Progress on Surface Fluxes From Reanalyses

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Summary of the project progress on surface fluxes from reanalyses

Objective:

Provide an assessment of climate reanalyses in representing air-sea **heat**, **freshwater**, and **momentum** fluxes in the context of the global energy and water budgets.

Major activities in 2015 and progress to date:

(1) Surface Freshwater fluxes:

- A manuscript is near-completion on "The ocean water cycle in reanalysis, satellite, and ocean salinity". It provides an assessment of the ocean-surface freshwater budgets in 9 reanalysis products and 2 combined satellite E-P products.

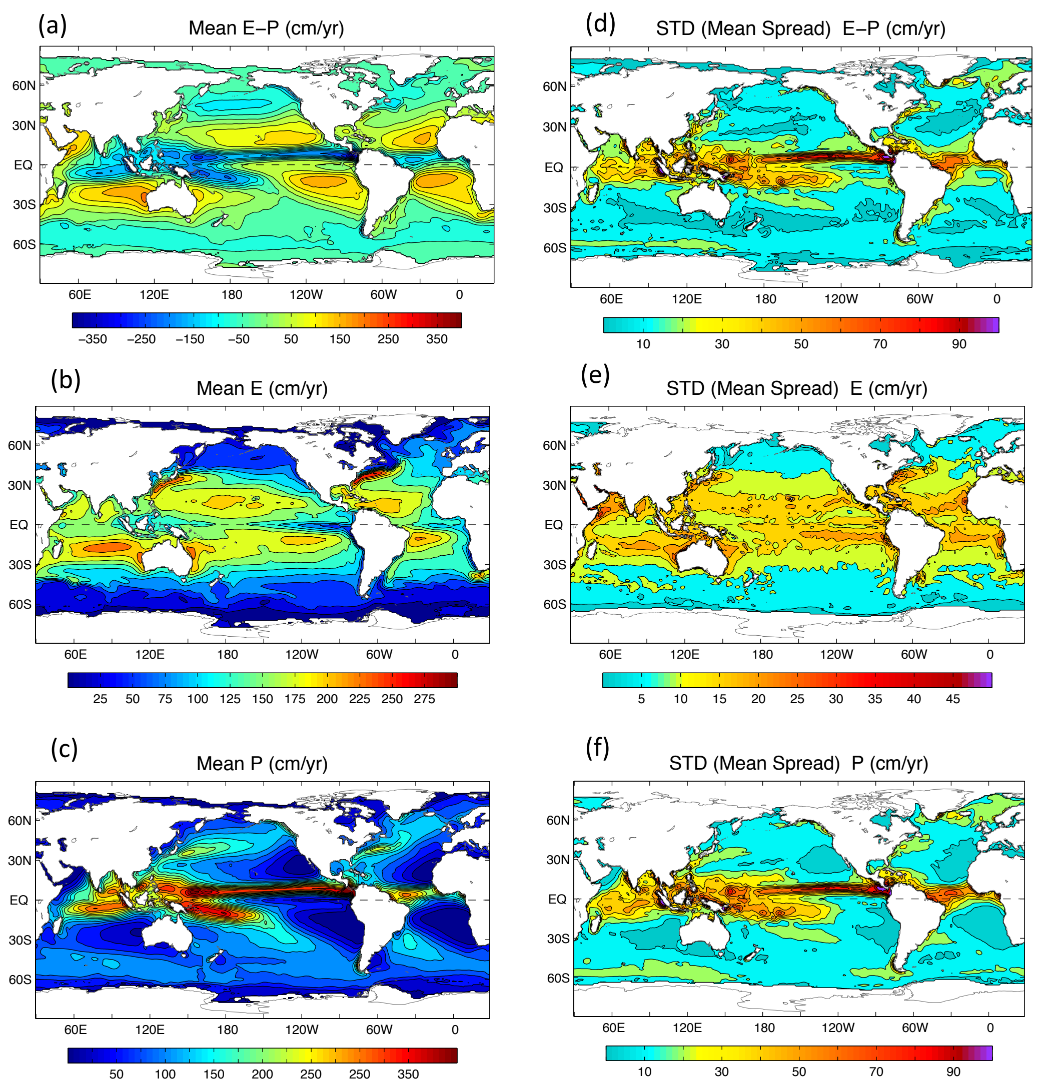
(3) Surface winds and wind stresses

- An assessment of the surface winds from reanalyses and satellite scatterometers in the tropical Pacific ocean is conducted. A manuscript is in preparation.
- We provided the assessment to the Tropical Pacific Observing System (TPOS) 2020 project planning.

(3) Surface Heat Fluxes:

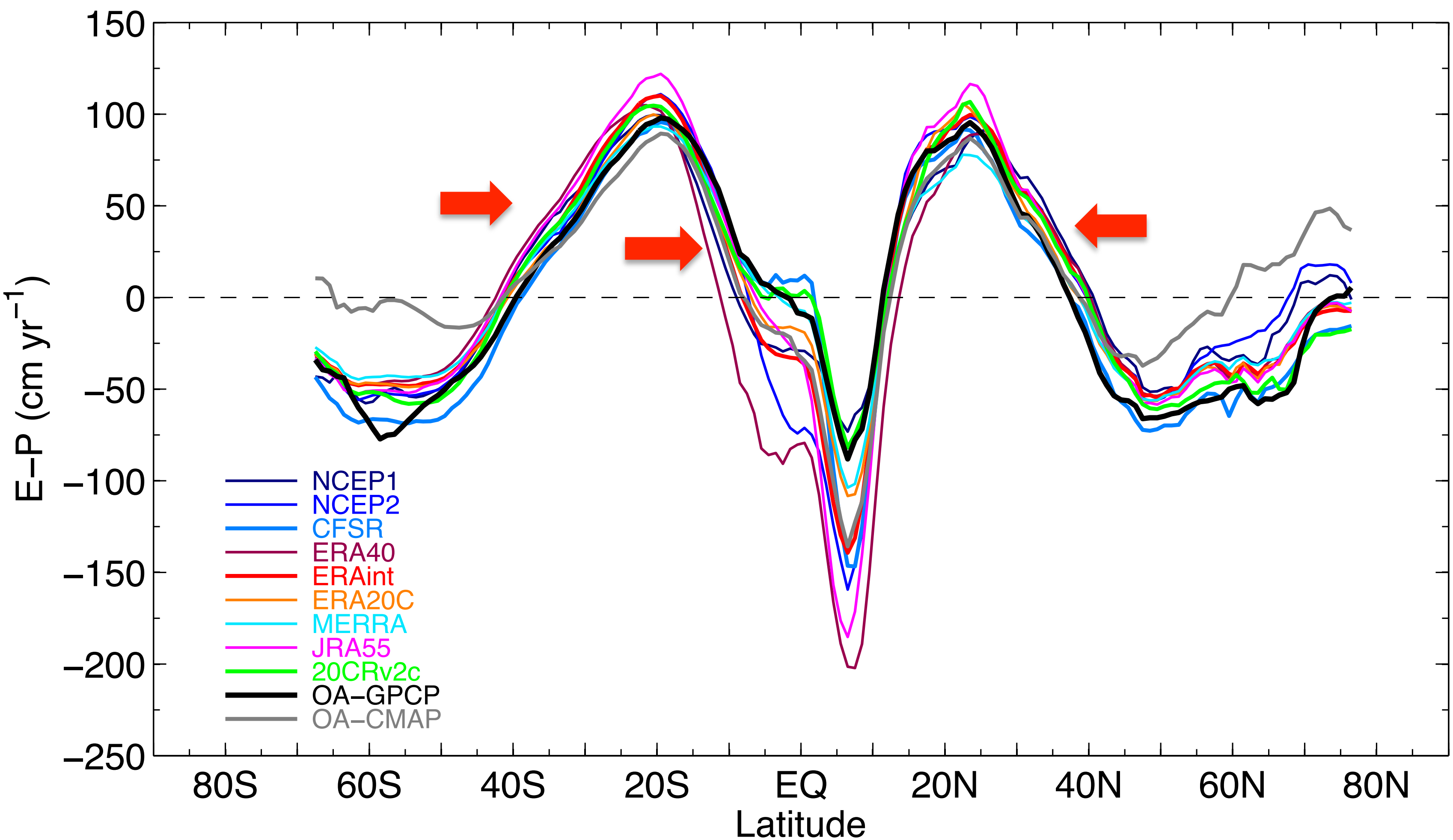
- A manuscript, entitled "Variations of the Global Net Air-Sea Heat Flux During the Hiatus Period (2001-2010)" by X. Liang (postdoc at MIT) and L.Yu, was submitted to J. Climate.
- L. Yu presented the climate reanalysis heat budget results in a keynote speech on "The Earth's surface budget: Outcomes, uncertainties, and drawbacks" at the workshop on Energy Flow Through the Climate System. September, 2015. Exeter, UK.

(1) Surface freshwater fluxes from Reanalysis – New results

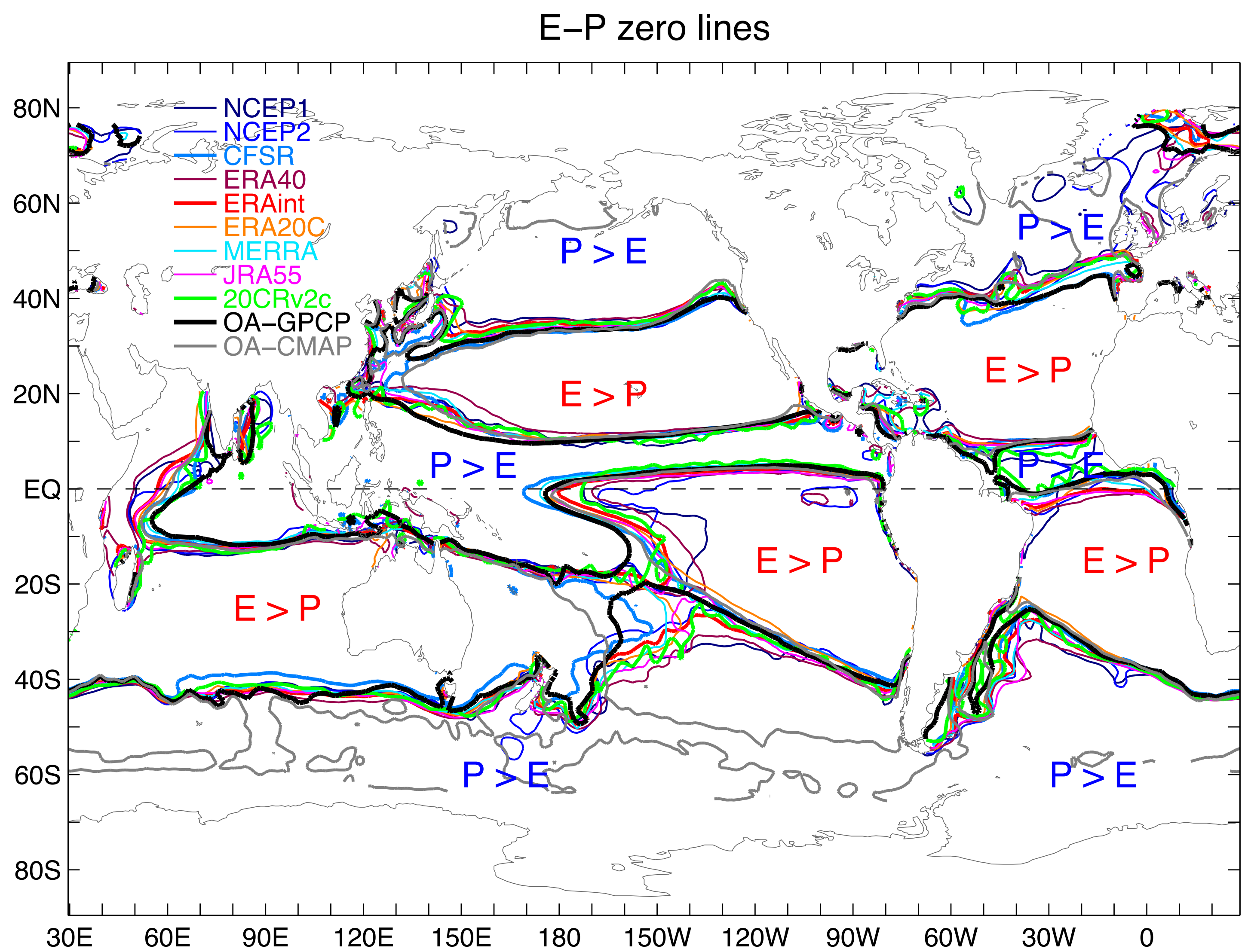


The spread in the reanalysis products is largest in the tropical ocean.

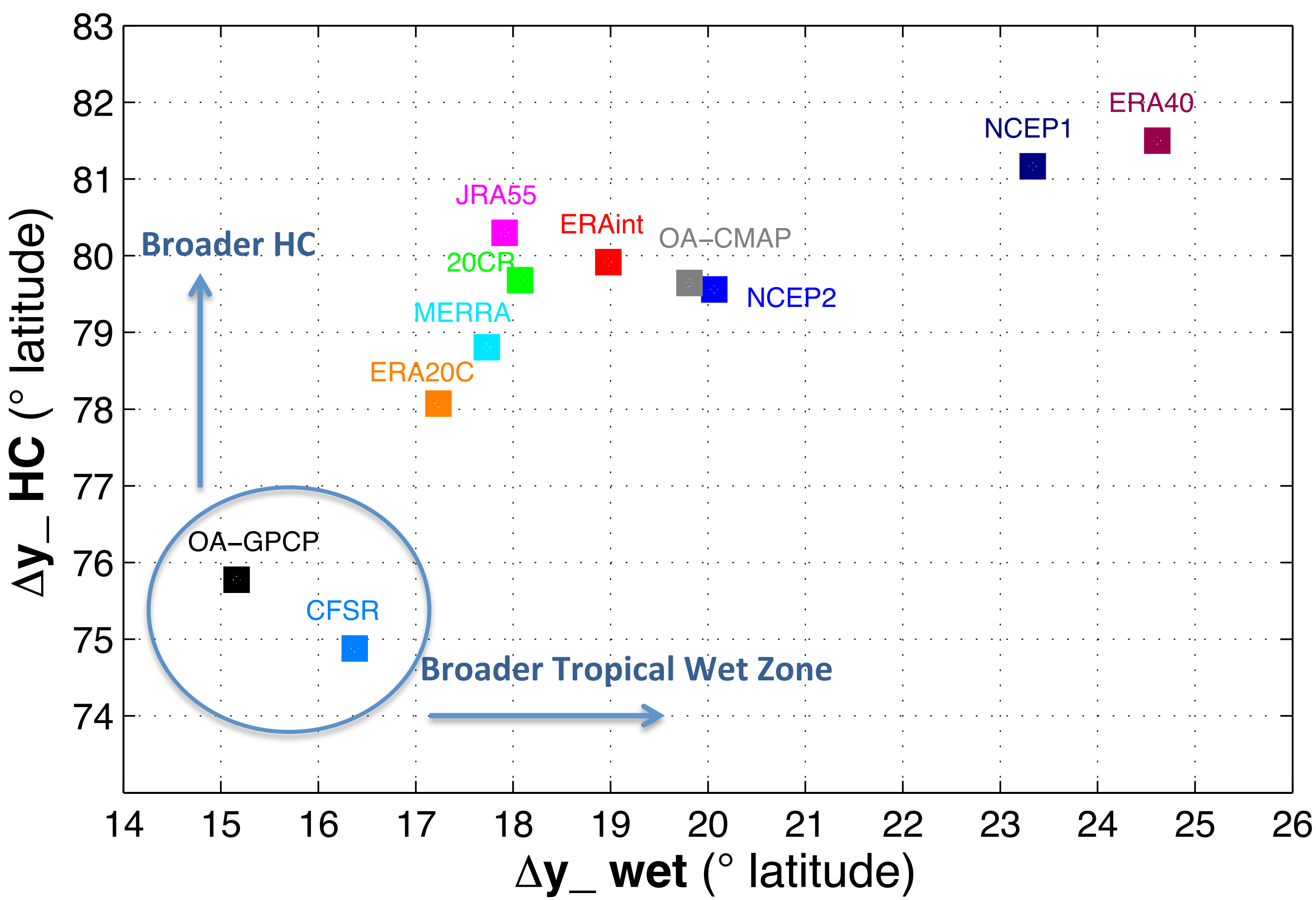
Zonal averages of E-P from 11 products



The tropical wet zone in the reanalyses appears to be broader than that in the satellite-based product.


E−P zero lines
NCEP1
NCEP2
CFSR
ERA40
ERAint
ERA20C
MERRA
JRA55
20CRv2c
OA−GPCP
OA−CMAP
P > E
E > P
P > E
E > P
P > E
E > P
P > E
E > P
E > P
E > P
P > E
P > E
80N
60N
40N
20N
EQ
20S
40S
60S
80S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0

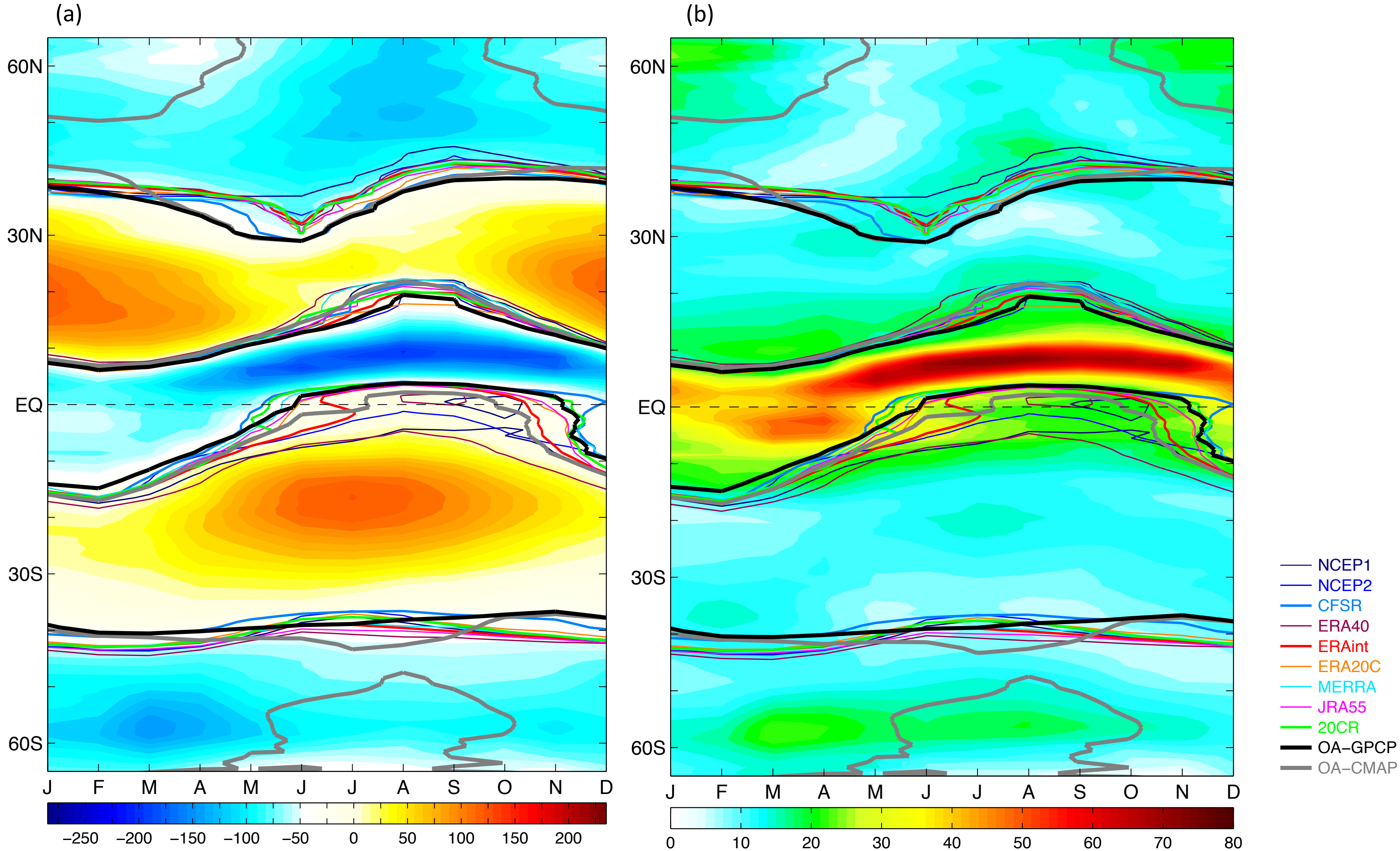
Width of the tropical wet zone (Δy_wet) versus Width of the Hadley Cell (Δy_HC)



Width of the tropical wet zone

Zonal AVG E-P, Mean

Zonal AVG E-P, STD between products



The superimposed colored lines denotes the zero E-P location depicted by the 11 products

Key findings on surface freshwater fluxes from climate reanalyses

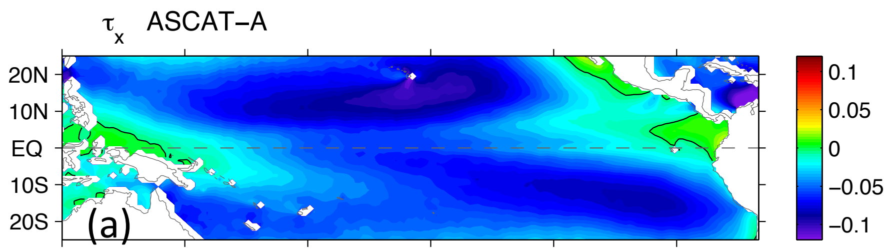
- The tropical wet zone in all reanalyses, except for the semi-coupled reanalysis of CFSR, has a broader meridional extent.
- One consequent impact is that the reanalyzed subtropical dry zones are displaced a few degrees of latitude poleward.
- The spread in the width of the tropical wet zone and hence, the magnitude of the tropical precipitation, is largest during June – November, when the southern subtropical dry zone is displaced equatorward and the reanalyses differ considerably in positioning the near-equatorial edge of the dry zone.

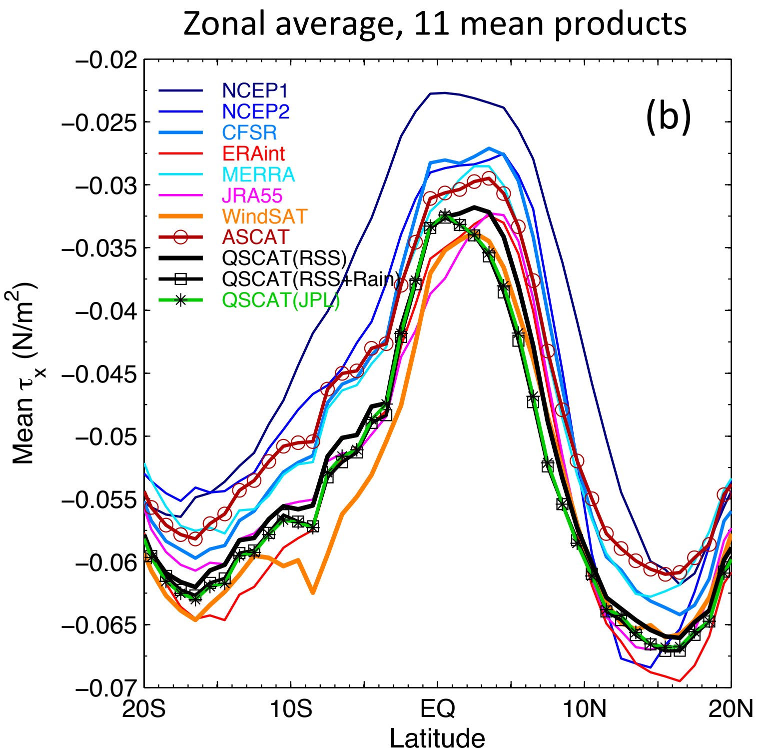
From the manuscript on “The ocean water cycle in reanalysis, satellite, and ocean salinity” by L.Yu, X. Jin, S. Josey, T. Lee, …

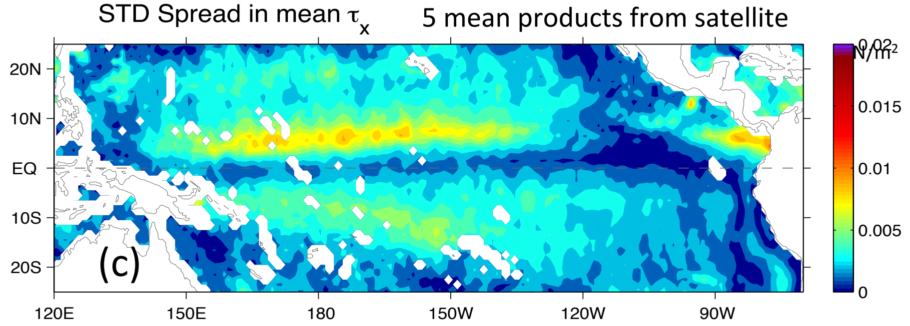
(2) Surface Winds from Reanalyses and Scatterometers

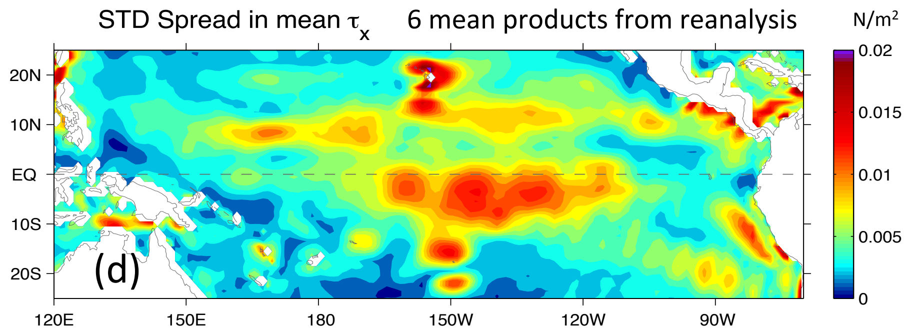
Zonal wind stress (τ_x) component

Mean and spread in the mean over the period 11/2007-10/2009



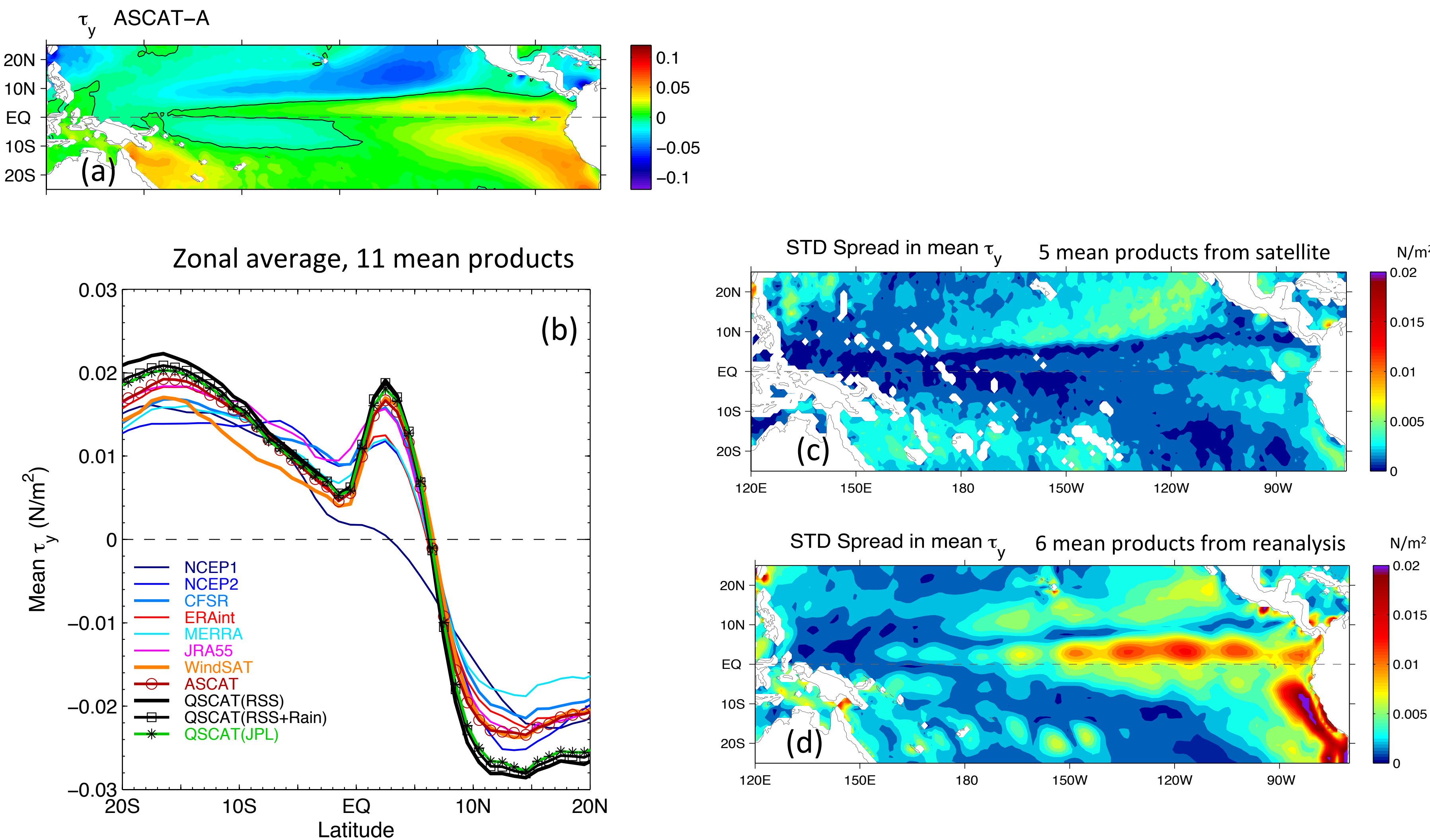






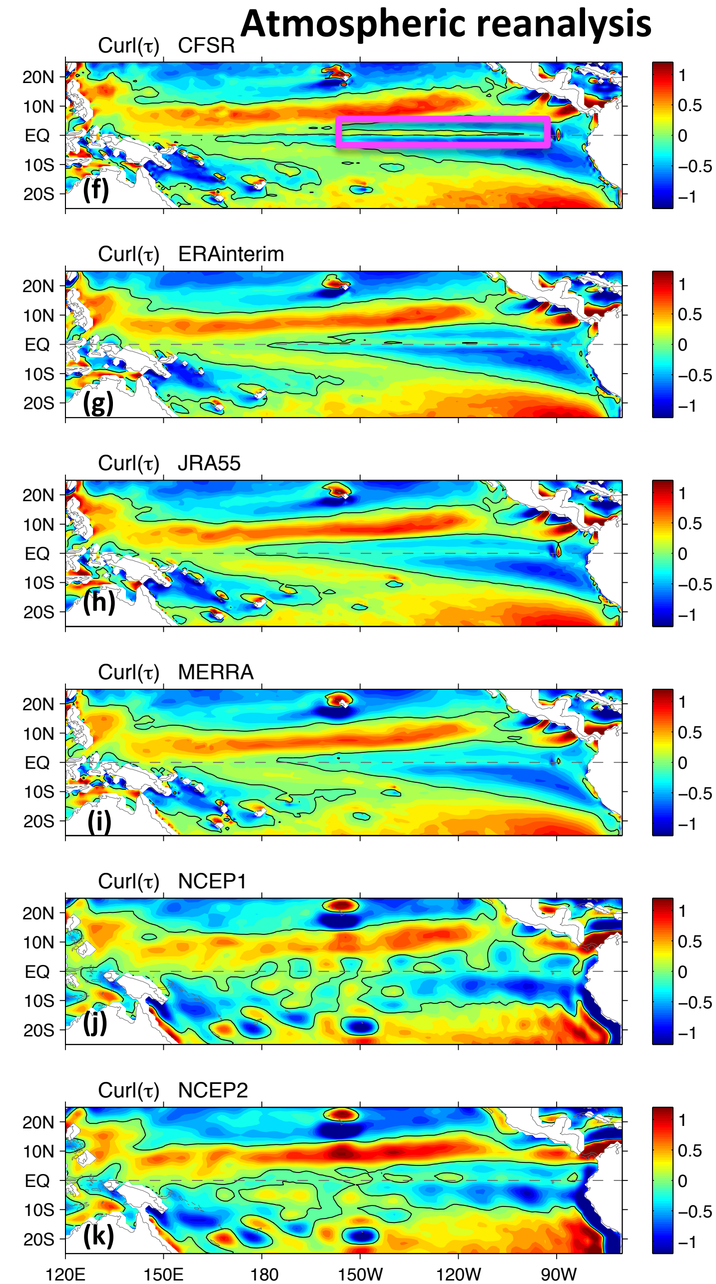
Meridional wind stress (τ_y) component

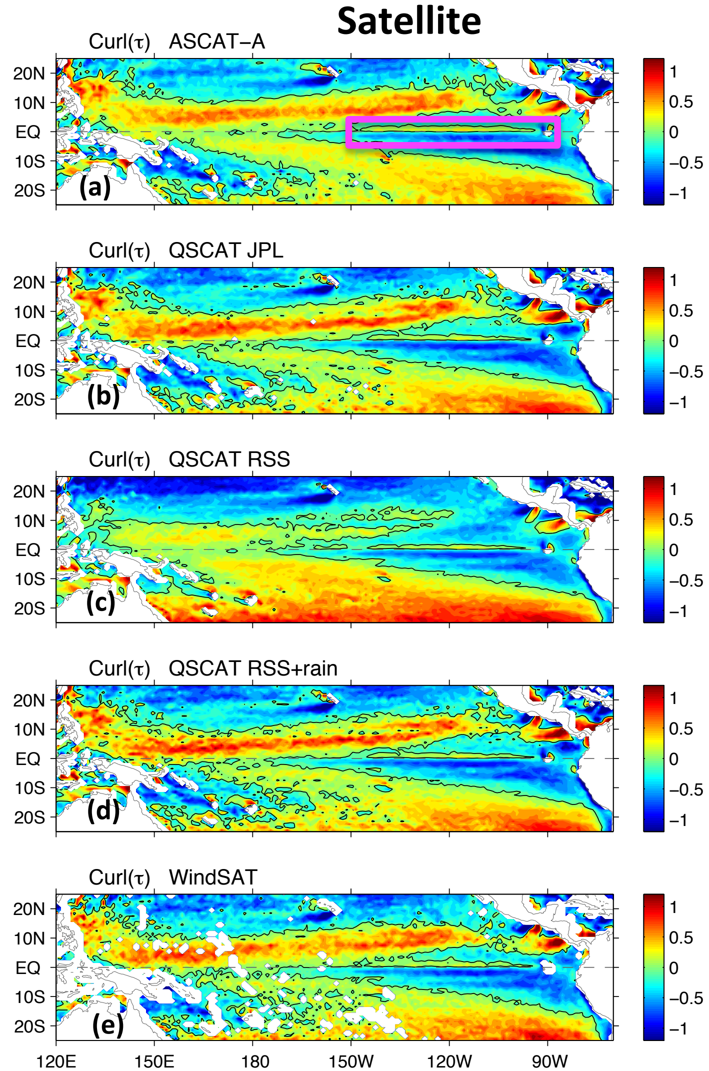
Mean and spread in the mean over the period 11/2007-10/2009



Wind Stress Curl

Mean average
11/2007-10/2009

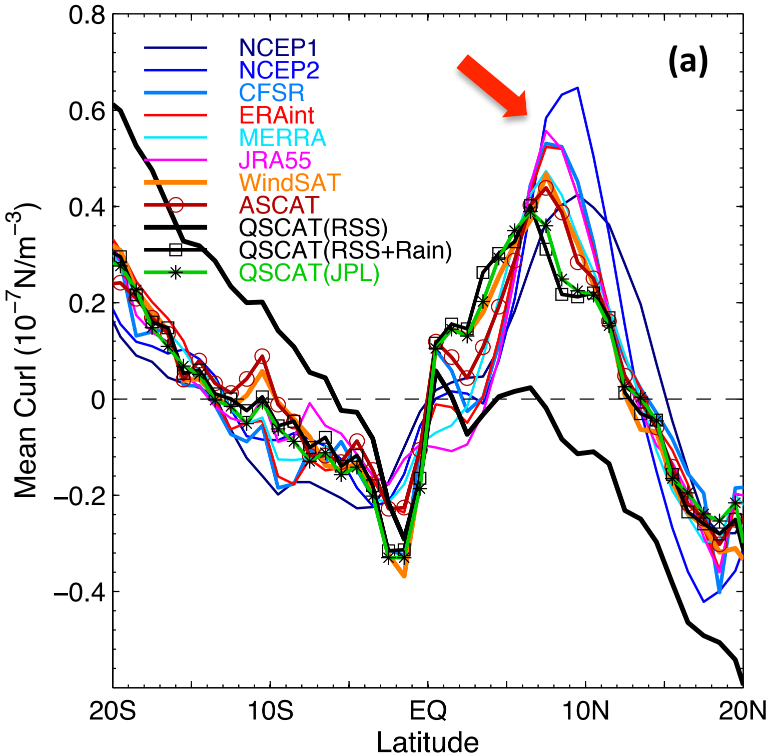




Period I 11/2007– 10/2009

ASCAT/QuikSCAT overlapping period

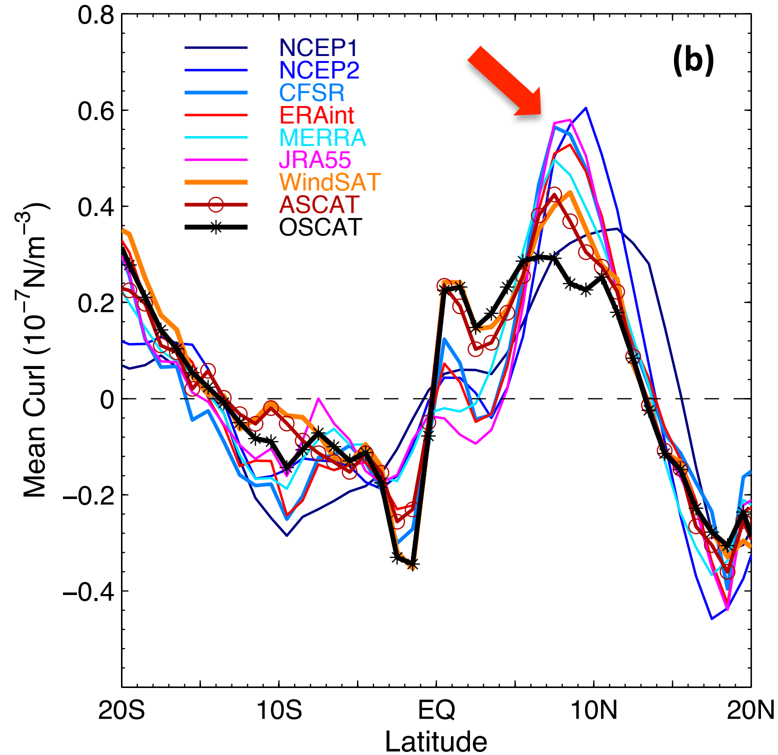
Zonally averaged mean curl(τ), 11 products



Period II 02/2010 – 01/2014

ASCAT/OSCAT overlapping period

Zonally averaged mean curl(τ), 9 products



Around 10N:

- The band of positive positive wind stress curl associated with the ITCZ is broader and more northward displaced in reanalyses compared to scatterometers.

Around 3N:

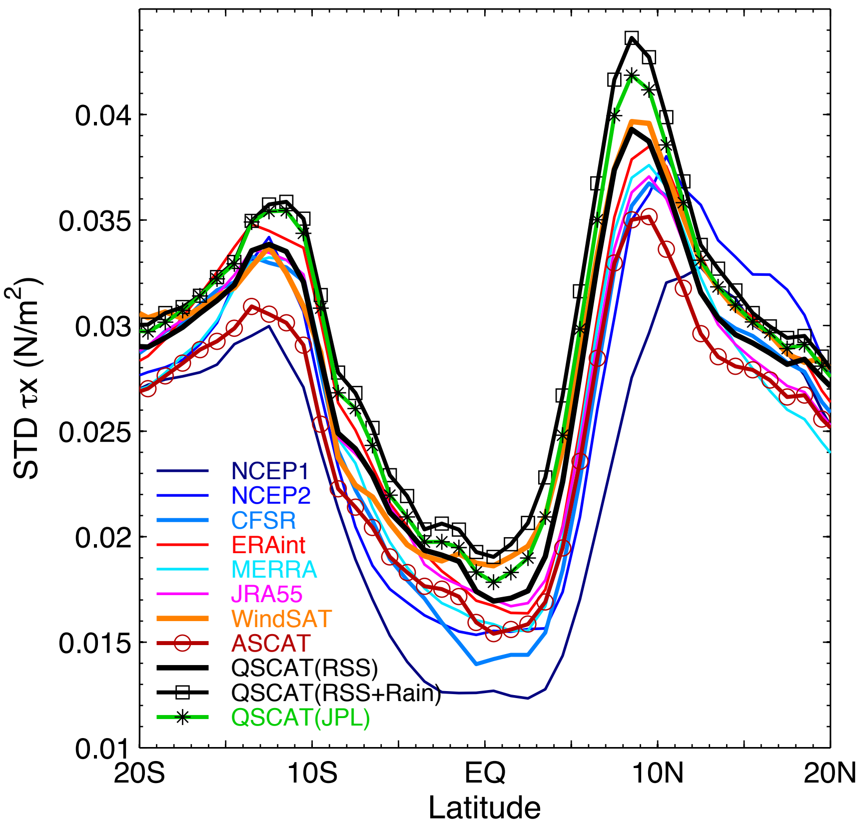
- CFSR is the only reanalysis that is able to depict the narrow band of positive wind stress curl.
- ERAinterm shows the positive curl band in recent years.

Seasonal variability: Wind stress components

Constructed from monthly-mean time series for the period 11/2007-10/2009

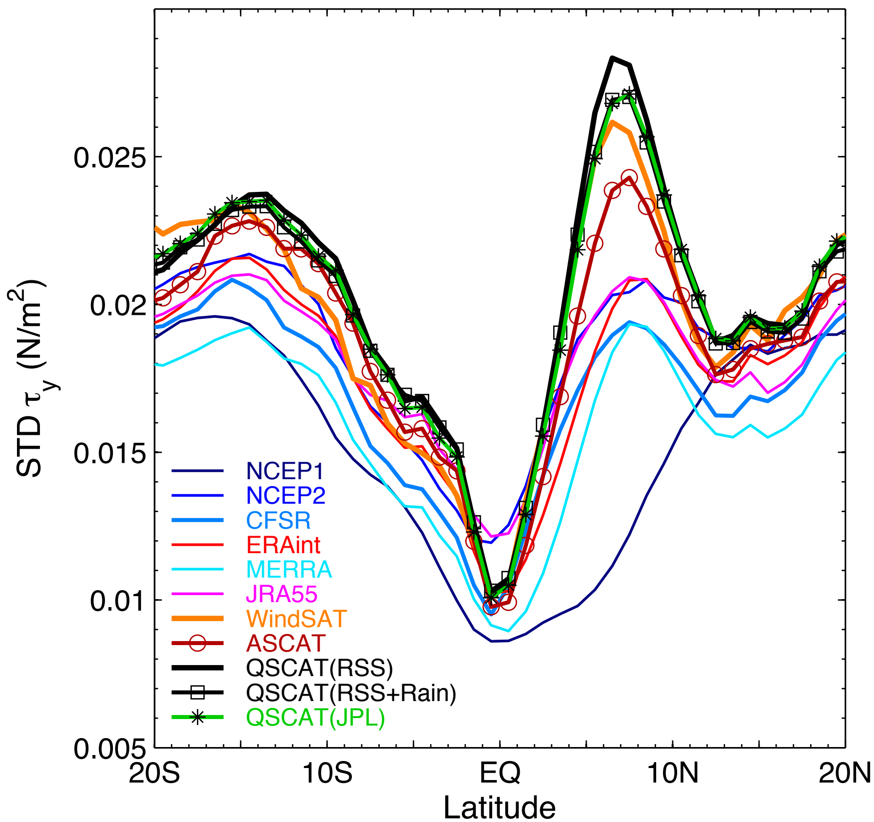
STD τ_x

Zonal average, 11 τ_x products



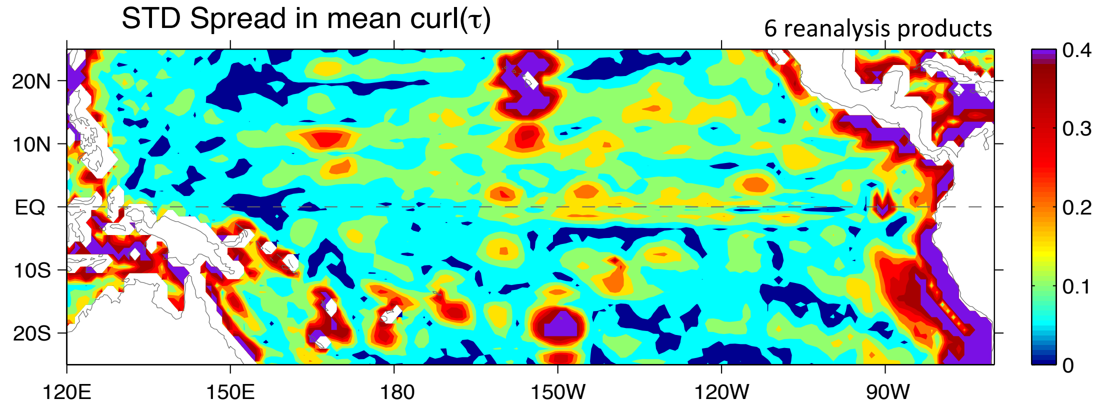
STD τ_y

Zonal average, 11 τ_y products

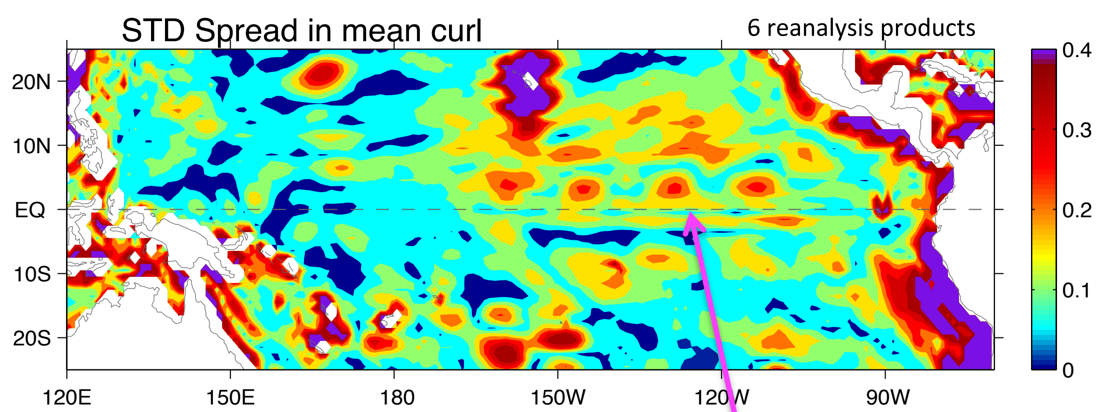


Spread in mean Curl(τ)

11/2007– 10/2009



02/2010 – 01/2014



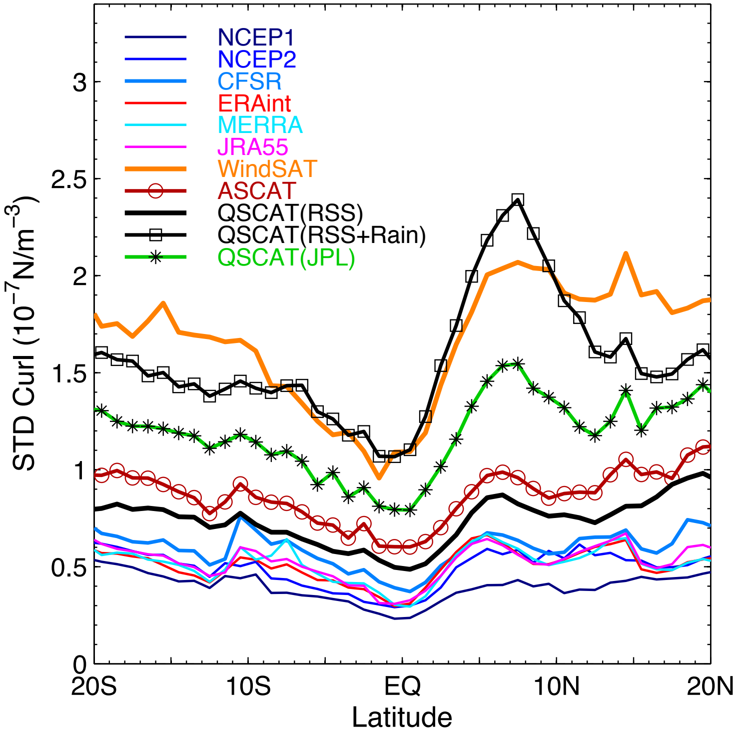
Bull's eyes around TAO buoys

Seasonal Variability: wind stress curl

Constructed from monthly-mean time series for the period 11/2007-10/2009

STD curl (τ)

Zonal average, 11 curl (τ) products



Reanalysis winds have weak variances

Comparison with buoy winds:

- Buoy winds are adjusted to equivalent neutral winds at 10m.
- Reanalysis winds are also adjusted to equivalent neutral winds at 10m.

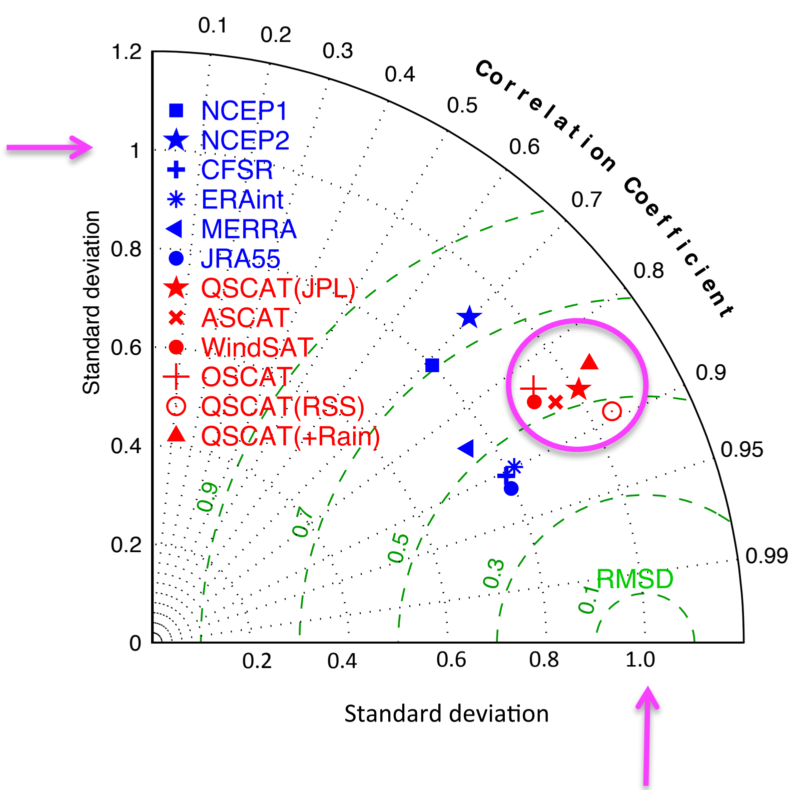
The Taylor diagram summarizes the statistics of buoy evaluation (2007-2012) at **4 near-equatorial sites**: (2N, 170W), (2N, 140W), (EQ, 140W), (2N, 110W).

The Taylor diagram:

- STD represents STD(product)/STD(buoy)
- RMSD represents STD(product-buoy differences)/STD(buoy)

→ The products is better compared to buoy if STD closes to 1 and RMSD closes to 0.

(c) Wind speed



Key findings on winds and wind stresses from climate reanalyses

(1) Winds from the latest reanalyses(CFSR, ERA-interim, MERRA, JRA55) are comparable to each other on both mean and seasonal timescales, but differ considerably from satellite winds. NCEP1 and NCEP2 assimilate TAO observations but no satellites, and have strong bulls-eye features collocating with mooring sites.

(2) Reanalysis wind products differ from satellite products mainly at two latitudes: 3N and 10N.

- Reanalysis products cannot produce the band of positive curl between 1-3°N, except for CFSR that is a coupled reanalysis and uses SST generated from an ocean model. The problem indicates that, in addition to the need of assimilating satellite winds, there is also the need of improving SST conditions in the reanalysis.

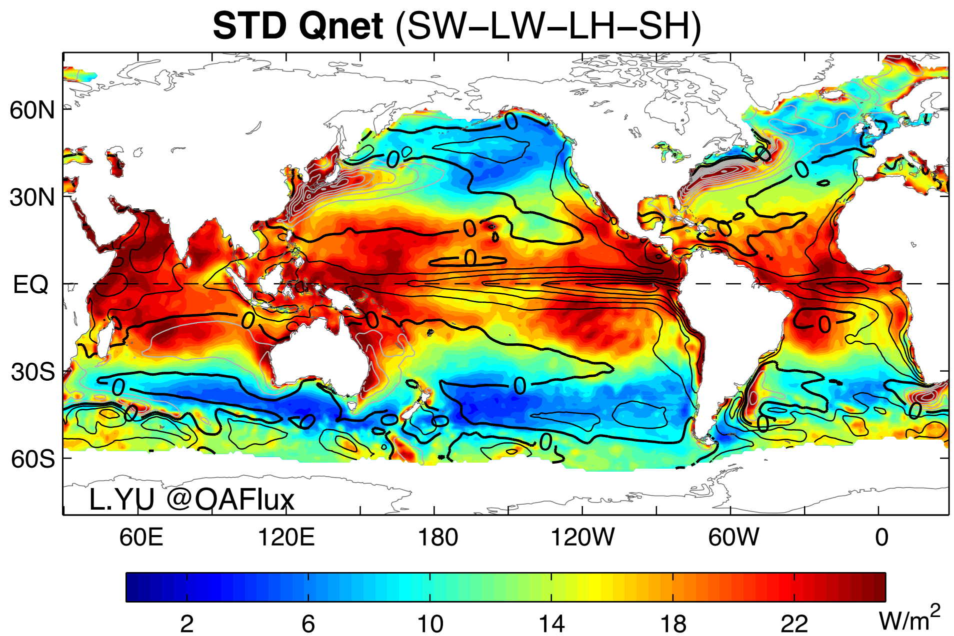
- Reanalysis products tend to produce a broader meridional extent for the positive curl(τ) associated with the ITCZ, and the effect is most evident at 10N when compared to satellite products.

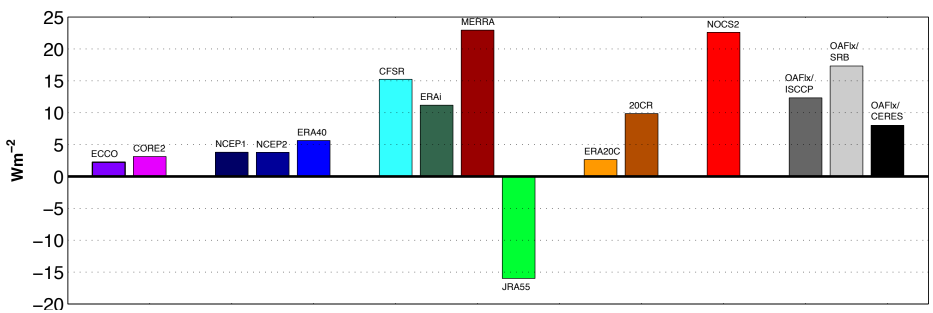
From the manuscript on "Scatterometer and reanalysis wind stress and stress curl in the tropical Pacific" by L. Yu, X. Jin, …

(3) Surface heat fluxes from reanalyses and satellite

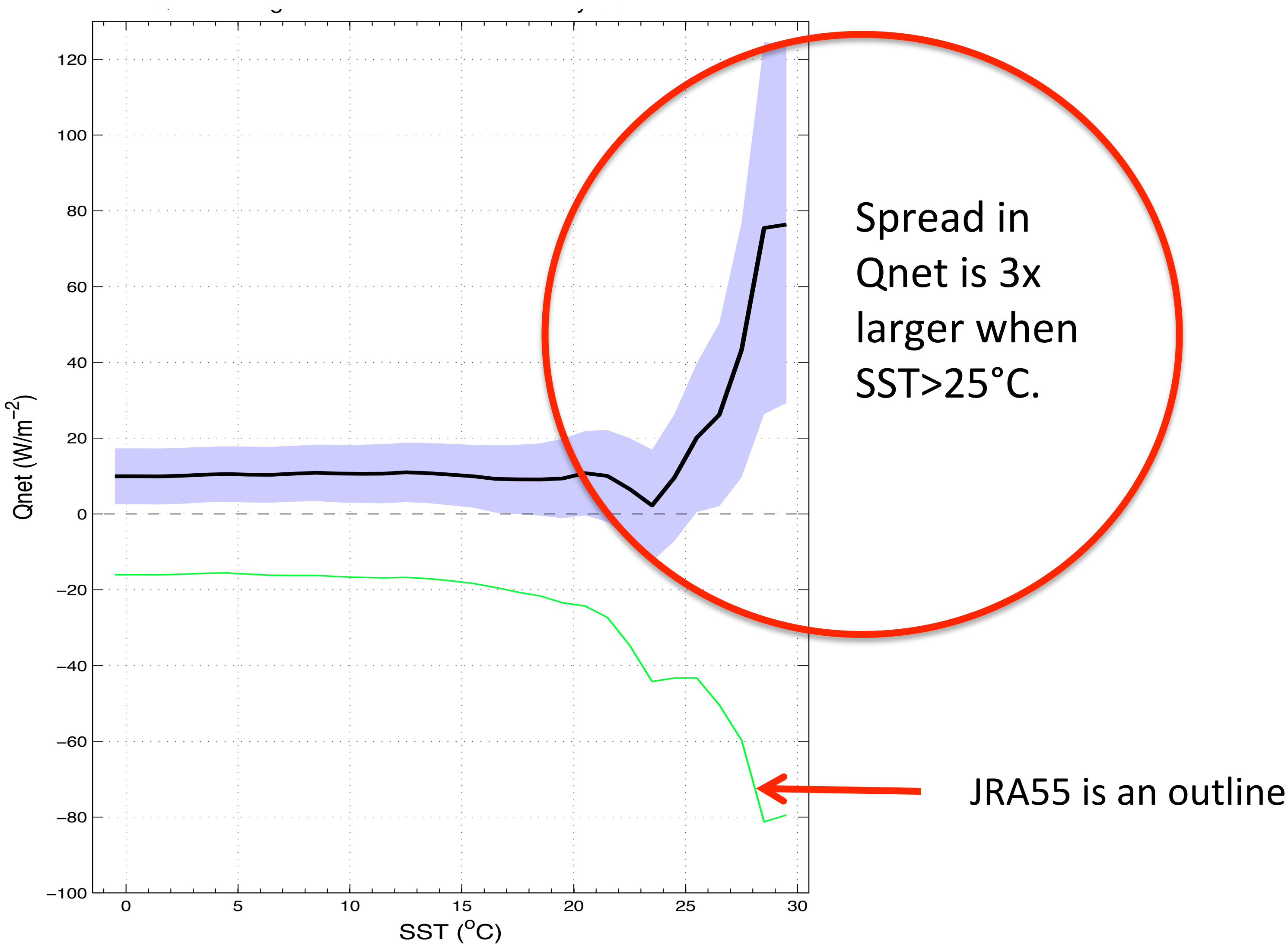
Global characterization of the uncertainty in Qnet: mean pattern

Spread in 15 Qnet products



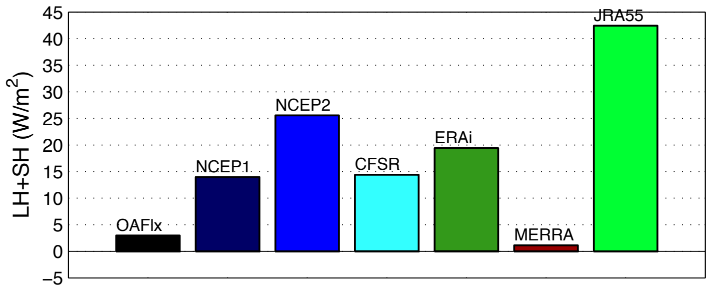


Uncertainty in Qnet: association with SST

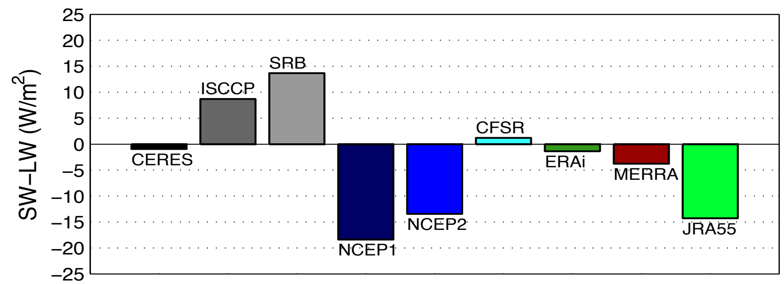


Buoy evaluation: turbulent heat fluxes

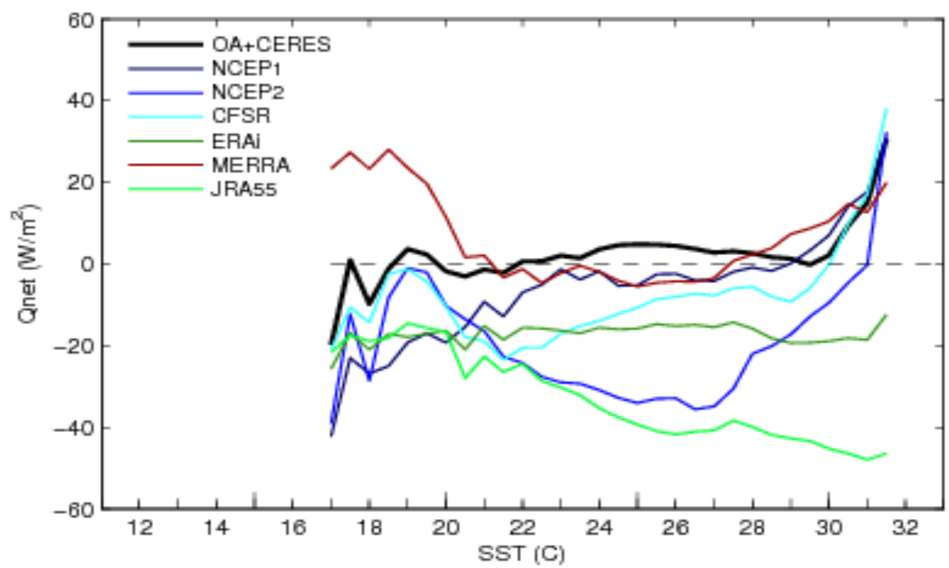
LH+SH Mean Diff (Product – buoy)



SW-LW Mean Diff (Product – buoy)



Distribution of DIFF (product – buoy) with SST



Key findings on surface heat fluxes from climate reanalyses

- The error characteristics of heat fluxes are highly dependent of SST.
- The spread in Qnet products is 3 times larger when SST > 25C.
- Over the tropical oceans, reanalysis heat fluxes tend to have weaker radiative heat input and stronger turbulent heat loss in the tropical oceans.

- Similar to surface freshwater flux products, surface heat flux products show also a large spread in the tropical ocean.
- A major source of error in reanalysis fluxes arises from the depiction of the ITCZ position and its seasonal movements.

From “The Earth’s Surface Budget: Outcomes, uncertainties, and drawbacks ” by L.Yu