Energy budget from Large Aperture Scintillometry during AGRISAR2006

W.J. Timmermans¹*, R.J.J. Dost¹, J.Timmermans¹, K. Weligepolage¹, A.H.B. Blenke²

1. Department of Water Resources, International Institute for Geo-information Sciences and Earth Observation, Box 6, 7500 AA, Enschede, The Netherlands
2. Department of Information Technology, International Institute for Geo-information Sciences and Earth Observation, Box 6, 7500 AA, Enschede, The Netherlands

*Corresponding author: timmermans@itc.nl)
Overview

- Introduction
- Experimental Setup
- Theoretical Background
- Results and Discussion
- Acknowledgements
Introduction

Reflection

Emission

Reflection

$R_n$

Radiation exchange
Introduction

Vaporization of water

\[ G_0 = H + LE \]

Heat

Heat

\[ R_n = G_0 + H + LE \]
Introduction

- LAS, measures H and LE is derived as a rest-term: LE = Rn - G0 - H
Introduction

- Objective(s):
  - Demonstrate use of LAS for turbulent flux determination for an agricultural area
  - Provide ground-truth for validating RS-based flux models
Experimental Setup

- Micro-meteo station, Wheat field 250, Week 27, 2006, 1 minute interval
  - Short and longwave incoming and outgoing (4-channel radiometer, Kipp & Zonen CNR1)
  - Soil heat flux (3x)
  - Soil temperature profile (4 depths)
  - Relative humidity & air temperature profile (2 heights)
  - Windspeed profile (2 heights)
  - Wind direction
  - Sensible heat (Kipp & Zonen Large Aperture Scintillometer, LAS)

- Scintillometer station, Corn field 222, Week 27, 2006, 1 minute interval
  - Sensible heat (Kipp & Zonen Large Aperture Scintillometer, LAS)
Experimental Setup

1. Görmin weather station
2. BREB station
3. LAS Receiver - field 250
4. LAS Transmitter - field 250
5. LAS Receiver - field 222
6. LAS Transmitter - field 222
Experimental Setup

- Micro-meteo station and LAS Receiver (a), LAS Transmitter (b)

(a) Micro-meteo station and LAS Receiver
(b) LAS Transmitter

@ Wheat field 250
Experimental Setup

- LAS Transmitter

@ Corn field 222:
Theoretical Background

- Scintillation method to measure turbulence (here: sensible heat)
  - EM radiation propagation is influenced by small changes in the refractive index of air that lead to intensity fluctuations known as scintillation (“air blurring over a hot road”)
  - Since the turbulent eddies transport heat and water vapor their refractive index is different from the surrounding which is measurable:

- Scintillometer is a receiver and a transmitter
  - Measures “scintillations” in an emitted beam, which is a measure for the turbulence of the atmosphere
  - The turbulence of the atmosphere describes the ability to transport sensible and latent heat
  - Measurement is path averaged observation, providing a link with area averaged RS measurements
Theoretical Background

- Scintillometer measurements need post-processing, requiring additional data:
  - Wind speed (u)
  - Air temperature (T)
  - Air pressure (p)
  - Bowen ratio estimate (β)
  - Friction velocity (u*) or surface roughness estimates (z_{0M})
  - Effective height (z_{eff}) of LAS

- Signal is integrated along path-length, following a weighting function
Theoretical Background

- Footprint analysis needed for validating RS-based flux models
Theoretical Background

- Footprint (Soegaard et.al. 2003) combined with LAS weighting function

1. Görmn weather station
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3. LAS Receiver- field 250
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6. LAS Transmitter - field 222
Results and Discussion

- Wheat field 250
  Net radiation & Soil heat flux
Results and Discussion

- Wheat field 250
  Sensible & Latent heat flux

![Graph showing energy flux vs. DOY 2006 with rainfall problems indicated.](image)
Results and Discussion

- Data quality Wheat Field # 250:

  - Net radiation shows normal development (after post-calibration), quality considered good
  - Soil heat fluxes show normal development, though slightly high amplitude due to late installation (no correction possible)
  - LAS measurements at end of period, 8-9 July, disturbed by rainfall, other days the quality is considered good

- Latent heat fluxes are calculated as a rest-term; error accumulation!
Results and Discussion

- Corn field 222
  Sensible heat flux

![Graph showing energy flux with peaks and dips, labeled Rainfall and Battery problems]
Results and Discussion

- Data quality Corn Field # 222:
  - Suffered from battery problems after rainfall
  - Required additional meteorological data for field 222 taken from observations in field 250
Results and Discussion

Data discussion:

- Sensible heat fluxes show similar stable behaviour for most of the days,
- Daily maxima around 130 W·m⁻² to 140 W·m⁻² for the wheat field # 250
- Slightly higher values, around 150 W·m⁻² are observed over the corn field # 222
- Night-time observations of LAS show rather large negative values (especially field # 250);
- There is no consensus on which method to use; night-time values are assumed zero…
- Sensible heat fluxes are rather low considering the dry and hot conditions

- Latent heat fluxes are thus rather high; crops are transpiring at potential rate, indicating water use from deeper soil layers
- Daily maxima around 400 W·m⁻²
- Daily totals of latent heat flux (i.e. actual evapotranspiration), converted to mm/day
Results and Discussion

- Water use of Wheat Field # 250
Acknowledgements

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