Studying Decadal Climate Variability

Using Satellite Scatterometer Data

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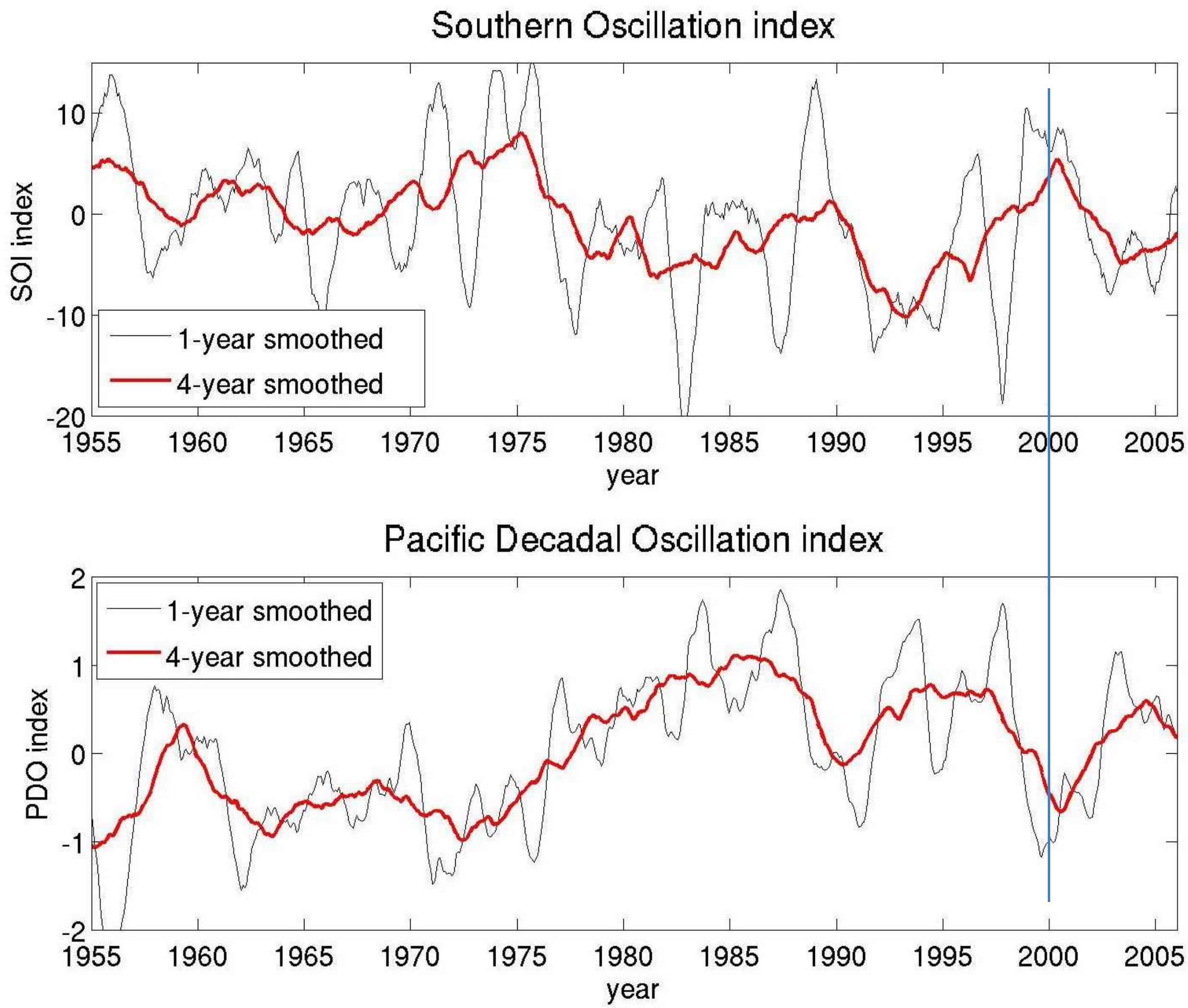
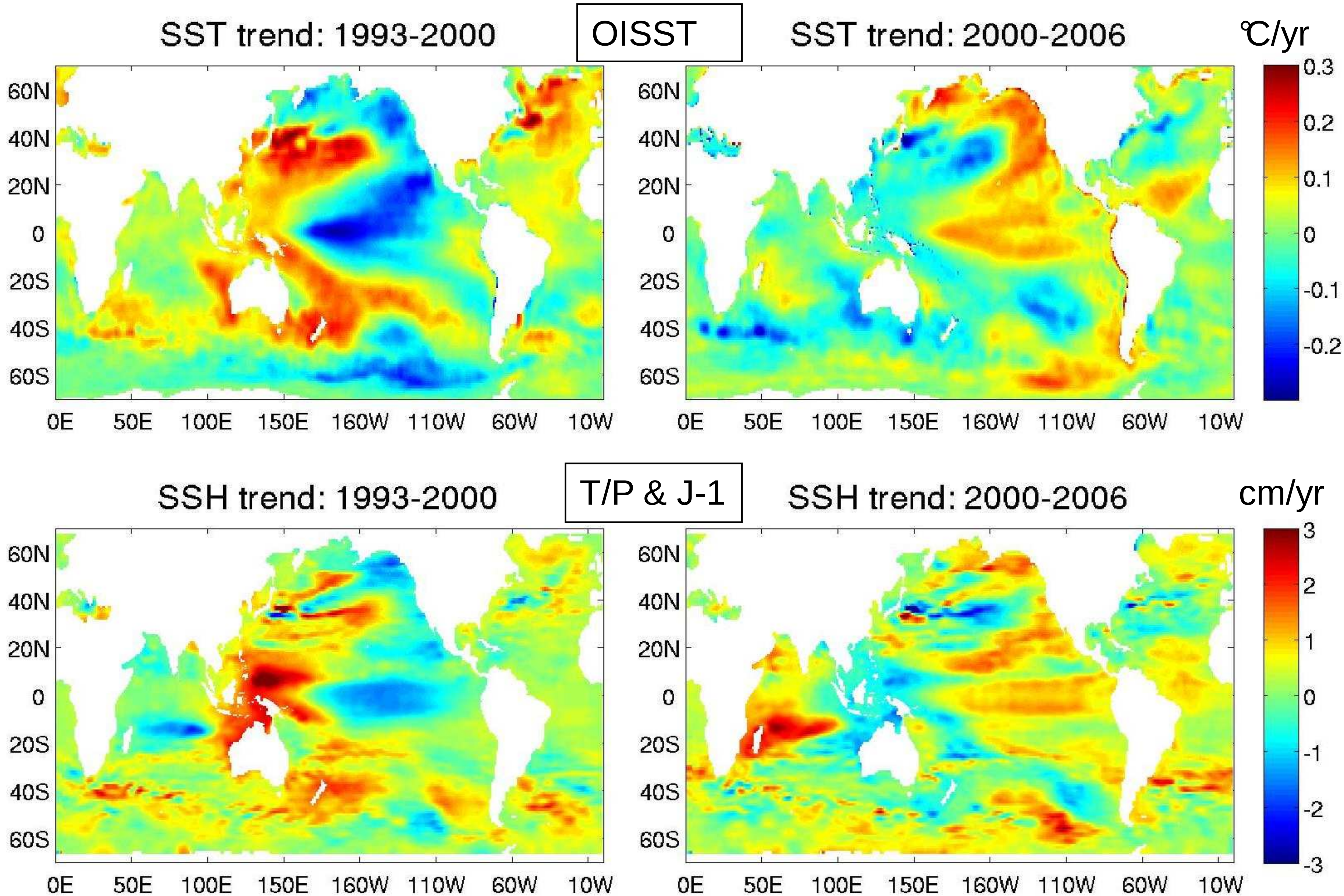
SOI & PDO indices

showing phase change of decadal signals at the end of the 20th century



Observed SST & SSH exhibit opposite decadal tendencies before & after year 2000 over much of Indo-Pacific domain



SSH time series (black) further illustrate the phase change around 2000

- Tropical Pacific leads other regions.
- SSH leads SST?
- Need wind obs. to understand SSH & SST

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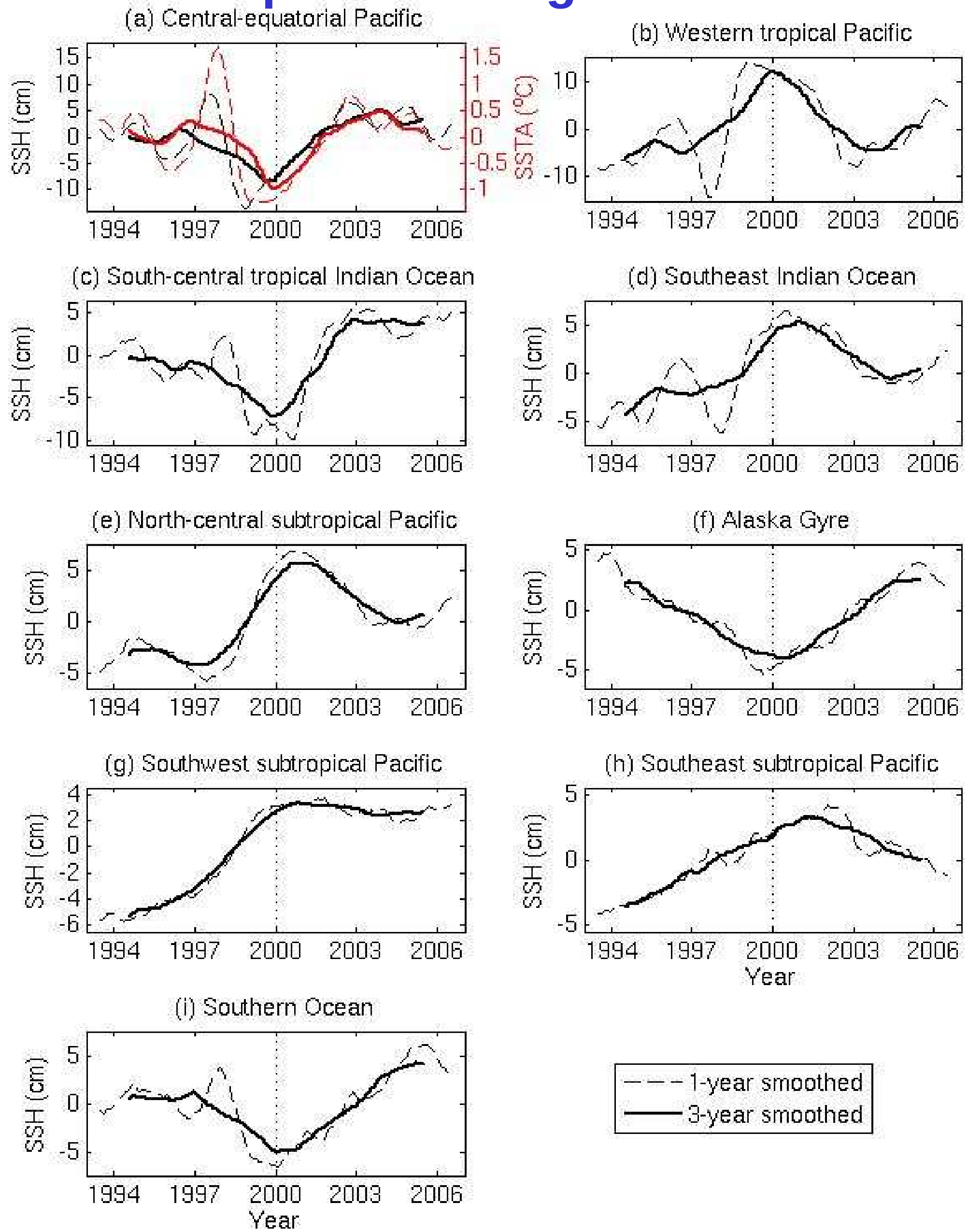
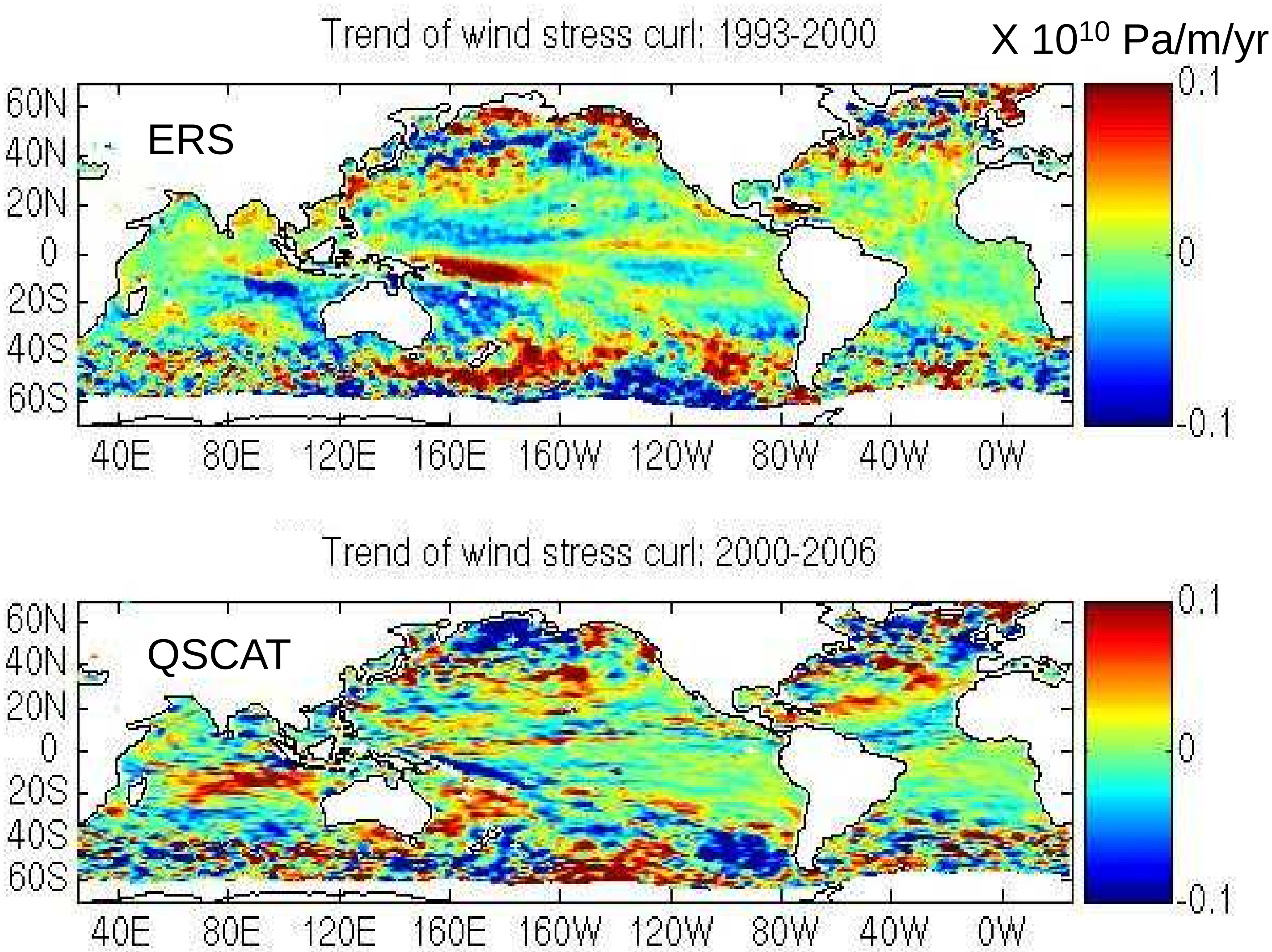
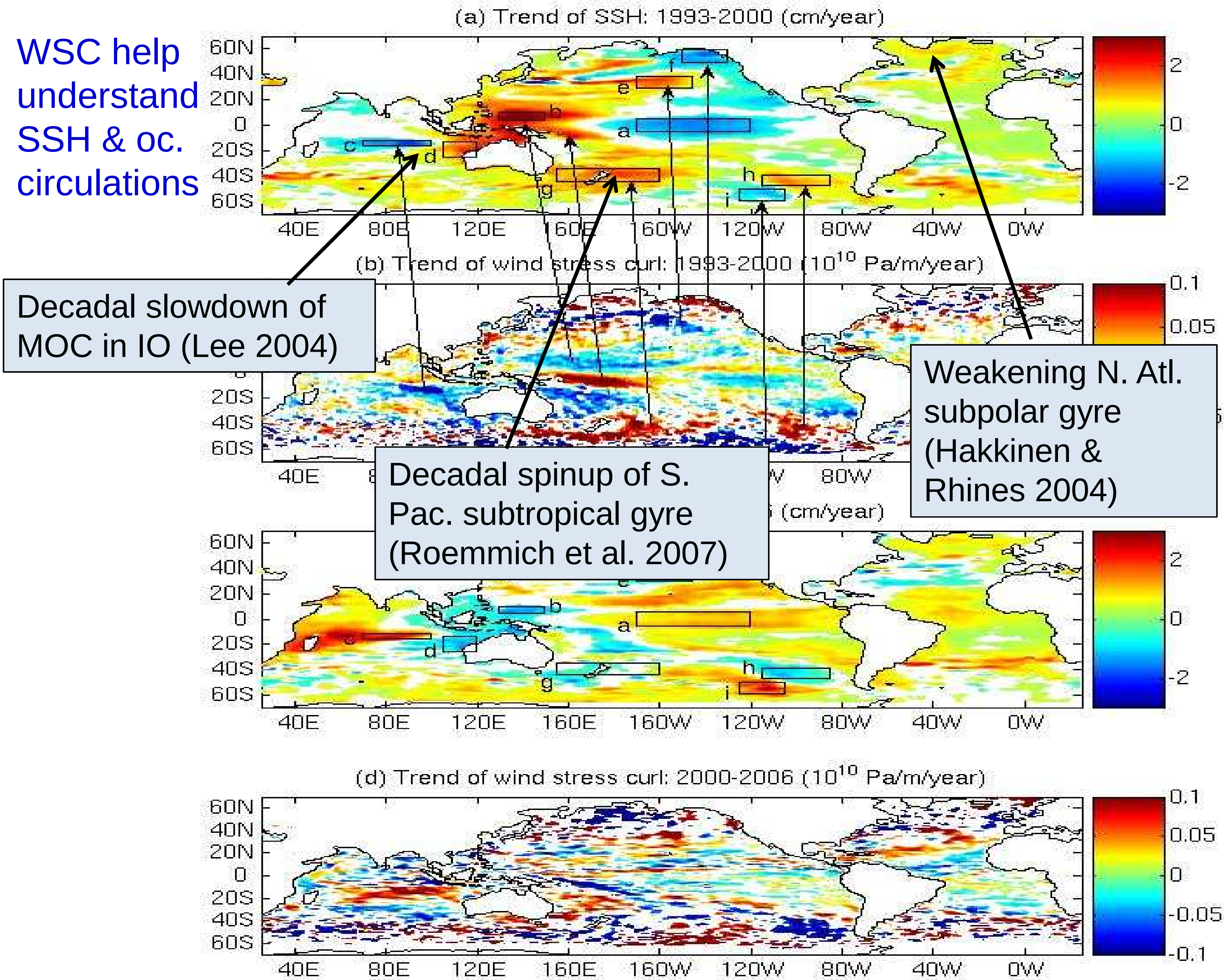


Opposite trends in large-scale wind stress curl (WSC) over much of Indo-Pacific before & after 2000

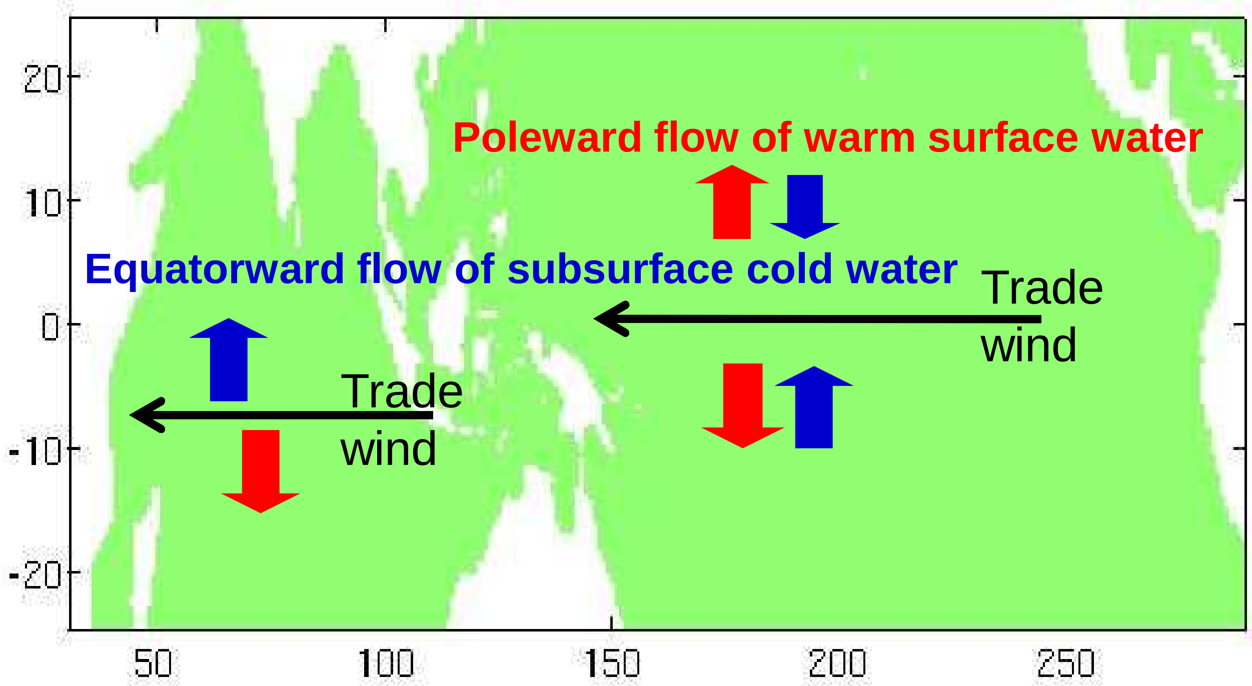


WSC help understand SSH & oc. circulations



Trade winds affect climate variability

by forcing meridional ocean circulations (MOCs) to redistribute heat between tropics & subtropics, which modulate ocean-atmosphere coupling



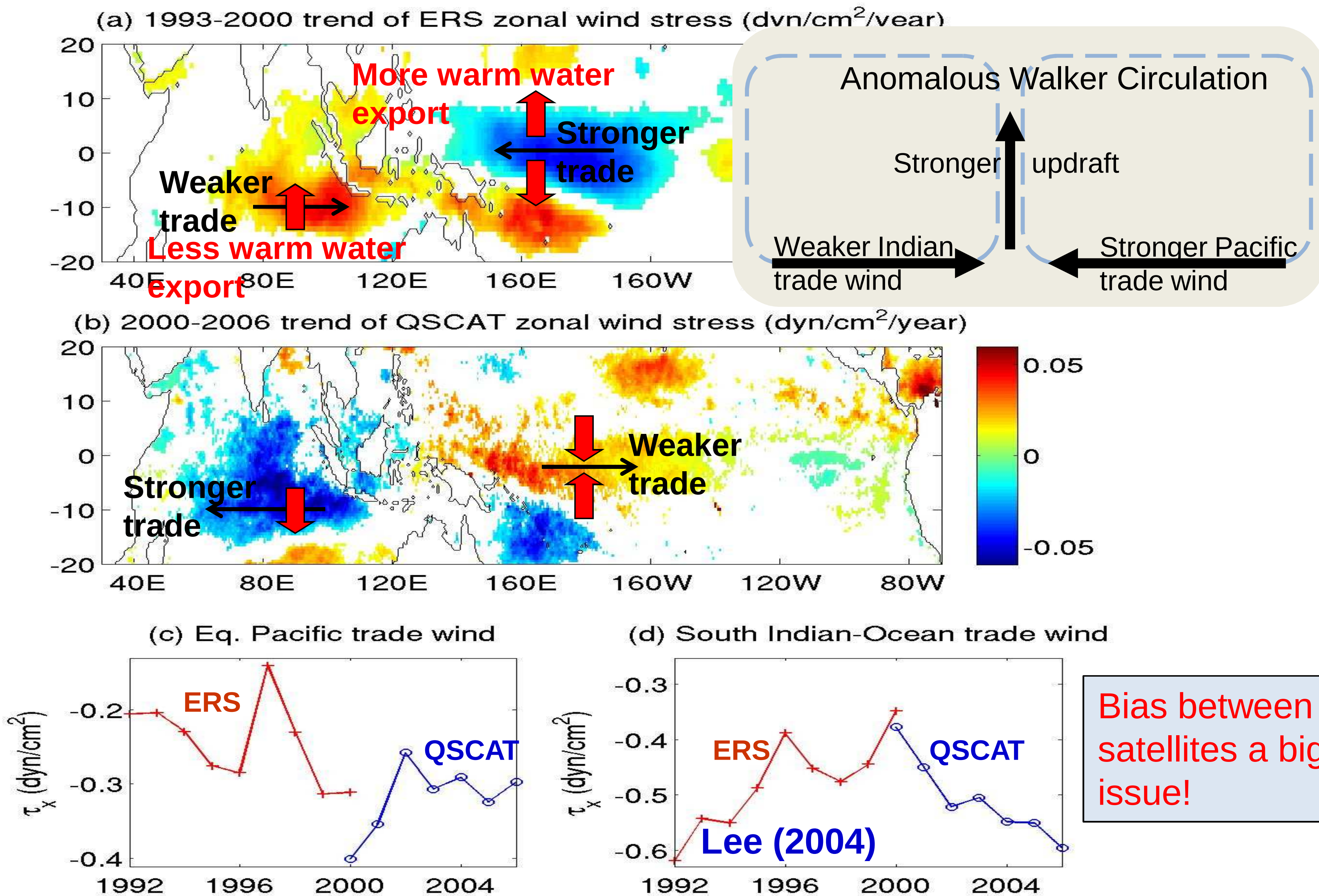
Satellite data critical to the study of these MOCs and heat transports:

Scatterometer data: divergence of warm surface water (Ekman flow)

Altimeter data: convergence of cold subsurface water (geostrophic flow)

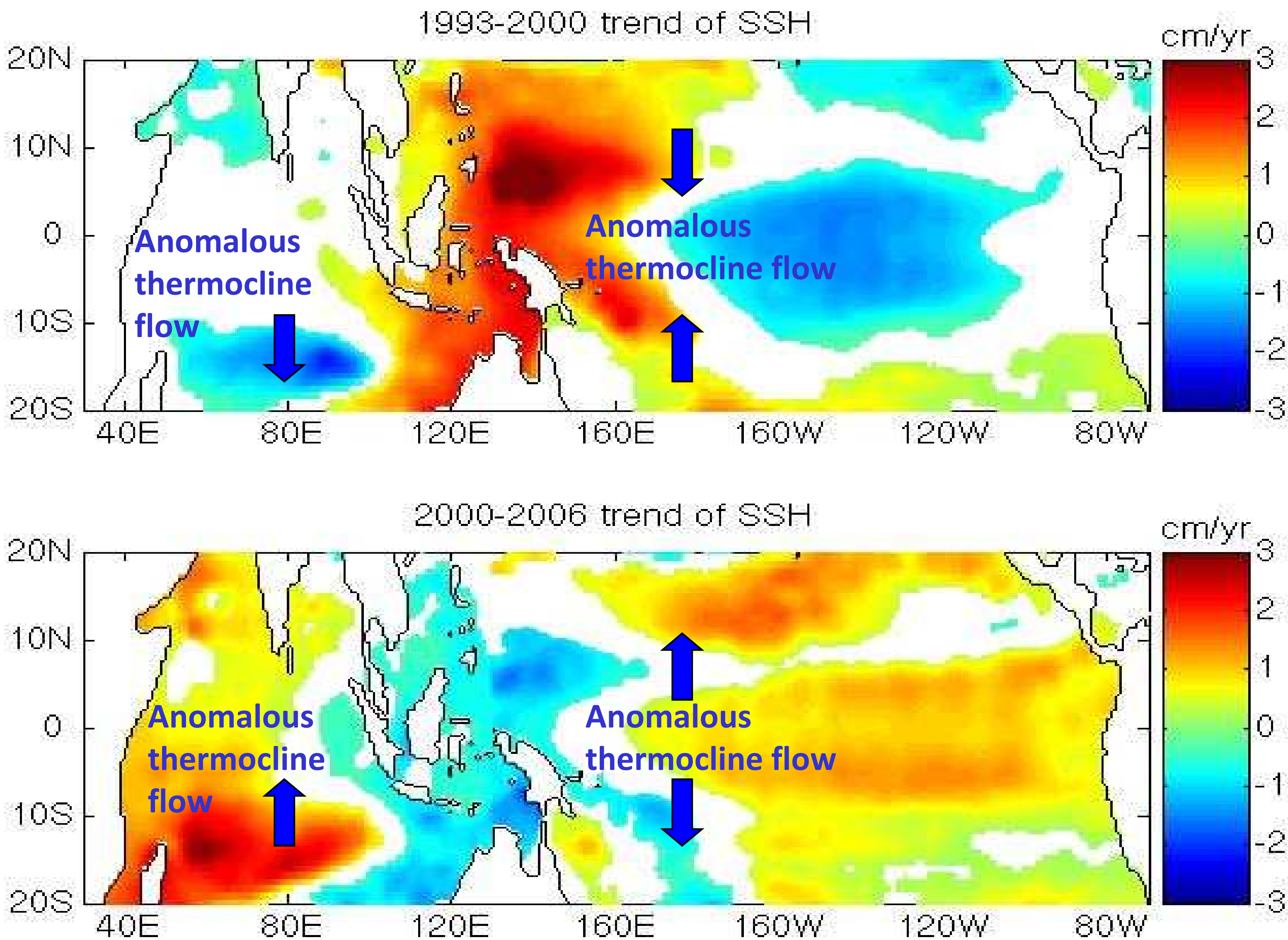
Decadal variation of trade winds & climate variability

Lee and McPhaden (2008)

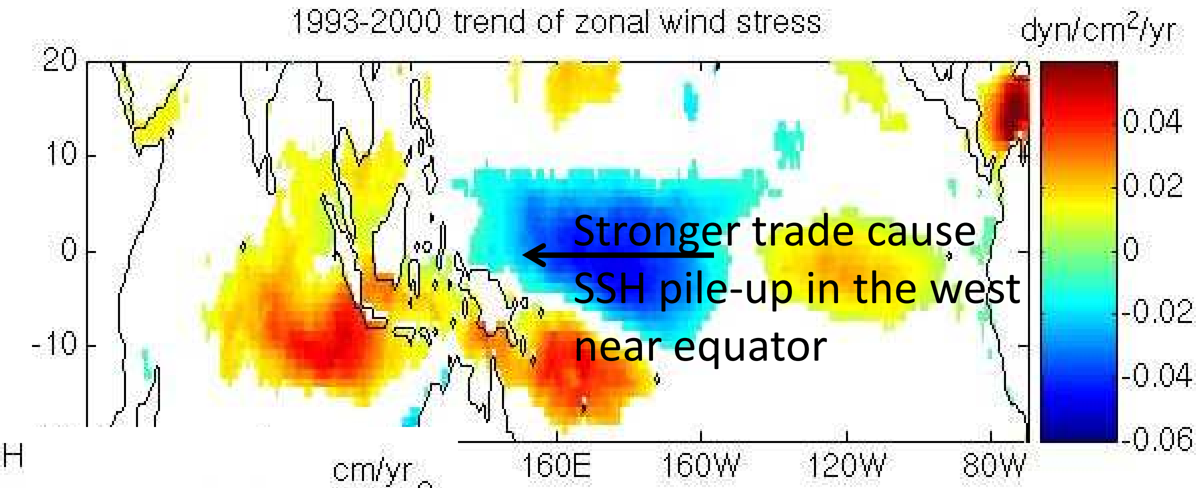


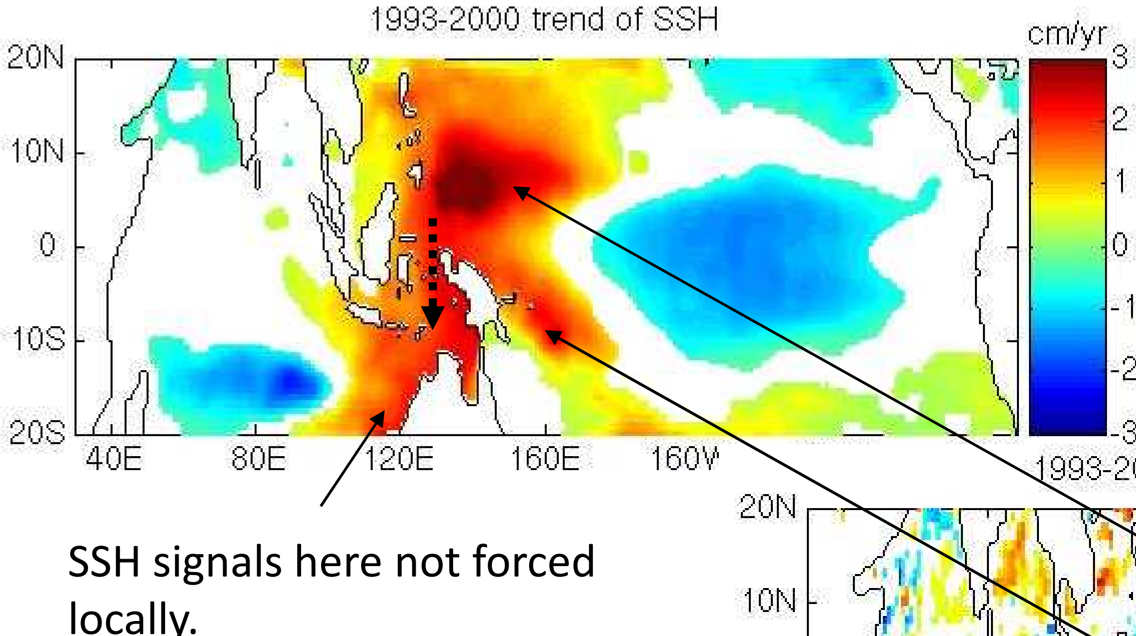
Bias between satellites a big issue!

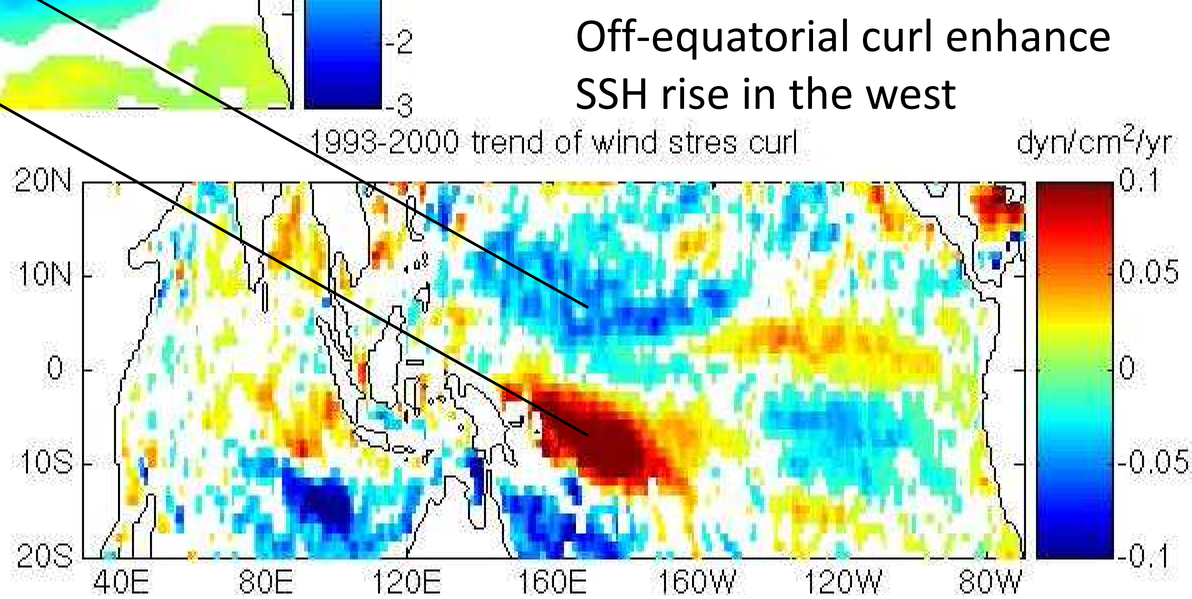
Opposite changes of SSH differences between E & W coasts: thus opposite roles of Pacific & IO meridional geostrophic flow (lower branch of MOCs)



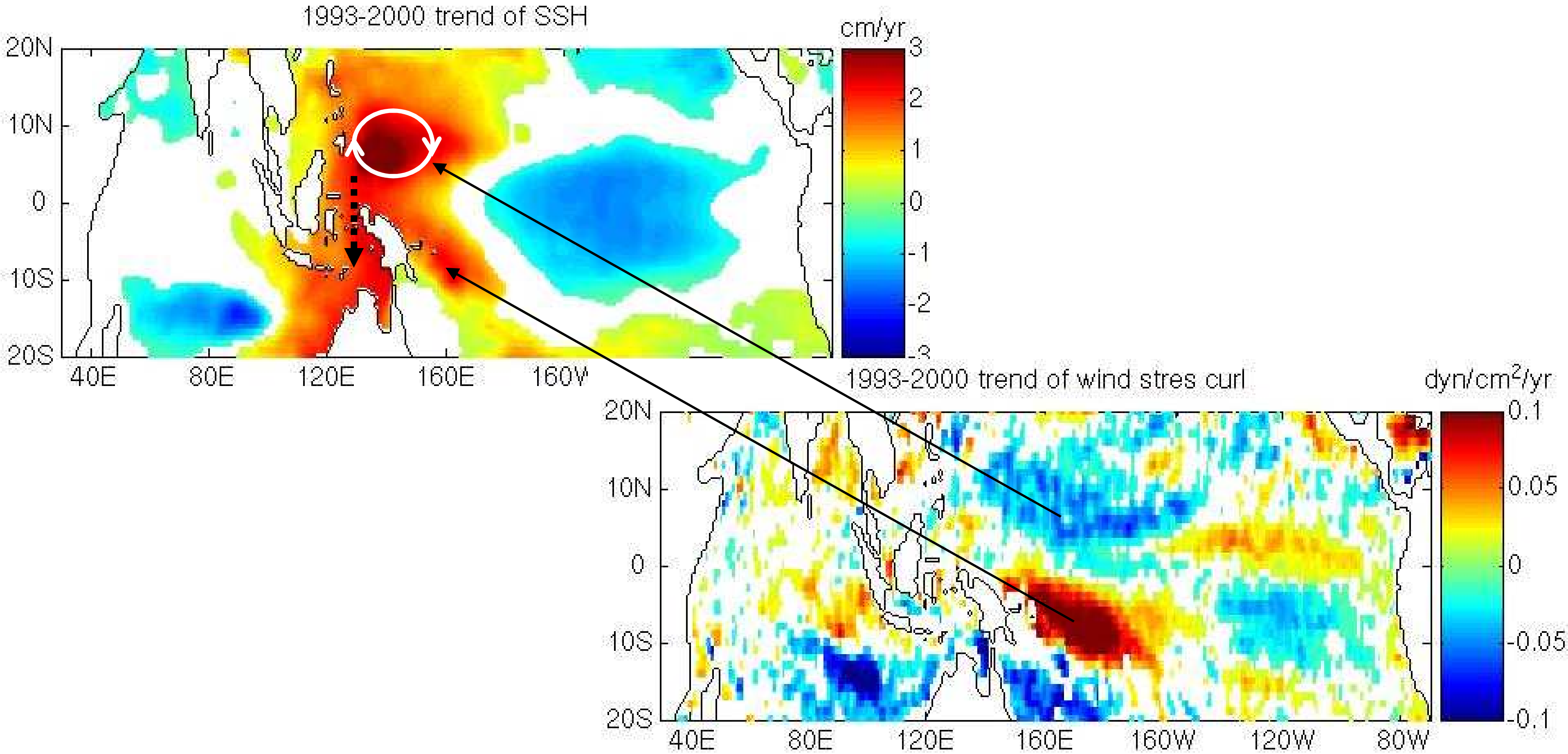
Tropical Pacific wind control E-W SSH differences (and thus lower limb of MOCs) in Pac. & IO through oceanic tunnel.



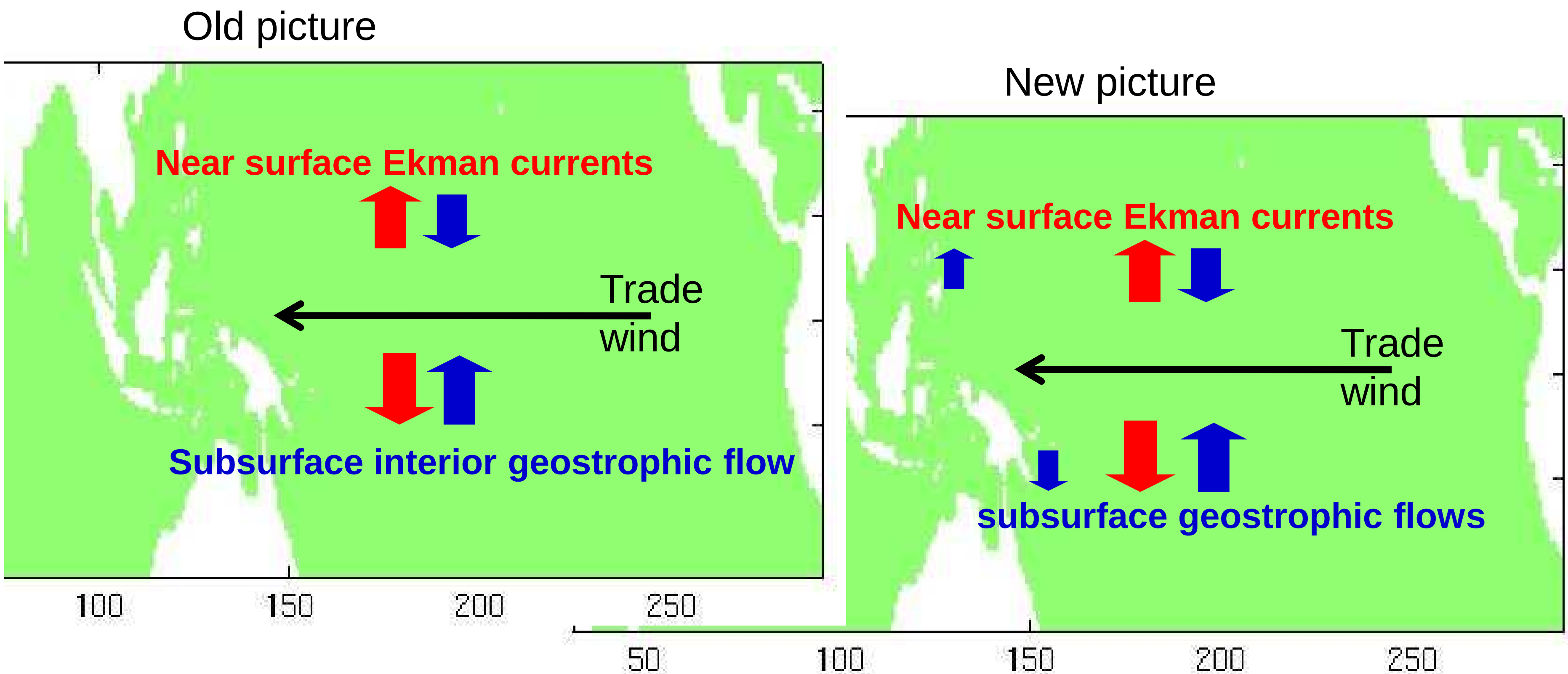




Off-equatorial wind stress curl cause anomalous gyres in western Pacific, resulting in counteracting geostropic flows in western boundary currents & interior (Lee and Fukumori 2003)



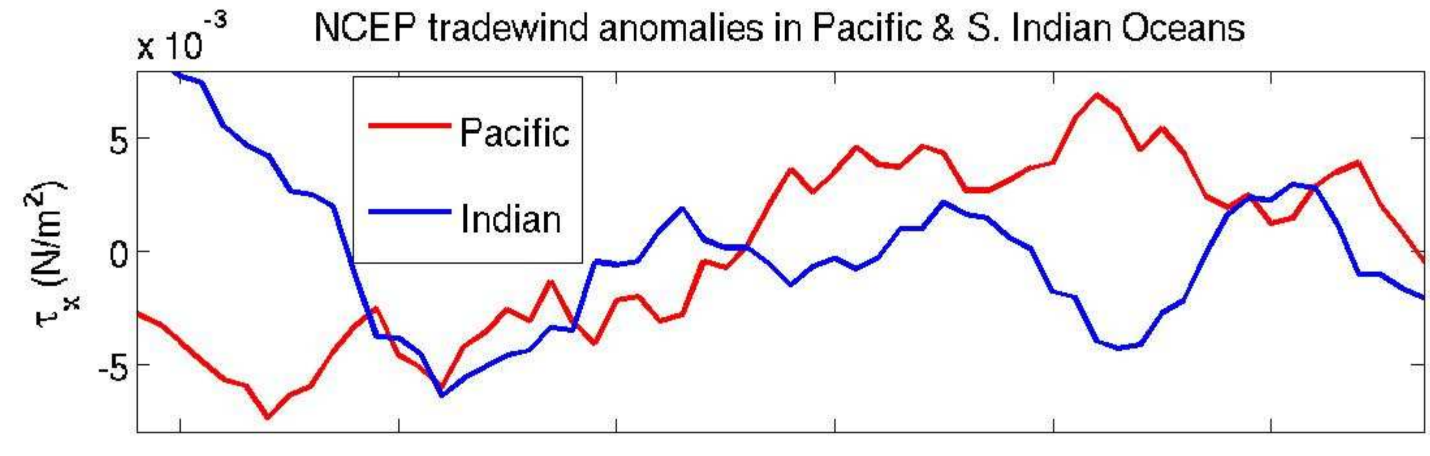
Scatterometer & altimeter obs. brought new insight about MOC structure & maintenance mechanism of tropical heat content



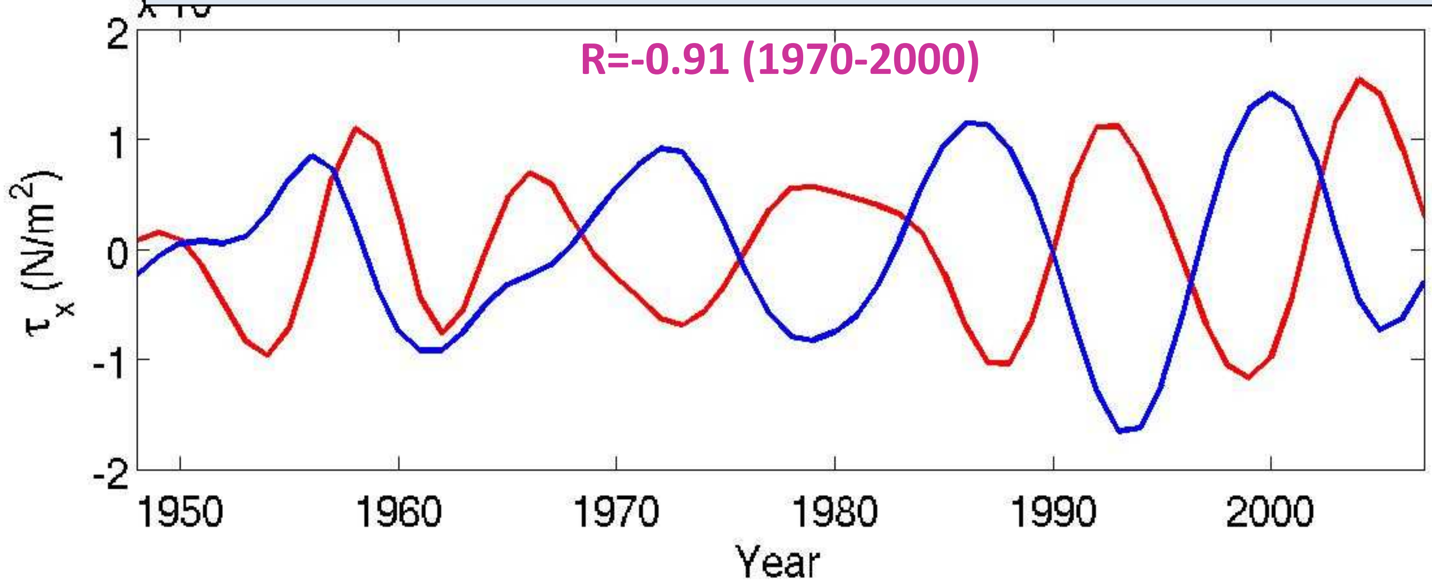
- 2-D (y-z) meridional transport stream function masks out counteracting roles of interior & WB flows;
- existing in-situ obs system do not cover WB flows adequately.

Scatterometer & altimeter data only cover the past 16 years, are the anti-correlated Dec. Var. between tropical Pacific & South Indian Oceans ubiquitous features in general?

Anti-correlated decadal variability in NCEP's trade winds in tropical Pacific (4°S-4°N) & Indian Ocean (9°-15°S)

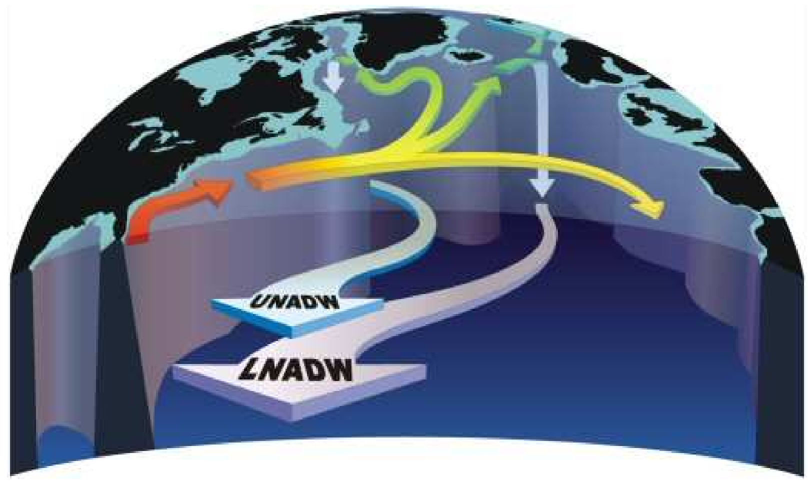


Are the multi-decadal changes real? Wind stress obs need to resolve/discern a 0.001 N/m^2 decade-to-decade difference (< 1 m/s). What's the required obs acuracy?



Atlantic Meridional Overturning Circulation (AMOC) and Climate

AMOC helps maintain a warmer climate in N. America & Europe.



Bryden et al. (2005): Slowing of the AMOC

Table 1 | Meridional transport in depth classes across 25° N

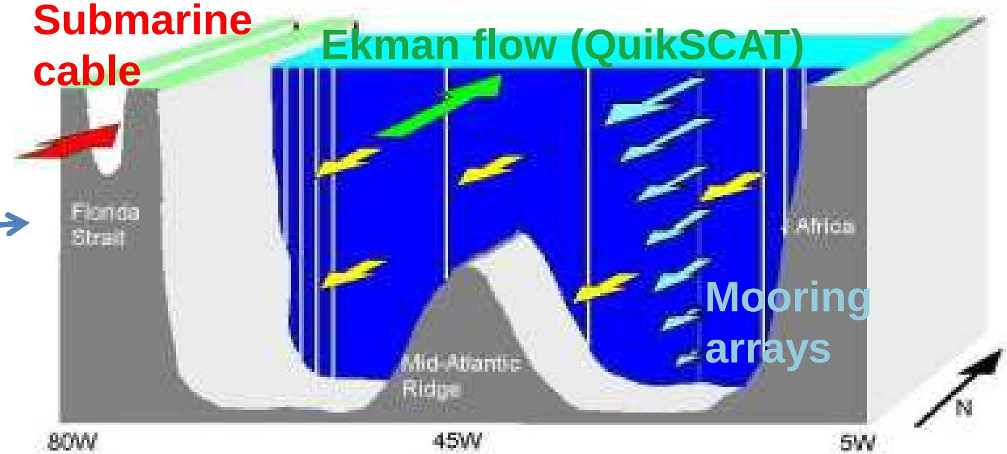
	1957	1981	1992	1998	2004
Shallower than 1,000 m depth					
Gulf Stream and Ekman	+35.6	+35.6	+35.6	+37.6	+37.6
Mid-ocean geostrophic	−12.7	−16.9	−16.2	−21.5	−22.8
Total shallower than 1,000 m	+22.9	+18.7	+19.4	+16.1	+14.8
1,000–3,000 m	−10.5	−9.0	−10.2	−12.2	−10.4
3,000–5,000 m	−14.8	−11.8	−10.4	−6.1	−6.9
Deeper than 5,000 m	+2.4	+2.1	+1.2	+2.2	+2.5

Values of meridional transport are given in Sverdrups. Positive transports are northward.

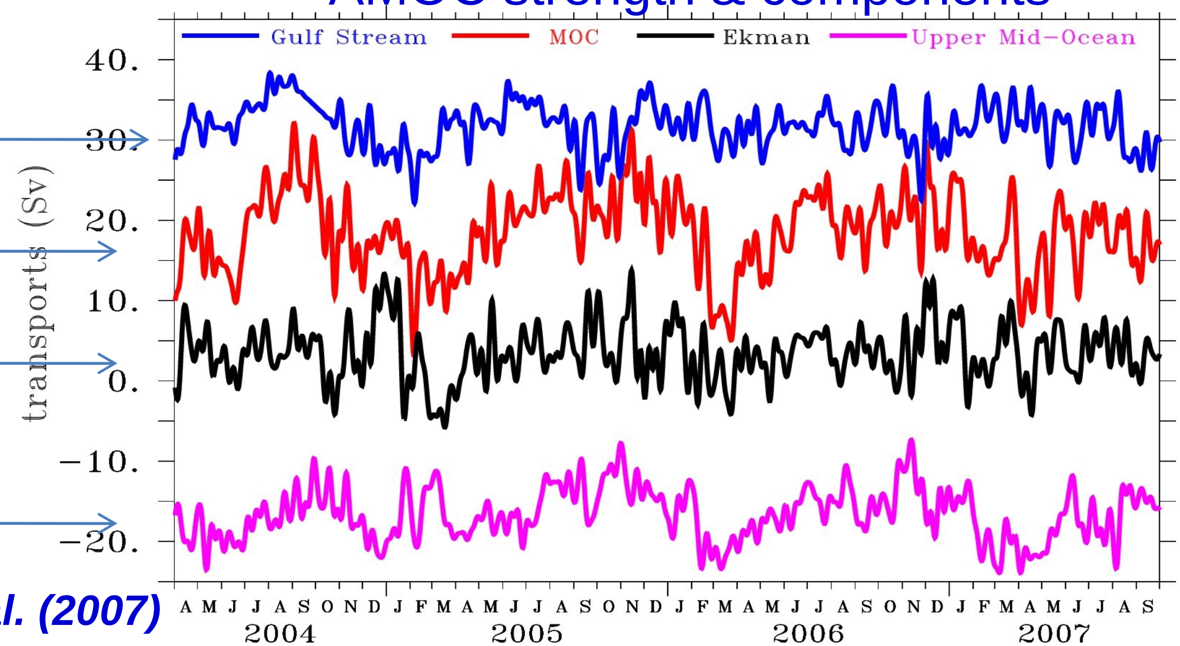
From NCEP

QuikSCAT wind – important element for monitoring the Atlantic MOC

RAPID Program's AMOC monitoring system



AMOC strength & components



(1) From submarine cable

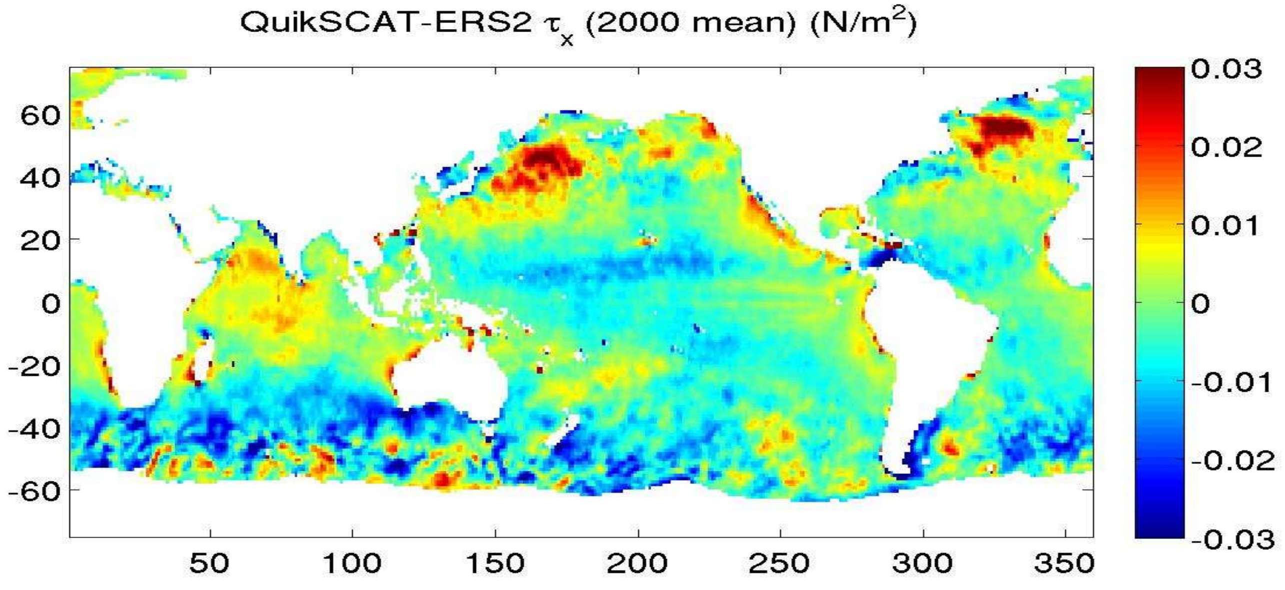
Total = (1) + (2) + (3)

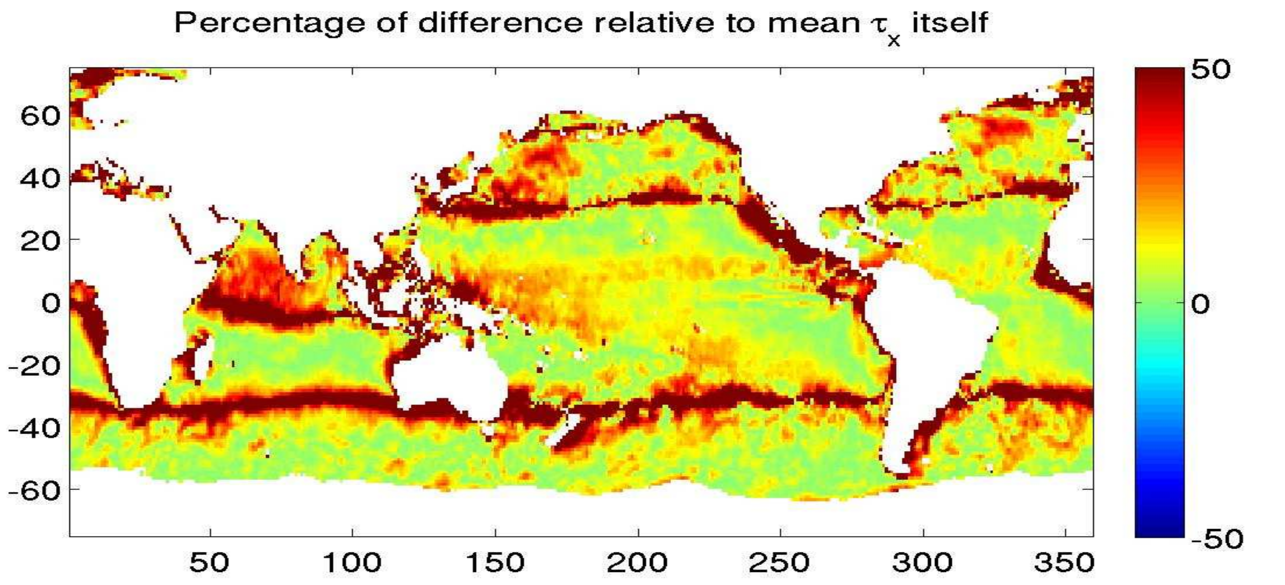
(2) From QuikSCAT

(3) From mooring arrays

Cunningham, Kanzow, Rayner et al. (2007)

Bias between sensors limit the scope for studying dec & longer variability/changes





Summary

- Scatterometer data have demonstrated its potential in studying decadal variability.
- Sustained and consistent scat. measurements are critical to further the understanding of decadal and longer variability – bias significantly hampers progress.
- Accuracy needed to resolve multi-decadal and longer time scales variability is more stringent than that of dec. var.