

Summary of χ pod / Chameleon EQ08 Analysis

Andy Pickering

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1 Overview

- This document is an attempt to provide an overview/summary of some analysis i've done with the EQ08 data. The motivation/goal for all this work is to show if /how well the CTD- χ pod method works for estimating χ, ϵ, K_T , etc from fast temperature (thermistor) profiles. The idea is to deploy χ pods on regular CTD casts on WOCE/CLIVAR cruises etc. to making mixing measurements.
- Before dealing with all the issues with the CTD deployments (depth loops, entrained water, rosette-induced turbulence etc.), I wanted to verify that the method itself worked w/out these complications.
- The Chameleon microstructure profiler has both thermistor and shear probes, so this seemed like an ideal way to test the method. I would apply the χ pod method to the chameleon thermistor data only (χ_χ, ϵ_χ), and compare to the 'true' results computed using the shear probes (χ, ϵ).

2 Data and Processing

- Data are from Chameleon profiles near the equator during the ‘EQ08’ experiment.
- χ pod method is applied to thermistor data from Chameleon profiles in : `ComputeChi_Chameleon_Eq08.m`
- The noise floor of Chamleon ϵ was determined to be $\log_{10}[\epsilon] = -8.5$. Values below this threshold were discarded. χ pod values below this threshold were also discarded, in order to make a valid comparison. An upper limit of $\log_{10}[\epsilon] = -5$ was also applied.
- I re-processed the Chameleon data (`run_eq08_AP.m`) using a fmax of 10hz for the χ calculations, based on looking at spectra and where they rolled off.
- Data including surface convection was identified and excluded in the analysis. The mixed layer depth was identified using a criteria of $\sigma_{-surface} = 0.04$. This depth is shown in figures 1 and 2. These depths were found w/ `Identify_ML_eq08.m`
- The figures in this document are made w/ `Make_Overview_Plots_eq08.m`.

3 Results

3.1 Overview

- χ pod method estimates of χ and ϵ capture the depth and time structure well (Figures 1,2).

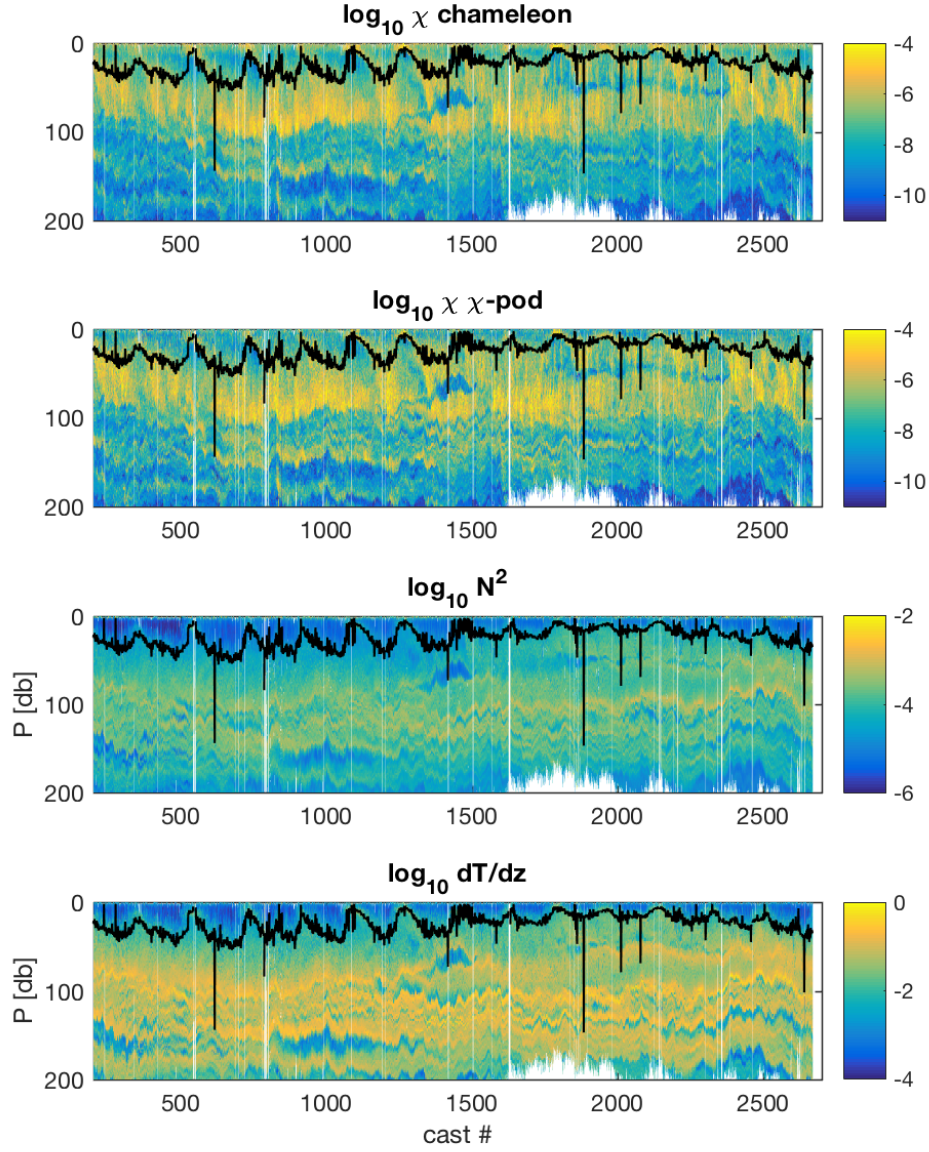


Figure 1: Comparison of χ from chameleon method and chi-pod method, for eq08 chameleon profiles. Data from each profile were averaged in 2m bins. Black line shows convective regions excluded in further analysis. N^2 and dT/dz from chameleon are also show in lower panels.

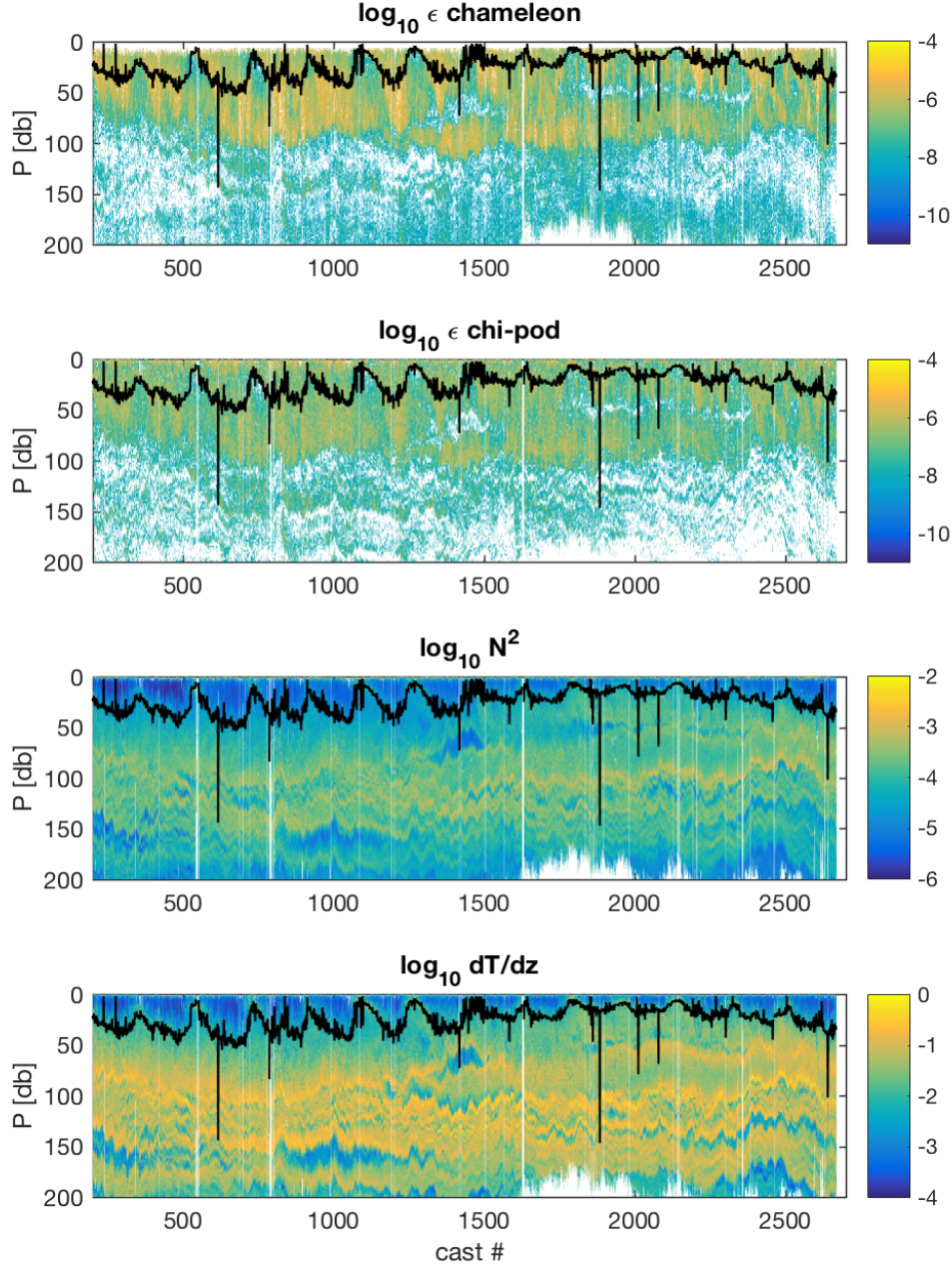


Figure 2: Comparison of ϵ from chameleon method and chi-pod method, for eq08 chameleon profiles. Each profile was averaged in 2m bins. Values of ϵ_χ and ϵ below chameleon noise floor ($\log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line shows convective regions excluded in further analysis. N^2 and dT/dz from chameleon are also show in lower panels.

3.2 ϵ_χ vs ϵ

I first compared ϵ_χ vs ϵ for the Chameleon data, where

$$\epsilon_\chi = \frac{N^2 \chi}{2\gamma T_z^2} \quad (1)$$

, using $\gamma = 0.2$. ϵ_χ underestimates ϵ , showing that that relationship (assumed in χ pod processing does not hold here.

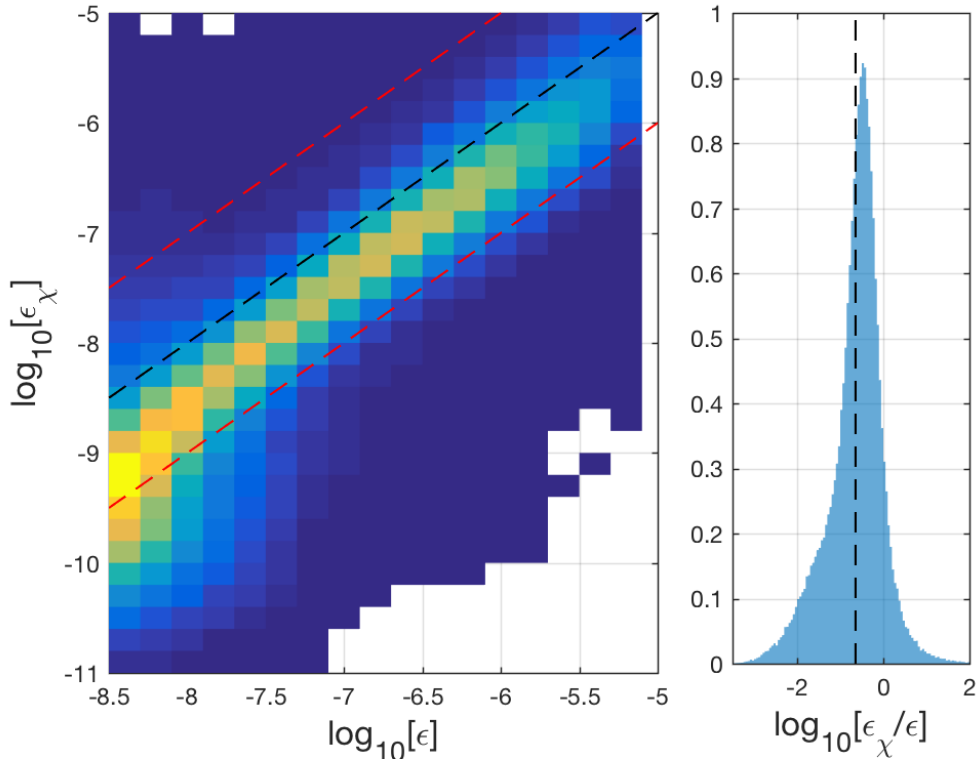


Figure 3: (Left) 2D histogram of ϵ_χ (eq. 1) vs ϵ for Chameleon data. (Right) Histogram of $\log_{10}[\epsilon_\chi/\epsilon]$

3.3 Comparing individual estimates of ϵ

- The χ pod method tends to slightly over-estimate χ , and underestimate ϵ (Figures 4,5). ϵ seems to be more under-estimated at higher values of ϵ .
- The bias in ϵ tends to be larger (more negative) at shallower depths (Figure 6).

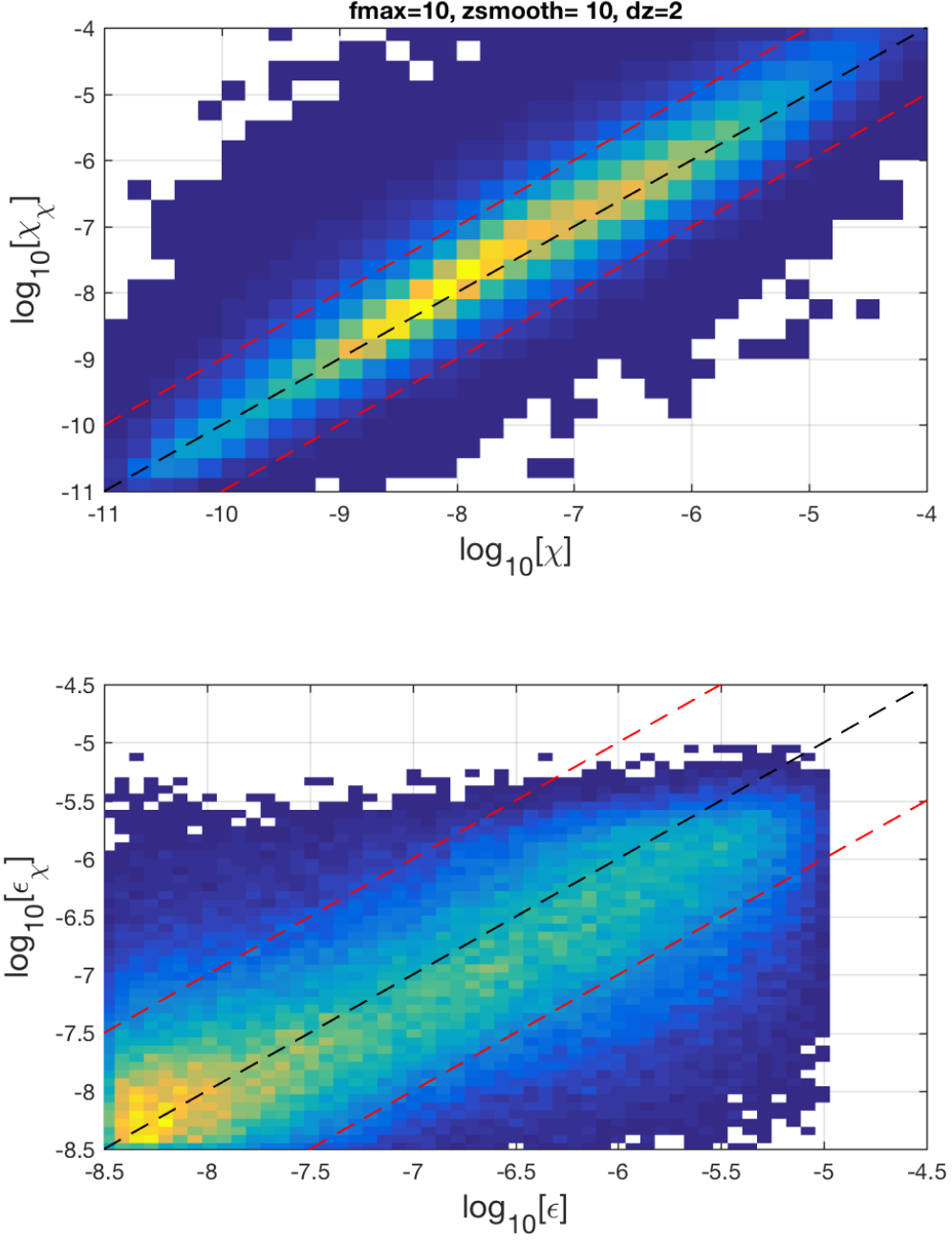


Figure 4: Comparison of χ (top) and ϵ (lower) from chameleon method and chi-pod method, for eq08 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ($\log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line is 1:1, red lines are \pm order of magnitude.

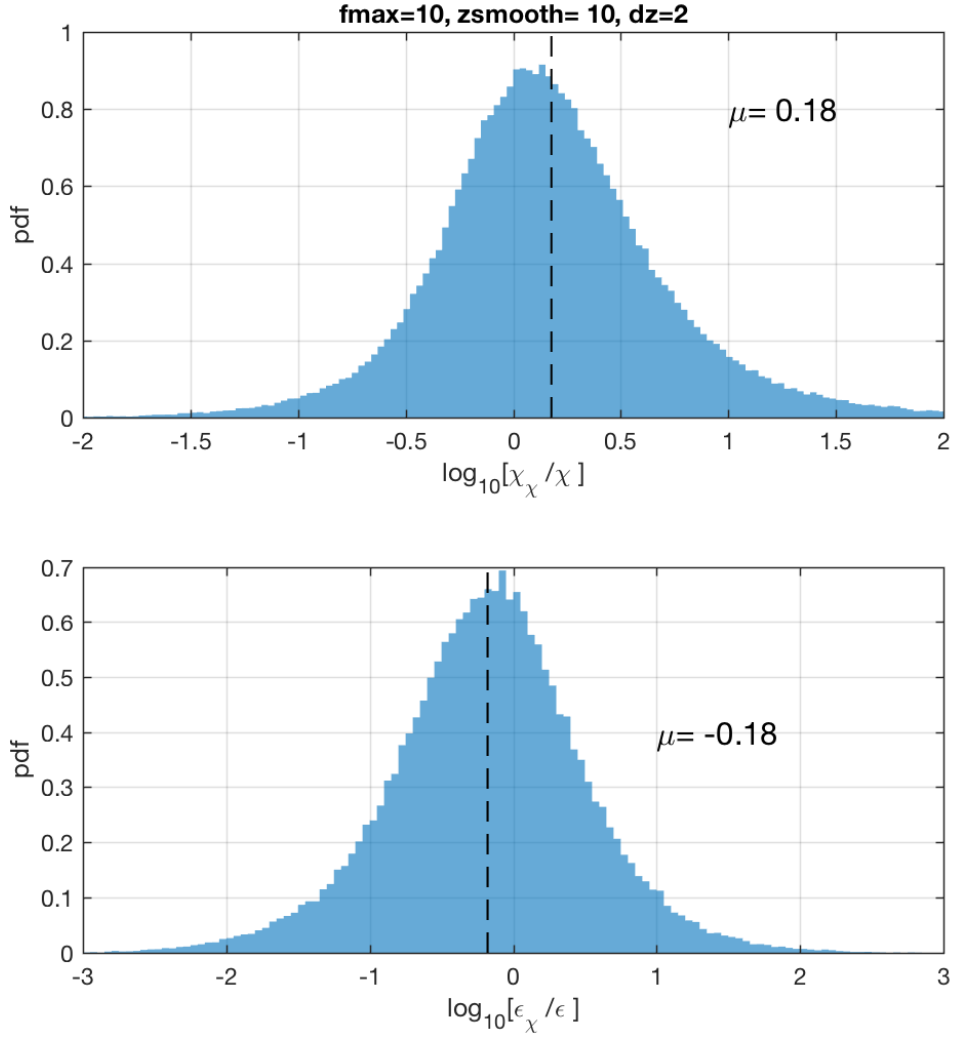


Figure 5: eq08: Histogram of the ratio of ϵ estimates from χ pod method to the chameleon values. Estimates for each profile were averaged in 10m depth bins. Vertical lines shows mean of $\log_{10}[\chi_{\chi}/\chi]$ and $\log_{10}[\epsilon_{\chi}/\epsilon]$.

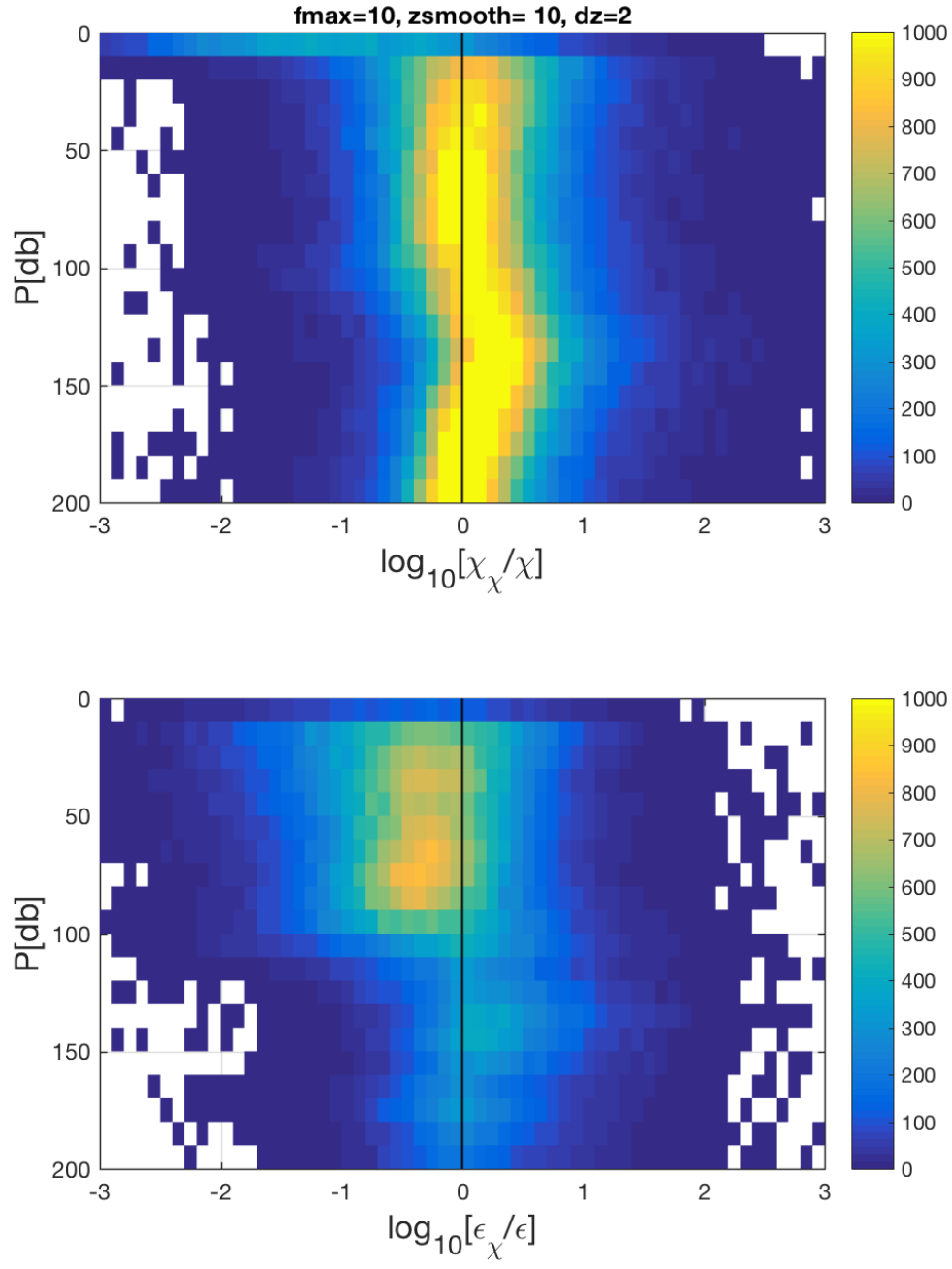


Figure 6: 2D histograms of ratios χ_χ/χ and ϵ_χ/ϵ ratios vs depth.

3.4 Dependence of bias on actual ϵ

Figure 7 shows that the bias in epsilon is inversely proportional to the actual ϵ measured by Chameleon. The bias in χ does not seem to have a strong dependence on ϵ .

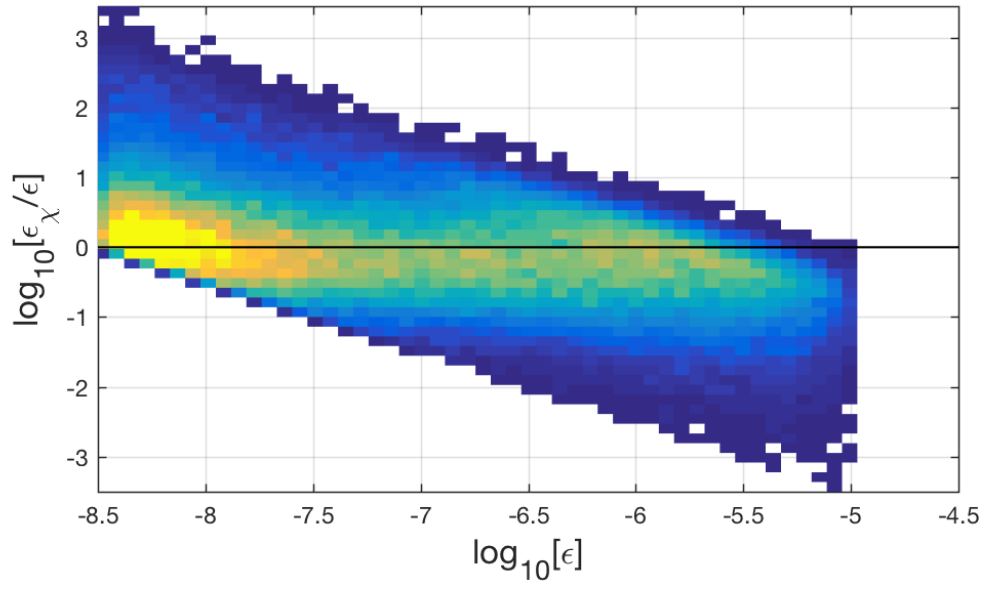
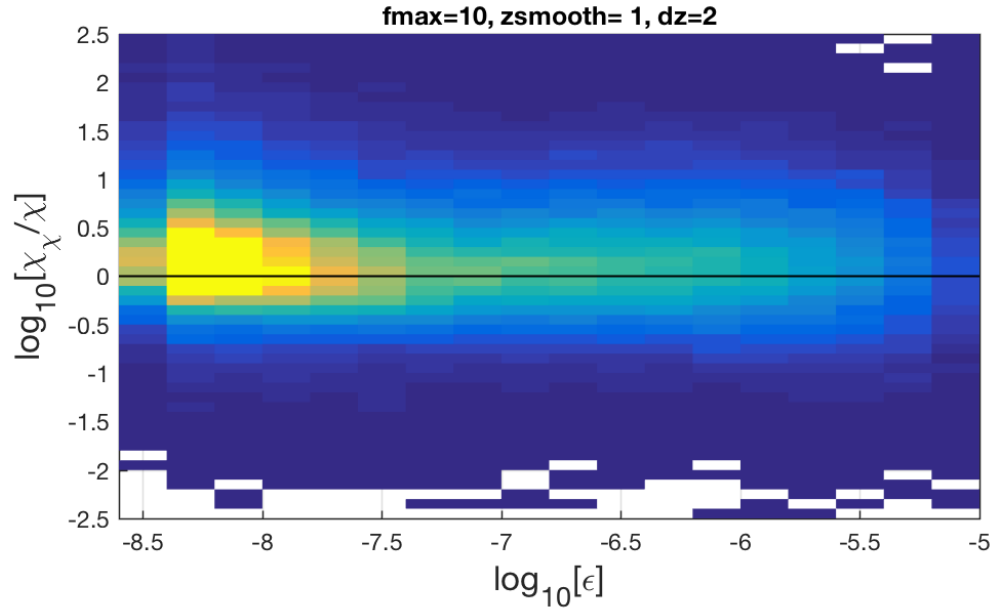


Figure 7: 2D histograms of ratios χ_χ/χ and ϵ_χ/ϵ ratios vs ϵ .

3.5 Normalized eps vs chi plots

Assuming that

$$\gamma = \frac{N^2 \chi}{2\epsilon \langle T_z \rangle^2} \quad (2)$$

, plotting $[\chi/t_z^2]$ vs $[\epsilon/N^2]$ should follow a straight line with slope equal to 2γ . The Chameleon data from EQ08 tend to fall near $\gamma = 0.1$ or slightly lower (Figure 8).

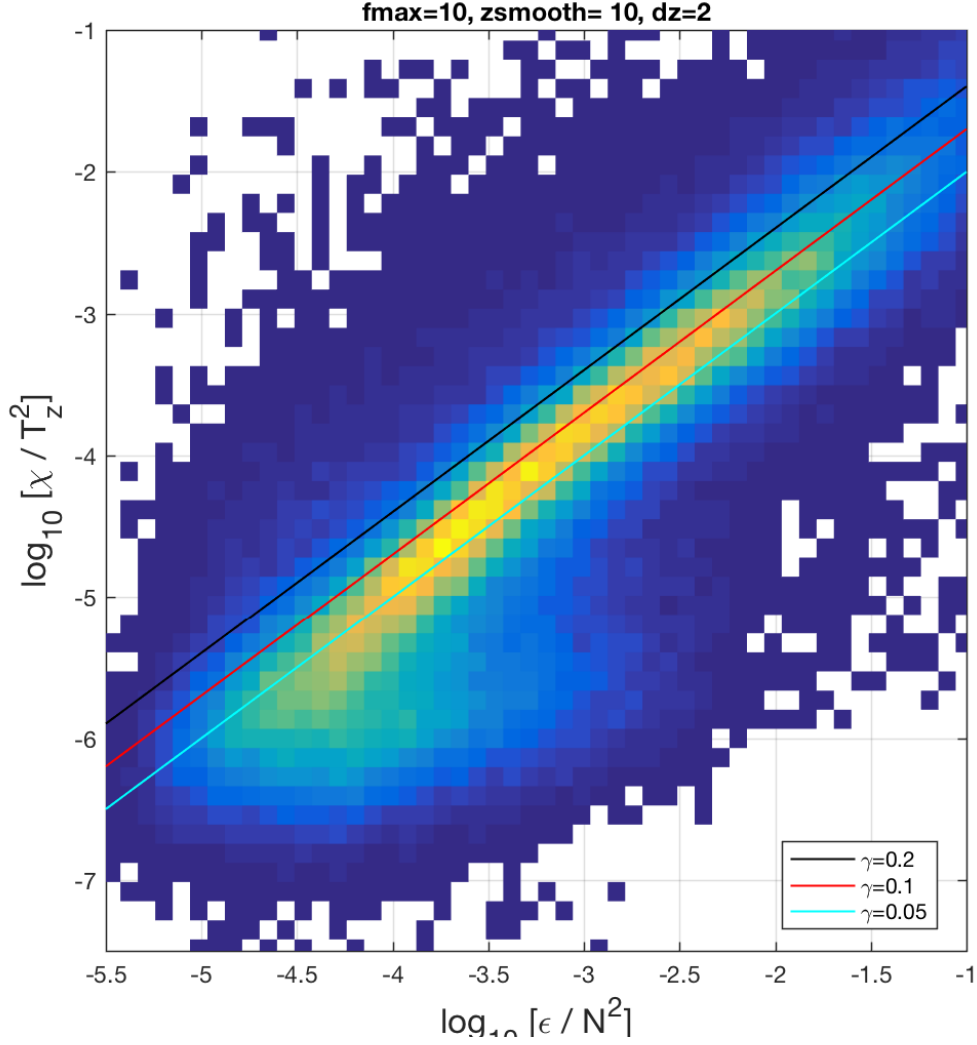


Figure 8: Chameleon ϵ/N^2 vs χ/t_z^2 . Lines show different values of γ (assuming eq. 2).

3.6 Averaging multiple profiles

- Averaging multiple profiles together does not seem to have much of an effect on the bias in χ or ϵ .

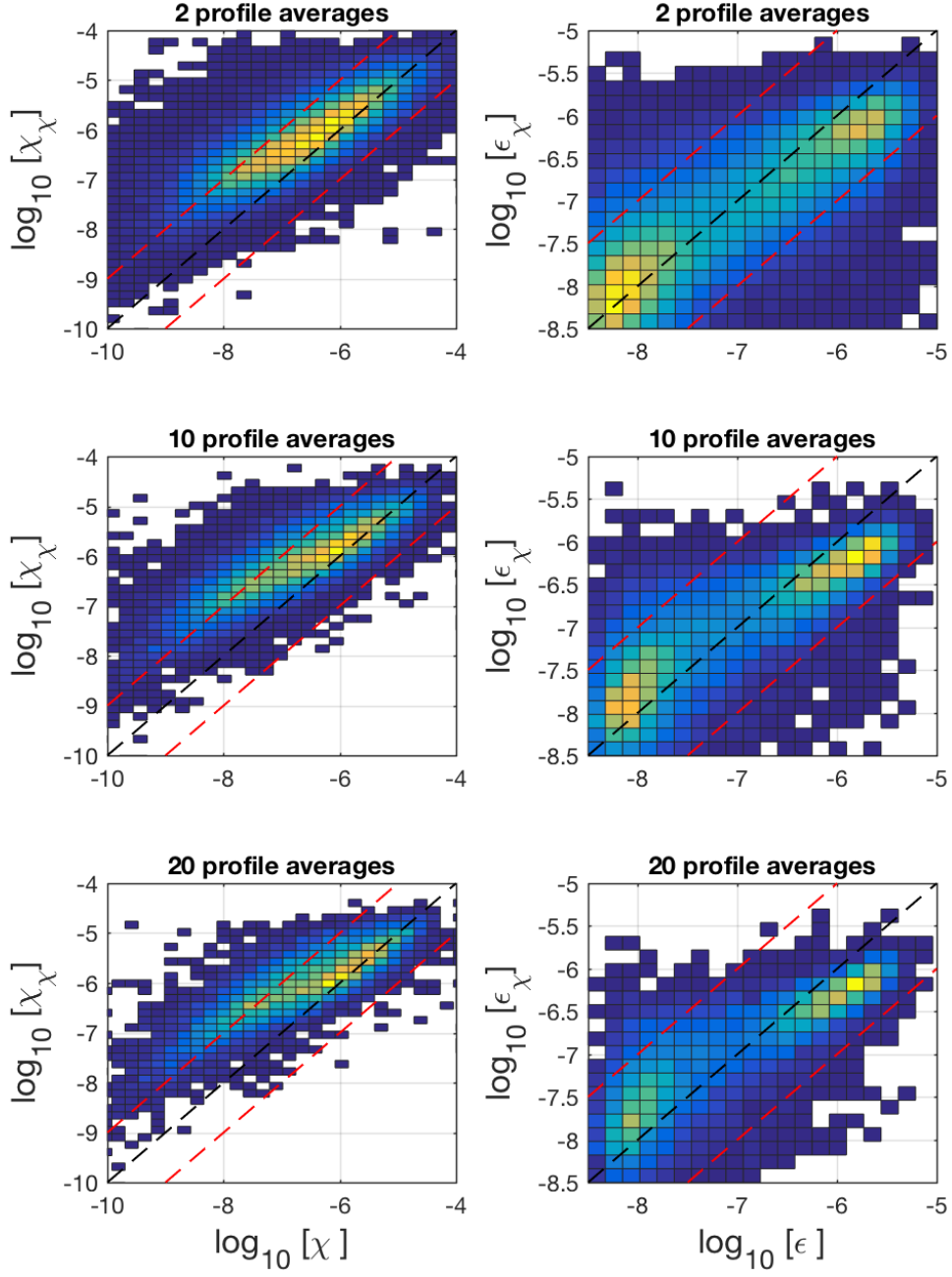


Figure 9: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) for different numbers of profiles averaged.

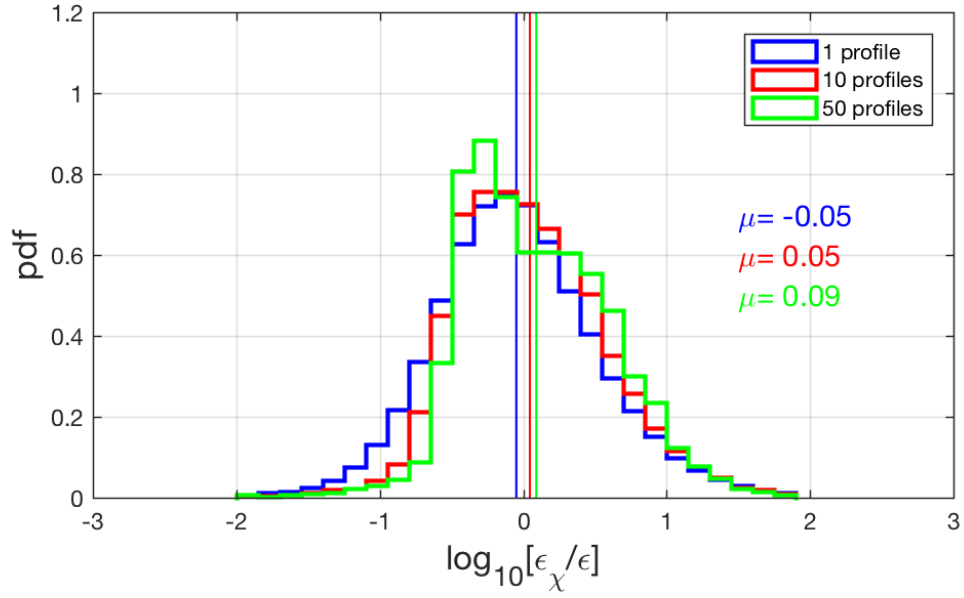
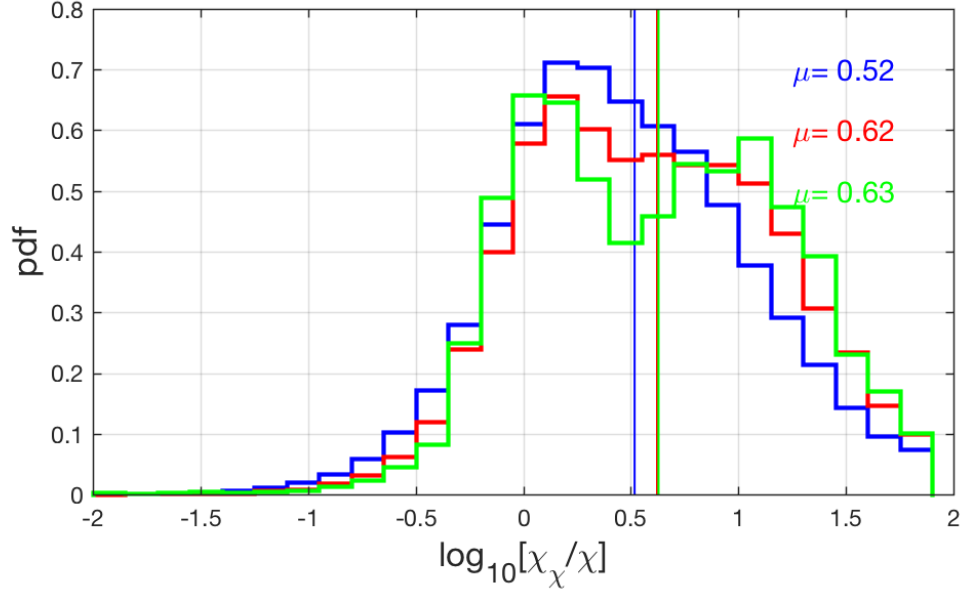


Figure 10: (\log_{10}) Ratio of ϵ_χ/ϵ for different numbers of profiles averaged. Consecutive chunks of N profiles were averaged, and then (normalized) histogram of the ratios was plotted. Vertical lines and numbers to right are mean of $\log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

3.7 Averaging over different-sized depth bins

I also looked at the effects of averaging each profile in different sized depth bins instead of averaging profiles.

- The bias in ϵ is decreased with averaging over larger depth intervals, although the bias in χ increases slightly (Figure 12).

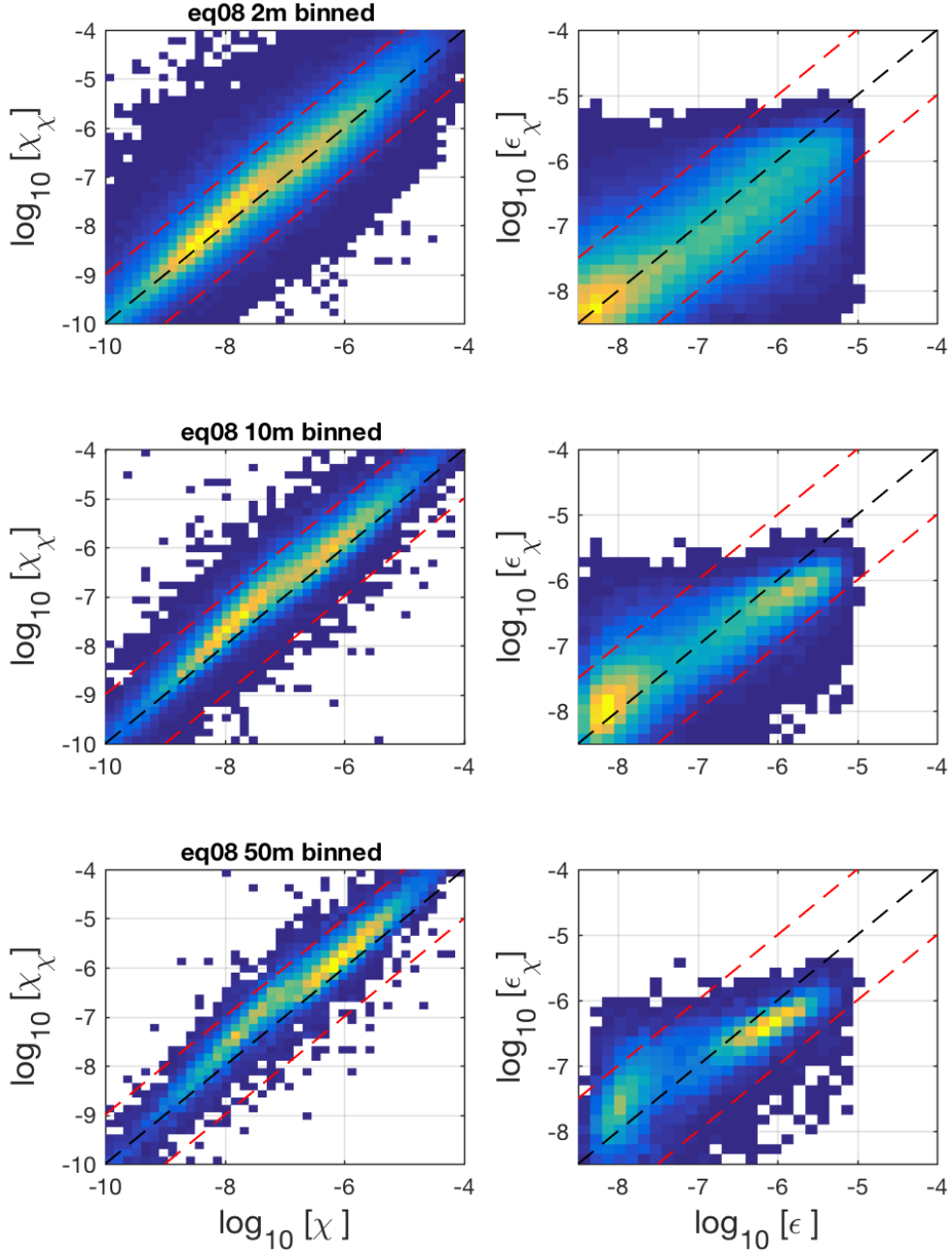


Figure 11: 2D Histograms of χ_{chi} vs χ (left) and ϵ_{χ} vs ϵ (right) averaged over different size depth bins

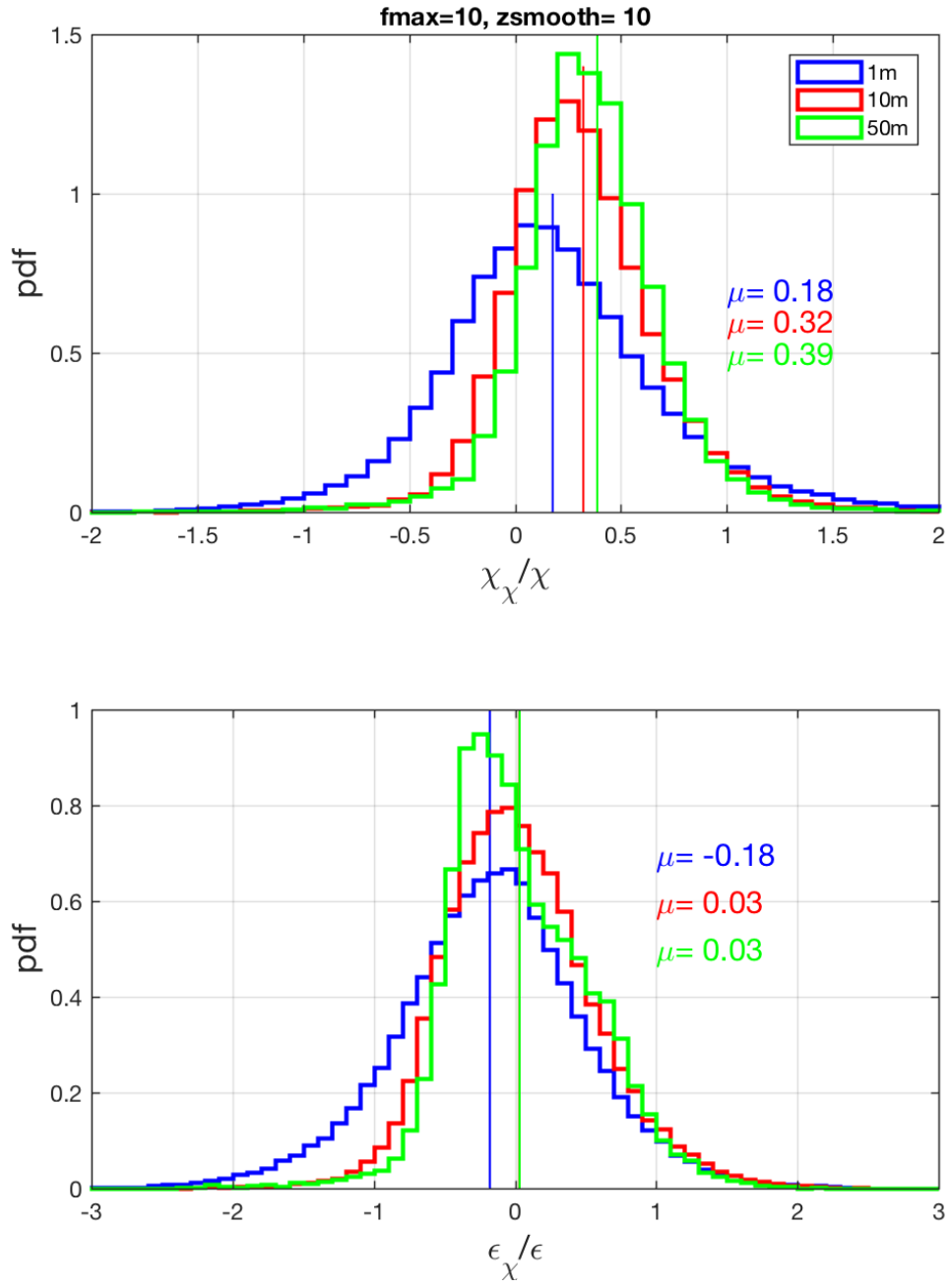


Figure 12: Histogram of \log_{10} of ratio ϵ_χ / ϵ for different amounts of vertical averaging. Vertical lines are mean of $\log_{10}[\epsilon_\chi / \epsilon]$ for each distribution.

4 Summary

- χ pod method estimates of χ and ϵ capture the depth and time structure well.
- The χ pod method tends to slightly over-estimate χ , and underestimate ϵ (Figures 4,5). ϵ seems to be more under-estimated at higher values of ϵ .
- The bias in ϵ tends to be larger (more negative) at shallower depths (Figure 6).
- γ estimated from the Chameleon data (eq. ??) tend to fall near $\gamma = 0.1$ or slightly lower (Figure 8).
- Averaging multiple profiles together does not seem to have much of an effect on the bias in χ or ϵ .
- The bias in ϵ is decreased with averaging over larger depth intervals, although the bias in χ increases slightly (Figure 12).