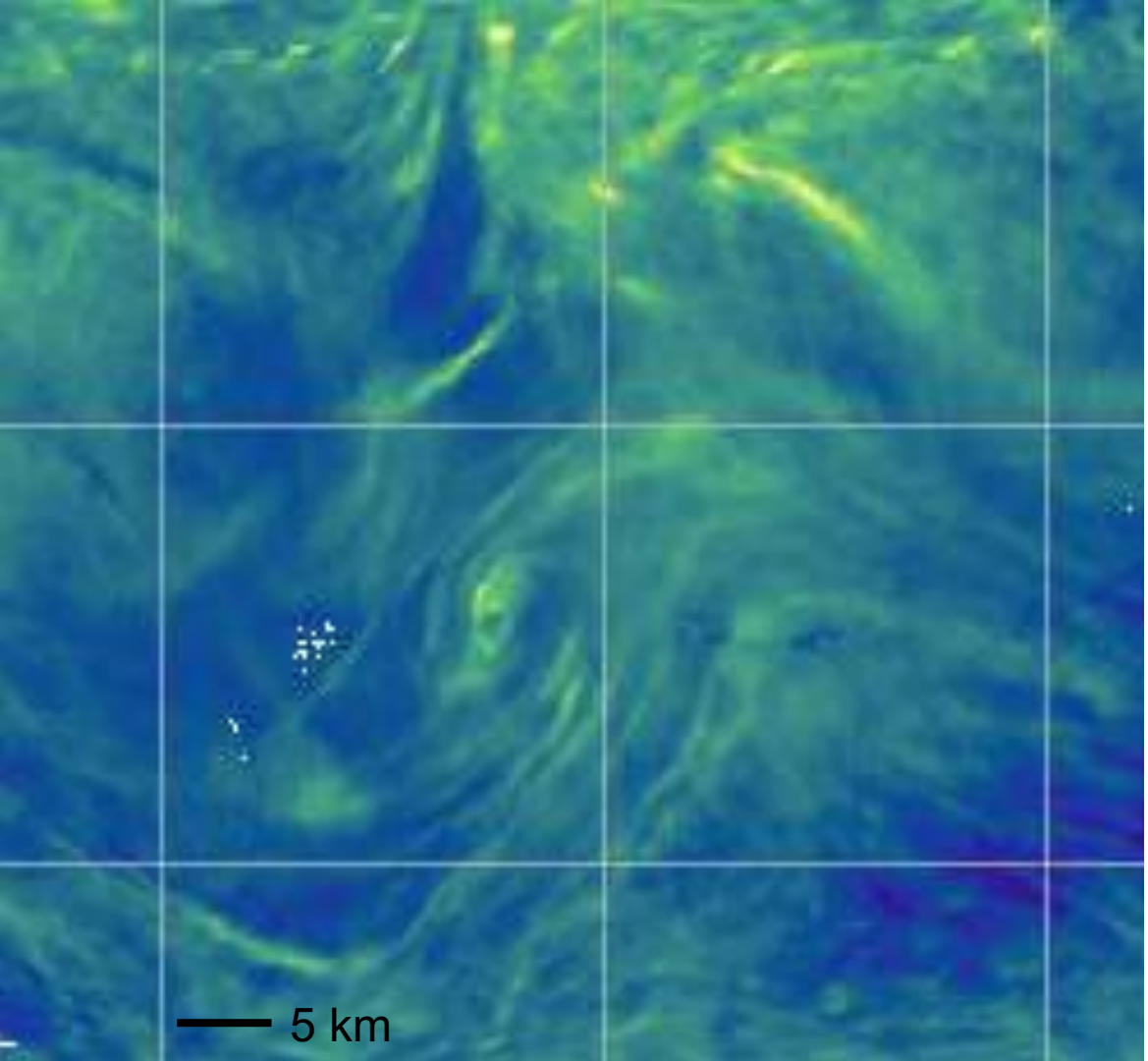


Ocean Vector Winds Science Team Meeting 2024

Characterizing Ocean Wind and Air-sea Coupling During the S-MODE Field Experiment with DopplerScatt

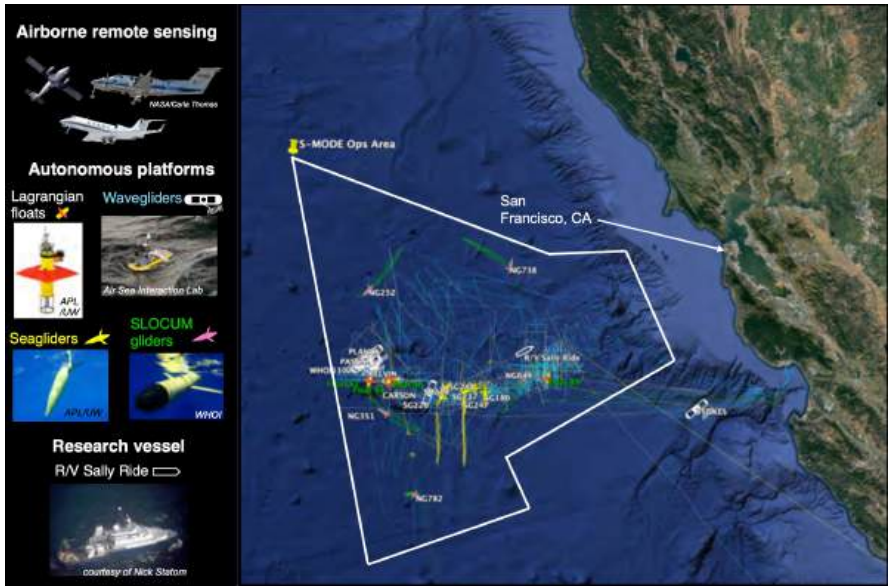
Alexander Wineteer, Ernesto Rodriguez, Hector Torres, Dragana Perkovic-Martin, Federica Polvarari, Ruzbeh Akbar
Jet Propulsion Laboratory

Jeroen Molemaker, Delphine Hypolite
UCLA

Jet Propulsion Laboratory
California Institute of Technology

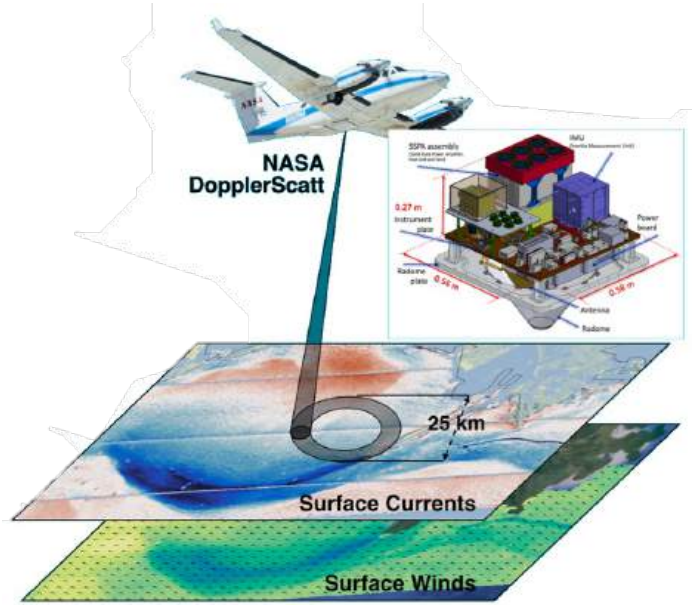
S-MODE

- The Submesoscale Ocean Dynamics Experiment brought together many airborne and in-situ platforms to study submesoscale currents and air-sea interactions.
- During S-MODE, DopplerScatt flew about 40 flights with coincident in-situ data.

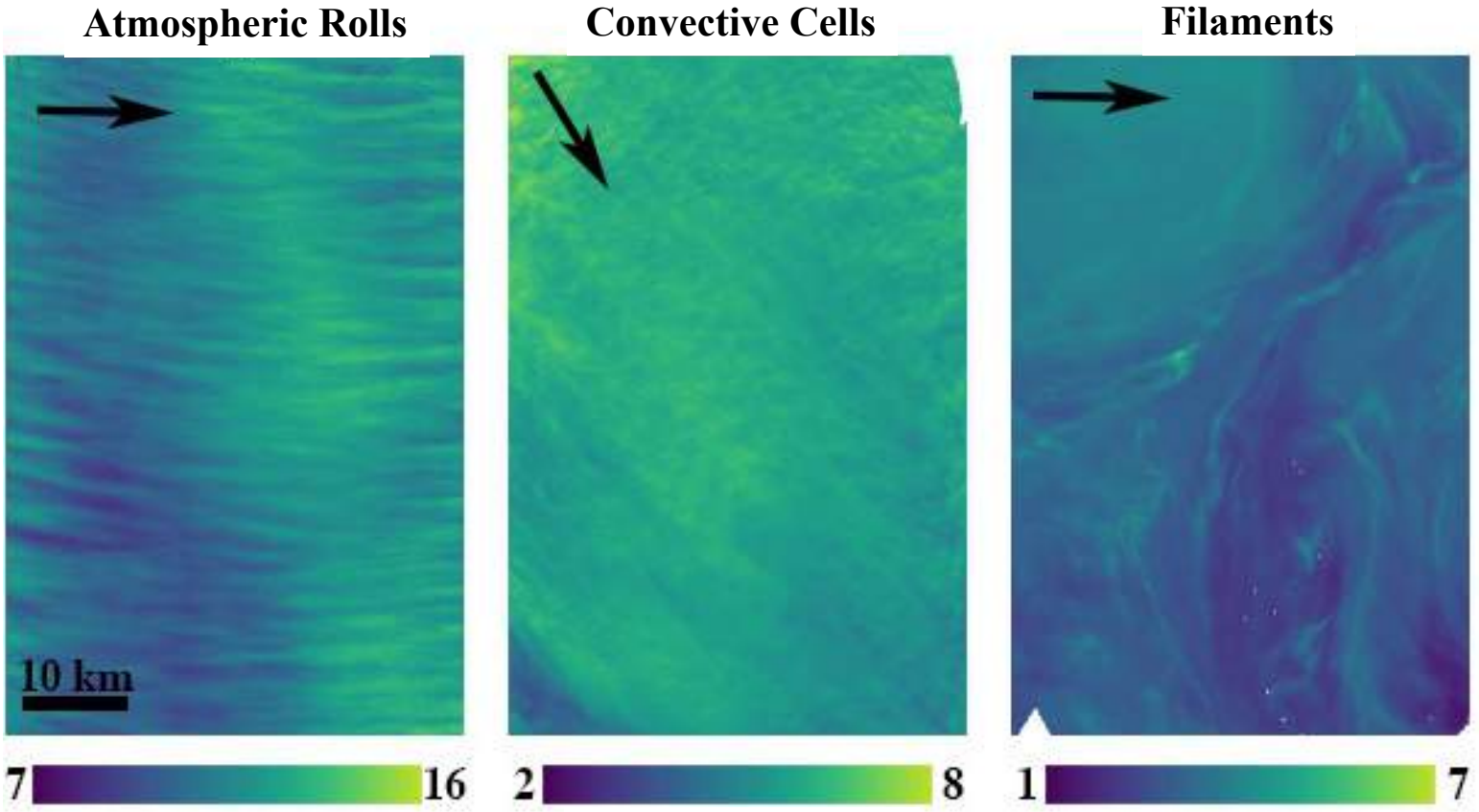


DopplerScatt

- Pencil beam Doppler Scatterometer simultaneously estimates ocean vector winds and currents
- Mapping capabilities: 25 km swath maps 100 km x 100 km area in about 3 hours
- Resolution: 200 meters

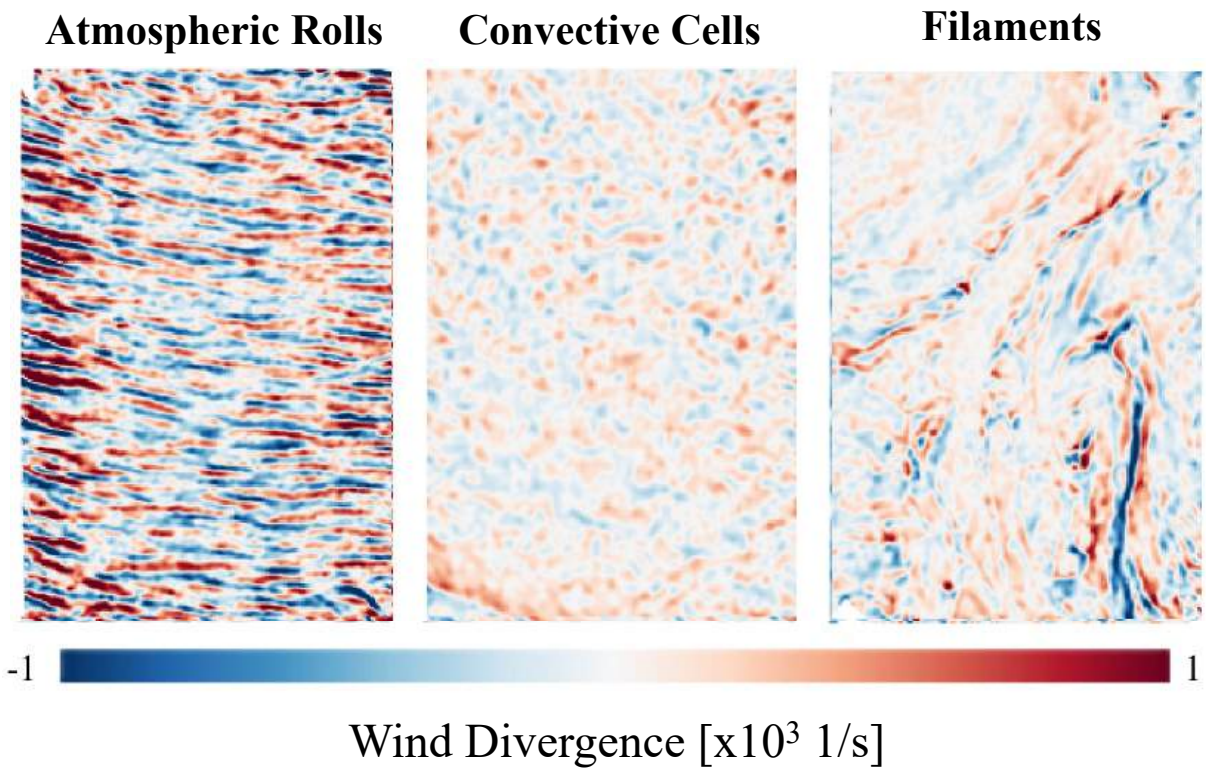


Types of Wind Fields Observed



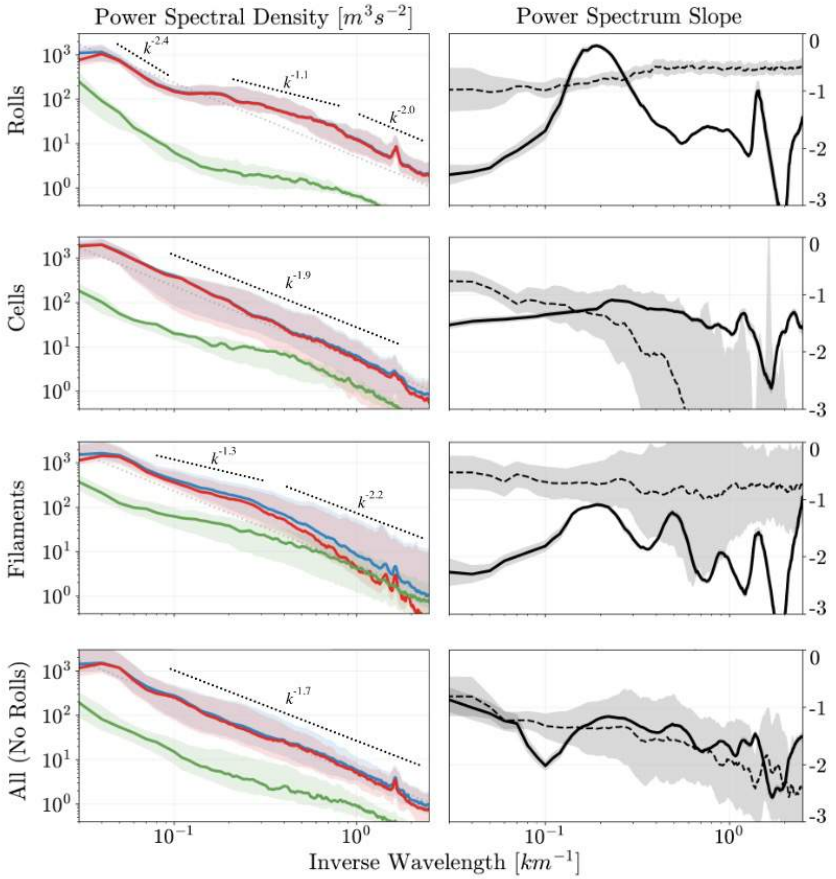
Wind Divergence

- Distinct patterns in each wind case.
- Very strong divergence, 10x Coriolis
- Order of magnitude larger than spaceborne studies.
- Integrating over 100 m results ~10 km vertical motion per day

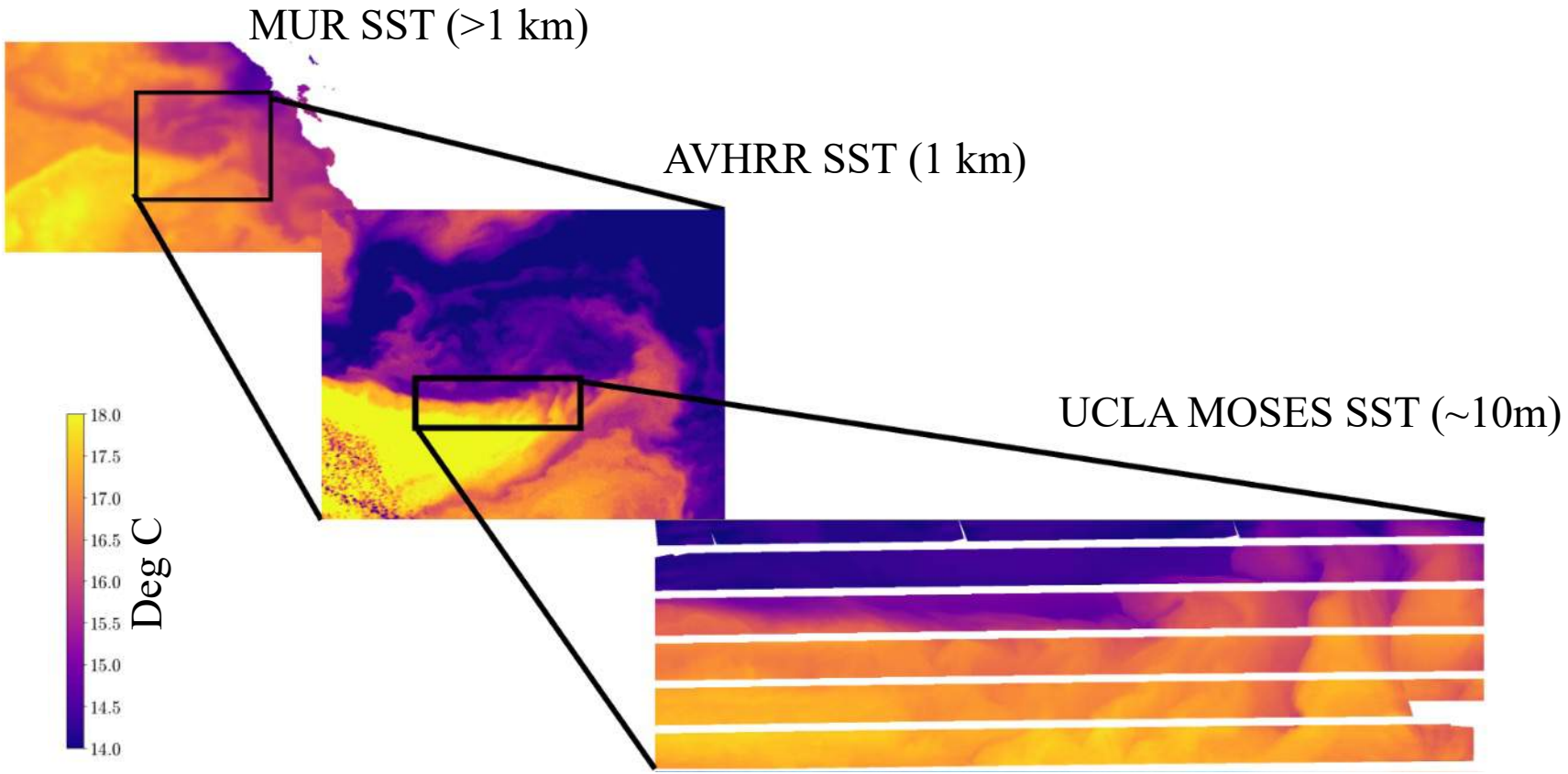


Wind Power Spectra

- Distinct behavior depending on the phenomena
  - Shallowing in atmospheric rolls
  - Increase in energy corresponding to submesoscale filaments
- Average power spectrum slope matches Nastrom-Gage $k^{-5/3}$
  - Transverse/Longitudinal ratio is consistent on average with isotropic 2D turbulence
- Individual cases themselves are non-isotropic.



Wind-SST Coupling



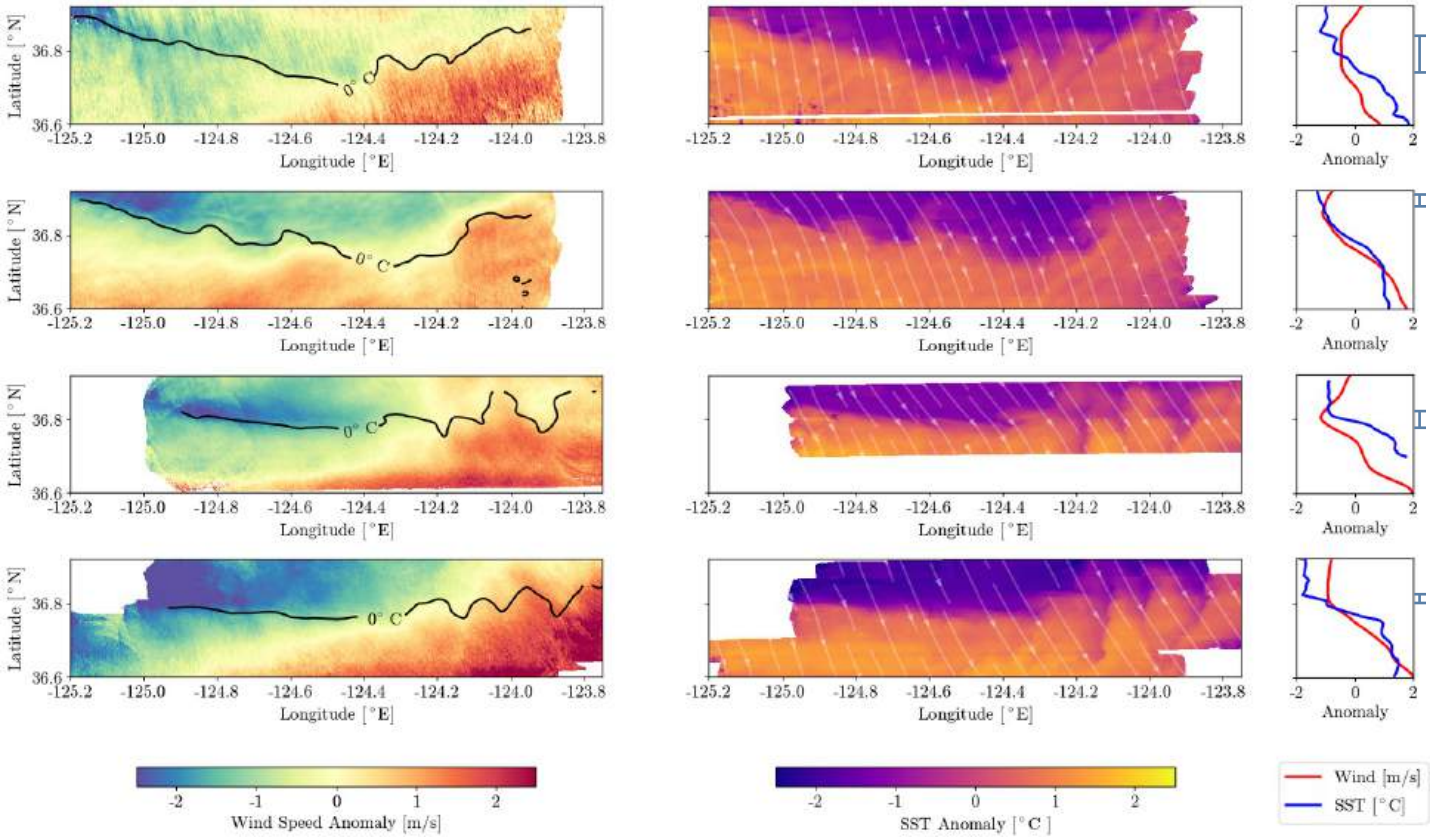
EN Winds Over a SST Front

Day 1
U_{10} = 12 m/s

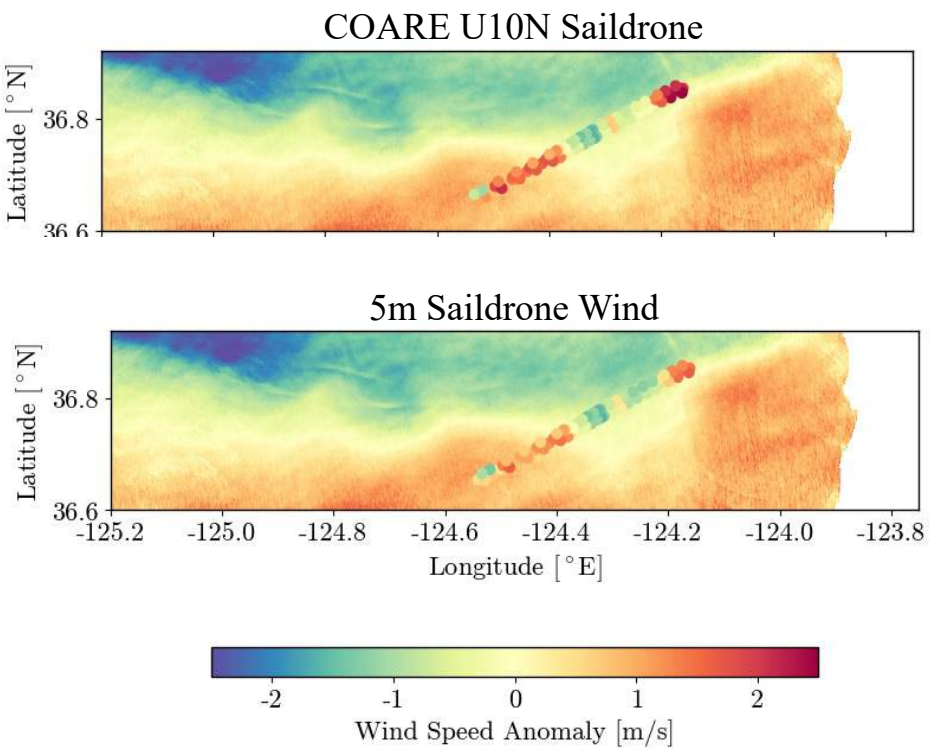
Day 2
U_{10} = 7 m/s

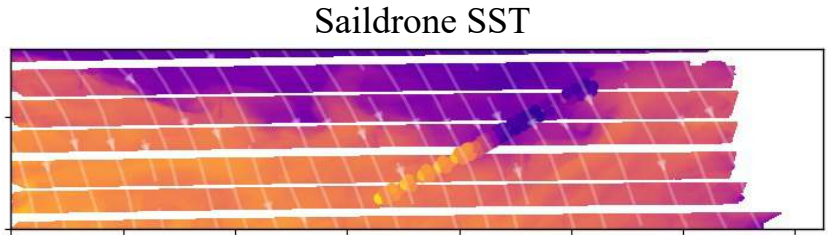
Day 4 AM
U_{10} = 8 m/s

Day 4 PM
U_{10} = 9 m/s



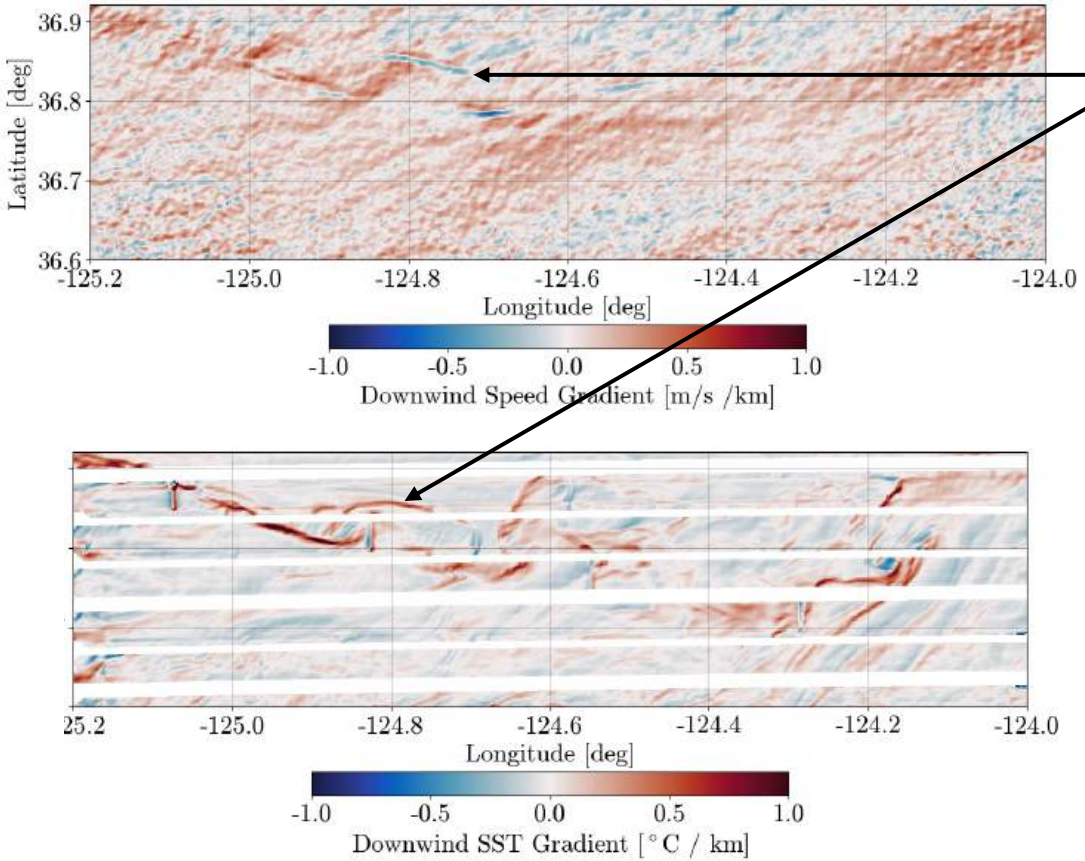
Is this only a stress effect or real changes in ATM wind?





- Raw Saildrone anemometer winds and COARE-adjusted U10N show the wind-SST coupling observed by DopplerScatt.
- ~24 hours of Saildrone data centered on the 3 hour DopplerScatt flight.

Wind-SST Coupling Projected Downwind



Dipole response: secondary circulation in atmosphere to very sharp SST gradients?

SST and wind gradients coupled on the order of 1 m/s/km.

Coupling coefficient itself is similar to O'Neill, Chelton results.

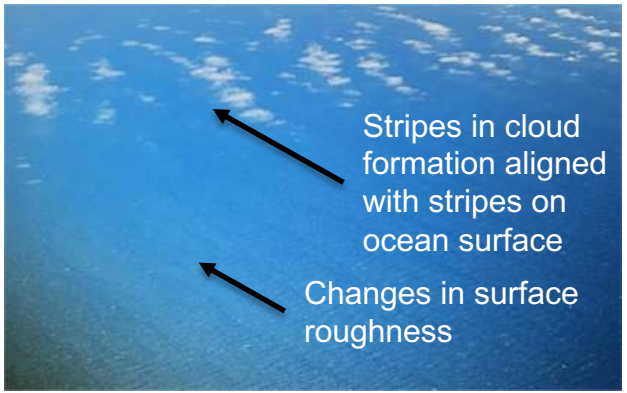
Summary

Observations of 2D vector winds by DopplerScatt:

1. Show strong coupling with surface currents at kilometer scales.
2. Show strong coupling with SST at kilometer scales that extends downstream
   - Coupling is confirmed in in-situ Saildrone anemometer winds.
3. Show strong divergence under conditions of atmospheric rolls, air-sea coupling, and convective cells, which represent a large fraction of S-MODE data.

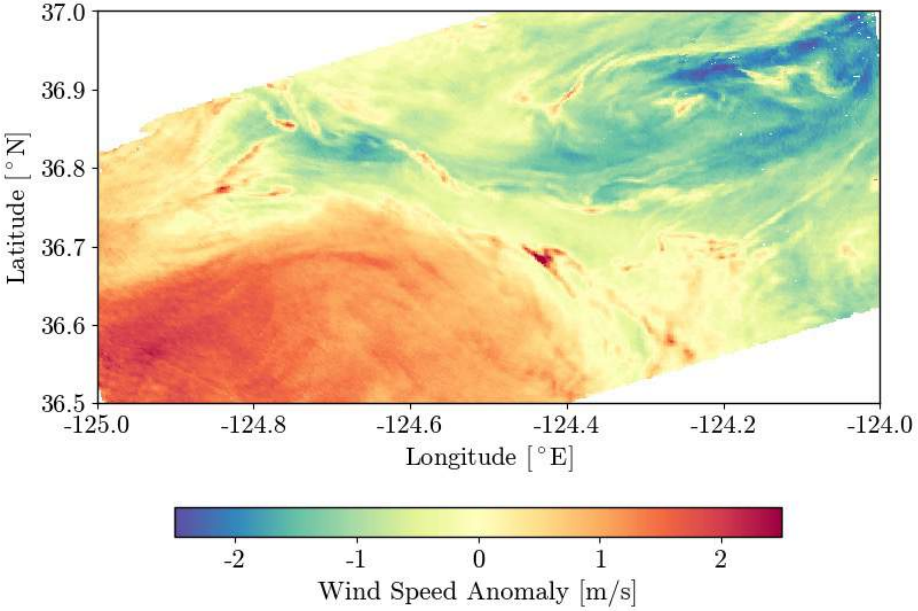
These findings show that:

1. Air-sea coupling is an important part of the wind spectrum at small scales.
2. Winds at small scales may have a spectrum consistent with isotropic 2D turbulence (Kolmogorov) and previous stratospheric (NG84) and low altitude 1D surveys, but in individual cases, the dynamics do not correspond to isotropic turbulence (T/L ratio) or 2D motion (strong divergence).

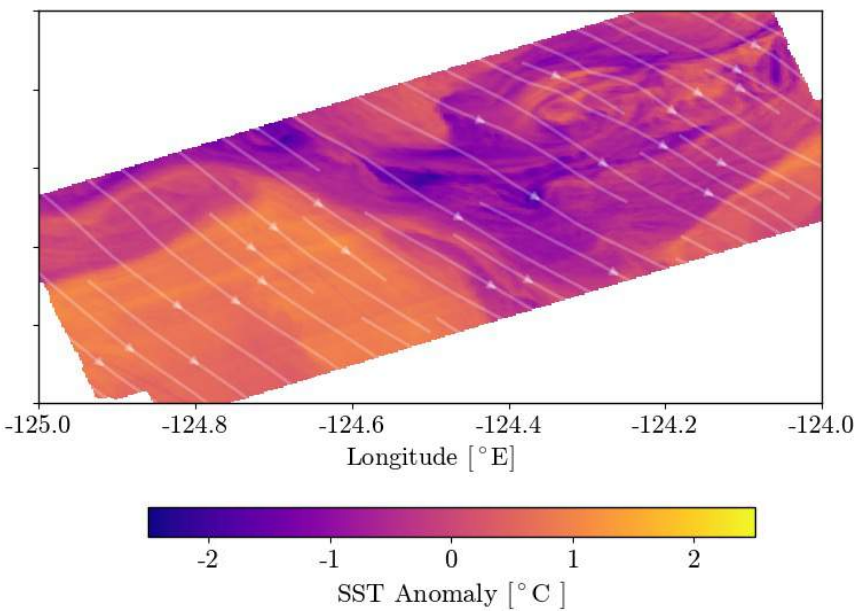


Wind Modulation Over a Submesoscale Eddy

DopplerScatt Wind Speed



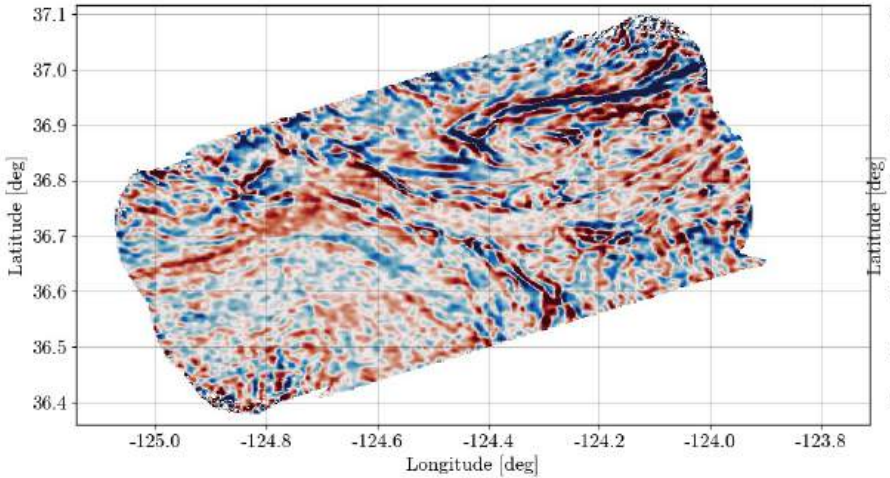
MOSES Sea Surface Temperature



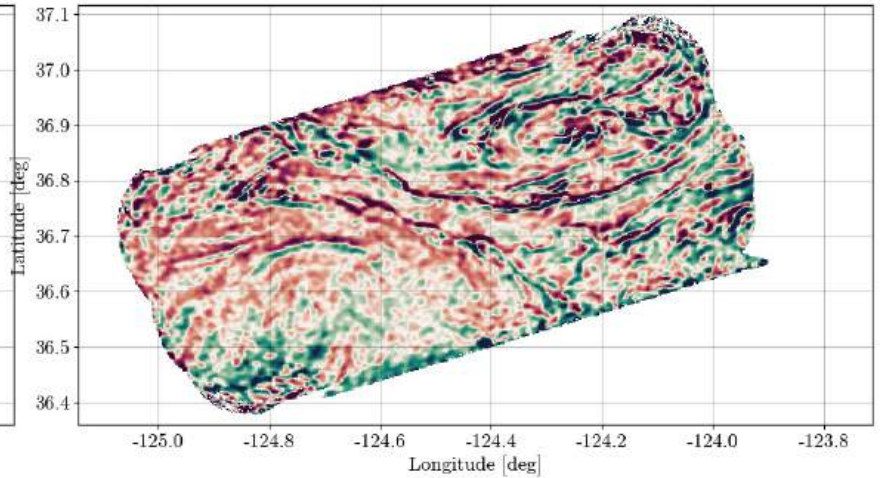
Wind divergence and vorticity

Kinematic response removed using DopplerScatt currents.

Wind Divergence



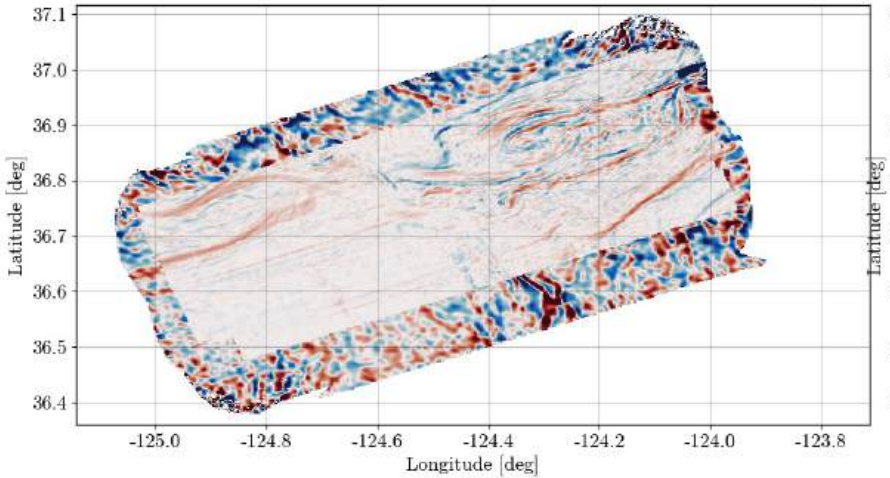
Wind Vorticity



Wind divergence and vorticity and SST gradients

Kinematic response removed using DopplerScatt currents.

Downwind SST Gradient



Crosswind SST Gradient