MF MEAT

Mobile Flux Measurement: Earth-Air Turbulence

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"Alright, I need a volunteer for a dangerous mission."
from the 1997 Movie "Turbulence"

Rationale

- Turbulence in the atmospheric boundary layer (ABL) occurs within the interface between the free atmosphere and the underlying surface.

- ABL turbulence is currently not sufficiently understood and modelled (e.g. Baklanov et al, 2011), particularly w.r.t. horizontal structure & horizontal diffusion.

- This affects numerical weather prediction and climate models, which consequently suffer from large uncertainties in surface thermodynamical properties, such as the well-known systematic overestimation of nocturnal temperature minima in climate simulations.

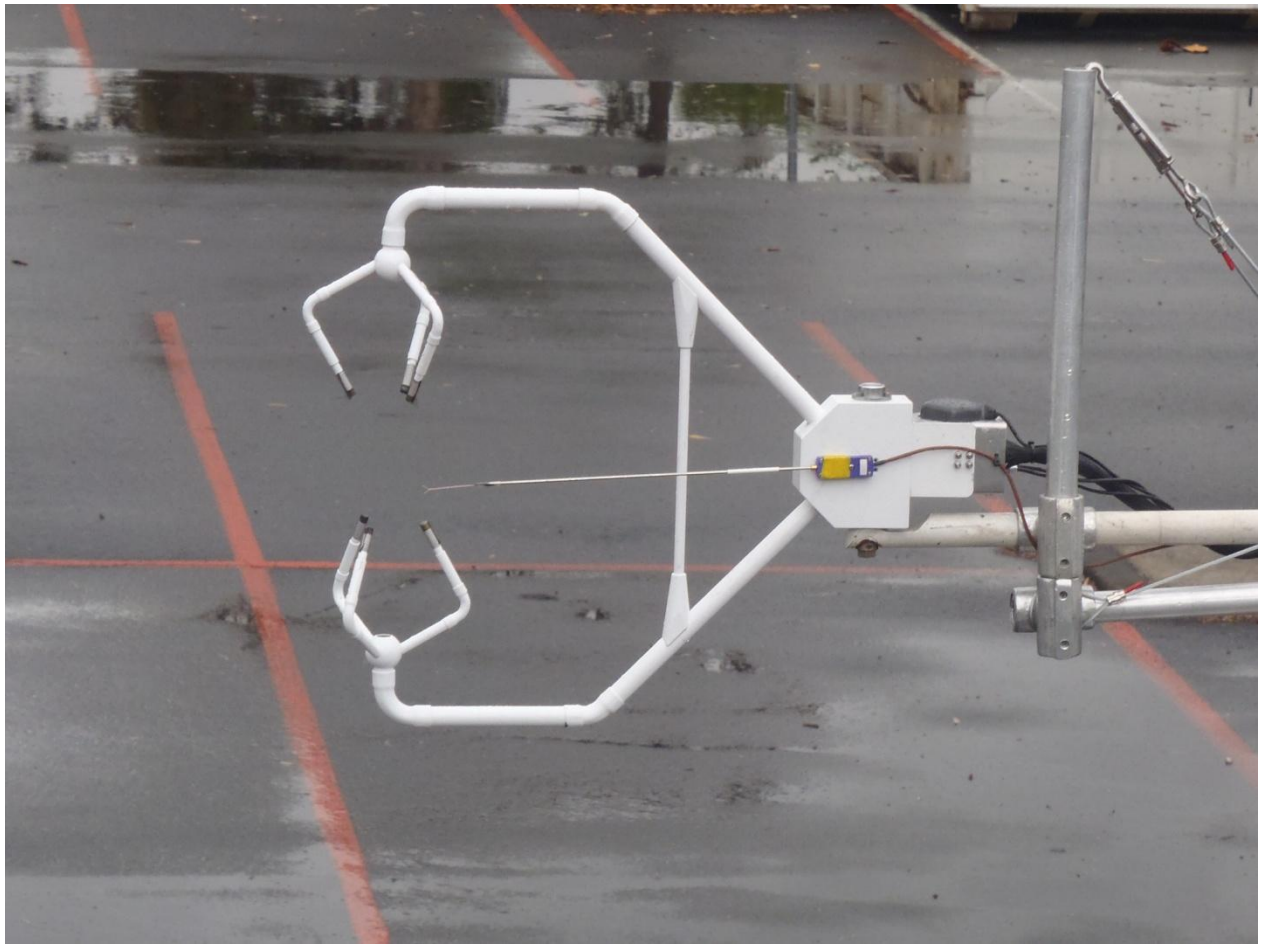
- The main tools for better understanding of complex ABL turbulence are direct measurements.
- Multiple observational techniques exist (Mahrt, 2010), but all have limitations.
- The two main techniques are surface-based measurements with eddy-covariance towers, and measurements using specially equipped research aircraft.

- Here we have a prototype development of a new and to our knowledge unique platform for turbulence measurements.

- It will incorporate the strengths of both the tower and aircraft measurements and also eliminate some of their inadequacies.

Using a light weight aluminium frame and stainless guys we can measure turbulence with a sonic anemometer placed in front of and above the wind deformation field of the vehicle

A CSAT3 with a fine wire thermocouple measures the 3D wind and fast response temperature. To measure the location of these measurements we use a low-cost GPS-enhanced Attitude and Heading Reference System (AHRS) IG-500N. It is fundamentally a miniature Inertial Navigation System with performance similar to those systems used in aircraft. It measures the 3D orientation, position and velocity at 100 Hz.



Tower vs Car Flux Measurements

Tower

- Uses the frequently faulty assumption of horizontal homogeneity
- Uses the frequently faulty conversion from the time to space domain (Taylor's hypothesis)
- Fixed in space, so misses stationary circulations

Car

- Measures the horizontal heterogeneity
- Measures directly in the space domain
- Mobile or Stationary

Aircraft vs Car Flux Measurement

Aircraft
Unable to keep a fixed height above the ground
Unable to go close to the surface
Unable to measure during the night
Limited airborne time yields limited sample sizes
Lots of aircraft induced noise
Expensive deployment
Can operate only at high speeds, usually around 100 m s^{-1}

Car
Always at a strictly fixed height above the ground
Near-surface measurements
Measures equally well during the day and night
Can provide large samples and repeated passes
Car motion less variable, so less noise
Low-cost field deployment
Can operate as both a stationary and a moving platform at any allowed speed

Aims of mobile ground-based measurements

- The car platform enables horizontal measurements of turbulence at a fixed height above the surface.
- Provides a completely new insights into boundary-layer horizontal structure.
- Measurements at a strictly fixed level above the ground are essential in calculating horizontal gradients needed for the determination of the horizontal diffusion.
- The horizontal diffusion in the state-of-the-art climate models is still based on purely numerical considerations, and has not yet been related to the real-world values (e.g. Belušić and Güttler, 2010).

Field testing of the CSAT and the INS-GPS
Find the flattest section of little used good quality road with no nearby trees or buildings.

Set up a stationary reference tower with its own GPS to synchronise time stamps.

Then drive past the base station at a range of speeds in either direction.

- Preliminary results actually involved initial testing on the Monash Freeway and associated roads and involved modification of the structure to minimise vibration.
- The mobile measurements compared well to the base station and the method shows promise.
- Next steps involve testing at different wind speeds, and adding an open path IRGA.
- We invite interested parties to contact us for further development of this method.
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- **References**

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- Mahrt, L., 2010: Computing turbulent fluxes near the surface: Needed improvements. *Agric. For. Meteorol.*, **150**, 501–509.