A comparison of ocean model data and satellite observations of features affecting the growth of the NECC during the strong 1997–1998 El Niño

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Introduction

Analysis of a 1/12° run of the Nemo ocean model showed that during the growth of the strong 1982-1983 and 1997-1998 El Niños, the North Equatorial Counter Current (NECC) dominated the transport of warm water into the eastern Pacific.

The result is contentious because the standard view is that only ocean waves and currents near the Equator contribute to the El Niño.

This poster reports on comparisons made between the model results and satellite observations of sea level to check key features of the model results.

Background

A study by Evans and Webster (2014) showed that sea surface temperatures greater than 28.5°C are needed to trigger deep atmospheric convection near the Equator.

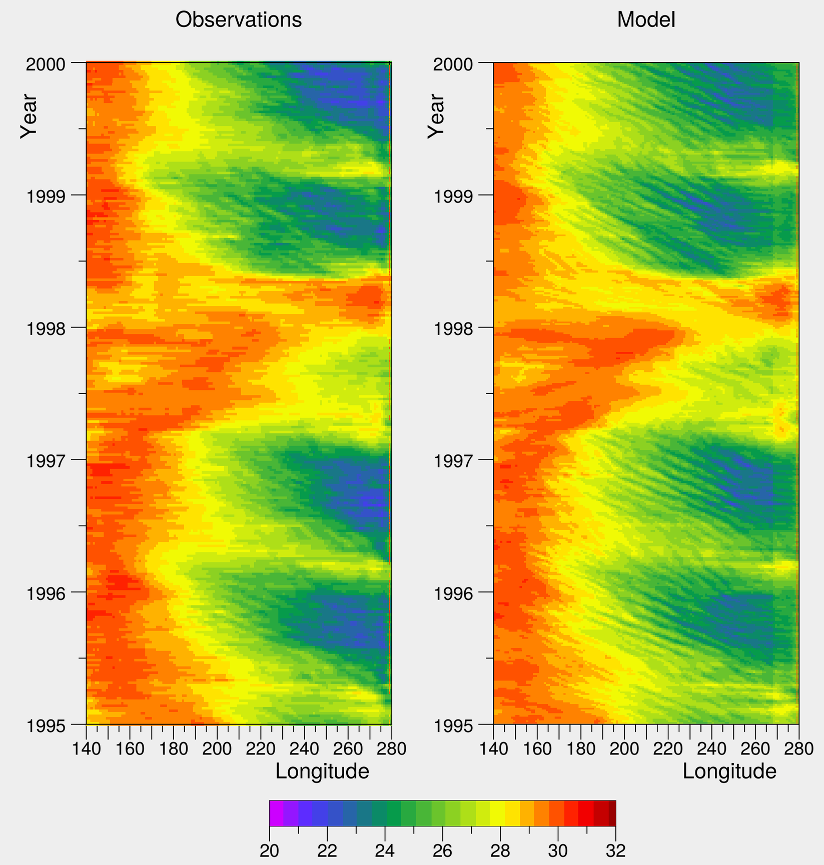
The Nemo model showed that during the growth of a strong El Niño, the NECC transported roughly four times the volume of >28.5°C water than the equatorial band. Two key physical processes were found to explain this.

1. The temperature of the NECC is usually too low to trigger deep atmospheric convection because tropical instability waves mix in cold upwelled water from the Equator. During an El Niño, the easterlies near the equator drop, upwelling stops and the instability waves die away – no longer cooling the NECC.

2. The growth of strong El Niños coincide with the second half of the year when the annual Rossby wave increases the NECC transport in the central Pacific. The wave deepens the North Equatorial Trough (NET) and may move it towards the Equator, both processes increasing the strength of the geostrophic NECC.

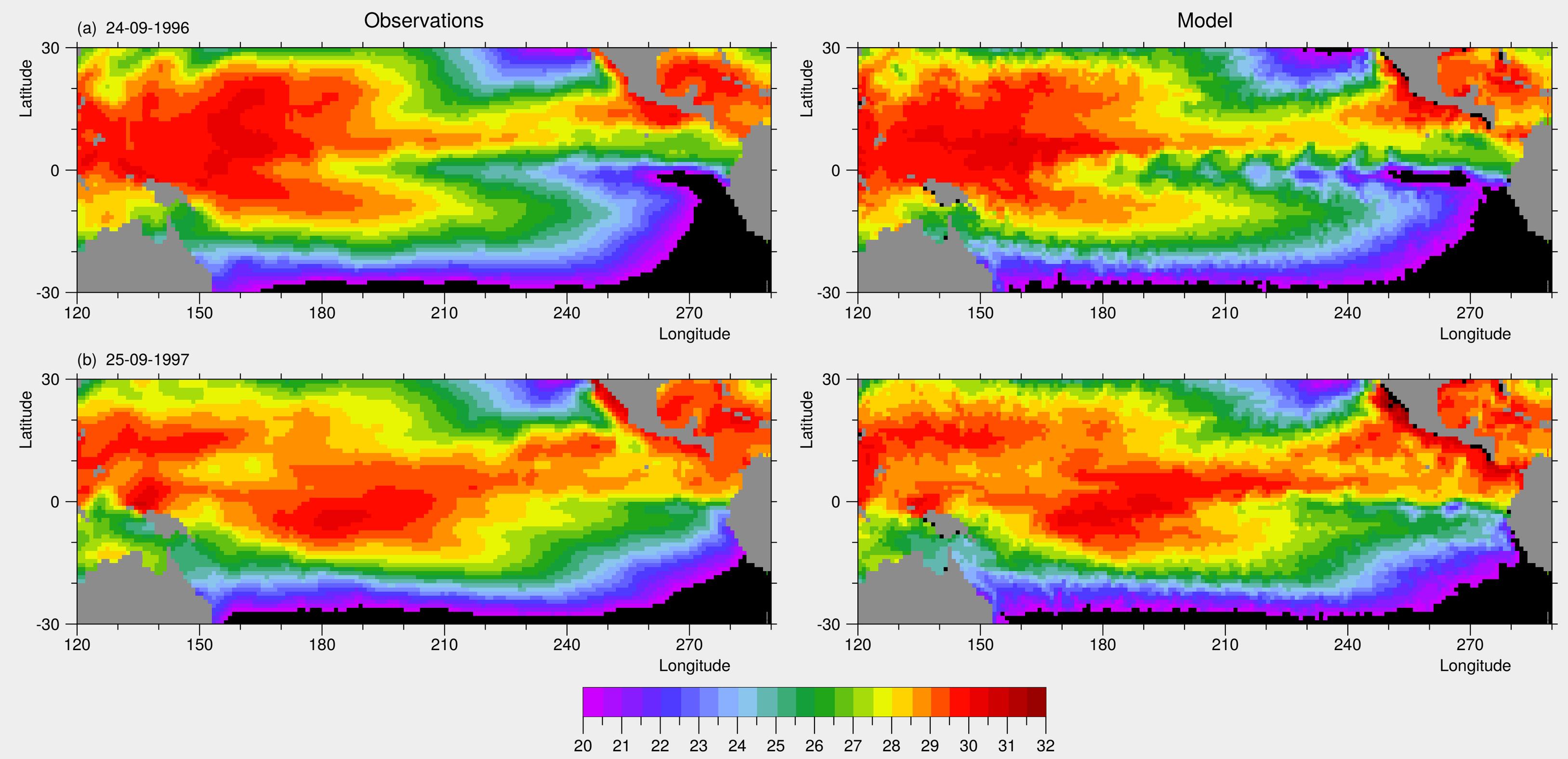
The model also highlighted a deepening of the NET in the western Pacific earlier in the year, prior to a strong El Nino. The deepening strengthens the NECC in the west, providing an increased transport of warm Western Pacific Water in time to meet the advancing annual Rossby wave. Later sea level rises on the Equator in the central Pacific also increase the strength of the NECC.

The NECC lies near the latitude the Intertropical Convergence Zone where the atmosphere is particularly unstable. As the NECC carries water >28.5°C across the Pacific it can help move deep convection further east and so increase the strength of the El Niño.



SST in the Equatorial Band

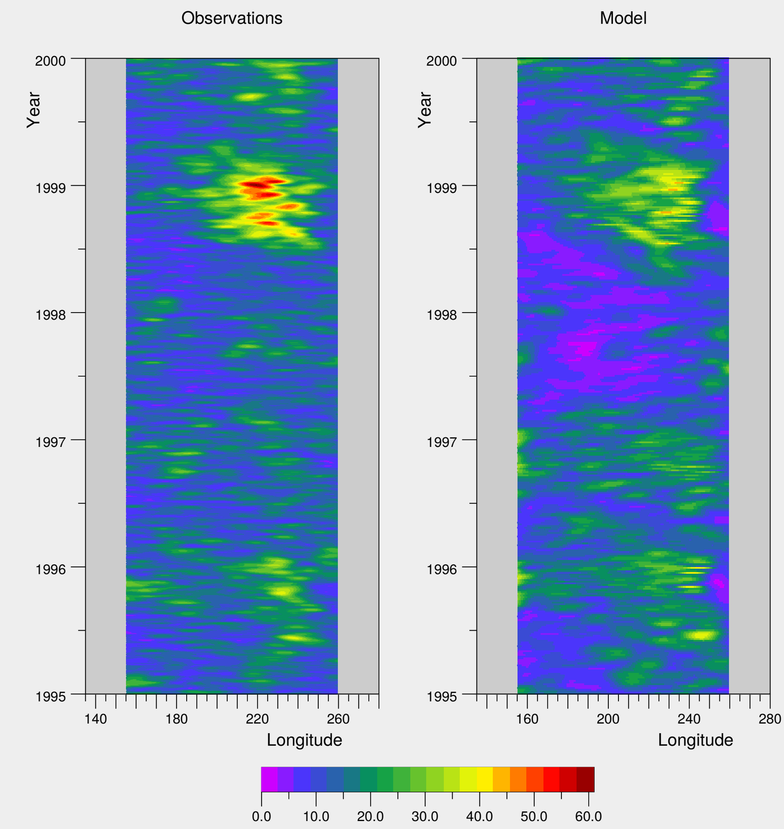
The figure compares average temperatures between 5°S and 5°N, from the model and the satellite observations. This band is the one used to define the standard Niño indices. The model closely follows the observations while the El Niño is developing during 1997.



SST in September 1996 and 1997

The figure compares model and sea surface temperatures in late September 1996, a normal year, and September 1997, during the growing El Niño. For this comparison the model data was averaged onto the same 1° geographical grid as used for the satellite observations. (Units °C).

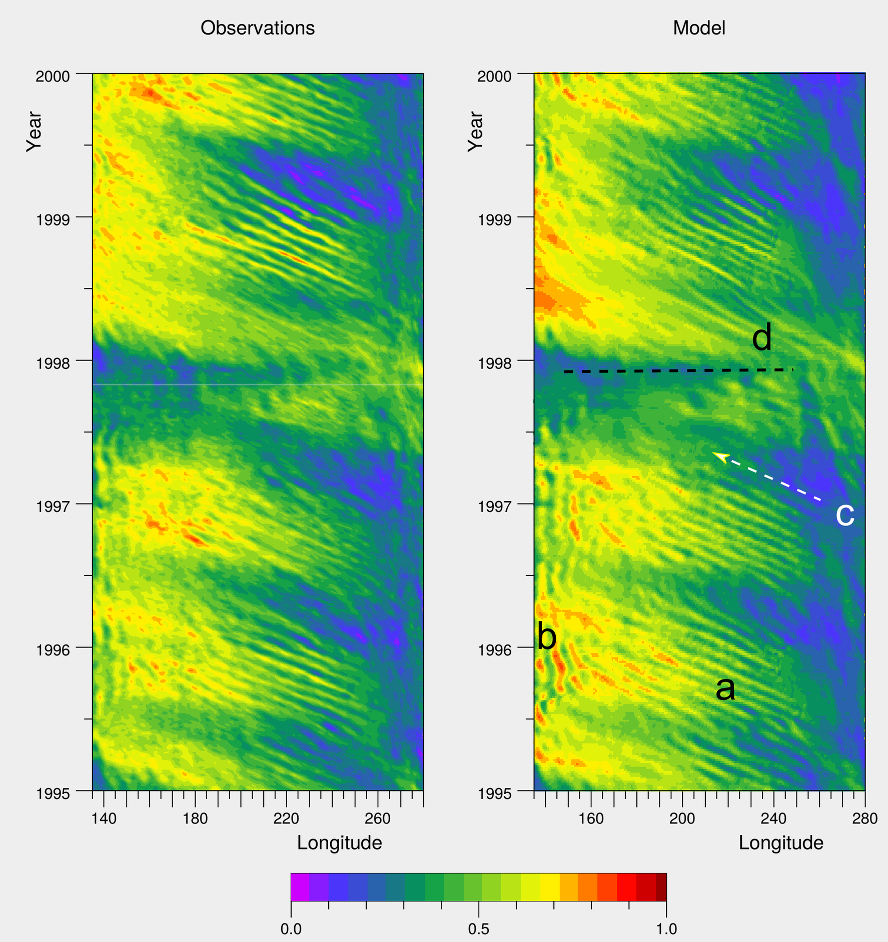
The figure shows the increased penetration of warm water into the eastern Pacific during 1997 and the reduced amplitude of tropical instability waves, although this is more obvious in the model than in the observations.



Strength of Tropical Instability Waves

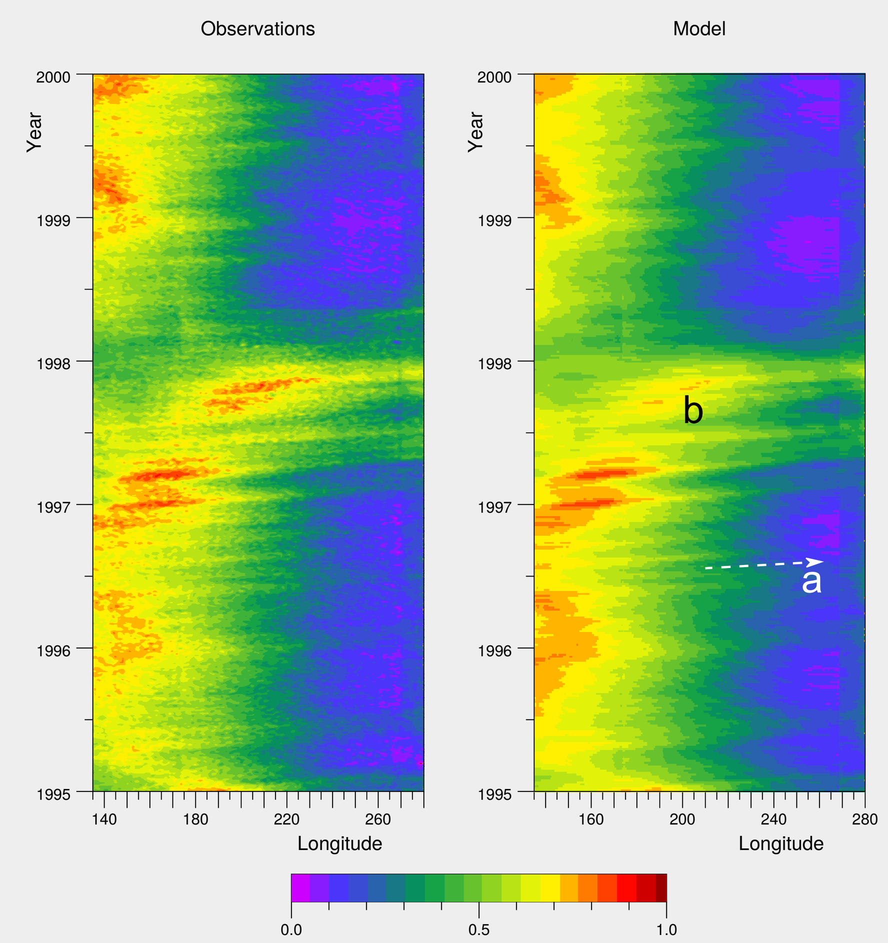
The figure compares the r.m.s. variance in the northward component of surface geostrophic velocity calculated from the model and satellite altimeter observations. (Units: cm/s).

The model shows the region of reduced variability, and by implication, reduced mixing that propagates eastward while the El Niño is developing. The observations only partly support this. This is disappointing but may be due to limited altimeter data during the period and the smoothing algorithm that had to be used.



Sea Level at 6N

The figure compares model and altimeter sea levels along 6N on the southern side of the North Equatorial Trough. Both figures show the influence of (a) tropical instability waves and (c) the annual Rossby wave. At (b) are the meanders at the start of the NECC. (d) is the sudden change in sea level that occurs at the end of the El Niño growth phase (Units: m).



Sea Level at the Equator

Sea level starts high in the west but, as the easterly winds there are replaced by westerlies it moves into the central Pacific (b). This increase helps to strengthen the NECC in the central region (Kug et al 2009).

The figure shows strong equatorial Kelvin waves in both the model and observations (a), but comparison with SST in the equatorial band shows that they do not result in high SST values (i.e.>28.5°C) in the eastern Pacific.

Conclusions

The model/observation comparisons were better than expected – with the exception of the r.m.s variance test. However, even in this case, there was no evidence of serious errors with the model.

For satellite altimetry: if the NECC is important, as the model suggests, it may be possible to predict strong El Niños six or more months in advance using sea level in the western Pacific.

Satellite Data Sources

The sea surface and satellite altimeter datasets are from:
SST: https: //doi.org/10.5067/REYN2OIMOW (Reynolds and Stokes, 1981).
SSH: ftp: //my.cmems-du.eu/Core/SEALEVEL_GLO_PHY _ L4_REP_OBSERVATIONS_008_047/dataset-duacs-rep-global-merged-allsat-phy-l4/, (Copernicus,2020).

References

Kug, Jin and An (2009) J. Climate 22,1499-1515.
Evans and Webster (2014) Aust. Meteorol. Ocean.,64, S1–S8
Webb (2018) Ocean Sci., 14, 633–660.
Webb, Coward & Snaith (2020) Ocean Sci., 16, 565–574.

Nullschool and the NECC

"earth.nullschool.net" is excellent for showing ocean currents, SST, surface winds, the ITCZ and the cold upwelled water being mixed into the NECC by tropical instability waves.