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APEC Climate Syposium 2013

Regional Cooperation on Drought Prediction Science to Support Disaster Preparedness and Management

APEC Climate Symposium 2013

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Jakarta, Indonesia
November 11-13, 2013

APEC Asia-Pacific Economic Cooperation
APCC
BMKG

APEC Climate Symposium 2013

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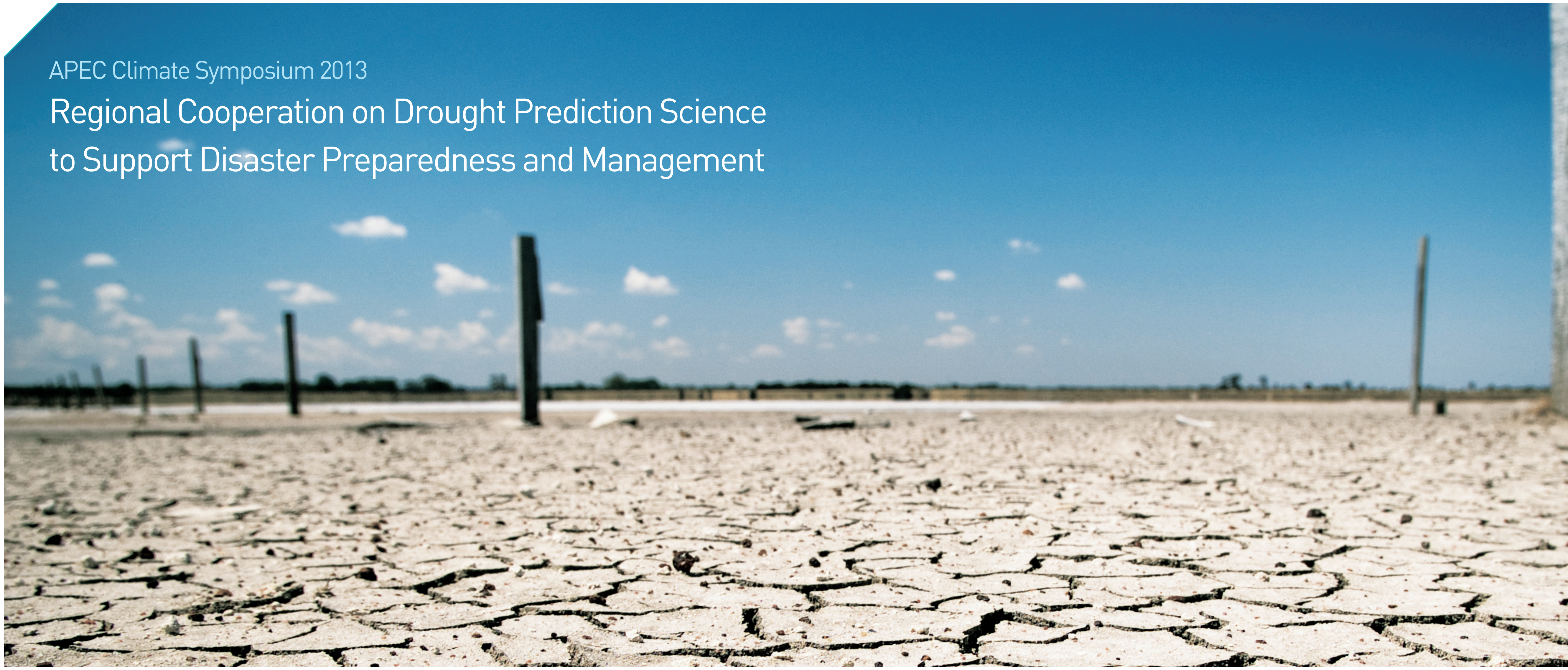


Contents

Welcome Message

On behalf of the organizers, the APEC Climate Center (APCC) is delighted to welcome you to Jakarta, Indonesia for the APEC Climate Symposium (APCS) 2013. Through close collaboration with the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG), the APEC Climate Center has developed this conference to explore the importance of advance climate information for supporting drought preparedness and disaster management. Reliable drought prediction and monitoring enable decision-makers to make well-reasoned management decisions, coordinate responses of government agencies, direct emergency relief, and reduce vulnerability to drought-related hazards; thereby realizing the APEC mission of protection of human security in the region.

With various participants hailing from over 20 different developed and developing countries coming together to share their experiences, this event provides a unique opportunity for countries which are projected to experience increasingly severe drought conditions under climate change to learn from the experiences of economies that have historically suffered from drought. It is our hope that participants will return to their home countries enriched by the information and case studies shared over the next couple days and can apply their learning toward reducing the vulnerability of their regions to the hazardous impacts of drought

APCS 2013 would not have been possible without the strong support of our valuable partners. I would like to offer our sincere gratitude to all of the members of the Organizing Committee members and our co-hosts at BMKG, as well as to all the speakers and participants.

We hope that you enjoy the symposium.

Thank you.

APCS 2013 Organizres

APEC Climate Center (APCC)

The Asia-Pacific Economic Cooperation (APEC) Climate Center is a leading climate information service provider in the Asia-Pacific region. We provide climate forecasts and information services, conduct research and development activities, and organize capacity building initiatives in the Asia-Pacific region. APCC was established in 2005 with the endorsement and warm welcome of the APEC senior officials and leaders. We annually organize the APEC Climate Symposium, which provides a forum for various scientists, academics, policy-makers and other stakeholders to share the latest science innovations in climate prediction and explore climate information applications.

Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG)

The Indonesian Agency for Meteorology, Climatology and Geophysics is a government institution whose duty and role is to implement weather, climate and earthquake information services for national development and public safety. As an archipelagic country, flanked by two continents and two oceans, and atop the equator, BMKG plays a pivotal role in the World Meteorological Organization (WMO), as part of Regional Area V (RA V – South East Asia and South Pacific Countries), as well as APEC. Under close cooperation with the governments of India and Australia, BMKG has been authorized as the Regional Tsunami Watch Provider. In cooperation with the Association of Southeast Asian Nations (ASEAN) Sub-Committee on Meteorology and Geophysics, BMKG engages in various regional collaborations for developing weather and climate prediction models and other tools and services.

APCS 2013 Speakers

OPENING REMARKS & CONGRATULATORY ADDRESS

• Dr. Chin-Seung Chung

Dr. Chin-Seung Chung joined the APEC Climate Center as the Director in April 2010 after four decades of professional experience in government services. Since his arrival, Dr. Chung has steered APCC toward becoming one of the leading research centers providing climate information to the Asia-Pacific region. APCC contributes to prediction and monitoring activities of weather and climate in the Asia-Pacific region and supports capacity-building by providing climate information services and technical support for the reduction of economic losses due to adverse climate conditions.

Prior to his position at APCC, Dr. Chung was a Dean and Professor at the Korea Development Institute (KDI) School of Public Policy Management. He received his Ph.D. in Economics from the University of Georgia in 1983 and commenced a career in government service at different institutions. Dr. Chung served as the Deputy and Vice Minister at the Korean Ministry of Environment. While he was working at the Ministry, he was a Head Negotiator for the Korean Delegation for the COP3 meeting of the UN Framework Convention on Climate Change, at which the Kyoto Protocol was adopted in 1997. He has also served as a member and advisor to various national committees, including the Presidential Commission on Sustainable Development in 2003, the National Economic Advisory Council from 2004 to 2006 and the Regulatory Reform Committee from 2004 to 2008. He was also the President of the Korea Environmental Economic Research Association, as well as a Senior Research Fellow at the Korea Development Institute for twenty-two years from 1972-94. He has lectured at Stanford University, the Korea Advanced Institute of Science and Technology (KAIST) and Sogang University. He has conducted research and published books and numerous articles related to industrial trade and environmental issues. He is the author of Economic Development and Economic Policy in Korea (2006) and Environmental Policy at the Age of Decentralization in Korea (1993).

• Dr. Andi Eka Sakya

Dr. Andi Eka Sakya, M.Eng is the Director General of the Agency for Meteorology, Climatology and Geophysics (BMKG), Indonesia. His educational background is in Aeronautical Engineering he began his career as a researcher in Experimental Aerodynamics at the Aero-Gas Dynamics and Vibration Laboratory of the Agency for the Assessment and Application of Technology – Indonesia. He has served professionally in several governmental positions, including the Executive Secretary of the Agency for Meteorology, Climatology and Geophysics (Indonesian – BMKG); the Indonesian Focal Person on Marine Current Energy; the Assistant to the Deputy Minister for Priority and Strategic Research Programs at the Ministry of Research and Technology; the Assistant to the Deputy Minister for Program Planning at the Ministry of Research and Technology; and the Head of the Division for Research and Development, Aero-Gas Dynamics and Vibration Technology.

OPENING REMARKS & CONGRATULATORY ADDRESS

• Mr. Young-sun Kim

Mr. Kim Young-sun is the Ambassador Extraordinary and Plenipotentiary to the Republic of Indonesia for the government of the Republic of Korea. He has served as a Korean diplomat with the Korean Ministry of Foreign Affairs in various positions since he passed the High Diplomatic Service Examination in 1977. Most recently, he was a special adviser and spokesperson for the Minister of Foreign Affairs and Trade. He has also served as the Ambassador to Lebanon and as a Minister at the Korean Embassy in Japan. Mr. Kim received a B.A. in Political Science from Seoul National University and an M.A. in Political Science from the Graduate School of Keio University in Tokyo, Japan

• Prof. Bin Wang

Dr. Bin Wang is a Professor and Chair of the Department of Meteorology, University of Hawaii. He serves as the Co-Chair of APCC Science Advisory Committee. His research fields include Climate Science, Tropical Meteorology and Geophysical Fluid Dynamics. Wang has published more than 270 refereed papers which have inspired numerous studies on climate as evidenced by his h-index (70) and citation rate of over 14,000 times since 2008. Wang was elected the American Meteorological Society Fellow in 2009 and American Geophysical Union Fellow in 2013. He received the "Scientist of the Year" Award from the ARCS (Achievement Awards for College Scientists) foundation in 2012 and University of Hawaii Regent's Medal for Excellence in Research in 2013.

APCS 2013 Speakers

KEYNOTE SPEAKERS

• Prof. Donald Wilhite

Donald Wilhite is a Professor of Applied Climate Science at the School of Natural Resources, University of Nebraska-Lincoln. Wilhite's research and outreach activities focus on drought monitoring, planning, mitigation, and policy, as well as the use of climate information in decision-making. He has authored or co-authored numerous journal articles, monographs, book chapters, and technical reports. Wilhite also is editor or co-editor of numerous books on drought and drought management, including Coping with Drought Risk in Agriculture and Water Supply Systems: Drought Management and Policy Development in the Mediterranean (Springer, 2009); Drought and Water Crises (CRC Press, 2005); From Disaster Response to Risk Management: Australia's National Drought Policy (Springer, 2005); and Drought: A Global Assessment (Routledge, 2000). He also edits a book series on Drought and Water Crises. Previously, Wilhite directed UNL's School of Natural Resources for five years and was the founding director of both the National Drought Mitigation Center in 1995 and the International Drought Information Center in 1989 at the University of Nebraska-Lincoln. He holds a doctorate in geography, climate and water resources from UNL.

• Dr. Wenju Cai

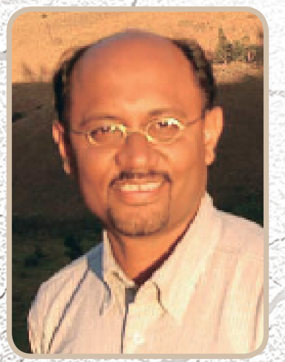
Dr. Wenju Cai obtained an M. Sc in height prediction of a tidal river from Xiamen University, China, and Ph D in Coastal Oceanography from the Flinders University of South Australia. He joined CSIRO in 1990, where he launched his climate research career. He is now a Senior Principal Research Scientist and leads an ocean climate team at CSIRO. Dr Cai specialises in global climate variability and change research. With 20 years of research and science leadership and experiece, his interest spans from identification of modes of climate variability (such as El Nino-Southern Oscillation, the Indian Ocean Dipole), and their mechanisms, to climate detection and attribution, through to impacts of individual forcing factors of increasing carbon dioxide, increasing anthropogenic aerosols, and stratospheric ozone depletion. Dr. Cai has received special awards and recognition as a contributing author to the IPCC AR4 and AR5 reports (for AR4 IPCC was awarded the Nobel Peace Prize in 2007), the CSIRO Best Science Communicator award in 2008, amd the CSIRO Strategic Excellence Award for the Climate Change in Australia Research in 2008. He was appointed as the Chair of the World Climate Research Programme CLIVAR Pacific Panel in 2009 and the CSIRO Office of Chief Executive Science Leader in 2011.

APCS 2013 Speakers

KEYNOTE SPEAKERS

• Mr. Neil Plummer

Mr. Neil Plummer has been the Head of Climate Information Services with the Australian Bureau of Meteorology since 2010. Our Climate services include the management and provision of data, monitoring and analysis of national and regional climate, climate prediction, and a liaison function. We are increasingly focusing on the monitoring and prediction of extremes, including droughts. Our main goal is to improve the decision-making capability of our customers so that governments, industry and communities derive social, economic and environmental benefits. Mr. Plummer has authored or co-authored more than 40 journal articles/technical papers, mostly on climate change, climate data and water forecasting. He led the organizing of the 2003 DroughtCom workshop and was lead author on reports. He also co-authored An assessment of the impact of climate change on the nature and frequency of exceptional climatic events prepared by CSIRO and the Bureau of Meteorology for the Australian Government's National Review of Drought Policy. Mr. Plummer holds positions on various World Meteorological Organization expert teams and management committees and been a coordinating author with the Intergovernmental Panel on Climate Change. Current positions include: Australia's alternate principal member of the Intergovernmental Board on Climate Services; Australia's National Global Climate Observing System Coordinator; Member APEC Climate Center Executive Council, Member of Science Advisory Group to the Australian Government's High Level Coordination Group on Climate Change. He joined the Bureau of Meteorology in 1986 and started his career as a weather forecaster. His climate-related roles have included climate change scientist and data manager. He shifted to the world of hydrology in 2008 as Manager Extended Hydrological Prediction before taking up current position as the Bureau's head of Climate Information Services. Mr. Plummer holds several tertiary qualifications in meteorology, management and IT and these include Masters Degrees in Science (climate change) and Business Administration.



• Prof. Rajib Shaw

Rajib Shaw is an Associate Professor in the Graduate School of Global Environmental Studies of Kyoto University, Japan. He works closely with local communities, NGOs, governments and international organizations, including United Nations, especially in the Asia Pacific region. He is currently the Chair of the United Nations Asia Regional Task Force for Urban Risk Reduction, and the President of the Asian University Network of Environment and Disaster Management. His research interests are: community based disaster risk management, climate change adaptation, urban risk management, and disaster and environmental education. He has published several books in the field of disaster and environmental management. Currently, he is the editor of a two-book series on disaster risk reduction from Springer and Emerald publishers. He is also the Chief Editor of the Asian Journal of Environment and Disaster Management.

APCS 2013 Program

November 11, 2013 (Monday)	APEC Climate Symposium 2013	
8:00-9:00	**Registration**	
9:00-9:20	**Opening Ceremony**	MC: Mr. Hyoung-Keun Yang
9:00-9:05	Opening Remarks	Dr. Chin-Seung Chung (Director, APEC Climate Center/ Korea)
9:05-9:10	Opening Remarks	Dr. Andi Eka Sakya (Director General, Agency for Meteorology, Climatology, and Geophysics/Indonesia)
9:10-9:15	Congratulatory Address	H.E. Mr. Young-sun Kim (Ambassador of the Republic of Korea to the Republic of Indonesia)
9:15-9:20	Congratulatory Address	Prof. Bin Wang (Chair, Department of Meteorology, Uni. of Hawaii/USA)
9:20-9:40	**Photo Session**	
9:40-10:00	**Cultural Presentation – Indonesian Traditional Dance Performance**	**BMKG**
10:00-10:20	**Coffee Break**	
10:20-11:40	Session I **Keynote Presentations**	Chair: Dr. Jinho Yoo (APEC Climate Center/Korea)
10:20-11:00	Managing Drought in a Changing Climate: The Role of National Drought Policies	Keynote - Prof. Donald Wilhite (Uni. of Nebraska-Lincoln/ USA)
11:00-11:40	BMKG's Potential Drought Monitoring Information System	Keynote - Dr. Andi Eka Sakya (Agency for Meteorology, Climatology, and Geophysics /Indonesia)
11:40-13:00	**Lunch**	
13:00-17:35	Session II **Drought Prediction and Science at Multiple Time-Scales**	Chair: Dr. Wenju Cai
13:00-13:30	Did Climate Change-Induced Trends Contribute to the Australian Decade-Long Millennium Drought?	Keynote – Dr. Wenju Cai (Commonwealth Scientific and Industrial Research Organisation /Australia)
13:30-13:55	Weekly to Decadal Predictability of Northwest Indian Ocean Rim Precipitation and Implications for Seasonal Drought Forecasting	Dr. Andy Hoell (Uni. Of California at Santa Barbara/USA)
13:55-14:20	IRI Forecast System and Drought Prediction: Providing Climate Information at Multiple Time-Scales	Dr. Nicolas Vigaud (International Research Institute for Climate and Society /USA)
14:20-14:40	**Coffee Break**	
14:40-15:10	Utilization of Dynamic Seasonal Climate Predictions for Drought Monitoring and Prediction Activities at NCEP/CPC	Dr. Jae-Kyung Schemm (National Oceanic and Atmospheric Administration /USA)
15:10-15:35	ENSO Index and Its Relationship to Standardized Precipitation Index (SPI) in the Maritime Continent	Mr. Amsari M. Setiawan (Agency for Meteorology, Climatology, and Geophysics /Indonesia)
15:35-16:00	Case Study of 2011/2012 Spring Rainfall in Taiwan	Dr. Jung-lien Chu (National Science and Technology Center for Disaster Reduction /Chinese Taipei)
16:00-16:20	**Coffee Break**	
16:20-16:45	An Assessment of Future Dryness over Korea Based on the Regional Climate Projection under A1B Emission Scenario	Dr. Eun-Soon Im (Center for Environmental Sensing and Modeling /Singapore)
16:45-17:05	TBA	Prof. Dennis Lettenmaier (Univ. of Washington/USA)
17:05-17:35	**Wrapping-up and Discussion**	
18:30-20:30	**Welcoming Reception hosted by APCC Location: Ancol, Jakarta**	

APCS 2013 Program

November 12, 2013 (Tuesday)	APEC Climate Symposium 2013	
9:00-12:15	Session III **Drought Monitoring and Information Systems**	Chair: Mr. Neil Plummer
9:00-9:30	Drought Monitoring and Information Systems: The Australian Experience	Keynote - Mr. Neil Plummer (Bureau of Meteorology/Australia)
9:30-9:55	Drought Monitoring in New Zealand	Dr. Brett Mullan (National Institute of Water and Atmospheric Research /New Zealand)
9:55-10:20	Drought Monitoring in the Pacific Islands: The COSPPac Project	Dr. Lynette Bettio (Bureau of Meteorology/Australia)
10:20-10:45	The New BMKG Climate Change Information System to Address Cross-Sectoral Drought Information Needs	Dr. Widada Sulistya (Agency for Meteorology, Climatology, and Geophysics /Indonesia)
10:45-11:05	**Coffee Break**	
11:05-11:30	Remote Sensing of Hydrological Drought Based on Precipitation and Evapotranspiration Estimates	Dr. Jinyoung Rhee (APEC Climate Center/Korea)
11:30-11:55	Drought Monitoring Using Japan's Space Technology	Dr. Shinichi Sobue (Remote Sensing Technology Center of Japan/Japan)
11:55-12:15	**Wrapping-up and Discussion**	
12:15-13:30	**Lunch**	
13:30-18:00	Session IV **Utilizing Drought Information for Policy and Decision Making**	Chair: Dr. Rajib Shaw
13:30-14:00	Drought Adaptation in Asian Monsoon Regions: Some Critical Observations	Keynote – Dr. Rajib Shaw (Kyoto University/Japan)
14:00-14:25	Developing and Implementing Drought Policies: Outcomes of the High Level Meetings on National Drought Policy (HMNDP)	Dr. Mannava Sivakumar (World Meteorological Organization/Switzerland)
14:25-14:50	Regional Cooperation in Policy and Decision Making for Better Drought Management: Experiences from the Greater Mekong Subregion	Dr. Javed Hussain Mir (Asian Development Bank/Philippines)
14:50-15:10	**Coffee Break**	
15:10-15:35	Drought Management in Thailand	Dr. Royol Chitradon (Hydro-Agro Informatics Institute/Thailand)
15:35-16:00	TBA	Dr. Rene Lobato-Sanchez (National Meteorological Service of Mexico, CONAGUA/Mexico)
16:00-16:25	Drought Vulnerability and Policy in Korea	Dr. ByoungJae Lee (Korea Research Institute for Human Settlements /Korea)
16:25-16:45	**Coffee Break**	
16:45-17:10	Regional-Scale Drought Measures for Effective Decision Making	Dr. Greg Carbone (Uni. South Carolina/USA)
17:10-17:35	Successfully Using Drought Information in Northern California Public Decision Making	Ms. Ane Deister (Parsons Corporation/USA)
17:35-18:00	**Wrapping-up and Discussion**	

APCS 2013 Program

November 13, 2013 (Wednesday)	APEC Climate Symposium 2013	
9:00-11:45	Session V **Wrapping-up and Panel Discussion**	Chair: Prof. Bin Wanga
9:00-9:15	Session II Wrap-up	Dr. Wenju Cai (Commonwealth Scientific and Industrial Research Organisation /Australia)
9:15-9:30	Session III Wrap-up	Mr. Neil Plummer (Bureau of Meteorology /Australia)
9:30-9:45	Session IV Wrap-up	Dr. Mannava Sivakumar (World Meteorological Organization / Switzerland)
9:45-10:05	**Coffee Break**	
10:00-11:30	Panel Discussion	Panelists: Dr. Wenju Cai, Mr. Neil Plummer, Dr. Mannava Sivakumar, Dr. Dodo Gunawan, Dr. Dewi Kirono
11:30-11:45	**Closing Remarks**	
11:45-13:00	**Lunch**	
13:00-18:00	Session VI **Tutorial Session on Assessment of Drought Severity Through Drought Indices and GIS Mapping Technologies**	Facilitator: Dr. Jong Ahn Chun
13:00-14:00	Introduction of Drought Indices	- Meteorological Drought Indices - Agricultural Drought Indices - Hydrological Drought Indices
14:00-14:20	**Coffee Break**	
14:20-16:00	GIS Mapping Tutorial	- Previous, current, and future months' drought index values for meteorological and agricultural drought (provided in raster format) - Creation of drought index maps using an Open Source GIS software - Clipping of maps to specific areas of interest
16:00-16:20	**Coffee Break**	
16:20-18:00	Strategic Monitoring Report & Communications Tutorial	- Analysis of drought conditions - Evaluation of changes in drought conditions - Report writing * Some ancillary data will be given for the analysis of the major cause of the changes in drought conditions

APCS Session Themes

Drought Prediction and Science at Multiple Time-Scales

In order for economies and societies to minimize the damage caused by episodes of drought, timely and reliable drought prediction is required. Advance drought prediction is currently being conducted at multiple time-scales, each with its own advantages and limitations. The focus of this session will be on the current capabilities of drought prediction and will discuss the development of new methods for improving the fidelity and lead time of drought predictions.

1. *How can we better understand and model the atmospheric and oceanic conditions that trigger drought episodes?*
2. *What research is being done to better understand patterns of extreme events that affect the severity and duration of droughts?*
3. *What work is being done by scientists to provide reliable seasonal, intraseasonal and inter-annual forecasts for drought outlooks that can influence decision-making? What level of accuracy is reasonably attainable with drought prediction and how do scientists work with stakeholders to communicate forecast skill?*
4. *How can scientists work to providing drought information at time-scales that are relevant to user's procedural needs? Is information being provided at appropriate times to support time-sensitive decisions? At what time-scale are the triggers or entry points for taking preventative actions?*
5. *How will climate change affect the severity and spatial extent of drought? What will be the effects in areas historically faced with recurrent/multi-year drought? What new areas can expect to face increased or prolonged drought episodes?*

Drought Monitoring and Information Systems

Drought monitoring refers to the careful observation of current drought conditions to assess its severity and spatial extent A variety of methods and indices can be applied since there are different types of drought (meteorological, hydrological, or agricultural) that may require assessment. This session will discuss appropriate methodologies and tools for drought monitoring and the development of drought information/Early Warning Systems.

1. *How can we comprehensively monitor and characterize the magnitude, spatial extent, trends, and duration of drought for areas of interest in a timely manner?*
2. *What work is being done to create comprehensive and integrated drought monitoring systems? What indicators (climate, water, soil, crop, and/or economic variables) are selected for monitoring each type of drought and why?*
3. *In order to better respond to the information needs of stakeholders, can these drought information/early warning systems include warning of the potential impacts on the economy, households, or the environment?*
4. *What are the requirements for successful drought information/early warning systems?*

Utilizing Drought Information for Policy and Decision Making

The value of drought information is limited if it does not stimulate any activity or decision making. In this session, government officials and other stakeholders will discuss how they use drought information when creating policy or response plans and will explain to what extent drought information influences their decision making. Furthermore, the stakeholders will express where they obtain drought information and will explain what information formats and communication channels would be optimal to guide their science-based decision making.

1. *How is information transferred from producers to end users? What channels and/or institutions are involved along the way? What are the most effective and inventive systems for delivering and disseminating drought information to support decision-making?*
2. *How can we improve the linkages and coordination between the drought information producers, government agencies, agribusiness, and other relevant water-use sectors?*
3. *How can we move beyond reactive, post-impact emergency response drought policies and toward drought risk reduction (i.e. increased preparedness for drought episodes and mitigation against drought impacts)?*
4. *How can we create drought preparedness strategies that involve appropriate mitigation or response actions at the appropriate time (e.g. during drought forecast, onset, termination, etc.)? How can these strategies be integrated with information provision and dissemination?*
5. *What financial policy mechanisms can governments and the private sector provide to encourage drought preparedness (e.g. drought insurance, matching of funds or tax-free loans to stimulate the development or implementation of drought risk reduction measures)?*

Session I

Managing Drought in a Changing Climate: The Role of National Drought Policies

Donald Wilhite

BMKG's Potential Drought Monitoring Information System

Andi Eka Sakya

MANAGING DROUGHT IN A CHANGING CLIMATE: THE ROLE OF NATIONAL DROUGHT POLICIES

Dr. Donald A. Wilhite

Professor, Applied Climate Science, School of Natural Resources, University of Nebraska, Lincoln, Nebraska U.S.A.

Abstract Summary: Drought is a normal part of climate for virtually all nations. Historically, governments have responded to drought in a reactive, crisis management mode—an approach that has been demonstrated to be ineffective, untimely, and poorly coordinated—often leading to greater societal vulnerability to the next drought event. With mounting pressure on our limited fresh water resources, periods of drought are increasingly leading to serious water management challenges and conflicts between water use sectors. As the frequency of extreme climatic events, such as drought, increase and with the projection that these events will continue to become more frequent, of greater severity, and of longer duration in the future as a result of our changing climate, a significant paradigm shift in drought management is required. The way forward is to adopt a more pro-active, risk-based management approach directed at a reduction in societal vulnerability through improved early warning, preparedness and risk-based national drought policies. Working in concert with the World Meteorological Organization, other United Nations' agencies, and the Global Water Partnership, greater attention is being brought to these important issues globally.

Keywords: *Drought policy, drought preparedness, drought planning, drought management, early warning systems*

1. INTRODUCTION

The implementation of a national drought policy based on the philosophy of risk reduction can alter a nation's approach to drought management by reducing the associated impacts (risk). This was a motivating factor that led the World Meteorological Organization's (WMO) Congress at its Sixteenth Session held in Geneva in 2011 to recommend the organization of a "High-level Meeting on National Drought Policy (HMNDP)." Accordingly, WMO, the Secretariat of the United Nations Convention to Combat Desertification (UNCCD) and the Food and Agriculture Organization of the United Nations (FAO), in collaboration with a number of UN agencies, international and regional organizations and key national agencies (Annex I), organized the HMNDP in Geneva from 11 to 15 March 2013. The theme of HMNDP was "Reducing Societal Vulnerability – Helping Society (Communities and Sectors)."

Concerns about the spiraling impacts of drought on a growing number of sectors, the current and projected increase in the incidence of drought frequency and severity and the outcomes and recommendations emanating from the HMNDP, is drawing increased attention from governments, international and regional organizations, and nongovernmental organizations on drought policy and preparedness planning. Simply stated, a national drought policy should establish a clear set of principles or operating guidelines to govern the management of drought and its impacts. The overriding principle of drought policy should be an emphasis on risk management through the application of preparedness and mitigation measures. This policy should be directed toward reducing risk by developing better awareness and understanding of the drought hazard and the underlying causes of societal vulnerability. The principles of risk management can be promoted by encouraging the improvement and application of seasonal and shorter-term forecasts, developing integrated monitoring and drought early warning systems and associated information delivery systems, developing preparedness plans at various levels of government, adopting mitigation actions and programs, creating a safety net of emergency response programs that ensure timely and targeted relief, and providing an organizational structure that enhances coordination within and between levels of government and with stakeholders. The policy should be consistent and equitable for all regions, population groups, and economic sectors and consistent with the goals of sustainable development.

As vulnerability to and the incidence of drought has increased globally, greater attention has been directed to reducing risks associated with its occurrence through the introduction of planning to improve operational capabilities (i.e., climate and water supply monitoring, building institutional capacity) and mitigation measures that are aimed at reducing drought impacts. This change in emphasis is long overdue. Mitigating the effects of drought requires the use of all components of the cycle of disaster management, rather than only the crisis management portion of this cycle. Typically, when drought occurs, governments and donors have followed with impact assessment, response, recovery, and reconstruction activities to return the region or locality to a pre-disaster state. Historically, little attention has been given to preparedness, mitigation, and prediction/early warning actions (i.e., risk management) and the development of risk-based national drought management policies that could reduce future impacts and lessen the need for government and donor interventions in the future. Crisis management only addresses the symptoms of drought as they manifest themselves in the impacts that occur as a direct or indirect result of drought. Risk-based management, on the other hand, is focused on identifying where vulnerabilities exist (particular sectors, regions, communities, or population groups) and addresses these vulnerabilities through systematically implementing mitigation and adaptation measures that will lessen the risk to future drought events. Because societies have emphasized crisis management in past attempts at drought management, countries have generally moved from one drought event to another with little, if any, reduction in risk. In addition, in many drought-prone regions, another drought event is likely to occur before the region fully recovers from the last event.

To provide guidance in the preparation of national drought policies and planning techniques, it is important to define the key components of drought policy, its objectives, and steps in the implementation process. An important component of national drought policy is increased attention to drought preparedness in order to build institutional capacity to deal more effectively with this pervasive natural hazard. The lessons learned by a few countries that have been experimenting with this approach will be helpful in identifying pathways to achieve more drought-resilient societies.

A constraint to drought preparedness has been the dearth of methodologies available to policy makers and planners to guide them through the planning process. Drought differs in its characteristics between climate regimes and impacts are locally defined by unique economic, social, and environmental characteristics. A methodology developed by Wilhite (1991) and revised to incorporate greater emphasis on risk management (Wilhite et al., 2005) has provided a set of generic steps that can be adapted to any level of government or geographical setting for the development of a drought mitigation plan.

In support of an initiative of the WMO and the Global Water Partnership, the drought preparedness planning methodology referred to above has been modified to define a generic process by which governments can develop a natural drought policy and drought preparedness plans at various levels of government that support the principles of that policy. This process has as its goal to provide a template that government or organizations can follow to reduce societal vulnerability to drought through drought policy and preparedness planning. A national drought policy can be a stand-alone policy or it could be a subset of a natural disaster or sustainable development plan or an integrated water resources plan.

2. CONCLUSION

For the most part, responses to drought in all parts of the world have been reactive, representing the crisis management approach. This approach has been ineffective (i.e., assistance poorly targeted to specific impacts or population groups), poorly coordinated, and untimely; more importantly, it has done little to reduce the risks associated with drought. This presentation is intended to set the stage for a new paradigm for drought management—one focused on risk reduction and imbedded within a framework for national drought policy that governments can follow in order to move from crisis to risk-based management. The goal of this new paradigm is to lessen societal vulnerability and, therefore, build resilience to future episodes of drought. Governments at all levels must undertake this task in partnership with stakeholders throughout the process to maximize the effectiveness of the outcomes.

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Wilhite, D.A. 1991. Drought planning: A process for state government. *Water Resources Bulletin* 27(1):29–38.

Wilhite, D.A., M.J. Hayes, and C.L. Knutson. 2005. Drought preparedness planning: Building institutional capacity (Chapter 5). In D.A. Wilhite (ed.), *Drought and Water Crises: Science, Technology, and Management Issues,* CRC Press, Boca Raton, Florida, pp. 93-136.

BMKG's POTENTIAL DROUGHT MONITORING INFORMATION SYSTEM

Andi E Sakya

Indonesian Agency for Meteorology, Climatology, and Geophysics

Abstract Summary: The complexity of atmospheric dynamics in Indonesia as the biggest archipelagic country lay right in topical line often causes anomalies that potentially lead to the increasing incidence of disastrous climate, one of them is drought. Anticipating such an event, BMKG embarked on establishing the so-called Climate Early Warning System (CEWS). The system provides extreme climate early warning information depicted the potential vulnerable drought areas. The information is much needed, particularly in the rice production center provinces. The daily operational activity related to the drought information dissemination is reported. Three types of information is produced and issued, namely Standardized Precipitation Index (SPI), Soil Water Content, and the recently established so-called Drought Early Warning based on the measure consecutive no-rain days.

Keywords: *CEWS, extreme climate, SPI, SCOPI, consecutive no-rain days.*

1. INTRODUCTION

Drought which correlates with the condition of water deficiency is a common phenomenon that takes place nearly every year in many areas of Indonesia, which influences many sectors such as agriculture. The persistence of drought may deteriorate particularly farmers and fisheries, and, in turns, hampering the local economy.

The common understanding of drought usually associates with no rainfall or minimal rainfall, and it therefore may be associated with climatic condition of the region where the influence of atmospheric circulation at surroundings becomes significant factors. Inter-annual climate variability such as El Nino and La Nina in the Pacific Ocean as well as the dipole-mode in the Indian Ocean play a significant role in the formation of water vapor to the growth of potential rain clouds, none-the-less for Indonesia. Together with sea surface temperature (SST) in the Indonesian maritime continent and the activity of Australian and Asian monsoon circulation, it affects significantly to the seasonal onset in many regions.

The Agency for Meteorology Climatology and Geophysics (BMKG) is a governmental agency assigned to disseminate weather, climate – including air quality – and earthquake information. BMKG collects data on weather, climate and earthquakes from more than 200 observation stations nationwide to provide weather, climate, earth quake and tsunami information services to Indonesian government departments, businesses and citizens.

As part of the daily operational activity, BMKG is used to issue rainy and dry seasonal onset quarterly. Monthly rain fall prediction is produced on monthly basis. The amount of rainfall, precipitation and temperature are plotted numerical for a certain region. Their patterns are mapped graphically either locally or regionally. Further, BMKG has also engaged on the so-called Climate Field School (CFS) in collaboration with Ministry of Agriculture and University to facilitate end-users (farmers) understanding the technical figures depicting the local seasonal onset.

Drought is not an un-common phenomenon that takes place nearly every year in many areas of Indonesia, which influences many sectors such as agriculture. Study on drought prediction in Indonesia using satellite rainfall data has been done at BMKG as part of international collaboration . The study recommended to further develop the method for Drought Early Warning Systems (DEWS) as part of daily operational us within the so-called Climatological Early Warning System, however, it suggested a thorough research to determine the bias correction in order to get better rain fall estimates, particularly in the region prone to water shortage.

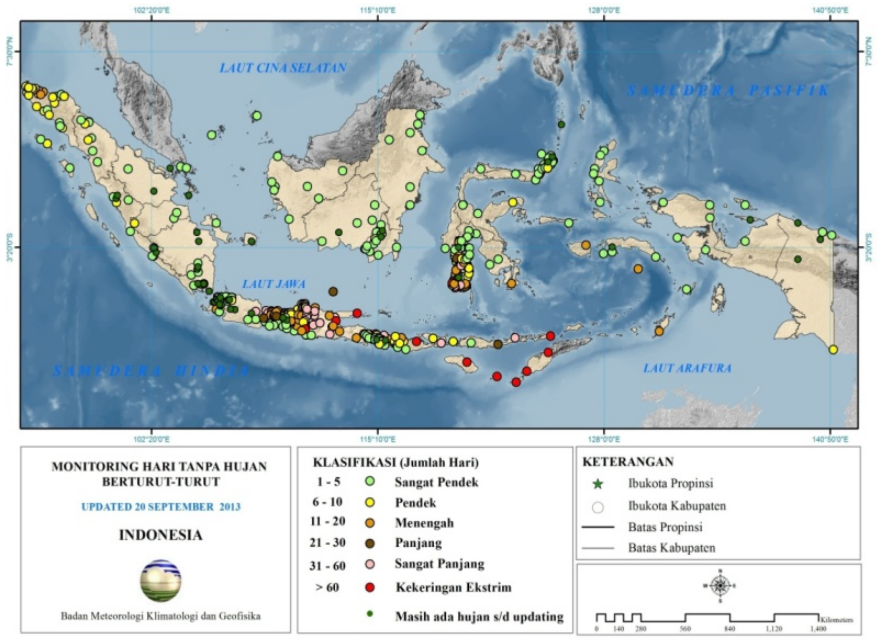

Figure 1. Monitoring of consecutive no-rain days

Other institution had also conducted drought assessment using satellite remote sensing, particularly for Java Island . It recognized that remote-sensing based drought prediction could be made more consistent and timely, if it were complemented with data in the fields (ground through).

Like other NMHs, BMKG issues rain fall prediction based on the observed data through-out nationwide. The data is transformed into percentage-to-normal index and plotted through-out the region all over Indonesia. Standardized Precipitation Index (SPI) is also provided using Seasonal Climate Outlooks for Pacific Island Countries (SCOPIC) software of BoM Australia. The seasonal outlook is used as a tool for defining and monitoring drought. In addition to that, BMKG also disseminates soil water content produced based on the evapotranspiration measured nationwide. The SWC is resulted using Thorntwaite and Mather's method.

For practical purposes, BMKG has established drought early warning on the basis of monitoring the consecutive dry days or consecutive no-rain days, recently. The information seems to be much more useable from the perspective of end-users, because it directly translates the meteorological drought. The dry spell information is updated every ten days. Although, it is still difficult for farmers to apply it directly for purposes such as planting, cultivating, or plowing, the facilitation through CFS may help easier for farmers to understand the potential vulnerable condition.

2. CONCLUSIONS

As the response to anticipating the drought disasters in Indonesia, BMKG began to develop Climate Early Warning System (CEWS) which provides extreme climate early warning information of natural disasters in several vulnerable regions, particularly in province considered as rice production center. Products of CEWS, particularly drought related information, are among others SPI, SWC and Consecutive No-Rain Days (CND).

Session II

DID CLIMATE CHANGE-INDUCED TRENDS CONTRIBUTE TO THE AUSTRALIAN DECADE-LONG MILLENNIUM DROUGHT?

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Abstract Summary: The decade-long millennium drought, spanning the late 1990s to late 2000s is the most severe drought since the instrumental record began. Apart from its devastating impacts, the drought stimulates a large body of research, enabling a better understanding of processes associated with rainfall variability on regional scales, and the relative importance of climate forcing factors in forcing the associated long-term change. This body of research is greatly aided by the unprecedented data resource of global climate models spanning across two model generations. These models are useful in terms of addressing whether climate change plays a role in inducing the rainfall trends. In this vein, the present study examines whether the observed rainfall trend is generated when much of the internal variability is removed, and whether the trend is consistent with the response of the El Niño-Southern Oscillation, the Indian Ocean Dipole, and the Southern Annular Mode (the three-headed dog of the Australian climate), as well as with impact of a poleward shift in the Hadley cell edge.

Keywords: *Climate, drought, variability, change*

1. INTRODUCTION

The Australian decade-long "Millennium drought" broke in the summer of 2010/11. The impact of this "Big Dry" was the most severe in many measures since instrumental records began in the 1900s (Cai et al. 2013). The inflow to Australia's longest river system, on which millions of people depends for water supply, Murray-Darling river system reached an unprecedented 12-month low of 770 GL^{-1} ending in March 2007, less than 7 % of the long-term average. The drought led to critical water shortages across southern and eastern Australia, with unprecedentedly low water levels in many regions with strict water restrictions. Facing the possibility of running out of water, many states opted to build water desalination plants to secure long-term water supply, in addition to significant short-term investment in water tanks and in research on water recycling, reuse, and storm water harvesting. The severity of the drought is also marked by extreme heat events and bushfire risks in southeast Australia, culminated in early 2009. The devastating ''Black Saturday'' bushfire inferno (7 February) occurred after a series of successive heat waves. Over 170 people perished in the bushfire disaster. Fanned by 100 km hr^{-1} winds and aided by the hottest day on record in many locations (Melbourne recorded 46.4^{o}C), a deadly line of bushfires burnt over 400,000 hectares of land, destroyed more than 2000 homes, and caused a loss of tens of thousands of livestock. A crucial question is whether climate change played a role in inducing the rainfall deficit.

2. AUSTRALIA RAINFALL AND MODES OF VARIABILITY, AND THEIR RESPONSE TO CLIMATE CHANGE

Influences on Australian rainfall by modes of climate variability are rather complex, and vary both regionally and seasonally. The pertinent climate modes include the Indian Ocean Dipole (IOD) affecting southern Australia in winter and spring; the Southern Annular Mode (SAM) impacting southern Australia but with an influence in winter opposite to that in spring; and El Niño-Southern Oscillation (ENSO) affecting northern and eastern Australia in most seasons, and southeastern Australia in spring through its coherence with the IOD. Furthermore, the poleward edge of the Southern Hemisphere Hadley cell, which indicates the position of the subtropical dry-zone, has possible implications for recent rainfall changes in autumn, namely due to the observed poleward shift in the cell's southern subtropical edge.

Using observations and simulations from the Coupled Model Intercomparison Project phase 5 (CMIP5), we show that the drought over southern Australia is in part attributable to long-term trends in some of these climate modes, which are described by indices: an upward SAM trend that contributes to the winter rainfall reduction in southwest Western Australia, with most models showing a reduction (Figure 1); an increasing trend of the IOD that may have contributed to the recent high frequency of positive IOD and the recent spring rainfall deficit over southeast Australia; and a poleward expansion of the subtropical dry-zone, largest in austral autumn, potentially affecting mid-to-late autumn rainfall decline over southeast Australia. The mid-to-late autumn rainfall decline is the largest of all seasons.

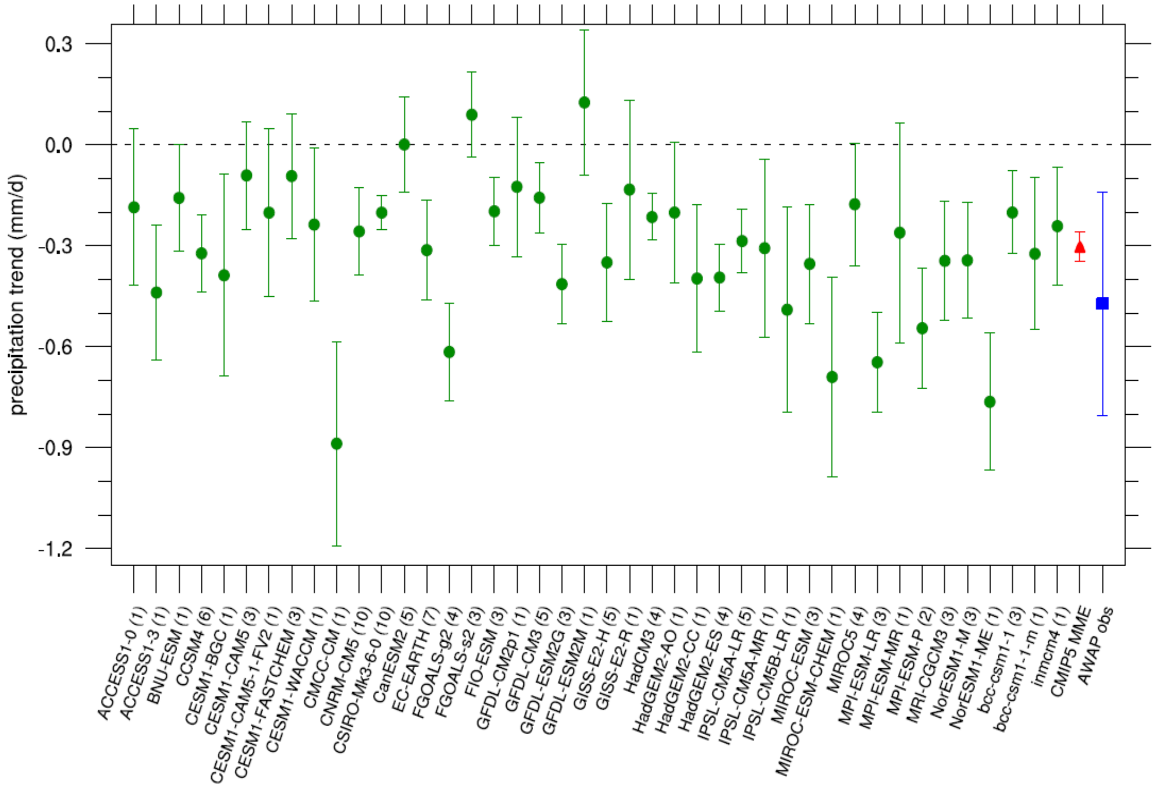

Figure 1. Examples of the observed and multi-model spread in rainfall trends over southwest west Australia (SWWA) in the June, July, August (JJA) season, one in which most annual rainfall is recorded. Where multiple runs for individual models are available, an ensemble average is first calculated. The number of runs for each model is indicated in brackets nex tto the model name. Individual models are shown as green circles, the multi-model ensemble average trends are shown as **red** triangles, and observed trends are shown as **blu**e squares. Error bars show the standard error associated with trends.

3. CONCLUSIONS

We have shown that Australian rainfall reduction during the Millennium drought is linked to the recent behavior of modes of climate variability affecting Australia. Some of the changes in the climate mode indices are, in turn, partially attributable to anthropogenic greenhouse warming and ozone depletion. Thus our results suggest that Australia's Millennium drought period can be at least partly attributed to an underlying human-induced climate change signal.

Acknowledgements:
This work is funded by Goyder Research Institute, and the Australia Climate Change Science Programme.

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WEEKLY TO DECADAL PREDICTABILITY OF NORTHWEST INDIAN OCEAN RIM PRECIPITATION AND IMPLICATIONS FOR SEASONAL DROUGHT FORECASTING

Andrew Hoell[1], Mathew Barlow[2], Chris Funk[1,3], Greg Husak[1], Shrad Skula[1], Amy McNally[1], James Verdin[3]

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Abstract Summary: The northwest Indian Ocean Rim (Fig. 1), which includes Central Asia, East Africa and the Middle East and Arabian Peninsula, is strongly affected by modes of climate variability operating on time scales of weeks to decades (Fig. 2). Substantial progress has been made in understanding the influences of climate modes operating on weekly to interannual time scales associated with the Madden-Julian Oscillation (MJO), the Indian Ocean Dipole (IOD) and El Nino-Southern Oscillation (ENSO) on northwest Indian Ocean Rim precipitation. However, the relationships between northwest Indian Ocean Rim climate and decadal-scale and longer variability associated with the Pacific Decadal Variability (PDV) and the long-term warming (TREND) of tropical Indo-west Pacific sea surface temperatures (SST) are not well understood. Our ability to provide reliable seasonal forecasts over the northwest Indian Ocean Rim hinges on improved understanding of the influences of decadal-scale climate variability and the combined effects of all climate modes.

1. KNOWN CLIMATE MODE IMPACTS

Each of the climate modes operating on weekly (MJO), monthly-to-seasonal (IOD) and interannual (ENSO) time scales modify the atmospheric convection and energy budgets similarly over the Indo-Pacific Ocean. During MJO phases 4-6, negative IOD and La Nina (the negative phase of ENSO), enhanced convection over the Maritime Continent and suppressed convection over the central tropical Pacific force high pressure over Central Asia (e.g. Barlow et al. 2005, Hoell et al. 2013) and enhance subsidence over East Africa by strengthening the Walker Circulation (e.g. Nicholson 1996, Behera et al. 2005). While La Nina oftentimes occurs simultaneously with negative IOD, the MJO phase and magnitude changes weekly and can cause predictable breaks in drought seasons (Hoell et al. 2012).

2. UNCERTAIN CLIMATE MODE IMPACTS

PDV and TREND also modify the atmospheric convection and energy budgets similar to MJO, IOD and ENSO, but on much longer time scales. Recently, noticeable long-term precipitation reductions over the Northwest Indian Ocean Rim have been linked to PDV and TREND. Williams and Funk (2012) showed that warming of the west Pacific Warm Pool associated with the TREND has been linked to diminished precipitation over East Africa. However, Lyon et al. (2013) has attributed the recent precipitation reductions over East Africa to PDV. As a community, it is important that we better understand the individual and synchronous contributions of the TREND and PDV.

3. CLIMATE MODE IMPACTS AND SEASONAL FORECASTS

We provide seasonal rainfall and climate forecasts to the Famine Early Warnings System Network (FEWS NET) to support agro-climatic monitoring over the Northwest Indian Ocean Rim. While Indo-Pacific climate modes operating on weekly to interannual time scales are generally a good indicator of short-term seasonal climate outlooks, improved understanding of decadal-scale variability will allow us to help FEWS NET prepare for climate conditions in the decades to come. This is precisely why our understanding of PDV and TREND, and their synchronous interaction with the MJO, IOD and ENSO are critical.

4. FIGURES

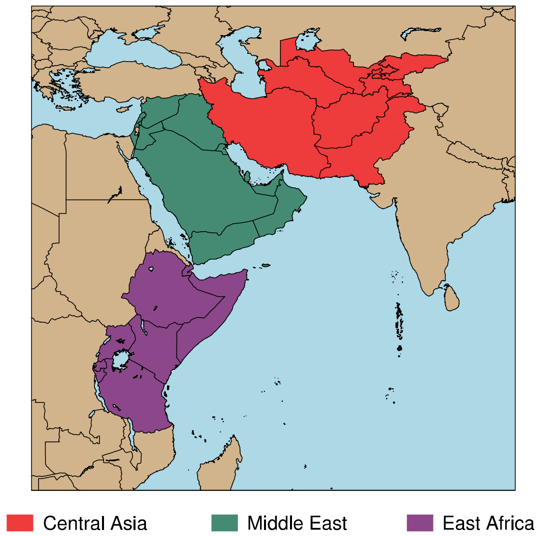

Fig. 1: Regions of the continental Northwest Indian Ocean Rim.

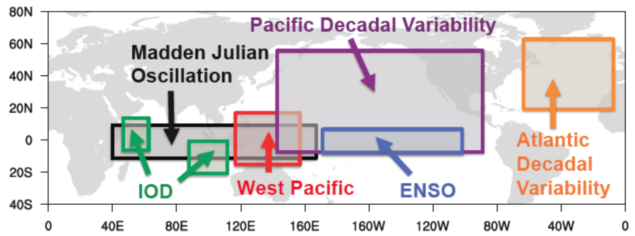

Fig. 2: Modes of climate variability that influence continental Northwest Indian Ocean Rim climate.

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IRI FORECAST SYSTEM AND DROUGHT PREDICTION: PROVIDING CLIMATE INFORMATION AT MULTIPLE TIME-SCALES

N.Vigaud, A.G. Barnston, M. Tippett, P. Ceccato, S. Li, B. Lyon and A.W. Robertson

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Abstract Summary: Climate forecasts at seasonal and sub-seasonal time-scales are potentially crucial ingredients for climate related risks management including drought prediction. A brief update will first be given on the Multi-model Ensemble probability forecast (MME) issued every month by the International Research Institute for Climate and Society (IRI). Amongst the different forecasts produced at IRI, the new Fire Early Warning System (EWS) developed in collaboration with Bogor University for Kapuas district in Kalimantan will then be presented. Under the same collaborative effort, another recent activity that will be discussed is the development of a dynamic crop calendar for managing drought risk in rice-based farming systems of Indonesia. Given the importance of sub-seasonal predictions for regions where seasonal predictability is weak and initial conditions/intra-seasonal oscillations are strong, potentials for sub-seasonal predictability will be examined using sub-monthly GCMs hindcasts for the Asian monsoon region. In the context of drought prediction, this will be illustrated through the skill of precipitation forecasts at sub-monthly time-scales, and the performance of these predictions associated to ENSO variability and the intra-seasonal Madden Julian Oscillation (MJO). The last part of this talk will present recent work done at IRI on East African droughts, in particular evidences of the abrupt decline in East African long rains since 1999 and its link with tropical Pacific SSTs at multi-decadal time-scales will be discussed.

Keywords: *Climate, Forecast, Multi-model ensemble, drought*

1. INTRODUCTION

Seasonal forecasting being most relevant for climate related risk management; it has been a major focus at the International Research Institute for Climate and Society (IRI) since many years. Amongst the different real-time seasonal forecasts made publicly available on the IRI website every month, updates will be given on the IRI Net Assessment forecast product and its tailoring through flexible quantile maps. A drought prediction tool developed over the US-Mexico region using the Standard Precipitation Index (SPI) will also be discussed.

In terms of drought predictions over the South East Asian region, recent works done in collaborations with Bogor Agricultural University will be presented, in particular the development of a Fire Early Warning System in Kapuas, Kalimantan and a dynamic crop calendar for managing drought risks in rice-based farming system in Indonesia.

Seasonal forecasts can allow preparedness to potential climate related disasters but are not sufficient to take further actions as the season advances. Climate information at shorter ranges are thus needed, and in regions of weak seasonal predictability and strong initial conditions/intra-seasonal oscillations, sub-seasonal predictions become very attractive. The potential for predictability at these time-scales will be illustrated through precipitation forecasts from sub-monthly GCMs hindcasts for the Asian monsoon region.

The last part of this presentation will then focus on recent drought prone conditions in East Africa. The severe drought in 2010-2011 was found to be associated with the failure of both short and long rains but the mechanisms at play are yet to be understood. The study hereby presented will examine the evolution of East African long rains since the last ten years and its relationship to large-scale changes in the global oceans.

2. FIRE EARLY WARNING SYSTEM IN KAPUAS, KALIMANTAN

Peatland fires are an increasing problem in Indonesia, where over 80% of Southeast Asia's peatlands are found. The new approach developed with the Center for Climate Risk and Opportunity Management (CCROM) at the Institut Pertanian Bogor (Bogor Agricultural University or IPB) will be discussed here including (i) the production of vulnerability maps based on environmental factors, (ii) the real-time monitoring of local rainfall anomalies from satellite data to estimate risks of fire incidences, and (iii) the development of a predictive tool for fire activity in Kapuas based on seasonal forecasts.

3. DEVELOPMENT OF A DYNAMIC CROP CALENDAR FOR MANAGING DROUGHT RISK

This new initiative developed with Dr Rizaldi Boer and his collaborators at CCROM aims to reduce farmers' vulnerability to climate risk by developing a dynamic crop calendar based on seasonal forecasts. Results will be presented for Java Island where about 50% of the total national rice production are produced. Lowland rice farming uses a double cropping system that is particularly vulnerable to drought at the end of the second planting season, during May-August. This vulnerability is exacerbated if the first season planting in October-December is delayed due to a late onset of the rainy season. In this respect, seasonal forecasts of monsoon onset date (good skill) as well as of May-August rainfall (much less predictable) are relevant, and the dynamic cropping calendar is thus designed to take both sources of forecast information into account.

4. POTENTIALS FOR SUB-MONTHLY PREDICTABILITY

In the context of climate related risk management, there is a real need for bridging the gap between medium-range and seasonal forecasts. But do GCMs have any skill at sub-seasonal time-scales? This will be discussed by identifying sources for sub-monthly predictability and examining their relative contribution to forecast skill. An analysis based on sub-monthly hindcasts from a few GCMs will show that there is a good skill in precipitation for the first week of the forecasts which generally drops dramatically for the following weeks. However, we show evidence of substantial skill out to week-3 over the Maritime Continent during boreal summer, particularly over Borneo, where the MJO and ENSO conspire to increase the predictability.

5. A RECENT DECLINE IN EAST AFRICAN LONG RAINS

The successive failure of East African short (October-December) and long (March-May) rains in 2010-11 led to a severe drought over the region. While poor short rains in 2010 were anticipated given linkage with La Niña prevailing conditions in the Pacific, the long rains do not exhibit such predictability. The results presented here support the idea that failure of the long rains was associated with a recurrent large-scale precipitation pattern following their abrupt decline in 1999. Linkage with large–scale patterns in the global oceans are then investigated, both observations and GCM experiments are suggesting similar abrupt changes in sea surface temperatures (SSTs) predominantly in the tropical Pacific.

6. CONCLUSIONS

Seasonal forecasts issued by IRI for fifteen years are popular ingredients used for climate related risk disaster management by several agencies and it is hoped that their tailoring (such as flexible quantiles for MME forecasts) would even be more relevant to decision makers needs. Over South East Asia, the recent collaborations with IPB led to the development of a predictive tool for fire activity in Kapuas, Kalimantan, allowing to estimate the risk of fire occurrences for the next three months. Through the same collaborative framework, efforts have been gathered to build a dynamic crop calendar based on a seasonal drought EWS, which is intended to provide a baseline for preparing cropping pattern scenarios within local decision processes.

In addition, potentials for sub-monthly predictability over Asian monsoon regions could be very attractive and the results presented here are rather encouraging with GCMs showing some skill beyond the first week of the forecast. With substantial relationships between the performance of these sub-monthly predictions and ENSO variability as well as the intra-seasonal MJO, improvements in the dynamical models could eventually help build more skill at sub-seasonal time-scales based on these large-scale modes of variability.

The study of the 2010-11 East African drought emphasized substantial teleconnections with the tropical Pacific at multi-decadal time-scales, a precious information given that the persistence of SST anomalies in the tropical Pacific would sustain poor long rains performance in East Africa. Such example actually contradicts conclusions from the last IPCC exercise projecting an increase in local rainfall for future scenarios. Instead, our results rather suggest the likelihood of prolonged multi-season drought in particular during La Niña years when the likelihood of drought during short rains is enhanced.

Acknowledgements:
We would like to thank all contributors from IRI and partners institutions, in particular the CCROM at Bogor Agricultural University and the Indonesian Meteorological Service (BKMG). These works have been funded by several sponsors including the US Agency for International Development (USAID) and the National Oceanic and Atmospheric Administration (NOAA) to whom we are very grateful.

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UTILIZATION OF DYNAMIC SEASONAL CLIMATE PREDICTIONS FOR DROUGHT MONITORING AND PREDICTION ACTIVITIES AT NCEP/CPC

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Keywords: drought, monitoring, prediction

1. INTRODUCTION

As part of the CPC operations, we routinely produce the Drought Outlook and participate in the drought monitoring activities over the United States. To support the operational functions, we monitor the drought and water resources. The US Drought Monitor is updated in weekly intervals and the US Monthly and Seasonal Drought Outlooks are issued in monthly intervals. The drought monitoring and prediction activities at CPC are performed in collaboration with the National Weather Service Regional Centers and several universities.

2. DROUGHT MONITORING

The drought monitoring is based on the observations such as the streamflow from the USGS and Standardized Precipitation Indices (SPI) derived from the CPC unified precipitation (P) analysis. We also rely on the North American Land Data Assimilation System (NLDAS) from the NCEP and the University of Washington to obtain information on the soil moisture for agricultural drought and runoff for hydrological drought. The NLDAS outputs depend on forcing and the land surface models used. The NLDAS system includes four land surface models; the NCEP Noah model, NASA/GSFC Mosaic model, Princeton University SAC model and University of Washington (UW) VIC model. The uncertainties of soil moisture (SM) percentiles and runoff indices are mainly due to the uncertainties of P forcing. How to generate accurate P forcing is a challenge for real time operation.

3. DYNAMIC SEASONAL DROUGHT PREDICTION

For dynamic seasonal climate prediction, we rely on the NCEP CFSv2 and the North American multi model ensemble (NMME) system. The NMME system consists of the seasonal forecasts with coupled climate prediction models from NOAA GFDL, Canadian CMC, NCAR and NASA/GFSC in addition to the NCEP CFSv2. More details on the NMME may be found at; http://www.cpc.ncep.noaa.gov/products/ctb/nmme. The 3-month SPI prediction is made with monthly P and surface air temperature (T) forecasts from the CFSv2 and NMME. Also, ensemble streamflow predictions are made using the UW VIC land model and the CFSv2-based VIC.

For the hydroclimate forecasts over the western interior United States, skill on short lead times comes from the persistence of the initial conditions. Therefore, accurate hydrologic states at the initial forecast time are crucial for successful hydroclimate forecasts. How to generate accurate initial conditions and skillful climate P forecasts on seasonal time scales is a challenge to improve drought prediction. Details of the CPC drought monitoring and prediction system will be presented at the 2013 APCC Climate Symposium.

ENSO INDEX AND ITS RELATIONSHIP TO STANDARDIZED PRECIPITATION INDEX (SPI) IN THE MARITIME CONTINENT

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Abstract Summary: El Nino phase affects Indonesian climate. It generally decreases amount of precipitation in and cause meteorological drought over Indonesian maritime continent. In order to monitor meteorological drought in this region, Standardized Precipitation Index (SPI) is employed. Various ENSO indices for Indonesian region have been investigated by analyzing the correlation between 12 ENSO indices and Standardized Precipitation Index (SPI) that is calculated from Global Precipitation Climatology Center (GPCC) monthly precipitation data of 57 years period (1951-2007). ENSO impacts in the region will be more easily seen when the analysis conducted using SPI data compared to precipitation data. Further investigation using Singular Value Decomposition (SVD) analysis between SPI and ENSO Indices shows the higher correlation expansion coefficients between ENSO indices and SPI for Indonesian region are ESPI, ECP-OLRA, CA92 and Nino 3.4. Spatial correlation analysis was made to determine which area that has a significant relationship to ENSO indices.

Keywords: *ENSO, Maritime Continent, SVD, SPI*

1. INTRODUCTION

The phenomenon of El Nino Southern Oscillation (ENSO) or better known as El Nino and La Nina affect every countries in different ways, especially related to its impact on drought and precipitation. ENSO decreases precipitation over Indonesia region, in particular during El Nino phase. Meteorological drought induced by this condition can occurs. The World Meteorological Organization (WMO) recommends that all national meteorological and hydrological services are supposed to use the Standardized Precipitation Index (SPI) method in meteorological drought monitoring. SPI is a way of measuring drought based on the probability of precipitation for any time scale. Many advantages can be obtained by employing this index when compared with other indices, e.g. can be calculated for time scales and different regions, can be used for early warning and drought classification, the calculation is much simpler and its value changes according to the period of data used (McKee et al. 1993)

There are various indices for determining the El Nino Southern Oscillation (ENSO) such as ENSO Precipitation Index (ESPI); Cheliah and Arkin OLRA ENSO Index (CA92); Eastern Central Pacific Outgoing Long wave Radiation Anomaly Index (ECP-OLRA); Sea Surface Temperature Anomaly (SSTA) Nino 1 +2, Nino 3, Nino 4, Niño 3.4; Southern Oscillation Index (SOI); Oceanic Nino Index (ONI), the Japan Meteorological Agency SSTA ENSO Index (JMA-SSTA); Multi-variate ENSO Index (MEI) and Trans Nino Index (TNI). In addition, various ENSO indices for Indonesian region have been investigated by analyzing the correlation between 12 ENSO indices and Standardized Precipitation Index (SPI) calculated from Global Precipitation Climatology Center (GPCC) monthly precipitation data of 57 years period (1951-2007). It is found that SPI is more able to draw the impacts of ENSO events rather than rainfall data (Setiawan. 2011). SPI values averaged over the Maritime Continent (All Maritime Continent SPI) are proposed to be used in various studies concerning ENSO-Monsoon relationship in Indonesia.

Furthermore, figure 1 shows the scatter plot of Nino 3.4 ENSO index. Those figures reveal that the correlation coefficient between Nino 3.4 ENSO index and mean precipitation over the Maritime Continent region (All Maritime Continent Precipitation) is greater than the correlation coefficient between Nino 3.4 ENSO index and 3 monthly SPI averaged over the Maritime Continent region (All Maritime Continent SPI 3). Therefore, ENSO impacts on land will be more easily spotted based on the SPI analysis relative to precipitation data analysis.

In addition, further investigation using Singular Value Decomposition (SVD) analysis between SPI and ENSO Indices shows that the higher correlation expansion coefficients between ENSO indices and SPI for Indonesian region are ESPI, ECP-OLRA, CA92 and Nino 3.4 (Figure 2). In general, ESPI showed its dominance in describing the relationship between ENSO and meteorological drought in Indonesia over various timescale; include short-term, medium, and long-term meteorological drought. Meanwhile, SOI, ONI, JMASST, MEI and TNI have relatively low correlation coefficient value when they are compared with other indices such as CA92, ECP-OLRA, Nino 3.4, Nino 1+2, Nino 3 and Nino 4.

Spatial correlation analysis was made to determine which area that has a significant relationship to ENSO indices e.g. ESPI, CA92 and Nino 3.4. Southern Sumatra, center to eastern part of Java, eastern part of Kalimantan, northern Sulawesi, southern and south eastern Sulawesi, Halmahera, and southern Papua are several regions that have significant relationship between SPI and ENSO.

2. TABLE AND FIGURE

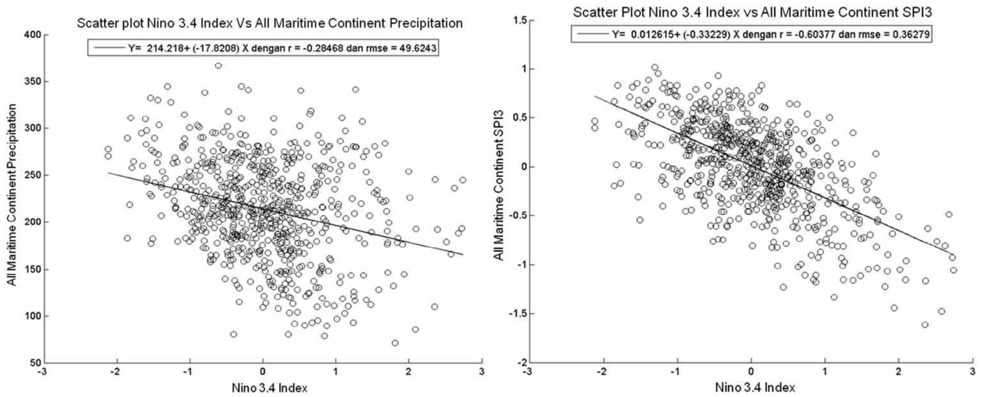

Figure 1. Scatter plot of Nino 3.4 ENSO index with all maritime continent precipitation (left) and 3 monthly Standardized Precipitation Index (SPI) averaged over the Maritime Continent region (All Maritime Continent SPI 3) (right).

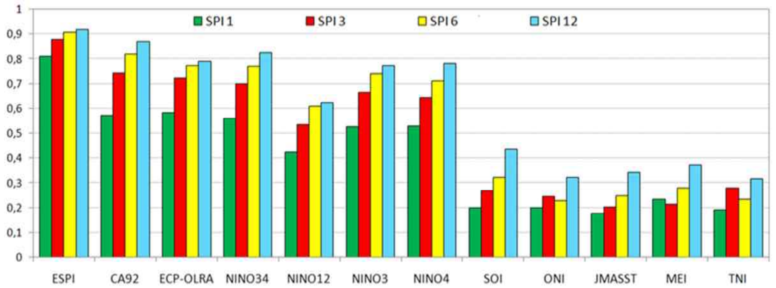

Figure 2. Correlation expansion coefficient from Singular Value Decomposition (SVD) analysis of Standardized Precipitation Index (SPI) over maritime continent with ENSO index

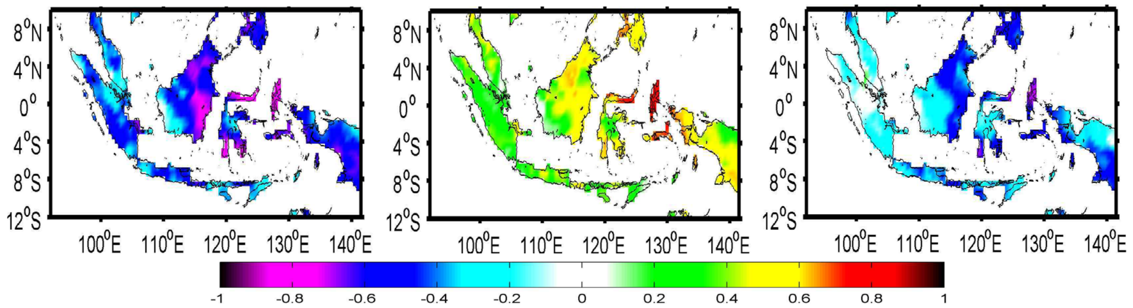

Figure 3. Spatial correlation coefficient 3 monthly SPI with ENSO index (Left), ESPI(Middle) CA92 (Right) Nino 3.4

4. CONCLUSIONS

SPI is more able to draw the impacts of ENSO events than rainfall data. Moreover, examination based on Singular Value Decomposition (SVD) analysis between SPI and ENSO Indices shows that the best reference ENSO indices for Indonesian region are ESPI, ECP-OLRA, CA92 and Nino 3.4.

Acknowledgements:
We thank Dr. Tri Wahyu Hadi (Bandung Institute of Technology – ITB) and all BMKG staffs in Climate Information Division for their contribution and discussion on this writing material.

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CASE STUDY OF 2011/2012 SPRING RAINFALL IN TAIWAN

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Abstract Summary: Drought happens frequently during season in Taiwan (from October to March) and always leads to a condition of water shortage. How to allocate limited water is a big challenge and how to predict and monitor drought has become a critical issue. In this study, characteristics of spring rainfall in Taiwan between 2011 (a drought year) and 2012 (a normal year) are compared. In 2011, the number of front observed to pass through northern Taiwan is rare, which may be associated with northeasterly anomaly and lesser moisture in lower atmosphere around Taiwan. However, the total numbers of spring time fronts in 2011 and 2012 are similar over East Asia. These results imply that the number and the frontal track may become potential indices for drought monitoring. Further investigation is required to understand the relationship between the frontal activity and large scale circulation over East Asia.

Keywords: *Spring rainfall, ENSO, Frontal System*

1. INTRODUCTION

The rainfall from February to April is generally called spring rainfall in Taiwan, which is more pronounced in northern Taiwan (Hung et al. 2004). High correlation is found between spring rainfall of northern Taiwan and ENSO (Jiang et al. 2003). Meanwhile, the fluctuation of spring rainfall of northern Taiwan is also coherent to the revolution of Pacific Decadal Oscillation (PDO; Hung et al. 2004). The frontal systems bringing spring rainfall to northern Taiwan are more active in a large-scale cyclonic environment characterized by an enhanced anti-cyclonic circulation in the Philippine Sea. The weakening of this large-scale circulation pattern will lead to less frontal activity and therefore less spring rainfall in northern Taiwan (Jiang et al. 2003; Hung et al. 2004).

Although cold episodes are found in both winters of 2010/2011 and 2011/2012, the following spring rainfall are quite different in Taiwan. Drought happened in spring of 2011 but above normal spring rainfall is observed in 2012. In this study, the association between ENSO and spring rainfall in Taiwan will be investigated. On the other hand, a case study will be made by analysing the difference between 2011 and 2012 on large-scale circulation and frontal activity around Taiwan during spring time.

2. DISCUSSION AND CONCLUTION

The averaged total rainfall amount is about 2500mm in Taiwan. The spring rainfall contributes almost 25% to annual rainfall in northern Taiwan. Higher coherence is found in between the spring rainfall of northern Taiwan and the SST of Nino3.4 of previous winter. Above normal precipitation are expected for warm episodes. However, the spring rainfall variation is not consistent for cold episodes. The cases of 2011 and 2012 are the example.

Table 1 shows the difference of frontal activity between 2011 and 2012. Spring of 2011 is a drought event in Taiwan. The number of front is ten and the duration of affecting Taiwan is about 1.5day. On the other hand, in spring of 2012, the number of front is seventeen and the frontal system stayed longer over Taiwan. The differences in front number and affecting time led to below normal spring rainfall in 2011 and above normal spring rainfall in 2012. Note that the total numbers of frontal system over East Asia of both years are similar (table not show).

Figure 1 shows the spring time large-scale circulation anomaly of lower troposphere in 2011 and 2012. Anticyclonic anomaly is found around Taiwan in 2011. Moisture transport from tropics to Taiwan area was suppressed by the Anticyclonic anomaly circulation, resulting in a dry area around Taiwan. On the other hand, in 2012, southwestly wind anomaly was found over South China Sea, helping to transfer moisture from tropics to Taiwan and causing above normal spring rainfall in Taiwan. Although further investigation is required to understand the relationship between the frontal activity and large scale circulation over East Asia, these results imply that the number and the frontal track may have the potential to be conducted into indices for drought monitoring.

TABLE AND FIGURE

Table 1. The duration and the number of frontal system over Taiwan

	2011	2012	2012/2011
Day of Frontal system	15	32	2.133
Number of Frontal system	10	17	1.07
Duration	1.5	1.9	1.25

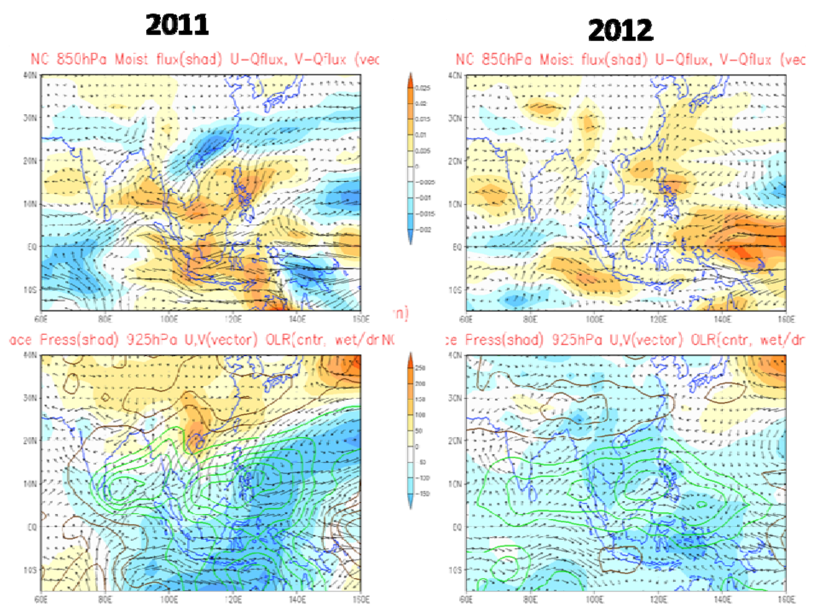

Figure 1 Anomaly circulation. Left and upper: 2011 850hPa moisture flux(shaded)、uQand vQ(vector); Left and lower: 2011 925hPa pressure(shaded)、Wind(vector)、OLR(contour); right and upper: 2012 850hPa moisture flux(shaded)、uQand vQ(vector); Right and lower: 2012 925hPa pressure(shaded)、Wind(vector)、OLR(contour)

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AN ASSESSMENT OF FUTURE DRYNESS OVER KOREA BASED ON THE REGIONAL CLIMATE PROJECTION UNDER A1B EMISSION SCENARIO

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Abstract Summary: We present an analysis of future dryness over Korea based on the downscaled temperature and precipitation projection under A1B emission scenario. For fine-scale climate information, the ECHAM5/MPI-OM simulation has been dynamically downscaled using the RegCM3 double-nested system. A 130-year long-term climatology (1971-2100) from the mother domain (East Asia: 60km) and nested domain (South Korea: 20km) is discussed. Based on the intercomparison with CMIP3 participant models, the ECHAM5/MPI-OM provides the climatic change information over the East Asia that is not markedly different from other projections. The downscaled results generally follow the behavior of ECHAM5/MPI-OM, but substantial fine-scale details are found in spatial pattern and the change signals become more enhanced at the local scale. In the future projection, the significant warming is found regardless of the season and region while the change in precipitation shows a mixed feature with the increasing or decreasing pattern. The increase of temperature enhances the evapotranspiration, and hence the actual water stress becomes more pronounced in the warmer climate. This is related to the negative trends of the self-calibrating Palmer Drought Severity Index (PDSI) to measure drought condition in Korea. Although PDSI is overall associated with the precipitation variation, its long-term trend tends to be modulated by the temperature trend. It is confirmed that the detrended temperature is shown to mask the decreasing tendency of the PDSI. The result indicates that without an increase in precipitation appropriate for atmospheric moisture demand, future dryness is a more likely condition under global warming.

Keywords: *Future dryness, global warming, dynamical downscaling*

1. INTRODUCTION

There is a growing agreement of the broad increase of precipitation over East Asia under global warming based on climate change projections with global climate models (GCMs; IPCC, 2007). Kim and Byun (2009) pointed out using 15 GCMs ensemble that increases in the mean and variability of precipitation are expected under the warming scenario over North and East Asia, and that precipitation changes are directly translated into weakening of drought. However, large quantitative differences among the models remain, and substantial discrepancies arise at the regional scale. Although the GCMs provide the foundation for future climate projections with improved confidence (IPCC, 2007), precipitation projections at the local or regional levels could lead to fairly different interpretations of the results due to large spatial and temporal deviations, which makes it difficult to arrive at any general conclusions.

The Korean peninsula appears to be a particularly representative region that can reveal the limitation of the GCM simulations due to complex geographical features. Therefore, we have developed a one-way double-nested regional climate model system to simulate climate information with a suitably fine-scale for reflecting the local climate characteristics over Korea. Using this modeling system, we perform a dynamical downscaling of the ECHAM5/MPI-OM climate model under the SRES A1B emission forcing covering the period of 1971-2100 (Im et al., 2011). As for the effective indication of water imbalance in atmospheric moisture supply and demand at the surface, we compute the self calibrating Palmer Drought Severity Index (PDSI) (Wells et al., 2004). The self-calibrating PDSI is the modified PDSI to account for the expected variability of precipitation between locations by automatically adjusting the climatic characteristic and calculating the duration factors based on the characteristics of the climate at a given location. As a result, the index performs more consistently and allows for more accurate comparisons of the index at different locations. Since the PDSI incorporates both precipitation and temperature in contrast to many other drought indices that are based on precipitation alone, it is advantageous in quantifying the direct attribution of dryness change to increased emission forcing. To assess the influence of the increasing temperature trend on drought intensity and trend, two sets of PDSI are calculated using different inputs: (1) the projected precipitation and temperature, and (2) the same as precipitation but detrended temperature. By such a comparison, we can enhance our understanding of the relative contribution and role of increasing temperature to future dryness under global warming.

2. RESULTS

According to the projection for the twenty-first century, the degree of warming is sharply accelerated, indicating a well-defined increasing trend. The temperature is projected to increase continuously up to 4^{o}C at the end of the twenty-first century. The projected change of precipitation is different, however. When viewed in the context of the whole twenty-first century, it is difficult to find any readily apparent trends in the precipitation evolution. However, since the trend depends on the selected period, for certain periods (e.g., 2021-2040) there is a visibly increasing trend while a deceasing pattern is discernible after the 2050s. This implies that projections derived for a short future period could produce erroneous interpretation of the results because the projected change could be skewed by unrecognized forced variability.

Changes in temperature and precipitation characteristics are attributed to the moisture budget. The increase or decrease of precipitation can be the root cause of moisture surplus or deficit in the atmosphere, and the increase of temperature can also control the atmospheric moisture demand through evapotranspiration. Using the monthly temperature and precipitation data, we calculate the PDSI for the whole integration period (130-year) in order to measure the evolution of drought conditions. Figure 1 describes the monthly PDSI averaged over 57 stations in Korea, and their trends derived from the observation (only recent 30-year period) and simulation (Reference: 1971-2000 and Future: 2001-2100). To demonstrate the effect of increasing temperature on the PDSI change quantitatively, we calculate the PDSI using the detrended temperature time-series (Fig. 1b). Although PDSI is overall associated with the precipitation variation, its long-term trend tends to be modulated by the temperature trend. It is confirmed that the detrended temperature has masked the tendency for the decreasing of the PDSI. The result indicates that without an increase in precipitation appropriate for atmospheric moisture demand, future dryness is a more favorable condition under global warming.

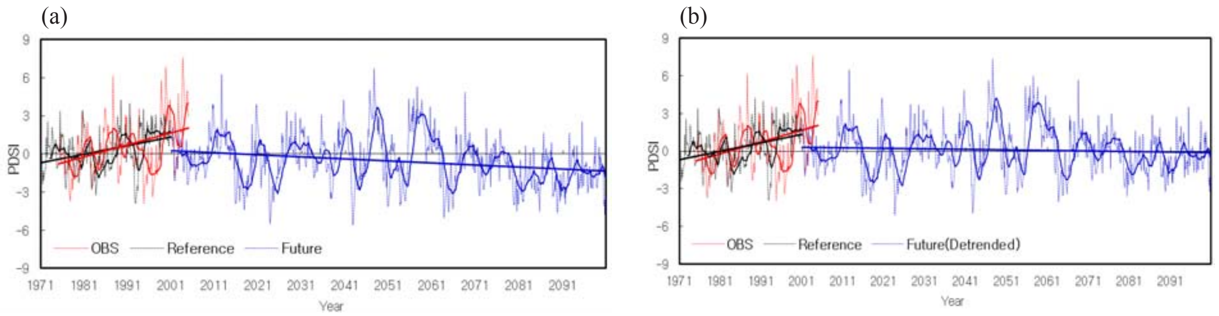

Figure 1. Time-series of the PDSI (dotted line), 25-month moving average (thick line), and its trend (thick linear line) derived from the observation (red color), reference simulation (black color), and future simulation (blue color) with original (a) and detrended (b) temperatures. Here, the time-series of the PDSI derived from the observation and reference simulation are the same as those in (a) and (b).

4. SUMMARY AND DISCUSSION

The changes in temperature and precipitation alter the budget of soil moisture, which in turn modifies future dryness. During the reference period, both the observed and simulated PDSI patterns show overall increasing trends with statistical significance at the 95% confidence level. However, the relevant decline of the PDSI is visible in the future projection, which is attributed to the combined effect of precipitation and temperature. Even though the changes in total precipitation do not show any relevant trend over the entire period, it is evident that the precipitation amount as well as the variability are reduced after the 2050s. Next, the much faster future increasing rate of temperature is more responsible for the PDSI decreasing trend compared to the reference period. The relationship between global warming and the PDSI is actually complicated and nonlinear, but one plausible explanation is related to the effect of the temperature trend in modulating the climatic long-term trend of the PDSI. Such an effect is supported by the fact that the downward trend of the PDSI mostly disappears when the detrended temperature is used to calculate the PDSI.

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Session III

Drought Monitoring and Information Systems:
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Neil Plummer

Drought Monitoring in New Zealand
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Drought Monitoring in the Pacific Islands:
The COSPPac Project
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The New BMKG Climate Change Information System to
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DROUGHT MONITORING AND INFORMATION SYSTEMS: THE AUSTRALIAN EXPERIENCE

Lynette Bettio, Neil Plummer, Mohammed Bari and David Jones

Australian Bureau of Meteorology

Abstract Summary: Drought management has recently shifted even further in Australia to focus on supporting preparedness and reducing and managing risks to land managers. To this end, information and forecasts become key supports for decision making. The Australian Bureau of Meteorology is currently expanding its drought service in close consultation with user communities and is looking to provide a seamless service across meteorological, agricultural and hydrological drought, which looks to the past, analyses the present and forecasts the future.

1. INTRODUCTION

Drought is a natural feature of Australia's climate, exacerbated by the location of Australia in the subtropics on the western edge of the Pacific Walker Circulation.

The most recent multi-year drought episode, was one of the most severe in Australian recorded history (Timbal et al. 2010). Recent work has examined the nature of drought in Australia and how this may change in the future (Hennessy et al. 2008; Mpelasoka et al. 2008), highlighting that drought risk is likely to increase under global warming, and be exacerbated by increased water demand and higher temperatures.

It is now considered that the most appropriate response to drought in Australia is one that recognises drought as an unavoidable and natural feature of our climate. The focus for drought response is then one of preparedness and risk reduction, rather than treating drought as a "natural disaster" or something that can be simply countered or avoided (PISC 2013).

2. RECENT DROUGHT MONITORING

Bureau data and associated environmental intelligence play a key role in the detection, monitoring and prediction of drought, and supporting decision making to reduce drought impacts. The preference for a risk based approached for drought is evidenced by recent changes in Australian Drought Policy. Historically, the Bureau's drought service has focussed on identifying climatologically significant deficits in rainfall over extended periods by placing current rainfall in a historical context using percentile (decile) analysis (Gibbs and Maher, 1967). For example, Figure 1 illustrates the rainfall deciles for southern Australia growing season during the most recent severe drought period. However, major improvements have been made to the drought service through improved data processing, spatial analysis and visualisation, while improved seasonal climate forecasts and streamflow predictions offer new service opportunities. The Bureau's growing water information services are also providing the organisation with greater capabilities.

3. CLIMATE CHANGE AND DROUGHT IN AUSTRALIA

Climate change presents further unique challenges to the preparedness model for drought in Australia, making precise estimates of risk problematic as the past is no longer a guide for the future. An example of the role of climate change on drought is the increasing cool season aridity in southern Australia, where autumn/early winter rainfall deficiencies have become a nearly annual occurrence since the mid-1990s (Hope 2010). The study by Hennessy et al. (2008) shows that under a mid-range climate change projection scenario the frequency of exceptionally dry years can be expected to approximately double in southeast Australia and more than triple in southwest Western Australia for the coming 30-years compared to the previous century as a whole.

3. FUTURE PLANS

Recent consultations undertaken by the Bureau have highlighted services that stakeholders would like to see provided by the Bureau to support drought preparedness. These include provision of a wider range of indices including Standardised Precipitation Index (SPI) and Palmer Drought Severity Index (PDSI), widely used internationally, and indices that have more direct application to different types of drought such as indices of soil moisture for agricultural drought. Also highlighted was the need to integrate seasonal forecasting into drought monitoring and so providing guidance about the evolution of future conditions.

4. CONCLUDING REMARKS

In this presentation we will describe the Bureau's current drought service, its use in the Australian context, and lessons learnt. Plans for service improvement will be outlined, particularly in the context of developing a fully integrated drought information service in support of drought risk management and improved drought preparedness.

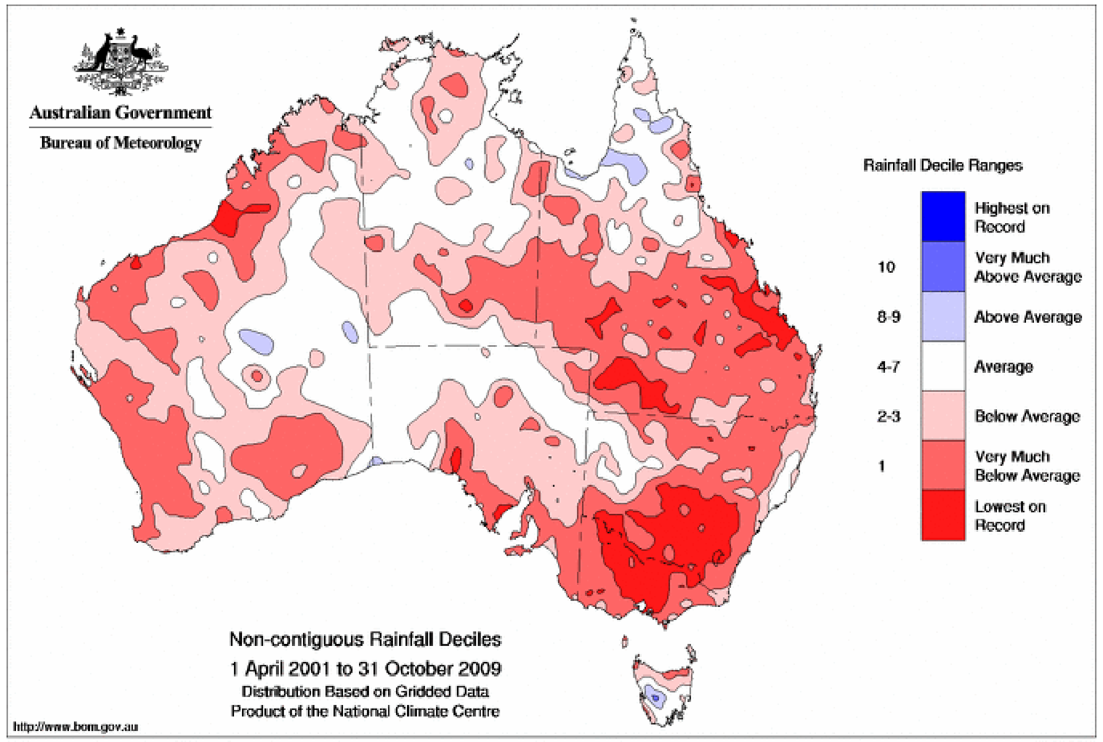

Figure 1. Southern Australia growing season (April to October) deciles for the severe drought period 2001 to 2009.

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DROUGHT MONITORING IN NEW ZEALAND

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National Institute of Water and Atmospheric Research Ltd (NIWA), New Zealand

Abstract: New Zealand regularly experiences drought conditions. Although such droughts are not of the severity or length as in some countries, they seriously affect the agricultural output upon which New Zealand's economy depends. Dry conditions during the 2012−13 agricultural season were unusually widespread across New Zealand, and particularly serious in the North Island. This event, along with the possibility that climate change could make such events more frequent in future decades, has stimulated NIWA's drought monitoring and research.

Keywords: *Climate, Agriculture, Evapotranspiration deficit, Spatial analysis*

1. INTRODUCTION

During the 2012-2013 growing season, New Zealand experienced one of the country's most widespread droughts on record. The New Zealand Treasury has estimated the drought cost the New Zealand economy up to NZ$2 billion, with the greatest impacts falling on the sheep and beef sector, but even some town water supplies were under threat. Government response to drought is coordinated through the Ministry for Primary Industries (MPI), which convenes a National Adverse Events Committee to advise on the severity of natural hazards, and which can initiate rural assistance payments and other measures. NIWA's network of monitoring sites, and near real-time analysis of rainfall and soil moisture conditions, allowed us to keep the MPI Committee up to date on the widespread nature of the drought as it intensified over the early months of 2013.

2. DISCUSSION

A key tool in NIWA's analysis is its "Virtual Climate Station Network" (VCSN), comprising interpolation of daily observations of a large number of weather variables on to a 5km grid across the country (e.g., Tait and Woods, 2009). Daily maps of estimated soil water content are the most widely-used product to enable visualisation of current dry conditions (http://www.niwa.co.nz/climate/daily-climate-maps). Other derived products have their uses too, such as potential evapotranspiration deficit (PED) accumulated over the growing season. This measure, updated regularly during the 2013 drought, allowed NIWA to advise MPI on how the 2013 event compared in severity and spatial extent to previous historical droughts at the same time of year. Such quantitative and independent information provided strong support for recommendations of Government financial relief.

In February 2013, MPI commissioned NIWA to provide a regular update on the extremely dry conditions affecting a large part of the North Island of New Zealand, including putting the 2012-13 drought into the longer-term historical context. The assessment was made using meteorological characteristics of the drought — principally based on estimates of soil water content during the dry period. A single-layer water balance model was used to calculate accumulated potential evapotranspiration deficit (PED), as a measure or index of drought, to compare the intensity and duration of the present drought with historically similar events. PED, derived from estimates of both the use of water by plants and the loss of water from the pasture environment, and measured in mm, can be thought of as the amount of water needed to be added as irrigation, in order to keep pastures growing at optimum levels.

The PED calculations were applied to selected long-period station observations, extending back as far as the early 1940s, and also to the 5km gridded VCSN record. PED was accumulated over the 'growing season', which we define as starting in July (mid-winter). Fig. 1, adapted from Porteous and Mullan (2013), shows the 2012–13 PED ranked against all previous 40 years in the VCSN period. For over one-third of the North Island, and a large part of the South Island west coast, the 2012–13 drought was the worst in 41 years (i.e., rank 1). The longer-record station calculations indicate an event of similar severity occurred in the 1945−46 season.

3. CONCLUSIONS

There are significant research challenges in forecasting extreme events such as the 2013 drought. New Zealand frequently experiences droughts in eastern parts of the country under the stronger than normal westerly airflows that occur during El Niño events. However, the 2013 drought coincided with very persistent blocking highs in the Tasman Sea under ENSO-neutral conditions. NIWA produces rolling three-month climate outlooks which describe the spatial pattern in anomalies in temperature, precipitation, soil moisture and river flow (http://www.niwa.co.nz/climate/sco). These outlooks are probabilistic in nature, and it is rare to forecast high probabilities of the extreme terciles.

Nevertheless, forecasts of soil moisture, in particular, benefit from a good knowledge of initial soil moisture conditions. Automated products are being developed to provide up-to-date maps and graphs of several indicators of drought: monthly and seasonal rainfall deciles, standardised precipitation index, soil moisture deficit, and potential evapotranspiration deficit. These products will all be viewable via the internet. A web-based tool will allow more direct communication with farmers, who can zoom in on their property, and view the calculated soil water balance plots at the nearest grid-point to their location.

4. FIGURE

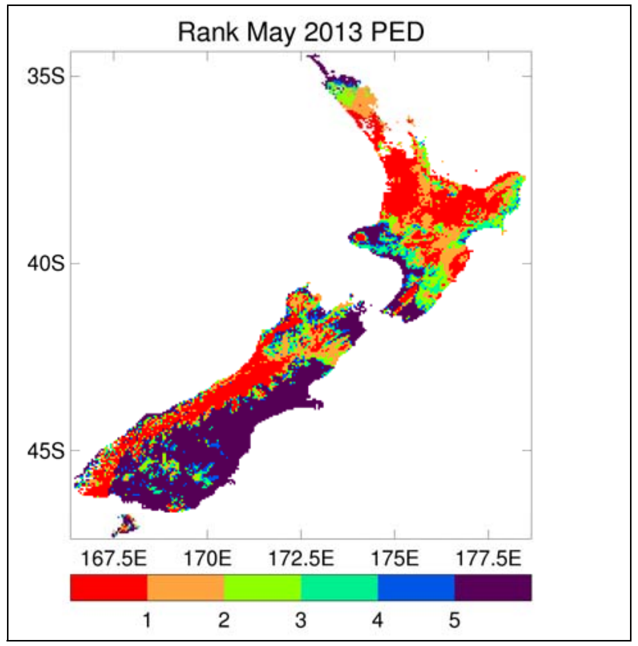

Figure 1. Ranking of July 2012-May 2013 accumulated potential evapotranspiration deficit (PED), relative to the previous 40 years in NIWA's 5km gridded climate data set. Rank = 1 or 2 (red and orange, respectively, in colour version) represents the largest or 2nd largest deficit in 41 years, and dominate the northern half of the North Island, and the west of the South Island. [Adapted from Porteous and Mullan, 2013].

Acknowledgements:
We thank the New Zealand Ministry for Primary Industries for funding the 2012-13 drought study. The underpinning methodological and dataset development has been supported by NIWA as part of its Government-funded, core research conducted through the National Climate Centre.

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DROUGHT MONITORING IN THE PACIFIC ISLANDS: THE COSPPAC PROJECT

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Abstract Summary: Due to their size and geographical location, many South Pacific Island countries have highly variable climates, experiencing distinct wet and dry seasons. Year-to-year variability is largely due to ENSO. The combined effects of climate variability and climate change may make these countries more vulnerable to climatic extremes such as drought. The Climate and Oceans Support Program in the Pacific (COSPPac) is a four-year climate services capacity building program, assisting fourteen partner Pacific Island Countries through the Australian Agency for International Development (AusAID) funding. Administered by the Australian Bureau of Meteorology (Bureau), COSPPac is a program focussed on benefiting Pacific communities through improved climate services. One such service, drought impact reduction, is discussed here.

1. APPLYING CLIMATE DECISION TOOLS IN THE PACIFIC ISLANDS

SCOPIC (Seasonal Climate Outlooks in Pacific Island Countries) is the main tool used to produce climate outlooks for the Pacific Islands (see Figure 1 for countries involved in the project). SCOPIC is a PC program which provides an easy-to-use statistical forecasting scheme, similar to that formerly used by the Bureau; it also includes a drought analysis module. Since its development in 2004, SCOPIC has been improved and extended in close collaboration with users. To diagnose drought, SCOPIC provides the Standardised Precipitation Index (SPI) or the decile method used at the Bureau (Gibbs and Maher, 1967) over varying climatically appropriate periods (see Figure 2 for an example of the SCOPIC drought analysis tool). Location-based results form the basis of drought warnings. Other diagnostic features such as ranking by the drought peak or duration are also available.

The next generation of SCOPIC, developed within the Climate and Ocean Monitoring and Prediction (COMP) component of COSPPac, will feature an enhanced drought module in which recovery rainfall totals are calculated. For example, how much rain is needed to raise the 12-month total from the 8th to the 40th percentile during the next three months? In addition, it will provide reverse scenarios for a worsening water shortage.

Recently COSPPac has worked with Fiji and Kiribati to develop customized drought services. In both countries, drought response plans are currently being refined in collaboration with local stakeholders. Drought thresholds are being determined based on rainfall levels and periods which affect the agricultural or hydrological sectors respectively. For example the drought threshold for household water-tanks will be different from one geared to a sugar-cane crop.

SCOPIC's drought module will assess current conditions against these defined thresholds. This assessment will be used in conjunction with the national drought response plans, which are likely to contain suggested guidelines for action at each drought level.

2. CONCLUDING REMARKS

Pacific Island countries face many climatic pressures, such as drought. In the Pacific many National Meteorological Services (NMSs), via their climate services section, produce a seasonal outlook which contains information about rainfall deficiencies. The COSPPac program utilising the SCOPIC drought module provides a scientific capability to these countries to produce forecasts of seasonal conditions and warn of approaching drought. The drought module in SCOPIC has generated significant interest as a tool for use by the NMSs to support national drought response plans and future collaboration may extend to this.

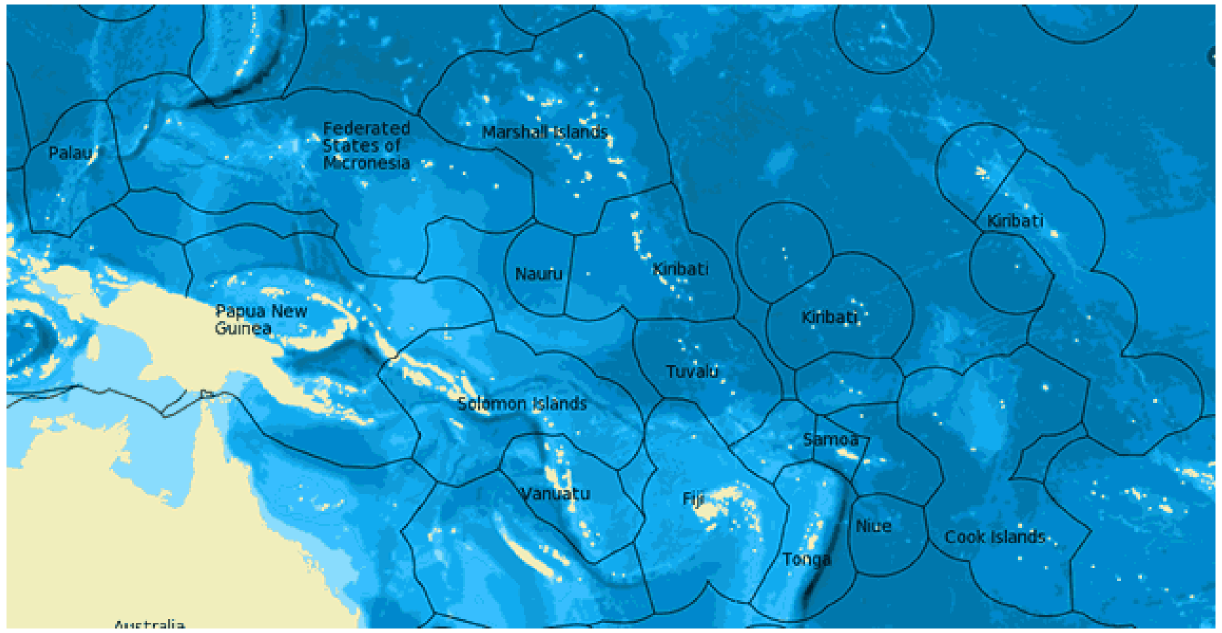

Figure 1. Countries involved in the COSPPac project.

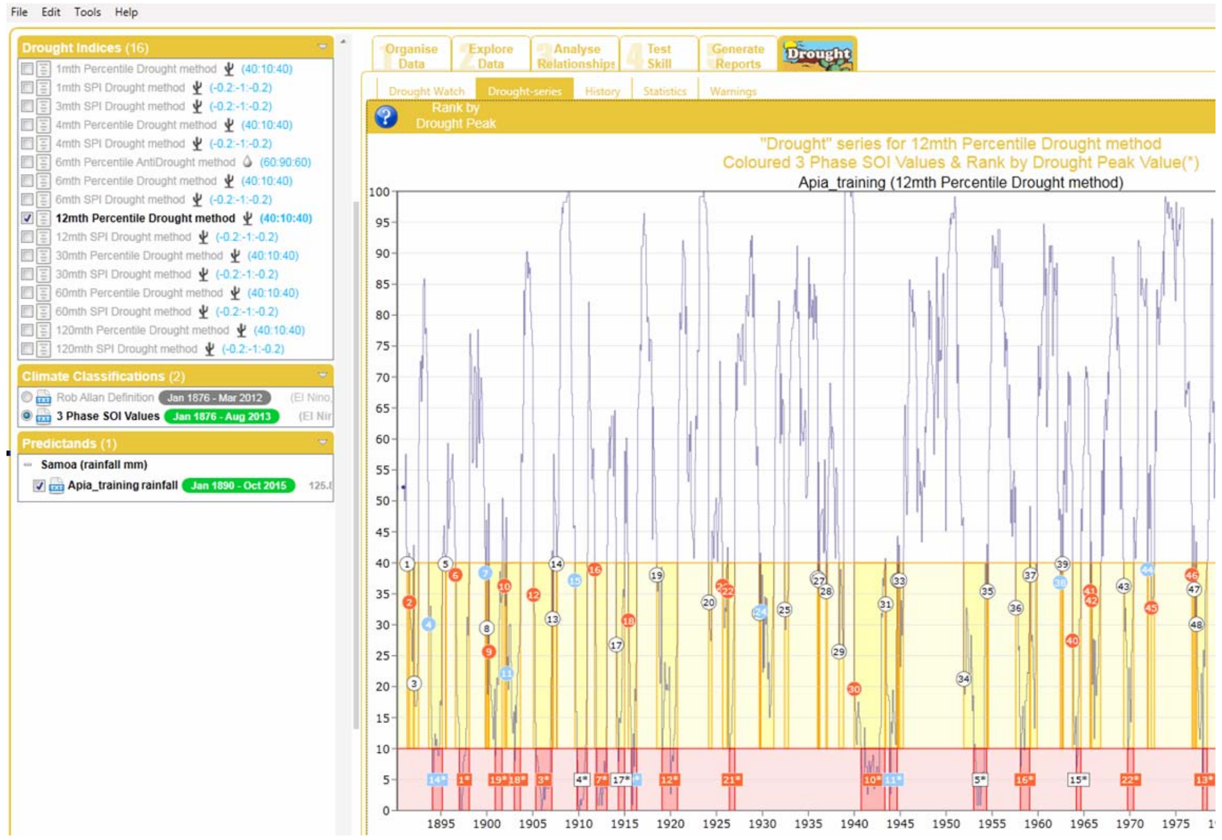

Figure 2. Example of SCOPIC drought analysis tool. A timeseries of the 12 month percentile method, one of a number of averaging periods to choose from, is displayed. The orange highlighting the 40th percentile and below and the red highlighting the 10th percentile and below. (The data displayed here was created for illustrative purposes.)

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THE NEW BMKG CLIMATE CHANGE INFORMATION SYSTEM TO ADDRESS CROSS-SECTORAL DROUGHT INFORMATION NEEDS

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Abstract Summary: Drought is always triggered by climate stimuli, consequently climate information is essential for drought management. The abstract describes the BMKG Climate Change Information System (CCIS) as a versatile tool to disseminate to other sectors in a user friendly way. The CCIS features a detailed user and climate product management to address individual user demands and information access rights. The climate products are compiled from user needs assessments and the Expert Team on Climate Risk and Sector-specific Indices (ET CRSCI). It is expected that the BMKG CCIS will cover an essential part of the demand of climate information for drought management.

1. INTRODUCTION

All types of drought (meteorological, hydrological, and agricultural) are driven by climatologic stimuli. Therefore, appropriate climate information is essential for drought planning and management. Furthermore, droughts have impacts on many sectors, for example food security, urban and rural water supply, energy and others. Drought pattern changes are one of the central climatic phenomena which climate changewill impose: Climate change is expected to increase the amount of land at risk from drought (Teixera et al, 2013). Furthermore, recent research finds that dry (and wet) anomalies will be greater in El Nino years (Power et al, 2013).

The national weather service BMKG is by law the sole climate information provider in Indonesia. Therefore it is mandatory for it to provide effective instruments for user oriented climate information dissemination. To address this BMKG and GIZ togetherdevelopsthe Climate Change Information System (CCIS) as the central web based climate information disseminationplatform. The CCIS predominantly addresses the public administration as the primary user.

2. APPROACH

The dissemination of climate information for cross sector drought management should follow a number of criteria to be effective: The most relevant is to bridge the gap between scientific useful climate information and technical usable climate information (Lemos et al, 2012). Different users have different needs and skill levels which need to be addressed appropriately. Furthermore legal and institutional constrains have to be considered for data and information dissemination. The following considerations have been taken into account for the CCIS development:

- The technical information portal alone cannot fully comply with the information needs, a technical debate between the information provider and the user is essential to create useful and useable information. Focal Group Discussions (FGD) with sector representative have been initiated by BMKG to ensure user orientation and trigger the needed technical discourse. The portal encloses comment functions which can supplement those discussions.
- The web portal has an extensive user and information product management. The operator is able to finely adjust the information access rights. This serves two purposes:
    - o BMKG as the information provider is able to control which user has access to which information.
    - o The users are not flooded with undesired information. The user can choose the information he needs and define pre-sets (agreement needed) in his personal dashboard e.g. the sectoral or spatial sub sets (e. g. province).
- The climate information for drought management can be featured with interpretation to assist the user evaluating the information in their individual sectoral context.

These features are intended to narrow the usability gap between the science based information provider BMKG and the sectoral users.

With regard to cross sectoral drought management, a wealth of actors and sectors are faced with the challenges of planning, managing and tracking droughts. Contexts and needs can diverge, yet they are also interlinked by the resource scarcities that droughts cause. Paying due consideration to these characteristics, the CCIS grants users a set of options for accessing, a variety of established climate indicators that are directly or indirectly related to drought.They are based on the results of the sectoral FGD and on the recommendations of the Expert Teamon Climate risk and Sector-specific Indices (ET CRSCI) of the WMO-Commission for Climatology (CCI) (Alexander et al, 2013). Users thus have means at their disposal to contextualize and tailor drought-related climate information compiled from weather station data to their needs, depending on their sectoral background or area of expertise.

3. DISCUSSION

The above mentioned sectoral focus group discussions between BMKG and the sector representatives had two major outcomes:

1. Drought is relevant across the sectors and additional information is urgently needed. Particularly for the public authority's unique official climate information for drought management is important.
2. The information covera large temporal window from short term weather forecast over seasonal prediction up to long term scenarios and climate averages. In short: seamless climate service would be desirable goal.

The CCIS will be able to serve a relevant part of this seamless climate service but only together with other climate services such as the BMKG Climate Early Warning System (CEWS) and the Meteorological Early Warning System (MEWS) to address the full spectrum of drought information needed. It will be relevant for the success for each of these systems to clearly communicate the different tasks of them to the users.

The user and information product management has been a result of a needs assessment of the users and the suppliers service mandate. Lessons learned from other information portals such as www.ci-grasp.org (version 1 and 2) have been taken into account (e.g. Wrobelet al, 2013). Nevertheless only the empirical acceptance test by the user under the regular working conditions will prove the usability evidence.

The content of the CCIS, compiled based on the FGD results combined with international recommended "good practice" by the ET CRSCI provides a unique climate stimuli information. This one stop cross sectoral drought information source supports the cross sector drought management by releasing official authorised and classified information which is in compliance with WMO good practices and user requests.

4. CONCLUSION AND OUTLOOK

The BMKG Climate Change Information System (CCIS) addresses the climate information needs of public authorities regarding essential climate information for drought management. Active assessment and involvement of users ensures scientifically sound and tailor made sectorial climate information on drought phenomena. It is expected, that the BMKG CCIS will substantially increase the demand for further climate information products for drought management. As a one-stop cross sectoral (drought) information source it then supports the cross sector drought management by releasing official authorised and classified information which is in compliance with WMO good practices and user requests. Further more comprehensive climate information such as climatological maps or climate modelling outputs is foreseen.

Acknowledgments:

The Development of theBMKG- Climate Change Information System was funded by the German Federal Ministry for the Environment, Nature Conservation and nuclear Safety (BMU) though the International Climate Initiative, ICI (http://www.international-climate-initiative.com/en/)

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TITLE: REMOTE SENSING OF HYDROLOGICAL DROUGHT BASED ON PRECIPITATION AND EVAPOTRANSPIRATION ESTIMATES

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Abstract Summary: This study investigates the use of remote sensing-based precipitation and potential evapotranspiration estimates for regional hydrological drought monitoring in three watershed basins in South Korea with high vulnerability under a changing climate. Monthly maximum and minimum air temperature were estimated using MODIS Atmospheric Profiles product and Land Surface Temperature products along with the CRU gridded dataset (averaged MAE 1.73~1.86 for maximum and 1.18~1.89 for minimum temperature, respectively), and the potential evapotranspiration was calculated using the Hargreaves method showing closer values to the ASOS based data based on Penman-Monteith method compared to the MODIS Global Terrestrial Evapotranspiration dataset. Precipitation was derived from TRMM daily precipitation product. The correlations between empirical percentiles of accumulated precipitation minus evapotranspiration (P-PET) and streamflow percentiles were examined. The streamflow percentiles showed good correlations with the empirical percentiles of 1-month P-PET for summer and 3-month P-PET for autumn (average R^2 = 0.74,0.70, and 0.63 for Mankyung-gang, Dongjin-gang, and Upper Namhan-gang, respectively). The results prove the usability of the remote sensing-based P-PET estimates for hydrological drought monitoring since hydrological droughts can occur due to abnormally dry rainy seasons. Further study for improving the spatial resolution of precipitation estimates should be performed since the effect of precipitation seems larger than the effect of potential evapotranspiration.

Keywords: *Air Temperature, Evapotranspiration, Hydrological Drought, Remote Sensing, Precipitation*

1. INTRODUCTION

In areas with sparse weather stations, drought conditions of unsampled locations may be estimated using statistical techniques such as a spatial interpolation of sampled drought index data or estimates from Land Surface Models. Although these methods provide valuable information on current drought conditions, high uncertainties may exist because many factors affect statistical processes and model parameterization. Remote sensing, extracting meteorological or biophysical characteristics of earth, has gained more attention for drought monitoring. In areas with limited sampling gauges, in particular, the use of remote sensing data may be the only available source of information for drought monitoring.

Hydrological drought in areas with limited observation data is difficult to monitor even with remote sensing. Fortunately, several methods have been developed for large-scale hydrological drought monitoring such as global-scale precipitation minus evapotranspiration estimates by GRACE satellite gravity measurements. There also exists a recently new index, Standardized Precipitation-Evapotranspiration Index (SPEI), which has been proven to be quite effective for large-scale monitoring of various types of drought (e.g. Vicente-Serrano et al. 2012). Evapotranspiration is pivotal in capturing drought impacts along with precipitation for monitoring hydrological drought. In order to estimate ET for areas with limited observation data, it is desirable to use only remotely sensed or global gridded dataset. The objective of this study is to obtain regional-scale remote sensing-based estimates of P-ET for the study area, and to evaluate the use the estimates for hydrological drought monitoring by comparing them to streamflow.

2. DATA AND METHODOLOGY

MODIS Atmospheric Profiles product from *Aqua* with 5km resolution and MODIS Land Surface Temperature (LST) product from *Aqua* with 1km resolution were used to estimate monthly maximum and minimum 2-m level air temperature (Mendez Jocik 2004). The estimated temperature data were corrected based on the overpass time of the satellite when the data are from the atmospheric profiles using the assumed diurnal cycle of temperature (not shown), and then were further corrected using the Climate Research Unit (CRU) TS3.20 global gridded dataset with 0.5° resolution. The Hargreaves method (1985) was applied to calculate PET. Precipitation data were obtained from TRMM 3B42 dataset with 0.25° resolution; the daily precipitation estimates were resampled and averaged for Mankyung-gang, Dongjin-gang, and Upper Namhan-gang watershed basins. Daily streamflow data for the three basins were obtained from the Water Management Information System (WAMIS) and converted to monthly data. For validation, MODIS Global Evapotranspiration dataset were obtained from the University of Montana. PET values at ASOS locations were calculated based on the modified Penman-Monteith (P-M) equation using sunshine hours, daily maximum and minimum temperature, relative humidity, and wind speed.

3. RESULTS AND DISCUSSION

Since the purpose of this study involves producing drought information for regions with limited *in-situ* data, the observation data from weather stations were only used for validation purposes. When the monthly maximum and minimum air temperature estimated by the vertical interpolation method using MODIS Atmospheric Profiles product were compared to the values based on MODIS LST product, seasonal differences were observed (Table 1 for maximum temperature, MAE values for minimum temperature are not shown but average MAE is between 1.18~1.89) and it was decided to use the CRU-corrected maximum and minimum air temperature from MODIS Atmospheric Profiles for summer and to use uncorrected temperature from MODIS LST for other seasons to estimate PET.

Empirical percentiles of P-PET were correlated with streamflow empirical percentiles, and the variables showed fairly good correlations for 1-month and 3-month time scales of data during summer and autumn, respectively (Figure 1 for 1-month time scale and summer; average R^2 = 0.74,0.70, and 0.63 for each basin). The P-PET estimates were closer to the gauge calculations based on the P-M method compared to the MODIS Global Terrestrial Evapotranspiration dataset for the study area (not shown).

Table 1. Monthly maximum air temperature Mean Absolute Error averaged for all validation gauges.

Season	Corrected using CRU		Uncorrected	
	Vertical Interpolation	Land Surface Temperature	Vertical Interpolation	Land Surface Temperature
Spring (MAM)	2.04	**1.85**	4.23	4.58
Summer (JJA)	**1.81**	1.94	2.80	3.38
Autumn (SON)	1.92	**1.73**	3.43	1.94
Winter (DJF)	1.92	**1.86**	2.38	1.88

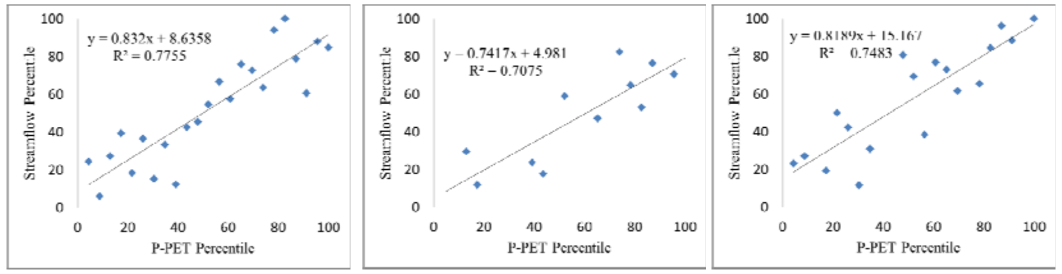

Figure 1. Scatterplots between 1-month P-PET and streamflow percentiles for (a) MK, (b) DJ, and (c) NS watershed basins.

4. CONCLUSIONS

The use of remote sensing data has improved the estimation of monthly maximum and minimum 2-m level air temperature, as well as potential evapotranspiration. Land surface temperature data tends to substitute air temperature in many regions lack of observation data, which is proven inappropriate especially during summer. By only using remote sensing and globally available gridded dataset, the method used in this study can be applied to the regions with limited observation data for estimating monthly maximum and minimum air temperature and potential evapotranspiration.

The fairly good performance of remote sensing-based precipitation and evapotranspiration estimates for hydrological drought monitoring for summer and autumn proved the usability of the remote sensing-based estimates with a simple method since hydrological droughts can occur due to abnormally dry rainy seasons. Further study for improving the spatial resolution of precipitation estimates should be performed since the effect of precipitation seems larger than the effect of potential evapotranspiration.

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DROUGHT MONITORING USING JAPAN's SPACE TECHNOLOGY

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Abstract Summary: To contribute to solving earth and environmental issues, particularly climate change mitigation and adaptation, Japan Aerospace Exploration Agency (JAXA) has developed and operated several types of earth observation remote sensing satellites starting with the Marine Observation Satellite-1 (MOS-1) in 1987. At the 2002 World Summit on Sustainable Development, the GEO (Group on Earth Observation) was proposed and established by the G8 (Group of Eight) leading industrialized countries. The GEO is constructing a Global Earth Observation System of Systems (GEOSS) on the basis of a 10-Year Implementation Plan for the period of 2005 to 2015. The Plan defines a vision statement for GEOSS, its purpose, scope, expected benefits, and the nine "Societal Benefit Areas" of disasters, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity. JAXA's earth observation satellite program is expected to develop GEOSS, particularly the areas of climate, water, and disaster. This paper describes the outline of JAXA's earth observation program, especially GCOM-W with Japan Meteorological Agency's geostationary satellite, MSTAT to provide drought related information.

Keywords: *Climate, Agriculture, Soil Moisture, GCOM-W*

1. JAXA'S SATELLITE FOR ENVIRONMENTAL MONITORING

Using TRMM observation with several microwave radiometers on the satellites, GSMaP (Global Satellite Mapping of Precipitation) was promoted for the study "Production of a high-precision, high-resolution global precipitation map using satellite data," sponsored by Core Research for Evolutional Science and Technology (CREST) of the Japan Science and Technology Agency (JST) during 2002–2007. Since 2007, GSMaP project activities are promoted by the JAXA Earth Observation Research Center (JAXA/EORC). JAXA/EORC offers hourly global rainfall maps 4 h after observation with a 0.1° grid in near real time (http://sharaku.eorc.jaxa.jp/GSMaP/). Global Precipitation Measurement (GPM) is a satellite program used to measure the global distribution of precipitation accurately in sufficient frequency so that the information provided by the program can drastically improve weather predictions, climate modeling, and understanding of water cycles. Its feasibility has been studied at the Goddard Space Flight Center of National Aeronautics and Space Administration (NASA) and JAXA as a successor of TRMM. The accurate measurement of precipitation will be achieved by the Dual-frequency Precipitation Radar (DPR) installed on the GPM core satellite. The DPR for the GPM Core satellite is being developed by JAXA and NICT. The GPM Core Satellite carrying DPR (KuPR and KaPR) and the GPM Microwave Imager (GMI) is scheduled to be launched in early 2014. Its orbit will be non-sun-synchronous, at 407 km altitude and 65° inclination.

The "Global Change Observation Mission" (GCOM) aims to construct, use, and verify systems that enable continuous global-scale observations of effective geophysical parameters for elucidating global climate change and water circulation mechanisms. GCOM will consist of two satellite series (GCOM-W and C) spanning three generations with one-year overlap in orbit, enabling over 13 years of observation in total. Water cycle variations have been observed by the Advanced Microwave Scanning Radiometer-2 (AMSR2) onboard the GCOM-W1 (Water) satellite, launched on May 18th, 2012. GCOM-W1 observes precipitation, water, sea surface wind speed, sea surface temperature, soil moisture, and snow depth, etc. Its orbit is sun-synchronous with 699.6 km altitude (over the equator), 98.186° inclination, and 13:30 local time of acending node. GCOM-W1 joined into the afternoon "A-Train" satellite constellation, which crosses the equator within a few minutes of each another at around 1:30 p.m. local time. The location of GCOM-W1 in the A-Train is 259.5 s ahead of Aqua.

Advanced Land Observing Satellite-2 (ALOS-2) is the satellite carrying an L-band SAR, meant to succeed PALSAR. ALOS-2 is a satellite with L-band SAR based on APAA technology. The APAA of ALOS-2 allows not only conventional stripmap and scanSAR but also Spotlight mode with electric beam steering to the direction of an azimuth. To cover wide areas, ALOS-2 has the capability of wide incidence angles from 8° to 70°, with electric beam steering and left- or right-looking by satellite maneuverability in about 2 min from the nominal look direction. ALOS-2 shall be continuously controlled to an orbit tube of 500 m to a reference orbit for high coherence repeat pass SAR interferometry, both between stripmap modes and scanSAR modes. ALOS-2 will be launched in the Japanese Fiscal Year (JFY) 2013.

2. DROUGH MONITORING USING JAPAN'S SATELLITES

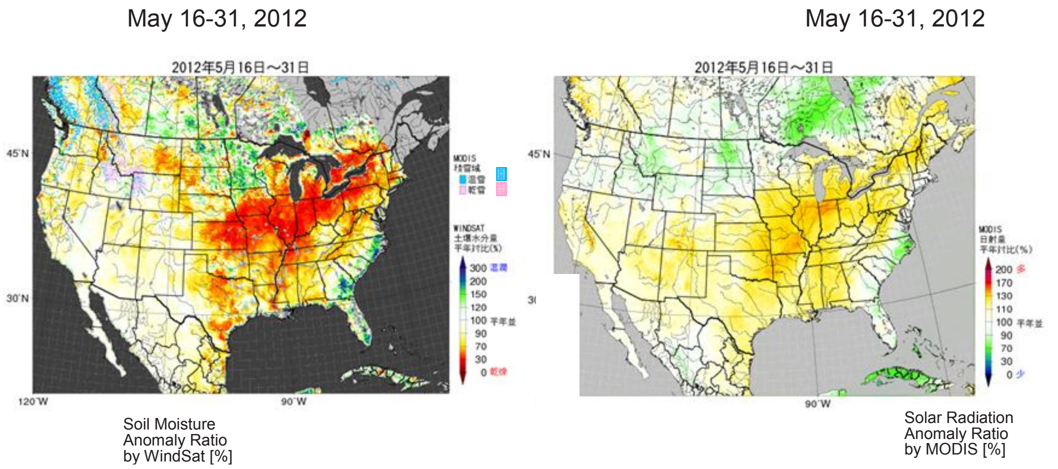


Figure 1. Agro-meteorological anomaly in the US, May 2012 (left is soil moisture and right is solar radiation (PAR)).

Drought monitoring and early warning are major components of drought risk management. The goal of drought risk management is to increase society's coping capacity, leading to greater resilience and a reduced need for government or donor interventions in the form of disaster assistance. In the agricultural area, drought is the major disaster besides flood and landslide.

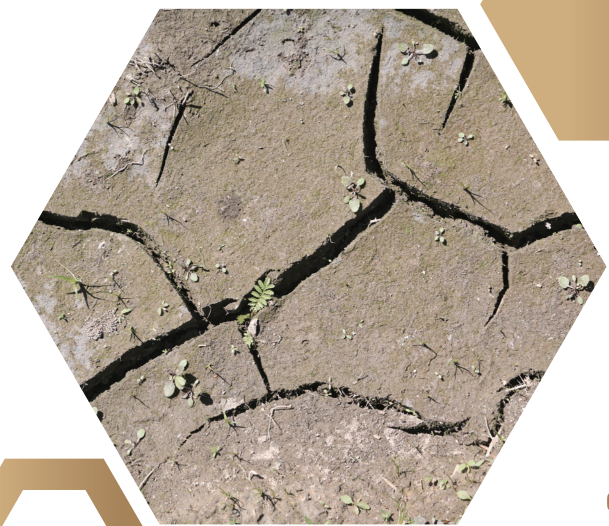
Since agro-meteorological information derived from earth observation satellites are very useful to provide transparent and high quality information as drought indicator globally. Soil moisture is derived from passive microwave radiometer and PAR is derived from coarse optical sensor. Figure 1 shows the soil moisture and solar radiation anomaly in the United States in May 2012. These information are derived from WINDSAT and MODIS respectively. In the near future, both information will be derived from GCOM series. The agro-meteorological information shown in Figure 1 is derived to ministry of agriculture, fishery and forest (MAFF), Japan to develop outlook information of commodity crop imported by Japan through JAXA's internet system (JASMAI).

In addition, the drought information and prediction derived from KBDI and other information is delivered every month to the end user through routine meeting activities, monthly bulletin, website and monthly report. Besides, developed system, which is showing drought situation by the WEB-GIS, is going to be integrated in a couple countries under the international cooperative project funded by ADB (Asia Develop Bank). And also developed approach to predict drought and a part of products, which is showing drought degree, are used in the other international cooperative project, such as Asia RiCE (Asia Rice Crop Estimation Monitoring) led by JAXA and which is a component of GEO GLAM, especially GEO GLAM rice outlook to FAO from September, 2013 under the cooperation between JAXA and ASEAN+3 food security information system (AFSIS) project.

3. CONCLUSIONS

Remote sensing information services are powerful tools to assist with development of adaptation and mitigation strategies for environmental change, disaster mitigation and prevention, and economic and social development. It is very important for observation and communication systems under international cooperation, such as GEOSS, to develop and operate integrated systems using satellites and ground systems. Japan's earth observation program wishes to play a key role in international initiatives, such as UNFCCC COP and ISCCP, and to contribute to strategy development and operation of climate change adaptation and mitigation using earth observation satellites including the GCOM series, ALOS series, TRMM/GPM and other sensors.

APRSAF/ SAFE prototyping is an ongoing activity to provide a bridge between satellite based technology and operational work in end users by technical supporters. SAFE prototypes have completed in several fields, and SAFE has gotten experiences more rich than before as initiative. Now it is time to be fumbled about the next step to make more success stories under the cooperation with donor agencies such as ADB, JICA, World bank, etc. Now, by showing various success stories including drought monitoring, such as utilization of developed system, clarified knowledge, solved causes and so on, SAFE prototypes can become a corner stone, contributing to accelerating climate change adaptation and mitigation strategy development, and to realize sustainable use of every SAFE result.



Session IV

Drought Management in Thailand
Royol Chitradon

TBA
Rene Lobato-Sanchez * Abstract not included in this publication

Drought Vulnerability and Policy in Korea
ByoungJae Lee

Regional-Scale Drought Measures for Effective Decision Making
Greg Carbone

Successfully Using Drought Information in Northern California Public Decision Making
Ane Deister

DROUGHT ADAPTATION IN ASIAN MONSOON REGIONS: SOME CRITICAL OBSERVATIONS

Rajib Shaw[1]

[1] *Graduate School of Global Environmental Studeis, Kyoto University, Japan*

Abstract Summary: This section should briefly summarize the main contents of your contribution. This section should give a clear indication of the objectives, scope, results and conclusion of your work. Recommended length is 10 lines using Time New Roman 9pt.

Keywords: *Climate, Agriculture (9pt in italics, maximum five words)*

1. INTRODUCTION

"Monsoon Asian" region has rainfall distribution much more than other regions of the world. The monsoon Asian countries are mostly characterized by flood and typhoon, which results from interplay between the ocean, atmosphere, and land. Monsoon Asian region has rice farming as a basis for food production. Agriculture in the Monsoon Asia is very diverse from north to south, while the monsoon Asian countries are all characterized by high biodiversity around rice fields. Therefore, the impacts of droughts are mostly known as the agriculture, rural livelihoods affected and rural migration.

The lower Mekong River Basin [MRB] region plays an important role in the well-being of China, Cambodia, Laos, Burma, Thailand, and Viet Nam as it is the major river supporting agriculture and many other economic activities in the region. The lower MRB region is also a cause of concern for many people, due to the regular floods it brings to the region, which have a significant impact on the lives of many in the river basin. However, in recent times, the Mekong River basin has become increasingly vulnerable to drought. A notable example was the drought of 2004, which began a couple of years earlier and grew to serious proportions. Dealing with drought requires strategies different from those for dealing with floods and typhoons, which have plagued the Mekong region for years. Local communities, governments, and NGOs know how to deal with these age-old problems but drought, being a slow-onset disaster with crippling impacts, needs to be looked at from a different perspective.

The Ganges River Basin [GRB] region has been among the perennially drought-prone regions of the world. From early 2000 onwards, severe drought affected vast areas of GRB region. India has reported droughts at least once in three years in the past five decades, while Bangladesh also suffers from drought frequently. Further, the latest IPPC report and other climate model predictions indicate that the global change is likely to increase the vulnerability of tropical countries to drought.

2. EARLY WARNING, MORNITORING OF DROUGHT

There are numerous natural drought indicators that should be monitored routinely to determine the onset and end of drought and its spatial characteristics. Severity must also be evaluated on frequent time steps. Although all types of droughts originate from a precipitation deficiency, it is insufficient to rely solely on this climate element to assess severity and resultant impacts because of factors identified previously. Effective drought early warning systems must integrate precipitation and other climatic parameters with water information such as stream flow, snow pack, groundwater levels, reservoir and lake levels, and soil moisture into a comprehensive assessment of current and future drought and water supply conditions. Monitoring drought presents some unique challenges because of its distinctive characteristics. Some of the most prominent challenges are as follows:

Meteorological and hydrological data networks are often inadequate in terms of the density of stations for all major climate and water supply parameters. Data quality is also a problem because of missing data or an inadequate length of record;

- Data sharing is inadequate between government agencies and research institutions, and the high cost of data limits their application in drought monitoring, preparedness, mitigation and response;
- Information delivered through early warning systems is often too technical and detailed, limiting its use by decision makers;
- Forecasts are often unreliable on the seasonal timescale and lack specificity, reducing their usefulness for agriculture and other sectors;
- Drought monitoring systems should be integrated, coupling multiple climate, water and soil parameters and socio-economic indicators to fully characterize drought magnitude, spatial extent and potential impact;

- Impact assessment methodologies, a critical part of drought monitoring and early warning systems, are not standardized or widely available, hindering impact estimates and the creation of regionally appropriate mitigation and response programmes;
- Delivery systems for disseminating data to users in a timely manner are not well developed, limiting their usefulness for decision support.

3. GOVERNMENT RESPONSES

At the national level, it is important to identify the policy options, which could be implemented by the governments, NGOs and communities. Emphasis has been given to identify a mix of policy options containing mitigation and response strategies. The policy options are a list of actions to solve the root-causes. The root-cause will be considered for make the actions list. For example, provision of more micro-finance to solve the problem of lacking financial capital; enhancing weather monitoring and forecasting for better drought preparedness; and regulations to restrict water usage through strict command level irrigation scheduling and water distribution to solve the problem of bad practice on water use and water management.

Local governments also include entities other than the drought community, e.g., county government offices. Local governments may assist their community water systems in drought management in the following ways:

1) *Assist With Planning:* Assist the drought community within their jurisdictions to plan and coordinate the development of water supplies, the extension of infrastructure and the coordination of resources, manpower and technical expertise. Assist the community water system in the development of the drought management plan.
2) *Implement Drought Responses:* Elected local government officials that have been involved in the development of the drought management plan will be informed about the trigger-points for the various drought phases and the planned responses. The local government may be able to assist in the implementation of some of those responses, especially those associated with emergency conditions. For instance, in certain phases of drought, local governments may be tasked to haul water for domestic and livestock use to self-supplied water users with inadequate sources.
3) *Mainstreaming Sustainable Land Management into Provincial Frameworks:* Mainstreaming is a two-pronged approach of embedding development concepts into the provincial plans while also effecting changes in the way of doing business, e.g. policy reforms, changes in planning, institutional structures, and coordination arrangements. It leads to increased recognition of the importance of land management in development and could increase investments by the public budget and international financial contributions.

4. COMMUNITY RESPONSES

For practical measures, some appropriate approaches below should be considered for drought risk management (see Table-1):

Table-1: Some measures for drought risk management

Possible measures for each aspect	Individual	Community	Local government
Environment	- Water usage management	- Community based forest management - Community based water management	- Reforestation - Land use management
Social impact	- Local lifestyles	- Local lifestyles	- Heath care service - Education
Economic impact	- Livelihood diversification	- Fodder bank - Micro credit - Livelihood diversification	- Irrigation system - Water management - Livelihood diversification

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DEVELOPING AND IMPLEMENTING DROUGHT POLICIES: OUTCOMES OF THE HIGH LEVEL MEETING ON NATIONAL DROUGHT POLICY (HMNDP)

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Abstract Summary: The context of current droughts calls for pro-active future actions to be able to cope with their associated imperatives. There is an urgent need to develop and implement coordinated, national drought policies that include effective monitoring and early warning systems to deliver timely information to decision makers, effective impact assessment procedures, pro-active risk management measures, preparedness plans aimed at increasing the coping capacity, and effective emergency response programmes directed at reducing the impacts of droughts. A High Level Meeting on National Drought Policy (HMNDP) was organized by WMO, UNCCD and FAO, in collaboration with a number of UN agencies, international and regional organizations in March 2013 in Geneva. The major outcomes of the HMNDP are described. The ultimate goal is to create more drought resilient societies.

Keywords: *Drought preparedness, drought risk management, early warning systems, drought monitoring*

1. INTRODUCTION

Drought is widely recognized as a slow creeping natural hazard that occurs as a consequence of natural climatic variability. In recent years, concern has grown worldwide that droughts may be increasing in frequency and severity given the changing climatic conditions. Responses to droughts in most parts of the world are generally reactive in terms of crisis management and are known to be untimely, poorly coordinated and disintegrated. Consequently, the economic, social and environmental impacts of droughts have increased significantly worldwide. Despite the repeated occurrences of droughts, no concerted efforts had ever been made to initiate a dialogue on the formulation and adoption of national drought policies. Hence the High-level Meeting on National Drought Policy (HMNDP) was organized by the World Meteorological Organization (WMO), the Secretariat of the United Nations Convention to Combat Desertification (UNCCD) and the Food and Agriculture Organization of the United Nations (FAO), in collaboration with a number of UN agencies, international and regional organizations in Geneva from 11 to 15 March 2013. Four hundred and fourteen participants from 87 countries as well as representatives of International Organizations, Regional Organizations and UN Agencies participated in the HMNDP.

2. OBJECTIVES OF THE HMNDP

The objective of the HMNDP was to provide practical insight into useful, science-based actions to address the key drought issues being considered by governments and the private sector under the UNCCD and the various strategies to cope with drought. National governments must adopt policies that engender cooperation and coordination at all levels of government in order to increase their capacity to cope with extended periods of water scarcity in the event of a drought. The ultimate goal is to create more drought resilient societies.

The goals of the national drought policies are:

- Proactive mitigation and planning measures, risk management, public outreach and resource stewardship as key elements of effective national drought policy.
- Greater collaboration to enhance the national/regional/global observation networks and information delivery systems to improve public understanding of, and preparedness for, drought.
- Incorporation of comprehensive governmental and private insurance and financial strategies into drought preparedness plans.
- Recognition of a safety net of emergency relief based on sound stewardship of natural resources and self-help at diverse governance levels.
- Coordination of drought programmes and response in an effective, efficient and customer-oriented manner.

3. ORGANIZATION OF THE HMNDP

The HMNDP was organized in two parts, a three and half days of Scientific Segment followed by one and half days of High-level segment. The Scientific Segment was organized in twelve sessions (including an opening session) covering different aspects such as Drought Monitoring, Early Warning and Information Systems; Drought Prediction and Predictability; Drought Vulnerability and Impact Assessment; Enhancing

Drought Preparedness and Mitigation; Planning for appropriate response and relief within the framework of national drought policy; and Constructing a framework for national drought policy: The way forward.

The High-level Segment was addressed by Heads of State and Government, ministers, heads and representatives of international organizations and sponsors.

4. MAIN CONCLUSIONS OF THE SCIENTIFIC SEGMENT OF THE HMNDP

The Scientific Segment of HMNDP concluded that:

- It is important to develop national drought policies and preparedness plans that place emphasis on risk management rather than crisis management;
- Establishment of scientifically sound, comprehensive and integrated Drought Monitoring and Early Warning Systems that provide integrated information to decision makers, vulnerable communities and sector based stakeholders is critical;
- Drought vulnerability and impact assessment should be facilitated through the systematic collection of common minimum datasets and account for context specificity by involving local communities;
- Emphasis should be placed on more integrated approaches for drought preparedness and mitigation through the application of science and technology for the development of more resilient communities and ecosystems and through social safety nets.
- Better understanding of drought phenomena and the associated risks and implications at all levels should be enhanced to provide appropriate response and relief to affected communities in a timely manner;
- Cooperation, consultation, communication, and partnerships at the international, regional, national and local levels should be promoted to construct effective national drought policies.

5. HMNDP DECLARATION ON DEVELOPING AND IMPLEMENTING NATIONAL DROUGHT MANAGEMENT POLICIES

The High-Level Segment of HMNDP adopted the Meeting Declaration encouraging all Governments around the world to develop and implement National Drought Management Policies, consistent with their national development laws, conditions, capabilities and objectives, guided, inter alia, by the following:

- Develop proactive drought impact mitigation, preventive and planning measures, risk management, fostering of science, appropriate technology and innovation, public outreach and resource management as key elements of effective national drought policy.
- Promote greater collaboration to enhance the quality of local/national/regional/global observation networks and delivery systems.
- Improve public awareness of drought risk and preparedness for drought.
- Consider, where possible within the legal framework of each country, economic instruments, and financial strategies, including risk reduction, risk sharing and risk transfer tools in drought management plans.
- Establish emergency relief plans based on sound management of natural resources and self-help at appropriate governance levels.
- Link drought management plans to local/national development policies.

6. CONCLUSIONS

Drought has major implications in terms of the loss of human lives, food insecurity, degradation of natural resources, negative consequences on the environment's fauna and flora, poverty and social unrest. To better cope with droughts, countries need to understand the need for improved risk management strategies and develop preparedness plans to reduce drought risks through the implementation of national drought policies.

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REGIONAL COOPERATION IN POLICY AND DECISION MAKING FOR BETTER DROUGHT MANAGEMENT: EXPERIENCES FROM THE GREATER MEKONG SUBREGION

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1. INTRODUCTION

As a regional development financing institution, the Asian Development Bank (ADB) provides strategic advisory support and investments as well as facilitates policy dialogue at regional and national levels to our developing member countries (DMCs). Most of our lending is in five core operational areas: infrastructure, environment, regional cooperation and integration, finance sector development and education.

This paper will cover regional cooperation and climate change adaptation, with a focus on drought management. It will use examples of our regional cooperation work on the food-energy-water nexus with the Greater Mekong Subregion (GMS) which covers Cambodia, the People's Republic of China (PRC, specifically Yunnan Province and Guangxi Zhuang Autonomous Region), Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam.

The paper will discuss subregional cooperation on information and knowledge systems for drought management and also introduce how these systems inform policy and decision makers at subregional and national levels through the Working Group on Environment and the Working Group on Agriculture.

Some practical examples that are included in the paper are the: pilot program on "Applying Remote Sensing Technology for Drought Management in the Greater Mekong Subregion" assist GMS countries to access to satellite-based drought monitoring and warning system be implemented under GMS Core Agriculture Support Program; "Regional knowledge base for climate change adaptation planning" which is a partnership with the Southeast Asia START Regional Center (SEA START RC) to develop an on-line regional knowledge base for climate change adaptation planning, including drought management. The on-line platform contains a future climate projection data archive along with analytical tools, a climate vulnerability assessment guideline, and training materials. The platform aims to serve as sustainable infrastructure to support decision making and knowledge exchange on climate risks and adaptation best practices in the GMS.

DROUGHT MANAGEMENT IN THAILAND

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Abstract Summary: This section is described how Thailand manages drought problem and use all information to plan and create cooperation between relevant agencies. The topic presents you about Thailand situation with Flood and Drought area map, Irrigation and Non-Irrigation Area, Thailand Data with National Hydroinformatics and Climate Data Center (NHC) and Communication Channel convey to end users.

Keywords*: *Water Resource Management

1. INTRODUCTION

Thailand has frequently suffered from flooding during the monsoon season, droughts in summer and even both in some particular areas.Additionally, climate change is a new threat that only amplifies the water resource tensions. Therefore managing flood and drought risks by taking climate change into account is essential to alleviate damage and the consequences of natural disasters and to increase agricultural production to ensure food security for the country.

Since Thailand faces both flood and drought problems every year including the climate changes dramatically which caused many damages both livelihood and country economic. For Thailand, only 17.1% agricultural areas are irrigated, whereas 82.9% are rain-fed areas. The best water resource management is necessary from national level to community level in order to increase their livelihood. The Ministry of Science and Technology (MOST), Thailand, by Hydro and Agro Informatics Institute (HAII) helps creating the readiness, as following,

1) **The National Level:** "National Hydroinformatics and Climate Data Center" or NHC is responsible for data gathering, collecting and coordinating the actions of 12 relevant agencies in water and weather issues, including HAII, during crisis operation. By integrating with the ground sensors to verify information such as wind, weather and rainfall from Mobile Integrated Geospatial Intelligence System, Autonomous robot boat for surveying, Closed Circuit Television (CCTV) from ground stations, Satellite to monitor and assess the disaster from flood, all data throughout the country will be collected to the central unit to promptly analyze the situation. The relevant information and data would be analyzed by the experts, who have knowledge, abilities, and experiences. All data would be in the same database and could be exchanged between agencies for mutual benefit in water resource management, situation control, disaster warning, and especially life and property protection. With all advanced technology and the linkage of all data to the Water Management Data System Center, is ready to operate and monitor water situation in Thailand. From now on, Thai people can be assured about the water situation. This is Thailand's sustainable water management.

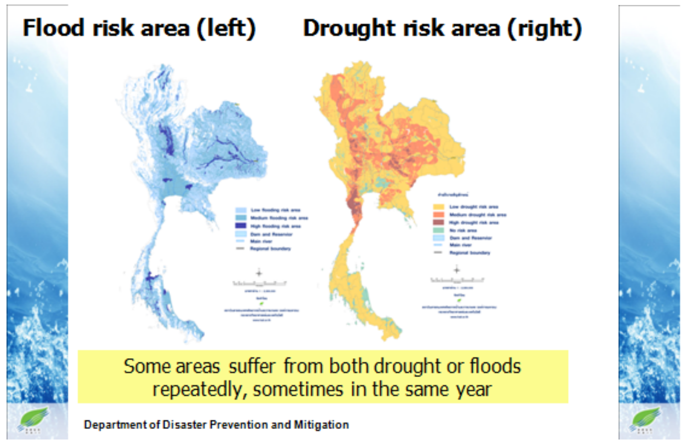
2) **The Community Level:** The application of technology and information systems is used to support the communities in making plans to solve problems in their communities. Local data has been stored for future use in the systematic manner called Local Content Management System. Other technological equipment such as THEOS satellite image maps, GPS receivers, and Internet GIS/MIS, are used to manage local natural resources.Best Practice Community in water resource management especially Management in Flood and Drought Risky areas to adapt and adding the community's potential in Marketing Product Planning.

In order to deliver all information to the end users, HAII has developed an easy technology called "RSS News Feed" through the automated water situation monitoring equipment **"Media Box".** The equipment represents the weather information, 3-7 days rainfall forecast, the country's water situation and storm formation including other information, which is very important to follow the weather and water situation. In 2011, HAII gave "Media Box" to 203 Local Administrations throughout the country to monitor water situation in their areas and use the information for community water resource management.

HAII has also developed "NHC Mobile Application" to monitor water and weather situation for 24 hours. Public could easily access to get rainfall data, weather data, runoff level, dam water level which including the real time data and forecasting data for example: Storm Track and wind speed, 7 days rainfall and wind forecast. Operating system for NHC Mobile Application are both iOS and Android by searching "NHC Thailand". After uploading the application, the user can follow up closely to the situation.

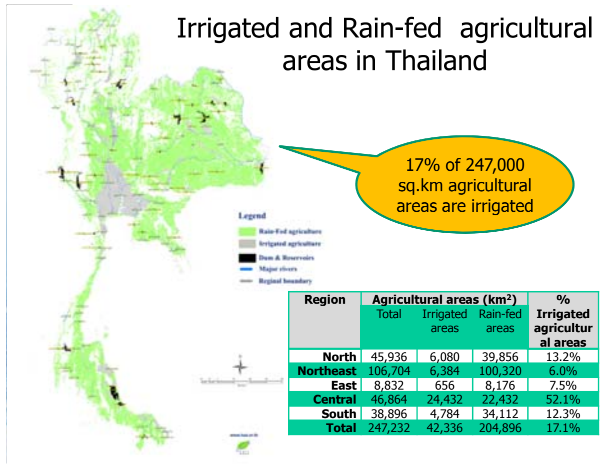
From the National Level, HAII deliver the information to provincial based level. The Best practice is "Prae Province".The details of Prae water resource management are gathered and shown in the website. The local governors and the community can reach the data and manage their water resources promptly and immediately, especially, in the crisis situation.

2. FIGURES



Year	Number of province	Loss of damage		
		Victim (person)	Damaged agriculture area (Rai)	Value (Million Baht)
2002	66	12,841,110	2,071,560	508.78
2003	63	5,939,282	484,189	174.32
2004	64	8,388,728	1,480,209	190.66
2005	71	11,147,627	13,736,660	7,565.86
2006	61	11,862,358	578,753	495.27
2007	66	16,754,980	1,350,118	198.30
2008	61	3,531,570	524,999	103.90
2009	62	17,353,358	594,434	108.34

Figure 1. Drought Information: Left: flood risk area and drought risk area in Thailand Right: Loss from drought in Thailand



Region	Agricultural areas (km²)			% Irrigated agricultural areas
	Total	Irrigated areas	Rain-fed areas	
North	45,936	6,080	39,856	13.2%
Northeast	106,704	6,384	100,320	6.0%
East	8,832	656	8,176	7.5%
Central	46,864	24,432	22,432	52.1%
South	38,896	4,784	34,112	12.3%
Total	247,232	42,336	204,896	17.1%

Figure 2. Irrigated and Rain-fed agricultural areas in Thailand

Figure 3. The official website of National Hydroinformatics and Climate Data Ceneter: http://Nhc.in.th/web

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Thanks to all good cooperation from our relevant agencies: The Marine Department, Royal Irrigation Department, Department of Groundwater Resources, Department of Water Resources, Department of Mineral Resources, Land Development Department, Thai Meteorological Department, Hydrographic Department, Royal Thai Navy (HDRTN), Electricity Generating Authority of Thailand, Bangkok Metropolitan Administration and, Geo-Informatics and Space Technology Development Agency (Public Organization), GISTDA

DROUGHT VULNERABILITY AND POLICY IN KOREA

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Abstract Summary: Korea is expected to experience many difficulties in terms of future water resources owing to regional and seasonal water shortages. A review of major water resources policies found four problems regarding drought issue. First, the policy considering drought vulnerability by region according to climate change is weak. Second, current drought policies fail to work in line with land use polices. Third, measures to secure water for agriculture are insufficient. Fourth, comprehensive water resources schemes at the river basin level are practically nonexistent. To establish an efficient drought policy which considers regional features, the drought vulnerability study was conducted for 232 local governments nationwide. Based on that, four efficient drought policy measures are proposed: 1. Rational policy measures considering the regional drought vulnerability features, 2. Combined drought policy measures using spatial schemes including urban planning and development, 3. Efficient policy measures through the re-establishment of agricultural water supply, 4. Comprehensive countermeasures through the establishment of a comprehensive river basin water resources scheme.

Keywords: *Drought Vulnerability, Policy, Climate Change*

1. INTRODUCTION

Although Korea's average rainfall is higher than the global average, the amount of usable water resources per person is low because of high population density. The seasonal deviation of usable water resources is also huge since most precipitation is concentrated in summer. Korea is expected to experience many difficulties in terms of future water resources owing to regional and seasonal water shortages and future uncertainties.

A review of major water resources policies found four problems regarding the preparations for climate change. First, the policy considering drought vulnerability by region according to climate change is weak. A majority of existing analyses on drought vulnerability do not sufficiently consider the climate change influences; they mainly analyze the vulnerability of national infrastructure. Moreover, analysis on climate change vulnerability at the local government level is not extensive, leading to a lack of differentiation of policies between local governments. Second, current drought policies fail to work in line with land use polices. Currently, linkages between land use patterns and development and water resources schemes are practically insufficient. Third, measures to secure water for agriculture, one of the largest consumptive of water resources, are insufficient. Out of the total amount of water resources of 124 billion tons, consumption is about 33.7 billion tons or 27%; agriculture accounts for 47% of that consumption. As such, efficient measures to use agricultural water are needed. Fourth, comprehensive water resources schemes at the river basin level are practically nonexistent. There exists no water resources scheme regarding major river basins between the national and local government level concepts. Thus the establishment of drought policies through regional cooperation and a comprehensive establishment of measures for the upper and lower reaches of rivers are lacking.

2. DROUGHT VULNERABILITY IN KOREA

To establish an efficient drought policy that considers regional features, a study assessing drought vulnerability should be conducted first. Sim et al. (2011) assessed the current and future levels of climate exposure and current drought sensitivity using assessment indicators targeting 232 local governments nationwide, and consequently established assessment methods to detect the current and future levels of drought vulnerability.

Vulnerability assessments on climate change found that the local governments of the Yeongnam region and Jeollanam-do coastal area are mainly vulnerable. In the future, vulnerable areas appear to expand along the Gyeongbu axis connecting the Seoul metropolitan area, the Chungcheong region, and the Yeongnam region. Vulnerable areas are forecast to increase by about 37% above present. Concerning drought sensitivity, the northern part of Gyeonggi-do, coastal areas of Gangwon-do and Jeollanam-do, and some parts of the Mt. Jiri area are considered to be vulnerable.

According to the current drought vulnerability assessment, the northern part of Gyeonggi, northern part and coastal area of Gangwon, coastal area of Gyeongsangbuk-do, coastal area of Jeollanam-do, inland area of Chungbuk, and some parts of the Mt. Jiri area were analyzed to be vulnerable, similar to the drought sensitivity assessment results.

The future drought vulnerability assessment results show a regional pattern similar to the current drought vulnerability assessment results, although vulnerable areas such as the inland area of Gangwon-do and some parts of the Mt. Jiri area show slight improvement.

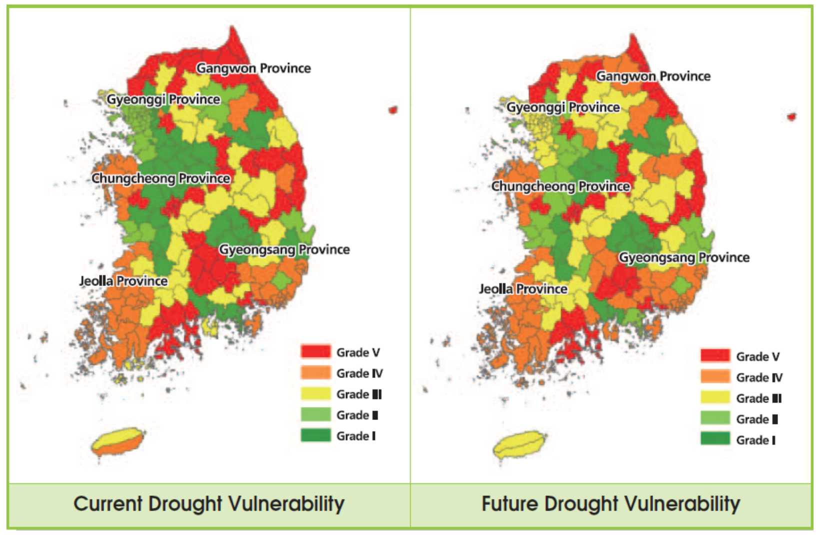

Figure 1. Drought Vulnerability According to Climate Change (Grade V being the most vulnerable)

3. KOREA'S DROUGHT POLICIES AGAINST CLIMATE CHANGE

Four efficient drought policy measures of national territory can be proposed:

1. Rational policy measures considering the regional drought vulnerability features

To devise policy measures considering the regional drought vulnerability features, a policy direction should be set according to climate exposure and drought sensitivity features as well as drought vulnerability derived from climate change by region. In addition, it is rational to review drought measures in detail by taking into account the vulnerability of each local government's levels of household water, industrial water, and agricultural water.

2. Combined drought policy measures using spatial schemes including urban planning and development

These measures aim at lowering the temperature levels in various urban sectors such as spatial structure, land use, infrastructure, complex formation, and buildings; and to consolidate the city's water protection and recreational water functions to build a sound water circulation system.

3. Efficient policy measures through the re-establishment of agricultural water supply

The current concept of agricultural water, which is water for agriculture and livestock, should be redefined as a concept including regional water (river water for recreation and environment improvement) and industrial water. Since water resources are insufficient, and agricultural water development is difficult due to the lack of systems for drought management in high drought sensitivity areas, i.e., imperfect irrigation fields including rain-fed paddy fields, it is necessary to review the concept of virtual water. Using virtual water as an efficient alternative within the areas concerned, including the farming of field crops instead of rice and farming of crops –requiring less water, may be possible.

4. Comprehensive countermeasures through the establishment of a comprehensive river basin water resources scheme

There exists a comprehensive long-term water resources scheme at the national level and a basic waterworks reorganization scheme at the local government level in Korea. However, there is no comprehensive river basin water resources scheme in between. Efforts to deal with climate change only on the local government level have limits. In addition, comprehensive, collaborative and across-the-board drought policies and measures should be devised. In some cases, water will have to be transported from the areas where water is abundant, and city development in the upper areas of a river can have an influence on securing stable water sources in the lower areas.

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REGIONAL-SCALE DROUGHT MEASURES FOR EFFECTIVE DECISION MAKING

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Abstract Summary: This paper documents recent efforts by a NOAA-sponsored research group to assess regional drought information needs, to measure the effectiveness of existing drought indicators for decision making, and challenges to regional- and local-scale tool development for drought monitoring. Through a series of regional-scale experiences, it explores the methods used for integrating drought information into decision making, some of the deficiencies of current practices, and challenges for the future. Our work has included basic needs assessment, resolution of inconsistent measures for drought that complicate management decisions, and tool development to enhance decision making by multiple sectors at different spatial and temporal scales. We explore many of the challenges associated with these activities.

Keywords: *drought, indices, sensitivity, technology transfer*

1. INTRODUCTION

During the past fifteen years, many parts of the Southeast United Drought have endured frequent droughts. These droughts, combined with growing demands for freshwater, and a series of regulatory events have created challenges for regional-scale drought management. In this presentation, we report on interactions with decision makers that use drought information to manage fresh water resources. The examples range from open dialogue regarding research needs on drought impacts in the region, to assessment of current practices in managing drought, to tool development to aid drought management.

2. ASSESSING USER NEEDS

The state of knowledge regarding drought impacts varies tremendously by sector and user group. In some cases, our collaboration with partners has started with an assessment of the current state of knowledge about how drought affects an ecosystem. For example, a series of focus groups revealed that drought impacts on the Atlantic coastal plain were poorly understood, including influences on estuarine and river habitats and species, water quality changes (including saltwater intrusion), groundwater-surface water interactions, and streamflow (Gilbert et al., 2012). While some short-term impacts and impacts to particular organisms or species may be well-understood, researchers lack adequate (both temporally/long-term and spatially) biological and ecological data, as well as models or tools which incorporate human influences on ecological impacts (e.g. socioeconomic data, land use, water allocation and permitting). Basic research was required to assess the quality and appropriateness of existing data networks and to identify which variables are most important to monitor and assess drought-impacted ecosystems (e.g. chemical, physical, or biological). The minimal level of understanding has led to "reactive" drought response and "stop-gap" measures. Resource managers report a general lack of knowledge about available drought-related data and information, conditions and impacts, and possible management tools. Cross-agency communication and coordination is also limited. Coastal ecosystem issues are not well-integrated into other management regimes, including state-level drought response management processes.

Other groups have much deeper understanding of drought impacts, but struggle with drought measures that may differ depending on the spatial scale or jurisdiction considered. Our research has evaluated the correlation between state-level drought indicators used by drought response committees for official drought stage determination in order to reveal any inconsistencies between indicators and to better understand the duration and probability of drought occurrence. The goal of this work has been to uncover inconsistencies between local drought plans centered on individual river basins and state-level mandates and to reconcile these inconsistencies with meaningful measures for management and decision making.

3. DEVELOPING DECISION-MAKING TOOLS

Our experience suggests that drought mitigation and planning require a monitoring system that considers a range of spatial and temporal scales, includes indices that relate to specific impacts, and meets the diverse needs of decision makers. We developed an interactive tool in response to a four-year drought in the Carolinas and to assist with water management negotiations associated with dam relicensing in large river basins. The drought monitoring system, called the Dynamic Drought Index Tool (DDIT; Carbone et al., 2008), accommodates decision makers that must consider drought across different physical and political units and in the context of state and local ordinances. Its flexible, open-architecture design meets these needs as well as the reality of wide-ranging definitions of and sensitivity to drought. Because the tool was developed collaboratively with stakeholders, it includes options relevant to state and local decision making during times of drought. Refining the DDIT involved technical changes to accommodate practices at a long-term host institution as well as incorporation of user-feedback from focus groups. The adjustments have been designed to bring stability and flexibility to the tool, and to make it as useful to a decision-making community as possible. These transitions required collaborative effort between developers, the intended host providers for the tool, and potential users.

User feedback is an essential part of any decision-making tool. Evaluators of the DDIT have included those interested in ecosystem health, streamflow, surface water and groundwater supplies, water quality, and wildlife management. They find the tool powerful, relatively easy to understand, and potentially helpful for their work, specifically for impact analyses (e.g. for endangered species), public service announcements, water resource decisions, and to justify management actions (such as policy or drought declarations). Focus group participants like customization features such as blending drought indices. They have also made recommendations for improvements to the tool's interface, data handling, and potential extensions.

A variety of challenges complicate the transfer of decision-support tools from research to operations. These include data handling, creating a virtual development environment, writing efficient and flexible computer code, and finding a sustainable operational home for software. Implementing good decision-support tools requires collaborative effort among team members with various skills, producing robust, complex products in tandem and across geographic space (Joshi and Sarker, 2007). The development and implementation of the DDIT included climate scientists, climate impacts specialists, decision-support designers, programmers, and systems analysts located at many different institutions. The group developed high levels of trust and communicated ideas and suggestions frequently and effectively, particularly those contributing actively to code development.

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SUCCESSFULLY USING DROUGHT INFORMATION IN NORTHERN CALIFORNIA PUBLIC DECISION MAKING

Ane D. Deister

Parsons Environment and Infrastructure

Abstract Summary: Northern Californians are acutely aware of water resources and have been fighting throughout the state and the west over policies, laws, delivery systems and water allocations for many decades. Topics such as drought preparedness and climate change adaptations can lead to heated discussions and conflicts with little warning. Yet after several years of dry and extremely dry water conditions it became apparent that Northern California was not immune to the impacts of drought. Five separate locally elected boards of directors engaged in a two-year collaborative process with other stakeholders using shared vision planning principles and shared vision modeling tools. Over time, the elected officials grew to trust one another, and accepted ideas and solutions from experts outside their region. Transparent communications and frequent face to face encounters provided the environment for the group to reach consensus on the likelihood of drought occurrences in the future, the possibility of climate change impacts, and an array of actions to prepare for and respond to water shortages throughout the region.

Keywords: *drought planning, decision making, shared visioning*

1. INTRODUCTION

El Dorado County is where the California Gold Rush (1848-1855) began. The gold seekers were called "forty-niners" as they emerged fully in 1849. The independent, conservative attitudes that drove these rugged pioneers to endure harsh conditions in search of a bright future are evident today with descendents growing wine grapes, stone fruits and serving in key locally elected offices. Beginning with the use of water in mining operations the founders of this northern California region understood the value of water to improve their lives. In 1933 the US federal government devised a water delivery system to regulate, store and deliver water from the water-rich Northern California region to the water-poor California Central Valley by means of canals, aqueducts and pumping plants. Fueled by federally subsidized water deliveries today the California Central Valley is one of the most productive agricultural centers in the state and in the country. In 1960 the state of California funded and built the State Water Project to deliver water from the north to the growing urban centers in Southern California's Los Angeles, San Diego, Ventura, Riverside, Orange and San Bernardino counties. Today two-thirds of the state's population resides in the southern counties along with their associated economies. As a result, under the best climate conditions Northern Californians are acutely aware that a significant amount of the water supplies originating in their region's watersheds is being transported to others outside their political boundaries.

Through a combination of multi-year dry weather conditions and increasing exports, Northern Californians have become vocal and active participants in the public policy dialog related to restoration of the Bay-Delta ecosystem, decreasing snow pack in the Sierra Nevada, and regulatory requirements that exacerbate conflicts over limited water resources. In the mid 2000's five elected boards of directors in El Dorado County agreed to meet and discuss their concerns about the weather, lack of water supply, and growing demand for water outside their region. Initially the group chose not to use the terms 'global warming' or 'climate change', preferring to use climate variability as a way to reduce political debates that could be deal breakers. The belief and value system surrounding those terms would often spur debates and conflicts and prevent productive decision making processes.

2. DISCUSSION

El Dorado county politicians engaged in a two-year interactive, collaborative dialog based on shared vision planning principles. Elected board members participating in the process included: El Dorado Irrigation District, El Dorado County Water Authority, Grizzly Flats Community Service District, Georgetown Divide Water District and El Dorado County Board of Supervisors. Among the elected and non-elected stakeholders there were both technical and non-technical members. As a result, the process valued both the recorded scientific data from federal, state and local water managers along with the anecdotal data passed down by family farmers and others through the generations. The data was projected in a user-friendly graphic using dash-board style review tools and simple Excel spreadsheets. With each addition of information there were qualitative and quantitative tests of the information to build agreement and trust among the participants.

The two-year long process used a series of workshops with all participants, caucuses of participants with similar issues and concerns, and included a public advisory committee comprised of a sub-set of elected officials, technical experts, and non-elected local leaders. The participants moved progressively through a series of facilitated, interactive workshops focused on: (1) Identifying values and issues: where the group reached agreement on the historical information to be used in the process, the educational methods to be used, drought response goals and expectations, and anticipated challenges to drought preparedness and response ; (2) Virtual drought conceptualization: where the group agreed upon the drought information and analytical techniques to be used, including supply scenarios and associated drought impacts; (3) Drought scenarios and impacts: where mitigation measures were identified and agreement was reached on which ones would be included in the study; (4) Mitigation measures: were tested, and the drought preparedness and response tools were agreed upon along with measures of success.

3. CONCLUSION

At the end of the two-year Shared Visioning Process the entire group of politicians, scientists, engineering, farmers, urban leaders, environmentalists, and others agreed to adopt the shared vision planning model as part of their respective decision making bodies, reflecting a 'shared view' of the drought issues, concerns and potential solutions. Success is attributable to some attributes built into the planning process: (1) transparency of diverse information, assumptions and decision factors; (2) ability for both technical and non-technical members to participate equally; (3) ability to quantitatively predict water supply shortfalls; (4) clear depiction of each of the water suppliers and their surrounding geographic characteristics; (5) ability to demonstrate the manner in which shortfalls could occur; (6) ability to evaluate effectiveness of drought responses; (7) ease in ability to update the model tool; (8) ability to test existing drought plans with proposed new plans; and (8) ability to incorporate the impacts of climate change without engaging in the politics embodied in the topic.

There are also a number of overarching interactive features that contributed to the overall success. The enthusiastic, engaged support of the diverse stakeholders significantly contributed to a successful planning process. Using facilitated dialogs ensured that all the voices were heard and valued, and that questions, disagreements and conflicts were resolved and not allowed to fester or grow. Including each of the water agencies as equals further contributed to the overall success. Today the participating agencies post an executive dash board on their websites for public viewing where water supply conditions are characterized as being green (sufficient supplies), yellow (conditions indicate potential shortages) or red (critical supply conditions). For each of the color-coded characterizations there are a number of recommended and required actions to trigger decision making. Finally, frequent updates in the data and feedback on the success of mitigation and response actions keep the planning process relevant, accurate and useful.