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# LAND SURFACE MODEL OVER FOREST AND LAKE SURFACES IN A BOREAL SITE-EVALUATION OF THE TILING METHOD

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# Motivation and tiling method

- The **tiling method** is a surface parameterization used to represent heterogeneity by dividing a gridbox into different surface types and resolving them in separate equations.
- Tiling method is used in many surface schemes (HTESSEL, JULES, TERRA ...)
- **Blending height assumption**: The tiling method implies the existence of an horizontal level above the heterogeneous patches where the air is well mixed, and the particular characteristics of the individual surfaces are not longer seen.
- Previous studies (Koster and Suarez 1992, Essery et al. 2002) have shown that although there is not much difference between tiling method and alternative approaches like aggregating heterogeneous surfaces, the biggest differences appear when the surface types are very dissimilar.

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- For this reason we analyse 2 contrasting surfaces in a boreal environment: A **forest** and a **lake**.
- A comprehensive set of observational data is available from two sites in southern Finland to validate the model's performance.

# ECMWF land surface model

- **HTESSEL** (Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land)

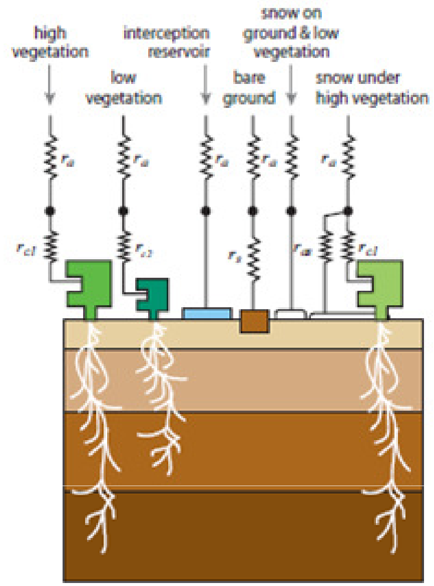
  Land heterogeneity is represented by dividing the grid-box in land surface types

  fractions, called tiles. There are currently 8 tiles:

  – Over sea (Open water, ice water)

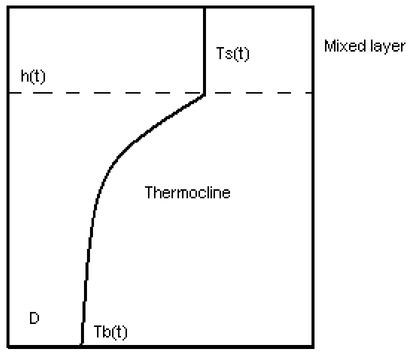
  – Over land (Low vegetation, high vegetation, snow on low vegetation or bare ground, high vegetation with snow beneath, bare ground, interception layer)

  Surface energy fluxes and skin temperature are calculated for each tile with separate energy balances, and then an area-weighted average is computed for the gridbox.




- **LAKEHTESSEL** (Adds a new tile for inland lakes)

  Includes FLake lake model, (Mironov, 2008) based on self similarity of the temperature profile, with prognostic variables: mixed layer depth and temperature, ice depth and temperature, shape factor, bottom temperature

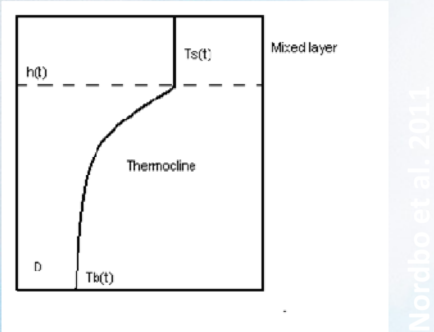


# Offline simulations

**Meteorological forcing:** ERA-Interim reanalysis

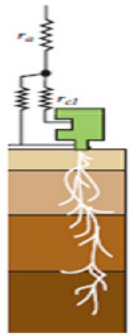
Model was run for the year 2006, doing 3 iterations

LAKEHTESSEL




**Lake**: Full coverage of inland water
Lake depth = 4 m
Water extinction coefficient = 3 $m^{-1}$

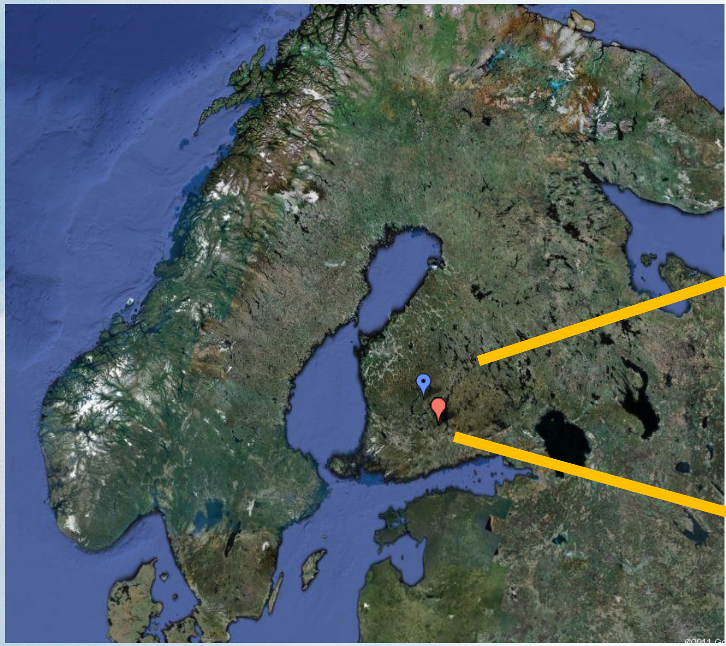
HTESSEL



**Forest**: Full coverage of high vegetation
Vegetation type: Evergreen needleleaf trees
Soil type: Medium texture

Energy balance in the surface $R_n + SH + LE = G$

# Observational sites in Finland





**Observational data available:**

**Validation data**:

•SH, LE (Eddy covariance technique)

•Net radiation

• Ground heat flux/lake heat storage

Forest: soil T, soil moisture, snow depth...

Lake: Water T at 13 depths, ice cover duration...

**Forcing data**:

•SW/LW downward radiation

•Surface pressure

•Specific humidity

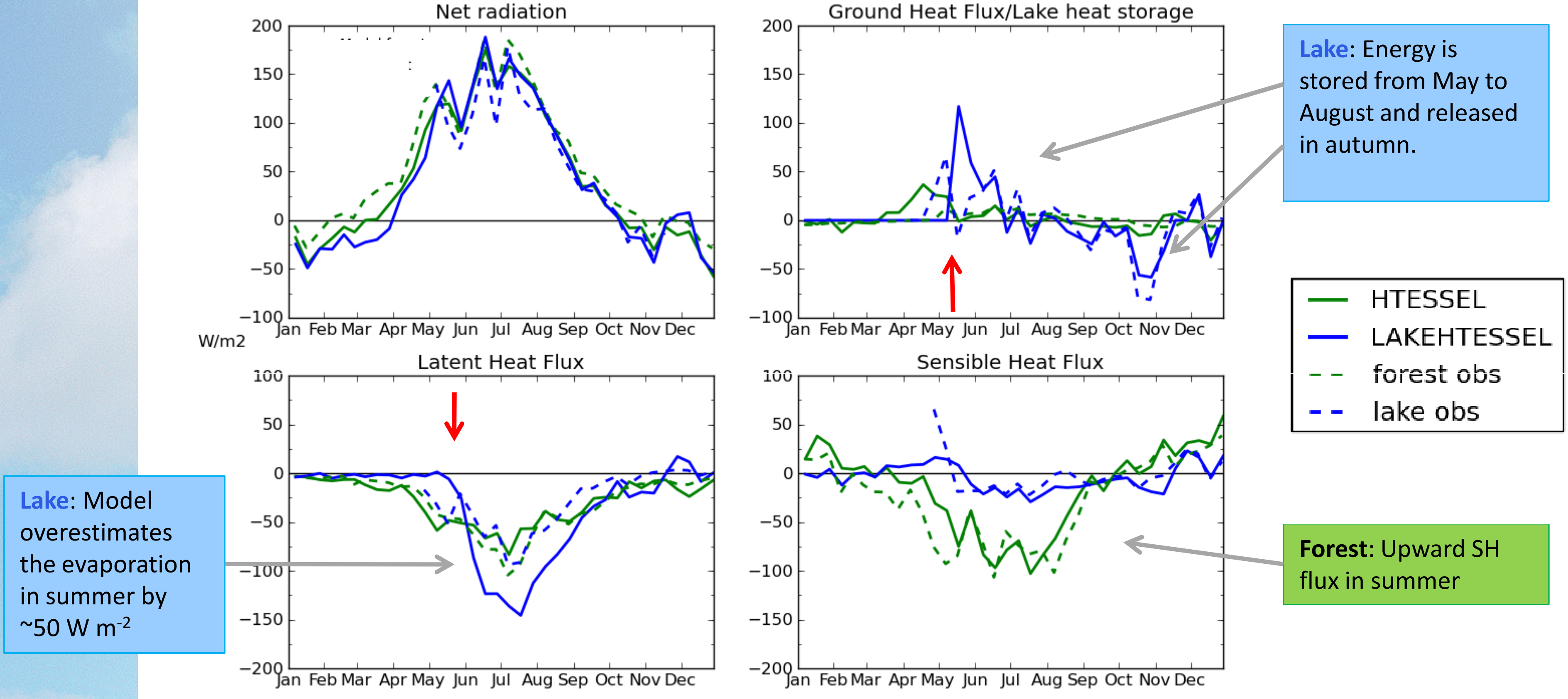
•Wind speed

•Rainfall, snowfall,

•T, wind ...

# Energy fluxes: Seasonal cycles

**Seasonal cycle of 10 day averages of energy fluxes**




Sign convention: Positive downwards

The timing of the lake's energy cycles is influenced by the ice cover break up, and it is delayed by 14 days in the model

**Main difference between both sites is found in the energy partitioning into SH and G**



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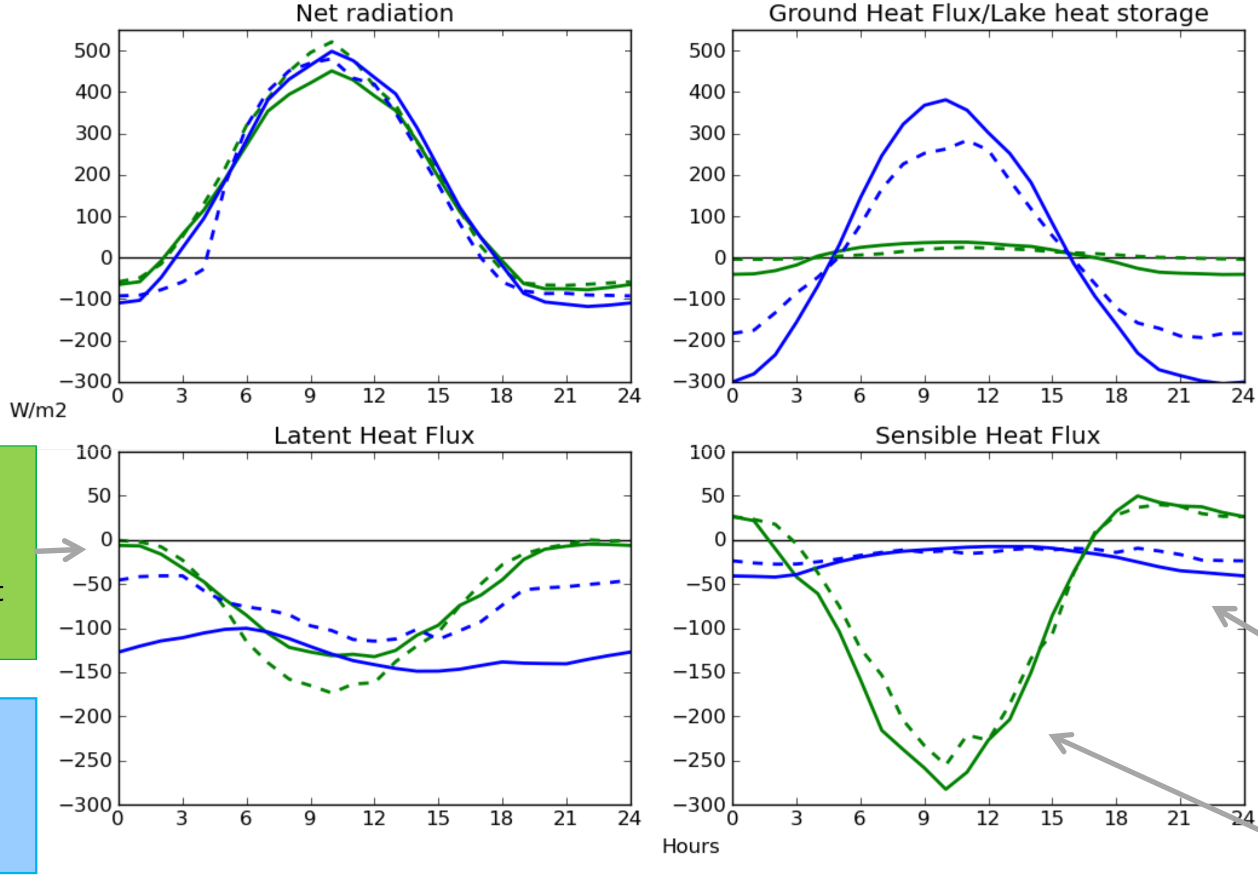
# Energy fluxes: Diurnal cycles

**Monthly diurnal cycle of energy fluxes for July**




Very good representation by the model of diurnal cycles and particularities of each surface

**Forest** evaporation is driven by vegetation, so it is zero at night

**Lake** LH diurnal cycle: overestimation in evaporation

**Lake** SH maximum is at night

**Forest** SH maximum is at midday

**Main difference between both sites is found in the energy partitioning into SH and G**



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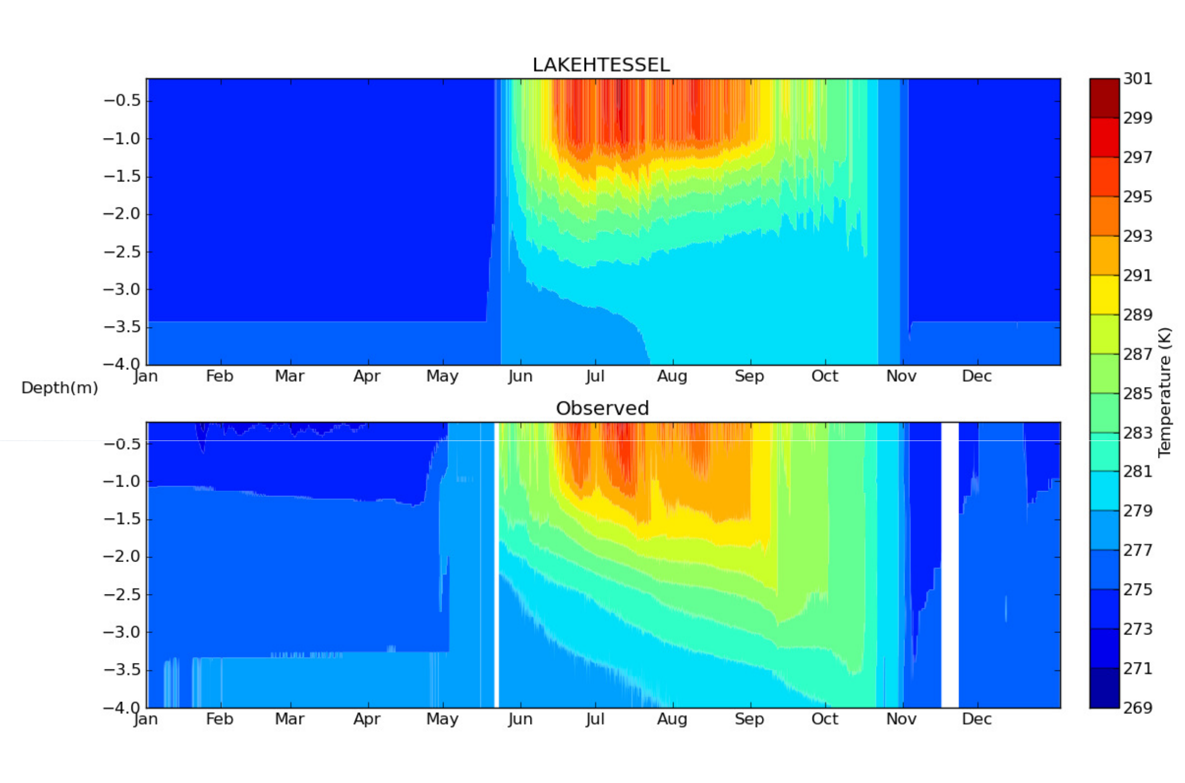
# Lake water temperature

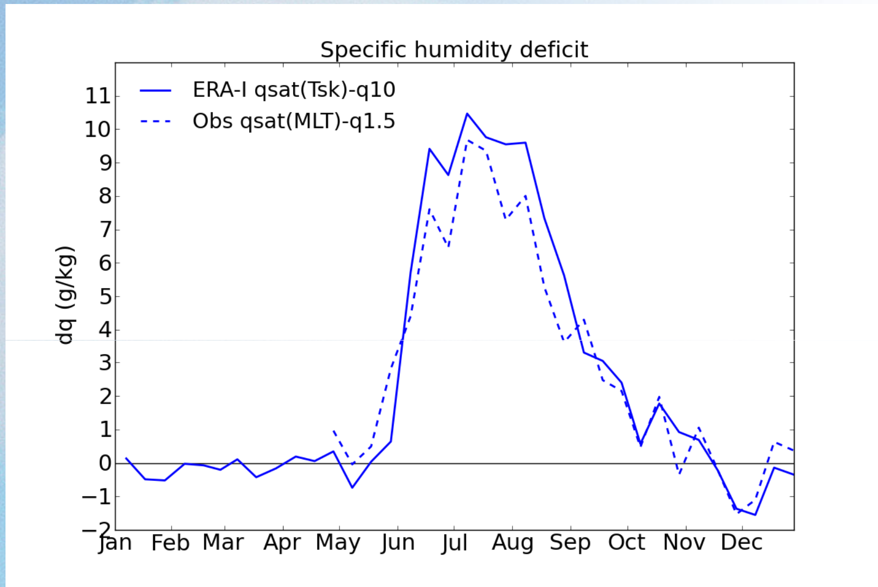
A correct energy partition is fundamental for numerical weather prediction, but we also want to verify the validity of the description of the physical processes in Flake.

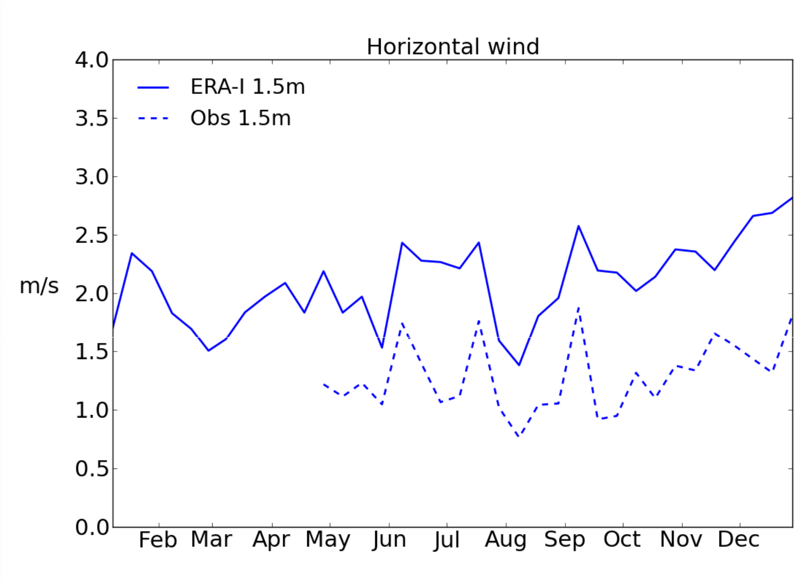



•The surface temperature is well reproduced
•During ice-covered period temperature profile is kept constant, but bottom layer is colder than observations because warming from bottom sediments is not considered
•Model's time of ice break-up is 14 days later than observed
•Model's ice formation is 5 days early
•Model fails to represent the deepening of the mixed layer

# Use of observed forcing vs ERA-Interim for the lake site

- The ERA-Interim forcing data used in the simulations come from a gridbox which is described as 75% of high vegetation, 8% bare ground and 17% of inland water.



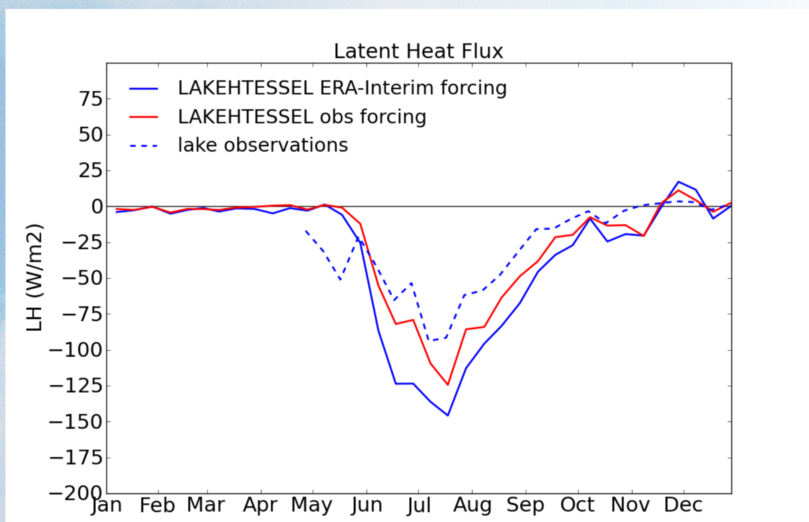



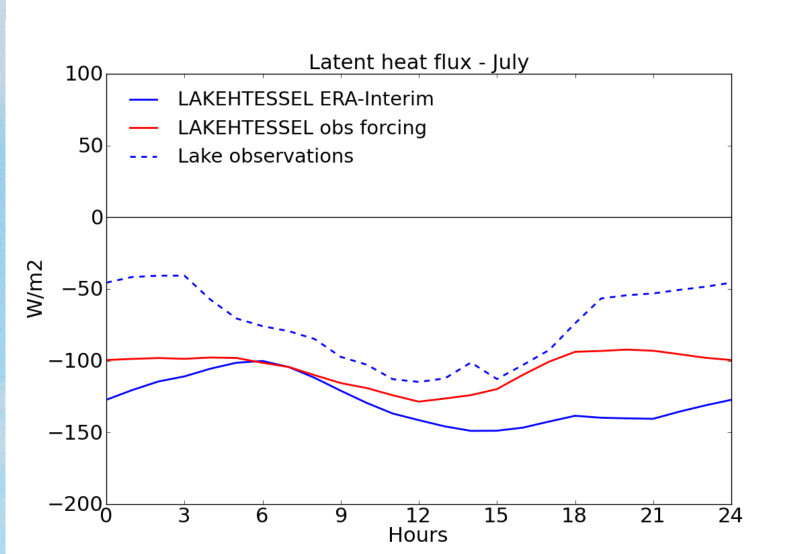

Specific humidity deficit is higher than observed on the lake

Horizontal wind speed is higher than observed on the site

A new simulation is run using the observed data on the lake site as forcing

# Use of observed forcing vs ERA-Interim for the lake site




Seasonal cycle:
The use of observed forcing reduces the RMSE in evaporation from 32 W $m^{-2}$ to 19 W $m^{-2}$

Diurnal cycle for July:
The evaporation is reduced, but errors remain at night. The model's transfer coefficients might not be appropriate for a calm situation



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# Conclusions and perspectives

- Simulations over two contrasting surfaces (boreal forest and lake) were performed by HTESSEL/LAKEHTESSEL and compared to in-situ observations.
- Generally a good representation of the energy balances is obtained showing the main difference of forest and lake:

  Net radiation being almost the same, when the surface is covered by a forest, this energy is transformed roughly equally into latent heat and sensible heat, whereas if there is a lake, energy is stored in the water, having very little sensible heat flux.

- This difference in energy partitioning shows the relevance for numerical weather prediction and advantages of a tiling system with separate balance equations for each tile.
- The limitation of the tiling method due to the blending height assumption are evaluated thanks to the availability of observed forcing , the main error appears in latent heat.
- Future studies: Analysis of the impact of larger lakes by offline and atmospheric coupled experiments.

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