Aquarius Brings New Understanding to Tropical Instability Waves (TIWs)

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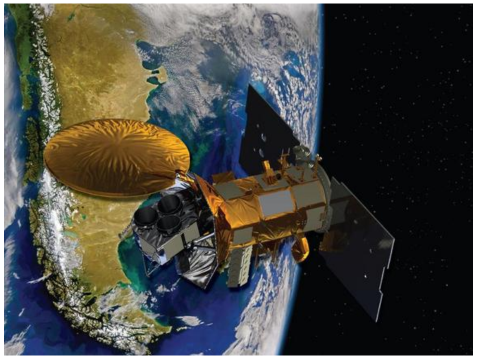

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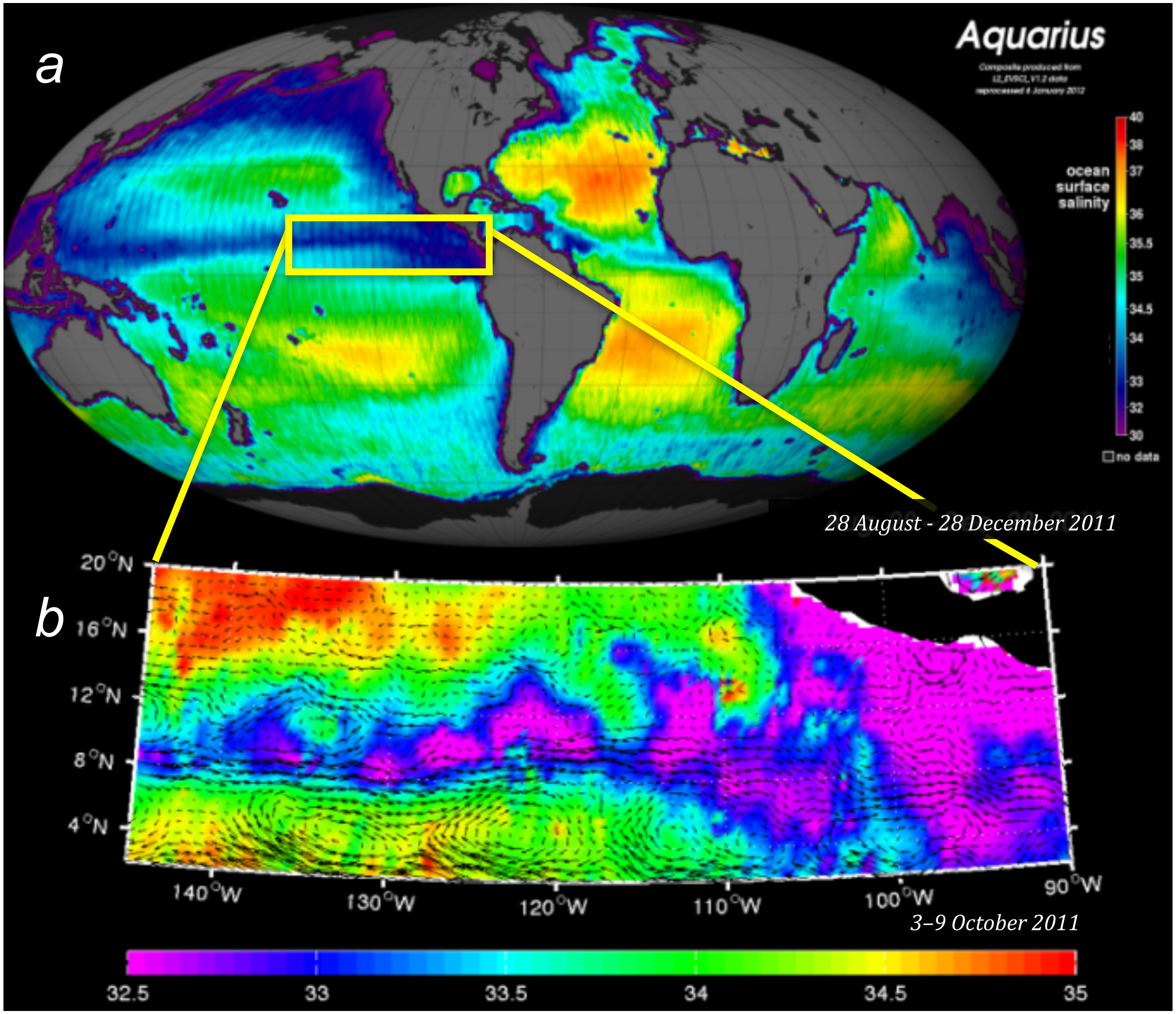
Early Aquarius images motivated TIW study

EOS Special Report & BAMS "State of the Climate 2011" by Lagerloef et al.



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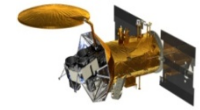
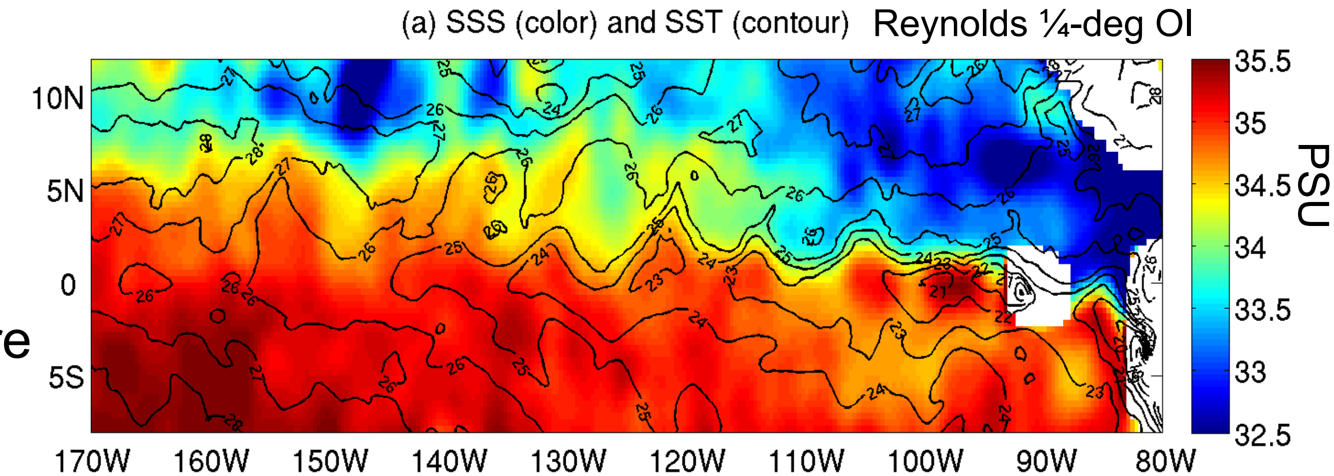
Aquarius Captures Pacific TIWs

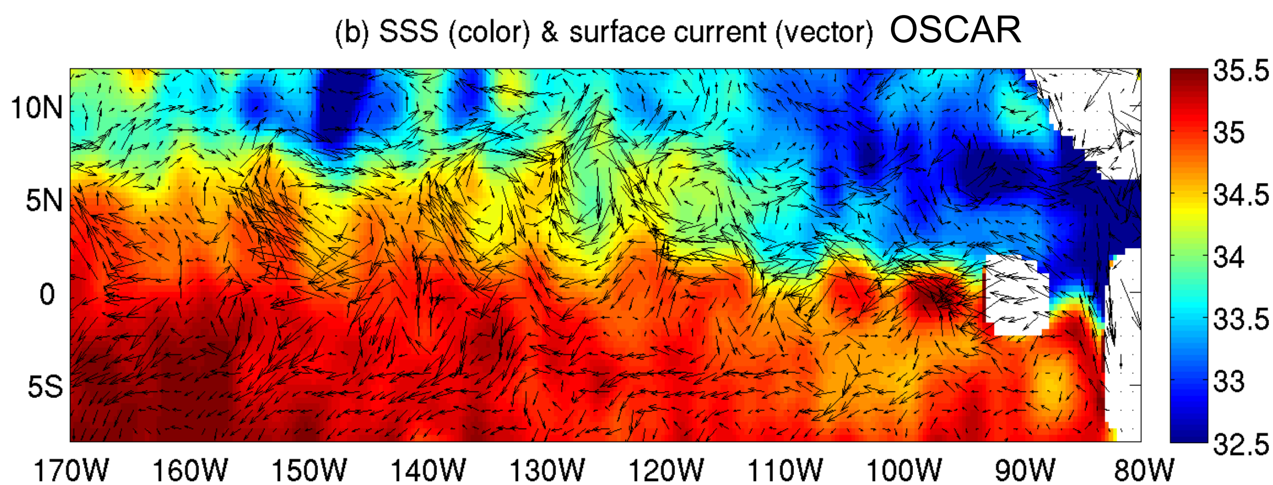


SSS from Aquarius (color shading), SST (contours in a), surface currents (arrows in b) on Dec. 11, 2011 (7-day maps)

- 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)





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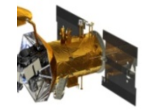
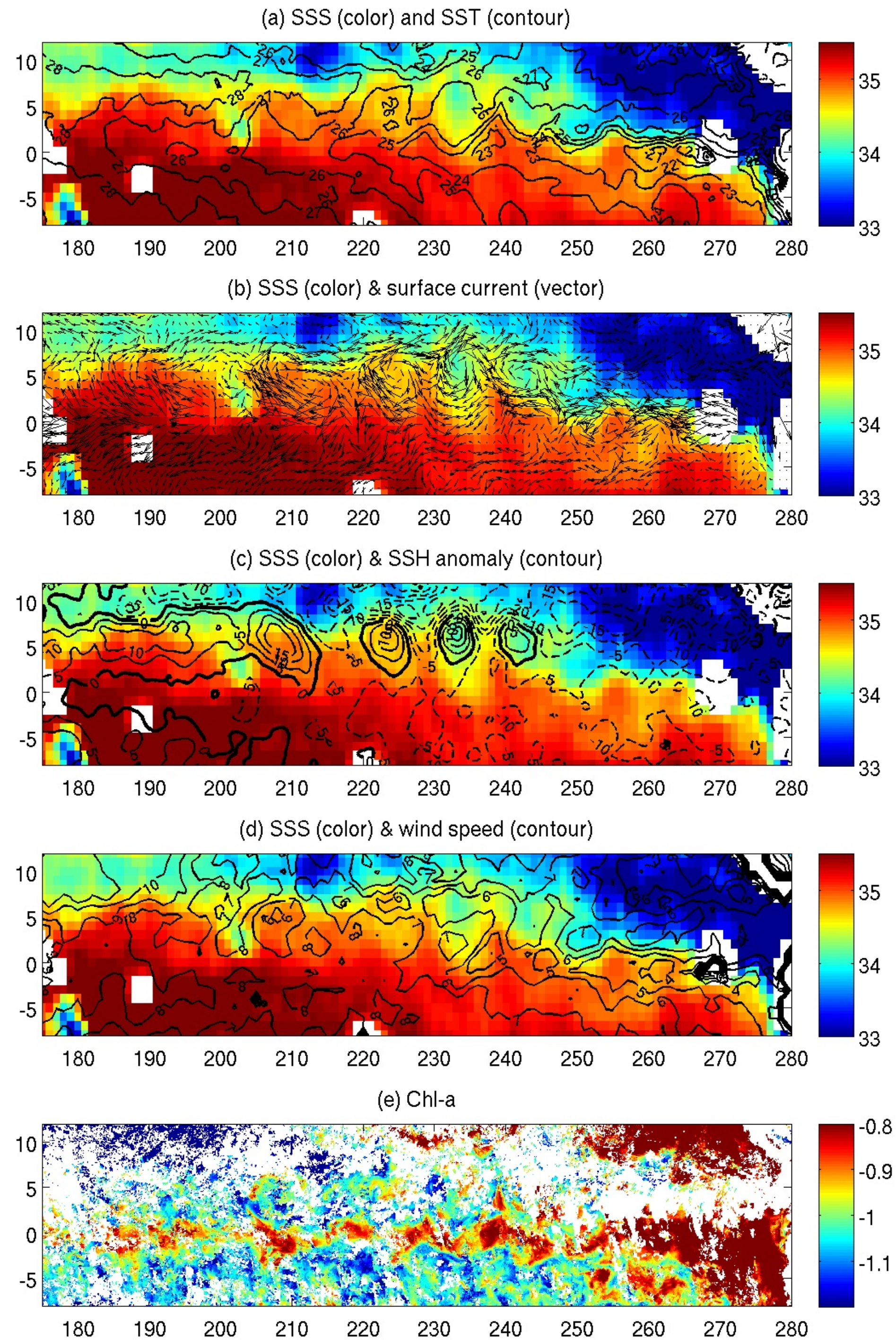
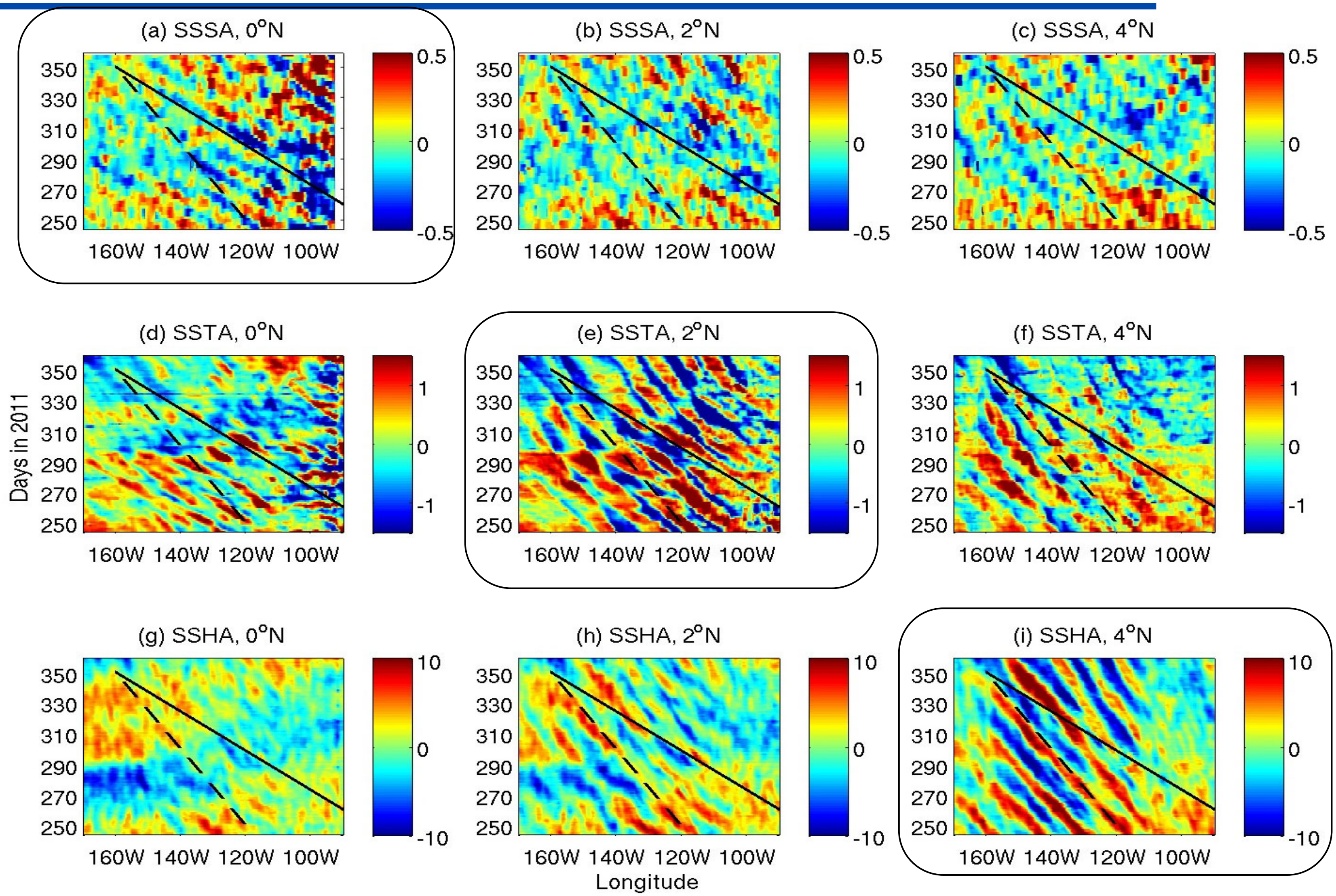


Multi-sensor observations of TIWs: Aquarius SSS along with infrared (Reynolds SST), altimetry (AVISO SSHA), scatterometry (ASCAT wind), and visible (MODIS ocean color, chl-a).



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 (50% larger at 2N than at equator).

- Meridional SSS gradient is larger near equator where salty South Pacific water meets the fresher water under the ITCZ (50% larger at equator than at 2N).

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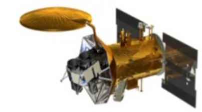
Why do dominant TIWs propagate faster near the equator?

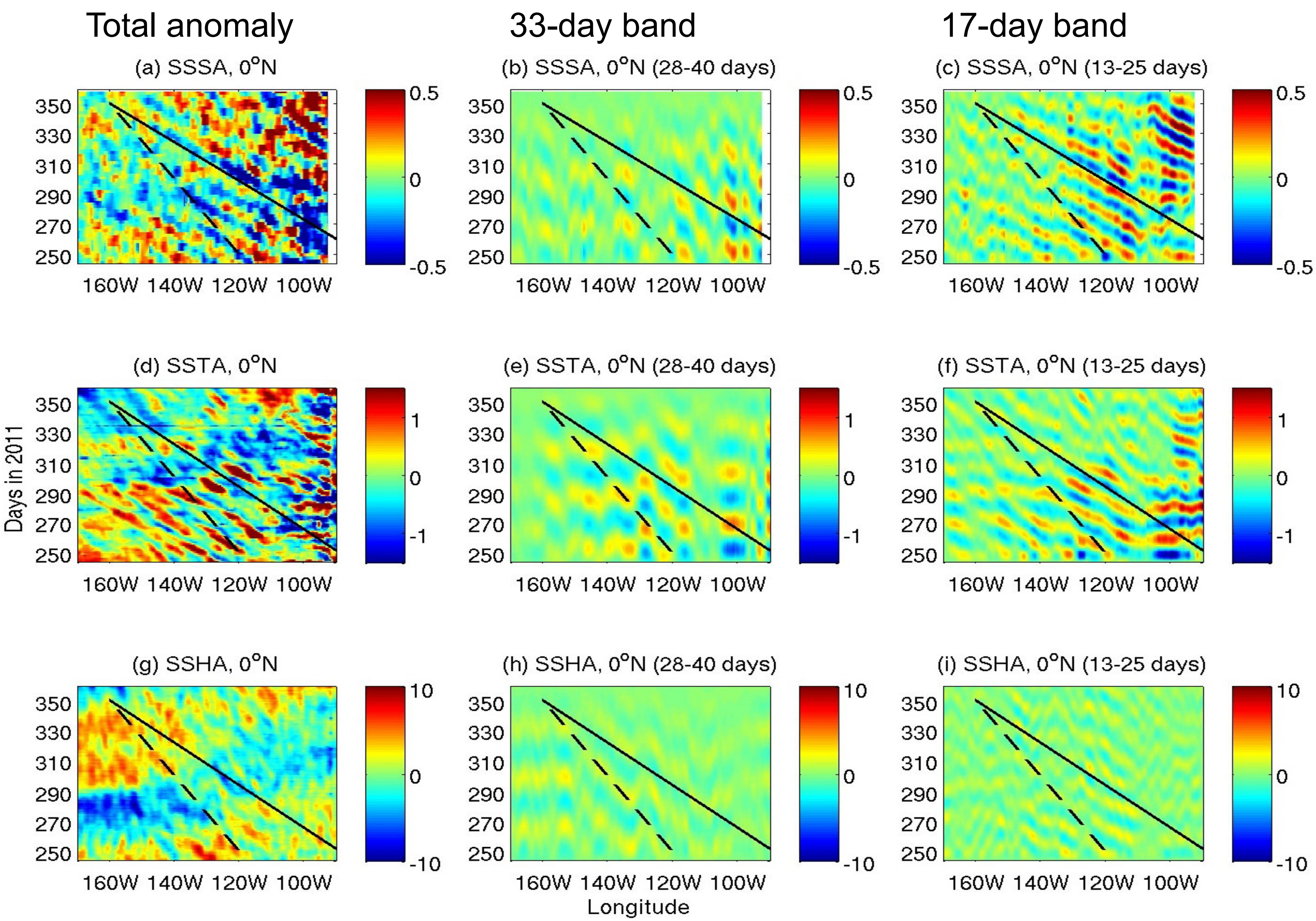


- Decades of literature consistently reported 0.5 m/s dominant speed of TIWs; Aquarius shows 1 m/s TIWs speed near equator.

- TOGA-TAO subsurface mooring data showed distinct 17-day & 33-day TIWs (Lyman et al. 2007):

  Near equator: 17-day TIWs dominate (Yannai-wave like)
  Off equator: 33-day TIWs dominate (Rossby mode)

TIW propagation at equator



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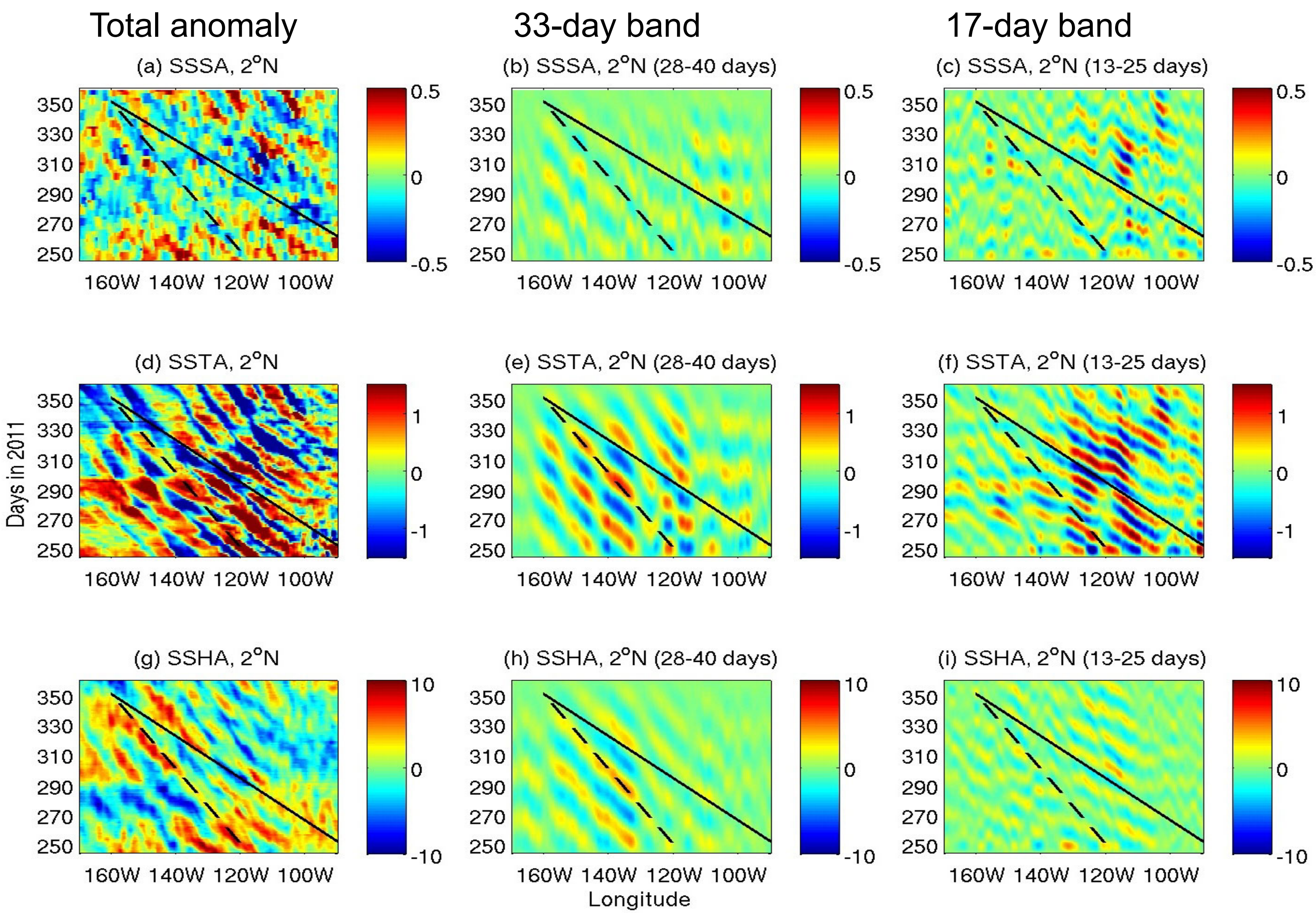
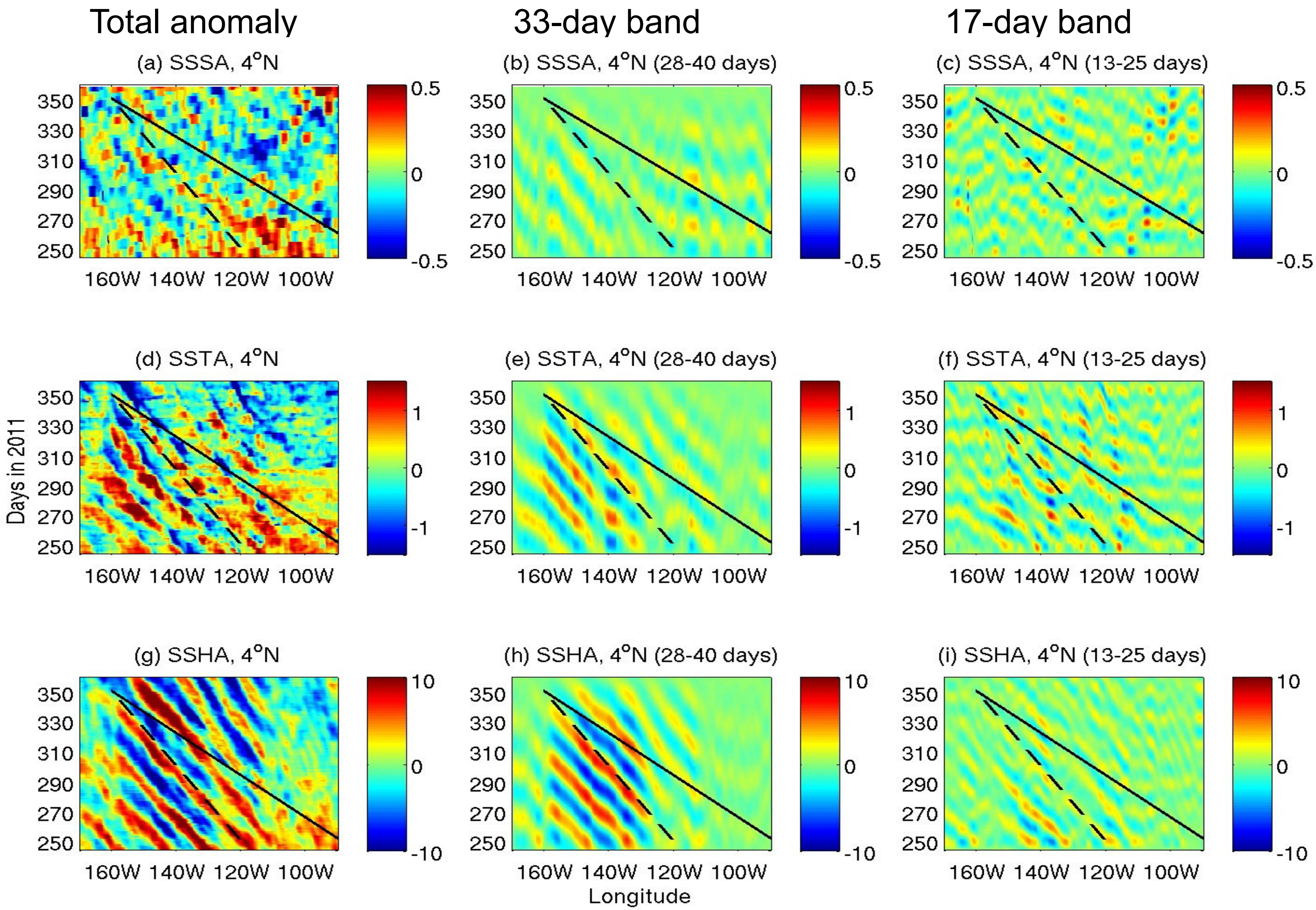
TIW propagation at 2N



TIW propagation at 4N



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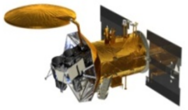
Implications for eddy(TIW)-mean flow interactions

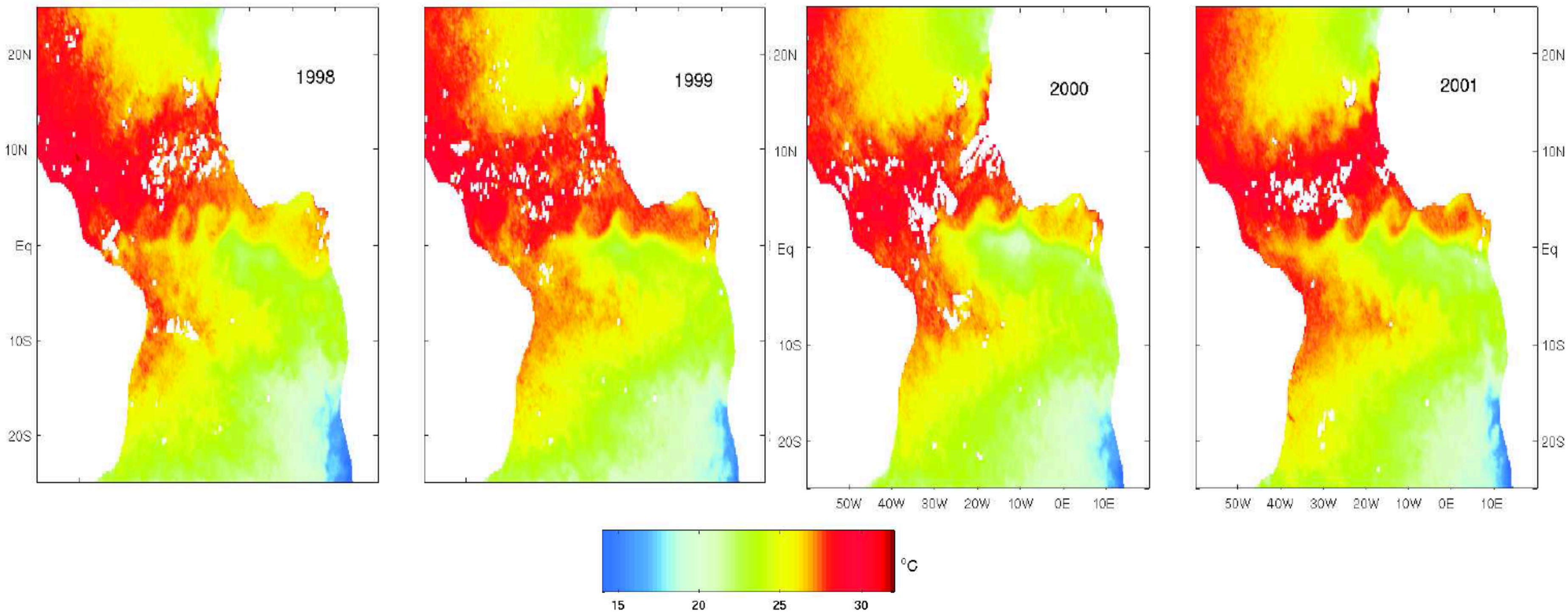


- **Baroclinic energy transfer** between TIWs and mean flow: The role of S larger at equator; the role of T larger near cold-tongue edge (Grodsky et al. 2005: dominant effect of S for Atlantic TIW).

- **Eddy mixing**:
  Depend on the difference between TIW and mean flow speeds (Ferrari and Nikurashin 2010).

Tropical Atlantic TIWs: what was known based on SST

Observations of Tropical Atlantic TIWs using TMI SST (Caltabiano et al. 2005):
TIWs **strongest in the eastern-central part (10-20W), very weak in the west**.



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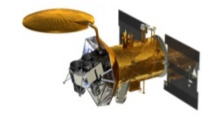
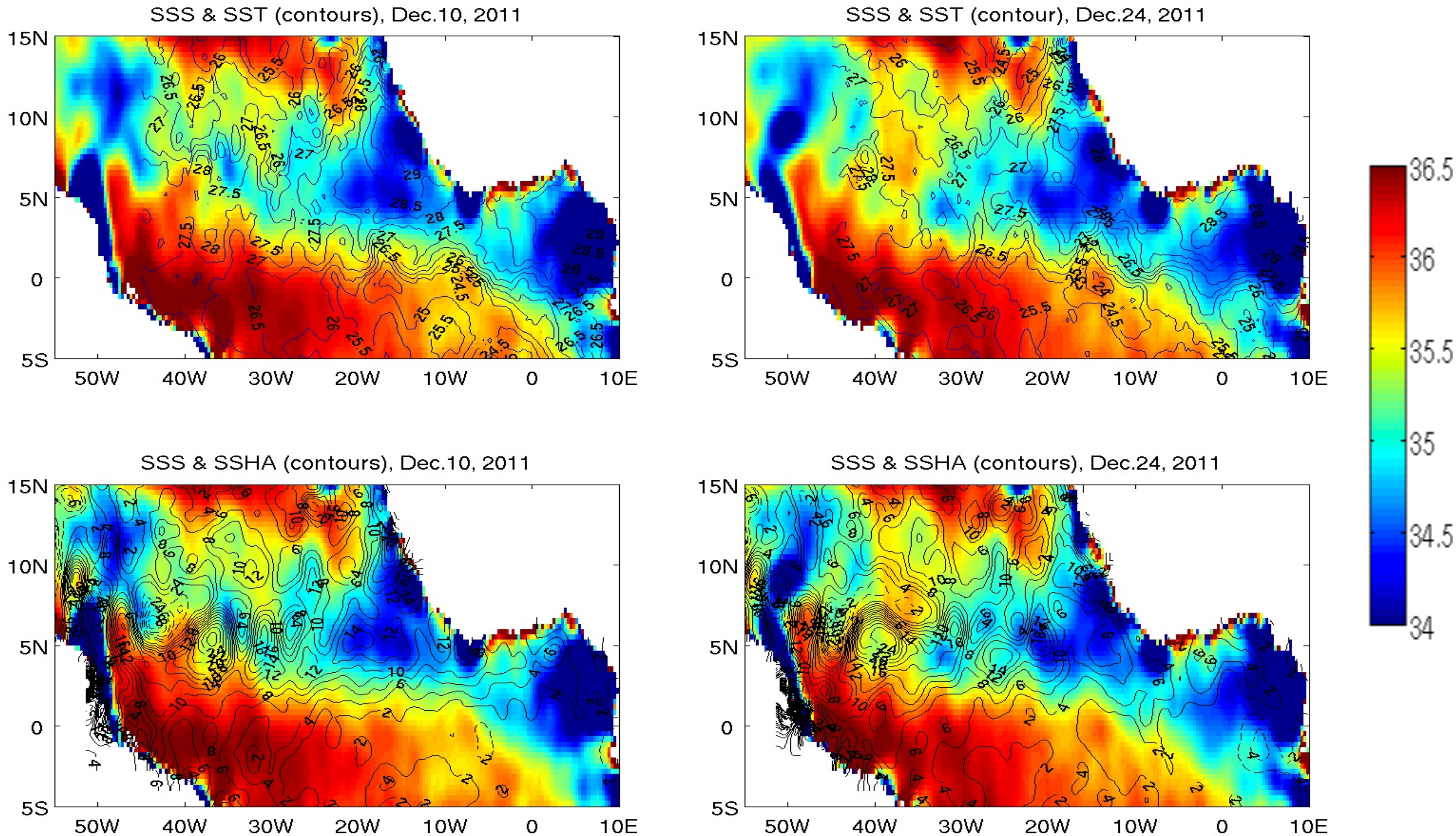
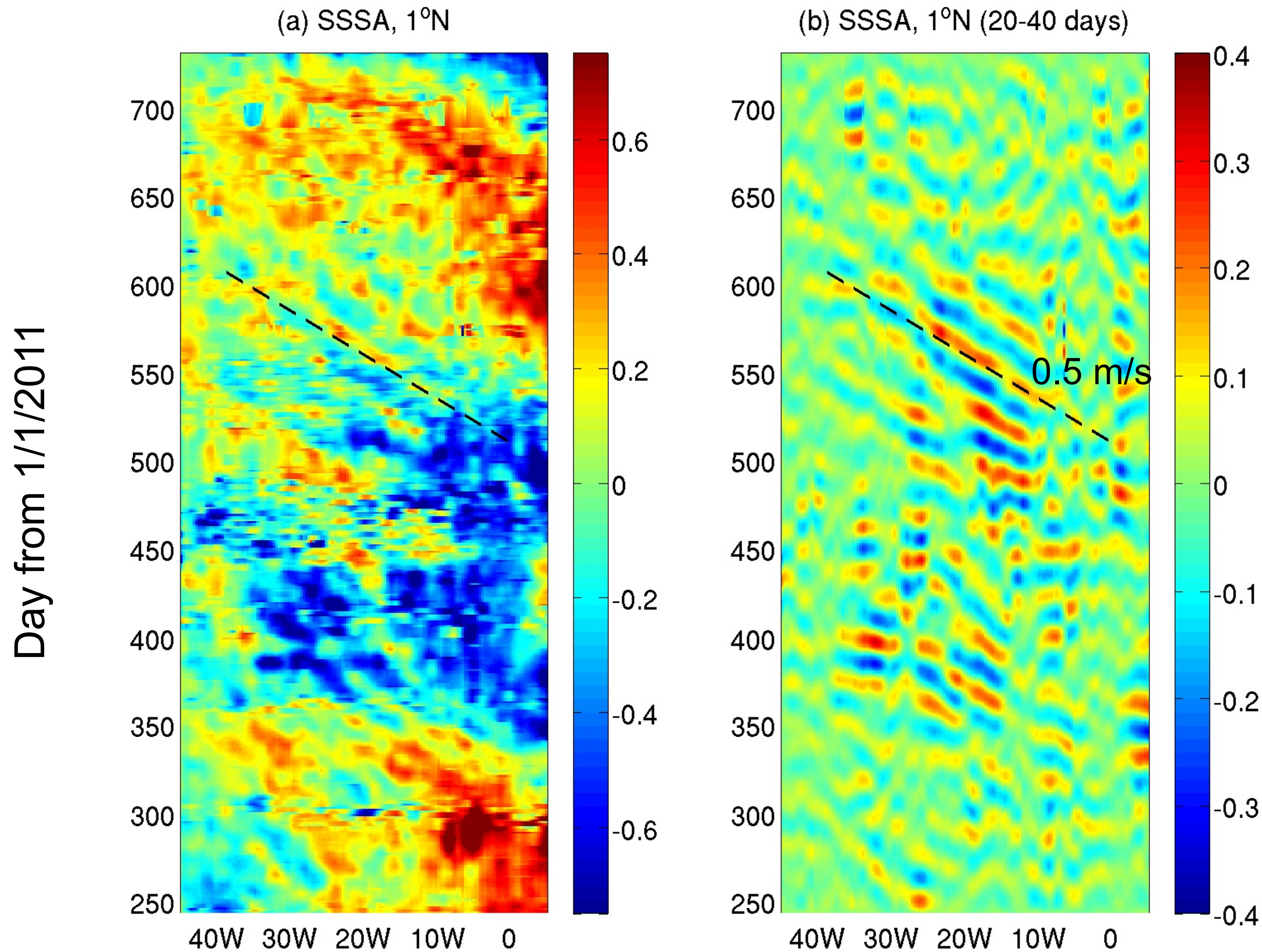


Tropical Atlantic TIWs: new features seen from SSS

- SSS show strong TIWs in the northwest tropical Atlantic (in contrast to SST).
- S may play a larger role than T in eddy-mean flow interaction in the NW.
- Active interactions with the ITCZ and Amazon River plume?



Tropical Atlantic TIWs: propagation



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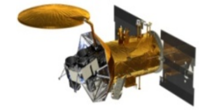
Summary



- Aquarius reveals TIW SSS structure for the 1st time from space.
- Complements other satellite & in-situ obs of TIWs.
- Pacific: TIW SSS signal stronger than SST near equator: implication to TIW-mean flow energy transfer.
- Dominant TIW speed at equator is 1 m/s: twice as fast as that reported in decades of literature: implications to eddy mixing.
- Attributed to the dominance of 17-day TIWs near equator and 33-day TIWs away from equator).
- Atlantic: SSS signature much larger than SST in the NW (interactions with mean flow, Amazon River Plume, & ITCZ).

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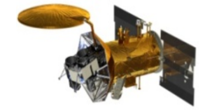
Thoughts about synergistic activities



- Combining Aquarius & SMOS to enhance the capability to observe SSS, esp. at higher frequencies & wavenumbers What does it take?

  - Better understanding of errors (incl. the sources).

  - Statistical techniques to exclude errors/extract signals

  - Regionally dependent error covariance in “blending”.

- Should we start thinking about & planning for a future virtual constellation for SSS (like altimetry and SST)?
- What can we learn from the altimetry experience (of merging multiple altimeters to monitor messcale eddies)?
- International Ocean Salinity Science Team (IOSST)?