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Future changes in sub-daily precipitation return levels over an alpine transect from a convection-permitting model

Eleonora Dallan[1], Bardia Roghani[1], Giorgia Fosser[2], Christoph Schaer[3], Marco Marani[4], Marco Borga[1], and Francesco Marra[5]

[1]University of Padua, Department of Land Environment Agriculture and Forestry, Legnaro, Italy (eleonora.dallan@unipd.it)
[2]University School for Advanced Studies - IUSS Pavia, Pavia, Italy
[3]Institute for Atmospheric and Climate Science, ETH Zürich, Zürich, Switzerland
[4]Department of Civil, Environmental and Architectural Engineering, University of Padova, Padova, Italy
[5]National Research Council, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Bologna, Italy

Fast hydro-geomorphic hazards such as flash floods and debris flows cause numerous fatalities and large damage, and are triggered by sub-daily extreme precipitation. Projecting future changes in these extremes is thus of great importance for risk management and adaptation strategies. High-resolution climate models, called convection-permitting models (CPMs), represent land-surface characteristics and small-scale processes in the atmosphere, such as convection, more realistically than coarser resolution models. Subdaily extremes could be better represented, and thus CPMs provide higher confidence in the estimate of future changes in extreme precipitation. However, the existing CPM runs are available for relatively short time periods (10–20 years at most) that are too short for deriving precipitation frequency analyses with conventional extreme value methods.

Here, we evaluate the potential of a novel statistical approach based on many “ordinary” events rather than just yearly maxima or a few values over a high threshold. This method has the potential to provide reliably estimate of rare return levels from short data record, thus offering the chance to be effectively applied to the analysis of CPM data for reliable frequency analysis on future precipitation. We focus on an Eastern Alpine transect, characterized by a complex orography, where significant changes in sub-daily annual maxima have been already observed. We estimate future changes under the RCP8.5 scenario using COSMO-crCLIM model simulations at 2.2 km resolution. We focus on three 10-year time slices (historical 1996-2005, near-future 2041-2050, and far future 2090-2099). A bias assessment is also performed by comparing the estimated extremes from the historical time-slice to the ones from long records of observed precipitation. We estimate extreme precipitation for duration ranging from 1 h to 24 h and assess the changes between the time periods. Specifically, we analyze: annual maxima, return levels, and parameters of the statistical model.

Although the storms' frequency will generally decrease in the region, the mean annual maxima exhibit a general increase in the near and far future, especially at shorter durations. The change in the extreme return levels shows a similar trend, with larger increase in the far future at the shorter duration. Interestingly, the changes show a spatial organization that can be associated to the orographic features of the area: the stronger increasing changes are located in the high elevation zone, while in the lowlands weak decrease and weak increase emerge in the near and far future, respectively.

This analysis demonstrates the possibility to have reliable estimates of future extreme precipitation from short CPM runs by using a novel method based on ordinary-events. The relevant findings from this analysis are useful for improving our knowledge about the projected future changes in extreme precipitation and thus for improving the strategies for risk management and adaptation.