Patch/Gamma Analysis for TIWE chameleon patches

Andy Pickering

March 16, 2017

Contents

1 Overview

The goal of this analysis is to estimate the mixing coefficent ($\gamma_{\chi\epsilon} = \frac{N^2\chi}{2\epsilon T_z^2}$) for patches in TIWE chameleon profiles, and see if we obtain values close to the normally-assumed $\gamma = 0.2$. Results are also compared to previous estimates used in Smyth et al 2001. The motivation for this analysis came from working on CTD-χpod data; the method assumes $\gamma = 0.2$, but it was found for some (1m binned) data this was not true. Therefore the method might need to be applied to patches instead.

2 Data

Data are made by the 'Chameleon' microstructure profiler near the equator during the 'TIWE' experiment. Data was shared by JN and my local copy is at:
`/Users/Andy/Dropbox/AP_Share_With_JN/date_from_jim/Tiwe91`

I'm using the raw Chameleon data files in:
`/Users/Andy/Dropbox/AP_Share_With_JN/date_from_jim/Tiwe91/cham/tw/`

All my analysis is in the main folder:
`/Users/Andy/Cruises_Research/ChiPod/TIWE`

3 Methods

- `Run_tiwe_AP.m` Runs the standard Chameleon processing, producing 1m avg quantities. I modifed this from `run_tw91.m`.
- `Combine_tiwe_avg_profiles.m` Combines the avg profiles made in `Run_tiwe_AP.m` into a single structure with common depths.
- `Process_tiwe_rawprofiles_AP.m` Processes raw Chameleon files and saves 'cal2' files which have the raw/ high-res profiles of temp and salinity. These are used to identify patches. χ and ϵ are not computed for these.
- `FindPatches_tiwe_Raw.m` Identifies patches in each profiles made by `Process_tiwe_rawprofiles_AP.m`, using potential temperature.
- `Compute_N2_dTdz_patches_tiwe_eachcast.m` Computes N^2 and T_z for patches, using several different methods. Saves results for each profile in a structure 'patches'.
- `add_binned_to_patches.m` Adds the binned (ie the standard 1m avg values) χ and ϵ to the profiles of patches at patch locations. Binned profiles are interpolated to patch depths.

- `Run_tiwe_AP_forPatches.m` Runs the Chameleon processing (including χ and ϵ) for just the patches identified in `FindPatches_tiwe_Raw.m` . This calls `average_data_PATCH_AP.m` instead of `average_data_gen1.m`.
- `add_patch_chi_eps_to_patches_tiwe_each_profile.m` adds the values of χ and ϵ from `Run_tiwe_AP_forPatches.m` to the patch profiles.
- `combine_patch_profiles.m` combines all the individual patch profiles into a single structure.

3.1 Overturns

Overturns (patches) are detected for each profile, using potential temperature (because salinity was noisy/spiky, see later section). The function `compute_overturns_discrete_AP.m` was used to identify patches.
The following criteria were also applied:

- Values of $\epsilon < 0.4 \times 10^{-9}$ were NaN'ed out, following the methods of Smyth et al 2001. Note the paper says 4×10^{-9} but I think that was a type based on looking at the data Bill sent me.
- Smyth et al 2001 used a minimum patch size of 15cm, and any patches separated by less than 15cm were joined together. We use a 40cm minimum in order to be able to calculate calculate accurate χ and ϵ from spectra.
- Only patches in the depth range 60-200m were used (as in Smyth et al 2001). This excludes mainnly buoyancy-driven turbulence associated with the diurnal cycle.
- For each patch, a linear fit is performed of salinity vs temperature and R^2 is computed to quantify how clear the T-S relationship is. We examine the results both with and without a minimum R^2 criterion

3.2 dTdz

Temperature gradient is computed for each patch using the following methods:

1. $dtdz_{line}$: Fit a straight line to sorted potential temperature using `polyfit`
2. $dtdz_{bulk}$: Use the 'bulk gradient' from Smyth et al 2001, which is the rms fluctuation from the background (sorted) temperature, divided by the thorpe scale (the rms re-ordering distances).

3.3 N2

N^2 is computed for each patch using the following methods:

1. N_{line}^2 : Fit a straight line to sorted potential density using polyfit to get $d\rho/dz$, then compute N2.

2. $N_l^2 ine_f it$: Salinity/density are computed from the T-S fit. Then N^2 is computed from the sorted density by fitting a line.

3. N_{bulk}^2 : Use 'bulk gradient' . This is calculated from the bulk T_z, using a linear fit between density and temperature in each patch.

4. N_4^2 : Compute N^2 from the sorted profile (sorted by potential density) using `sw_bfreq`, then take average over the patch. I believe this method is used by some commonly-used overturn codes.

3.4 Mixing coefficient (Efficiency)

Mixing coefficient $\gamma_{\chi\epsilon}$ (often referred to as efficiency) is computed from the following equation using differerent N^2 and dT/dz values.

$$\gamma_{\chi\epsilon} = \frac{N^2\chi}{2\epsilon T_z^2} \tag{1}$$

χ and ϵ are computed over each patch from the Chameleon data. $\gamma_{\chi\epsilon}$ is computed for the following 4 combinations:

1. γ_{bin} : Binned (1m) γ interpolated to patch depths.

2. γ_{line} : N_{line}^2, $dtdz_{line}$

3. γ_{bulk} : N_{bulk}^2, $dtdz_{bulk}$

4. γ_{range} : N_4^2, $dtdz_{line}$

4 Results

- Figure 1 shows a summary of the 1m-binned data. Ydays 324-327 correspond to cast numbers 2836 : 3711. For some reason many χ values below 150db are bad/missing? Not sure why.

- The median $\gamma_{\chi\epsilon}$ computed using the 1m avg data is 0.056 (Figure 3).

- Median patch values of γ are given in table 1 and histograms in Figure 4.

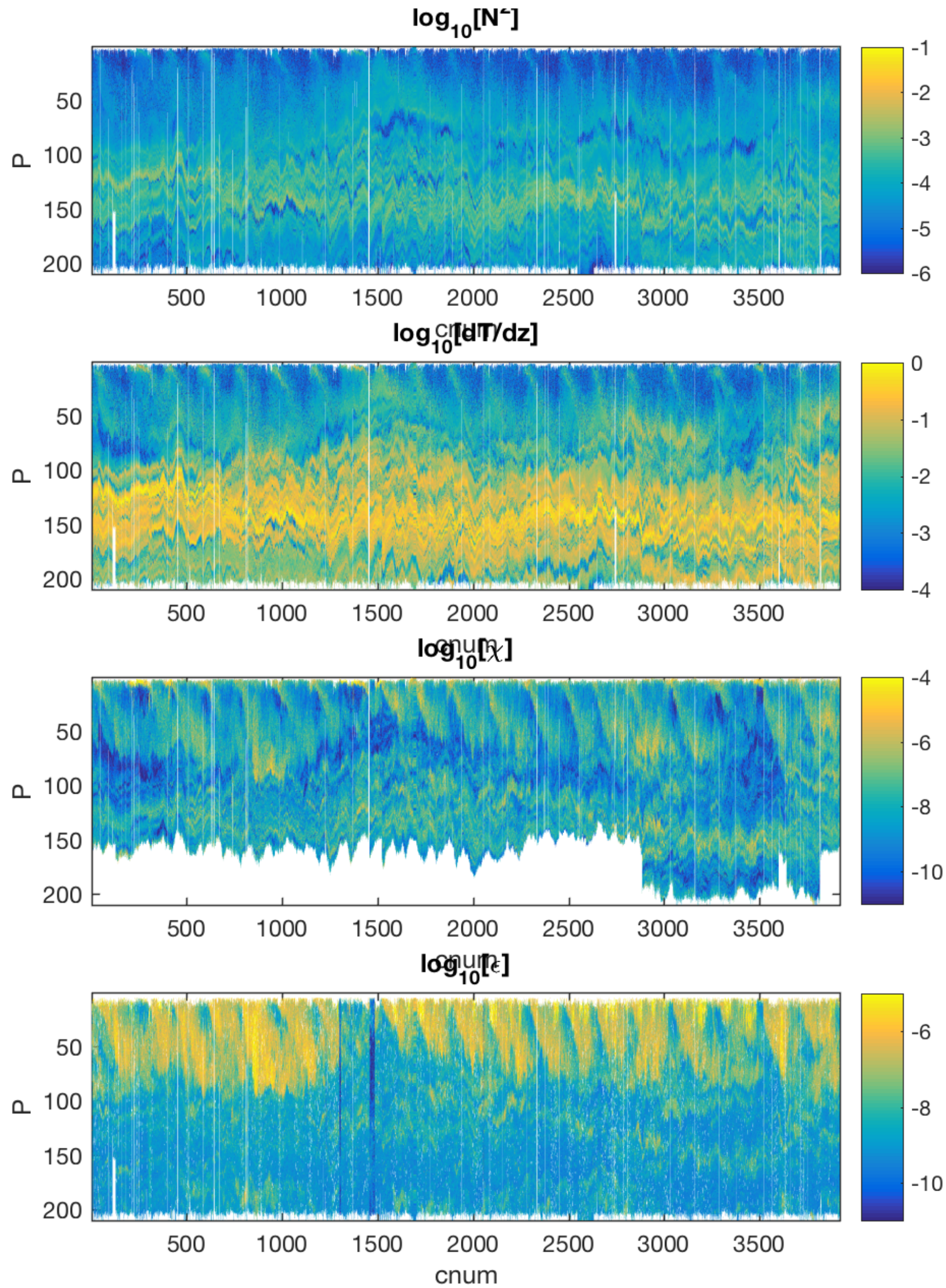

Figure 1: Pcolor of the combined 1m avg chameleon data for TIWE. * Note for some reason many χ values below 150db are bad/missing.

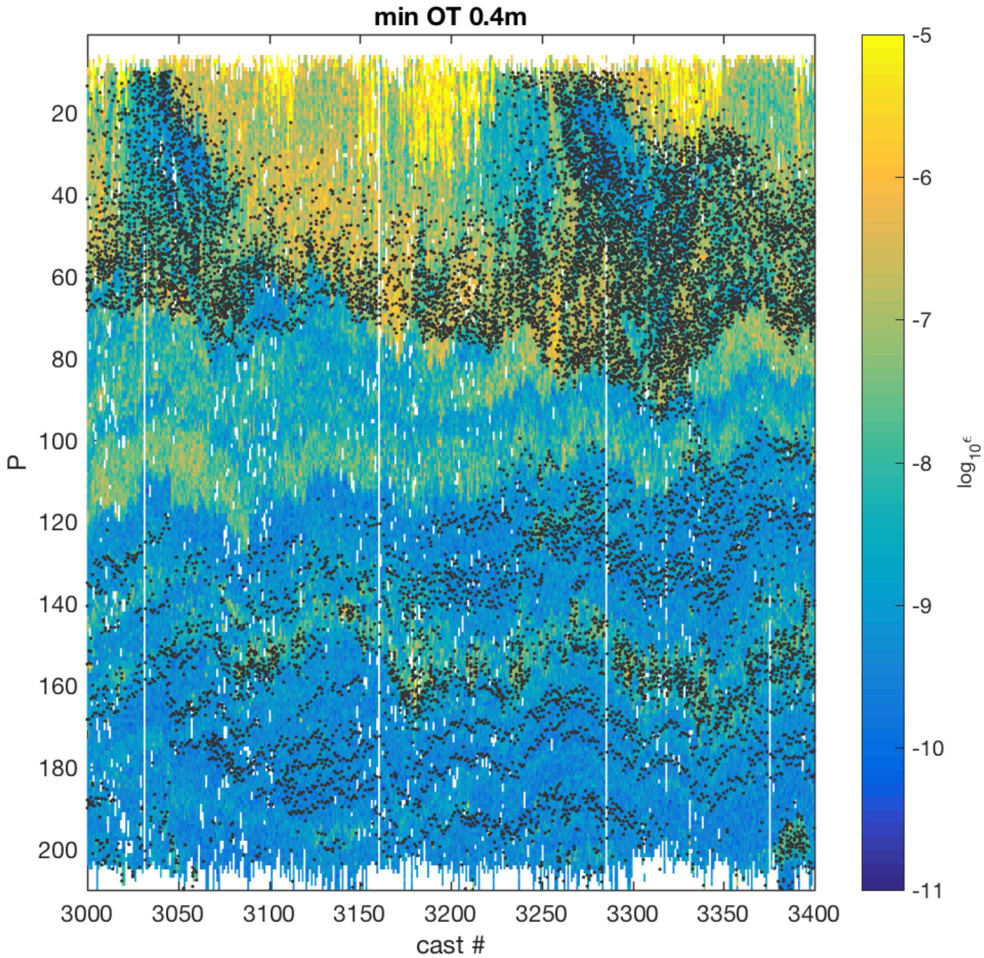

Figure 2: Pcolor of the combined 1m avg chameleon epsilon for TIWE, and patch locations for a period between yday 324-327. Patches above 60m have not been discarded yet.

Table 1: Statistics for patches using various parameters. γ values are medians for each distribution. Only patches between 60-200m and on yday 324-327 are considered for all.

minOT	usetemp	minR2	γbin	$\gamma line$	γfit	$\gamma bulk$	Npatches
0.4	1	0	0.13	0.57	0.11	0.53	16329
0.4	1	0.5	0.14	0.22	0.12	0.21	3761
0.75	1	0	0.15	0.62	0.14	0.59	9175
0.75	1	0.5	0.15	0.25	0.16	0.26	2358
1	1	0	0.16	0.71	0.15	0.68	6893
1	1	0.5	0.16	0.29	0.17	0.29	1779

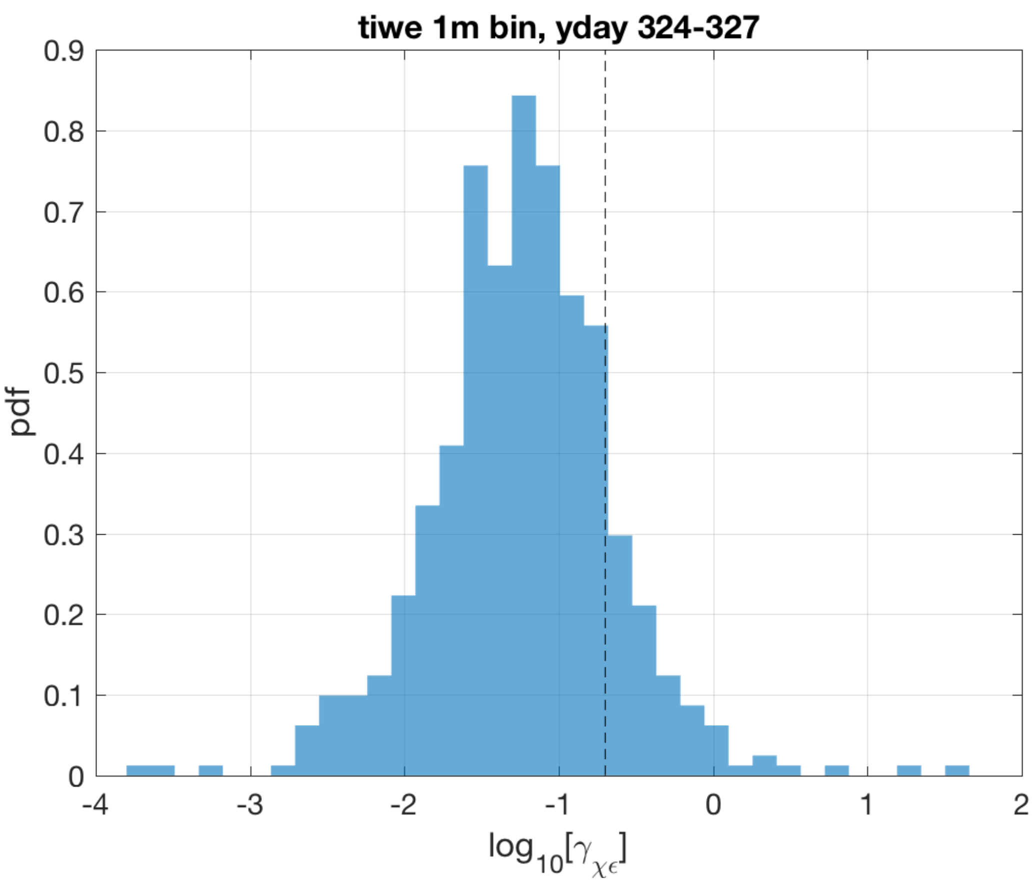

Figure 3: Histogram of $\gamma_{\chi\epsilon}$ for 1m avg chameleon profiles on yday 324-327, between 60-200m(no patch analysis applied). Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$.

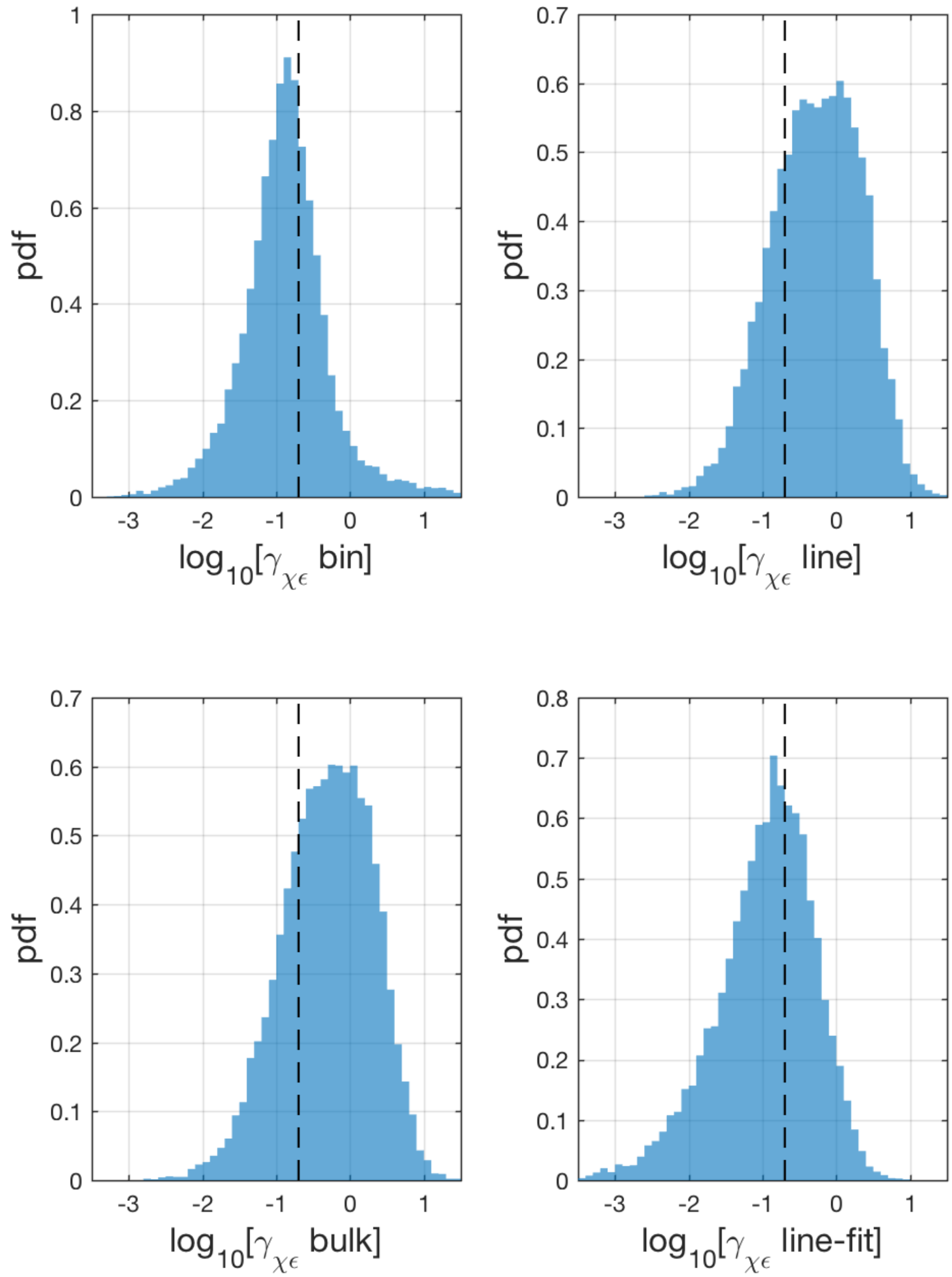

Figure 4: Histogram of $\gamma_{\chi\epsilon}$ for patches using temperature and min OT size of 40cm, using different estimates of N^2 and T_z. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

4.1 Temp vs Density

Comparing overturns compute from temperature vs those computed vs density. Ideally we would use density, but salinity in this dataset looks very noisy/spiky, which could introduce false overturns. Using temperature would avoid this, but only works if there is a tight T-S relationship. This does not appear to be the cast here (Figure 5). Manual inspection fo some profiles also showed overturns that were identified in temperature, but were stable in density due to the influence of salinity. So what to do? Use density, but smooth or lowpass filter salinity? Or use a larger minimum overturn size ?

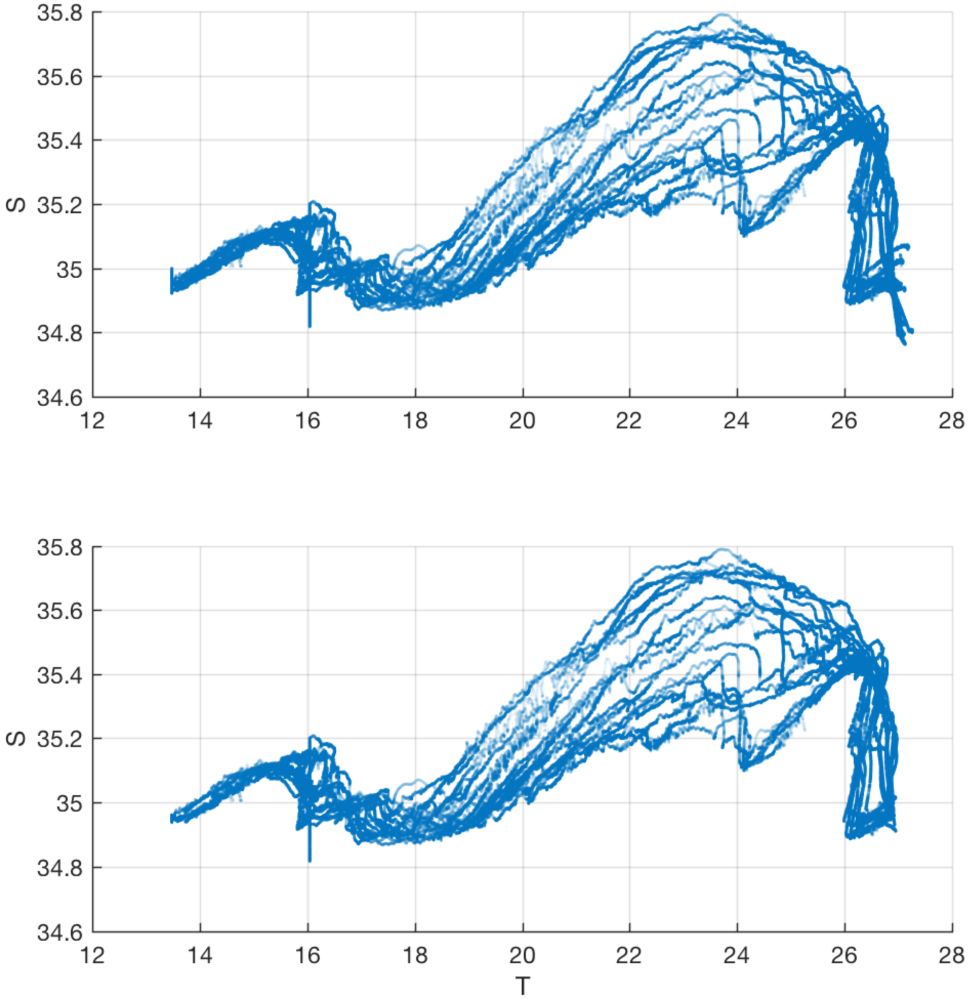

Figure 5: Raw T vs S for a subset of TIWE Chameleon profiles between yday 324-327 (corresponding to data used in Smyth et al).

4.2 γ vs depth

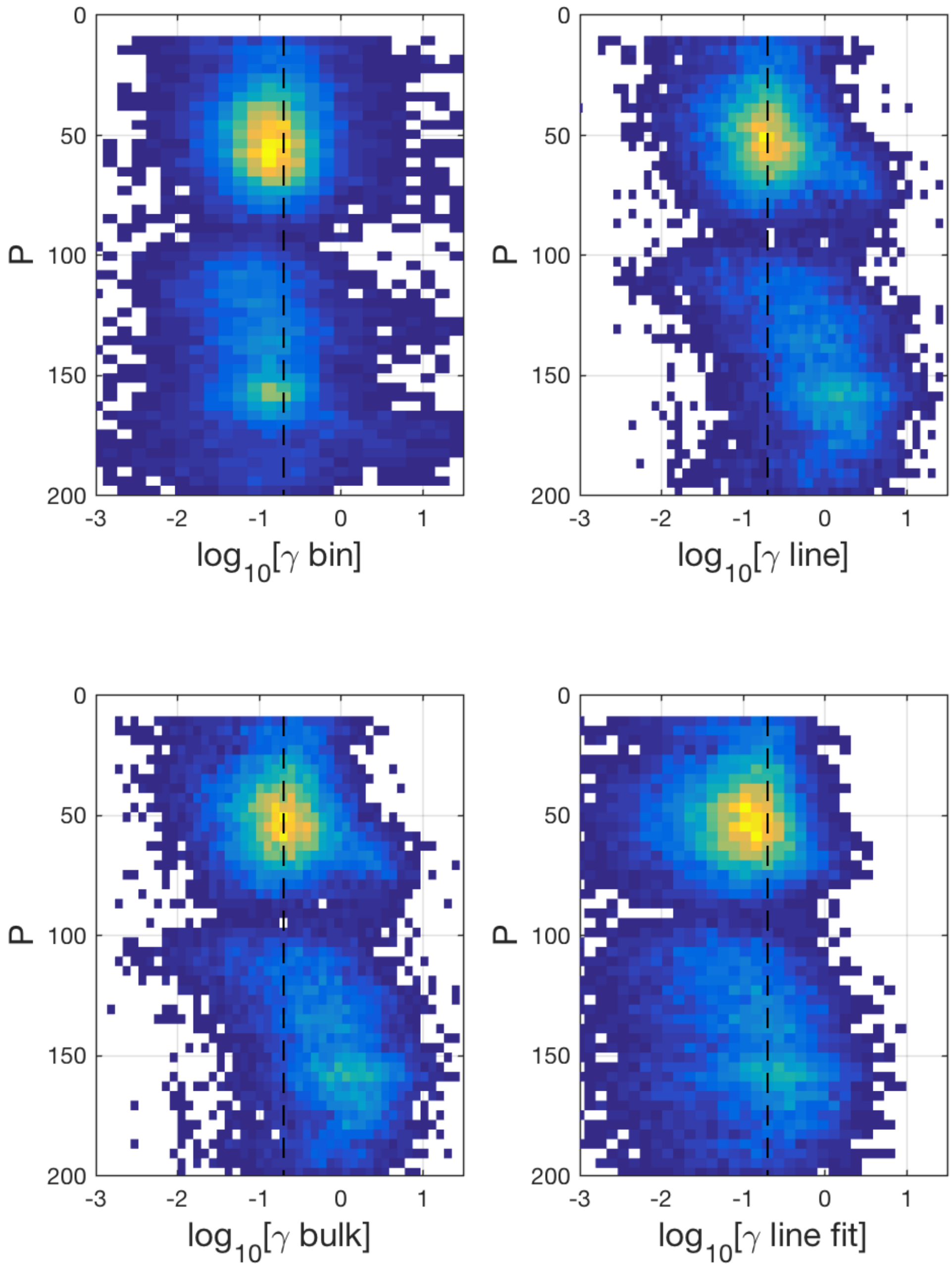

Figure 6: Plot of $\gamma_{\chi\epsilon}$ vs depth for patches identified from temperature with min OT size 40cm. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

4.3 γ vs ϵ

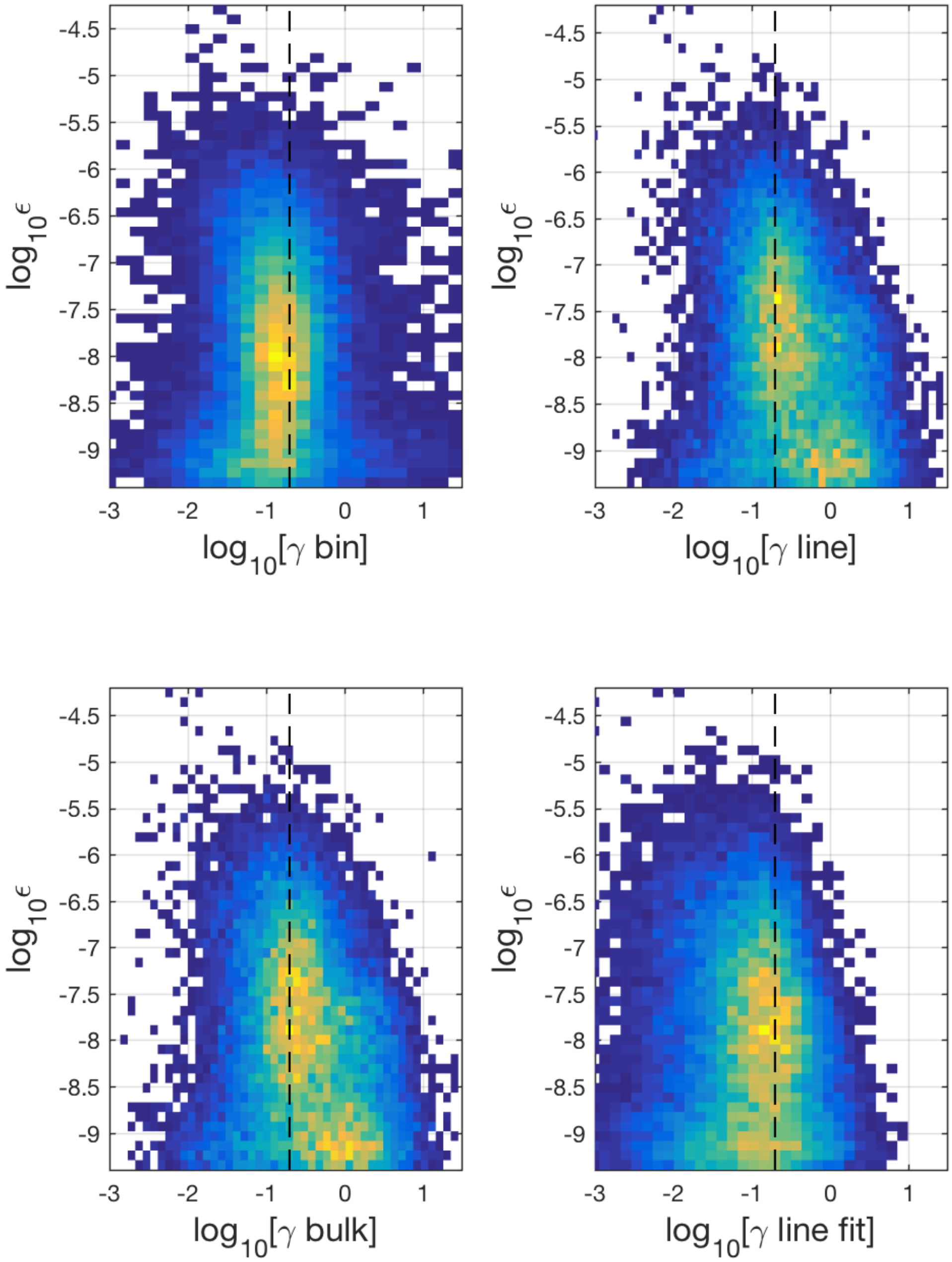

Figure 7: Plot of $\gamma_{\chi\epsilon}$ vs ϵ for patches computed from temperature with min OT size 40cm. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 .

5 Comparison to previous analysis

Bill send me results of a previous patch analysis for tiwe: `events_TIWE.mat` . Here i'll compare my results to those. His dataset contains 1155 patches, with a mean γ of 0.45 . See `compare_patches_tiwe_AP_Bill.m` . It looks like my values of T_z, and χ tend to be significantly smaller than Bill's (Figure 8).

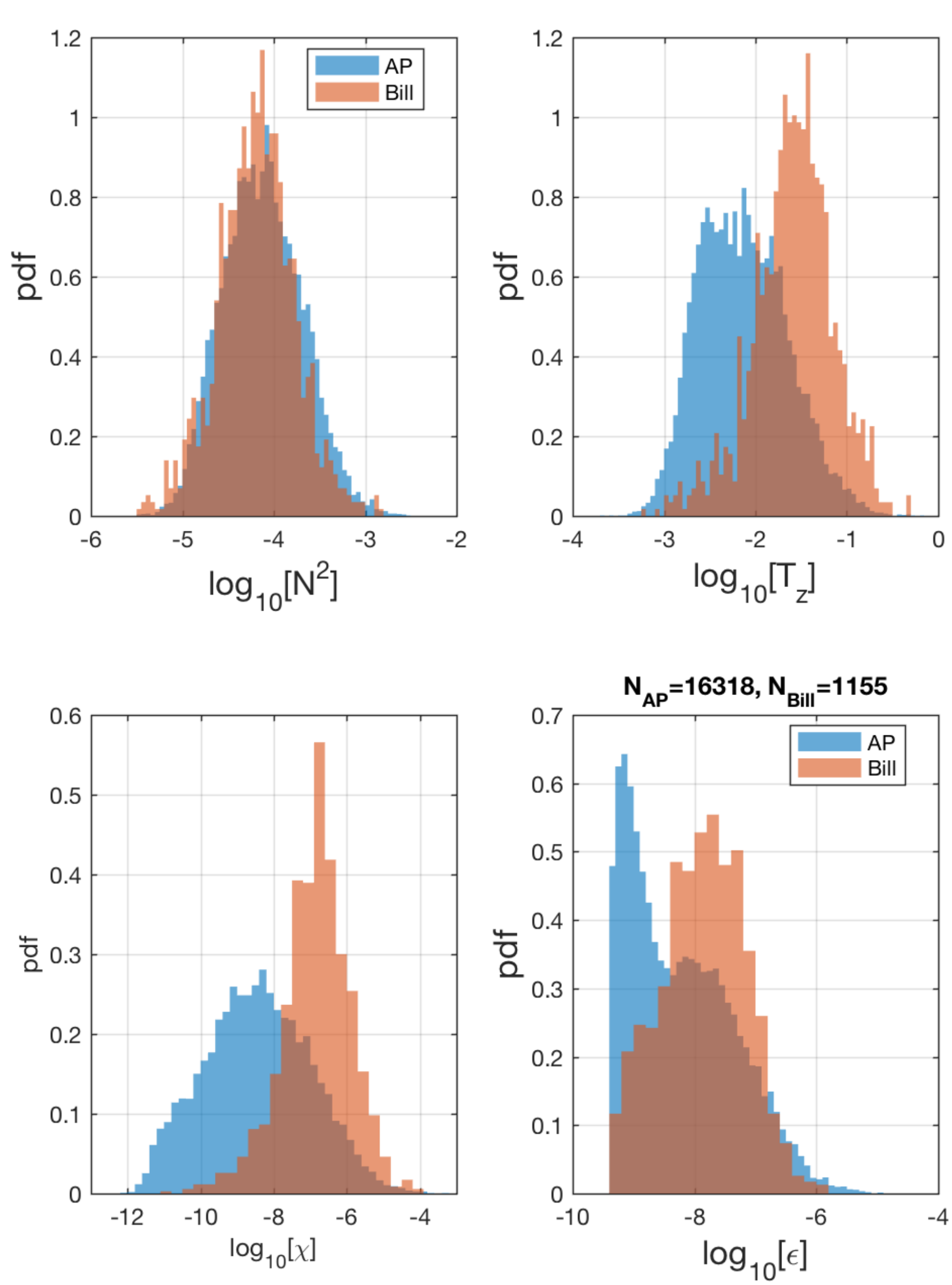

Figure 8: Histograms of N^2 , T_z, χ, and ϵ for patches analyzed by myself and Bill. Data for profiles on yday 324-327, between 60-200m depth.

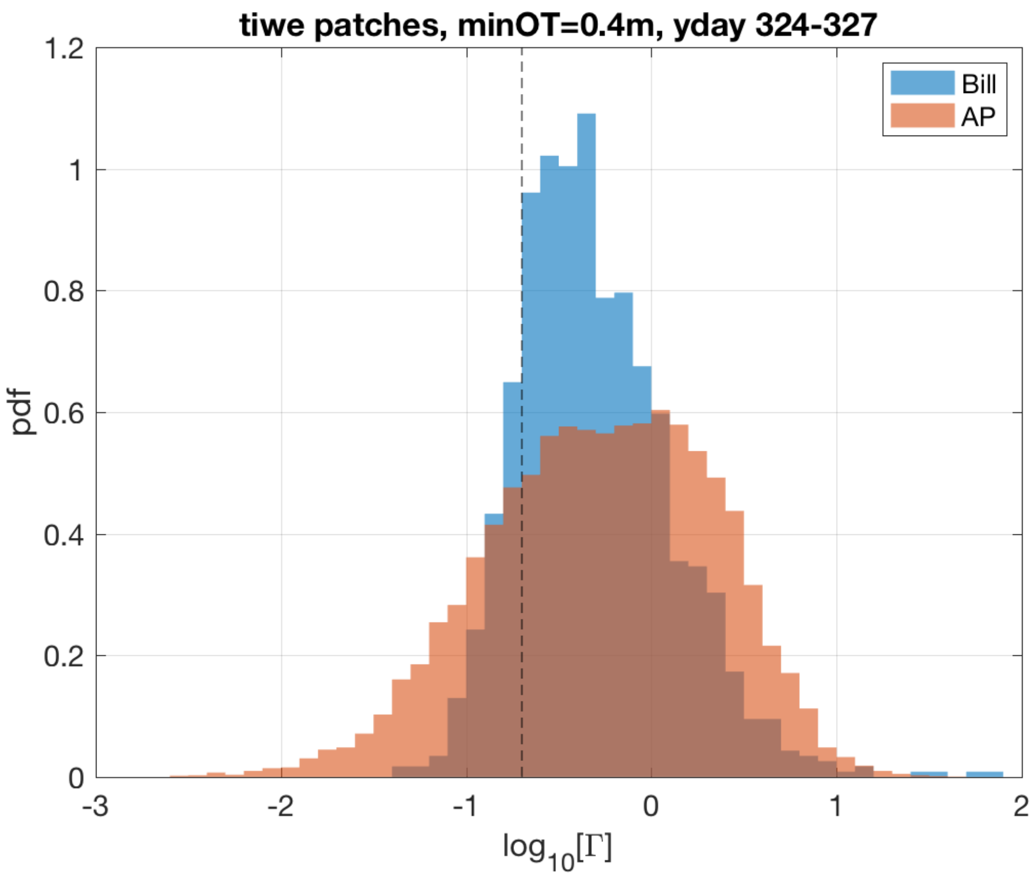

Figure 9: Histograms of $\gamma_{\chi\epsilon}$ for patches analyzed by myself ('line' method) and Bill. Data for profiles on yday 324-327, between 60-200m depth.