XBT Data Processing – MOPS 1990 DSJ

XBT data were collected with SEAS software (Shipboard Environmental data Acquisition System, NOAA/AOML) on the NOAA Ship David Starr Jordan, Aug 11 through Dec 5, 1990. Typically, XBT drops were conducted every three hours during daylight operations. Sippican T-6 and T-4 Expendable Bathythermograph (XBT) probes 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\1990_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. The DVDs were frequently created at the end of each leg. Sometimes data from each leg were backed up separately, while at other times the backups included all data collected (e.g., data collected on legs 1-3 were backed up at the end of leg 3) . Consequently, there can be a great deal of overlap among the DVDs.

However, for the data collected on the DSJ during MOPS 1990, no DVD's were found. Rather, files had been copied to the network at some earlier time. These files were copied to P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Raw\DSJ\.

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

Perl program XBTRawFileInfo was used to get a summary of the raw files. There were 81 files whose dates were in 1980 rather than 1990. It appears that the date was reset to 1/1/1980 on 8/24/1990. These files were manually edited to have the correct date. However, note that the file names, which include the date, were not changed. These corrections will be verified in the step that compares against TSG positions at that time. The drop after 169 had been given the number 2, the drop after that was 170. Drop 2 was manually changed to 169A. All RDF files had matching EDF Files, and vice versa.

Data Checks

Position Check

Perl program XBTPositionCheck compares the positions and times of the XBT drops to positions and times in the final TSG "Track Check" file. The program reads the following information from its .ini file: the location of the EDF files, the location of the final TSG Track Check file, and the number of seconds to search the TSG file for a record that matches each XBT file's time. Positions for stations without corresponding TSG data are checked against the XBT Log and ODL.

For 1990 MOPS DSJ, all Longitude's were positive. This is incorrect for the western hemisphere. The Longitudes were manually negated in all of the EDF files. After that correction, 57 XBT drops were greater than 1 nautical mile from TSG positions matched by time.

- 10 were in spots where the TSG positions suddenly jumped, so the TSG was presumed to be inaccurate. Since there was no ODL to check either position, these were all accepted.
- 4 were because the XBT date was incorrect.
- 7 were a bit off the TSG track line, and were corrected based on TSG position at that time. These were all manually corrected.
- The remaining 36 were within 2 nautical miles of TSG. Given the known inaccuracies of the TSG data, these were accepted.

After the above corrections were made, the program reported the following:

```
      386   EDF files read
        0   were missing date, time, latitude, or longitude
        0   were not in a valid format
        7   did not have a TSG record within 120 seconds in
    P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\TSG\Current_Version\Intermediate
    \TSGReformat_1990_MOPS_DSJ.dat

      379   lines were compared to TSG

  1.47147   Root-mean-square-error of distances
       46   Distances >= 1 nautical mile
 19.52353   Max distance
```

The points that are more than 2 nautical miles from TSG are because TSG jumped at that point.

Station and Drop Lists

Perl program XBTStationAndDrops 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 1990 MOPS DSJ, there were 386 drops. 385 of those used T-6 probes, the other one used a T-4 probe.

Here is the output from program XBTEdit:

```
386     lines read from input file
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTDrops_1990_MOPS_DSJ_PFedits.txt
0       lines started with an apostrophe, so were ignored
11      lines had an RJ code, so were ignored

375     records written to
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTEdit_1990_MOPS_DSJ.dat

2       lines were not good enough for NODC, so their drop numbers were negated
373     records written to
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTNODC_1990_MOPS_DSJ_6.691_0.00225.dat

13.11   Average temperature of all 261650 output points whose drops met the Min
        To Avg depth
21.51   Average temperature of all 53856 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
```

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 needed to be made, and recorded that information in file XBTDrops_1990_MOPS_DSJ_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:

```
386     lines read from input file
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTDrops_1990_MOPS_DSJ_PFedits.txt
0       lines started with an apostrophe, so were ignored
11      lines had an RJ code, so were ignored

375     records written to
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTEdit_1990_MOPS_DSJ.dat

2       lines were not good enough for NODC, so their drop numbers were negated
373     records written to
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTNODC_1990_MOPS_DSJ_6.691_0.00225.dat

13.13   Average temperature of all 262014 output points whose drops met the Min
        To Avg depth
21.55   Average temperature of all 54230 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
```

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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\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTEdit_1990_MOPS_DSJ.dat...
T-6: Thermal Bias = 0.06733, A = 6.749, B = 0.00307, Offset = 1.801
T-4: Thermal Bias = 0.06733, A = 6.749, B = 0.00307, Offset = 1.801

376     lines read from
        'P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interm
        ediate\XBTEdit_1990_MOPS_DSJ.dat'
0       lines started with an apostrophe, so were ignored
374     records written to
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTCorrect_1990_MOPS_DSJ_T-6.dat
1       records written to
        P:\Surveys\Data\ETP\1990_MOPS\Oceanographic\XBT\Current_Version\Interme
        diate\XBTCorrect_1990_MOPS_DSJ_T-4.dat

2       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_1990_MOPS_DSJ_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 (ºC) 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_1990_MOPS_DSJ_T-4.dat
    XBTCorrect_1990_MOPS_DSJ_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:

```
..., 0.2, 0.9, 1.6, 2.2, 2.9, 3.6, 4.3, 4.9, 5.6, 6.3, 7.0, 7.6, 8.3, 9.0,...
```

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01 June 2021