperature and humidity adjustments. Second, introduce GPS-Met TPW as an additional cost term in the variational LAPS cost function. The TPW assimilation capability will be evaluated against the current humidity analysis with a low bound analysis. The goal is to collaborate with CWB colleagues on a journal paper demonstrating the new humidity analysis.

Task #4 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that NOAA/NSSL (National Severe Storms Laboratory) will continue research towards maintenance, refinement, and improvement of the High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) applications required for TECRO's designated representatives, CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB). The NSSL research is directed towards the improvement of the current dual-polarization (dual-pol) radar quantitative precipitation estimation (QPE) products in the HRQ2 system and development of new advanced applications using observations from local areas in Taiwan. Such data sources include disdrometeor, and, potentially, precipitation profiler radars.

This task will include development of new radar reflectivity (Z) - rain rate (R) relationships based on disdrometer data observed during several field experiments in Taiwan. Such Z - R relations will better represent the precipitation physics in Taiwan than pre-defined Z - R relations obtained from other regions. Development of a three-dimensional hydrometer classification product is another research focus during IA#25. Such development is important to provide the hydrometer information of precipitation that can enhance the performance of operational radar QPE. This task will also continue providing technical support for CWB for its Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPESUMS) operations.

NOAA/NSSL will make available to TECRO's designated representative, CWB, as requested, software source code for new radar reflectivity Z - R relationships and three-dimensional hydrometer classification algorithms. NOAA/NSSL will also make available to CWB, as requested, the implementation of aforementioned modules in the real-time HRQ2 system.

Task #5 - Enhancement of Nowcasting Decision Assistance Tools

The Meteorological Development Laboratory (MDL) of the National Weather Service (NWS) has developed a comprehensive suite of decision assistance tools which is implemented in AWIPS to cover the full scope of hydro-meteorological phenomena and forecaster responsibilities. These tools are System for Convection Analysis and Nowcasting (SCAN), SCAN Digital Mesocyclone Detection (SCAN DMD), Flash Flood Monitoring and Prediction (FFMP), System on AWIPS for Forecasting and Evaluation of Seas and Lakes (SAFESEAS), System for Nowcasting of Winter Weather (SNOW), Fog Monitor, General User Alert Display Panel (GUARDIAN), and the graphic user interface to AutoNowCaster (ANC). In the past few years, MDL assisted and supported porting some of those decision assistance tools into the Weather Integration and Nowcasting System (WINS) for Taiwan Central Weather Bureau (CWB), including SCAN, SCAN DMD, SAFESEAS, ANC-AWIPS Bridge and GUARDIAN applications.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that MDL will continue to provide technical support and training to TECRO's designated representative, CWB, to enhance CWB's current WINS system in the area of nowcasting decision assistance tools that have been implemented. That support includes source code modification and configuration appropriate for CWB use for the application tools already ported. In the year of 2013, MDL will continue to provide CWB with more thorough customization and training support on MDL's decision assistance tools, such as improving forecasters' understanding on the SCAN QPF (Quantitative Precipitation Forecast) algorithm.

Another important piece of this task in IA #25 for MDL is to assist CWB to customize the FFMP tool to process and display various data sources. The FFMP is an integrated suite of multi-sensor applications which detects, analyzes, and monitors precipitation and generates short-term warning guidance for flash flooding automatically within NWS's AWIPS system. It conducts precipitation analyses in a "basin world," which means all QPE and QPF calculations over a certain time period are done over the areas of small basins. The main development of FFMP for the year 2013 would be to continue providing configuration support of FFMP localization for various data sources, such as QPESUM and rain gauge observation. The importance of including rain gauge data into FFMP is to assure the quality of radar estimate on precipitation. FFMP has an ability to compare the radar precipitation estimate over a radar bin with the rainfall observation from a rain gauge at which the radar bin is located, called "Virtual Gauge Basin." MDL will help CWB to include rain gauge static information into FFMP localization and then associate the gauge data into FFMP Basin Trend display.

For the last 7-8 years, CWB forecasters have used their WINS system, which was prototyped from NWS's AWIPS system, to display a wide variety of satellite, radar, surface observations, computer model data and furthermore many combinations of these data sets to meet their needs, depending on the weather. Such a system even allows the forecasters to issue tornado and severe thunderstorm warnings in a very timely manner. However, over the past several years, it has become clear that the aging AWIPS software is not flexible enough to handle the needs of a 21st century forecaster. Computer models have grown in size, scope, and complexity; radar and satellite data are coming more frequently and with more variables; and the GIS -- underlying maps have become more numerous and more detailed. To help the NWS move into this new era, a next-generation AWIPS system called "AWIPS II" has been developed.

The design of the AWIPS-II system architecture is driven by the requirements for expandability, flexibility, availability, and portability so that the system will allow for the introduction of new functionality and augmentation of network and processing capabilities. AWIPS II can accommodate the evolving state of operational forecasting to enable the NWS to meet the objectives of the modernization effort. AWIPS-II is designed so that software and data can be migrated to new platforms as technology evolves.

AWIPS-II replaces a large portion of the existing AWIPS data ingest, processing, and storage capabilities. It also consolidates many forecaster applications into a single visualization tool. The primary AWIPS-II application for data ingests, processing, and storage is the Environmental Data Exchange (EDEX); and the primary AWIPS-II application for forecaster visualization/data manipulation is the Common AWIPS Visualization Environment (CAVE).

Based upon those changes to the AWIPS system, CWB wants to study the AWIPS II system and then start the implementation of their WINS II system based on AWIPS II framework and architecture.

Task #6 – Development of High-Resolution Product Generation Assistance Tools

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, will provide technical support for the Graphical Forecast Editor (GFE), Text Formatter (TF), and the GFE Smart Tools. These will support CWB's development of formatter infrastructure of the Forecast Information Editing System (FIES).

GFE/verification system software training (BOIVerify) was coordinated by AIT's designated representative, NOAA/ESRL/GSD, to TECRO's designated representative, CWB, during Implementing Arrangements #21, #22, #23 and #24. CWB plans to customize the BOIVerify software package which is developed by the Boise Weather Forecast Office (WFO) of Idaho. GSD will continue to coordinate as necessary for CWB forecasters to use and configure BOIVerify during hazardous weather situations in IA #25. The purpose of this task is for CWB to understand the details of the BOIVerify software package so CWB can modify it to satisfy their needs.

Task # 7 – Development of Intra-seasonal to Inter-annual Climate Monitoring and Forecast

The goal of this task is for the Climate Prediction Center (CPC) and Environmental Modeling Center (EMC) of NOAA/NWS (National Weather Service)/NCEP (National Centers of Environmental Prediction (NCEP), to support and partner with CWB in advancing monitoring and forecast capabilities, in particular for the intra-seasonal to inter-annual time scales. The task includes:

(1) NCEP International Monsoon Training Desk Program

The "Monsoon Desk" at NCEP/CPC serves as a focal point for training the international utilizations of NCEP Climate Forecast System (CFS), partnering R&D, diagnostic and verifications of GFS simulations between NCEP and the national meteorological centers in the monsoon regions. During 2011~2012, two CWB personnel attended the Desk. In addition to receiving lectures on the forecast fundamentals for intra-season to inter-annual variability, CWB

personnel also collaborated with CPC scientists studying the CFS predictability for Tropical Cyclones of the West Pacific. CWB plans to participate in the training program by sending one trainee per year to CPC.

(2) CWB Workshop on development planning for the next generation Global Forecast Model: "Taiwan-West Pacific Climate Forecast System"

The year of 2013 marks the 30th anniversary that CWB started the numerical weather prediction project. Over the years, CWB has strived to develop a global forecast system skillful in capturing the leading signals of monsoon, tropical waves and cyclones, in particular for the West Pacific Ocean and Asia Continent. Most of the weather extremes of Taiwan area are highly modulated by these systems posing dire hazards to lives and environment, and impacting economy and national security.

Nevertheless, the rapid progress in the development of new numerical models, in particular the trend of going to very high-resolution atmosphere-ocean coupled global models, is a daunting task for a single meteorological server to carry out alone. Albeit, undertaking the development, the operational procedures and tasks, as well as the management of routine products take the precedent priority. To face the challenges, CWB needs to draft a 6-year strategic plan of 2015-2020 for advancing numerical global weather and climate predictions in the Taiwan and Western Pacific region. This strategic plan will guide CWB's development and operation of intra-seasonal to inter-annual forecasts into the third decade of the century. The objectives of this workshop are: 1) to bring the CWB, NCEP and Taiwan meteorological community together to review the current operation and development status of the global weather/climate models; 2) to identify key strengths and deficiencies in CWB global forecast system development, and 3) to help identify most promising strategies for the next steps in the development of the CWB global forecast system.

(3) The 38th Climate Diagnostic and Prediction Workshop (CDPW)

The CDPW is the primary workshop attended by prominent scientists of the world for more than three decades. Over the recent years, scientists from CWB have attended the workshop regularly. The planned 38th CDPW will continue to address the status and prospects for advancing climate prediction, monitoring, and diagnostics pertinent to the long lead forecasts by all the operational meteorological centers. The workshop covers subjects in 1) improving climate prediction tools and techniques through dynamical and statistical models and methods, forecaster practices and protocols, data and model improvements, and scientific concepts; 2) prospects for improved understanding, prediction, and simulation of intra-seasonal, seasonal, and inter-annual climate variability, including the extra-tropical annular modes, stratosphere/troposphere coupling, tropical-extra-tropical interactions, land-surface forcing, etc.; 3) climate variability and prediction in relation to the hydrologic cycle; and 4) prediction and attribution of recent high impact weather and climate events. It is a great forum for CWB to exchange forecast experiences as well as development results.

There are three main areas AIT's designated representative, NOAA/ESRL/GSD, will work on in Year 2013: 1) assist CWB in sending a trainee to the NCEP International Monsoon Desk for a four-month training program; 2) assist with the CWB Workshop on development planning of the next generation Global Forecast System by bringing in three NCEP experts of Global Modeling; 3) assist CWB in sending two scientists to participate the 38th Climate Diagnostics and

Prediction Workshop to be held during 21-25 October, 2013 at College Park, MD.; and 4) to visit CPC and/or other NOAA facilities for three days before or after the Workshop.

Task #8 - 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 facilities of TECRO's designated representative, CWB. The task for AIT's designated representative, NOAA/ESRL/GSD, in this area is the development of new tools that extend and enhance the forecast applications. Further NOAA/ESRL/GSD interaction with CWB is critical to keep CWB staff up to date on current AWIPS II developments. This task will directly improve and update CWB's current forecast assistant and decision making systems at appropriate levels, including ALPS (which is an update of AWIPS) and the new AWIPS-II. The task includes the delivery of relevant forecast assistant application software releases and available documents.

AWIPS II is being developed under a NOAA/NWS contract with the Raytheon Technical Services Company that was established in 2006. The system is based on a Services Oriented Architecture (SOA). As AIT's designated representative, NOAA/ESRL/GSD, is tasked with performing an Independent Validation and Verification (IV&V) for each task order (i.e. system improvement) released by Raytheon. NOAA/ESRL/GSD will provide training and share AWIPS II experiences with CWB visiting scientists in the areas of SOA, Environmental Data Exchange (EDEX) – which provides the handling of data ingest, storage and communication, and the Common AWIPS II Visualization Environment (CAVE) – which is the graphical user interface.

NOAA/ESRL/GSD has U.S. export control approval to provide CWB with AWIPS II software as released by the contractor. However, this transfer cannot occur until AWIPS II is declared operational by the NWS. NOAA/ESRL/GSD will train CWB visiting scientists on the new AWIPS II extended/enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by NOAA/ESRL/GSD.

AIT's designated representative, NOAA/OAR/GSD, released the latest AWIPS test datasets to TECRO's designated representative, CWB, near the end of 2010. These datasets are currently being used by NOAA/NWS. AWIPS 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. Since CWB will access data from two new dual-pol radars soon, this new radar product display capability will add significant capability to its forecast and decision making operations. NOAA/ESRL/GSD will continue to make available any of the latest AWIPS II - build software (after permission to release is gained from the NWS), and technical support of new AWIPS II applications, such as warning tools (WarnGen, GHG), if applicable, during IA #25.

AIT's designated representative, NOAA/ESRL/GSD, has a long history of supporting research and operational weather forecasting by developing advanced prototype display systems, including an ongoing AWIPS Linux Prototype System (ALPS) development. NOAA/ESRL/GSD will provide necessary support in the area of porting ALPS during IA #25.

For the data feed support, NOAA/ESRL/GSD will continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes during IA #25. A preliminary test of wavelet data compression technique for high-resolution ocean model data was performed during IA #24 with good preliminary results. NOAA/ESRL/GSD will continue to examine the real-time operational requirements so that the compressed data can be transferred from NOAA/ESRL/GSD to CWB for its current model operation during IA #25.

This continuing interaction task will benefit TECRO's designated representative, CWB, with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including the recently deployed AWIPS II system. This task also provides the important data feed of NOAAPORT for CWB's daily numerical weather prediction operation needs. Finally, NOAA/ESRL/GSD will provide necessary training and support to CWB visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

Article IV - 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 #25.

Article V - 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 #25.

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. \$1,340,000. 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, NOAA/ESRL/GSD, 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 forecast system of AIT's designated representative's, NOAA/ESRL/GSD, 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 December 31, 2013, and the termination date of this Implementing Arrangement is June 30, 2014.

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

Ta-Tung J. Chang

Ta-Tung J. Chang
Deputy Representative

July 26, 2013

Date

FOR THE AMERICAN INSTITUTE
IN TAIWAN

Barbara J. Schrage

Barbara J. Schrage
Managing Director

5/7/13

Date

Statement of Work
For Implementing Arrangement #25
Development of a Hazardous Weather Monitoring
and Forecasting System

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

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), the designated representative of the American Institute in Taiwan (AIT) and personnel of the Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO) in accordance with the terms of Implementing Arrangement #25 of 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, which provides for technical cooperation between TECRO's designated representative, the Taiwan Central Weather Bureau (CWB) and AIT's designated representative, the U.S. National Oceanic and Atmospheric Administration's Global Systems Division (NOAA/ESRL/GSD). The two designated representatives cooperate on the development of meteorology and forecast systems.

The Weather Forecast Office system (WFO-Advanced) currently under development at NOAA/ESRL/GSD in Boulder, Colorado, has been deployed as an essential part of the Advanced Weather Interactive Processing System (AWIPS) for the U.S. National Weather Service (NWS). The WFO-Advanced system development has been a very important cooperative activity between TECRO's and AIT's designated representatives, CWB and NOAA/ESRL/GSD to support the mission of establishing hazardous weather monitoring and forecasting. [Figure 1](#) illustrates the potential WFO-Advanced components listed here:

- National and local data feeds
- 3DVAR data assimilation and NWP (Numerical Weather Prediction)
- Satellite and remote sensing products
- HRQ2 (High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast) applications
- The interactive display system (D2D) and SOS (Science On a Sphere[®])
- Nowcasting decision assistance tools
- The AWIPS Forecast Preparation System (AFPS)
- Hydrological applications developed at the National Weather Service (NWS) Office of Hydrology
- A component that contains General X applications
- Dissemination of high spatial and temporal forecast and warning products

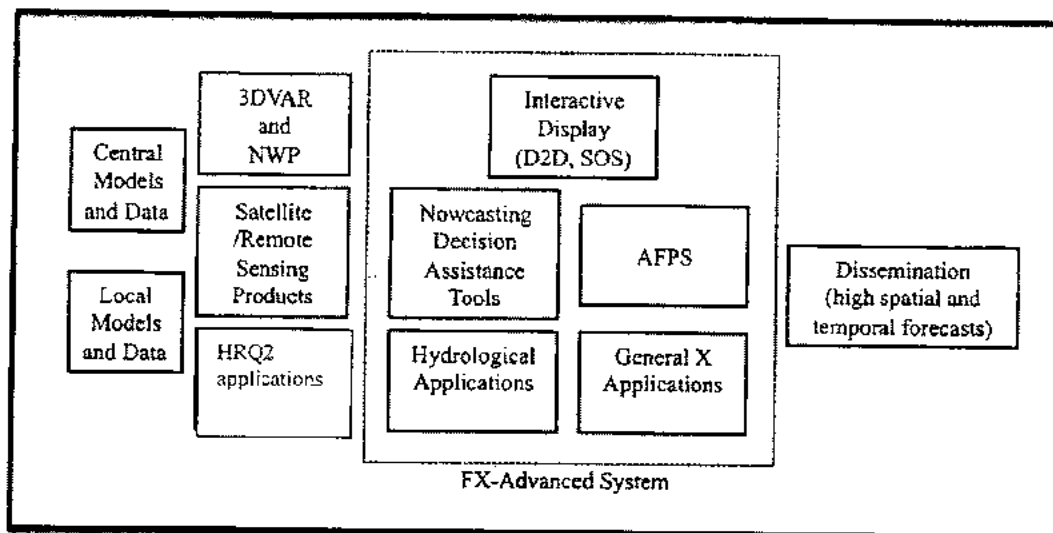


Figure 1: WFO-Advanced

Eight tasks are identified: (1) Development and improvement of satellite products for tropical storm monitoring and prediction; (2) Real-time Analysis and Forecast with the Advanced Regional Prediction System (ARPS); (3) Improvement and verification of short-range forecasting using variational LAPS, which includes the Space-Time Mesoscale Analysis System (STMAS), with remote sensing data; (4) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement; (5) Enhancement of Nowcasting Decision Assistance Tools; (6) Development of High-Resolution Product Generation Assistance Tools; (7) Development of intra-seasonal to inter-annual climate monitoring and forecast; and (8) Continuing Interaction on earlier cooperative projects.

The tasks will be undertaken by the CWB-NOAA/ESRL/GSD Joint Team as the designated representatives of the TECRO and AIT working at the NOAA/ESRL/GSD facility in Boulder, Colorado, the NOAA/NESDIS facility in Camp Springs, Maryland, 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 CWB-NOAA/ESRL/GSD Joint Team under the terms of Implementing Arrangement #25. It describes the performance period, deliverables, and resource requirements.

2.0 - Task Descriptions

In terms of the overall program schedule, the following eight tasks have been identified as critical during the January 1 to December 31, 2013 time period. Each task is listed in detail below, along with the estimated proportion of resources that is to be allocated to each task.

Task #1 Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction

In 2012, STAR/SMCD (Center for Satellite Applications and Research/Satellite Meteorology and Climatology Division) has been supported by the GOES-R (Geostationary Operational Environmental Satellite R-Series) and JPSS (Joint Polar Satellite System) proving ground program to develop a satellite data assimilation system for HWRF (Hurricane Weather Research and Forecasting model) applications. .

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that STAR/SMCD will lead this task. NOAA/STAR/SMCD will continue providing NOAA satellite data from heritage instruments on board NOAA-18-19 and METOP-A satellites, continue providing geostationary satellite precipitation products from MTSAT (Multi-functional Transport Satellite), and develop an HWRF satellite data assimilation system for CWB to improve typhoon prediction and precipitation forecasts. After the NPP launch, microwave products have been updated with the Advanced Technology Microwave Sounder (ATMS) soundings that are unique for hurricane and typhoon monitoring and forecasting due to their improved horizontal and vertical sounding resolution. The Microwave Integrated Retrieval System (MIRS) is being updated with ATMS data for all temperature and moisture profiles. The operational version of ATMS products will be developed and the ATMS products will be generated.

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

Resources Required: 16.6 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

- | | |
|---|----------|
| 1. Polar level 1b or SDR radiances and products from SSMIS, AMSU-A/MHS from DMSP, NOAA and METOP-A satellites | 06/30/13 |
| 2. Technical report on updated MIRS including NPP and METOP-B | 06/30/13 |
| 3. Beta version of HWRF satellite data assimilation system from Pacific region applications | 11/15/13 |

Task #2 Real-time Analysis and Forecast with ARPS

The principal goal of Task #2 is to configure, demonstrate, and deploy a real-time forecasting system at convection-allowing resolution (2.5 km grid spacing) for TECRO's designated representative, CWB, in order to obtain accurate 0-4 hour heavy precipitation forecasts. The forecast system uses the Advanced Regional Prediction System (ARPS) developed at the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma. ARPS is a comprehensive regional-to-storm-scale atmospheric modeling system. It is a complete system that includes a real-time data analysis and assimilation

system, a forward prediction model, and a post-analysis package. The assimilation of radar and other high-resolution observations for convective-scale forecasting is a noted strength of ARPS. The 3DVAR/Cloud Analysis package of ARPS is computationally efficient for producing convective-scale initial conditions, including radar data.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that CAPS at the University of Oklahoma will lead this task. For the IA #25, CAPS will focus on three main task areas: 1) to upgrade ARPS system to the newest version with CWB added capability; 2) to test partial cycling that includes several assimilation cycles for each forecast cycle, evaluate its performance relative to single analysis cycle, make necessary adjustments to cloud analysis, and make recommendations for real-time implementation; and 3) to investigate and report on maintaining initial convection and avoiding quick dissipation.

These tasks will benefit CWB by improving its very-short-range forecasting capabilities, in particular those related to 0-4 hour heavy precipitation forecasts.

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

Resources Required: 8.4% NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

- | | |
|--|----------|
| 1. Upgrade ARPS system | 08/31/13 |
| 2. Test, evaluate, and adjust partial cycling strategy | 11/15/13 |
| 3. Investigate and report on maintaining initial convection and avoiding quick dissipation | 11/15/13 |

Task #3 – Improvement and Verification of Short-range Forecast Using Variational LAPS (STMAS) with Remote Sensing Data

STMAS (Space and Time Multi-scale Analysis System) is a new and advanced data assimilation technique with a superior analysis advantage. STMAS combines the advantages of objective analysis and modern variational analysis into a unified data assimilation system and removes the limitations of these data assimilation schemes. NOAA/ESRL/GSD is starting to use variational LAPS for STMAS in order to replace the traditional LAPS analysis by STMAS as a default analysis system. During the past few years, TECRO's designated representative, CWB, has demonstrated its benefit from using STMAS for its operational applications especially for surface analysis and verification against observation data.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, will further

improve STMAS 3D analysis for CWB short-range forecasts. Further improvements have also been identified, such as assimilating new datasets (derived radar wind velocity, GPS and satellite data) and developing a variational cloud analysis. For the IA #25, there are two main task areas: 1) testing variational LAPS analysis of AMSU-B (Advanced Microwave Sounding Unit-B) data in real time; 2) assimilating GPS-Met (Global Positioning System Meteorology) TPC (total precipitable water) observations.

In the previous IA #24, AIT designated representative, NOAA/ESRL/GSD tested variational analysis of AMSU-B data using the Morakot Typhoon as a case study. It has been done as standalone software. In IA #25, NOAA/ESRL/GSD will integrate this standalone software into the variational LAPS analysis. It requires connecting the analysis variables to CRTM (Community Radiative Transfer Model) for real analysis. This involves selecting consistent control variables with the variational analysis, checking the convergence rate and evaluating the analysis and its forecasts with colleagues at TECRO's designated representative, CWB. Based on previous experiments, some AMSU-B channel data results in slow minimization convergence. Effort has been spent investigating this and some improvement strategies have been considered. In this year's task, one of these strategies may be implemented when integrating the standalone software into variational LAPS system. If successful, this will lead to the implementation of CRTM in real-time analysis.

There are 15 or more GPS-Met receivers available to CWB. The current variational LAPS analysis has not assimilated these data yet. In last year's task, effort was put into developing a variational humidity analysis. These GPS-Met data would benefit the analysis by constraining the humidity analysis and reducing its humidity bias. This task would require modifying the current humidity analysis to accommodate the GPS-Met data constraints. To use radar reflectivity data to improve humidity analysis, reflectivity data has been used to derive a humidity low bound estimate for humidifying the analysis. When GPS-Met TPW (total precipitable water) observations are available, an adjustment is required to relax the humidity low bound derived from radar reflectivity. Instead of assuming humidity low bounds, both temperature and humidity will be adjusted to satisfy certain saturation, that is, to relax humidity adjustment and let temperature adjustment in so that both adjustments will meet the saturation. Therefore, humidity can have the freedom to meet the GPS-Met TPW requirements. Thus, this task involves two major efforts. First of all, modify the humidity low bound to a full temperature and humidity adjustments. Second, introduce GPS-Met TPW as an additional cost term in the variational LAPS cost function. The TPW assimilation capability will be evaluated against the current humidity analysis with a low bound analysis. The goal is to collaborate with CWB colleagues on a journal paper demonstrating the new humidity analysis.

The following summarizes the schedule and resources required for Task #3:

Resources Required:

9.9 % NOAA/ESRL/GSD/FAB

Deliverables and Schedule:

1. A variational LAPS analysis with AMSU-B assimilation capability and installed at CWB 07/31/13
2. GPS-Met TPW data assimilation 10/31/13
 - a. Replacing the existing humidity low bound analysis with a variational analysis of humidity and temperature
 - b. Adding an additional cost term into the variational cost function of GPS TPW for constraining the humidity analysis

Task #4 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that NOAA/NSSL (National Severe Storms Laboratory) will continue research towards maintenance, refinement, and improvement of the High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) applications required for TECRO's designated representatives, CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB). The NSSL research is directed towards the improvement of the current dual-polarization (dual-pol) radar quantitative precipitation estimation (QPE) products in the HRQ2 system and development of new advanced applications using observations from local areas in Taiwan. Such data sources include disdrometeor and potentially precipitation profiler radars.

This task will include development of new radar reflectivity (Z) - rain rate (R) relationships based on disdrometer data observed during several field experiments in Taiwan. Such Z-R relations will better represent the precipitation physics in Taiwan than pre-defined Z-R relations obtained from other regions. Development of a three-dimensional hydrometer classification product is another research focus during IA#25. Such development is important to provide the hydrometer information of precipitation that can enhance the performance of operational radar QPE. This task will also continue providing technical support for CWB for its Quantitative Precipitation Estimation and Segregation Using Multiple Sensors (QPESUMS) operations.

NOAA/NSSL will make available to TECRO's designated representative, CWB, as requested, software source code for new radar reflectivity Z-R relationships and three-dimensional hydrometer classification algorithms. NOAA/NSSL will also make available to CWB, as requested, the implementation of aforementioned modules in the real-time HRQ2 system.

The following summarizes the schedule and resources required for Task #4:

Resources Required: 10.6 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

1. Integration of the new synthetic C-band polarimetric radar QPE into the QPESUMS 03/30/13
2. Development of a three-dimensional hydrometer classification product 06/30/13
3. Technical support for QPESUMS operations 11/30/13

Task #5 - Enhancement of Nowcasting Decision Assistance Tools

The Meteorological Development Laboratory (MDL) of the National Weather Service (NWS) has developed a comprehensive suite of decision assistance tools that is implemented in AWIPS to cover the full scope of hydro-meteorological phenomena and forecaster responsibilities. These tools are System for Convection Analysis and Nowcasting (SCAN), SCAN Digital Mesocyclone Detection (SCAN DMD), Flash Flood Monitoring and Prediction (FFMP), System on AWIPS for Forecasting and Evaluation of Seas and Lakes (SAFESEAS), System for Nowcasting of Winter Weather (SNOW), Fog Monitor, General User Alert Display Panel (GUARDIAN), and the graphic user interface to AutoNowCaster (ANC). In the past few years, MDL assisted and supported porting some of those decision assistance tools into the Weather Integration and Nowcasting System (WINS) for Taiwan Central Weather Bureau (CWB), including SCAN, SCAN DMD, SAFESEAS, ANC-AWIPS Bridge and GUARDIAN applications.

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, agrees that MDL will continue to provide technical support and training to TECRO's designated representative, CWB, to enhance CWB's current WINS system in the area of nowcasting decision assistance tools that have been implemented. That support includes source code modification and configuration appropriate for CWB use for the application tools already ported. In the year of 2013, MDL will continue to provide CWB with more thorough customization and training support on MDL's decision assistance tools, such as improving forecasters' understanding on the SCAN QPF (Quantitative Precipitation Forecast) algorithm.

Another important piece of this task in IA #25 for MDL is to assist CWB to customize the FFMP tool to process and display various data sources. The FFMP is an integrated suite of multi-sensor applications which detects, analyzes, and monitors precipitation and generates short-term warning guidance for flash flooding automatically within NWS's AWIPS system. It conducts precipitation analyses in a "basin world," which means all QPE and QPF calculations over a certain time period are done over the areas of small basins. The main development of FFMP for the year 2013 would be to continue providing configuration support of FFMP localization for various data sources, such as QPESUM and rain gauge observation. The importance of including rain gauge data into

FFMP is to assure the quality of radar estimate on precipitation. FFMP has an ability to compare the radar precipitation estimate over a radar bin with the rainfall observation from a rain gauge at which the radar bin is located, called "Virtual Gauge Basin." MDL will help CWB to include rain gauge static information into FFMP localization and then associate the gauge data into FFMP Basin Trend display.

For the last 7-8 years, CWB forecasters have used their WINS system, which was prototyped from NWS's AWIPS system, to display a wide variety of satellite, radar, surface observations, computer model data and furthermore many combinations of these data sets to meet their needs, depending on the weather. Such a system even allows the forecasters to issue tornado and severe thunderstorm warnings in a very timely manner. However, over the past several years, it has become clear that the aging AWIPS software is not flexible enough to handle the needs of a 21st century forecaster. Computer models have grown in size, scope, and complexity; radar and satellite data are coming more frequently and with more variables; and the GIS -- underlying maps have become more numerous and more detailed. To help the NWS move into this new era, a next-generation AWIPS system called "AWIPS II" has been developed.

The design of the AWIPS-II system architecture is driven by the requirements for expandability, flexibility, availability, and portability so that the system will allow for the introduction of new functionality and augmentation of network and processing capabilities. AWIPS-II can accommodate the evolving state of operational forecasting to enable the NWS to meet the objectives of the modernization effort. AWIPS II is designed so that software and data can be migrated to new platforms as technology evolves.

AWIPS-II replaces a large portion of the existing AWIPS data ingest, processing, and storage capabilities. It also consolidates many forecaster applications into a single visualization tool. The primary AWIPS-II application for data ingests, processing, and storage is the Environmental Data Exchange (EDEX); and the primary AWIPS-II application for forecaster visualization/data manipulation is the Common AWIPS Visualization Environment (CAVE).

Based upon those changes to the AWIPS system, CWB wants to study the AWIPS II system and then start the implementation of their WINS II system based on AWIPS II framework and architecture.

The following summarizes the schedule and resources required for Task #5:

Resources Required: 28.4% NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

- | | |
|--|----------|
| 1. FFMP | 11/15/13 |
| <ul style="list-style-type: none"> a. Continue support to configure various data sources to be processed and displayed on WINS system b. Continue the support for data conversion and display of Flash Flood Guidance (FFG) c. Support of rain gauge data inclusion into Basin Trend display d. Technical support to implement the alarm/alert tool to show where the heaviest precipitation accumulation occurs on GUARDIAN e. User training support for operational use | |
| 2. Other Decision Assistance Tools | 11/15/13 |
| <ul style="list-style-type: none"> a. Continue technical support for WINS maintenance and customization b. Continue user training | |
| 3. AWIPS II Support | 11/15/13 |
| <ul style="list-style-type: none"> a. Assessment of WINS/AWIPS II system transition support: <ul style="list-style-type: none"> • Meet CWB's lead developer to discuss possible approach for CWB's WINS system migration. No written suggestion/implementation is included. • Support developer training at MDL for 6-months to learn AWIPS II framework and structures | |

Task #6 – Development of High-Resolution Product Generation Assistance Tools

During IA #25, AIT's designated representative, NOAA/ESRL/GSD, will provide technical support for the Graphical Forecast Editor (GFE), Text Formatter (TF), and the GFE Smart Tools. These will support CWB's development of formatter infrastructure of the Forecast Information Editing System (FIES).

GFE/verification system software training (BOIVerify) was coordinated by AIT's designated representative, NOAA/ESRL/GSD, to TECRO's designated representative, CWB, during Implementing Arrangements #21, #22, #23 and #24. CWB plans to customize the BOIVerify software package, which is developed by the Boise Weather Forecast Office (WFO) of Idaho. NOAA/ESRL/GSD will continue to coordinate as necessary for CWB forecasters to use and configure BOIVerify during hazardous weather situations in IA #25. The purpose of this task is for CWB to understand the details of the

BOIVerify software package so CWB can modify it to satisfy their needs.

The following summarizes the schedule and resources required for Task #6:

Resources Required: 9.7 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

- 1: Support CWB's FIES development
 - a. Provide technical support on GFE Smart Tools for CWB's TF development 11/15/13
 - b. Provide CWB forecaster assistance to use and configure BOIVerify software package for CWB's customization and development and helping coordination of technical exchange meetings with scientists of Boise WFO on BOIVerify software package 11/15/13

Task # 7 – Development of Intra-seasonal to Inter-annual Climate Monitoring and Forecast

The goal of this task is for the Climate Prediction Center (CPC) and Environmental Modeling Center (EMC) of NOAA/NWS (National Weather Service)/NCEP (National Centers of Environmental Prediction (NCEP)), to support and partner with CWB in advancing monitoring and forecast capabilities, in particular for the intra-seasonal to inter-annual time scales. The task includes:

(1) NCEP International Monsoon Training Desk Program
The "Monsoon Desk" at NCEP/CPC serves as a focal point for training the international utilizations of NCEP Climate Forecast System (CFS), partnering R&D, diagnostic and verifications of GFS simulations between NCEP and the national meteorological centers in the monsoon regions. During 2011–2012, two CWB personnel attended the Desk. In addition to receiving lectures on the forecast fundamentals for intra-season to inter-annual variability, CWB personnel also collaborated with CPC scientists studying the CFS predictability for Tropical Cyclones of the West Pacific. CWB plans to participate in the training program by sending one trainee per year to CPC.

(2) CWB Workshop on development planning for the next generation Global Forecast Model: "Taiwan- West Pacific Climate Forecast System"
The year of 2013 marks the 30th anniversary that CWB started the numerical weather prediction project. Over the years, CWB has strived to develop a global forecast system skillful in capturing the leading signals of monsoon, tropical waves and cyclones, in particular for the West Pacific Ocean and Asia Continent. Most of the weather extremes of Taiwan area are highly modulated by these systems posing dire hazards to lives and environment, and impacting economy and national security.

Nevertheless, the rapid progress in the development of new numerical models, in particular the trend of going to very high-resolution atmosphere-ocean coupled global models, is a daunting task for a single meteorological server to carry out alone. Albeit, undertaking the development, the operational procedures and tasks, as well as the management of routine products take the precedent priority. To face the challenges, CWB needs to draft a 6-year strategic plan of 2015-2020 for advancing numerical global weather and climate predictions in the Taiwan and Western Pacific region. This strategic plan will guide CWB's development and operation of intra-seasonal to inter-annual forecasts into the third decade of the century. The objectives of this workshop are: 1) to bring the CWB, NCEP and Taiwan meteorological community together to review the current operation and development status of the global weather/climate models; 2) to identify key strengths and deficiencies in CWB global forecast system development, and 3) to help identify most promising strategies for the next steps in the development of the CWB global forecast system.

(3) The 38th Climate Diagnostic and Prediction Workshop (CDPW)

The CDPW is the primary workshop attended by prominent scientists of the world for more than three decades. Over the recent years, scientists from CWB have attended the workshop regularly. The planned 38th CDPW will continue to address the status and prospects for advancing climate prediction, monitoring, and diagnostics pertinent to the long lead forecasts by all the operational meteorological centers. The workshop covers subjects in 1) improving climate prediction tools and techniques through dynamical and statistical models and methods, forecaster practices and protocols, data and model improvements, and scientific concepts; 2) prospects for improved understanding, prediction, and simulation of intra-seasonal, seasonal, and inter-annual climate variability, including the extra-tropical annular modes, stratosphere/troposphere coupling, tropical-extra-tropical interactions, land-surface forcing, etc.; 3) climate variability and prediction in relation to the hydrologic cycle; and 4) prediction and attribution of recent high impact weather and climate events. It is a great forum for CWB to exchange forecast experiences as well as development results.

There are three main areas AIT's designated representative, NOAA/ESRL/GSD will work on in Year 2013: 1) assist CWB in sending a trainee to the NCEP International Monsoon Desk for a four-month training program; 2) assist with the CWB Workshop on development planning of the next generation Global Forecast System by bringing in three NCEP experts of Global Modeling; 3) assist CWB in sending two scientists to participate the 38th Climate Diagnostics and Prediction Workshop to be held during 21-25 October, 2013 at College Park, MD,; and 4) to visit CPC and/or other NOAA facilities for three days before or after the Workshop.

The following summarizes the schedule and resources required for Task # 7:

Resources Required:

No funding exchanged
NOAA/ESRL
NOAA/NWS/NCEP/CPC
NOAA/NWS/NCEP/EMC

Deliverables and Schedule:

- | | |
|---|------------|
| 1. Support CWB personnel attending NOAA/NCEP's Monsoon Desk training | 11/30/2013 |
| 2. Support CWB Workshop on development planning for the next generation Global Forecast Model | 11/30/2013 |
| 3. Support NOAA's 38th Climate Diagnostics and Prediction Workshop and visit | 10/31/2013 |
| 4. Report on tasks of the year | 11/30/2013 |

Task #8 - 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 facilities of TECRO's designated representative, CWB. The task for AIT's designated representative, NOAA/ESRL/GSD, in this area is the development of new tools that extend and enhance the forecast applications. Further NOAA/ESRL/GSD interaction with CWB is critical to keep CWB staff up to date on current AWIPS II developments. This task will directly improve and update CWB's current forecast assistant and decision-making systems at appropriate levels, including ALPS (which is an update of AWIPS) and the new AWIPS-II. The task includes the delivery of relevant forecast assistant application software releases and available documents.

AWIPS II is being developed under a NOAA/NWS contract with the Raytheon Technical Services Company that was established in 2006. The system is based on a Services Oriented Architecture (SOA). As AIT's designated representative, NOAA/ESRL/GSD, is tasked with performing an Independent Validation and Verification (IV&V) for each task order (i.e. system improvement) released by Raytheon. NOAA/ESRL/GSD will provide training and share AWIPS II experiences with CWB visiting scientists in the areas of SOA, Environmental Data Exchange (EDEX) – which provides the handling of data ingest, storage and communication, and the Common AWIPS II Visualization Environment (CAVE) – which is the graphical user interface.

NOAA/ESRL/GSD has U.S. export control approval to provide CWB with AWIPS II software as released by the contractor. However, this transfer cannot occur until AWIPS II is declared operational by the NWS. NOAA/ESRL/GSD will train CWB visiting scientists on the new AWIPS II extended/enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by NOAA/ESRL/GSD.

AIT's designated representative, NOAA/OAR/GSD, released the latest AWIPS test datasets to TECRO's designated representative, CWB, near the end of 2010. These datasets are currently being used by NOAA/NWS. AWIPS 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. Since CWB will access data from two new dual-pol radars soon, this new radar product display capability will add significant capability to its forecast and decision making operations. NOAA/ESRL/GSD will continue to make available any of the latest AWIPS II -build software (after permission to release is gained from the NWS), and technical support of new AWIPS II applications, such as warning tools (WarnGen, GHG), if applicable, during IA #25.

AIT's designated representative, NOAA/ESRL/GSD, has a long history of supporting research and operational weather forecasting by developing advanced prototype display systems, including an ongoing AWIPS Linux Prototype System (ALPS) development. NOAA/ESRL/GSD will provide necessary support in the area of porting ALPS during IA #25.

For the data feed support, NOAA/ESRL/GSD will continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes during IA #25. A preliminary test of wavelet data compression technique for high-resolution ocean model data was performed during IA #24 with good preliminary results. NOAA/ESRL/GSD will continue to examine the real-time operational requirements so that the compressed data can be transferred from NOAA/ESRL/GSD to CWB for its current model operation during IA #25.

This continuing interaction task will benefit TECRO's designated representative, CWB, with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including the recently deployed AWIPS II system. This task also provides the important data feed of NOAAPORT for CWB's daily numerical weather prediction operation needs. Finally, NOAA/ESRL/GSD will provide necessary training and support to CWB visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

The following summarizes the schedule and resources required for Task #8:

Resources Required: 16.4 % NOAA/ESRL/GSD/CWB

Deliverables and Schedule:

- | | |
|---|----------|
| 1. ALPS system (necessary technical support) | 06/30/13 |
| 2. AWIPS II training to CWB users | 11/30/13 |
| 3. NOAAPORT data supply support | 11/30/13 |
| 4. Wavelet Data Compression technical support | 11/30/13 |
| 5. Visitors and travel support | 11/30/13 |

3.0 - Schedule

Tasks	Functions	Milestones
1. Provide satellite products, algorithms and improvement on NWP		11/30/13

- modeling and data assimilation
2. Provide upgrade ARPS for real-time QPE evaluation 11/30/13
 3. Provide STMAS 3D update with remote sensing data 11/30/13
 4. Provide improved HRQ2 system to support operation and evaluation 11/30/13
 5. Provide technical support on decision assistance tools (FFMP, SCAN and GUARDIAN) and AWIPS II training support (optional) 11/30/13
 6. Provide technical support on GFE/BOIVerify for CWB's FIES development 11/30/13
 7. Provide training facility at NCEP International Monsoon Training Desk to a CWB visitor 11/30/13
 8. Provide technical support and software of ALPS, AWIPS II and NOAAPORT data transition, data compression and relevant documents 11/30/13

Schedule by Month

<u>Task 1 Satellite application</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
Polar level 1b (or SDR) radiance and products	x	x	x	x	x	x						
Technical support on MIRS improvement and updates	x	x	x	x	x	x						
Beta version of HWRF satellite data assimilation system from Pacific region applications	x	x	x	x	x	x	x	x	x	x	x	
<u>Task 2 ARPS</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
ARPS software upgrade	x	x	x	x	x	x	x	x				
ARPS test, evaluate and adjust partial cycling strategy	x	x	x	x	x	x	x	x	x	x	x	
ARPS report on maintaining initial convection and avoiding quick dissipation	x	x	x	x	x	x	x	x	x	x	x	
<u>Task 3 STMAS 3D</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
STMAS 3D with AMSU-B assimilation capability	x	x	x	x	x	x	x	x	x	x	x	x
STMAS 3D with GPS TPW data assimilation	x	x	x	x	x	x	x	x	x	x	x	x
<u>Task 4 HRQ2 (NSSL)</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
Integrate the new synthetic C-band radar	x	x	x									
Improve spatial and temporal representation of radar ZR	x	x	x	x	x	x						

relationship

QPESUMS technical support	x	x	x	x	x	x	x	x	x	x	x	x
<u>Task 5 nowcasting decision tools (MDL)</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
FFMP support including configuration, FFG, basin trend display, alarm/alert tool and user training support	x	x	x	x	x	x	x	x	x	x	x	
Other decision assistance tools	x	x	x	x	x	x	x	x	x	x	x	
Technical support for WINS												
AWIPS2 software training support for CWB to transition from WINS to AWIPS2 system	x	x	x	x	x	x	x	x	x	x	x	
<u>Task 6 high resolution forecast product generation</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
Support CWB's FIES development (GFE smart tool support)	x	x	x	x	x	x	x	x	x			
Provide CWB forecaster assistance on BOIVerify software package	x	x	x	x	x	x	x	x	x			
<u>Task 7 Climate monitor and forecast (NWS/CPC)</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
Organize Monsoon Desk visit	x	x	x	x	x	x	x	x	x	x	x	
Support CFSv2 workshop / visit	x	x	x	x	x	x	x	x	x	x	x	
Support 38 th workshop / visit	x	x	x	x	x	x	x	x	x	x	x	
Annual task report	x	x	x	x	x	x	x	x	x	x	x	x
<u>Task 8 interaction on earlier projects</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
ALPS system support (if necessary)	x	x	x	x	x	x						
AWIPS II training	x	x	x	x	x	x	x	x	x	x		
NOAAPORT data support	x	x	x	x	x	x	x	x	x	x	x	
Wavelet data compression support	x	x	x	x	x	x	x	x	x	x	x	
CWB visitors and travel support	x	x	x	x	x	x	x	x	x	x	x	

4.0 - Budget

The following are the estimated costs for IA #25

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	\$207,500	\$ 15,000	\$222,500

Task #2 (OU)	\$97,500	\$ 15,000	\$ 112,500
Task #3 (GSD)	\$117,500	\$ 15,000	\$132,500
Task #4 (NSSL)	\$127,500	\$ 15,000	\$ 142,500
Task #5 (MDL/GSD)	\$365,000	\$ 15,000	\$ 380,000
Task #6 (GSD)	\$115,000	\$ 15,000	\$ 130,000
Task #7 (NCEP/CPC)	(no funding exchanged)		
Task #8 (GSD)	\$205,000	\$ 15,000	\$ 220,000
Total	\$ 1,235,000	\$ 105,000	\$ 1,340,000

As stated in IA #25, the funds available from TECRO to support the tasks, travel, and meeting expenses described in this Statement of Work will be a total of US\$ 1,340,000. NOAA and AIT understand that US\$ 990,000 will be provided by CWB, US\$ 250,000 by the Water Resources Agency (WRA), and US\$ 100,000 by the Soil and Water Conservation Bureau (SWCB). All budget figures are estimated. Actual amounts will be accrued for purposes of fulfilling the financial arrangements described in the Implementing Arrangement, in accordance with the terms of the Umbrella 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 U.S. Government Fiscal Year 1991, a facility charge has been applied to all programs to cover management and administrative costs as well as the use of the NOAA/ESRL/GSD facility and all associated equipment and data.

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

5.0 - CWB Joint Team Assignments at NOAA/ESRL/GSD

Several tasks encourage CWB staff-in-residence at NOAA/ESRL/GSD, NOAA/NESDIS, and NOAA/NWS/MDL. The primary effort of CWB staff at NOAA during IA #25 period will be directed towards the satellite data, GFE and AWIPS II development tasks. The primary effort of CWB staff at NOAA/NCEP/CPC during IA #25 period will be to get familiar with the operations of the CPC International Monsoon Desk. It is important that qualified CWB staff be available to work at NOAA research and operations facilities during the period of this Implementing Arrangement. Specific assignments will be made to most efficiently use the available personnel resources. Assignments for the qualified CWB staff members would be as follows:

- Development of high-resolution forecast product generation assistance tool to support CWB's FIES;

- Development of short-range forecasting using STMAS with remote sensing data;
- Development of forecast applications under AWIPS II environment;
- Receiving training at the NCEP International Monsoon Desk.