CTD-χpod Processing Guide

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1 Introduction

This is a guide to processing data from CTD-χpods. χpods are self-contained instruments developed by the OSU Ocean Mixing Group to measure turbulence. They have a FP07 thermistor that measures temperature and temperature gradient, sampled at 100Hz.

2 Brief Outline of Major Processing Steps

1. Find chipod data for each CTD cast
2. Align chipod data with CTD data
3. Calibrate chipod data
4. Apply chipod calc in 1 sec windows

More details are given in the rest of the document.

3 Software

The processing is done with Matlab codes, which are maintained in a github repository: `https://github.com/OceanMixingGroup/mixingsoftware`.
The CTD-χpod specific codes are in the folder `/CTD_Chipod`. Codes for processing raw CTD data (.hex format) are contained in `/ctd_processing`.

4 Preferred Data Organziation

- `/Data/raw/Chipod/SNxxxx` : Raw χpod data.
- `/Data/raw/CTD/` : Raw CTD data (.hex,.XMLCON,.hdr).
- `/Data/proc/Chipod` Processed χpod data
- `/Data/proc/CTD` Processed CTD data. (/24Hz,/binned).

5 CTD data

CTD data needs to be obtained and processed before running the χpod processing. Processing requires:

1. 24Hz data: used to determine the time offset between the CTD data and χpod data, by aligning (highpassed) dp/dt from the CTD with w estimated by integrating vertical chipod accelerations. 24Hz temperature is also used to calibrate the chipod temperature voltages and convert to physical units.

2. 1-m binned data: used to calibrate chi-pod T, and calculate dT/dz and N^2.

I prefer to use codes in `/mixingsoftware/ctd_processing/` to process standard Seabird hex files into standard mat files to use in chi-pod processing. See `Process_CTD_hex_Template.m` for an example. The data can be processed using other methods, but must contain the specific fields required by the processing routines as listed below:

5.1 24Hz CTD Data

Required fields for 24Hz CTD data are:

- dnum : datenum
- t : temperature [C]
- p : pressure [db]

5.2 1-m Binned CTD Data

Required fields for binned CTD data

- dnum : datenum
- t : temperature [C]
- p : pressure [db]
- s : salinity [psu]
- lat : Latitude [^{o}]
- lon : Longitude [^{o}]

6 Processing steps

All templates are located in `/mixingsoftware/CTD_Chipod/Templates/`

1. Modify `Load_chipod_paths_template.m` . This specifies filepaths to raw data, as well as where output will be saved.

2. Modify `Chipod_Deploy_Info_template.m` with info for specific deployment. Much of the rest of the processing uses information from the above two files.

3. Plot the raw chi-pod data (`Plot_Raw_Data_template`?). This will let you see quickly if any sensors or files are obviously bad. If there are bad files you can specify these in a `Bad_File` list so they will not be loaded during processing (this is not necessary, but will reduce time loading bad files, and may prevent bad data from accidentally being used). Figure **??** shows an example of a normal-looking file. Figure **??** shows an example of file that looks bad.

4. Modify `MakeCasts_CTDchipod_Template.m` for specific cruise. This script finds χpod data for each cast, aligns the data, calibrates the data, and saves a file with data for each cast.

5. Run `MakeCasts_CTDchipod` for one good cast for each SN. Check time-offset / alignment; if not right, probably need to modify `az_correction` or switch AX and AZ. Figure **??** shows an example of where AX and AZ are flipped. * figures showing example of flipped ax etc*

6. Once that is figured out, run `MakeCasts_CTDchipod` for all casts.

7. Run `SummarizeProc_Template`. This makes some summary tables and figures from the 'Xproc.mat' data saved during `MakeCasts_CTDchipod`.

8. `Plot_TP_profiles_EachCast_Template.m` For each cast, this plots the temperature derivative from all chi pod sensors on the same scale so you can compare them and check for bad profiles.

9. Modify `DoChiCalc_Template.m` and run for all casts. This does the chi calculation for all the cast files made in `MakeCasts_CTDchipod`.

10. `Make_Combined_Chi_Struct_Template`

11. `PlotXCsummaries_Template`. Make summary plots

7 χpod Processing Parameters

Variable parameters for the processing are specified in a 'Params' structure.

- fmax : Maximum frequency to integrate temperature gradient spectrum to (default XX ? Hz).

- gamma : Assumed mixing efficiency (default 0.2).

- `resp_corr` : Option to apply frequency response correction (default 0).

- fc : Cutoff frequency for response correction (if applied) (default 99 for naming purposes).
- `z_smooth` : The distance [m] over which N^2 and dT/dz are smoothed (default 10m).

8 Output File Formats

8.1 cast

'Raw' (ie uncalibrated) χpod data for each cast. Structure 'cast' with fields:

- datenum
- T1 = Temperature [V]
- T1P - dT/dt [V]
- AX - X-acceleration [V]
- AZ - Z-acceleration [V]
- `chi_files` - List of raw chipod files from which data was combined into this structure.
- `time_range` - Time range of CTD cast.
- castname - Name of CTD cast.

Ex. filename :

8.2 cal

Calibrated data for each cast. Up and down casts are saved in separate files. Structure 'C' with fields:

- datenum
- P
- T1P
- fspd
- castidr
- info
- ctd

Ex. filename : `rh10011_SN2013_downcast.mat`

8.3 avg

Result of χpod calculations. Contains data points for each 1 sec window.

- Params
- datenum
- P
- N2
- dTdz
- fspd
- T
- S
- theta
- sigma
- chi1
- eps1
- KT1
- TP1var
- samplerate
- nu
- tdif
- lat
- lon
- castname
- castdir
- Info

Ex. filename : `avg_08402_downcast_SN1013_T1.mat`

9 Notes

There is a template for standard latex notes that can be modified for each cruise/deployment: `Chipod_Notes_Template_AP`.

10 Post-processing Analysis

- Plot χpod time-offsets. The time-offset should drift linearly with time, and may be reset during the cruise. Typically should be less than 20 sec (depends on how accurately time was set). In some cases, the time was set wrong (off by a day, wrong time zone etc.); in this case the processing script needs to be modified to correct this.
- Compare different sensors and cast directions: The quality of data obtained depends heavily on the setup of the CTD and the χpod mounting. Typically the upward looking sensors on the upcasts are the cleanest data.
- Sensitivity to parameters: see details below.

11 Sensitivity Analysis

12 Standard Plots made by processing

- `cast_001_RawChipodTS` (Figure 1).
- `cast_001_w_dTdtSpectraCheck` (Figure 2). This compares the analog dT/dt (T1P) to the differentiated T signal. The spectral amplitudes should agree up to a certain frequency where the digital dT/dt becomes dominated by noise. If the spectra below the noise level don't match, the time-constant used in calibration might need to be modified.
- `cast_001_w_TimeOffset` (Figure 3)
- `cast_001_w_TimeOffset_Zoom` (Figure 4). Shows a zoomed-in period of the time-offset. The two timeseries should match in the lower panel.
- `cast_001_T_P_dTdz_fspd` (Figure 5). Summary of the alilgned and calibrated data.
- `cast_001_upcast_chi_SN600_T1_avg_chi_KT_dTdz` (Figure 6). Summary of the final data ('avg' structure).

13 m-files

Processing files are kept in a GitHub repository `/mixingsoftware/CTD_Chipod/mfiles/`

- `AlignChipodCTD` : Align CTD and chipod data.
- `Compute_N2_dTdz_forChi`
- `get_chipod_chi` : Main function that does chipod calculation.
- `load_chipod_data`
- `MakeCtdChiWindows`
-

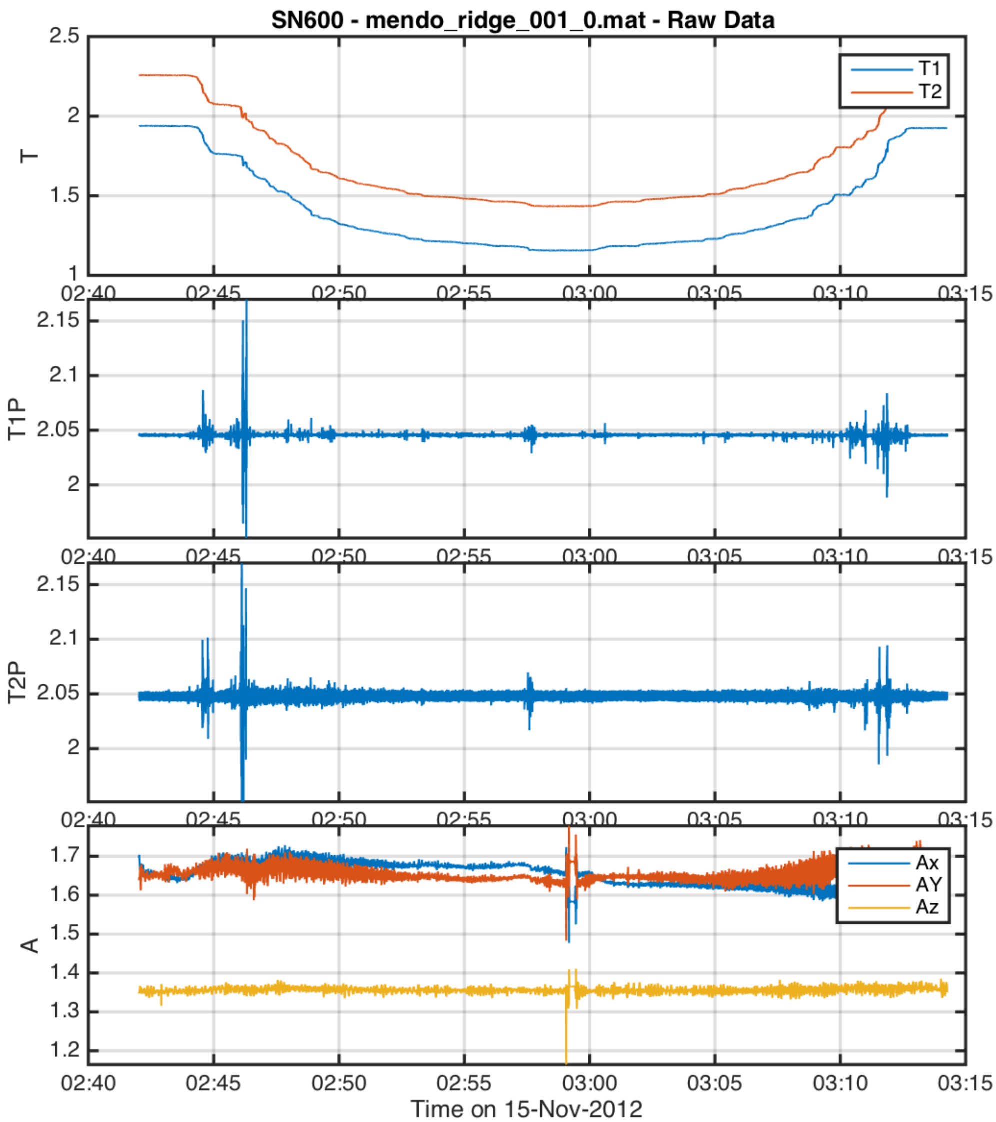

Figure 1: Time-series of raw χpod data for one cast.

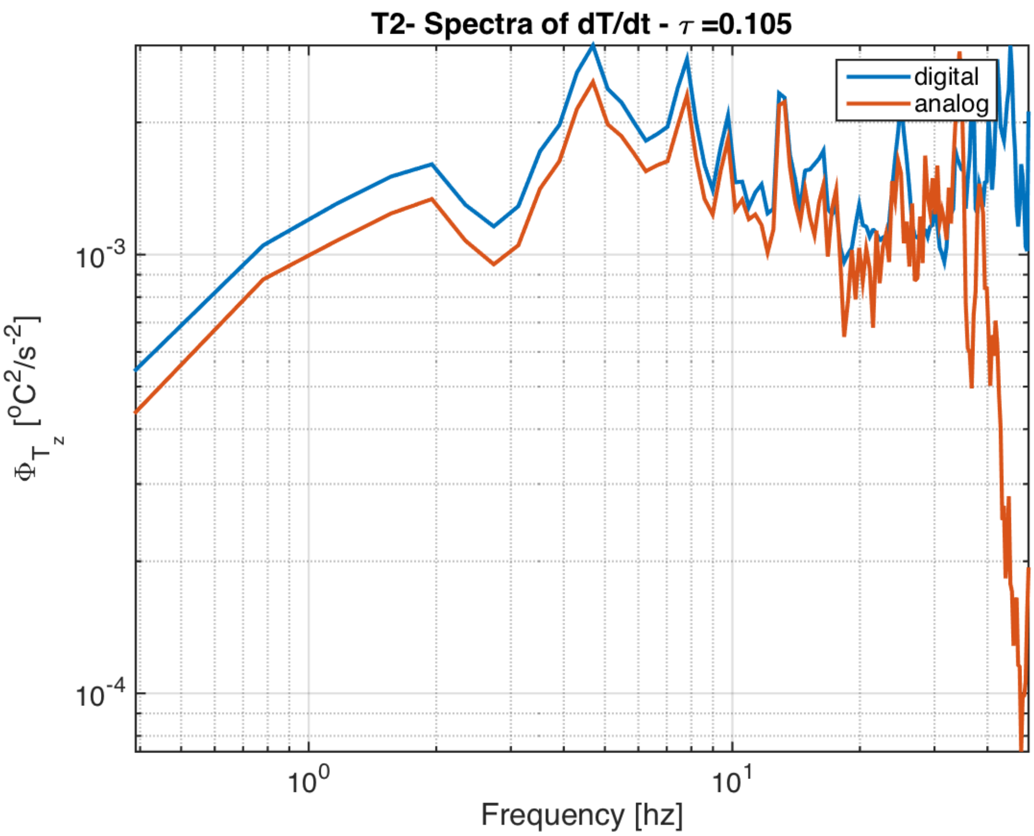

Figure 2: dT/dt spectra for analog (TP) and digital derivatives. Spectra levels should match; if not time-constant may be wrong.

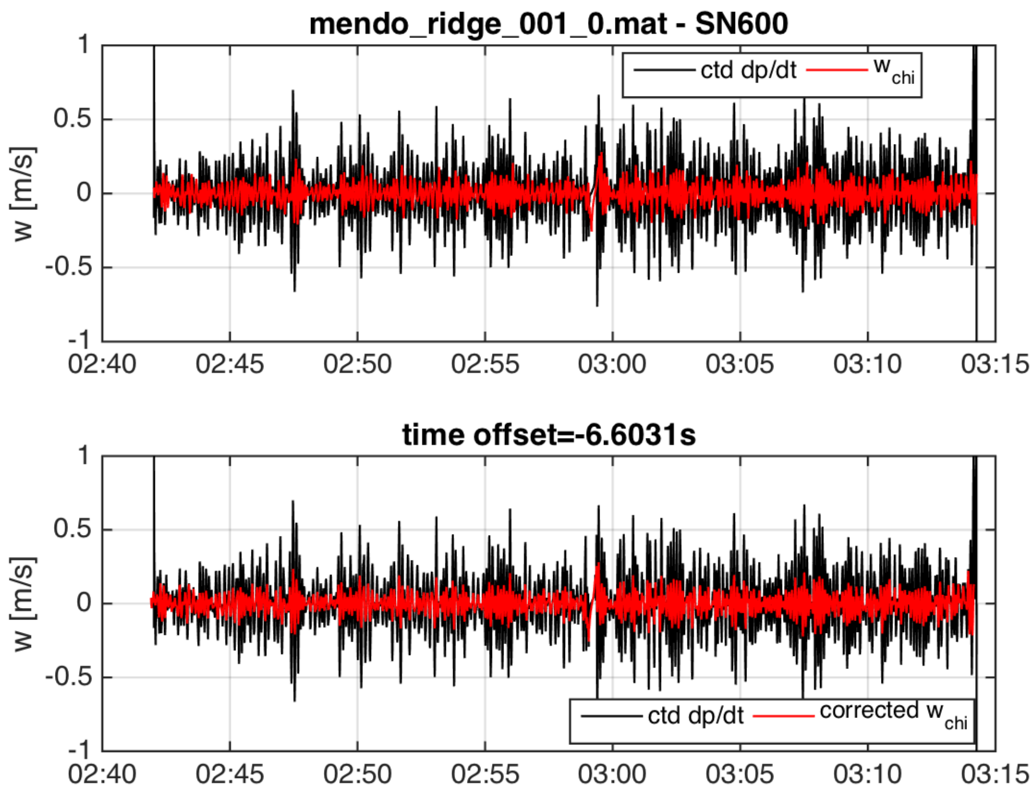

Figure 3: Time series of dp/dt CTD and chipod w. Top is original, bottom is after time-offset applied to chipod.

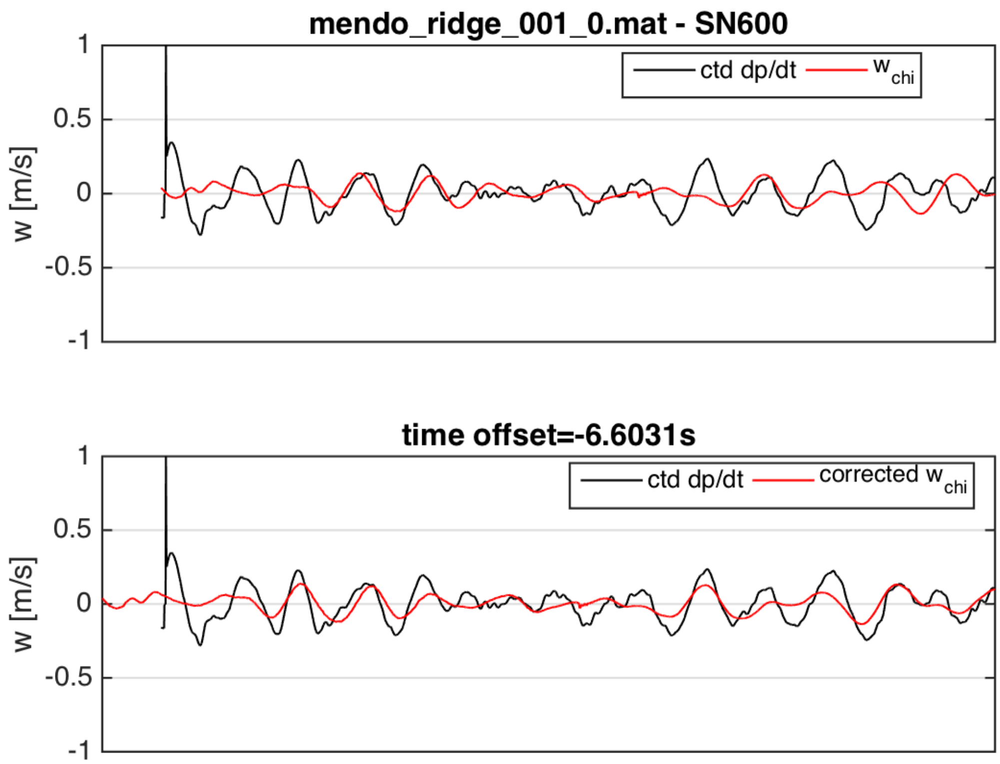

Figure 4: Zoom-in of dp/dt and chipod w allowing one to check if time-offset is correct. Bottom panel should match.

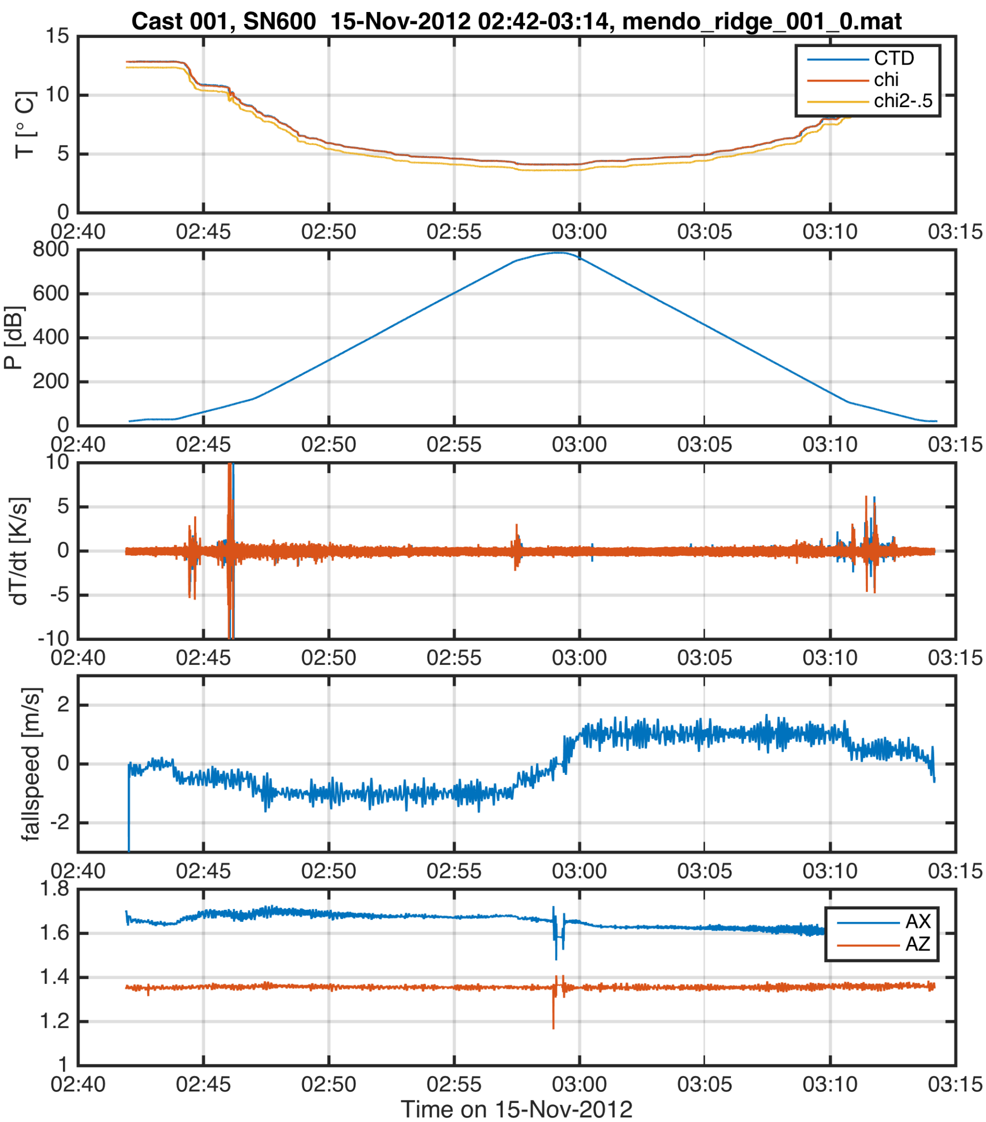

Figure 5: Time series of aligned and calibrated chipod data for one cast.

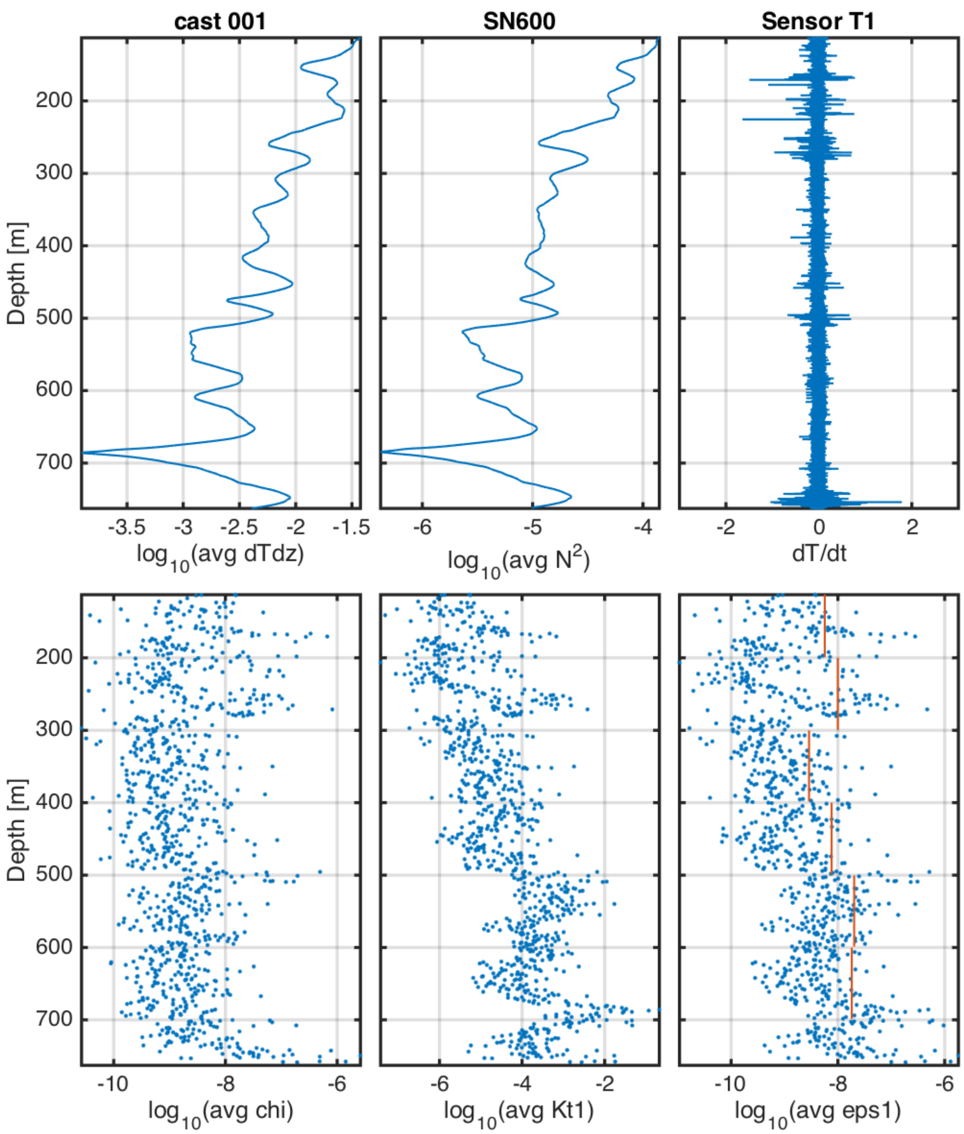

Figure 6: Results of chipod calculation for one cast. Red lines in lower panel are 100m? binned averages.