From microstructure to global teleconnections: internal ocean variability forces atmospheric variability

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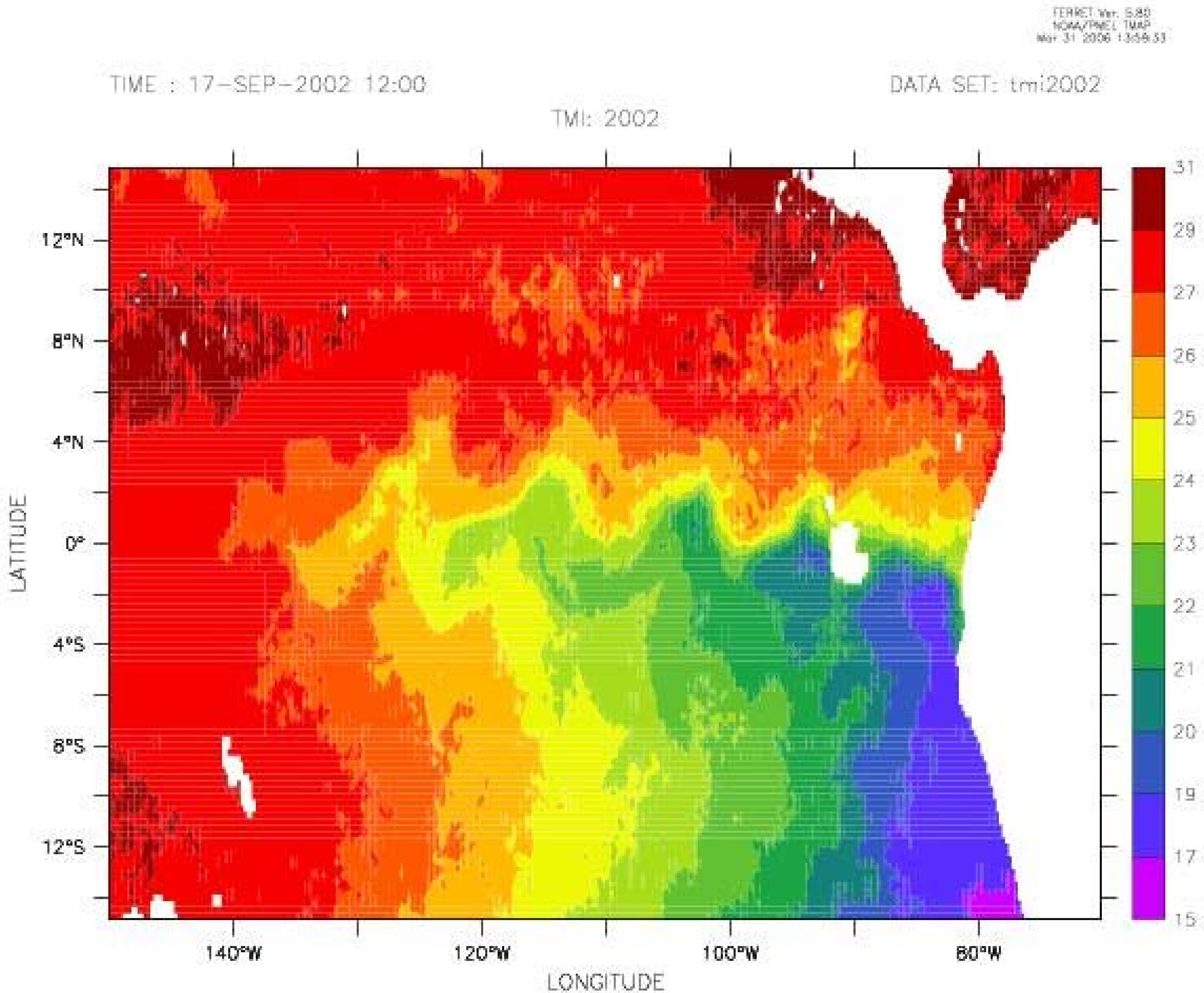
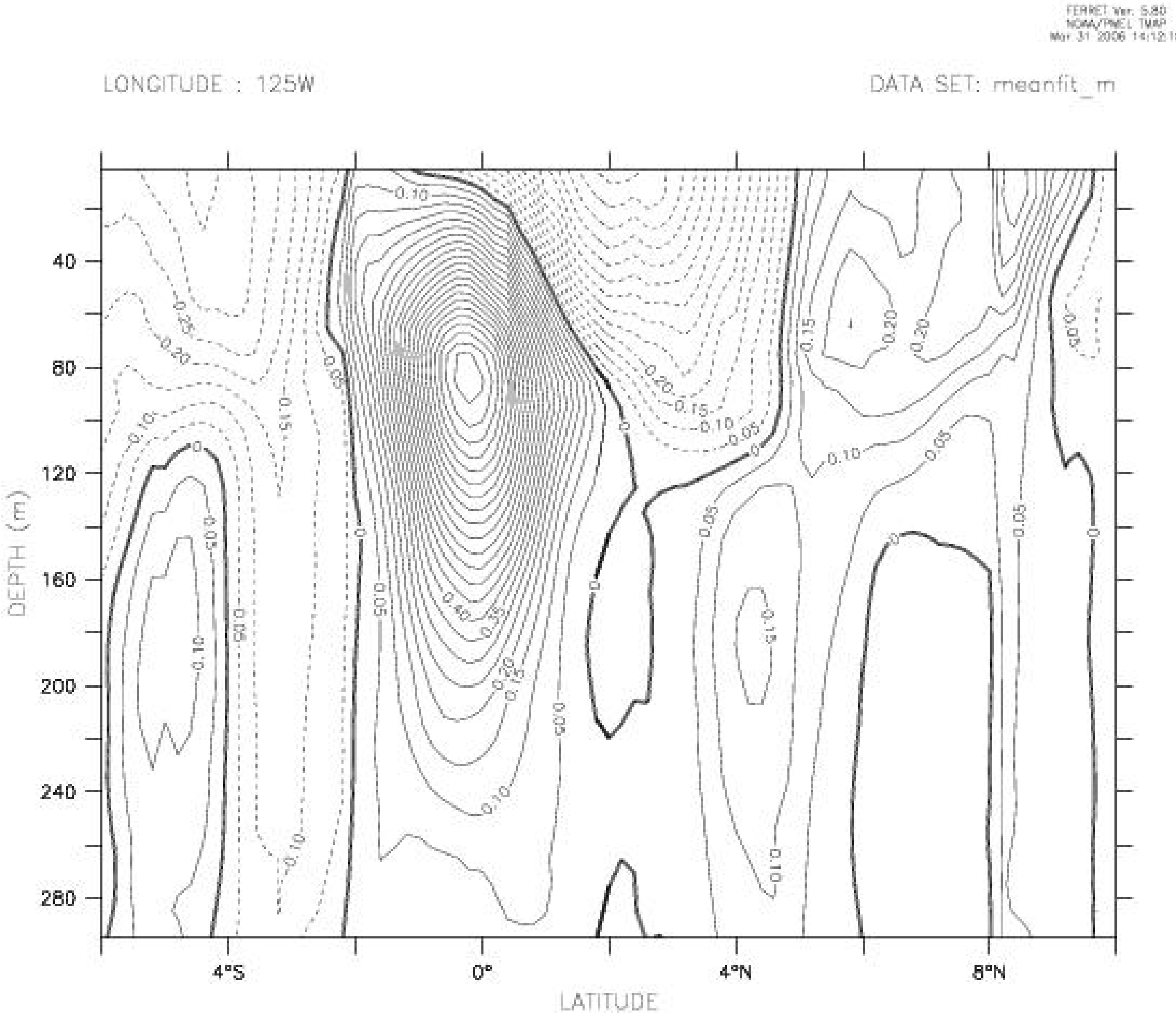
IMAGE workshop, NCAR, 5/18/06

From equatorial mixing to rainfall in Boulder

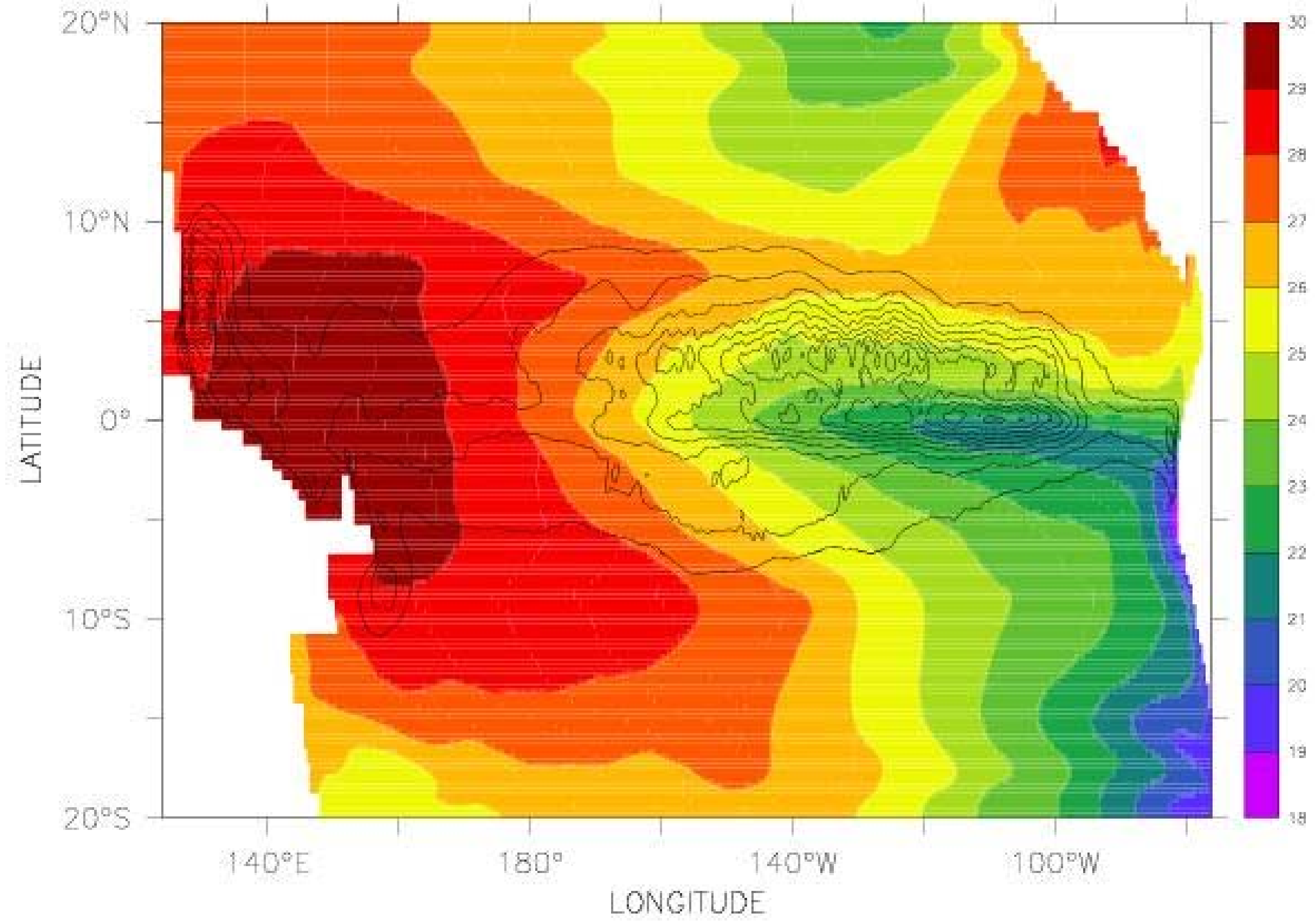
- Tropical Instability Waves, background
- the equatorial ocean heat budget
- the structure of TIW heating
- nonlinear effects
- atmospheric response on interseasonal to interannual time scales



SST from SSMI, 9/17/02



Zonal velocity at 125W (Johnson et al., 2000)



SST and EKE from eddy resolving Gent & Cane model

The Temperature Equation

The model equations for ML heat and thickness are (Gent and Cane, 1989):

$$\frac{\delta(hT)}{\delta t} + \nabla \cdot (\vec{u}hT) + \frac{\delta(w_e T)}{\delta s} = \frac{1}{\rho c_p}\frac{\delta Q}{\delta s} + hD \qquad (1)$$

$$\frac{\delta h}{\delta t} + \nabla \cdot (\vec{u}h) + \frac{\delta w_e}{\delta s} = 0 \qquad (2)$$

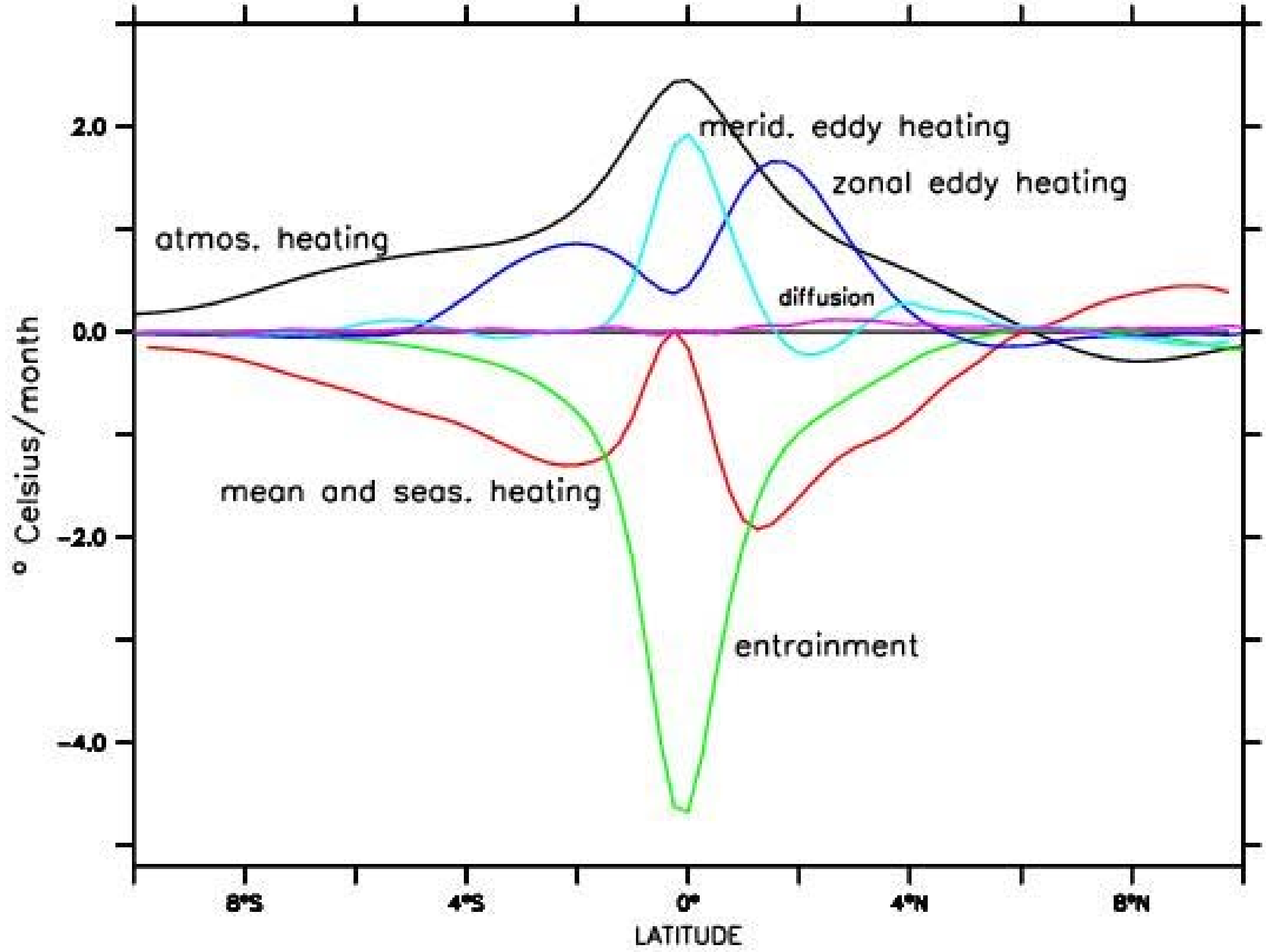
combining (1) and (2) yields:

$$h\frac{\delta T}{\delta t} + h\vec{u} \cdot \nabla T + w_e \frac{\delta T}{\delta s} = \frac{1}{\rho c_p}\frac{\delta Q}{\delta s} + hD \qquad (3)$$

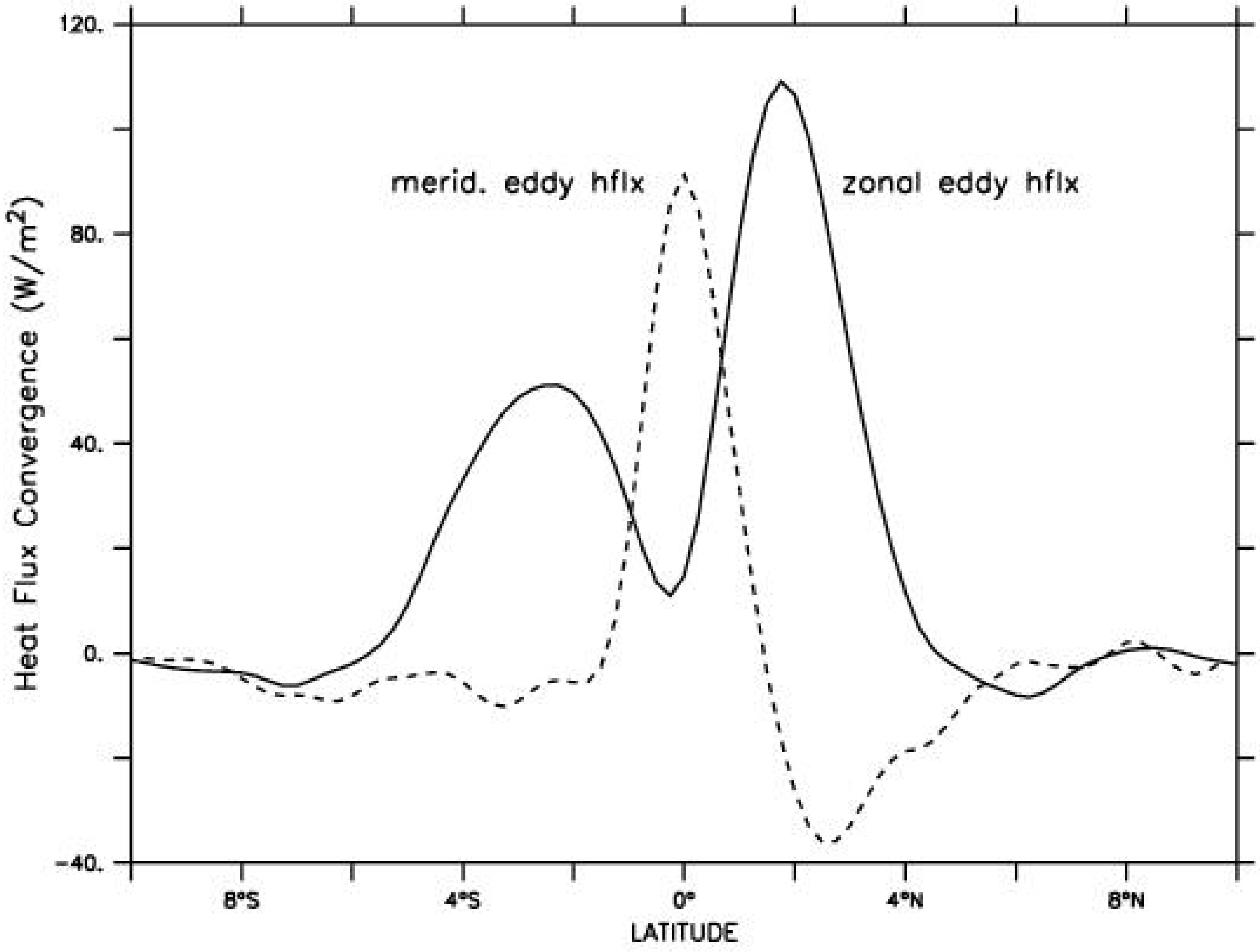
$$\frac{\delta T}{\delta t} + \vec{u} \cdot \nabla T + \frac{w_e}{h}\frac{\delta T}{\delta s} = \frac{1}{h\rho c_p}\frac{\delta Q}{\delta s} + D \qquad (4)$$

... and Reynolds averaging leads to:

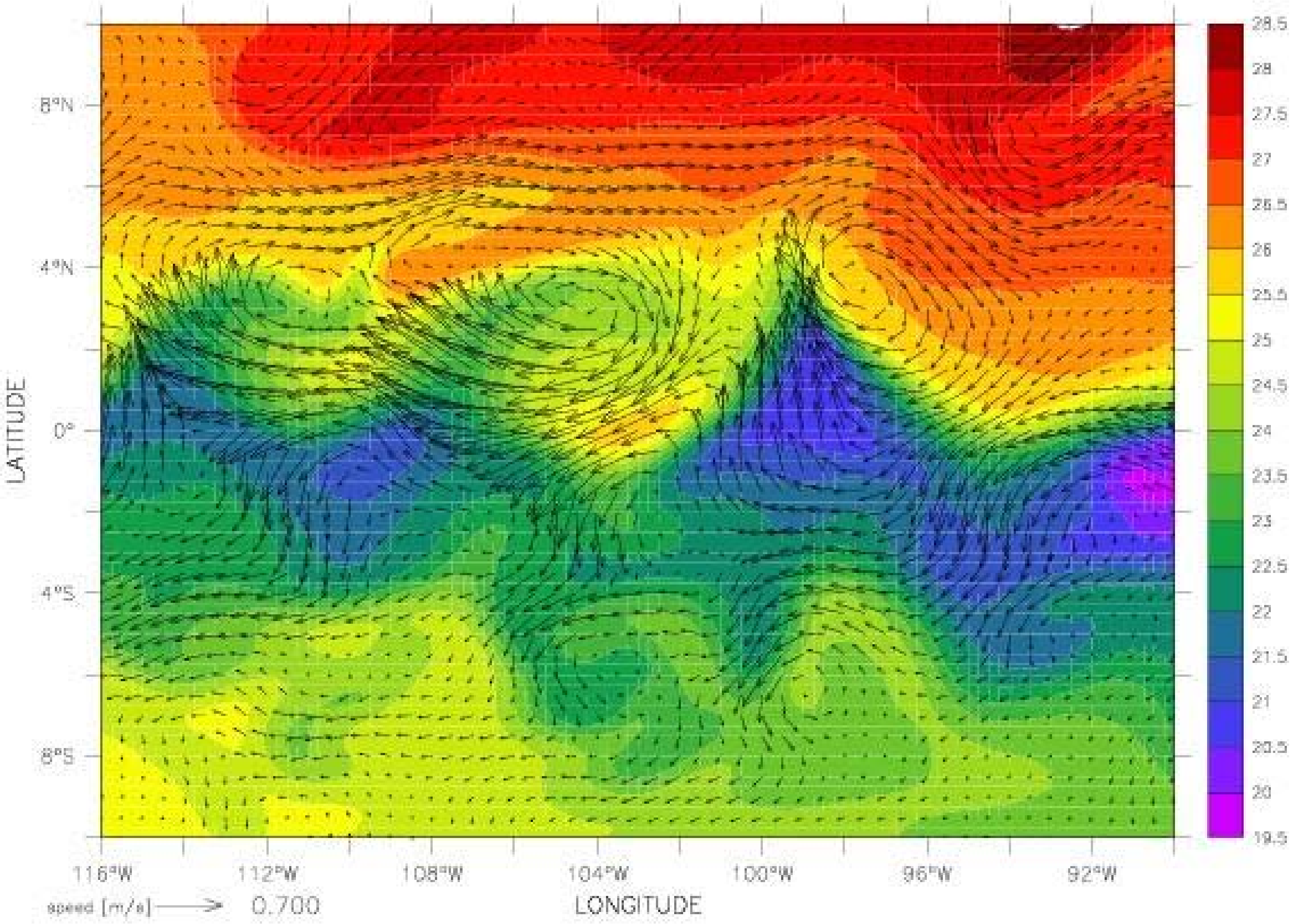
$$\overline{\vec{u_s} \cdot \nabla T_s} + \overline{\vec{u_s} \cdot \nabla T'} + \overline{\vec{u'} \cdot \nabla T_s} + \overline{\vec{u'} \cdot \nabla T'} = \overline{q_{atmos}} - \overline{q_{ent}} + \overline{q_{diff}}, \qquad (5)$$



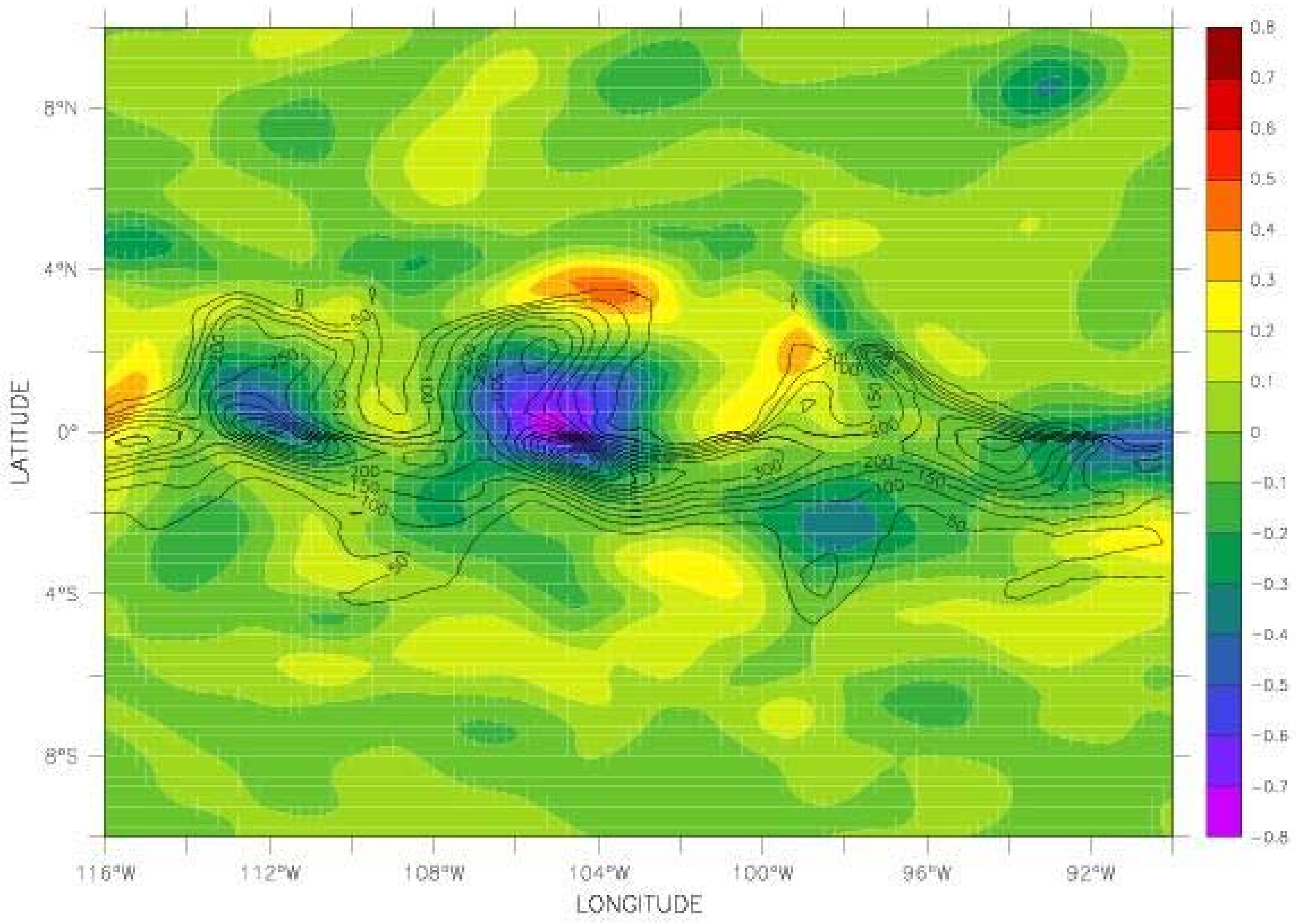
Temperature Advection between 145W-135W



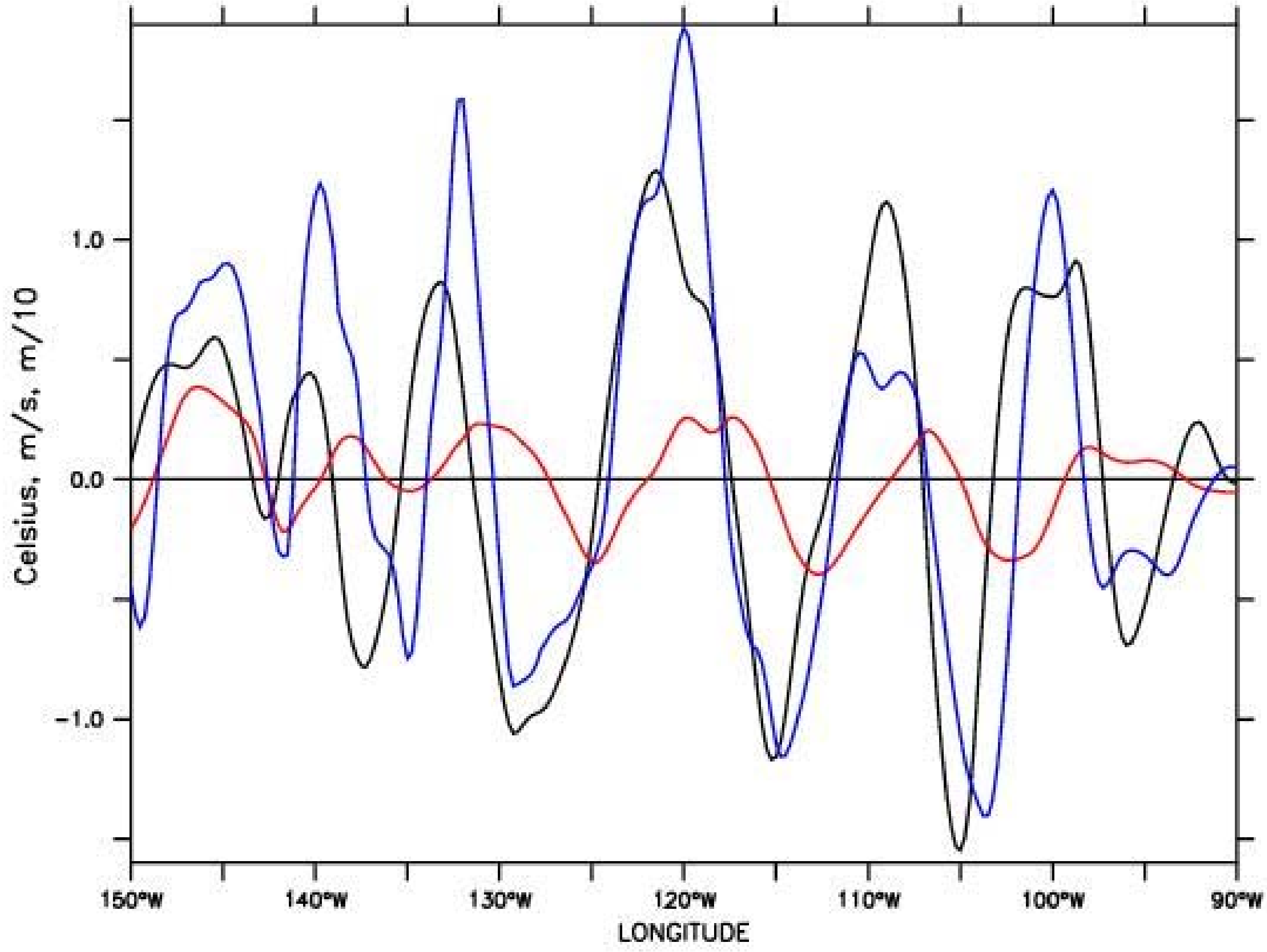
TIW heat flux convergence between 145W-135W.



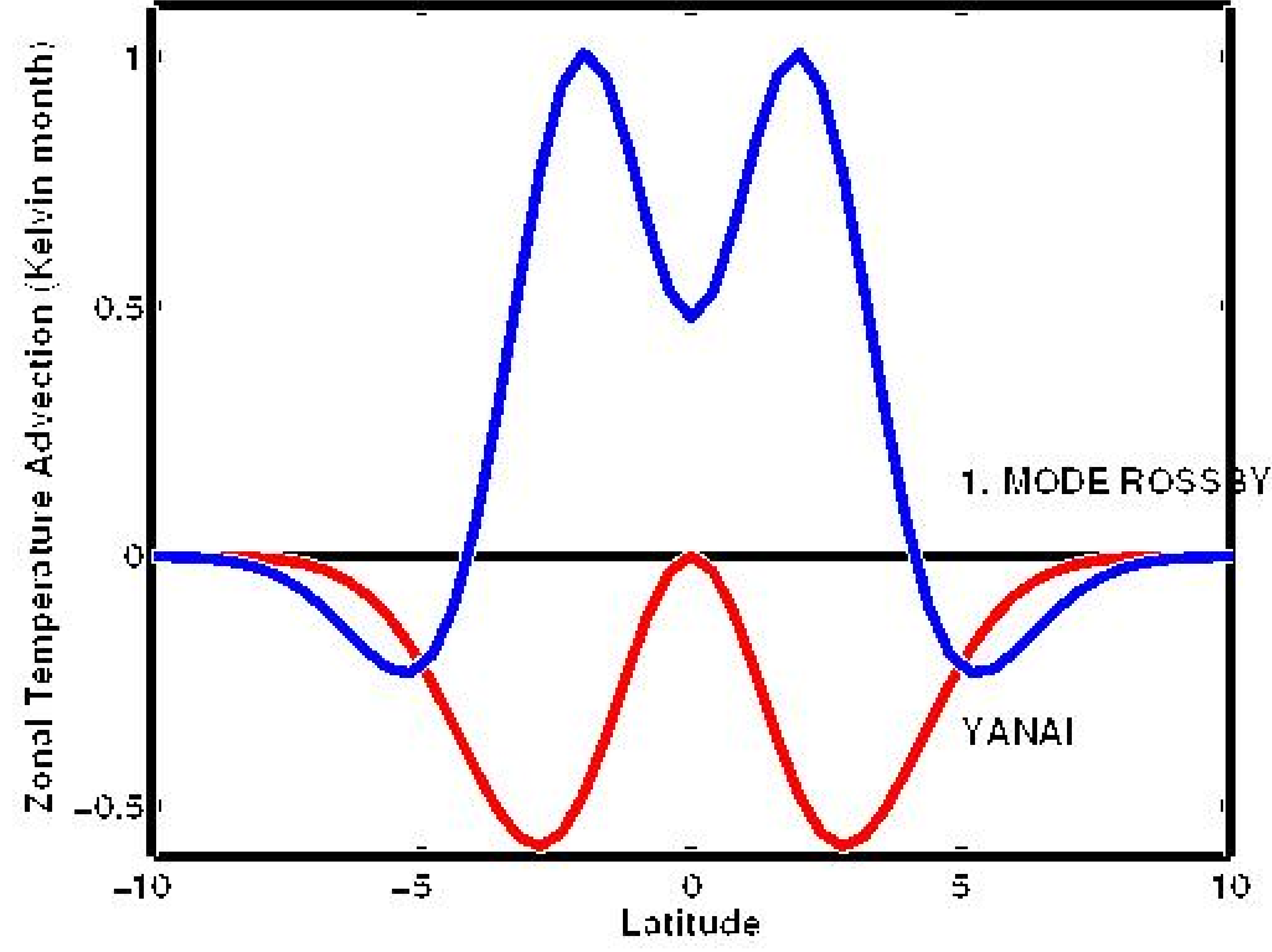
Snapshot of SST and mixed layer velocity



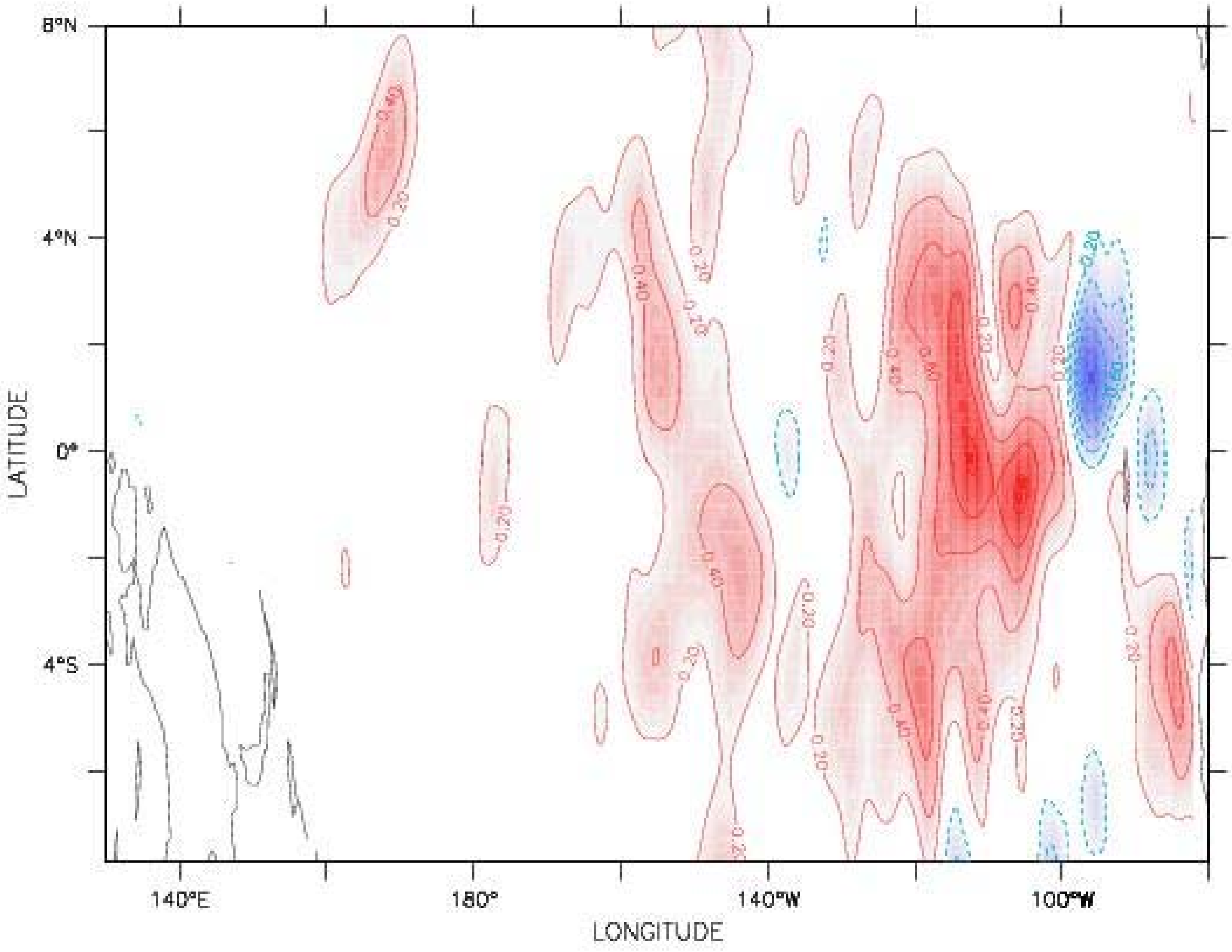
Snapshot of zonal velocity and entrainment at ML depth



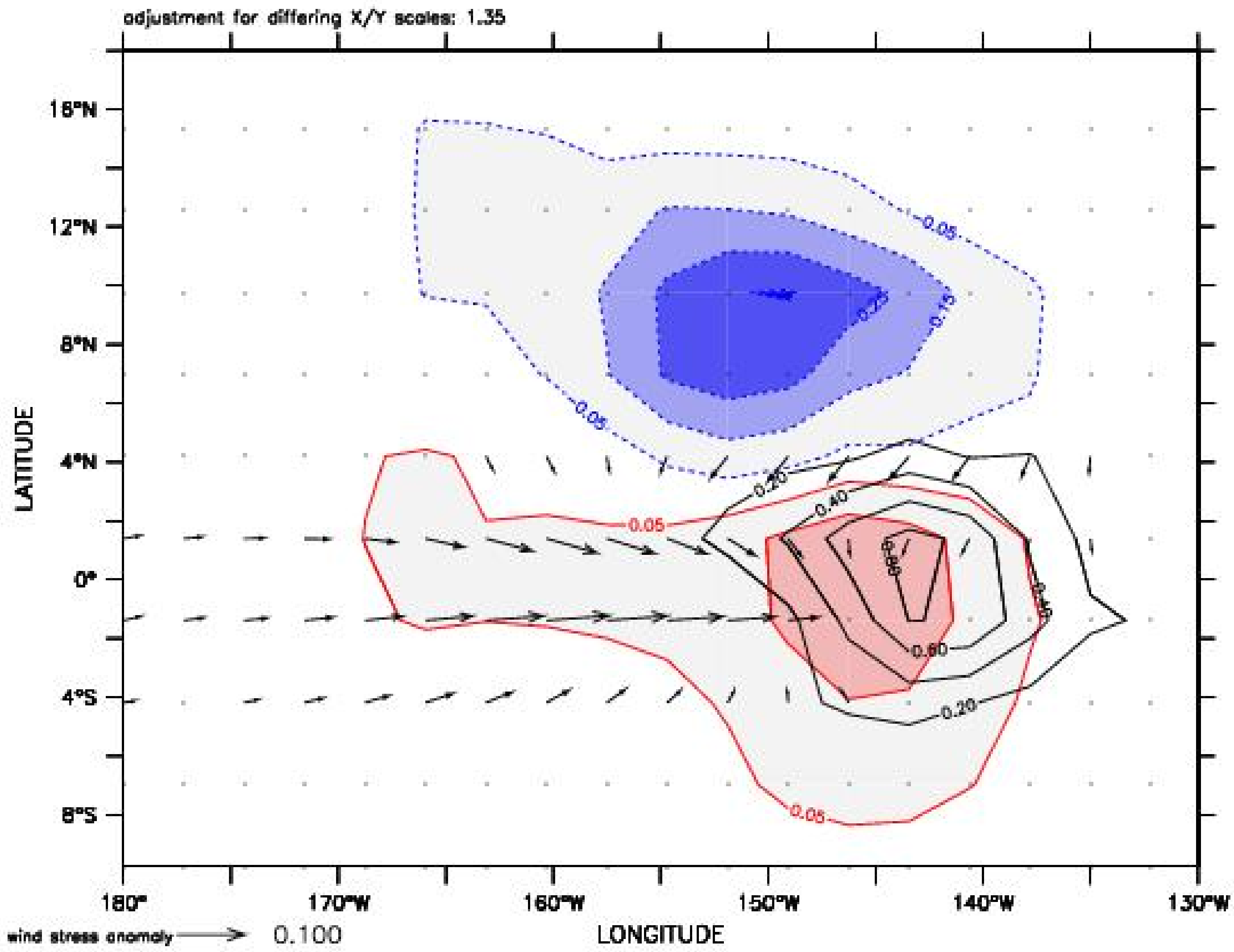
Snapshot along 2N of anomalies of:
SST (black), mixed layer depth (blue), zonal velocity (red)



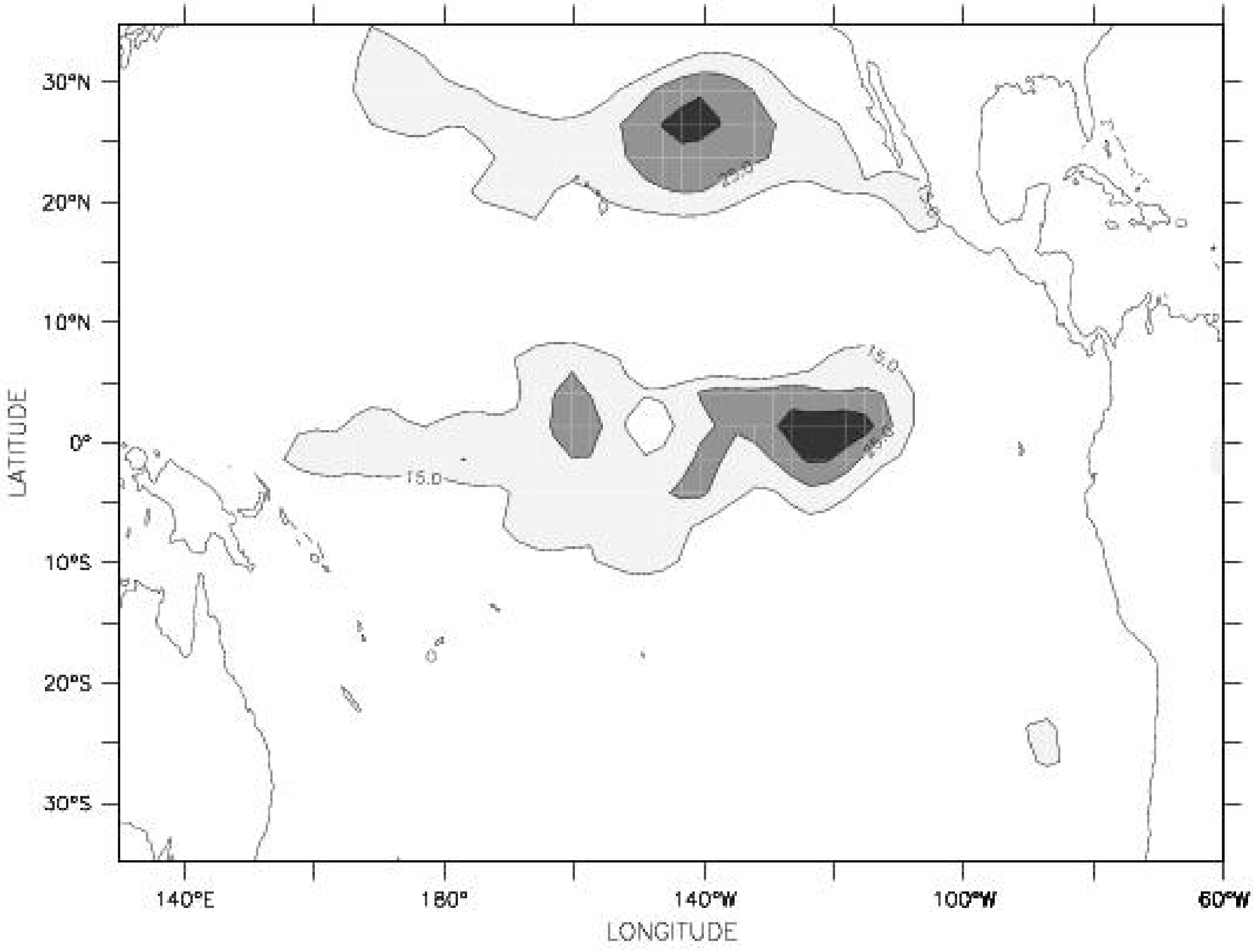
Zonal Temperature Advection (Kelvin month)
1
0.5
0
−0.5
−10
−5
0
5
10
Latitude
1. MODE ROSSBY
YANAI



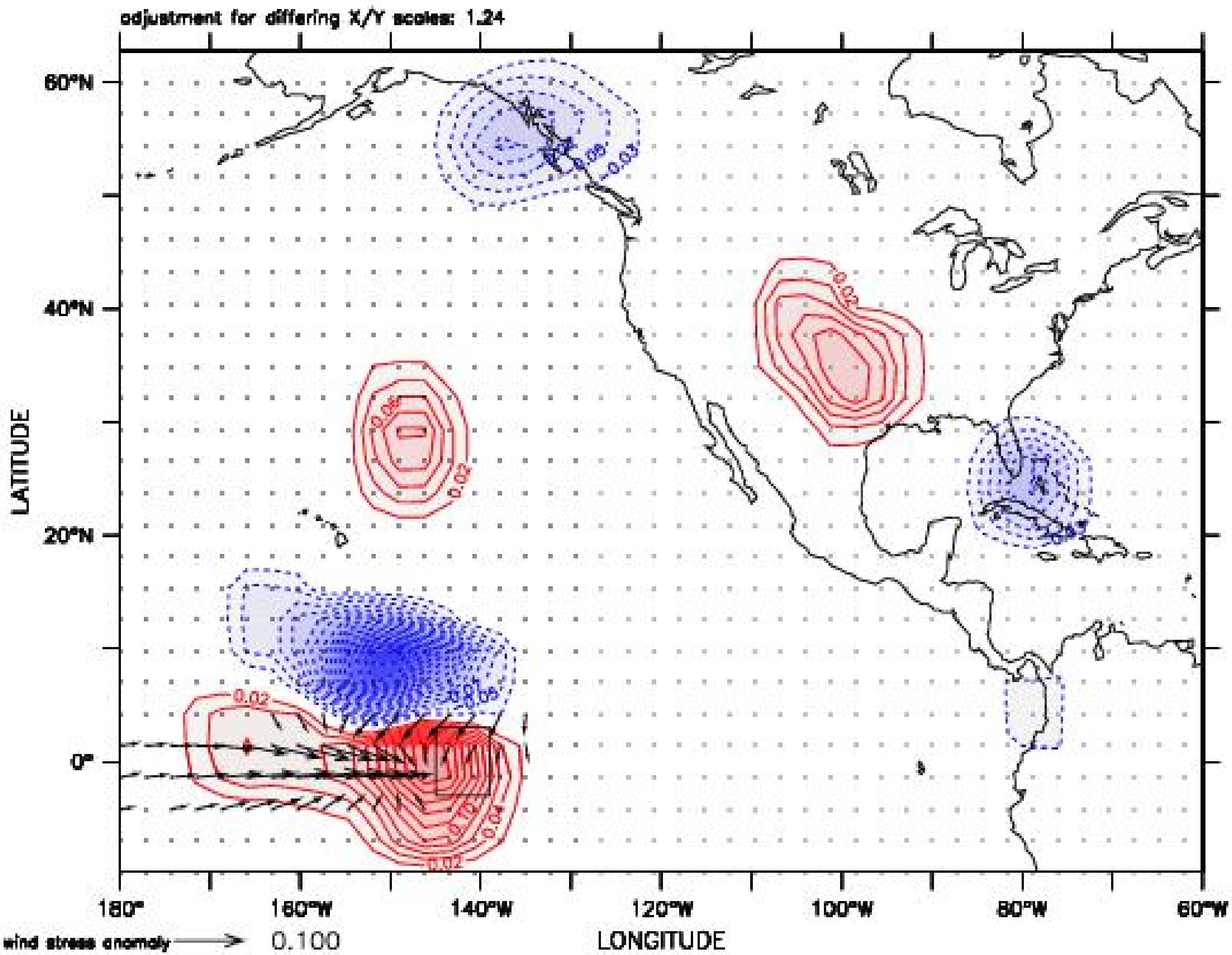
Sample monthly SST anomaly from 100 year run



Regression of wind and rain anomalies on SST anomaly at 0N/143W



Increase in wind stress anomalies in CAM due to TIWs



Regression of rain and wind that is sign. correlated with SST var. in box

Conclusions

- The zonal heat flux convergence of TIWs is much larger than the meridional
- TIWs do not stir heat horizontally but pump heat from the atmosphere into the equatorial thermocline
- Due to their nonlinearity TIWs increase rainfall and wind variability on seasonal to interannual timescales.