

DECADAL COUPLED VARIABILITY IN OBSERVATIONS AND MODELS

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IS THERE ANY COUPLED VARIABILITY IN MID-LATITUDES?

- mid-latitude SST anomalies are weak (0.1–0.2 deg C)
- LINEAR atmospheric response to them is very weak

NONLINEAR SENSITIVITY TO SST?? (small anomalies cause large atmospheric response)

OCEAN DYNAMICS???

- wind-driven circulation (inertial recirculations?)
- thermohaline circulation (not that nonlinear?)

CONCLUSIONS

- We found evidence for decadal-to-interdecadal variability in the North Atlantic Ocean–Atmosphere system
- The atmospheric time dependence is characterized by changes in the occurrence frequency of anomalously persistent zonal-flow regimes. These variations are correlated, at multi-year lags, with sea-surface temperature variability characterized by centers of action along the North Atlantic ocean’s western coast. This suggests that the regimes are affected, through midlatitude ocean–atmosphere interaction, by intrinsic ocean dynamics
- Accompanying modeling results suggest that interdecadal variability associated with monopolar SST anomalies in the region of Gulf Stream separation from US coast is due to nonlinear dynamics of the ocean inertial recirculations, while the decadal oscillation that involves tripolar SST pattern (Deser and Blackmon 1993) is due to variations of the oceanic thermohaline circulation

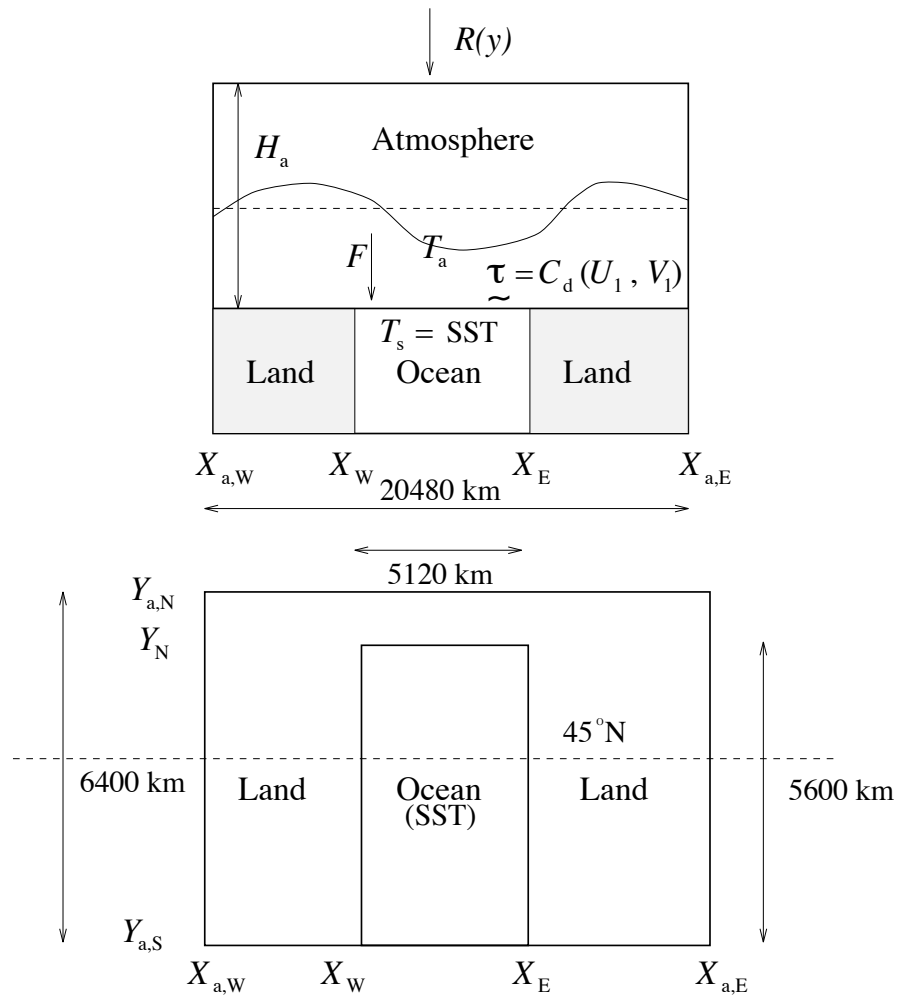


Figure 1: Coupled model geometry. Two different coupled models are used, which share a common atmospheric model, but employ different ocean model formulations.

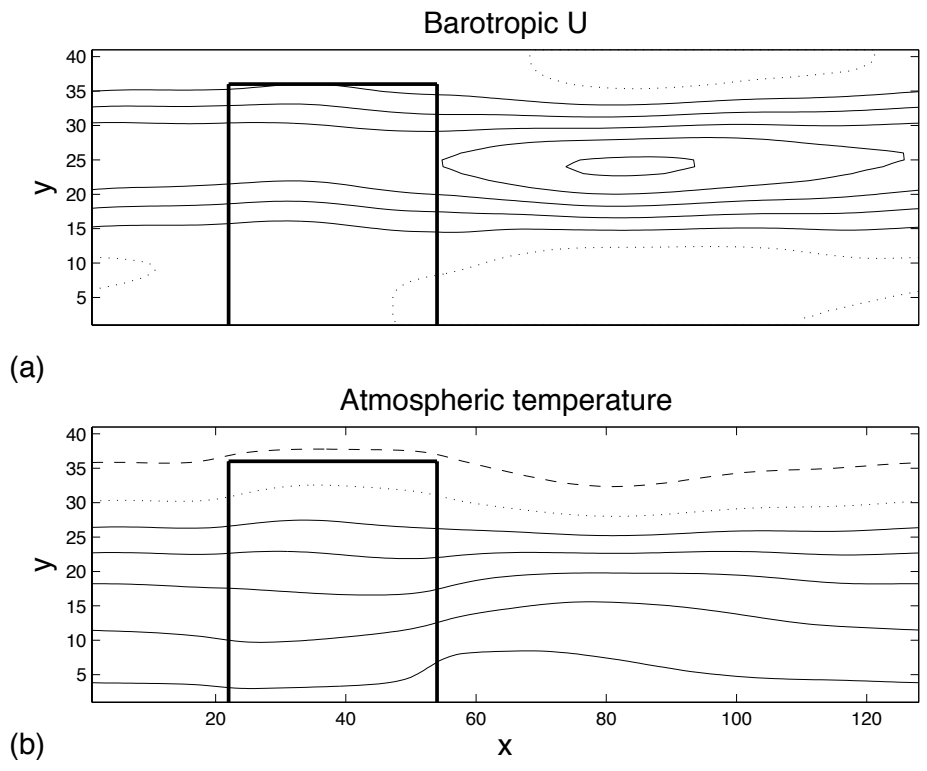


Figure 2: Typical atmospheric climatology of both coupled models

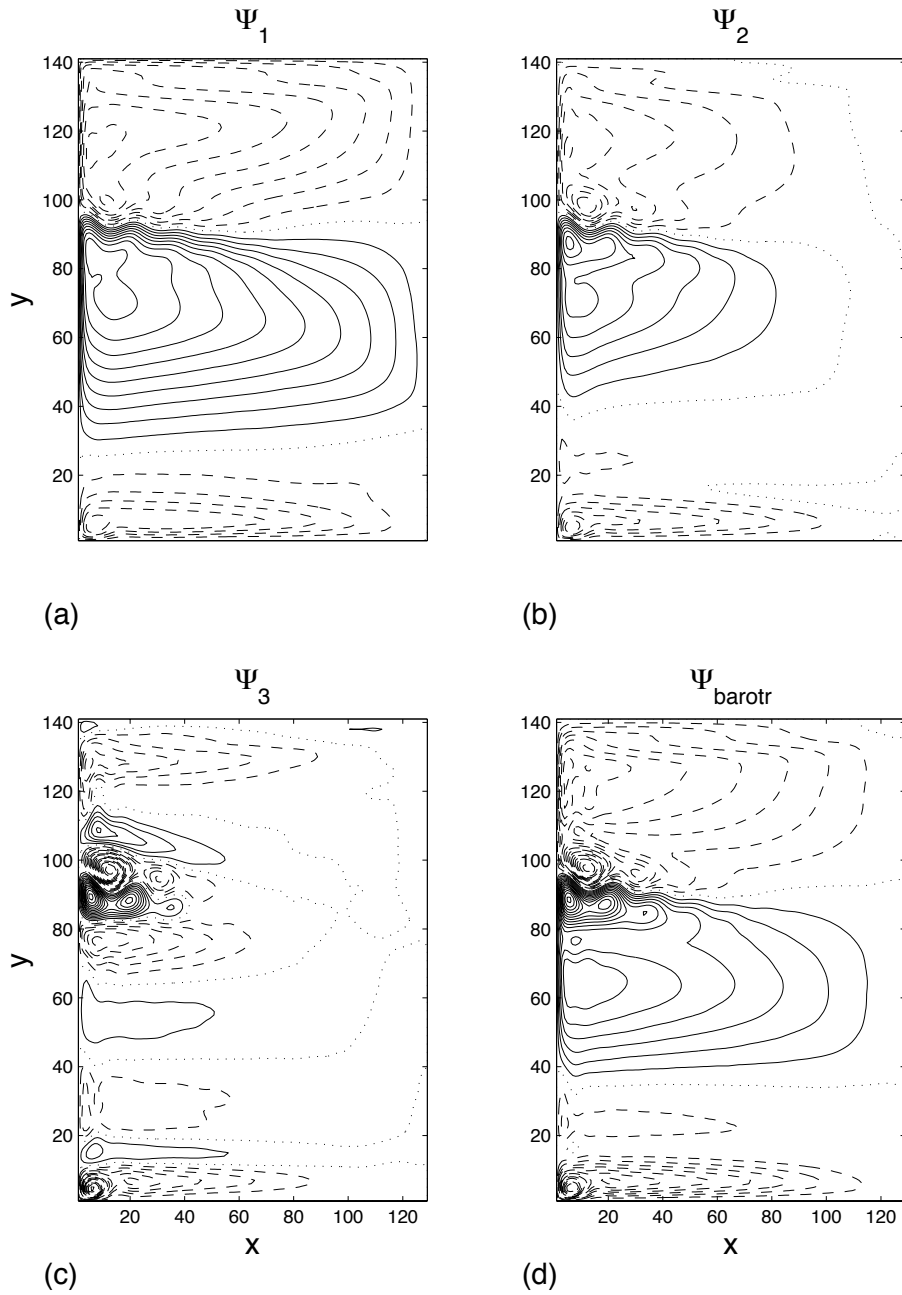


Figure 3: Climatology of a three-layer quasi-geostrophic (QG) coupled ocean. Shown are layer streamfunctions.

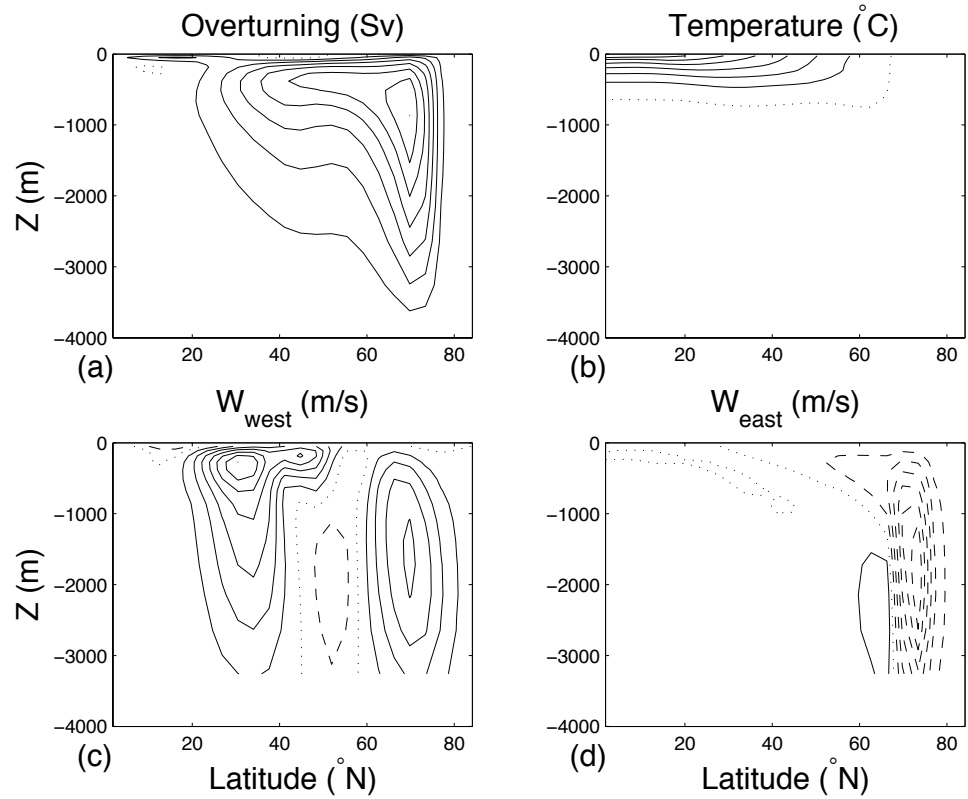


Figure 4: Climatology of a 15-level PE coupled ocean; ocean resolution is 400 km. Shown are meridional overturning streamfunction, zonally averaged temperature, and vertical velocity at eastern and western ocean boundaries.

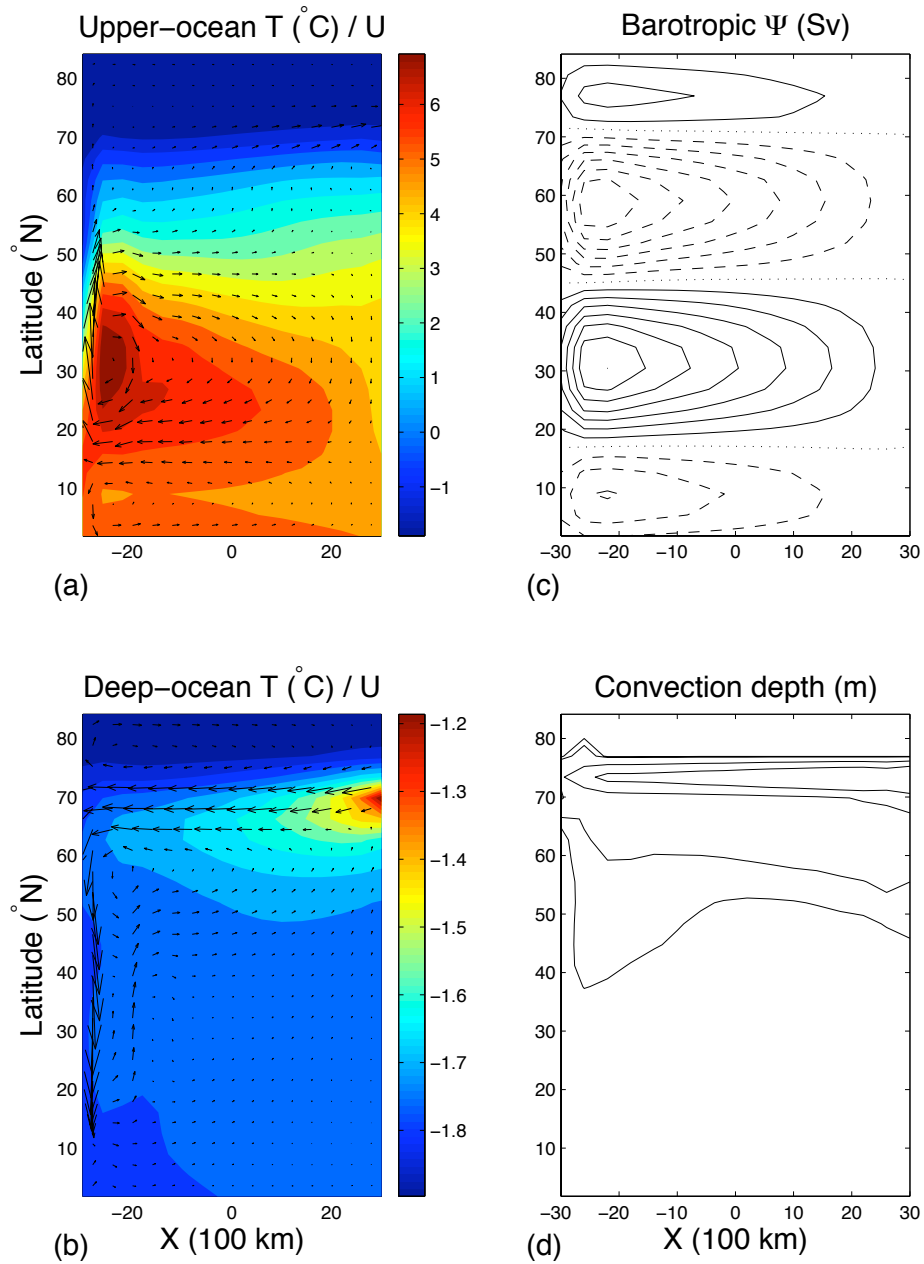


Figure 5: Same as in Fig. 4, but for upper and deep ocean temperature/velocity, as well as barotropic streamfunction and convection depth.

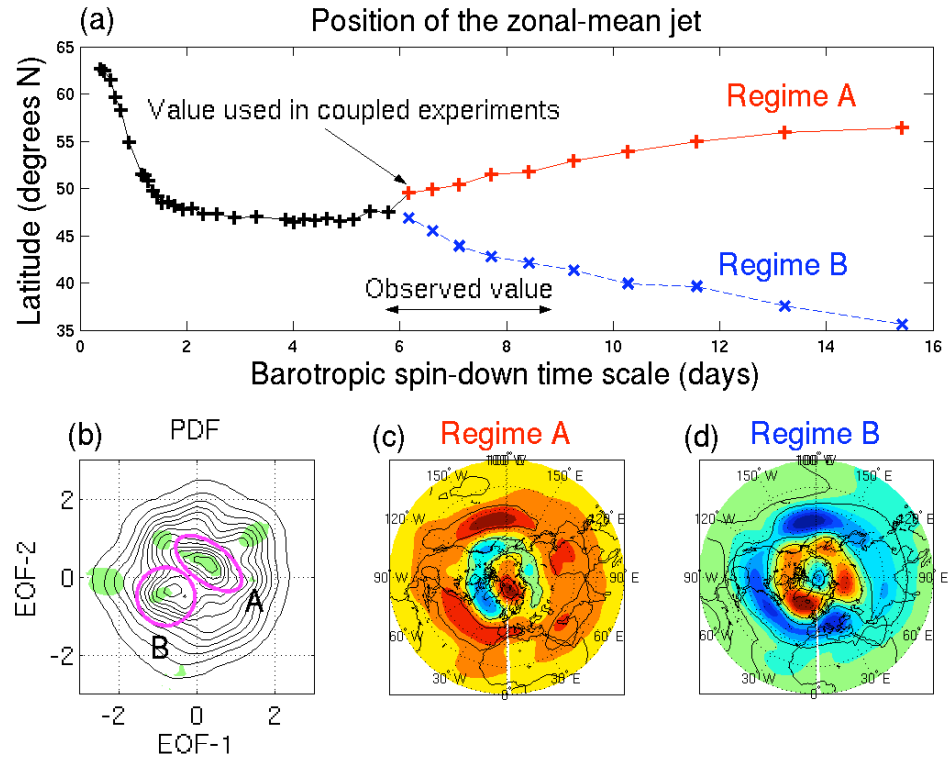


Figure 6: Bimodality in models and observation. Upper panel: position of the zonal-mean jet in the model as a function of surface friction; bimodal behavior is found at low and intermediate values of surface friction. Lower row: PDF of zonally-averaged zonal wind based on NCEP reanalysis and composites of high-latitude and low-latitude regimes. The latter are similar to those found in the model.

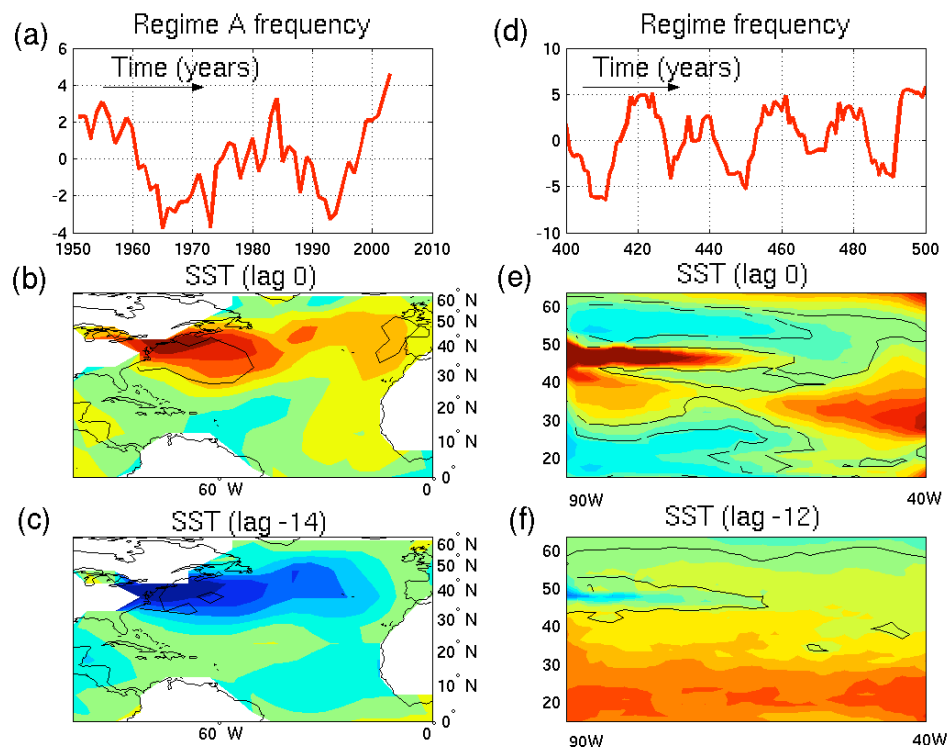


Figure 7: 20-year mode in observations (left column) and a coupled model with QG ocean (right column). Upper panels: regime occurrence frequency time series; Lower panels: SST regressed onto the time series of regime occurrence frequency at various lags. Main features of observed and modeled variability are similar.

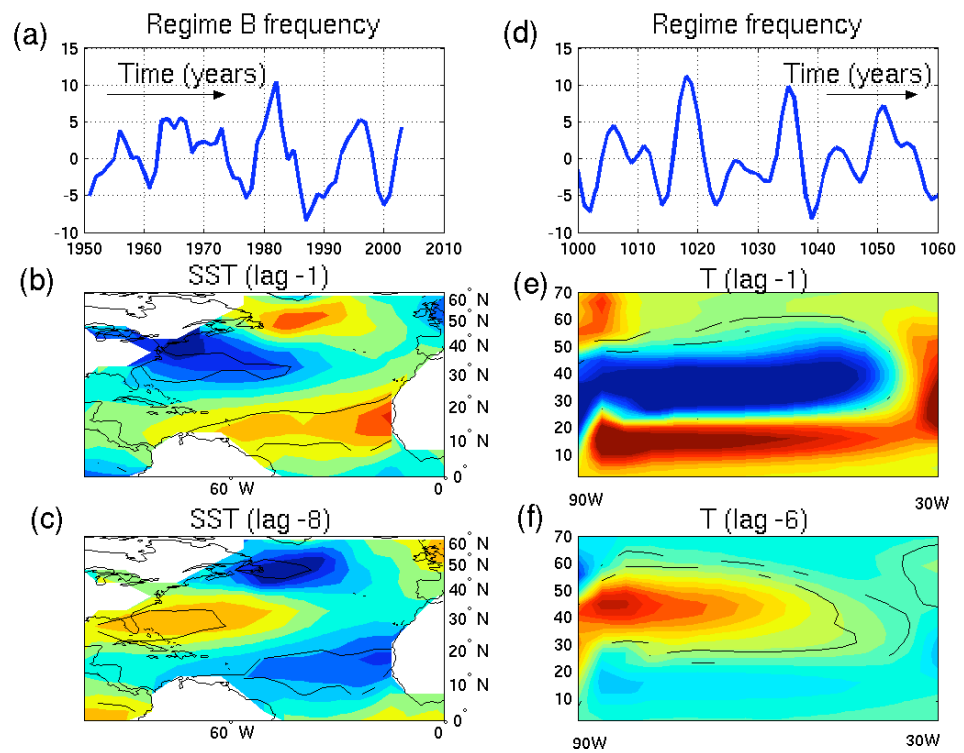


Figure 8: 10-year mode in observations. Same as in Fig. 7, but for different observed regime and a coupled model with coarse resolution PE ocean. The tripolar pattern and decadal time scale of the oscillation are like those found by Deser and Blackmon (1993).

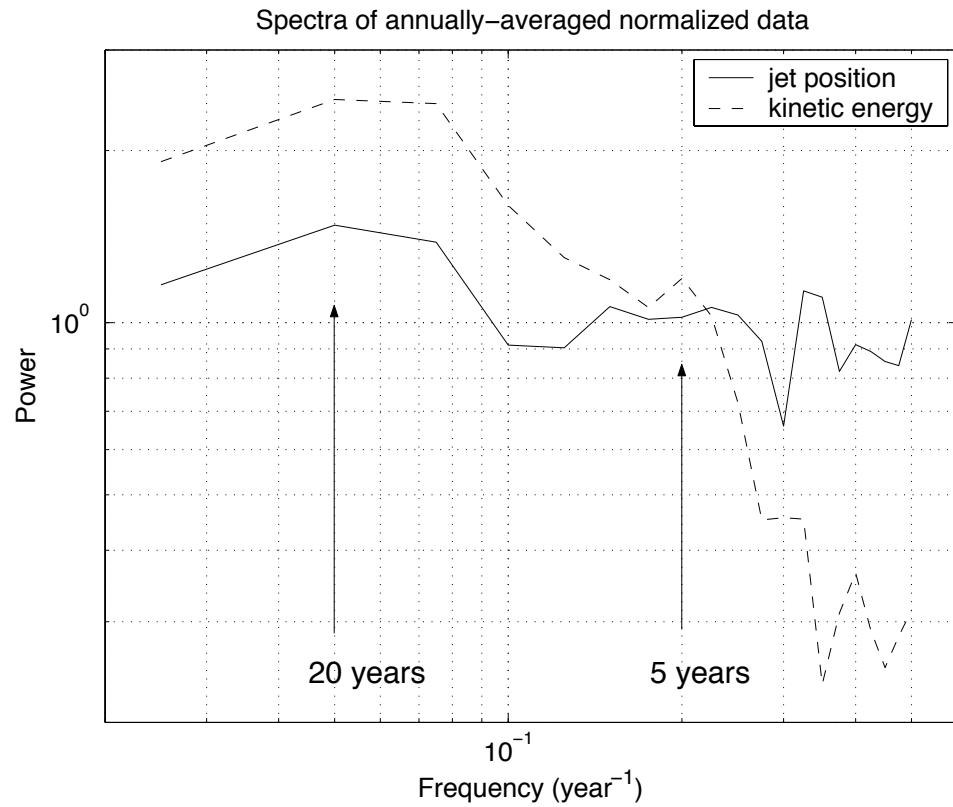


Figure 9: Power spectra of ocean kinetic energy and atmospheric jet position from a coupled model using QG high-resolution ocean, showing enhancement of power at periods close to 20 years.

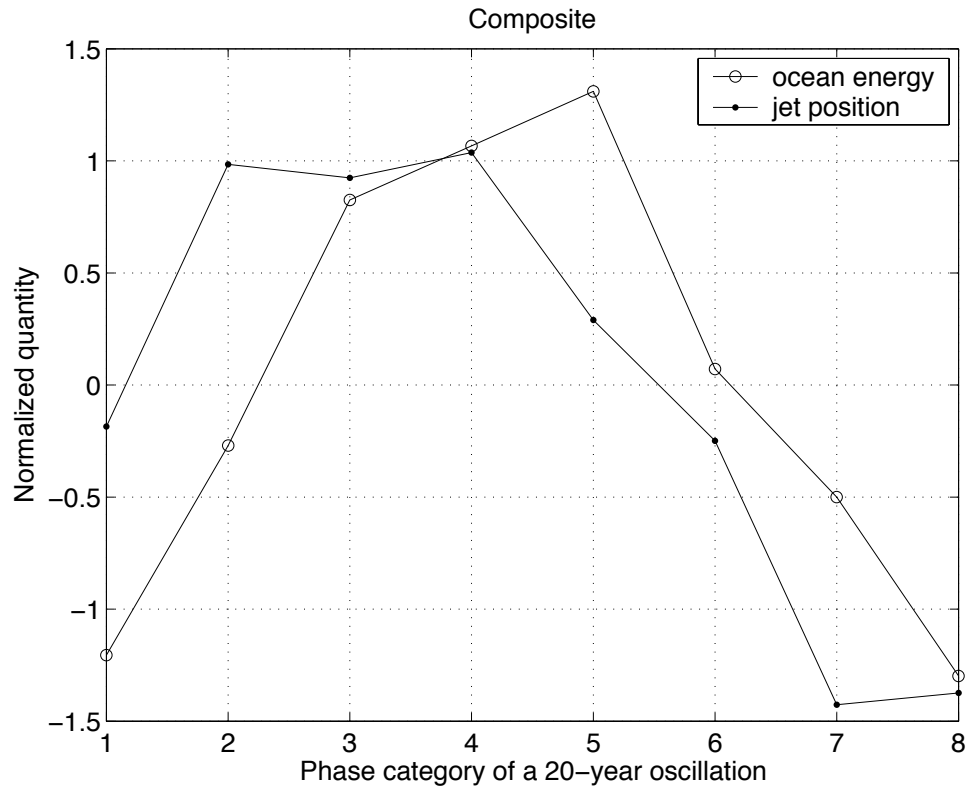


Figure 10: Composite of ocean kinetic energy and atmospheric jet position for a 20-year oscillation. Jet-position time series lead ocean energy by a quarter of a cycle. High-energy state in the ocean corresponds to an intense Gulf Stream and inertial recirculations spun up by atmospheric jet in its high-latitude state, while in low energy state the ocean current is less well defined and eddies dominate the circulation. The time scale of the cycle is determined by ocean eddy adjustment to atmospheric transitions from low- to high-latitude state and back

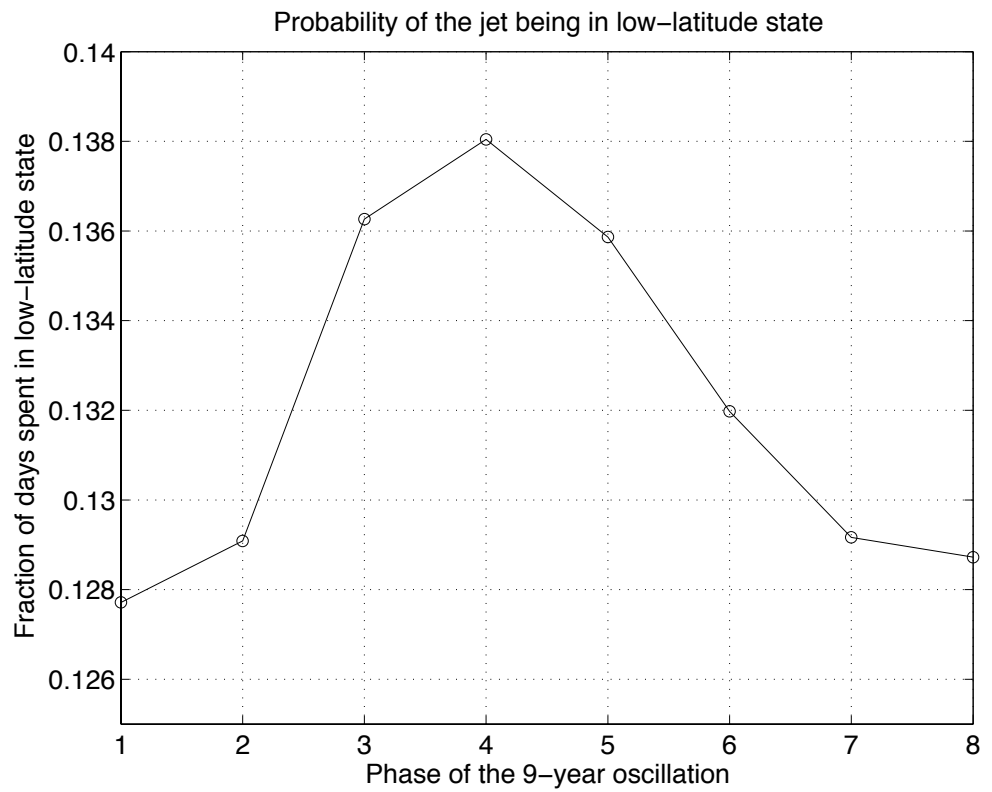


Figure 11: The probability of the atmospheric jet to be in its low-latitude state is affected by the ocean-induced SST anomalies in the course of the oscillation. This nonlinear sensitivity is essential for the oscillation to exist.

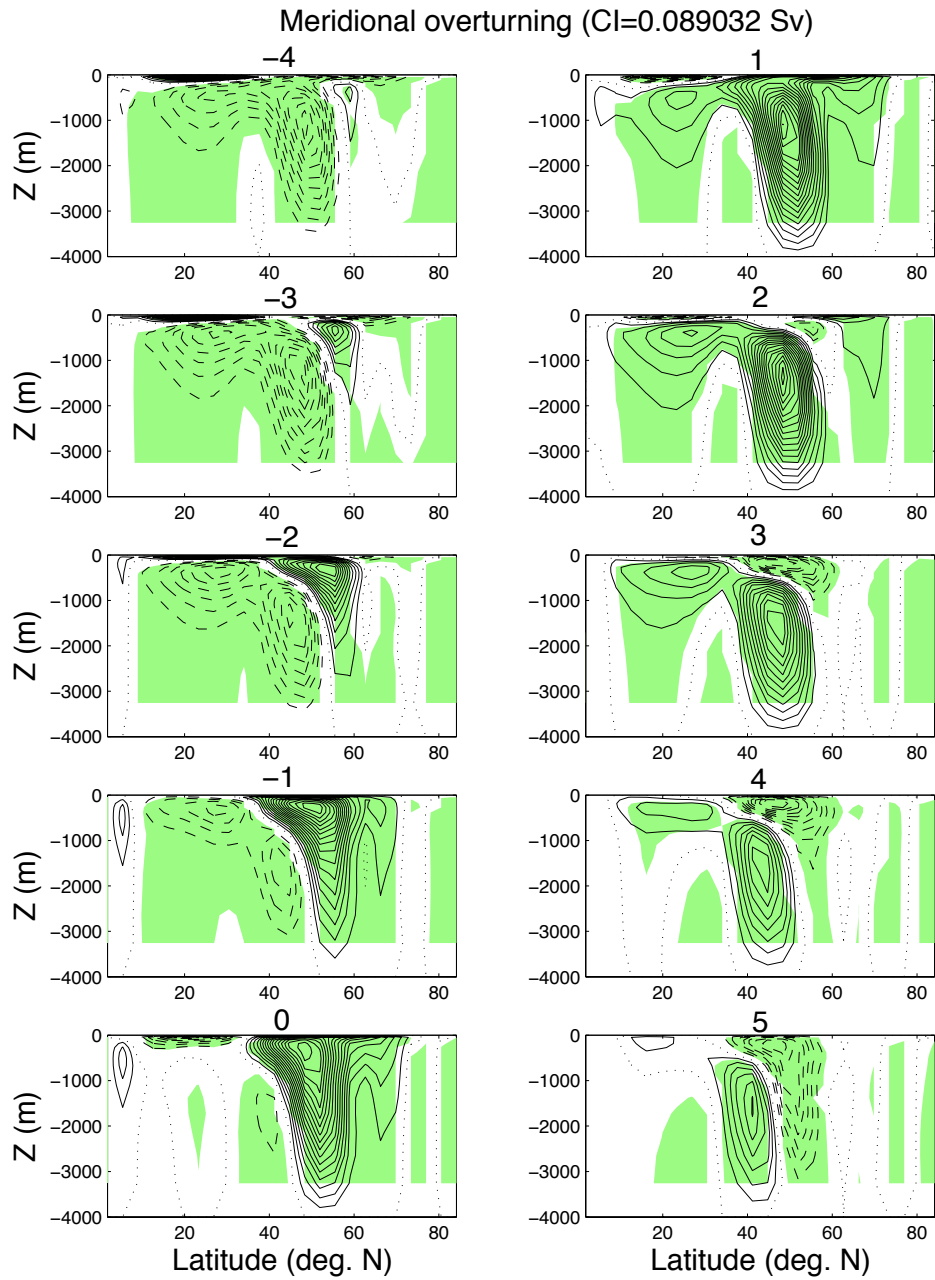


Figure 12: Decadal coupled mode in coupled model with PE ocean involves changes in THC.

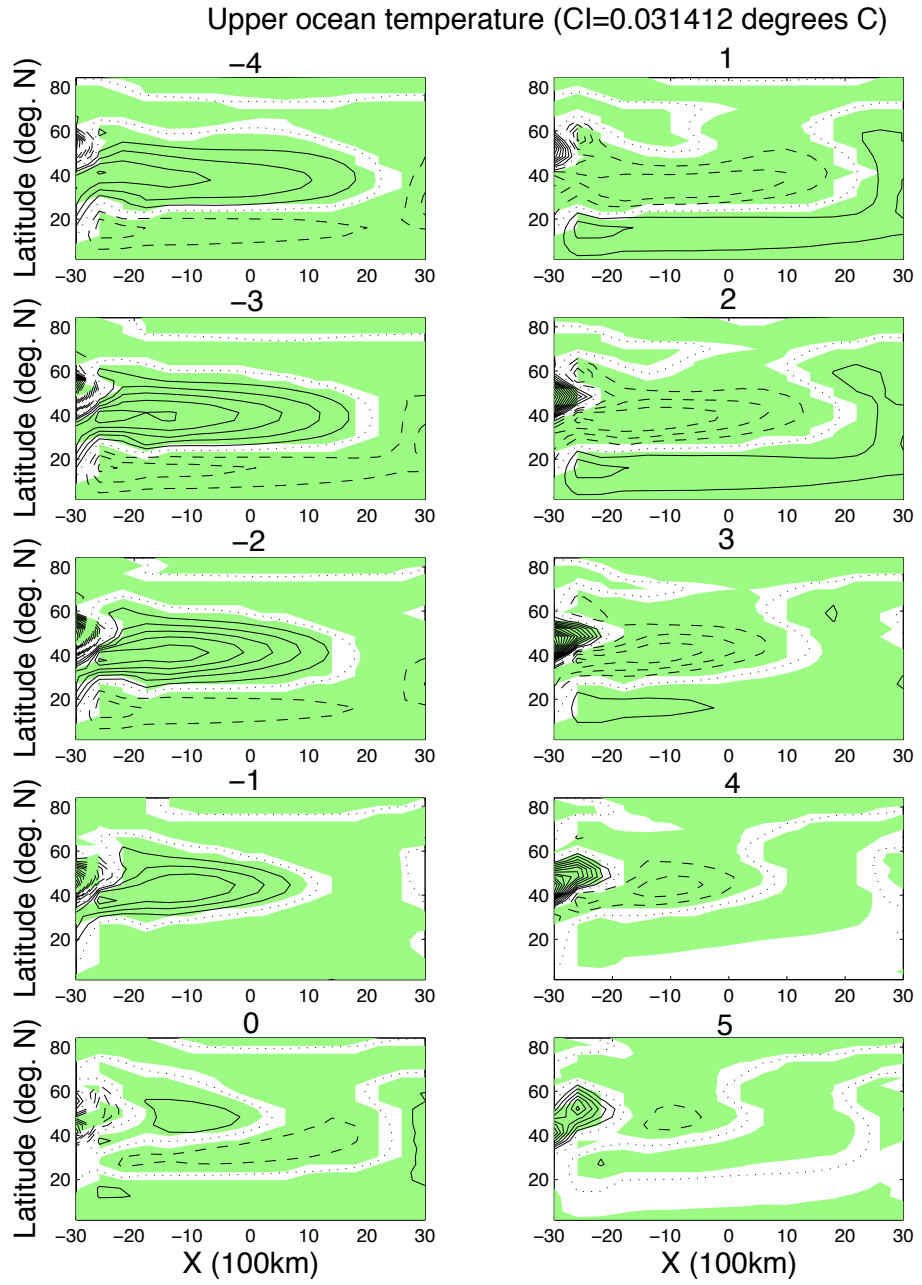


Figure 13: Upper ocean temperature anomalies are like those shown in Fig. 8.