Implementing Arrangement #29

Development of a hazardous weather monitoring and forecast system
Pursuant to the
Agreement between the
Taipei Economic and Cultural Representative Office in the United States
and the American Institute in Taiwan
for
Technical Cooperation in Meteorology and Forecast Systems Development

Article I - Scope

This Implementing Arrangement describes the scientific and technical activities to be undertaken by the American Institute in Taiwan (AIT), through its designated representative, the Global System Division (GSD) (formally the Forecast Systems Laboratory) of the Earth System Research Laboratory (ESRL) of the National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce (hereinafter NOAA/ESRL/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 Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO), and NOAA/ESRL/GSD. This Implementing Arrangement is of mutual interest to both TECRO and AIT, hereafter referred to as the parties. The products of this Implementing Arrangement will provide substantial value through development of new and upgraded capabilities and applications that can be integrated into other NOAA/ESRL/GSD systems.

Article II - Authorities

The activities described in this Implementing Arrangement will be carried out under and are subject to the general terms and conditions established by the Agreement between TECRO and AIT for Technical Cooperation in Meteorology and Forecast Systems Development signed on October 21 and 20, 2016, and any subsequent amendment thereof agreed to by the parties. This Implementing Arrangement is the twenty-ninth such arrangement under a succession of umbrella agreements between TECRO and AIT.

Article III - Services

During the period of Implementing Arrangement #29 (IA #29), NOAA/ESRL/GSD and CWB will continue a new phase VI program on hazardous weather monitoring and forecasting. Therefore the NOAA/ESRL/GSD-CWB joint team will expand work to address this hazardous weather theme. Seven tasks are identified: (1) Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction (2) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement (3) Enhance 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 and (7) Development of GOES-R decision support products from Himawari-8. Tasks under this Implementing Arrangement range from full scale developmental collaboration to system upgrades and support that allow systems to operate with the latest technical and scientific capabilities and specifications. These ongoing activities, described in more detail in the Statement of Work, will include the following seven tasks:

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

During IA #29, NOAA/ESRL/GSD has agreed that NOAA/STAR/SMCD will lead this task. NOAA/STAR/SMCD will develop surface solar insolation algorithm from WRF forecast and generate surface solar insolation product from Advanced Himawari Image (AHI) for renewable solar energy forecast and validation and renewable energy distribution. The benefit is to provide real-time forecast of solar energy distribution.

Due to the similarity between Himawari AHI and GOES-R ABI instruments, the sixteen bands (three visible, three near-infrared and ten infrared) for the AHI provided a unique opportunity for Convective Initialization (CI) nowcasting and monitoring capability. CI is also a challenging for model to capture at the right time and right location. NOAA/STAR/SMCD will convert Convective Initiation (CI) software package from Matlab to Fortran, so CWB can assess the impact of CI on convective precipitation.

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

During IA #29, NOAA/ESRL/GSD, has agreed that NOAA/NSSL (National Severe Storms Laboratory) will continue research towards maintenance, refinement, and improvement of the High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) applications required for the CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB).

This task will include a training of CWB visitors on the radar ingesting software. This training will provide CWB with capabilities to customize its new radar integration process. NSSL will work with CWB to refine and streamline radar quantitative precipitation estimation (QPE) workflow and to enhance the CWB's capability to improve its operational products. NSSL will develop blockage reference data sets for new precipitation radars to facilitate the integration of the new radars into the operational system.

NOAA/NSSL will make available to the CWB, as requested, the radar ingest software and blockage reference data sets for the new radars. NOAA/NSSL will also provide CWB, as requested, consultations as part of QPESUMS technical support.

Task 3 - Enhance 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 hydrometeorological 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 #29, NOAA/ESRL/GSD has agreed that the MDL will 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.

First, MDL will continue to focus on more thorough customization support to the Flash Flood Monitoring and Prediction (FFMP) tool on its operational use at the Forecast Center after the Hydrologic Unit Code (HUC) layer implementation was made in IA #27 as the HUC layers would add more important hydrological characteristics beyond the implementation of Township layer and small-basin layer that were completed under prior IAs.

In order to enhance the collaboration between CWB's WINS team and MDL staff in the area of AWIPS II software and decision assistance tools developed by MDL, MDL will assist CWB to get access to NOAA's VLab (Virtual Laboratory), which is an innovation collaboration framework to provide AWIPS II software development environment. VLab will greatly benefit the CWB development team's efforts to engage in software development and conduct customization for CWB local environment.

Secondly, MDL will continue to technically support CWB on its implementation of System on AWIPS for Forecasting and Evaluation of Seas and Lakes (called SAFESEAS) under AWIPS II development environment.

Thirdly, MDL will continue to provide CWB training and technical support on the AutoNowCaster (ANC) system. The MDL's version of ANC, which is substantially different from its original NCAR version and has been improved with far fewer software crashes and much easier configuration for its operational use, was delivered to CWB along with a verification package in IA #28. The ongoing training and technical support are needed to configure it, use it, and interpret its results so that the CWB's forecasters make informed use of ANC's output.

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

The National Weather Service (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 U.S. National Weather Service (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.

During IA #27, NOAA/ESRL/GSD, received permission from NWS to provide an evaluation copy of the AWIPS II software to CWB. This support continued through IA #28, with periodic updates provided. GSD also provided AWIPS II training for CWB developers. One CWB visitor

to GSD in 2016 learned many details about AWIPS II and, with GSD, began design/development work on some components specifically needed by the CWB.

For IA #29, GSD will continue to support CWB developers by providing updated versions of the AWIPS II software. GSD will work with NWS/Meteorological Development Laboratory to set up a shared software repository, where GSD and CWB visitor(s) will maintain code that they will share with other CWB staff who are developing and testing new software.

GSD has explored the new FDSE (Forecaster Decision Support Environment) system to view data pertinent to the given weather scenario. There are three major components that make up the FDSE: Ensemble tools, Grid monitor and Short-term update tool. During IA #29, GSD will continue to provide some training of FDSE to CWB forecasters to explore new data management and processing capabilities to enhance situational awareness, allow forecasters to work more efficiently, and improve model ensemble capabilities in order to explore probabilistic forecast products. Additional collaborative work will address ingest and display of CWB-specific lightning, satellite, and grid datasets.

During IA #29, GSD will continue to provide technical support for the Graphical Forecast Editor (GFE), GFE Smart Tools (techniques to automate or semi-automate grid editing), and the text formatters (TF) used in CWB's Forecast Information Editing System (FIES). In conjunction with NWS, GSD continues to work on improvements in Smart Tools, and is developing new forecast monitoring and ensemble-based forecast support tools, some of which will be included in the AWIPS II release in 2017.

This interaction will benefit NOAA and CWB, with updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #29, NOAA/ESRL/GSD will provide training and support to CWB visitors and forecasters, continue the exchange of visits, provide reports, attend annual meetings, and continue e-mail interactions.

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

During IA #29, NOAA/ESRL/GSD has agreed that NWS/NCEP (National Centers of Environmental Prediction)/EMC (Environmental Modeling Center) will lead this task. EMC will facilitate CWB modeling staff to participate in NOAA/NWS's NGGPS (Next Generation Global Prediction System) activity. Dr. Vijay Tallapragada, Chief of Global Modeling Branch will be the official POC for this task and will coordinate the collaborative activities related to this task between NOAA and CWB.

NGGPS's goal is to design/develop/implement a new global atmospheric prediction model with non-hydrostatic scalable dynamics with advanced physics, improved data assimilation and apply next generation high performance computing. Under the NGGPS program, a test plan consisting of three phases was implemented to test and evaluate the best dynamic core from six candidate models (two from NCEP/EMC, one from NCAR, one from NOAA/ESRL, one from Navy and one from NOAA/GFDL). GFDL's Finite Volume Model Cubed Sphere (FV3) dynamic core was selected after Phase 2 in June 2016. The Phase 3 is for operational implementation of FV3 dynamic core with community based common physics package (CCPP) and improved data assimilation.

Specific for IA #29, NCEP/EMC will assist in hosting a long-term CWB modeling staff to participate in the NGGPS operational testing and implementation activities, so CWB can actively

make contribution for this program. Through this collaboration, CWB could position its own development of a next generation global forecast system from NOAA's NGGPS knowledge and operational experience. NCEP/EMC will also support a joint annual NCEP-CWB global modeling workshop involving EMC scientists to exchange science and operational knowledge in the area of Global Forecast System (GFS) and Global Ensemble Forecast System (GEFS).

Task #6 - Continuing Interaction on Earlier Cooperative Projects

Several earlier cooperative tasks have been completed. Technology has been transferred successfully and is beginning to be used operationally at the facilities of the CWB. The task for NOAA/ESRL/GSD in this area is the development of new tools that extend and enhance the forecast applications. Further NOAA/ESRL/GSD interaction with CWB is critical to keep CWB staff up to date on current AWIPS II developments. This task will directly improve and update CWB's current forecast assistant and decision making systems at appropriate levels.

NOAA/ESRL/GSD has U.S. export control approval to provide CWB with AWIPS II software as released by the contractor. The software was first made available to CWB in 2013. During IA #29, NOAA/ESRL/GSD will continue to provide updated versions and training to CWB visiting scientists on the new AWIPS II extended/ enhanced forecaster applications such as GFE improvements and Collaboration that are being developed by NOAA/ESRL/GSD.

NOAA/ESRL/GSD will continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes during IA #29. This continuing interaction task will benefit NOAA and CWB, with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #29, NOAA/ESRL/GSD will provide necessary training and support to CWB visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

During IA #29, NOAA/GSD and NWS/NCEP/CPC will continue to assist CWB in developing capability for climate services, by providing training such as through NCEP's International Monsoon Training Desk Program.

During IA #28, GSD had coordinated an assessment study of installing a few DART® (Deep-ocean Assessment Reporting of Tsunamis) buoys south of Taiwan for CWB's tsunami warning system. DART®, originally developed by NOAA, is a critical component of the NOAA tsunami program. During IA #29, GSD will continue to coordinate additional training on the NWW3 (NOAA Wave Watch III) model for CWB's Marine Meteorological Center. This training will provide CWB with knowledge to review the NWW3 product and customize the NWW3 for regional applications. NWW3 training will be provided by Marine Modeling and Analysis branch of NCEP/EMC (Environmental Modeling Center).

During IA #29, NOAA/STAR/SMCD will continue to improve the satellite data application in CWBGFS (CWB Global Forecast system). NOAA/STAR/SMCD will provide technical support on satellite data assimilation implementation and improvement.

Task #7 Development of GOES-R decision support products from Himawari-8

During IA #29, NOAA/ESRL/GSD has agreed that University of Wisconsin – Space Science and Engineering Center (SSEC) / Cooperative Institute for Meteorological Satellite Studies (CIMSS) will lead this task.

This task will include documentation of (a) Implementation of current CLAVR-x (Clouds from AVHRR Extended) algorithms and (b) High Rate Information Transmission (HRIT) of Himawari-8 data. CLAVR-x is NOAA's operational cloud processing system for the AVHRR on the NOAA-POES and EUMETSAT-METOP series of polar orbiting satellites. CLAVR-x algorithms are analogs of those developed for the GOES-R AWG (Algorithm Working Group) Cloud Application Team.

A version of CLAVR-x capable of processing Himawari-8 Advanced Himawari Imager (AHI) radiances is currently running at the Meteorological Satellite Center (MSC) in the CWB. Running the retrieval algorithms, including all of the byproducts produced as part of this process, generates dozens of different cloud, radiometric and atmospheric fields that have the capacity to be produced as output. There are several opportunities for collaboration between CIMSS and MSC/CWB to exploit and enhance CLAVR-x capabilities. These include: 1) Identification of existing products that may meet needs of the MSC/CWB (e.g. Cloud Optical Path and Cloud Solar Transmission); 2) Reduction of the time it takes to process a AHI full-disk through CLAVR-x; 3) Development of pathways from CLAVR-x output to Advanced Weather Interactive Processing System (AWIPS)-compatible formats.

CIMSS will provide support and expertise to MSC/CWB personnel in the development and use of True Color and RGB imagery that meets MSC/CWB operational requirements.

CIMSS will develop a conversion process to ingest native HRIT files into CLAVR-x. The data is from the HimawariCast data stream service (via communication satellite) already in place at MSC/CWB. The goal would be to create a secondary method of processing real-time CLAVR-x. One potential method would be to use a McIDAS Abstract Data Distribution Environment (ADDE) to read in the HRIT files and format to McIDAS AREA files. CIMSS would then develop a new CLAVR-x module to read-in converted AREA files and perform navigation/formatting/calibration before processing through CLAVR-x.

CIMSS will initiate the implementation of the Advanced Dvorak Technique (ADT) algorithm to generate objective and automated estimates of Typhoon Intensity at MSC/CWB. This will be done in two phases: 1) Phase one will include training and familiarization of the ADT algorithm and its performance behaviors in collaboration with CWB personnel, and packaging/preparation of the code at CIMSS to be delivered and operate in the MSC/CWB environment 2) Phase two will involve the validation of the CWB estimates against the version currently running at CIMSS, troubleshooting, and maintenance. No commercial packages are required for this implementation, however, the ADT algorithm expects input satellite data streams (e.g., Himawari, LEO) to be locally available at CWB and the input file formats to conform to the code readers.

Article IV - Responsibilities of AIT

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

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

B. Provide administrative support for preparing reports for delivery to CWB in accordance

with this Implementing Arrangement;

C. Assign appropriate staff to perform the activities defined in this Implementing Arrangement and provide support in accordance with the terms of the terms of the Agreement for Technical Cooperation in Meteorology and Forecast Systems Development between TECRO and AIT; and

D. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #29.

Article V - Responsibilities of TECRO

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

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

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

C. Fulfill its responsibilities under the Statement of Work for Implementing Arrangement #29.

Article VI - Financial Provisions

In accordance with the Umbrella Agreement, TECRO is required to reimburse AIT for all costs incurred by NOAA/ESRL/GSD in association with the project covered by this Implementing Arrangement. AIT shall transfer to NOAA/ESRL/GSD all payments made by TECRO to AIT for costs incurred by NOAA/ESRL/GSD in association with this Implementing Arrangement.

The total cost for activities described in this Implementing Arrangement is mutually agreed to be U.S. $1,835,000. TECRO agrees to transfer fifty percent of the funds to AIT in advance, with the remaining fifty percent to be transferred upon completion of the year's activities, to the extent that funds for this purpose have been provided by TECRO.

NOAA Information
Treasury Symbol: 13x1450
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ALC: 13-14-0001
OMB MAX CODE: 006-48
BETC CODE: COLL

The performance by NOAA/ESRL/GSD of activities under this Implementing Arrangement is subject to the availability of funds.

Article VII - Intellectual Property Considerations

No intellectual property considerations are expected to arise in conjunction with activities described in this Implementing Arrangement. Existing system designs and computer software of the forecast system of NOAA/ESRL/GSD are in the public domain. Reports, specifications, and computer software prepared under this Implementing Arrangement also will be in the public domain once NOAA and CWB have approved them in final form.

Article VIII - Effective Date, Amendment, and Termination

This Implementing Arrangement is effective on the date of the last signature hereto. This Implementing Arrangement may be amended and/or terminated in accordance with the terms of the Umbrella Agreement. The estimated completion date for the activities described in this Implementing Arrangement is December 31, 2017, and the termination date of this Implementing Arrangement is June 30, 2018.

FOR THE TAIPEI ECONOMIC AND CULTURAL REPRESENTATIVE OFFICE IN THE UNITED STATES	FOR THE AMERICAN INSTITUTE IN TAIWAN
Remus Chen	
Remus Li-Kuo Chen	**John J. Norris Jr.**
Deputy Representative	**Managing Director**
09-15-2017	09-15-2017
Date	**Date**

Statement of Work
For Implementing Arrangement #29
Development of a Hazardous Weather Monitoring and Forecasting System

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

1.0 - Background and Objectives

This Statement of Work addresses tasks that will be undertaken by the joint team of the Global Systems Division (GSD) of the Earth System Research Laboratory (ESRL), the designated representative of the American Institute in Taiwan (AIT) and personnel of the Central Weather Bureau (CWB), the designated representative of the Taipei Economic and Cultural Representative Office in the United States (TECRO) in accordance with the terms of Implementing Arrangement #29 of 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, signed by TECRO and AIT on October 21 and 20, 2016, which provides for technical cooperation between AIT's designated representative, the U.S. National Oceanic and Atmospheric Administration's Global Systems Division (NOAA/ESRL/GSD) and TECRO's designated representative, the Taiwan Central Weather Bureau (CWB). The two designated representatives cooperate on the development of meteorology and forecast systems.

The Weather Forecast Office system (WFO-Advanced) currently under development at NOAA/ESRL/GSD in Boulder, Colorado, has been deployed as an essential part of the Advanced Weather Interactive Processing System II (AWIPS II) for the U.S. National Weather Service (NWS). The WFO-Advanced system development has been a very important cooperative activity between TECRO's and AIT's designated representatives, NOAA/ESRL/GSD and CWB to support the mission of establishing hazardous weather monitoring and forecasting. Figure 1 lists the important components and Figure 2 illustrates the software architecture for WFO-AWIPS II here:

Environmental Data Exchange(EDEX)	Common AWIPS Visualization Environment(CAVE)	User System
- Notification Subscription Interface - Statistical Analysis - Event framework - Sync Manager - Bandwidth Manager - Authorization Framework - Retrieval Framework - ebXML Manager - PostgreSQL and PDO Database	- Subset Manager - Dataset Discovery Browser - Subscription Manager - Notification Center - System Management - Bandwidth Utilization Graph - Statistics Display - User Admin	-NOAAPORT -GFE -HS -FFMP (MDL) -global model -NESDIS -WSR-88D

Figure 1. The important components of WFO-AWIPSII and Users System

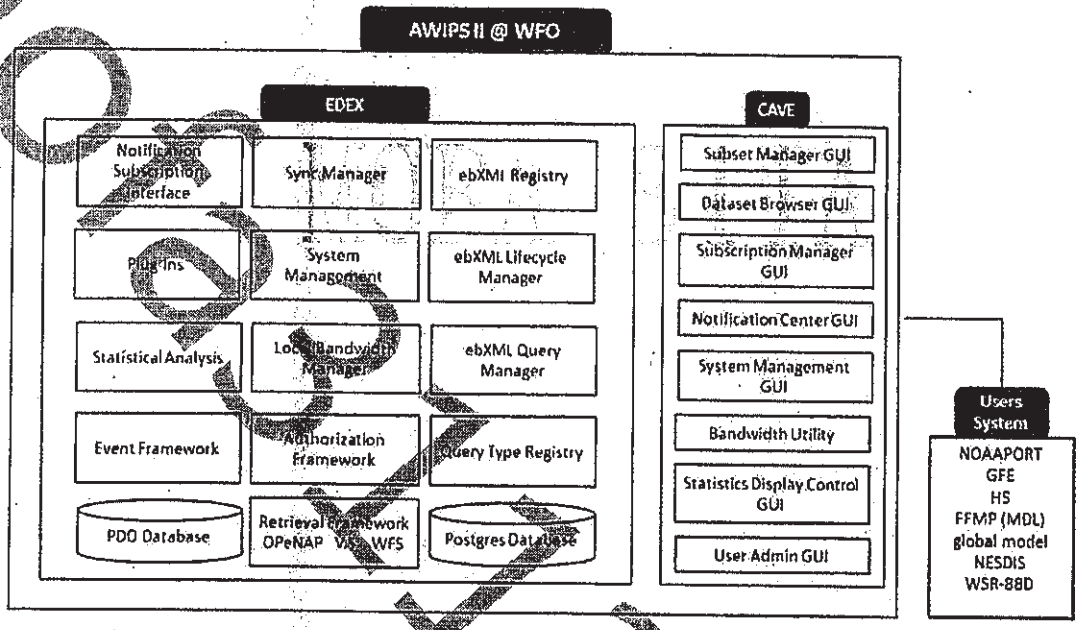

Figure 2. Software architecture for WFO-AWIPSII and Users System

Seven tasks are identified: (1) Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction; (2) High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement; (3) Enhance 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; and (7) Development of GOES-R decision support products from Himawari-8.

The tasks will be undertaken by the NOAA/ESRL/GSD-CWB Joint Team as the designated representatives of the TECRO and AIT, working at the NOAA/ESRL/GSD facility in Boulder, Colorado, the NOAA/NSSL(National Severe Storms Laboratory) in Norman Oklahoma, the NOAA/NESDIS (National Environment Satellite, Data, and Information Services) and NOAA/NCEP/CPC (Climate Prediction Center) facility in College Park, Maryland, the NOAA/NWS/MDL (Meteorological Development Laboratory) in Silver Spring, Maryland, the University of Wisconsin – Space Science and Engineering Center (SSEC) / Cooperative Institute for Meteorological Satellite Studies (CIMSS) and by CWB staff at the CWB facility in Taipei, Taiwan, as appropriate. This Statement of Work addresses only tasks that will be undertaken by the NOAA/ESRL/GSD - CWB Joint Team under the terms of Implementing Arrangement #29 (IA #29). It describes the performance period, deliverables, and resource requirements.

2.0 – Task Descriptions

In terms of the overall program schedule, the following seven tasks have been identified as critical during the January 1 to December 31, 2017 time period. Each task is listed in detail below, along with the estimated proportion of resources that is to be allocated to each task.

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

During IA #29, NOAA/ESRL/GSD has agreed that NOAA/STAR/SMCD will lead this task. NOAA/STAR/SMCD will develop surface solar insolation algorithm from WRF forecast and generate surface solar insolation product from Advanced Himawari Image (AHI) for renewable solar energy forecast and validation and renewable energy distribution. The benefit is to provide real-time forecast of solar energy distribution.

Due to the similarity between Himawari AHI and GOES-R ABI instruments, the sixteen bands (three visible, three near-infrared and ten infrared) for the AHI provided a unique opportunity for Convective Initialization (CI) nowcasting and monitoring capability. CI is also a challenging for model to capture at the right time and right location. NOAA/STAR/SMCD will convert Convective Initiation (CI) software package from Matlab to Fortran, so CWB can assess the impact of CI on convective precipitation.

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

Resources Required: 13.6 % NESDIS/GSD/CWB

Deliverables and Schedule:

1. Surface Solar Insolation algorithm and product development — 11/15/17
    a. WRF Fortran source codes for solar insolation
    b. BAHI Fortran source codes for solar insolation
2. CI algorithm source codes in Fortran package — 11/15/17

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

During IA #29, NOAA/ESRL/GSD has agreed that NOAA/NSSL (National Severe Storms Laboratory) will continue research towards maintenance, refinement, and improvement of the High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) applications required for the CWB, the Water Resources Agency (WRA), and the Soil and Water Conservation Bureau (SWCB).

This task will include a training of CWB visitors on the radar ingesting software. This training will provide CWB with capabilities to customize its new radar integration process. NSSL will work with CWB to refine and streamline radar quantitative precipitation estimation (QPE) workflow and to enhance the CWB's capability to improve its operational products. NSSL will develop blockage reference data sets for new precipitation radars to facilitate the integration of the new radars into the operational system.

NOAA/NSSL will make available to the CWB, as requested, the radar ingest software and blockage reference data sets for the new radars. NOAA/NSSL will also provide CWB, as requested, consultations as part of QPESUMS technical support

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

Resources Required: 13.6 % NSSL/GSD/CWB

Deliverables and Schedule:

1. Enhancements of radar ingest processes 11/15/17
   a. Completion of administrative processes and logistics for hosting CWB visitors
   b. Training of the radar decoding and ingesting software
2. Integration of new radars 11/15/17
   a. Gather scan strategy information of the new radars
   b. Develop blockage reference data sets for the integration of new radars.
3. Improvements of radar quantitative precipitation estimation processes 11/15/17
   a. Streamlining and enhancements of radar quantitative precipitation estimation workflow.
   b. Refinements of radar QPE based on real-time evaluations
4. Technical support for QPESUMS operations 11/15/17

Task 3 - Enhance 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 hydrometeorological 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 #29, NOAA/ESRL/GSD has agreed that the MDL will 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.

First, MDL will continue to focus on more thorough customization support to the Flash Flood Monitoring and Prediction (FFMP) tool on its operational use at the Forecast Center after the Hydrologic Unit Code (HUC) layer implementation was made in IA #27 as the HUC layers would add more important hydrological characteristics beyond the implementation of Township layer and small-basin layer that were completed under prior IAs.

In order to enhance the collaboration between CWB's WINS team and MDL staff in the area of AWIPS II software and decision assistance tools developed by MDL, MDL will assist CWB to get access to NOAA's VLab (Virtual Laboratory), which is an innovation collaboration framework to provide AWIPS II software development environment. VLab will greatly benefit the CWB development team's efforts to engage in software development and conduct customization for CWB local environment.

Secondly, MDL will continue to technically support CWB on its implementation of System on AWIPS for Forecasting and Evaluation of Seas and Lakes (called SAFESEAS) under AWIPS II development environment.

Thirdly, MDL will continue to provide CWB training and technical support on the AutoNowCaster (ANC) system. The MDL's version of ANC, which is substantially different from its original NCAR version and has been improved with far fewer software crashes and much easier configuration for its operational use, was delivered to CWB along with a verification package in IA #28. The ongoing training and technical support are needed to configure it, use it, and interpret its results so that the CWB's forecasters make informed use of ANC's output.

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

Resources Required: 16.3 % MDL/GSD/CWB

Deliverables and Schedule:

1. Support on Decision Assistance Tools 11/15/17
    a. Continue to support the FFMP user and

developer training.

b. Continue to support the SAFESEAS, SCAN implementation in AWIPS II environment.

c. Support the migration of FFMP from AWIPS I to AWIPS II systems and provide document training on how to make local customization.

d. Provide VLab (Virtual Laboratory) access account.

2. ANC System Configuration Support 11/15/17

a. Consultation for inclusion of new predictor(s).

b. Continue support the MDL's version ANC for CWB to have the comparable functions with the current operational TANC. 11/15/17

c. Technical support for MDL version ANC operations. 11/15/17

d. Continue support CWB using the verification package to verify the 60-minute nowcast of the operational TANC. 11/15/17

e. Consultation for input data format conversion of ANC. 11/15/17

f. Consultation for performing existing auto-tuning system. 11/15/17

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

The National Weather Service (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 US National Weather Service (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.

During IA #27, NOAA/ESRL/GSD received permission from NWS to provide an evaluation copy of the AWIPS II software to CWB. This support continued through IA #28, with periodic updates provided. GSD also provided AWIPS II training for CWB developers. One CWB visitor to GSD in 2016 learned many details about AWIPS II and, with GSD, began design/development work on some components specifically needed by the CWB.

For IA #29, GSD will continue to support CWB developers by providing updated versions of the AWIPS II software. GSD will work with NWS/Meteorological Development Laboratory to set up a shared software repository, where GSD and CWB visitor(s) will maintain code that they will share with other CWB staff who are developing and testing new software.

GSD has explored the new FDSE (Forecaster Decision Support Environment) system to view data pertinent to the given weather scenario. There are three major components that make up the FDSE: Ensemble tools, Grid monitor and Short-term update tool. During IA #29, GSD will continue to provide some training of FDSE to CWB forecasters to explore new data management and processing capabilities to enhance situational awareness, allow forecasters to work more efficiently, and improve model ensemble capabilities in order to explore probabilistic forecast products. Additional collaborative work will address ingest and display of CWB-specific lightning, satellite, and grid datasets.

During IA #29, GSD will continue to provide technical support for the Graphical Forecast Editor (GFE), GFE Smart Tools (techniques to automate or semi-automate grid editing), and the text formatters (TF) used in CWB's Forecast Information Editing System (FIES). In conjunction with NWS, GSD continues to work on improvements in Smart Tools, and is developing new forecast monitoring and ensemble-based forecast support tools, some of which will be included in the AWIPS II release in 2017.

This interaction will benefit NOAA and CWB, with updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #29, NOAA/ESRL/GSD will provide training and support to CWB visitors and forecasters, continue the exchange of visits, provide reports, attend annual meetings, and continue e-mail interactions.

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

	Resources Required:	11.0 %	GSD/CWB
	Deliverables and Schedule:		
a.	Prepare and deliver updated versions of AWIPS II software		11/15/17
b.	Provide technical support for text workstation and WarnGen and AWIPS II/GFE Smart Tools for CWB's TF localization		11/15/17
c.	AWIPS II software development support		11/15/17

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

During IA #29, NOAA/ESRL/GSD has agreed that NWS/NCEP (National Centers of Environmental Prediction)/EMC (Environmental Modeling Center) will lead this task. EMC will facilitate CWB modeling staff to participate in NOAA/NWS's NGGPS (Next Generation Global Prediction System) activity. Dr. Vijay Tallapragada, Chief of Global Modeling Branch will be the official POC for this task and will coordinate the collaborative activities related to this task between NOAA and CWB.

NGGPS's goal is to design/develop/implement a new global atmospheric prediction model with non-hydrostatic scalable dynamics with advanced physics, improved data assimilation and apply next generation high performance computing. Under the NGGPS program, a test plan consisting of three phases was implemented to test and evaluate the best dynamic core from six candidate models (two from NCEP/EMC, one from NCAR, one from NOAA/ESRL, one from Navy and one from NOAA/GFDL). GFDL's Finite Volume Model Cubed Sphere (FV3) dynamic core was selected after Phase 2 in June 2016. The Phase 3 is for operational implementation of FV3 dynamic core with community based common physics package (CCPP) and improved data assimilation.

Specific for IA #29, NCEP/EMC will assist in hosting a long-term CWB modeling staff to participate in the NGGPS operational testing and implementation activities, so CWB can actively make contribution for this program. Through this collaboration, CWB could position its own development of a next generation global forecast system from NOAA's NGGPS knowledge and operational experience. NCEP/EMC will also support a joint annual NCEP-CWB global modeling workshop involving EMC scientists to exchange science and operational knowledge in the area of Global Forecast System (GFS) and Global Ensemble Forecast System (GEFS).

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

Resources Required: 1.0 % NCEP/EMC/CWB

Deliverables and Schedule:

1.	Facilitating and hosting long term (9 months or longer) CWB modeling staff to participate in NGGPS operational testing and implementation activity.	11/15/17
2.	NCEP/EMC colleagues to visit CWB to attend NCEP-CWB annual workshop in the area of Global Forecast System (GFS) and Global Ensemble Forecast System (GEFS).	06/15/17
3.	Facilitating CWB managers short visiting EMC for project review meeting.	11/15/17

Task #6 - Continuing Interaction on Earlier Cooperative Projects

Several earlier cooperative tasks have been completed. Technology has been transferred successfully and is beginning to be used operationally at the facilities of the CWB. The task for NOAA/ESRL/GSD in this area is the development of new tools that extend and enhance the forecast applications. Further NOAA/ESRL/GSD interaction with CWB is critical to keep CWB staff up to date on current AWIPS II developments. This task will directly improve and update CWB's current forecast assistant and decision making systems at appropriate levels.

NOAA/ESRL/GSD has U.S. export control approval to provide CWB with AWIPS II software as released by the contractor. The software was first made available to CWB in 2013. During IA #29, NOAA/ESRL/GSD will continue to provide updated versions and training to CWB visiting scientists on the new AWIPS II extended/ enhanced forecaster applications such as GFE improvements and collaboration that are being developed by NOAA/ESRL/GSD.

NOAA/ESRL/GSD will continue to provide the NOAAPORT data feed and data transmission support for CWB's data assimilation and forecasting purposes during IA #29. This continuing interaction task will benefit NOAA and CWB, with the updated knowledge of the forecast assistant and decision making systems developed at NOAA including AWIPS II. Throughout the period of IA #29, NOAA/ESRL/GSD will provide necessary training and support to CWB visitors and forecasters, continue the exchange of visits, provide necessary papers and reports, attend annual meetings, and continue e-mail interactions, as applicable.

During IA #29, NOAA/GSD and NWS/NCEP/CPC will continue to assist CWB in developing capability for climate services, by providing training such as through NCEP's International Monsoon Training Desk Program.

During IA #28, GSD had coordinated an assessment study of installing a few DART® (Deep-ocean Assessment Reporting of Tsunamis) bouys south of Taiwan for CWB's tsunami warning system. DART®, originally developed by NOAA, is a critical component of the NOAA tsunami program. During IA #29, GSD will continue to coordinate additional training on the NWW3 (NOAA Wave Watch III) model for CWB's Marine Meteorological Center. This training will provide CWB with knowledge to review the NWW3 product and customize the NWW3 for regional applications. NWW3 training will be provided by Marine Modeling and Analysis branch of NCEP/EMC (Environmental Modeling Center).

During IA #29, NOAA/STAR/SMCD will continue to improve the satellite data application in CWBGFS (CWB Global Forecast system), NOAA/STAR/SMCD will provide technical support on satellite data assimilation implementation and improvement.

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

Resources Required: 20.9 % GSD/CWB

Deliverables and Schedule:

1.	AWIPS II training to CWB users	11/15/17
2.	NOAAPORT data supply support	11/15/17
3.	NCEP's Monsoon Desk training	11/15/17
4.	MMC training on NWW3	06/15/17

5. Visitors and travel support 11/15/17
6. Satellite data assimilation improvement and technical support for CWBGFS 11/15/17
   a. GSI package update for CWBGFS
   b. AHI BUFR data software
   c. Test Himawari AHI BUFR imager data assimilation in CWBGFS

Task #7 Development of GOES-R decision support products from Himawari-8

During IA #29, NOAA/ESRL/GSD has agreed that University of Wisconsin – Space Science and Engineering Center (SSEC) / Cooperative Institute for Meteorological Satellite Studies (CIMSS) will lead this task.

This task will include documentation of (a) Implementation of current CLAVR-x (Clouds from AVHRR Extended) algorithms and (b) High Rate Information Transmission (HRIT) of Himawari-8 data. CLAVR-x is NOAA's operational cloud processing system for the AVHRR on the NOAA-POES and EUMETSAT-METOP series of polar orbiting satellites. CLAVR-x algorithms are analogs of those developed for the GOES-R AWG (Algorithm Working Group) Cloud Application Team.

A version of CLAVR-x capable of processing Himawari-8 Advanced Himawari Imager (AHI) radiances is currently running at the Meteorological Satellite Center (MSC) in the CWB. Running the retrieval algorithms, including all of the byproducts produced as part of this process, generates dozens of different cloud, radiometric and atmospheric fields that have the capacity to be produced as output. There are several opportunities for collaboration between CIMSS and MSC/CWB to exploit and enhance CLAVR-x capabilities. These include: 1) Identification of existing products that may meet needs of the MSC/CWB (e.g. Cloud Optical Path and Cloud Solar Transmission); 2) Reduction of the time it takes to process a AHI full-disk through CLAVR-x; 3) Development of pathways from CLAVR-x output to Advanced Weather Interactive Processing System (AWIPS)-compatible formats.

CIMSS will provide support and expertise to MSC/CWB personnel in the development and use of True Color and RGB imagery that meets MSC/CWB operational requirements.

CIMSS will develop a conversion process to ingest native HRIT files into CLAVR-x. The data is from the HimawariCast data stream service (via communication satellite) already in place at MSC/CWB. The goal would be to create a secondary method of processing real-time CLAVR-x. One potential method would be to use a McIDAS Abstract Data Distribution Environment (ADDE) to read in the HRIT files and format to McIDAS AREA files. CIMSS would then develop a new CLAVR-x module to read-in converted AREA files and perform navigation/formatting/calibration before processing through CLAVR-x.

CIMSS will initiate the implementation of the Advanced Dvorak Technique (ADT) algorithm to generate objective and automated estimates of Typhoon Intensity at MSC/CWB. This will be done in two phases: 1) Phase one will include training and familiarization of the ADT algorithm and its performance behaviors in collaboration with CWB personnel, and packaging/preparation of the code at CIMSS to be delivered and operate in the MSC/CWB environment. 2) Phase two will involve the validation of the CWB estimates against the version currently running at CIMSS, troubleshooting, and maintenance. No commercial packages are required for this implementation, however, the ADT algorithm expects input satellite data streams (e.g., Himawari, LEO) to be locally available at CWB and the input file formats to conform to the code readers.

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

13.6 % CIMSS/GSD/CWB

Resources Required:

Deliverables and Schedule:

1.	Identification of additional CLAVR-x products that meet MSC/CWB operational needs (e.g. cloud optical path and cloud solar transmission)	11/15/2017
2.	Completion of CLAVR-x module for ingest and processing of Himawari-8 HRIT data, including navigation/formatting/calibration.	11/15/2017
3.	CLAVR-x technical and training support and True color/RGB imagery support	11/15/2017
4.	Completion of Phase 1 to deliver ADT typhoon intensity estimate algorithm to MSC/CWB.	11/15/2017

3.0 - Schedule

Tasks	Functions	Milestones
1.	Development and Improvement of Satellite Products for Tropical Storm Monitoring and Prediction	11/15/17
2.	High-Resolution Quantitative Precipitation Estimation and Quantitative Precipitation Forecast (HRQ2) Applications Improvement	11/15/17
3.	Enhance Nowcasting Decision Assistance Tools	11/15/17
4.	Development of High-Resolution Product Generation Assistance Tools for AWIPS II	11/15/17
5.	Development of Next Generation Global to Regional Prediction System	11/15/17
6.	Continuing Interaction on Earlier Cooperative Projects	11/15/17
7.	Development of GOES-R decision support products from Himawari-8	11/15/17

Schedule by Month

Task 1 Satellite application	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Surface Solar Insolation algorithm and product development	x	x	x	x	X	x	x	x	x	X	x	
2. CI algorithm source codes in Fortran package	x	x	x	x	x	x	x	x	x	X	x	

Task 2 HRQ2 (NSSL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Enhancements of radar ingest processes	x	x	x	x	x	x	x	x	x	x	x	
2. Integration of new radars	x	x	x	x	x	x	x	x	x	x	x	
3. Improvements of radar quantitative precipitation estimation processes	x	x	x	x	x	x	x	x	x	x	x	
4. Technical support for QPESUMS operations	x	x	x	x	x	x	x	x	x	x	x	

Task 3 Enhanced Nowcasting Decision tools (MDL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Support on Decision Assistance Tools	x	x	x	x	x	x	x	x	x	x	x	
2. ANC System Configuration Support	x	x	x	x	x	x	x	x	x	x	x	

Task 4 High-resolution forecast product generation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Prepare and deliver updated versions of AWIPS II software	x	x	x	x	x	x	x	x	x	x	x	
2. Technical support for text workstation and WarnGen	x	x	x	x	x	x	x	x	x	x	x	

3. AWIPS II software development support	x	x	x	x	x	x	x	x	x	x	x	

Task 5 Development of Next Generation Global to Regional Prediction System (EMC)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Facilitating and hosting longterm (9 months or longer) CWB modeling staff to participate in NGGPS operational testing and implementation activity.	x	x	x	x	x	x	x	x	x	x	x	
2. NCEP/EMC colleagues to visit CWB to attend NCEP-CWB annual workshop in the area of Global Forecast System (GFS) and Global Ensemble Forecast System (GEFS).	x	x	x	x	x	x						
3. Facilitating CWB managers short visiting EMC for project review meeting.	x	x	x	x	x	x	x	x	x	x	x	

Task 6 interaction on earlier projects	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. AWIPS II training to CWB users	x	x	x	x	x	x	x	x	x	x	x	
2. NOAAPORT data supply support	x	x	x	x	x	x	x	x	x	x	x	
3. NCEP's Monsoon Desk training	x	x	x	x	x	x	x	x	x	x	x	
4. MMC training on NWW3	x	x	x	x	x							
5. Visitors and travel support	x	x	x	x	x	x	x	x	x	x	x	
6. Satellite data assimilation improvement and technical support for CWBGFS	x	x	x	x	x	x	x	x	x	x	x	

Task 7 Development of GOES-R decision support products from Himawari-8	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Identification of additional CLAVR-x products that meet MSC/CWB operational needs (e.g. cloud optical path and cloud solar transmission)	x	x	x	x	x	x	x	x	x	x	x	
2. Completion of CLAVR-x module for ingest and processing of Himawari-8 HRIT data, including navigation/formatting/calibration.	x	x	x	x	x	x	x	x	x	x	x	
3. CLAVR-x technical and	x	x	x	x	x	x	x	x	x	x	x	

	training support and True color/RGB imagery support											
4	Completion of Phase I to deliver ADT typhoon intensity estimate algorithm to MSC/CWB	x	x	x	x	x	x	x	x	x	x	x

4.0 - Budget

The following are the estimated costs for IA #29:

Tasks	Personnel	Travel/Training	Total
Task #1 (NESDIS/GSD)	$235,000	$ 15,000	$ 250,000
Task #2 (NSSL)	$235,000	$ 15,000	$ 250,000
Task #3 (MDL/GSD)	$285,000	$ 15,000	$ 300,000
Task #4 (GSD)	$185,000	$ 15,000	$ 200,000
Task #5 (NCEP/EMC)	$185,000	$ 15,000	$ 200,000
Task #6 (GSD)	$335,000	$ 50,000	$ 385,000
Task #7 (CIMSS)	$235,000	$ 15,000	$ 250,000
Total	**$1,695,000**	**$140,000**	**$ 1,835,000**

As stated in IA #29, the funds available from TECRO to support the tasks, travel, and meeting expenses described in this Statement of Work will be a total of US$ 1,835,000. US$ 1,455,000 will be provided by CWB, US$ 265,000 by the Water Resources Agency (WRA), and US$ 115,000 by the Soil and Water Conservation Bureau (SWCB). All budget figures are estimated. Actual amounts will be accrued for purposes of fulfilling the financial arrangements described in the Implementing Arrangement in accordance with the terms of the Umbrella Agreement.

All programs within the Global Systems Division (GSD) use the same budget procedures, whether they are base-funded programs or externally-funded programs. Beginning in U.S. Government Fiscal Year 1991, a facility charge has been applied to all programs to cover management and administrative costs as well as the use of the NOAA/ESRL/GSD facility and all associated equipment and data.

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

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

Several tasks encourage CWB staff-in-residence at NOAA/ESRL/GSD, NOAA/NESDIS, and NOAA/NWS/MDL. The primary effort of CWB staff at NOAA during the IA #29 period will be directed towards the satellite data, AWIPS II development tasks. The primary effort of CWB staff at NOAA/NCEP/CPC during the IA #29 period will be to get familiar with the operations of the CPC International Monsoon Desk. It is important that qualified CWB staff be available to work at NOAA research and operations facilities during the period of this Implementing Arrangement. Specific assignments will be made to most efficiently use the available personnel resources. Assignments for the qualified CWB staff members would be as follows:

- 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.