Maximizing the Scientific Value of Ocean Current data from Shipboard ADCP

University of Hawaii / SOEST
STEMSEAS - M.G.Langseth
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SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MĀNOA

HAVFORSKNINGSINSTITUTTET
INSTITUTE OF MARINE RESEARCH

National Oceanography Centre

SCHMIDT OCEAN INSTITUTE

Dr. Julia M. Hummon
University of Hawaii
hummon@hawaii.edu

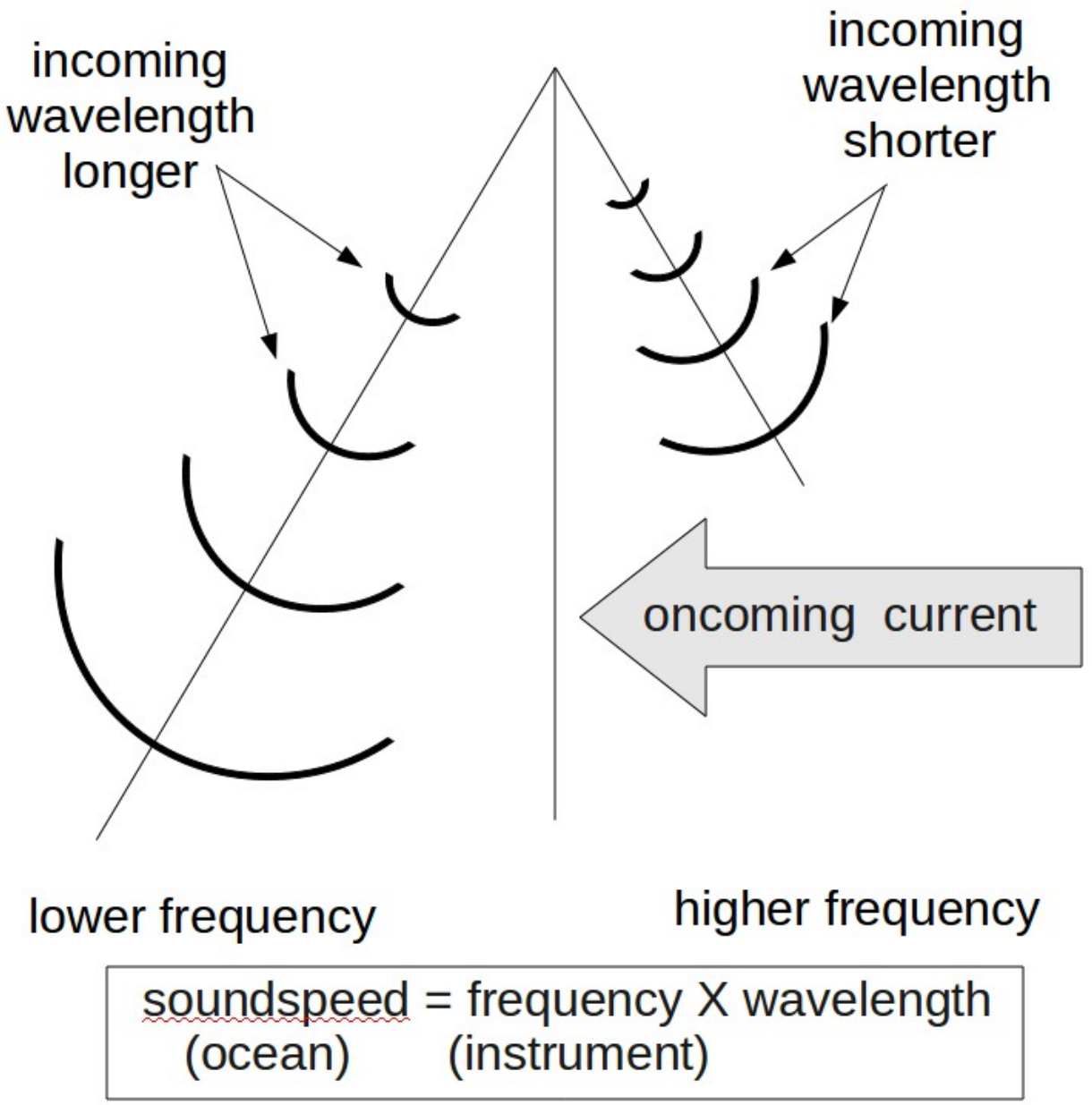
https://currents.soest.hawaii.edu
https://uhdas.org

Overview

1) What is shipboard ADCP?
2) How is SADCP data used?
3) What does UHDAS do?
   - at sea: acquisition, processing, serving
   - on land: monitoring
4) Tour of the UHDAS at-sea web site

ADCP

Acoustic
Doppler
Current
Profiler



more details: Calculating ocean currents from ADCP

ADCP: Getting Ocean Currents

Collect Data

ADCP

heading

position

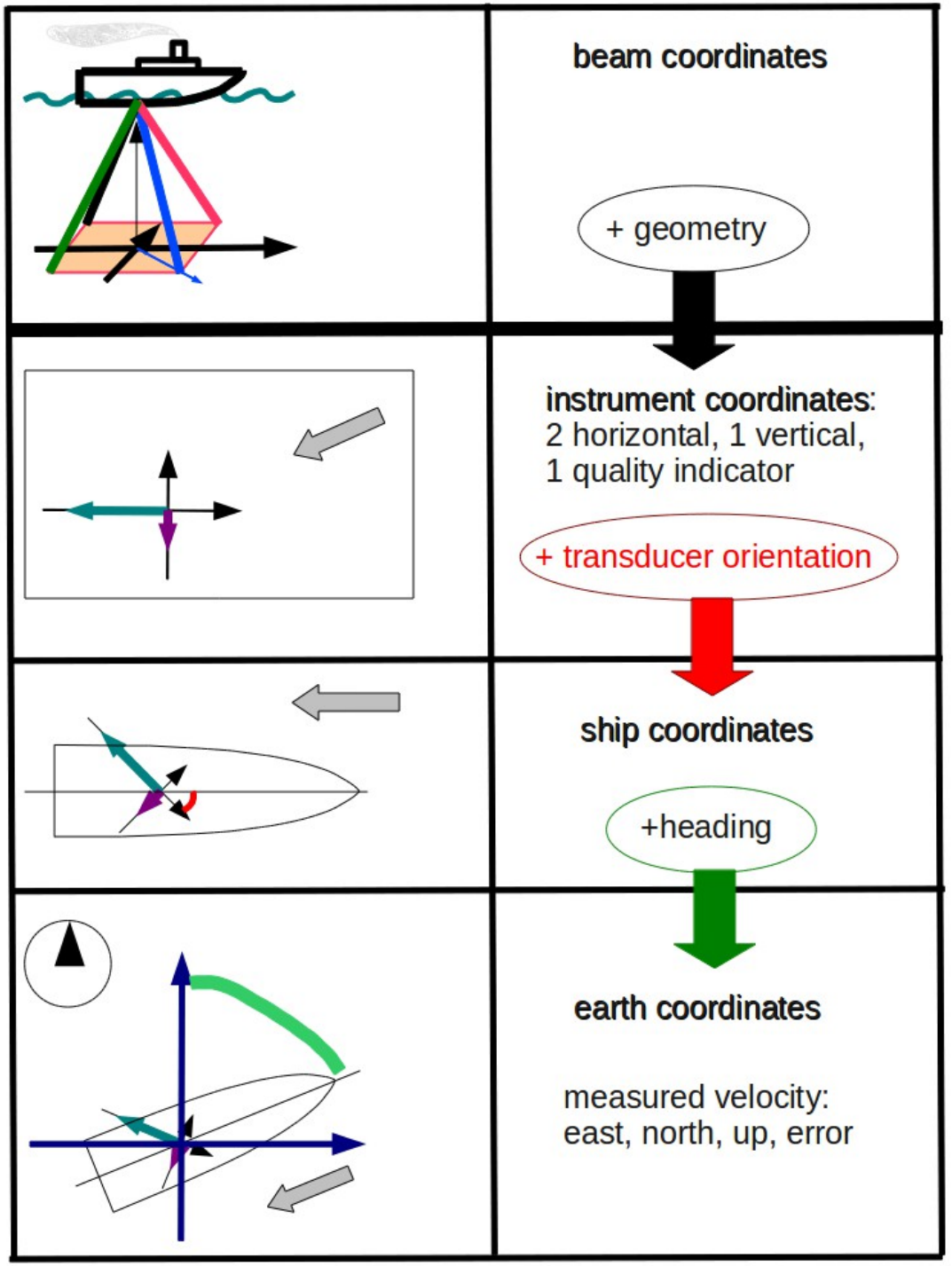
Transformations

Doppler to beam
(occurs in the ADCP)

- beam to instrument
- instrument to ship
- ship to earth

Preliminary Processing

- single-ping editing
- averaging
- remove ship's speed

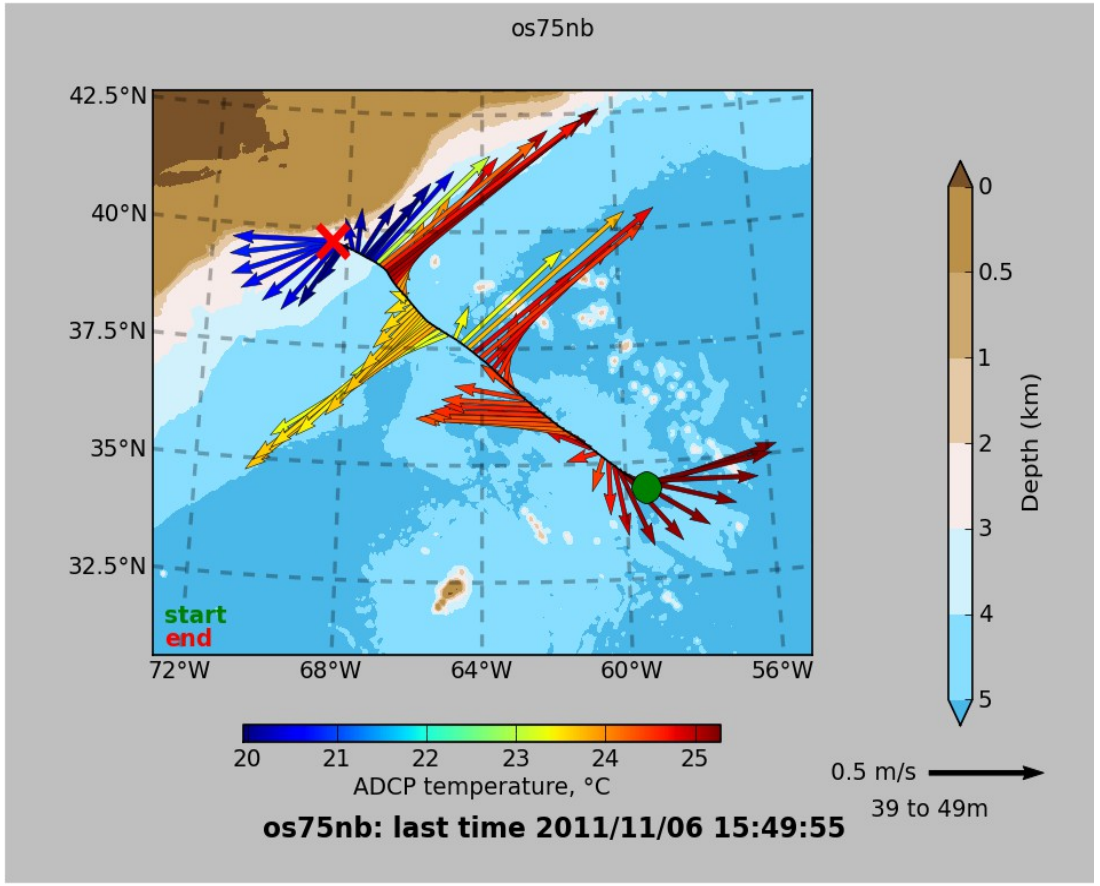


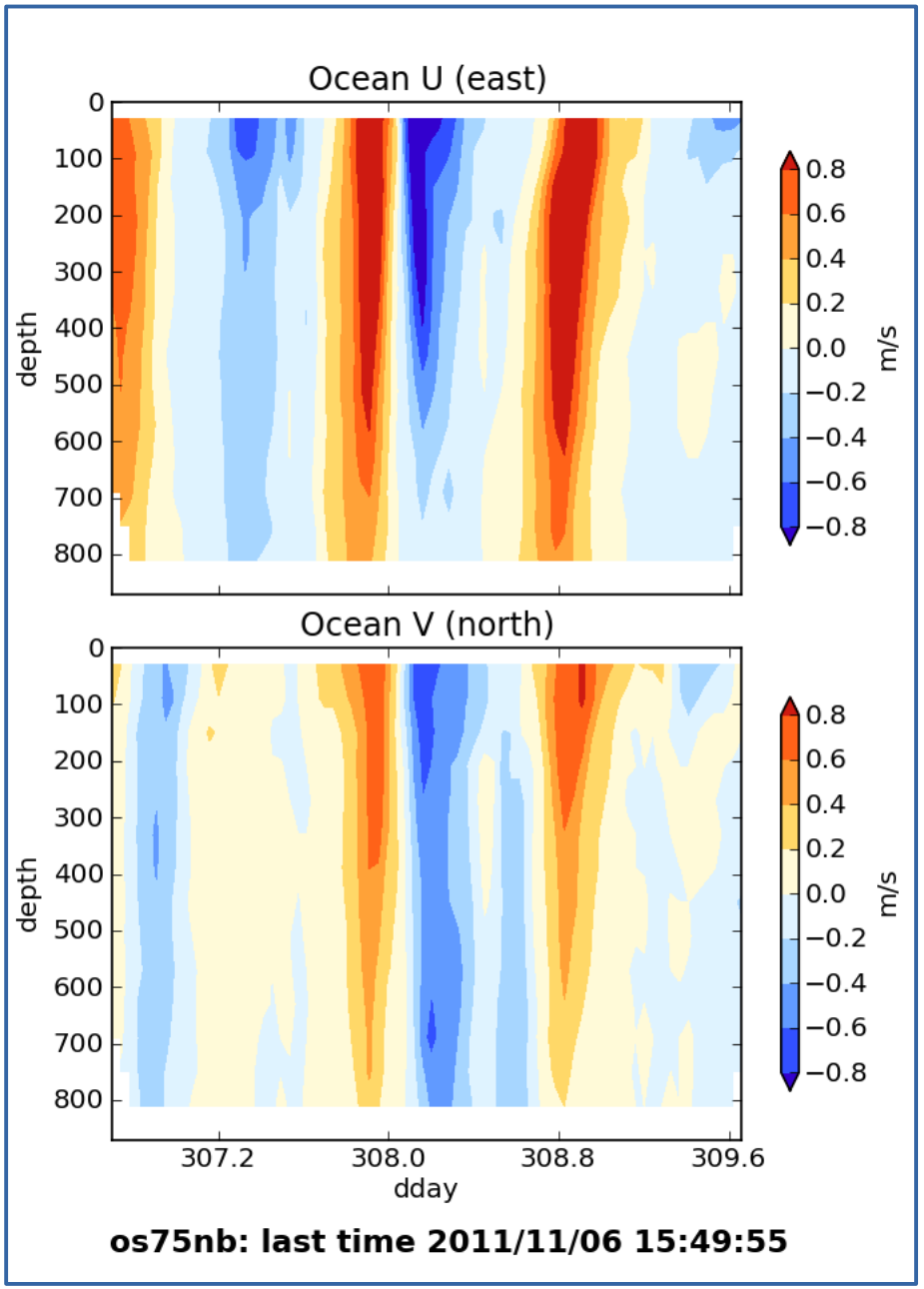
Time, ADCP, Position, Attitude

primitive (raw) data

After Processing

AfterProcessing





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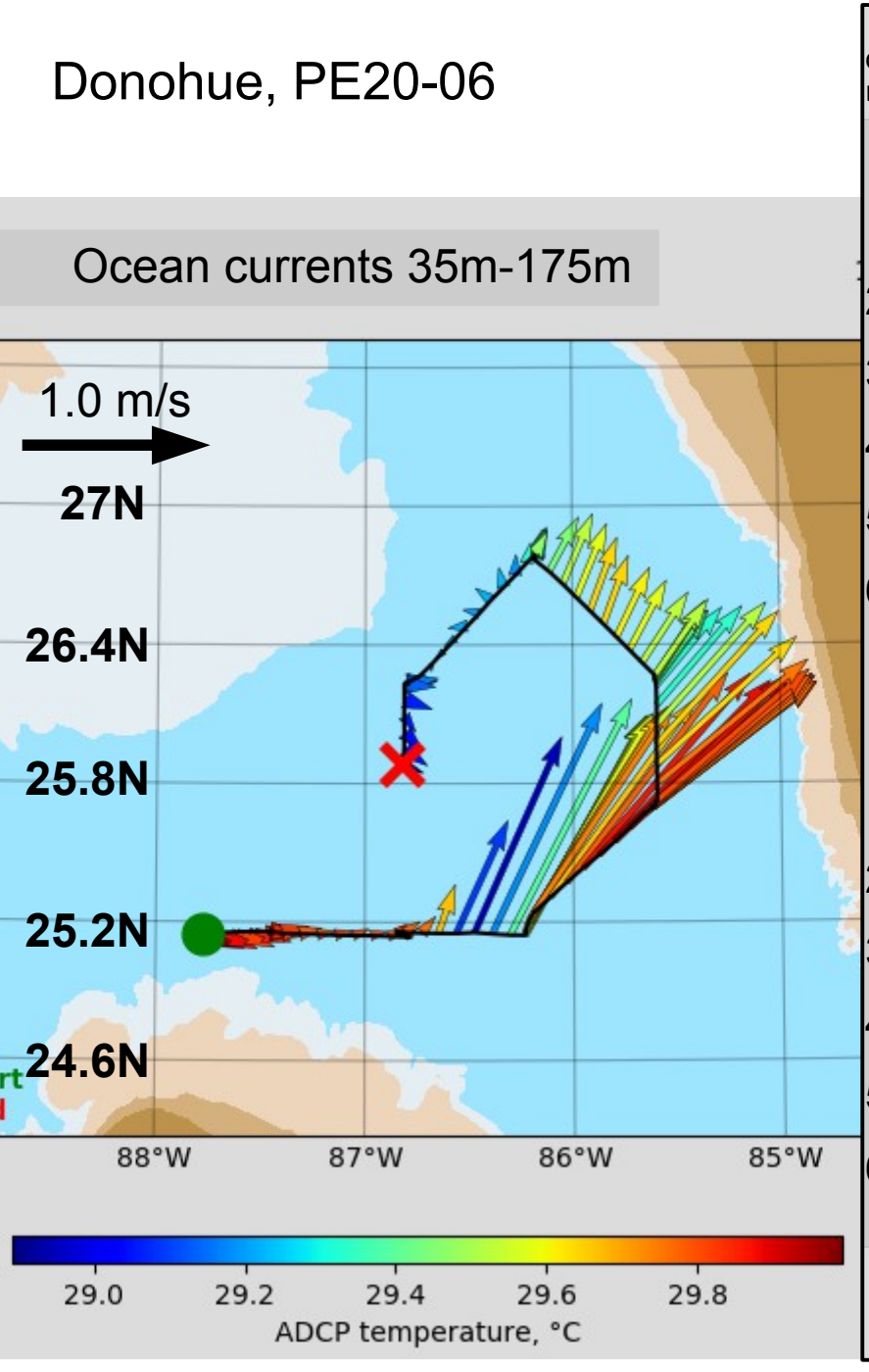
Operational uses of shipboard ADCP data

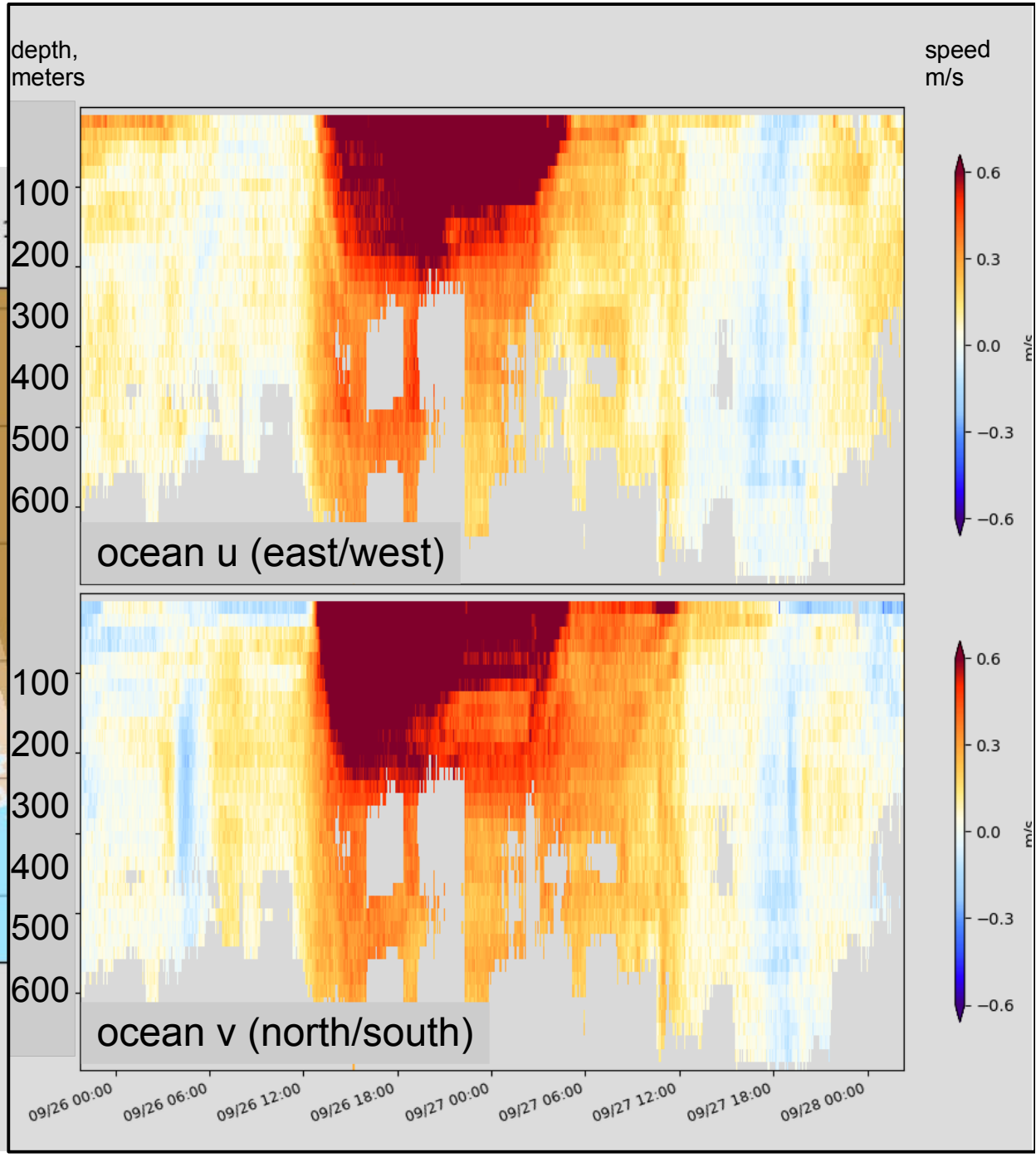
at sea:

- operations, eg:
  - currents for over-the-side work (moorings, CTD)
  - backscatter levels for targeted biological sampling
  - currents for ROV operators
- dynamic sampling, eg:
  - where is the front?
  - when did we cross the front?
  - which direction will the instrument drift after deployment?

R/V Pelican Mooring cruise, Gulf of Mexico

Donohue, PE20-06



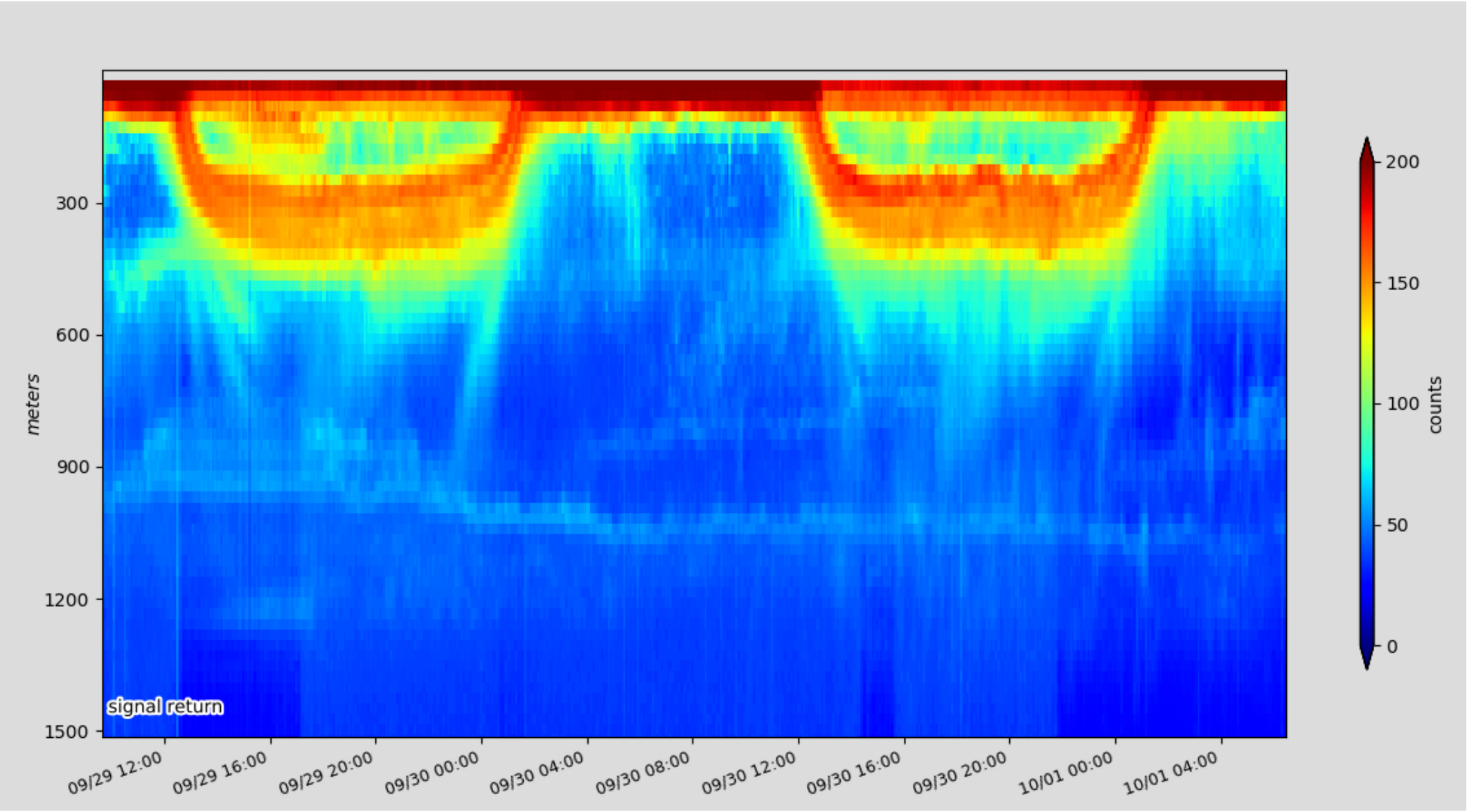


Scientific relevance of shipboard ADCP data

- backscatter (even if uncalibrated)
- process studies:
  - near-inertial motion
  - internal wave energy (upward propagation of phase)
  - high-frequency internal waves (on station)
  - deep eddies
  - context for small-scale mixing studies
- time series
  - dedicated, on station (HOT, BATS)
  - transects: Drake Passage, Oleander
  - after the fact: equatorial Pacific
- comparison with satellites

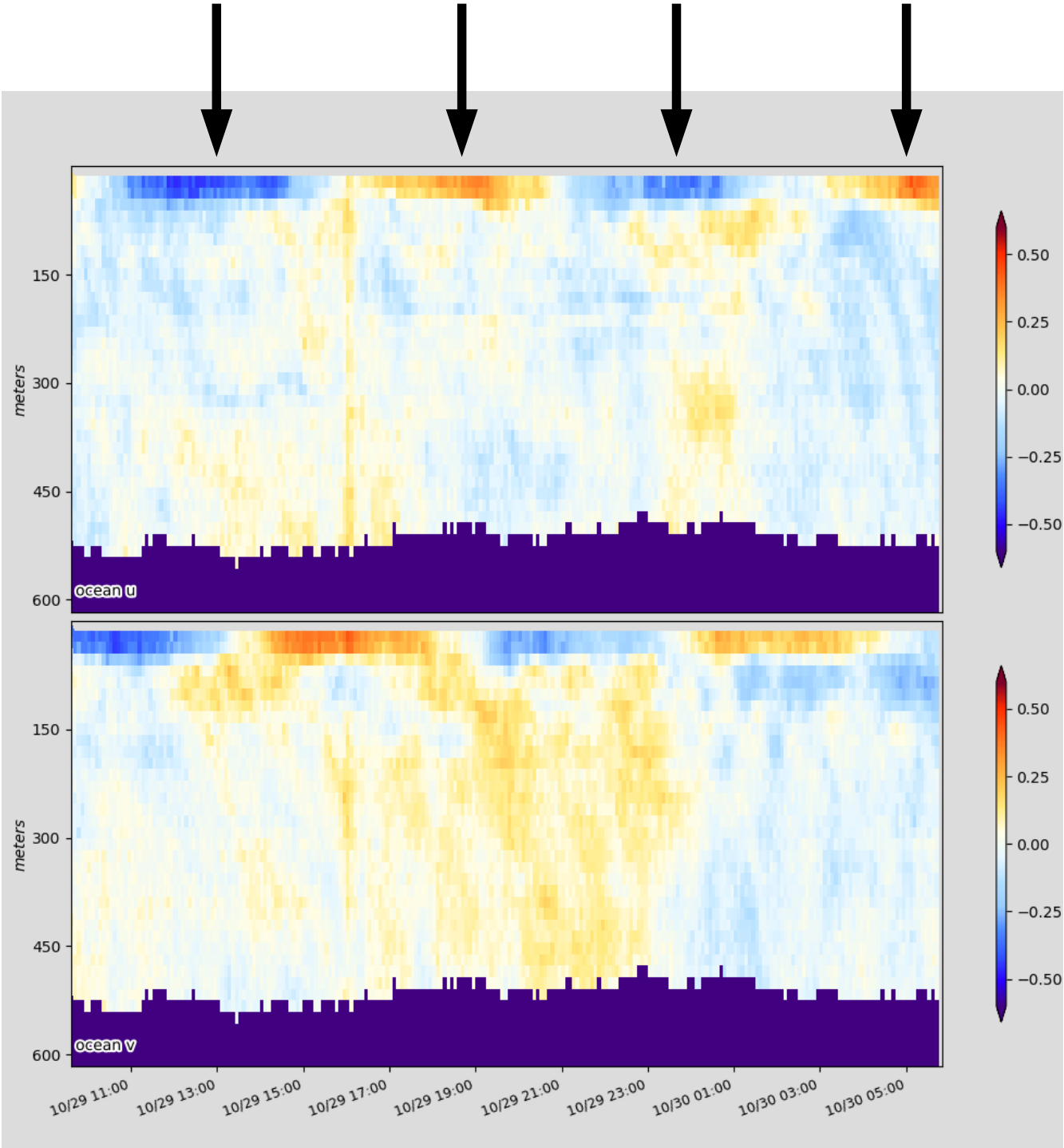
examples follow...

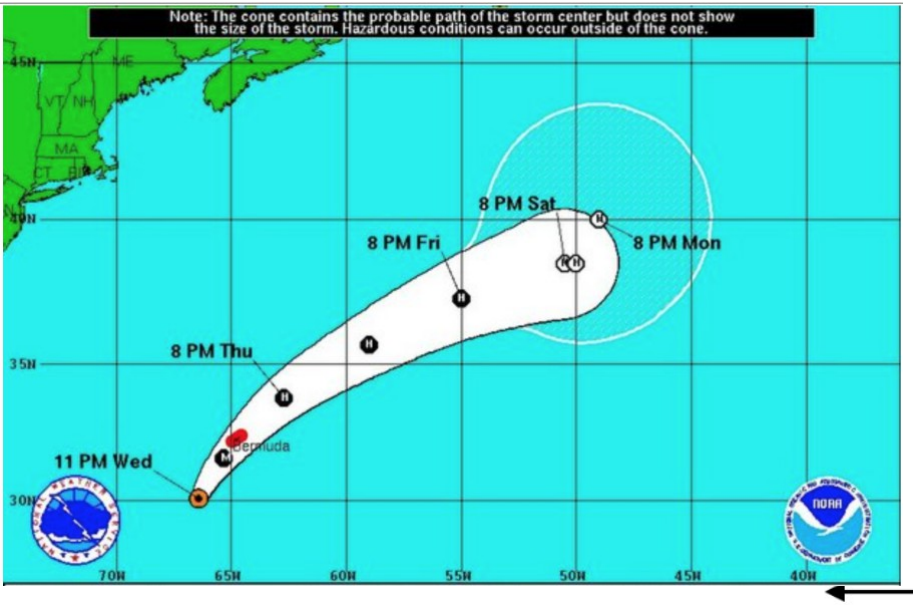
Kilo Moana: 38kHz ADCP backscatter (tropical eastern pacific)

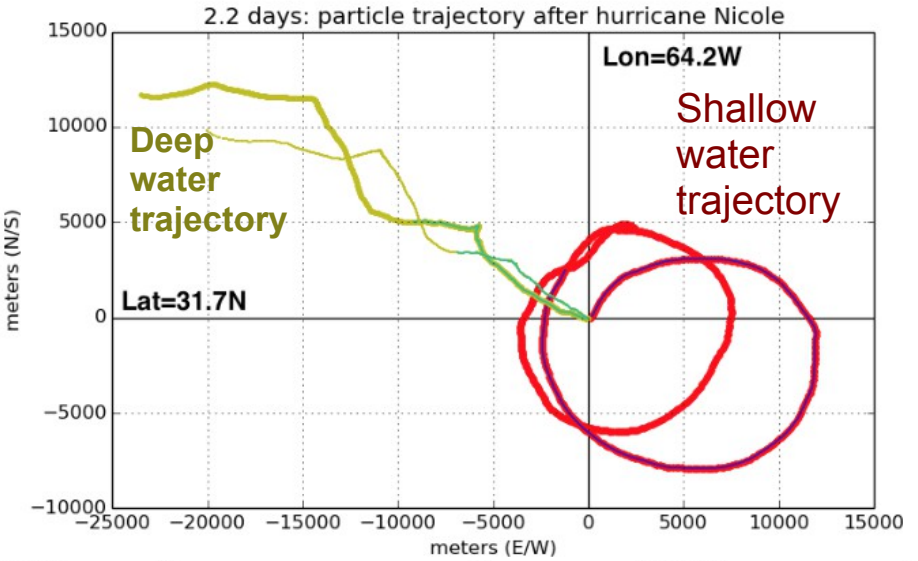


Near-inertial motion caused by strong winds;

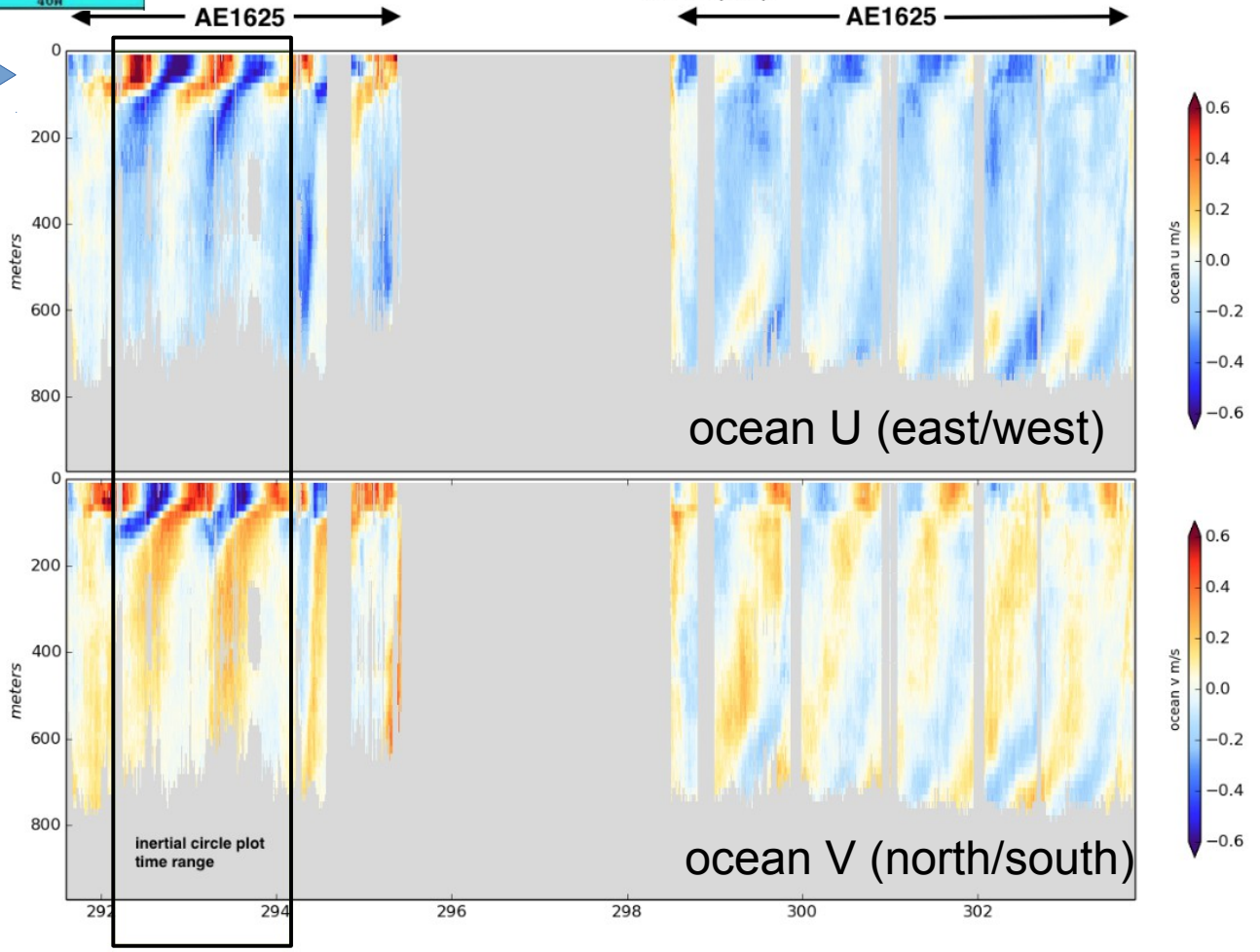
stratified ocean keeps the energy at the surface







shallow inertial signal

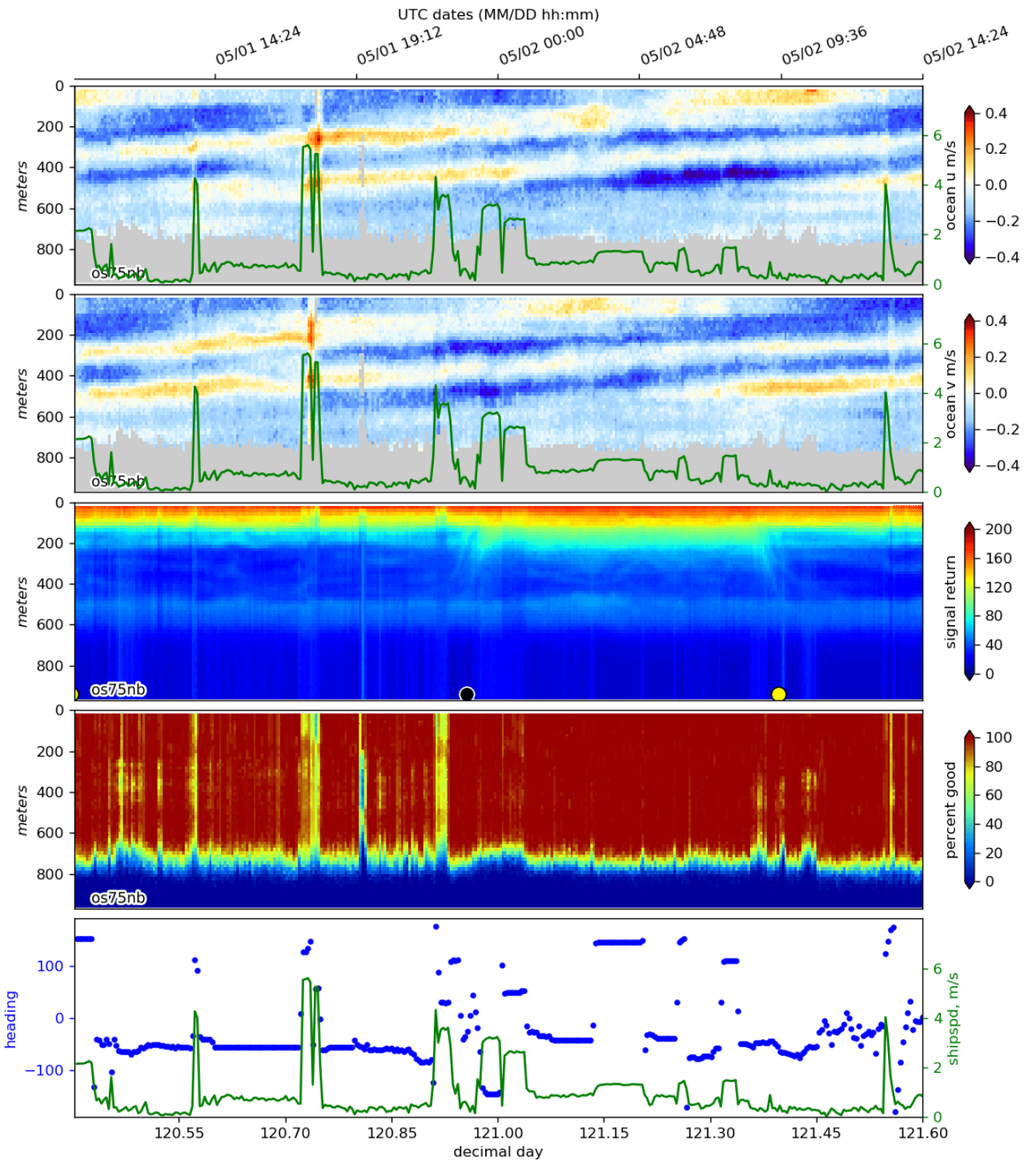


Hurricane Nicole
Oct 12, 2016

deep inertial signal later

Atlantic Explorer

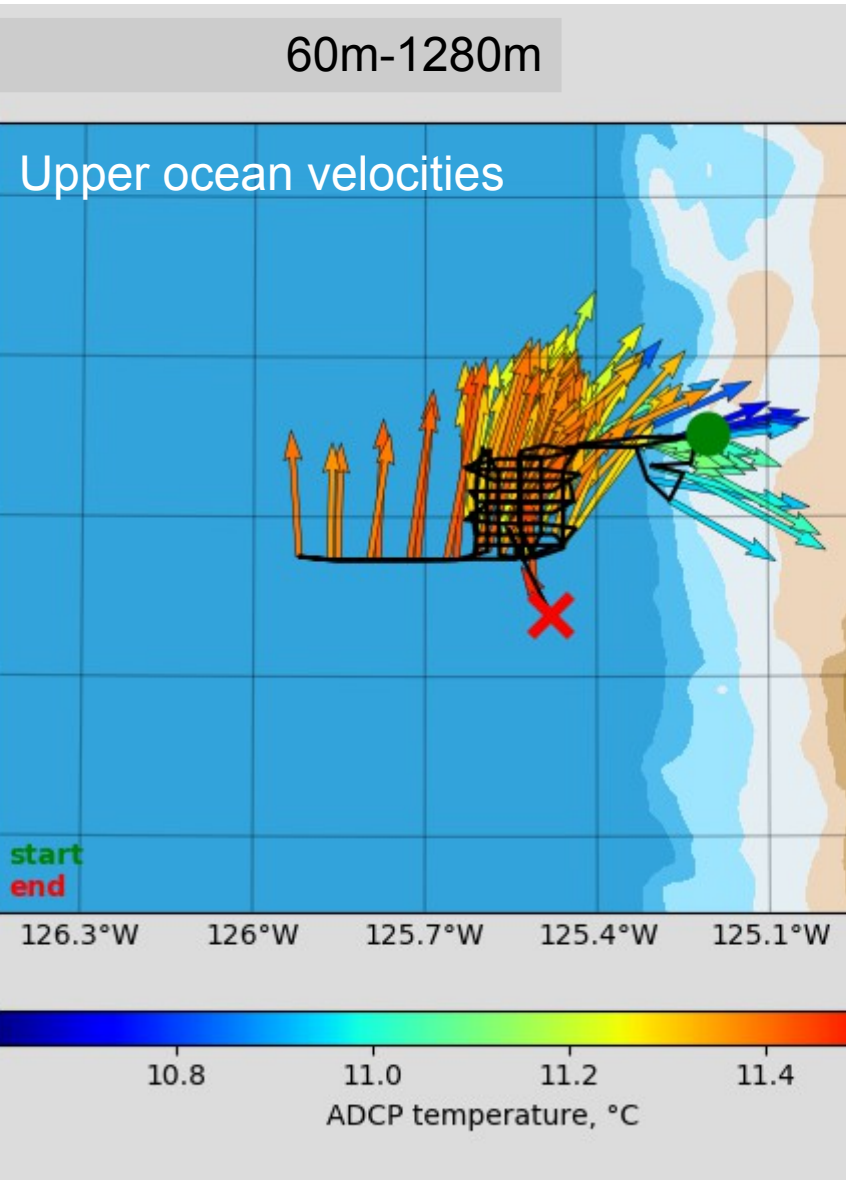
near-intertial energy at depth

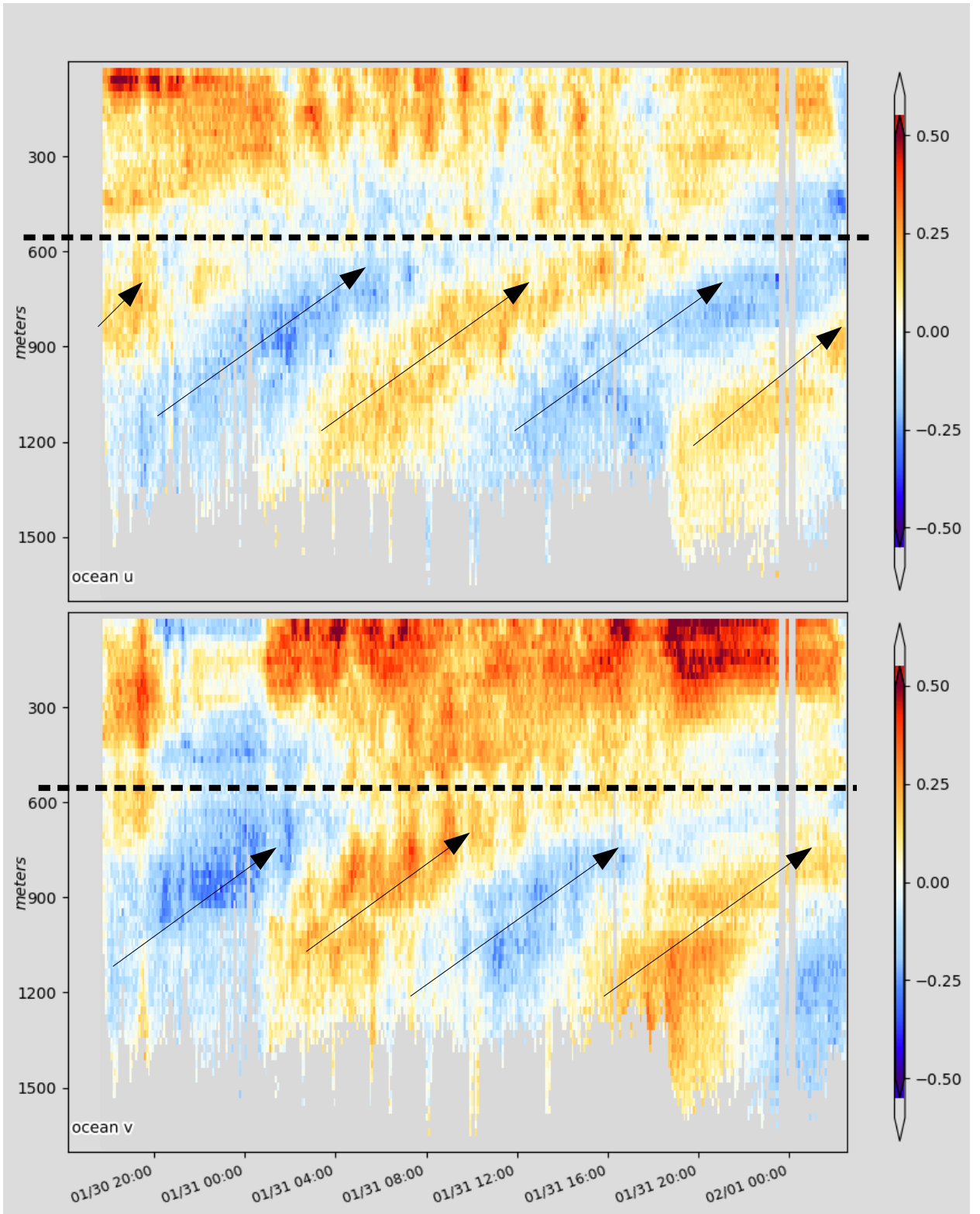


120.41 to 121.6 (1.20 days)

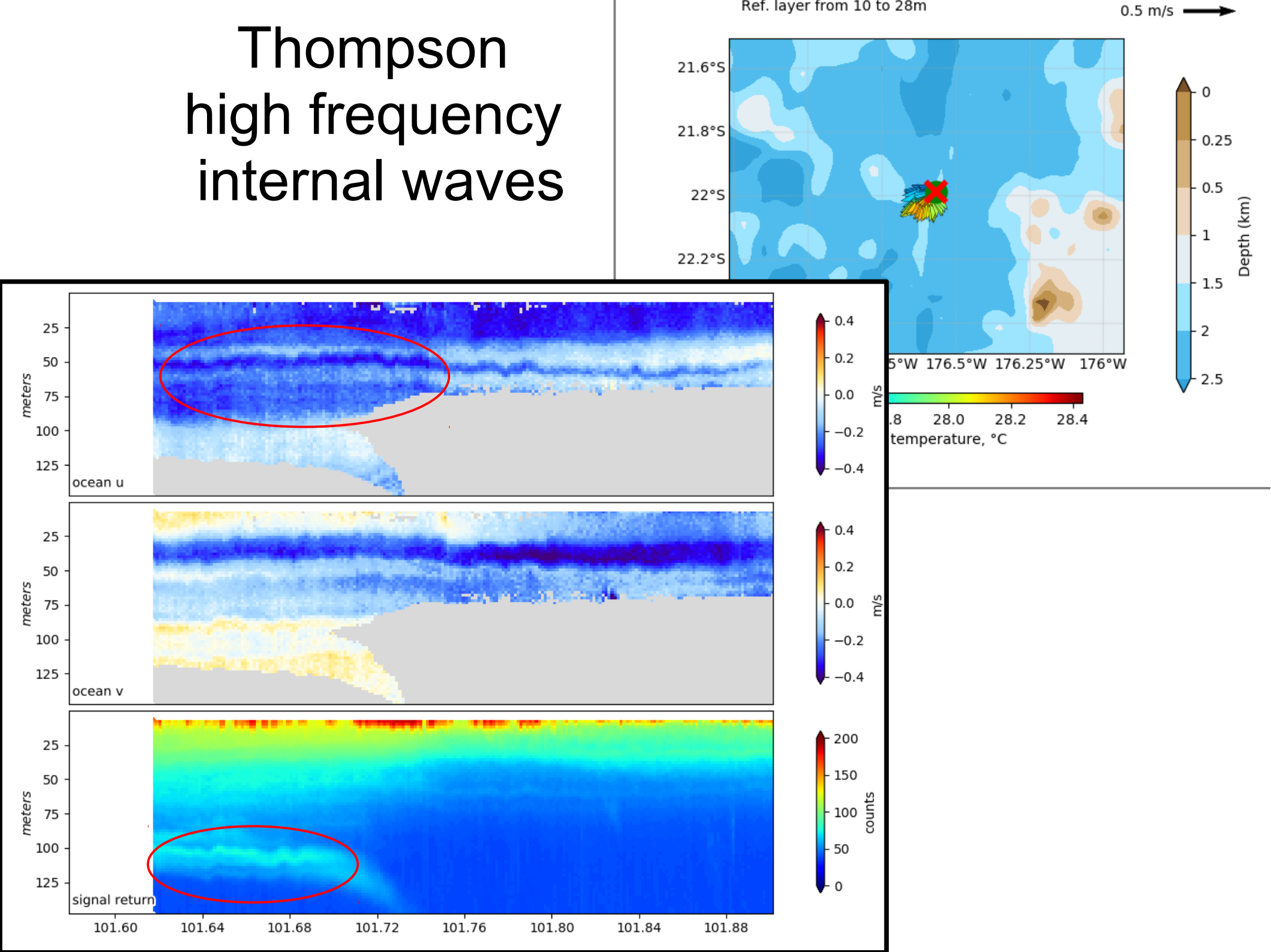
2022/05/01 09:44 to 2022/05/02 14:29

Kilo Moana (45N) off the Oregon Coast: internal tide beam, energy downward (phase upward) below 600m

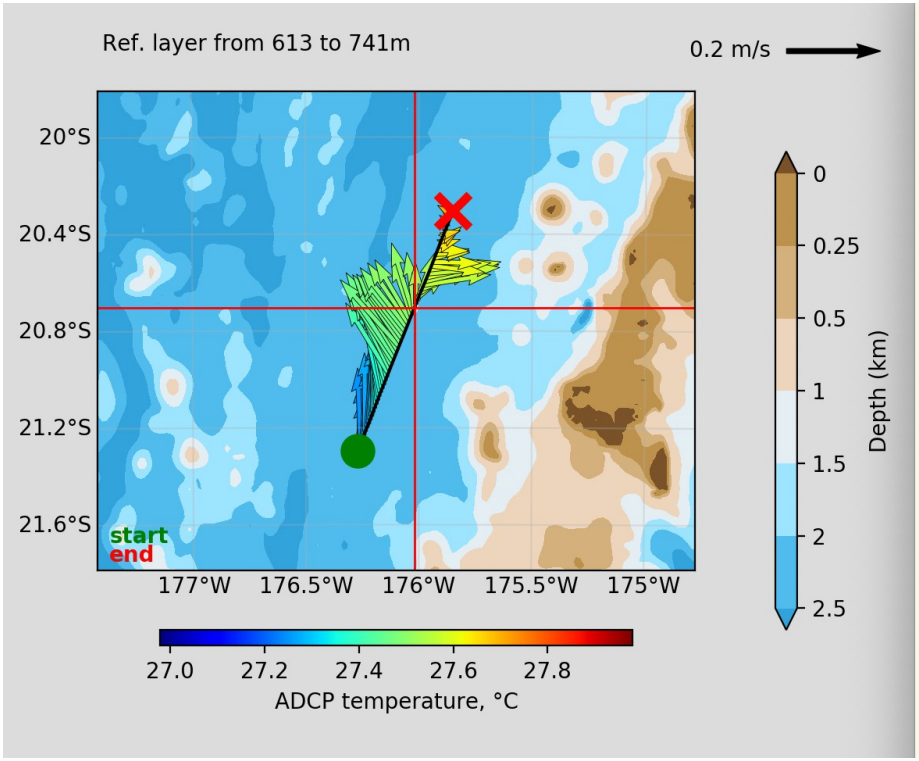


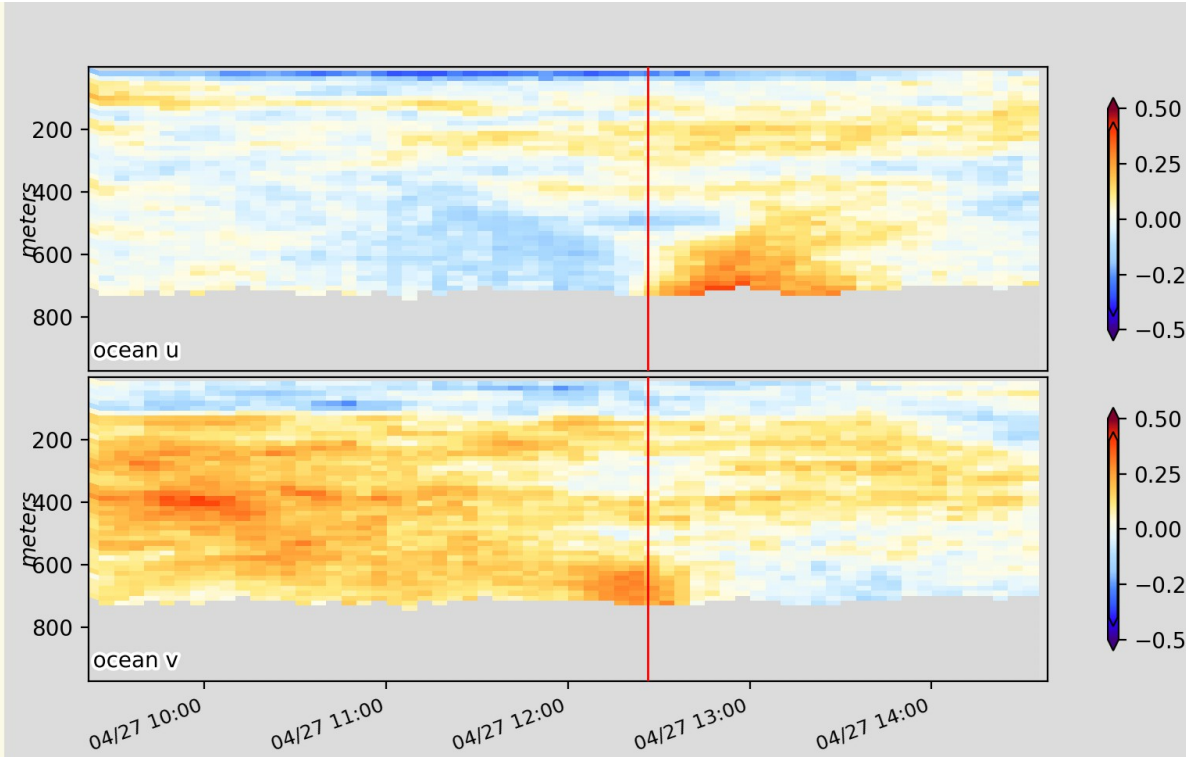


Thompson high frequency internal waves



Deep eddies: Lau Basin (Thompson)



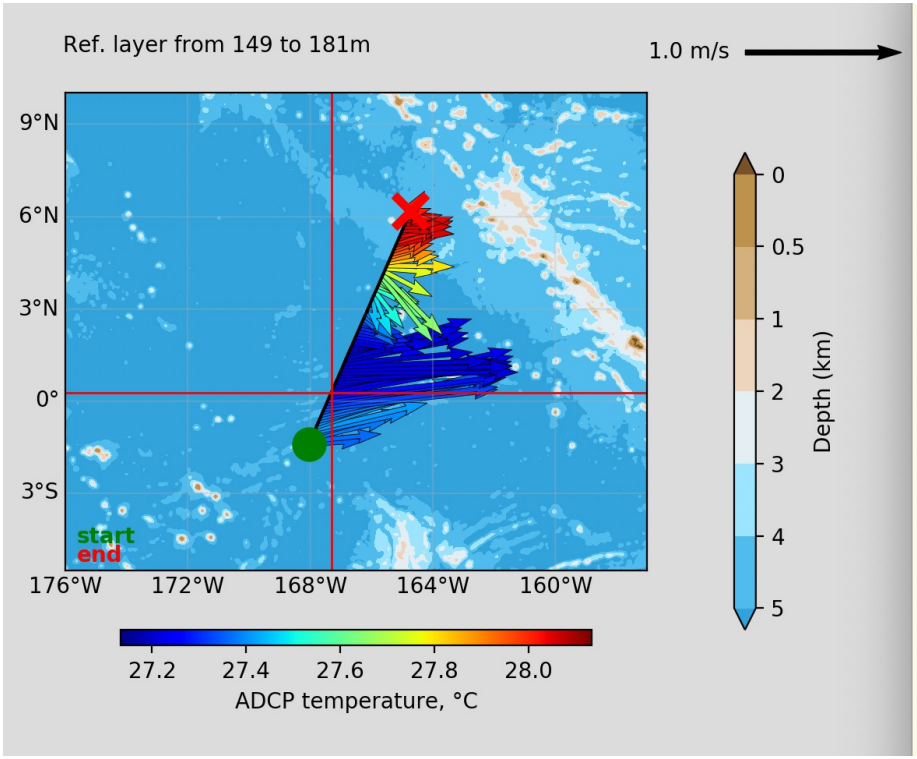


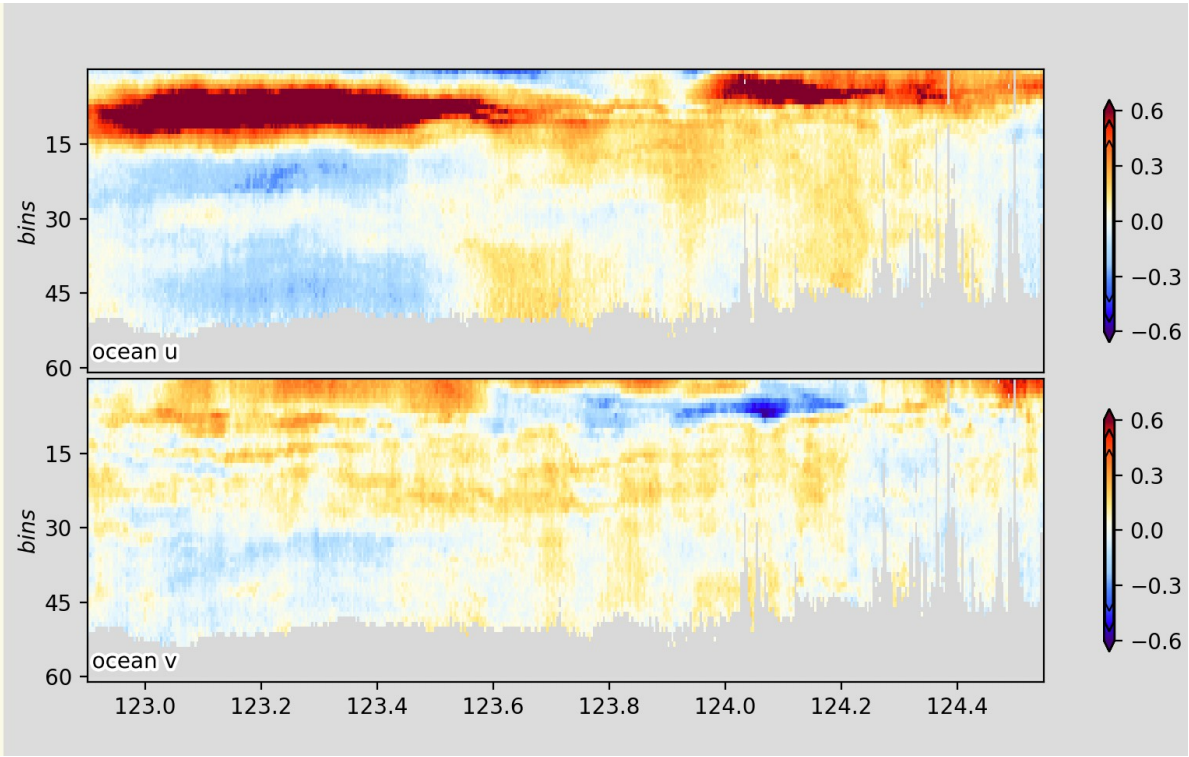
Explore: Lau Basin Eddies

Beaufort Sea Eddies

Other subsurface Eddies

Opportunistic timeseries data: eg. Equatorial crossing

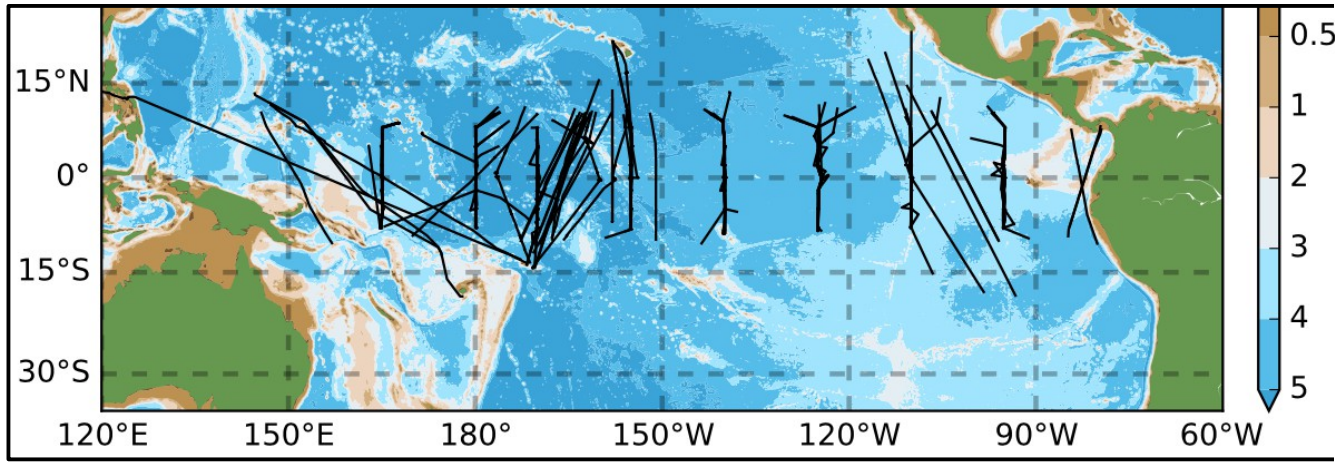




- Notice data of interest
- Ask for permission to use it
- Use for training; process and release for others to use

Time Series: Equatorial Pacific

SADCP from TAO sections
Crevatte et al, JMR 2017



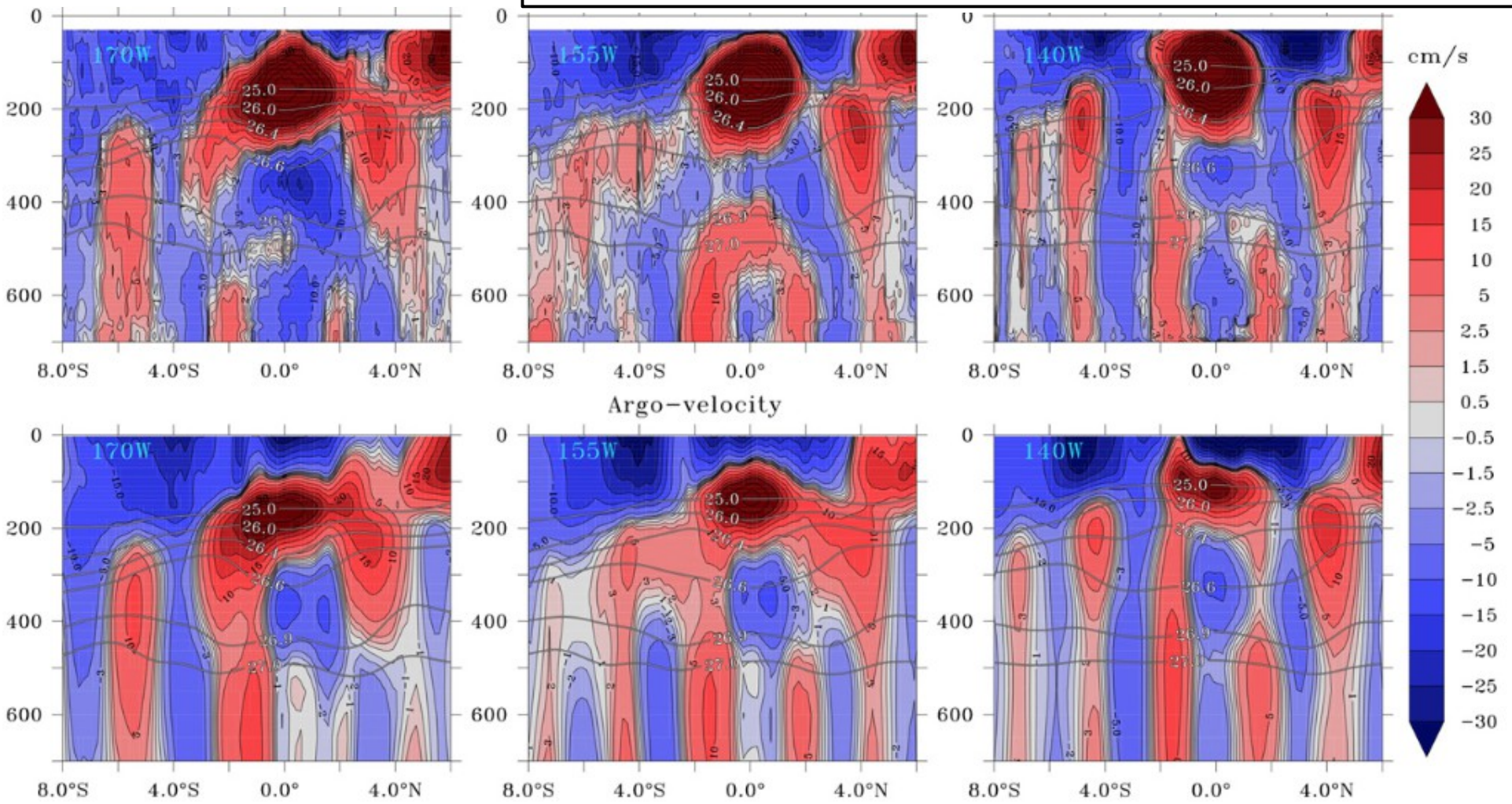
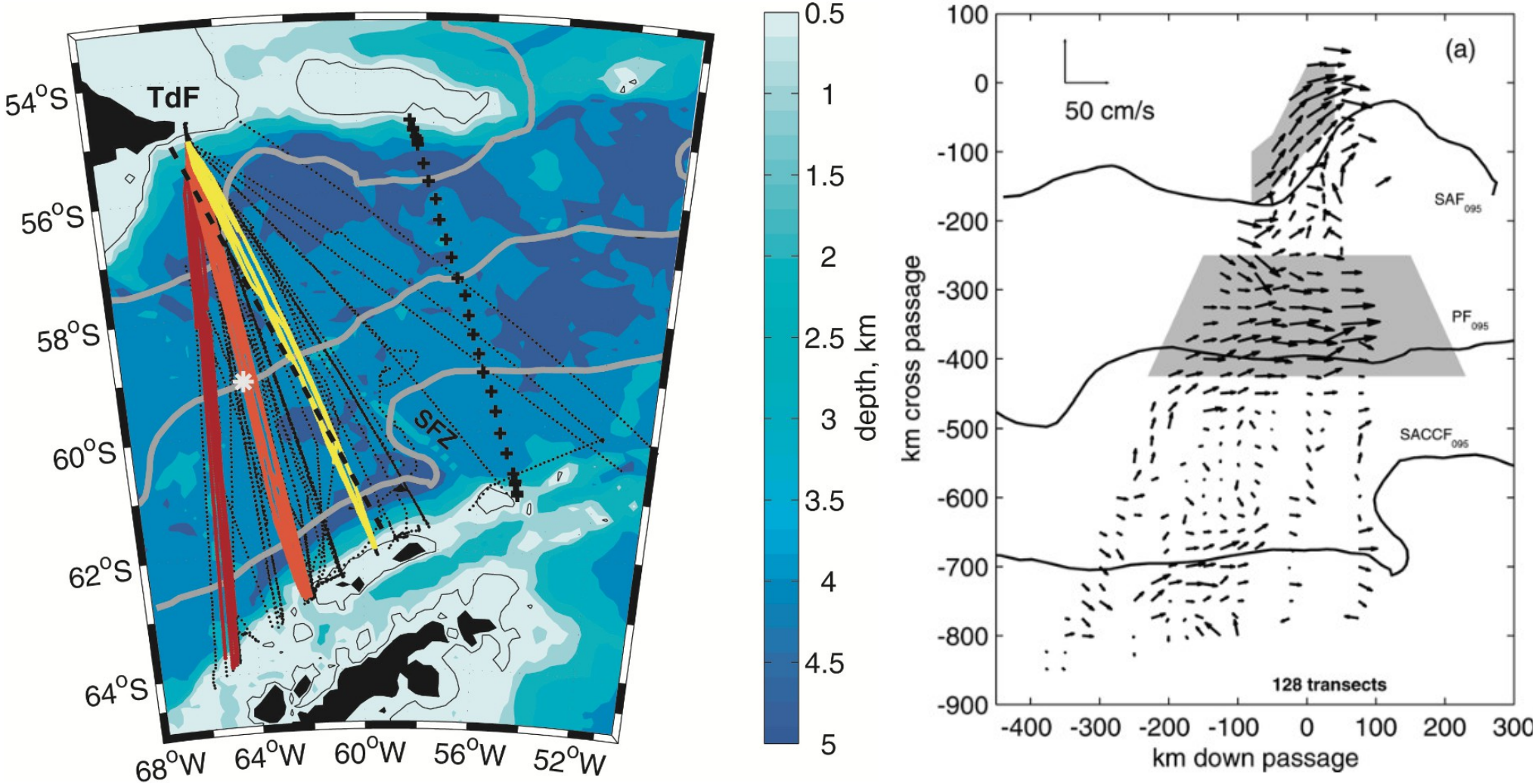


FIG. 12. Mean zonal velocity from (top) SADCP data and (bottom) Argo velocity product at (left) 170°W, (center) 155°W, and (right) 140°W in cm s^{-1}. Superimposed are some selected isopycnals.

Time Series Examples

Laurence M. Gould: Drake Passage

Lenn et all, JMR, 2007



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Where are scientific shipboard ADCPs installed?

In the United States:

- Academic Research Fleet (**UNOLS ~20 ships**, all with UHDAS)
- Nat'l Oceanographic and Atmospheric Admin (**NOAA 11 ships**)
- smaller science vessels

Internationally:

- oceanographic research vessels (UHDAS on ~10)
- smaller science vessels
- Navy ships

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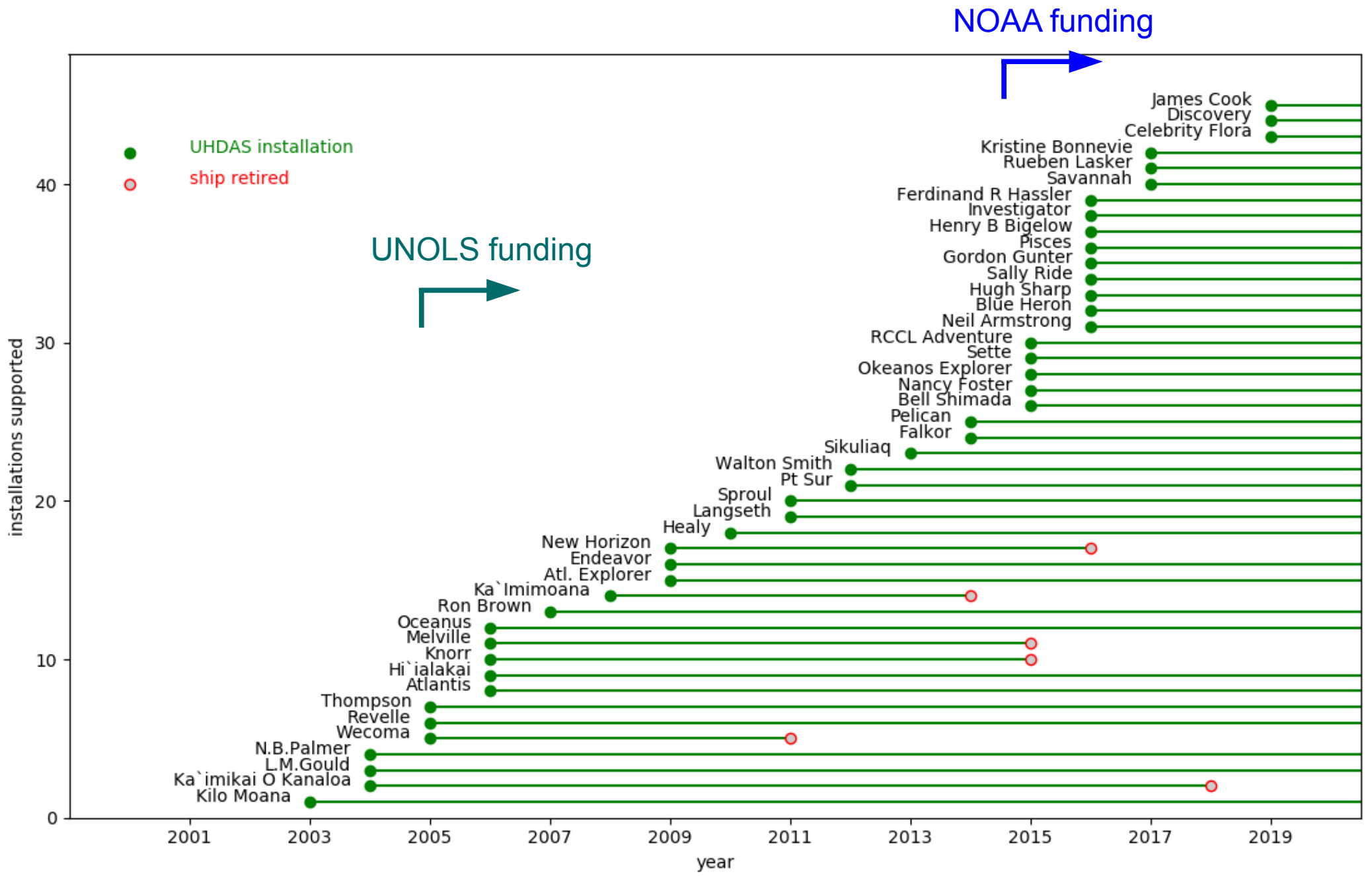
(1) Teledyne RDI is the only company making viable shipboard ADCPs at this point
(2) Most RDI installations would use their Windows program for acquisition ("VmDAS")

UHDAS Installations supported: by year



How UHDAS improves the quality of shipboard ADCP data

- **acquisition** (ADCP, position, heading)
  - easy to use; can return to known-working settings
- **automated processing** ("pre-processing" at sea)
- **monitoring**
  - on ship: via at-sea web site
  - on land: automated daily emails to UHDAS Team
  - feedback to technicians on the ship
- **data and products**
  - operations and science at sea
  - ease of post-processing after the cruise
  - discovery/evaluation in the future

ADCP preliminary Processing

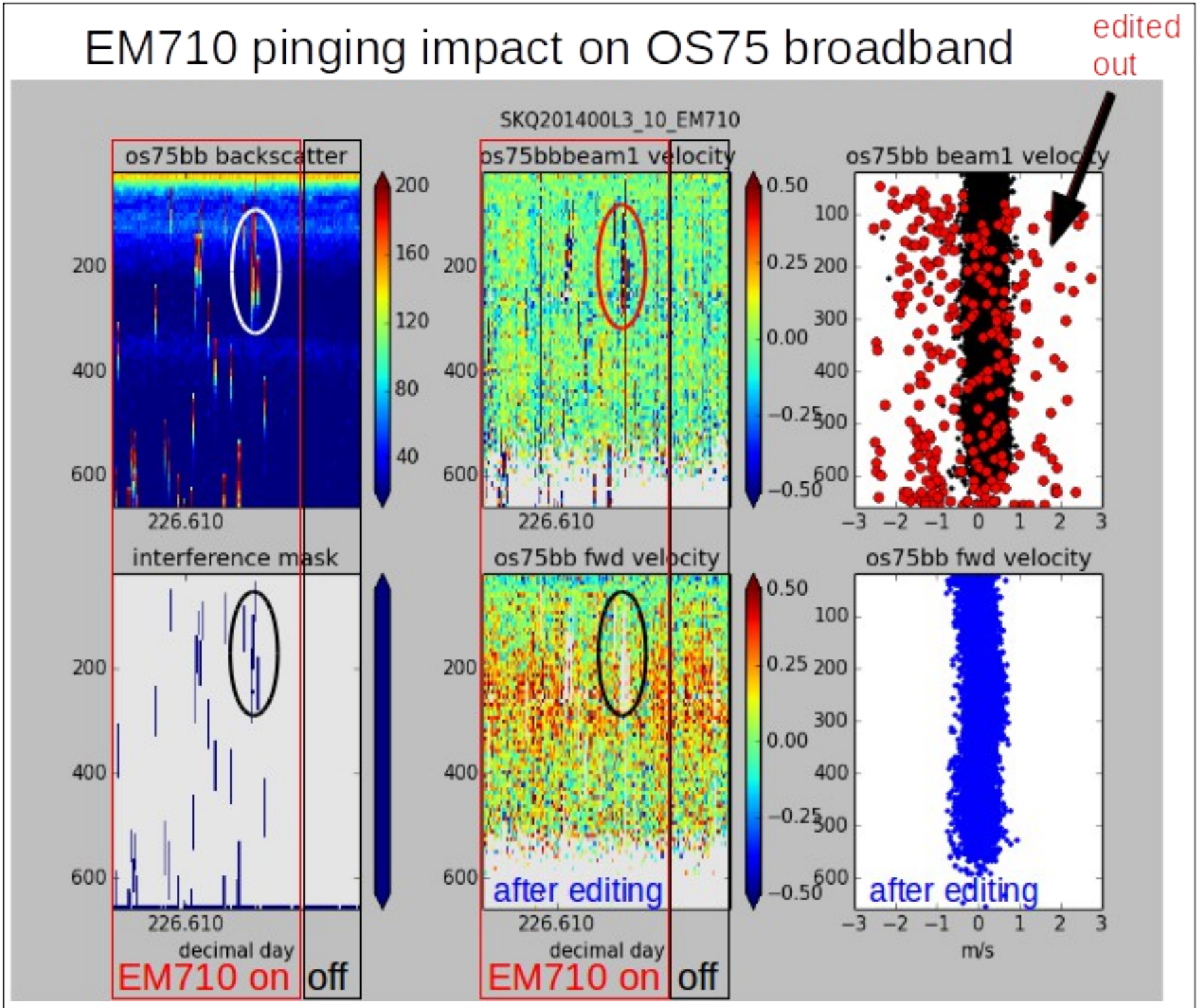
"processing" requires (at minimum)

- transform from beam coordinates to horizontal
- rotation into ship coordinates
- further rotation based on heading
- account for ship's speed
  - acoustic interference
  - data below the bottom
  - short, biased profiles (bubbles)
  - remaining statistical outliers
- averaging
  - **CODAS directory is staged for post-processing**

CODAS single-ping editing: remove bins due to...

link: CODAS+UHDAS documentation
https://currents.soest.hawaii.edu/docs/adcp_doc/index.html

CODAS single-ping editing based on acoustic interference



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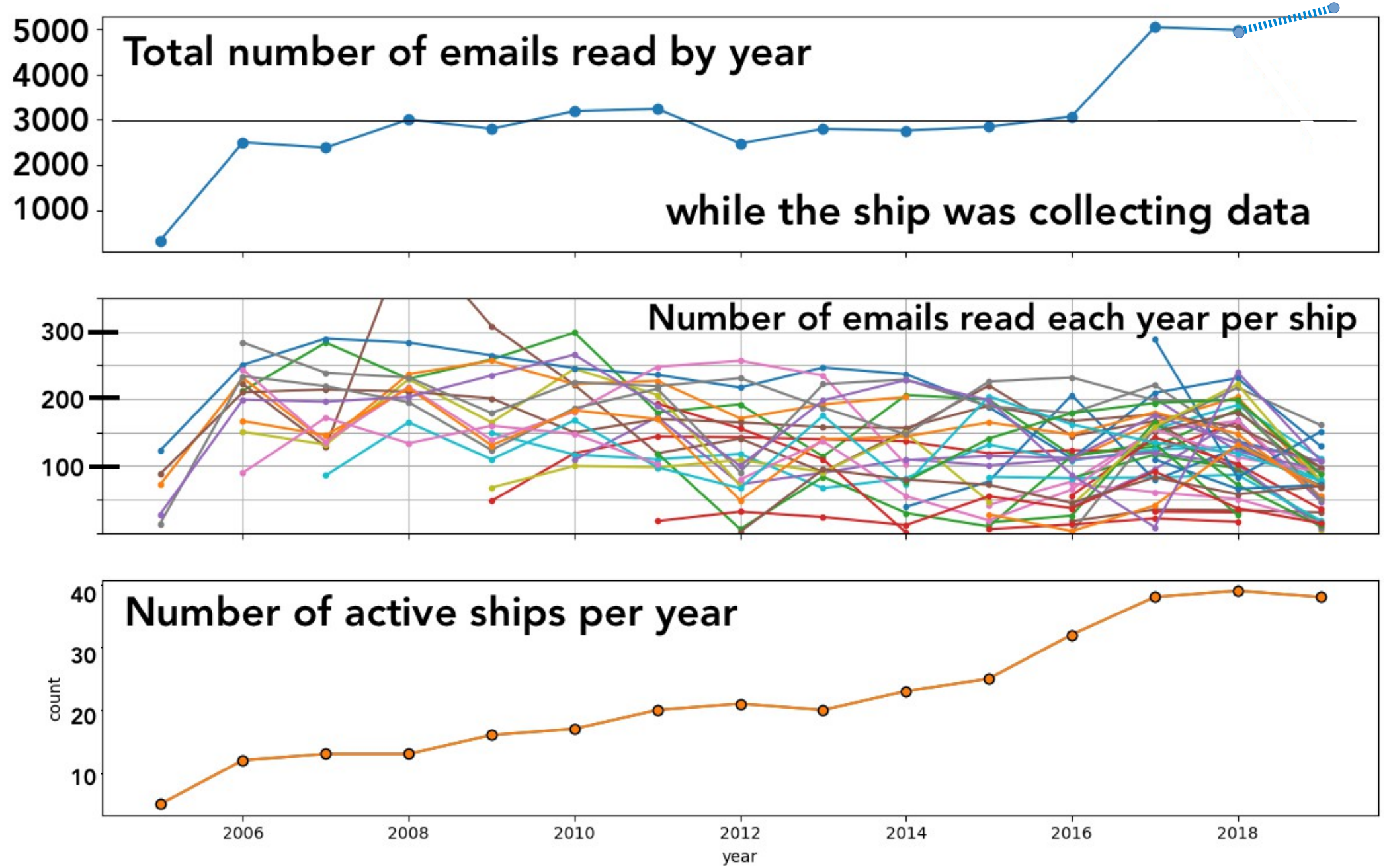
Monitoring

- on ship:
  - via web site on ship (science and diagnostic figs)
- on land
  - automated daily emails to UHDAS Team
  - dashboard with
    - cruise status
    - links to figures, diagnostic files
  - ticketing system: first pass at identifying problems:
    - notifies the UHDAS team of a problem
    - mechanism for tracking problems (eg, cruise, ship, instrument)
    - has guidance for common problems
- Team provides feedback to technicians on the ship

UHDAS ship and email metrics



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CODAS data and products

At sea:

- **Example At-Sea UHDAS web site** (M.G.Langseth May, 2022)
  - figures for operations and science at sea
  - netCDF data files for science
  - matlab data files
  - archive of daily figures
  - calibration from processing
  - settings used during processing
- complete CODAS+UHDAS documentation

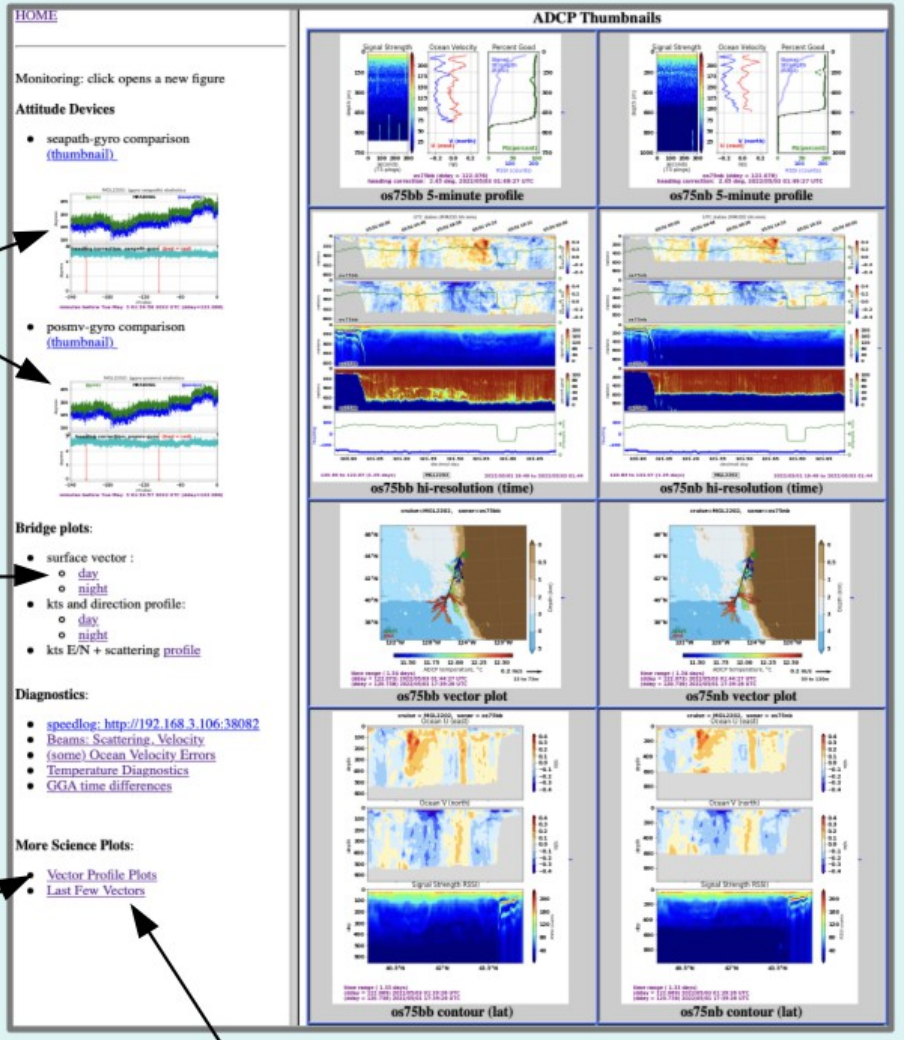
Tour of the UHDAS at-sea web site figures

UHDAS Figures (live)

Diagnostic and Operational

Science plots: one column per instrument+pingtype

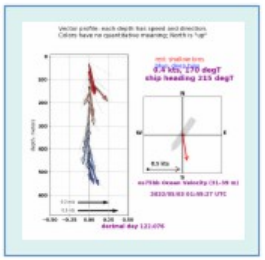
os75bb os75nb



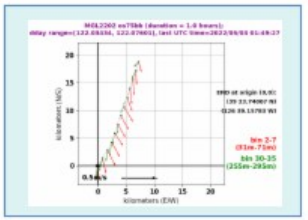
monitor heading devices

Bridge vector plot

vector profile plot



last few vectors



Link to documentation about figures

References

Drake Passage

- ***Vertical structure and transport of the Antarctic Circumpolar Current in Drake Passage from direct velocity observations***

  Journal of Geophysical Research, 116, C08015; 2011; Y. Firing, T. Chereskin, M. Masloff

- ***Mean jets, mesoscale variability and eddy momentum fluxes in the surface layer of the Antarctic Circumpolar Current in Drake Passage***

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Equatorial Pacific

- ***Subthermocline and Intermediate Zonal Currents in the Tropical Pacific Ocean: Paths and Vertical Structure***

  Journal of Physical Oceanography, 47, 2305-2324,2017; S. Cravatte, E. Kestenare, F. Marin, P. Dutrieux, E. Firing

- ***Annual Reversal of the Equatorial Intermediate Current in the Pacific: Observations and Model Diagnostics***

  Journal of Physical Oceanography, 40, 915-933, 2010; F. Marin, E. Kestenare, T. Delcroix, F.Durand, S. Cravatte, G. Eldin

Equatorial Cross-section
R/V James Cook
Oct 21-24, 2019