Deep atmospheric structure anchored by surface wind convergence near major ocean fronts

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Given stable stratification, is it possible for extratropical ocean changes to influence the atmosphere above the boundary layer?

1. Gulf Stream (Minobe et al. 2008 Nature) & Kuroshio Extension

2. Subtropical countercurrent over the Northwest Pacific (Kobashi et al. 2008, JC)
1. Convergence
2. Evaporation: large (Ts-Ta) & strong wind
3. Baroclinicity
AGCM Runs with observed SST vs smoothed SST.

Precipitation band disappears in the smoothed run. Therefore, the sharp SST front is essential for the precipitation band.
Colored contour: wind convergence.
Black contour: boundary layer height.

Gulf Stream-induced upward motion penetrates into the upper troposphere, forcing planetary waves that propagate along the westerly jet stream.

Subtropical countercurrent (STCC) is an eastward current in the south subtropical gyre, where the Sverdrup theory predicts westward flow.


Yoshida & Kidokoro (1967)

Kobashi et al. (2006 JGR)
The subtropical countercurrent (STCC) anchors in May:

- Minimum in NE trade winds;
- Island of weakly positive curls in a sea of negative curls;
- Local maximum in column-integrated water vapor → a deep moist layer.
Anomalies of \((v, w)\) & humidity when curl is positive

SLP & wind curl composites

(a) lag = -2.0 day
(b) lag = -1.0 day
(c) lag = 0 day
(d) lag = +1.0 day
(e) lag = +2.0 day
(f) lag = +4.0 day
Summary

• Deep atmospheric response is found along the fronts of the Gulf Stream and North Pacific subtropical countercurrent (STCC).

• The Gulf Stream front anchors surface wind convergence and intensifies surface evaporation on the warm flank, both effects enhancing convective rainfall.

• The North Pacific STCC front maintains a band of weakly positive wind curls by anchoring a zone of enhanced baroclinicity, along which cyclonic disturbances grow.