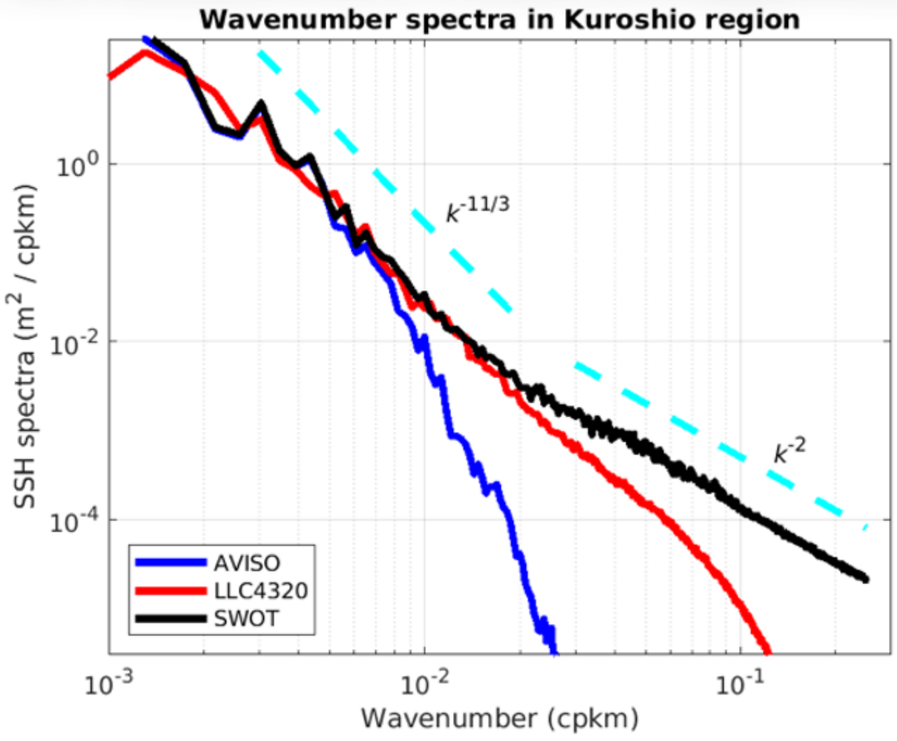
Internal tides, eddies, and spectra from SWOT and high-resolution modeling

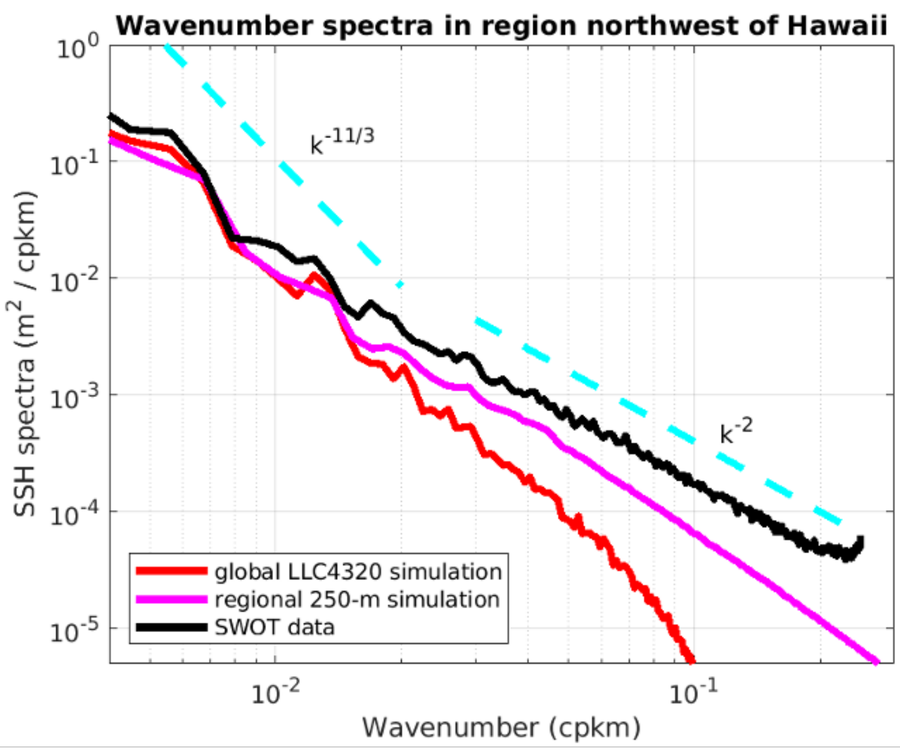
Brian K. Arbic[1], Maarten C. Buijsman[2], Takaya Uchida[3], Badarvada Yadidya[1], Eric Chassignet[3], Ritabrata Thakur[4], Dimitris Menemenlis[5], Kayhan Momeni[6], Yulin Pan[1], W. R. Peltier[6], Joseph Skitka[7], Matthew H. Alford[8], Yuchen Ma[6]

[1]University of Michigan, [2]University of Southern Mississippi, [3]Florida State University, [4]IIT Delhi, [5]Jet Propulsion Laboratory, [6]University of Toronto, [7]WHOI, [8]SIO

SWOT high-wavenumber signals confront our models with a need for improvement

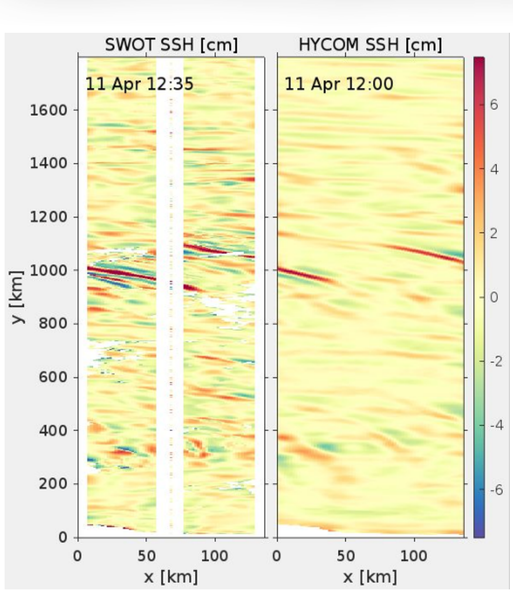


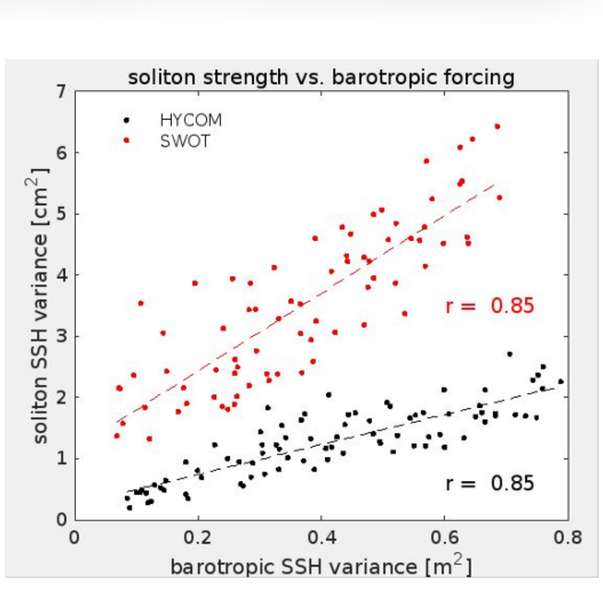
- The wavenumber spectra in global high-resolution models capture more high-wavenumber activity than gridded AVISO products made from nadir altimetry, and lie close to the SWOT spectrum down to about 50 km.
- However, the SWOT spectrum has more energy than the global models at high wavenumbers.
- What is this high-wavenumber energy? Internal waves? Something else? Whatever it is, it is missing from even the highest-resolution global models.



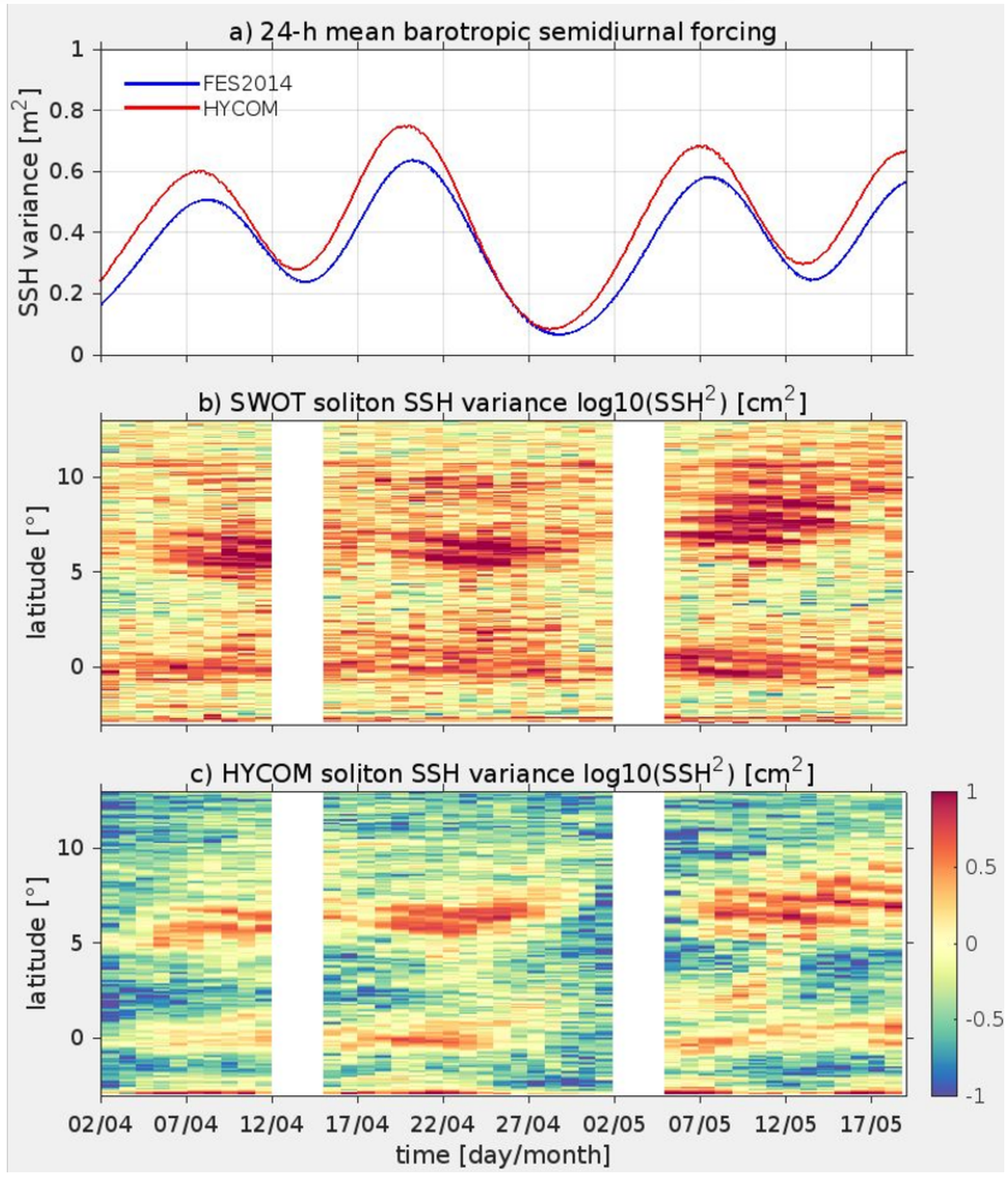
- Our regional simulations (Thakur et al. 2022) feature much finer horizontal and vertical grid spacing than global LLC4320, and they include remotely generated internal waves (from global LLC4320) at their lateral boundaries. The regional models come closer to the SWOT data but are still insufficiently energetic at high wavenumbers.
- So, what is missing? Do we need to improve the global models that serve as boundary conditions? Do we need even higher resolution in the regional models? Larger supercomputers would help!

Observed soliton variability in the Amazon basin is well-predicted with HYCOM forecasts





- The variability in time and space of solitons (scales <40 km) in the Amazon basin observed in SWOT are well predicted by 4-km HYCOM forecasts that employ data assimilation (DA)
- Soliton strength is mainly determined by the semidiurnal spring-neap cycle in the barotropic forcing at the Amazon shelf:
- large (small) soliton SSH variance is observed at ~6° N (y≈1000 km) about 4 days after the spring (neap) tide at the shelf due to travel time
- SWOT features larger variance at small scales than HYCOM, application of nested high-resolution nonhydrostatic simulations



Dynamic Mode Decomposition on SWOT

MrCOSTS, a dynamic-mode decomposition (DMD) method, is applied to the one-day-repeat SWOT orbit (panel a). We extract the slowly-varying component in geostrophic balance (panels b & d). There is some spatial consistency with the daily-averaged AVISO but the mrCOSTS' slow component from SWOT has sharper spatial features. Taking the relative vorticity and strain rate directly from raw SWOT observations leads to fictitiously large values (panels e, g & i). MrCOSTS yields a more plausible range of values (panels f, h & j).