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# Bias Correction used for Climate Projections from Climate Models – A Critique

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The evaluation of present day Global Circulation Models (GCMs) and Regional Climate Models (RCMs) versus observational data from the past decades reveal biases of the atmospheric variables, which depend on time and space as well as on forcing conditions. This bias structure of the model fields is a result of the complex interaction between land-surface-biosphere-atmosphere processes. As already the hindcasts are biased, climate projections with GCMs and RCMs will most likely be biased as well.
However, the society asks for climate projections, which can be used for impact modeling and decision making. Impact modelers, e.g., hydrologists and agricultural scientists, require unbiased data for impact studies or to force other models such as hydrological models. This calls either for an extensive characterization of bias or for bias correction. Recently, bias correction became a common postprocessing method, i.e. the GCM output is corrected towards 'true' fields. The correction parameters are determined during an observed period of time and applied on this and the projection period (see e.g. Hagemann et al. (2011) or Themeßl et al. (2011)).
However, due to the non-stationary and complex nature of feedback processes the correction scheme needs to be highly sophisticated and it still needs to be proven, that the applied method is holding under varying forcing conditions and extreme climate conditions. For example:
• The bias correction of extreme values not included in the GCM output during the simulation period requires an extrapolation of the transfer function beyond the range of observed values. That means, for example, that GCM rainfall needs to be bias-corrected beyond physical limits.
• The bias correction may affect the relative magnitude of values among grid cells and months, i.e. a temperature gradient from one grid cell to the next could be flipped.
• The bias correction alters the spatiotemporal covariance structure of a GCM field. This destroys the main advantage of dynamic models to create thermodynamic fields with an autocorrelation structure and spatial correlation structure that are consistent with atmospheric physics. From a hydrological point of view, changes in the covariance structure may strongly affect hydrological functioning whenever non-linear processes are involved, e.g. surface runoff generation, macropore flow initiation, etc.
• The bias correction affects the correlation among different fields, while it is not yet clear whether observed field correlations remain stable (and are thus applicable) to changing climatic conditions (Piani et al. 2010).
We are convinced that most bias correction schemes that tune the output of GCMs to mask their obvious errors lead to nowhere due to the above limitations. We propose to rather improve the GCMs and RCMs to further downscale to the desired resolution for impact research. Recent results from campaigns and modeling activities within projects of the World Weather Research Program (WWRP) demonstrate advanced model performance if the models are operated on the convection-permitting scale (Rotach et al. 2009, Wulfmeyer et al. 2011).
This presentation is discussing the present bias correction methods and presents their limitations. The respective advantages and disadvantages of high-resolution modeling are compared with bias correction of coarse resolution models such as GCMs. With this presentation, we would like to stimulate an open debate on the issue of bias correction in climate change research.

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