Climate variability in the tropical Pacific is dominated by the El Niño/Southern Oscillation (ENSO), which has global impacts, most notably in drought-prone regions such as the southwestern USA and Australia. How will the tropical Pacific fluctuate in the coming decades to centuries? A first-order answer from both paleoclimate records and climate models is that the Pacific will continue to be characterized by large seasonal and interannual variability during the coming century. Seasonally resolved tropical-Pacific paleoclimate records from periods in the Earth’s history that were both warmer and colder than today point to interannual variability (Watanabe et al. 2011; Scroxton et al. 2011; Koutavas and Joannis 2009; Tudhope et al. 2001). And models too have thus far not been able to rid the tropical Pacific of ENSO variability by either warming (Huber and Caballero 2003; Galeotti et al. 2010; von der Heydt et al. 2010; hope et al. 2001). And models too have still wide open. For example, can ENSO have long periods of quiescence? What causes decadal and multidecadal variability in the tropical Pacific? Are they influenced by greenhouse-gas forcing?

Limitations of the instrumental record do not allow us to fully address the question of decadal variability in the tropical Pacific (Fig. 1). Annually resolved paleoclimate proxies are key to filling in the low-frequency part of the spectrum. Some paleoclimate proxies suggested that the Pacific climate has natural variability on timescales of centuries and even millennia (T. Ault, pers. comm.). We do not yet know of an appropriate mechanism, though feedbacks involving low-level clouds, among others, have been invoked (Clement et al. 2011). Current climate models, being deficient in their representation of low-level clouds (Clement et al. 2004), might not simulate Pacific decadal variability properly. Detection and attribution of anthropogenic change in the tropical Pacific may thus remain an extraordinary problem for the foreseeable future.

As to predictability, one of the great achievements in the late 20th century was the development of a monitoring and prediction system that can predict ENSO on seasonal to interannual timescales. This system has been active since the 1970s, but it has been improved significantly. Further, there is now an ongoing international effort to improve the test of hindcasting past climate fluctuations. Here again, the observation of ENSO is now an ongoing international effort to improve hindcasting past ENSO fluctuations. This reconstruction and prediction system that can predict ENSO on season-to-interannual timescales is limited by our ability to put them to the test of hindcasting past climate fluctuations. How well do observations compare to hindcasts of hindcasts? How do long observational records compare to hindcasts of hindcasts?

As for physics, some recent proxy reconstructions and paleoclimate archives suggest a link between ENSO and the Pacific Decadal Oscillation (PDO). This is not a new idea; it is differently important today. What are the mechanisms driving this link, and what are the implications for future climate change? What are the mechanisms driving this link, and what are the implications for future climate change?

Dispite considerable progress in understanding the El Niño-Southern Oscillation (ENSO) over recent decades, several mysteries remain:

- How irregular is ENSO?
- What causes its decadal modulation?
- How does radiative forcing (in particular anthropogenic forcing) influence this system?

The paleoclimate record can shed light onto some of these questions. As recounted by A. Clement (this issue) there is resolved variability in ENSO since the Pliocene warm epoch and through glacial cycles, suggesting that the phenomenon is rather impervious to external influences. The details are far thornier, for even a small change in the character of ENSO or its teleconnections can have far-reaching societal impacts (e.g. Hisan et al. 2011).

Since very high-resolution archives take ENSO’s pulse from the heat of the tropical Pacific, one must rely on archives from remote sites, which are vulnerable to interferences from local effects or changing teleconnections. This is an ongoing effort that is bound to be productive for the foreseeable future. One might conclude that the positive Bjerknes feedback standing of ENSO suggests that the phenomenon is rather impervious to external influences. The details are far thornier, for even a small change in the character of ENSO or its teleconnections can have far-reaching societal impacts (e.g. Hisan et al. 2011).

What is the outlook for ENSO? Were such a link eventually to be elucidated by new proxy observations, there is no guarantee that ENSO will react similarly to greenhouse forcing as it did to a changing Sun: greenhouse forcing has a very different vertical structure from solar forcing, it is differently impacted by clouds and aerosols, and acts 24 hours a day, unlike the Sun. These differences limit the extent to which natural forcings can serve as analogs for anthropogenic ones. Therefore, one should not view ENSO’s past as a set of prophecies, but, rather, as a rich laboratory in which to test the models used to predict its future. The ENSO-sponsored FIMIP 3 dust model intercomparison effort is expected to bring much insight into this problem.