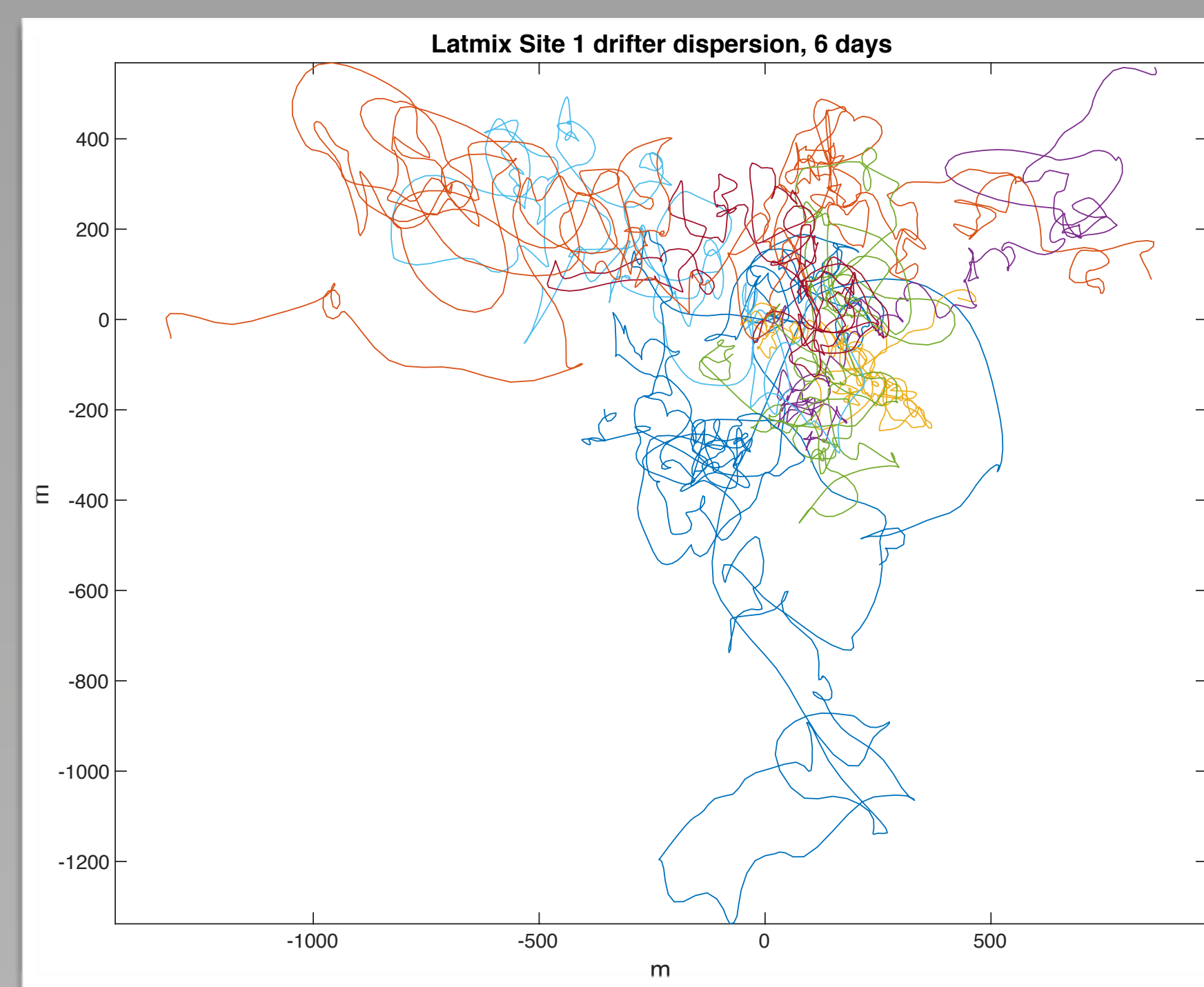


Motivation

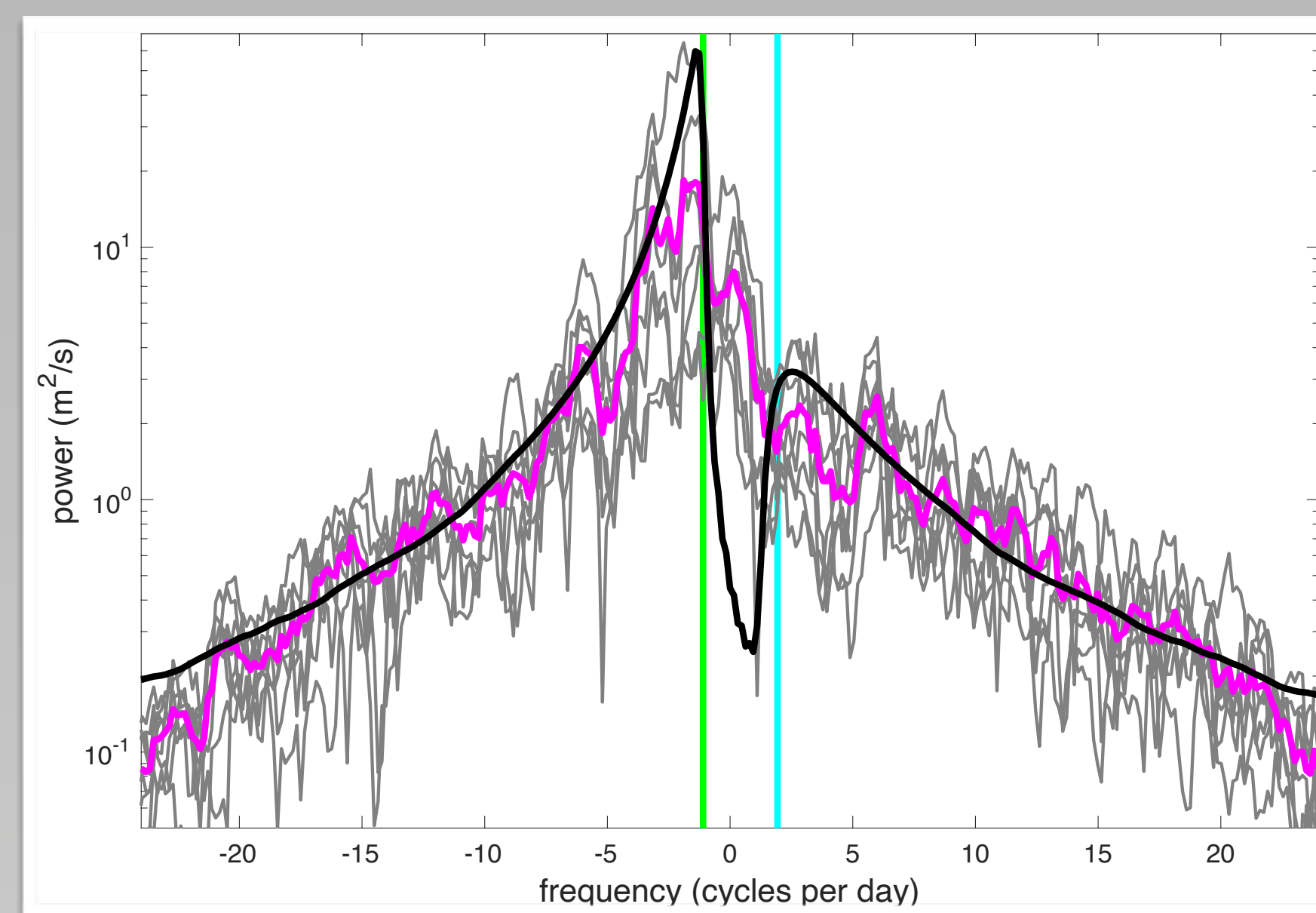
What processes are responsible for the observed stirring at the submesoscales?

Observations

- Tracer release and surface drifters show $O(1)$ m^2/s lateral diffusivity.



- Drifter spectra show internal waves across all resolvable frequencies $> f$.



The figure shows the rotary spectrum of the horizontal velocity of the drifters (gray) and their average (magenta). The black line shows the comparable Garrett-Munk spectrum.

Hypothesis

The frequency spectrum of drifters from both 7-day experiments point to internal waves. Can linear internal waves cause the observed stirring?

Approach

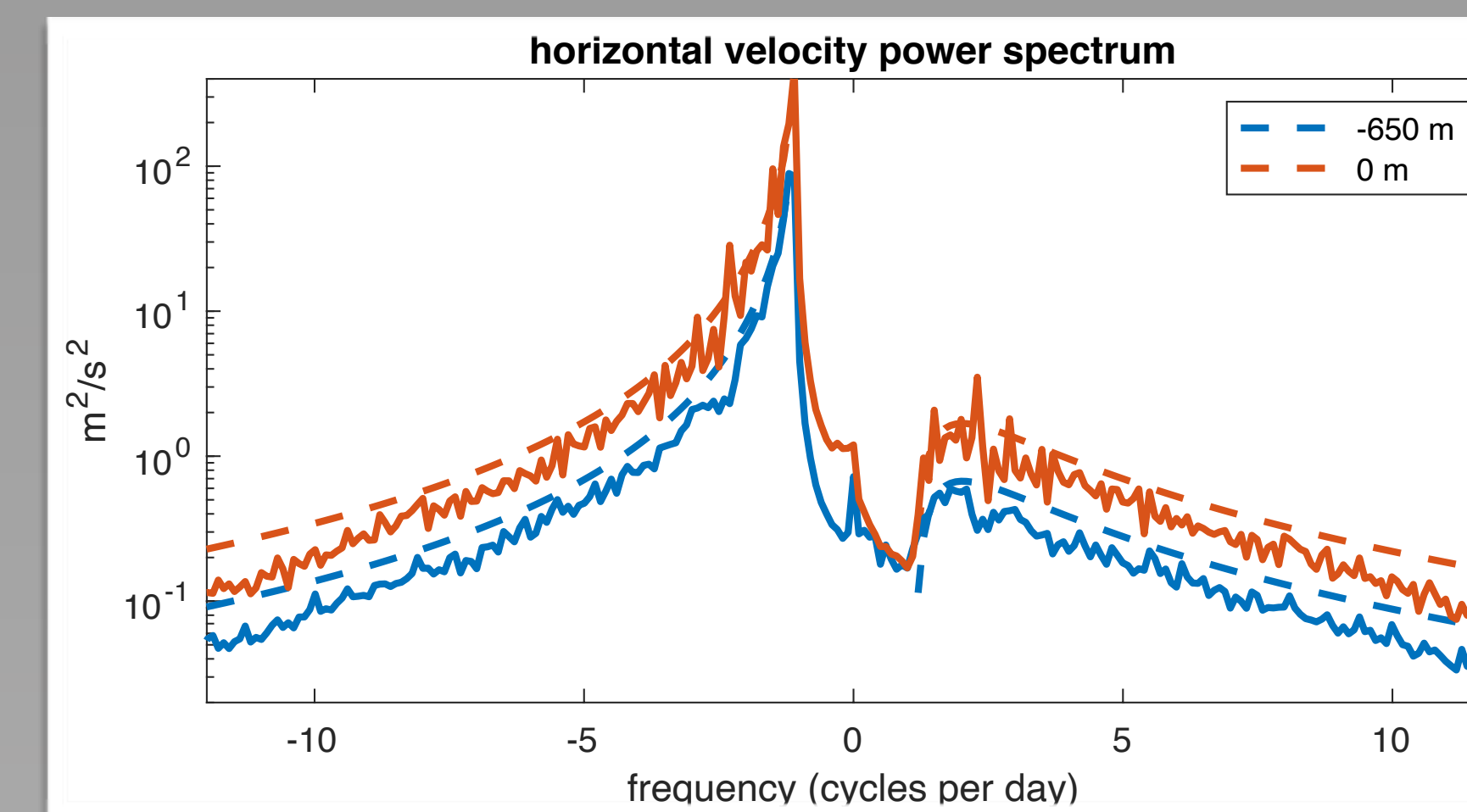
Setup a non-hydrostatic numerical model with *only* internal waves and compare dispersion between linear and nonlinear runs, in steady-state conditions.

Modeling Challenges

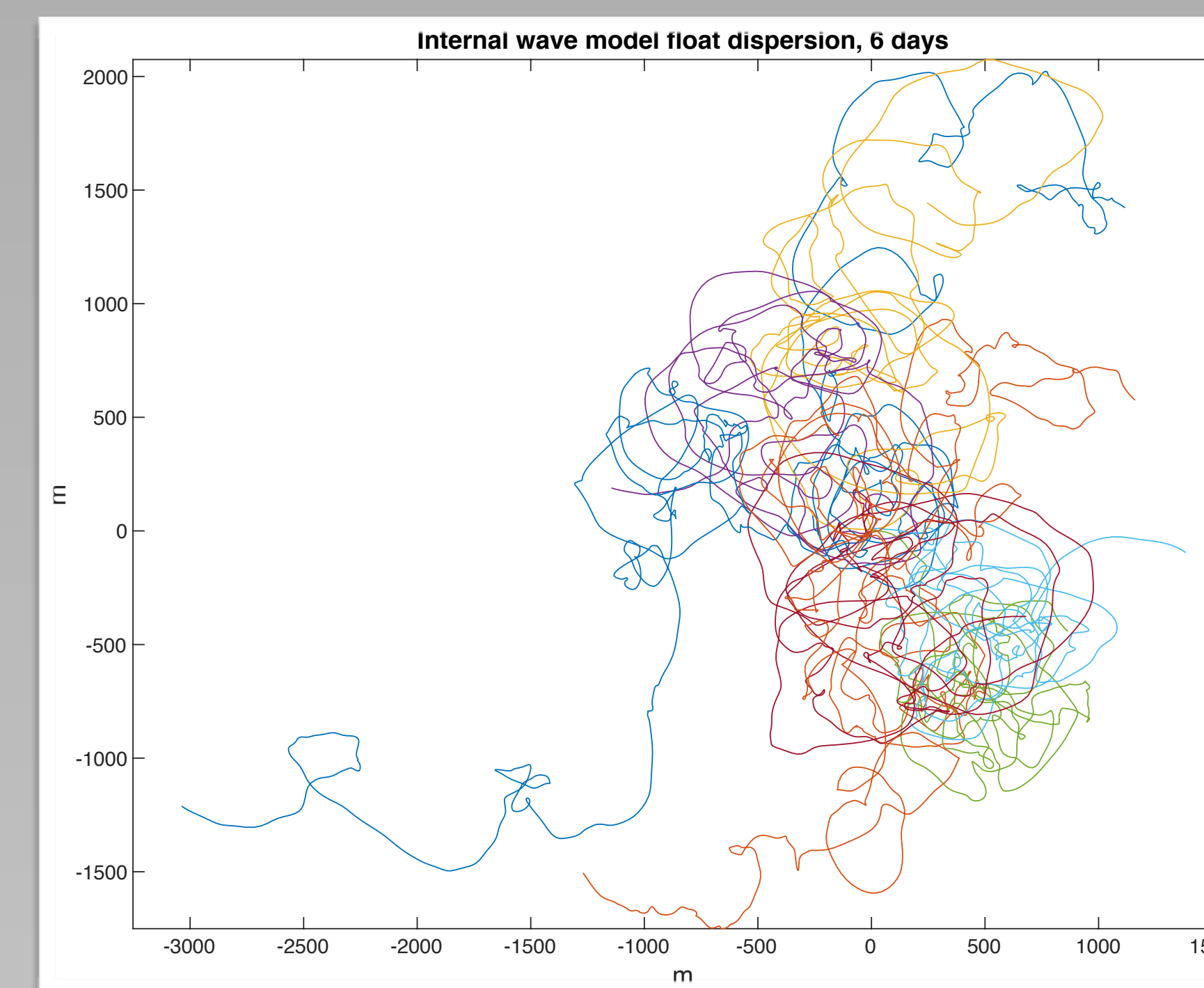
- Realism**—we want to match horizontal and vertical energy densities of the internal wave field in the model as close as possible to values from observations.
- Big bounded waves**—the most energetic part of the internal wave field are near inertial waves. Over 50% of the energy in the internal wave field is at scales over 50 km, and these waves feel the effects of vertical boundaries.
- Small dispersions**—The observed dispersions imply particles will spread only 1 square km after 10 days. This is a big challenge for any numerical scheme also capturing 300 km scale features.
- Steady state**—dispersion statistics assume steady-state conditions. Need to force correctly to main the internal wave field.

Results

We can match a steady-state Garrett-Munk spectrum reasonably well, despite the limitations of using constant stratification.

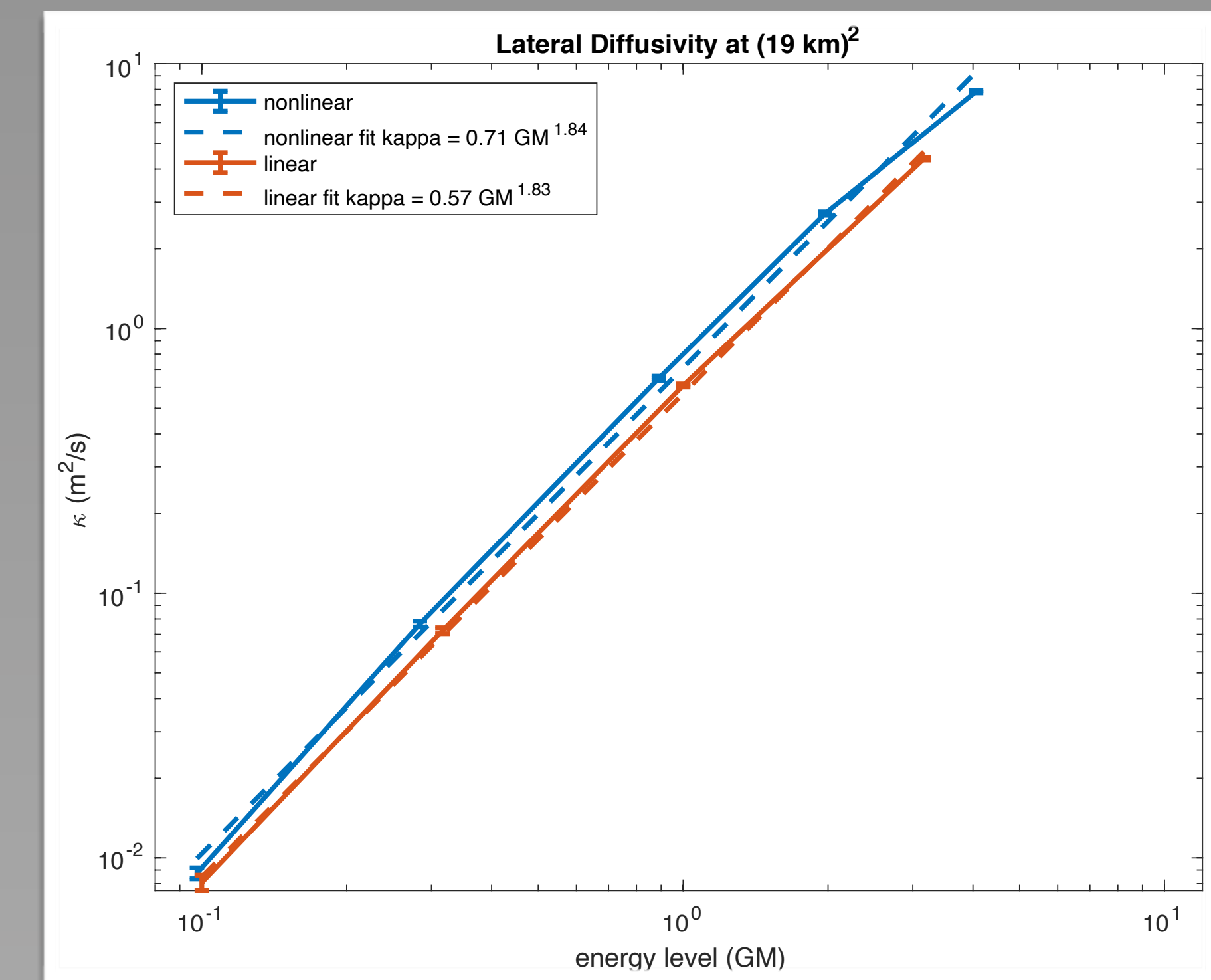


Model dispersion, whether run linearly or nonlinear, match the observed lateral diffusivity of the observations.

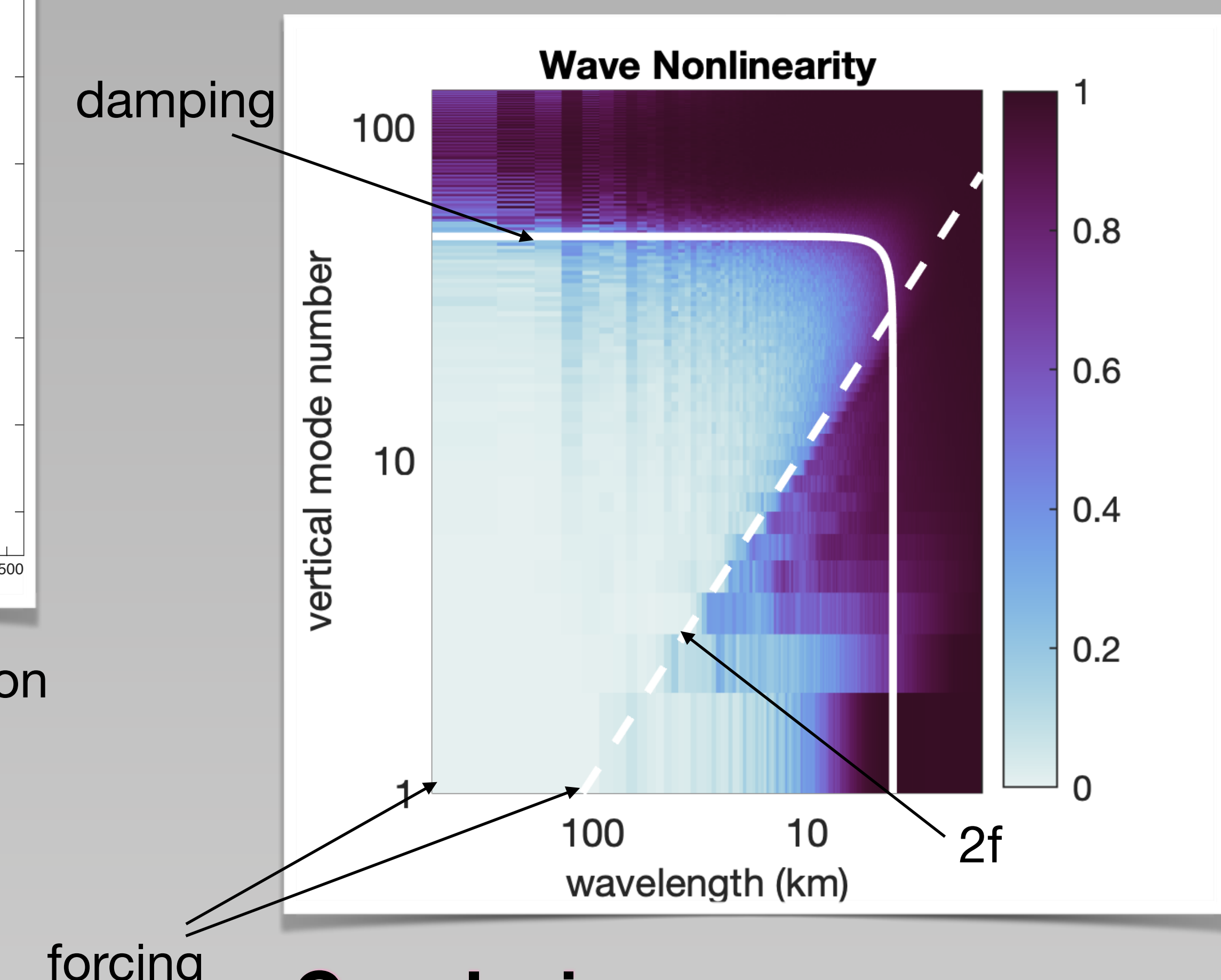


Particle dispersion and tracer dispersion match, as expected.

Linear vs Nonlinear



- At 20 km separations, dispersion statistics between linear and nonlinear model runs are nearly identical.
- Hints of difference emerge at this scale which we can attribute to potential vorticity.



Conclusions

- We cannot reject the hypothesis that *linear* internal waves explain the stirring at the submesoscales.
- Vortical mode (PV), when present, plays a big role at these scales.