Summary of χpod Chameleon EQ14 Analysis

Andy Pickering

May 4, 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).
- I found that the estimates of χ agreed well, but ϵ_χ was biased low compared to ϵ (Figure 1,2,3).
- The χpod method requires assuming a mixing efficiency, and uses the normal assumption that $\gamma = 0.2$. I computed gamma from the chameleon data (formula) and found that it was about an order of magnitude smaller than 0.2; hence the low epsilon estimates?
- The comparison of ϵ_χ to ϵ seems to improve with increased averaging (of either multiple profiles or larger depth ranges).

2 Data and Processing

- Data are from Chameleon profiles near the equator during the 'EQ14' experiment.
- 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 assumed 32Hz.
- `ComputeChi_Chameleon_Eq14.m` : Applies χpod method to Chameleon profiles from EQ14.
- `Make_Overview_Plots.m` Makes almost all the figures in this document.
- 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 using a criteria of $\sigma -_{surface} = 0.04$.

3 Results

3.1 Overview

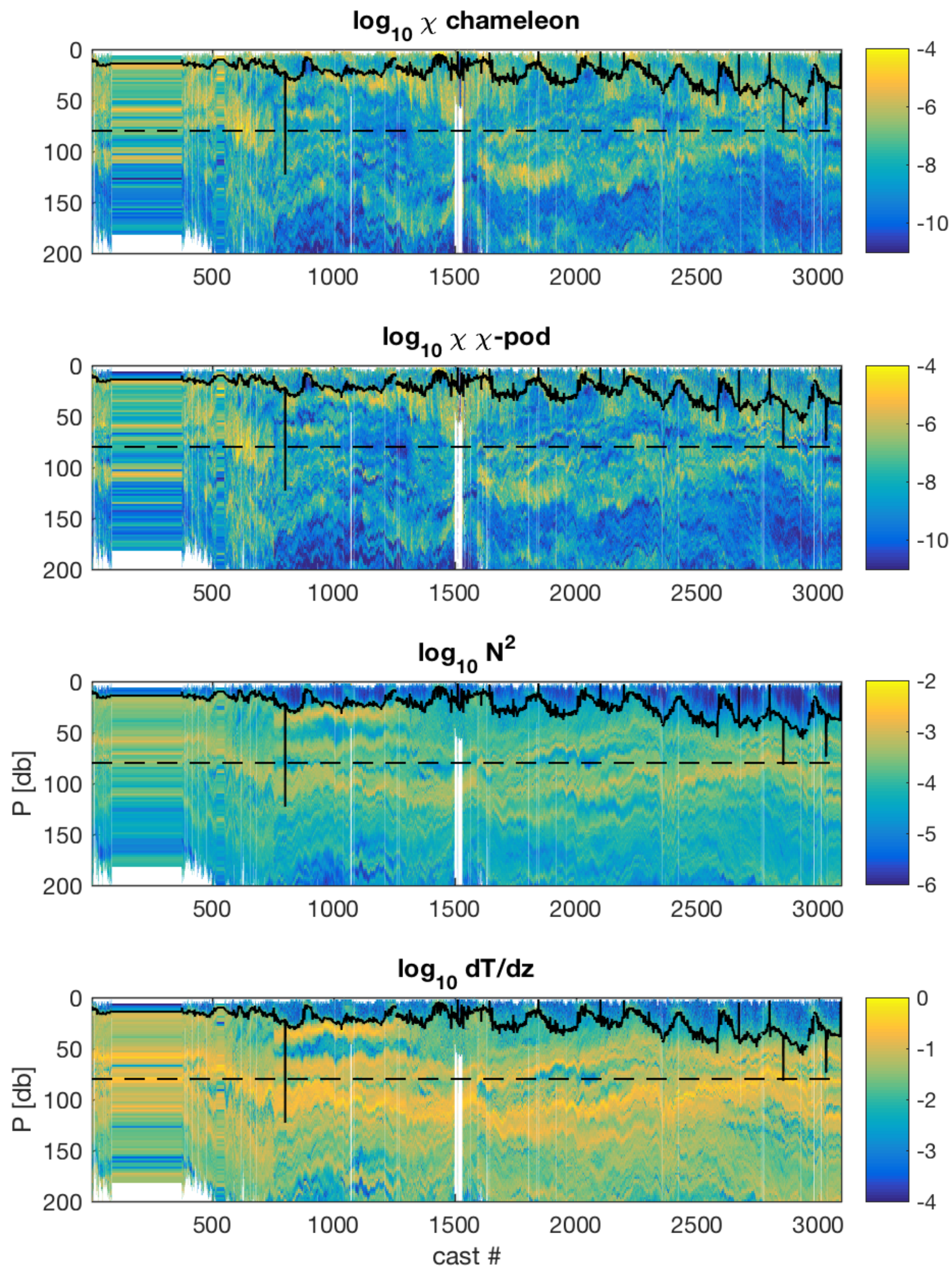


Figure 1: Comparison of χ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Black line shows shows convective regions excluded in further analysis.

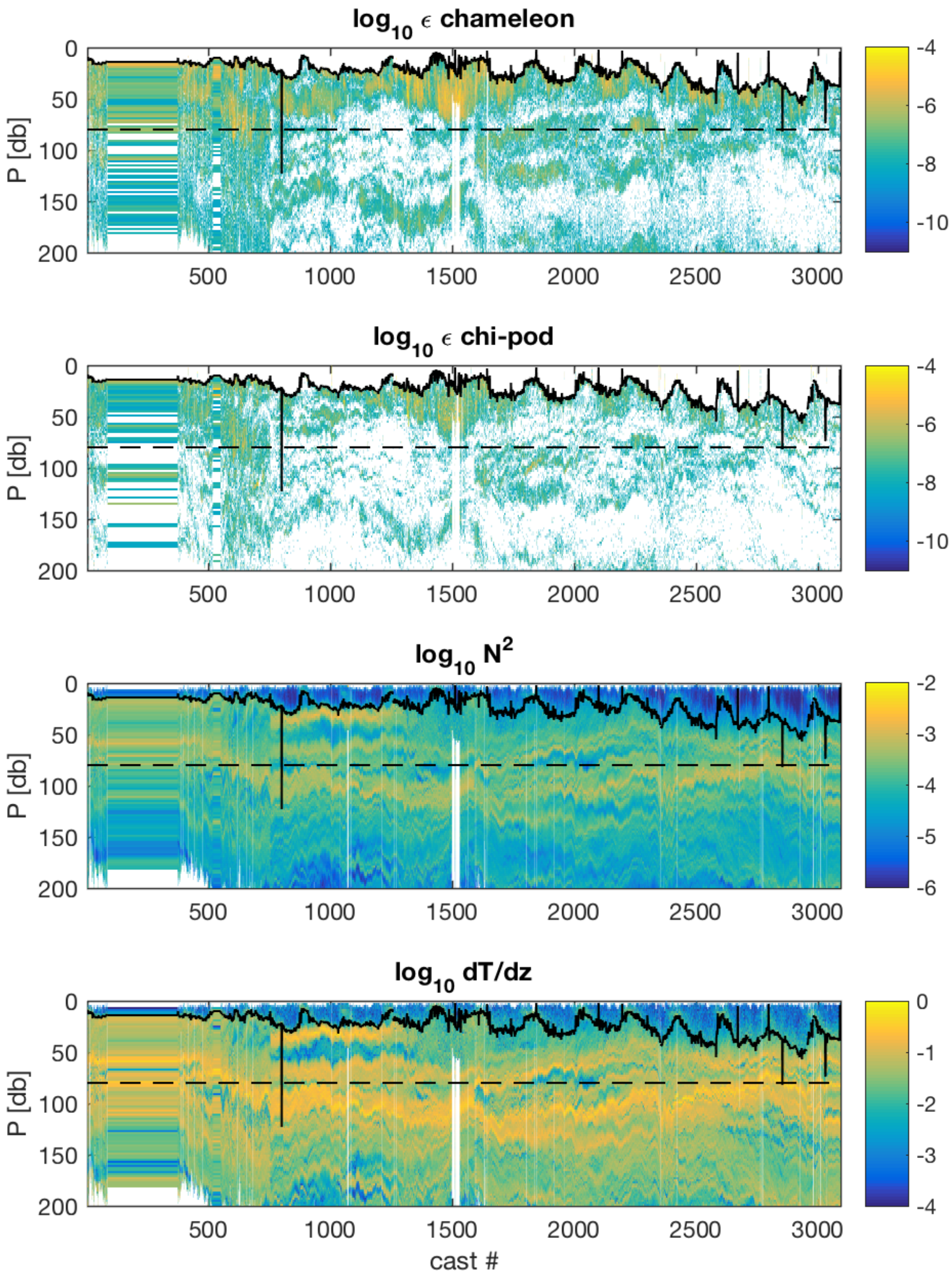


Figure 2: Comparison of ϵ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of ϵ_χ and ϵ below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line shows shows convective regions excluded in further analysis.

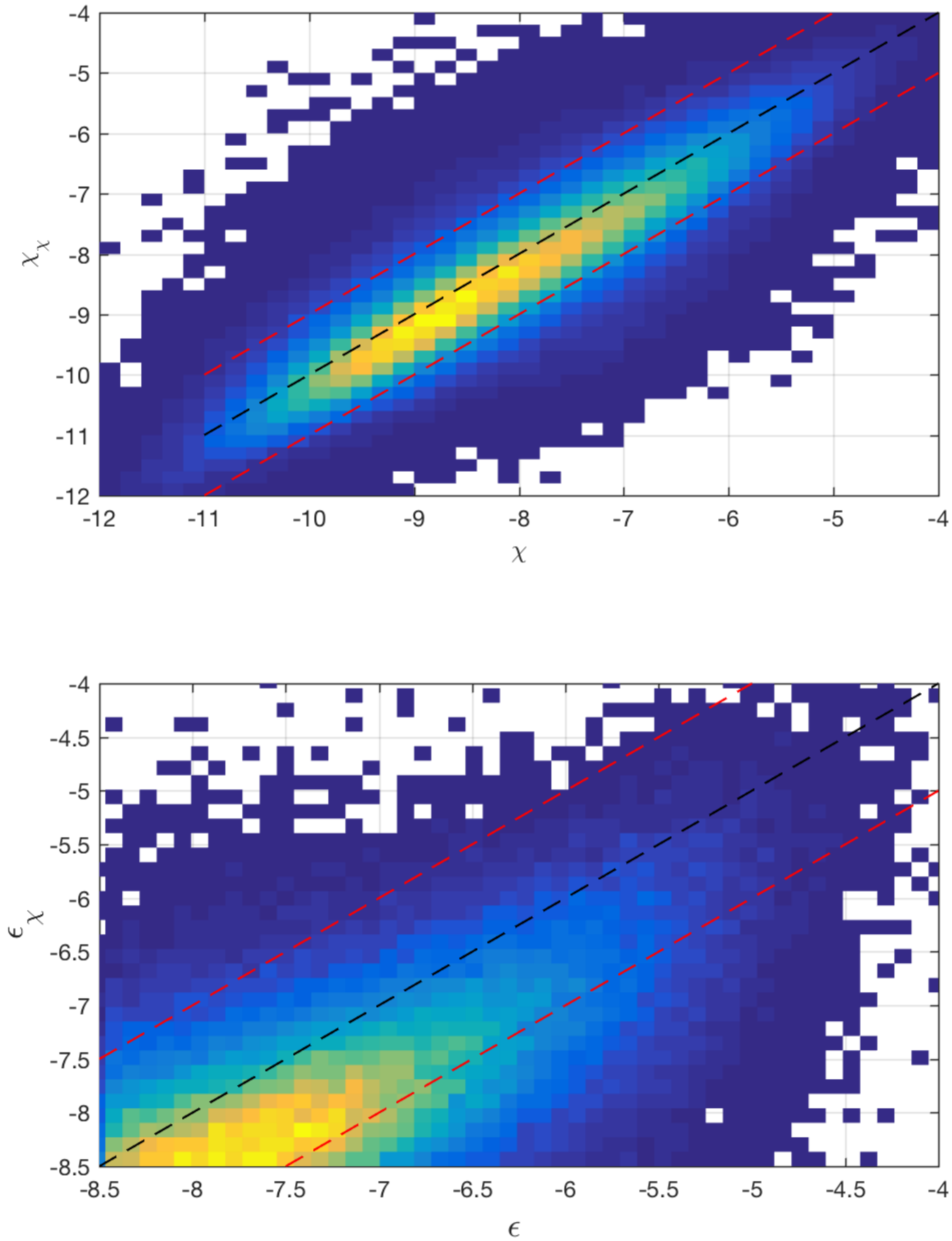


Figure 3: Comparison of χ (top) and ϵ (lower) from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line is 1:1, red lines are $+/-$ order of magnitude.

3.2 Comparing individual estimates of ϵ

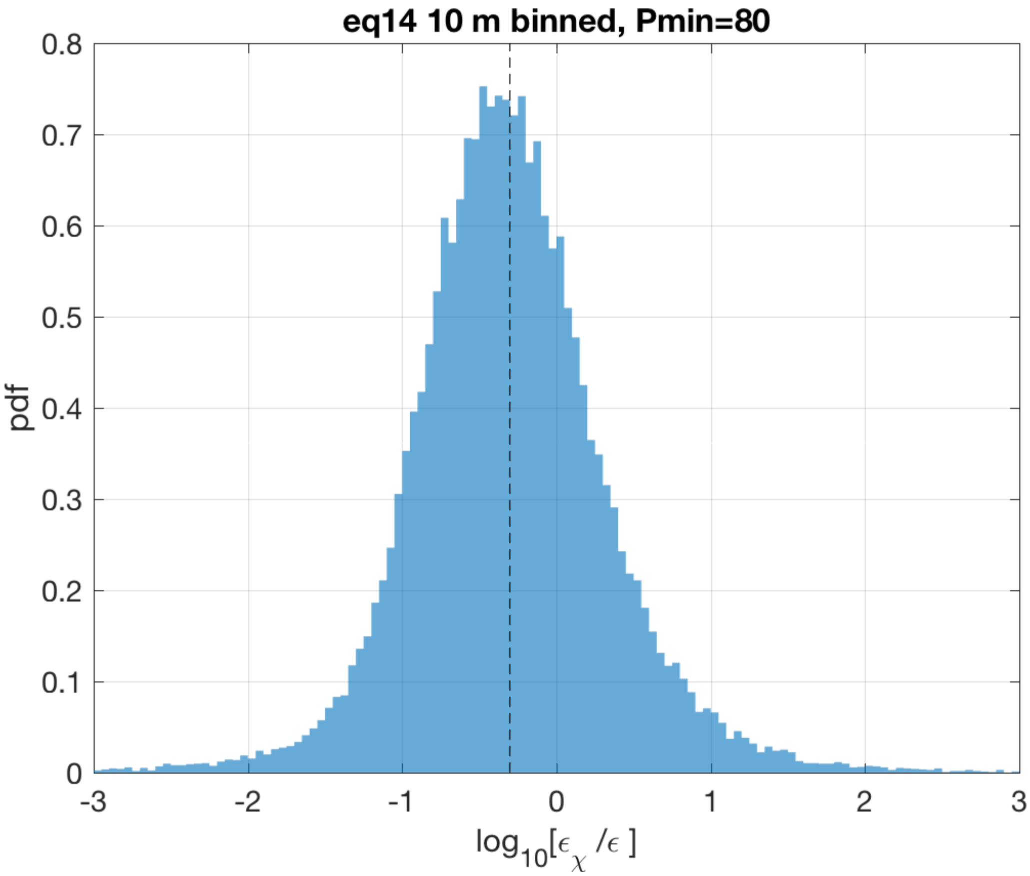


Figure 4: EQ14: Histogram of the ratio of ϵ estimates from χpod method to the chameleon values, for χpod method applied to 1m binned profiles, and applied to just patches. Estimates for each profile were averaged in 10m depth bins. Vertical line shows mean of $log_{10}[\epsilon_\chi/\epsilon]$.

3.3 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.

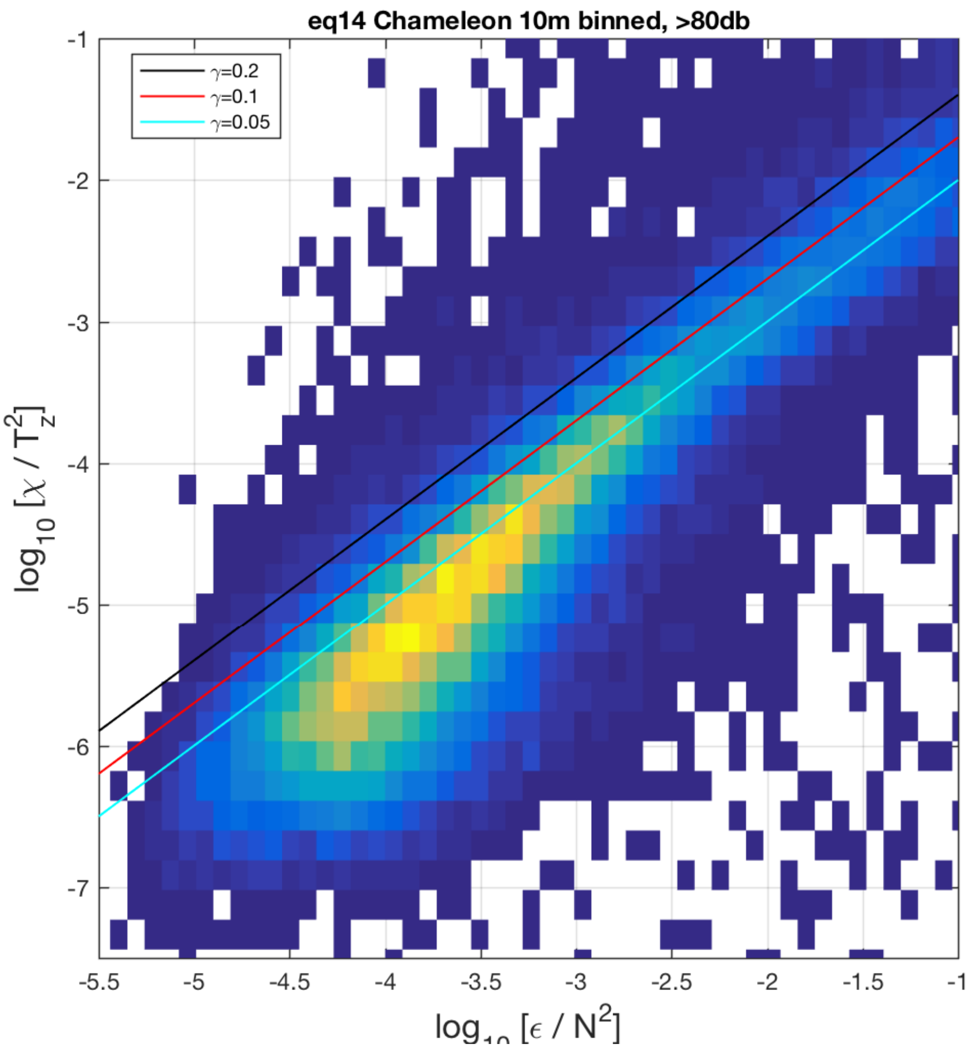


Figure 5: EQ14: 10m binned chameleon $\epsilon/N\hat{2}$ vs χ/t_z^2 for *below 80db*. Lines show different values of γ. Values of ϵ below noise floor ($log_{10}\epsilon < -8.5$) are discarded also.

3.4 Averaging many profiles of ϵ

Figure 6 shows one example. A folder with many profiles is located at: `https://github.com/OceanMixingGroup/Analysis/tree/master/Andy_Pickering/eq14_patch_gamma/figures/chi_eps_profiles_40profavgs`.

I tried making plots of normalized chi vs eps, and scatterplots of chi-pod vs chameleon epsilon, for data averaged across different numbers of profiles.

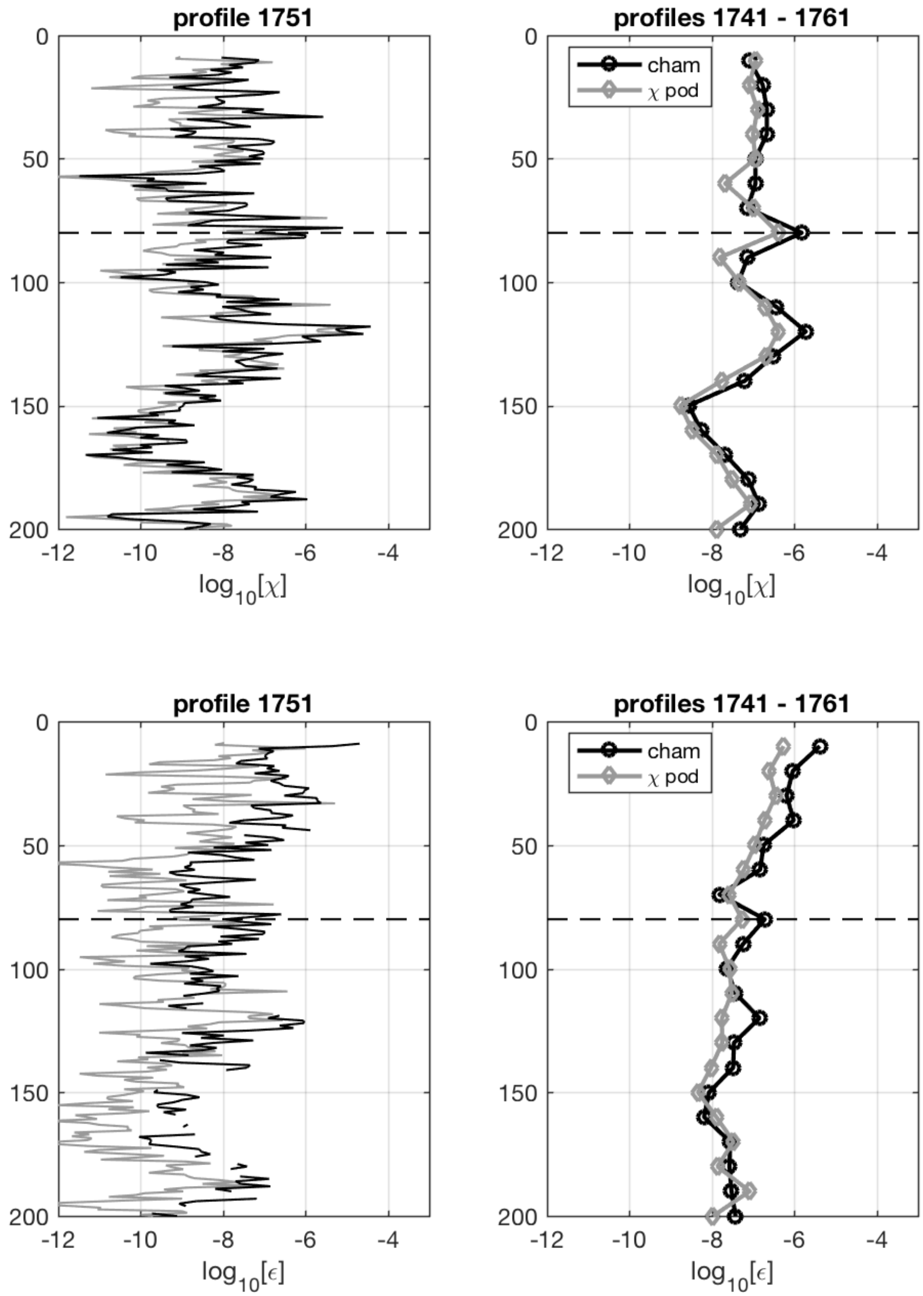
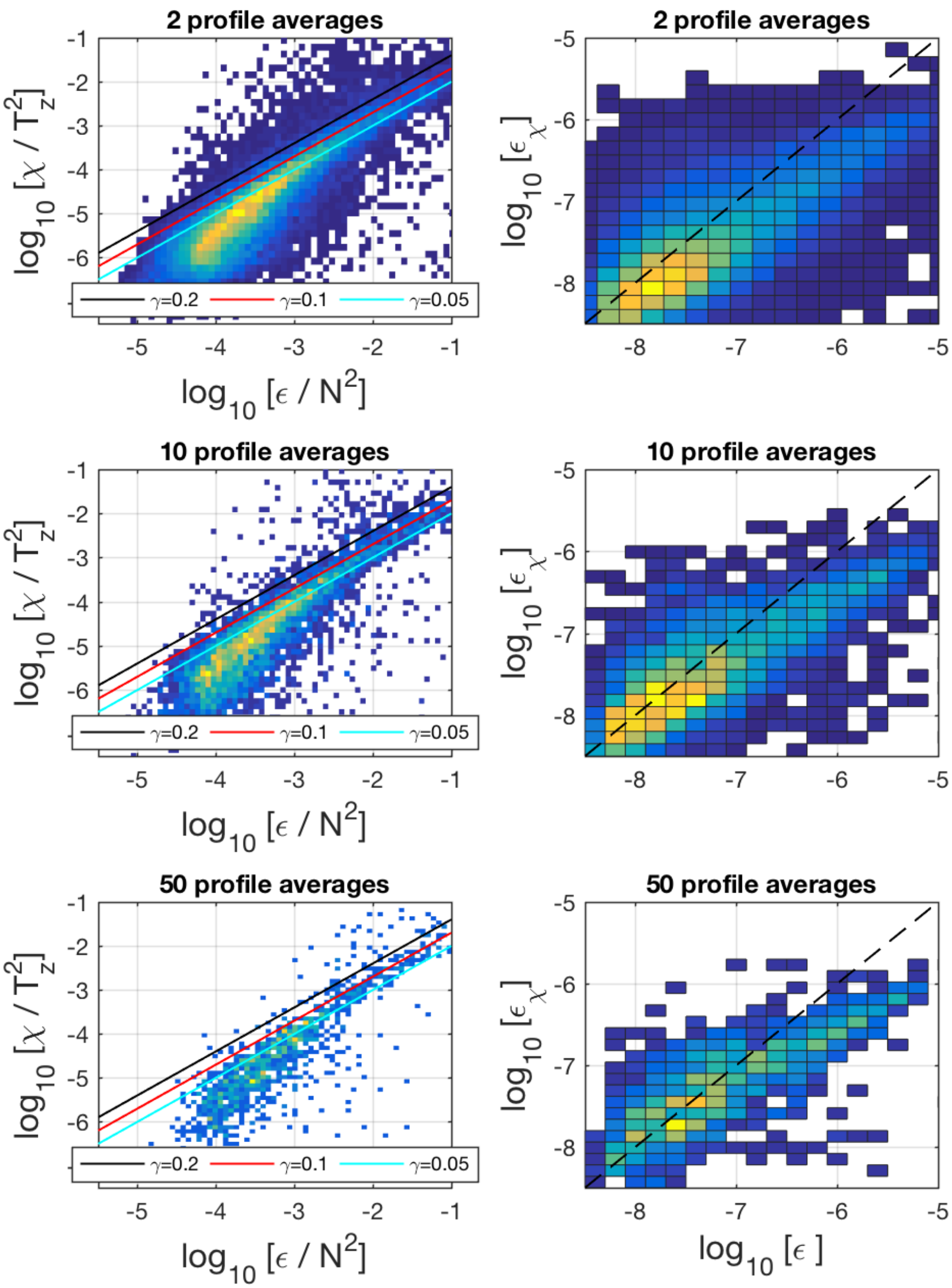


Figure 6: Example of averaging multiple profiles together. Left panels show a single profile from chamleeon and chi-pod method. Right panels show average of +/− 40 profiles, averaged in 10m depth bins.



2 profile averages
2 profile averages
10 profile averages
10 profile averages
50 profile averages
50 profile averages
γ=0.2
γ=0.1
γ=0.05
log10 [χ / Tz2]
log10 [ϵ / N2]
log10 [ϵχ]
log10 [ϵ]

Figure 7:

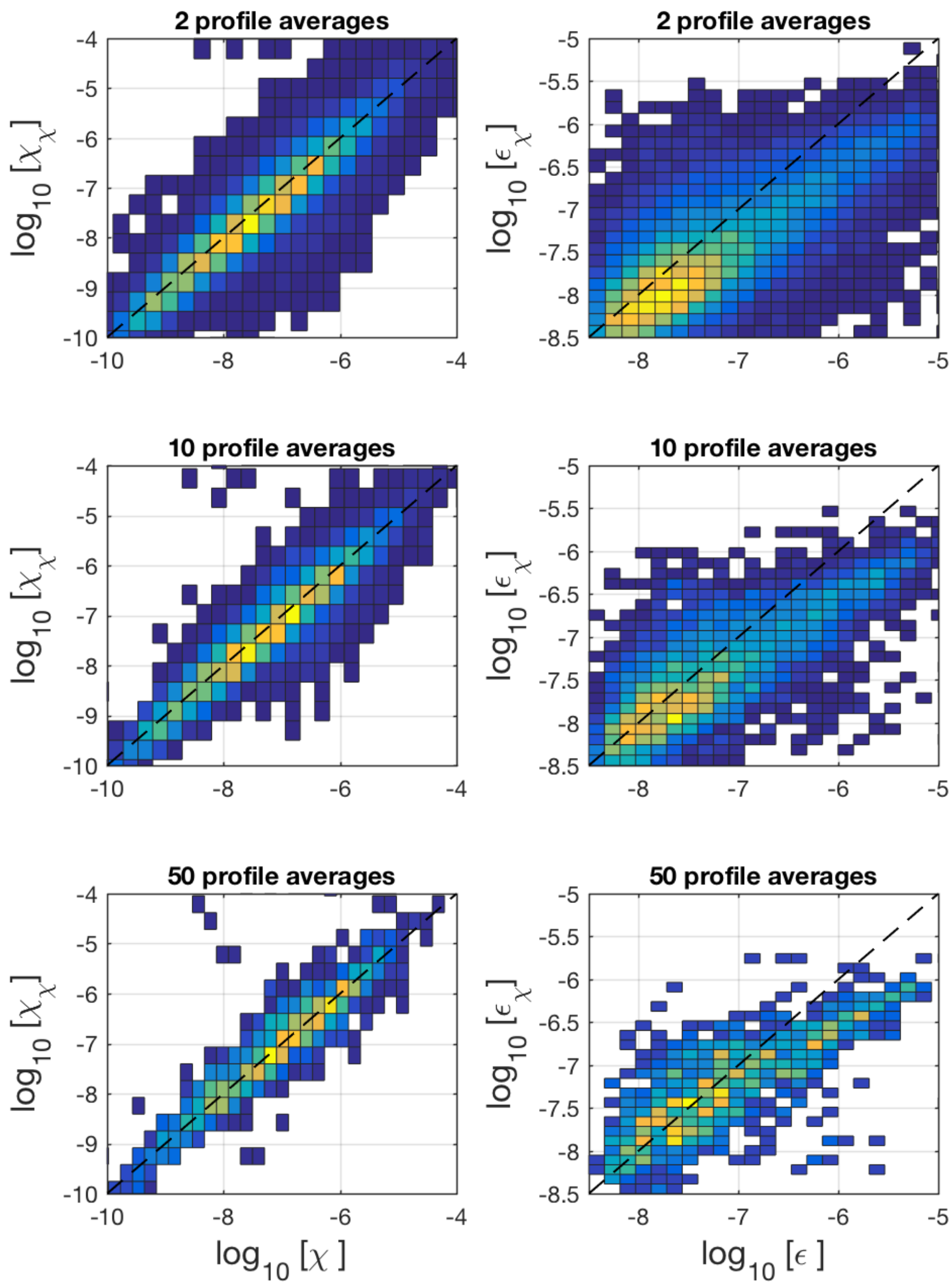


Figure 8: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) for different numbers of profiles averaged.

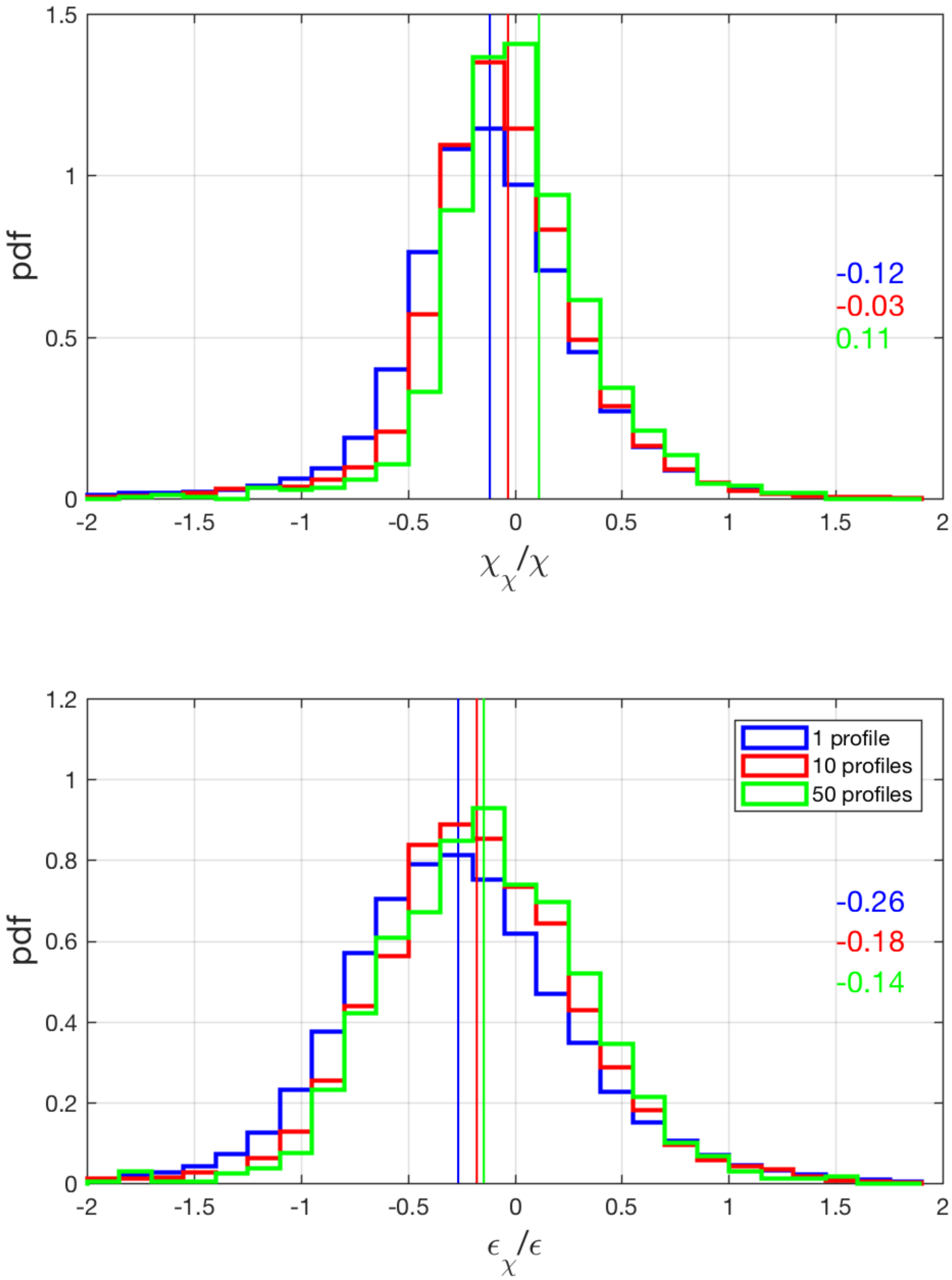


Figure 9: (log10) Ratio of ϵ_χ/ϵ for different numbers of profiles averaged. Consecutive chunks of N profiles were averaged, and then (normalized) histogram of the ratios was plotted. Vertical lines are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

3.5 Effects of averaging in different-sized depth bins

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

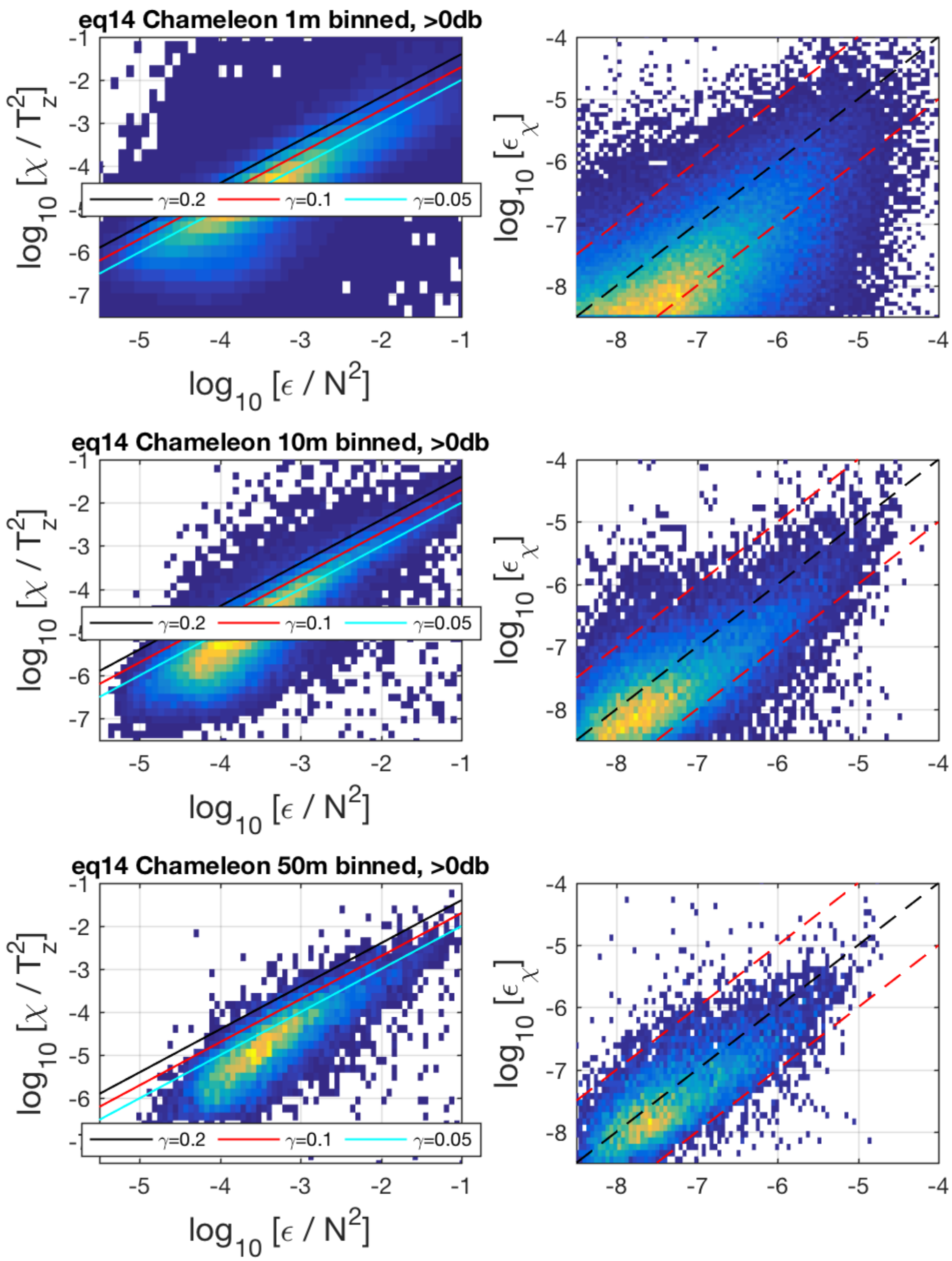


Figure 10: Normalized plots of χ vs ϵ for different amounts of vertical averaging.

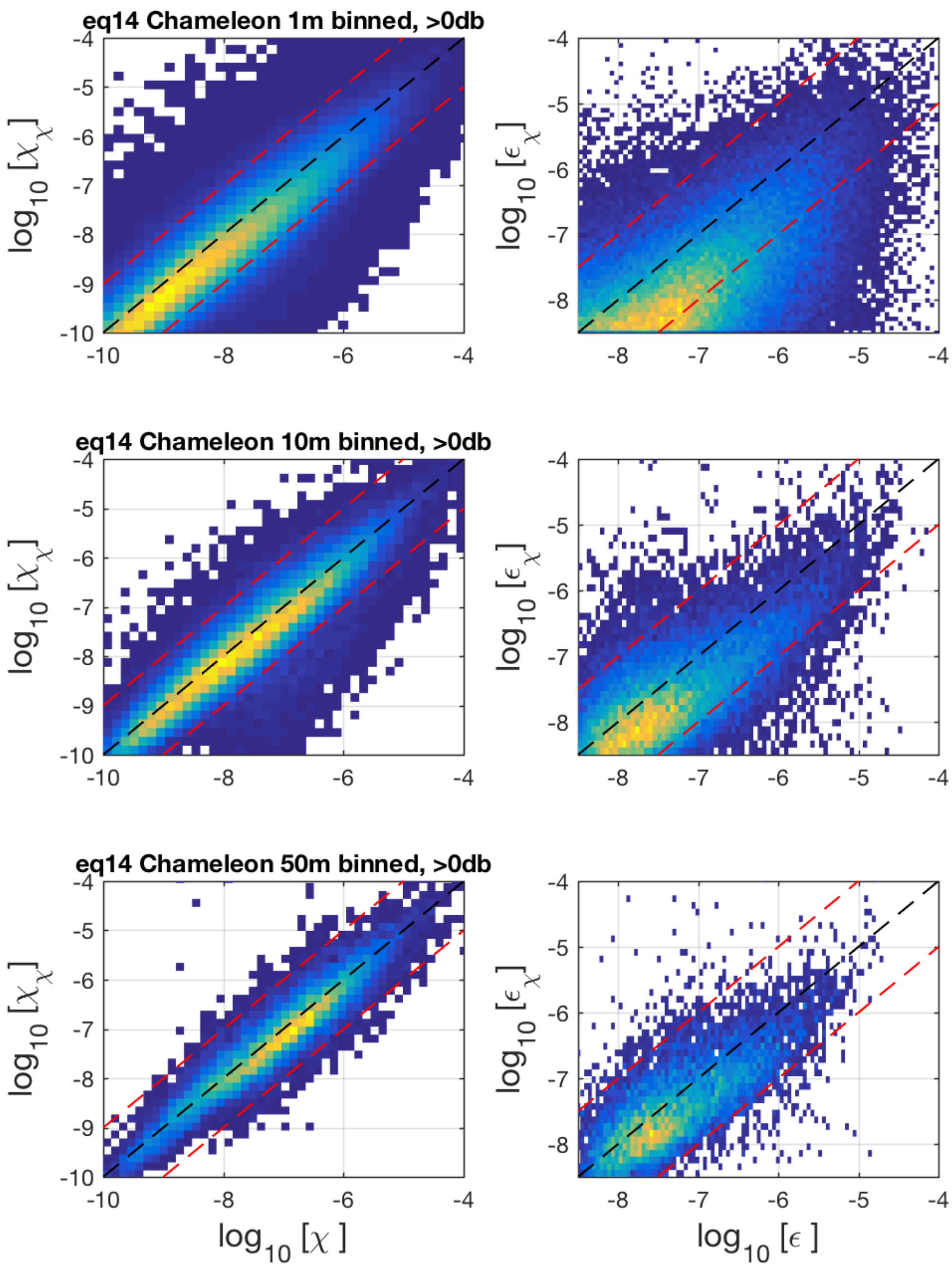


Figure 11: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) averaged over different size depth bins

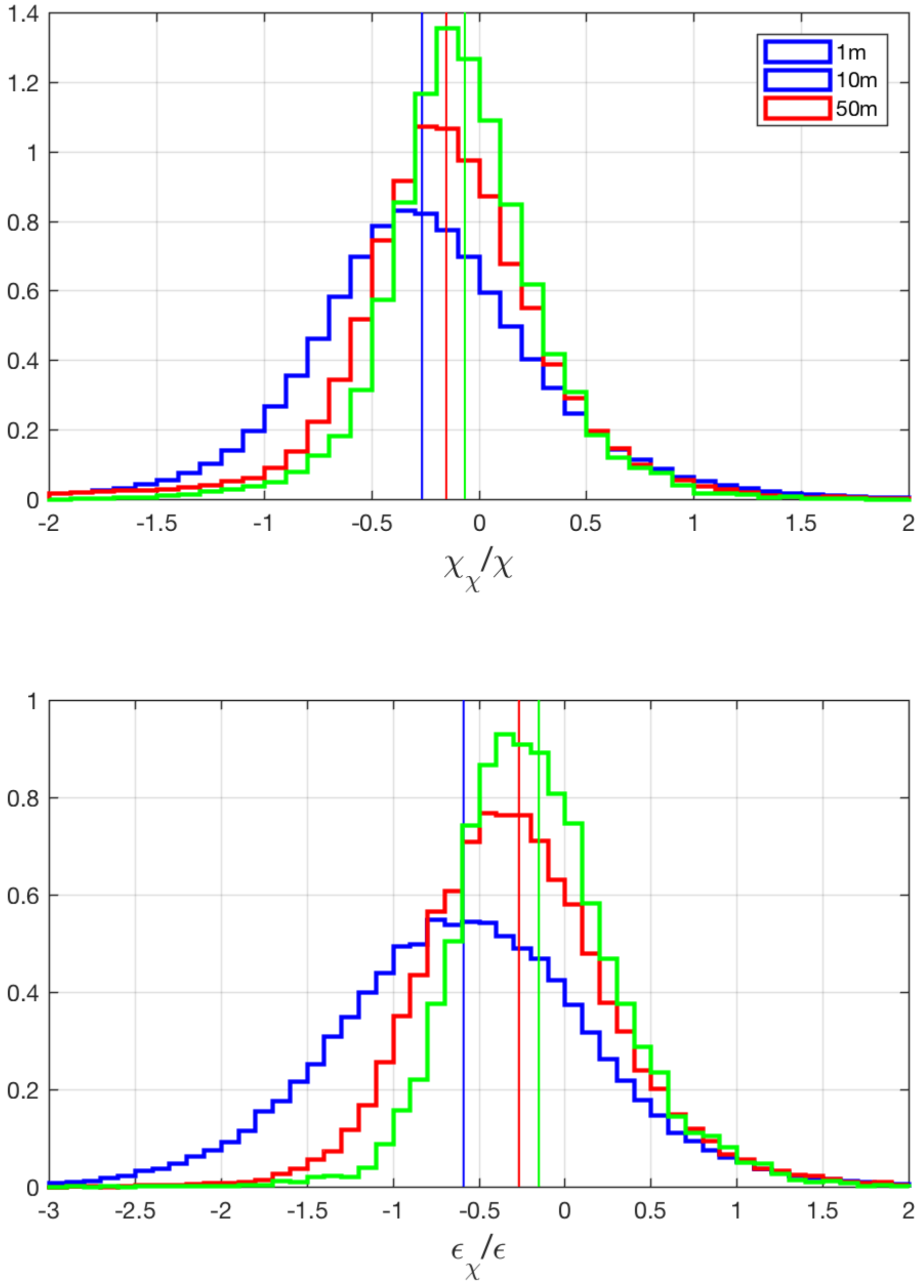


Figure 12: Histogram of log10 of ratio ϵ_χ/ϵ for different amounts of vertical averaging. Vertical lines are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

3.6 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 (Figures **??**,13) but still slightly less than 0.2 .

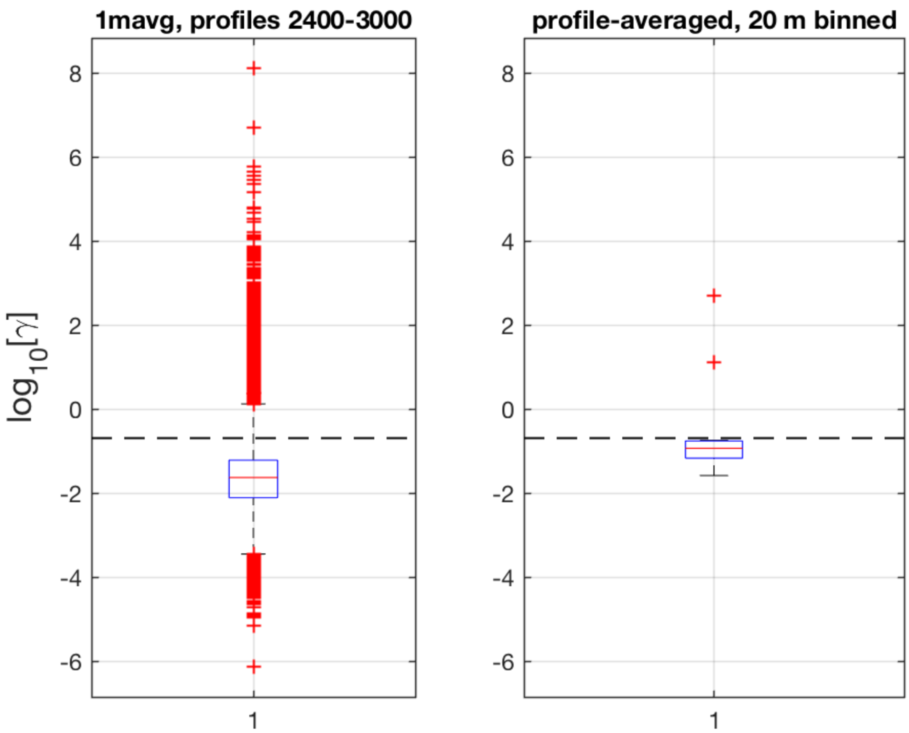


Figure 13: Boxplots of $log_{10}[\gamma]$ for a set of profiles from EQ14. Left is for all 1m avg data. Right is for data from all profiles averaged in 10m bins. Horizontal dashed line indicates $\gamma = 0.2$.

4 Summary

- Inidivudal (and 10m binned) χpod estimates of ϵ_χ are biased low compared to Chameleon ϵ.
- This appears to be because γ computed from the Chameleon data is lower than the assumed 0.2
- γ computed from averaged (across profiles) N^2, T_z, χ, and ϵ is closer to 0.2
- Averaging many ϵ profiles reduces the bias (if we use same noise floor for ϵ as Chameleon).
- Increased depth-averaging also reduces bias.

Questions:

- Would be good to have 'standard' code to compute χ from thermistor data etc.? Thermistor response/noise level varies a lot though, would need a standard way to determine correction.