

# Institute of Marine Research

---

Dr. Julia M. Hummon  
Bergen, Norway  
Oct 7, 2016

---

## CODAS+UHDAS: ADCP Acquisition, Processing, and Monitoring on Oceanographic Research Vessels

# Outline

---

1. ADCP

2. Processing (“CODAS”)

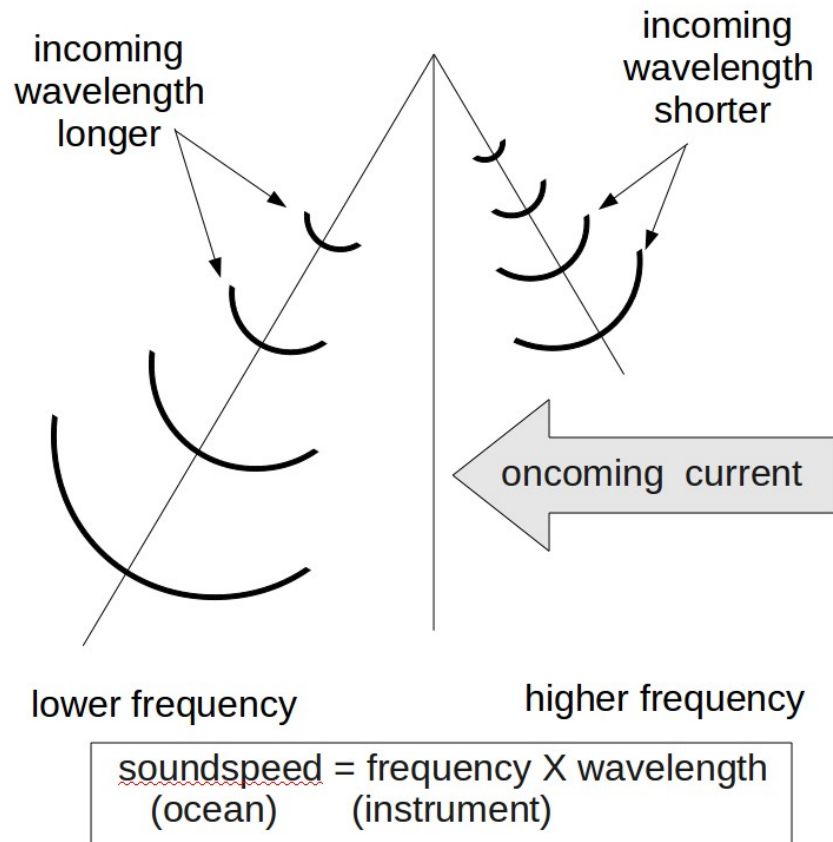
3. UHDAS

- Acquisition
- Processing
- Monitoring
  - At Sea
  - On Land

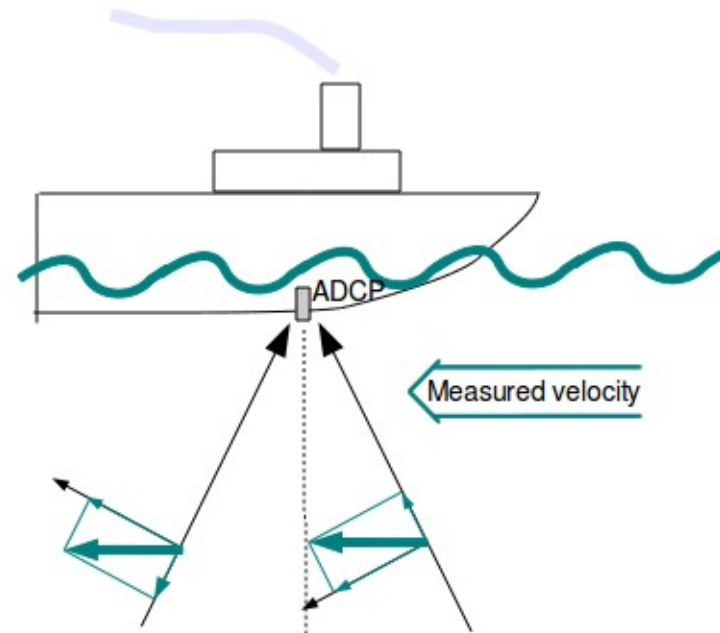
4. Benefits

# ADCP: Acoustic Doppler Current Profiler

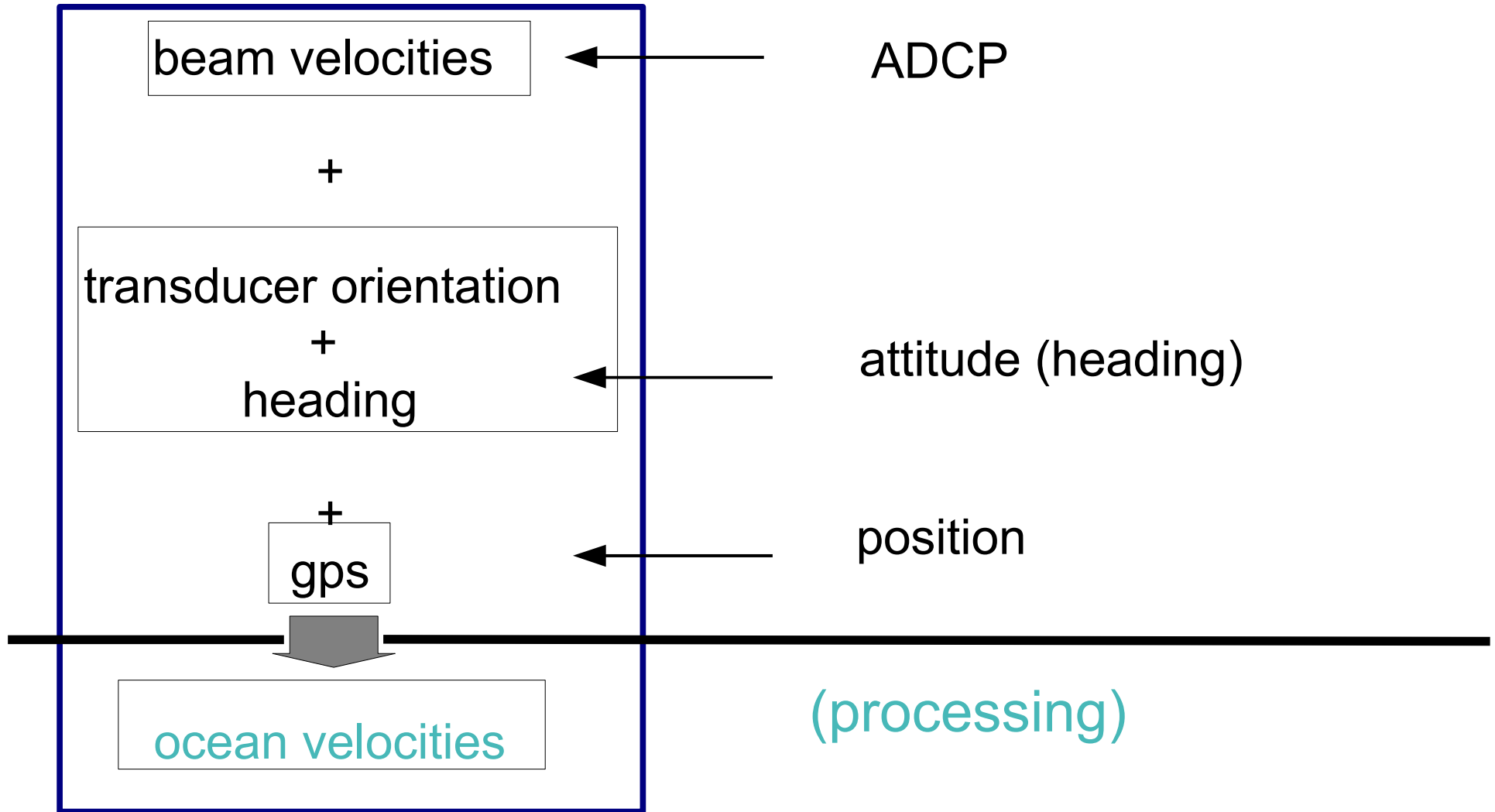
## Doppler Shift



## Hull-Mounted



# ADCP: Data components



# Outline

---

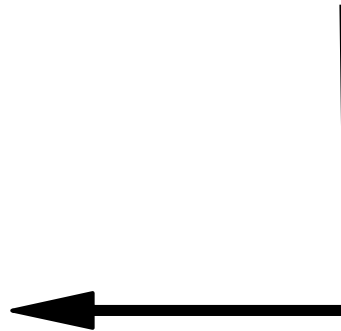
1. ADCP

2. Processing (“CODAS”)

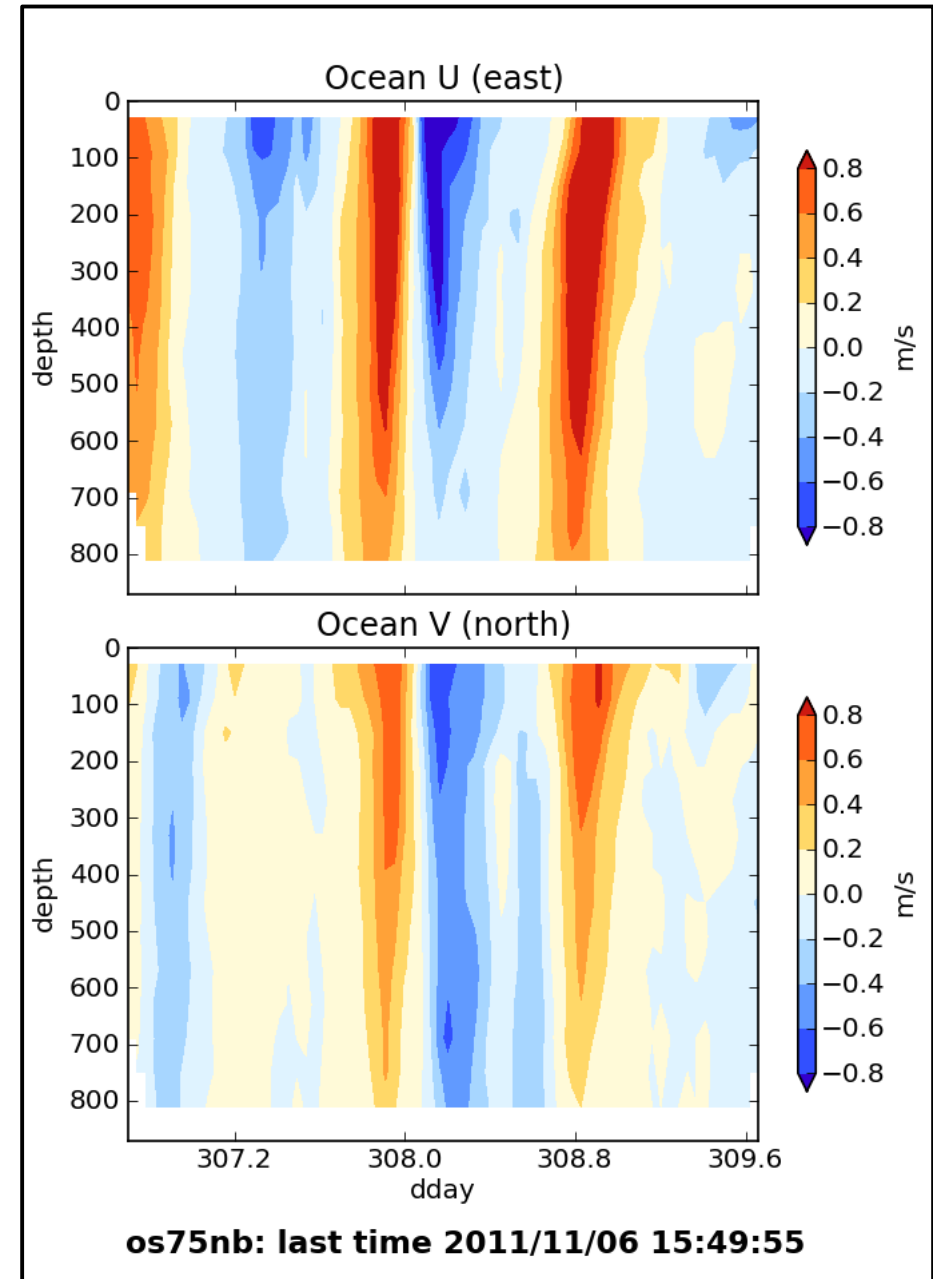
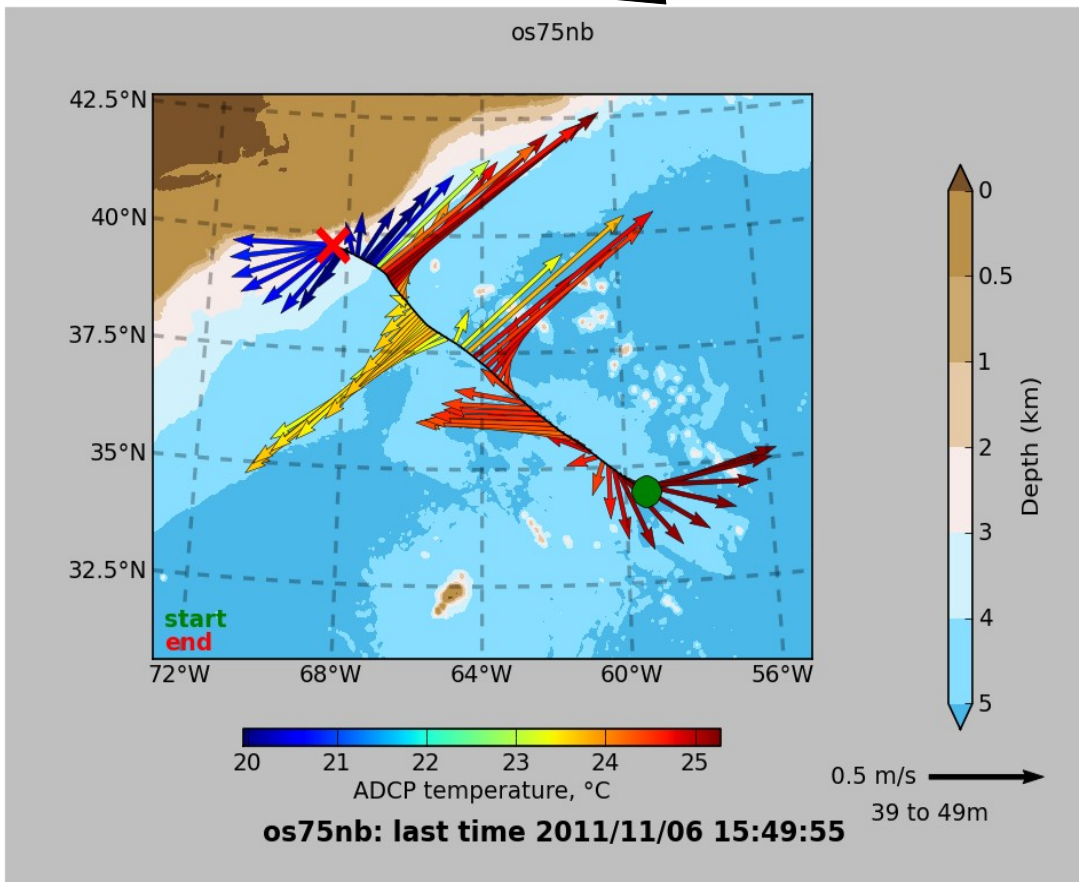
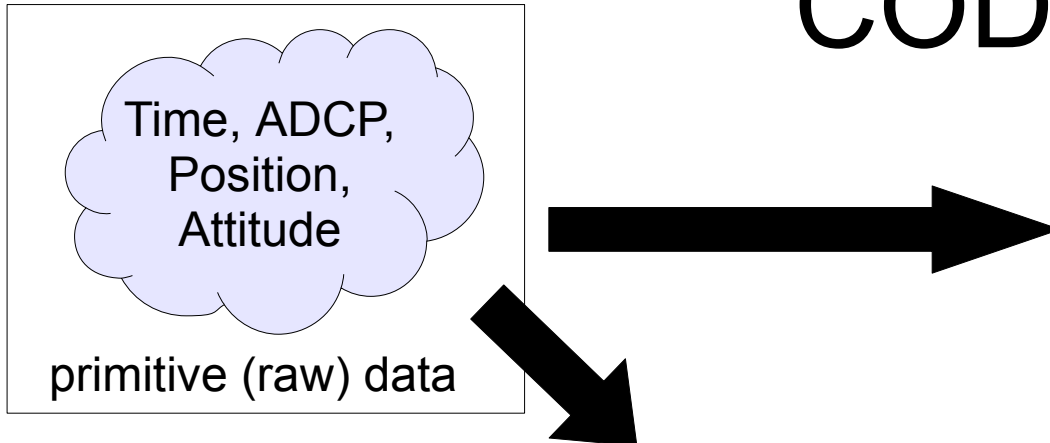
3. UHDAS

- Acquisition
- Processing
- Monitoring
  - At Sea
  - On Land

4. Benefits



# CODAS Processing



# CODAS software

- C-code: database administration (read,write)
- Python: scripts, extraction, manipulation, plots
- **Installation:**
  - Scipy stack: Anaconda (Windows, OSX, Linux)
  - Virtual Computer (linux: all pre-installed)
  - Linux Xubuntu 14.04 (soon 16.04) packages

<http://uhdas.org>

CODAS+UHDAS Documentation

# “CODAS” ADCP Processing

---

## Goals

- run on multiple operating systems
- open source
- now free (Python)

## Processing


- written for ADCP data
- works on on **most ADCP data acquisition systems**
  - (UHDAS, VmDAS, DAS2.48)
- balance one-pass processing with configurable components
- single-ping editing
- manual (graphical+threshold) editing of averaged data



# ADCP Single-ping Editing

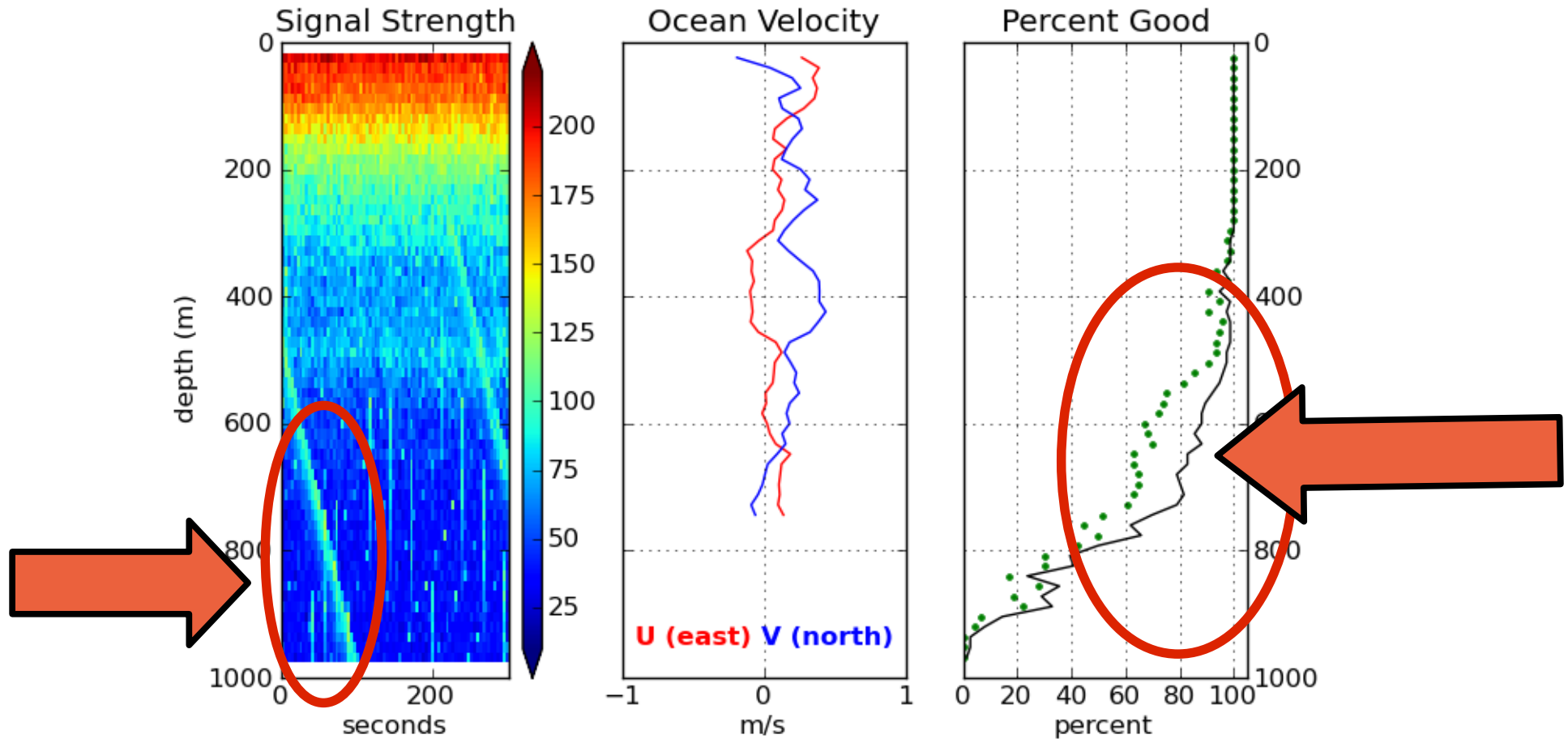
The most common causes of error  
(addressed by single-ping editing )

- Acoustic Interference
- Bubbles
- Below bottom

 (some limitations)

# ADCP Processing

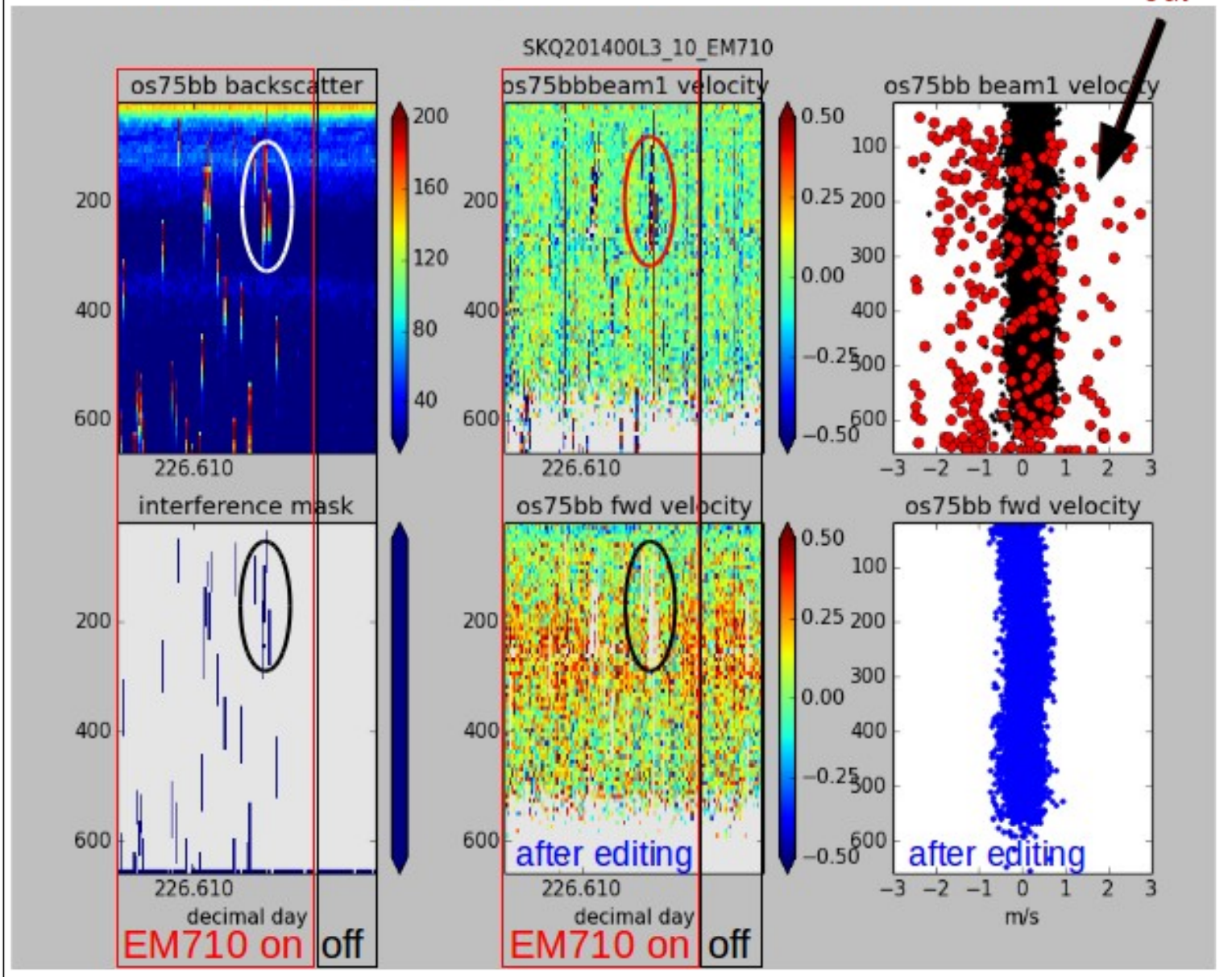
Singleping editing: acoustic interference



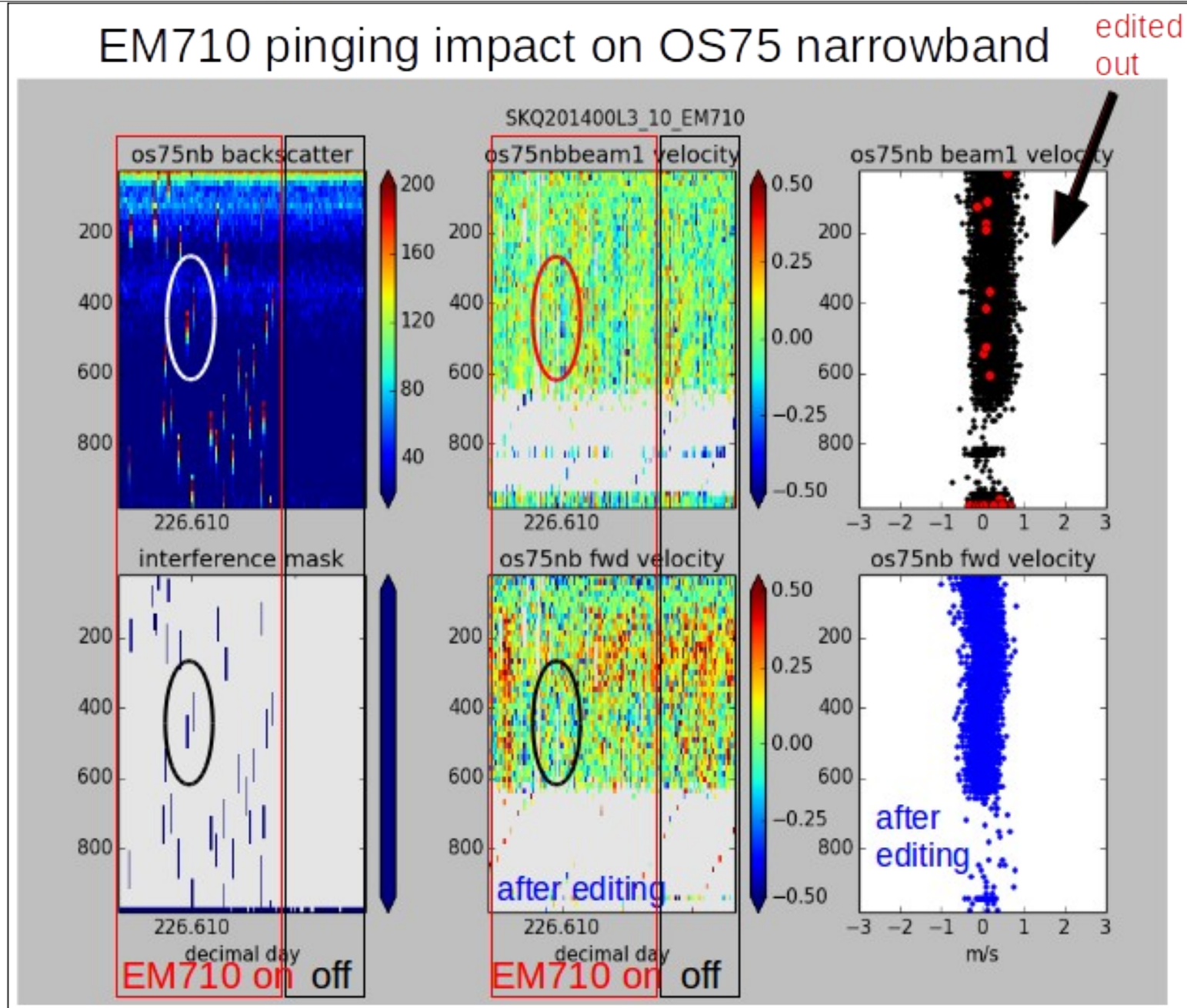
# ADCP Processing: editing out interference

EM710 pinging impact on OS75 broadband

edited out



# ADCP Processing: editing out interference

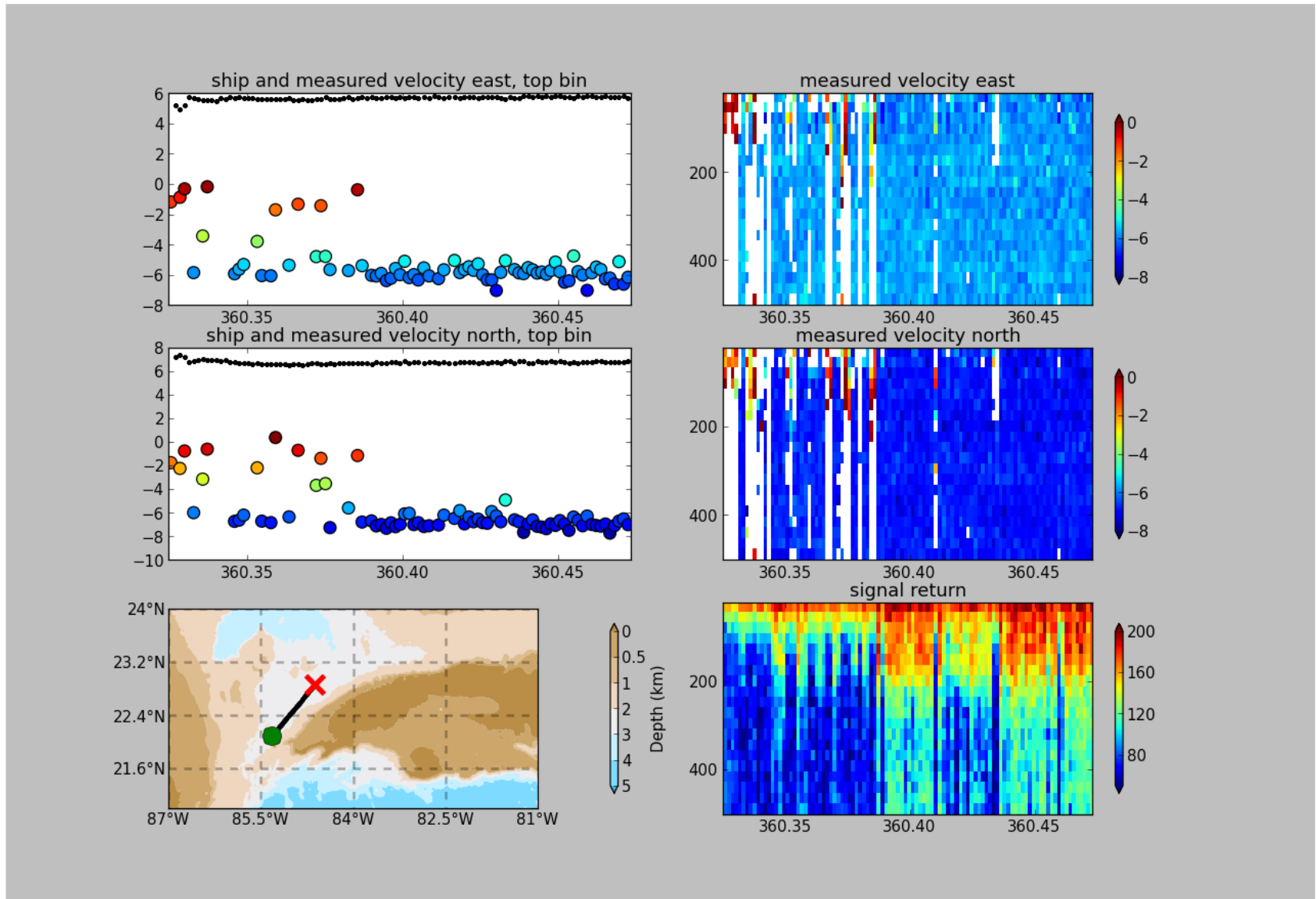


# ADCP Single-ping Editing

The most common causes of error  
(addressed by single-ping editing)

- Acoustic Interference
- **Bubbles**
- Below bottom

# single-ping editing: underway bias





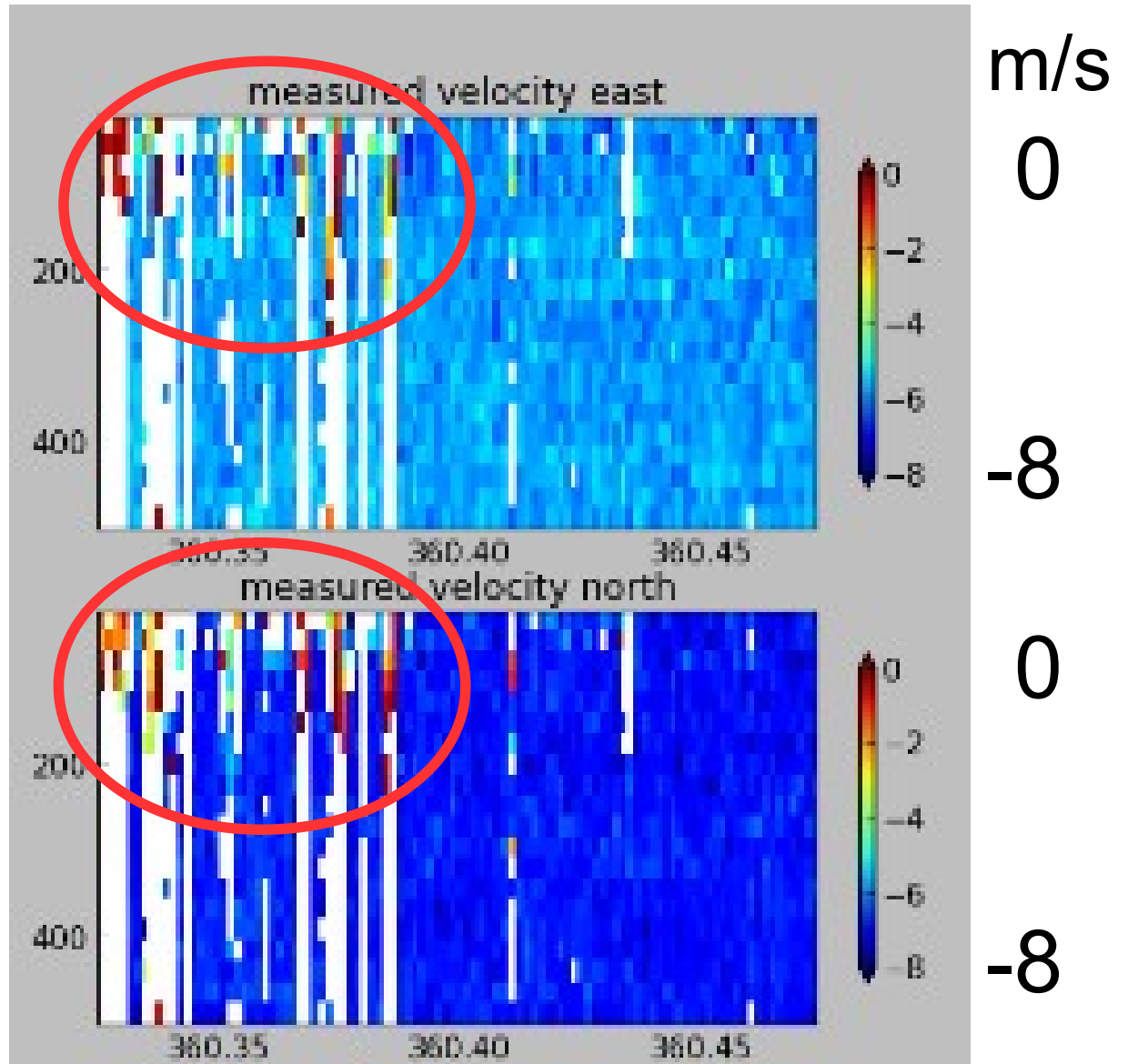
# ADCP Data: effect of bubbles

## Bubbles:

- short profiles
- strongly biased towards zero

## Untreated:

- biased ocean velocities



# ADCP Single-ping Editing

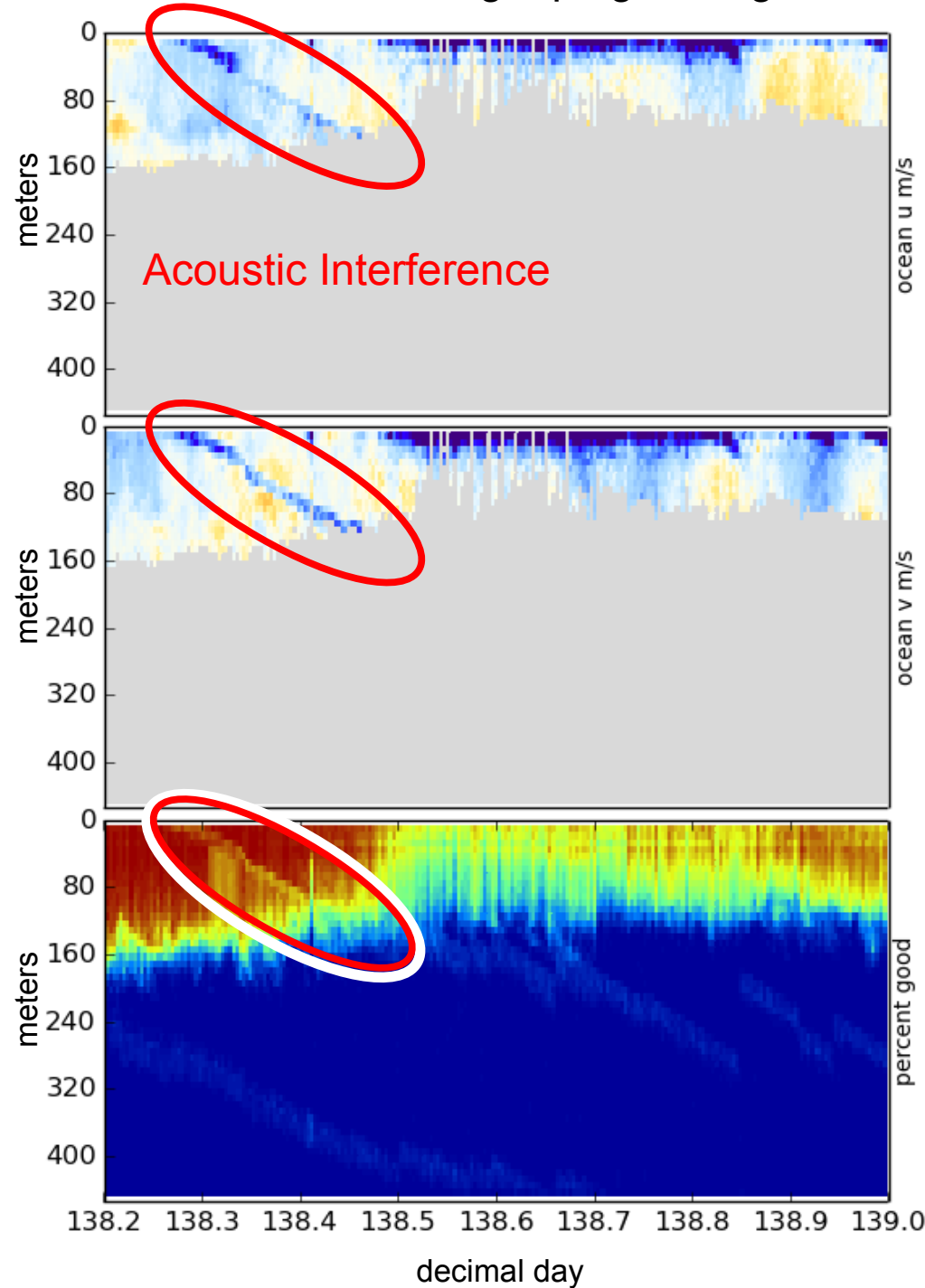
The most common causes of error  
(addressed by single-ping editing)

- **Acoustic Interference**
  - **Bubbles**
  - Below bottom
- } example with both

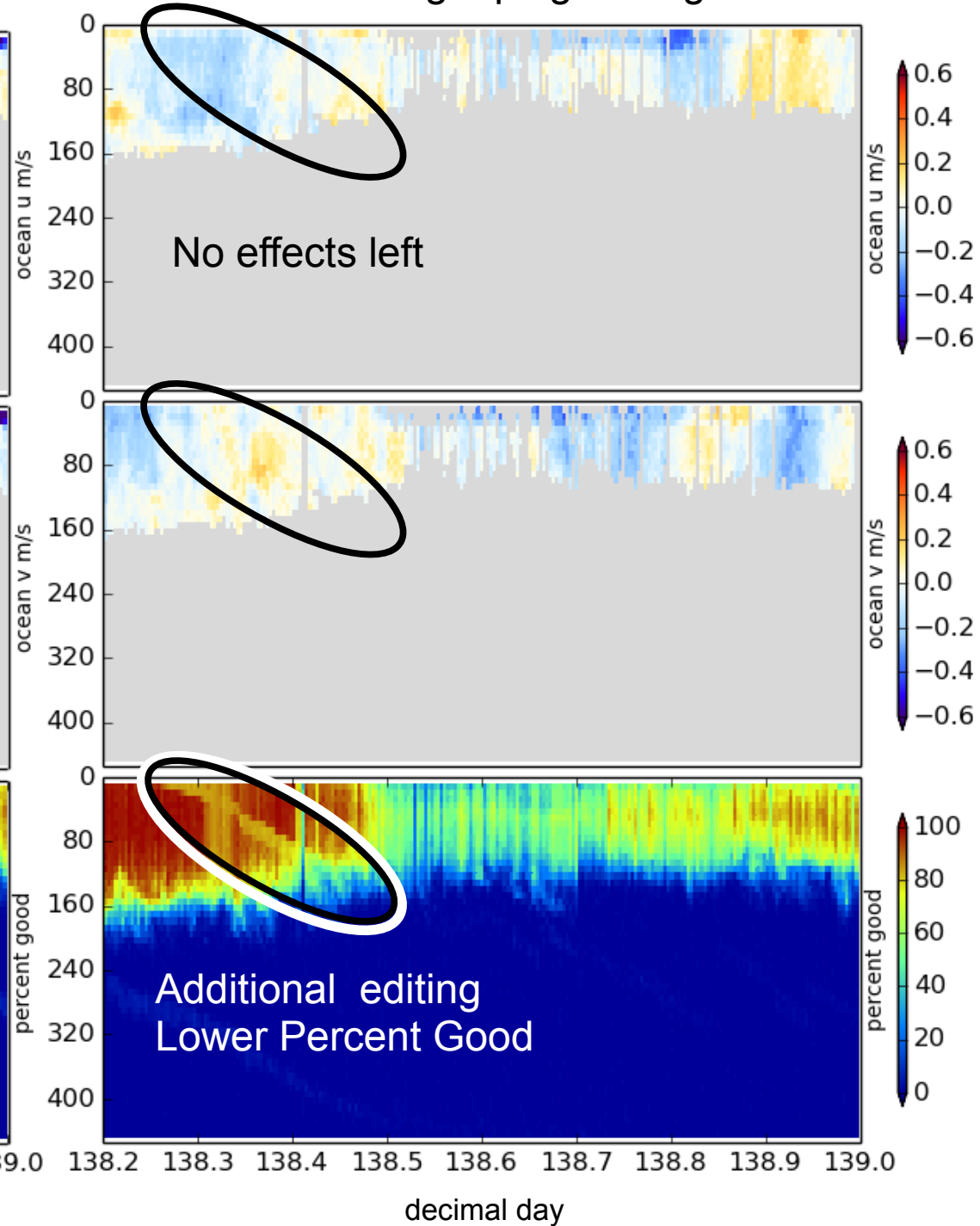


# Acoustic Interference

NO single-ping editing

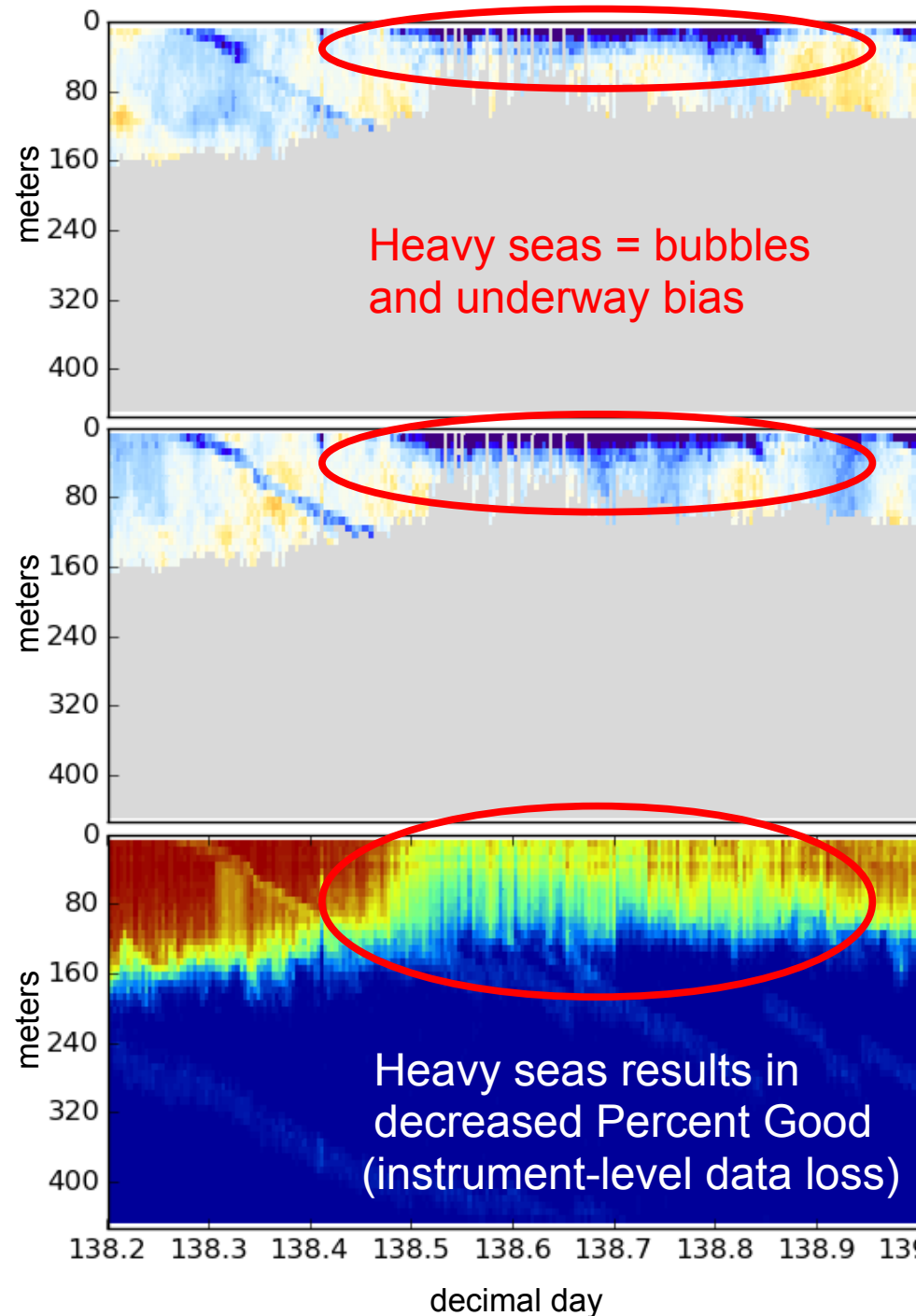


AFTER single-ping editing

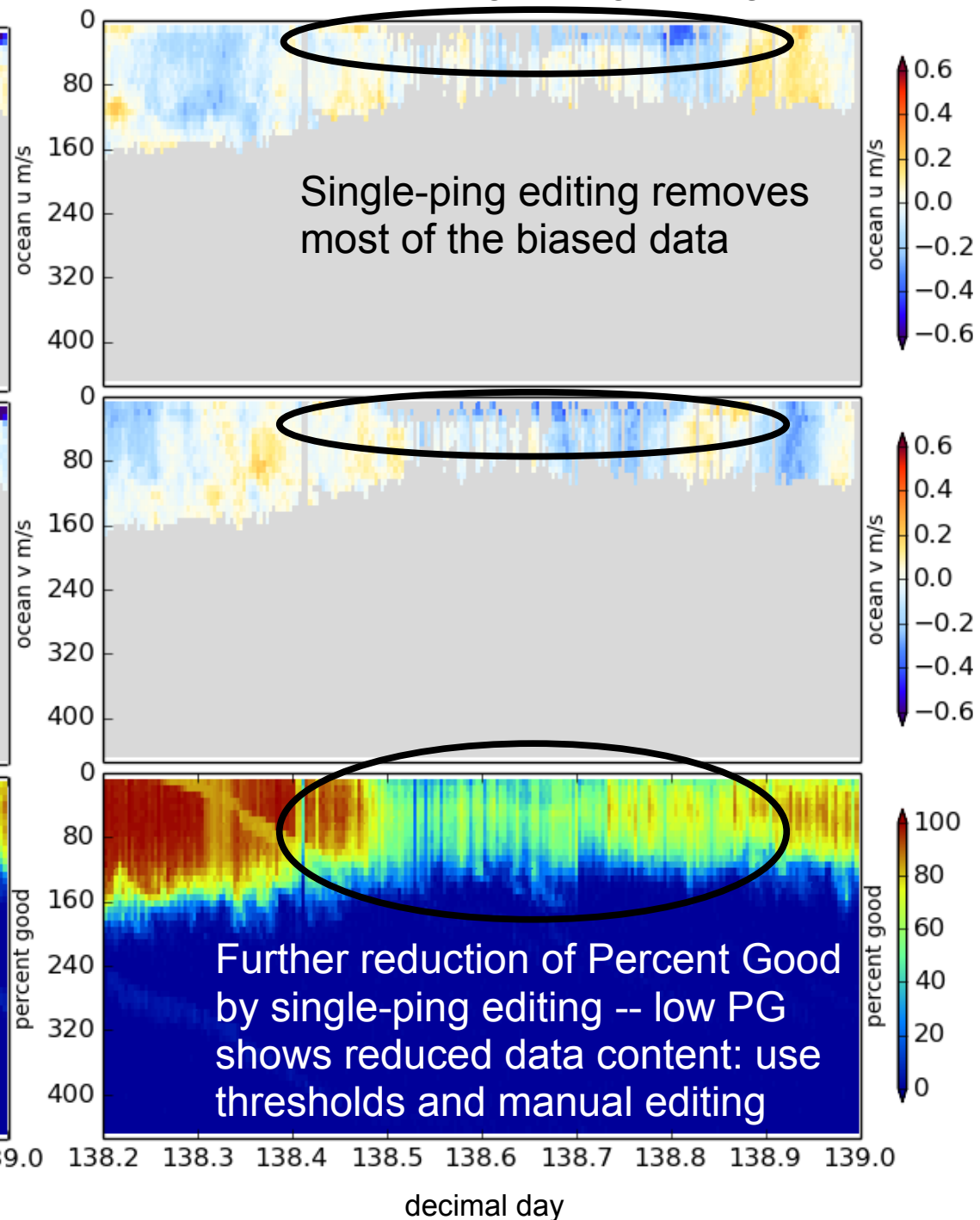


# Bubbles and alongtrack bias

NO single-ping editing



AFTER single-ping editing



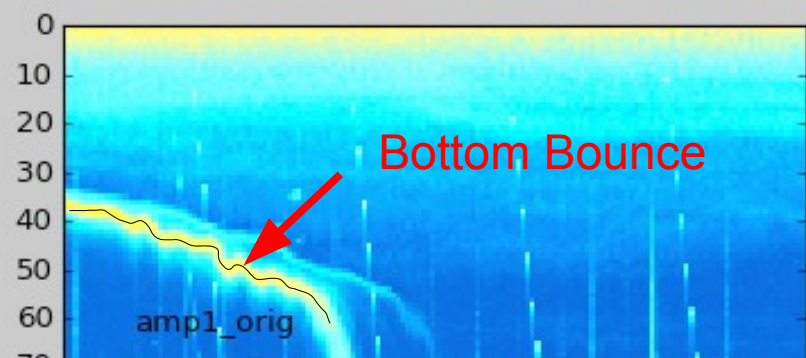
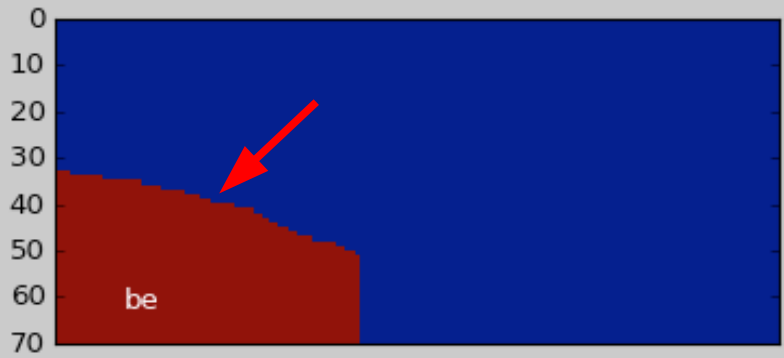
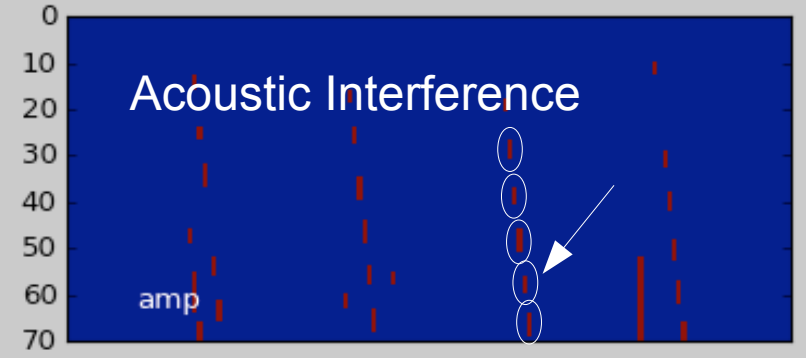
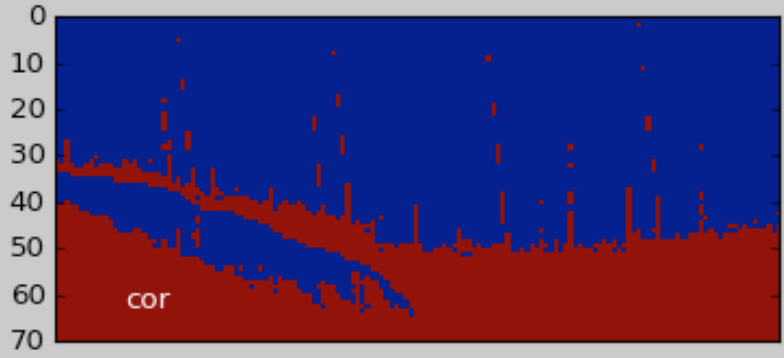
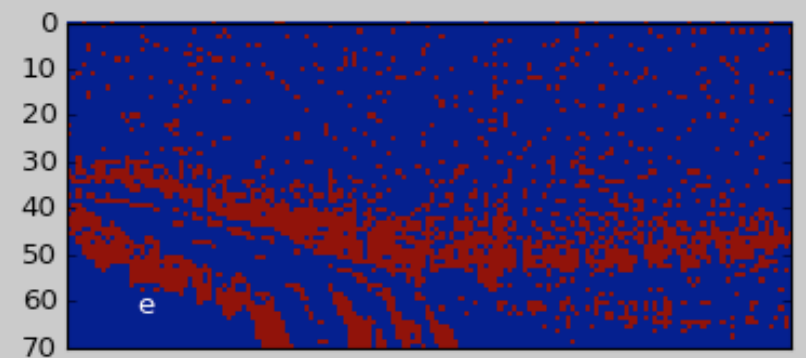
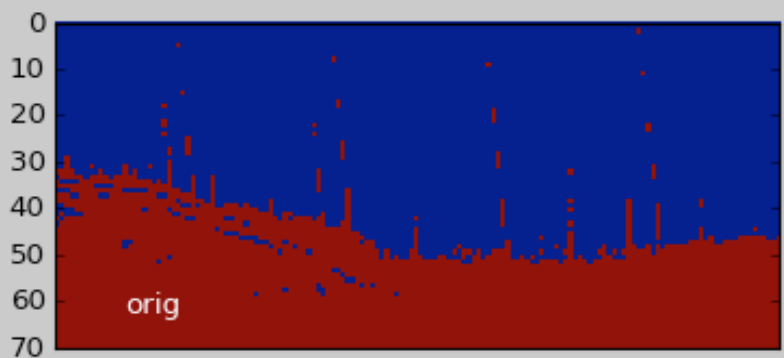
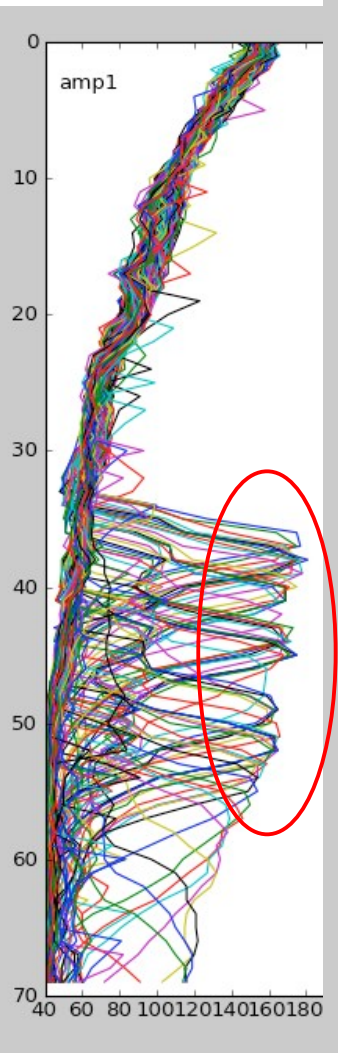
# ADCP Single-ping Editing

The most common causes of error  
(addressed by single-ping editing)

- Acoustic Interference
- Bubbles
- **Below bottom**

# Bottom Editing:

- remove acoustic interference, identify maximum amplitude
- calculate region of side-lobe interference
- flag as BAD all data below the bottom or with side-lobe interference

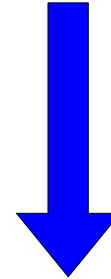


# CODAS Postprocessing

---

- Editing (single-ping)
  - Acoustic interference
  - Bubbles
  - Below bottom

AFTER AVERAGING



**Load into CODAS database**

- Interpolate missing heading correction
- Apply calibrations
  - Rotation
  - Scale factor
  - Transducer offset (new)
- Manually edit CODAS database averages “gee-autoedit”

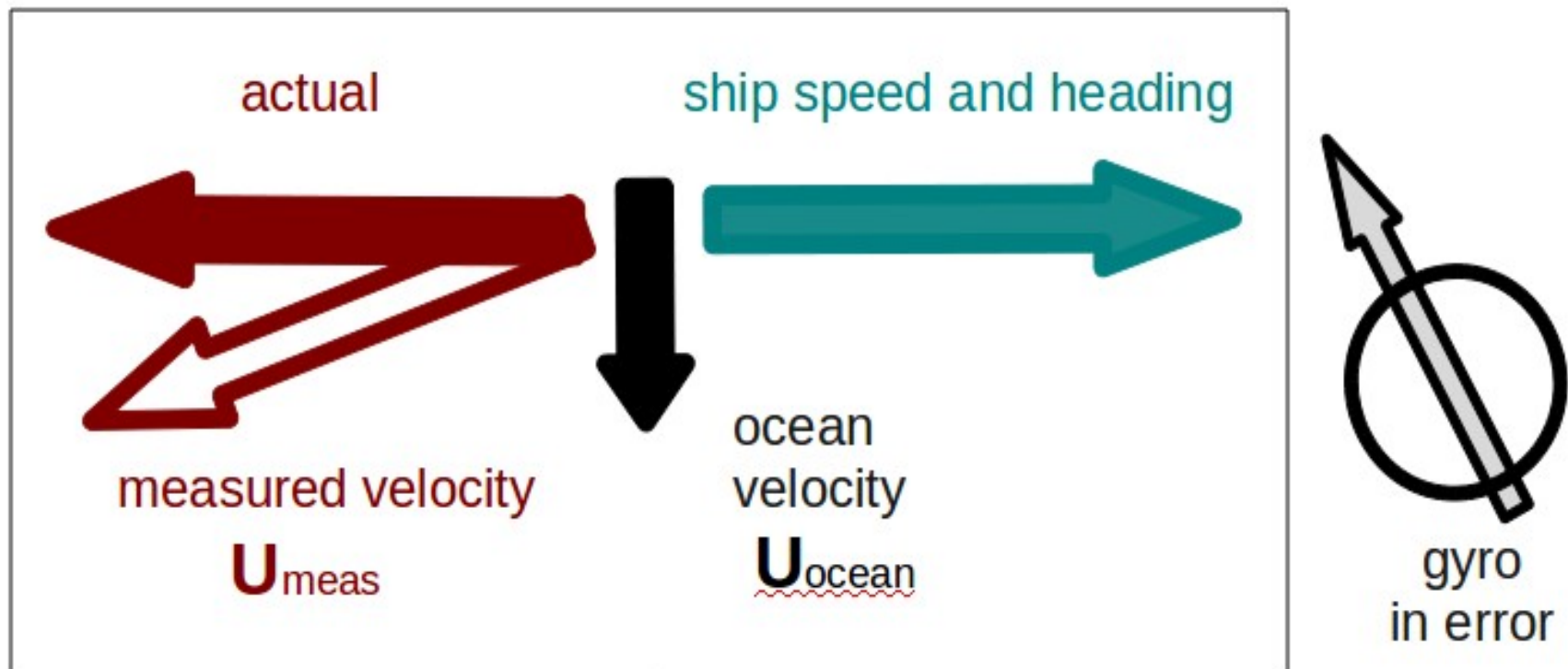
# CODAS Processing: Calibration

---

- Cross-track error (angle error)
    - Incorrect transducer angle (constant)
    - Inaccurate heading (time-varying)
  - Alongtrack bias (scale factor)
    - Soundspeed (old transducers (eg.NB150))
  - Transition Error
    - Offset between GPS and ADCP
- magnified when underway
- transition: (speed or direction)

# Calibration: Angle Error

Cross-track bias in ocean velocity from angle error:  
(heading + transducer angle)



# Symptom = Cross-Track Error

## Cause = incorrect **angle applied**

---

**Angle applied** comes from

- Transducer angle (beam “3” clockwise from bow)
- Heading of ship
  - **VmDAS**,
    - “Primary” heading, often no QC message
    - If “Primary” fails, replace with “Secondary”
  - **UHDAS**,
    - Reliable heading for each ping (eg gyro)
    - Heading correction for each averaging period
    - Calculated relative to devices such as Ashtech, POSMV, Seapath, Mahrs, Phins (hopefully with QC fields)



Symptom = Cross-Track Error  
Cause = incorrect **angle applied**

---

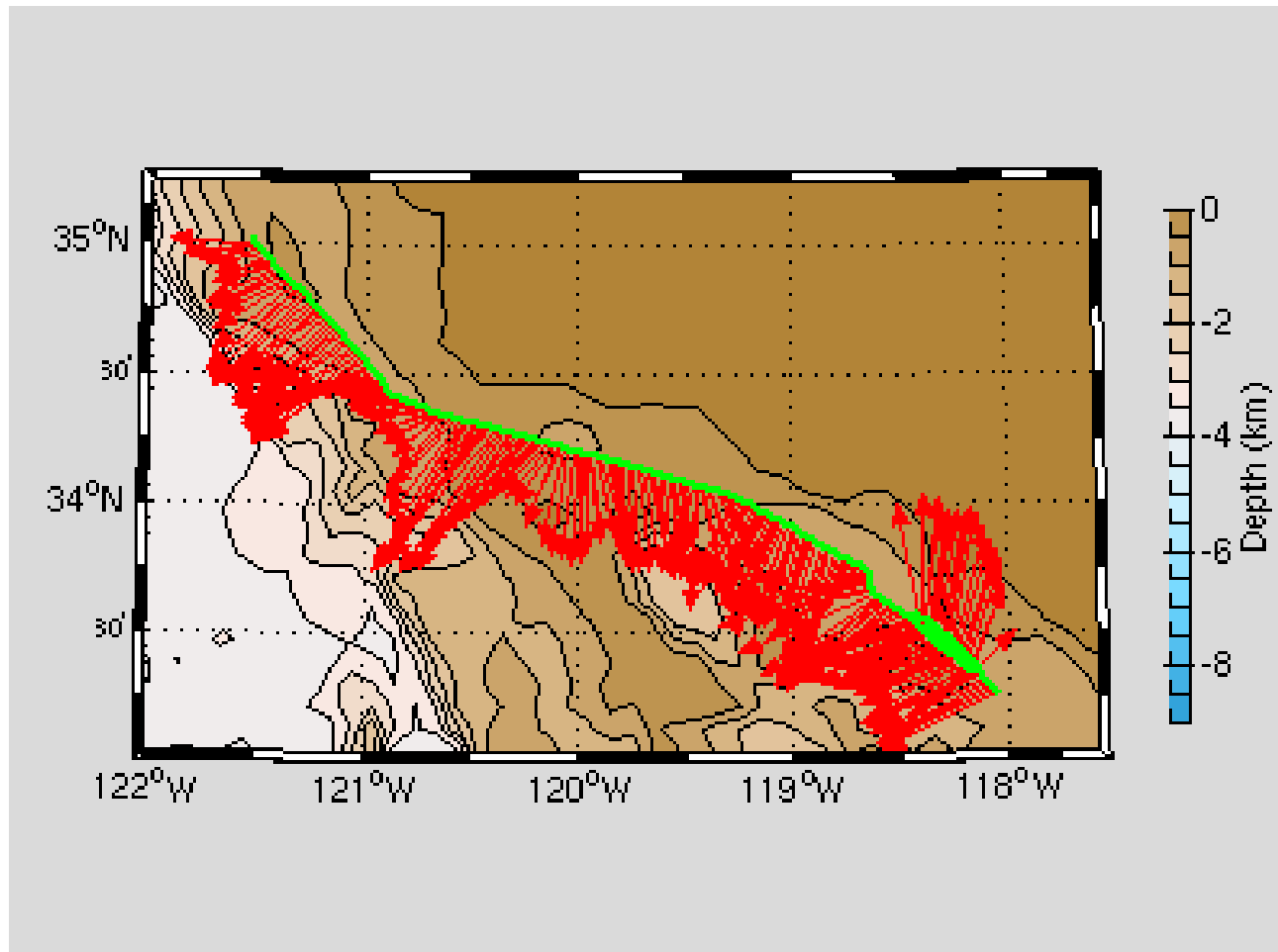
Angle applied comes from

- Transducer angle (beam “3” clockwise from bow)

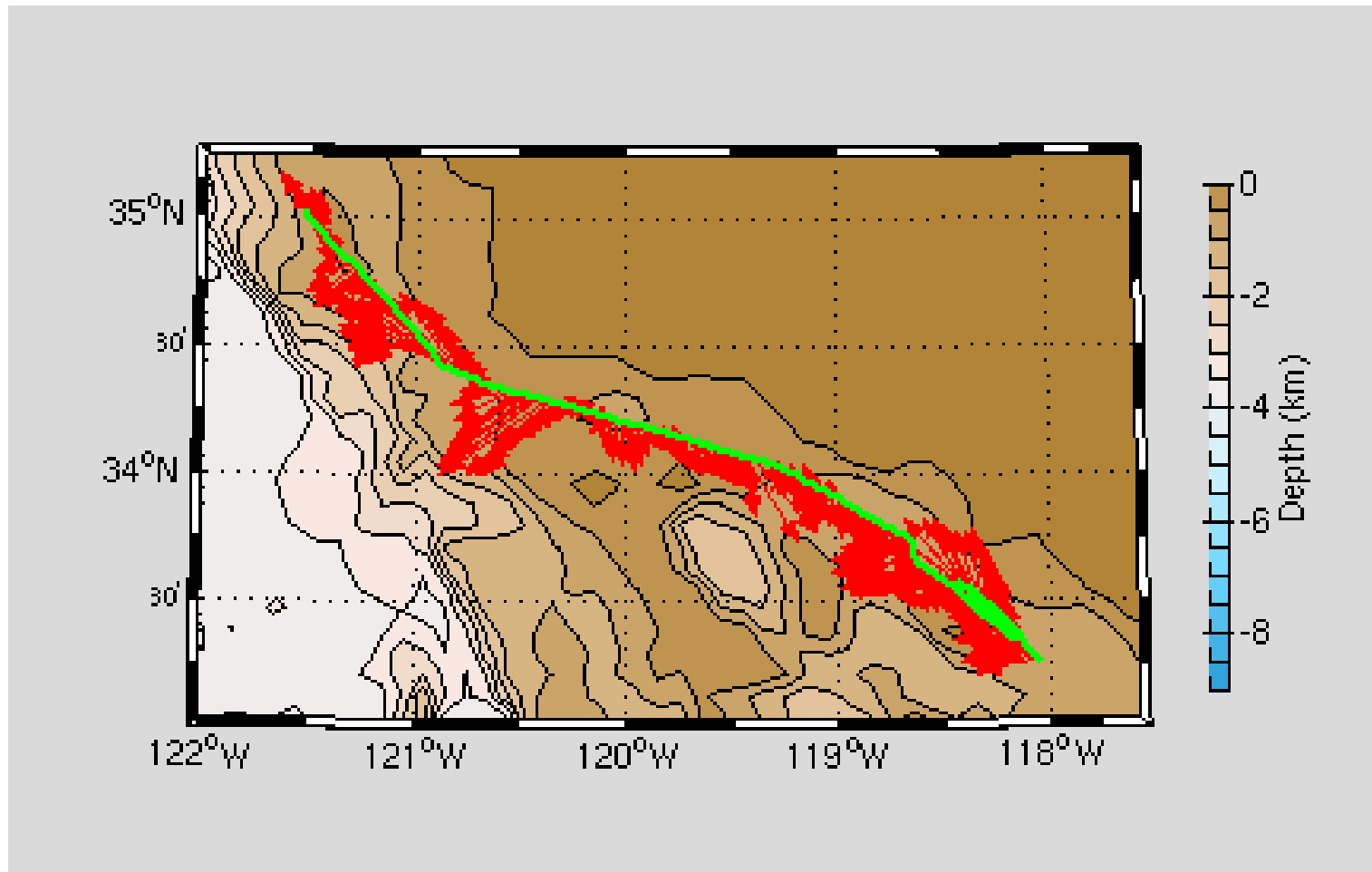
This is a **constant value** for the whole cruise

Examples of error in transducer angle follow...

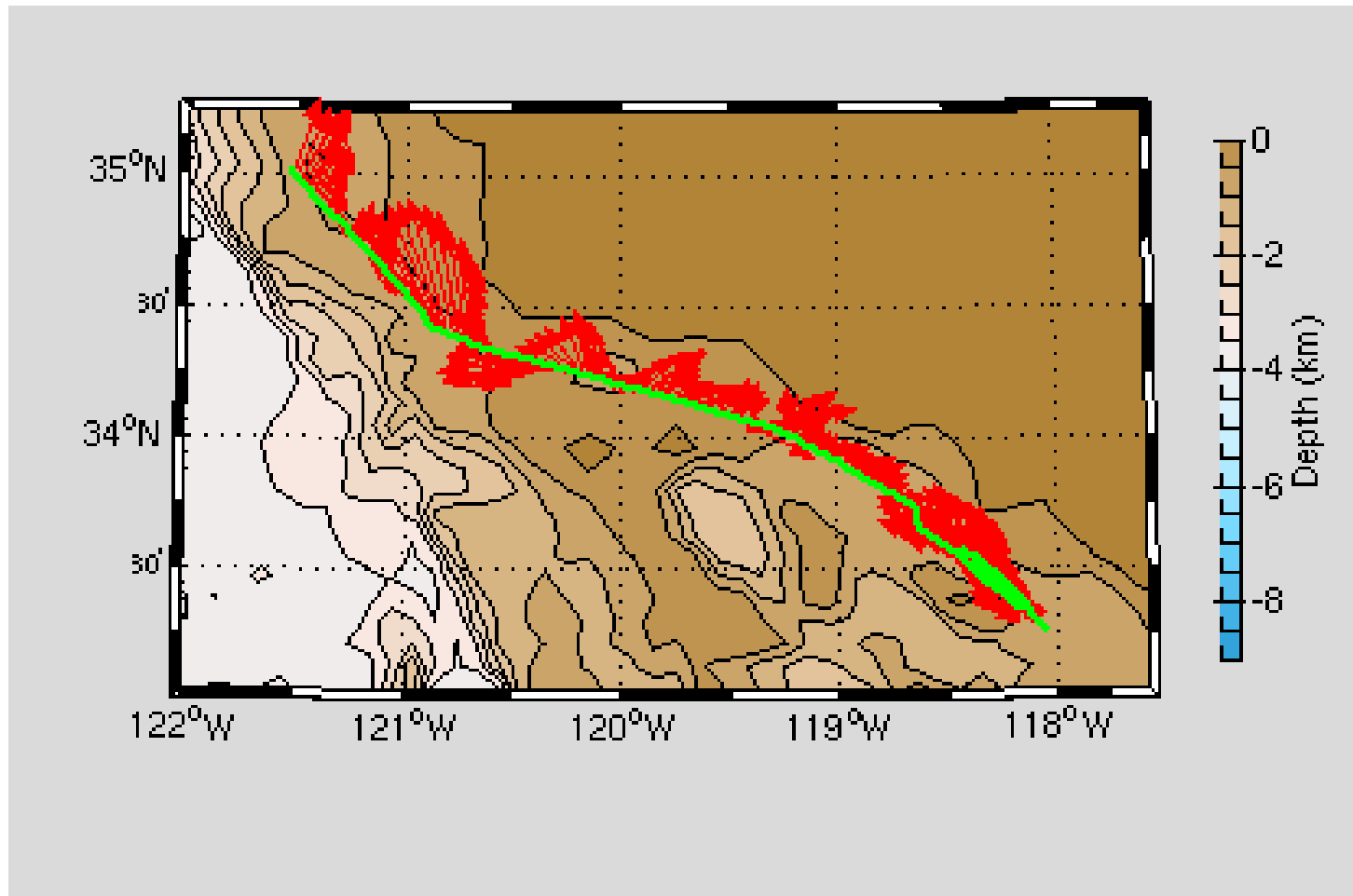
# Calibration: angle error -3.6deg



# Calibration: angle error -1.6



# Calibration: angle error 0.4



Symptom = Cross-Track Error  
Cause = incorrect **angle applied**

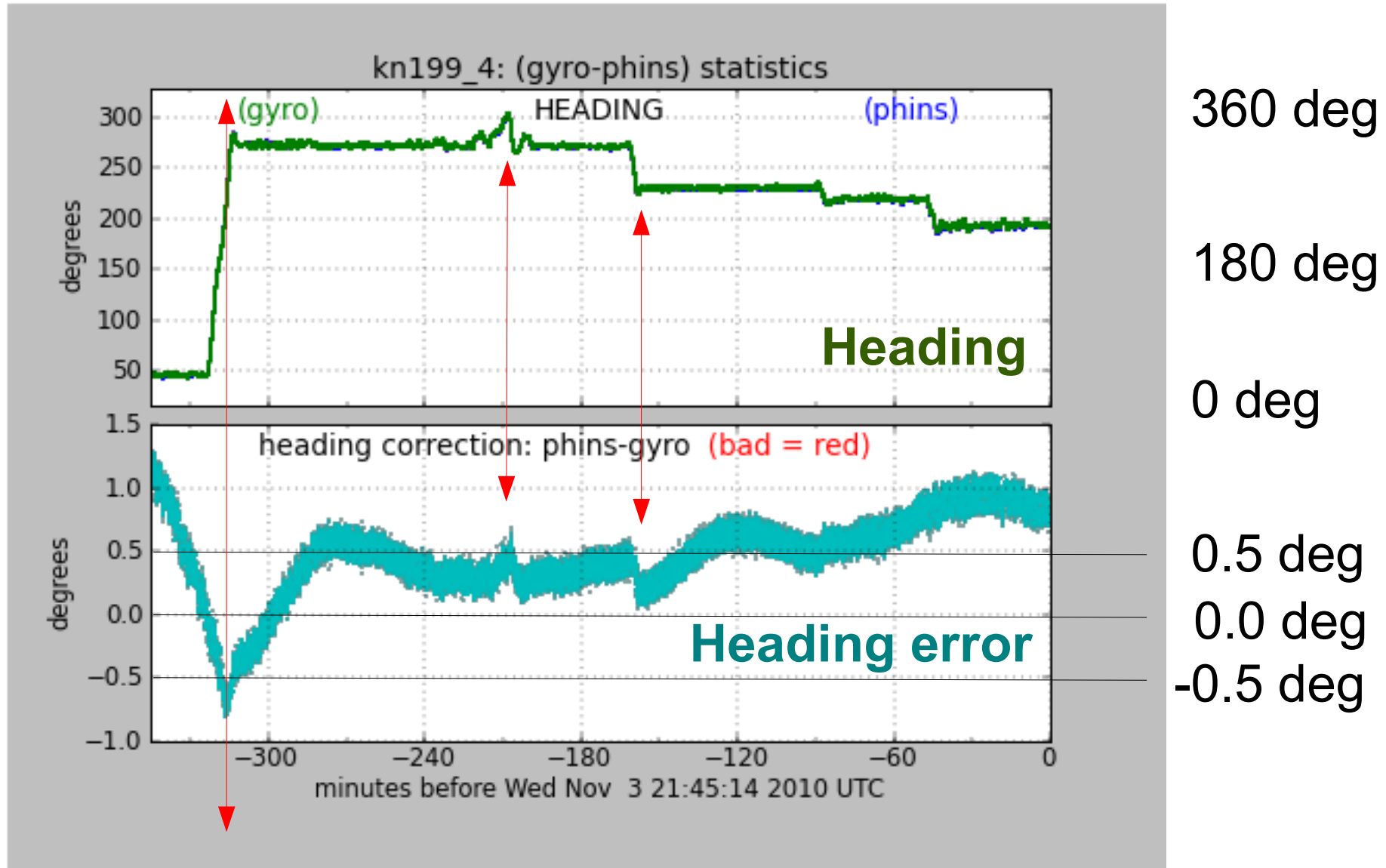
Angle applied comes from

Heading, which may be in error by

- A constant offset
- A **time-dependent offset**

Example follows ...

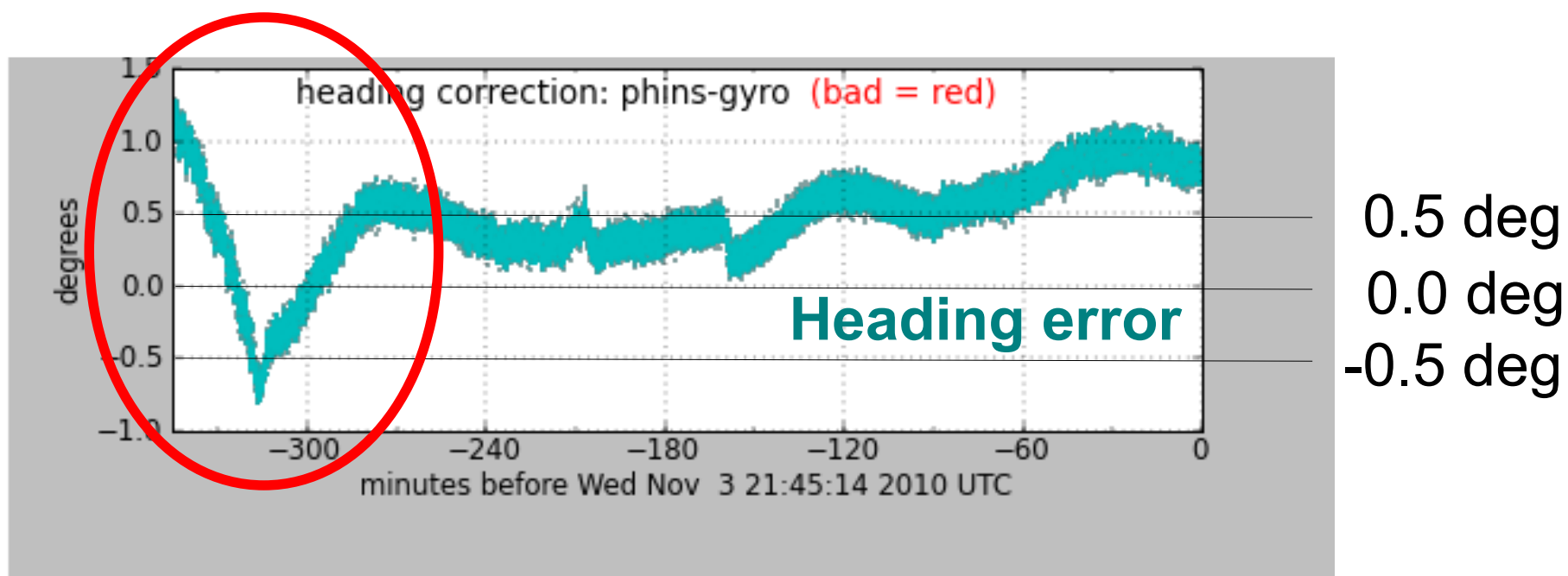
# Phins-Gyro difference varies with time



Changes in ship's heading affect heading error

# Effect of Time-Dependent Heading Error on Ocean Velocities

- 1 degree error in heading means:
- 0.1m/s error in ocean velocity
- velocity
- in the cross-track direction



Changes in ship's heading affect heading error

# Examples of along-track error

---

Remove during single-ping editing

- Acoustic interference
- Bubbles (underway bias)

Correct after averaging:

- Scale factor (NB150 soundspeed correction)



# Calibration: scale factor (alongtrack bias)

Ocean U (original)

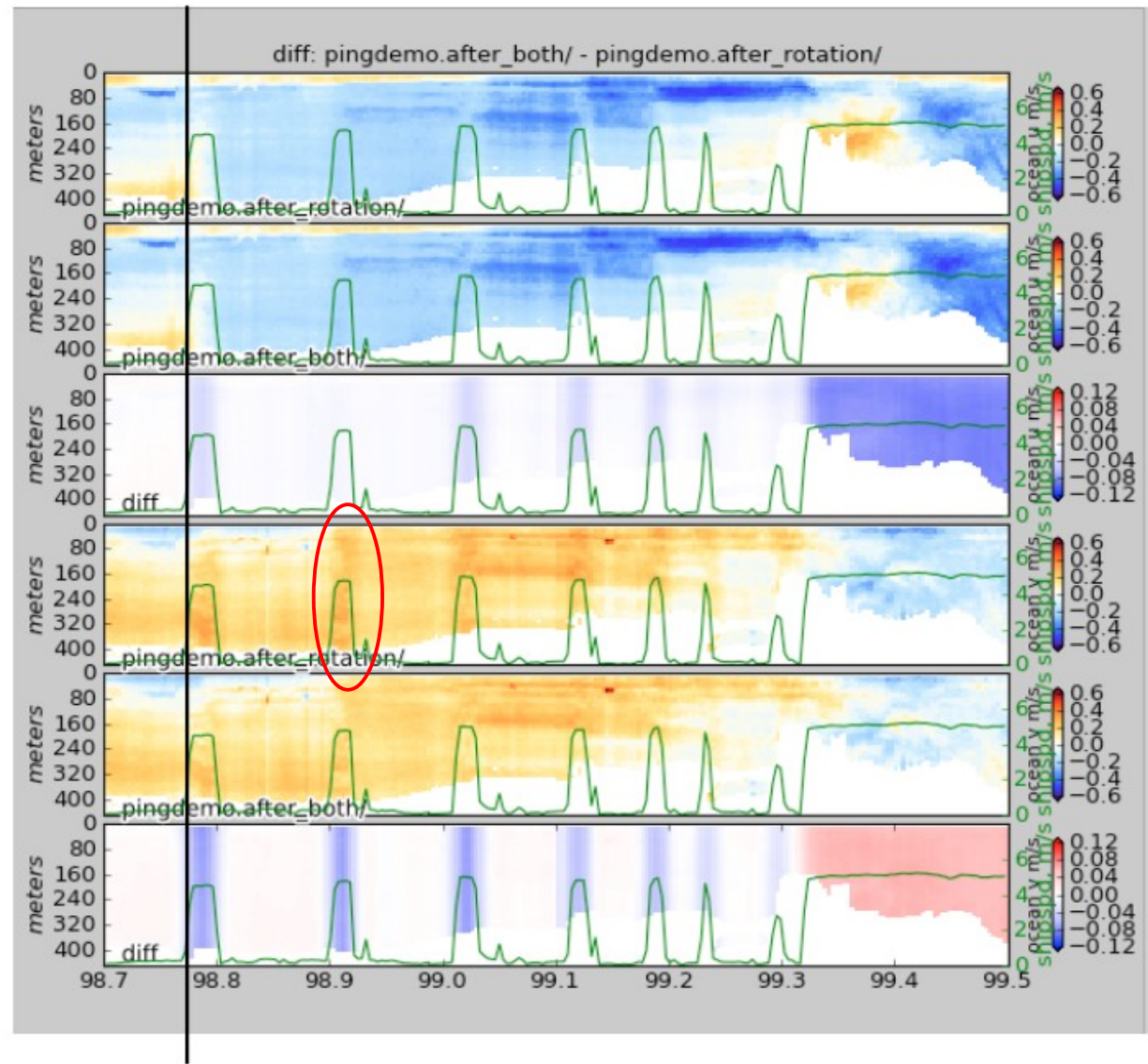
Ocean U (after scalefactor)

Diff: after-before

Ocean V (original)

Ocean V (after scalefactor)

Diff: after-before

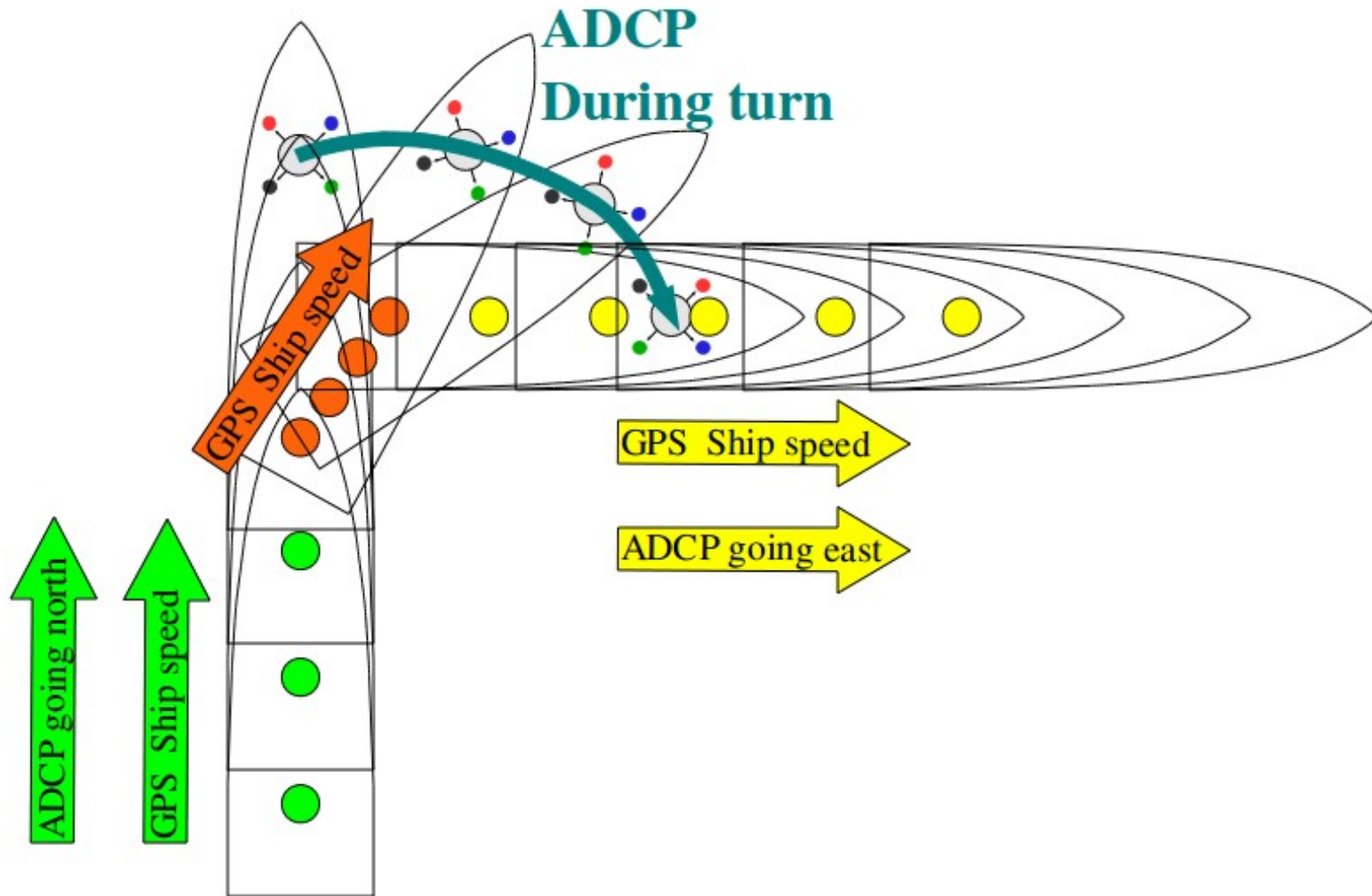


# Calibration: ADCP-GPS offset

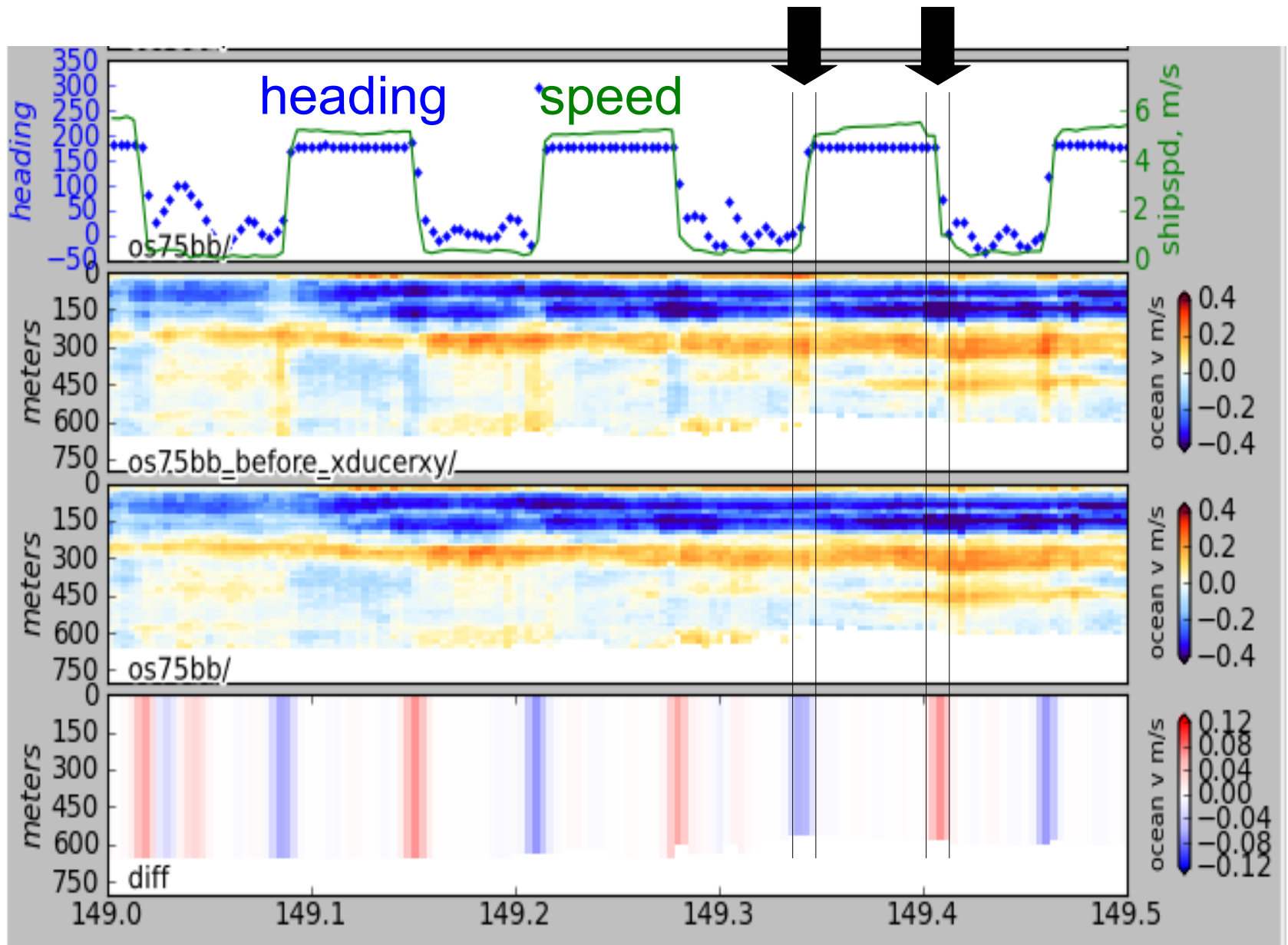
---

- Cross-track error (angle error)
    - Incorrect transducer angle (constant)
    - Inaccurate heading (time-varying)
  - Alongtrack bias (scale factor)
    - Soundspeed (old transducers (eg.NB150))
  - Transition Error
    - Offset between GPS and ADCP
- magnified when underway
- transition: (speed or direction)

# Example: offset between ADCP and GPS creates an artifact during maneuvering



# ADCP-GPS offset – error occurs: **transition** between on-station and underway



...using  
actual  
location

...using  
shifted GPS  
location

difference

# Manual Editing

---

- Bottom interference (data below the bottom)
- Wire interference
- Scattering layers
- Ringing
- Bad shallow PG and underway bias

(see [GeeAutoedit](#) (`gautoedit.py`) documentation)

# Outline

---

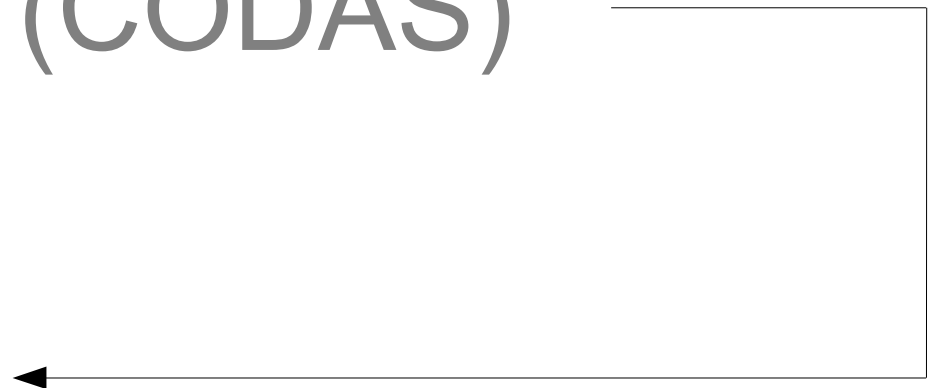
1. ADCP

2. Processing (CODAS)

3. **UHDAS**

- Acquisition
- Processing
- Monitoring
  - At Sea
  - On Land

4. Benefits



# UHDAS: What it does

---

- **(1) Data Acquisition**
  - timestamp data, write to disk
  - keep log files about activities
  
- **(2) Processing**
  - parse NMEA messages
  - grid NMEA messages
  - all CODAS processing

# UHDAS: What it does:

---

## **(3) Data Access...**

- web site on ship with
  - 5-minute profile (updated 5min)
  - 3-day vector and contour plot (updated 15min)
  - matlab files via web (used in 3-day plots)
  - full-resolution data (matlab, netcdf, CODAS)
- on land
  - full-resolution data (matlab, netcdf, CODAS)
  - archive of figures from cruise



# UHDAS: What it does

---

## (4) Monitoring...

- **at sea:**

- data acquisition (UHDAS gui tool)
- processing
- health of accurate heading device

green=good  
red=rubbish

web site  
figures

web site  
figures

- **from shore: ([uhdas.org](http://uhdas.org))**

- sends daily email with attachment
- diagnostic files
- data snippet for shore-based figures

# Monitoring at Sea

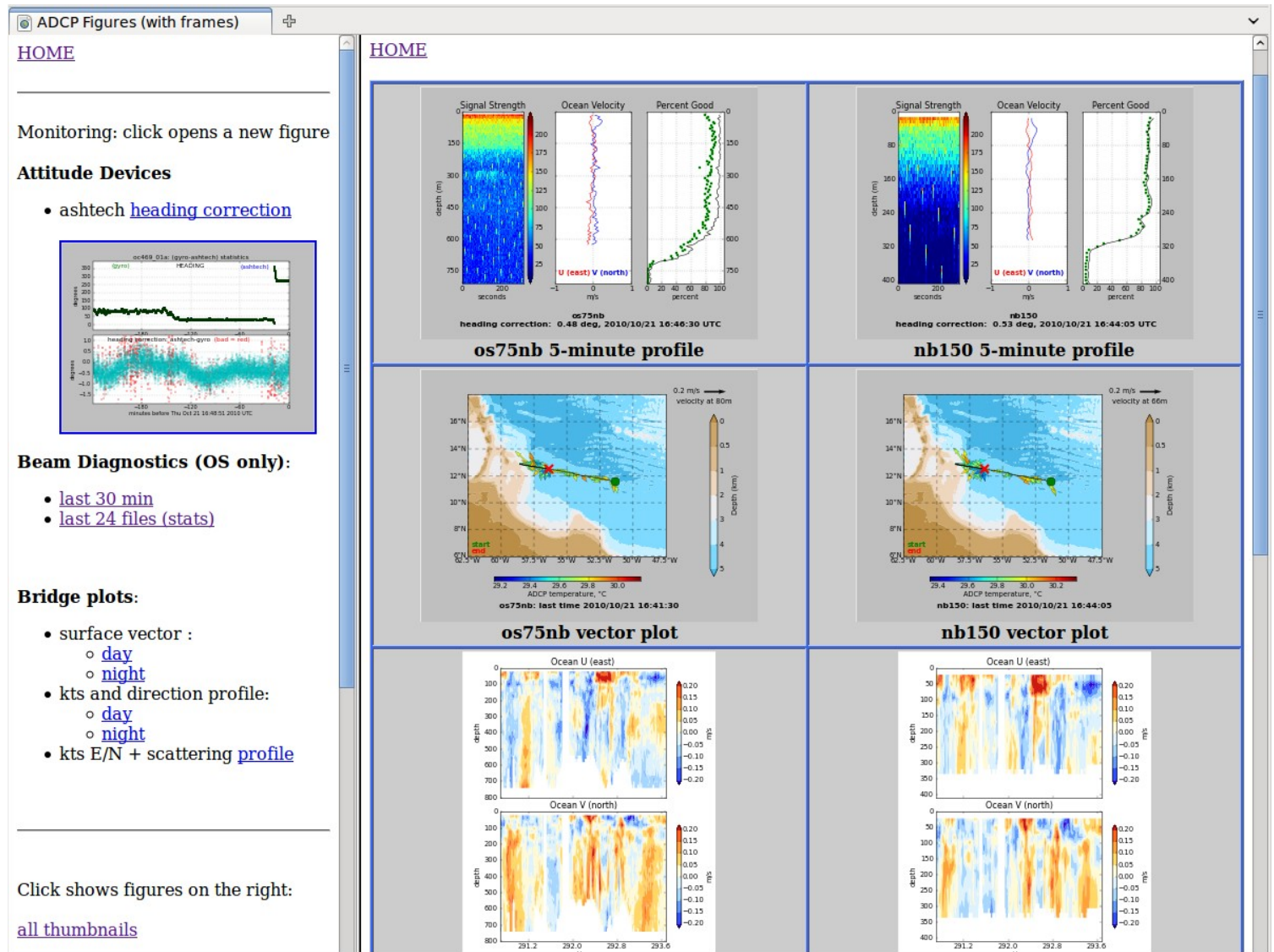
- wrong baud rate
- wrong port
- cable fell out

The screenshot shows the UHDAS monitoring software interface. At the top, there are tabs for 'Control', 'Terminal', 'Monitor', 'Plots', 'Avg Plots', 'Info', 'Log', and 'Errors'. The 'Monitor' tab is active. Below the tabs, there are several sensor monitoring panels. Each panel displays the sensor name, start time, good/bad counts, error counts, and a log of data points. The 'Soundspeed' panel is highlighted in red, and an arrow points from the red text in the top right to this panel. The other panels show green data logs.

Sensor	Start	Good	Errors	Data Log
os38 ttyS0	2004/10/01 02:15:15	856	2	275 03:16:18 np2004_274_08144.raw 2272170 2670 275 03:16:22 np2004_274_08144.raw 2274840 2670 275 03:16:26 np2004_274_08144.raw 2277510 2670 275 03:16:30 np2004_274_08144.raw 2280180 2670
nb150 ttyn1g	2004/10/01 02:15:15	3619	0	275 03:16:31 np2004_274_08144.raw 2092506 579 275 03:16:32 np2004_274_08144.raw 2093085 579 275 03:16:33 np2004_274_08144.raw 2093664 579 275 03:16:34 np2004_274_08144.raw 2094243 579
Soundspeed ttyn1e	2004/10/01 02:15:15	5765	0	2004/10/01 03:16:04
Seapath ttyn1c	2004/10/01 02:15:15	10953	0	\$PSXN,23,-0.21,-0.12,102.42,-0.01*11 \$GPGGA,031634.17,3649.895438,S,17447.058891,E,1,10,0.9,29.55,M,,M,,*66 \$PSXN,20,1,0,0,0*3A \$PSXN,23,-0.22,-0.07,102.39,0.01*37
GPS Tm ttyn1a	2004/10/01 02:15:15	3650	0	\$GPGGA,031630.493,3649.8950,S,17447.0586,E,1,06,1.2,040.1,M,-026.4,M,,*53 \$GPGGA,031631.493,3649.8950,S,17447.0587,E,1,06,1.2,040.2,M,-026.4,M,,*50 \$GPGGA,031632.493,3649.8950,S,17447.0587,E,1,06,1.2,040.3,M,-026.4,M,,*52 \$GPGGA,031633.493,3649.8950,S,17447.0587,E,1,06,1.2,040.3,M,-026.4,M,,*53
Gyro ttyn1d	2004/10/01 02:15:15	3649	0	\$HEHDT,102.83,T*17 \$HEHDT,102.93,T*16 \$HEHDT,103.03,T*1e \$HEHDT,102.94,T*11

# Monitoring At Sea: UHDAS web site

Snapshot  
from at-sea  
web site



# UHDAS: Monitoring from shore

Link to on-shore monitoring: [UHDAS ships](#)

- text email
- diagnostic files
- figures

letters	ship name	figures	last email		cruise name	status	daily report	daily email
ae	Atlantic Explorer	<a href="#">figs</a>	1d	18hr	AE1623	logging	<a href="#">dir</a>	<a href="#">email</a>
ar	Neil Armstrong	<a href="#">figs</a>		18hr	ar08A	(not logging)	<a href="#">dir</a>	<a href="#">email</a>
at	Atlantis	<a href="#">figs</a>		18hr	AT37_03	logging	<a href="#">dir</a>	<a href="#">email</a>
bh	Blue Heron	<a href="#">figs</a>		14hr	(not set)		<a href="#">dir</a>	<a href="#">email</a>
en	Endeavor	<a href="#">figs</a>		18hr	EN589	logging	<a href="#">dir</a>	<a href="#">email</a>
ex	Okeanos Explorer	<a href="#">figs</a>	3d		(not set)		<a href="#">dir</a>	<a href="#">email</a>

# Monitoring: From Shore

---

- **from the text email** (read):
  - CODAS Processing
  - accurate heading device quality
  - timeserver
  - ADCP settings
  - hardware problems
  - acquisition

- 
- **data snippets for figures**
  - **diagnostic files**
- } (tarball)

# UHDAS email message : all is good

```
2009/09/26 18:40:02 ← date when email was generated
currents 2.6.24-24-generic ← cruise name
Current cruise: X0908a ← ** is logging ** ← UHDAS status (no warnings)
Database time ranges:
  os75bb 2009/09/23 22:25:13 to 2009/09/26 18:19:55 (20 min. ago) ← database times; good
  os75nb 2009/09/23 22:25:17 to 2009/09/26 18:19:55 (20 min. ago) ← (under 40 minutes)

---- heading correction ----
(heading correction from "adu_at2")
----- adu_at2 -----
adu_at2_gyrodh.asc

ddrange: 267.7815397 to 268.7711230
(2009/09/25 18:45:25 to 2009/09/26 18:30:25)

number of good points: 284 out of 286 (99%) ← heading correction statistics
heading correction statistics:
min dh = -0.22, max dh = 2.17
mean dh = 0.68
stddev dh = 0.24

----- uptime -----
18:40:02 up 7 days, 2:57, 1 user, load average: 0.30, 0.16, 0.10

----- ps -ef | grep ntpd | grep -v grep -----
ntpd is not running
-----

figures are at http://currents.soest.hawaii.edu/uhdas\_fromships/atl\_explorer/figs/ ← click this link to see the figures
```

# Monitoring: From Shore

---

- **text email** (read)
- 

- **data snippets for figures**

- **from the diagnostic files:**

- data acquisition
- processing
- troubleshooting

(tarball)

automatically:

- download
- unpack
- plot

# Outline

---

## 1. ADCP

## 2. Processing (CODAS)

## 3. UHDAS

- Acquisition
- Processing
- Monitoring
  - At Sea
  - On Land

## 4. Benefits



# Benefits of UHDAS

---

## At sea

- All ADCPs logged by one computer
- Nearly science-ready data for use during the cruise
- Figures and data files accessible via ship's network
- Useful for real-time operations, eg. instrument deployment
- Components to help in monitoring (including daily email)
- Support by email (to/from shore)

## On land

- post-cruise: UHDAS data directory contains
  - at-sea processed data exported as Matlab and NetCDF files
  - Summary of diagnostics (“reports” directory), including figures
- Post-processing software (CODAS)
  - Free, multiplatform, documented, supported, continually improving
- Daily email with information to help in monitoring
- ADCP experts reading the email every day