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Expected enhancement of statistical downscaling method induced by a use of gridded daily precipitation dataset

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The major factors that have hampered progress in the examination of possible impacts of climate change and adaptation strategy on a smaller scale are the limitation of spatiotemporal resolution and systematic error (called bias) of general circulation models (GCMs). Despite the rapid progress of GCMs, climate data with higher spatiotemporal resolution and less bias are required for impact and adaptation studies for particular regions: this is the downscaling issue. Researchers thereby relay on dynamical and statistical downscaling methods to provide climate data that can meet such needs. Regional climate models (RCMs) used for dynamical downscaling provide physically coherent spatiotemporal variation of climatic elements. RCMs can reduce GCM bias in many cases but coincidentally they could be a source of additional bias. In addition, RCMs require comparatively intensive computer resources. By contrast, statistical downscaling methods (SDMs) can provide less-biased climate data at a specific station without intensive computer resources. However, they have the limitation on stationarity assumption and applicability to spatial analysis because the geographical pattern of climate element derived from SDMs strongly depends on the density of observation network. Moreover, the reproductive capability of SDMs for precipitation extremes (i.e., intense precipitation and consecutive dry days) is less accurate compared to other climatic elements. Consequently, the evaluation of dynamical and statistical downscaling methods in terms of reproductive capability of precipitation extremes and understanding of their strengths and weaknesses in a particular region are essential prior to downscaling of a GCM output under emission scenario experiments. To do so, the use of reanalysis data as a boundary condition of RCM and a predictor of SDM, instead of a GCM output, is the best test bed. The presented study assessed the accuracy of the downscaled precipitation-based extreme indices under the current climate during the 20 years (1985-2004) on a 20-km grid size derived from the four RCMs and one SDM forced by the common reanalysis data (JRA25) and highlighted their respective strengths and weaknesses in downscaling, taking Japan region as the study area. These RCMs outputs were provided in the S-5-3 project funded by Ministry of the Environment, Japan and kindly offered from Japan Meteorological Agency/Meteorological Research Institute, National Research Institute for Earth Science and Disaster Prevention, and University of Tsukuba. To meet the needs from impact and adaptation studies aimed to assess the risk of water shortage and drought-induced crop failure, the following four precipitation-based extreme indices were assessed : (1) annual mean precipitation, Pav; (2) number of days with precipitation >=10 mm/day, R10; (3) maximum number of consecutive dry days (daily precipitation <1 mm/day), CDD; and (4) simple daily intensity index (annual total precipitation divided by number of days with daily precipitation >=1 mm/day), SDII. The inter-method comparison highlights the following features of the SDM: (1) it is comparable with the RCMs in terms of the representation of geographical patterns if dense observation network is applicable, suggesting the possibility that a combination of the SDM with gridded precipitation dataset (e.g., APHRODITE products) will make more accurate spatial analysis possible; (2) it is more accurate than the RCMs in terms of long-term statistics and precipitation frequency but less accurate in terms of interannual variation pattern and representation of areal differences; (3) it is applicable to long-term risk analysis but has the limitation for case study that requires the representation of specific events even when the reanalysis data are used as the predictor; and (4) it accurately works to reproduce the extreme indices without complex modeling and intensive computer resources.

Keywords: climate change impacts, gridded daily precipitation data, precipitation extremes, regional climate change scenario, regional climate model, statistical downscaling method