TiP Atmosphere Ecology Cluster

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Surface-Atmosphere Interactions: Mesoscale Circulations at Nam Co Lake

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Introduction

The Tibetan Plateau (Fig. 1) has been known for a long time as one of the most influential factors on regional climate. It may not be the main driving force of the monsoon circulation, but certainly is one of its influencing factors. Due to its high elevation and the clean atmosphere solar irradiation is very high as long as no clouds are present. This leads to strong turbulent surface fluxes that carry energy, momentum and water into the atmosphere above (Fig. 2).

Such local processes are highly variable and depend on local influences of topography, surface conditions and water availability. Surface-atmosphere interactions and the development of mesoscale circulations play an important part in the energy balance of the plateau. We investigate those at Nam Co lake.

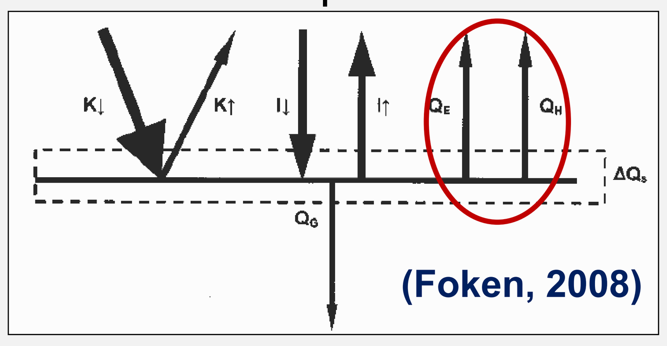

Fig. 2: Concept of surface energy fluxes with shortwave (K), long-wave (I) radiation and its distribution into turbulent fluxes of heat (Q_H) and water vapor (Q_E) being dependent on surface conditions

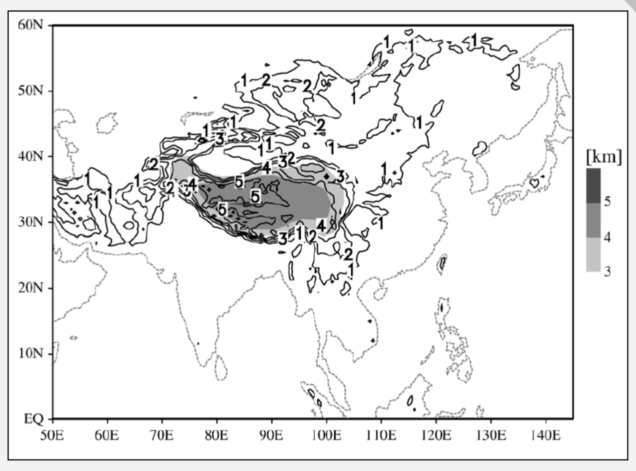

Fig. 1: The Tibetan Plateau and its elevation(shaded - Cui et al., 2006).

Research Questions

Our high resolution modelling approach aims at:

- Investigating the relationship and feedbacks between solar radiation, turbulent fluxes of sensible and latent heat and the development of boundary-layer clouds
- Process studies of mesoscale circulation development with complex terrain
- Explore the conditions at which such thermal circulations develop
- Quantify the contributions of such circulations to transport of energy and moisture from the lake to the surrounding mountains.
- Further development of Active Tracer High-resolution Model

Study Area

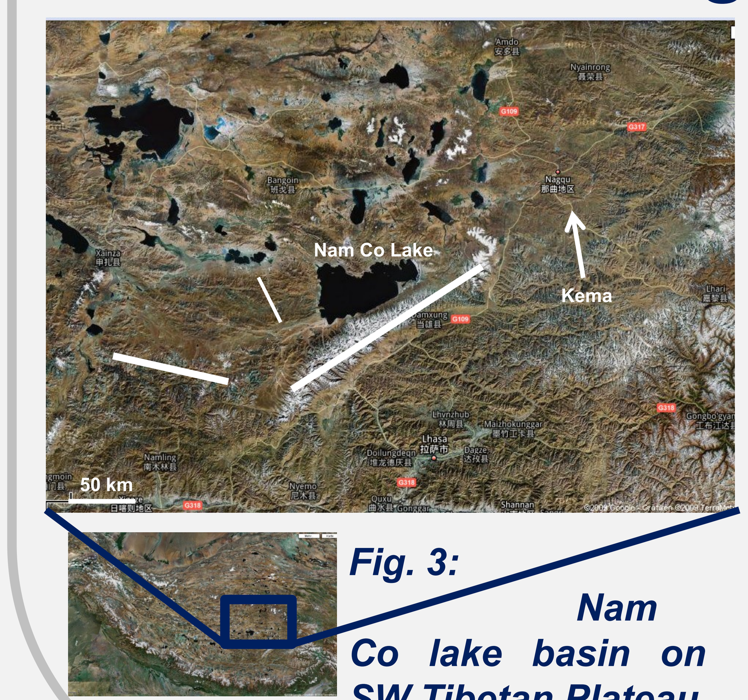

Fig. 3: Nam Co lake basin on SW Tibetan Plateau © pic: google maps

The Nam Co lake (Fig 3. - surface area: ~1920 km²) basin is situated at approx. 4730 m altitude on the southwest Tibetan Plateau, north of the *Nyenchen Tanglha* mountain range, which is has its highest peak at 7162 m.

In summer 2009 a field campaign was conducted from June to August with eddy covariance measurements in order to gather turbulent energy fluxes and the components of the surface energy balance at the south shore of the lake close to the multi-sphere observatory of ITP.

Modelling Approach

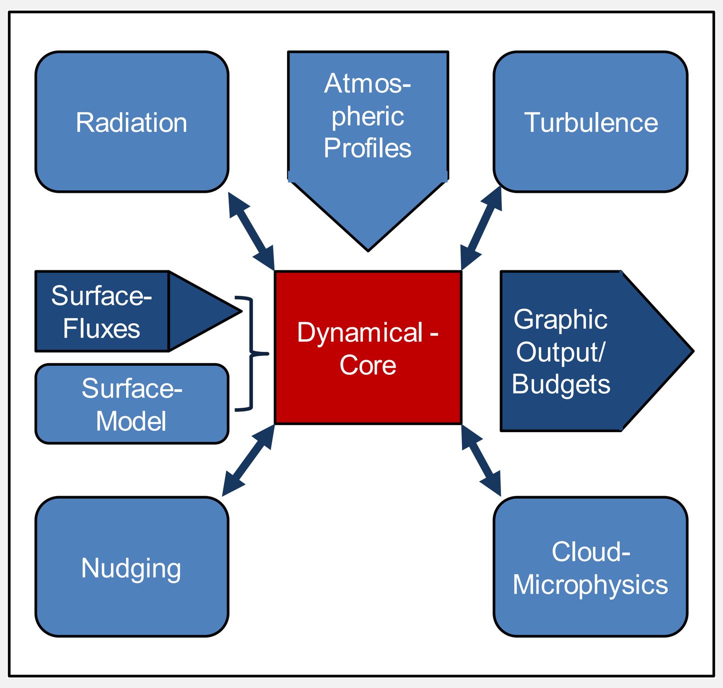

Figure 4: Modular structure of the ATHAM model, simulating the transport of active tracers and convective events (Herzog et al., 98 ; Oberhuber et al., 2008)

The cloud resolving Active Tracer High Resolution Atmospheric Model (ATHAM - Fig.4) is used and developed by the University of Cambridge.

Features:

- 2D/3D stretched Cartesian grid
- Transport of passive and active tracer (atmospheric trace gases, water vapor, ice and water particles)
- Modules for turbulence, Cloud Micro-physics (Kessler), LW and SW radiation.
- Very high resolutions in space and time possible (i.e. 100 m).
- Surface-model for interactive surface-fluxes: Hybrid (Friend & Kiang, 1995)

We conducted 2-D preliminary studies in order to test the model for its suitability in this complex and challenging environment. These tests included varying degrees of idealization. The next step will be the extension to 3D. For this study we used the fully coupled land surface model complex with a resolution of 250 m at the centre of the model domain, topography was taken from ASTER DEM with ca. 90 m resolution and the vertical profile was modified from GFS-FNL data. The simulation commenced on 6:00 BST. Maximum time step was 5 seconds..

Results

Nam Co shows a clear see breeze circulations system that develops almost every day (Fig. 4). There is only a few days where no such system develops.

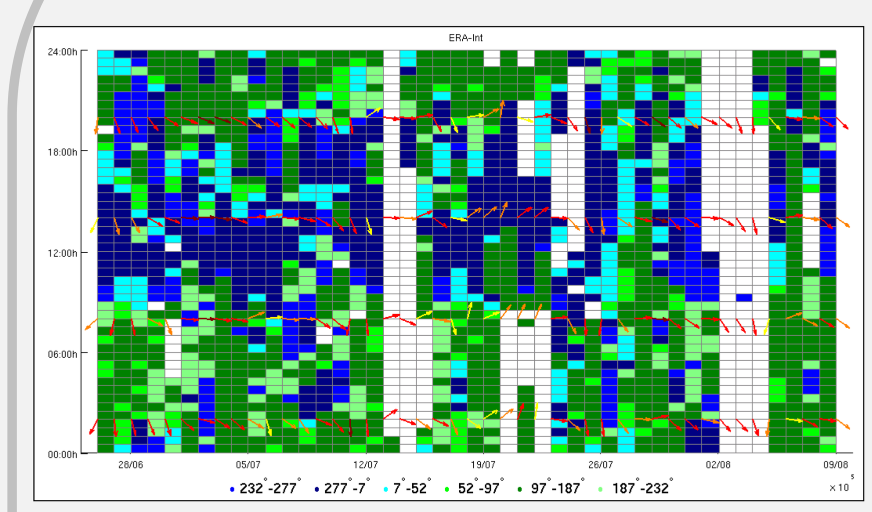

Fig. 4: Circulation Regime at Nam Co Surface wind dir (boxes) and ERA 40 wind at 500 hPa (Arrows, color indicates wind speed)

We tested our surface model (Hybrid) against measured fluxes (Fig. 5) and a SVAT Model (SEWAB). It is clearly visible that the fluxes are in reasonable comparison with each other.

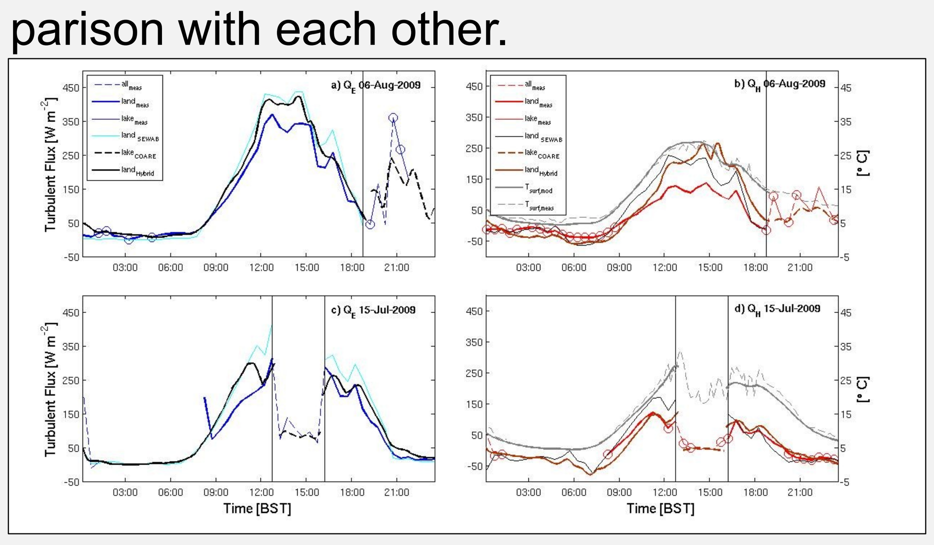

Fig. 5: Comparison of modeled and measured fluxes

The development of a temperature gradient at the land lake interface leads to development of the lake breeze (Fig. 6). LB onset is about 11:15 and the maximum occurs ~14:15 BST. Modeled speed and inland penetration are of reasonable values. Convective rolls interact and create vertical movement of air that first leads to the development of boundary-layer clouds and later potentially to deep convection.

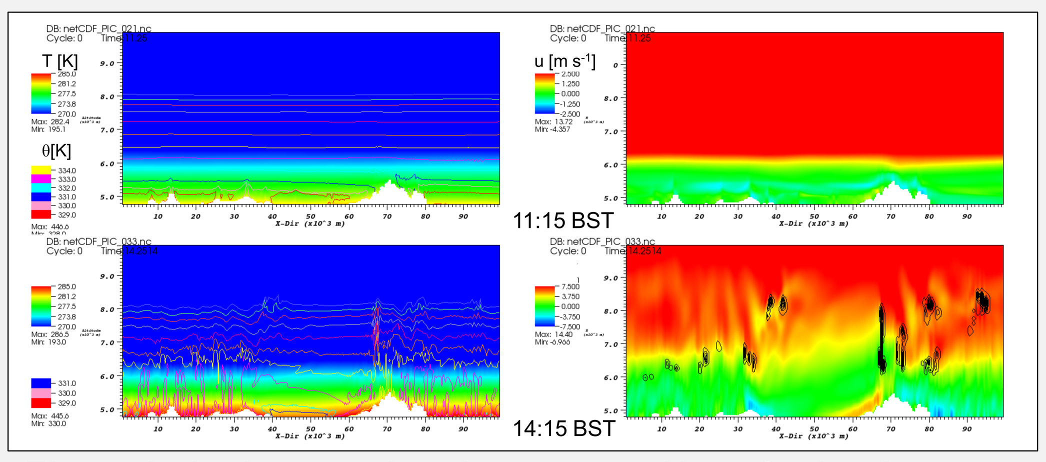

Fig. 6: Lake breeze development at Nam Co basin

This is displayed in Figure 7. The solar irradiation and the resulting fluxes of latent and sensible heat lead to the generation of convective up-drafts. Further heating and the release of latent heat may lead to deep convection above mountains. The atmospheric moisture partially comes from the lake

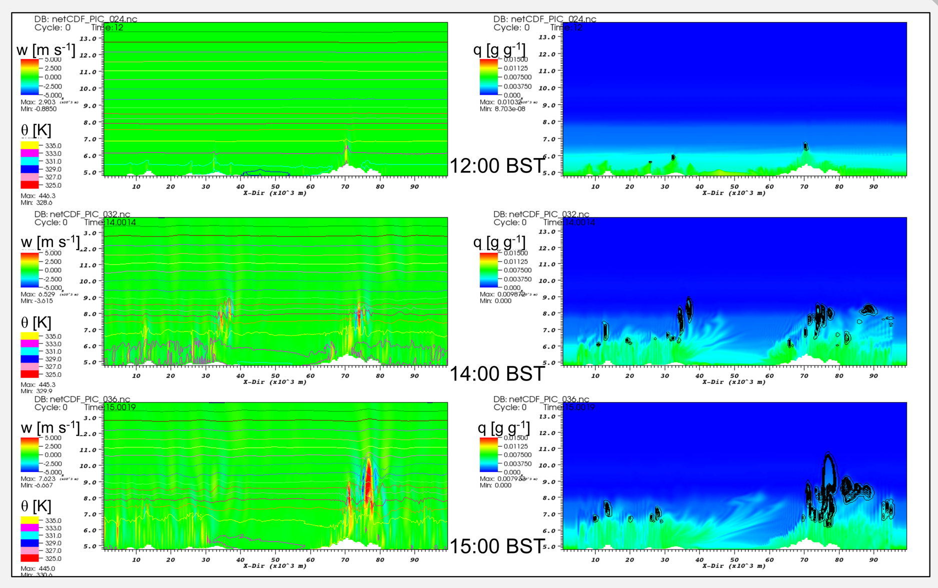

Fig. 7: Convection development at Nam Co basin

Clouds and the circulation will impose a feedback on surface processes and thereby determine the further development of such a system. The interaction of small scale clouds, that are not resolved by regional models and their impact on the surface energy balance may even be of importance for the plateau scale.

It should be noted though that actual atmospheric processes are extremely dependent on the actual vertical state of the atmosphere. Such data is quite variable with due to topography and local processes on the plateau.

Conclusion

The high resolution modelling approach is suitable, but requires careful initialization. Next step will be the extension to 3D and the further exploration of the system.

Acknowledgments:
This work is funded within the framework of DFG-SPP 1372: Tibetan Plateau Research – Formation Climate Ecosystems and the Atmosphere, Ecology, Glaciology Cluster therein . ASTER GDEM is a product of METI and NASA, GFS-FNL is provided by Computational and Information Systems Laboratory (CISL) at the National Center for Atmospheric Research (NCAR).

7th Sino-German Workshop on Tibetan Plateau Research
Hamburg, Germany, March 3th - 6th 2011

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funded by: Deutsche Forschungsgemeinschaft DFG