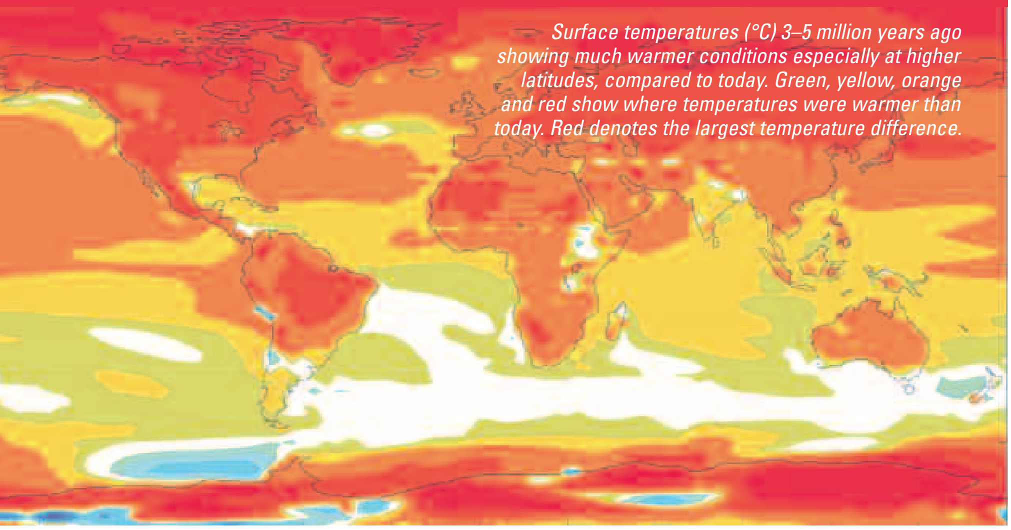
The future of El Niño?

How did El Niño behave three-to-five million years ago when average global temperatures were around 3°C warmer than today? **Alan Haywood**, **Paul Valdes** and **Victoria Peck** explore.



Surface temperatures (°C) 3–5 million years ago showing much warmer conditions especially at higher latitudes, compared to today. Green, yellow, orange and red show where temperatures were warmer than today. Red denotes the largest temperature difference.

Upwelling of cool, nutrient rich waters makes the Pacific coast of South America one of the most productive fishing sites in the world, except during an El Niño year that is. El Niño, Spanish for 'the little boy', is an unwelcome climate phenomenon that occurs every few years, usually around Christmas time, and is recognised by unusually high sea surface temperatures extending across the central and eastern tropical Pacific Ocean. Trade winds are weaker than usual and fail to upwell the fertile waters that sustain the fishing industry in this region, devastating local economies.

Fishermen are not the only trade to take a keen interest in El Niño. Climate scientists are also on the case because it dominates climate variability in the tropical Pacific and further afield. El Niño is an extreme part of a larger climate phenomenon known as El Niño Southern Oscillation (ENSO). The opposite extreme is La Niña, characterised by a temperature drop in the central Pacific.

El Niño events may become more frequent, persistent and intense in the future as greenhouse gas concentrations in the atmosphere increase. However, despite an enormous effort, researchers are still unable say with any certainty what will happen to El Niño, but examining El Niño in the distant past may help.

Three-to-five million years ago, during the Pliocene period, the world was about 3°C warmer than today. Carbon dioxide levels were probably slightly higher than current levels (levels were around 380-400 parts per million). Palaeoceanographers use tiny planktonic organisms, foraminifers – a bit like an amoeba with a calcite shell, preserved as fossils in deep-sea sediments – to investigate past sea surface temperatures. The distribution of cold and warm water species of foraminifera tell us about surface conditions at the time.

Two papers published in *Science* in 2005 dispute the state of ENSO during this period. Two groups of palaeoceanographers, one American and one British, published conflicting reconstructions of eastern equatorial Pacific sea surface temperatures using the ratio of magnesium to calcium in the foraminifera skeletons preserved in deep-sea sediments recovered by the Integrated Ocean Drilling Program. The British group, argue that permanent La Niña-like conditions prevailed, the American group however, disagrees and argues that the Pliocene was characterised by permanent El Niño-like conditions.

How can we tell which, if either, of these scenarios is correct? We produced sophisticated past climate reconstructions using climate models. The results reveal a number of interesting findings. Firstly, the pattern of change of sea surface temperature and surface air temperature in the tropical Pacific suggests alternating El Niño and La Niña conditions just like today. Secondly, the model suggests that the magnitude of the variability is greater (about 20 percent) in the Pliocene experiment than it is for the equivalent present-day experiment. This means that El Niño and La Niña events were more intense and/or more frequent in the past. This translates into more frequent and more extreme droughts and floods in South America and Indonesia in the past and potentially for the future too.

So does the work provide any suggestions as to why the studies carried out by the two groups differ so dramatically? Close investigation into the fossil records revealed two factors that certainly contributed. Firstly, different cleaning practices and protocols were used by the two groups, which may have biased initial results. Secondly, the groups used different calibrations to convert the magnesium and calcium ratios into sea surface temperatures, which account for up to 2.5°C of the offsets. Whatever the reasons for the differences, this study has highlighted substantial changes to ENSO in a warmer world, which could provide us with a clue as to how ENSO may behave in the future.

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