MODIS and Landsat TM scaling study on the evapotranspiration at mid-latitude

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Abstract

The sensible heat flux in a landscape at mid-latitude is calculated based on MODIS and Landsat TM satellite scenes. An aggregation model is used for the surface flux calculation. Satellite-based input maps from satellite on land cover type, leaf area index and radiant surface temperature are used. From in-situ meteorological observations, the local roughnesses of all land cover types are known and the values are assigned to the land cover map in order to obtain a local roughness maps. The sensible heat flux is compared to field observations. These observations are part of the CARBO-EUROFLUX project. A case from May 2001 is presented.

Aggregation model overview

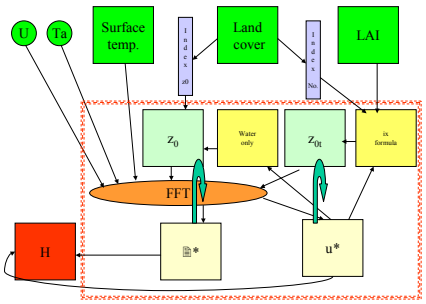

Fig. 1 Microscale model based on Hasager and Jensen (1999) but with new inclusion of land cover type and leaf area index maps for direct calculation of the aggregated scalar roughness, z_{0t} (Hasager et al. 2002).

Sketch of model results for u_*

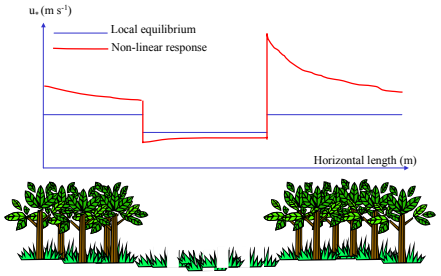

Fig. 2 The friction velocity (u_*) varies downstream as a function of local roughness and patch size. The equilibrium values (for very large pacthes) and the real non-linear behaviour is shown.

Study site in Denmark at Zealand

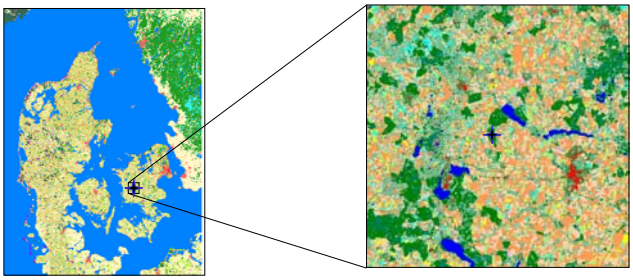

Fig. 3 Land cover type map of Denmark from Areal Information System (NERI 2000)

Position of the mast

Land cover	z_0 (m)
Non-classified	0.09
Grass	0.03
Winter grain	0.09
Winter grain	0.09
Rape	0.06
Spring grain	0.05
Peas	0.06
Beets	0.004
Grass	0.03
Shrubs	1.4
Decidous forest	1.8
Spruce forest	1.8
Sand	0.01
Built-up	0.5
Water	0.001

Fig. 4 Land cover map from Zealand, Denmark based on Landsat TM satellite data. Various crops are in orange, pale green and yellow. Urban areas in red, water bodies in blue and forest in dark green. An area of 30 km by 30 km is shown. The roughness values are from Hasager et al. 2003.

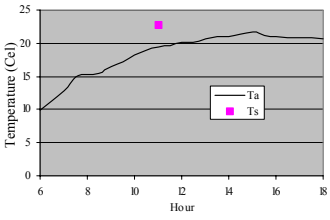

Figure 5. Air temperature (T_a) at 37 m and surface temperature (T_s) from Landsat TM during the day, May 12, 2001 at Lille Boegeskov, Soroe, Denmark.

Model data inputs are

- land cover map based on Landsat TM (Fig. 4)
- roughness from table near Figure 4
- map of Leaf Area Index (LAI) based on Landsat TM according to Boegh et al. 2003
- map of LAI based on MODIS
- surface temperature map from Landsat TM
- wind speed, direction and air temperature (Fig. 5) from the 37 m mast in a forest (Granier et al. 2002)

Model results are

- maps of surface sensible heat (H) (Fig. 6)
- sensible heat flux (H) and roughness (z_{0t}/z_0) (see below)

	MODIS LAI	Landsat TM LAI	No LAI	Mast
H (W m^{-2})	222	277	192	309
z_{0t}/z_0	0.018	0.006	0.1	-

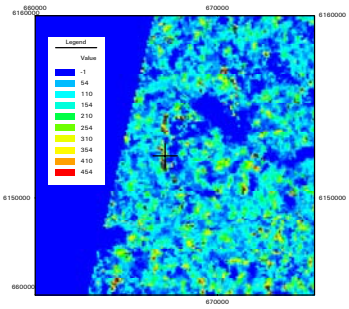

Fig. 6 Surface sensible heat flux map from Zealand, Denmark at May 12, 2001 11 a.m. The met-mast in the forest is located at the +. Land cover type and surface temperature is from Landsat and LAI is from MODIS

Discussion and conclusion

Comparison of surface sensible heat flux results shows that the model result based on LAI from Landsat TM gives the best agreement with the in-situ mast observation. In this case the roughness ratio is only 0.006, a value that is directly calculated by the model. If a map of LAI is not available, it is necessary to estimate the roughness ratio. In case the ratio is assumed to be e.g. 0.1, the surface sensible heat flux is underestimated. It is well-known that the roughness ratio is highly variable within several orders of magnitude. Therefore it seems to be an improvement to directly calculate the roughness ratio and the sensible heat flux.

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