Summary of χpod / Chameleon EQ14 Analysis

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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 un-averaged ϵ_χ was biased low compared to ϵ (Figure 1,2,4).
- 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 $\sigma -_{surface} = 0.04$. This depth is shown in figures 1 and 2.

3 Results

3.1 Overview

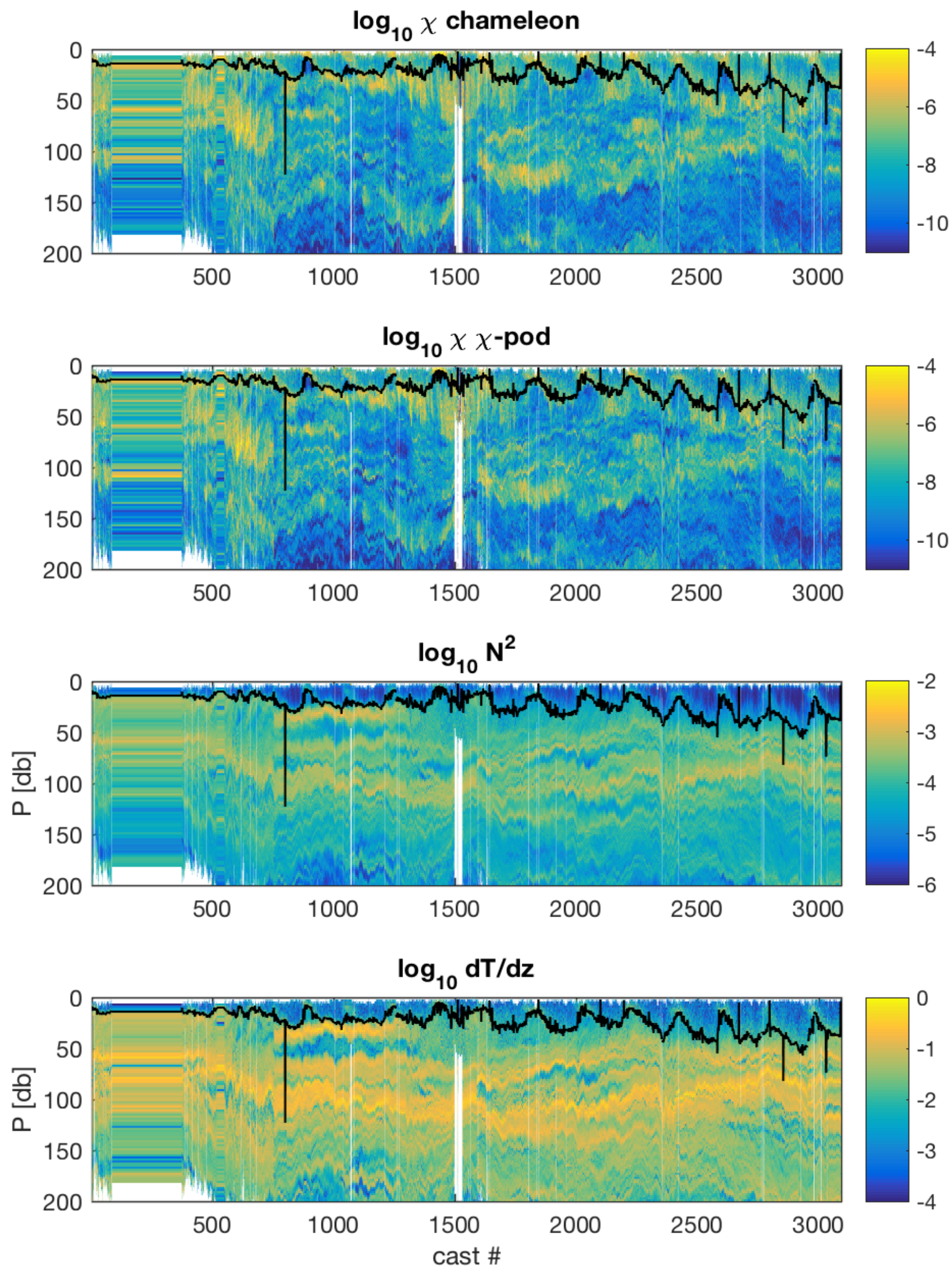

Figure 1: Comparison of χ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Black line shows shows convective regions excluded in further analysis.

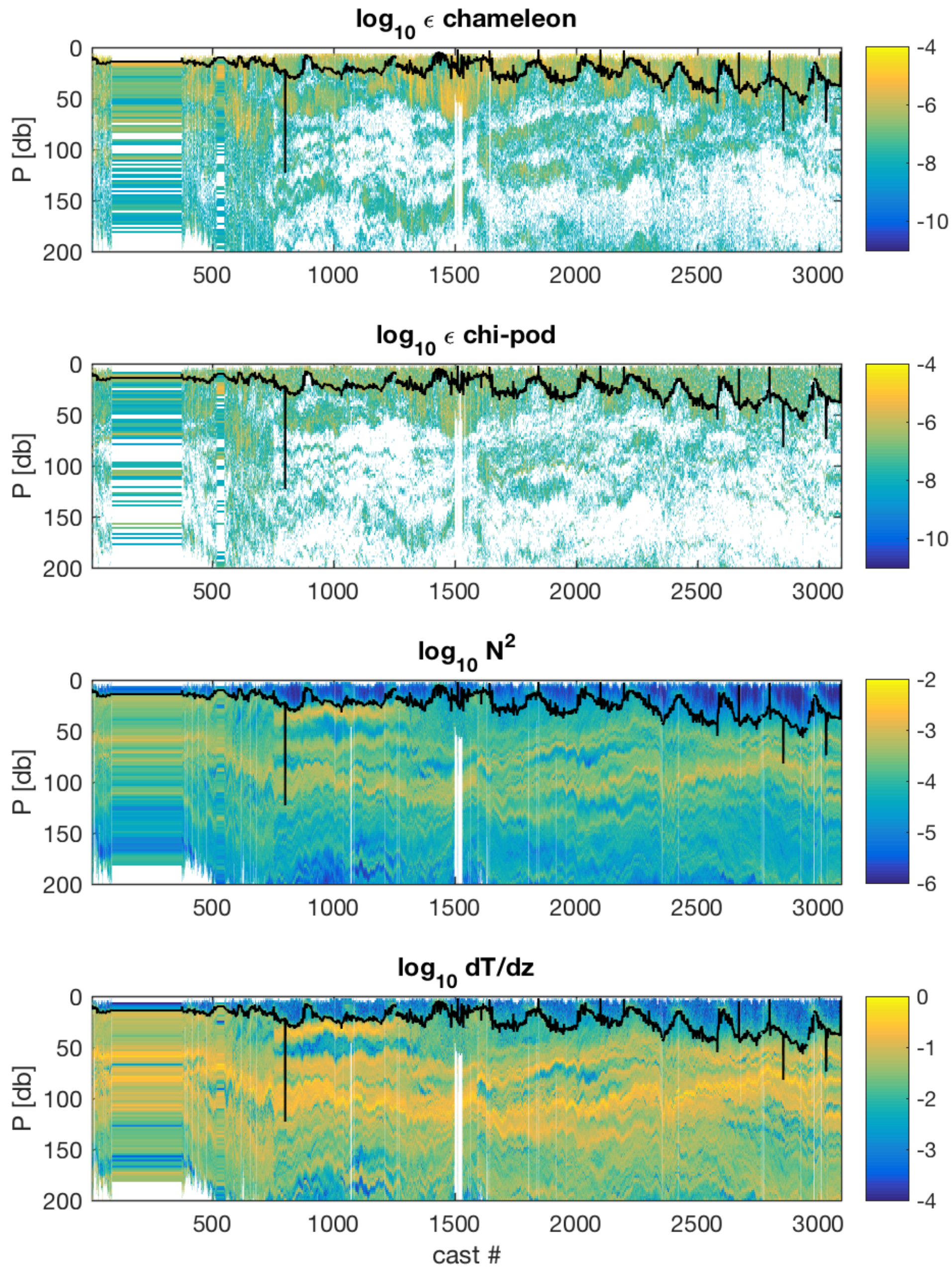

Figure 2: Comparison of ϵ from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of ϵ_χ and ϵ below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line shows shows convective regions excluded in further analysis.

3.2 Comparing individual estimates of ϵ

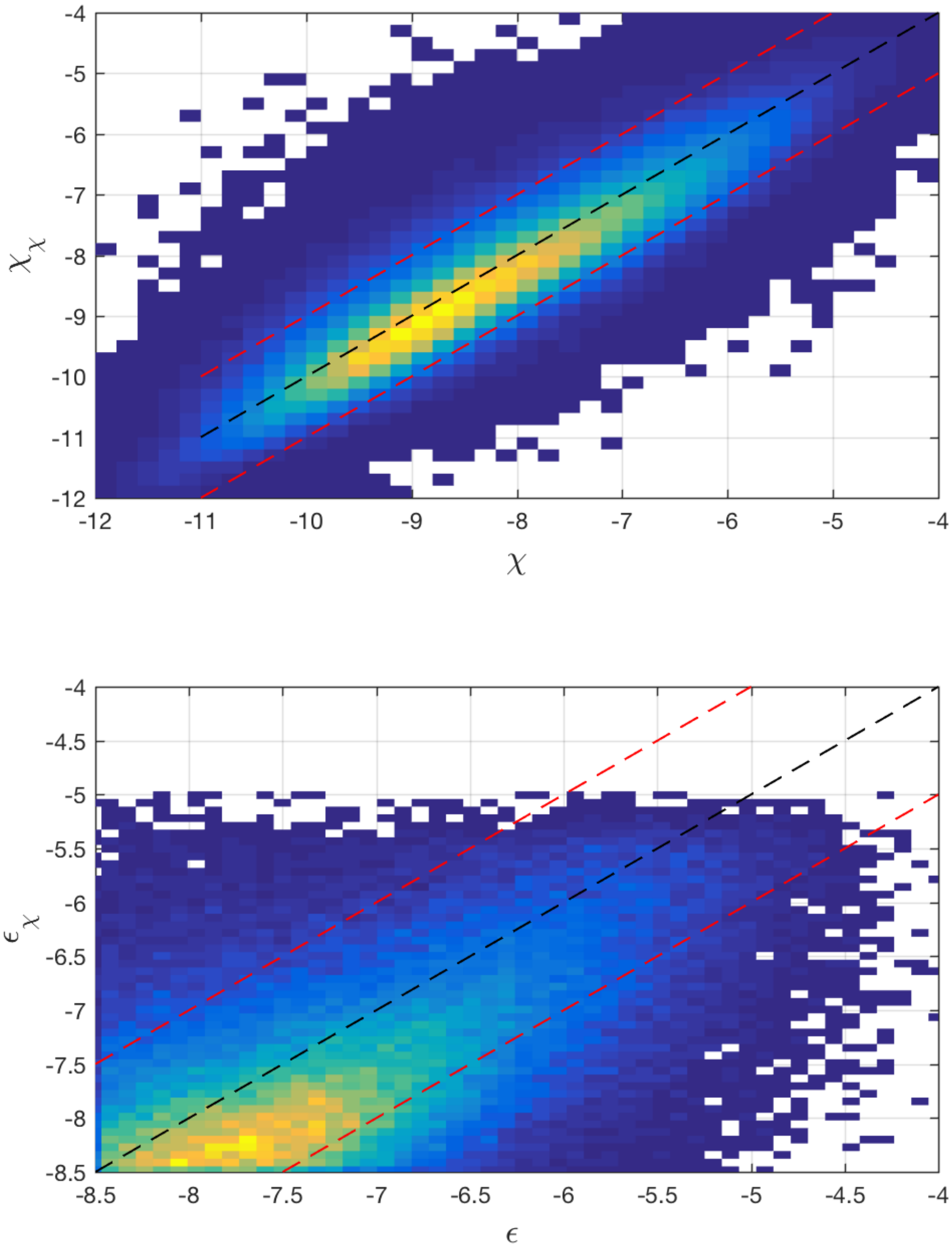

Figure 3: Comparison of χ (top) and ϵ (lower) from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ($log_{10}[\epsilon] = -8.5$) have been nan'd out. Black line is 1:1, red lines are $+/-$ order of magnitude.

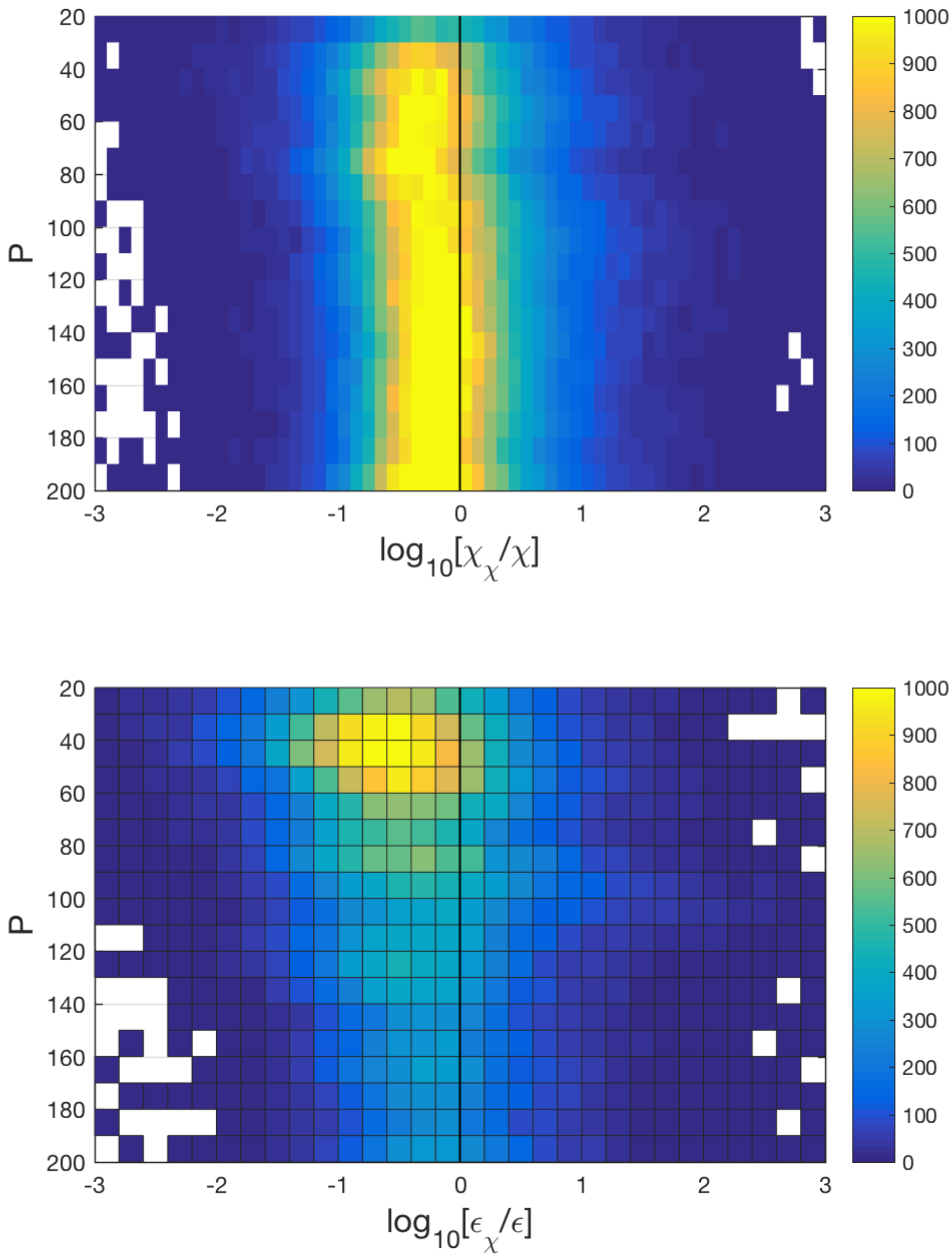

Figure 4: 2D histograms of ratios χ_χ and ϵ_χ ratios vs depth.

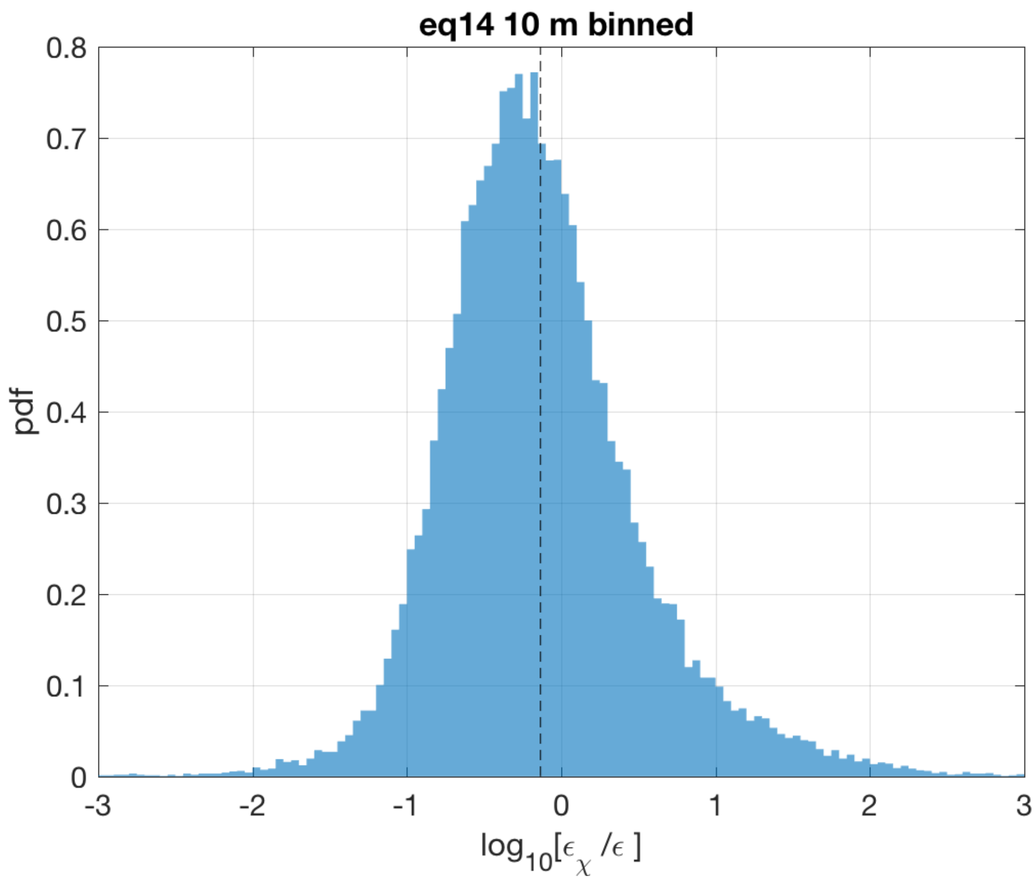

Figure 5: EQ14: Histogram of the ratio of ϵ estimates from χpod method to the chameleon values. Estimates for each profile were averaged in 10m depth bins. Vertical line shows mean of $log_{10}[\epsilon_\chi/\epsilon]$.

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.

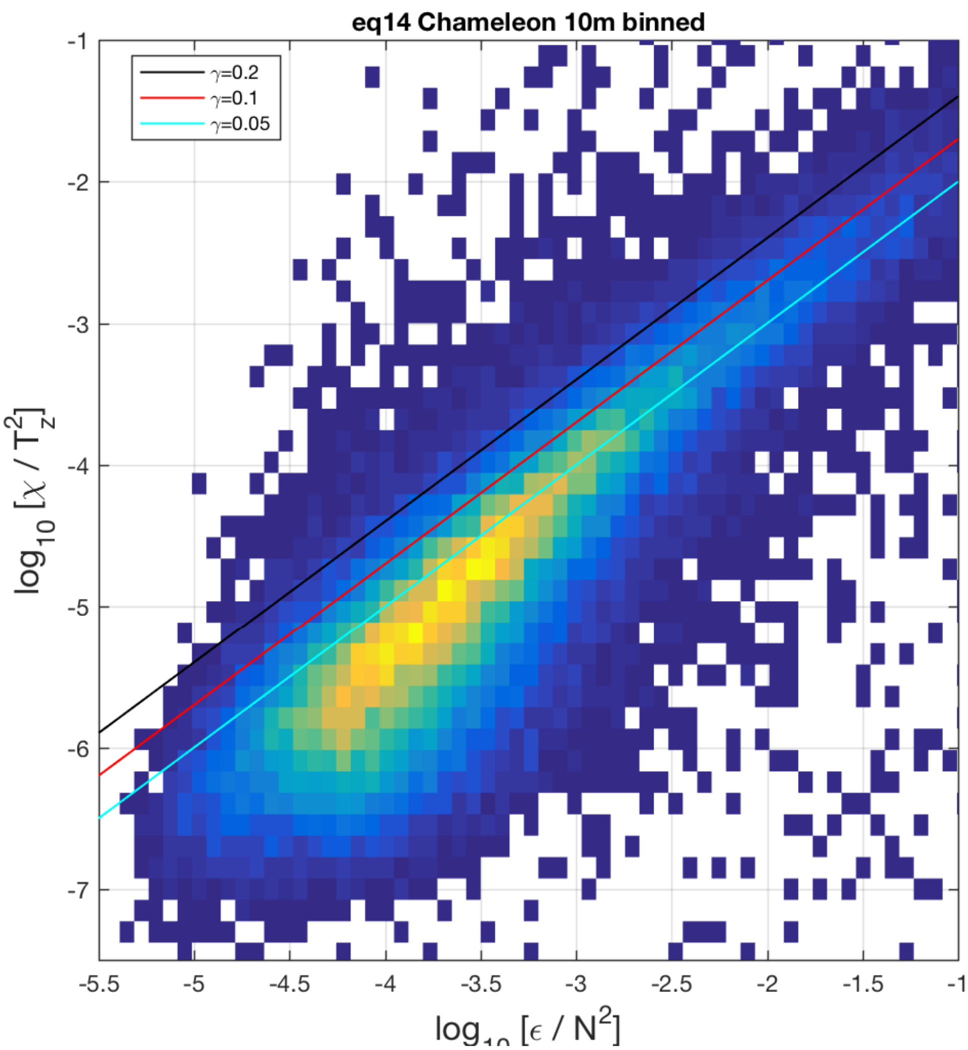

Figure 6: EQ14: 10m binned chameleon $\epsilon/N\hat{2}$ vs χ/t_z^2. Lines show different values of γ. Values of ϵ below noise floor ($log_{10}\epsilon < -8.5$) are discarded also.

3.4 Averaging many profiles of ϵ

Figure 7 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_diffNprof_profavgs/zsm10m_fmax7Hz_respcorr0_fc_99hz_gamma20_nfft_128_screen_chi_1`.

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.

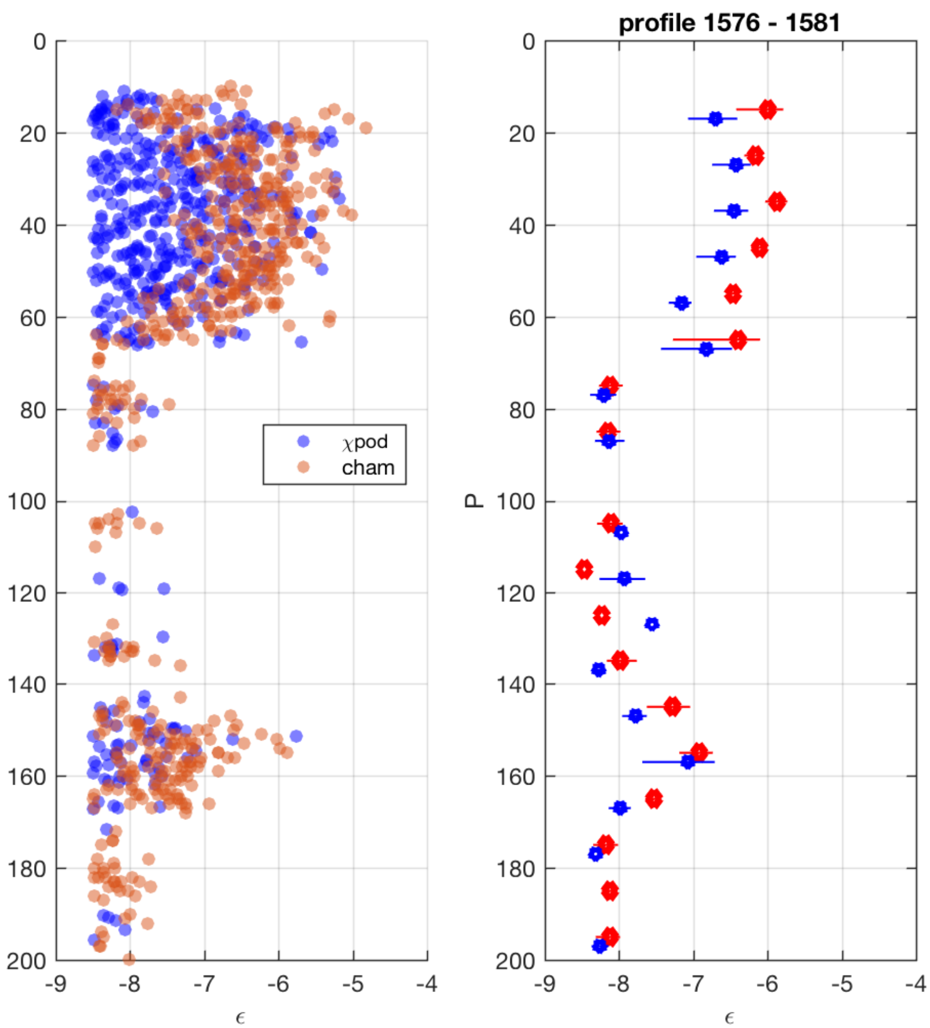

Figure 7: Example of averaging multiple profiles together. Left panels show a single profile from chamleeon and chi-pod method. Right panel shows bootstrap average of 5 profiles, averaged in 10m depth bins, with 95% confidence intervals. Data in mixed layer and shallower than 20m have been excluded.

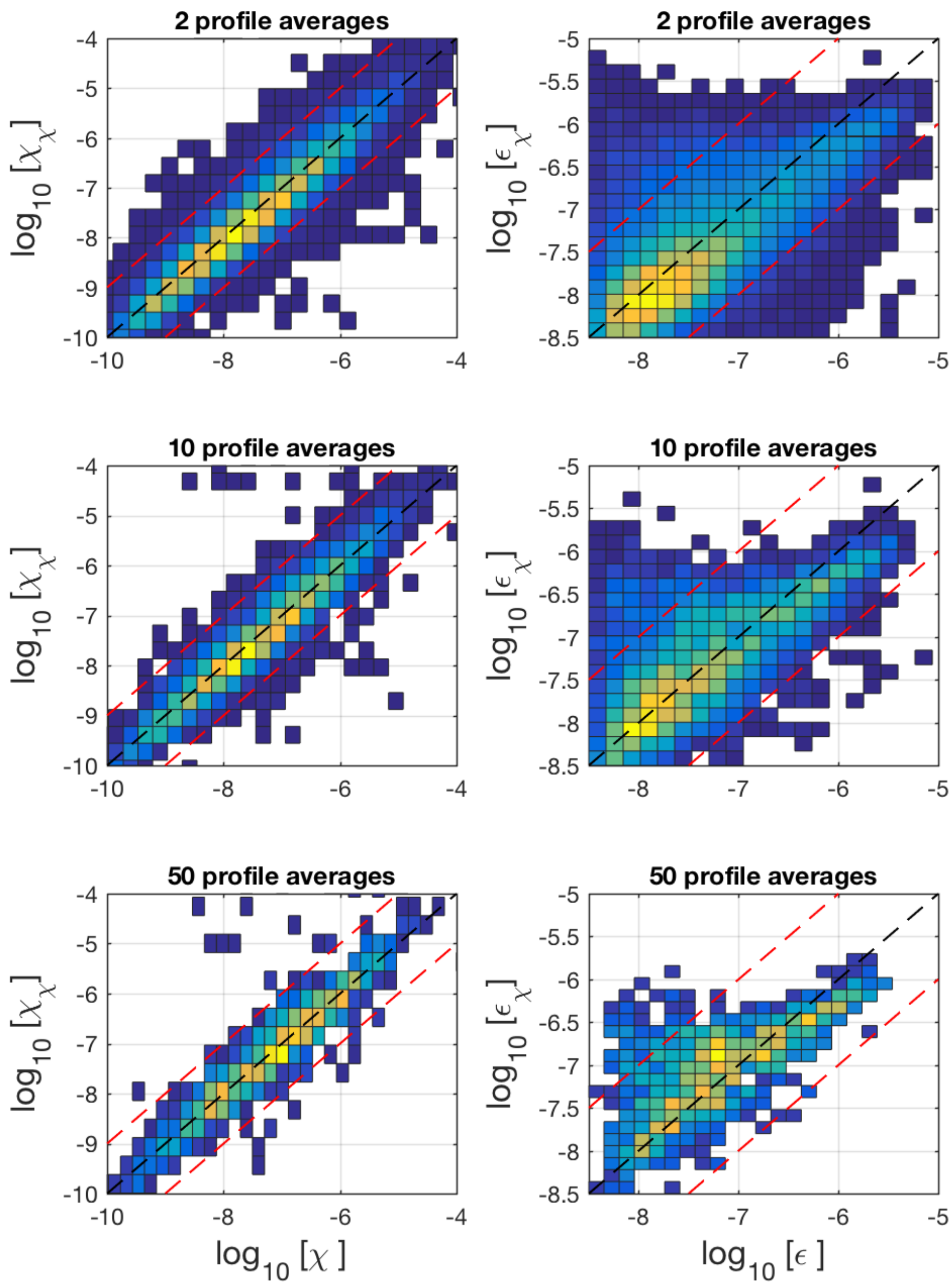

Figure 8: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) for different numbers of profiles averaged. Using *1m* smoothed N2 and Tz.

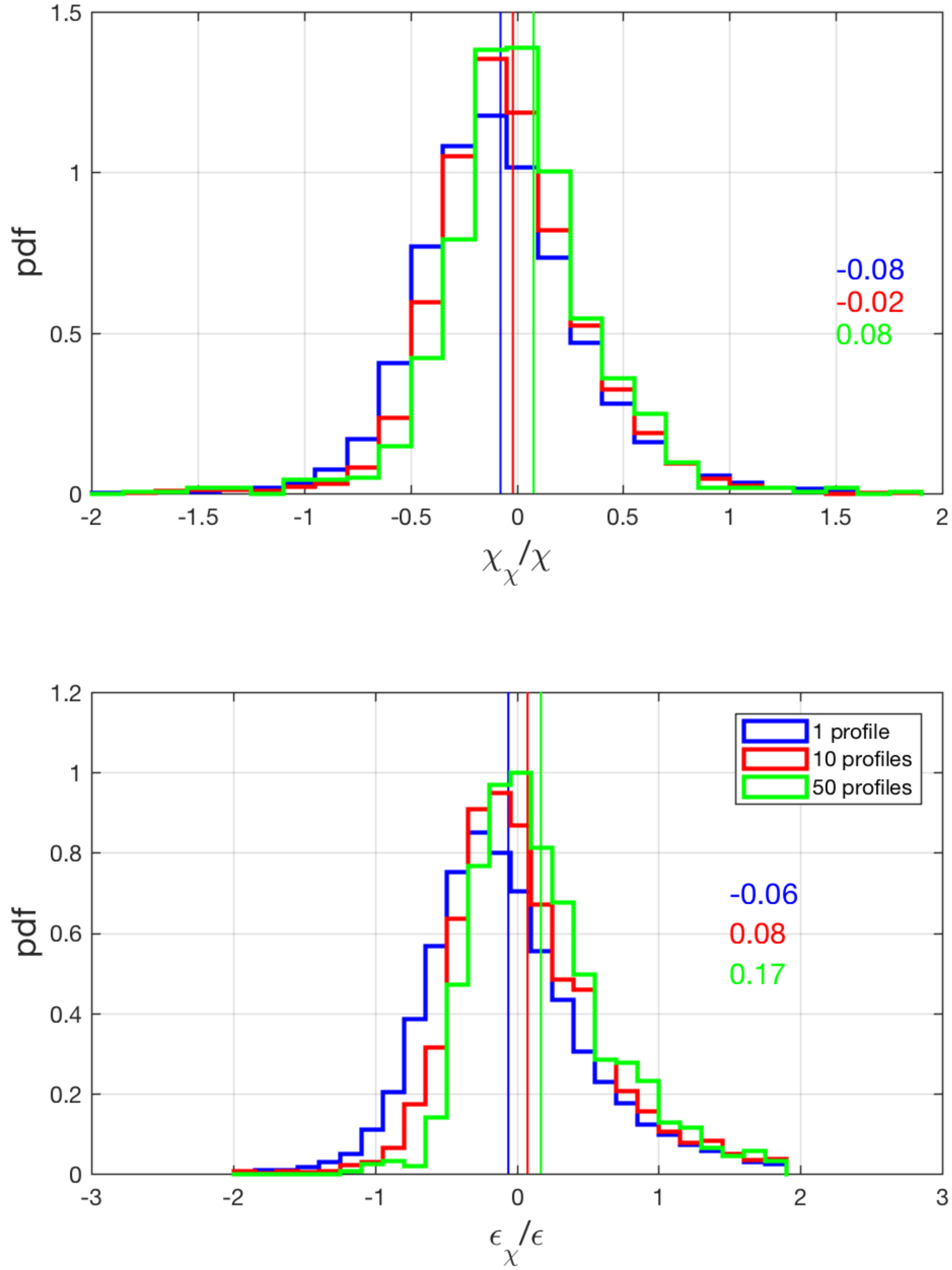

Figure 9: (log10) Ratio of ϵ_χ/ϵ for different numbers of profiles averaged. Consecutive chunks of N profiles were averaged, and then (normalized) histogram of the ratios was plotted. Vertical lines and numbers to right are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

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.

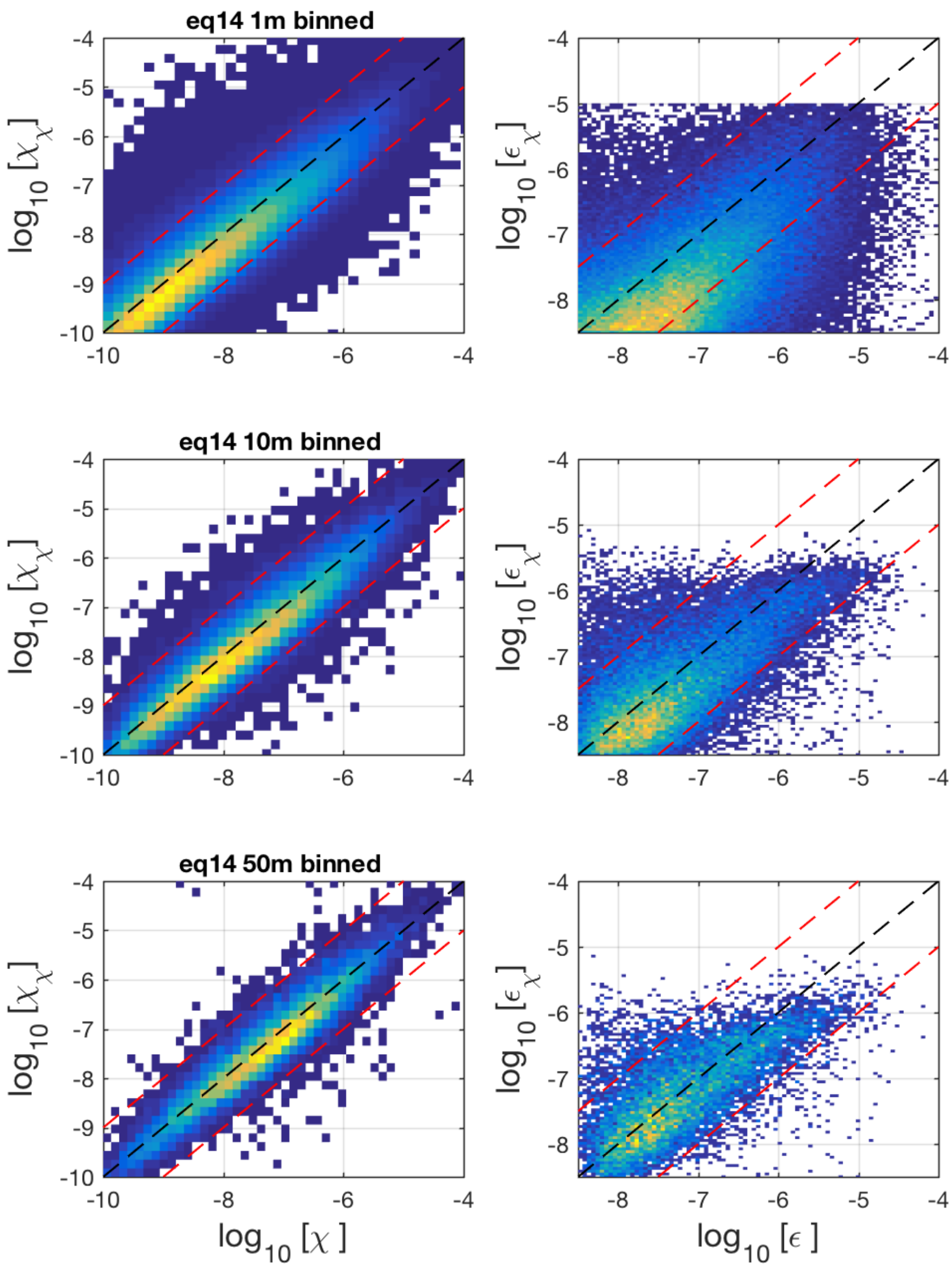

Figure 10: 2D Histograms of χ_{chi} vs χ (left) and ϵ_χ vs ϵ (right) averaged over different size depth bins

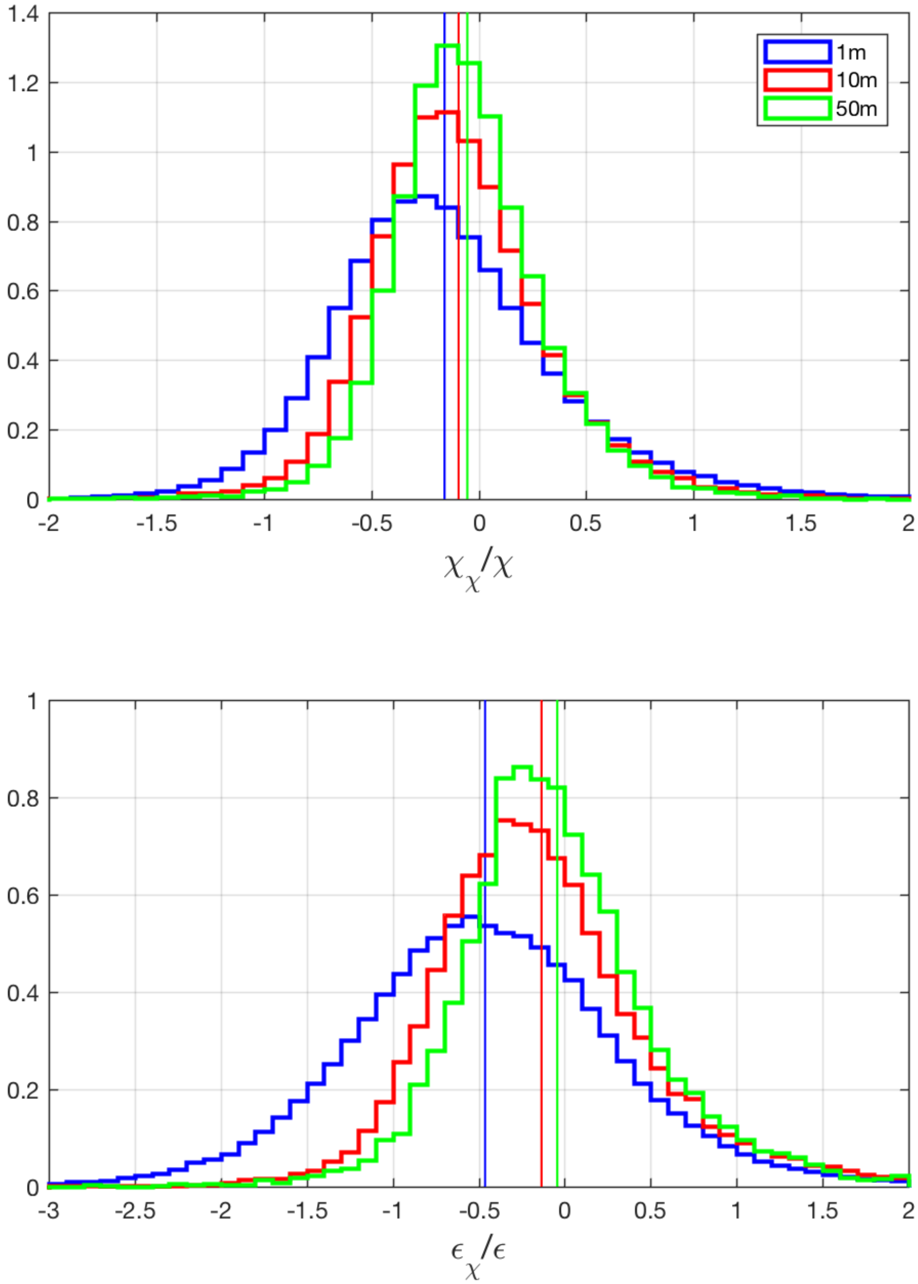

Figure 11: Histogram of log10 of ratio ϵ_χ/ϵ for different amounts of vertical averaging. Vertical lines are mean of $log_{10}[\epsilon_\chi/\epsilon]$ for each distribution.

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 (Figure 12) but still slightly less than 0.2 .

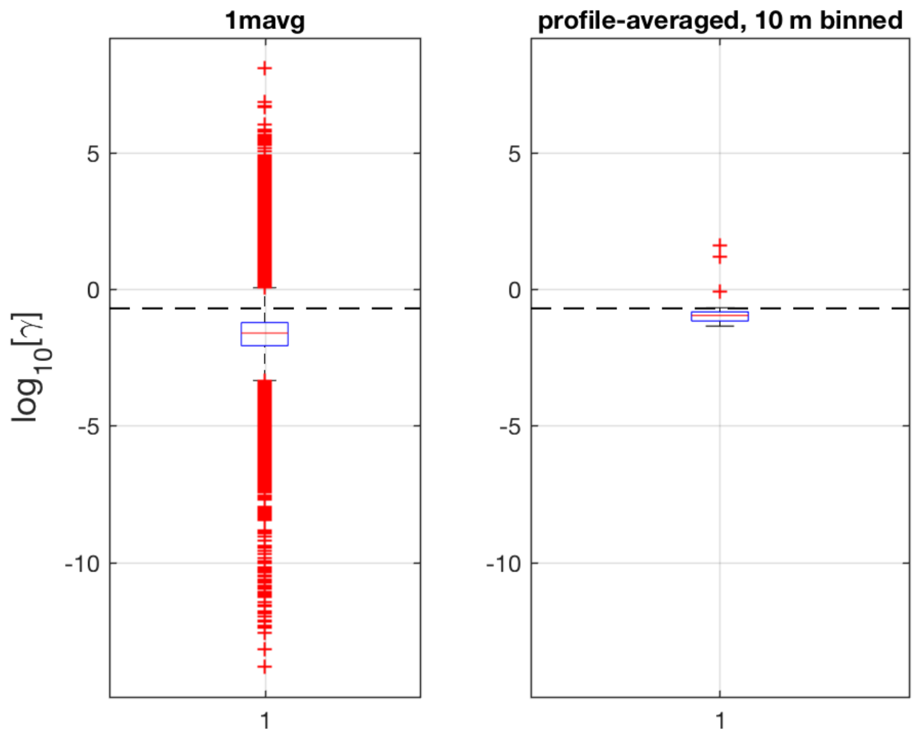

Figure 12: Boxplots of $log_{10}[\gamma]$ for a set of profiles from EQ14. Left is for all 1m avg data. Right is for data from all profiles averaged in 10m bins. Horizontal dashed line indicates $\gamma = 0.2$.

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 data (across profiles) N^2, T_z, χ, and ϵ is closer to 0.2
- Averaging many ϵ profiles or averaging depth reduces the bias