Patch/Gamma Analysis for EQ14 chameleon patches

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Contents

1 Overview

The goal of this analysis is to compute mixing 'coefficient' $\gamma_{\chi\epsilon} = \frac{N^2\chi}{2\epsilon T_z^2}$ for patches in EQ14 chameleon profiles, and see if we obtain values close to $\gamma_{\chi\epsilon} = 0.2$. A similar analysis was done for TIWE data. 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 'EQ14' experiment. The data was shared with me by Sally/Jim. My copy is located at :

`/Users/Andy/Cruises_Research/ChiPod/Cham_Eq14_Compare/`

Chameleon data already processed by Sally is in :
`/Users/Andy/Cruises_Research/ChiPod/Cham_Eq14_Compare/Data/chameleon/processed/`

This analysis is in the main folder:
`/Users/Andy/Cruises_Research/Analysis/Andy_Pickering/eq14_patch_gamma/` . This is also a github repository.

3 Methods

- `FindPatches_eq14_Raw.m` Identifies patches in the profiles made by `Process_tiwe_rawprofiles_AP.m`, using potential temperature.
- `Compute_N2_dTdz_patches_eq14_eachcast.m` Computes N^2 and T_z for patches, using several different methods. SAves results in a structure 'patches'.
- `add_binned_to_patches.m`
- `run_eq14_for_PATCHES.m` Runs the Chameleon processing (including χ and ϵ) for just the patches identified in `FindPatches_eq14_Raw.m` . This calls `average_data_PATCH_AP.m` instead of `average_data_gen1.m`.
- `add_patch_chi_eps_to_patches_eq14_each_profile.m` Adds χ and ϵ comptued over patches (in `run_eq14_for_PATCHES.m`) to patch profiles.
- `combine_patch_profiles_eq14.m` Combines all patch profiles into 1 structure.

3.1 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).

3.2 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^2_{bulk} : Use 'bulk gradient' . This is calculated from the bulk T_z, using a linear fit between density and temperature.

3. 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.

3.3 Mixing Efficiency

Mixing Efficiency $\gamma_{\chi\epsilon}$ 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 is computed for the following 4 combinations:

1. γ_{bin} : 1m binned data interpolated to patch depths.

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

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

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

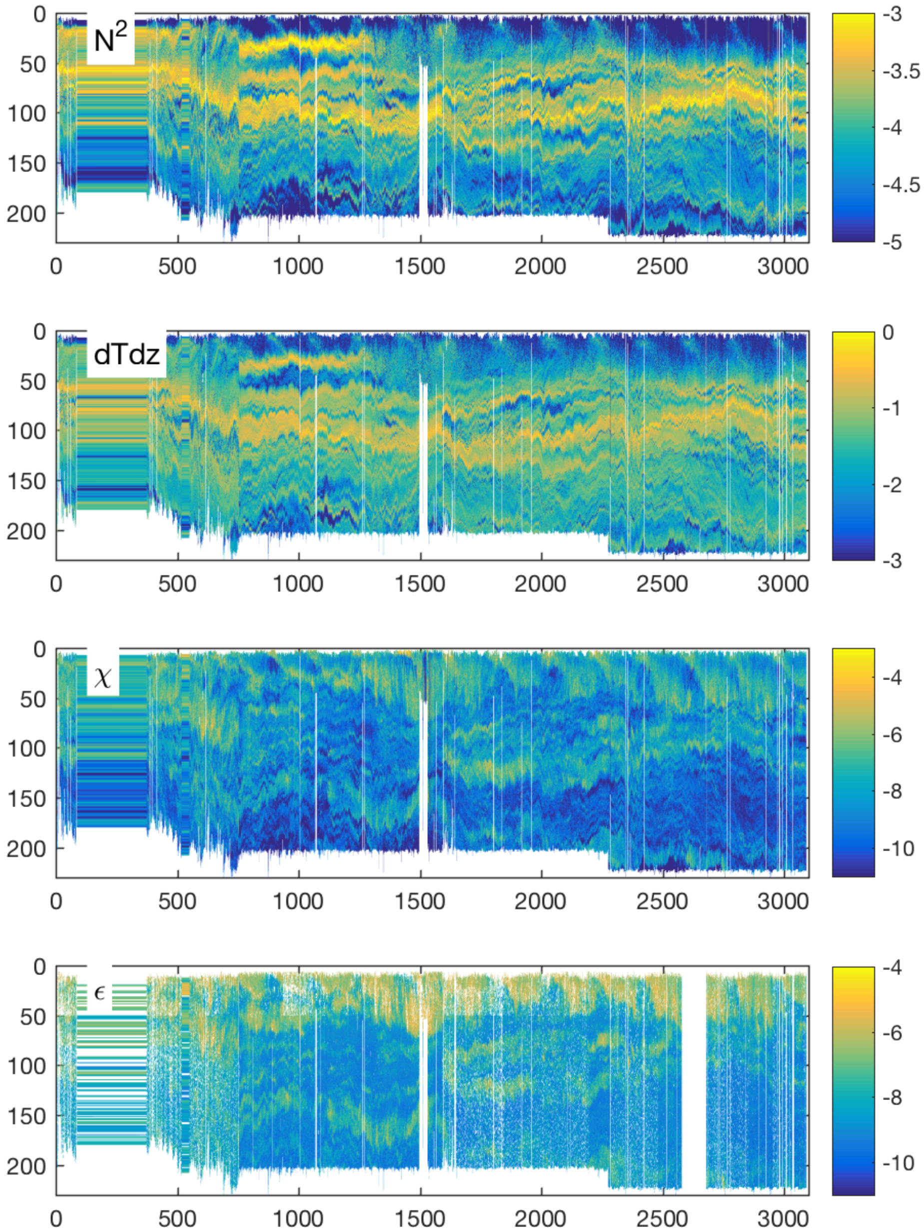

Figure 1: Summary of N^2, T_z, χ, and ϵ from standard 1m avg Chameleon data.

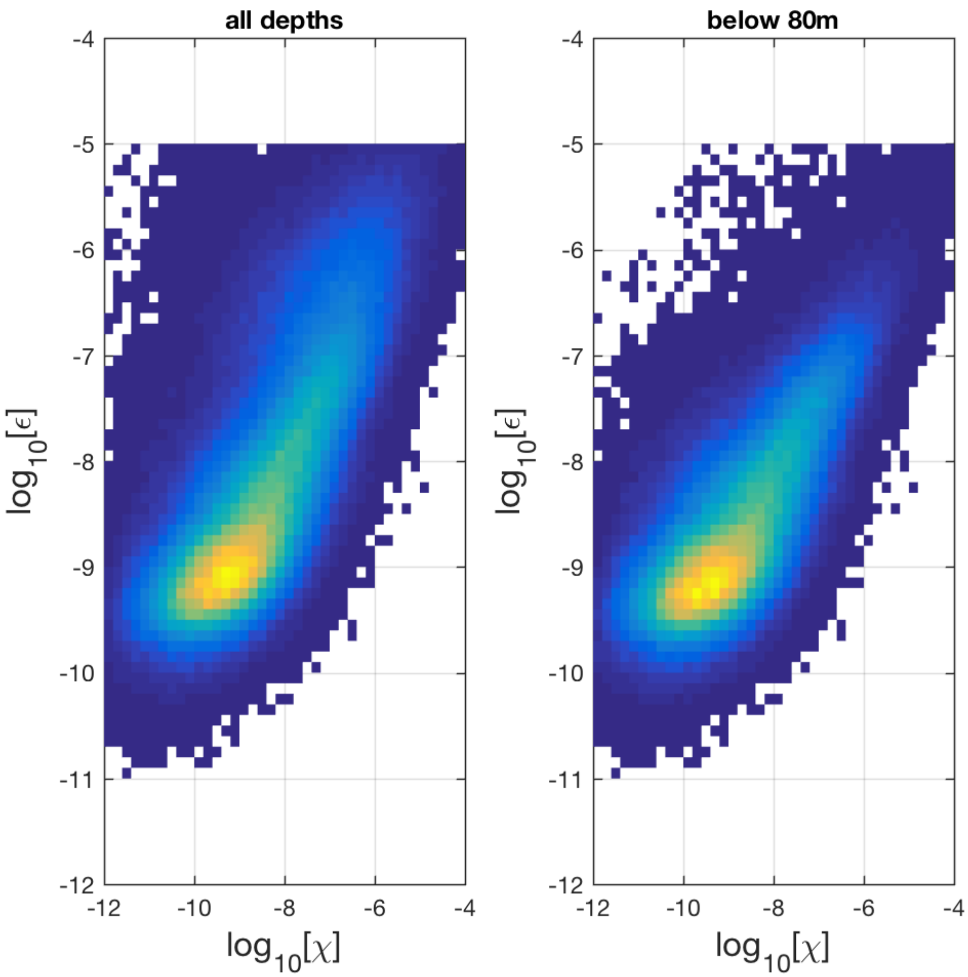

Figure 2: ϵ vs χ from standard 1m avg Chameleon data.

4 Overview of Data

5 Results

- $\gamma_{\chi\epsilon}$ computed for 1m avg ('binned') data is about an order of magnitude less than 0.2 (Figure 4). It has a median value of $\gamma = 0.015$ for data between 60-200m. The data was processed by Sally w/ 2 different c-star values, this doesn't seem to make any difference in the estimated $\gamma_{\chi\epsilon}$.
- $\gamma_{\chi\epsilon}$ computed for just patches (Figure 5) varies depending on which method is used. The 'line' and 'bulk' methods have median values around $\gamma = 0.1$. The bin and line-fit estimates are much smaller than 0.2

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

minOT	usetemp	minR2	γbin	$\gamma line$	γfit	$\gamma bulk$	Npatches
0.4	1	0	0.03	0.21	0.09	0.18	9329
0.4	1	0.5	0.03	0.14	0.11	0.12	1302
0.75	1	0	0.05	0.2	0.08	0.18	4076
0.75	1	0.5	0.05	0.13	0.1	0.12	520
1	1	0	0.06	0.2	0.08	0.19	2829
1	1	0.5	0.05	0.15	0.11	0.14	387

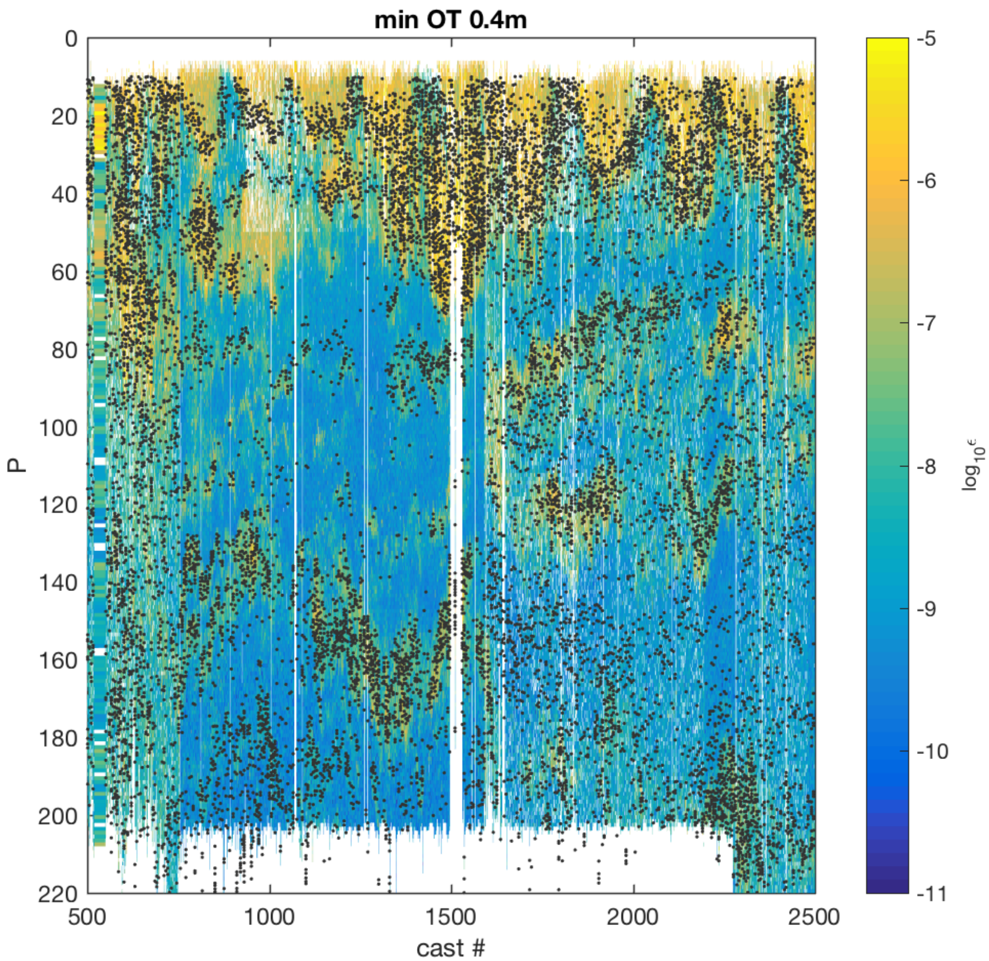

Figure 3: Patch locations (mean depth) plotted on top of epsilon.

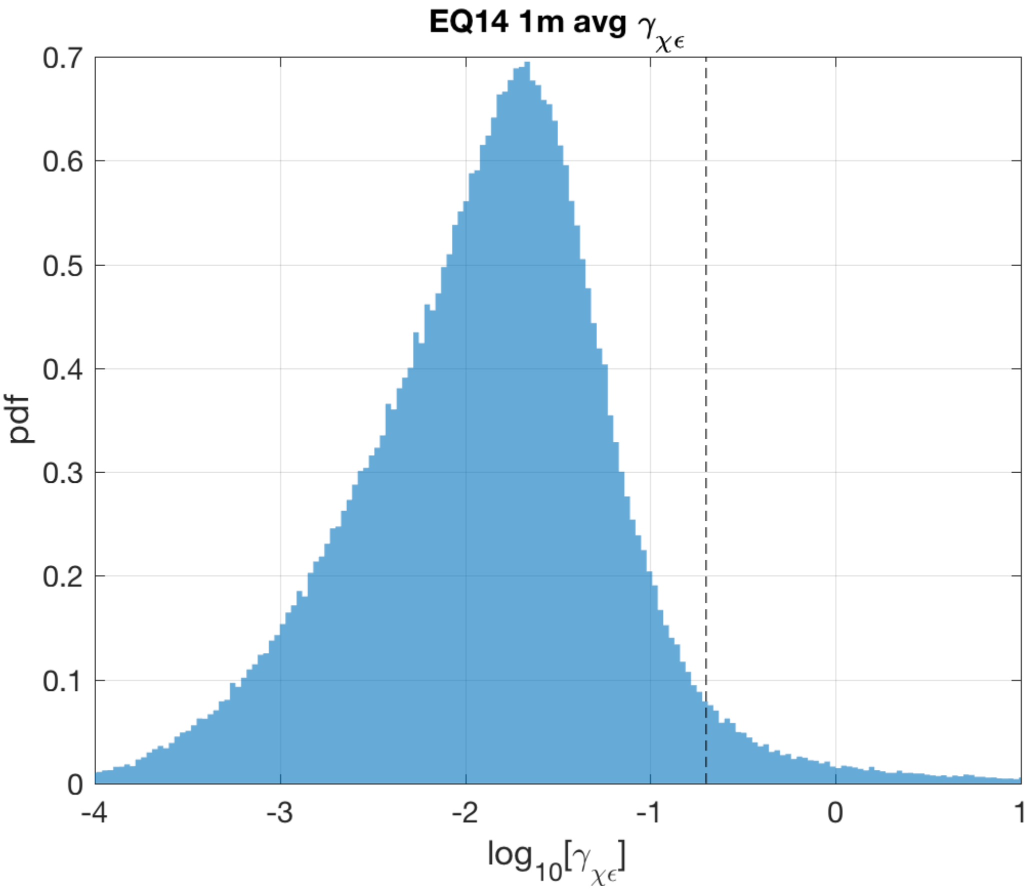

Figure 4: Histogram of $\gamma_{\chi\epsilon}$ for 1m avg chameleon profiles between 60-200m depth. Vertical dashed line shows $\gamma = 0.2$.

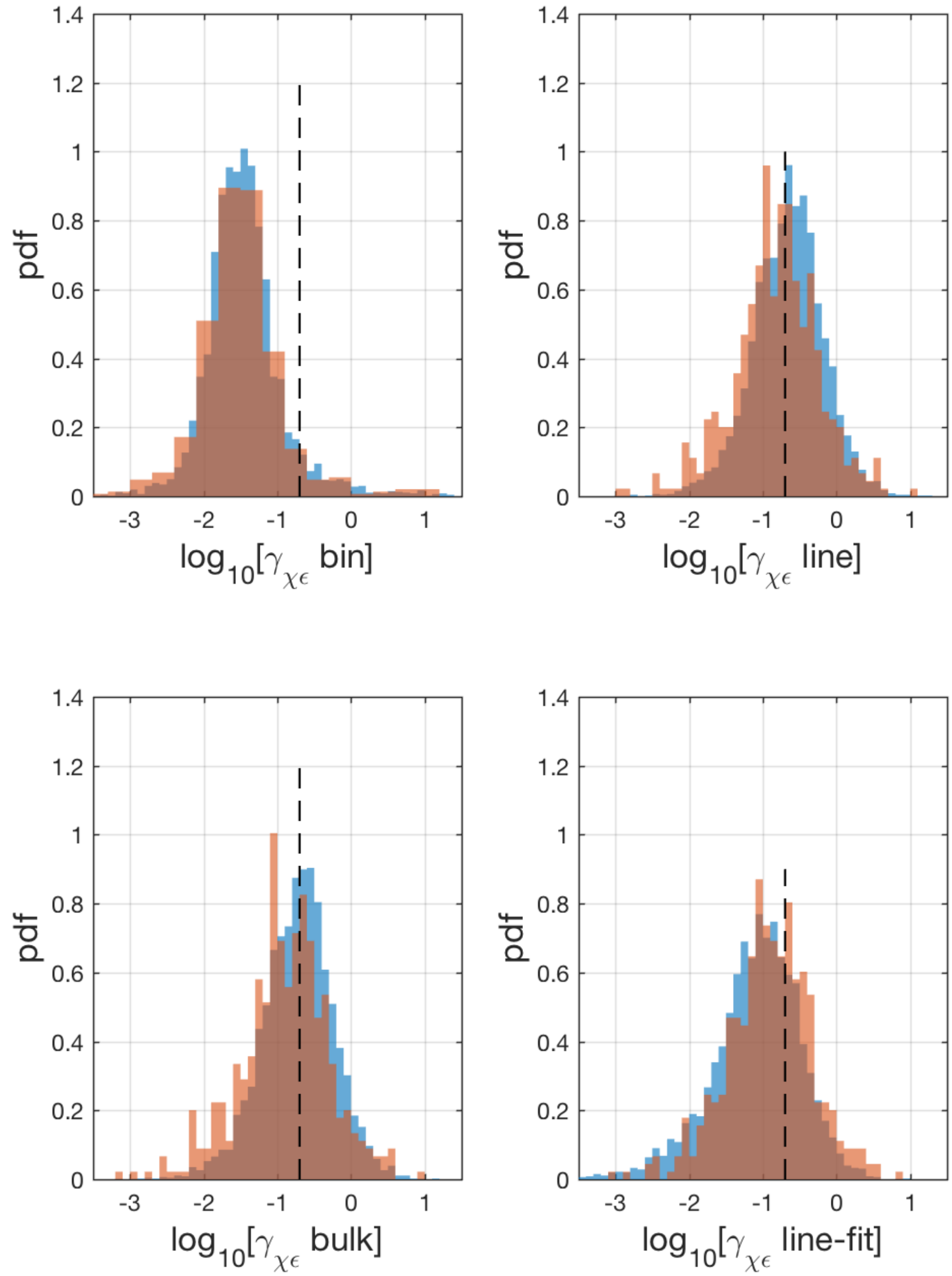

Figure 5: Histogram of $\gamma_{\chi\epsilon}$ for patches, using different estimates of N^2 and T_z. Vertical dashed line shows $\gamma = 0.2$. For all profiles, all depths.

5.1 Using smaller fmax?

I believe the Chameleon data processed by Sally used the standard fmax=32Hz correction/cutoff for the thermistor data. However when I was trying to apply the χpod method to that data, I looked at some spectra and it looked like the thermistor rolled off much lower, around maybe 7-10hz. So I re-ran the processing using fmax=7hz. Estimates of $\gamma_{\chi\epsilon}$ are about 2-3 times larger (Figure 6), but still significantly less than 0.2 .

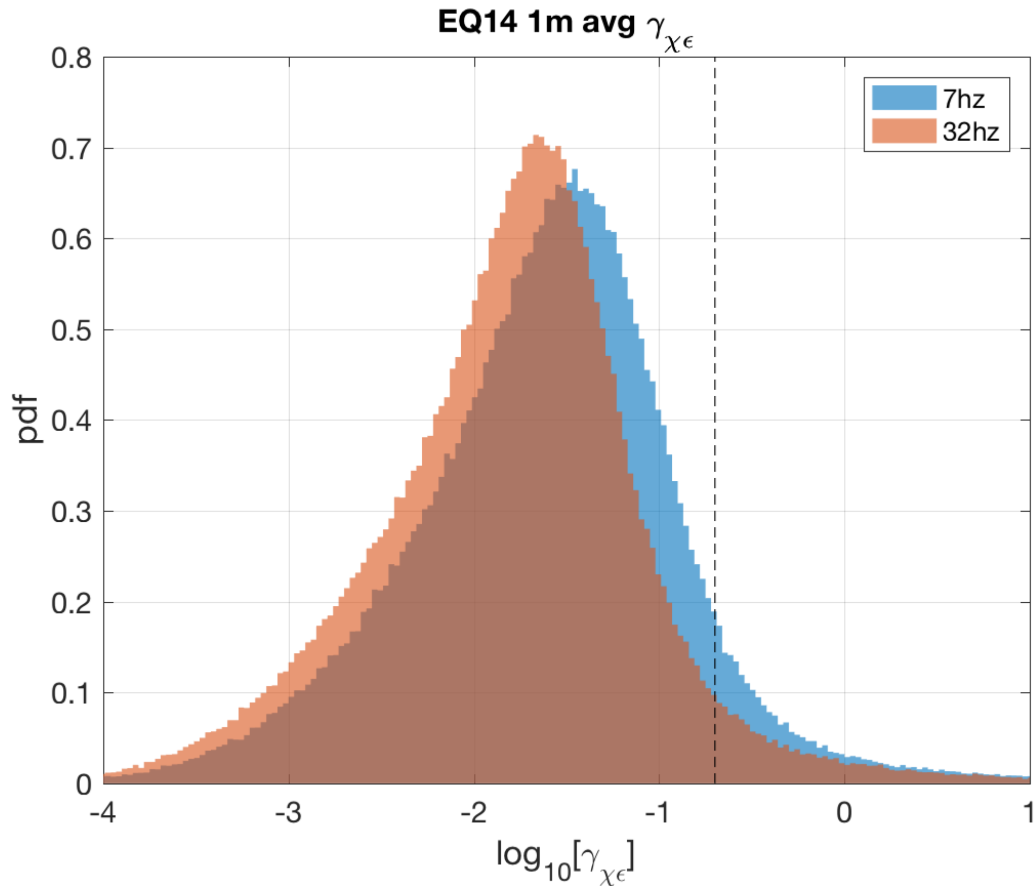

Figure 6: Histogram of $\gamma_{\chi\epsilon}$ for 1m avg chameleon profiles, for standard fmax32hz as well as fmax7hz. Vertical dashed line shows $\gamma = 0.2$.

5.2 Variation of $\gamma_{\chi\epsilon}$ with epsilon

See Figure 7:

- For 'bin' and 'linefit' methods, γ does not show much dependence on ϵ. But magnitude is less than 0.2 .
- For 'line' and 'bulk' methods, magnitude of γ is closer to 0.2, but shows an inverse dependence on ϵ.

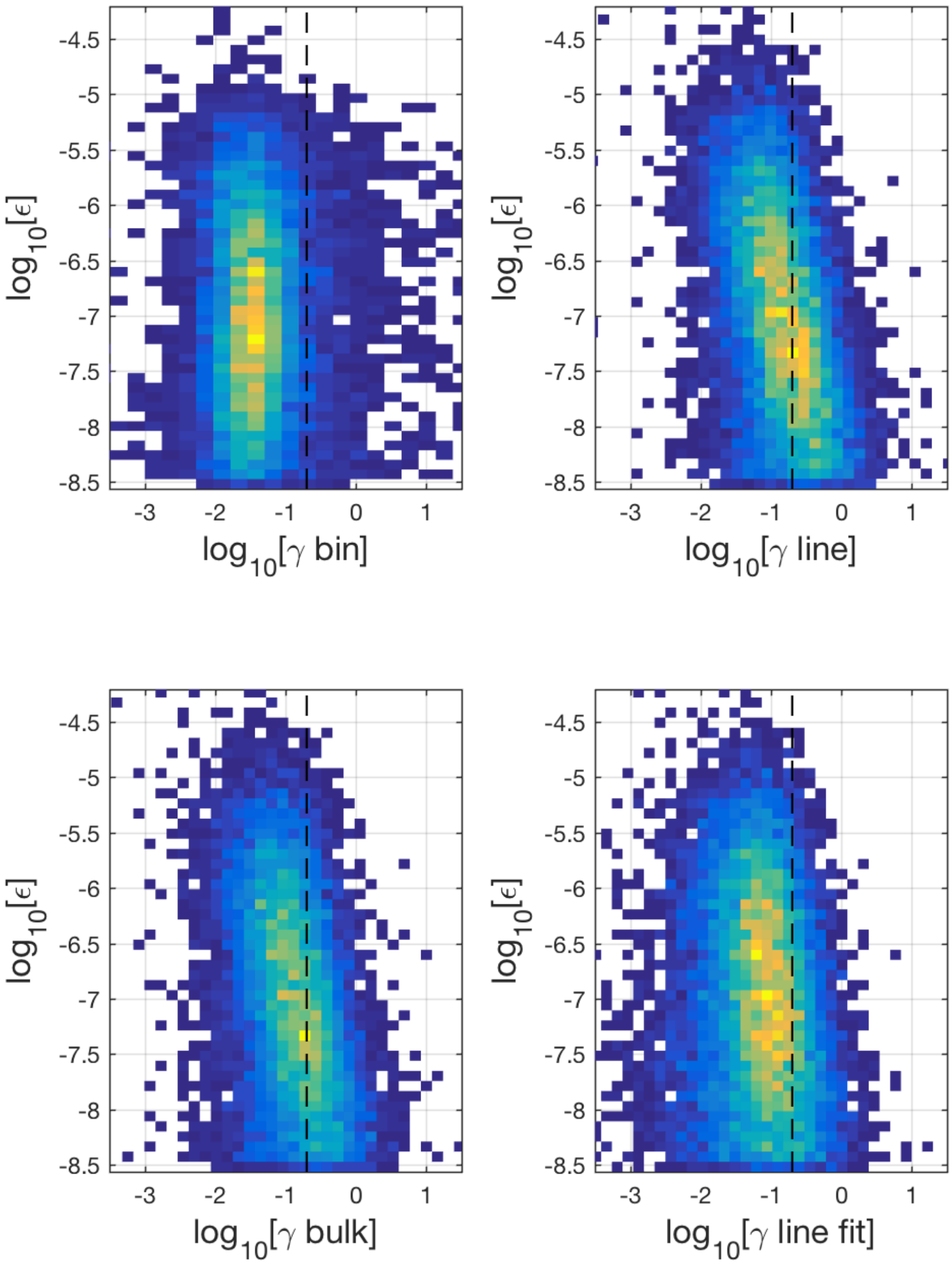

Figure 7: Plot of ϵ versus $\gamma_{\chi\epsilon}$ for patches. Vertical line is $\gamma = 0.2$.

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

To investigate whether $\gamma_{\chi\epsilon}$ varies over time, I plotted $\gamma_{\chi\epsilon}$ vs cast number (Figure 8).

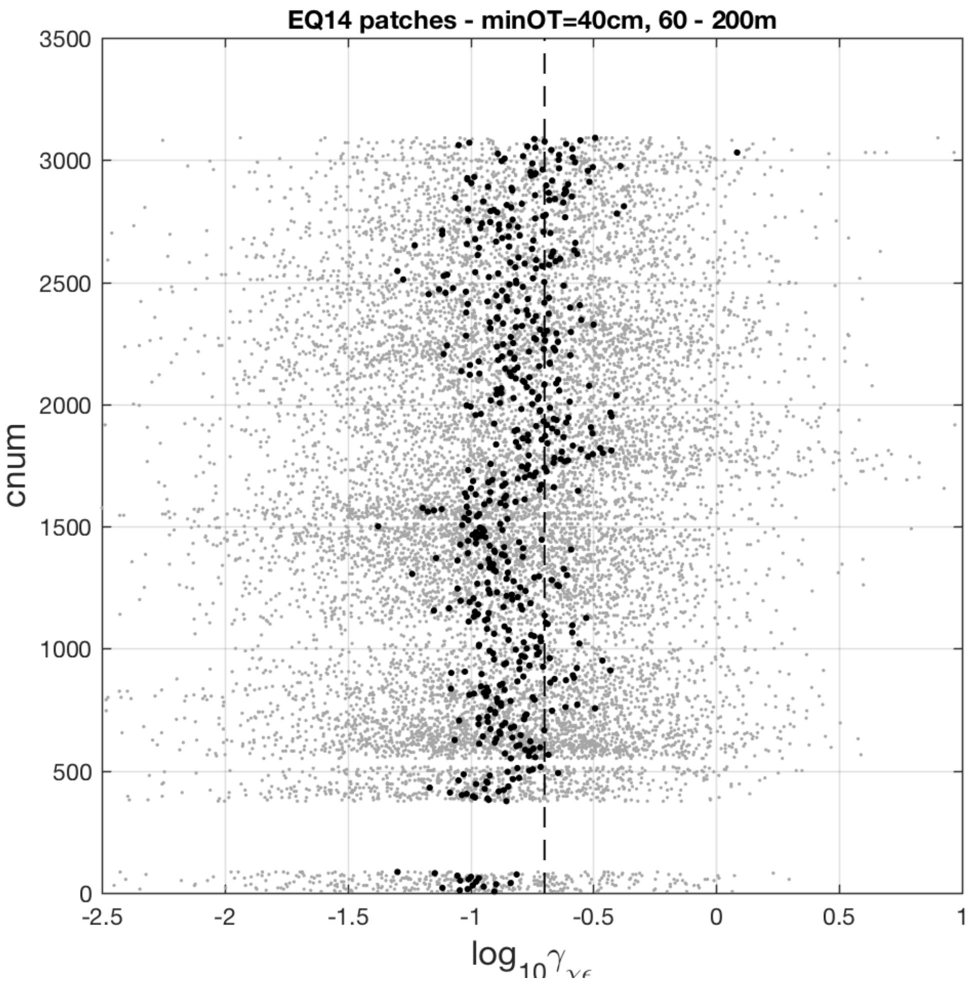

Figure 8: Plot of $\gamma_{\chi\epsilon}$ for patches vs cast number. Vertical line is $\gamma = 0.2$. Black points are the median value for each cast.

5.4 Variation of $\gamma_{\chi\epsilon}$ over depth

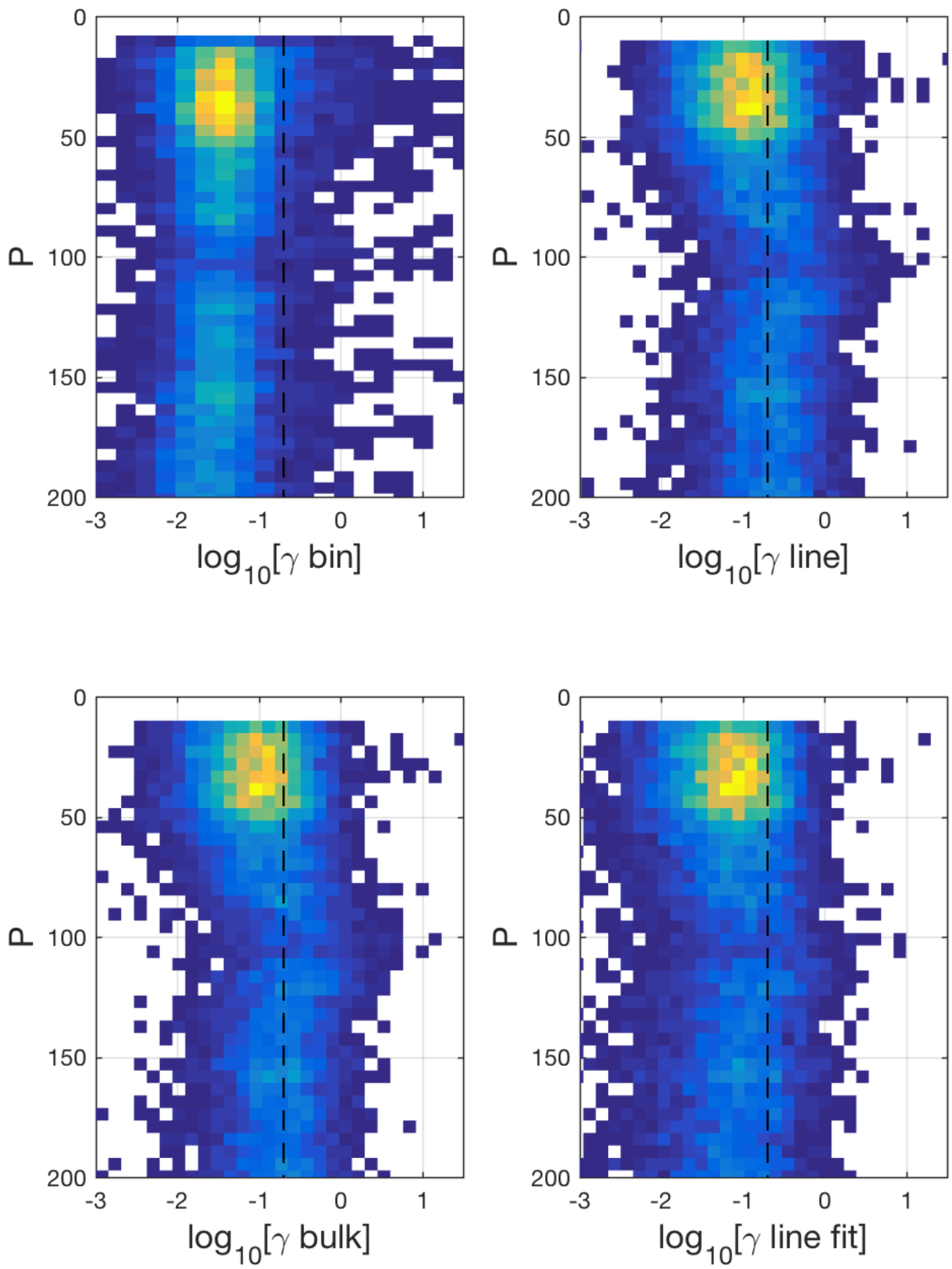

Figure 9: Plot of $\gamma_{\chi\epsilon}$ for patches vs depth. Vertical line is $\gamma = 0.2$.

6 Application of χpod method to patches

The χpod method was applied to patches to see if the agreement between χpod-estimated χ and ϵ improved. Applying the χpod method to the entire profiles gave decent agreement in χ, but χpod-estimated γ was biased low by about an order of magnitude (which is what motivated this whole patch analysis). The χpod method is applied in `ComputeChi_Chameleon_Eq14_PATCHES.m`, using N^2 and T_z from patches. It was done using both the actual γ from patches to test, and a constant $\gamma = 0.2$. All the profiles are combined into one structure in `Combine_ChipodMethodPatches.m`.

- The magnitudes of χpod estimated ϵ for patches are closer to the actual chameleon values when using patch vs binned data (Figure 11,lower panels). However, the slope appears to be less than one for the patch estimates (lower right panel).
- The ratio of χpod estimated ϵ to chameleon ϵ (Figure 12) is improved when using patches instead of binned data.
- ** checking if bulk vs line makes a difference **

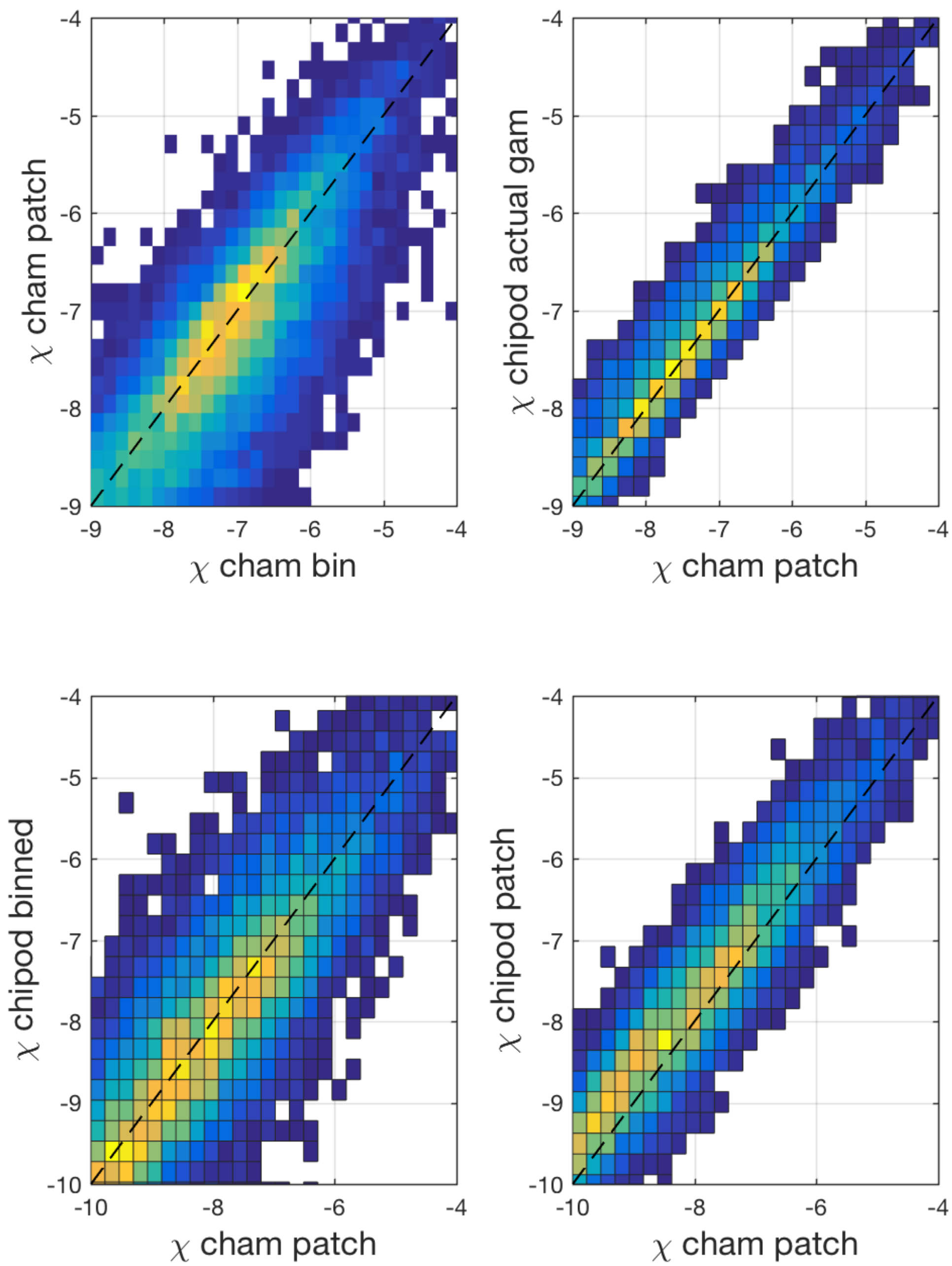

Figure 10: Comparison of χ from chameleon and χpod method applied to patches. (Top-left) Comparison of χ from patches to binned χ interpolated to patch locations. (Top-right) χ from χpod method using actual patch γ to patch χ from chameleon. (Lower-left) χ from χpod method using binned data, interopolated to patch locations, compared to patch χ from chameleon. (Lower-right) χ from χpod method using a constant $\gamma = 0.2$ to patch χ from chameleon.

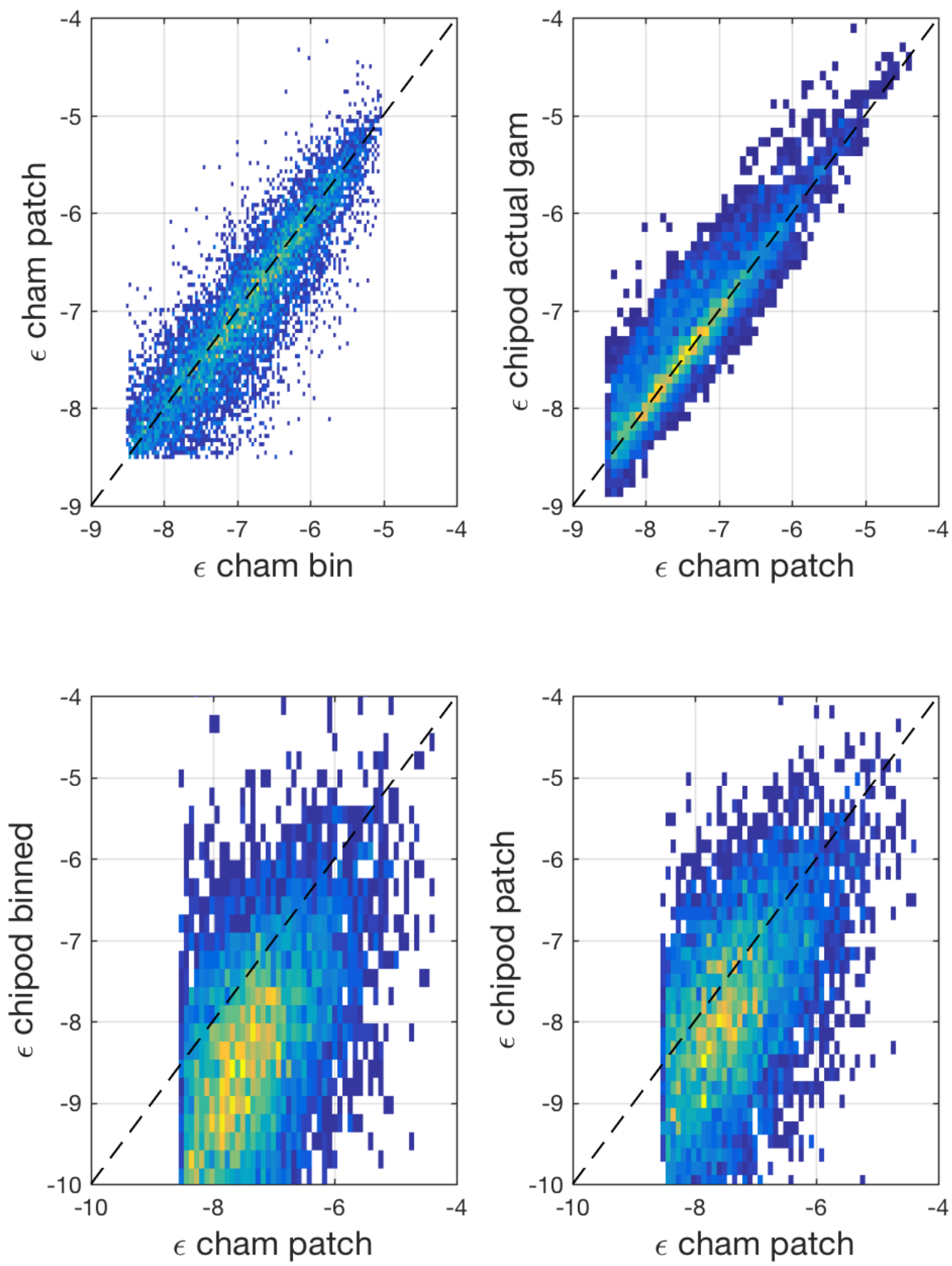

Figure 11: Comparison of ϵ from chameleon and χpod method applied to patches. (Top-left) Comparison of ϵ from patches to binned ϵ interpolated to patch locations. (Top-right) ϵ from χpod method using actual patch γ to patch ϵ from chameleon. (Lower-left) ϵ from χpod method using binned data, interopolated to patch locations, compared to patch ϵ from chameleon. (Lower-right) ϵ from χpod method using a constant $\gamma = 0.2$ to patch ϵ from chameleon.

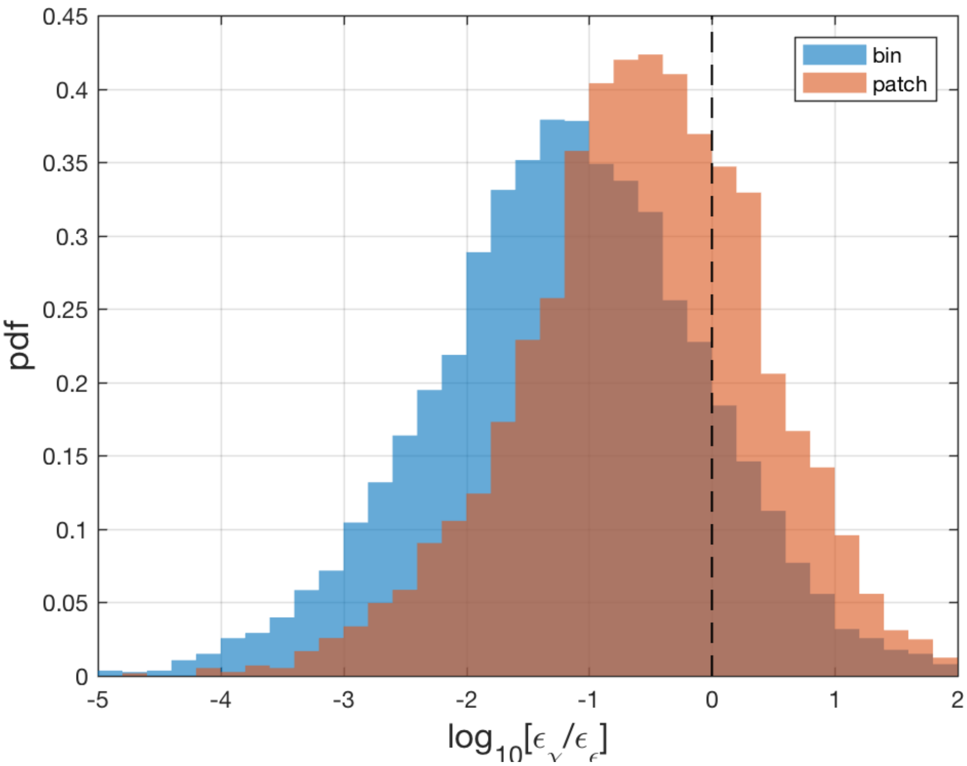

Figure 12: Histogram of log_{10} of the ratio of χpod estimated ϵ to chameleon ϵ for patches, for both binned data (interpolated to patch locations), and using only patch data.

7 Summary

- $\gamma_{\chi\epsilon}$ computed from 1m binned data (the standard Chameleon processing) is about 10 times smaller than the typical assumed value of 0.2.
- $\gamma_{\chi\epsilon}$ computed for just patches varies depending on what method of choosing T_z and N^2 is used. The 'line' and 'bulk' methods give γ estimates close to 0.1.