Patch/Gamma Analysis for TIWE chameleon patches

Andy Pickering

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Contents

1 Overview

The goal of this analysis is to compute 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 $\Gamma = 0.2$.

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.
`compute_overturns_discrete_AP.m` was used to identify patches.
Following Smyth et al 2001, the following criteria were also applied:

- Values of $\epsilon < 0.4 \times 10^{-9}$ were NaN'ed out. Note the paper says 4×10^{-9} but I think that was a type based on looking at the data Bill sent me.

- A minimum patch size of 15cm, and any patches separated by less than 15cm were joined together.

- Only patches in the depth range 60-200m were used.

Smyth et al 2001 also have an additional criteria that compares the Thorpe scale from temperature to the Thorpe scale from density and require the ratio to be in a certain range. I have not implemented this yet; i'm not sure how to compute that ratio since the patch boundaries computed from temperature and density wont' necessarily match?

3.2 dTdz

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

1. $dtdz_{range}$: Take the range of T over the patch and divided by patch height

2. $dtdz_{line}$: Fit a straight line to sorted T using `polyfit`

3. $dtdz_{bulk}$: 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^2_{range} : Take the range of potential density over the patch divided by the patch height $(d\rho/dz)$, then compute $N^2 = \frac{-g}{\rho_o}\frac{d\rho}{dz}$ where ρ_o is the mean potential density over the patch.

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

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

4. N^2_4 : 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 $\gamma_{\chi\epsilon}$ 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_{range} : N^2_{range}, $dtdz_{range}$

2. γ_{line} : N^2_{line}, $dtdz_{line}$

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

4. γ_{range} : N^2_4, $dtdz_{line}$

Values where ϵ is below the noise floor of $log_{10}[\epsilon] = -8.5$ are discarded.

4 Results

- 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 0.063 (Figure 3).

- Gammas computed over patches is larger than the binned gamma, and vary with method. (Figure 4).

4.1 γ vs depth
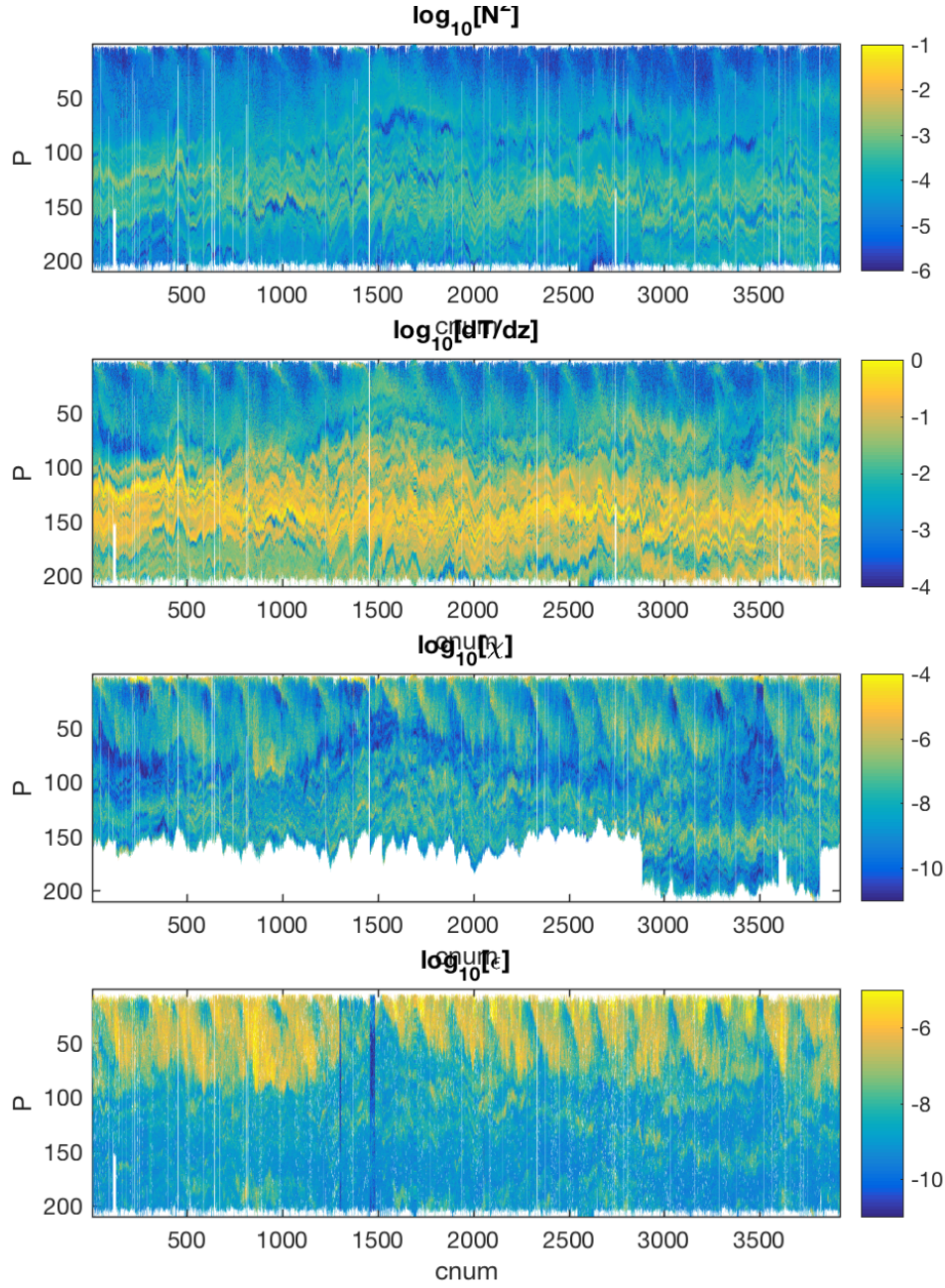
4.2 γ vs ϵ

Figure 1: Pcolor of the combined 1m avg chameleon data for TIWE. * Note for some reason many χ values below 150db are bad/missing.
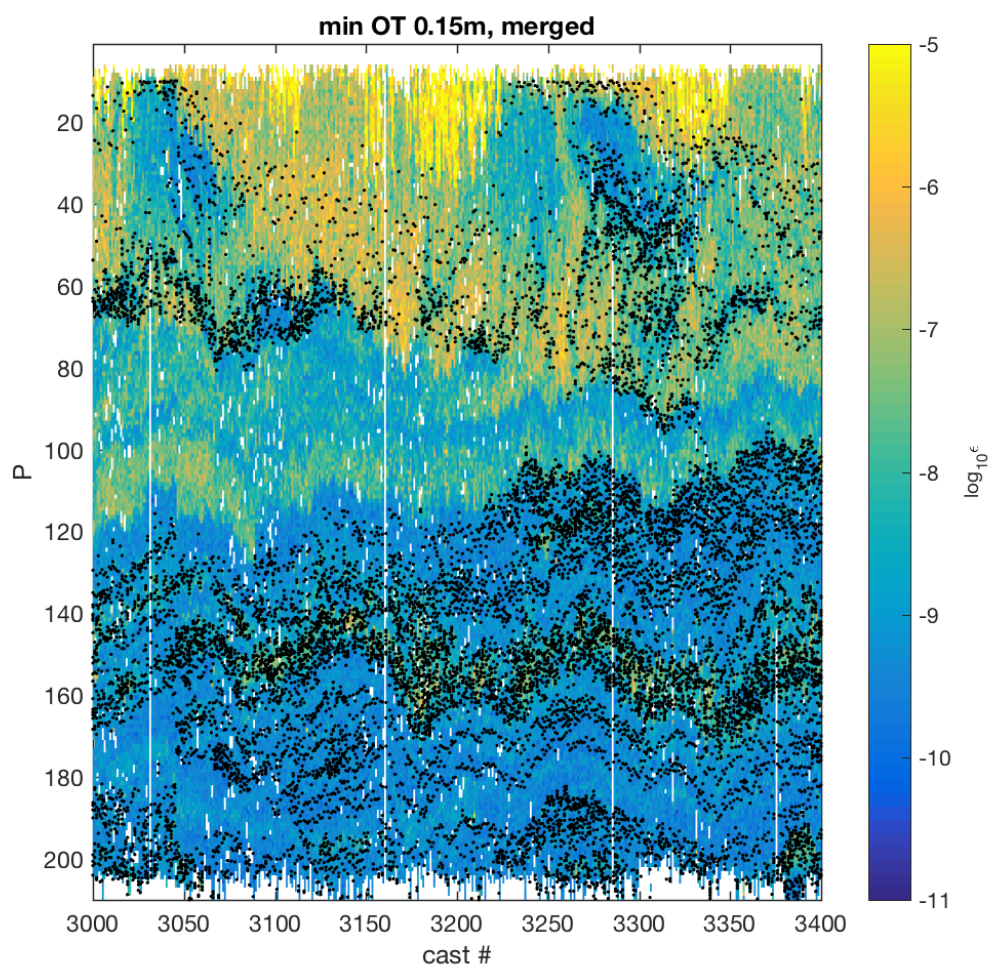
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Figure 2: Pcolor of the combined 1m avg chameleon epsilon for TIWE, and patch locations for a period between yday 324-327. Patches above 60m have not been discarded yet.
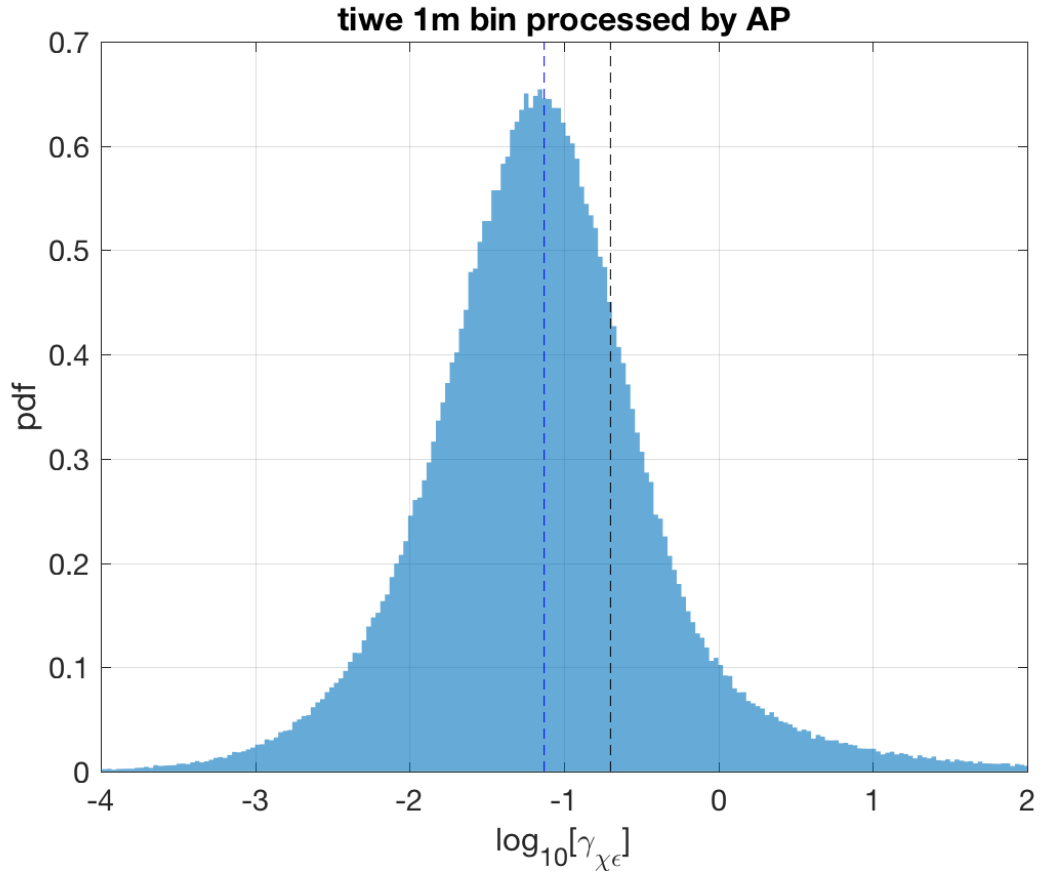
Figure 3: Histogram of $\gamma_{\chi\epsilon}$ for 1m avg chameleon profiles (all data, no patch analysis applied). Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$.
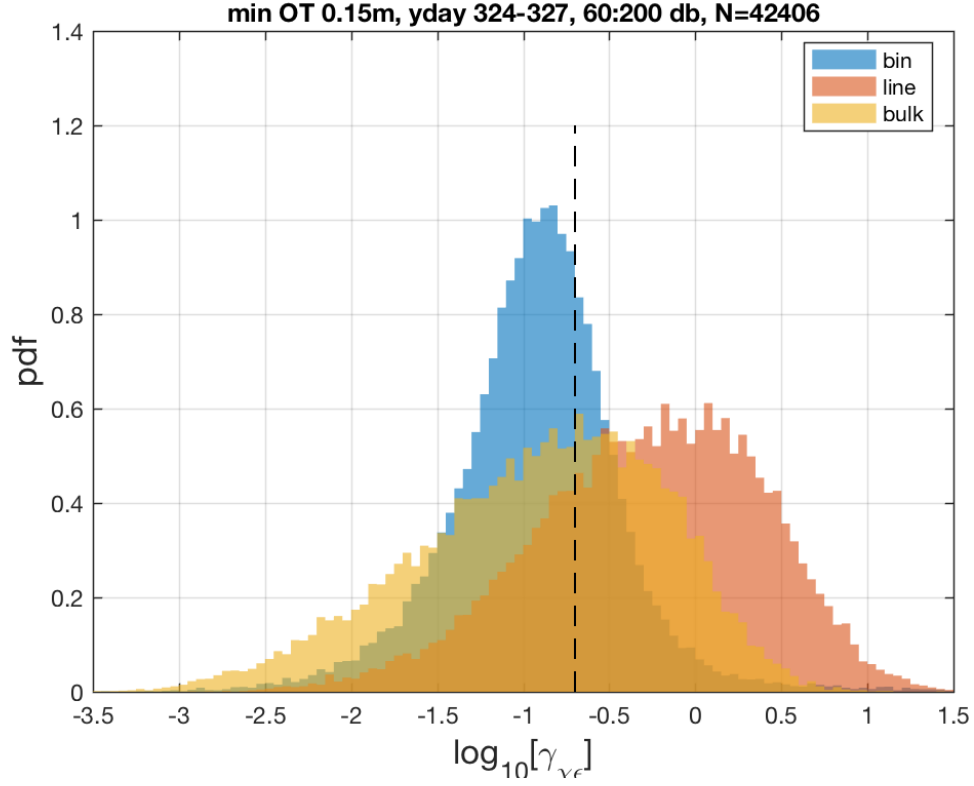
Figure 4: Histogram of $\gamma_{\chi\epsilon}$ for patches, using different estimates of N^2 and T_z. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).
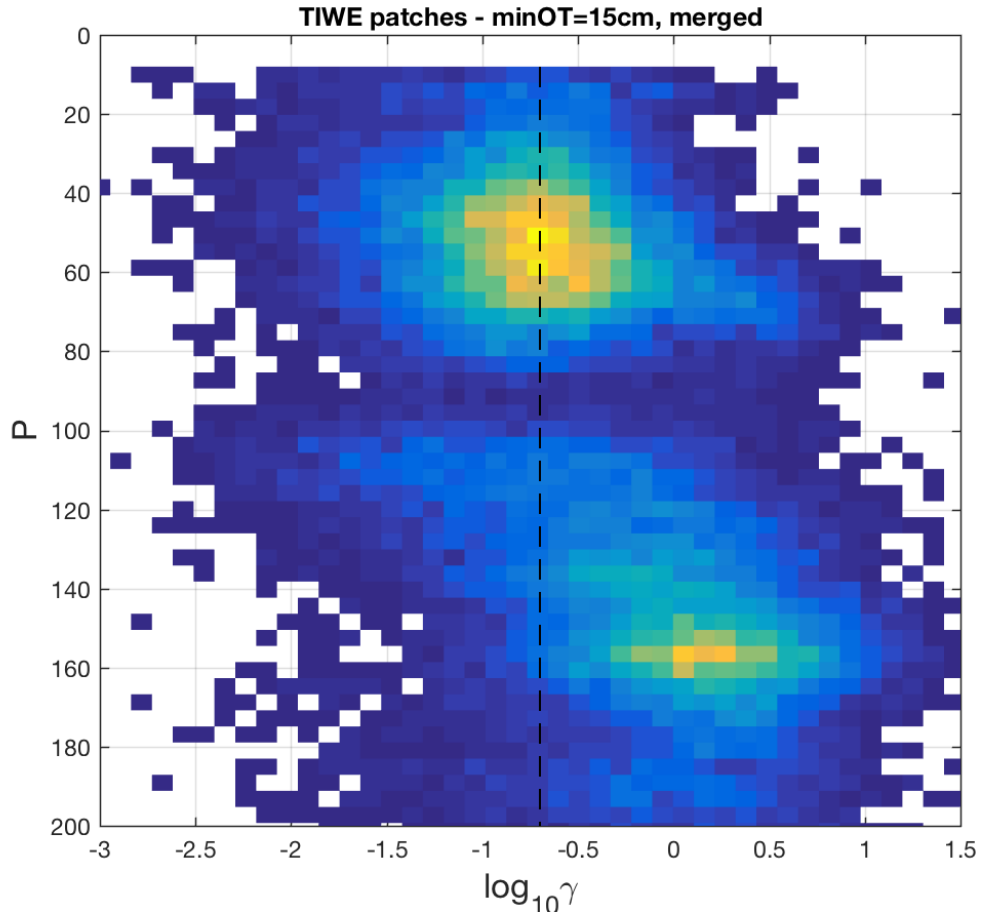
Figure 5: Plot of $\gamma_{\chi\epsilon}$ vs depth for patches. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).
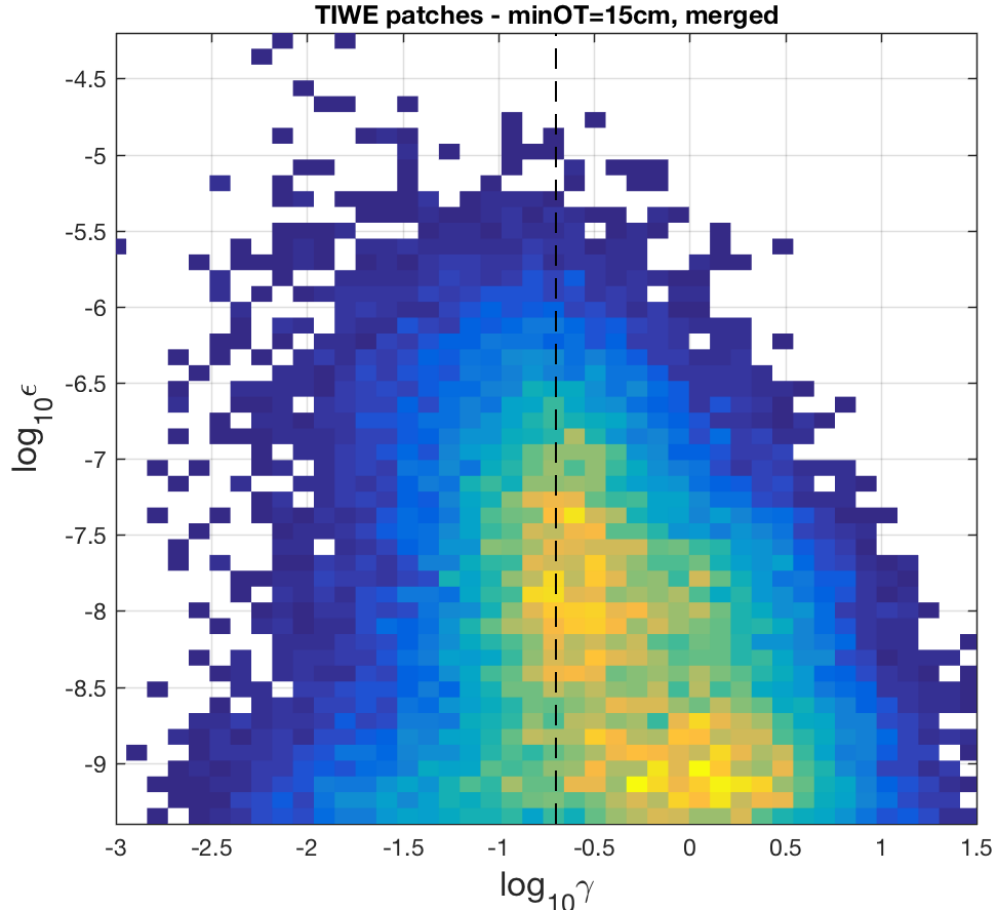
Figure 6: Plot of $\gamma_{\chi\epsilon}$ vs ϵ for patches. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

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. 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 7). Gamma computed from my patch values (using all profiles) is smaller than 0.2 (median 0.08), while gamma from Bill's values is larger than 0.2 (median 0.4),(Figure 8).

* Note that in Smyth et al 2001, it says patches where $\epsilon < 4 \times 10^{-9}$ were discarded. But there are epsilon values smaller than this in the data Bill shared (bottom=-right of Figure 7)?
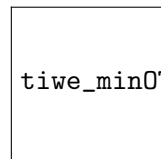
`tiwe_minOT_25_usetemp_1_n2_tz_chi_eps_apvsbill_hist_yday_307_329.png`

Figure 7: Histograms of N^2 , T_z, χ, and ϵ for patches analyzed by myself and Bill. Data for *all* profiles.

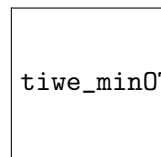`tiwe_minOT_25_usetemp_1_gam_apvsbill_hist_yday_307_329.png`

Figure 8: Histograms of $\gamma_{\chi\epsilon}$ for patches analyzed by myself and Bill. Data for *all* profiles.

5.1   Yday 324-327

I noticed that in Smyth et al 2001, only data from ydays 324-327 is used for the TIWE patches. So I remade the previous figures using only data from that time period (Figures 9,10). Using this data, I get gammas centered around 0.2 and close to Bill's estimates.
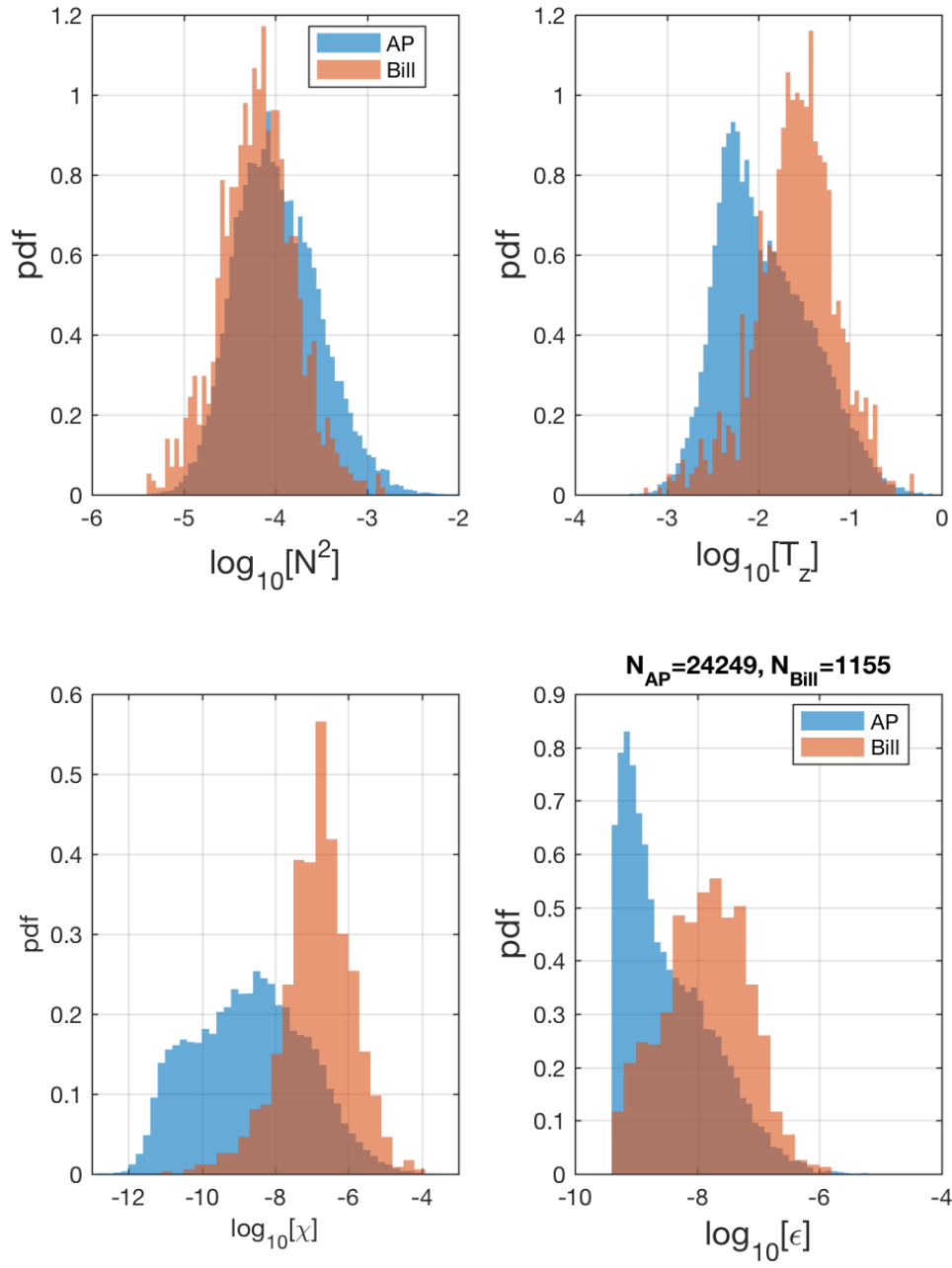
Figure 9: Histograms of N^2, T_z, χ, and ϵ for patches analyzed by myself and Bill. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).
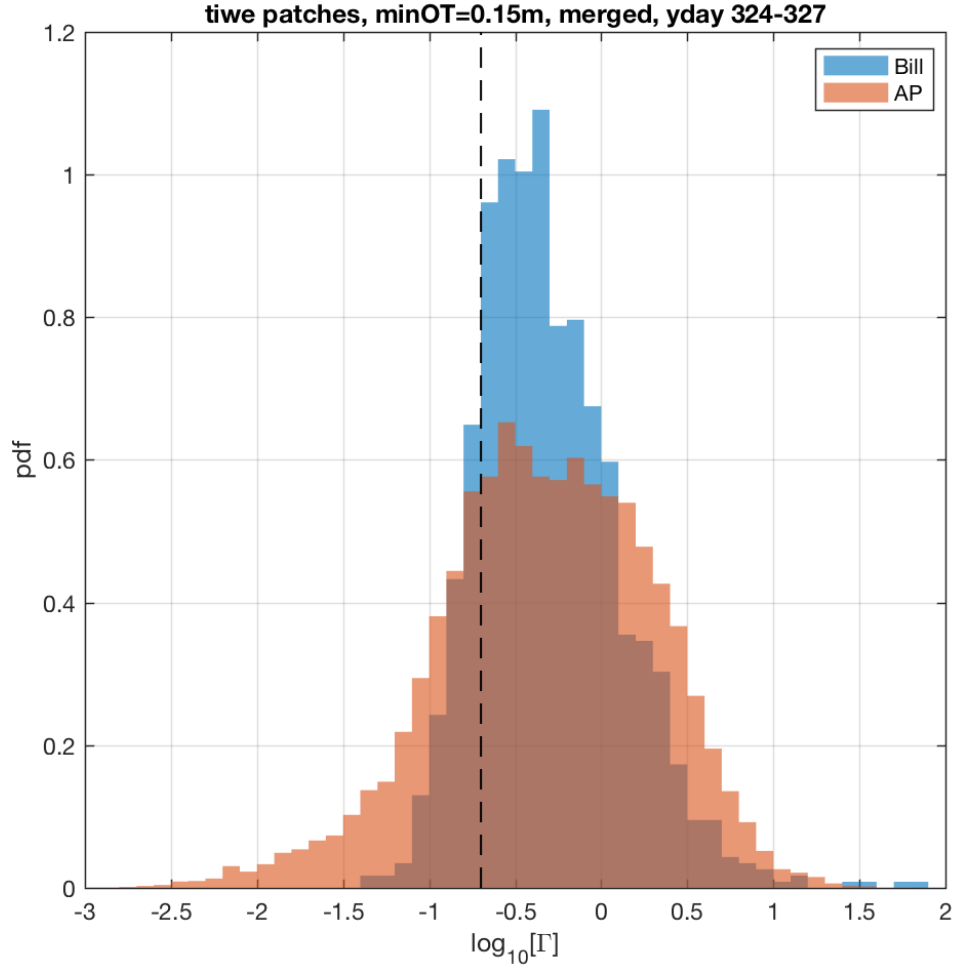
Figure 10: Histograms of $\gamma_{\chi\epsilon}$ for patches analyzed by myself and Bill. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

5.2 Variation of $\gamma_{\chi\epsilon}$ over time

Since it appears that $\gamma_{\chi\epsilon}$ can vary for different time periods, I wanted to investigate this more. I plotted $\gamma_{\chi\epsilon}$ vs yday (Figure 11). It looks like the median $\gamma_{\chi\epsilon}$ is smaller than 0.2 for ydays less than 315, and then about equal to 0.2 after that (a few days are abnormal and might not have many profiles).
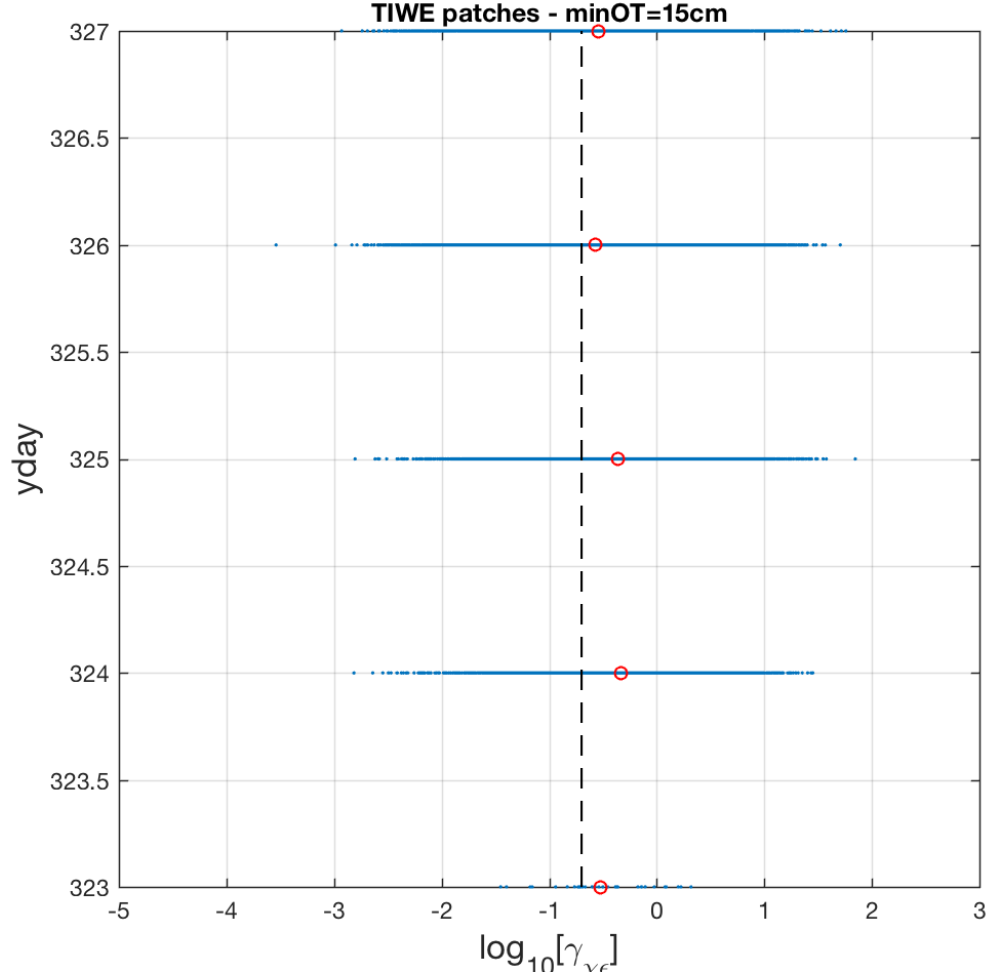

Figure 11: Plot of $\gamma_{\chi\epsilon}$ for patches vs yday. Vertical line is $\gamma_{\chi\epsilon} = 0.2$. Red circles are the median value for each day. * what happend on yday 322.326?

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