2.4 STABLE AND UNSTABLE ATMOSPHERIC STRATIFICATION

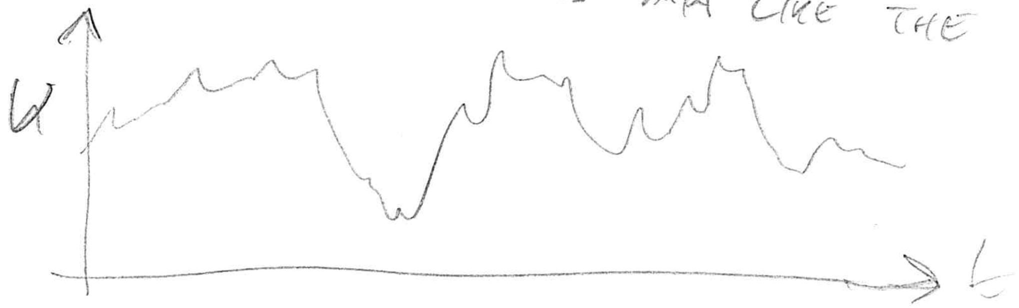
RISING AIR EXPANDS AND THEREFORE GETS COOLER.
THE "DRY ADIABATIC LAPSE RATE" IS ABOUT $\boxed{1°C/100\,m}$
I.E. RISING AIR COOLS DOWN 1°C PER 100m.

IF THE <u>AMBIENT AIR</u> GETS COOLER ~~[illegible]~~ LESS PER 100m ~~[illegible]~~ THAN THIS, IT MEANS THAT THE ATMOSPHERE IS STABLE. IF IT GETS COOLER QUICKER, IT IS UNSTABLE: A RISING PIECE OF AIR BECOMES -RELATIVELY- HOTTER AND RISES MORE.
THE STANDARD ATMOSPHERIC LAPSE RATE IS 0.66°C/100m AND THUS CORRESPONDS TO A <u>STABLE STRATIFICATION</u>.
EVEN MORE STABLE IS AN "INVERSION" (IF AIR BECOMES HOTTER WITH HEIGHT).

GENERALLY, WIND SHEAR IS STRONGER FOR STABLE CONDITIONS, BECAUSE LESS MIXING BETWEEN LAYERS OCCURS, THUS, LESS MOMENTUM IS TRANSFERRED.
AT STRONG WINDS, MIXING LEADS TO NEUTRAL CONDITIONS (I.E. ATMOSPHERIC LAPSE RATE EQUALS ADIABATIC LAPSE RATE

2.5 STATISTICS OF WIND

AT A GIVEN SITE, WIND SPEED & DIRECTION VARY WITH TIME. IF ONLY SPEED IS REGARDED, ONE CAN PLOT TIME SERIES DATA LIKE THE FOLLOWING:



ONE CAN COMPUTE E.G. MEAN $\bar{U}$ AND VARIANCE σ_u^2

DIFFERENT DISTRIBUTIONS CAN BE USED TO DESCRIBE THE PROBABILITY DENSITY FUNCTION (PDF) $p(U)$ OF WIND SPEEDS, AND CUMULATIVE DISTRIBUTION FUNCTION (CDF) $F(U) = \int_0^U p(u)\,du$

a) GAUSSIAN

$$p(U) = \frac{1}{\sqrt{2\pi\sigma_u^2}} \exp\left(-\frac{(U-\bar{U})^2}{2\sigma_u^2}\right)$$

b) WEIBULL DISTRIBUTION (WITH "SCALE PARAM." c AND "SHAPE PARAM." k)

$$p(U) = \left(\frac{k}{c}\right)\left(\frac{U}{c}\right)^{k-1} \exp\left(-\left(\frac{U}{c}\right)^k\right)$$

$$F(U) = 1 - \exp\left(-\left(\frac{U}{c}\right)^k\right)$$

(GET $p(U) = F(U)'$)

ONE CAN SHOW THAT $\bar{U}$ AND σ_U

CAN BE COMPUTED FROM c & k USING

THE "GAMMA-FUNCTION" $\Gamma(x) := \int_0^\infty e^{-t} t^{x-1} \, dt$

AS FOLLOWS:

$\Gamma(n) = (n-1)!$ $\quad \Gamma(1) = 1$

$\Gamma(2) = 1$

$$\bar{U} = c \cdot \Gamma\left(1 + \frac{1}{k}\right)$$

$$\sigma_U^2 = c^2 \, \Gamma(1 + 2/k) - c^2 \left(\Gamma\left(1 + \frac{1}{k}\right)\right)^2$$

MOMENTS: $E\{U^n\} = c^n \, \Gamma\left(1 + \frac{n}{k}\right)$

A SPECIAL CASE OF WEIBULL IS THE

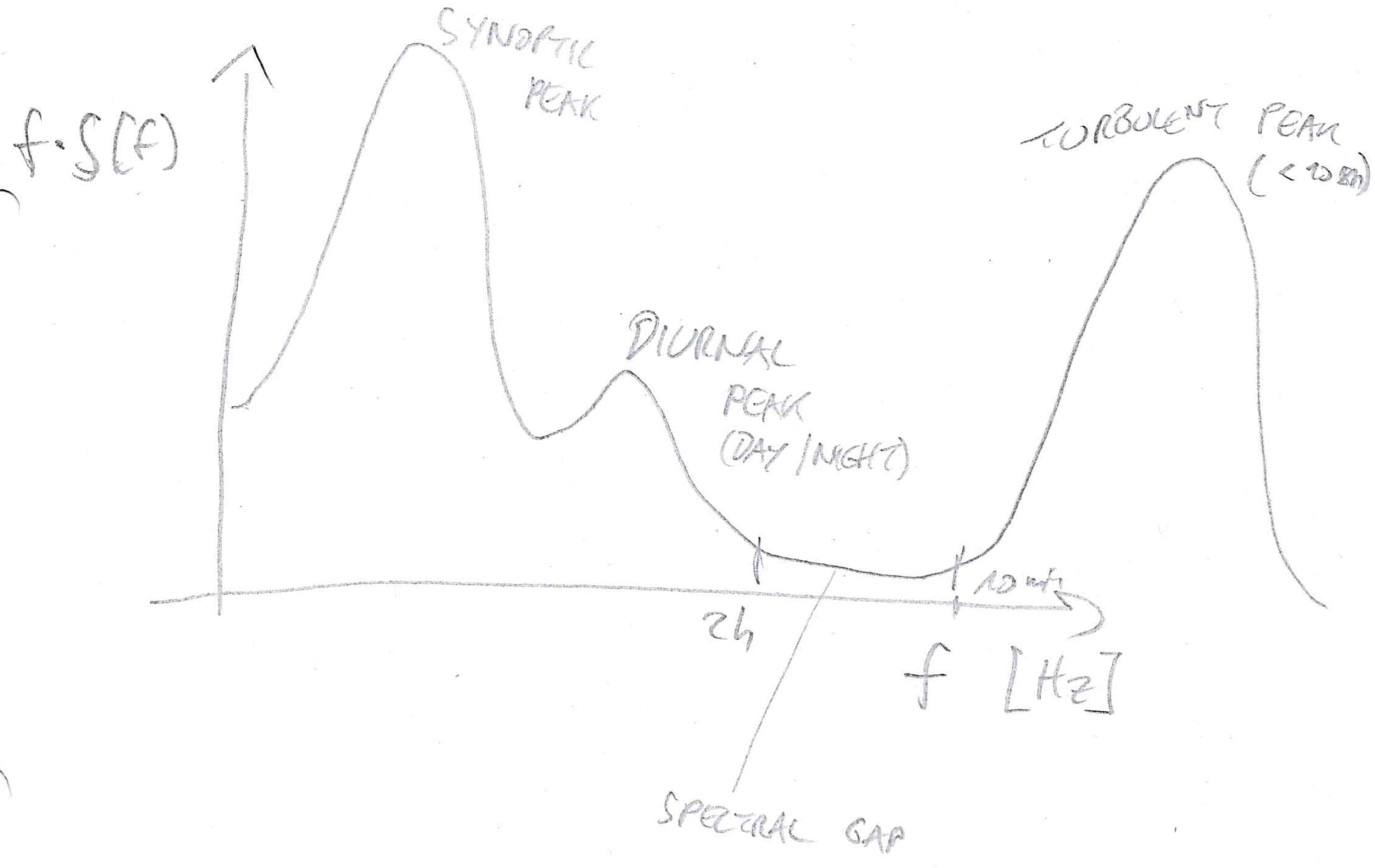
<u>RAYLEIGH</u> DISTRIBUTION WITH $k=2$.

HERE, $\Gamma\left(1 + \frac{1}{2}\right) = \sqrt{\frac{\pi}{4}}$, i.e. $c = \frac{\bar{U}}{\sqrt{\frac{\pi}{4}}}$

NOTE: RAYLEIGH CORRESPONDS TO VECTOR MAGNITUDE OF 2-DIMENSIONAL GAUSSIAN DISTRIBUTION

2.6 SPECTRAL PROPERTIES OF WIND

IF A FOURIER SERIES IS TAKEN, THE POWER SPECTRAL DENSITY $S(f)$ B OBTAINED. IT OFTEN LOOKS AS FOLLOWS



TURBULENCE HAPPENS AT TIME SCALES BELOW 10 MINUTES

TURBULENCE INTENSITY IS DEFINED AS $\boxed{\dfrac{\sigma_u}{\bar{U}}}$

WHERE $\bar{U}$ IS MEAN OVER 10 minutes,

AND σ_u STANDARD DEVIATION OF E.G. 1 SECOND SAMPLE

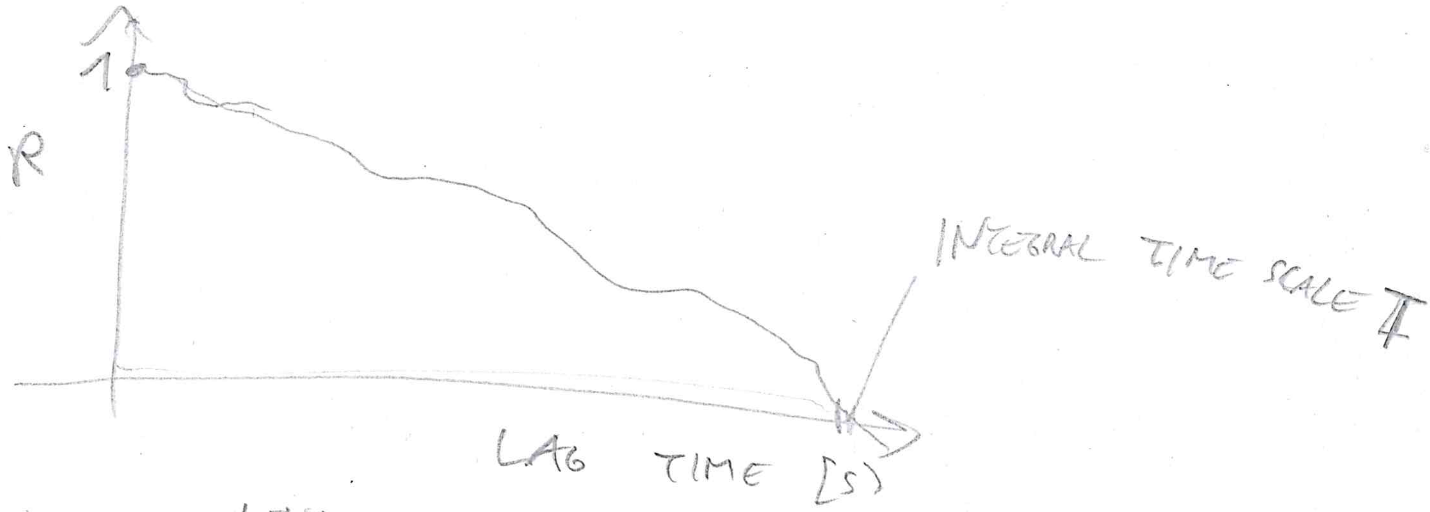
ANOTHER INTERESTING QUANTITY IS

AUTO CORRELATION

$$R(r\Delta t) = \frac{1}{\sigma_u^2 (N-r)} \sum_{i=1}^{N-r} u_i \, u_{i+r}$$

WITH Δt = SAMPLING TIME, r = LAG NUMBER,

$r \cdot \Delta t$ = LAG TIME



INTEGRAL LENGTH SCALE:

$$L = \bar{U} \cdot T$$

(≈ SIZE OF EDDIES)