Off-equatorial meridional transport during a composite El Niño

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- Original motivation was to understand the interannual fluctuations of the New Guinea Coastal Current (glider sections).

- Most previous work is based on the available "good data": satellites, moorings ⇒ since about 1992-93.

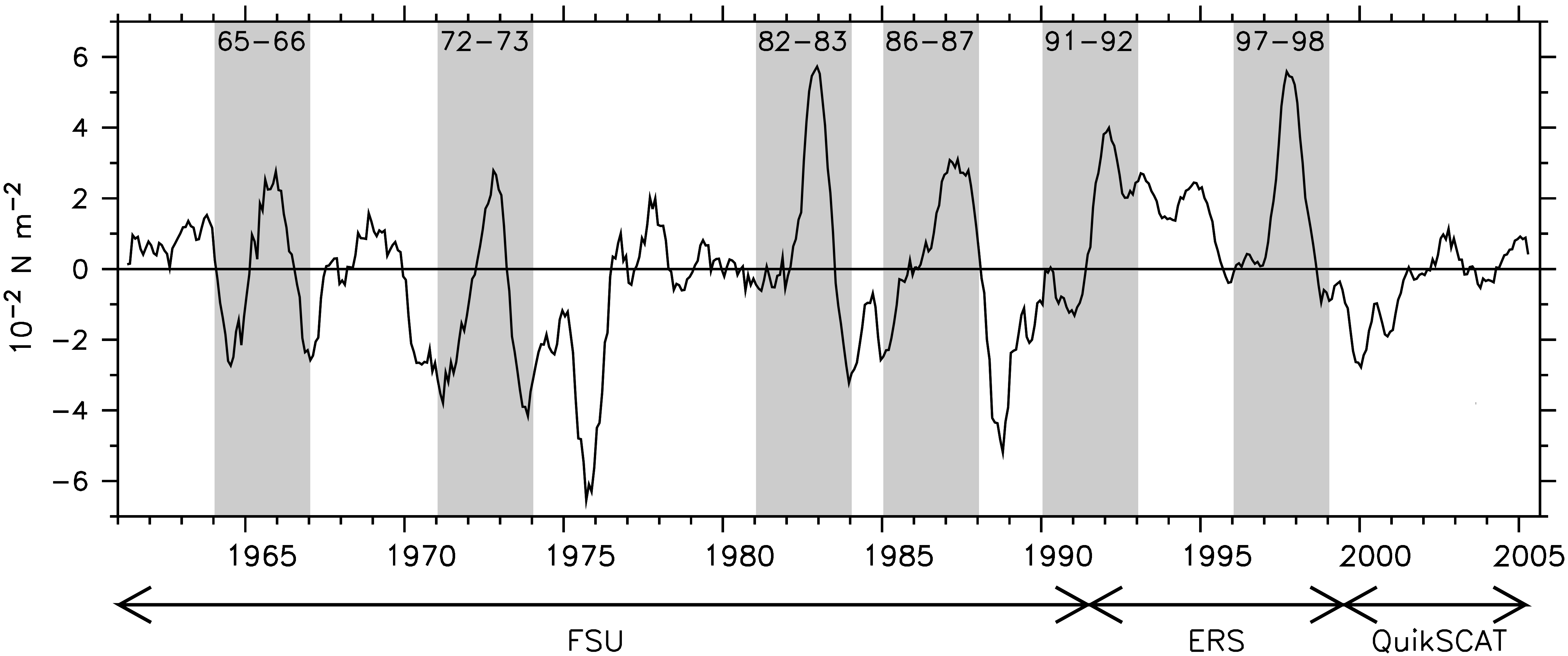
  Dominated by 1997-98 ⇒ Make a composite El Niño from 1960.

- It turned out that the NGCC is pretty straightforward

  ⇒ the more interesting part is that El Niño effects in mid-basin depend on the phase of the seasonal cycle ... Today's talk.

El Niño periods chosen for composite

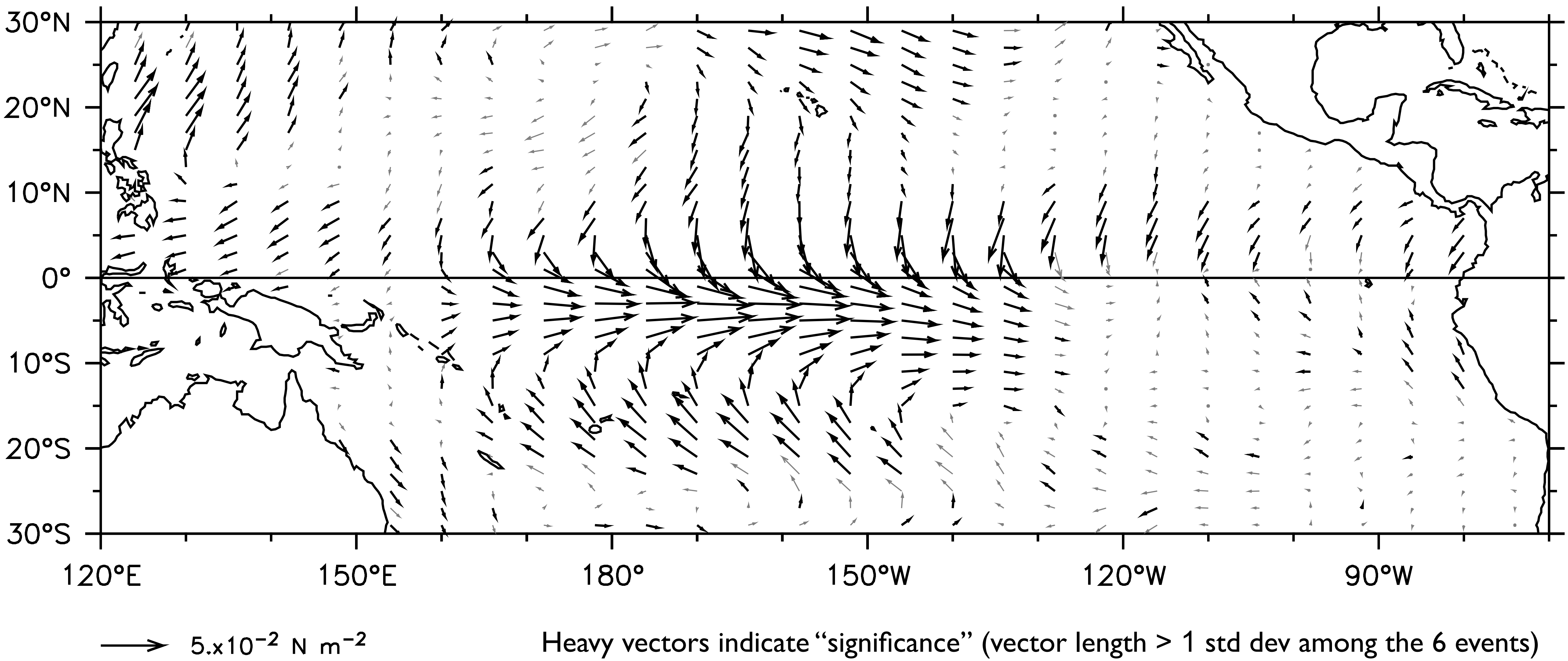
Example of zonal stress at 0°,170°W: 6 large events



The composite is a simple monthly bin-average
for the 3 years spanning a warm event.
These are denoted Years −1, 0, +1.

Mean El Niño composite winds during Nov Yr 0 to Apr Yr +1

Includes events of 1965, 1972, 1982, 1986, 1991, 1997



Heavy vectors indicate "significance" (vector length > 1 std dev among the 6 events)

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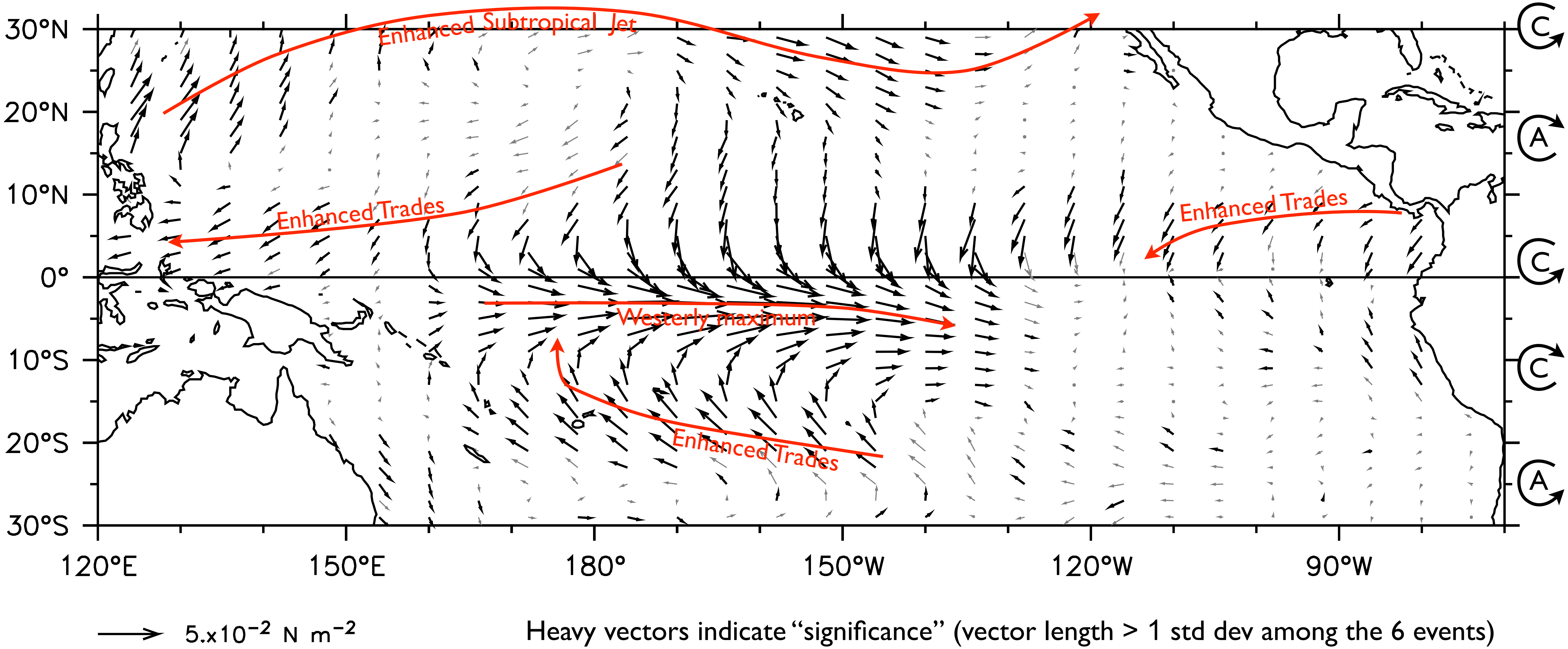

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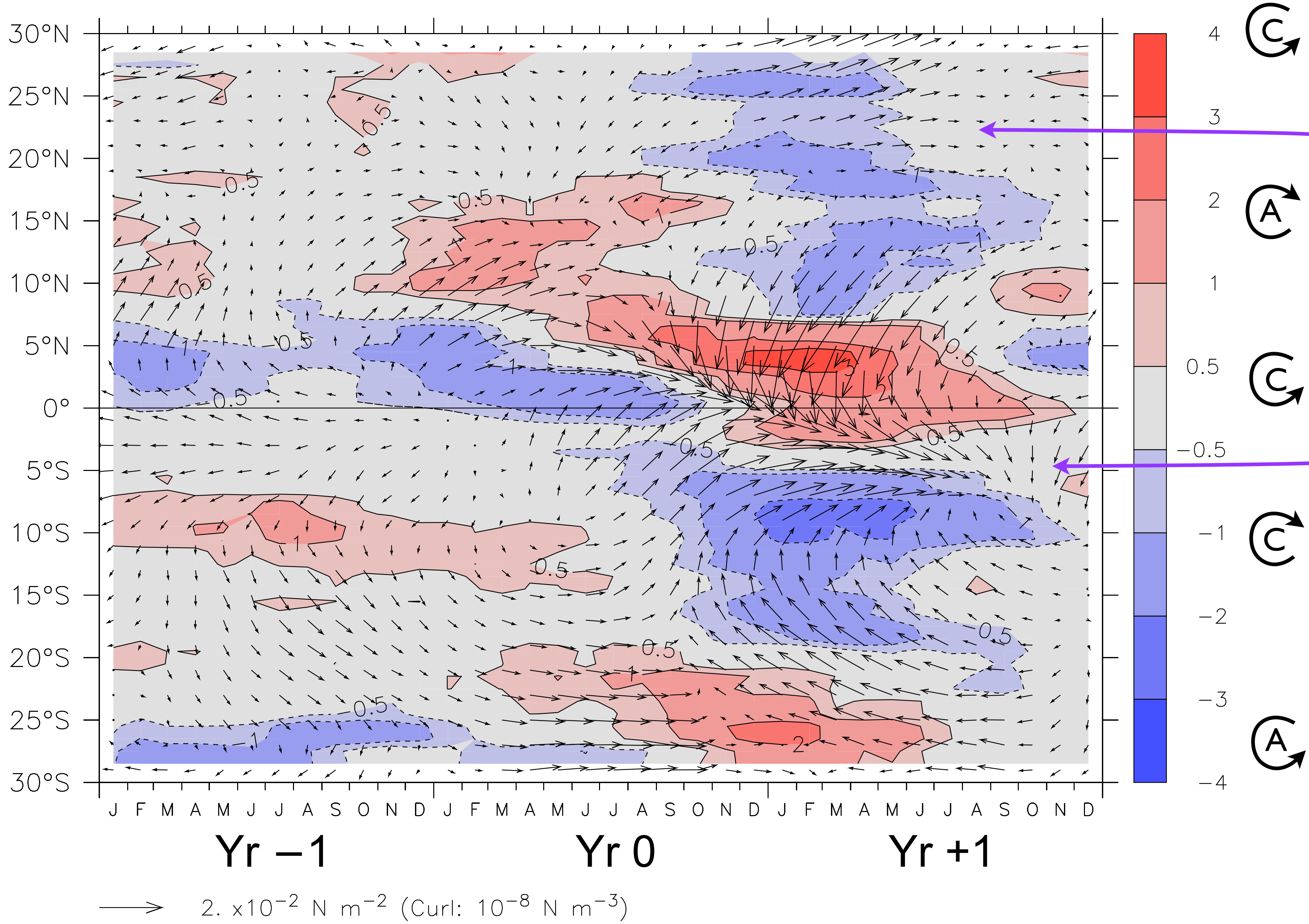
Composite El Niño Curl(τ) zonal average

Includes events of 1965, 1972, 1982, 1991, 1997



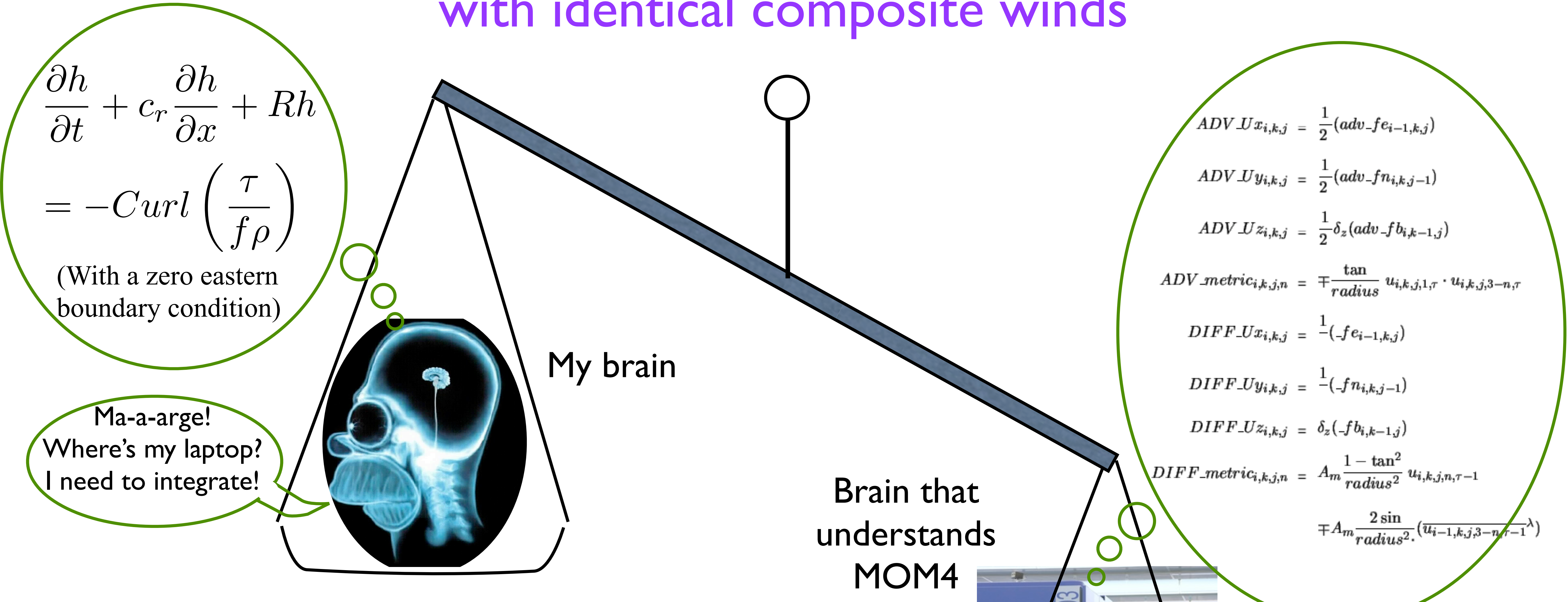
Cyclonic and Anti-cyclonic Curl latitudes during the event peak.

The pattern of curl anomalies is shifted southward 5°-10°.

Enhanced downwelling curl from Subtropical Jet (can only occur in boreal winter).

Southward shift of westerly max in austral summer: convection responds to absolute SST. (Vecchi+Harrison)

Force both a Rossby model and an OGCM with identical composite winds



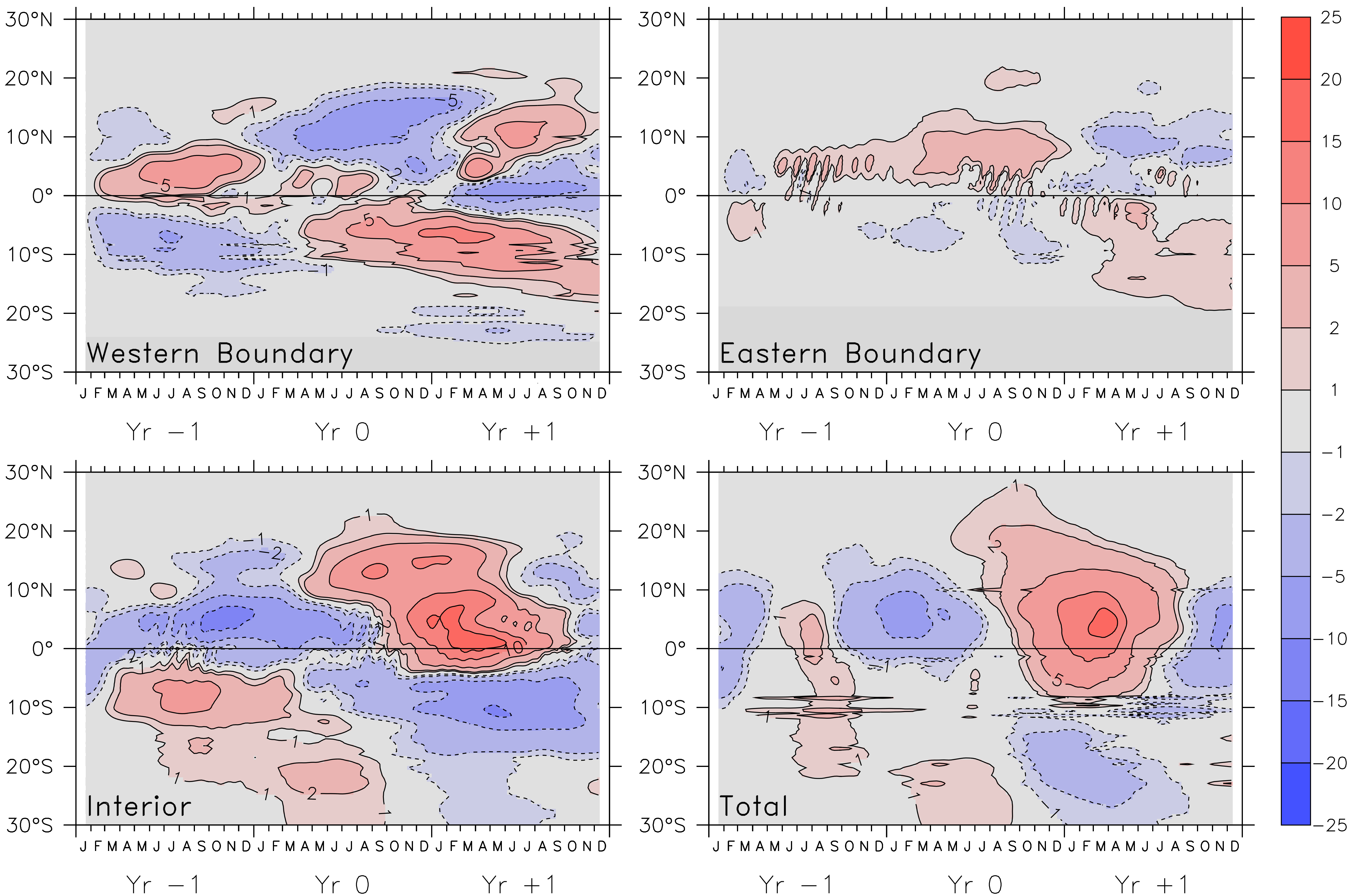
The Rossby model identifies the linear solution due to interior wind forcing. No Kelvin waves or boundary reflections.

A better brain than mine (Stuart Godfrey) has shown that the western boundary transport due to arriving Rossby waves can also be calculated within the linear context.

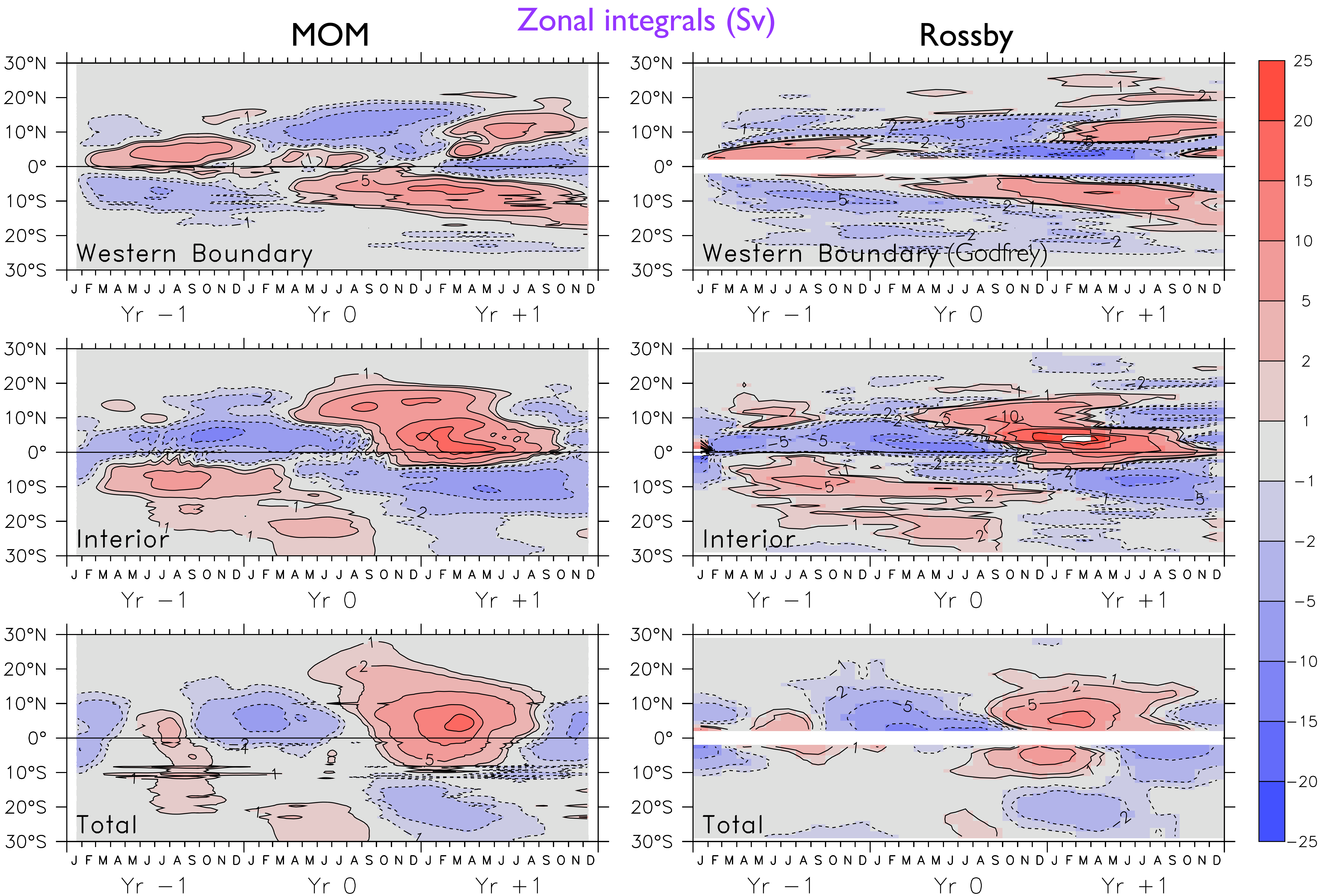
El Niño composite meridional transport anomalies above 15°C

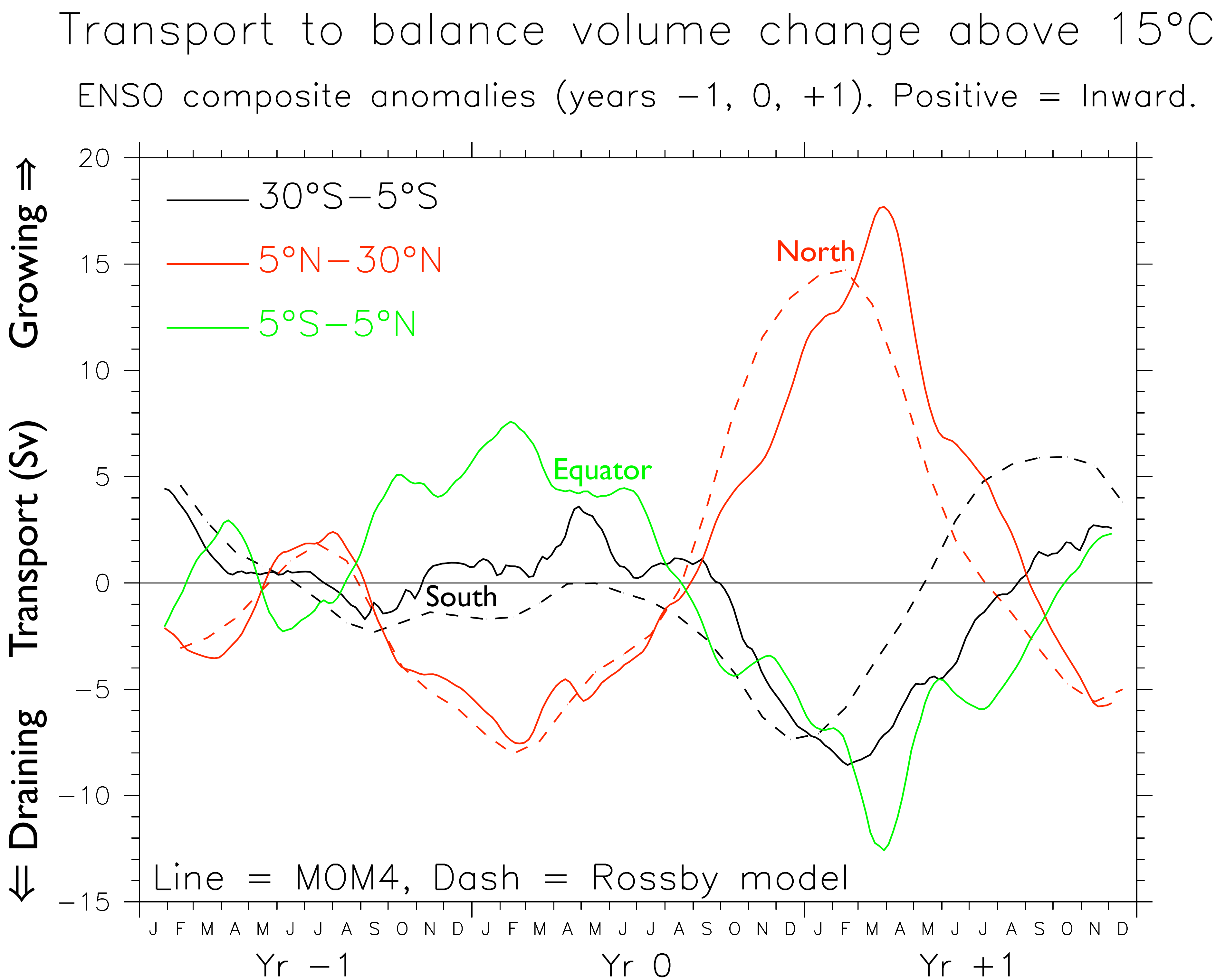
MOM4. Zonal integrals over each region. Transport in Sv.

Red = Northward, Blue Southward



Transport anomalies: MOM vs Rossby model





Most of the equatorial recharge (green) occurs from the north (red). Then, during the height of the event and after, both the equatorial region and the southern hemisphere (black) drain to the north.

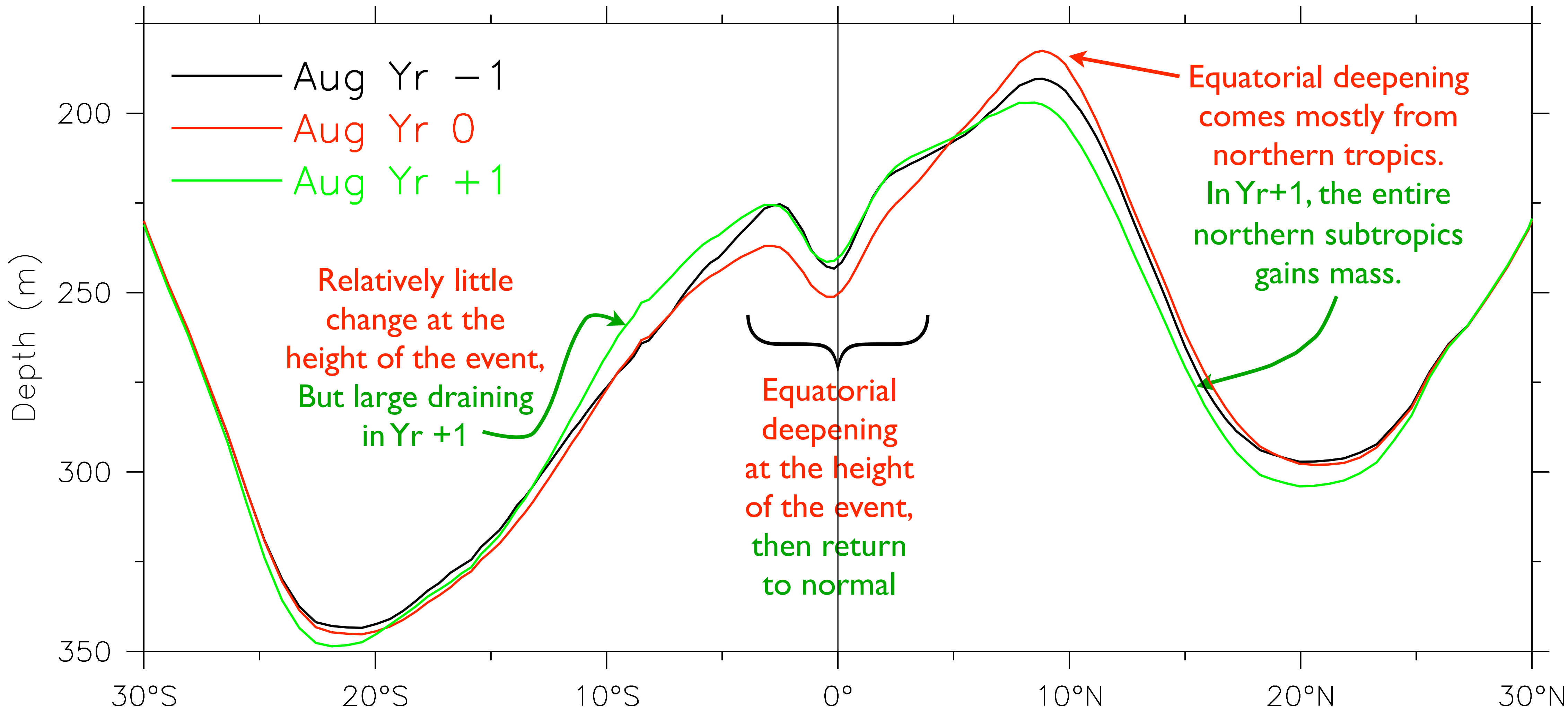
(Also see Kug et al. 2003)

The Rossby model is similar to the MOM4 solution, but leads it by 1-2 months.

(Corresponding plot for 10°S/N is similar, with about 2/3 the magnitudes)

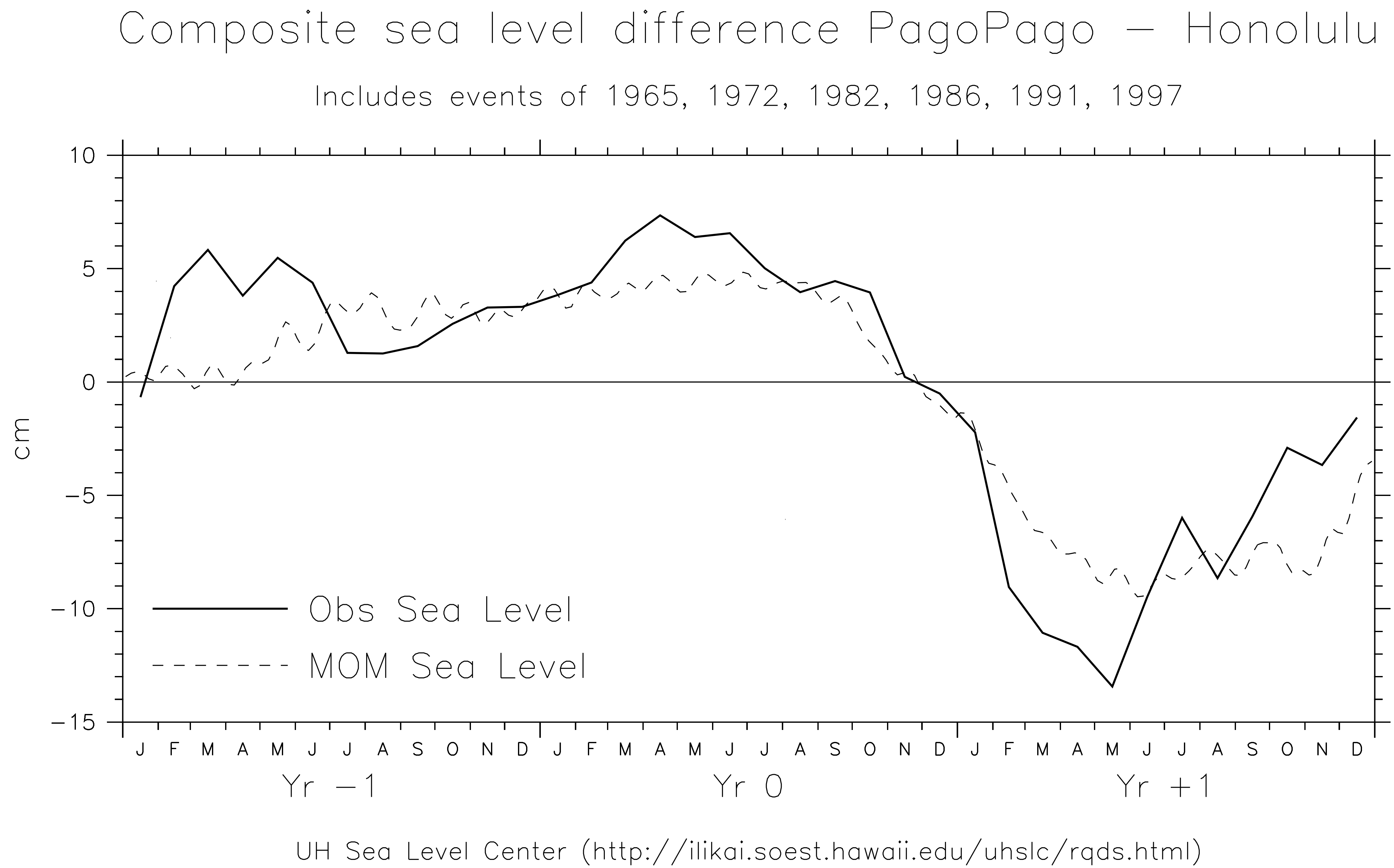
Depth of 15°C during El Nino composite Augusts

MOM4. Zonal averages



A net transfer of mass from the southern to the northern subtropics

The northward mass transfer is probably real: Island Sea Level



(Wyrtki and Wenzel 1984)

Conclude

- Significant meridional exchange occurs well off the equator.
- Most of the net meridional mass exchange occurs between the northern subtropics and the equator.
- Although there are large transports in the South Pacific, the interior transports tend to be compensated by the western boundary. (Because the forcing is near the western boundary?)
- The eastern boundary plays only a small role.
- The southward shift of the cyclone/anti-cyclone pattern of winds during the El Niño peak is *probably* due to the background seasonal cycle, which then probably in turn determines the northern bias in subtropical-equatorial mass exchange during an El Niño event.

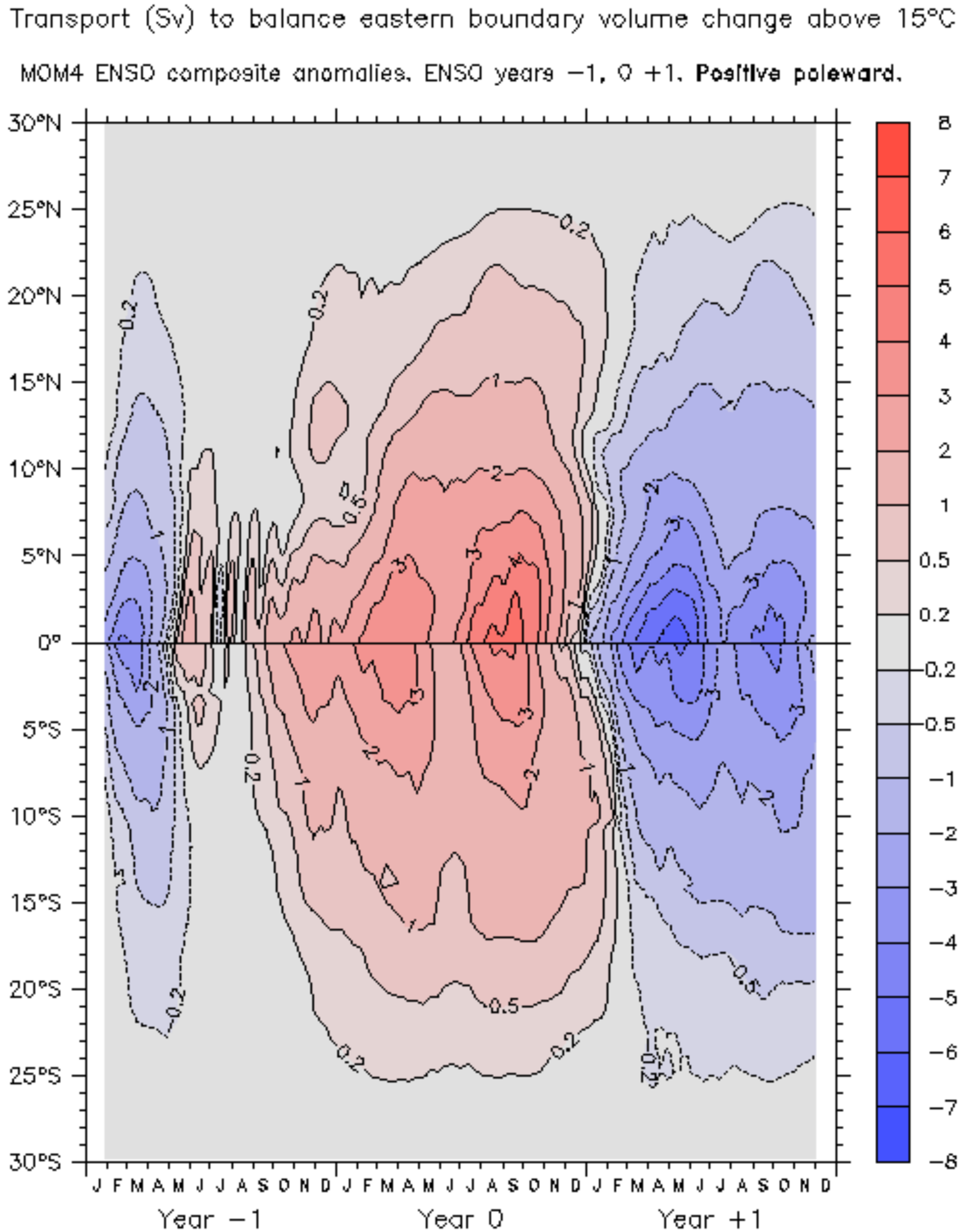
⇒ Why is El Niño phase-locked to the seasonal cycle?

Extra

Figures

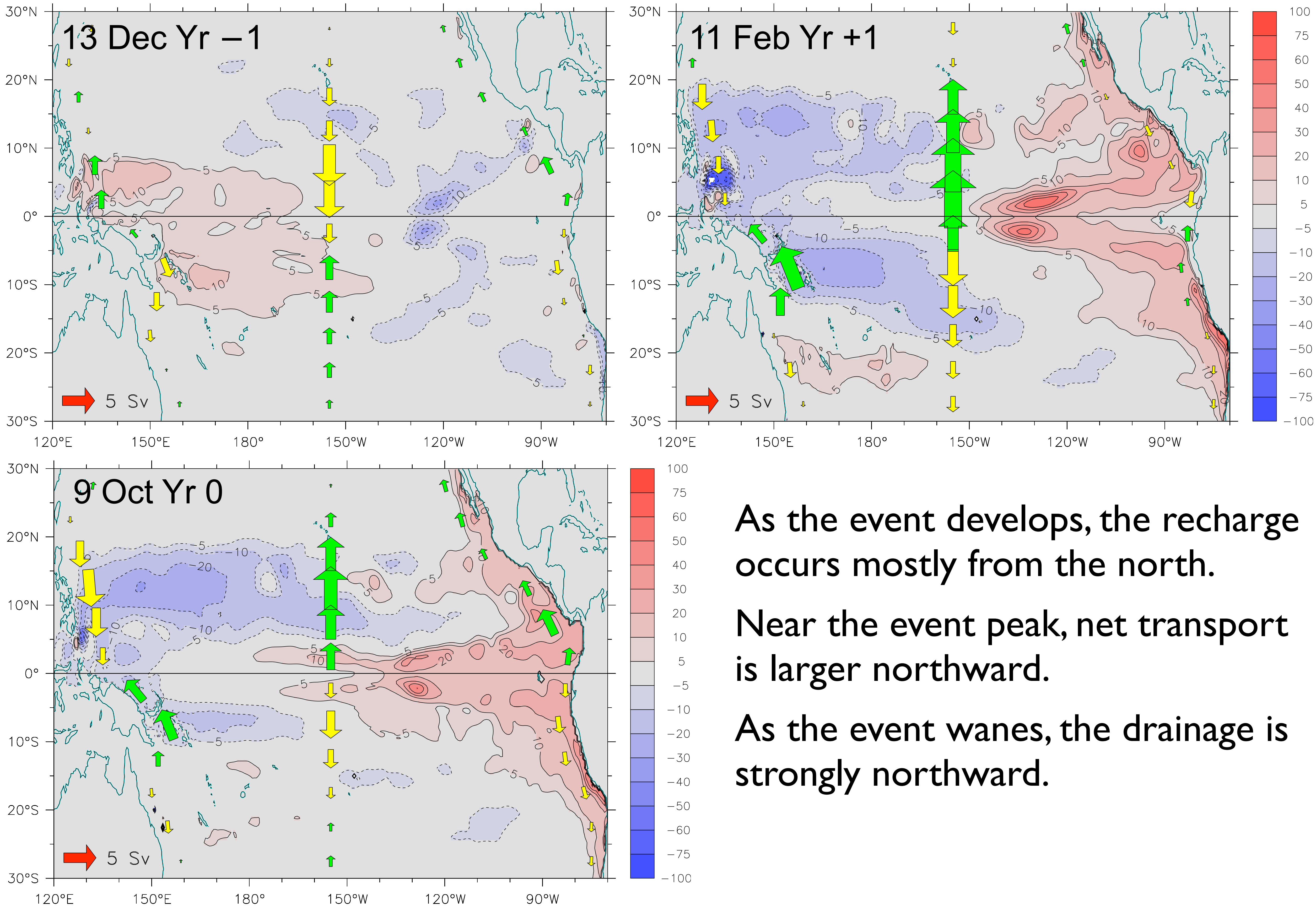
Follow

....



Transport (Sv) to balance eastern boundary volume change above 15°C
MOM4 ENSO composite anomalies. ENSO years −1, 0 +1. Positive poleward.
30°N
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Year −1
Year 0
Year +1
8
7
6
5
4
3
2
1
0.5
0.2
−0.2
−0.5
−1
−2
−3
−4
−5
−6
−7
−8

Z15 depth and WB, Interior, EB transport



As the event develops, the recharge occurs mostly from the north.

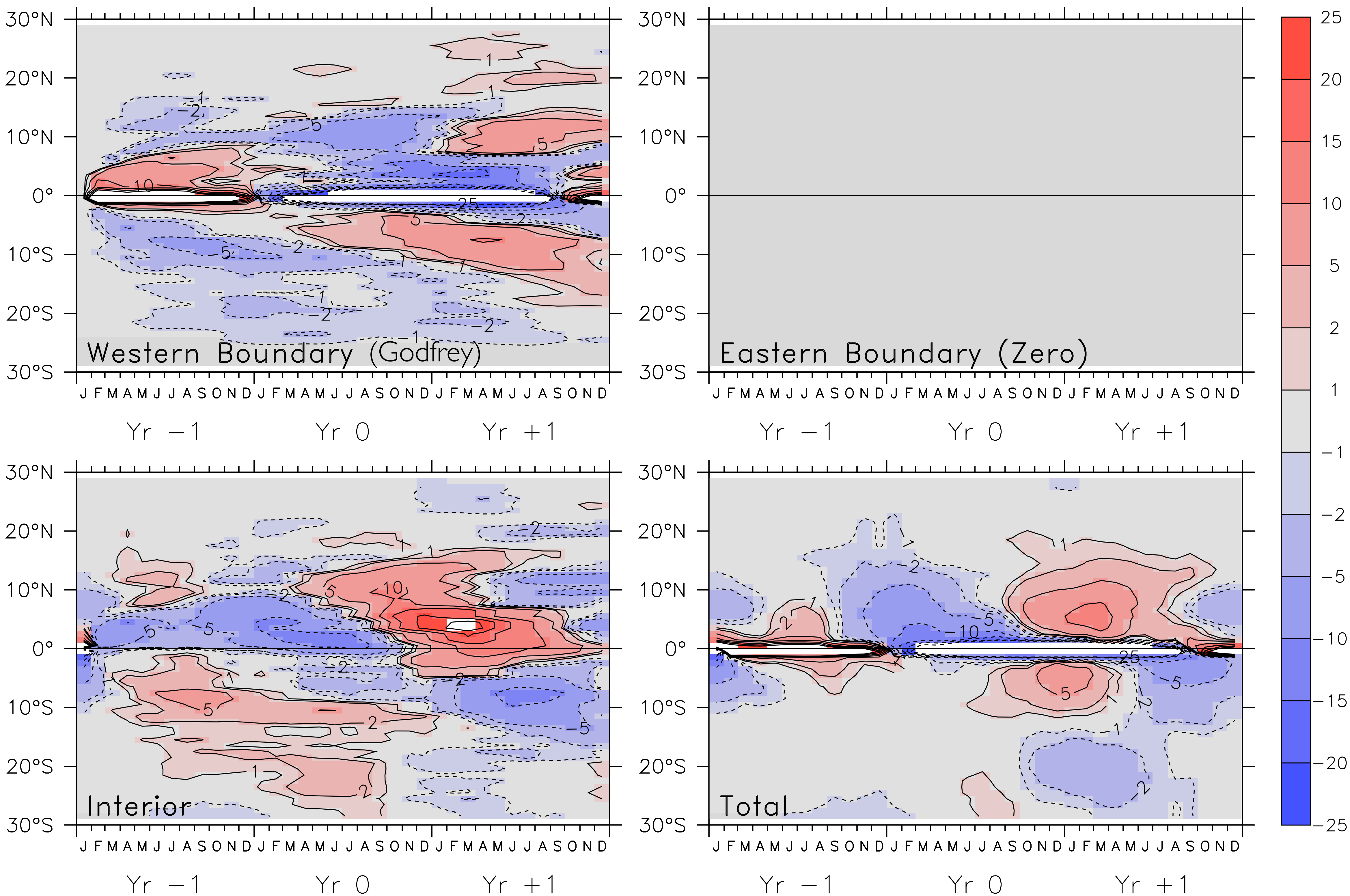
Near the event peak, net transport is larger northward.

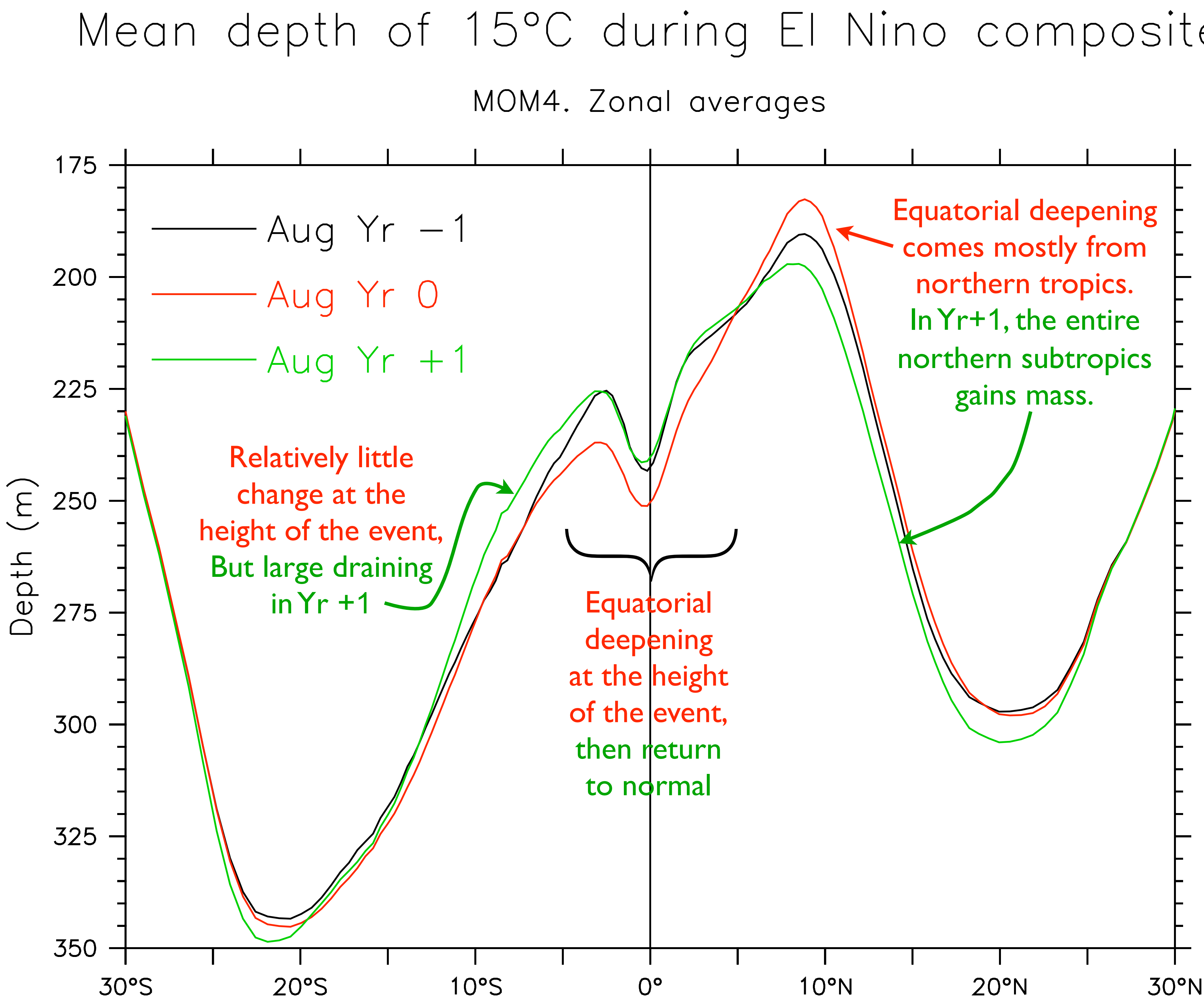
As the event wanes, the drainage is strongly northward.

El Niño composite meridional transport anomalies

Rossby model (Godfrey WBCs). Zonal integrals over each region. Transport in Sv.

Red = Northward, Blue Southward





El Niño appears to produce a net transfer of mass from the southern to the northern subtropics

Composite El Niño Curl(τ) zonal average

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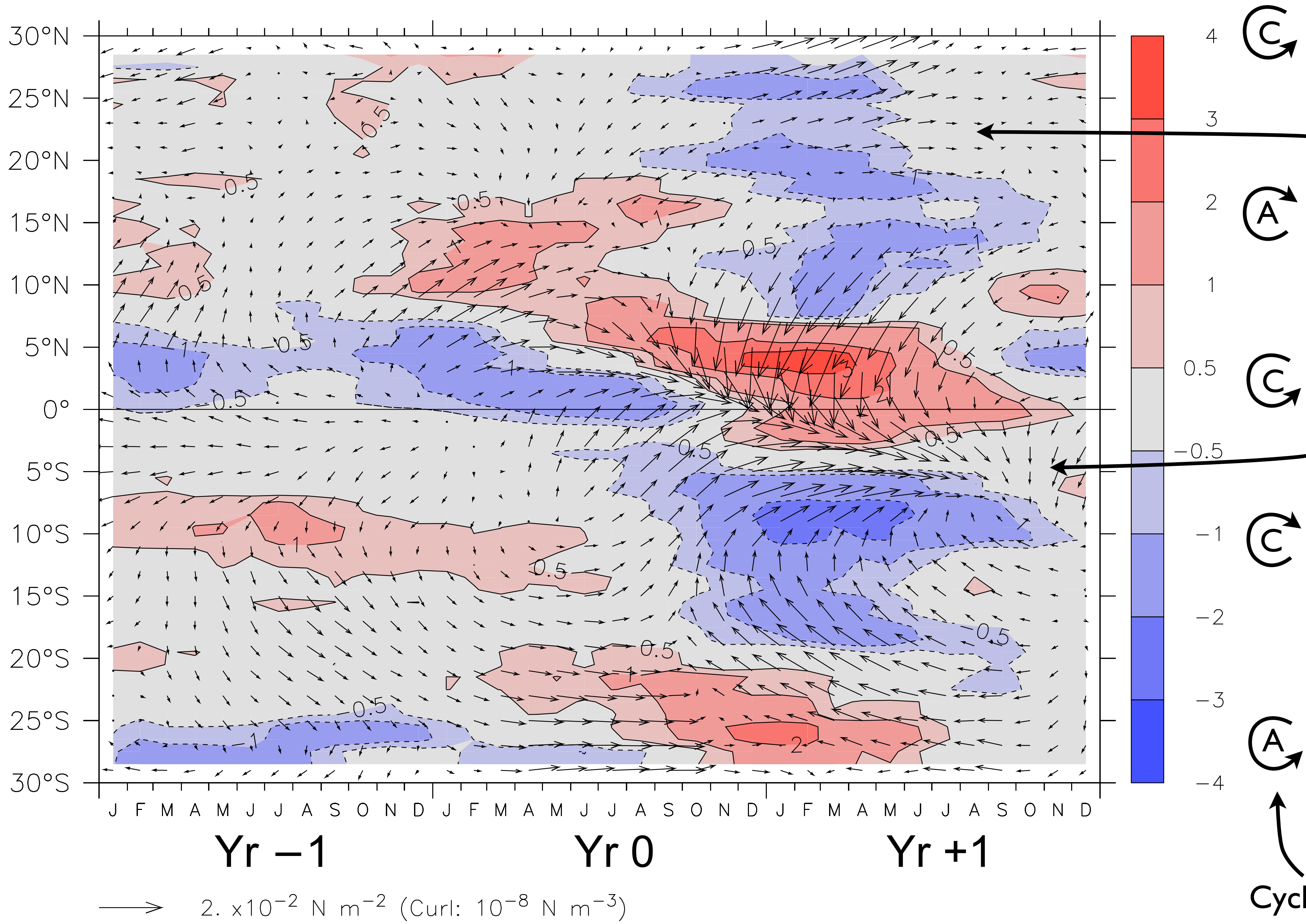

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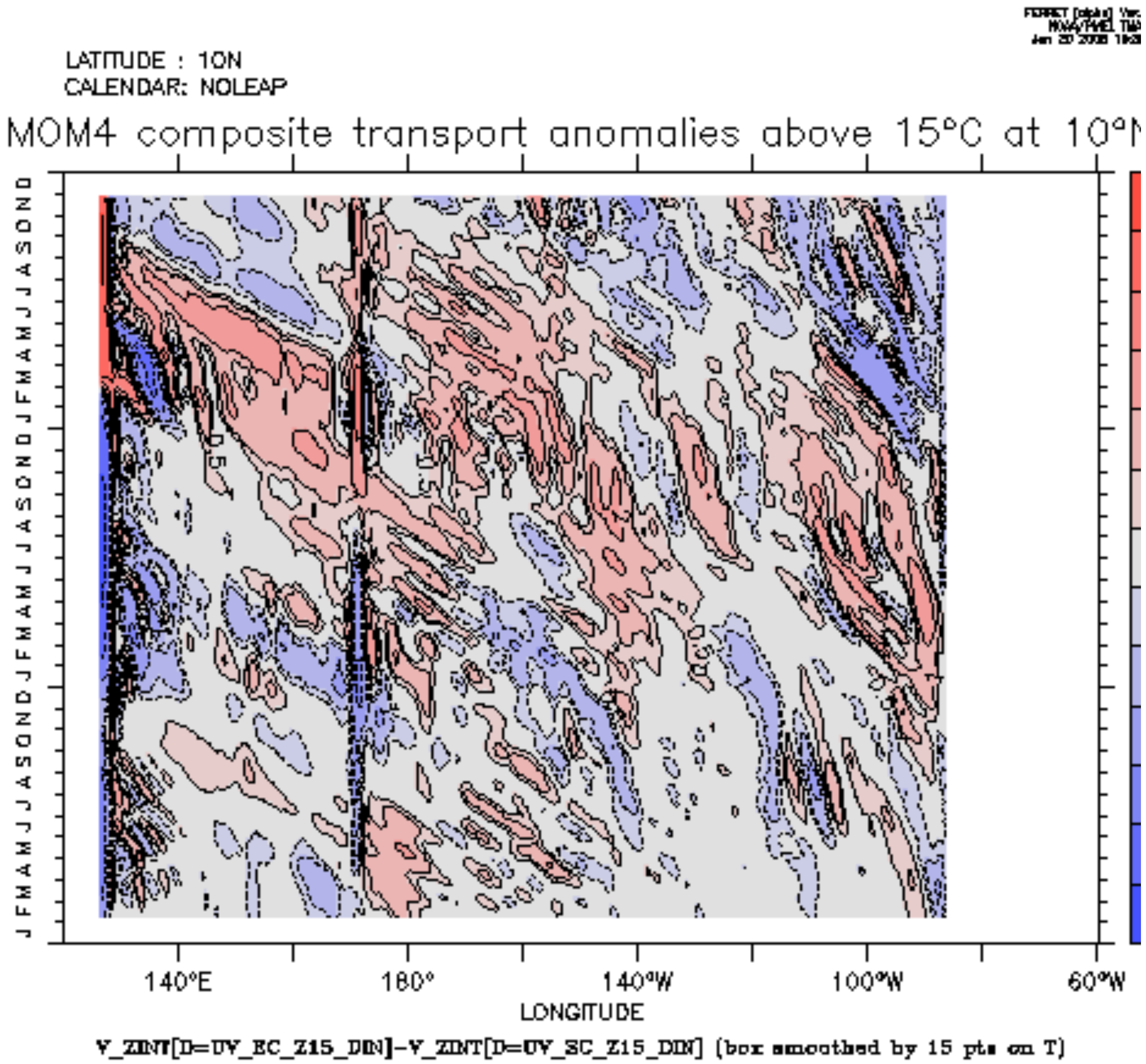
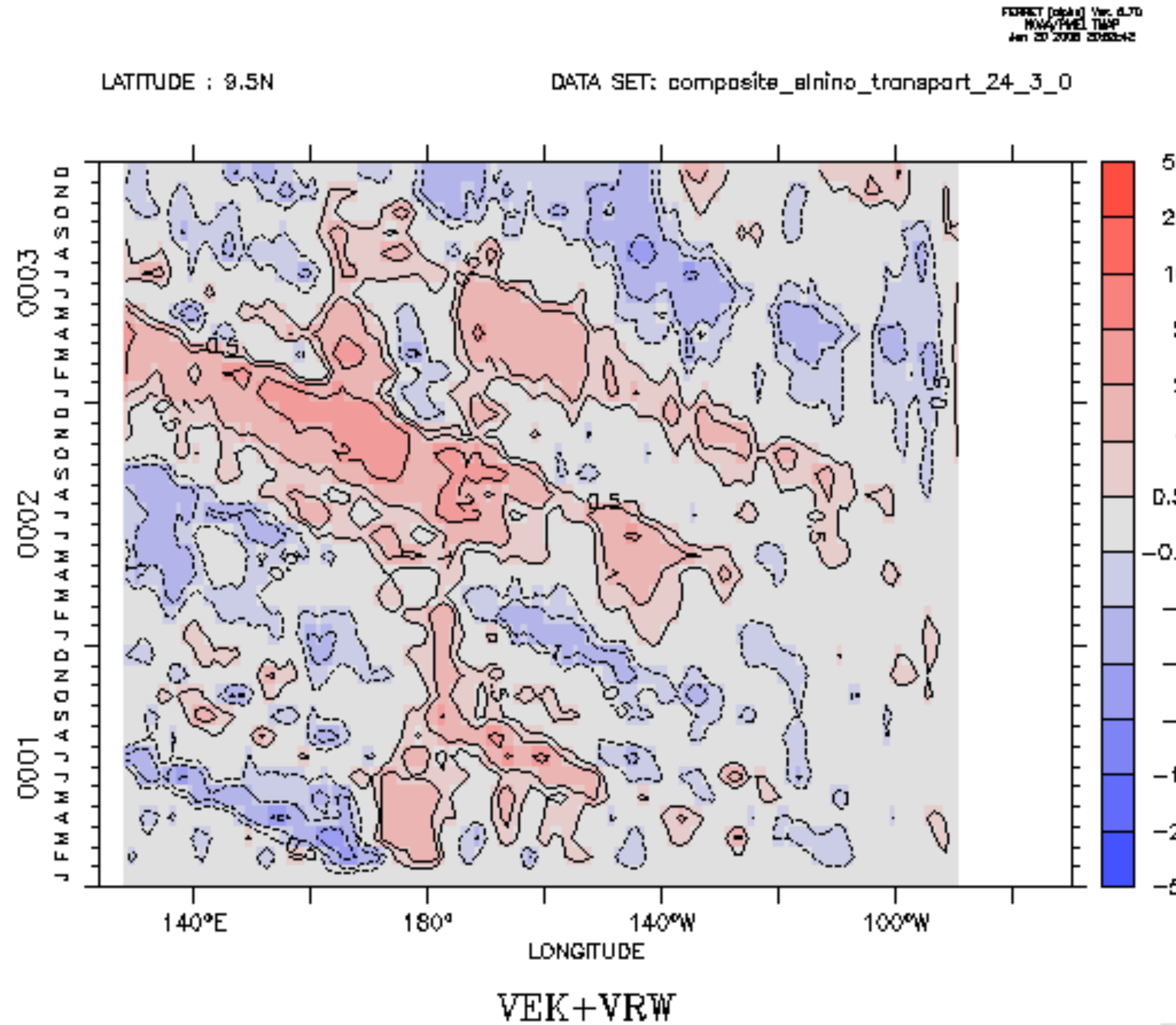

LATITUDE : 10N
CALENDAR: NOLEAP
MOM4 composite transport anomalies above 15°C at 10°
0000
0001
0002
140°E
180°
140°W
100°W
60°W
LONGITUDE
V_ZINT[D=UV_EC_Z15_DIN]-V_ZINT[D=UV_SC_Z15_DIN] (box smoothed by 15 pts on T)


LATITUDE : 9.5N
DATA SET: composite_elnino_transport_24_3_0
0001
0002
0003
140°E
180°
140°W
100°W
LONGITUDE
50
25
10
5
2
1
0.5
-0.5
-1
-2
-5
-10
-25
-50
VEK+VRW