Water and energy budget from airborne optical imagery during AGRISAR2006


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Overview

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Introduction

- Interest in spatial distribution of surface fluxes...
Introduction

Heat vaporization of water

\[ G_0 = H + LE + \text{Heat} \]

Vaporization of water

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

- Objective(s):
  - Demonstrate how,
    - high (spatial and spectral) resolution,
    - optical (visible and thermal) imagery
  - can attribute to accurate flux mapping in an agricultural area

- Validation versus ground observations over different land use units
- Comparison with spatially distributed hydrologic models
Energy Balance Modeling

- Required model parameters (not complete)

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Albedo_s, fPAR, ε, T_s
LAI, LIDF, LWC

Radiative
K_s
Thermal
Soil moisture
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- Biophysical
- Micro-meteorological

- ε, T_s
- u_a, T_a, e_a
- LAI, LIDF, LWC
Energy Balance Modeling: Remote Sensing based SVAT model

- Dual source modeling has higher physical realism
Energy Balance Modeling: Remote Sensing based SVAT model

- Multiple scattering net radiation divergence model

Separate treatment of:
- Soil and vegetation
- Visible and near-infrared radiation
- In-canopy-transmissivity and reflectivity
- Direct (“beam”) and in-direct (“diffuse”)

Requires LAI and FVC
Energy Balance Modeling: Remote Sensing based SVAT model

- Non-linear mixing model to separate soil and canopy temperature

\[ T_R^4 = f_C(\theta) \cdot T_C^4 + (1 - f_C(\theta)) \cdot T_S^4. \]
Energy Balance Modeling: Remote Sensing based SVAT model

- Component (sensible and latent) heat flux parameterization

\[
H = H_{\text{soil}} + H_{\text{canopy}}
\]
Energy Balance Modeling: Hydrological models

- TOPMODEL-based Land-Atmosphere Transfer Scheme: TOPLATS
  - Famiglietti and Wood, 1994; Peters-Lidard et al., 1997

- Process Oriented Multiscale EvapoTranspiration model: PROMET
  - Mauser and Schadlich, 1998

- Adapted here for spatially distributed input (landcover, soil type, terrain elevation, etc.)
Experimental Setup: Ground Observations

- Bowen Ratio and LAS stations in field #250 and LAS in field #222
Experimental Setup: Airborne Observations

- “Optical” airborne surveys on 6th and 10th of June, 4th and 5th of July 2006
- Here 2 overpasses on July 5th at 10:20 and 10:31 utc are used to extract:
  - Land surface Temperature (LST) from AHS data
  - Fractional Vegetation Cover (FVC) from AHS data
  - Leaf Area Index (LAI) from CASI data
Experimental Setup: Airborne Observations (LST)

- LST derived from AHS using adapted TES algorithm, Sobrino et.al. (2004)

[Image of LST map with LST [K] legend: 295.0, 302.5, 310.0, 317.5, 325.0]

AHS flight line P05AD @ 10:20 utc, 5th July 2006
Experimental Setup: Airborne Observations (FVC)

- FVC derived from AHS using scaled NDVI, Carlson & Gillies (2004)
Experimental Setup: Airborne Observations (LAI)

- LAI derived from CASI using MCARI1 index, Fernandez & Moreno (2006)

In-situ measured LAI equal to 1.87 during AGRISAR-2006 Field Campaign
Experimental Setup

- Landcover map from AGRISAR database, attributes aerodynamic properties
Results and Discussion

- Model outputs instantaneous fluxes (for both soil and canopy):
  - Net radiation (Rn-s, Rn-c)
  - Soil heat flux (Gs)
  - Sensible heat flux (Hs, Hc)
  - Latent heat flux (LEs, LEc)

- Possibility to derive daily estimates of water use…
Results and Discussion: Model Results

- Spatially distributed instantaneous sensible heat flux (example)
  - Generally low sensible heat fluxes,
  - and thus high latent heat fluxes
  - At spots even negative sensible heat
  - Large variation in wheat field # 250
  - High sensible heat over built up areas
Results and Discussion: Model Results

- Instantaneous fluxes versus ground observations

![Graph showing instantaneous fluxes versus ground observations with modelled and observed values for Rn, G, H, and LE. The RMSD values are 8, 45, 26, and 25 for Rn, G, H, and LE respectively.]
Results and Discussion: Spatial Comparison

- Spatially distributed latent heat flux
  - Hydrologic models more “flat” response, but patterns are somehow similar
  - Corn field 222; more resemblance between TSEB and PROMET
  - Wheat field 250; more resemblance between TSEB and TOPLATS
Acknowledgements

- This work has been partly funded through ESA 19974/06/I-LG

- Thank you Ard Blenke, Remco Dost, Joris Timmermans, Kitsiri Weligepolage for assisting in installation and maintenance of the LASses

- Thanks to Gabrielle de Lannoy, Davy Loete and Ingo Keding for their help in installing and maintaining the Bowen Ratio station

- Thanks to Edgar Zabel for maintaining the Bowen Ratio station in between field campaigns