Maximizing the Scientific Value of Ocean Current data from Shipboard ADCP

University of Hawaii / SOEST
Oceanography Department Seminar
Feb 6, 2020

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

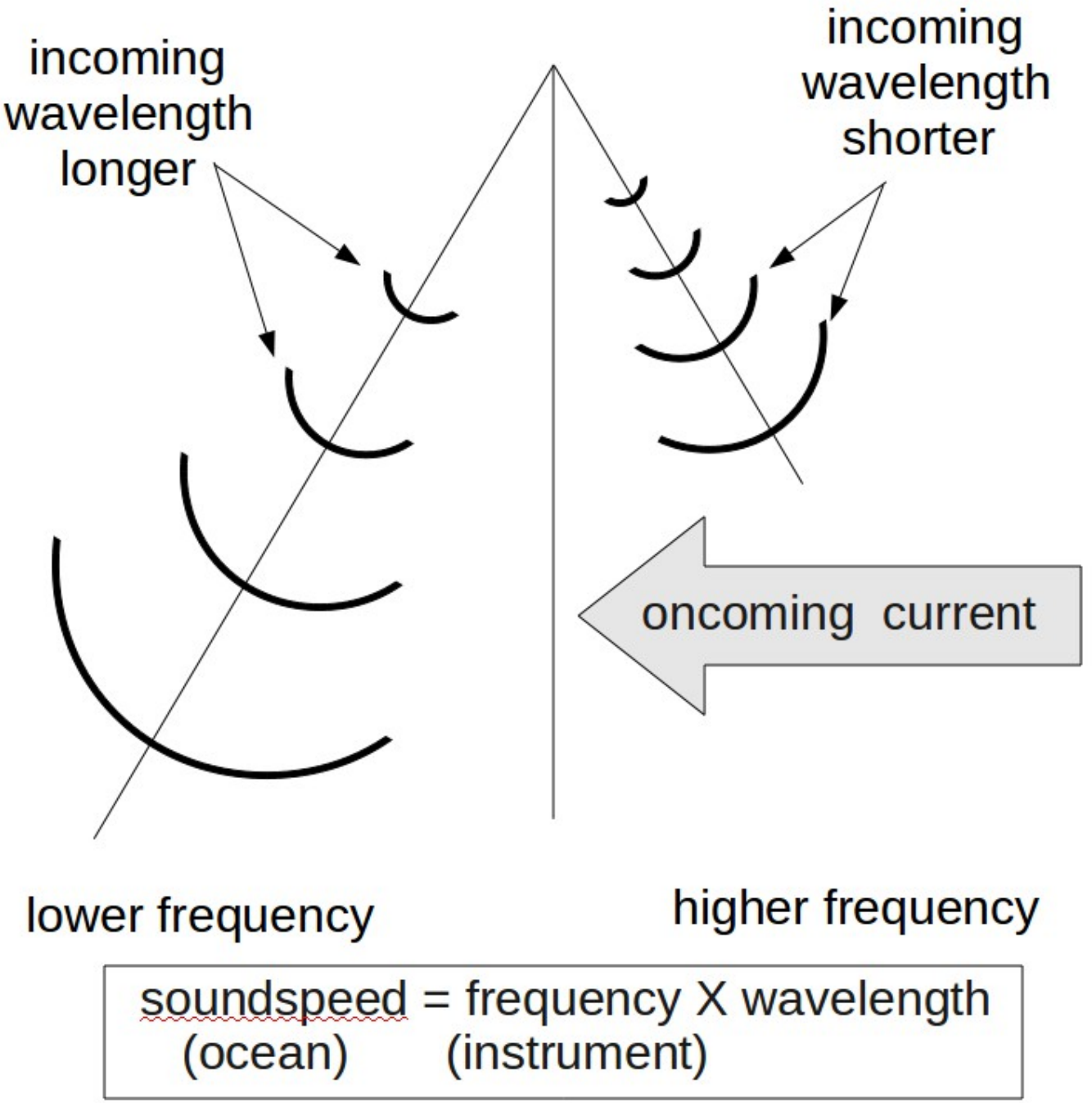
https://currents.soest.hawaii.edu
https://uhdas.org

Overview

- what is shipboard ADCP? who uses the data?
- where are SADCPs installed?
  - introduction to U.S. Academic Research Fleet; NOAA
- data flow (part 1):
  - acquisition, data on the ship
- maximizing scientific value of shipboard ADCP
  - make it work well; keep it working well
  - make it available immediately and in the future
  - be able to reprocess after the cruise
- data flow (part 2):
  - roles of processing, scientists, national archive

ADCP

Acoustic
Doppler
Current
Profiler

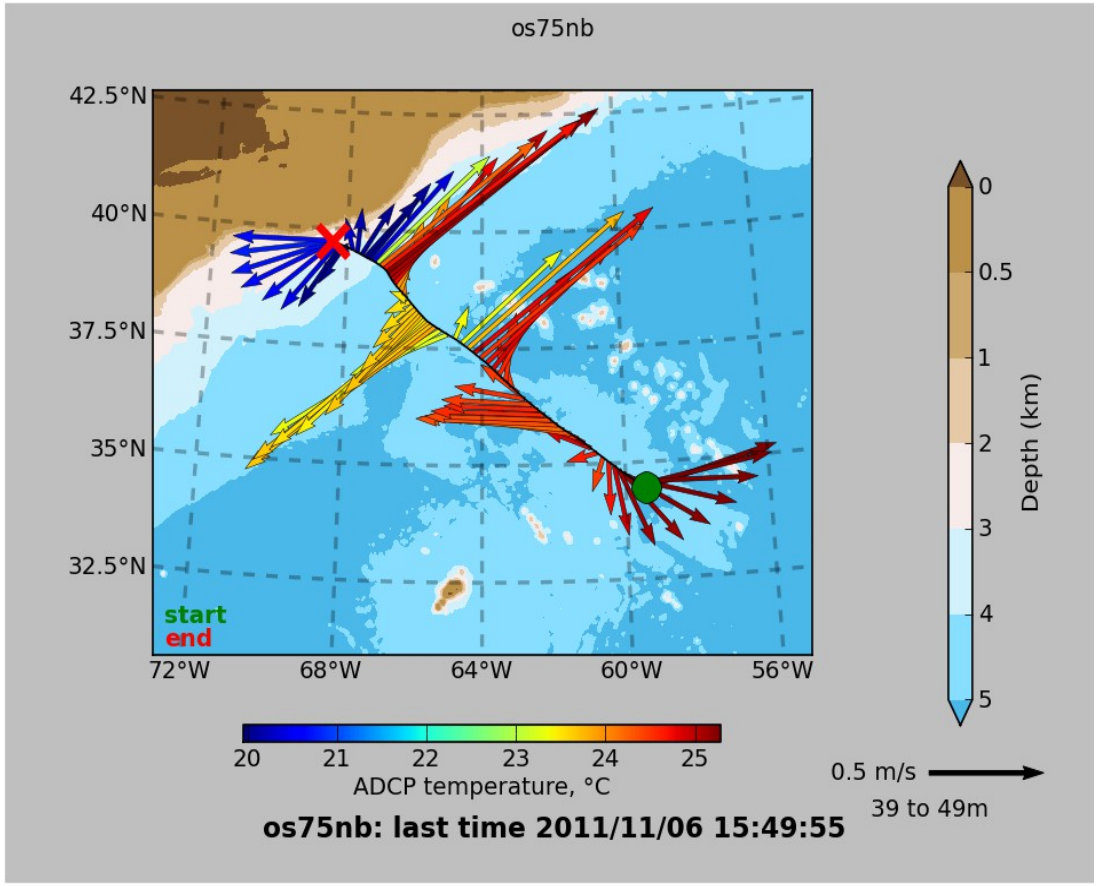


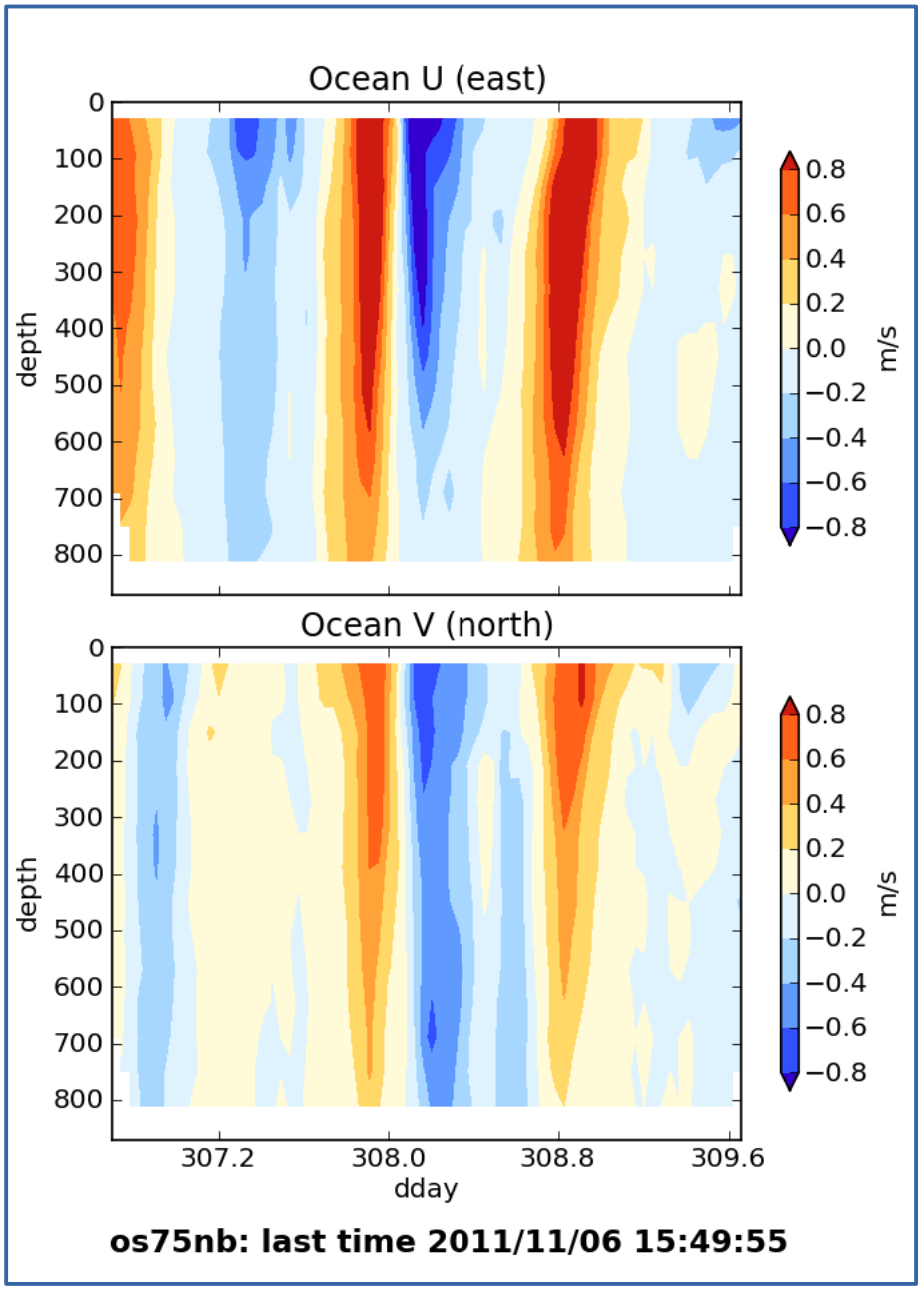
Time, ADCP, Position, Attitude

primitive (raw) data

After Processing

AfterProcessing





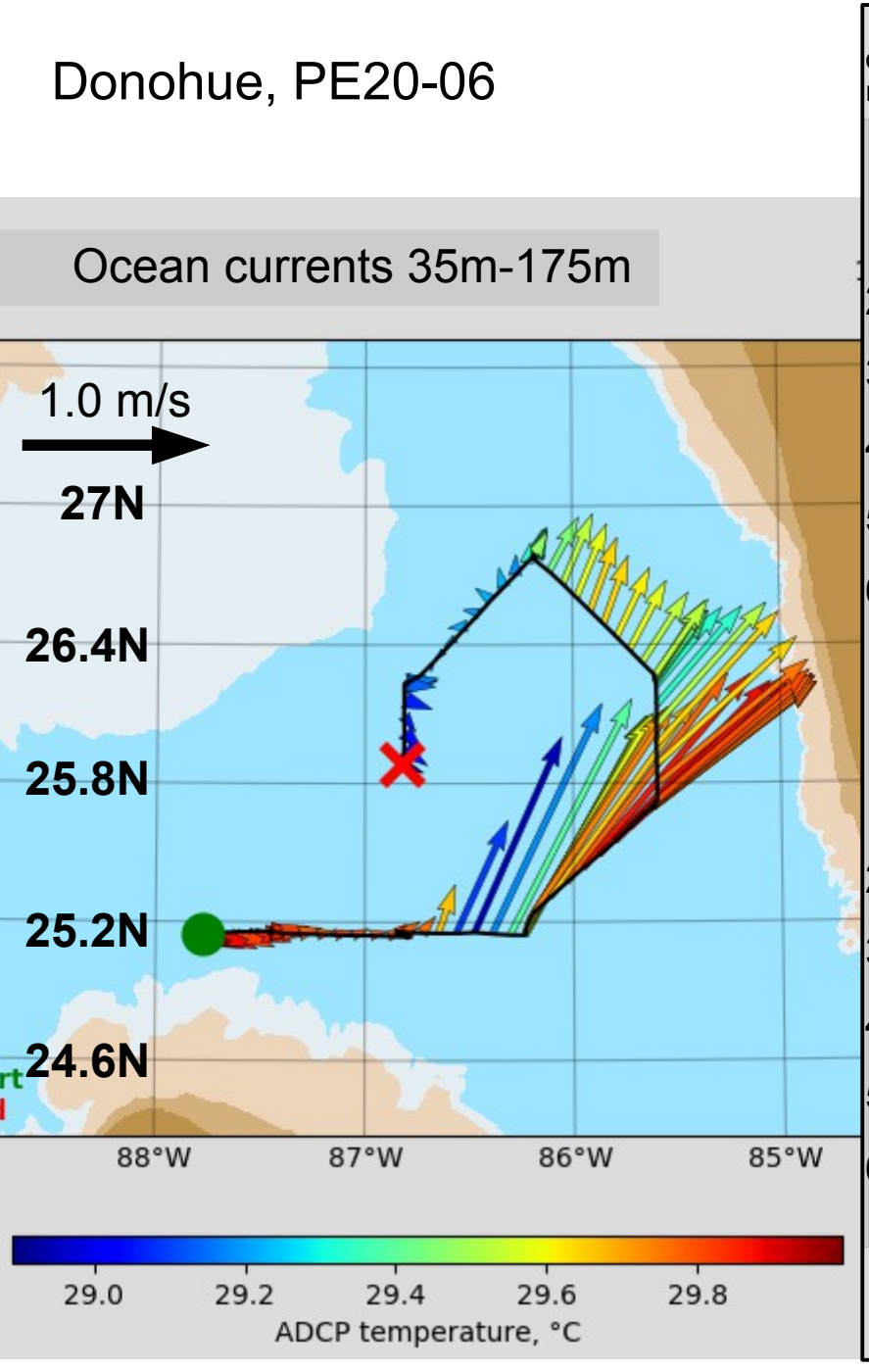
Who uses the data? What is it good for?

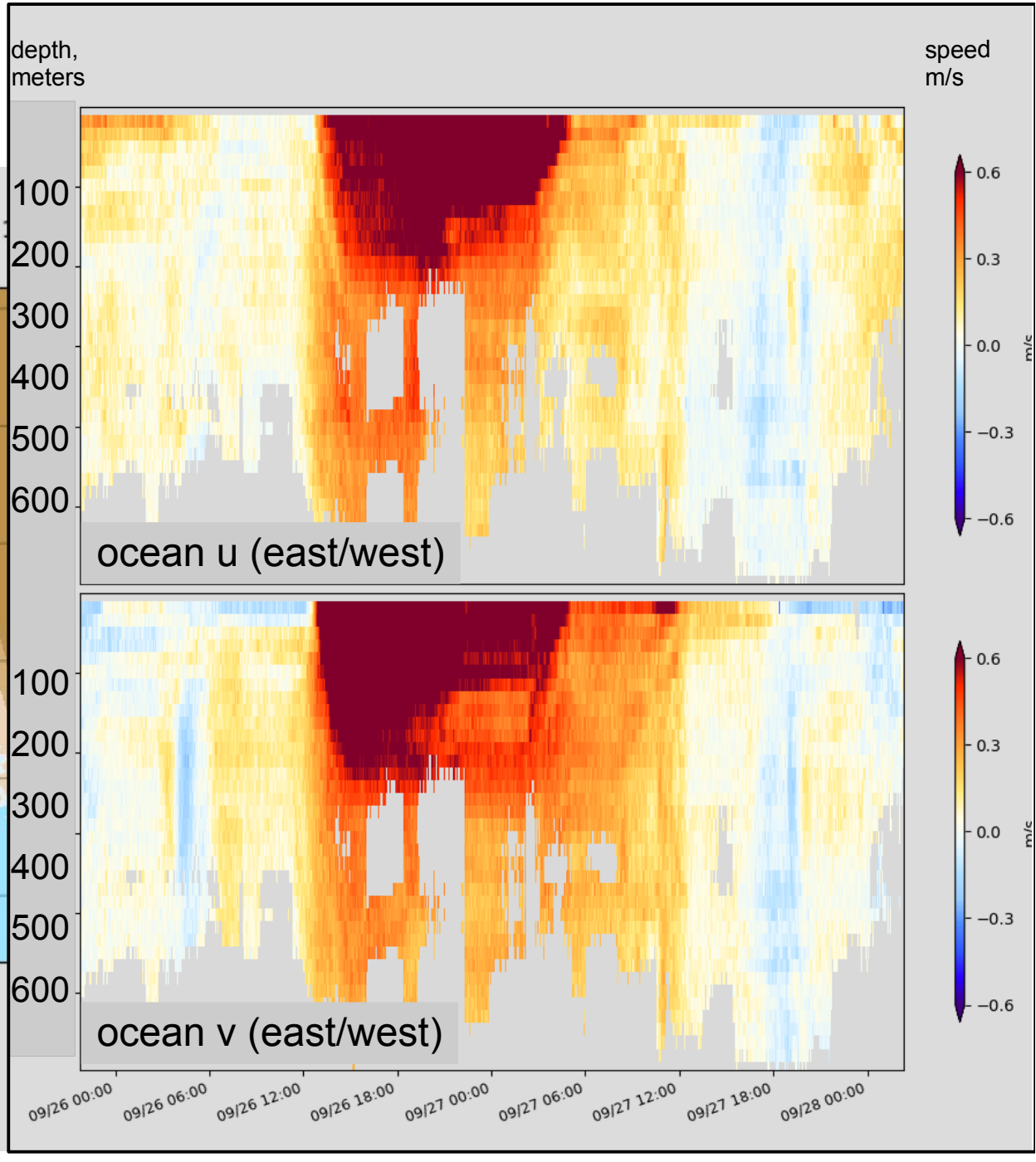
at sea:

- 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



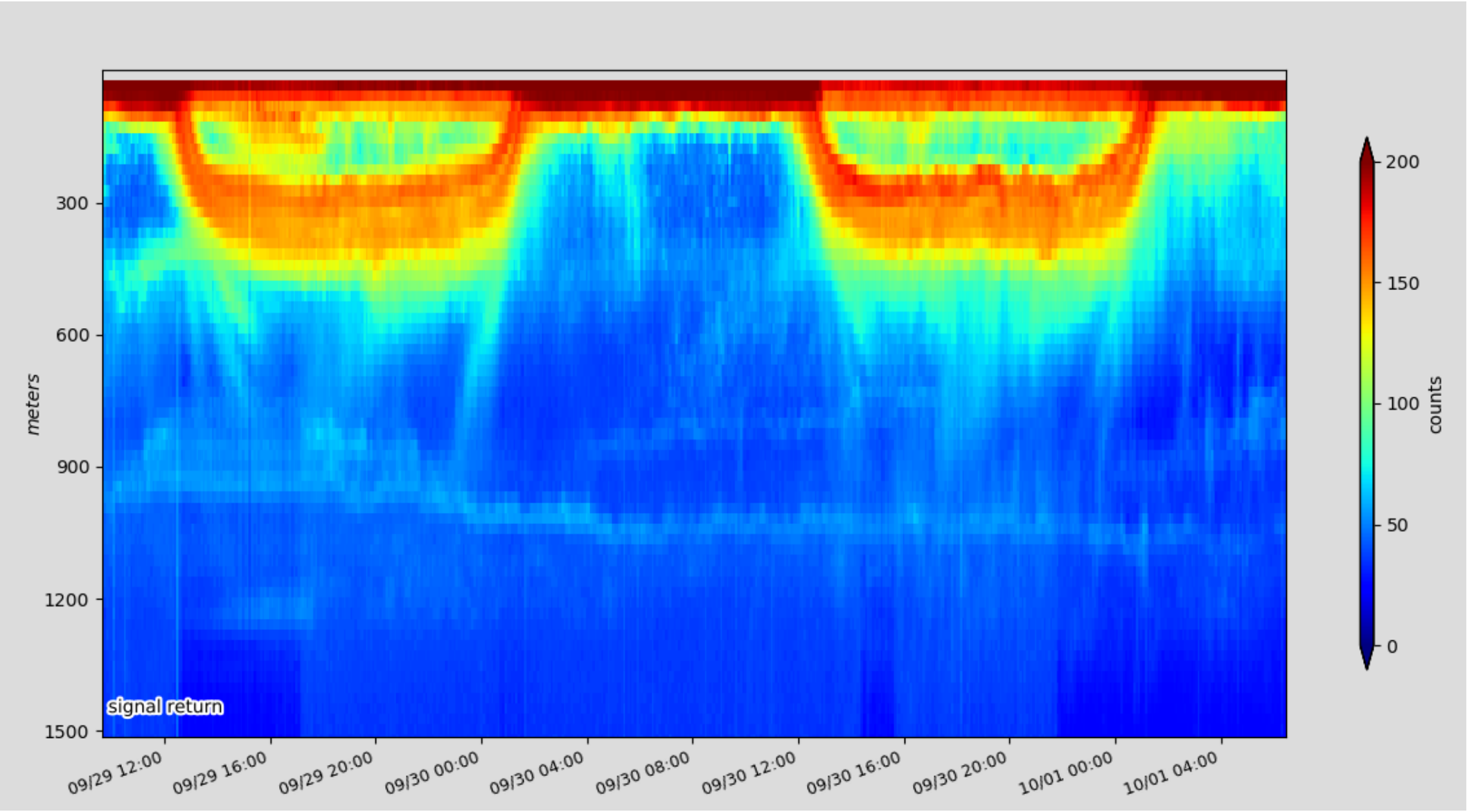


Scientific relevance of shipboard ADCP data

- backscatter (even if uncalibrated)
- process studies:
  - near-inertial motion
  - internal wave energy (upward propagation of phase)
  - high-frequency internal waves (on station)
  - 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

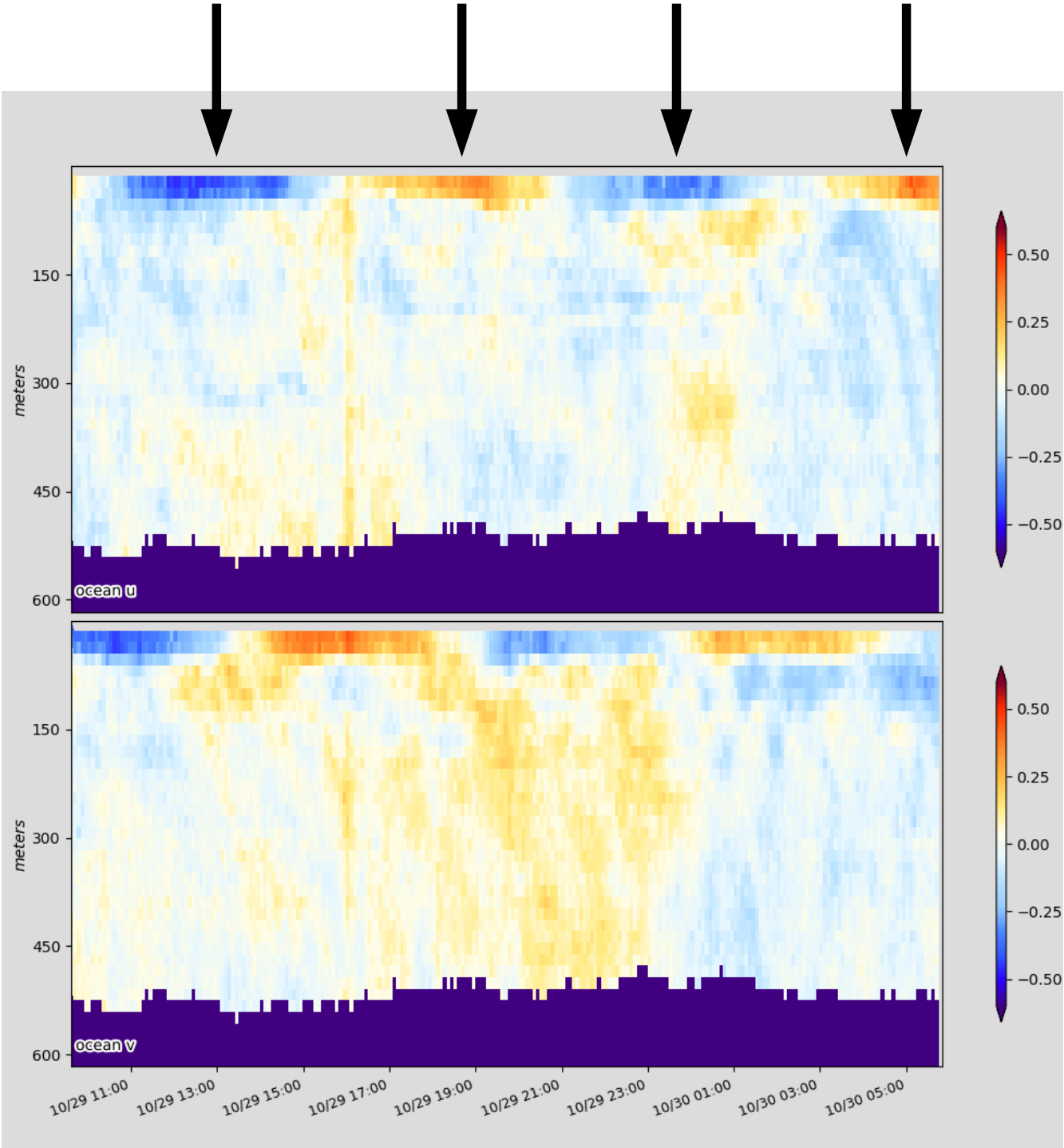
examples follow...

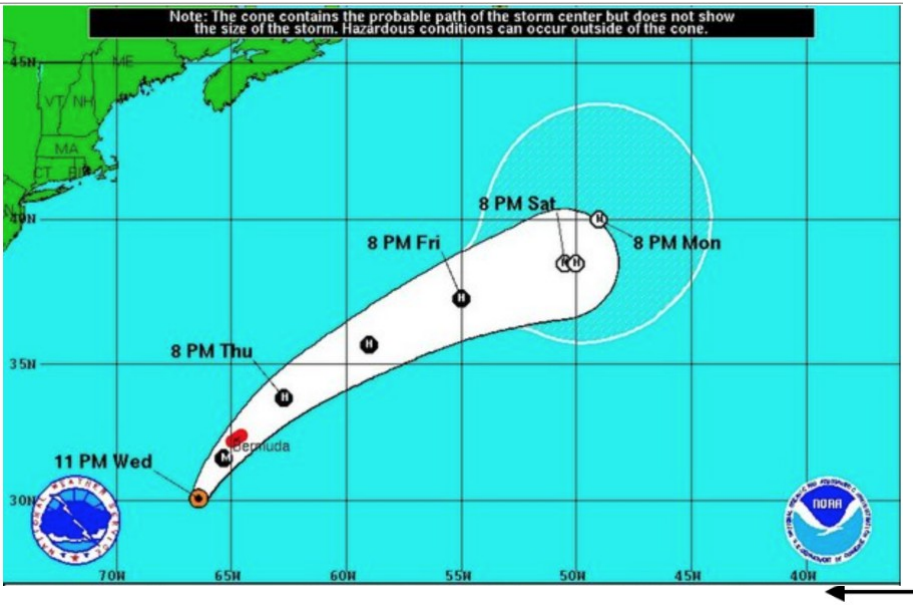
Kilo Moana: 38kHz ADCP backscatter (tropical eastern pacific)

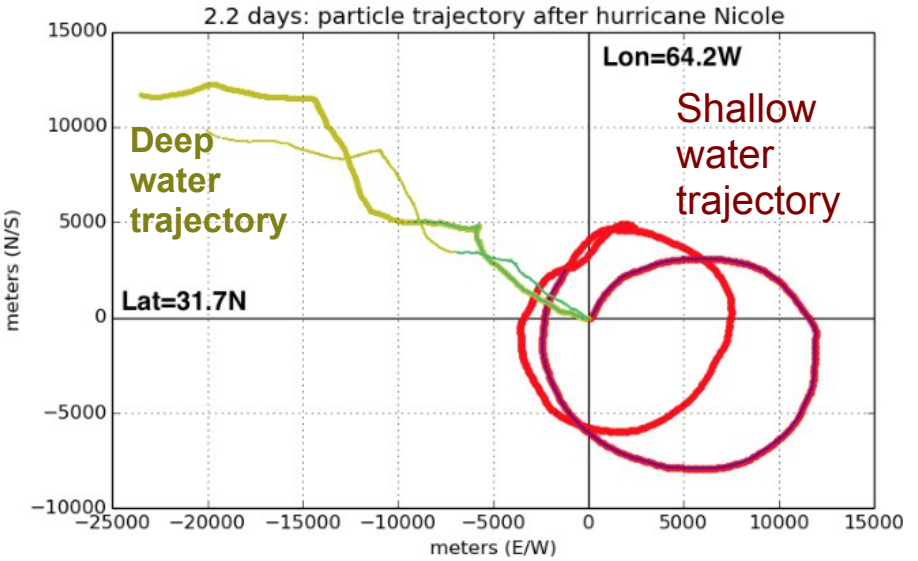


Near-inertial motion caused by strong winds;

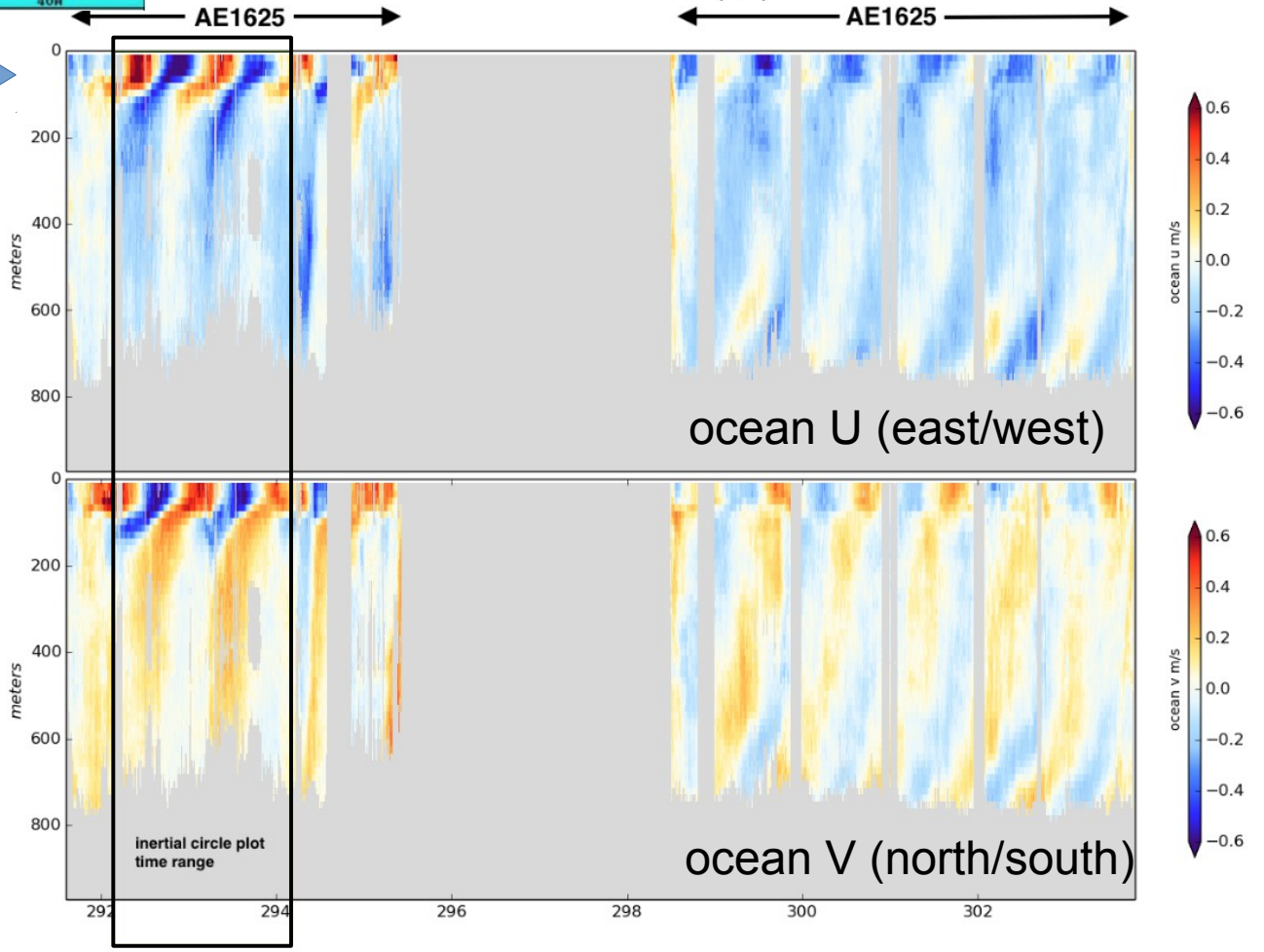
stratified ocean keeps the energy at the surface







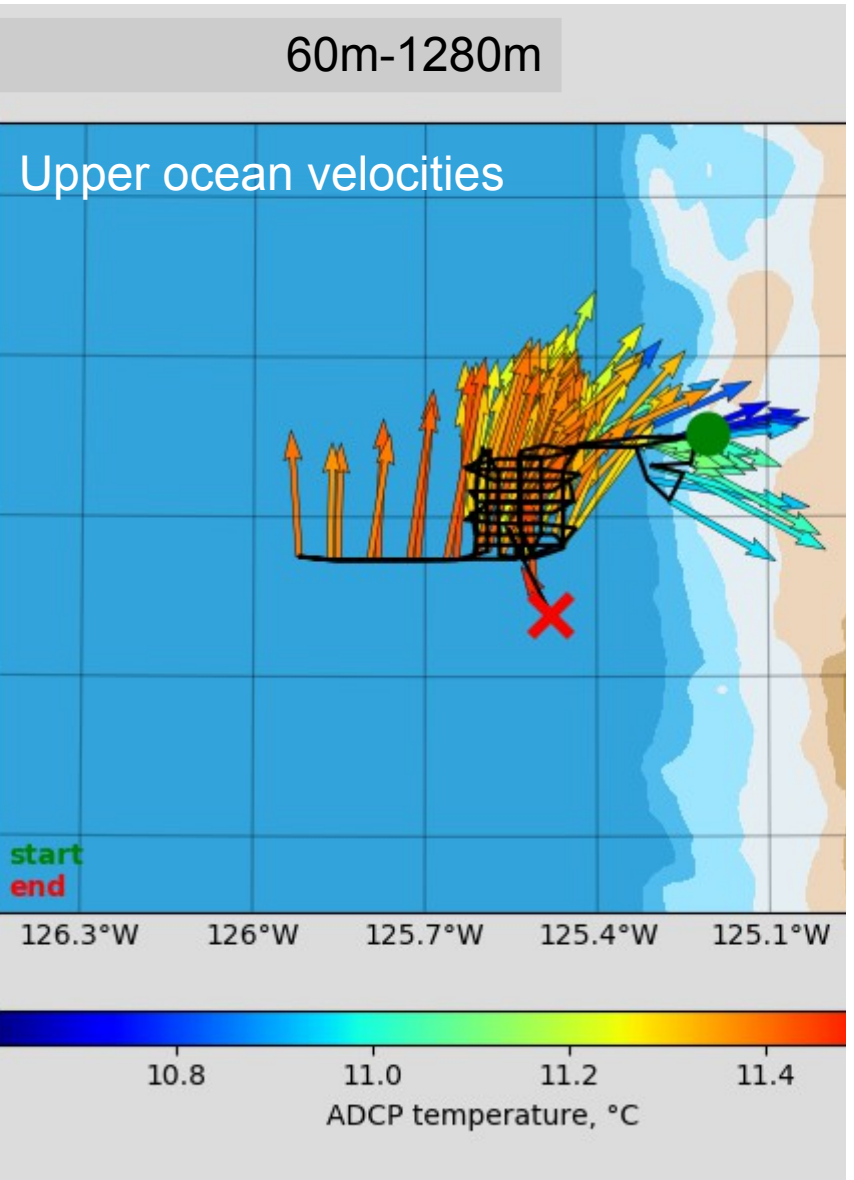
shallow inertial signal

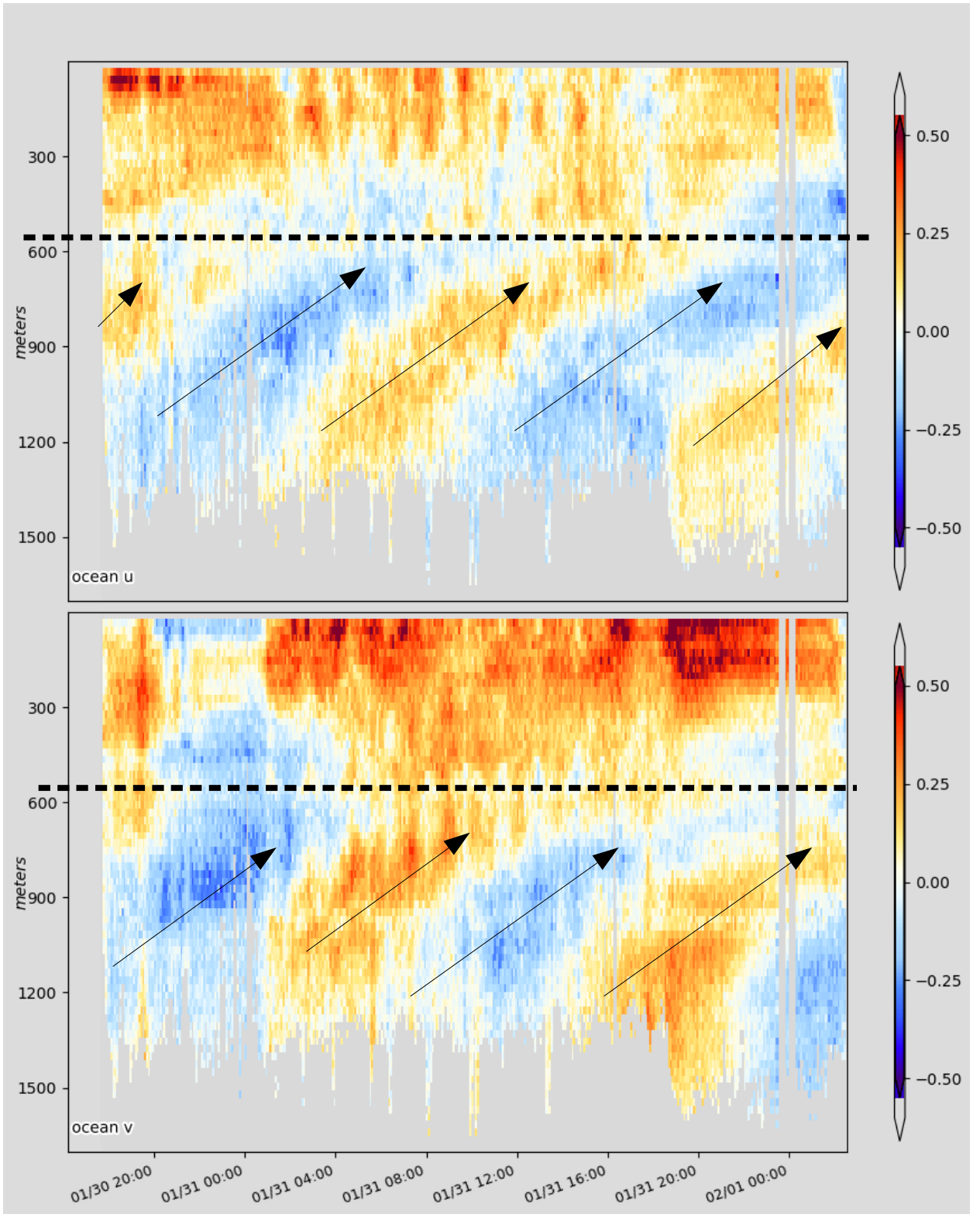


Hurricane Nicole
Oct 12, 2016

deep inertial signal later

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

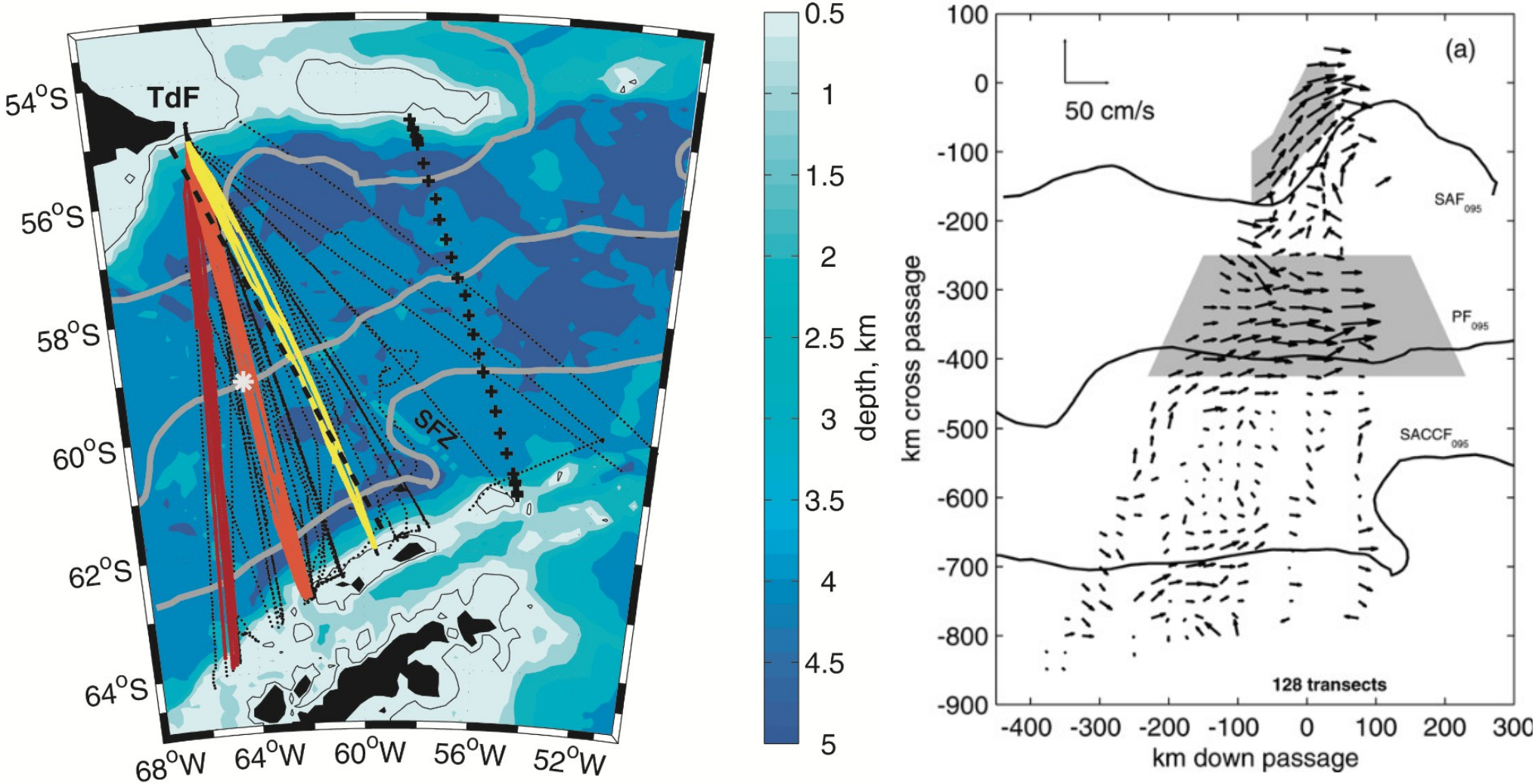




Time Series Examples

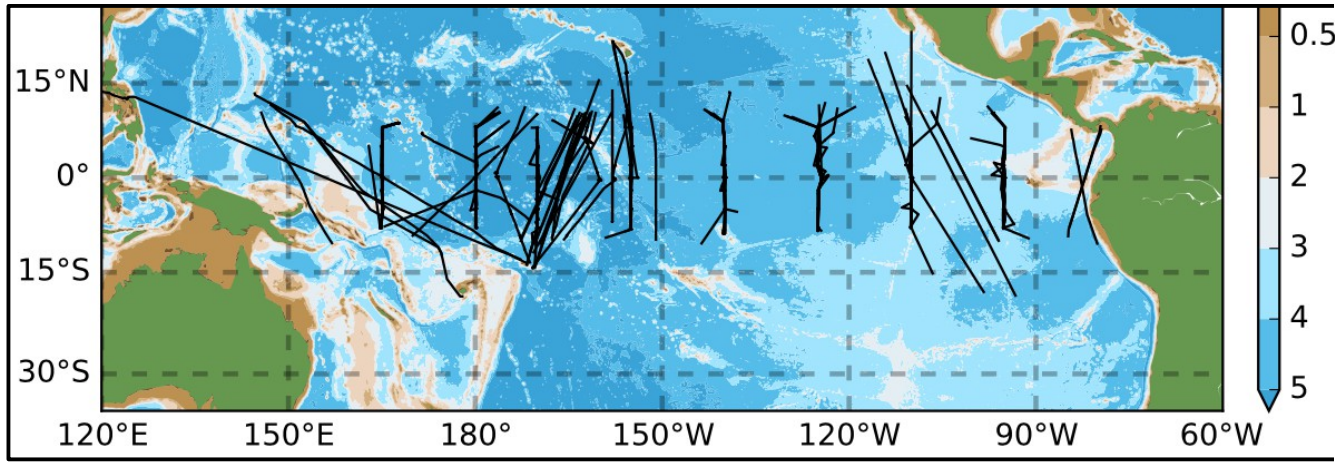
Laurence M. Gould: Drake Passage

Lenn et all, JMR, 2007



Time Series: Equatorial Pacific

SADCP from TAO sections
Crevatte et al, JMR 2017



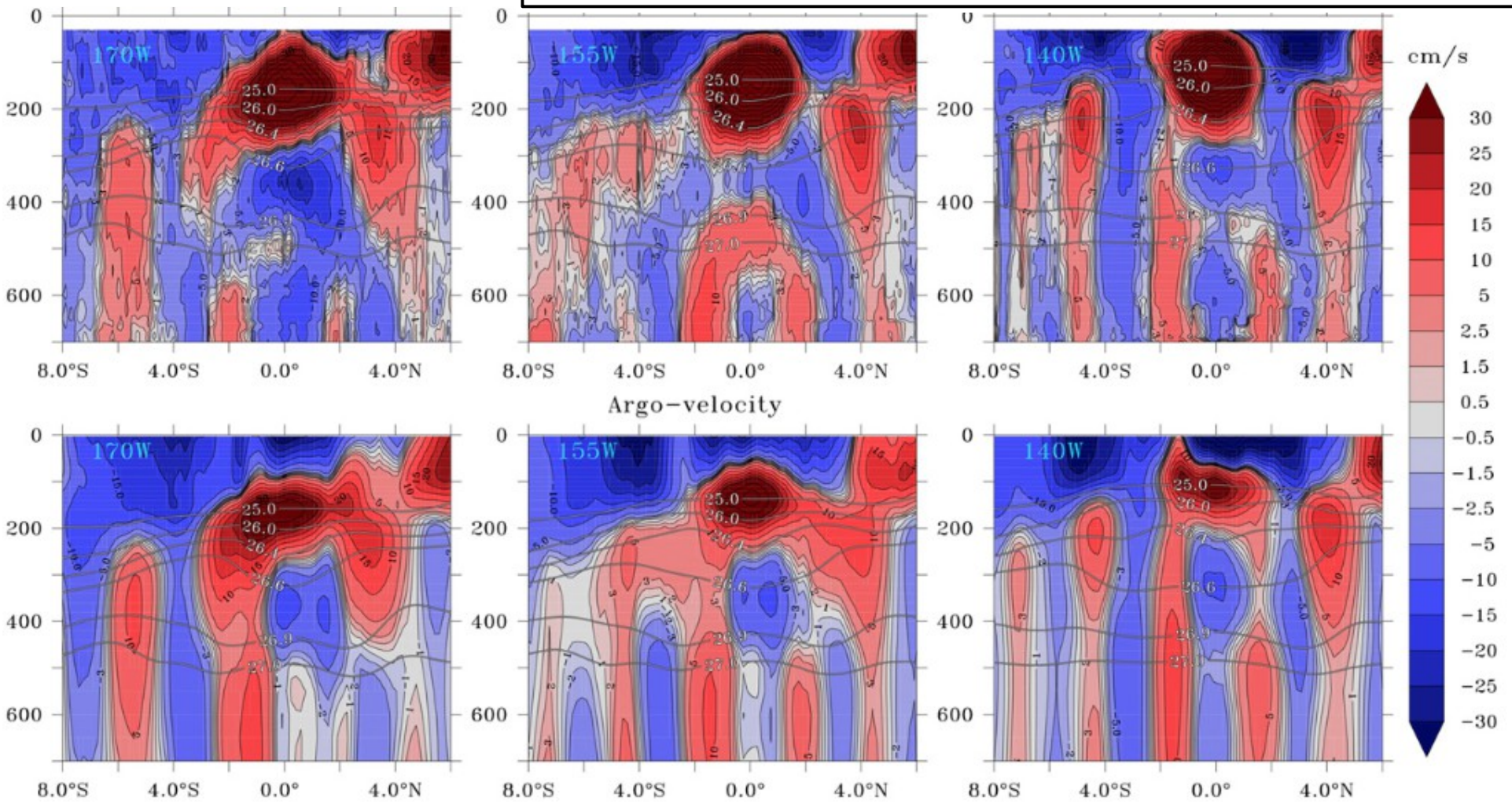


FIG. 12. Mean zonal velocity from (top) SADCP data and (bottom) Argo velocity product at (left) 170°W, (center) 155°W, and (right) 140°W in cm s^{-1}. Superimposed are some selected isopycnals.

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***

  Journal of Marine Research, 65, 27–58, 2007; Y.-D. Lenn,T. K. Chereskin, J. Sprintall, E. Firing

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

Where are scientific shipboard ADCPs installed?

In the United States:

- Academic Research Fleet ("**UNOLS**" = ~20 ships)
  - general oceanography: 30m-85m, polar: 70m-130m
  - operated by 12 different institutions
  - each ship sails with 1-6 techs (depending on ship size)
- Nat'l Oceanographic and Atmospheric Admin (**NOAA**=11 ships)
  - each ship sails with 2 techs
- smaller science vessels

- Internationally:
  - oceanographic research vessels
  - smaller science vessels
  - Navy ships

Maximizing the Scientific Value of Shipboard ADCP

- make it work well; keep it working well
- make it available immediately and in the future
- be able to reprocess it in the future

One vetted ADCP manufacturer for vessel-mounted use:
(T.R.D.Instruments)
- ADCP ships with VmDAS (Windows acquisition program)
- U.H. Currents Group developed UHDAS as an alternative

links:

UHDAS Operations

Comparison between UHDAS and VmDAS

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: Getting Ocean Currents

Collect Data

ADCP

heading

position

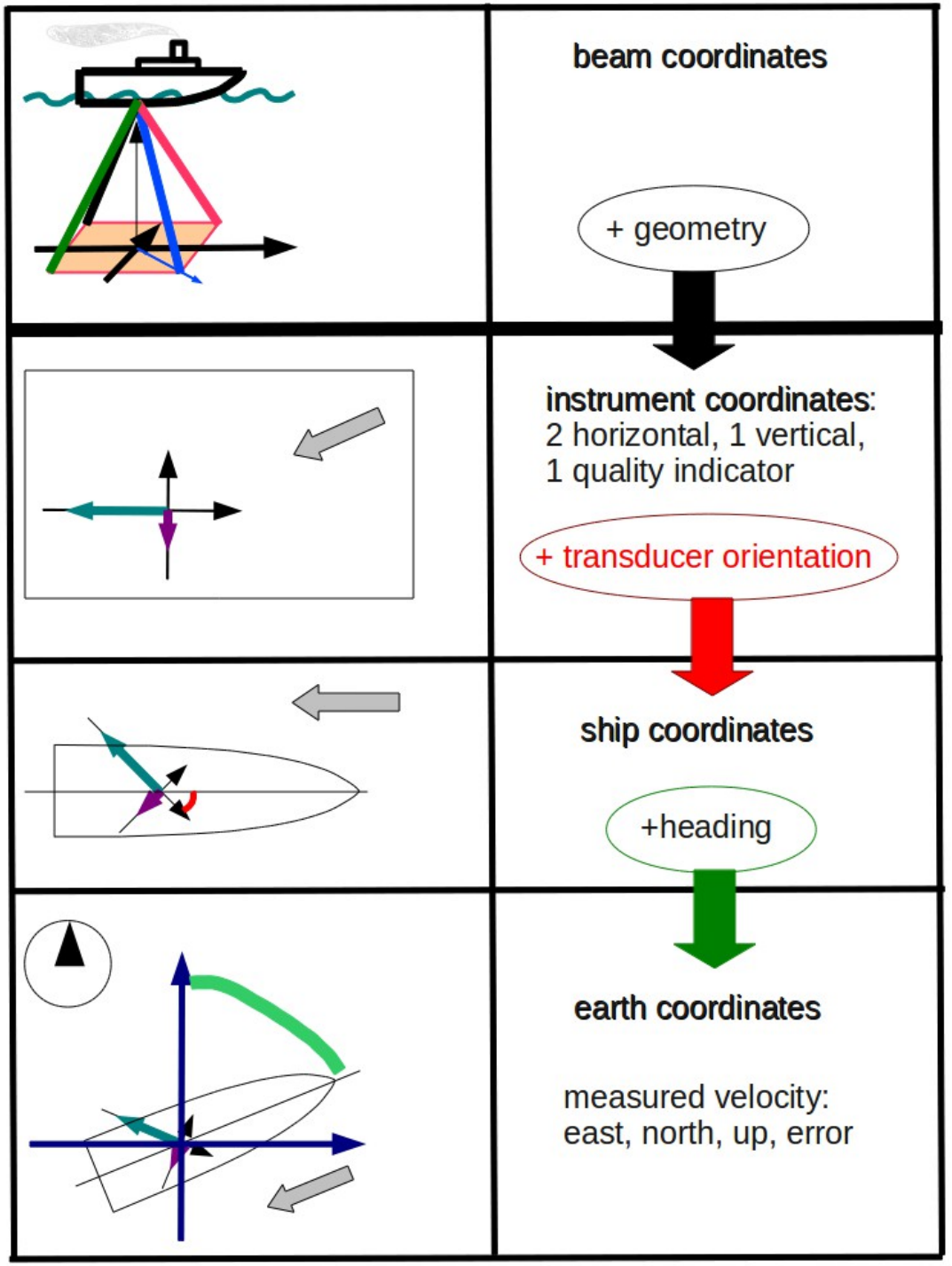
Transformations

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



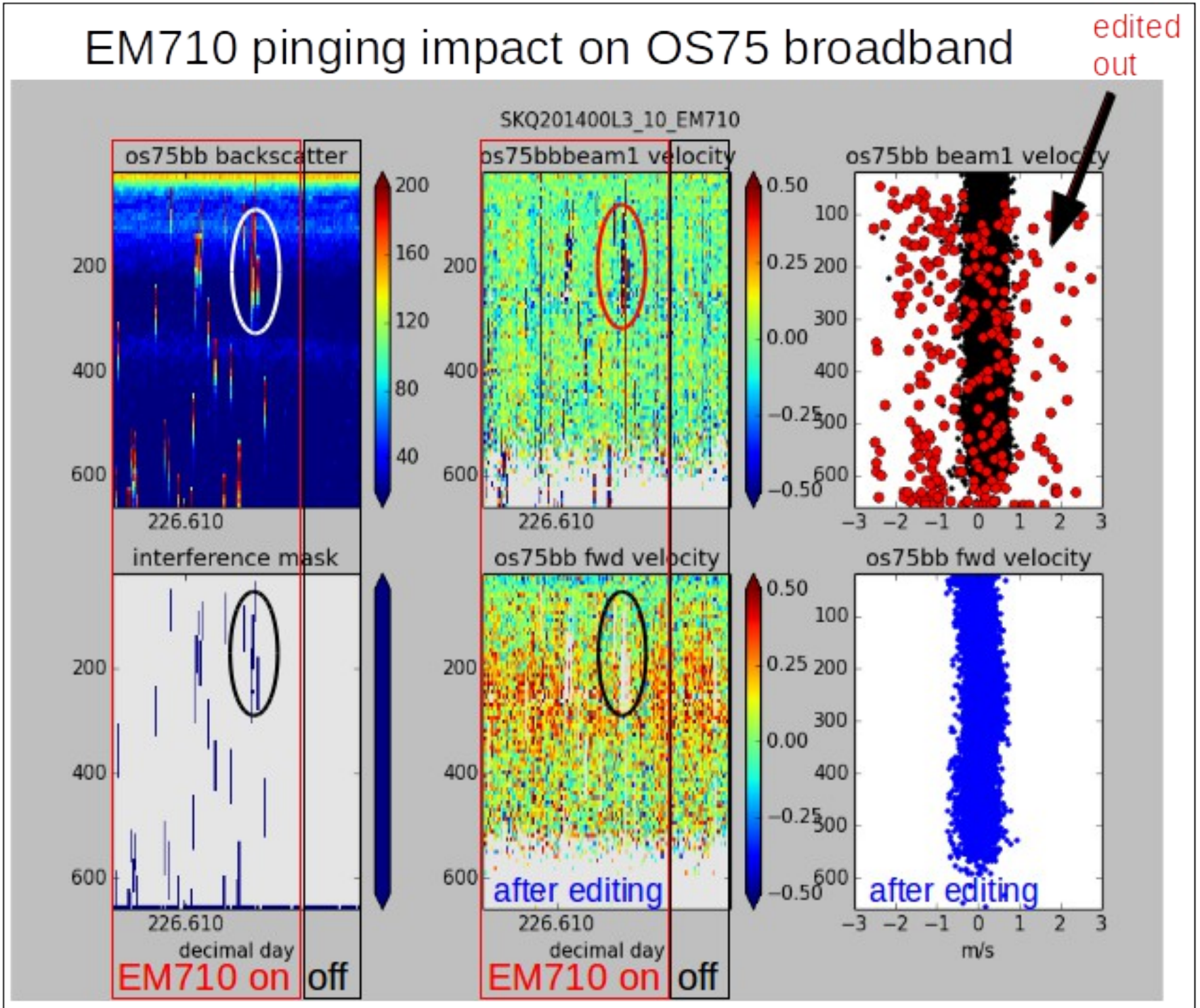
ADCP preliminary Processing

"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**
  - **5Gb cruise directory distilled down to 50Mb-100Mb**

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

CODAS single-ping editing based on acoustic interference



CODAS software details

- built from scratch for shipboard ADCP
- data are stored in a CODAS database; routines for manipulation
- open source (Python3, C)
- runs natively on Mac, Linux
- fully functional virtual linux computer available (Virtual Box)
- modular, configurable
- pairs well with UHDAS data, (can be used for VmDAS data)
- visualization tools, calibration tools
- documented and freely available

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

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- **data and products**
  - operations and science at sea
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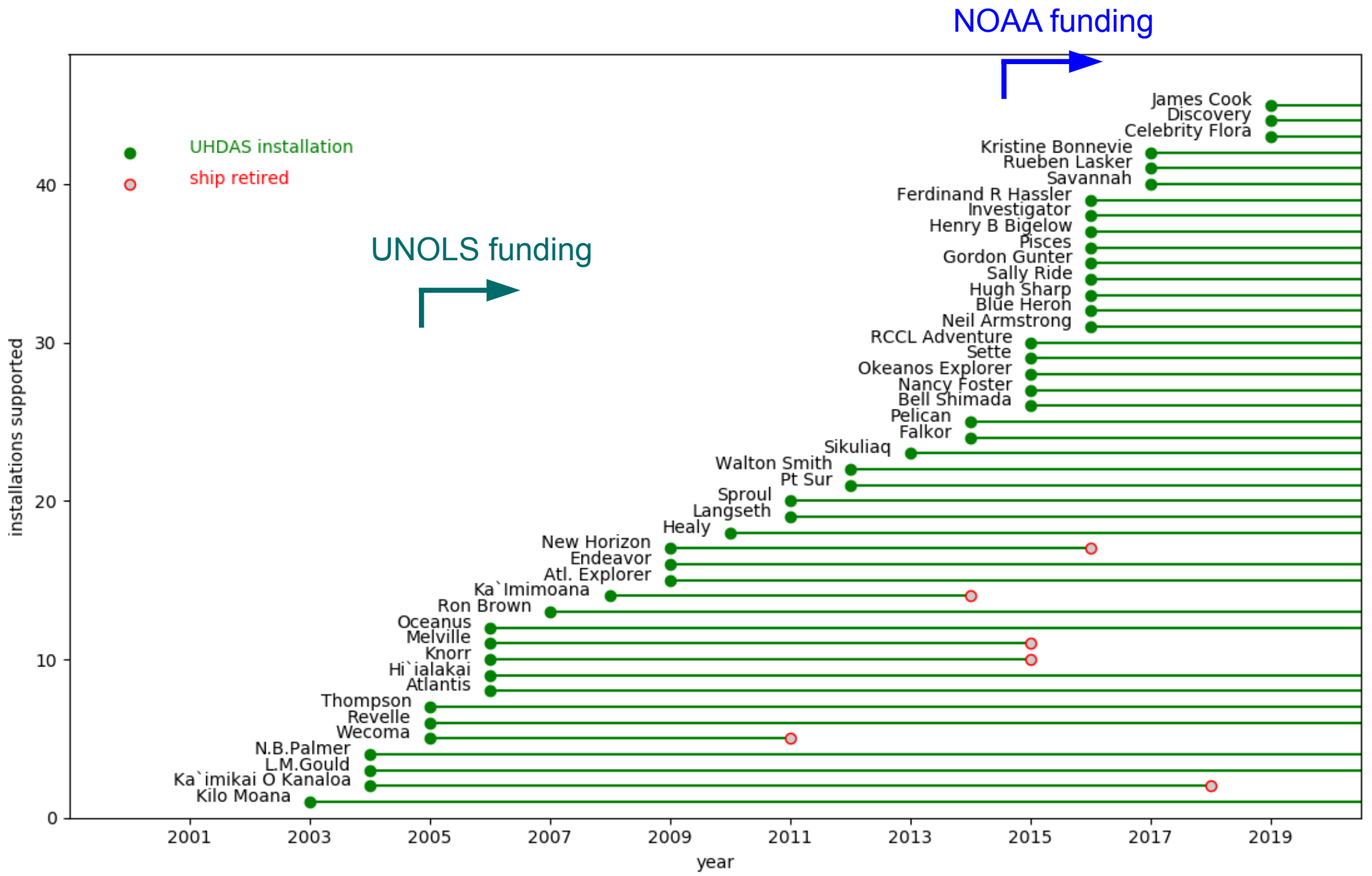
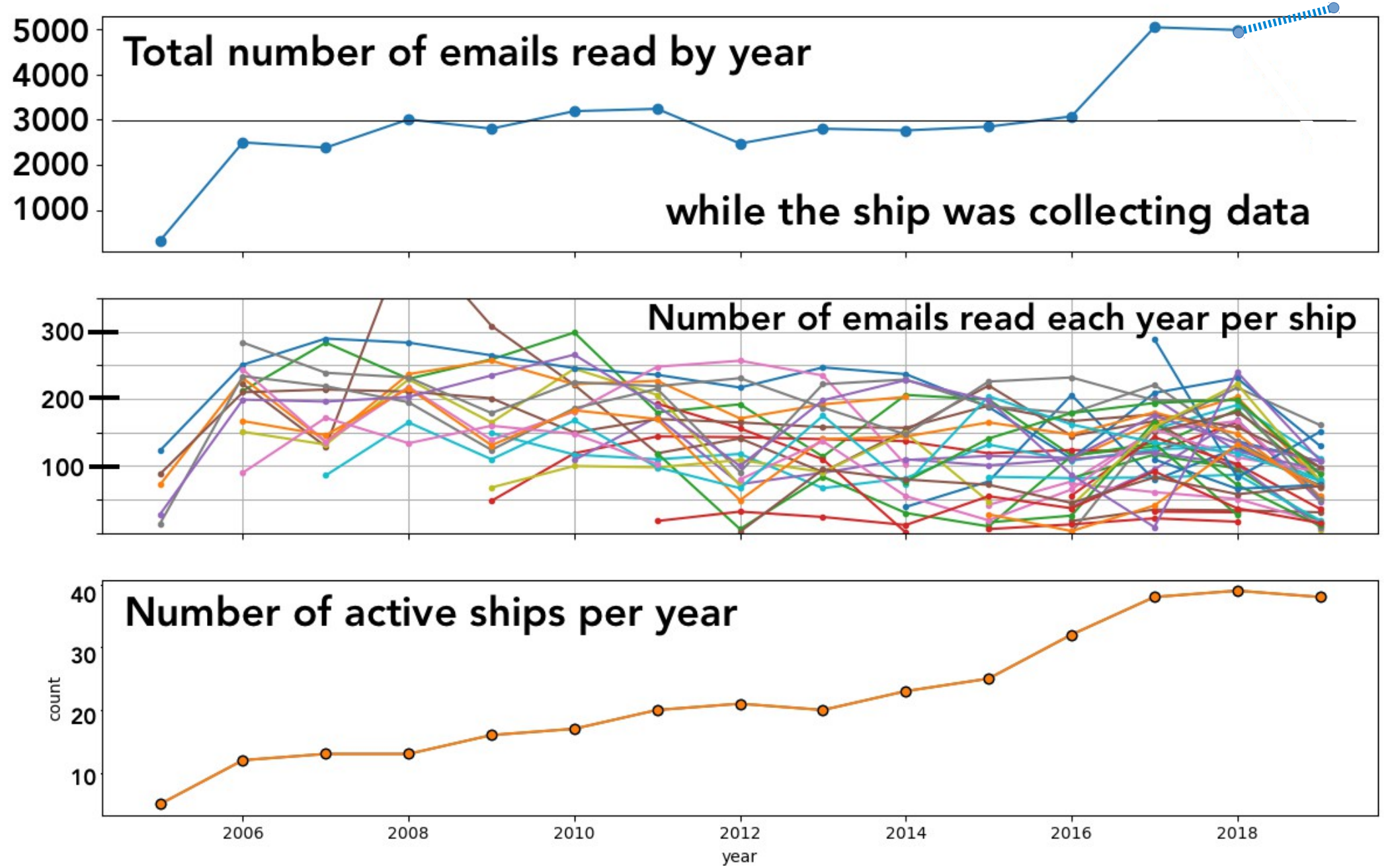
Monitoring

- 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 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 Installations supported: by year



UHDAS ship and email metrics



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  - feedback to technicians on the ship
- **data and products** for
  - operations and science at sea
  - ease of post-processing after the cruise
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CODAS data and products

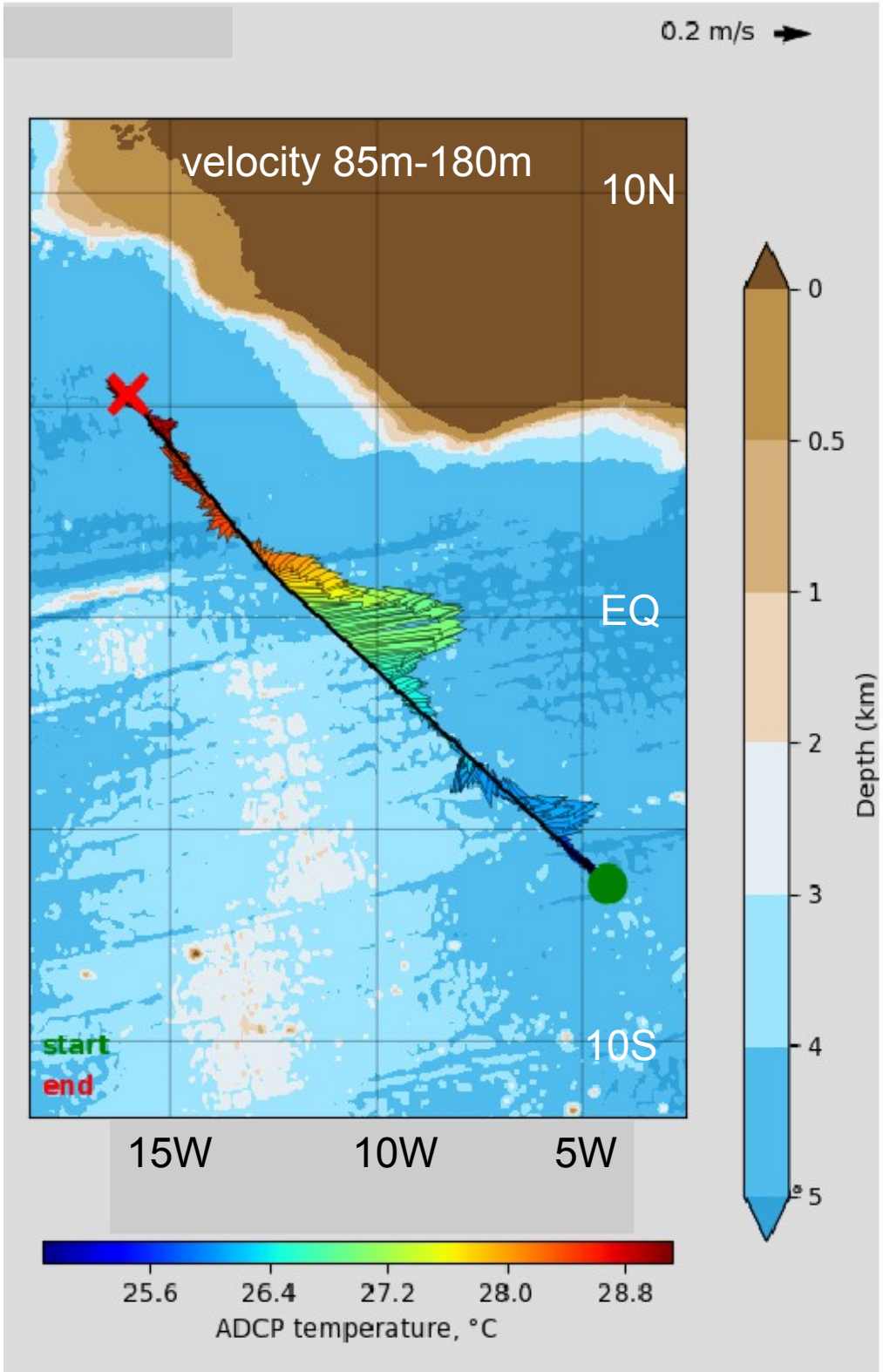
At sea:

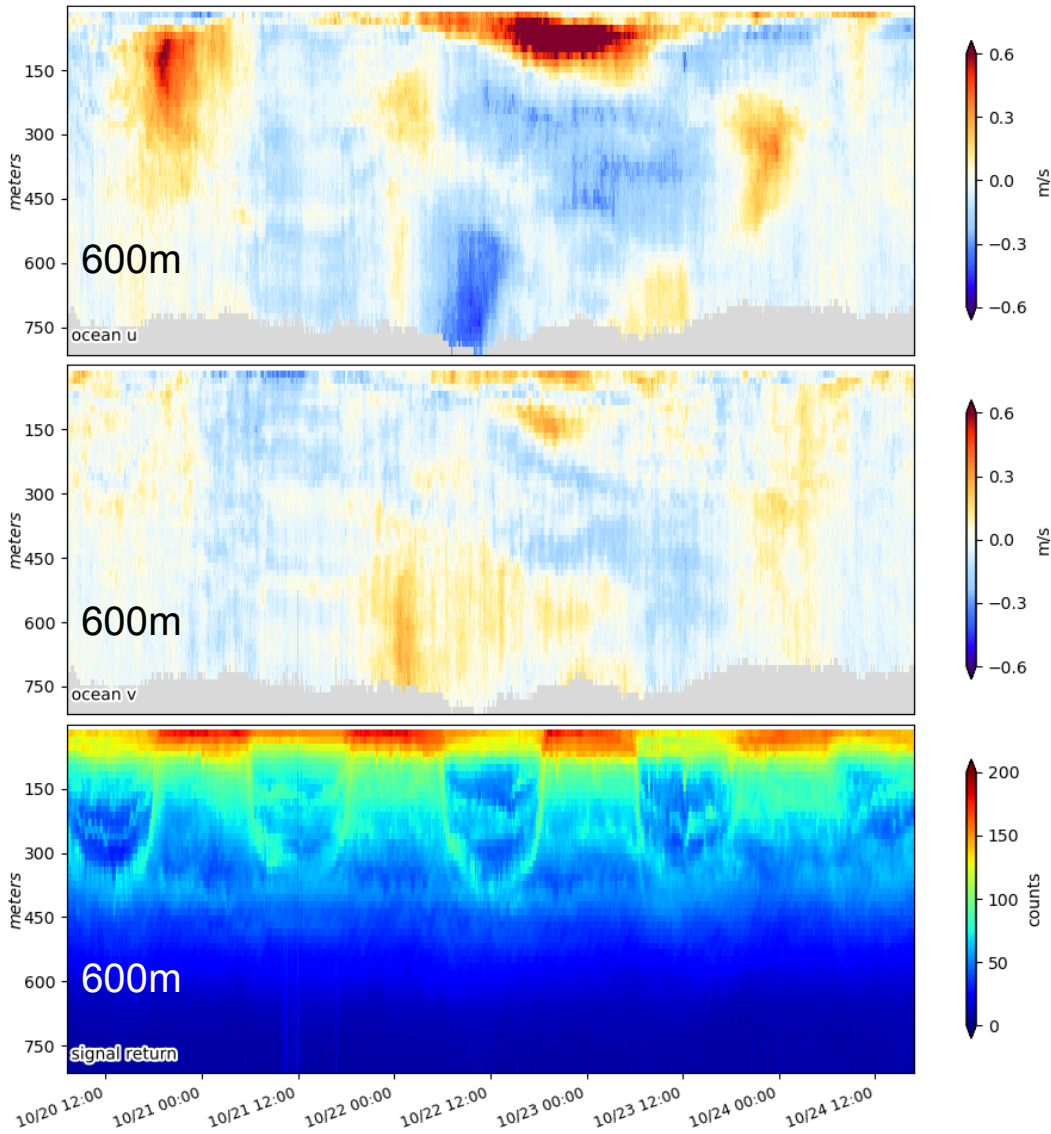
- **example at-sea web site** (James Cook Oct 31,2019)
  - figures for operations and science at sea
  - netCDF data files for science
  - matlab data files
  - archive of daily figures
  - calibration from processing
  - settings used during processing
- complete CODAS+UHDAS documentation

CODAS data and data products, cont

- **After the cruise**:
  - processing directories
    - matlab data files
    - netCDF file
    - archive of daily figures
    - ready for post-processing
    - calibration from processing
    - settings used for processing
  - raw data directories
    - evaluate quality of the ADCP or ancillary data
    - reprocess with different inputs
    - reprocess with different averaging duration

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





CODAS data and data products, cont

After the cruise:

For future use, cruise directory has

- "reports" directory, with summaries of
  - calibration
  - settings used
  - figures from the cruise
- This is suitable for showing on a web site, to allow exploration of older datasets, and to find "low-hanging fruit"

  example (Atlantis)

Archiving and long-term use ... 

Data flow: from ship to science

- acquisition, data on the ship
  - VmDAS (available from RDI, windows)
  - **UHDAS** (from University of Hawaii, linux)

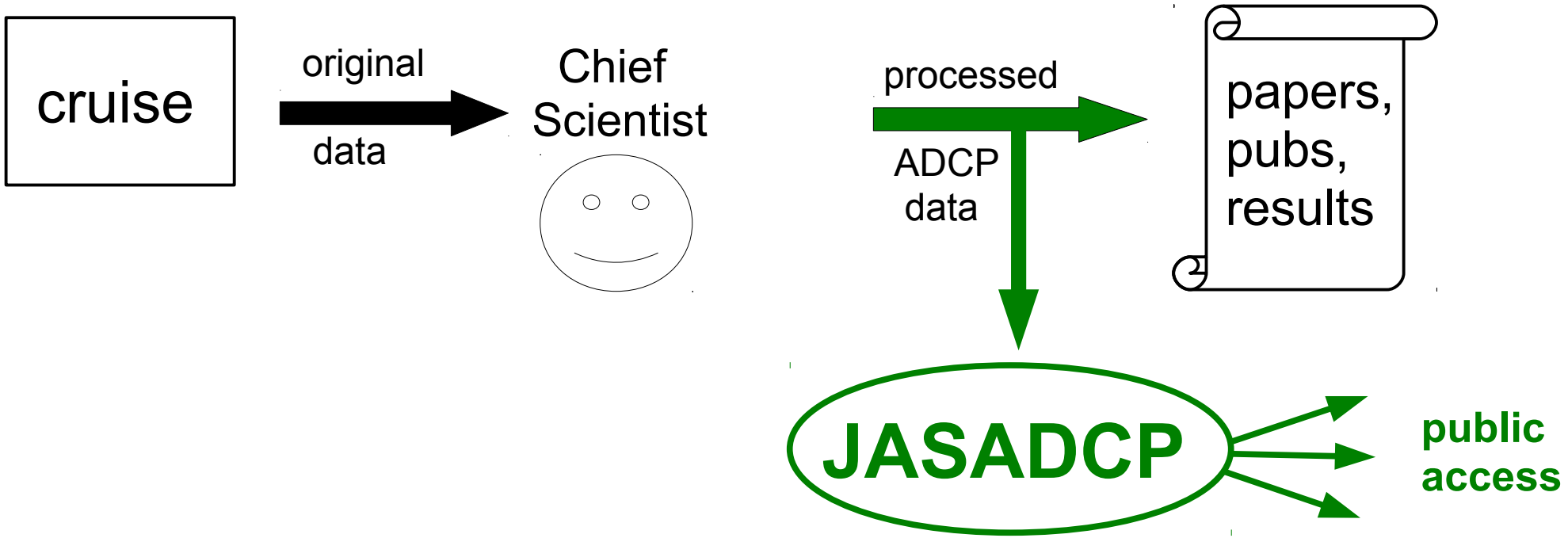
- U.S. national archive
  - NCEI: UHDAS data via R2R “as collected” (*)

  - after a human does the final processing:
  - JASADCP (for processed science-ready SADCP)

(*) in the Global Ocean Current Database

Historically in the U.S.

Past and Present



Joint Archive for Shipboard ADCP

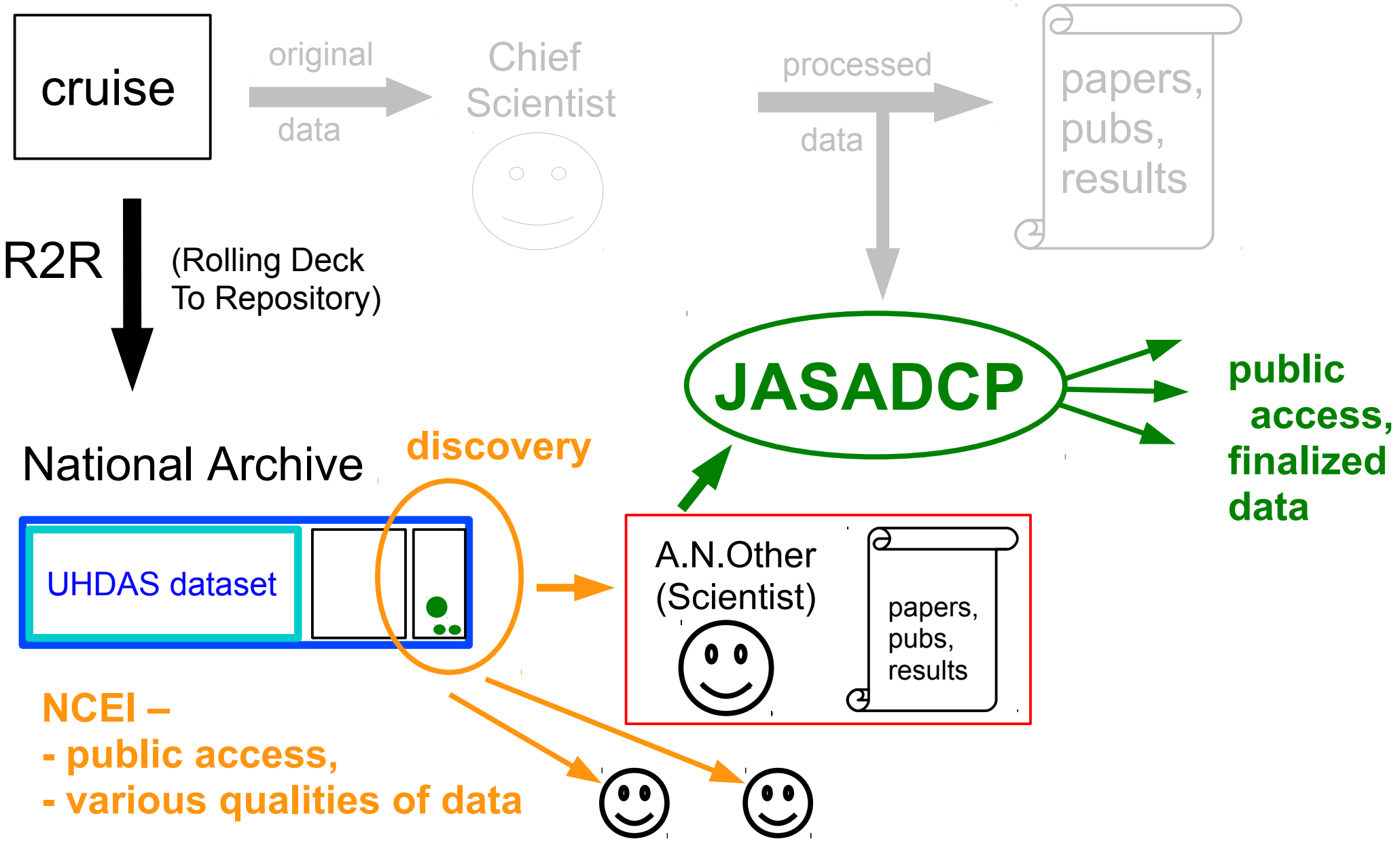
Part of NCEI

Serving science-ready data since 1992.

Over 800 cruises so far...

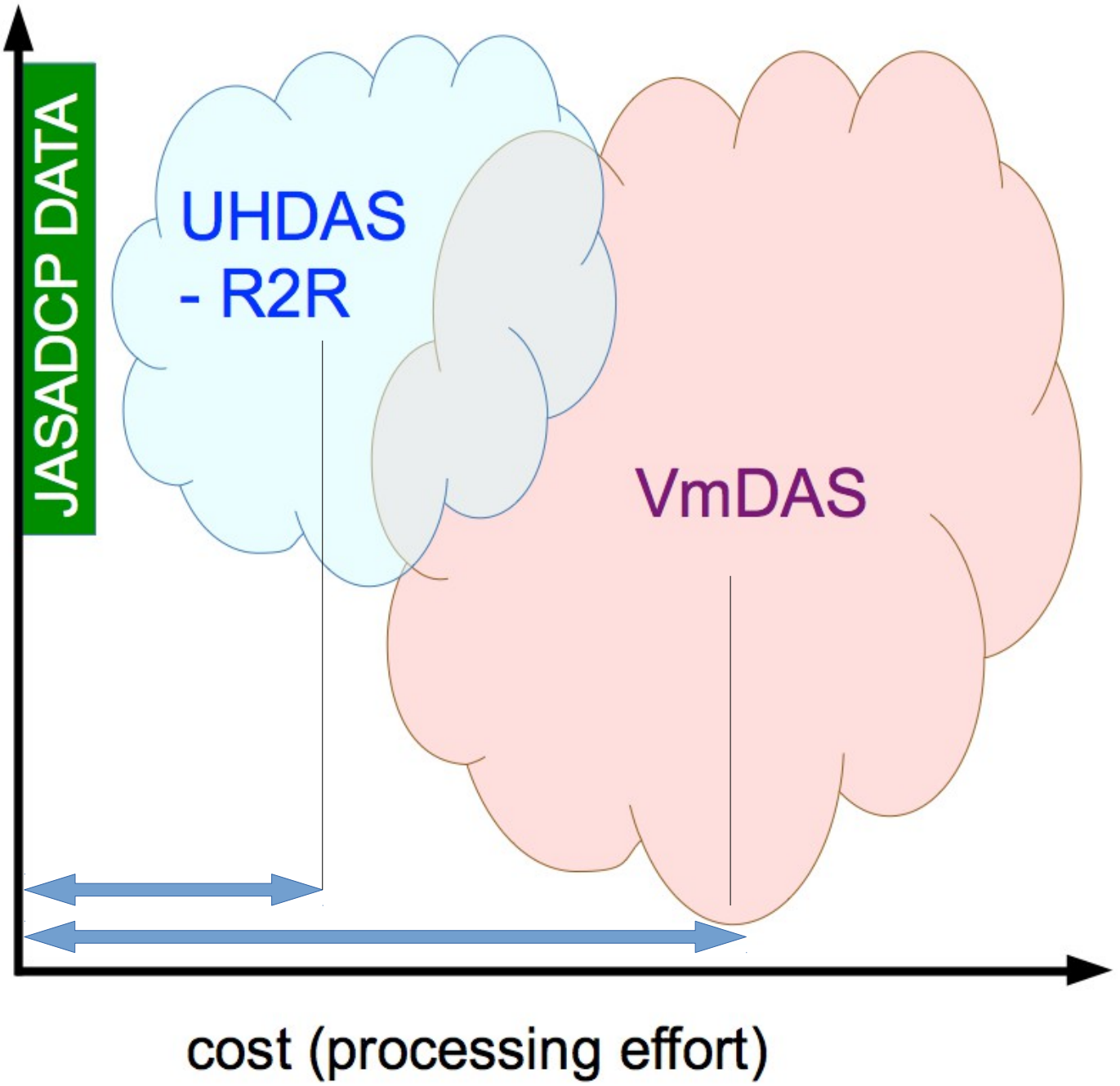
Present and Future:

- two paths to finalized public data
- more opportunities for original data to be used



UHDAS vs/ VmDAS data quality and processing effort

JASADCP:
science-ready
shipboard ADCP
ocean currents



UHDAS designed to:
- maximize raw data quality
- reduce total processing effort

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