Temporal Downscaling – A Method to Reduce the Climatic Input Requirements of Impact Models

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Dynamic models used to study possible impacts of climatic change often require daily or even hourly weather data as inputs. Reducing the input requirements of these models can help to match the limited precision of the climatic scenarios simulated by global climate models, and generally to increase the robustness of impact assessments. A strategy termed temporal downscaling, which aims at reducing the climatic input requirements of impact models is presented and discussed in the context of two case studies. In analogy to spatial downscaling, which serves the estimation of changes in regional-scale weather and climate from large-scale weather patterns, the basic idea in temporal downscaling is to simulate weather at a high (e.g., hourly) temporal resolution conditional on a small set of coarse-resolution (e.g., monthly) weather inputs.

A temporal downscaling procedure for local weather has been implemented in the form of a computer program named *WeathGen*. *WeathGen* stochastically simulates based on 22 monthly weather inputs 11 daily weather variables, which are in turn used to simulate 5 hourly weather variables related to precipitation, temperature, global radiation, vapour pressure and wind speed. Each of these transitions is accomplished with the aid of a Richardson-type stochastic model whose parameters are adjusted in function of the inputs given at the respectively coarser temporal resolution. In order to ensure consistency among temporal aggregation levels, *WeathGen* further repeatedly simulates daily (hourly) weather sequences until the statistics of a weather sequence for a given month (day) are sufficiently close to the prescribed monthly (daily) inputs.

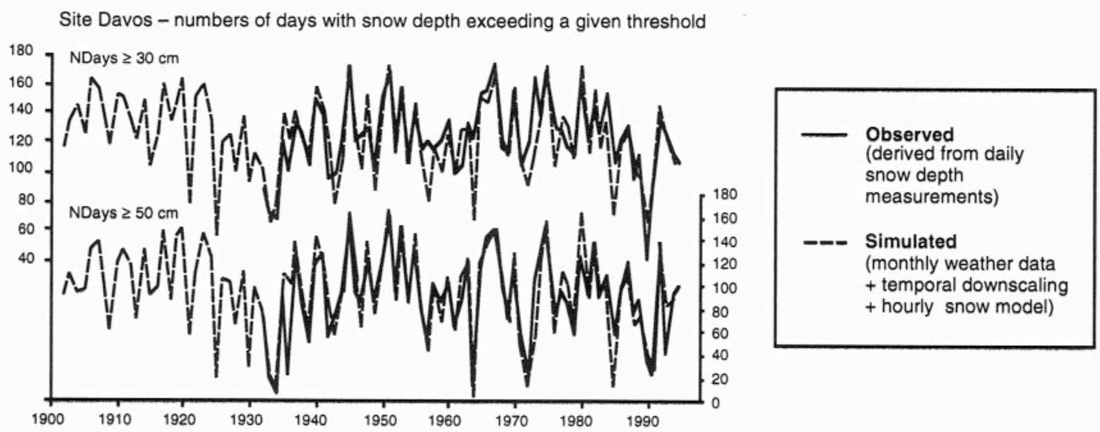

Fig. 1. Observed vs. simulated numbers of winter (Nov.-April) days with snow depth exceeding 30 and 50 cm (relevant for ski tourism) at the site Davos (1590 m.a.s.l.), Switzerland. Simulated values refer to the response of a dynamic snow model driven by hourly temperature and precipitation. Model inputs were stochastically generated from monthly weather data by means of a temporal downscaling procedure. Shown is the average model response from 30 simulations per winter. The parameters of the downscaling procedure were determined for the years 1981-1985, those of the the snow model for the years 1982-1994.

The proposed temporal downscaling approach was tested by driving a dynamic snow and a grassland ecosystem model with temporally downscaled hourly weather data and comparing the model outputs with observed, or based on measured weather data simulated, system responses. All parameters required by *WeathGen* were estimated from only 5 years of hourly measurements. It was found that the long-term means and the within-season to decadal-scale variability of several system outputs of interest, such as the annual numbers of days with snow-depths exceeding a given threshold (Fig. 1), or the annual grass yield and growing-season evapotranspiration, can be reproduced at very good accuracy.

Our results show that: 1) Temporal downscaling allows to drastically reduce the number of parameters that need to be considered for climatic impact assessments. This is accomplished without having to develop new parameterizations for fast processes in an impact model. 2) The appropriateness of parsimonious climatic scenarios can be objectively tested. 3) Past system responses can be readily simulated using only monthly weather data as an input, e.g. for the long-term validation of an impact model. 4) The here proposed approach is general, flexible, efficient, and can provide an arbitrary number of realizations for the daily or hourly weather. Climate change estimates obtained from spatial downscaling of climate model output can be easily incorporated (e.g., by perturbing the monthly inputs) and flexibly combined with any additional assumptions on possible future changes in climate, including its variability.

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