## Instability

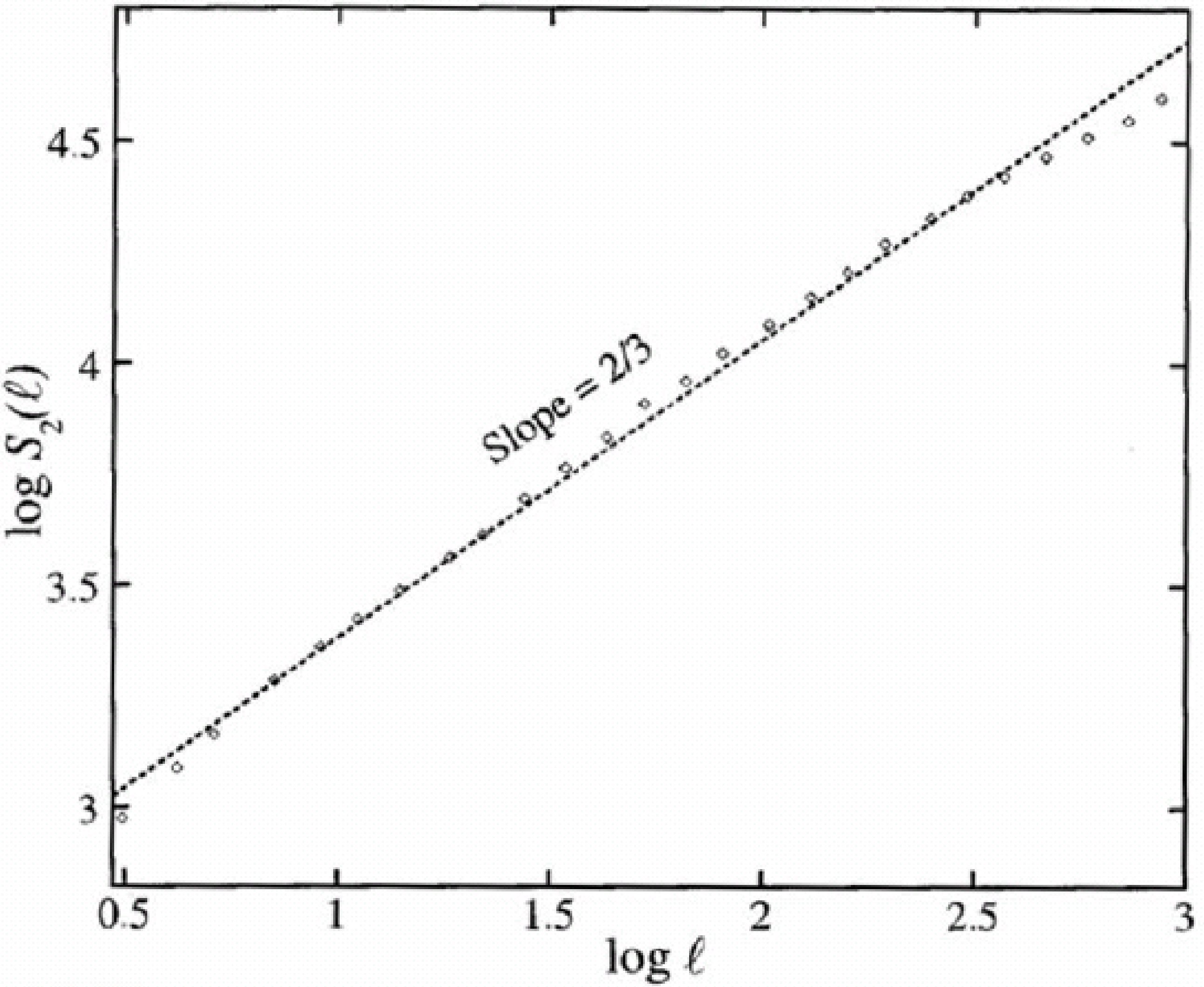
- The *dry* adiabatic lapse rate is defined as:

$$\Gamma_d = -\frac{dT}{dz} = \frac{g}{c_p}$$

- The *saturated* (or wet or moist) adiabatic lapse rate is given (approximately) by:

$$\Gamma_s = -\frac{dT}{dz} = \frac{g}{c_p} + \frac{L}{c_p}\frac{dw_s}{dz}$$

- $w_s$ is the mass fraction of water in air at saturation.



4.5
4
3.5
3
0.5
1
1.5
2
2.5
3
$\log S_2(\ell)$
$\log \ell$
Slope = 2/3

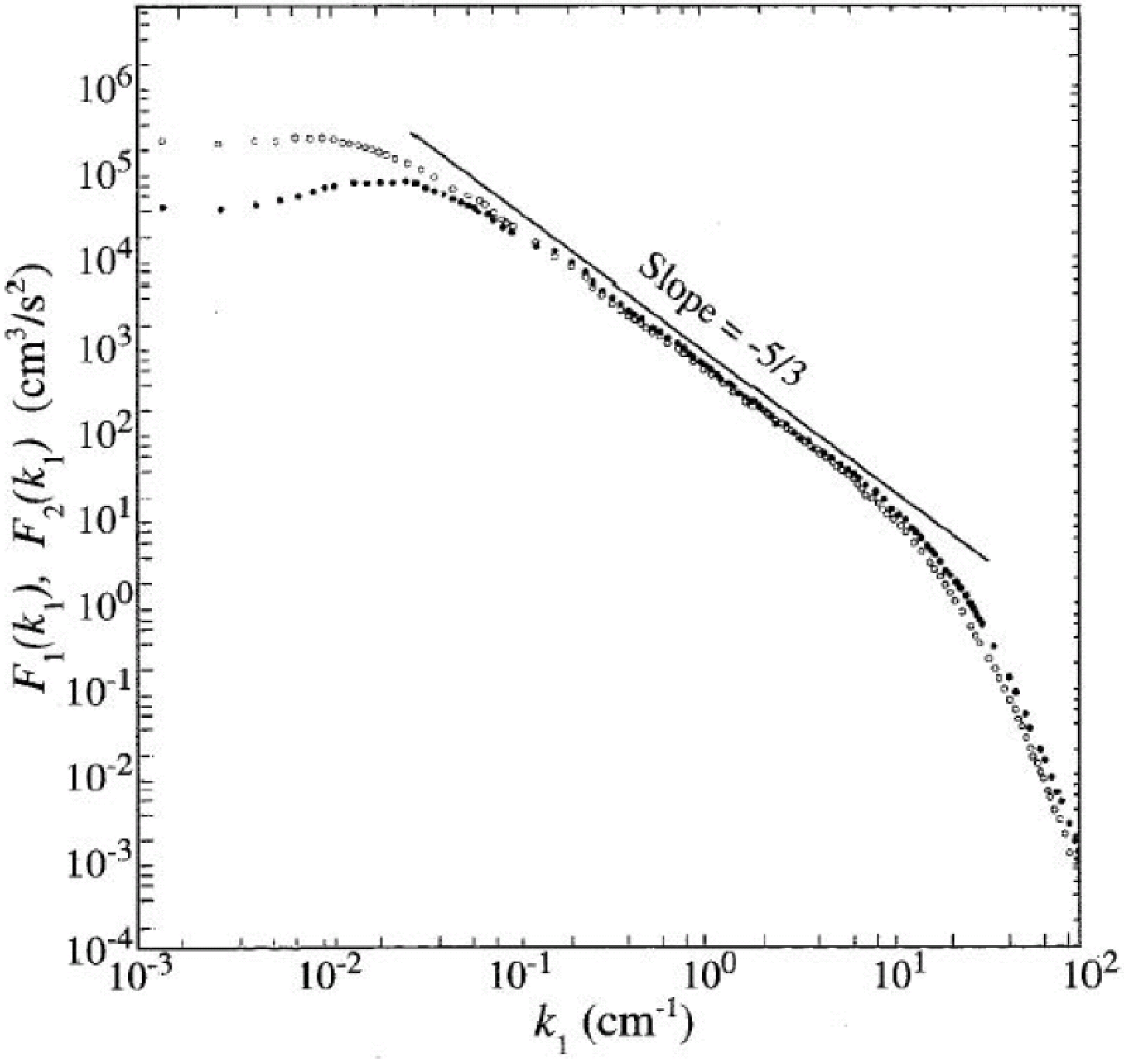


Fig. 5.7. log–log plot of the energy spectra of the streamwise component (white circles) and lateral component (black circles) of the velocity fluctuations in the time domain in a jet with $R_\lambda = 626$ (Champagne 1978).

**Table 4-1.** The Davenport-Wieringa roughness-length classification.

| $z_0$ (m) | Classification | Landscape |
|---|---|---|
| 0.0002 | sea | sea, paved areas, snow-covered flat plain, tide flat, smooth desert |
| 0.005 | smooth | beaches, pack ice, morass, snow-covered fields |
| 0.03 | open | grass prairie or farm fields, tundra, airports, heather |
| 0.1 | roughly open | cultivated area with low crops & occasional obstacles (single bushes) |
| 0.25 | rough | high crops, crops of varied height, scattered obstacles such as trees or hedgerows, vineyards |
| 0.5 | very rough | mixed farm fields and forest clumps, orchards, scattered buildings |
| 1.0 | closed | regular coverage with large size obstacles with open spaces roughly equal to obstacle heights, suburban houses, villages, mature forests |
| ≥ 2 | chaotic | centers of large towns and cities, irregular forests with scattered clearings |

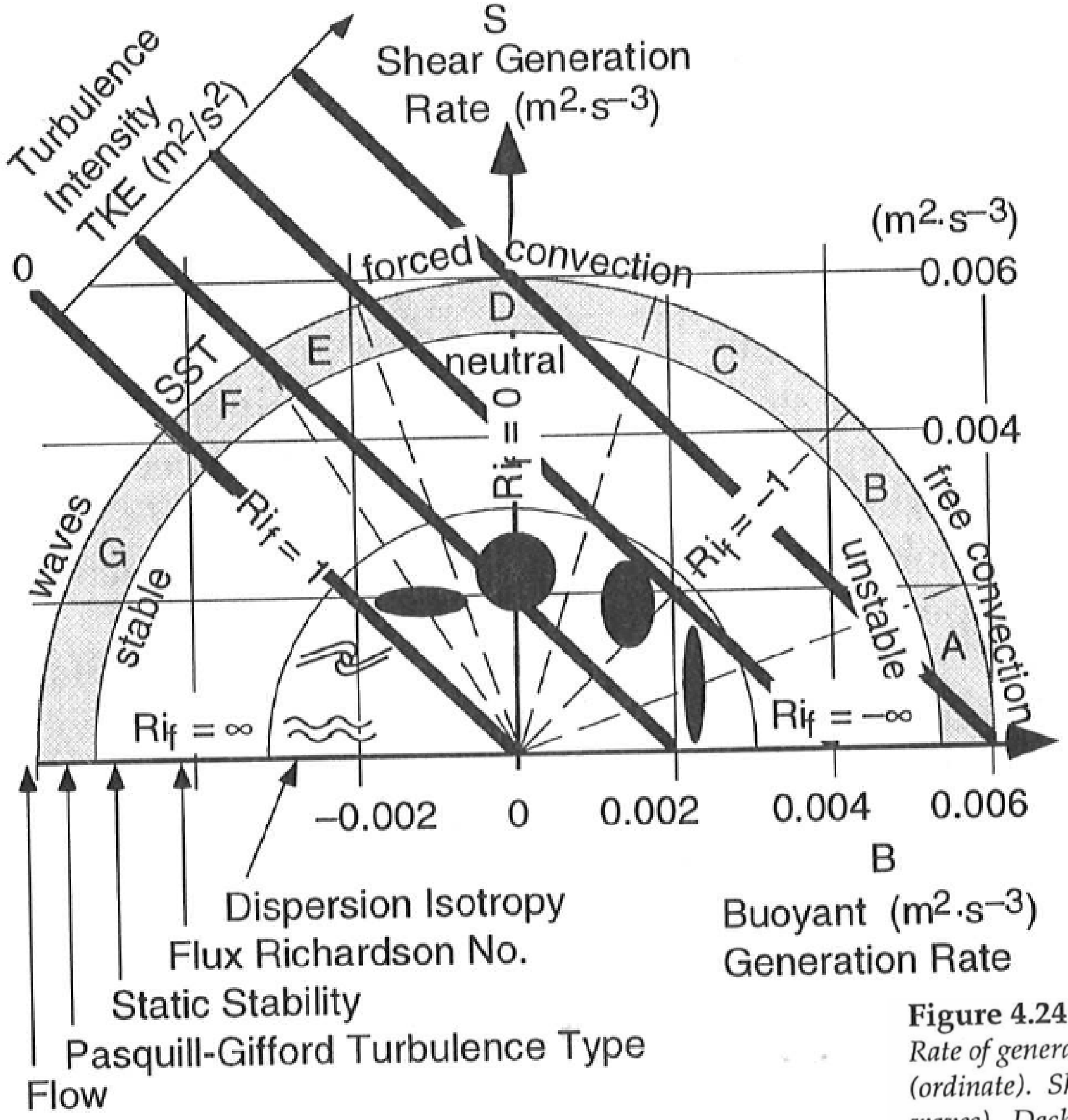


**Figure 4.24**

*Rate of generation of TKE by buoyancy (abscissa) and shear (ordinate). Shape and rates of plume dispersion (dark spots or waves). Dashed lines separate sectors of different Pasquill-Gifford turbulence type. Isopleths of TKE intensity (dark diagonal lines). $R_f$ is flux Richardson number. SST is stably-stratified turbulence.*

# Shear-produced turbulence

**Friction velocity**

$$u* = \left[\overline{u'w'}^2 + \overline{v'w'}^2\right]^{1/4} \simeq C_D \cdot V_{10}^2$$

Measures turbulent drag

$C_D$ = drag coefficient

Range: 0.1 m/s to 1 m/s

$V_{10}$ = wind velocity at 10 m

**Deardorff velocity**

$$w* = \left[\frac{g \cdot \triangle z}{T_v} \overline{w'\theta'}\Big|_{surface}\right]^{1/3}$$

Typical velocity of convection

$\Delta z$ = boundary layer depth

Range: 0.3 to 3 m/s

$T_v$ = virtual temperature near surface