Summary of χpod / Chameleon EQ14 Analysis

Andy Pickering

June 13, 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).

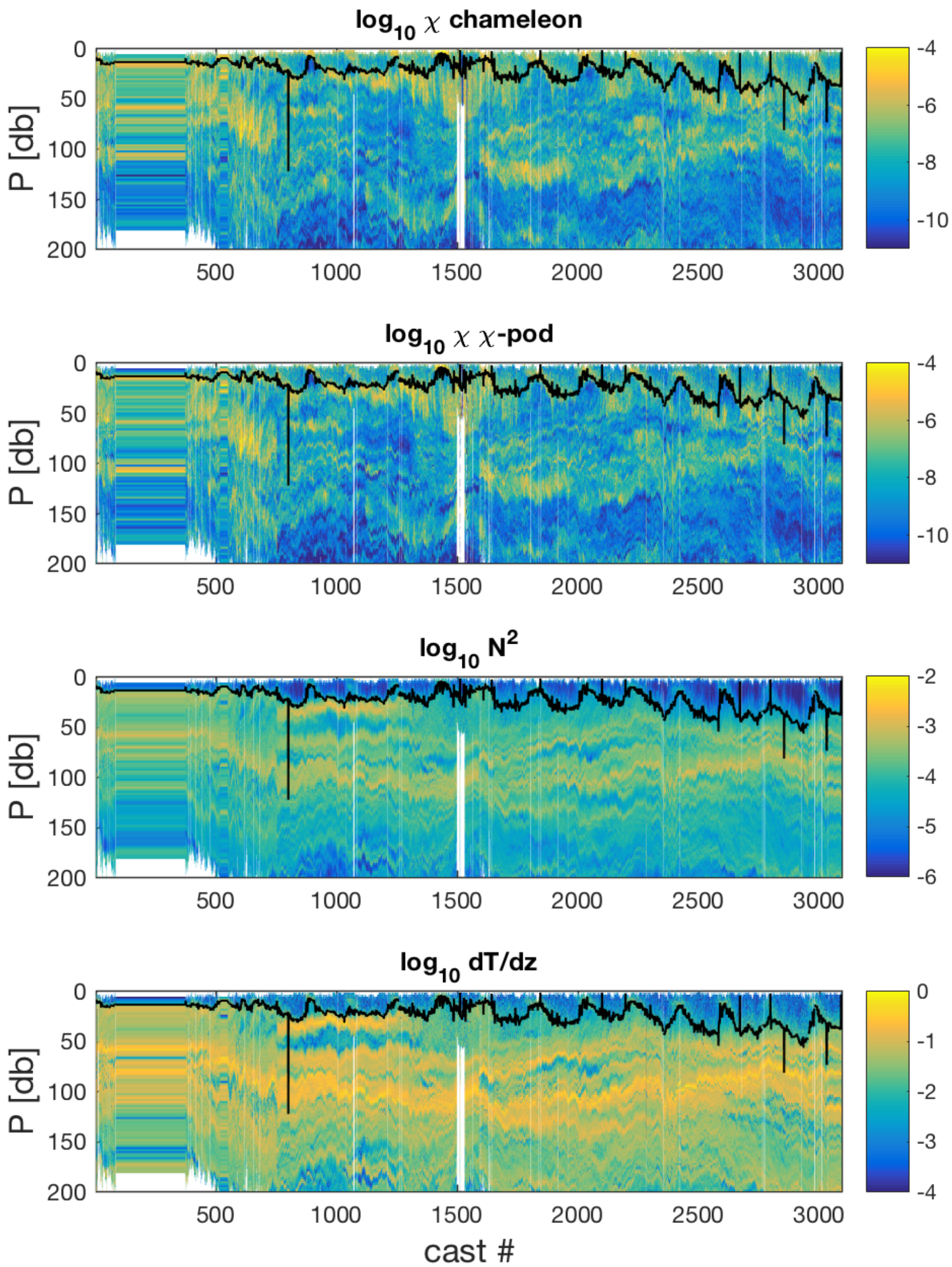

Figure 1: Comparison of χ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Black line shows shows convective regions excluded in further analysis.

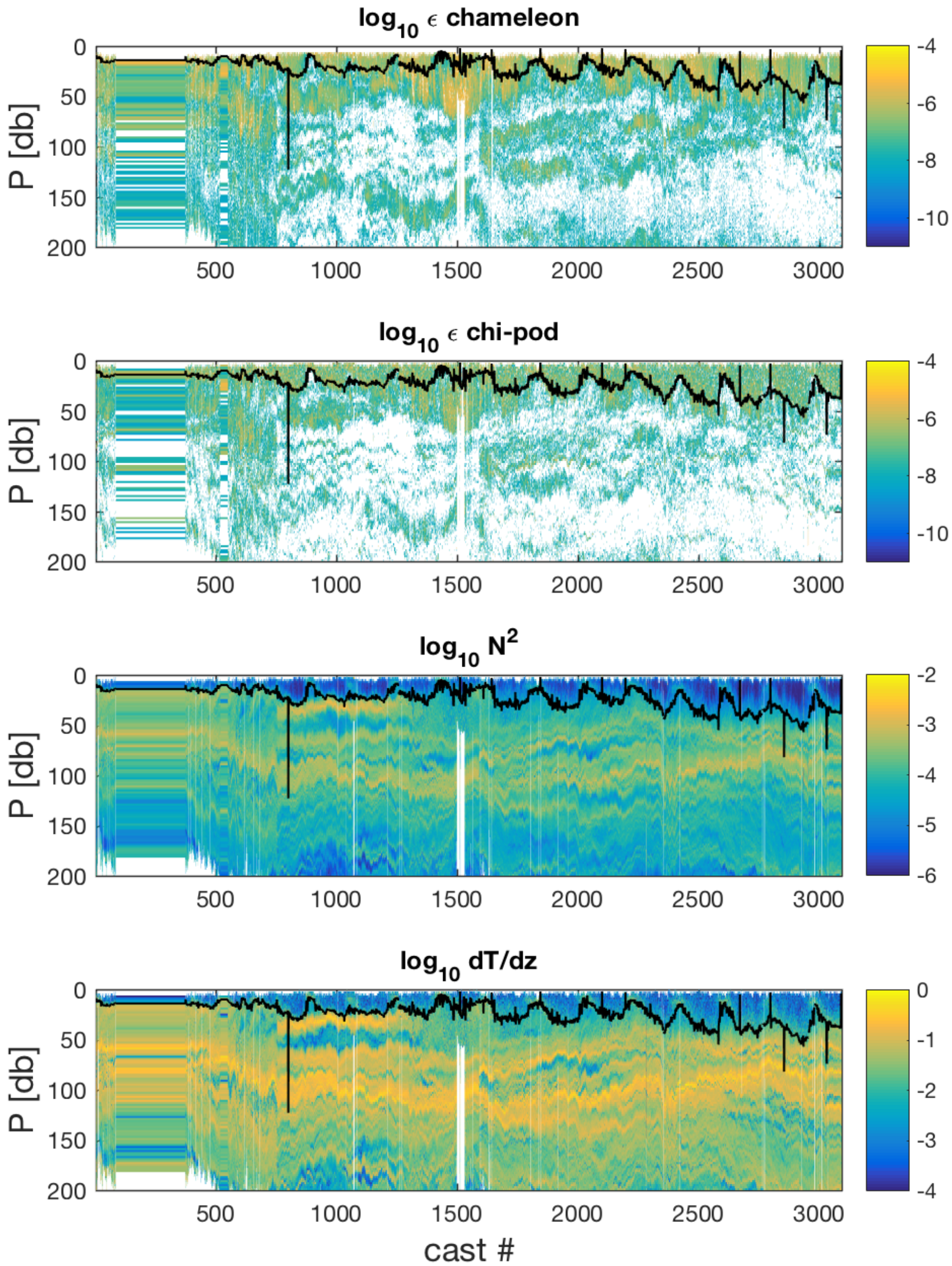

Figure 2: Comparison of ϵ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of ϵ_χ and ϵ below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line shows shows convective regions excluded in further analysis.

3.2 Comparing individual estimates of ϵ

- Both χ_χ and ϵ_χ are biased low (Figures 3,4); 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 5).

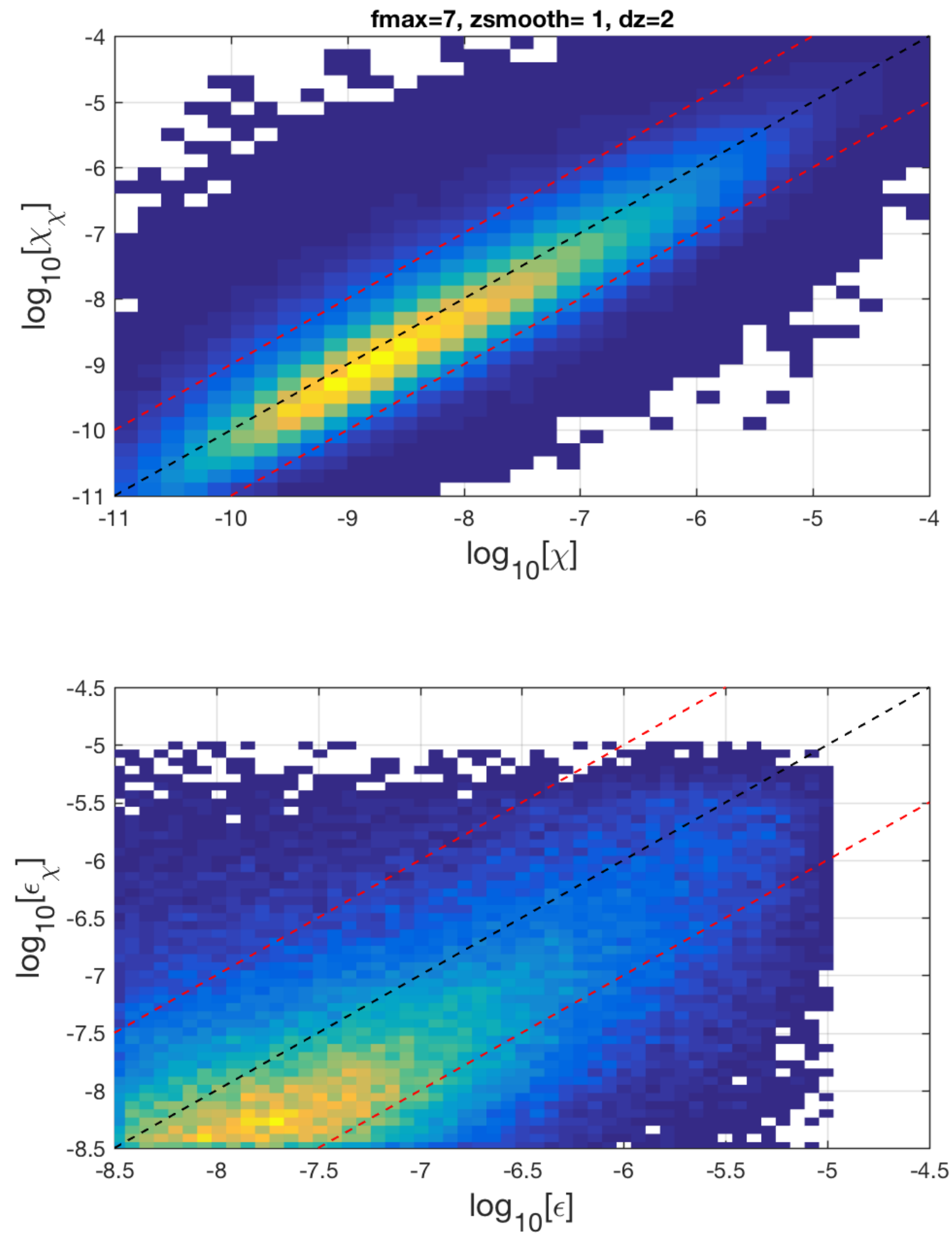

Figure 3: Comparison of χ (top) and ϵ (lower) from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line is 1:1, red lines are $+/-$ order of magnitude.

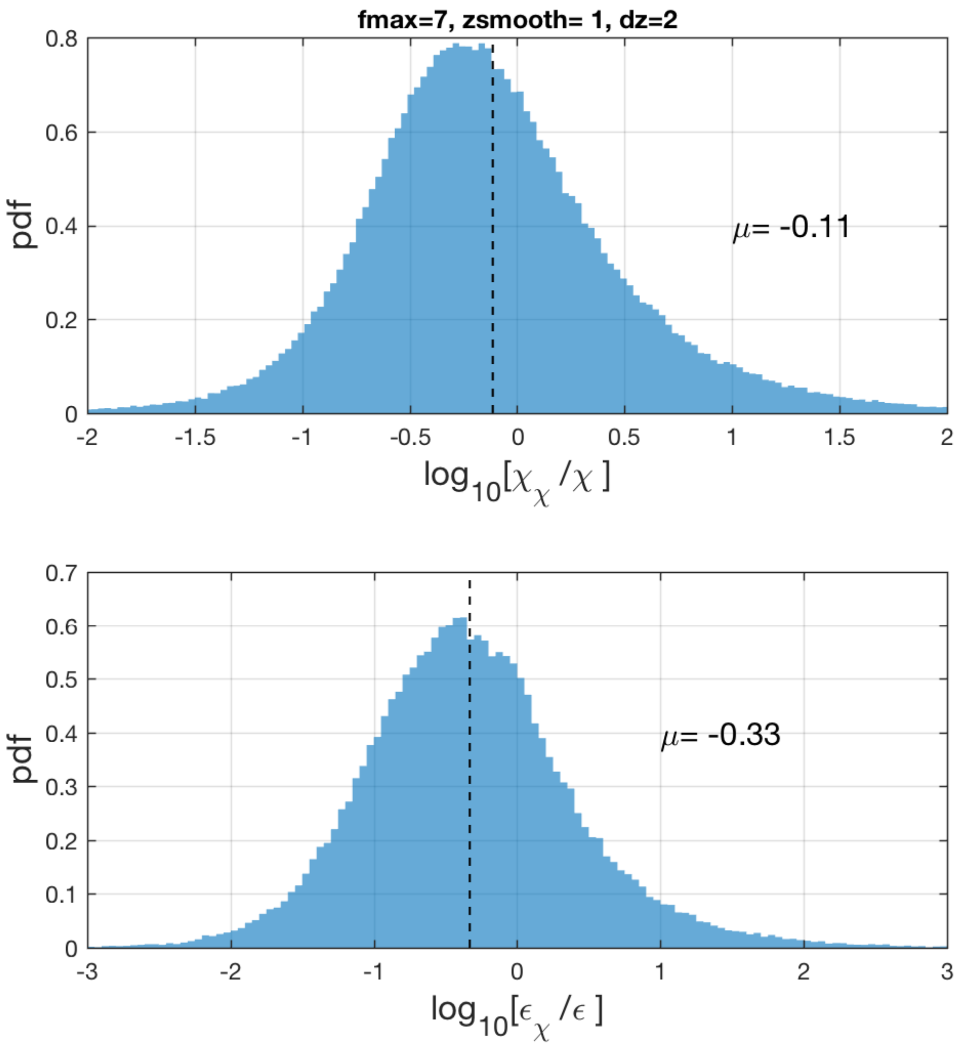

Figure 4: Histograms of the ratios of χ_ϵ/χ (top) and ϵ_χ/ϵ (lower) .

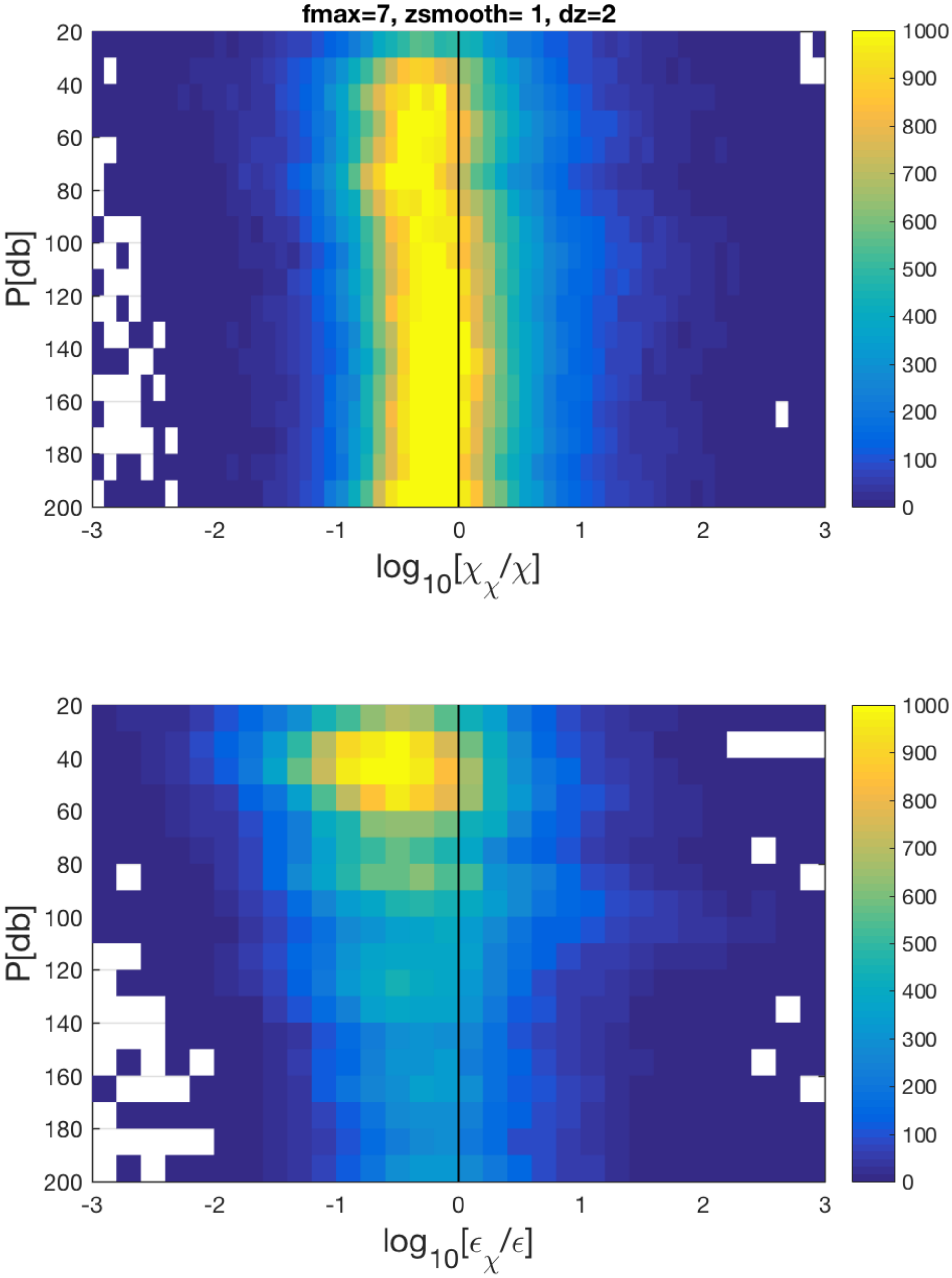

Figure 5: 2D histograms of ratios χ_χ and ϵ_χ ratios vs depth.

3.3 Dependence of bias on actual ϵ

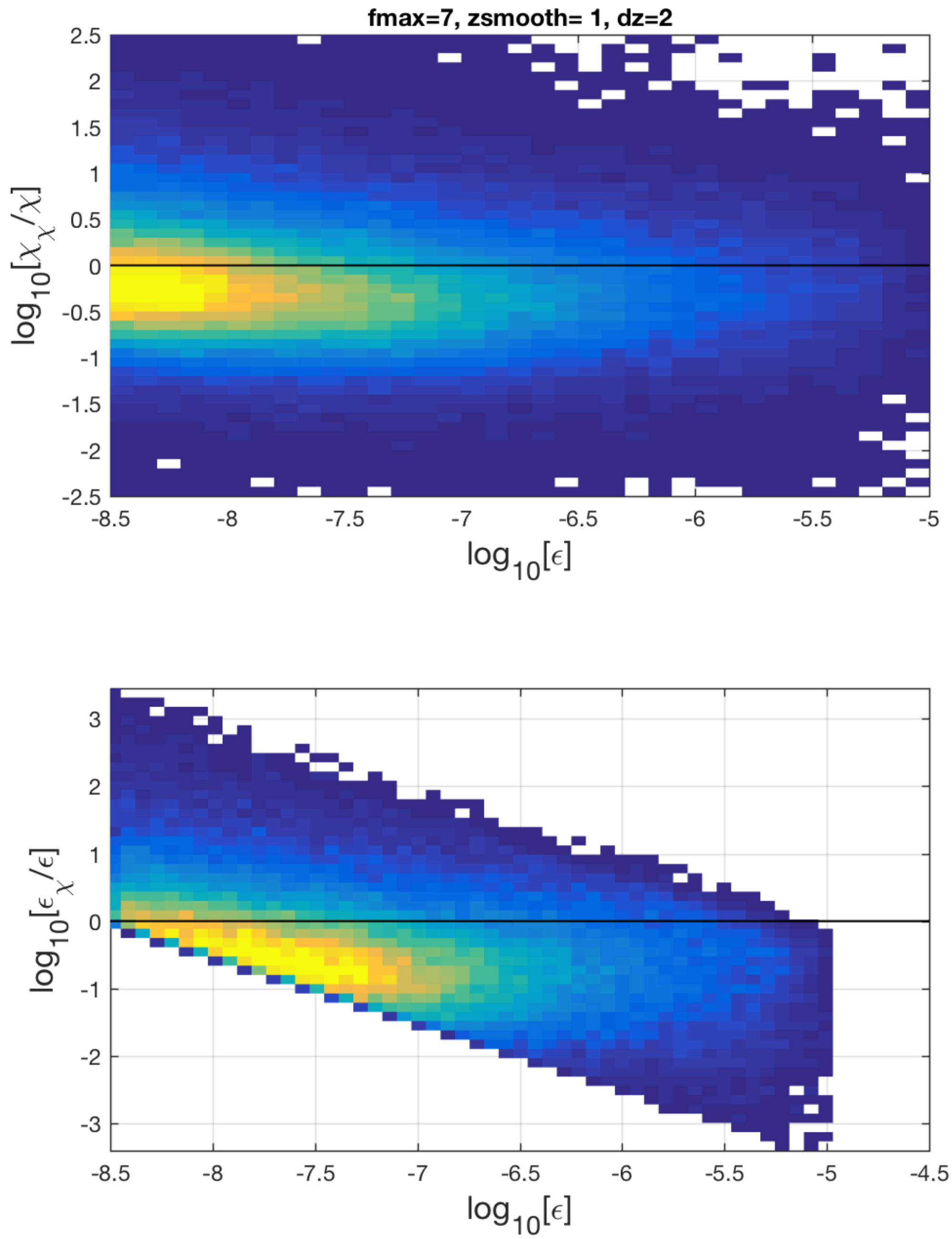

Figure 6: 2D histograms of ratios χ_χ/χ and ϵ_χ/ϵ ratios vs ϵ.

3.4 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 6).

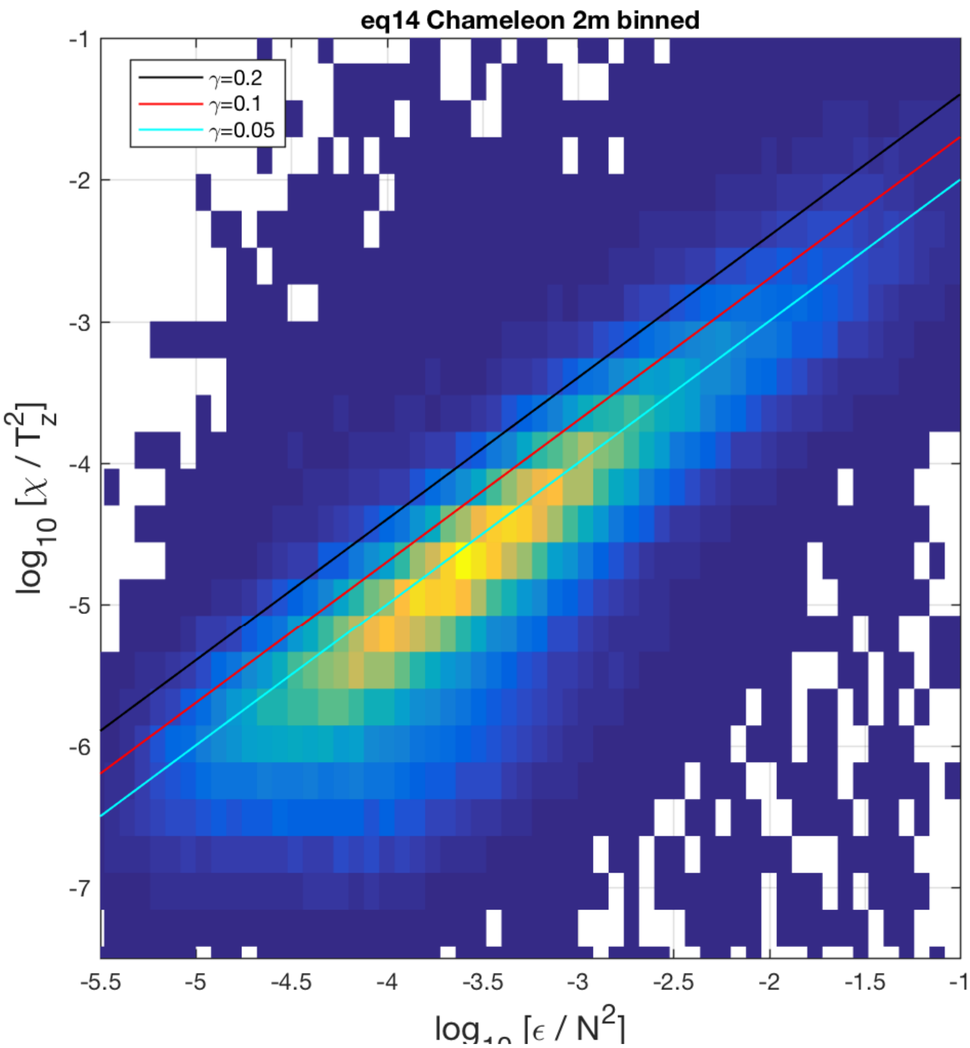

Figure 7: EQ14: 2m binned chameleon $\epsilon/N\hat{2}$ vs χ/t_z^2. Lines show different values of γ. Values of ϵ below noise floor ($log_{10}\epsilon < -8.5$) are discarded also.

3.5 Averaging multiple profiles of ϵ

- Averaging over multiple profiles reduces the bias in both χ and ϵ (Figures 7,8).
- Averaging 10 profiles together seems to give the smallest bias.

Figure 9 shows one example.

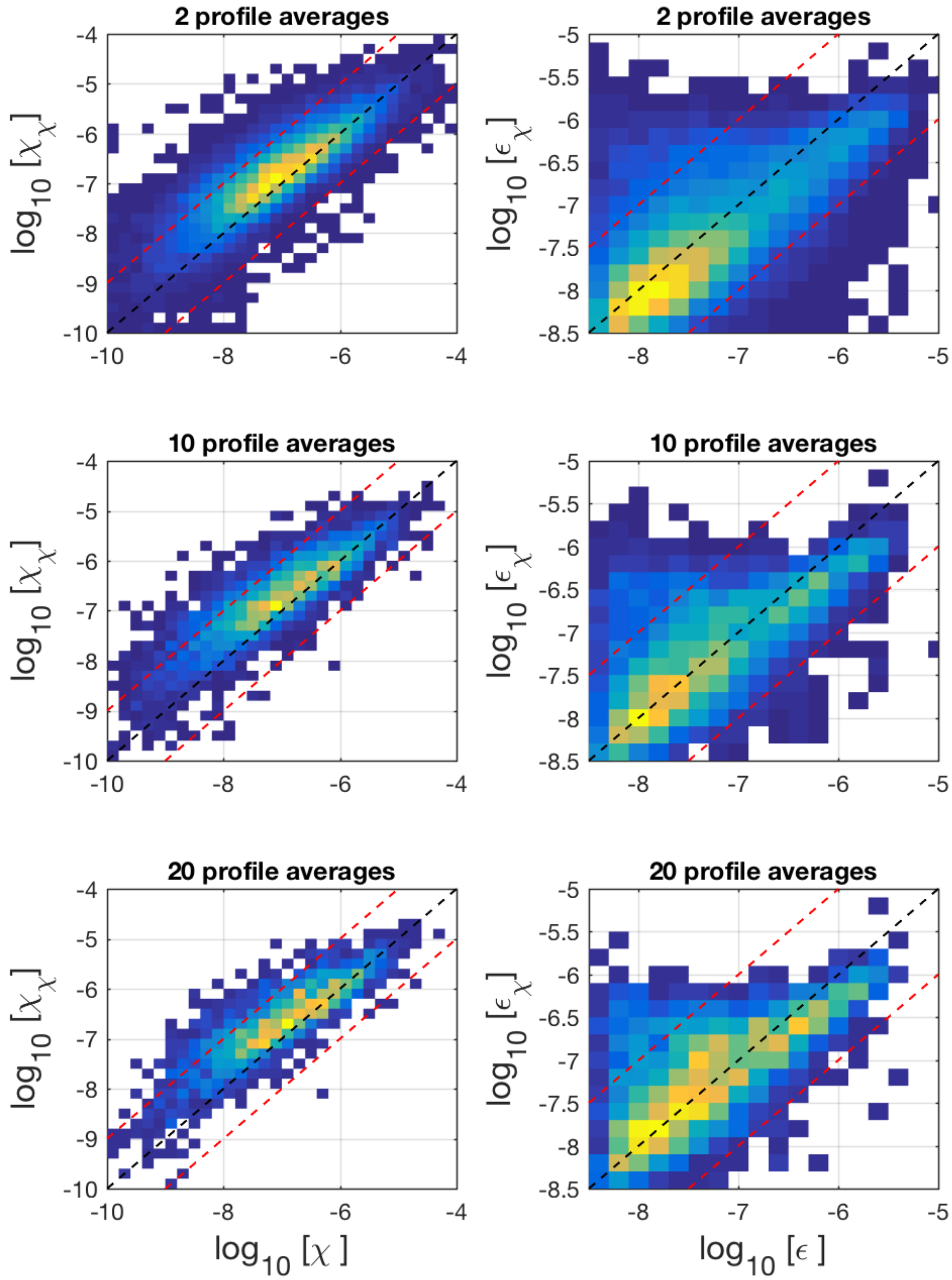

Figure 8: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) for different numbers of profiles averaged.

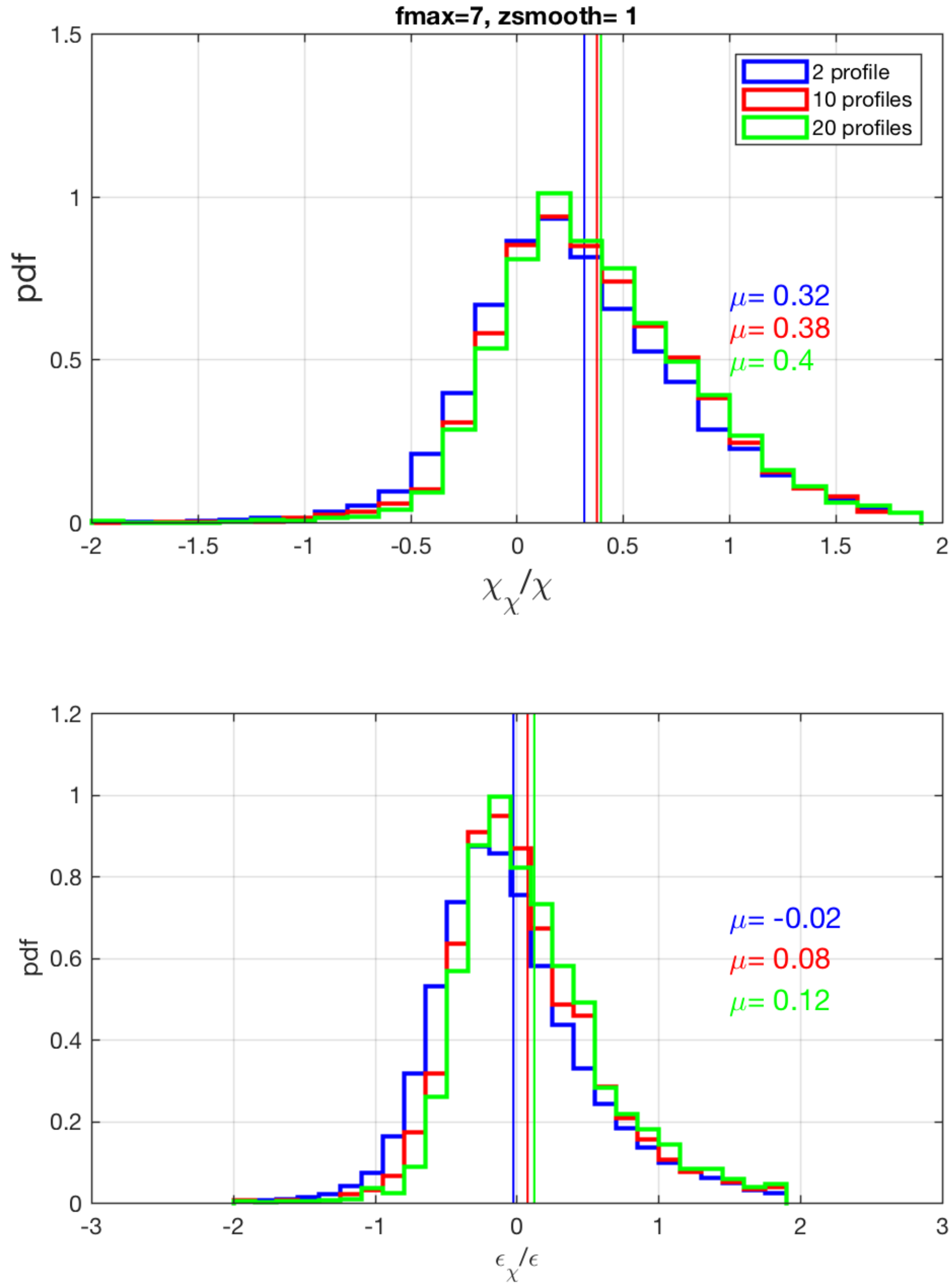

Figure 9: (log10) Ratio of ϵ_χ/ϵ for different numbers of profiles averaged. Consecutive chunks of N profiles were averaged, and then (normalized) histogram of the ratios was plotted. Vertical lines and numbers to right are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

eps_boot_prof_cnum_1576.png

Figure 10: Example of averaging multiple profiles together. Left panels show a single profile from chamleeon and chi-pod method. Right panel shows bootstrap average of 5 profiles, averaged in 10m depth bins, with 95% confidence intervals. Data in mixed layer and shallower than 20m have been excluded.

3.6 Averaging over different-sized depth bins

- Averaging over large depth bins reduces the bias in both χ and ϵ (Figures 10,11).

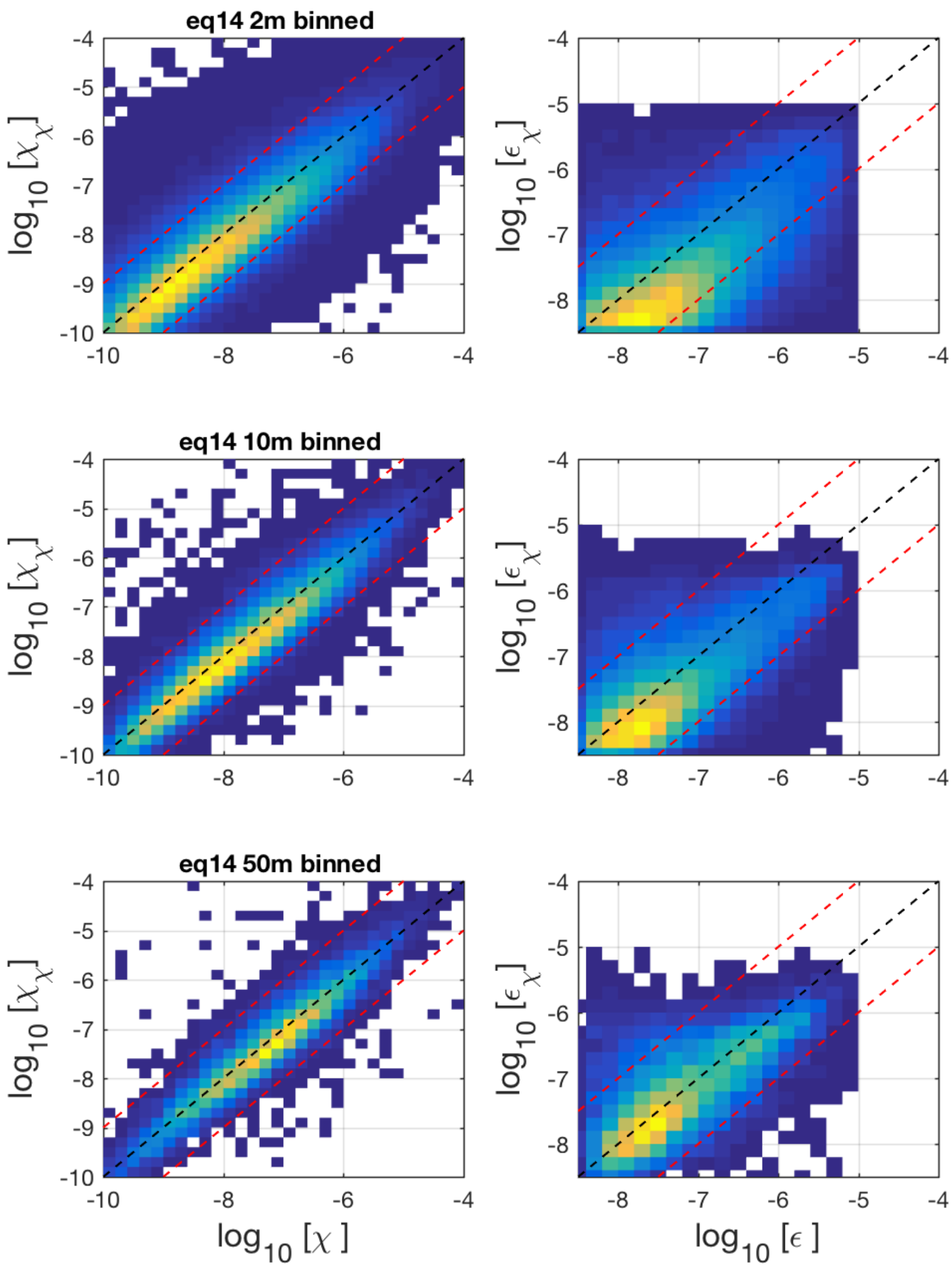

Figure 11: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) averaged over different size depth bins

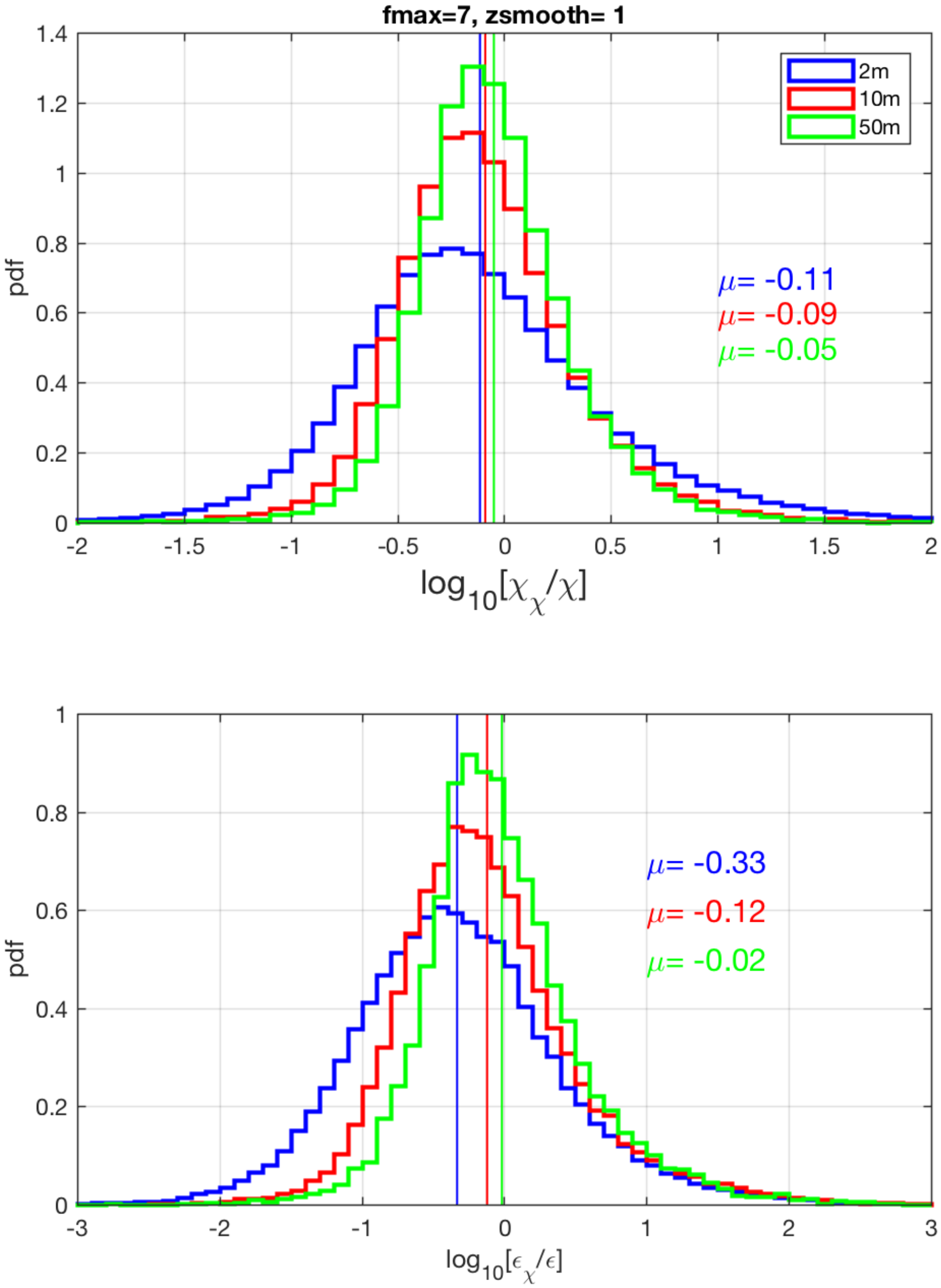

Figure 12: Histogram of log10 of ratio ϵ_χ/ϵ for different amounts of vertical averaging. Vertical lines are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

3.7 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 12) but still slightly less than 0.2 .

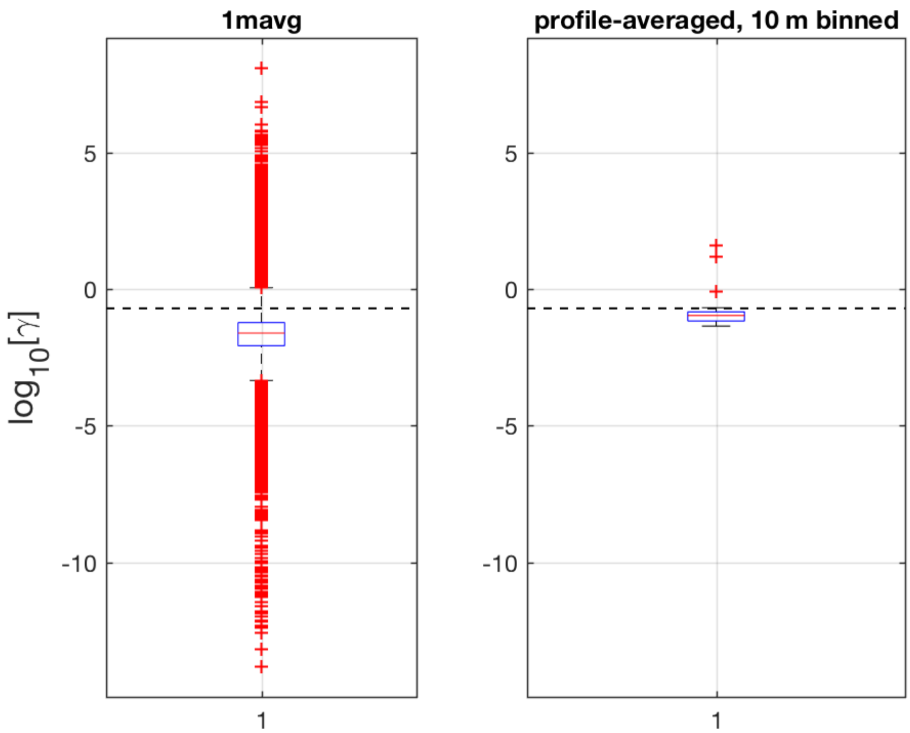

Figure 13: Boxplots of $log_{10}[\gamma]$ for a set of profiles from EQ14. Left is for all 1m avg data. Right is for data from all profiles averaged in 10m bins. Horizontal dashed line indicates $\gamma = 0.2$.