Seeing measurements using sonic anemometers

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Contents

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Seeing

The main sources of seeing degradation

- Free atmosphere
- Dome environment
- Surface Boundary Layer

Measuring method of Boundary Layer component

II

C_T^2 method

$C_T^{\,2}$ method

temperature fluctuation constant $C_T^2(\rho) = \dfrac{<(\theta(r+\rho)-\theta(r))^2>}{\rho^{2/3}}$

$$\begin{pmatrix} \theta = \mathrm{T} - <\mathrm{T}> : \text{temperature fluctuations} \\ \rho : \text{separation between two points} \end{pmatrix}$$

refractive index fluctuation constant $\mathrm{C}_\mathrm{N}^2 = \left(\dfrac{80\times10^{-6}P}{T^2}\right)^2 C_T^2$

seeing $\varepsilon_{\mathrm{FWHM}} = 5.25\,\lambda^{-1/5}\left(\int_z^{\infty}\mathrm{C}_\mathrm{N}^2(\mathrm{h})\,\mathrm{dh}\right)^{3/5}$ (Fried 1966)

$C_T{}^2$ method

Assuming the atmospheric turbulence follows Kolmogorov's power law . . .

$$C_T^2 = 13.67 S_\theta(f) f^{5/3} U^{-2/3}$$

$$S_\theta \propto f^{-5/3}$$ (Muschinski 2001)

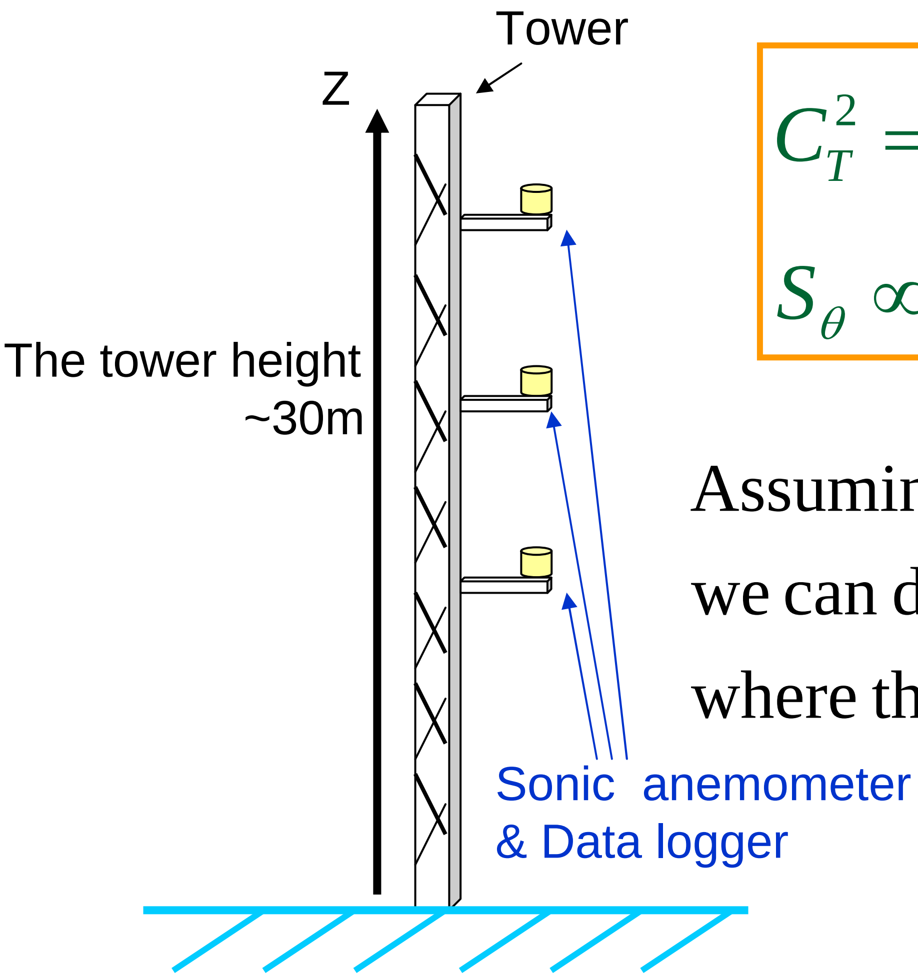
(U : wind speed f : frequency

S_θ : power spectrum of temperature fluctuations)

⇨ C_T^2 can be determined by measuring S_θ and U

⇨ Sonic anemometer

C_T^2 method



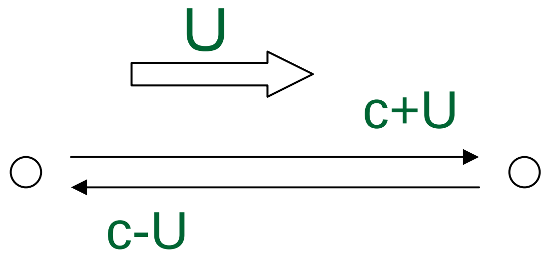
$$C_T^2 = 13.67 S_\theta(f) f^{5/3} U^{-2/3}$$

$$S_\theta \propto f^{-5/3}$$

Assuming $C_T^2(z) \propto e^{-\frac{z}{z_h}}$,

we can determine z_h and estimate the height where the telescope should be set up

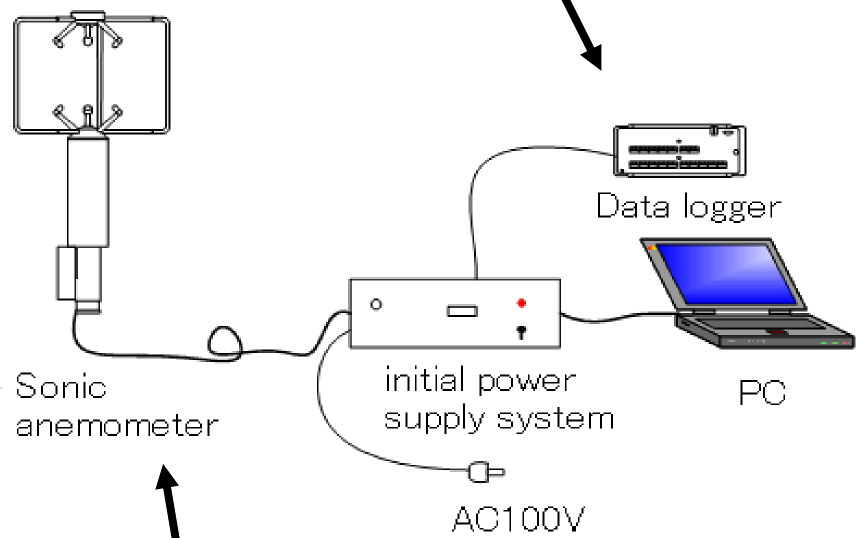
Sonic anemometer



- This device determines the wind speed and the sound speed by measuring the time of flight of sonic pulses between pairs of transducers
- This device calculates the sonic temperature by the measured sound speed
- The lack of moving parts makes this operate in a tough environment

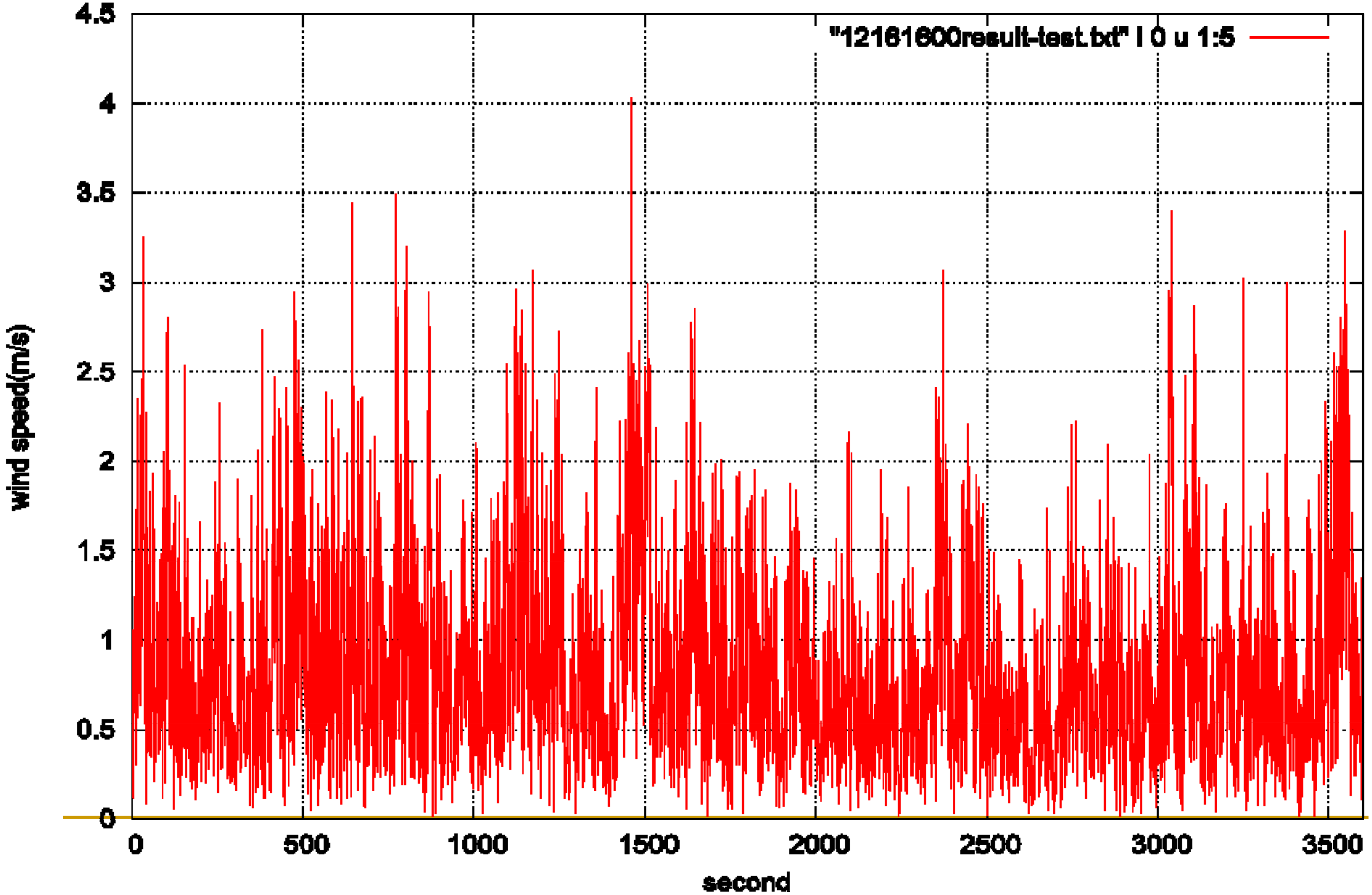
Measurement system

All data acquisition are executed every 0.2s(5Hz)

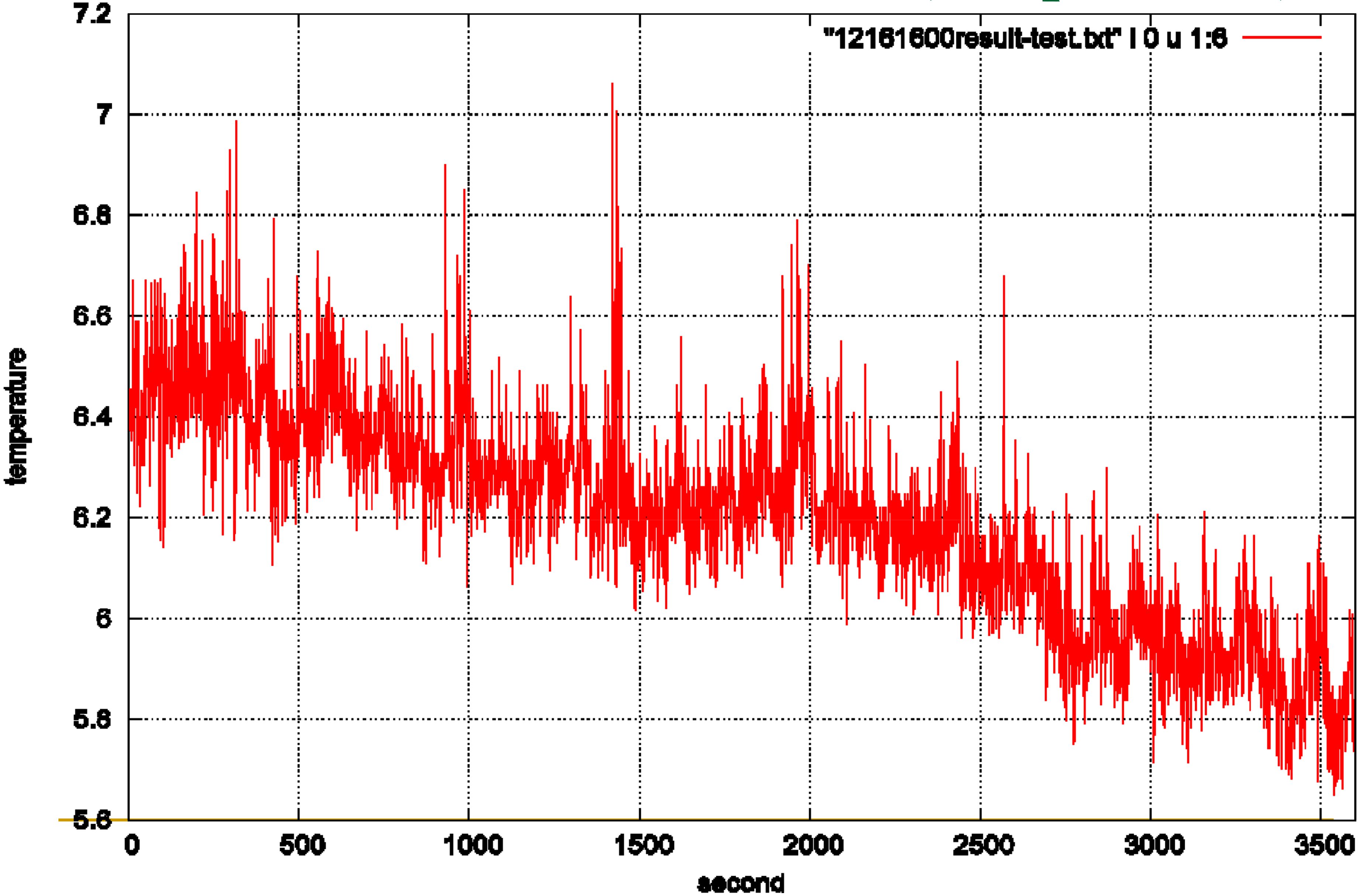


The outputs are 3d wind components and sonic temperature (4Hz~32Hz)

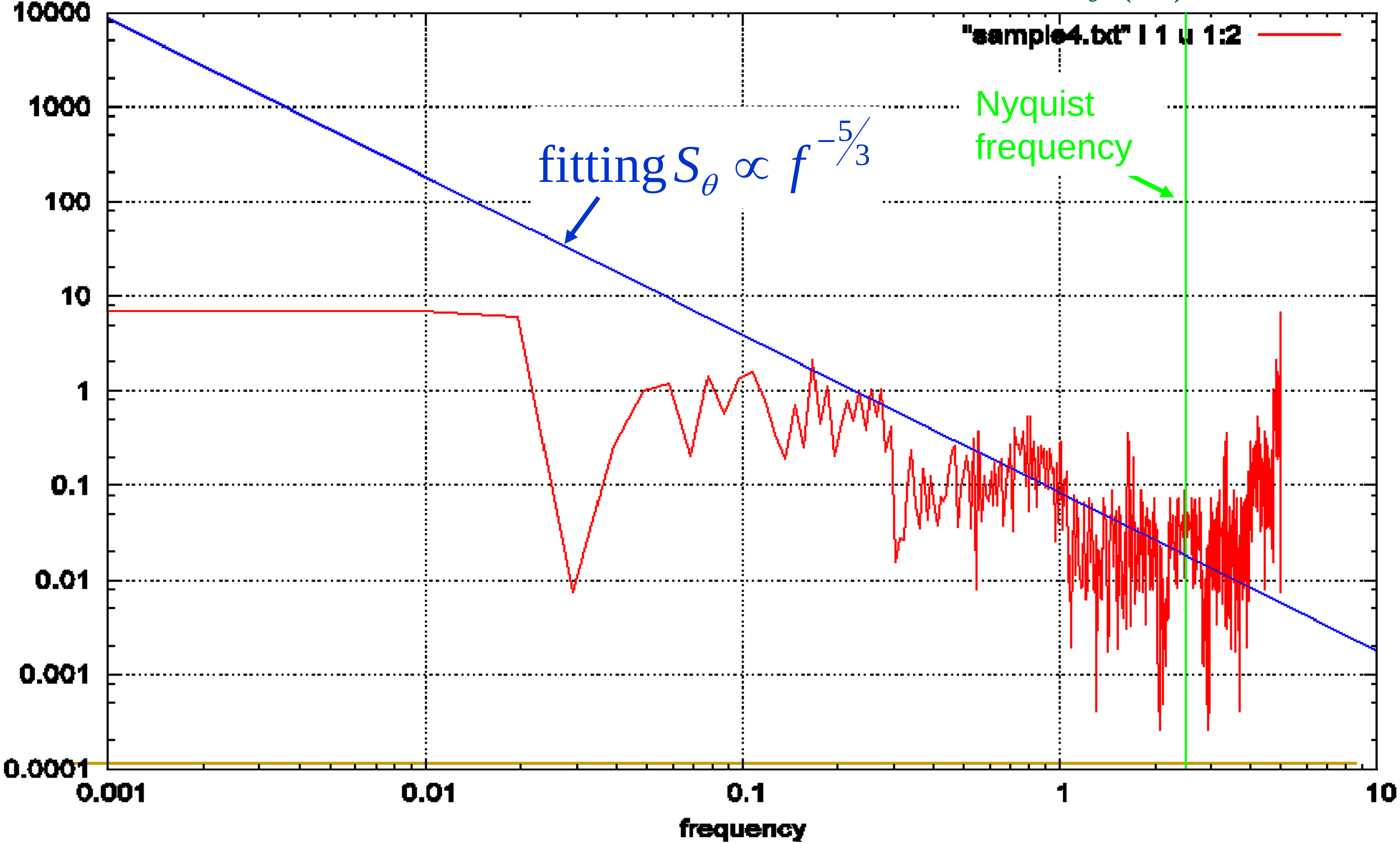
Results of test measurement (wind speed)



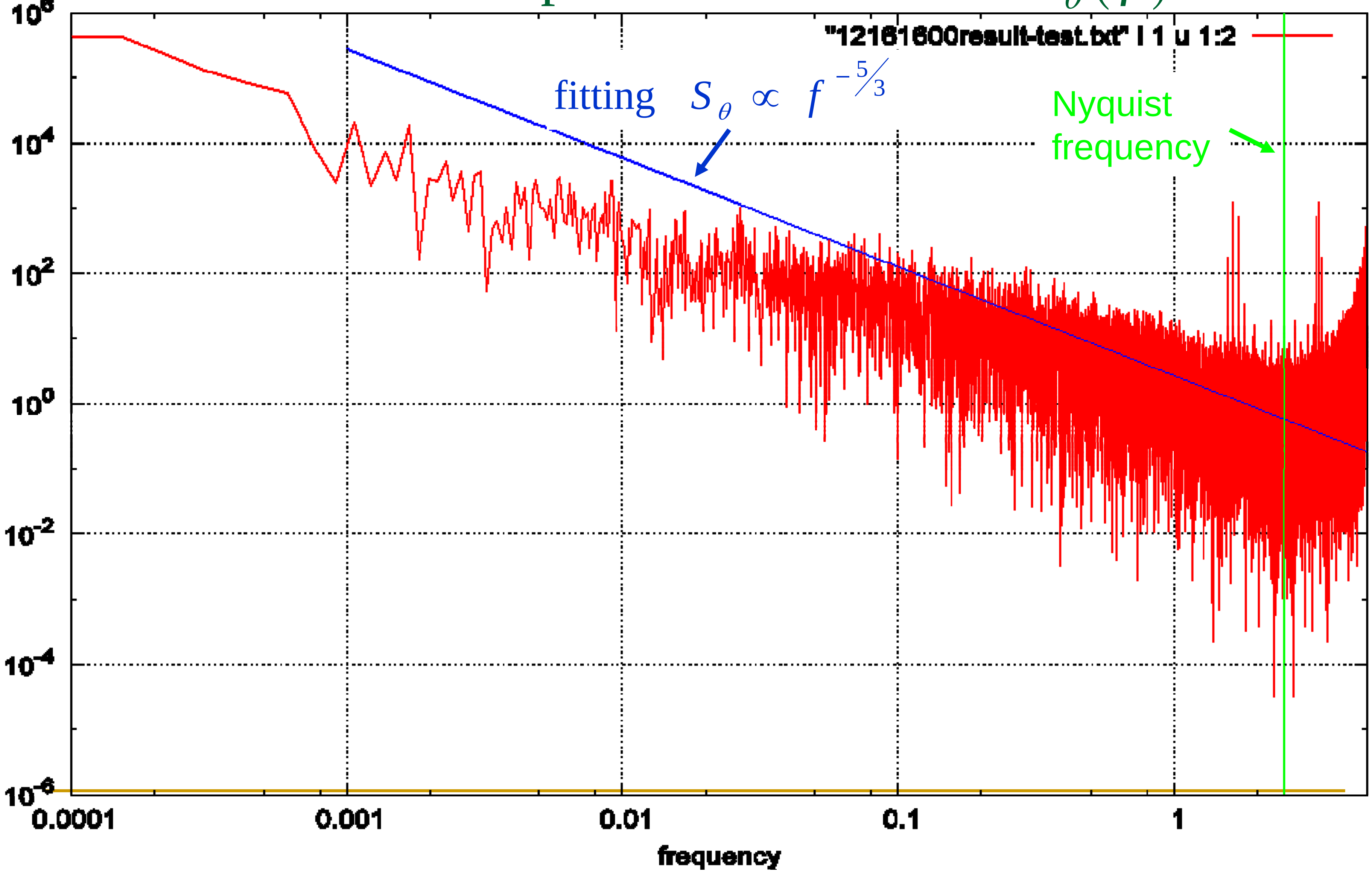
Results of test measurement (temperature)



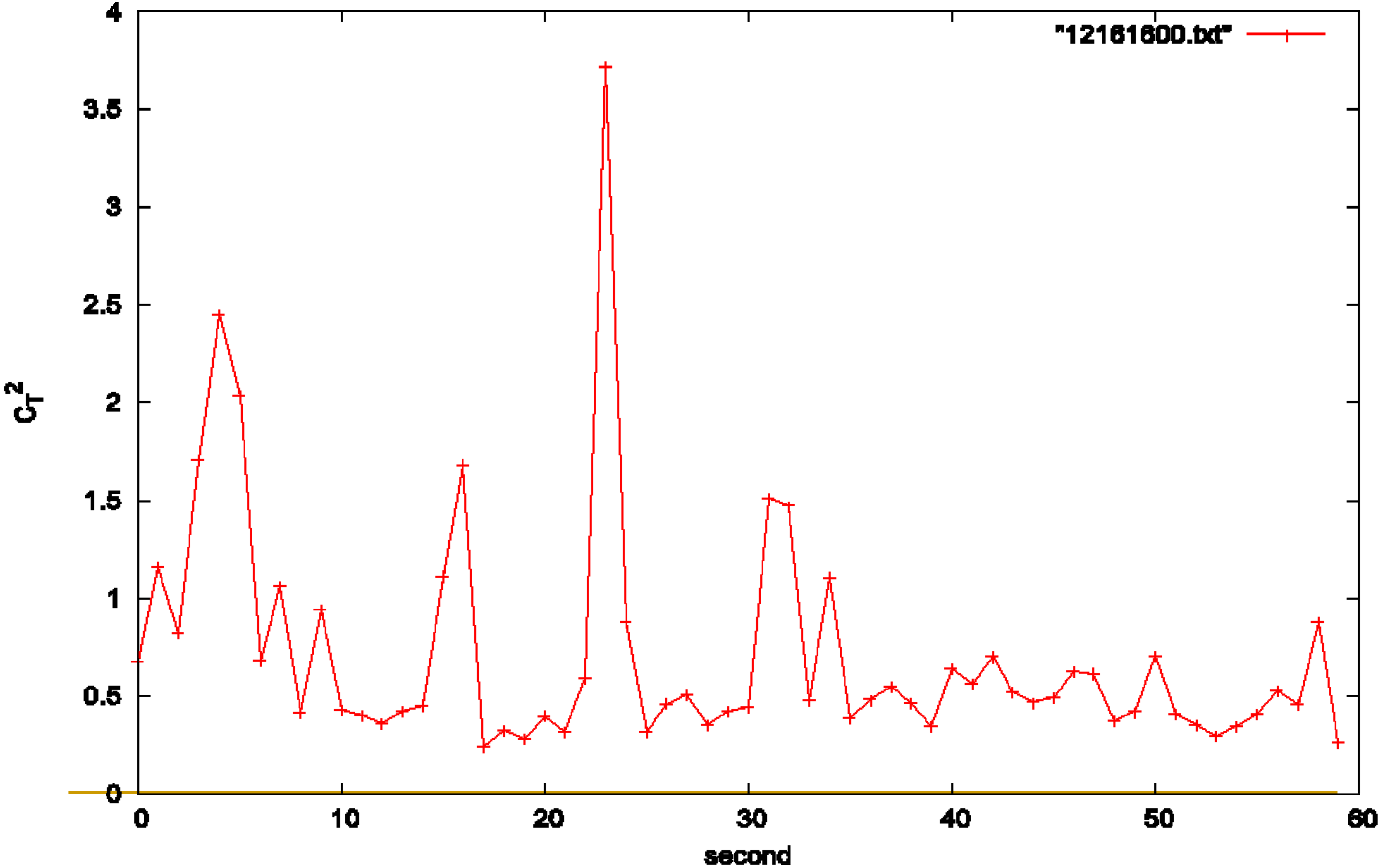
Calculation of the power spectrum of temperature fluctuations $S_\theta(f)$ (1)



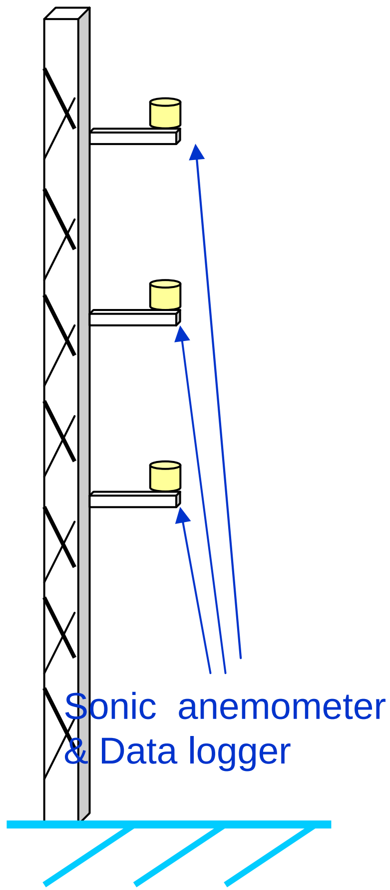
Calculation of the power spectrum of temperature fluctuations $S_\theta(f)$ (2)



Results of test measurement (C_T^2)



Future Work



- Using several sonic anemometers, we will develop a system that observes the altitude dependence of C_T^2 and determines the scale height of the boundary layer

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We will be able to determine the most suitable height where the telescope should be set up in Antarctica

Future Work

- Calculation of C_N^2 and seeing from C_T^2 values and Comparison with the DIMM measurements
- Investigation of the best fitting frequency range and time interval, when calculating the power spectrum of temperature fluctuations S_θ
- Cold test

$$C_N^2 = \left(\frac{80 \times 10^{-6} P}{T^2} \right)^2 C_T^2$$

$$\varepsilon_{FWHM} = 5.25\, \lambda^{-1/5} \left(\int_z^{\infty} C_N^2(h)\, dh \right)^{3/5}$$