SWOT stresses need to improve high-resolution ocean-atmosphere models

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Summary: High-resolution, global, ocean-atmosphere models highlight that ocean scales smaller than 30-50 km, called submesoscales, explain almost 50% of the vertical heat fluxes in the first 500 m below the surface (Su et al., 2018) and intensify air-sea interactions, in particular, the latent heat fluxes (i.e., humidity fluxes) by up to 30% (**Figure 1** and Strobach et al., 2022). SWOT observations indicate that a large part of the energy of oceanic scales smaller than 30-50 km is underestimated by the most recent global models (**Figure 2**). As such, SWOT emphasizes the need to increase the spatial resolution of numerical ocean-atmosphere models. This increase in spatial resolution is critical for a more accurate estimation of heat exchanges between the ocean interior and the upper troposphere in the context of climate change and associated weather forecasts. NASA High End Computing resources can play a key role in enabling these advances (**Figure 3**).

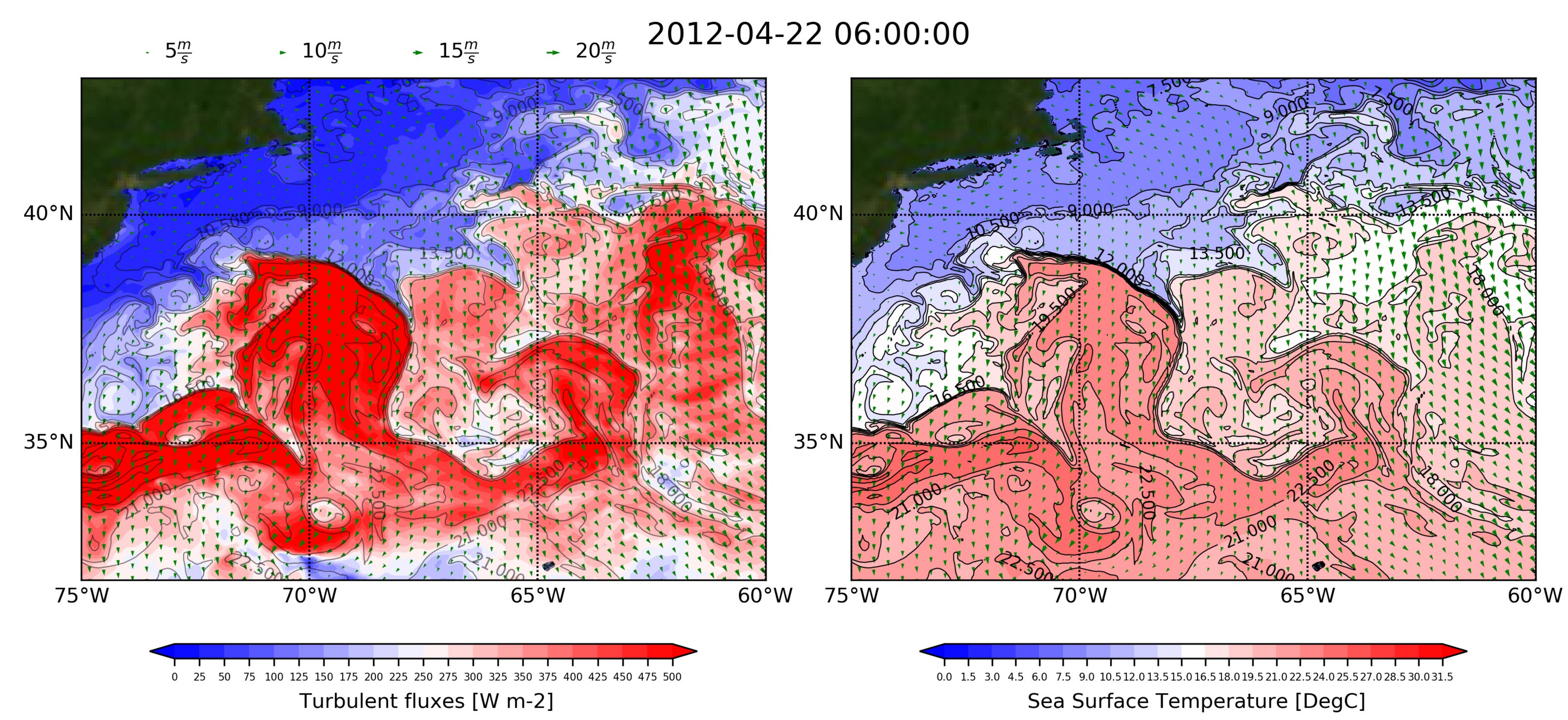

Figure 1: Ocean eddies observed by SWOT explain 30 to 50% of moisture supply from ocean to atmosphere. As such, these eddies are a significant driver of the global hydrological cycle. High-resolution ocean currents from SWOT observations, combined with microwave and infrared Sea Surface Temperature (SST) images, enable reconstruction of SST fronts around mesoscale eddies, which are critical to the estimation of latent heat fluxes at the air-sea interface and therefore of moisture supply to the atmosphere. (Adapted from Strobach et al., 2022)

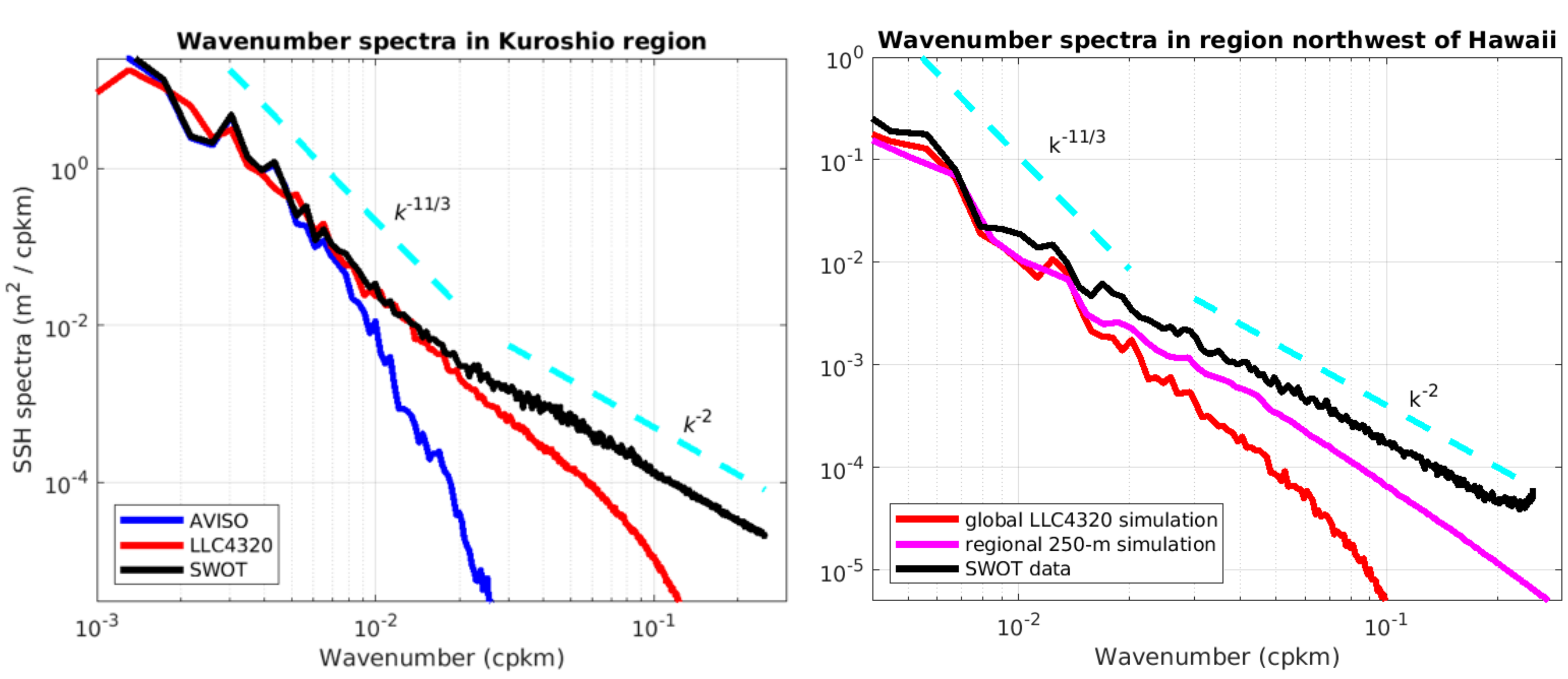

Figure 2: Wavenumber spectra in global high-resolution models capture more activity than gridded AVISO products made from nadir altimetry, and lie closer to the SWOT spectrum down to about 50 km. However, the SWOT spectrum has more energy than the global models at high wavenumbers. Regional simulations that feature much finer horizontal and vertical grid spacing than global simulations, e.g., Thakur et al. 2022, come closer to the SWOT data but are still insufficiently energetic at high wavenumbers. 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!

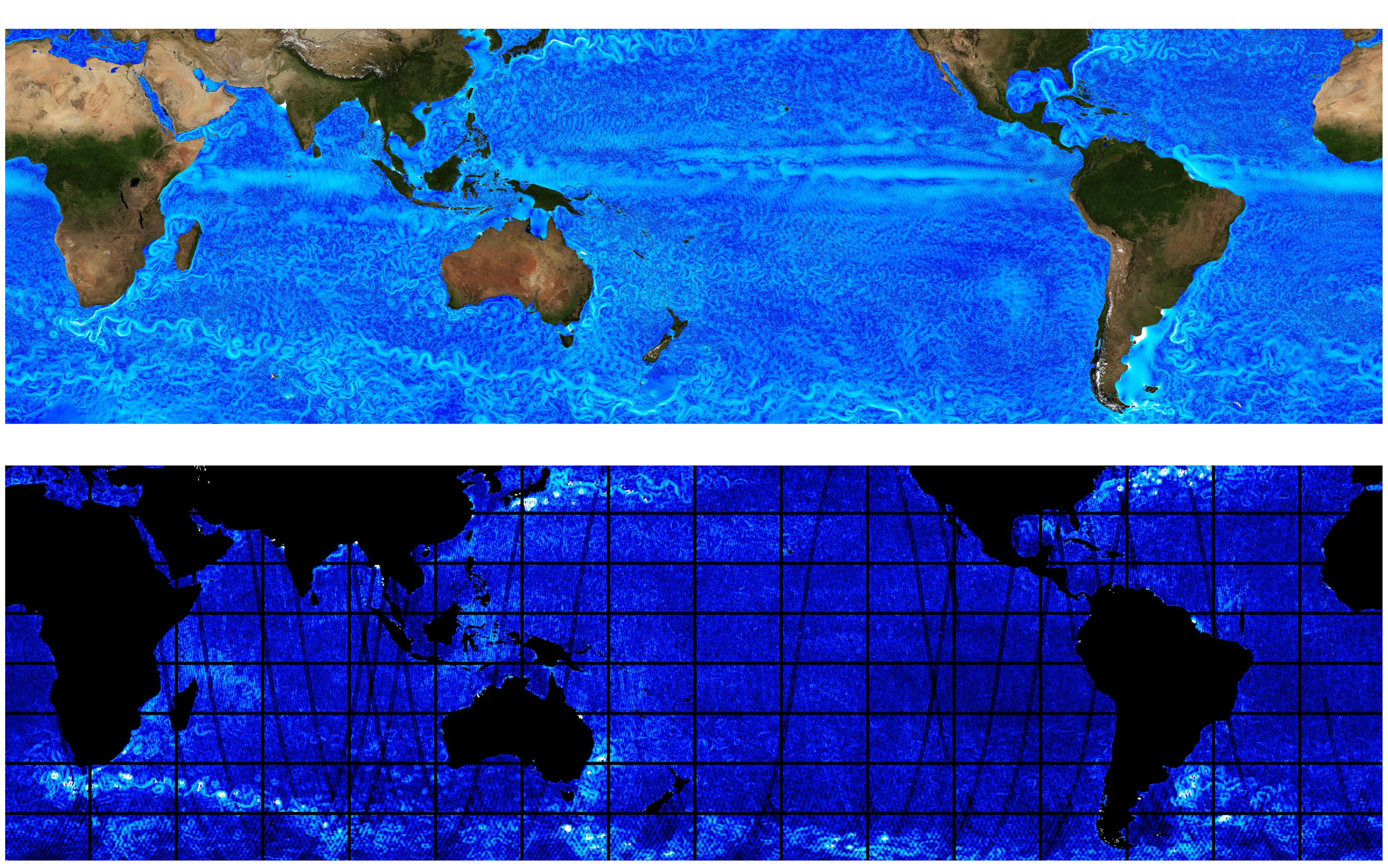

Figure 3: NASA Ames compute and visualization assets are being used to simulate ocean circulation and to compare model output to SWOT observations.

Top panel shows snapshot of sea surface speed from a 1/48-degree global-ocean simulation (Arbic et al., 2018).

Bottom panel shows a preliminary visualization of SWOT sea surface height gradient. The NASA Ames hyperwall enables close-to-pixel-by-pixel posting of global 250-m SWOT data. A detailed visual comparison of NASA high-resolution model output from ocean-only and coupled ocean-atmosphere simulations with SWOT observations is underway. We expect that these comparisons will enable interpretation of physical details in SWOT observations and improvement of the realism of the global numerical simulations.

Model output and SWOT data:

Model output used for Figure 1 is available at: https://data.nas.nasa.gov/geosecco

Visualizations from simulation used in Figure 1: https://data.nas.nasa.gov/geoseccoviz

Model output used for Figs. 2&3 is available at: https://data.nas.nasa.gov/ecco/eccodata/llc_4320

Visualizations from simulation used in Figs. 2&3: https://data.nas.nasa.gov/eccoviz

To facilitate SWOT analysis and comparisons with high-resolution NASA simulations, a complete mirror of SWOT level-2 and level-3 data sets is made available at NASA Ames High-End Computing under directory pfe:/export1/nmccurdy/public/swot

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