Potential Predictability of the Tropics

Comparing SST with Biogeochemical Fields

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Introduction

El Niño-Southern Oscillation (ENSO) is the largest tropical interannual mode of climate variability and it is a common feature forecasted by operational centres that deliver seasonal to multi-year forecasts. Here we explore the potential predictability of the tropical Pacific using the Climate Analysis Forecasting Ensemble (CAFE) system and compare the predictability of Sea Surface Temperature (SST) with the predictability of air-sea CO_2 flux (FCO2) and Net Primary Production (NPP) .

CAFE system

The CAFE climate model is similar to CM2.1 (Ref 1), and it uses:

- MOM5 ocean model with SIS sea ice. The grid is tri-polar with nominal resolution of 1°, with extra latitudinal resolution in the tropics (0.33° at the equator) and in the Southern Ocean (0.25° at 75°S). Subgrid processes are adopted from CM2.1, including neutral physics (Redi diffusivity and Gent-McWilliams skew diffusion), Brian-Lewis vertical mixing profile, Lagrangian friction scheme and a K-profile parameterisation for the mixed layer calculation.
- AM2 atmosphere model with resolution of 2° in latitude and 2.5° longitude, and 24 hybrid (sigma-pressure or terrain following pressure) vertical levels.
- LM2 land model which is on the same horizontal grid as AM2.

The climate model is run for 500 years (Ref 2) and the climate displays significant multi-decadal variability as demonstrated by the change in NINO3.4 variability over the simulated period (Fig. 1).

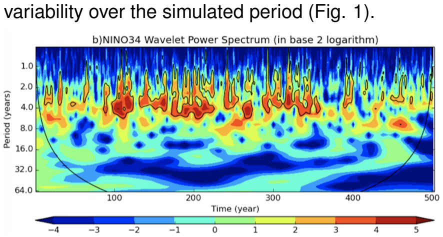

Figure 1: NINO3.4 Wavelet power spectrum as a function of the year of the climate simulation

Forecast Simulations

An ensemble forecast of 10 members is made on January 1 for every fifteenth year from model years 305 to 455 (12 forecasts). The initial climate state for the forecast is generated by adding random perturbations (less than 0.001°C) to the SST in the tropics (20°S to 20°N) to the true climate state.

Predictability

NINO3.4

There is significant predictability (r $>$0.5) out to 24 months (Fig. 2).

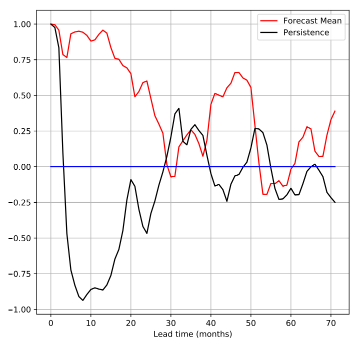

Figure 2: NINO3.4 Anomaly Correlation Coefficient

SST

At both 12 and 24 month lead times most of the tropical Pacific displays significant predictability (Fig. 3).

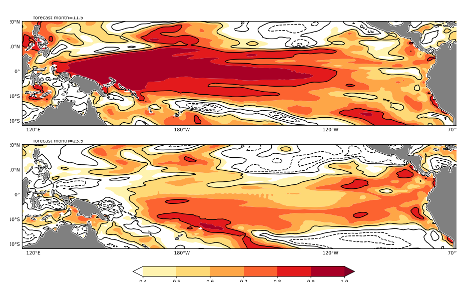

Figure 3: SST anomaly correlation coefficient for monthly forecasts at 12-month (top) and 24-month (bottom) lead times.

Air-Sea CO_2 Flux

The CO_2 flux displays significant predictability with the region of predictability moving to the west with lead time (Fig. 4).

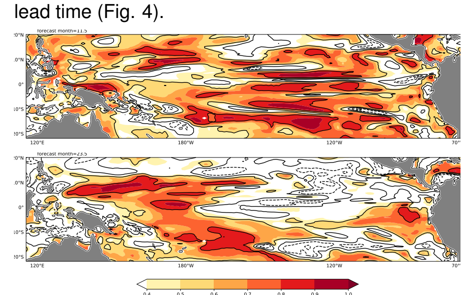

Figure 4: FCO2 anomaly correlation coefficient for monthly forecasts at 12-month (top) and 24-month (bottom) lead times

Net Primary Production

NPP displays patches of predictability (Fig. 5), which change with lead time.

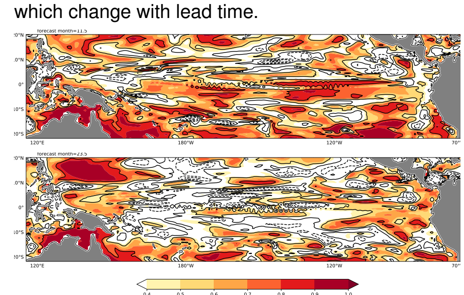

Figure 5: NPP anomaly correlation coefficient for monthly forecasts at 12-month (top) and 24-month (bottom) lead times

Summary

- Predictability is greatest for SST
- FCO2 has comparable predictability to SST but FCO2 shows a prominent shift in predictability to the west with longer lead times.
- In contrast to previous work (Ref. 3), NPP shows less predictability than SST. Perhaps NPP predictability is sensitive to how biological processes are parameterised.
- Greater predictability of FCO2 than NPP suggests that FCO2 is more sensitive to physical variability than biological variability.
- Additional forecasts are needed to isolate the cause of the poor NPP predictability

FOR FURTHER INFORMATION
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REFERENCES
1. Wittenberg, A. T. et al., Journal of Climate, 19(5), 2006.
2, O'Kane, et al., Journal of Climate, revised, 2018.
3, Seferian, R. et al., PNAS, 15, 2013.

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