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Modeling Surface-Atmosphere Interactions: A simple, coupled surface model applied at Nam Co Lake

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Surface-Modeling approach

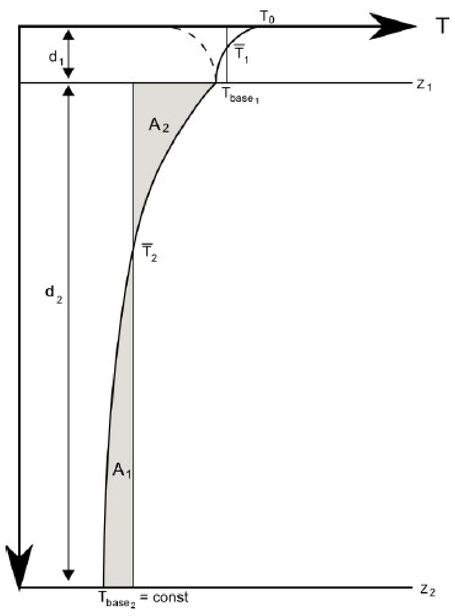


Fig. 1: Conceptional drawing of the assumed quadratic subgrid soil temperature profile

A modified form of the Hybrid Ecosystem model (Friend & Kiang, 1995) is used for the estimation of surface fluxes. Hybrid has two surface layers.

The basic assumption of the modified version is a quadratic subgrid soil temperature profile (Fig. 1) in each soil layer (Gerken et al., 2012).

$$T_{1,2}(z_{\mathrm{rel}}) = a_{1,2}\ \left(z_{\mathrm{rel}} - d_{1,2}\right)^2 + T_{\mathrm{base}_{1,2}}$$

Initial parameters Tbase,2, a1/2 are derived from the measured soil heat content:

$$a_1 = \frac{\frac{E_1}{c_{\mathrm{ps},1}} - d_1 T_{\mathrm{base}_1}}{\frac{-z_1{}^3}{3}} \qquad a_2 = \frac{\frac{E_2}{c_{\mathrm{ps},2}} - d_2 T_{\mathrm{base}_2}}{\frac{d_2{}^3}{3}}$$

Offline flux calculations

- A good agreement between observed and modeled fluxes was reached for off-line flux calculation (Fig 2.a+b).
- Improved fit compared to original surface model version.

1) Moist site with lake-breeze influence

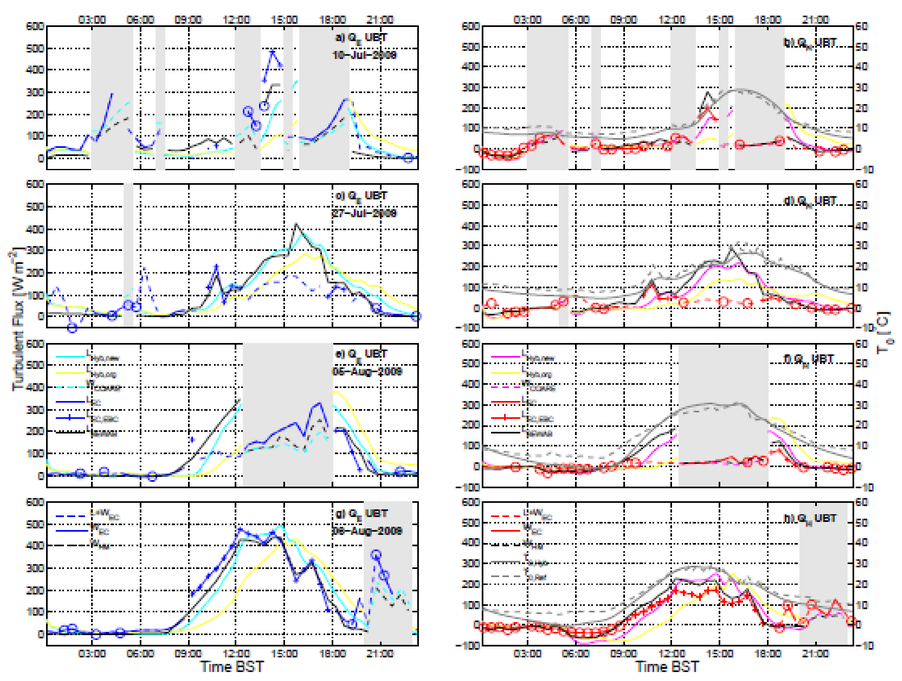


Fig. 2a: Comparion of turbulent fluxes measured and modeled (original and modified Hybrid) at Nam Co Lake UBT site

2) Dry site without lake-breeze influence

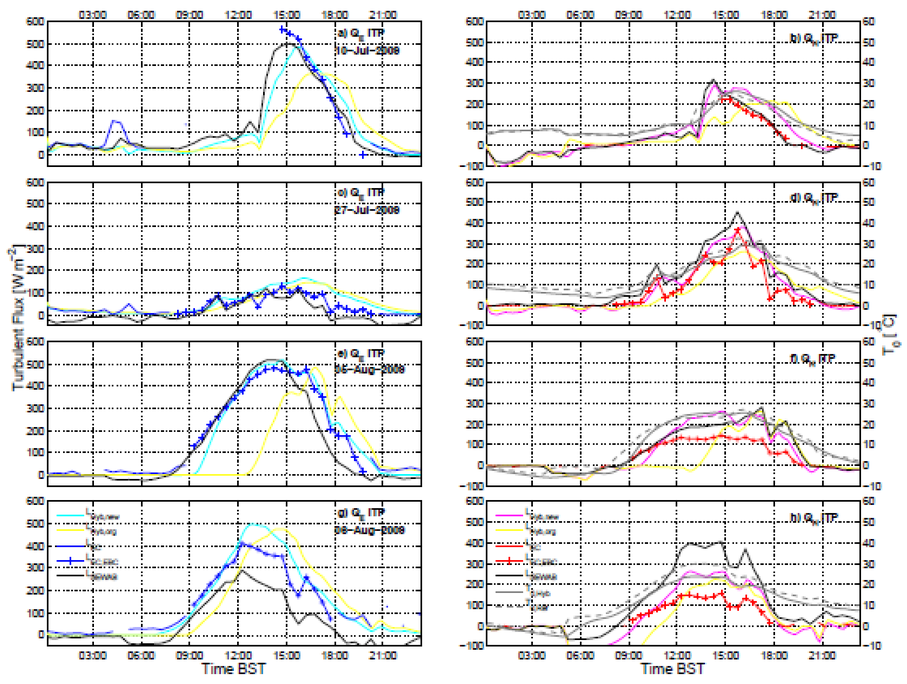


Fig. 2b: Comparion of turbulent fluxes measured and modeled (original and modified Hybrid) at Nam Co Lake UBT site

At Nam Co Lake 4730 m a.s.l. on the Tibetan Plateau local and regional circulation is influenced by the large water body, the SW-NE oriented *Nyenchen Tanglha* mountain range and the large land surface fluxes. We investigate those processes at Nam Co Lake. The surface is characterized by Alpine Steppe with moist surfaces close to the lake.

Motivation

- What are the relationships and feedbacks between solar radiation, turbulent heat fluxes and boundary layer clouds?
- Under which conditions (vertical profiles, surface initializations) do mesoscale circulations develop?
- What are the contributions of such circulations to transport of energy and moisture from the lake to the surrounding mountains?.
- How does topography interact with the Lake Breeze?
- For this we use a cloud resolving model at high resolution coupled to a fast reacting surface model.
- As the Hybrid has only two layers, the surface model was modified to react faster

The Modeling System

The cloud resolving Active Tracer High Resolution Atmospheric Model (Oberhuber et al, 1998) coupled to the Hybrid two layer surface/ecosystem model.

- Transport of passive and active tracer (atmospheric trace gases, water vapor, ice and water particles, …)
- Modules for turbulence, cloud microphysics (Kessler), LW and SW radiation.
- Very high resolutions in space and time possible (Order: Δx =100 m, Δt = 2s).

Model Initialisation

- Flux calculation is dependent on realistic surface temperature.
- Theoretical parameter space for surface temperatures is much greater than the realistic parameter space.
- As surface temperature is modeled as a function of layer heat contents, careful model initialization is needed.
- Soil initial energy content and thus layer temperatures were estimated from interpolated soil temperature measurements.

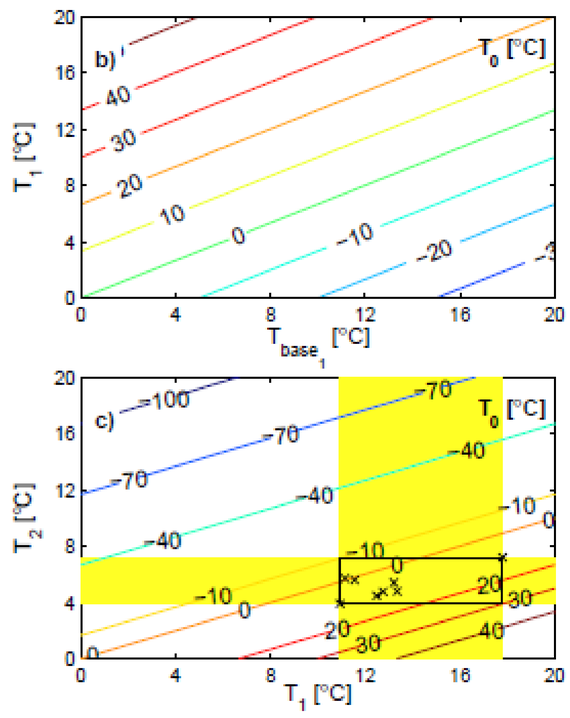
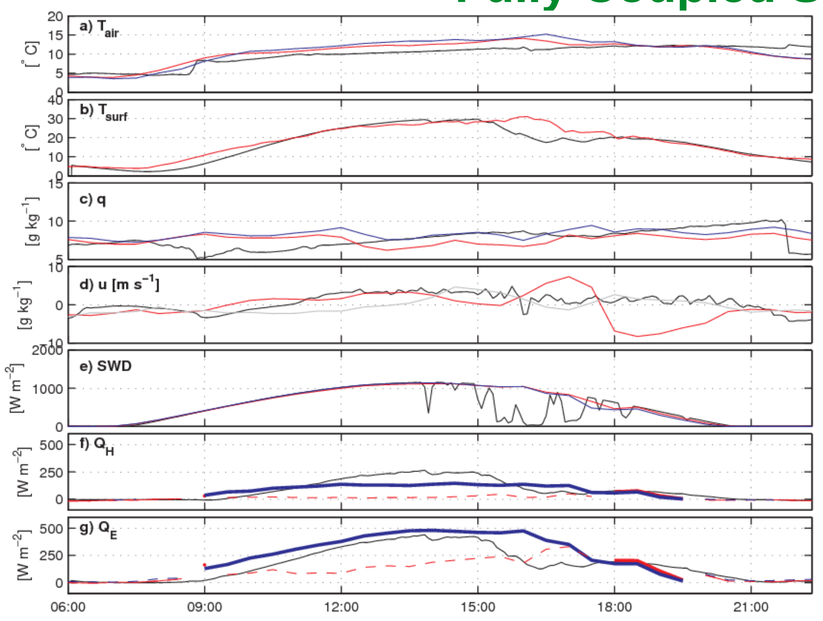


Fig. 3: Dependency of soil temperature parameters on model initialization. The black rectangle indicates the theoretical parameter space and the black crosses mark the actual configurations.

Fully Coupled Simulation



- Current work is focused on the fully coupled surface-atmosphere interactions.
- This adds many more degrees of freedom in a high resolution, cloud resolving model.
- Realistic model initialization is difficult

Fig. 4: Comparison of modeled and measured atmospheric and surface variables with the 2D interactive model for August 05, 2009 for two locations at Nam Co Lake. Atmospheric quantities are scaled to measurement height. Measured fluxes are not energy balance closed.
Due to model resolution both wet and dry site are located in the same grid cell. ***Modeled: Black****, Dry site: Blue, Wet site: Red*

Conclusions

- The surface model performance was increased significantly with a modified surface formulation
- Offline fluxes are close to observations and coupled simulations produce reasonable results.
- The initialization of both the surface and the atmosphere above is key for success
- Coupled model results are in line with expectations, but do not necessary resemble observations due to lack of observational data.
- Development of mesoscale system is strongly influenced by local conditions
- This project is not about modeling specific days or exact structures, but about exploration about the sensitivities of such a system

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References:
Gerken et al. 2012: DOI 10.5194/hess-16-1095-2012 ⊟ Get the Paper⊟
Friend & Kiang 95: 10.1029/1999GB900085;
Oberhuber et al. 98: 10.1016/S0377-0273(98)00099-7

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