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Gap Filling of Turbulent Flux Data over a Land and a Lake Surface at Nam Co

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Introduction

This study applies a hydrological multilayer model (HM) and a Surface Energy and Water Balance (SEWAB) scheme as gap filling mechanisms of turbulent flux data from a lake and a land surface, respectively. Eddy Covariance (EC) measurements as conducted within the framework of CEOP-AEGIS from June 27th to August 8th, 2009 at the shore of a small lake (Figures 1a,b) provide basic input for (regional) climate models. Continuous time series are a prerequisite for all models however, at high elevation environments such as the Tibetan Plateau data acquisition is especially challenging (Metzger et al., 2006) therefore suitable gap filling mechanisms are required.

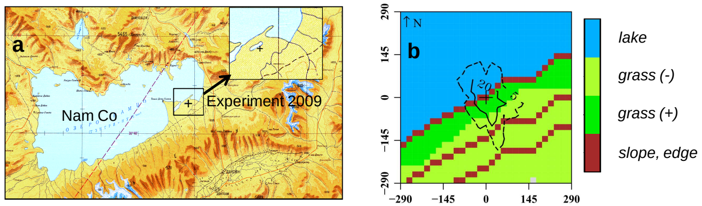

Figure 1: **(a)** *Location of the experimental site at a small lake near Nam Co, Tibet (modified from http://en.poehali.org/maps). The + marks the location of the EC Station.* **(b)** *Footprint climatology of the EC station calculated for all stratification regimes and land use. The solid line encloses 80% and the dashed line 95% of the data. Unit of the x- and y-axis is meters.*

Gap Filling Schemes

Water Model

The original hydrological multilayer model by Foken (1986) computes the energy exchange over ocean surfaces. In order to calculate the turbulent fluxes over the lake surface a correction term for shallow water (Panin et al., 2006) was added:

$$Q_{E,H}^{Lake} = Q_{E,H}^{Ocean} \cdot \left(1 + \frac{2h}{H}\right) \qquad (1)$$

with H being the depth of the lake, h being the mean-square waves height of the lake at measuring point, and $Q_{E,H}^{Ocean}$ and $Q_{E,H}^{Lake}$ being the evaporation or sensible heat exchange of deep water and the evaporation or sensible heat exchange of shallow water, respectively.

SEWAB

The one-dimensional Surface Energy and Water Balance (SEWAB) scheme is similar to many other soil-vegetation-atmosphere-transfer models with respect to the calculation of the turbulent fluxes (Mengelkamp et al., 1999). It is based on the one-layer concept for vegetation with emphasis put on the description of soil processes.

Results

Energy Balance Closure

SEWAB uses an iteration scheme to close the energy budget (EB), therefore the EC measured fluxes were corrected by dividing the residual according to the Bowen ratio and adding it to the corresponding fluxes. For HM this was not done. It appears the model slightly overestimates the fluxes from the lake (Figure 2).

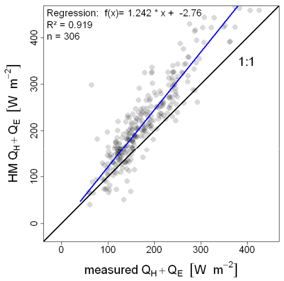

Figure 2: Slight overestimation of the turbulent fluxes (flag 1-3) over the water surface by the water model.

Correlation

Fluxes calculated by SEWAB are highly correlated to the fluxes measured over land (Figures 3a,b). HM results are also in agreement with EC-measured Q_H and Q_E (Figure 3c,d).

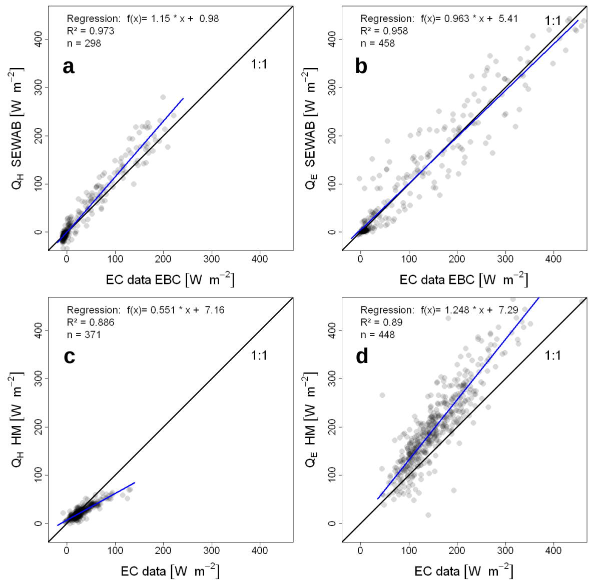

Figure 3: Correlations between EC measured and calculated fluxes. Only high quality EC data (flags 1 to 3) were used. EBC = Data Energy Balance corrected via Bowen ratio. **(a)** *and* **(c)** *Correlations of EC measured Q_H with SEWAB and HM calculated fluxes.* **(b)** *and* **(d)** *Correlations of EC measured Q_E with SEWAB and HM calculated fluxes.*

Time Series

The mean diurnal cycle of Q_E and Q_H (flags 1 to 6, Figure 4) drops at around 6 am. This might be due to changing wind directions. During daytime a steady air flow from lake direction prevailed, occasionally interrupted by winds from the land surface. Generally winds from the land dominated (Figure 1b).

Agreement between EC measured and modeled data are shown in Figures 5a and 5b for July 25th, 2009 (HM) and July 15th, 2009 (SEWAB).

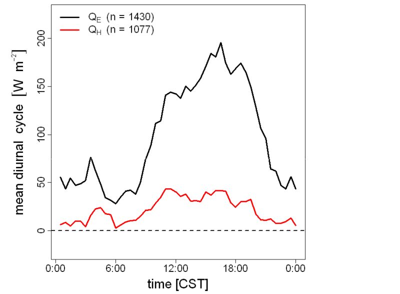

Figure 4: Mean diurnal cycle of Q_E and Q_H over the measuring period. Data with quality flags 1 to 6 were used. CST = Chinese Standard Time.

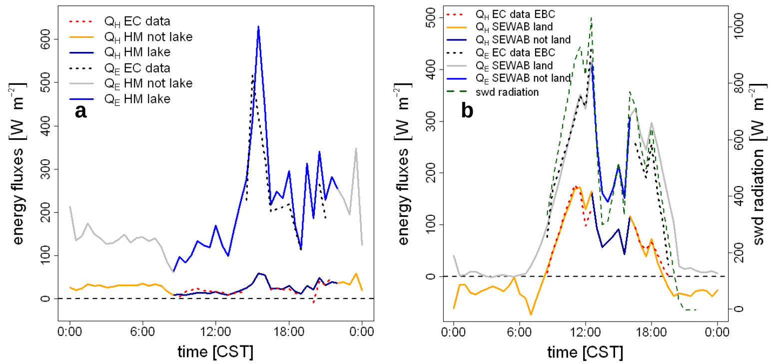

Figure 5: Time series of measured (quality flags 1 to 6) and modeled fluxes at two exemplary days. Different colors indicate varying wind directions. CST = Chinese Standard Time. **(a)** *HM calculated Q_E and Q_H at July 25th, 2009.* **(b)** *SEWAB calculated Q_E and Q_H at July 15th, 2009. The drop in the turbulent fluxes at 12 noon is due to cloud cover and a respective drop of shortwave downwelling radiation.*

Conclusion

- The combination of SEWAB and HM is useful for filling gaps in turbulent flux data that originated from different land use types.
- However, parameterizations were only controlled for certain times of day because of the typical daily flux pattern.
- HM appears to slightly overestimate the turbulent fluxes from the lake, possibly due to an influence from the land surface.
- The parameterizations of SEWAB and HM are site specific, but much more complex for SEWAB.

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