Canopy aerodynamic distance (z-d) estimation and impact on eddy covariance measurements

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• Objectives:
  – Is turbulent transport impacted by canopy aerodynamic distance \((z - d)\) variability in the roughness sublayer?
  – How to estimate canopy aerodynamic distance?
• The Vielsalm Terrestrial Observatory (VTO)

- Increased heterogeneity at FLUXNET stations might be a more general problem for trend analysis of long-term data sets.
- Babel, 2016
• The Vielsalm Terrestrial Observatory (VTO)
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Aerodynamic measurement height estimation based on cospectra:

- Observed mean cospectrum
- Theoretical cospectrum

Poster A29, 17:30–19:00, Hall A
• Canopy aerodynamic distance ($z-d$):
  – Validation by confronting the results to:
    • the expected changes in $d$ (as canopy height was variable)
    • the observed changes in $z$ (as the measurement height was changed)
**Correlation coefficients:**

- Correlation coefficients may be referred to as normalized covariances or transport efficiencies as they indicate how much \( w \) is related to \( u \), \( T \) and \( c \).
- Repeatable measurements require constant correlation coefficient during all the measurement period.

\[
\begin{align*}
r_{uw} &= \frac{u'w'}{\sigma_u \sigma_w} ; \\
r_{wT} &= \frac{w'T'}{\sigma_w \sigma_T} ; \\
r_{wc} &= \frac{w'c'}{\sigma_w \sigma_c}
\end{align*}
\]

- \( r_{uw} \) (neutral conditions): pronounced temporal dynamics
- \( r_{wc} \) and \( r_{wT} \) (unstable conditions): no temporal dynamics.
- \( r_{uw}, r_{wc} \) and \( r_{wT} \): pronounced spatial variability (\( r_{uw} > r_{wT} > r_{wc} \)).
• Canopy aerodynamic distance and correlation coefficients:

- Momentum correlation coefficient \( r_{uw} \) is strongly linked to \( z-d \).
  → Characteristic of the roughness sublayer.
- Heat and CO\(_2\) correlation coefficients \( r_{uw}, r_{wc}, r_{wT} \) independent of \( z-d \).
  → More homogeneous sources-sinks distribution.
- Difference between azimuthal direction sectors in \( r_{wc} \) and \( r_{wT} \) (more pronounced).
  → Not related to \( z-d \) variability.
• Why is there a difference between NE and W for $r_{wT}$ and $r_{wc}$?
  – Tree height transition between high Douglas firs and beeches?
• Why is it more pronounced for $r_{wT}$ than for $r_{wc}$?
  – Horizontal/vertical heterogeneity in sources/sinks distribution?
  – Large turbulence structures?
  – Occurrence of cloud passages?
  – Active role of temperature?
• **Canopy aerodynamic distance (z-d) estimation:**
  - Original z-d estimation method based on single point eddy covariance measurements with a relatively high temporal and spatial resolution.
  - z-d temporal dynamics and spatial variability fairly well reproduced.

• **Relation to turbulence statistics**
  - $r_{uw}$ directly related to z-d $\rightarrow$ roughness sublayer.
  - $r_{wc}$ and $r_{wT}$ not related to z-d even in the roughness sublayer
  - Other parameters need to be considered in order to explain the observed spatial variability.

• **Next step**
  - Consider the fluxes themselves by considering footprint issues.
Thank you for your attention
More information?

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- Poster session (A29, 17h30, Hall A)
- Paper submitted (AFM)