El Niño 2015

CONFERENCE
NOVEMBER 17-18, 2015

REPORT

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Introduction

Shared Experiences: 20 Years of Climate Services and Framing the Next Steps in the Research and Development for Climate Resilience

Since early 2015, experts have monitored the development of one of the largest El Niño events of the last 50 years, and notably, the largest since the 1997-98 El Niño that shocked global food, water, health, energy and disaster-response systems and erased years of development gains. The current El Niño, which peaked at the end of 2015, offered a unique opportunity for governments, scientists, economists, humanitarian agencies, development professionals and the media to share perspectives on the transformation of climate forecasts to climate services in the past two decades. It allowed the expert community to focus attention on framing next steps in climate-services research, which are critical for achieving the sustainable development goals. Climate doesn't act in isolation. We need to understand the interaction climate has with socioeconomic and ecological systems in order to address its negative impacts, as well as take advantage of times when climate conditions are favorable

In November 2015, the International Research Institute for Climate and Society at Columbia University, in collaboration with the World Meteorological Organization, the U.S. Agency for International Development and the U.S. National Oceanic and Atmospheric Administration convened the El Niño 2015 Conference. Other members of the organizing committee included scientists from Centro Internacional para la Investigación del Fenómeno de El Niño, University of Arizona, Indian Institute of Tropical Meteorology, Climate Prediction Center – NOAA, and the Australian Bureau of Meteorology. The Conference received additional sponsorship from the Earth Institute, as well as the Initiative on Extreme Weather and Climate at Columbia University and the Reinsurance Association of America. The two-day gathering provided a platform for strategic dialogue to evaluate the big picture and ask questions related to El Niño, extreme events and variability on multiple time scales, including long-term climate change. The sessions were a combination of lectures and panel discussions designed to foster insight and interaction between attendees.

Key objectives of the El Niño 2015 Conference:

- Provide an overview of the 2015 El Niño and its potential impacts
- Examine the progress over last 20 years in international, national and regional climate services, with a focus on El Niño
- Foster a dialog between high-level scientific experts and development practitioners on next steps for the research and development
- Explore the connection between the current El Niño and Global Change

While conference attendance was limited to direct invitation, an additional 3,000 people viewed the proceedings via live-streaming and recordings. Outreach efforts on Twitter by our communications teams and dozens of participants yielded a potential reach of nine million people for the #elninoconf hashtag. We are grateful for the hard work and support by our staff, partners, sponsors and volunteers, as well as the enthusiastic participation and interaction of our invited speakers and attendees. They made the conference a successful event. We trust that the conference has served as a launching pad for new ideas, discussions, and collaborations that will continue to develop far beyond those two inspiring days in November.

Sincerely,

Lisa Goddard

Director, International Research Institute for Climate and Society

The Earth Institute, Columbia University

Conference Program

Tuesday, November 17, 2015

8:30 – 9:00 – WELCOME & INTRODUCTION: Lisa Goddard (Host), Kathy Jacobs (Conference Chair)

9:00 – 9:10 – Opening Remarks: Jerry Lengoasa, Deputy Secretary-General, WMO (Read by Maxx Dilley)

9:10 – 10:30 – PANEL: 20 Years since the International Forum on Forecasting El Niño and Launching IRI (Moderated by Jim Buizer, University of Arizona)

- Michael Crow, President Arizona State University (via video)
- Mark Cane, Columbia University
- Mickey Glantz, University of Colorado
- Mike Hall, Retired NOAA

11:00 – 11:30 – Implications of a large El Niño event on global economy and development. Jeff Sachs, Director, Earth Institute – Columbia University

11:30 – 11:50 – Update on 2015 El Niño event. Michelle L'Heureux, NOAA-Climate Prediction Center

11:50 – 12:10 – Associated extreme climate impacts and their certainty. Adam Sobel, Columbia University

12:10 – 12:30 – ENSO modeling and prediction: Evolution and Outstanding Challenges. Lisa Goddard, CLIVAR-WCRP; IRI, Columbia University

13:30 – 14:00 – Overview structure of available ENSO information & coordination – from a WMO perspective. Maxx Dilley, WMO

14:00 – 15:00 – PANEL: Overview structure of available ENSO information and coordination Moderated by David Corcoran, formerly NYTimes Science Times)

- Zinta Zommers, UNEP
- Richard Choularton, WFP
- Sezin Tokar, USAID/OFDA
- Stewart McCulloch, WorldVision International

15:30 – 17:00 – PANEL: Case Studies on current event information, plans as well as current and anticipated impacts. (Moderated by Simon Mason, IRI)

- Latin America: Rodney Martinez, Centro Internacional para la Investigación del Fenómeno de El Niño, Ecuador

- Peru: Ken Takahashi, Instituto Geofísico del Peru
- Caribbean: David Farrell, Caribbean Institute for Meteorology & Hydrology, Barbados
- Greater Horn of Africa: Guleid Artan, IGAD Climate Prediction & Applications Centre, Kenya
- India: Sulochana Gadgil, India Meteorological Department
- Philippines: Tony Lucero, Philippine Atmospheric, Geophysical and Astronomical Services Administration

17:00 – 18:20 – PANEL/Plenary Discussion: Messaging on El Niño – How do we inform the public (who informs what public), and what do they hear? How has this evolved over the last 10-20 years? (Moderated by David Herring, NOAA)

- Journalists in developing countries. Patrick Luganda, Network Climate Journalists in the Greater Horn of Africa
- Societal perceptions of forecasts and risk. Mickey Glantz, University of Colorado
- Communicating climate information. Eric Roston, Bloomberg News

<u>Wednesday, November 18, 2015</u>

9:00 – 9:30 – El Niño and Global Change (Marc Levy, CIESIN, Columbia University)

9:30 – 10:50 - PANEL: Sectoral impacts of El Niño – What have we learned since 1997-98. (Moderated by Roger Pulwarty, NOAA)

- Health: Madeleine Thomson, IRI
- Water: Upmanu Lall, Columbia Water Center, Columbia University
- Disasters: Carina Bachofen, Red Cross Red Crescent Climate Centre
- Energy: Alberto Troccoli, U. East Anglia

11:20 – 12:40 – PANEL: El Niño 2015 Response Strategy – what is or should be in place (Moderated by Heidi Cullen, Climate Central)

- Seasonal fire early warning system: Rizaldi Boer, CCROM-SEAP
- Regional actions and support network: Jen Stephens, UNDP
- Food Security: Amir Abdulla, World Food Programme
- Insurance: Megan Linkin, SwissRe

13:40 – 15:00 PANEL: What is needed to evolve science towards increased societal benefit? (Moderated by Francesco Fiondella, IRI, Columbia University)

- Climate: Simon Mason, IRI
- Process of developing climate services: Jim Buizer, University of Arizona
- Development Banks: Kanta Kumari, World Bank
- Social Sciences: Ed Carr, Clark University

- Agriculture: Andy Jarvis, CIAT

15:30 – 16:00 – WCRP/CLIVAR efforts to understand El Niño in a changing climate. Eric Guilyardi, IPSL-France

16:00 – 16:30 – The Intersection of El Niño and Climate Change – El Niño's contribution to 2015 global temperature. Kevin Trenberth, NCAR

16:30 – 17:00 – El Niño, ecosystems for & carbon. Miguel Angel Pinedo-Vasquez, EICES, Columbia University; CIFOR

17:00 – 18:00 – PANEL: Young Scientists: exploring new ideas to connect research, the operational communities and the users: "reinventing climate services" (Moderated by J. Michael Hall, Retired Director of NOAA's Office of Global Programs)

- Teddy Allen (IRI)
- Ángel Muñoz (IRI)
- Aisha Muhammad (IRI)
- Roop Singh (IFRC Climate Centre)

18:00 – 18:30 – Concluding Perspective. Maxx Dilley, WMO.

18:30 – 18:45 – Wrap Up, Final Remarks. Kathy Jacobs and Lisa Goddard

Post-Summit discussion of the Organizing Committee: Synthesize key messages and agree on report structure.

Opening Remarks

Given by Maxx Dilley on behalf of Jerry Lengoasa, Deputy Secretary-General World Meteorological Organization.

Ladies and Gentlemen, good morning.

It is a great pleasure to open El Niño 2015 Conference on the occasion of the 20th anniversary of the International Research Institute for Climate and Society — a key institution that I would like to thank for making climate science and information available for the benefit of society, and for being such an important collaborator with WMO in many areas.

I would like to thank all the other partners of WMO and the co-sponsors that made this conference possible: NOAA and USAID, Columbia University and the Reinsurance Association of America. Thanks also to the other members of the organizing committee – the representatives from the Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), the Indian Institute of Tropical Meteorology, and the Australian Bureau of Meteorology.

I am confident that the Conference will share lessons learned from managing El Niño impacts, develop key messages about this event for policy makers, practitioners and the public, and identify directions for future work in climate services for El Niño. For this reason, participants include not only climate scientists but also experts engaged in translating climate information into action for societal benefit.

This meeting coincides with one of the strongest El Niño events since 1950. It is a timely opportunity to reflect on what has been learned since the last major event in 1997-98 and to identify additional needs for improving climate services going forward. In the intervening nearly two decades since the 1997-1998 event, an enormous effort has been made to improve El Niño modeling, develop enhanced seasonal climate predictions, and to establish systems for making that information available in useable form.

WMO has contributed to this effort through its network of National Meteorological and Hydrological Services, its support for National Climate Forums and National Climate Outlook Forums, its Regional Climate Centres and support for Regional Climate Outlook Forums, and its Global Producing Centres for Long-range Forecasts. The RCOFs, started in advance of the 1997-98 event, have become a global institution, with on-going forums covering most of Africa, Asia and the Pacific, Central America and the Caribbean, South America and the Greater Mediterranean Region.

This El Niño will be an important test of the efficacy of those measures. Clearly the world is more informed about El Niño and its impacts than it was 20 years ago. Information about this

event and measures that can be taken to improve related socio-economic outcomes are also considerably more accessible than previously.

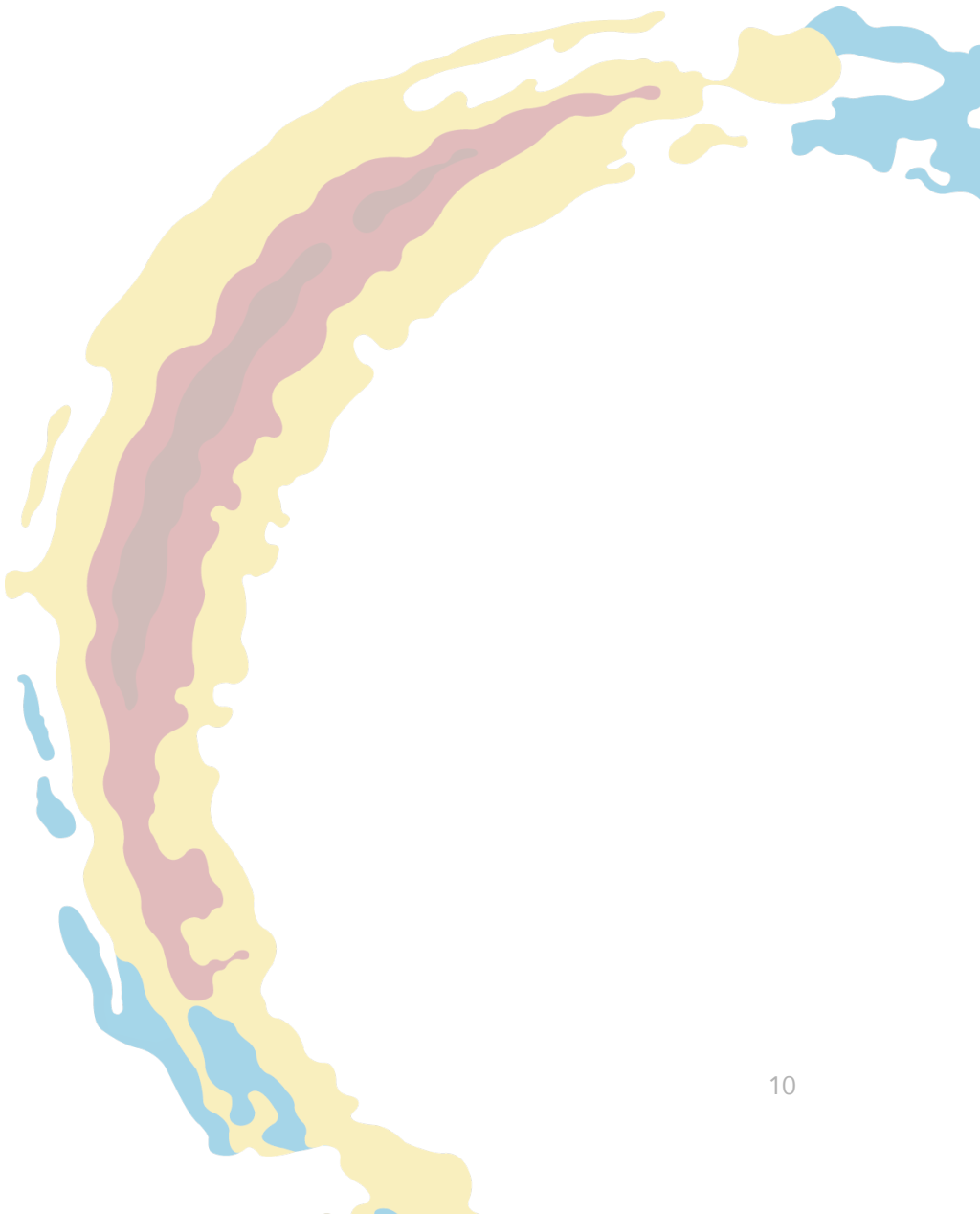
The Conference is an opportunity to identify specific priority actions that can be taken to help society prepare and to develop shared recommendations on El Niño messaging for development and practitioner communities as well as the public. The Conference can also enrich the discussion about long-term needs for improving climate services, in which El Niño and seasonal climate forecasts play an important role.

A principal vehicle for this is the Global Framework for Climate Services, which many of you have contributed to conceiving and launching and some are now working to implement. The GFCS provides a structure for systematic delivery of climate information and therefore has the potential to benefit from and assimilate the findings from the Conference. Your ideas as to how the GFCS can support the delivery of information about El Niño, its climate effects, impacts, and guidance on managing them will be directly relevant to its future implementation.

I am confident that the wealth of knowledge and experience represented at the Conference will generate new ideas and directions that will assist in managing the impacts of this event and those in the future. With the UNFCCC COP21 only weeks away, I assure you that WMO will do everything possible to take the climate services agenda, including the results of this meeting, forward during the UNFCCC negotiations and thereafter.

DAY 1

Tuesday, November 17, 2015



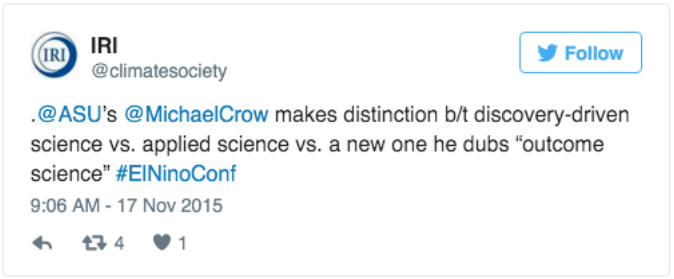
PANEL

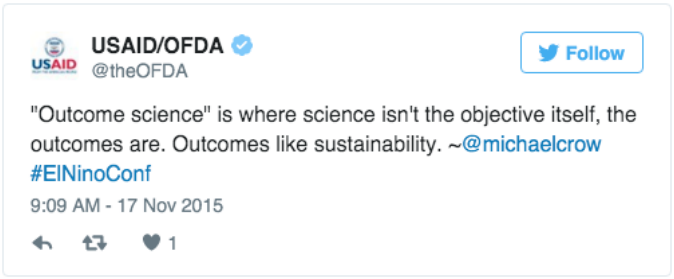
Looking Back to Move Forward

20 Years since the International Forum on Forecasting El Niño and launching IRI

Michael Crow, *Arizona State University (via video)*
Mark Cane, *Columbia University*
Mickey Glantz, *University of Colorado*
Mike Hall, *Retired, NOAA*
Moderated by **Jim Buizer**, *University of Arizona*

The opening panel of the conference consisted of pioneers in the field of El Niño-Southern Oscillation (ENSO) forecasting, ranging from those in academic administration and government who identified and supported the need for "outcome-based science," to one of the physical modelers who provided a foundation for the ENSO forecasting, to the critical social scientists who helped bring ENSO forecasting to the end user.





The coupling of "simple" ocean and atmospheric models in the Cane/Zebiak ENSO model was considered groundbreaking, significantly contributing to the future of not just ENSO forecasting, but climate forecasting in general. In **Mike Crow**'s discussion about the early days of the formation of the IRI, he mentioned the importance of translating scientific information for use beyond the scientific community. Crow stressed the importance of the transition from weather forecasting to climate forecasting, and noted that the development of scientific tools should contribute to mid- and long-term decision-making in the economic and political spheres and enhance quality of life. Crow referred to this as "outcome science," in which the objective is to seek an outcome. He hopes someday there will be a network of institutions focused on this kind of science, and that scholars across many disciplines will be involved.

Mark Cane provided anecdotal context around the first ENSO forecast. He recalled the skepticism at the time from broader climate science community towards the first Cane/Zebiak model results and subsequent forecast, and he reflected on their hesitancy to release the El

Niño forecast in 1986. Interestingly, this type of push-back is not uncommon across many technical and scientific fields, but is particularly relevant in the fields of climate science and climate mitigation engineering. Within the context of the first ENSO forecast, Cane framed the discussion around "What if you are wrong?" versus "What if you are right?" – two seemingly straightforward questions that have complex, far-reaching answers.

Mickey Glantz discussed the critical requirement of the social science component to climate forecasting and emphasized that climate science doesn't stop at the results from the physical models. Without the ability to carry the message beyond the physics to the relevant stakeholders and other users of El Niño information, the impact of the scientific or technical findings will be lost in the lack of translation or communication. A third end to the traditional end-to-end concept must be made explicit: that is, the forecast and research community must solicit input from stakeholders and other users of El Niño forecasts and warnings about their effectiveness and about what forecast information must include.

Q&A highlight

What would you like to be a turning point from this conference that really made a difference to how we conceive development today?

Answers

Hall: We need to really work at interdecadal variability and modes of variability and need to address North Atlantic thermohaline circulation.

Glantz: ENSO can serve as link between 'here and now' and climate change adaptation. Disaster relief efforts are inadequately tied to preparation and that we need "resilient adaptation" -- not preparing for the future so much as constantly preparing and adapting.

Cane: We need to develop trust, we can't worry just about the next 100 years but the next year, the next decade. There used to be a prohibition against talking about adaptation instead of mitigation. Now we can talk about adaptation, but need to talk about adaptation to climate in general, not just climate change.

Glantz memorably named some of the significant El Niño events that have occurred over the last 150 years, namely:

- 1877-78 El Niño.
- 1891: the downwelling phenomenon was first named "El Niño" at a conference in Lima, Peru. By 1982, this event was being described as the previous 'biggest El Niño'.
- 1957-58: **"The International Geophysical Year (IGY) El Niño"** Project to investigate coastal upwelling processes off the west coast of the US and Peru.
- 1972-73: **"The El Niño of the Scientists"** The collapse of Peruvian fisheries, and the identification of the ENSO teleconnections generated scientific concern.
- 1982-83: **"The El Niño of the Governments"** This El Niño was labeled the "El Niño of the Century" and generated awareness of El Niño as an economic threat to many governments, funding for monitoring increased.

- 1997-98: **"The El Niño of the People"** People around the globe became aware of the El Niño phenomenon.
- 2015: **"The El Niño of Response and Preparedness"** Naming this event a "Godzilla" El Niño did a disservice to the the seriousness of forecasting and raised expectations of potential impacts that fell short of reality.

Continuing with the overall theme of this panel, **Mike Hall** discussed the evolution of climate services and proposed the idea of a National Climate Service, stating that as with weather, constant assessment is necessary. He emphasized the importance of planning, stating that planning is what prepares you for the eventuality -- for being able to adapt, adjust and continue to move forward.

Hall named three key drivers that led to the creation of the IRI: 1) the implementation of general circulation models capable of capturing climate phenomena, 2) the application of physical science to "real people's real problems" and 3) identifying the value and necessity of incorporating social science as an integral component to the overarching climate science realm. These three drivers summarize the key points as discussed by the other members of the panel, with each member providing context from his specific discipline.

TALKS

The Current El Niño

Implications of a large El Niño event on global economy and development

Jeffrey Sachs
Director, Earth Institute, Columbia University

Key topics presented:

- Links between El Niño and global economy
- El Niño's compounding influence in areas already in crisis
- Effect on agriculture can lead to local shocks
- El Niño impacts in middle-income countries could be tipping points for global-level economic crisis
- Some regions of particular concern for instability

Several major El Niño events over the last 40 years (1972-1973, 1982-1983, 1997-1998) have been associated with global macroeconomic crises. While there isn't necessarily a tightly-coupled relationship between El Niño and the global economy, the impacts associated with El Niño teleconnections are potentially destabilizing, given the underlying states of geopolitics and economies.

At the global scale, Sachs said there are two big macroeconomic risks: simultaneous crops failures or other ENSO-related emergencies in impoverished countries; and tipping points in several middle-income countries already on the edge of crises.

ENSO can act as a shock or a crisis amplifier to countries that are already politically or financially stressed. For example, in poor countries with weather-dependent agriculture that have little buffering to shocks of ENSO, the shocks may lead to local conflict. The potentially more far-reaching economic effects are those in middle-income countries, where El Niño is an additional force that affects instability.

With respect the 2015-16 El Niño event, there are regions of instability significant enough that the El Niño teleconnections could create new tipping points or positive feedbacks that could be globally destabilizing. These regions include Middle East and North Africa,Southeast Asia (ASEAN countries), the Horn of Africa, South Africa and South America. In these regions, the impacts of El Niño have the potential to compound the effects of ecological vulnerabilities, geopolitical tensions and financial instabilities.

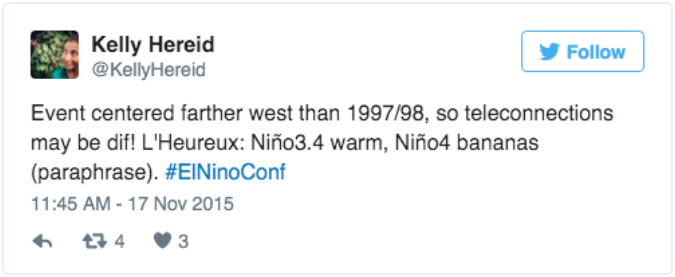
Update on 2015 El Niño event

Michelle L'Heureux
Climate Prediction Center, NOAA

Key topics presented:

- Definition of El Niño: historical and real time
- ENSO interacts with short-term variability (Madden-Julian Oscillation) and long-term warming
- Comparison of sea-surface temperatures, subsurface temperatures, winds, sea level pressure and precipitation in 2015 and 1997
- Comparative challenges that models had in 2014 and 2015 forecasts

L'Heureux's talk focused on the characteristics of the 2015-2016 El Niño event and how it has evolved. She pointed out that in a historical sense, NOAA defines El Niño by looking at the 3-month average of Niño 3.4 over five consecutive months. Operationally, however, the agency doesn't have the luxury of waiting eight months to determine if there's an El Niño, and therefore has to bring in other measures.

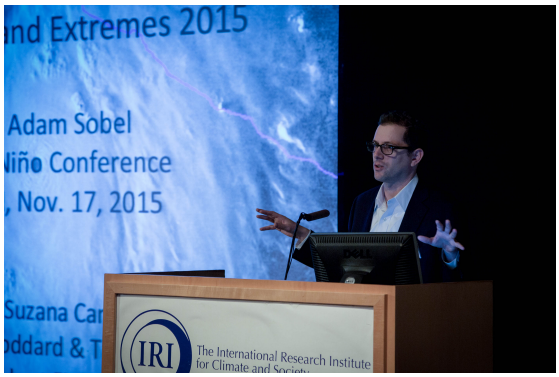


Sea-surface temperatures in the Niño 3.4 give only some indication of an El Niño's strength. For example, sea-surface temperatures in the Niño 3.4 region are comparable between the 2015-2016 and 1997-1998 events, but other indicators, including atmospheric components, point to 1997-1998 being a stronger event.

Associated extreme climate impacts and their certainty

Adam Sobel
Initiative on Extreme Weather and Climate, Columbia University

Key topics presented:



- There is no particular evidence that there are more disasters during El Niño years.
- Disasters are more predictable during El Niño years - we can see them coming.
- ENSO does make some extreme things happen that would be unlikely otherwise.
- Likelihood increases for active tropical cyclone season in the Pacific.
- El Niño and California drought
- This year's Indonesia fire season is one of the worst.
- Predictability of noncanonical sea-surface temperature features related to this El Niño

Sobel's talk focused on extreme climatic impacts associated with El Niño and their potential predictability. The onset of an El Niño event doesn't amplify the magnitude of every disaster, but it can cause extreme events to occur. Sobel also mentioned several other associated atmospheric anomalies with currently unknown relations to El Niño episodes, and questioned the potential for predictability in these aspects.

ENSO modeling and prediction: Evolution and outstanding challenges

Lisa Goddard
CLIVAR-WCRP; Director, IRI, Columbia University

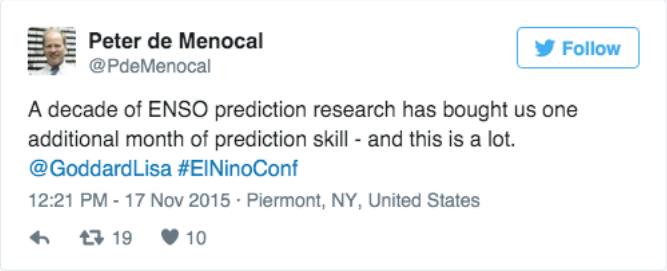
Key topics addressed:

- Challenges of modeling El Niño
- Biases in models and assessment of current conditions
- Challenge of representing physical climate processes faithfully
- The amount of time/effort to improve forecasts is not insignificant, but payoff can be substantial.
- The need for improvement on the characterization of risk and uncertainty in climate information

Goddard stated that missed forecasts provide the opportunity to improve models. Although the magnitude of the strong 1997-98 El Niño was accurately forecasted, challenges remain in predicting ENSO events and their impacts, as well as in acting on ENSO forecast information. Sea-surface temperature forecasts exhibit the highest skill in the El Niño region but lower skill in the western Pacific Ocean and the Indian Ocean. Other oceanic areas aren't predicted well, even with a short lead time.

Prediction systems consist of models, observational networks and data assimilation systems. Modeling challenges for El Niño include: 1) model biases, 2) biases and imbalances in the ocean-atmosphere state estimation and 3) representation of processes. Data assimilation challenges (e.g., from spotty observations and imperfect models) and the resulting initial conditions may lead to biases in the ocean-atmosphere state estimation. Poor characterization of wind variability is an example of a challenge in process representation.

Expected impacts do not quantify the likelihood of impacts; there is a need to translate model uncertainty into forecast risk or likelihood. Climate information can give decision makers objective and transparent ways to respond to El Niño impacts, but that climate information must be translated into socio-economic impacts and meaningful action.



Overview structure of available ENSO information & coordination – from a WMO perspective

Maxx Dilley
Director, Climate Prediction and Adaptation Branch, World Meteorological Organization

Key topics presented:

- Climate Finance - funding sources
- GFCS Meeting on Implementation Coordination
- El Niño information leading to climate services, examples from Bhutan and Burkina Faso
- Overview of the Global Framework for Climate Services including history, governance, priority areas and needs

Dilley began by introducing recent climate-related developments, such as the Sendai Framework for Disaster Risk Reduction, and he provided updates on the progress of the Sustainable Development Goals. A key priority is to attract investments in climate services to provide decision makers with better-tailored information.

He noted that disasters involving hydrometeorological hazards affect 55 times as many people and account for nine times the deaths and three times the economic losses as all other hazards combined.

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PANEL

ENSO Information and Coordination

Overview structure of available ENSO information and coordination

Zinta Zommers, *United Nations Environment Program*
Richard Choularton, *World Food Program*
Sezin Tokar, *US Agency for International Development/Office of U.S. Foreign Disaster Assistance*
Stewart McCulloch, *WorldVision International*
Moderated by **David Corcoran**, *former editor, New York Times Science Times*

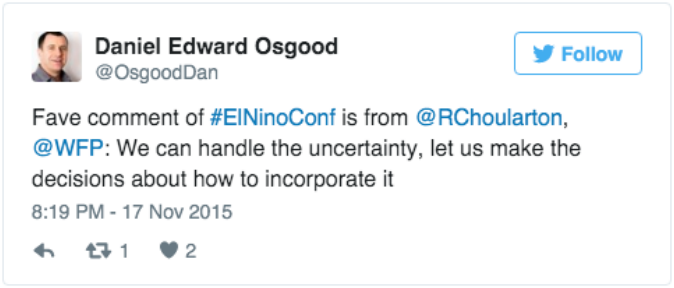
David Corcoran contextualized this discussion by pointing out that many individuals outside of the conference attendees know little to nothing about El Niño, let alone coordinating available information around it. Corcoran admitted that he knew very little about El Niño prior to being asked to moderate the panel, despite his time as science editor at the New York Times. Awareness of El Niño Southern Oscillation (ENSO) may not be necessary for some individuals, but there are decision makers across sectors (e.g. water and energy), who could utilize ENSO information (and climate information generally) to inform and improve their decision-making processes.

Corcoran asked the panelists to describe the human dimension of El Niño and how it affects the work their organizations do.

Zinta Zommers stated that the focus of the UNEP is through the lens of ecosystems to evaluate impacts on both ecosystems and society. She said that during El Niño years UNEP works with governments to build capacity on designing better early-warning systems, to understand the role of ecosystem services in disaster-risk reduction and to foster south-south learning.

Sezin Tokar explained that USAID OFDA leads disaster response abroad for US government. In recent years OFDA has responded to 65 disasters in 55 countries, e.g. Ebola response, Haiti earthquake response. The office also supports disaster-risk reduction, improved early warning systems and preparedness. During the 1997-1998 El Niño response, OFDA responded to 22 El Niño related disasters as well as engaged in climate outlook forums and worked with policy makers and practitioners to use climate information.

Stewart McCulloch said World Vision International works in 100 countries. He described microfinance initiatives that help one million families and a project funded by the UK's Department for International Development that is issuing microfinance loans to enhance recovery efforts.



Richard Choularton stated that WFP provides food aid to 80-100 million people each year. He also said that hunger and poverty are underlying issues exacerbated by climate shock. WFP helps people respond to climate disasters, and the only way it can do that is to understand the links between climate and food security and get better about acting. He noted that he is vice chair on the Global Framework for Climate Services' Partners Advisory Committee, which enables him to listen to the conversation and drive the agenda in a meaningful way from the users' perspective. "We don't need scientists telling us what we need to know, we need to inform them on what information we need to make decisions," he said.

The panelists also acknowledged climate risks and challenges that lie ahead, including vulnerabilities associated with reliance on rain-fed agriculture in many places. They posed some fundamental questions moving forward. For example, Zommers asked, "Is early warning a human right?" Tokar asked at another instance, "How do we get policy makers, practitioners and disaster managers to use climate information?"

Corcoran asked the panelists about their organizations get information, the quality of the information and how they disseminate it.

Choularton said WFP has a very sophisticated early warning system that includes climate and weather information. Over the years it has enhanced its understanding about the quality of the information and how to translate it into impacts. Determining the usefulness of the climate information -- for example, the level of uncertainty associated with seasonal forecasts -- is a significant task.

WFP reconstructed its early-warning and risk-assessment processes to include a chain of scientists and technical specialists who can filter the information before it is passed along to decision makers. These experts come from the World Meteorological Organization, national meteorological services and regional climate centers, as well as from technical food security partners.

Limitations with forecast certainty were highlighted to WFP in 1997-1998, when the organization was ultimately criticized for planning for a drought in southern Africa that never materialized. He underscored the importance of forming relationships and processes over

time that allow science partners to provide information to WFP technical staff who can send this to policy makers.

USAID OFDA relies on national meteorological services, NOAA and regional climate centers for information. Translating that information into response is often the trickiest part, said Tokar, who acknowledged that the vulnerability and exposure portions of risk calculations are often more difficult to predict than the climate conditions. Like Choularton, Tokar and later McCulloch stressed the need for reliable networks of experts, regional partners, NGOs, UN agencies and disaster management agencies from which to draw knowledge and information. She also said the information being provided could be more crisp and tailored.

Zommers noted that a lot of work goes into repackaging climate information for public consumption. She encouraged those organizations that operate in the space between climate information producers and users to relay information in a way that maximizes the diversity of potential climate information users. She also said that sometimes constituents trust religious institutions and NGOs more than government sources of information.

Relatedly, McCulloch stressed that suppliers of studies and data should communicate more with the nongovernmental organizations and other non-scientific groups. At some point, the individuals on the ground have more pertinent information than the scientists, he noted.

"You can't be a good supplier of information if you don't understand the need," said McCulloch, and similarly, "if people don't understand how to use the information it isn't going to be used well."

In response to a question regarding the media's role in covering El Niño, Tokar and Choularton noted that the media does a great job of bringing awareness to issues including El Niño. On the other hand, the media can sensationalize stories and often fails in communicating the uncertainties associated with possible impacts of El Niño. Tokar noted that the sensational media treatment of the potential 'Godzilla' El Niño in 2014 placed USAID in a difficult position. The panelists cited the need for better media accountability to represent uncertainties. Everyone agreed that it would be hard to imagine a news anchor explaining that there is a 75% chance that a moderate-to-strong El Niño event will occur in the upcoming winter months and that, as a result, there is a 60% chance a region will experience above-normal precipitation. It may be helpful to create and disseminate tailored talking points to news agencies which avoid the 'monotone bore' often associated with scientific explanation but still which retain the meaningful information associated with seasonal forecasts.

The panel provided a great opportunity for physical scientists in the audience to understand the perspectives of the organizations that depend on climate information products such as seasonal forecasts. The panelists suggested that going forward more communication is necessary between physical scientists who create climate products, organizations that filter and disseminate information and end users. In this way, the work done by the physical scientists can be better targeted and translated into appropriately flexible, useful products.

PANEL

Current Event Case Studies

Case Studies on current event information, plans as well as current and anticipated impacts

Rodney Martinez, *Centro Internacional para la Investigacion del Fenomeno de El Niño (CIIFEN), Equador*
Ken Takahashi, *Instituto Geofisico del Peru*
David Farrell, *Caribbean Institute for Meteorology and Hydrology (CIMH), Barbados*
Guleid Artan, *IGAD Climate Prediction & Applications Centre (ICPAC), Kenya*
Sulochana Gadgil, *India Meteorological Department*
Tony Lucero, *Philippine Atmospheric, Geophysical and Astronomical Services Administration*
Moderated by **Simon Mason**, *IRI, Columbia University*

Six international experts convened for this panel session to discuss how El Niño is addressed in their respective climate service organization. Overall, two common themes emerged among the panelists: identifying seasonal climate and weather variability during an El Niño event and communicating its impacts.

El Niño can have both local and regional impacts. The Caribbean region experienced one of the strongest droughts on record during the summer of 2015, and water resource deficits are expected to continue into the winter dry season. Water demand during the dry season is compounded by the increasing number of tourists that visit the Caribbean during the popular winter months. Thus, **David Farrell** from CIMH suggested a more integrated method to develop water-resource decisions is needed in order to sustain the local population while supporting the lucrative tourism industry. While the seasonal climate impact from El Niño is regional throughout the Caribbean, local convection-scale impacts are observed in other parts of the world, such as in the Philippines. **Tony Lucero** noted that the strong likelihood of reduced rainfall during an El Niño event increases the risk of drought in the Philippines. The most severe droughts the country experienced over the last several decades occurred during the strong El Niño events of 1982-83, 1986-87 and 1997-98.

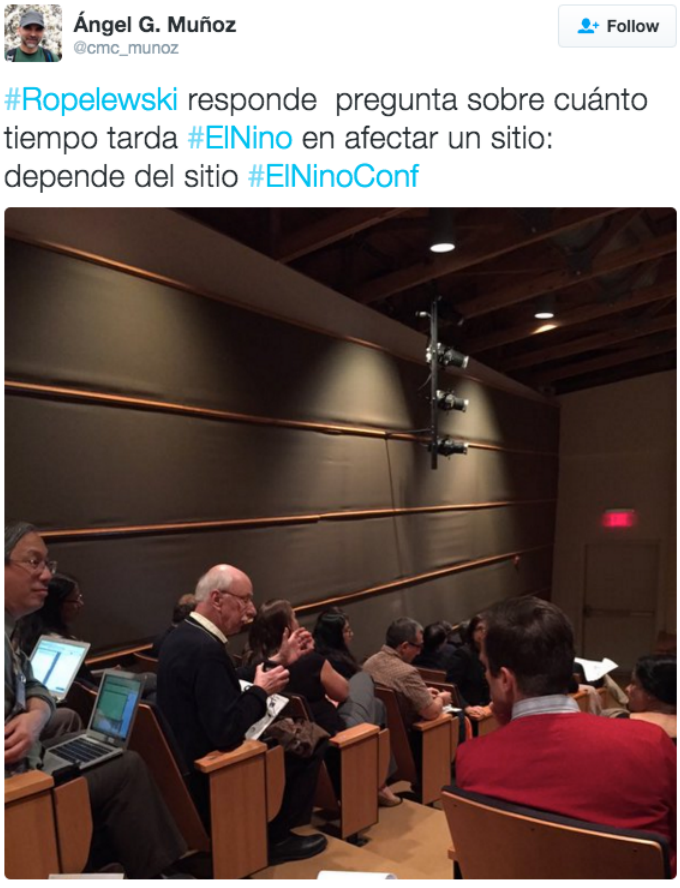
Peru, on the other hand, experiences impacts from both local and remote forcings. **Ken Takahashi**, in representation of ENFEN (the official Peruvian El Niño assessment committee), noted that regional impacts along the Peruvian coast, such as heavy rainfall and flooding in this otherwise arid region, depend on local sea surface temperature (SST; e.g. Niño 1+2 region), while remote warming in the central

Pacific (e.g. Niño 3.4 region) can lead to rainfall deficit in the Peruvian Andes and Amazon. The difference between remote and local effects imply a strong sensitivity of the impacts to the El Niño pattern and strength. However, the large diversity among events (e.g. eastern Pacific vs central Pacific El Niño) makes it difficult to assess the El Niño impacts in general. Particularly, the very large eastern Pacific warming during El Niño in 1982-83 and 1997-98 produced rainfall equivalent to the other forty rainiest years combined in northern Peru.

Thus, for decision making in Peru, it is critical that "El Niño" is not used as a catch-all phrase but that potential impacts are assessed considering both the SST pattern and strength, for which ENFEN uses both Niño 1+2 and Niño 3.4 SST as its main reference indices. Information from reliable foreign sources using less nuanced definitions continue to generate confusion in the Peruvian population and authorities.

CIIFEN, based in Ecuador, and ICPAC in Kenya were developed to improve climate services at regional scale to contribute on risk management and adaptation. CIIFEN emerged after the 1997-1998 El Niño from the demand to develop and communicate El Niño impact information for decision makers in Latin America and is now a designated WMO Regional Climate Center.M

Rodney Martinez of CIIFEN said it is crucial to communicate the diverse impacts of El Niño while emphasizing the regional and national particularities which could help minimize confusion. He highlighted how much the similarities of the current El Niño with previous events could help people better understand the potential impacts. Also potentially useful to strengthen the interface with policy makers is to quantify El Niño's effect, e.g., impact on gross domestic product or other sectorial and social indicators. The scale factor could trigger decision making and foster climate services requests/ provision at national level. Limited but clear climate information, successfully delivered, could make the difference to enhance users' responses and mitigate El Niño's impacts. The poorest segments of the population are the least informed, Martinez noted.



ICPAC was established in 1989 in response to prolonged drought in East Africa during the 1970s-1980s. **Guleid Artan** said the current event is unlikely to be similar to the 1997-98 one for Kenya, but it still faces the risk of devastating floods. Both CIIFEN and ICPAC work to apply local scales of knowledge from information provided by larger global forecast centers to monitor and forecast hydrologic variability related to El Niño.

In some cases, such as India, the government responds directly to climate service information on critical phenomena such as droughts of the monsoon by the India Meteorological Department. The seasonal forecasts of a drought of the Indian summer monsoon rainfall in 2015, issued by this national service, proved to be very accurate. **Sulochana Gadgil** mentioned that the government of India developed a cell under the cabinet of secretary to monitor drought and advise about agricultural strategies and water management during the El Niño drought of 2002. This cell was also used to tackle the droughts of 2009, 2014 and 2015.

The importance of integrated decision making was discussed by all of the panelists. Better integration can stem from, for example, networks of regional consortiums, improved national political structure or interaction between national sectors. A second topic of discussion centered on the use of analogs to compare current events to historical events of similar magnitude. The obvious example during this session was the comparison between the 1997-98 El Niño and the current El Niño. Physically, no two El Niño events are alike, which can cause exact comparisons to be misleading. However, memory between similar events makes impact communication easier for each of the organizations represented in the panel.

PANEL

Messaging on El Niño

How do we inform the public (who informs what public), and what do they hear? How has this evolved over the last 10-20 years?

Patrick Luganda, *Chairman, Network Climate Journalists in the Greater Horn of Africa*
Mickey Glantz, *Director, The Consortium for Building Capacity, University of Colorado*
Eric Roston, *Bloomberg News*
Moderated by **David Herring**, *Director of Communication and Education, Climate Program Office*

David Herring introduced the topics to be discussed by asking whether people outside the science community would identify the commonalities between, for example, crop failures and Indonesian fires in 1998. He argued that in the 1980s and 1990s, the public became more aware of El Niño and its impacts, partly due to both the media and scientists becoming better communicators of science. He then asked the panelists and audience to comment on how science communication has evolved in recent years.

Comments from the audience related that El Niño Southern Oscillation (ENSO) information exists, but does not necessarily reach the public and when it does it may not be in a useful or "actionable" form. The audience also questioned what is considered useful; different public sectors might interpret utility in different ways. Additionally, communicating uncertainty is, in the view of some in the audience, still an issue that reflects on the science credibility.

The panelists were invited to state their views on communicating climate science.

Mickey Glantz questioned the usefulness for the public to understand El Niño. He noted the differences in the public's understanding of climate information. Some are dismissive, while others are more attentive to the available information. Some are "gatekeepers," having the task of informing the policy makers. And finally, there are the decision makers themselves. He also mentioned that if forecasting El Niño onset, for example, is hard and uncertain, this should be communicated to the public and labeled "experimental" while the regular forecast remains the main "operational" product. There is no silver bullet forecast that will please all. Glantz continued by asking scientists and science communicators to educate people about the consequences of ENSO, because the real first responders are the victims; they are the ones that need to take action when hazard is imminent. He also added that this year's El Niño will hopefully be known as the El Niño of adaptation, or response, not the "Godzilla" El Niño.

Patrick Luganda stated that there is an assumption that victims need to be rescued, as El Niño is portrayed to bring losses and there is a lack of communication about opportunities. He added that early intervention has proved successful, citing the example of Red Cross intervention in Uganda to prevent losses from floods. He explained that ordinary people translate scientific jargon into their own language and understand that two ENSO events are not the same. Luganda concludes that scientists and science communicators should learn from communities, and that there is generally need for more scientists and media involved in getting the stories across.

Comments from the audience echoed Luganda's assessments. One participant mentioned communities in Kenya taking advantage of floodwaters upstream to their benefit, while another participant mentioned that understanding how civil defense agencies work increases the usefulness of the forecast.

Eric Roston was asked how media attention can help ENSO awareness, to which he responded, "Take facts and exaggerate!"

Roston cited some headlines that capture people's attention, such as "Huge El Niño spreads mayhem around the world", or others in which studies show relationships between extreme heat and low birth rates. He also alluded to the power of media to force action, recalling the case when problems with defective data buoys were solved prior to the release of a media report. Roston also argued that there are two interpretations to climate change: one that is political and another that recognizes climate change is happening, prompting industries and communities to change behavior accordingly. He added that while communicating climate information, one should get people interested by linking the topic to their own interests, and that data visualization drastically

Q&A highlight

Could this El Niño help get people interested in climate change?

Answer

Roston: There is immense appetite for ENSO news, especially from investors.

Talks in this conference have discussed response to extreme events and disasters, but is better preparedness the result of better communication or because people have adapted to previous events?

Answers

Luganda: Communicating disaster effectively can mean the difference between life and death. Delays in ENSO forecast can lead to food crisis, and there is little room for debating forecast, thus people tend to trust the information.

Roston: The way in which communicators reach people is as important as the information they're trying to get across.

For whom are we communicating?

Answer

Luganda: In the US, food is in your pocket. Food is purchased from your wallet. For subsistence farmers, food is in your garden that responds to the environment. Quality and type of information differs depending on the audience.

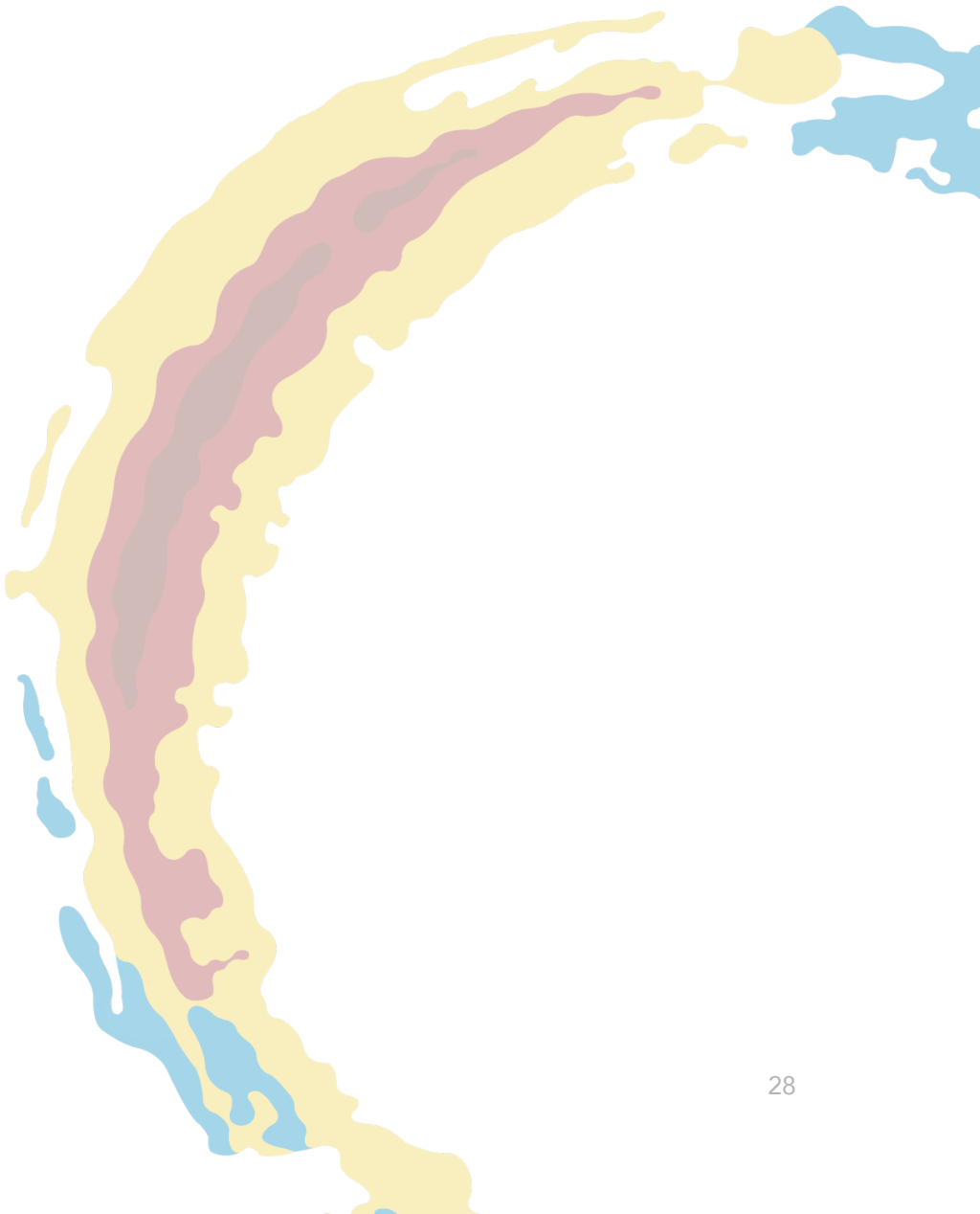
improves information dissemination, but it must be simplified. Finally, he noted that climate variability is a harder topic to understand compared to climate change.

Audience member Kevin Trenberth, in response to Mickey Glantz' question of what it means to be "El Niño ready" asked, "what is El Niño?" In the context of climate change, El Niño is very hard to define. He added that the responsibility of a local forecaster is to tell people what that forecast really means. Glantz challenged this assessment, commenting that scientists coined the term El Niño and now seem doubtful of its definition. Luganda noted that El Niño means different things for different communities.

Herring described his experience in trying to address very specific user's questions related to the California forecast. He asked whether we are interacting with the public in a way that meets their needs. To that question an audience member asked whether regular forecast updates from the World Meteorological Organization are useful, to which Luganda replied that they are indeed useful and that there is a lot of confidence in those products. In his opinion, the physical science is doing well, but the social science needs to improve.

DAY 2

Wednesday, November 18, 2015



PANEL

Sectoral impacts of El Niño – What have we learned since 1997-98?

Madeleine Thomson, *IRI, Columbia University*
Upmanu Lall, *Columbia Water Center, Columbia University*
Carina Bachofen, *Red Cross Red Crescent Climate Centre*
Alberto Troccoli, *University of East Anglia*
Moderated by **Roger Pulwarty**, *National Oceanic and Atmospheric Administration*

Roger Pulwarty framed both physical phenomena and the responses to those phenomena along a timescale continuum from subseasonal to centennial. For example, short term events can be forecast through early-warning systems, interannual events can alter our resource allocation and decadal to centennial events can alter infrastructure design. This set the tone for one of three main themes in the session, which were:

1. How each sector responds to climate variability across the continuum of time scales.
2. The necessity to focus on the connections between sectors. These problems are systems-level issues that cannot be sectioned off into compartmentalized aspects.
3. We need to disseminate information to users in a manner that is accessible and digestible.

Madeleine Thomson touched on this continuum in the context of making climate data available to users as a means to improve the decision-making process. She pointed out that much has changed since the 1997-1998 El Niño – not only in our ability to predict its occurrence and impacts but also in social and economic development that underpins population vulnerability. She noted that in the case of malaria, precipitation and temperature influence the suitability of the vector carrying the disease. When ENSO alters the patterns of precipitation and temperature, forecast information can be applied to resource allocation and prevention efforts. This requires, however, that historical as well as current information is available to decision-makers. Such information has been lacking in many developing countries, but with new initiatives such as Enhancing National Climate Services, known as ENACTS, products and services are increasingly available online in a number of African countries. In Ethiopia for example, the government was forewarned about the likelihood of a significant drought in July-September 2015 and was much better prepared to respond than during previous extreme drought emergencies.

Upmanu Lall discussed how the water sector responds to risks, and why we may not be very good at responding to long-term risks. For example, due to operating procedures, politics

and historical precedent, government agencies tend to take action only when information is very certain. So although water is a public good, we may need to turn to the private sector, which is more able to capitalize on probability and risk issues. The financial sector is a good example. Lall noted that every country is interested in economic productivity, and he stated that we need a linkage for structural elements of (climate) risk management that are backed up by financial instruments. But this isn't very common in the infrastructure community. Reinsurers need to aim reinsurance at infrastructure since the construction and running of this infrastructure is on timescales divorced from decision making.

Carina Bachofen provided a prime example linking health, financial instruments and climate forecasts through the Red Cross Red Crescent Climate Centre's initiative of Forecast Based Financing. She explained the shortfall of funding between short term disaster-response measures and long-term disaster planning. The Climate Centre is looking at how to release funding following a forecast but in advance of a disaster to mitigate risks by not needing to wait for the disaster to occur. Just before this conference, the Uganda Red Cross distributed non-food aid triggered by forecast-based financing that was made available by the climate forecast. In this way NGOs are looking to bridge the scales inherent in both the physical phenomena and in consequent responses.

Alberto Troccoli spoke about the impacts of climate on the energy sector, noting that supply and demand of energy are highly sensitive to variations in climate. When considering timescales for infrastructure development he stressed that we need to focus on the long term rather than the short term. Many companies currently develop solar or wind infrastructure based on between one and three years of data. But climate phenomena such as ENSO and other longer-term fluctuations and trends can significantly impact these energy sources via changes in incoming solar radiation, wind speeds and other variables, so estimates based on a few years may be misleading. He noted a few specific impacts of climate variability on the energy sector, including hydropower dam water levels in Kenya, heat waves and nuclear power production in France and flooding of coal mines in Australia. Troccoli said that action and discussion is moving through the Global Framework for Climate Services and the World Energy & Meteorology Council, and that there is an active community developing climate services for the energy sector.

Each panelist also spoke on the second theme -- the necessity to consider these problems as systems-level issues. Lall framed his talk almost entirely as a systems-level problem, and he

proposed that we start looking for systems-level solutions that may be outside of one specific sector. His example was to use financial instruments to fund infrastructure as a climate risk reduction measure. Bachofen focused on the need to develop standards for disaster risk reduction. Disasters tend to encompass climate, communities, finance and infrastructure. In this way we need a metric for these linkages so funders can be assured of the reliability of a project. Troccoli brought up interconnectedness among sectors again in his concluding remarks. As we often have short and scattered observational records within sectors, he stressed the need for collaboration on this interconnectedness across sectors.

Bachofen spoke of the need to disseminate information using accessible media, the third theme that emerged from the panel. As an example, she showed an animation that brought together climate scientists, animators and celebrities to produce a number of short animations locally tailored to the public in Vanuatu about risks from ENSO and potential ways to prepare for the impacts. Bachofen also mentioned the initiative Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED), in which multiple NGOs have come together to coordinate tailored information using webinars, online discussions, data portals etc. Thomson used the example of a climate data portal developed in conjunction with the Ethiopian government as a way of encouraging exploration of risks specific to Ethiopia.

TALKS

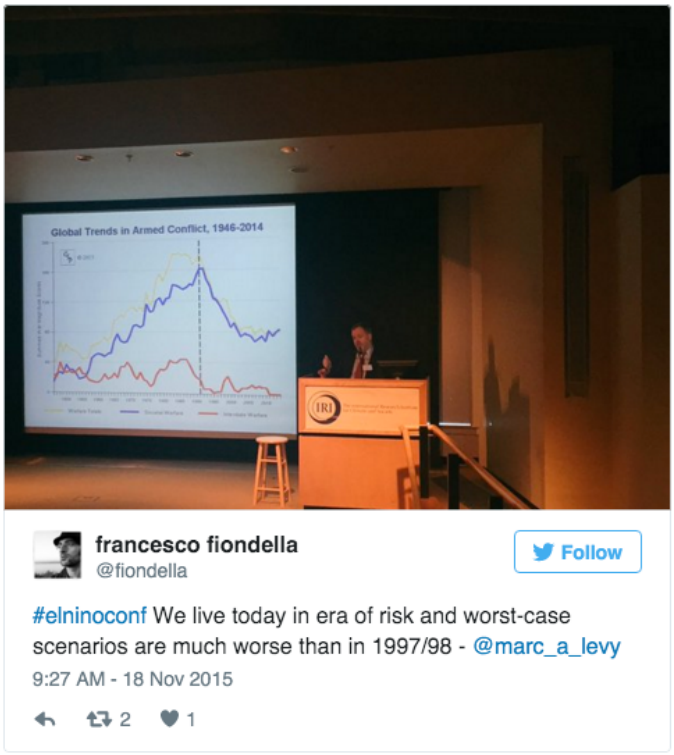
El Niño and Climate Change

El Niño and Global Change

Marc Levy
Deputy Director, Center for International Earth Science Information Network (CIESIN), Columbia University

Key topics presented:

- What makes this El Niño different in the global social, economic and political arenas
- Social changes have many parallels to the dynamics of the climate system.
- Exponential increase in social-driven pressures
- Changes in climate as well as social and economic structures mean this El Niño is taking place in a different world than previous major El Niño events.
- We are in a state of intense political transition.



Levy's talk focused on how the 2015-16 El Niño has unfolded given the different global context compared to past El Niño events. Impacts of climate are felt in the social, economic and political realms. With a rapid increase in socially-driven pressures such as globalization, population change and political transitions, Levy argued that our world today is less El Niño-resilient than during the 1997-98 event. Risk profiles of nations and individuals have changed, and the potential damages of the El Niño are worse than before.

WCRP/CLIVAR efforts to understand El Nino in a changing climate

Eric Guilyardi
IPSL/LOCEAN - France, and NCAS-Climate/University of Reading - United Kingdom

Key topics presented:

- CMIP3 model biases are substantial, underestimating both Bjerknes wind stress feedback and heat flux response.
- There is no clear improvement of the biases going from CMIP3 to CMIP5.
- Without enough statistical data, we have to rely on physical understanding and process-based metrics.
- New research is focusing on the role of the atmosphere and climate dynamics.
- The TAO-TRITON array has been essential to ENSO progress. Updates to that observing platform presents a unique opportunity to design something ambitious, but the community must proceed with caution when making fundamental changes.

The Climate and Ocean: Variability, Predictability and Change project, or CLIVAR, is one of the four core projects of the World Climate Research Programme. Guilyardi introduced CLIVAR's objectives in its study of changes in the Earth's climate system.

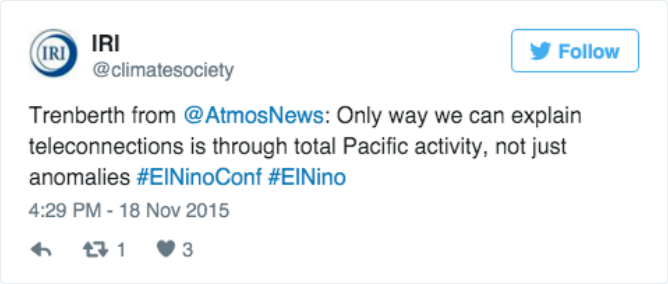
As no two El Niño events are alike, statistics alone don't help us understand changes in the El Niño-Southern Oscillation. A minimum of 250 years of observational data is required for simulations to statistically distinguish changes in ENSO amplitude. Guilyardi made a case for moving from a sea-surface temperature performance metric to process-based metrics in studying ENSO and the likelihood of extreme El Niños in unmitigated climate change.

The Intersection of El Niño and Climate Change – El Niño's contribution to 2015 global temperature

Kevin Trenberth
Climate & Global Dynamics, National Center for Atmospheric Research

Key topics presented:

- Comparison of historical record of temperature, CO2 levels and ENSO
- Quantification of El Niño's influence on global mean temperature
- Earth's heat budget and ocean heat loss/gain during El Niño/La Nina
- El Niño's influence on the jet stream, floods and droughts
- Global temperature and the Pacific Decadal Oscillation
- Global warming and its impacts on frequency of El Niño events and intensity and frequency of floods and droughts



Trenberth discussed the relationship between climate change and El Niño. illustrated that El Niño Southern Oscillation (ENSO) is the main source of interannual variability in global mean temperature. La Niña and El Niño events also affect floods and droughts around the world. He brought up the question of how best to measure the state of El Niño and its impacts. Trenberth also provided evidence of global warming and discussed the interaction between climate change and El Niño. He noted that climate change could potentially lead to more intense and frequent occurrences of floods and droughts.

El Niño, ecosystems & carbon

Miguel Angel Pinedo-Vasquez
Earth Institute Center for Environmental Sustainability, Columbia University; Center for International Forestry Research (CIFOR)

Key topics presented:

- Indonesia's emissions mostly come from burning of peatlands; however, estimates are poor because data collection/validation is weak.
- Peat fires often burn underground and are hard to detect with satellites, so more on-the-ground measurements needed to improve the observational network.
- Misnomer of Fall 2015 "haze." Health impacts that followed were a "humanitarian crisis" and "silent tragedy."
- Fire issue is complex, involving multiple actors, multiple land-use types and multiple drivers (e.g., social, political, economic, climate, weather).

Pinedo-Vasquez discussed the role of land use in Indonesia with respect to global carbon emissions, the 2015 haze event and the human dimensions of the carbon cycle in Indonesia. In the Southern Hemisphere, 65% of the variation in interannual CO2 concentration comes from changes in the biosphere, while the remaining 35% is from fire emissions (land use). In addition, annual increases in CO2 are higher during El Niño years. Pinedo-Vasquez indicated that there are significant gaps in understanding how deforestation contributes to emissions. The AR5 report by the Intergovernmental Panel on Climate Change indicates a decrease in CO2 emissions from forestry and other land uses due to a slow down in deforestation. However, this masks regional trends in Asia, where a reduction in emissions is primarily due to afforestation in China, while in Indonesia, emissions from deforestation have increased since 2000 and recently stabilized. Pinedo-Vasquez stressed the need for downscaling global climate information to regional scale, more field observations, and a greater focus on impacts on economies and human health.

PANEL

Responding to El Niño

2015 Response Strategy – What is or should be in place

Rizaldi Boer, *Director, Centre for Climate Risk and Opportunity Management in Southeast Asia Pacific*
Jen Stephens, *United Nations Development Program*
Amir Abdulla, *Deputy Executive Director, World Food Programme*
Megan Linkin, *SwissRe*
Moderated by **Heidi Cullen**, *Climate Central*

The objective of this session was to highlight response strategies currently in place for the 2015 El Niño. Several themes emerged from the talks presented during this session:

- There is a need for strengthened early warning systems to inform decision-making.
- A spectrum of actions can be taken to enhance preparedness, resilience and responses to climate shocks.
- There is a need for capacity building and inter-institutional and inter-sectoral cooperation to enhance risk management.
- Seasonal forecasts are being used to plan for and respond to climate-related impacts.

Rizaldi Boer provided insight into how Indonesia is managing fire risk and how fire risk management could evolve to be more anticipatory given the relationship between El Niño, drought and increased fire risk. Boer explained how "hotspots" of increased fire risk are identified using both rainfall and other vulnerabilities (e.g. biophysical sensitivity, adaptive capacity and exposure). This information is used to create fire risk maps to inform when and where resources should be allocated to coordinate fire management efforts. Government users have provided feedback that the tool needs to be more simple. Boer also noted that often early-warning systems do not provide enough lead time for adequate, active preparation measures. In addition to improved early warning, Boer described the need for a long-term fire management strategy that incorporates anticipatory, preventative and emergency response actions over a timescale of days (emergency) to years (anticipatory). A strategy such as this would be part of a larger program of sustainable development. Developing and implementing such a strategy requires "tiered" partnerships and alliances from the local to the national level as well as cooperation from private entities. Finally, Boer listed ideas for incentive programs as well as stronger law enforcement as strategies for changing behavior that increases fire risk.

Jen Stephens emphasized the need for enhancing climate risk management within the context of long-term development and building resilience to buffer communities when shocks or disasters occur. She highlighted three areas where more effort is needed to enhance disaster preparation and resilience efforts: 1) information management, 2) coordination and 3) technical support. Within these areas, Stephens also noted the need for strengthening early-warning systems, in addition to building regional mechanisms to share and disseminate information, building partnerships, and strengthening institutions and policy systems. Examples from Uganda (water management strategies) and Kenya (alternative livelihoods) demonstrated efforts to enhance community resilience and preparedness. In addition, both countries developed national contingency plans that outline multi-sectoral strategies for preparing for, responding to and recovering from El Niño impacts. Stephens remarked that awareness of El Niño in theses two countries is quite high, but there is more to be done with respect to capacity building and enhancing risk management within the context of both climate variability and climate change.

Q&A highlight

What is the range of timescales of weather and climate information SwissRe uses to develop insurance indices?

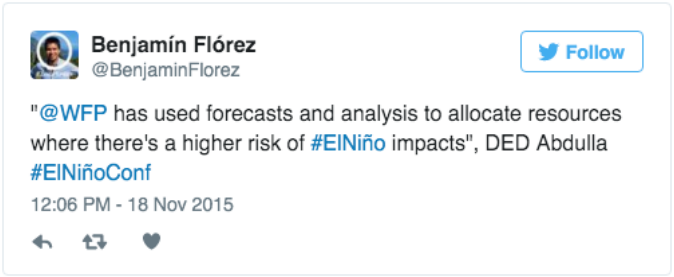
Answer

Linkin: It depends on the sector and hazard. Information used can range from two-week forecasts (e.g., for hurricanes) to seasonal or multi-seasonal forecasts (e.g., for the energy and commodity sector) to decadal phenomena such as the Atlantic Multidecadal Oscillation.

Amir Abdulla described the evolution of the World Food Programme's use of seasonal forecast information to inform the its activities. Over the years, WFP has adapted to preparing for El Niño impacts on food security in addition to responding to food security challenges posed by El Niño. This includes using early warning systems and seasonal forecasts to inform resource allocation, procurement activities and financing. Abdulla noted that one of the advances he has observed in WFP's approach to preparing for El Niño and minimizing food security impacts is the use of seasonal forecasts to inform "forward procurement" and advanced financing. Forward procurement minimizes impacts to supply chains, while advance financing allows the purchase of food supplies pre-disaster, when the food prices are generally lower. Abdulla acknowledged that while forecasts can be wrong, the risks of not taking action are too great, and thus WFP continues to rely on seasonal forecasts to develop flexible, reliable response systems and build resilient communities. He stressed the need for building resilience, noting that some communities or regions are subject to cumulative impacts of multiple El Niño events over many years. Finally, Abdulla commented on the need for funding and financing mechanisms to allow for continued research and response.

Economic and insured losses have been increasing over time due to more people and assets located in areas that are at high risk for hazards or disasters. **Megan Linkin** described an alternative to traditional insurance known as parametric or index-based insurance, which is

based on the characteristics of a natural hazard or disaster rather than losses. She noted that the indices are developed by independent third parties (e.g., the U.S. Geological Survey). SwissRe is especially interested in ENSO's influence on droughts and Atlantic hurricanes. Although not explicitly considered in SwissRe's modeling framework, El Niño-related impacts and events are important for the energy, commodities and agricultural sectors and, consequently, the insurance contracts associated with those sectors. Thus, Linkin noted that reliable weather and hazard data is needed to inform index-based insurance.



Heidi Cullen summarized the key points. She noted that, starting with the initial work of Mark Cane and Stephen Zebiak, the climate community has learned that it can investigate science, improve forecasts, and respond early to the impacts of El Niño.

PANEL

Science for Society

What is needed to evolve science towards increased societal benefit?

Jim Buizer, *University of Arizona*
Simon Mason, *IRI, Columbia University*
Andy Jarvis, *The International Centre for Tropical Agriculture*
Ed Carr, *Clark University*
Kanta Kumari, *World Bank*
Moderated by **Francesco Fiondella**, *IRI, Columbia University*

Francesco Fiondella opened with a straw man question: With the improvement of climate models and with societies continuously having benefitted from improved scientific understanding, why not just keep on a current business-as-usual path?

Jim Buizer spoke first, asking, how do we define a climate service? He listed some milestones in climate information services:

- 1986: Mark Cane and Steve Zebiak's first forecast of El Niño, beginning of a climate information service.
- 1995: Formation of the International Research Institute for Climate Prediction.
- 1997 Regional Integrated Sciences and Assessments
- 1997-98: Regional Climate Outlook Forums
- 2006: National Integrated Drought Information System (NIDIS)
- 2012: Global Framework for Climate Services
- 2013: International Research and Applications Program

Buizer also put forth some ideas to be explored, namely, the tension between local and scaled services as well as defining our entry point. He made the following recommendations for moving forward:

- Revisit our notions of institutions – the current approach will not work for the 21st century
- Form fully integrated teams that include end users and scientists
- Centralize things that are efficiently centralized, and decentralize the rest of our operations
- Put stories and data together
- Build rigorous evaluation from the outset -- quantitative if possible

In order to help illustrate the challenge of identifying information that would actually be required to facilitate a decision, **Simon Mason** used an example of going to the doctor. During his visits, Mason is mainly concerned with three questions: 1) how long will I be off running? 2) Do I have to take all of these pills? 3) Do I have to give up chocolate? These questions disregard the underlying medical condition. Mason contended that such a framing could apply to climate information as well. Sometimes we ask the wrong questions, Mason said.

Low skill of seasonal forecasts often isn't the problem. Insurers, for example, can profit from highly uncertain forecasts. The problem, and limiting factor, is the uncertainty of the impacts. If we can quantify the uncertainty of the impacts, deciding what actions to take would be simplified. But we need to start by quantifying the uncertainty in the climate forecasts properly. Many regional forecast forums include discussion of model results. But often there isn't talk about whether the models in the ensemble have skill in the locations of interest, or how the model results might be interpreted given the skill. The model uncertainty needs to be represented in a more accurate and useful way.

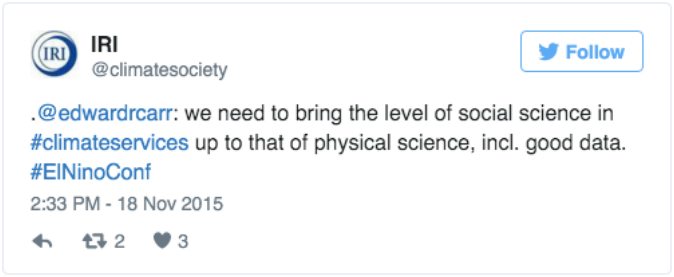
Mason said the onus is on both information providers and users to ensure the information is relevant and useful. For example, seasonal forecasts should be converted to products with sensible indications of uncertainty rather than simplistic model outputs. The NOAA Climate Prediction Center is providing good examples, Mason said. "We need to stop releasing our naïve model outputs and release properly calibrated forecasts." He said we can move beyond the tercile forecasts and instead present the information in more flexible ways that can address many questions.

There is a lot of hype about agriculture and climate services, said **Andy Jarvis**, yet many farmers do not know about the information available. Climate services stop at the service provider–the website where the information is stored–and are often not used. They will improve with feedback up and down the chain of product generation (scientists) and users (farmers).

While there are few examples of services reaching the farmer, Senegal serves as a success story. A program there began as a pilot with thousands of farmers, Jarvis explained. The national institutions then became involved, and the program is now reaching 3 million farmers, who receive novel climate information that they appreciate. The success of the program was due to lining up climate people, meteorological people, government, farmers, etc. Colombia has also been successful: farmers have much more information on when to plant and what to plant. Jarvis commented that luck plays a role in some of this work. "In Senegal, we correctly predicted the timing of rain onset during the first year of the program. This created a huge amount of trust and awareness. On the other hand, we should be careful not to launch information that is highly uncertain."

Jarvis also noted that farmers have three levels of questions, each with increasing complexity: 1) when to plant and when not to plant, 2) what to plant, 3) how to plant, i.e., management.

How do we get to this last level? Agriculture management model development is even richer now due to climate information services and climate science, said Jarvis. These models have potentially tremendous impacts.



Ed Carr asserted that the focus should be on pointing out and discussing relevant climate information. For example, projecting levels of rainfall as percentages or other scales above or below some kind of historical normal doesn't make much sense if there is practically no rain anyway in the period of the projection (as there can be huge swings in percentage above/below normal with very little total change in precipitation) and there is no activity which would require the rain during that period of projection.

"There is way too much social science dilettantism. You don't want me to run climate models, so let social scientists help all you physical scientists."

Conversations with users are difficult, Carr said, because we need to ask and understand not just what they are doing but why they are doing things. The identities of individuals play a role in how people are making a living. People with different identities often undertake different activities, and do so for different reasons, than those with other identities. Some of these people undertake activities where climate information is useful. Others do not. Some can act on particular forms of climate information, or particular timescales, while others cannot.

Carr recalled an observation during his work in Senegal: if a women makes too much money by switching crops (i.e. making a rational switch between crops after being told by outsiders that a crop switch will be beneficial), she may open herself up to other sanctions, such as being beaten by her husband because she has "gotten out of line" by becoming the breadwinner at home.

"Let's not get too self-congratulatory about the social science work being done. Things are being published in climate journals that wouldn't be published elsewhere in social science literature. We need better social science in this area."

Carr also pointed out that we act progressive about engaging end users with our information, right up until there is a crisis. Then we revert to colonial mindsets about saving people and stop engaging them seriously (see Gadgil's point below). This is a major problem, because climate services are used for disaster-risk reduction and adaptation work, and both of these are areas where crisis narratives can set in and disempower the end users

Kanta Kumari said that the scaling up from pilot programs is key. She noted that hydrometeorological agencies are important, but they are low in the hierarchy of the system in many places around the world. How do we elevate them in the system? And how does development need to be framed differently to harness the science properly? As a community, Kumari suggested we should pursue partnerships (e.g. between IRI and other applications-based research institutes with development agencies). She noted that the development community needs decadal scale information as well.

For example, Zambia has taken climate variability and climate change very seriously. When the government started its resilience program, it thought about the full chain of information flow, from farmers to the districts to the ministers. Still, Kumari noted that getting the right climate information will be essential.

Highlights of audience comments:

In response to an audience comment about how institutions need to better integrate with one another, Buizer added that there are some transferable lessons between places, and that we shouldn't be too caught up in the notion that absolutely every village is different from all others. He also noted that the field of behavioral science is missing in the community represented at the conference.

Sulochana Gadgil explained that experience in India suggests we still need to do a lot of work in how we generate recommendations. We should be more rigorous about generating the recommendations to farmers. She asked if scientists should take responsibility for farmer

suicides. “We are not talking enough to farmers, colonial attitude is indeed the norm now. Now the colonials are the scientists.”

Cedric Van Meerbeeck: As climate scientists we still randomly assume that we can tell whether people’s habits are good or bad based on our climate products. We also assume that people will unlearn their bad habits because we say that they should.

Mike Hall suggested that a new term called “scale-matching” should be explored. As those generating the information we ought to ask: for whom are we generating this information?

PANEL

Young Scientists

Exploring new ideas to connect research, the operational communities and the users: "reinventing climate services"

Teddy Allen, *IRI, Columbia University*
Ángel Muñoz, *IRI, Columbia University*
Aisha Muhammad, *IRI, Columbia University*
Roop Singh, *Red Cross Red Crescent Climate Centre*
Moderated by **J. Michael Hall**, *retired Director, Office of Global Programs, NOAA*

Each panelist contributed perspectives on a broad set of topics related to their work or the work of others represented at the El Niño conference.

Teddy Allen challenged the audience to continue to search for ways to bridge the gap in scientific understanding between the timescales of weather and climate. Allen also shared his excitement for richer and more user-friendly data visualization techniques with the potential to increase the application of scientifically created products such as seasonal climate forecasts.

Ángel Muñoz promoted the importance of considering the cross time-scale interactions of climate science, such that in the near future El Niño by itself is not the main topic of discussion, but how El Niño interacts with other climate and non-climate phenomena at multiple timescales. Muñoz noted that these interactions relate to and intersect social dynamics, and that social forecasting seems to be the new challenge for institutes interested in providing useful information to decision-makers.

Aisha Muhammad reminded us that every El Niño event is different, both in terms of sea surface temperature structure and regional impacts. **Roop Singh** noted that learning as we go and continuing to innovate is increasingly important as we move into the future.

After each panelist offered initial insights, the conversation shifted toward a synthesis of the presentations and exchanges of the previous two days. Criticisms of top-down strategies for providing climate information made earlier in the conference were reinforced by several of the panelists. Muhammad stressed the importance of strengthening our efforts to gain feedback from climate information users and to truly adopt bottom-up development of climate products.

Relatedly, Singh encouraged the audience to replace the term "end users" with "co-producers" in an effort to increase feedback between the climate scientists and those who

stand to benefit from climate information. On the other hand, Singh discussed the challenges of communicating the science of El Niño and other climate phenomena when words common to the climate-science community (such as teleconnection and convection) are meaningless to many people outside of the field. Singh's point served as a reminder that bottom-up development can be difficult when climate information producers and users can't communicate with a common vocabulary.

The challenge of communicating scientific information also highlights how social scientists working at the intersection of the users and the producers are a critical part of a successful end-to-end-to-end implementation. The idea of end-to-end-to-end was a theme throughout many panels of the conference and was generally defined to represent: 1) the generation and communication of climate information from the producer to the end user (end to end), and 2) gathering feedback from the end user in an effort to improve the product (i.e. transmit information back to the first end).

The audience became actively engaged on several occasions. Allen was challenged by one audience member to move beyond the standard definition of climate as time-averaged weather and toward defining weather as the conditions in the atmosphere and climate as the system of complex interactions between the oceans, land surface, atmosphere, etc. Jim Buizer proposed a hypothetical scenario in which he was a farmer in Chile who has researched how to plant and manage his crop of choice in order to maximize profits. In that case, why is it his responsibility to find out what's occurring on seasonal timescales? Muñoz suggested that it is a "collective" responsibility to consider not only the seasonal scale, but multiple timescales. While the panelists generally noted that cooperative efforts were the key to progress in the area of climate information dissemination, Buizer's question served to bring the two-day series of scientific talks, panels and poster sessions full circle by addressing the fundamental issue of where the responsibilities of product generators and users lie.

Mike Hall asked the panel if scientists were being too passive by not pressuring the media to review the role of climate and weather conditions on world conflicts and events (such as the conflict in Syria and the fires in Indonesia). The panelists saw this as a complex question; Muñoz quipped that opening your mouth too much can get you into trouble, and that the role of climate and weather in certain social events is not always clear. Allen noted a tension between the idea of speaking up more as a physical scientist and allowing social scientists to be the ones to diagnose and analyze the socially-related impacts of climate. In making his point, Allen referenced a discussion earlier in the day that highlighted the need for physical scientists to utilize the expertise of social scientists to a further extent. Hall's question sparked

Muhammad to call for scientists to consider pursuing political office later in their lives in an effort to bridge the divide between scientists and politicians.

The reflections by the young panelists gave the audience insight into how the next generation of scientists absorb, react to and hope to push forward the work of their senior colleagues. The power of partnership among scientists across disciplines, as well as politicians and citizens emerged as the central takeaway from the conference for the young panelists.

A CONCLUDING PERSPECTIVE

Conference summary reflecting participant participant comments, and peer reviews[1] [1]

Maxx Dilley
Director, Climate Prediction and Adaptation Branch, World Meteorological Organization

Key observations from the Conference can be summarized in four areas:

I. What have been the key areas of progress since the last major event in 1997-98 – in formulating, communicating and/or using El Niño information?

Overall the models and forecasts for anticipating the behavior of El Niño and its effects on regional climates are improving, though challenges still persist. Lead times have improved by up to one month. The IRI net assessment probabilities have become more confident while remaining reliable. El Niño and associated regional climate forecasts have not improved as much as was expected 15 years ago, however.

Regional institutions as well as countries have much improved capacities to generate and interpret forecasts. This is evidenced by the examples provided by the International Research Center on El Niño (CIIFEN), IGAD Climate Prediction and Applications Center , and other regional centers, as well as activities within the India Meteorological Department, the Philippine Atmospheric, Geophysical and Astronomical Services Administration, and the National Meteorology Agency of Ethiopia. Since 1997-98 there has been a significant increase in interactions among the international community, regional and national centers and communities related to forecast generation, interpretation, and use.

Institutions (including international, the private sector, NGOs, and governments) are considerably more adept and active in requesting, seeking out, and using climate, as well as El Niño, information for planning, preparedness, and prevention. This is evidenced by many examples provided, of the actual use of information and decision support tools for taking actual decisions and improving outcomes (from Peru, Uganda, Kenya, Ethiopia, the U.S. Agency for International Development, World Food Programme, United Nations Development Programme, World Health Organization, International Federation of Red Cross and Red Crescent Societies, World Vision International, SwissRe, disaster risk management, health, water, energy, and, soon, Indonesia fire risk management).

There is a greater awareness of El Niño, its impacts, and what to do about it across society in directly, as well as indirectly, affected areas. In a historical overview, Mickey Glantz observed

[1] With special thanks to Rodney Martinez, Sezin Tokar, Mike Halpert, Andrew Watkins, Michael Glantz, Kevin Trenberth and two anonymous reviewers. All views expressed are the responsibility of the author alone.

that that the 1972-73 El Niño could be called the El Niño of the Research community because of the interest generated at that time by its global impacts. The 1982-83 event could be called the El Niño of the Governments, having captured their attention of its impacts on their economies. The 1997-98 El Niño can be considered the people's event, in that El Niño was on its way to becoming a household word in many countries. The 2015-16 might well be called the El Niño of awareness and preparedness by civil society.

There is apparent greater, and considerably earlier, preparedness for the current, 2015-16 event than was the case in advance of the one in 1997-98. This is likely linked to increasingly systematic implementation of climate services, accompanied by enhanced media interest and coverage, and overall improvements in societal resilience in the face of a changing climate.

II. What are some key areas to address going forward?

Continued improvements are needed in all areas of research – including the social sciences, data, models, stakeholder engagement, tailored products, communication and feedback, documentation and evaluation of results. Science priorities need to be set; for example, we still struggle to predict the onset of an event until it is already reflected in the Sea Surface Temperatures. Observing systems need to be continuously strengthened. Societal vulnerabilities and adaptation options need to be better understood, and the latter more effectively communicated in order to take advantage of scientific advances.

There is a need for greater engagement by the interdisciplinary community that has extensive experience and expertise in the field of climate services. Major resources for implementing climate services are coming on-line, fueled by the rise of climate on the international development agenda. The El Niño/Southern Oscillation (ENSO) experience provides valuable lessons for managing risks and impacts in the context of climate change.

There is a need to complement scattered efforts with a move towards systematic support for full-suite implementation of relevant climate services (historical, tailored, multiple time scales, end-to-end[2]), focused primarily at country level, including evaluation as part of design, demonstrating substantial improvements in climate-related outcomes, as well as identifying gaps. The Global Framework for Climate Services can play a central role in this regard.

The effective use of climate information to manage risk and enhance resilience requires an iterative partnership with stakeholders. Toward this end, the climate community needs to explicitly devote considerably more effort to areas such as two-way communication, visualization, and evaluation, to stimulate the formation of a broad community that can interact with the information effectively in a practical context.

Beyond anecdotal evidence of the use and utility of El Niño information, can we undertake a comparative analysis of the impacts of the current event compared with the 1997-98

[2] observations to products to communication

baseline, taking into consideration the need to control for the variability in the strength of the regional anomalies, vulnerability and exposure? The prospect of such an undertaking underscores the need for on-going monitoring of climate and its impacts, in order to have the necessary data.

III. What are some key messages to communicate about this particular event?

No two ENSO events are the same. The strong 2015-16 El Niño is not identical to any previous event.

- At the moment, for instance, eastern tropical Pacific Ocean temperatures are as warm as the significant 1997-98 El Niño, but western Pacific SSTs are higher, thereby reducing gradients and winds across the Pacific, while sea surface temperatures away from equator are also warmer. Higher SSTs exacerbate heavy rainfalls and risk of flooding by supplying more moisture increasing potential for adverse impacts.
- The antecedent climate conditions in many regions as compared with those during the most recent similarly strong event in 1997-98 are different as well.
- Even if the current ENSO imitated previous ones, the impacts would still differ significantly, as these are affected by dynamic social and economic factors.

As a result, regional impacts from the 2015-16 El Niño will differ from those of previous events.

El Niño forecasts from official/credible sources have improved greatly since 1997-98. As a result, climate services are providing a high level of assistance to decision makers.

To be effective, the available climate information needs to be translated into action, particularly at the country and local levels. This entails sustained stakeholder interest and engagement throughout the ENSO cycle, encompassing not only El Niño events, which recur quasi-periodically every two to seven years, but also the neutral and La Niña phases, the latter of which has its own signature effects on regional climates.

IV. What are some key implications of global change for this event and others going forward?

Using previous El Niño events as analogues is increasingly challenging, as the climate in which these events are occurring is changing, e.g. rising sea temperatures, decreasing ice extent, and decreasing temperature gradient from equator to poles. Therefore, although analogues are an important vehicle for communication concerning potential impacts, their use for such communication – previously caveated by noting that no two events are the same, nor are their societal and environmental consequences – must now be even more carefully qualified as a result of ongoing global climatic, environmental and societal changes.

In addition to climatic factors, risks and outcomes related to the 2015-16 event will also be a product of many other significant changes in socio-economic and political factors and contexts. These include population increase, settlement in hazard prone areas, environmental degradation, political transitions, instability and increased armed conflict, expansion of ungoverned areas, higher food prices and lower stocks, etc.

The 2015-16 event is a factor in 2015's being the warmest year on record – reaching nearly halfway to the UNFCCC 2°C above pre-industrial levels upper threshold – but temperature spikes associated with El Niño are nonetheless occurring in the context of a consistently upward global temperature trend (La Niña, on the other hand, recharges heat into the ocean, temporarily lowering global surface temperatures).

El Niño is associated with an increase in in rain areas over the ocean and the land surface area affected by drought (mainly in the tropics). ENSO occurrence needs to be taken into account, therefore, when assessing regional precipitation trends.

Dry conditions increase risks of wildfires, which release more CO2 into the atmosphere during El Niño events.

Global warming intensifies the hydrologic cycle, which is expected to affect the behavior of extreme events. **Events such as drought and floods associated with ENSO will reflect any intensification of the hydrologic cycle which has occurred due to climate change.** Research is ongoing concerning the degree to which extreme event behavior is being affected by climate change. This is also true concerning the degree to which El Niño and related extreme events will be affected by climate change, and how.

POSTERS

Fair Weather or Foul? The Macroeconomic Effects of El Niño

Author(s): Paul Cashin, Kamiar Mohaddes, and Mehdi Raissi

Early warning of climate variability and change from seasonal forecasts

Author(s): Sarah Ineson (on behalf of the Met Office monthly-to-decadal forecast group)

ENSO forecasting in South Africa

Author(s): Willem Landman, Asmerom Beraki

Assessing ENSO risks for the coming decades

Author(s): Andrew T. Wittenberg

Enhanced seasonal predictability of the Asian Summer Monsoon rainfall following an El Nino event

Author(s): Chul-Su Shin, Bohua Huang, Jieshun Zhu, Lawrence Marx, James L. Kinter III and J. Shukla

Vectorial Capacity (VCAP) and El Nino Southern Oscillation (ENSO)

Author(s): Israel Ukawuba

El Nino's Impact on California Rainfall: Timing, Location and Intensity

Author(s): Bor-Ting Jong, Mingfang Ting and Richard Seager

Copernicus Information Services at ECMWF

Author(s): Jean-Noel Thepaut, Dick Dee, Anca Brookshaw, Tim Stockdale and Laura Ferranti

Sub-seasonal teleconnections between El Nino and East African long rains

Author(s): N. Vigaud, B. Lyon and A. Giannini

Implementing Forecast based Financing Mechanism in Peru to enable Preparedness for El NIÑO Impacts

Author(s): Juan Bazo, Elisabeth Stephens, Erin Coughlan de Perez, Mathieu Destrooper

Long−lead ENSO predictability from CMIP5 decadal hindcasts

Author(s): Paula L. M. Gonzalez, Lisa Goddard

The ENACTS ENSO Map-rooms

Author(s): Tufa Dinku, IRI Data Library team

Climate Risk Management Strategy in the Tropics- Exploiting the Regional Heterogenenous Response Introduced by the El Nino Tele-connection

Author(s): Pradipta Parhi

El Nino and Insurance through participatory design

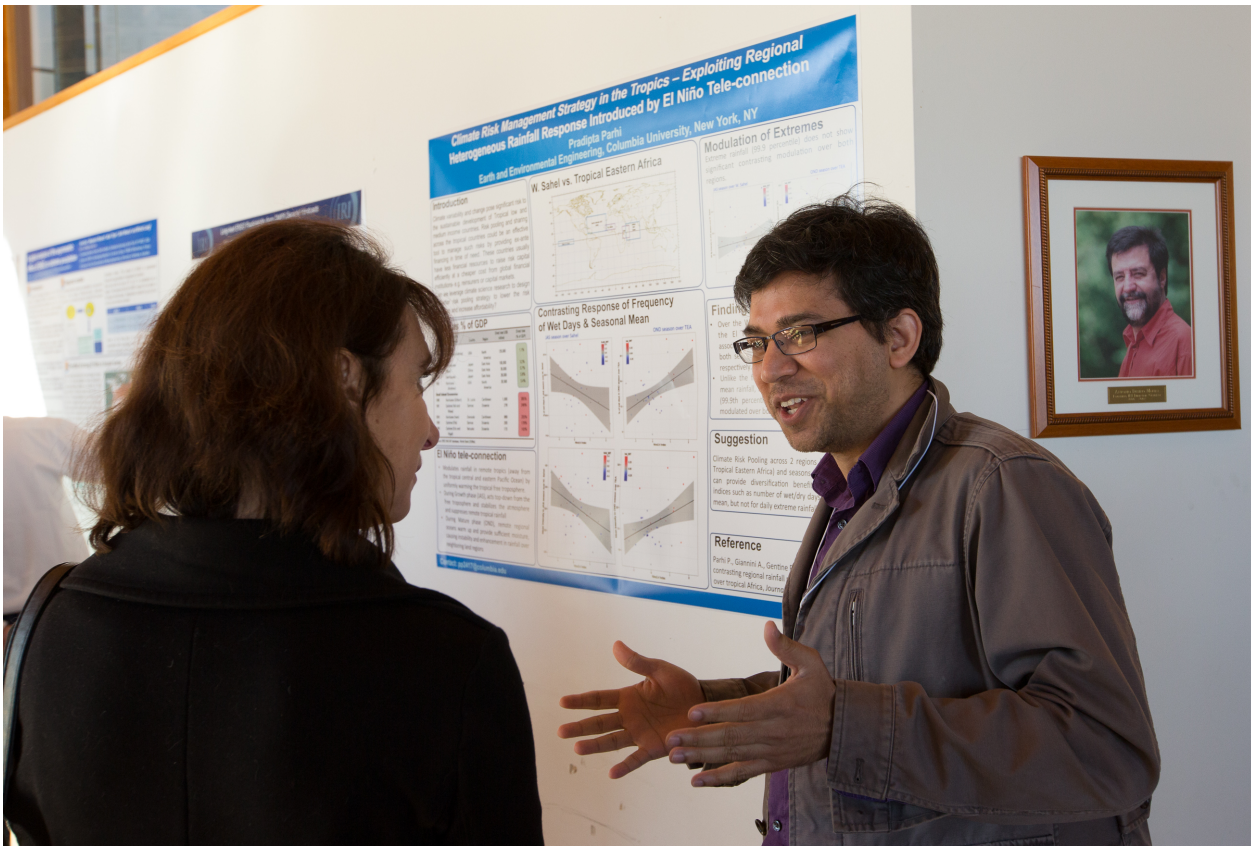
Authors(s): Kelly Armstrong, Sarah Blakeley, Melody Braun, Miguel Carriquiry, Rahel Diro, Samantha Garvin, Helen Greatrex, Margot LeGuen, Bristol Mann, Sofia Martinez, Geoffrey McCarney, Daniel Osgood, Jessica Sharoff, Radost Stanimirova, Katya Vasilaky, Jacob Zeitlin

Hail, Tornadoes and the Climate System: Analyzing the impacts of the El Niño Southern Oscillation on Interannual Variability

Author(s): John Allen, Michael Tippett, Adam Sobel

A global analysis of the asymmetric effect of ENSO on extreme precipitation

Author(s): Xun Sun, Benjamin Renard, Mark Thyer, Seth Westra and Michel Lang



FEEDBACK

This section contains a sample of results from the survey given to all conference goers following the event, as well as feedback given via video interviews.

Did the conference enhance your knowledge of the 2015-16 El Niño event?

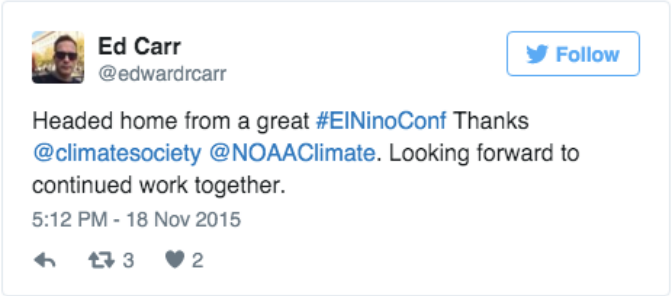
"Yes! Especially emphasizing the point that no two El Niño events are the same. This is often the challenge when communicating about El Niño, that the 'public' often immediately assume the current event will the same as the last. Which also reflects on people's understanding of what El Niño really is..."

Do you think that the conference will change or influence decisions your stakeholders will make now?

Yes - 42% // No - 58%

Do you think that the conference will change or influence decisions your stakeholders will make in the future?

Yes - 58% // No - 42%



Did the conference broaden or improve your understanding of impacts likely in this El Niño event?

"Somewhat - impacts are often very context specific and for that, there is often not much information."

"We need more precise studies and effect/impact evaluation and monitoring. We attribute to El Niño many impacts which might be due to other climate drivers unless we change the definition of El Niño events."

Will the conference change or influence the direction of your own work?

Yes - 47% // No - 53%

"Yes, and it started just the week after the conference; when attending the Regional Climate Outlook Forum for the Mediterranean Region."

What were the most important messages/ideas you took away from the conference?

"1. Continued improvements are needed in all areas - not just science but also communication and feedback. 2. Partnership with stakeholders is key to climate services' greater and more strategic contribution to decision making for resilience"

"El Niño research has come a long way but there's still a ways to go to really connecting with society. (And that this year will be an interesting case study in that regard.)"

"We need to improve climate scientists' ability to engage decision-making publics, and to tell them what we *can* say definitively that helps them make more informed decisions. I feel the science community, overall, is still somewhat lacking a clear focus and purpose in this regard."

"The ability for climate scientists to directly influence long standing practices and policies is very limited and requires years of persistent engagement to build the needed understanding and trust."

What did you think about the diversity of expertise and regional/organizational representation among the invitees? If you think an important perspective was missing please use the box to explain.

"Very good - many different perspectives which led to enthusiastic discussion."

"Would like to have seen more examples on how seasonal forecast in the past have actually made a difference to operations and decision-making."

"It felt like a lot of scientists talking to scientists, which definitely has value. But I didn't think the end users of potential information/services were fully represented. It would also have been nice to have a more diverse group of presenters."

"Great diversity of expertise, perspectives, and experiences represented at the IRI conference."

Did you have many conversations with people outside of your field and region?

Yes - 89% // No - 11%

Did you establish any new relationships or partnerships?

Yes - 83% // No - 17%

Did new ideas or new proposals come from your interactions at the conference?

Yes - 42% // No - 58%

If future networks are created, what subject would be of most interest to you?

Climate research - 41%

Climate services implementation - 47%

Climate user interfaces in specific sectors - 53%

BIOGRAPHIES

Conference Chair

Kathy Jacobs is the director of the Center for Climate Adaptation Science and Solutions and a professor at the University of Arizona. From 2010 to 2013, Jacobs worked in the White House, leading the National Climate Assessment and advising on water science and climate adaptation. Prior to her work in DC, Jacobs was the executive director of the Arizona Water Institute from 2006-2009, and she has more than 20 years of experience as a water manager for the Arizona's Department of Water Resources. Her research interests include water policy, connecting science and decision making, stakeholder engagement and climate change adaptation.

Speakers

Maxx Dilley directs the Climate Prediction and Adaptation Branch at the World Meteorological Organization. Prior to joining WMO he led the Disaster Risk Reduction and Recovery Team and was a policy and partnerships advisor at the United Nations Development Programme. He was previously a Research Scientist in the International Research Institute for Climate and Society (IRI) at Columbia University in New York, where he directed the Africa program and co-directed climate impacts research. Before that he worked for two years at the World Bank Disaster Management Facility and for seven years at the U.S. Agency for International Development's Office of U.S. Foreign Disaster Assistance.

Lisa Goddard is the Director of Columbia University's International Research Institute for Climate and Society. She is also an adjunct associate professor in Columbia's Department of Earth and Environmental Sciences. Dr. Goddard is a globally recognized expert on El Niño and La Niña, decadal prediction and near-term climate change. She sits on the Board on Atmospheric Sciences and Climate of the U.S. National Academies of Science, as well as four others. She also co-chairs CLIVAR, under the World Climate Research Programme. In 2007, she developed PACE, a national post-doctoral program that explicitly links recent climate Ph.D.s with decision making institutions.

Eric Guilyardi is a climate scientist at IPSL in Paris and University of Reading in the UK. He is an expert in tropical variability and climate change. Eric is also lead author of the IPCC Fifth Assessment chapter on model evaluation. He co-chairs the CLIVAR Research Focus "ENSO in a changing climate".

Marc Levy is Deputy Director of CIESIN (the Center for International Earth Science Information Network), a unit of Columbia University's Earth Institute. He also teaches in Columbia's School of International and Public Affairs and directs the new Environment, Peace and Security Certification Program in the University's School of Professional Practice. He is a political scientist focusing on how humans can better manage complex, interlinked systemic risk, with a major focus on climate-security dynamics. He was a Lead Author on the IPCC Fifth Assessment chapter on Human Security.

Michelle L'Heureux is the lead of the ENSO forecasting team at the NOAA Climate Prediction Center in College Park, Maryland. In addition to her operational responsibilities, she is involved in research that

applies our understanding of tropical variability to prediction over the United States. Michelle also coordinates the ENSO blog on NOAA Climate.gov.

Dr. Miguel Pinedo-Vasquez does research on issues related to the impact of resource management and land use on the sustainable provision of ecosystem services and goods. More recently, Dr. Pinedo-Vasquez has been working on the smallholder's responses to the emerging challenges and opportunities produced by urbanization, climate change, and other socio-environmental shifts. He is an adjunct professor at the Department of Evolution, Ecology and Environmental Biology. He is the Director of International Programs at the Earth Institute Center for Environmental Sustainability (EICES). Dr. Pinedo-Vasquez is also a Senior Associate Scientist at the Center for International Forestry Research (CIFOR).

Jeffrey D. Sachs is the Director of The Earth Institute, Quetelet Professor of Sustainable Development, and Professor of Health Policy and Management at Columbia University. He is Special Advisor to United Nations Secretary-General Ban Ki-moon on the Millennium Development Goals, having held the same position under former UN Secretary-General Kofi Annan. He is Director of the UN Sustainable Development Solutions Network. He is co-founder and Chief Strategist of Millennium Promise Alliance, and is director of the Millennium Villages Project. He has authored three New York Times bestsellers in the past seven years.

Adam Sobel is a professor at Columbia University's Lamont-Doherty Earth Observatory and School of Engineering and Applied Sciences. He studies the dynamics of climate and weather, including extreme events such as hurricanes, tornadoes, floods, and droughts. He directs the Columbia Initiative on Extreme Weather and Climate. His book about Hurricane Sandy, Storm Surge, received the 2014 Atmospheric Science Librarians International Choice Award in the popular category and the 2016 Louis J. Battan Award from the American Meteorological Society.

Dr. Kevin E. Trenberth is a distinguished senior scientist in the Climate Analysis Section at the National Center for Atmospheric Research. From New Zealand, he obtained his doctorate from Massachusetts Institute of Technology. He has been prominent in most of the Intergovernmental Panel on Climate Change (IPCC) scientific assessments of Climate Change and has also extensively served the World Climate Research Programme (WCRP) and many U.S. national committees. He is a fellow of the American Meteorological Society, the American Association for Advancement of Science, the American Geophysical Union, and an honorary fellow of the Royal Society of New Zealand.

Moderators

Jim Buizer is a professor in the School of Natural Resources and the Environment, and Founding Director of the Climate Adaptation and International Development Program in the Institute of the Environment at the University of Arizona. His research focuses on integrating climate information and decision processes for regional climate resilience. He is on the board of directors for the National Council for Science and the Environment and for Second Nature. At Arizona State University, he led the design and establishment of the Global Institute of Sustainability. Prior to ASU, Jim was Director of NOAA's Climate and Societal Interactions Division.

David Corcoran recently retired as editor of Science Times, The New York Times's weekly science section. He joined The Times in 1988 and worked in a variety of positions, including education editor

and deputy Op-Ed editor. He came to The Times after a 19-year career at The Record in North Jersey, where he was editor of the editorial pages. He is the editor of The New York Times Book of Science, published by Sterling in September 2015.

Dr. Heidi Cullen serves as Chief Scientist for Climate Central and leads the World Weather Attribution program. She was The Weather Channel's first on-air climate expert. She also serves as a member of the AMS Council and the National Academy of Sciences Board on Atmospheric Science and Climate. She received a Bachelor of Science degree in Industrial Engineering from Columbia University and a Ph.D. in climatology and ocean-atmosphere dynamics at the Lamont-Doherty Earth Observatory of Columbia University. Dr. Cullen also serves as Chief Science Advisor for the Years of Living Dangerously project and is the author of The Weather of the Future.

Francesco Fiondella is the head of communications at the International Research Institute for Climate and Society. His writing and photography focuses on how the world's most vulnerable people struggle with droughts, extreme weather, epidemics and other climate risks, and what science is doing about it. He recently joined the advisory board of Planet Forward, a nonprofit that promotes ideas to solve global environmental challenges. He is the co-creator of the 2014 Climate Models calendar, a crowdfunded project that turned climate scientists into fashion models. Before joining IRI, Francesco was an editor in the Wall Street Journal's news graphics group.

Dr. J. Michael Hall is currently retired from the Federal Senior Executive Service. Prior to his retirement, he was Director of the Office of Global Programs within NOAA, where he managed a multidisciplinary research program in climate variability, long-term environmental change, and their societal relevance. In over thirty years of public service, Dr Hall held a series of senior management positions in weather, climate, oceanography, and environment, and helped found the U.S. Global Change Research Program (USGCRP) in the early 1990's. Dr. Hall has received numerous awards for management and scholarship, including the Presidential Rank Award for Meritorious Executive (1998), the Cleveland Abbe Award of the American Meteorological Society (1999), the U.S. Department of Commerce Gold Medal (1989), and the Waldo E. Smith Medal of the American Geophysical Union (2004).

David Herring is a science writer with extensive experience communicating about climate and Earth system science. David works in NOAA's Climate Program Office as Director of Communication and Education, and Program Manager of NOAA's Climate.gov website. In 2013, David was asked by the Executive Office of the President to lead development of the U.S. Climate Resilience Toolkit (toolkit.climate.gov), published in November 2014. David trained in journalism, science education, and technical communication at East Carolina University, where he received his Masters Degree in 1992. He is an elected Fellow of the American Association for the Advancement of Science (AAAS).

Simon Mason has been with the IRI since 1997, and has worked on seasonal forecasting since shortly after the death of Confucius, it feels. He assists National Meteorological Services and Regional Climate Centres to implement their climate services, and works with humanitarian organizations to develop climate information fit for their purposes. He works closely with the World Meteorological Organization in defining and promoting standards, and was a lead author of the Implementation Plan for the Global Framework for Climate Services. He is the developer of the Climate Predictability Tool (CPT), which is used throughout the world for making seasonal forecasts.

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Panelists

Amir Mahmoud Abdulla is the Deputy Executive Director of the World Food Programme, currently based in New York. Mr Abdulla is responsible for coordinating WFP's activities and relationships within the UN system, including the many summits and events in 2015 and 2016. Mr Abdulla previously served as WFP's Chief Operating Officer (COO), overseeing the WFP Regional Directors and Directors of Emergency and Field Security, and Chief Financial Officer (CFO). During his tenure as CFO he led WFP's successful implementation of IPSAS (International Public Sector Accounting Standards), the first large-scale adoption of IPSAS within the UN system.

Teddy Allen is a postdoctoral research scientist at the IRI (PhD Meteorology, University of Miami) and primarily investigates Caribbean rainfall diagnostics and prediction. His work at the IRI currently focuses on climate services between local meteorological services and farming communities in the western Caribbean. In addition to research activities in synoptic climatology, Mr. Allen also supports international data rescue projects as the Director of Scientific Applications with IEDRO.

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Carina Bachofen is a senior program manager and policy officer at the Red Cross Red Crescent Climate Centre, developing and facilitating approaches to experiential learning and dialogue on climate risk management. She serves as Head of Learning and Uptake for DFID's flagship programming Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED), in which she provides strategic guidance and oversight to knowledge exchange on resilience across the programme. Carina has over a decade of experience working at the interface between climate and development at the World Bank, International Union for the Conservation of Nature and the German Institute for International and Security Affairs.

Rizaldi Boer is the director of the Centre for Climate Risk and Opportunity Management in Southeast Asia and Pacific (CCROM-SEAP), Bogor Agricultural University, Indonesia. Most of his research activities deal with climatic risk analysis and climate change. He has been involved and has led a number of national and/or regional projects related to adaptation and mitigation. He also works as senior lecturer at the Department of Geophysics and Meteorology, Faculty of Mathematics and Natural Science, Bogor Agricultural University since 1987. In addition, he is assigned by WMO as chairperson for RA V Working

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Jim Buizer (see Moderators)

Mark A. Cane is the G. Unger Vetlesen Professor of Earth and Climate Sciences at the Lamont-Doherty Earth Observatory of Columbia University. With Stephen Zebiak, he devised the first numerical model able to simulate El Niño, and in 1985 they made the first physically based forecasts of El Niño. Cane was instrumental in the creation of the International Research Institute for Climate and Society and he founded and directed the interdisciplinary Master of Arts Program in Climate and Society. His honors include the Sverdrup Gold Medal of the American Meteorological Society (1992), the Cody Award in Ocean Sciences from the Scripps Institution of Oceanography (2003), the Norbert Gerbier-MUMM International Award from the World Meteorological Organization (2009), and the Maurice Ewing Medal of the American Geophysical Union (2013). He is a member of the American Academy of Arts and Sciences and the National Academy of Sciences.

Ed Carr is a tenured professor and director of the International Development, Community, and Environment Department at Clark University, where he also directs the Humanitarian Response and Development Lab (HURDL). For nearly 20 years he has worked in rural sub-Saharan Africa on issues of globalization, development and environmental change, living among and working with various rural communities. He has held numerous academic and professional positions in the world of development, including with USAID and the World Bank, and is the author of more than 50 publications and reports on issues of development, adaptation to climate change, and the changing global environment.

Richard Choularton is Chief of WFP's Climate and Disaster Risk Reduction Programmes Unit. He is an expert on early warning, preparedness, risk financing, resilience, and food security. He is leading a major push to trigger finance and action based on climate forecasts.

Michael M. Crow is the sixteenth president of Arizona State University, since July 2002. He is guiding the transformation of ASU into one of the nation's leading public metropolitan research universities, an institution combining academic excellence, inclusiveness, and societal impact—a model he terms the "New American University." During his tenure ASU has developed a new era academic design built around innovation, established more than 15 transdisciplinary schools and research initiatives. He was previously executive Vice Provost and professor of science and technology policy at Columbia University. A fellow of the American Association for the Advancement of Science (AAAS) and the National Academy of Public Administration, he is the author of books, articles and designs for new knowledge enterprises, new science and technology policies, new highly adaptive higher education institutions and new transdisciplinary concepts for enhanced human welfare.

David Farrell manages the Caribbean Institute for Meteorology and Hydrology as its Principal. Dr. Farrell is involved in various Caribbean and international scientific projects related to hydrogeology, hydrology, geophysics and climate services. Dr. Farrell sits on a number of Technical Advisory Committees for regional disaster management and climate change projects and is the WMO Hydrological Advisor to the British Caribbean Territories. He also sits on the Management Board of the Intergovernmental Board for Climate Services and has led the CIMH on its path to becoming a WMO Regional Climate Centre for the Caribbean.

Sulochana Gadgil, a Ph. D. in Applied Mathematics from Harvard University, worked for a year with Prof. Jule Charney before joining the Indian Institute of Science, Bangalore in 1973. She has made major contributions to our understanding of monsoon variability and prediction and its application to agriculture. She played a key role in establishing and nurturing the Centre for Atmospheric and Oceanic Sciences at IISC, spearheaded the efforts to formulate and execute the Indian Climate Research Program (ICRP) and has been an active player in several global change programmes, serving on committees of WCRP, of IGBP and START.

Mickey Glantz is director of the Consortium for Capacity Building (CCB) at the University of Colorado-Boulder. The CCB is now focused on developing the concept of "El Nino Ready Nations" and "El Niño Ready Cities" and what it means to be El Nino Ready. He has studied the societal impacts of El Niño since 1975. In 1981, he and J.Dana Thompson published the first multidisciplinary El Niño book: "Resource Management and Environmental Uncertainty: Lessons from Coastal Upwelling Fisheries." In 2000, he led a 16-country study on "Lessons Learned from the 1997-98 El Nino: Once Burned, Twice Shy." Since 2012, he has been working with USAID/OFDA on "Lessons Learned about Hydromet Disaster Risk Reduction in a Changing Climate."

J. Michael Hall (see Moderators)

Andy Jarvis is the Director of the Decision and Policy Analysis Area in the International Centre for Tropical Agriculture (CIAT) and is a Flagship Leader on the CGIAR Research Program for Climate Change, Agriculture and Food Security (CCAFS), based in Cali, Colombia. He has 10 years research experience in developing countries to support the goals of alleviating poverty and protecting essential ecosystem services of importance to humanity. In 2003 Dr. Jarvis won the Crop Science Society of America (CSSA) C-8 Genetic Resources award, and in 2009 received the prestigious Ebbe Nielsen award for innovative research in bioinformatics and biosystematics.

Kanta Kumari Rigaud is the Lead Environmental Specialist with the Climate Policy Team at the World Bank where she works on the knowledge agenda on resilience. Most recently, she led the development of the climate and disaster risk screening tools and coordinated the Bank's work on the Turn Down the Heat Series. She is also the World Bank's Focal point for the Pilot Program for Climate Resilience (PPCR) working with Bank teams and participating countries to nurture shared learning, knowledge exchange to advance the climate resilient agenda. Earlier she worked in Middle East North Africa Region, and with the Global Environment Facility.

Upmanu Lall is the Alan and Carol Silberstein Professor of Earth and Environmental Engineering and the director of the Columbia Water Center, a unit of the Columbia University's Earth Institute. Professor Lall has over 33 years of experience in statistical and numerical modeling of hydrologic and climatic systems and water resource planning and management. Lall has pioneered an approach to applied research that emphasizes the importance of viewing water issues through several different traditional academic disciplines in order to understand the global dimension and interconnected nature of water challenges. He received his B.S. from the Indian Institute of Technology and both his M.S. and Ph.D. in Civil Engineering from the University of Texas.

Megan Linkin is a natural hazards expert for the Global Partnerships team at Swiss Re, based in Armonk, NY. Megan's primary responsibility is risk analysis and structuring of public-private transactions which protect public entities against losses incurred due to natural catastrophes. Prior to

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Anthony Lucero is a Senior Weather Specialist and currently the Officer-In-Charge of the Climate Monitoring and Prediction Section of the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). He has worked for more than 30 years at PAGASA winning numerous awards, and is a pioneer of the climate prediction group in the Philippines. He teaches climatology at meteorologist training courses in PAGASA and the local university. He is also involved in the application of seasonal climate forecasts to agriculture, water management, fisheries, and in the establishment of community climate information centers for climate change adaptation and disaster risk management.

Patrick Luganda is the CEO of Farmers Media Link Centre, Chairman of the Network of Climate Journalists in the Greater Horn of Africa, Vice President of the Africa Ecosystems-Based Adaptation Food Security Assembly (EBAFOSA), and Team Leader of the Regional Network of Farmers in Africa and South Asia (RENOFASA). Patrick is a science communications expert on climate, climate change, and agriculture communication. He is a science media trainer and consultant with several global organizations and institutions. He worked as a science journalist for over 20 years, and has played a lead role in building the capacity of climate change communication in several countries in Africa and beyond.

Rodney Martinez is an oceanographer and project manager by training. He has been the Scientific Coordinator of CIIFEN (the Regional Climate Centre for the Andean countries of South America) since 2004 to 2015, and its International Director since 2015. He is a member of the WMO Commission for Climatology, the World Climate Research Programme Joint Scientific Committee and the Global Climate Observing System Joint Scientific Committee.

Simon Mason (see Moderators)

Stewart McCulloch has been the Global Insurance Director of VisionFund for over two years and is responsible for the delivery of microinsurance solutions to VisionFund's 1 million clients. Stewart has also been leading the development of an insurance backed "Disaster resilient microfinance" approach with support from Professor Jerry Skees, DFID, Rockefeller, Asian Development Bank and FMO. Prior to joining VisionFund Stewart had a 30 year career in international insurance including leading an international insurance broker as CEO.

Ángel Muñoz is a Graduate Research Fellow in climate sciences at IRI and a PhD student in the Columbia University Department of Earth and Environmental Sciences. Before arriving at the IRI in 2011, he was associate professor in the Department of Physics of Universidad del Zulia in Venezuela. At the CMC he helped create the Latin American Observatory, a regional partnership aimed at improving regional capacities and networking to provide useful, climate-smart products for decision-makers in Latin American countries. Muñoz's research interests include predictability of sub-seasonal-to-decadal extreme events and climate services.

Aisha Muhammad is a Senior Research Staff Assistant for the Climate Information for Public Health Action team at the IRI. The majority of her work and research involves using climate services and tools, such as ENACTS and the IRI Map Rooms, to help African countries interpret and integrate climate data into sound health policy. She recently obtained her MA in Climate & Society from Columbia University. Before returning to graduate school, she received her BS in Meteorology from the University of Oklahoma, and served as meteorologist and career development coach for several years.

Eric Roston covers energy, climate change, and science for Bloomberg.com. He is author of the critically acclaimed book THE CARBON AGE: How Life's Core Element Has Become Civilization's Greatest Threat. Eric joined Bloomberg in 2011 to launch its sustainability coverage, after serving as a senior analyst on the National Commission on the BP Deepwater Horizon Oil Spill. He worked at Duke University's climate change policy think tank, the Nicholas Institute. Previously, Eric wrote for TIME magazine, covering science, technology, and politics. Roston is fluent in Russian and holds an M.A. in Russian history, and a B.A. in modern European history, both from Columbia University.

Roop Singh is a Technical Advisor for the Red Cross Red Crescent Climate Centre where she provides decision-making support for disaster managers and practitioners using climate and weather information. She also coordinates the Reality of Resilience initiative which monitors and investigates extreme events in real-time to understand what works to strengthen resilience in Africa and Asia. Singh earned her MA in Climate and Society from Columbia University and her B.Sc. in Atmospheric Science from Cornell University.

Jen Stephens is UNDP's Programme Coordinator of the Integrated Climate Risk Management Programme and covers UNDP's work on integrating disaster and climate change risk management globally. Jen has worked for UNDP on climate change and disaster risk reduction for the past 6 years, especially supporting regional and global programmes, including the Africa Adaptation Programme (in 20 countries) and the Strategic Initiative to Address Climate Change in LDCs ('Boots on the Ground' Programme—in 26 countries). Prior to joining UNDP, Jen worked as a disaster risk reduction expert for UNEP's Post-Conflict and Disaster Management Branch.

Ken Takahashi is a Climate scientist with a current research focus on the prediction of extreme El Niño events. He has a Ph.D. in Atmospheric Sciences from the University of Washington, Seattle, and a Postdoc through the NOAA Climate & Global Change fellowship at GFDL/Princeton. He is a research scientist and director of Sciences of the Atmosphere and Hydrosphere at the Geophysical Institute of Peru. He is currently coordinator of the Peruvian official El Niño prediction committee (ENFEN).

Madeleine Thomson is a Senior Research Scientist at the International Research Institute for Climate and Society and Senior Scholar at the Mailman School of Public Health, Department of Environmental Health Sciences – at Columbia University. She is also the Director of the IRI/PAHO-WHO Collaborating Centre (US 306) for Early Warning Systems for Malaria and Other Climate Sensitive Diseases. She trained originally as a field entomologist and has spent much of her career engaged in operational research in support of large-scale health interventions, mostly in Africa. She is also a founding member of the Meningitis Environmental Risk Information Technologies (MERIT) research consortium.

Sezin Tokar is the Senior Hydrometeorological Hazard Advisor with USAID's Office of U.S. Foreign Disaster Assistance (OFDA). She is also OFDA's technical lead on disaster risk reduction programs to help prevent and reduce the impacts of natural hazards. Notably, she developed and oversaw the

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Alberto Troccoli is a visiting Professor at the University of East Anglia (UK) and Director of the World Energy and Meteorology Council, a fledgling organization devoted to promoting and enhancing the interaction between the energy industry and the weather, climate and broader environmental sciences community. Formerly, leader of the Earth Assessment group and head of the Weather and Energy Research Unit at CSIRO (Australia), Alberto has nearly 20 years of experience in several aspects of meteorology and climate and their application to the energy sector. He has held research positions also at NASA, ECMWF and the University of Reading (UK).

Zinta Zommers is a Programme Officer with UNEP's Chief Scientist's Office, currently working with the UN Secretary-General's Climate Change Support Team. She is developing a new global climate resilience initiative, A2R – From Risk to Resilience – that will be announced by the Secretary-General at COP 21. Between 2012- 2015, Zinta was based in Nairobi. She led UNEP's Climate Change Early Warning Project, working directly with communities in Kenya, Ghana and Burkina Faso. She co-authored the book, "Preventing Disaster: Early Warning Systems for Climate Change", published in 2014. Prior to joining UNEP, Zinta was based at the University of Oxford, first as a Rhodes scholar and then as a Junior Research Fellow.

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Special thanks to Kathy Jacobs from the University of Arizona for her role as the conference's master of ceremonies.

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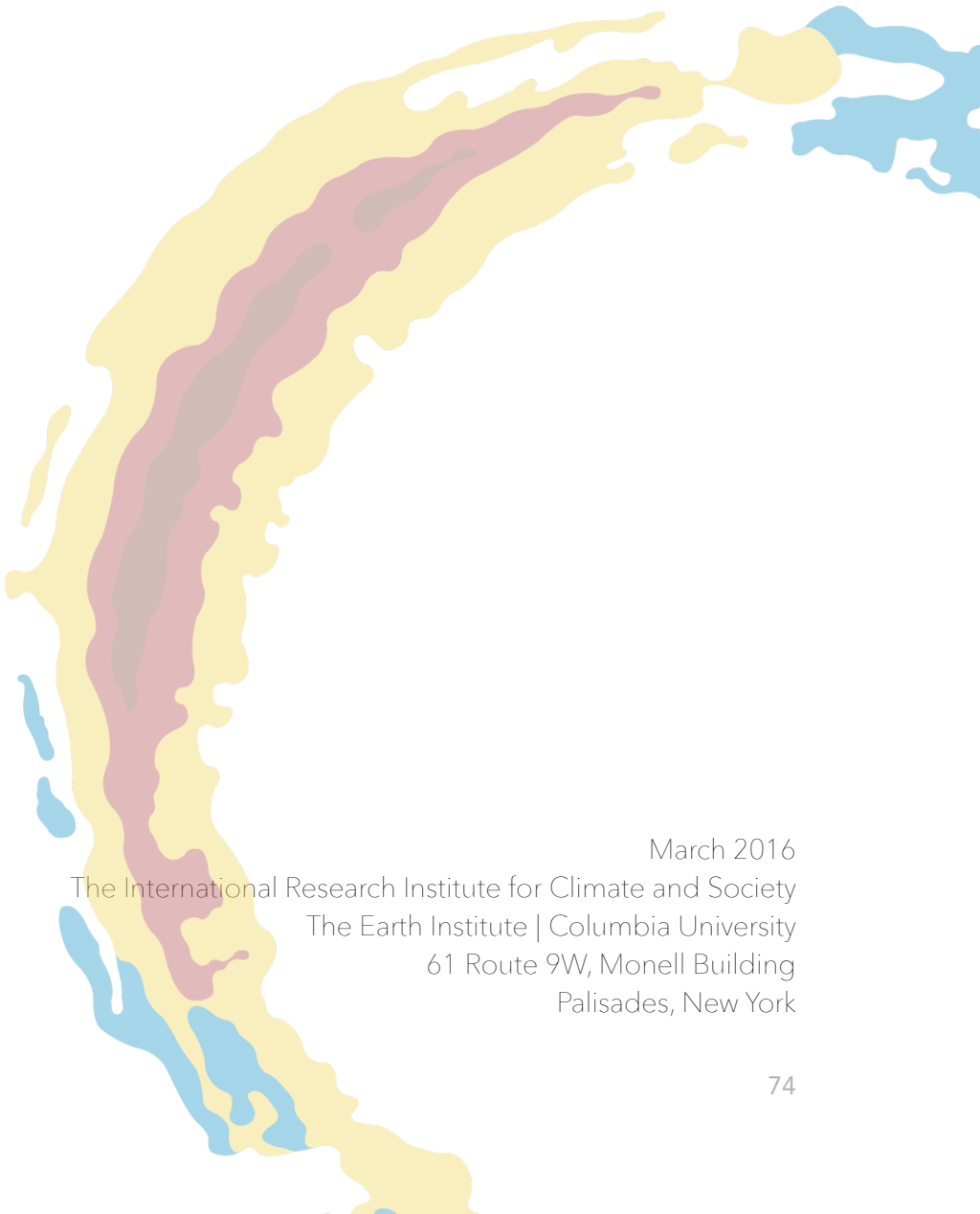
Online Resources

Conference webpage www.iri.columbia.edu/elnino2015conference/	**Multimedia conference report** bit.ly/ElNinoConfReport	**Video playlist** bit.ly/ElNinoConfVIDS	**Twitter** www.twitter.com/#elninoconf



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