CLIMATE SCIENCE

Beyond the spring barrier?

Predicting an El Niño or La Niña event before the preceding spring has proved to be difficult. Taking into account coupled ocean–atmosphere modes in the Indian Ocean region that have a two-year periodicity may provide the basis for longer forecasting lead times.

Peter J. Webster and Carlos D. Hoyos

The El Niño cycle is the most powerful multiannual climate oscillation on Earth. Because of its influence on global patterns of temperature and precipitation[1], El Niño directly affects the livelihoods of millions of people worldwide, as well as the state of terrestrial and marine ecosystems. Predicting the onset of an El Niño or La Niña phase as far in advance as possible has therefore long been a goal of climate science. Yet the advance warning achieved by El Niño forecasts has been limited by an apparent predictability barrier: forecasts issued before the preceding Northern Hemisphere spring, about two months before the onset and nine months before the full manifestation of an El Niño event, typically show very limited skill[2]. Writing in *Nature Geoscience*, Izumo and colleagues[3] suggest that a better understanding of the role the Indian Ocean Dipole may allow El Niño and La Niña to be predicted more than a year in advance, thus leaping over this springtime predictability barrier.

In 1924, in the search for atmospheric parameters that would allow the prediction of the strength of the ensuing Indian monsoon[4], a global-scale long-period atmospheric pressure oscillation was identified and termed the Southern Oscillation. This phenomenon was later found to be associated with the aperiodic warming (El Niño) and cooling (La Niña) of the eastern Pacific Ocean and became known as the El Niño–Southern Oscillation (ENSO). El Niño events result from ocean–atmosphere feedbacks that produce a weakening of the trade winds and a basin-wide shift of warm sea surface temperatures to the eastern Pacific Ocean[5]. Subsequent theories have explained the transition of an El Niño event into a La Niña event that usually takes place during the following year. However, available theories have failed to predict the initial onset of an El Niño cycle until after the Northern Hemisphere springtime: the spring predictability barrier[2].

Statistically, ENSO accounts for about 30% of the rainfall variability within the Indian monsoon, although the relationship between monsoons and ENSO has waxed and waned from decade to decade. Furthermore, when the association between the Indian monsoon and ENSO is strong, the spring predictability barrier is especially troublesome for forecasts of the summer monsoon. Even a perfect forecast after spring would be of limited value, because by spring it is too late to allow farmers to prepare adequately for a weaker (or stronger) than average monsoon season. New physical understanding, and a prediction methodology that would allow longer-range forecasts of La Niña and El Niño by somehow transcending the

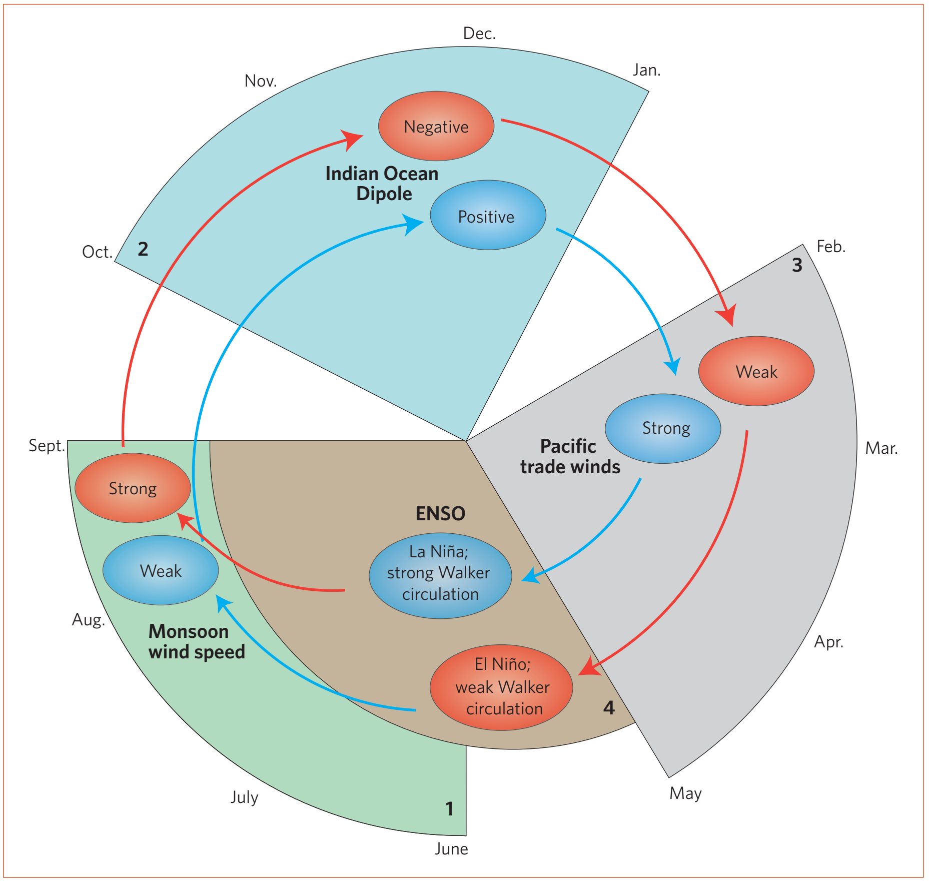

Figure 1 | Schematic biennial climate oscillation in the Pacific and Indian oceans. A strong monsoon in the June–September period (red, panel 1) leads to the development of negative anomaly in the Indian Ocean Dipole (IOD) index (red: panel 2)[6,8,9]. As a consequence of the demise of the negative IOD anomaly, the Pacific trade winds decelerate[3] (red: panel 3), which leads, in turn, to the formation of an El Niño phase[3,4] and a decrease in the strength of the Walker Circulation[3,8,9] (red: panel 4). In response to these changes, the South Asian monsoon weakens[8] (blue, panel 1) and the second annual cycle follows the same pattern, but with opposite signs. Izumo and colleagues[3] suggest that the evolution from an anomaly in the Indian Ocean Dipole to an El Niño or La Niña event could help improve ENSO forecasts at lead times of up to 14 months.

spring predictability barrier, could help with monsoon predictions and with climate forecasts in other regions where ENSO has a strong influence.

Izumo and colleagues[3] focus on the Indian Ocean Dipole — a quasi-biennial oscillation in sea surface temperatures between the eastern and western parts of the Indian Ocean — as a prominent component in the development of El Niño or La Niña. Their findings indicate that the research emphasis on the Pacific Ocean may have precluded a more complete understanding of the predictability of ENSO. The possibility that independent modes related to ENSO exist gained credibility with the discovery of the Indian Ocean Dipole[6,7]. Izumo and colleagues show that the negative dipole phase, characterized by a warm eastern Indian Ocean and a cold western basin tends to be followed by the formation of an El Niño event more than a year later. The opposite phase of the Indian Ocean Dipole leads a La Niña by a similar period. They suggest a physical connection between the Indian Ocean Dipole and ENSO, whereby the rapid changes of the surface wind field in the Pacific region after the demise of the Indian Ocean Dipole anomaly cause the change of phase in ENSO. Because the Indian Ocean Dipole anomaly typically decays in northern autumn or winter, this theory — if confirmed — provides a bridge over the spring predictability barrier. However, the degree of predictability achieved in this way has yet to be explored in detail. And it is not known if taking into account the Indian Ocean Dipole will also allow forecasting of the magnitude and location of the anomalous conditions associated with a subsequent El Niño or La Niña event with similar lead times.

Associations between the Indian Ocean Dipole and ENSO have been noted before[6–8]. But the development of an Indian Ocean Dipole anomaly has usually been thought of as a response to external forcing, rather than as an intrinsic Indian Ocean mode[3]. A combined diagnostic and modelling study[8,9] suggested that the development of the Indian Ocean Dipole comes from a response of the Indian Ocean to either an anomalously weak monsoon, in the case of the positive phase, or a strong monsoon for the negative phase. The vigour of the monsoon wind-gyre would, in turn, be determined by whether or not El Niño or La Niña conditions exist. This idea of an externally determined Indian Ocean Dipole is supported by the observation that both phases of the Indian Ocean Dipole are initiated during the summer monsoon season. This sequence of events, depicted in Fig. 1, has a strong biennial period[8].

Whether the enhanced predictability of ENSO as reported by Izumo and colleagues[3] is merely reflecting the statistics of the strong two-year rhythm of the Indian and Pacific oceans remains to be determined. Furthermore, it is important to test whether the interactions described by Izumo and colleagues are a reoccurring feature of the climate of the Indian and Pacific basins and not restricted to the 1981–2008 period they consider. This test can be accomplished by extending their analysis over the 100 years or so during which sea surface temperature data are reliable. This extension is important, because a study using sea surface temperature data from 1890 to 2008 has shown interdecadal variations in the magnitude and period of the Indian Ocean Dipole[10]. But, overall, a clear message emerges. If the prediction horizon of El Niño and La Niña is to be extended, then both the Indian and Pacific ocean basins must be included in empirical and dynamical forecasting schemes. ❐

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PALAEOCEANOGRAPHY

No signs of Southern Ocean CO_2

The rise in atmospheric carbon dioxide levels at the end of the last glacial period has been attributed to a release of carbon from the abyssal ocean. Radiocarbon analyses from the Chilean margin have failed to find evidence that supports this hypothesis.

Lowell Stott

Pleistocene ice-age terminations are arguably among the most compelling examples of Earth's dramatic climate variability. Each of the five ice ages of the past 500,000 years ended abruptly: warming and continental ice-sheets retreated in roughly one-tenth of the time it took for the Earth's climate to cool and for ice sheets to reach to their maximum extent. Ice-core records from Greenland and Antarctica showed that each glacial termination was accompanied by an ~80 ppm rise in atmospheric carbon dioxide concentration[1,2]. Because of the close temporal relationship between deglacial warming and the rise in atmospheric carbon dioxide, greenhouse-gas forcing is considered important to such rapid warming. But the source of carbon dioxide added to the atmosphere during deglaciations remains elusive. A recent hypothesis invokes the release of carbon dioxide from the deep sea through the Southern Ocean[3]. However, writing in *Nature Geoscience*, De Pol-Holz and colleagues[4] report that intermediate water formed in the Southern Ocean during the last glacial termination does not show the anomalous radiocarbon activity that would be expected if the carbon dioxide was indeed released through the Southern Ocean.

Between 18,000 and 11,600 years ago, during the last deglaciation, atmospheric carbon dioxide concentrations rose while

Correction

In the News & Views 'Beyond the spring barrier?' (*Nature Geosci.* **3,** 152–153; 2010), in the fourth sentence of the first full paragraph on page 153, 'western' and 'eastern' should have read 'eastern' and 'western', respectively. The HTML and PDF versions of the text are correct.