Late Quaternary changes in vegetation, Indian monsoon and westerly circulation derived from pollen data from the Himalayan Lake Tso Kar, NW India: *An attempt of quantitative reconstruction and comparison with model simulation results*

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HIMPAC Himalaya: Modern and Past Climates

DFG Research Unit

1. THE RESEARCH UNIT *HIMPAC*

1.1 THE HIMPAC INITIATIVE

is an interdisciplinary, multiproxy and multi-archive attempt towards unravelling the characteristics of the Indian Monsoon during the Holocene on high resolution time scales funded by the German Research Foundation (DFG). Investigations are focused on climatically sensitive regions of the Himalaya, eastern, and central India. With the aim to quantify palaeoclimate variability driven by large-scale climate processes the project involves geomorphological, geochemical, dendroclimatological, peat bog and palynological investigations as well as speleothem studies, absolute dating and climate modelling. The selected study sites are mapped in Fig. 1.

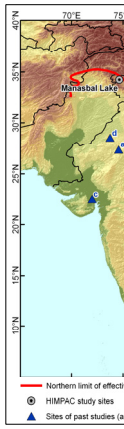


Fig. 1 Overview of study site locations of the HIMPAC initiative and past palaeoclimatic investigations in the region of subcontinental India

1.2 THE GOAL OF THE FREIE UNIVERSITÄT-BASED PROJECT

is to better understand past environmental dynamics, the role of vegetation feedbacks in glacial-interglacial climate variations, and to validate vegetation and climate models with respect to the region of northwestern India.

1.3 THE STUDY METHODS

consist of conventional pollen analysis and quantitative reconstruction of past vegetation cover using the modern-analogue method (Guiot, 1990) and the biomisation method (Prentice et al., 1996). Prospective palynological analyses will be performed on sediment records extracted from Tso Moriri. Whereas most sites in past palaeoenvironmental studies are located in less climatically sensitive regions, this high mountain lake is located close to the steppe/tundra-forest and steppe/tundra-desert margin (Fig. 2; 3) and to the northern limit of effective Indian Summer Monsoon (ISM) influence (Fig. 1). Hence, according to Birks (2011), it is most suitable for palaeoclimatic/palaeoecological studies.

2. A FIRST ATTEMPT:

THE BIOMISATION METHOD –

Does it "work" for the region of NW India?

2.1 Climate-derived biomes

The modern climate data set produced by New et al. (2002) was employed to simulate potential vegetation cover on a regional scale around the study site using the BIOME1 model (Prentice et al., 1992). Considering semidesert (SEDE) corresponds to alpine desert (ALDE) and conclusions of Prentice et al. (1992) after which the BIOME1 model incorrectly assigns tundra (TUND) to cool steppe (COGS) for parts of the Tibetan Plateau, the results (Fig. 2) are visually in good agreement with botanical data in Fig. 3 and Fig. 4. Detailed distribution of vegetation complexes along a transect (A-B) is demonstrated in Fig. 5. In a next step the environmental constraints of the STEP- and TUND-biome are to be refined. The resulting regionally adjusted BIOME1 model would allow future direct comparison of pollen-derived biome reconstructions with climate/vegetation model simulations.

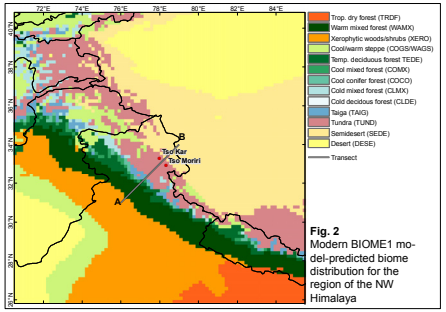


Fig. 2 Modern BIOME1 model-predicted biome distribution for the region of the NW Himalaya

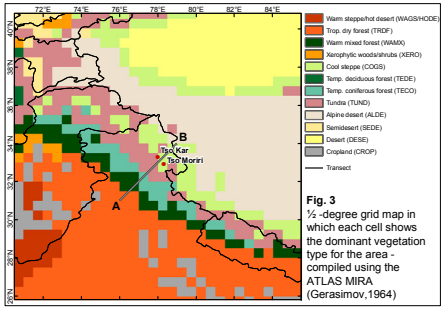


Fig. 3 ½ -degree grid map in which each cell shows the dominant vegetation type for the area - compiled using the ATLAS MIRA (Gerasimov,1964)

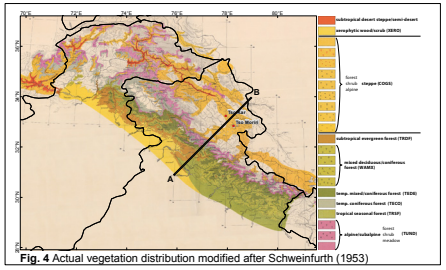
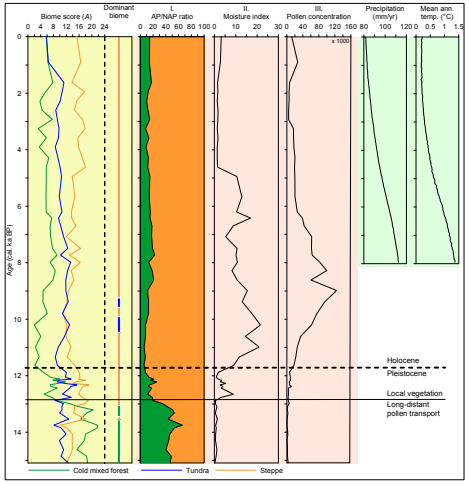


Fig. 4 Actual vegetation distribution modified after Schweinfurth (1953)

2.2 Pollen-derived biomes

In order to test the reliability of quantitative pollen-derived biome reconstructions the biomisation method was applied to the pollen spectra of recent palaeoecological studies on sediment cores from Tso Kar (location in Fig. 2) analysed by Demske et al. (2009) and Wünnemann et al. (2010). The assignment of pollen taxa to biomes was performed using published biomes - plant functional types - taxa matrices (e.g. Prentice et al., 1996; Tarasov et al., 1998). Comparison of the reconstructed biome scores with the pollen analysis results from the respective publications shows good agreement and represents a first evidence for the accuracy of the taxa-biome assignment and the environmental thresholds set for each biome (Fig. 6). However additional verification by comparison of actual and reconstructed biomes using regional surface pollen spectra is crucial to ensure the reliability of biomisation results. Further consistency of calculated biomes is suggested by simulated Holocene changes in precipitation produced by the coupled climate-carbon cycle model CLIMBER2-LPJ (Fig. 6). The biome scores together with simulated changes in mean annual temperature and tree cover point to a southwestwards shift of the northern limit of effective ISM influence between 1ka - 8ka BP likely due to a less pronounced depression above the Tibetan plateau during summer (Fig. 6; 7).



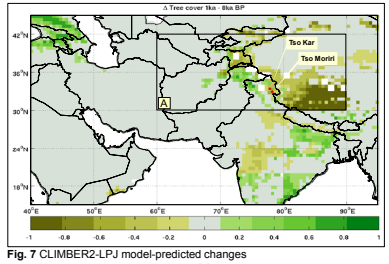


Fig. 7 CLIMBER2-LPJ model-predicted changes in tree cover between 1ka - 8ka BP

Fig. 6 Results of the:

biome reconstruction,

selected pollen-based proxies from Tso Kar: I. Arboreal/non-arboreal pollen ratio in %, II. *Artemisia*/Chenopodiaceae ratio as moisture index in % III. Pollen and spore concentration in grains/cm³,

CLIMBER2-LPJ model-simulations for quadrant A (Fig.7) between 1ka - 8ka BP

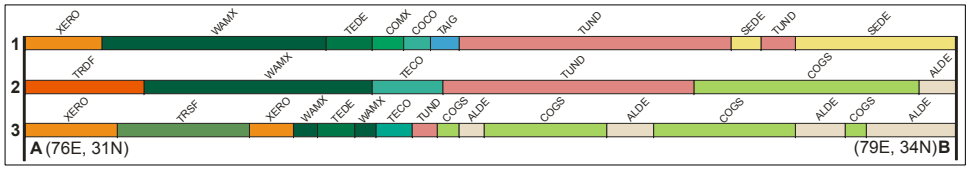


Fig. 5 Biome transects (A-B) from: (1) the BIOME1 model prediction; (2) the botanical data after Gerasimov (1964); (3) the botanical map after Schweinfurth (1953)

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