

# Summary of $\chi$ pod Chameleon EQ14 Analysis

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April 26, 2017

## Contents

<b>1</b>	<b>Overview</b>	<b>2</b>
<b>2</b>	<b>Data and Processing</b>	<b>3</b>
<b>3</b>	<b>?</b>	<b>4</b>
<b>4</b>	<b>Comparing individual estimates of <math>\epsilon</math></b>	<b>8</b>
<b>5</b>	<b>Normalized eps vs chi plots</b>	<b>9</b>
<b>6</b>	<b>Averaging many profiles of <math>\epsilon</math></b>	<b>10</b>
<b>7</b>	<b>Effects of averaging in different-sized depth bins</b>	<b>13</b>
<b>8</b>	<b><math>\gamma</math> computed from averaged quantities</b>	<b>15</b>
<b>9</b>	<b>Summary</b>	<b>16</b>

# 1 Overview

- This document is an attempt to provide an overview/summary of what i've found in my  $\chi$ pod analysis.
- The motivation/goal for all this work is to show if and how well the CTD- $\chi$ pod method works for estimating  $\chi, \epsilon, K_T$ , etc from fast temperature profiles. The idea is to deploy  $\chi$ 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, entraining 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  $\chi$ pod method to the chameleon thermistor data only ( $\chi_\chi, \epsilon_\chi$ ), and compare to the 'true' results computed using the shear probes ( $\chi, \epsilon$ ).
- I found that basically the estimates of  $\chi$  agreed, but  $\epsilon_\chi$  was about an order of magnitude smaller than  $\epsilon$  (Figure 1,2,3).
- The  $\chi$ pod 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.
- Is gamma really different here? Am I calculating it wrong? What does gamma mean? Sasha found something similar previously in EQ08 and other Chameleon datasets, gives me a little more confidence that i'm not doing something obviously wrong..
- One idea was that we should be computing gamma over patches, and it's meaningless outside of patches. Previous work has found gamma is close to 0.2 . So I tried computing patches and gamma. This can be a whole other can of worms (lots of choices to make in how to identify patches, compute N2, Tz etc), but I found I could get gammas close to 0.2 . And on a point-by-point basis,  $\epsilon_\chi$  agreed better with  $\epsilon_\chi$ . But then we have much fewer data points...
- Looked at whether averaging multiple profiles agreed better. Doesn't seem to make epsilon agree. However, gamma computed from average quantities is closer to 0.2?
- So, is gamma really small here, or am I just computing it wrong? Look at other locations/regimes?

## 2 Data and Processing

- `ComputeChi_Chameleon_Eq14.m` : Applies  $\chi$ pod method to Chameleon profiles from EQ14.
- Sally shared w/ me Chameleon data that she and Jim processed. I ended up re-processing it using a smaller  $f_{\max}$  (7Hz) because it looked like the thermistor spectra rolled off much lower than the assumed 32Hz.

**3 ?**

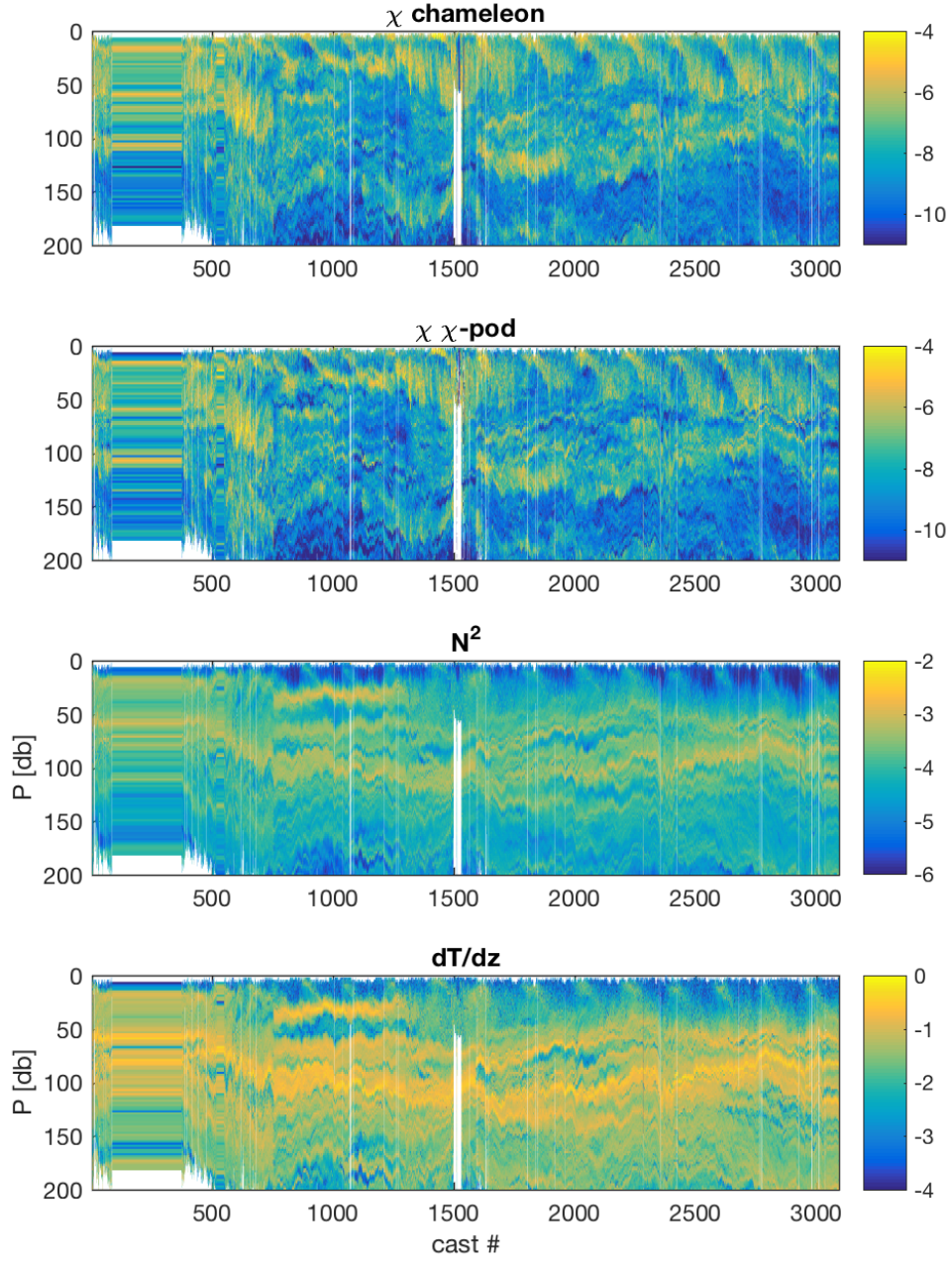


Figure 1: Comparison of  $\chi$  from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins.

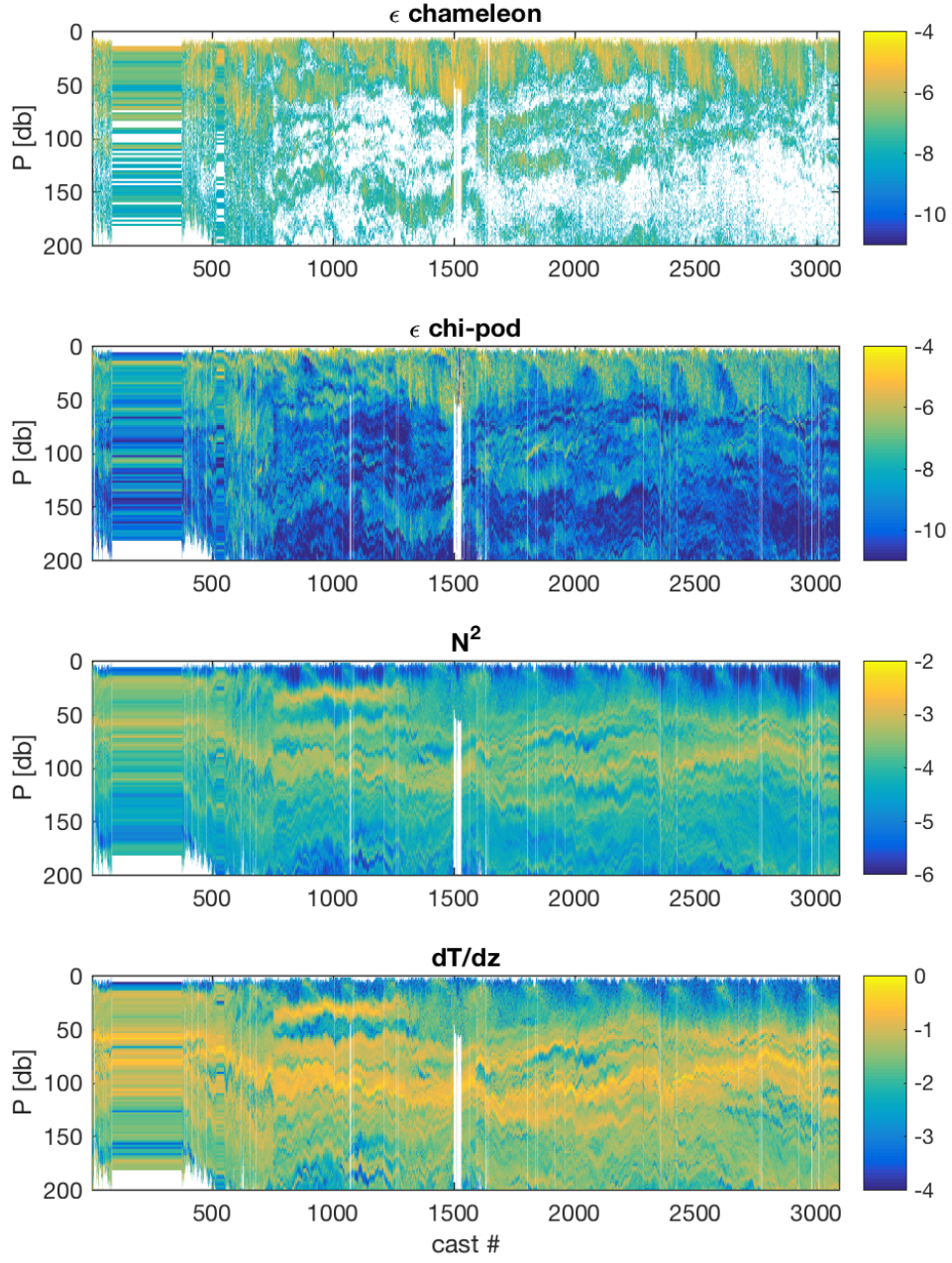


Figure 2: Comparison of  $\epsilon$  from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ( $-8.5$ ) have been naned out

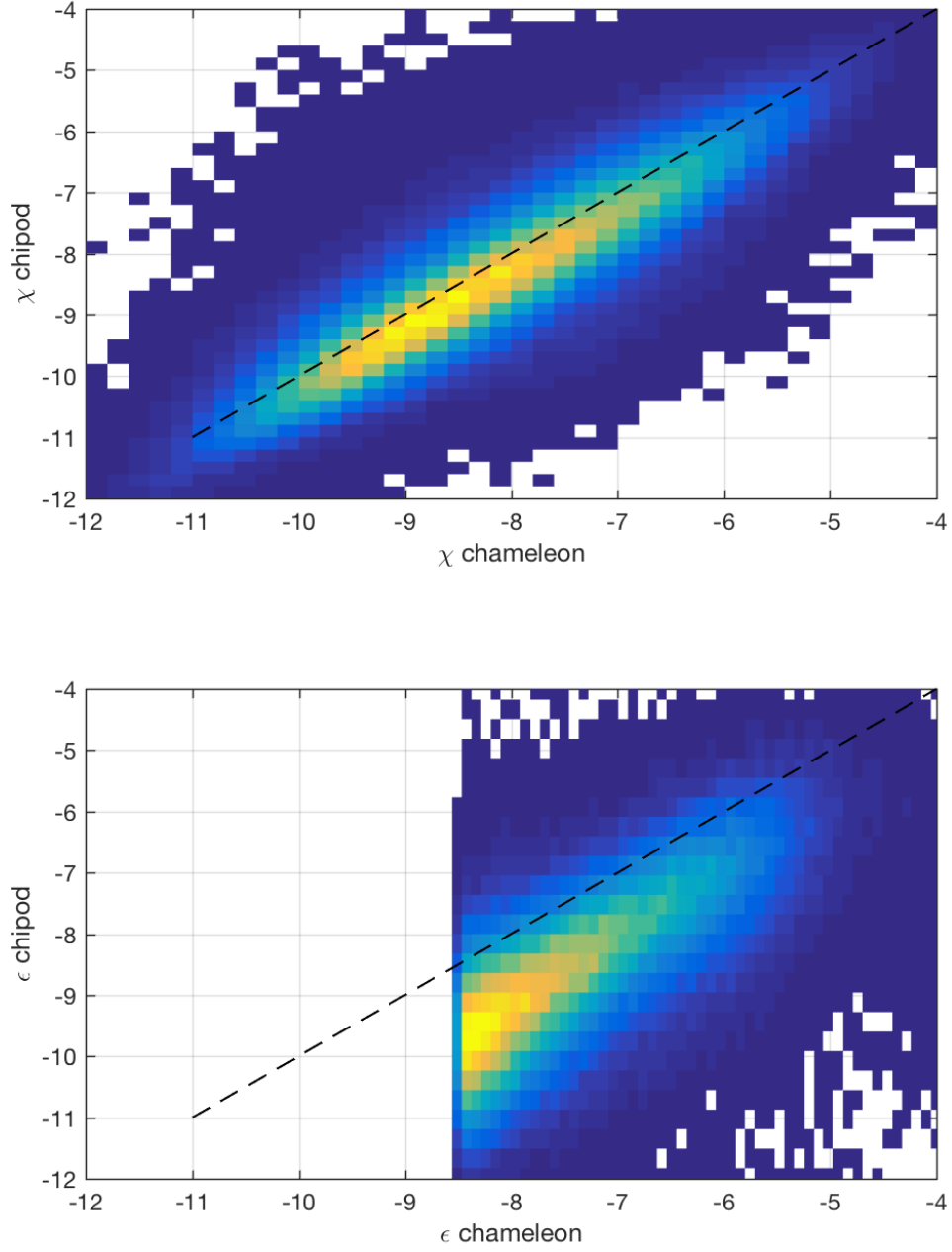


Figure 3: Comparison of  $\chi$   $\epsilon$  from chameleon method and chi-pod method, for EQ14 chameleon profiles. Each profile was averaged in 2m bins. Values of below chameleon noise floor ( $-8.5$ ) have been naned out

#### 4 Comparing individual estimates of $\epsilon$

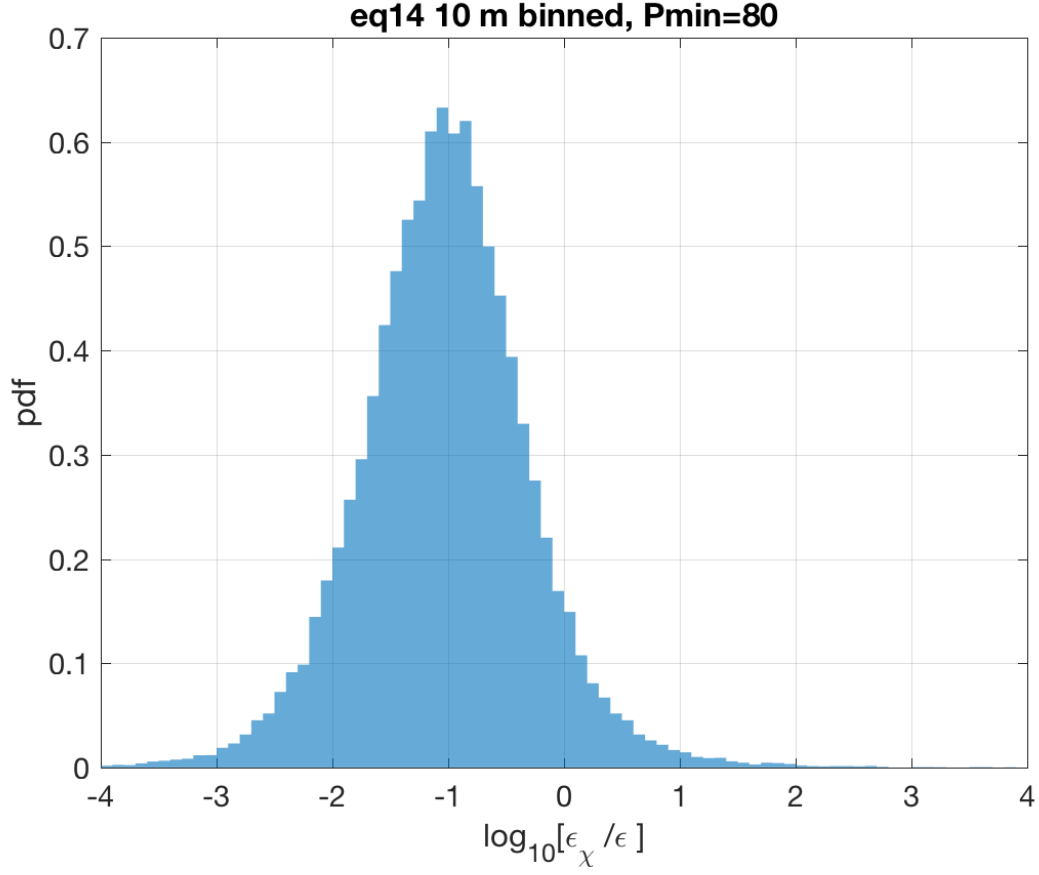


Figure 4: EQ14: Histogram of the ratio of  $\epsilon$  estimates from  $\chi$ pod method to the chameleon values, for  $\chi$ pod method applied to 1m binned profiles, and applied to just patches. Estimates for each profile were averaged in 10m depth bins.



## 5 Normalized eps vs chi plots

Assuming that

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

, plotting  $[\chi/t_z^2]$  vs  $[\epsilon/N^2]$  should follow a straight line with slope equal to  $2\gamma$ .

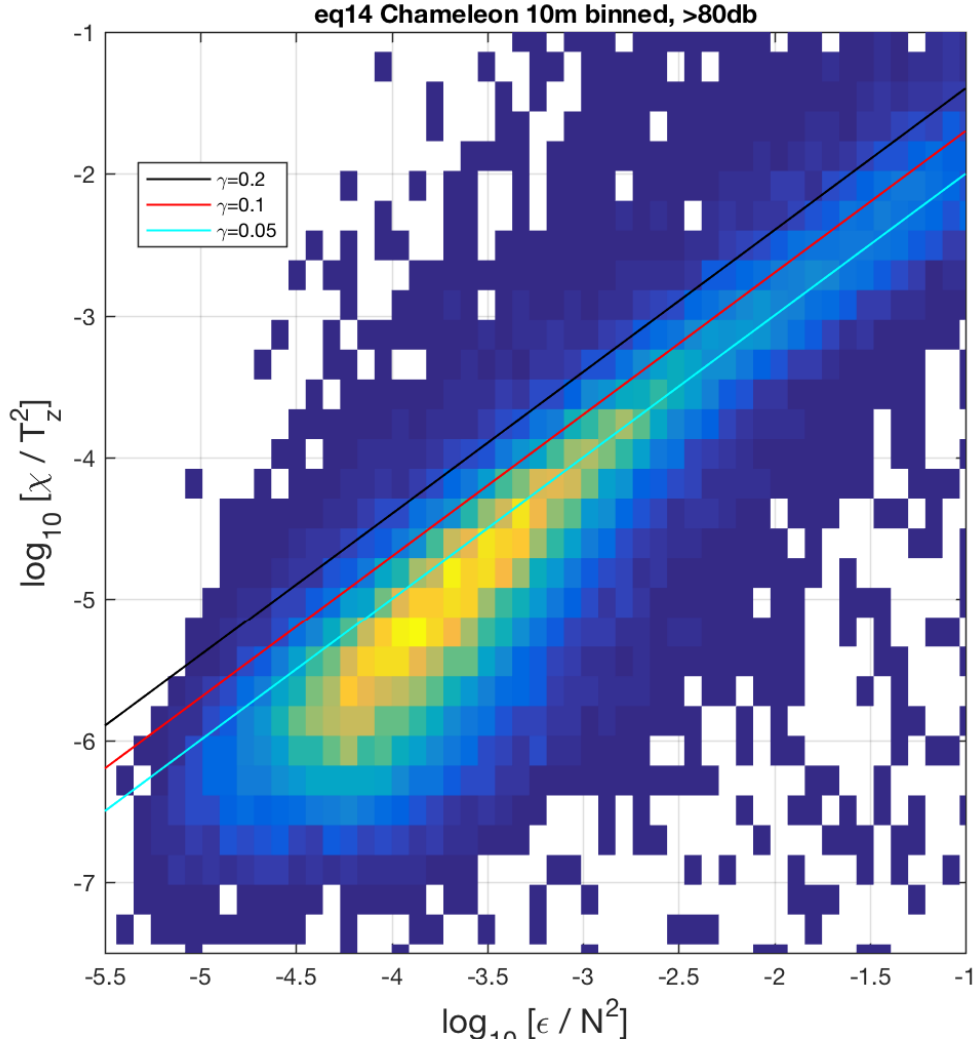


Figure 5: EQ14: 10m binned chameleon  $\epsilon/N^2$  vs  $\chi/t_z^2$  for \*below 80db\*. Lines show different values of  $\gamma$ . Values of  $\epsilon$  below noise floor ( $\log_{10}\epsilon < -8.5$ ) are discarded also.

## 6 Averaging many profiles of $\epsilon$

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](https://github.com/OceanMixingGroup/Analysis/tree/master/Andy_Pickering/eq14_patch_gamma/figures/chi_eps_profiles_40profavgs). In general, it seems that averaging profiles does not change the comparison much;  $\epsilon_\chi$  is still biased low.

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. This doesn't seem to change either.

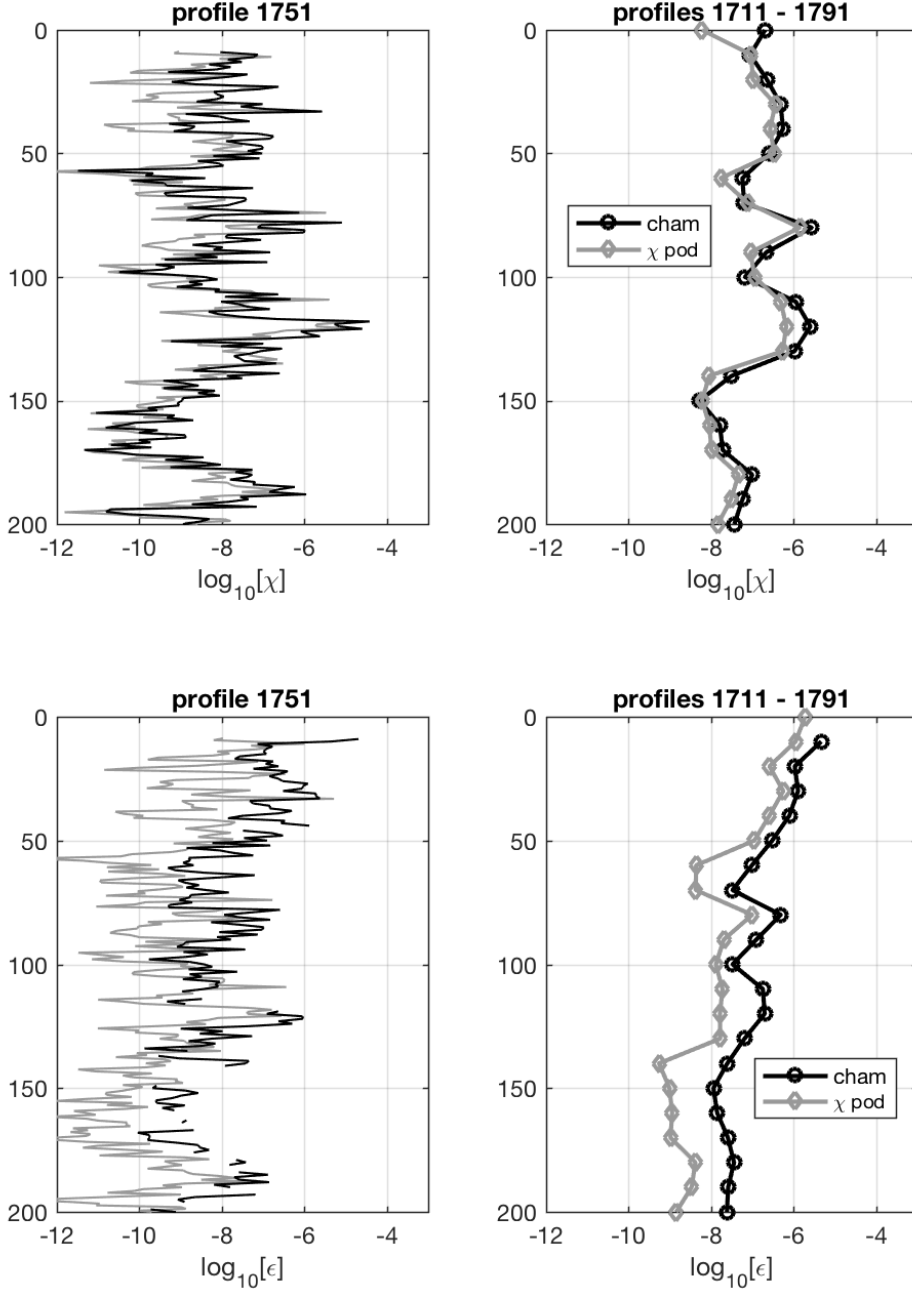


Figure 6: Example of averaging multiple profiles together. Left panels show a single profile from chamleon and chi-pod method. Right panels show average of  $\pm 40$  profiles, averaged in 10m depth bins.

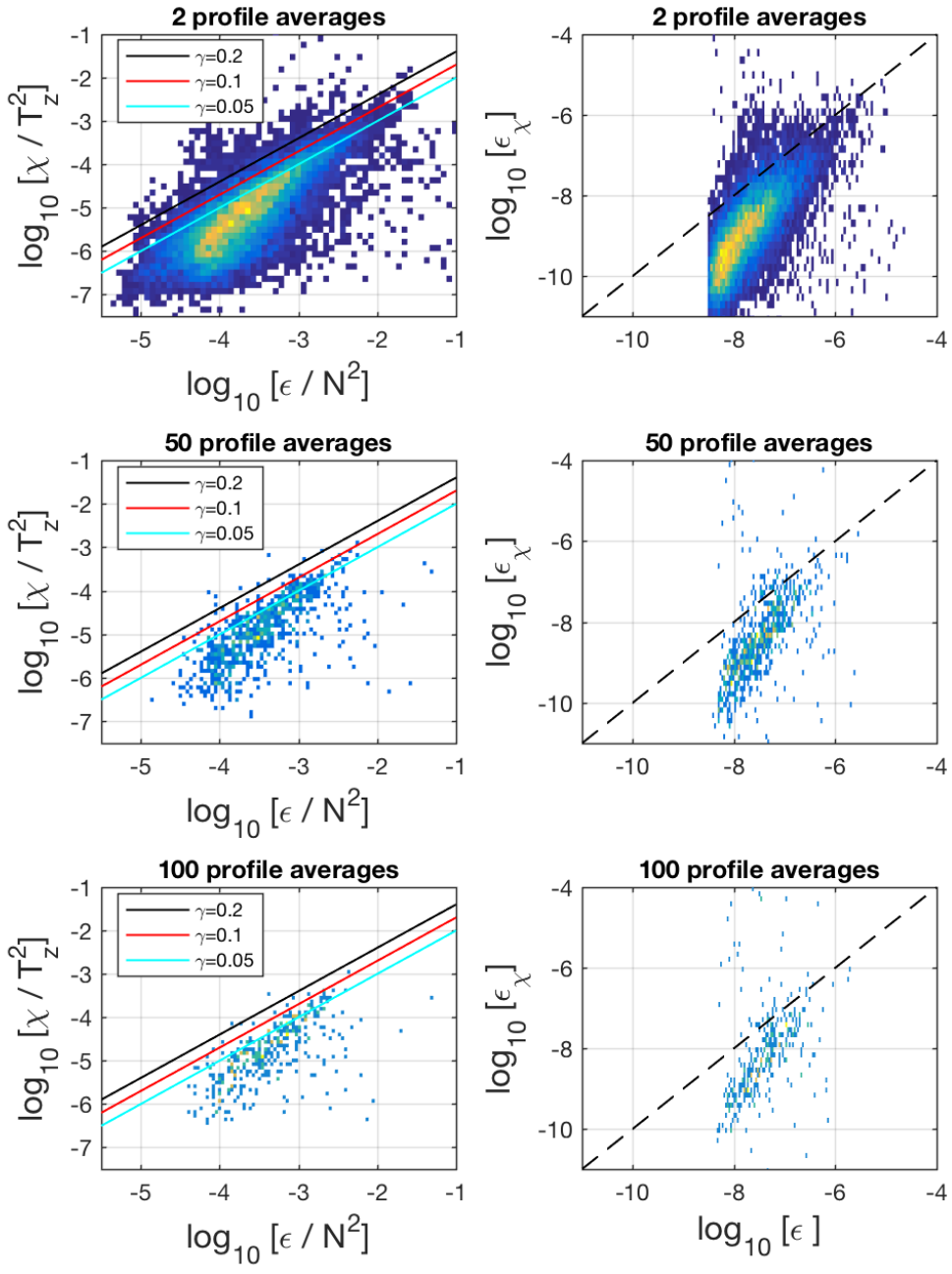


Figure 7:

## 7 Effects of averaging in different-sized depth bins

I tried making plots of normalized chi vs eps, and scatterplots of chi-pod vs chameleon epsilon, for data averaged in different-sized depth bins (for each profile, not across profiles). They don't seem to change.

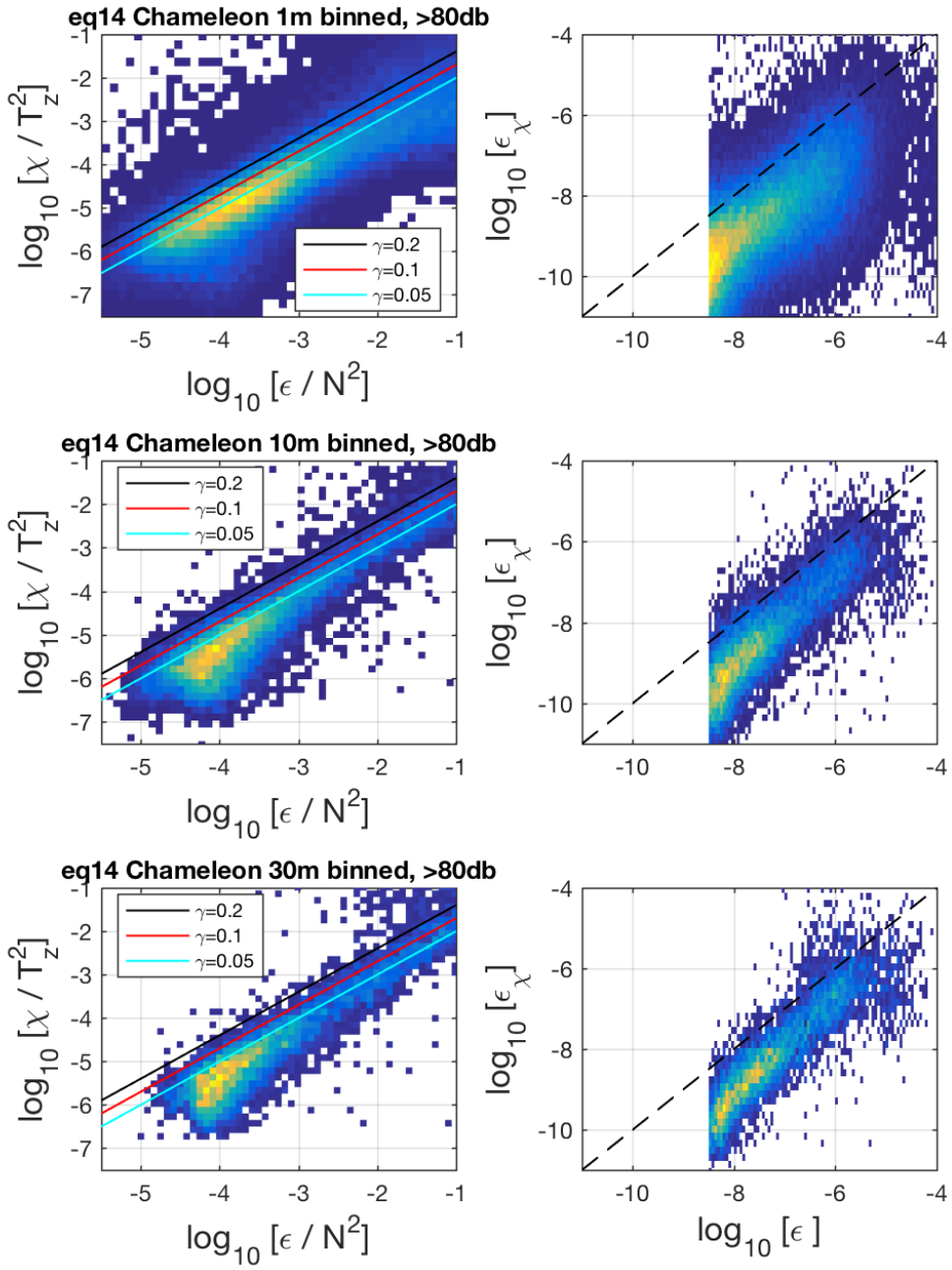


Figure 8:

## 8 $\gamma$ computed from averaged quantities

If we compute gamma from time-averaged  $N^2, T_z, \chi, \epsilon$  do we get  $\gamma = 0.2$  (or a different gamma)? Estimates from the averaged data are larger (Figures ??,9) but still slightly less than 0.2 .

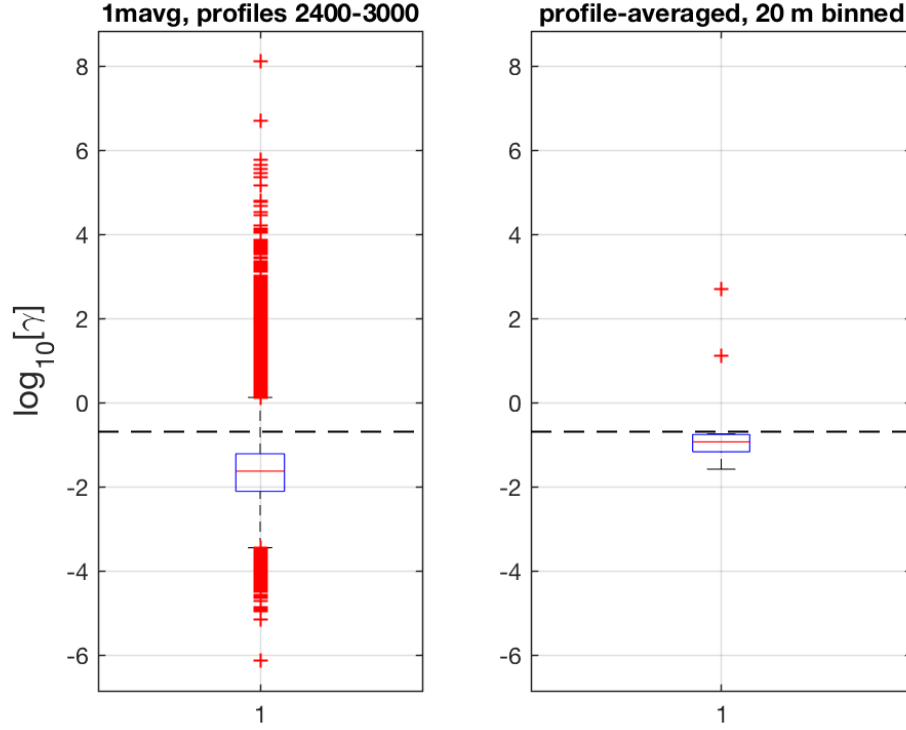


Figure 9: Boxplots of  $\log_{10}[\gamma]$  for a set of profiles from EQ14. Left is for all 1m avg data. Right is for data from all profiles averaged in 10m bins. Horizontal dashed line indicates  $\gamma = 0.2$ .

## 9 Summary

- Individual (and 10m binned)  $\chi$ pod estimates of  $\epsilon_\chi$  are biased low compared to Chameleon  $\epsilon$ .
- This appears to be because  $\gamma$  computed from the Chameleon data is lower than the assumed 0.2
- $\gamma$  computed from averaged (across profiles)  $N^2$ ,  $T_z$ ,  $\chi$ , and  $\epsilon$  is closer to 0.2
- But averaging many epsilon profiles doesn't appear to improve comparison.

Questions:

- Is gamma really different here? Or is it an issue with the instrument or processing?
- Would be good to see what gamma you get from other instruments/locations (I think Amy did this for some of the database and found gamma was about 0.2?)
- Would be good to have 'standard' code to compute  $\chi$  from thermistor data etc.? Thermistor response/noise level varies a lot though, would need a standard way to determine correction.