Pacific Ocean Variability in an ACCESS $1/4^{\circ}$-ocean Coupled Model

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COSIMA Meeting, Hobart
26th May 2016

1. **Past Work: Tropical Instability Waves and Mixing**
2. **Future Work: Pacific Ocean Variability**
3. $1/4^{\circ}$**-ocean ACCESS Coupled Model: Some Initial Analysis**

Outline

1. Past Work: Tropical Instability Waves and Mixing
2. Future Work: Pacific Ocean Variability
3. $1/4^\circ$-ocean ACCESS Coupled Model: Some Initial Analysis

ROMS Modelling of Tropical Instability Waves (TIWs)

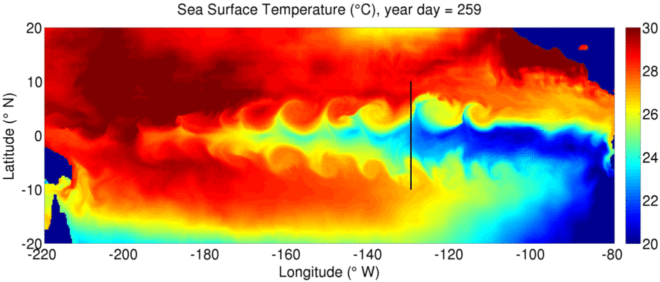

Figure: TIWs propagating along the cold tongue in a $1/4^{\circ}$ ROMS model of the tropical Pacific

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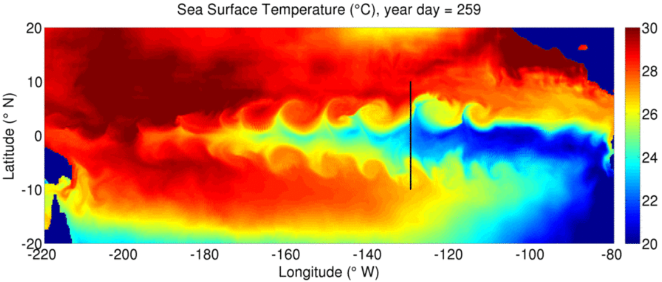


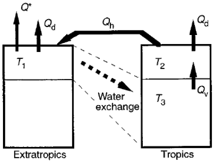
Figure: TIWs propagating along the cold tongue in a 1/4° ROMS model of the tropical Pacific

TIWs play an important role in the SST budget (both lateral and vertical fluxes).
Graham (2014) [1]: TIW eddy heating 37% larger in a 1/4° vs. 1° NEMO simulation. ENSO state dependent: 74% larger during La Nina/Neutral conditions.

Outline

What role does the ocean play in decadal variability in the Pacific?

- North Pacific Rossby waves
- Gyre and WBC anomalous advection, non-eddying and eddying gyre modes
- Meridional overturning: Subtropical cell variability



Proposed experiments with both 1° and 1/4°-ocean ACCESS CMs:

- Partial coupling: SST pacemaker in North Pacific, how does this constrain tropical variability?
- Partial blocking:
  1) Remove oceanic tunnel between extratropics and tropics.
  2) Remove the mid-latitude Rossby wave pathways?

What role does the eddy-driven circulation play in the tropics?

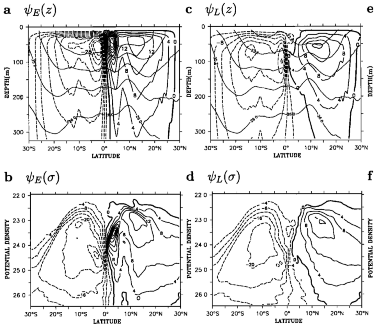


Figure: (left) Mean and (right) residual overturning streamfunctions in the tropical Pacific. From Hazeleger et. al. (2001) [2]

- TIWs are well-resolved at $1/4^{\circ}$, but not at 1°.
- TIWs are assymmetric w.r.t. hemisphere and ENSO events.

Need for accumulation of sub-monthly eddy fluxes.

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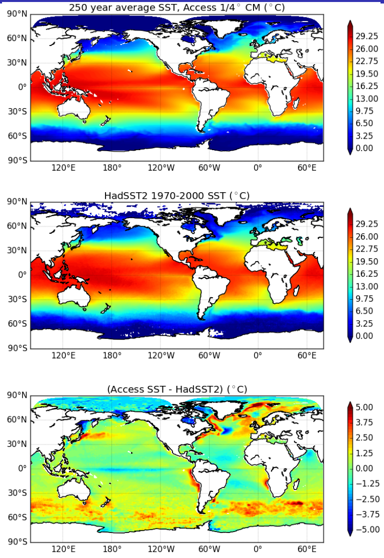


Figure: Comparison of ACCESS CM and HadSST2 mean SST

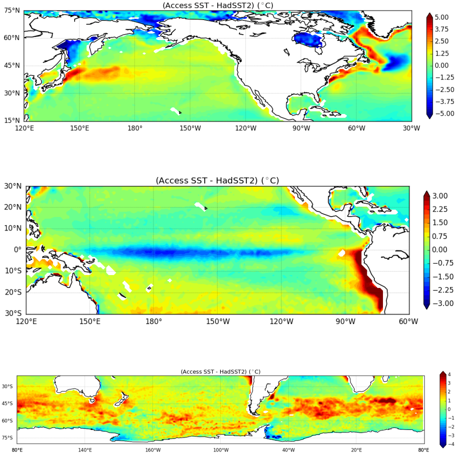


Figure: Focus on key regions

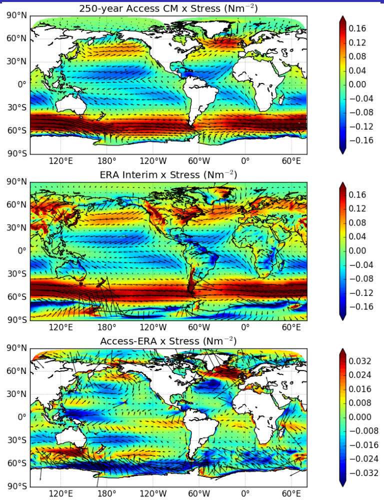


Figure: Comparison of ACCESS CM and ERA Interim wind stresses

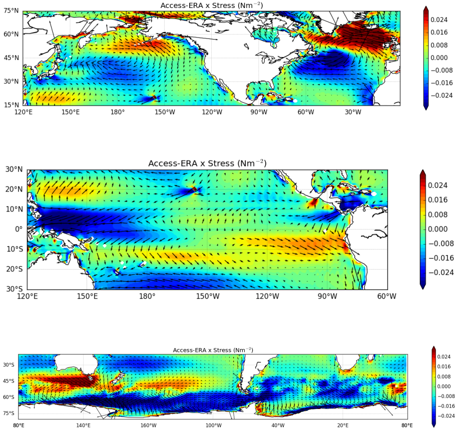


Figure: Focus on key regions

ACCESS $1/4°$ Interannual Variability: ENSO

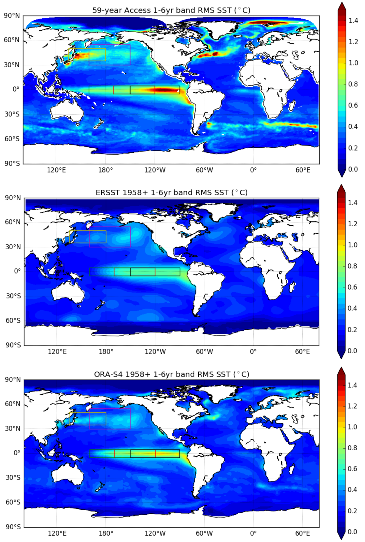
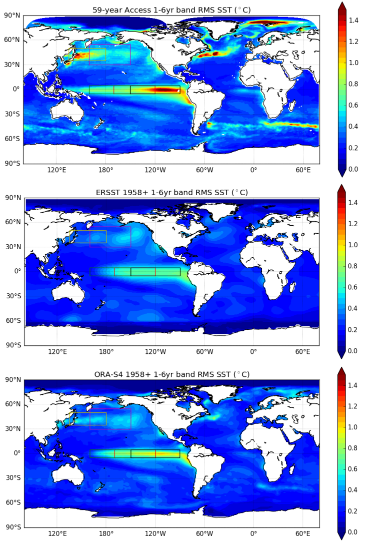
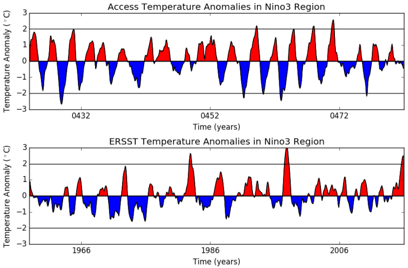


Figure: 1-6yr RMS Variability





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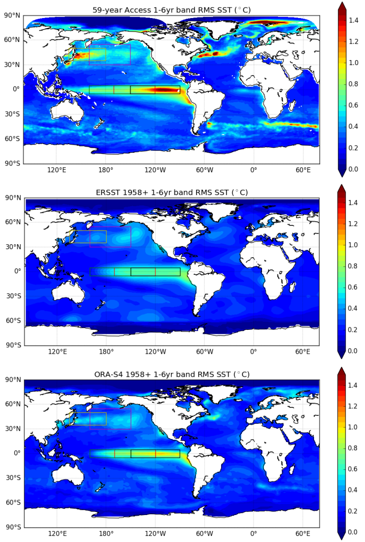

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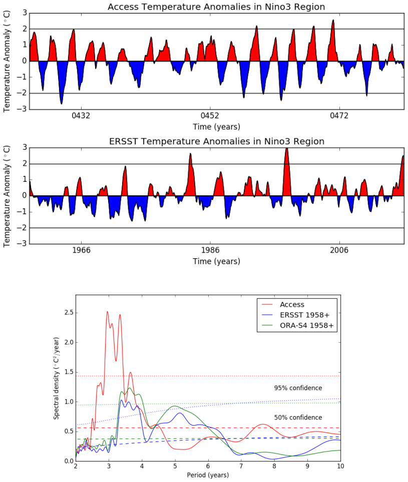


Figure: (top) Nino 3 Eastern Pacific index and (bottom) power spectra

ACCESS $1/4^{\circ}$ Interannual Variability: ENSO

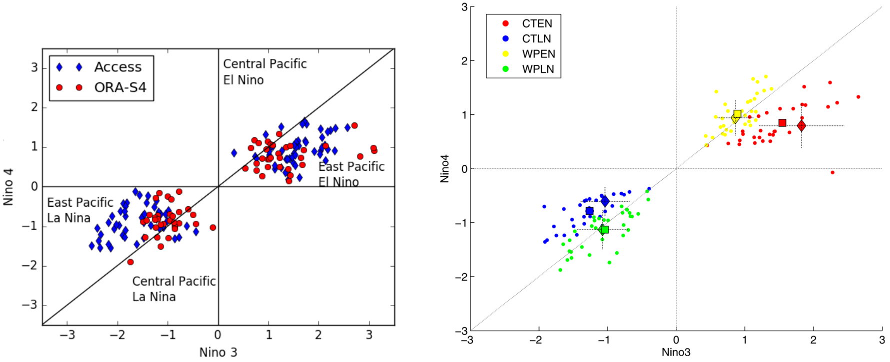


Figure: (left) Nino 3 (East Pacific) vs. Nino 4 (Central Pacific) DJF anomalies for identified La Nina and El Nino events. (right) Similar figure from CMIP5 simulations (Taschetto et. al. (2014)) [4].

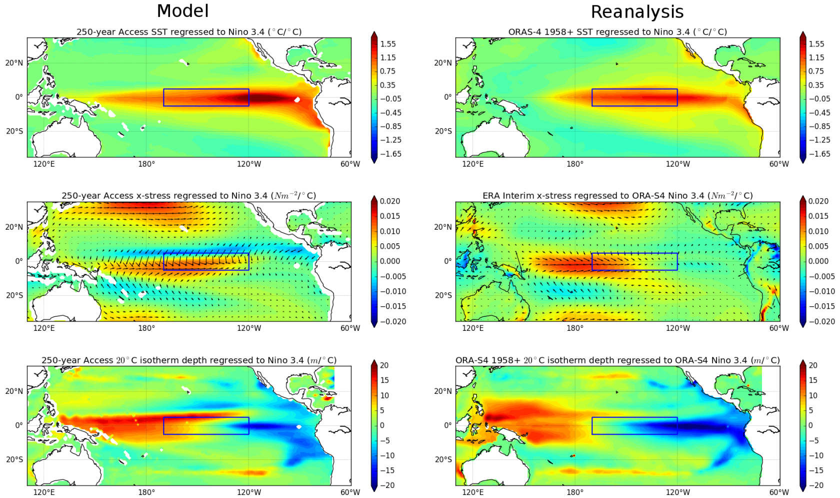


Figure: Regressions of (top) SST, (middle) wind stress and (bottom) 20°C isotherm depth anomalies onto onto Nino 3.4

ACCESS $1/4^\circ$ Interannual Variability: El Nino composites

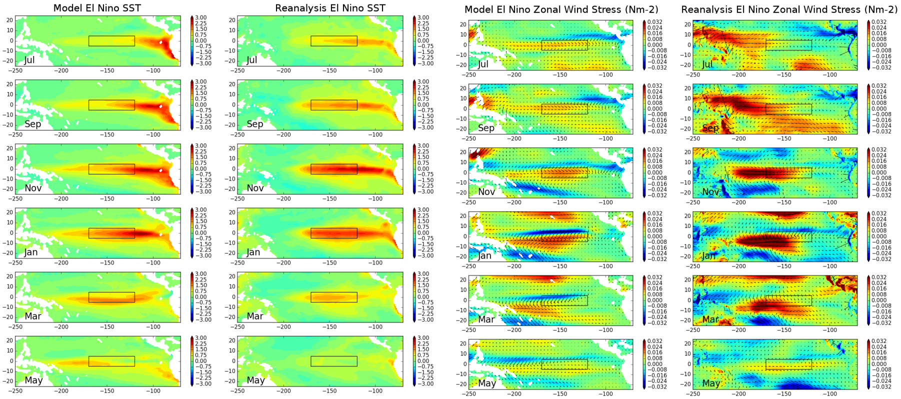


Figure: (left) SST and (right) τ_x anomaly composites for El Nino.

ACCESS $1/4^\circ$ Interannual Variability: La Nina composites

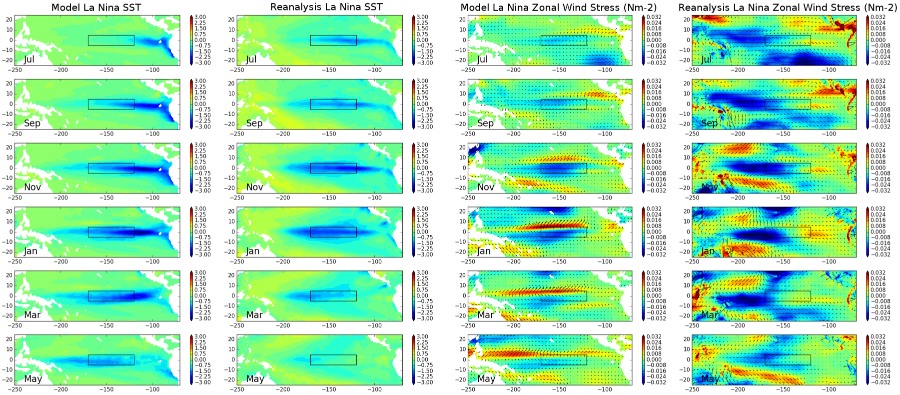


Figure: (left) SST and (right) τ_x anomaly composites for La Nina.

ACCESS $1/4^{\circ}$ Decadal Variability

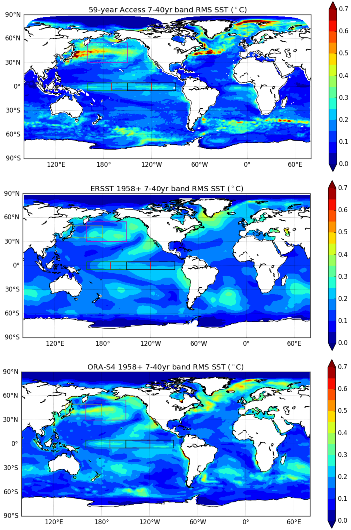
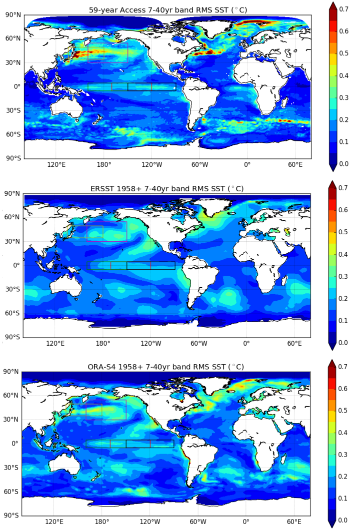


Figure: 7-40yr band-passed RMS Variability



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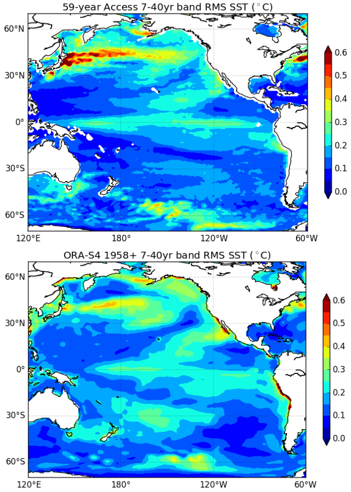

Figure: Pacific Sector ACCESS (top) vs. ORA-S4 reanalysis (bottom)

ACCESS $1/4^\circ$ Decadal Variability: PDO

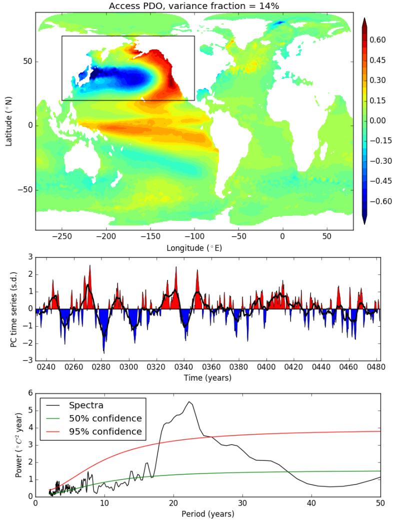

Figure: ACCESS 250-year PDO

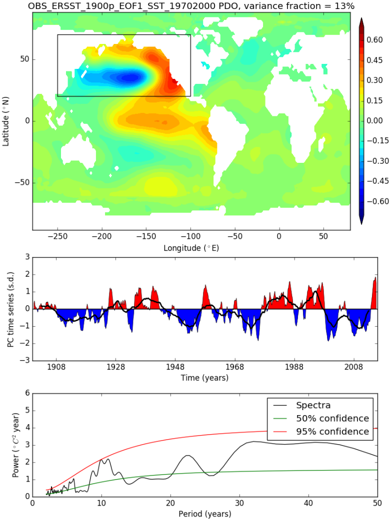

Figure: ERSST 1900+ PDO

ACCESS $1/4^{\circ}$ Decadal Variability: IPO

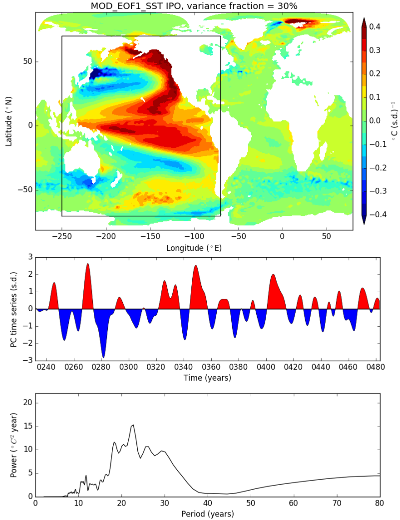

Figure: ACCESS 250-year IPO

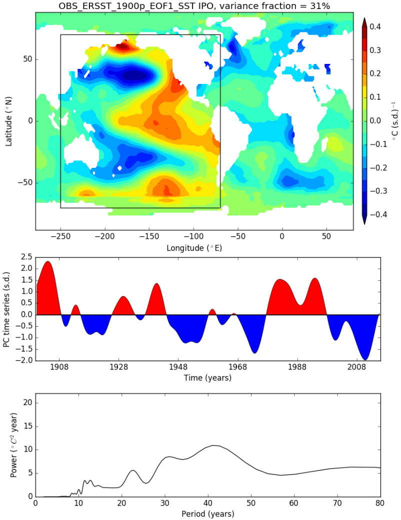

Figure: ERSST 1854+ IPO

IPO tripole index of Henley et. al. (2015) [3].

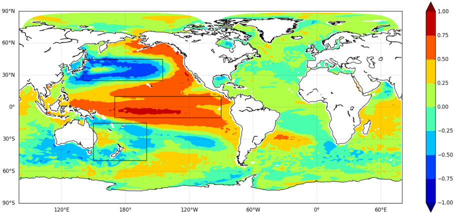

Figure: ACCESS 250-year correlation between SST and IPO tripole index.

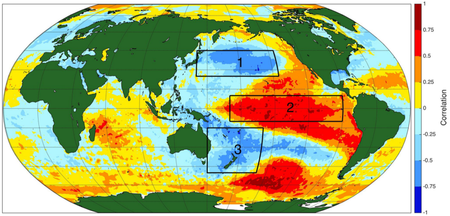

Figure: Correlation between IPO tripole index and HadISST2 (from Henley et. al. (2015)).

ACCESS $1/4^\circ$ Decadal Variability: Meridional Overturning

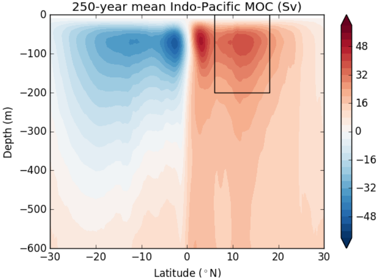

Figure: 250-year eulerian mean meridional overturning streamfunction in the Indo-Pacific.

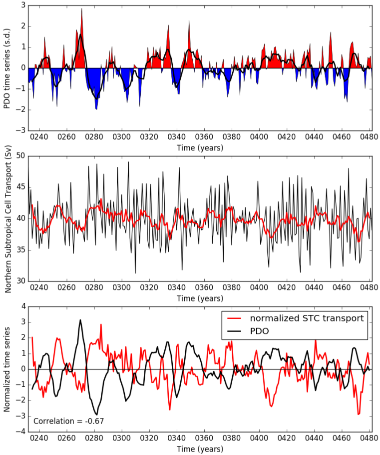

Figure: (top) PDO time series. (middle) Northern subtropical cell transport. (bottom) 6-year rolling-mean normalized time series.

Summary of initial analysis of $1/4^{\circ}$-ocean coupled ACCESS

- Mean SST biases:
  - Western boundary currents ($3-4^{\circ}$C too warm)
  - Eastern upwelling regions ($3-5^{\circ}$C too warm)
  - Southern ocean ($2-3^{\circ}$C too warm)
  - Western Equatorial Pacific ($1-2^{\circ}$C too cold)

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  - Too strong in the eastern Pacific
  - Too fast (2.5-4 years vs. 3-7 years)
  - Too symmetric: El Nino vs. La Nina
  - Extreme eastern Pacific La Nina's (DJF Nino 3 reaching -2.6°C). Outside observational and CMIP5 range.

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  - Extreme eastern Pacific La Nina's (DJF Nino 3 reaching -2.6°C). Outside observational and CMIP5 range.
- Pacific decadal variability is:
  - Too strong in WBC region.
  - Biased to Northern Hemisphere.

[1] T. Graham. The importance of eddy permitting model resolution for simulation of the heat budget of tropical instability waves. *Ocean Model.*, 79(0):21 – 32, 2014.

[2] W. Hazeleger, P. de Vries, and G. J. van Oldenborgh. Do tropical cells ventilate the indo-pacific equatorial thermocline? *Geophys. Res. Lett.*, 28(9):1763–1766, 2001.

[3] B. J. Henley, J. Gergis, D. J. Karoly, S. Power, J. Kennedy, and C. K. Folland. A tripole index for the interdecadal pacific oscillation. *Climate Dynamics*, 45(11-12):3077–3090, 2015.

[4] A. S. Taschetto, A. S. Gupta, N. C. Jourdain, A. Santoso, C. C. Ummenhofer, and M. H. England. Cold tongue and warm pool enso events in cmip5: Mean state and future projections. *Journal of Climate*, 27(8):2861–2885, 2014.

ACCESS $1/4^{\circ}$ Interannual Variability: Nino 3.4 Seasonality

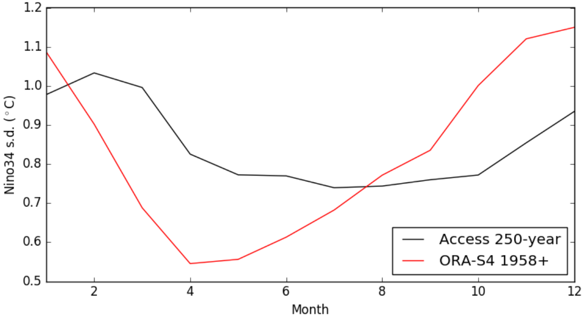


Figure: Nino 3.4 seasonality.

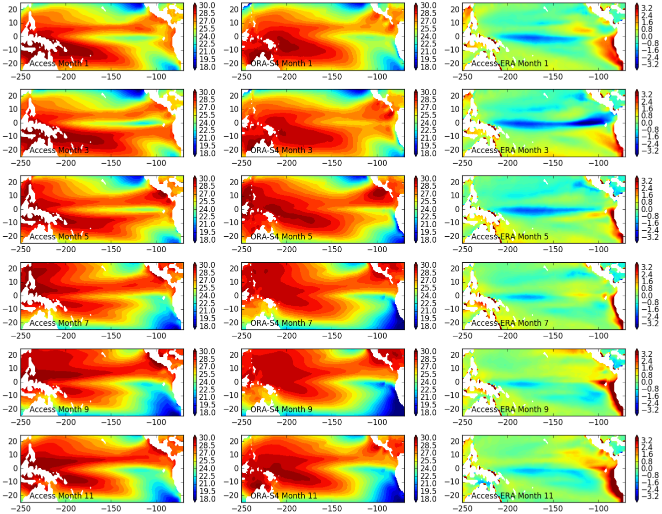


Figure: Seasonality of the mean SST.

ACCESS $1/4^\circ$ Decadal Variability: PDO

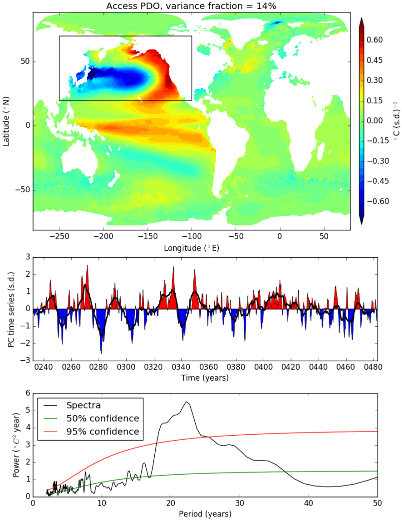


Figure: ACCESS 250-year PDO

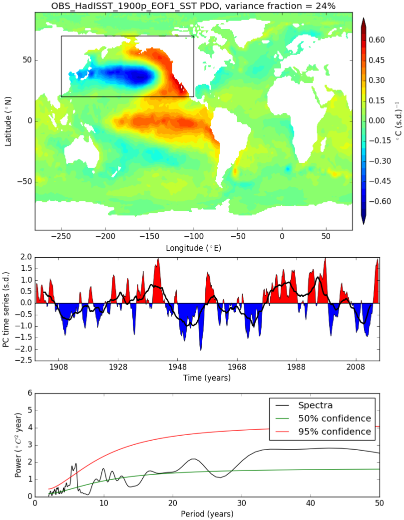
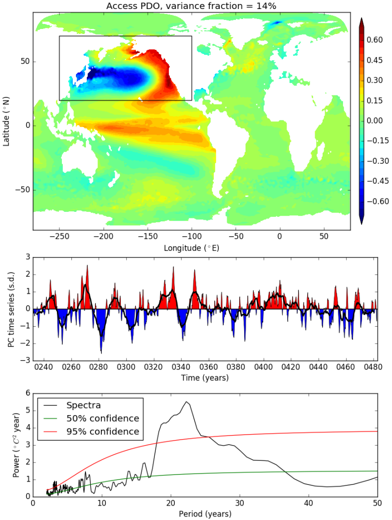


Figure: HadISST 1900+ PDO

ACCESS $1/4°$ Decadal Variability: PDO



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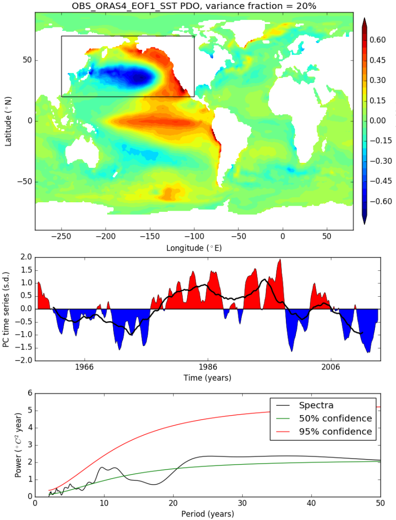

Figure: ORA-S4 1958+ PDO

ACCESS $1/4^\circ$ Decadal Variability: PDO

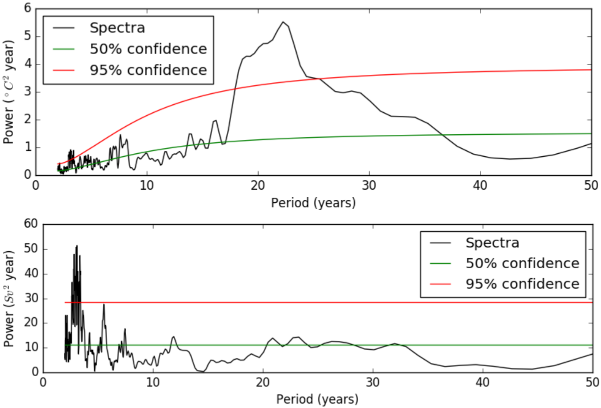

Figure: (top) ACCESS PDO Spectra (bottom) Northern Subtropical cell transport Spectra.