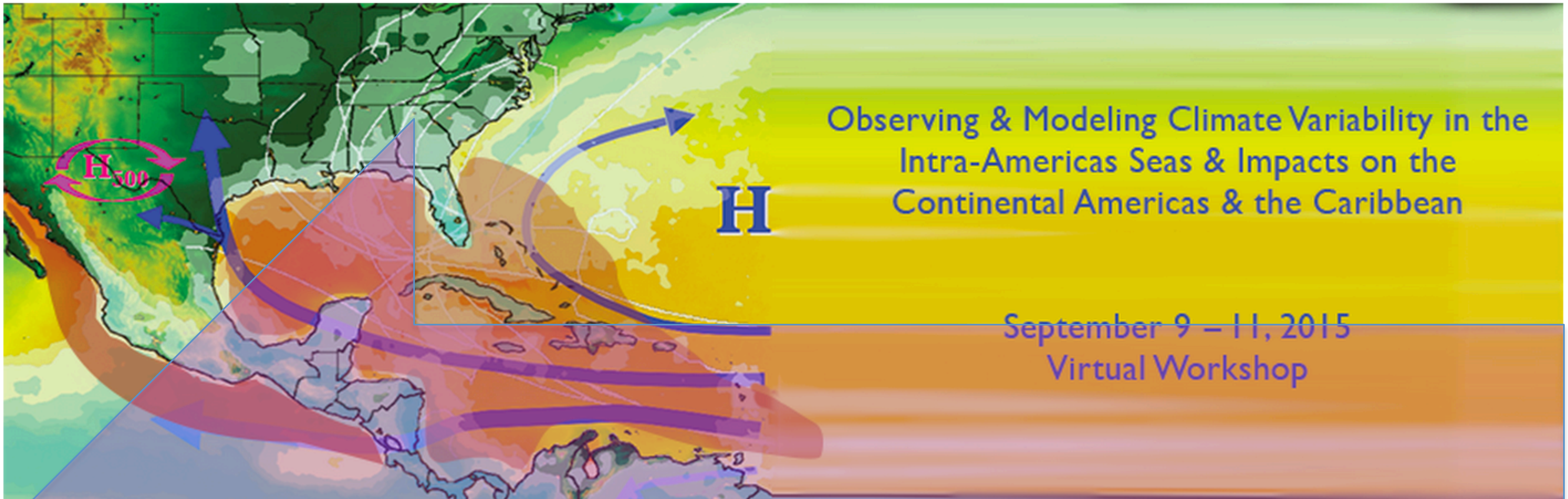


Shaping of IAS summer weather by zonal mean momentum

Brian Mapes and Patrick Kelly
RSMAS, University of Miami

Outline

- <[u]> a meaningful entity, not just a statistic
- Seasonal: Americas midsummer drying
- Interannual: regressions (ENSO entangled)
  - Tropical cyclones, precip

What is <[u]> ?

- [u] is zonal mean
  - makes $-\partial\Phi/\partial x$ term ~vanish on RHS
  - u^*v^* are 'eddy' deviations (Starr, Lorenz notation)

- <u> is vertical mean – 'barotropic'
  - makes fv term ~vanish on RHS

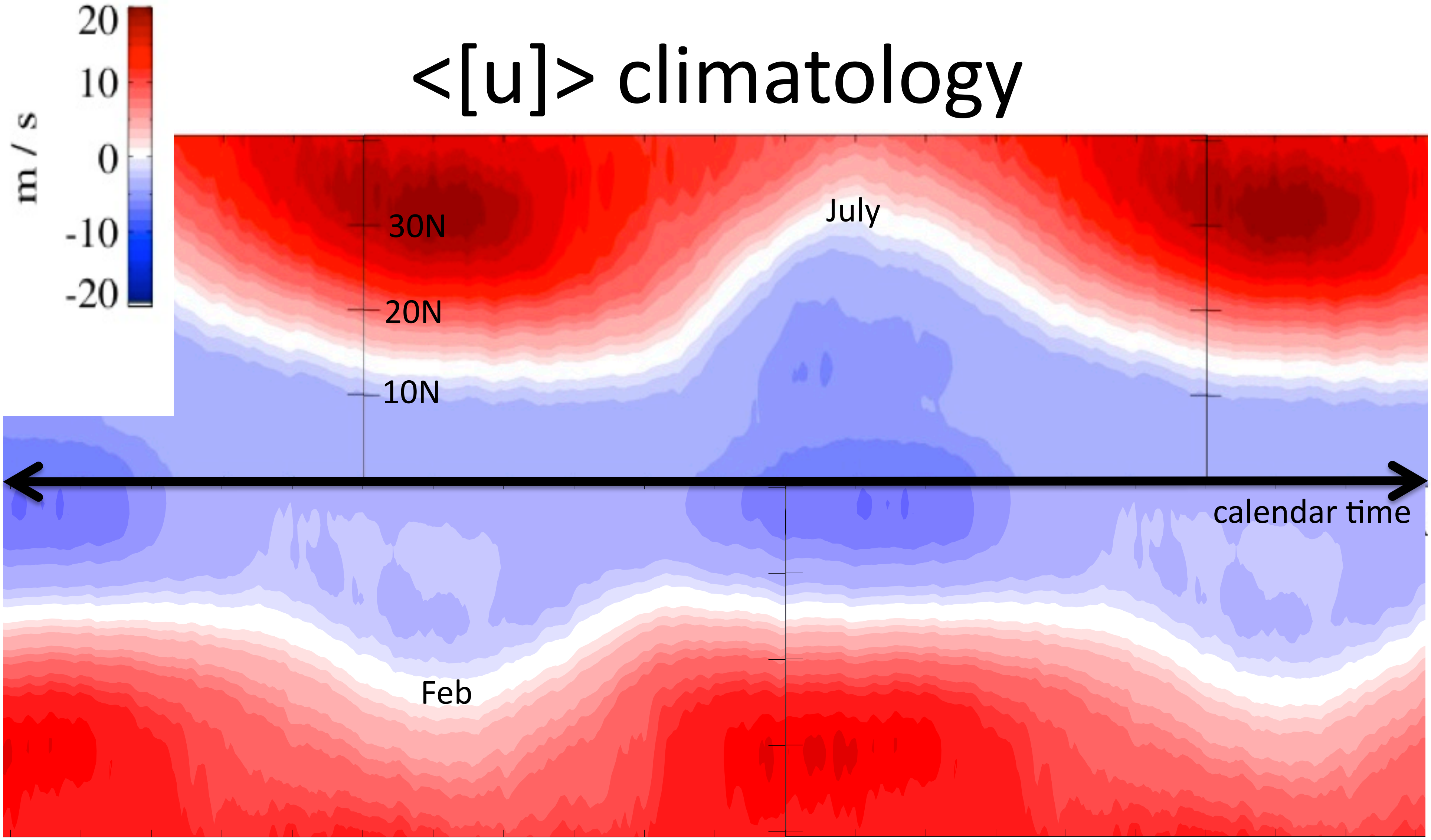
- <[u]> is ***barotropic zonal mean momentum***
  - a function of latitude and time only
  - AAM is its (weighted) latitudinal integral

"Meaningful" averaging and <[u]>

- <[u]> obeys an equation w/ few terms on RHS
- It thus has an existence *more substantive* than u
  - » an entity, a player, a climate sub-system
  - » more fundamental than a “jet” (isotach) or "pool" (isotherm)

- I'll speak of <[u]> as a wind that "advects" scalars. But of course advection is by local u(lon,p)
  - » of which <[u]> is one ‘component’...

<[u]> climatology

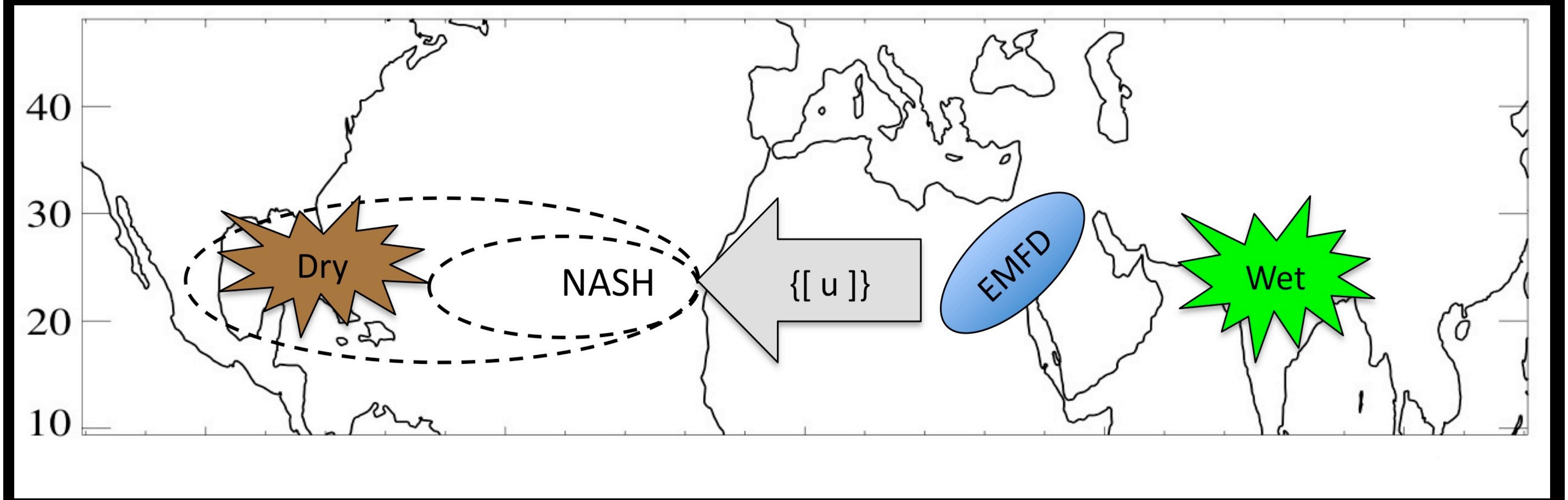


NCEP R1 climatology

W. Atl. midsummer drying

driven ultimately by Asian monsoon, via

global zonal momentum dynamics

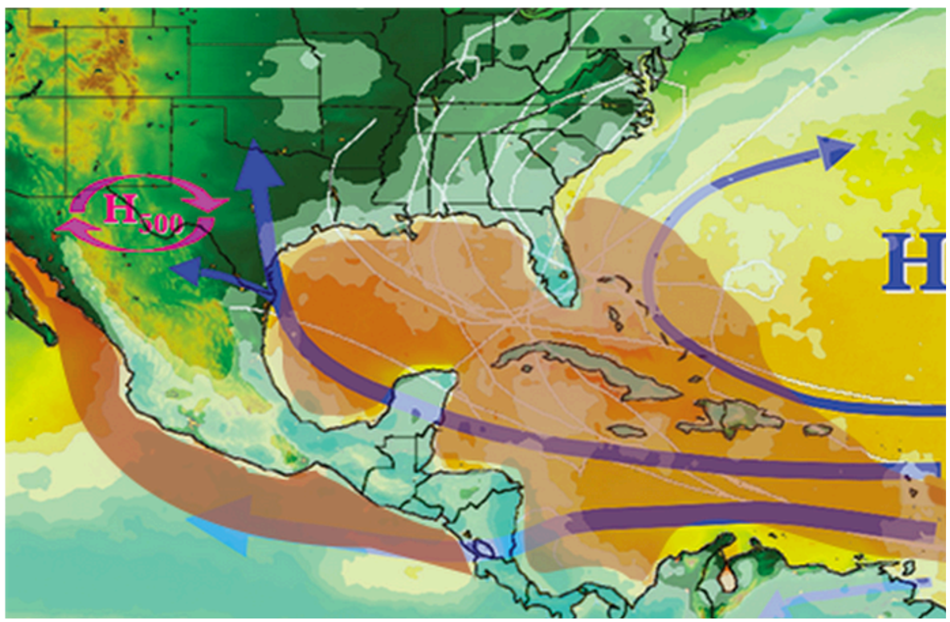


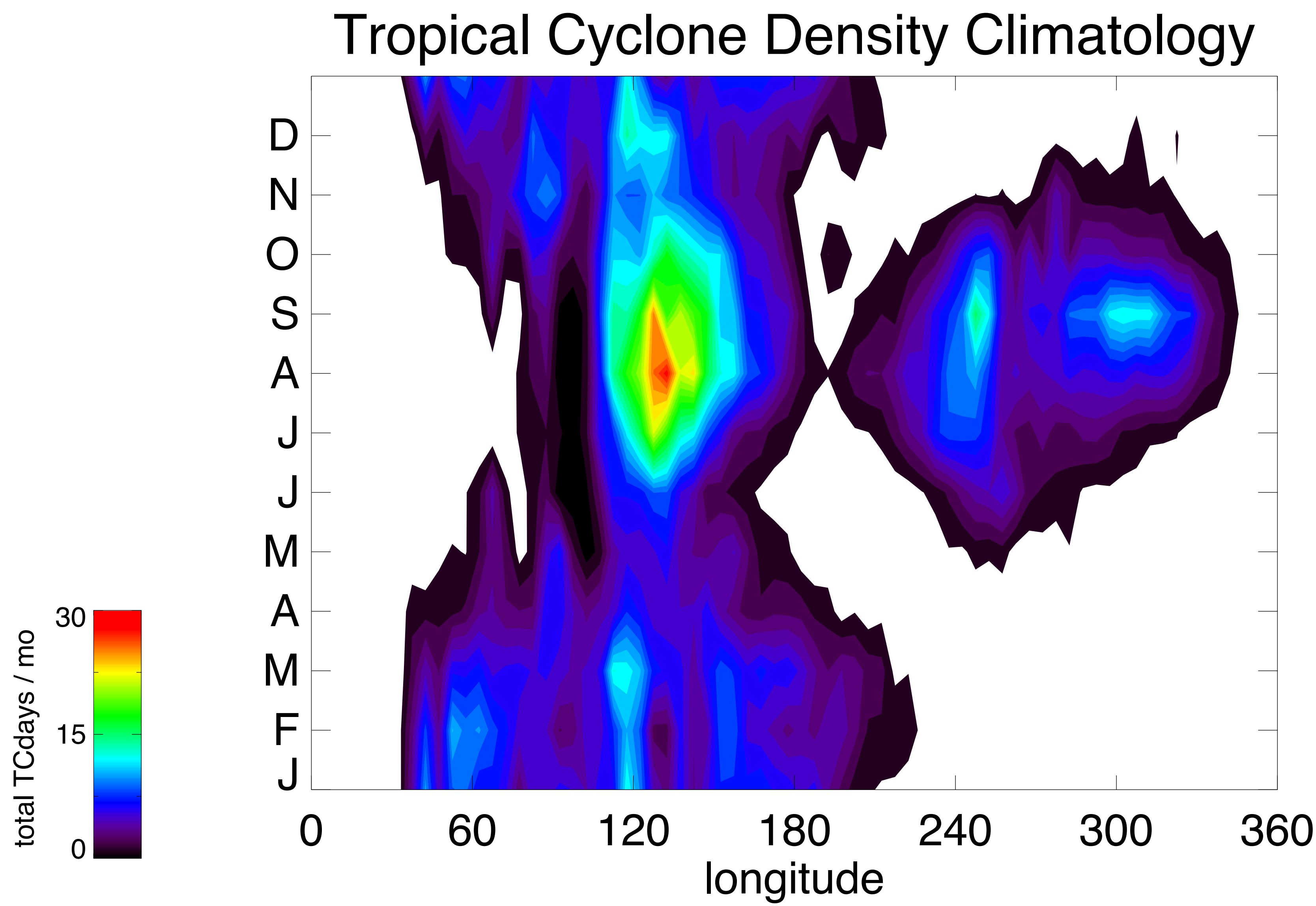
Kelly and Mapes 2011 obs. (JGR)

Kelly and Mapes 2013 model clincher (J. Climate)

If <[u]> shapes the anticyclones,

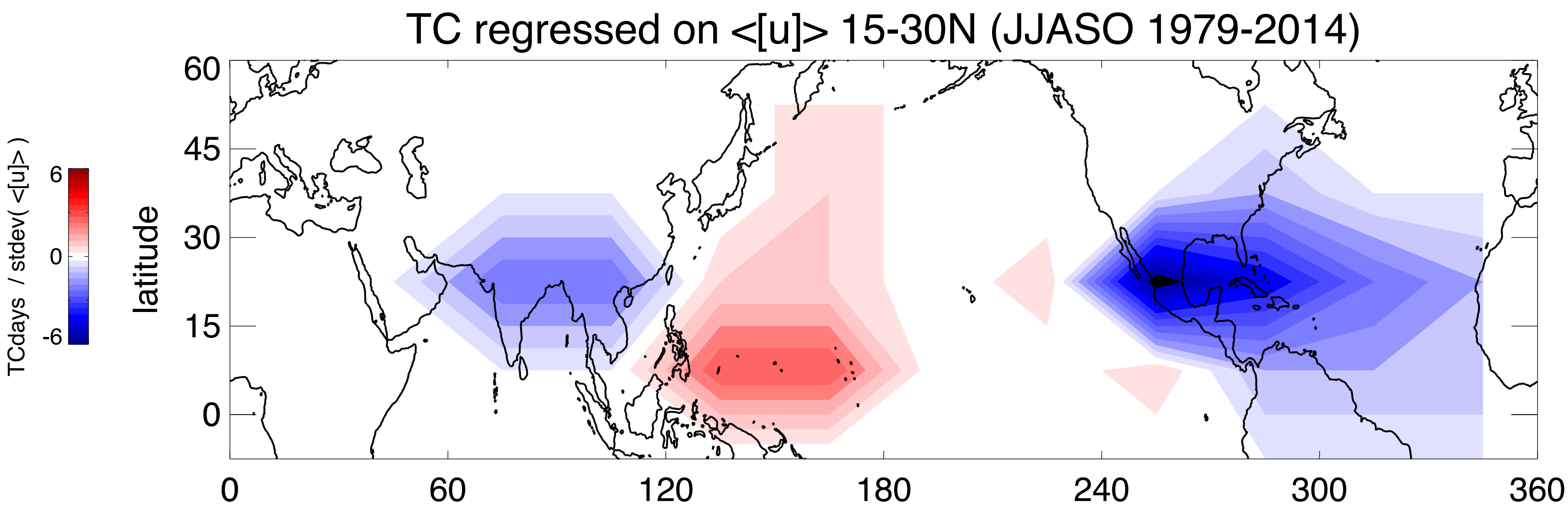
- *Pacific too?*
- *TC steering impacts as well as rain?*





Data: IBTrACS

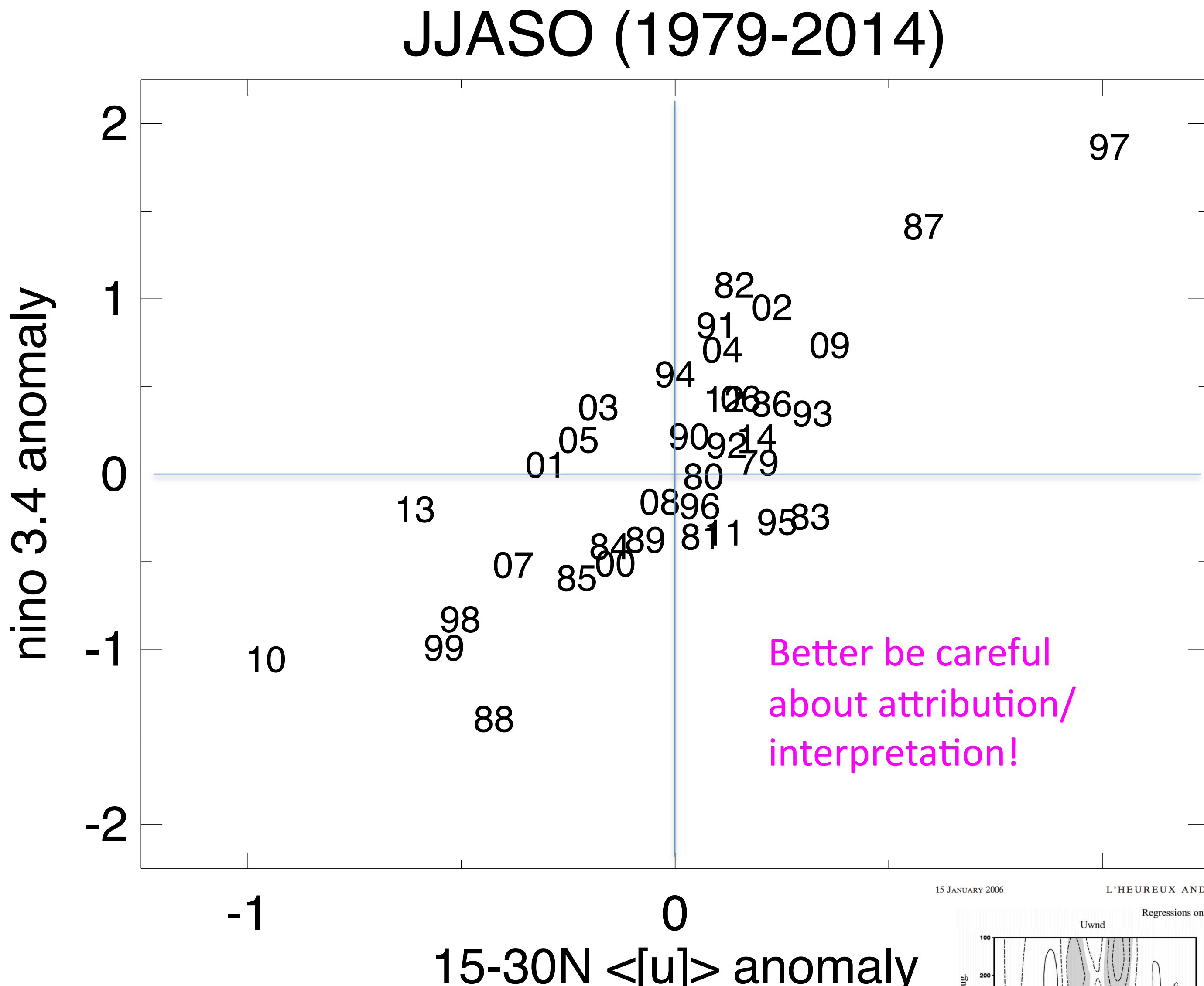
<[u]> regressed Cyclone Days in each grid cell

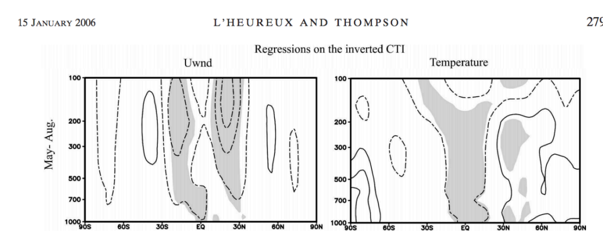


Subtropical westerlies negatively associated with IAS region TCs

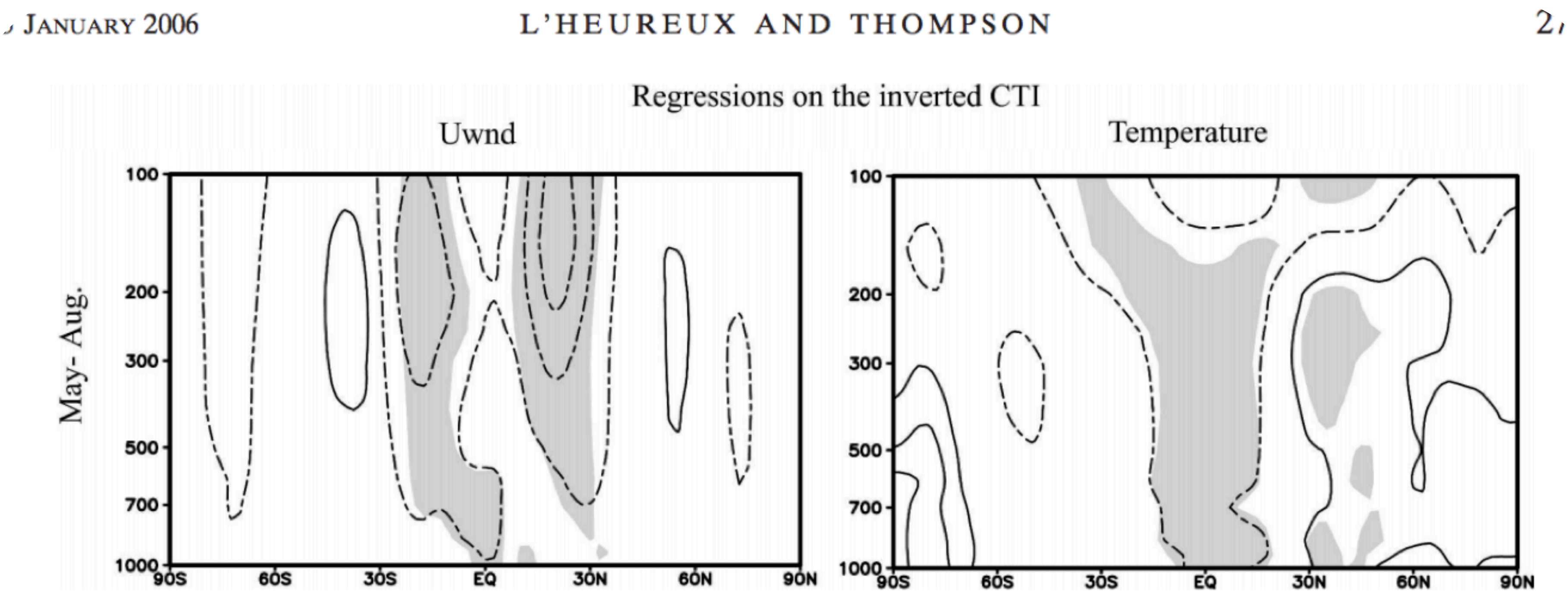
30x15deg bin size

But wait – ENSO affects <[u]> !





But wait – ENSO affects <[u]> !



- In thermal wind sense (EQ-pole T diff mnemonic works)
- Barotropic mean goes as upper levels in that mnemonic
- Shear goes as [u] in that mnemonic

Attribution to 2 factors

- Pure <[u]> regression: postulate this form:

$$TC = c_u \langle [u] \rangle + err_u$$

Optimize c_u by minimizing $RMS(err_u)$

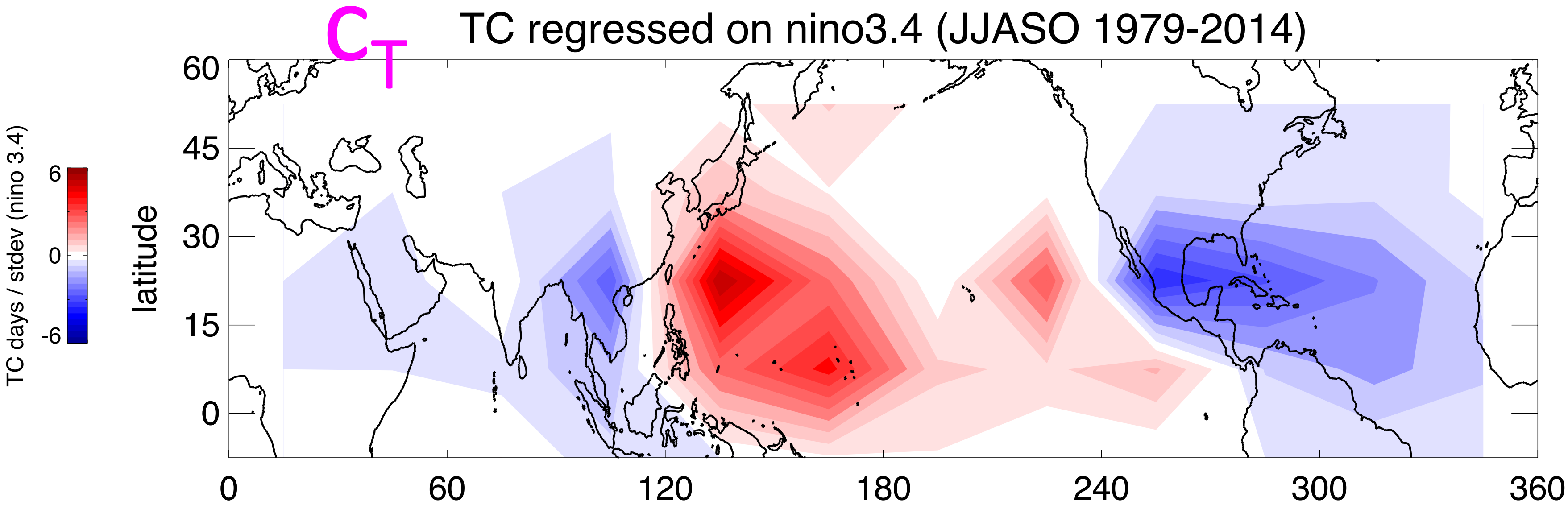
Attribution to 2 factors

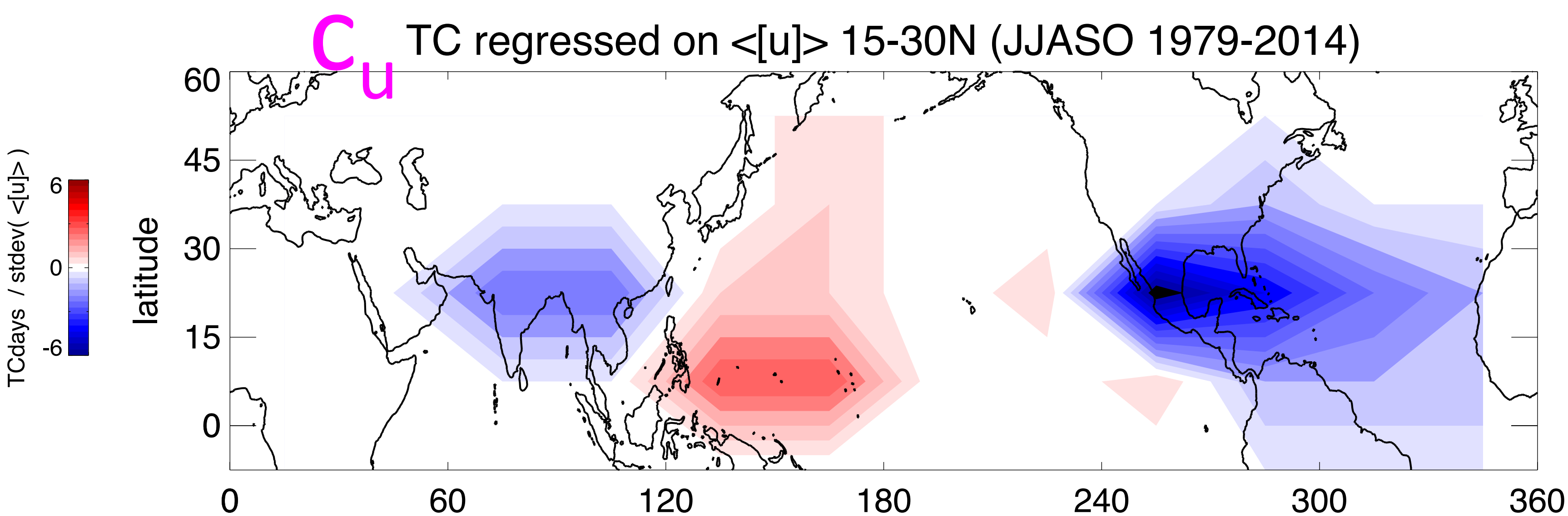
- Pure SST regression: postulate this form:

$$TC = c_T \, SST + err_T$$

Optimize c_T by minimizing $RMS(err_T)$

ENSO and <[u]> univariate regressions: comparable variance explained





30x15deg bin size

Attribution to 2 factors

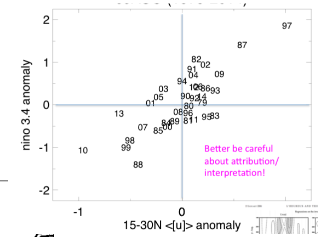
- **Joint** (partial) regression: postulate this form:

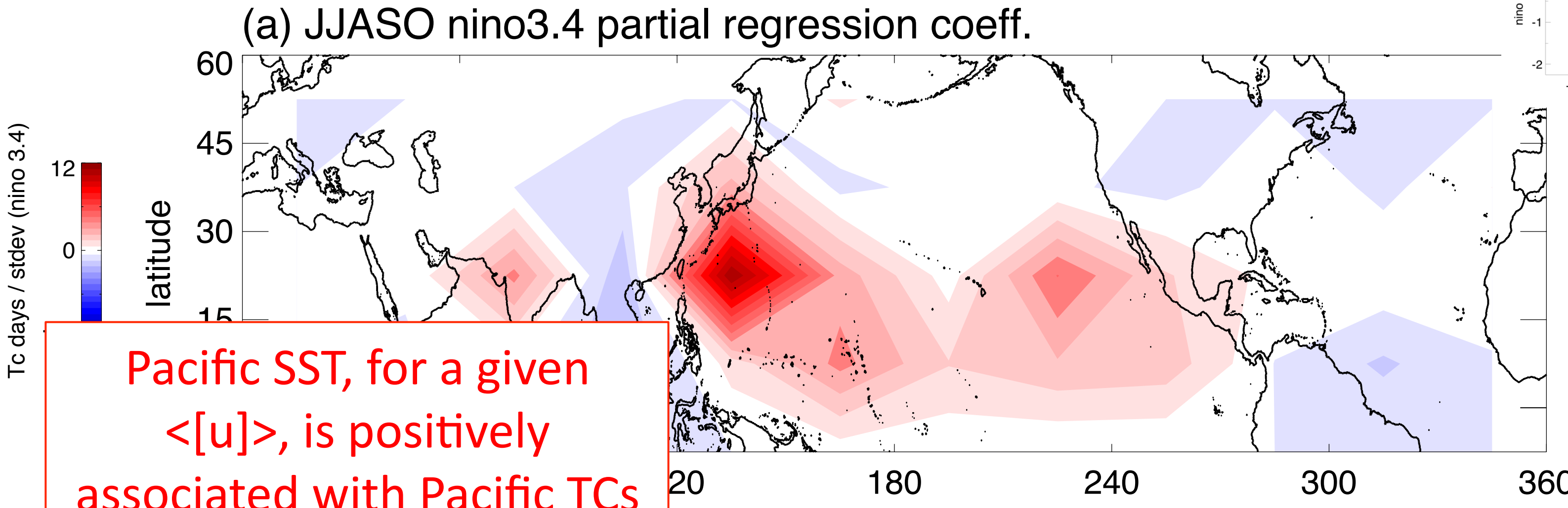
$$TC = c_{T,u}\, SST + c_{u,T} <[u]> + err_{Tu}$$

Optimize $c_{T,u}$ *and* $c_{u,T}$ wrt RMS(err_{Tu})

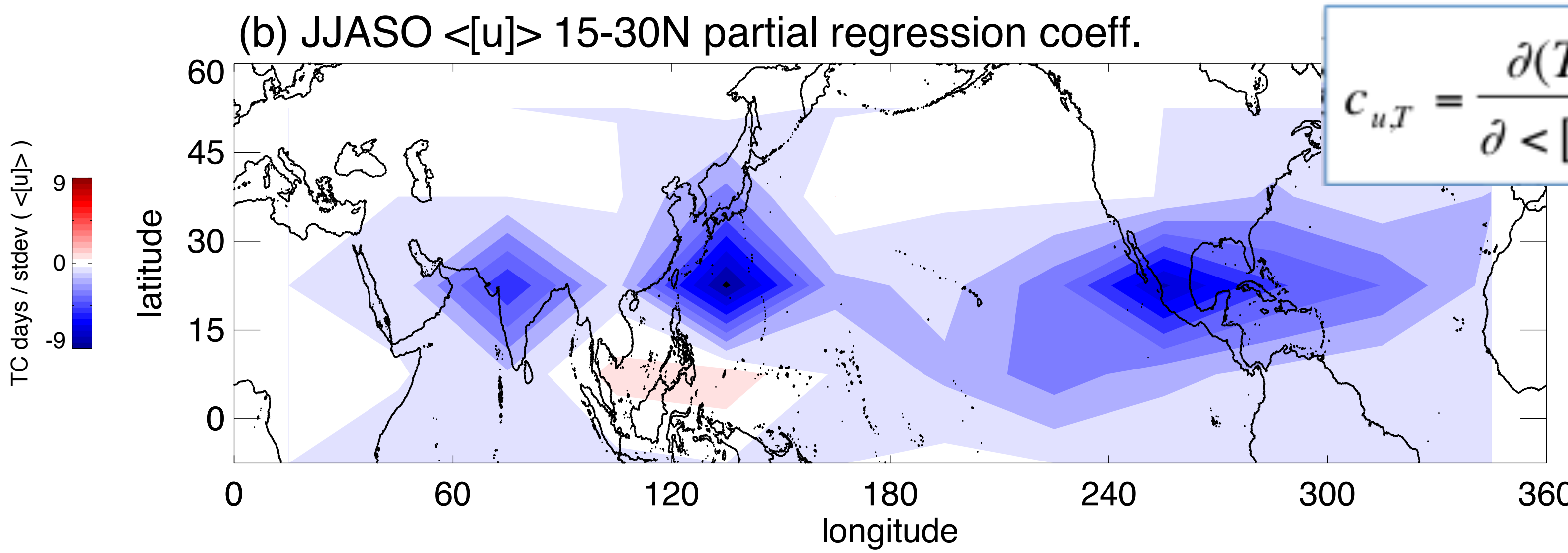
$$c_{u,T} = \left. \frac{\partial (TC)}{\partial <[u]>} \right|_{NinoSST}$$

Canceling effects by positively correlated predictors





Pacific SST, for a given <[u]>, is positively associated with Pacific TCs



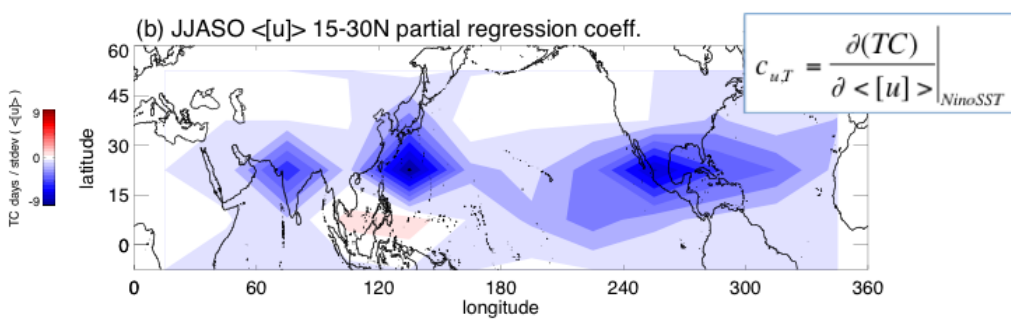
$$c_{u,T} = \left. \frac{\partial (TC)}{\partial < [u] >} \right|_{NinoSST}$$

Subtropical westerlies negatively associated with all TCs, for a given Nino34 SSTA

Q: If <[u]> shapes the anticyclones,

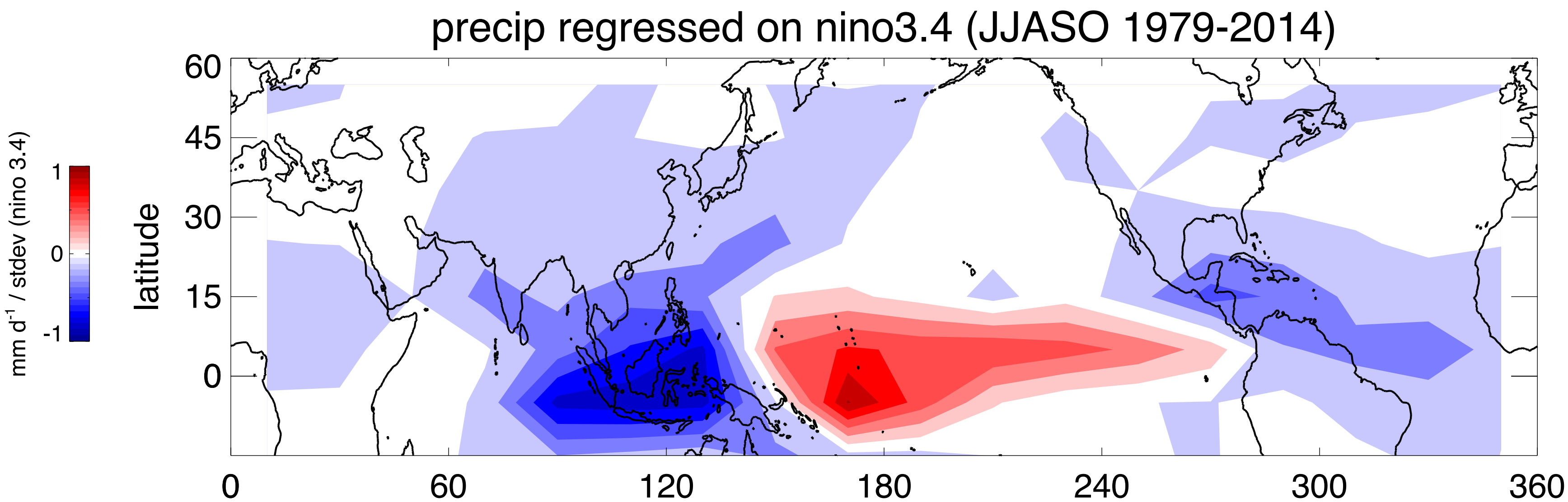
- *Pacific too?*
- *TC steering impacts as well as rain?*

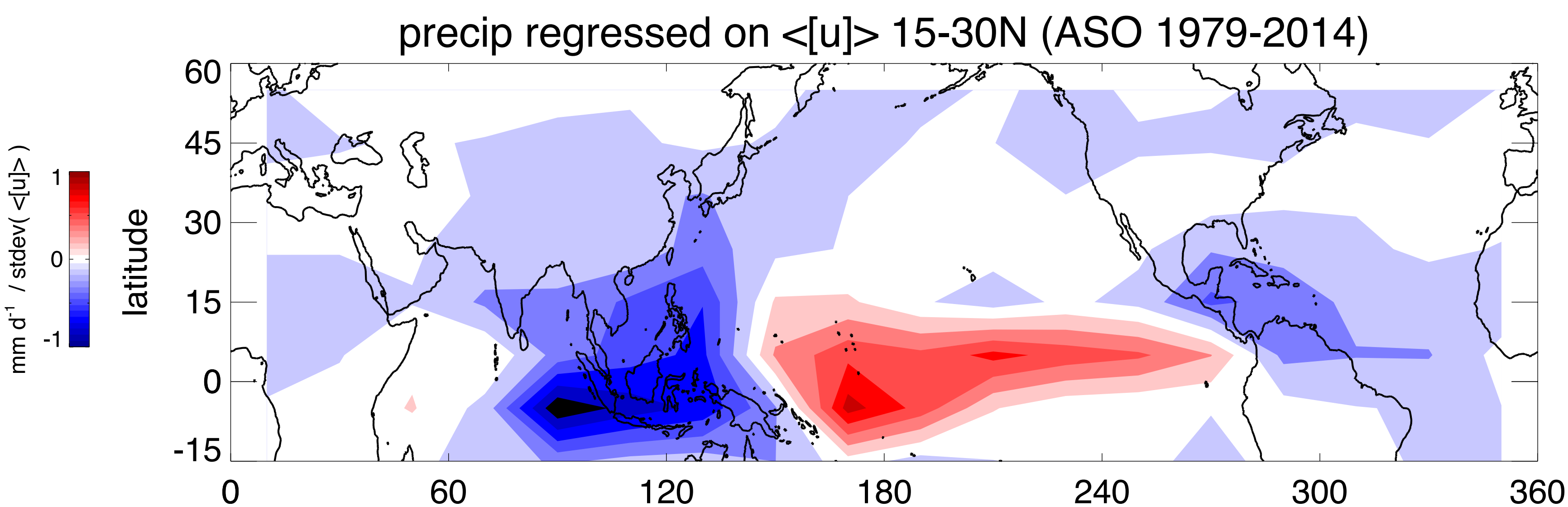
  – *A: Not E-W dipoles Not just “steering” !*



Subtropical westerlies negatively associated with TCs, for a given Nino34

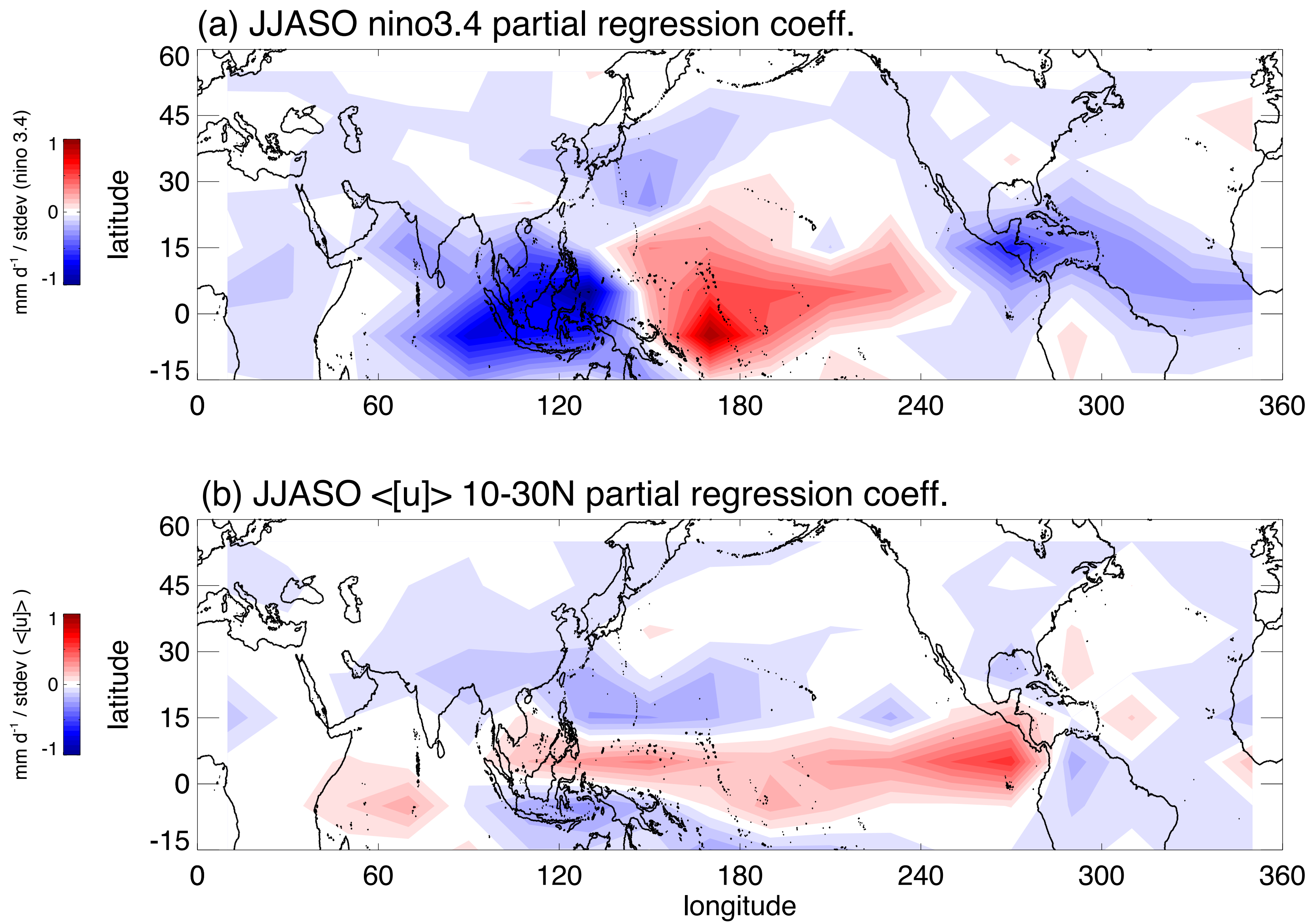
CMAP rain regressions are even more redundant (or entangled)





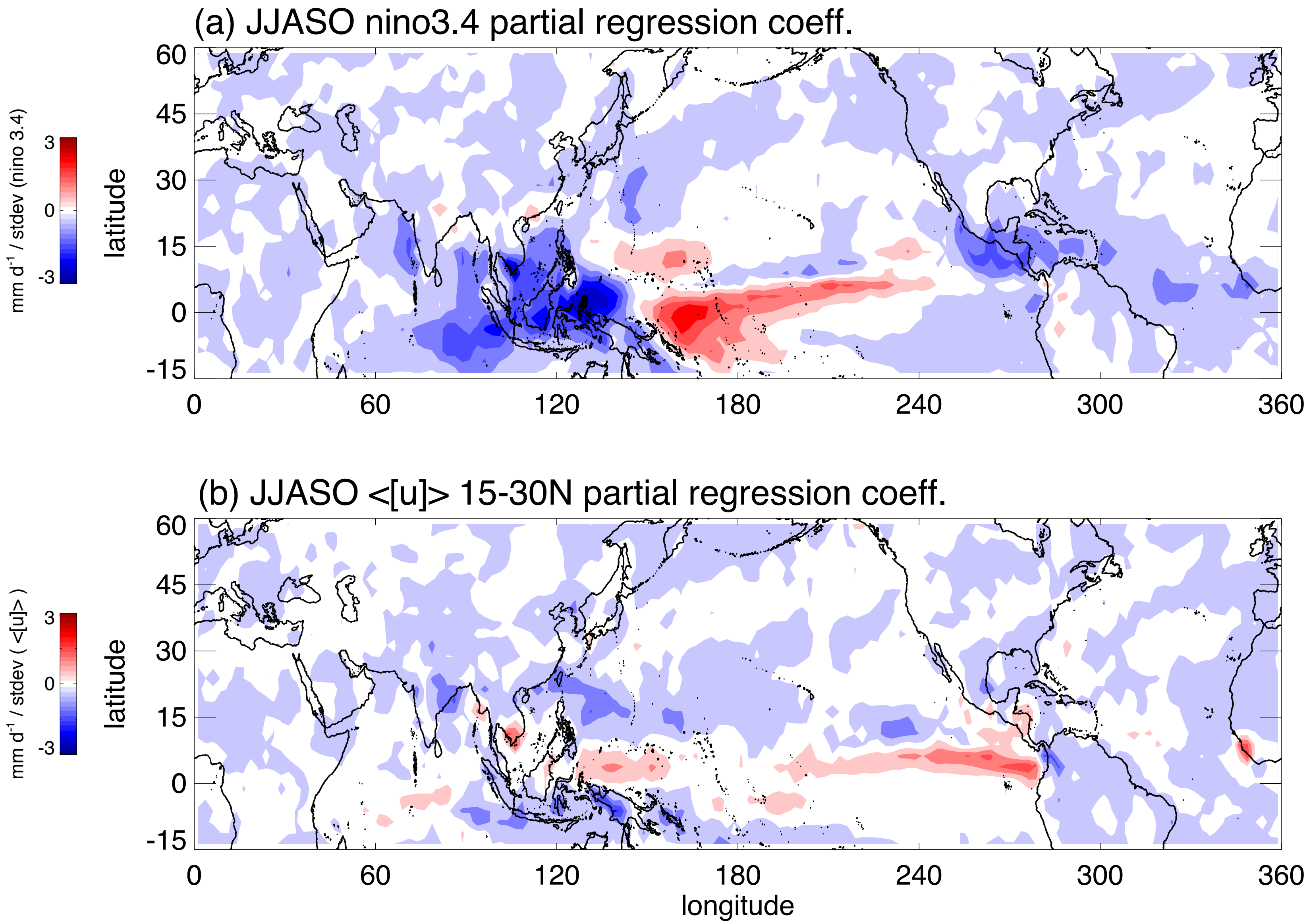
20x10deg bin size

CMAP partial regression sparates effects very starkly



20x10deg bin size

Precip (CMAP)



native 2.5deg res

Interpretation

- Always a tricky business...

- Source of ENSO variance well understood
- Sources of <[u]> variance *other than ENSO* not
  - monsoon-driven stationary eddy [u*v*]?
    - but then monsoon & ENSO are correlated?

Interpretation

- Always a tricky business...

- Framing the problem is important and subtle – *a coherent account of the phenomena & mechanisms is essential, not an afterthought*
- A data analysis will not solve its own framing
  - » *but wait -- by variance explained per predictor?*
  - » *but then, from a list of candidate predictors: framing again*

Conclusions

- <[u]> is arguably a climate "entity", not just a statistic
  - its budget has few terms, chiefly [u*v*] at upper levels

- <[u]> has regional impacts (Americas and elsewhere)
  - its y-shear helps shape the subtropical anticyclone
  - it contributes as a component to u isotach (jet)
  - it discourages TCs, for a given ENSO state

- Part of <[u]> variability is an ENSO signal
  - mustn't ascribe ENSO effects to one's pet ENSO-correlated thing

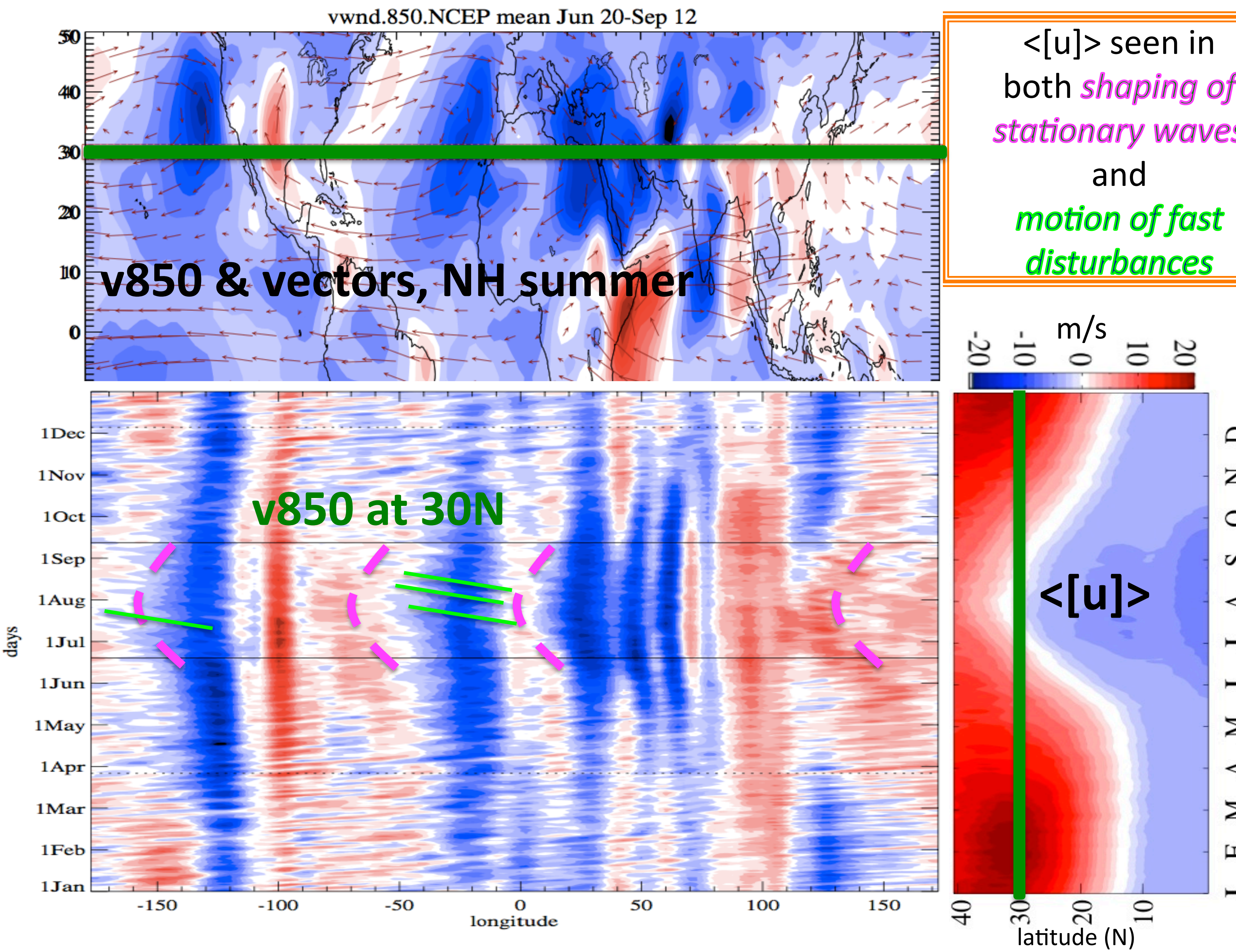
- Might non-ENSO parts of <[u]> include unique predictable signals, or valuable lessons about weather-climate interaction mechanisms?

Extra slides

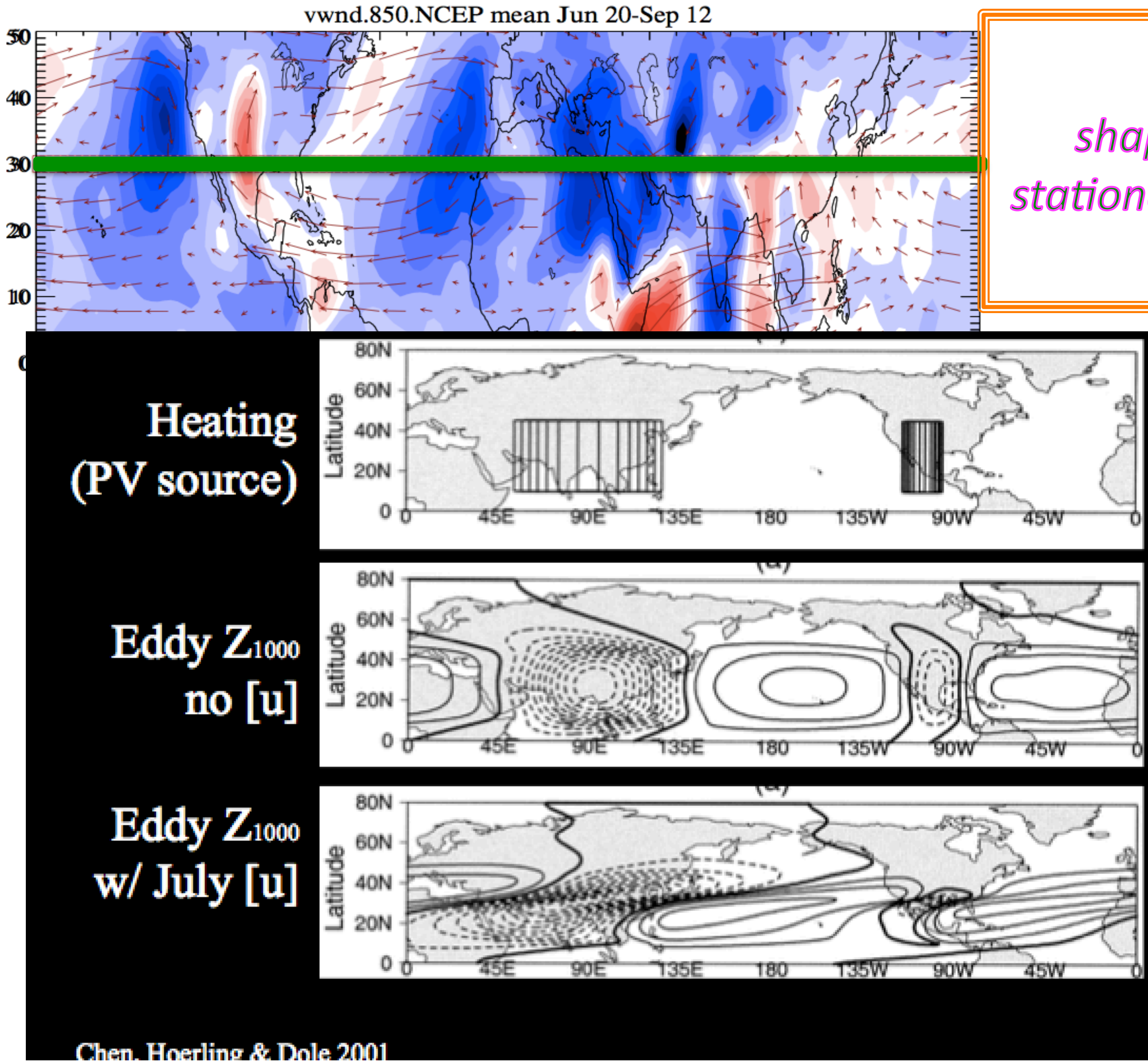
The case for <[u]> → MSD

- Mechanism: upper stationary eddy flux [u*v*]
- Ultimate cause: Asian monsoon

- Obs. evidence: interannual correlations
- GCMs able to reproduce signal
- Model clincher: darker India soil → more
  - ✔

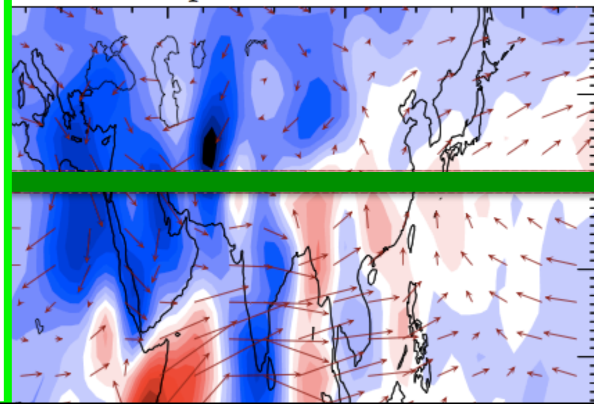


<[u]> seen in both *shaping of stationary waves* and *motion of fast disturbances*

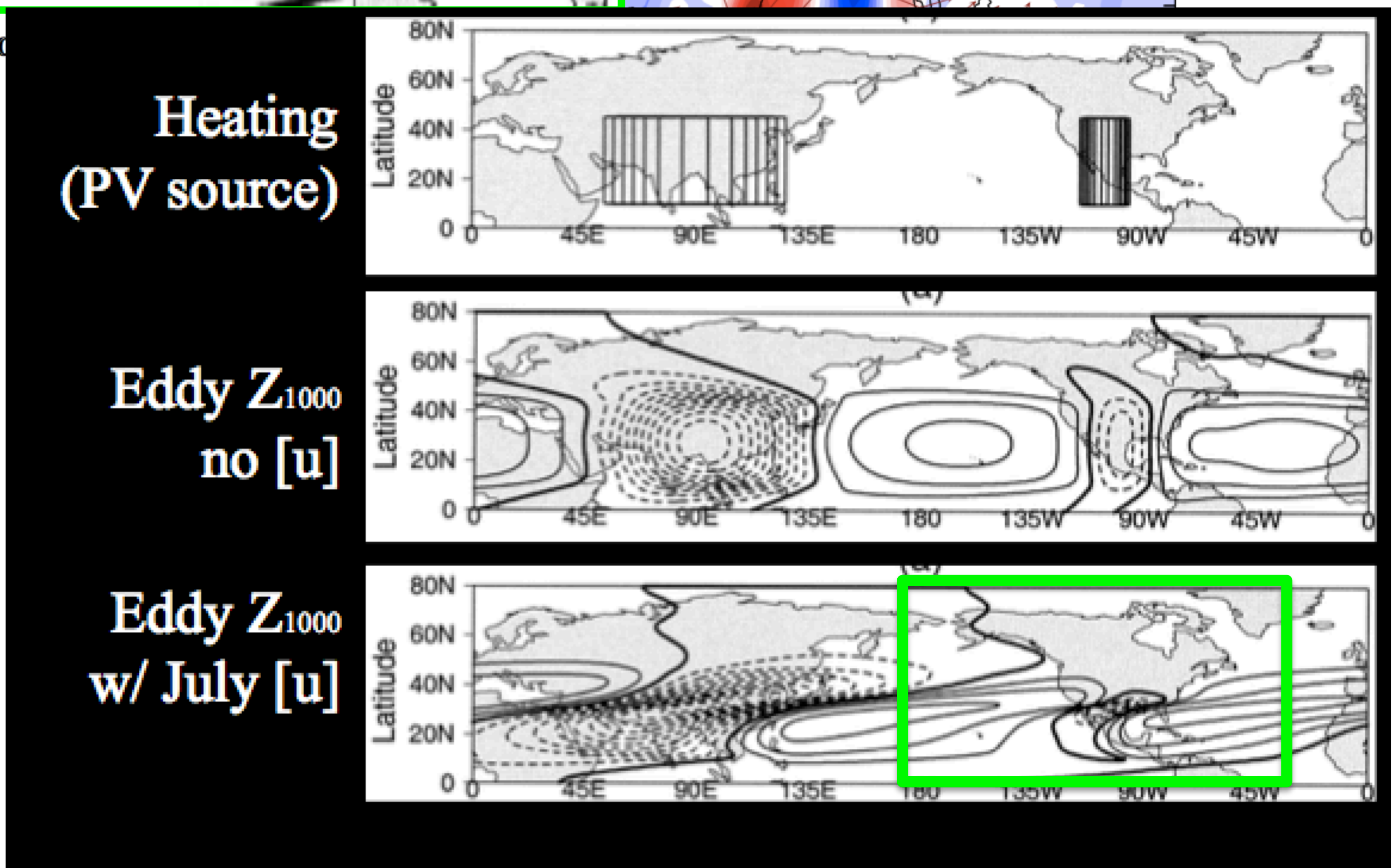


shaping of stationary waves

vwnd 850 NCEP mean Jun 20-Sep 12



shaping of stationary waves

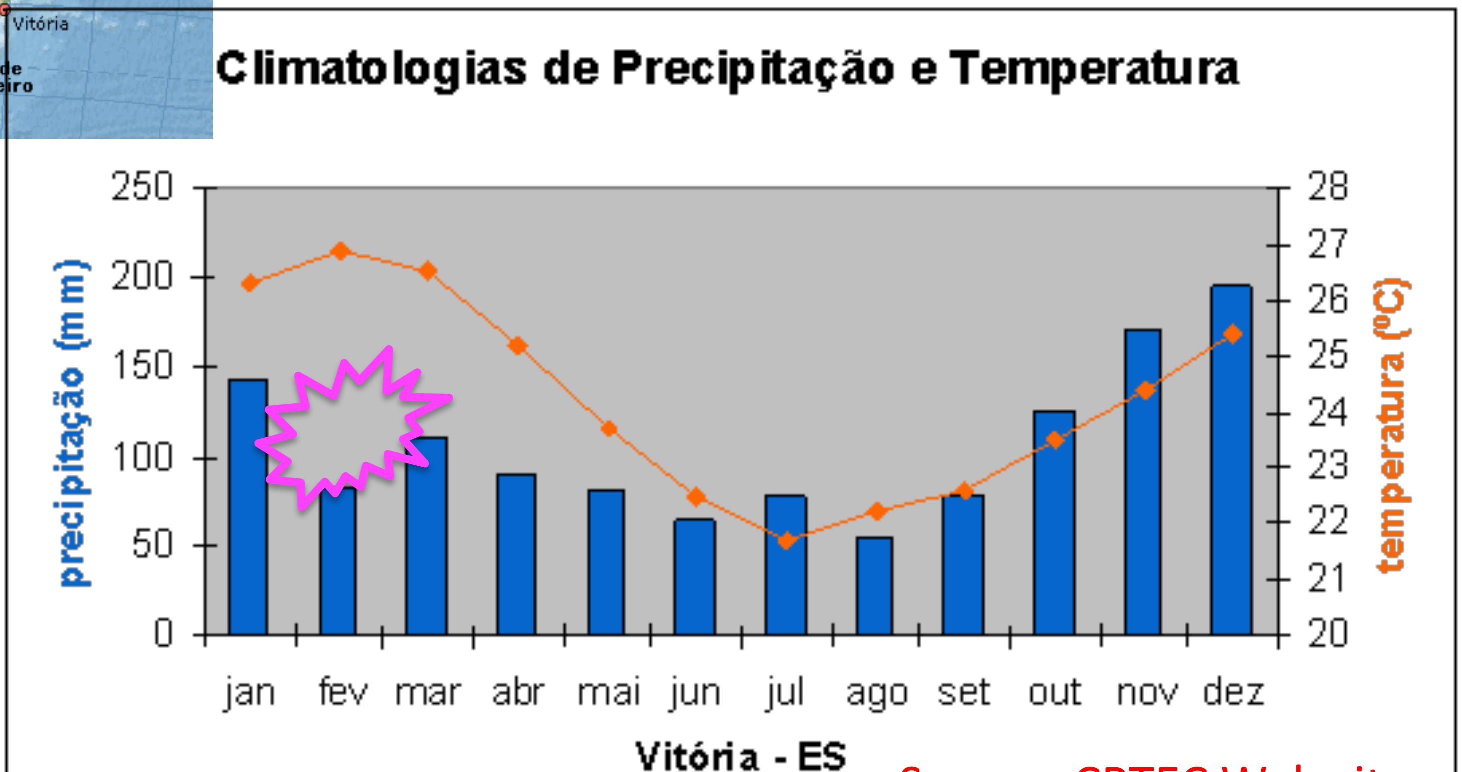


Chen, Hoerling & Dole 2001

The case for <[u]> effects

- Further clincher: southern hemisphere

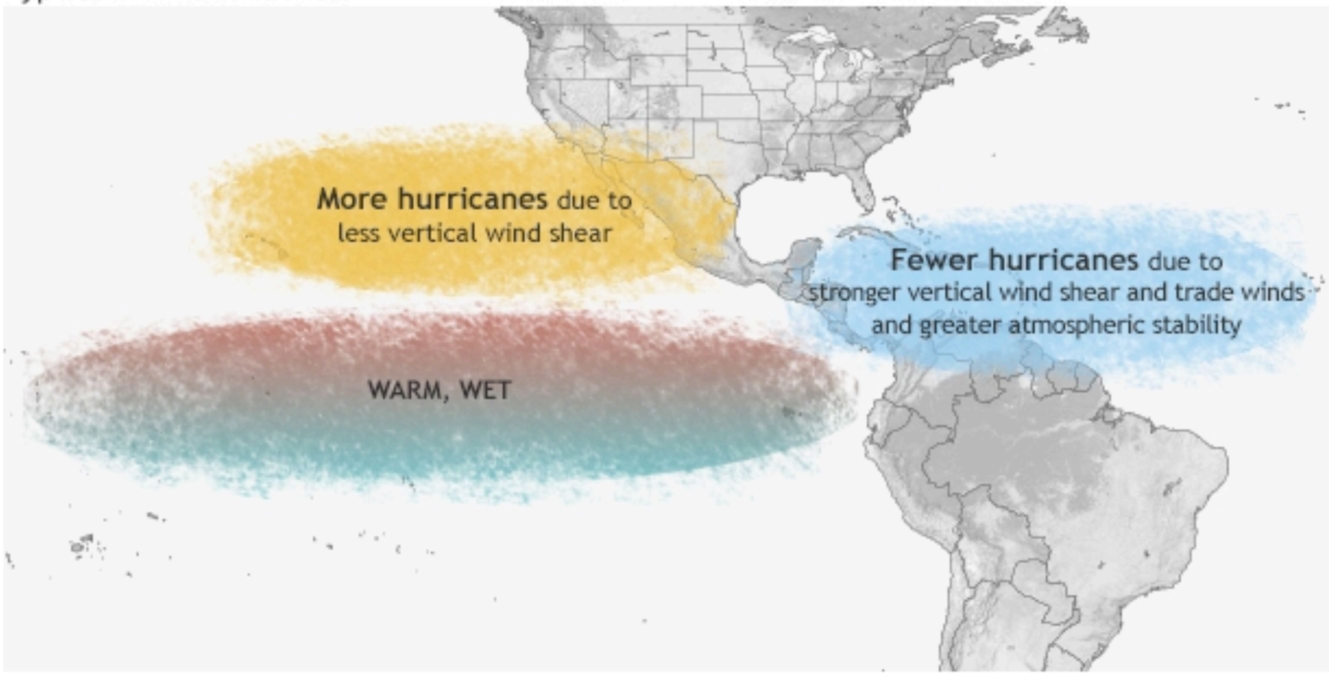
Águas de Março
(dryness of February)



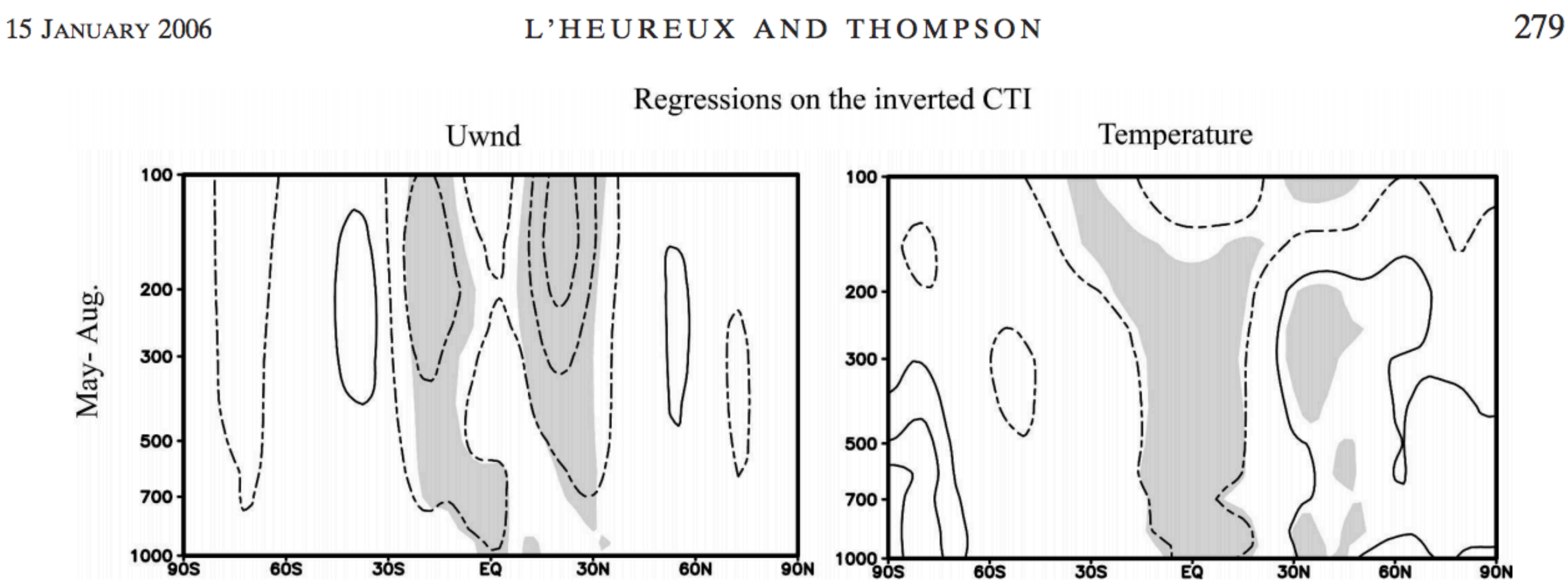
Source: CPTEC Web site

Kelly and Mapes – submitting this week

Typical El Niño influence

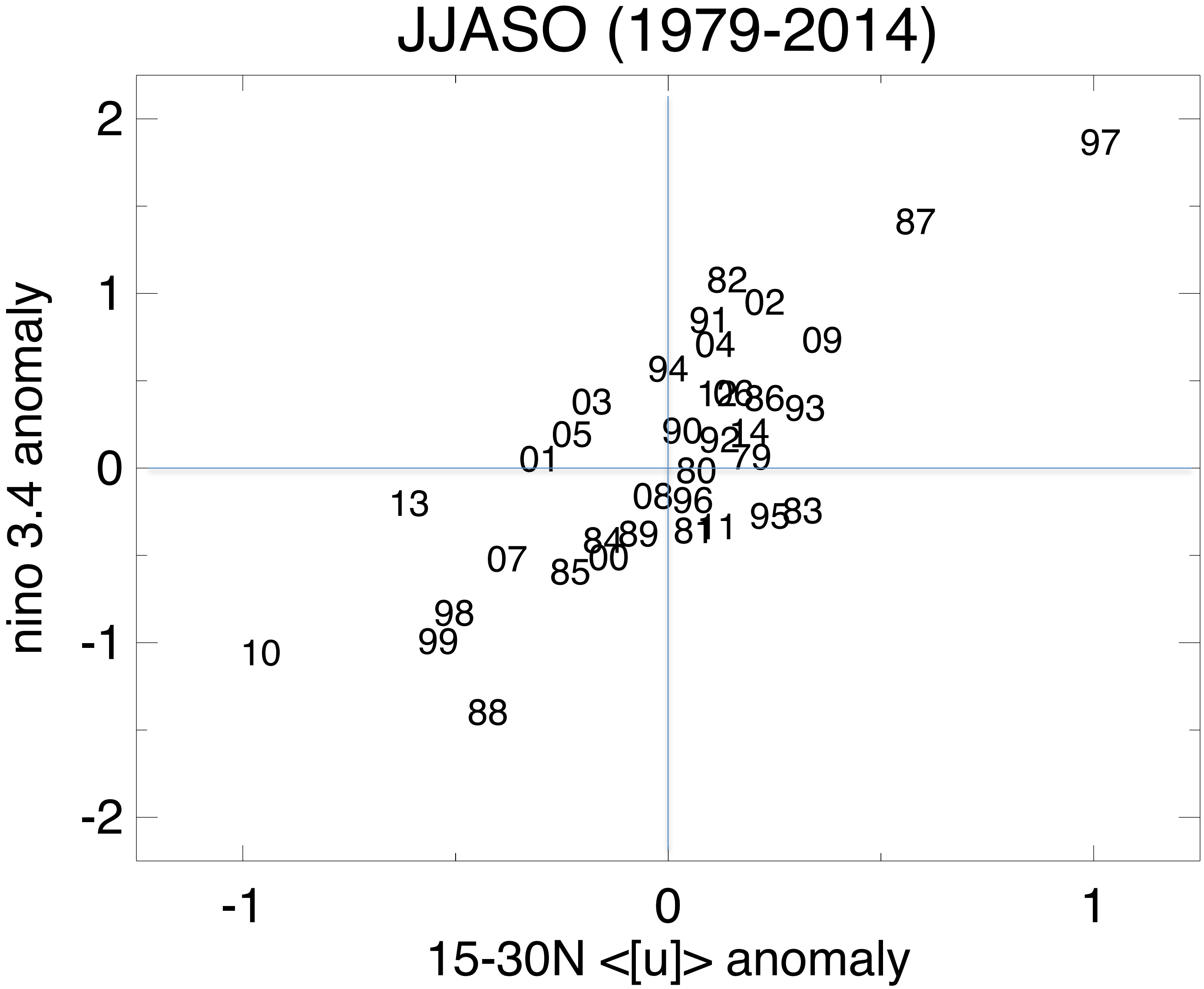


Typical influence of El Niño on Pacific and Atlantic seasonal hurricane activity. Map by NOAA Climate.gov, based on originals by Gerry Bell.



Warm ENSO → increase E-P Temp gradient → increased Westerly <[u]> in subtropics

Cold ENSO → decreased E-P Temp gradient → decreased Westerly <[u]> in subtropics


JJASO (1979-2014)
nino 3.4 anomaly
15-30N <[u]> anomaly
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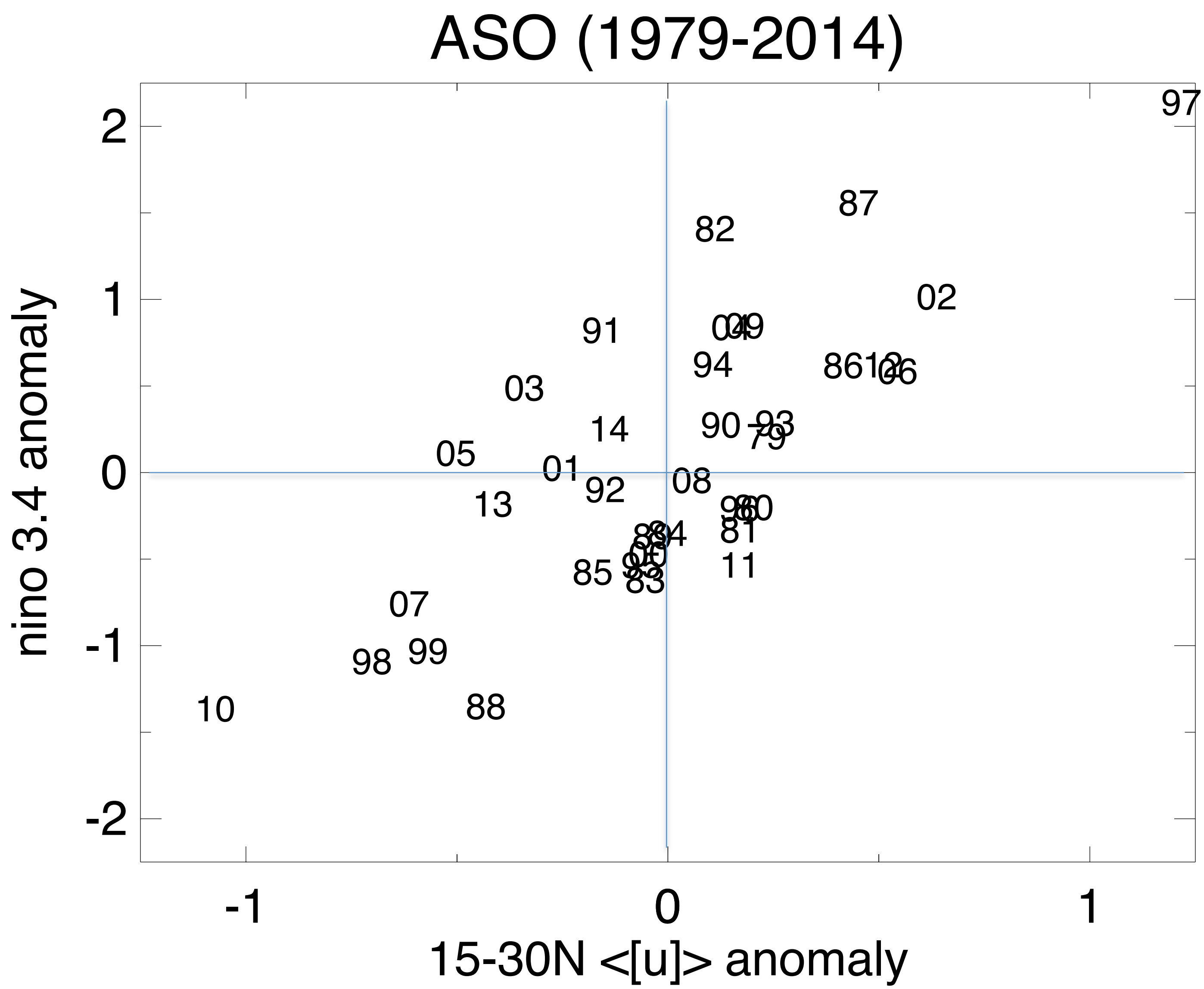
ASO (1979-2014)
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