Patch/Gamma Analysis for TIWE chameleon patches

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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 (because salinity was noisy/spiky, see later section). The function `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. **Actually use 40cm minimum to calculate chi and epsilon?**

- Only patches in the depth range 60-200m were used. This excludes mainnly buoyancy-driven turbulence associated with the diurnal cycle.

For each patch, a linear fit is performed of salinity vs temperature. Only patches where R2 for this fit is greater than X are kept. Salinity is then computed from the fit to temperature.

3.2 dTdz

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

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

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

3. N^2_{bulk} : Use 'bulk gradient' . This is calculated from the bulk T_z, using a linear fit between density and temperature. **(The fit is done for each patch?)**

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

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

minOT	usetemp	γbin	$\gamma line$	γfit	$\gamma bulk$	Npatches	N $R^2 > 0.5$
0.4	1	0.13	0.44	0.12	0.14	16329	9299
0.4	0	0.14	0.08	0.02	0.16	34256	24884
1	1	0.16	0.63	0.17	0.17	6893	5385

- 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).

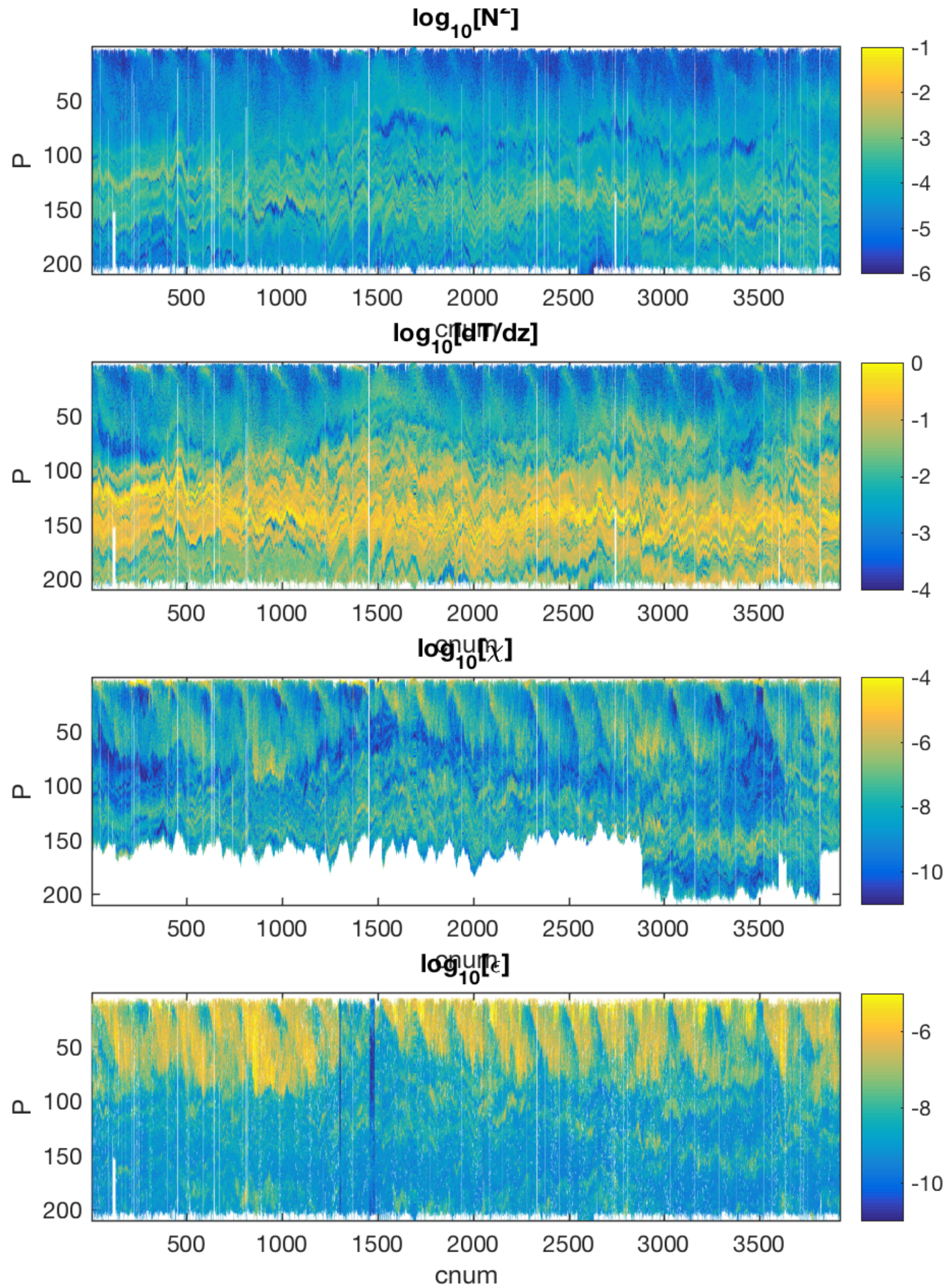

Figure 1: Pcolor of the combined 1m avg chameleon data for TIWE. * Note for some reason many χ values below 150db are bad/missing.

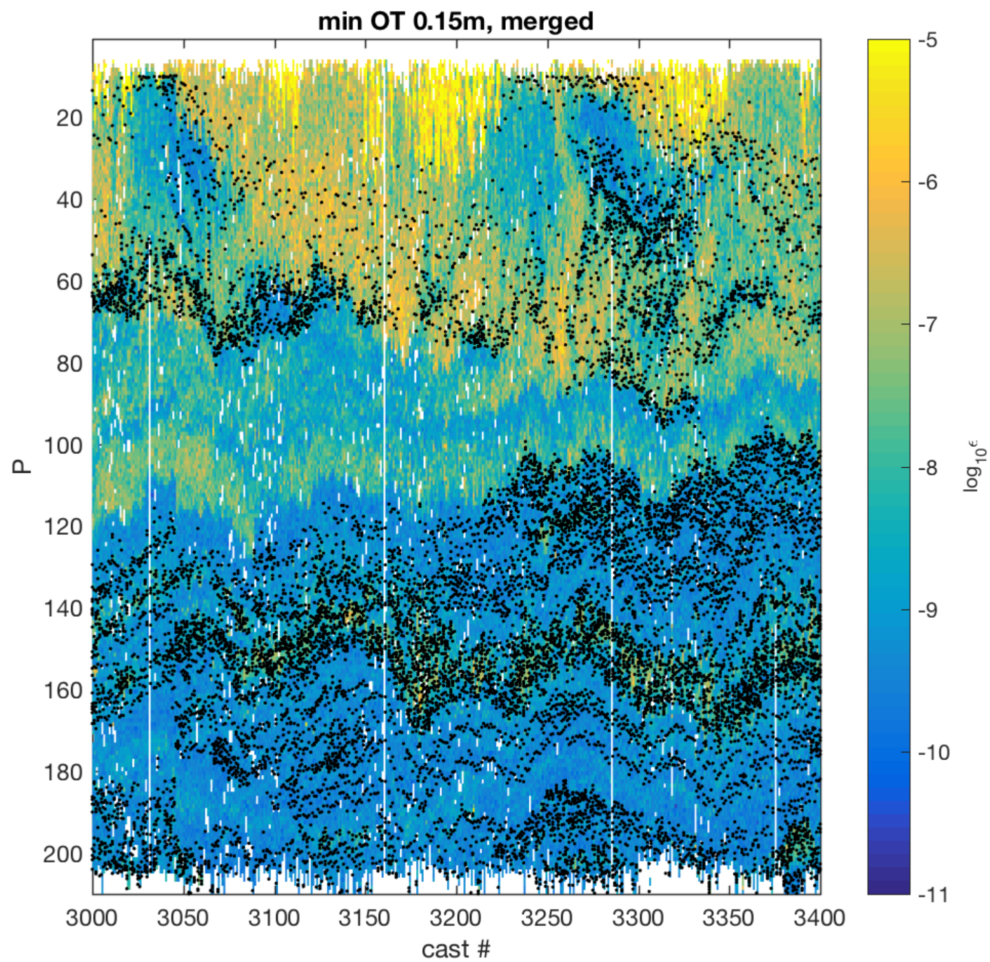

Figure 2: Pcolor of the combined 1m avg chameleon epsilon for TIWE, and patch locations for a period between yday 324-327. Patches above 60m have not been discarded yet.

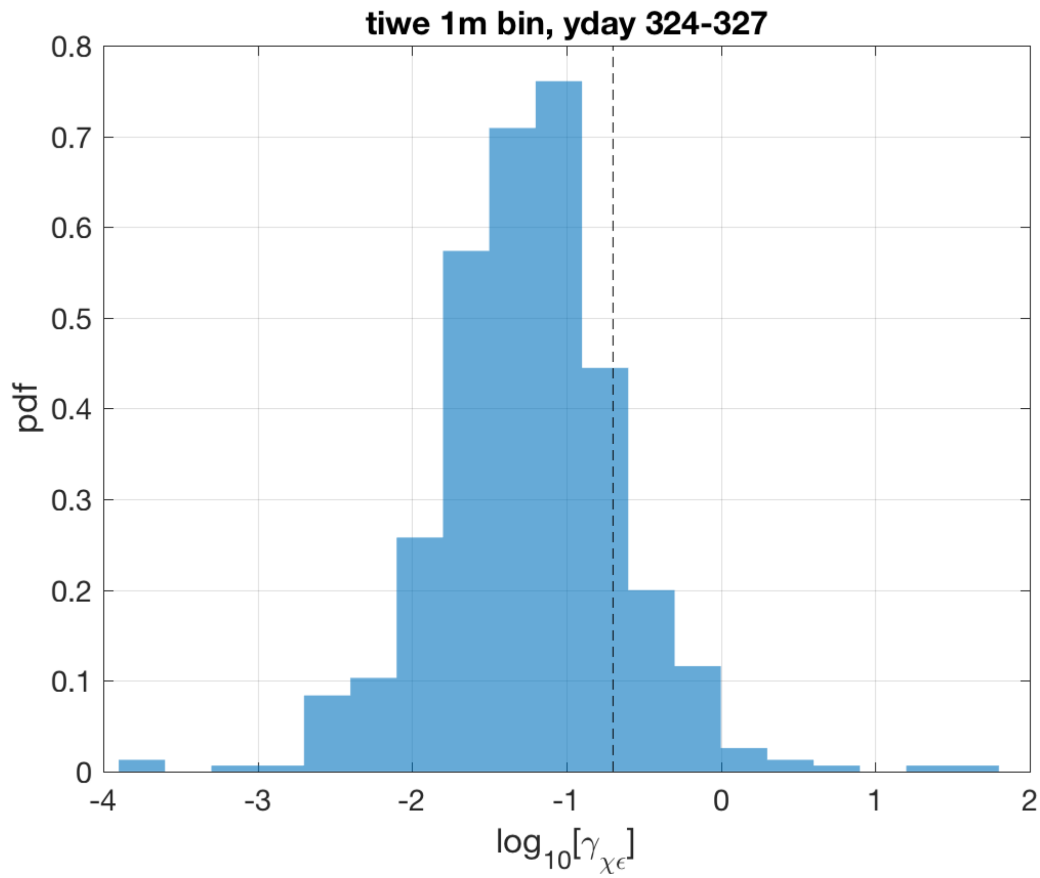

Figure 3: Histogram of $\gamma_{\chi\epsilon}$ for 1m avg chameleon profiles (all data, no patch analysis applied). Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$.

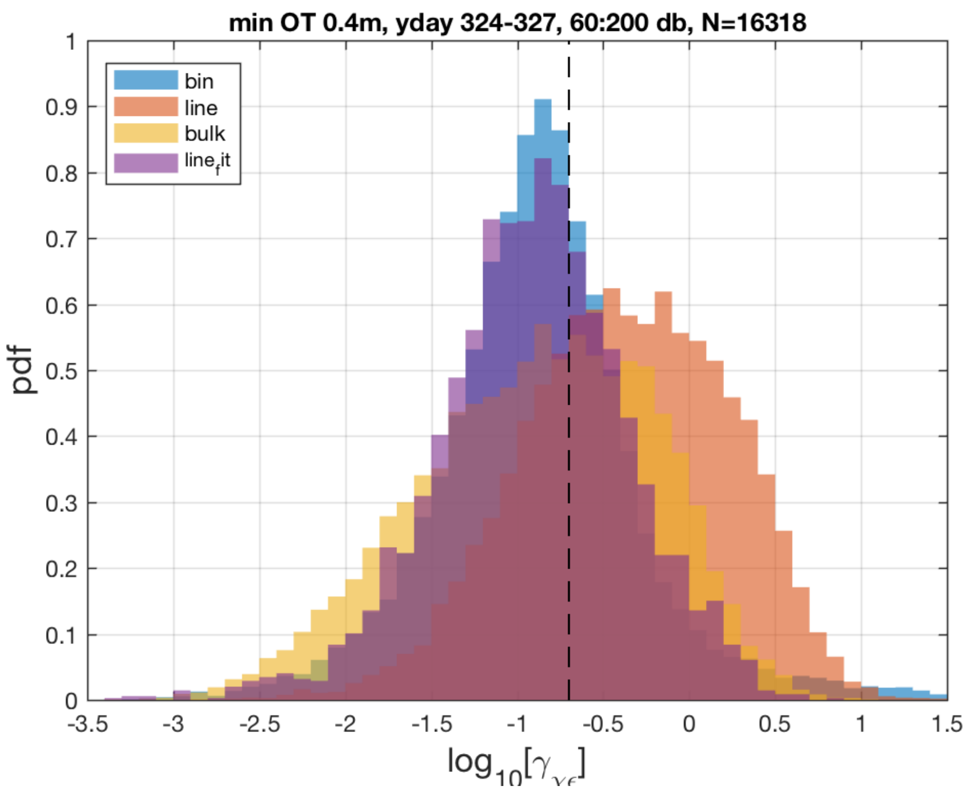

Figure 4: Histogram of $\gamma_{\chi\epsilon}$ for patches, using different estimates of N^2 and T_z. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

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 ?

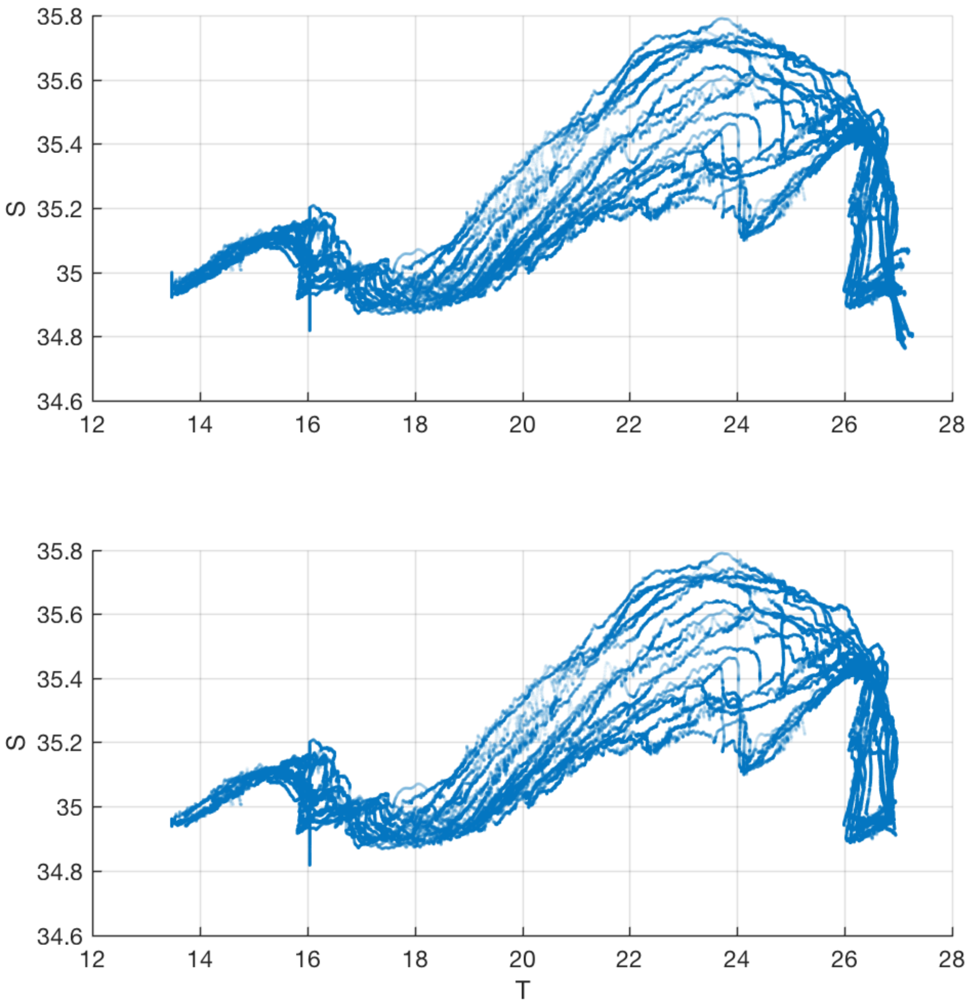

Figure 5: Raw T vs S for a subset of TIWE Chameleon profiles between yday 324-327 (corresponding to data used in Smyth et al).

4.2 Different min OT sizes

The analysis was run for different minimum overturn sizes; here I compare the results.

- Doesn't seem to make a difference for the binned estimates of γ (1m binned values interpolated to patch locations).
- It does make a significant difference when γ is computed over each patch. Patches computed from temperature tend to have larger estimated γ.

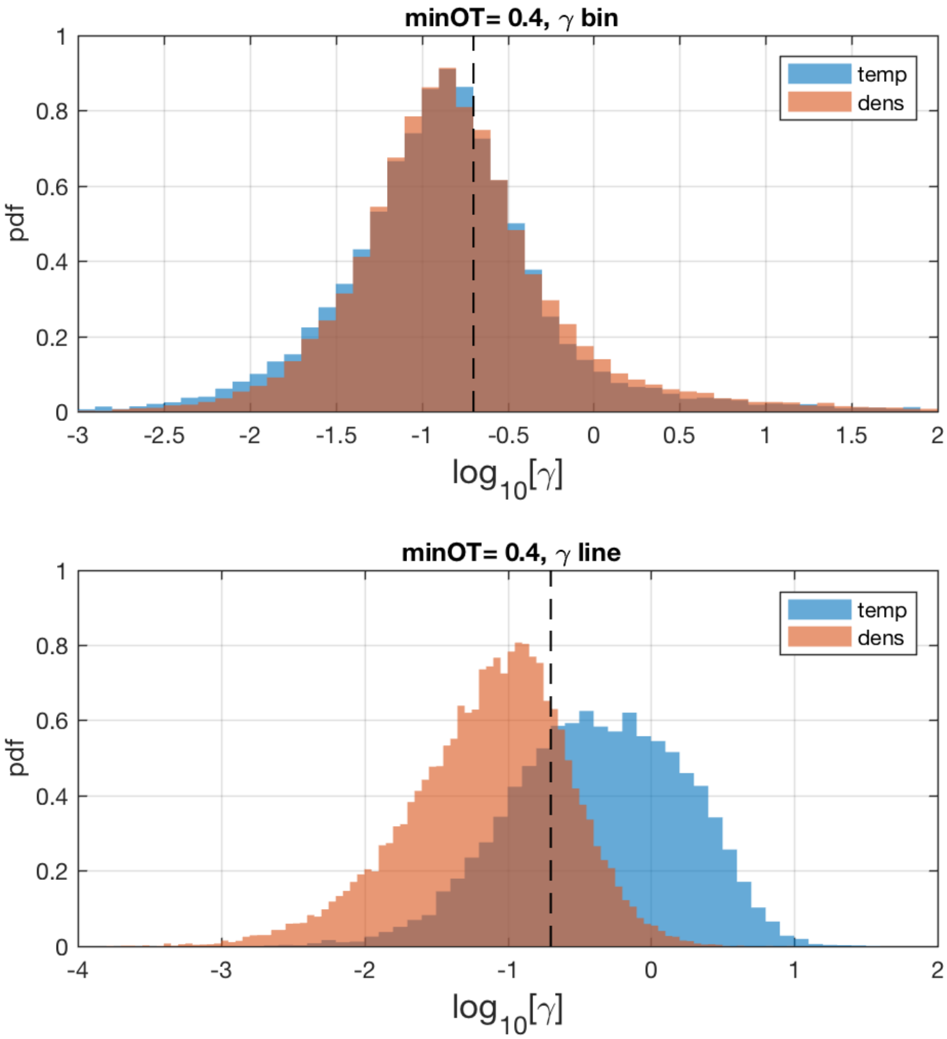

Figure 6: Comparison of γ for patches with minimum size 40cm, computed from temperature vs density.

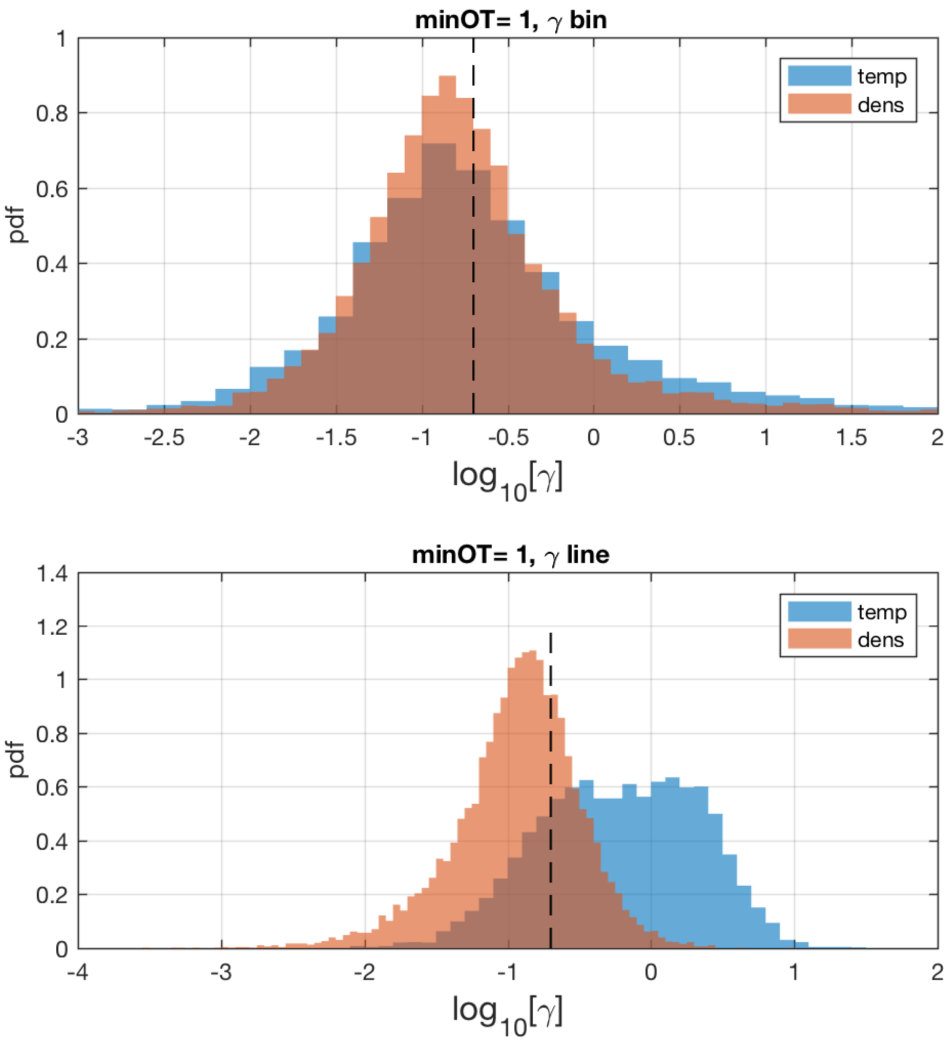

Figure 7: Comparison of γ for patches with minimum size 1m, computed from temperature vs density.

4.3 γ vs depth

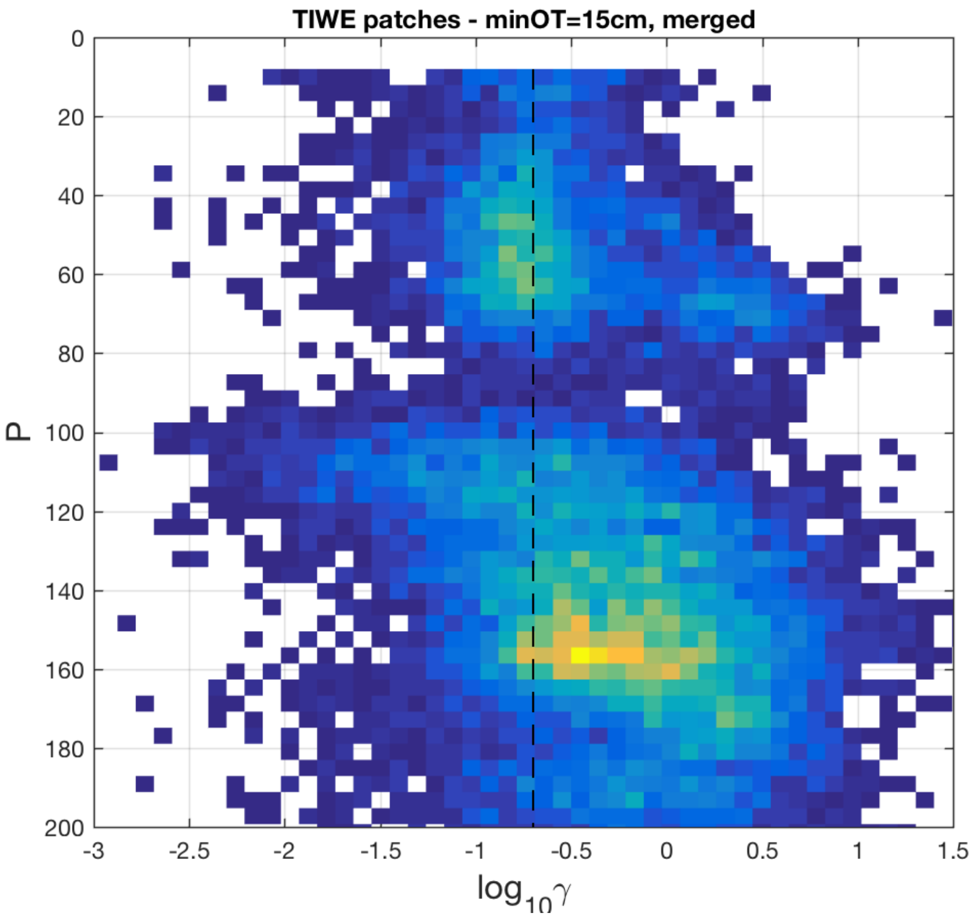

Figure 8: Plot of $\gamma_{\chi\epsilon}$ vs depth for patches. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

4.4 γ vs ϵ

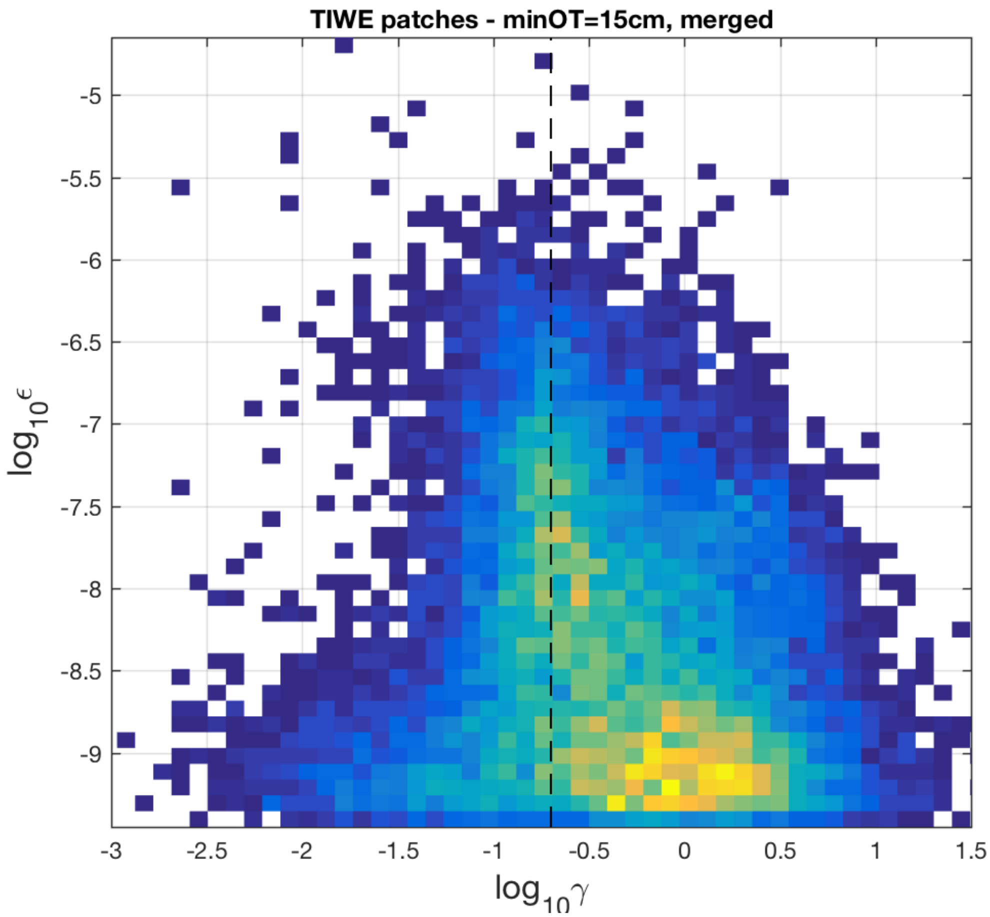

Figure 9: Plot of $\gamma_{\chi\epsilon}$ vs ϵ for patches. Vertical dashed line shows $\gamma_{\chi\epsilon} = 0.2$. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

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 10). 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 11).

* 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 10)?

`tiwe_minOT_25_usetemp_1_n2_tz_chi_eps_apvsbill_hist_yday_307_329.png`

Figure 10: 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 11: 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 12,13). Using this data, I get gammas centered around 0.2 and close to Bill's estimates.

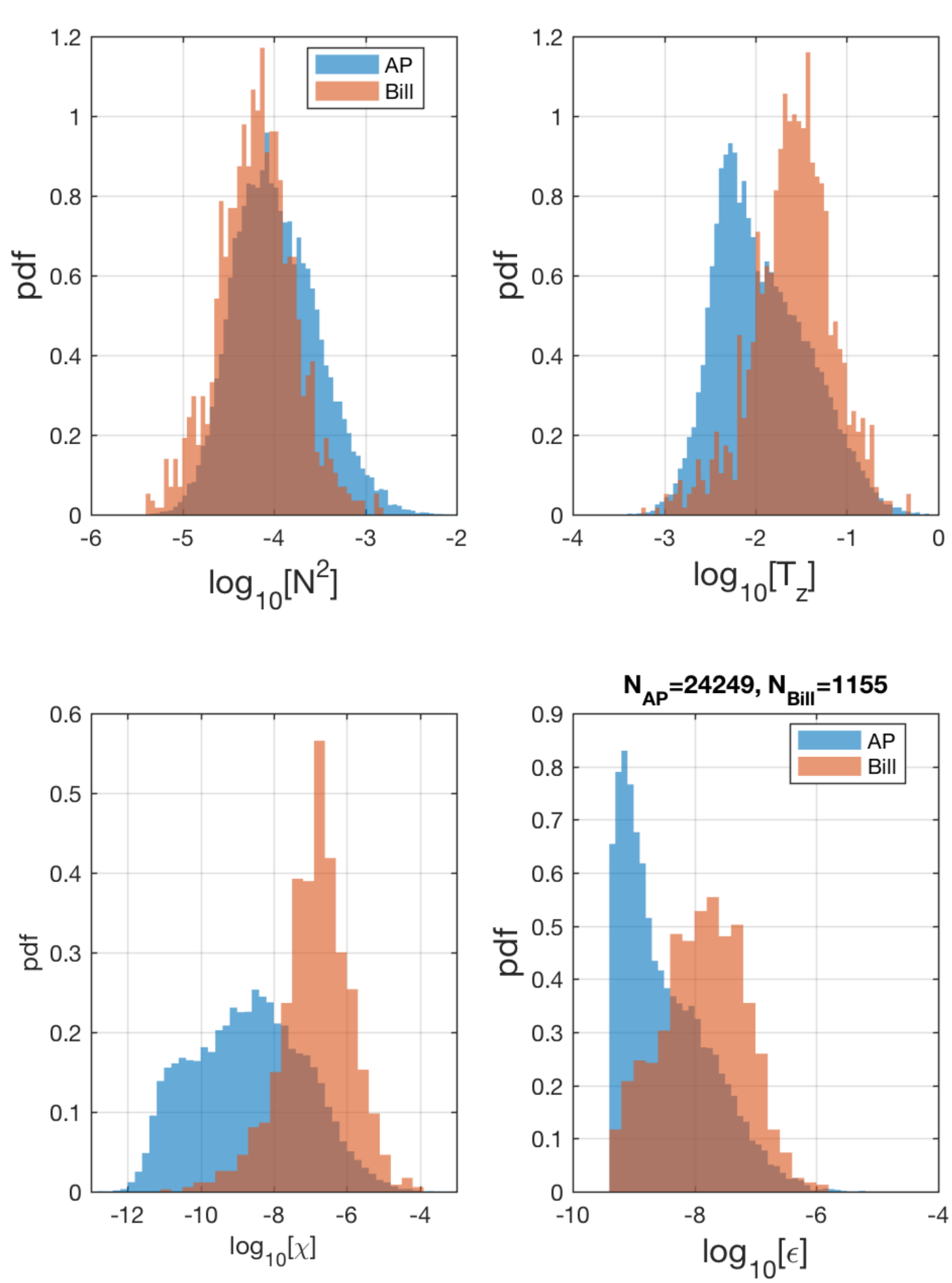

Figure 12: Histograms of N^2 , T_z, χ, and ϵ for patches analyzed by myself and Bill. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

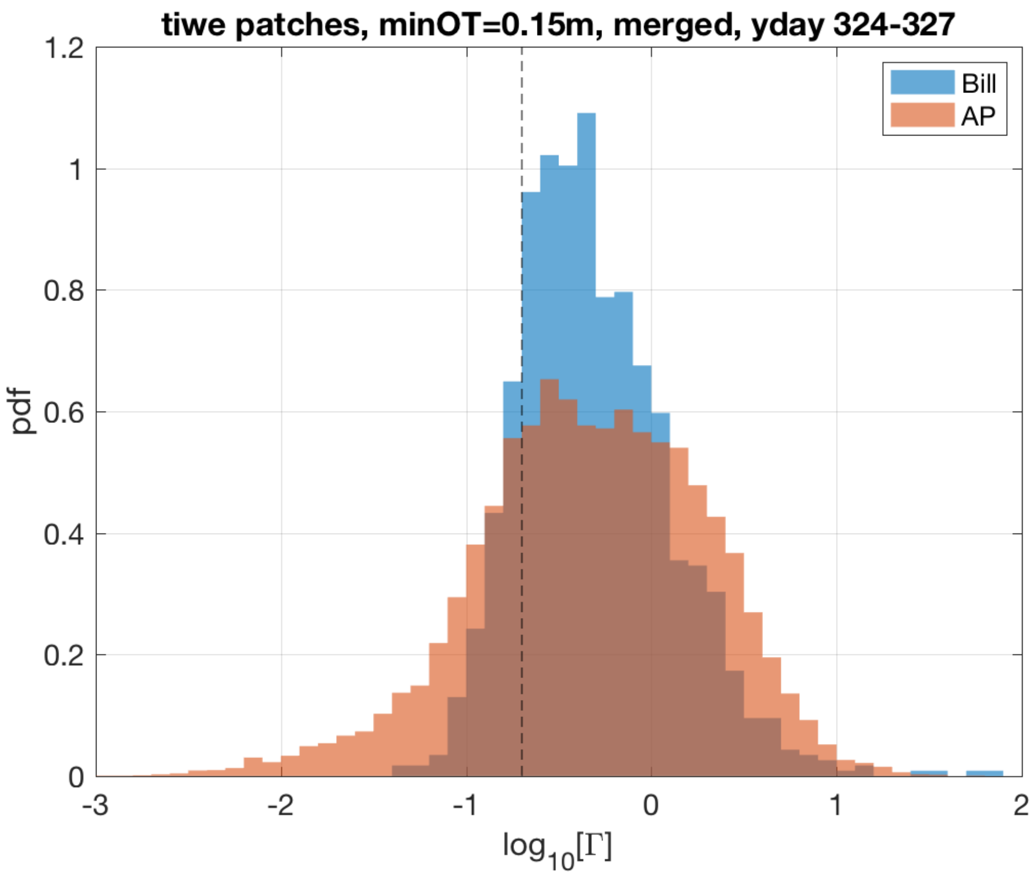

Figure 13: Histograms of $\gamma_{\chi\epsilon}$ for patches analyzed by myself and Bill. Data for profiles on yday 324-327 (corresponding to data used in Smyth et al).

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 14). 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).

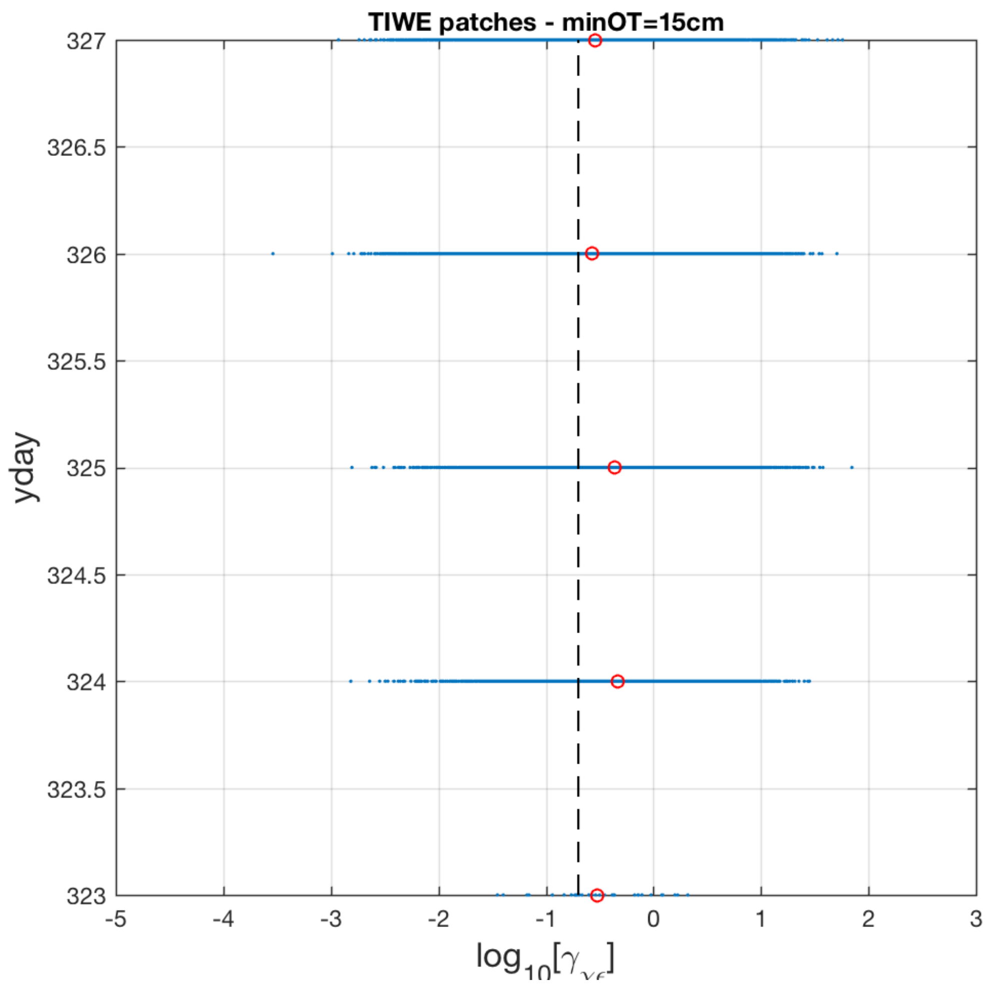

Figure 14: Plot of $\gamma_{\chi\epsilon}$ for patches vs yday. Vertical line is $\gamma_{\chi\epsilon} = 0.2$. Red circles are the median value for each day. * what happend on yday 322.326?