# The atmospheric response to a shift in the Oyashio SST front

Dimitry Smirnov[1,2], Matthew Newman[1,2], Michael Alexander[2], Young-Oh Kwon[3] and Claude Frankignoul[4]

*[1]University of Colorado – CIRES*
*[2]NOAA-ESRL*
*[3]Woods Hole Oceanographic Institution*
*[4]Université Pierre et Marie Curie*

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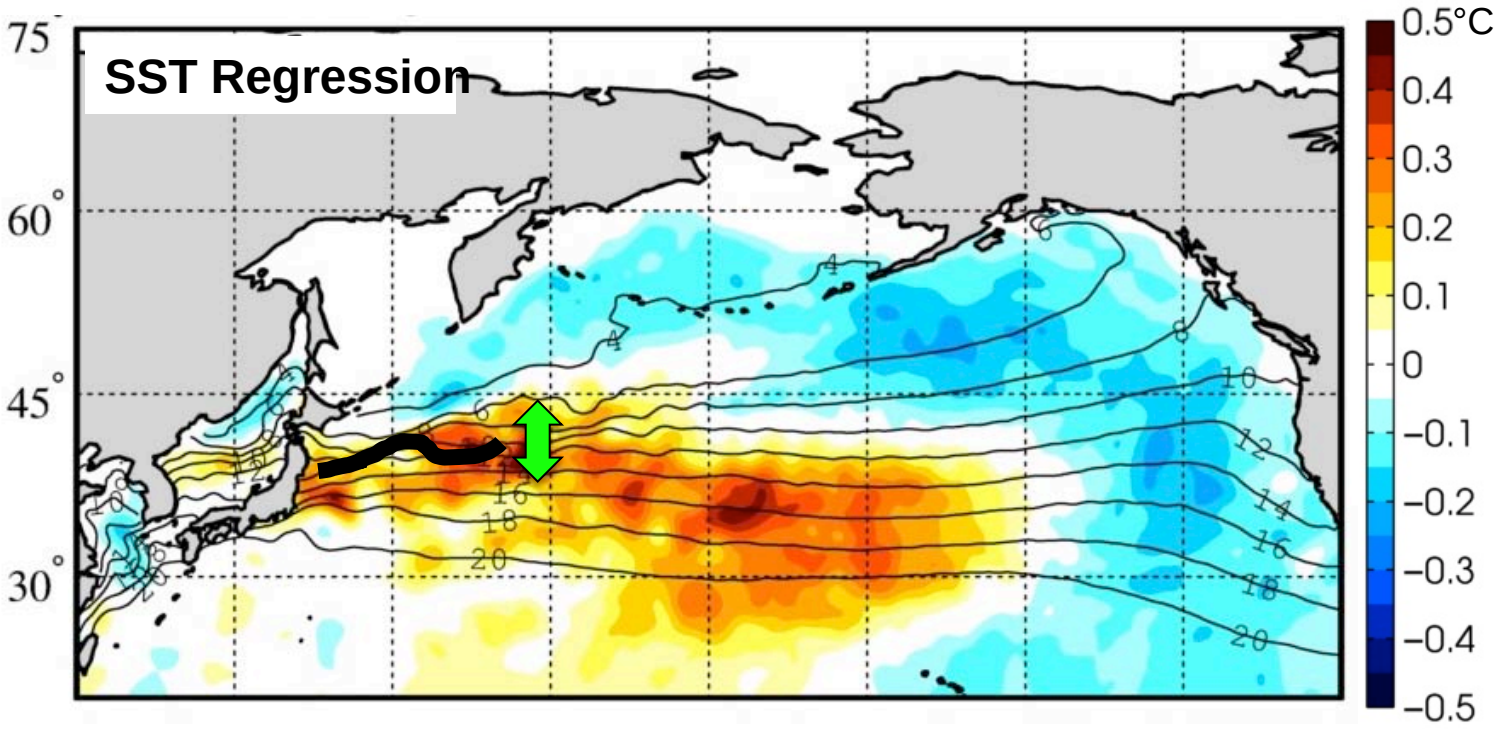
NCAR

# **O**yashio **E**xtension **I**ndex



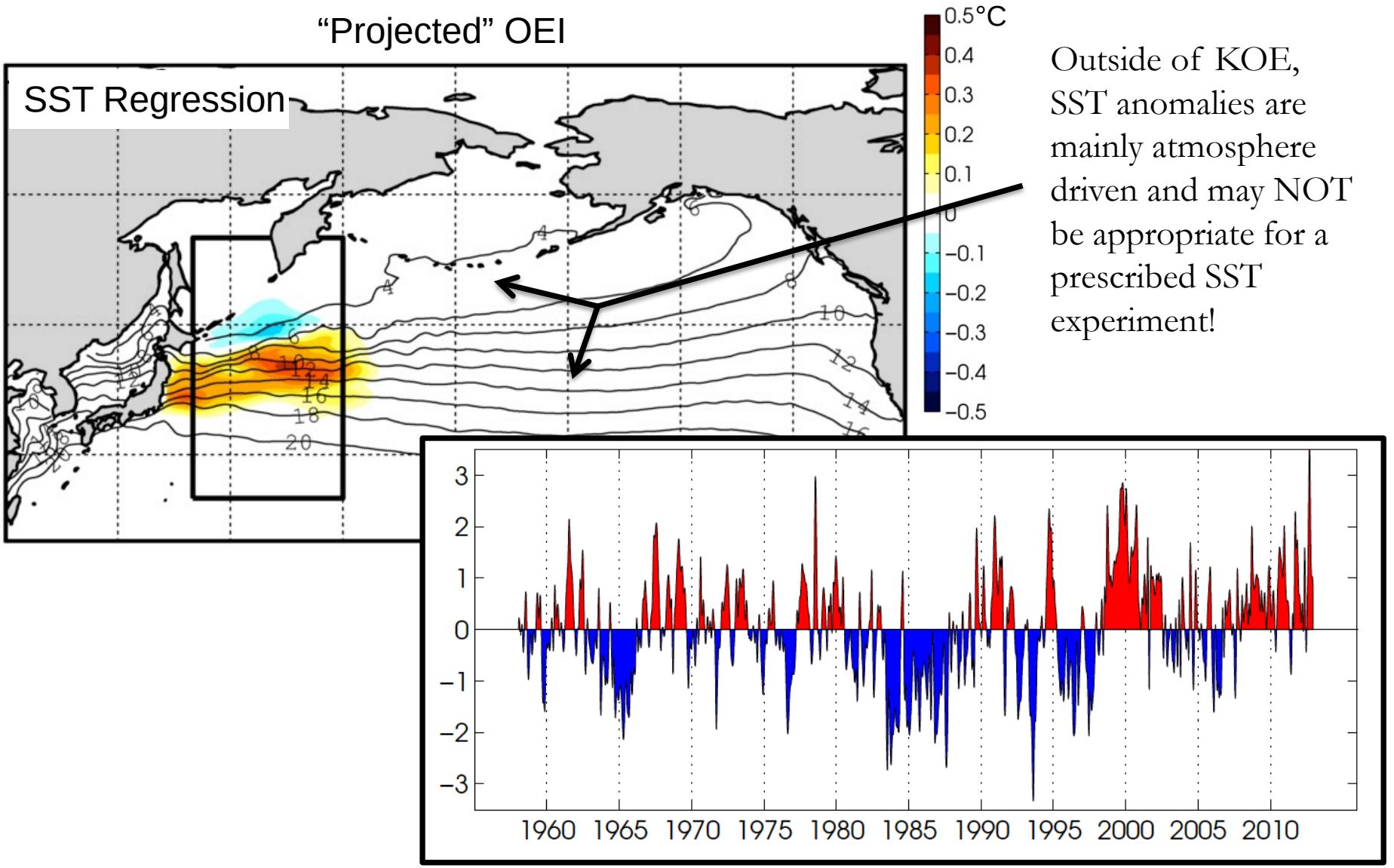

- Kuroshio-Oyashio Extension (KOE) system is a key component of the North Pacific ocean-atmosphere system with connections to the PDO

➢ **Can an atmospheric GCM capture the atmospheric response to a shift in the Oyashio SST front?**

➢ **Is a high resolution model required?**

OEI from Frankignoul et al. (2011)

# Prescribing SST



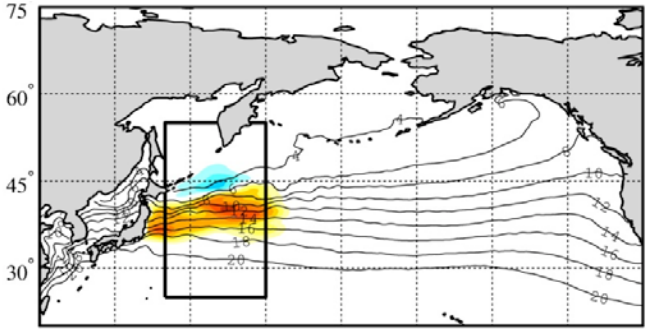

Outside of KOE, SST anomalies are mainly atmosphere driven and may NOT be appropriate for a prescribed SST experiment!

Smirnov et al. (2014)

# Experimental design

- NCAR's Community Atmosphere Model, version 5 (CAM5)
- 25 warm/cold ensembles with different atmospheric initial states from control run (taken a year apart)
- Two 6-month simulations (1 Nov – 31 Mar):
  1. High-resolution (**HR**) – 0.25°
  2. "Low"-resolution (**LR**) – 1.0°

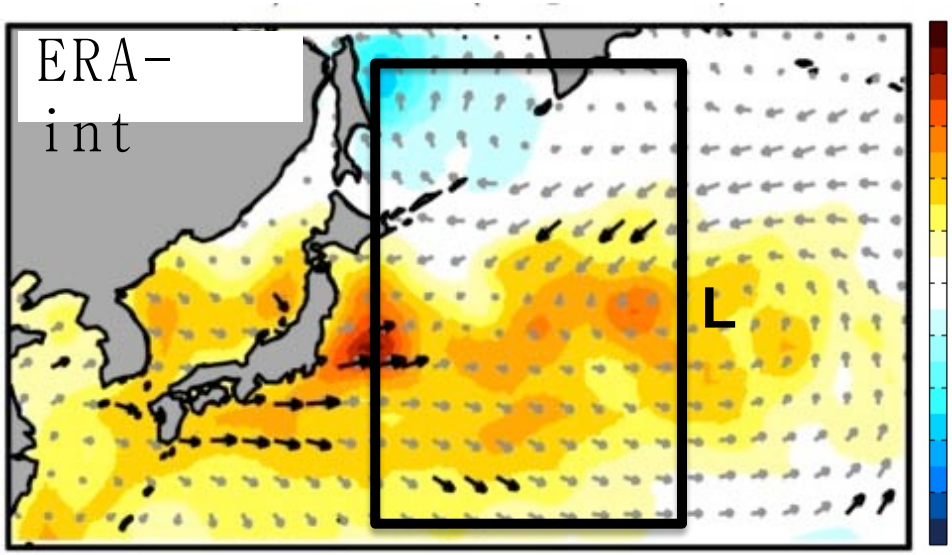
"WARM"→ Northward shift

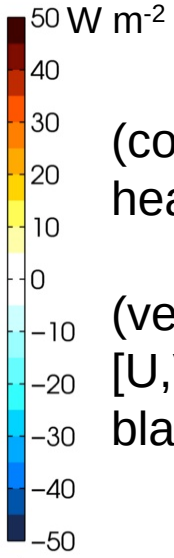



- Identical initial land, sea-ice and atmospheric initial conditions
- Compare the *mean difference* (WARM – COLD) between the HR and LR model responses

➢ Compare to ERA-interim (1979-2012) using a regression on the POEI

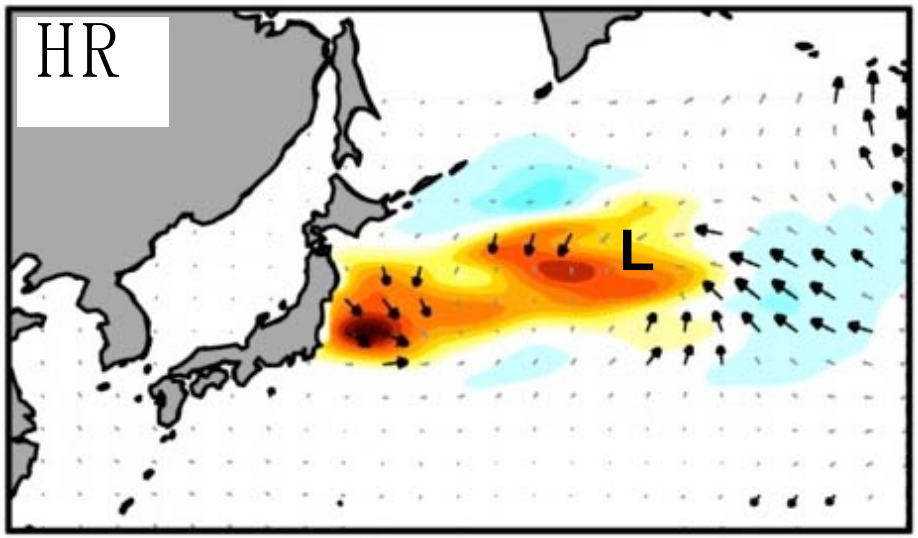
# Near surface circulation

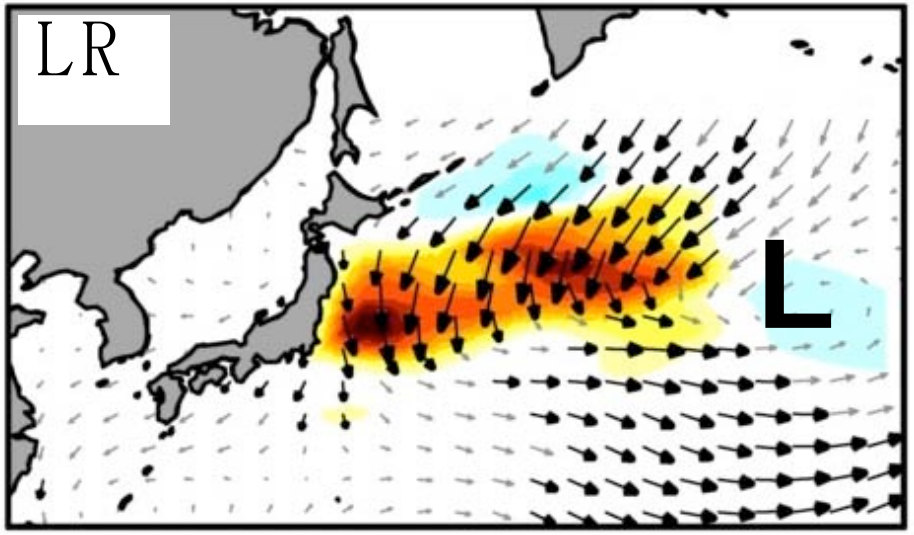



(color) Turbulent heat flux

(vector) 10-m [U,V]
black → p = 0.025



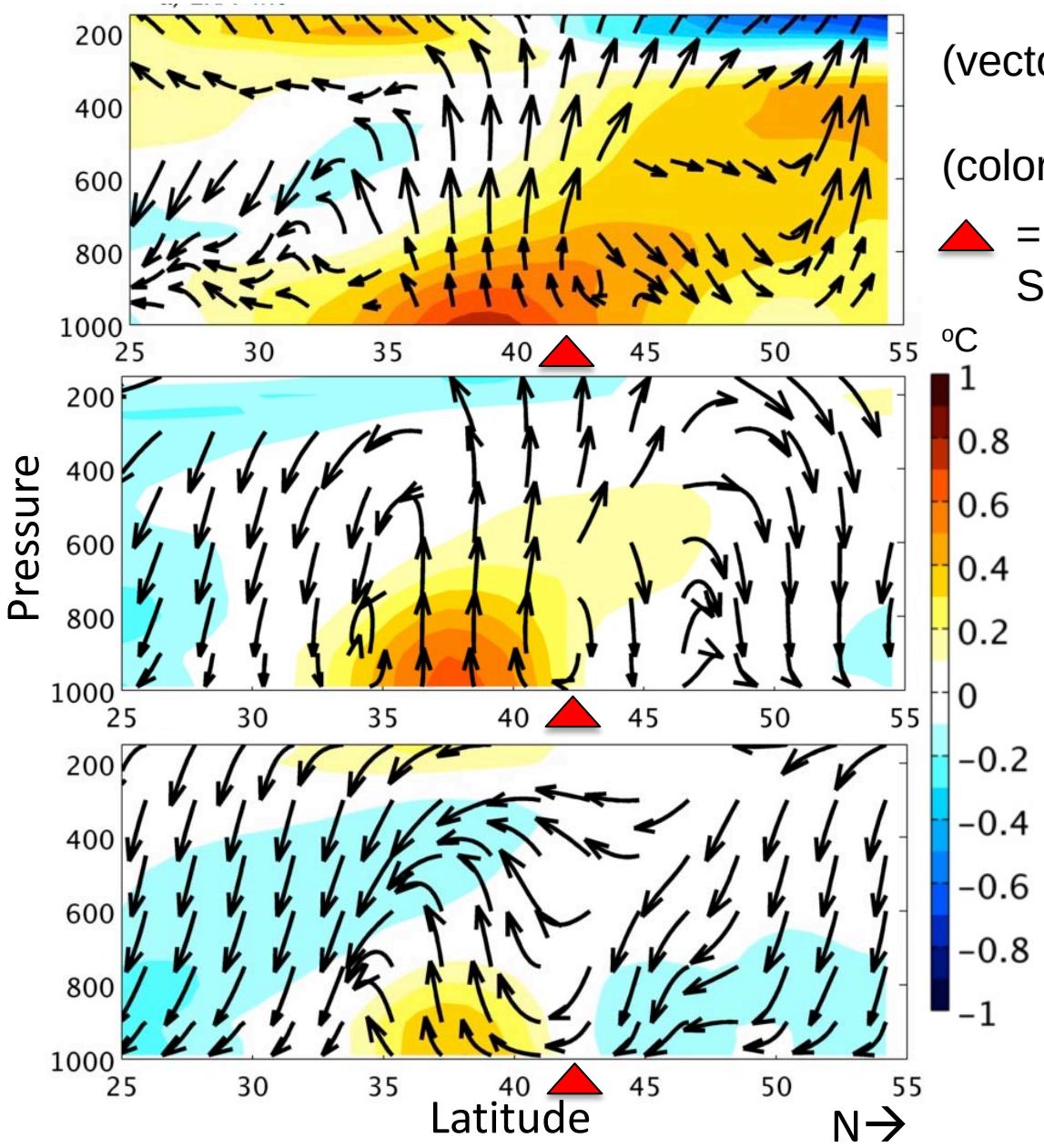



# Across front circulation

**ERA-int**

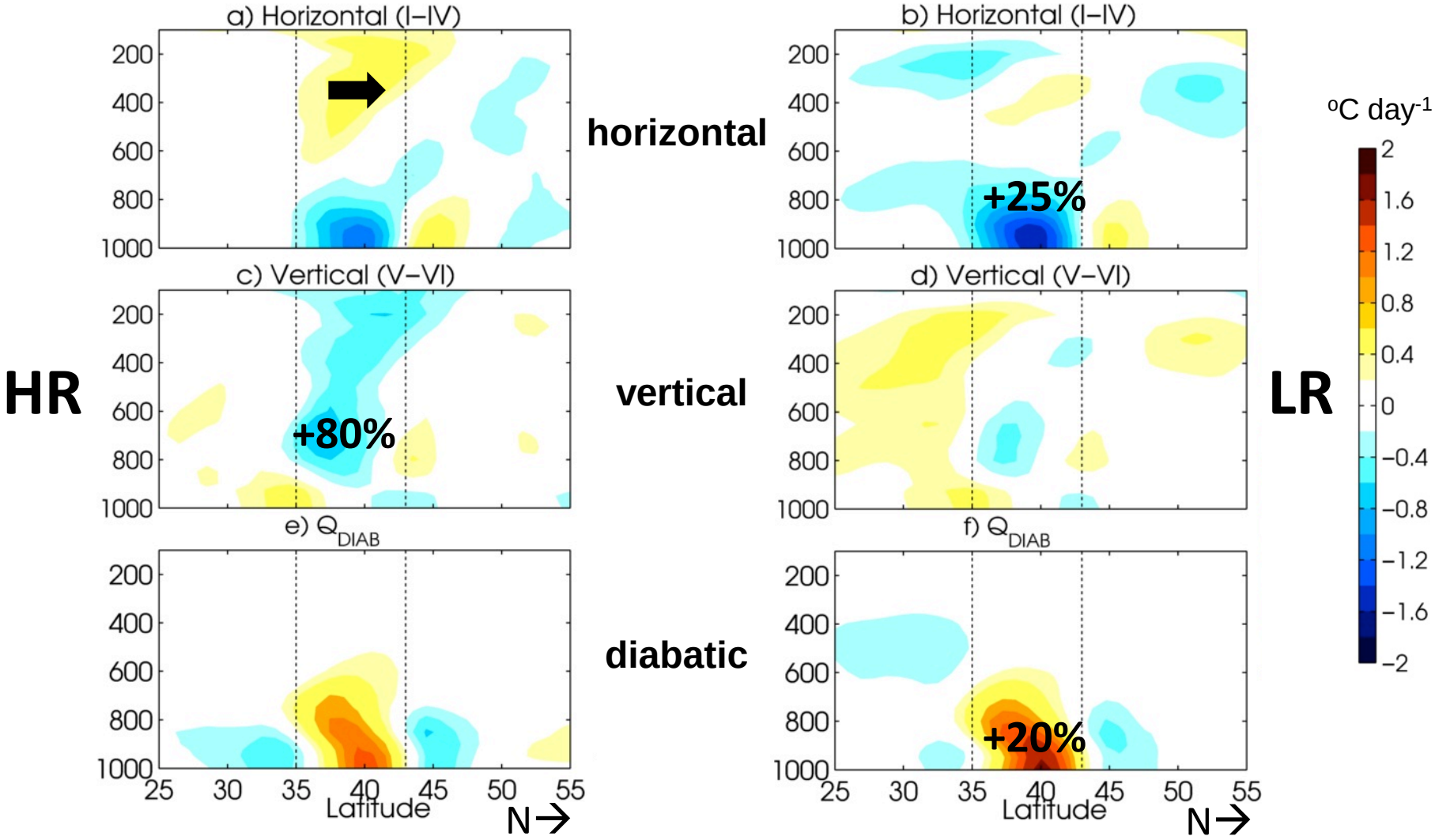
**HR**

**LR**



# Thermodynamic budget

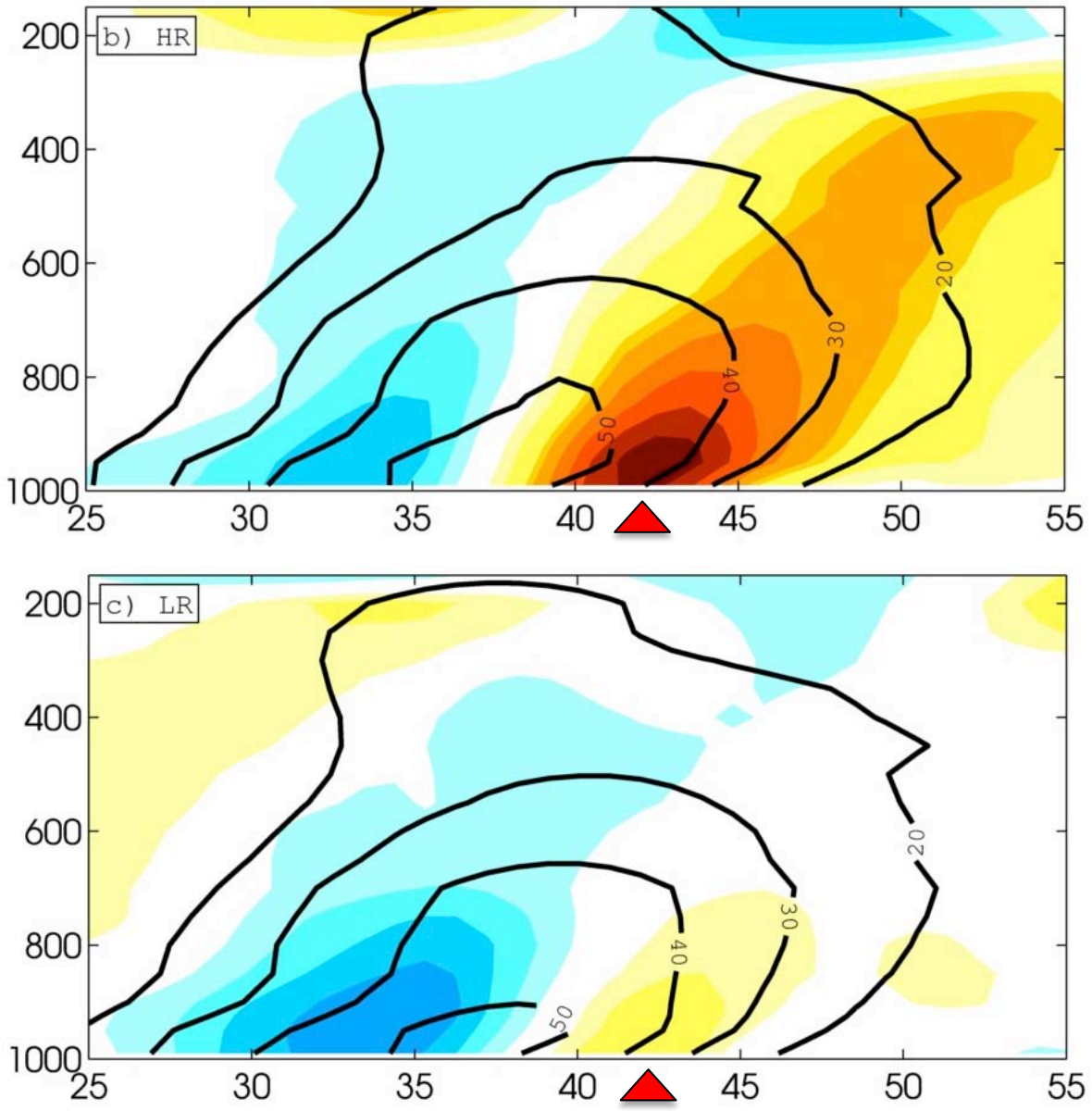
$$-u\frac{\partial \overline{T}}{\partial x}-v\frac{\partial \overline{T}}{\partial y}+\frac{\partial}{\partial x}\overline{u'T'}+\frac{\partial}{\partial y}\overline{v'T'}+\left[\frac{\kappa}{p}\overline{\omega}\,\overline{T}-\overline{\omega}\frac{\partial \overline{T}}{\partial p}\right]+\left[\frac{\kappa}{p}\overline{\omega'T'}-\frac{\partial \overline{\omega'T'}}{\partial p}\right]=\overline{Q}$$



# Eddy response

**HR**

**LR**




(line) mean $\overline{v'\theta_E'}$

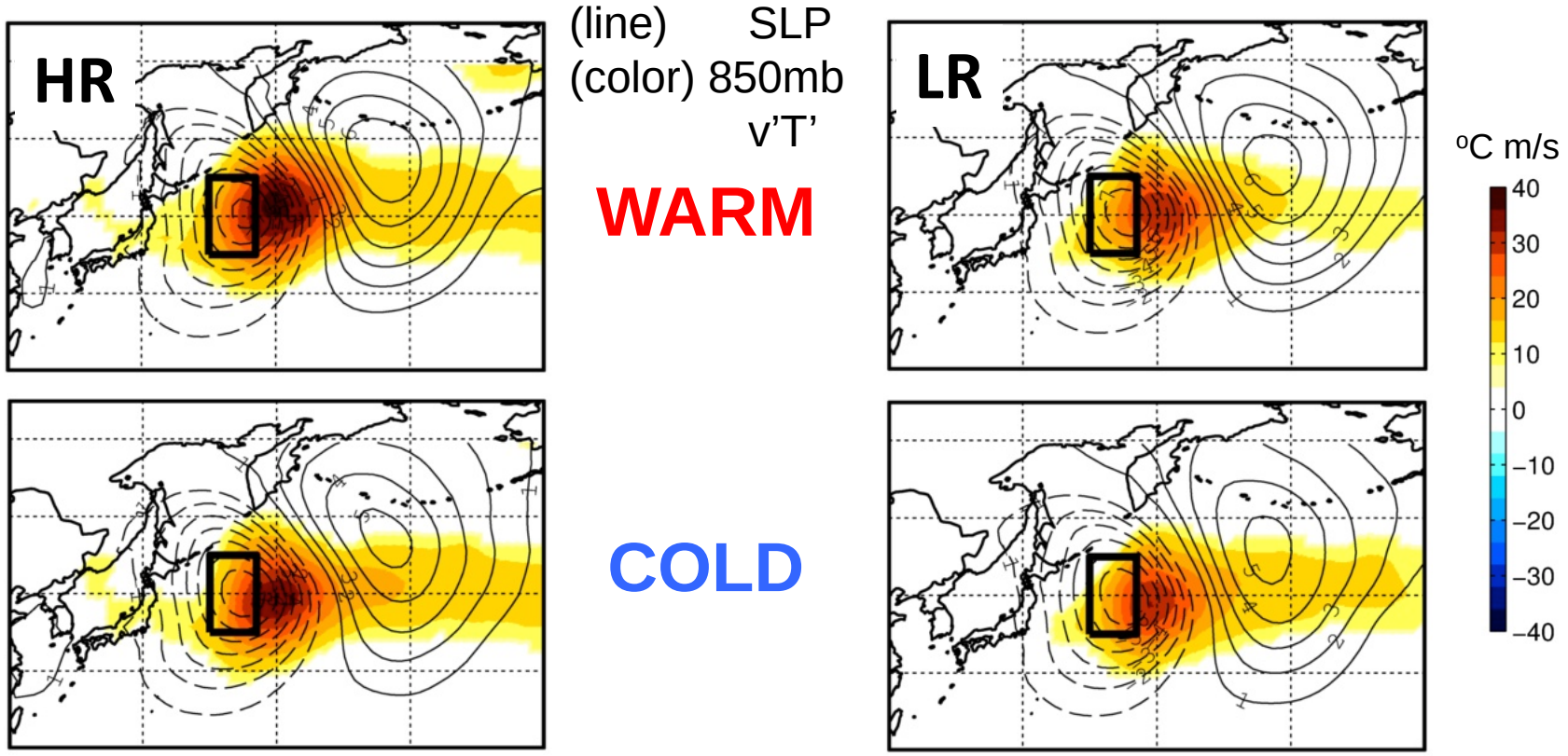
(color) $\Delta\overline{v'\theta_E'}$

▲ = climo SST front

$^{o}C\ m\ s^{-1}$

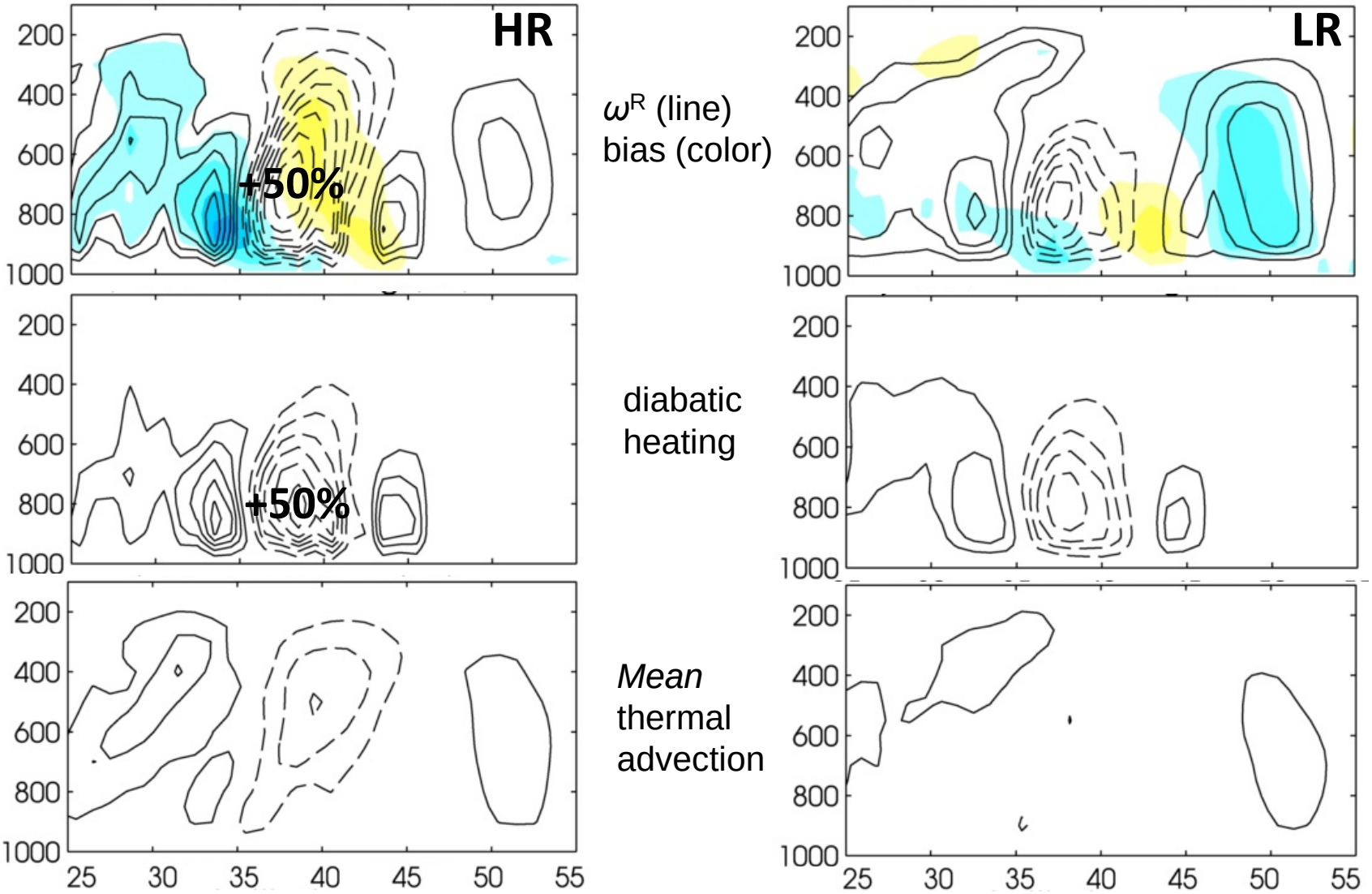
8
6.4
4.8
3.2
1.6
0
−1.6
−3.2
−4.8
−6.4
−8

# Storm-centric response



# $\omega$ budget

$$\left(\bar{\sigma}\nabla^2 + f^2\frac{\partial^2}{\partial p^2}\right)\omega^R = \nabla^2\left[V\cdot\nabla\left(-\frac{\partial\phi}{\partial p}\right)\right] + f\frac{\partial}{\partial p}\left[V\cdot\nabla(\zeta+f)\right] - \frac{\kappa}{p}\nabla^2 Q$$

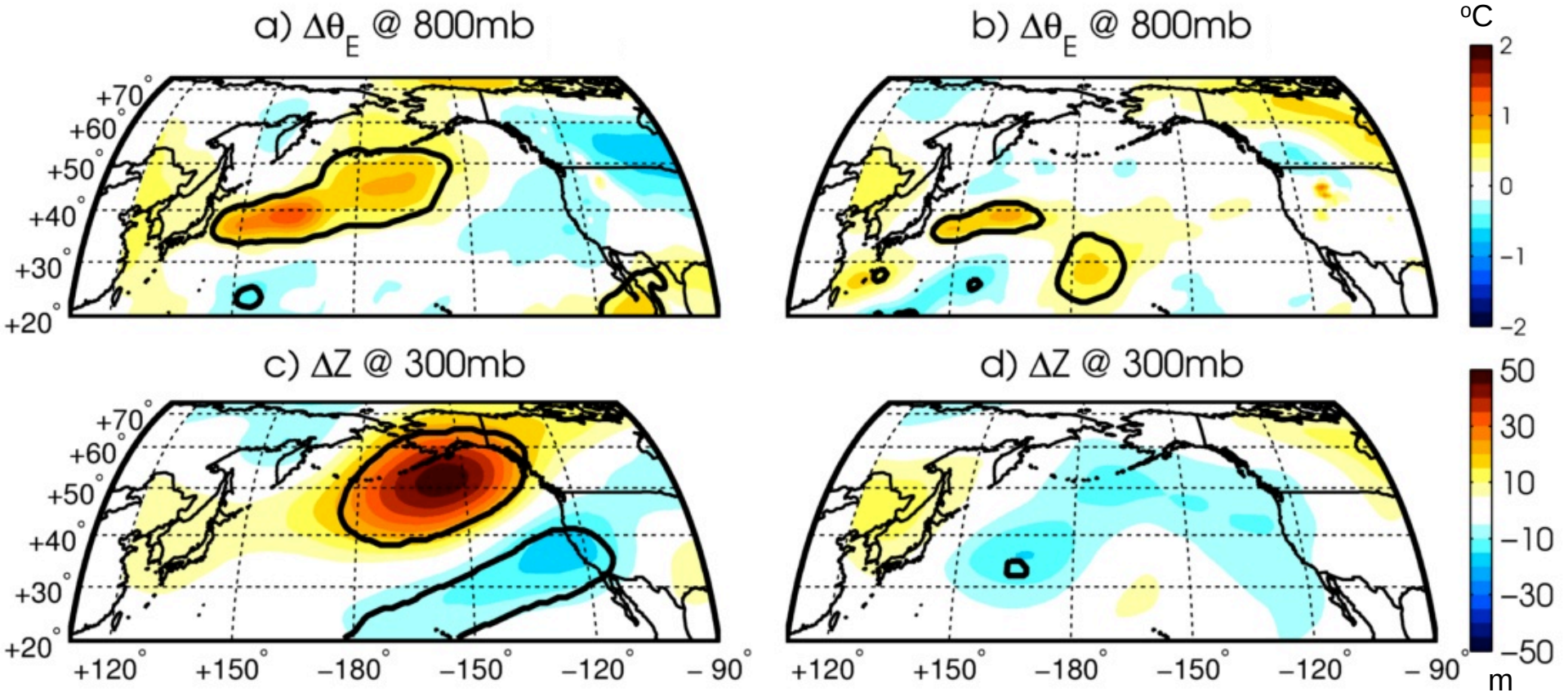



$\omega^R$ (line)
bias (color)

diabatic
heating

*Mean*
thermal
advection

# Remote response

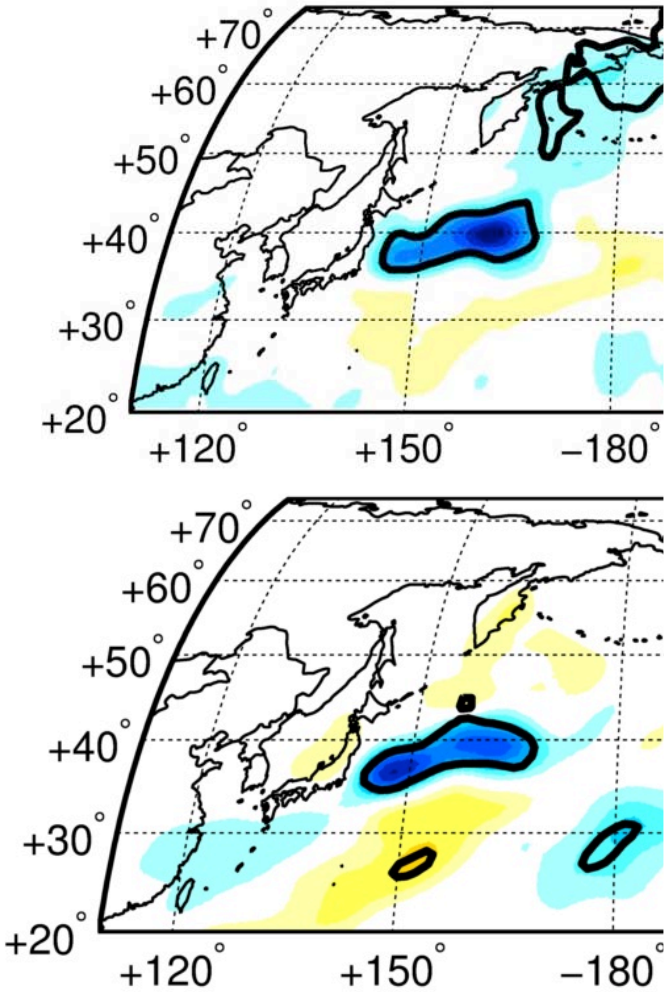


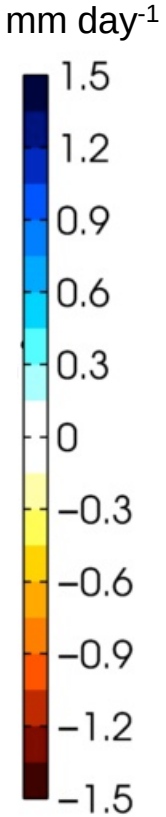
# Sensible impact

## Precipitation response

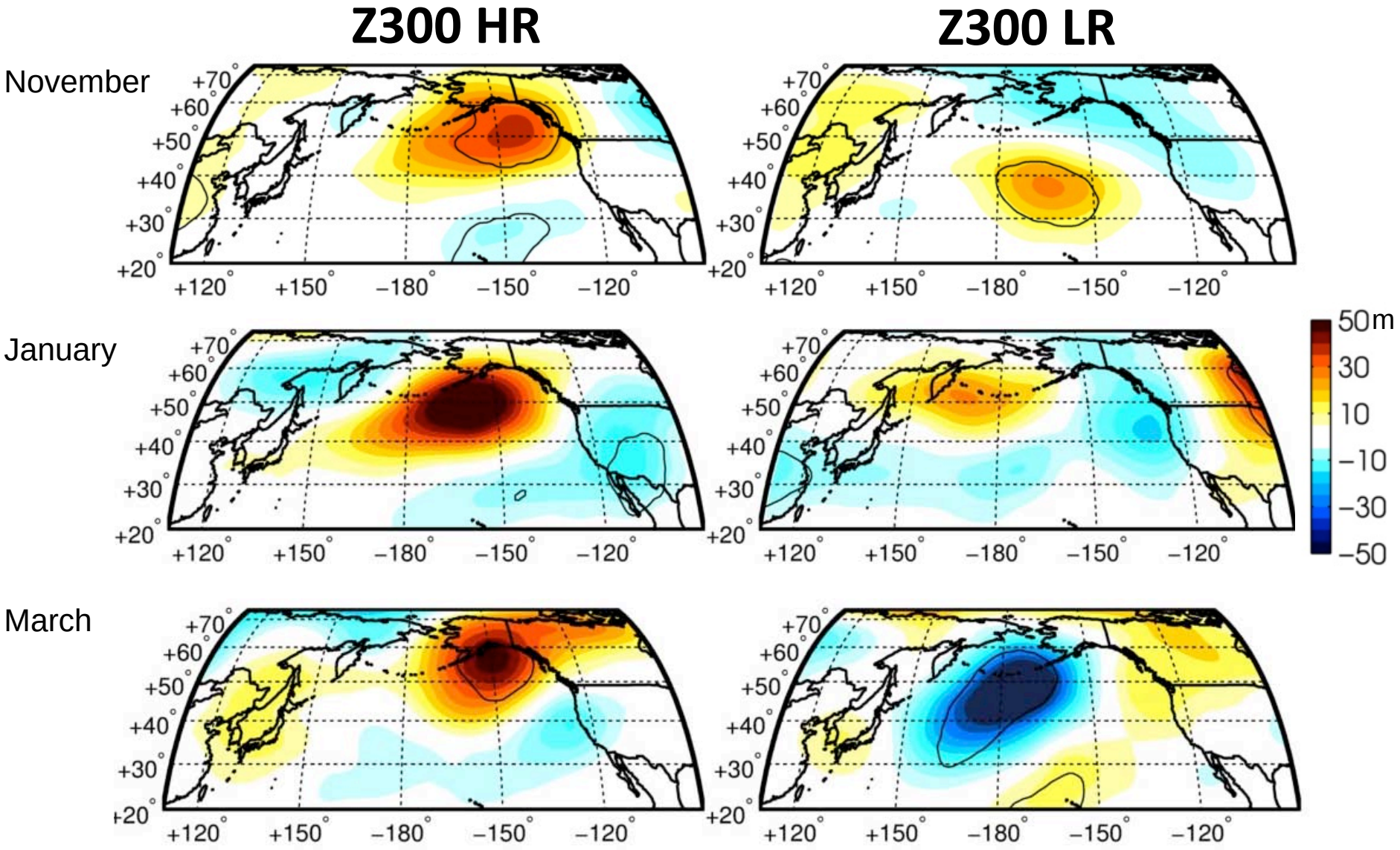
**HR**

**LR**



# Sensitivity to seasonality?



# Conclusion

- CAM5 is capable of capturing the atmospheric response to a shift in the Oyashio SST front
  - ➢ BUT high-resolution is required (at least <1°)
- SST induced warming is balanced by fundamentally different heat transport:

| | **high-res (0.25°)** | **low-res (1°)** |
|---|---|---|
| Mean vs. eddy | Eddy | Mean |
| Horizontal vs. vertical | Vertical | Horizontal |

- Implication for coupled variability?