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

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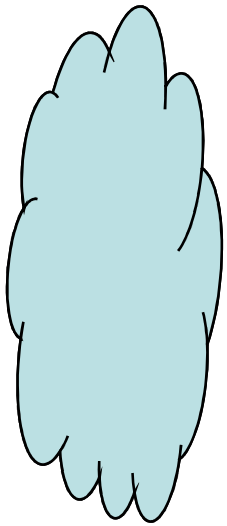
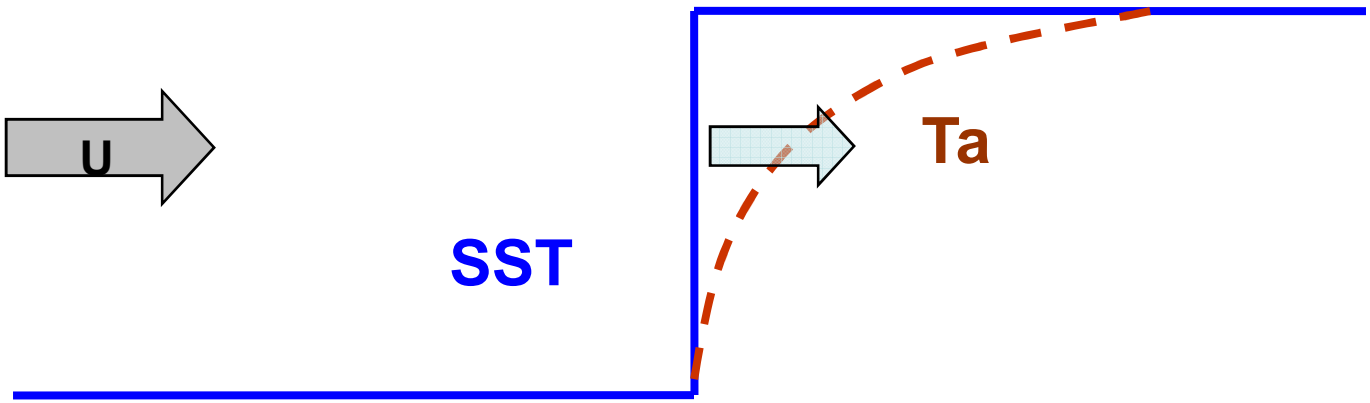
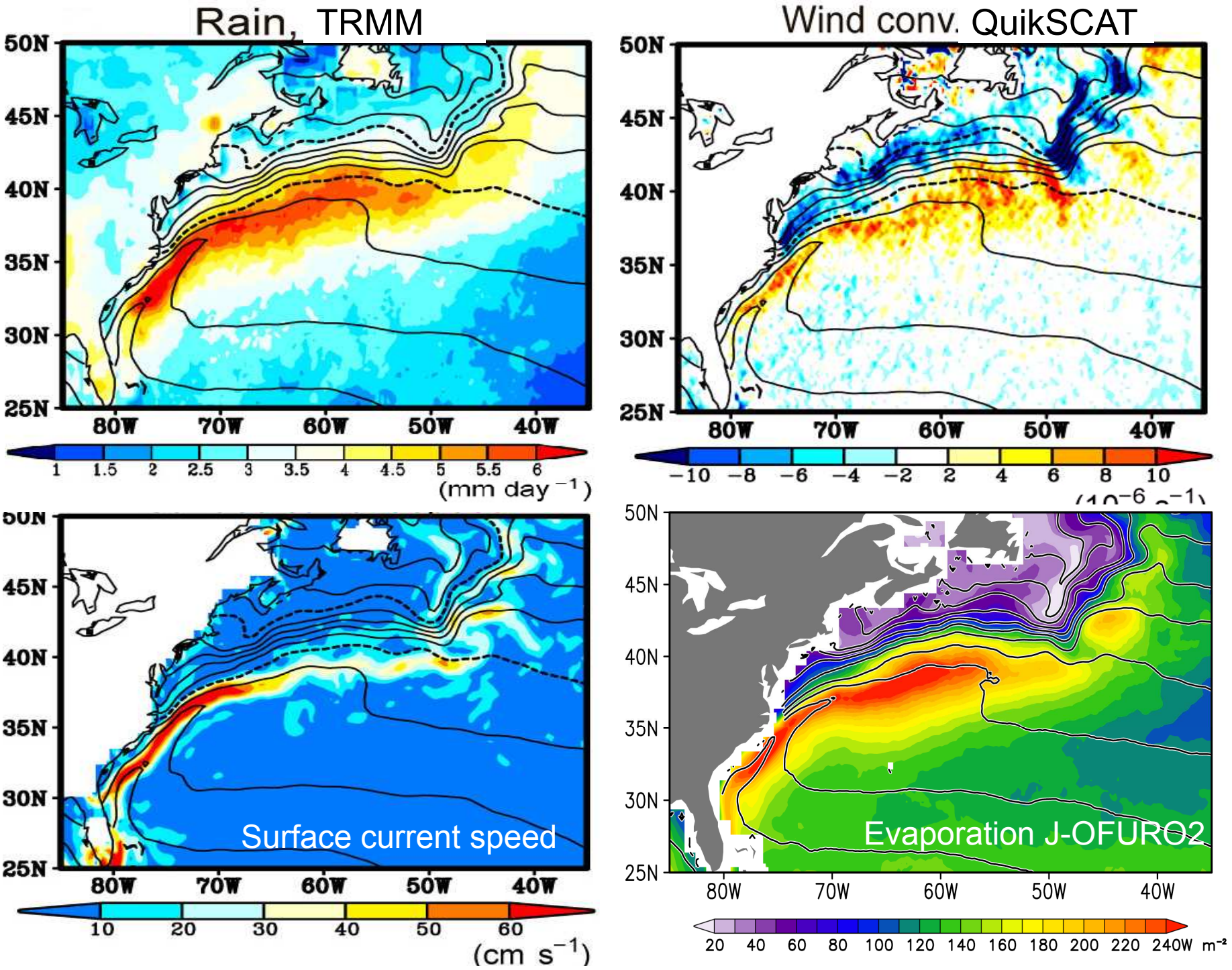
Given stable stratification, is it possible for extratropical ocean changes to influence the atmosphere above the boundary layer?

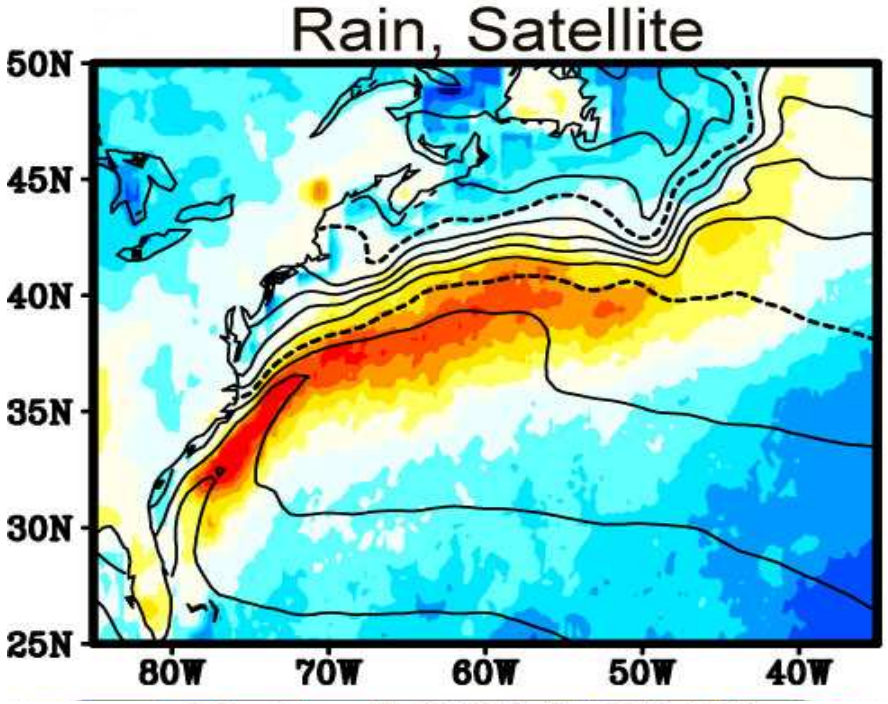
1. Gulf Stream (Minobe et al. 2008 *Nature*) & Kuroshio Extension
2. Subtropical countercurrent over the Northwest Pacific (Kobashi et al. 2008, *JC*)



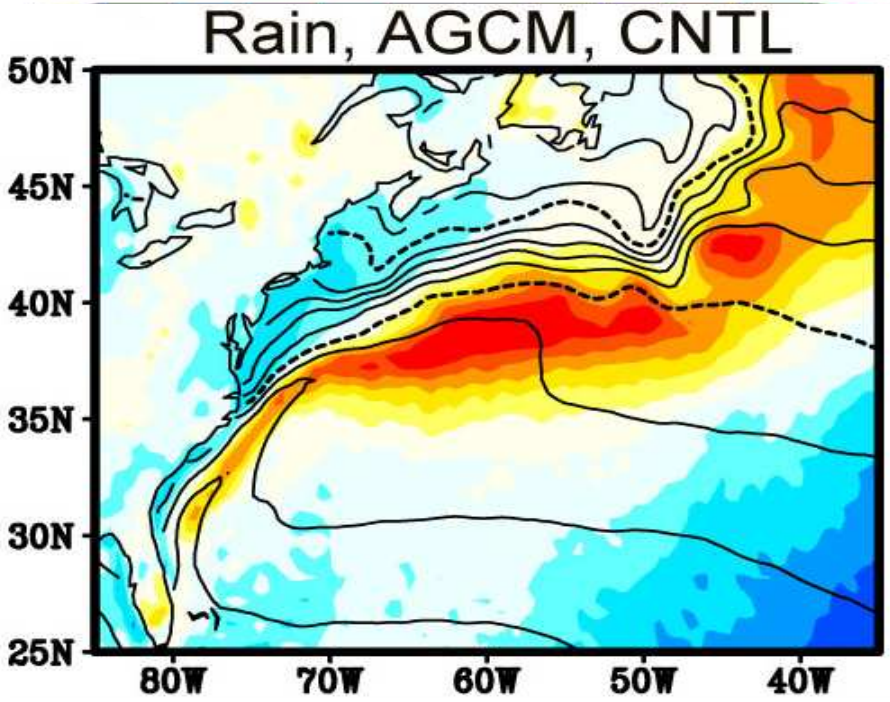
1. **Convergence**
2. **Evaporation**: large (Ts-Ta) & strong wind
3. **Baroclinicity**

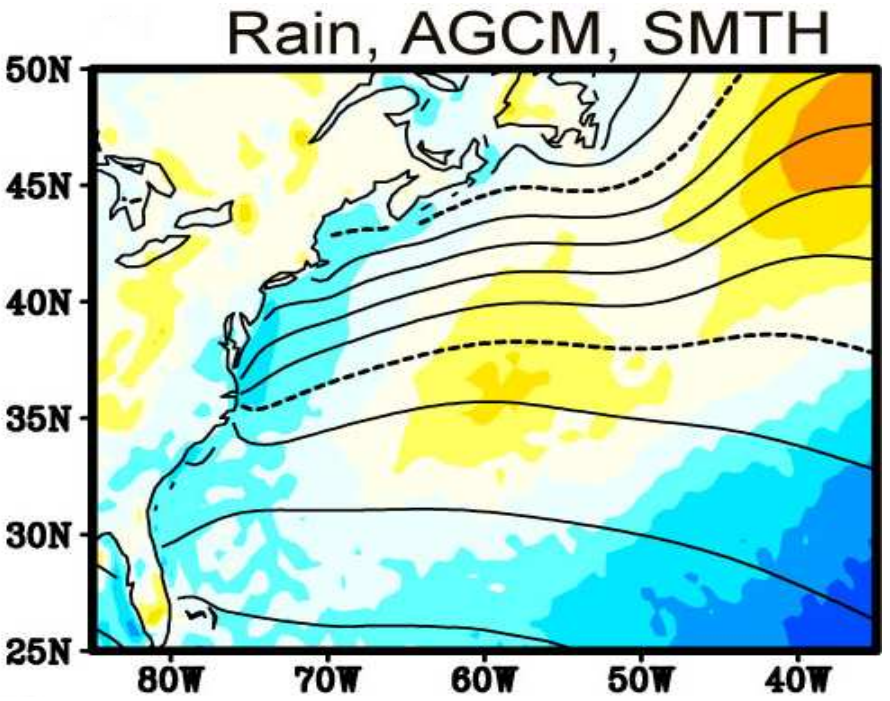


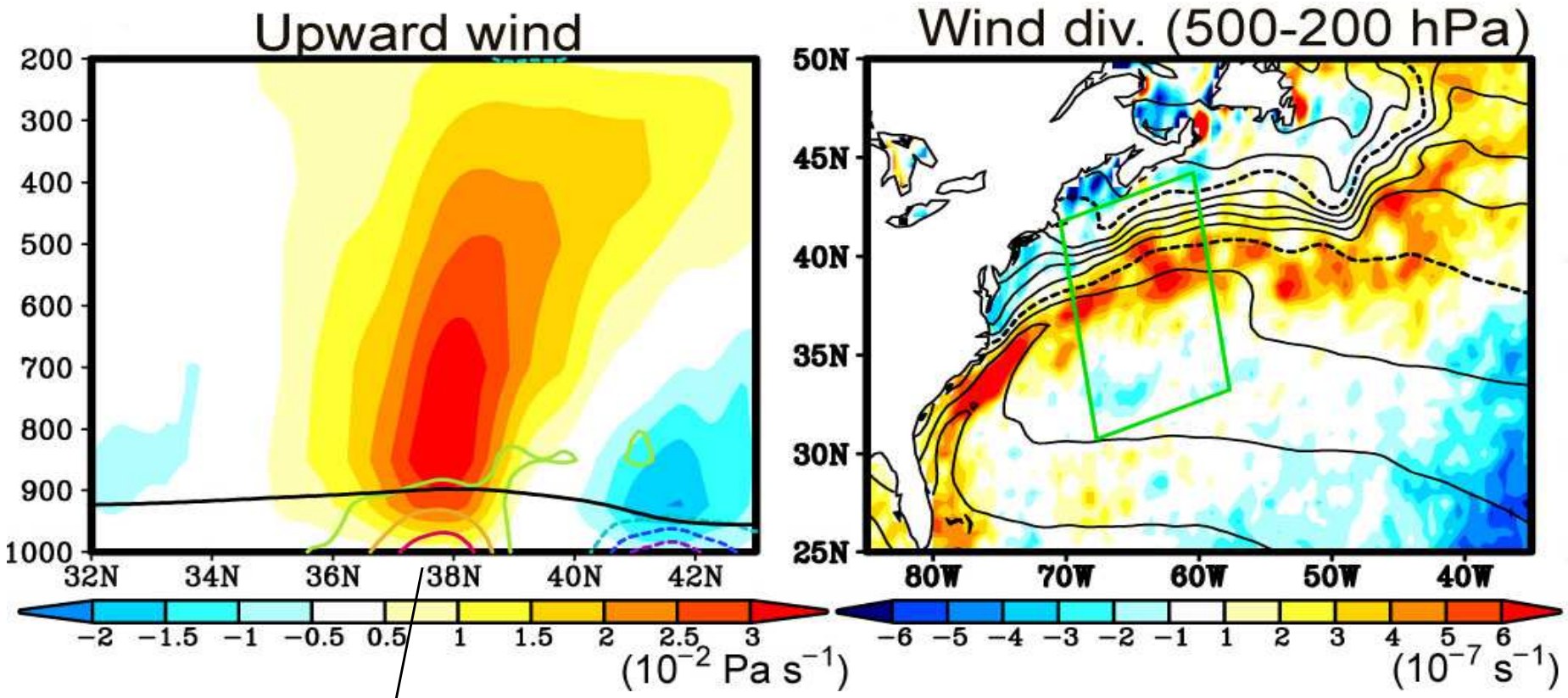

Rain, TRMM
50N
45N
40N
35N
30N
25N
80W
70W
60W
50W
40W
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
(mm day −1)
Wind conv. QuikSCAT
−10
−8
−6
−4
−2
2
4
6
8
10
Surface current speed
10
20
30
40
50
60
(cm s−1)
Evaporation J-OFURO2
20
40
60
80
100
120
140
160
180
200
220
240W m−2



- 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.



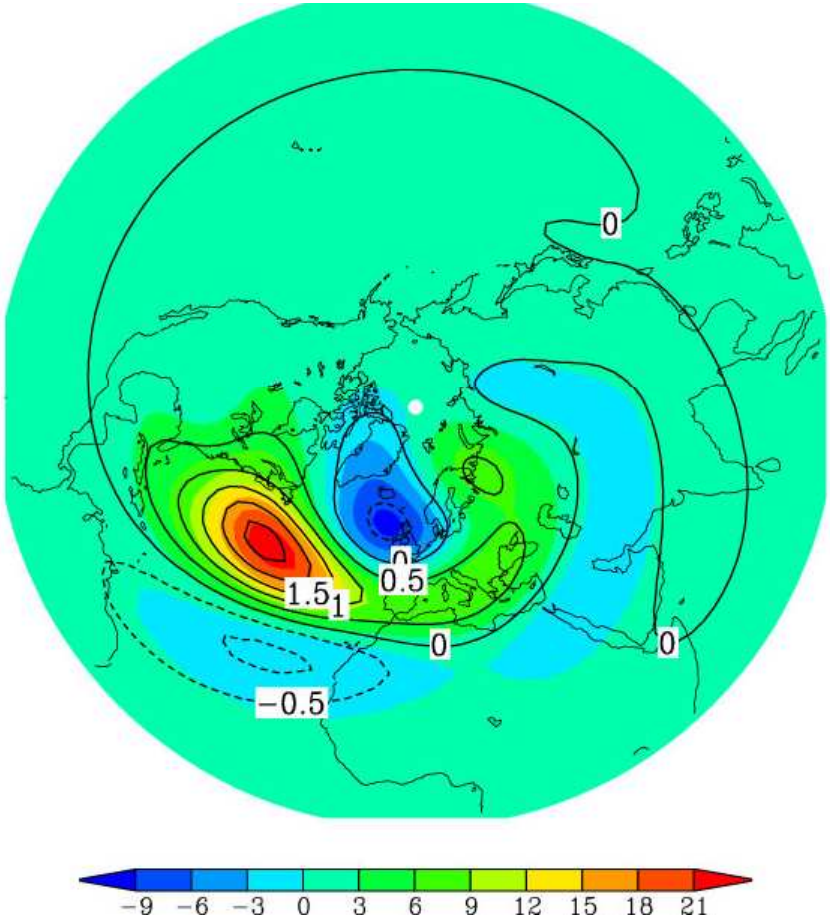




Colored contour: wind convergence.
Black contour: boundary layer height.

Minobe, S., A. Kuwano-Yoshida, N. Komori, S.-P. Xie, and R.J. Small, 2008: Influence of the Gulf Stream on the troposphere. *Nature*. **452**. 206-209.

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



Upper tropospheric response to Gulf-Stream heating: Geopotential height at 250 hPa

Minobe, S., A. Kuwano-Yoshida, N. Komori, S.-P. Xie, and R.J. Small, 2008: Influence of the Gulf Stream on the troposphere. *Nature*, **452**, 206-209.

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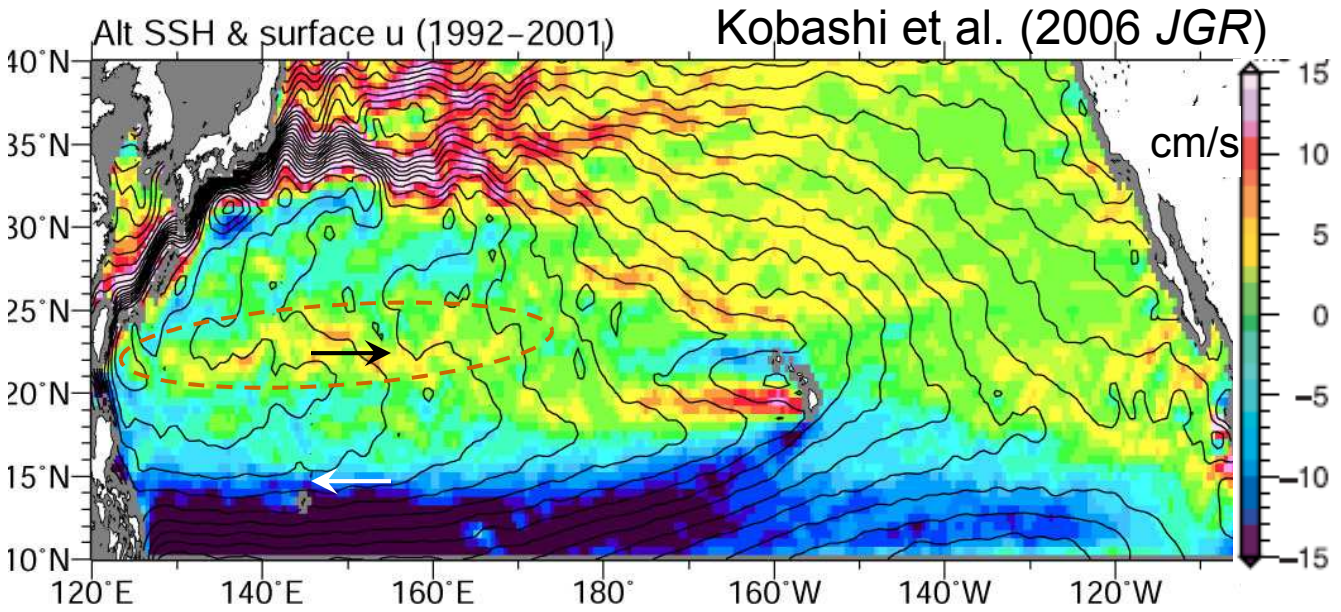
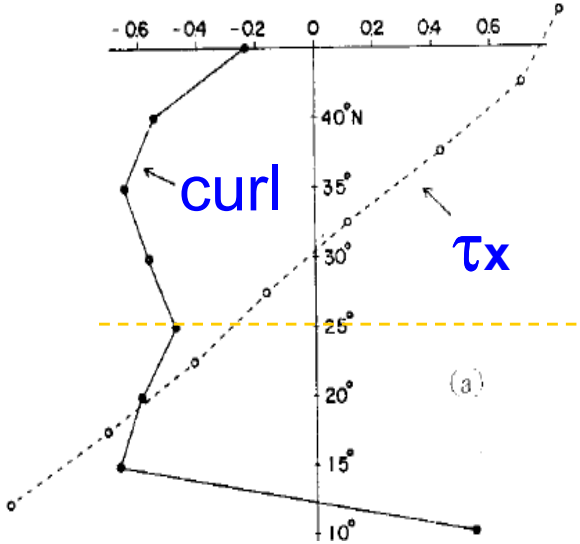
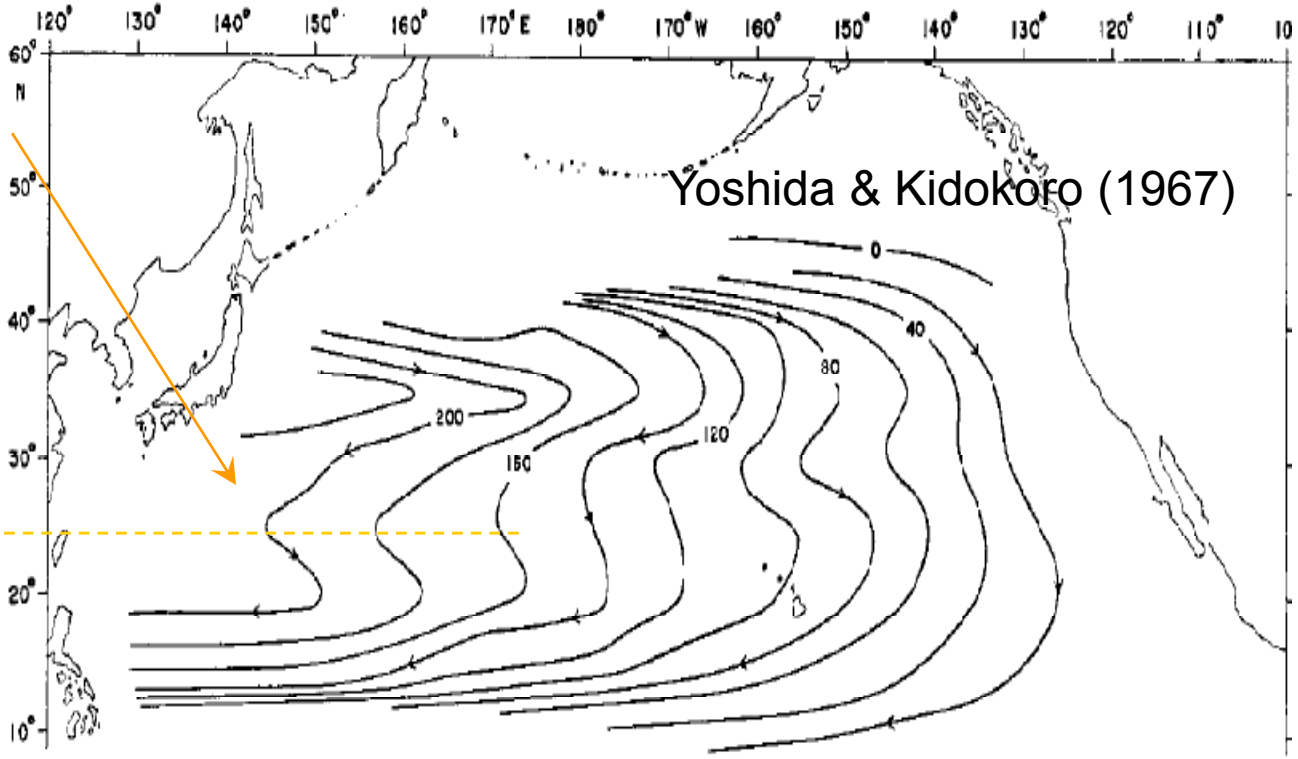
Subtropical countercurrent (STCC) is an eastward current in the south subtropical gyre, where the Sverdrup theory predicts westward flow.



Wind Atlas of 1958 &
Sverdrup stream function
for Mar-Apr-May

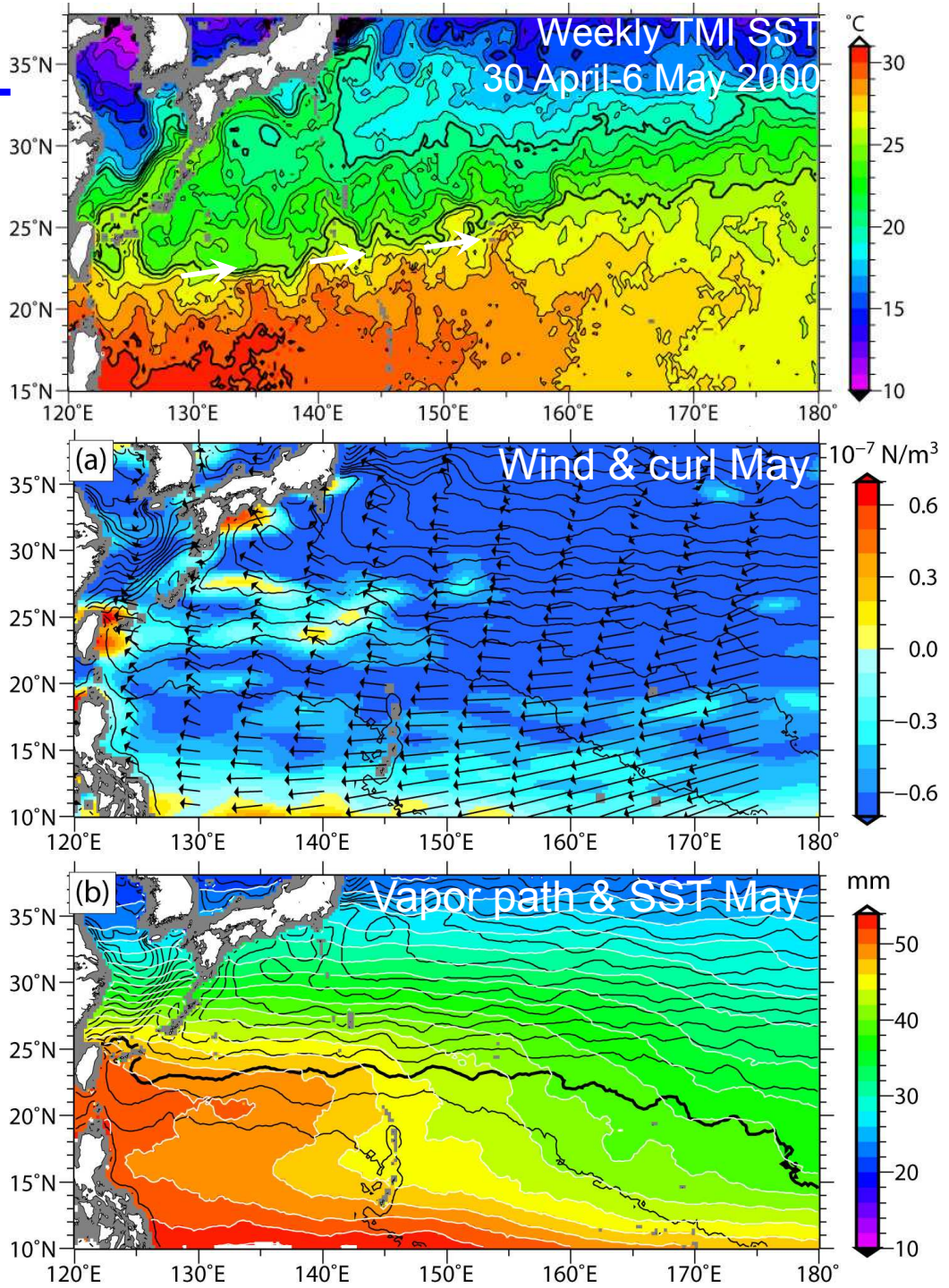




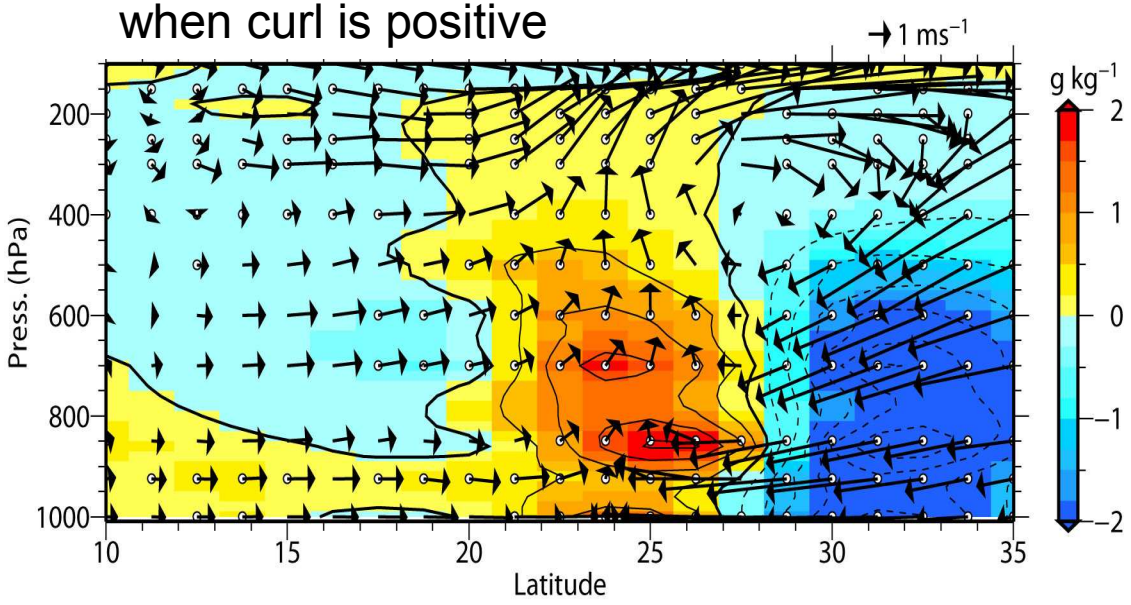
Revisit wind with QuikSCAT

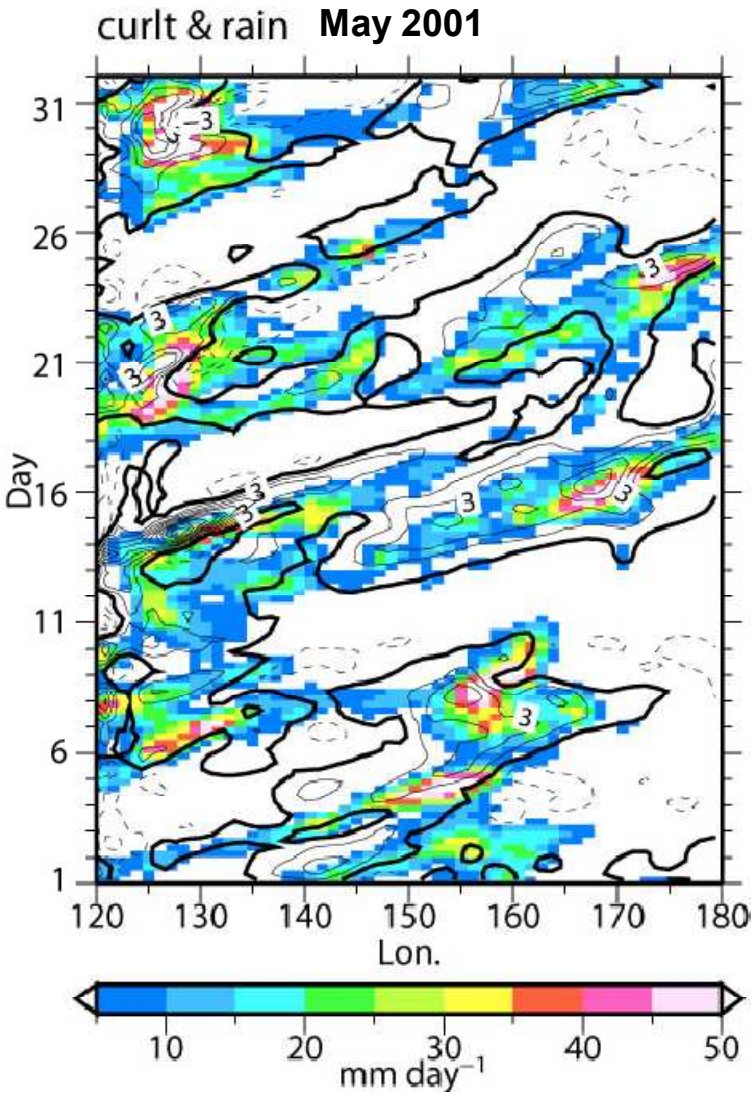
The subtropical countercurrent (STCC) anchors in May:

- 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.



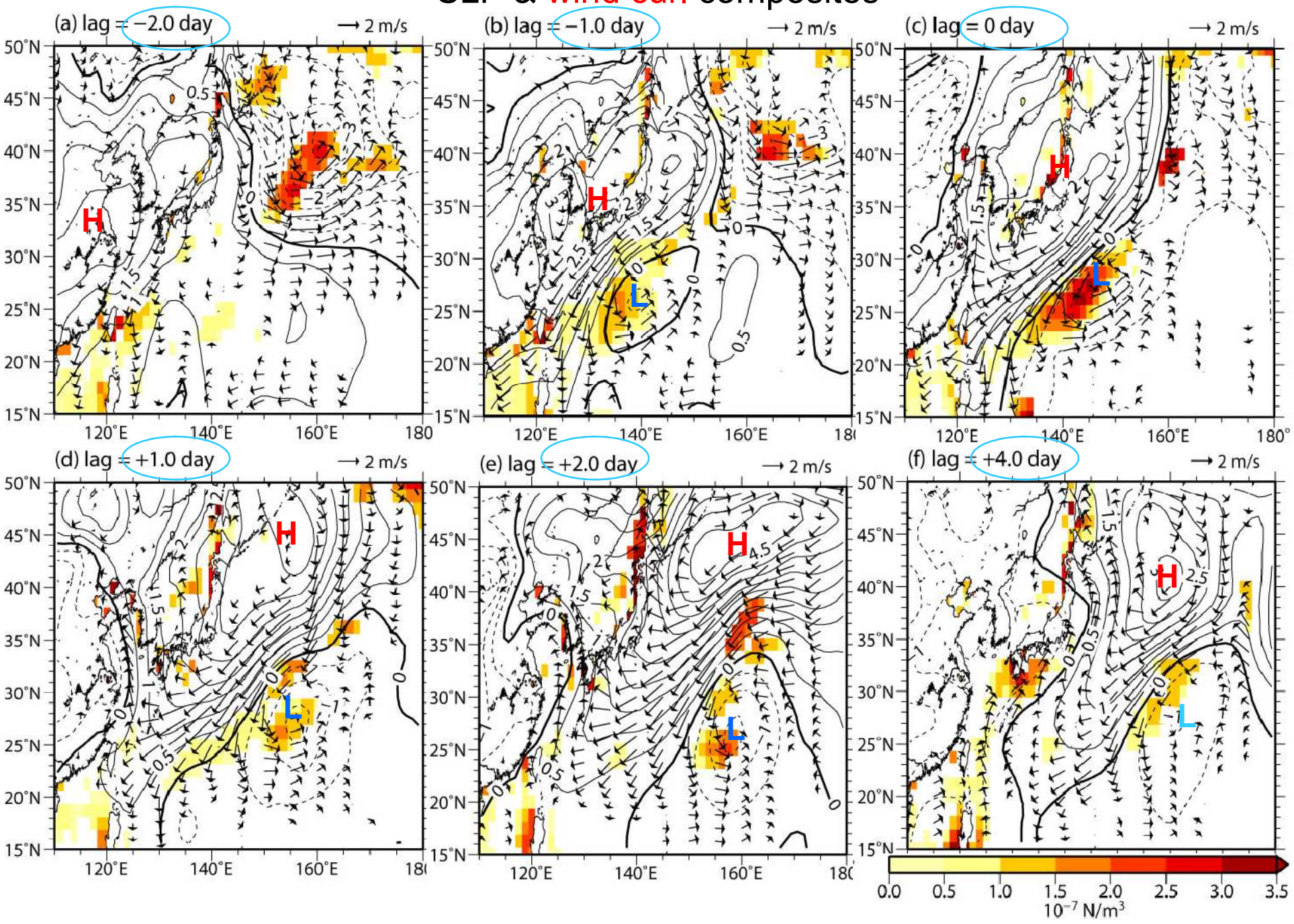
Anomalies of (v, w) & humidity
when curl is positive





Kobashi, F., S.-P. Xie, N. Iwasaka and T. Sakamoto, 2008: Deep atmospheric response to the North Pacific oceanic subtropical front in

SLP & wind curl composites



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.