APL – ADCP workshop
June 12-14, 2012

UHDAS ADCP data Acquisition and CODAS processing

UHDAS + CODAS Documentation

http://currents.soest.hawaii.edu/docs/adcp_doc/index.html

Outline

1. ADCP
2. UHDAS Acquisition
3. CODAS Processing
4. Things go wrong: evaluation

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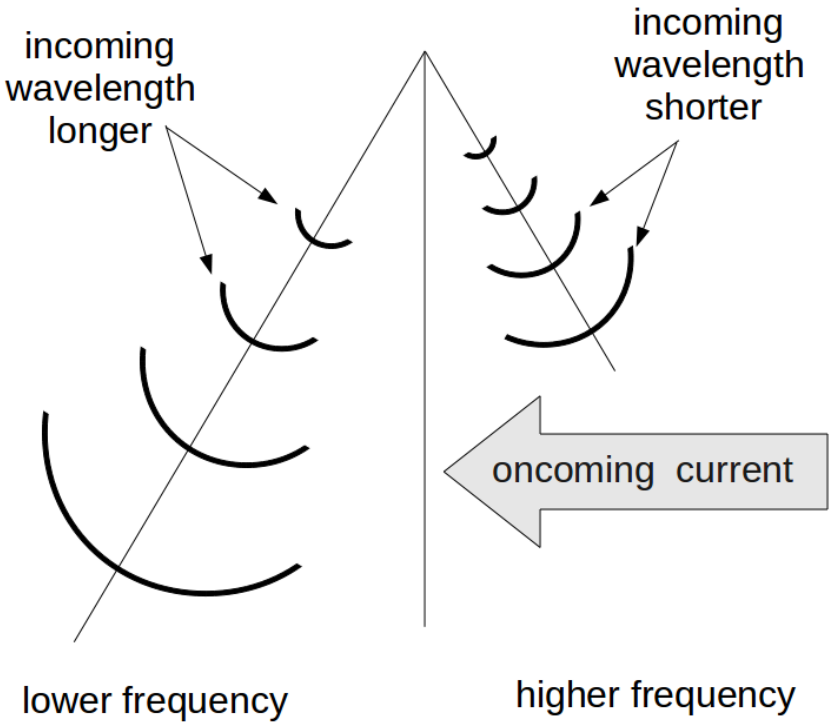
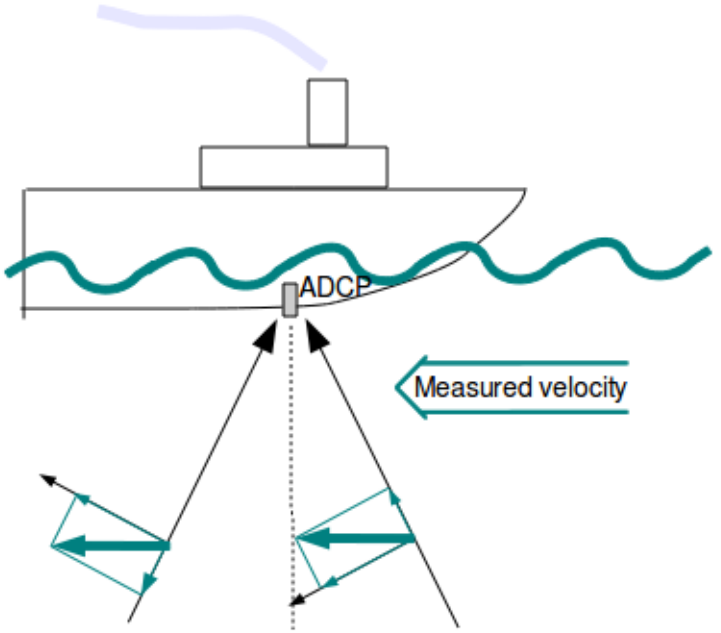
ADCP: **A**coustic **D**oppler **C**urrent **P**rofiler

Doppler Shift



soundspeed = frequency X wavelength
(ocean) (instrument)

Hull-Mounted



ADCP:

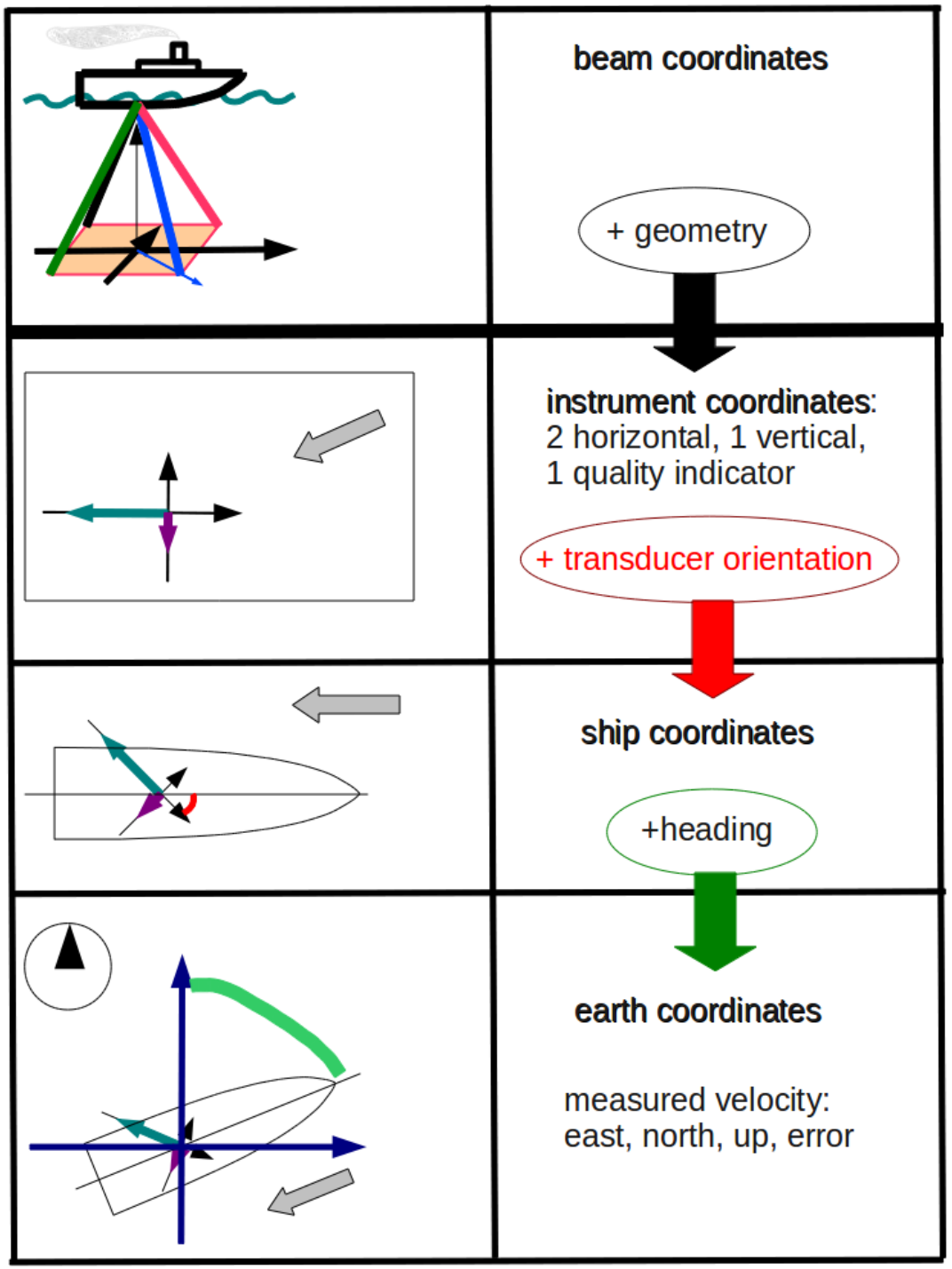
Getting Ocean Currents

Summary of steps:

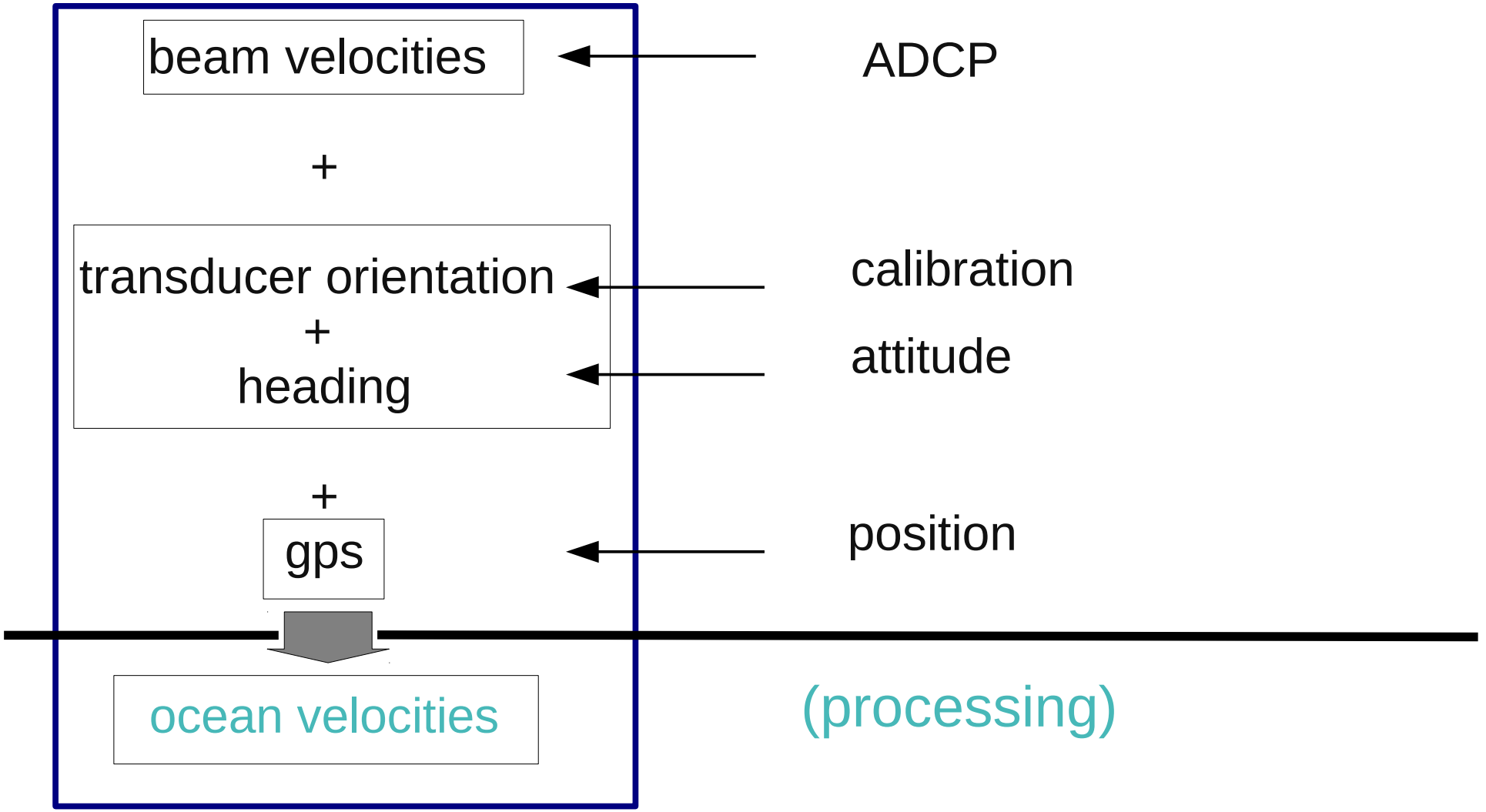
Doppler to beam
(previous slide)

<u>below here: horizontal+vertical</u>

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



ADCP: Data components



Outline

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UHDAS: what it does

- Data acquisition
- Data processing
- Data access (for scientist at sea)
- Monitoring tools
  - at sea
  - from shore

Acquisition: Serial Setup

	UHDAS	VmDAS
ADCPs	multiple	one (per instance)
feeds	any number	3 (older version=2)
messages	many types can add more subsample feed choose messages	fewer types record all record all
gui controls	instrument settings	everything
operation	simple	simple/confusing
protected	serial Processing	nothing protected

Acquisition: Data Logging

	UHDAS	VmDAS
data logging	separate processes	one big program
time tagging	buffered tag every line	unbuffered tag ensemble
data formats	multiple	TRDI ADCP
data directory	heirarchical	flat
time range	match per file	match for one logging period
filenames sort (time=ascii)	always	one logging period
metadata	stored with data	text file elsewhere

UHDAS cruise directory structure

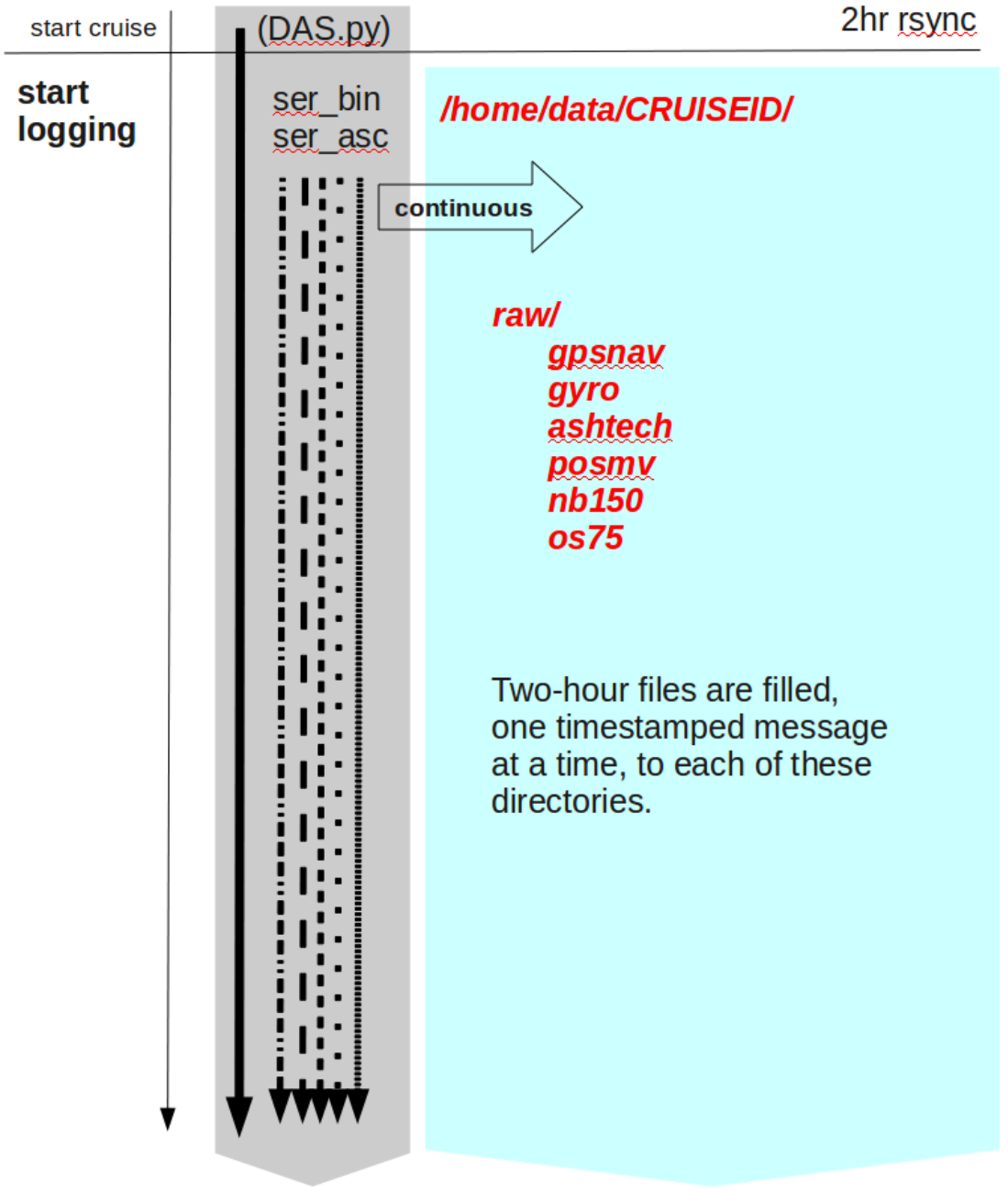
Data for scientists:

There are three categories of data, all located in the logging directory, /home/data/[CRUISEID]:

ADCP logging directories

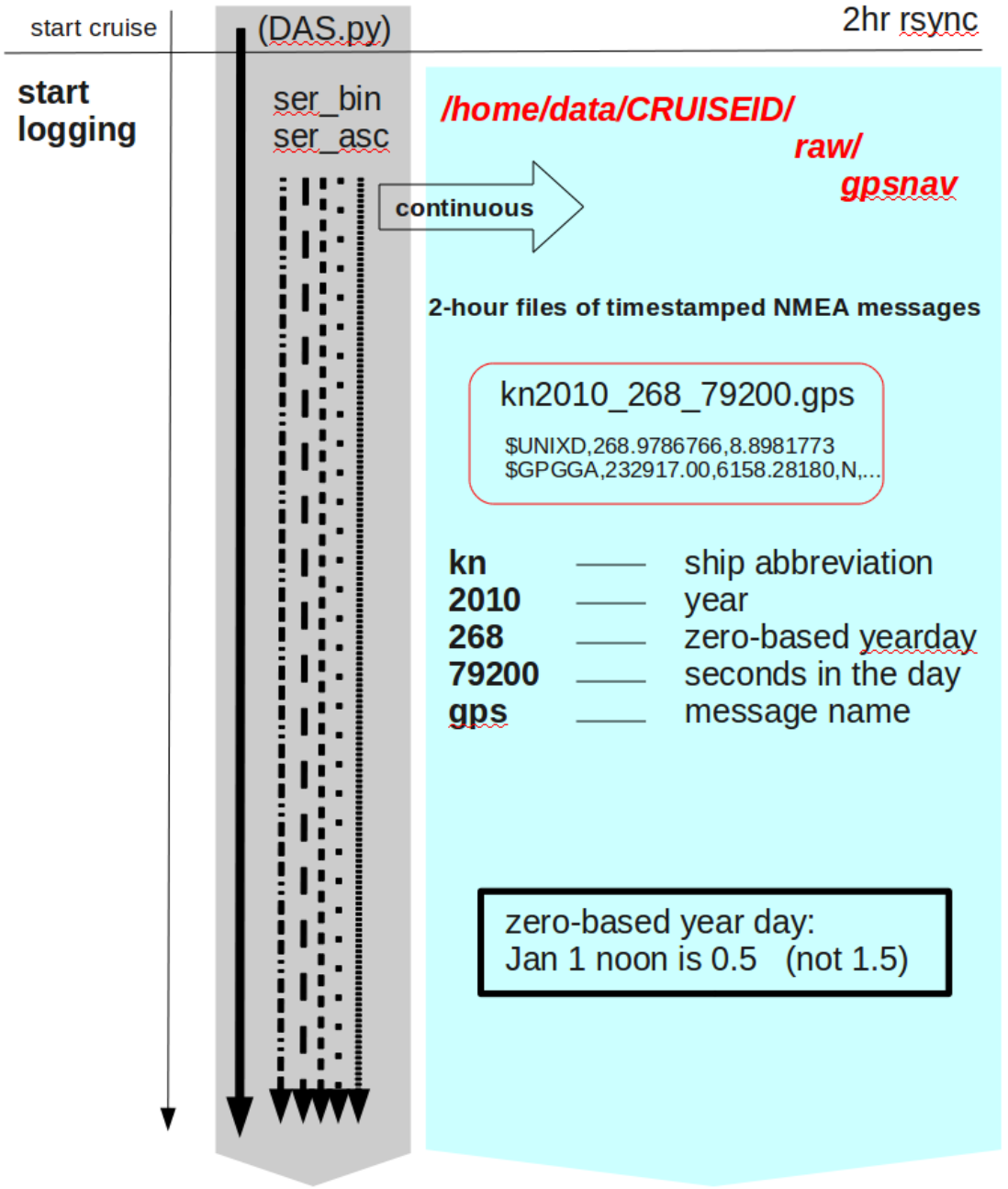
subdirectory	contents	importance	back up for...
raw	all raw data	critical	◦ archiving ◦ scientists who ask for it
rbin	intermediate files	nice to have	anyone who gets **raw**
gbin	intermediate files	nice to have	anyone who gets **raw**
proc	◦ final processing ◦ codas database ◦ underway figure archive ◦ matlab files	final product	science CDs after cruise

serial logging (raw files)

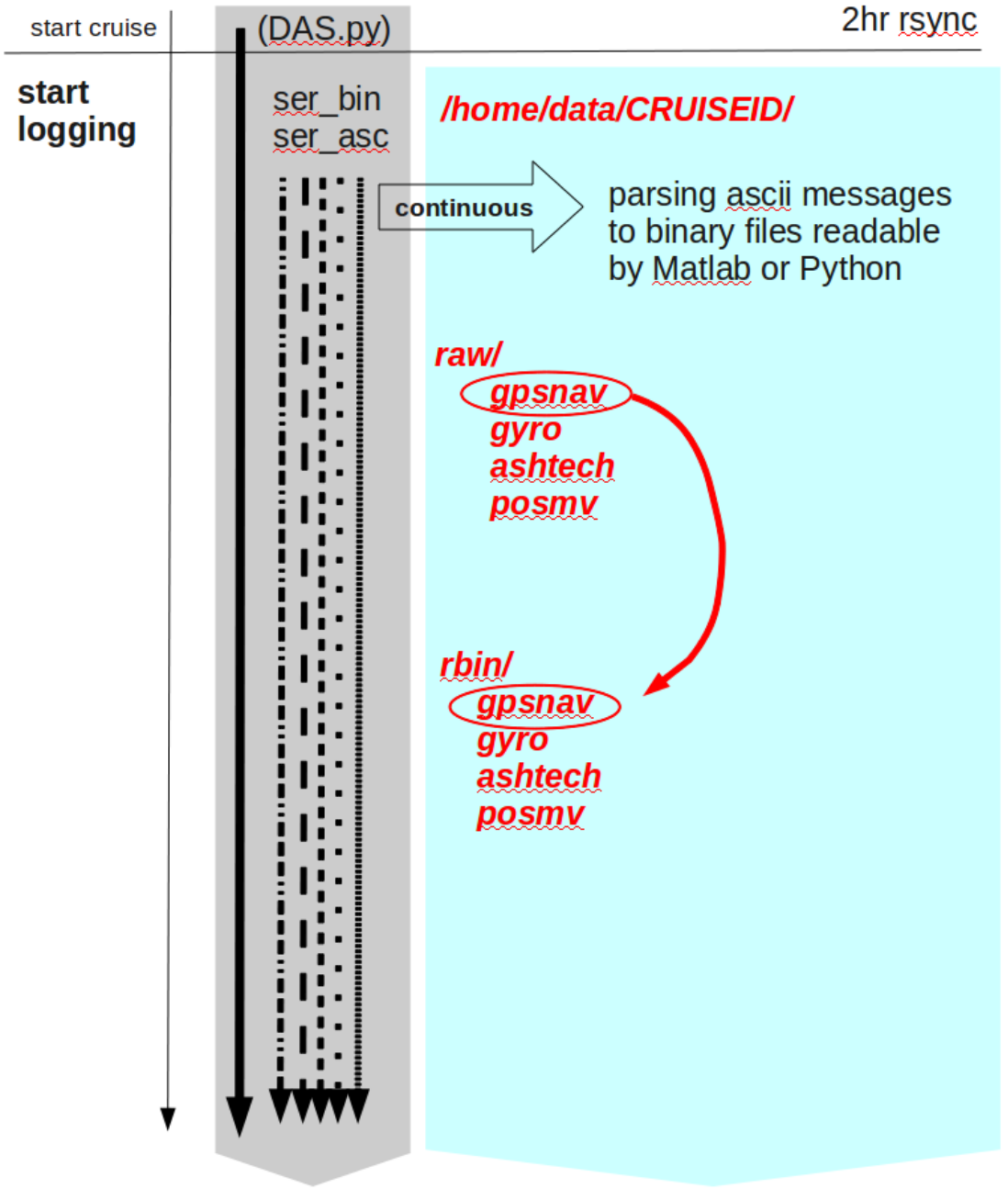


12:

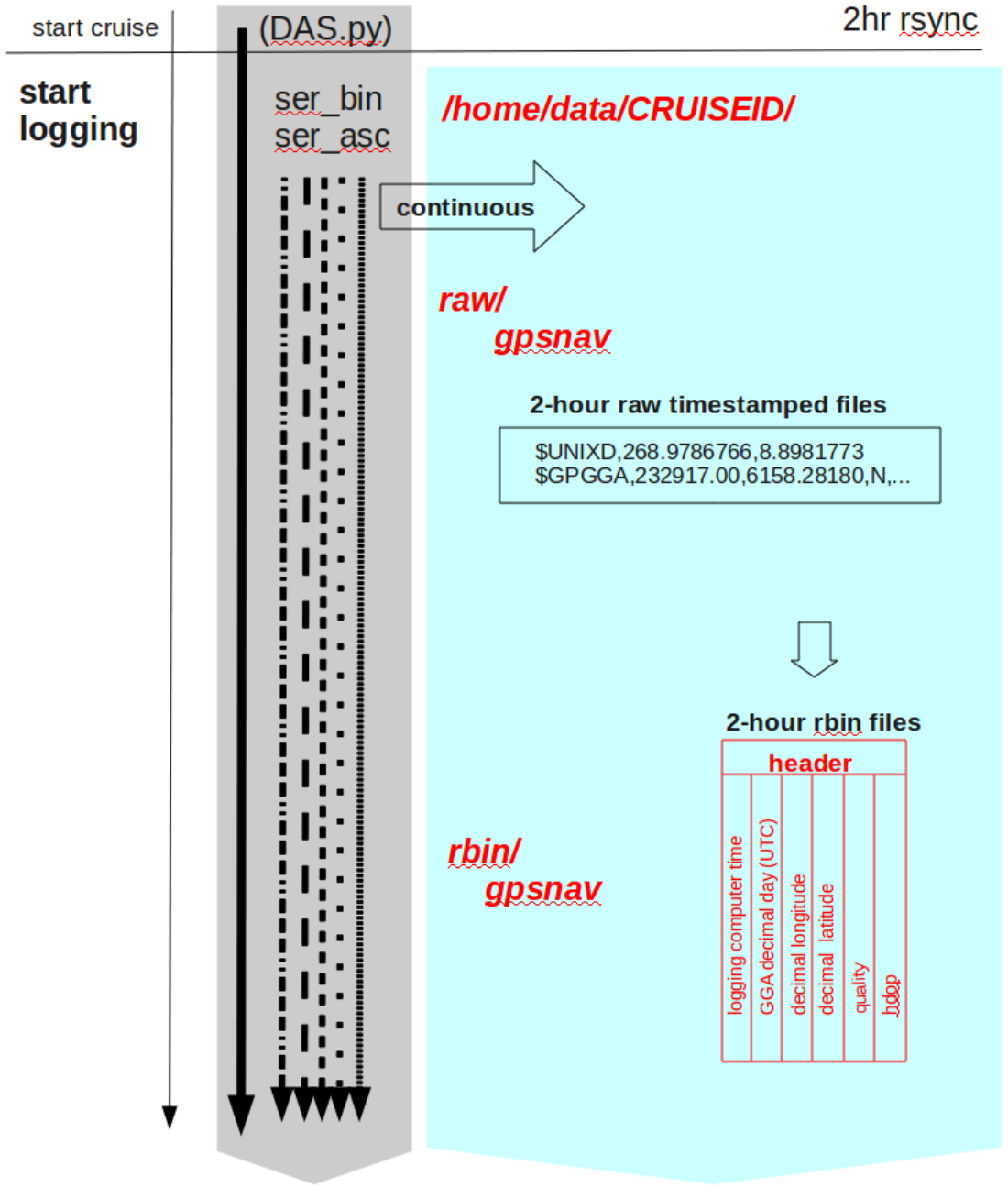
serial logging (write raw file)



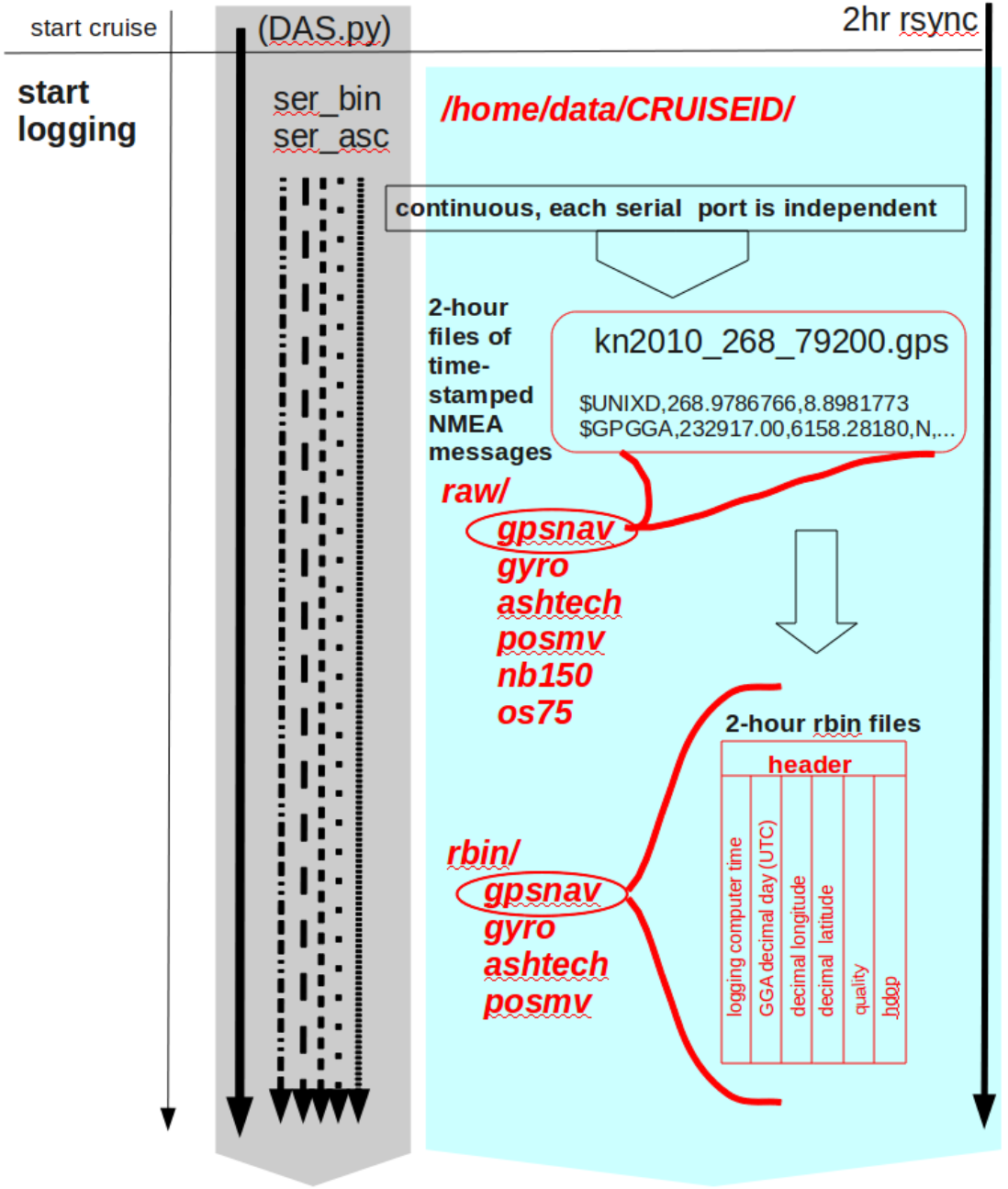
serial logging (raw ➡ rbin)



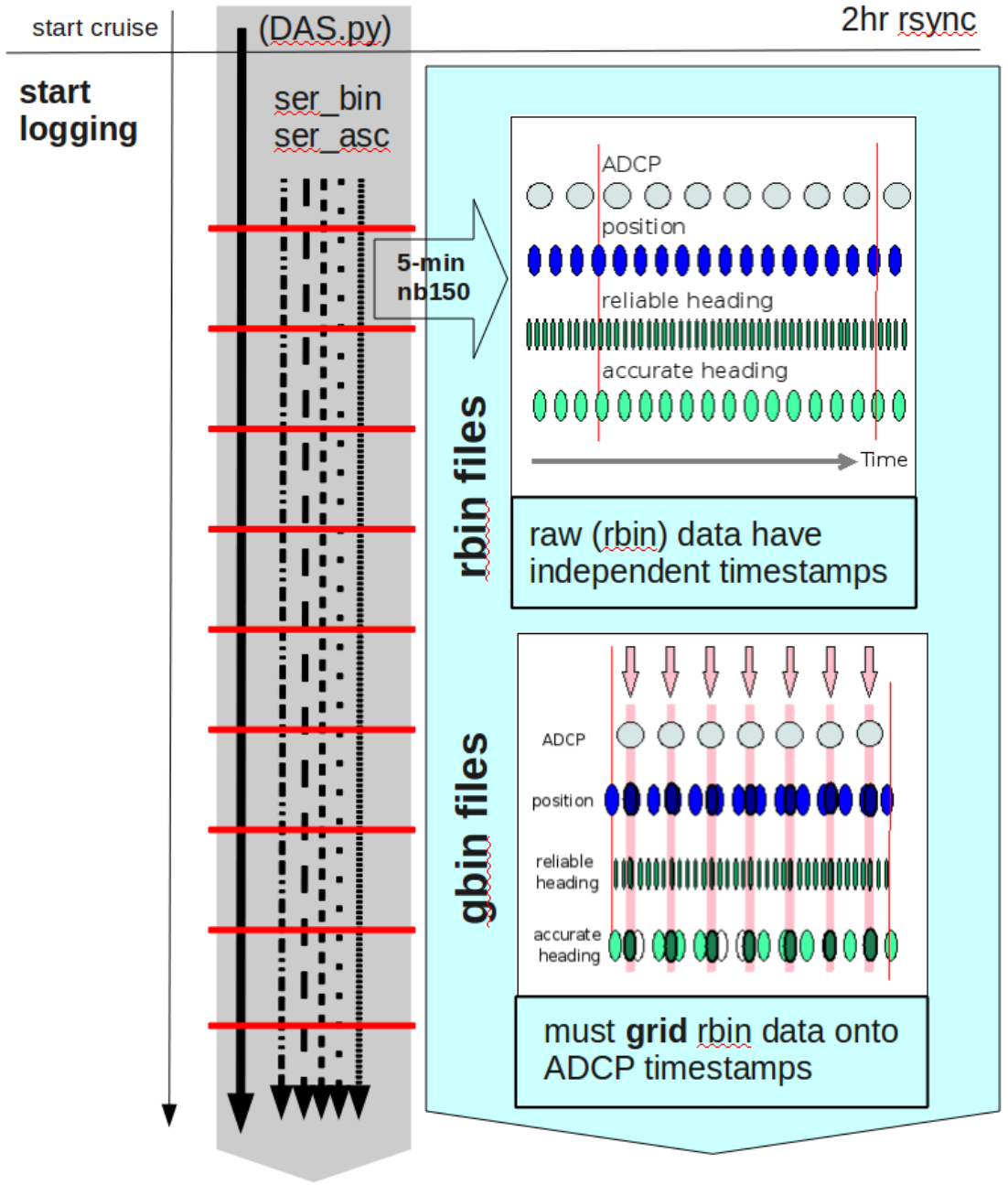
serial logging (rbin file contents)



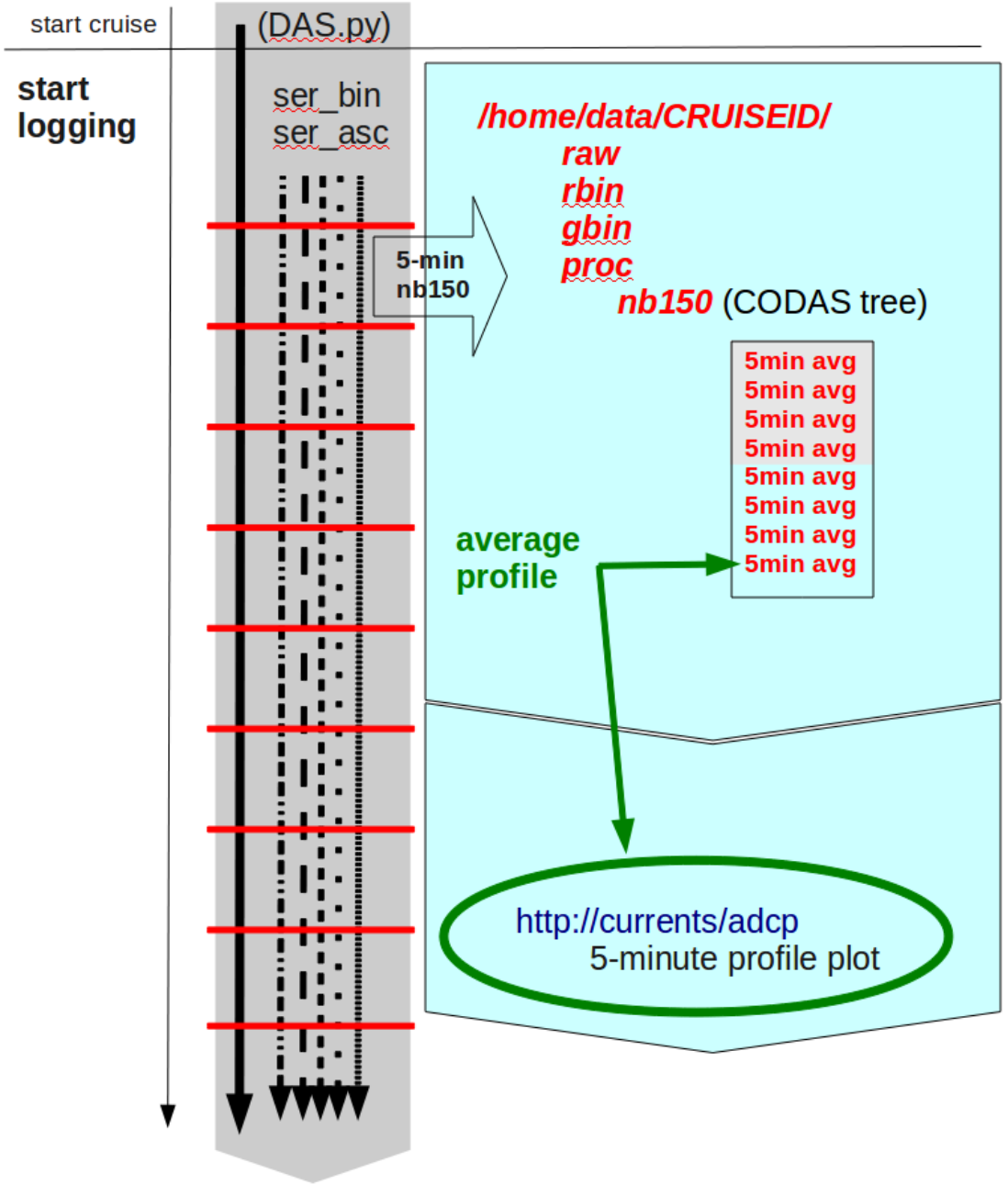
serial logging (raw, rbin)



UHDAS: 5min timer (make gbins)



UHDAS 5-minute timer: make profile



Outline

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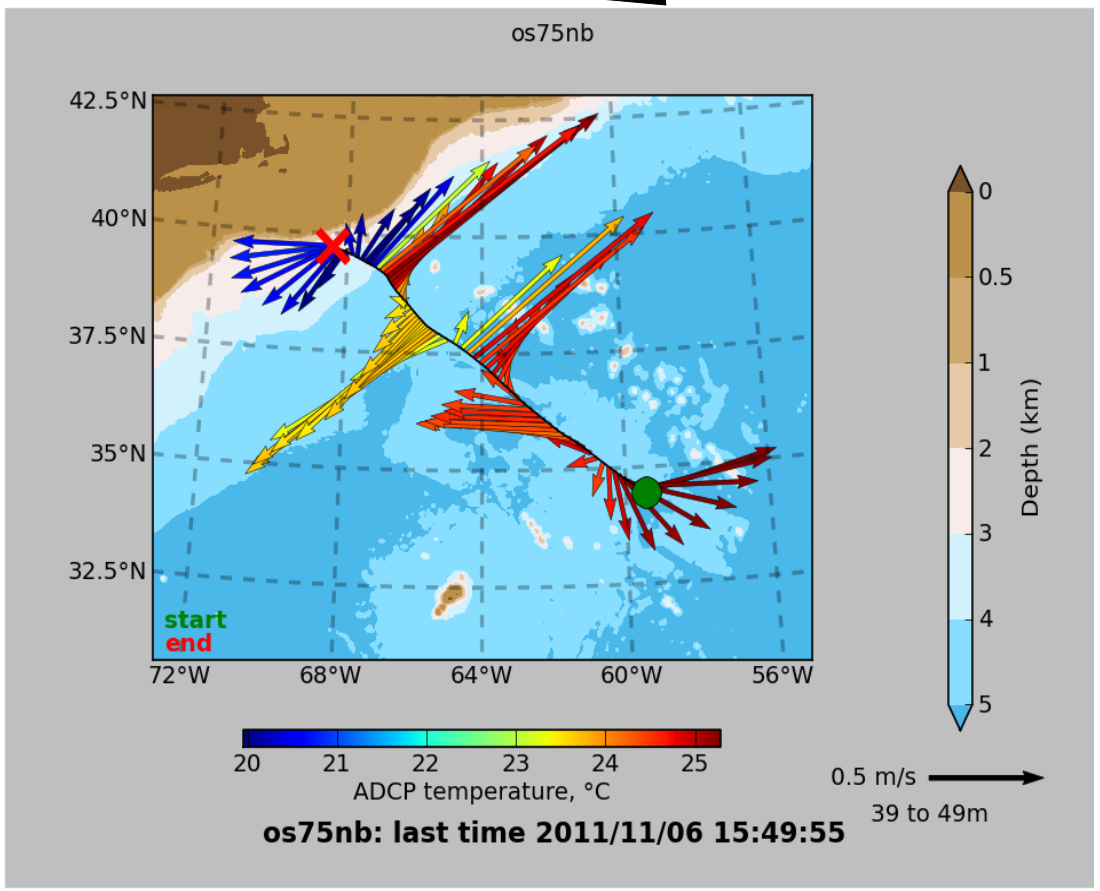
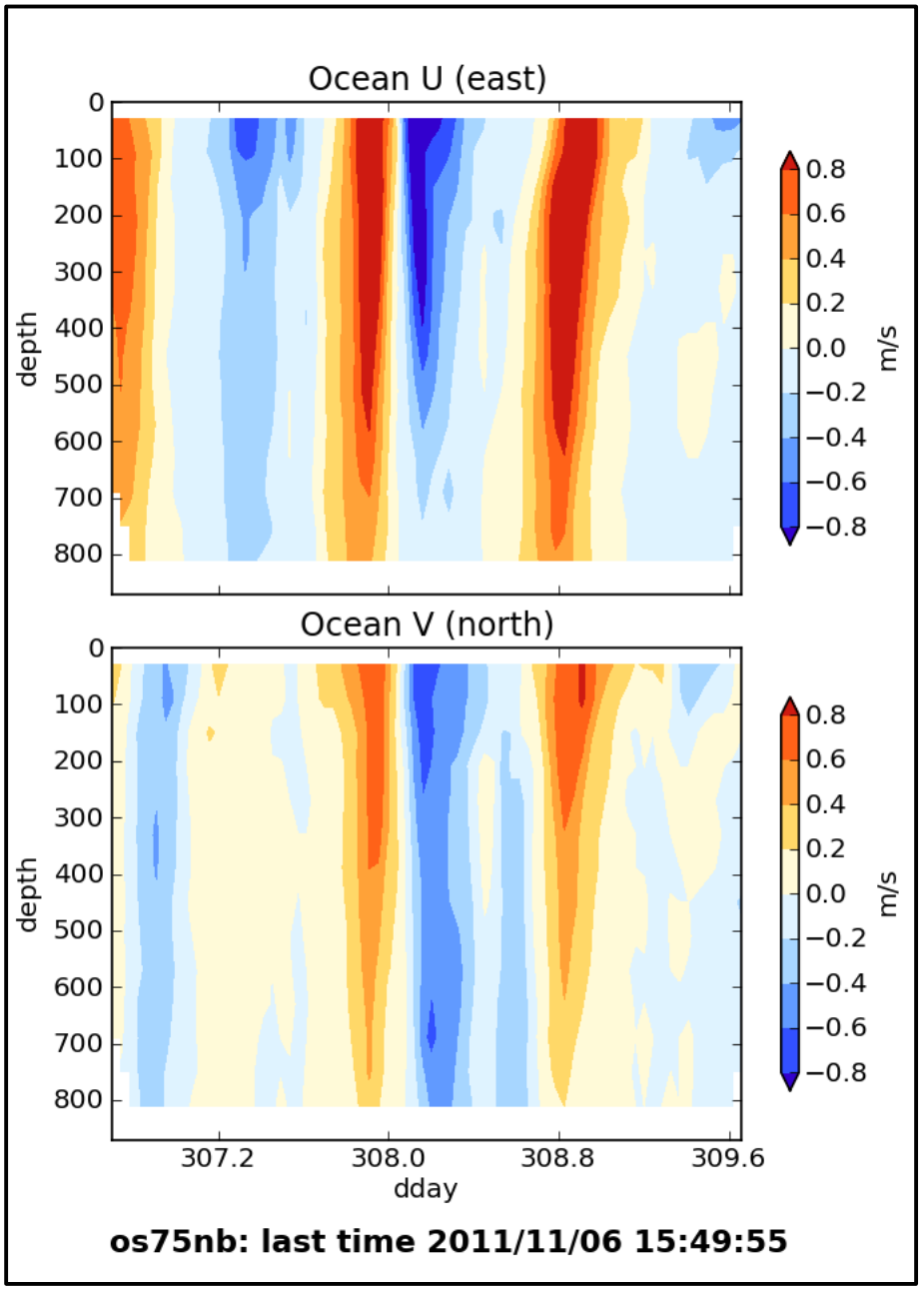
2. UHDAS Acquisition
3. CODAS Processing
4. Things go wrong: evaluation

CODAS Processing

Time, ADCP, Position, Attitude

primitive (raw) data





CODAS Processing Overview

CODAS: Common Ocean Data Access System

- Portable
- Self-descriptive
- aggregated files (vs/ netCDF which is one file)
- designed for ADCP data

“CODAS Processing” → produce ocean velocities

- tools to access and modify CODAS files

“CODAS” ADCP Processing

Goals

- run on multiple operating systems (Windows, OSX, linux)
- open source
- now free (Python) or Matlab

Processing

- written for ADCP data
- works on most ADCP data acquisition systems
- balance real-time product with recoverable dataset
- single-ping editing
- calibration

CODAS = “**C**ommon **O**cean **D**ata **A**ccess **S**ystem”

CODAS Processing Supports...

Acquisition program	instrument	ping type		file type (suffix)	Averaged? or raw?		procesing in matlab? python?	
DAS2.48	NB150	nb		pingdata	avg		matlab	
VmDAS	Broadband or Workhorse		bb	LTA, STA	avg		matlab	python
				ENS, ENX		raw	matlab	
	Ocean Surveyor	nb		LTA, STA	avg		matlab	python
				ENS, ENX		raw	matlab	
				ENR(N1R,N2R)		raw		python
			bb	LTA, STA	avg		matlab	python
				ENS, ENX		raw	matlab	
				ENR(N1R,N2R)		raw		python
		nb	bb	ENS, ENX		raw	matlab	
				ENR(N1R,N2R)		raw		python
UHDAS	NB150,NB300	nb		raw		raw	matlab	python
	Ocean Surveyor	nb		raw		raw	matlab	python
			bb	raw		raw	matlab	python
		nb	bb	raw		raw	matlab	python
	WH300		bb	raw		raw	matlab	python

CODAS Processing Steps

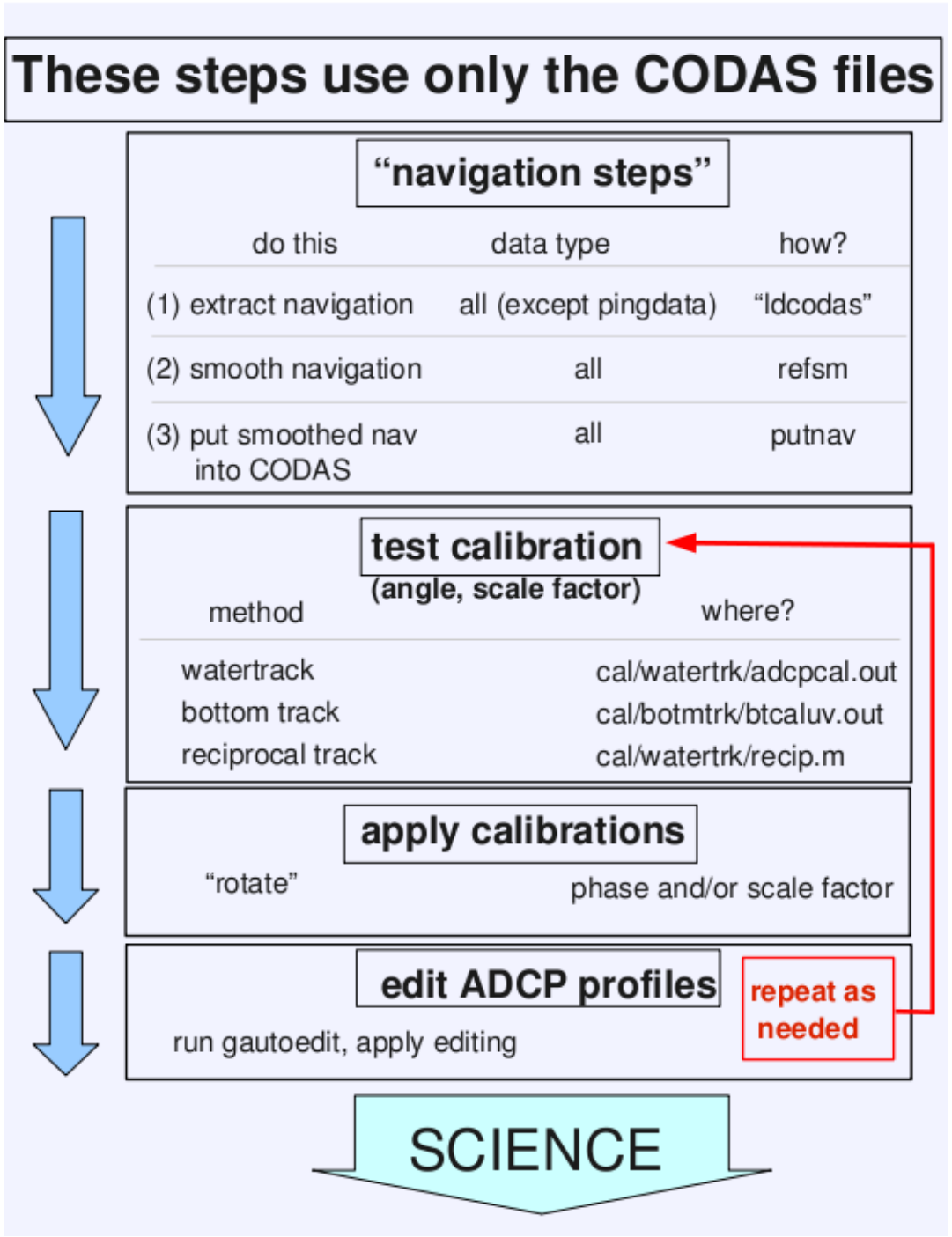
- read ADCP + ancillary data
- [transform, edit single-pings, average]
- load into CODAS database

- nudge positions to get smooth reference layer
- apply heading corrections (calculated from difference between gyro and accurate heading)
- determine calibration values (angle, scale factor),
  - apply angle and scale factor
- edit out bad profiles of averaged data

Acquire the data, write to disk → Fill the CODAS database

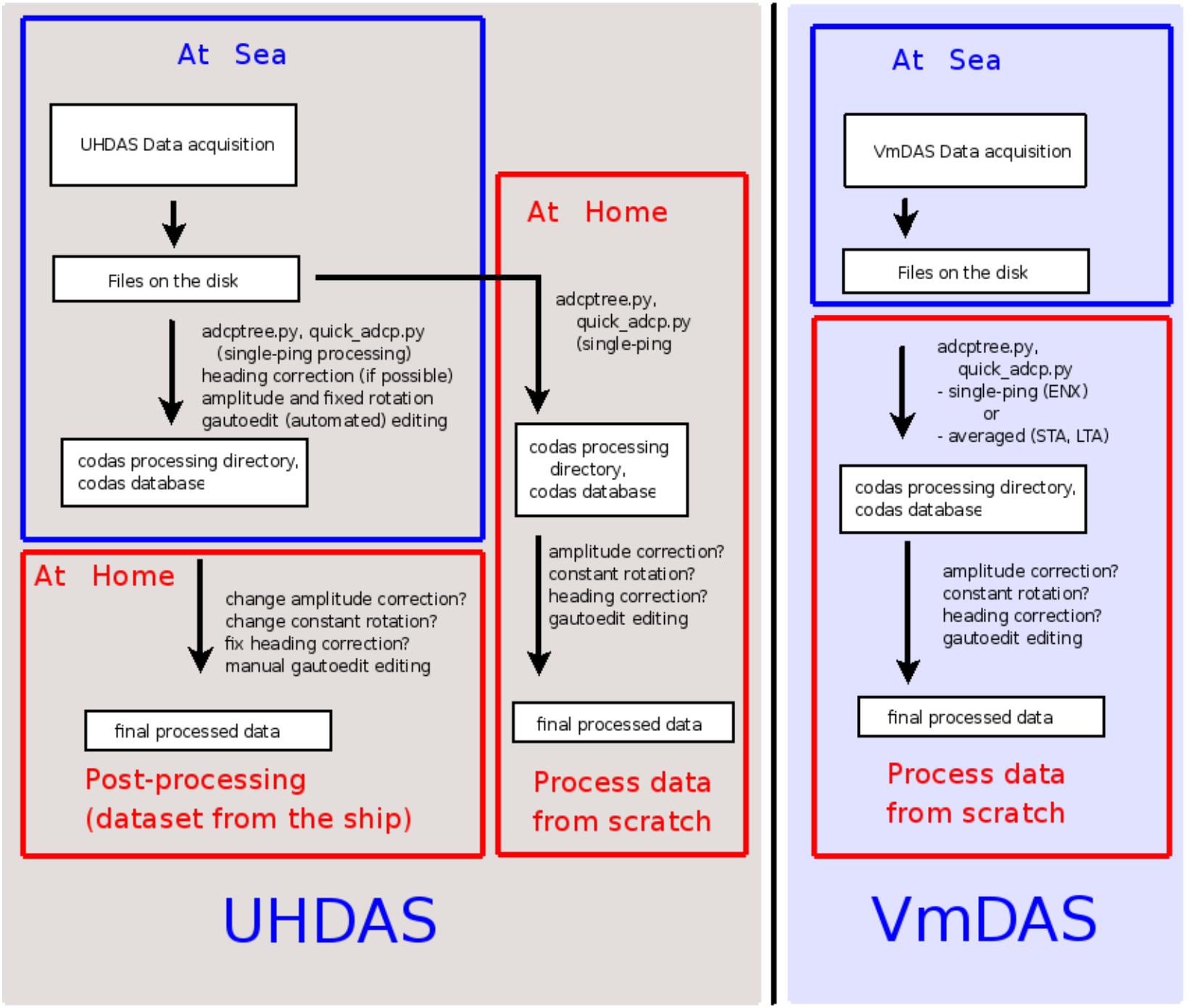
acquisition	data stored to disk		load the database	
program name	averaged	singleping	translate to *.bin + *.cmd	executable (to load)
DAS2.48	pingdata.*		(no)	loadping
VmDAS	*.STA *.LTA		load_lta.m	ldcodas
VmDAS		*.ENR *.ENS *.ENX	load_ens.m	ldcodas
UHDAS		*.raw	load_uhblk	ldcodas

All subsequent steps use
only the data in the CODAS files


These steps use only the CODAS files
"navigation steps"
do this
data type
how?
(1) extract navigation
all (except pingdata)
"ldcodas"
(2) smooth navigation
all
refsm
(3) put smoothed nav into CODAS
all
putnav
test calibration
(angle, scale factor)
method
where?
watertrack
cal/watertrk/adcpcal.out
bottom track
cal/botmtrk/btcaluv.out
reciprocal track
cal/watertrk/recip.m
apply calibrations
"rotate"
phase and/or scale factor
edit ADCP profiles
run gautoedit, apply editing
repeat as needed
SCIENCE

At
Sea

At
Home



CODAS Editing

- Editing (single-ping)
  - Acoustic interference
  - Bubbles
  - Below bottom
- Editing CODAS database averages “gee-autoedit”
- Interpolate missing heading correction
- Apply calibrations
  - Scale factor
  - Rotation
  - Transducer offset (uncommon/experimental)

CODAS Editing

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

BEFORE AVERAGING

- Editing CODAS database averages “gee-autoedit”
- Interpolate missing heading correction
- Apply calibrations
  - Scale factor
  - Rotation
  - Transducer offset (uncommon/experimental)

ADCP Single-ping Editing

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

- Acoustic Interference
- Bubbles

Both tend to cause bias towards zero
in measured velocity

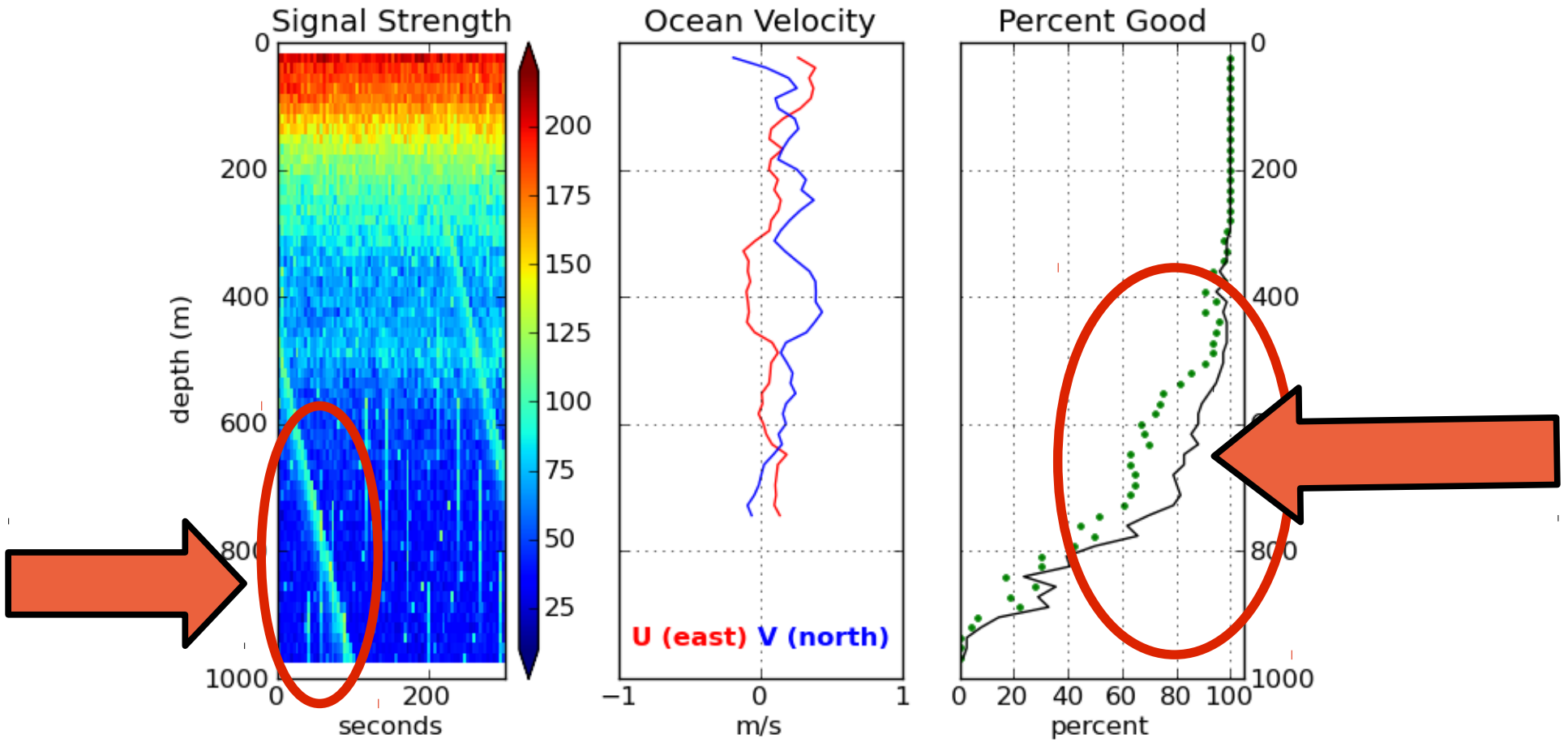
ADCP Single-ping Editing

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

- Acoustic Interference
- Bubbles

ADCP Processing

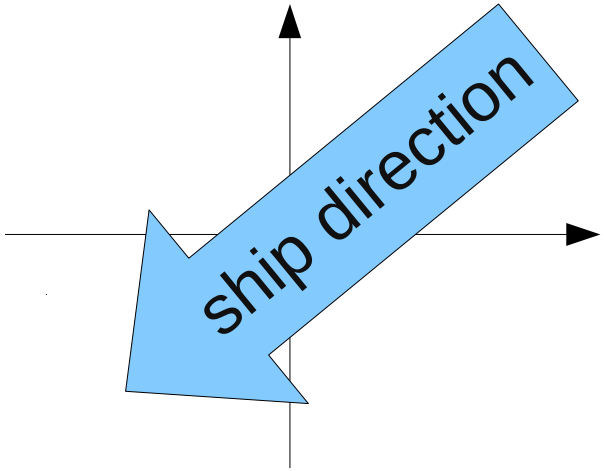
Singleping editing: acoustic interference

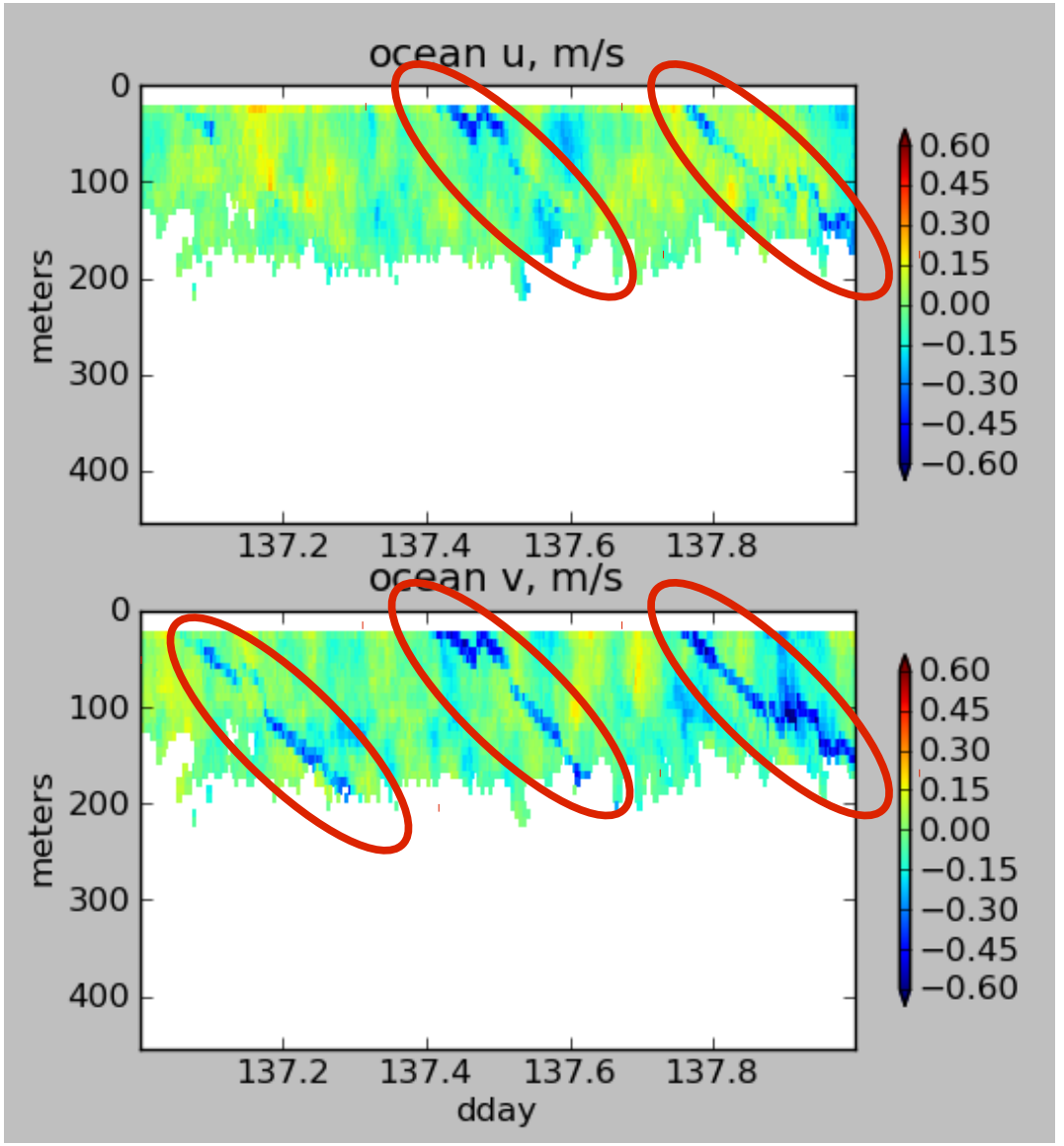


ADCP Processing **without** singleping editing

Averaged
ocean velocities

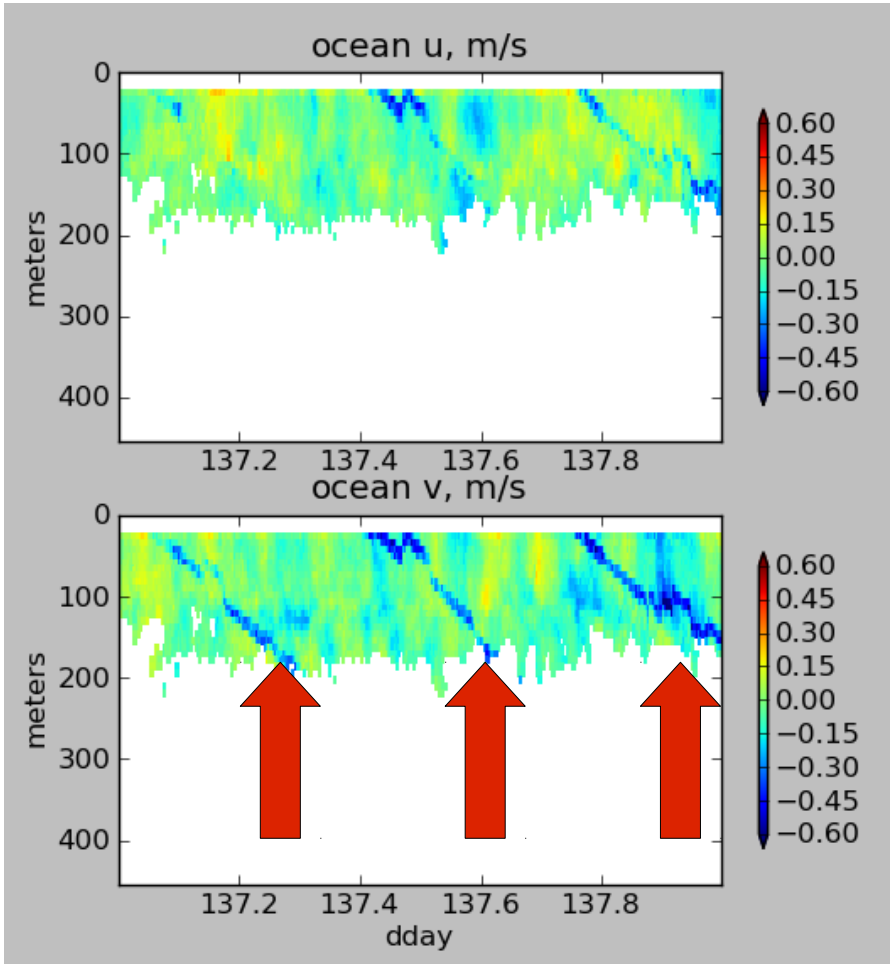
NOTE: along-track
direction bias



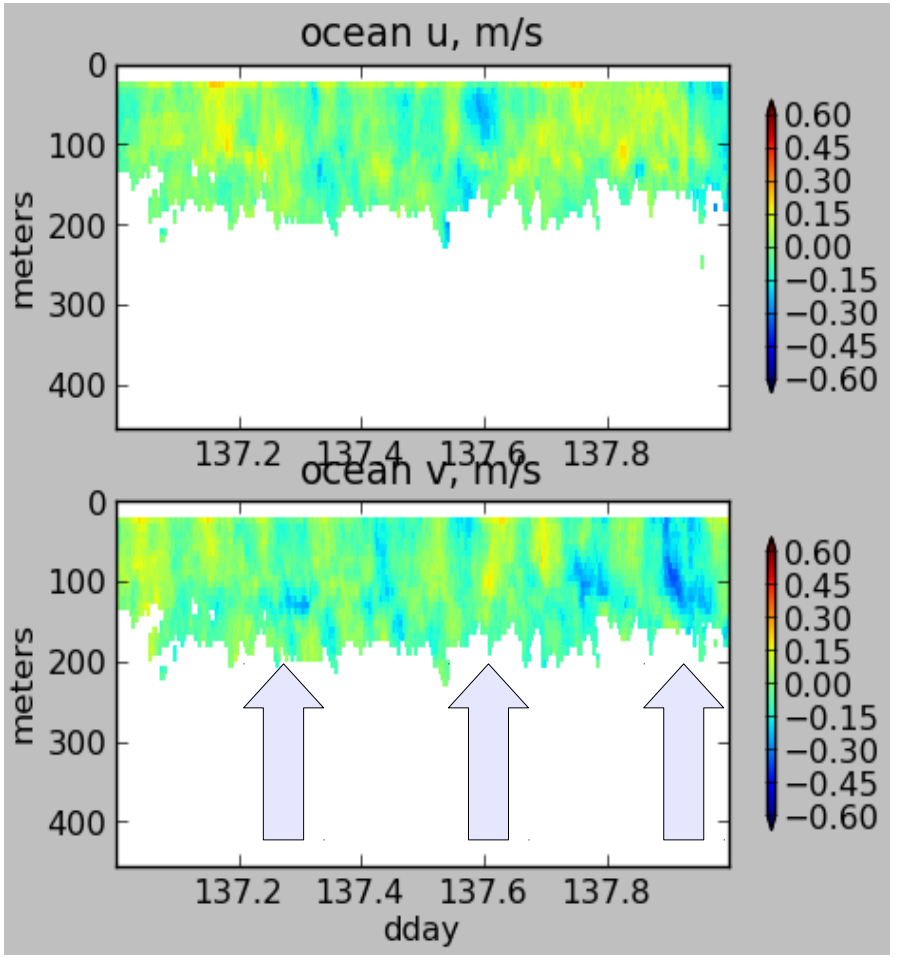


ADCP Processing: acoustic interference

WITHOUT
singleping editing



USING
singleping editing

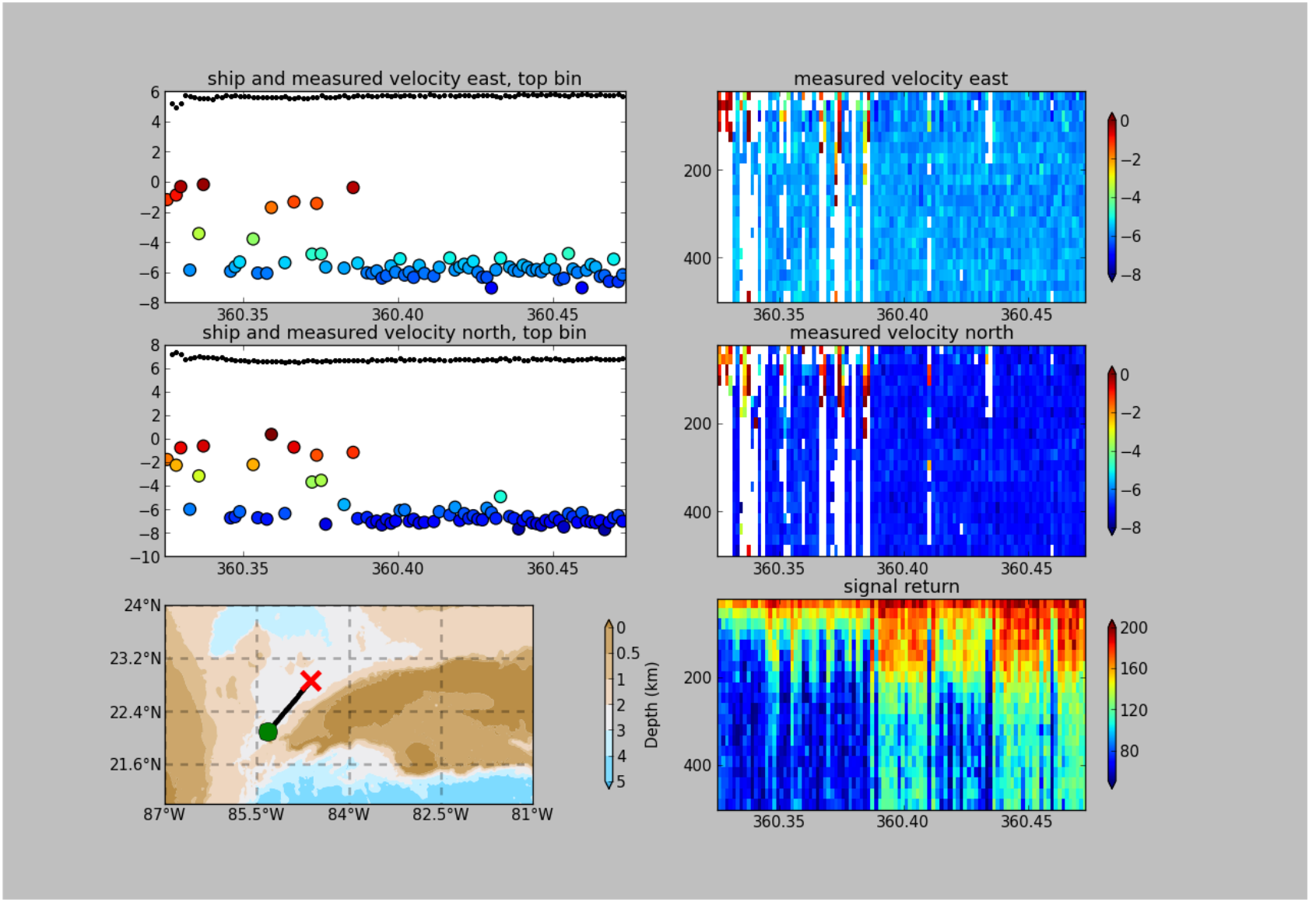


ADCP Single-ping Editing

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

- Acoustic Interference
- Bubbles

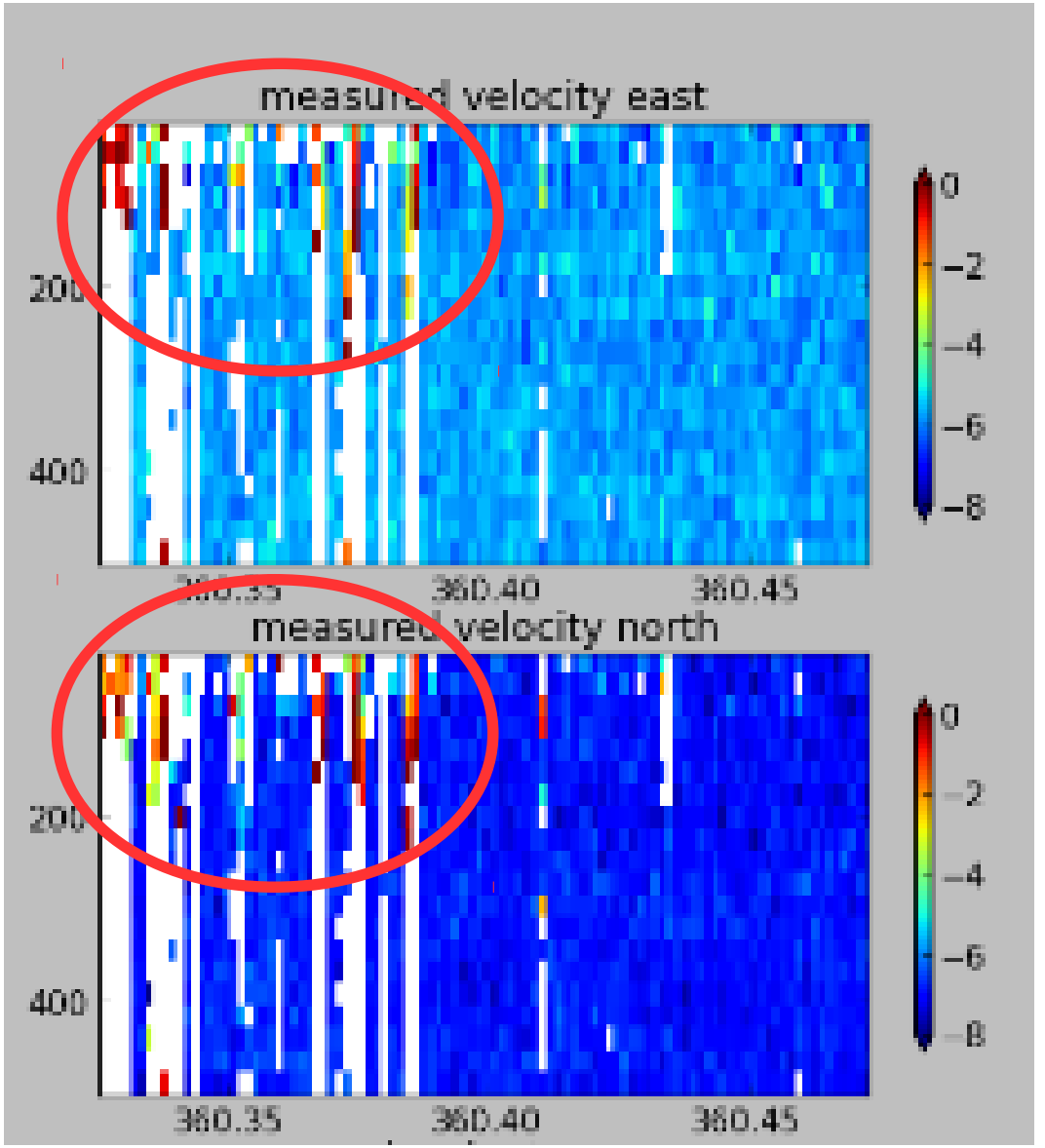
single-ping editing:underway bias



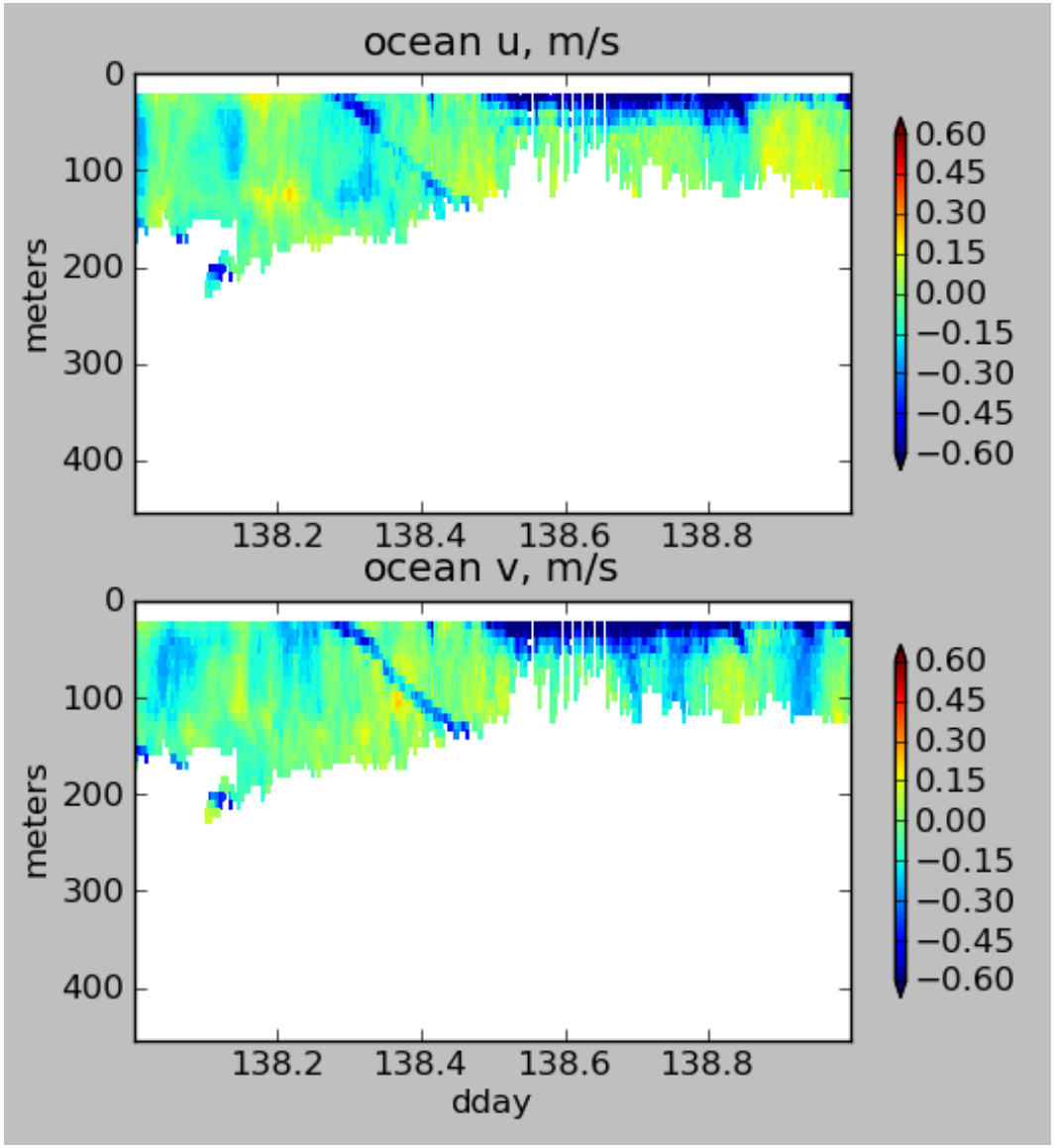
ADCP Data: effect of bubbles

Bubbles:
- short profiles
- strongly biased towards zero

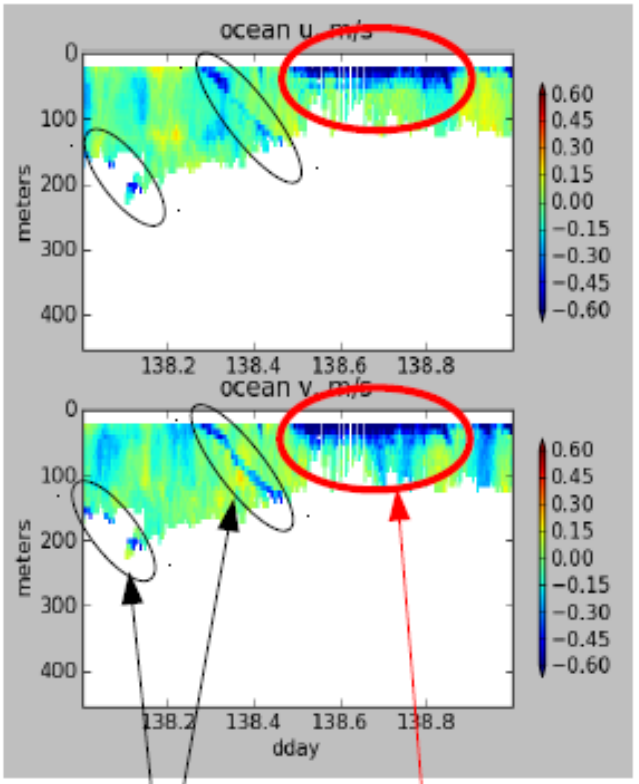
Untreated:
- biased ocean velocities

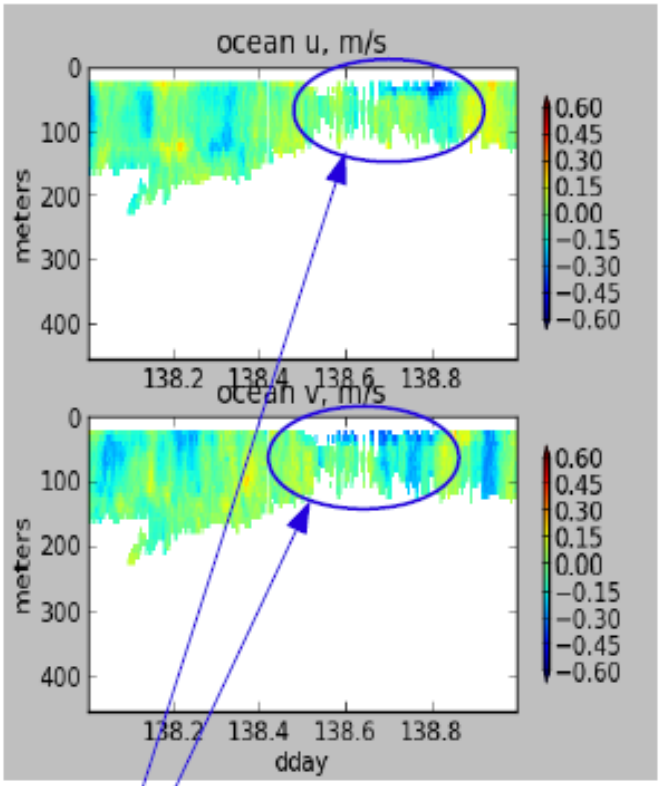


Averaged (unedited) data:
Acoustic interference and underway bias (bubbles)



OS150 underway bias due to poor weather conditions





acoustic Interference from OS75 on OS150

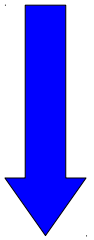
Biased pings mostly edited out, but manual post-processing is required

Biased pings, due to bad weather
- bias towards zero in measured velocities
- bias in direction of motion in ocean velocities
- shorter profiles (degraded quality)

CODAS Editing

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

AFTER AVERAGING



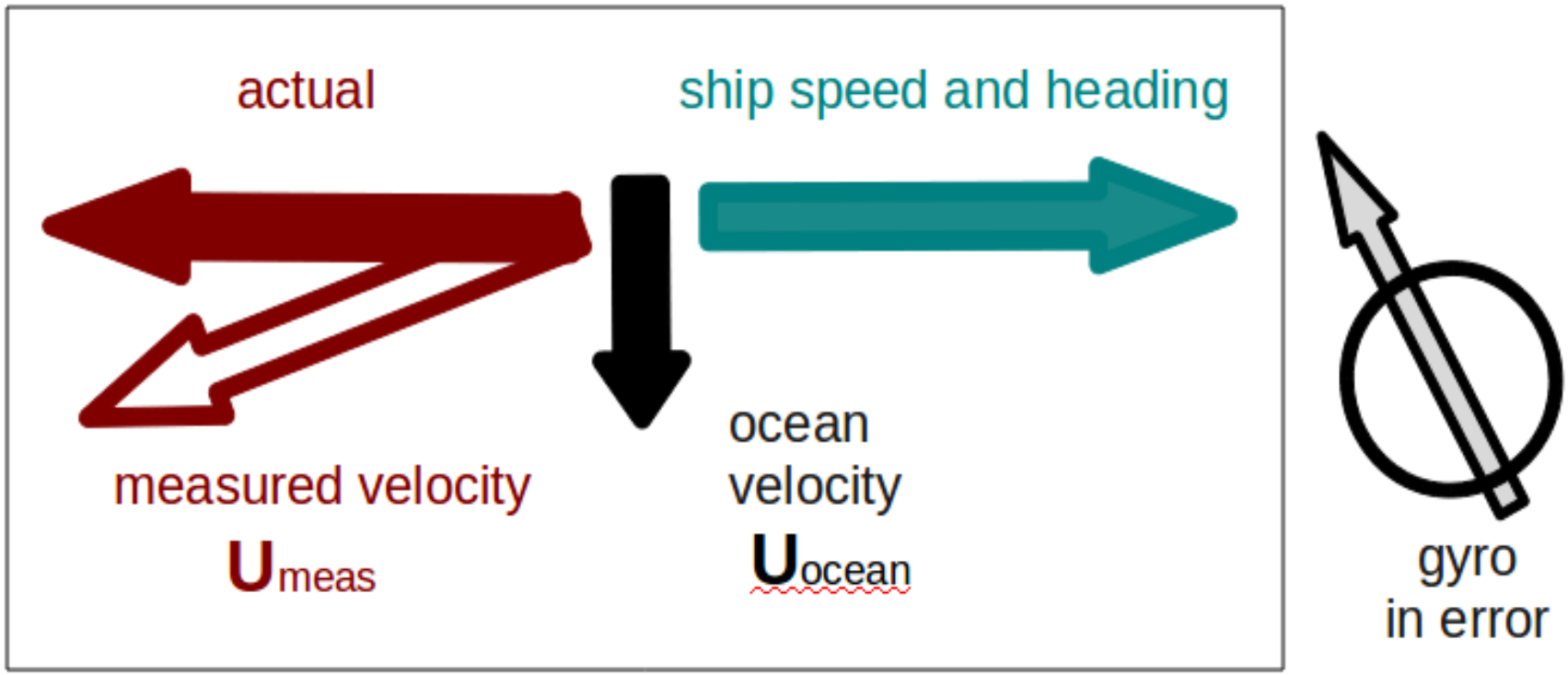
- Editing CODAS database averages “gee-autoedit”
- Interpolate missing heading correction
- Apply calibrations
  - Scale factor
  - Rotation
  - Transducer offset (uncommon/experimental)

CODAS Processing: Calibration

- After single-ping editing, create averages
- Edit out remaining bad bins (profiles)
- Calibration of averaged data:
  - (remaining) alongtrack bias (scale factor)
    - Soundspeed (single-ceramic transducers only)
  - Cross-track error (angle error)
    - Incorrect transducer angle (constant)
    - Inaccurate heading (time-varying)
  - Transition Error
    - Offset between gps and adcp

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
- If 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

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

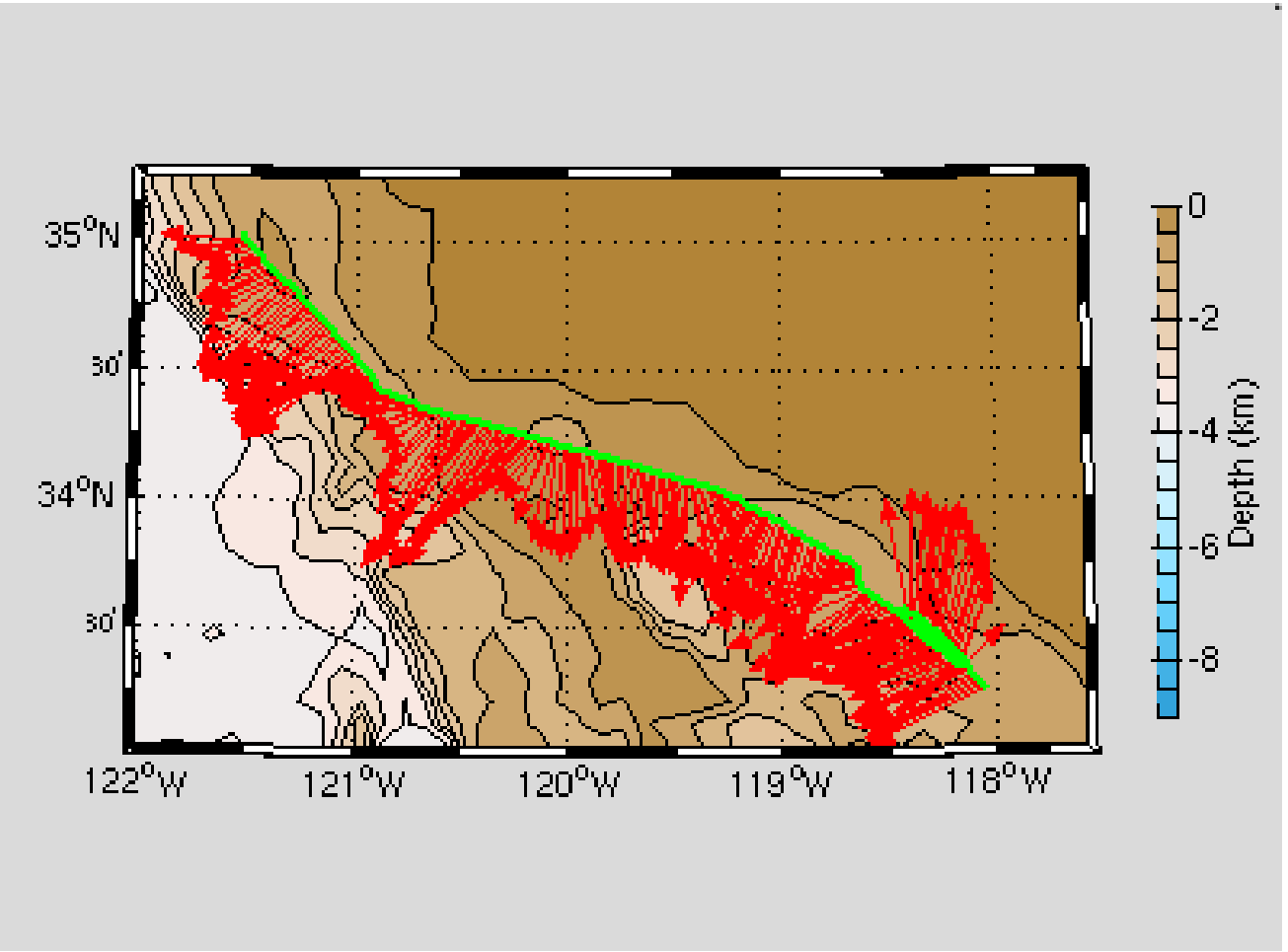
Angle applied comes from

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

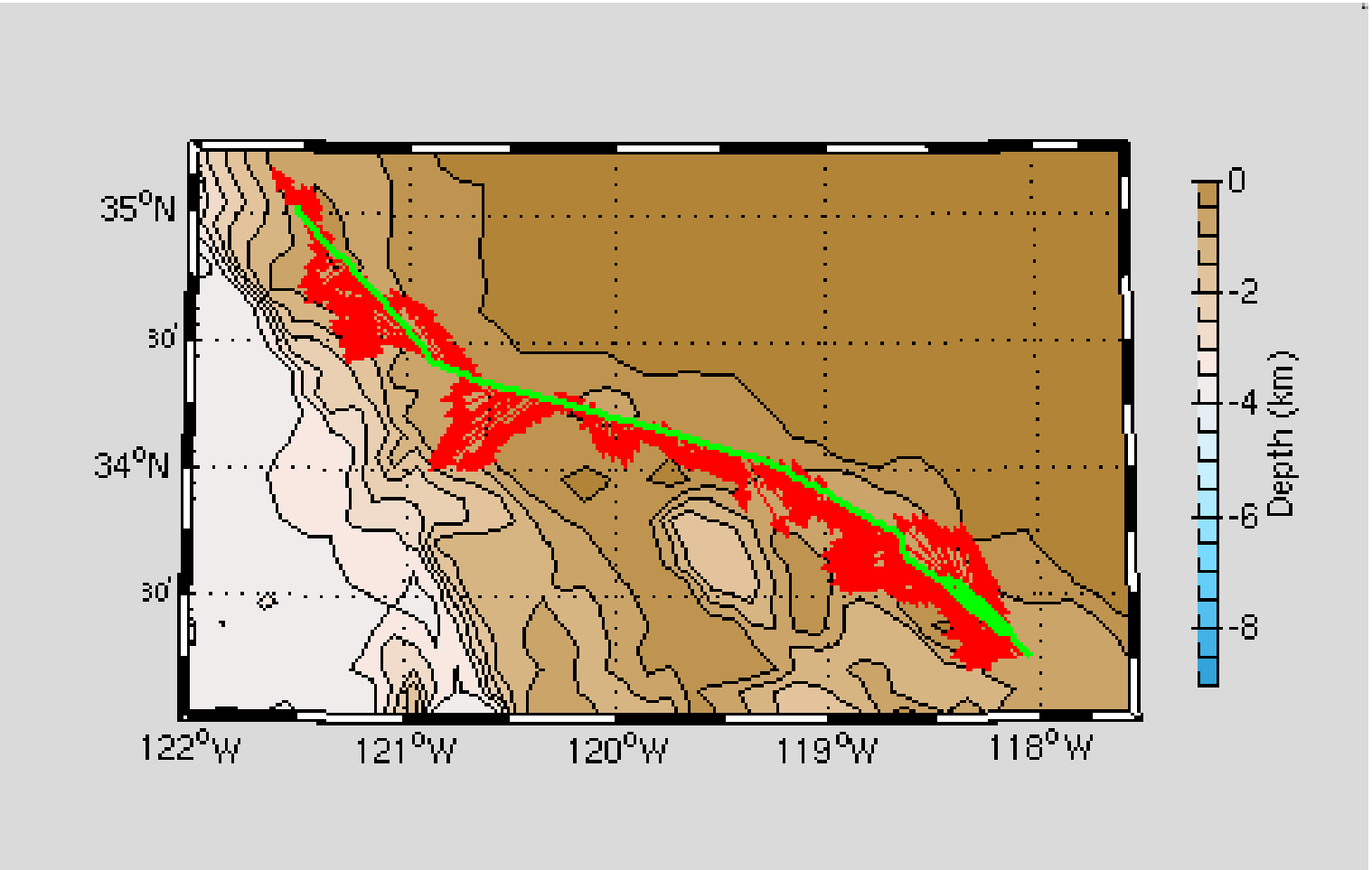
This is a **constant value** for the whole cruise

Examples of error in transducer angle follow...

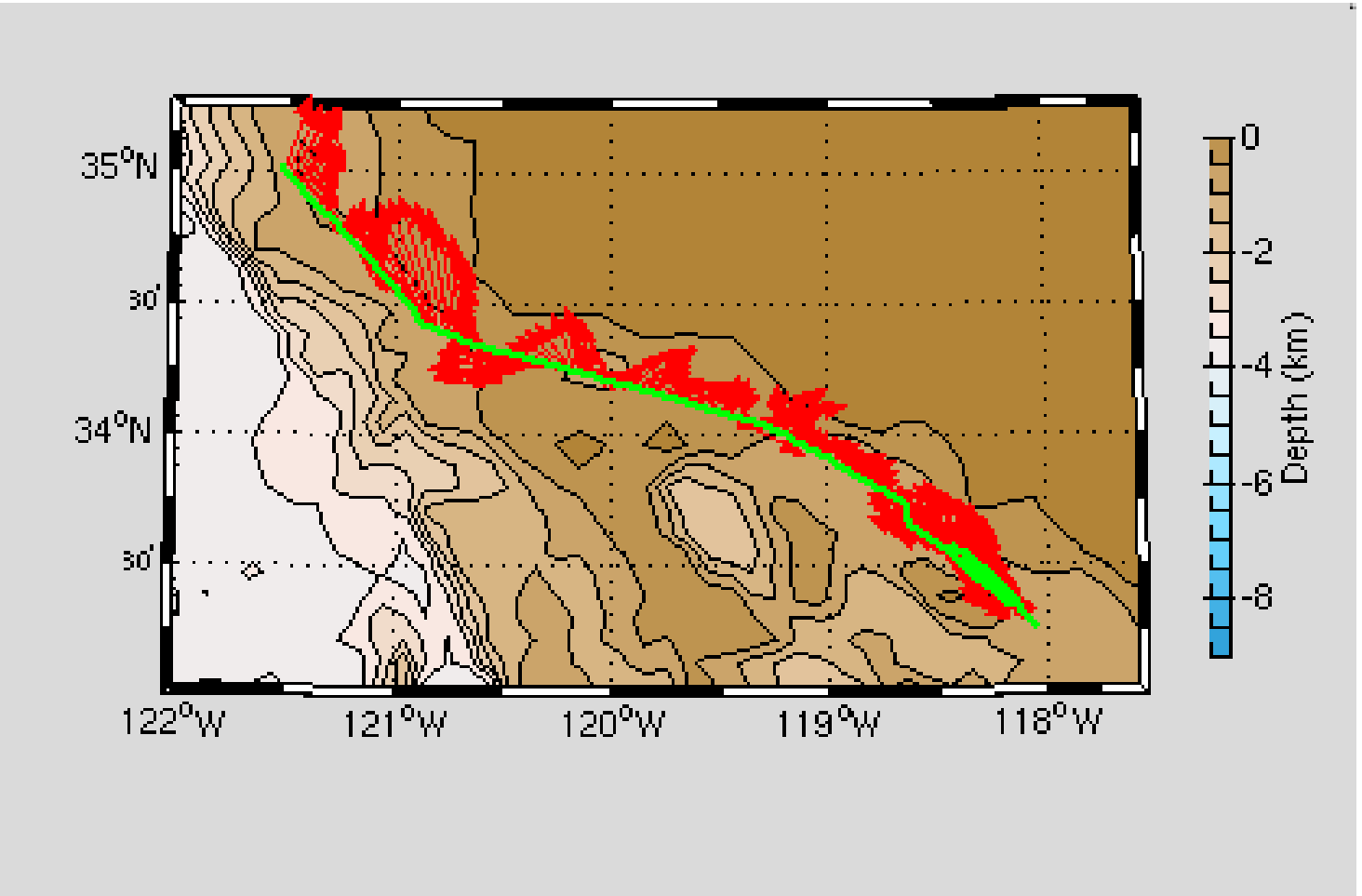
Calibration: angle error -3.6deg



Calibration: angle error -1.6



Calibration: angle error 0.4



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

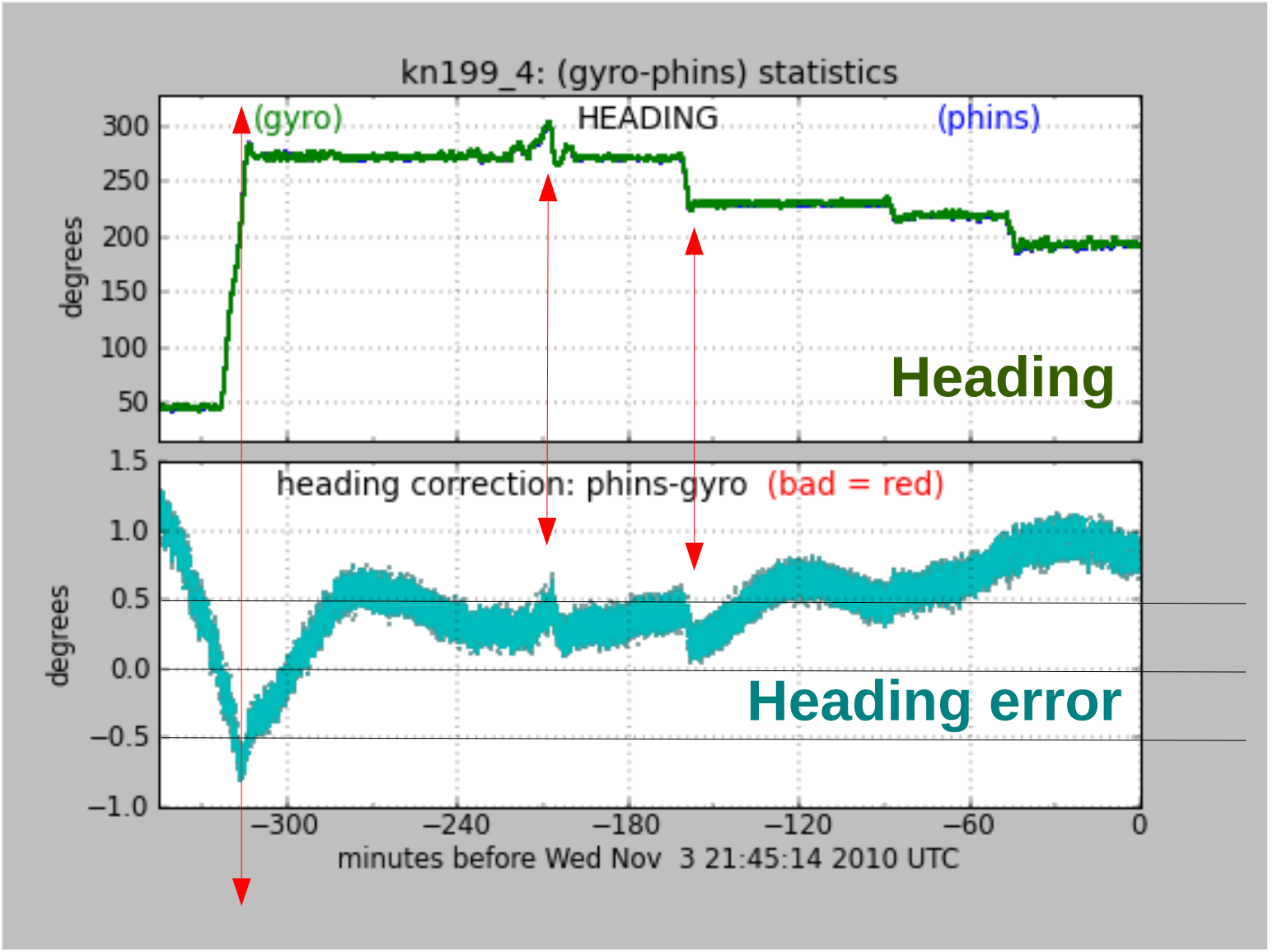
Angle applied comes from

Heading, which may be in error by

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

Example follows ...

Phins-Gyro difference varies with time

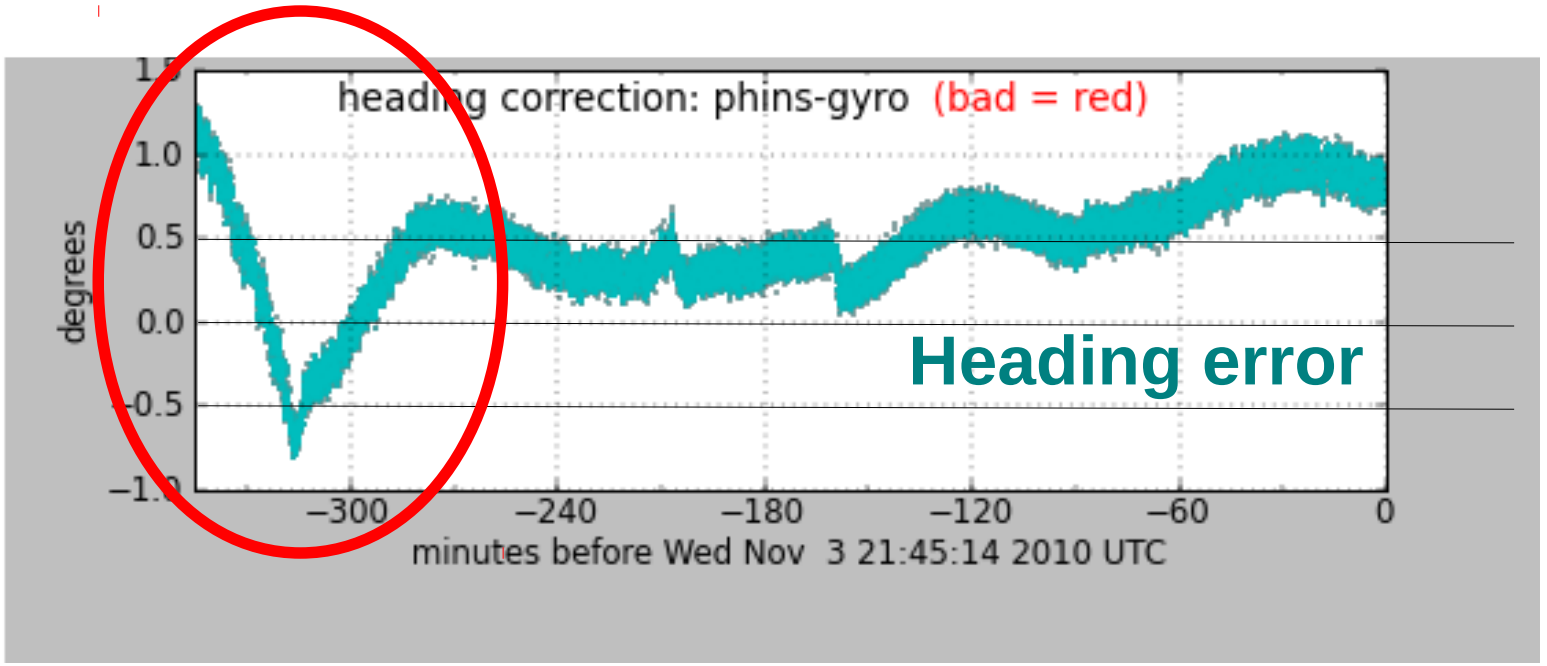


Changes in ship's heading affect heading error

Effect of Time-Dependent Heading Error on Ocean Velocties

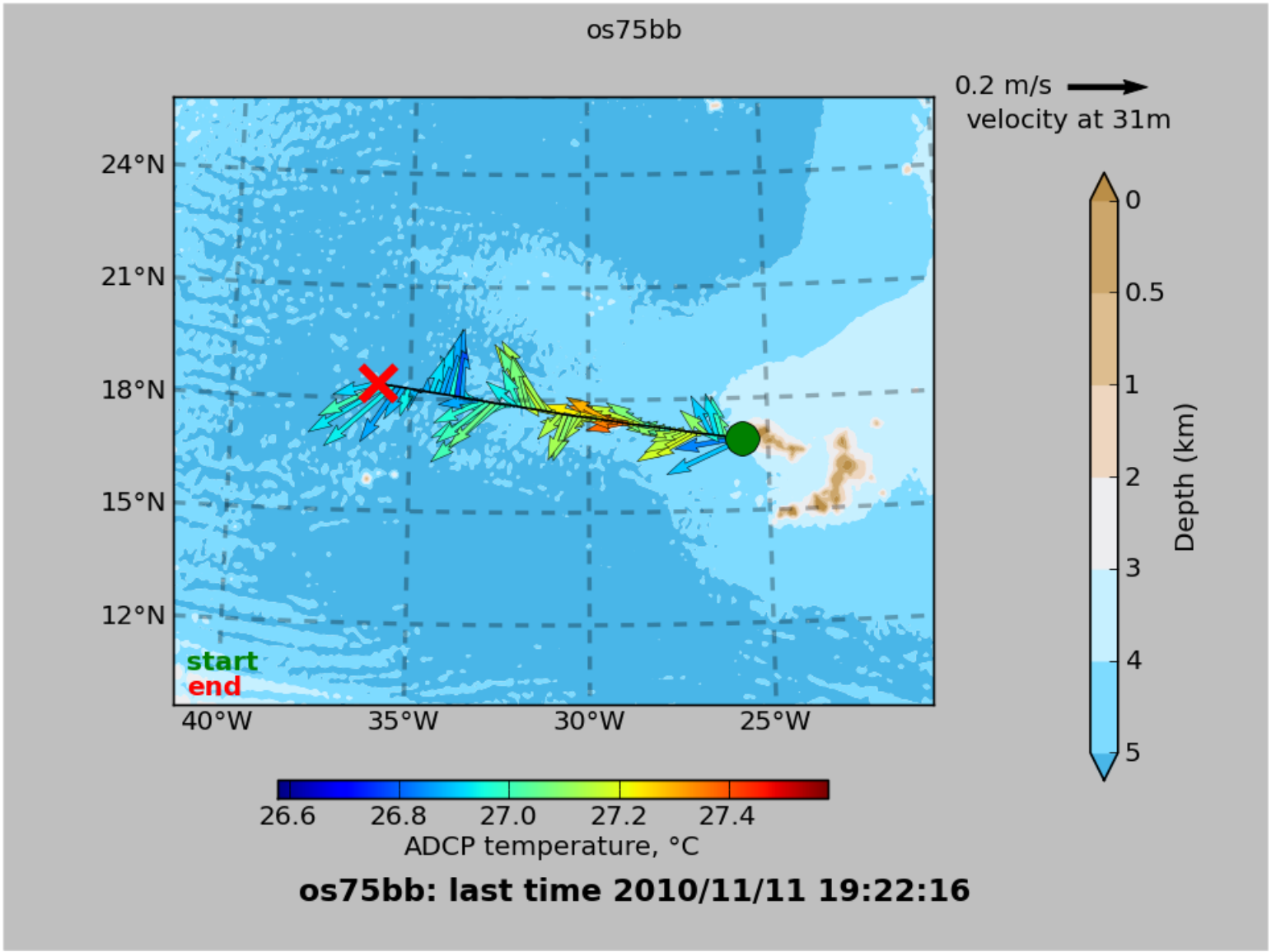
1 degree error in heading means:

- 0.1m/s error in ocean velocity
- in the cross-track direction



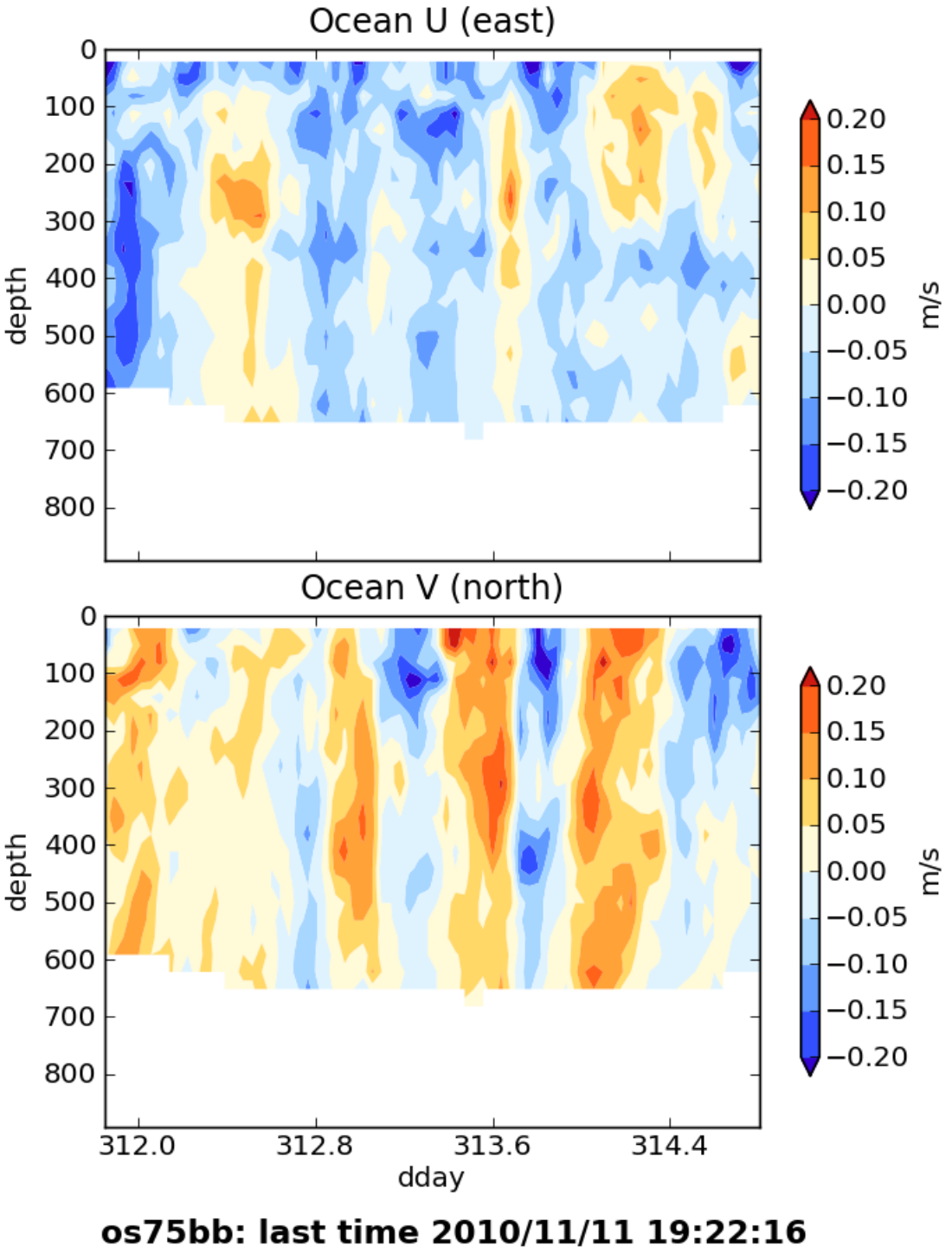
Changes in ship's heading affect heading error

Is this a heading error?



Contour plot:

Is this cross-track signal (stripes in N/S ocean velocity) due to a heading error?



Answer

Actually, it's really the ocean, but we can't tell without knowing the quality of the accurate heading device.

Examples of along-track error

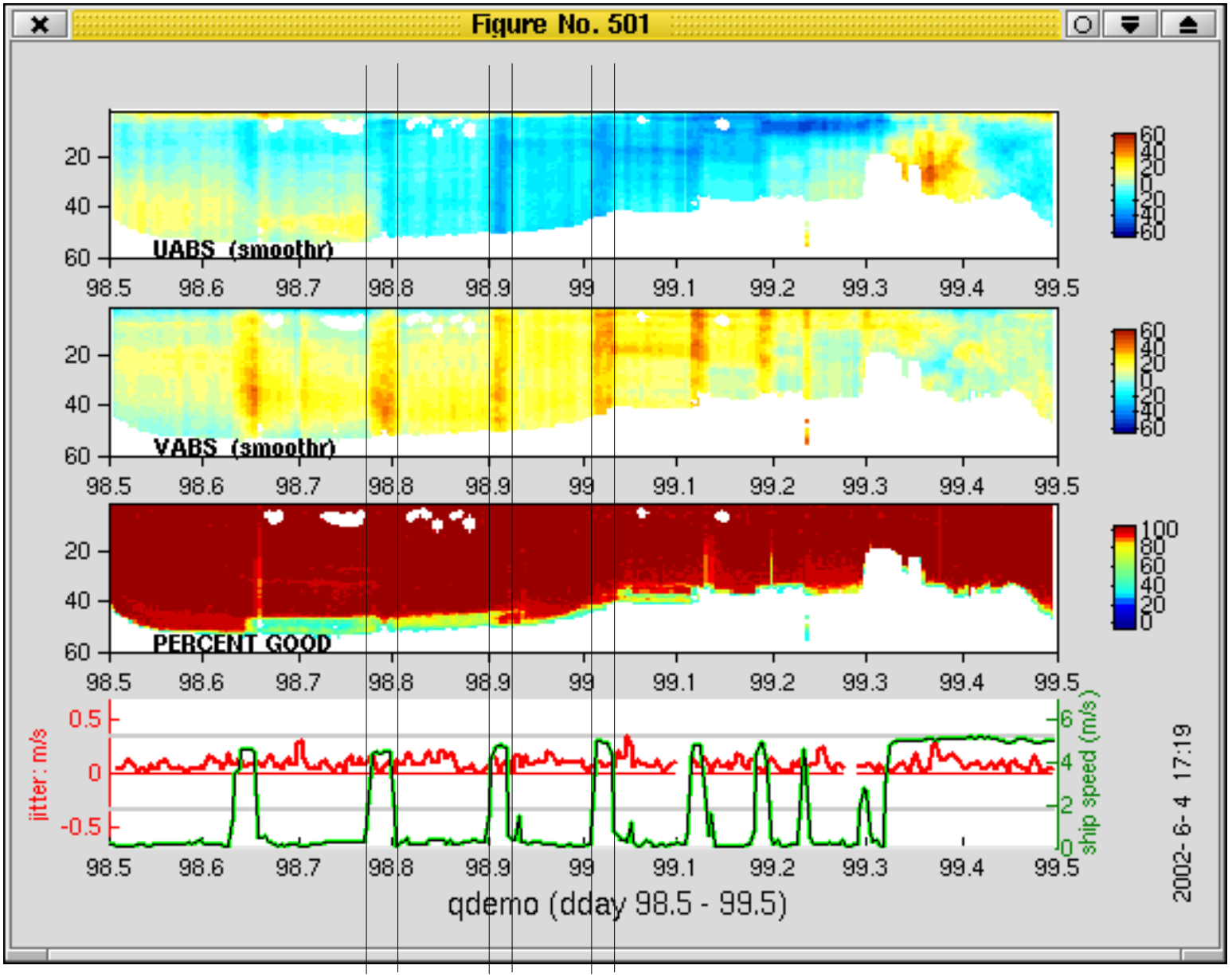
Remove during single-ping editing

- Acoustic interference
- Bubbles (underway bias)

Correct after averaging:

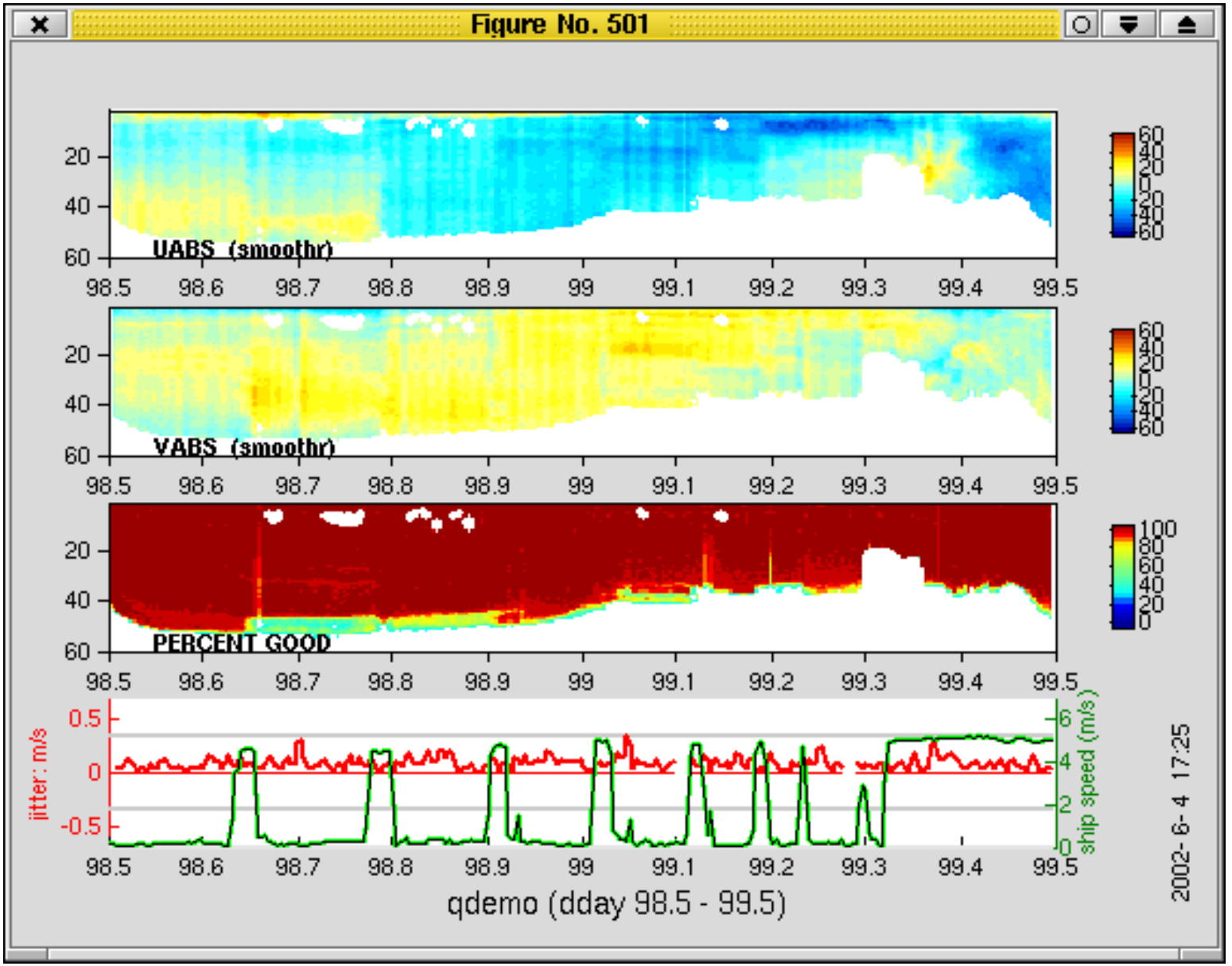
- Scale factor (NB150 soundspeed correction)

scale factor: alongtrack bias



55: Things go wrong (scale factor, before)

After scale factor applied



56: Things go wrong (scale factor, after)

What can go wrong in the data product

(1) Cross-track error:

- recovery requires accurate heading

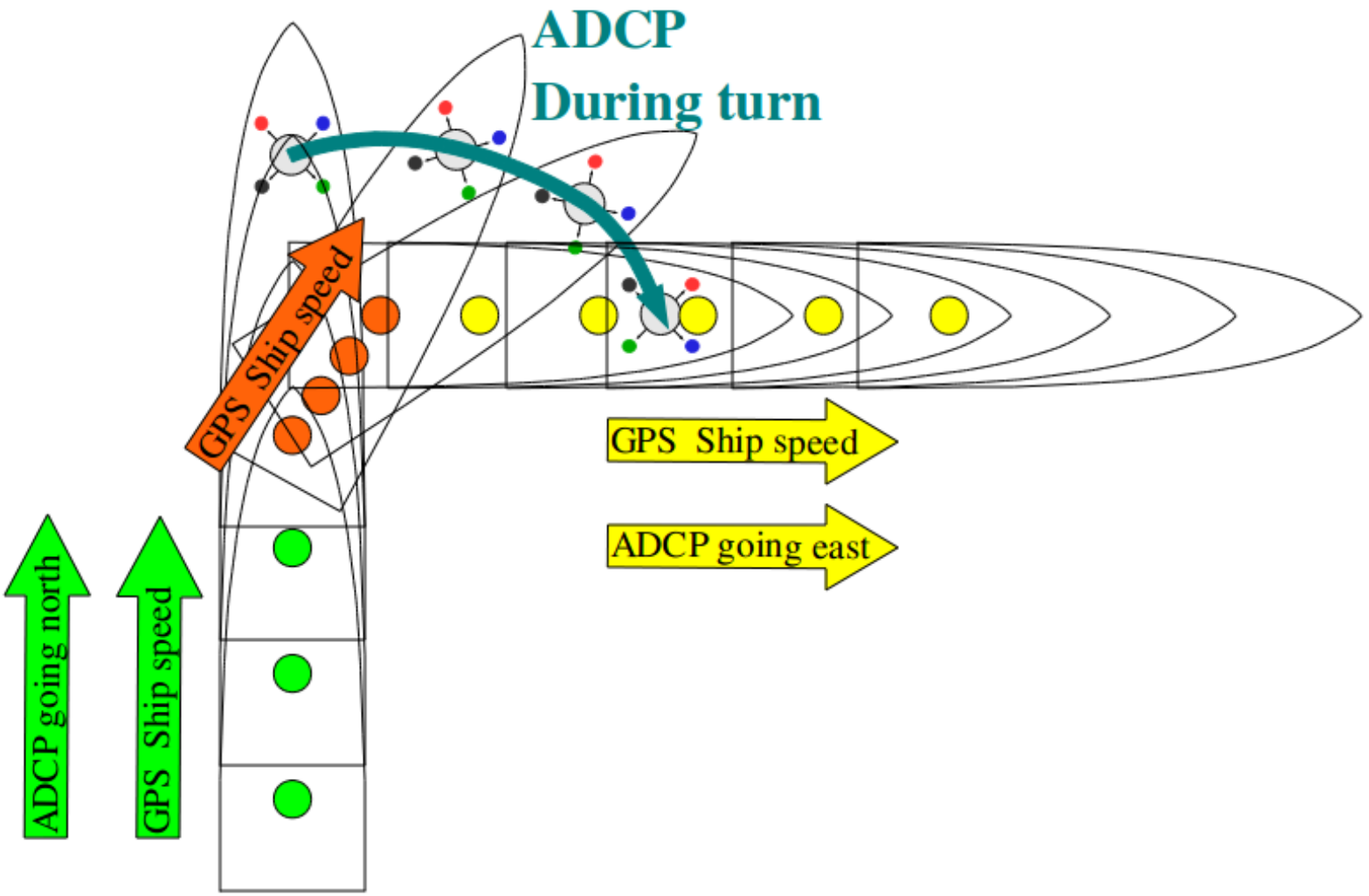
(2) Along-track error:

- may indicate a serious problem
- recovery may be possible, incomplete, ambiguous

(3) Transition/maneuvering error

- Lag or offset in time or space

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



Transducer offset from GPS--error occurs: **transition** between on-station and underway

...using actual location

...using shifted GPS location

difference