Summary report on
The Asian Water Cycle Initiative (AWCI) Training Course on Improved Bias Correction and Downscaling Techniques for Climate Change Assessment including Drought Indices
held
at the University of Tokyo, Hongo Campus, Tokyo, Japan, 18 – 20 June 2013

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.

The course included two and a half day of lectures with hands-on exercises, during which the participants used the data of their country demonstration basin. In the afternoon of the last day, the participants visited the DIAS core system at the Institute of Industrial Science (IIS), on the Komaba campus of UT. In total, 22 representatives of 18 AWCI countries and 6 local participants undertook the training course, 6 invited experts provided thematic lectures and 6 trainers of UT assisted the participants during the hands-on exercise sessions.

The scope of the teaching sessions covered:

- A method for selection relevant models out of the CMIP family of general circulation models (GCMs) and necessary tools (on-line).
- A comprehensive statistical method for bias correction of the GCM precipitation output (historical simulation and future projection) including heavy, normal and low rainfall events and using rain-gauge data provided for the AWCI CCAA study; necessary tools (on-line).
- A statistical spatial downscaling method using available rain-gauge data within the basin; necessary on-line tools; (option to use GSMaP data to obtain spatial distribution in case of very limited number of stations will be explained but not actually used).
- Running WEB-DHM using the bias corrected and downscaled precipitation data of one pre-selected GCM, other forcing data will also be extracted from this GCM (not bias-corrected). Only basins that participated in the March 2011 will be considered for this step, i.e. Meghna (Bangladesh), Punatsangchhu (Bhutan), Sangker (Cambodia), Citarum (Indonesia), Tone (Japan), Langat (Malaysia), Tuul (Mongolia), Shwegyin (Myanmar), Narayani (Nepal), Soan (Pakistan), Pampanga (Philippines), Kalu Ganga (Sri Lanka), Mae Wang (Thailand), Huong (Vietnam).
- A method to generate drought indices and drought assessment method and tools using corrected precipitation outputs for past and future AND simulated river discharge by WEB-DHM. The full method using further spatial hydrological outputs by WEB-DHM (groundwater, soil moisture, surface fluxes) will be explained but not actually used for the training (time limitation).
- In-situ data quality control tool.

Training Course Agenda

Tuesday 18 June: GCM Selection, Bias Correction, Downscaling

08:00 – 08:30 Registration

08:30 – 09:10 Opening Session
08:30 – 08:40 Welcome remarks: Toshio Koike (UT)
08:40 – 09:10 Opening Lecture: Climate Change Impact Assessment in Asia (Toshio Koike, UT)

09:10 – 10:45 Lectures
09:10 – 09:20 The training course design (Petra Koudelova, UT)
09:20 – 09:40 Development of Statistical Bias correction and Downscaling scheme for climate change impact assessment at a basin scale (Cho Thanda Nyunt, UT)

09:40 – 10:00 BREAK

10:00 – 10:30 Introduction of Global Satellite Mapping of Precipitation (Satoshi Kida, JAXA)
10:30 – 10:45 Asia Pacific Network for Global Change Research (APN) Activities (Taniya Koswatta, APN Secretariat)

10:45 – 18:00 Training, part 1: GCM Selection, Rainfall Bias Correction, Downscaling
10:45 – 12:00 Hands-on training session: GCM selection (DIAS on-line system, Excel sheets)

12:00 – 12:10 Group Photo (Kentaro Aida, UT)
12:10 – 13:15 LUNCH

13:15 – 18:00 Training, part 1: GCM Selection, Rainfall Bias Correction, Downscaling: Continue
13:15 – 14:00 Hands-on training session: GCM selection (DIAS on-line system, Excel sheets) – continue
14:00 – 14:15 Introduction of the on-line system for the bias correction and downscaling (Mohamed Rasmy, UT)
14:15 – 15:30 Hands-on training session: Rainfall bias correction and Downscaling for the historical baseline period (1981 – 2000) and future projection period (2046 – 2065) (DIAS on-line system) and preparation of the WEB-DHM precipitation forcing data

15:30 – 15:50 BREAK
15:50 – 17:30 Hands-on training session: Rainfall bias correction and Downscaling (DIAS on-line system) and preparation of the WEB-DHM precipitation forcing data – continue

17:30 ADJOURN

18:00 – 20:00 Cocktail and Discussion Session (UT Café)

Wednesday 19 June: WEB-DHM running for historical and future periods; Drought Indices

08:30 – 12:00 Training Part 2: WEB-DHM
08:30 – 09:05 Hydrological modeling for climate change impact assessment – importance of in-situ precipitation data and Drought under the climate change (Toshio Koike, UT)
09:00 – 09:15 Climate change impact assessment on water resources sector in Malaysia (Nurul Huda Md. Adnan, NAHRIM)
09:15 – 09:30 Hydrological Modeling (WEB-DHM) for the AWCI/CCAA Climate Change Impact Assessment Studies (Patricia Ann Jaranilla-Sanchez, UT)
09:30 – 09:45 WEB-DHM with an advanced, energy balance based snow-melt scheme and glacier-melt component: WEB-DHM-S (Maheswor Shrestha, UT)

09:45 – 10:00 BREAK

10:00 – 11:30 Hands-on training session: Visual analysis of bias corrected and downscaled rain (Grads); Off-line preparation for running WEB-DHM

11:30 – 12:45 LUNCH

12:45 – 13:30 Hands-on training session: Running WEB-DHM

13:30 – 14:00 In-siu data management system for AWCI - Introduction and the on-line tool demonstration (Katsunori Tamagawa, Hiriko Kinutani, Misa Oyanagi, UT)

14:00 – 17:30 Training Part 3: WEB-DHM outputs, Drought Indices & Presentation on JRA55
14:00 – 14:30 Drought Indices: methodology and applications for drought assessment (Patricia Ann Jaranilla-Sanchez)
14:30 – 16:00 Hands-on training session: WEB-DHM and Drought Indices generation using the bias corrected precipitation and WEB-DHM historical baseline and future period outputs (prepared in advanced by the UT team).

16:00 – 16:30 BREAK

16:30 – 16:45 JRA55 reanalysis by JMA (Kazutoshi Onogi, JMA)
16:45 – 17:30 Hands-on training session: Drought Indices generation using the bias corrected precipitation and WEB-DHM historical baseline and future period outputs. Continue.

17:30 ADJOURN

Thursday 20 June: WEB-DHM output review, Drought Indices, Excursion to IIS

08:30 – 11:00 Training Part 3 - Continue: WEB-DHM outputs, Drought Indices
08:30 – 09:45 Hands-on training session: Drought Indices generation – continue; Review and discussion on the WEB-DHM results of the previous day runs.

09:45 – 10:00 BREAK

10:00 – 11:00 Hands-on training session: Result analysis, conclusions, Q&A.
11:00 – 11:20 Change of precipitation and soil moisture on the Mongolian Plateau from 2001 to 2012 (Ichirow Kaihotsu, Hiroshima University)

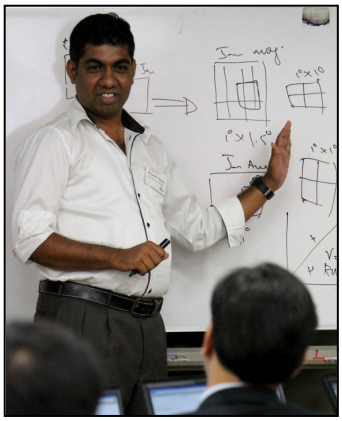
11:20 – 12:10 Closing Session
11:20 – 11:30 Closing Remarks
11:30 – 12:00 Certificate Ceremony
12:00 – 12:10 Logistics of the afternoon excursion

12:10 – 13:50 LUNCH

14:20 – 18:00 Excursion to the DIAS core system at the Komaba Campus of the University of Tokyo
14:20 Meeting in front of the Engineering Bldg. No.1 (ginkgo tree)
14:30 Departure to the Komaba campus (subway)
16:00 – 17:30 Visit of the DIAS core system

19:30 – 21:30 Meeting Dinner (Boat Cruise at Tokyo Bay)

21:30 ADJOURN



Full Report

1. The training course design

The training course was an augmented follow-up on the previous AWCI training event held at the Univ. of Tokyo in March 2011 (http://monsoon.t.u-tokyo.ac.jp/AWCI/meetings/Tokyo_Mar2011/index.htm). This year course was organized as a part of the AWCI project "Impact of Climate Change on Glacier Melting and Water Cycle Variability in Asian River Basins", which is mainly focusing on water cycle variability in glacier and snow fed basins but is also oriented more on drought issues of the AWCI basins. Accordingly, the intention was to provide training on climate change impact assessment methods for researchers of the AWCI countries to be able to carry out assessment analyses for their respective basins, with focus on drought events. To initiate a preliminary analysis in these basins was the second objective of the course and the results of participants' work during the course are expected to contribute to this objective.

The participants of the training course had been nominated by country representatives on the AWCI International Coordination Group (ICG) and included experts and scientists from meteorological and hydrological institutions of the AWCI countries. 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, and proficiency in various software tools that would be used during the course. The results of this participant survey have been reflected in the course preparation.

The training part of the course included three main sessions:

1. Preparation of the precipitation data for a hydrological model: GCM selection, bias correction of the GCM precipitation output and downscaling – methods explanation and application using on-line tools.
2. Water and Energy Budget Distributed Hydrological Model (WEB-DHM) – model explanation and running pre-set simulations using the precipitation prepared in the Session 1.
3. Standardized Anomaly Drought (SA) Indices – explanation and calculation of indices using the WEB-DHM simulation outputs and the statistical software tool.

At the beginning of each session, thematic lectures were provided to explain in detail the physical, mathematical and statistical background of proposed methodologies as well as the usage of necessary software tools. After the lectures, practical hands-on exercises were conducted, during which one trainer was explaining the procedure, while the participants worked individually on provided PCs. A group of

supporting trainers assisted the participants, if they encountered difficulties. Printed hand-outs and templates for each session were provided to the participants. All the tasks to be completed by the participants during the course had been resolved by the trainers in advance to have the results available for verification and in case some of the participants could not complete certain steps.

In addition, several invited talks on relevant topics were scheduled during the training course that complemented the theoretical background of the climate change assessment analyses and drought phenomena.

2. Training sessions

2.1 GCM Selection, bias correction, downscaling.

This session was opened by a comprehensive lecture on climate change and its impacts on water cycle by Prof. Toshio Koike. It explained physical laws of interactions between various components of water cycle and climate and provided theoretical background of climate change impact assessment approaches including use of GCM historical simulation and future projection outputs as forcing data for hydrological models to reveal possible changes in hydrological regimes at the basin scale. The need for bias correction and downscaling of the GCM output for this purpose was also explained, followed by introduction of the improved bias correction and downscaling method developed by the University of Tokyo and to be used during this training course as well as in the proposed AWCI preliminary CC impact assessment analysis.

After the opening lecture, the author of the bias correction and downscaling methods, Ms. Cho Thanda Nyunt, has provided detailed explanation of these methods, referring to the published paper that was also provided among the hand-outs (Nyunt et al., 2013). Firstly, a method for selection suitable GCMs for a region of interest out of the CMIP3 set of models was introduced. This method was already used at the March 2011 training course and main features of the scoring approach to assess suitability of each GCM were explained. The scores are calculated based on the spatial correlation coefficients and root mean square errors for the model output vs. reference data (GPCP in case of precipitation).

The comprehensive statistical bias correction method is using in-situ and covers extreme rainfall, normal rainfall and frequency of dry days. Heavy rainfall is corrected by fitting a Generalized Pareto Distribution (GPD) to peak over threshold series, which is an improvement from the approach of the bias correction

method used during the March 2011 training course that considered every year maximum rainfall (and only single extreme value per year) in the extreme rainfall “sub-series”. A gamma distribution is used for normal rainfall correction on a monthly scale and ranking order statistics of the entire time series is employed to correct frequency of wet days in the GCM output. Validation of the method was done in the Pampanga basin, Philippines, via long-term seasonal climatologic rainfall, ranking extreme rainfall, and return-period estimates by the GPD.

A statistical downscaling method exploiting the JAXA Global Satellite Mapping of Precipitation (GSMaP) products was also developed and introduced during this lecture. At the training course, the downscaling method based on multiple rain gauge observation datasets within the targeted basin was used. In this case, the GCM output is corrected for bias using every available rain gauge dataset within the basin and the corrected rainfall distributed according to these rain gauges using the inverse distance method.

After the lectures, the practical hands-on exercise took place consisting of two steps: (i) Suitable model selection and (ii) Bias correction and downscaling. Both steps were based on the use of an on-line tool that had been developed for evaluation of CMIP3 model output and facilitating the use of these datasets for climate change impact assessment studies. The tool is a part of the DIAS system and is publicly available at: https://dias-dss.tkl.iis.u-tokyo.ac.jp/model-eval/stable/index.html, however registration is required.

The model selection step was conducted by Dr. Petra Koudelova and the bias correction and downscaling steps by Dr. Mohamed Rasmy. The participants obtained hand-outs and templates and were provided with sufficient time for individual self-practice to complete these tasks. All participants identified a subset of suitable GCMs for their respective basins. Due to the time limitation during this course, only one, the most suitable model output according to the scoring technique was used for further analysis. By the end of the day, all participants have produced spatially distributed, bias corrected rainfall output for the 20-year historical period (1981 – 2000) and for the 20-year future period (2046 – 2060).

2.2 WEB-DHM

The WEB-DHM session included three explanatory lectures on the model structure, physics and applicability for the climate change assessment analyses. The first lecture was provided by Prof. Toshio Koike, who focused on the importance of a suitable hydrological model for the region of interest and also

great importance of good quality in-situ observations for obtaining sound results from model simulations. In addition, the uncertainty of the GCM simulations, in particular future projections, was highlighted and the need of an ensemble approach in the climate change assessment analyses emphasized.

The second lecture was given by Dr. Patricia Ann Jaranilla-Sanchez, who explained the WEB-DHM features that demonstrated its suitability for the targeted climate change assessment analyses in most of the AWCI basins and provided examples of such WEB-DHM applications (three basins in Philippines). While WEB-DHM is a top-tool for hydrological applications in most of the climatologic conditions, it is not very suitable for basins, where snow and glacier-melt phenomena significantly influences runoff. To overcome this issue, the WEB-DHM-S version had been developed at UT (Shrestha et al., 2010), which introduces an advanced, physically based energy balance snowmelt scheme into WEB-DHM. This model had been verified in the Himalayas region in Nepal and applied to the AWCI basin in Nepal and Bhutan. The third lecture during this session was provided by Dr. Maheswor Shrestha, who introduced the advanced snow and glacier features of WEB-DHM-S.

After the lectures, the practical session was led by Dr. Jaranilla-Sanchez, during which the participants accessed a remote server and run the pre-set WEB-DHM simulations using the rainfall data they prepared on the previous day. Hand-outs were provided with specific steps highlighted. Due to the limited time, this training course was not designed to teach full scope of WEB-DHM and its setting and data preparation because it require about a full-week intensive training. Therefore the runs had been pre-prepared by the trainers and the necessary procedures were highlighted but not explained in detail and undertaken by the participants. The runs on the remote server took several hours (depending on the size of the catchment) and thus the results were only available on the following day. In the meantime, generation of drought indices was explained.

2.3 Drought Indices

The drought-focused session also included three lectures that introduced the phenomenon and the methods and tools for assessment of droughts and also impacts of climate change on droughts. The overview lecture on drought was provided by Prof. Toshio Koike. Dr. Patricia Ann Jaranilla-Sanchez explained the basis of SA drought indices, their meaning and how to calculate them using the output of WEB-DHM simulations, providing examples of applications in the AWCI basins. The third lecture was given by Prof. Ichirow Kaihotsu, who introduced soil moisture monitoring activities in the Mongolian

Plateau and analysis of the observation results for the period from 2001 through 2012, highlighting the changes in precipitation and soil moisture.

The hands-on practical part of the session included several modules focused on individual steps of the generation procedure of temporal and spatial SA using the WEB-DHM output for the two 20-year periods (historical and future). The session was conducted by Dr. Jaranilla-Sanchez, the author of the SA indices method for assessing the drought. The participants were provided with detailed hand-outs covering all the modules and a template sheet for their work and were led step by step through the individual tasks. The procedure was firstly explained and trained on sample datasets from previous analyses and when the WEB-DHM runs have been completed, the participants applied the learned technique on the obtained results for their respective basins. Like at the previous practical sessions, the individual work of the participants was supported by a group of assisting trainers.

3. Invited talks

The training course also included several invited talks. Ms. Taniya Koswatta represented the APN Secretariat, and introduced their activities in the field of global climate change research and opportunities APN is providing for scientist and practitioners in the arena of water cycle related issues. The participants were encouraged to consider their application in relevant APN programmes.

Dr. Satoshi Kida introduced the JAXA Global Satellite Mapping of Precipitation (GSMaP) project, which provides near real time (with 4-hours delay only) hourly global precipitation data produced from satellite observations between the latitudes of 60N – 60S. The data is freely available at: http://sharaku.eorc.jaxa.jp/GSMaP/. The comprehensive algorithm using data of various sensors on multiple satellites was explained and the future improvements and expansion of the products were outlined. The participants were also informed on how to register to receive a user account.

Dr. Kazutoshi Onogi provided insightful presentation on the JRA-55 reanalysis, which covers year 1958 - 2012. The improvements over the JRA-25 datasets were discussed and plans for release of the data for research use in autumn 2013 mentioned. The data will be available through the DIAS system. In spring 2014, JRA-55 real-time products will be released. In another talk, Ms. Nurul Huda Md. Adnan, NAHRIM,

Malaysia, presented the climate change impact assessment study in the Peninsular Malaysia that utilized the statistical bias correction and downscaling method explained at the previous training course in March 2011. She mentioned that simultaneously, dynamical bias correction and downscaling method was applied and the results compared. The statistical method suggests more severe impacts than the dynamical one.

In addition, demonstration of the in-situ data quality control system developed at UT as part of DIAS and tailored for the needs of AWCI was provided by Mr. Katsunori Tamagawa, Dr. Hiroko Kinutani, and Dr. Misa Oyanagi. The system provides on-line based interactive tools of data visualization and provides options for data revision and flagging. It had been designed for in-situ data providers to facilitate the data quality control. The participants were encouraged to perform the quality control of their basin long-term datasets that have been provided to the AWCI Phase 2 for the purpose of the climate change assessment study.

4. Closing and Follow-up

The training course was concluded by the Certificate ceremony session, at which all the participants received the Certificate of Accomplishment for duly completing all the required tasks of the course. At the same time, the participants were requested to submit a participant report consisting of two parts, a questionnaire providing feedback to the organizers and trainers and a technical report including summary of participant activities and results of his/her work. The due date for the report submission is 31 July 2013. The reports will be compiled into a single document and attached to the Progress report of Dr. Rasul's APN funded project.

5. Visit to the DIAS core system

After the Certificate ceremony session and lunch break, the participants gathered again and went to the Komaba campus of UT to visit the DIAS core system, which is administered by the Institute of Industrial Science, UT. The visit included a demonstration of the DIAS data visualization tools, showing an advanced, real-time monitoring system over the research area in Cambodia and an visual analysis of NCEP reanalysis data over the Tibetan Plateau to investigate the role of the Plateau in the onset and maintaining of the Asian summer monsoon. After this demonstration, the group moved to the computer system room, where the DIAS large data storage is located. The kindness of the IIS team to provide such an informative tour was greatly appreciated by the participants.