Real- and Delayed- time XBT data quality control at NOAA/AOML

Gustavo Jorge Goni
And the NOAA/AOML SOOP investigators and science support personnel

GSOP Meeting
Hobart, June 2013
Frequently repeated (FR) mode (25):
Low density (LD) mode (0):
High Density (aka High Frequency) mode (24): 4 repetitions/year, every ~20-25km

AX08: 500 XBTs per repetition
AX32 (Oleander) 34 years of repeated XBT transects
~20K XBTs per year from ~75 ships (cargo, cruise, research)
XBT Sampling

XBT Deployments 2011 (Total 17611)

XBT Deployments 2012 (Total 16965)
XBT observations: Temporal sampling

LD termination initiated
Focus on HD mode

LD terminated
Most on HD mode

# observations (*1000)

<table>
<thead>
<tr>
<th></th>
<th>LD termination initiated</th>
<th>LD terminated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus on HD mode</td>
<td>Most on HD mode</td>
</tr>
<tr>
<td>Argo</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>XBTs</td>
<td>41</td>
<td>12</td>
</tr>
<tr>
<td>TRANSECT</td>
<td>Institution</td>
<td># yr</td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
<td>------</td>
</tr>
<tr>
<td>AX01</td>
<td>AOML/UP</td>
<td>4</td>
</tr>
<tr>
<td>AX02</td>
<td>AOML/UP</td>
<td>4</td>
</tr>
<tr>
<td>AX07</td>
<td>AOML</td>
<td>4</td>
</tr>
<tr>
<td>AX08</td>
<td>AOML</td>
<td>4</td>
</tr>
<tr>
<td>AX10</td>
<td>AOML</td>
<td>4</td>
</tr>
<tr>
<td>AX18</td>
<td>AOML</td>
<td>2</td>
</tr>
<tr>
<td>AX20</td>
<td>AOML/UP</td>
<td>1</td>
</tr>
<tr>
<td>AX25</td>
<td>AOML/UCT</td>
<td>3</td>
</tr>
<tr>
<td>AX32*</td>
<td>AOML/URI</td>
<td>12</td>
</tr>
<tr>
<td>AX97</td>
<td>AOML/FURG</td>
<td>7</td>
</tr>
<tr>
<td>IX01, 12, 28*</td>
<td>BOM/CIRO/AOML</td>
<td>648</td>
</tr>
<tr>
<td>MX01</td>
<td>ENEA/AOML</td>
<td>2</td>
</tr>
<tr>
<td>MX02</td>
<td>ENEA/AOML</td>
<td>2</td>
</tr>
<tr>
<td>MX04</td>
<td>ENEA/AOML</td>
<td>5</td>
</tr>
<tr>
<td>Fall rate</td>
<td>AOML</td>
<td>N/A</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>41</td>
</tr>
</tbody>
</table>
AOML Real-time QC of XBT data

RT Transmission

SEAS Server

Real Time (A and V) QC

RT Data

GTS

AOML RT db

NODC

AOML DT db

Data Download

Delayed Time QC

Corrected or discarded profile

Yes-No Profile is not modified

DT Data

(1) AOML Atlantic profiles  (2) AOML Atlantic profiles + SIO profiles
XBT data we have at AOML

Real-time:

0.1 sec averages ascii data since October 1994.

GTS data since 2001

Delayed-time:

Quality controlled for HD transects: AX07, AX08, AX10, AX18, AX97, AX25
AOML Real-time AQC of XBT data (1)

- Gross check
- Constant value
- Spike
- Vertical Gradient
- Climatology
- Analysis
- Date
- Location
- Depth
AOML Real-time QC of XBT data (2)

- Gross check
  This test checks the extreme depth and temperature values:
  Good: $-2.5^\circ C < T < 40.0^\circ C$
  $0.0 \leq Z < 11000.0 \text{ m}$

- Constant value (global flag)
  This test checks if the profile is constant from top to bottom:
  Good: $T_{\text{min}} \neq T_{\text{max}}$

- Spike
  A measurement fails this test if tolerance of $0.4^\circ C$ for difference between observed temperature and the associated median (of 3 observations) is exceeded
  \[ T_{\text{test}} = | T_2 - \left( \frac{T_3 + T_1}{2} \right) / 2 | - | \left( \frac{T_3 - T_1}{2} \right) | \]

- Vertical Gradient
  Flags gradients and inversions. A measurement fails this test if the temperature gradient is outside of range $0.2^\circ C/\text{m}$ to $1.0^\circ C/\text{m}$
  \[ \text{grad}(T)_{\text{test}} = \left( \frac{T_2 - T_1}{Z_2 - Z_1} \right) \]
AOML Real-time QC of XBT data (3)

- **Climatology**
  Comparison of profiles with Levitus WOA climatology. A measurement fails this test if it is outside of the 3 standard deviation envelope around the mean profile.

- **Analysis**
  Comparison of profiles with NCEP’s weekly analysis data. A measurement fails this test if it is outside of the 3 standard deviation envelope around the mean profile.

- **Date (global flag)**
  Checks for impossible date and time:
  **Good:**
  
  - Year > 1997;
  - 0 ≤ Hour < 24
  - Month = 1, 2, ..., 12;
  - 0 ≤ Min. < 60
  - Day = 1, ..., corresponding max.

- **Location (global flag)**
  Checks for impossible locations
  **Good:**
  
  - -180 ≤ Longitude ≤ 180
  - -90 ≤ Latitude ≤ 90

- **Depth (global flag)**
  Checks for profiles located at sea using ETOPO5.
### AOML Real-time QC of XBT data (4)

**QC Statistics of XBT profiles during 2010**

<table>
<thead>
<tr>
<th></th>
<th>max/day</th>
<th>mean/day</th>
<th>sum</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No. of Profiles</td>
<td>122</td>
<td>29.2</td>
<td>10343</td>
<td></td>
</tr>
<tr>
<td>Profiles Approved in the AQC</td>
<td>82</td>
<td>20.8</td>
<td>7358</td>
<td>(71.1%)*</td>
</tr>
<tr>
<td>Profiles Rejected in the AQC</td>
<td>57</td>
<td>8.4</td>
<td>2985</td>
<td>(28.9%)*</td>
</tr>
<tr>
<td>Profiles Approved in the VQC</td>
<td>52</td>
<td>7.1</td>
<td>2498</td>
<td>(83.7%)**</td>
</tr>
<tr>
<td>Profiles Rejected in the VQC</td>
<td>25</td>
<td>1.4</td>
<td>487</td>
<td>(19.5%)**</td>
</tr>
<tr>
<td>Total No. of Profiles to the GTS</td>
<td></td>
<td></td>
<td>9856</td>
<td>(95.3%)*</td>
</tr>
</tbody>
</table>

* Relative to the total No. of profiles received
** Relative to the No. of profiles rejected in the Auto QC
AOML Real-time QC of XBT data (5)
AOML  Delayed-Time QC of XBT Data (1)

- Data come from the rider **via e-mail or in cd** for AX07, AX08, AX10, AX18, AX25, AX97
- Data come from the rider **via e-mail or ftp downloaded** for AX01, AX02, AX20
- Data come from the rider **via e-mail** MX01, MX02, MX04

In addition to the RT (A and V) QC tests, Delayed-Mode QC Tests includes:

- Speed
- Position
- Duplicate
- Hit Bottom
- Premature launch
- Temperature offset
- Consistency
- XBT transect ‘climatology’
- Completed (not a test) with $S(z)$ and DH estimates
AOML Delayed-Time QC of XBT Data (2)

Most common problems:

- Premature launch error (→ corrected profile)
- Temperature offset error (→ discarded profile)
- Wire break error or touching side of ship (→ corrected)
- Spike error (→ corrected)
- High frequency error (→ corrected)
- Just bad profile (→ discarded)
AOML Delayed-Time QC of XBT Data (3)

<table>
<thead>
<tr>
<th>Stn</th>
<th>Lat</th>
<th>Lon</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>-20.000</td>
<td>-9.885</td>
</tr>
<tr>
<td>59</td>
<td>-22.000</td>
<td>-10.167</td>
</tr>
<tr>
<td>60</td>
<td>-20.000</td>
<td>-10.433</td>
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</table>

<table>
<thead>
<tr>
<th>Stn1</th>
<th>Stn2</th>
<th>Speed(m/s)</th>
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</thead>
<tbody>
<tr>
<td>57</td>
<td>58</td>
<td>4.85 m/s</td>
</tr>
<tr>
<td>58</td>
<td>59</td>
<td>38.38 m/s</td>
</tr>
<tr>
<td>59</td>
<td>60</td>
<td>39.15 m/s</td>
</tr>
<tr>
<td>60</td>
<td>61</td>
<td>4.74 m/s</td>
</tr>
</tbody>
</table>

Corrected Location for Station 59:

<table>
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<tr>
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<tr>
<td>60</td>
<td>-20.000</td>
<td>-10.433</td>
</tr>
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</table>
Launch error: XBT profiles are corrected
AOML Delayed-Time QC of XBT Data (5)

Temperature Offset:
XBT profiles are discarded
AOML Delayed-Time XBT Data

Raw and QC’d data are kept in *.NDC format and AOML format and distributed via www.

WOCE XBT
Line Number: AX18
Principal Investigator: Dr. Gustavo Goni
Dr. Sylvia Garzoli
Dr. Molly Baringer
Data Quality Control: Qi Yao

Dates: Aug 9 - 18, 2005
Ship: M/V EVER GENERAL
Data Availability: Data is available in delayed mode via this web site (Raw Data), and can also be obtained from NODC. Real-time data was transmitted via Inmarsat-C and distributed via the Global Telecommunications System.

Additional Information:
179 XBTs Deployed
3 BAD, 12 Questionable
Surface Drifters Deployed: 6
ARGO Floats Deployed: 6
Immediate Work and Challenges

**work:**

Run tests in BUFR with flags

Run tests of CQXBT, an XBT probe with 2 pressure switches

**Challenges:**

Report and save (more) metadata

Continue communicating the scientific and operational value of XBT observations in view of new funding cuts