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Discussions

Interactive comment on "Climate change and uncertainty in high-resolution rainfall extremes" *by* B. Kianfar et al.

Anonymous Referee #2

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Paper summary:

The reviewed manuscript applies existing methods and tools to assess whether the effects of climate change can be traced down to the distribution of sub-daily rainfall maxima. This is done using high-resolution (i.e. 10-min) rainfall data from 22 stations in Switzerland, and 10 GCM/RCM simulations for the current climate, and two future climatic periods. More precisely, the Authors use: a) a Neymann-Scott rectangular pulse model to simulate daily rainfall, and b) two alternative versions of a multiplicative random cascade (MRC) model to disaggregate the simulations from (a) to sub-daily scales. Both models are fitted using the historical data, while GCM/RCM simulations are used solely to obtain factors of change (FoC) of the statistics used to fit the Neymann-Scott rectangular pulse model, between the current and future climates. The parameters of the MRC model variants are kept constant along the timeline. The

Authors conclude that the effect of the climate change signal on rainfall maxima, as embodied in the calculated FoCs, decreases with increasing temporal resolution, making climate change assessments of high-resolution rainfall extremes uncertain.

Contribution and audience:

While the presented material is not new (see references in the manuscript), and the results of the study are more or less expected (i.e. small-scale variability masks the effects of the climate change signal on high-resolution extremes), from an application point of view, the work should be of interest to the hydrologic community, and certainly within the scopes of the SI in HESS. That said, I would consider changing the title of the manuscript to something that is more oriented towards research application; e.g. "Assessing Climate change and uncertainty in high resolution rainfall extremes: An application in Switzerland"

Below are a few comments and suggestions in the direction of strengthening the presented work, and improving its readability.

General Comment 1:

To assess the effects of climate change on sub-daily rainfall maxima, the Authors select the FoC approach. In this way, they perturb the parameters of a stochastic rainfall simulator, based on the climate change signal obtained from GCM/RCM simulations. Please note that the main reason why one prefers to perturb the model parameters estimated from actual rainfall records, instead of fitting the stochastic model directly to climate model rainfall products, is the large biases associated with the latter. I think the Authors should explicitly state this fact and, in addition, at least refer to the classical notion of stochastic weather generators (i.e. not rainfall simulators), where the parameters of the rainfall model (and hence the rainfall structure) are conditioned directly on the statistics of atmospheric predictors (e.g. geopotential height, surface pressure, divergence). Note that conditioning model parameters on atmospheric predictors allows for more flexibility in bypassing the issue of biases in GCM/RCM rainfall simulations, and is free of certain limitations associated with perturbation of the parameters of stochastic models. A detailed discussion and some recent developments on the subject can be found in Langousis and Kaleris (2014), and Langousis et al. (2016).

General Comment 2 (technical soundness):

The applied methodology is technically sound, and all assumptions and limitations are explicitly stated. My only concern is that the level of detail of the presented methods is somewhat coarse. For example, in Section 3.1, what distribution model is used for the multiplicative weights? How was this fitted, and how good was the obtained fit? Shouldn't the Authors use some type of measure to quantify the goodness-of-fit? Also, how the parameters of the fitted distribution model depend on the scale of temporal averaging (models MRCA and MRCB), and the large-scale rainfall intensity (model MRCB)? It would be very insightful to illustrate this dependence through a couple of Figures. Also, in Section 3.2, the Authors should briefly describe (maybe some equations and/or Tables are useful here) how the FoC's are used to perturb the parameters of the Neymann-Scott rectangular pulse model. Although the Authors refer to their previous works, I think that the level of detail sought by the HESS readership is somewhat higher. Regarding Section 4, I would recommend that the Authors do not lie on visual inspection of the Figures, but rather base their arguments (especially to what concerns the goodness-of-fit of the stochastic model) on quantitative measures.

Specific Comments:

Page 2, line 13: Why short duration rainfall extremes are by definition rare events? I do not understand the meaning of this sentence (at least from a statistical point of view). Either explain briefly, or eliminate.

Page 3, lines 1-2: I do not think that presentation and application of an existing model can be considered an objective of a research article. I think just the second objective suffices.

Page 3, line 23: What do the Authors mean by intermittency? I suppose they refer to the probability of zero rainfall. Please clarify.

Page 4, lines 31-32: The Authors might want to expand their reference list regarding the use of multiplicative random cascades in modeling extremes. Possible options include: Gupta and Waymire (1990, 1993), Lovejoy and Schertzer (1995), Over and Gupta (1996), Hubert et al. (1998), Menabde et al. (1997), Menabde and Sivapalan (2000), Deidda et al. (1999), Deidda (2000), Veneziano and Furcolo (2002), Veneziano and Langousis (2005a,b), Langousis and Veneziano (2007), Veneziano et al. (2009), Langousis et al. (2009, 2013), and the reviews in Veneziano et al. (2006b) and Veneziano and Langousis (2010).

Page 5, line 5: The Authors might want to refer to some additional studies dealing with the dependence of the distribution of the multiplicative weights on scale and the large-scale rainfall intensity. Possible options include: Perica and Foufoula-Georgiou (1996a,b), Menabde et al. (1997), Olsson (1998), Schmitt et al. (1998), Deidda (2000), Menabde and Sivapalan (2000), Güntner et al. (2001), Paulson (2002), Paulson and Baxter (2007), Veneziano et al. (2006a), and the reviews in Veneziano et al. (2006b), and Langousis and Veneziano (2010).

Page 5, lines 26-29: The Authors should provide additional detail on the scaling methods used, and their specific application in the context of the study. Simple reference to the original studies of Marani and Zanetti (2007), and Molnar and Burlando (2005) is not enough. Also, some diagrams should be of help here, especially regarding the issue of extrapolation of FOC's to sub-daily scales.

Page 5, line 29: I do not understand the statement of the Authors that the skewness is independent of the scale of temporal averaging. The only case this is possible is when the skewness is zero. Also, skewness in the labels of Figures 3 and 4 is unit free. Do the Authors mean skewness coefficient?

Page 6, lines 20-25: The statement of the Authors regarding lag-1 correlation and skewness is inaccurate. The departures shown in Figures 3(c, d) and 4(c, d) are not small. This is especially the case for Figure 4(c). I suppose this is caused by model fitting (page 5, lines 25-29), where lag-1 autocorrelations are not used, and skewness is assumed independent from the scale of temporal averaging. Please explain.

Page 8, lines 15-16: This statement is inaccurate. The Authors do not do rainfall downscaling but, rather, they properly perturb the parameters of a stochastic rainfall simulator to study the effect of the climate change signal on sub-daily rainfall maxima. Please rephrase or eliminate.

Figures 3(a) and 4(a): Please note that all curves collapse to a single one, if intensity (instead of rainfall depth) is used.

Figures 3(c) and 4(c): Is it skewness, or skewness coefficient? Please clarify and check the units.

Reference list: Please thoroughly check all references. For example, there is no citation in the main text for Veneziano and Langousis (2010).

Prior publication:

To my knowledge, neither the same nor very similar work has been published elsewhere.

Recommendation:

For the reasons mentioned above, it is recommended that the paper is published in HESS after moderate revisions.

References:

Deidda, R. (2000) Rainfall Downscaling in a Space–time Multifractal Framework. Water Resour. Res., 36, 1779–1794.

Deidda, R., R. Benzi and F. Siccardi (1999) Multifractal Modeling of Anomalous Scaling

Laws in Rainfall, Water Resour. Res., 35, 1853–1867.

Güntner, A., J. Olsson, A. Calver and B. Gannon (2001) Cascade-based Disaggregation of Continuous Rainfall Time Series: The Influence of Climate, Hydrol. Earth Syst. Sci., 5, 145-164.

Gupta, V. K., and E. C. Waymire (1993) A Statistical Analysis of Mesoscale Rainfall as a Random Cascade, J. Appl. Meteorol, 32, 251–267.

Gupta, V.K. and E.C. Waymire (1990) Multiscaling Properties of Spatial Rainfall and River Flow Distributions, J. Geophys. Res. 95, 1999-2009.

Hubert, P., H. Bendjoudi, D. Schertzer and S. Lovejoy (1998) A Multifractal Explanation for Rainfall Intensity-duration-frequency Curves, Proceedings, Int. Conf. On Heavy Rains and Flash Floods, Istanbul, Turkey.

Langousis A, D. Veneziano, P. Furcolo, and C. Lepore (2009) Multifractal Rainfall Extremes: Theoretical Analysis and Practical Estimation, Chaos Solitons and Fractals, 39, 1182-1194, doi:10.1016/j.chaos.2007.06.004.

Langousis, A. and D. Veneziano (2007) Intensity-Duration-Frequency Curves from Scaling Representations of Rainfall, Wat. Resour. Res., 43, doi: 10.1029/2006WR005245.

Langousis, A. and V. Kaleris (2014) Statistical framework to simulate daily rainfall series conditional on upper-air predictor variables, Water Resour. Res., 50(5), 3907-3932, doi: 10.1002/2013WR014936

Langousis, A., A. Mamalakis, R. Deidda and M. Marrocu (2016) Assessing the relative effectiveness of statistical downscaling and distribution mapping in reproducing rainfall statistics based on climate model results, Water Resour. Res., 52, doi:10.1002/2015WR017556

Langousis, A., A.A. Carsteanu and R. Deidda (2013) A Simple Approximation to Multifractal Rainfall Maxima using a Generalized Extreme Value Distribution Model, Stoch. Environ. Res. Risk Assess., doi: 10.1007/s00477-013-0687-0

Lovejoy, S. and D. Schertzer (1995) Multifractals and Rain, In: New Uncertainty Concepts in Hydrology and Hydrological Modelling, Edited by: Kundzewicz, A.W., Cambridge press.

Menabde, M. and M. Sivapalan (2000) Modelling of Rainfall Time Series and Extremes using Bounded Random Cascades and Levy-stable Distributions, Wat. Resour. Res., 36(11), 3293-3300.

Menabde, M., D. Harris, A. Seed, G. Austin and D. Stow (1997) Multiscaling Properties of Rainfall and Bounded Random Cascades, Wat. Resour. Res., 33(12), 2823-2830.

Olsson, J. (1998) Evaluation of a Scaling Cascade Model for Temporal Rain-fall Disaggregation, Hydrol. Earth Syst. Sci., 2, 19-30.

Over, T.M. and V.K. Gupta (1996) A Space-Time Theory of Mesoscale Rainfal Using Random Cascades, J. Geophys. Res., 101(D21), 26 319- 26 331.

Paulson, K.S. (2002) Spatial-temporal Statistics of Rainrate Random Fields, Radio Sci., 37(5), doi:10.1029/2001RS002527.

Paulson, K.S. and P.D. Baxter (2007) Downscaling of Rain gauge Time series by Multiplicative Beta Cascade, J. Geophys. Res., 11(2), doi:10.1029/2006JD007333.

Perica, S. and E. Foufoula-Georgiou (1996a) Linkage of Scaling and Thermodynamic Parameters of Rainfall: Results from Midlatitude Mesoscale Convective Systems, J. Geophys. Res., 101(D3), 7431-7448.

Perica, S. and E. Foufoula-Georgiou (1996b) Model for Multiscale Disaggregation of Spatial Rainfall Based on Coupling Meteorological and Scaling Descriptions. J. Geophys. Res., 101(D21), 26347-26361.

Schmitt, F., S. Vannitsem, and A. Barbosa (1998) Modeling of Rainfall Time Series

Using Two-state Renewal Processes and Multifractals, J. Geophys. Res., 103(D18)92, 23181-23193

Veneziano D. and A. Langousis (2010) Scaling and Fractals in Hydrology, In: Advances in Data-based Approaches for Hydrologic Modeling and Forecasting, Edited by: B. Sivakumar and R. Berndtsson, World Scientific, 145p

Veneziano, D. and A. Langousis (2005a) The Areal Reduction Factor a Multifractal Analysis, Wat. Resour. Res., 41, doi:10.1029/2004WR003765.

Veneziano, D. and A. Langousis (2005b) The Maximum of Multifractal Cascades: Exact Distribution and Approximations, Fractals, 13(4), 311-324.

Veneziano, D. and P. Furcolo (2002) Multifractality of Rainfall and Intensity-duration-frequency Curves, Wat. Resour. Res., 38(12), 1306-1317.

Veneziano, D., A. Langousis and C. Lepore (2009) New Asymptotic and Pre-Asymptotic Results on Rainfall Maxima from Multifractal Theory, Wat. Resour. Res., 45, doi:10.1029/2009WR008257.

Veneziano, D., A. Langousis, and P. Furcolo (2006b) Multifractality and Rainfall Extremes: A Review, Wat. Resour. Res., 42, doi:10.1029/2005WR004716.

Veneziano, D., P. Furcolo and V. Iacobellis (2006a) Imperfect Scaling of Time and Space-Time Rainfall, J. Hydrol., 322(1-4), 105-119.

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