Estimation of spatial high resolution temperature fields for the Tibetan Plateau and the adjacent lowlands based on an elevation and bias corrected ERA-Interim Data Set

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Since near surface temperature is one of the main parameters controlling environmental processes, temporal and spatial high resolution information about its mean values, its variability and its rate of change is required for many ecological investigations and modeling approaches. This is e.g. the case for the investigation of timberline dynamics in the Rolwaling Valley / Nepal within the framework of the DFG-funded Project TREELINE. Likewise our partners in the BMBF-funded Project CLASH (*Climate variability and landscape dynamics in Southeast-Tibet and the eastern Himalaya during the Late Holocene reconstructed from tree rings, soils and climate modeling)* require high resolution temperature data for the exploration of ecosytem dynamics. Due to the fact that meteorological stations are sparsely distributed in high mountain environments, the variability of near surface air temperature is not sufficiently represented by observations. Hence climate model output data with limited spatial resolution are frequently used. Facing the growing demand for spatial high resolution temperature data we present a SAGA-GIS-based approach to improve the resolution of climate model and reanalysis data by means of elevation and bias adjustment. The methods are subsequently applied to estimate daily temperature fields for the Tibetan Plateau and the adjacent mountain ranges with a grid size of 1 by 1 km and sufficiently evaluated using available observations.

Since low resolution climate models do not satisfactory represent the topographical variety of mountain regions, a systematic bias of modeled temperature data arises. Most meteorological stations are situated in valleys with elevations beyond the corresponding grid cell, thus observed temperatures tend to be warmer than climate model results. Frequently the elevation induced bias of climate model output data is adusted by means of an invariant laps rate of 0.65 °C / 100 m, however measured laps rates in complex terrain highly depend on the synoptic situation and hence vary in different seasons [1]. Methods which consider the current stratification of the atmosphere derived from climate model intern temperature profiles seem to be promising alternatives since they allow e.g. the reproduction of inverse atmospheric temperature profiles, which occur mainly during winter [2].

Based on that assumption, we processed daily ERA-Interim reanalysis fields on different pressure levels (1000, 925, 850, 700, 600, 500, 300 and 200 hPa) to estimate the temporal variability of laps rates and subsequently calculated near surface temperature fields for the Tibetan Plateau and the main mountain ranges of High Asia with spatial high resolution for the period from 1989 to 2010.

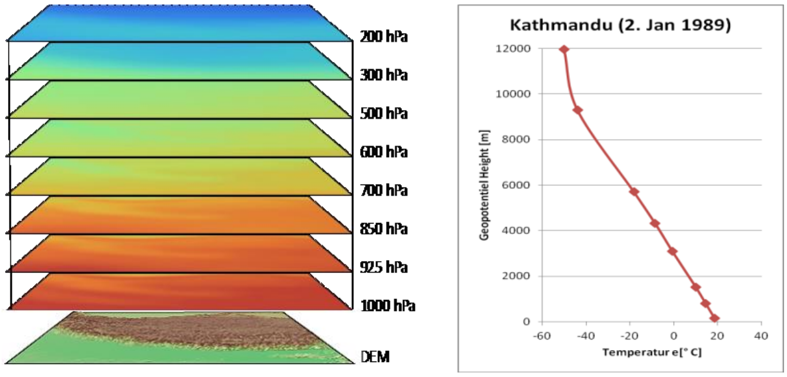

Fig 1: Temperature fields of different ERA-Interim pressure levels for Jan 2nd 1989 and the derived temperature profile for the location of Kathmandu (27°42'N 85°20'E)

The ERA-Interim fields for temperature and geopotential height were used to apply a third order polynomial regression which enables us to estimate local temperature profiles (see Fig. 1). In conclusion the free atmospheric temperature at ground level was calculated using the local regression functions.

The results of the altitude corrected ERA-Interim data set were subsequently compared with daily in situ observations of 78 MetStations. Since the altitude correction approach generates free atmospheric temperatures without accounting for surface energy balance processes, residuals were remarkable high, with values up to 6°C. For all stations a seasonal cycle of residuals could be identified. While in winter the in situ observations tend to be colder than the modelled values, a warm bias is characteristic for the summer season. The cycle of residuals was found to be most pronounced on the Tibetan Plateau which is supposed to be due to high rates of incoming solar radiation. For the adjustment of those residuals monthly mean values were calculated and spatially interpolated.

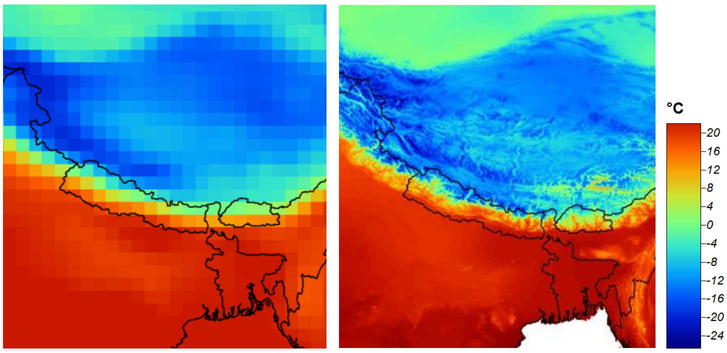

Fig 2: Near surface temperature distribution of the ERA-Interim Reanalysis with a resolution of 0.7 by 0.7 ° ; Right: result of the altitude and bias correction approach for Jan 2nd 1989.

By means of the presented methods the quality of climate model output data can be significantly improved. The representation of the elevation determined distribution of near surface temperatures in the highly structured target area is well represented by the altitude and bias corrected ERA-Interim data set (see Fig 2). The rmse of modeled daily temperature was found to be less than 2°C for almost all available MetStations. Thus the approach clearly outperforms simple altitude adjustment methods based on an invariant laps rate (with rmse values of up to 6°C).

Based on the elevation and bias adjusted data set, the spatial and seasonal distribution of temperature trends in the target area was investigated and evaluated using available observations. The largest trend magnitudes were found during winter and premonsoon season, particularly in the high elevations of the Tibetan Plateau and the bordering mountain ranges. During summer and postmonsoon season the detected trends are in general smaller with maximum values in the lowlands of India and the Tarim Basin.

The presented methods have been implemented in the FOSS-GIS platform SAGA as a complete tool and were recently published [3].

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