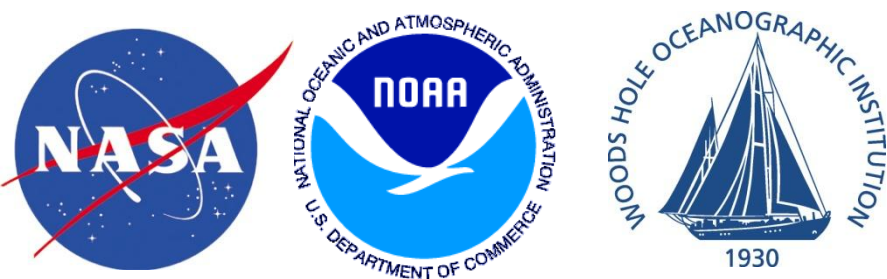


25-Year Global High-Resolution Analysis of Ocean-Surface Heat Fluxes, Evaporation, and Wind Stress

Lisan Yu

Woods Hole Oceanographic Institution

Collaborator: Xiangze Jin (WHOI)



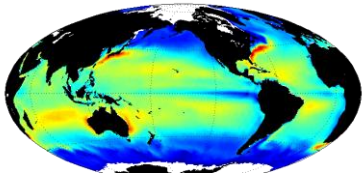
International Ocean Vector Wind Science Team Meeting
Kona, Hawaii. 6-8 May 2013

OAFlex Research Products

Two resolutions:

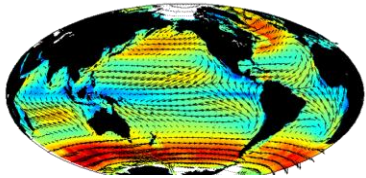
- 1-degree (1958 onward)
- 0.25-degree (1987 onward)

Evaporation



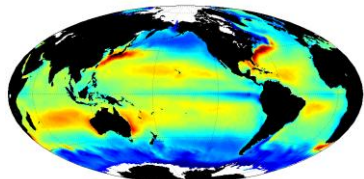
Online: 55-year data record , 1958 onwards, 1°, daily, monthly
To be released: 25-year data record, 1987-onwards, 0.25°, daily
(*Yu and Weller, 2007; Yu et al. 2008, Tech Report;*
Jin and Yu, 2013, JGR-Oceans)

Wind and Wind Stress

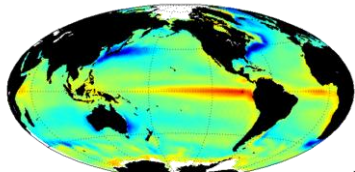


Schedule to release (2013): 1987-present, daily, 0.25°
(*Yu and Jin, 2012, JGR; 2013, Tech Report*)

Latent and sensible heat fluxes



Net Heat flux

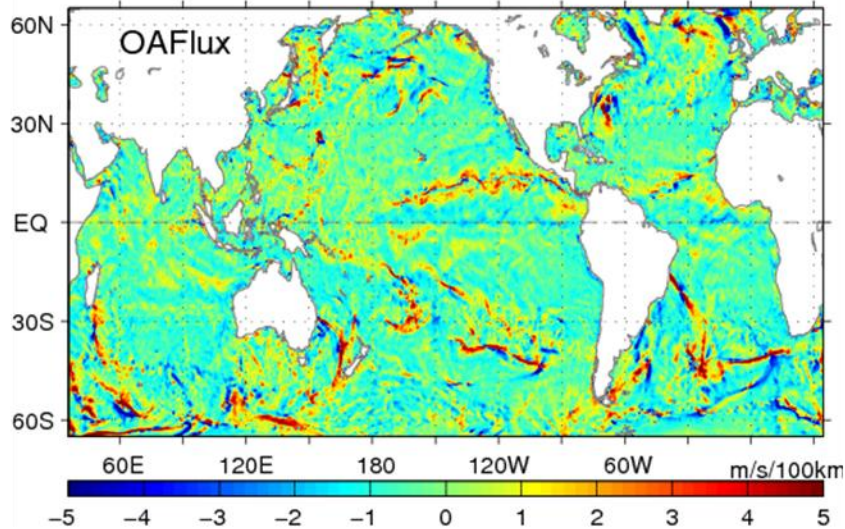


Online: 55-year data record , 1958 onwards, 1°, daily, monthly
To be released: 25-year data record, 1987-onwards, 0.25°, daily
(*Yu et al. 2008, Tech Report; Jin and Yu, 2013, JGR-Oceans*)

Work in progress: 1983-present, 1°, daily

OAFlex Winds versus Scatterometers

OAFlex (6 sensors, 12 samplings)



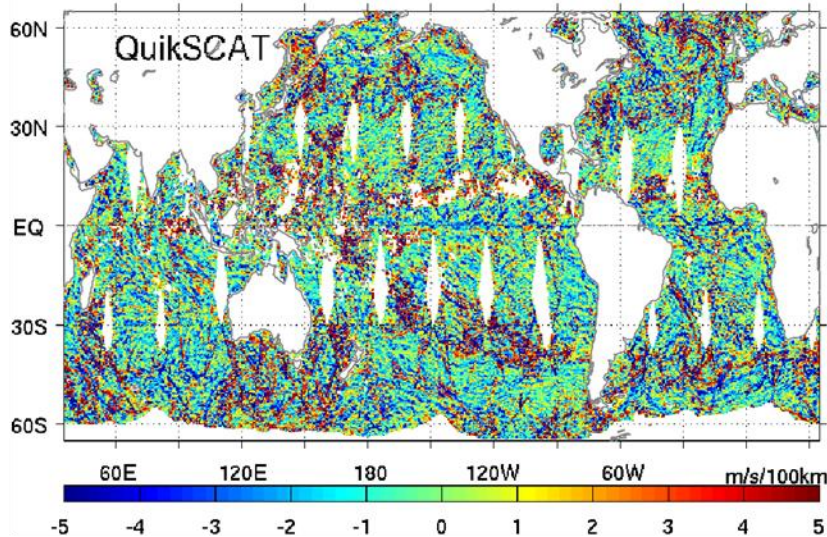
Daily mean, 22 AUG 2009
wind derivatives

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}$$

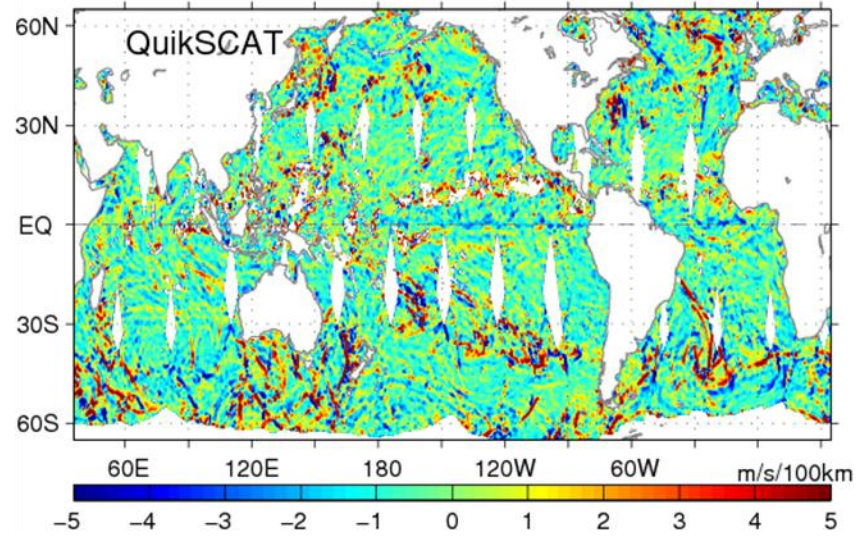
Convergence (+)

Divergence (-)

QuikSCAT (1 sensor, 2 samplings)



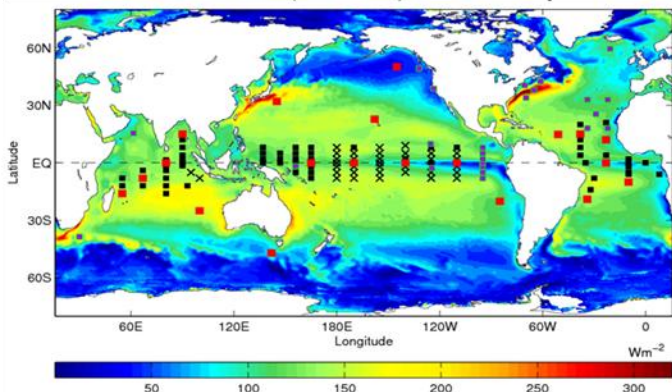
QuikSCAT 1-2-1 Smoothed 3 times



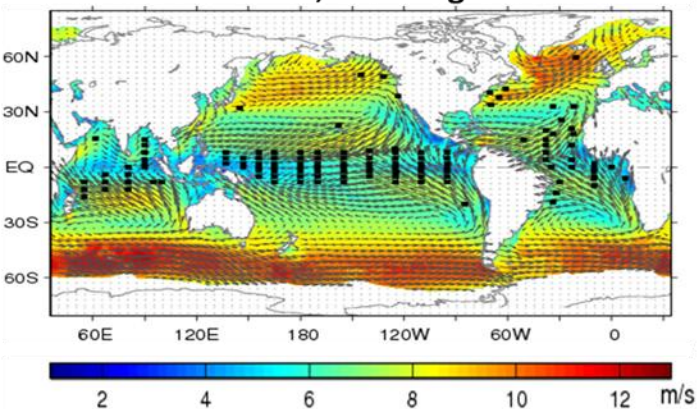
All products are validated using in situ measurements

Error estimates are provided for each daily field.

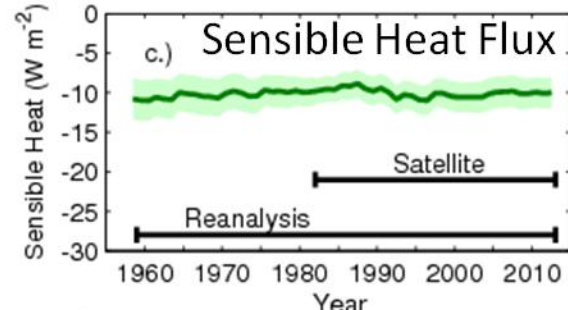
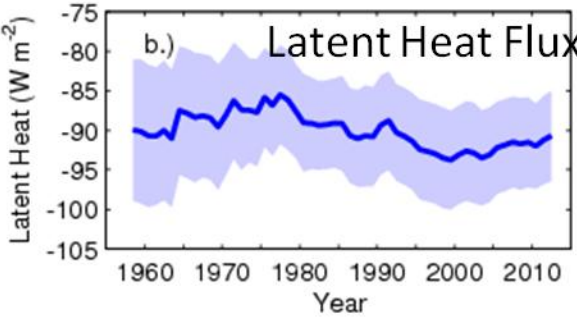
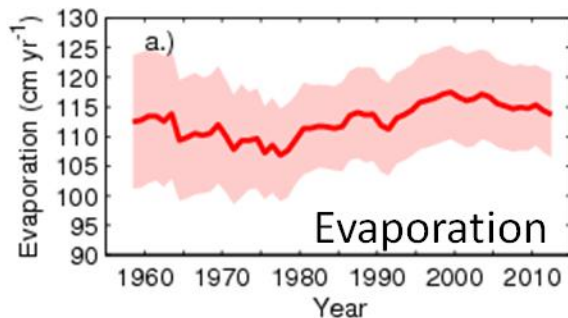
Latent+sensible heat fluxes, 0.25-degree



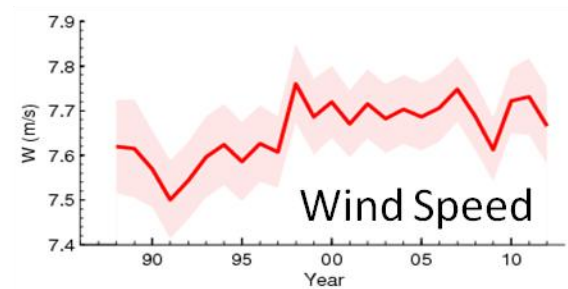
Wind, 0.25-degree



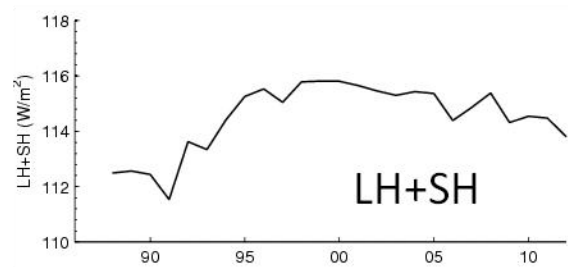
50-yr Annual Mean, 1°



25-yr Annual Mean, 0.25°



Satellite



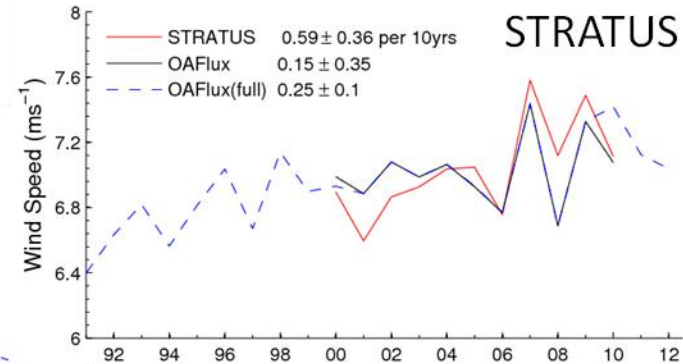
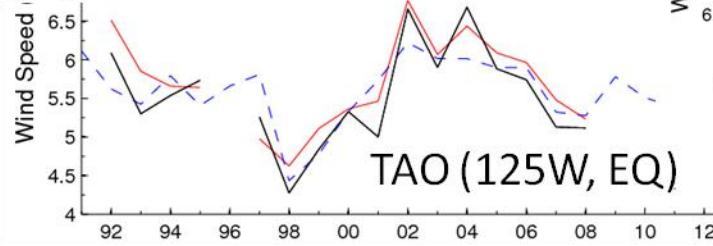
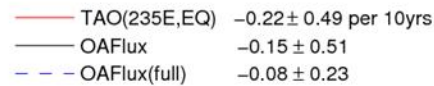
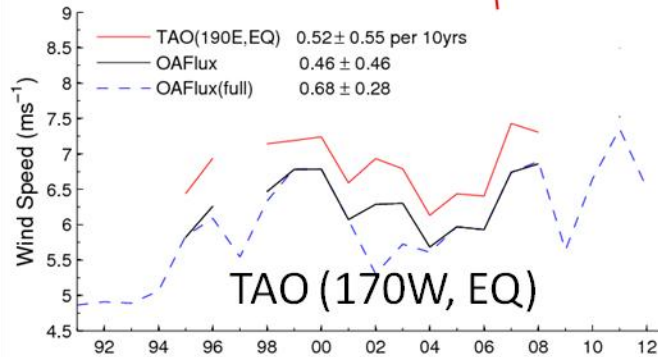
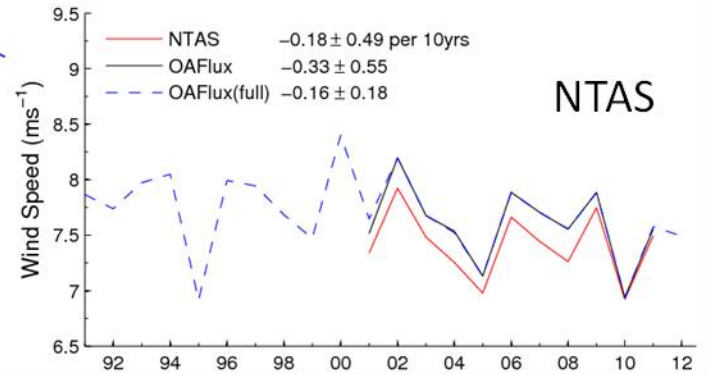
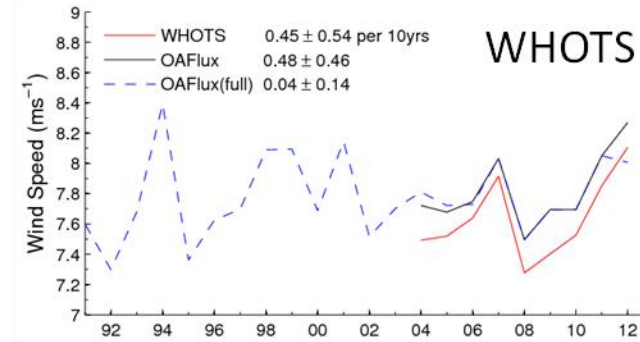
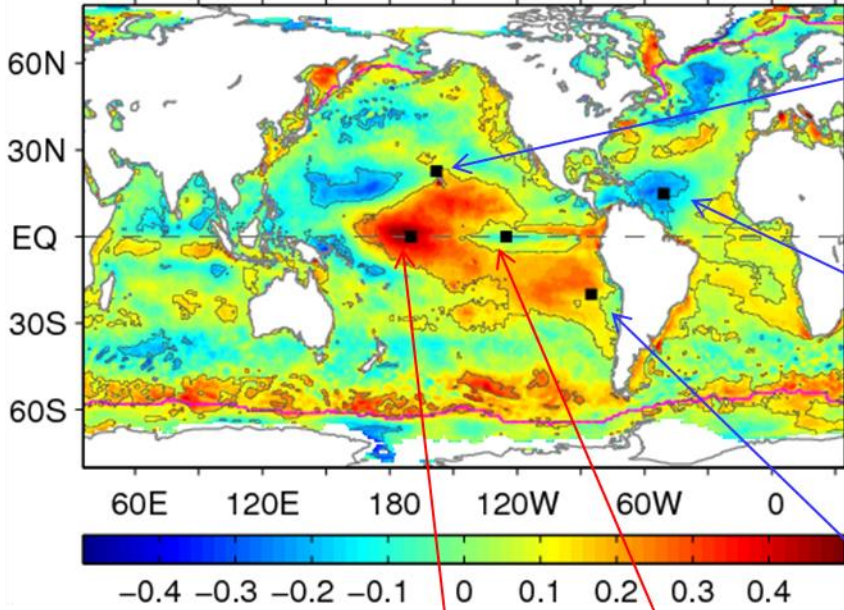
We are working on the error estimation.

- All components, Active
- All components, archive
- No Q_{LW}
- x No Q_{LW} and Q_{SW}

(Josey, Gulev, and Yu, 2013
Book Chapter 3, WOCE)

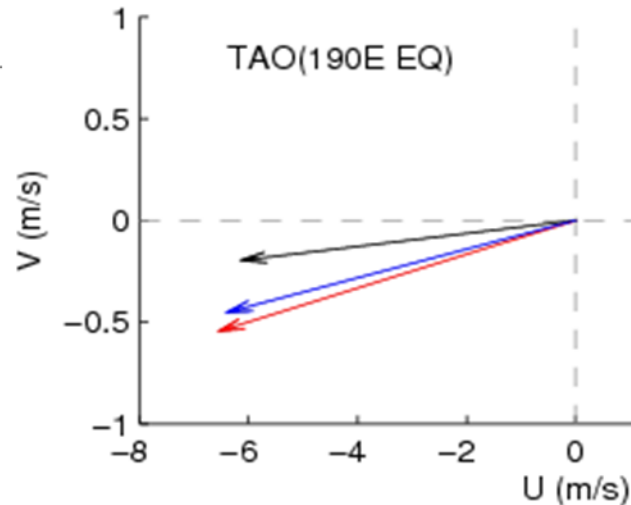
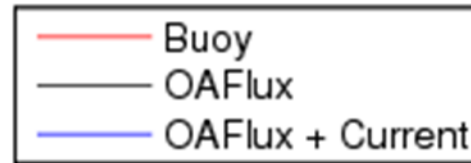
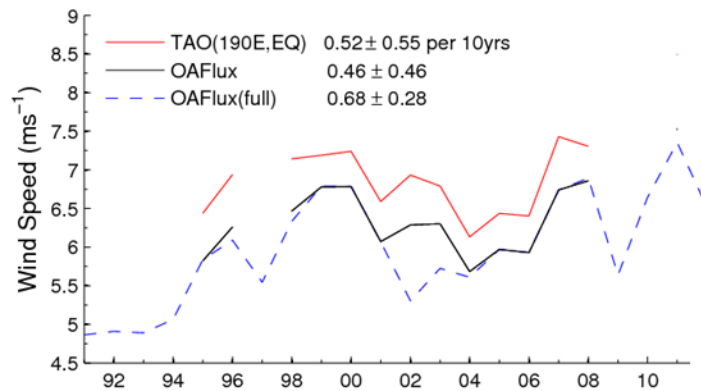
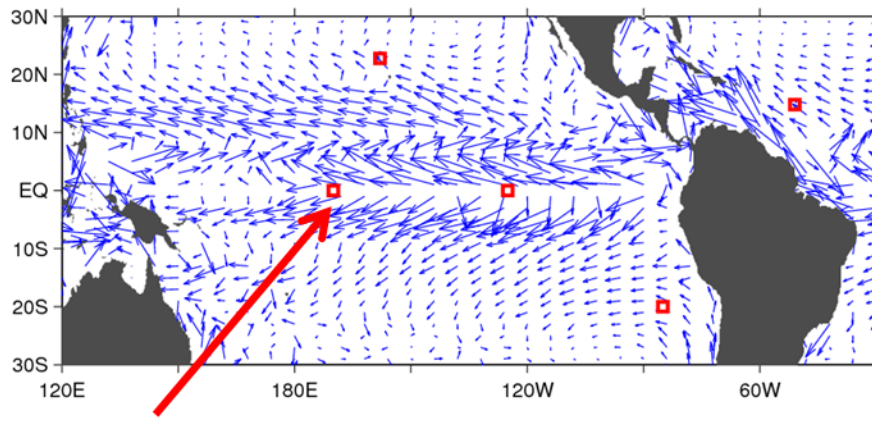
Decadal changes in wind stress from satellite and buoys

w 1988–2012 Trend (ms^{-1} per decade)

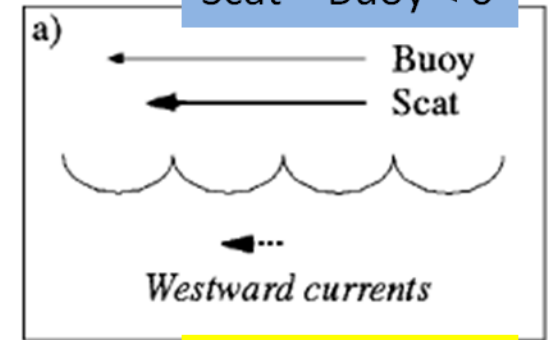


Current effect on satellites

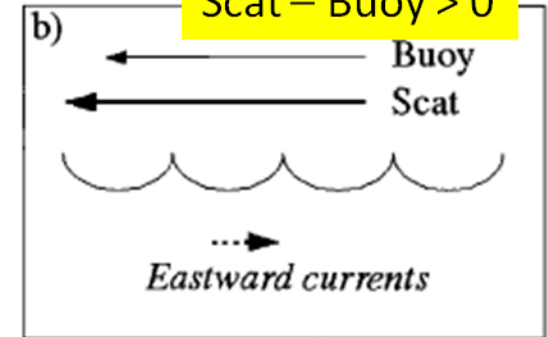
Mean surface currents from the drifter-derived climatology
(Lumpkin and Garraffo, 2005)



Scat - Buoy < 0



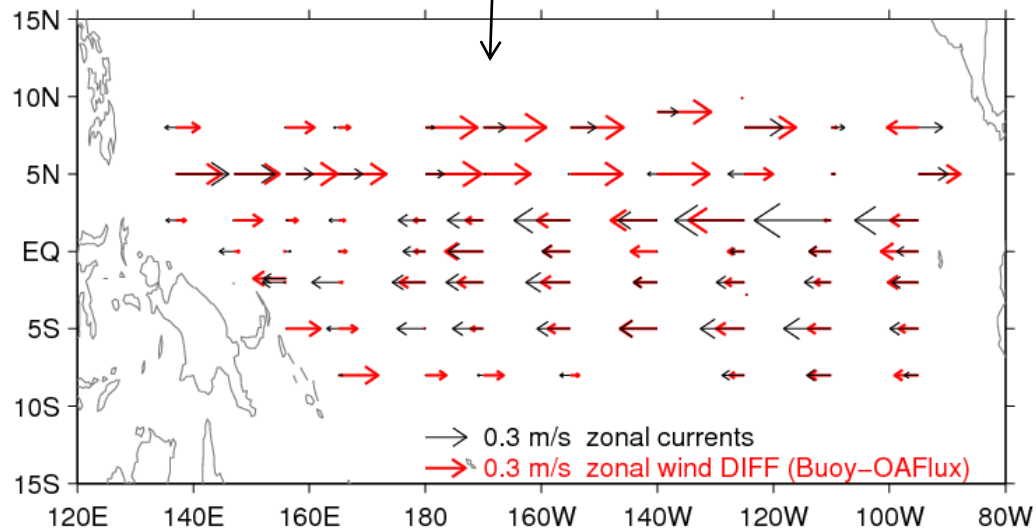
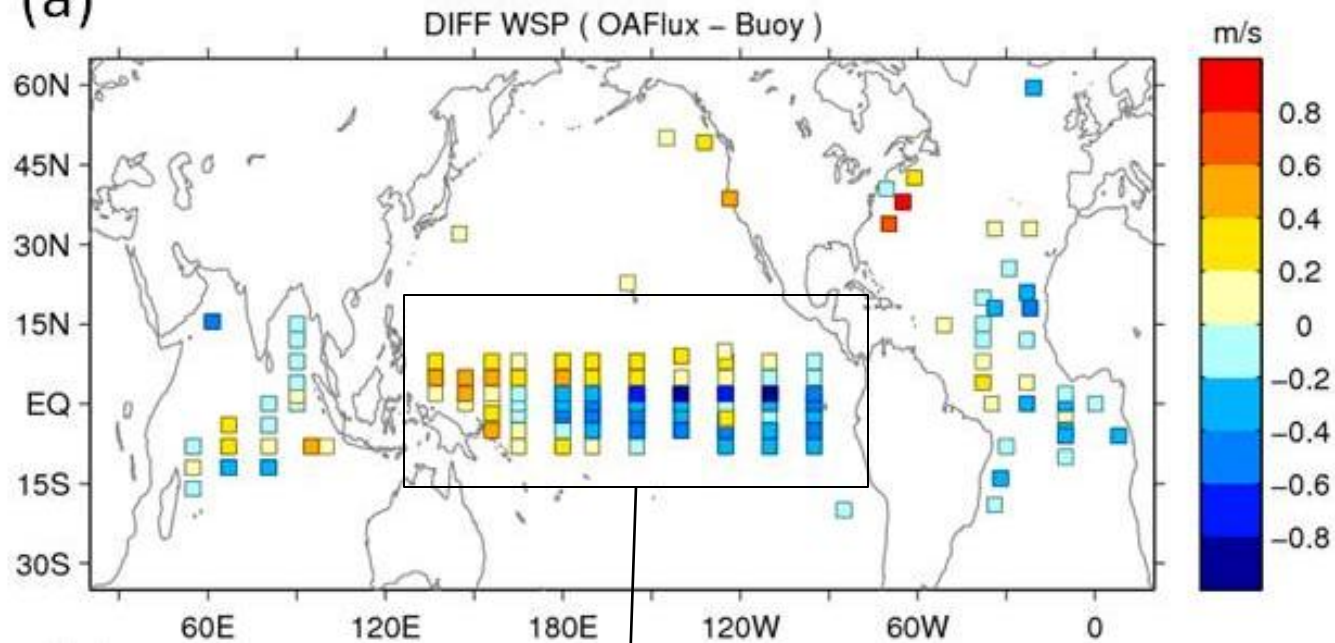
Scat - Buoy > 0



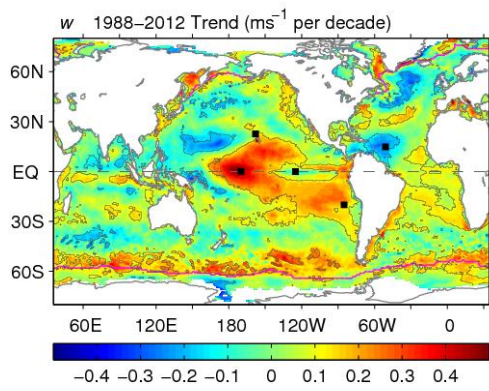
(from Kelly et al. 2001)

Can scatterometer be a currentmeter?

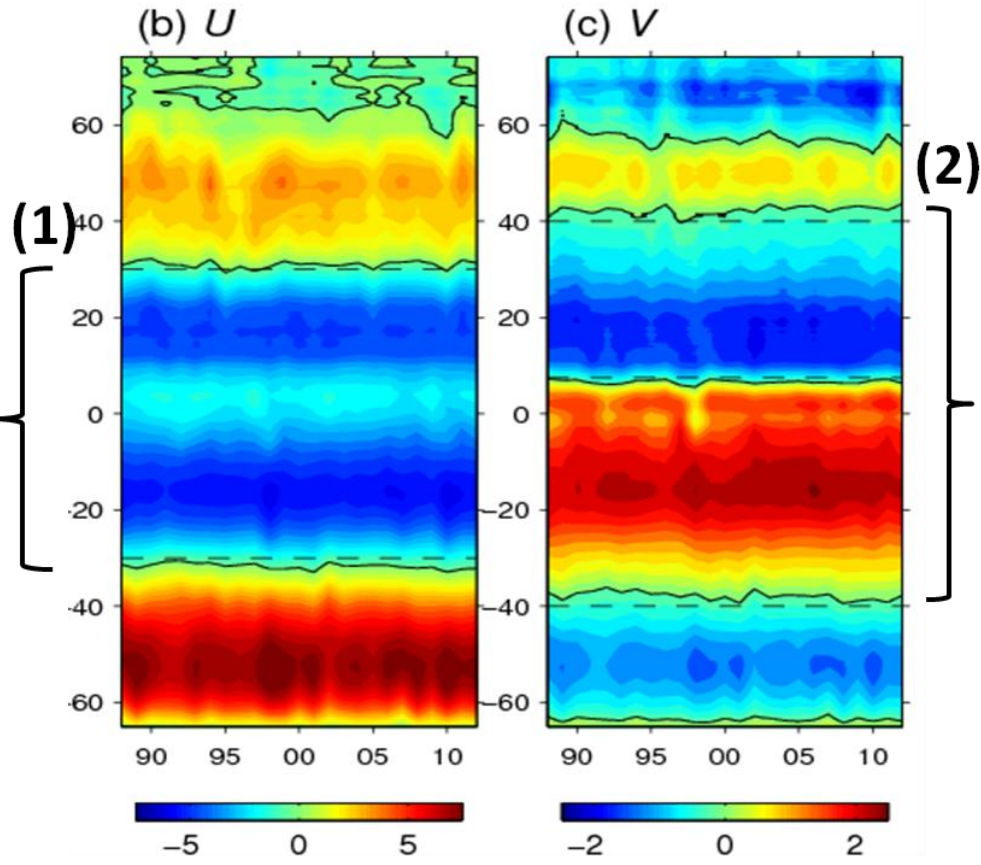
(a)



Black vectors: surface currents (Lumpkin and Garraffo, 2005)

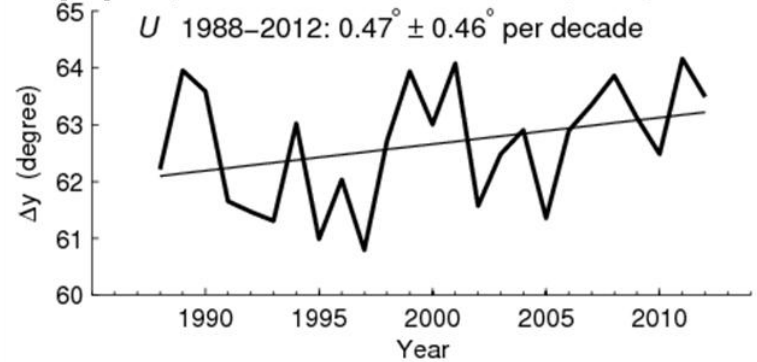


The observed change in tropical winds is related to poleward expansion of Hadley cells

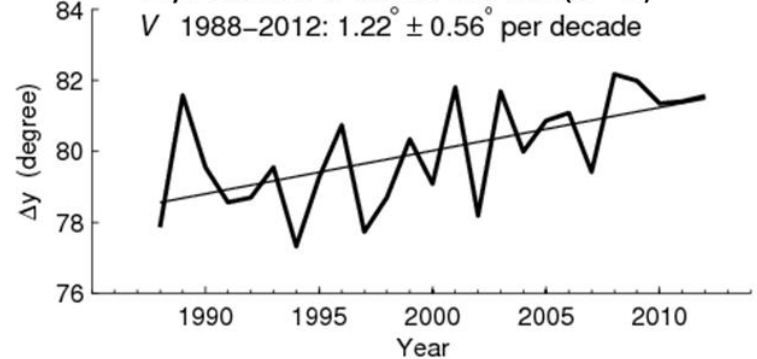


Widening of the tropical belt estimated from OAFlux winds

(1) Δy : width based on $\text{Lat}(u=0)$

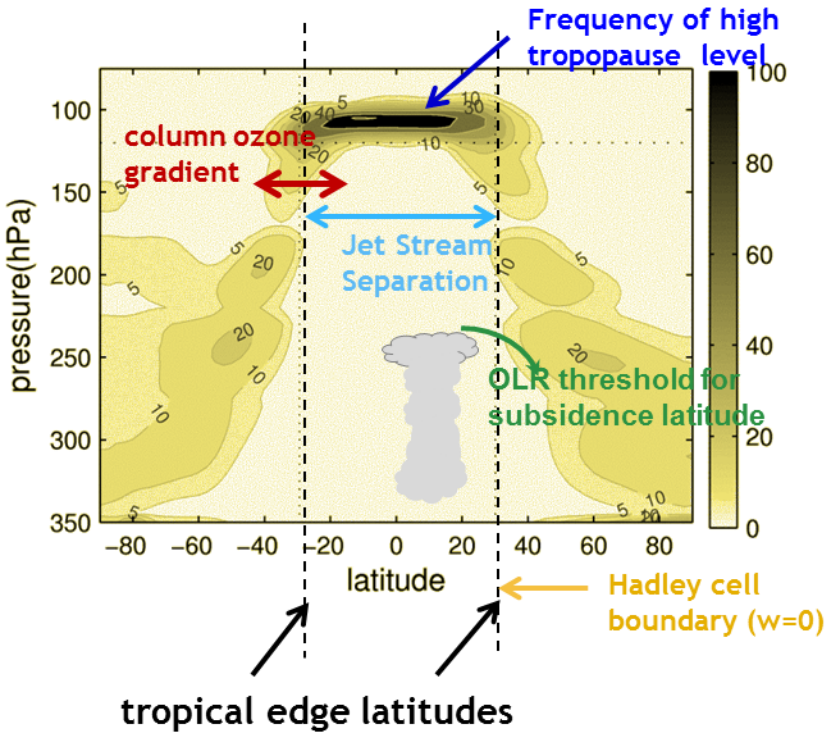


(2) Δy : width based on $\text{Lat}(v=0)$



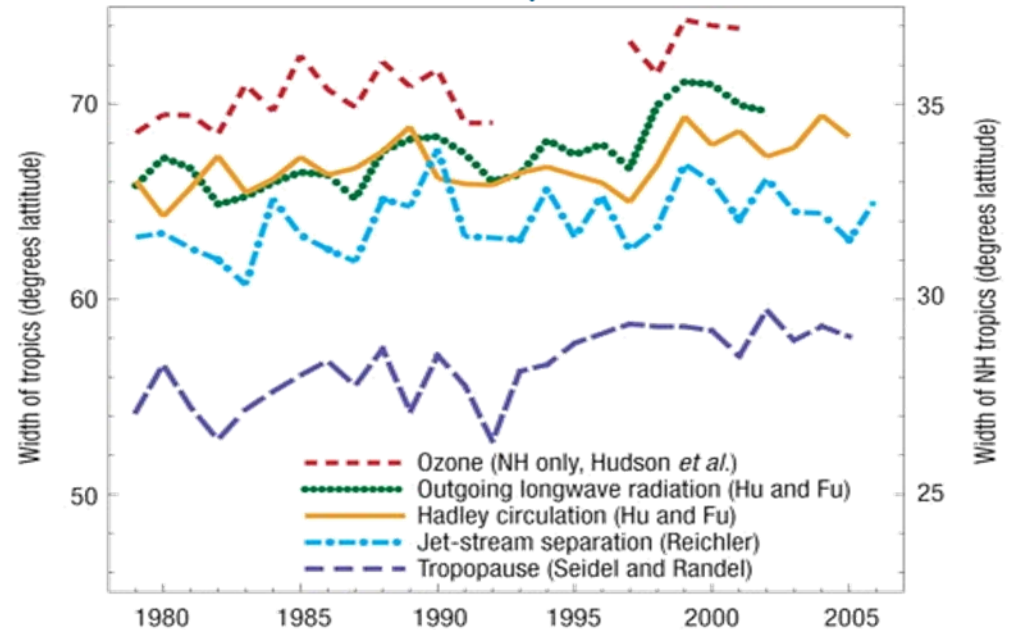
Widening of the tropical belt in Literature

Metrics for width of the tropics



Widening of the tropical belt is indicated by all metrics.

(Seidel et al, 2007)

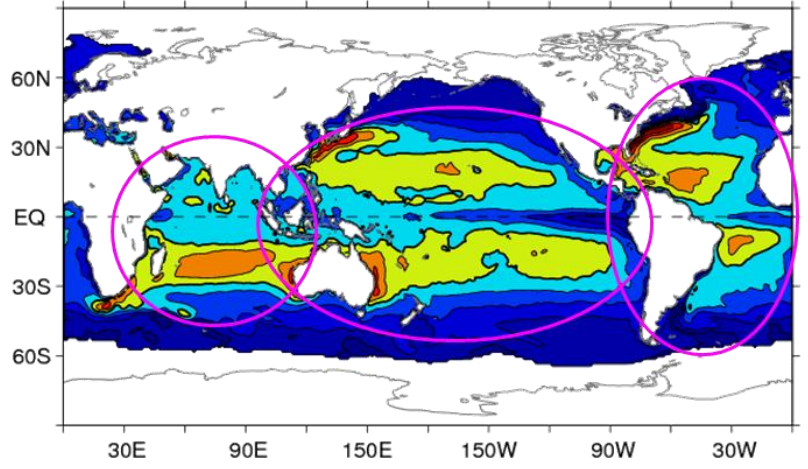


Net increase: 2- 4.5° in 25 years

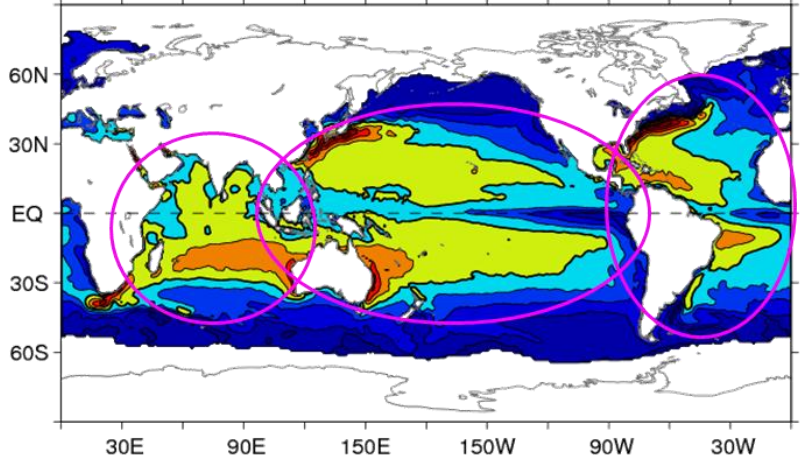
Higher rate of Evaporation in the trade wind zone

Subtropical Evaporation zones have widened

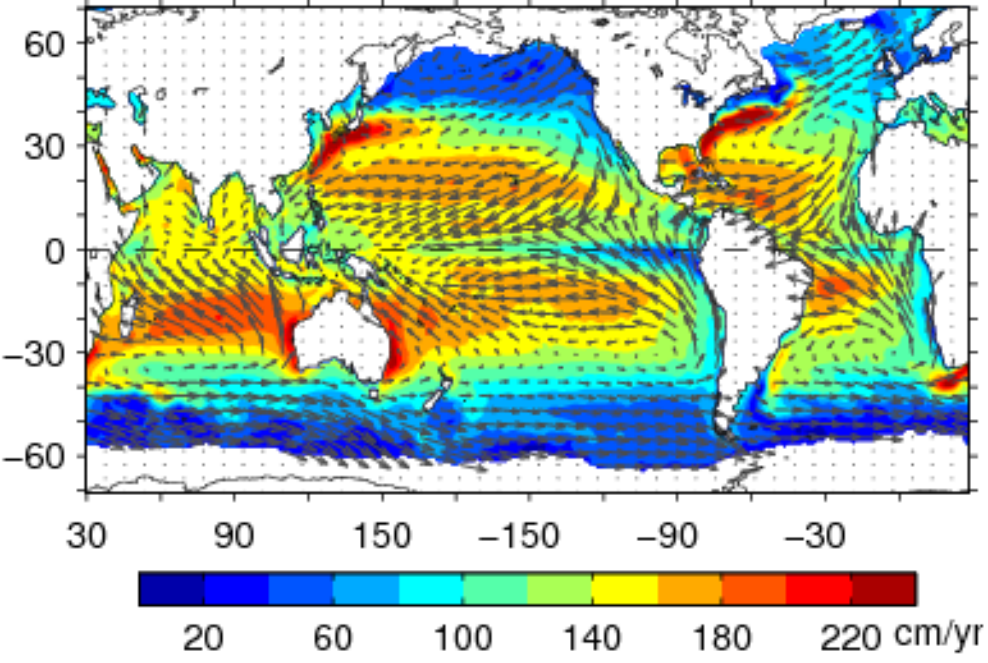
1979 - 1986



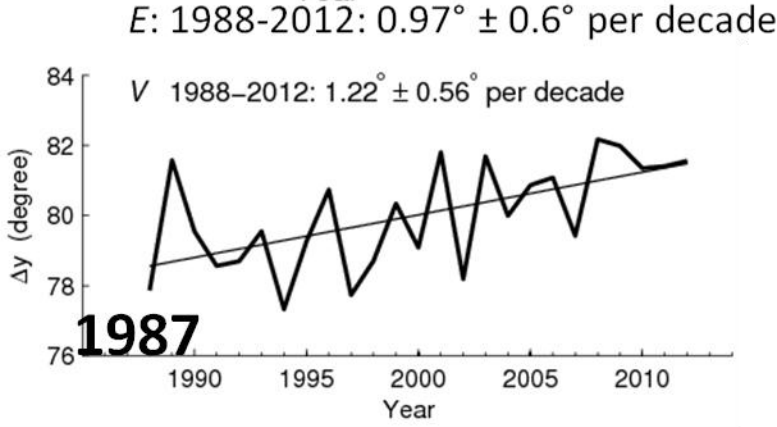
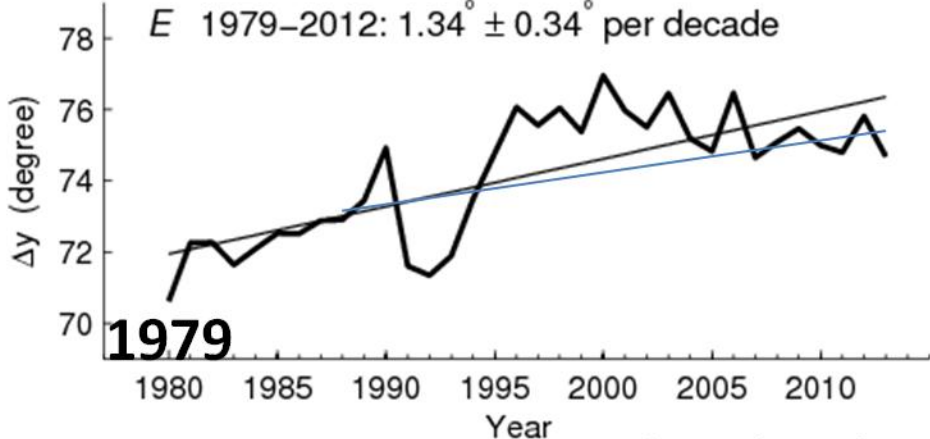
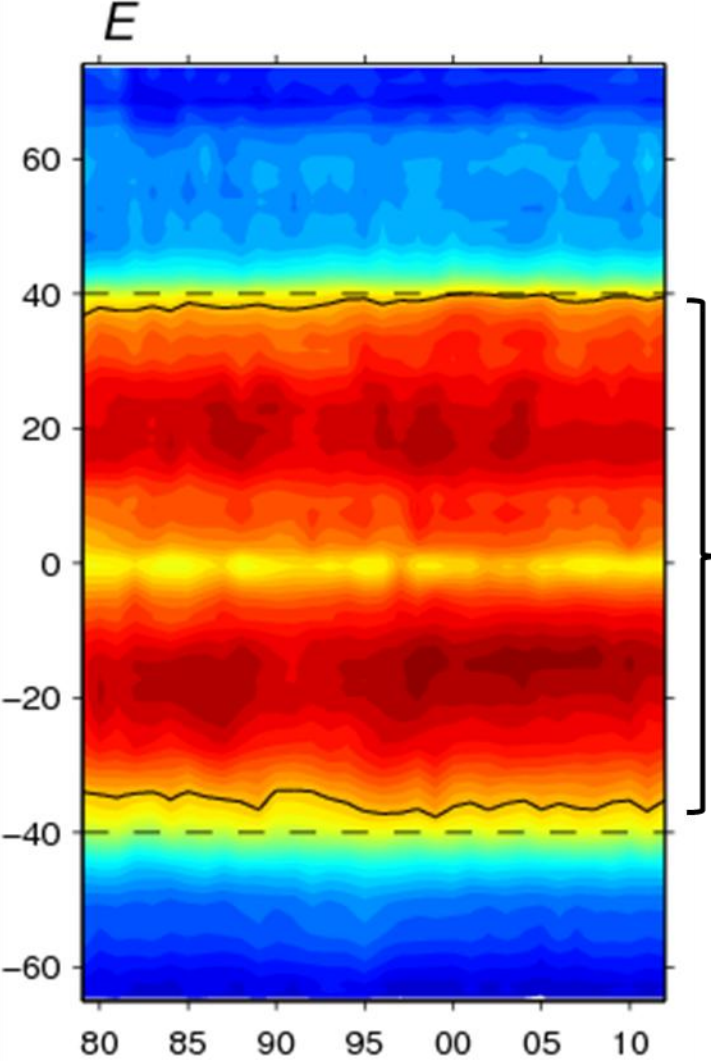
1999 - 2006



(a) Mean *E* and 10m winds

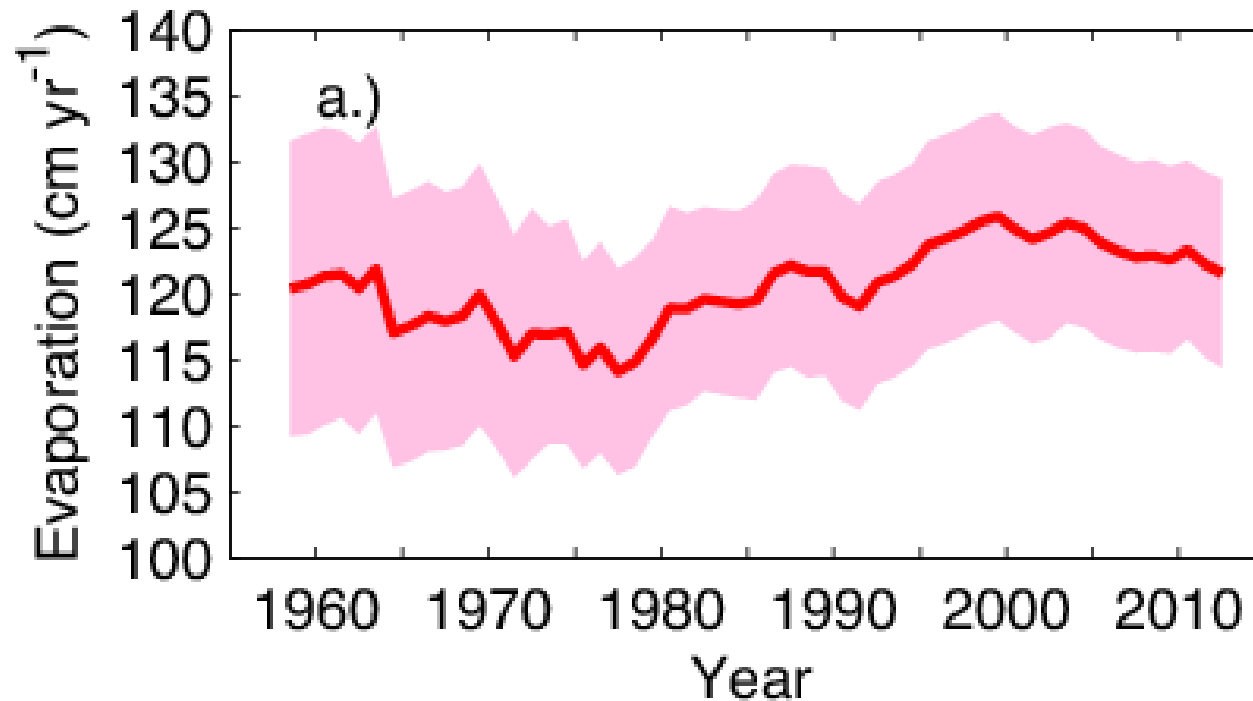


Subtropical **Evaporation Zones** have widened associated with the poleward expansion of the tropical belt



The widened subtropical evaporation zones appears to be a primary cause of the decadal change in E since 1979.

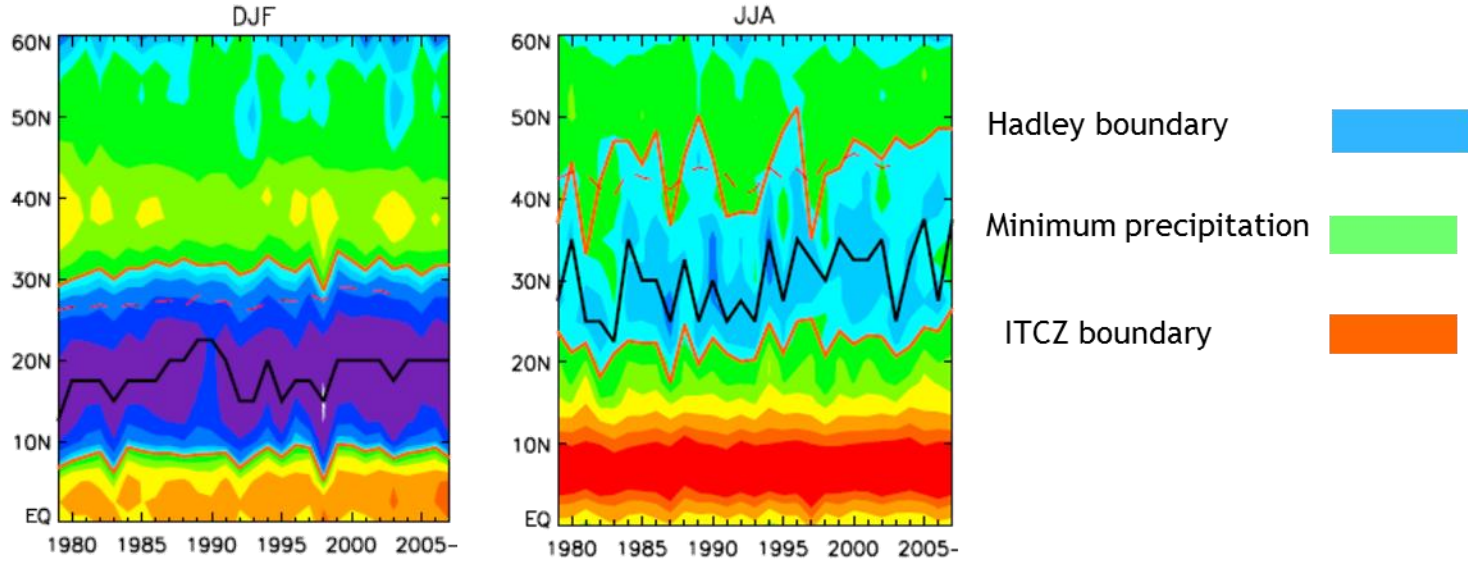
But there is clear interdecadal variability in ocean evaporation as shown by the 55-year time series.



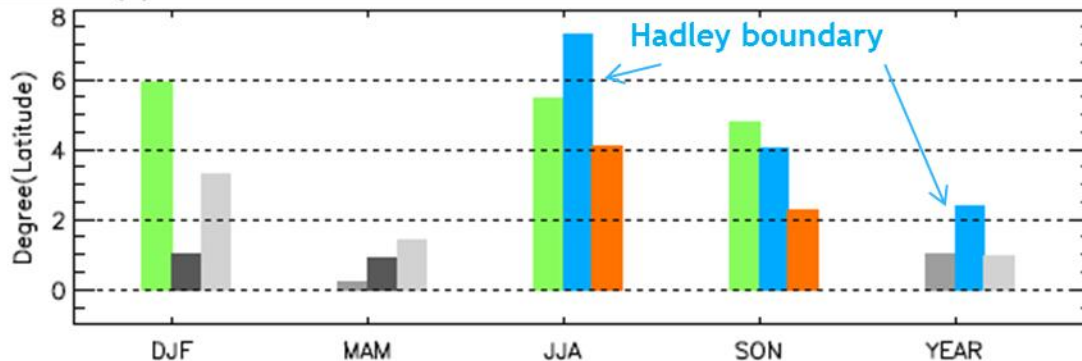
Expansion of the tropical belt: evidence from GPCP (Global Precipitation Climatology Project)

(Zhou et al., 2011)

Zonal mean, North Hemisphere





Total expansion of the tropics



Net increase:
2.5° in 25 years

Summary and Conclusions

- (1) OAFlux products include air-sea turbulent heat fluxes, evaporation, and wind
 - 1° analysis (online)
 - 0.25° analysis (to be released in 2013)
- (2) All products are validated using in situ buoy measurements.
 - The buoy-based evaluation shows the effects of current on satellite winds.
 -  It seems that retrieving surface currents from scatterometers is a plausible concept.
- (3) It appears that the changes in tropical winds are associated with the widening of the tropical belt.
- (4) Expansion of subtropical evaporation zones is evident and is consistent with the precipitation pattern of change.
 -  The framework connects the change of ocean water cycle with the changing atmospheric circulation.