Multidecadal variability in strongly eddying coupled climate models

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Intro
• Modes of multi-decadal variability influence the evolution of the global climate by altering the ocean heat uptake for decades at a time.
• Coupled climate models with low resolution ocean components, like they are used in the last IPCC report, fail to accurately represent multidecadal variability.
• High resolution ocean models are capable of simulating mesoscale eddies which affect the background state of the ocean as well as the vertical heat exchange.
• It is not trivial that short-lived eddies should influence multidecadal variability.

Approach
• We compare a high and low resolution coupled climate model to observations:
  - Observations: HadISST years 1870 - 2018
  - simulation 1: 0.1° resolution; 300 model years
  - simulation 2: 1° resolution; 565 model years

Results
• At multidecadal time scales, global mean surface temperature variability is closer to observations.
• With eddies, the ocean heat content variability is larger.

Conclusions
• Resolving mesoscale eddies alters the ocean background state which increases the variability of the global mean surface temperature & ocean heat content on multidecadal timescales.
• The representation of the observed modes of variability is improved.

Methods
Detrending: To compare model simulation results to observations, the forced signal must be estimated and removed. We estimate this forced response in the observations as the CMIP5 multivariate mean global mean surface temperature and as a linear trend in the simulations. These signals are scaled and removed at each SST grid point.

Indices: The SST indices are 13 year low-pass filtered, area averages of the detrended SST fields and are based in known modes of variability.

Regression: The SSTs are regressed on the indices: $SST = a + b \times \text{Index}$ for significance test autocorrelation and filtering has been accounted for.

Spectra: Multi-taper spectra are tested against filtered AR(1) processes.

Modes of variability
Atlantic: The Atlantic Multidecadal Oscillation (AMO) is a mode localized in the North Atlantic whose mechanism is based on thermal Rossby waves.
Pacific: The interdecadal Pacific Oscillation is a Pacific-wide mode of interdecadal variability and can be identified by the Tripole Index (TPI).
Southern Ocean: The Southern Ocean Mode (SOM) is a result of weakening and strengthening it periodically.

References