Summary of Participant's Reports

on the **AWCI Training Course on Improved Bias Correction and Downscaling Techniques for Climate Change Assessment including Drought Indices**

held on 18 – 20 June 2013 at the University of Tokyo, Hongo Campus, Tokyo, Japan

Introduction

The event has been proposed and undertaken as a part of activities of the AWCI project "Impact of Climate Change on Glacier Melting and Water Cycle Variability in Asian River Basins", which is funded under the Asia-Pacific Network for Global Change Research (APN) CAPaBLE Programme and led by Dr. Ghulam Rasul, Pakistan Meteorological Department (PMD). The training course has also contributed to the AWCI project "GEOSS/Asian Water Cycle Initiative/Water Cycle Integrator (GEOSS/AWCI/WCI) funded under the APN ARCP Programme and led by Dr. Shizu Yabe, Japan Aerospace Exploration Agency (JAXA). Further sponsors included the University of Tokyo (UT), who hosted the event, and the Hiroshima University. The training course website is available at:
http://monsoon.t.u-tokyo.ac.jp/AWCI/meetings/Tokyo_Jun2013/index.htm.

The training had two main objectives:
Capacity Building. The aim was to provide explanation of and teach how to apply improved climate change assessment techniques and tools including general circulation model (GCM) output selection, model output (precipitation) bias correction, downscaling of the corrected output to a basin scale and generation of drought indices and drought assessment.

Preliminary Climate Change Impact Analysis in AWCI participating basins. The results obtained during the training course are expected to be usable for regional analysis of climate change impacts on water resources, in particular droughts.

Total Number of AWCI Supported Participants: 21

Participant Reports

1. In advance Questionnaire
The participants had been asked to fill out a questionnaire in advance that inquired about their specialization, expectations of the course, familiarity with the AWCI activities and demonstration basins, previous experiences with climate change assessment methods. The replies were analyzed and reflected in preparation of the course design. The summary is shown here:

- *Research Focus of Participants:*
  - Climate Change/Meteorology: **9** participants
  - Hydrology/Water Resources: **13** participants (**2** Droughts)
- *Expectations – to learn:*
  - Bias correction and downscaling
  - Drought indices
  - WEB-DHM
- *Involvement in AWCI:* **8** participants
- *Involvement in any CCA study:* **15** participants
- *Experience with the methods to be taught:*
  - Bias Correction, Downscaling: **8** participants
  - Drought: **4** participants
  - No experience: **12** participants
- *Familiarity with own country basin:* **12** participants

2. Training Course Evaluation Questionnaire

After the training course, the participants were asked to complete an evaluation questionnaire aimed at participants' perception of the course merits for their future work and also at their assessment of the course design and teachers' performance. In addition, the participants were asked to draft a brief technical report on their work and achievements during the course and also suggestions and plans for further research. The requested attachments included:

Part 1: Model Selection, Bias Correction and Downscaling:

- The **model selection excel sheet** that you have completed using the on-line system for model output evaluation at: http://dias.tkl.iis.u-tokyo.ac.jp/model-eval/stable/index.html
- If possible, any figure of the bias corrected and downscaled precipitation data using the GrADS software.

Part 2 & 3: WEB-DHM runs and drought indices:

- The Discharge and Drought SA analysis excel file (multiple sheets) as explained by at the course.

A one-month period was provided for the participants to complete their reports. The received inputs have been compiled in two files. The first one is an excel sheet summarizing the questionnaire answers (AWCI2013Training-Evaluation_Participants.xls), the second one is a compilation of technical reports (AWCI2013Training-CCA_drought-ParticipantReports.doc).

The questionnaire.

The questionnaire answers showed that the training course met expectations of most of the participants and most of them felt they had learned some new and useful knowledge for their future work. On the other hand, the participants felt the time was rather limited to fully grasp all the details of the taught methods and thus further study (even self-study) or cooperation with the methodology authors would be necessary to be able use it for future applications in their countries. Nevertheless, many of the participants expressed their further interest in these climate change assessment techniques and intention of their institutions to use these techniques. In addition, more than half of the participants could derive at least some indicative results for their basin from the standard anomaly drought indices generated during the training course. These results will be further explored and appropriately published.

Technical reports summary.

The training course tasks included:

- Selection of suitable GCM(s) for given study area
- Bias correction and downscaling of the selected GCM output(s) using the in-situ data
- Setting up the WEB-DHM runs and running WEB-DHM
- Processing and analyzing the WEB-DHM output
- Standard Anomaly (SA) drought indices generation from the WEB-DHM output

The climate change assessment studies are being done using an ensemble of GCM outputs, where the ensemble consists of "suitable" GCMs for the study area. The suitability of a GCM in the introduced methodology is assessed using a "scoring" method based on RMSE and Spatial correlation between the GCM output and a reference dataset (derived from observations or reanalysis). Using this method, which is incorporated in the on-line tool explained during the training course, the participants obtained a set of suitable models for their individual basins. For all basins, the model "gfdl_cm2_1" was either the first or second best and thus it was decided to use this model output for the training course purposes and only this one output due to the limited time available.

The GCM outputs cannot be used directly for hydrological simulations at the basin scale because of significant biases and coarse resolution and thus bias correction and downscaling methods must be applied to the GCM output. A user-friendly on-line tool has been developed for this purpose and was introduced at the training course. The participants used the tool to generate bias corrected and downscaled precipitation data for their respective basins. While the tool is very handy, some participants felt it would be useful to also see the procedure be done step by step with explanation of the theory behind each step.

After producing the suitable precipitation data for the baseline historical period (1981 – 2000) and the investigated future period (2046 – 2060), the pre-prepared and calibrated WEB-DHM models for individual basins were set up using the generated precipitation data and other forcing data pre-prepared from JRA25 reanalysis. The participants run their WEB-DHMs on the distant server, generating necessary outputs for basin water budget assessment.

WEB-DHM was used to simulate past (1980-2000) and future (1946-1965) river discharge by using the selected GCM result as input. Although the simulation was conducted in daily time step, statistical analysis to capture river discharge variations throughout the year was computed in monthly basis. To evaluate the extreme event, simulation result was normalized based on the best-fit distribution for each monthly series. JMP software was used for this statistical analysis. By using the criteria of extreme event from standard deviation, the number of event with category "Extremely dry" (Stdev < -2.0), "Severely dry" (-2.0 ≤ Stdev < -1.5), and "Moderately dry" (-1.5 ≤ Stdev < -1.0) can be computed. In this way, most of the participants were able to generate the SA drought indices for the baseline historical period and the investigated future period. Due to the limited time, some participants were not able to complete the final step that involved the commercial statistical software JMP10 and thus were not able to finalize their work later if they were not able to obtain the software.

Some Indications

Tone (Japan)

The participants, who worked with the Japanese Tone river basin data (because the database for their country basin has not been fully developed for this kind of study yet, namely India, Lao, Uzbekistan), have concluded that the obtained results indicated **increase** in the river discharge in future and **decrease** of the frequency of "severe" and "moderate" drought events.

Citarum (Indonesia)

In general, the results indicated more extreme months in past scenario than in future scenario for both for dry or wet months. However, the event in future scenario tends to be more extreme than in the past scenario, especially for wet event. For example, there were only six events in past scenario with Standard Deviation > 2.5 (very extreme wet), while in future scenario, the number of event increased to 8 events, and there were 2 events with Standard Deviation > 4.0. The trend in extreme dry event seems not as clear as wet event. Although the average simulated discharge of future scenarios is lower than past scenarios, it seems still in range of 'near normal event'.

The Indonesian participant provided two comments. The first one is regarding the reference precipitation data used for model selection, i.e. GPCP data: *Probably, GPCP is one the best data precipitation available for long term and large scale study. However, comparison with TRMM and station data in study area shows that GPCP data tend to be overestimate especially in Java Island, the location of Citarum River Basin.* Comparison of multiple GCM outputs with TRMM data showed that better results for other GCMs than the selected gfdl_cm2_1 model.

Secondly: *WEB-DHM result showed that the average daily discharge in past scenario (1981-2000) is 89.7m3/s while in future scenario (2046-2065) the value is **decrease** to 66.2m3/s. This result is slightly different with figures in IPCC report which suggest that precipitation in South East Asia tend **increase** in the future.*

Langat (Malaysia)

From the standardized anomaly (SA) index analysis of Langat streamflow, most of the monthly temporal distribution of SA indexes for both past period 1981-2000 and future period 2046-2065 lies within the 'normal' category. In 1981-2000, there are twenty (20) occurrences of 'moderately dry' months with the lowest SA index of -1.377 in May 1986. However, there was no drought or water stress incidents reported for the year. Whilst the second lowest index is -1.33 which is in May 1998. From historical analysis it is known there was a prolonged dry months in 1998 in the basin, the event had caused major water crisis and shortage of water supply in Klang Valley and Langat basin, which had affected 1.8 million residents. However, the calculated indexes for the months are classified as 'moderately dry'.

As for the future period, it is estimated that eighteen (18) 'moderately dry' months and two (2) 'severely dry' months would occur. The temporal distribution evaluated, although is inadequate, but could be a quick reference & rough estimate of future possible drought occurrences.

Swan (Pakistan)
The discharge in the past has peak values for the years 1985-1987 and in 1992-1998; in between these time slots the peak sometimes has decreasing and increasing trend otherwise. For the future simulation of discharge the peak values appear in the year 2052-2054 and 2060-2062. However the peak values are not much greater than the peak values of the past. This shows the moderate dryness of the basin in the future. The monthly discharge is prominently increasing for the August, September and October months in the future (2046-2065).

The standardized anomaly index calculated for the past and future discharge simulated by WEB-DHM was calculated for three different categories (1) Extremely Dry, (2) Severely Dry and (3) Moderately Dry. The frequency of extremely dry conditions was higher for future as compared to the past whereas for the other two categories the values are equal or less to the past.

Kalu Ganga (Sri Lanka)
Monthly Discharges of each month in the Past and Future periods were fitted the bets statistical distribution using JMP10 software. The statistical parameters Location and Scale were derived for each month from the selected distribution. Drought indices were estimated. Number of months that extremely dry, severely dry and moderately dry conditions for past and future GCM discharge output was compared indicating **increase** in the river discharge in future and **decrease** of the frequency of “severe” and “moderate” drought events.

Mae Wang (Thailand)
The obtained results indicated **increase** in the river discharge in future and **decrease** of the frequency of “extremely”, “severe” and “moderate” drought events. Future work on this research should include a more extensive validation small-scale patterns with statistical methods involving height regressions, the differences of bias - corrected data. If this project has also developed algorithms combined with high resolution remote sensing and physically - based patterns, could greatly improve the realism of the resulting.

Huong (Vietnam)
The obtained results indicated **increase** in the river discharge in future and **decrease** of the frequency of “severe” and “moderate” drought events.

Besides the work done during the training course, the introduction of satellite rainfall GSMap and the exploitation of this data are useful for all participants when they return to their country to apply to mining operations as well as exploiting data sources for research. A stark example such as Vietnam, where network of hydro- meteorological observations are lack in some basins, affects strongly on forecast as well as research of my center. Satellite rainfall GSMap is a door where we can help solve this problem.