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Downscaling reanalysis data to high-resolution variables above a glacier surface (Cordillera Blanca, Peru)

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Recently initiated observation networks in the Cordillera Blanca provide temporally high-resolution, yet short-term atmospheric data. The aim of this study is to extend the existing time series into the past. We present an empirical-statistical downscaling (ESD) model that links 6-hourly NCEP/NCAR reanalysis data to the local target variables, measured at the tropical glacier Artesonraju (Northern Cordillera Blanca). The approach is particular in the context of ESD for two reasons. First, the observational time series for model calibration are short (only about two years). Second, unlike most ESD studies in climate research, we focus on variables at a high temporal resolution (i.e., six-hourly values). Our target variables are two important drivers in the surface energy balance of tropical glaciers; air temperature and specific humidity. The selection of predictor fields from the reanalysis data is based on regression analyses and climatologic considerations. The ESD modelling procedure includes combined empirical orthogonal function and multiple regression analyses. Principal component screening is based on cross-validation using the Akaike Information Criterion as model selection criterion. Double cross-validation is applied for model evaluation. Potential autocorrelation in the time series is considered by defining the block length in the resampling procedure. Apart from the selection of predictor fields, the modelling procedure is automated and does not include subjective choices. We assess the ESD model sensitivity to the predictor choice by using both single- and mixed-field predictors of the variables air temperature (1000 hPa), specific humidity (1000 hPa), and zonal wind speed (500 hPa). The chosen downscaling domain ranges from 80 to 50 degrees west and from 0 to 20 degrees south. Statistical transfer functions are derived individually for different months and times of day (month/hour-models). The forecast skill of the month/hour-models largely depends on month and time of day, ranging from 0 to 0.8, but the mixed-field predictors generally perform better than the single-field predictors. At all time scales, the ESD model shows added value against two simple reference models; (i) the direct use of reanalysis grid point values, and (ii) mean diurnal and seasonal cycles over the calibration period. The ESD model forecast 1960 to 2008 clearly reflects interannual variability related to the El Niño/Southern Oscillation, but is sensitive to the chosen predictor type. So far, we have not assessed the performance of NCEP/NCAR reanalysis data against other reanalysis products. The developed ESD model is computationally cheap and applicable wherever measurements are available for model calibration.