Geophysical Research Abstracts
Vol. 14, EGU2012-7416, 2012
EGU General Assembly 2012

A stochastic methodology for simulating long-term hourly time series of meteorological variables across a continuous of elevations

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Time series of meteorological variables at different elevations are required for studies of hydrological, ecological, biogeochemical, or geomorphological dynamics across altitudinal gradients. While deriving spatially averaged long-term climatic field is rather straightforward, continuous time series of meteorological variables across elevation bands are rarely available at the fine, sub-daily time scales. Few meteorological networks have the density capable of capturing climate conditions to characterize altitudinal differences of few hundred meters. Simple interpolation of meteorological variables is problematic and generates "smoothed" fields, especially for highly dynamic variables such as precipitation, solar radiation, and wind speed. This study uses ground observations of the MeteoSwiss network and an hourly weather generator, AWE-GEN, to construct synthetic climatic gradients of several meteorological variables, i.e. precipitation, air temperature, cloud cover, relative humidity, wind speed, solar radiation, and atmospheric pressure. Specifically, the developed methodology uses observed data for stations located along an altitudinal gradient for parameterization of the weather generator. The parameters are successively interpolated at different elevations using both linear and non-linear functions. The re-parameterized weather generator is able to produce a consistent gradient of climate across the elevation range, preserving the co-variation among the principal climate variables. In this study, we show the potential of the methodology by constructing two exemplary synthetic climate gradients. One is representative of a dry, sheltered internal valley (Valais) and the other one of a wet, exposed mountain side (Bernese Oberland). Thirty years of hourly time series are simulated for several elevation bands from 500 up to 3500 m a.s.l. The simulated hourly time series reproduce meteorological variables at the hourly scale in a good agreement with observations. First and high-order statistics show a consistent transition across all of the elevations.