National Aeronautics and Space Administration

Explorer Ocean Vector Winds & Currents

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Earth System Explorer - Strategic Initiative Leader: Sabrina Feldman

Objectives:

The objective of this work is to mature science and technology related to an ocean vector winds and currents Earth System Explorer concept: ODYSEA. This effort has been split into three components: 1.) development and public release of an ODYSEA science simulator and error model; 2.) improving our understanding of near inertial oscillations and modeling them from simulated ODYSEA observations; and 3.) studies of ocean-atmosphere coupling based on ODYSEA capabilities and new coupled ocean-atmosphere simulations.

Approach and Results:

ODYSEA Simulator

We developed an ODYSEA mission simulator that is capable of quickly generating satellite swath data. This simulator can be used to co-locate ocean/atmosphere model data to the satellite swath, and add realistic instrument noise (Fig 1). Additionally, a time series can be generated for individual points as if ODYSEA viewed it. Using this simulator, we found the global effective resolution of the mission's measurements will vary depending on surface processes and averaging period between 5-20 km.

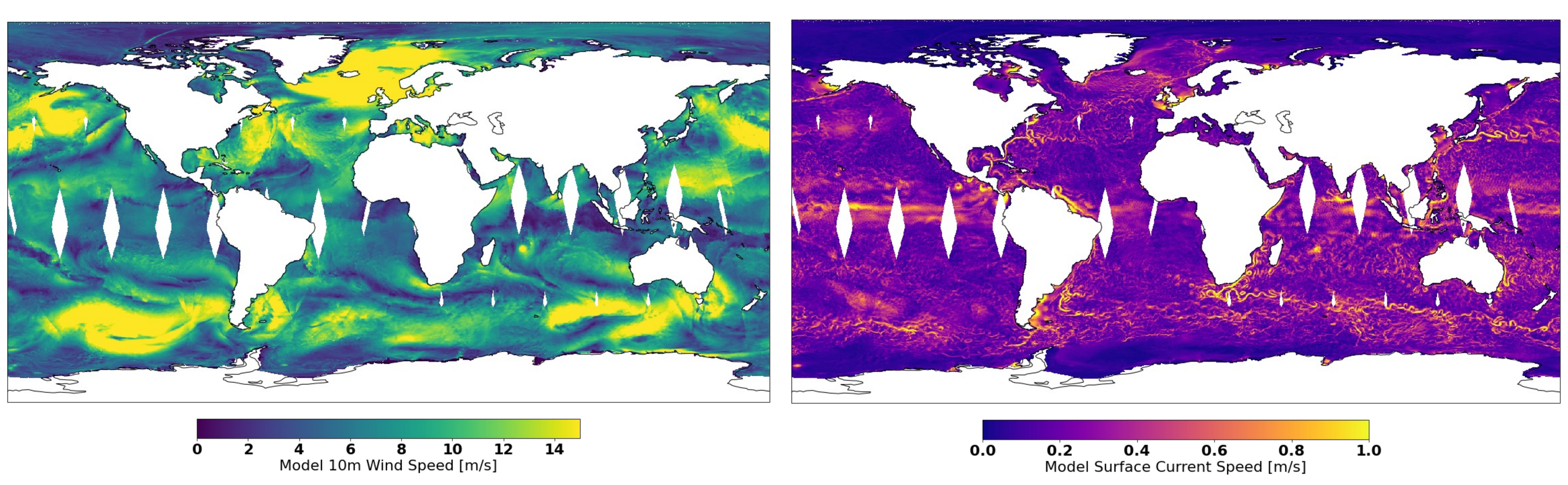


Figure 1: One day of simulated ODYSEA wind (left) and current (right) data.

Near Inertial Oscillations

Because ODYSEA samples ocean winds and currents with ~12 hourly resolution, high frequency ocean currents are not well resolved and can be aliased back onto lower frequency signals. This work used ODYSEA time sampling of winds and currents combined a least square fit slab ocean model to understand how well near inertial oscillations (NIO) can be estimated from ODYSEA data. This method allows for both the removal of the aliased signal from ODYSEA measurements, but also a new opportunity for a global NIO estimate from ODYSEA. Our results show that in regions of strong NIO activity, NIOs can be effectively modeled using our approach (Fig. 2).

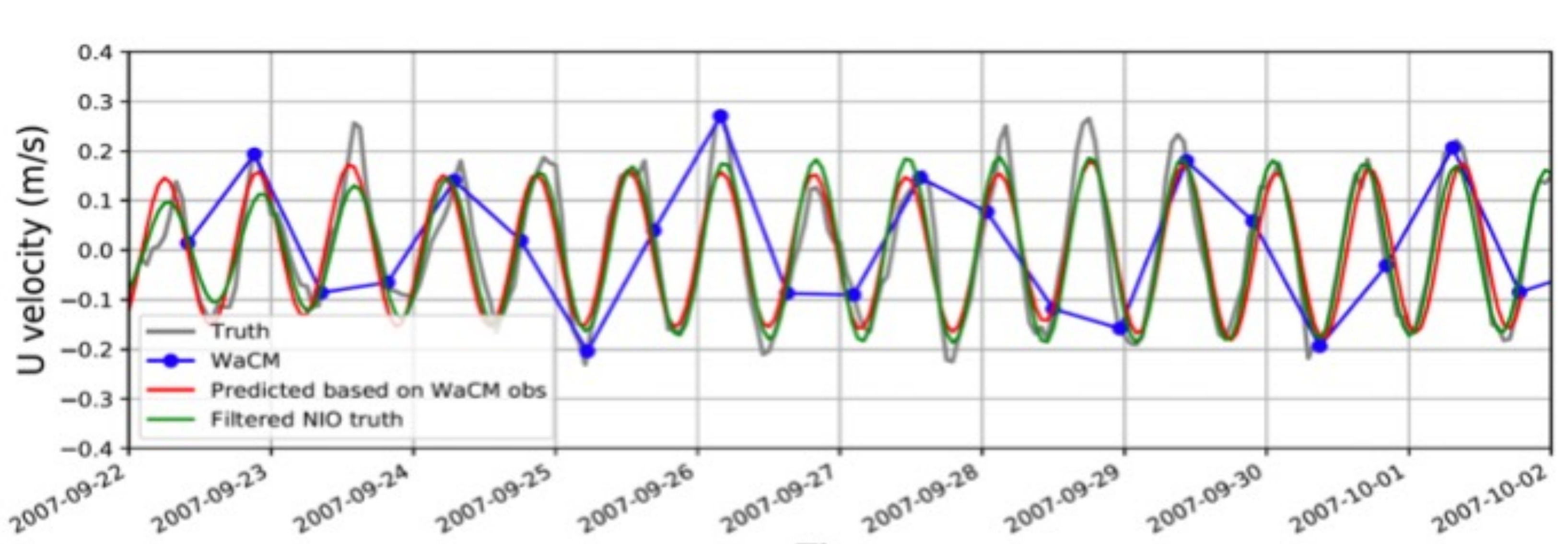


Figure 2: WaCM/ODYSEA sampled data and predicted NIOs compared to observations at mooring station Papa.

Background:

Ocean vector winds and currents are tightly coupled, essential climate variables that mediate the transfer of energy, gasses, and tracers between the atmosphere and the ocean. ODYSEA is a concept for the wide-swath, global measurement of ocean vector winds and currents from space, called out in the 2018 Earth Science Decadal Survey. The purpose of this work was to illuminate areas of high-impact science where ODYSEA can make significant contributions, and reduce risks associated with unwanted geophysical signals in ODYSEA data.

Air-Sea Interactions: Wind-Current Coupling

The ocean and the atmosphere are known to strongly couple where ocean current gradients are large, and in these places, vertical fluxes of heat, gasses, and evaporation are intensified, causing downstream weather effects. Using coupled ocean model data, we found strong correlations between latent heat flux (evaporation) and strong surface current gradients (Fig. 3). Furthermore, we found that the correlation between ocean surface curl (turning) is strongly correlated with curl in the atmosphere. This coupling is well known already at coarse resolution, but we further discovered an important scale dependence that will help drive ODYSEA sampling requirements.

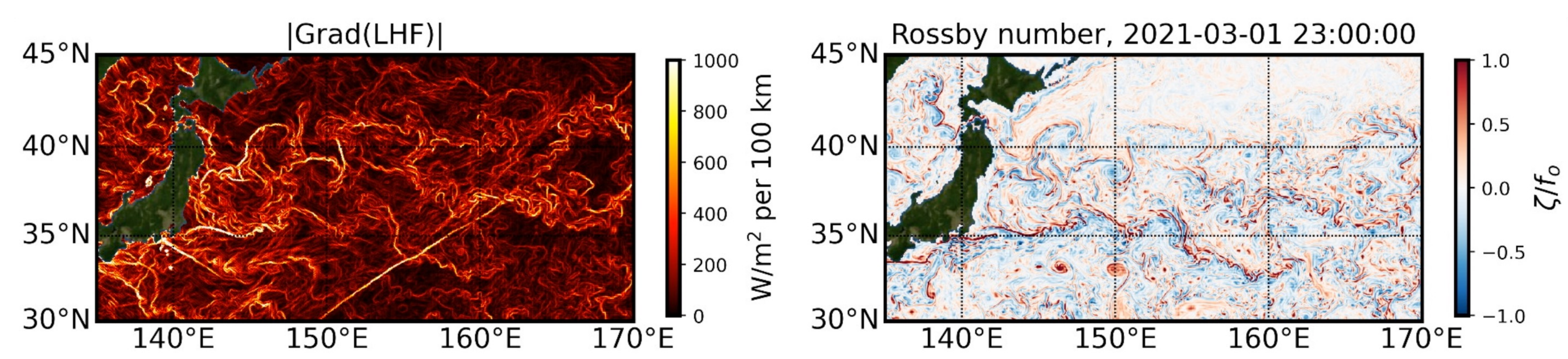
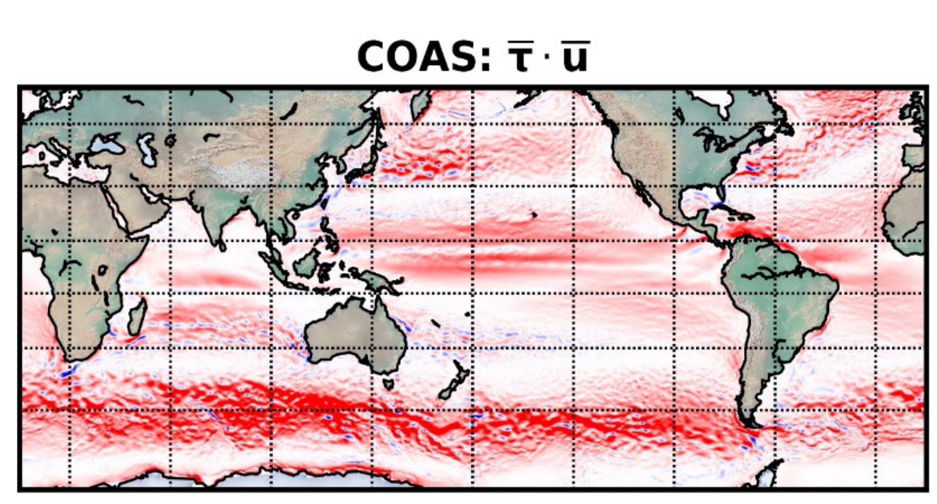


Figure 3: Patterns in latent heat flux are associated with patterns in ocean current relative vorticity. This is the first such observation of this correlation.

Air-Sea Interactions: Wind Work

Wind work is the transfer of kinetic energy between the ocean and the atmosphere and is an important part of the atmosphere-ocean coupled system. Using a new, high resolution coupled ocean-atmosphere simulation, we estimated global wind work has a magnitude of 5.21 TW, a value much larger than reported by previous uncoupled modeling studies (Fig. 4a). The complex and consequential coupling of surface winds and currents in numerical simulations motivates the need for a winds-and-currents satellite mission to directly observe wind work components. A second study using the ODYSEA simulator shows that from ODYSEA, we can estimate the wind work with significantly better accuracy than our present observational capabilities (Fig 4b).



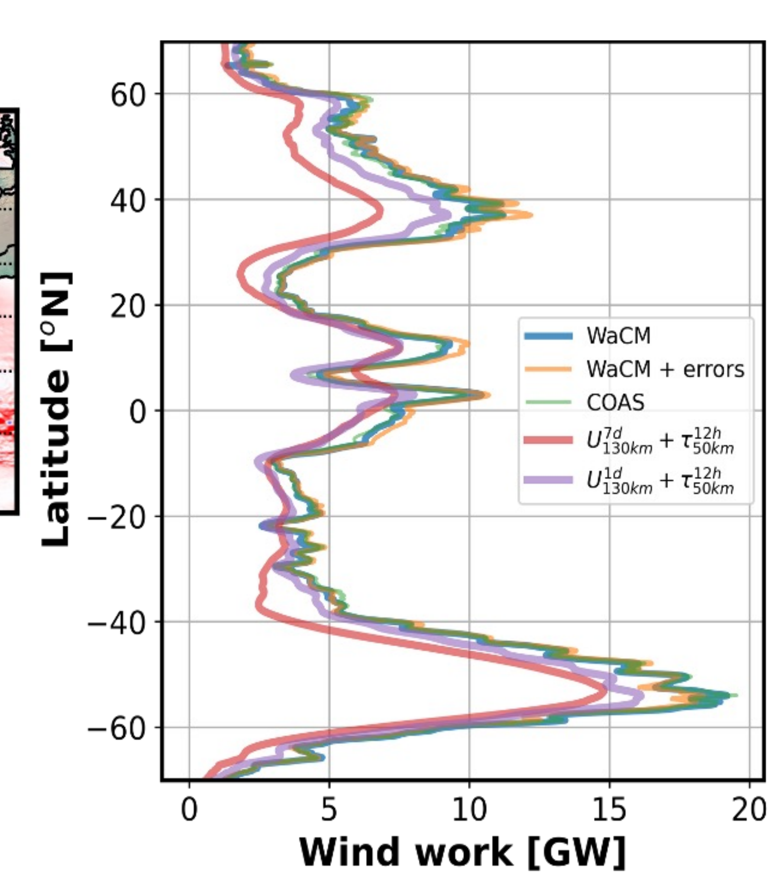


Figure 4: Left: Coupled model wind work. Right: Zonal wind work for ODYSEA (blue/orange) vs model (green) and present observational capabilities (red).

Significance/Benefits to JPL and NASA:

The ODYSEA mission simulator developed during this SR&TD has been submitted for open-source release. This will allow for further observing system experiments across a range of applications beyond which JPL could execute. This will help encourage community engagement in the mission, improve its scientific basis, and ultimately make it more competitive for NASA selection. Requests for this simulator have already come from the US Navy, NOAA, and international partner organizations. The air-sea interaction results provide further motivation for a winds and currents mission, showing the importance of the scales and processes ODYSEA can observe, and highlighting the shortcomings of our present capabilities. By providing a framework for estimating near inertial oscillations from ODYSEA data, we have reduced the geophysical contamination caused by these currents, while producing a scientifically useful dataset for researchers interested in NIOs.

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Publications:

Torres, H. S. et al.: Wind work at the air-sea interface: A Modeling Study in Anticipation of Future Space Missions, EGUsphere, https://doi.org/10.5194/egusphere-2022-294, 2022.

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