

χ pods and Mixing Efficiency

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March 24, 2017

Introduction

TIWE

EQ14

Applying χ pod method to patches

Comparing Different Experiments

Summary

The CTD- χ pod

- ▶ Measures temperature gradient w/ FP07 thermistor
- ▶ Easily deployed on traditional CTD, Tz not as sensitive to package vibration
- ▶ Goal: estimate χ and ϵ w/o full microstructure

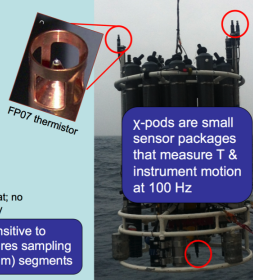
$$\chi = 2D_T \langle (\nabla T)^2 \rangle$$

χ = dissipation rate of small-scale temperature variance,
→ computed from temperature gradient spectra,
→ dominated by small (1-50 cm) scales.
→ characterizes irreversible mixing

$$K_T = \frac{\frac{1}{2} \chi}{\langle (dT/dz)^2 \rangle}$$

K_T is turbulent diffusivity of heat; no assumption of mixing efficiency

measurement is not sensitive to platform vibration; requires sampling of "clean" fluid over O(1m) segments



FP07 thermistor

χ -pods are small sensor packages that measure T & instrument motion at 100 Hz

χ pod Method

In small windows:

- ▶ Convert dT/dt to dT/dz using fallspeed, frozen-flow hypothesis
- ▶ Compute spectra of dT/dz
- ▶ Iterative method to estimate χ, ϵ
- ▶ Assumes $K_T = K_\rho$
- ▶ Assumes mixing efficiency (coefficient) $\gamma = 0.2$

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

CTD- χ pod Validation

- ▶ To validate, compare w/ Chamelon microstructure profiles (1m avg).
- ▶ Apply χ pod method to Chameleon thermistor data only (no shear probes)
- ▶ Compare to 'true' Chameleon estimates using shear probes.

Results:

- ▶ χ compares well
- ▶ But ϵ biased low by about 10X

Why is ϵ Biased so Low?

- ▶ Turns out using the 1m avg Chameleon data, $\gamma \approx 0.02$, not 0.2 .
- ▶ Apparently Sasha found something similar for EQ08 and other Chameleon datasets?

What if We Compute γ over patches?

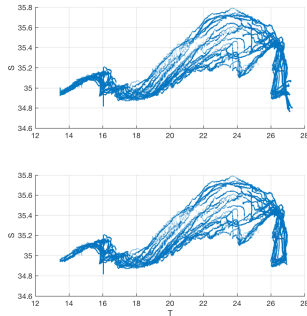
- ▶ But everyone says $\gamma = 0.2...$
- ▶ Maybe we have to compute it over patches. If there's no mixing, does γ even make sense?
- ▶ So began the journey into patches...

Patches

- ▶ Turns out computing γ over patches not so simple...
- ▶ Lots of options for how to identify patches, calculate T_z and N^2 etc.
- ▶ Lots of salinity spikes, need to use temperature.

Salinity spikes

- ▶ Salinity looks noisy, lots of spikes.
- ▶ Not a constant T-S relationship
- ▶ use R^2 to quantify 'tight' T-S relationships in patches?



dT/dz and N^2

- ▶ T_z "bin" : Interpolate binned T_z to mean depth of each patch.
- ▶ T_z "line" : Fit a straight line to sorted temperature within patch.
- ▶ T_z 'bulk' : Method from Smyth et al 2001. More robust when there are multiple layers within patch?
- ▶ N^2 "bin" : Interpolate binned N^2 to mean depth of each patch.
- ▶ N^2 "line" : Fit a straight line to sorted density within patch.
- ▶ N^2 "fit" : Fit a straight line to density computed from T-S fit in patch.
- ▶ N^2 'bulk' : Use 'bulk' T_z , and ratio between density and temperature.

γ

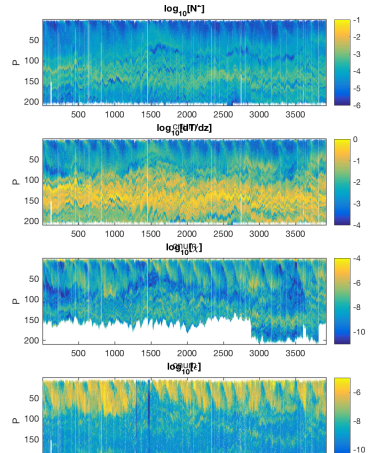
This gives us several estimates of γ :

- ▶ γ bin : Binned T_z, N^2 interpolated to patch locations.
- ▶ γ 'line' : 'line' T_z, N^2
- ▶ γ 'bulk' : 'bulk' T_z, N^2
- ▶ γ 'linefit' : 'line' T_z , 'line-fit' N^2

TIWE - Overview

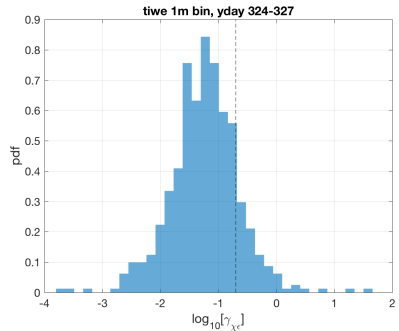
- ▶ Looked at TIWE 1st because there were some previous patch analysis and gamma estimates (Bill, Jim).
- ▶ Not sure why χ isn't full-depth for 1st part of experiment
- ▶ Use profiles from yday

224-227



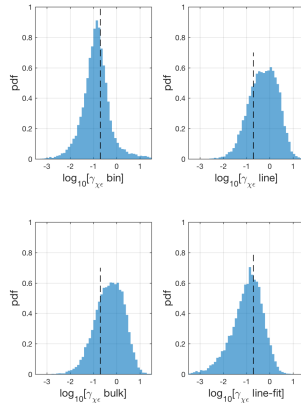
TIWE binned γ

- Binned γ smaller than 0.2, has median of 0.05.



TIWE patch γ

- Patch estimates of γ are all equal or greater than 0.2
- 'bin' and 'line-fit' are centered close to 0.1 . 'line' and 'bulk' are centered greater than 0.2

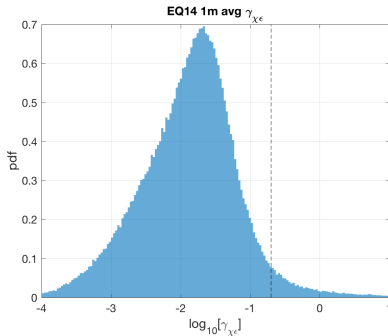


Results table

Table: Statistics for patches using various parameters. γ values are medians for each distribution. Only patches between 60-200m and on yday 324-327 are considered for all.

minOT	usetemp	minR2	γ_{bin}	γ_{line}	γ_{fit}	γ_{bulk}	Npatches
0.4	1	0	0.13	0.57	0.11	0.53	16329
0.4	1	0.5	0.14	0.22	0.12	0.21	3761
0.75	1	0	0.15	0.62	0.14	0.59	9175
0.75	1	0.5	0.15	0.25	0.16	0.26	2358
1	1	0	0.16	0.71	0.15	0.68	6893
1	1	0.5	0.16	0.29	0.17	0.29	1779

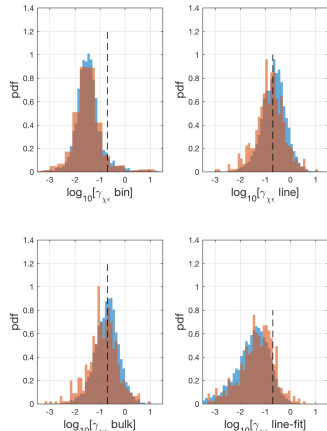
EQ14 binned



- Binned γ smaller than 0.2, has median of 0.02 .

EQ14 patch γ

- Patch estimates of γ vary depending on method used.
- bin and line-fit are smaller than 0.2. line and bulk are centered near 0.2 .



EQ14

Table: Statistics for patches using various parameters. γ values are medians for each distribution. Only patches between 60-200m are considered.

minOT	usetemp	minR2	γ_{bin}	γ_{line}	γ_{fit}	γ_{bulk}	Npatches
0.4	1	0	0.03	0.15	0.02	0.13	9326
0.4	1	0.5	0.03	0.09	0.02	0.08	1301
0.75	1	0	0.05	0.13	0.02	0.12	4075
0.75	1	0.5	0.05	0.08	0.03	0.08	520
1	1	0	0.06	0.12	0.02	0.12	2829
1	1	0.5	0.05	0.08	0.04	0.08	387

Applying χ pod method to patches

Comparing Different Experiments

Summary

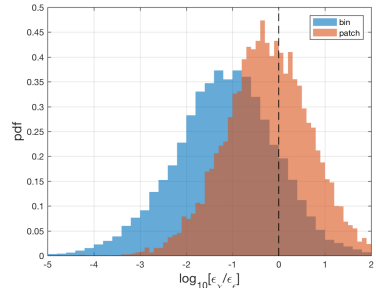
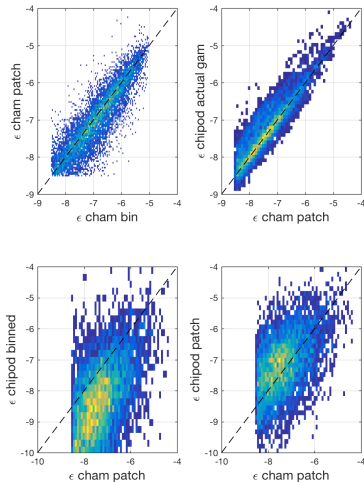
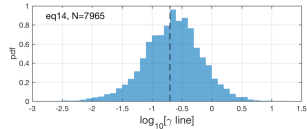
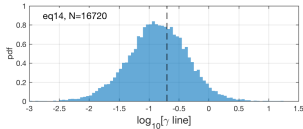
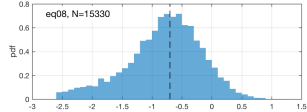
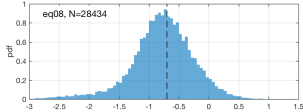
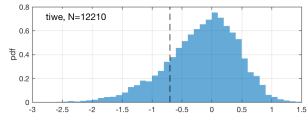
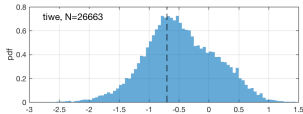


Figure: Ratio of χ pod estimated ϵ to Chameleon ϵ for patches.

Summary



Summary

- ▶ γ sensitive to many choices of parameters/methods. Difficult to tell if γ actually changes.
- ▶ In general, it seems that using 1m binned data tends to give γ smaller than 0.2, while using patches gives something closer to 0.2 .
- ▶ Suggests we should be using some kind of patch values in CTD χ pod calculations (since a constant $\gamma = 0.2$ is assumed).
- ▶ Applying χ pod method to patches from EQ14 Chameleon profiles improves magnitude of ϵ estimates, but dependence on actual ϵ may be off.