National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Explorer Ocean Vector Winds & Currents

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Strategic Focus Area: Earth System Explorer – Science Definition and Technology Maturation **| Strategic Initiative Leader:** Sabrina M 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.

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.

Significance/Benefits to JPL and NASA:

The ODYSEA science simulator is publicly available as an open-source package. This enables wide ranging experiments beyond which JPL could execute, increasing community engagement, improving ODYSEA's scientific basis, and ultimately making ODYSEA more competitive for selection. NOAA, the US Navy, and international organizations are already using this simulator in support of ODYSEA. The air-sea interaction work highlights the importance of the scales and processes ODYSEA can observe, while showing the shortcomings of our present capabilities. We discovered new correlations between currents and latent heat flux that may open new applications for ODYSEA related to atmospheric rivers. Our framework for estimating NIOs from ODYSEA data reduces geophysical contamination, while producing a scientifically useful dataset for researchers.

Publications:

Wineteer, A. and Torres, H. (2023). ODYSEA Science Simulator "awineteer/odysea-science-simulator: Zenodo archive version 1 (v1.0.0)", Zenodo

Wang, Jinbo, Hector Torres, Patrice Klein, Alexander Wineteer, Hong Zhang, Dimitris Menemenlis, ClementUbelmann, and Ernesto Rodriguez. 2023. "Increasing the Observability of Near Inertial Oscillations by a FutureODYSEA Satellite Mission" Remote Sensing

Torres, Hector, Alexander Wineteer, Patrice Klein, Tong Lee, Jinbo Wang, Ernesto Rodriguez, Dimitris Menemenlis, and Hong Zhang. 2023. "Anticipated Capabilities of the ODYSEA Wind and Current MissionConcept to Estimate Wind Work at the Air–Sea Interface" Remote Sensing

Torres, H., P. Klein, J. Wang, A. Wineteer, B. Qiu, A. Thompson, L. Renault, E. Rodriguez, D. Menemenlis, A.Molod, C. N. Hill, E. Strobach, H. Zhang, M. Flexas, and D. Perkovic-Martin (2022), Wind work at the air-sea interface: a modeling study in anticipation of future space missions, Geosci. Model. Dev.

deCharon, A., Hector Torres., Alexander Wineteer, Patrice Klein, Tong Lee, Jinbo Wang, Ernesto Rodriguez, Dimitris Menemenlis, and Hong Zhang. 2023. Wind at Work: https://storymaps.arcgis.com/stories/a06ada5f195c497d9bcb10f35c9e7580

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Approach and Results:

ODYSEA Simulator (publication 1)

We developed an ODYSEA mission simulator that is capable of quickly generating satellite swath data without any embedded JPL-proprietary engineering information. This simulator can co-locate ocean/atmosphere model data to the satellite swath and add realistic measurement noise (Figure 1).

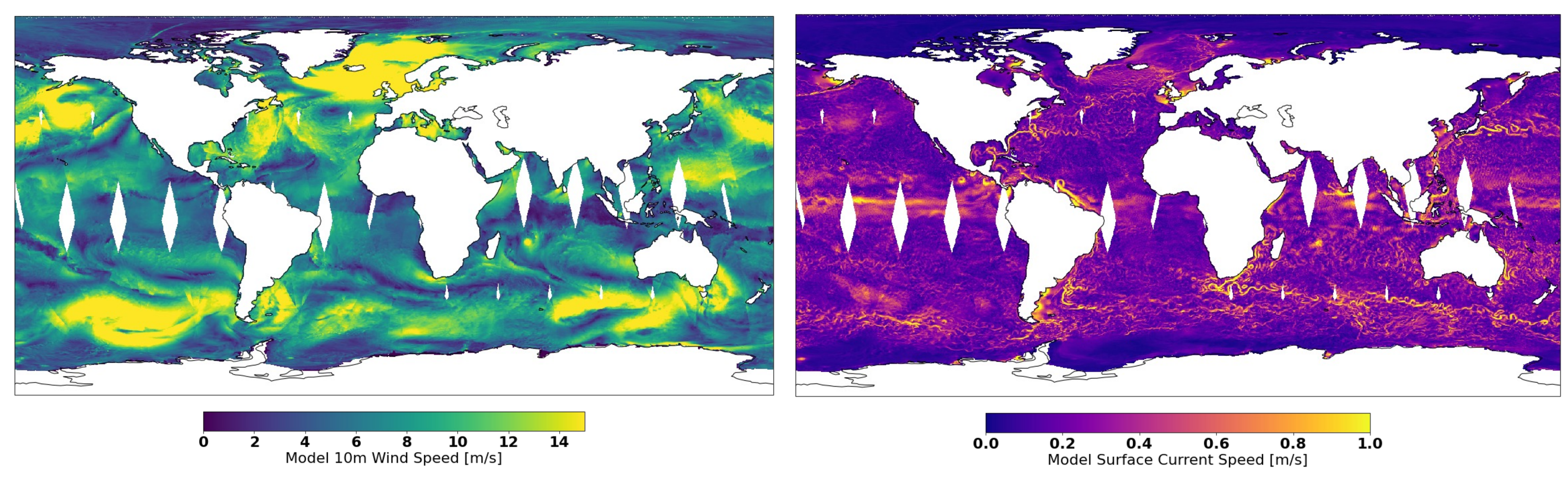

Figure 1: One day of simulated ODYSEA wind (left) and current (right) data.

Near Inertial Oscillations (publication 2)

ODYSEA samples currents every ~12 hours, so high frequency near inertial ocean oscillations (NIOs) are not well resolved. We used the ODYSEA simulator, combined a least square fit slab ocean model to estimate NIOs from ODYSEA data. This method successfully predicts NIOs (Fig. 2), removing the aliased signal from ODYSEA measurements, and also produces a global NIO dataset.

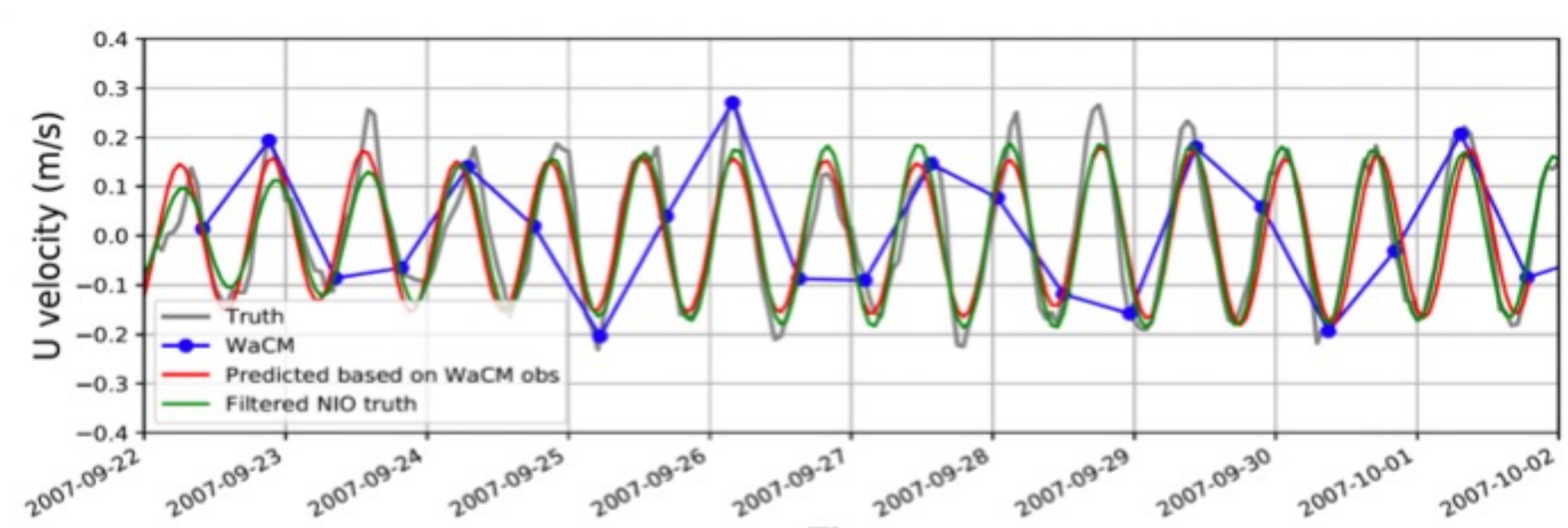

Figure 2: WaCM/ODYSEA sampled data and predicted NIOs compared to observations at mooring station Papa.

Air-Sea Interactions: Wind Work (publications 3,4,5)

Wind work is the transfer of kinetic energy between the ocean and the atmosphere. Using a new coupled ocean-atmosphere simulation, we estimated global wind work of 5.21 TW, much larger than previous uncoupled studies (Fig. 4a). Such variability in model results motivates the need for a winds-and-currents satellite mission to directly observe wind work, and ODYSEA can estimate the wind work much better than present capabilities (Fig 4b).

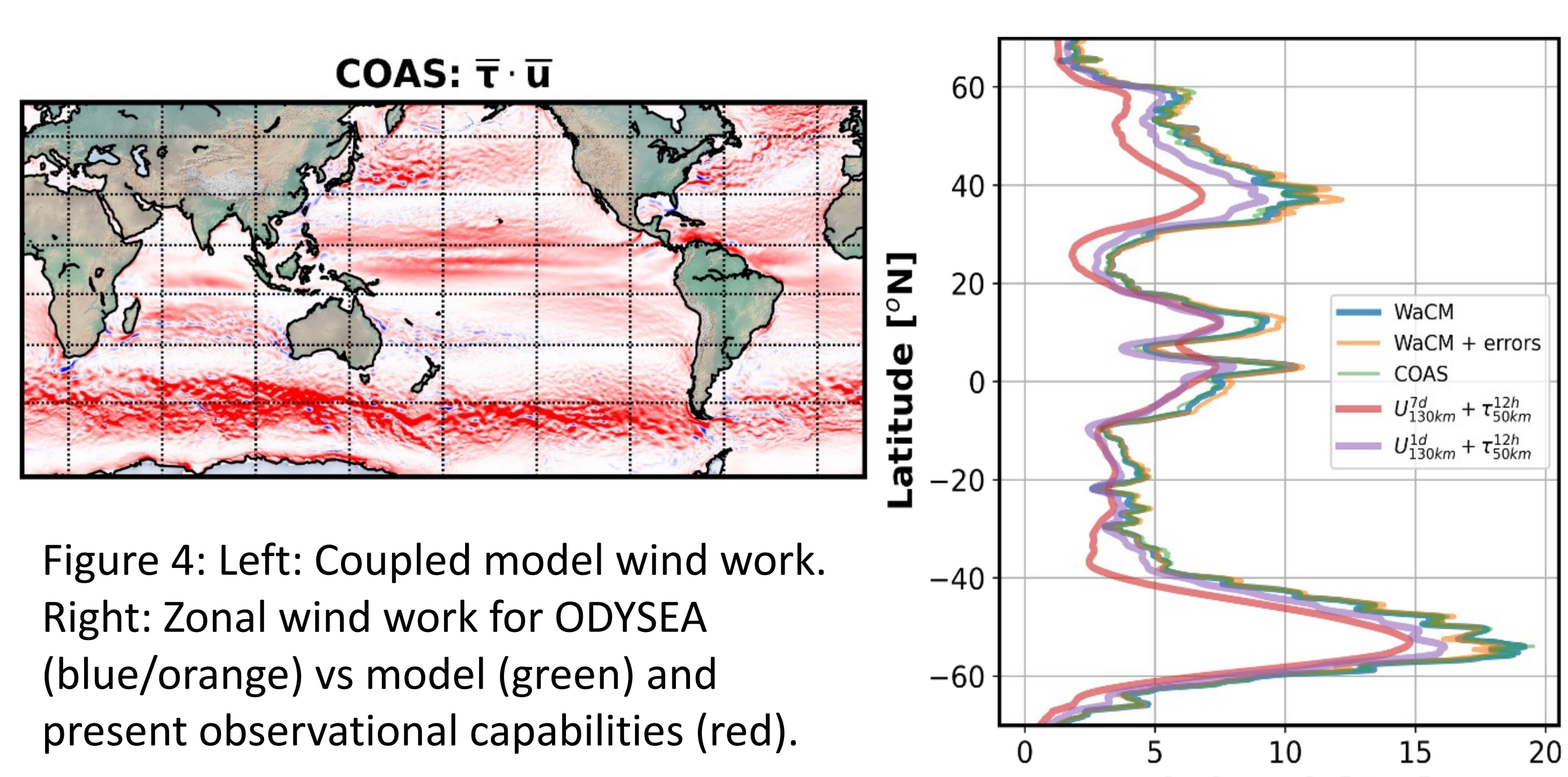

Figure 4: Left: Coupled model wind work. Right: Zonal wind work for ODYSEA (blue/orange) vs model (green) and present observational capabilities (red).

Air-Sea Interactions: Wind-Current Coupling

The ocean and the atmosphere couple at current gradients, intensifying vertical fluxes of heat, gasses, and evaporation, causing downstream weather. Using coupled ocean model data, we found correlations between evaporation and current gradients and that the correlation between ocean surface curl (turning) is strongly correlated with curl in the atmosphere. We also discovered an new scale dependence that will drive ODYSEA requirements.

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