gap between the scientific consensus and the public's divided beliefs.

But as troubling as the 'local warming' effect may be, it is not unusual: individuals regularly make assessments about society-wide conditions (like unemployment or crime) from their own experiences (of, say, losing a job or being mugged on the street). Considering that one of the chief effects of global warming is to raise the prevalence of unusually hot days, drawing conclusions about the existence of global warming from local weather is not entirely irrational. Zaval and colleagues show us that such reasoning stems from placing undue weight on this highly salient information compared with other information — like scientific research — that is much more relevant. The challenge facing scientists and climate change communicators is to raise the awareness of this latter information so that Americans might be encouraged to focus on large-scale patterns rather than the weather outside. ❐

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ATMOSPHERIC SCIENCE

A boost in big El Niño

Computer models and theory do not offer a consensus on how El Niño will change under global warming. Despite this disagreement, a study indicates a robust increase in the frequency of extreme El Niño episodes.

Nathaniel C. Johnson

About once every four years, on average, one of the most powerful and far-reaching climate phenomena, known as El Niño, extends its influence to most continents and oceans of the world. This phenomenon, which originates in the tropics and is characterized by unusually warm and wet conditions in the equatorial eastern Pacific Ocean, triggers large-scale weather patterns that disrupt remote regions through floods, droughts, heat waves and cold spells. During extreme El Niño episodes, as occurred in 1982/83 and 1997/98, the worldwide societal, economic and environmental impacts have been particularly costly, with damages totalling in the tens of billions of US dollars and thousands of lives lost[1]. Although the physical mechanisms and effects of El Niño in today's climate are relatively well understood, there is considerable uncertainty regarding how the El Niño phenomenon will respond to global warming[2]. Even in the face of this uncertainty, in this issue of *Nature Climate Change* Cai and colleagues[3] identify and report on a robust change in climate models — extreme El Niño episodes will increase in frequency under global warming.

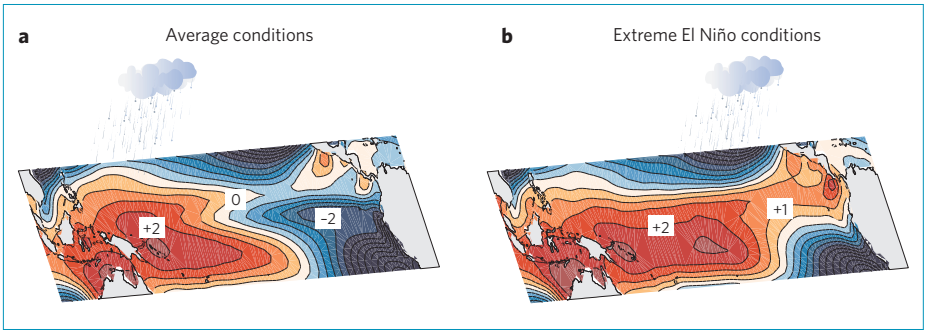

Figure 1 | Illustration of extreme El Niño conditions. **a**, Average sea surface conditions during austral summer (December–February). The filled contours represent the sea surface temperatures (°C) relative to the long-term, area-averaged (20° S–20° N) tropical mean (that is, a value of zero is the long-term tropical mean, ~27 °C in the current climate). Warm (cold) colours represent sea surface temperatures above (below) the tropical mean. Most of the tropical deep convection and heavy rainfall occur in the western equatorial Pacific Ocean. **b**, Sea surface conditions during extreme El Niño episodes. The eastern equatorial Pacific warms dramatically, the sea surface temperature gradient nearly vanishes, and most of the deep convection shifts to the central and eastern equatorial eastern Pacific.

Usually, during austral summer, which is the peak season of El Niño, conditions in the equatorial eastern Pacific Ocean region are very dry and relatively cool and most tropical ocean rainfall is confined to the warmer western Indo-Pacific region (Fig. 1a). During typical El Niño episodes, the eastern Pacific Ocean warms considerably and tropical rainfall shifts towards the equatorial central Pacific, but the equatorial eastern Pacific stays dry because the atmosphere remains stable. However, more dramatic eastern Pacific warming during extreme El Niño episodes disrupts the eastern Pacific sea surface temperature gradients, breaks the stability barrier and triggers enormous increases in deep showers and thunderstorms (Fig. 1b). This atmospheric convection, manifesting as heavy rainfall, is the primary driver of El Niño-related extreme weather in remote regions. Cai and colleagues focus on the

mechanism by which global warming may impact the occurrence of extreme eastern Pacific rainfall events during these rare El Niño episodes. Although there is considerable uncertainty regarding how the sea surface temperature variability may change, the authors find a more robust link with extreme rainfall, which is tied to the pattern of equatorial Pacific sea surface warming.

As the ocean surface warms under increasing greenhouse gas concentrations, climate models project a pattern of enhanced warming in the equatorial eastern Pacific relative to the rest of the tropical oceans[2,4]. This pattern of enhanced warming essentially reduces the barrier to deep atmospheric convection in the normally dry eastern Pacific, making it easier for a sea surface temperature increase associated with El Niño to induce extreme rainfall in the region. Thus, under global warming, Cai and colleagues find that the same El Niño-related sea surface temperature anomalies induce larger eastern Pacific rainfall events, which signifies more frequent eastern Pacific extreme rainfall even if the sea surface temperature variability does not change. Therefore, a robust change emerges when the authors define extreme El Niño by rainfall rather than sea surface temperature, which is likely to be a more useful definition for making links to remote societal impacts.

This increase in the frequency of extreme El Niño events is dependent on a pattern of enhanced warming in the equatorial eastern Pacific Ocean. How much confidence can we place in the consistency of such a pattern under global warming? Climate scientists have debated the expected tropical response to global warming, with an ocean dynamical 'thermostat' mechanism favouring suppressed eastern Pacific warming[5], but a reduction in heat transport away from the equator[2] and the expected surface latent heat flux adjustment[4] favouring enhanced equatorial Pacific warming. Contrary to the expected pattern from climate models, over the past 35–40 years the tropical sea surface temperature trend has actually featured suppressed warming in the equatorial eastern Pacific[6]. However, there is strong observational evidence of the expected enhanced equatorial eastern Pacific warming if the analysis is extended to include the past 60 years[7]. Cai and colleagues have theoretical, observational and modelling support at the foundation of their findings, nevertheless, the pattern of equatorial sea surface warming will remain an active area of research.

Another key question relates to implications for the associated changes in extreme weather under global warming, given that the severe impacts from extreme El Niño episodes depend on the interaction between the eastern Pacific rainfall and the background state. Will more frequent extreme rainfall episodes in the equatorial eastern Pacific lead to more frequent extreme impacts under global warming, or will changes in the background state alter the impacts, possibly even taming some of the effects? A recent study[8] supports the contention of the new findings, demonstrating that El Niño-related hydroclimate variability will become intensified under global warming, particularly in regions, such as southern Asia, that are already severely stressed by variations in droughts, floods and crop yields. However, the same study also notes that the changes in rainfall patterns are more complex in other regions, which invites further scrutiny when we limit consideration to extreme El Niño episodes. Potential changes in regional temperature variability raise additional questions: another recent study[9] indicates a projected decrease in temperature variability under global warming. Will extreme El Niño episodes under global warming feature muted temperature variability, or will the more frequent extreme episodes lead to more frequent extreme temperature swings in some regions?

Although some questions remain unanswered, Cai and colleagues provide a solid foundation for future investigations. Their study underscores that the frequency of extreme rainfall episodes in the equatorial eastern Pacific Ocean associated with El Niño episodes will increase as long as the region warms faster than the rest of the tropical oceans. Furthermore, the increased frequency of these extreme rainfall episodes are likely to inflict more frequent severe impacts over some regions of the world. ❐

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REDD+ POLICY

Corridors of carbon and biodiversity

Reducing tropical deforestation has huge potential for mitigating climate change and saving the Earth's most biologically diverse biome. Corridors connecting existing protected areas represent an elegant means of attaining both goals.

Oscar Venter

In Poland last year, climate negotiators finally agreed to a mechanism for paying developing countries for reducing their forest-based emissions — which account for roughly 15% of global emissions. With pitch-perfect timing, Jantz and colleagues[1] propose, in this issue of *Nature Climate Change,* a framework for harnessing these funds to contribute to biodiversity conservation in the tropics. In their paper they demonstrate that by carefully targeting carbon funds at corridors linking existing protected areas, large benefits can be gained for biodiversity conservation without compromising the new mechanism's primary aim of slowing anthropogenic climate change.

The carbon mechanism is termed REDD+ (Reducing Emissions from Deforestation and