Sea surface salinity and barrier layer variability in the equatorial Pacific

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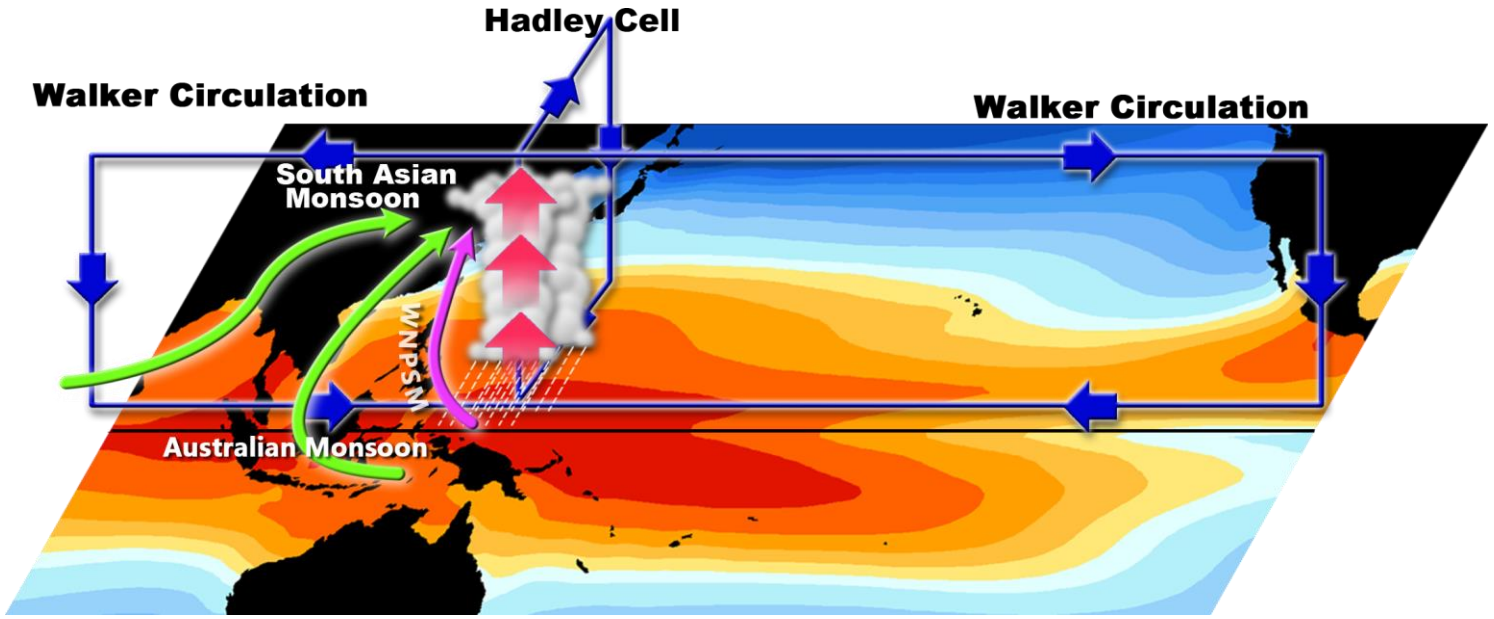
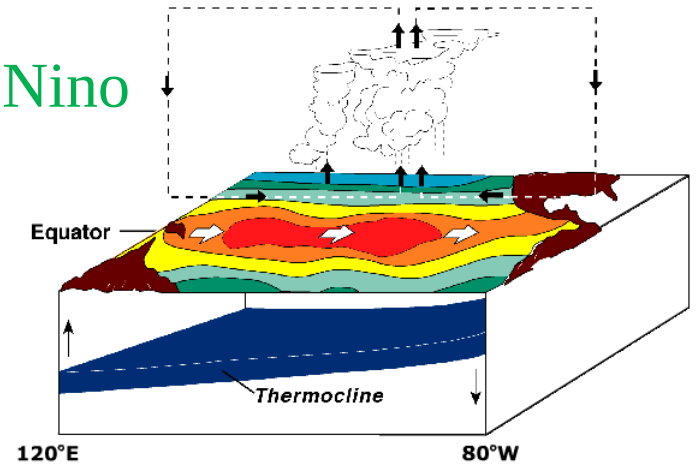
Western Pacific warm pool is where El Nino begins.

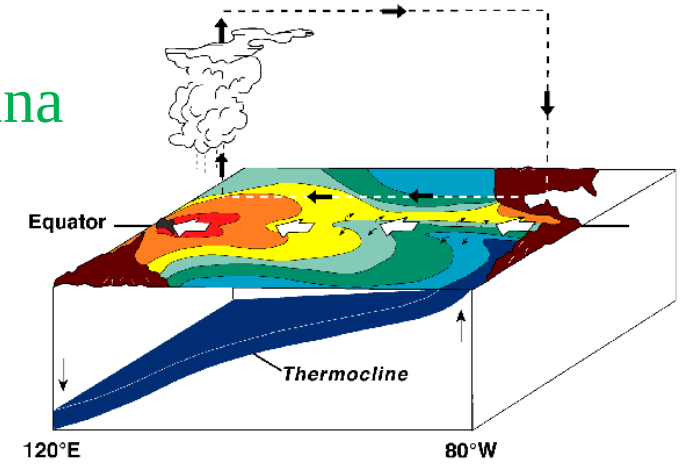
---------Its zonal displacement is one of the key characteristics of ENSO.



El Nino



La Nina



Eastern edge of the warm pool is not well defined,

because the zonal SST gradient along the equator is rather small.

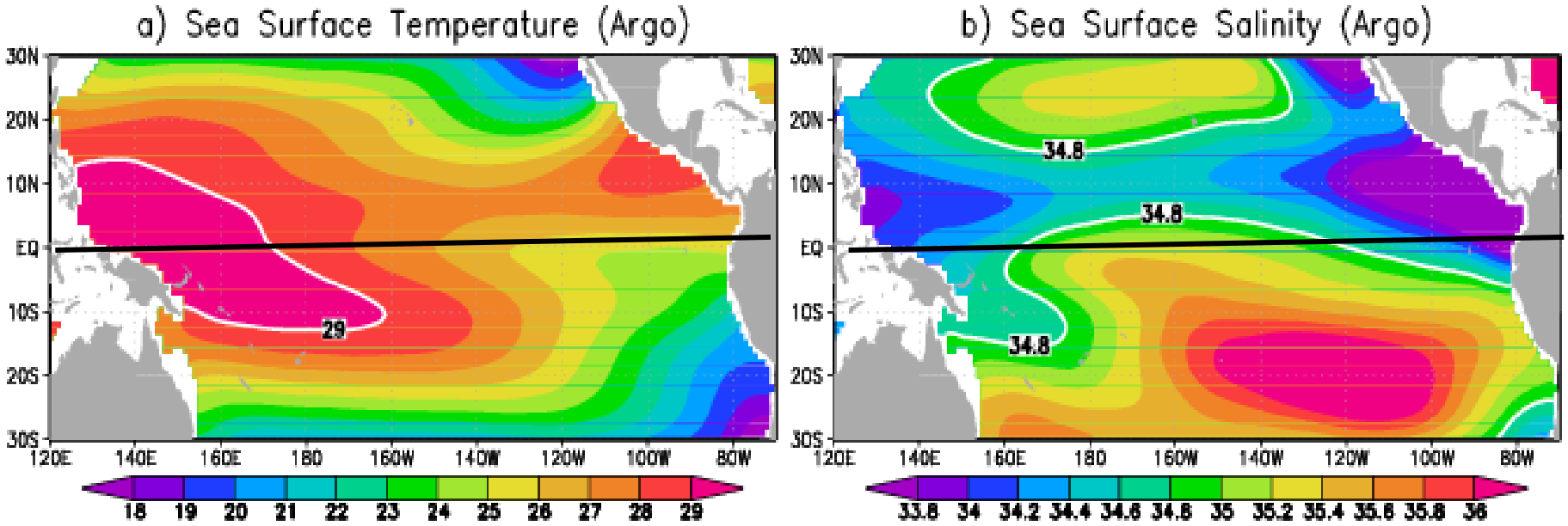


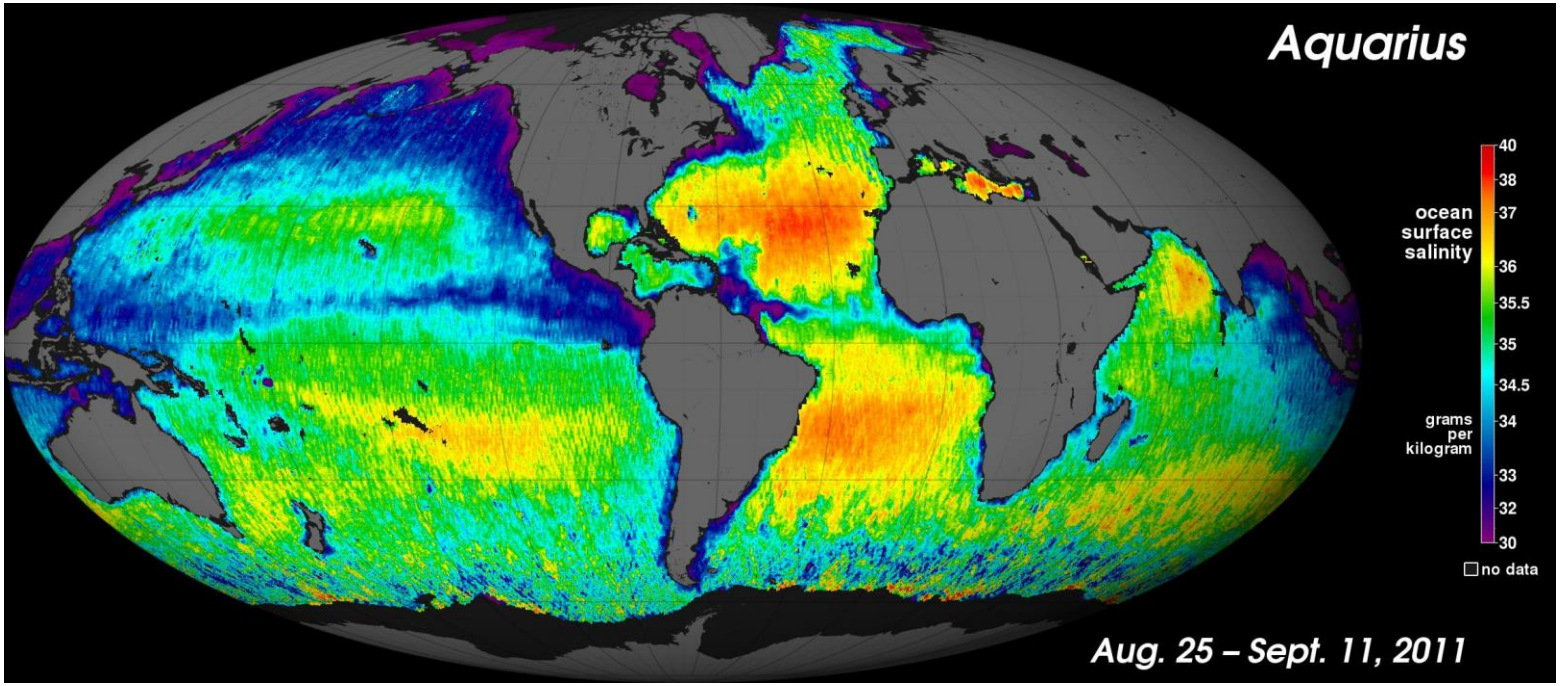
Figure: Mean SST and SSS distribution in the tropical Pacific from Argo (2005-2013)

For this reason, regional averages of SST (e.g., Nino-4, Nino-3) instead of the eastern edge of the warm pool are used to monitor the evolution of ENSO.

The eastern edge of the warm pool is actually characterized by a strong SSS front, which sometimes exceeds 0.5 psu in 1º longitude.

Good news: Space-based remote sensing is revolutionizing ocean observations

Aquarius was successfully launched !

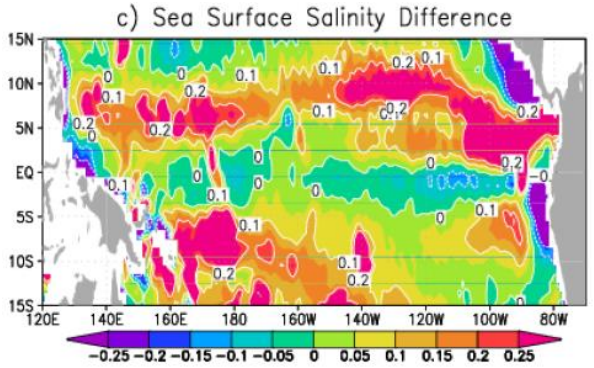


Providing a global observing capability of the ocean, generating near-synoptic SSS maps on global scale at a spatial resolution of ~150 km every 7 days.

Validation---Annual mean

The two datasets show reasonable agreement, except along the ITCZ/SPCZ (~0.2 psu), presumably due to the ocean's skin effect.

The discrepancy between the two is typically less than 0.05 psu along the equator except in the far eastern Pacific.



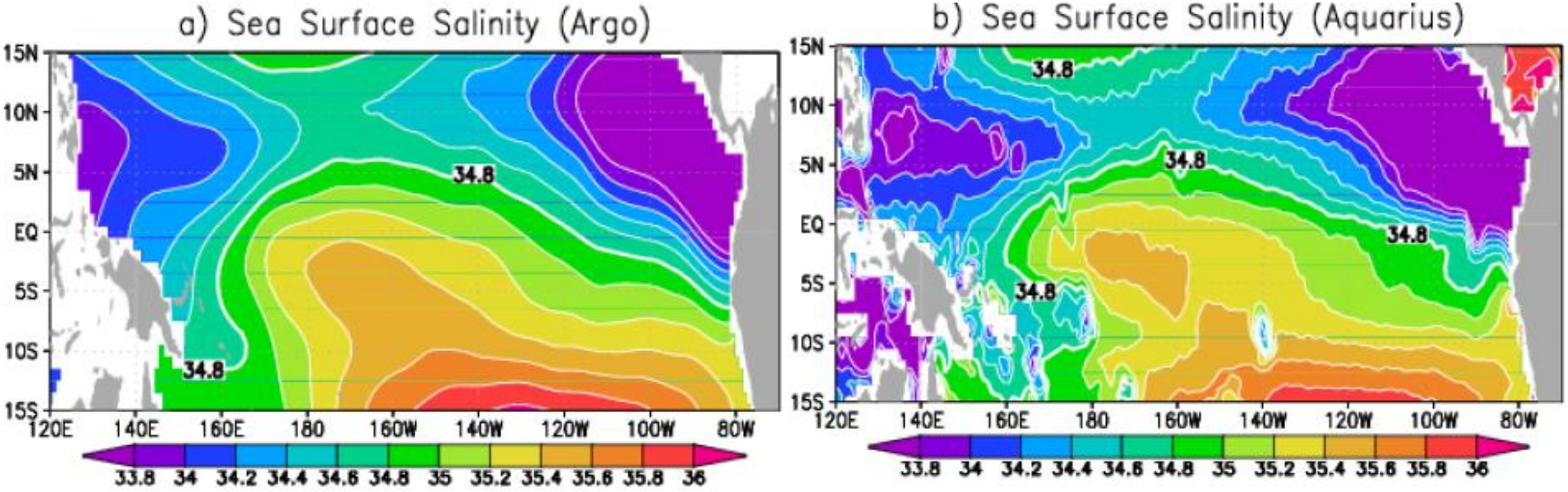
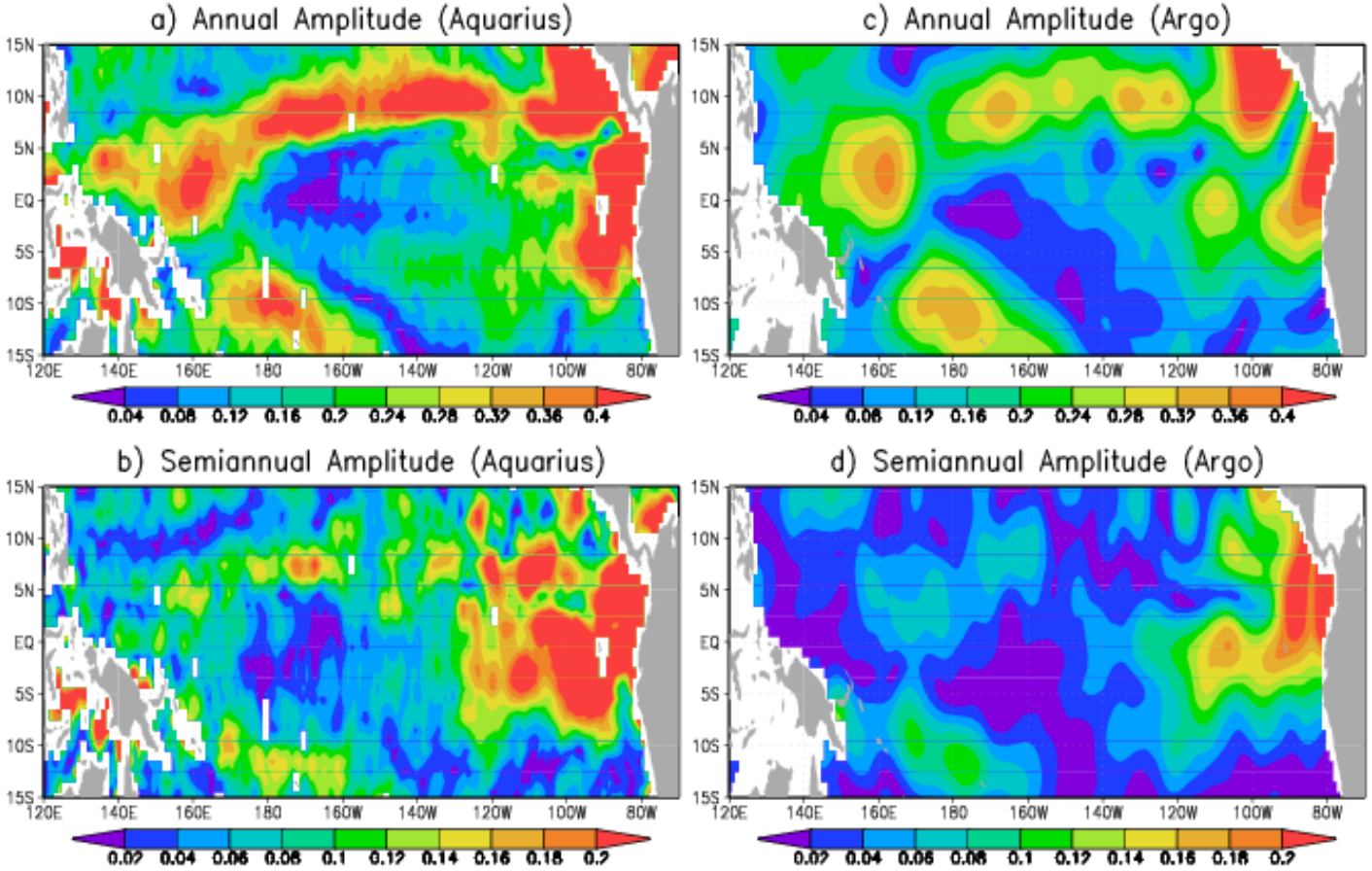


Figure: Mean SSS observed by Aquarius compared with Argo in the tropical Pacific

Validation---Seasonal Cycle

A coherent band of annual amplitude >0.2 psu is along the ITCZ/SPCZ.

Areas with semiannual cycle >0.03 psu include the eastern equatorial Pacific and ITCZ/SPCZ.

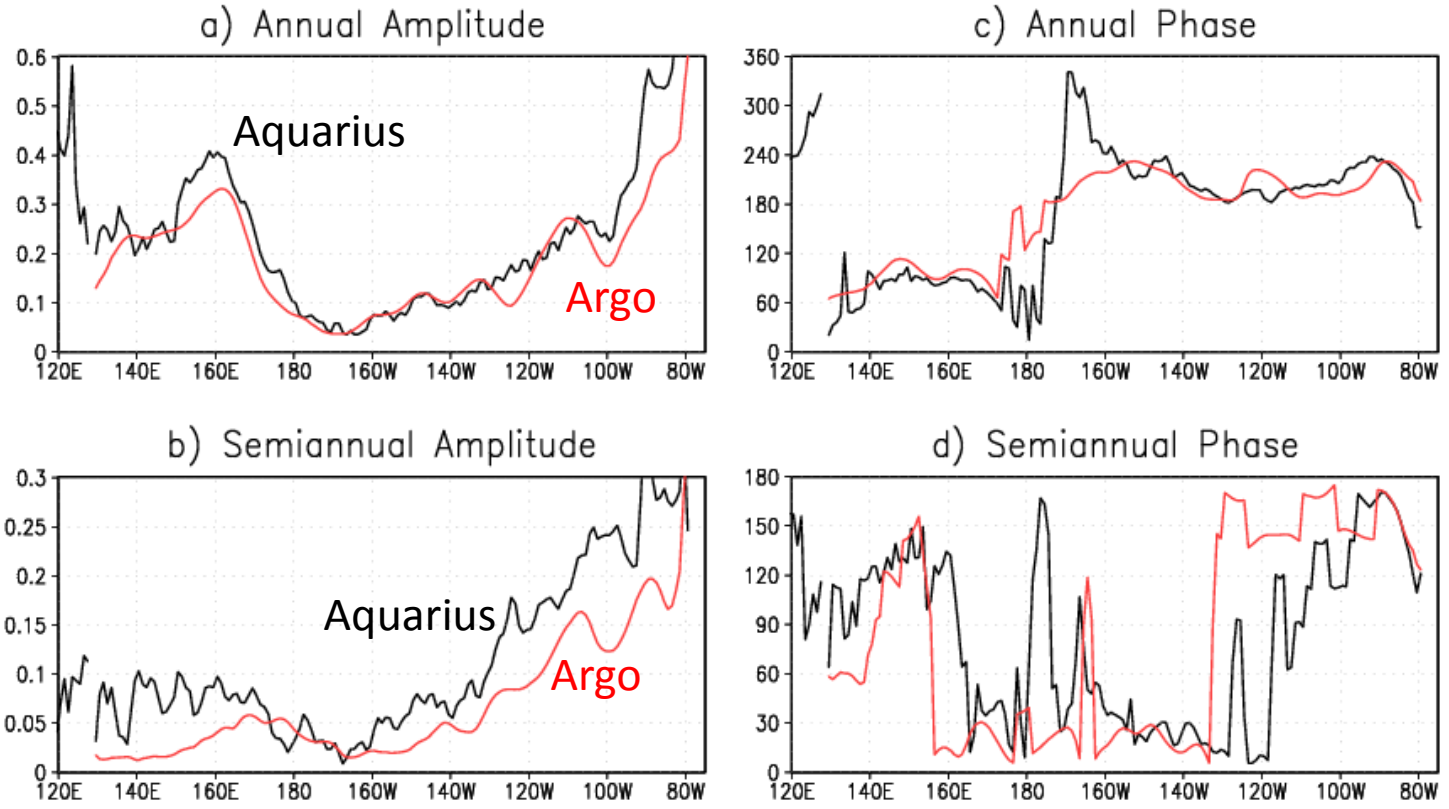


Despite some quantitative differences, the annual and semiannual amplitudes from the two datasets show essentially the same pattern.

Validation---Seasonal Cycle along the equator

Both amplitude and phase from two datasets are nearly identical.

Seasonal cycle is strongest in the eastern Pacific, is weakest in the central Pacific, and gets stronger again in the western Pacific.



Aquarius captures both the annual and semiannual variations fairly well along the equator.

SSS front observed by Aquarius

The SSS front along the equator can be nicely resolved by Aquarius .

Mean SSS gradient.
----------0.03 psu per degree longitude;

Monthly SSS gradient,
----------0.09 psu per degree longitude

Weekly SSS gradient:
----------0.26 psu per degree longitude

Occasionally,
----------0.5 psu per degree longitude

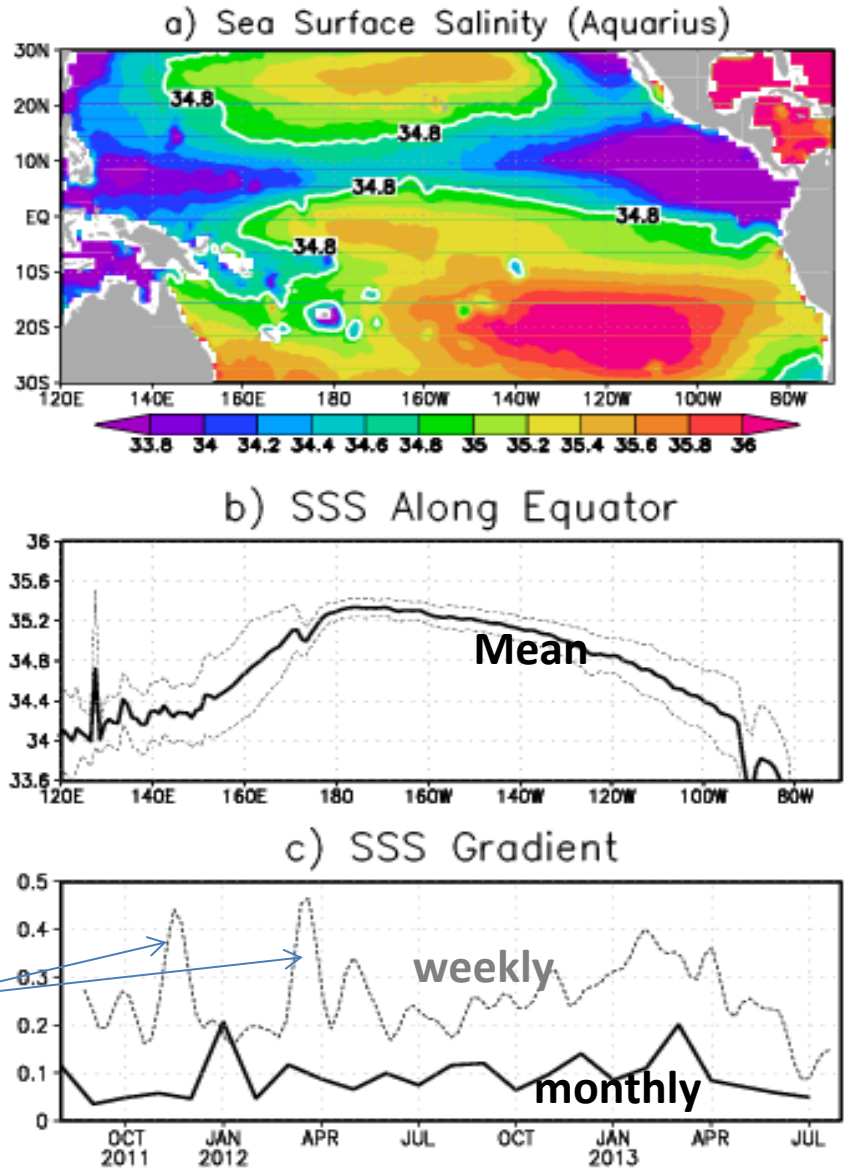


Figure: Mean SSS a) in the tropical Pacific and b) along the equator (3°S-3°N) from Aquarius. Also included in c) is the zonal SSS gradient across the 34.8 psu isohaline along the equator on monthly (black) and weekly (red) time scales. The light lines in b) indicate the range of one standard deviation above and below the mean values.

Zonal displacement of the SSS front

The 34.8 psu isohaline can be used as a proxy of SSS front along the equator.

Aquarius can capture more features than Argo.

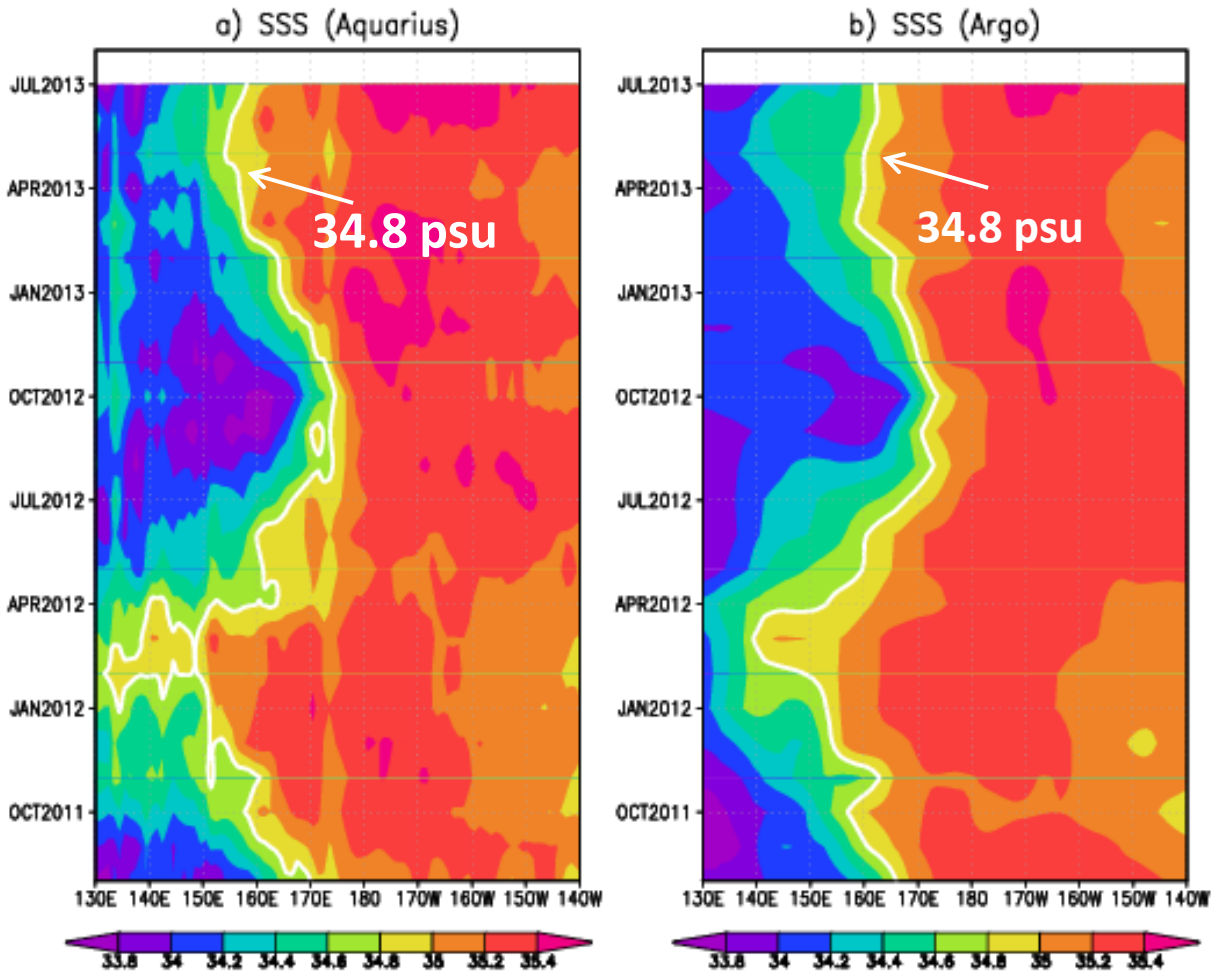


Figure: Time-longitude distribution of SSS along the equator (3S-3N) from a) Aquarius and b) Argo during 08/2011/07/2013

The correlation=0.85.

Barrier layer--A layer between the bottom of the mixed layer and the top of the thermocline, which is believed to play a critical role in the maintenance and evolution of the warm pool (Lindstrom et al., 1987; Lukas and Lindstrom 1991)

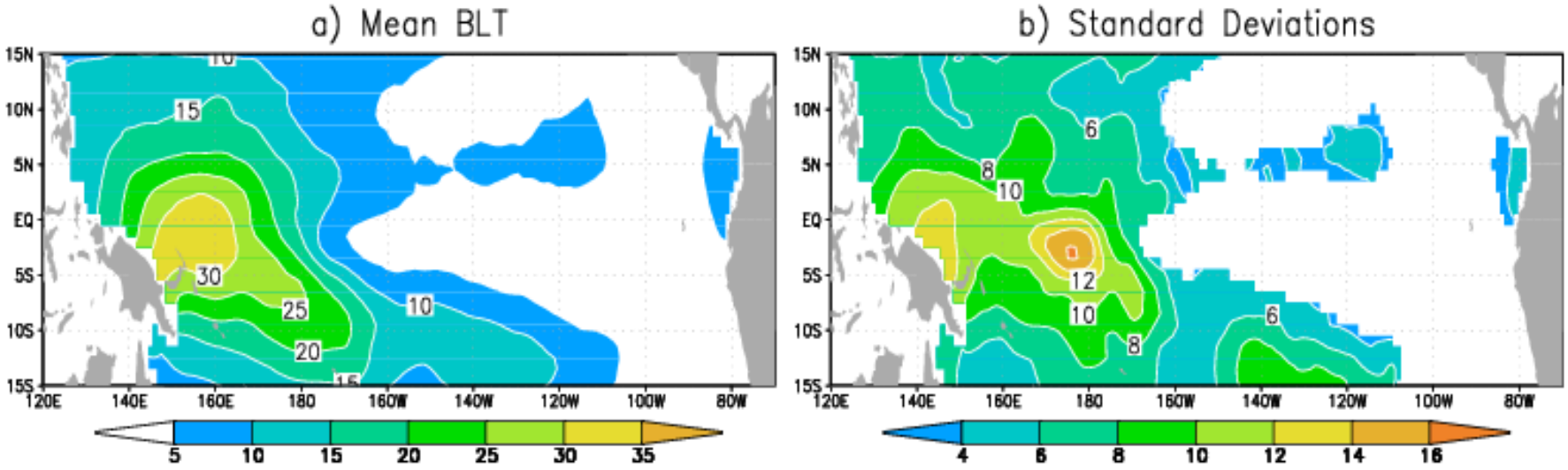


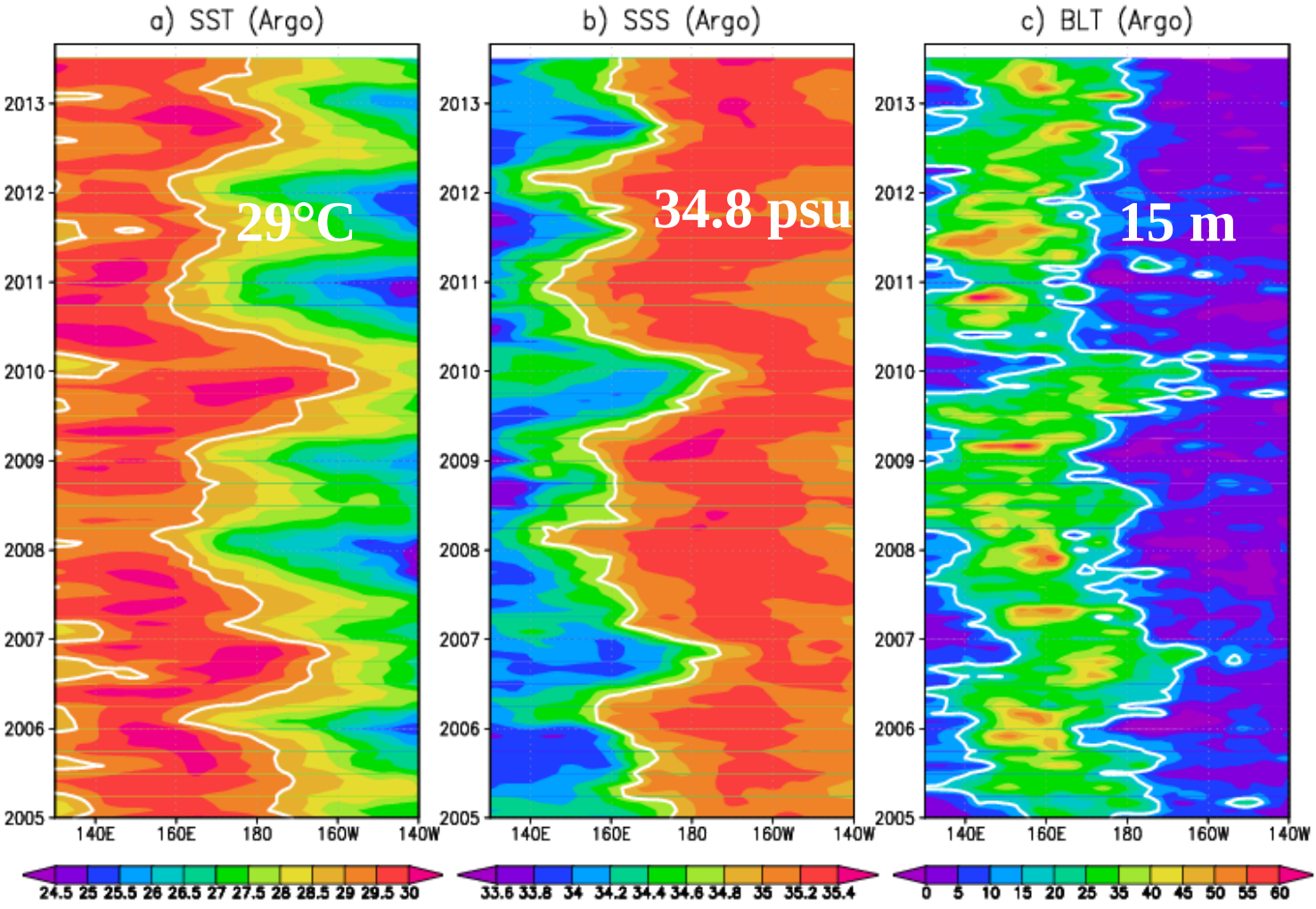
Figure: Barrier layer thickness (BLT) and its root mean square variation from Argo

On average, the barrier layer is >30 m in the far western equatorial Pacific, while its largest variability (>15 m) takes places near the dateline.

Zonal displacement of thick barrier layer

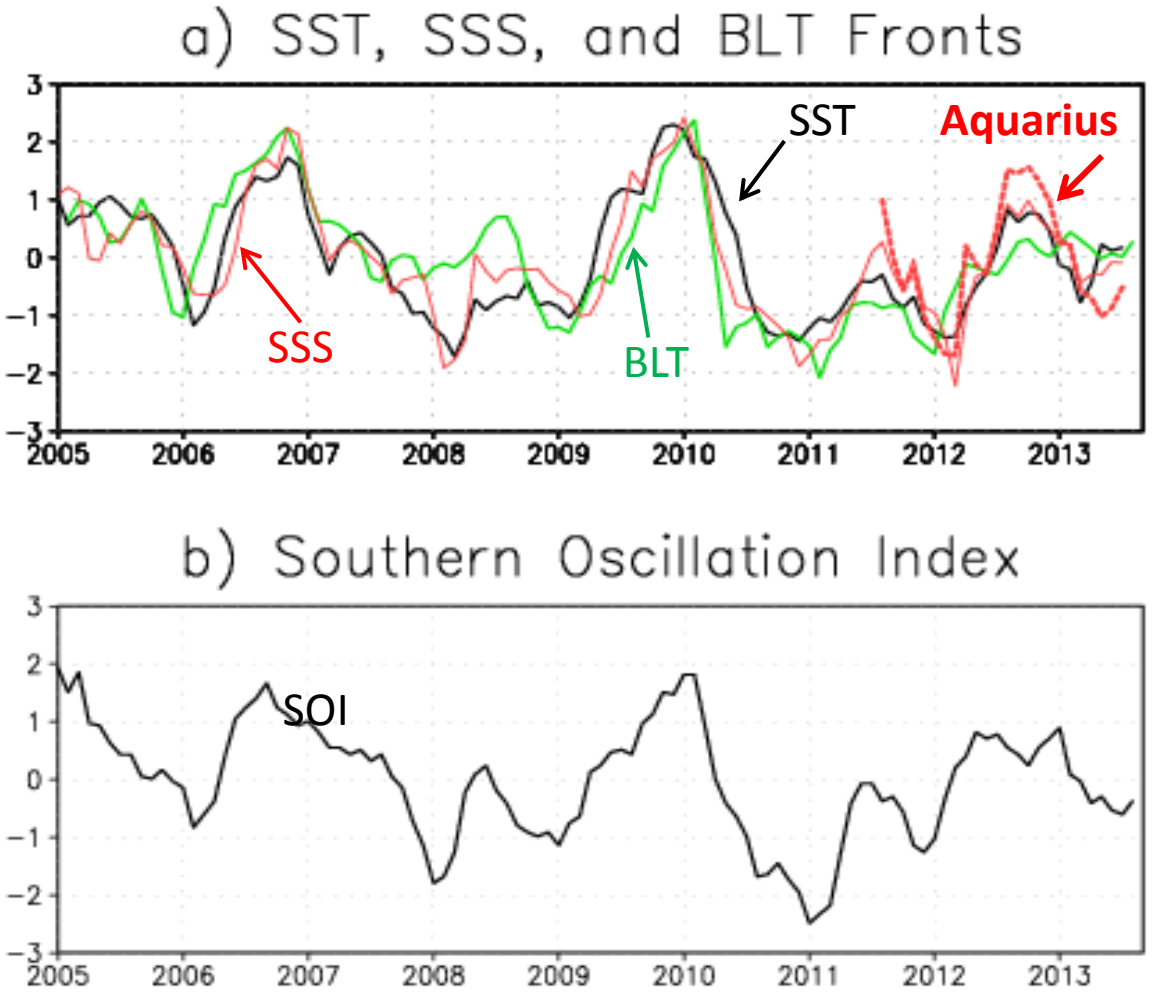
----It's a natural idea that the zonal displacement of SSS front must alter the surface stratification and consequently the barrier layer thickness.

The thick barrier layer can be represented by the 15m contour. Its correlation with the SSS front reaches 0.79 during the period of observation (2005-2013).



Link to ENSO

----Time series of 29C isotherm, 34.8 psu isohaline, and 15 m BLT compared with SOI.



They are all highly correlated.

Correlations

Table: Correlations among the eastern edge of the warm pool (29°C), SSS front (34.8 psu), thick barrier layer (15 m), and SOI. Numbers in the brackets indicate the time (in months) that variables in the first column lag those in the first row.

Correlation	Eastern Edge WP	SSS Front	Thick BL	SOI
Eastern Edge WP	1.00 (0)	0.90 (0)	0.76 (1)	-0.82 (1)
SSS Front (34.8)	0.90 (0)	1.00 (0)	0.79 (1)	-0.84 (1)
Thick BL (15 m)	0.76 (-1)	0.79 (-1)	1.00 (0)	-0.81 (0)
SOI	-0.82 (-1)	-0.84 (-1)	-0.81 (0)	1.00 (0)

Interestingly, the thick barrier layer appears to lead both the eastern edge of the warm pool and the SSS front along the equator by one month. **Does this reflect the importance of subsurface processes**?—A question for future study.

Summary

(1) Aquarius SSS agrees reasonably well with Argo and can precisely detect the SSS front in the equatorial Pacific;

(2) The SSS front nicely represents the eastern edge of the warm pool, and both of them have a strong signature of ENSO;

(3) A thick barrier layer is always present on the western side of the SSS front, moving back and forth with the ENSO cycle.

Take-home messages :

(1) Aquarius may offer an opportunity to predict ENSO by monitoring the SSS front along the equator;

(2) Aquarius may have an observing capacity of subsurface processes (e.g., the barrier layer) through tracing the imprints of SSS.


Thank you
and Mahalo!