Summary of χpod / Chameleon EQ14 Analysis

Andy Pickering

June 14, 2017

Contents

1 Overview

- This document is an attempt to provide an overview/summary of what i've found in my χpod analysis so far.
- The motivation/goal for all this work is to show if /how well the CTD-χpod method works for estimating χ,ϵ, K_T, etc from fast temperature (thermistor) profiles. The idea is to deploy χpods 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 χpod 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 'EQ14' experiment. On my laptop, they are located in the folder:
`/Cham_Eq14_Compare/Data/chameleon/processed/`

- Sally shared w/ me Chameleon data that she and Jim processed. I ended up re-processing it using a smaller fmax (7Hz) because it looked like the thermistor spectra rolled off much lower than the normally-assumed 32Hz. These data are located at:
`/Cham_Eq14_Compare/Data/chameleon/processed_AP_7hz/`

- The χpod method is applied to Chameleon profiles (thermistor only, not shear probe) from EQ14 in `ComputeChi_Chameleon_Eq14.m`

- The noise floor of Chamleon ϵ was determined to be $log_{10}[\epsilon] = -8.5$. Values below this threshold were discarded. χpod values below this threshold were also discarded, in order to make a valid comparison. An upper limit of $log_{10}[\epsilon] = -5$ (determined by Jim?) was also applied.

- Data including surface convection was identified and excluded in the analysis. The mixed layer depth was identified (`Identify_mixedlayer_eq14.m`) using a criteria of $\sigma -_{surface} = 0.04$. This depth is shown in figures 1 and 2.

- `Make_Overview_Plots.m` Makes the figures in this document.

3 Results

3.1 Overview

- Both χ_χ and ϵ_χ appear to capture the depth and time structure of χ and ϵ well (Figures 1,2).

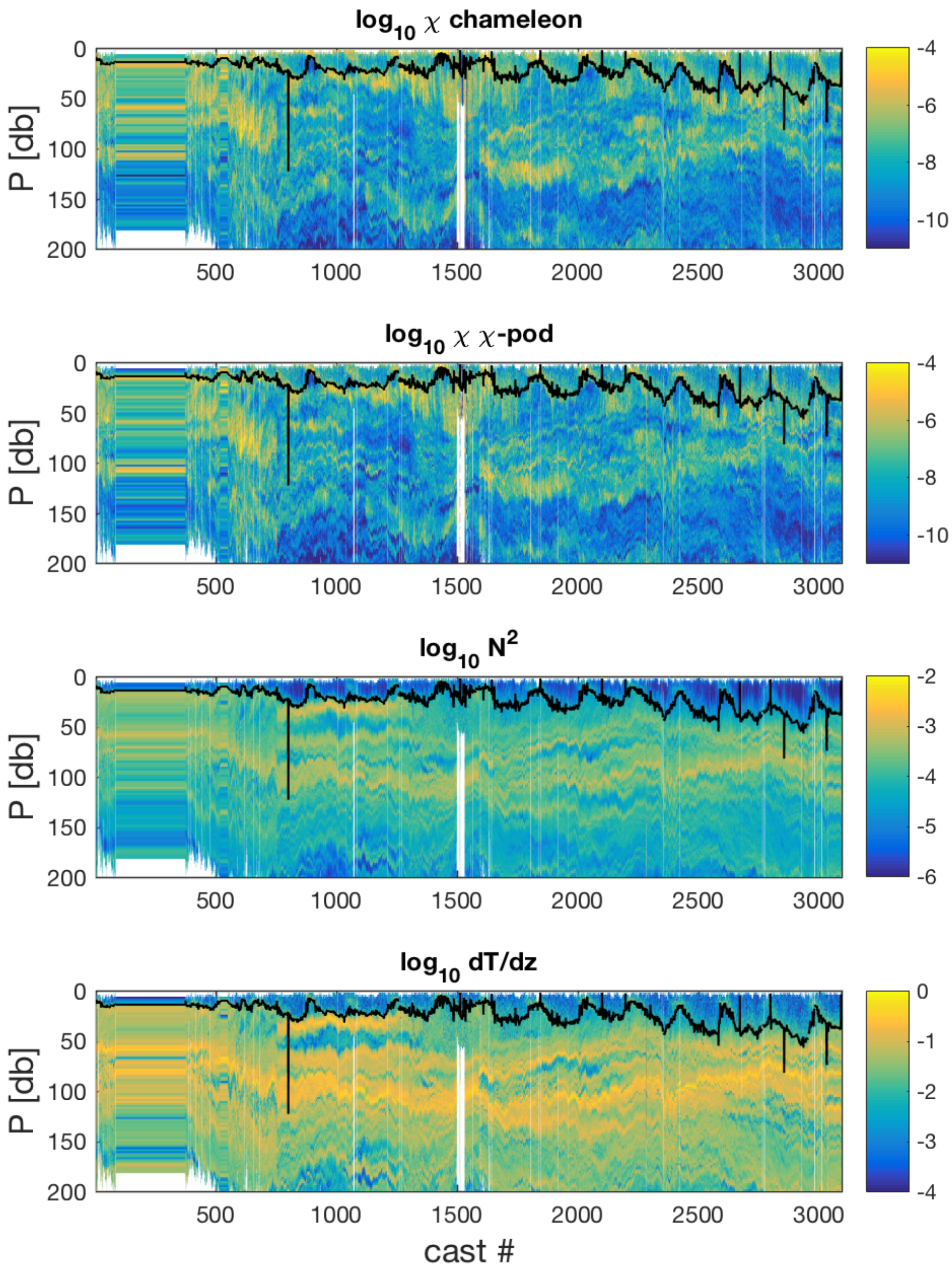

Figure 1: Comparison of χ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Black line shows shows convective regions excluded in further analysis.

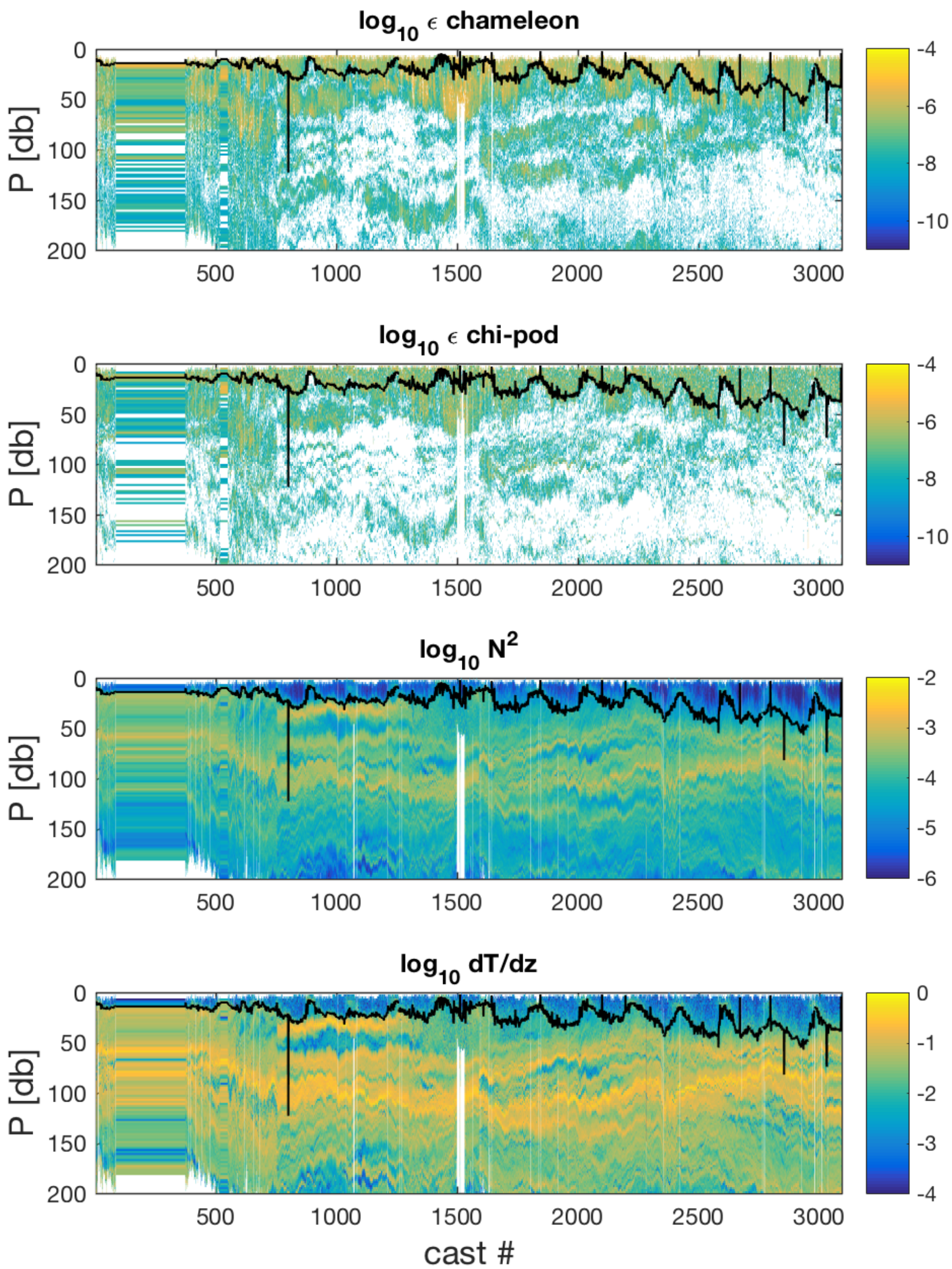

Figure 2: Comparison of ϵ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of ϵ_χ and ϵ below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line shows shows convective regions excluded in further analysis.

3.2 ϵ_χ vs ϵ

I first compared ϵ_χ vs ϵ_χ vs ϵ for the Chameleon data, where $\epsilon_\chi = N^2\chi/2/\gamma/T_z^2$, using $\gamma = 0.2$. ϵ_χ underestimates ϵ, showing that that relationship (assumed in χpod processing does not hold here.

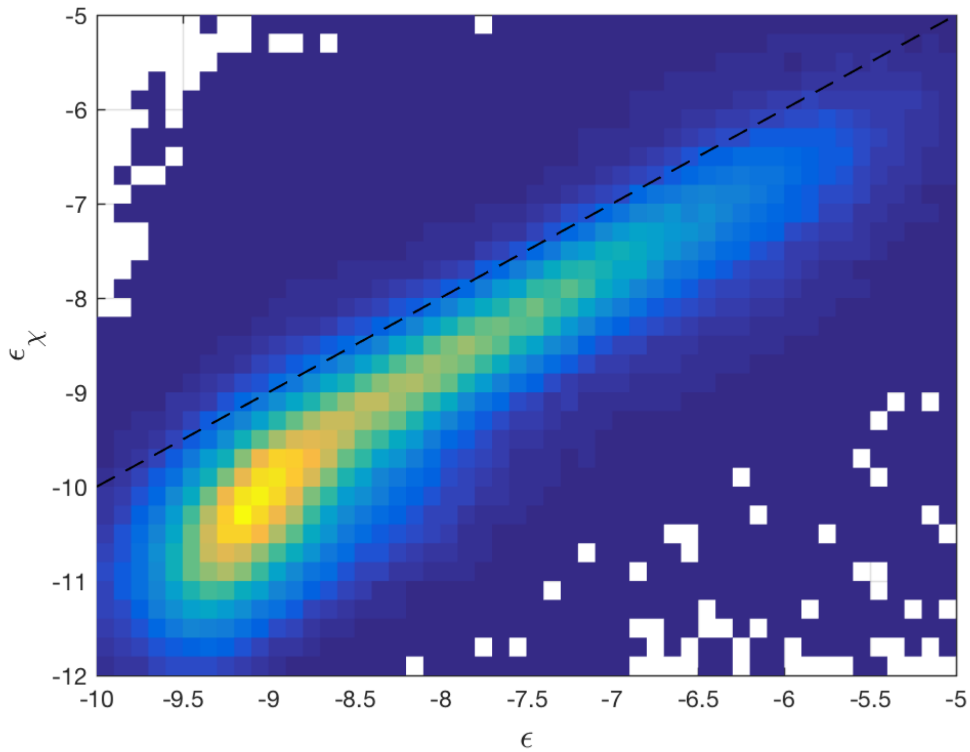

Figure 3: 2D histogram of ϵ_χ vs ϵ for Chameleon data.

3.3 Comparing individual estimates of ϵ

- Both χ_χ and ϵ_χ are biased low (Figures 4,5); the ϵ_χ bias is larger (more negative).
- The bias in χ is relatively constant with depth; the bias in ϵ is more negative at shallower depths (Figure 6).

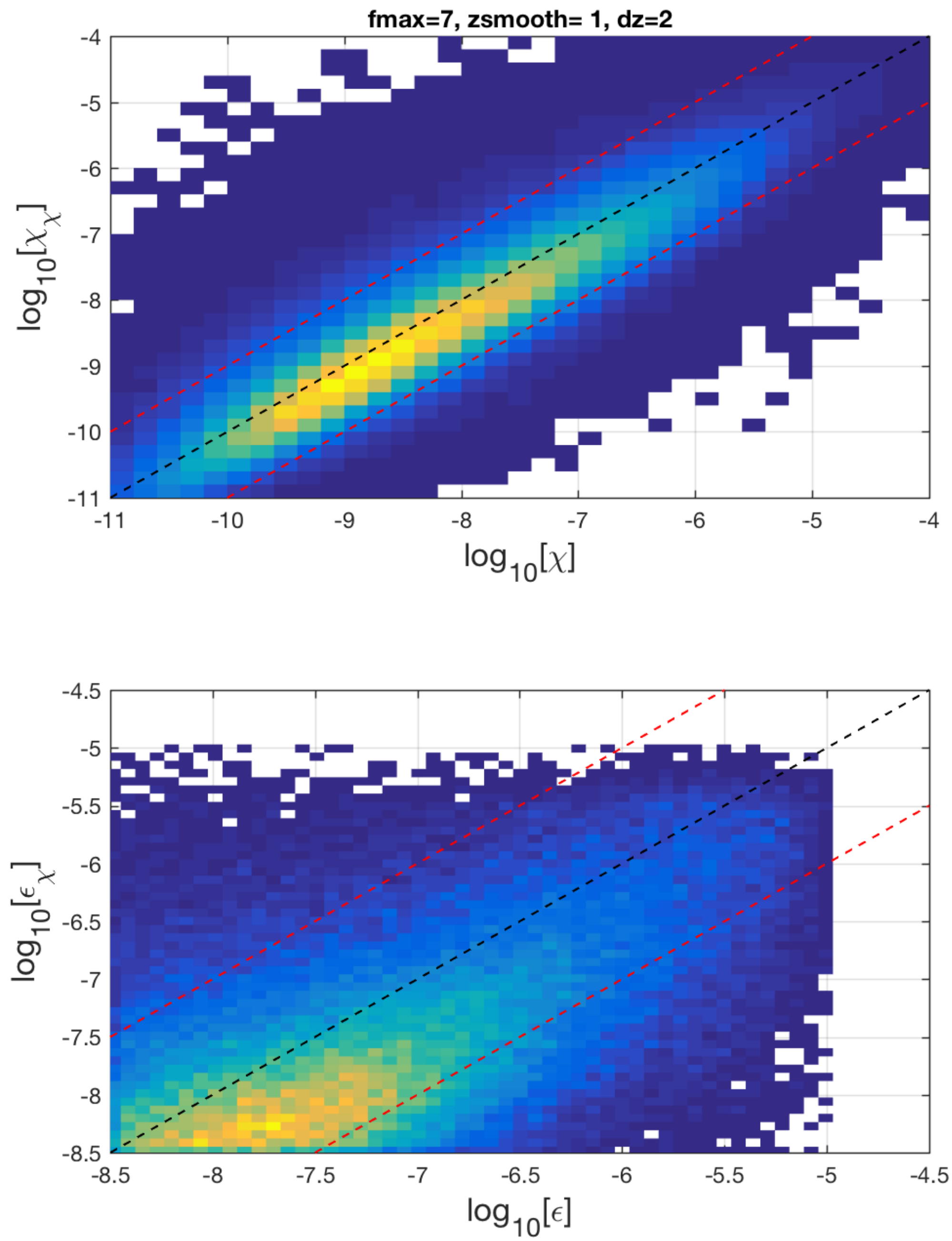

Figure 4: Comparison of χ (top) and ϵ (lower) from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line is 1:1, red lines are $+/-$ order of magnitude.

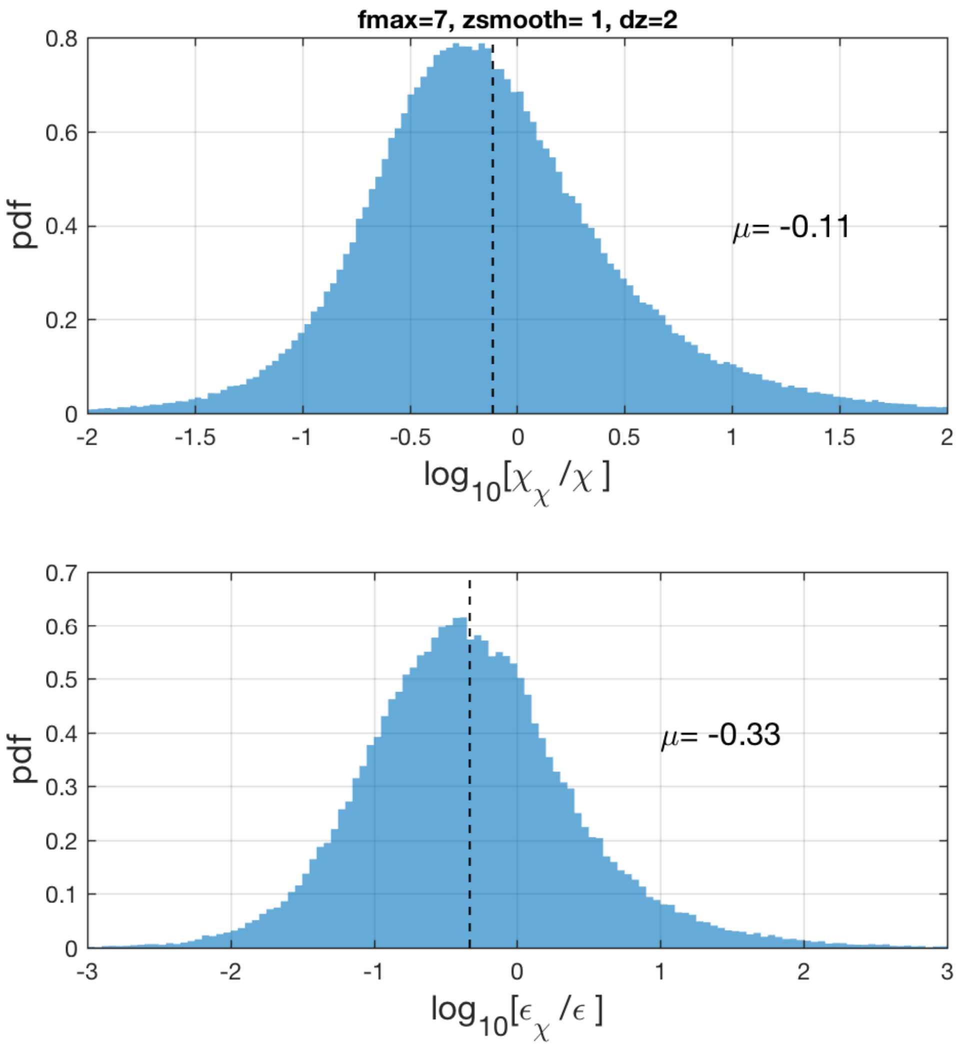

Figure 5: Histograms of the ratios of χ_ϵ/χ (top) and ϵ_χ/ϵ (lower) .

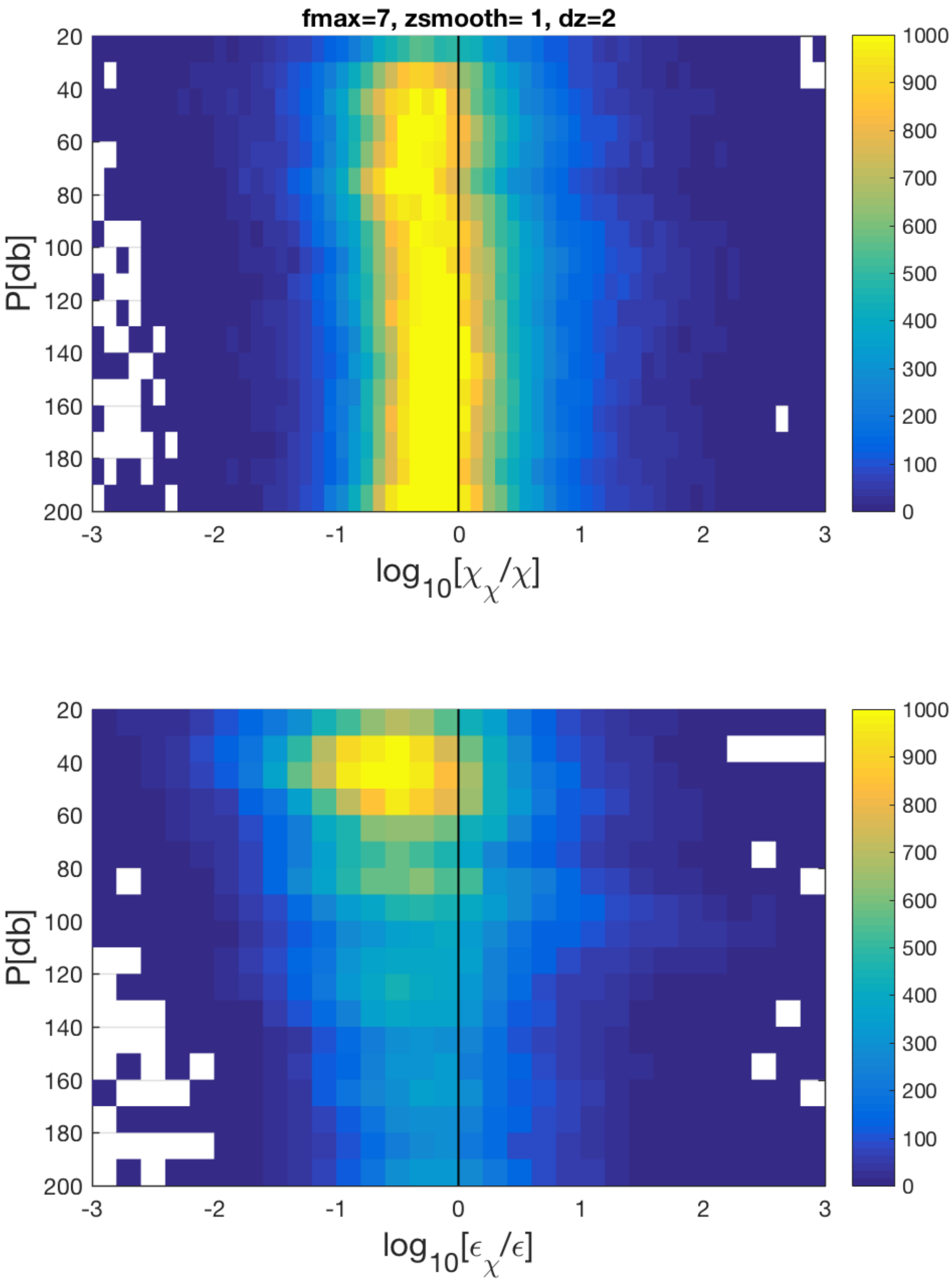

Figure 6: 2D histograms of ratios χ_χ and ϵ_χ ratios vs depth.

3.4 Dependence of bias on actual ϵ

Figure 7 shows that the bias in χ and ϵ is inversely proportional to the actual ϵ measured by Chameleon. The dependence of bias in χ not as strong as for ϵ.

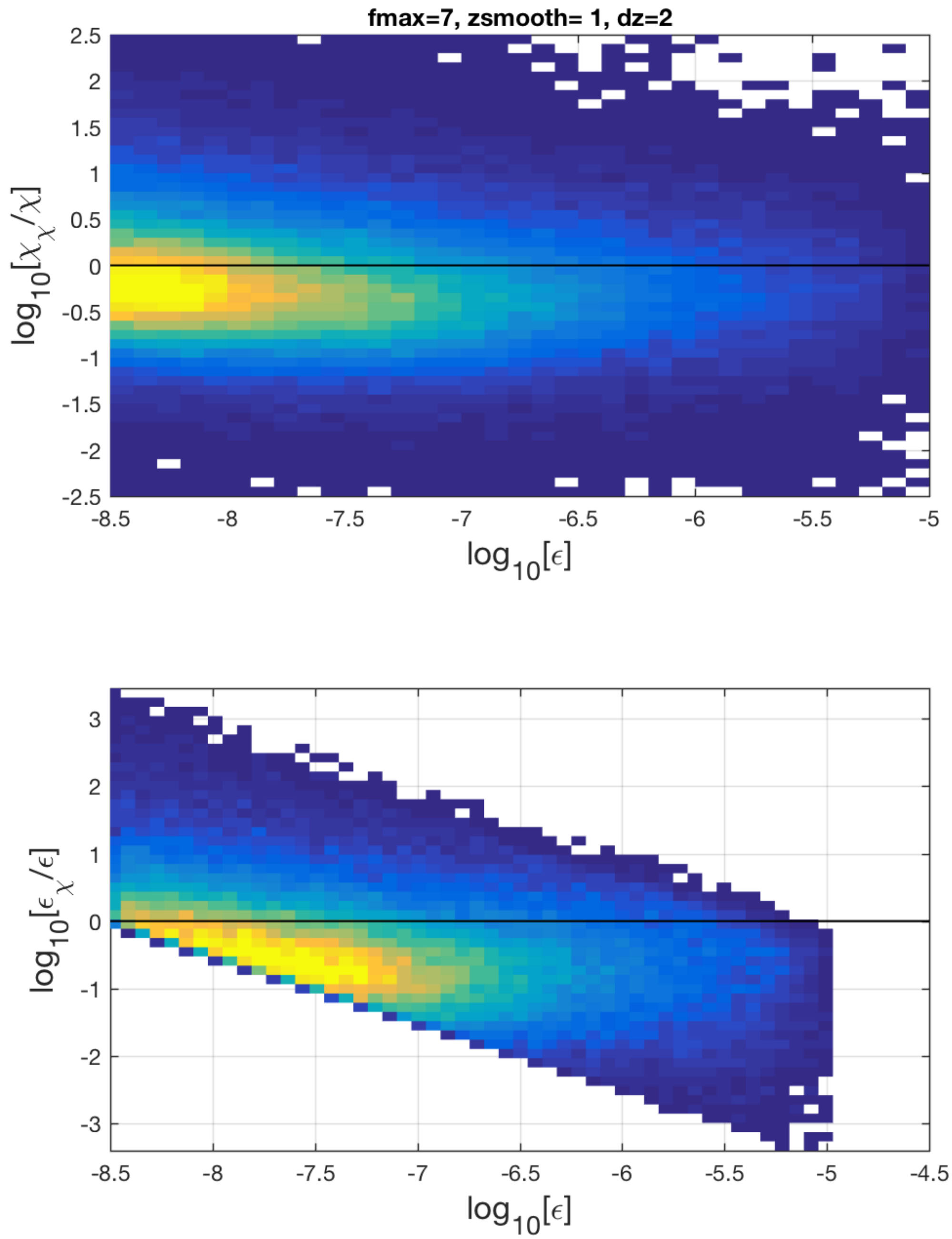

Figure 7: 2D histograms of ratios χ_χ/χ and ϵ_χ/ϵ ratios vs ϵ.

3.5 Normalized eps vs chi plots

Assuming that

$$\gamma = \frac{N^2 \chi}{2\epsilon < T_z >^2} \tag{1}$$

, plotting $[\chi/t_z^2]$ vs $[\epsilon/N\hat{2}]$ should follow a straight line with slope equal to 2γ. Chameleon data from EQ14 tend to fall near $\gamma = 0.05$ (Figure 8).

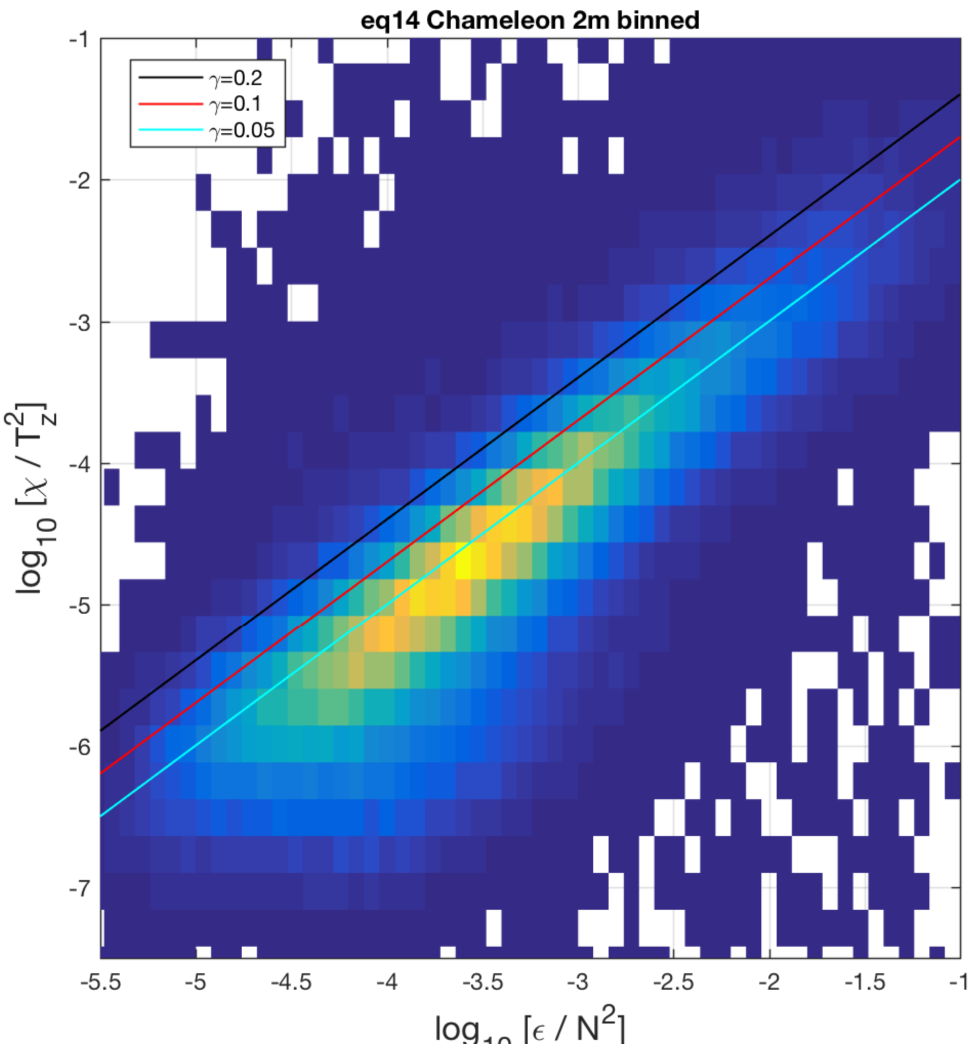

Figure 8: EQ14: 2m binned chameleon $\epsilon/N\hat{2}$ vs χ/t_z^2. Lines show different values of γ. Values of ϵ below noise floor ($log_{10}\epsilon < -8.5$) are discarded also.

3.6 Averaging multiple profiles of ϵ

- Averaging over multiple profiles does not seem to have much of an effect on the bias in both χ and ϵ (Figures 9,10).

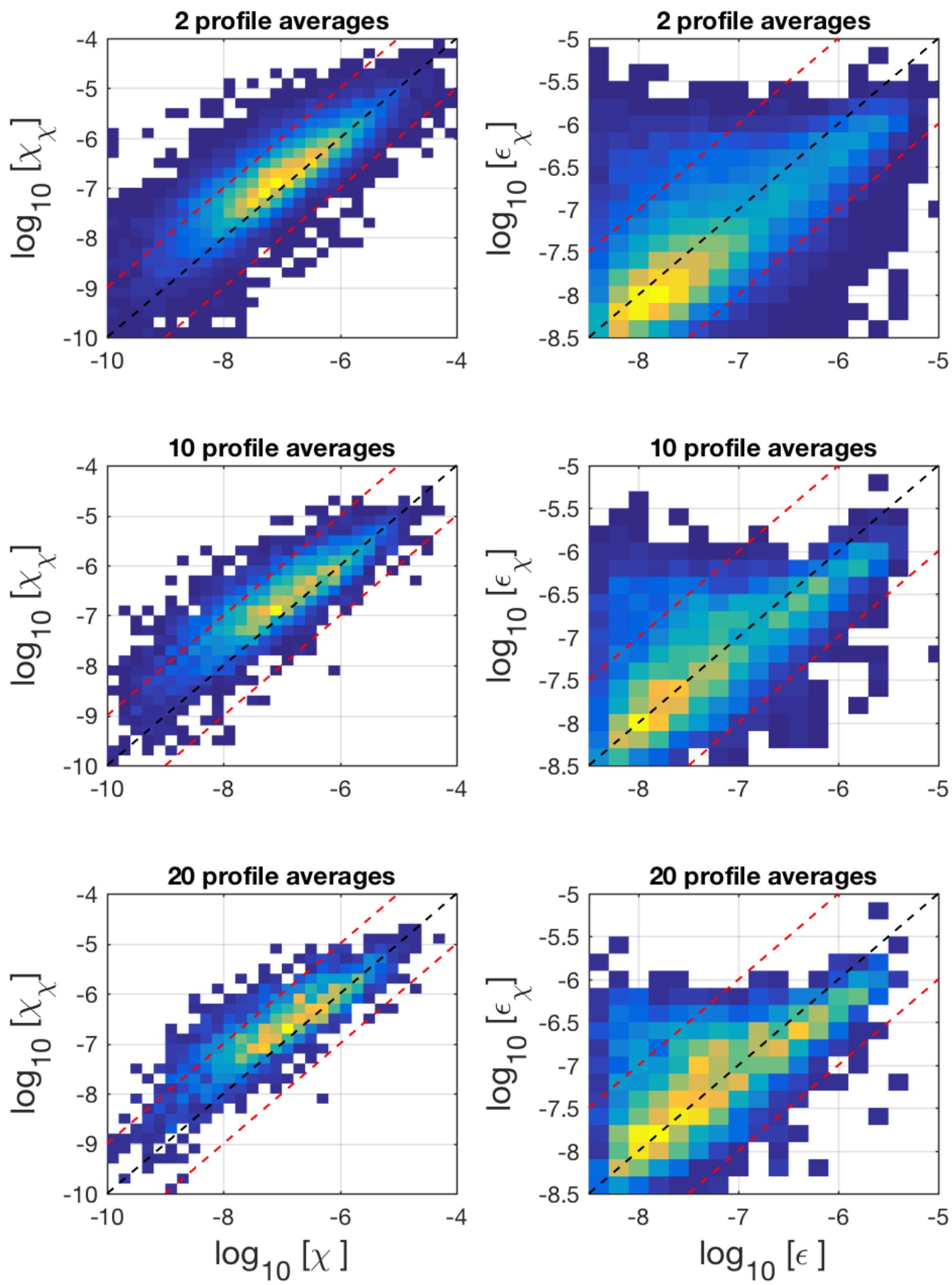

Figure 9: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) for different numbers of profiles averaged.

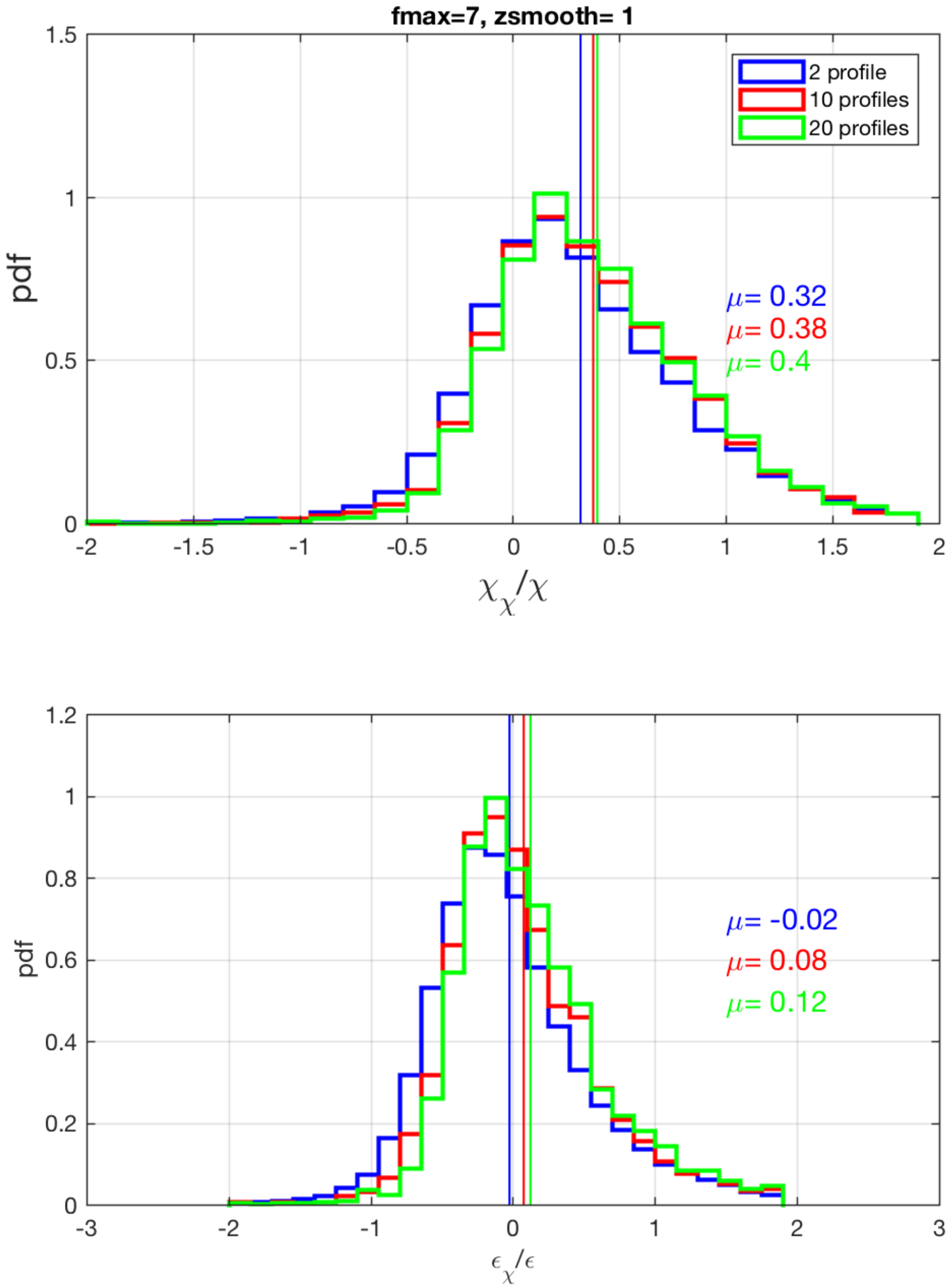

Figure 10: (log10) Ratio of ϵ_χ/ϵ for different numbers of profiles averaged. Consecutive chunks of N profiles were averaged, and then (normalized) histogram of the ratios was plotted. Vertical lines and numbers to right are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

3.7 Averaging over different-sized depth bins

- Averaging over large depth bins reduces the bias in both χ and ϵ (Figures 11,12).

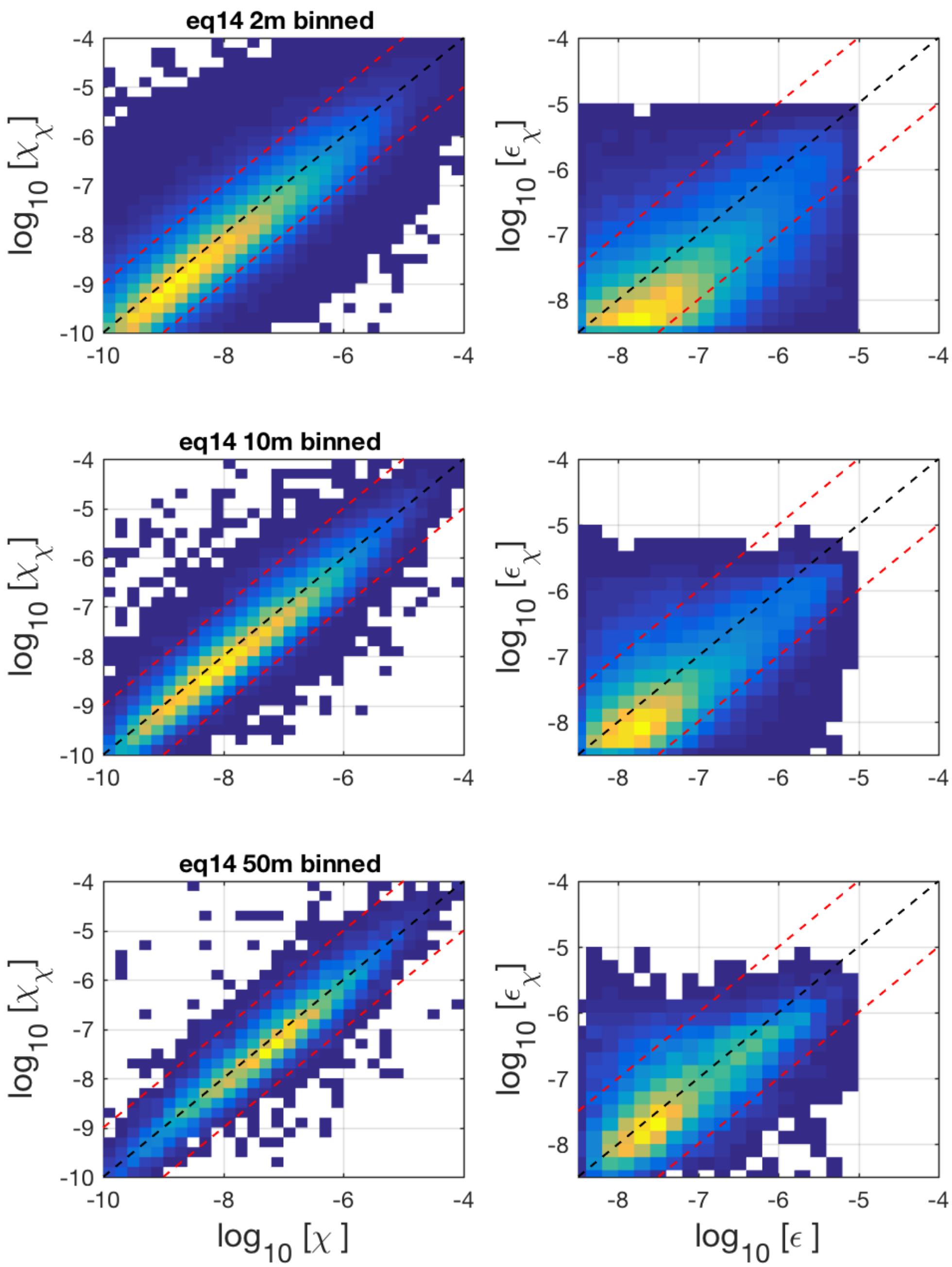

Figure 11: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) averaged over different size depth bins

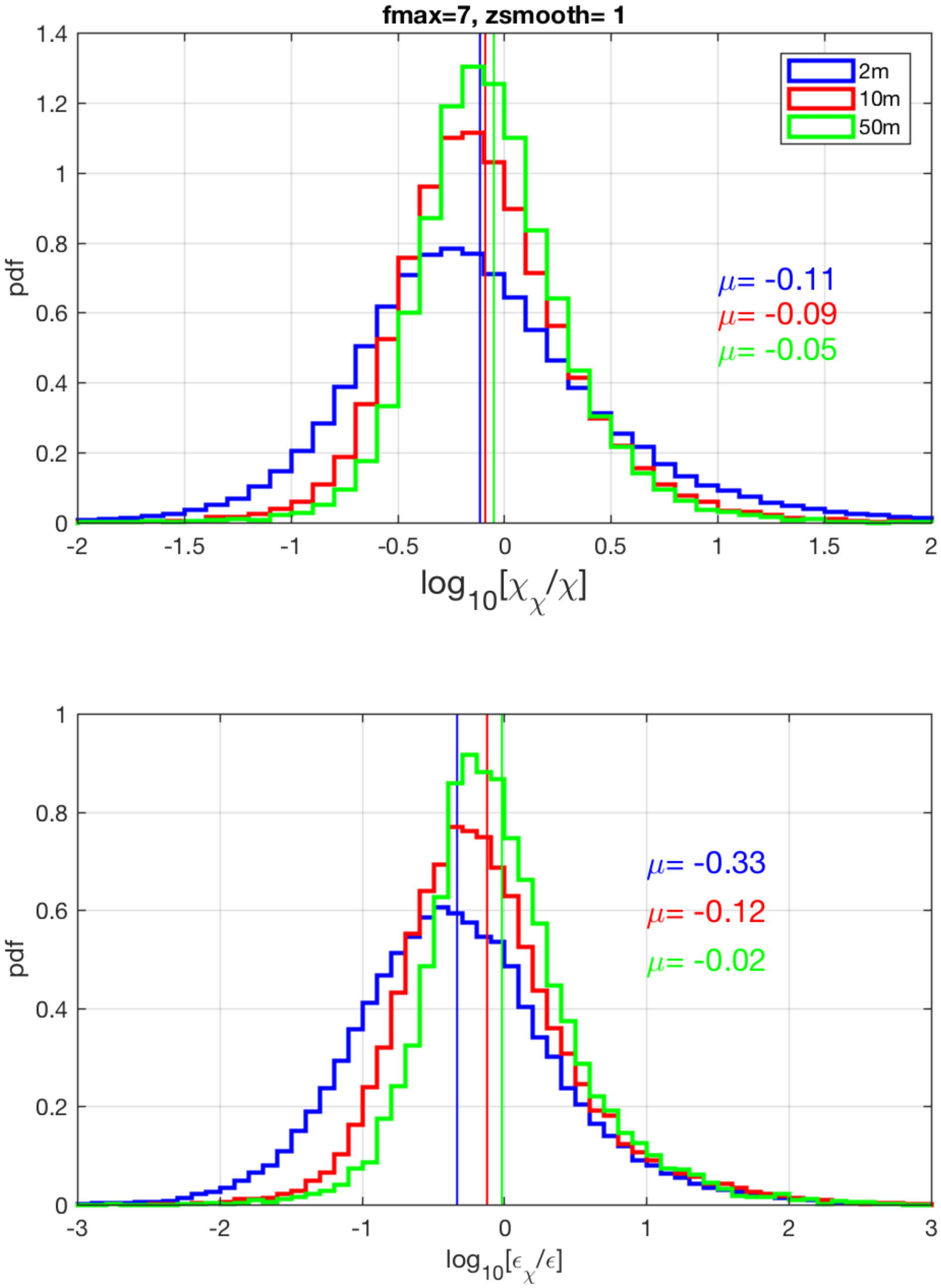

Figure 12: Histogram of log10 of ratio ϵ_χ/ϵ for different amounts of vertical averaging. Vertical lines are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

3.8 γ computed from averaged quantities

If we compute gamma from time-averaged N^2, T_z, χ, ϵ do we get $\gamma = 0.2$ (or a different gamma)? Estimates from the averaged data are larger (Figure 13) but still slightly less than 0.2 .

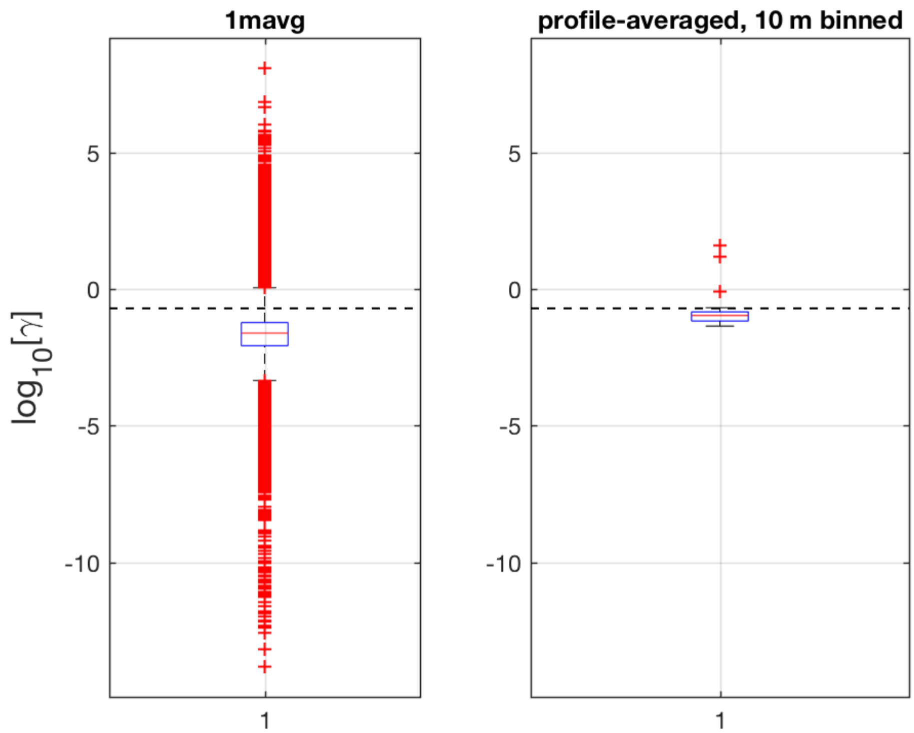

Figure 13: Boxplots of $log_{10}[\gamma]$ for a set of profiles from EQ14. Left is for all 1m avg data. Right is for data from all profiles averaged in 10m bins. Horizontal dashed line indicates $\gamma = 0.2$.

3.9 Summary

- Both χ_χ and ϵ_χ appear to capture the depth and time structure of χ and ϵ well (Figures 1,2).
- Both χ_χ and ϵ_χ are biased low (Figures 4,5); the ϵ_χ bias is larger (more negative).
- The bias in χ is relatively constant with depth; the bias in ϵ is more negative at shallower depths (Figure 6).
- Figure 7 shows that the bias in χ and ϵ is inversely proportional to the actual ϵ measured by Chameleon. The dependence of bias in χ not as strong as for ϵ.
- Averaging over multiple profiles does not seem to have much of an effect on the bias in both χ and ϵ (Figures 9,10).
- Averaging over large depth bins reduces the bias in both χ and ϵ (Figures 11,12).