Geophysical Research Abstracts
Vol. 19, EGU2017-18384, 2017
EGU General Assembly 2017

Humans have already increased the risk of major disruption to Pacific rainfall

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Intermittent disruptions to rainfall patterns and intensity over the Pacific Ocean lasting up to approximately one year have major impacts on severe weather, agricultural production, ecosystems, and disease within the Pacific, and in many countries beyond. These disruptions are primarily driven by the El Niño/La Niña cycle, which is a naturally occurring phenomenon centered in the tropical Pacific.

Recent research concluded that global warming under scenarios with further large increases in global greenhouse gas emissions will increase the frequency of disruptions to Pacific rainfall over the 21st century. Fortunately governments from around the world recently agreed to markedly reduce emissions over coming decades. But will these cuts be sufficient to prevent a human-forced increase in the risk of major disruption? And has the risk (i.e. likelihood) of major disruption driven by year-to-year rainfall variability already increased relative to pre-industrial times?

These issues are addressed here (Power et al., Nature Communications, in press). We examined disruption in CMIP5 models under climatic conditions corresponding to the pre-industrial era, the historical period and the remainder of the 21st century under the RCP2.6, RCP4.5 and RCP8.5 scenarios. RCP2.6 results in global warming in the late 21st century that is likely to be in the range of approximately 0.9-2.3°C (relative to the latter half of the 19th century). The equivalent figures for RCP8.5 are 3.2-5.4°C (IPCC 2014).

We use a simple measure of disruption or volatility: the time evolving RMS difference in seasonal rainfall over the Pacific relative to a changing climatological value of seasonal rainfall. The CMIP5 models, the observations and an SST-forced AGCM all indicate that while both El Nino and La Nina can cause major disruptions, the largest disruptions occur during El Nino years. We also show that there is a 26% increase in the frequency of major disruptions in the models by the early twentieth century and a 28% increase by the end of the twentieth century, relative to the pre-idustrial value of approximately one major disruption every nine years. Under RCP8.5 there is a 90% increase in the early 21st century and a 126% increase during the late 21st century, again relative to the pre-industrial value.

The increase in the frequency of disruption arises from an increase in the frequency of El Niño and La Niña events in some models, and a non-linear boost in precipitation anomalies during El Niño and La Niña events caused by the associated global warming. This boost occurs even if the underlying sea-surface temperature anomalies during El Niño and La Niña events are unchanged from pre-industrial times. The non-linear boost increases the likelihood that a given El Niño or La Niña event will cause major disruption to rainfall.

Unfortunately, even the stringent mitigation represented in RCP2.6 does not prevent further increases in the frequency of disruption: there is a 56% increase in the early twenty first century, and a 61% increase in the late 21st century.

Four important conclusions can be drawn from these climate model results. First, the risk of major disruption to Pacific rainfall had already increased by the end of the 20th century and the early 21st century. This means, for example, that some of the disruption actually witnessed in the real world might have been partially due to anthropogenic increases in greenhouse gas concentrations that had already occurred by that time. Second, the risk is elevated today relative to pre-industrial times, and will remain elevated over coming years. Third, further increases in the risk of major disruption during the remainder of the 21st century can be strongly moderated if major and sustained cuts to global emissions of GHGs are made, but elevated risk for at least the remainder of the 21st century might arise, even if global action is successful in restricting emissions to RCP2.6 levels.