

CLIVAR REPORT

Climate and Ocean: Variability, Predictability, and Change



Meeting Report

Report on the IV International Conference on El Niño Southern Oscillation: ENSO in a warmer Climate

16-18 October 2018. Guayaquil, Ecuador



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1. Introduction

CLIVAR (through the Pacific Region Panel and the ENSO Research Foci) and the Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), successfully organised the IV International Conference on El Niño Southern Oscillation: ENSO in a warmer Climate (ENSO2018). The purpose of the conference was to bring together the most outstanding scientists of the area at a national and international level, to analyze and discuss the dynamics of El Niño-La Niña, as well as its implications to society.

ENSO2018 took place in the STEM building of Escuela Superior Politécnica del Litoral (ESPOL), from October 16 to 18, and was devoted to analyze the current state of ENSO in terms of its diversity (types of El Niño), development of extreme events, predictability, impacts and teleconnections in the current context of a warmer climate. 136 people from 20 countries participated in the conference. The conference was held in six plenary sessions including 42 oral presentations (See [Annex 1](#) for Daily Programme), with parallel poster sessions exhibiting 75 posters (See [Annex 2](#) for List of Posters), as well as 3 international exhibitions on climate services. A poster competition in two groups (Early Career Scientists and Students) was organized and the 'Best Overall Posters' and two 'Outstanding Posters' were selected from each category (See [Annex 3](#) for List of Poster Awards Winners). The [abstract book](#), [presentations](#) and [photos](#) are available online.

13 outstanding professionals dedicated to ENSO research contributed greatly to the organisation of the conference, acting as members of the Scientific Committee (See [Annex 4](#)). Three of them will take the lead as associated editors to produce a special issue on International Journal of Climate with selected works from the conference.

2. Workshop Highlights

2.1 Opening Ceremony

Opening remarks were made by the Minister of Foreign Relations of Ecuador, Mr. Jose Valencia (by video). He welcomed the participants on behalf of the President of Ecuador, highlighted the importance of ENSO in the region because of its impacts, and wished for a successful meeting.

Executive Director of the International CLIVAR Project Office, Ph.D. Jose Luis Santos, talked about the role of CLIVAR on Ocean and Climate Research, and the importance of the meeting given the latest forecast for ENSO and the just released IPCC report on the raise of 1.5C.

Director of CIIFEN, Mr. Rodney Martínez, mentioned that this is the fourth conference on ENSO and all previous have been held in Ecuador, and emphasized the commitment from CIIFEN on supporting ENSO research in the region.

Director of ESPOL, Ph.D. Cecilia Paredes Verduga, talked about the impacts of ENSO in Ecuador and the research that ESPOL has provided in the topic, welcomed all the participants and made the formal inauguration of the event.

2.2 Session 1: Ocean Observations

Session 1 was focused on ENSO Observations. Starting from the 2015-16 El Niño, Dr. Michael McPhaden pointed out in his keynote speech that to occur an El Niño event needs fuel (positive heat content anomalies) and a spark to ignite it (Westerly Wind Bursts). He also conveyed the

message that combining with the continuing global warming, El Niño has generated high impacts worldwide during the extreme 2015-16 El Niño.

In the second keynote speech presented by Dr. Kim Cobb, the advances in paleo-ENSO research have been introduced. According to Dr. Cobb, the paleo records indicate that the present-day ENSO amplitude has strengthened compared to the pre-industrial era. Also, new reconstruction allowed to address interannual and decadal to centennial scale variability at monthly resolution over the last 200 years.

Dr. Magdalena Balmaseda from the European Centre for Medium-Range Weather Forecasts (ECMWF) talked about ENSO Complexity from a monitoring and forecasting perspective. She called on increasing monitoring capabilities in order to enable the characterization of ENSO energy budget. According to Dr. Balmaseda, the new ECMWF seasonal forecast scheme (SEAS5) improves the ENSO prediction with less cold bias, more realistic air coupled feedback, and more realistic WWBs. She also introduced a full range of new datasets at ECMWF, which consists of ERA5, experimental reanalyses ERA-20CM/ORA-20C, CERA-20C (coupled) as well as reforecasts.

Dr. Shiheng Hu from Scripps Institution of Oceanography (SIO) mentioned that robust strengthening of cross-equatorial winds in the tropical Pacific has been observed since 1980, which was unlikely to be caused by ENSO changes but partly forced by the tropical north Atlantic warming. According to Hu, the cross-equatorial wind strengthening induced La Niña-like mean shift, an ITCZ crossing the equator less frequently, a weaker ENSO variability, and a shift from EP to CP El Niño events.

Dr. Julia Cole from University of Michigan then moved to the new insights on ENSO and Pacific Decadal variability and trends through analysing the Galapagos Coral records. According to Dr. Cole, the paleo-proxy in the Galapagos indicated that ENSO variance is stronger at both the early and end of the 20th century. Also, the paleo-proxy at Darwin pointed towards a strong decadal variability in the eastern equatorial Pacific, which were probably caused by the decadal variability of Central Pacific ENSO.

Grandy Rosales from Peru introduced impacts of the Pacific equatorial undercurrent (EUC) on the Northern Peruvian coast. She noted that the peak occurrence of density is decreased from 26.5 to 26.1 while the EUC traverses from 147°E to 110°W; furthermore the similarity in the water properties found between off Northern Peruvian Coast and that in the downstream EUC along the equator 110°W, supports the theory that the EUC feeds the EUC Southern Coastal branch (EUCSCb) off the Northern Peruvian Coast.

According to the last presentation given by Scott Power in session 1, the impact of global warming on ENSO is clearer now than ever before, with evidence that the ENSO-driven precipitation has increased by ~15-20% in most regions, and there is a strong possibility that this trend will continue in the future. However, the projected changes in ENSO-driven SST variability remains unclear.

2.3 Session 2: ENSO Dynamics

Session 2 began with the keynote from Dr. Ken Takahashi, introducing concepts, impacts and dynamics the El Niño in the far-eastern Pacific. According to Dr. Takahashi, ENSO exists along a multi-axis space between eastern Pacific, central Pacific (Modoki flavors) where the “strength” of an individual event relies strongly on the pattern that people are using to describe it. In a stochastically-driven version of the recharge-discharge (RD) oscillator, noise is essential to

explain strong El Niño events outside standard RD phase space. However, little attention has been paid to the coastal El Niño, despite its importance for impacts in Ecuador and Peru (especially due to heavy rainfall).

The second keynote given by Dr. Shayne McGregor focused on the precursors of ENSO events. He highlighted that equatorial westerly wind events (WWE) are more effective at generating Rossby wave response than off-equatorial WWE, where Rossby waves can generate discharge of equatorial heat content as part of the recharge-discharge oscillator. Also, WWE on the equator can drive an instantaneous response in warm water volume that adds to the longer-term warm water volume changes related to the recharge-discharge oscillator (i.e. coming and going of El Niño's and La Niña's). Dr. McGregor pointed out that since 2000, instantaneous component of the WWV has dominated, whereas the longer-term adjustment variability has been virtually absent, which is an important characteristic to consider in understanding the dynamics underlying this extended period of relatively weak ENSO variability.

Dr. Christina Karamperidou from Hawaii University introduced the hierarchy of models for ENSO diversity. She illustrated that the climate models that could better reflect the observed spectrum of spatial patterns/strengths of ENSO exhibit a better distribution of ENSO strength (which is bimodal), and have a stronger annual cycle. In a CESM (Community Earth System Model) simulation of the last 24 thousand years (DiNezio, pers comm), the indication is that ENSO properties are sensitive to spring/fall insolation.

The fourth talk given by Dr. Sulian Thual focused on the Stochastic Skeleton Model for the MJO and ENSO. He constructed a simple physically-based model of the Madden-Julian Oscillation (MJO) and ENSO, which includes parameterizations for westerly wind bursts and associated convective activity, in order to test influence on ENSO properties.

During his presentation, S.A. Dixit explained the (slow) nonlinearity in ENSO observations. He has built a simple low-order model of ENSO, based on a 5-dimensional delay embedding of reconstructed NINO3.4 SST data, which reproduces the main nonlinear features and asymmetries of the observed ENSO time series.

The last talk of this session was given by Ruihuang Xie from China. He has investigated the potential for non-linear bimodal model of ENSO that contains eastern Pacific (EP) and central Pacific (CP) ENSO, plus non-linear noise as a good dynamical framework for reproducing observed ENSO properties.

Apology was received by Dr. Petrova Desislava for being unable to attend the conference and present her work during session 2.

2.4 Session 3: ENSO and Modes of Climate Variability

The first keynote in this session discussed the role of intraseasonal variability in ENSO, presented by Dr. Matthieu Lengaigne, co-chair of the CLIVAR Pacific Region Panel. Dr. Lengaigne indicated that intraseasonal equatorial westerly wind events have a stronger dependence on the state of ENSO than easterly events (i.e. correspond to multiplicative and additive forcing, respectively) and, because of this, the westerly events can more effectively affect the development of El Niño. He also highlighted that although a charged ocean heat content state is necessary for El Niño to develop, frequent summer-time westerly events are also essential. He also indicated that ocean nonlinear processes are of minor importance for the rectification of high-frequency forcing into ENSO timescales.

Dr. Antonietta Capotond then discussed the decadal variability of ENSO in the second keynote in this session. Dr. Capotondi used the linear inverse model (LIM) framework to address the question of whether the differences in ENSO activity between the periods 1958-1977 and 1978-1997 was just a matter of chance or it is associated with different ENSO dynamics or forcing. Her results suggest that the difference in dynamics as captured by the LIM operator were the dominant effect. It should be noted that this operator also reflects the effect nonlinearities in the dynamics and in the forcings.

Dr. Samantha Stevenson then revisited the issue of the climate change in extreme El Niño events as measured by the associated extreme precipitation in the eastern Pacific. She found that even though the future changes in the sensitivity of precipitation to sea surface temperature (SST) is similar among models, the difference in the pattern of SST changes results in diversity in the projected changes in extreme rainfall. In particular, the results suggest that the zonal gradient in these patterns is more relevant than the meridional gradient, as previously proposed.

Dr. Yuko Okumura addressed the link between ENSO and tropical Pacific decadal variability (TPDV). Using a climate model, she showed that the two dominant patterns of TPDV have different effects on ENSO. Warming with the first pattern is associated with more frequent and persistent El Niño, while the second leads to stronger and shorter/longer El Niño/La Niña. The results also suggest that the first pattern is not itself influenced by ENSO.

Dr. Aaron Levine explored the effect of multidecadal temperature variability in the Atlantic Ocean onto ENSO. Through "pacemaker" experiments in which he imposed periodic warming and cooling in the Atlantic in a numerical model, he verified that the warming leads to stronger trade winds in the Southeastern Pacific. His results show that the Atlantic forcing enhances the decadal variability in the eastern Pacific, making the model more consistent with the observed trends in the Walker circulation.

Dr. Gerald Meehl used long climate model simulations to explore the role that ENSO events play on the transition between decadal phases in the tropical Pacific. In particular, the transitions between the negative and positive phase involve the arrival of positive off-equatorial heat content anomalies to the western boundary, which then return as downwelling Kelvin waves to the eastern Pacific. The analysis finds a higher probability of El Niño to happen at this transition.

M.Sc. Anika Arora reported on the effect of increasing the spatial resolution of the CFS climate model on the ENSO prediction skill. She found that although skill was slightly enhanced in the Niño 1+2 region, it was reduced in the Niño 3.4 and Niño 4 regions.

2.5 Session 4: ENSO Modelling and Prediction

This session included two keynote presentations (Dr. Andrew Wittenberg and Dr. Erick Guilyardi), and five oral presentations (Dr. Michelle L'Heureux, Dr. Sarah Larson, Dr. John Mejia, Dr. Matthew Newman and Dr. Tobias Bayr), which raised the following points:

In spite of their mean biases and inaccuracies in the representation of ENSO, models are invaluable tools for data assimilation, seasonal-to-decadal forecast, to aid detection and attribution activities, for future projections, and, if used properly, to aid understanding. There has been a lot of progress in ENSO modelling. Indeed, now all CMIP-type models have a recognizable ENSO, improved ENSO amplitude, spectrum, and spatial diversity. Most importantly, the mechanisms underlying ENSO behaviour are more correct. Also, although imperfect, climate models can help detect real-world sensitivities from inter-model diversity. This is the basis of the new concept of "emergent constraints".

The use of metrics for ranking model's performance is very important to address the need of a large community of users. Extensive work has already been carried out on this front through the activities of the CLIVAR ENSO research focus group. Such metrics can provide a concise characterization of model performance.

Prediction studies performed with a Linear Inverse Model (LIM) in the tropical Pacific show skill comparable to individual NMME models, as well as the multi-model mean (MMM). The LIM outperforms all the models and the MMM in the western Pacific, where the models have a too far west extension of ENSO SST anomalies. This result highlights how linear dynamics is an excellent approximation in the tropical Pacific, with the fast nonlinearities arising from the ocean-atmosphere interactions being treated as noise. Another approach to ENSO prediction, the "analog method", which exploits long control simulations to determine analog conditions to the initial state of interest for the system prediction some time later also performs as well as the NMME models. Analog-based predictions for either signs of a given initial condition show comparable skill. This result also supports the idea that ENSO is primarily a linear and stochastically-forced dynamical system.

2.6 Session 5: ENSO Impacts and Reginal Process

In the first keynote of this session, Dr. Boris Dewitte exposed the analysis based on observations and reanalysis products, to investigate the inter-event variability among moderate to strong El Niño events. He showed that warm conditions off the coast of Ecuador and Peru in Austral fall were associated with an equatorial westward-propagating air-sea mode that yields the development of Eastern Pacific (canonical) El Niño events, but also to the emergence of equatorial easterlies east of 130°W in Austral summer that prevents them to develop as extreme events. The analysis showed that these easterlies have been particularly active during the 2015 El Niño event. In particular, the equatorial Kelvin wave during the development of the 2015 El Niño was shown to experience a strong dissipation in the far eastern Pacific compared to the 1997/98 El Niño event. This pattern suggests the importance of the eastern boundary current dynamics for El Niño development. The global climate models (GCMs) do not adequately account for the diversity in the evolution of moderate El Niño events.

Dr. Bor-Ting Jong explained in the second keynote the characteristics and impacts on North America during the developing season of La Niña events. The results showed that during the summer with La Niña conditions transitioned from an El Niño, the tropical Pacific shares the characteristics of both the decaying El Niño and the developing La Niña. The teleconnections triggered by these depressed deep convective activities resulted in a significant anomalous ridge over Northeast North America, together with a robust warming signal over the Midwest, which is one of the predominant crop regions in the US, and thus imposed threat on the maize and soybean yields. It was noted that this unique warm anomaly happens only during the El Niño to La Niña transition summer. For the persistent La Niña, where only the central and eastern tropical Pacific cooling and the accompanied reduced convection are present, the responses in North America were much weaker and insignificant. These results suggest that it is necessary to separate the transitioning and persistent La Niña events as their features and impacts are essentially different, which could provide useful information for improving the skill of seasonal temperature and precipitation prediction – and subsequently agricultural managements – over North America.

Dr. Aguilera presented the Oceanographic signals observed during the year 2016-17 at the Equatorial Pacific zone. He presented a Weekly-to-synoptic time series of temperature, salinity, oxygen, size-fractionated chlorophyll (Chl), and total alkalinity measurements, as well as pCO₂ estimates performed during a year (January 2015 to 2016) in the upper layer (30 m) of the subtropical coastal upwelling area off Antofagasta (23°S), in the Humboldt Current system. Pulsatile upwelling episodes prevail year round at this latitude, providing cold and oxygen poor waters to the surface. This scenario changed markedly at the beginning of the winter period when

positive deviations from annual means were observed. These positive deviations from annual means, which lasted for around 3 months when also phytoplankton biomass was largely supported (>60%) by small-size phytoplankton fraction, configure oceanographic symptoms associated with remotely forced oceanographic perturbations. Salinity values >34.6 and pCO₂ levels > 400 μ atm have been associated to Equatorial Sub Surface Waters, suggesting poleward Kelvin waves associated with El Niño 2015-16, decoupled the upwelling-driven synoptic repositioning of water masses and its impact on phytoplankton biomass.

Dr. Weston Anderson explained that the modes of climate variability, particularly the El Niño Southern Oscillation (ENSO), are considered as a risk to regional and global food security. For the first time, they estimated the relative contribution of major modes of climate variability to crop yield variability at the global scale. They found that past studies have overemphasized the importance of modes of climate variability for globally aggregated soy and wheat production, but that ENSO does, in fact, pose a significant correlated risk to maize yields capable of forcing globally synchronous crop failures. To illustrate this point, he demonstrate that the largest synchronous crop failure in the post-1960 historical record is directly attributable to ENSO. The study suggests the influence of not only ENSO, but also the Indian Ocean Dipole (IOD), tropical Atlantic variability (TAV) and the North Atlantic Oscillation (NAO). They find that modes of climate variability account for 4% and 8% of globally aggregated soy and wheat production variability, respectively. For maize, however, ENSO accounts for a staggering 41% of global production variability, with minor additional variability (2%) attributable to the IOD and TAV. ENSO-forced maize production anomalies do not offset at the global scale because production is concentrated in regions with same-sign yield anomalies, notably the United States, Brazil and southeast Africa. ENSO can (and has) forced globally-synchronous crop failures.

Dr. Boyin Huang showed how the Monthly Extended Reconstructed Sea Surface Temperature version 5 (ERSSTv5) and Daily Optimum Interpolation Sea Surface Temperature version 2 (DOISST) are frequently used for El Niño, La Niña, and Southern Oscillation (ENSO) monitoring and assessment. ERSSTv5 uses in situ observations from ships, buoys, and Argo floats. DOISST uses observations from ships, buoys, and satellites, while biases of satellite observations are corrected according to in situ observations. Therefore, in situ observations (both number and area coverage) are critical to these sea surface temperature (SST) analyses. The study suggested that the impact by buoys is large over 2000–2005 when the number of Argo floats was low, and becomes smaller over 2010–2016 when the number and area coverage of Argo floats increased. The magnitude of El Niño and La Niña decreased when observations from buoys, Argo floats, or both are excluded, suggesting the importance of observations in ENSO monitoring. The impact by the Tropical Atmosphere Ocean (TAO) and Triangle Trans-Ocean Buoy Network (TRITON) is small in normal years and during El Niño events.

Dr. Eleftheria Exarchou showed the influence of Atlantic variability on ENSO frequency and variability. The mechanism of the Atlantic/Pacific teleconnection involves an anomalous Walker circulation triggered by the anomalous SST over the eastern Tropical Atlantic, which results in anomalous easterly winds over the western Pacific and thermocline perturbations that propagate eastward thus favoring the development of ENSO conditions. They find that the June initialized forecasts had consistently higher skill in predicting ENSO than the February initialized at longer lead times, indicating a source of ENSO predictability in the initialization of June. They further found that models with high prediction skill over the summer Tropical Atlantic tended to both better reproduce the connection between the summer Tropical Atlantic SST and the winter Tropical Pacific SST, and also had higher skill in predicting the winter Tropical Pacific SST. This study emphasized the importance of correctly representing the Tropical Atlantic mean state and variability in order to improve Tropical Pacific predictability.

Dr. Juan Sulca explained the impacts of El Niño in the eastern and central Pacific on the rainfall of South America. He performed linear regression analysis of EP and CP indices of SST, as well as precipitation indices for the SPCZ and ITCZ. The results showed that positive C induces dry conditions along the tropical Andes and northern South America (NSA), while wet conditions

prevailed over southeastern South America (SESA). Moreover, it produced wet anomalies in the northwestern Peruvian Amazon. Contrary, positive E induces wet anomalies along the coasts of Ecuador and northern Peru associated with the southward displacement of the eastern Pacific ITCZ and at the same time induces dry conditions in the Altiplano, Amazon basin, and northeastern Brazil (NEB). The results also showed that both SPCZ indices, the zonal position of the SPCZ and its latitudinal displacement, suppressed rainfall along western Peruvian Andes when were positive, but the latter also inhibited rainfall over the Bolivian Altiplano. The southward displacement of the eastern Pacific ITCZ also induced wet anomalies in SESA while dry anomalies prevail over NEB, the western Amazon basin, and Bolivia. Oppositely, the southward displacement of the central Pacific ITCZ induced dry anomalies in NEB and along the northern coast of Peru; while wet anomalies occurred mainly in eastern Brazil, Paraguay, and Bolivia through an enhancement of the low-level jet.

2.7 Session 6: Climate Information and Sustainable Development

Session 6 hosted two keynotes and 5 presentations covering a wide range of issues. The two keynotes, Rodney Martinez and Jose Santos provided an overview of current strategic implementation for adapting to climate change impact and climate extremes with a focus on comparing the 1997 and 2015 El Niño events. They also both emphasized in their presentations the need for innovative interactions between research and operational communities.

Rodney Martinez presented some recommendations of the WCRP strategic implementation and recalled the sustainable development goals of the UN agenda, emphasizing the need for effective climate services information system to connect the global science with the regions to support countries and foster resilience of the communities impacted by extreme El Niño events.

Jose Santos made a nice review of extreme El Niño impacts in Ecuador and Peru, illustrating how the alerts of El Niño were sometimes confusing for Ecuador. In particular, 2015 did not have an impact for Ecuador (in terms of precipitation), while in other parts of the world the impact was as important as the 1997 El Niño. He also mentioned the need to develop the observing system in the far eastern Pacific and engage The countries in the western coast of South America into TPOS2020.

Luis Icochea presented on-going work trying to relate observations of sea surface temperature variability along the coast of Chile and equatorial variability, illustrating the potentially important consequences for the pelagic and demersal species distribution along the Peruvian Coast.

Bushra Khalid presented an analysis of satellite data (landsat) aimed at documenting the land use/cover changes associated to flooding events, showing that the transition between El Niño to La Niña in 2010 was certainly important to explain the severity of the flood in the Jhang district.

Mercy Borbor-Cordova provided a nice overview of current knowledge and understanding of the relationship between episodes of infectious disease epidemics (with a focus on arbovirus) and climatic conditions in the Latin America and Caribbean region, illustrating challenges and opportunities to enhance climate services as an operative approach for early warning system.

Maria Caballero presented a conceptual view of the interaction between the climate and social systems, with the objective to optimize climate risks management in developing countries, with a focus on Peru.

Finally, Fangli Qiao made a review of his work on the impact of surface wave-induced vertical mixing on the simulation of the mixed-layer depth in the global ocean, nicely illustrating the perspective for improving global coupled models.

2.8 Poster Awards and Closure of the Conference

Early career scientists and students attending the 2018 ENSO Conference and presenting posters were eligible to be considered for outstanding poster awards. A distinguished committee of 16 senior and junior career scientists have reviewed and identified outstanding posters given by students and early career scientists. The posters were evaluated based on the following criteria:

- Scientific merit and novelty
- Originality of work
- Aesthetics of display
- Clarity of the poster
- Oral presentation of the poster and responses to questions

The 'Best Overall Posters' and two 'Outstanding Posters' were selected from each category (See [Annex 3](#) for List of Poster Awards Winners).

Dr. Andrew Wittenberg finally closed the meeting by expressing the appreciation to the participants, also to the local host for all the logistics arrangements.

2.9 Poster express session

Poster Express sessions were organised by the end of each session. Poster presenters were invited to make a 2-minute presentation of their posters in the main conference room at selected time. Early Career Scientists Students, in particular from Latin America countries, showed great interest in presenting at the poster expressed session, which had provided a great opportunity for them to interact with senior scientists, as well as to practise their presentation skills in the public. There were totally 25 presented in the six poster express sessions during the conference (See posters with * in [Annex 2](#)).

2.10 CLIMATE SERVICES Stage

During lunch time (12h30 – 13h30) of the 3-day conference, the CLIMATE SERVICES Stage was organized (Annex 5). The CLIMATE SERVICES stage is a special venue where selected ENSO Conference participants shared their practical experiences about climate services related topic, project or initiatives. Its aim was to widen the array of topics that are discussed at the Conference beyond those that are presented in the main specialized sessions. The objectives of the CLIMATE SERVICES stage were to review existing and successful multi-sectoral experiences (national, regional, and international) of the use of climate services for the different sectors. Particular attention was paid to the extent to which experiences demonstrate a significant level of user ownership, of direct or associative financial and political/institutional commitment, and of complementarity in synergy with similar initiatives. Specific themes for the CLIMATE SERVICES Stage included:

- I. Global and Regional Climate services: good practices and remaining challenges.
- II. National Climate services: good practices and remaining challenges.
- III. Climate services and stakeholder engagement: from scientists to decision makers and Authorities

3. Follow-up actions

The highlighted researches from the conference were scheduled to be published as a special issue in the International Journal of Climatology (IJOC). This has been initially agreed by the chief editor of IJOC and by Wiley. Jose Marengo (CEMADEN, Brazil), Rodney Martinez (CIIFEN, Ecuador), and Jose Santos (ICPO, China) will be the associated editors for the special issue. An announcement is to be made to all the participants of 2018 ENSO Conference, calling for submission of their works, which will then be decided by the editors to consider for the issue.

Also, during the conference, both Dr. Cobb and Dr. Guilyardi have called on the actions to offset the carbon footprint generated by conference participants. Tree plantings could be one of the most effective ways.

4. Acknowledgement

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Annex 1: Daily Programme

Day 1: Tuesday, October 16

8:30- 9:00	<i>Registration</i>
9:00- 10:00	Opening Ceremony (30 min) Inaugural Keynote (30 min) ENSO science and predictions and the UN Decade of Ocean Science. Salvatore Arico. IOC
10:00- 10:30	<i>Coffee Break</i>
10:30- 12:30	Oral Session Session 1(a): ENSO Observations <i>Chairs: Wenju Cai, Matthieu Lengaigne</i> <ul style="list-style-type: none"> • Michael McPhaden: The 2015-16 El Niño and Climate Change (<i>Keynote</i>, 30 min) • Kim Cobb: Advances in paleo-ENSO: A past to future perspective (<i>Keynote</i>, 30 min) • Magdalena Balmaseda: ENSO complexity: A monitoring and forecasting perspective (20 min) • Shineng Hu: El Niño diversity, cross-equatorial winds, and the intertropical convergence zone (20 min) • Julia Cole: ENSO variability in Galápagos corals: New insights on variability and trends (20 min)
12:30- 13:30	<i>Lunch. Climate Services Stage</i>
13:30- 14:10	Oral Session Session 1(b): ENSO Observations <i>Chairs: Wenju Cai, Matthieu Lengaigne</i> <ul style="list-style-type: none"> • Gandy Rosales: Impacts of the Pacific Equatorial Undercurrent on the Northern Peruvian Coast (20 min) • Scott Power: The impact of global warming on ENSO is clearer now than ever before (20 min)
14:10- 14:30	Poster Express Session 1
14:30- 15:30	Oral Session Session 2(a): ENSO Dynamics <i>Chairs: Andrew Wittenberg, Kim Cobb</i> <ul style="list-style-type: none"> • Ken Takahashi: El Niño in the far-eastern Pacific: Concepts, impacts and dynamics (<i>Keynote</i>, 30 min) • Shayne McGregor: Understanding ENSO event precursors (<i>Keynote</i>, 30 min)
15:30- 16:00	<i>Coffee Break</i>
16:00-17:40	Oral Session Session 2(b): ENSO Dynamics <i>Chairs: Andrew Wittenberg, Kim Cobb</i> <ul style="list-style-type: none"> • Christina Karamperidou: A hierarchy of models for ENSO diversity in past, present and future (20 min) • Sulian Thual: A stochastic skeleton model for the MJO and ENSO (20 min) • S.A. Dixit: Decrypting the nonlinearity in ENSO observations, potential for skillful predictions (20 min) • Ruihuang Xie: ENSO modes-annual cycle interaction and ENSO complexity (20 min)

	<ul style="list-style-type: none"> • Petrova Desislava: The Role of the Western Pacific Heat Buildup in the Development and Prediction of El Niño (20 min)
17:40- 18:00	Poster Express. Session 2
18:00	<i>Adjourn</i>

Day2: Wednesday, October 17

9:00- 10:00	Oral Session Session 3(a): ENSO and Modes of Climate Variability <i>Chairs: Michael McPhaden, Ken Takahashi</i> <ul style="list-style-type: none"> • Matthieu Lengaigne: The role of intraseasonal variability in ENSO (<i>Keynote</i>, 30 min) • Antonieta Capotond: Decadal Variability of ENSO (<i>Keynote</i>, 30 min)
10:00- 10:30	<i>Coffee Break</i>
10:30- 12:10	Oral Session Session 3(b): ENSO and Modes of Climate Variability <i>Chairs: Michael McPhaden, Ken Takahashi</i> <ul style="list-style-type: none"> • Samantha Stevenson: Extreme El Nino events and 21st century climate change: Attributing inter-model differences in future projections (20 min) • Yuko Okumura: Decadal modulation of ENSO and the linkage to tropical Pacific decadal variability (20 min) • Aaron Levine: Atlantic Impacts on Multi-decadal ENSO diversity and Amplitude Variability (20 min) • Gerald Meehl: The role of interannual ENSO events in decadal timescale transitions of the Interdecadal Pacific Oscillation (20 min) • Anika Arora: Effect of increasing atmospheric resolution on prediction skill of ENSO in coupled forecast system (CFS). (20 min)
12:10- 12:30	Poster Express Session 3
12:30- 13:30	<i>Lunch. Climate Services Stage</i>
13:30- 14:30	Poster viewing (Sessions 1, 2, 3)
14:30- 15:30	Oral Session Session 4 (a): ENSO Modelling and Prediction <i>Chairs: Antonieta Capotondi, Jose Santos</i> <ul style="list-style-type: none"> • Andrew Wittenberg: ENSO in climate models: Progress and opportunities (<i>Keynote</i>, 30 min) • Eric Guilyardi: Consensus climate model evaluation for end users: an example with ENSO metrics (<i>Keynote</i>, 30 min)
15:30- 16:00	<i>Coffee Break</i>
16:00- 17:40	Oral Session Session 4 (b): ENSO Modelling and Prediction <i>Chairs: Antonieta Capotondi, Jose Santos</i> <ul style="list-style-type: none"> • Michelle L'Heureux: A Bird's Eye View of Operational ENSO Prediction: Methods, Challenges, and Paths Forward (20 min) • Sarah Larson: Does the equatorial recharge/discharge increase ENSO predictability? (20 min) • John Mejia: Improved skill in North American multi-model ensemble for the Americas (20 min) • Matthew Newman: Characterizing tropical Pacific SST predictability (20 min) • Tobias Bayr: Tuning ENSO in a Climate Model (20 min)

17:40- 18:00	Poster Express Session 4
18:00	<i>Adjourn</i>

Day 3: Thursday, October 18

9:00- 10:00	Oral Session Session 5(a): ENSO impacts and Regional process <i>Chairs: Chairs: Eric Guilyardi, Rodney Martinez</i> <ul style="list-style-type: none"> • Boris Dewitte: Air-sea interactions off Peru and Ecuador and the development of Eastern Pacific El Nino events (<i>Keynote</i>, 30 min) • Bor-Ting Jong: ENSO teleconnections and impacts on North America during la Niña summers (<i>Keynote</i>, 30 min)
10:00- 10:30	<i>Coffee Break</i>
10:30- 12:10	Oral Session Session 5(b): ENSO impacts and Regional process <i>Chairs: Eric Guilyardi, Rodney Martinez</i> <ul style="list-style-type: none"> • Victor Aguilera: Oceanography, total alkalinity and pCO₂ levels during El Niño 2015-16 in a subtropical coastal upwelling area of Humboldt Current (20 min) • Anderson Weston: How relevant is ENSO to global crop production? (20 min) • Boyin Huang: The role of buoy and Argo observations in ENSO in two SST analyses (20 min) • Eleftheria Exarchou: Impact of Tropical Atlantic variability on Tropical Pacific predictability (20 min) • Juan Sulca: Impacts of different ENSO flavors and tropical Pacific convection variability (ITCZ, SPCZ) on austral summer rainfall in South America, with a focus on Peru (20 min)
12:10- 12:30	Poster Express Session 5
12:30- 13:30	<i>Lunch. Climate Services Stage</i>
13:30- 14:30	Poster viewing (Sessions 4,5,6)
14:30- 15:30	Oral Session Session 6(a): Climate information and sustainable development <i>Chairs: Boris Dewitte, Fangli Qiao</i> <ul style="list-style-type: none"> • Rodney Martinez: Keeping climate science fundable: Challenges and opportunities of the 2030 Agenda for Sustainable Development (<i>Keynote</i>, 30 min) • Jose Santos: Towards an ENSO Early Warning System in Ecuador: Lessons learned (<i>Keynote</i>, 30 min)
15:30- 16:00	<i>Coffee Break</i>
16:00- 17:40	Oral Session Session 6(b): Climate information and sustainable development <i>Chairs: Boris Dewitte, Fangli Qiao</i> <ul style="list-style-type: none"> • Luis Icochea Salas: Differences between ENSO 2014-2017 and another strong ENSO events (20 min) • Khalid Bushra: Impacts of ENSO and summer monsoon rainfall on riverine flooding in Upper Indus Basin of Pakistan (20 min) • Mercy Borbor-Cordova: Climate Services for Public Health: the use of El Niño and other climate modes for arbovirus forecasting in Latin

	America and the Caribbean (20 min) • Caballero Espejo Maria Esther: Climate System Interactions for Climate Risks Management in Developing Countries (20 min) • Fangli Qiao: Ocean and climate models improvements by including the surface wave (20 min)
17:40- 18:00	Poster Express Session 6
18:00- 18:20	Closure & Poster awards
18:20	<i>Adjourn</i>

Annex 2: List of Posters

Posters with * were presented during poster express sessions.

Name	Title
Session 1: Ocean Observations	
* Eric Alfaro	The 1877-1878 Mega Niño and its social impact in Costa Rica, Central America
Juan Leonardo Moreno	Sea surface temperature inter-annual variability in the northeastern tropical Pacific and its relationship with El Niño and La Niña conditions
John Nielsen-Gammon	ENSO Indices for a Changing Climate
Enzo Pinheiro	Assessment of twentieth century reanalyses to represent ENSO impacts over the Tropical Atlantic and Ceará rainy season
Isabel Ramos Parado	Spatial and temporal analysis of daily precipitation during the coastal El Niño 2017 in Peru
José Antonio Rodríguez	ENSO Influence on the Precipitation Pattern Along the Ecuadorian Coast
Hernán Salas	Uncertainty estimation of rainfall anomalies during ENSO in Colombia
Maria Elisa Silva	Spectral Analysis of Sea Surface Temperature on the Equatorial Pacific from 1950 to 2014
Gladys Torres	Distribution of functional groups of phytoplankton in the Pacific Equatorial Post El Nino 2015-2016
Jacob Warner	Insights Into ENSO and Paleo-ENSO From Short-Lived Bivalves
Anika Arora	What makes Protracted El Niño to last longer than Canonical El Niño?
Eduardo Zambrano Quiñonez	Oceanic and atmospheric variability of the eastern Pacific associated with El Niño Costero 2017
*Mabel Zavala	Description of La Niña 2007-08 event in the Eastern Tropical Pacific
Andréé Galdos	Presence of oceanic Kelvin waves during the 2017 coastal El Niño event
* Freddy Hernández Vaca	Is El Niño current part of the equatorial current system?
Hailong Liu	Variability of Barrier Layer in the Equatorial Pacific associated with ENSO
Helen McGregor	External and internal origins of ENSO modulation revealed by Holocene corals and climate model simulations
Session 2: ENSO Dynamics	
Wenju Cai	ENSO under greenhouse warming: the impact of model biases
Aude Carreric	ENSO diversity and global warming
* Takeshi Izumo	On the physical interpretation of the lead relation between Warm Water Volume and the El Niño Southern Oscillation
Myriam Khodri	The influence of volcanic forcing on Pacific Ocean inter-annual to decadal variability over the last centuries
* Yann Planton	The warm water volume, a better predictor of La Niña than of El Niño
Wolfgang Schneider	La Niña 2010 originated in the Amundsen and Bellingshausen Seas
Illy Serykh	Pole tide in the Pacific Ocean can trigger El Niño
Juan Sulca	Nonlinear Walker Circulation feedbacks on El Niño diversity in CMIP models

Name	Title
* Fousiyat Shahul Hameed	Mid-Holocene ENSO teleconnections to the Indian Summer Monsoon: A PMIP3 narration
Jing Wang	The response of the equatorial Pacific Ocean to the winds during 2014-2015
Guojian Wang	Definition of Extreme El Niño and Its Impact on Projected Increase in Extreme El Niño Frequency
* Christian Wengel (Presented by Tobias Bayr)	What controls ENSO-amplitude diversity in climate models?
Weipeng Zheng	Mechanism of the weakened ENSO amplitude during mid-Holocene
Session 3: ENSO and Modes of Climate Variability	
* Khalid Bushra	El Niño event of 2015-16 and its impact on vulnerable communities of Tharparkar, Pakistan
* Ana Lucia Caicedo	Influence of El Niño Southern Oscillation and Contemporary Climate Change on wave conditions of the Pacific Ocean and the Colombian Pacific
* Lenin Campozano	The Pacific Decadal Oscillation modulation of ENSO influence on the precipitation in Ecuador
Gustavo De La Cruz	Interdecadal Change in the Precipitation Anomaly over Peru's Central-Southern Andes
Bruna Simões Lima	ENSO Influence on the South American Atmospheric Circulation and Precipitation at Different Phases of the Pacific Decadal Oscillation between 1970 and 2003
Xiaopei Lin	The relationship between Indian summer monsoon rainfall and tropical variability
Cristina Recalde	MJO and ENSO interaction on the modification of rainfall impacts over the Northwest of South America.
Illy Serykh	ENSO as a Component of the Global Atmospheric Oscillation
Juan Sulca	Influence of ENSO Flavors in the interdecadal atmospheric teleconnection between North Atlantic Oscillation and rainfall in the Central Andes (Peru-Bolivia)
Daniel Vimont	The role of noise forcing in generating ENSO diversity
Session 4: ENSO Modelling and Prediction	
Pascale Braconnot	Long term Holocene trends, change in seasonality and ENSO variability
Carlos Enciso	ENSO Influence on the Predictability and Forecast Skill of Drought Events over the Amazon Basin
* Nicola Maher	Do we project a frequency change of robustly classified El Niño types?
Cristian Martinez-Villalobos	El Niño-La Niña asymmetry in a Linear Inverse Model Framework
Othoniel Palacios	ENSO Conditions at the Eastern Equatorial Pacific Ocean Using a High Resolution Regional Ocean Modeling System
Belen Rodriguez-Fonseca	Conciliating tropical Atlantic impacts on ENSO
* Sheila Serrano	Tropospheric Water Vapor as a Predictor to ENSO Intense Rain Phase
Miguel Tasambay-Salazar	ENSO Potential Predictability from its Seasonal Teleconnections
* Miguel Tasambay-Salazar	Comparison of the Niño3.4 Index Longer Lead Predictability Skills Scored by Linear and Nonlinear Statistical Models
Yongqiang Yu	Evaluation of the zonal wind stress response to SST in the CMIP5 AMIP simulations
Session 5: ENSO impacts and Regional process	

Name	Title
* Vanesa Pántano	ENSO signal on the distribution of precipitation, improving seasonal information for stakeholders
Maria Mercedes Poggi	The role of ENSO in the seasonal prediction of daily precipitation extremes in the Pampas region (Argentina)
* Janeet Sanabria	Rainfall along the coast of Peru during strong El Niño events
Janeet Sanabria	Rainfall and moisture patterns associated with strong El Niño events in the eastern Pacific region
Nadja Zeiher	Searching for mesoscale processes in ENSO influenced tree ring proxies
Xuebin Zhang	ENSO-related Global Ocean Heat Content Variations
Teresita Canchala Nastar	Precipitation Anomalies in the South of Colombia and Associated Features to the El Niño Southern Oscillation (ENSO)
Jonathan Cedeño	Categorical predictability of precipitation in the Ecuadorian coast and Galapagos islands using Support Vector Machines
Julien Cretat	ENSO and the Indian Summer Monsoon: mid-Holocene to present relationship in transient global simulations
* César Manuel Díez Chirinos	Reliability of installing oceanic thermal energy sources around South America
* Ma. Gabriela Escobar Franco	Short term prediction of Ecuadorian rainfall from macroclimatic variables: A transfer function model approach
* María Esther Espinoza Celi	Modelling of tidal propagation and currents velocity for the Gulf of Guayaquil during the El Niño 2015 vs normal conditions, using Delft3D model
Cristian Febre	Cause of severe droughts in Southern Peru during 1965 - 2010
Teresita de los Ángeles Hernández Cordero	Evaluation of the influence of ENSO on the tropical cyclonic activity and its pluviometric contributions in the province of Camagüey, Cuba.
* Hugo Hidalgo	Precursors of severe and sustained drought in the Central America Dry Corridor
* Santiago Hurtado	Observed Precipitation variability induced by ENSO
* MARIO Hurtado Domínguez	Distribution and composition of the main small pelagic fish in Gulf of Guayaquil during La Niña event (March 2018)
Juan Carlos Jimenez	The role of ENSO flavors in recent droughts over Amazon forests
Juan Nieto	Evolution, vulnerability and the economic and social impacts of El Niño 2015-2016 in Latin America
* Franklin Ormaza-González	How High and Low Frequency Events could be Affecting Bigeye Tuna Fishing in the Eastern Pacific
Danys Ortiz Olarte	Coastal Kelvin waves associated with El Niño phenomenon and its impact on the Central and South America coast
Session 6: Climate information and sustainable development	
* Luis Altamirano	Remote data acquisition for ENSO (RENSO): A low budget locally developed approach
Maria Esther Caballero Espejo	Ecosystem-based adaptation to El Nino Impacts in Peru
César Manuel Díez Chirinos	Evolution of Relative Humidity over the Pacific Ocean
Mariela González-Narváez	Behavior phytoplankton in the Eastern Equatorial Pacific, in relation to environmental variations caused by the presence of warm events.
Débora Simón Baile	Tracking the variability of marine productivity in the Gulf of Guayaquil throughout 2016: local evidences of ENSO events?

Annex 3: List of Poster Awards Winners

1. Best Overall Poster

Name	Title of posters	Country	Group
Cristian Martinez-Villalobos	El Niño-La Niña asymmetry in a Linear Inverse Model Framework	USA	ECS
Mabel Zavala	Description of La Niña 2007-08 event in the Eastern Tropical Pacific	Ecuador	Student

2. Outstanding Poster

Name	Title of Posters	Country	Group
Cristian Febre	Cause of severe droughts in Southern Peru during 1965 - 2010	Peru	ECS
Isabel Ramos Parado	Spatial and temporal analysis of daily precipitation during the coastal El Niño 2017 in Peru	Peru	ECS
Vanesa Pántano	ENSO signal on the distribution of precipitation, improving seasonal information for stakeholders	Argentina	ECS
Sheila Serrano	Tropospheric Water Vapor as a Predictor to ENSO Intense Rain Phase	Ecuador	Student
Janeet Sanabria	Rainfall along the coast of Peru during strong El Niño events	France	Student
Nadja Zeiher	Searching for mesoscale processes in ENSO influenced tree ring proxies	Germany	Student

Annex 4: List of Scientific Committee Members and Local Organising Committee Members

Scientific Organizing Committee

Title	Institute
Mike McPhaden (Co Chair)	NOAA – Pacific Marine Environmental Laboratory. USA
Andrew Wittenberg (Co Chair)	NOAA – Geophysical Fluids Dynamics Laboratory. USA
Jose Santos (Co Chair)	International CLIVAR Project Office. China
Wenju Cai	Commonwealth Scientific and Industrial Research Organization. Australia
Kim Cobb	Georgia Institute of Technology. USA
William Kessler	NOAA – Pacific Marine Environmental Laboratory. USA
Eric Guilyardi	Institut Pierre-Simon Laplace. France
Boris Dewitte	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales. France
Lisa Goddard	International Research Institute for Climate and Society. USA
Rodney Martinez	Centro Internacional para la Investigación del Fenómeno de El Niño. Ecuador
Ken Takahashi	National Meteorology and Hydrology Service in Peru. Peru
Jose Marengo	Centro Nacional de Monitoramento e Alertas de Desastres Naturais. Brazil

Local Organizing Committee

Title	Institute
M. Pilar Cornejo	Escuela Superior Politécnica del Litoral. Ecuador
Jonathan Cedeño	Escuela Superior Politécnica del Litoral. Ecuador
Mercy Borbor	Escuela Superior Politécnica del Litoral. Ecuador
Juan José Nieto	Centro Internacional para la Investigación del Fenómeno de El Niño. Ecuador

Annex 5: CLIMATE SERVICES Stage

Day 1. Tuesday 16 October 12h30-13h30

Theme: Global and Regional Climate services: good practices and remaining challenges.

Facilitator: Juan José Nieto (CIIFEN)

Invited Panelists:

- Michelle L'heureux (USA - Climate Prediction Center, NOAA)
- Rodney Martinez (International Research Center on El Niño CIIFEN)
- Eleftheria Exarchou (Spain, Barcelona Supercomputing Center)

Day 2. Wednesday 17 October (12h30-13h30)

Theme: National Climate services: good practices and remaining challenges..

Facilitator: Mercy Borbor-Cordova (ESPOL)

Invited Panelists:

- Juan Bazo (Peru - Red Cross Red Crescent Climate Centre, Climate Services for Humanitarian Response)
- Carolina Rueda (Colombia - Meteorological Service of the Air Force)
- Eric Alfaro (Costa Rica - University of Costa Rica)

Day 3. Thursday, 18 October (12h30-13h30)

Theme: Climate services and stakeholder engagement: from scientists to decision makers and practitioners.

Facilitator: Jonathan Cedeño (ESPOL)

Invited Panelists:

- María del Pilar Cornejo, (Ecuador - ESPOL & Centro Internacional del Pacífico para la Reducción de Riesgos de Desastres).
- Palmira Cuéllar (Mexico - UNAM)
- Shadananan Nair Krishnapillai, (India - Centre for Earth Research and Environment Management).
- Boris Dewitte (France - LEGOS/CNRS)

Annex 6: Selected photos of the conference

	
<p>Salvatore Arico, IOC-UNESCO</p>	<p>Cecilia Paredes, Director of ESPOL</p>
	
<p>Jose Santos, Executive Director of ICPO</p>	<p>Rodney Martinez, Director of CIIFEN</p>
	
<p>Mike McPhaden from NOAA, co-chair of the Scientific Committee of the conference</p>	<p>Andrew Wittenberg from NOAA, co-chair of the Scientific Committee of the conference</p>



Young Scientist presenting at the conference



Young Scientist presenting at the conference



Poster session



Poster award winners