IMPLEMENTING ARRANGEMENT #34

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 2022, 2023 and 2024, as allowed under 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 on March 15 and 16, 2021 (hereinafter "Umbrella Agreement"). The Parties to this IA are the Taipei Economic and Cultural Representative Office in the United States (TECRO) and the American Institute in Taiwan (AIT). This IA continues the scope of work as described in Implementing Arrangement #33 under the Umbrella Agreement, with modifications as reflected in Article II of this IA.

The activities under this IA shall be performed consistent with the Umbrella Agreement and shall be limited to providing for the addition of a statement of work, a visitor plan, and cost estimates for ongoing work efforts in 2022, 2023 and 2024. This IA does not change the provisions or the terms and conditions of the Umbrella Agreement.

This IA is numbered IA #34 to distinguish it from the prior IA #33 and IA #32, which was attached as an annex to the Umbrella Agreement, and the prior 31 Scopes of Work (SOWs) approved by TECRO and AIT under prior TECRO-AIT agreements related to meteorology and forecast systems development since 1989.

Article II – 2022, 2023 and 2024 Scopes of Work

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

I. 2022 Work Plan

A. Air Quality

1. Report on the analysis of PM2.5 and PM10 morphology over Taiwan
2. Delivery of aerosol detection (smoke and dust) algorithm for AHI (November 2022)

3. Report on the potential improvements to the accuracy of PM2.5 product using GEMS NO 2 and aerosol layer height as input to the GWR algorithm (November 2022)
4. Report on the potential improvements to the accuracy of PM2.5 product using AHI aerosol type as input to the GWR algorithm (November 2022)

B. GETD4CWB Development
1. Refine ALEXI model parameters for GETD4CWB
2. Refine the surface parameters of GETD4CWB
3. Streamline GETD4CWB input data downlinks
4. Collect all ET related in situ data for GETD4CWB ET product validation
5. Collect CWB feedback on refined GETD4CWB output
6. Plan and support migration of GETD4CWB to CWB facility

II. 2023 Work Plan

A. GETD4CWB Continuation:
1. Generate ET from GETD4CWB for a longer time period when AHI data are available
2. Comprehensively validate the long time period ET data
3. Generate ESI and QuickDRI for drought monitoring from the ET and other data
4. Collect satellite soil moisture data for the same time period of the ET data products and analyze its relationship with landslides for prediction.
5. Collect CWB feedback on the ET, ESI and QuickDRI data

B. Minimize gaps in the AOD (mostly due to clouds) and therefore estimated PM2.5 data from AHI, NESDIS wants to develop gap filling techniques to fill in the missing retrievals in the satellite imagery.

III. 2024 Work Plan

A. GETD4CWB (final delivery)
1. Refine GETD4CWB software system
2. Reprocess ET, ESI and QuickDRI data with the refined system
3. Assist TECRO, through its designated representative, CWB, with information on building a soil moisture in situ measurement capacity
4. Analyze relationship between soil moisture and landslides for prediction

B. Provision and demonstration of using new and higher spatial/spectral resolution observations from small satellites to enhance regional weather forecast and environmental monitoring in the Taiwan region, such as COWVR/TEMPEST.

C. Coordinate with TECRO, through its designated representative, CWB, in utilization of AHI AOD and PM2.5 products along with ground monitoring for Asia-AQ field campaign.

D. Trace gases retrieved from GEMS and TROPOMI instruments (Nitrogen Dioxide, Sulfur Dioxide, Formaldehyde, Glyoxal, Ozone, and aerosols). Additional enhancements to aerosol retrievals (such as aerosol particle size, layer height, UV aerosols index)

E. New Fused GEO+LEO Multi-Satellite Product: Stereo-Winds from Collocated ABI and VIIRS Datasets

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

I. 2022 Work Plan

A. Spatiotemporal analysis of high-frequency radar and gauge rainfall data
   1. Collect 10-min radar and gauge rainfall data with 2-min update cycle from different precipitation regimes
   2. Analyze probability distribution of the high-frequency 10-min rainfall intensity
   3. Analyze spatiotemporal variations of the high-frequency 10-min rainfall intensity

B. Enhancements of the operational radar QPE (quantitative precipitation estimation)
   1. Identify events where the operational radar QPE had significant errors or artifacts
   2. Investigate potential contributing factors to the errors in the radar QPE processes
   3. Refine the radar QPE processes (e.g., quality control, precipitation rate estimation) to mitigate the errors

C. Technical support for the QPE Verification System (QVS) operations

II. 2023 Work Plan

A. Explore local gauge correction of the radar QPE at high-frequencies
   1. Compare 10-min gauge rainfall with 10-min radar QPE
   2. Develop an experimental local gauge corrected (LGC) 10-min radar QPE with 2-min update cycle
   3. Evaluate the high-frequency LGC radar QPE and document the results

B. Taiwan operational radar QPE R&D support
   1. Trouble shoot errors and artifacts in the operational radar QPE
   2. Develop mitigations to reduce the errors and artifacts

C. Technical support for the QPE Verification System (QVS) operations

III. 2024 Work Plan

A. Mitigate wet bias in light rain for C-pol radar QPE
   1. Collect cases where the C-pol radar QPE exhibited wet bias in light rain
   2. Analyze environmental data associated with the cases
   3. Develop new radar-rain rate relationships to reduce the bias

B. Taiwan operational radar QPE R&D support

C. Technical support for the QPE Verification System (QVS) operations

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

I. 2022 Work Plan

A. AWIPS2/ VLab

1. Continue support for the use of extra data sources and the customization of MDL decisions-assistance applications
2. Provide scientific consultation on new NWS applications used for operational forecasts
3. Continue support for the Virtual Lab use for TECRO, through its designated representative, CWB, to access AWIPS2 resources

II. 2023 Work Plan

A. AWIPS2/ VLab

1. Continue support for the use of extra data sources and the customization of MDL decisions-assistance applications
2. Provide scientific consultation on new NWS applications used for operational forecasts
3. Continue support for the Virtual Lab use for TECRO, through its designated representative, CWB, to access AWIPS2 resources

III. 2024 Work Plan

A. AWIPS2/ VLab

1. Continue support for the use of extra data sources and the customization of MDL decisions-assistance applications
2. Provide scientific consultation on new NWS applications used for operational forecasts
3. Continue support for the Virtual Lab use for TECRO, through its designated representative, CWB, to access AWIPS2 resources

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

I. 2022 Work Plan

A. Hazard Services

1. Couple CWB GFE to formatted products
2. Training Sessions-System Architecture Introduction & Localization/Customization Development Skills
3. One CWB (Information Center) staff member is to visit GSL to receive in-person training for 4 months (funded by TECRO, through its designated representative, CWB, contingent upon travel restrictions)

B. Support Migration from WINS to AWIPS-II and Consulting

II. 2023 Work Plan

A. Hazard Services

1. Assist in GridBasedTool implementation to couple with GFE for forecaster-assisted hazard event creation using artificial intelligence methods (recommenders)

2. Assist in variety of scientific recommenders development
3. Continued Training Sessions for Hazard Services

B. AWIPS-II Technical Support and Consulting

III. 2024 Work Plan

A. FACETs (probabilistic information) applications and implementation consulting
B. Assist in Marine Hazard product development
C. Continued Training Sessions
D. AWIPS-II Technical Support and Consulting

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

I. 2022 Work Plan

A. Continued engagement in model, physics, ensemble, and DA development activities
   1. Unified physics parameterizations for models across different temporal and spatial scales (Global Modeling/Physics)
   2. Coupled Model Prototypes using UFS coupled System (Global Modeling/Ensembles)
   3. Weakly Coupled Data Assimilation (Global Modeling/DA)
   4. RRFS for high-resolution mesoscale modeling (Regional Modeling/Short-range weather)
   5. HAFS for typhoon predictions (Regional Modeling/Typhoons)
B. Continued engagement in Marine Modeling and DA development activities
   1. Taiwan region products/data from operational RTOFS-DA in support of HyCOM DA
   2. MOM6 and HyCOM based global and regional DA
   3. JEDI-SOCA Data Assimilation for ocean and wave modeling
C. Re-establish Visiting Scientist opportunities (travel permitting)
D. Plan for an in-person workshop in 2022 (travel permitting, with limited participation from NCEP and CWB)
E. Expand S2S studies to include forecast skill evaluation on weekly and subseasonal (weeks 3&4) time scales with additional focus on calibrated forecast distribution instead of ensemble mean including AI/ML.

II. 2023 Work Plan

A. Continued engagement in model, physics, ensemble, and DA development activities
   1. Unified physics parameterizations for models across different temporal and spatial scales (Global Modeling/Physics)

2. Coupled Model Prototypes using UFS coupled System (Global Modeling/Ensembles)
3. Weakly Coupled Data Assimilation (Global Modeling/DA)
4. RRFS for high-resolution mesoscale modeling (Regional Modeling/Short-range weather)
5. HAFS for typhoon predictions (Regional Modeling/Typhoons)

B. Continued engagement in Marine Modeling and DA development activities
   1. Taiwan region products/data from operational RTOFS-DA in support of HyCOM DA
   2. MOM6 and HyCOM based global and regional DA
   3. JEDI-SOCA Data Assimilation for ocean and wave modeling

C. Continue supporting Visiting Scientists

D. Plan for in-person workshop in 2023 (broader engagement with NCEP, CWB and collaborators)

E. Expand S2S studies to include forecast skill evaluation on weekly and subseasonal (weeks 3&4) time scales with additional focus on calibrated forecast distribution instead of ensemble mean including AI/ML.

III. 2024 Work Plan

A. Continued engagement in model, physics, ensemble, and DA development activities
   1. Unified physics parameterizations for models across different temporal and spatial scales (Global Modeling/Physics)
   2. Coupled Model Prototypes using UFS coupled System (Global Modeling/Ensembles)
   3. Weakly Coupled Data Assimilation (Global Modeling/DA)
   4. RRFS for high-resolution mesoscale modeling (Regional Modeling/Short-range weather)
   5. HAFS for typhoon predictions (Regional Modeling/Typhoons)

B. Continued engagement in Marine Modeling and DA development activities
   1. MOM6 and HyCOM based global and regional DA
   2. JEDI-SOCA Data Assimilation for ocean and wave modeling

C. Continue supporting Visiting Scientists

D. Plan for in-person workshop in 2024 (limited participation from NCEP and CWB)

E. Expand S2S studies to include forecast skill evaluation on weekly and subseasonal (weeks 3&4) time scales with additional focus on calibrated forecast distribution instead of ensemble mean including AI/ML.

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

I. 2022 Work Plan

A. Project Management supporting
B. DART consultation and a site visit support
C. Visitors and travel support
D. Utilize the real-time S4 scintillation index provided by the newly installed Septentio and GNSS receiver at CWB to develop new scintillation products
E. Compare the line-of-sight S4 index with ROTI calculated at the same location to quantify and the relationship between S4 and ROTI at Taiwan region
F. Increase the availability of data such as solar flux measurements for use by other groups in Taiwan such as Central Weather Bureau (CWB), Taiwan Analysis Center for COSMIC (TACC) and the other groups in Taiwan.
G. Compare the ground-based scintillation results with geolocated product from the COSMIC-II mission
H. Provide the research version of the WAM-IPE for TECRO, through its designated representative, CWB, and share the WAM-IPE forecast products with TECRO, through its designated representative, CWB

II. 2023 Work Plan

A. Project Management supporting
B. DART consultation and a site visit support
C. Visitors and travel support
D. Utilize the real-time S4 scintillation index provided by the newly installed Septentio and GNSS receiver at CWB to develop new scintillation products
E. Compare the line-of-sight S4 index with ROTI calculated at the same location to quantify and the relationship between S4 and ROTI at Taiwan region
F. Increase the availability of data such as vertical plasma drift velocity for use by other groups in Taiwan such as Central Weather Bureau (CWB), Taiwan Analysis Center for COSMIC (TACC) and the other groups in Taiwan.
G. Compare the ground-based scintillation results with geolocated product from the COSMIC-II mission
H. Provide the research version of the WAM-IPE for TECRO, through its designated representative, CWB, and share the WAM-IPE forecast products with TECRO, through its designated representative, CWB

III. 2024 Work Plan

A. Project Management supporting
B. DART consultation and a site visit support
C. Visitors and travel support
D. Utilize the real-time S4 scintillation index provided by the newly installed Septentio and GNSS receiver at CWB to develop new scintillation products
E. Compare the line-of-sight S4 index with ROTI calculated at the same location to quantify and the relationship between S4 and ROTI at Taiwan region

F. Increase the availability of data such as the magnetic activity parameter for use by other groups in Taiwan such as Central Weather Bureau (CWB), Taiwan Analysis Center for COSMIC (TACC) and the other groups in Taiwan.
G. Compare the ground-based scintillation results with geolocated product from the COSMIC-II mission
H. Provide the research version of the WAM-IPE for TECRO, through its designated representative, CWB, and share the WAM-IPE forecast products with TECRO, through its designated representative, CWB

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

I. 2022 Work Plan

A. Continued development and support of existing AI satellite products
   1. Atmospheric Cloud-based QPE
   2. Aircraft Icing Threat (Daytime/Nighttime)
   3. Near-surface Visibility
B. CLAVR-x products
   1. High resolution 1 km cloud mask and products for Himawari-08
   2. Ingest Korean UHRIT Full Disk data and generate cloud products
C. Tuning for product retrieval
D. ADT code updates to the following
   1. Intensity derivation schemes for extratropical and subtropical storms
   2. 2-dimentional wind field estimation scheme
   3. Tropical cyclone storm center determination scheme (ARCHER)
E. Continue AXI-tools and CLAVR-x product support
F. Provide technical and training support to CWB visitor for 3 months at facility in Madison, Wisconsin, subject to allowability per applicable pandemic restrictions.

II. 2023 Work Plan

A. Continued ADT upgrades for Cat 1 & 2 TCs
B. Himawari-9 scheduled to replace Himawari-8 in 2022
   1. Support for existing AI satellite products will be added for Himawari-9
   2. High resolution cloud products for Himawari-9
C. High Resolution (1 km) Himawari-8/9 cloud products
D. CLAVR-x support for GEO-KOMPSAT-2A
E. CLAVR-x support for Metop-SG
F. QPE development
   1. Expand training data to include Mei-Yu season
   2. Include topographical information in AI model
   3. Perform a more extensive radar evaluation
   4. Validate mask product versus QPE product
   5. Code read-in lat/lon limits from CLAVR-x L2 files

III. 2024 Work Plan

A. Near-surface Visibility development
   1. Replace climatological AOT with the operational product currently run at CWB

B. Daytime/Nighttime aircraft icing development
   1. Validation studies
   2. Training data expansion, TAMDAR data, CONUS 2021 and H8 to 2016
   3. DNB lunar illumination as a proxy, short and long term.
   4. Intensity prediction
   5. Pixel resolution modelling
   6. Automate day/night mode detection

C. AI-based Synthetic radar
   1. Builds upon QPE product to produce synthetic radar values from satellite retrievals

D. Surface evaporation product
   1. Clear air surface evaporation retrievals and validation

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

I. 2022 Work Plan

A. Host/provide ComMIT training at a CWB facility or online, pending travel restrictions

B. Develop a forecast model for the Windfarm (Huxi and Kohu) from the priority list, thus making available 6 forecast models for CWB tsunami warning operations via Tweb

C. Update Tweb version to new back-end version, to include updated inversion algorithms of DART data and Taiwan-specific interface features

D. Complete integration of the CWB real-time data into Tweb, to include real-time stream from DART.

E. Develop/work on Application Program Interface (API) development for DART data web streaming in collaboration with TECRO, through its designated representative, CWB, and SAIC.

II. 2023 Work Plan

A. Forecast model development tasks:
   1. Create system of computational grids using available bathymetry data
   2. Develop reference model for baseline accuracy testing
   3. Develop optimized real-time model with acceptable accuracy and computation speed
   4. Test the model for accuracy and robustness of operations with multiple scenarios
   5. Implement the model-into Tweb environment for operations
   6. Subtotal budget for flooding forecast models for Keelung and 2 North Power Plants

B. Tweb development/maintenance

1. Develop/update new robust backend for operations, including updated automated data inversion and new real-time modeling environment

C. Training/support
   1. Technical team travel for updates, development, discussion and training (preparation, PMEL people travel, conduct training)

III. 2024 Work Plan

A. Forecast model development tasks:
   1. Create system of computational grids using available bathymetry data
   2. Develop reference model for baseline accuracy testing
   3. Develop optimized real-time model with acceptable accuracy and computation speed
   4. Test the model for accuracy and robustness of operations with multiple scenarios
   5. Implement the model-improvements into Tweb environment for operations
   6. Subtotal budget for flooding forecast models for Cheng Kung and Taitung

B. Tweb development/maintenance
   1. Develop/update new robust backend for operations, including updated automated data inversion and new real-time modeling environment

C. Training/support
   2. Technical team travel for updates, development, discussion and training (preparation, PMEL people travel, conduct training)

Task #9 –Weather Archive and Visualization Environment Development And Related Research for the Territory Represented by TECRO by AIT, through its designated representative, NOAA

I. 2022 Work Plan

A. Weather Archive and Visualization Environment Development
   1. Identification and procurement of necessary hardware at CWB to run WAVE
   2. Delivery of WAVE Code and Translated Documentation
   3. Initial Training on WAVE system complete
   4. Initial WAVE running with example data at CWB

B. Continued development of Tropical Cyclone Intensification Algorithm
   1. Discussion of landslide project tasks and requirements
   2. Delivery of TD to TC Intensification Algorithm to CWB
   3. Data gathered for landslide project
   4. Training completed on TD to TC Intensification Algorithm
   5. Initial results of landslide project delivered to CWB
   6. Discussion of 2023 Machine Learning (ML) Tasks

II. **2023 Work Plan**

A. Weather Archive and Visualization Environment Development
   1. Training on adding new datasets and regions complete
   2. Initial CWB datasets and regions added to CWB WAVE System
   3. Delivery and implementation of any WAVE code updates

B. Continued development of Tropical Cyclone Intensification Algorithm

1. Refine tasking based on lessons learned in first year
2. Discussion of landslide project tasks and requirements
3. Provide training to CWB staff on applying ML methods
4. Data for landslide project gathered
5. Delivery of first implementation of AI algorithm,
6. First prototype of landslide project algorithm complete
7. Discussion of 2024 Machine Learning (ML) Tasks

III. 2024 Work Plan

A. Weather Archive and Visualization Environment Development
   1. Final Delivery of latest WAVE code and documentation updates
   2. Online training for WACE code and operation

B. Continued development of Tropical Cyclone Intensification Algorithm 2023 Work
   1. Discussion of project requirements for 2024 ML Tasks
   2. Provide training to CWB staff
   3. Delivery of implementation of latest AI algorithm
   4. Delivery of updated landslide algorithm

Article III - 2022, 2023, 2024 Visitor Plan

TECRO and AIT intend that four research assistants from CWB Weather Forecast Center are to visit NOAA/ESRLs/GSL for up to 6 months if not restricted by COVID-19 Pandemic restrictions in the territory represented by TECRO or the territory represented by AIT.

Article IV - 2022, 2023 and 2024 Annual Budget Plan

Tasks for 2022	**Personnel**	**Travel/Training**	**Total**
Task #1 (NESDIS/GSL)	$200,000		$200,000
Task #2 (NSSL)	$220,000		$220,000
Task #3 (MDL/GSL)	$100,000		$100,000
Task #4 (GSL)	$250,000		$250,000
Task #5 (NCEP/EMC)	$120,000		$120,000
Task #6 (GSL)	$250,000	$203,400	$453,400
Task #7 (CIMSS)	$200,000		$200,000
Task #8 (PMEL)	$120,000		$120,000
Task #9 (GSL)	$200,000	$120,000	$320,000
Total	$1,660,000	$323,400	$1,983,400

Tasks for 2023	**Personnel**	**Travel/Training**	**Total**
Task #1 (NESDIS/GSL)	$200,000		$200,000

Task #2 (NSSL)	$220,000		$220,000
Task #3 (MDL/GSL)	$100,000		$100,000
Task #4 (GSL)	$250,000		$250,000
Task #5 (NCEP/EMC)	$120,000		$120,000
Task #6 (GSL)	$250,000	$233,400	$483,400
Task #7 (CIMSS)	$200,000		$200,000
Task #8 (PMEL)	$120,000		$120,000
Task #9 (GSL)	$200,000	$120,000	$320,000
Total	$1,660,000	$353,400	$2,013,400

Tasks for 2024	**Personnel**	**Travel/Training**	**Total**
Task #1 (NESDIS/GSL)	$200,000		$200,000
Task #2 (NSSL)	$220,000		$220,000
Task #3 (MDL/GSL)	$100,000		$100,000
Task #4 (GSL)	$250,000		$250,000
Task #5 (NCEP/EMC)	$120,000		$120,000
Task #6 (GSL)	$250,000	$233,400	$483,400
Task #7 (CIMSS)	$200,000		$200,000
Task #8 (PMEL)	$120,000		$120,000
Task #9 (GSL)	$200,000	$120,000	$320,000
Total	$1,660,000	$353,400	$2,013,400

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 its designated representative, 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

Washington, D.C.

Place

10/24/2022

Date

FOR THE AMERICAN INSTITUTE IN TAIWAN

Ingrid Larson

Ingrid D. Larson
Managing Director

Arlington, VA

Place

10/20/2022

Date