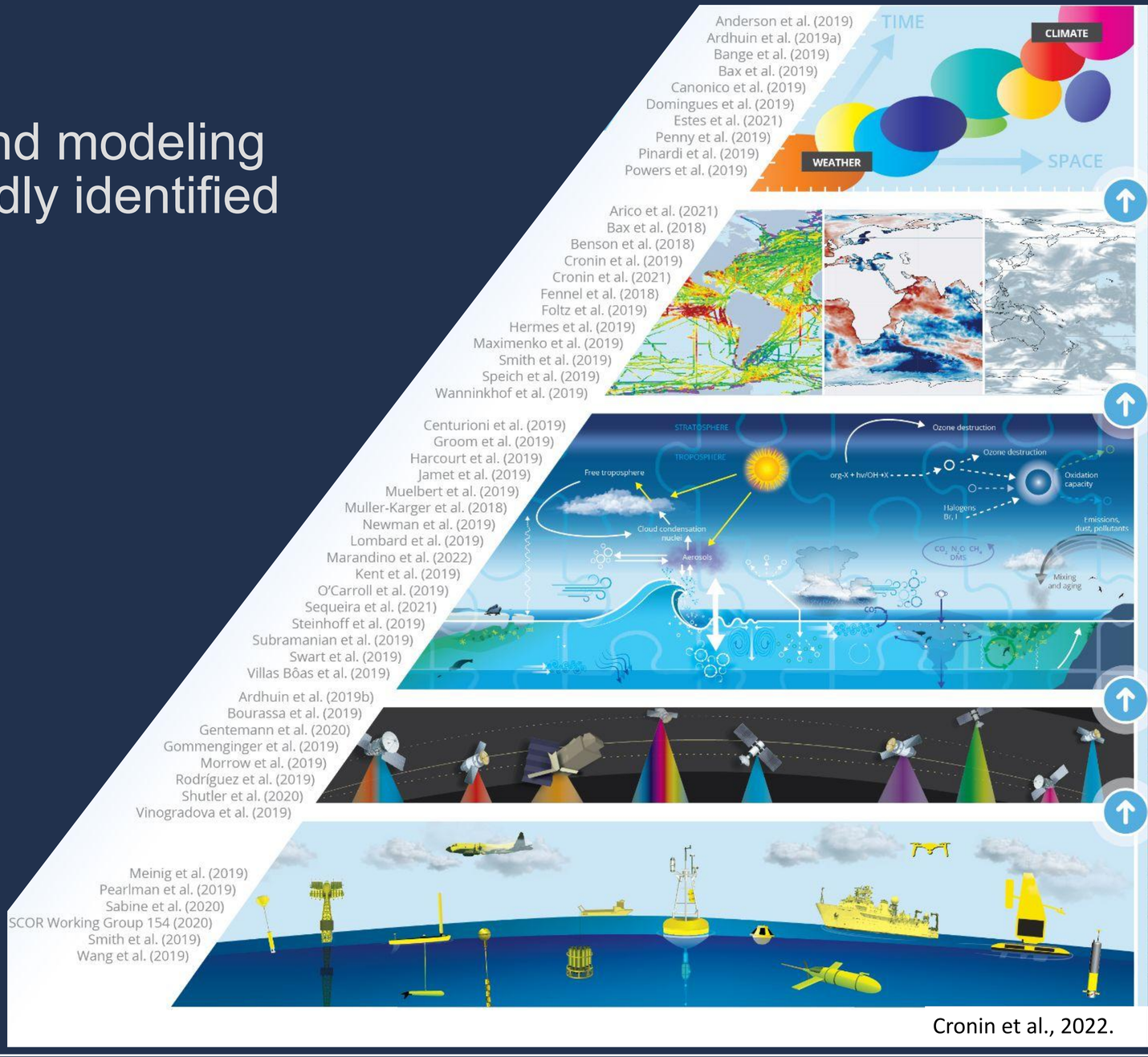
What to do when we can't have

EVERYTHING EVERYWHERE ALL AT ONCE

Bia Villas Bôas | villasboas@mines.edu

With material from: ASTZ study group, ODYSEA and S-MODE science teams, OASIS community, and Seo et al. (2023).

The need for improved observation and modeling of ASTZ processes has been repeatedly identified by the community.



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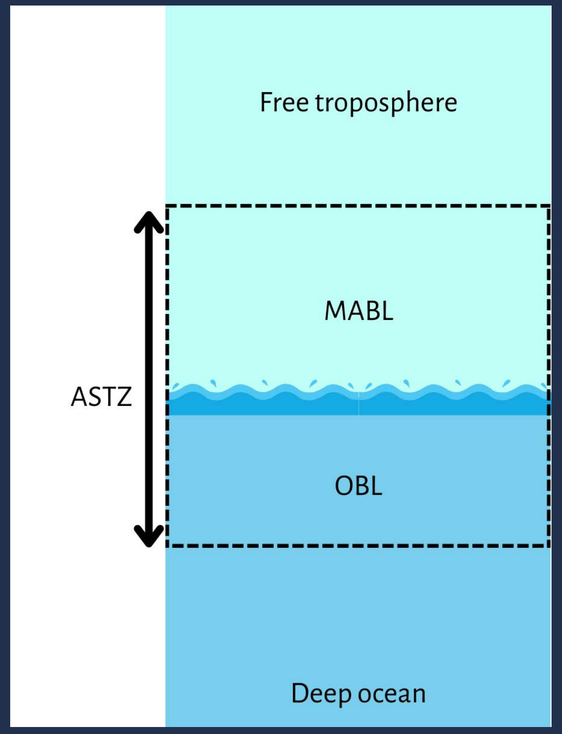

Air-Sea Transition Zone

Image: ASTZ Study Group

Anderson et al. (2019)
Ardhuin et al. (2019a)
Bange et al. (2019)
Bax et al. (2019)
Canonico et al. (2019)
Domingues et al. (2019)
Estes et al. (2021)
Penny et al. (2019)
Pinardi et al. (2019)
Powers et al. (2019)

Arico et al. (2021)
Bax et al. (2018)
Benson et al. (2018)
Cronin et al. (2019)
Cronin et al. (2021)
Fennel et al. (2018)
Foltz et al. (2019)
Hermes et al. (2019)
Maximenko et al. (2019)
Smith et al. (2019)
Speich et al. (2019)
Wanninkhof et al. (2019)

Centurioni et al. (2019)
Groom et al. (2019)
Harcourt et al. (2019)
Jamet et al. (2019)
Muelbert et al. (2019)
Muller-Karger et al. (2018)
Newman et al. (2019)
Lombard et al. (2019)
Marandino et al. (2022)
Kent et al. (2019)
O'Carroll et al. (2019)
Sequeira et al. (2021)
Steinhoff et al. (2019)
Subramanian et al. (2019)
Swart et al. (2019)
Villas Bôas et al. (2019)

Ardhuin et al. (2019b)
Bourassa et al. (2019)
Gentemann et al. (2020)
Gommenginger et al. (2019)
Morrow et al. (2019)
Rodríguez et al. (2019)
Shutler et al. (2020)
Vinogradova et al. (2019)

Meinig et al. (2019)
Pearlman et al. (2019)
Sabine et al. (2020)
SCOR Working Group 154 (2020)
Smith et al. (2019)
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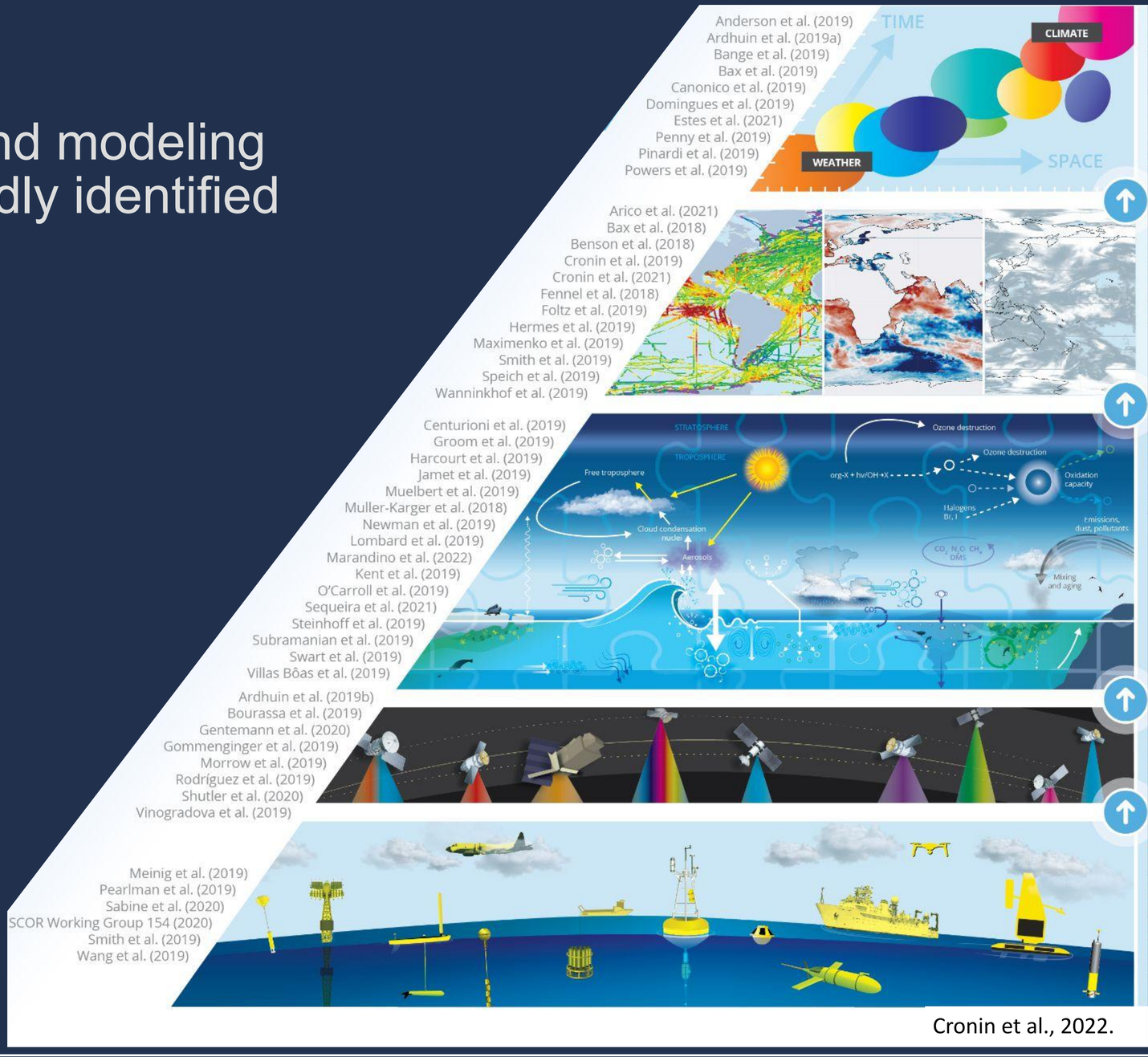

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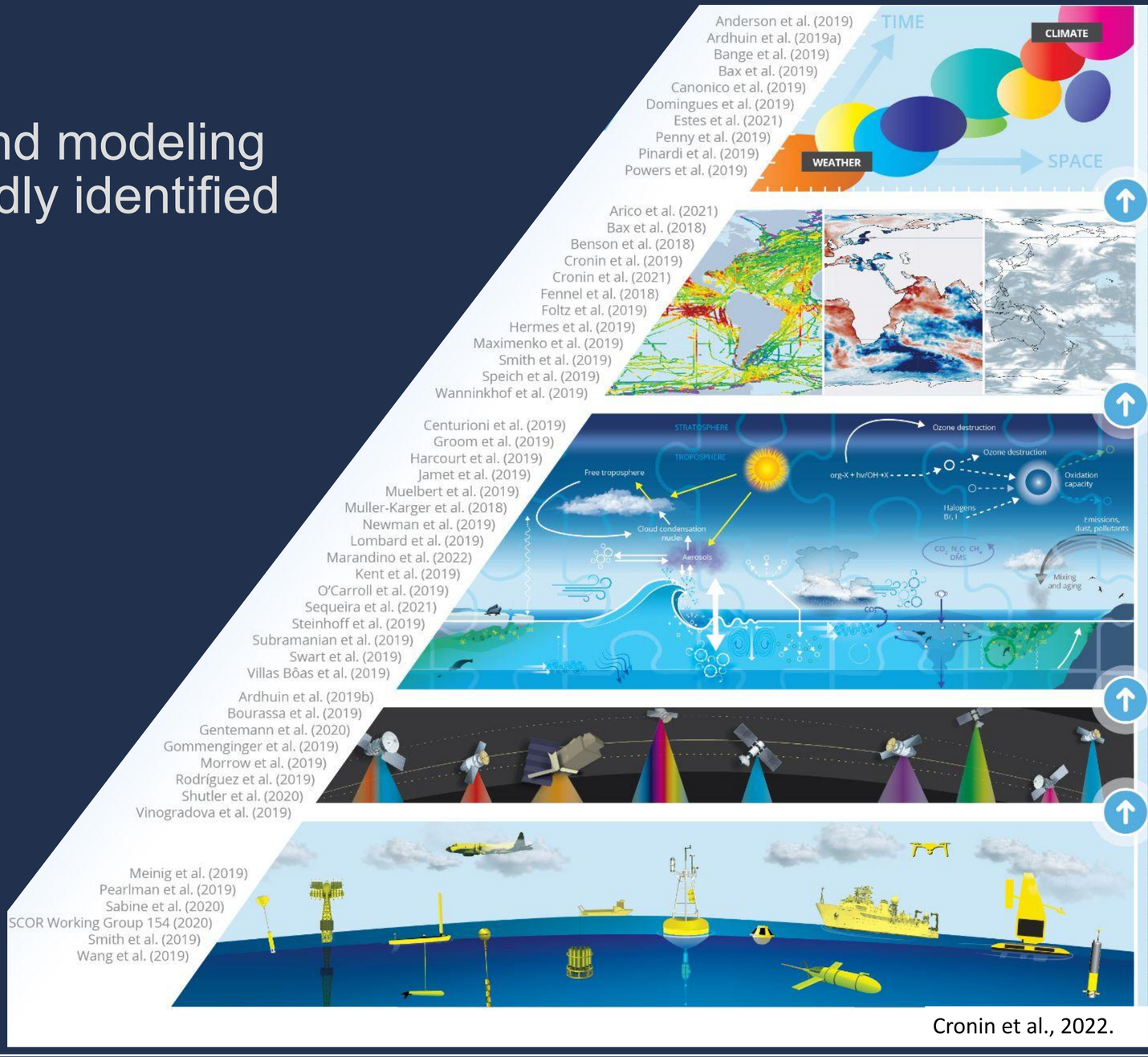


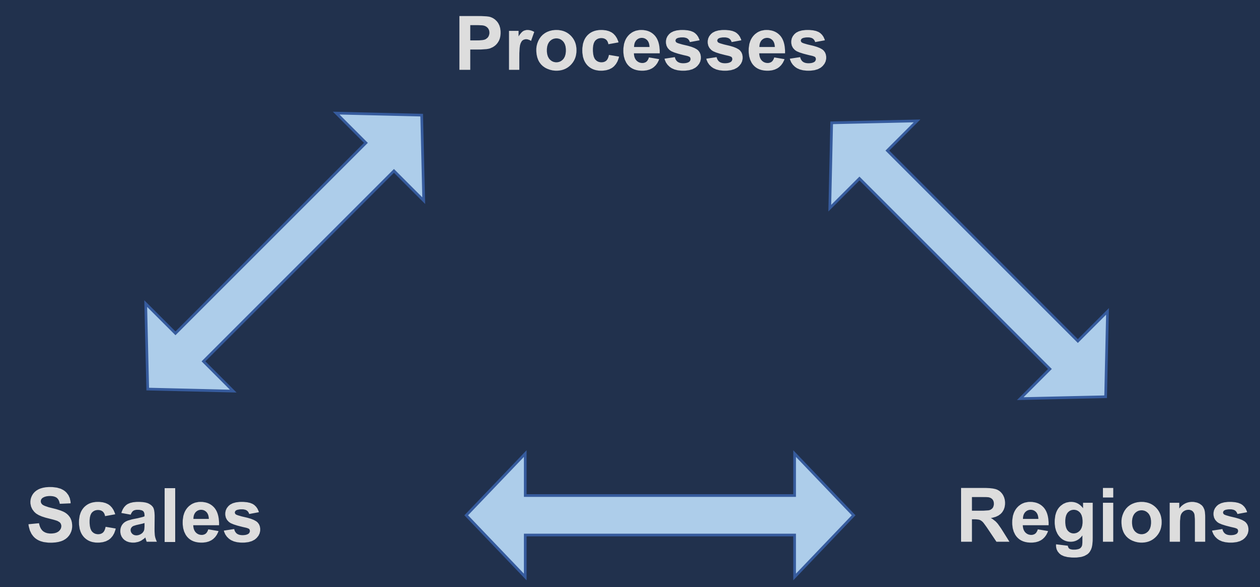
Cronin et al., 2022.

Q1: What are the **gaps** in observations and modeling capability that need to be addressed to properly determine the role of ASTZ processes in weather and climate variability?

- What regions, observables, and time and space scales should be a focus of modeling and observations?

Q2: What are potential outcomes of concerted modeling and observational programs focused on the ASTZ?

Processes, **scales**, and **regions** define needs and help to identify gaps.



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Surface processes: fluxes and sea state

- Quantify the role of the sea state and ocean meso and submesoscales in mediating air-sea fluxes

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Extremes

- Improve prediction skill for floods & droughts, tropical cyclones, marine heat waves, atmospheric rivers …

Research Highlights that support needs

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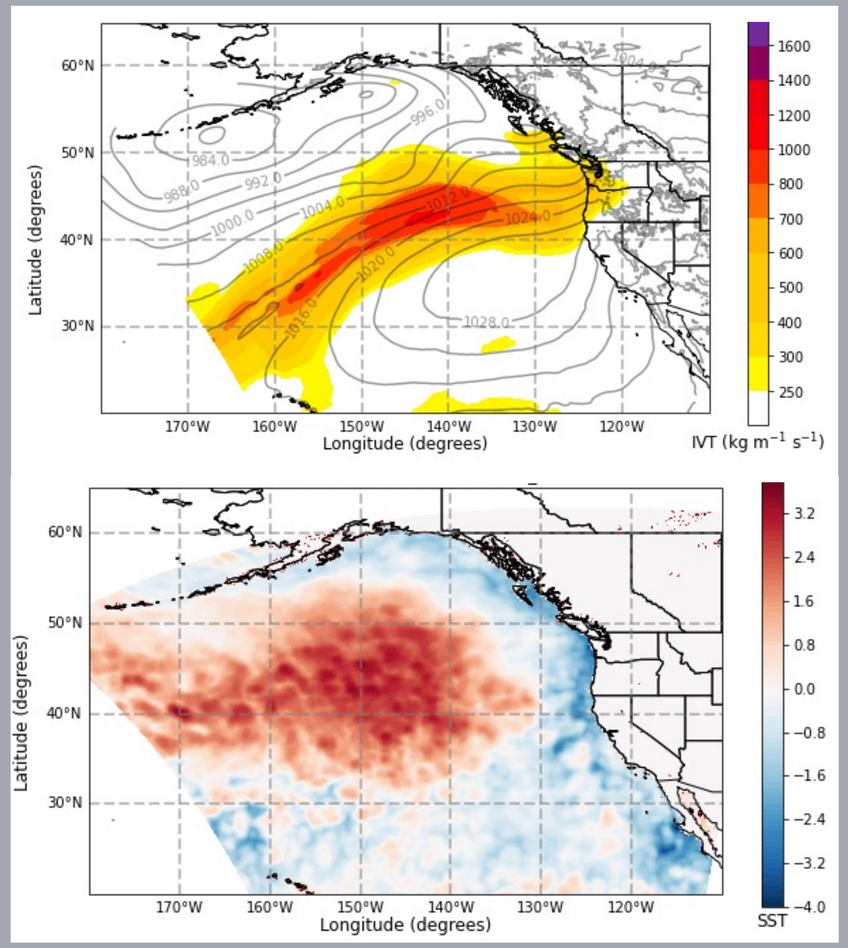
Impact of the “blob” on ARs



Ally Cobb’s poster

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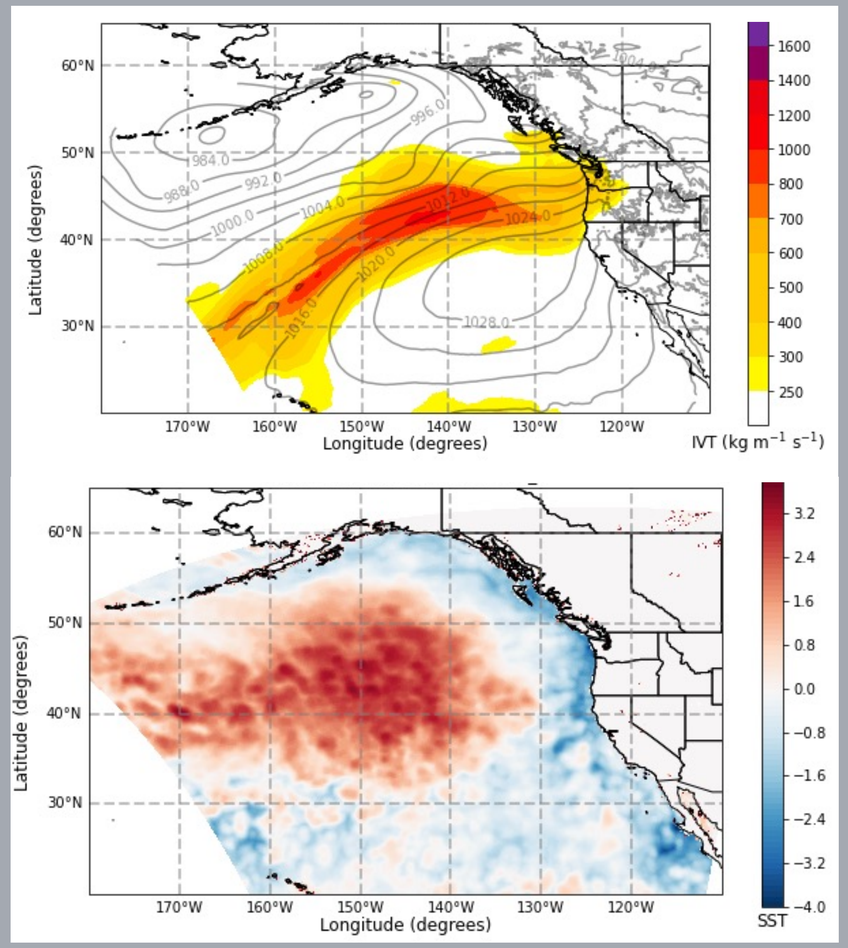

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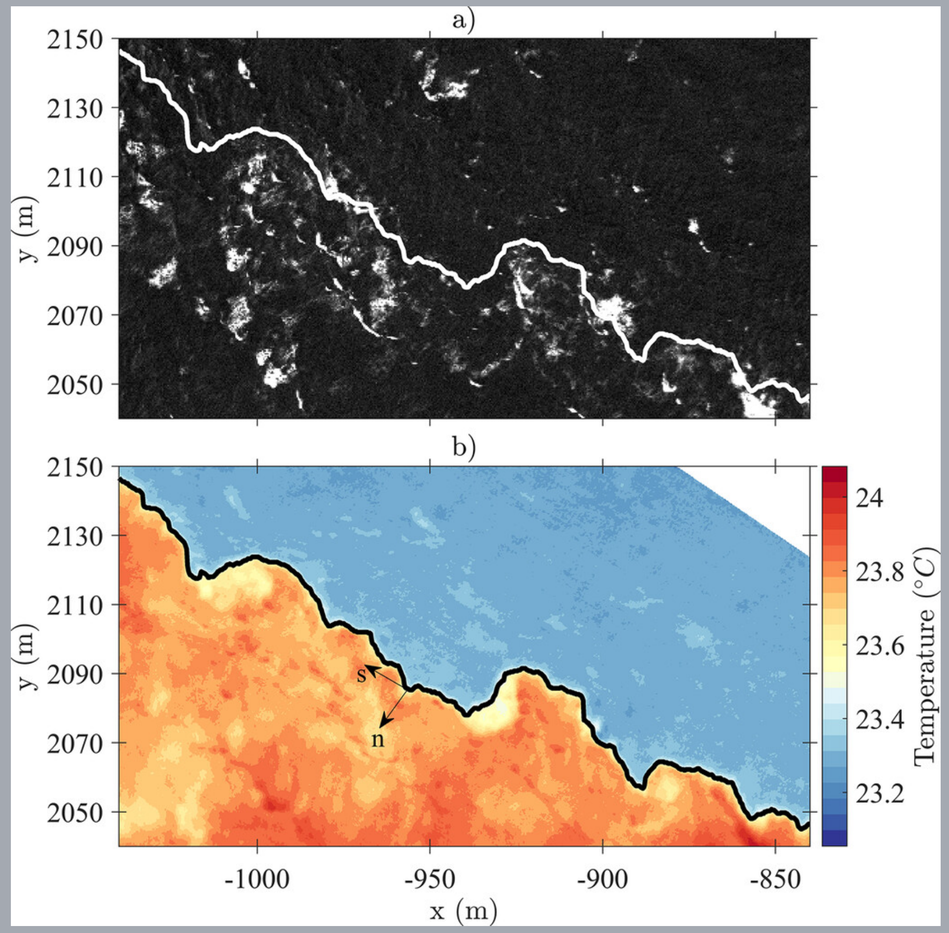
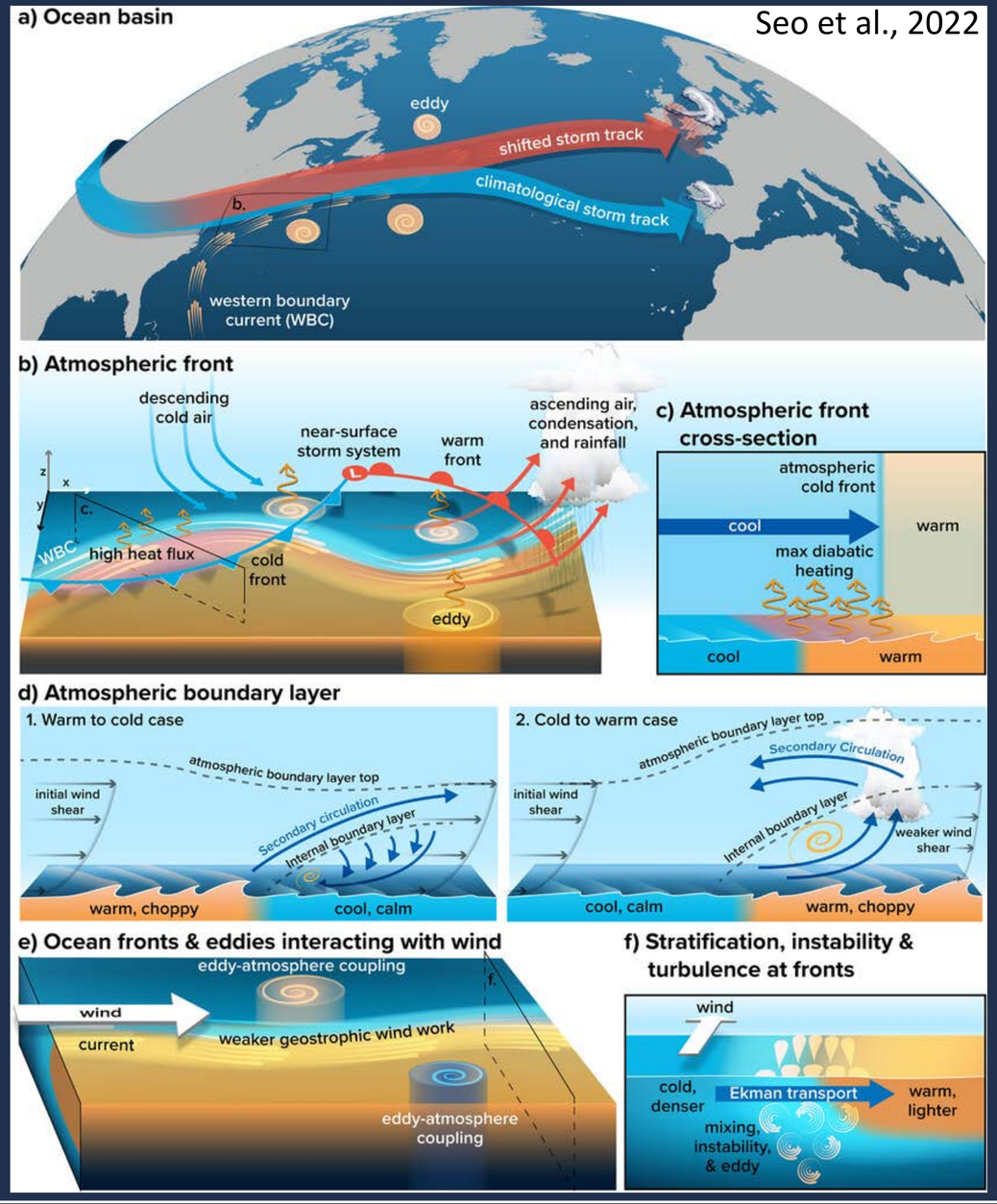
Modulation of wave breaking by fronts



Nick Pizzo’s poster. Also Vrećica et al., 2022

2. Needs from scales



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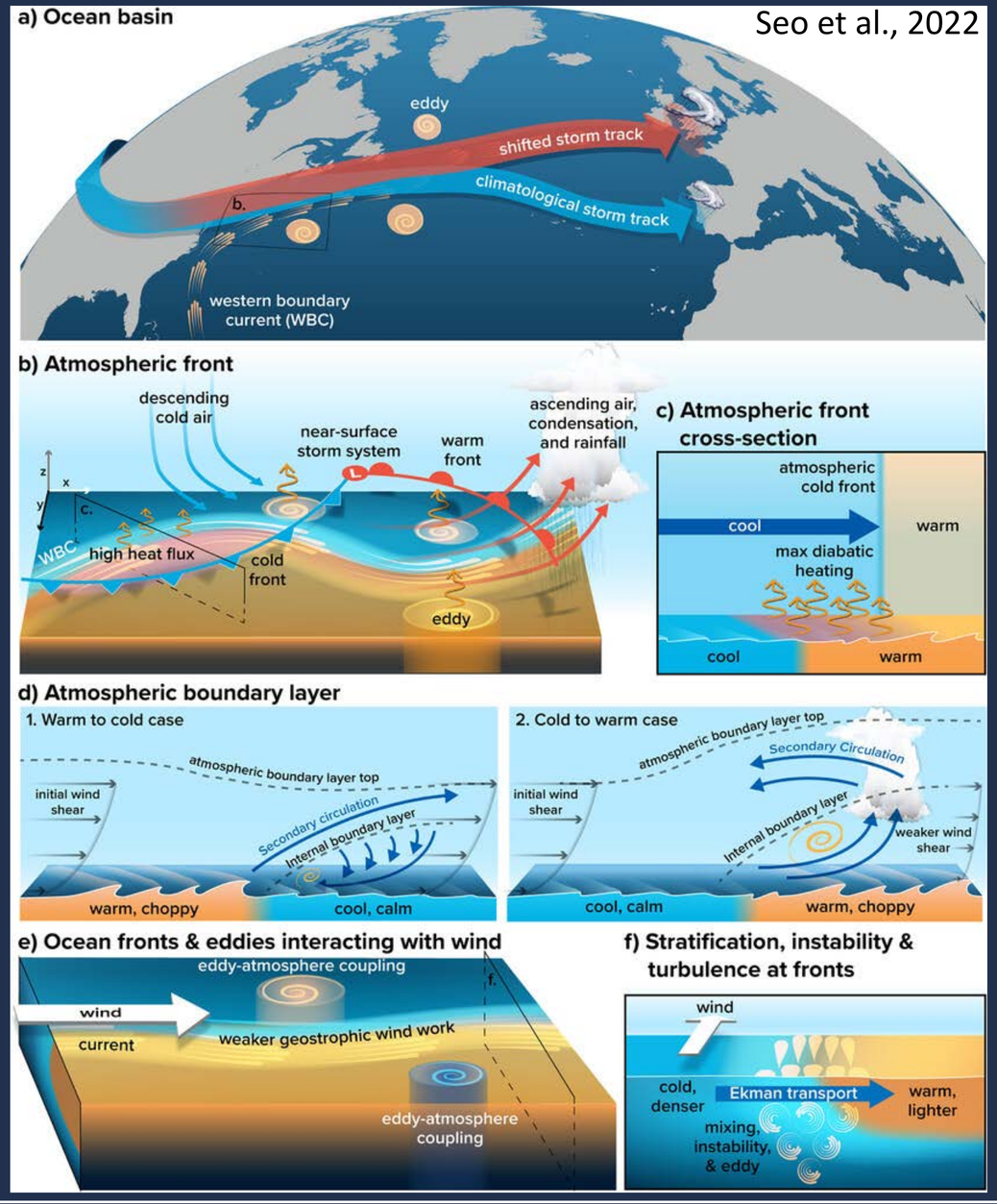
Large scale

- Better constrain the effects of ocean forcing on synoptic storms, storm tracks, and rainfall patterns



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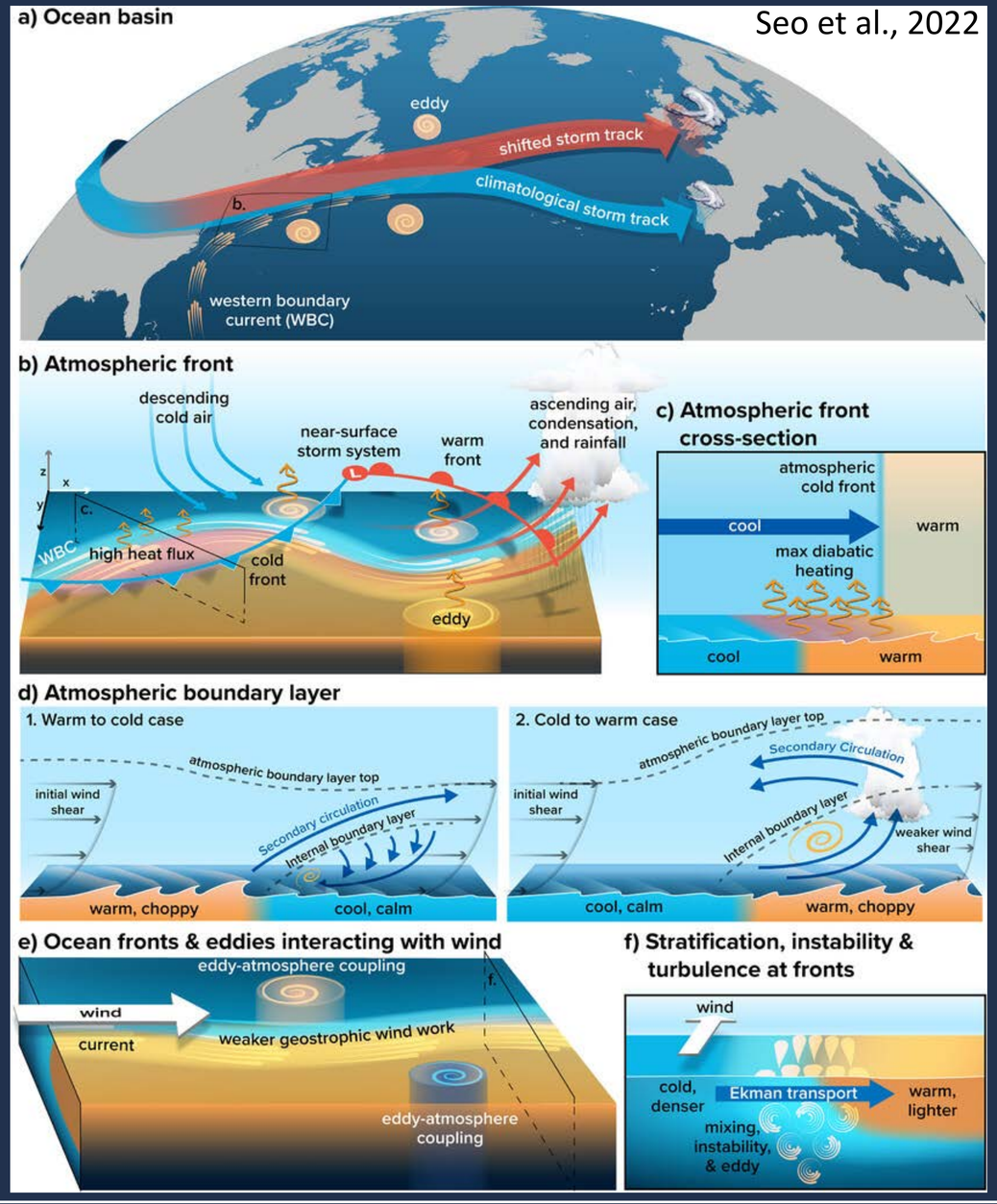

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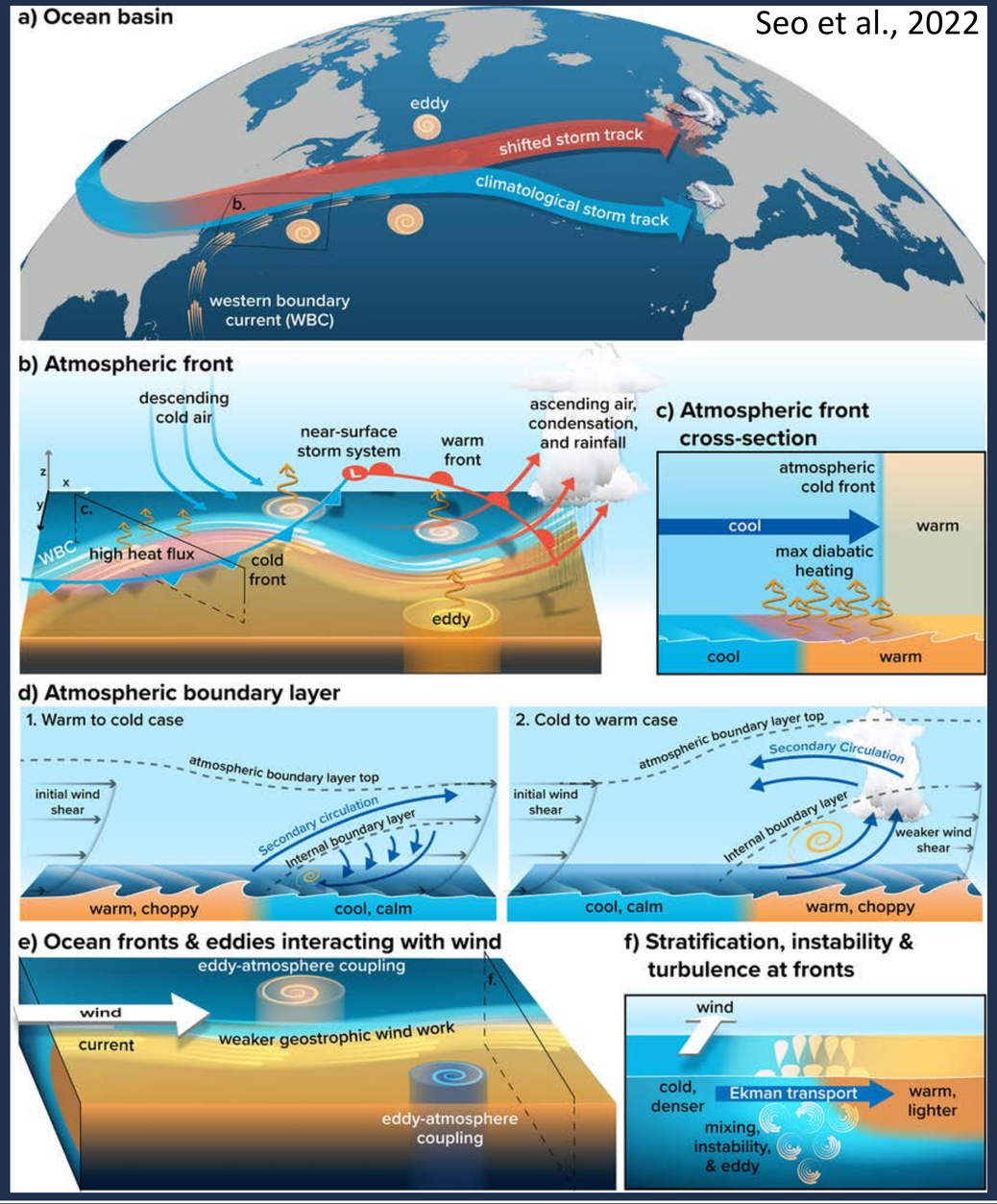
Oceanic submesoscale

- Quantify the relative importance of thermal and current feedback



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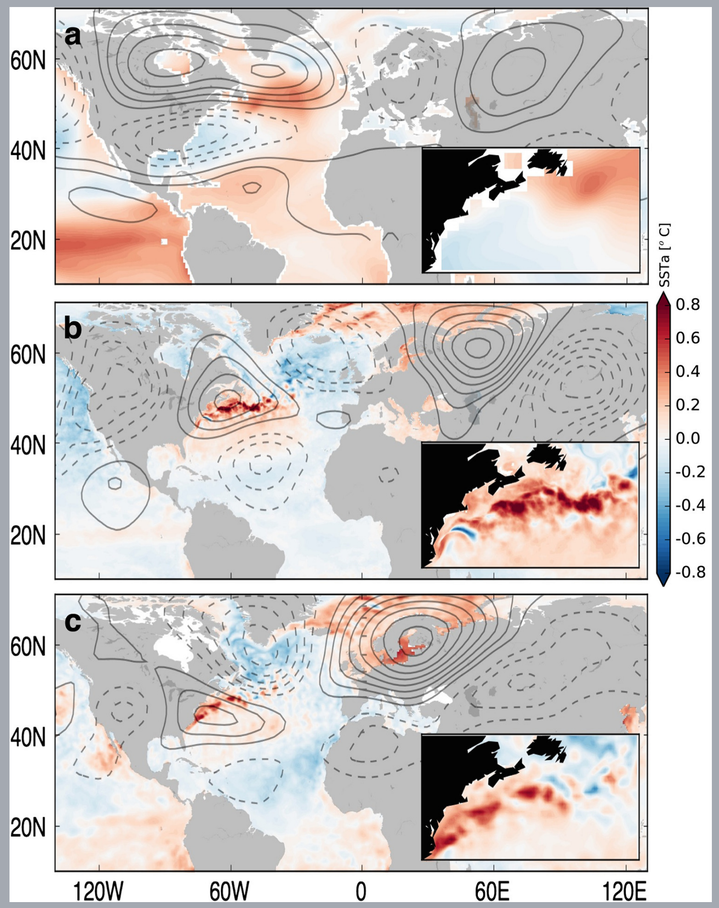
Assessment of near-term climate predictability requires models that resolve oceanic mesoscale



Siqueira and Kirtman, 2016

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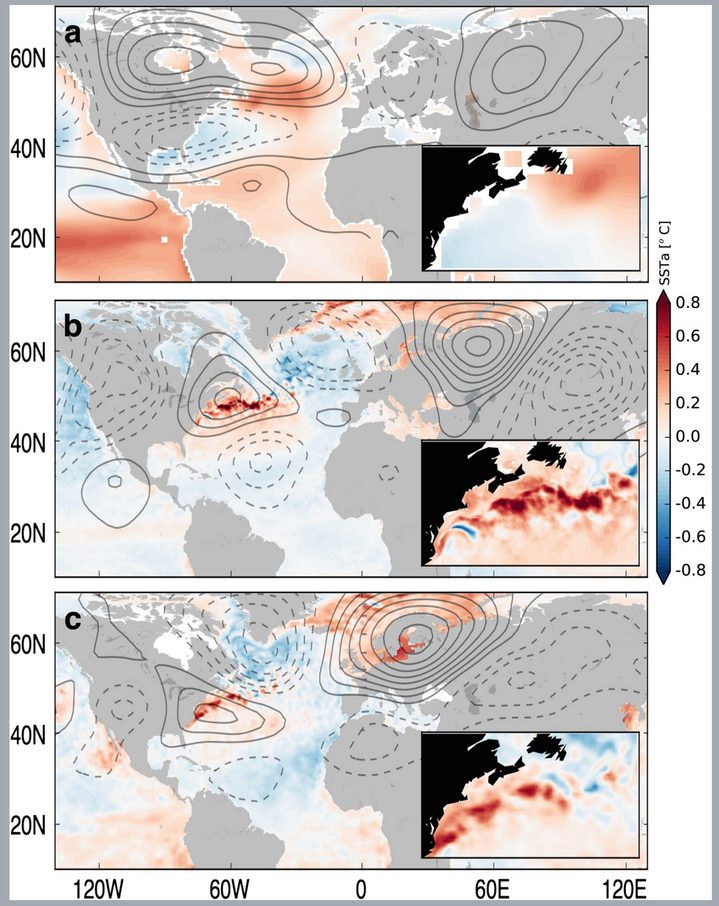
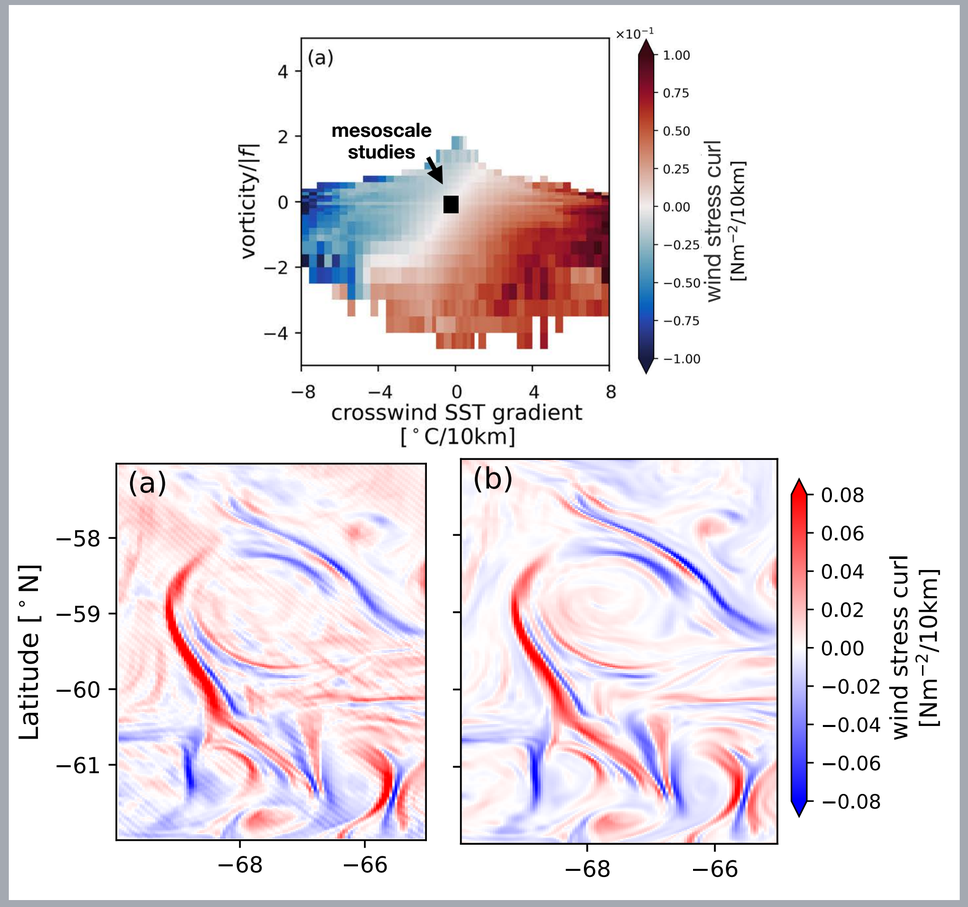


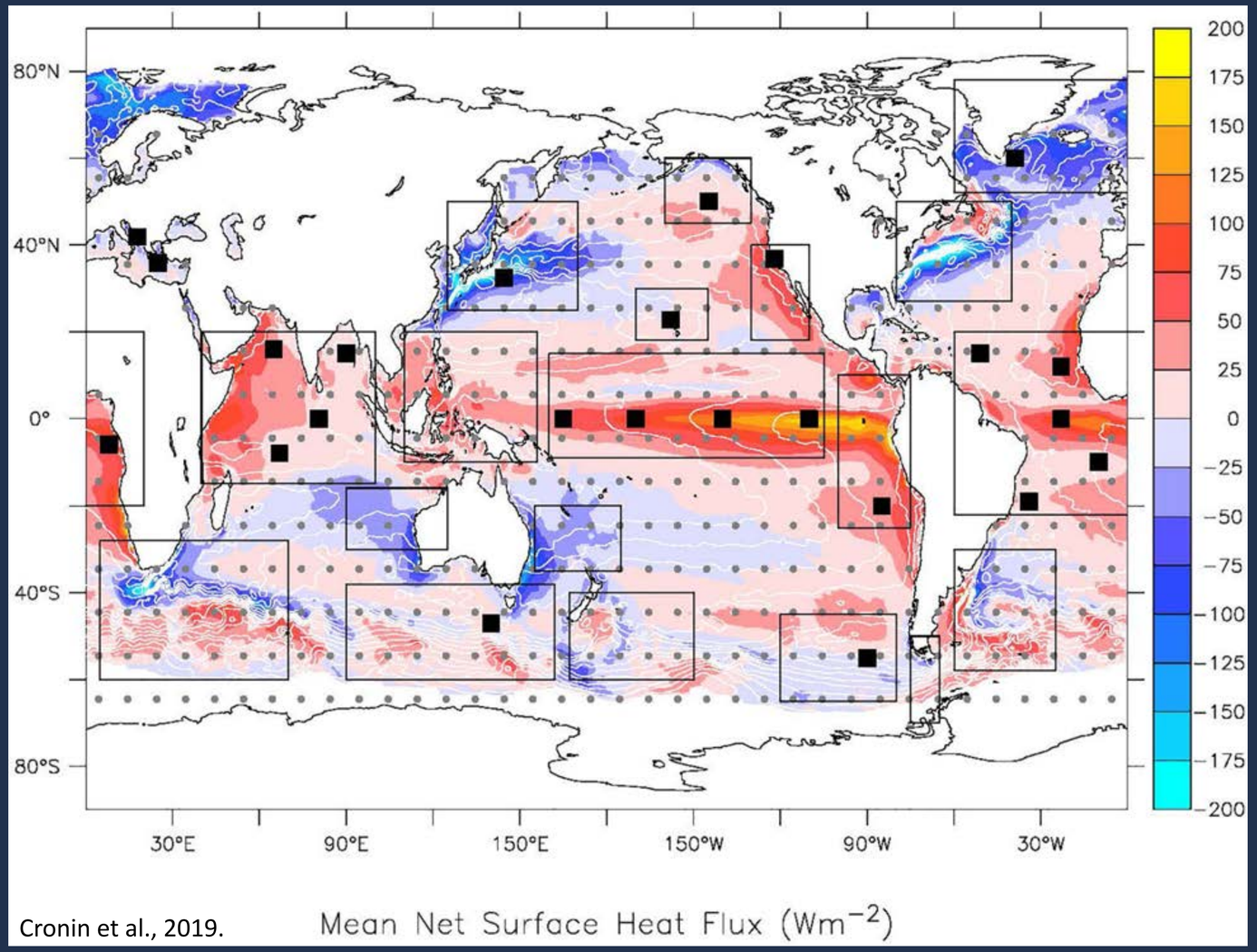
Siqueira and Kirtman, 2016

Current and thermal feedback (together) modify wind stress gradients



Luna Bai's talk

3. Needs from regions



Cronin et al., 2019.

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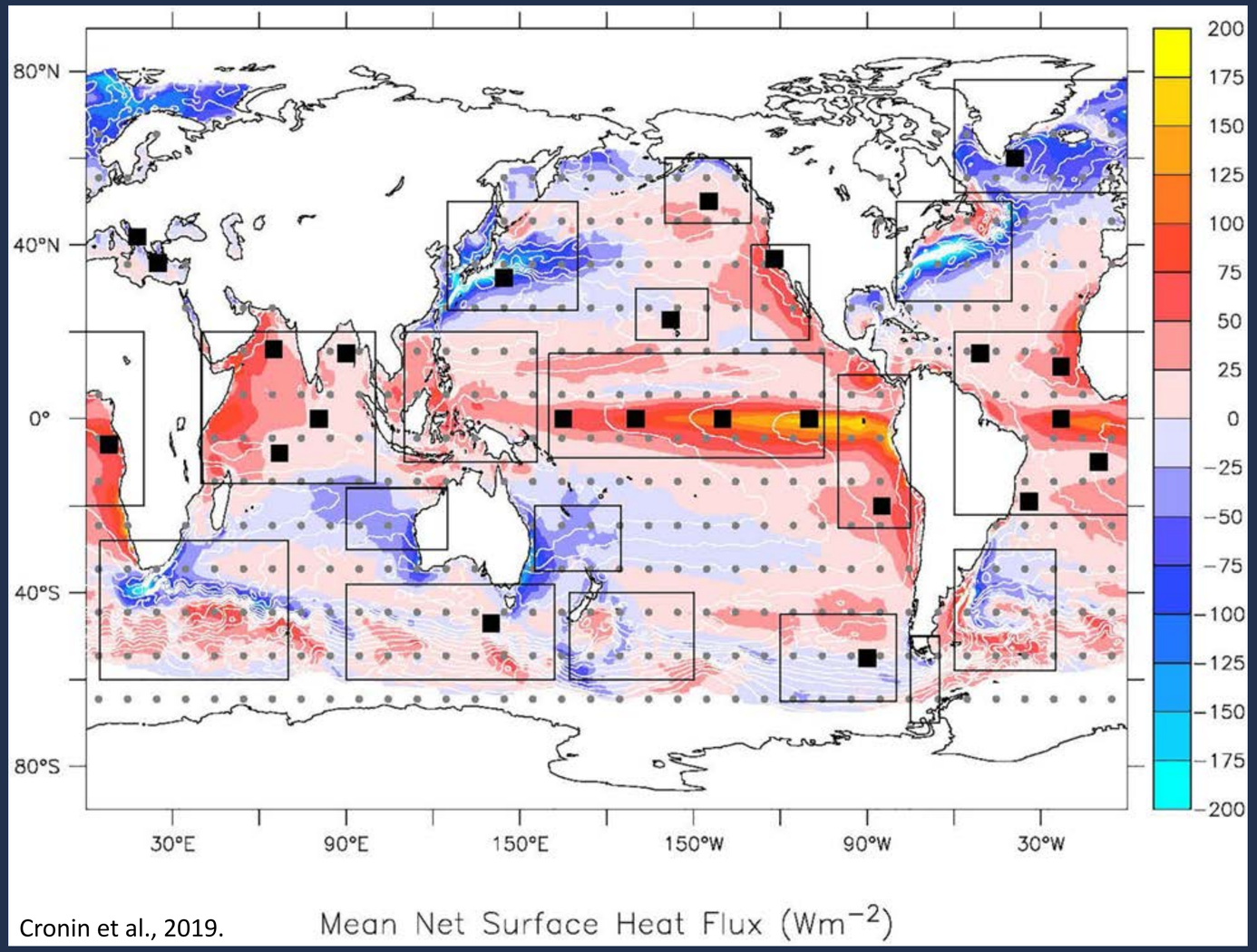

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High Latitudes + MIZ

- Large disagreement between surface flux observational products (MOST/bulk falls apart, extreme winds and waves, ice cover)

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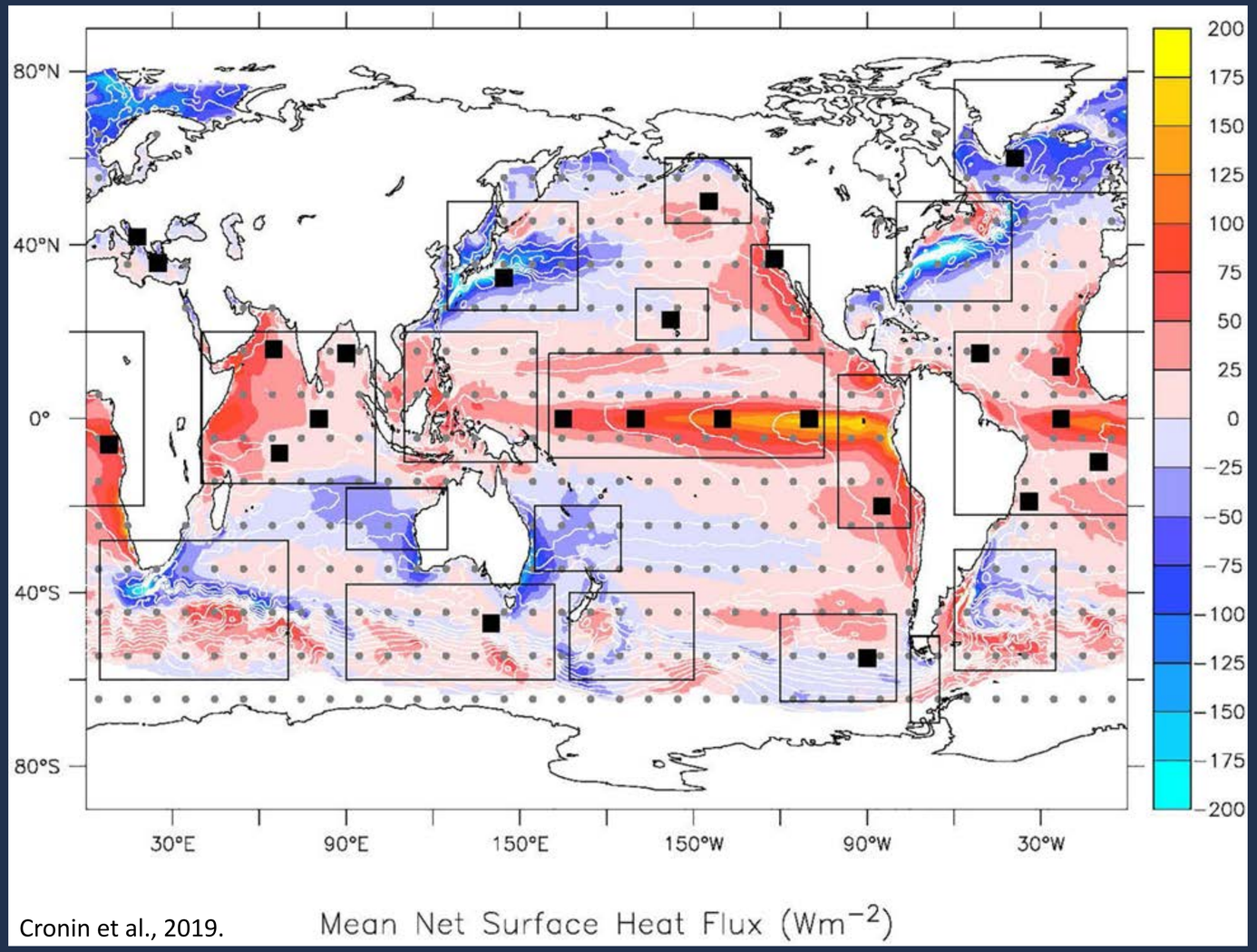

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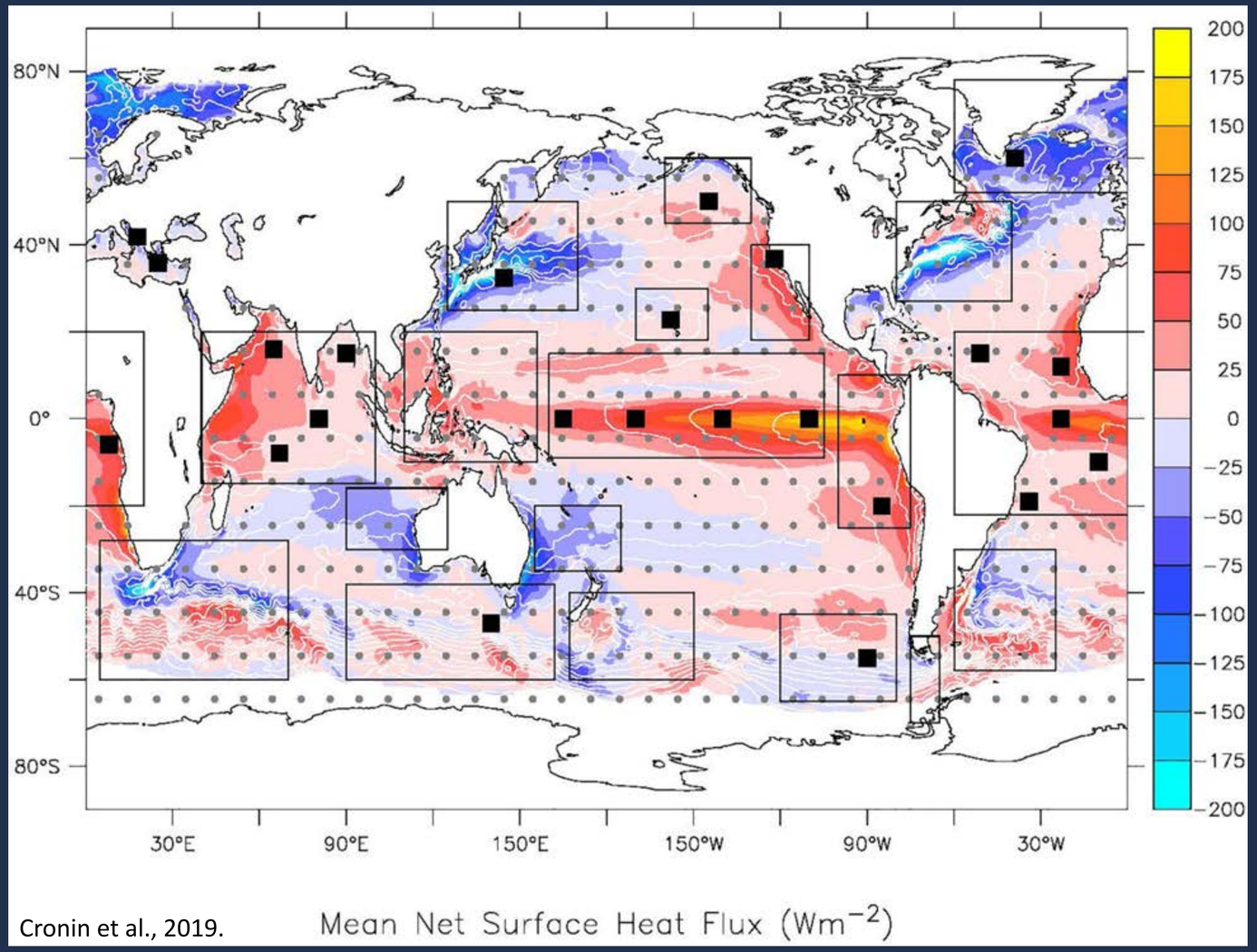

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Tropics

- Diurnal variability of the ABL, SST, OBL, and fluxes can be stronger than intraseasonal and annual cycles.

Research Highlights that support needs

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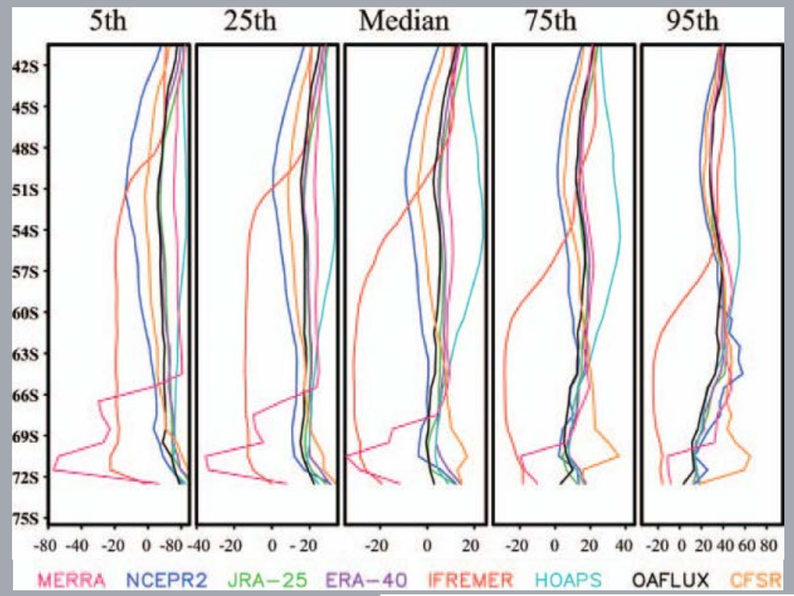
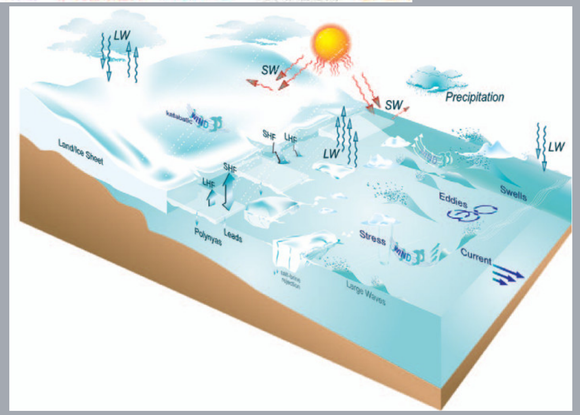
Flux products largely disagree at high latitudes



Bourassa et al., 2013 (BAMS)



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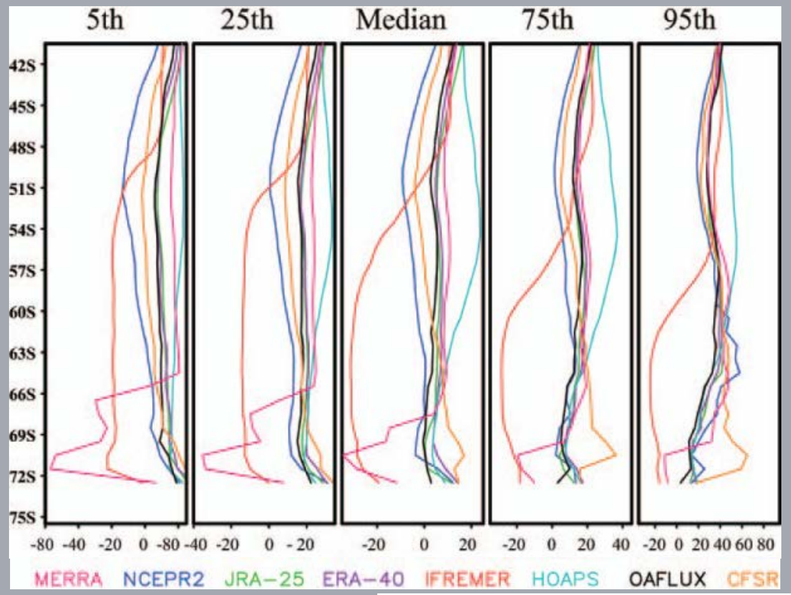

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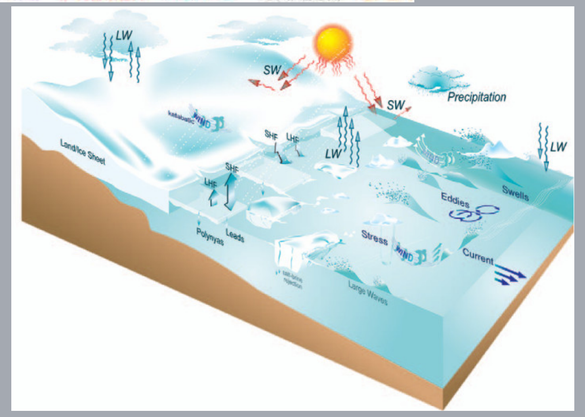
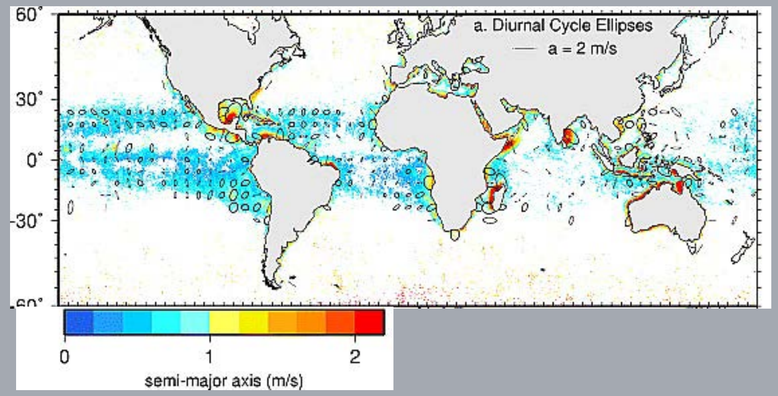
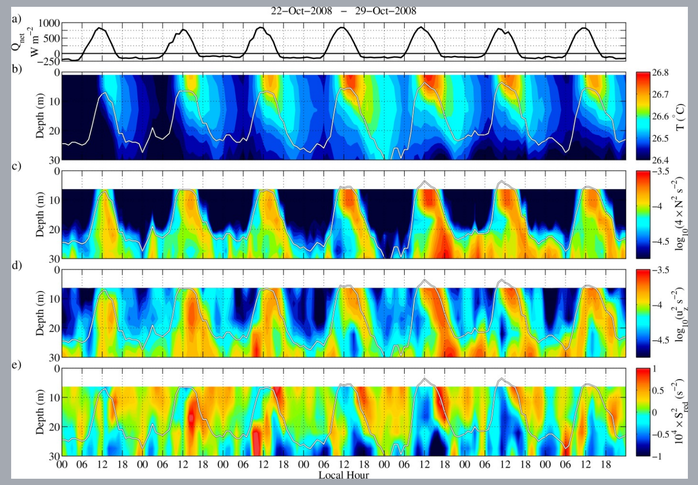


Strong diurnal variability of ASTZ variables in the tropics



Gille et al., 2005

Wenegrat and McPhaden, 2014.



Q2: What are potential outcomes of concerted modeling and observational programs focused on the ASTZ?

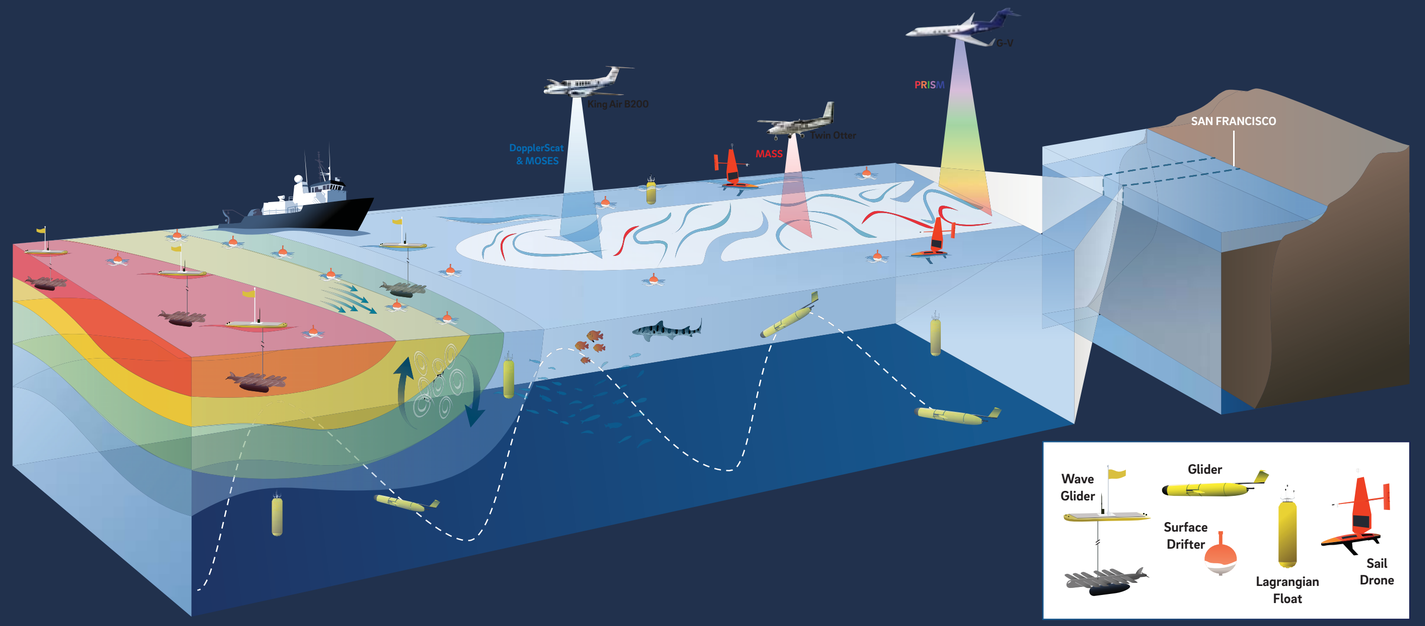
The Sub-Mesoscale Ocean Dynamics Experiment (S-MODE)

- NASA Earth Venture Suborbital mission (EVS-3)
- **Hypothesis:** ocean submesoscale processes make important contributions to vertical exchange of climate and biological variables in the upper ocean.

✅ Pilot Campaign (Fall 2021)

✅ IOP-1 (Fall 2022)

⏳ IOP-2 (Spring 2023)



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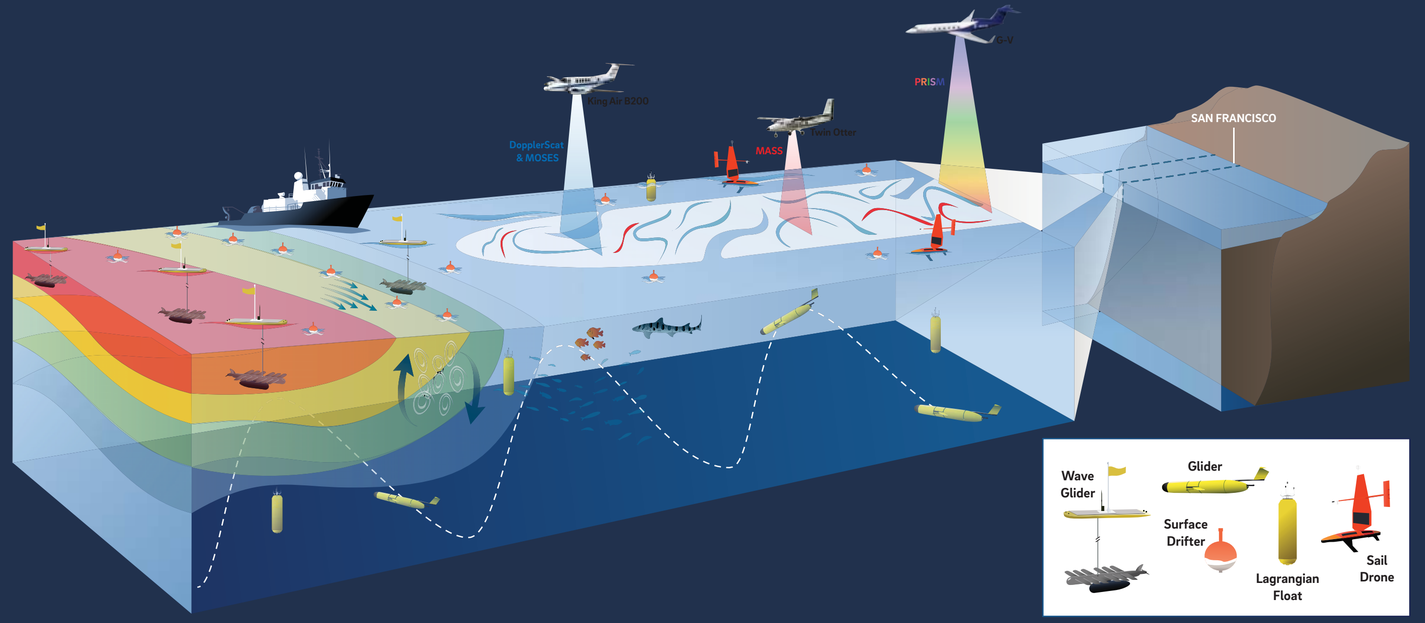

Colocated observations of ASTZ variables

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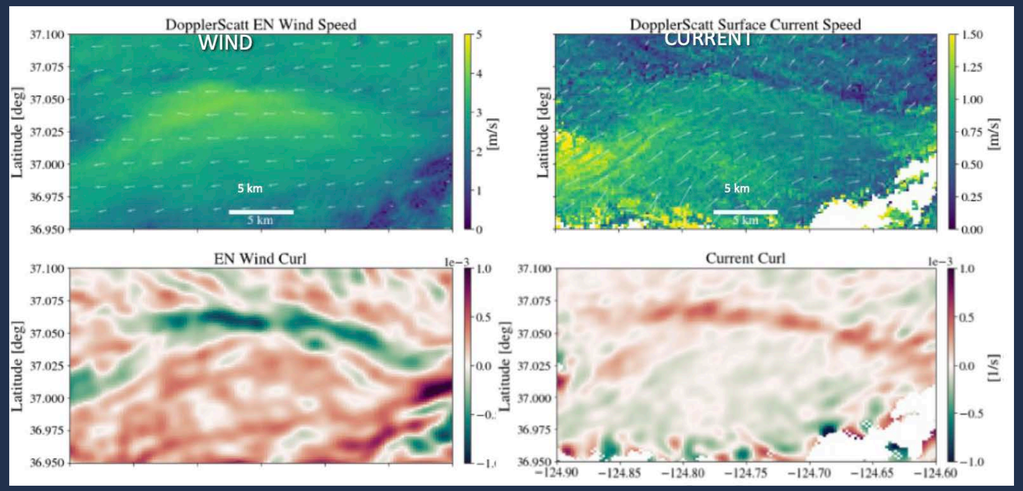
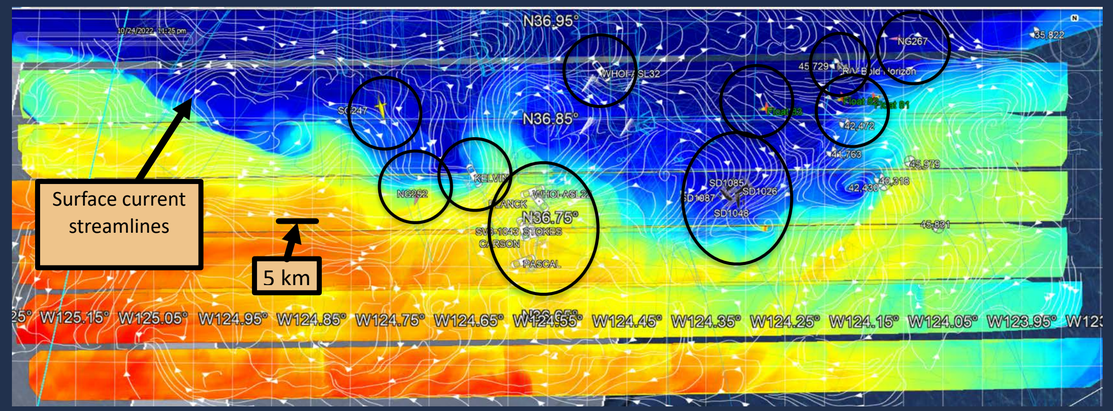
Wind-current coupling observed by DopplerScatt



Alex Wineteer &

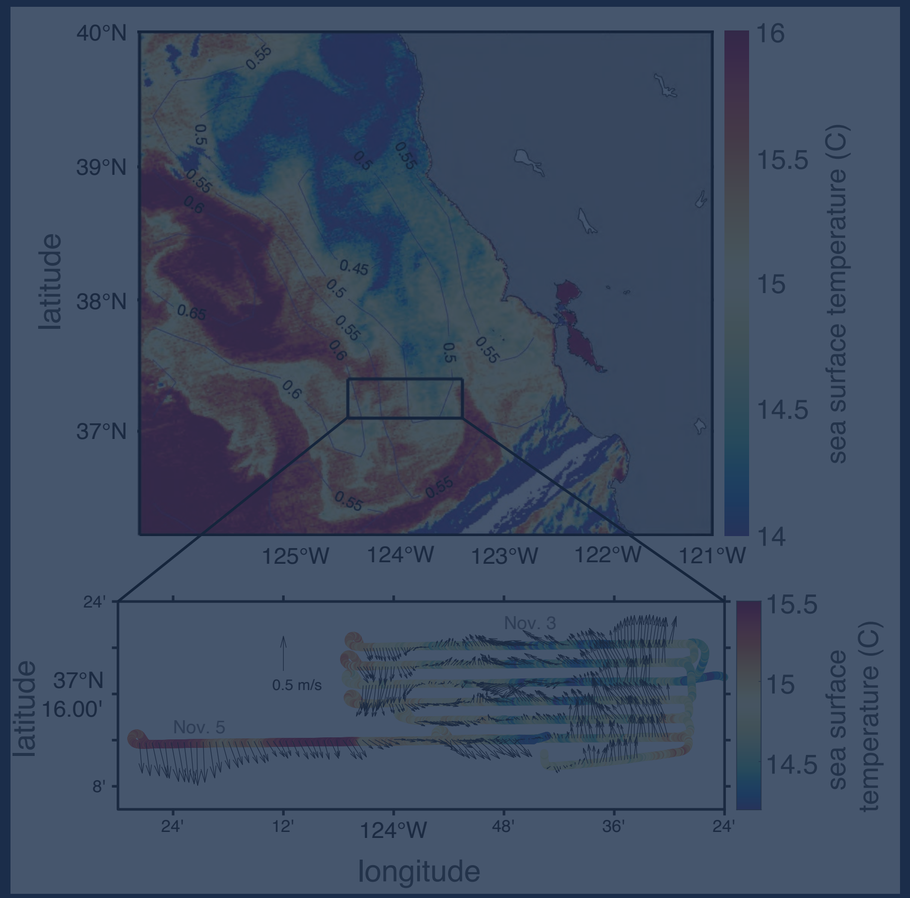
Ernesto Rodriguez (JPL)

Current-SST coupling observed by DopplerScatt + MOSES



J. Molemaker (UCLA)

Current-SST coupling observed by MASS/DoppVis



Mara Freilich's poster

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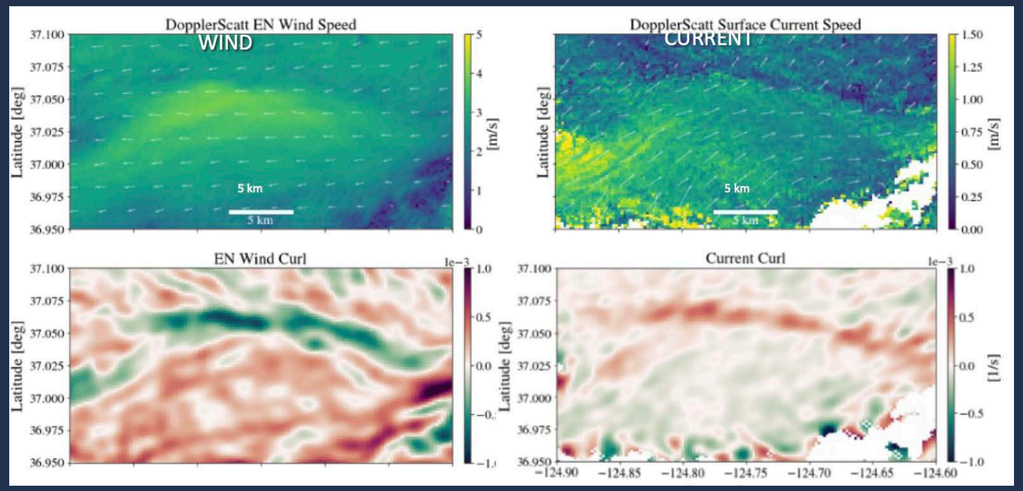

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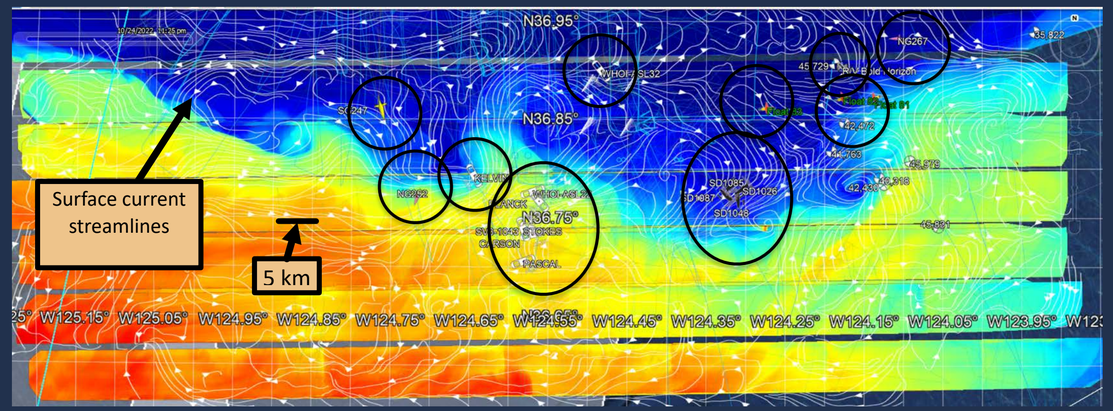

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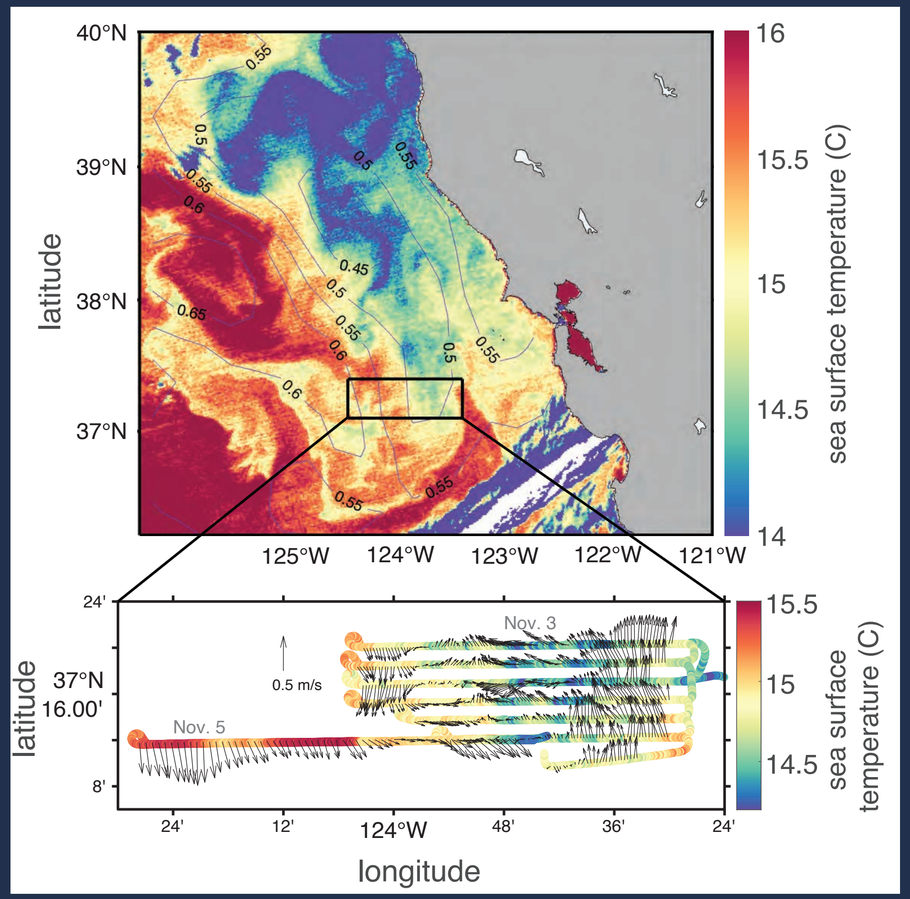
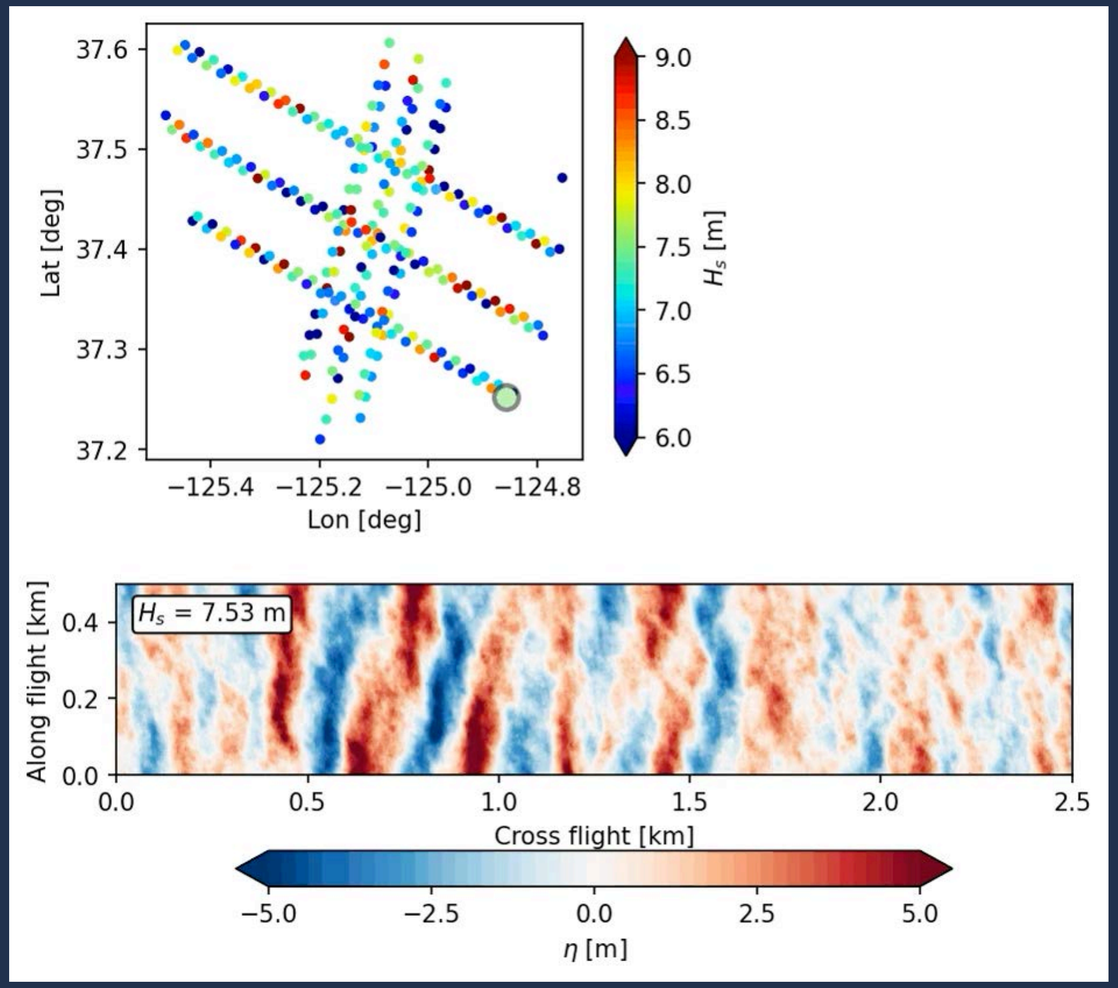
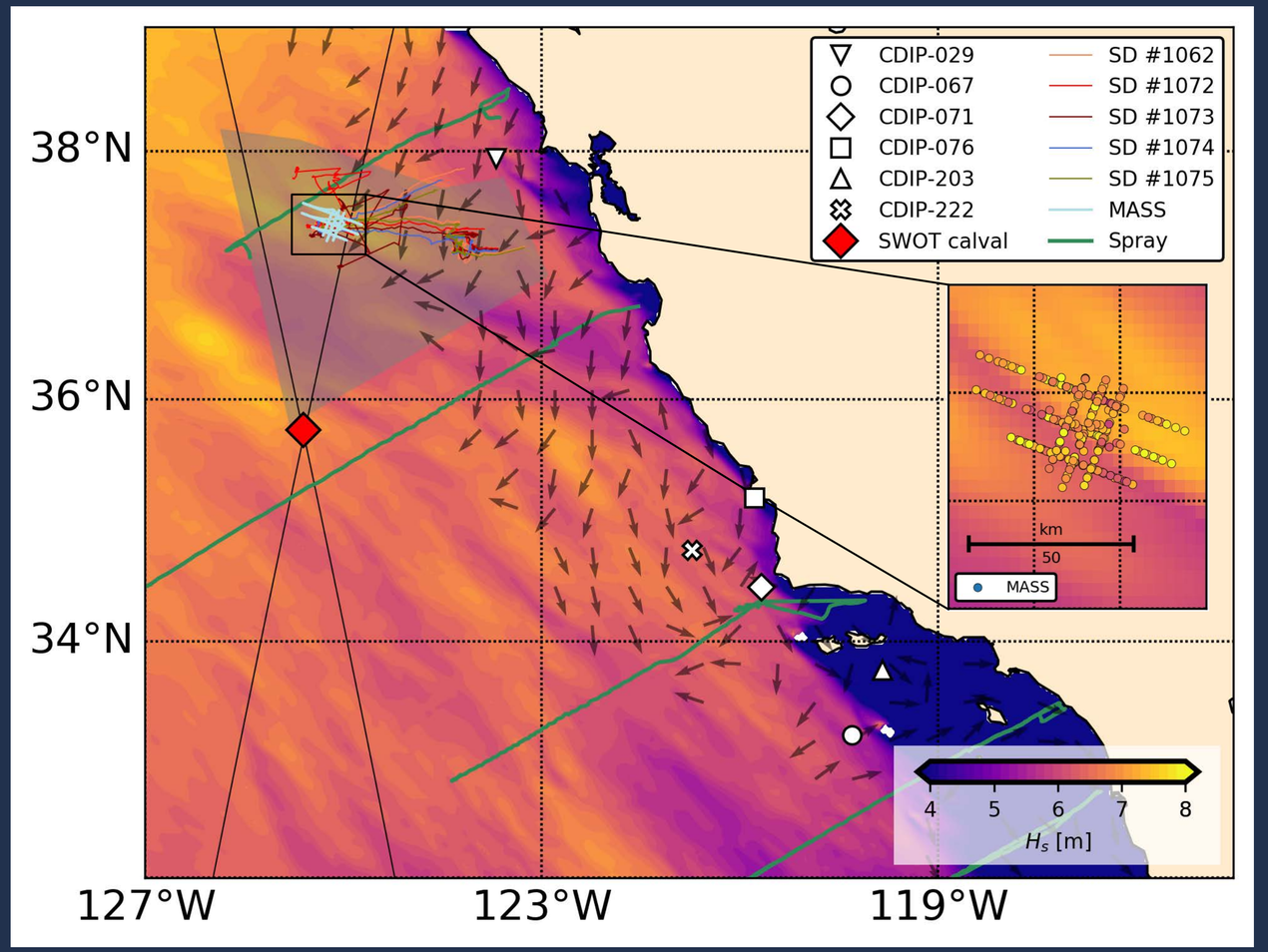


Mara Freilich's poster

Using laser altimetry to understand sea state gradients





Marechal et al., in prep

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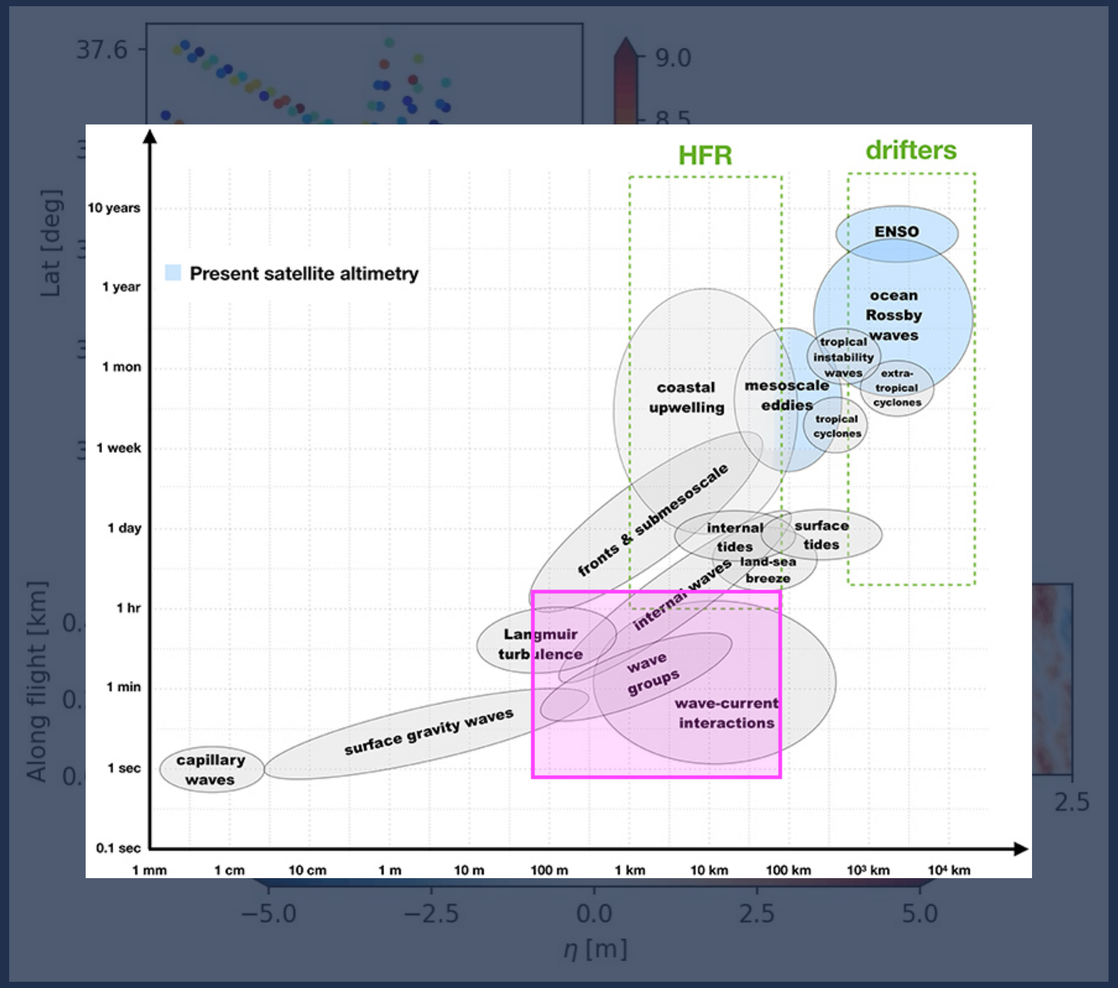
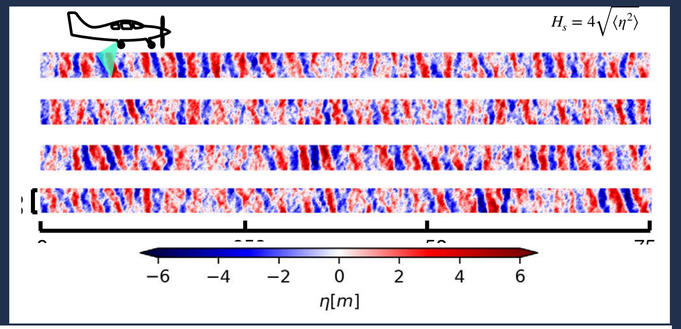
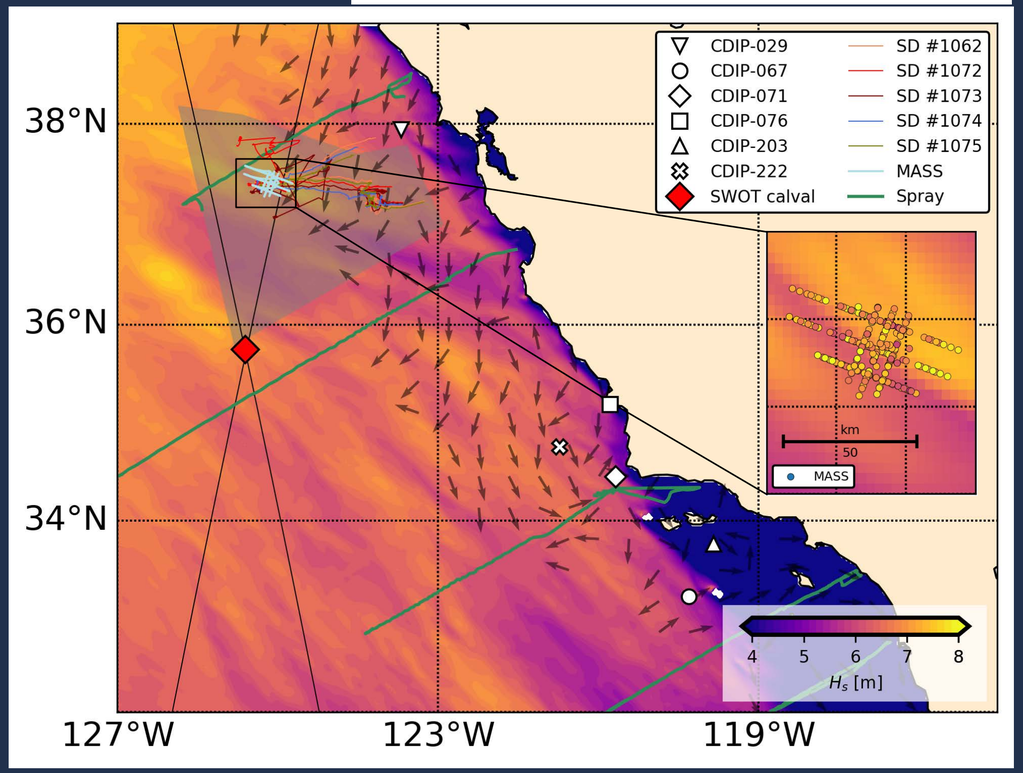


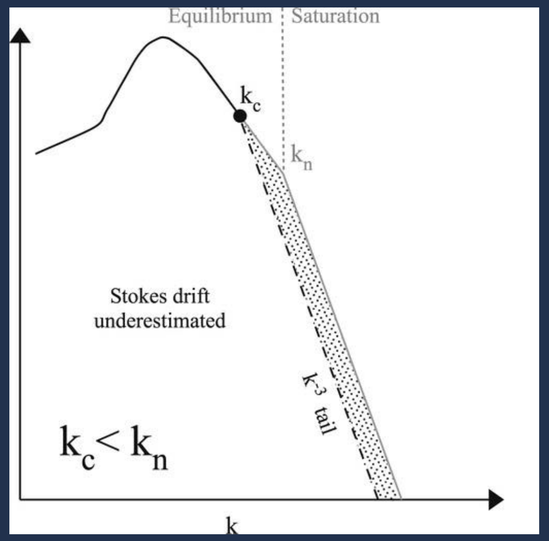




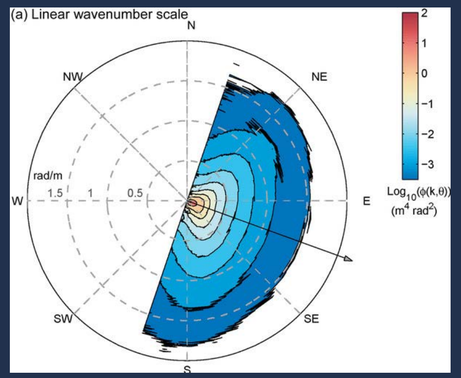
Marechal et al., in prep

Most sea state parametrizations consider spatially smooth surface wave fields

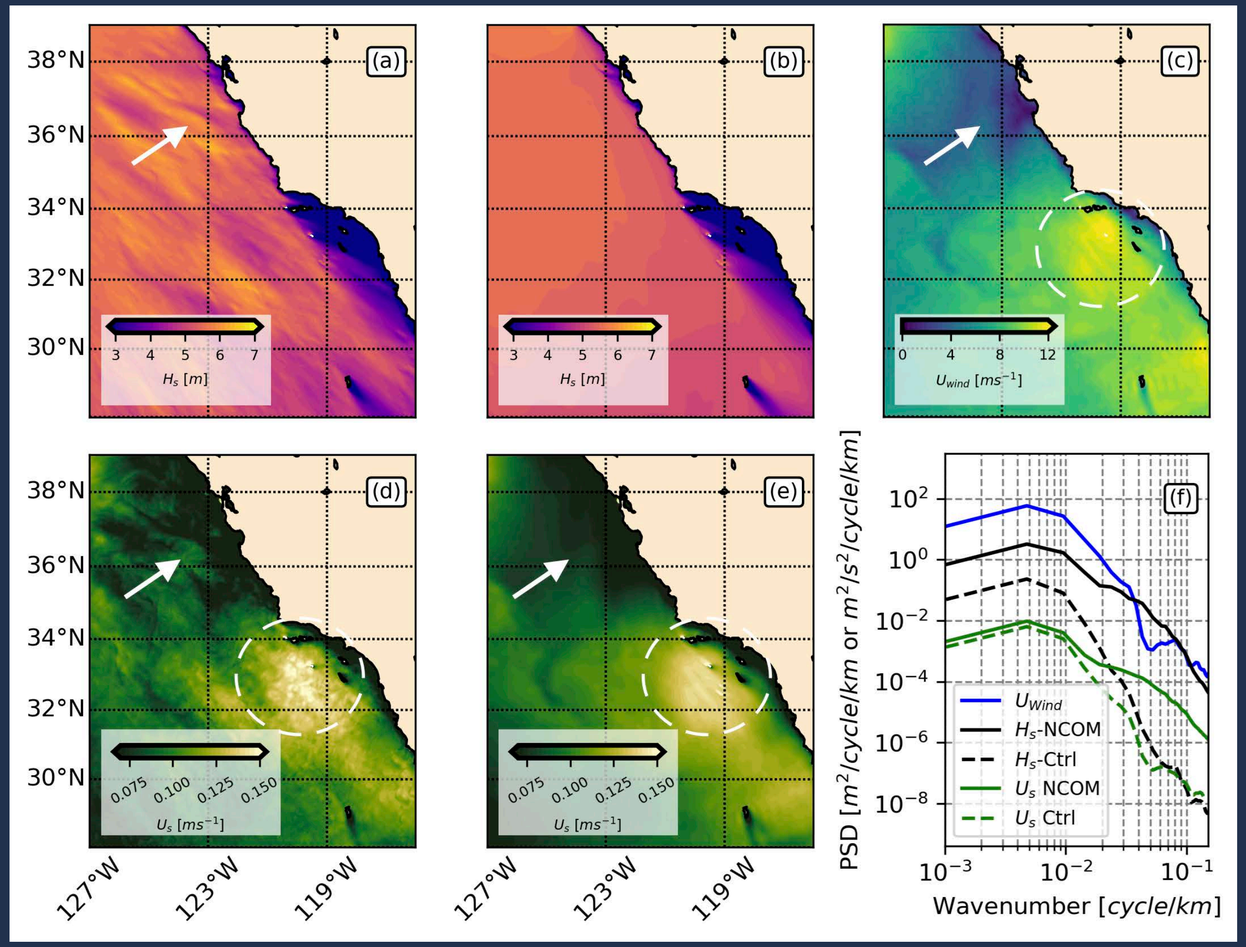
- The spatial variability of Stokes drift results from a combined response to wind forcing and amplitude modulation due to currents
- Full directional spectrum is key for accurately estimating Stokes drift and improving model parametrizations



Lenain and Pizzo, 2020

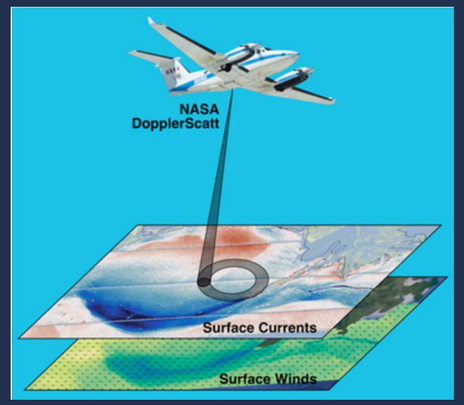


Lenain and Melville, 2017

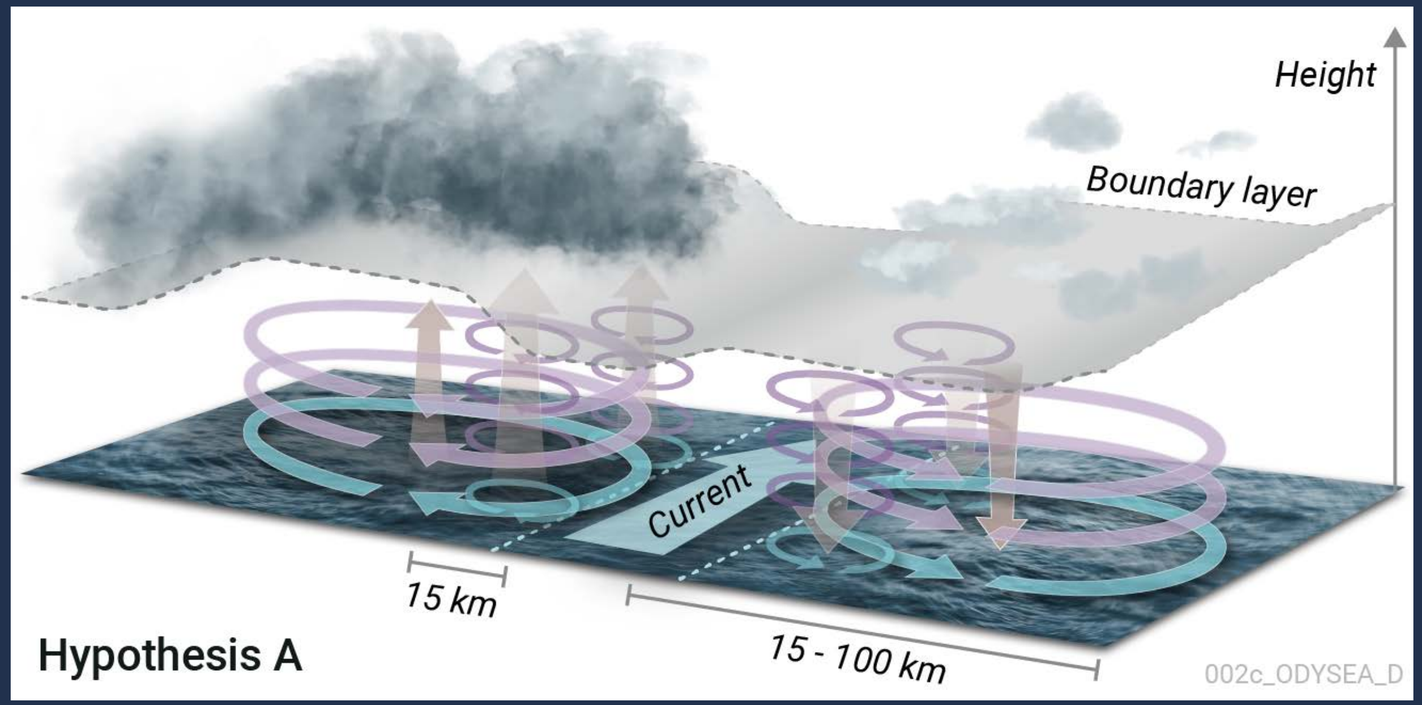


Marechal et al., in prep.
See also Ardhuin et al., 2017; Romero et al., 2020;

Ocean Dynamics and Surface Exchange with the Atmosphere – The ODYSEA mission concept



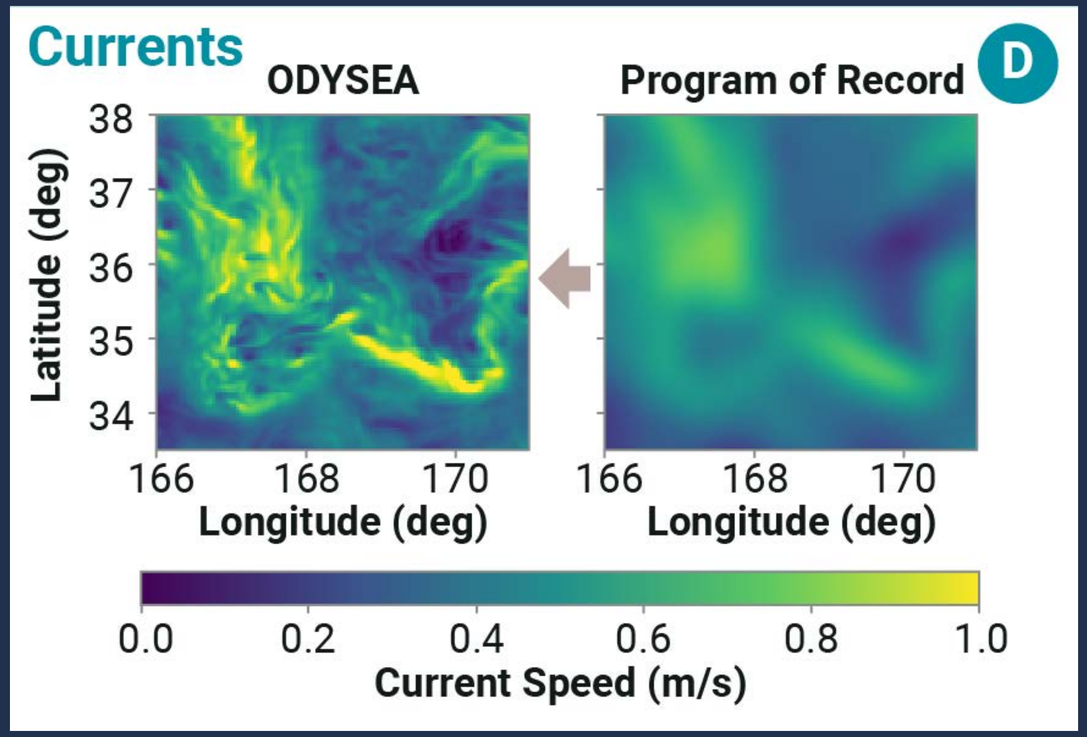
- How do ocean currents evolve at small and fast scales?

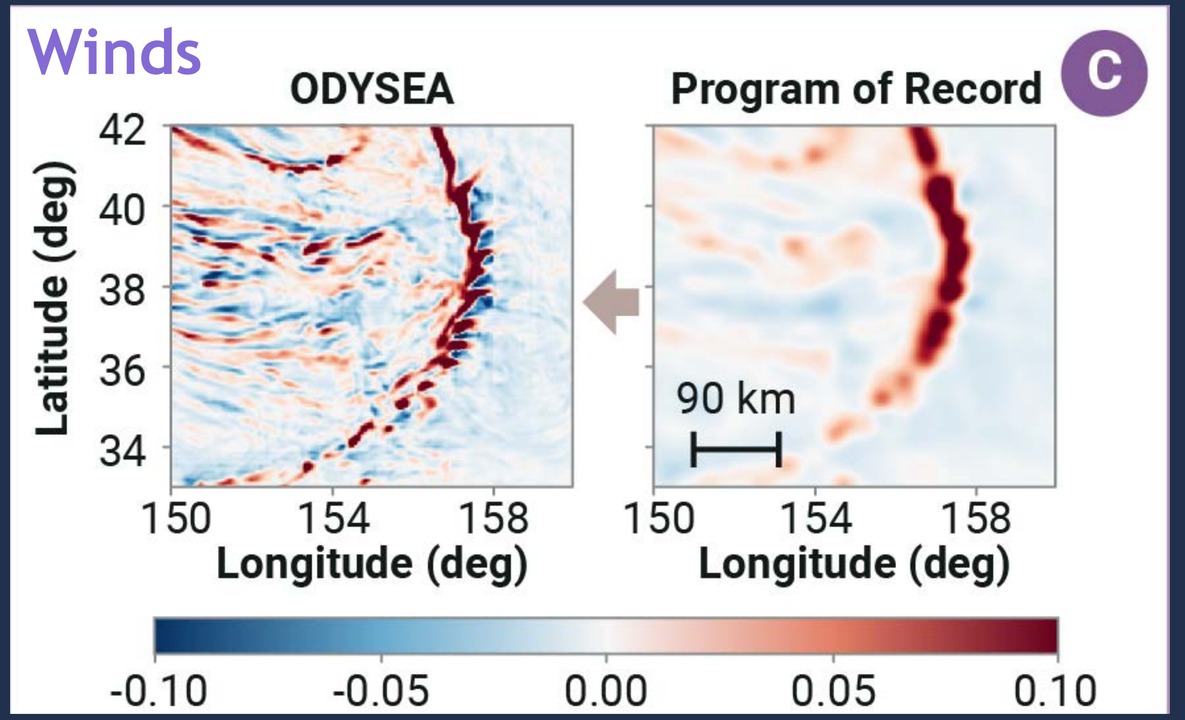


ODYSEA will bring into focus daily global surface currents and their interactions with winds to explore the Earth system and to improve weather & climate predictions

Learn more at: odysea.ucsd.edu

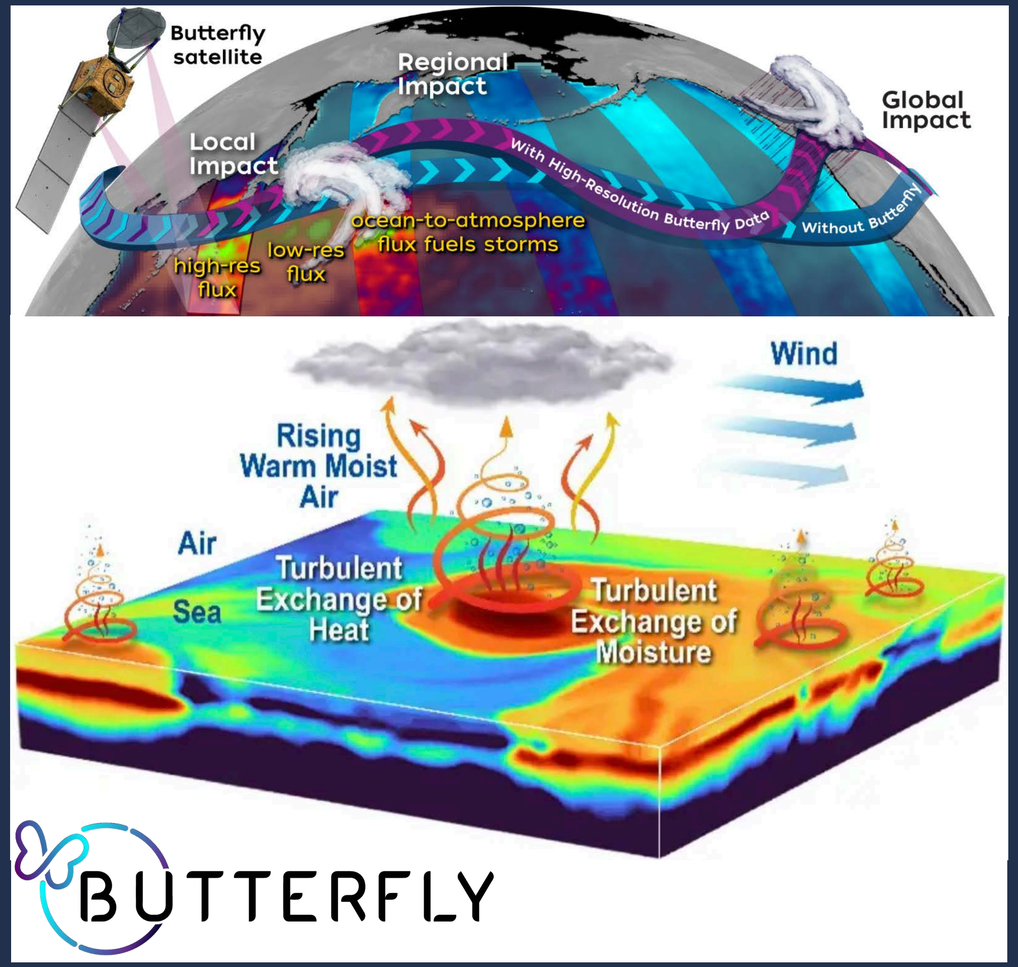
Ocean Dynamics and Surface Exchange with the Atmosphere – The ODYSEA mission concept



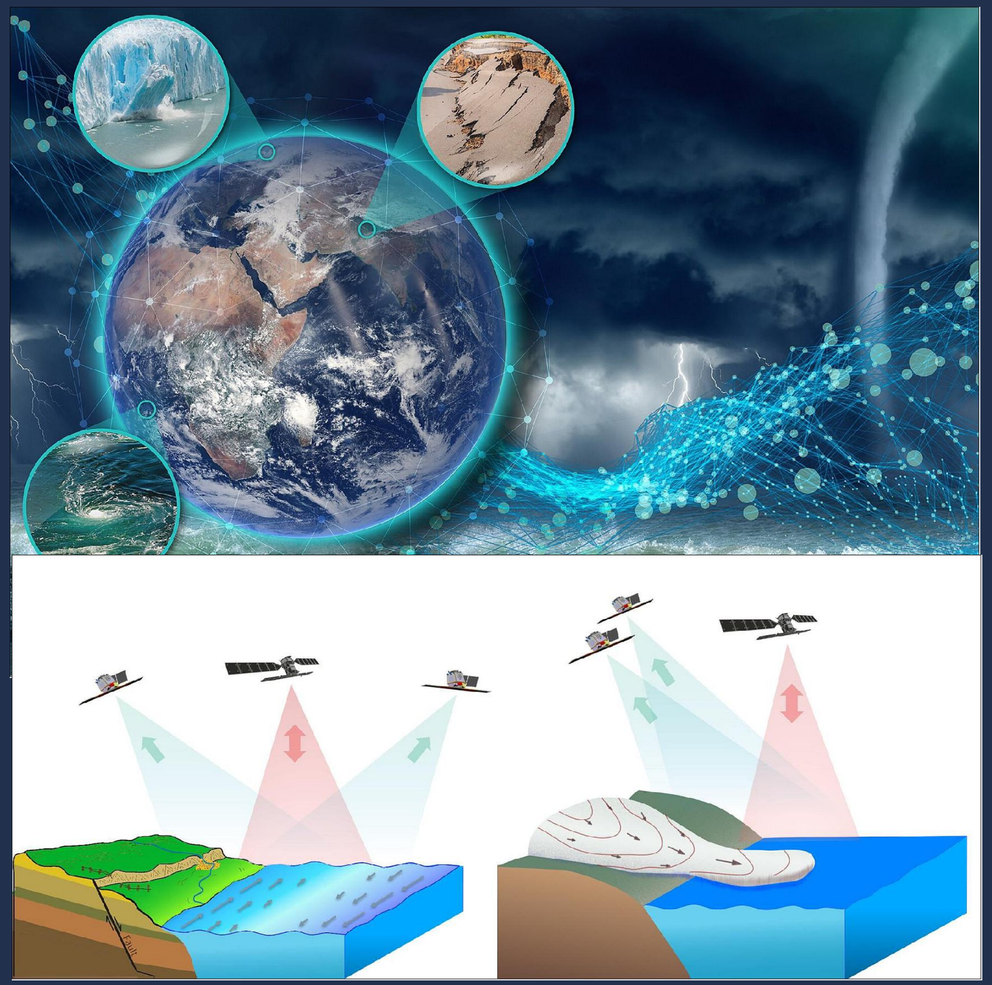


Check out the ODYSEA simulator: https://github.com/awineteer/odysea-science-simulator

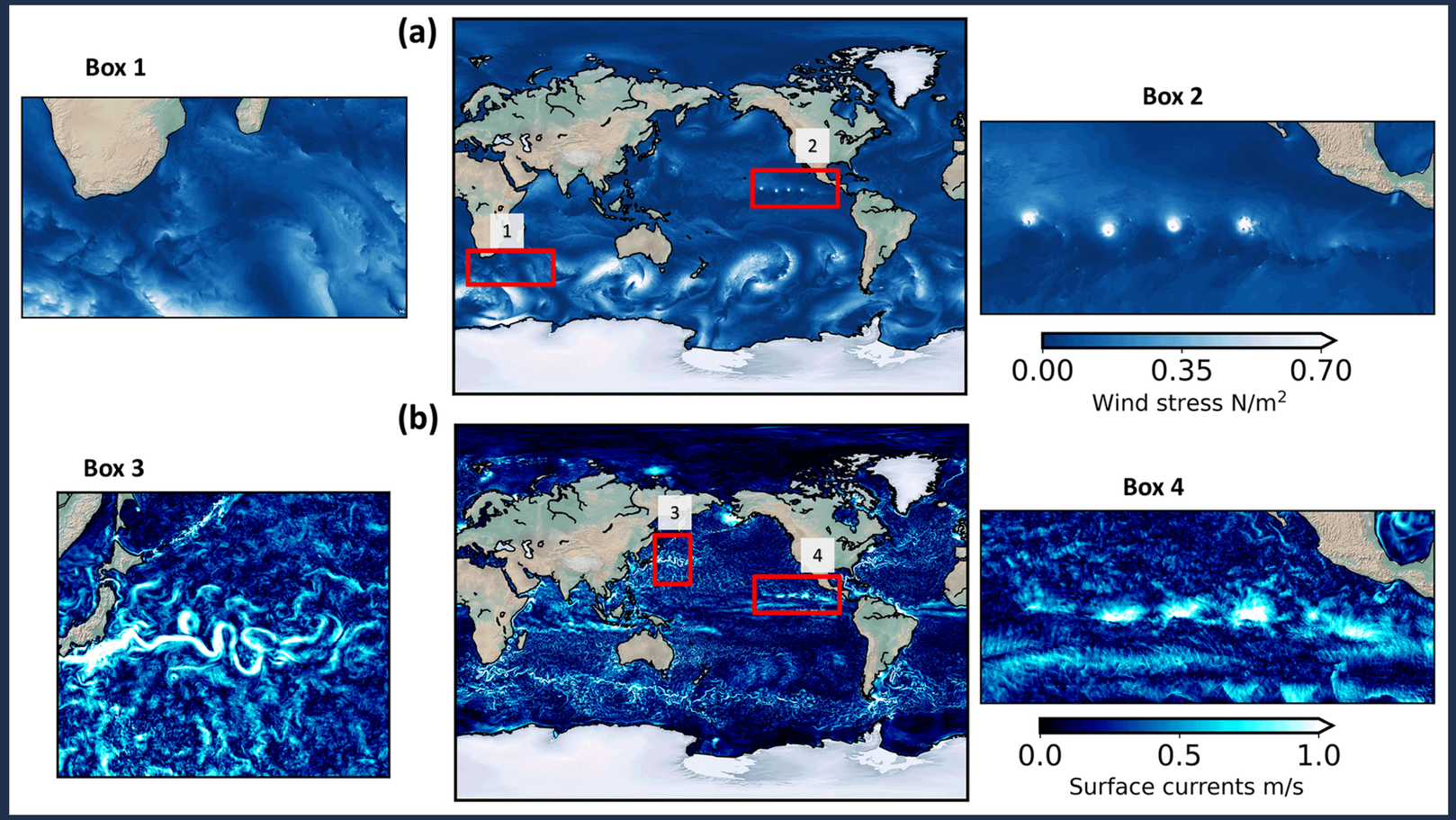
Butterfly (next talk): Measuring fluxes from space



Harmony: Wind, waves, currents, temperature, clouds, and ice flow



GEOS/MITgcm Coupled Global Simulation (c1440 - llc2160)

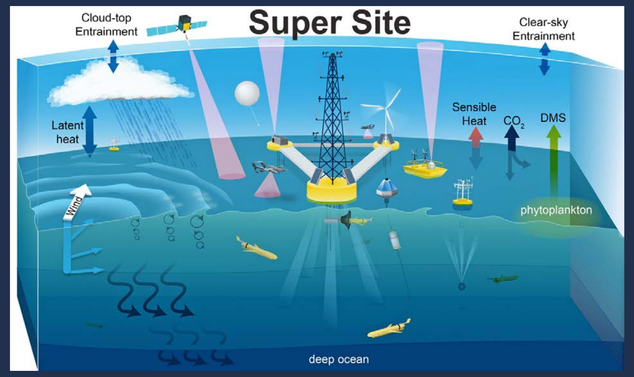


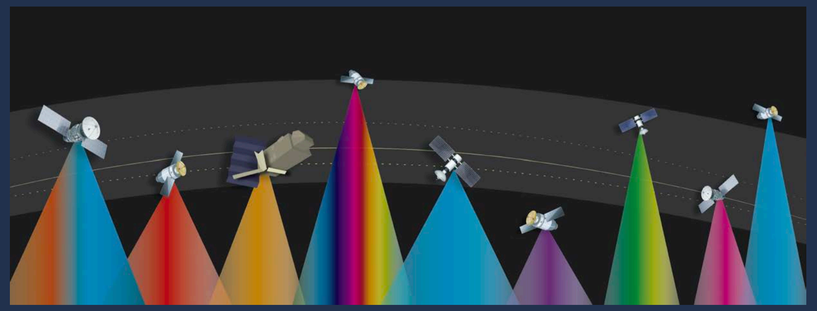
Torres et al., 2022

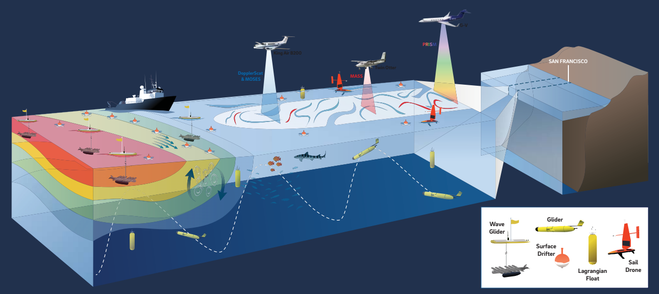
- We need coupled simulations that can serve as nature runs for OSSEs
- The uncoupled nature run has to be forced with consistent atmosphere/ocean to allow for comparisons
- Easier to do for regional scale/ short time scale (see several studies by Renault et al., but challenging at global scale)

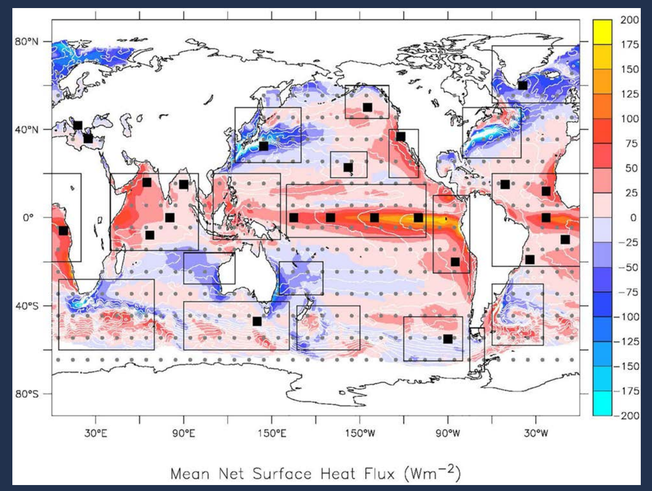
What to de when we can’t have everything everywhere all at once?

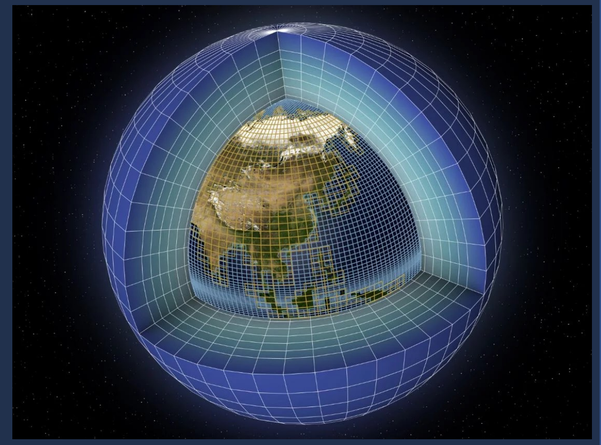
Echoing the vision of several groups











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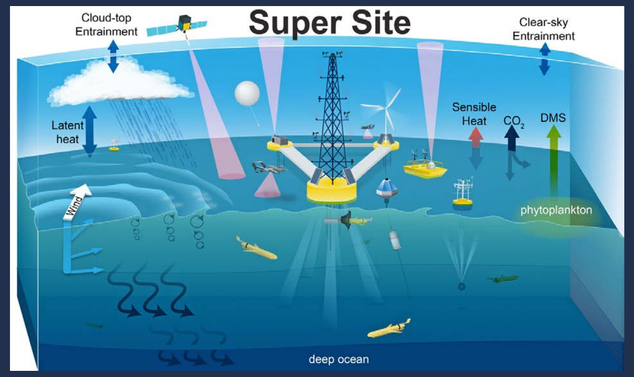
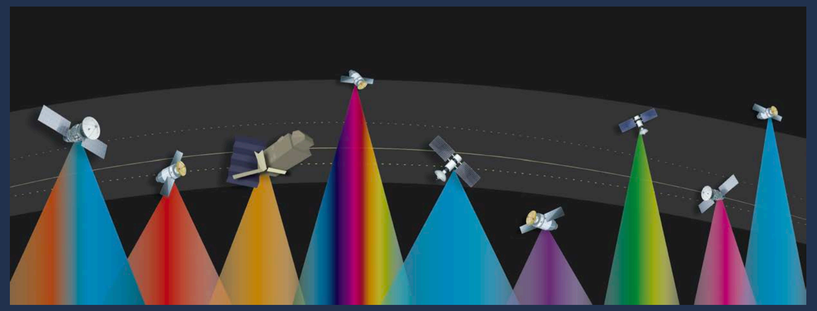
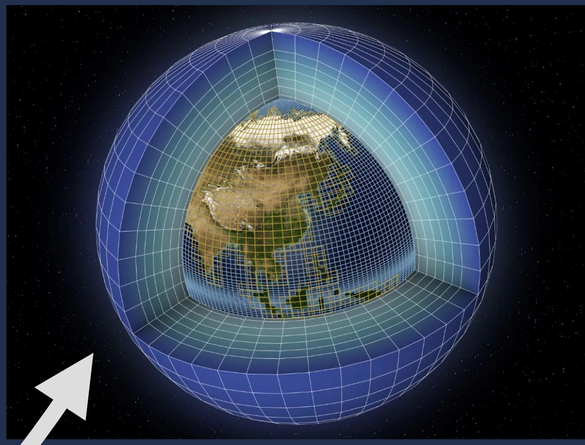
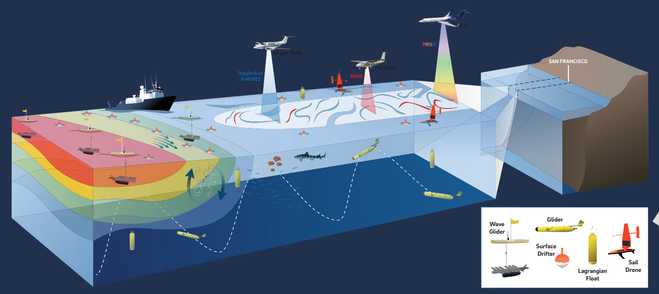
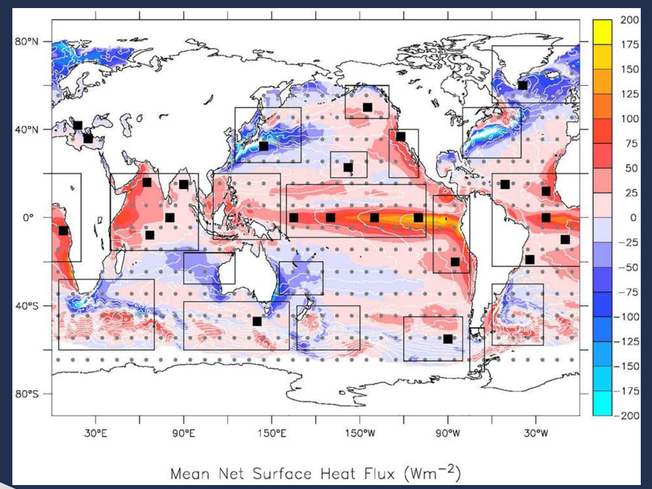


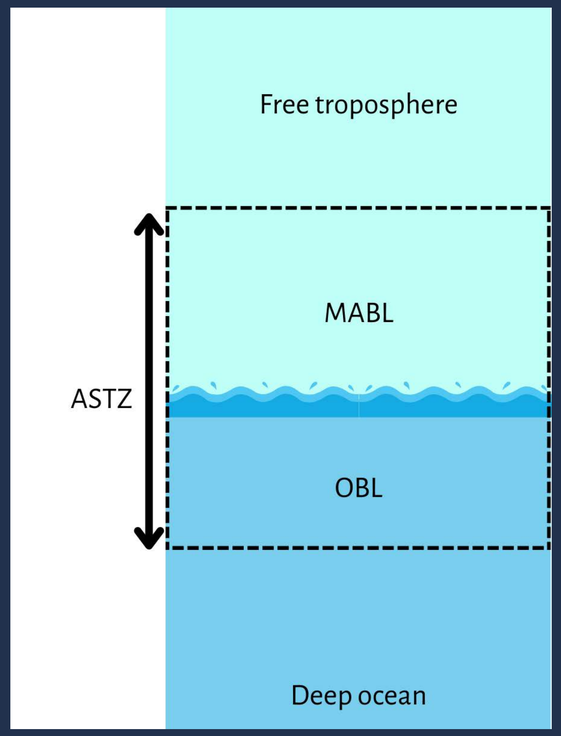








We need an integrated approach!



To move forward, we need to treat the ASTZ as a **unit** for both modeling and observation efforts

- How can we promote integrated ocean-atmosphere model development at the modeling center level?
- How can we promote funding for *integrated* ocean and atmosphere research?
- How can we promote closer collaborations among observationalists, theoreticians, and model developers to coordinate observations with ongoing efforts to evaluate and improve models, develop new parameterizations, and advance coupled data assimilation?
    - Inter-agency “synergy maker”

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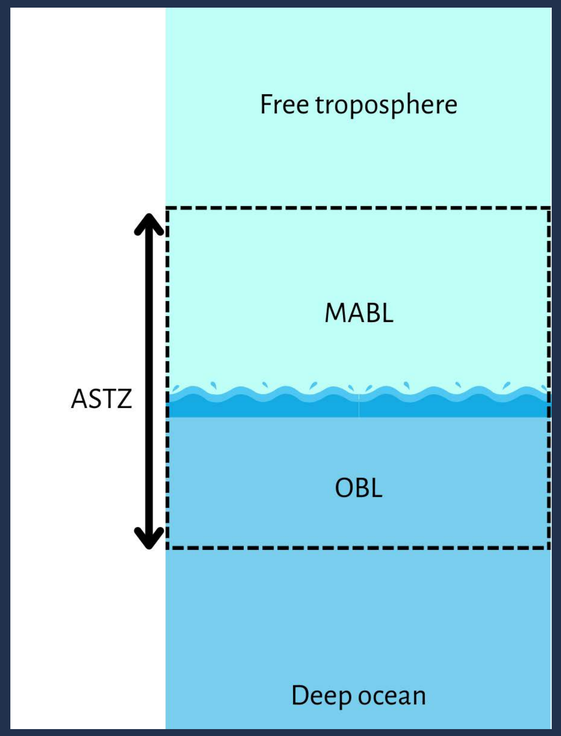

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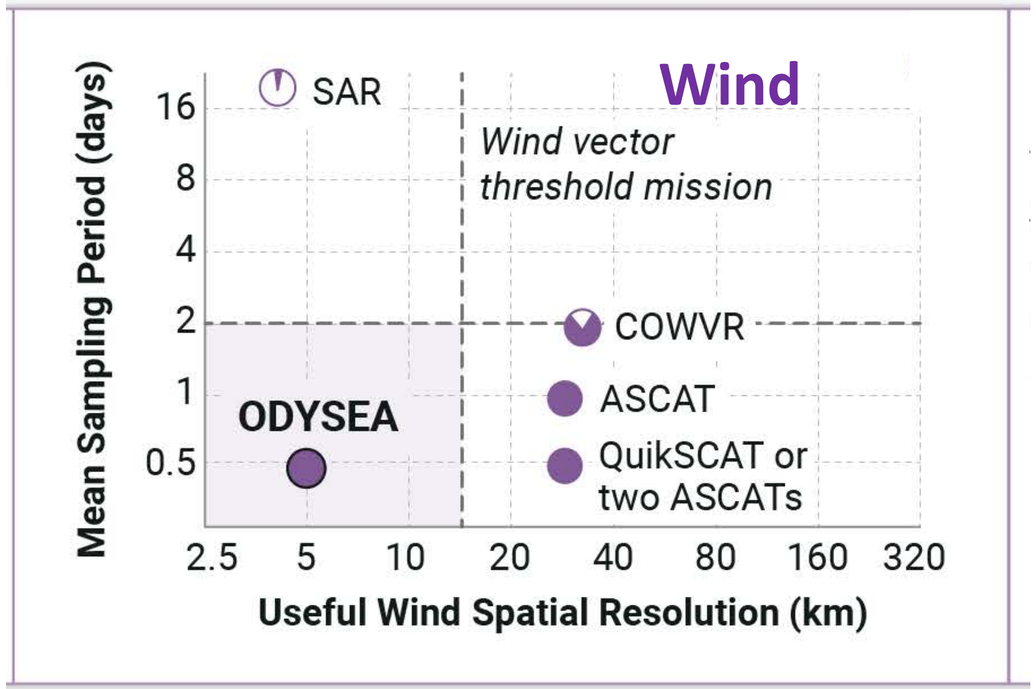
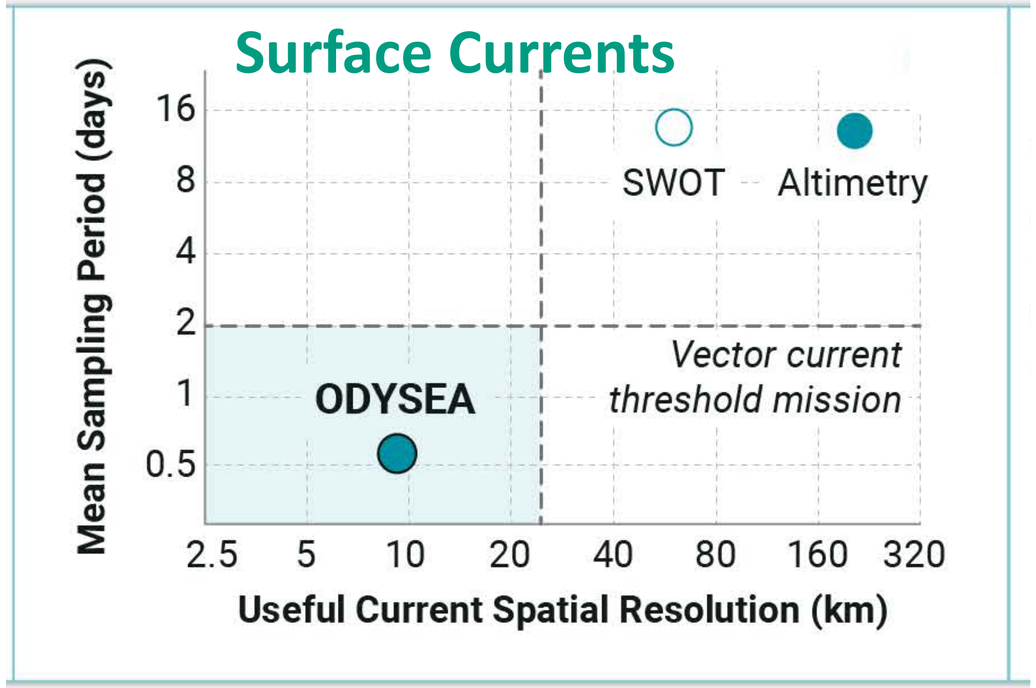
villasboas@mines.edu

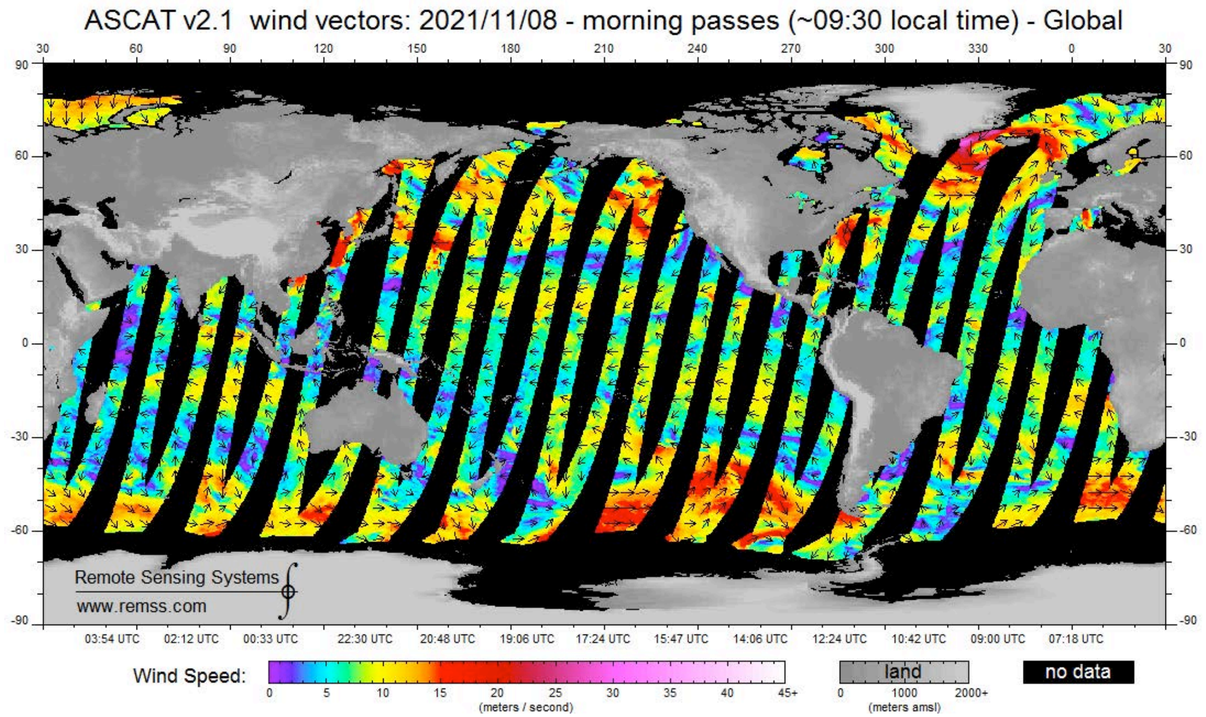
ODYSEA will provide unprecedented spatial and temporal coverage

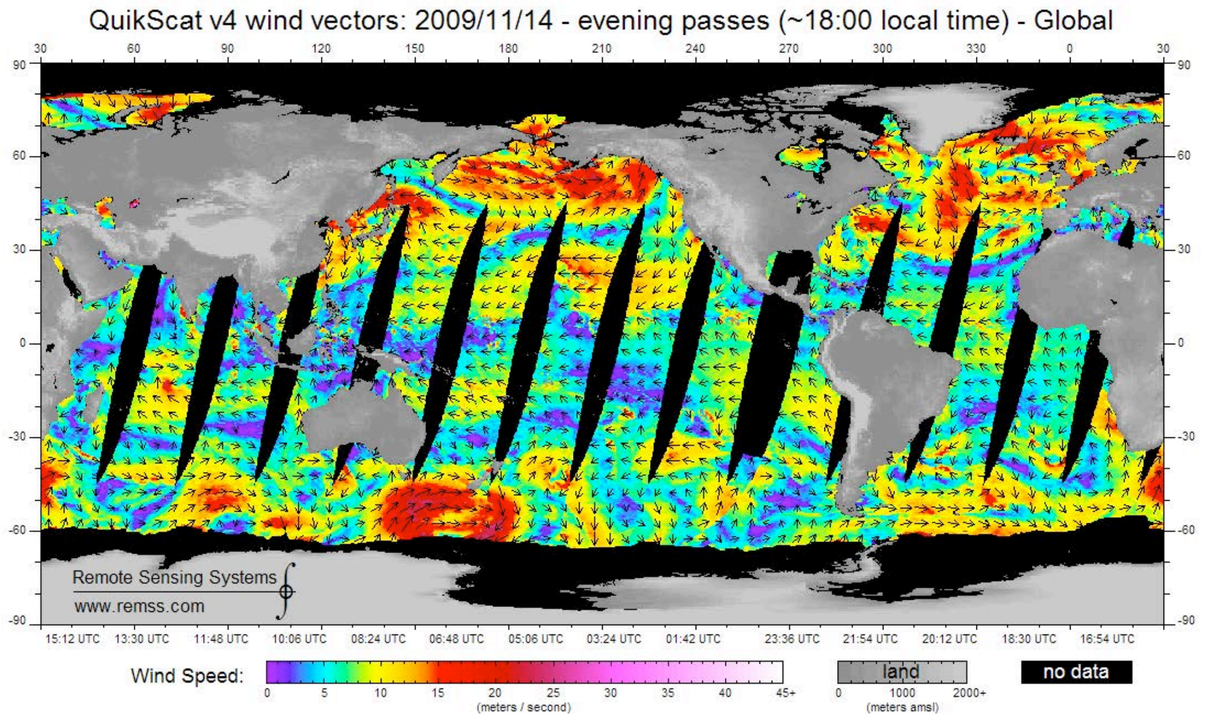
- 5 km postings, averaged for currents to reduce noise
- Possibility of 1 km postings to support coastal applications





What we gain: Daily global wind coverage





ASCAT coverage:

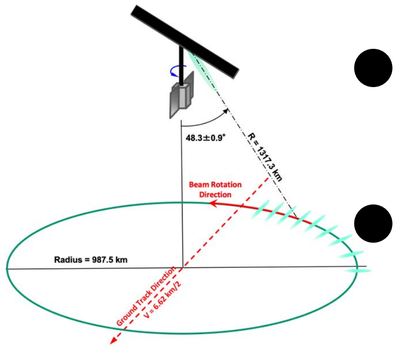
- 550 km swath;
- 25 km resolution

ODYSEA coverage:

- 1700 km swath (more like QuikScat)
- 5 km resolution

Jet Propulsion Laboratory
California Institute of Technology

ODYSEA Mission Overview

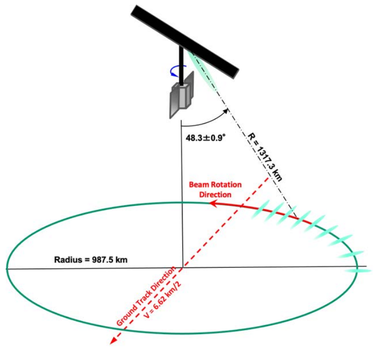


- There are no sensors in orbit that measure total surface currents
- There are no US operational scatterometers that measure winds. The existing wind sensor constellation needs additional sensors to sample changing winds.

- Scaling DopplerScatt to space fills both of these needs
- 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)
- Intend to serve Near Real-Time data products to operational agencies (Navy, NOAA, Air Force)
- Proposal due date anticipated to be late June/early July

Jet Propulsion Laboratory
California Institute of Technology

ODYSEA Mission Overview



- SO1: Fill key knowledge gaps in the coupling mechanisms between currents and winds by observing, quantifying, and understanding the salient processes

- SO2: Fill key knowledge gaps in fundamental patterns of surface currents globally and the dynamical ocean processes underlying these motions.