National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Measuring Winds and Currents from Space

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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, Clement Ubelmann, and Ernesto Rodriguez. 2023. "Increasing the Observability of Near Inertial Oscillations by a Future ODYSEA 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

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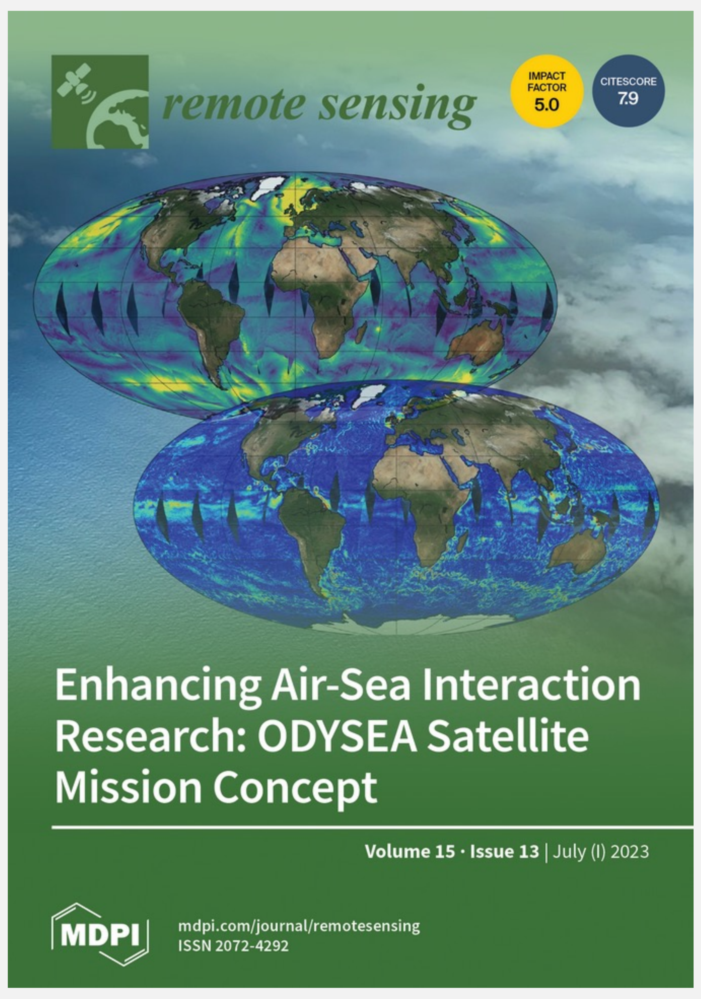

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Approach and Results:

ODYSEA Simulator

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).

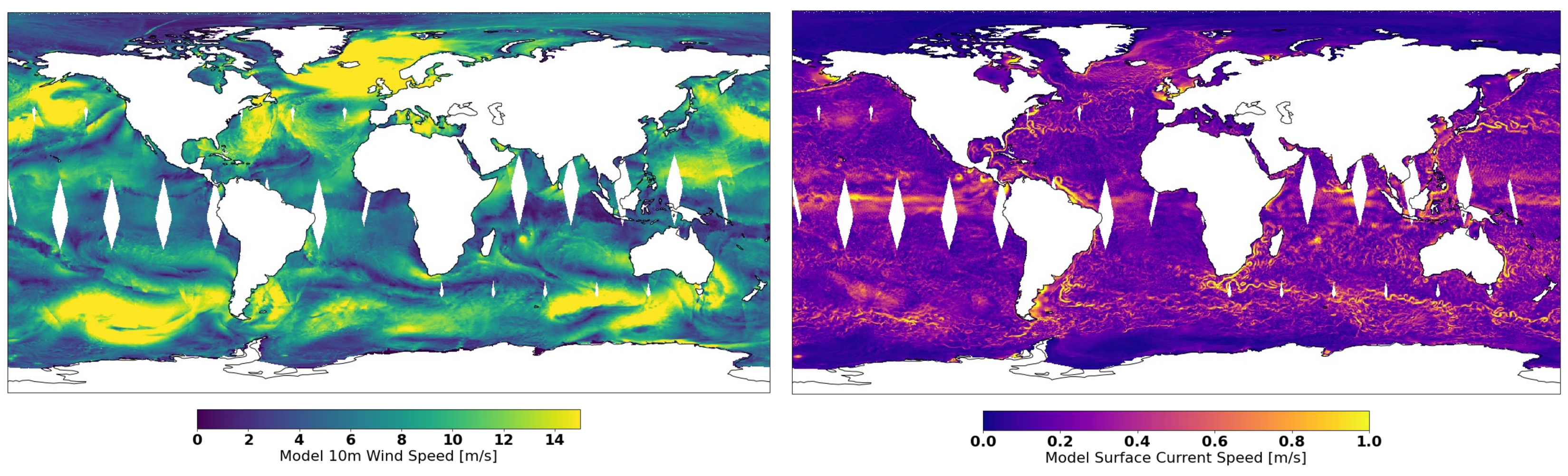

Figure 1: One day of simulated ODYSEA wind (left) and current (right) data.

Air-Sea Interactions

We used the ODYSEA simulator, in combination with a high resolution coupled ocean model, to explore the connection between frontal ocean features and atmospheric dynamics. Near the edges of ocean fronts, changes in SST trigger vertical atmospheric motion that carries warm, moist air into the troposphere where it freezes. This process can affect precipitation far downstream due to increased atmospheric ice and cloud water content

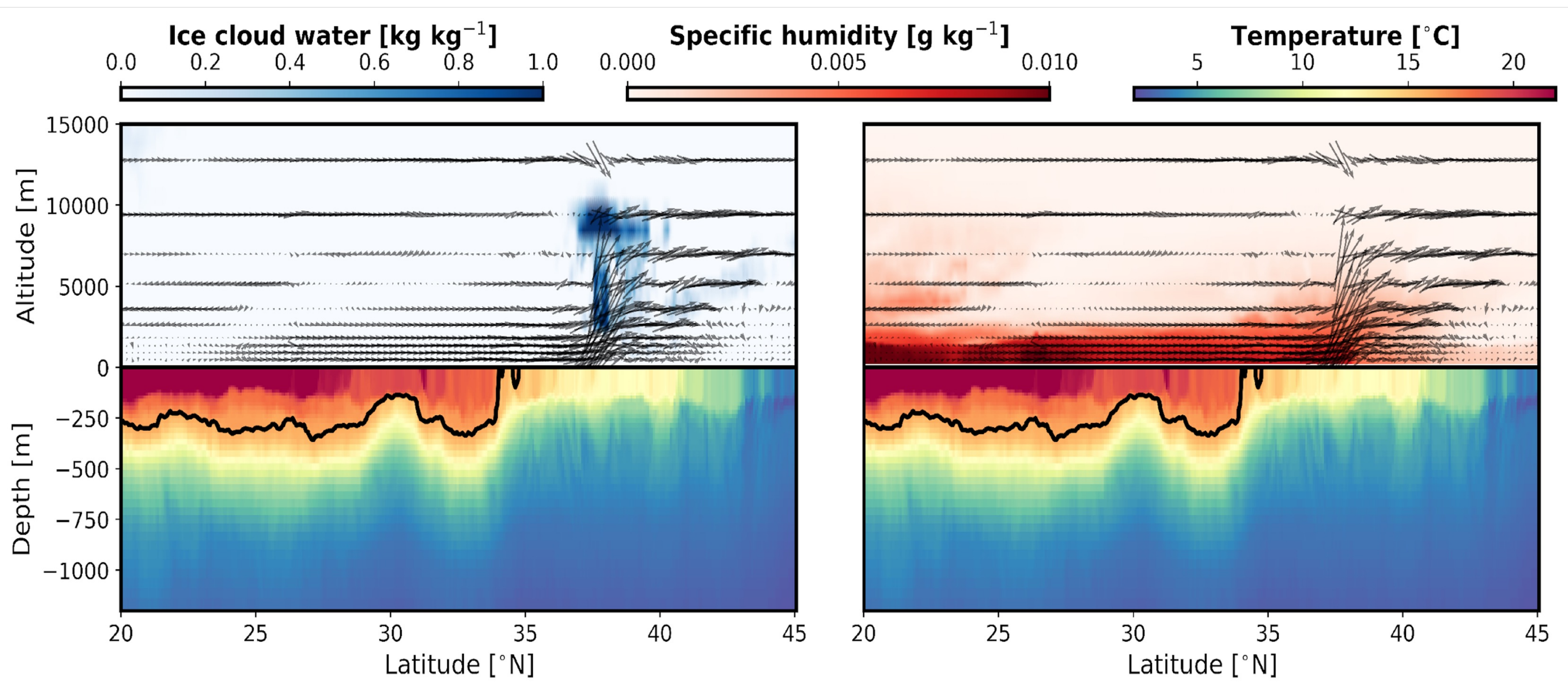

Figure 2: Observed air-sea interactions in model data. The ocean surface affects the troposphere.

Equatorial Dynamics

The tropics are one of the areas of strongest coupling between the ocean and atmosphere and are poorly measured by altimeters and poorly represented by models. We studied how ODYSEA observables of surface currents and winds constrain Equatorial dynamics, paying close attention to constraints on vertical velocities and upwelling, since this is one of the major global upwelling regions. We identified correlations between surface ocean divergence and deeper vertical velocities. This allows for ocean interior processes to be identified from ODYSEA measurements at the surface.

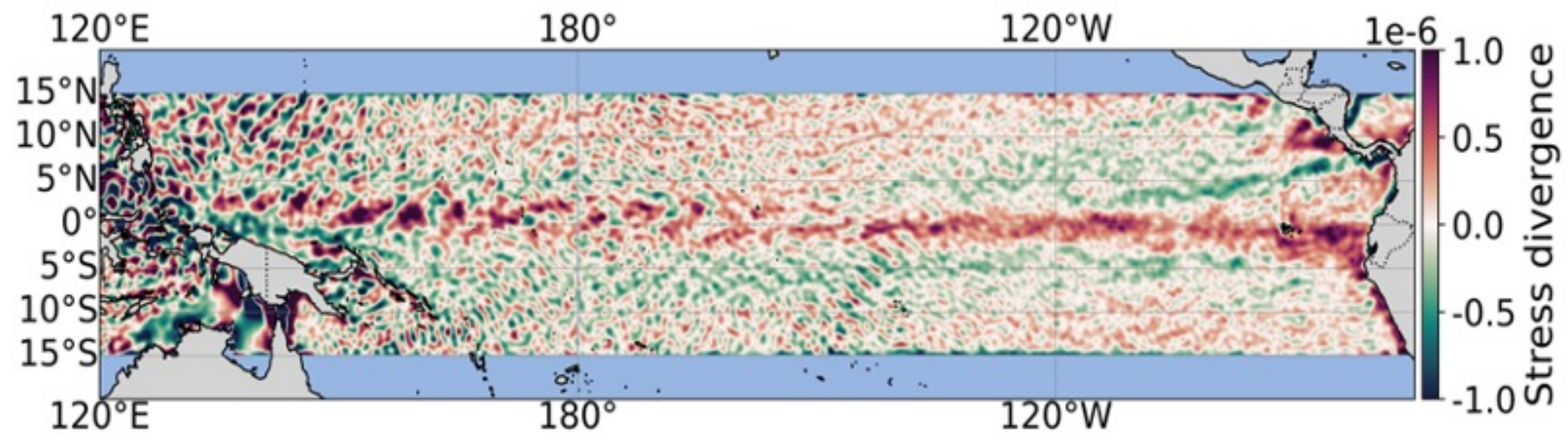

Figure 4: Equatorial upwelling identified from ODYSEA measurements

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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