High resolution atmospheric modelling on the Tibetan Plateau : How to understand a system with sparse observations?

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The Tibetan Plateau is a key environment for global change

- The Tibetan Plateau **(Fig. 1)** is located north of the Himalaya, it is the world's largest mountain highland and has a mean elevation of more than 4500 m with large parts covered by *Kobresia* pastures.
- Important for regional climate as largest glaciated area outside the poles (3rd pole) **(i.e. Qui, 2008),** source region of East-Asian river systems with > 1.5 billion people living in their catchments (water towers for humanity) **(i.e. Immerzeel, 2010)** and modifier of monsoon circulation **(Boos & Kuang, 2010).**
- The surface energy balance **(Fig. 2)** is very variable and depends on local influences of topography, cloud cover and soil moisture.
- The surface energy balance is important for weather and climate.

→ Crucial to get it right

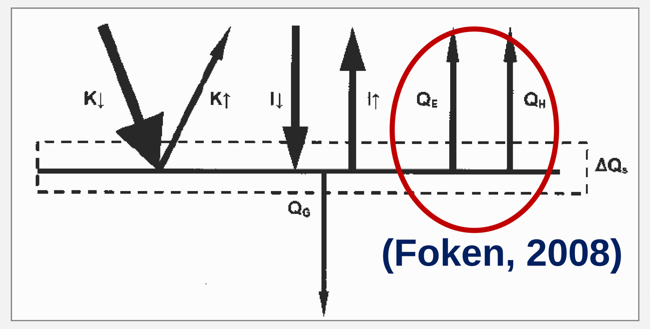

Fig. 2: Concept of surface energy balance with shortwave (K), long-wave (I) radiation and its distribution into turbulent fluxes of heat (Q_H) and water vapor (Q_E) being dependent on surface conditions

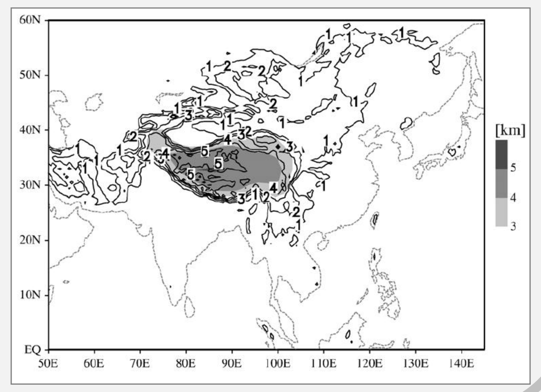

Fig. 1: The Tibetan Plateau and its elevation (shaded - Cui et al., 2006; Glob. Plan. Change).

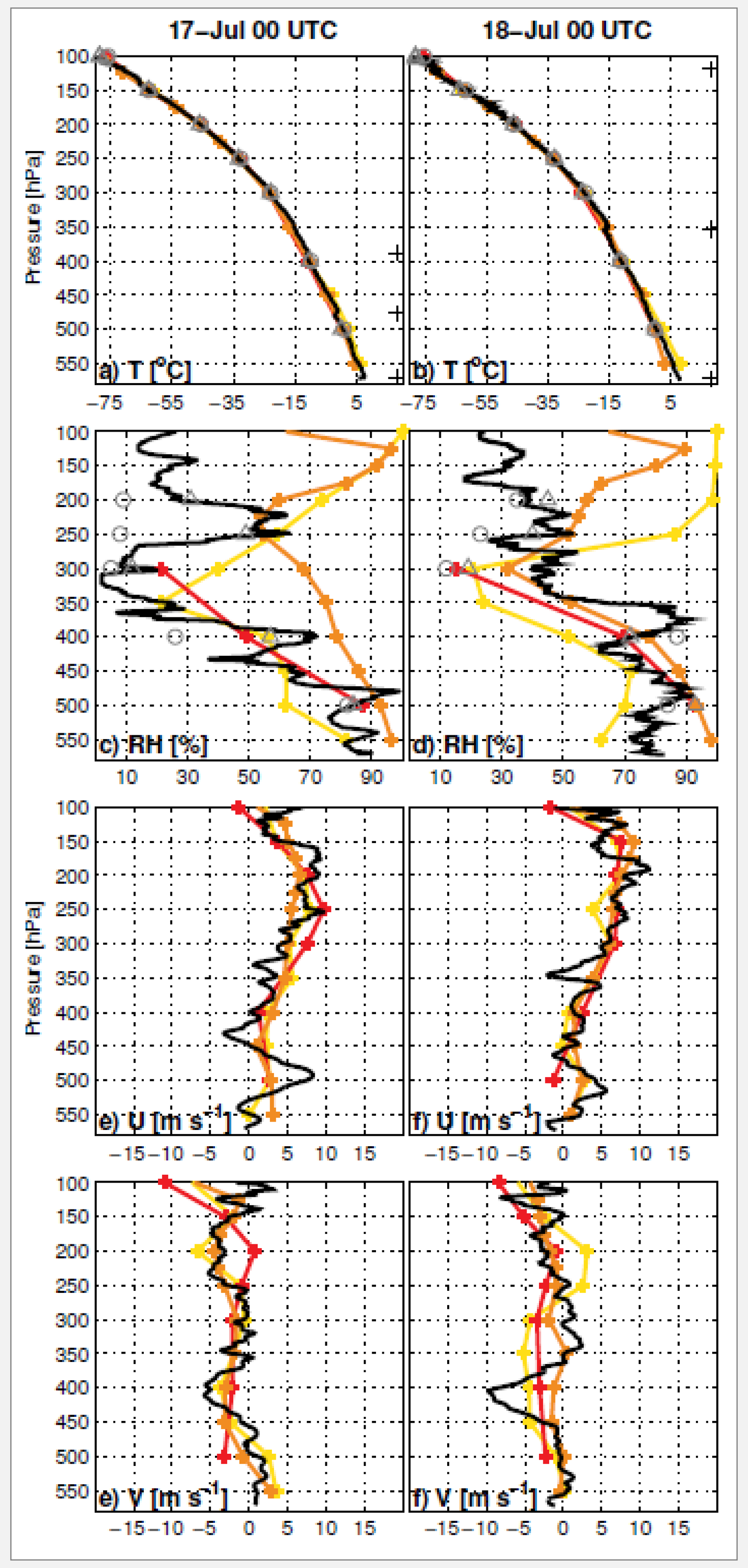

Fig. 7: Atmospheric profiles for Nam Co station on 17+18.7.2012, from radiosondes , NCEP-I , ERA-Int , GFS-FNL (Gerken et al., 2013b, subm. JGR)

- There is a large uncertainty for model boundary conditions: Both for the atmosphere **(Fig. 7)** and for the surface.
- We have shown that our modelling approach is capable of reproducing the most important interactions between the surface and the atmosphere and atmospheric dynamics **(Fig. 8)**.
- Using different atmospheric conditions: Radiosondes and gridded data products as commonly used for climate research, the model produces very different convection developments (*e.g. thunderstorms*) and amounts of rain **(Fig. 9)**
- Thus, through cloud surface interactions, the surface energy balance is quite different **(Fig. 10)** **→ Large uncertainty**
- Typically not represented in coarser resolution models as clouds are not resolved and profiles are taken from stock

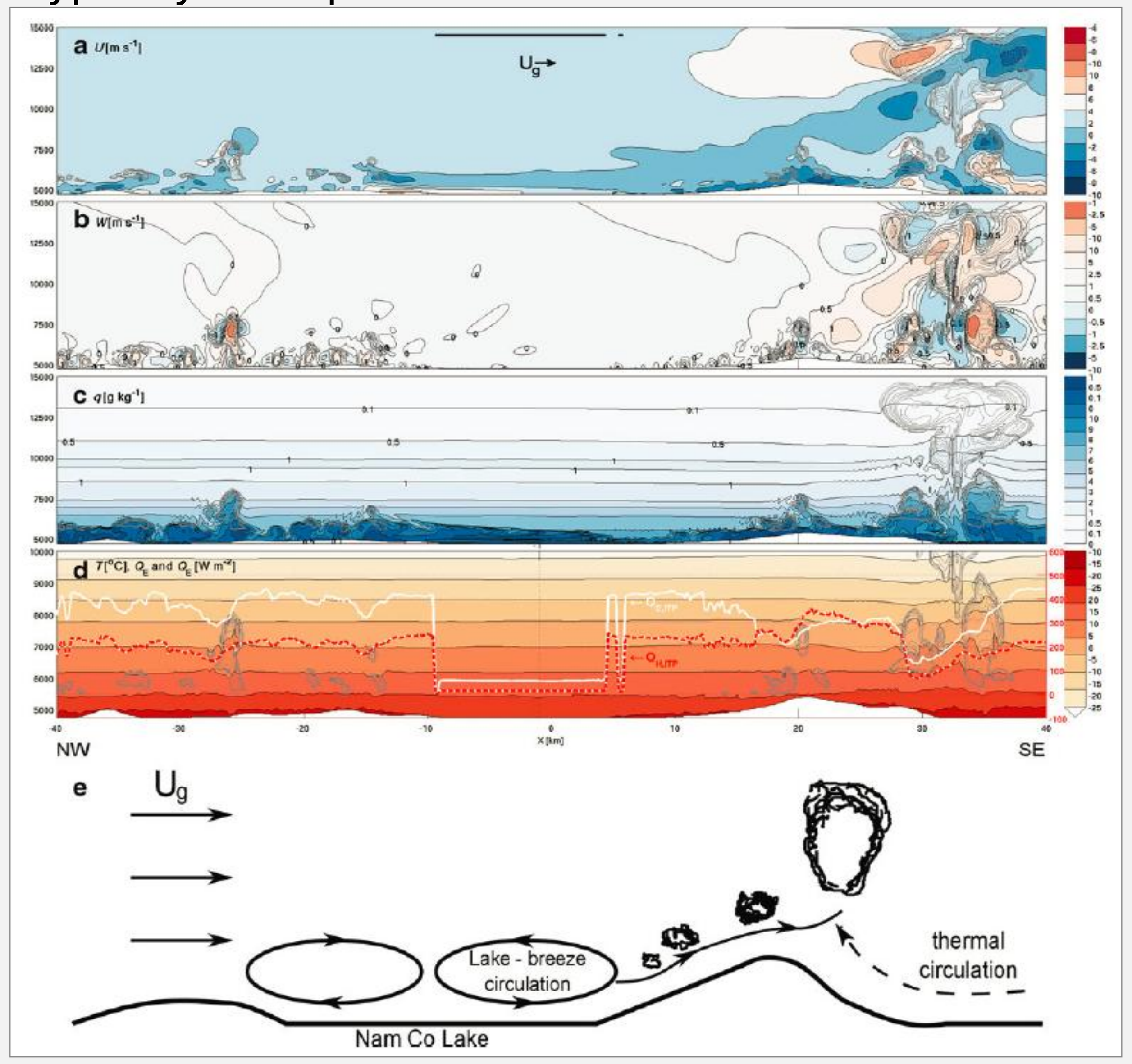

Fig. 8: Illustration of convection development at Nam Co Lake for 6.8.2009 (Gerken et al., 2013a, Theor. Appl. Clim.)

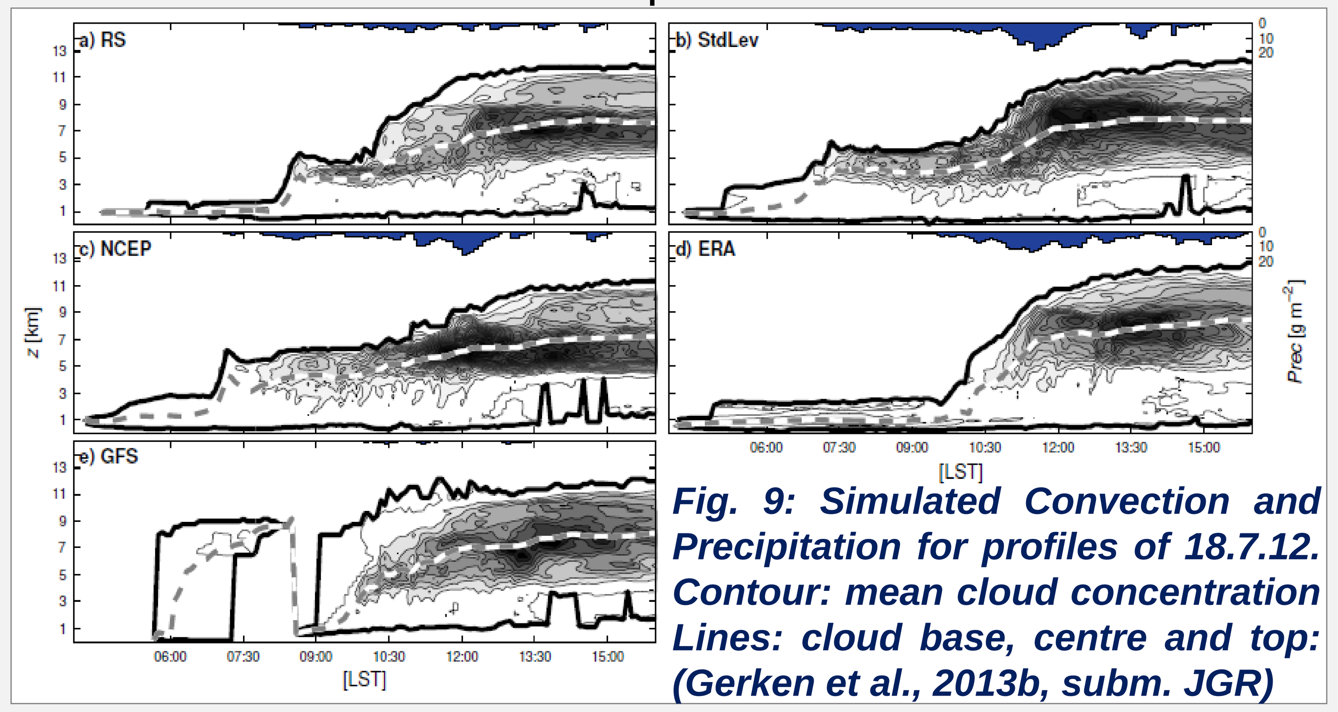

Fig. 9: Simulated Convection and Precipitation for profiles of 18.7.12. Contour: mean cloud concentration Lines: cloud base, centre and top: (Gerken et al., 2013b, subm. JGR)

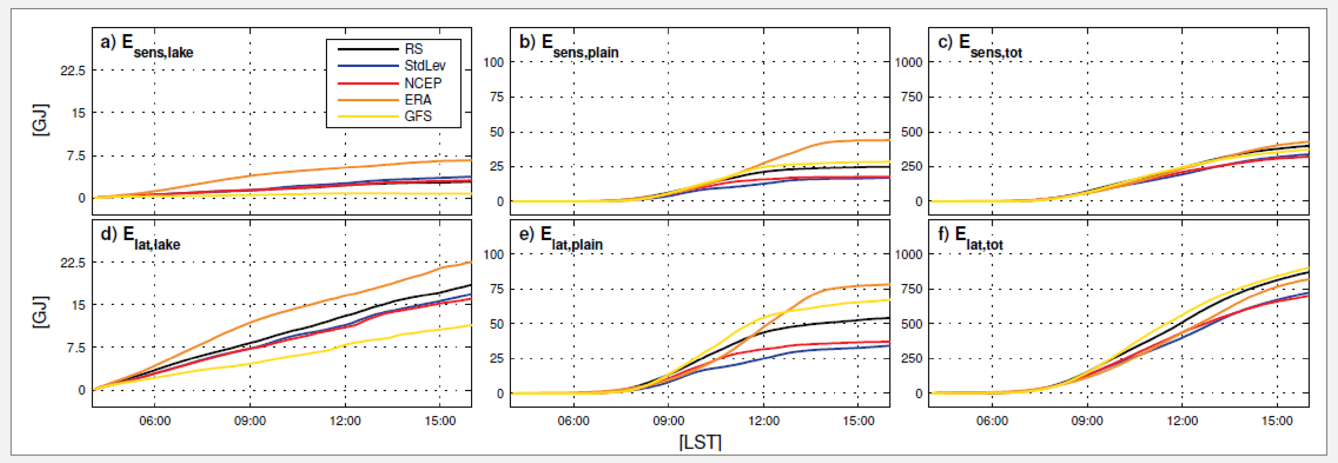

Fig. 10: Simulated surface energy transfer for lake, plain area and total domain for profiles of 18.7.12 (Gerken et al., 2013b, subm. JGR)

→ Large uncertainty of measurements due to remote location and complex terrain.
→ "Normal" models are too coarse to resolve topography, clouds and use very uncertain input data.
→ This leads to systematic errors in simulated surface energy balance and weather.
→ Thus, novel approaches are needed to investigate uncertainties for climate.

Sparse Observations = Uncertain Models

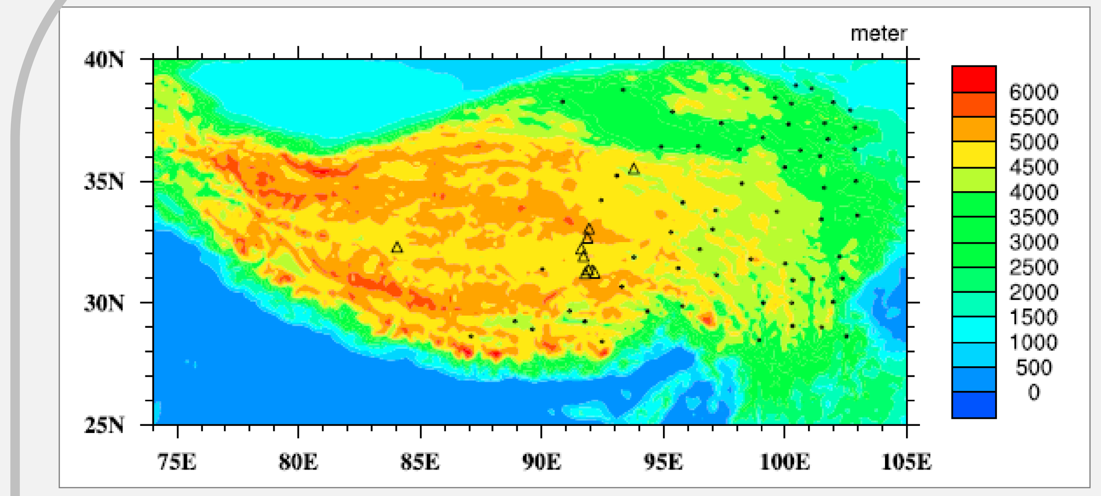

Fig. 3: Topography and locations of weather stations (CMA: dots, CAMP: triangles) on Tibetan Plateau (Wang & Zhang, 2012; JGR)

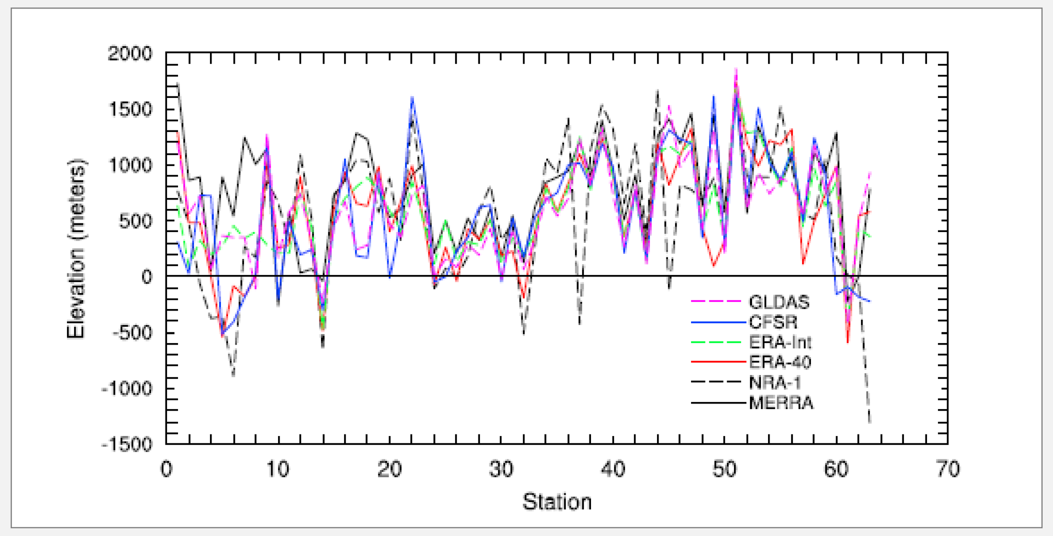

Fig. 4: Surface elevation differences between reanalysis grid cells and station locations. (Wang & Zhang, 2012; JGR)

- Tibetan Plateau is a remote area with very complex terrain and variable surface conditions.
- This means that access and running high quality, continuous measurements is difficult and station locations are often not chosen for representativeness of an area, but facility of access.
- Weather stations are concentrated in the "populated" and lower eastern TP **(Fig. 3)**.
- Stations are usually at lower elevation than corresponding reanalysis grid cell **(Fig. 4)** and no permanent stations above 4800 m **(Maussion, 2011)**
- Reanalysis and satellite data not reliable and often with coarse resolution like degree scale (1°≈100km)

High Resolution Modelling at Nam Co Lake

- Mesoscale models typically operate on ~10 km resolution, which is too coarse to adequately represent topography. Input information is even coarser.
- High resolution studies in order to estimate behavior and sensitivities of system.
- Our area of interest is the Nam Co Lake basin **(Fig. 5)** 4730m above sea level and surrounded by mountain chains up to 7000 m high.
- We use the Active Tracer High-resolution Atmospheric Model – ATHAM **(Herzog et al., 1998 ; Oberhuber et al., 2008)** for 2D simulations with 200 m horizontal resolution .
- Simulation of daily cycles: Surface fluxes driven by solar radiation lead to the evolution of fair weather clouds to convection (tall clouds with precipitation) **(Fig. 6)**.
- Investigation of the influence of atmospheric and surface conditions.

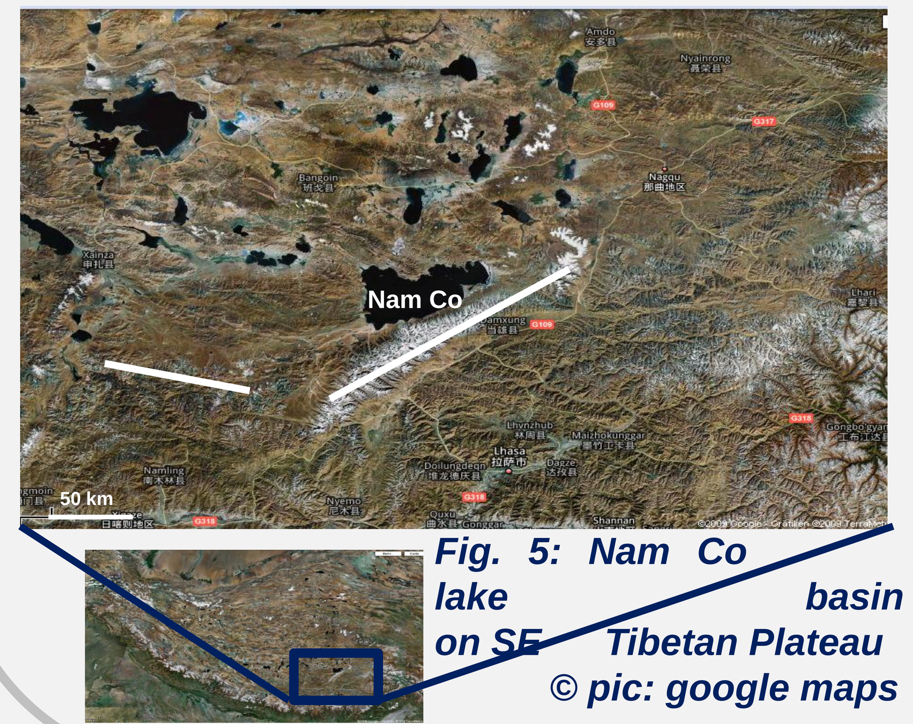

Fig. 5: Nam Co lake basin on SE Tibetan Plateau © pic: google maps

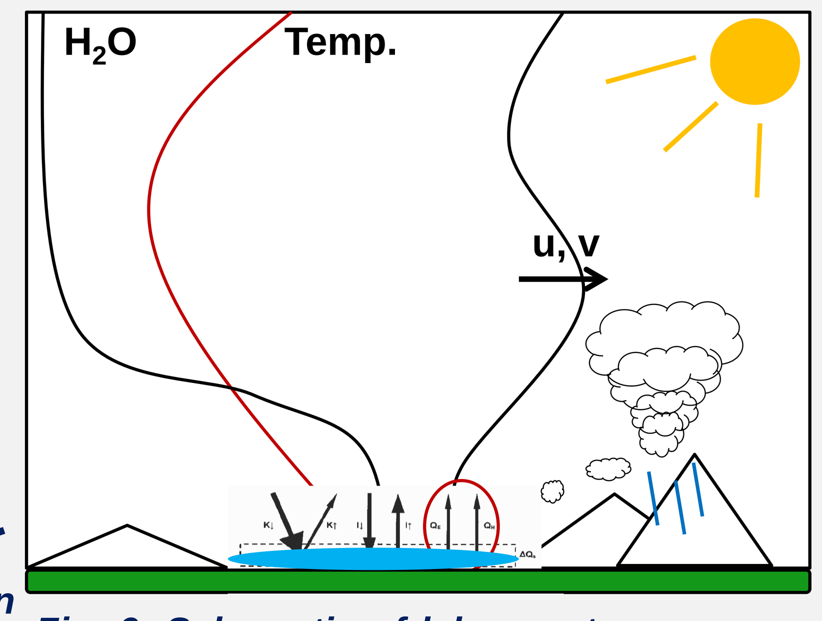

Fig. 6: Schematic of lake, pasture, mountain system: Nam Co Lake and evolution from small clouds to convection.

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