

A world map with a color-coded overlay representing wind and surface current data. The colors range from blue (low values) to red (high values), with yellow and green in between. The overlay is most prominent in the mid-latitude oceans, showing complex patterns of flow and wind. The text is overlaid on the map.

Simultaneous Winds and Surface Currents via the Proposed ODYSEA Doppler Scatterometer

Sarah Gille (SIO/UCSD, sgille@ucsd.edu)

with the ODYSEA team: Tong Lee, Fabrice Ardhuin, Justin Boland, Mark A. Bourassa, Paul Chang, Sophie E. Cravatte, J. Thomas Farrar, Melanie R. Fewings, Fanny Girard-Ardhuin, Gregg A. Jacobs, Zorana Jelenak, Florent Lyard, Jackie C May, Elisabeth D Rémy, Lionel Renault, Ernesto Rodriguez, Clément Ubelmann, Ana Beatriz Villas Bôas, and Alexander G. Wineteer

A satellite image of the Earth showing two hurricanes, Idalia and Franklin, over the Atlantic Ocean. The image is a top-down view of the planet, with the continents of North and South America visible on the left. The Atlantic Ocean is the central focus, with two large, swirling white clouds representing the hurricanes. Hurricane Idalia is on the left, and Hurricane Franklin is on the right. The text "Hurricane Idalia and Hurricane Franklin" and "August 29, 2023" is overlaid in the top left corner. A URL is at the bottom.

Hurricane Idalia and Hurricane Franklin
August 29, 2023

<https://www.noaa.gov/media-advisory/noaa-to-announce-2024-atlantic-hurricane-season-outlook>

The ocean drives disruptive weather

Latest Atmospheric River Brings Heavy Rain, Flooding and Thunderstorms to California

The New York Times



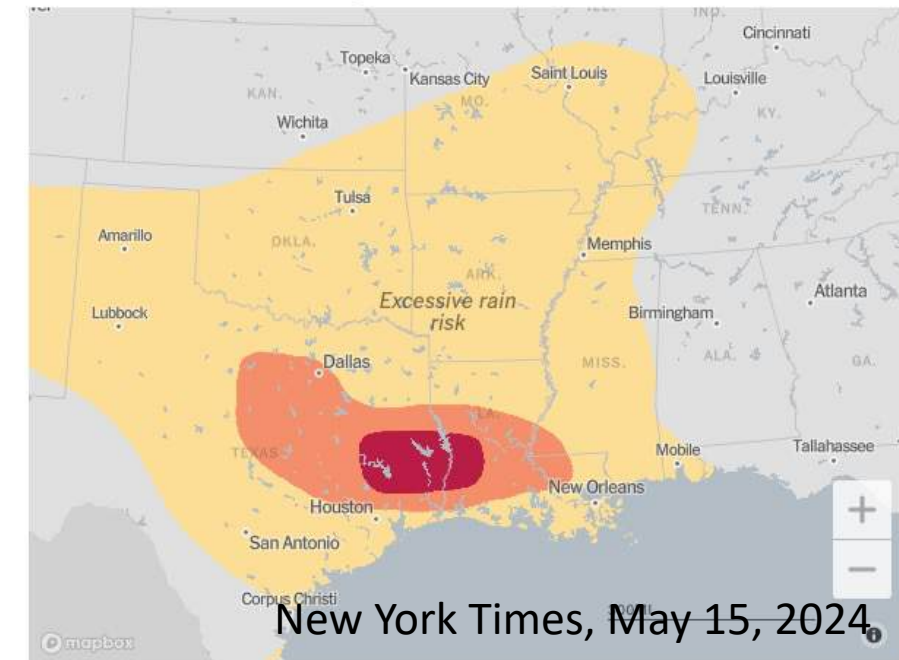
East Texas, Already Soaked, Prepares for a 'Nightmare Scenario' of More Rain

Some places in Texas have seen a year's worth of rainfall since January.

Listen to this article · 2:44 min [Learn more](#) [Share full article](#)

Forecast risk of excessive rain for Thursday

Risk ■ Some ■ Moderate ■ High



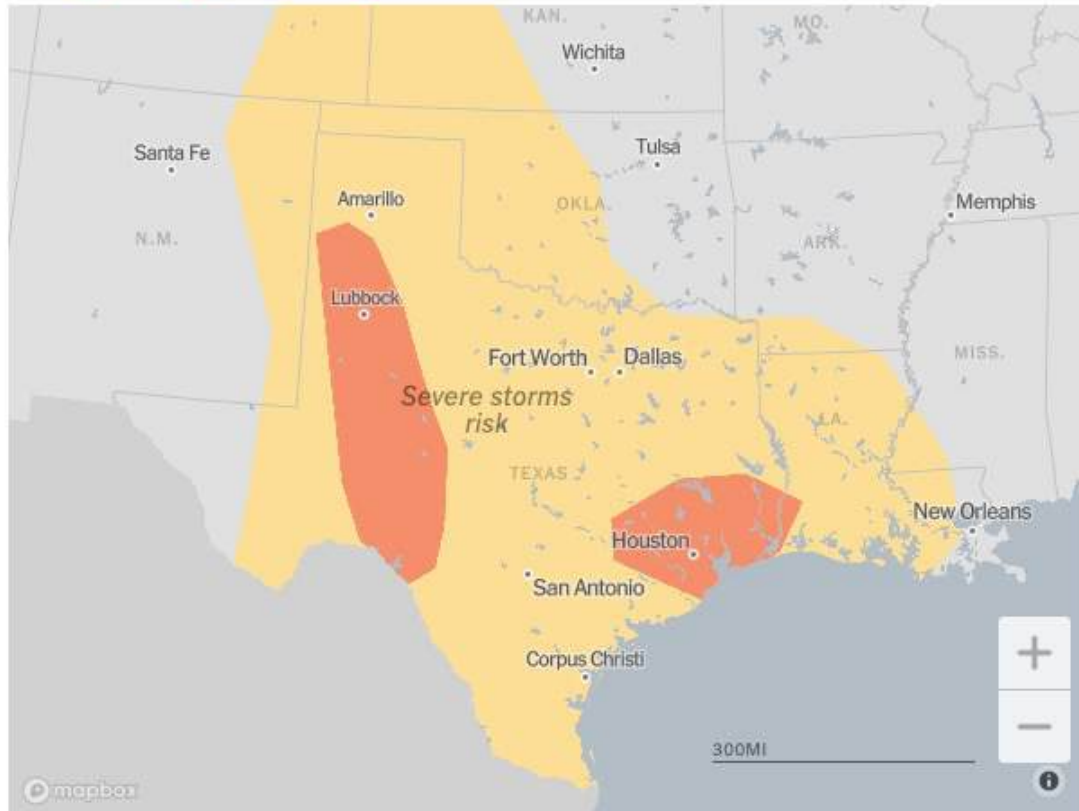
Even tornadoes.....

Damaging Winds and 'Very Large Hail' Hit Central Texas

Nearly 830,000 customers were without power after hail the size of golf balls and dangerous winds hit Texas. More severe weather was likely later on Tuesday.

Forecast risk of severe weather for Tuesday

Risk ■ Some ■ Moderate ■ High





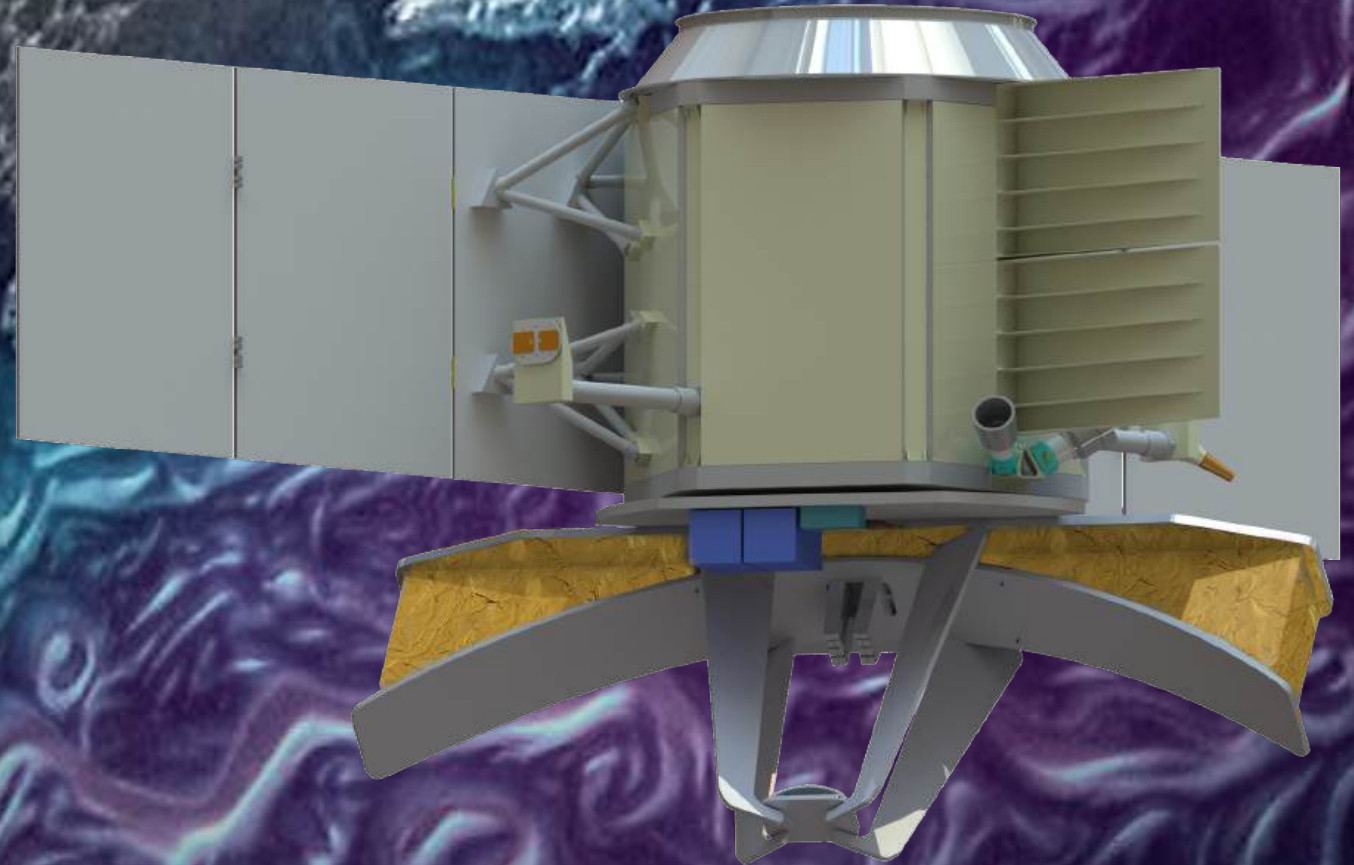
ODYSEA

Ocean Dynamics and Surface Exchange with the Atmosphere

Earth System Explorer
proposal to measure winds,
surface currents, and their
interactions

Objectives:

- What does ODYSEA measure?
- What can we do with ODYSEA's measurements?
- What's the status? And how can you be involved?



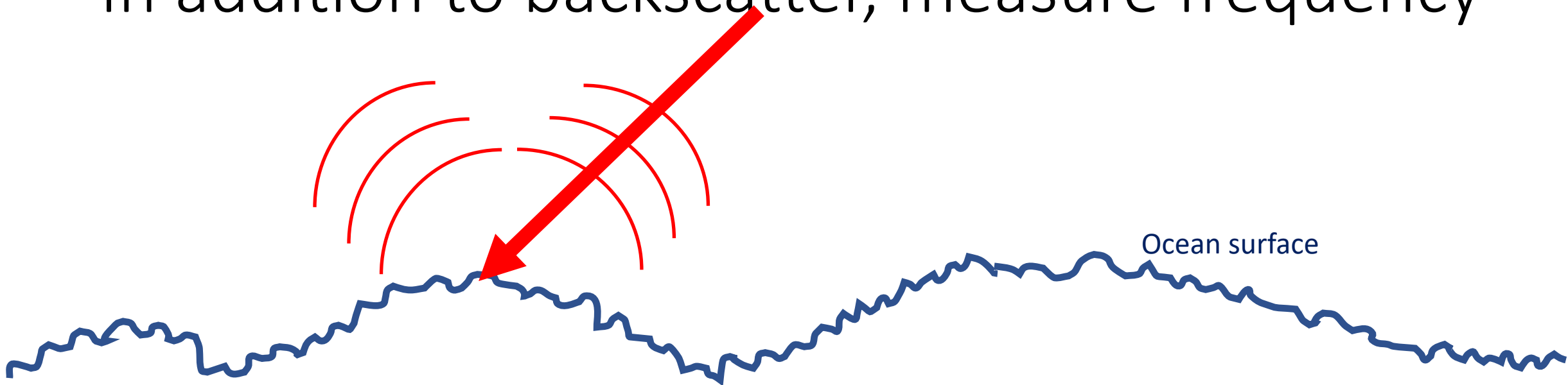
Scatterometers respond to capillary waves

Radar scatters off capillary waves

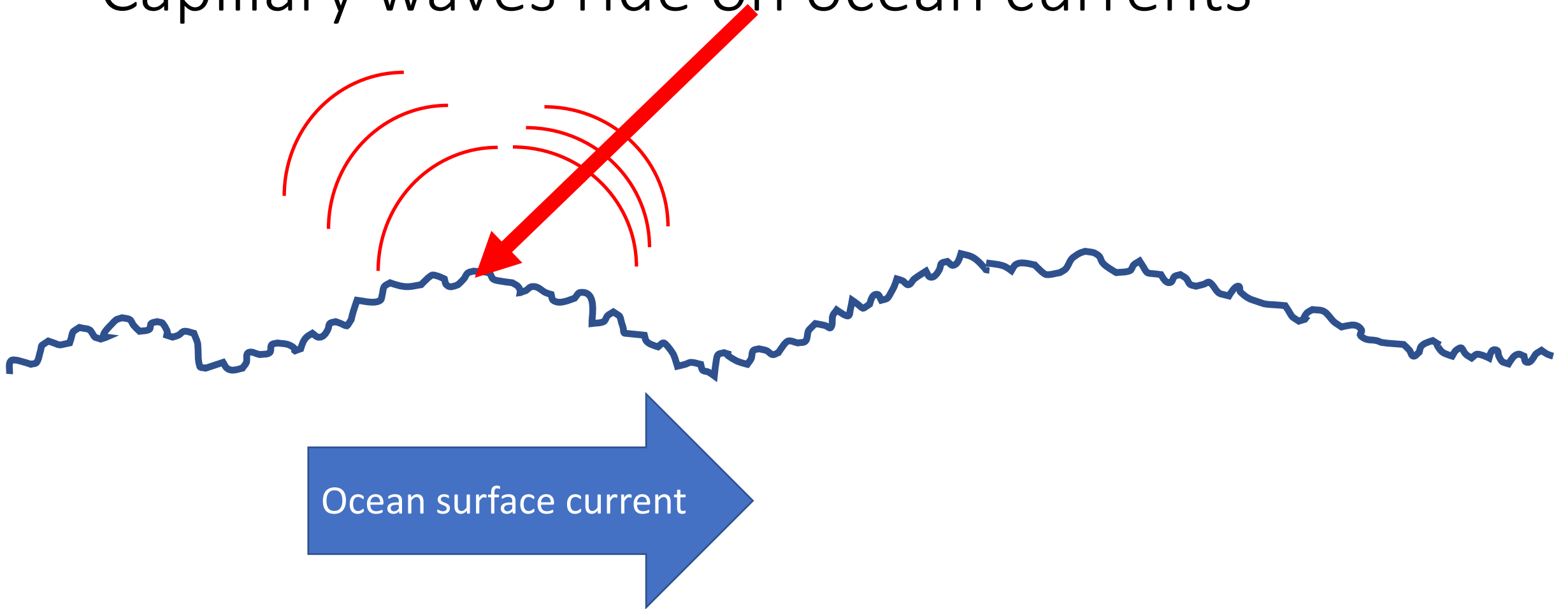


Scatterometers obtain wind direction through multiple looks at the same patch of ocean

In addition to backscatter, measure frequency



Capillary waves ride on ocean currents

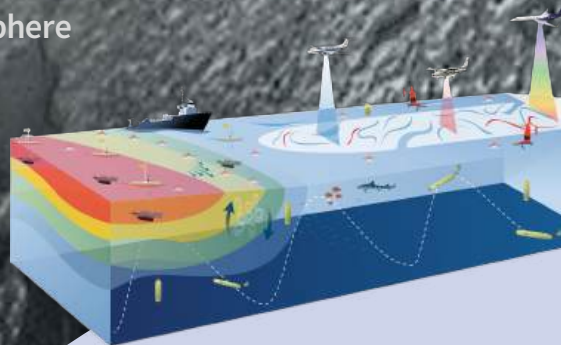


- Backscattered radar frequency Doppler shifted due to surface currents
- With multiple looks, determine current speed and direction



ODYSEA

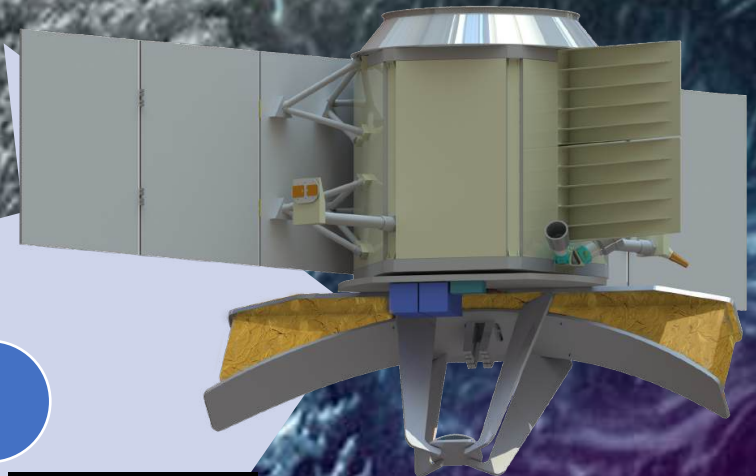
Ocean Dynamics and Surface Exchange with the Atmosphere



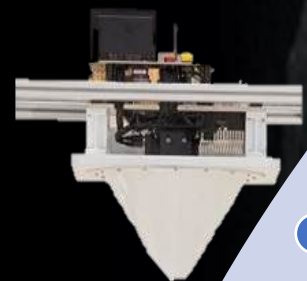
S-MODE
EVS-3 (2019)



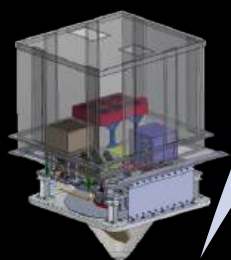
ODYSEA
ESE (2023)



DopplerScatt
AIT (2016)



DopplerScatt
IIP (2014)



DopplerScatt
Concept (2013)

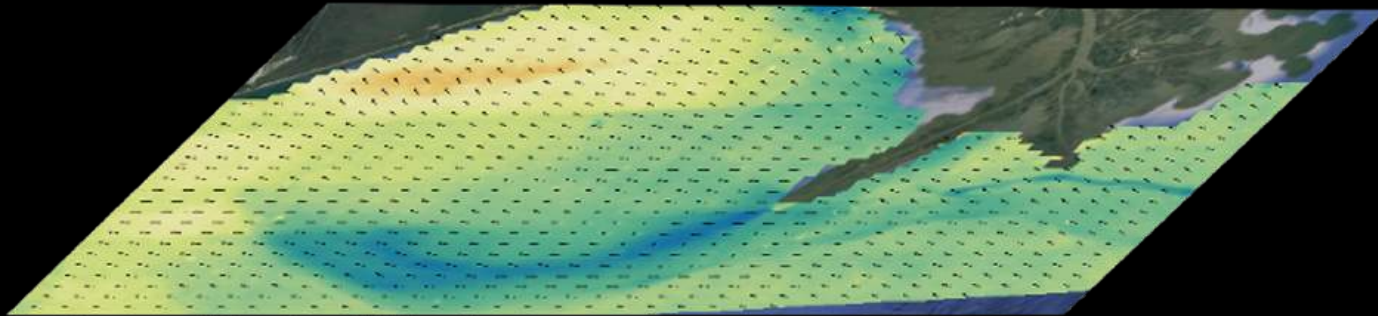


ODYSEA

Ocean Dynamics and Surface Exchange with the Atmosphere

ODYSEA's Ka-band Doppler Scatterometer

Provides the **first-ever** global measure of total surface currents. Includes simultaneous ocean vector winds with improved resolution for coupled air-sea science and applications closer than ever to the coast.



Ocean Vector Winds



Total Surface Currents

Earth System Explorer proposed to NASA with strong support from CNES (+ US Space Force)

Advanced to next phase!

Web: odysea.ucsd.edu

PI: Sarah Gille sgille@ucsd.edu

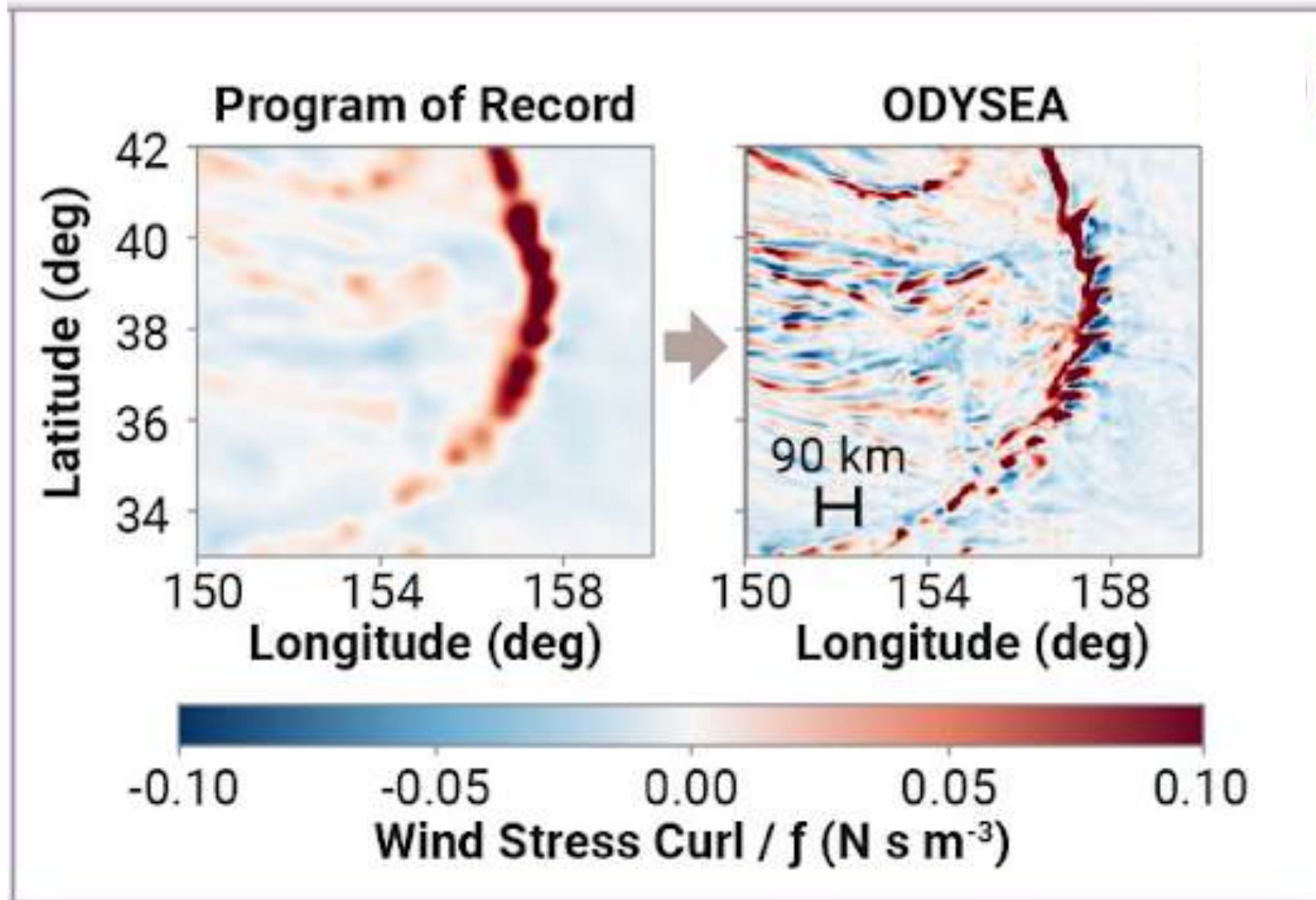
Project Scientist: Tong Lee, tlee@jpl.nasa.gov

5 km postings

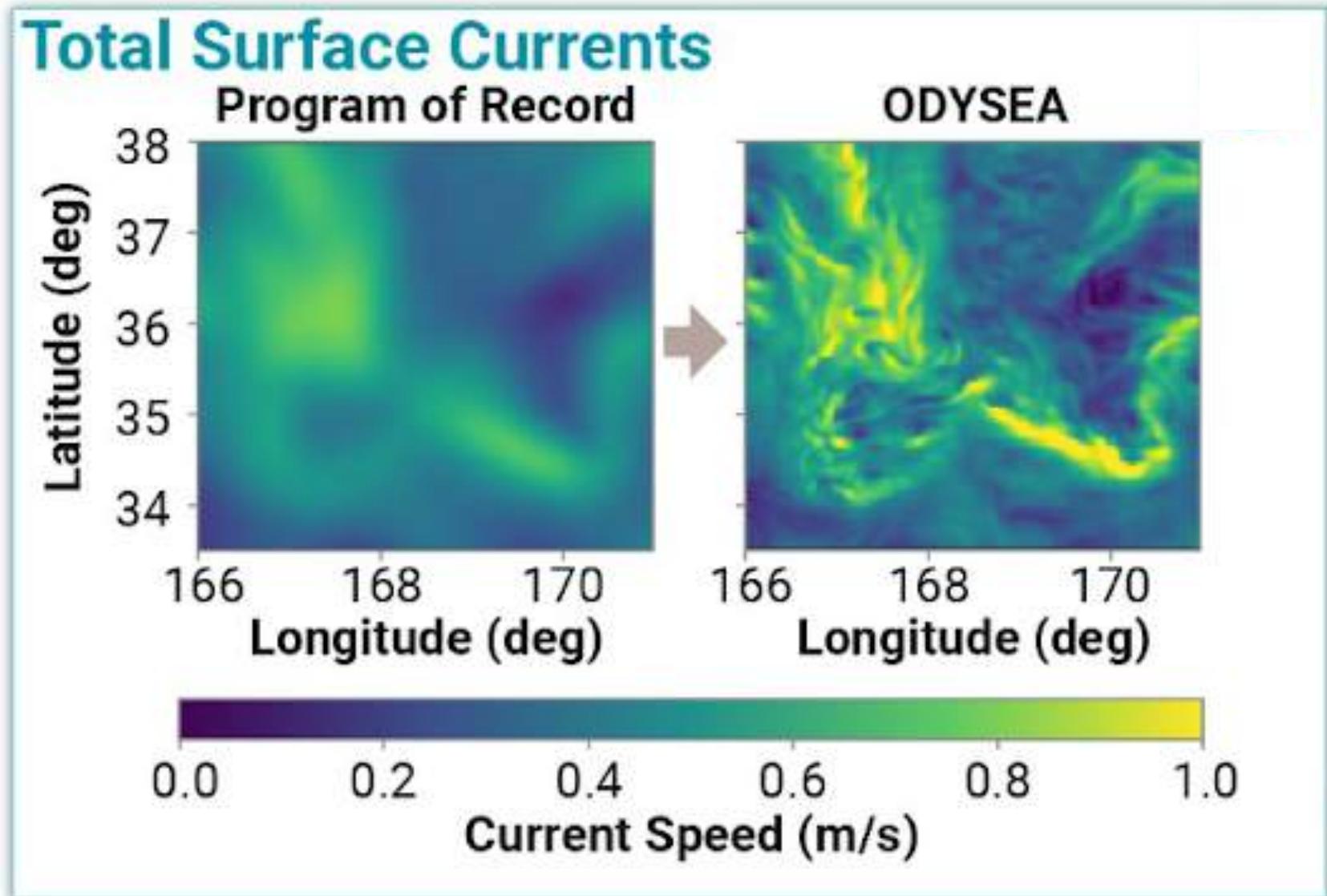
1700 km swath

Daily coverage, near-real time

ODYSEA will bring small-scale wind gradients into focus

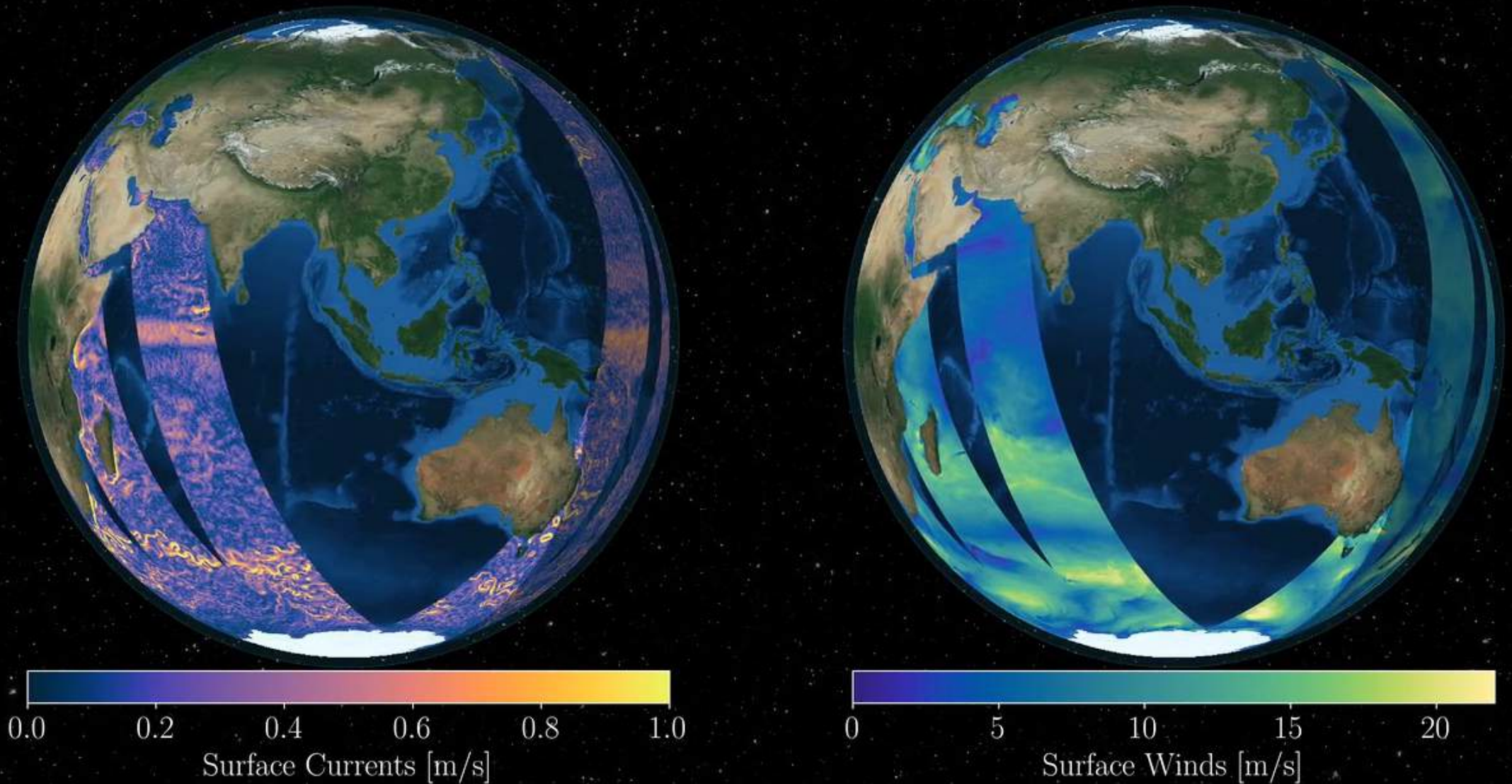


And show us currents and eddies as never seen before



What can we do with winds and currents?

2012-03-01 08:19:20

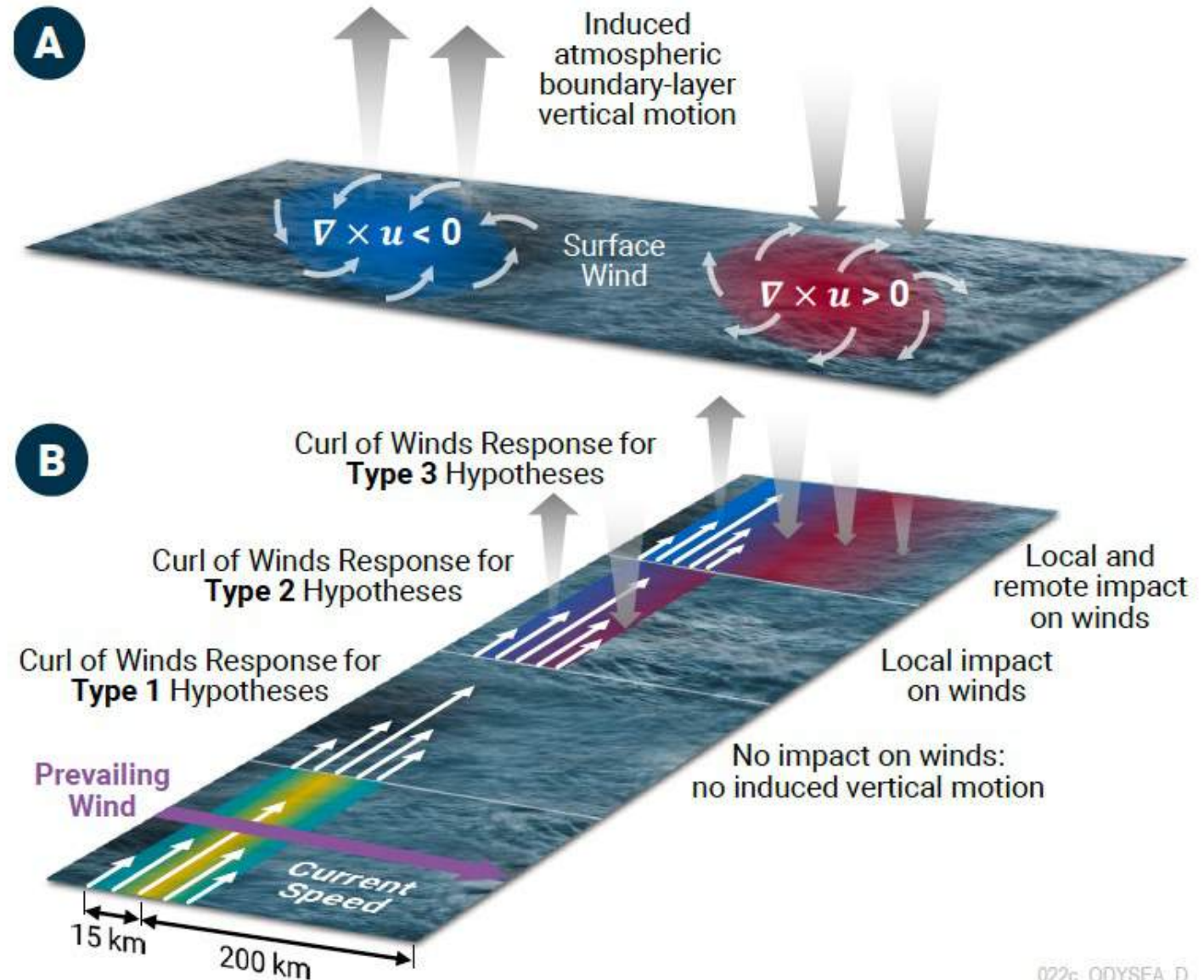


- 2 science objectives

- 1 applications objective

Science

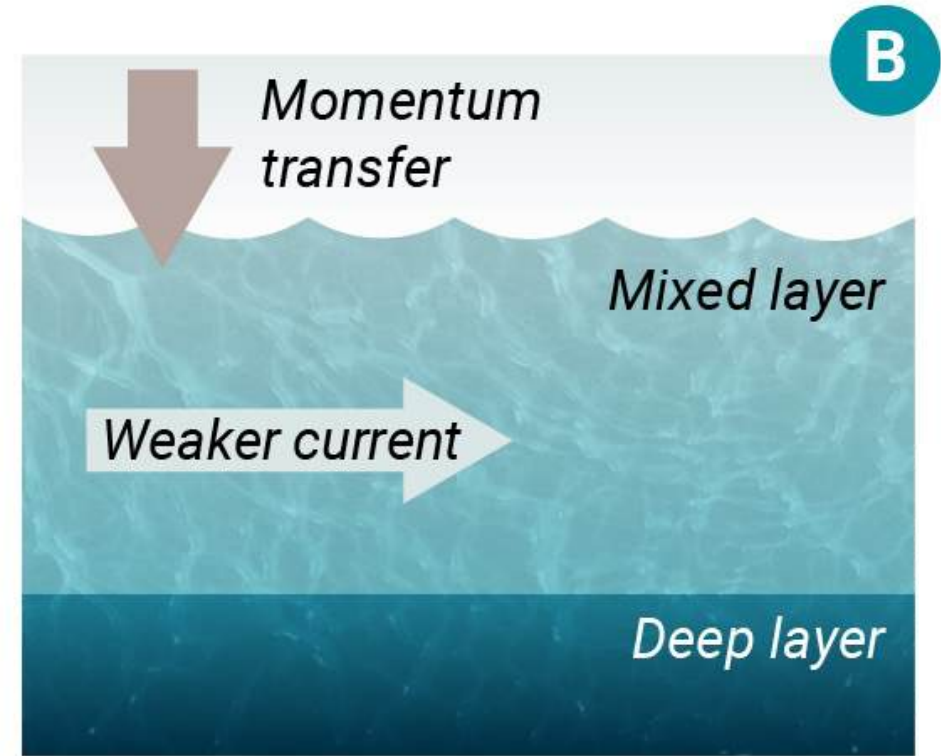
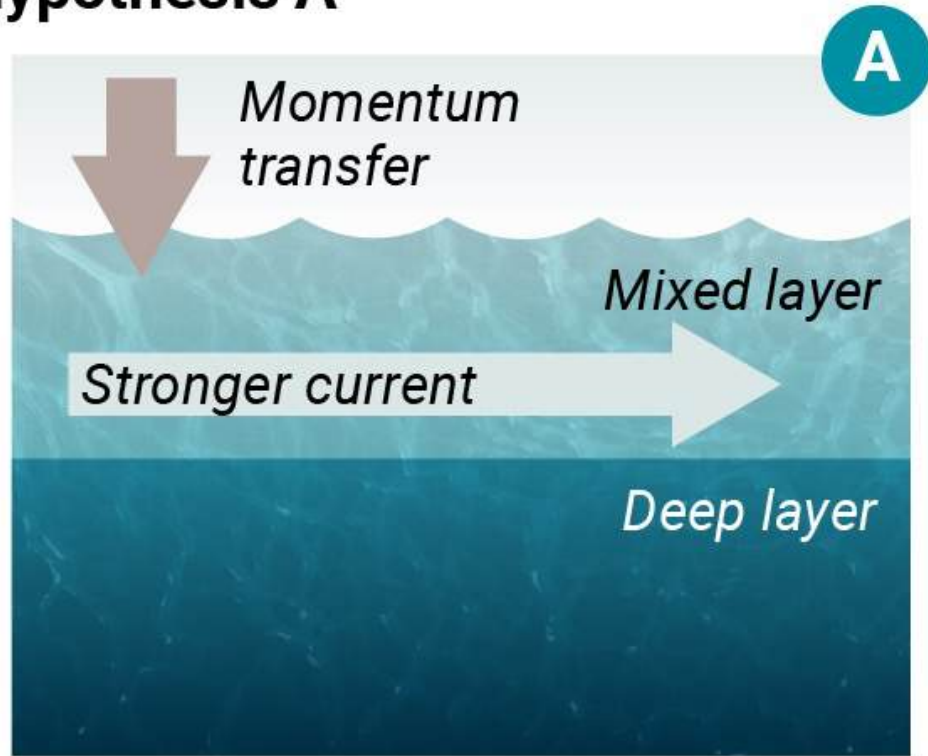
Objective 1: Competing hypotheses of wind—current coupling



Science Objective 2:

Hypothesis: High stratification implies faster surface currents

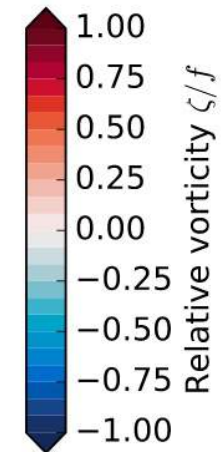
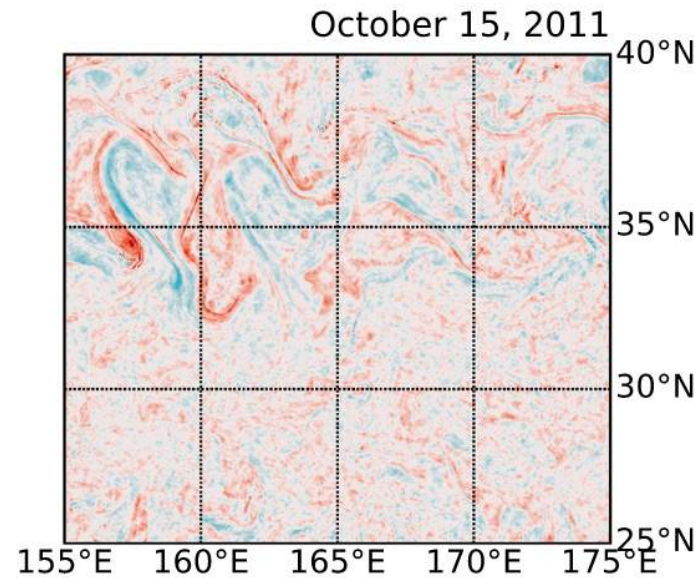
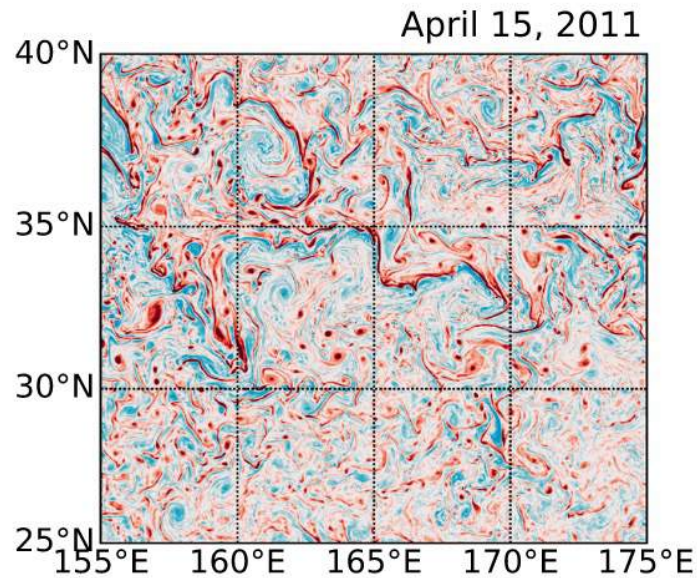
Hypothesis A



Or seasonal sub-mesoscale dynamics govern velocity?

End of winter

End of summer

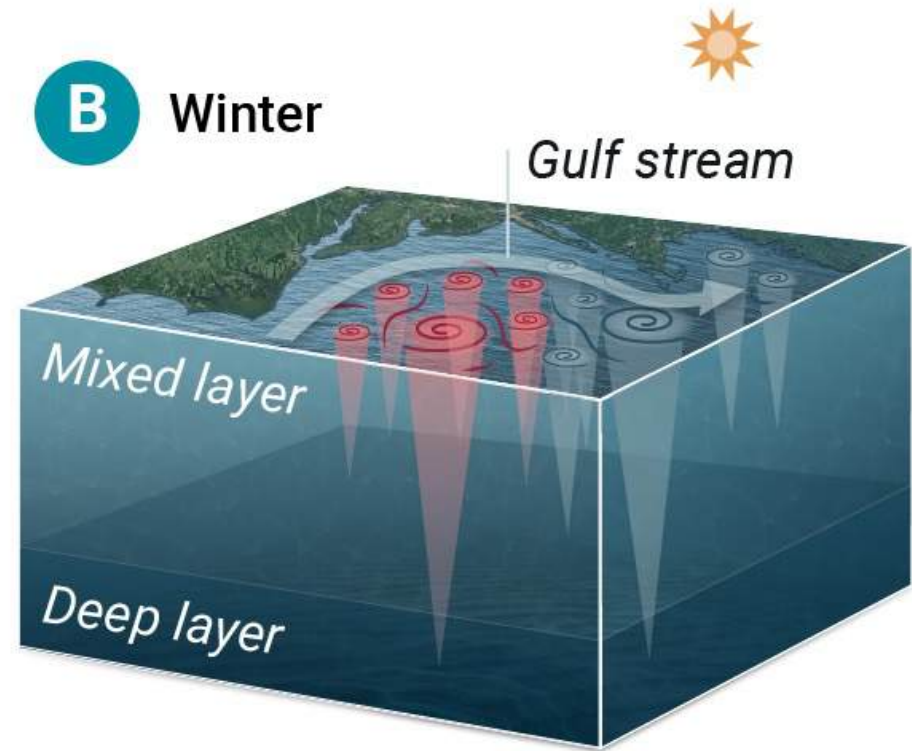
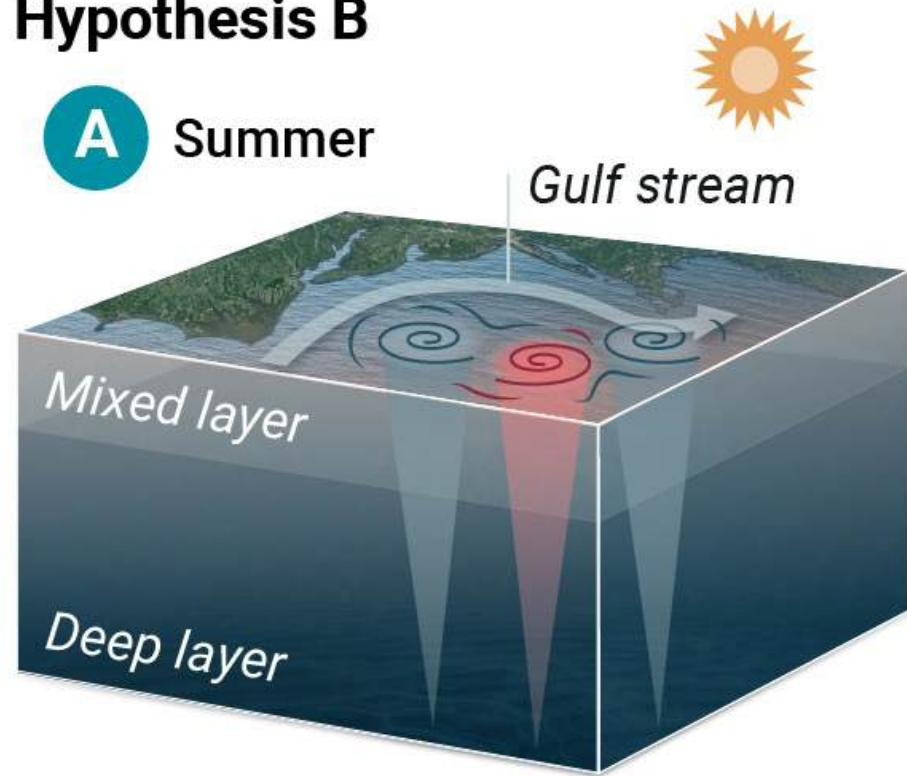


Kuroshio Extension
submesoscale
motions energized
in late winter/spring

Available potential
energy lower in
summer due to
stratification.

Hypothesis: Low stratification means more potential energy storage and ultimately faster currents

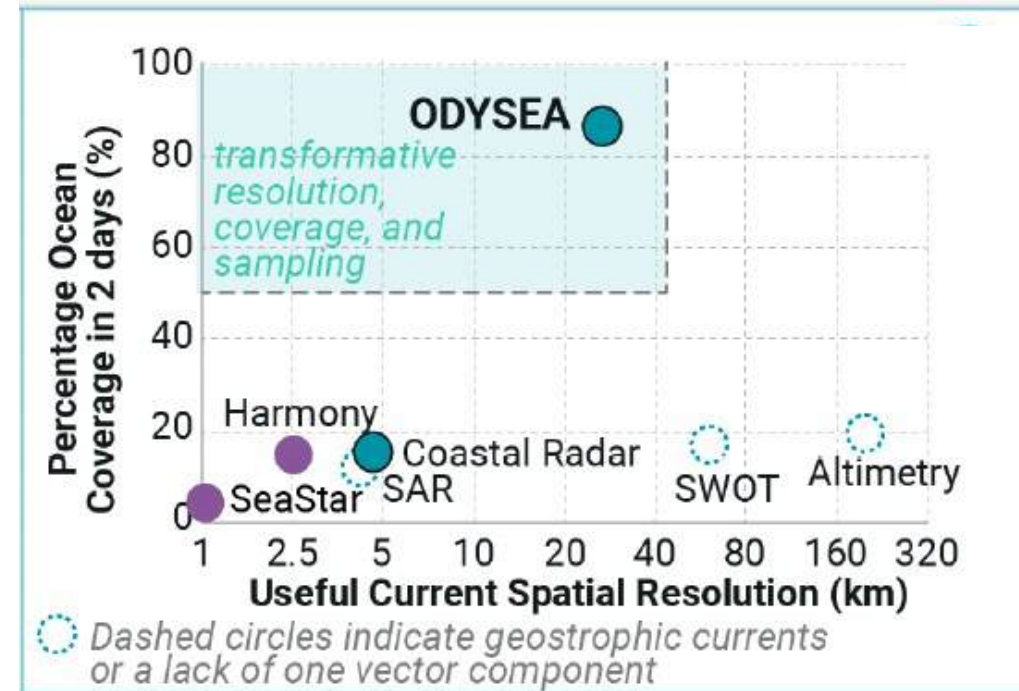
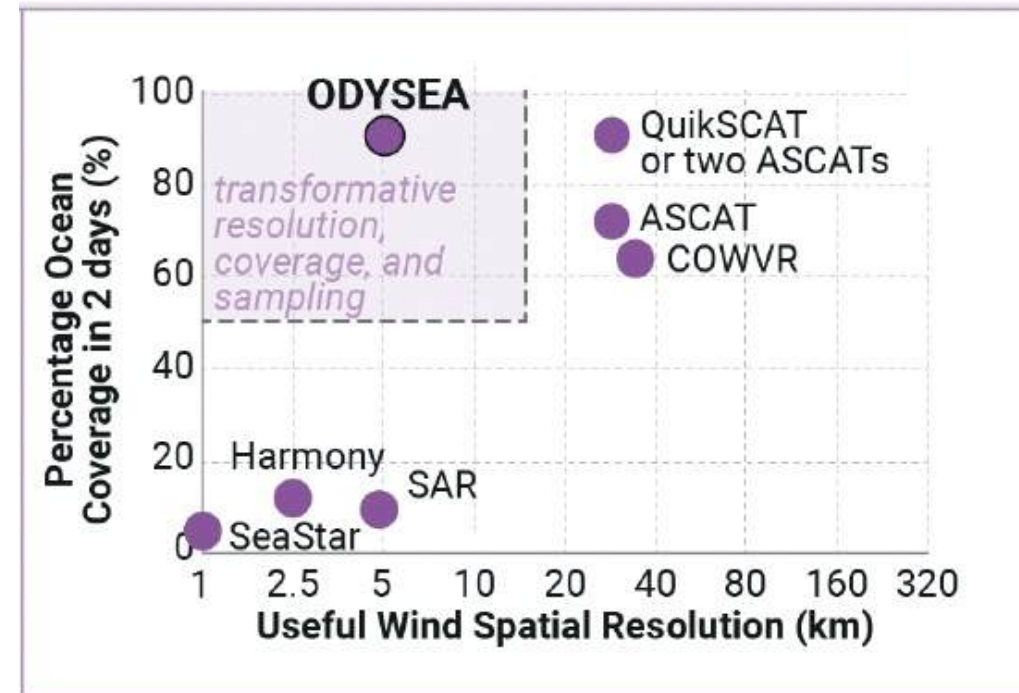
Hypothesis B



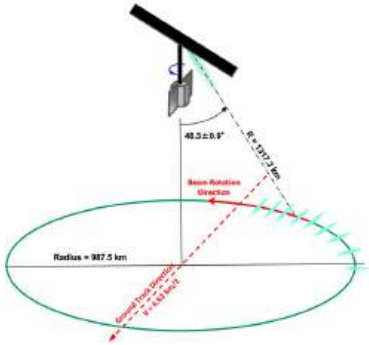
Underscores need for more extensive global observations of winds and currents

Meeting operational needs

- Near real time winds and currents
- Storm evolution, surface waves, maritime safety, debris transport
- Support NOAA, Navy, Coast Guard Search and Rescue, Mercator Ocean international



ODYSEA Mission Overview



- Science and operational capabilities fill a void
 - No satellites measure total surface currents
 - No US scatterometers measure winds, no 5-km postings, no sun synchronous measurements in midnight—6 am time range
- 90% global coverage < 1 day (2x/day in many places)
- ~650 km sun-synchronous terminator (4:30 am/4:30 pm) orbit
- Capability for near-real time ocean wind and currents data products (<6 hour latency)
- One of four Earth System Explorers selected for 9 months of further study
 - Science has been reviewed; now demonstrate that goals can be achieved on time and on budget
- 2 missions will be selected for launch in 2030 and 2032

How can you get involved?

1. Test science ideas using the ODYSEA simulator (<https://odysea.ucsd.edu>)

2. Discuss the science:
OASIS Grand Idea #2: Air-Sea Fluxes from Space

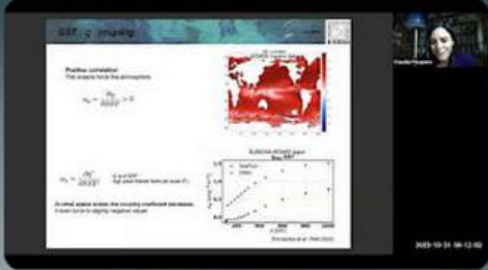
Webinar Tuesdays at 8 am PT, 11 am ET, 5 pm CET

Sign up from the OASIS web site: <https://airseaobs.org/>

Find previous recordings on youtube

Steering committee:

- Mara Freilich, Brown University
- Sarah Gille, Scripps Institution of Oceanography, UC San Diego
- Christine Gommenginger, National Oceanography Centre
- Tony Lee, Jet Propulsion Lab
- Paco Lopez-Dekker, Technical University Delft
- Claudia Pasquero, Università di Milano - Bicocca
- Aneesh Subramanian, University of Colorado
- Bia Villas Bôas, Colorado School of Mines



**OASIS Webinar Series:
Air-Sea Flux from Space**

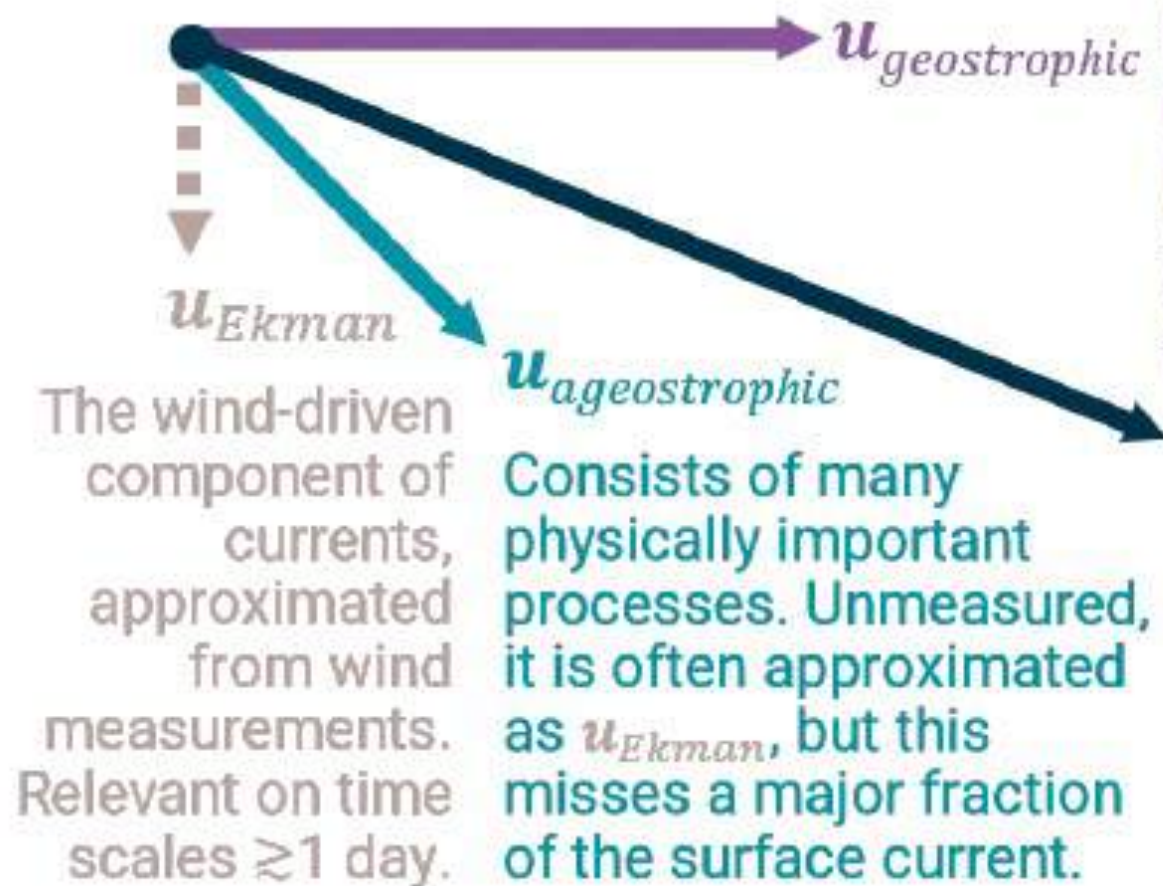
OASIS Community
59 videos 128 views Updated 5 days ago

⋮ ↻ ⋮

▶ Play all Shuffle

A weekly OASIS webinar series on Tuesdays at 8 am Pacific to advance community discussion of key science, with a multi-satellite focus on "Air-sea fluxes from space". Register for the series at airseaobs.org/webinars

$$\mathbf{u}_{total_curr} = \mathbf{u}_{geostrophic} + \mathbf{u}_{ageostrophic}$$



The blurred lens through which we see large-scale currents today; approximated from altimeter sea surface height measurements at scales ≥ 200 km. SWOT provides sea surface height gradients at 21-day intervals within 100-km wide swaths, yielding $\mathbf{u}_{geostrophic}$ but only to the extent that geostrophy holds on scales < 100 km.

\mathbf{u}_{total_curr}

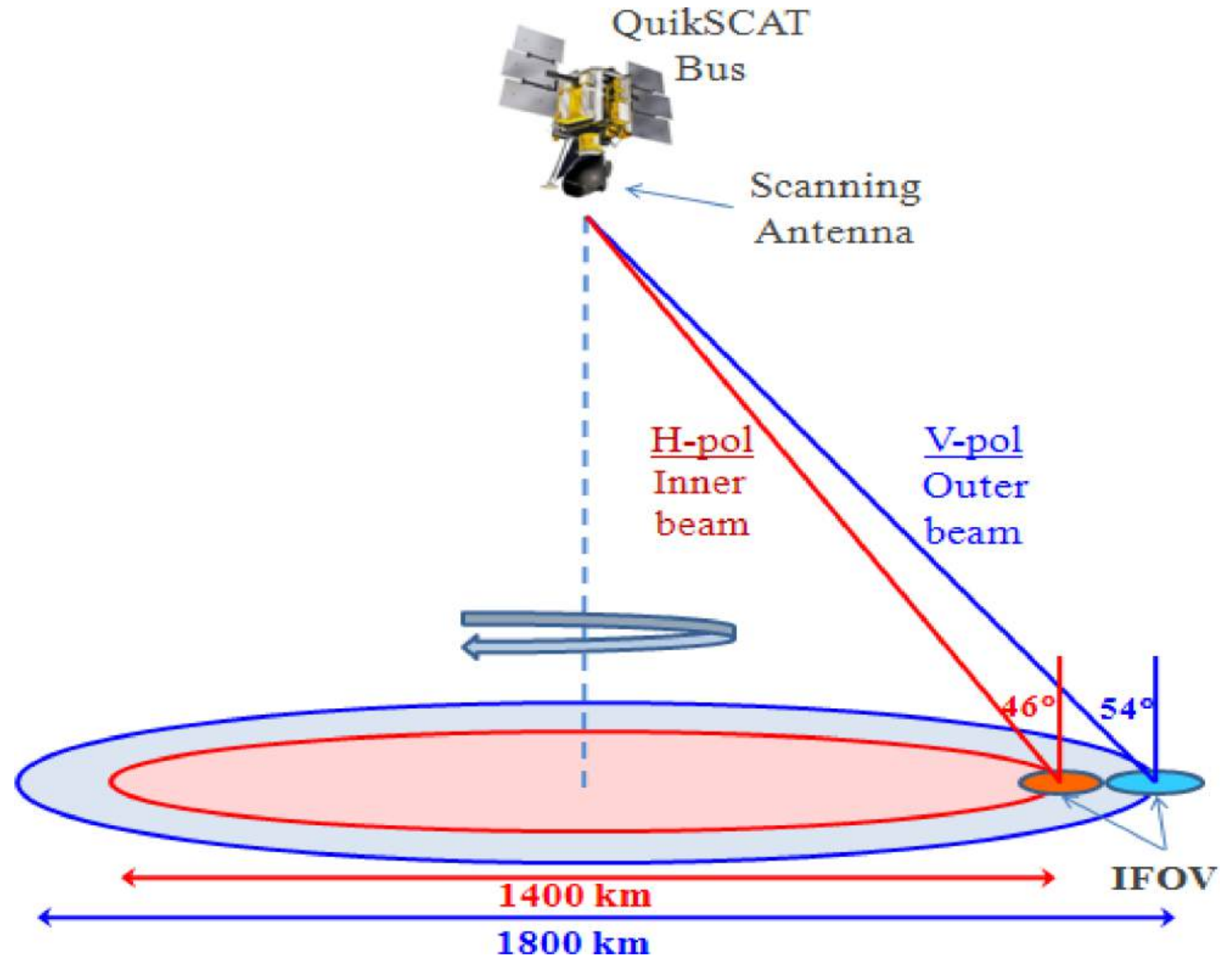
ODYSEA measures the true ocean surface current without approximations, enabling study of all these processes.

Measuring wind with scatterometry

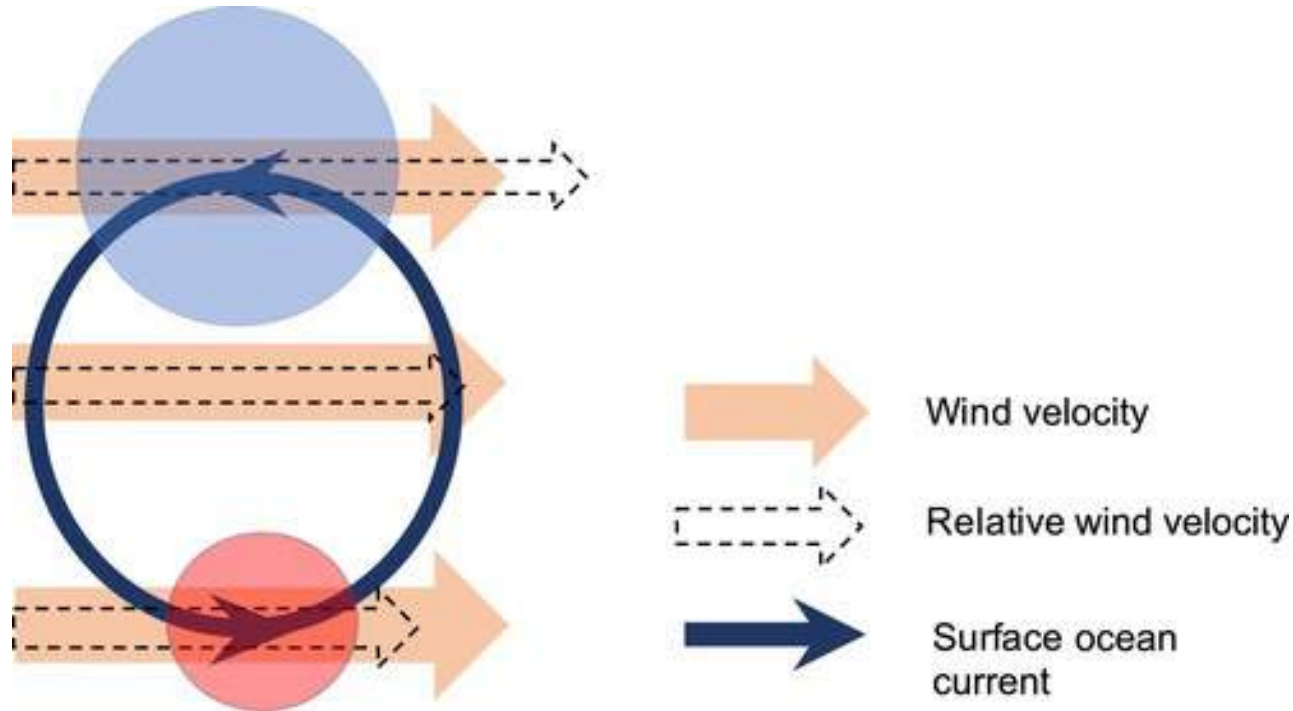
Multiple looks at each patch of ocean.

Use backscattered radar signal to identify wind speed and direction.

Passive instruments (e.g. COWVR) use emitted radiation



Why relative winds?



Rai et al, Science Advances, 2021

Winds counter to currents strengthen the relative wind and exert more stress on the ocean

Winds aligned with currents imply less relative wind and less stress to drive the current.

- Capillary waves measured by satellite depend on wind relative to current, so if satellites were our only means to measure wind, we could ignore relative winds.
- But we calibrate to in situ winds and use models without relative effects, so, we need to be able to tease these components apart.

Vec

Satellite	ECT/Lon	Orbit	DLR	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	
CIMR-A	06:00 desc	SunSync							X	X	X	X	X	
CIMR-B	06:00 desc	SunSync							Passive sensors			X	X	X
ISS COWVR	51.6 °	DRIFT		X										
HY-2L	07:00 desc	SunSync			X	X	X	X						
HY-2D	66 °	DRIFT		X	X	X							China	
HY-2E	06:00 desc	SunSync		X	X	X	X	X						
HY-2F	66 °	DRIFT			X	X	X	X	X					
WSF-M1	06:00 desc	SunSync		X	X	X	X	X	X	X				
WSF-M2		SunSync						X	X	X	X	X	X	
OceanSat-3 (EOS-06)	12:00 desc	SunSync		X	X	X	X							
OceanSat-3A	12:00 desc	SunSync			X	X	X	X	X	X				
Metop-SG-B1	09:30 desc	SunSync				X	X	X	X	X	X	X	X	
Metop-SG-B2	09:30 desc	SunSync											X	
Metop-SG-B3	09:30 desc	SunSync												
Meteor-MP N1	15:30 asc	SunSync			X	X	X	X	X	X	X	X		
Meteor-MP N2	09:30 desc	SunSync				X	X	X	X	X	X	X	X	
FY-3E	05:40 desc	SunSync		X	X	X	X	X	X				China	
FY-3J	05:00 desc	SunSync					X	X	X	X	X	X	X	
Metop-B	09:31 desc	SunSync	88	X	X	X								
Metop-C	09:31 desc	SunSync	108	X	X	X	X							
HY-2B	06:00 desc	SunSync	533	X									China	
HY-2C	66 °	DRIFT	618	X	X									

How to measure wind from satellite



Capillary waves are cm-scale waves

Waves align consistently relative to wind

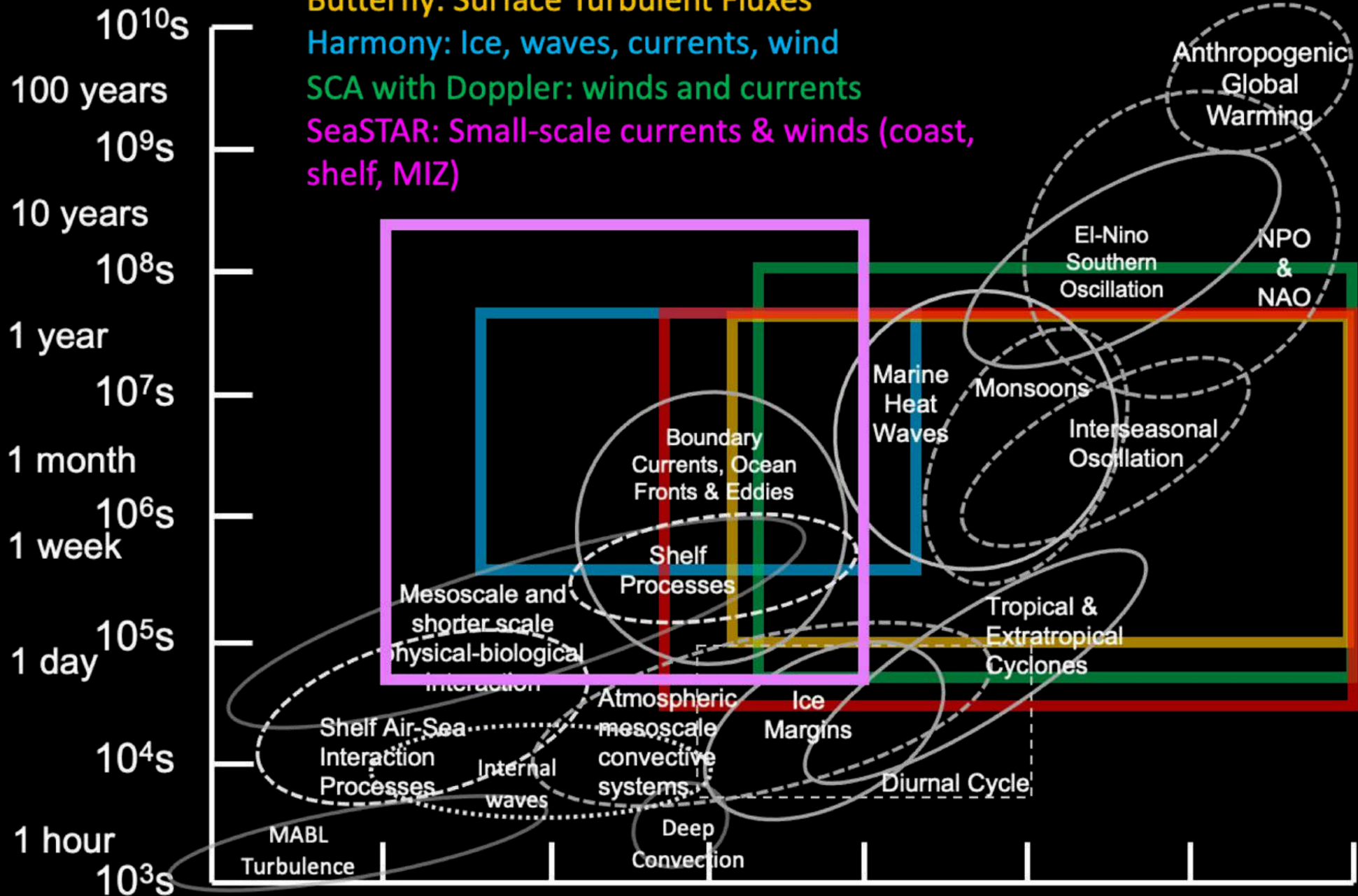
ODYSEA: Winds and Current Coupling

Butterfly: Surface Turbulent Fluxes

Harmony: Ice, waves, currents, wind

SCA with Doppler: winds and currents

SeaSTAR: Small-scale currents & winds (coast, shelf, MIZ)





ODYSEA

Ocean Dynamics and Surface Exchange with the Atmosphere

- 2 science objectives
- 1 applications objective

OBJECTIVES



Determine if **wind–current coupling impacts the positions** of major currents and causes rotation in surface winds that drives vertical motion in the atmosphere.



Determine how **surface currents exchange kinetic energy** at large and small scales and whether **surface current response to wind** is stronger when the ocean surface mixed layer is shallower.



Incorporate **total surface current and simultaneous wind** measurements in ocean and coupled ocean–atmosphere models at NOAA, DoD, and Mercator Ocean International.