APEC Climate Symposium 2014
Proceedings

Nanjing, China

October 27-29, 2014

This document summarizes the presentations and discussions from the APEC Climate Symposium (APCS) 2014, held in Nanjing, China at the Nanjing University of Science and Information Technology on October 27-29, 2014

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Summary

1. The APEC Climate Symposium 2014 was conducted from October 27-29, 2014 at the Nanjing University of Science and Information Technology**,** in Nanjing, China. A meeting of the APCC Science Advisory Committee was also held in conjunction with the event.

2. The event was attended by around 70 participants from 8 economies – Australia, China, Chinese Taipei, India, Japan, Korea, the United Kingdom, and the USA. The participants included keynote and invited speakers, representatives from National Meteorological and Hydrological Services (NHMSs), government officials, and academics. Experts in disaster management and hydrology were invited to the conference to discuss the importance of climate information and its application to extreme weather events. A complete list of participants can be found in Annex I.

Opening Ceremony

3. The APEC Climate Symposium 2014 opened on Monday, October 27, 2014. The Opening Ceremony began at 9:00 am with Ms. Hannah Kim, the Head of the External Affairs Department at the APEC Climate Center (APCC), opening the ceremony and welcoming everyone to the event. She introduced the guests sitting on the stage. Ms. Kim introduced Dr. Chin Seung Chung, the Director of APCC. Chung gave his Opening Remarks and spoke about the importance of this event. He concluded his speech by welcoming everyone. Prof. Jianqing Jiang, the President of Nanjing University of Science and Information Technology (NUIST), followed with Opening Remarks for the symposium's co-host. Jiang gave his speech in Chinese. Dr. Allan Bollard, the Executive Director of the APEC Secretariat gave a Congratulatory Address via video. In his video, Dr. Bollard discussed the important work of APEC and the APEC Climate Center. Mr. Sangchan Gu, the Consul General of Korea in Shanghai also gave a Congratulatory Address. Ms. Qingchen Chao, Deputy Director General of National Climate Center in China gave a short Congratulatory Address. The final Congratulatory Address was delivered by Dr. Bin Wang, Chair of the Department of Meteorology at the University of Hawaii and Co-Chair of the APCC Science Advisory Committee who spoke about both the work of APCC and NUIST.

The opening ceremony was followed by a gift giving ceremony between APCC and NUIST.

Session I: Keynote Presentations

4. Session I commenced at 10:00 a.m. and consisted of keynote presentations by three distinguished scientists. The session was chaired by Dr. Jinho Yoo, the Head of the Climate Research Department at APCC.

5. **Dr. David Rogers, Senior Advisor, World Bank, Global Facility for Disaster Reduction and Recovery (GFDRR) "Impact Forecast and Warning Services"**

   Dr. Rogers talked about the work of the World Bank investing in developing countries to build capacity to provide forecasts prediction and looked at a case study in the Philippines. The tsunami was well forecasted and the government responded well, but still over 6,000 people died and there was a large amount of property damage. People still do not understand why the warning did not trigger appropriate reactions from people. There was a lack of capacity in the Philippines; people did not understand how to translate it into impact.

   Dr. Rogers then looked at a case study in India in Uttarakhand from June 2013. There was 375 percent of normal monsoon rainfall with approximately over 5,700 fatalities and 4,200 villages were affected. They had good weather forecasts; that were actually published in newspapers. Government workers just did not understand how to interpret the data. The forecast said very heavy rain but they did not know what the magnitude of the storm was. Dr. Rogers gave quote from Vice Chair, NDMA, India. The whole system was incapable of taking action despite the good information. Dr. Rogers talked about helicopter crashes from Air Force in India and people losing their lives. There was a lack of adaptability to translate information into hazard impact. There was a lack of utilization of hazard maps.

   Dr. Rogers then looked at the case study of Typhoon Fitow in Shanghai, China. The Chinese government had all the things that are missing the Philippines and India, and more than 80 million people were warned, but still many people were trapped in their vehicles because it happened during rush hour. Typhoon Fitow caused 5 billion USD in damages. Dr. Rogers talked about coping mechanisms and how to transfer risks

and create financial structures like insurance.

The World Bank has supported a lot of studies in the Western Pacific, and every house in the Pacific Islands has been assessed via satellite. This has been done independently of forecasting. People who are informed will take much more appropriate actions. Dr. Rogers talked about when a warning was issued in Tonga, someone asked citizens when they evacuated, they said "when my house collapsed" you need to tell people their house will be destroyed and that they need to evacuate. Dr. Rogers said there is push back from smaller meteorological organizations because they believe they do not have the capacity to handle this. Dr. Rogers spoke about using smartphones to alert people. He gave the example of risk of overturning vehicles in UK biggest risk is in London area. Dr. Rogers talked about the information flow of basic forecasting information.

Dr. Rogers then applied this information to his case study example of Tropical Cyclone (TC) Fitow and how it could have been used. He spoke about developing a Natural Hazard Partnership. It can be difficult to get hydrology services to interact with meteorological agencies. There is a need common criteria for impact forecasts, risk transportation, and resilient infrastructure. Dr. Rogers spoke about China not sharing road data because it is classified. He concluded his speech.

An audience member asked how World Bank can help developing countries. Dr. Rogers gave the example of how the World Bank has helped out in the Western Pacific; they know vulnerability to the household level. Another way to improve the capacity of meteorological services is to provide better flood guidance. There is a need to improve communication. They need to look at how to improve housing infrastructure and have financial tools available immediately to respond to recovery.

An attendee asked how do we communicate with the public to how to deal with information? Dr. Rogers said they are trying to understand how people make decisions during a crisis, people still need to make decisions and we want to understand how they make decisions. They do not want to over warn but they need to get people to take action.

An audience member asked about obstacles to form partnerships and what are incentives to work together? Dr. Rogers spoke about the example of Northern India. Every agency that participates/collaborates is helping to save lives. These disasters are in part caused by a lack of collaboration. It took three years to get everyone work

together in the UK. They cannot save infrastructure but they can help to save lives. In developing countries it can actually be easier to collaborate because the government is so small and everyone is in the same building.

6. **Dr. Zhiyu Liu, Vice-president of the Commission for Hydrology, World Meteorological Organization (WMO), "Priorities of the WMO Commission for Hydrology"**

   Dr. Liu spoke about the long term development goals of WMO. He talked about WMO regional associations. The WMO carries out work through ten different programs. Dr. Liu discussed the hydrology and water resources program and its long term objectives and purposes. They want to assess the quantity and quality of water resources and mitigate the impact of water events. This programme has three mutually supporting components: basic system in hydrology, forecasting and applications in hydrology, and capacity building in hydrology and water resource managements. Dr. Liu then discussed the WMO Technical Commissions. There are 150 members of the Commission for Hydrology (CHy). Dr. Liu wants to improve relationships with other international organizations like United Nations Educational, Scientific and Cultural Organization (UNESCO). Dr. Liu discussed the CHy's activities in flood and drought management. He then spoke about Global Flash Flood Guidance Program. Dr. Liu talked about the "Help Desk" which is a facility to provide guidance on flood related issues to countries that adopt IFB protocols. Dr. Liu then talked about Global Framework for Climate Services. He discussed a slide on WMO capacities with various statistics about different service levels, only 13 percent of members provide advance services.

   Dr. Liu said that the Hydrology and Water Resources Programme and CHy can contribute to the Global Framework for Climate Services (GFCS) through existing work and further development. CHy activities are in the theme areas of water, climate, and risk management. He discussed the contributions of CHy to the implementation of GFCS. Dr. Liu looked at extended hydrological prediction and the use of climate models with down scaling and ensemble schemes.

   Dr. Liu discussed National Observing Stations in China and the increase in the number of Automatic Weather Stations (AWS) from 15507 in 2008 to 36181 in 2012. Dr. Liu talked about NUIST being an outstanding training facility for the WMO. Dr.

Liu concluded his presentation.

Dr. Cho from APCC asked about a user interface platform to share information. Dr. Liu said CHy is trying to use their ability to issue hydrological data to the public.

7. **Dr. Konstantine Georgakakos, Managing Director, Hydrologic Research Center, "Operational Prediction for Flash Flood Warning and Reservoir Management – Utility for Climate Impact Studies"**

   Dr. Georgakakos started by outlining his presentation about operational prediction for flash flood warning and reservoirs. Dr. Georgakakos talked about two different Hydrologic Research Center (HRC) programs and gave facts about flash floods. Flash floods have highest mortality rate of all natural disasters. There are no flash floods warnings for many parts of the world.

   Dr. Georgakakos discussed the differences between large river flooding (LRV) and flash flooding (FF). LRV allows long lead times but FF is very fast. Local information is less important for LRV but more valuable to FF. Dr. Georgakakos talked about a Global Initiative to tackle this issue and flash flood warning systems. Dr. Georgakakos spoke about the concept of Flash Flood Guidance, which uses expectation of rainfall; this is simple warning for forecasters so they can look at it more closely. He gave an example with South Africa. Dr. Georgakakos discussed the machinery behind the flash flood guidance system, showed schematic of the models. He talked about the current Multi-Sensor Strategy. HRC uses National Environmental Satellite, Data, and Information Service (NESDIS) for short latency and the CPC Morphing Technique (CMORPH) for longer latency. This allows them to make corrections to NESDIS.

   Dr. Georgakakos spoke about Dynamic Bias Adjustment. It is based on common filtering and it is a stable algorithm. He discussed biases adjustment for low to medium rain, gave an example of the Mekong River. He looked at simulation in Panama and estimated flash flood guidance. When the data is adequate, the models do represent what is going on in flash floods. Dr. Georgakakos spoke about their training simulator and how they use it to train people understand the flash flood process. Dr. Georgakakos spoke about reservoir management in Northern California under climatic variability and change. The effect of reservoirs depends on the weather. Dr. Georgakakos looked at the project sponsors and collaborators in California and he

talked about waters importance to the Central Valley. He spoke about the goals and objectives of the project and gave a schematic. The point of this project was to demonstrate the utility of climate and hydrological forecasts for water resource managements in Northern California. Dr. Georgakakos talked about the main policy differences between current and adaptive policies for climate change and the benefits of adaptive policies. Dr. Georgakakos concluded his speech.

An audience member asked about data for urban areas. Dr. Georgakakos said this system does not have an urban component to it. It is not fully operational yet. You cannot use it everywhere; you need to have great data.

Session II: Climate Forecasting for Water Management

8. The afternoon session of October 27 commenced at 2:00 pm. Session II discussed Climate Forecasting for Water Management and was chaired by Dr. Yuriy Kuleshov, a Senior Professional Officer at the National Climate Centre, Bureau of Meteorology in Australia.

9. **Dr. Bryson Bates, Centre for Environment and Life Sciences Commonwealth Scientific and Industrial Research Organisation (CSIRO), "From Prediction To Scenario Analysis: An Australian Perspective"**

   Bates began with the outline of his speech and talked about water planning in an urban environment. Bates spoke about a willingness to consider non-traditional resources. Bates talked about predictions, forecasts, projects and scenarios and showed a graph dealing with the uncertainness of predications. Bates discussed the decline in rainfall in Perth from 1940 to 2010. Bates discussed the General Circulation Model (GCM) selection problem. Bates discussed flow duration curve and approaches to systems planning. He then talked about robust adaption strategies, which looked at climate change with an additional dimension of risk. He advised to adopt the most robust solution, not the best under one scenario, with no regret benefits even in absence of climate change. He closed by talking about prudent action under uncertainty. There needs to be a continuous cycle of planning and evaluation with contingency plans that have trigger points for alternative courses of action. We must compare costs of immediate adaptation and retrofitting.

10. **Dr. Julien Lerat, Environment and Research – Forecast Systems, Bureau of Meteorology Australia (BOM), "A Seasonal Streamflow Forecasting Service for Australia: Methods, Implementation and Way Forward"**

    Lerat talked about how droughts have shaped the history of Australia. Lerat spoke about why BOM is doing water forecasting. This is important for dam operations, environmental flows and cropping strategies. Lerat spoke about Seasonal Streamflow Forecasting Service, BOM has 86 forecast locations. He discussed the BOM website that provides forecast summaries. Lerat showed an example of a forecast product. He showed more on their products including cross validation for individual seasons.

    He then turned to look at forecasting models. He showed a schematic of the different models and talked about the work of CSIRO. He talked about merge forecasts that will be released in July 2015. Lerat talked about verification metrics. He concluded by talking about the importance of water availability to Australia as a major challenge and about the importance of engaging with stakeholders and needing to simply products to make them more useable.

11. **Dr. QJ Wang, Water for Healthy Country Flagship, CSIRO, "Ensemble Forecasting of Seasonal Streamflow Using Climate Forecasts as Inputs"**

    Wang began his presentation and talked about the FoGGS Model (Forecast Guided Stochastic Scenarios). Wang talked about Concerns-Based Adoption Model (CBaM) to overcome issues with CGM. Wang looked at hydrological modelling including uncertainty, Stage 1: monthly water balance modelling using a monthly water partition and balance model (WAPABA), Stage 2: bias correction, Stage 3: adaption, injecting and propagating hydrological uncertainty out to 12 months.

    Wang talked about two different example forecasts. Wang looked at 20 sites for Continuous Ranked Probability Skill (CRPS) Score. He spoke about issues with Tasmania and the catchment. Wang gave his conclusion. The FoGGS model is for ensemble forecasts of monthly stream flow out to 12 months. CBaM is used to post-process GCM climate forecast for use in a catchment water balance model. FoGGS adequately represents rainfall forecast uncertainty, hydrological uncertainty, persistence in stream flow, and uncertainty propagation. FoGGS does what the water agencies have been asking for. FoGGS is ready for operational deployment. His

presentation concluded.

12. **Dr. Yuriy Kuleshov, Bureau of Meteorology, National Climate Centre Australia, "Seasonal Forecasting of Climate Extremes: Droughts and Floods"**

    Kuleshov talked about the International Climate Change Adaptation Initiative and about the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Partner countries, which is made up of Pacific Islands nations in the Western Pacific. Kuleshov talked about the 2012 Fiji Flood and the damages it caused. Kuleshov spoke about seasonal climate prediction and the Pacific Seasonal Climate Precipitation Portal. He showed a slide on rainfall accumulation over three months. He then spoke about extensive training programs for Pacific Islanders.

    In his conclusion, Kuleshov talked about that projected extremes in climate should be taken into consideration when doing aid projects in the Western Pacific. His organization concludes with confidence that seasonal prediction is an effective solution for Pacific Islands countries when dealing with climate change.

13. **Dr. Eric Wood, Princeton University, "A Seamless Framework for the Global Monitoring and Prediction of Droughts"**

    Wood began his speech by talking about the impacts of flood and droughts. Wood looked at the cost of droughts, heatwaves and drought cause the largest amount impact of any disasters. Wood looked at death rates from droughts, talked about decrease in deaths but that still leaves a lot of human suffering. Wood explored droughts over the past few years ending with the recent drought in California. Wood talked about the different steps to take for protection and recovery. He showed a schematic on the mechanism of drought how to improve prediction and a slide on the timeline of the elements of a seamless monitoring and predication framework. Wood looked at the global model validation, and then historical analysis of droughts. Wood talked about the Sahel Drought in Africa in the 1980s. He then talked about understanding the mechanisms of the recent drought in California. The maximum winter temperature has been very high, and the minimum number has been increasing as well, leading to less snowpack. Wood discussed stream flow forecasts and looked at the Ohio River Valley basin from 1988 to 2005.

    Next Princeton University's African drought and flood monitoring and forecasting

system was discussed. They partnered with the UNESCO- International Hydrological Programme network of water centers. They wanted to understand how local communities would see information to try to improve water and food security. Wood explored stream flow monitoring and short term forecasts. Wood then looked at the Horn of Africa drought. Through the monitoring, you can see the progression of the drought. Wood then talked about capacity building done at AGRHYMET (Agriculture, Hydrology, Meteorology) and IGAD Climate Prediction and Applications Centre (ICPAC) in Nairobi, Kenya. Their goals are improving data dissemination, providing training and allowing for feedback, followed by a validation plan. Wood talked about expansion to global monitoring capability. He spoke about the challenges of getting new sources of observational data and the need to understand the utility of climate/drought information. Wood talked about using communication technology, and using Short Message Service (SMS) messaging because it is so cheap to use. There are potential flows that can diversify the distribution of this information to local people. Wood finished his presentation.

An attendee asked how reliable is your prediction in relation to historical droughts? Wood said sources of uncertainties in Africa are problems with the data, and they have tried hard to get the best data they can.

14. **Dr. Hi Ryon Byun, Pukyong National University, "The Available Water Climatology (AWC) and its Applications"**

Byun spoke about Available Water Climatology. He outlined the contents of his presentation; it will look at the differences between AWC and CPC and how to calculate the AWC indexes (AWRI, LWI, SWI). Byun talked about what is Available Water Climatology (AWC). There are many clear cases of time distribution of PCN. Time distribution is more important than total distribution. Byun spoke about climate classification in Korea. Byun talked about AWRI developed in 1999. Byun spoke about drought index problem that he solved. Byun looked at the long term water index.

Byun explained the differences between AWC and CPC. He spoke about the Effective Drought Index. Byun looked at daily drought monitoring in North and South Korea yesterday. He showed a map of droughts in Korea. Byun talked about the detection of floods and looked at a 1998 flood in Seoul. Talked about definition of LIWAS and

WAS.

15. **Session Wrap up:** Wood said there are unresolved scientific questions and we need to develop information to pass on to the user community, to try to improve their decisions to assess the models and see how people use it. Lerat talked about the human side of the forecasting. Bates talked about forecast and predications to improve knowledge. Kuleshov said a good product is not necessarily translated into real action. This is what he saw in Pacific Island Countries. In 2012, he was in Fiji and observed and how the meteorology worked closely with disaster management. We need proper tools to deliver and understand.

    Wood talked about crop insurance and how crowd sourcing was seen as more reliable than forecasting. Social scientist need to work on understanding people decision making process.

    There was a question about people being reluctant to use information, how can we let water managers know this is reliable information? Lerat said this takes a long time and you need to manage expectations.

Session III: Managing Risk from Droughts and Water Scarcity

16. The morning session of October 28 commenced at 9:00 am. Session III discussed Managing Risk from Droughts and Water Scarcity and was chaired by Dr. Ximing Cai, the Colonel Harry F. And Frankie M. Lovell Endowed Professor at the University of Illinois.

17. **Dr. Ximing Cai, University of Illinois, "Impact of Climate Change on Agricultural Land and Water Sustainability – A Global Projection"**

    Cai asked how climate change will change the world. He gave a Chinese proverb about things changing Cai looked at climate change and agricultural sustainability. Cai spoke about trends in abrupt change in temp and precipitation. Cai discussed findings from existing assessments [Food and Agriculture Organization (FAO), the International Food Policy Research Institute (IFPRI), and Intergovernmental Panel on Climate Change (IPCC)]. He talked about pessimism, uncertainties, and regional impacts in these assessments and looked at FAO framework and different systems.

Cai looked at the arable land available under climate change. He cited his study from 2011 and looked at different regions (China, Russia, U.S.) some countries had increases in arable land. Cai talked about arable land decreasing in Africa. Africa is more vulnerable to climate change.

Cai then looked at irrigation water requirements change He talked about the corn growing season, and replacing corn with wheat. Cai then talked about water stress in NW China. In U.S. and EU there may be large impact on rain fed crops, so they might need to develop additional irrigation. Next, Cai discussed the impact of droughts on other extreme weather events. Cai gave two examples of how extreme weather can impact agriculture in Midwest U.S. and Northern India. Cai showed a map of U.S. Midwest and he looked at a case study in Nebraska. He saw mixed impacts even within in the same county. Cai then turned to look at droughts in Northern India. He used a dataset from Eric Wood for this study. He compared the drought characteristics versus the return period over the different sites. He concluded his talk by talking about regional and local challenges. Climate change will have mixed impacts on agriculture.

An attendee asked about how technology impacts this? Cai said technology will always play a role; they did not use this in their scenarios. He talked about the role of globalization.

18. **Dr. Dennis Lettenmaier, University of Washington, "U.S. Drought Trends"**

Lettenmaier's presentation addressed U.S. drought trends. Lettenmaier showed a graph on damages of U.S. droughts. Lettenmaier talked about deaths by heatwave, he questioned the validity of these numbers, and you get big numbers in U.S. when there is impact in Corn states. Lettenmaier talked about drought characteristics, droughts are a creeping disaster, typically impacting very large area. Lettenmaier spoke about different drought models Lettenmaier looked at the UW Surface Water Monitor for the continental U.S. He showed a map from the height of the Dust Bowl in 1934.

Lettenmaier discussed defining drought extent and explored the evolution of droughts by looking at Dust Bowl. Lettenmaier talked about IPCC Special Report on Emissions Scenarios report from 2012 on the increase of droughts. Lettenmaier showed a reconstruction of U.S. soil moisture trends. Lettenmaier spoke about trends in U.S. drought durations from 1915-2003. He then turned to look at a paper he wrote

with Cindy Wang about China from 1950-2006. In NE China, there have been more droughts. Lettenmaier spoke about work of Kingste Mo from NOAA who looks at flash droughts. This term was popularized in 2012. Lettenmaier defined a flash drought. Studies have been impacted by lack of satellite data from a long time ago. He then looked at different types of flash droughts.

Lettenmaier looked at frequency of occurrence in the U.S. Midwest. Lettenmaier talked about issues with almond trees versus crops like alfalfa. Lettenmaier looked at UW Drought Monitoring System for West Coast of U.S., they have higher resolution there. Lettenmaier talked about lack of rain in California. Lettenmaier discussed trend analysis. Lettenmaier said climate models mostly predict continental drying leading to increasing drought frequency and length. He questioned if this is just natural manifestation of natural variability or if there is some fundamental issue in climatic sensitivity of the global models.

There was a question about best model for a small area like South Korea. Lettenmaier said to try to understand through historic reconstructions and talked about downscaling.

19. **Dr. Heekyung Park, Korean Advanced Institute of Science and Technology (KAIST), "Cost-Effective Variety (CEV) can Reduce Variety in Real World: Diversity in Water Infrastructure System"**

Park spoke about system control and the variety of disturbances with many different drivers. He talked about different ways to deal with variety and talked about Alexander the Great and the Gordian knot. Park looked at study by Ashby from 1957 about requisite variety. Ashby said variety can destroy variety. Park said it is impossible to avoid disaster; we just need to reduce impact. Park talked about developing plans for cities. Park spoke about the framework of the CEV model method. Park showed a schematic and looked at an example case of drought in Korea. Park talked about identifying the system state and identifying water scarcity. Park then looked at quantifying VOR. Park looked at analyzing return and validity of individual options. Park looked again at the framework of CEV method He spoke about analyzing risk in future scenarios. Park looked at creating RCV graph. Park talked about different criteria for risks and then concluded his speech.

Georgakakos asked a question about how you can consider adaptability within your

control scheme. Park said when we establish a plan, every five years we will have a facility in place to reevaluate; we need to consider data that changes over time.

20. **Dr. Ilwon Jung, APEC Climate Center, "Utilizing APCC Multi Model Seasonal Forecast to Support Planning and Operation of Dams In South Korea"**

    Jung began by talking about importance of dams in Korea. Jung talked about general multipurpose dam operations. Jung looked at potential threats to sustainable water supply due to climate variability and change. Jung looked at trends in dam inflow in Soyang Dam. Jung talked about spring and early summer drought in 2014 in Korea. There was restriction of water supply. Jung looked at APCC's Multi-Model Ensemble (MME) seasonal forecast and gave further details on MME forecast. He spoke about its use in hydrology application; there is systematic bias problem and problems with downscaling. Jung looked at seasonal hydrological forecast framework and looked at the correlation of National Centers for Environmental Prediction (NCEP) reanalysis and hindcast of GCMs. Jung discussed performance of water balance models and talked about lead times for dams.

    Jung discussed skill scores for wet and dry seasons. He talked about a seasonal forecast being more useful for the dry season. Jung then talked about empirical hydrological prediction using teleconnection. Jung looked at improving hydrological forecast. Jung concluded his speech by talking about by talking about APCC MME forecasts but we need to develop hybrid technique to improve prediction.

    There was a statement from QJ Wang about telecommunication using to establish model. Wang said from their experience most skill comes from condition, the nature of climate is variable. He said there is a risk to do a certain kind of correlation analysis which leads to artificial skill. Wang said it is great work but we could share experience with you.

21. **Dr. Francis Chiew, CSIRO, "Droughts And Water Security in South-Eastern Australia: Science and Management"**

    Chiew's presentation focused on hydro-climate variability and water resources management in Australia, and droughts and declining rainfall trends in SE Australia. Chiew looked at water-food-energy nexus under climate change and growing population. Chiew talked about CSIRO research areas. Australian hydrology is

different; it is a very dry country with high evaporation. Chiew looked at the global picture compared to Australia. Chiew said climate change will amplify impacts in Australia. Chiew talked about a drying trend in Australia and amplified stream flow. Chiew talked about over allocation due to increasing demand and declining water availability. There is a greater competition for resources in Australia now due to mining and other factors. Chiew showed a cartoon about water availability in Australia. Water supply in NE Australia is okay, South Australia is in bad shape, SE Australia is not good but not as dire as South Australia. Chiew explained the millennium drought in SE Australia. There has been a decline in cool season rainfall. Chiew looked at climate attribution of unprecedented stream flow decline. Chiew looked at climate variability and climate change. Chiew said there will be decline in stream flow. In Australia, there is push to move agriculture to North Australia where there will be more water in future.

Chiew looked at CSIRO water resources assessments. Chiew spoke about adaption of irrigated agriculture through water trading Chiew looked at water reform in the Murray Darling Basin. He talked about different projects, there was a large project to upgrade irrigation infrastructure and improve water use efficiency and to purchase water for the environment. Chiew spoke about sustainable diversion limits set for all catchments in the basin. Chiew looked at water issues for the city of Melbourne. There is declining water supply and increasing demand form the expanding population. They placed severe restrictions on use and created a conservation program. Chiew took a look at the long term plan for water resources. Chiew summarized his presentation.

Eric Wood said Australia must determine if there is going to be enough water to have economic activity in the future like they do currently. Chiew said it will never impact people in coastal cities but talked about issues facing agriculture.

22. **Dr. Qian Ye, Integrated Risk Governance Project, "National Disaster Response Strategies for Droughts of China - From Integrated Risk Governance Perspectives"**

    Ye's presentation discussed current response strategies to drought, lesson learned and future directions. Drought is a creeping phenomenon. Ye referenced study from 1985 from Wilhite and Glantz about not being able to define drought. He looked at a chart

of meteorological drought with the causes and impacts of droughts. Ye talked about similarities between U.S. and China, and about China suffering historically from droughts. There is a major drought almost every two years. Ye explored geographical differences in China and agricultural loss due to severe drought. Ye said risk is hazard, exposure and vulnerability. Ye talked about local management knowledge being lost when people move around so much and about the top-down organization in China. Ye spoke about developing legal framework to locate resources to tackle droughts and its impact. Ye said since 1987, China has been improving legislation and regulations, spoke about different national policies. Ye looked at disaster coordination agencies chart. He said the role of science has improved greatly in the past thirty years in China. Ye spoke about new challenges that the China is facing, climate change uncertainties lead to greater drought risks. Economic development leads to new emerging drought risks. There are urban drought risks and ecological droughts, which lead to ecosystem destruction. A drought is no longer single event. Ye spoke about large chain of droughts; droughts in U.S. can lead to famine in Africa. Ye looked at new opportunities in agricultural insurance, catastrophic bonds, and different technological innovation. Ye summarized his presentation. Government must play central role in governing drought risk. We need to live with drought through innovation and explore opportunities.

Cai asked Ye about risk in China. Ye said people are now thinking more for the long term and insurance companies are getting more involved.

23. **Session Wrap Up:** Ye said he wanted to bridge science, change from bridge to landing, need co-production and co-design, need to get more users. Jung said we need to identify end users real needs and use appropriate downscaling models. Chiew talked about Australia being test case. Lettenmaier talked about showing three examples from U.S. Lettenmaier talked about linkages with the engineering community. Park said we must live disasters and talked about resiliency. There is a need for community and social approach not just engineering. He wants to add measures to assess social resiliency. Cai talked about impacts from climate change, different areas will have different impacts from climate change.

    Park talked about Sewol Accident and how that led to a big discussion on disaster management and system. KAIST suggested establishing a common platform. Usually

disasters are divided into different areas. In Korea, there are thirty different types of disasters and they are managed by the appropriate government agency. Korea needs to think about creating new links. Each government platform will use same technology. Park talked about different channels of communication. Chiew spoke about reactionary nature of government.

Lettenmaier talked about issues in U.S. and his involvement with climate change policy with U.S. government. There is money for those on the science side. There is less money for people who work on decision making. There used to be more emphasis on this issues, this is unfortunate. Lettenmaier talked about Eagleson report. Water engineering has gone away. Talked about a few famous water resource people in the U.S. but there are not many because it is not funded. We need to train the next generation to deal with non-stationery issues. Wang talked about public being confused by hearing contradictory reports from different scientists. Lettenmaier said it is complicated. The problem in the realm of climate change is that it is highly politicized.

Session IV: Changes in Hydrological Extremes: Floods and Typhoons

24. The afternoon session of October 28 commenced at 2:00 pm. Session IV discussed Changes in Hydrological Extremes: Floods and Typhoons and was chaired by Eric Salathé, a Professor and Director of Northwest Climate Science Center at the University of Washington.

25. **Dr. Eric Salathé, University of Washington, "Developing Climate Scenarios and Management Tools to Reduce Vulnerabilty to Future Flood Risk"**

    Salathé spoke predominantly about the U.S. Pacific Northwest (PNW). Salathé talked about simulating atmospheric rivers. He showed a slide on a satellite image on derived total predictable water (TPW). Salathé talked about mean synoptic conditions and extreme precipitation and climate change. Salathé spoke about integrated water vapor transport (IVT), models of precipitation, and the increase in global extreme weather events. This is a thermodynamically driven response. Studies of historic precipitation of U.S. West Coast have mixed results. Salathé said there is a debate about variability. He turned to look at simulations in the PNW in the 21st century.

Salathé looked at an ECHAM5 Downscaled Forecast and at regional climate model projections of future flood risk. Salathé showed the results form statistical downscaling of flow in river basins in PNW. He concluded with projected changes in Atmospheric Rivers yield increases in local intense precipitation. Changes in intense precipitation alter flood risk in warm basins. Orographic effects likely contribute to flood risks.

Salathé spoke about Howard Hanson Dam and the Green River in the Seattle area. He looked at unregulated hydrology and explored the flood magnitude in the Green River. He then talked about the reservoir refill for summer water storage for Howard Hanson dam. Salathé talked about doing infill earlier. Salathé talked about Flood Plains by design program being used in Snohomish County. He concluded his talk.

Georgakakos asked about precipitation. Salathé talked about percent change in precipitation and issues with elevation. Bin Wang asked about global mean temperatures increase. Bin Wang said this conclusion can be generalized to other regions. Salathé said on the West Coast of North America, we see similar temperature change as global mean. Salathé talked about scaling upwards with moisture.

26. **Nobuhito Mori, Disaster Prevention Research Institute, "Impact Assessment of Typhoon and Related Storm Surge Considering Climate Change"**

Mori talked about the Sousei program at his university. Mori focused on natural disasters and spoke about coastal disasters. The western part of Japan suffers from extreme coastal disasters. He then looked at river disasters and potential mitigation ideas. The lesson from 2011 Tohoku Earthquake Tsunami made them very interested in worst case scenarios. Mori is focused today on climate change impacts. He looked at coastal flood and alliance height. Mori talked about impact assessment of storm surge. They are currently in the middle of this research project, so they do not have a result. Mori talked about the extent of their downscaling, they do 1-3 km downscaling for certain disasters. Mori talked about historical runs of rainfall and discharges. Mori spoke about the impact assessment of inundation depth and showed a slide on the Osaka area highlighting the differences with different infrastructure. Mori looked at a study from 1958 about Tropical Cyclone (TC) Vera. Mori spoke about complex inundation.

Mori looked at an analysis of economic loss and then spoke about the Mekong River

Delta; Mori looked at future change of extreme in storm surges. He then turned to talk about tropical cyclone tracks. Things change will be in one or two degree in a direction. Mori spoke about the Stochastic Tropical Cyclone Model (STM), a random model for TC. Mori looked at a stochastic TC model validation. The total number will decrease from 112 a year to 101. TC location will shift to center of the basins. There will be a longitudinal shift as well. He concluded by talking about GCM.

27. **Dr. Lian-shou Chen, China Meteorological Administration, "A Review of Heavy Rainfall Out of Tropical Cyclone Envelope"**

    Chen presentation was on heavy rainfall out of tropical cyclones (TC). Chen talked about Morakot typhoon that impacted Taiwan and mainland China in 2011 he talked about Megi storm from 2010. Chen talked about inner dynamics that impact tropical cyclone rainfall and looked at favorable conditions for land falling tropical cyclone rainfall. Chen talked about TC between landfall and monsoon surge. Chen showed slide on how typhoons interact with trade wind, torrential rains can be produce. Chen looked at the squall line in front of a TC. He gave statistics on typhoons and TC for 2007-2009. The squall line usually last around 4 to 6 hours. He looked at a simulated mesocale filtering stream field after 26-29 hours head of initial time. Chen showed a cross section diagram on zonal distribution. He talked about three precipitation systems for radar observations on the Kii Peninsula. TC interacts with monsoon surge, trade wind, and mid latitude trough will prominently increase rainfall. Chen talked about heavy rainfall out of TC.

28. **Dr. Sunkwon Yoon, APCC, "Hydrometeorological Variability and its Integrated Flood Risk Assessment for the Korean Han River Basin during different El Niño Phases"**

    Yoon began his presentation by looking at his outline. His talk focused on hydro-meteorological variables for mitigating the impacts of climate change on water disasters. Yoon talked about his research goals. Yoon wants to give policy makers risk analysis so they can make good decisions. Yoon talked about the background of his research. He looked at a studies from 2000 and 2011 seasonal characteristics of hydro-meteorological variability are closely related to global climate phenomena and climate change. Yoon discussed a new type of El Nino called El Nino Modaki. Yoon

looked at projections of future typhoons. He talked about historical flooding in China and the millions of deaths it caused in 1887 and the 1930s. Yoon looked at floods in Thailand in 2011 and India in 2010 and 2014. Yoon spoke about flooding on Han River in 1990 and 2002 and the deaths caused by all of these floods. Yoon discussed the different study areas of his study, the five main river basins in ROK. Yoon looked at global precipitation patterns over Asia.

Yoon talked about an empirical Probability Density Function using Kernel Density Function. He discussed an integrated flood risk map for decision making. He developed a conceptual framework and he briefly showed his data set. He talked about a spatial distribution of flood risk and showed an integrated flood risk map.

29. **Dr. Taesam Lee, Gyeongsang National University, "Temporal Downscaling of Hydrometeorological Variables for Mitigating the Impacts of Climate Change on Water Disasters"**

    Lee started talking about temporal downscaling from daily to hourly. He showed pictures of the main city square in Seoul being flooded in a short period of time that illustrated his point. Lee talked about employed nonparametric techniques. He talked about kernel density estimate (KDE), GA based sampling, and about K-nearest neighbor resampling (KNNR). Lee talked about temporal downscaling and showed the results in the Jinju area of South Korea. Lee showed the mean difference between historical and downscaled information. Lee talked about geological relation of mean changes. He spoke about problems with Nam River basin in South Korea and the many problems it causes. It has two dams because the land around can be very easily flooded. He spoke about local government opposing the federal government flooding a little stream. There is a lot of conflict in Korea over these dams. Lee spoke about pros and cons of NPD in Korea.

    Lee began the second part of his talk and showed the historical temperature in London. Lee talked about the Non-stationary Oscillation Resampling (NSOR). Lee talked about the future evolution of hydrological extremes in Quebec and the impact of this on hydropower in Quebec. Lee spoke about relation between North Atlantic Oscillation (NAO) and Min7D flow. Lee looked at a K-nearest neighbor (KNN) based local linear regression and the historical and simulated values.

30. **Dr. Swadhin Behara, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), "Climate Variations Link to Extreme Streamflows"**

    Behara focused on climate variations with links to extreme stream flows. Behara showed a slide on the scales of weather and climate**.** Behara talked about rivers in Indonesia and Brazil. He looked at the mean climate. Behara talked about stream flows of the river in Indonesia. Behara showed a composite of anomalies of SST, wind and OLD during the boreal fall season. Behara then showed a slide on the composite of extremely low stream flow events. Behara talked about sea-level variations related to El Nino and Nino Modoki. Modoki is related to low stream events. Behara talked about Africa in relation to low and high stream events. He looked at different latitudes. Behara discussed the Science and Technology Research Partnership for Sustainable Development (SATREPS) project between South Africa to Japan. It is between Japan International Cooperation Agency (JICA) and JAMSTEC and partners in South Africa. Behara spoke about a conceptual climate based early warning system for Malaria.

31. **Session Wrap Up:** Yoon talked about precipitation and summarized his talk. Lee talked about climate assessment not being inside our house. We need to scale down and look at our local problems. We need a really good example to show to other cities and areas. Our techniques have been developed well enough to solve local problems. Mori talked about TC and natural disasters. Behara hopes to extend prediction from a few days to a season ahead this will help with develop preparedness skill to help society. You can apply this to extreme stream flows and health. Chen said up to now forecasting is very important but we need to advance the forecasting capability. Important thing is tropical storm rainfall. Chen talked about science and technology.

    Lee talked about historical data sets and statistical modeling. Jain had a question about CMIN5 assessment.

    Rogers had a comment about Chen's presentation about operational forecast on extreme events. We need to focus on the impact of the precipitation. Rogers talked about the impact of Sandy in NYC. Need to get away of categorization of storms in a simplistic way. Bin Wang had comment about Chen's presentation. Chen talked about radar and weather stations. Chen spoke about topography effect and the TRP event. Georgakakos asked about statement about targeting climate extremes, he wondered if

we have enough data. He talked about events in Panama a few years ago, that was twice highest flow ever observed in that area.

Behara tried to answer; it can be hard to capture extreme events. He said the 2010 event was related to La Nina, we expected it to be high but not that high. Lee said dynamic modeling cannot do extremes. Bin Wan talked about Meteorological Research Institute creating something for TC. Bin Wang talked about skills of dynamic modeling that had a high correlation. Lee said that may be possible only for certain times. Lee then said with extreme events we do not expect the prediction of extreme events and he talked about designing dams and levees. Lee said we need a 10,000 year data set, we should not expect this to all be predictable, and we can see mean or some variability.

Session V: Climate Impacts on Water Quality

32. The morning session of October 29 commenced at 9:00 am. Session IV discussed Climate Impacts on Water Quality and was chaired by Dr. Heejun Chang, a Professor of Geography from Portland State University.

33. **Dr. Heejun Chang, Portland State University, "Impacts of Climate Change On Stream Temperature in the Pacific Northwest of USA"**

Chang will talk about climate change in U.S. Pacific Northwest (PNW). Chang thinks water temperature is most important issue. Chang talked about salmon and stream temperatures. He looked at the decline of salmon run. Chang talked about temperature in the Willamette River in Oregon. He talked about solar radiation and impact on stream temperature. Chang looked at trends in September and March runoff from 1958-2008. Chang looked at effects of urban development of stream flow. Chang looked at two different case studies. The first one dealt with climate change impacts on stream temperature in the Willamette. Chang talked about climate drivers and thermal sensitivity. Chang looked at changes in air temperature, stream flow and stream temperature in Johnson Creek in Oregon. Chang talked about change in 7DADMAX (7-day average of the daily maximum temperatures) stream temperature by decade for two streams in Oregon. Chang started talking about his second case based on his previous research with his students. He spoke about spatial and temporal

change in water temperature under climate change. Chang talked about a stream enhancement project in the Tualatin. He then talked about the number of days that water resources exceed 20 Celsius under base and high climate change scenarios. Chang finished his presentation.

34. **Dr. Leon van der Linden, Australia Water Quality Centre, "Adapt to What? Projections of Direct Impacts of Climate Change on Surface Reservoir Water Quality in Australia and Taiwan"**

    Linden will focus on direct impacts of climate change on surface reservoir water quality in Australia and Chinese Taipei. Linden gave an overview of his presentation. His goals are to use models to facilitate operational responses to hydro hazards and have prudent investment in infrastructure. Linden spoke about different water infrastructure. He showed a slide of a hydrograph. Linden spoke about water quality issues in Sydney in 2008. Linden looked at water columns. Linden spoke about problems of water supply in Adelaide. Linden spoke about the Happy Valley water infrastructure and talked about elevated temperatures on catchment process and climate change impact on water quality**.** He spoke about reservoirs in Chinese Taipei. Linden looked at surface water temperature in Hsinshan Reservoir. Linden looked at temperature profiles for the reservoir. They are satisfied with their models. Linden spoke about CE-Quall W2 model performance for the Hsinshan reservoir. Linden explored projected ensemble temperature chance in the future in Chinese Taipei. He compared model to model results and discussed the dissolved oxygen profile. Linden gave his conclusions on water quality trends. He looked at the future direction of integration with catchment models. Linden talked about lead times that could by assisted by more information and then he talked about capacity of availability for projected inflows. Linden discussed the ensemble techniques and then thanked his research partners and finished.

35. **Dr. Jaepil Cho, APEC Climate Center, "Climate Change Impacts on Agricultural Non-Point Source Pollution by Considering Uncertainty of CMIP5"**

    Cho talked about four rivers project in Korea. Cho talked about Algae bloom in the Nakdong River. Cho looked at pollutant sources. Cho gave an overview of his presentation. He asked how well a climate change scenario reproduces the spatial and

temporal pattern during a historical period. Cho talked about problems why we need to use MME method. Cho talked about the importance of downscaling. Cho looked at historical records from Jeonju in Korea. Cho looked at soil and water assessment tool (SWAT). Cho spoke about temporal reproducibility and pollutant loads. Cho looked at sediment yields from HRU to stream from 2011 to 2040. Cho started talking about survey that targeted water related government agency, public enterprise, and research institutes. Cho looked at downscaling of seasonal forecasts. Cho talked about problems with global model. He talked about moving window regression looking at data from 1983-2005.

Cho talked about basin modeling approach. Cho spoke about the integration of the different types of outputs. Cho gave his summary of his presentation. Linden had a question about SWAT and uncertainties and GCM selection. Cho talked about a procedure at beginning of GCM process. Park had a question about the platform, thought it was only for professionals not normal people. Cho talked about the workshop APCC put on two years ago. He agreed with Park's statement but the platform here is a short term bridge to the future.

36. **Dr. Shaleen Jain, University of Maine, "Extreme Hydroclimatic Events and Environmental Quality: Use-inspired characterization of change, thresholds and transitions"**

Jain's presentation was on hydro-climatic events and environmental quality. Jain talked about state and federal entities being focused on resource and hazards. Jain showed a slide saying we need to carefully select collaborative work between scientists. Jain talked about usable knowledge to address water problems. Jain showed a schematic on sustainable environmental systems and discussed compromised storm water infrastructure due to extreme rainfall events. Jain talked about the case of malfunctioning culverts. Jain gave a quote about how easy it is to draw schematics versus seeing what is really going on. He showed a slide on the delineated knowledge system to support community based adaption with a focus on storm water infrastructure. Jain gave the example of Hurricane Irene. He talked about sewage overflows. He then looked at time-varying return periods. Jain spoke about his stakeholders being interested in temporal changes in seasonality. He talked about date of annual maximum precipitation events, nonparametric statistical framework to

assess changes and characterization of PDF, short record length, and it aligns with culver maintenance calendars. Jain's work was highlighted in the recent U.S. National Climate Assessment. Jain spoke about climatic drivers of lake water quality transitions and his current work. Jain talked about the inclusion of ecosystems as stakeholders and climate environmental flow linkages. Jain talked about typhoons impacting Korea and the health of the ecosystem.

37. **Dr. Jyotish Basu, West Bengal State University "Heat Waves, Precipitation and Water related Disease Vector in Drought and Flood Prone areas of West Bengal, India"**

    Basu talked about being an economist. He used his knowledge to look at impact on human health. He talked about impact of climate change on heatwaves and floods. He looked at the IPCC report third and fourth that discussed rising temperature. Basu talked about 2003 heatwave in Europe that killed many people. Basu spoke about his study. Basu showed web of climate change, human health, adaption and mitigation. He spoke about the objectives of his study. He looked at the eastern part of India. Basu discussed India Meteorological Department's definition of a heatwave. He looked at characteristics of temperature across the different regions of India. Basu talked about the maximum temperature across India in different regions. Basu talked about heat wave and human causalities. Basu looked at trends of heat wave deaths in India. He discussed the relationship between temperature and deaths in India.

    Basu talked about season rainfall statistics for all India in homogenous regions. He looked at trends in monsoon precipitation in India. Basu showed a map of malaria in India and then discussed the trends. Basu then discussed link between rainfall and malaria. Basu spoke about trends in Dengue and Diarrhea.

38. **Dr. Xuhui Lee, Nanjing University of Information Science and Technology, "The Taihu Eddy Flux Network: An Observational Program on Energy, Water and Greenhouse Gas Fluxes of a Large Freshwater Lake"**

    Lee asked how lake evaporation will change in a future warmer world and why are lake-land breeze circulations less prevalent in the lake basin than in lake basins in the northern latitude? Lee looked at different zones of Lake Taihu. The lake is very shallow but large. He spoke about observed water temperature and measuring

concentration gradient. Lee spoke about greenhouse gas concentrations in surface water. He looked at greenhouse gases in water and the composition of lake water. Lee talked about monthly mean latent heat flux versus available energy. He compared their findings with other lake systems in the world. Lee spoke about comparisons of methane influx. Lee talked about CO^2 flux comparisons between BFG and DPK.

Note: This session ran over time and there was not time available for a wrap up.

Session VI - Wrap up and Panel Discussion

39. The Panel Discussion and Wrapping-Up Session on October 29 commenced at 2:00 pm. The session was chaired by Dr. Bin Wang from the International Pacific Research Center at the University of Hawai'i.

40. **Session II:** Dr. Yuriy Kuleshov talked about each of the presentations in his session. He first talked about Bates presentation. Next he spoke about Lerat's presentation and talked about seasonal stream flow forecasting service for Australia. Kuleshov then talked about his own presentation where he looked at Pacific Islands nations like Tuvalu and Fiji. He then spoke about Eric Wood's presentation and gave a short summary. Kuleshov closed talking about Byun's presentation.

41. **Session III:** Dr. Ximing Cai talked about the main points of his sessions. They are trying to understand the scale for impact assessment. Cai spoke about science issues, what are the approaches or solutions? Cai talked about Park's presentation. We need a variety of responses to deal with a variety of disturbances. Cai talked about risk management issues (under-preparedness vs. over-preparedness). These are large issues for engineers. Cai then talked about a bridge between scientists and user communities through a holistic platform; identify end-users needs. Cai spoke about dealing with "messy" decision making problems. Cai talked about the decision making process.

42. **Session IV:** Dr. Eric Salathé summarized each presentation in his session. He summarized Chen's TC presentation; it was interesting to him because he grew up

impacted by storms. Thought this was nice demonstration of impact of TC. Salathé spoke about Yoon's presentation and issues with different phases of El Nino and La Nina. Salathé looked at some common themes in his session. Creating scenarios of future risks of extremes for management decisions (all of speakers); brining climate to the house scale: downscaling hourly disaggregation, extreme precipitation mechanisms (Lee, Chen); analysis of large scale controls to improve climate predictability and climate change guidance (Yoon, Behera, and Mori).

43. **Session V:** Dr. Heejun Chang summarized his session with a excel table. Chang talked about Lee's surprising findings regarding methane. He outlined his session main points and talked about the useful versus useable data. He touched upon climate impact assessment across spatial and temporal scales. Chang talked about cross-scale integration (local to global feedback). We need to educate the general public and maybe change zoning laws.

44. **Panel Discussion: QJ Wang, Bin Wang, David Roger, Konstantine Georgakakos, Eric Wood, Zhiyu Liu**

    Bin Wang asked what main issue that has come out of this event. Rogers thanked APCC on behalf of the World Bank and GFRDR for being invited and talked about investing in infrastructure. He said all the presentations here somewhat touched upon the work of the World Bank and talked about how the science has come so far we can actually start talking about using it. Rogers then talked about not connecting with the end user. We can begin to see how we will be able to use this information in the future.

    Georgakakos commented on forecasts and operational disaster and reservoir management. We need links to local information. There is always upstream regulation. Georgakakos talked about low flows and sustainable capacity building, which will take decades not a year or two. He commented on close interaction between forecasting management agencies. He noticed how people adjust to what people want, he does not think that engages users; users need to have a vested interest. He talked about being behind in linking forecast with management. Managers need metrics to use forecasts. Georgakakos spoke about the demonstration projects. These will be very useful in bridging the gap because there is a need for a common language to

communicate. Most managers were skeptical before he began his project; he said there is a need to demonstrate the need to people.

Bin Wang spoke about downscaling and who should do it? Georgakakos said downscaling is more a research area, what he was talking about is the value of the dynamic of the statistical downscaling.

Liu thanked everyone on behalf of WMO. He was very impressed, that this was very high academic level and he thanked APCC for their research activities. Liu talked about Global Framework for Climate Services (GFCS). He talked about symposium being a great contribution to science in the region.

Liu called for more cooperation between providers and users (water managers) there is a need for more links between the hydrological society and the meteorological society. Liu talked about five pillars of GFCS. Liu spoke about statistical modeling. He reiterated the need for more cooperation.

Eric Wood thanked APCC and everyone involved. Wood agrees with what others say. He talked about water supply and extreme events. There is a need to convert them into hydrological variables. He touched upon downscaling as a research problem. Wood talked about a task force on drought and he thought APCC could play a role to coordinate projects in Asia-Pacific region. Wood agreed with what Lettenmaier said about water management. We need to strengthen the core education, it is more than just capacity building. Wood talked needing local information. We need to get the silent stations waking up and reporting. We need to get all the stations on the map, to start to develop more skillful systems.

Bin Wang talked about WMO needing policy to get people to contribute. Wood thinks the only reason we share weather data is because of air travel but water is not the same. WMO has a policy, but it is only policy not action. Rogers talked about lack of data in developing world. Hydrology is poorly served in having global data An attendee talked about the importance of rain gauge data and how difficult data it is to get data from China. Data from China is very important for Korea, but he cannot get access to it. Liu said WMO is trying to get members to share data. Hydrological data has a boundary, WMO respects member’s policies on data, but we encourage members to share but we respect countries policies.

Wang talked about the terrific work of APCC. This work can save lots of resources because people can go along with their project the right way. QJ Wang talked about

how well Europeans work together. In the APEC community, we are not doing that APCC is doing wonderful job but we need more. Wang thinks between symposiums we could have smaller meetings. Wang asked about APCC extending their leadership.

Rogers talked about capacity building in the region and seasonal forecasts. Some countries in the region have very low capacity. There is a framework for climate services and we clearly have a lot of capacity in the region but that does not translate to help to everyone in the region. He talked about issues in Australia and New Zealand about sustainable of resources.

Wood responded to what Rogers said about the emergences of climate services. Wood thinks the government's role and the WMO's role is to make sure data is available, but he talked about the importance of the private sector. Rogers spoke more about the importance of the World Bank; every project for World Bank needs a climate change aspect.

Wood talked about how it would be hard for engineer to do this research if he was trying to make reservoir for World Bank project. Rogers said Wood's point was well taken. Chang talked about the benefits of information. APEC is a microcosm for the world and can be a test case for cooperation. Lerat worried about quality control for data. Liu talked about data quality information. Their main activity at WMO is to develop the standards.

Rogers talked about focusing on impact and about the use of mobile phone applications. Rogers talked about the importance of pilot projects. We should have the tools even some of the least developed areas have smart phone technology.

45. Dr. Chin-Seung Chung, the Director of the APEC Climate Center, concluded the symposium with a speech reiterating the main points of the symposium while thanking everyone for their active participation.

ANNEX: APEC Climate Symposium 2014 Participants List

Number	Country	Affiliation	Title	Name
1	Australia	National Climate Centre - Bureau of Meteorology (BOM)	Dr.	Yuriy Kuleshov
2	Australia	Commonwealth Scientific and Industrial Research Organisation/Australia (CSIRO)	Dr.	Bryson Bates
3	Australia	Water for Healthy Country Flagship, CSIRO	Dr.	Quan Jun Wang
4	Australia	Environment and Research – Forecast Systems, BOM	Dr.	Julien Lerat
5	Australia	The Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Dr.	Francis Chiew
6	Australia	Australian Water Quality Centre	Dr.	Leon van der Linden
7	China	World Meteorological Organization (WMO)	Dr.	Zhiyu Liu
8	China	Chinese Academy of Meteorological Sciences (CAMS)	Dr.	Lianshou Chen
9	China	National Climate Center, China Meteorological Administration (NCC/CMA)	Prof.	Yihui Ding
10	China	National Climate Center, China Meteorological Administration (NCC/CMA)	Ms.	Qingchen Chao
11	China	Institute of Atmospheric Physics (IAP)	Prof.	Hui-Jun Wang
12	China	Nanjing University of Information Science and Technology	Prof.	Xuhui Lee
13	China	Nanjing University of Information Science and Technology	Prof.	Jianqing Jiang
14	China	Nanjing University of Information Science & Technology	Prof.	Jinzhong Min
15	China	Jiangsu Provincial Department of Education	Dr.	Zhaochen Zhang
16	China	Foreign Affairs Office of Jiangsu Provincial People's Government	Dr.	Yanmei Fang
17	Chinese Taipei	Central Weather Bureau (CWB)	Ms.	Meng-Shih Chen
18	India	West Bengal State University	Dr.	Jyotish Basu
19	Japan	Disaster Prevention Research Institute (DPRI)	Dr.	Nobuhito Mori
20	Japan	Atmosphere and Ocean Research Institute	Prof.	Kimoto Masahide
21	Japan	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Dr.	Swadhin Behera
22	Korea	Ministry of Foreign Affairs	Mr.	Sangchan Gu
23	Korea	Ministry of Foreign Affairs	Mr.	Heesang Kim
24	Korea	Pukyong National University (PKNU)	Prof.	Hi-Ryong Byun
25	Korea	Geyongsang National University (GNU)	Prof.	Taesam Lee
26	Korea	Pukyong National University (PKNU)	Mr.	Chang-Kyun Park
27	Korea	Pukyong National University (PKNU)	Mr.	Sang-Hun Kwon
28	Korea	Pukyong National University (PKNU)	Ms.	Ga-Byn Kim
29	Korea	Pukyong National University (PKNU)	Ms.	Hee-Nae Kwon
30	Korea	Pukyong National University (PKNU)	Ms.	Ji-in Kang
31	Korea	University of Seoul	Dr.	Jong-Suk Kim

32	Korea	Pukyong National University (PKNU)	Prof.	Jaiho Oh
33	Korea	Korean Advanced Institute of Science and Technology (KAIST)	Prof.	Heekyung Park
34	Korea	Korea Maritime University (KMOU)	Prof.	Kihwan Lee
35	Korea	APEC Climate Center (APCC)	Dr.	Chin-Seung Chung
36	Korea	APEC Climate Center	Dr.	Jinho Yoo
38	Korea	APEC Climate Center	Dr.	Yoobin Yhang
39	Korea	APEC Climate Center	Dr.	Ilwon Jung
40	Korea	APEC Climate Center	Dr.	Jaepil Cho
41	Korea	APEC Climate Center	Dr.	Sunkwon Yoon
42	Korea	APEC Climate Center	Dr.	Hongwei Yang
43	Korea	APEC Climate Center	Ms.	Hannah Kim
44	Korea	APEC Climate Center	Ms.	Sooyang Joo
45	Korea	APEC Climate Center	Mr.	Gyeongseok Jo
46	Korea	APEC Climate Center	Mr.	Joseph Larsen
47	USA	Global Facility for Disaster Reduction and Recovery (GFDRR)	Dr.	David Rogers
48	USA	Hydrologic Research Center (HRC)	Dr.	Konstantine Georgakakos
49	USA	Princeton University (Princeton)	Prof.	Eric Wood
50	USA	University of Illinois at Urbana-Champaign (UIUC)	Prof.	Ximing Cai
51	USA	University of Washington (UW)	Prof.	Dennis Lettenmaier
52	USA	Integrated Risk Governance Project / International Human Dimensions Programme (IRGP/IHDP)	Dr.	Qian Ye
53	USA	University of Washington (UW)	Dr.	Eric Salathé
54	USA	Portland State University (PSU)	Prof.	Heejun Chang
55	USA	University of Maine	Dr.	Shaleen Jain
56	USA	I.M. Systems Group, Inc. (IMSG)	Dr.	Sean Lam
57	USA	I.M. Systems Group, Inc. (IMSG)	Dr.	Paul Chan
58	USA	International Pacific Research Center/University of Hawaii (IPRC/UH)	Prof.	Bin Wang
59	USA	Naval Postgraduate School	Prof.	Chi-Pei Chang