U.S. NAVAL RESEARCH LABORATORY

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Nonstationarity in HYCOM Internal Tides

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THE UNIVERSITY OF SOUTHERN MISSISSIPPI 1910

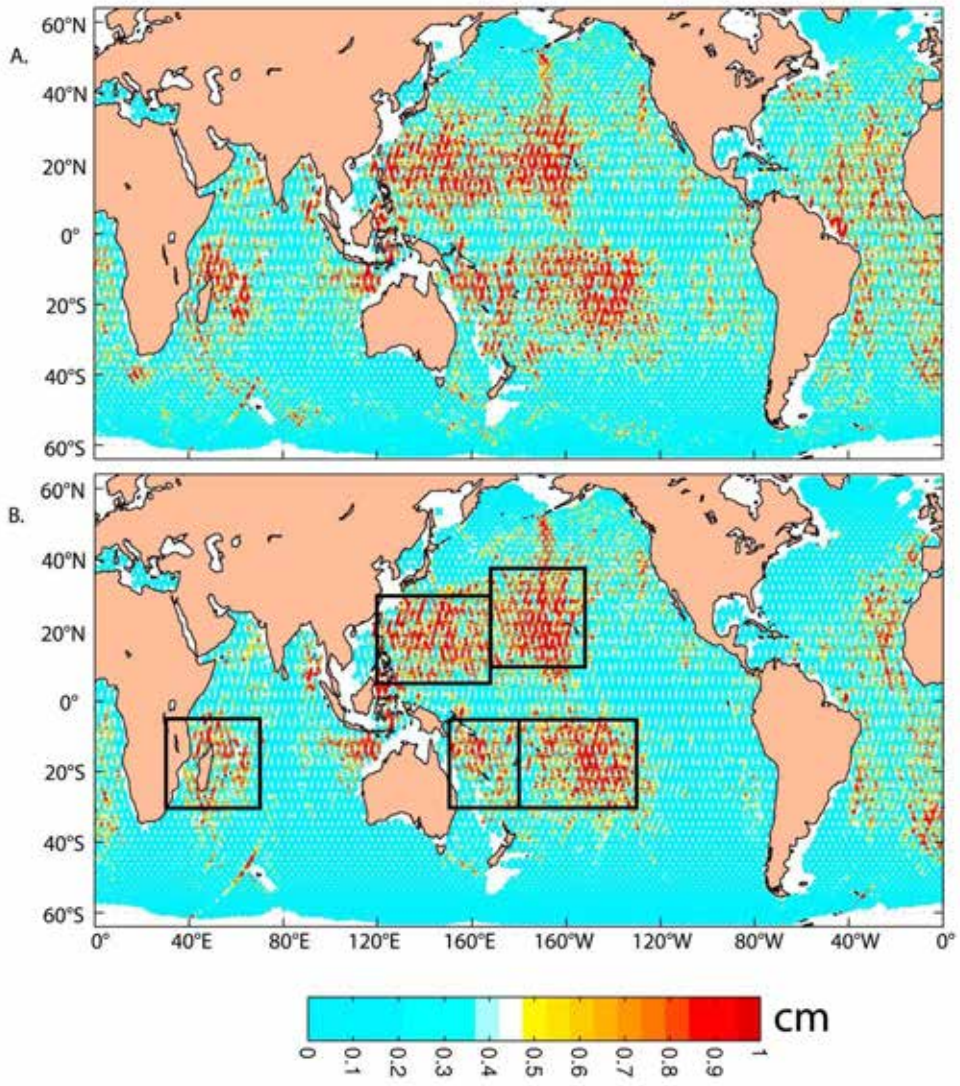
UNIVERSITY OF MICHIGAN

FLORIDA STATE UNIVERSITY 1851

Definitions

- Baroclinic/internal tides: generated by barotropic tidal currents when they are vertically displaced by topography (internal waves)
- Cause surface displacements on order of cm
- Like all waves, can dissipate, reflect, refract, diffract, and scatter
- Stationary tide: Defined as $A\cos(\omega t + \varphi)$ for some constituent with angular frequency ω
- Nonstationary tide: What's left in tidal band after stationary tide is subtracted out

A Mystery



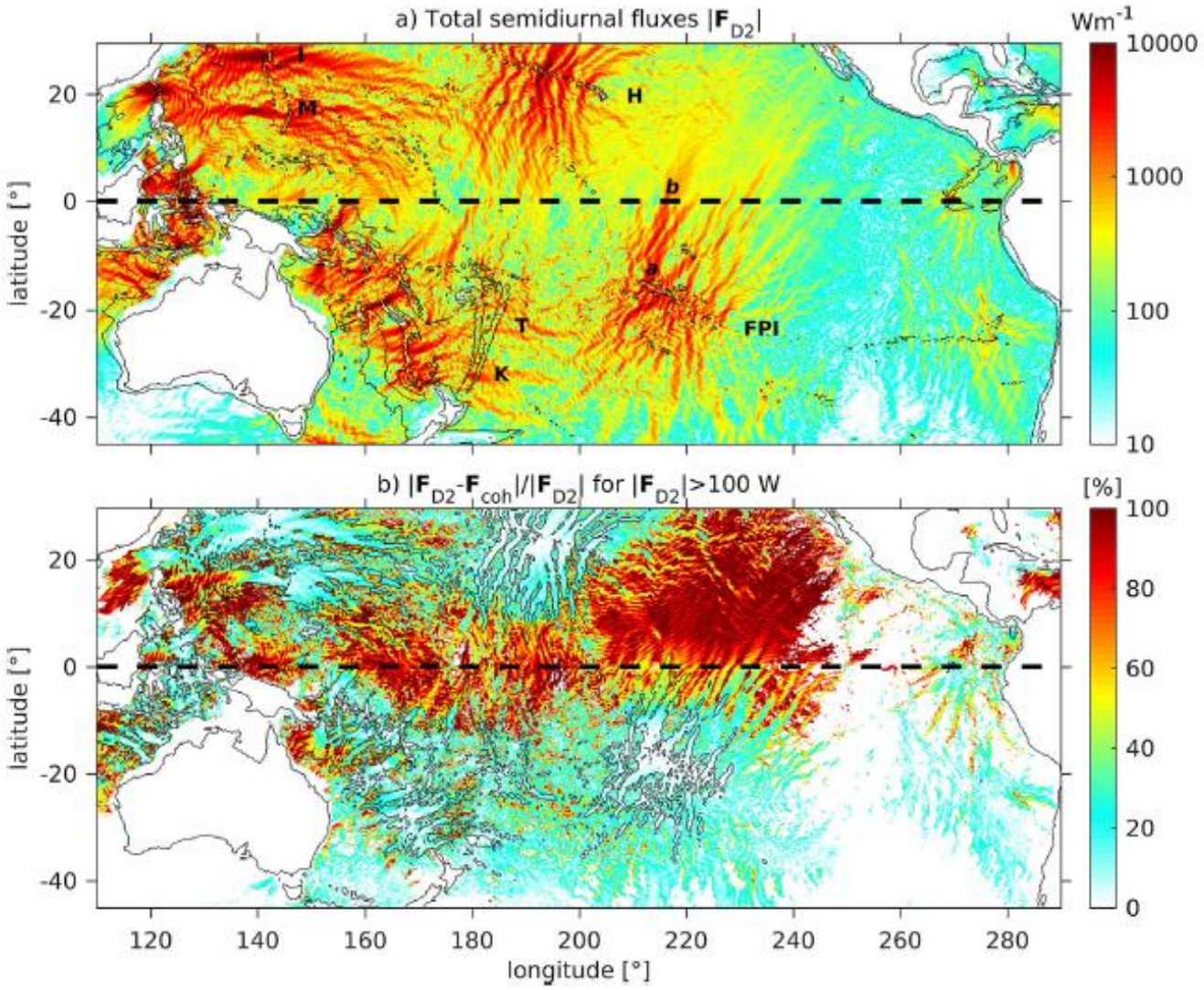
Shriver et al. (2012): M2 stationary internal tide ssh amplitude

←Along-track altimeter data

←Along-track sampled from HYCOM

A mystery: Why do the propagating stationary internal tides disappear in some regions (e.g. along the equator)? Where does the energy go? Dissipation? Phase change?

An Answer



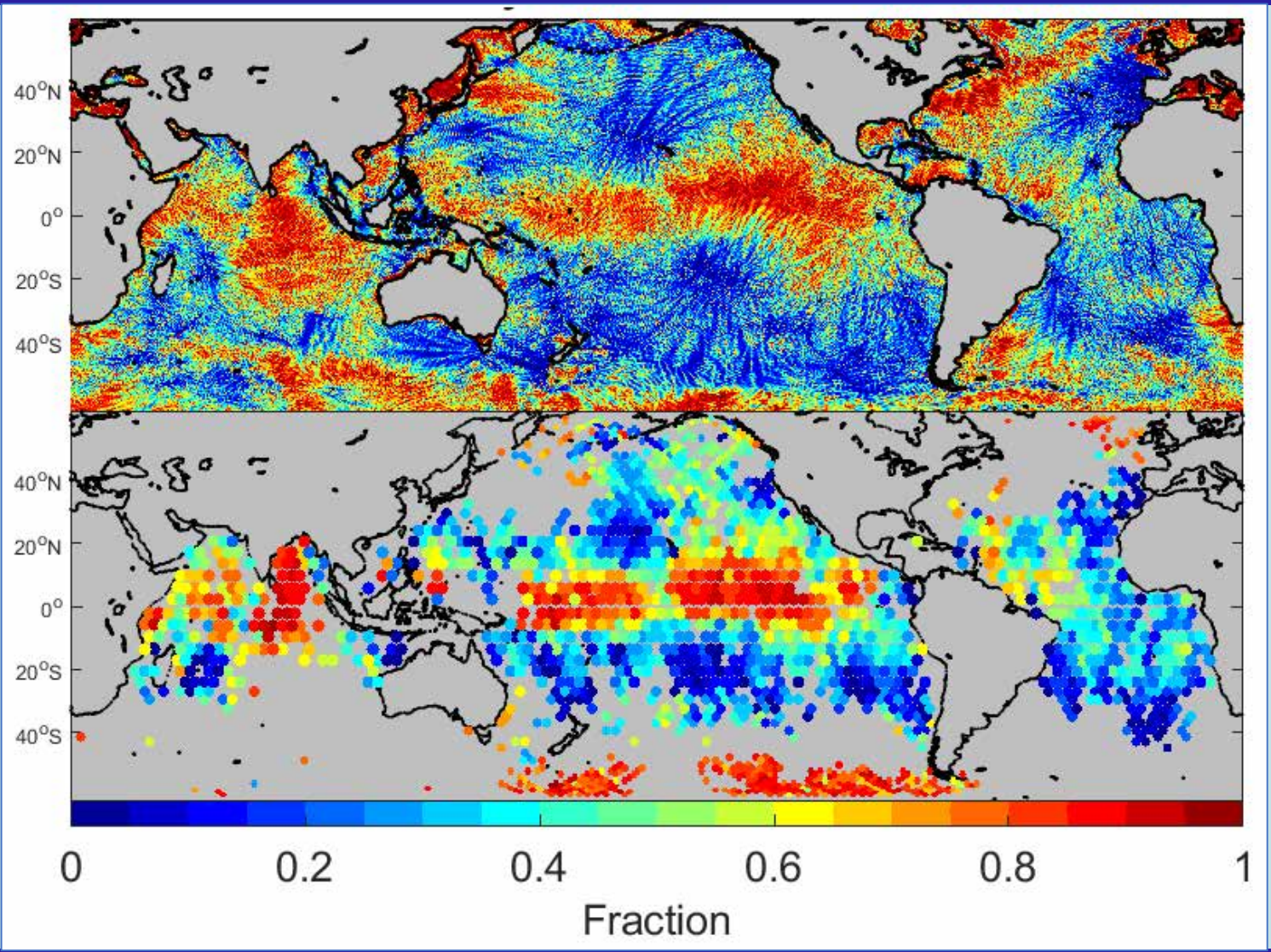
Buijsman et al. (2017):

(top) annual mean semidiurnal band-passed energy flux

(bottom) percent of sum of annual mean nonstationary and cross-term fluxes to the band-passed flux

As internal waves cross the equator, stratification change and deflection by currents causes them to refract and become nonstationary.

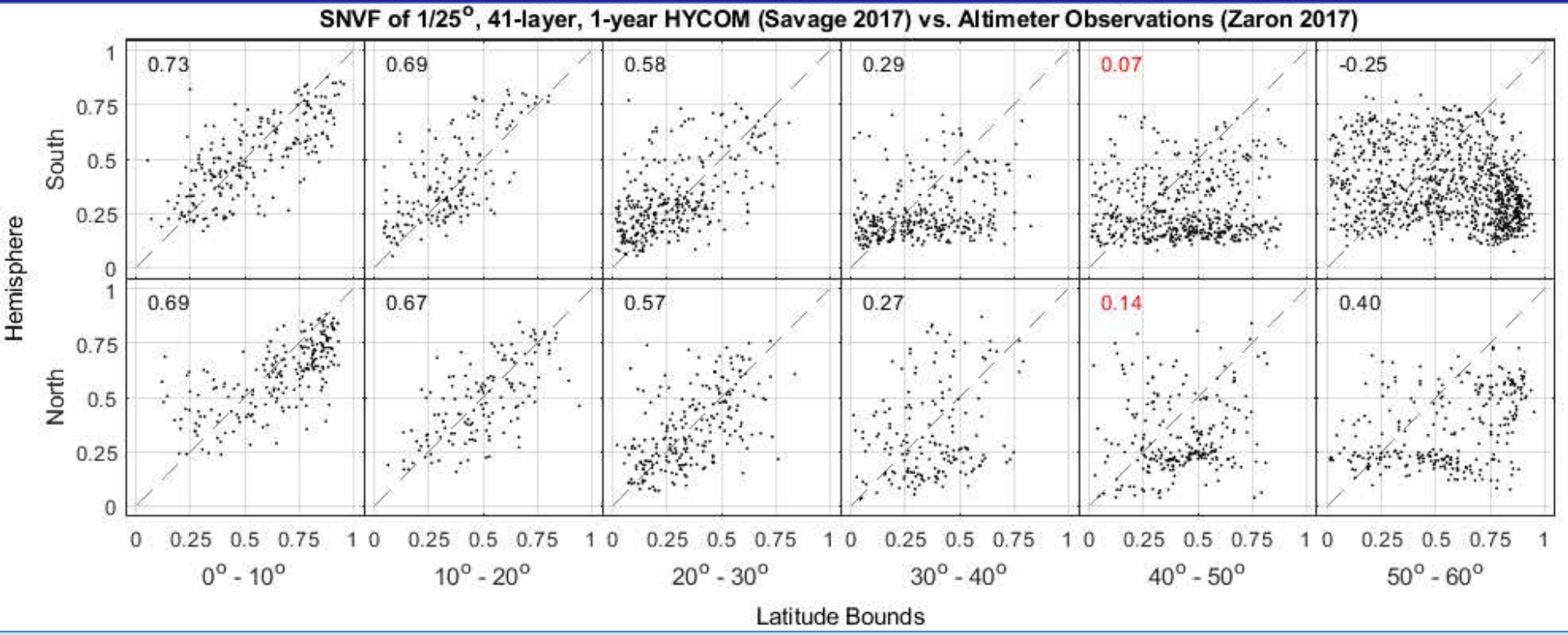
How well does HYCOM estimate nonstationarity?



← Data from Savage et al. (2017): HYCOM, 0.04º, 1-year, freq.-space

← Zaron (2017) Fig.9: T/P-J altimeter data, 17-year, wavenum.-space

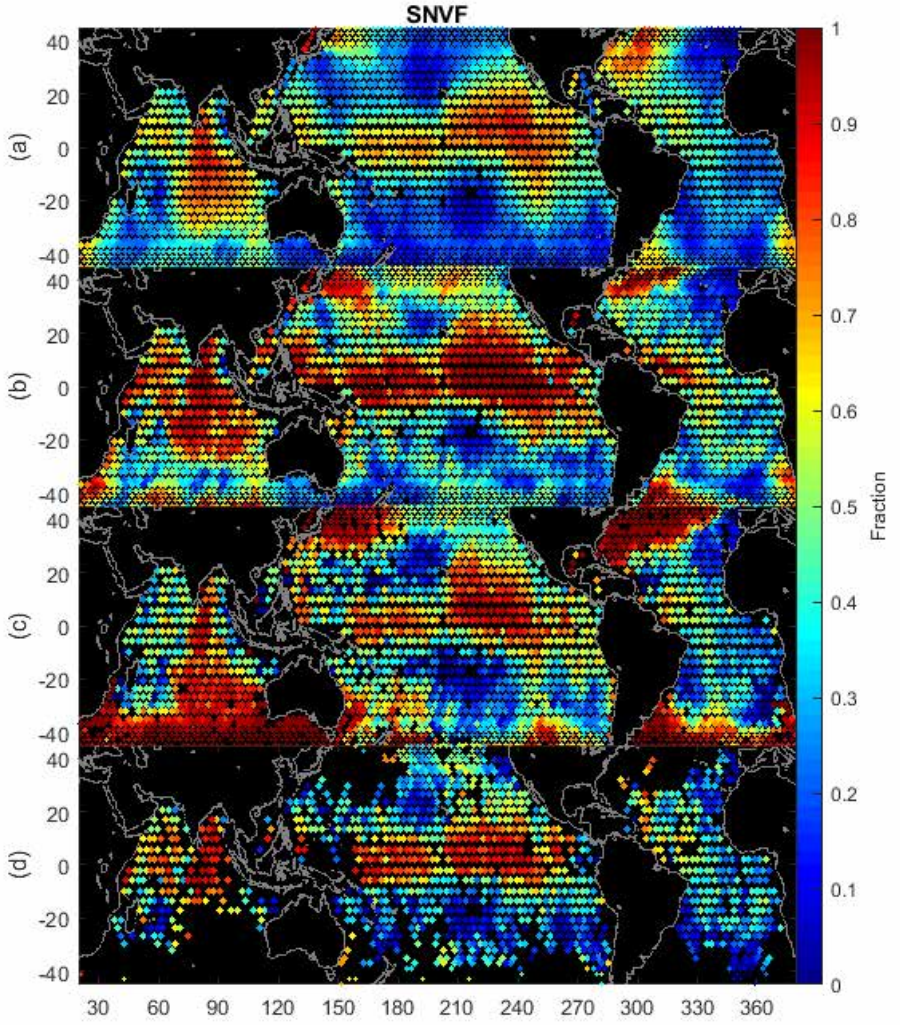
How well does HYCOM estimate nonstationarity?



Scatter plots with correlations of semidiurnal nonstationary variance fraction (SNVF) in 10° latitude bins.

They grossly compare okay in equatorial ocean, but what's happening at high latitudes? Is this a failure of the model, or is this due to the difference in the methodologies (freq.-space vs. wavenum.-space)?

How well does HYCOM estimate nonstationarity?



HYCOM, 0.08º, 32-layer, 5 years

← Freq.-space, hourly data

← Wavenum.-space, hourly data

← Wavenum.-space, 9.9156-day data

← Zaron (2017)

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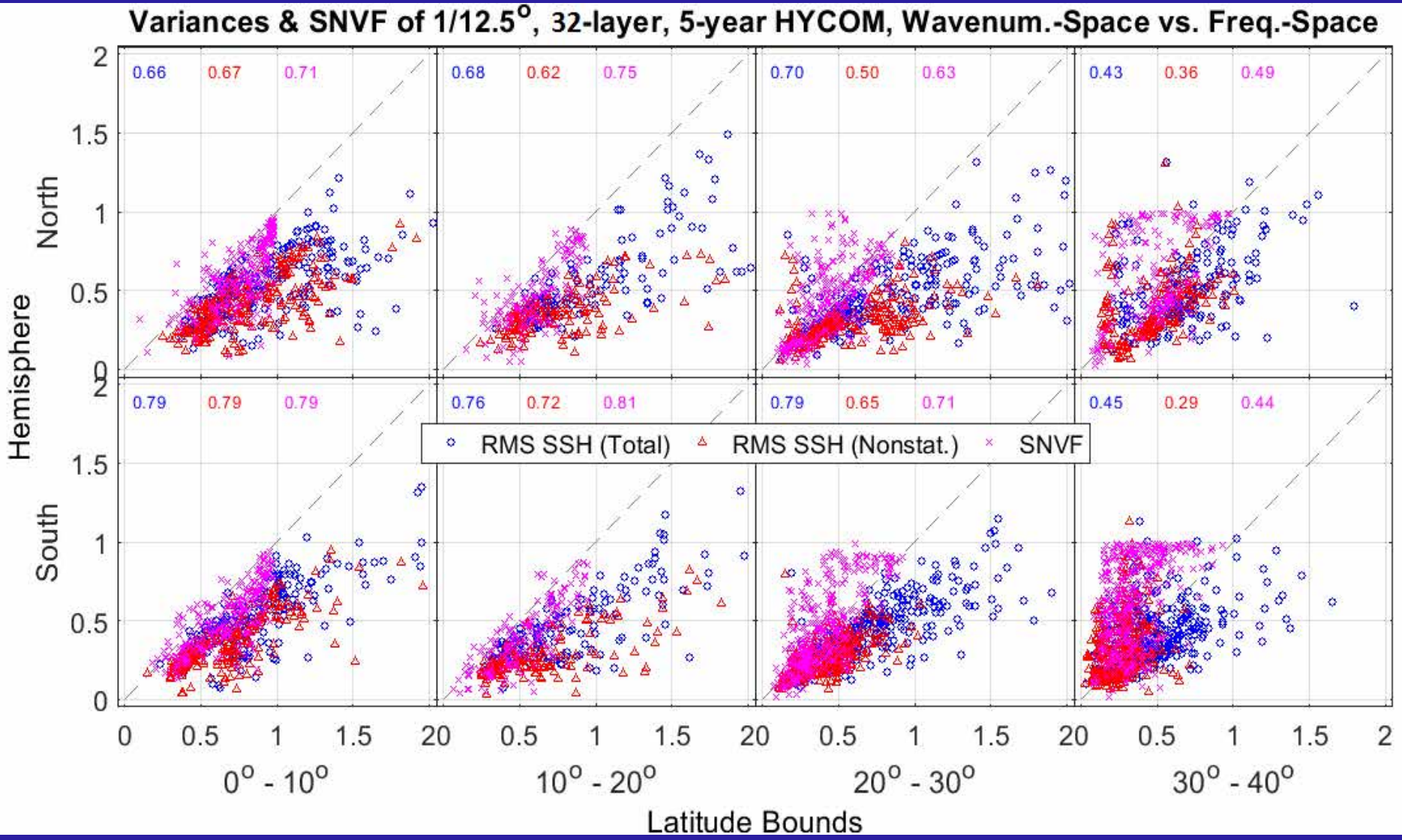

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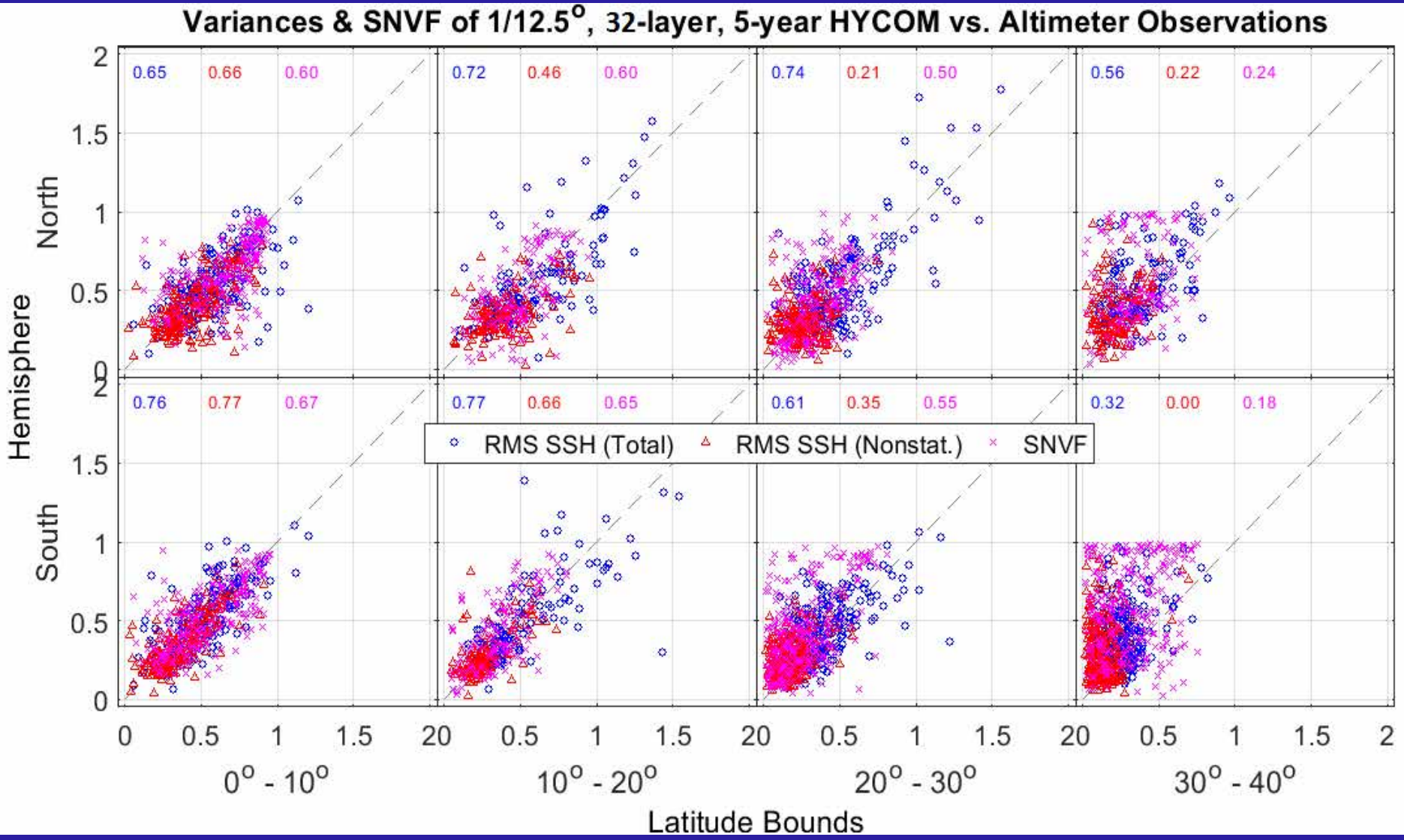

Conclusions & Future Work

- Total semidiurnal variance between HYCOM and observations agrees well (correlate typically above 0.7)

- Nonstationary semidiurnal variance agrees well near the equator (0.6-0.7) due to large spatial scale separation between internal waves and mesoscale, but agreement declines quickly with latitude (~0.35 fo 20^o-30^o, ~0.2 for 30^o-40^o)

- SNVF agrees slightly better than nonstationary variance alone, but agreement still declines with latitude

- Lingering questions:
  - Is this a failure of observations? The model? Both?
  - Is there a better way to process altimeter observations (e.g. a more 2D approach)?

References of Note

- **Ray & Zaron (2011):** Nonstationary internal tides observed with satellite altimetry.
- **Shriver et al. (2014):** How stationary are the internal tides in a high-resolution global ocean circulation model?
- **Ponte & Klein (2015):** Incoherent signature of internal tides on sea level in idealized numerical simulations
- **Savage et al. (2017):** Frequency content of sea surface height variability from internal gravity waves to mesoscale eddies.
- **Zaron (2017):** Mapping the nonstationary internal tide with satellite altimetry.
- **Buijsman (2017):** Semidiurnal internal tide incoherence in the equatorial Pacific
- **Arbic et al. (2018):** A primer on global internal tide and internal gravity wave continuum modeling in HYCOM and MITgcm
- **Nelson et al. (in progress):** The Global Semidiurnal Internal Tide Non-Stationary Variance Fraction in Models and Satellite Altimetry