Implementing Arrangement #31

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 (IA) provides a framework for a project between the Taipei Economic and Cultural Representative Office in the United States (TECRO) and the American Institute in Taiwan (AIT), collectively referred to as the "Parties." It describes the scientific and technical activities to be undertaken by the AIT, through its designated representative, the National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce, including but not limited to NOAA's Global System Division (formally the Forecast Systems Laboratory) of the Earth System Research Laboratory (hereinafter "GSD"). 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 Parties, through their designated representatives. This IA is of mutual interest to both TECRO and AIT. The products of this IA will provide substantial value through development of new and upgraded capabilities and applications that can be integrated into other NOAA systems.

Article II - Authorities

The activities described in this IA shall be carried out under and are subject to the general terms and conditions established by the Agreement between AIT and TECRO for Technical Cooperation in Meteorology and Forecast Systems Development, signed by the Parties as of October 21, 2016, and any subsequent amendment thereof agreed to by the Parties (hereinafter the "Umbrella Agreement"). This IA is the thirty-first arrangement under a succession of umbrella agreements between AIT and TECRO, since approximately 1989, specific to the scope of weather forecast improvement.

Article III - Services
The Parties agree that the tasks shall be undertaken as appropriate through the designated representatives of AIT and TECRO. The lead NOAA organization is the GSD in Boulder, Colorado, which shall coordinate activities with the Central Weather Bureau of Taiwan (CWB) staff at the CWB facility in Taipei, Taiwan, as appropriate, and other NOAA organizations and affiliates which include: NOAA's National Severe Storms Laboratory (NSSL) in Norman, Oklahoma; NOAA's National Environment Satellite, Data, and Information Services (NESDIS); NOAA's Climate Prediction Center (CPC) facility in College Park, Maryland; NOAA's National

Centers of Environmental Prediction/Environmental Modeling Center (EMC) in College Park, Maryland; NOAA's Meteorological Development Laboratory (MDL) in Silver Spring, Maryland; NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington; and NOAA's cooperative affiliate, the University of Wisconsin's – Space Science and Engineering Center/Cooperative Institute for Meteorological Satellite Studies (CIMSS).

During the period of IA #31 AIT and TECRO, through their respective designated representatives continues the phase VI under the Umbrella agreement, a program on hazardous weather monitoring and forecasting. Specifically, the GSD and CWB shall work together, as designated representatives of AIT and TECRO, to expand work to address this hazardous weather theme. Eight tasks are identified as:

> (1) Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction
> (2) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement
> (3) Enhancement of Nowcasting Decision Assistance Tools
> (4) Development of High-Resolution Product Generation Assistance Tools for AWIPS II
> (5) Development of Next Generation Global to Regional Prediction System
> (6) Continuing Interaction on Earlier Cooperative Projects
> (7) Development of GOES-R Decision Support Products from Himawari-8
> (8) Tsunami Warning Enhancement Efforts for the territory represented by TECRO

Tasks under this IA 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 and statement of work are described in more detail below.

Task #1 Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction

During IA #31, the Parties agree that AIT, through GSD shall coordinate with NOAA's NESDIS Center for Satellite Applications and Research (STAR) who shall lead this task. STAR shall improve the Aerosol Optical Depth (AOD) algorithm (with the preliminary surface reflectance relationships) l and package and deliver it to TECRO, through CWB along with sample input and output data, as well as documentation. NESDIS shall also continue to refine the regression models by stratifying the analysis into different seasons, regions, and times of the day. Using additional information such as smoke/smog and dust masks derived from Advanced Himawari Imager (AHI) aerosol detection algorithm, data shall be stratified to investigate if regression models will be better predictors of surface Particulate Matter (PM) 2.5 when aerosol composition information is used to separate regression model parameters (mainly the slope of AOD vs. PM 2.5 is expected to be a function of aerosol composition). In performance pursuant to this IA, the aerosol detection algorithm shall be implemented on AHI for 2018 data to flag AOD for cases of dust and smoke/smog. The reprocessed data shall be used to matchup with surface PM 2.5 to see if statistical regression model parameters can be stratified based on aerosol type. For the surface solar radiation, the current version of the algorithm (with the preliminary Narrowband to

Broadband (NTB) conversion) will be packaged and delivered to CWB along with sample input and output data, as well as documentation.

The Community Radiative Transfer Model (CRTM) surface model and aerosol scattering scheme may be the major causes of the current CRTM bias at AHI visible & near-infrared channels. A new version of CRTM with an enhanced land surface visible and near-infrared model is under implementation, which shall be used for CRTM-based Surface solar insolation (SSI) product development. Cloud contamination is another factor affecting CRTM performance analysis. An efficient cloud filtering model shall be incorporated into the CRTM-Based SSI product.

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

Deliverables and Schedule:
1. Aerosol optical depth (AOD)   11/15/19
   a. Revise/update/fine-tune the surface reflectance relationships for the area of interest:
      - use more, seasonally representative Advanced Himawari Imager (AHI) data, and
      - better account for time-of-day changes in land-surface spectral reflectance relationships;
   b. Implement and test updated surface reflectance relationships;
   c. Re-evaluate AHI AOD product;
   d. Update/complete document;
   e. Prepare updated package (code + documents + test data) for delivery.
2. Air quality estimation   11/15/19
   a. Revise AOD vs. surface PM 2.5 regression analysis and apply the models to generate surface PM 2.5 maps for the territory represented by TECRO in near real time
      - Provide the maps to CWB for evaluation
   b. Conduct quantitative evaluation of AHI derived surface PM 2.5 with ground-based observations
   c. Implementation of AHI aerosol detection algorithm on tars.umd.edu and completion of 2017-2018 AHI dust detection data
   d. Tag AHI AOD vs. surface PM 2.5 with smoke/smog and dust mask flags and stratify the data for regression analysis.
3. Surface solar radiation   11/15/19
   a. Revise/update narrowband-to-broadband conversions,
   b. Implement and test updated conversions;
   c. Re-evaluate AHI Direct Solar Radiation (DSR) product;
   d. Update/complete document;
   e. Prepare updated package (code + documents + test data) for delivery.
4. Derivation of Surface Solar Insolation From CRTM   11/15/19
   a. The interface modules to couple the CRTM outputs with the existing new NESDIS STAR AHI SSI algorithm are developed and will be delivered together with the improved CRTM package.

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Task #2 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement

During IA #31, the Parties agree that AIT, through GSD shall coordinate with NOAA's NSSL (National Severe Storms Laboratory) to 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.

This task shall include a study of using machine learning techniques for dual-polarization radar quantitative precipitation estimation (QPE). This study shall provide TECRO, through CWB, an in-depth assessment of the merits and limitations of machine learning techniques for meteorological applications. The task also includes continued refinements and enhancements of current operational radar QPE products for CWB. NSSL shall host a CWB staff visit for three months in Norman, Oklahoma, and provide training on the latest dual-polarization radar techniques.

The Parties agree that the CWB staff shall work with NSSL scientists on the refinements of S-band and C-band radar QPEs for the environment of the territory represented by TECRO. The training and study shall provide CWB capabilities to customize and enhance their operational radar products using real-time disdrometer observations and the newly deployed precipitation radars.

The Parties agree that AIT, through NOAA/NSSL, shall make available to TECRO's designated representative, CWB, as requested, the updated radar quality control and QPE software for the new radars. The Parties further agree that AIT, through NSSL shall also provide TECRO, through CWB, as requested, consultations as part of Quantitative Precipitation Estimation and Segregation Using Multiple Sensor (QPESUMS) technical support.

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

Deliverables and Schedule:
1. Machine learning (ML) based single radar QPE   11/15/19
   a. collect and process training and validation data
   b. establish a ML model and perform initial training
   c. analyze results and document merits and limitations of the model
2. Operational radar QPE research and support of the territory represented by   11/15/19
   TECRO
   a. S-band R(A) QPE case studies and refinements
   b. C-band dual-pol radar QPE case studies and refinements
   c. draft manuscript on QPE system of the territory represented by TECRO
   d. draft manuscript on R(A) QPE applications in the territory represented by TECRO
3. Hosting one visitor for 3 months in Norman, Oklahoma   11/15/19
4. Technical support for QPESUMS operations   11/15/19

Task#3 - 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 cover the full scope of hydro-meteorological phenomena and forecaster responsibilities. In the past few years, the MDL has assisted and supported porting various applications into the Weather Integration and Nowcasting System (WINS) of the CWB.

As part of IA #31, the Parties agree that AIT, through GSD shall coordinate with NOAA's MDL and shall continue to provide technical and training support to TECRO's designated representative, the CWB, to enhance the CWB in the area of nowcasting decision assistance tools that have already been implemented. That support includes source code and configuration modification that is appropriate for CWB's use.

AIT, through MDL shall continue to focus on migration support of Flash Flood Monitoring and Prediction (FFMP) to Advanced Weather Interactive Processing System II (AWIPS II) systems and continue the technical support on System of Convection Analysis Nowcasting (SCAN) tools. The Parties agree that AIT, through MDL shall also continue to support TECRO's CWB developers on VLab (Virtual Laboratory) use so that TECRO, through CWB developers, may access AWIPS II's user manuals, download AWIPS II source code and get AWIPS II development training.

The Parties agree that MDL shall continue to provide TECRO, through CWB, technical support on the MDL's version of AutoNowCaster (ANC) system for its operational use. The ongoing training and technical support are needed to configure, use, and interpret ANC's results so that the CWB's forecasters can make informed use of ANC's output. Also, to improve the ANC system on forecasting convective initiation, the Parties agree that AIT, through MDL shall make attempts to use new "Machine Learning (ML)" technology to explore potential predictor candidates for convective storms of the territory represented by TECRO.

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

Deliverables and Schedule:
1. Continue the technical support on FFMP development for AWIPS II   11/15/19
   a. QPESUMS data source use;
   b. Rain gage data comparison with radar estimates;
2. Continue the technical support on SCAN customization in AWIPS II   11/15/19
3. Continue to provide technical and training support to CWB developers for NWS   11/15/19
   Virtual Lab (VLab) uses.
4. Provide scientific consultation on ML approach and exploratory development of   11/15/19
   local -thunderstorm predictors in the territory represented by TECRO.
   a. MDL subject matter expert will visit CWB to explore potential predictor candidates for convective storms.
   b. Obtain data, thunderstorm inputs, other available inputs (especially those that would provide mesoscale boundary information such as the sea breeze, mountain-valley circulations, Mei-Yu front, information about land use and topography), and verification for training and testing.
   c. Test a hierarchy of machine-learning models, beginning with logistic

regression and simple multi-layer perceptron (MLP) artificial neural networks, and extending to evolutionary programming (EP) models. Based on initial performance metrics (Brier Score), determining which approach is optimal (including an adaptive approach).

5. Support the MDL's version of ANC at the CWB for its use in operations.   11/15/19

Task #4 - Development of High-Resolution Product Generation Assistance Tools for AWIPS II

During IA #31, the Parties agree that AIT, through GSD shall lead this task. NWS has been developing AWIPS II for several years. The AWIPS II is a replacement for the original AWIPS system which is the basis for the CWB Weather Integration and Nowcasting System (WINS). The AWIPS II system has been used operationally in the NWS Weather Forecast Offices (WFOs) since 2015. AWIPS II provides essentially the same appearance and function ("look and feel") as AWIPS I, reducing the need for extensive forecaster training. The underlying software is written largely in Java and loosely follows a service oriented architecture (SOA) design. AIT, through GSD will continue to support TECRO, through CWB developers, by providing updated versions of the AWIPS II software.

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

Deliverable and Schedule:
1. Primary Task Area 1: Continued general AWIPS II support and transition   11/15/19
   assistance
   a. Provide System Administration Training at CWB by GSD subject matter experts.
   b. Provide User Training at CWB by GSD subject matter experts.
   c. Assist with upgrade to Build 18.1

Primary Task Area 2: Common AWIPS Visualization Environment (CAVE)   11/15/19
Annotation Tool (to replace Weather Contour Editor)
   d. Deliver evaluation version 2.0
      • Improve core code
      • CWB import-export converters
      • Application interface and framework
      • Additional new features
   e. Deliver production version 1.0
      • Basic support operation
      • Transitional capabilities
      • Improve performance
   f. Deliver production version 2.0
      • Enhance capabilities based on feedback
      • Improve performance
2. Primary Task Area 3: Hazard Services transition (to modernize warning   11/15/19
   capabilities)

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a. Host CWB visitor to learn Hazard Services functionality and development for 4 to 6 months at GSD in Boulder CO.
b. Assist with assessing CWB requirements for Hazard Services
   - Hazard types
   - Product output formats

Task #5 – Enhancement of Next Generation Global to Regional Prediction System

During IA #31, the Parties agree that AIT through NOAA's EMC shall lead this task. The Parties agree that AIT, through EMC shall facilitate CWB modeling staff to participate in NOAA/NWS's NGGPS (Next Generation Global Prediction System) development and enhancement activity.

NGGPS program has accomplished a significant milestone through accelerated design, development, and implementation a new GFDL's Finite Volume Model Cubed Sphere (FV3) dynamic core based Global Forecast System (GFS) in early 2019 with advanced physics, and improved Global Data Assimilation System (GDAS). Continuous advancements to the FV3GFS will enable NCEP and its partners to provide world's best numerical guidance for weather forecasts. Future enhancements for the FV3GFS includes implementation of advanced physics, increased resolution, coupling to earth system components, and advanced data assimilation techniques, and development of a Stand Alone Regional (SAR) model for high-resolution convective allowing forecasts and rapid initial condition updates using radar data assimilation.

Specific for IA #31, the Parties agree that AIT, through EMC shall assist in hosting a CWB modeling staff member for 12 months at EMC in College Park, Maryland, to participate in the FV3GFS development and advancement activities, so CWB can actively make contributions to this program.

Through this collaboration, TECRO, through CWB could position its own development of a next generation global forecast system from NOAA's experience. AIT, through EMC shall also support short-term focused technical visits to CWB involving EMC scientists to exchange science and operational knowledge in the area of GFS, GDAS and Global Ensemble Forecast System (GEFS). In addition, the Parties agree that AIT, through EMC shall assist TECRO, through CWB Marine Meteorology Center (MMC) in developing The Local Ensemble Transform Kalman Filter (LETKF) based Ocean Data Assimilation System for the territory represented by TECRO to effectively assimilate in situ and remote sensing ocean observations into a high resolution regional ocean model.

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

Deliverables and Schedule:

1. Hosting CWB modeling visitor to participate in FV3GFS testing, evaluation and   11/15/19 implementation activity for 12 Months at EMC in College Park, Maryland.

2. EMC colleagues to visit CWB to conduct technical workshops on FV3GFS,   11/15/19 FV3CAM, GDAS, GEFS (four visits, 1-2 EMC scientists for each visit) for 1 to

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2 weeks.

3. Facilitating CWB manager's visit to EMC for project review meeting for 1 week. 11/15/19

4. Deliver QA/QC model and documents (including test cases) for preprocessing data. EMC assign 1 contact person for technical support. 3/31/19

5. EMC assign 1 expert to Virginia Institute of Marine Science, College of William and Mary, technical support for deploying (HYCOM)-LETKF of Taiwan area code at CWB. 11/15/19

6. Build Hybrid Coordinate Ocean Model (HYCOM)-LETKF based regional Ocean Data Assimilation (ODA) system for the island of Taiwan. Transfer of technology to MMC for near-real-time applications of an ocean forecast system for Taiwan. 10/15/19

Task #6 - Continuing Interaction on Earlier Cooperative Projects

Several cooperative tasks have been completed under previous implementing arrangements. Technology has been transferred successfully and is beginning to be used operationally at the facilities of the CWB. The task for AIT, through GSD, in this area is the development of new tools that extend and enhance the forecast applications. Further AIT's interaction with TECRO, through GSD and CWB, respectively is critical to keep TECRO, through 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.

During IA #31, the Parties agree that AIT, through GSD shall continue to provide updated versions and training to TECRO, through CWB's visiting scientists on the new AWIPS II extended/ enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by GSD.

AIT, through GSD, shall continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes. This continuing interaction task will benefit AIT and TECRO, with the updated knowledge of the forecast assistant and decision-making systems developed at NOAA including AWIPS II. Throughout the period of IA #31, AIT, through GSD, shall provide necessary training and support to TECRO, through CWB's visitors and forecasters, and continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

Visitors from CWB may visit various facilities for durations from several days to 2 weeks.

During IA #31, GSD shall continue provide CWB MMC (Marine Meteorology Center) with technical support for CWB DART® (Deep-ocean Assessment Reporting of Tsunamis) buoys by Dr. Eddie Bernard. GSD shall support CWB/MMC to visit NOAA/ NDBC for Dart buoys technical meeting and invite a NOAA/NOS scientist, a NDBC scientist and two NWW3 data assimilation scientists to visit CWB/MMC. GSD will also help the MMC to get the NWW3 data assimilation tool package beta version.

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

<u>Deliverables and Schedule</u>:
1. NOAAPORT data supply support   11/15/19
2. NWW3 data assimilation tool package   08/15/19
3. DART consultation and a site visit support   11/15/19
4. Visitors and travel support   11/15/19

Task #7 – Development of GOES-R Decision Support Products from Himawari-8

During IA #31, the Parties agree that AIT, through GSD shall, coordinate with NOAA's partner the University of Wisconsin – Space Science and Engineering Center (SSEC) / Cooperative Institute for Meteorological Satellite Studies (CIMSS). The Parties agree that AIT, through GSD's coordination with CIMSS, shall continue research in support of satellite-based decision support products.

This task shall include hosting a CWB visitor to facilitate training and transfer of Himawari-8 decision support products from CIMSS to CWB. Part of this visit will be a collaborative development of a Himawari-8 visibility product based on CWB fog detection and cloud/aerosol optical depth retrievals from the CIMSS CLAVR-x (Clouds from AVHRR Extended) processing system. CIMSS will also make available the precipitation retrieval product through the Clouds from AVHRR Extended (CLAVR-x) processing system. AIT, through NOAA's partnership with CIMSS, shall work with TECRO, through CWB, to tune the precipitation product to Himawari-8/AHI using radar data.

AIT, through NOAA's partnership with CIMSS shall continue support for (Red Green Blue) RGB and CLAVR-x products for Meteorological Satellite Center (MSC)/CWB. Tasks include creating updated look-up tables for the CLAVR-x naïve Bayesian cloud mask tuned specifically to Himawari-8. AIT, through NOAA's partnership with CIMSS shall also provide files and instructions for transferring NOAA standard annotations (e.g. colorbars, ranges, labels) into the AWIPS II environment for key CLAVR-x products. This builds upon the completed IA task of importing CLAVR-x products into AWIPS II.

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

<u>Deliverables and Schedule</u>:
1. Develop Himawari-8 visibility product (Phase I)   11/15/19
    a. Host visitor and collaborate on integrating fog and cloud/aerosol optical depth products into visibility.
2. Implement cloud-based Precipitation product   11/15/19
    a. Tune for Himawari-8/AHI using radar data
    b. Upgrade CLAVR-x installation at MSC/CWB to include tuned precipitation
3. Continue RGB and CLAVR-x product support   11/15/19
    a. Identify key CLAVR-x products and create xml files for The Geostationary Operational Environmental Satellite-R Series (GOES-R) annotation in AWIPS II (colorbar, axis labels, ranges)
    b. Update training of the CLAVR-x cloud mask from collocated The

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Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO)/ Himawari-8 scenes

c. Deliver a updated utility package being tested to convert AHI "HSD" format as well as HimawariCast tools (L1b imagery) and geo2grid (L2) to CWB

Technical and training support to CWB visitor for 3 months at its facility in Madison, Wisconsin.   11/15/19

Task #8 –Tsunami Warning Enhancement Efforts for Taiwan

During IA #31, the Parties agree that AIT, through GSD, shall coordinate with PMEL a leader in research and developing technologies for the detection of tsunamis and forecasting tsunami impacts. PMEL has also been instrumental in the development of software tools for NOAA's Tsunami Warning Centers (TWCs) and scientists in the tsunami field. One of these tools, Tsunami web (Tweb), has functionality that allows TWC forecasters to evaluate possible tsunami generating earthquakes and determine the risks the tsunami could pose to coastal areas.

The tsunami-related software tools available at the moment are geared towards scientists or the TWCs. Tweb application will allow TECRO, through CWB to use data from CWB DART stations near the territory represented by TECRO, as well as data from the entire DART network, to forecast tsunami impacts at populated coastal communities in the territory represented by TECRO in real time.

The goal of this project is to enable TECRO, through CWB's Tsunami Warning Center (TWC) to provide real-time tsunami inundation forecast for coastal communities of the territory represented by TECRO using a web-based tool of tsunami-related software. The project shall incorporate tsunami flooding models, developed by Professor Tso-Ren Wu of the National Central University, into the Tweb application. The two phases of the project include model development (Phase I) and local software implementation (Phase II). Phase I shall implement existing tsunami inundation models of the territory represented by TECRO into existing Tweb to ensure seamless implementation and verified product development. Once the project has successfully demonstrated the inclusion of tsunami flooding models of the territory represented by TECRO and the Tweb forecast capabilities, an operational plan for Phase II implementation at CWB shall be developed. The ultimate goal is to provide predictions for tsunami inundation around the coast of the territory represented by TECRO. However, until the cost of installing the Hualien tsunami flooding model in T-web is known, it is impossible to estimate the cost of covering all major coastal population centers.

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

Deliverables and Schedule:
1. Construct Hualien tsunami flooding model (or another site in the territory   11/15/19
   represented by TECRO with available data) for use in T-web software
   environment and validate using tide gauge data from the 2011 Japan tsunami.
   Requires bathymetric data at 50m resolution from Professor Wu.
2. Provide CWB training for Tweb and ComMIT.   11/15/19

3. Provide maintenance and support of the Tweb and ComMIT software for testing and experimental forecast use.   11/15/19

4. Provide software for modeling with a customized initial tsunami source. ComMIT interface for tsunami forecast modeling would allow for custom sources integration, in addition to the pre-computed source selection. Pre-computed sources allow for fast forecast computations for real-time predictions. The custom sources provide capabilities for additional custom tsunami sources, but they may not be suitable for real-time forecast purposes.   11/15/19

5. Construct as many tsunami flooding models for population centers of the territory represented by TECRO as resources permit. Ideally, these models will cover locations of 40 gauges around Taiwan to allow independent validation of the tsunami forecast with the tide gage records, and to perform tests with data from prior tsunami events. Bathymetry information is to be supplied to PMEL by the CWB.   11/15/19

Article IV – Schedule Summary

Task Function	Milestone
1. Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction	11/15/19
2. High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement	11/15/19
3. Enhance Nowcasting Decision Assistance Tools	11/15/19
4. Development of High-Resolution Product Generation Assistance Tools for AWIPS II	11/15/19
5. Development of Next Generation Global to Regional Prediction System	11/15/19
6. Continuing Interaction on Earlier Cooperative Projects	11/15/19
7. Development of GOES-R decision support products from Himawari-8	11/15/19
8. Tsunami Warning Enhancement Efforts for the territory represented by TECRO	11/15/19

Article V - Responsibilities of AIT

In addition to participation in the joint project team, AIT, through its designated representative as appropriate, shall:

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

B.   Provide administrative support for preparing reports for delivery to TECRO, through CWB in accordance with this IA;

C.   Assign appropriate staff to perform the activities defined in this IA and provide support in accordance with the terms of the Umbrella Agreement; and

D.   Fulfill its responsibilities for this IA.

Article VI - Responsibilities of TECRO

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

A.   Provide overall coordination project activities at the CWB facility;
B.   Assign appropriate staff to perform the activities defined in this IA and provide support in accordance with the terms of the Umbrella Agreement; and
C.   Fulfill its responsibilities for IA #31.

Article VII - Financial Provisions and Budget

In accordance with Article VII – Financial Arrangements, of the Umbrella Agreement, TECRO shall pay AIT, in association with the project covered by this IA.

The total cost for activities described in this IA is mutually agreed to be U.S. $2,250,000, to support the tasks, travel, and meeting expenses described herein. TECRO agrees to transfer 50 percent of the funds to AIT in advance, with the remaining 50 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 following are the estimated costs for IA #31:

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	$250,000	$35,000	$285,000
Task #2 (NSSL)	$250,000	$0	$250,000
Task #3 (MDL/GSD)	$270,000	$0	$270,000
Task #4 (GSD)	$240,000	$35,000	$275,000
Task #5 (NCEP/EMC)	$210,000	$80,000	$290,000
Task #6 (GSD)	$305,000	$95,000	$400,000
Task #7 (CIMSS)	$250,000	$0	$250,000
Task #8 (PMEL)	$200,000	$30,000	$230,000
Total	**$1,975,000**	**$275,000**	**$2,250,000**

All budget figures are estimated. Actual amounts shall 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 Fiscal Year 1991 of the territory represented by AIT, 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 staff time is charged at the employee's salary plus the normal NOAA benefit, leave, and overhead charges. GSD professional staff people are primarily in the civil service grade scales

of GS-11 to GS-14. Contract staff is in equivalent categories. The performance of activities by AIT, through NOAA under this IA is subject to the availability of funds.

Article VIII - CWB Joint Team Assignments at NOAA/ESRL/GSD

Several tasks encourage CWB visitors at GSD, NESDIS, and MDL. The primary effort of TECRO, through CWB staff at NOAA during the IA #31 period shall be directed towards the satellite data, AWIPS II development tasks. The primary effort of TECRO, through CWB staff at CPC during the IA #31 period shall 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 IA. Specific assignments shall be made to most efficiently use the available personnel resources. Assignments for the qualified CWB staff members would be as follows:

- Surface Solar Insolation algorithm and product development;
- Enhancement of radar ingest process including decoding software;
- ANC verification package and new predictor(s);
- Development of GOES-R (H-8) algorithm in the area of SST and AMV (Atmospheric Motion Vectors);
- Localization of Decision Assistance Tool called SCAN (System for Convection Analysis and Nowcasting) under AWIPS II environment;
- Receiving training at CPC International Monsoon Desk;
- NGGPS modeling testing and implementation activity.

Article IX – Privileges, Exemptions, and Immunities

For purposes of visits and any other travel contemplated in this IA, staff of the Parties' designated representatives shall be considered consultants to AIT and TECRO, respectively, when in the territory represented by the counterpart organization. The Parties acknowledge that such individuals generally shall not be eligible for privileges, exemptions, and immunities pursuant to the 2013 Agreement on Privileges, Exemptions and Immunities between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office in the United States ("2013 Agreement") if the visit or any other travel is less than 90 days in duration or if the individual is-working at a location other than a facility of the sending organization. Nothing here is intended by the Parties as an amendment or other change to the 2013 Agreement, the provisions of which must be satisfied before any privileges, exemptions, or immunities may be provided by either Party.
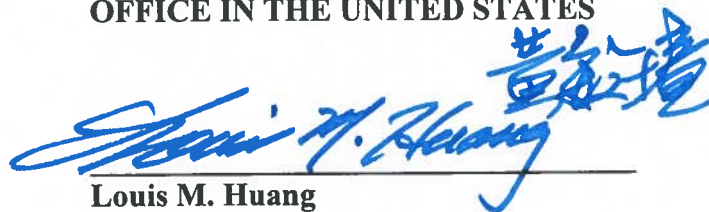
Article X - Intellectual Property Considerations

No activity described in this IA, or any technology or other information exchanged in the course of activities under this IA, is expected to give rise to, or implicate any existing, intellectual property rights. Reports, specifications, and computer software prepared under this IA are also expected not to be subject to intellectual property protection

Article XI - Effective Date, Amendment, and Termination

This IA becomes operative on the date of the last signature hereto This IA may be amended and/or terminated in accordance with the terms of the Agreement. This IA becomes effective upon signature of both parties. The estimated completion date for the activities described in this IA and the period of performance end date of this IA is December 31, 2020.

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

Louis M. Huang
Deputy Representative

11 December 2019

Date

FOR THE AMERICAN INSTITUTE
IN TAIWAN

John J. Norris Jr.
Managing Director

12/11/2019

Date

Implementing Arrangement #31

Development of a hazardous weather monitoring and forecast 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 (IA) provides a framework for a project between the American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Representative Office in the United States (TECRO), collectively referred to as the "Parties." It describes the scientific and technical activities to be undertaken by the AIT, through its designated representative, the National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce, including but not limited to NOAA's Global System Division (formally the Forecast Systems Laboratory) of the Earth System Research Laboratory (hereinafter "GSD"). 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 Parties, through their designated representatives. This IA is of mutual interest to both AIT and TECRO. The products of this IA will provide substantial value through development of new and upgraded capabilities and applications that can be integrated into other NOAA systems.

Article II - Authorities

The activities described in this IA shall be carried out under and are subject to the general terms and conditions established by the Agreement between AIT and TECRO for Technical Cooperation in Meteorology and Forecast Systems Development, signed by the Parties as of October 21, 2016, and any subsequent amendment thereof agreed to by the Parties (hereinafter the "Umbrella Agreement"). This IA is the thirty-first arrangement under a succession of umbrella agreements between AIT and TECRO, since approximately 1989, specific to the scope of weather forecast improvement.

Article III - Services
The Parties agree that the tasks shall be undertaken as appropriate through the designated representatives of AIT and TECRO. The lead NOAA organization is the GSD in Boulder, Colorado, which shall coordinate activities with the Central Weather Bureau of Taiwan (CWB) staff at the CWB facility in Taipei, Taiwan, as appropriate, and other NOAA organizations and affiliates which include: NOAA's National Severe Storms Laboratory (NSSL) in Norman, Oklahoma; NOAA's National Environment Satellite, Data, and Information Services (NESDIS); NOAA's Climate Prediction Center (CPC) facility in College Park, Maryland; NOAA's National

Centers of Environmental Prediction/Environmental Modeling Center (EMC) in College Park, Maryland; NOAA's Meteorological Development Laboratory (MDL) in Silver Spring, Maryland; NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, Washington; and NOAA's cooperative affiliate, the University of Wisconsin's – Space Science and Engineering Center/Cooperative Institute for Meteorological Satellite Studies (CIMSS).

During the period of IA #31 AIT and TECRO, through their respective designated representatives continues the phase VI under the Umbrella agreement, a program on hazardous weather monitoring and forecasting. Specifically, the GSD and CWB shall work together, as designated representatives of AIT and TECRO, to expand work to address this hazardous weather theme. Eight tasks are identified as:

(1) Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction
(2) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement
(3) Enhancement of Nowcasting Decision Assistance Tools
(4) Development of High-Resolution Product Generation Assistance Tools for AWIPS II
(5) Development of Next Generation Global to Regional Prediction System
(6) Continuing Interaction on Earlier Cooperative Projects
(7) Development of GOES-R Decision Support Products from Himawari-8
(8) Tsunami Warning Enhancement Efforts for the territory represented by TECRO

Tasks under this IA 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 and statement of work are described in more detail below.

Task #1 Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction

During IA #31, the Parties agree that AIT, through GSD shall coordinate with NOAA's NESDIS Center for Satellite Applications and Research (STAR) who shall lead this task. STAR shall improve the Aerosol Optical Depth (AOD) algorithm (with the preliminary surface reflectance relationships) l and package and deliver it to TECRO, through CWB along with sample input and output data, as well as documentation. NESDIS shall also continue to refine the regression models by stratifying the analysis into different seasons, regions, and times of the day. Using additional information such as smoke/smog and dust masks derived from Advanced Himawari Imager (AHI) aerosol detection algorithm, data shall be stratified to investigate if regression models will be better predictors of surface Particulate Matter (PM) 2.5 when aerosol composition information is used to separate regression model parameters (mainly the slope of AOD vs. PM 2.5 is expected to be a function of aerosol composition). In performance pursuant to this IA, the aerosol detection algorithm shall be implemented on AHI for 2018 data to flag AOD for cases of dust and smoke/smog. The reprocessed data shall be used to matchup with surface PM 2.5 to see if statistical regression model parameters can be stratified based on aerosol type. For the surface solar radiation, the current version of the algorithm (with the preliminary Narrowband to

Broadband (NTB) conversion) will be packaged and delivered to CWB along with sample input and output data, as well as documentation.

The Community Radiative Transfer Model (CRTM) surface model and aerosol scattering scheme may be the major causes of the current CRTM bias at AHI visible & near-infrared channels. A new version of CRTM with an enhanced land surface visible and near-infrared model is under implementation, which shall be used for CRTM-based Surface solar insolation (SSI) product development. Cloud contamination is another factor affecting CRTM performance analysis. An efficient cloud filtering model shall be incorporated into the CRTM-Based SSI product.

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

Deliverables and Schedule:
1. Aerosol optical depth (AOD)   11/15/19
   a. Revise/update/fine-tune the surface reflectance relationships for the area of interest:
      - use more, seasonally representative Advanced Himawari Imager (AHI) data, and
      - better account for time-of-day changes in land-surface spectral reflectance relationships;
   b. Implement and test updated surface reflectance relationships;
   c. Re-evaluate AHI AOD product;
   d. Update/complete document;
   e. Prepare updated package (code + documents + test data) for delivery.
2. Air quality estimation   11/15/19
   a. Revise AOD vs. surface PM 2.5 regression analysis and apply the models to generate surface PM 2.5 maps for the territory represented by TECRO in near real time
      - Provide the maps to CWB for evaluation
   b. Conduct quantitative evaluation of AHI derived surface PM 2.5 with ground-based observations
   c. Implementation of AHI aerosol detection algorithm on tars.umd.edu and completion of 2017-2018 AHI dust detection data
   d. Tag AHI AOD vs. surface PM 2.5 with smoke/smog and dust mask flags and stratify the data for regression analysis.
3. Surface solar radiation   11/15/19
   a. Revise/update narrowband-to-broadband conversions,
   b. Implement and test updated conversions;
   c. Re-evaluate AHI Direct Solar Radiation (DSR) product;
   d. Update/complete document;
   e. Prepare updated package (code + documents + test data) for delivery.
4. Derivation of Surface Solar Insolation From CRTM   11/15/19
   a. The interface modules to couple the CRTM outputs with the existing new NESDIS STAR AHI SSI algorithm are developed and will be delivered together with the improved CRTM package.

Task #2 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement

During IA #31, the Parties agree that AIT, through GSD shall coordinate with NOAA's NSSL (National Severe Storms Laboratory) to 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.

This task shall include a study of using machine learning techniques for dual-polarization radar quantitative precipitation estimation (QPE). This study shall provide TECRO, through CWB, an in-depth assessment of the merits and limitations of machine learning techniques for meteorological applications. The task also includes continued refinements and enhancements of current operational radar QPE products for CWB. NSSL shall host a CWB staff visit for three months in Norman, Oklahoma, and provide training on the latest dual-polarization radar techniques.

The Parties agree that the CWB staff shall work with NSSL scientists on the refinements of S-band and C-band radar QPEs for the environment of the territory represented by TECRO. The training and study shall provide CWB capabilities to customize and enhance their operational radar products using real-time disdrometer observations and the newly deployed precipitation radars.

The Parties agree that AIT, through NOAA/NSSL, shall make available to TECRO's designated representative, CWB, as requested, the updated radar quality control and QPE software for the new radars. The Parties further agree that AIT, through NSSL shall also provide TECRO, through CWB, as requested, consultations as part of Quantitative Precipitation Estimation and Segregation Using Multiple Sensor (QPESUMS) technical support.

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

Deliverables and Schedule:
1. Machine learning (ML) based single radar QPE   11/15/19
    a. collect and process training and validation data
    b. establish a ML model and perform initial training
    c. analyze results and document merits and limitations of the model
2. Operational radar QPE research and support of the territory represented by   11/15/19
   TECRO
    a. S-band R(A) QPE case studies and refinements
    b. C-band dual-pol radar QPE case studies and refinements
    c. draft manuscript on QPE system of the territory represented by TECRO
    d. draft manuscript on R(A) QPE applications in the territory represented by TECRO
3. Hosting one visitor for 3 months in Norman, Oklahoma   11/15/19
4. Technical support for QPESUMS operations   11/15/19

Task#3 - 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 cover the full scope of hydro-meteorological phenomena and forecaster responsibilities. In the past few years, the MDL has assisted and supported porting various applications into the Weather Integration and Nowcasting System (WINS) of the CWB.

As part of IA #31, the Parties agree that AIT, through GSD shall coordinate with NOAA's MDL and shall continue to provide technical and training support to TECRO's designated representative, the CWB, to enhance the CWB in the area of nowcasting decision assistance tools that have already been implemented. That support includes source code and configuration modification that is appropriate for CWB's use.

AIT, through MDL shall continue to focus on migration support of Flash Flood Monitoring and Prediction (FFMP) to Advanced Weather Interactive Processing System II (AWIPS II) systems and continue the technical support on System of Convection Analysis Nowcasting (SCAN) tools. The Parties agree that AIT, through MDL shall also continue to support TECRO's CWB developers on VLab (Virtual Laboratory) use so that TECRO, through CWB developers, may access AWIPS II's user manuals, download AWIPS II source code and get AWIPS II development training.

The Parties agree that MDL shall continue to provide TECRO, through CWB, technical support on the MDL's version of AutoNowCaster (ANC) system for its operational use. The ongoing training and technical support are needed to configure, use, and interpret ANC's results so that the CWB's forecasters can make informed use of ANC's output. Also, to improve the ANC system on forecasting convective initiation, the Parties agree that AIT, through MDL shall make attempts to use new "Machine Learning (ML)" technology to explore potential predictor candidates for convective storms of the territory represented by TECRO.

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

Deliverables and Schedule:
1. Continue the technical support on FFMP development for AWIPS II   11/15/19
   a. QPESUMS data source use;
   b. Rain gage data comparison with radar estimates;
2. Continue the technical support on SCAN customization in AWIPS II   11/15/19
3. Continue to provide technical and training support to CWB developers for NWS   11/15/19
   Virtual Lab (VLab) uses.
4. Provide scientific consultation on ML approach and exploratory development of   11/15/19
   local -thunderstorm predictors in the territory represented by TECRO.
   a. MDL subject matter expert will visit CWB to explore potential predictor candidates for convective storms.
   b. Obtain data, thunderstorm inputs, other available inputs (especially those that would provide mesoscale boundary information such as the sea breeze, mountain-valley circulations, Mei-Yu front, information about land use and topography), and verification for training and testing.
   c. Test a hierarchy of machine-learning models, beginning with logistic

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regression and simple multi-layer perceptron (MLP) artificial neural networks, and extending to evolutionary programming (EP) models. Based on initial performance metrics (Brier Score), determining which approach is optimal (including an adaptive approach).

5. Support the MDL's version of ANC at the CWB for its use in operations.   11/15/19

Task #4 - Development of High-Resolution Product Generation Assistance Tools for AWIPS II

During IA #31, the Parties agree that AIT, through GSD shall lead this task. NWS has been developing AWIPS II for several years. The AWIPS II is a replacement for the original AWIPS system which is the basis for the CWB Weather Integration and Nowcasting System (WINS). The AWIPS II system has been used operationally in the NWS Weather Forecast Offices (WFOs) since 2015. AWIPS II provides essentially the same appearance and function ("look and feel") as AWIPS I, reducing the need for extensive forecaster training. The underlying software is written largely in Java and loosely follows a service oriented architecture (SOA) design. AIT, through GSD will continue to support TECRO, through CWB developers, by providing updated versions of the AWIPS II software.

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

Deliverable and Schedule:
1. Primary Task Area 1: Continued general AWIPS II support and transition   11/15/19
    assistance
    a. Provide System Administration Training at CWB by GSD subject matter experts.
    b. Provide User Training at CWB by GSD subject matter experts.
    c. Assist with upgrade to Build 18.1

Primary Task Area 2: Common AWIPS Visualization Environment (CAVE)   11/15/19
Annotation Tool (to replace Weather Contour Editor)
    d. Deliver evaluation version 2.0
        • Improve core code
        • CWB import-export converters
        • Application interface and framework
        • Additional new features
    e. Deliver production version 1.0
        • Basic support operation
        • Transitional capabilities
        • Improve performance
    f. Deliver production version 2.0
        • Enhance capabilities based on feedback
        • Improve performance
2. Primary Task Area 3: Hazard Services transition (to modernize warning   11/15/19
    capabilities)

a. Host CWB visitor to learn Hazard Services functionality and development for 4 to 6 months at GSD in Boulder CO.
b. Assist with assessing CWB requirements for Hazard Services
    - Hazard types
    - Product output formats

Task #5 – Enhancement of Next Generation Global to Regional Prediction System

During IA #31, the Parties agree that AIT through NOAA's EMC shall lead this task. The Parties agree that AIT, through EMC shall facilitate CWB modeling staff to participate in NOAA/NWS's NGGPS (Next Generation Global Prediction System) development and enhancement activity.

NGGPS program has accomplished a significant milestone through accelerated design, development, and implementation a new GFDL's Finite Volume Model Cubed Sphere (FV3) dynamic core based Global Forecast System (GFS) in early 2019 with advanced physics, and improved Global Data Assimilation System (GDAS). Continuous advancements to the FV3GFS will enable NCEP and its partners to provide world's best numerical guidance for weather forecasts. Future enhancements for the FV3GFS includes implementation of advanced physics, increased resolution, coupling to earth system components, and advanced data assimilation techniques, and development of a Stand Alone Regional (SAR) model for high-resolution convective allowing forecasts and rapid initial condition updates using radar data assimilation.

Specific for IA #31, the Parties agree that AIT, through EMC shall assist in hosting a CWB modeling staff member for 12 months at EMC in College Park, Maryland, to participate in the FV3GFS development and advancement activities, so CWB can actively make contributions to this program.

Through this collaboration, TECRO, through CWB could position its own development of a next generation global forecast system from NOAA's experience. AIT, through EMC shall also support short-term focused technical visits to CWB involving EMC scientists to exchange science and operational knowledge in the area of GFS, GDAS and Global Ensemble Forecast System (GEFS). In addition, the Parties agree that AIT, through EMC shall assist TECRO, through CWB Marine Meteorology Center (MMC) in developing The Local Ensemble Transform Kalman Filter (LETKF) based Ocean Data Assimilation System for the territory represented by TECRO to effectively assimilate in situ and remote sensing ocean observations into a high resolution regional ocean model.

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

Deliverables and Schedule:
1. Hosting CWB modeling visitor to participate in FV3GFS testing, evaluation and   11/15/19
    implementation activity for 12 Months at EMC in College Park, Maryland.

2. EMC colleagues to visit CWB to conduct technical workshops on FV3GFS,   11/15/19
    FV3CAM, GDAS, GEFS (four visits, 1-2 EMC scientists for each visit) for 1 to

2 weeks.

3. Facilitating CWB manager's visit to EMC for project review meeting for 1 week.   11/15/19

4. Deliver QA/QC model and documents (including test cases) for preprocessing data. EMC assign 1 contact person for technical support.   3/31/19

5. EMC assign 1 expert to Virginia Institute of Marine Science, College of William and Mary, technical support for deploying (HYCOM)-LETKF of Taiwan area code at CWB.   11/15/19

6. Build Hybrid Coordinate Ocean Model (HYCOM)-LETKF based regional Ocean Data Assimilation (ODA) system for the island of Taiwan. Transfer of technology to MMC for near-real-time applications of an ocean forecast system for Taiwan.   10/15/19

Task #6 - Continuing Interaction on Earlier Cooperative Projects

Several cooperative tasks have been completed under previous implementing arrangements. Technology has been transferred successfully and is beginning to be used operationally at the facilities of the CWB. The task for AIT, through GSD, in this area is the development of new tools that extend and enhance the forecast applications. Further AIT's interaction with TECRO, through GSD and CWB, respectively is critical to keep TECRO, through 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.

During IA #31, the Parties agree that AIT, through GSD shall continue to provide updated versions and training to TECRO, through CWB's visiting scientists on the new AWIPS II extended/ enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by GSD.

AIT, through GSD, shall continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes. This continuing interaction task will benefit AIT and TECRO, with the updated knowledge of the forecast assistant and decision-making systems developed at NOAA including AWIPS II. Throughout the period of IA #31, AIT, through GSD, shall provide necessary training and support to TECRO, through CWB's visitors and forecasters, and continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

Visitors from CWB may visit various facilities for durations from several days to 2 weeks.

During IA #31, GSD shall continue provide CWB MMC (Marine Meteorology Center) with technical support for CWB DART® (Deep-ocean Assessment Reporting of Tsunamis) buoys by Dr. Eddie Bernard. GSD shall support CWB/MMC to visit NOAA/ NDBC for Dart buoys technical meeting and invite a NOAA/NOS scientist, a NDBC scientist and two NWW3 data assimilation scientists to visit CWB/MMC. GSD will also help the MMC to get the NWW3 data assimilation tool package beta version.

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

Deliverables and Schedule:
1.	NOAAPORT data supply support	11/15/19
2.	NWW3 data assimilation tool package	08/15/19
3.	DART consultation and a site visit support	11/15/19
4.	Visitors and travel support	11/15/19

Task #7 – Development of GOES-R Decision Support Products from Himawari-8

During IA #31, the Parties agree that AIT, through GSD shall, coordinate with NOAA's partner the University of Wisconsin – Space Science and Engineering Center (SSEC) / Cooperative Institute for Meteorological Satellite Studies (CIMSS). The Parties agree that AIT, through GSD's coordination with CIMSS, shall continue research in support of satellite-based decision support products.

This task shall include hosting a CWB visitor to facilitate training and transfer of Himawari-8 decision support products from CIMSS to CWB. Part of this visit will be a collaborative development of a Himawari-8 visibility product based on CWB fog detection and cloud/aerosol optical depth retrievals from the CIMSS CLAVR-x (Clouds from AVHRR Extended) processing system. CIMSS will also make available the precipitation retrieval product through the Clouds from AVHRR Extended (CLAVR-x) processing system. AIT, through NOAA's partnership with CIMSS, shall work with TECRO, through CWB, to tune the precipitation product to Himawari-8/AHI using radar data.

AIT, through NOAA's partnership with CIMSS shall continue support for (Red Green Blue) RGB and CLAVR-x products for Meteorological Satellite Center (MSC)/CWB. Tasks include creating updated look-up tables for the CLAVR-x naïve Bayesian cloud mask tuned specifically to Himawari-8. AIT, through NOAA's partnership with CIMSS shall also provide files and instructions for transferring NOAA standard annotations (e.g. colorbars, ranges, labels) into the AWIPS II environment for key CLAVR-x products. This builds upon the completed IA task of importing CLAVR-x products into AWIPS II.

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

Deliverables and Schedule:
1.	Develop Himawari-8 visibility product (Phase I)	11/15/19
	a. Host visitor and collaborate on integrating fog and cloud/aerosol optical depth products into visibility.	
2.	Implement cloud-based Precipitation product	11/15/19
	a. Tune for Himawari-8/AHI using radar data	
	b. Upgrade CLAVR-x installation at MSC/CWB to include tuned precipitation	
3.	Continue RGB and CLAVR-x product support	11/15/19
	a. Identify key CLAVR-x products and create xml files for The Geostationary Operational Environmental Satellite-R Series (GOES-R) annotation in AWIPS II (colorbar, axis labels, ranges)	

    b. Update training of the CLAVR-x cloud mask from collocated The
       Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
       (CALIPSO)/ Himawari-8 scenes
    c. Deliver a updated utility package being tested to convert AHI "HSD"
       format as well as HimawariCast tools (L1b imagery) and geo2grid (L2)
       to CWB

Technical and training support to CWB visitor for 3 months at its facility in   11/15/19
Madison, Wisconsin.

Task #8 –Tsunami Warning Enhancement Efforts for Taiwan

During IA #31, the Parties agree that AIT, through GSD, shall coordinate with PMEL a leader in research and developing technologies for the detection of tsunamis and forecasting tsunami impacts. PMEL has also been instrumental in the development of software tools for NOAA's Tsunami Warning Centers (TWCs) and scientists in the tsunami field. One of these tools, Tsunami web (Tweb), has functionality that allows TWC forecasters to evaluate possible tsunami generating earthquakes and determine the risks the tsunami could pose to coastal areas.

The tsunami-related software tools available at the moment are geared towards scientists or the TWCs. Tweb application will allow TECRO, through CWB to use data from CWB DART stations near the territory represented by TECRO, as well as data from the entire DART network, to forecast tsunami impacts at populated coastal communities in the territory represented by TECRO in real time.

The goal of this project is to enable TECRO, through CWB's Tsunami Warning Center (TWC) to provide real-time tsunami inundation forecast for coastal communities of the territory represented by TECRO using a web-based tool of tsunami-related software. The project shall incorporate tsunami flooding models, developed by Professor Tso-Ren Wu of the National Central University, into the Tweb application. The two phases of the project include model development (Phase I) and local software implementation (Phase II). Phase I shall implement existing tsunami inundation models of the territory represented by TECRO into existing Tweb to ensure seamless implementation and verified product development. Once the project has successfully demonstrated the inclusion of tsunami flooding models of the territory represented by TECRO and the Tweb forecast capabilities, an operational plan for Phase II implementation at CWB shall be developed. The ultimate goal is to provide predictions for tsunami inundation around the coast of the territory represented by TECRO. However, until the cost of installing the Hualien tsunami flooding model in T-web is known, it is impossible to estimate the cost of covering all major coastal population centers.

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

Deliverables and Schedule:
1. Construct Hualien tsunami flooding model (or another site in the territory   11/15/19
    represented by TECRO with available data) for use in T-web software
    environment and validate using tide gauge data from the 2011 Japan tsunami.
    Requires bathymetric data at 50m resolution from Professor Wu.
2. Provide CWB training for Tweb and ComMIT.   11/15/19

3. Provide maintenance and support of the Tweb and ComMIT software for testing and experimental forecast use.   11/15/19

4. Provide software for modeling with a customized initial tsunami source. ComMIT interface for tsunami forecast modeling would allow for custom sources integration, in addition to the pre-computed source selection. Pre-computed sources allow for fast forecast computations for real-time predictions. The custom sources provide capabilities for additional custom tsunami sources, but they may not be suitable for real-time forecast purposes.   11/15/19

5. Construct as many tsunami flooding models for population centers of the territory represented by TECRO as resources permit. Ideally, these models will cover locations of 40 gauges around Taiwan to allow independent validation of the tsunami forecast with the tide gage records, and to perform tests with data from prior tsunami events. Bathymetry information is to be supplied to PMEL by the CWB.   11/15/19

Article IV – Schedule Summary

Task Function	Milestone
1. Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction	11/15/19
2. High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement	11/15/19
3. Enhance Nowcasting Decision Assistance Tools	11/15/19
4. Development of High-Resolution Product Generation Assistance Tools for AWIPS II	11/15/19
5. Development of Next Generation Global to Regional Prediction System	11/15/19
6. Continuing Interaction on Earlier Cooperative Projects	11/15/19
7. Development of GOES-R decision support products from Himawari-8	11/15/19
8. Tsunami Warning Enhancement Efforts for the territory represented by TECRO	11/15/19

Article V - Responsibilities of AIT

In addition to participation in the joint project team, AIT, through its designated representative as appropriate, shall:
A.   Provide overall coordination project activities at the GSD facility in Boulder, Colorado;
B.   Provide administrative support for preparing reports for delivery to TECRO, through CWB in accordance with this IA;
C.   Assign appropriate staff to perform the activities defined in this IA and provide support in accordance with the terms of the Umbrella Agreement; and
D.   Fulfill its responsibilities for this IA.

Article VI - Responsibilities of TECRO

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

A.   Provide overall coordination project activities at the CWB facility;

B.   Assign appropriate staff to perform the activities defined in this IA and provide support in accordance with the terms of the Umbrella Agreement; and

C.   Fulfill its responsibilities for IA #31.

Article VII - Financial Provisions and Budget

In accordance with Article VII – Financial Arrangements, of the Umbrella Agreement, TECRO shall pay AIT, in association with the project covered by this IA.

The total cost for activities described in this IA is mutually agreed to be U.S. $2,250,000, to support the tasks, travel, and meeting expenses described herein. TECRO agrees to transfer 50 percent of the funds to AIT in advance, with the remaining 50 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 following are the estimated costs for IA #31:

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	$250,000	$35,000	$285,000
Task #2 (NSSL)	$250,000	$0	$250,000
Task #3 (MDL/GSD)	$270,000	$0	$270,000
Task #4 (GSD)	$240,000	$35,000	$275,000
Task #5 (NCEP/EMC)	$210,000	$80,000	$290,000
Task #6 (GSD)	$305,000	$95,000	$400,000
Task #7 (CIMSS)	$250,000	$0	$250,000
Task #8 (PMEL)	$200,000	$30,000	$230,000
Total	$1,975,000	$275,000	$2,250,000

All budget figures are estimated. Actual amounts shall 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 Fiscal Year 1991 of the territory represented by AIT, 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 staff time is charged at the employee's salary plus the normal NOAA benefit, leave, and overhead charges. GSD professional staff people are primarily in the civil service grade scales

of GS-11 to GS-14. Contract staff is in equivalent categories. The performance of activities by AIT, through NOAA under this IA is subject to the availability of funds.

Article VIII - CWB Joint Team Assignments at NOAA/ESRL/GSD

Several tasks encourage CWB visitors at GSD, NESDIS, and MDL. The primary effort of TECRO, through CWB staff at NOAA during the IA #31 period shall be directed towards the satellite data, AWIPS II development tasks. The primary effort of TECRO, through CWB staff at CPC during the IA #31 period shall 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 IA. Specific assignments shall be made to most efficiently use the available personnel resources. Assignments for the qualified CWB staff members would be as follows:

- Surface Solar Insolation algorithm and product development;
- Enhancement of radar ingest process including decoding software;
- ANC verification package and new predictor(s);
- Development of GOES-R (H-8) algorithm in the area of SST and AMV (Atmospheric Motion Vectors);
- Localization of Decision Assistance Tool called SCAN (System for Convection Analysis and Nowcasting) under AWIPS II environment;
- Receiving training at CPC International Monsoon Desk;
- NGGPS modeling testing and implementation activity.

Article IX – Privileges, Exemptions, and Immunities

For purposes of visits and any other travel contemplated in this IA, staff of the Parties' designated representatives shall be considered consultants to AIT and TECRO, respectively, when in the territory represented by the counterpart organization. The Parties acknowledge that such individuals generally shall not be eligible for privileges, exemptions, and immunities pursuant to the 2013 Agreement on Privileges, Exemptions and Immunities between the American Institute in Taiwan and the Taipei Economic and Cultural Representative Office in the United States ("2013 Agreement") if the visit or any other travel is less than 90 days in duration or if the individual is-working at a location other than a facility of the sending organization. Nothing here is intended by the Parties as an amendment or other change to the 2013 Agreement, the provisions of which must be satisfied before any privileges, exemptions, or immunities may be provided by either Party.
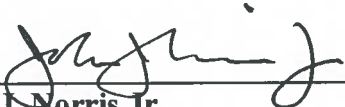
Article X - Intellectual Property Considerations

No activity described in this IA, or any technology or other information exchanged in the course of activities under this IA, is expected to give rise to, or implicate any existing, intellectual property rights. Reports, specifications, and computer software prepared under this IA are also expected not to be subject to intellectual property protection

Article XI - Effective Date, Amendment, and Termination

This IA becomes operative on the date of the last signature hereto This IA may be amended and/or terminated in accordance with the terms of the Agreement. This IA becomes effective upon signature of both parties. The estimated completion date for the activities described in this IA and the period of performance end date of this IA is December 31, 2020.
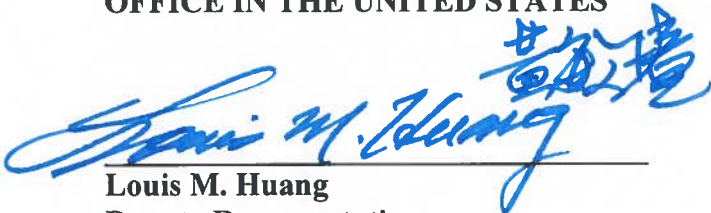
**FOR THE AMERICAN INSTITUTE
IN TAIWAN**

John J. Norris Jr.
Managing Director

12/11/2019

Date

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

Louis M. Huang
Deputy Representative

11 December 2019

Date