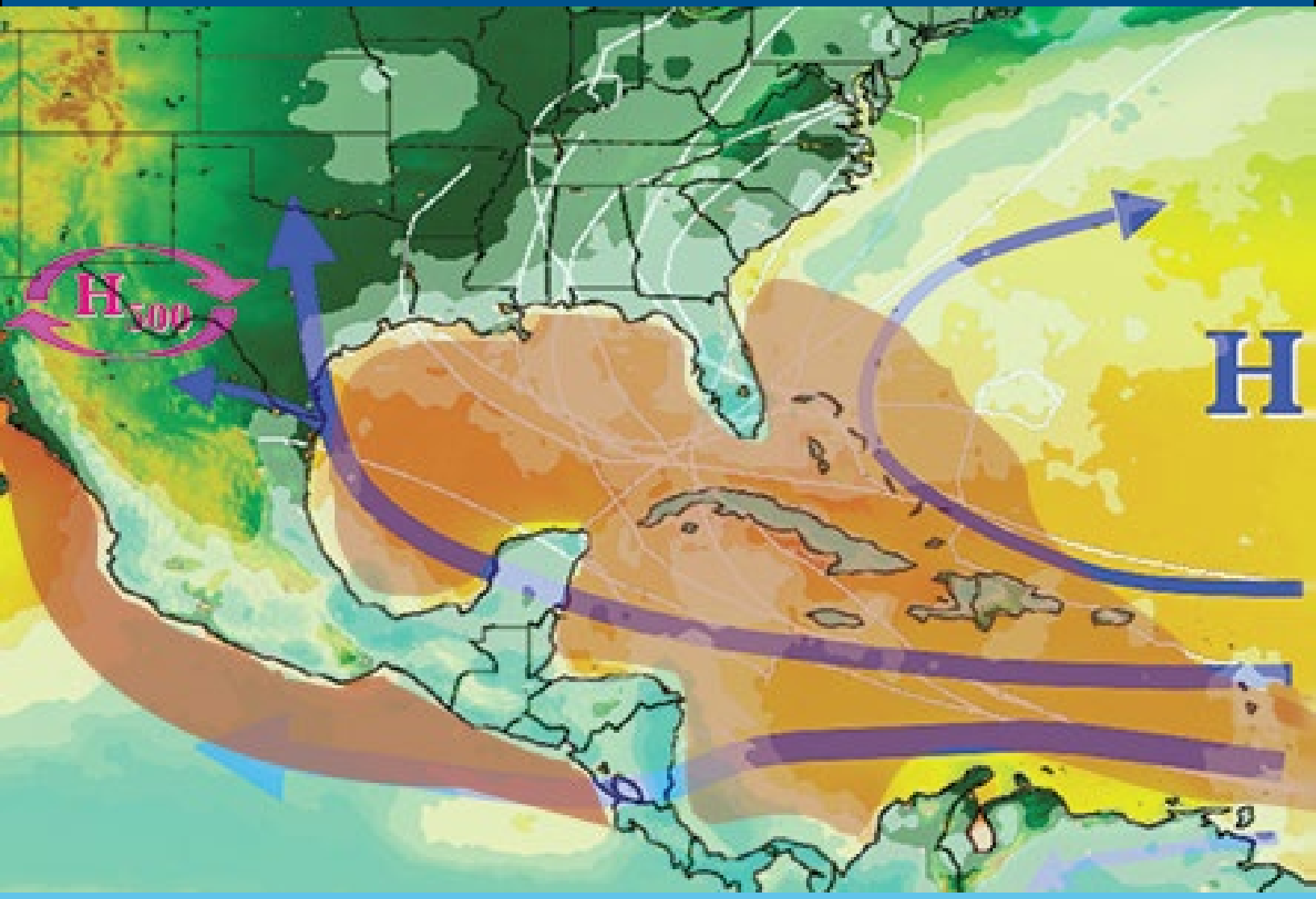

US CLIVAR
Climate Variability & Predictability

OBSERVING & MODELING CLIMATE VARIABILITY IN THE INTRA-AMERICA SEAS & IMPACTS ON THE CONTINENTAL AMERICAS & THE CARIBBEAN

September 9-11, 2015
Virtual Workshop

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COVER IMAGE

A schematic showing the Western Hemisphere warm pool (in brown shade) overlaid with lower tropospheric wind circulation (in blue arrows), mid-tropospheric subtropical high pressure (in magenta), with tropical cyclone tracks (in white lines), and rainfall (in shades of green) with topography in yellow.

BACK COVER IMAGE

COCONet station CN18, located at Swan Island, Honduras. Credit: Michael Fend, UNAVCO.

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Executive Summary

The virtual workshop was held over three half-day sessions (September 9-11, 2015) and featured 47 oral and poster presentations that spanned observational and modeling studies and timescales from the paleoclimate to secular change, and also covered a wide range of phenomenological studies (e.g., tropical cyclones, mid-summer droughts, low level jets). The virtual nature of the workshop enabled an unprecedented gathering of the Intra-Americas Study of Climate Processes (IASCliP) science community members from over 20 countries and a large number of early career scientists.

The workshop clearly recognized the importance of the Intra-Americas Seas (IAS) as a source of anomalous moisture for weather and climate events in local and remote regions. There were several studies that highlighted the importance of the low level jets (LLJs) in their generation of copious rainfall in terrestrial regions around the IAS. Similarly, the importance of the ocean mesoscale features, like air-sea interactions and the prevalent strong warm surface currents and eddies in heat transport, was also highlighted. Several presentations emphasized the prevailing influence of the upper ocean processes of the IAS and the associated overlying atmospheric conditions (e.g., vertical shear, stability) on the seasonal and longer-term variations of Atlantic tropical cyclones.

The workshop addressed limitations of climate models in simulating the IAS climate, such as the pervasive cold bias in the sea surface temperature (SST) over the IAS, the erroneous seasonal phasing and magnitude of the LLJ's, and the varied representation of the intraseasonal variability in climate models. It reviewed the role of local and remote climate variations in modulating the model bias over the IAS.

Furthermore, the diminishing coverage of in situ atmosphere and ocean observations in and around the IAS is of concern to the community. In situ observations of ocean heat content and mixing processes are thought to be critical to understand air-sea interaction processes in high impact weather events (e.g., tropical cyclones). Remotely sensed products of surface meteorology and upper ocean were also discussed as ways to augment the observing network for climate monitoring in the IAS, in addition to sustaining new initiatives of Global Positioning System (GPS) stations to monitor natural hazards in the region.

1 Introduction

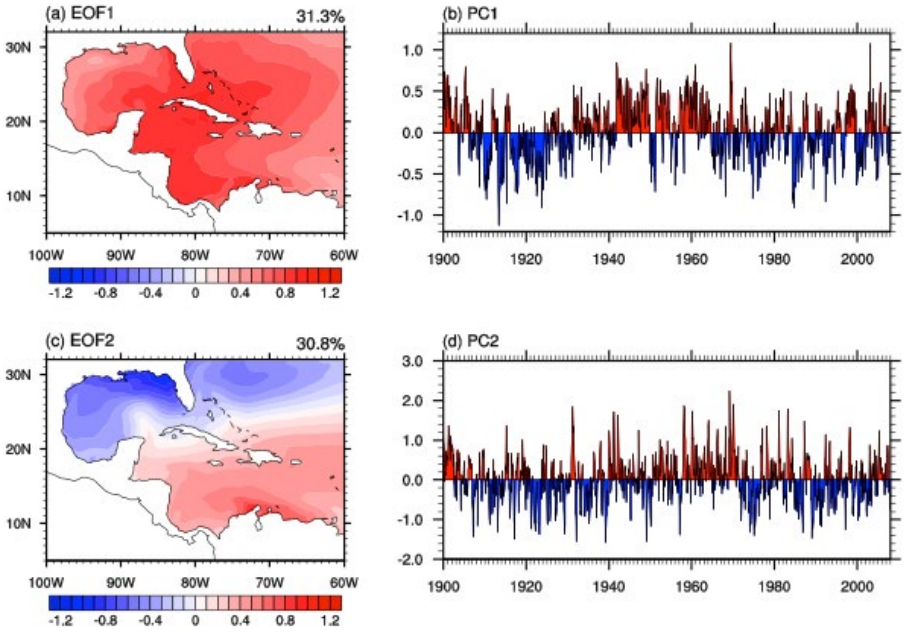
This workshop was the first planned meeting of the IASCLiP community members since the program was established in 2008. Previously, some of the governing members had met informally at meetings of opportunity. Membership in this program is established through a simple registration at http://www.eol.ucar.edu/mailman/listinfo/iasclip. Current membership spans a wide range of fields with interest in IAS climate and climate change. This workshop, therefore, gave an ideal platform for members of the IASCLiP program to showcase their research progress on the topic of climate variability and predictability in the IAS region, including the surrounding land regions.

The IAS comprises the Gulf of Mexico (GoM) and the Caribbean Sea, which is characterized by seasonally appearing very warm SST (>28.5°C) in the boreal summer and fall seasons. The IAS forms part of a larger Western Hemisphere warm pool (WHWP; Wang and Enfield 2001), second only to the western Pacific warm pool in its spatial extent. Its influence is wide ranging from the local to broader remote locations of the North American hydroclimate (Wang and Enfield 2003). This warm pool in the IAS is sustained largely by robust ocean circulations with fine mesoscale features that essentially bring warm and fresher water from the tropical North Atlantic (Lee et al. 2007; Misra et al. 2013) and local air-sea fluxes influenced by cloud-radiative interactions (e.g., Wang and Enfield 2001, 2003).

The IAS is also characterized by a seasonally varying low-level atmospheric jet system over the Caribbean Sea, with the strongest winds observed in July and a secondary maximum in February (e.g., Wang 2007; Amador 2008). IAS land areas experience significant rainfall variability associated with local SST and LLJ variability (e.g., Wang 2007; Amador 2008), as well as in response to remote forcing through excitation of extra-tropical stationary waves (Wang et al. 2008). A particularly important feature of the rainfall variability over the Caribbean islands, Central America, and northern part of South America is the mid-summer drought, or minimum in the rainfall during mid-summer (e.g., Magana et al. 1999; Poveda et al. 2006; Curtis and Gamble 2008). The cause of the mid-summer drought is not well understood and is likely a combination of several factors including the seasonal variations in the Intertropical Convergence Zone (ITCZ), WHWP, LLJ system, and solar cycle over the region.

The northward branch of the LLJ, known as the Great Plains Low-Level Jet (GPLLJ), extends into North America during boreal summer and winter (e.g., Bonner 1968; Whiteman et al. 1997; Zhu and Liang 2013) impacting rainfall across the central Great Plains predominantly during the warm season (e.g., Mestas-Nunez et al. 2007; Weaver and Nigam 2008). The strength and variability of the GPLLJ and its associated moisture transport is significantly influenced by anomalies in the warm pool, in conjunction with global SST anomalies (Mestas-Nunez et al. 2007; Wang et al. 2007). The warm pool in the IAS also alternates with the Amazon as the seasonal heating source for the Walker/Hadley circulations in the Western Hemisphere (Wang et al. 2010). During boreal summer and fall, a strong Hadley-type circulation is established, with ascending motion over the warm pool and subsidence over the southeastern tropical Pacific (Wang et

al. 2010). The inter- and intra-basin SST gradient between the IAS and the tropical western Atlantic and northeastern Pacific also play an important role in the regional climate of the IAS and surrounding land areas on intraseasonal to interannual timescales (Klein et al. 1999; Munoz et al. 2008; Taylor et al. 2011). Embedded within these defining features of the warm pool are extreme events fueled by Atlantic hurricanes (Wang et al. 2007, 2008, 2011; Klotzbach 2014), tornadoes in the southeastern US (Lee et al. 2013), and anomalous rainy seasons in Mesoamerica and across the US east of the Rockies through the modulation of atmospheric rivers (Lavers and Villarini 2013).



Sea surface temperature variability in the IAS exhibits interannual and decadal signals. EOF analysis identifies two leading modes: the first (EOF1) associated with the Atlantic Multidecadal Oscillation and the second (EOF2), dubbed the IAS dipole mode. Source: Yanyun Liu, University of Miami.

On the Pacific side of the IAS, the dynamics of the Choco LLJ is coupled with the presence of mesoscale convective systems (MCSs) throughout the year, with maximum activity during September-October-November and minimum during December-January-February seasons (Poveda and Mesa 2000; Poveda et al. 2014). The LLJ and the MCSs together contribute to the presence one of the rainiest regions on Earth along the Pacific coast of Colombia (Zipser 2015). The Choco LLJ is responsible for the transport of moisture into southern Central America during the boreal summer and fall (Durán-Quesada et al. 2010). There is a need to understand the interactions between the Caribbean and Choco LLJs, and in turn their influence and feedbacks with MCSs over the region, at a wide range of timescales from the diurnal cycle to intraseasonal, annual, and interannual timescales.

Like the double ITCZ problem in the tropical eastern Pacific, successive generations of climate models have produced a serious cold SST bias in the IAS (Misra et al. 2009; Kozar and Misra 2012; Liu et al. 2012, 2013) with a systematic error of SST of up to 3°C. Central America and southern Mexico are “hot spots” for future drying; however, due to the large bias in IAS SST there is little confidence in these projections despite the consensus among CMIP3 and CMIP5 models (e.g. Maloney et al. 2014). Additionally, such serious SST errors would likely have an implied bias in the heat content for the IAS that,affects the steering flow of Atlantic tropical cyclones, modulates the Great Plains and Caribbean LLJs and related moisture flux into the United States and Mesoamerica, and impacts the remote teleconnections associated with the Gill type atmospheric response to diabatic heating released during late summer and fall over the warm pool (Wang et al. 2010).

1.1 Workshop Objectives

The virtual workshop was the first such planned event of the IASCLiP community under the aegis of US CLIVAR to understand and address the issues of model bias and poor observational coverage and highlight the importance of the IAS in the hydroclimate anomalies and extreme events of the continental regions of the Americas spanning across timescales (intraseasonal to secular change). This open workshop had the objective of bringing the community of climate modelers (ocean, atmosphere, and land), observational scientists (instrument/remote sensing), and other potential interest groups (government, non-profit, public and private institutions) who could possibly benefit from or contribute to the outcomes of the workshop.

The purpose of the workshop was to provide a platform to facilitate discussions to:

- Explore the potential of exploiting the teleconnections of the continental monsoons of the Americas and the variability in the IAS,
- Understand and improve the intraseasonal to interannual predictability in the region,
- Examine the potential role of the IAS in decadal predictability of the Americas,
- Assess the impacts of climate change throughout the Continental Americas and the Caribbean,
- Address the systematic model bias in the region,
- Improve the rapidly deteriorating observational network, and
- Entrain early career scientists and students into these issues.

Six oral sessions covered observational and modeling aspects of IAS physical processes across temporal variations spanning from the intraseasonal to secular change, including extremes, highlighting the current limitations of the observational network and model simulations. The presentations were intended to promote new ideas to enhance the observing systems in the region, develop new modeling strategies to enhance prediction skill, and foster collaborations.

Twenty-three poster presentations addressed the same range of topics as the oral presentations. These posters were made available for viewing on the workshop website two weeks prior to the start of the workshop (and one week after) with the ability of viewers to post their questions to the authors on a dedicated verbal chat link for each poster. Poster presenters could then respond to each question, with the responses available for viewing to all visitors of the poster. The poster session was in many accounts very successful in meeting the objectives by giving sufficient exposure to the audience and being highly interactive, even in the absence of oral interaction between the viewers and the presenters, with over 80 questions answered for all posters.

1.2 Workshop Structure

Organizing committee

The scientific organizing committee was comprised of five members, chosen based on their active research engagement on the IAS related to modeling and observational analysis and ability to attract both domestic and international attendees to the workshop. This committee helped in making the agenda and soliciting the invited speakers to the workshop.

The members of the scientific organizing committee included:

- Vasubandhu Misra, Department of Earth, Ocean and Atmospheric Science & Center for Ocean Atmospheric Prediction Studies, Florida State University, USA (Co-chair)
- Chunzai Wang, Atlantic Oceanographic and Meteorological Laboratory, National Oceanographic & Meteorological Laboratory, USA (Co-chair)
- Yolande Serra, Joint Institute for the Study of Atmosphere and Ocean, University of Washington, USA
- German Poveda, School of Geosciences and Environment, Universidad Nacional de Colombia, Sede Medellin, Colombia
- Erick Rivera Fernandez, School of Physics and Center for Geophysical Research, University of Costa Rica, Costa Rica

The program organizing committee helped with the logistics of setting up the virtual workshop, training the oral presenters to use the software, setting up the posters, and in the overall management of the workshop.

The program organizing committee included:

- Mike Patterson, US CLIVAR
- Jill Reisdorf, UCAR
- Kristan Uhlenbrock, US CLIVAR

Meeting format

The workshop was held over three half-days on September 9, 10, and 11, 2015. Each day, there were two sessions, consisting of four talks each, inclusive on one invited speaker, and an hour break in which we hosted a virtual poster session. The final session of the workshop was a panel featuring three invited speakers. Time was allotted after each talk for discussion. The questions from the participants came both through audio and the online chat feature. Members of the scientific organizing committee chaired and moderated each session.

Attendees

The attendees came from academia, government agencies, non-profit, and private companies. There were 47 oral and poster presentations, including 22 early career scientist presentations. The attendees represented 20 countries including the US. The distribution of the attendance during the three days of the workshop is provided in the table below. For a full is of participants, see Appendix A.

	Wednesday (9/9)	**Thursday (9/10)**	**Friday (9/11)**
Total participants	108	89	79
Peak in number of participants	88	80	57

Early Career Scientist Award Recipient

Early career scientist, Yanyun Liu, was the winner of a travel award for the best oral or poster presentation, as selected by the scientific organizing committee. She presented a poster entitled “Potential Impact of Climate Change on the Intra-Americas Sea: A Dynamic Downscaling of the CMIP5 Model Projections.” This poster addressed fundamental questions of climate variability and change in the Gulf of Mexico region and highlighted the important issue of bias in ocean transport that plagues a majority of CMIP5 models.

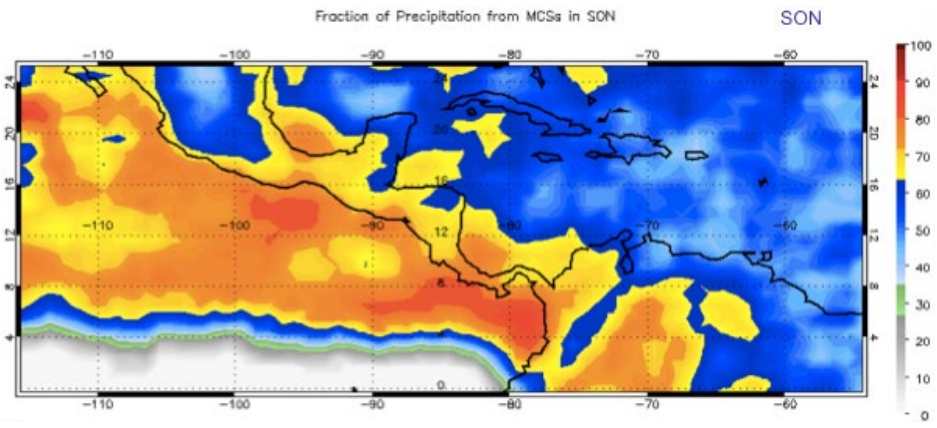
2 Topical Sessions

The workshop covered a wide range of issues including observational analysis, modeling studies, extreme weather and climate anomalies, paleoclimate reconstructions, land-atmosphere interactions, air-sea interactions, and observational climate monitoring networks. Slides and recordings of all oral presentations are available on the workshop website.

2.1 Session I: Identifying opportunities and challenges of observing and modeling IAS variability and its teleconnections (Chair: German Poveda)

In his invited talk, Edward Zipser gave an overview of mesoscale convective systems (MCSs) in the IAS region, with emphasis on the world-record breaking rainfall region over the Pacific coast of Colombia, pointing out different precipitation features and lightning characteristics identified from the Tropical Rainfall Measuring Mission's (TRMM) precipitation radar and as well as TRMM Microwave Imager (TMI), Lightning Imaging Sensor (LIS), and Visible Infrared Scanner (VIRS).

Neena Joseph Mani presented an analysis of the skill of different models to predict eastern Pacific intraseasonal variability, its different phases (convective and subsident), and its behavior during the active and quiescent phases of the Madden-Julian Oscillation (MJO). An evaluation of hindcasts from eight models shows the typical single member prediction skill for intraseasonal variability in the eastern Pacific is in the range of 7-12 days, with ensemble prediction providing only slight improvement in skill. Predictability estimates range from 15-23 days for single model members to 20-30 days for the ensemble mean.



The IAS region is notable for the size and intensity of mesoscale convective systems (MCSs). Sixteen years of TRMM data enables characterization of occurrence and distribution of MCS and their contribution to precipitation over the IAS region. The East Pacific, Central America, and Columbia have a large fraction of rain from MCS, while the Caribbean does not. Source: Edward Zipser, University of Utah.

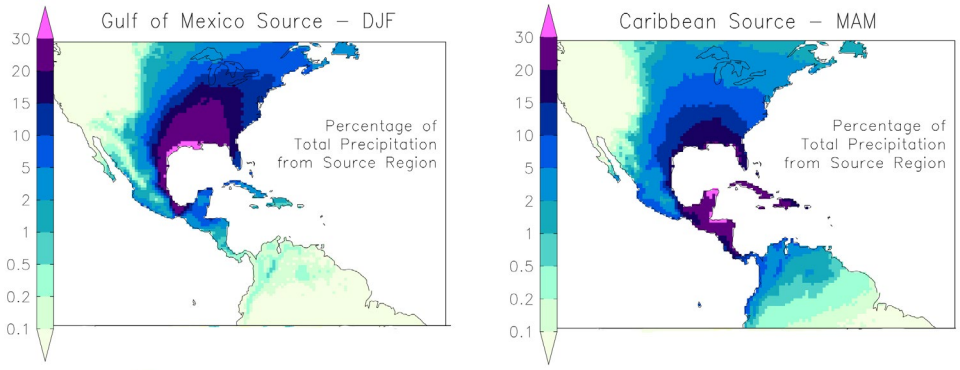
Brian Mapes spoke about the importance of the atmosphere's zonal mean momentum and its role in the IAS summer weather, in the IAS mid-summer drying, and in shaping the anticyclones over the region, as well as the influence of the Asian monsoon and El Niño-Southern Oscillation (ENSO).

Ernesto Muñoz rounded out the session with an overview about the possibilities of employing the Community Earth System Model (CESM) for understanding and simulating diverse IAS phenomena. He highlighted the ability of the high-resolution version of the model to resolve the general circulation of the Gulf of Mexico, including the Loop Current and the Yucatan Channel flow.

2.2 Session II: Ocean-land-atmosphere interactions of the Continental Americas and the Caribbean (Chair: Erick Rivera)

Using gridded observations and reanalysis data, the invited speaker, Paul Dirmeyer, showed estimates of the sources of moisture for precipitation over continental areas across the IAS region. He highlighted the major contributions from oceanic regions, such as the Gulf of Mexico and the Caribbean Sea, especially during extreme flooding events in the central United States.

Isabel Hoyos presented the results from three backward trajectory models to show that moisture from the Atlantic Ocean and terrestrial recycling are the most important sources of moisture over Colombia, with the tropical Pacific being important only during the Choco Jet season (September to December).



Estimated sources of moisture supplying rainfall over IAS land regions using gridded observational data sets of precipitation and MERRA atmospheric reanalyses. Considerable moisture is transported from Caribbean and Gulf of Mexico westward and northward into Central and North America, but very little southward into South America. During winter, the Gulf provides moisture for heavy precipitation and flooding over the South and Southwest US. In spring, the Caribbean Sea provides moisture for heavy rain and flooding in Mexico, and in a band from the northern Great Plains to the Great Lakes. Source: Paul Dirmeyer, Center for Ocean-Land-Atmosphere Studies, George Mason University.

Julien Jouanno presented a regional ocean modeling study aimed at quantifying the role of the Orinoco and Amazon freshwater discharges in the weakening of tropical cyclone-induced cool wakes and its impact on hurricane growth potential. He argued that only about 10% cooling of the ocean waters is caused by river runoff.

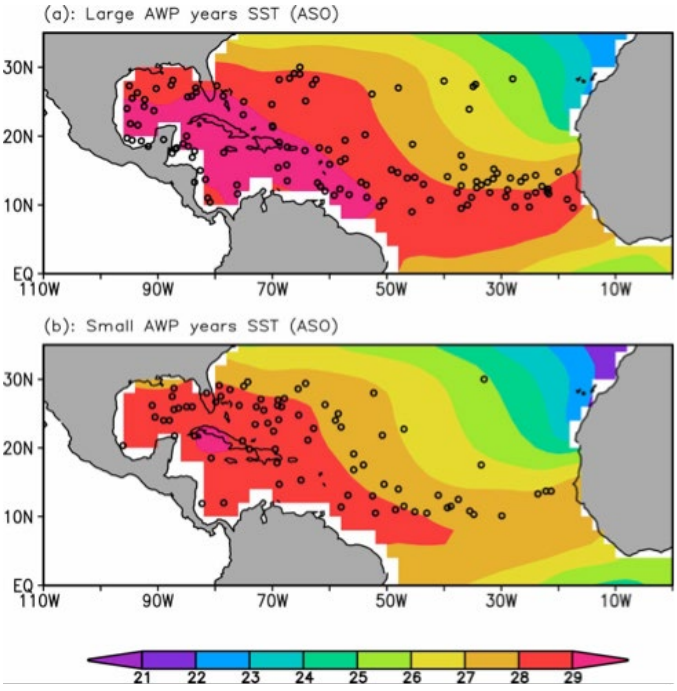
Lakshmi Krishnamurthy spoke about the relationship between the GPLLJ and ENSO by using observations and coupled model simulations. She hypothesizes that ENSO influences the GPLLJ via the tropical Atlantic

(Caribbean low-level jet) during the spring and summer seasons, which shows the need for better representation of ENSO variability in the climate models.

2.3 Session III: Weather and climate extremes in the Americas (Chair: Chunzai Wang)

Gabriel Vecchi introduced GFDL's coupled global climate models that provide a unified framework towards the understanding, prediction, and projection of tropical cyclones. The models show skill at seasonal predictions of the frequency of the most intense hurricanes (Category 3-4-5 and Category 4-5). These models are also used to explore the response of tropical cyclones to increasing greenhouse gases. The models display an increase in the frequency of intense tropical cyclones under increasing greenhouse gases, including the development of a substantial number of "Category 6" cyclones (storms with maximum winds exceeding 80 m/s).

Chunzai Wang presented the influences of the Atlantic warm pool (AWP) on Atlantic hurricane activity by using observations and numerical model experiments. A large (small) AWP increases (decreases) the number of Atlantic hurricanes and reduces (enhances) the possibility for hurricanes to make landfall in the southeastern United States. An increased number is attained through AWP-induced changes of vertical wind shear and moist static instability of the troposphere in the Atlantic hurricane main development region. A large AWP shifts the hurricane genesis location eastward, decreasing the landfalling possibility. A large AWP also induces the eastward and northward steering flow anomalies along the southeastern seaboard of the United States. Due to these two mechanisms, hurricanes are steered toward the north and northeast without making landfall in the southeastern United States during large AWP years. The opposite is true during small AWP years.



High SSTs in the Atlantic Warm Pool influence the occurrence of hurricanes by enhancing water vapor content to fuel moist convection and reducing the vertical wind shear in the hurricane development regions of the Atlantic. A large AWP increases the number of hurricanes, with many more originating in eastern Atlantic and less favorable for making landfall in the southeast US. Source: Chunzai Wang, NOAA AOML.

Yolande Serra examined a prolonged drought in Central America since the summer of 2014. The large-scale atmospheric conditions supporting this drought may be related to the El Niño conditions that have persisted across the tropical Pacific. Serra also showed the interaction of the topographically forced diurnal convection with synoptic waves propagating northwestward along the Pacific coast of Central America, as well as the modulation of these interactions by the large-scale conditions associated with the interannual variability in the region. She also discussed whether the current observational network is sufficient to monitor the region during extreme

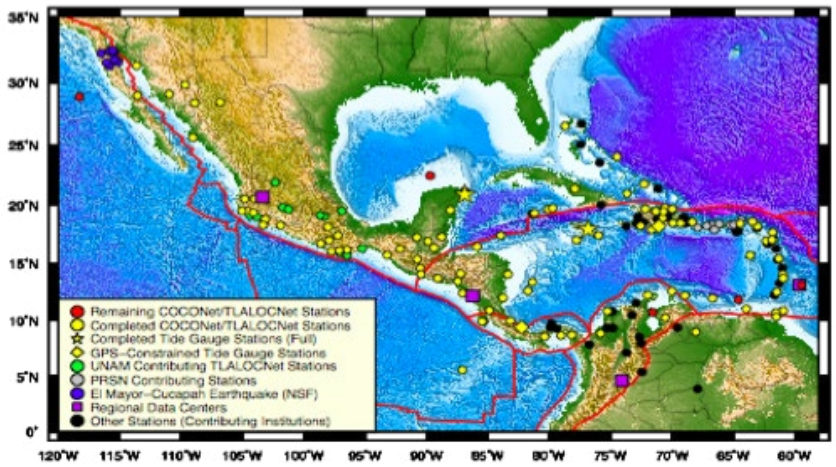
weather conditions, such as the current drought, as well as whether these observations can be used to understand the physical mechanisms responsible for the reduced rainfall over the region.

Angel Munoz showed the subseasonal-to-seasonal extreme rainfall scenarios for the Caribbean, using a method involving an objective classification of atmospheric circulation patterns using velocity potential anomalies at 850 mb. These circulation regimes, or weather types, characterize different precipitation patterns in the Caribbean, and their seasonal frequency of occurrence modulates the spatial and temporal distribution of precipitation through the season. The weather types are linked to particular SST anomalies in both the Pacific and Atlantic Oceans in the months preceding the seasons under analysis, suggesting potential predictability.

2.4 Session IV: Initiatives to improve observational coverage of the ocean, land, and atmosphere (Chair: Yolande Serra)

This session focused on new observations and emerging technologies within the IAS that are addressing some of the outstanding scientific questions for the region. The invited speaker, John Braun, provided an overview of COCONet (Continuously Operating Caribbean Observational Network) and TLALOCNet (Trans-boundary Land and Atmosphere Long-term Observational and Collaborative Network). These networks provide surface meteorological observations, including rainfall, as well as total column precipitable water vapor using GPS technology at sites throughout the Caribbean, northern South America, Central America, and Mexico. These data are available in real-time at high time resolution and are thus useful for both weather forecasting as well as research applications. COCONet sites also provide sea level observations at island and coastal sites.

David Adams discussed specific applications of the GPS meteorological network data to studies of deep convection over Mexico and the Amazon. He reported on the ability of the GPS data to establish a robust timescale for shallow-to-deep convective transition, provide measures of propagation speed and intensity of sea-breeze convective lines, and to capture the diurnal cycle water vapor and convective activity. His results demonstrate the ability of the GPS network to provide observationally derived metrics of convection that can be used for model evaluation.



The figure presents the locations of installed (87) and planned (21) COCONet and TLALOCNet GPS and surface met stations deployed by September 2015. The sites retrieve precipitable water and surface pressure, temperature, relative humidity, winds, and precipitation. More than a third of the stations have collected data for three years; some for nearly a decade. Source: John Braun, UCAR Cosmic Program Office.

Frank Muller-Karger presented an overview of a 20-year biogeochemical

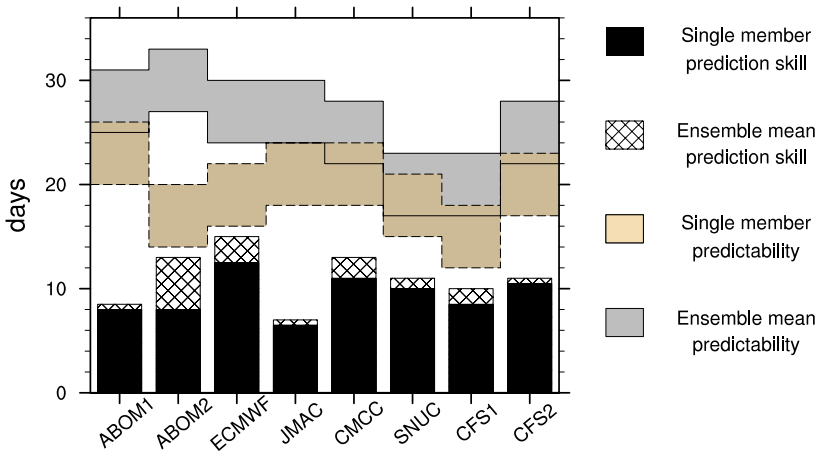
dataset from the Cariaco Basin. The CARIACO project uses autonomous and shipboard measurements to understand ecological and biogeochemical changes in the tropical continental margin of northern South America and how these relate to regional and global climatic and ocean variability. Understanding the relationship between the physical drivers and biogeochemistry is important for reconstructing past ocean and climate conditions using the basin's sediment record.

Ricardo Domingues presented results from their pilot network of underwater gliders, which was implemented in 2014 by NOAA as part of a multi-institutional project to carry out sustained and targeted upper-ocean observations to 1000 m depth in the Caribbean Sea and tropical North Atlantic Ocean. This pilot glider network was implemented to enhance our knowledge of the role that the ocean plays in the intensification of tropical cyclones, and to assess the impact of these observations on tropical cyclone intensity forecasts.

These presentations provided valuable information to the community on existing datasets in the IAS. However, there was general agreement that the existing observations are insufficient for atmosphere and ocean model development and for improving our fundamental understanding of important physical processes in the region.

2.5 Session V: Identifying sources of model biases for the IAS in both coupled and ocean or atmospheric models (Chair: Vasu Misra)

Eric Maloney, the invited speaker, reviewed the observed and modeled representation of intraseasonal variations in the IAS. Mechanisms regulating intraseasonal variability in the region include local destabilization associated with surface fluxes, radiative feedbacks, and convective heating; transient feedbacks associated with easterly waves; and remote influences of variability associated with the MJO. Vertically integrated gross moist stability, a partial measure of convective moisture discharge efficiency, provides an important metric for evaluating model simulation of East Pacific intraseasonal variability. Finally, Maloney suggested that a proposed east Pacific field program, the Organization of Tropical East Pacific Convection (OTREC), might help address outstanding questions on processes driving intraseasonal variability in the region.



Atmospheric intraseasonal variability (ISV) in the eastern Pacific significantly influences climate over the IAS region, notably Caribbean precipitation, tropical cyclone formation, Central American mid-summer drought, and the North American monsoon. Climate models exhibit skill in forecasting the occurrence of ISVs. The number of days for which each of eight climate models exhibit prediction skill (correlation greater than 50%) are calculated above for the first mode of East Pacific ISV. Typical single member prediction skill is 7-12 days, with ensemble prediction only slightly improving. Estimates of model predictability, shown as 6-day ranges, are much higher – from 15 to 23 days for single model members and 20-30 days for model ensembles. Source: Neena Joseph Mani, Indian Institute of Science Education and Research, Pune.

Juan Pablo Sierra presented an assessment of the ability of CMIP5 models to simulate features of the western Colombia LLJ, known as Choco, which plays an important role in moisture transport from the Eastern Pacific Ocean and related precipitation maximum over the Colombian Pacific coast. His analysis demonstrates key model biases, including underestimate of jet core velocities and southward displacement of the jet, owing to misrepresentation of inter-hemispheric temperature differences, ocean-land temperature and pressure differences, and poorly resolved orography.

Vasu Misra presented a study on the sensitivity of the model simulations to prescribed bathymetry in the IAS. Simulations using coarsely resolved bathymetry exhibit widespread SST bias across the IAS associated with changes in the prevalent upper ocean currents, particularly an unrealistically weak flow through the Yucatan Channel and a weak Loop Current. Upper ocean heat content and surface eddy kinetic energy are also significantly underestimated in the coarse resolution model simulations, reinforcing the importance of prescribed bathymetry in high resolution models to effectively simulate IAS upper ocean climate and variability.

Dian Putrasahan gave the final talk on ocean variability, air-sea interaction, and heat transport in the Gulf of Mexico as diagnosed in a high- and low-resolution ocean versions of the Community Climate System Model. As seen in observations, the high-resolution simulation reveals a positive correlation of latent heat flux with SST, indicating ocean forcing of the atmosphere in the region (whereas the low-resolution version of the model shows the opposite relationship). Warm SST anomalies – and related wind/moisture convergence and increased convective precipitation – are supported by submonthly divergence of ocean heat flux.
Broadly speaking, the first two talks exposed the limitations of atmospheric phenomenon of the intraseasonal variations and the LLJs, while the latter two talks highlighted the importance of the ocean mesoscale circulation features in the IAS. A clear message that threads through all of these talks is that the manifestation of the biases in a given phenomenon (e.g., intraseasonal variability, LLJs, mesoscale ocean circulation) over the IAS is a reflection of larger-scale errors. In addition, these talks also suggested that ignoring small-scale sustained phenomenon (e.g., LLJs, ocean eddies) through the adoption of coarser models could also be contributing to the systematic errors.

2.6 Session VI: Panel discussion: Observations, modeling, predictability and prediction of the region (Moderator: Vasu Misra)

George Huffman, Lynn Shay, and Shang-Ping Xie participated in a panel discussion to review observational and modeling challenges and opportunities. The three respectively covered the topics of NASA's current and future observing platforms that could potentially help in the observational coverage of the IAS region, the importance of in situ ocean observations in the IAS to understand the mixed layer processes, and the issue of model bias over the IAS.

NASA, with its launch of the Global Precipitation Measurement (GPM) project that has a constellation of nine satellites, is offering higher-resolution precipitation datasets with improved instruments compared to TRMM and additional coverage over higher latitudes as well. These data would help in addressing the data gaps resulting from the deteriorating observing network of rain gauge stations in the Latin American and the Caribbean countries surrounding the IAS region. However, like many other satellite-retrieved products of rainfall, GPM also suffers from bias in orographic regions, especially when the calibration data is scarce to resolve the strong gradients in rainfall.

Lynn Shay emphasized the role of momentum flux in the mixed layer budgets of the IAS. She argued that momentum from ocean current and current shear are central to weather and seasonal variability in the dynamics of the wind-forced mixed layer in the IAS. Several unanswered questions on the fidelity of the model simulations of the deeper circulation patterns in the absence of corresponding long-term verification data make it extremely difficult to understand the interaction/impact of surface circulation patterns on mid-depth (e.g., thermocline level) circulations. Furthermore, satellite remote sensing products provide the larger scale context but are inadequate to study the fine scale mesoscale features. The call for in situ data over the IAS becomes even more critical during the passage of weather events (e.g., hurricanes), when current shears (and instability) are responsible for a large fraction of the vertical mixing, which is parameterized in the ocean models. Lastly, a discussion on the optimal mix of ocean observations in the IAS is justifiable given the complex circulation patterns and relatively high frequency of shear-instability events. Shang-Ping Xie emphasized the similarity of the pervasiveness of cold bias in the IAS, double ITCZ issue in the eastern Pacific, and the egregious error of reversed zonal gradient of SST in the equatorial Atlantic. Some of these errors may be caused by errors in convection schemes, insufficient vertical momentum transport in the atmosphere, a diffuse thermocline, insufficient stratocumulus cover, and weak alongshore winds. Furthermore, it was pointed out that the impact of these errors in the Atlantic on seasonal predictions and global change projections is largely unexplored.

Following the presentations and a brief question and answer period with the panel, the floor was opened to a general discussion by participants to identify outstanding science questions, opportunities to improve understanding of processes in the IAS, and next steps for the community to make progress. This discussion is summarized in the following outcomes section of report.

2.7 Poster Sessions

The poster sessions were convened over each day's hour break. During this time, participants were able to have their questions answered in real-time by the poster presenters through an interactive commenting section. However, posters were available for viewing two weeks before the start of the workshop and one week after. This allowed for viewers to post their questions at any time to the authors during this period. There were 23 posters that spanned both observational and modeling studies across timescales from the intraseasonal to secular change. There were approximately eight posters per day for interactive sessions between the authors and the viewers, which were not in any specific order. Discussion for most posters occurred prior to the start of the workshop or a within a week after the workshop ended. Some of the posters showcased new datasets, including the analysis of archived meteorological datasets from local weather stations in Latin America and ground validation and variance in the satellite retrieved rainfall products over the continental regions of the IAS. Other posters covered topics such as the seasonality and the variability of the local LLJs in Latin America, observed secular changes in surface meteorological variables, intraseasonal variations including the phenomenon of the mid-summer drought witnessed from Central America across to the far eastern Caribbean islands, Saharan dust transport, variability of seasonal eastern Pacific and western Atlantic tropical cyclone activity and the landfalling tropical cyclone characteristics in the IAS coasts, and seasonal predictability and variability of the teleconnections from the IAS and their secular change.

3 Workshop Outcomes

The workshop achieved its aim of drawing together the community of IAS scientists working on the wide range of IAS research topics to share findings and identify future research activities to capitalized on them and collectively advance the science. Importantly, the innovative web-based approach for the workshop enabled broad participation from multiple countries without incurring the time and cost for travel. Feedback from the participants on the effectiveness of the workshop is summarized in Appendix C. Drawing from the workshop presentations and discussion, the Scientific Organizing Committee has developed the following set of key outcomes and next steps.

3.1 Review of current state of understanding

The workshop clearly highlighted the growing involvement of a number of researchers (especially early career scientists) on the theme of IAS climate. The presentations and the discussions that followed in the workshop pervasively recognized the importance of the Atlantic and Northeastern Pacific warm pools and the associated atmospheric and oceanic circulations. The role of the IAS, as a significant moisture source for remote terrestrial weather events and anomalous seasonal means, was highlighted in presentations throughout the workshop. Similarly, the role of the IAS in the modulation of the seasonal and longer temporal variations of Atlantic tropical cyclone activity was also strongly articulated.

The workshop also emphasized the importance of the LLJ's of not only the Great Plains and the Caribbean but also the Choco LLJ in Colombia and their roles in the copious generation of rainfall. The misrepresentation of these LLJ's in the climate models and the rather pathological cold bias of SST in the IAS were recurring themes concerning the shortcomings of the models. The varied representation of the intraseasonal activity obfuscated the search for a silver bullet to understand the shortcomings of simulating this feature in models. But there is a growing consensus that momentum transport in deep convection has a larger role to play than initially thought on the simulation of the intraseasonal variations.

There was a clear consensus that in situ observations of atmosphere as well as the ocean are critical from the perspective of climate monitoring and validation of remotely sensed products. The observation of ocean heat content across the IAS, to understand its role in the modulation of Atlantic tropical cyclones and air-sea interaction, was recognized to be critical, yet lacking. Similarly, the role of upper ocean mixing in sustaining and varying the heat content of the IAS was conveyed to be very important especially during the passage of transients like Atlantic tropical cyclones and easterly waves, which is limited by the continuous monitoring of such data.

The role of the local and remote influences of climate variations on the fidelity of the model simulations over the IAS was discussed in several talks. Presenters also looked at whether model biases in other

tropical ocean basins manifest in ways and forms that would influence the simulation of models over the IAS. Observational and mechanistic modeling studies seem to suggest that Asian monsoon variations have an impact on the barotropic mean flow that influences the mid-summer drought over the Caribbean and Central America, while also influencing the number of cyclone days in the IAS through its influence on the vertical shear. Similarly, there was evidence from one model to suggest that bias in ENSO seasonal cycle could have a bearing on the interannual variations of the GPLLJ. The local influence of ocean eddies, cloud radiative interactions, air-sea fluxes, and ocean heat transport accentuated by the prevalent mesoscale ocean currents and eddies were also considered to have a strong bearing on the evolution of the upper ocean features of the IAS. However, the discussions on these topics suggested that more research is needed to be conclusive.

3.2 Outstanding questions relating to climate prediction and predictability of the region

While the workshop updated our understanding of many features of the IAS and its influence on regional climate, it also clarified the following questions that remain to be addressed:

1. In order to better understand intraseasonal modes in the eastern Pacific and the IAS, IASCLiP should consider the following questions:

    - Is there an independent 30-60 day mode (eastern Pacific MJO) in the eastern Pacific?
    - What is the nature of the 20-day mode in the eastern Pacific? Is there increased predictability of tropical cyclones or subseasonal land-based precipitation with this mode?
    - What are the low amplitude, intraseasonal variations in the IAS?
    - What modes offer the greatest predictability of tropical cyclone activity on intraseasonal and seasonal time scales?

2. What are the Atlantic SST modes on interannual to decadal time scales and their relationships to the higher frequency modes?

3. What are the relationships of Atlantic SST modes on interannual to decadal time scales to important climatic features of the region including the MSD, EW activity, tropical cyclone activity, CLLJ and other LLJs?

4. What is the impact of local SSTs on local rainfall?

5. What is the impact of local SSTs on tropical cyclone development? [There is evidence to suggest that high resolution modeling with flux correction do best at recreating tropical cyclone climatology.]

6. What is the role of land and diurnal convection in propagation of the MJO across the region? Does the isthmus act like the Maritime Continent in how it affects MJO propagation? Do convectively coupled equatorial waves propagate more readily across the land bridge because they do not interact with diurnal cycle of convection?

7. What is the reason for the displacement of the ITCZ southward from the highest SSTs in the Gulf of Mexico?

8. What are the sources of the model biases in the region? How do biases relate to one another and the bias in remote regions? What are the similarities and differences between AMIP versus coupled model biases? [Follow on high-resolution model experiments need to be performed.]
9. What is the role of hydrological processes occurring over the Amazon River basin on diverse ocean-atmosphere processes in the tropical North Atlantic and Caribbean Sea?
10. How is the oceanic barrier layer formed and how does it respond to wind forcing?
11. What are the relationships between IAS variability and the Atlantic meridional overturning circulation (AMOC)?

3.3 Targeted metrics to diagnose model errors

A key recommendation emerging from the workshop is for the community to develop metrics for modeling studies to identify biases, their relationship to one another, and remote influences and effects. Metrics capturing the following features are a priority.

Although the LLJ's (e.g., Caribbean, Great Plains, Choco) are mesoscale features, they play an important role not only in moisture transport but also have critical interactions with the mean flow and large-scale features (e.g., the interaction of the Choco jet with the eastern Pacific ITCZ, the Caribbean LLJ and its interaction with the North Atlantic subtropical high). Therefore, the diagnosis of the LLJ bias is critical to examine the fidelity of model simulations of the IAS region. More specifically, in regards to the Caribbean LLJ, some of the important characteristics include:

- Horizontal gradients in the zonal wind particularly in the meridional direction;
- Vertical structure over Central America and the Caribbean Sea;
- Diurnal and seasonal cycle, and interannual variability; and
- Role of the ocean in Caribbean LLJ.

Diurnal cycles of precipitation, water vapor, and low-level winds (including sea breeze circulations) over southern Mexico, Central America, and along the northern coast of South America at sea level and higher elevations are important features of the continental hydroclimate around the IAS. Therefore, with the advent of TRMM and GPM observations and other (scarcely) available in situ observations, systematic analysis of model bias with regard to their diurnal variability is desired. An outgrowth of this workshop is that a research proposal for ground validating TRMM and GPM satellite rainfall with in situ data throughout Colombia is being put forward among NASA (Walt Petersen), Universidad Nacional de Colombia at Medellin (German Poveda) and IDEAM (Meteorological Agency of Colombia; Maria Teresa Martinez).

Diagnosis of the ocean circulation including ocean eddies and flow through channels needs to be conducted systematically given their importance in transporting heat from warm tropical waters to the subtropical oceans.

The understanding of the SST bias in the entire IAS region is necessary. Large model biases in SST need immediate attention as it affects the teleconnections to the North American hydroclimate and TC activity. Systematic and detailed surface energy budgets are needed to diagnose the reasons for the model biases.

3.4 Opportunities and recommendations to improve understanding of the coupled processes in the region

The workshop generated the following set of opportunities for the IASCLiP community to foster.

1. IASCLiP should encourage sustaining and leveraging the established COCONet and TLALOCNet observations of surface meteorological parameters and total column water vapor through international partnerships.

2. TRMM and GPM satellite observations of precipitation are useful resources. However, IASCLiP recommends that they can yield improved retrievals if they are validated and calibrated using reliable rain gauge observations, especially in orographic regions of Latin America. COCONet and TLALOCNet surface precipitation estimates should prove helpful in this regard.

3. IASCLiP should define requirements for IAS ocean observations for the region, such as gliders, additional Argo floats adjusted for shallow profiling, and/or additional buoys with enhanced surface and sub-surface measurement capabilities, building up on the following existing products:

    - Satellites for remotely sensed heat content;
    - Satellite SSTs;
    - Argo floats (limited density due to international waters in the region and depth considerations);
    - NOAA National Data Buoy Center (NDBC) buoys (concentrated in Gulf of Mexico and provide only surface meteorology, wave height, and SST);
    - PIRATA moorings in the far western Atlantic;
    - COCONet (surface meteorology, precipitation, total column water vapor, and sea level at islands and along coasts); and
    - Gliders during hurricane season (not operational).

4. The TPOS 2020 Project will evaluate all elements that contribute to the Tropical Pacific Observing System (TPOS) based on a modern understanding of tropical Pacific science. The project aims for enhanced effectiveness for all stakeholders, informed by the development and requirements of the operational prediction models that are primary users of TPOS data. IASCLiP should engage with this effort and provide feedback on needs for long-term observations in the tropical East Pacific related to key science questions in the IAS region for the coming decades.

5. Similarly, IASCLiP should engage with the TPOS2020 counterpart in the Atlantic, AtlantOS, to identify long term observing needs in the tropical West Atlantic.

6. Model hindcast and simulation repositories like CORDEX simulations of the Central American region, the National Multi-Model Ensemble (NMME), and other model repositories can be further exploited for improved diagnostics. IASCLiP should coordinate with CORDEX to conduct ensemble runs over the region at high resolution, both in AMIP and coupled runs.

4 Acknowledgements

The Scientific Organizing Committee appreciates the preparation and presentation of research results by the 47 oral and poster presenters, as well as the participation of an additional 60 members of the IAS community.

We thank Kristan Uhlenbrock, Jill Reisdorf, and Tania Sizer of US CLIVAR and UCAR for their expert support, without which this effort would not have succeeded. In particular, Kristan provided essential training of oral presenters in the use of the online system, effective facilitation of each session, and (with her colleagues) developed an innovative approach for online discussion of posters.

We also wish to acknowledge the sponsoring funding agencies – NASA, NOAA, NSF, and DOE – for approving the virtual workshop through the US CLIVAR Project Office, and the considerable staff time the Office provided to plan and execute this first-ever US CLIVAR web-based workshop.

Appendix A: List of Participants

Name	Institution
David Adams	Universidad Nacional Autónoma de México, Mexico
Eric Alfaro	University of Costa Rica, Costa Rica
Diego Alfaro	Universidad Nacional Autónoma de México, Mexico
Weston Anderson	Columbia University
Moises Angeles	City College of New York
Paola Arias	Universidad de Antioquia, Colombia
Kelli Armstrong	International Research Institute for Climate and Society
Nicole Basenback	University of Maryland
Melissa Bender	Columbia University
Sarah Berthet	LEGOS, France
Richard Bouchard	University of Maryland
John Braun	Columbia University
Jodi Brewster	University of Miami
Julio Canon	Universidad de Antioquia, Colombia
Jessie Carman	NOAA
Eamon Carrig	Autonomous Marine Systems Inc.
Rodrigo Castillo Rodríguez	Universidad de Costa Rica, Costa Rica
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Mingyue Chen	NOAA Climate Prediction Center
Eurydice Chrisagi	National and Kapodistrian University of Athens, Greece
Jonathan Cox	Caribbean Institute for Meteorology & Hydrology, Barbados
Palmira Cuellar Ramirez	Universidad Nacional Autónoma de México, Mexico
Wenjun Cui	University of North Dakota
Scott Curtis	East Carolina University
Dale Destin	Antigua and Barbuda Meteorological Service
Paul Dirmeyer	George Mason University
Christian Dominguez	Universidad Nacional Autónoma de México, Mexico
Francina Dominguez	University of Illinois
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Andrea Donaldson	National Environment and Planning Agency, Jamaica
Renee Elder	Arizona State University
David Enfield	University of Miami
Gloria Esthefany	Universidad de Antioquia
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Douglas Gamble	Univeristy of North Carolina, Wilmington
Ivonne M. García Martínez	Ensenada Center for Scientific Research and Higher Education, Mexico
Santiago Giraldo Cárdenas	Universidad de Antioquia, Colombia

Diana Carolina Giraldo Mendez	International Center for Tropical Agriculture, Colombia
Equisha Glenn	City College of New York/NOAA-CREST
Jorge Gonzalez	City College of New York/NOAA-CREST
Danielle Groenen	Florida State University
Helmer Guzmán	Universidad Nacional de Colombia, Colombia
Elizabeth Harris	Ariel Re, Bermuda
Wafiq Harris-Ashby	Caribbean Institute for Meteorology and Hydrology, Barbados
Ruoying He	North Carolina State University
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Alexander Holsteinson	Geomedicion, Instrumentos y Sistemas, SRL, Dominican Republic
Isabel Hoyos	Universidad de Antioquia, Colombia
Hunter Jones	NOAA Climate Program Office
Karen Keith	NOAA
Hyemi Kim	Stony Brook University
Hey-Jin Kim	Scripps Institution of Oceanography
Jesse Krisher	Self Employed
Lakshmi Krishnamurthy	UCAR/NOAA Geophsycal Fluids Dynamics Laboratory
Gary Lackmann	North Carolina State University
Sang-Ki Lee	University of Miami
Gloria León	ECOSAGA, Colombia
Zhenhua Li	University of Saskatchewan, Canada
Xin-Zhong Liang	University of Maryland, College Park
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Elinor Martin	University of Oklahoma
John Martinez	University of Arizona
Rachindra Mawalagedara	University of Nebraska, Lincoln
Edgar Mejia	National Autonomous University of Honduras, Honduras
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Vasu Misra	Florida State University
Sukarni Mitro	Meteorological Service Suriname, Suriname
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Juliet Perdigón	National Autonomous University of Mexico, Mexico
Bhaleka Persaud	Wilfrid Laurier University, Canada
Valeria Prando	University of New South Wales, Australia
Dian Putrasahan	University of Miami
Beatriz Quesada Montano	Uppsala University/Universidad de Costa Rica, Sweden
Graciela Raga	Universidad Nacional Autónoma de México, Mexico
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Jill Reisdorf	Univeristy Corporation for Atmospheric Research
Juan C. Restrepo	Universidad del Norte, Colombia
Rafael Ricardo	Colombia´s Naval Academy, Colombia
Geidy Rodríguez	Universidad Nacional Autónoma de México, Mexico
Alexander Rojas	Fedearroz, Colombia
Rosario Romero-Ceneno	Universidad Nacional Autónoma de México, Mexico
Clint Rowe	University of Nebraska
Johna Rudzin	University of Miami
Adam Rydbeck	Colorado State University
Tom Sabbatelli	RMS, United Kingdom
Fernan Saenz	Universidad de Costa Rica, Costa Rica
Hernan Salas	Universidad Nacional de Colombia, Colombia
Angie Sánchez	National Autonomous University of Honduras, Honduras
John Scalzi	WWSB News Channel, Florida
Marla Schwartz	University of California, Los Angeles
Andrea Sealy	Caribbean Institute for Meteorology and Hydrology, Barbados
Yolande Serra	University of Washington
Nelson Sevilla	National Autonomous University of Honduras, Honduras
Lynn (Nick) Shay	University of Miami
Julio Sheinbaum	Ensenada Center for Scientific Research and Higher Education, Mexico
Juan Sierra	Universidad de Antioquia, Colombia
Bohar Singh	George Mason University
Hajoon Song	Massachusetts Institute of Technology
Juan Mauricio Soto	Universidad Nacional de Colombia, Colombia
Alejandra Straffon	Universidad Nacional Autónoma de México, Mexico
Aneesh Subramanian	Scripps Institution of Oceanography
Juan Sulca	State University of New York, Albany
Juan Sulca	Universidad Nacional Mayor de San Marcos, Peru
Luyu Sun	University of Maryland, College Park
Zoltan Szuts	University of Washington
Jim Todd	NOAA Climate Program Office
Suz Tolwinski-Ward	AIR Worldwide
Valeria Torres	University of Puerto Rico
Jill Trepanier	Louisiana State University
Kristan Uhlenbrock	US CLIVAR
Gloria Esthefany Valderrama	Universidad de Antioquia, Colombia
Jose Mauro Vargas	National University of Costa Rica, Costa Rica
Gabriel Vecchi	NOAA Geophysical Fluid Dynamics Laboratory

Hector Velez	US Environmental Protection Agency
Sara Vieira	Universidad de Antioquia, Colombia
Rolf Vieten	University of Puerto Rico at Mayaguez
Nicolas Vigaud	International Research Institute for Climate and Society
Xana Villa	Universidad Nacional de Colombia, Colombia
Chunzai Wang	NOAA Atlantic Oceanographic Meteorological Laboratory
Jeremy Weiss	University of Arizona
Shem Willie	Saint Lucia Met. Service, Saint Lucia
Paul Wilson	RMS, United Kingdom
Tingyin Xiao	Stony Brook University
Shang-Ping Xie	University of California, San Diego
Johanna Yepes	Universidad Nacional de Colombia, Colombia
Jin-Ho Yoon	Pacific Northwest National Laboratory
Leila Zambrano	Agrarian University of Ecuador, Ecuador
Xiangming Zeng	North Carolina State University
Yang Zhou	Stony Brook University
Edward Zipser	University of Utah

Appendix B: Workshop Agenda

Wednesday, September 9, 2015		
Session I: Identifying opportunities and challenges of observing and modeling IAS variability and its teleconnections (chair: German Poveda)		
13:00	Introductions/logistics	German Poveda (chair),
13:05	Mesoscale Convective Systems (MCSs) in the Intra-Americas Seas (IAS): Evidence from TRMM	Edward Zipser, University of Utah
13:25	Predictability of Eastern Pacific Intraseasonal Variability	Neena Joseph Mani, University of California, Los Angeles
13:45	IAS summer weather and its shaping by the atmosphere's zonal mean momentum	Brian Mapes, University of Miami
14:05	Advancing the understanding of the IAS with the Community Earth System Mode	Ernesto Munoz, National Center for Atmospheric Research
1430	Poster Session I	
Session II: Ocean-Land-Atmosphere interactions of the Continental Americas and the Caribbean (chair: Erick Rivera)		
15:30	Introduction	Erick Rivera, chair
15:35	Water Cycle Linkages Between the Intra-American Seas and Continental Areas	Paul Dirmeyer, George Mason University
15:55	Moisture origin and transport processes in Colombia, northern South America	Isabel Hoyos, Universidad de Antioquia, Colombia
16:15	Do the Amazon & Orinoco freshwater plumes really matter for hurricane-induced ocean surface cooling ?	Julien Jouanno, LEGOS, France
16:35	The Seasonality of the Great Plains Low-Level Jet and ENSO Relationship	Lakshmi Krishnamurthy, NOAA Geophsycal Fluids Dynamics Lab
17:00	End of Day 1	

Thursday, September 10, 2015		
Session III: Weather and climate extremes in the Americas (chair: Chunzai Wang)		
13:00	Introduction	Chunzai Wang, chair
13:05	Toward a unified system for understanding, predicting and projecting regional hurricane activity	Gabriel Vecchi, University of Miami
13:25	Impacts of the Atlantic Warm Pool on Atlantic Hurricanes	Chunzai Wang, NOAA Atlantic Oceanographic and Meteorlogical Lab
13:45	Diurnal to Intraseasonal Variability and the Central American Drought	Yolande Serra, University of Washington
14:05	Subseasonal-to-seasonal extreme rainfall scenarios for the Caribbean Basin	Angel Munoz, International Research Institute for Climate and Society
14:30	Poster Session II	
Session IV: Initiatives to improve observational coverage of the ocean, land, and atmosphere (chair: Yolande Serra)		
15:30	Introduction	Yolande Serra, chair
15:35	COCONet and TLALOCNet: Providing the Intra-Americas Seas Region with Enhanced Atmospheric Observational Capacity	John Braun, University Corporation for Atmospheric Research
15:55	GPS Meteorological Networks for Process-Oriented Studies of Tropical Deep Convection	David Adams, Universidad Nacional Autónoma de México, Mexico
16:15	The CARIACO Ocean Time-Series: two decades of biogeochemistry and ecological research to understand ocean and climate variability	Frank Muller-Karger, University of South Florida
16:35	Sustained and Targeted Ocean Observations for Improving Atlantic Tropical Cyclone Intensity and Hurricane Seasonal Forecasts	Ricardo Domingues, University of Miami, NOAA Atlantic Oceanographic and Meteorological Lab
17:00	End of Day 2	

Friday, September 11, 2015		
Session V: Identifying sources of model biases for the IAS in both coupled and ocean or atmospheric models (Chair: Vasu Misra)		
13:00	Introduction	Vasu Misra, chair
13:05	Intraseasonal variability in the IAS and Its Representation in Models	Eric Maloney, Colorado State University
13:25	The western Colombia low-level jet and its simulation by CMIP5 models	Juan Pablo Sierra, Universidad de Antioquia, Colombia
13:45	The Sensitivity of Regional Coupled Ocean-Atmosphere Simulations over the Intra-Americas Seas to the Prescribed Bathymetry	Vasu Misra, Florida State University
14:05	The importance of ocean mesoscale variability for air-sea interactions and heat anomaly distribution in the Gulf of Mexico	Dian Putrasahan, University of Miami
14:30	Poster Session III	
Session VI: Panel discussion: observations, modeling, predictability, and prediction of the region (chair: Vasu Misra)		
15:30	Introduction	Vasu Misra, chair
15:35	NASA Precipitation and Other Earth Science Data	George Huffman
15:45	Ocean Observing in the Intra-American Seas	Lynn (Nick) Shay, University of Miami
15:55	Model Biases in the Intra-American Seas	Shang-Ping Xie, Scripps Institution of Oceanography
16:05	Panel discussion, wrap-up	
17:00	End of Day 3	

Posters

Wednesday, September 9, 2015

Observed (1970-1999) climate variability in Central America using a high-resolution meteorological dataset with potential for climate change studies
Eric Alfaro, University of Costa Rica

Characterization and prediction of the mid-summer drought in the Tempisque river basin, North of Costa Rica, Central America, using ENSO and AMO relationships
Eric Alfaro, University of Costa Rica

Evaluation of GPCP 1DD precipitation product using NEXRAD Q2 precipitation estimates over the CONUS
Wenjun Cui, University of North Dakota

Detection of recent regional sea surface temperature warming in the Intra-Americas Region, 1982-2012
Equisha Glenn, The City College of New York, NOAA-CREST

Potential impact of climate change on the Intra-Americas Sea: A dynamic downscaling of the CMIP5 Model projections
Yanyun Liu, University of Miami, NOAA/AOML

Analysis of superficial sea temperature anomalies in the Colombian Basin - Caribbean Sea
Angela Rodríguez, Universidad Nacional de Colombia

Choco and Caribbean low-level jets: observations and sensitivity analysis in regional climate models
Johanna Yepes, Universidad Nacional de Colombia

Thursday, September 10, 2015

MJO, NAO, ENSO, and mid-summer rainfall in the Caribbean
Scott Curtis, East Carolina University

Ocean-atmosphere variability related with the midsummer drought over Mexico and Central America in the CFSR reanalysis
Ivonne M. García-Martínez, Centro de Investigación Científica y de Educación Superior de Ensenada, México

Saharan dust transport to northern South America: A case of study
Santiago Giraldo Cárdenas, Universidad de Antioquia, Colombia

The warm pool variability of the tropical northeast Pacific and its relation to the Atlantic warm pool
Danielle Groenen, Florida State University

A coupled ocean circulation, wave, atmosphere and marine ecosystem prediction system for the IAS
Ruoying He North, Carolina State University

On the dynamics of the Caribbean low-level jet
Eduardo Herrera, Universidad Nacional Autónoma de México, Mexico

Fifty years of African dust studies in the Caribbean Basin: The role of dust in climate and air quality
Joseph Prospero, University of Miami

Friday, September 11, 2015

Building the weather to climate bridge: The Caribbean rain-belt
Teddy Allen, International Research Institute for Climate and Society

The 2010-2012 extreme wet season in northern South America: causes and moisture sources
Paola Arias, Universidad de Antioquia, Colombia

The contribution of tropical cyclones to seasonal precipitation over Mexico
Christian Dominguez, Universidad Nacional Autónoma de México, Mexico

Characteristics of tropical cyclones making landfall on the Pacific coast of Mexico: 1970-2014
Luis M. Farfán, Center for Scientific Research and Higher Education at Ensenada (CICESE)

Can we predict seasonal changes in high impact weather in the US?
Eunsil Jung, University of Miami

Inhomogeneous influence of the Atlantic warm pool on United States precipitation
Hailong Liu, Shanghai Jiao Tong University, China

Uncertainty quantification for a climatology of the frequency and spatial distribution of North Atlantic tropical cyclone landfalls
Susan Tolwinski-Ward, AIR Worldwide

Spatial risk of extreme hurricane winds over the Gulf of Mexico and North Atlantic
Jill Trepanier, Louisiana State University

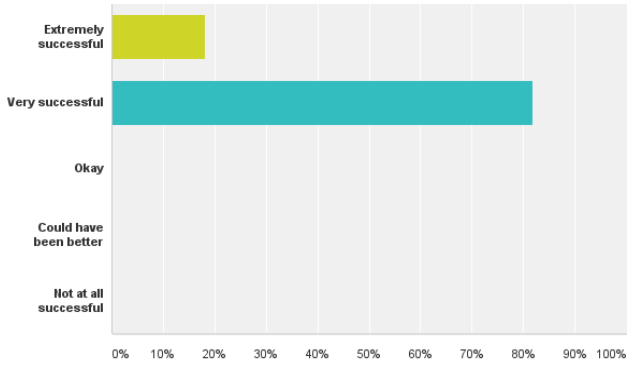
A typology of convection regimes observed over the Caribbean from May to November
Nicolas Vigaud, International Research Institute for Climate and Society

Appendix C: Participant Survey Analysis

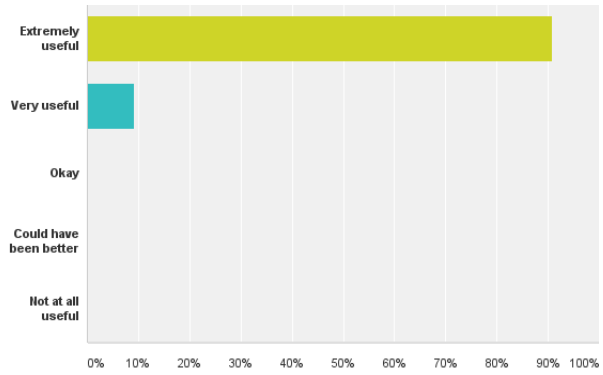
ORAL PRESENTER RESPONSES

Total responses: 11

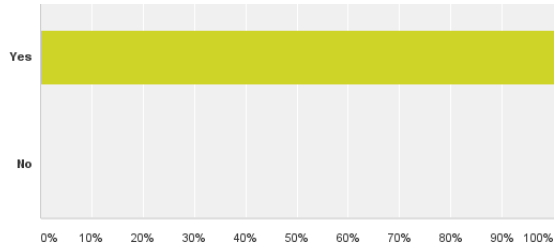
How successful was the virtual workshop format?



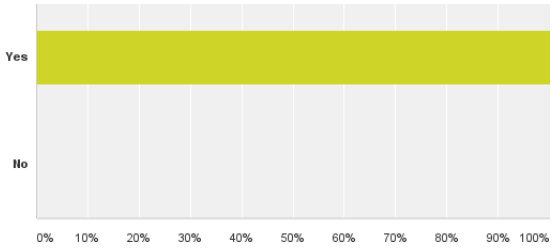
How useful were the trainings, logistics, and support to help you prepare?



Did you participate in the virtual poster session at any point before or during the workshop?



Would you be willing to participate in a virtual workshop again?



ORAL PRESENTER RESPONSES CONTINUED
Total responses: 11

Comments on what was postive:

- I liked that we could have presenters from all over the world in the same session (without having to travel).
- The quality and scope of presenters.
- I really enjoyed this format of meeting. It is objective and very effective for communicating science.
- Ease of presenting and taking questions from audience and the ability to answer.
- I enjoyed having the time to think about my answers before responding. There is something about writing the text in the chat box that gives you time for a more thoughtful answer. And, as with the posters, all is recorded so you can go back and look at the questions you received about your presentation.
- Having a chance to participate without traveling to Tallahassee. And some reactions from a few of the organizers to my talk might lead to some interesting follow-up research.
- I enjoyed to discuss with other scientists.
- The ability to hear all the questions and answers, and accessibility to all discussions.
- I really enjoyed the oral presentations, and to be in touch with great and experienced scientists.
- I was invited to the panel, and this is realistically the only way I could afford to participate, both in time and travel budget. I was very pleased to make at least three contacts for future discussion and possible interaction. That exceeded my expectations. The conferencing software worked pretty well, and because *everyone* was virtual, and multiple schemes for interacting (voice, chat) were used, the interactions were better than, say, Skyping into a physical meeting.

Commens on what could be improved:

- One thing that was confusing were the questions and answers. I answered a question through the chat, but then it disappeared.
- The quality of sound.
- Viewers should be able to see other participants part of the workshop. If possible, it would be nice to see voice enabled for poster presenters.
- It would be nice to see as the audience how many others are there. I noticed as a presenter that I can see the audience but not as a participant. But I would not consider this a big issue.
- Don't take down the talks or posters so soon!
- More portals for audio discussions.
- The use of the telephone is something that need to be improved.
- We're all still learning how to do this, including etiquette about muting. Also, it's really hard to stay engaged with what's on the screen when one is sitting in the office. Maybe one issue is the anonymity of the process. I put my picture on the title slide just to establish a little more contact with the audience.

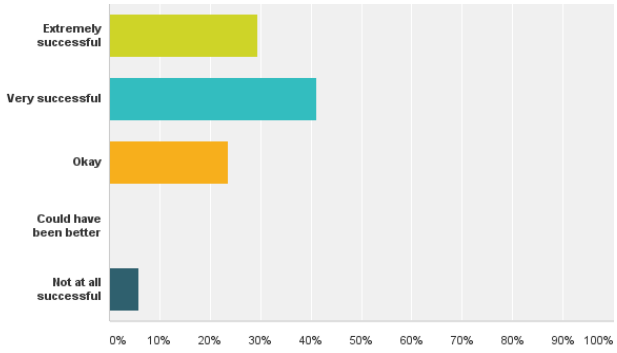
Other comments:

- I thought it went very well overall. Thanks for all your efforts to set it up and keep it running smoothly.
- I'd like to find time to communicate with more of the presenters. One of the problems with this format during the school year is that if it conflicts with classes or other obligations, it means that I don't get to hear other talks.
- This is more advice for myself - because this wasn't originally "my" meeting, and it lacked all the overhead of making arrangements and traveling, I went in with less forethought than a physical meeting.

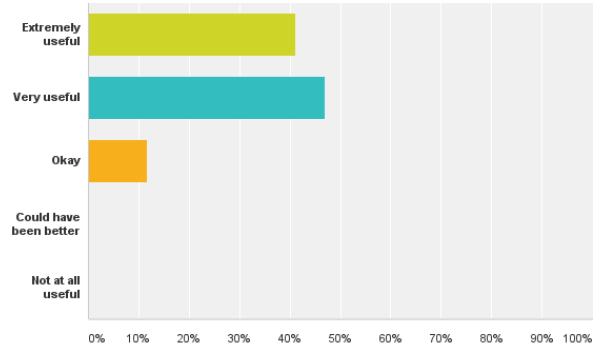
POSTER PRESENTER RESPONSES

Total responses: 17

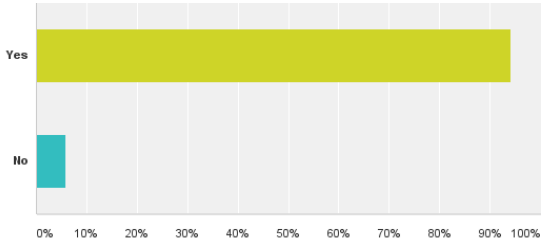
How successful was the virtual workshop format?



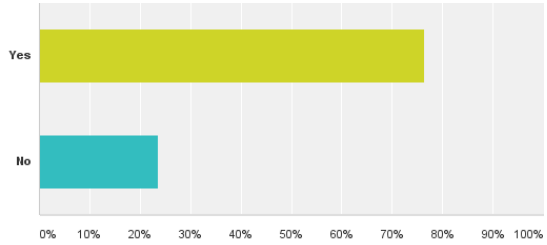
How useful were the logistics and support to help you prepare?



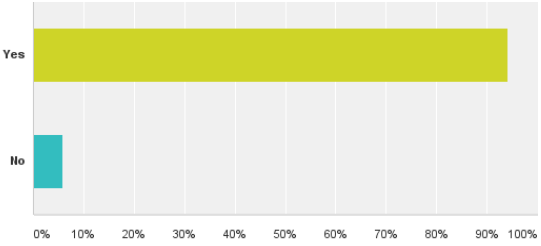
Did you view or comment on other posters at any point before or during the workshop?



Did you like how the comment section worked?



Would you be willing to participate in a virtual workshop again?



POSTER PRESENTER RESPONSES CONTINUED
Total responses: 17

Comments on what was positive:

- It was well organized and the website made it easy to view and comment on posters.
- I really enjoyed interactions with participants either answering or asking in the comments section.
- The possibility of having my poster online for a long time allows for many people from different regions to view it.
- Relaxed, extended time period to comment on other posters and formulate Q&A; Really nice format for discussing new and current research and getting feedback.
- I enjoyed the ample time to provide poster comments. I liked the ability to follow other poster's comments & dialog.
- How easy it was to view and comment on others posters.
- The schedule to comment, it was opened at any hour, so I didn't worry about times.
- I believe using this virtual format is as good as (or maybe even better than) a live (oral) presentation, because you have more time to check out and comment on the posters. Besides, you also have the opportunity of be aware of the comments on other posters, something you are not able to do in an ordinary-fate to face format.
- The opportunity to exchange questions/answers at any time of the days, any day.
- It was a virtual workshop so I could attend it at my workplace. Instruction for the poster (e.g. sending out a poster example a weaker earlier) was extremely helpful to me. Timing and format of poster allowed for more interaction.
- The comments about our poster; people gave us many ideas and positive complements to our investigation.
- The ability to attend those parts that were of interest - and to comment interactively. And the ability to do this without interrupting in a serious way one's work schedule.
- I liked the collaboration atmosphere of the virtual workshop.
- It allowed for interaction among different scientists and students. Much of the oral talks were presented by very recognized scientists, which was pretty interesting.
- There were more questions than during a regular conference session. This may have to do with the limited number of posters, or just the fact that people had unlimited time to view posters and form questions.
- I really liked the monitoring of the sessions. Everything ran very smoothly.

Comments on what could be improved:

- I wish I could have been given an option of which day to present.
- The only minor issue that I experienced was that I was not electronically notified if my comment on other people's posters was addressed. Comments made to my own poster were relayed electronically, but it would have been nice to be alerted to replies on posters other than mine. This is just a minor issue to an overall great format.
- I don't like the way of interacting while commenting some posters because only the poster presenter received an email of notice when someone left replies and the other ones (poster's visitors) didn't receive any emails when the author answered their questions or comments.
- Some of the speakers voices are kind of quiet/low, though the organizer did a really great job to make sure of it. (not all of them, but some of them). Overall, good enough. I wish I could "modify" my reply/comments in the poster section. I couldn't find any modify/delete function there. Also, I wanted to show one figure to answer the comment better, but there was no option that I could attach the file/figure (or simply I could not find the function).
- Generate spaces for collaboration across the region.
- The level of sound some times was better to listen by cellphone than the computer.
- I would like to have gotten a notification when someone replied to my comment on their poster, similar to Facebook. I had to go and search back to see their reply to my comment.
- I think it is a matter of culture to interact more around posters. I felt there was not enough interaction.

POSTER PRESENTER RESPONSES CONTINUED
Total responses: 17

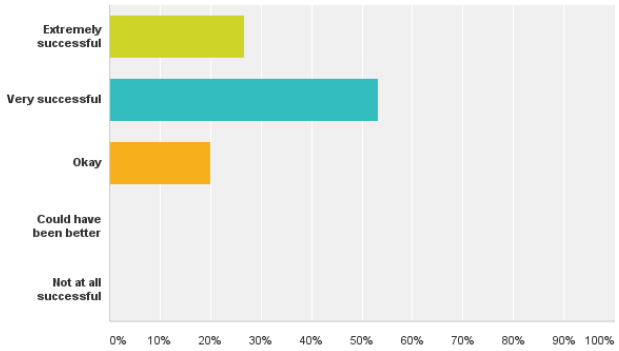
Other comments:

- I really enjoyed the virtual workshop. I look forward to the next one.
- I really appreciate the opportunity to share my results in advance. I've never been in a virtual workshop before and I think it was a successful and productive experience. It is a very promising event. Keep it on!
- Due to the nature of the conference, the poster section might not be very striking, at least during the hour assigned each day.
- The remote poster format allowed for 2 main things: 1) Oral presenters could review poster comments prior to their presentations so that general feedback could be incorporated into their oral presentation. 2) Users could follow all of the comment threads for every poster on their own time. I feel that the mid-session "poster-breaks" may not be necessary, but instead a reminder to view the posters during that time would suffice.
- I think it was very well done.
- The workshop was great but I consider that the way of interacting can be improved much more. For example, some social networks send emails to people when somebody mention them in comments. Perhaps, this kind of service could be implemented (receive emails when authors answer your questions or comments)
- It was a very nice experience. As a poster presenter I really enjoyed it and learn from it.
- Personally I liked the time of the workshop (I mean, not the entire day but a half day) I had a computer connection problem on the first day, so I could not join the workshop. So, recording and posting the talks are really helpful (thanks!)
- Maybe a special issue in some journal.
- We just want to say thank you, was a very gratifying experience.
- It provided me with the opportunity to meet and interact with some scientists who are active in the region. I would otherwise not have been aware of their work.
- I would recommend to identify other ways to promote interaction around posters, and even oral talks.

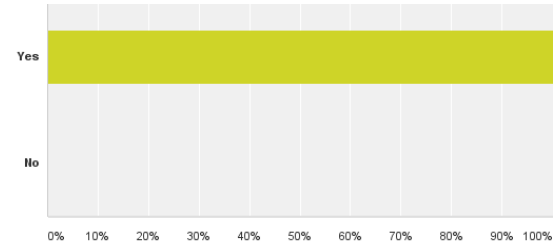
GENERAL PARTICIPANT RESPONSES

Total responses: 15

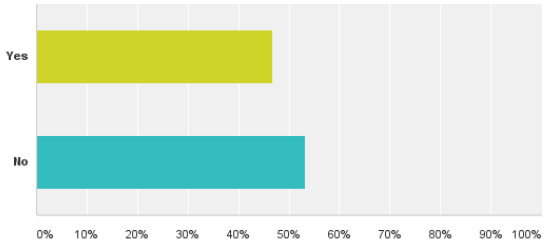
How successful was the virtual workshop format?



Would you be willing to participate in a virtual workshop again?



Did you participate in the virtual poster session at any point before or during the workshop?



If not, why?

- There were no posters of close enough interest to me. Had there been I would have participated.
- Some were not optimized for viewing online.

GENERAL PARTICIPANT RESPONSES CONTINUED
Total responses: 15

Comments on what was positive:

- The opportunity to share works realized in South America.
- The chosen format allowed the participation of top experts as presenters.
- I liked being able to tune into the talks of particular interest to me. (Most were atmospheric, though, and I'm interested in the oceanic side, so there were only a few talks of particular interest to me.)
- Length of time to review posters.
- All presentations and posters of the workshop were of great interest to me, allowed me to update me on the current state of research on climate variability in our region with the best experts on these topics.
- The ability to attend only to the talks I was interested in each session
- The variety of topics related to the region. Not having to pay travel expenses to attend the workshop. Funding in the Caribbean region is limited.
- The presentations of the speakers were great: very informative of fundamental issues as well as current research. I really liked the list of speakers. The opportunity to see research by local groups, like those from Costa Rica, Colombia, etc. This is very valuable, as it is difficult to have a meeting for this region.
- I can attend it without traveling and the presentations are documented.
- It was a great way to see recent work that other people are doing that I have been unaware of.
- I could stay in my office.
- So nice to have it all available online. A family issue intervened and I couldn't be "at" the workshop, but I'll download talks anyhow.

Comments on what could be improved:

- Some presentations were difficult to follow.
- By my own actions, I only participated as a passive participant. As a presenter, and even as a passive participant, I would think that an updated acknowledgement of who was signed in would be good for the presenter & the audience.
- Sometimes, online transmission had failures. I do not know if it could be improved in the future.
- The sound was not good enough.
- Moderating to ensure speakers stick within the given time frame.
- Maybe the panel discussion. It would be nice to hear discussion and general comments from observations oriented researchers as Professor Zipser, as well as from local researchers, as Professor Poveda or Professor Amador.
- I thought it was well done and valuable.
- Perhaps, a video conference could be useful.

Other comments:

- Others important topics like hydrology and climatic change can be included.
- Have more workshops of this type.
- This was a very useful way to share information as a community without needing to go to distant meeting.
- I can only thank all those who encourage these types of workshops where many researchers in the field can exchange experiences and knowledge. I hope to participate as a speaker in the future as my area of research is absolutely related to these topics.
- In general the virtual workshop was very good, specially for a region with a lack of conventional meetings.
- I totally agree with the 1/2 day format.
- Is there a way to have a virtual social interaction during breaks?

Appendix D: List of acronyms

AMIP: Atmosphere Modeling Intercomparison Project
AWP: Atlantic Warm Pool
CESM: Community Earth System Model
CARIACO: Carbon Retention in a Colored Ocean
CLLJ: Caribbean Low-Level Jet
CMIP: Coupled Model Intercomparison Project
COCONet: Continuously Operating Caribbean Observational Network
CORDEX: Coordinated Regional Climate Downscaling Experiments
ENSO: El Niño Southern Oscillation
GPLLJ: Great Plains Low-Level Jet
GPM: Global Precipitation Measurement
GPS: Global Positioning System
IAS: Intra-Americas Seas
IASCLiP: Intra-Americas Seas Climate Processes
ITCZ: Intertropical Convergence Zone
LIS: Lightning Imaging Sensor
LLJs: Low-Level Jets
MJO: Madden-Julian Oscillation
MSCs: Mesoscale Convective Systems
MSD: Mid-summer Drought
NDBC: National Data Buoy Center
NMME: National Multi-Model Ensemble
OTREC: Organization of Tropical East Pacific Convection
SST: Sea Surface Temperature
TLALOCNet: Trans-boundary Land and Atmosphere Long-term Observational and Collaborative Network
TMI: TRMM Microwave Imager
TPOS: Tropical Pacific Observing System
TRMM: Tropical Rainfall Measuring Mission
VIRS: Visible Infrared Scanner
WHWP: Western Hemisphere warm pool

For more information visit:

http://usclivar.org/meetings/2015-iasclip-virtual-workshop

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