IMPLEMENTING ARRANGEMENT 33

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 for a scope of work, budget estimates, and visitor plan for 2021, as allowed under the 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." That framework is found in 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, signed March 16, 2021 (hereinafter "Umbrella Agreement"). This IA continues the scope of work as described in Implementing Arrangement #32 under the Umbrella Agreement, with modifications as reflected in Article II of this IA.

The activities under this IA are performed consistent with the Umbrella Agreement and are limited to providing for the addition of a statement of work, a visitor plan, and cost estimates for ongoing work efforts in 2021. This IA does not change the provisions of the terms and conditions of the Umbrella Agreement.

This IA is numbered IA #33 to distinguish it from the prior IA #32 attached as an annex to the Umbrella Agreement and the prior 31 Scopes of Work (SOWs) approved between TECRO and AIT under prior Agreements related to Meteorology and Forecast System Development since 1989.

Article II - 2021 Scope of Work

Task #1 Development and Improvement of Satellite Products for Surface Radiation and Air Quality Monitoring and Prediction by AIT, through NOAA

1. Development of Evapotranspiration Data Product from Advanced Himawari Imager for TECRO
    a. Definition and collection of ancillary and AHI satellite data sets is completed
    b. Refine GETD parameters for TECRO
    c. Tailor GETD for Taiwan domain

d. Test data sets are defined, GETD4CWB software system is tested using the test data sets, and sample ET data output generated and delivered to CWB for preliminary evaluation

2. Surface Radiation
    a. Derive a fully empirical NTB conversion for the full disk AHI domain using a longer record of AHI and CERES matchup data. This is a slow and tedious process requiring careful attention to matching data from different orbits and spatial resolutions.
    b. Implement the updated NTB conversion in the SRB algorithm and test the software
    c. Evaluate the surface radiation, retrieved from the updated SRB algorithm for at least six months, by comparing the AHI fluxes with ground measurements
    d. Prepare final package (code + documents + test data) for delivery
    e. Deliver final package to CWB
3. Aerosol Optical Depth
    a. Update the surface reflectance relationship (SRR) for the full disk AHI domain using more, seasonally-representative AHI data
    b. Update formulation of SRR used in version 2.1 of the AOD algorithm
    c. Implement the updated surface reflectance relationship and test the software
    d. Evaluate the aerosol optical depth, retrieved from the updated AOD algorithm for at least six months, by comparing the AHI AOD with ground measurements
    e. Prepare final package (code + documents + test data) for delivery
    f. Deliver final package to TECRO, through CWB
4. Monitoring Air Quality over Taiwan using Advanced Himawari Imager (AHI) Aerosol Optical Depth
    a. The GWR algorithm code delivered to CWB via anonymous FTP
    b. Assessment of CWB report on the GWR algorithm implementation including reviewing test products
    c. Evaluate the regression relationship between AHI AOD and surface PM10 data provided by the CWB/EPAT
    d. Develop a new GWR algorithm to derive surface PM10
    e. End of the year summary report through AIT and TECRO to CWB, in November 2021

Task #2 – High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement by AIT, through NOAA

1. Machine learning (ML) based radar QPE

a) Generate the initial ML QPE model for RCWF and for a C-pol radar
b) Set up the real-time ML QPE generation for RCWF and the C-Pol radar
c) Evaluate the real-time ML QPE performance for RCWF and the C-pol radar

2. Taiwan operational radar QPE R&D support
   a) Investigate the data voids in the operational radar QPE and develop a solution
   b) Investigate the circular artifacts in the operational radar QPE and develop a solution
   c) Improve the C-pol radar QPE
3. Technical support for the QPE Verification System (QVS) operations
   a) Implement the single-radar QPE display with the gauge overlay
   b) Implement the time series plot of single-radar QPE and gauge data
   c) Implement the single radar QPE vs. gauge scatter plot
   d) Develop the single-radar QPE and gauge comparison statistics

Task #3 - Enhancement of Nowcasting Decision Assistance Tools by AIT, through NOAA

1. AWIPS2/ VLab
   a) Continue support the use of extra data sources and the customization of MDL decisions-assistance applications
   b) Provide scientific consultation on new NWS applications used for operational forecasts
   c) Continue support the Virtual Lab use for TECRO, through CWB to access AWIPS2 resources
2. Visitors supporting for three forecasters from TECRO's Designated Representative

Task #4 - Development of High-Resolution Product Generation Assistance Tools for AWIPS II by AIT, through NOAA

1. Continued development towards operational functionality of the CAVE Annotation Tool (CAT)
   a) CWB CAT Application Plugins
   b) Configurable GUI Feature
   c) Operationalize/Improve existing capabilities
   d) CAT Application Programing Interface (API)
   e) CAT Training
2. Initial prototype of existing CWB weather warnings in Hazard Services (HS)
   a) Gather requirements for CWB watch/warning/advisory types
   b) Configure hazard types and associated metadata
   c) Configure skeletal product generation/product output
   d) Demonstrate functionality on AWIPS2 Cloud Instance with CWB forecasters
3. Development of a dedicated AWIPS Cloud Instance prototype for CWB to evaluate
4. Provide support and technical expertise to aid in CWB's migration onto AWIPS2

Task #5 – Enhancement of Next Generation Global to Regional Prediction System by AIT, through NOAA

1. Enhancement of Next Generation Global to Regional Prediction System
   a) Host CWB modeling visitor to participate in FV3GFS testing, evaluation and implementation activity for 12 Months at NOAA's Environmental Modeling Center (EMC) in College Park, Maryland (pending COVID-19 related travel approvals).
   b) EMC colleagues visit CWB to conduct technical workshops on FV3GFS, FV3CAM, GDAS, GEFS (four visits, 1-2 EMC scientists for each visit) for 1 to 2 weeks (pending COVID-19 related travel approvals).
   c) Facilitating CWB manager's visit to EMC for the project review meeting for 1 week.
   d) Deliver QA/QC model and documents (including test cases) for preprocessing data. EMC assigns 1 contact person for technical support.
2. Enhancement of Marine Modeling at CWB
   a) EMC continues to support Virginia Institute of Marine Science, College of William and Mary for deploying (HYCOM)-LETKF of Taiwan area code at CWB.
   b) Provide further enhancements to 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.
   c) Develop a comprehensive plan for regional wave DA and share the tasks between EMC and CWB.
   d) EMC shall provide assistance as needed to the technical team at CWB for setting up the regional HYCOM forecast system.
   e) EMC shall help with observation data for HyCOM DA for CWB region. Subsets of global observations/HyCOM restart files and analysis files from Global HyCOM/RTOFS-DA which was implemented at NCEP in December 2020 shall be made available for use at CWB.

Task #6 - Continuing Interaction on Earlier Cooperative Projects by AIT, through NOAA

1. Project Management supporting
2. DART consultation and a site visit support
3. Visitors and travel support
4. GSL Machine learning work
5. Utilize the real-time S4 scintillation index provided by the newly installed Septentio GNSS receiver at CWB to develop new scintillation products
6. Compare the line-of-sight S4 index with ROTI calculated at the same location to quantify the relationship between S4 and ROTI at Taiwan region
7. Increase available data through other resources in Taiwan

8. Compare the ground-based scintillation results with geolocated product from the COSMIC-II mission
9. Provide the research version of the WAM-IPE for TECRO, through CWB
10. Share the WAM-IPE forecast products with CWB

Task #7 – Development of GOES-R Decision Support Products from Himawari-8 by AIT, through NOAA

1. Development and support of existing satellite products
   a) Machine learning (ML) Near-Surface Visibility product
      - Improvement of training database
      - Development of visibility categorization products
   b) Cloud property-derived ML Quantitative Precipitation Estimate (QPE)
      - Improvement of intensity categorization product
      - Validation against hourly aggregate radar product
   c) Surface emissivity and Land Surface Temperature (LST)
      Produce new coefficients for Himawari-8 dual-channel LST retrieval using surface radiation stations
2. Satellite aircraft icing threat
   a) Generate training data from observations (e.g. PIREPS)
   b) Daytime ML based aircraft icing threat
      Based on Himawari-8/CLAVR-x daytime cloud products
   c) Nighttime ML based aircraft icing threat
      Based on Himawari-8/CLAVR-x IR optical properties and VIIRS day night band (DNB)
   d) Deliver daytime/nighttime aircraft icing threat code to MSC/CWB
3. AXI-tools and CLAVR-x product support
   a) Provide troubleshooting for CLAVR-x issues
   b) Provide code updates
4. Host CWB visitor for 3 months at CIMSS at University of Wisconsin – Madison for training and technical support

Task #8 –Tsunami Warning Enhancement Efforts for the Territory Represented by TECRO by AIT, through NOAA

1. ComMIT training is planned at CWB facility at the time determined during 2021, based on changing travel regulations.
2. Houbihu and one more coastal model from the priority list are planned to be developed. As a result, 5 forecast models shall be available for CWB tsunami warning operations by the end of 2021.
3. Tweb version shall be updated to new back-end version. This version shall include updated inversion algorithms of DART data, new propagation model database with global coverage that would eliminate the problem with ocean basin boundaries for tsunami propagation modeling.

4. Complete integration of the CWB real-time date into Tweb. The data should include the real-time stream from DART and Taiwan coastal tide-gauges. This shall require Application Program Interface development for DART data web streaming in collaboration with CWB. A test interface to the CWB tide-gauge data has already been developed, the work is planned to be completed in 2021.

Article III 2021 Visitor Plan

Two research assistants from CWB Weather Forecast Center shall visit NOAA/ESRLs/GSL for up to 3 months if not restricted by COVID-19 Pandemic restrictions in the territory represented by TECRO or the territory represented by AIT.

Article IV 2021 Annual Budget Plan

Tasks	**Personnel**	**Travel/Training**	**Total**
Task #1 (NESDIS/GSL)	$200,000	$0	$200,000
Task #2 (NSSL)	$220,000	$0	$220,000
Task #3 (MDL/GSL)	$200,000	$0	$200,000
Task #4 (GSL)	$250,000	$0	$250,000
Task #5 (NCEP/EMC)	$120,000	$0	$120,000
Task #6 (GSL)	$640,000	$30,000	$670,000
Task #7 (CIMSS)	$200,000	$0	$200,000
Task #8 (PMEL)	$120,000	$0	$120,000
Total	$1,950,000	$30,000	$1,980,000

Article V - Financial Provisions and Budget

Financial and budget provisions of this IA shall be made consistent with the provisions in the Umbrella Agreement. The performance by AIT, through NOAA, of activities under this IA is subject to the availability of funds.

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

Robin Cheng

Robin J.C. Cheng, Deputy Representative

12/01/2021

Date

FOR THE AMERICAN INSTITUTE IN TAIWAN

Ingrid Larson

Ingrid D. Larson, Managing Director

12/3/21

Date