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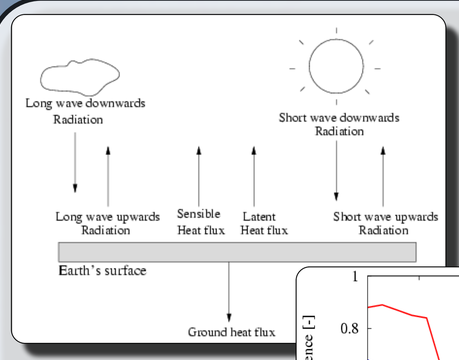
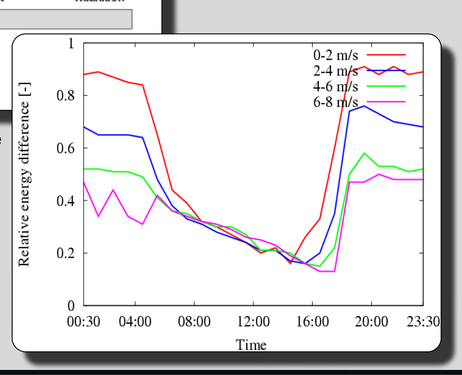
Introduction



Earth's surface energy balance



The energy difference between the available energy and the turbulent fluxes

The energy balance closure problem in the surface layer of the atmosphere is an important topic in the atmospheric sciences. The available energy, i.e. the sum of the net radiation and the ground flux, is found to be larger than the sum of the turbulent fluxes of sensible and latent heat.

In this study, the vertical wind velocity fluctuations are determined using both Laser Doppler Anemometry (LDA) and Sonic Anemometry. Laser Doppler Anemometry may provide a means to determine the entire turbulent energy spectrum, i.e. from the production scale down to the Kolmogorov scale. To assess the feasibility of the technique an LDA system is developed that can operate under atmospheric conditions. Measurements are performed at a grassland site at Cabauw in the Netherlands.

The sonic anemometer at the Cabauw site

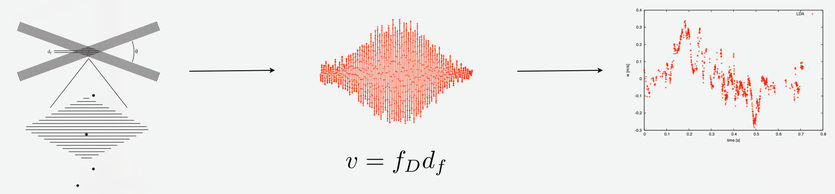
Experimental Setup

The setup before the start of the measurements

The LDA system during the measurements

LDA is an optical technique which allows the measurement of the local instantaneous velocity of tracer particles suspended in the flow. The tracer particles are provided by a conventional smoke-machine and distributed by a circle segment at 25 meter distance from the LDA and the sonic anemometer. In the experiment a forward scatter LDA is used to achieve the highest possible data rate. The sonic anemometer is placed next to the LDA for validation purposes.

Principle of LDA (fringe model):



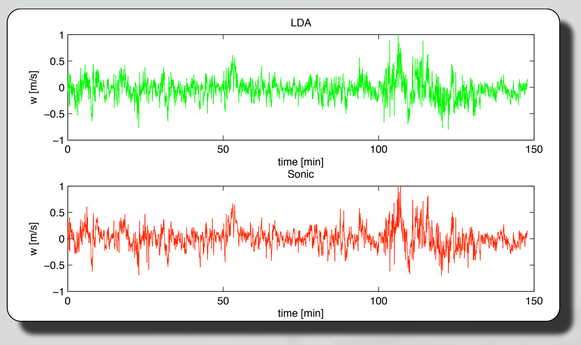
Two intersecting laser beams form a fringe pattern. A crossing particle scatters light.

The velocity of the particle can be calculated as the product of the fringe spacing and the Doppler frequency.

Sequential crossing particles give a velocity time series.

The source of tracer particles distributed by a circle segment of 20m

Results

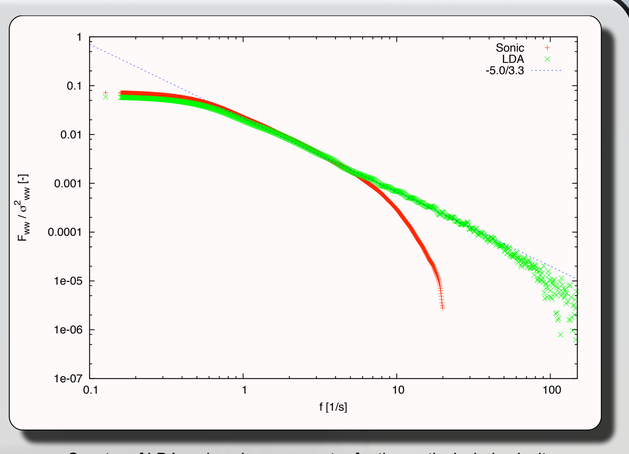


The LDA and the sonic anemometer vertical wind velocity signal of the same period

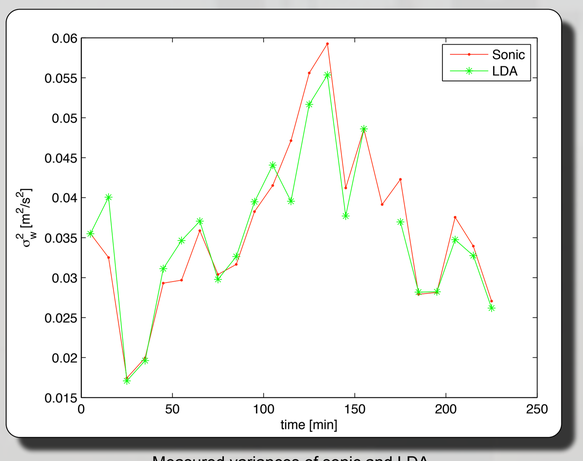
The measurements were taken at 1m height at Cabauw during the night of 8 February 2008. First the LDA and sonic anemometer were directed to measure the same volume. The measured vertical velocities closely resemble.

The measurement started at 20hr and stopped at 24hr local time. The LDA system collected more than 4 million samples at an averaged sampling frequency of 440Hz. It was a stable night with a friction velocity of about 0.15 m/s.

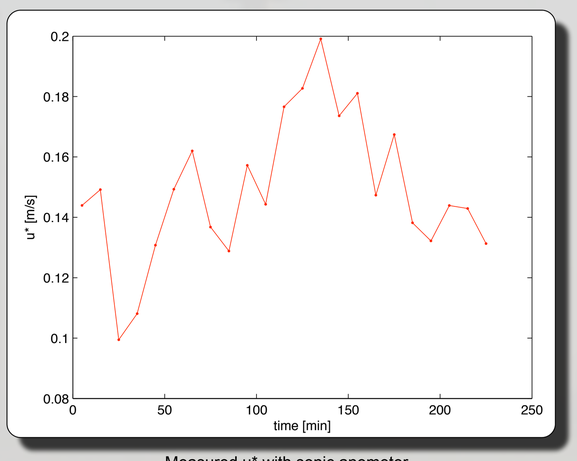
The spectra of both techniques appear to be in good agreement in the low frequency range. However, compared to the sonic, much smaller scales can be detected by the LDA system. This shows that the LDA technique can be succesfully operated in atmospheric conditions.



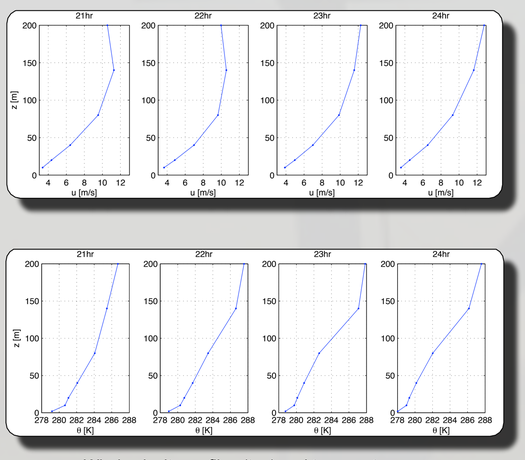
Spectra of LDA and sonic anemometer for the vertical wind velocity



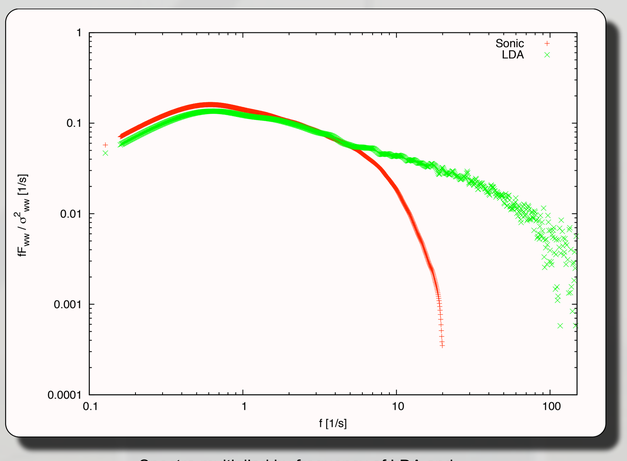
Measured variances of sonic and LDA



Measured u* with sonic anometer



Wind velocity profiles (top) and temperature profiles (bottom) at the Cabauw site



Spectra multiplied by frequency of LDA and sonic anemometer for the vertical wind velocity

Future

Current system: one-component LDA system

Measurements will be performed at different nights with different stabilities. On the basis of these results, it is possible to estimate the amount of flux underestimation using Sonic Anemometry. The present one-component (w only) will be extended to a two-component (u and w) LDA system.

Seeding system: conventional smoke-machine

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