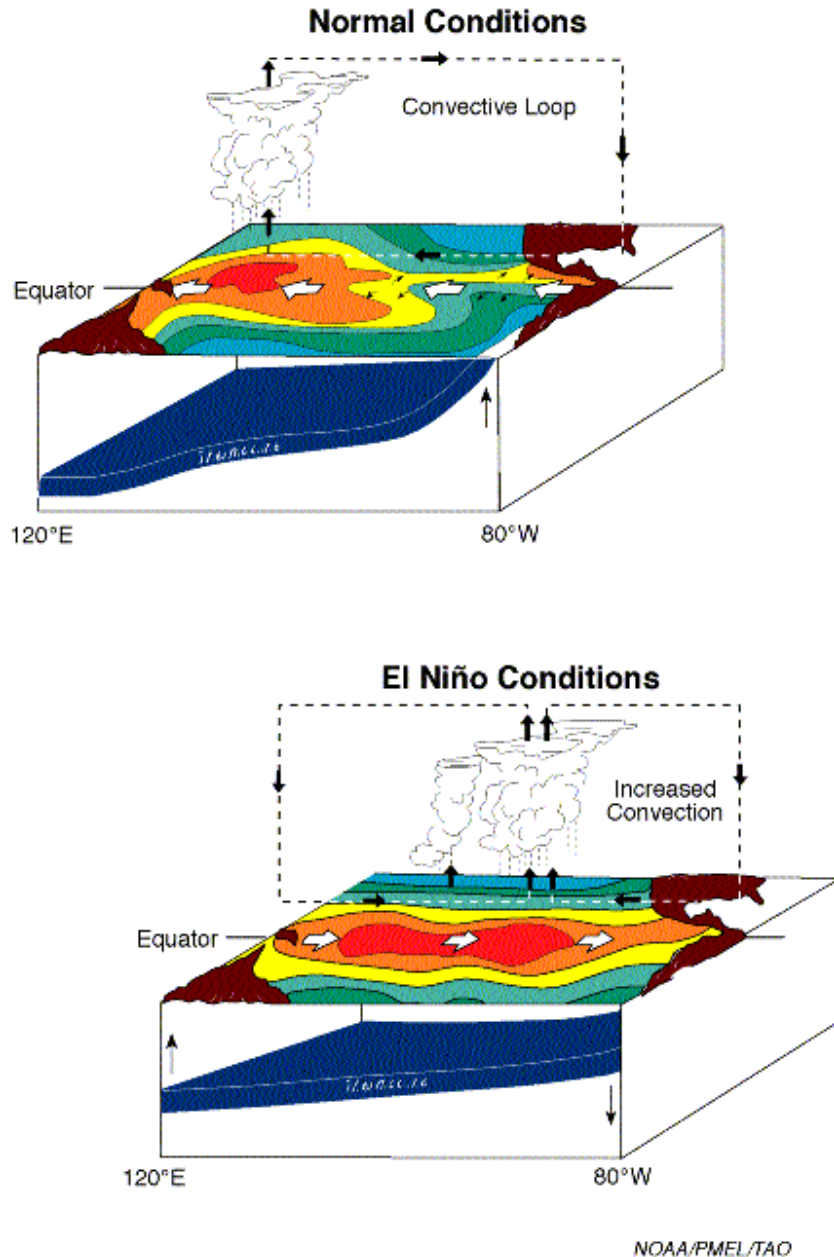


Understanding the link between El Niño and global climate change

Steven J. Phipps

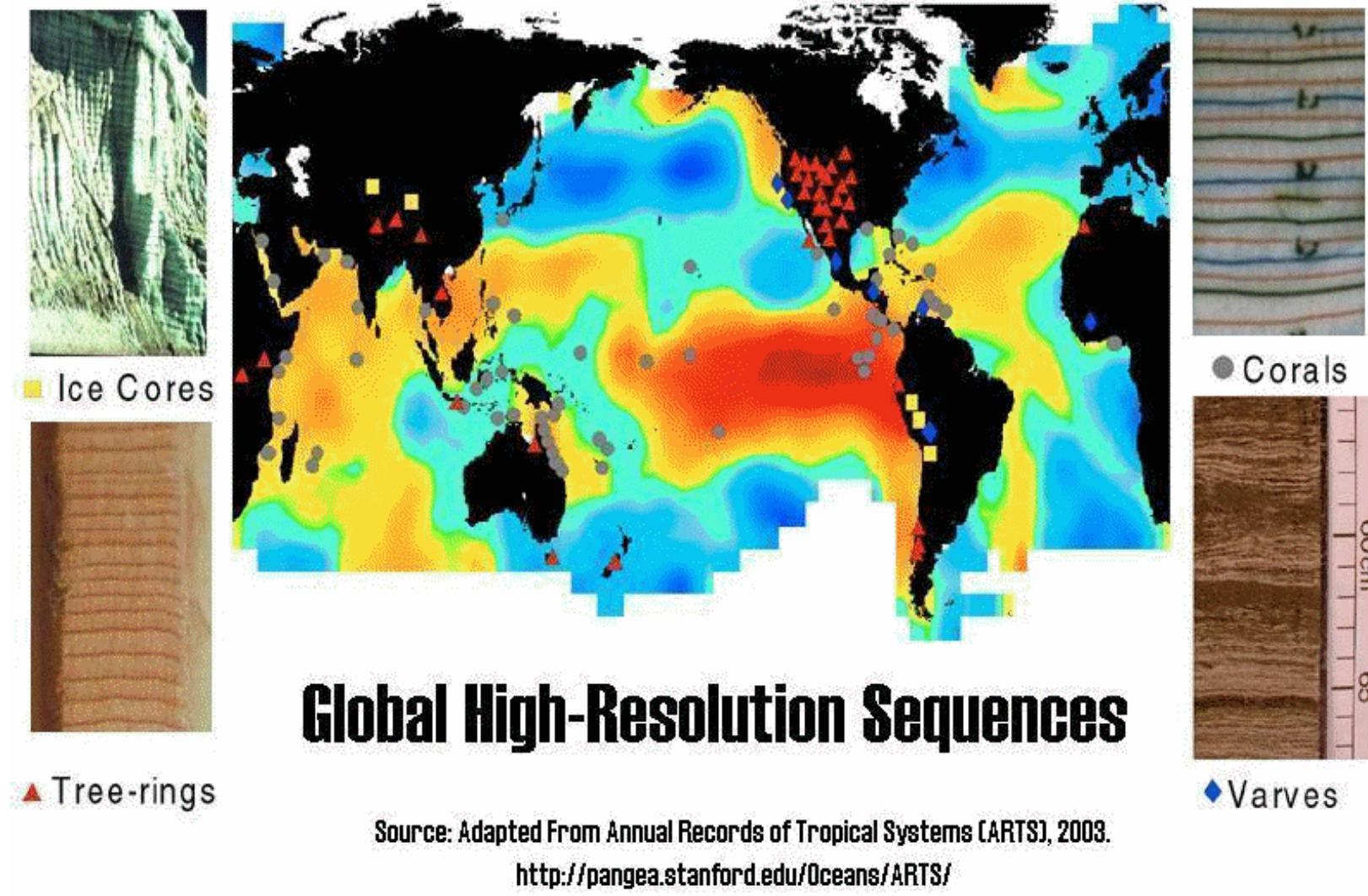
Climate Change Research Centre
University of New South Wales

What is El Niño?

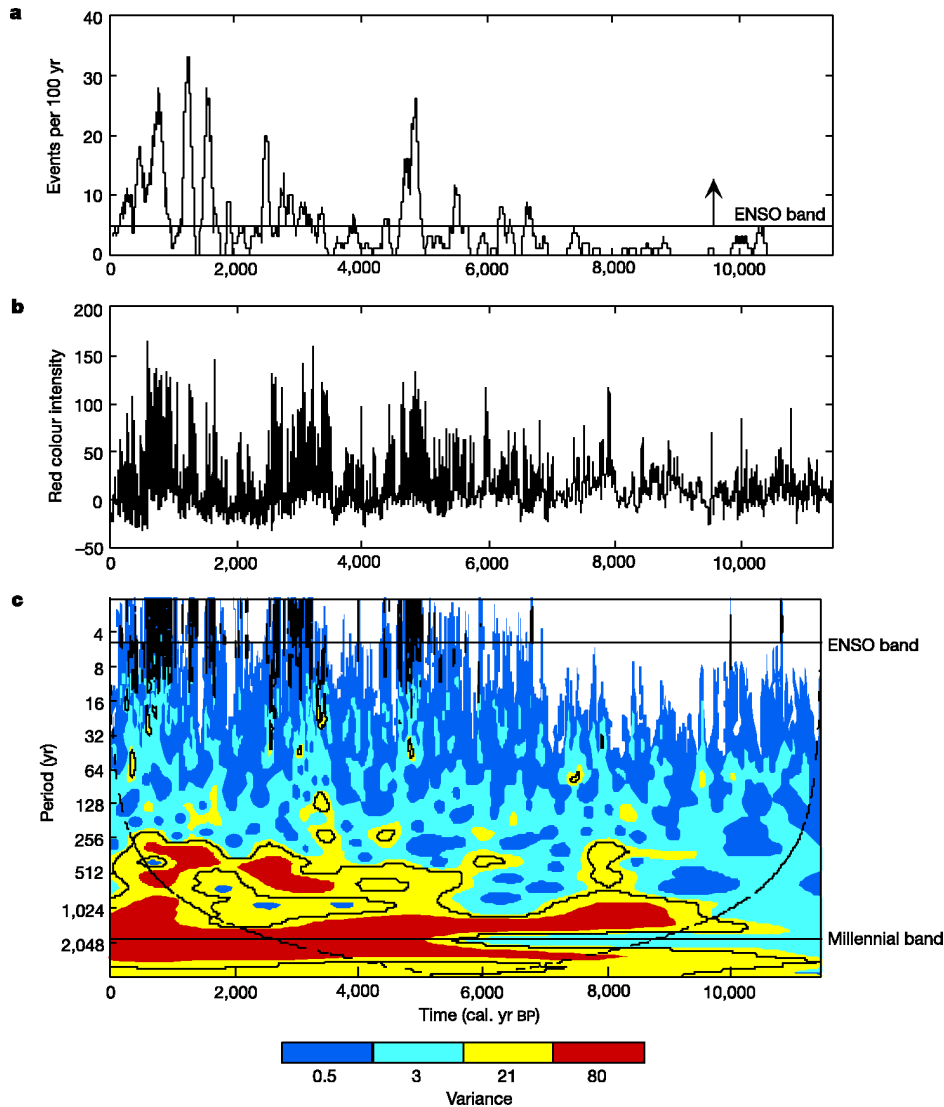


- Dominant mode of internal variability within the coupled atmosphere-ocean system
- Irregular period of $\sim 2-7$ years
- Average state of the system involves strong easterly trade winds pushing warm water to the east
- In an El Niño event, these winds slacken and the warm water flows eastwards
- Increased rainfall in the eastern Pacific, reduced rainfall in the west

Evidence of past El Niño events is all around us



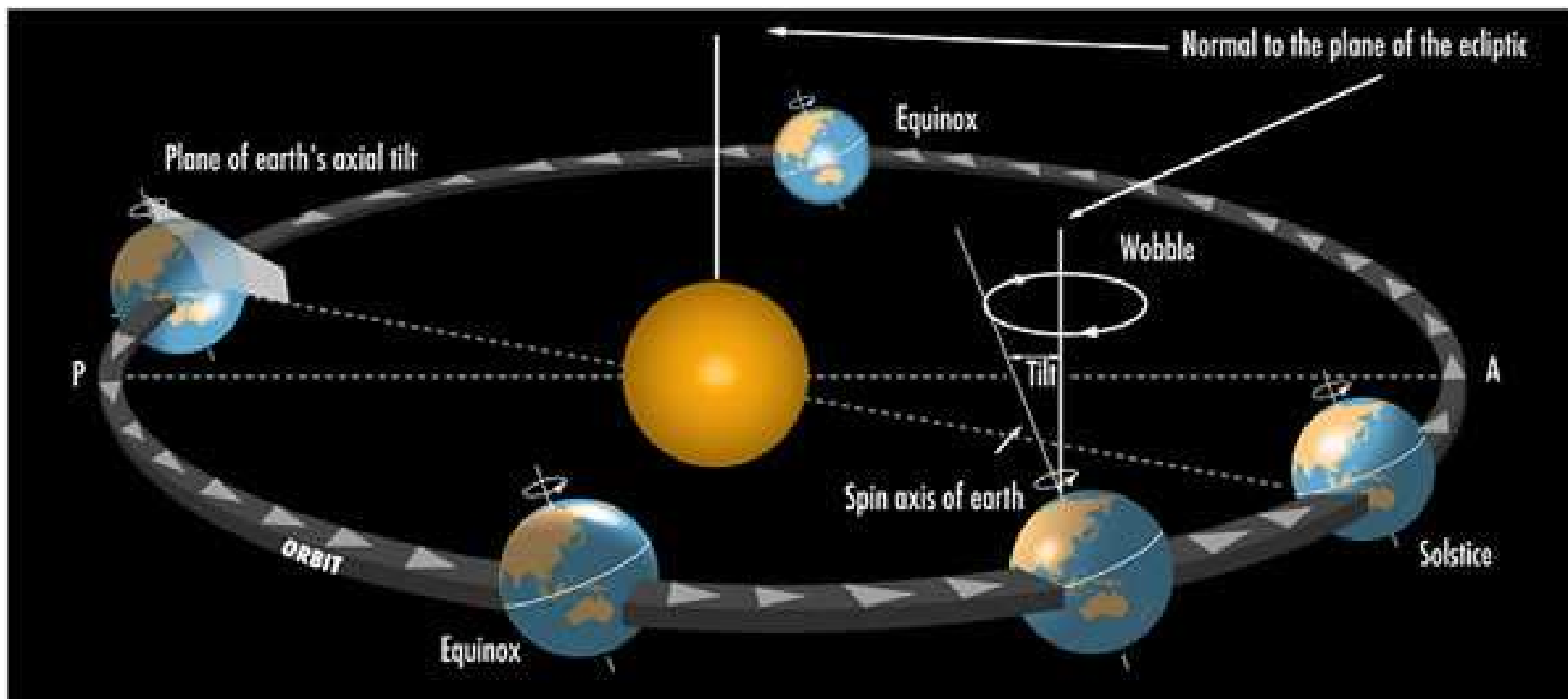
El Niño has changed ...



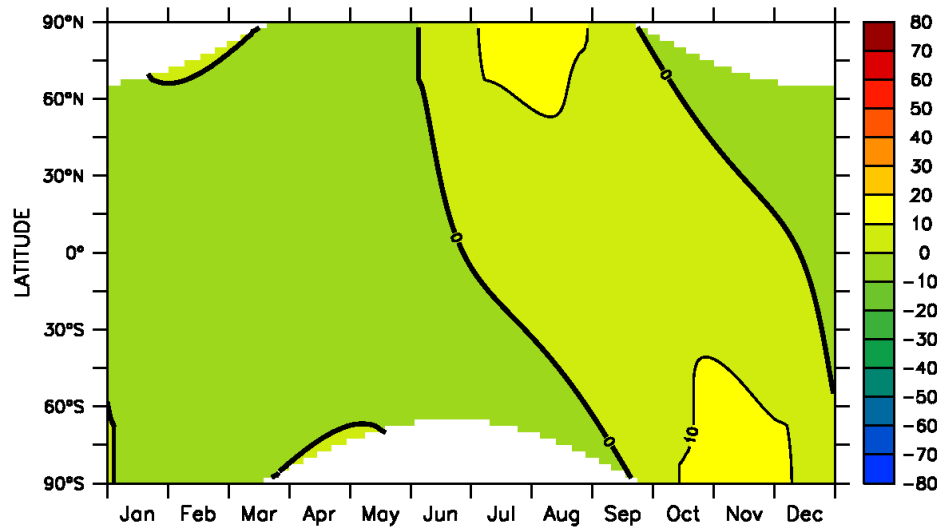
- “Modern” El Niño began 5000-7000 years ago, with only weak decadal-scale variability beforehand
- El Niño was 15-60% weaker 6000 years ago than at present
- Gradual increase in El Niño variability thereafter
- Evidence of a peak in strength around 1500 years ago

Moy et al. (2002), *Nature*

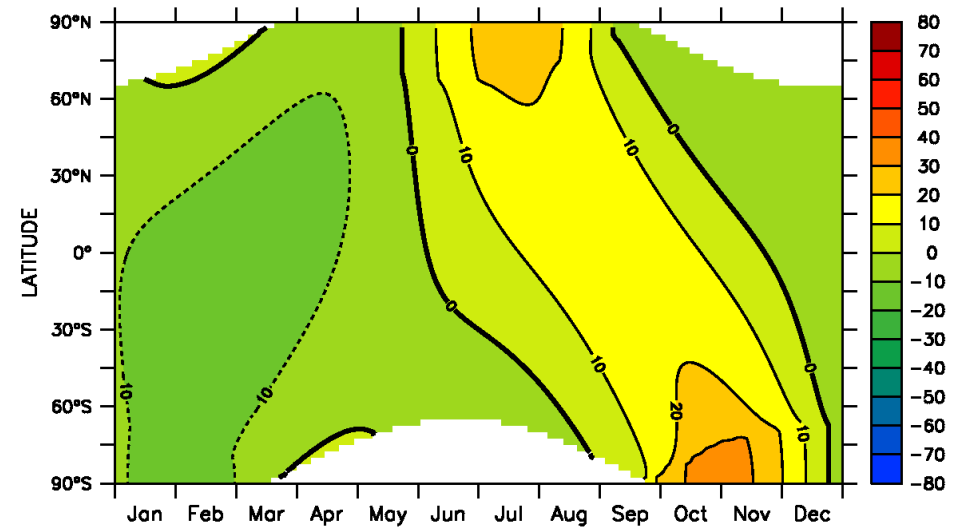
... driven by changes in the Earth's orbital geometry ...



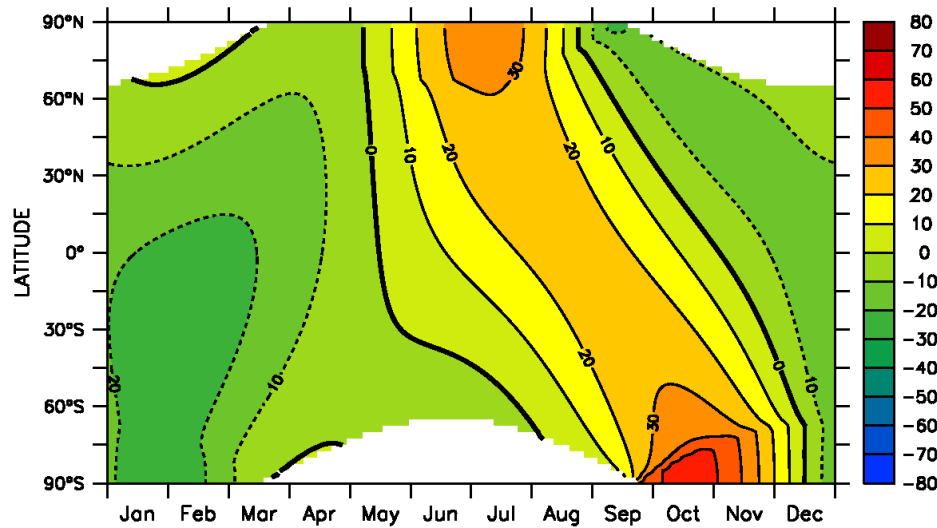
... which cause large changes in seasonal insolation



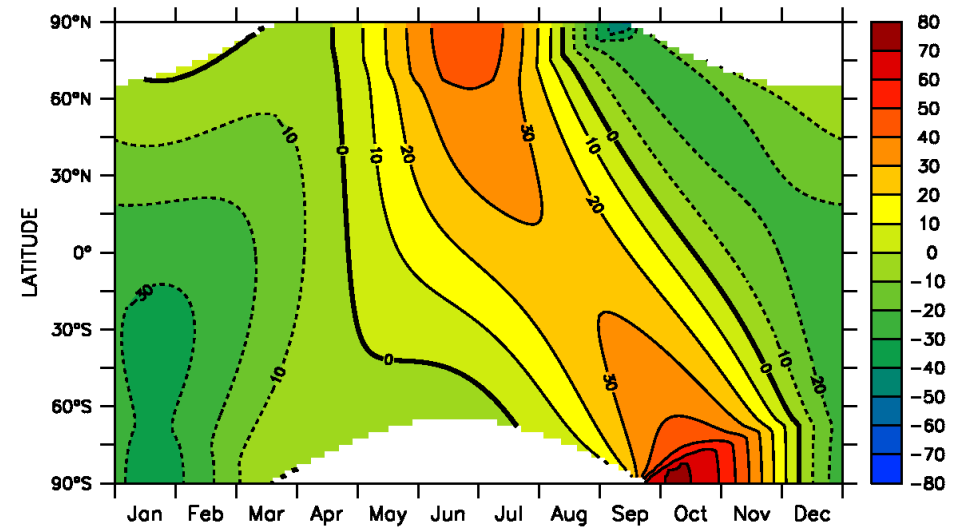
Insolation anomaly (Wm^{-2}): 2ka BP



Insolation anomaly (Wm^{-2}): 4ka BP



Insolation anomaly (Wm^{-2}): 6ka BP

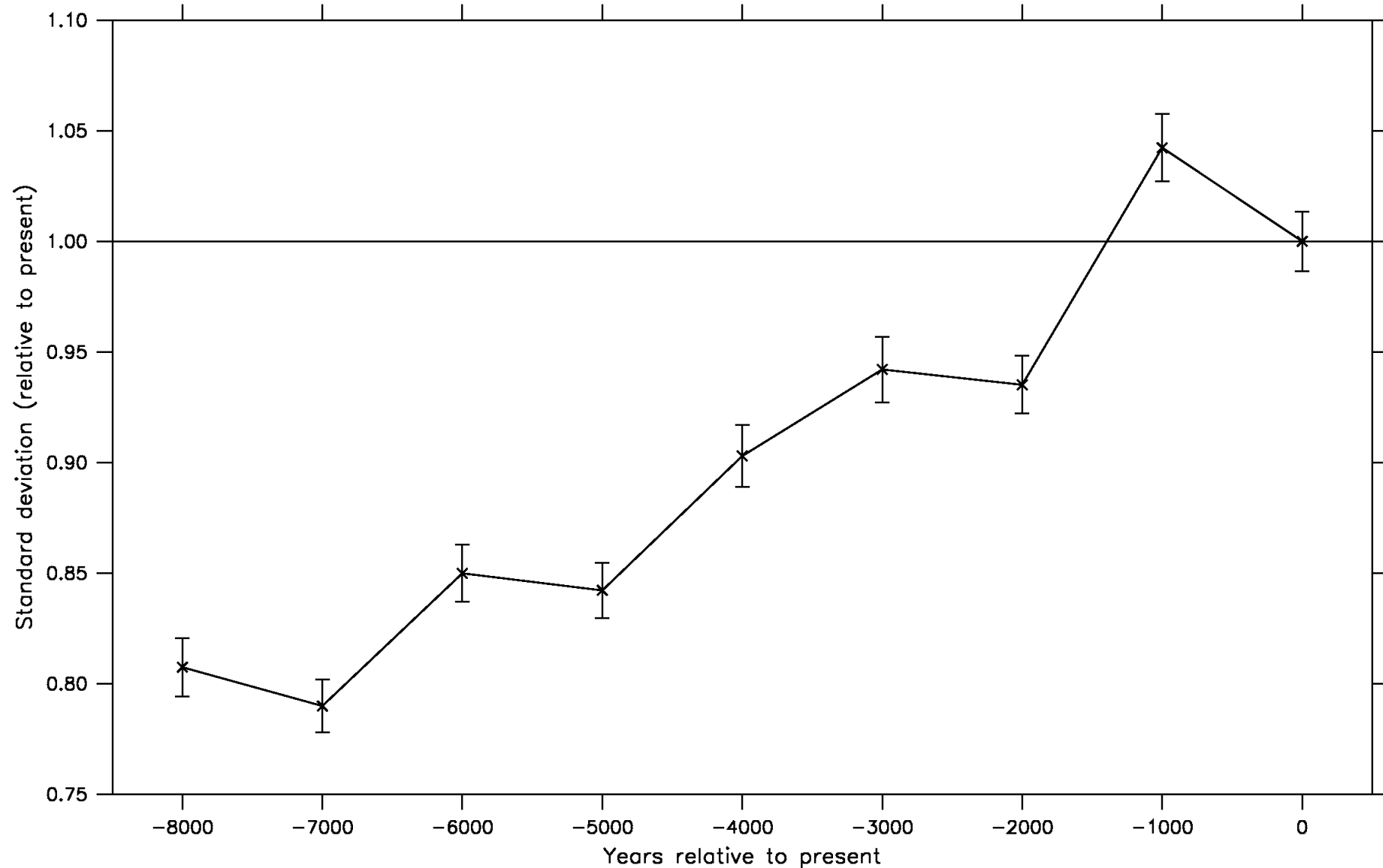


Insolation anomaly (Wm^{-2}): 8ka BP

Exploring El Niño in a climate system model

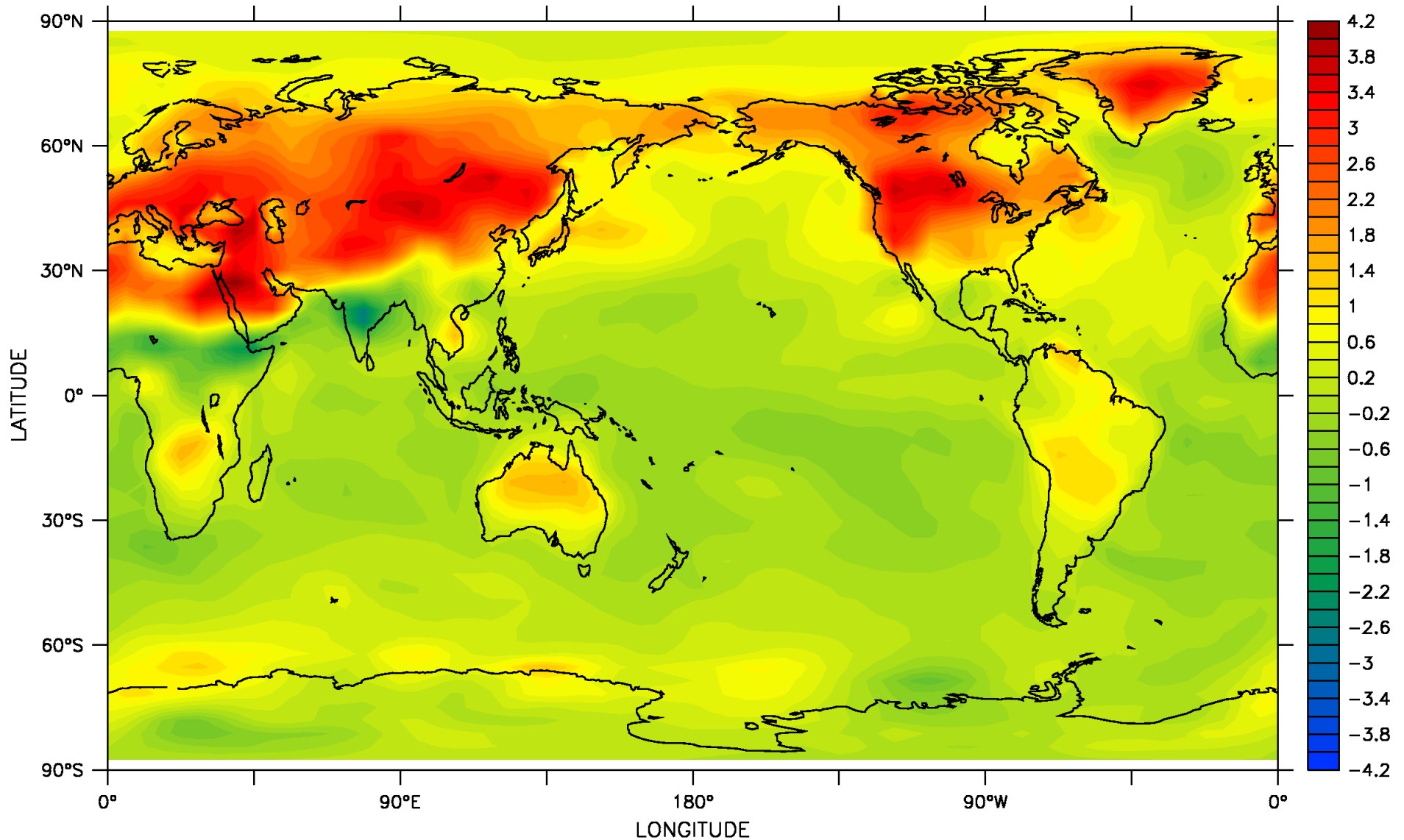
- CSIRO Mk3L climate system model:
 - 3D atmosphere ($5.6^\circ \times 3.2^\circ$, 18 vertical levels)
 - 3D ocean ($2.8^\circ \times 1.6^\circ$, 21 vertical levels)
 - Sea ice
 - Land surface
 - Can simulate 1000 years in a month
- Simulations for 8, 7, 6, 5, 4, 3, 2, 1 and 0 thousand years BP:
 - Only the Earth's orbital geometry is varied
 - Atmospheric CO₂ concentration = 280ppm
 - Solar constant = 1365 Wm^{-2}
 - Integrated for 1000 years

Simulated changes in El Niño variability



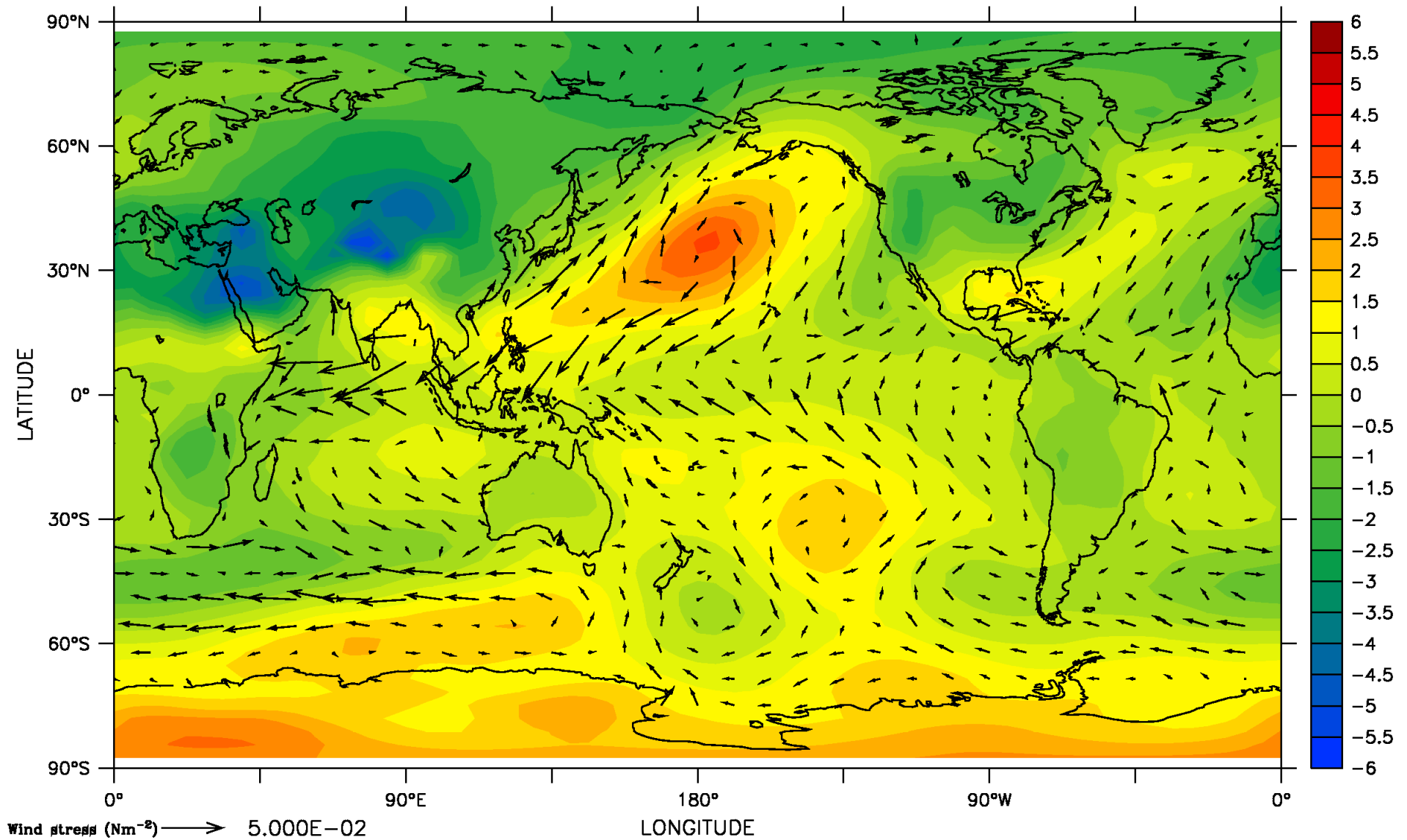
Standard deviation of monthly SSTs in central Pacific

Northern Hemisphere summers were warmer 8000 years ago ...



June–July–August surface air temperature, 8ka minus 0ka BP (°C)

... which enhanced the monsoonal circulation over Asia



June-July-August mean sea level pressure, 8ka minus 0ka BP (hPa)

Conclusions

- The study of past climates allows us to explore the links between El Niño and the global climate system.
- Using a climate system model, we have shown that changes in the Earth's orbital geometry can explain the increase in El Niño variability over the past 8000 years.
- Decreasing summer insolation over this period has resulted in a weakening of the Asian monsoon. This has reduced the stability of the background state of the tropical Pacific, making it easier for El Niño events to take place.
- However, this mechanism does not explain the apparent peak in El Niño variability 1500 years ago. Other mechanisms therefore appear to be at work.