

XBT Data Processing – MOPS 1988 MAC

XBT data were collected with SEAS software (Shipboard Environmental data Acquisition System, NOAA/AOML) on the NOAA Ship McArthur, July 29 through December 5, 1988. Typically, XBT drops were conducted every three hours during daylight operations. Sippican T-4 and T-6 Expendable Bathythermograph (XBT) probes were used; both measure the temperature of the water column to 460 m.

Raw data files were checked for date/time and position and then edited to remove erroneous temperature data. All valid and edited profiles were then combined into final files. The XBTCorrect file has depth and temperature corrections according to Cheng et al. (2016, Bull. American Meteorological Soc., June 2016, 923-933). The XBTArchive file has depths calculated with the fall rate equation of Hanawa et al. (1995, Deep-Sea Research I 42:1423-1451) and excludes incomplete profiles that do not extend through the thermocline. This file is for archiving and allows for optional correction of depth and temperature by users.

All data and programs are stored in sub-folders of P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\.

The raw data files are in the sub-folder Raw. The programs used to process the data are stored in the sub-folder Current_Version\Programs. These programs read year-specific information from *.ini files, which are stored in the same folder as the programs. The intermediate files created during the processing steps are stored in the sub-folder Current_Version\Intermediate. The final processed data and documentation are stored in the sub-folder Current_Version\Final.

Raw Data Files

SEAS raw data files were converted to *.edf files with Fortran program SEAS2EDF. No *.ini file is used by the SEAS2EDF program.

Raw File Summaries

The data collected on each survey were backed up on several DVD's. However, for 1988_MOPS, there were no DVD's or diskettes were found. Instead, files that had been previously copied to the network were used. These files were copied to P:\Surveys\Data\ETP\1988_PODS\Oceanographic\XBT\Raw\MAC\.

No XBT spreadsheets or Elog databases were created during the cruise.

Perl program XBTRawFileInfo was used to get a summary of the raw files. It showed that all RDF files had matching EDF Files, and vice versa.

Data Checks

Position Check

For cruises that had TSG positions, Perl program XBTPositionCheck compares the positions and times of the XBT drops to positions and times in the final TSG "Track Check" file.

However, for MOPS 1988 MAC, there was no final TSG file, so could not be used to check the XBT positions. Therefore, Perl program XBTrackCheck was used instead. This checks for latitude and longitude problems by calculating the apparent speed between consecutive records. It flags any record where the apparent speed is greater than a maximum value read from XBTrackCheck.ini. It also checks for records with identical coordinates, which may indicate a problem with the GPS or that the ship was stopping. If the speed from the previous record is greater than the threshold used to indicate that the ship may have been stopping (the threshold is read from XBTrackCheck.ini), the record is flagged as a potential GPS error. If the speed is less than the threshold, we assume the ship was stopping and the records are retained.

In PODS 1988 MAC, all drops had positive Longitude, which is incorrect for the western hemisphere. In addition, 3 drops' positions were incorrect, and 5 drops' dates were incorrect. These were primarily transcription errors (e.g. 50 degrees rather than 5 degrees). The EDF files were manually corrected. There were also two drops that did not have Latitude or Longitude information, so were excluded from processing.

Station and Drop Lists

Perl program XBStationAndDrops creates the Station and Drops files. From its ini file, it reads the location of the EDF files, and the location of the time offsets file. The Drop file is simply a list of the EDF Files. The Station file lists additional information for each drop: time and location, number of data points, probe type, start and end depths, and drop rate coefficients in the EDF file.

For 1988 MOPS MAC, there were 419 drops. 10 of those used T-4 probes, the remaining 409 used T-6 probes.

Profile Review and Edit

At the lab, profiles were examined by Paul Fiedler using the Visual Basic program ProfileViewer, which is located in

P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\ProfileViewer. The reviewer decided what edits need to be made, and recorded that information in file XBTDrops_1988_MOPS_MAC_PFedits.txt. Each XBT drop has a line in that file, with the EDF file name. If the profile requires any editing, the reviewer added codes for the edits to be applied. Codes are based on Bailey et al. (Quality Control Cookbook for XBT Data, CSIRO Marine Laboratories Report 221, 1994). The Quality Control Cookbook can be found in P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\ . Codes are as follows, where ddd.d is the depth exactly as recorded in the .edf file:

>RJ	Reject profile.
>NN	The profile is not suitable for submission to the NCEI World Ocean Database, but is good enough for deriving surface temperature and mixed layer depth, and perhaps thermocline variables, for MMTD purposes.
>XD ddd.d ddd.d	Exclude data within the profile. Reject data between the first and second specified depths.
>BD ddd.d	Exclude data at the bottom end of the profile. Reject data deeper than ddd.d.
>FT ddd.d	False trigger, data recorded before the probe entered the water. This error is rare. Reject all data above ddd.d and change the depth at ddd.d to 0.7m, which is the starting depth for all drops (and then increment the depth estimates per Hanawa et al. 1995).
>ST ddd.d	Surface transient, identified by warming or cooling as the probe temperature equilibrates. Reject data before depth ddd.d. All temperatures at depths ≤ 4.0 m are rejected to routinely dismiss surface transients, so this flag is only effective if a depth >4.0 m is indicated. If the profile also contains an FT error, ddd.d is an integer that indicates the number of records after the FT correction that should be rejected.

Profile rejections and data exclusions are usually explained in a comment following an apostrophe ('): wb = wire break, ws = wire stretch, hb = the probe hit the bottom, ip = insulation penetration.

Apply Profile Edits

Perl program XBTEdit reads the editing codes entered by the reviewer, and creates edited output files. From its ini file, it reads: The location of the edit file (created in the previous step), the location of the time offsets file, the location of the raw XBT files, and the coefficients for the fall rate equation. It creates output files with the editing codes applied. (e.g. Drops marked with RJ are excluded, depths marked with XD are removed, etc.) Here is the output from program XBTEdit:

```

417      lines read from input file
      P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interme
      diate\XBTDrops_1988_MOPS_MAC_PEdits.txt
0      lines started with an apostrophe, so were ignored
19     lines had an RJ code, so were ignored

398     records written to
      P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interme
      diate\XBTEdit_1988_MOPS_MAC.dat

```

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3      lines were not good enough for NODC, so their drop numbers were negated
395    records written to
      P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interme
      diate\XBTNODC_1988_MOPS_MAC_6.691_0.00225.dat

13.23  Average temperature of all 263325 output points whose drops met the Min
      To Avg depth
20.94  Average temperature of all 57420 output points <= 100 m whose drops met
      the Min To Avg depth
      Note that this is based on depths calculated using the Hanawa et al
      1995 formula

```

Depth and Temperature Corrections

Perl program XBTCorrect was used to correct depths and temperatures, using the method described in P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\CH XBT fall-rate method.pdf. Here is the output from program XBTCorrect:

```

Reading XBTCorrect.ini...
Reading CH14 table 'P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\Fall
rate\CH14_table1.txt'...
Reading CH14 table 'P:\Surveys\Data_Processing_Resources\Oceanographic\XBT\Fall
rate\CH14_table2.txt'...
Processing
      P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interme
      diate\XBTEdit_1988_MOPS_MAC.dat...
T-6: Thermal Bias = 0.08979, A = 6.796, B = 0.00339, Offset = 2.073
T-4: Thermal Bias = 0.08979, A = 6.796, B = 0.00339, Offset = 2.073

399    lines read from
      'P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interm
      ediate\XBTEdit_1988_MOPS_MAC.dat'
0      lines started with an apostrophe, so were ignored
388    records written to
      P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interme
      diate\XBTCorrect_1988_MOPS_MAC_T-6.dat
10     records written to
      P:\Surveys\Data\ETP\1988_MOPS\Oceanographic\XBT\Current_Version\Interme
      diate\XBTCorrect_1988_MOPS_MAC_T-4.dat

3      had negative drop numbers, which means their data was not good enough
      for NODC

```

Final data files

The NODC file created in the XBTEdit step was copied to \Final and was renamed as:
 XBTArchive_1988_MOPS_MAC_T-4, T-6.dat.

Each drop record in a XBTArchive file starts with fields under the following column headers:

UTC Date, UTC Time, Time Offset, Local Date, Local Time, Latitude, Longitude,
Drop #, Probe Type, # Points, H95 FRE Coefficients...

The column headers after that are depths (m), based on the Hanawa et al 1995 fall rate equation, e.g:

..., 0.7, 1.3, 2.0, 2.7, 3.3, 4.0, 4.7, 5.4, 6.0, 6.7, 7.4, 8.0, 8.7,...

The drop records data in those columns are temperatures (°C) at those depths. Missing data (e.g., surface transients) are blank.

The files that had depth and temperature corrected based on Cheng et al were also copied to \Final. These files are:

XBTCorrect_1988_MOPS_MAC_T-4.dat

XBTCorrect_1988_MOPS_MAC_T-6.dat

Each drop record in a XBTCorrect file starts with fields under the following column headers:

UTC Date, UTC Time, Time Offset, Local Date, Local Time, Latitude, Longitude,
Drop #, Probe Type, CH14 Values, # Points...

The column headers after that are depths (m), based on the Cheng et al fall rate correction, e.g:

..., 0.0, 0.6, 1.3, 2.0, 2.7, 3.4, 4.0, 4.7, 5.4, 6.1, 6.8, 7.4, 8.1, 8.8,...

Longitudes were recorded as positive in the raw files, but were corrected to negative values (W longitude) in the XBTArchive and XBTCorrect files.

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