Influence of Ocean Variability on Land Surface Temperatures

MONASH University Science

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ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

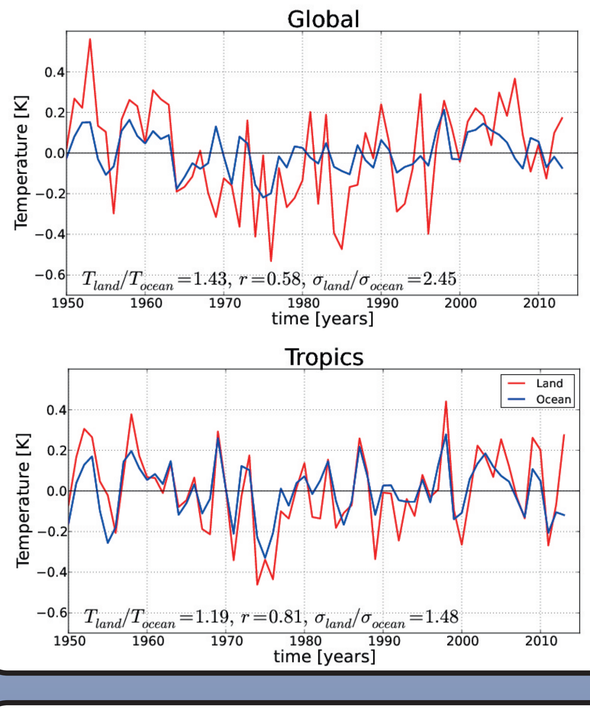


Figure 1. Obs. annual mean Tland and Tocean, detrended HadSST2 and CruTEMP4 data

Motivation

Increased interannual variability of land temperatures compared to ocean temperatures leads to a land/sea temperature contrast. In a transient climate, oceanic feedbacks increase the magnitude of warming over land - above what would be expected simply due to the lower thermal inertia of land. We investigate whether on interannual timescales similar processes can lead to ocean surface temperature variability forcing increased variability of land surface temperatures.

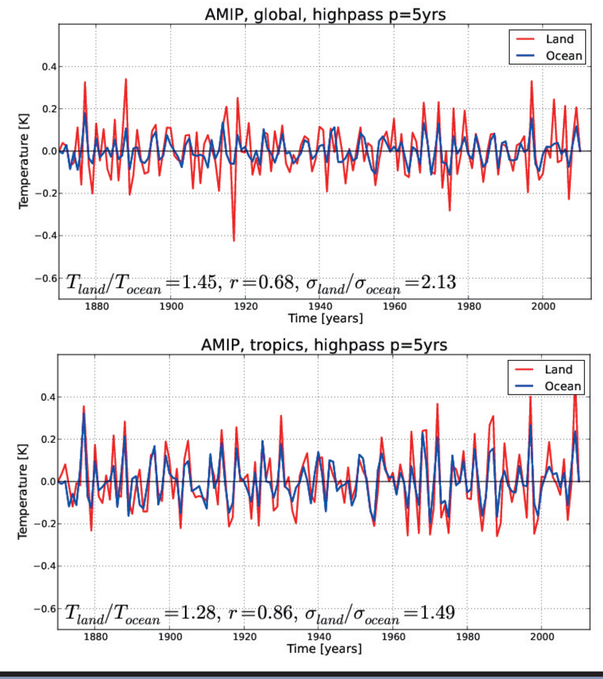
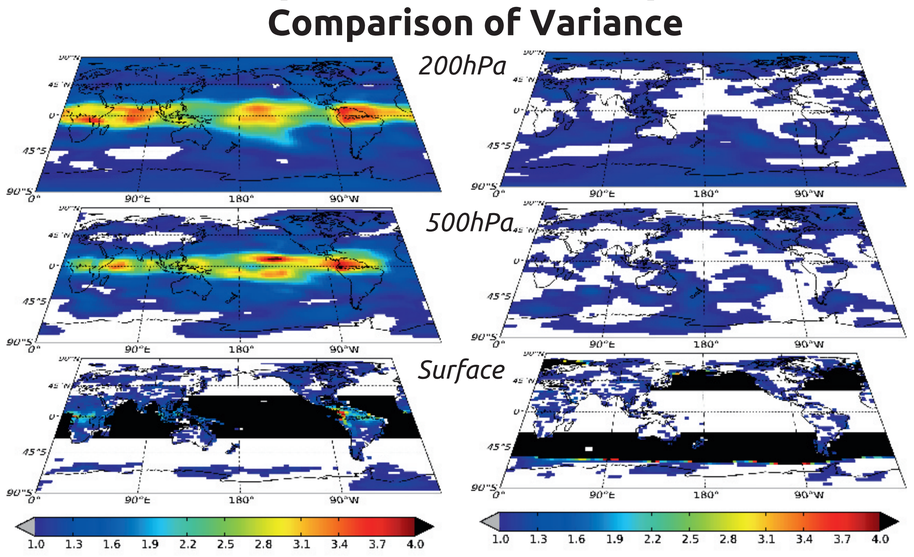


Figure 2. AMIP annual mean Tland and Tocean. Long term variability removed with 5 year highpass filter

Sensitivity experiments in Tropics and Extratropics

Comparison of Variance



Figures 4. Comparison of variance between HADISST in tropics only (left) and extratropics only (right) and climatology. At surface, 500hPa and 200hPa. Increased variability is seen throughout troposphere for SST variability in tropics but not for extratropics.

Setup:

• AMIP-like experiments using HadISST data in tropics and fixed climatological SSTs in extratropics, or varying SSTs in extratropics and fixed SSTs in tropics.

Results:

- Tropical SST variability;
  - Strongly influences land temperature variability in tropics.
  - Some influence of continental temperatures at higher latitudes.
  - Influence occurs via tropospheric temperatures.
- Extra-tropical SST variability;
  - Small impact on continental temperature variability.
  - No signal from the extra-tropical oceans in the troposphere.

Regressions with Surface Temperature

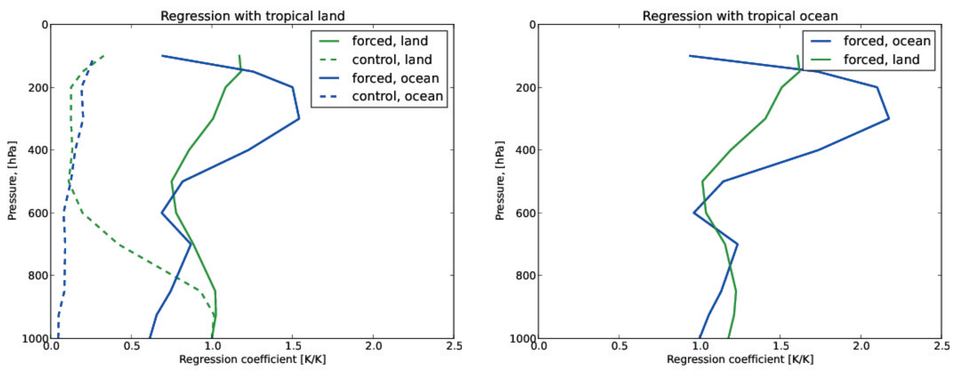


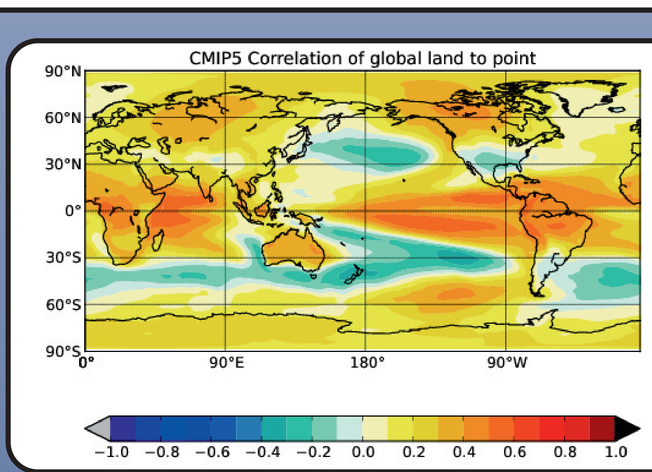
*Figure 7 Linear regression coefficients for temperature above tropical land and ocean as linear model of a) Tland (1000hPa surface) and b) Tocean, for forced run (solid) and control run (dashed). i.e. Tplv,land = a*Tsfc,land + b, and Tplv,ocean = a*Tsfc,land + b*

Control run:

- Higher level tropical temperatures over land areas are only weakly related to Tland
- Atmospheric internal Tland variability is limited to the near surface layers, not strongly related to the upper free tropospheric temperatures.

Forced run:

- Strong relationship between upper tropospheric temperatures and surface Tland variability.
- Relation of Tland with upper level temperatures over ocean areas shows a strong increase with height.



Global Land/Ocean connection

ENSO is the most significant global climate driver on interannual timescales yet the ENSO region has a lower correlation with land temperatures than adjacent regions and the other ocean basins.

Figure 3. Correlation between globally averaged Tland and Tsurf , combined annual means from 35 CMIP5 pre-industrial control runs.

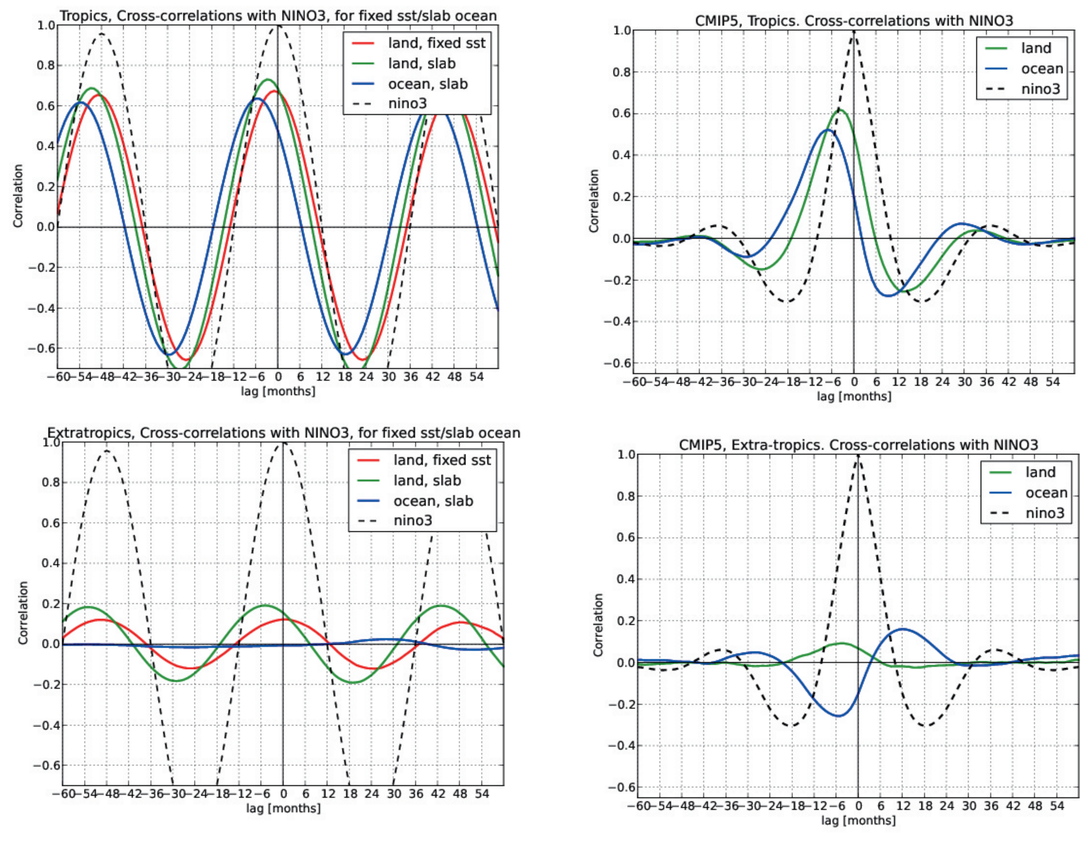
Enso-like signal in tropical Pacific

Setup:

- An ENSO-like pattern was oscillated with a period of 4 years. Outside of the tropical Pacific the SSTs were either fixed, climatological SSTs or a Slab Ocean.

Results:

- Climatological SSTs: no lag in land surface temperature response.
- Slab ocean: realistic lag in land surface temperatures.
- Land temperatures exhibited increased variability for the slab ocean run.



Figures 5. Cross-correlations between NINO3 and land/ocean, for oscillating ENSO-like pattern with fixed SSTs or slab ocean. Tropics (top) Extra-tropics (bottom).

Figures 6. Cross-correlations between the NINO3 region and land/ocean using CMIP5 models. Tropics (top) Extra-tropics (bottom).

Discussion

- SST variability in the tropical ocean regions leads to tropospheric temperatures at higher levels above the oceans with larger amplitudes due to the latent heat release by moist convection.
- The well mixed free troposphere transports the amplified SST signal over land
- The surface Tland follows the upper temperature variability, but with smaller amplitudes.
- The amplification of the SST variability is not happening over land, but is achieved locally over ocean regions by moist convection.
- This amplification leads to a land/ocean temperature contrast greater than unity for interannual variability.