Statistics of the turbulent ocean field

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Project for MPO624

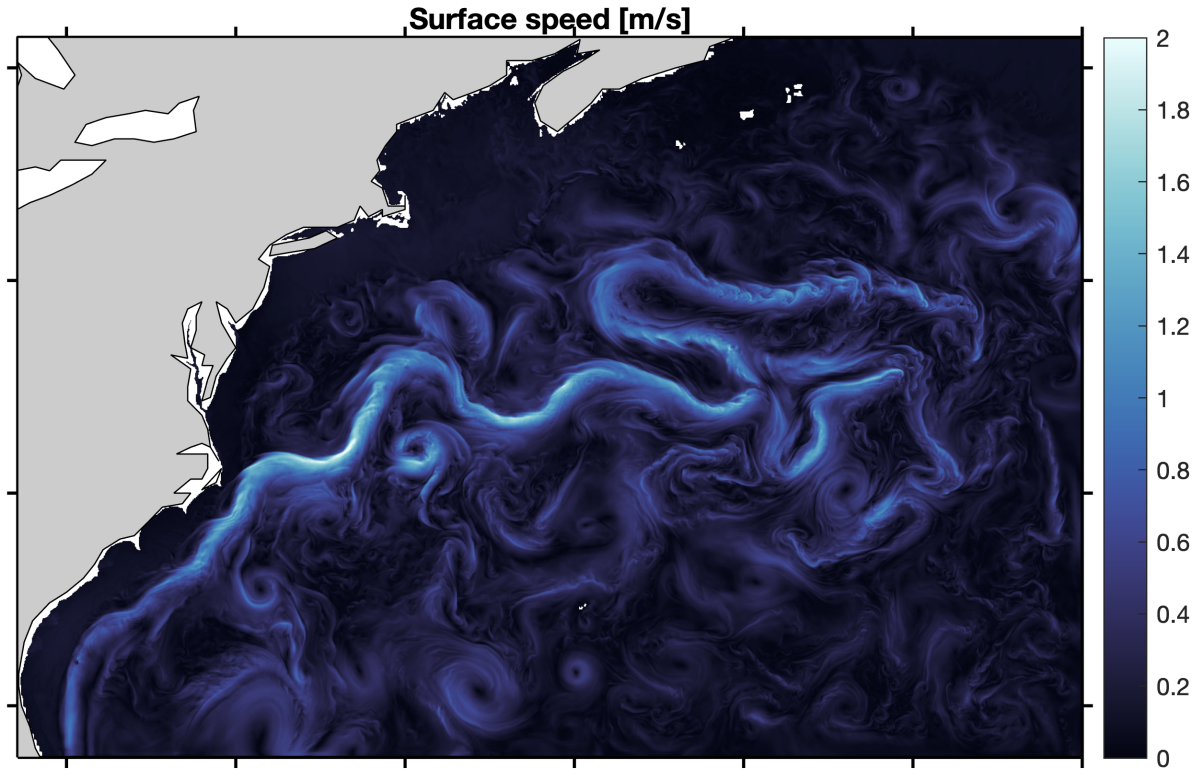
Data

Model

- Gulf Stream region
- Resolution: 1/48º, 12h
- Snapshots on the surface and deep layer (>1000m)

Analysis

- Is the probability density of velocity field Gaussian?
- Does wavenumber spectrum of velocity field follow certain power law?



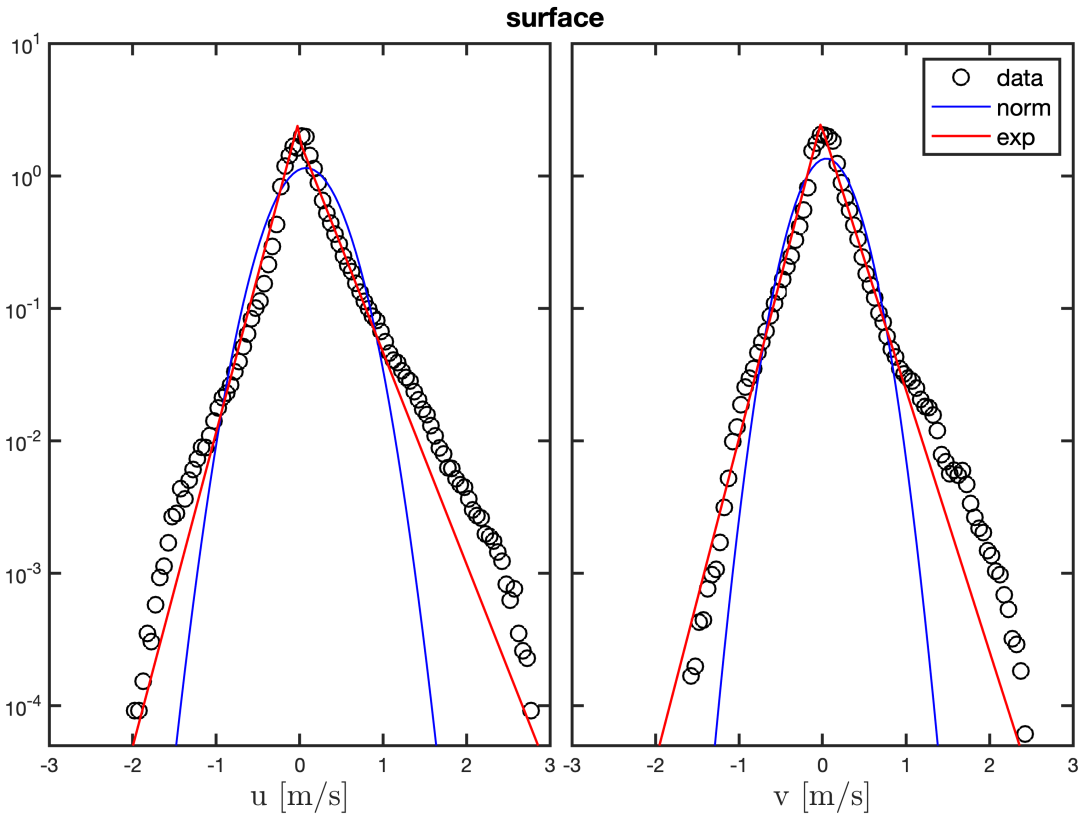
Array size: 1073 X 1573

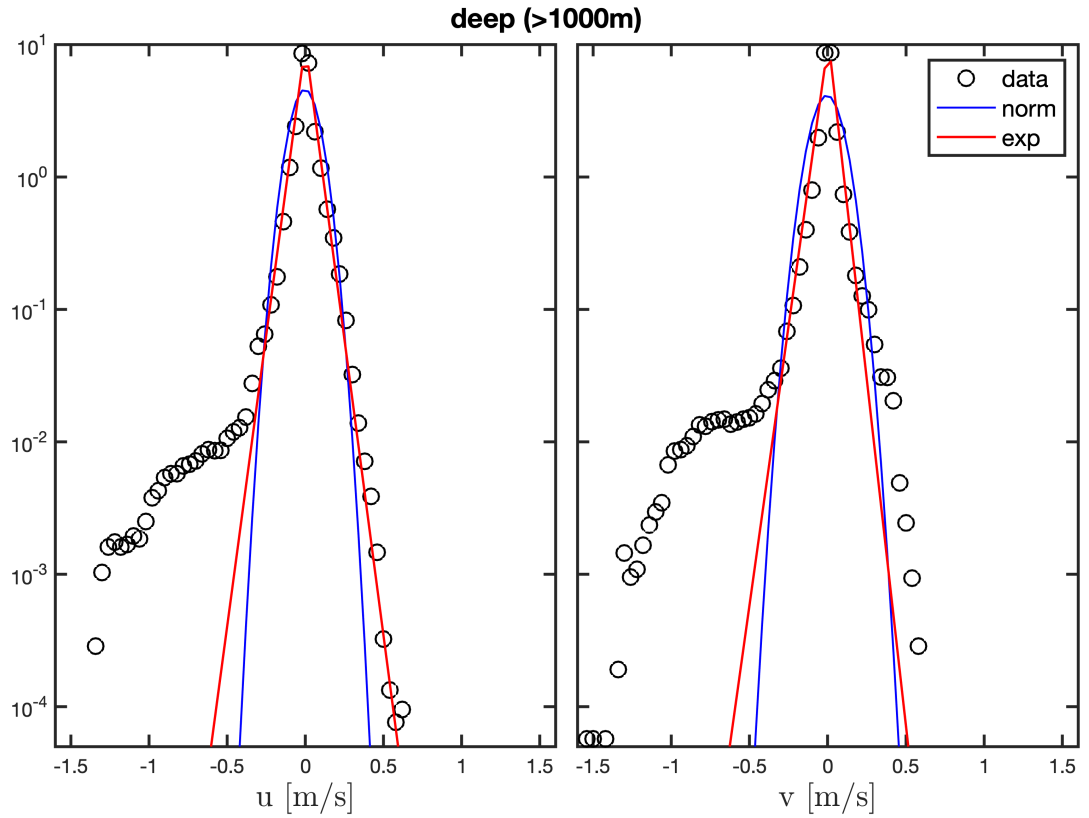
Probability density function

Normal distribution: $f(u) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{u^2}{2\sigma^2}\right)$

Exponential distribution: $g(u) = \frac{1}{2u^*} \exp\left(-\frac{|u|}{u^*}\right)$

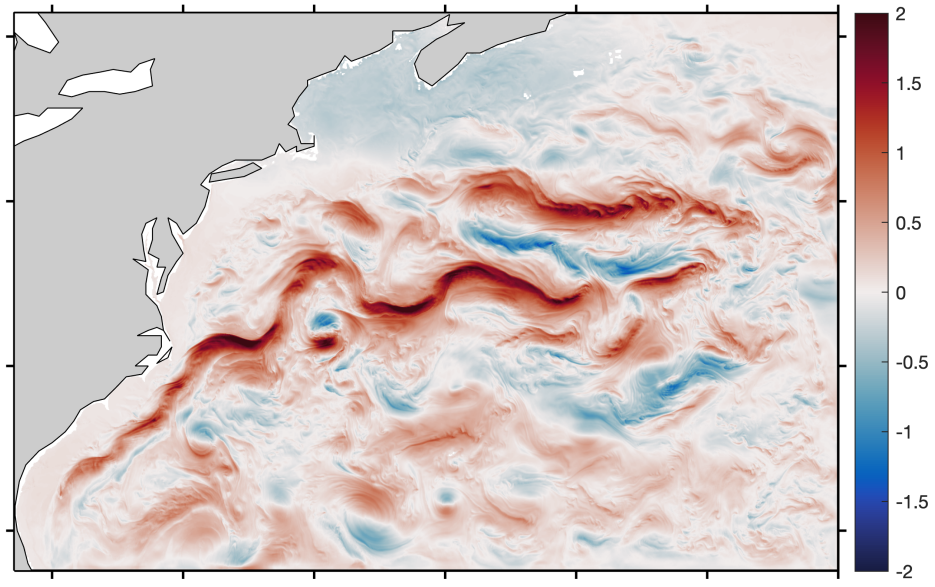
- Velocity distribution departs from normality.
- Low velocities are close to exponential distribution.
- Tails are due to inhomogeneity.



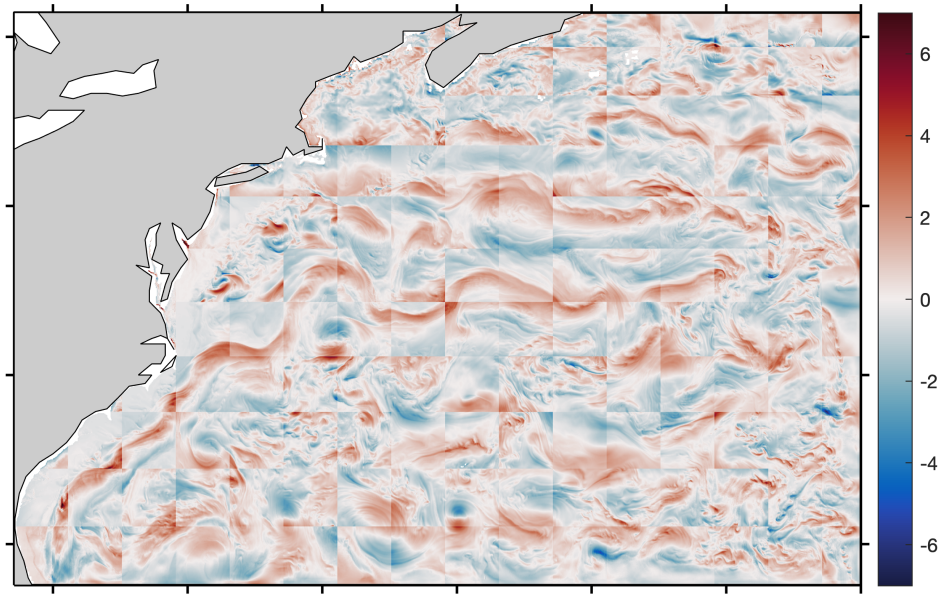


Bin-wise normalization

- Normalize velocities within each 2º bin.
- To eliminate the inhomogeneity of velocity field.



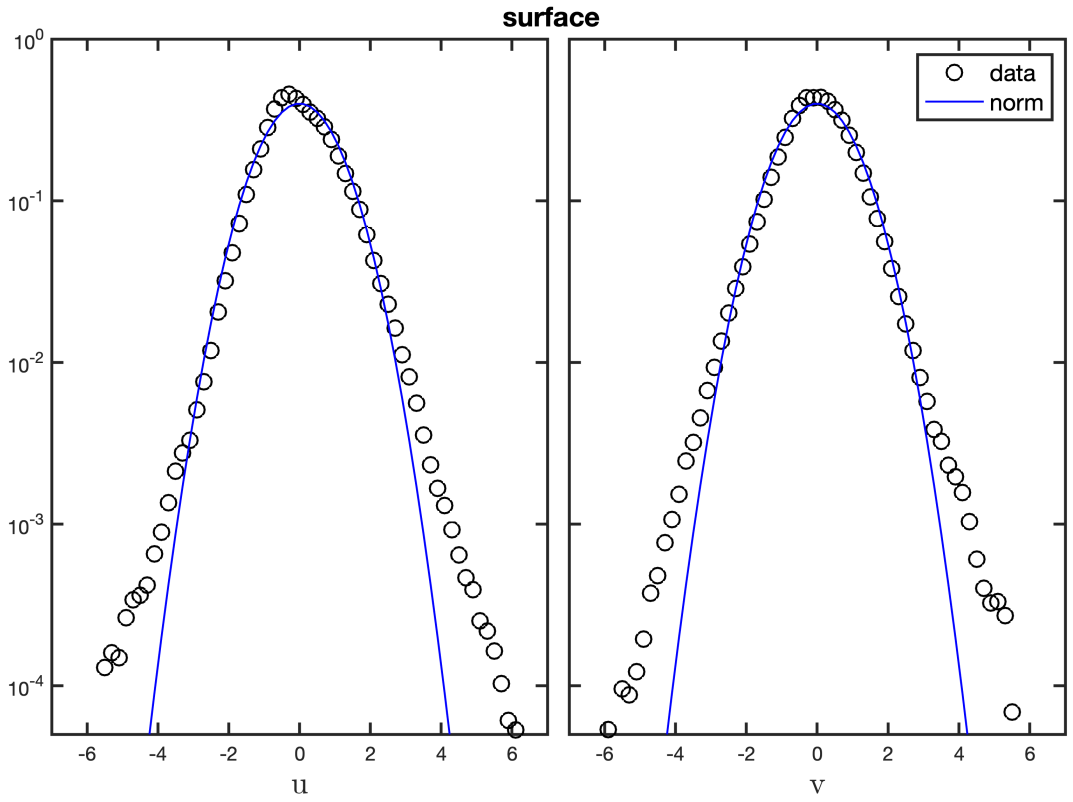
Surface zonal velocity
Bin-wise normalized

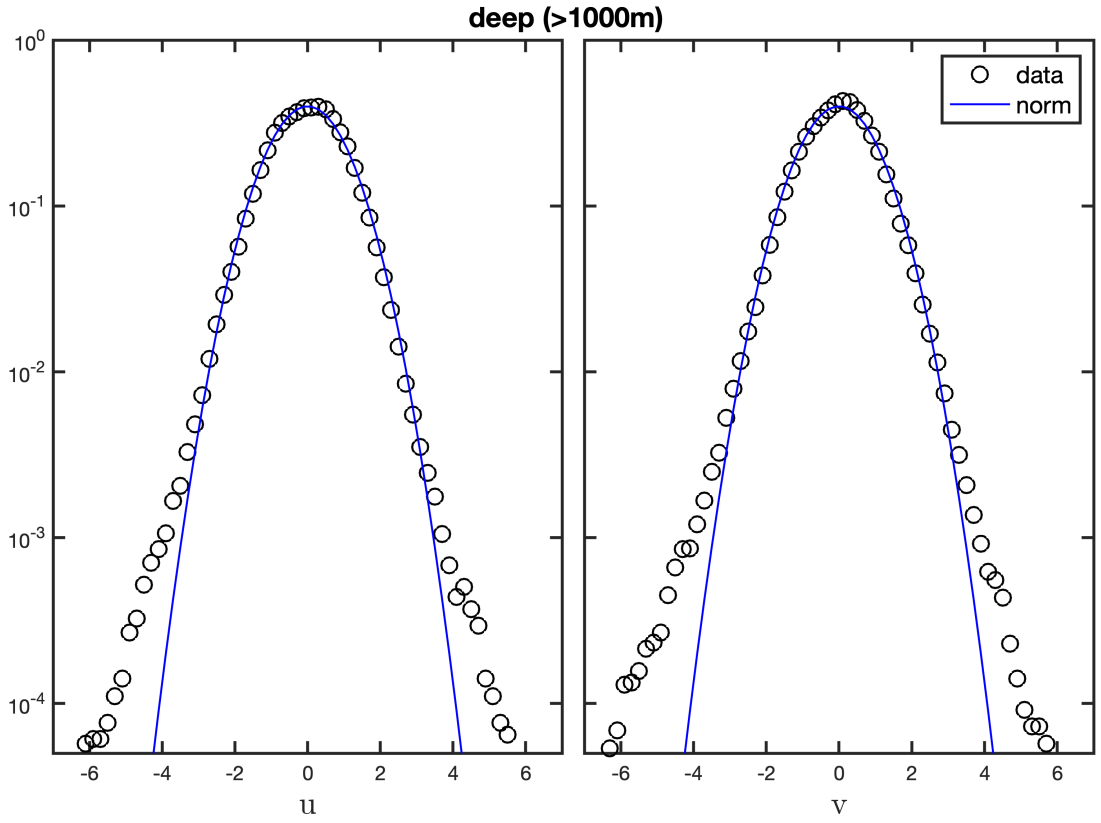


Normalized PDFs

- A Gaussian central core but extended exponential tails.
- Kurtoses are ~4.8, larger than the Gaussian values of 3.
- Kolmogorov–Smirnov statistics are ~10^(-5), indicating rejection of the H_0 at the 95% level (Bracco et al., 2000).

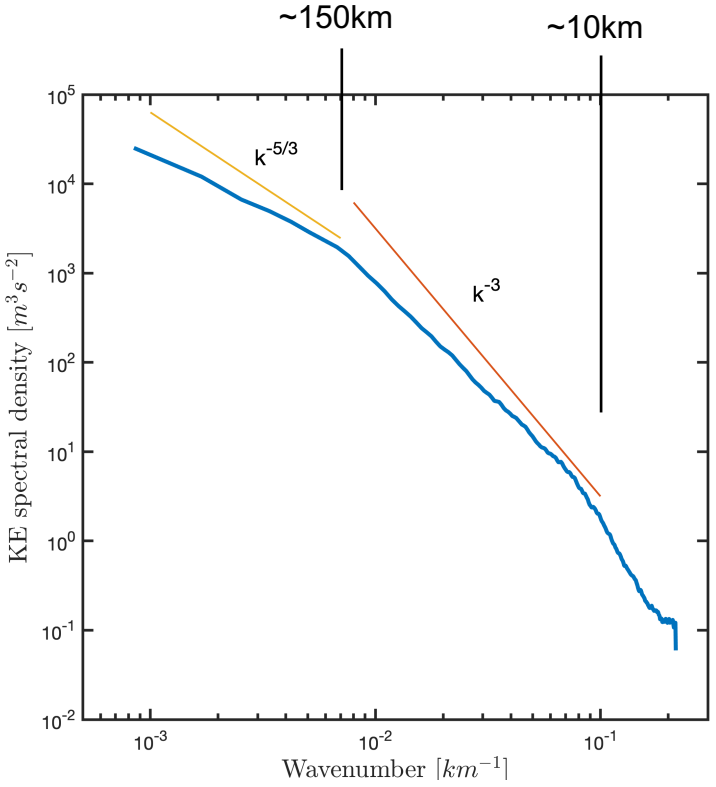
- Marked wings in the former PDFs are essentially remedied by the binning process.



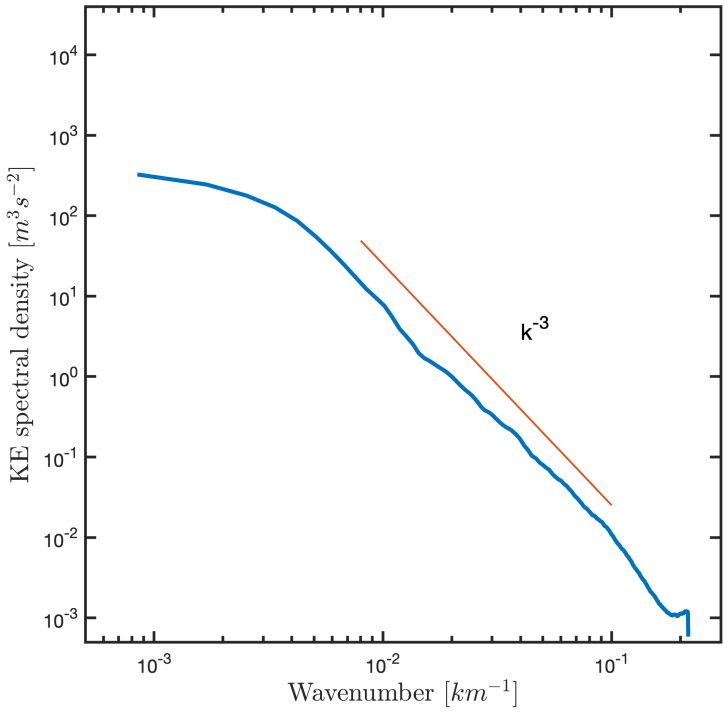


Wavenumber Spectrum

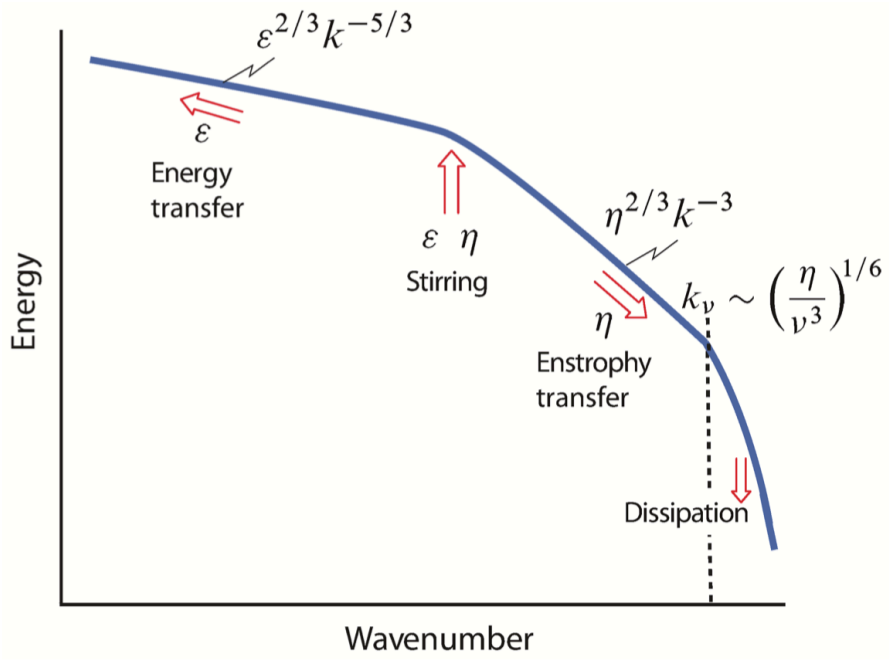
- Meridional mean of KE wavenumber spectra along latitude line (30-45ºN).
- Two characteristic scales to be noted, 150km and 10km.
- Spectrum within the ‘mesoscale’ range in deep ocean is more consistent with -3 power law than at the surface.



Surface



Deep



The energy spectrum of 2D turbulence (Vallis, 2017)

Conclusion

- The velocity PDFs in the (simulated) ocean is non-Gaussian.
- Binning process can reduce the inhomogeneity. But the resultant PDFs still have exponential wings.
- Wavenumber spectra of KE indicate a ‘-3’ power law within the mesoscale range in deep ocean.