Aquarius Brings New Understanding to Intraseasonal Variability in Tropical Oceans

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Material based on

Lee, T., G. Lagerloef, M.M. Gierach, H.-Y. Kao, SS. Yueh, and K. Dohan, 2012: Aquarius reveals salinity structure of tropical instability waves. *Geophys. Res. Lett.*, 39, L12610, doi:10.1029/2012GL052232.

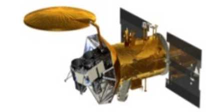
Grunseich, G., B. Wang, S. Bulusu, 2013: The Madden-Julian oscillation detected in Aquarius salinity observations. Geophys. Res. Lett., 40, DOI: 10.1002/2013GL058173.

Guan, B, **T. Lee**, D. Waliser, and D. Halkides, 2014: Aquarius Surface Salinity and the Madden-Julian Oscillation: the Role of Salinity in Surface Layer Density and Potential Energy. Geophys. Res. Lett., 41, doi:10.1002/2014GL059704.

Yin, X., J. Boutin, G. Reverdin, **T. Lee**, S. Arnualt, and N. Martin, 2014: SMOS sea surface salinity signals of tropical instability waves. J. Geophys. Res., accepted.

Lee, T., G. Lagerloef, H.-Y. Kao, M.J. McPhaden, J. Willis, M. Gierach, 2014: The influence of salinity on tropical Atlantic instability waves. J. Geophys. Res., accepted.

AQUARIUS/SAC-D



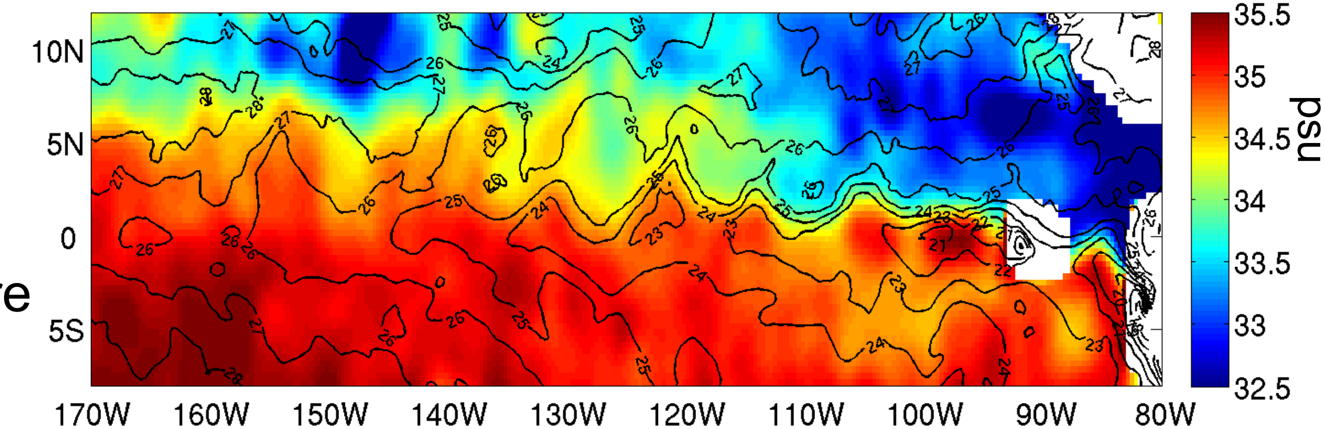
Aquarius Captures Pacific Tropical Instability Waves (TIWs)

SSS from Aquarius (color shading), SST (contours in a), surface currents (arrows in b) on Dec. 11, 2011 (7-day maps)

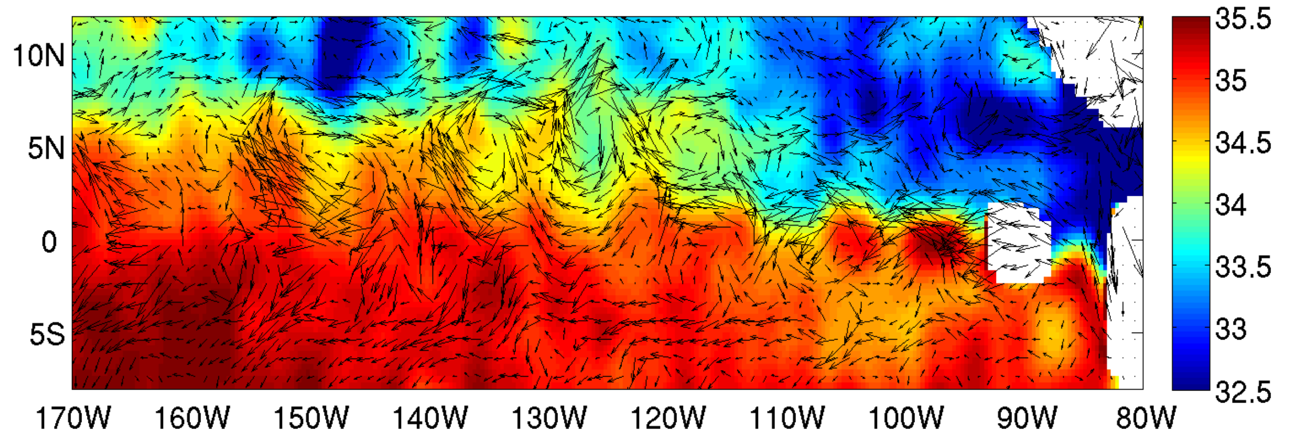
- TIWs affect ocean, climate, biogeochemistry
- Aquarius reveals TIWs salinity structure for the 1st time from space).
- Brings new understanding to TIWs.

Lee, Lagerloef, Gierach, Yueh, Dohan (2012, June GRL)

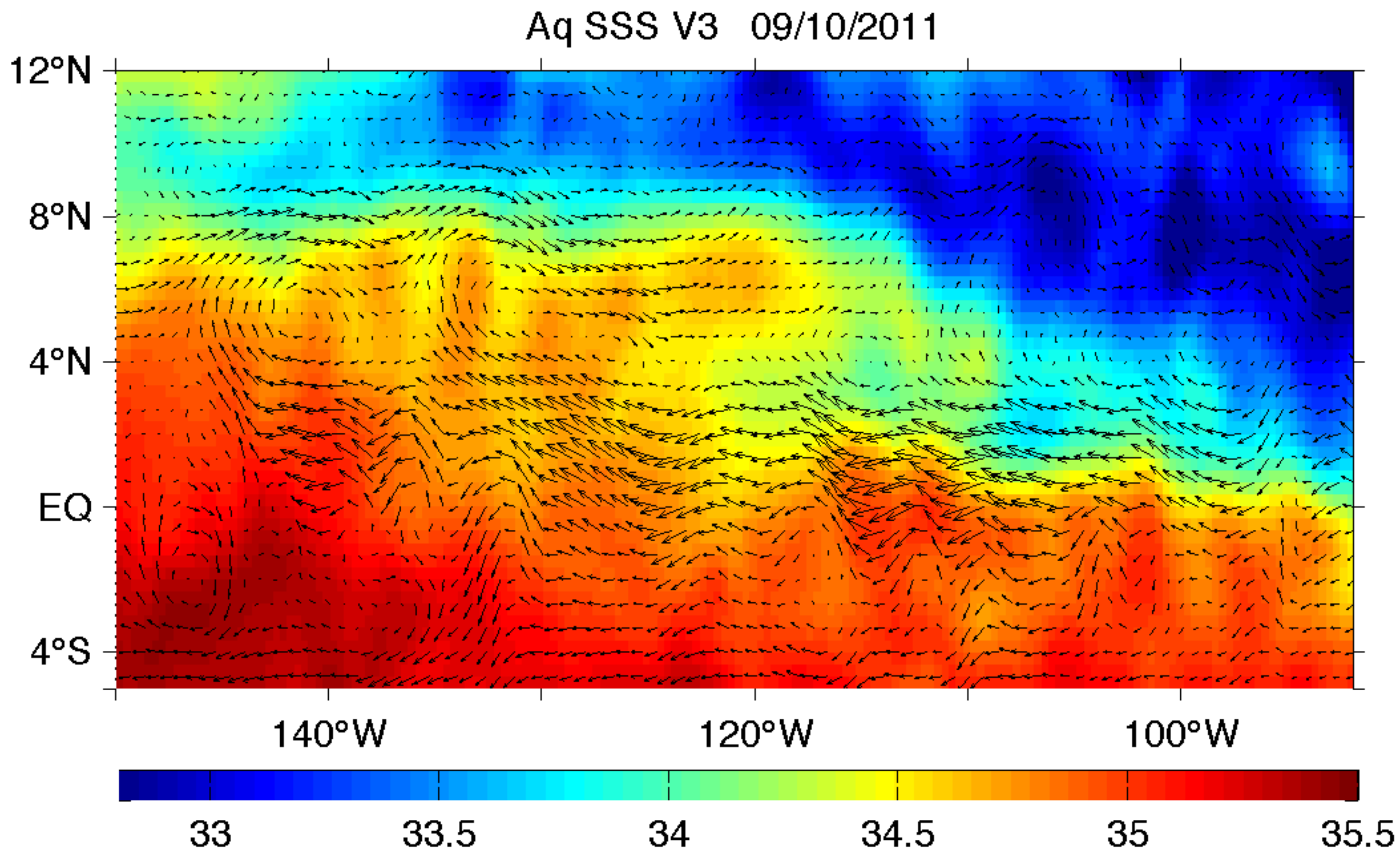
(a) SSS (color) and SST (contour) Reynolds ¼-deg OI



(b) SSS (color) & surface current (vector) OSCAR



Aquarius SSS & OSCAR surface current



Animation produced by Hsun-Ying Kao, Earth & Space Research

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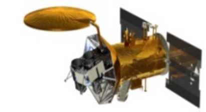
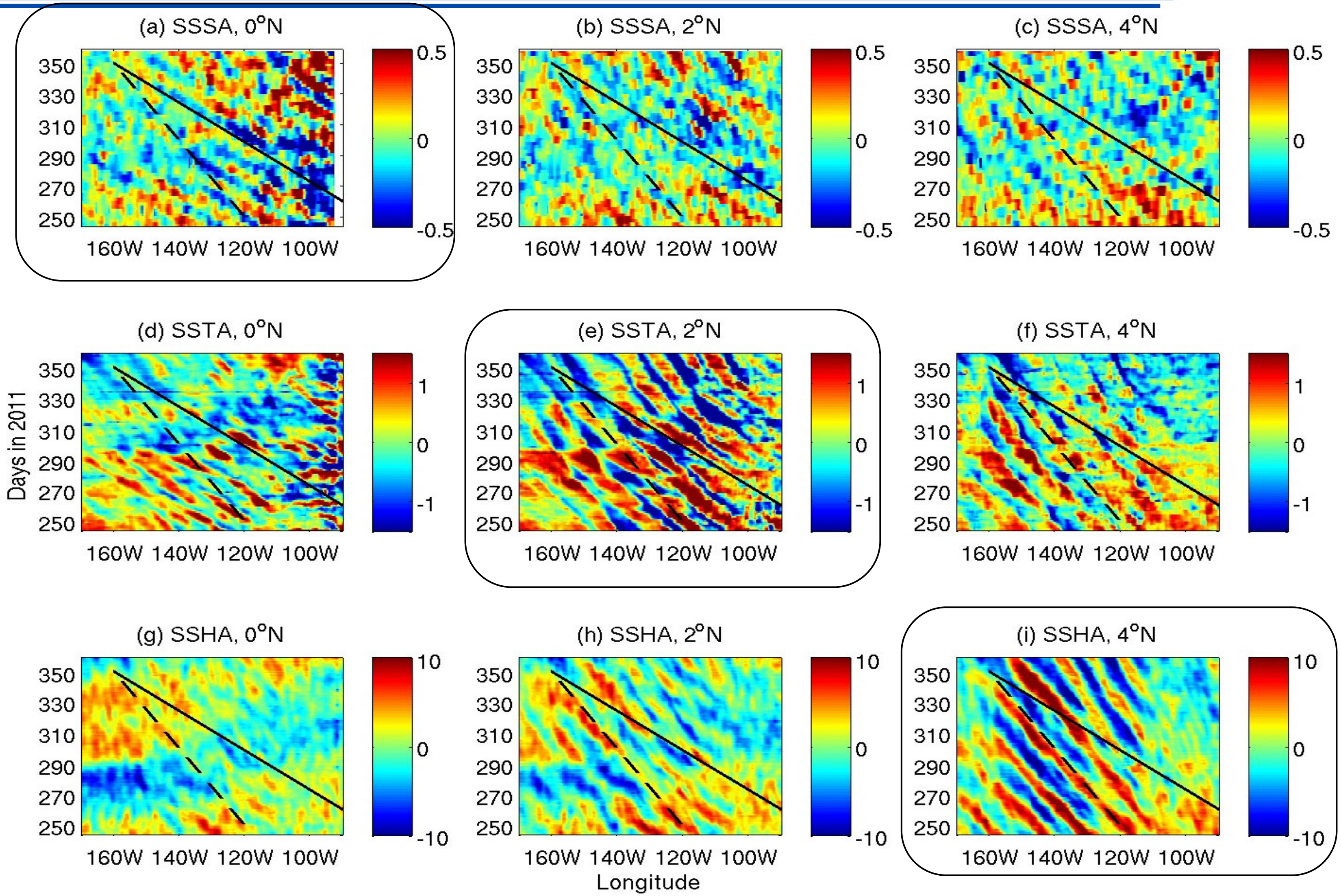
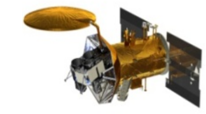
TIW propagation in SSS, SST, SSH





- **SSS, SST, SSH show strongest propagation at 0, 2, 4N, complementary**
- **Faster speed at equator (≈1 m/s) than away from equator (≈0.5 m/s).**

Why is TIW signal stronger in SSS than in SST near the equator?



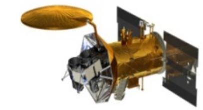
TIWs travel along latitudes with large meridional property gradient:

- Meridional SST gradient is larger in the northern edge of the cold tongue (near 2N).
- Meridional SSS gradient is larger near equator where salty South Pacific water meets the fresher water under the ITCZ.

Implications:

SSS plays a larger role in TIW energetics at the equator (indeed demonstrated by Hasson and Lee 2014, in prep.)

Why do dominant TIWs propagate faster near the equator?



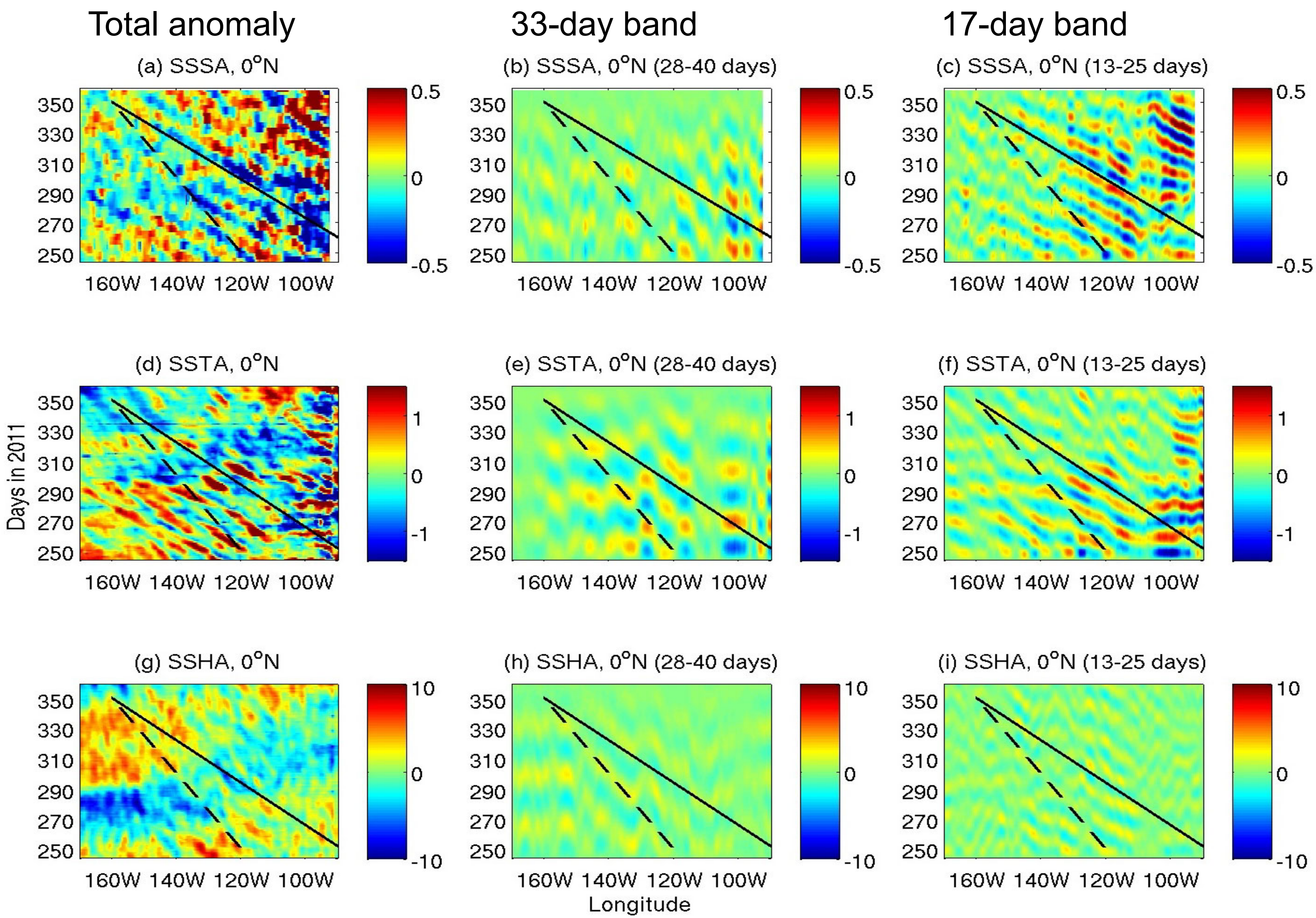
- Decades of literature consistently reported ≈0.5 m/s dominant speed of TIWs; Aquarius shows faster propagation (1 m/s) near equator in 2011 (Yin et al. 2014 showed with SMOS data that the speed varies between 1.5 and 0.6 m/s from strong La Nina in 2010 to neutral condition in 2013).

- Reason for faster propagation near equator: 17-day TIWs (Yannai mode) dominate near equator, 33-day TIWs (Rossby mode) more prevalent away from equator.

Implications:

eddy-mean flow interaction and eddy mixing

TIW propagation at equator



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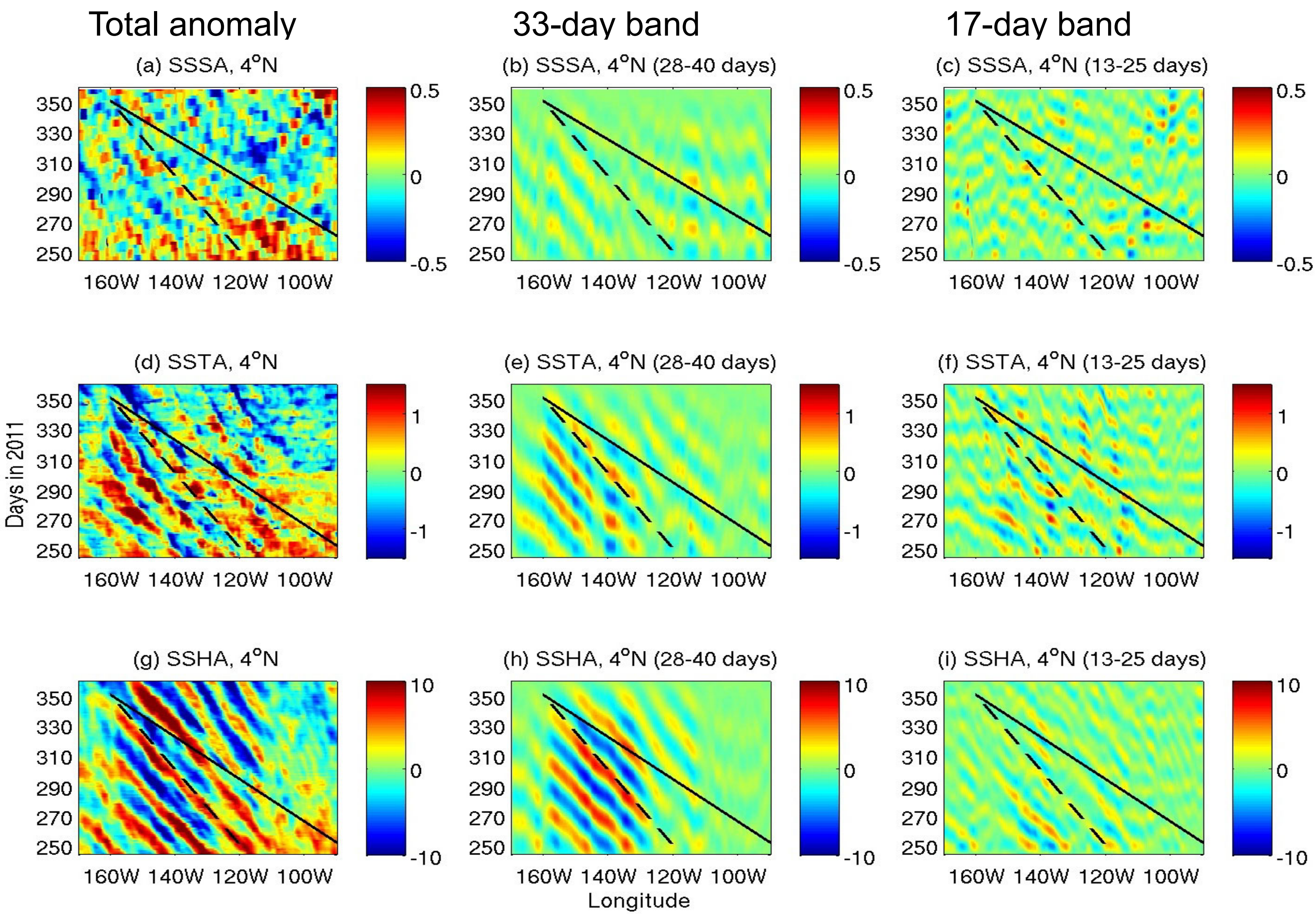
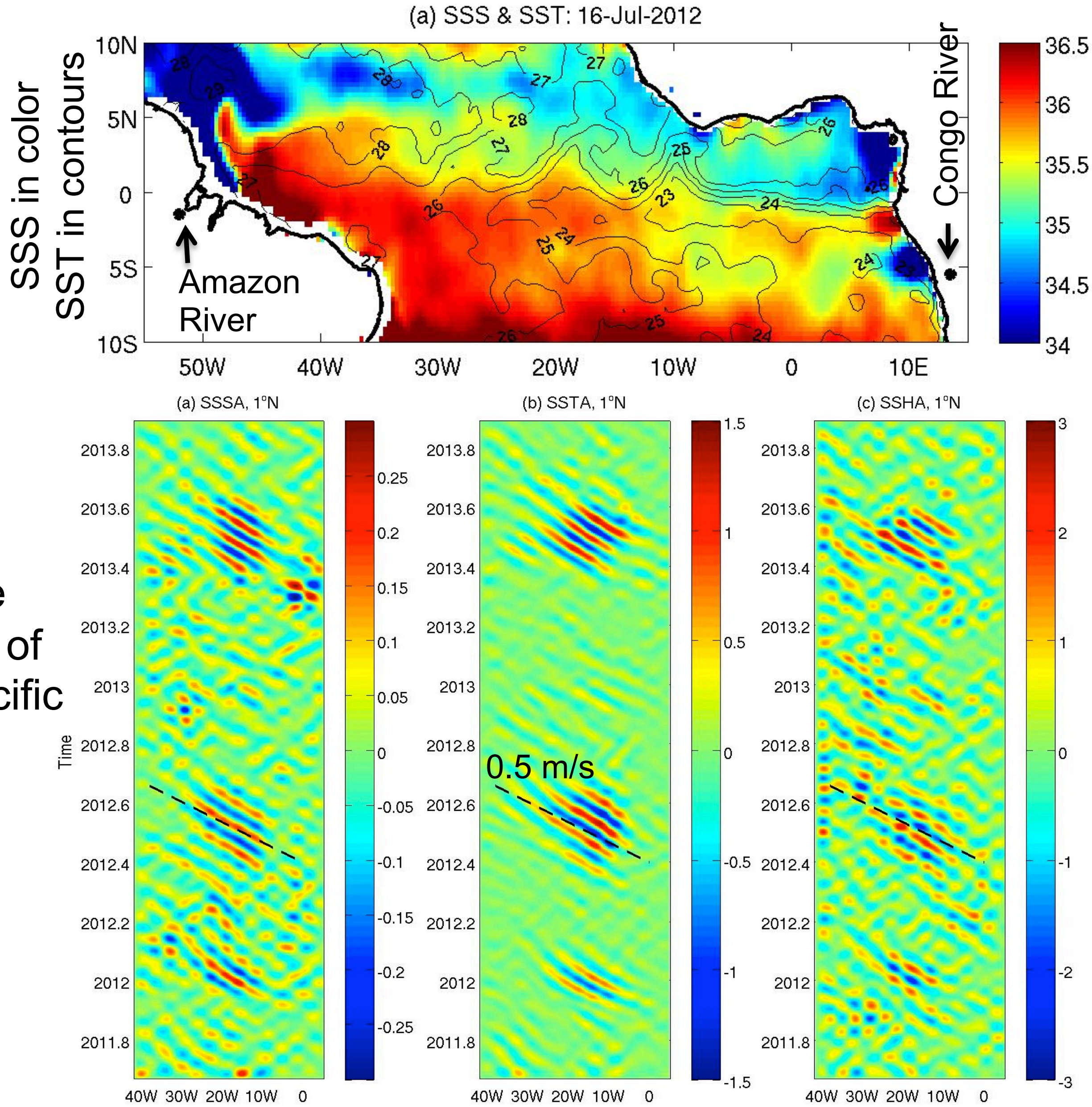
TIW propagation at 4N



Aquarius also captures the much weaker Atlantic TIWs

Lee, Lagerloef, Kao, McPhaden, Willis, and Geriach (2014, JGR accepted)



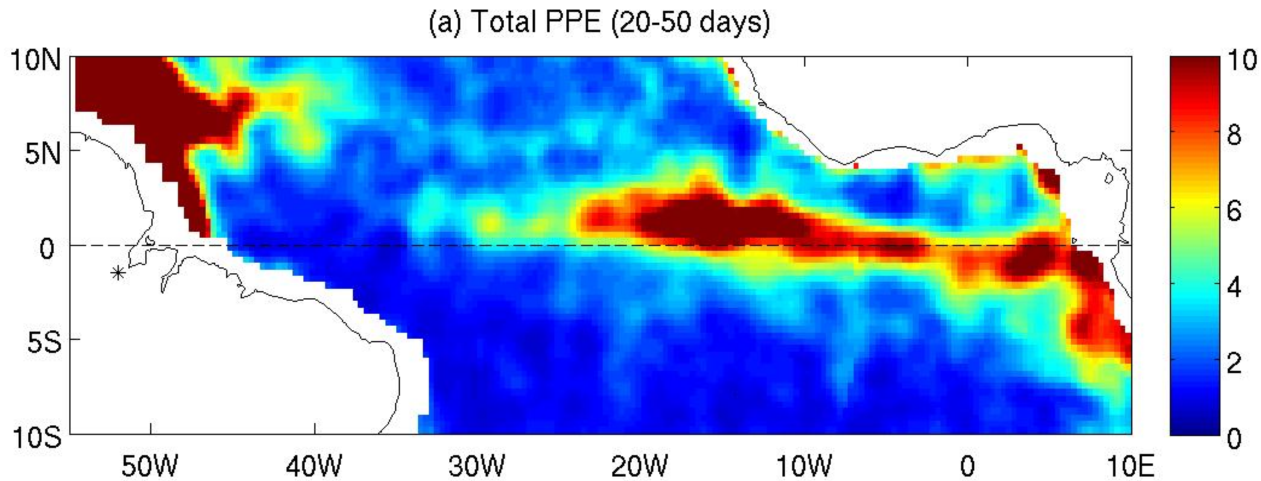
SSS' magnitude about half of that of Pacific TIWs

Substantial influence of salinity on energetics of tropical Atlantic TIWs

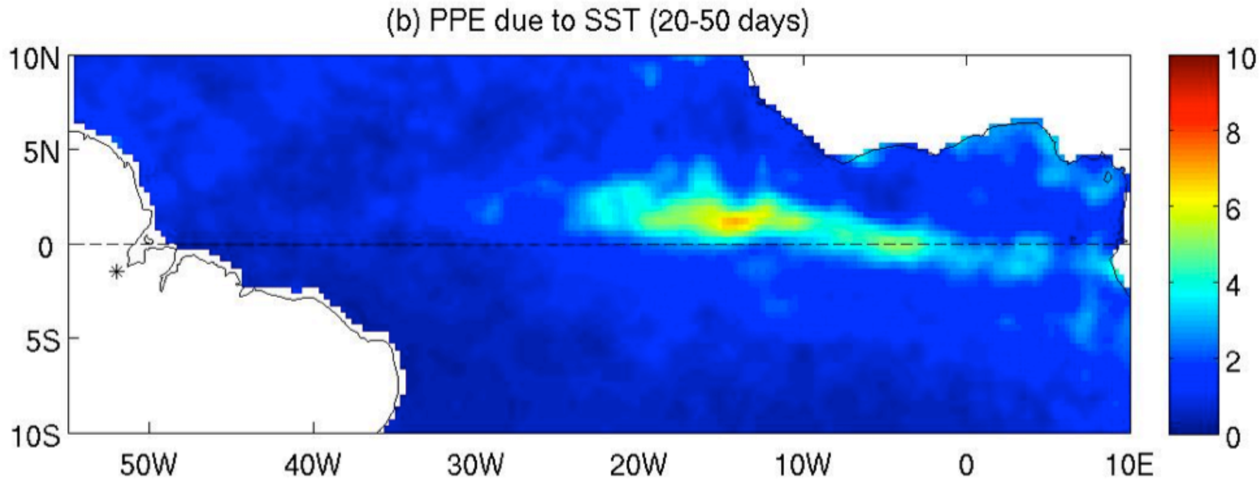
Lee, Lagerloef, Kao, McPhaden, Willis, and Gierach (2014, JGR, accepted)

20-50 day surface perturbation potential energy (PPE)

accounting for SSS & SST contributions



considering only SST contribution

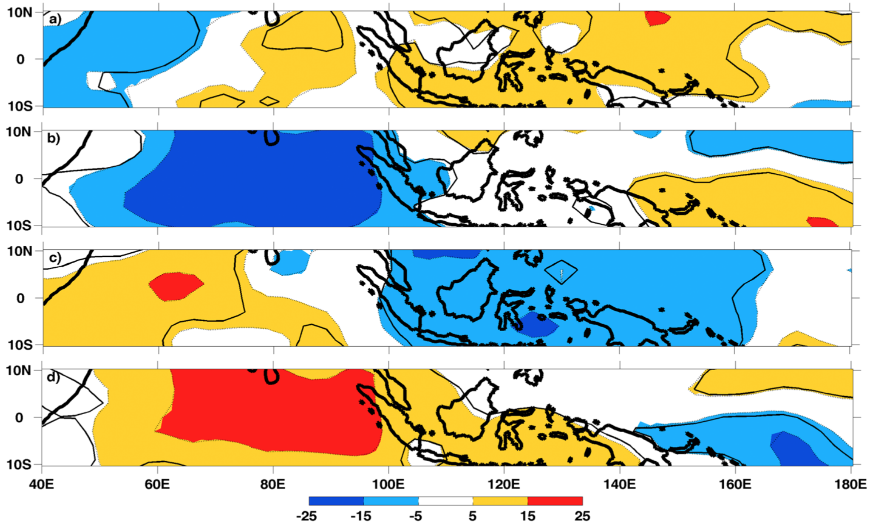


Ignoring salinity under-estimates surface PPE by 3 times in the central eq. Atl!

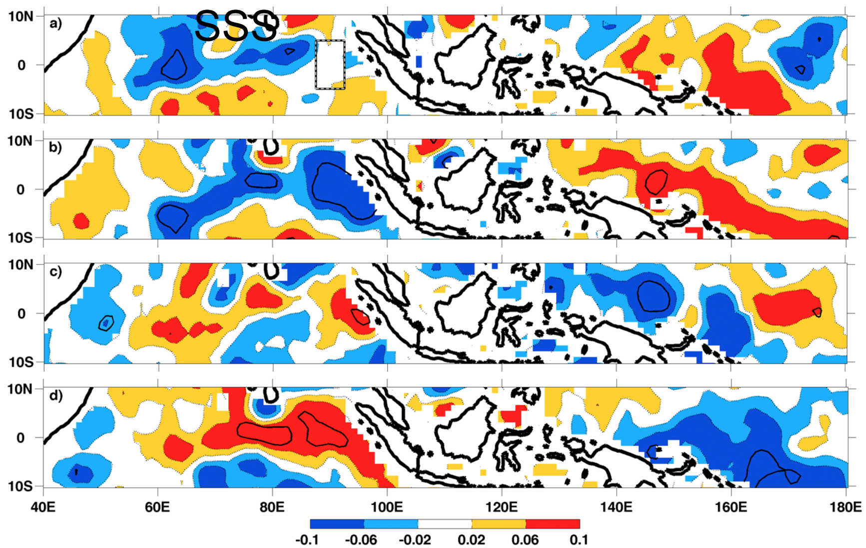
Aquarius reveals MJO-related SSS signature & importance of SSS

Grunseich, Subrahmanyam, & Wang (2013, GRL) *Guan, Lee, Halkides, & Waliser (2014, GRL)*

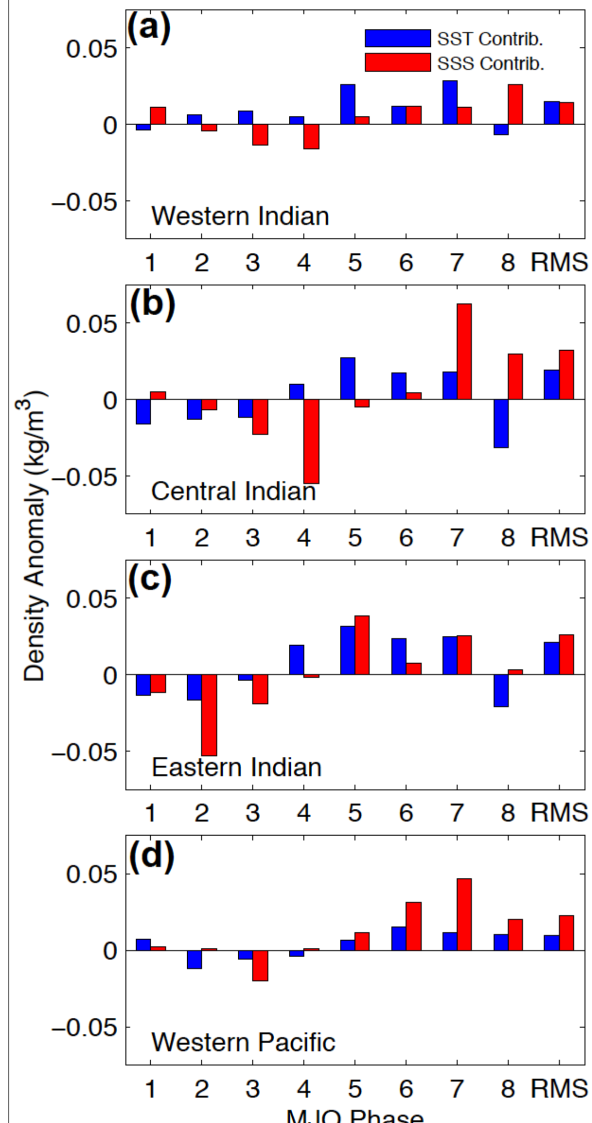
MJO composite pattern of outgoing longwave radiation



MJO composite pattern of SSS



Density



Based on 8-phase WH Index

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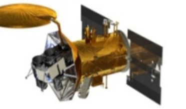
Summary



- Aquarius has brought significant new understanding to intraseasonal variability in the ocean associated with TIWs and MJO that are important to ocean dynamics, climate variability, and biogeochemistry.
- Resolving these features (esp. TIWs) went beyond the original expectation of science return (seasonal-interannual time scales).
- Demonstrates complementarity with other observing systems (e.g., SST & SSH do not show TIW propagation as well at the equator; Argo floats do not resolve TIWs).
- A major strength of Aquarius SSS relative to in-situ SSS is the ability to estimate spatial gradient, which is critical to the studies of eddy-mean flow interaction and related air-sea interaction.

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TIW propagation at 2N

Total anomaly | 33-day band | 17-day band