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Empirical downscaling of atmospheric key variables above a tropical glacier surface (Cordillera Blanca, Peru)

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Glaciers in the outer tropical Cordillera Blanca (Peru, South America) are of major socio-economic importance, since glacier runoff represents the primary water source during the dry season, when little or no rainfall occurs. Due to their location at high elevations, the glaciers moreover provide important information about climate change in the tropical troposphere, where measurements are sparse. This study targets the local reconstruction of air temperature, specific humidity and wind speed above the surface of an outer tropical glacier from NCEP/NCAR reanalysis data as large scale predictors. Since a farther scope is to provide input data for process based glacier mass balance modelling, the reconstruction pursues a high temporal resolution. Hence an empirical downscaling scheme is developed, based on a few years' time series of hourly observations from automatic weather stations, located at the glacier Artesonraju and nearby moraines (Northern Cordillera Blanca). Principal component and multiple regression analyses are applied to define the appropriate spatial downscaling domain, suitable predictor variables, and the statistical transfer functions. The model performance is verified using an independent data set. The best predictors are lower tropospheric air temperature and specific humidity, at reanalysis model grid points that represent the Bolivian Altiplano, located in the South of the Cordillera Blanca. The developed downscaling model explaines a considerable portion (more than 60%) of the diurnal variance of air temperature and specific humidity at the moraine stations, and air temperature above the glacier surface. Specific humidity above the glacier surface, however, can be reconstructed well in the seasonal, but not in the required diurnal time resolution. Wind speed can only be poorly determined by the large scale predictors (r^2 lower than 0.3) at both sites. We assume a complex local interaction between valley and glacier wind system to be the main cause for the differences between model and observations.