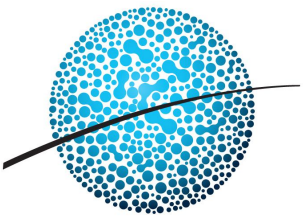
The 7th APEC Climate Symposium 2011
Harnessing and Using Climate Information for Decision Making

Honolulu, Hawaii, USA
17 – 20 October 2011

Note: This document summarizes the discussion at the APEC Climate Symposium on Harnessing and Using Climate Information for Decision Making held at the East West Center, Honolulu, Hawaii, USA on 17-20 October 2011.

Asia-Pacific Economic Cooperation



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Acknowledgements

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APCC would like to extend its sincerest thanks to the funders and all participants for making the events both meaningful and successful.

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Symposium Proceedings

Summary

1. The APEC Climate Symposium 2011(7th APEC Climate Symposium): Harnessing and Using Climate Information for Decision Making was successfully held from October 17 – 20, 2011 at the East West Center in Honolulu, Hawaii, USA in conjunction with the following related meetings and activities: Climate and Agriculture Workshop, Climate and Water Resource Management Workshop, Climate and Energy Workshop, US-Korea workshop on Use of High Resolution Model for ISI Prediction of Extreme Events and Its Regional Impacts and Climate Variability and Change, Working Group Meeting, APCC Science Advisory Committee Meeting, and a tutorial Session on Downscaling and CLIK.

2. The events were attended by around 120 participants from 20 APEC member economies – Australia, Canada, Chile, China, Chinese Taipei, Hong Kong China, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, The Philippines, Russia, Singapore, Thailand, the United States, and Vietnam – and 2 other economies(India and Italy). Participants included invited speakers, representatives from National Meteorological and Hydrological Services (NHMSs), academics and students. Experts from climate application field such as agriculture, water, and energy were invited to the symposium to discuss the importance of climate information and its application. The list of participants can be viewed in Annex I.

APEC Climate Symposium 2011

3. APEC Climate Symposium 2011 opened on Monday, October 17, 2011. The Opening Ceremony began at 9:00 a.m. with opening remarks by Dr. Chin-Seung Chung, APEC Climate Center Director and Prof. Kevin Hamilton, the Director of International Pacific Research Center. The first congratulatory address was given by Lt. Gov. Brian Schatz from Government of Hawaii. Dr. Brian Taylor, the Dean of School of Ocean and Earth Science and Technology (SOEST) also gave congratulatory remarks on

behalf of the President of the University of Hawaii, Dr. M.R.C. Greenwood. A Co-Chair of APCC Science Advisory Committee, Prof. JagadishShukla was also invited for the congratulatory address.

Session I: Keynote Presentations

4. The opening session commenced at 9:55 a.m. and consisted of keynote presentations by five distinguished climate scientists. Session I: Keynote Presentations was chaired by Dr. Vladimir Kattsov from Main Geophysical Observatory, Russia. Dr. Yukio Masumoto from Japan Agency for Marine-Earth Science and Technology, Japan and Dr. James Renwick from National Institute of Water and Atmospheric Research, New Zealand served as rapporteur for the session.

5. Dean Rosina Bierbaum from University of Michigan, USA gave an excellent overview talk entitled *Adaptation to Climate Change: A Rich and Timely Agenda* which describes 'avoiding the unmanageable (mitigation) and managing the unavoidable (adaptation)'. She stressed that both aspects of the climate change response are important and inter-linked and are required for better management of land, water, and energy sectors. There is general acceptance these days that adaptation is considered important by policy-makers, whereas in the past, mitigation had a much higher profile. A key for success of adaptation would be exchanges of idea among economists, ecologists, climate scientists, and key stakeholders, since the climate change issue involves wide spectra of activities and needs multi-disciplinary approaches. To improve our preparedness to impacts of the global warming, the adaptation research needs to be bolstered. Downscale predictions and early warning systems are important tool for providing useful and "usable" data for adaptation.

6. Professor Jagadish Shukla from Center for Ocean-Land-Atmosphere Studies, George Mason University, USA gave a review of the analysis of forced and unforced patterns of decadal variability entitled *Prospects for Continental Scale Decadal Prediction*. Observed climate variability is the sum of forced variability, unforced internal variability, and 'noise'. Is unforced decadal (internal) variability predictable? COLA

has analyzed 300 years of pre-industrial control simulations from AR4-era CGCMs, looking for predictable internal modes. The leading global mode has features of the PDO and AMO. It has an e-folding time of about 5 years, so may be predictable. However, prior potential predictability studies show little predictability over the land surface, and the leading internal modes show almost zero correlation with land surface temperature or precipitation. So, a search was carried out for the SST pattern that maximizes land surface predictability, for 6 continental regions separately (using 150 years data for training and 150yr for testing). In each region, the leading temperature pattern is very large-scale, with same-sign anomalies everywhere. The North American pattern maximizes over NE Canada and Greenland, with another maximum over Alaska. For Europe, the result was the weakest, as the SST 'forcing' appears to be solely local. For precipitation, very little predictability was found. Looking at the forced signal (using 20th century runs, with GHG increase), the predictable patterns are similar to those for unforced variability, though the locations of maxima are somewhat different. Hence, forced and unforced variability have similar patterns, on decadal time scales, so are hard to untangle from observational data. This implies that attribution may be difficult on these time scales.

7. Professor In-Sik Kang from Seoul National University, Republic of Korea reviewed briefly about the present status of cloud microphysics parameterization in state-of-art AGCMs. Since model resolutions are not yet enough to resolve the cloud processes directly in the most GCMs with the resolution of about 10 to 100km, some parameterizations are required to represent small-scale convective processes. In this regard, understanding of cloud processes and development of better parameterization schemes are one of the challenging issues in the climate research community. However, in some cases, inclusion of such the parameterization generate precipitation patterns that are much worse, in terms of intensity and horizontal distribution, compared to the case without any parameterization, in which only the large-scale condensation process is considered. Motivated by this difficult situation, professor Kang tried to compare results from a very high-resolution model with the cloud microphysics parameterization. The result shows that, in 10-km resolution model, patchy heavy rainfall regions appear while weak precipitation spreads widely in the

1-km resolution case. Total precipitation seems to be the same magnitude in both cases. Also the vertical profiles of the moist convective energy between the two cases indicate that the 10-km resolution model has relatively dry and stable profile compared to the 1-km case. In addition to the cloud microphysics parameterization, inclusion of enhanced mixing can improve model performance to simulate more realistic large-scale distribution pattern in the precipitation. He concluded, however, that further studies on this topic would be needed.

8. Professor Bin Wang from International Pacific Research Center, University of Hawaii, USA presented a new approach to understand summer rainfall in East Asia, using an index of the Western North Pacific Subtropical High (WNPSH). Asian monsoon prediction in JJA shows very little skill. This talk investigated what controls the variability in this region. Interannual variability in H850 maximizes in the western end of the North Pacific subtropical high; this must be well forecasted to get EASM rainfall right and to correctly predict typhoon occurrence. An index of WNPSH variability was defined and related to SST and circulation. ENSO plays a role, as does northern Indian Ocean SST. The two leading EOFs of SST and low-level winds suggest that there are two important influences: a local air-sea interaction, where increased NE wind flow from an enhanced WNPSH leads to lower SST, leading to reduced convection and increased subsidence higher pressure and warming in the northern Indian Ocean appears to be a response (tropical wave theory); and a remote 'forcing' from the central Pacific (ENSO, where cooling in the central Equatorial Pacific (La Niña) leads to an enhanced WNPSH through Ross by wave propagation. The two EOF series capture most of the WNPSH variability – a regression model that uses the SST difference between the northern Indian Ocean and the western North Pacific, the seasonal change in SST in the central Pacific, and an index of the NAO is a very good fit to the WNPSH index. This implies that the skill of predicting related EASM precipitation variability and WNP typhoon activity (6-month forecasts from DJF to JJA) can be increased.

9. Mr. Neil Plummer from Bureau of Meteorology, Australia introduced extensive activities of the organization about how they communicate with stakeholders and

users of the climate information. It is estimated that 5% of Australian GDP (A$58 billion) is dependent on climate variability, suggesting that improved and accurate climate forecast and appropriate use of the climate information could save a lot of loss in the economy. As examples of the BoM's activities, applications of seasonal forecasts in the areas of agriculture, water resource management, and energy sector are introduced and they include seasonal climate outlook, seasonal streamflow forecast, national climate and water briefing series, and Pacific Island – Climate Prediction program. There are strong needs for the climate forecasting from many stakeholders, but the level of understanding varies widely and rather low. To develop the seasonal climate outlook, Bureau developed user-oriented design with four different levels of information: (1) overview; (2) confidence about the forecast; (3) simple outlook; and (4) advanced outlook. A statistical forecast for the stream flow in the Murray-Darling Basin is introduced as a second example. Bureau is also considering a dynamical forecasting system in the future. This activity and the delivering of climate information through the national climate and water briefing series in Canberra are developed on extensive dialogues with user communities. Such communications are essential to improve level of understanding of users and ability of dissemination of correct information from providers. It also contributes to enhance the relation between the users and providers. Pacific Island – Climate Prediction program is one example of the climate forecast application in the Pacific island countries, funded by AusAID for the past 8 years. There are many pilot projects in this program, focusing variety of application fields, including energy sector in Samoa. There is no "one size fits all" solution for delivering the climate information to end users, and continuous interactions, education, and improvements both at the user and provider sides are necessary.

Session II: Updates on climate Prediction Systems of the Asia-Pacific

10. The afternoon session of October 17 commenced at 1:30 pm. The session II discussed *updates on climate prediction systems of the Asia-Pacific* and was chaired by Dr. Antonio Navarra from Euro-Mediterranean Centre for Climate Change (CMCC), Italy and Professor Yihui Ding from China Meteorological Administration, China. Dr.

Flaviana Hilario from Philippine Atmospheric, Geophysical and Astronomical Services Administration, Philippines and Dr. Hyun-Kyung Kim from Korea Meteorological Administration in Republic of Korea were appointed rapporteurs.

11. Session II was opened by Dr. Oscar Alves from Bureau of Meteorology, Australia, in a talk entitled *The New POAMA2 Seasonal and Multi-Week System*. Dr. Alves introduced POAMA-2, a new version of POAMA dynamical seasonal prediction system. POAMA-2 will replace current statistical seasonal forecast system of Australia for both seasonal and intraseasonal (multi-week) timescale forecasts. By utilizing multi-model ensemble strategy, a new pseudo-Ensemble Karman Filter Ocean data assimilation scheme, and a couple breeding technique for generating forecast perturbations, significant improvements were made especially for the regional rainfall forecast skill over Australian and intraseasonal variability come from a new initialization method or the improvements of model itself. Dr. Alves responded a new initialization method might lead the improvements of model results.

12. Dr. Jae-Kyung E. Schemm from Climate Prediction Center of National Oceanic and Atmospheric Administration, USA introduced a new version of the NCEP Climate Forecast System (CFSv2) which was implemented on March 2011. In order to realize the seamless prediction, intraseaonal(3-6 weeks) forecast runs are now performed, which fill the gap between 2 weeks and seasonal forecasts. CFSv2 incorporates the 2009 version of NCEP Global Forecast System coupled to the Noah Land Model and the GFDL MOM4 ocean model. Instead of fixed CO2 concentration, variable CO2 condition is applied for more realistic atmospheric composition change. For the model initialization and verification, CFS Reanalysis and Reforecast (CFS RR) data were used. Model results show considerable improvement in MJO prediction skill and temperature over the land area.

13. Dr. Siegfried Schubert from NASA/Goddard Space Flight Center, USA gave a presentation entitled *An Update on Experimental Climate Prediction and Analysis Products being Developed at NASA's Global Modeling and Assimilation Office*. The experiments include a large suite of subseasonal and seasonal hindcasts and forecasts

as a contribution to the US National MME and a series of high resolution simulations for the selected cases. MERRA reanalysis data were used for the verification. Using high resolution configuration, the 2010 Russian and 2011 US heat waves were reasonably well simulated. The results indicate the 2010 Russian heat waves were mostly affected by specific land condition not by the SST condition. The efforts to develop an experimental global drought early warning system (GDEWS) were discussed, and Dr. Schubert invited APCC to participate in the development of GDEWS.

14. Dr. Jyh-Wen Hwu from Central Weather Bureau in Chinese Taipei introduced performance of CWB-CFSv1 and the development of CWB-CFSv2. CWB-CFSv1 is a multi-model and multi-member 2-tier system: utilizing CWB AGCM and ECHAM5 for the atmosphere, and a statistical-dynamical global SST forecast system developed at CWB and the operational NCEP/CFS SST products for the ocean. A SVD-based statistical downscaling module is applied to generate the categorical probability forecasts for temperature and precipitation at 9 stations. The results show the maximum prediction skill comes from SST followed by precipitation and temperature. As the next generation seasonal forecast system of CWB (CWB-CFSv2), one-tier forecast system is being developed by coupling the CWB AGCM to MOM3 with higher resolution (T119L40).

15. Dr. Michael Tippett from International Research Institute for Climate and Society from USA gave a presentation on recent changes to the IRI Net Assessment. IRI dynamical seasonal forecasts are based on 2-tier system, atmospheric GCMs forced with observed SST rather than forecast SST, calibration (post-processing) on a gridpoint-by-gridpoint basis and forecasts limited to tercile probabilities. In a new system, atmospheric GCMs are forced by forecast SST and pattern based (EOF) calibration are applied for spatial corrections. For the temperature and precipitation, parametric probability density functions are fit to hindcast errors to allow flexible forecasts using 1981-2010 new climatology.

16. Dr. Antonio Navarra from Euro-Mediterranean Centre for Climate Change, Italy gave

a talk entitled *Seasonal and Decadal Predictions at CMCC*. Dr. Navarra started the talk by stating that universities have departments, society has problems. He argued that the science of climate change is converging, meaning that numerical and mathematical modeling is providing the context to share methods and concepts, leading to faster innovations, cheaper implementations and better solutions. Also, he described the history and role of CMCC and explained the CMCC-INGV seasonal prediction system. He concluded that we are facing a new international research paradigm and we need to identify the new question, to mobilize new source of funding, and new global institutional solutions.

17. Dr. KazutoshiOnogi from Japan Meteorological Agency, Japan introduced the operational seasonal forecast model in JMA and JRA-55 Reanalysis. JMA operated two separateseasonal forecast systems for different timescales: extended-range (one-month) forecast and long-range (seasonal) forecast. For the extended-range forecasts, AGCM with initial land surface conditions obtained from JMA Land Surface Analysis System is forced by persisted SST anomaly as a boundary condition. . The model is run weekly basis with 50 members and one-month forecast is issued every Friday. The ocean-atmosphere coupled model is used for the long-range forecasts with 51 ensemble members. The three-month forecast is issued every month and a warm/cold season forecast five times a year(in February, March, April, September and October). Also new reanalysis data set(JRA-55) were introduced, which covers 55 years extending back to 1958. KRA-55 system is based on the JMA operational NWP system as of December 2009 which utilizes higher resolution, a new radiation scheme, 4D-Var and Variational Bias Correction (VarBC) for satellite radiances. Comparisons with other reanalysis data sets such as CFS RR and MERRA are being planned to be performed.

18. Mr. Nguyen Dang Quang from National Center for Hydormeteorological Forecastings of Viet Nam gave a presentation entitled *Two monsoon indices and their relationship to seasonal rainfall predictability in Viet Nam*. Viet Nam is affected by monsoon system, especially rainfall associated with the monsoon. In order to improve the prediction skill of rainfall over Viet Nam, two monsoon indices were examined

focusing on the relationship to summer rainfall over Viet Nam: the Goswami Monsoon Hadley Circulation Index (MHI-Goswami) and the Wang-Fan convective index(CI). The two indices were chosen to present the characteristics of both South Asia monsoon and Southeast Asia monsoon because of geographical position of Viet Nam. Simple linear regression model results show promising prediction skill of summer rainfall over Viet Nam.

19. Dr. Bertrand Denis from Meteorological Service of Canada discussed the new Canadian coupled multi-seasonal forecasting system. According to Dr. Denis, the Canadian Meteorological Center (CMC) in collaboration with the Canadian Centre for Climate Modeling and Analysis (CCCma) is currently implementing a new ne-tier climate prediction system which will replace the present two-tier 4 model forecasting system (presently used for forecasts of months 1 to 4) and the CCA statistical forecasting system (presently used for forecasts of months 4 to 12). The new coupled system combines ensemble forecasts from the CanCM3 and CanCM4 versions of CCCma's coupled global climate model and will provide dynamical atmospheric and oceanic predictions for lead times out to 12 months. He discussed the system and the forecast skill improvements were shown. The implementation of this new system will allow the issuance of ENSO forecasts, which was not possible before.

20. Dr. Zhaohui Lin of Institute of Atmospheric Physics, China presented an assessment of seasonal predictability of summer precipitation over the Huaihe river basin with multiple APCC models. The study showed that the potential predictability measured by the analysis of variance (ANOVA) is relatively low, with the rainfall variability over the Huaihe region dominated by the internal variability. The Multi Model Ensemble (MME) method, which has been demonstrated as a valuable approach to reduce the model bias and to increase the model predictability, has been adopted for assessing the seasonal predictability. The prediction skill of Predict_SST MME with 5 models is higher than that of 10-model ensemble, the temporal correlation coefficient of basin averaged summer precipitation between hindcast and observation can reach about 0.3. This skill is also higher than other MMEs, as the TCC for "Obs_SST" MME are around zero. The empirical orthogonal function (EOF) analysis

showed that two major rainfall patterns of summer precipitation over the Huaihe river region have been identified, with the maximum summer rainfall centered in the Southern part of Hua river basin for the first dominant model, while the maximum rainfall centered in the north for the second dominant mode.

21. Dr. Rongcai Ren from Institute of Atmospheric Physics, China discussed the linkage of the lagged winter stratospheric circulation anomalies to leading El Nino Southern Oscillation (ENSO) forcing. His study showed that there is a negative correlation between ENSO and the strength of the polar vortex, but the maximum correlation is found in the next winter season after the mature phase of ENSO event, rather than in the concurrent winter. Specifically, the stratospheric polar vortex tends to be anomalously warmer and weaker in both the concurrent and the next winter season following a warm ENSO event, and vice versa. The delayed stratospheric response to ENOS is characterized with poleward and downward propagation of temperature anomalies, suggesting an ENSO-induced interannual variability of the global mass circulation in the stratosphere.

22. Dr. Lijuan Chen from China Meteorological Administration discussed the development of a downscaling method in the regional precipitation prediction of China. The downscaling was done by utilizing the optimal subset regression based on the hindcast data of the Coupled Ocean-Atmosphere General climate Model of National Climate Center (CGCM/NCC), the historical reanalysis data, and the observations. To remove the influence of the interannual variations on the selection of predictors for the RSPP, the data were detrended. Optimal predictors were selected through calculation of anomaly correlation coefficients (ACCs) twice to ensure that the high-skill areas of the CGCM/NCC are also those of observations, with the ACC value reaching the 0.05 significant level. One-year out cross-validation and independent sample tests indicate that the downscaling method is applicable in the prediction of summer precipitation anomaly across most of China with high and stable accuracy, and is much better than the direct CGCM/NCC prediction. The predictors used in the downscaling method for the RSPP are independent and have strong physical meanings, thus leading to the improvements in the prediction of regional precipitation anomalies.

23. Mr. Ji-Won Kim of APEC Climate Center located in Republic of Korea presented an analysis of the changes in East Asian Winter Monsoon (EAWM) due to the effect of the El Nino Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) interaction. The results showed that the relationship between EAWM and ENSO on the interannual timescale is strongly modulated by interdecadal variations of PDO. The EAWM tends to be significantly stronger or weaker when ENSO and PDE are in phase. However, when they are out-of-phase the EAWM does not exhibit strong features. His study also looked into the winter-time variations in the intensities of the western North Pacific subtropical high (WNPSH) and Siberian high (SH). The results showed that when EL Nino (La Nina) occurs during the high (low) phase of PDO, the WNPSH is strengthened (weakened) but SH is weakened (strengthened) implying warmer (colder) East Asian winter climate. However, in other cases, there are no tendencies toward warming or cooling suggesting that confidence in ENSO-based long-range climate forecasts should be considered with the interdecadal variations of the PDF phase.

24. Dr. Saji Hameed from University of Aizu, Japan gave a talk entitled *Self-Organizing Maps – An alternative method for studying climate variability*. The goal of self-organizing maps (SOM) is to transform an incoming signal pattern of arbitrary dimension into a one or two dimensional discrete map and to perform this transformation adaptively in a topologically ordered fashion. In a manner similar to most other clustering methods, SOM can be used in climatological analysis. The nodes in a SOM array resulting from "self-organization" effectively represent a continuum of categories within the data set, compared with discrete realizations produced through most traditional methods. In the first part of his talk, Dr. Hameed provided basic information about using and interpreting SOM. The second part of his talk, applications of SOM in interpreting climate and weather variability was discussed. Finally, presented some preliminary results from an ongoing work that uses SOM to identify non-linear intraseasonal phases of East Asian Summer monsoon variability.

25. Dr. Lorenz Magaard, Director of the International Center for Climate and Society (ICCS), University of Hawaii, USA discussed that climate prediction can be both a blessing and a curse. When climate prediction is correct, it is a blessing while bad prediction can be a curse. Based on his experience as an investor trading weather futures on climate prediction, significant gains is enormous for good prediction while loses can be similarly impressive due to bad prediction. He discussed the need to improve the forecast and that the gains could outweigh the costs by a wide margin. He also proposed that there should be cooperation between different disciplines, hence, he presented a plan to develop a cross-disciplinary doctoral program between natural sciences and social sciences called environmental finances.

Session III: Climate Change and Interdecadal Climate Prediction

26. The session was chaired by Dr. Hariharasubramanian Annamalai from International Pacific Research Center, USA and Dr. Oscar Alves from Bureau of Meteorology in Australia. Dr. Michael Tippett from International Republican Institute, USA and Dr. Jyh Wen Hwu from Central Weather Bureau of Chinese Taipei were appointed rapporteurs.

27. Session III began with Dr. Vladimir Kattsov from Main Geophysical Observatory in Russia. Dr. Kattsov presented "Assessment of Macroeconomic Impacts of Climate Change over the Territory of Russian Federation until 2030 and Beyond". Several reports have identified top priorities, culminating in the "climate doctrine of the Russian Federation". However, more information rather than more science is needed. Key issues mentioned included extremes, seamless prediction, permafrost carbon and Arctic sea ice. Climate services must include communication between users and producers of information and doing so will reduce the problem of "useless information" vs. "stupid question". The recent heat wave raised questions regarding the role of climate change and perhaps more importantly made clear that there is a deficit in adaptation capability. Better quantification of impacts is needed. While CMIP5 projected changes in water resources look un-dramatic, changes in soil moisture look more ominous. There is needed for prediction of societally relevant

quantities such as temperature extremes, road icing, and frost days within growing season. The global framework for climate services has an important role. Currently, decision makers are determining priorities.

28. Dr. Flaviana Hilario from Philippine Atmospheric, Geophysical and Astronomical Services Administration gave a talk entitled *Climate Change Projections in the Philippines*, focusing on projections for 2010 and 2050. The Philippines are one of the hot spots for climate change. It already experiences 20 tropical cyclones (TCs) per year. The islands have many low-lying areas and are susceptible to sea extremes such as TCs, heavy rainfall, and drought. Observations indicate an increasing number of hot days and warm nights but a decreasing number of cold days and cold nights with minimum temperatures increasing faster than maximum temperature. While there is some indication of increase in extreme daily rainfall, they are not significant. Likewise there appears to be no significant trends in the observed number of TCs. Climate change scenarios were downscaled using PRECIS from the Hadley Center. High resolution is required to resolve the topography. Warmer conditions are indicated with the dry season MAM getting drier and the wet season JJA getting wetter in the north.

29. Dr. James Renwick from National Institute of Water and Atmospheric Research in New Zealand continued with the talk, *Scenarios for Drought and Extreme Winds over New Zealand*. Overall, in New Zealand, there is drying over the north, and wetter condition in the southwest. Warming is occurring at 70% of the global rate. Partial Least Squares downscaling was performed on a 5 x 5 km grid. MSLP and temperature were used to predict maximum temperature and an index of soil moisture. Drought was defined as the percent of time that soil moisture was below the 10^{th} percentile for at least for a month. In the future, drought probabilities double. Drought is already a big money issue with implications for water management and irrigation. Dairy farming may be unsustainable in the future. Changes in winds were investigated using the Hadley Center GCM and RCM. There will be changes in extreme winds; increases in winter and decreases in summer. And there will be increases in westerlies especially in the south and in winter. Overall there will be

poleward movement, in storm tracks and decreased convection. It is necessary to work with users and understand their assets, risk profiles, and adaptation capabilities. More work is needed on both science and uptake.

30. Mr. Sai-Ming Lee from Hong Kong Observatory described the latest climate change in Hong Kong China. According to Mr. Lee, temperature is rising but urbanization can contribute to the warming signal since observations are taken in the center of the city. The number of hot nights is increasing while the number of cold days is decreasing. Extreme indices show the number of cold nights is going down. Using GEV to compute the return period shows that, for cold events, the return period has gone from 6 years to 132 years, and for warm events from 32 years to 4.5 years. Annual rainfall is increasing, but rainy days are decreasing. Therefore, intensity is increasing and the fraction due to extreme rainfall is increasing. The extreme hourly rainfall return period has gone from 37 years to only 18 years and many hourly rainfall records have been set. Projections were made using 30 sets of global data. Multiple regression technique was used for downscaling, which incorporated urbanization effect in temperature projection. The result showed that temperature would rise; there will be fewer cold days and more hot days. There is a great uncertainty among the models in case of rainfall. Overall, however, the models suggest rainfall will increase and the number of rainy days will decrease, raising the risk of floods and landslides. HKO is involved in public education and outreach, giving talks at schools and producing educational packages and webpages.

31. Professor Cheng-Ta Chen form National Taiwan Normal University in Chinese Taipei presented *Regionalization of Future Projectionson the High-Impact Weather and Climate Extremes over East Asia*. He argues that estimating high frequency quantities from low-resolution model precipitation is difficult. There is a mismatch between scales. This mismatch makes it hard to validate daily extremes. High-resolution observation cab used to study scale dependence. A statistical model was developed to remove scale dependence and cover extremes on one grid to another resolution.

32. Dr. Ok-Yeon Kim from APEC Climate Center, Republic of Korea addressed the

chances in extreme temperature events and if they would increase in the future. A number of indices were used. Observed warming trends in extremes are well represented by GCMs except for diurnal temperature range. Percentile trends are comparable. Spatial trend patterns are comparable except in the Tibetan plateau region. Precipitation trends in models are more uncertain with larger variability than observed. In projections, warm events increase. There is more increase in the APEC region (temperature and precipitation) compared to the global region.

33. After 15-minute of coffee break, Prof. Yihui Ding from China Meteorological Administration gave an intriguing talk entitled *A Projection of Future Changes in Summer Precipitation and Monsoon in East Asia*. Professor Ding used IPCC A1B scenario to project the precipitation and monsoon circulation change in East Asia. 19 climate models in AR4 are used in this study. 19 models in AR4 cab be divided into 3 categories; very good, good, and averaged. There are 9 models in the very good and good categories. The ensemble of 19 models is used for the future projection. Summer precipitation over East Asia is slightly increasing from 2010, and abrupt change into larger increasing after 2040. On average, models show abrupt precipitation change around 2040. EOF analysis of summer precipitation from 2010 to 2099 has been conducted and the first three factors account more than 70% of total variance: EOF1 for global warming and EOF 2 and 3 for natural forcing. According to latitude-time diagram, there seems larger increasing of precipitation over North China after 2004 due to increases of moisture transfer. Also, it can be seen that major rain-belt moves northward by 2040 but unstable.

34. Dr. Hariharasubramanian Annamalai from International Pacific Research Center, USA presented monsoon variability in a changing climate. Many literature and results show that the global warming will increase the precipitation over India and Pacific Ocean area, but the amplitude varies greatly. Dr. Annamalai argued that it is more important how much the change in the tails of the distribution in the future climate rather than just time mean response. Using long time (2000 years) GFDL coupled model control simulation, it is shown that the PDF distributions of precipitation over South Asia and Nino3.4 have a correlation of -0.45 (very high). It suggests that the

change in ENSO will affect the precipitation over South Asia. Active and break phase of monsoon is also analyzed. Observation shows large number of short break (3 days) and long break (more than 7 days). GFDL_CM2.1 shows similar break distribution. It seems that the extended breaks are the result of intraseasonal variability and the boundary forcing. The result of using the couple model SST to force AGCM shows that the increased precipitation in central Pacific Ocean will induce vorticity around Indian subcontinent which induces dry air advection from the north and cases less precipitation over India. Moisture budget also shows that dry air advection from the north leads MSE or negative precipitation anomalies and initiates extended breaks over central India. The extended breaks will become more during El Nino year. The result of the comparison of PDFs of control, 20c3m, and 2xco2 shows that 2xco2 will have not only more strong-ENSO but also more weak-monsoons. In terms of the future projection of south Asian summer monsoon rainfall, the weak summer monsoon has a tendency of "decadal clustering". These 30 – 50 years of rainfall deficit should be considered in the adaptation strategy.

35. Dr. Shang-Ping Xie from International Pacific Research Center, USA discussed the dynamics of regional climate change. Dr. Xie stressed that all oceanic warming under CO2 forcing is not going to be uniform: global warming is not uniform and the precipitation is even more spatially various. He presented two hypotheses to explain the dynamics mechanism. Hypothesis 1 is that 'the wet gets wetter.' Even though the air temperature increase is in uniform, the increase of specific humidity is higher and concentrated near the surface of equatorial region. Therefore, one can conclude that rain will be intensified in rainy areas and perhaps decreased in dry areas. One can confirm this by assuming that the oceanic warming is uniform. Experiment with AGCM with uniform warming SST indeed can get an increase of rainfall in major tropical rainbands with little change elsewhere. But in a coupled ocean and atmosphere system most likely warming in SST is not uniform. Hypothesis 2 is that 'the warmer gets wetter.' The upper troposphere warming is spatially uniform in the tropics. The SST warming is going to create moist instability. That is the reason why the rainfall pattern needs to follow the SST pattern. The key is that the equatorial wave is going to wipe out the spatial distribution of temperature in the upper

troposphere. In the tropical Indian Ocean, the projection of the next 50 years highly varies, which resembles the IOD pattern. This rainfall pattern indeed supports the "warming gets wetter" hypothesis. The corresponding wind anomaly is easterly which shoaling the thermocline in the eastern Indian Ocean. Even though IOD events seem to increase due to this positive feedback, the IOD interannual variation shows little change throughout 300 years with increasing CO2. Dr. Xie's research shows that the thermocline feedback increases but the atmospheric feedback weakens. He also concluded that Indian Ocean capacitor could be intensified in the ENSO decay summer under global warming. Further study should be taken to determine if the recent intensification of IO capacitor is part of natural variability of due to global warming.

36. Dr. Qing Bao from Institute of Atmospheric Physics in China started his presentation by questioning what the changes of EASM in the future scenarios, respectively in its climatology, seasonality, interannual variations and its relationship with ENSO are. He used Flexible Global Ocean-Atmosphere-Land System (FGOALS) for this research. In the feature projection, both the rainfall and westerly flow are enhanced, which is consistent with previous studies. The enhancement of summer monsoon is the result of increasing land sea contrast by global warming. In terms of seasonal cycle, it is shown that EASM has more abrupt onset (less precipitation before onset and more precipitation after onset). The pattern of leading EOFs is similar to each, but the variance of leading EOF pattern increases in the high emission case. The question is why variance increases in high emission case, but not in the medium emission case. The correlations between ENSO and medium and high emission cases are the same – higher than historical run. However, Dr. Bao argued that the ENSO also influences EASM. The SST difference of high emission in winter is larger than the medium emission case. The leading EOF in SST in high emission explains larger percentage of variance than both historical and medium emission. This means that the ENSO has been changed in the high emission scenario, and, therefore, there is stronger interannual variation in EAS. The increase of correlation between ENSO and EASM also suggests the increase of predictability in future projection.

37. Dr. Tim Li from International Pacific Research Center, USA presented projected future changes of the global monsoon and Pacific tropical cyclone activity. According to him, an issue to any climate projection problems is "can we obtain robust signals across different model physics and SST patterns?" Specifically, what are the robust features of future change of the global monsoon and regional TC activity in north Pacific? High-resolution AGCMs such as MPI ECHAM5 T319L31, MRI T959 AGCM, GFDL HiRAM2.1 are used in this research along with additional two sensitive experiments of ECHAM5 T106 with spatially varying and uniform SST warming patterns. Dr. Li defined in this study that Global Monsoon Area (GMA) as regions where annual precipitation range is more than 2mm/day and local summer precipitation is more than 55% of annual rainfall, Global Monsoon Precipitation (GMP) as total summer monsoon rainfall falling in the monsoon domain, and Global Monsoon Intensity (GMI) as monsoon precipitation per unit area. He concluded that high-resolution AGCM simulations project a consistent increasing trend of the GMA, GMP, and GMI throughout 21 century, suggesting that the strengthened global monsoon is a robust signal across model physics and future SST patterns. The increase of global monsoon precipitation is attributed to the increased moisture convergence and surface evaporation. High-resolution AGCMs project a significant increase of TC frequency in CNP but a significant decrease in WNP. This signal appears robust from sensitivity runs with different model physics and different future SST patterns.

Session IV: Climate and Agriculture Workshop - The climate Risk Management Game

38. The afternoon Session IV was broken up into two parallel sessions of climate and agriculture workshop and US-Korea workshop and commenced at 1:30 pm. The Climate and Agriculture Workshop – The Climate Risk Management Game was chaired by Professor Holger Meinke from University of Tasmania, Australia and co-facilitated by Dr. Melissa Finucane (East West Center, USA), Dr. Alberto Troccoli (Commonwealth Scientific and Industrial Research Organisation, Australia), Dr. Robert Field (NASA Goddard Institute for Space Studies, USA), and Dr. Jin-Ho Yoo(APEC Climate Center, Republic of Korea). Dr. Bertrand Denis from

Meteorological Service of Canada and Ms. Lam Vu Thanh Noi from Asian Institute of Technology Thailand were appointed rapporteurs.

39. The climate risk management game session was divided by three parts: talk by Professor Holger Meinke, game simulation, and discussion and report. Professor Meinke presented Climate Information for Adaptation Science in Agriculture and Natural Resource Management. One of the goals was to give participants the context for the game (simulation). Some of the issues that attendees were going to face are as following;
    - Decision makers are exposed to an avalanche of largely unfiltered, irrelevant data disguised as 'information';
    - Climate service providers lack a broad, inclusive mandate and ability to create effective engagement mechanisms;
    - Climate-related problems are complex and often require only 'basic' climate science; and
    - A lack of engagement mechanisms leads to failure to create much needed local & regional adaptive capacity.

    He put emphasis on those as such:
    - Salience: do not provide 'data dump' – critically assess information in terms of relevance for the decision maker; we do not need 'downscaling' but 'right scaling',
    - Credibility: establishment of relationships and trust; services embedded within communities, and
    - Legitimacy: no undeclared interests; long-term funding commitment independent of politics; leadership in coordination.

    And he argued to embed climate risk management principles, to establish priorities for action based on regional or local consultations and risk assessment, to use existing networks and organizational structures to create and support lasting boundary organizations with capacity to serve concerned stakeholders, to support base initiative via the creation of multidisciplinary, sector-focused and solution-driven R&D teams with secure funding, to embrace 'Adaptation Science' as a solution-oriented scientific endeavor without a pre-defined disciplinary lens, and to focus on designing climate

robust systems to better manage climate variability and change. Then he explained the rules of the game and then the roles were attributed. The scenario was that the information of climate forecast was provided from national governments to local government with many stakeholders such as prime minister, agricultural minister, mayor, researchers, small businesses, farmers, messengers, etc. According to the information from messengers, the local stakeholders designed their action plan for near future.

40. The game results showed that (1) it is very difficult to design the action plan when stakeholders get the uncertain climate information, (2) good weather prediction condition brings benefit for all stakeholders and socio-economic development, and (3) governments are too busy and cannot set up the good strategic respond to climate change in near future.

41. Regarding the climate and agriculture workshop, five posters were displayed and the authors were allowed to answer questions during the break time.

42. Dr. Robert Field from NASA Goddard Institute for Space Studies in USA presented a poster entitled *The Need for a Fire and Haze Early Warning System for Equatorial Southeast Asia*. Dr.Field's poster was about a proposal for developing an early warning system based on MME precipitation forecast. His poster explained that smoke haze from biomass burning is among equatorial Southeast Asia's most serious environmental problems. Under sufficiently dry conditions, fires lit to clear vegetation waste can lead to uncontrollable burning of drained peat lands. The resulting emissions represent a singularly large source of greenhouse gases at a global scale and severely degrade air quality at a regional scale. Research over the last decade has led to a reasonable understanding of the human and climatic causes of these fires. Subsequently, meteorological agencies in Indonesia and Malaysia have developed operational fire danger rating systems to monitor for dangerously dry conditions. These systems are being steadily adopted by land management agencies to trigger fire prevention and pre-preparedness measures. However, given the immense effort required to mobilize resources, current fire danger rating systems are

hampered by the absence of operational forecasting. The potential therefore exists to capitalize on gains made in seasonal climate prediction, particularly for precipitation. Dr.Field's poster reviewed the causes and impacts of biomass burning in equatorial Southeast Asia, the current status of operational systems, and the potential for linking a fire and haze early warning system at the APCC to the standard operating procedures of local land managers.

43. Ms. Ana Liza Solmoro Solis from Philippine Atmospheric, Geophysical and Astronomical Services Administration presented a poster entitled Forecasting the Number of Dry Days for the Benefit of Farmers and Rice Production in the Philippines: A preliminary analysis. Dr. Solmoro Solis' poster explained that food security poses a great threat from unpredictable changes in climate. Based from the Intergovernmental Panel on Climate Change (IPCC, 2007), under the projected climate change scenarios, rice production in Asia could decline by 3.8% by the end of the 21st century. Climate variability, causing events such as dry spells, El Niño and extreme weather events such as typhoons, floods and drought, are already affecting the rice production and economy in the Philippines and any part of the world.Her study focuses on what type of seasonal climate information can be integrated and utilized for the benefit of farmers and rice production in the Philippines. And also on how can seasonal dry day forecast be introduced to and accepted by farmers of Western Visayas Region as a new tool for agricultural planning and decision-making to enhance their preparedness to climate variability. They undertook experimental dry day (a day with less than 1.0 mm of rain) forecast simulation. The statistical model showed that the correlation is higher for number of dry days, 0.757 than rainfall amount with correlation of 0.423 during March-April-May season, an indication of more predictability. Thus, seasonal dry day forecast is more skillful than models that try to predict the seasonal rainfall amount. Thus, the result of such analyses lays an important outcome in the context of tailoring information for agricultural risk management applications and as a potential operational seasonal dry day forecast product by the national meteorological and hydrological centre of the Philippines (PAGASA) for the benefit of farmers and various stakeholders. Finally, the emergence of the Climate Field School in the study area was identified as an

instrument to introduce the new type of seasonal forecast information and continue its activities in incorporating weather and climate information in decision making for agriculture by the national and local agricultural officers as well as enhancing the capacity of local farmers, extension workers and other stakeholders on the use, access and understanding of seasonal climate forecast.

44. Ms. Indah Budiani from Climate Change Trust Fund in Indonesia presented a poster entitled *Improving livelihood of farmer through climate field school by utilizing climate information*. According to her poster, biodiversity plays important role for human livelihood. Case study of apple production in Bumiaji (Indonesia) showed that apple production is affected by the amount of rain days, temperature and wind speed during certain period. The production slightly decreases along with the changing of climate element. Climate field school (SLI) is an instrument in the form of an informal school for farmers aimed to increase public awareness of farmers about the impacts of climate change (CC). A success story of climate field school revealed how knowledge on climate information cloud really influences farmers in choosing the right varieties of crops to improve their livelihood upon the challenge of CC.

45. Dr. S. Senthilnathan from International Pacific Research Center in USA presented a poster entitled *Socio-economic impact of climate change on rice production in Southern India and assessing uncertainties in regional climate model projections*. This research brings overview of agricultural situation in Tamilnadu (India), glimpse of uncertainties in current climate model, rice yield versus various climate model variables were examined to understand the impact of climate model variability on yield prediction. The data showed that agricultural economy is vulnerable to rainfall variability. Global climate model projections indicate significant changes in the behavior of major monsoon systems, including the Indian monsoon. Other factors that influence agricultural production are urbanization, industrialization, infrastructure development, labor migration and markets, population. The initial results suggest that the uncertainty in the regional model projections get reflected in the yield prediction.

46. Dr. Rogelio Cosio from Pampanga Agricultural College, Philippines presented a poster entitled *Vulnerability and adaptive capacity to CC on the Guagua and Candaba communities in central Luzon, Philippines*. Candaba and Guagua are among the Philippines's high risk municipalities in Papanga Central Luzon. Floods frequent these areas due to their low elevation as well as high tide. This research investigated CC vulnerabilities by gathering information through community/public consultation, key informant interviews and focus group discussion about CC impacts in the study areas. The data showed flood is regularly experienced in research areas; other hazards that affect the communities are drought, continuous or prolonged rain, typhoon, and delay on the onset of the rainy season. The study proposed CC adaptations for vulnerable groups in research areas with clear measures at community level.

Session V: US-Korea Workshop on Use of High Resolution Model for ISI Prediction of Extreme Events and Its Regional Impacts and Climate Variability and Change

47. The US-Korea Workshop occurred simultaneously with the Climate and Agriculture Workshop. The theme was Use of High Resolution Model for ISI Prediction of Extreme Events and Its Regional Impacts and Climate Variability and Change and chaired by Dr. Emilia Jin from Korea Institute of Atmospheric Prediction Systems, Republic of Korea and Dr. Siegfried Schubert from NASA, USA. Dr. Jong-SeongKug from Korea Polar Research Institute and Dr. Yoo-Geun Ham from NASA, USA were appointed rapporteurs.

48. Dr. Emilia Jin from NGMDC, Republic of Korea started the workshop by giving an overview of the 2nd US-Korea workshop. The workshop is for discussing the use of high-resolution model for ISI prediction of extreme events and its regional impacts. The detail scientific goal of this workshop is also provided. In addition, Athene project and some results are introduced.

49. Dr. Vijay Tallapragada from National Centers for Environmental Prediction in United States gave a talk entitled *High-Resolution Tropical Cyclone Forecasting using NCEP Operational HWRF*. Using NCEP operational HWRF couple model, the

prediction of tropical cyclone is performed with movable nesting. The prediction skill with movable nesting is compared to that in global model. Plus, the details of updated version of HWRF are provided. The possible improvement would be archived through the improvement of model physics, and vortex initializations as well as through the resolution increase.

50. Dr. Myong-In Lee from Ulsan National Institute of Science and Technology in Republic of Korea presented tropical storm simulations using a high-resolution GCM. He explored the potential predictability of tropical storms based on long-term high-resolution (25-50km) GEOS-5 experiments. Positive impact of Tokioka constraint in terms of simulating tropical storm over Atlantic and western Pacific is shown using long-term model integration with ensemble simulations. It is also shown that prescribed SST significantly modulates the tropical storm activity. The possibility of storm genesis due to the large-scale condensation is discussed.

51. Dr. Julia Maganello from Center for Ocean-Land-Atmosphere Studies, George Mason University, USA discussed the role of horizontal resolution in simulating tropical cyclone activity with the ECMWF integrated forecast system. The simulation of tropical cyclone using ECMWF model with different horizontal resolutions are shown. The density of tropical cyclone tends to be increased over the western Pacific with higher resolution. The genesis and intensity of tropical cyclone becomes similar to the observed as the horizontal resolution is increased. The possible relationship between tropical cyclone genesis and mean state is discussed.

52. High resolution NASA GEOSS model for simulating mean and extreme climate characteristics was presented by Dr. Young-Kwon Lim from NASA, USA. He evaluated the quality of the recent high-resolution GEOS-5 model version and assessed the seasonal mean features, climate variability and extremes focusing on winter and summer season. Through the AMIP type simulations, it is shown that the mean state of GEOS-5 is similar to the observed. Energy transport like kinetic energy transport or moisture transport is also compared to the observed to show the performance quality of GEOS-5. The dominant variability related to ENSO, NAO, and probability of extreme events is also successfully simulated in GEOS-5

simulations.

53. Dr. Yoo-Geun Ham from NASA, USA gave a talk *entitled Improvement of Seasonal Forecasts with Inclusion of Tropical Instability Waves on Initial Conditions*. Due to coarse observational networks and deficiencies in widely used initialization methods (e.g. 3DVAR or OI methods), TIW variability in oceanic initial conditions is excessively suppressed. Through 20-year ensemble forecast experiments, it is shown that seasonal TIWV with TIWs-seeded initial conditions is significantly stronger until 2-month lead time. Enhanced TIWV amplifies nonlinear relationship between TIWs and ENSO, which leads realistic simulation of the El Nino-La Nina asymmetry.

54. Professor Jagadish Shukla from Center for Ocean-Land-Atmosphere Studies George Mason University, USA, moderated discussion session. Four points about high-resolution modeling were mentioned. First, the performance improvement in many climate models is robust. Second, too many experiments are given after simply changing the resolution, but few experiments after changing the model physics. Third, parameterization is still needed with high-resolution simulation. Fourth, the role of tropical instability waves on seasonal prediction, or climate phenomena are important. The possible role of Tokioka parameterization, condensation time-scale is discussed, as the results are very sensitive to the parameterization. The discussion pointed out that the mean state change with high-resolution is necessary, and how to generate PDF for stochastic component of parameter.

55. Dr. Xiouhua Fu from International Pacific Research Center, USA presented the improvement of MJO forecasting using different initialization method and models. The update of CFS model from version 1 to version 2 leads significant MJO prediction skill. Doubling MJO intensity in R2 increases MJO predictability from one week to two weeks. The regional dependency of MJO prediction skill is discussed. The forecast skill of tropical cyclone related to the MJO is provided.

56. Dr. Yanju Liu from China Meteorological Administration investigated the relationship between the monsoon and Yantze-Huaihe River. There is significant negative

correlation between intensity of Mejyu and the frequency of tropical cyclone over the western North Pacific (WNP). This relationship will be useful for Mejyu seasonal prediction.

57. Dr. June-Yi Lee from International Pacific Research Center in USA summarized the activity of CliPAS project in recent few years. The limitation of the current models and some improvement to overcome these deficiencies are discussed. The predicting summer mean precipitation over monsoon region is relatively poor. This may be due to the poor simulation of climatology and seasonal cycle over the monsoon regions. Using the multi-model results, the clear relationship between mean state and dominant monsoon variability is shown.

58. Dr. Jae-Nyung Lee from NASA Jet Propulsion Laboratory, USA provided a presentation entitled *MISR Cloud/Aerosol and Their Variability through ENSO*. The low-cloud amount and aerosol in Asian dust related to the ENSO is investigated. The low-cloud provided by MISR shows low amount of low-level clouds over the central Pacific during the El Nino. The MISR aerosol provides unique valuable distributions of Asian dust and interannual variability in addition to MODIS and OMI.

59. Dr. Hiroki Tokinaga from International Pacific Research Center in USA gave a talk entitled *A Long Consistent Surface Wind Dataset for Climate Change Analysis: Application over the Tropical Indo-Pacific*. The surface wind derived can be generated from wind-wave height obtained from observations using the ship. The annual mean trend from derived wind is shown. The Walker circulation is shifted for recent decades. It is also shown that the change of wind is consistent with that of cloudiness, or SLP. The trend of subsurface temperature is also investigated.

60. Professor Jian Liu from Chinese Academy of Science in China argued that quantifying and understanding of the past Global Monsoon Precipitation (GMP) change is essential for projection and attribution of climate change. To understand the GMP change on multidecadal-centennial time scale in past, model integrations are performed for 1000 years with given solar and volcanic forcing.The strong global

monsoon is related to the warming the mid-latitude Pacific.

61. Dr. Oliver Elison Timm from International Pacific Research Center, USA gave a talk entitled *Future Climate Change in Hawaii*. The precipitation change in Hawaii due to the global warming is investigated. After the global warming, the change for the heavy rain events in Hawaii tends to be increased. But over some regions the precipitation is rather decreased. The significant test for the climate change is performed to confirm the climate change in Hawaii is significant.

Session VI: Climate and Water Resource Management Workshop

62. Session VI was commenced 9am on October 19 2012 and was facilitated by Mr. Mark Svoboda from National Drought Mitigation Center, University of Nebraska-Lincoln, USA. Mr. Sai-Ming Lee from Hong Kong Observatory was an appointed rapporteur.

63. Mr. Mark Svoboda from National Drought Mitigation Center from USA gave a presentation entitled *Decision Support for Drought Risk Management: Focus on the Future*. He opined that future water resource management would be very challenging due to a number of factors including climate change, population growth, population migration, regional conflict and land degradation. Careful planning and management are necessary to deal with the challenges. He stressed the importance of drought monitoring and management of drought risk because drought could have a large spatial as well as temporal span and the damage caused by droughts is by no means minimal. He added that more emphasis should be put on risk management instead of crisis management. The NDMC's mission is to lessen societal vulnerability to drought by promoting planning and the adoption of appropriate risk management techniques Its objectives include (i) improving the science of drought monitoring, planning, and mitigation; (ii) building awareness of drought and its impacts on society and the environment, and how human actions affect out vulnerability to drought; and (iii) focusing the attention of policy makers on the importance of drought policy and planning in the wise stewardship of natural resources. Mr. Svoboda described NDMC's main program areas and reiterated the importance of

tracking and understanding impacts of drought, as well as that of drought plans which should comprise of monitoring, early warning, vulnerability assessment, mitigation and response actions.

64. Mr. Neil Plummer from Bureau of Meteorology, Australia gave a presentation entitled *Seasonal Streamflow Forecasts: Assisting Decision-Making in Water Resource Management*. Mr. Plummer gave an overview of potential applications of the seasonal stremflow forecasts which include, but not limited to, improving water allocation announcements in key irrigation basins, enhancing the decision making process for announcing and lifting urban water restrictions and optimizing water trading between agencies and moving water around the Victorian Water Grid. He then described the processes of planning for the seasonal streamflow forecasts, engaging stakeholders by organizing workshops and designing of products and websites. He emphasized the importance of engaging users to understand their needs and how users influenced the product design. Presentation of historical and forecast data is required to meet users' needs. The forecast products are built on quality research and science, using CSIRO Bayesian Joint Probability Model. Relevant support information will help to increase users' understanding of the products. The initial target catchments of the forecasts, which started in December 2010, consisted of 21 locations in southeast Murray-Darling Basin. 15 new sites will be released in November 2011 and the forecast will be extended to more sites using hybrid dynamical/statistical method n 2012. In June 2013, operational seasonal forecasts will be implemented based on blended statistical/dynamical method.

65. Professor Thomas Giambelluca of the University of Hawaii, USA gave a presentation entitled *Challenges for Projecting Future Climate Change Impacts on Water Resources in Hawaii*. Prof. Giambelluca first described the secular temperature change in Hawaii and then Hawaii temperature index's variation with the Pacific Decadal Oscillation and local sea surface temperature. He moved on to show the long-term decrease of Hawaii rainfall and the decline in heavy rainfall frequency. Accompanied with these long-term changes are the increasing occurrence of dry days and the declining stream base flow. Prof. Giambelluca explained the method of

projecting rainfall change by statistical downscaling large-scale circulation to point rainfall. The first principal component of seven independent spatial-dependent variables was used to project rainfall for 131 stations. Six models were used in the projection. The projection results indicated that in the last 20 years of this century, there would be more areas with significant increase rather than significant decrease in winter drought probabilities. Nevertheless, the confidence in rainfall and drought event projections is not as high as that in temperature and mean sea level projection.

66. Professor Hee-Kyung Park from Korea Advanced Institute of Science and Technology in Republic of Korea described the increasing trend of temperature and rainfall in Korea. The intensity and frequency of heavy rain are also increasing. Frequency and severity of extreme rainfall events are projected to increase in the 21st century. Adaptive capacity needs enhancement in order to cope with the increasing variability. Prof. Park talked about a severe urban flood event occurred in Seoul this July, which caused the estimated damage of about 300 million USD and 39 casualties. He pointed out that conventional practice in enhancing adaptive capacity would require huge amount of investment in infrastructure, which is unaffordable. New approach is certainly needed. Prof. Park described the three principles of control dynamics in adaptation mechanism: principle of accuracy, principle of sufficiency, and principle of variety. He concluded his talk with an example of adaptation options for urban flooding using Unclogging Surface Filtering Elastic Paving (USFEP) technology and facility.

67. Ms. Lam Vu Thanh Noi from Asian Institute of Technology, Thailand gave a talk entitled *Assessment of Vulnerabilities to Climate Change for Water and Wastewater Infrastructure Management in Vietnam: A Case Study of Ho Chi Minh City*. She started the presentation by stating a research question of how to conduct climate change vulnerability assessment for urban water and wastewater infrastructures at local level. She stated that the main objective of the research is to present a case of rapid vulnerability assessment (RVA) for urban water and wastewater infrastructure in Ho Chi Minh City and to recommend the next step for climate change adaptation measures. The study was conducted through the assessment process of (1) identifying

climate change related risk factors, (2) investigating vulnerabilities, and (3) assessing current adaptive capacity. Thu Duc District and Binh Thanh were selected as research areas. She concluded that this study contributes in presenting information of hazards, vulnerabilities, perception of climate change adaptations at top-down scale level promoting climate change risk assessment at local level. She recommended to further study developing climate change risk assessment with applicable tools/techniques.

68. Ms. Daisy Ortega from Philippine Atmospheric, Geophysical and Astronomical Services Administration gave a presentation entitled *Vulnerability of Water resource to El Nino Southern Oscillation (ENSO) in the Philippines: The 2007 – 2008 La Nina and 2009 – 2010 El Nino Impacts on Angat Dam*. She explained the multiple functions of Angat Dam which are to provide irrigation, to supply domestic and industrial water, to generate hydroelectric power, and to serve as flood control to downstream towns and villages. Angat region has rainy season from May to November with peak in August. Ms. Ortega presented the impacts of 2007-2008 La Nina such that Angat dam has lost 30 percent of its capacity to supply water for domestic use, irrigation and power generation and water disruptions in the network of water service providers have resulted to water rationing during July. Also 2009 – 2010 El Nino influenced Angat dam to hardly get enough replenishment from July 2010. She argued that climate forecast information that is localized, timely and easily understandable by the end-users needs to be improved.

Session VII: Climate and Energy Workshop

69. The Climate and Energy Workshop was facilitated by Dr. Alberto Troccoli of Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia and was commenced 1:30 pm. Dr. Kazutoshi Onogi from Japan Meteorological Agency, Mr. Kwan Kok Foo and Ms. Nurul Akmal Binti Ahmad from Ministry of Science, Technology and Innovation, Malaysia were appointed rapporteurs. The workshop consisted of two presentations, a brainstorming session, and case study discussion.

70. Dr. Alberto Troccoli from Commonwealth Scientific and Industrial Research

Organization (CSIRO) in Australia gave a presentation on weather and climate impacts on energy planning, operations and maintenance. He pointed out that energy services are a necessary input for development and growth, and the planning of sustainable energy systems requires full consideration of relevant varying climate factors. He stressed that the entire energy supply chain is significantly vulnerable such that climate variability and extreme events can affect energy resources and supplies as well as influence seasonal demand. He also mentioned some of the climate and energy interactions such as interactions between mining industry and flooding, oil industry and tropical storm, nuclear energy and heat wave, and gas demand and market response as well as wing energy grid.

71. Dr. Ines Lima Azebedo from Center for Climate and Energy Decision Making, Carnegie Mellon University, USA talked on energy efficiency and climate data. She introduced decision-making on greenhouse gas mitigation strategy and elaborated on progresses related to the development of mitigation strategies as well as education and outreach of adaptation.

72. The brainstorming session has the objectives (a) to identify vulnerabilities of energy sector to weather and climate events, (b) to identify impediments to the use of weather/climate information for the energy sector, and (c) to suggest ways to improve and/or facilitate the transfer of knowledge between weather/climate scientist and the energy experts to allow an optimal use of climate risk management. To achieve these objectives, group discussions were concentrated to outline briefly the requirements by energy sector for weather/climate information in terms of weather /climate parameters required, frequency of observations/information and accuracy/precision of information. They were also to identify the energy sector vulnerabilities shared with other sectors and define specific inter-sectoral issues to be tackled.

Session VIII: Culmination Session"Crafting the Climate Science Community's Response to Present Challenges"

73. The session opened with the Co-chair, Prof. Jagadish Shukla introducing Co-Chair Prof. Holger Meinke and the members of the panel Dr. Vladimir Kattsov, Dr. James

Renwick, Dr. Alberto Troccoli, Mr. Mark Svoboda, and Dr. Melissa Finucane.

74. Prof. Shukla stressed the need to act now on the issue of climate change since it takes about 20-30 years for the public to implement a policy to address a major problem. How we can communicate climate information is a real challenge. The problem has been framed too much in terms of global warming and climate change. There are problems of poverty, equity, sustainable development, agricultural sustainability and the problem can be framed in these terms.

75. Climate change reflects the amplitude and frequency of all modes of natural variability, not just temperature. Things like ENSO and hurricane tracks will change and the challenge is for scientists to handle the problem in seamless manner and predict statistics of modes of variability. He asserts that we need better models, better computers, and better organizations. He summed up that this was an encouraging meeting. It was evident from the presentations that scientists are making progress in modeling, increasing resolution, and making better simulation. However, he stressed that we have to go further. Much of the demands for climate information are still in the seasonal scale: agriculture, winter and summer temperatures and so on. There is a need to provide better seasonal forecasts and give a better idea on extreme events.

76. Prof. Holger Meinke followed by first thanking the organizers. He notes in the conference that there is a groundswell of change in the science community, in how climate science is approached as one of the first meetings where a group of largely climate scientists seriously talked about stakeholder engagement, bringing whole communities together in thinking about how to better target the knowledge to their needs. He noted that there is a need to stop looking at things through a restrictive climate lens, that we look at the complexity of the issue, and that we engage in a co-learning exercise with the people who ultimately have to make the decisions with the information that we can provide.

77. He briefly talked about the Agriculture Workshop where the climate science game was played. One of the guiding principles was that people actually had to play the

roles of the stakeholders and step into their shoes. He identified three principles that Cash et al put forward in their paper in PMAS in 2003. Is the information that scientists provide relevant? Is it salient to the decision making? Have scientists arrived in it in such a way that people actually see the need for it and use it to engage? The second point is the information credible? That is where scientific integrity comes in and that's where relationships come in because there needs to be a relationship with the stakeholders based on mutual understanding and trust. Finally, is the information that we provide legitimate? Legitimacy is at the core of scientists' business, that scientists are not taking an advocacy role for a particular interest group, or if they do, they should be open about it. He asserted that the times when we could say that science is a value-neutral activity has passed, and the sooner we recognize it and the sooner we start to seriously engage with the key stakeholders, the better it will be for society because climate is a very important issue, and very important decisions have to be made on them. One last point that he made is the need to understand what it means to engage with policy makers versus some industry decision makers due to different needs. His own agency, the Tasmanian Institute for Agricultural Research, is actively developing a science-policy dialogue where they write down the rules of engagement. Questions that are addressed include how do we engage with policy as scientists? What does policy expect from us? What do we expect from policy and where are the boundaries. How do we negotiate those boundaries? How do we maintain such a dialogue in the long term so that we manage the expectations? He made the final point that it really comes down to expectations.

78. Dr. Vladimir Kattsov followed by highlighting the importance of grand challenges in climate science that include predictability, components of the climate system, new components which have not been taken into account, and others. He asserted that it is clear that there will continue to be increasing complexity of the models scientists are using. Under this complexity, it is important to communicate uncertainties to users and then to guide them through uncertainties. There is also the duty to monitor the result of using recommendations of the sciences given to the users and demonstrating success. He explains that there are not many convincing examples of how science helped in making decisions. The questions of when, where, what to do and how much

it will cost have to be answered. He thinks that we have to find some instrument, some metric, to measure the value of our guidance of the information we are providing, something like the economics of climate change. He went on to note that the Global Framework for Climate Services sheds some light on the issue. Next year an urgent congress of the WMO will be convened, highlighting the importance of the GFCS.

79. Dr. James Renwick went on to discuss his reflections on the meeting. In crafting the climate sciences' response to current challenges, he observes two components: one is the physical science. Based on the discussions over the week and the literature, there is the move toward higher resolution modeling. There appears to be a number of groups who are running climate models of at least 30km resolution and the progress of modeling tropical cyclones is rapidly improving. Also notable is the understanding of how the ENSO works in the tropics and the east tropics and pulling a path towards climate variability and change versus natural variability. Research in those areas has to go on.

80. For him, however, the most exciting part of this meeting is on the human dimension side. He cited his experience playing the climate game saying that playing a journalist made him think about the media in ways he had not actually thought about. He highlighted the growing importance of communication as part of the work of climate scientists. They have to engage in the communities they are working with and get to know about the energy sector or agriculture for example as much as they need to communicate information to them.

81. In closing, he talked about how scientists tend to speak from the head with technical knowledge about how the physical system works. However, to tell a good story one really needs to speak from the heart and from the gut. And engagement is really about engaging people and speaking in ways that matter. It is important to be able to speak across timescales to people about climate variability and climate change.

82. The talk was followed by Dr. Alberto Troccoli's coments. He pointed out that it is important to come up with a scientific problem that captured the imagination not only

of the sciences but also of the public. He encouraged the group to think of a very substantial problem, and to take risks. He suggested a problem on his mind, one that is not crystallized yet: the problem of solar radiation, which is something very relevant for solar energy, for agriculture, and for many other sectors. It's not only on solar radiation, but looking at cloud evolution, cloud dynamics which are critical issues of climate science. This problem could be sold it to the public as a problem that will give us a leap ahead.

83. Mr. Mark Svoboda gave a few points based on his experience working on drought. He cited the issue of trust, to be transparent and to be accessible to users, and to understand their needs. He explained that scientists need to keep things simple. A lot of times things are so complex that we must take the time to translate complexity. Instead, why not just make things simple in the first place and reduce the need for translation of science.

84. He stressed the need to capitalize on grassroots efforts of citizen science, such as the National Weather Service Cooperative Network, which is composed of volunteers taking observations following very rigid standards. There is also the Community Collaborative Hail, Rain and Snow Network that now has 15 thousand volunteers in 50 states collecting precipitation, hail and drought information.

85. He also learned that if you build information services, the demand would come. He has seen policy work where his organization developed a monitoring product that they knew there to be a clear need for. They did it with no budget and now the product is being shown on the Weather Channel and is in the Farm Bill as one of the triggers for farm policy.

86. Mr. Svoboda mentioned the advantages of capitalizing on focused events and to use those as windows of opportunity. There are limited resources and decision makers tend not to see the value in something that is not occurring right now. Having a plan in place when this particular hazard hits works right at the opportune time. He said that the bias of a working on drought, scientists need to be proactive. The time to plan

for drought is not when you are in one. He encouraged the group to use the resources on the National Drought Mitigation Center website.

87. The final speaker was Dr. Melissa Finucane. She quoted a professor from Carnegie Mellon University that said that the climate challenge is nothing we've ever faced before not only in the scope of the problem, but in the complexity of the, the requirement of understanding ocean, atmosphere, ecosystems and human interactions and that how to address a complex problem like that is to involve a very multidisciplinary multi-level, multi-method approach. Both the people from natural sciences and the social sciences such as communication specialists, program designers need to be involved. To that she also added community leaders, like the leaders of faith-based organizations or cultural groups and the media and program evaluators.

88. She explained that many social scientists have methods and approaches that lead us to make precise measurements of things like risk perception and decision processes. In her field in decision science, there are models that more and more accurately describe exactly how decision-maker characteristics such as worldviews and values affect decision processes and outcomes, how information, uncertainty, and representation affect processes and outcomes, and how the context in which the decisions are being made can have an impact. She continued saying that often what happens in the face of uncertainty, is that people rely on worldviews and values, some of these more intangible influences of framing the problem and framing our response to it. It is important to engage with decision makers because this helps us put a finger on the pulse of what is driving people's interests, their priorities, their concerns, and their satisfaction with different processes like identifying solutions and implementing them.

89. She explains the value of that boundary organizations like Pacific RISA and several others have in allowing interdisciplinary collaborative approaches and in being adaptable and flexible in responding to issues that are driven by climate events or changes in the social context. She asserted that there is a need for some formal evaluation of what has worked, where and why because sometimes, efforts to

translate information or implement programs fail not because of design problems or lack of science but because there are changes in the external context like a change in administration where they deprioritize the value of climate information, or changes in funding availability because of a global economic meltdown. If these things can be tracked as much as we track any of the other metrics that we are interested in, the science community can get a better handle on what works, when and for whom.

Session IX: Working Group Meeting

90. Dr. Song opened the meeting by outlining the agenda and transferring chairmanship to Dr. Jae-Kyung Schemm, following the rotation scheme that follows APEC hosting countries. Dr. Schemm welcomed the group on behalf of the National Weather Services of the United States.

91. The meeting started with a round of introductions. The Working Group members present were the following:

- Dr. Siegfried Schubert from NASA
- Mr. Kazutoshi Onogi from JMA
- Mr. Neil Plummer from BOM
- Dr. James Renwick from NIWA
- Mr. Quang Nguyen from NCMWF
- Dr. Bertrand Denis from MSC
- Dr. Lin Zhaohui from IAP
- Dr. Hyun-Kyung Kim from KMA
- Dr. Lijuan Chen from BCC
- Mr. Alan Llacza from SENAMHI
- Mrs. Claudia Villaroel from National Weather Service
- Dr. Flaviana Hilario from PAGASA
- Mr. Saiming Lee from HKO
- Mr. Kwan Kok Foo from MMD
- Mr. Antoyo Setyadipratikto from BMG
- Mr. Jyh Wen Hwu from CWB

- Dr. Bong-Geun Song from APCC

92. There were two presentations from the meteorological services of Chile and Peru. Mrs. Villarroel from Chile discussed seasonal forecasting. The seasonal forecast skill comes from ENSO conditions in the Central and South areas. About 40 degrees South, the Antarctic oscillation is more important. Mr. Alan Llacza gave an introduction on the hydrometeorological system of SENAMHI from forecasting methods, products to dissemination across various media.

93. The presentations were followed by an annual report by Dr. Bong-Geun Song of APCC. He gave an overview of the new structure and teams at APCC, particularly the Climate Research Department that reflects new activities on climate change and climate informatics and applications. Another notable development is the increase of staff up to 37 personnel. Dr. Song also discussed joint research projects done with other organizations, climate products and services offered by APCC, and research and development goals of the organization. He then gave an overview of plans for 2012 and beyond. New areas of research and operations include work on climate change, development of dynamical downscaling, and improvement of MME skill using the climate filter concept.

94. APCC requested model providers to give longer hindcast data sets up to 2009 with more overlapping data periods. Canada replied that their hindcast data go up to 2010 and will provide data within the cutoff date required by APCC. NASA replied that they already supply the new model. Mr. Onogi clarified data restrictions of JMA and that they can only distribute to registered users.

95. Dr. Schemm mentioned that model providers have satisfied most APCC requests and that it should draw up an extended list of variables to be requested from model providers. Providing data sets is a big commitment from model providers and APCC would perhaps need to show a plan on how to use the daily datasets.

96. Dr. Schemm then opened the floor to solicit Working Group members' requests from

APCC. Mr. Onogi requested that the agenda be distributed beforehand so that members could prepare. Dr. Hilario raised the issue of dynamical downscaling as being among the services APCC can offer in the future. She also mentioned that most of their users want monthly forecasts whereas APCC provides three-month forecasts. Mr. Antoyo Setyadipratikto asked if APCC is looking into monsoon onset information. Dr. Song mentioned that APCC can consider it while Dr. Hyun-Kyung Kim said that it may be of interest to monsoon scientists as a research topic and not as an operational product. Many of the working group members agreed that the Working Group Meeting should be extended to a full day to discuss APCC activities and products more.

Session X: Tutorial Session on Downscaling and CLIK

97. Dr. Saji Hameed prepared the curriculum for the Tutorial Session on Techniques for Higher Resolution Regional Forecasts using CLIK for Statistical Downscaling. More than 30 scientists from APEC economies and APCC scientists participated in the tutorial session.

Session XI: Science Advisory Committee Meeting

98. The Science Advisory Committee (SAC) meeting commenced at 09:15 am and concluded at 02:00 pm with Prof. Jagadish Shukla, and Prof. In-Sik Kang co-chairing the session. Also in attendance were Dr. Oscar Alves, Prof. Yihui Ding, Dr. Antonio Navarra, Dr. Yukio Masumoto on behalf of Prof. Masahide Kimoto, Dr. Vladimir Kattsov, Prof. Bin Wang, Prof. C. P. Chang, Dr. Chin-Seung Chung and Dr. Jin-Ho Yoo. Ms. Sangwon Moon and Ms. Sooyang Joo recorded the meeting proceedings.

99. Dr. Chin-Seung Chung, Director of APCC was invited to give opening remarks and he thanked the SAC for their presence and active participation in the event. Prof. Jagadish Shukla gave his opening remarks focusing on the importance of having a strategic vision of APCC suggesting APCC's 5-year plan on the agenda.

    Prof. In-Sik Kang gave his opening remarks focusing on two basic attitudes the SAC should function; (1) SAC should function as an advisory body to the Director and not

more than that. SAC should also try to present international opinion to APCC. (2) As APCC is facing a new phase increasing in terms of activities and its budget, SAC should provide more expertise and resources in research activities. SAC should voluntarily function for APCC to enter into an international entity and counterpart.

Prof. Shukla agreed with Prof. Kang that the world gave special identity to APCC providing all the model outputs but there are still needs to put energy and support to APCC to improve. He brought this agenda to be discussed later this meeting.

100. Dr. Jin-Ho Yoo gave a brief report which APCC has done in the past year, the action taken on SAC 2010 recommendations, and the work that will be continued.

101. There was a lot of discussion on the seasonal forecast. SAC members recommended that APCC should put more effort to improve the seasonal forecast system doing more projects on this issue, however, as this takes long time to be successful, APCC should divide steps to achieve to provide better seasonal prediction outputs. Prof. Shukla also emphasized that APCC's production of seasonal forecast is fundamentally based on a collection of large number of data. To build more scientific path on the activities, SAC members should visit APCC more often, give proper advice and update what SAC members can provide.

102. Prof. Shukla moved on to the next agenda, the '5-year Strategic Plan of APCC.' He has prepared the plan and briefly outlined it to the SAC members. APCC has a very large network in the region and APCC should not only collect data but also provide a data platform. To be a leading research center in this field, Prof. Shukla's eight ideas on SAC's commitment to APCC were agreed to help APCC to improve.

103. Dr. Shukla brought the last agenda of the SAC member reshuffle. Dr. Chin-Seung Chung announced that he will circulate the list of new SAC members in a month.

104. Dr. Chung also concluded the meeting with appreciation. He also remarked that as APCC is increasing by its size and researches, he specially requested SAC members to support APCC giving proper advice and information by visiting APCC.

ANNEX: Participants List

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