The Antarctic Circumpolar Current's monthly barotropic transport variability in 2002-2004, as seen by GRACE

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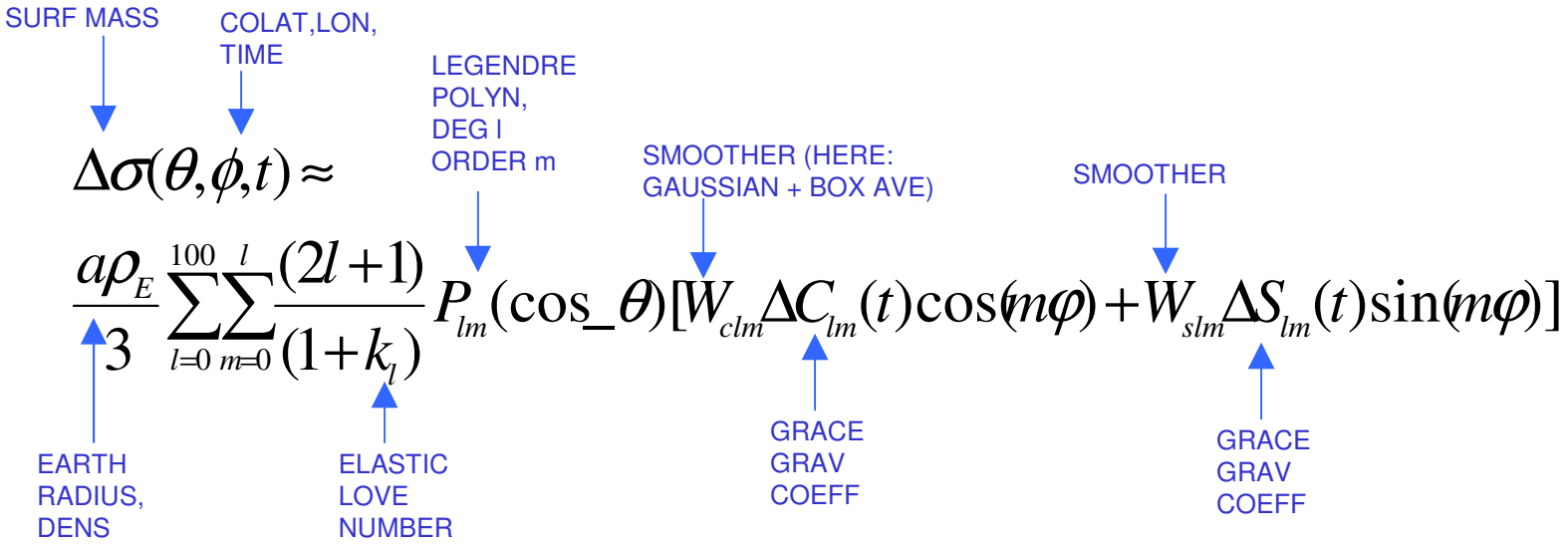
TIME VARYING: DEFINITIONS

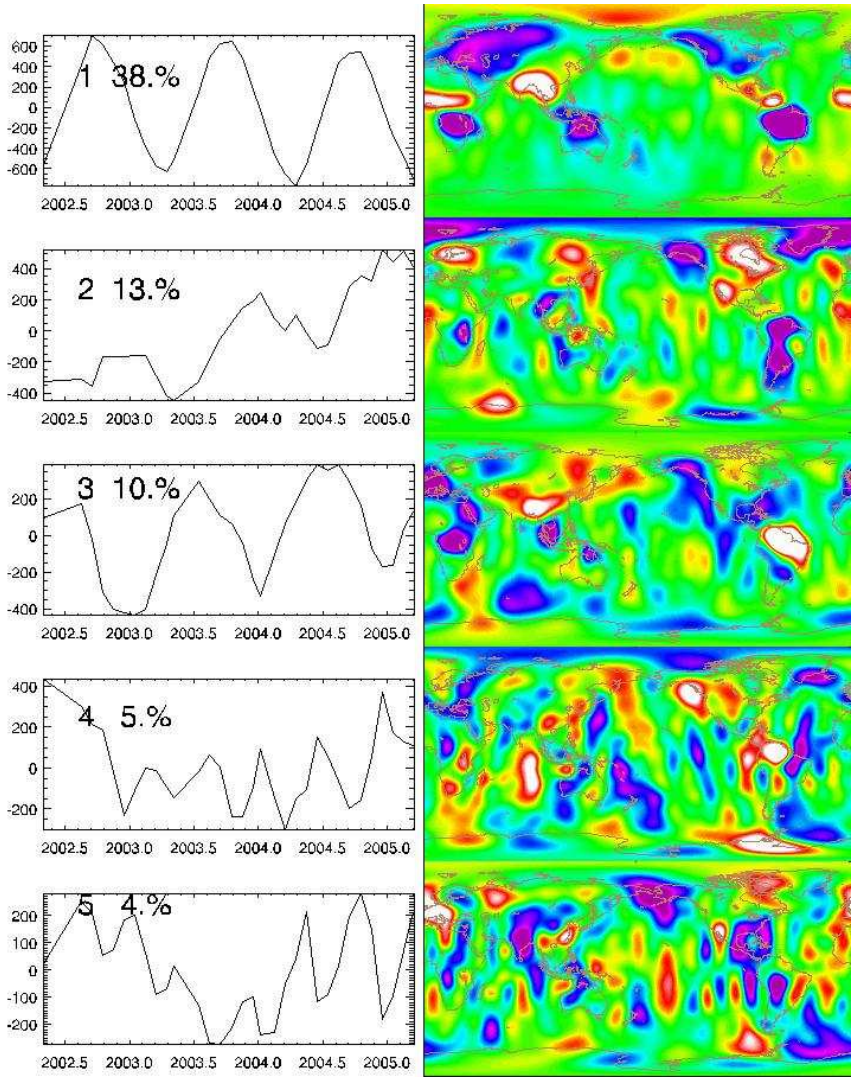
Δ(gravity)/Δt $\Longrightarrow$ Δ(surfacemass)/Δt = $\Delta\sigma/\Delta t$



$\Delta\sigma/\rho_W$ = water thickness $\Longrightarrow$ OBP over the oceans

GRACE 'WATER' GLOBAL: EOFs

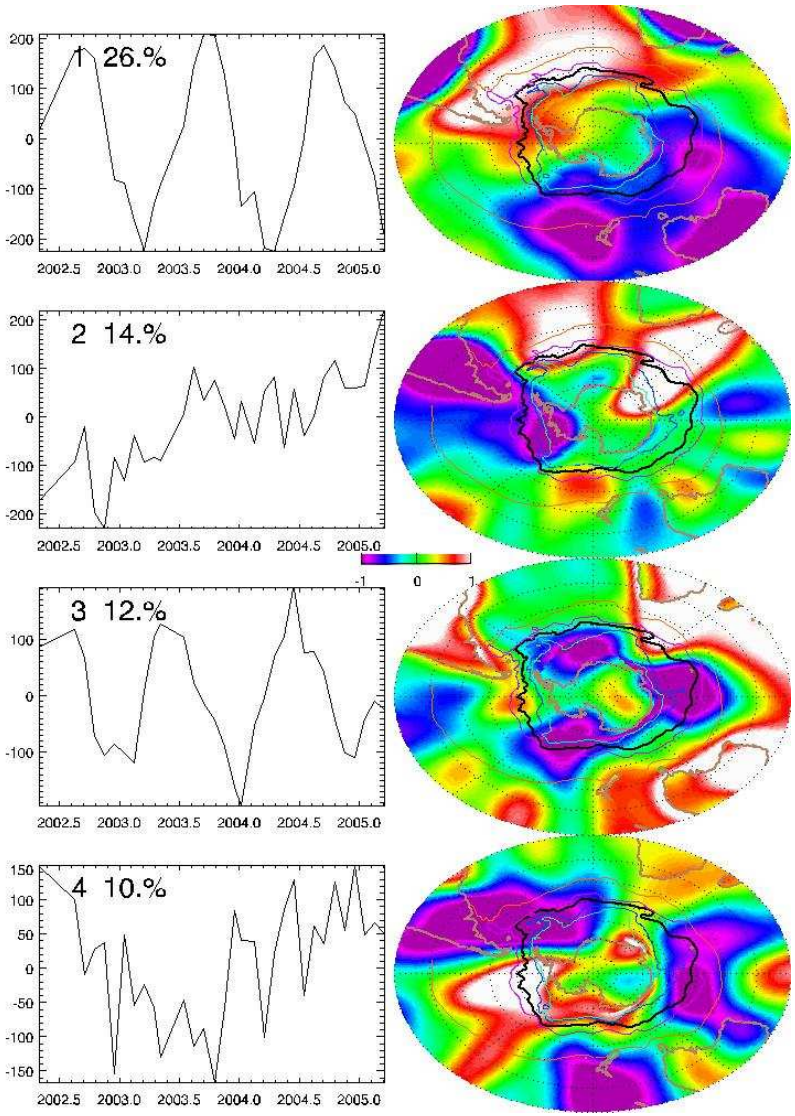
700 km smooth



- Filter: gaussian, f=0.5 at 700 km radius.
- EOF 1 **LAND**: notice clean, strong annual signals over Amazon, Central America, N. Australia, SE Asia, Africa.
- EOF 2, **TREND**: at high lats, trends and PGR mix. But S. America?
- **EOF 3**: part of annual propagating signal, but noisy.
- EOFS 4, 5: N-S 'stripiness' <-> data noise, much clearer over oceans (alternating N-S currents?)
- Official GRACE data release: 22 months, 5/2004.
- Test release 34 months, 6/2005 used here.

GRACE 'WATER' ACC: EOFs

1000 km smooth

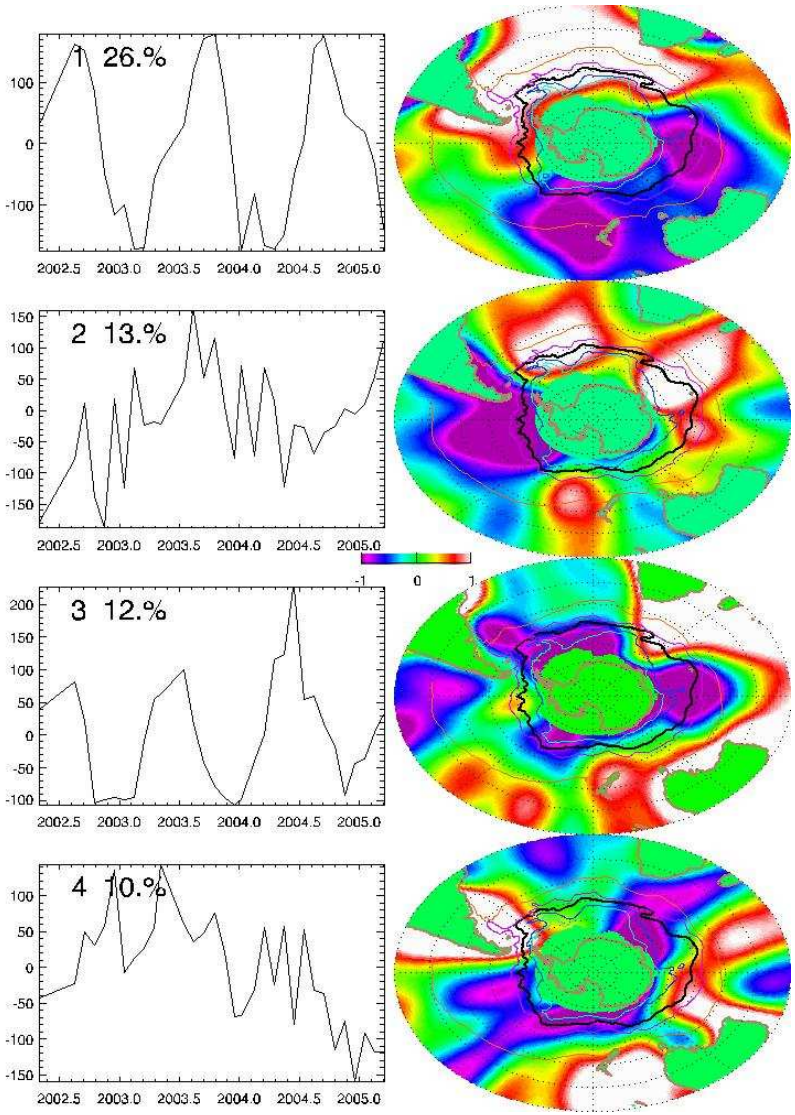


- EOFs taken only for data south of 30°S
- 1000 km gaussian filter
- ACC fronts from Orsi.

- EOF 1: Land and Ocean signal, annual, 'knows' about ACC fronts.
- EOF 2: trend, perhaps controlled by land.
- EOF 3: annual, but land dominates.

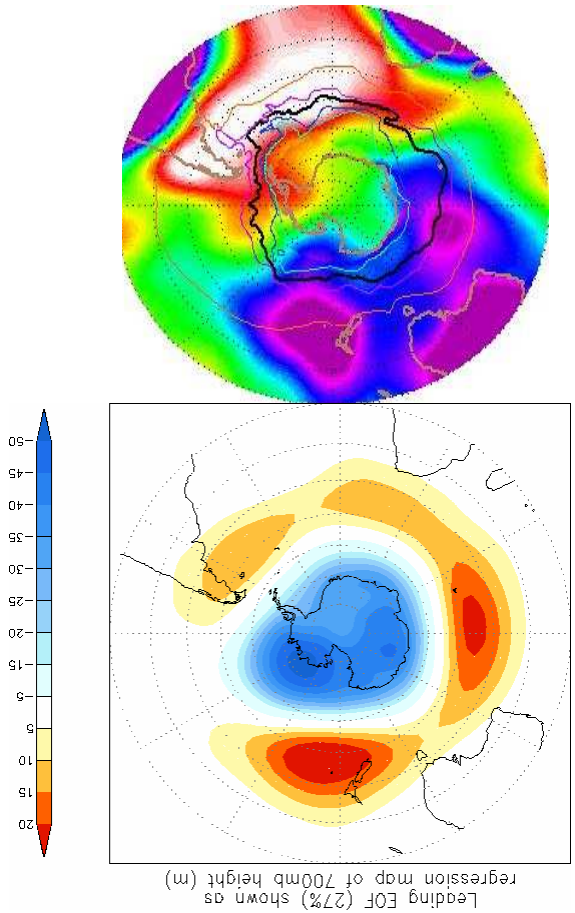
GRACE 'OBP' ACC: EOFs

1000 km smooth



- EOFs taken only for data south of 30°S, land and sea ice mask excluded; land leakage band *not* excluded
- 1000 km gaussian filter
- Similar patterns as 'water' (EOF 4 flipped signs)
- Can use EOF 1-3 with confidence.

GRACE 'OBP' ACC: EOF 1 vs AAO



Leading EOF (27%) shown as regression map of 700mb height (m)

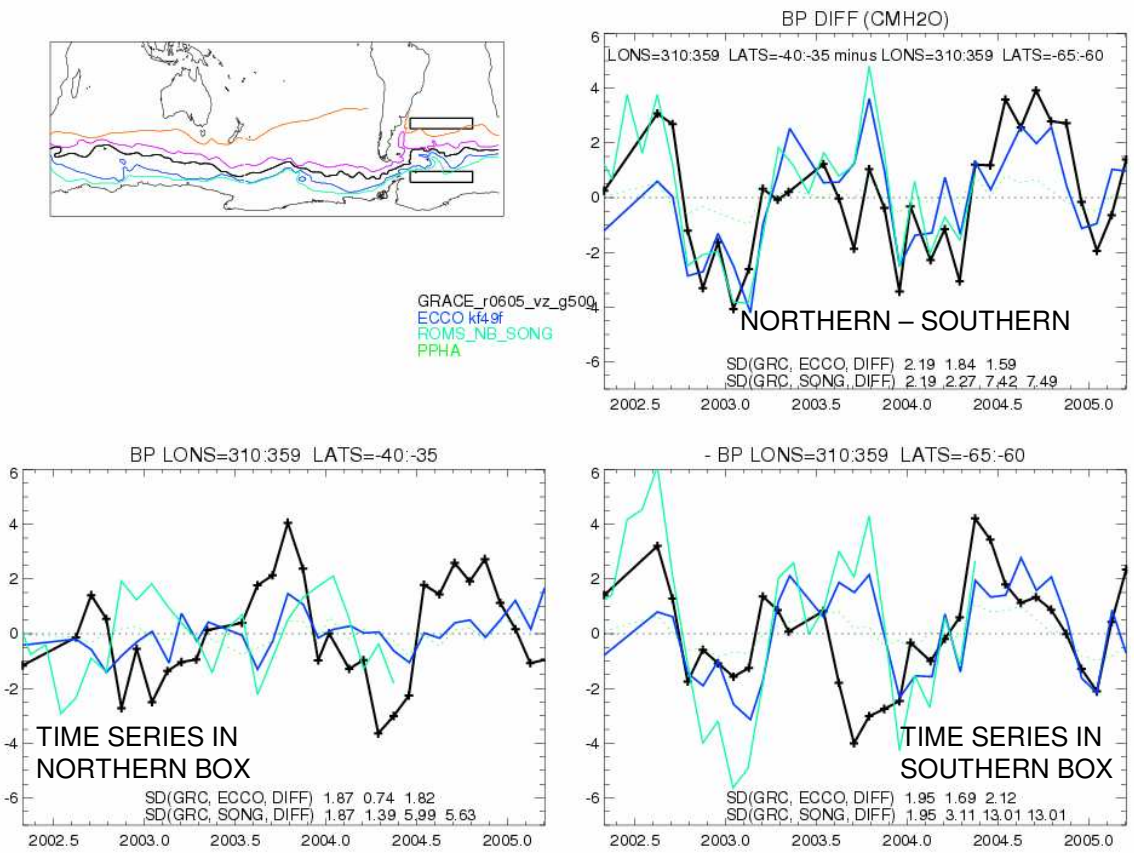
EOF 1 of GRACE water, 1000 km ave, 26% var.

AAO = SAM = EOF 1 (27% var) of monthly mean 700 hPa height, 1979-2000, dominant pattern of **non-seasonal** tropospheric circulation variations south of 20°S. (Thompson and Wallace, 2000. Fig. from NOAA CPC)

NOT ALIKE: Indian and Pacific energetic centers are the same, but Atlantic region opposite phase

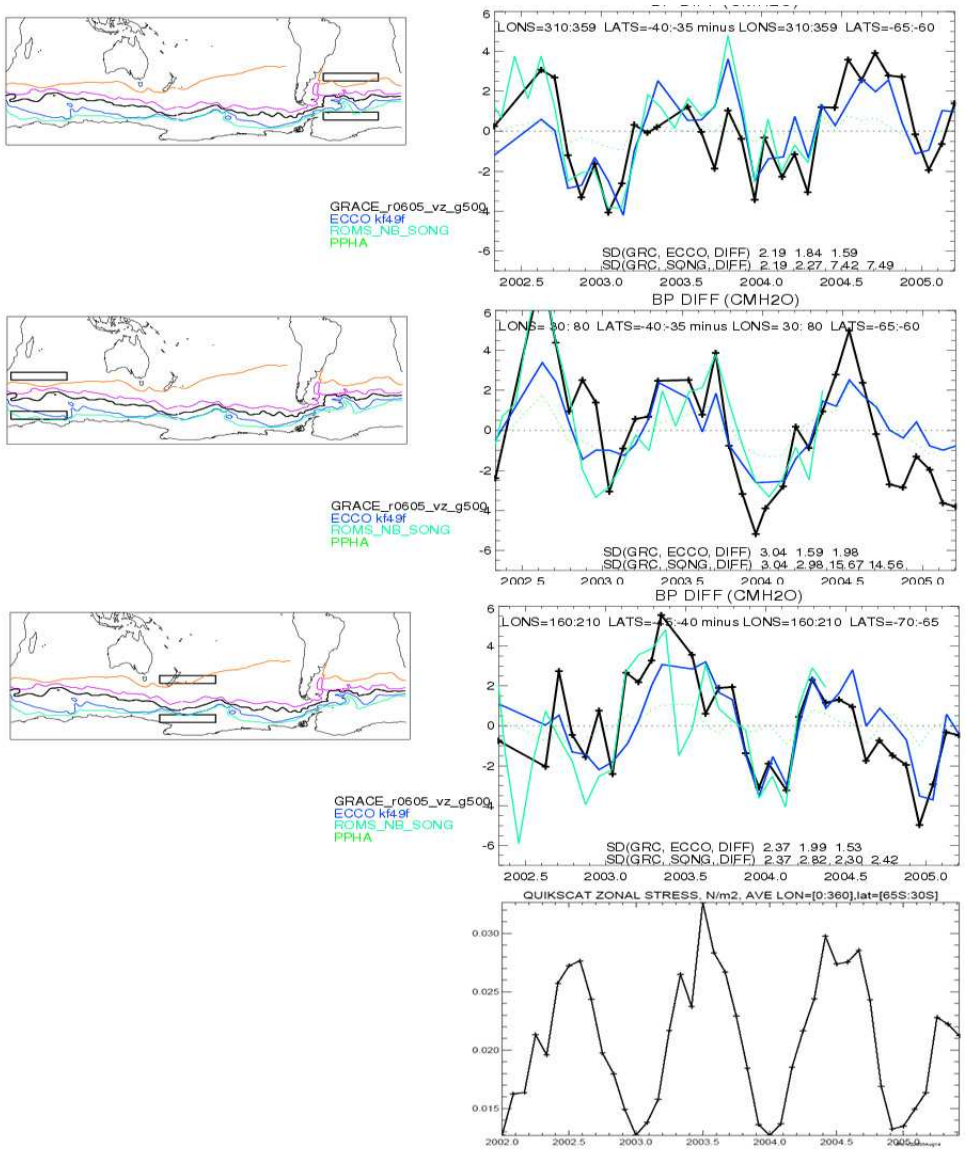
Possible GRACE dealiasing residual error?:

OBP DIFF ACROSS ACC (1)



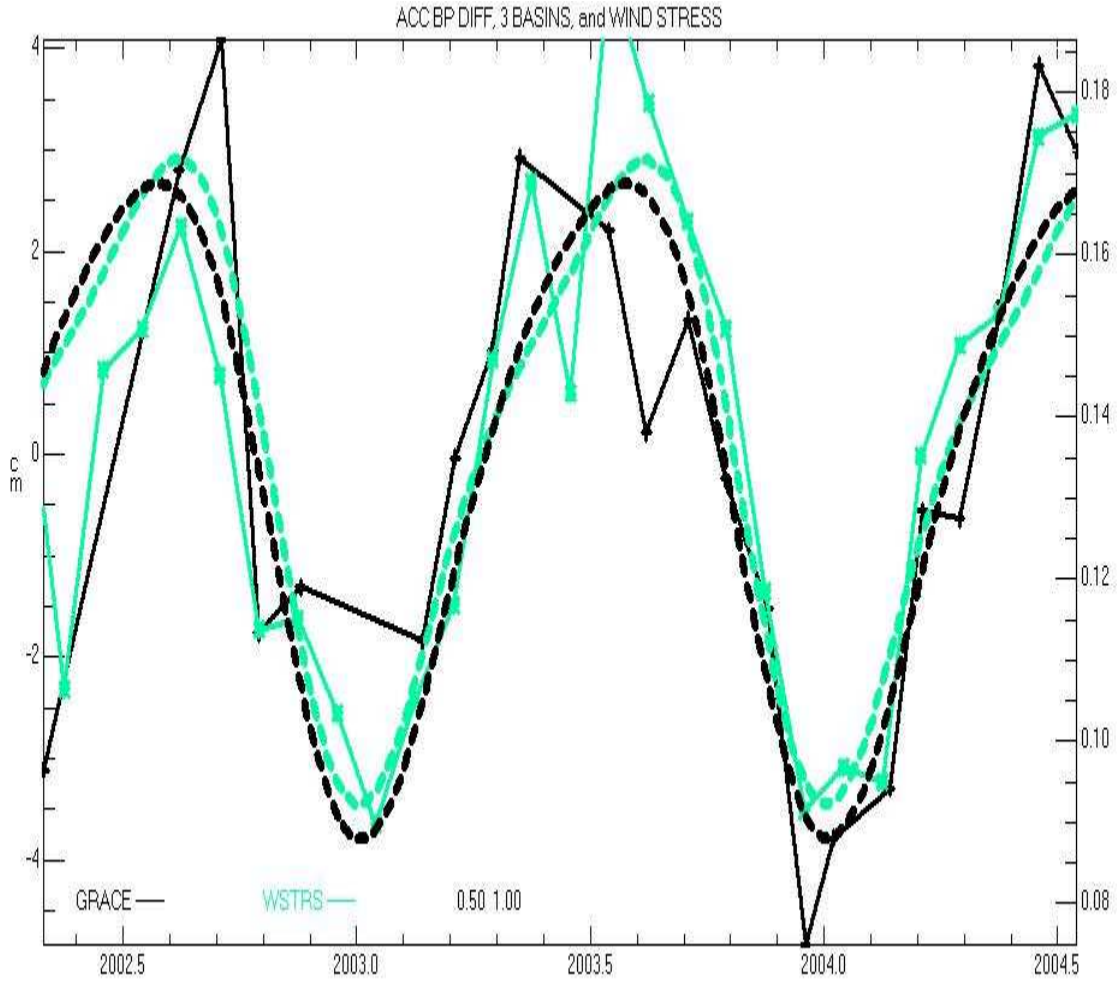
- 500 km gaussian filter, further averaged over 40^{o} lon (5^{o} lat box)
- GRACE 'BP', ECCO/JPL BP (assimilates Jason, XBT), SCRUM/SONG BP (non-Boussinesq, no data assim)

OBP DIFF ACROSS ACC (2)



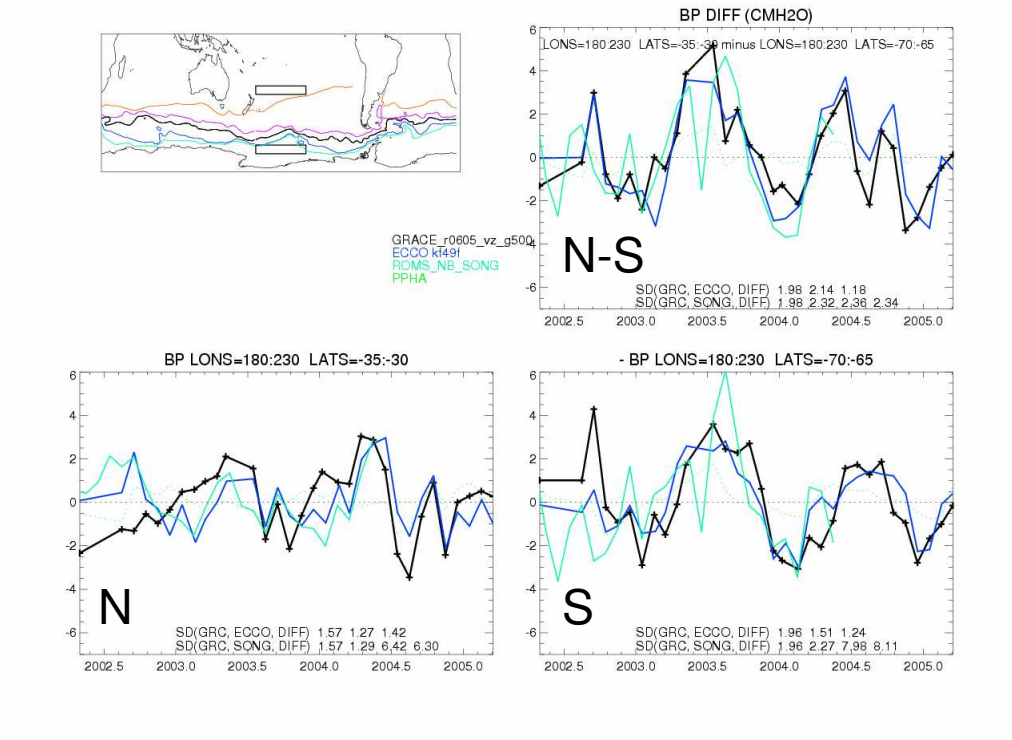
- Boxes across ATL, IND, PAC sectors of ACC. N-S diffs.
- General agreement in amplitude and phase.
- Wind stress, zonal, Quikscat has ~same phase

GRACE 'BP' vs QSCAT WIND



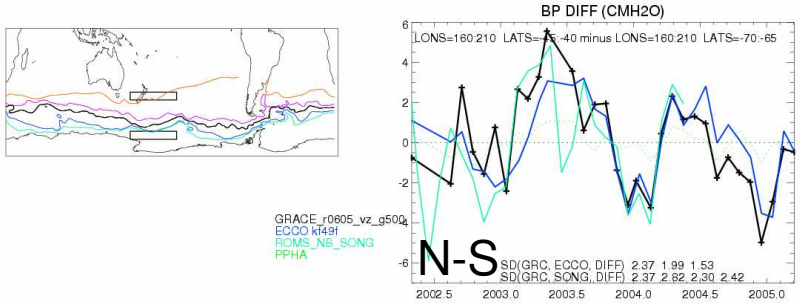
- Averaged BP over 3 basins
- Quikscat east wind stress, averaged over all lons, lats:30S to 65S.
- Annual and semiannual sinusoid fit: wind and current variability in phase, max at the annual frequency on days 199(w) and 194(bp), semiannual at days 77(w) and 81(bp).
- Ekman mechanism of Hall & Visbeck, 2002 Seasonal vs interannual?

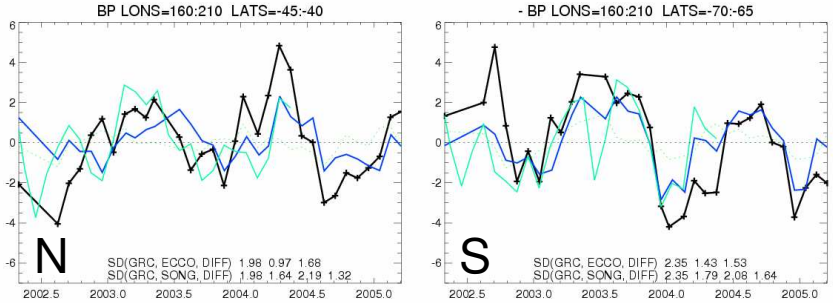
SENSITIVITY TO NORTHERN BOUNDARY (1)

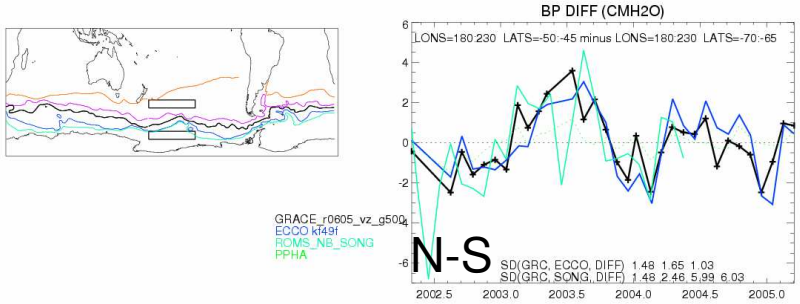


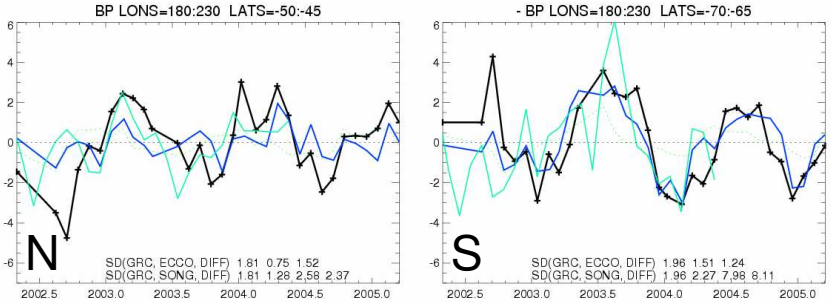
- The northern boundary of the ACC is not well defined. Many recirculation and local patterns.
- Variability along southern boundary has been increasingly accepted as a measure of ACC strength, based on Ekman mechanism.
- Next two figures show effect of different, but reasonable northern boundary choices.

SENSITIVITY TO NORTHERN BOUNDARY (2)



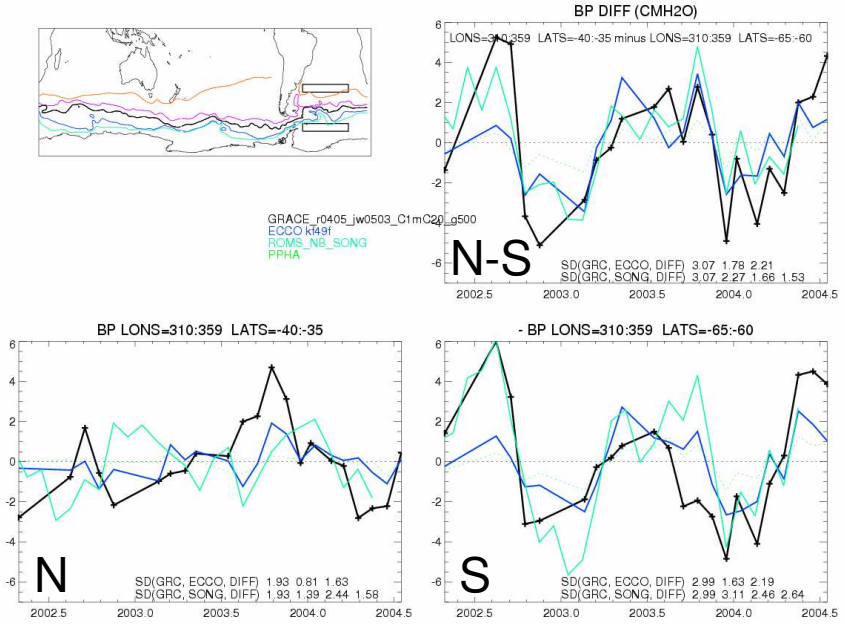






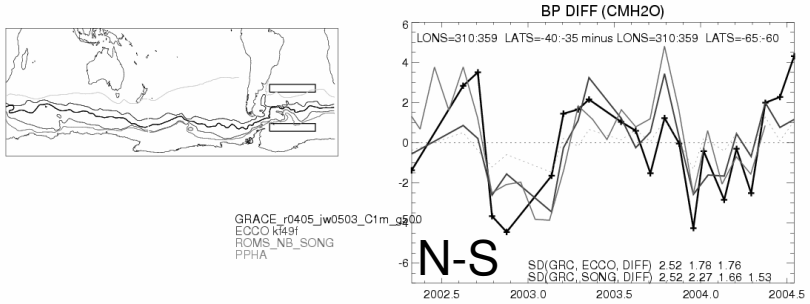
Notice the change in the difference time series as the Northern boundary is changed.

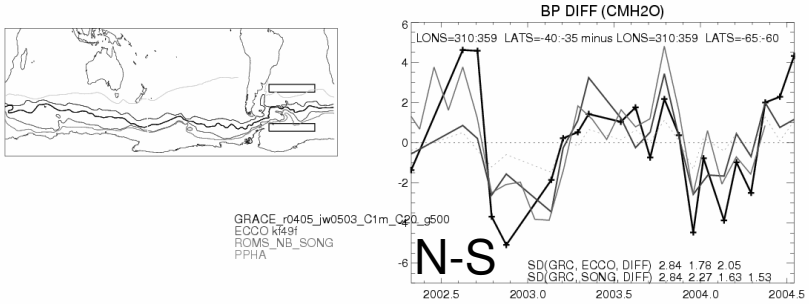
SENSITIVITY TO C/S_{1m}, C/S_{20} (1)

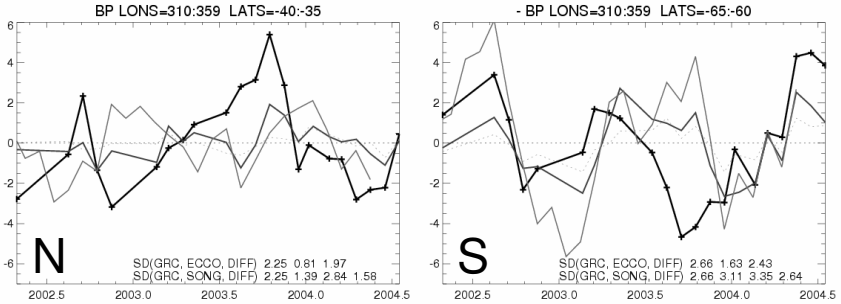


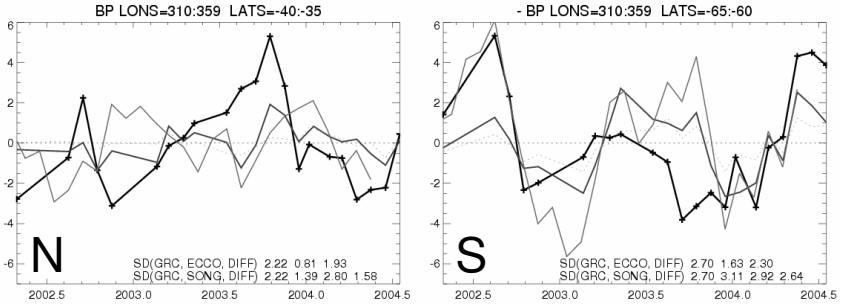
- However, choosing only the Southern boxes makes the results more sensitive to uncertain coefficients (1,m), (2,0)
- Here the (1,m) coefs are from X. Wu, the (2,0) from Cheng.
- The next 2 figures illustrate the issue.

SENSITIVITY TO C/S_{1m}, C/S_{20} (2)









SUMMARY

The accuracy in the initial data release, of ~ 1.4 cmH_2O averaged with 1,000km radius(1/2 height) gaussian means a) focus on very energetic ocean signals, like ACC, or b) average over broader areas, including entire basins (Chambers) to obtain accurate results.

- Error pattern: stronger in zonal direction (N-S stripes)
- Length scales greater > 2,000km. Strong signals.

- ACC has strong signals. Zonal extent ~ 28,000km. Ideal.

- EOF 1 of GRACE BP:
  - seasonal cycle
  - clean spatial pattern. Matches SAM, AAO spatial patt
- BP diff across ACC from GRACE
  - agree with ECCO to +/- < 2 cm
  - Have excellent agreement with pure Quikscat wind stress data
  - Sinusoidal fit of annual + semiannual shows phase agreement to +/- 5 days.
- To use Southern edge of ACC
  - advantage: insensitive to recirculating patterns to the North
  - disadvantage: sensitive to (1,m), (2,0) coefficients