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Utility of daily vs. monthly large-scale climate data: an intercomparison of two statistical downscaling methods

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Abstract. Downscaling of climate model data is essential to local and regional impact analysis. We compare two methods of statistical downscaling to produce continuous, gridded time series of precipitation and surface air temperature at a 1/8-degree (approximately 140 km^2 per grid cell) resolution over the western U.S. We use NCEP/NCAR Reanalysis data from 1950–1999 as a surrogate General Circulation Model (GCM). The two methods included are constructed analogues (CA) and a bias correction and spatial downscaling (BCSD), both of which have been shown to be skillful in different settings, and BCSD has been used extensively in hydrologic impact analysis. Both methods use the coarse scale Reanalysis fields of precipitation and temperature as predictors of the corresponding fine scale fields. CA downscales daily large-scale data directly and BCSD downscales monthly data, with a random resampling technique to generate daily values. The methods produce generally comparable skill in producing downscaled, gridded fields of precipitation and temperatures at a monthly and seasonal level. For daily precipitation, both methods exhibit limited skill in reproducing both observed wet and dry extremes and the difference between the methods is not significant, reflecting the general low skill in daily precipitation variability in the reanalysis data. For low temperature extremes, the CA method produces greater downscaling skill than BCSD for fall and winter seasons. For high temperature extremes, CA demonstrates higher skill than BCSD in summer. We find that the choice of most appropriate downscaling technique depends on the variables, seasons, and regions of interest, on the availability of daily data, and whether the day to day correspondence of weather from the GCM needs to be reproduced for some applications. The ability to produce skillful downscaled daily data depends primarily on the ability of the climate model to show daily skill.

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1 Introduction

Climate models are the primary tool to evaluate the projected future response of the atmosphere-land-ocean system to changing atmospheric composition (MacCracken et al., 2003; Stocker et al., 2001), and they underpin most climate change impacts studies (Wilby and Harris, 2006). However there is a mismatch between the grid resolution of current climate models (generally hundreds of kilometers), and the resolution needed by environmental impacts models (typically ten kilometers or less). Downscaling is the process of transforming information from climate models at coarse resolutions to a fine spatial resolution. Downscaling is necessary, as the underlying processes described by the environmental impact models are very sensitive to the nuances of local climate, and the drivers of local climate variations, such as topography, are not captured at coarse scales.

There are two broad categories of downscaling: dynamic (which simulates physical processes at fine scales) and statistical (which transforms coarse-scale climate projections to a finer scale based on observed relationships between the climate at the two spatial resolutions) (Christensen et al., 2007). Dynamic downscaling, nesting a fine scale climate model in a coarse scale model, produces spatially complete fields of climate variables, thus preserving some spatial correlation as well as physically plausible relationships between variables. However, dynamic downscaling is very computationally intensive, making its use in impact studies limited, and essentially impossible for multi-decade simulations with