Turbulent water jet

166. Turbulent water jet. Laser-induced fluorescence shows the concentration of jet fluid in the plane of symmetry of an axisymmetric jet of water directed downward into water. The Reynolds number is approximately 2300. The spatial resolution is adequate to resolve the Kolmogorov scale in the downstream half of the photograph. *Dimotakis, Lye & Papantoniou 1981*

Note range of eddy scales and self-similar structure.

"Big whirls have little whirls,
That feed on their velocity;
And little whirls have lesser whirls,
And so on to viscosity."

- L. F. Richardson's prescient 1922 book:
Weather Prediction by Numerical Process

Lag-correlation and integral timescale for turbulence

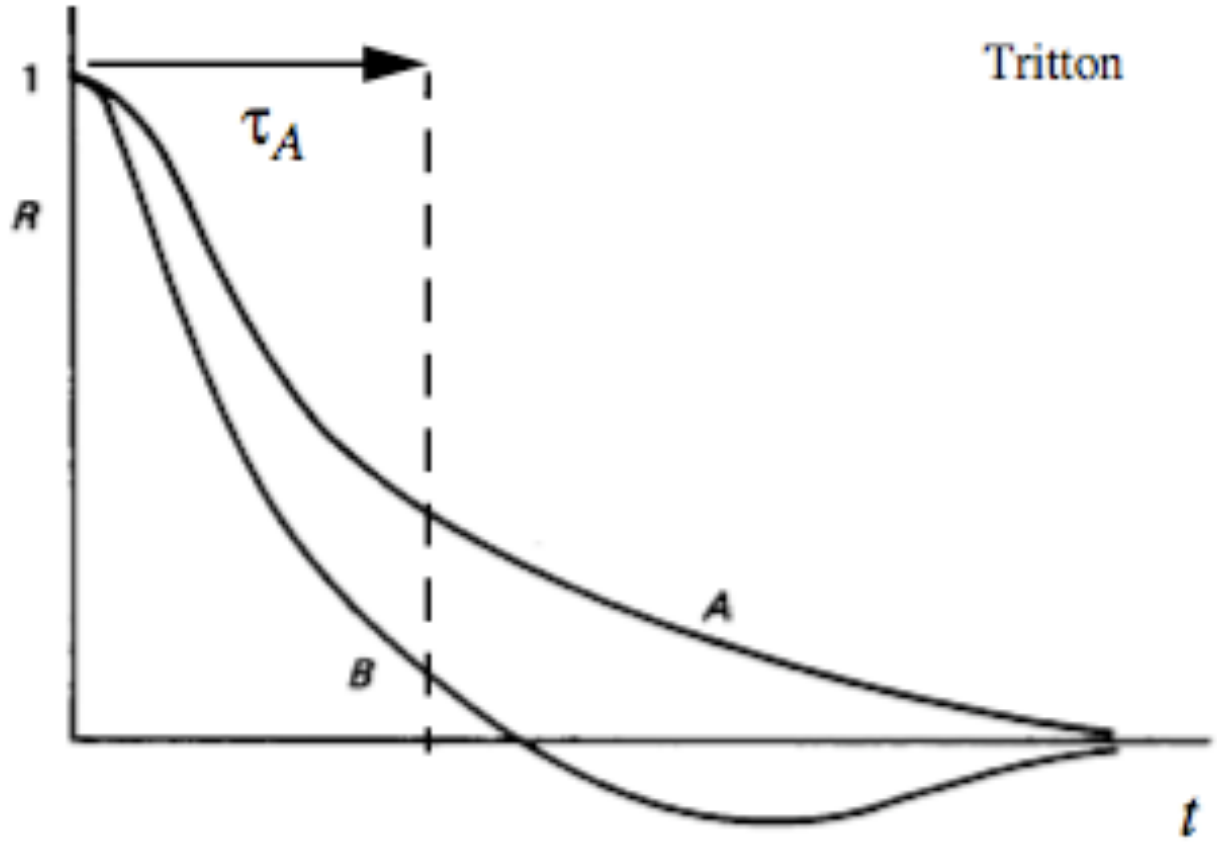
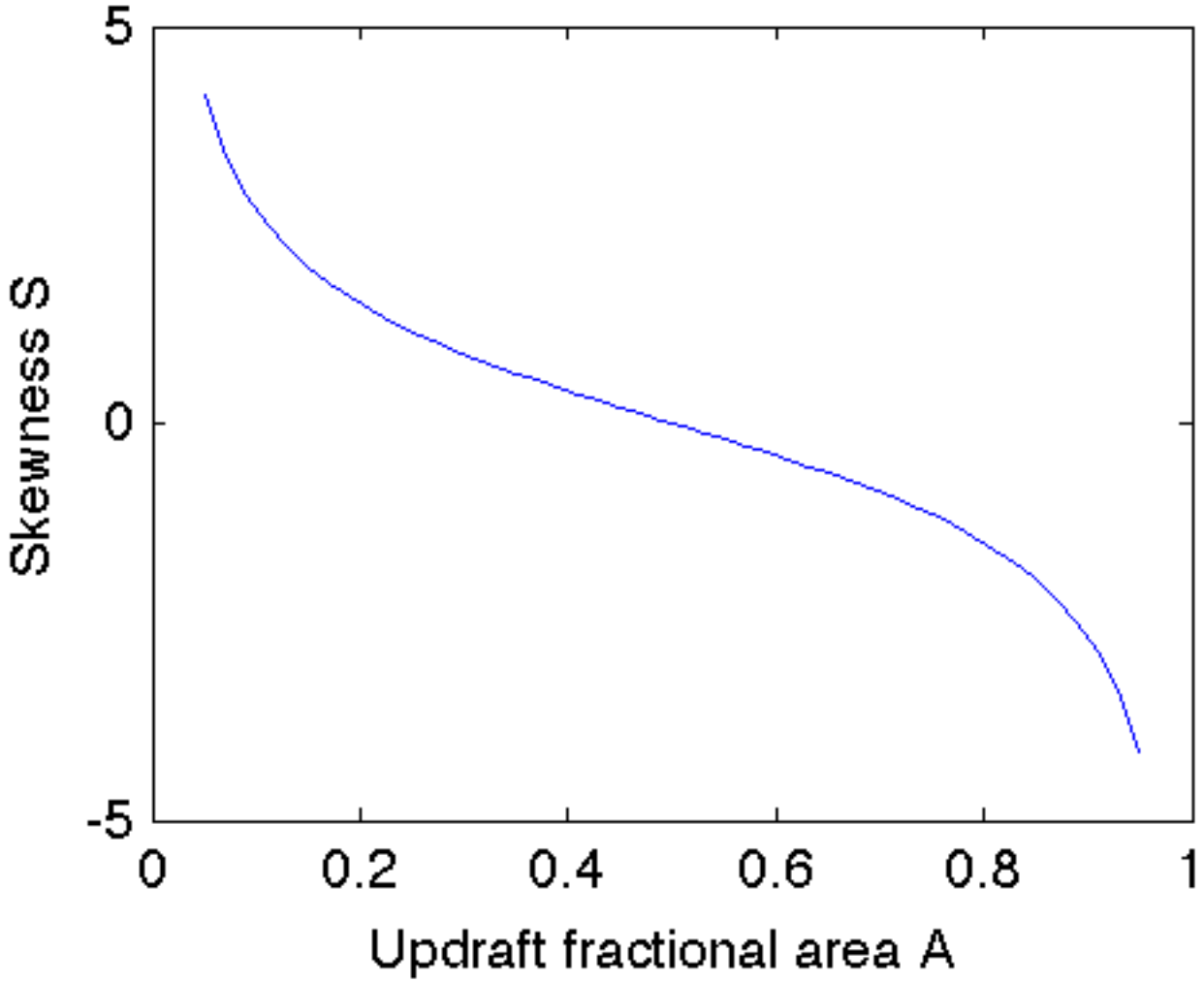


Figure 20.5 Typical correlation curves.

Skewness



Schematic turbulent energy spectrum

Garratt

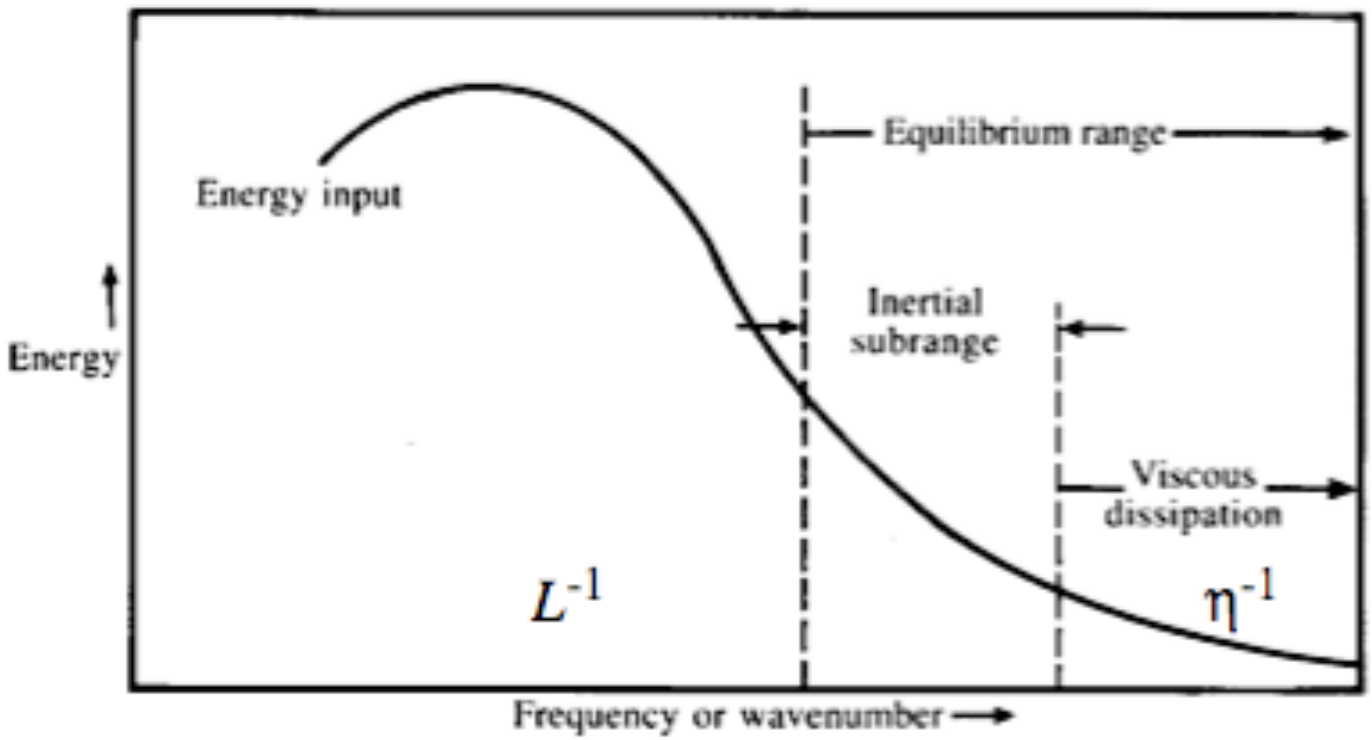
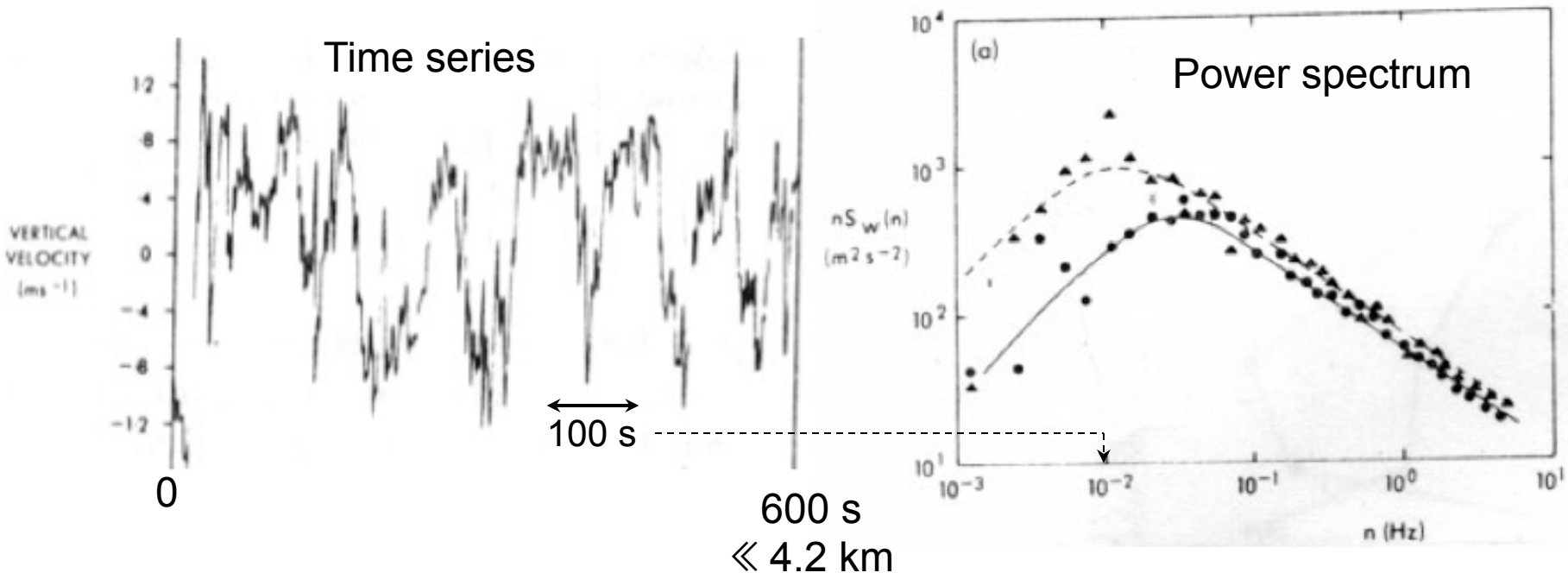


Fig. 2.1 Schematic representation of the energy spectrum of turbulence.

Time series/power spectrum of w in convection



2D

velocity cascades to large scales
vorticity to small scales

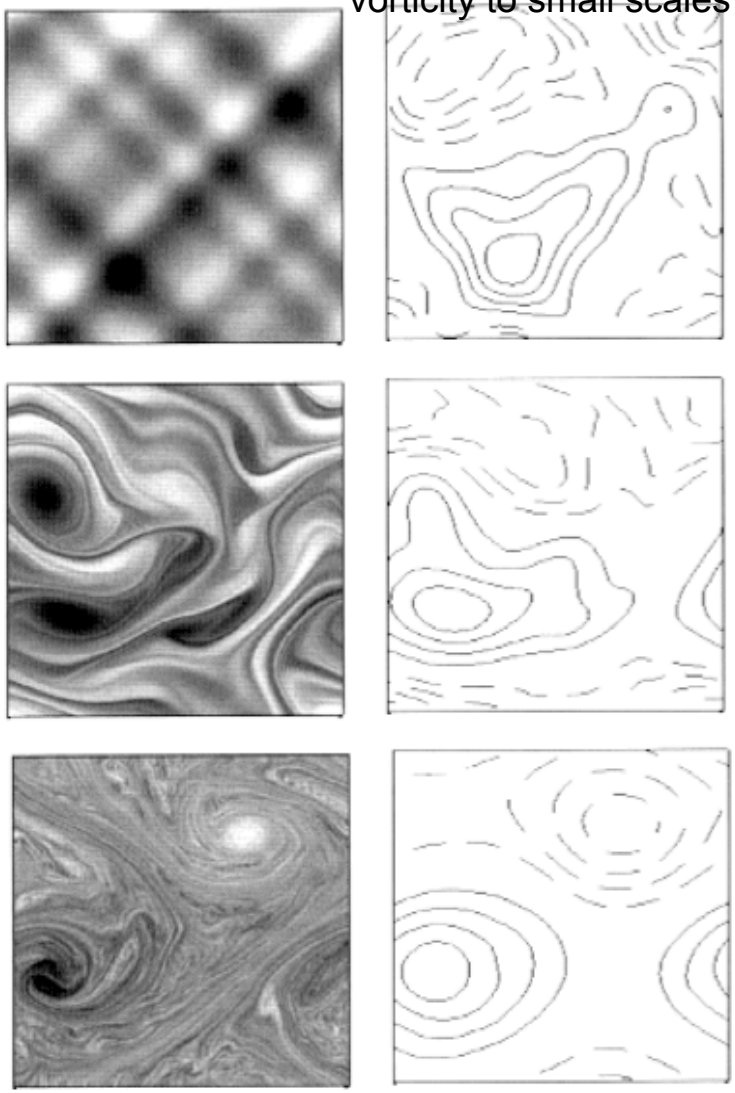
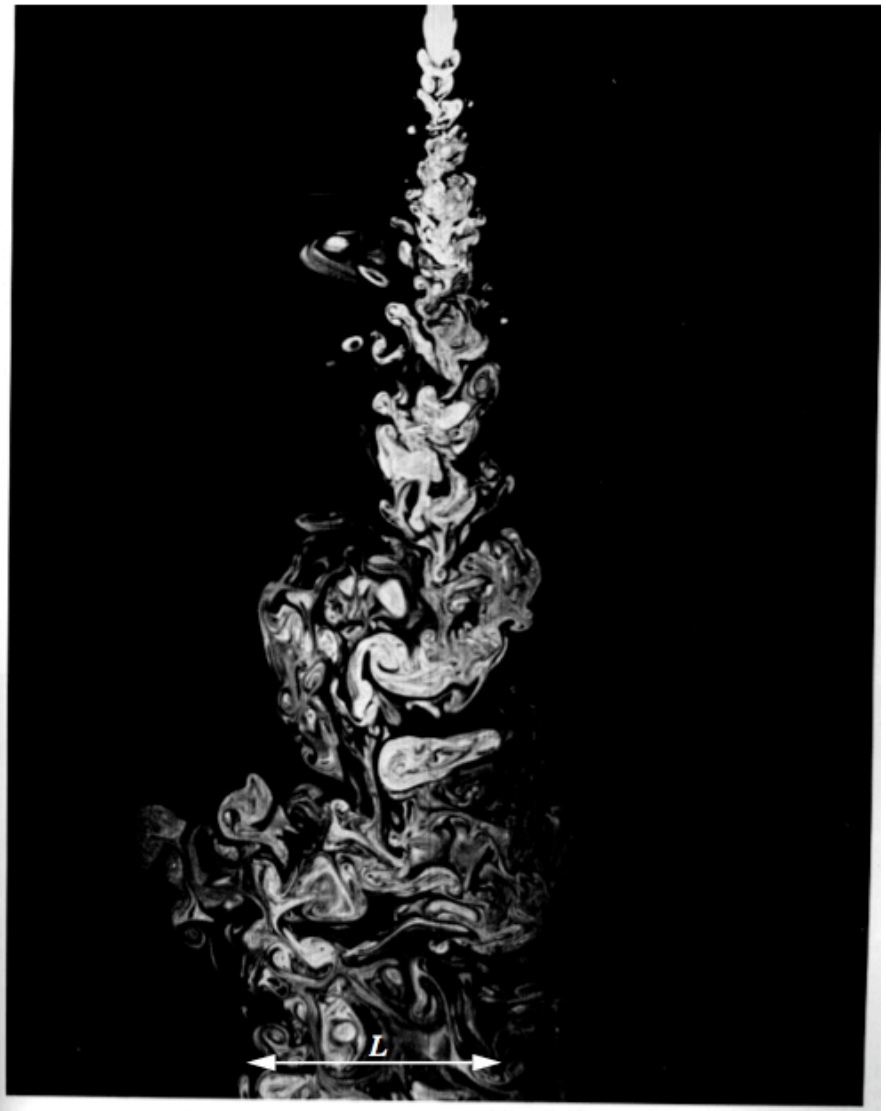


Fig. 8.8 Nearly free evolution of vorticity (left column) and streamfunction (right column) in a doubly-periodic square domain (of length 2π) at times (from the top, and in units of inverse vorticity) $t = 0$, 50 and 260, obeying the two dimensional vorticity equation with no forcing but with a weak viscous term. The initial conditions have just a few non-zero Fourier modes with randomly generated phases, producing a maximum value of vorticity of about three. Kelvin-Helmholtz instability leads to vortex formation and roll-up (as in Fig. 6.6), and like-signed vortices merge, ultimately leading to a state of just two oppositely-signed vortices. Between the vortices, enstrophy cascades to smaller scales. The scale of the streamfunction grows larger, reflecting the transfer of energy to larger scales.

3D turbulence



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Quasigeostrophic turbulence (2D-like ζ vortices, filaments)