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Invited ViewPoint

Achieving the reduction of disaster risk by better predicting impacts of El Niño and La Niña

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ABSTRACT

Extreme phases of the El Niño Southern Oscillation (ENSO) show relationships with economic damages due to disasters worldwide. Climate forecasts can predict ENSO months in advance, enabling stakeholders to take disaster risk reducing actions. An understanding of risks during ENSO extremes is key for adequate response. Here, we review the effects of ENSO on disaster risks, including droughts and floods. We show that ENSO may increase the risk of water scarcity and low crop yields globally, and change the probabilities of extreme rainfall, and coastal and river flooding. We provide recommendations on how to reduce risks using ENSO forecasts.

Contents

1. Introduction

The recent 2015–16 El Niño event was one of the strongest ever recorded. El Niño conditions began to emerge in mid-2014 and intensified throughout 2015. El Niño conditions contributed to severe droughts and water shortages in Africa for two consecutive years, and increased food insecurity and famine [1•,2]. Donors, such as the European Union, raised funds to more than €500 million to address the impacts related to the ensuing drought and water shortage crisis in East Africa [3]. Simultaneously, the 2015–16 El Niño contributed to severe flooding in the northwest of Latin America, forcing the evacuation of more than 150,000 people in Paraguay, Argentina, Brazil and Uruguay [4].

El Niño conditions occur when there are unusually warm oceanic and atmospheric conditions in the tropical Pacific. This can cause the trade winds, that usually blow towards Indonesia and Australia, to slow down or even reverse direction, allowing the warmer water to spread east towards the South American coast [1•]. As opposed to El Niño, the so-called La Niña emerges when unusually cold oceanic and atmospheric conditions are observed in the eastern tropical Pacific. El Niño and La Niña events occur roughly every two to seven years. These oceanic and atmospheric variations are known as the El Niño Southern Oscillation (ENSO), which is the dominant driver of interannual variability in global climate conditions [5]. ENSO can affect weather patterns worldwide through so-called "teleconnections" [6]. In turn, these changes in weather patterns can influence the frequency and severity of extreme hazards, including droughts and floods. The impacts of ENSO on floods and droughts are well-studied at local and regional scales, while increased attention has

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recently been placed on understanding of how ENSO impacts societies at the global scale [2,7–9•,10•].

Over the past decades, the skill of ENSO predictions has improved considerably. The 2015–2016 event was predicted months in advance [11]. In general, ENSO events can now be predicted with reasonable skill at lead times up to 14 months [12]. Reliable forecasts enable the prioritization of risk reduction efforts in the most affected regions ahead of extreme events, and allow for early warning and action by local governments and non-governmental organizations, such as the Red Cross and Red Crescent Climate [13], especially when there is a good understanding of the likelihood of societal impacts that may be influenced by ENSO.

Since such impact-based information with long-lead times may also substantially support the shift towards more anticipatory and preventative risk management, as urged in several international frameworks such as the Sendai Framework for Disaster Risk Reduction [14], in this article we summarize recent research on the global effects of ENSO on disaster risk. This is especially timely given that current forecasts give a 76% chance of El Niño conditions developing again in the boreal spring of 2019 [15].

2. Increased likelihood of disaster risk due to El Niño and La Niña events

2.1. Drought and water scarcity

The connection between ENSO events and rainfall deficits, droughts, and water scarcity is increasingly well understood [16]. Connections between ENSO and low river flows exist in northern America [17], Southeast Asia [18], Southern Africa [19], and Australia [20]. Worldwide, disasters triggered by droughts occur twice as often during the second year of an El Niño event than during other years, especially in Southern Africa and Southeast Asia [19]. Regions where rainfall and hydrological extremes are influenced by ENSO [21,22] also show a connection between ENSO and annual total water availability or water scarcity conditions. In these areas, rainfall deficits during an ENSO event feed droughts, which can result in water scarcity events if consumptive demands outweigh the available water resources [16]. In result, regional water scarcity conditions become more extreme under El Niño and La Niña phases for almost one-third of the global land area [8].

2.2. Food security and agricultural production, with cascading effects on livelihoods

ENSO influences global agriculture in several ways, including changes in hydro-meteorological conditions (Fig. 1) [23,24] and climate extremes [25], which may affect crop yields [2] and export prices.

The global mean yields of major crops, such as maize, rice, and wheat, are likely to be below normal during both El Niño and La Niña conditions (−4.0 to −0.2%). However, El Niño events are linked to increased soybeans yields (+2.9 to +3.5%), especially in the United States of America and Brazil, where most of the global soybean is currently produced [26]. Furthermore, a recent study has found that ENSO may affect both negatively and positively crop productivity in 28% of global cropland area, inhabited by 1.5 billion people [2].

ENSO can affect food security and agricultural production, with cascading effects on livelihoods and health. For instance, the rapid shift between El Niño and La Niña conditions in 2016 intensified the shortage of rainfall, driving major hydrological crises over Eastern and Southern Africa, where 29 million people were faced with food insecurity due to the combination of drought exacerbated conditions [1•]. Furthermore, recent work has shown that the 2015–2016 El Niño event may have triggered a series of global disease outbreaks in areas affected by ENSO teleconnections [27•].

2.3. Extreme rainfall and river flooding

El Niño or La Niña intensify extreme rainfall mostly in boreal winter, and least during summer seasons [28]. The deviations from normal conditions are often asymmetric, which means that most parts of the world experience higher or lower extremes for either El Niño or La Niña conditions. Extreme rainfall during ENSO conditions can be up to 50% higher compared to neutral conditions. Extremes are more severe in the boreal winter during El Niño, mainly in central and southern North America, southeast and northeast China, and southeast South America, and during La Niña in western Pacific areas [28].

ENSO exerts a significant influence on annual floods in river basins covering over a third of the world's land surface [29]. While, about one-fifth of the global land surface is more likely to experience abnormally high river flow during El Niño conditions, especially in the tropics [10•]. As with extreme precipitation, these deviations from normal conditions are often asymmetric between ENSO phases [30]. ENSO also influences the duration of flooding, with flood duration appearing to be even more sensitive to ENSO than is the case for flood frequency [31]. In terms of economic damage, El Niño years are associated with anomalies in expected annual urban damage in 29% of the Earth's land surface, with significantly higher urban damage for 10% and lower damage for 19%. During La Niña years, significant anomalies are simulated across 23% of the Earth's land surface, with higher damage for 10% and lower damage for 13% [32].

2.4. Coastal hazards

ENSO events have been linked with increased probabilities of beach erosion and coastal flooding around the world. Two mechanisms cause this [9•]: (1) warmer ocean temperatures and changes in ocean circulation can induce an increase in mean sea level; and (2) perturbations of the tropical and subtropical atmospheric circulation influence storm activity around the world. Increases in mean sea level particularly affect the tropical Pacific [9•]. El Niño and La Niña conditions result in changes of mean sea level of ±20–30 cm [33]. During the five largest El Niño events between 1979 and 2012, mean sea levels along the North American west coast were on average 0.11 m higher [34]. In regions with a large change in mean sea-level and a small tidal range, these variations in mean sea level can have a significant influence on the occurrence of extremes [9•]. ENSO events can also induce changes in tropical cyclone activity [35], as well as extra-tropical cyclone activity [36]. Such changes in storm activity can have an impact on the occurrences of storm surge and waves. A recent study has shown that ENSO has a significant but small effect on the number of people potentially exposed to coastal flooding at the globally aggregated scale [9•].

3. Policy implications and recommendations

3.1. Responding to ENSO forecasts

The likelihood of extreme hazards can vary from year to year due to ENSO. As ENSO can be predicted with reasonable skill, individuals, organizations, and governments can make use of such ENSO forecasts to take actions that reduce the impacts of extreme hazards. In Fig. 2, we show the global probabilities of below- and above-normal precipitation for the 2019 boreal spring season based on ENSO forecasts.

Governments are increasingly interested in using seasonal forecasts of ENSO to reduce disaster risk. Peru provides a prime example. In the past, El Niño events have contributed to huge economic losses. For example, during the 1982–83 El Niño disaster losses exceeded 2 billion USD [37] and during the 1996–97 El Niño losses exceeded 3.5 billion USD [38]. This is because Peru's main economic activities (e.g. fishing, agriculture and tourism), are heavily exposed to the effects of El Niño. In response to the forecast of a strong ENSO in 2015, the Peruvian government declared a 60-day state of emergency, and spent around 20 million USD for flood and drought prevention. This included building reservoirs in areas predicted to be affected by drought, dredging and deepening rivers in flood-prone areas, and providing agricultural insurance for farmers [39]. In addition, an El Niño contingent insurance product has been developed for the region of Piura to compensate firms for lost profits or extra costs likely to occur as a result of floods [40,41]. Lastly, to reduce the impacts

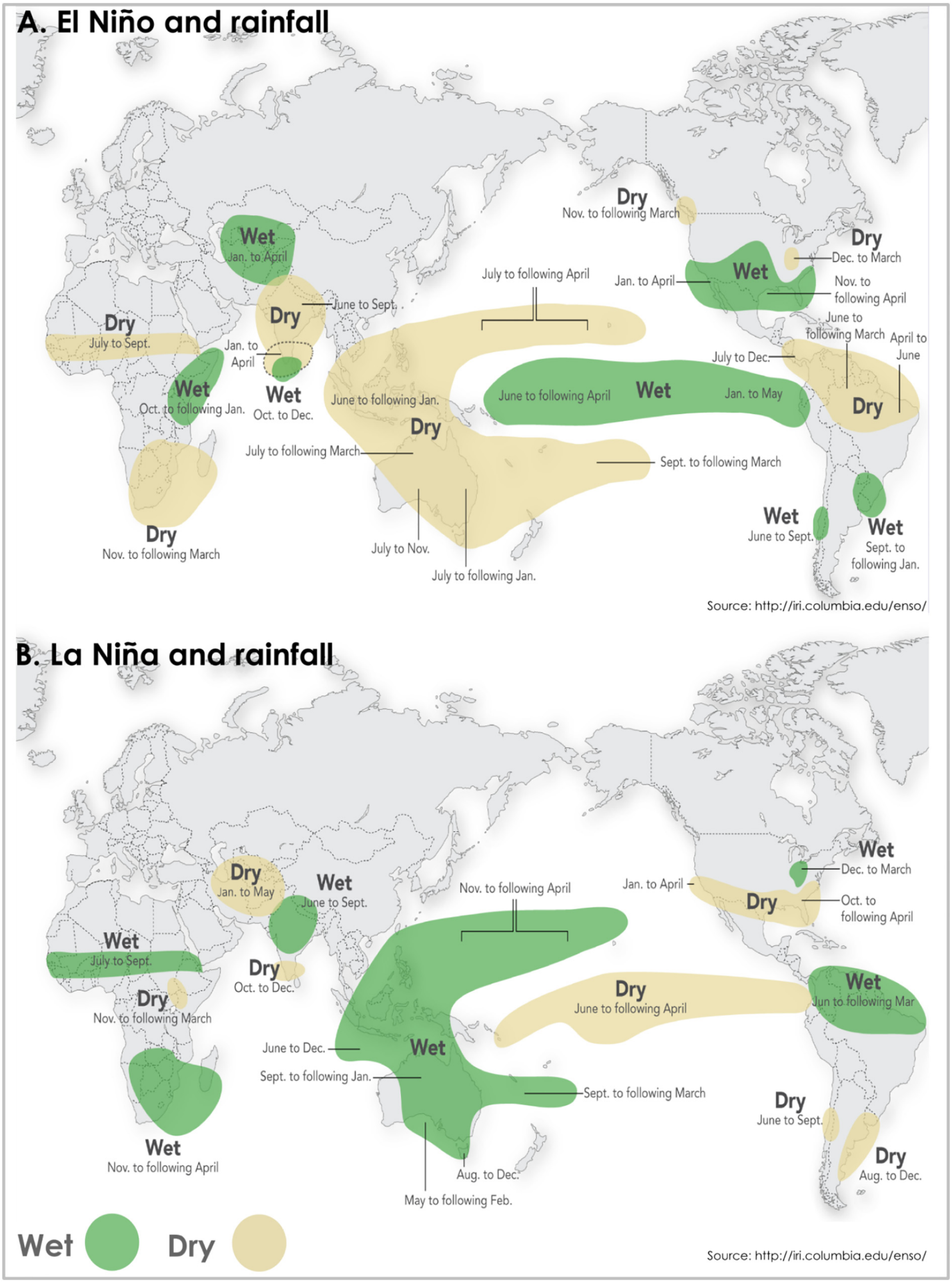

Fig. 1. Typical changes in rainfall observed during (A) El Niño and (B) La Niña episodes. Areas in green or yellow are likely to become wetter or dryer than normal during the indicated months. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Source: http://iri.columbia.edu/enso/

of heavy rains, the Peruvian Red Cross has defined a comprehensive set of early actions based on ENSO forecasts, which are triggered when an ENSO-based threshold is met [42].

Similar strategies are being implemented in Africa, where ENSO forecasts are used to assist agricultural producers to select crops most likely to be successful in the coming growing season [43]. At the same time, crop

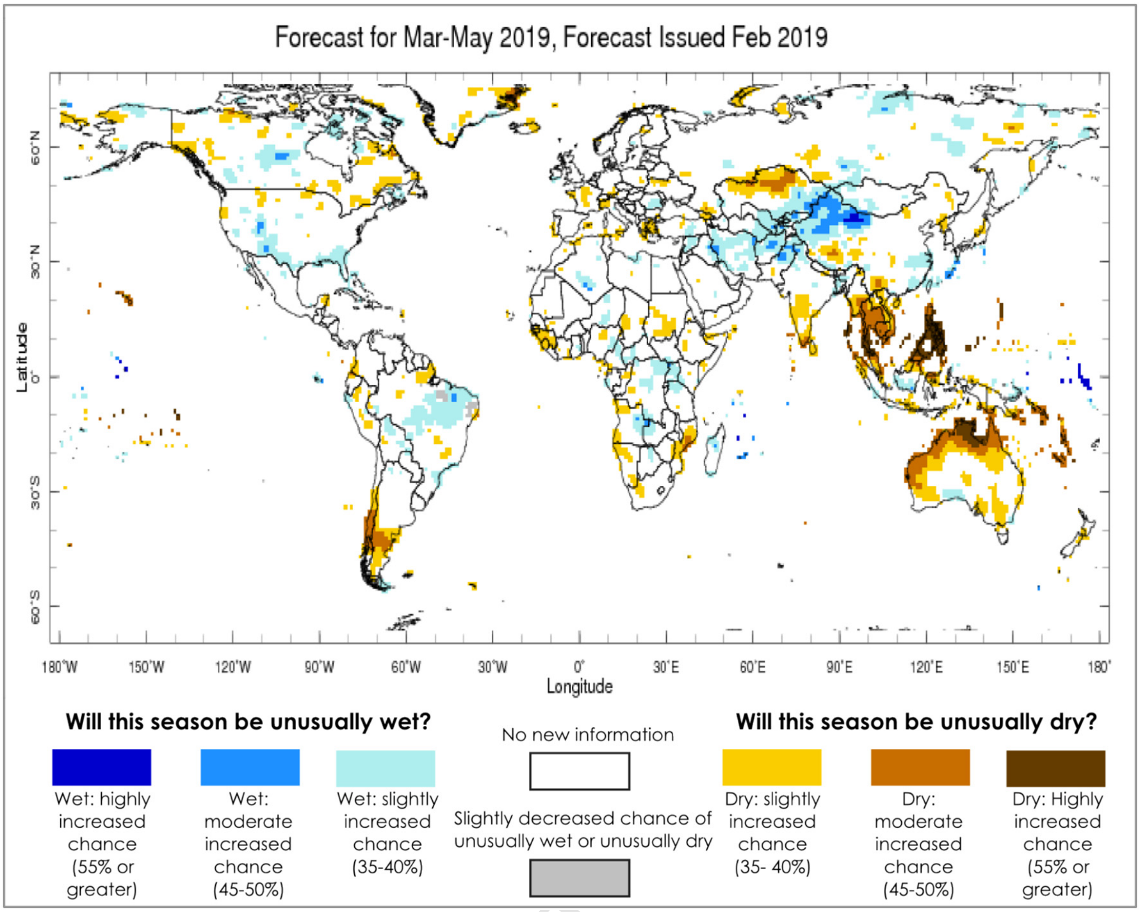

Fig. 2. This map shows the likelihood that total 3-month precipitation will be unusually high or low between March and May 2019. Source: http://iri.columbia.edu/enso/

insurance systems based on ENSO forecasts are becoming more established. An example is the African Risk Capacity, an index-based insurance mechanism for infrequent, severe drought events [44]. Early warning systems, such as the Famine Early Warning System, are providing outlooks that help governments and non-governmental organizations to foresee humanitarian crises [1•] and better plan for mitigating the upcoming risks.

3.2. Challenges

Despite an increased understanding of ENSO and improvements in ENSO forecast skill, its socioeconomic impacts continue to surprise the world [5]. Several constrains to action still exist for those who wish to respond to ENSO forecasts. First, we need to improve our understanding of ENSO dynamics and likelihood. For instance, in 2014 the National Oceanic and Atmospheric Administration Climate Prediction Center issued a forecast in early July that indicated close to 80% chance of a strong El Niño forming in that year during the Northern Hemisphere fall. However, sea surface temperature anomalies began to decay, and seasonal forecasts became increasingly uncertain by the end of 2014 [5]. Moreover, uncertainties surrounding ENSO's influence on the likelihood of droughts or floods are high. Each ENSO event is unique and can have a different signature. For instance, during the strong 2015–16 El Niño, several countries took preparedness measures for expected flooding. While Peru experienced severe flooding, no floods were registered in other locations with an elevate probability of flooding, such as Japan [10•]. Second, we need to develop a better understanding of how ENSO extremes may unfold into socioeconomic impacts. This is due to the fact that the severity of these disasters and their consequent losses not only depends on the intensity and frequency of hazards, but on the mutual interactions between social and physical systems [45]. Third, we need to improve our understanding on the influence of climate change on ENSO dynamics given that the changing climate may also have an effect on the frequency and strength of ENSO events [46]. Hence, it is important to enhance our knowledge of how ENSO may respond to climate change in the future.

Given these challenges, communicating and mobilizing funds to mitigate ENSO-related impacts remains difficult, which includes translating uncertain early warning information into multiple and flexible early actions. However, in response to the growing interest in forecasts from development agencies, governments and the humanitarian community [47•], there has been an emerging literature on ways to ‘automatically’ trigger early action based on forecast systems, using predetermined thresholds. For instance in 2015, based on an El Niño forecast, funds were released through the World Food Program for Zimbabwe and Guatemala to help both countries to reduce the negative consequences of droughts [48]. Furthermore, since mid-2015, the Central Emergency Response Fund has allocated 117.5 million USD to 19 countries for early action in response to disasters associated with El Niño. Reflecting recent pledges and new funding requests of a total of 5 billion USD by twenty-three countries, the funding gap in 2016 was almost 3.1 billion USD [49]. Ex-ante information regarding the spatial configuration of risk could support a more efficient allocation of financial resources and actions, and the development of disaster financing schemes that could alleviate the abrupt financial burden of disasters. For instance, a recent study showed that ex-ante cash transfers before a drought can be more cost-effective than ex-post compensations based on indicators of climate variability, including ENSO [50•].

4. Conclusions

ENSO events have been linked to high economic damages in large parts of the world, by increasing the likelihood of extreme events such as floods and droughts. Climate forecasts can predict ENSO several months in advance, and some governments and humanitarian organizations are increasingly taking precautionary measures to reduce disaster risks based on these forecasts. To take adequate action requires an understanding of the hotspots of risks during El Niño and La Niña events. There are more and more examples of good practices of actions taken to reduce the socio-economic burden of extreme events based on ENSO forecasts, such as the ones carried in Peru. Consequently, an enhanced understanding of current and future risks, at all scales, is needed to foster improvement in the management of ENSO-related hazards, and to mobilize innovation and finance that enable risk-informed sustainable development. However, several constrains to action still exist for those who wish to respond to ENSO forecasts, such as the limited understanding of ENSO dynamics; the relationship between ENSO extremes and socioeconomic impacts; and the influence of climate change on future ENSO extremes. Nevertheless, we believe that ex-ante information regarding the spatial configuration of risk leveraged by impact-based forecasts with long lead times can support a shift towards a more anticipatory and preventative risk management, as urged by the Sendai Framework for Disaster Risk Reduction.

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References and recommended reading[•,••]

[1•] Funk C, et al. Recognizing the famine early warning systems network (FEWS NET): over 30 years of drought early warning science advances and partnerships promoting global food security. Bull Am Meteorol Soc 2019. This article provides an overview of the Famine Early Warning Systems Network experiences in forecasting and monitoring global drought and food insecurity risks. Such early warning information is derived using a combination of socioeconomic and climate models, such as ENSO forecasts, and used for over three decades to guide effective humanitarian relief efforts.
[2] Heino M, et al. Two-thirds of global cropland area impacted by climate oscillations. Nat Commun 2018;9.
[3] Francis O. Combat East Africa famine, drought Bloomberg (20 Mar. 2017); 2017.
[4] BBC News. Flooding 'worst in 50 years', as 150,000 flee in Paraguay, Argentina, Brazil and Uruguay. at https://www.bbc.com/news/world-latin-america-35184793>; 2015.
[5] McPhaden MJ. Playing hide and seek with El Niño. Nat Clim Chang 2015;5:791–5.
[6] Santoso A, Mcphaden MJ, Cai W. The defining characteristics of ENSO extremes and the strong 2015/2016 El Niño. Rev Geophys 2017;55:1079–129.
[7] Ward PJ, et al. Usefulness and limitations of global flood risk models. Nat Clim Chang 2015;5:712–5.
[8] Veldkamp TIE, Eisner S, Wada Y, Aerts JCJH, Ward PJ. Sensitivity of water scarcity events to ENSO-driven climate variability at the global scale. Hydrol Earth Syst Sci 2015;19:4081–98.
[9•] Muis S, Haigh ID, Guimarães Nobre G, Aerts JCJH, Ward PJ. Influence of El Niño-southern oscillation on global coastal flooding. Earth's Future 2018;6:1311–22. This article assesses ENSO's influence on extreme sea levels using a global reanalysis of tides and storm surges, which allows for a full assessment of the global coastline. As a novelty, it analyses the relationship between ENSO and the number of people potentially exposed to flooding at the globally aggregated scale.
[10•] Emerton R, et al. Complex picture for likelihood of ENSO-driven flood hazard. Nat Commun 2017. https://doi.org/10.1038/ncomms14796. This article examines the relationship between ENSO and anomalies in river flows at the global scale. It shows that obtaining the right likelihood of increased or decreased flood hazard during ENSO events can be a complex task, and that probabilities may vary greatly across the globe, given large uncertainties in the datasets.
[11] Bureau Of Meteorology. ENSO outlook 28 march 2017 - an alert system for the El Niño–southern oscillation. at http://www.bom.gov.au/climate/enso/outlook/>; 2017.
[12] Gonzalez PLM, Goddard L. Long-lead ENSO predictability from CMIP5 decadal hindcasts. Climate Dynam 2016;46:3127–47.
[13] Coughlan De Perez E, et al. Forecast-based financing: an approach for catalyzing humanitarian action based on extreme weather and climate forecasts. Nat Hazards Earth Syst Sci 2015;15:895–904.
[14] UNISDR, U. N. O. Sendai framework for disaster risk reduction 2015–2030. Proceedings of the 3rd United Nations World Conference on DRR, Sendai, Japan 14–18; 2015.
[15] IRI. IRI ENSO forecast. at https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-iri_plume>; 2019.
[16] Dilley M, Heyman BN. ENSO and disaster: droughts, floods and El Niño/Southern Oscillation warm events. Disasters 1995;19:181–93.
[17] Ryu JH, Svoboda MD, Lenters JD, Tadesse T, Knutson CL. Potential extents for ENSO-driven hydrologic drought forecasts in the United States. Clim Change 2010; 101:575–97.
[18] Lü A, et al. El Niño-southern oscillation and water resources in the headwaters region of the yellow river: links and potential for forecasting. Hydrol Earth Syst Sci 2011;15: 1273–81.
[19] Richard Y, Fauchereau N, Poccard I, Rouault M, Trzaska S. 20th century droughts in Southern Africa: spatial and temporal variability, teleconnections with oceanic and atmospheric conditions. Int J Climatol 2001;21:873–85.
[20] Chiew FHS, Piechota TC, Dracup JA, Mcmahon TA. Nino/Southern Oscillation and Australian rainfall, streamflow and drought : links and potential for forecasting, vol. 204; 1998; 138–49.
[21] Dai A, Wigley TML. Global patterns of ENSO-induced precipitation. Geophys Res Lett 2000;27:1283–6.
[22] Dettinger MD, Diaz HF. Global characteristics of stream flow seasonality and variability. J Hydrometeorol 2000;1:289–310.
[23] Ward PJ, Beets W, Bouwer LM, Aerts JCJH, Renssen H. Sensitivity of river discharge to ENSO. Geophys Res Lett 2010;37:1–6.
[24] Guimarães Nobre G, Jongman B, Aerts J, Ward PJ. The role of climate variability in extreme floods in Europe. Environ Res Lett 2017;12:84012.
[25] Trenberth KE, Fasullo JT. Climate extremes and climate change: the Russian heat wave and other climate extremes of 2010. J Geophys Res Atmos 2012;117:1–12.
[26] Iizumi T, et al. Impacts of El Niño Southern Oscillation on the global yields of major crops. Nat Commun 2014;5:3712.
[27•] Anyamba A, et al. Global disease outbreaks associated with the 2015–2016 El Niño event. Sci Rep 2019;9:1930. This article analyzes global patterns of some disease outbreaks during the strong 2015–2016 El Niño event in relation to climate anomalies derived from satellite measurements. It identifies regions where ongoing global satellite monitoring of key climate variable anomalies could be used for forecasting disease outbreaks with sufficient lead time, which could potentially lead to disease prevention, and reduced burden and spread of ecologically coupled diseases.
[28] Sun X, Renard B, Thyer M, Westra S, Lang M. A global analysis of the asymmetric effect of ENSO on extreme precipitation. J Hydrol 2015;530:51–65.
[29] Ward PJ, Eisner S, Flörke M, Dettinger MD, Kummu M. Annual flood sensitivities to El Niño–Southern Oscillation at the global scale. Hydrol Earth Syst Sci 2014;18:47–66.
[30] Lee D, Ward PJ, Block P. Identification of symmetric and asymmetric responses in seasonal streamflow globally to ENSO phase. Environ Res Lett 2018. https://doi.org/10.1088/1748-9326/aab4ca.
[31] Ward PJ, Kummu M, Lall U. Flood frequencies and durations and their response to El Niño Southern Oscillation: global analysis. J Hydrol 2016. https://doi.org/10.1016/j.jhydrol.2016.05.045.
[32] Ward PJ, et al. Strong influence of El Nino Southern Oscillation on flood risk around the world. Proc Natl Acad Sci 2014;111:15659–64.
[33] Becker M, et al. Sea level variations at tropical Pacific islands since 1950. Global Planet Change 2012;80–81:85–98.
[34] Barnard PL, et al. Coastal vulnerability across the Pacific dominated by El Niño/Southern Oscillation. Nat Geosci 2015;8:801–7.
[35] Saunders MA, Chandler RE, Merchant CJ, Roberts FP. Atlantic hurricanes and NW Pacific typhoons: ENSO spatial impacts on occurrence and landfall. Geophys Res Lett 2000;27:1147–50.
[36] Eichler T, Higgins W. Climatology and ENSO-related variability of North American extratropical cyclone activity. J Climate 2006;19:2076–93.
[37] Lagos P, Buizer J. El nino and Peru: a nation's response to interanunual climate variability; 1992.
[38] UNISDR. Americas hit hard by El Niño; 2015 [at <News Archive>].
[39] Hillier D, Magrath J. El Niño 2015/6 briefing: urgent action now can prevent major suffering and loss; 2016 [at <file:///C:/Users/User1/Downloads/ib-el-nino-key-messages-en-20151120 (1).pdf>].
[40] Coughlan De Perez E, et al. Forecast-based financing: an approach for catalyzing humanitarian action based on extreme weather and climate forecasts. Nat Hazards Earth Syst Sci 2015. https://doi.org/10.5194/nhess-15-895-2015.
[41] Cavanaugh, G., Collier, B. & Skees, J. Incorporating weather index insurance with territorial approaches to climate change (TACC) in northern Peru. Unpubl Work Pap (2010).
[42] German Red Cross. Forecast-based financing Peru. at https://www.forecast-based-financing.org/projects/peru/>.
[43] Tall A, Jay A, Hansen J. Scaling up climate services for farmers in Africa and South Asia. CCAFS working paper; 2012.
[44] African Risk Capacity. African risk capacity: transforming disaster risk management & financing in Africa. at http://www.africanriskcapacity.org/>.
[45] Di Baldassarre G, et al. Debates - perspectives on socio-hydrology: capturing feedbacks between physical and social processes. Water Resour Res 2015. https://doi.org/10.1002/2014WR016416.
[46] Cai W, et al. Increasing frequency of extreme El Niño events due to greenhouse warming. Nat Clim Chang 2014;5:1–6.

• Of special interest.
•• Of outstanding interest.

[47] Tozier de la Poterie AS, et al. Understanding the use of 2015–2016 El Niño forecasts in shaping early humanitarian action in Eastern and Southern Africa. Int J Disaster Risk Reduct 2018. https://doi.org/10.1016/j.ijdrr.2018.02.025. This article examines how forecast-based early action were triggered to response to seasonal forecasts issued during the 2015–2016 El Niño in five countries. It identifies enabling factors for taking early action, and opportunities and constraints to the use of seasonal forecasts by humanitarian organizations.

[48] World Food Programme. FoodSECuRE - food security climate resilience facility supporting community resilience-building before and after climatic shocks. at http://documents.wfp.org/stellent/groups/public/documents/communications/wfp279583.pdf?_ga=2.214535189.368957664.1513674688-1083946025.1513674688>; 2016.

[49] OCHA. El nino: Overview of impact, projected humanitarian needs and response; 2016.

[50] Nobre GG, et al. Financing agricultural drought risk through ex-ante cash transfers. Sci Total Environ 2019;653:523–35. This article examines the cost-effectiveness of ex-ante and ex-post humanitarian aid (cash transfer). It provides novel early warning information of key indicators of agricultural droughts (including ENSO) that can be used for monitoring drought risks, and useful for increasing the effectiveness of existing aid programmes.