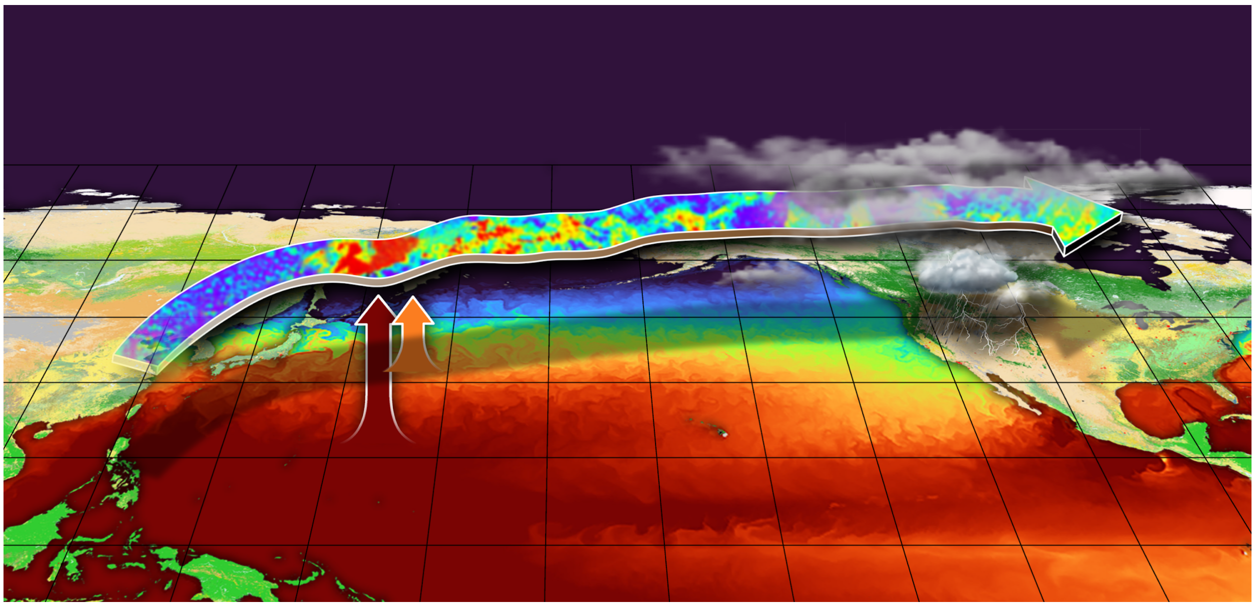

Title: Butterfly: how the small-scale air-sea exchange of heat and moisture affects large-scale weather and climate

1. Contact Info:

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2. Abstract:

The transfers of heat and water between the ocean and atmosphere influence global weather and climate as well as the water cycle. Understanding the interactions that contribute to the cumulative air-sea exchanges are fundamental for predicting weather and extreme events, such as floods and drought, as well as for understanding and predicting climate variability. Yet, no existing satellite is designed to measure these exchanges and in situ observations are extremely sparse. We are proposing a NASA Earth Venture Mission, Butterfly, which represents the state-of-the-art in microwave radiometer measurement of the near-surface ocean and atmosphere properties needed to accurately monitor the global air-sea flux of heat and moisture.

Butterfly's science objectives are designed to advance our understanding of small spatial scale fluxes and their contributions to our weather and climate:

1. Determine whether small-scale spatial variations in air-sea fluxes near warm ocean currents affect large-scale storm evolution and improve prediction of long-term weather.
2. Determine whether small-scale variations in the air-sea boundary layers contribute significantly to the large-scale air-sea exchange of heat and water.

With these objectives, we will determine if air-sea interaction processes on relatively small spatial scales affect large-scale atmospheric variability, thereby influencing weather and climate.

3. Relevant Ocean Decade Challenge(s):

Butterfly is relevant to Challenge 5 (improve predictions for the ocean, climate and weather), Challenge 6 (enhance multi-hazard early warning services for … weather, climate), and Challenge 7 (ensure a sustainable ocean observing system).

4. Vision and potential transformative impact:

Recent research has revealed the importance of small-scale (~25 km) oceanic features in regulating atmospheric variability from synoptic to seasonal timescales, affecting the skill of predicting extreme events like drought, flooding and heat waves. Current and planned satellite missions tell us how large-scale air-sea heat and moisture fluxes affect the atmosphere but not how the small-scale fluxes contribute. Until now our knowledge of the importance of these smaller-scale air-sea interactions has been based solely on model simulations, with little data to assess how accurately these exchanges, and their impact on weather and climate variability, are modeled. With Butterfly, we are for the first time able to observe the ocean-atmosphere interactions at fine enough scales with sufficient accuracy that allow us to examine the real strength of the ocean-atmosphere coupling. Butterfly fills a major gap in our knowledge of how small-scale air-sea exchanges of heat and moisture affect large-scale weather and climate, potentially improving forecast accuracy from days to a season by providing global measurements of the air-sea turbulent heat and moisture fluxes.

5. Realizable, with connections to existing U.S. scientific infrastructure, technology development, and public-private partnerships:

Recent OceanObs'20 community papers call for improving heat and moisture flux estimates. Four of the five panels in the 2017 Earth Science Decadal Survey raised at least one pressing science/societal question that points to the need for improved measurements of evaporation, boundary layer structure, and/or surface fluxes of heat or water vapor. This report described 11 "Most Important" or "Very Important" science objectives needing improved planetary boundary layer profiles and/or air-sea fluxes. Butterfly will be proposed to NASA's Earth Venture Mission - 3 competition by a diverse team that includes representatives from industry, academia, and government partners. The expansion of accurate flux measurements from OceanSites and boundary layer profile data from a recently funded NOPP project to miniaturize upward looking radiomenters support validation of Butterfly science data.

6. Scientific/technological sectors engaged outside of traditional ocean sciences:

Butterfly is a mission about the air-sea interface that engages with both traditional oceanographers as well as meteorologists and climate scientists. Our focus on long-term weather (including the impacts of ocean-influence weather systems over land) and seasonal climate provides an opportunity to engage the broad scientific communities, including those conducting research of water availability, impacts on ecosystems, wildlife, and human health.

7. Opportunities for international participation and collaboration:

Numerical Weather Prediction models routinely assimilate a wide variety of operational and research satellite radiances. European Centre for Medium-Range Weather Forecasts (ECMWF) and UK Met Office have expressed interest in testing the impacts of assimilating Butterfly measurements on weather or ocean forecasts. These agencies are well positioned to assimilate new satellite radiances from Butterfly that provide more accurate, high-resolution, simultaneous measurements.

Additionally, Butterfly bridges JAXA’s AMSR-3 on GOSAT-GW (2023 launch) and ESA’s CIMR (2028 launch), enhancing the resilience of the passive microwave data stream for sea surface temperature and wind speed while offering better spatial resolutions.

8. Develops global capacity and encourages the development of the next generation of ocean scientists:

The Butterfly mission will provide free and open access to all science data on the cloud, with an explicit goal of increasing participation of historically excluded groups in next-gen cloud-based open science. Providing open data on the cloud increases opportunities for global collaborations, while promoting scientific innovation, transparency, and reproducibility. The mission team members and institutions will participate in international hackweeks, science teams, and mentorship programs designed to develop the next generation of ocean scientists.