

**STATEMENT OF WORK FOR IMPLEMENTING ARRANGEMENT #6  
CONSULTANCY SERVICE FOR THE ENHANCEMENT OF THE CWB DATA  
ASSIMILATION SYSTEM TO THE AGREEMENT BETWEEN THE TAIPEI ECONOMIC  
AND CULTURAL REPRESENTATIVE OFFICE IN THE UNITED STATES AND THE  
AMERICAN INSTITUTE IN TAIWAN**

**I. Task Descriptions**

**1. Task #1 – Support for the WRFVar component of the CWB operational system (OP2) and improvement of the performance of WRFVar V3**

During the year 2009, TECRO's designated representative, the Central Weather Bureau (CWB), implemented WRFVar V3.0/WRF V3.0, and WPS V3.0 in the CWB operational environment. The WRFVar/WRF system has been in operation since July 2009. In 2010 the staff of AIT's designated representative, the University Corporation for Atmospheric Research (UCAR), will work closely with the CWB staff, and will continue to provide technical support to the CWB staff on the WRFVar component of the CWB operational system.

Based on results from the operational system in 2009 and the retrospective experiments for June and December 2008, TECRO's designated representative, CWB, decided to replace the current CV5 BES (background error statistics) with CV3 BES as the background error statistics option for the CWB operational system. In order to improve the performance of the analysis, however, additional work on CV3 BES is needed. The same CV3 BES files are used for both the WRFVar and GSI (Grid-Point Statistical Interpolation) data assimilation systems. It would be desirable to adapt some features that are proven to be advantageous from GSI for WRFVar applications. It is also desirable to perform additional tuning for the CWB BES to further improve its operational performance.

During the 2009, TECRO's designated representative, CWB, noted deficiencies in the analyses, particularly the geopotential height fields. The CWB operational system is based on full cycling of WRFVar and WRF. The deficiency in the height analysis is the result of several complicated factors, including vertical interpolation, WRFVar and WRF. In 2010, AIT's

designated representative, UCAR, will examine these factors carefully to identify the sources of the problem and will work with CWB staff to resolve the issue. For the data assimilation component, UCAR and CWB will examine the various components of WRFVar that may contribute to this problem. The interface between WRFVar and WRF will also be examined carefully.

The goal for this task is to improve the performance of the WRFVar/WRF operational system at CWB. With this objective in mind, UCAR proposes the following sub-tasks for 2010.

### **1.1 Support for the WRFVar component of CWB operational system (0.30FTE)**

TECRO's designated representative, CWB, will inform AIT's designated representative, UCAR, in a timely fashion (via e-mail or teleconferences) of any WRFVar problems encountered during operation. UCAR will troubleshoot WRFVar-related problems in modules OBS\_FGGE\_PROC, 3DVAR\_OBSPROC, WRFVar and update\_bc. UCAR will provide technical consultation, and work with CWB to keep all of the codes synchronized between UCAR and CWB. UCAR will continue to provide training to CWB with regard to basic theory in variational data assimilation and the code structure of WRFVar. By working closely with UCAR, CWB will develop experience and expertise in WRFVar problem diagnosis and troubleshooting.

The WRFVar team, at AIT's designated representative, UCAR, will work closely with the WRF modeling group to study the geopotential height problem. First, UCAR will identify which steps were responsible for the geopotential height problem. UCAR will then develop solutions and adapt the new algorithms related to the geopotential height calculation in WRFVar.

### **1.2 Improve the performance of WRFVar V3 (0.5FTE)**

Based on previous work carried out by TECRO's designated representative, CWB, the performance of the CV3 BES is comparable or slightly better than CV5 BES. However, additional work is needed to improve the performance of the CV3 BES options, and the work is described in the following sub-tasks:

#### **1.2.1 Implementation of outer-loops with CV3 BES**

Previous work has shown that the use of outer-loop for CV5 BES is beneficial to tropical cyclone analysis. Now that TECRO's designated representative, CWB, has decided to use CV3 BES (instead of CV5 BES) for operation, it is desirable to implement outer-loop for CV3 BES. In 2010, AIT's designated representative, UCAR, will perform single observation tests to ensure that CV3 BES works properly with the outer-loop; UCAR will then conduct a case study with CV3 BES outer-loops to look at the convergence of the increments from each of the outer-loops; finally, UCAR will conduct the test runs over the domain with 45-km resolution for a month-long period (June or December 2008).

#### **1.2.2 Tuning for CV3 BES**

In order to improve the performance of CV3 BES in an operational application, it is desirable to perform additional tuning. As a first step, AIT's designated representative, UCAR, should fully understand the performance of CV3 BES, i.e., the regression coefficients, variances, horizontal and vertical scale-lengths, high order recursive filters, etc. Then, UCAR will determine the tuning factors with the objective and subjective estimates by conducting a series of experiments. These experiments will be performed by TECRO's designated representative, CWB, with the guidance of UCAR.

#### 1.2.3 Technical consultation on improving the utilization of operationally available observations.

Eric Chiang, from TECRO's designated representative, CWB, will visit AIT's designated representative, UCAR, for two months starting in March 2010. His major task is to investigate the impact of various data on analyses. In particular, Eric Chiang will examine the impact of surface data assimilation on WRFVar analysis and on subsequent forecasts. UCAR will provide the necessary technical assistance in support of his work. Eric Chiang will also examine the influence of surface data assimilation on the 500 hPa geopotential height analysis.

### **1.3 Improve the GPSRO data assimilation for CWB regional application (0.50FTE)**

In 2009, TECRO's designated representative, CWB, conducted operational assimilation of GPSRO (GPS radio occultation) data. Although there were some improvements in the analysis and short-range forecasts with the assimilation of GPSRO data when verified against GPSRO observations and available soundings, the quality of the geopotential height analysis was degraded. It is clear that the performance of GPSRO assimilation needs to be improved. In 2010, AIT's designated representative, UCAR, will attempt several avenues to improve the performance of GPSRO assimilation. First, UCAR will diagnose the sources for the degradation of geopotential height. UCAR will also examine the latitudinal dependence of BES and the impact of BES on the analysis. UCAR will investigate the GPSRO assimilation methods from other operational centers, including the NCEP GSI system. UCAR will adopt and test GPSRO data quality control procedures and fine tune observation error statistics. Other promising approaches will be explored with a goal to improve the performance of the WRFVar assimilation of GPSRO data for CWB operation. For this subtask, UCAR will perform short duration assimilation experiments. When the results look promising, UCAR will transfer the codes to CWB in order for them to conduct longer period testing.

### **1.4 Training and technical consultation (0.45 FTE)**

In 2010, AIT's designated representative, UCAR, will continue to provide training and technical consultation to TECRO's designated representative, CWB, in the area of data assimilation. This will include the WRFVar system as well as the GSI system.

#### 1.4.1 Consultation on CWB ZTD (Zenith Total Delay) data assimilation

TECRO's designated representative, CWB, has an operational ground-based GPS network. This data set is extremely valuable for prediction of significant weather (such as heavy rainfall events), particularly during the Mei-yu and typhoon periods. In 2010, CWB will continue to perform experimental assimilation of GPS ZTD data from the CWB GPS network, and assess its impact on analysis and prediction. The performance of GPS ZTD assimilation may be impacted by data quality control and observation error specification. Occasionally, there may be anomalies associated with data processing. AIT's designated representative, UCAR, will provide necessary technical consultation to CWB with regards to GPS ZTD assimilation. This sub-task will have close interaction with Task#3.

#### 1.4.2 Provide guidance to CWB staff visiting UCAR

In 2010, several staff from TECRO's designated representative, CWB, will be visiting Boulder, Colorado to collaborate with staff from AIT's designated representative, UCAR. UCAR will provide basic guidance and training on the WRFVar system. UCAR staff will also discuss experiment results with the CWB staff, and provide suggestions about their future work. Through these interactions, CWB will develop skills in the applications and diagnosis of the WRFVar system.

#### 1.4.3 Technical consultation on general data assimilation issues

In 2010, TECRO's designated representative, CWB, will perform a month-long experiment with the NCEP GSI data assimilation system and compare its performance with WRFVar. AIT's designated representative, UCAR, will provide necessary technical consultation with regard to the use of the GSI data assimilation system. UCAR may also serve as an interface between CWB and other GSI developers, as needed.

#### 1.4.4 Provide WRFVar training courses at CWB

Yong-Run Guo, from AIT's designated representative, UCAR, will visit TECRO's designated representative, CWB, for two weeks and will provide training on WRFVar. The topics will include: the basic WRFVar system, observation operators and their tangent and adjoint coding techniques for surface data, GPS Zenith Total Delay and Precipitable Water (ZTD/PW), and GPSRO. The training will help CWB understand the various observation operators, and their implementation within WRFVar. Through this training, CWB will be able to improve and develop WRFVar code for certain types of observations in the future.

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

#### Performance Period:

- |                                     |                     |
|-------------------------------------|---------------------|
| a. Provide support for WRFVar       | 01/01/10 – 11/30/10 |
| b. Improve performance of WRFVar V3 | 01/01/10 – 11/30/10 |

- |                               |                     |
|-------------------------------|---------------------|
| c. Improve GPSRO assimilation | 01/01/10 – 11/30/10 |
| d. Training and consultation  | 01/01/10 – 11/30/10 |

Resources Required: 1.75 FTE UCAR staff

Deliverables:

- |  |          |
|--|----------|
| 1. Observation operators, tangent, adjoint coding training | 04/30/10 |
| 2. CV3 outer-loop code                                     | 11/30/10 |
| 3. Report on the assimilation of GPSRO data with WRFVar    | 11/30/10 |

## **2. Task #2 – Testing and Development support for the WRF/DART Ensemble Data Assimilation System**

In 2010, AIT's designated representative, UCAR, and TECRO's designated representative, CWB, will continue testing and tuning of the WRF/DART ensemble system at CWB. UCAR will tune the WRF/DART configuration and collaborate with CWB to obtain improved performance under the CWB's operational environment.

### **2.1 Modify and test WRF/DART to run in CWB's six-hour cycling operation**

AIT's designated representative, UCAR, will set up six-hourly cycling of WRF/DART over the domain of TECRO's designated representative, CWB, for CWB's future quasi-operational test. UCAR will conduct significant modification and testing of the WRF/DART system, including tuning the initial perturbation algorithm, adaptive inflation, horizontal and vertical localization, and revising observation processing. Specifically, the adaptive inflation will be tuned for the six-hourly assimilation interval. The observations within the +/- 1.5 hours around each six-hourly analysis time will be used for the new configuration. As a consequence, the adaptive localization will also need to be changed and tested accordingly. UCAR will test these parameter tunings for the typhoon cases Sinlaku (2008) and Morakot (2009). Various combinations of the experiments will be done for these two typhoon cases. The initial version of the six-hourly WRF/DART code and name\_lists will be delivered to CWB for testing as soon as possible.

### **2.2 Detailed evaluation of WRF/DART performance for SoWMEX (Southwest Monsoon Experiment) and winter cases**

AIT's designated representative, UCAR, will perform WRF/DART, a two-week assimilation for the SoWMEX period (1-30 June 2008) and for one winter month (December 2008) over the CWB 45 km domain. UCAR will conduct a detailed evaluation of the WRF/DART analyses and forecasts comparing them with NCEP analyses as well as observations for the most relevant variables and model levels. UCAR will investigate any abnormal behavior of

the analyses and provide fixes for them.

AIT's designated representative, UCAR, will conduct assimilation with and without COSMIC GPSRO data for heavy rainfall events during SoWMEX-2008 using the WRF/DART system. UCAR will then examine the impact of COSMIC data on the analysis and forecast of heavy rainfall events. A report about the results will be delivered to TECRO's designated representative, CWB. CWB will perform COSMIC GPSRO assimilation using the WRFVar system, and the results will be compared against those from the WRF/DART system. UCAR will work with CWB to compare the two assimilation systems in terms of performance, computing requirements, and stability. This will allow CWB to have a realistic assessment on the feasibility of using WRF/DART for operational applications.

### **2.3 Provide Support and Training for WRF/DART at CWB**

AIT's designated representative, UCAR, will develop detailed educational materials about WRF/DART code and related theories. These materials will be delivered to TECRO's designated representative, CWB, before UCAR visits CWB. In addition, UCAR staff member, Hui Liu, will visit CWB (11-25 April 2010) to provide onsite training on WRF/DART and support for the WRF/DART code update.

AIT's designated representative, UCAR, will provide remote assistance and technical consultation to TECRO's designated representative, CWB, for running the WRF/DART system at CWB. This collaboration will continue through the project period.

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

#### Performance Period:

- |   |                   |
|---|-------------------|
| a. Modify and tune WRF/DART for 6-hourly cycling                    | 1/1/10 – 11/30/10 |
| b. Evaluate the performance of WRF/DART for SoWMEX and winter cases | 1/1/10 – 11/30/10 |
| c. Provide support and training for WRF/DART at CWB                 | 1/1/10– 11/30/10  |

#### Resources Required:

0.5 FTE UCAR staff

#### Deliverables:

- |  |          |
|--|----------|
| 1. An improved version of WRF/DART code and name_lists, as well as the ensemble verification tools | 11/30/10 |
| 2. Report on the evaluation of the performance of WRF/DART for SoWMEX and winter cases             | 11/30/10 |
| 3. Documentation and tutorials on ensemble filters and DART  | 11/30/10 |

### **3. Task #3 – Support and Improvement of Water Vapor Retrievals Using CWB GPS**

## Networks

The tasks related to GPS retrievals of atmospheric water vapor in the 2009 agreement between AIT's designated representative, UCAR, and TECRO's designated representative, CWB, focused on the continued analysis of data from the CWB GPS network to produce continuous estimates of ZTD and PW and the modification of the analysis software to support the hourly updates in these atmospheric products. UCAR also reprocessed data collected during the 2008 SoWMEX/TIMREX (Terrain-induced Monsoon Rainfall Experiment) field campaign so that all GPS stations operating during the field experiment would have water vapor estimates. The original processing did not include all station data because of delays in downloading data from more remote GPS receivers. For 2010, UCAR proposes to support the continued analysis of the current network and to develop and implement a new module that produces more realistic error statistics for each ZTD and PW estimate. It is expected that CWB can then use these new error statistics within their WRFVar assimilation into the WRF model and subsequently improve the impact of the ZTD/PW data on the CWB operational forecasts. The proposed tasks are designed to provide CWB with reliable and accurate ZTD/PW products that can be used within their operational environment.

### 3.1 Analysis of CWB GPS Network

AIT's designated representative, UCAR, will continue to analyze and monitor the analysis of the CWB GPS network for atmospheric purposes. This task will ensure that the derived PW products are available to both researchers and forecasters who are interested in using these data. UCAR will implement all Bernese software updates as needed, and incorporate any new stations into the processing. Because TECRO's designated representative, CWB, has plans to implement the GPS ZTD/PW products into their operational systems, data analysis improvements will focus on reliability, error detection, and quality control of the derived data products. UCAR will also implement the following quality control statistical comparisons into the routine analysis:

- Automating a statistical comparison between the near real-time and the daily processing. This will provide a simple and convenient way to monitor the quality of the results. These comparisons will be made available on the established web page.
- Design and automate a method to compare the interpolated surface observations to the meteorology data collected at approximately 15-20 CWB GPS stations. The results of this comparison will be published on the GPS PW web page.

### 3.2 Development of Improved Error Statistics for Use in WRFVar Assimilation

A new strategy for computing error statistics for both ZTD and PW data products is proposed. Current uncertainties for each ZTD and PW estimate are simple formal error statistics taken from the least squares estimation algorithms that are used within the Bernese software. These formal errors do not fully represent the actual uncertainty in each ZTD/PW estimate. AIT's designated representative, UCAR, will develop a new algorithm that will scale the formal error based on the satellite geometry for each particular PW estimate and the un-modeled residuals computed during the ZTD estimation routine. This will allow for an improved scaling of GPS ZTD/PW errors within the WRFVar assimilation routines. This task will have a close interaction with task 1.4.1.

Table 1: Proposed Task List for 2010

Description	CWB tasks	UCAR tasks
Analysis of CWB Network	<ul style="list-style-type: none"> <li>• Continue collection of GPS data.</li> <li>• Continue providing surface meteorology observations for use in GPS analysis.</li> <li>• Make radiosonde data available for statistical comparisons to PW.</li> </ul>	<ul style="list-style-type: none"> <li>• Continued monitoring and analysis of GPS data.</li> <li>• Implement all software updates as needed.</li> <li>• Add additional stations into the analysis as they become available.</li> <li>• Automate statistical comparisons of near real-time, daily, and radiosonde PW estimates.</li> <li>• Automate comparisons of interpolated surface observations to pressure and temperature fields measured at each GPS location.</li> </ul>
Develop algorithm to improve uncertainty parameter for ZTD/PW estimates.		<ul style="list-style-type: none"> <li>• Develop new program to compute ZTD/PW uncertainty parameters based on satellite geometry and un-modeled carrier phase residuals.</li> <li>• Evaluate the new uncertainties against other observational systems including radiosondes and microwave water vapor radiometer.</li> </ul>
Technical Support	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Assist CWB staff with technical support on as needed basis.</li> </ul>

Performance Period:

- |   |                     |
|---|---------------------|
| a. Analysis of CWB GPS Network                        | 01/01/10 – 11/30/10 |
| b. Improved uncertainty parameter in ZTD/PW estimates | 01/01/10 – 06/30/10 |
| c. Technical support of GPS analysis                  | 01/01/10 – 11/30/10 |

Resources Required:

.25 FTE UCAR staff

Deliverables:

1. New program for ZTD/PW uncertainty computation 06/30/10

#### **4. Task #4 – Support the Installation and Testing of the UCAR High-Resolution Land Data Assimilation System (HRLDAS)**

In 2010, TECRO's designated representative, CWB, plans to further advance the update cycle with the coupled WRF/Noah land surface modeling system. During 2009, much progress was made on implementing HRLDAS, validating Noah in Taiwan, and creating a new real-time land surface update at CWB. In 2010, major project goals will be to implement the use of HRLDAS initial states in operations and to further the development of observed MODIS surface properties.

During 2010, AIT's designated representative, UCAR, will provide assistance and technical consultation to TECRO's designated representative, CWB, for the installation of HRLDAS and related testing.

##### **4.1 Transfer HRLDAS updated land states to operations and evaluation**

- 4.1.1 AIT's designated representative, UCAR, will assist in the evaluation conducted by TECRO's designated representative, CWB, to compare HRLDAS results with available observations and provide suggestions to adjust HRLDAS/Noah parameters accordingly.
- 4.1.2 UCAR scientists will deliver to CWB the up-to-date coupled HRLDAS-WRF system including scripts and source code based on CWB's operational WRF configuration in April 2010 (WRF V3.1). UCAR will execute the coupled system for at least a one-week test and show that the results are reasonable.
- 4.1.3 CWB will retrospectively test the coupled HRLDAS/WRF initial conditions. UCAR will assist in the improvement/tuning of the HRLDAS/WRF parameter specification.
- 4.1.4 HRLDAS/WRF will begin initial testing in August 2010 with transfer to the parallel-operational system in October 2010.

##### **4.2 Incorporate and further develop MODIS LAI/fPAR and albedo climatology products**

AIT's designated representative, UCAR, will continue to assist in the development of LAI/fPAR and albedo climatologies.

It is anticipated that there will be no exchange of visitors on this task. Therefore, most of the collaboration will be carried out through email and teleconferences.

The following summarizes the schedule and resources required for this task:

Performance Period:

a. Up-to-date HRLDAS-WRF system with one-week testing	01/01/10 - 04/30/10
b. Retrospective testing and parameter improvement	05/01/10 – 08/31/10
c. HRLDAS initial testing at CWB	08/01/10 - 09/30/10
d. HRLDAS transfer to CWB parallel operational system	10/01/10 – 11/30/10
e. Assist in the development of MODIS climatology	01/01/10 – 11/30/10

Resources Required: 0.3 FTE UCAR staff

Deliverables:

1. Up-to-date coupled HRLDAS-WRF system (WRF V3.1)	04/30/10
2. New CWB-specific land surface model parameters	08/31/10
3. Final report documenting the results of HRLDAS performance	11/30/10

5. Task #5 – Improvement of WRF Model Operational Performance

During 2010, AIT's designated representative, UCAR, and TECRO's designated representative, CWB, will collaborate on improving the WRF model's operational performance at CWB. The operational WRF forecasts at CWB during 2008 and 2009 occasionally exhibited poor performance, especially for convective events. UCAR will assist CWB with investigations of such events and with testing modifications to the WRF model that will lead to improved performance. Additionally, UCAR will assist CWB with testing of the new 20-km WRF grid and provide consultation on other aspects of the operational WRF system, as well as advise CWB visitors during their visit to UCAR.

**5.1 Investigate the improvement of model QPF (quantitative precipitation forecast) via enhancements to PBL (planetary boundary layer) and Convective Parameterization Schemes (0.6 FTE)**

AIT's designated representative, UCAR, will collaborate with TECRO's designated representative, CWB, on investigation and improvement of the forecasts of convective weather phenomena. CWB has identified several cases and weather situations which resulted in poor convective forecasts. The origin of these failures is complicated, but these forecasts might be improved by enhancements to WRF's PBL and convective parameterizations. UCAR will collaborate with CWB on investigation of these cases. Modifications to the WRF physics code will be tested and, if demonstrated to be successful, will be supplied to CWB. Bao-Jao Chen from CWB will be investigating convective parameterization in the WRF model and UCAR will provide assistance as needed.

- 5.1.1 Investigate the excessive deepening of mesovortices.
- 5.1.2 Investigate cases of too strong oceanic surface winds.
- 5.1.3 Investigate the cause of unreasonable moisture profiles in the tropics.
- 5.1.4 Investigate the behavior of oceanic of convection predicted by the KF scheme.
- 5.1.5 Investigate the tendency for modeled convective systems to weaken over Taiwan.

**5.2 Assist CWB with testing of 20-km grid (0.1 FTE)**

AIT's designated representative, UCAR, will assist TECRO's designated representative, CWB, with testing of a new WRF grid. During 2009 CWB began semi-operational testing of a new, higher-resolution (20-km) grid configuration. UCAR will assist CWB with testing of this new WRF grid, including providing suggestions for physics, numerics, and name\_list options.

### **5.3 Consult and advise CWB on the operational WRF model and provide assistance to CWB visitors to UCAR (0.1 FTE)**

AIT's designated representative, UCAR, will consult and advise TECRO's designated representative, CWB, about the operational WRF model as necessary. This task will include an investigation of WRF forecasts of geopotential height and technical consultation on WRF DFI (Digital Filter Initialization) and PBL parameterization.

Ya-Ting Tsai from TECRO's designated representative, CWB, will visit AIT's designated representative, UCAR, for three months to work on DFI. During 2010, UCAR will develop a DFI capability for WRF nests and it is anticipated that the CWB visitor will assist with this task. Mei-Yu Chang from CWB) will visit UCAR for two months (June/July) to work on improving the PBL parameterization. UCAR staff will assist the CWB visitor with this task.

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

#### Performance Period:

- |  |                   |
|--|-------------------|
| a. Improve model QPF via enhancements to PBL and Convective Parameterization Schemes | 1/1/10 – 11/30/10 |
| b. Assist CWB with testing of 20-km grid   | 1/1/10 – 11/30/10 |
| c. Consult and advise CWB on the operational WRF                                     | 1/1/10 – 11/30/10 |

#### Resources Required:

0.8 FTE UCAR staff

#### Deliverables:

- |   |          |
|---|----------|
| 1. Code modifications to WRF parameterization schemes | 11/30/10 |
| 2. Final report on WRF forecast performance           | 11/30/10 |

### 6. Task #6 – Continued Interaction on WRF Modeling and Data Assimilation Systems

Because the tasks proposed for 2010 require close collaboration between TECRO's designated representative, CWB, and AIT's designated representative, UCAR, the exchange of information and progress between CWB and UCAR in a timely manner is crucial. Effective and efficient communication methods, such as the web pages for the project, and the data transfer "ftp" command must be established and updated on a timely and regular basis. The exchange visits between CWB

and UCAR staff are also necessary to ensure the smooth execution of the project. The following work will be included under this task:

### **6.1 Update and Improve the CWB Project Web Pages on both the CWB and the UCAR Sides**

With the CWB and UCAR web pages, the updated version of the 3D-Var system, WRF/DART system, experimental results, and progress reports, etc. are easily exchanged between the two groups. In 2010, AIT's designated representative, UCAR, will continue to maintain, improve, and conduct timely updates of the web pages to keep TECRO's designated representative, CWB, informed on current developments.

### **6.2 Site visit to CWB**

To ensure smooth execution of the project, it is desirable for AIT's designated representative, UCAR, to visit TECRO's designated representative, CWB. Such visits are highly valuable to resolve technical problems and report on the progress of the project. It is anticipated that Drs. Hui Liu, James Bresch, and Yong-Run Guo will visit CWB for a two week period. In addition, other UCAR staff, including Drs. Bill Kuo, Michael Barlage, and John Braun will visit CWB as needed. Additional trips by Yong-Run Guo and James Bresch will be scheduled if needed by CWB. It is also expected that senior CWB staff (Drs. Chin-Tzu Fong and Jing-Shan Hong) will visit UCAR as needed.

### **6.3 Teleconferences**

To ensure smooth execution of the project, periodic telephone conferences will be held. These telephone conferences will focus on specific topics of interest to both parties. The telephone conferences can be initiated by either TECRO's designated representative, CWB, or AIT's designated representative, UCAR, as required by the project.

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

#### Performance Period:

- |  |                   |
|--|-------------------|
| a. Update and maintain both CWB and UCAR CWB project web pages | 1/1/10 – 11/30/10 |
| b. Site visit to CWB   | 1/1/10 – 11/30/10 |
| c. Telephone conferences via Skype                             | 1/1/10 – 11/30/10 |

#### Resources Required:

0.1 FTE UCAR staff

#### Deliverables:

- |                                 |          |
|---------------------------------|----------|
| 1. Updated Web Page for Project | 11/30/10 |
| 2. Site Visits                  | 11/30/10 |

## **II. Schedule**





Site visit to CWB	X	X	X	X	X	X	X	X	X	X	X	X
Teleconference	X	X	X	X	X	X	X	X	X	X	X	X

### III. Budget

The following are the estimated costs for Implementing Arrangement #6

Tasks	FTE	Personnel Cost	Travel/Training	Total
Task #1	1.75 FTE	\$330,000	\$5,000	\$ 335,000
Task #2	.50 FTE	\$80,000		\$ 80,000
Task #3	.25 FTE	\$40,000		\$ 40,000
Task #4	.30 FTE	\$50,000		\$ 50,000
Task #5	.80 FTE	\$136,000	\$5,000	\$ 141,000
Task #6	.10 FTE	\$20,000	\$10,000	\$ 30,000
<b>Total</b>	<b>3.7 FTE</b>	<b>\$656,000</b>	<b>\$20,000</b>	<b>\$ 676,000</b>

The budget under Personnel Cost is used to support staff of AIT's designated representative, UCAR, to perform tasks described in this Statement of Work. The budget includes benefits and overhead. The Travel/Training budgets in Tasks #1, #5 and #6 are used to support travel to visit TECRO's designated representative, CWB. The travel processed by UCAR also includes the necessary overhead. As stated in the Implementing Arrangement #6, the total firm fixed price available from CWB to support the tasks, travel and meeting expenses described in this Statement of Work will be a total of US\$ 676,000. The detailed financial arrangements are described in the Implementing Arrangement #6, Article IV – Financial Provisions.

### IV. CWB Joint Team Assignments at UCAR

In order to successfully carry out this CWB-UCAR project, strong collaboration is needed between AIT's designated representative, UCAR, and TECRO's designated representative, CWB. The tasks to be performed by UCAR scientists are detailed in this Statement of Work. CWB staff will collaborate with UCAR scientists on various tasks. Some of the tasks will be performed in Taipei at CWB. Some of the tasks will be carried out by CWB staff, while they are on assignment at UCAR. Specific assignments will be made to most efficiently use the available personnel resources. Assignments for the CWB staff members will be as follows:

- Testing of the CWB operational WRFVar V3.1/WRF V3.1 system for a longer period of time
- Providing the necessary datasets to UCAR
- Participating in WRFVar and WRF/DART data assimilation experiments and results analysis
- Performing WRF physics tests
- Performing WRF tests of the new grid configuration