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Observation and modelling of energy fluxes above Nam Co lake and the surrounding grassland on the Tibetan plateau

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Motivation

The Tibetan Plateau (TP) is considered to play a key role in the climate system and to be highly sensitive to climate change. The TP influences the East Asian Monsoon and hosts the headwaters of East Asia's large rivers. Present-day research questions deal with the impact of the energy and water balance on river discharge in East Asia and to understand the mechanisms and feedbacks between TP's land surface and the atmosphere. The *Kobresia* pastures represent a prominent ecosystem on the TP, with high impact on water and carbon balance. Amongst different land surface types also lakes cover a relevant area on the TP.

These research questions require mesoscale modelling and upscaling of energy and matter exchange between the atmosphere and the underlying surface, but spatial heterogeneity poses a major challenge for these objectives. Therefore high quality flux measurements from different surface types are a prerequisite, but these are scarce on the Tibetan Plateau.

Experiment and site description

- Eddy Covariance and energy balance measurements at a small lake near Nam Co lake, period: June 27th to August 8th, 2009
- As the EC complex was situated directly at the shoreline (Figure 1), turbulent fluxes correspond to land or lake surface, according to wind direction
- Providing the first EC data over lake on the TP as far as we know

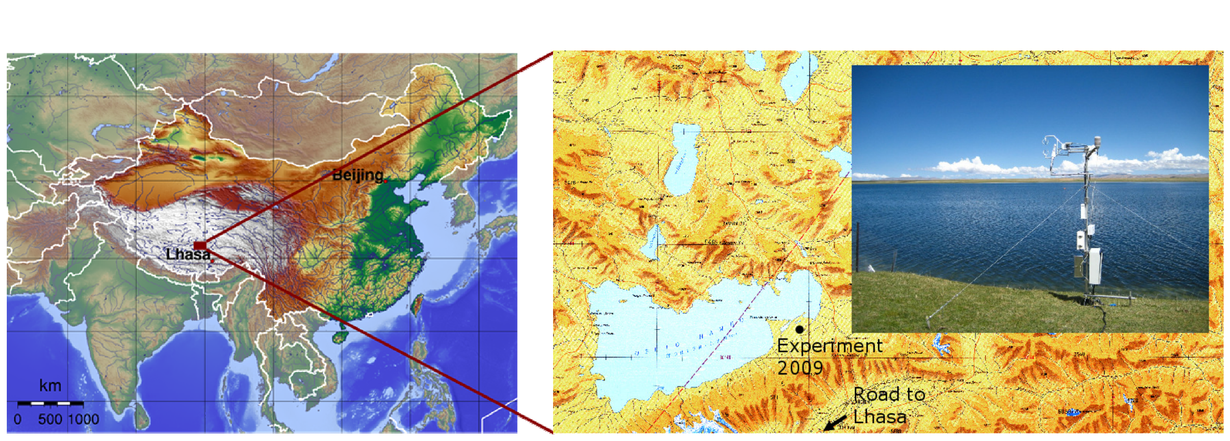

Figure 1: Location of the NamCo-2009 experiment and setup of the EC station.

Data processing

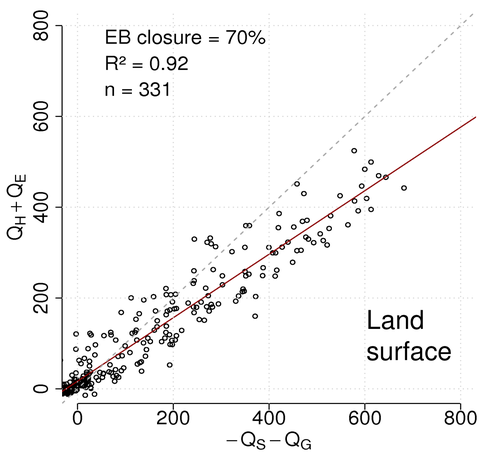

Figure 2: Available energy versus turbulent fluxes for the shoreline grassland surface

- state of the art flux corrections
- quality filtering
- footprint analysis
- energy balance closure (EBC) for the land surface (Figure 2)
- separation into land and lake fluxes
- EBC correction of land surface fluxes with the Bowen ratio (Twine et al, 2000)
- modelling of land and lake surfaces

Surface modelling

Lake

- Hydrodynamic multilayer (HM) model by Foken (1986).
- Supplemented with a shallow water correction term by Panin et al. (2006)
  → increased turbulent fluxes

Land

- Surface Energy and Water Balance (SEWAB) by Mengelkamp et al. (1999).
- Parameter estimation by in situ measurements, laboratory investigation of soil characteristics and literature values

Both models were forced with standard meteorological in situ measurements.

Results

- Land surface model shows reasonable performance (Figure 3)
- Estimation of energy balance closure above the lake surface problematic due to lack of detailed water temperature and lake depth data
- Lake model achieves reasonable coherence to the observations, but with slight bias for the latent heat flux Q_E
- Best fit of lake model with an assumed lake depth of 2m: reasonable estimate within the footprint of the observations
- Sharp differences in diurnal cycles (Figure 4) are well represented by the models

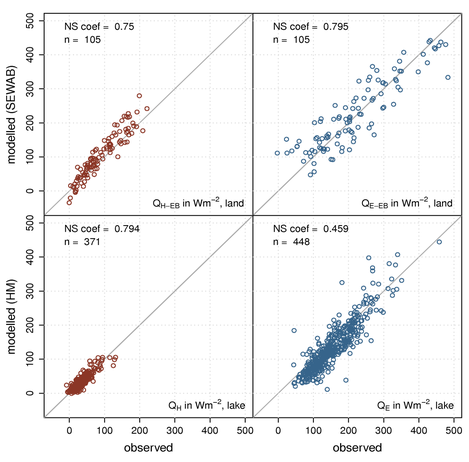

Figure 3: Upper panel: energy balance corrected (EB) fluxes over grass vs. SEWAB model simulations. Lower panel: Turbulent fluxes over lake vs. HM model runs. Model performance is indicated with the Nash-Sutcliffe coefficient.

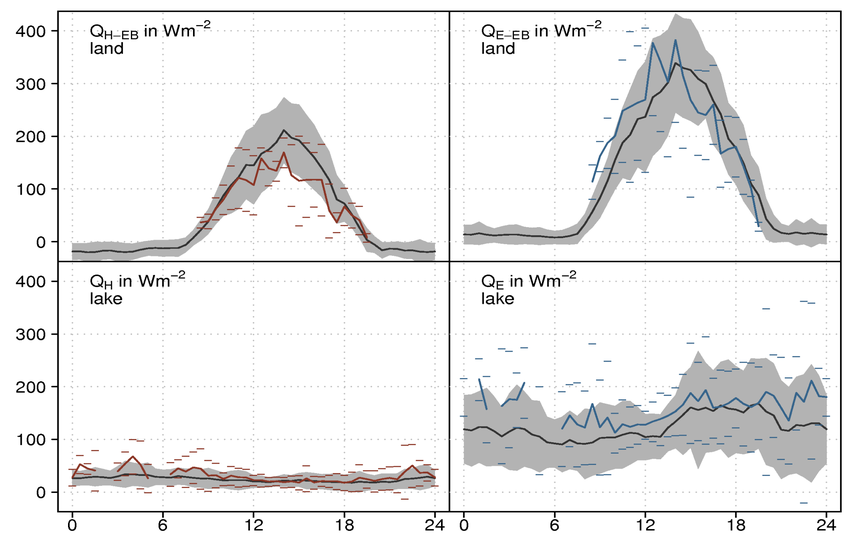

Figure 4: Mean daily cycles for the whole measurement period. Time axis in CST, approx. 2h ahead compared to LT. Observed fluxes are denoted by coloured solid lines, the horizontal bars indicate the respective standard deviation; Black lines show the modelled fluxes with standard deviations given by the grey shaded area.

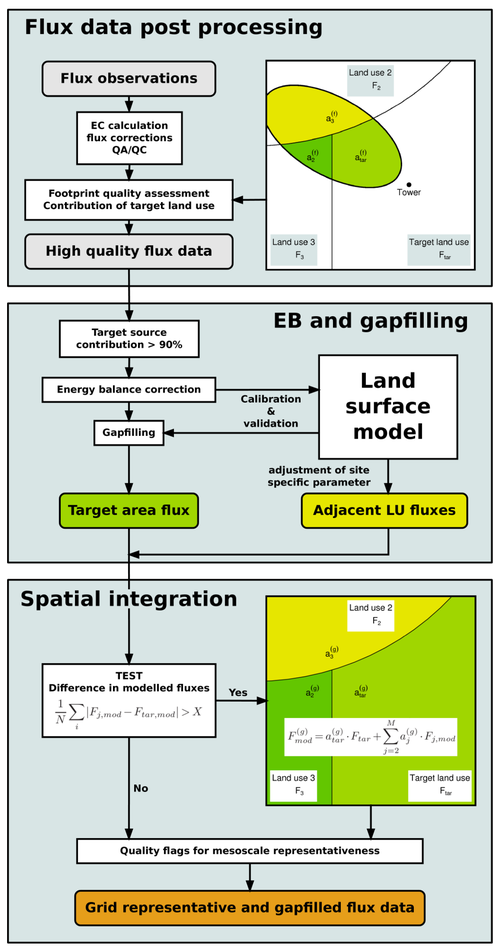

Figure 6: Sketch of an upscaling scheme from target land use measurements to a heterogeneous grid cell utilizing footprint and land surface modelling (Babel et al., 2011)

Outlook

- Gap filled turbulent fluxes for lake and wet alpine steppe available for the monsoon season at Nam Co lake.
- Physically based upscaling approach possible for validation of remote sensing and mesoscale modelling (Babel et al., 2011, Figure 5)
- Further efforts needed in determination of the energy balance closure of EC data above the lake surface

Impact on scientific progress

The surface separated and gapfilled turbulent fluxes provide additional information for up-scaling of ground based measurements and modelling energy and matter exchange above the Tibetan plateau.

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