Pathways of temperature variance in the NATRE region

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Motivations:

Temperature variance is dissipated at the molecular scale at a rate χ. What processes generate that variance, and how does it cascade down to the molecular scale for eventual dissipation?

Hypothesis: Two stirring processes: vertical stirring of the mean gradient by "turbulence" and horizontal stirring of lateral gradients by mesoscale eddies. Also double diffusion. (Garrett 1992; Davis 1994; Ferrari & Polzin 2005)

(i) Models represent "variance cascade pathways" using parameterizations (Gent-McWilliams, Redi diffusivities, vertical mixing schemes).
(ii) Parameterization values are somewhat unconstrained
(iii) Turbulence measurements infer χ.

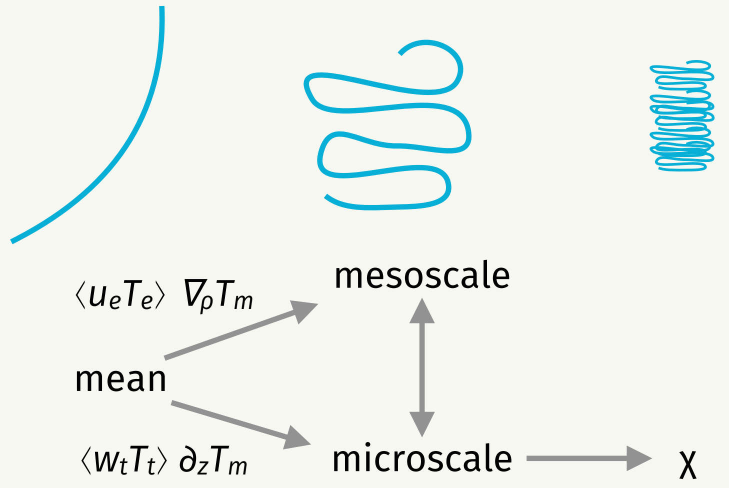
Can we use microstructure measurements to test mesoscale stirring parameterizations?

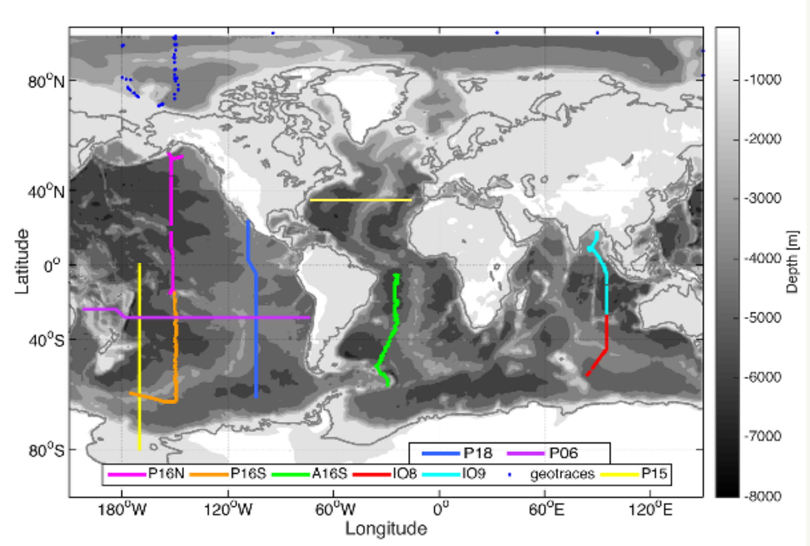
Yes! Ferrari & Polzin (2005)

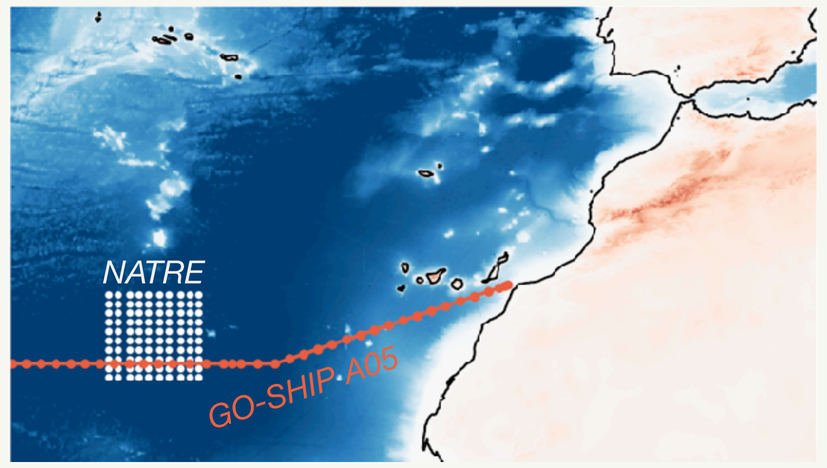
Framework:

Assume we are away from sources of variance.
Triple decomposition following Garrett (1992)

T =	mean	+	mesoscale	+	turbulence
=	1000km		O(100) km		O(10m)
	O(100m)		O(50m)		O(10m)
	multiple years		O(months)		O(minutes)
=	T_m	+	T_e	+	T_t







Plans:

Do variance budget analysis of Ferrari & Polzin (2005) with new basin-wide CTD-χpod dataset. Compare against estimates of Redi diffusivities, high-res and coarse simulations, state estimates (ECCO).

This poster:

1. Replicate Ferrari & Polzin (2005) analysis with NATRE dataset.
2. Compare to high-resolution POP 1/10° ocean model simulations

Conclusions:

1. There is information in the χ field that cannot be recovered from only ε measurements or finescale parameterizations (which estimate ε, K_ρ)
2. Spectacular agreement between mesoscale resolving 1/10° simulation, NATRE observations.
3. Decent agreement with diffusivity estimates of Cole et al (2015); Groeskamp et al (2020)

Acknowledgments:

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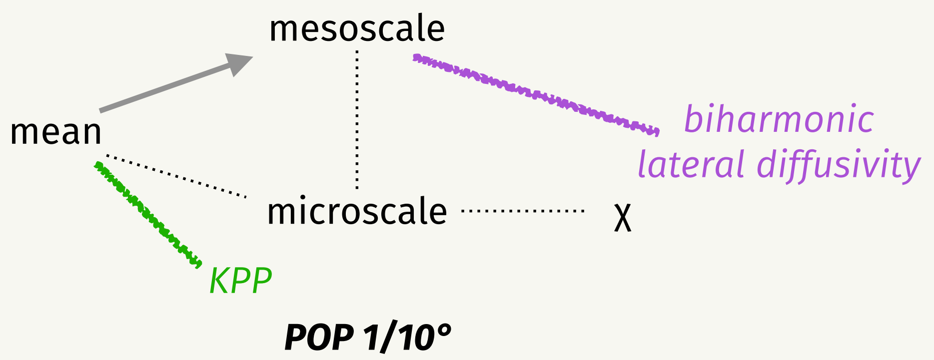
Mesoscale budget: POP 1/10° (Guo, Bishop, Bryan)

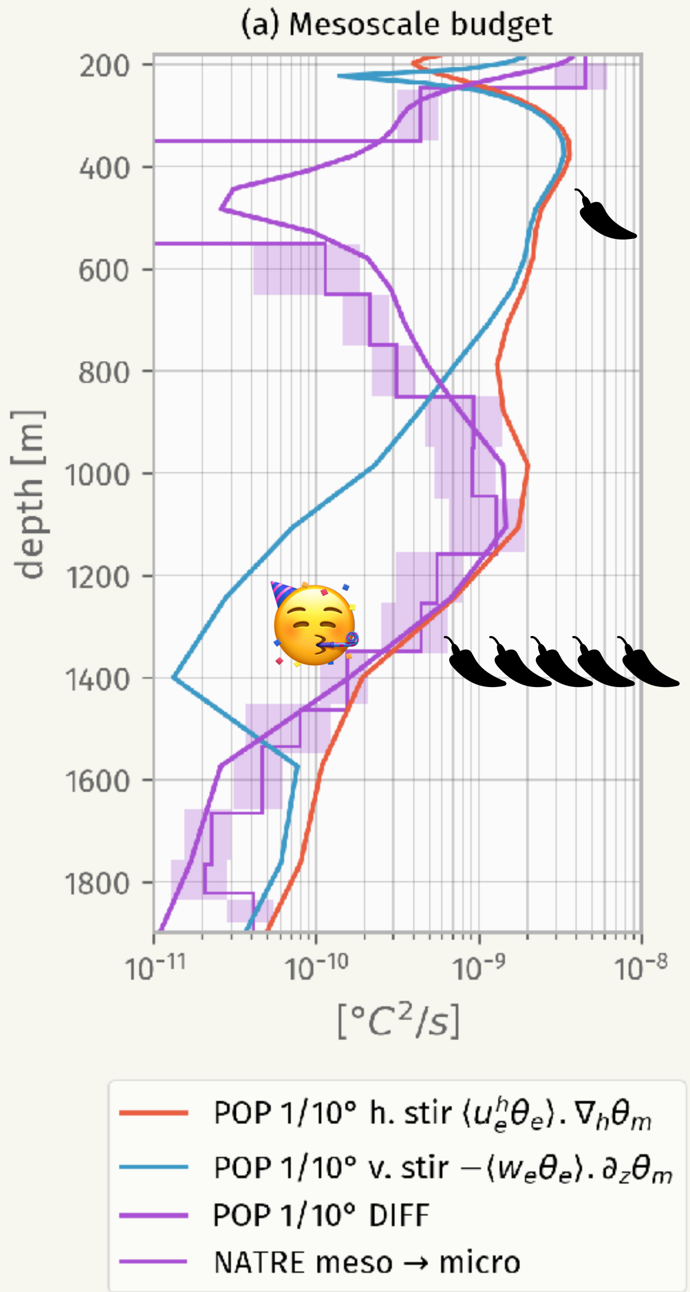
Explicitly resolves mesoscale eddies, vertical resolution ~ 150m at 1000m depths

200m-800m: T, ρ are mostly aligned (low spiciness), eddy stirring of temperature; generates density, PE anomalies; conversion of eddy potential energy to eddy kinetic energy (Gent-McWilliams).

800m-1600m: T, ρ are not aligned (spicy!); eddy stirring of T along isopycnal generates strong horizontal gradients dissipated by artificial biharmonic lateral diffusivity

"Mesoscale dissipation term" agrees with mesoscale production term from Ferrari & Polzin (2005)





NATRE observations (Toole, Polzin, Ferrari)

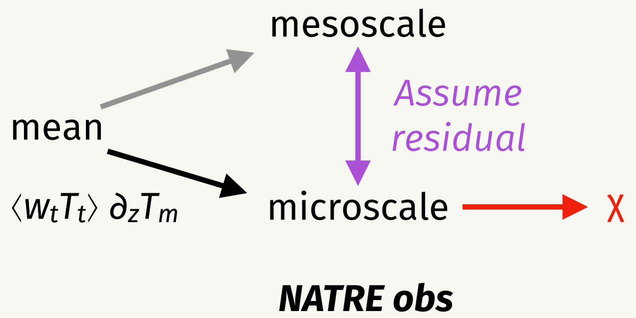
χ measurements in 10°x10° box (100 casts). Estimate turbulence stirring of mean as $\langle w_t T_t \rangle\ \partial_z T_m$.

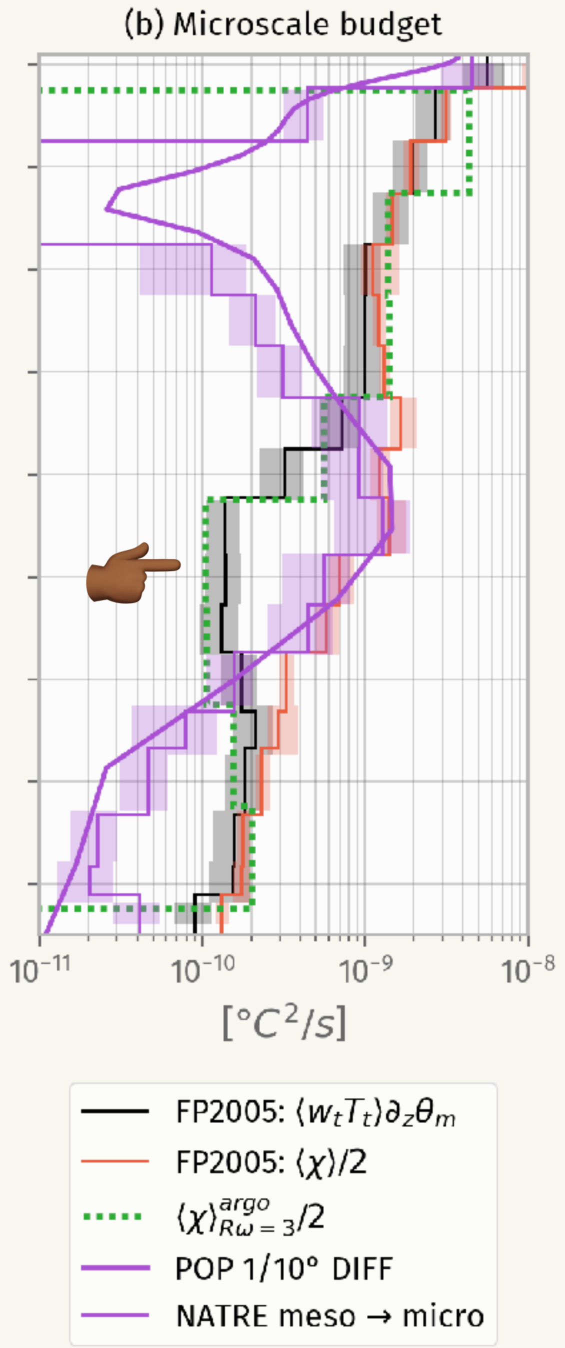
200m-800m: χ is mostly balanced by turbulence stirring of the mean.

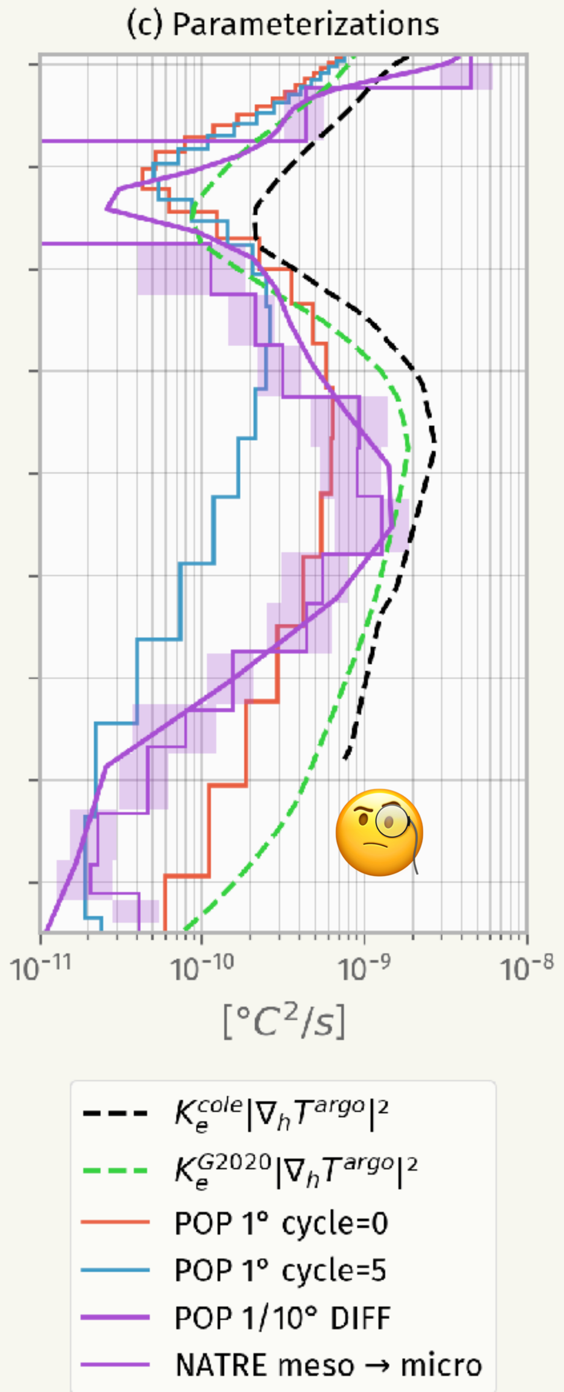
800m-1600m: χ is larger than $\langle w_t T_t \rangle\ \partial_z T_m$. Interpret the residual as a source term from the mesoscale.

"Microscale budget residual" agrees with mesoscale production term from Guo et al's analysis of the POP 1/10° model.

Argo finescale estimate of $\langle \chi/2 \rangle$ agrees well with NATRE $\langle \chi/2 \rangle$ (Estimated assuming K_T=K_ρ for each 200m segment; χ=$K_T T_z^2$; and ⟨⟩ is an average of all 200m segments)

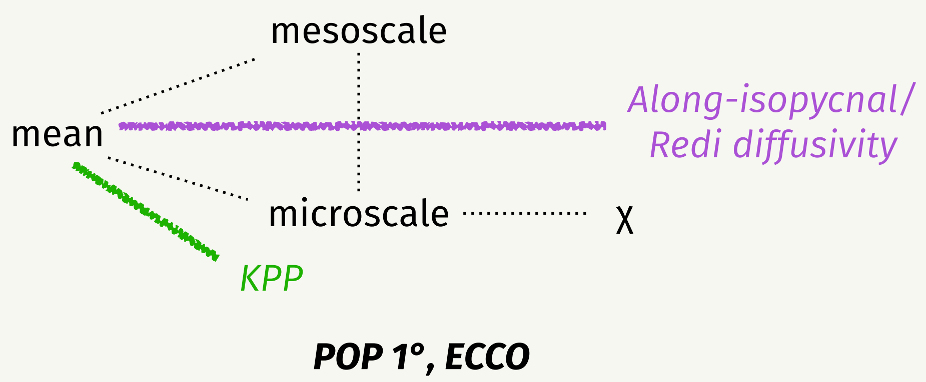






Parameterizations (Toole, Polzin, Ferrari)

Estimate $K_{redi}\ |\nabla_\rho T|^2$ with
1. observational estimates of K_{redi} (Cole et al 2015; Groeskamp et al 2020);
2. Output from POP 1° simulation (cycles 0, 5)



Lets talk about
1. Can we use T,S measurements to detect if an eddy stirring signal has been sampled?
2. Should ocean state estimation procedures (ECCO) adjust to an inferred diffusivity (a scale dependent parameter) or an inferred χ?