ADCP processing workshop(s) 2017
Oct 11,12,13 -- U. Southern Mississippi
Oct 18,19,20 -- Texas A&M

UHDAS ADCP data Acquisition and CODAS processing

UHDAS + CODAS Documentation
http://currents.soest.hawaii.edu/docs/adcp_doc/index.html
Outline

Day 1: Morning: Presentation
1. ADCP: components to currents
2. ADCP Data Acquisition
   - compare: VmDAS ↔ UHDAS
3. CODAS Processing
4. Data Stewardship

After: Practice
UHDAS - What it does (follow the data)

1. **Acquisition**  
   - ADCP + position + heading

2. **Processing**

3. **Data Access**
   - At Sea
   - On Land (after the cruise)

4. **Monitoring**
   - At Sea
   - On Land
UHDAS - What it does (follow the data)

(1) Acquisition
(2) Processing
(3) Data Access
  - At Sea
  - On Land (after the cruise)
(4) Monitoring
  At Sea
  On Land
UHDAS: What it does

• (1) Data Acquisition
  • communicate with ADCP
  • 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
  - plots for science and operations
  - full-resolution data (matlab, netcdf, CODAS)
- on land (in the cruise directory)
  - 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
• from shore: (uhdas.org)
  • sends daily email with attachment for review
  • diagnostic files
  • data snippet for shore-based figures for review

---

green=good
red=rubbish
web site figures
web site figures
Outline

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After: Practice
(I) ADCP: Getting Ocean Velocity

ADCP:

Acoustic (it pings along beams at a frequency)

Doppler (uses frequency shift to get velocity along the beam)

Current (include many more steps to get ocean velocity)

Profiler (listen for the return in small chunks of time to create a vertical profile)
ADCP introduction

- **Acoustic Doppler Current Profiler** (shipboard)
- 4-beams, Doppler shifted currents as ship moves
- To obtain ocean currents:
  1. transform **beam coordinates** into instrument coordinates
  2. rotate horizontal velocities into ship coordinates using **transducer angle in the hull** (EA command for VmDAS)
  3. rotate velocities on ship to North (using **heading**)
     - yields measured velocities in Earth coordinates
  4. remove ship’s speed using **positions**
- link to diagrams
(I) ADCP: Getting Ocean Velocity

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

![Diagram](image)

\[ \text{soundspeed} = \text{frequency} \times \text{wavelength} \]

(ocean) (instrument)
ADCP: Acoustic Doppler Current Profiler

incoming wavelength longer

incoming wavelength shorter

oncoming current

lower frequency

higher frequency

\[
\text{soundspeed} = \text{frequency} \times \text{wavelength} \quad (\text{ocean})
\]

\[
\text{soundspeed} = \text{frequency} \times \text{wavelength} \quad (\text{instrument})
\]}
“Gating” the return over time results in “bins” in the vertical, creating a profile of information.
**ADCP**: Getting Ocean Currents

**Plan View**

- **Ship steaming forward**
- **Heading alignment 45deg** (beam 3 is “forward” in instrument coordinates)
- **Ocean Surveyor beams**
  - Beam1
  - Beam2
  - Beam3
  - Beam4
ADCP: Getting Ocean Currents
ADCP

Getting Ocean Currents

Four beams
- 90deg apart
- 30 (or 20)deg up from vertical
- “forward beam” is #3
- usually 45deg starboard of forward
ADCP
Getting Ocean Currents

Four beams
- 90deg apart
- 30 (or 20)deg up from vertical
- “forward beam” is #3
- usually 45deg starboard of forward
ADCP
Getting Ocean Currents

Two opposite beams make a vertical plane
Now we have two vertical planes at 90deg to each other.

These are the basis of the horizontal and vertical velocities.

Horizontal velocities will be used to get ocean velocities.

Vertical velocities will be used for error-checking.
Two beams make one vertical plan.

This shows the velocities determined by the Doppler shift; “beam velocities”
Interpret the two beam velocities: one horizontal and one vertical velocity.
Now we see the horizontal and vertical velocities on the two planes.

Use the horizontal velocities for determining ocean velocities requires more steps.
ADCP: Getting Ocean Currents

This is a top-down view of the measured horizontal velocity in instrument coordinates (from the two planes made by the beams) (determining ocean velocities requires more steps)
ADCP:
Getting Ocean Currents

This is a top-down view of the measured horizontal velocity in ship coordinates.

The instrument coordinates values are rotated by the transducer angle.

(determining ocean velocities requires more steps)
ADCP: Getting Ocean Currents

This is a top-down view of the measured horizontal velocity in earth coordinates.

The instrument coordinates values are rotated by the ship's heading.

(determining ocean velocities requires more steps)
ADCP: Getting Ocean Currents

Summary of steps:

Doppler to beam (not shown)

below here: horizontal+vertical

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

beam coordinates

+ geometry

instrument coordinates:
2 horizontal, 1 vertical, 1 quality indicator
+ transducer orientation

ship coordinates
+ heading

earth coordinates
measured velocity: east, north, up, error
ADCP:
Getting Ocean Currents

Earth coordinates + GPS gives ship speed
add ship speed to measured velocity to get ocean velocity

Earth coordinates

If no ocean currents:
\[ U_{\text{meas}} = -U_{\text{ship}} \]

With Ocean current
\[ U_{\text{meas}} = -U_{\text{ship}} + U_{\text{ocean}} \]
\[ U_{\text{meas}} + U_{\text{ship}} = U_{\text{ocean}} \]
ADCP: Getting Ocean Currents

Complete summary:

- Beam velocities
- Transducer orientation
- Heading
- GPS

Earth coordinates

With Ocean current

\[
\mathbf{U}_{\text{meas}} = -\mathbf{U}_{\text{ship}} + \mathbf{U}_{\text{ocean}}
\]

\[
\mathbf{U}_{\text{meas}} + \mathbf{U}_{\text{ship}} = \mathbf{U}_{\text{ocean}}
\]

Beam velocities + Transducer orientation + Heading + GPS = \mathbf{U}_{\text{ocean}}
ADCP: Data components

- beam velocities
- transducer orientation
- heading
- gps

ADCP

- calibration
- attitude
- position

(ocean velocities)

(processing)
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After: Practice
DATA ACQUISITION

Time, ADCP, Position, Attitude

(primitive (raw) data)

DATA PROCESSING

Timestamp, Write to disk

(DATA PRODUCTS) (Visualization)
ADCP Acquisition Systems

There are two acquisition systems for vessel-mounted ADCPs:

- VmDAS (provided with purchase)
- UHDAS (developed at Univ Hawaii)
  - Installed on UNOLS ships, rolling out to NOAA ships
  - Link to Table of ships

Components – Overview:

- Basic requirements
- Processing
- Monitoring
ADCP Acquisition Systems: Overview

- Basic requirements:
  - Control ADCP settings
  - Acquire ADCP data
  - Acquire ancillary data
    - Position
    - Attitude (heading)
  - Timestamp all

- Processing
- Monitoring
ADCP Acquisition Systems: Overview

- Basic requirements
- Processing
  - Coordinate transformation
  - Editing
  - Averaging
  - Graphical Displays
- Monitoring
ADCP Acquisition Systems: Overview

- Basic requirements
- Processing
- Monitoring
  - Computer system
  - Data acquisition
  - Processing
  - Access to data
ADCP Acquisition systems: Details

- Basic requirements:
  - Overview
  - Serial setup
  - Data logging

- Processing
- Monitoring

Comparison
(UHDAS/VmDAS)
Outline

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After: Practice
## ADCP Acquisition Systems - Overview

<table>
<thead>
<tr>
<th>developer</th>
<th>Univ Hawaii</th>
<th>TRDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>style</td>
<td>linux system</td>
<td>windows application</td>
</tr>
<tr>
<td>source</td>
<td>open source</td>
<td>executable</td>
</tr>
<tr>
<td>purpose</td>
<td>seagoing</td>
<td>all-purpose</td>
</tr>
<tr>
<td></td>
<td>oceanographers</td>
<td></td>
</tr>
<tr>
<td>goals</td>
<td>maximize</td>
<td>off-the-shelf</td>
</tr>
<tr>
<td></td>
<td>- usefulness at sea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- long-term value</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for research</td>
<td></td>
</tr>
<tr>
<td>evolution</td>
<td>continuous</td>
<td>incremental</td>
</tr>
<tr>
<td>setup</td>
<td>complex</td>
<td>confusing</td>
</tr>
</tbody>
</table>
## ADCP Acquisition: Serial Setup

<table>
<thead>
<tr>
<th></th>
<th>UHDAS</th>
<th>VmDAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCPs</td>
<td>multiple</td>
<td>one (per computer)</td>
</tr>
<tr>
<td>feeds</td>
<td>any number</td>
<td>3 (older version=2)</td>
</tr>
<tr>
<td>messages</td>
<td>many types</td>
<td>fewer types</td>
</tr>
<tr>
<td></td>
<td>can add more</td>
<td></td>
</tr>
<tr>
<td></td>
<td>subsample feed</td>
<td>record all</td>
</tr>
<tr>
<td></td>
<td>choose messages</td>
<td>record all</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GUI controls</td>
<td>instrument settings</td>
<td>everything</td>
</tr>
<tr>
<td>operation</td>
<td>simple</td>
<td>simple/confusing</td>
</tr>
<tr>
<td>protected</td>
<td>serial processing</td>
<td>nothing protected</td>
</tr>
</tbody>
</table>
## Acquisition: Data Logging

<table>
<thead>
<tr>
<th></th>
<th><strong>UHDAS</strong></th>
<th><strong>VmDAS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>data logging</strong></td>
<td>separate processes</td>
<td>one big program</td>
</tr>
<tr>
<td><strong>time tagging</strong></td>
<td>buffered</td>
<td>unbuffered</td>
</tr>
<tr>
<td></td>
<td>tag every line</td>
<td>tag ensemble</td>
</tr>
<tr>
<td><strong>data formats</strong></td>
<td>multiple</td>
<td>TRDI ADCP</td>
</tr>
<tr>
<td><strong>data directory</strong></td>
<td>heirarchical</td>
<td>flat</td>
</tr>
<tr>
<td><strong>time range</strong></td>
<td>match per file</td>
<td>match for one logging period</td>
</tr>
<tr>
<td><strong>filenames sort</strong></td>
<td>always</td>
<td>one logging period</td>
</tr>
<tr>
<td>(time=ascii)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>metadata</strong></td>
<td>stored with data</td>
<td>text file elsewhere</td>
</tr>
</tbody>
</table>
ADCP Acquisition Systems: Comparison

- Basic requirements
  - Overview
  - Serial setup
  - Data logging

- Processing
  - Processing components
  - Accessing data products

- Monitoring
## Processing: Comparison

<table>
<thead>
<tr>
<th></th>
<th>UHDAS</th>
<th>VmDAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>editing</td>
<td>CODAS</td>
<td>minimal</td>
</tr>
<tr>
<td>heading</td>
<td>reliable</td>
<td>primary</td>
</tr>
<tr>
<td>secondary heading heading</td>
<td>corrected to accurate</td>
<td>replaced by fallback</td>
</tr>
<tr>
<td>pings</td>
<td>interleaved</td>
<td>first</td>
</tr>
<tr>
<td>configure plots??</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>plots</td>
<td>oceanographic:</td>
<td>profile (speed, dir)</td>
</tr>
<tr>
<td></td>
<td>- profiles (E,N)</td>
<td>vector</td>
</tr>
<tr>
<td></td>
<td>- vector (+topo)</td>
<td>vector</td>
</tr>
<tr>
<td></td>
<td>- contour</td>
<td>WinADCP?</td>
</tr>
<tr>
<td></td>
<td>- bridge (mariner)</td>
<td></td>
</tr>
</tbody>
</table>
## Accessing Data Products

<table>
<thead>
<tr>
<th></th>
<th>UHDAS</th>
<th>VmDAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>access plots</td>
<td>ship's web console</td>
<td>console only</td>
</tr>
<tr>
<td>data formats</td>
<td>TRDI, Matlab, netCDF</td>
<td>TRDI</td>
</tr>
<tr>
<td>access data</td>
<td>ship's web, windows share, NFS</td>
<td>acquisition PC, windows share</td>
</tr>
<tr>
<td>documentation</td>
<td>ship's web, www</td>
<td>acquisition PC, www</td>
</tr>
<tr>
<td>speedlog out</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
ADCP Acquisition Systems: Comparison

- Basic requirements
  - Overview
  - Serial setup
  - Data logging

- Processing
  - Processing components
  - Accessing data products

- Monitoring
<table>
<thead>
<tr>
<th>monitor</th>
<th>UHDAS</th>
<th>VmDAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>computer</td>
<td>daily_report</td>
<td>no</td>
</tr>
<tr>
<td>serial</td>
<td>daily_report</td>
<td>LOG and console messages configure tables</td>
</tr>
<tr>
<td>ADCP</td>
<td>beam plots</td>
<td>configure plots</td>
</tr>
<tr>
<td>Processing</td>
<td>daily_report plots configuration plots</td>
<td></td>
</tr>
<tr>
<td></td>
<td>calibration</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>ping rate</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>bottom track</td>
<td>no</td>
</tr>
<tr>
<td>remotely</td>
<td>email to anyone</td>
<td>no</td>
</tr>
</tbody>
</table>
DATA ACQUISITION

Time, ADCP, Position, Attitude

primitive (raw) data

DATA PROCESSING

Time
ADCP
Position
Heading

Timestamp, Write to disk

(Data Products)
(Visualization)
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After: Practice
Break now?  
or in 10-15 min?  

(information flow is better if we hang on for one more section...)
CODAS Processing

UHDAS:
- acquisition

Cruise directory structure
Gridding raw data before averaging
<table>
<thead>
<tr>
<th>subdirectory</th>
<th>contents</th>
<th>importance</th>
<th>back up for ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw</td>
<td>all raw data</td>
<td>critical</td>
<td>archiving</td>
</tr>
<tr>
<td>rbin</td>
<td>intermediate files</td>
<td>nice to have</td>
<td>anyone who gets ‘raw’</td>
</tr>
<tr>
<td>gbin</td>
<td>intermediate files</td>
<td>nice to have</td>
<td>anyone who gets ‘raw’</td>
</tr>
<tr>
<td>proc</td>
<td>processed data</td>
<td>final at-sea product</td>
<td>science CD after cruise</td>
</tr>
<tr>
<td></td>
<td>• codas database</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• underway figure archive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• matlab files</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reports</td>
<td>mini-webpage with metadata and overview of processed data</td>
<td>nice to have</td>
<td>science CD after cruise</td>
</tr>
<tr>
<td></td>
<td>(only in modern cruise directories)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(link in documentation – [raw+rbin+gbin] directories)
serial logging (raw files)

/home/data/CRUISEID/

raw/
gpsnav
gyro
ashtech
posmy
nb150
os75

Two-hour files are filled, one timestamped message at a time, to each of these directories.
serial logging (write raw file)

2-hour files of timestamped NMEA messages

kn2010_268_79200.gps

$UNIXD,268.9766766,8.8961773
$GPGGA,232917.00,6158.28180,N,...

kn   ship abbreviation
2010 year
268 zero-based yearday
79200 seconds in the day
gps message name

zero-based year day:
Jan 1 noon is 0.5 (not 1.5)
serial logging (raw → rbin)

start cruise

start logging

(DAS.py)

ser_bin
ser_asc

continuous

2hr rsync

/home/data/CRUISEID/

Parsing ASCII messages to binary files readable by Matlab or Python

raw/
gpsnav
gyro
ashtech
posmv

rbin/
gpsnav
gyro
ashtech
posmv
serial logging (rbin file contents)

/home/data/CRUISEID/

raw/
gpsnav

2-hour raw timestamped files

$r$UNIXD,268.9786766,8.8981773
$GPGGA,232917.00,6158.28180,N,...

rbin/
gpsnav

2-hour rbin files

<table>
<thead>
<tr>
<th>header</th>
</tr>
</thead>
<tbody>
<tr>
<td>logging computer time</td>
</tr>
<tr>
<td>GGA (decimal day [UTC])</td>
</tr>
<tr>
<td>decimal longitude</td>
</tr>
<tr>
<td>decimal latitude</td>
</tr>
<tr>
<td>quality</td>
</tr>
<tr>
<td>$mode$</td>
</tr>
</tbody>
</table>
serial logging (raw, rbin)

start cruise

start logging

(DAS.py)

ser_bin
ser_asc

/home/data/CRUISEID/

continuous, each serial port is independent

2-hour files of time-stamped NMEA messages

kn2010_268_79200.gps

$UNIXD,268.9786766,8.8981773
$GPGRX,232917.00,6.158.28180,N,...

raw/ 

/gpsnav 

gyro 
ashtech 
psmv 

raw/

nb150
os75

2-hour rbin files

header

logging computer time
GGA (decimal day, UTC)
decimal longitude
decimal latitude
quality
nmea
UHDAS: 5min timer (make gbins)

start cruise (DAS.py)

start logging

ser_bin
ser_asc

2hr rsync

5-min nb150

rbin files

raw (rbin) data have independent timestamps

gbin files

must grid rbin data onto ADCP timestamps
UHDAS 5-minute timer: make profile

/home/data/CRUISEID/
  raw
  rbin
gbin
  proc
  nb150 (CODAS tree)

average profile

http://currents/adcp
5-minute profile plot
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After: Practice
CODAS Processing

Time, ADCP, Position, Attitude

primitive (raw) data
CODAS: Common Ocean Data Access System

- Portable (multiple operating systems)
- Self-descriptive
- Aggregated files (like netCDF, but multiple files)
- Designed for ADCP data

“CODAS Processing” → produce ocean velocities

- Tools to access and modify CODAS files
CODAS = “Common Ocean Data Access System”

Goals

- Run on multiple operating systems
  - (Windows, OSX, Linux)
- Open source, free (Python)
- Flexible (tweak, tune, patch, augment)

Processing

- Written for ADCP data
- Works on most ADCP data acquisition systems (link)
- Balance real-time product with recoverable dataset
- Single-ping (automated) and manual editing
- Calibration diagnostics and routines

(*) via VirtualBox pre-configured Linux computer
### Python CODAS support

<table>
<thead>
<tr>
<th>Acquisition program</th>
<th>Instrument</th>
<th>Ping type</th>
<th>File type (suffix)</th>
<th>Averaged? or raw?</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAS2.48</td>
<td>Narrowband</td>
<td>nb</td>
<td>pingdata</td>
<td>avg</td>
</tr>
<tr>
<td>VmDAS</td>
<td>Broadband/ or Workhorse</td>
<td>bb</td>
<td>LTA, STA</td>
<td>avg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ENR</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td>Ocean Surveyor</td>
<td>nb</td>
<td>LTA, STA</td>
<td>avg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ENR(N1R,N2R)</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bb</td>
<td>LTA, STA</td>
<td>avg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ENR(N1R,N2R)</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nb bb</td>
<td>ENR(N1R,N2R)</td>
<td>raw</td>
</tr>
<tr>
<td>UHDAS</td>
<td>NB150,NB300</td>
<td>nb</td>
<td>raw</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td>Ocean Surveyor</td>
<td>nb</td>
<td>raw</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bb</td>
<td>raw</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nb bb</td>
<td>raw</td>
<td>raw</td>
</tr>
<tr>
<td></td>
<td>WH300</td>
<td>bb</td>
<td>raw</td>
<td>raw</td>
</tr>
</tbody>
</table>
CODAS processing: 2 modes

(1) process single-ping data
   - beam-to-earth coordinates
   - single-ping editing (acoustic interference, bottom)
   - create averages; save to disk
   - load averages into CODAS database

(2) load averaged data into CODAS database
   - 1980’s PINGDATA
   - VmDAS: *.LTA, *.STA
   \[\text{(no single-ping editing)}\]

Next: “post-processing steps”
CODAS post-processing:

- View figures and logfiles
- Fix heading:
  - patch gappy but accurate heading correction (if relevant)
  - apply time-dependent heading correction
- Determine corrections/calibrations, then apply
  - remaining transducer offset
  - scale factor (if relevant)
  - transducer-GPS offset (in meters)
- Manually edit out bad data ("gee-autoedit" tutorial)
  - graphically select bins, profiles
  - using thresholds
- check calibrations
- make figures (web page); export data (matlab, netCDF)
CODAS software tools:

- Tools for raw (single-ping) ADCP data:
  - Visualization of beam values
    - RSSI (signal return)
    - Beam velocity
  - Estimate EA (transducer angle)
  - Conversion of NMEA strings to "rbin" data files
    - N1R, N2R, N3R (from VmDAS)
    - UHDAS raw serial data
  - Tools to plot rbin data:
    - Plot POSMV quality
    - Plot navigation over topography
    - Plot one (or compare two) rbin data streams
<table>
<thead>
<tr>
<th>program name</th>
<th>data stored to disk</th>
<th>load the database</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAS2.48</td>
<td>pingdata.*</td>
<td>(no)</td>
</tr>
<tr>
<td>VmDAS</td>
<td>*.STA *.LTA</td>
<td>load_lta.m</td>
</tr>
<tr>
<td>VmDAS</td>
<td>*.ENR *.ENS *.ENX</td>
<td>load_ens.m</td>
</tr>
<tr>
<td>UHDAS</td>
<td>*.raw</td>
<td>load_uhblk</td>
</tr>
</tbody>
</table>
These steps use only the CODAS files so work on any averaged data, regardless of the source:
- single-ping editing
- LTA/STA
- PINGDATA
CODAS Processing

- 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 (new)
CODAS Processing

- 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)

BEFORE AVERAGING
ADCP Single-ping Editing

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

- Acoustic Interference
- Bubbles
- Below bottom

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
- Below bottom
ADCP Processing

Singleping editing: acoustic interference
ADCP Processing: editing out interference
ADCP Processing: editing out 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
- Below bottom
single-ping editing: underway bias
ADCP Data: effect of bubbles

Bubbles:
- short profiles
- strongly biased towards zero

Untreated:
- biased ocean velocities
Acoustic Interference

NO single-ping editing

AFTER single-ping editing

Acoustic Interference

No effects left

Additional editing
Lower Percent Good
Heavy seas = bubbles and underway bias

Heavy seas results in decreased Percent Good (instrument-level data loss)

Further reduction of Percent Good by single-ping editing -- low PG shows reduced data content: use thresholds and manual 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

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

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

UHDAS processing demo
CODAS Postprocessing

- Editing (single-ping)
  - Acoustic interference
  - Bubbles
  - Below bottom
- Interpolate missing heading correction
- Apply calibrations
  - Rotation
  - Scale factor
  - Transducer offset (new)
- Manually edit CODAS database averages “gee-autoedit”
CODAS Processing: Calibration

- Calibration of averaged data:
  - Cross-track error (angle error)
    - Incorrect transducer angle (constant)
    - Inaccurate heading (time-varying)
  - Alongtrack bias (scale factor)
    - Soundspeed (single-ceramic transducers only)
  - Transition Error
    - Horizontal 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
  • 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:
- 0.1 m/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)
Calibration: scale factor (alongtrack bias)
Calibration: ADCP-GPS offset

(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
Manual Editing

- Bottom interference
- Wire interference
- Scattering layers
- Ringing
- Bad shallow PG and underway bias

(see GeeAutoedit documentation)
Outline

Day 1: Morning: Presentation
1. ADCP: components to currents
2. ADCP Data Acquisition
   - compare: VmDAS ↔ UHDAS
3. CODAS Processing
4. Data Stewardship

After: Practice
Another break?
UHDAS Shipboard ADCP Data
(Raising the Profile of Ocean Currents)

UHDAS Data Archiving and Stewardship
Who uses ocean currents from Shipboard ADCP?

At Sea:

• near-realtime guidance for sampling
  • “are we inside or outside the eddy”
  • “did we cross the front yet?”
  • “where do we find the zooplankton?”
• preliminary calculations for science
  • characterize data based on flow regime
• operationally
  • aid in dynamic sampling strategy
  • predict trajectory of drifting objects
  • towing, over-the-side work, dive operations
Who uses ocean currents from Shipboard ADCP?

Post-Cruise Analysis:

• Look in detail (calculations or context) for one cruise
  - apply calibrations, edit; reprocess if problems are found

• Climatology/Time-series using multiple cruises
  - requires multiple datasets that are already finalized
  - project-based example:
    - instrumented Volunteer Observing Ship (eg. Oleander)
    - Drake Passage crossings to Antarctica (L.M.Gould)
  - opportunistic example:
    - Pacific Equatorial currents (many ships, eg TAO buoy service)
(2) What does UHDAS do?

Performs these tasks:

- Data acquisition
- Data processing (create ocean currents)
- Generates data products (multiple formats)
- Generates tools and components for monitoring (at sea and on shore)
What are our data goals?

- Data should be as close to "final" as possible (for an automated system)
- Data should be useful for science and operations at sea
- Require minimal post-processing for science
- Enhance the utility and visibility of ADCP data
- Open Source code, clear documentation
- Reprocessing on multiple operating systems (Linux, Mac, Windows)
(3) Data benefits of UHDAS

- Remote monitoring by ADCP guru:
  - ensure good configurations, reasonable settings
  - catch problems early

- Long-term usefulness:
  - Open source software
  - Existing path to NCEI

- Open communication with scientists and techs
Typical UHDAS dataset sizes

- Full at-sea directory (eg. month-long cruise) 5Gb
- Subset necessary to completely reprocess 4Gb
- Final averaged data product for scientists 25Mb

ADCP data submission from a cruise

- Original data from instruments, logged by UHDAS
- (intermediate stages)
- automated processing
  - directories
  - products
- plots: diagnostic, science
  logs: evaluation, calibration
- data: ocean currents

nuggets for science use/evaluation
(4) Archiving, Serving, Stewardship

PAST and PRESENT

• diagram of information flow

• JASADCP – long-term archive for finalized shipboard ADCP data

PRESENT and FUTURE

• UHDAS, R2R, and NEIC
  • historical data to JASADCP
  • mine historical data for low-hanging fruit, other uses
Flow of information

Old Model

- cruise
  - original data
  - Chief Scientist
  - processed data
  - papers, pubs, results

Other people
- can read about the results
- cannot use the data (or must get it from Chief Scientist)
Flow of information

Past and Present

- cruise
- original data
- Chief Scientist
- processed ADCP data
- papers, pubs, results

created 1992: Joint Archive for Shipboard ADCP
- centralized dissemination center processed (finalized)
- shipboard ADCP data
- anyone can access standardized, science-ready data
**Joint Archive for Shipboard ADCP**

- accepts science-ready ocean current data
  - over 800 cruises (multiple instruments on some ships)
  - from multiple countries, multiple acquisition systems
  - this represents only a small fraction of historical data
- regularly used by scientists from 1992 - present
- (new) higher-resolution data available now/soon
JASDCP and UHDAS

Finalize processing then submit to JASADCP

UHDAS data directory from a cruise

Finalize processing then submit to JASADCP

public access
NCEI: archiving UHDAS datasets

- UNOLS cruises
  - ship submits to R2R (http://www.rvdata.us/catalog)
  - R2R adds value, pushes to archive to NCEI
- NCEI creates data accession
- cruises under NCEI
  Global Ocean Currents Database
- “originator data” R2R shipboard ADCP (507 cruises)
- UHDAS group: work with NOAA to
  - get UHDAS ADCP data from NOAA ships into NCEI
  - improve discovery and use of archived datasets
Present and Future:
- two paths to finalized public data
- more opportunities for original data to be used
Summary: What We Did

1. ADCP instrument
   - What it is; getting ocean velocities

2. ADCP Data Acquisition
   - Acquisition, processing, monitoring
   - Comparison: UHDAS ↔ VmDAS
   - UHDAS data details

3. CODAS Processing
   - Single-ping editing
   - Postprocessing
     - Calibration
     - Editing

4. Data Stewardship (more discovery, more recovery)
ADCP:
Getting Ocean Currents

Summary of steps:

Doppler to beam (not shown)
below here: horizontal + vertical

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

beam coordinates
+ geometry

instrument coordinates:
2 horizontal, 1 vertical, 1 quality indicator
+ transducer orientation

ship coordinates
+ heading

earth coordinates
measured velocity: east, north, up, error
ADCP: Data components

- beam velocities
- transducer orientation
- heading
- gps

ADCP
- calibration
- attitude
- position

Ocean velocities

(processing)
UHDAS: 5min timer (make gbins)

start cruise

(DAS.py)

start logging

ser_bin
ser_asc

2hr rsync

5-min nb150

rbin files

raw (rbin) data have independent timestamps

must grid rbin data onto ADCP timestamps

ADCP position

reliable heading

accurate heading

Time
# UHDAS cruise directory structure

<table>
<thead>
<tr>
<th>subdirectory</th>
<th>contents</th>
<th>importance</th>
<th>back up for ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw</td>
<td>all raw data</td>
<td>critical</td>
<td>archiving</td>
</tr>
<tr>
<td>rbin</td>
<td>intermediate files</td>
<td>nice to have</td>
<td>anyone who gets ‘raw’</td>
</tr>
<tr>
<td>gbin</td>
<td>intermediate files</td>
<td>nice to have</td>
<td>anyone who gets ‘raw’</td>
</tr>
<tr>
<td>proc</td>
<td>processed data</td>
<td>final at-sea product</td>
<td>science CD after cruise</td>
</tr>
<tr>
<td></td>
<td>• codas database</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• underway figure archive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• matlab files</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reports</td>
<td>mini-webpage with</td>
<td>nice to have</td>
<td>science CD after cruise</td>
</tr>
<tr>
<td></td>
<td>metadata and overview of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>processed data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(link in documentation – [raw+rbin+gbin] directories)
CODAS Processing

Time, ADCP, Position, Attitude

primitive (raw) data

Ocean U (east)

Ocean V (north)

os75nb: last time 2011/11/06 15:49:55

os75nb: last time 2011/11/06 15:49:55
Present and Future:
- two paths to finalized public data
- more opportunities for original data to be used

R2R

NCEI

cruise

Chief Scientist

JASADCP

discovery

A.N.Other (Scientist)

papers, pubs, results

public access, finalized data
Workshop: What We Will Do

1. ADCP instrument
   - What it is; getting ocean velocities

2. ADCP Data Acquisition
   - Acquisition, processing, monitoring
   - Comparison: UHDAS $\leftrightarrow$ VmDAS
   - UHDAS data details

3. CODAS Processing
   - Single-ping editing
   - Postprocessing
     - Calibration
     - Editing

4. Data Stewardship

Day 1 afternoon
Day 2
Day 3