Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-283-AC2, 2016

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Characteristics of rainfall events in RCM simulations for the Czech Republic" *by* V. Svoboda et al.

V. Svoboda et al.

vsvoboda@fzp.czu.cz

Received and published: 28 September 2016

Referee #1 general comments:

The paper evaluates the performance of an ensemble of regional climate models (RCMs) for simulation of heavy rainfall events for the Czech Republic. In recent years, a large number of papers have performed similar analyses of the performance of RCMs by (i) considering different RCMs with different spatial resolutions, (ii) studying different regions of the world, and (iii) analysing a range of rainfall characteristics.

Much of this work has been referred to and discussed in the paper. However, the purpose of the current study and its contribution compared to state-of-the-art in this area is not clear. The authors state that "Characteristics of individual heavy rainfall events (such as event depth, duration, and intensity) in RCM simulations have not been

studied to date" (Page 2, line 25-26). The authors may define rainfall characteristics differently than what has been done in other studies, but the novelty of this compared to the range of other rainfall characteristics that have been analysed in similar studies seems limited. This is confirmed by the fact that the main findings of the study do not provide any convincing new insights. In the Discussion (Section 5.3) the authors discuss their results and compare with previous studies. Basically, all their findings are in agreement with previous studies.

Our response to general comments:

In line with the referee we admit that there has been a plethora of studies concerning the evaluation of various precipitation characteristics in global and regional climate models. The vast majority of these studies, however, focused on daily or longer temporal scales, while sub-daily model performance has received relatively little attention to date (Westra et al., 2014). Particularly, we are not aware of another study that would look in detail into rainfall event characteristics in RCMs (which are important with respect to hydrological impacts, as detailed below). The few existing studies on RCM-simulated sub-daily rainfall are typically looking at precipitation maxima in a number of temporal aggregations (Hanel and Buishand, 2010; Gregersen et al., 2013), dependence of RCM performance on its resolution (Prein et al., 2016; Sunyer et al., 2016), diurnal cycle of simulated hourly precipitation (Prein et al., 2015 and references therein) or scaling of precipitation extremes with temperature (Lenderink and van Meijgaard, 2008; Ban et al., 2015). Although some of these results can partly be related to rainfall event characteristics (e.g. performance of an RCM in simulating annual precipitation maxima may be related to that in simulating rainfall event maxima), they cannot address questions such as "is the depth of a simulated rainfall event comparable to that of a real event?", "is the performance influenced by the rainfall depth itself?", "are the simulated events of proper length and rain rate?" etc. The importance of these questions in evaluating climate models has been highlighted e.g. by Westra et al. (2014) who suggested (among other things) to focus on (spatial structure and) temporal evolution of rainfall events and their timing and intermittency.

Moreover, characteristics of rainfall events determine characteristics of various hydrological processes, e.g. overland flow generation and shape of the resulting hydrograph (Singh, 1997), soil moisture dynamics (Wang et al., 2008; He et al., 2012), infiltration (Ran et al., 2012), rainfall erosion (Wischmeier and Smith, 1978), evaporation (Dunkerley, 2008), storm sewer flow rates and direct runoff (Schilling, 1991; Giulianelli et al., 2006). Therefore information on changes in these characteristics is highly relevant for river basin management, urban hydrology, flood protection, erosion control etc. That is why we consider these characteristics important also in RCM evaluation studies.

Assessments of simulated precipitation at sub-daily time scales often face problems with data availability – sub-daily RCM simulations are in general not easily available and relevant (sub-daily) observational products allowing for comparison between RCMs (representing spatial averages) and observations (point measurements) are lacking. Deflation of maxima due to spatial averaging is well recognized and expressed by so-called areal reduction factors (Svensson and Jones, 2010). Clearly the spatial averaging also affects the rainfall event characteristics, however, any quantitative assessment is lacking in the literature.

The novelty of our study can be summarized in the following points:

- evaluation of simulated sub-daily precipitation using a large ensemble of RCM simulations from the ENSEMBLES and CORDEX projects

- development of a methodology allowing for comparison of RCM-simulated rain event (spatial) characteristics to (point) observations

- assessment of rainfall event characteristics, such as event depth, event duration, event rain rate, event maximum intensity and indices of rainfall erosivity, which are only indirectly related to commonly considered indices and are relevant for river basin management, urban hydrology, flood protection, erosion control etc.

We agree that these points could be stated more explicitly in the manuscript, and we will elaborate them in the revised manuscript in detail.

Our results are indeed consistent with previous studies, however, we also address points that have not been studied before, e.g. the frequency of heavy rainfall events within a year and the skill of climate models in representing the basic characteristics of temporal structure of sub-daily rainfall in particular. We agree that the discussion currently included in the manuscript is to a large extent focused on comparison with other studies instead of addressing the possible impacts on hydrological conditions, water resources, extreme hydrological events, and consequences for climate change impact assessment at short temporal scales in general. Such discussion will be supplemented in the revised manuscript.

Detailed comments:

The results are not presented in a clear and concise way. The Results section provides a detailed enumeration of results shown in the figures. This part should be more to the point and focus on main results.

Our response to detailed comments:

In agreement with this point as well as concerns of Referee #2 we believe that the paper will be improved by reductions in the result section (focusing on the key findings) together with some clarifications in the methods description.

References

Ban, N., Schmidli, J. and Schär, C.: Heavy precipitation in a changing climate: does short-term summer precipitation increase faster?, Geophys. Res. Lett., 42, 1165–1172, doi: 10.1002/2014GL062588, 2015.

Dunkerley, D. L.: Intra-storm evaporation as a component of canopy interception loss in dryland shrubs: observations from Fowlers Gap, Australia, Hydrol. Process., 22, 1985–1995., doi:10.1002/hyp.6783, 2008.

Giulianelli M., Miserocchi F., Napolitano F., and Russo F.: Influence of space-time rainfall variability on urban runoff, In Proceedings of the 17th IASTED international conference on Modelling and simulation, ACTA Press: Anaheim, CA, 546–551, 2006.

Gregersen, I. B., Sørup, H. J. D., Madsen, H., Rosbjerg, D., Mikkelsen, P. S., and Arnbjerg-Nielsen, K.: Assessing future climatic changes of rainfall extremes at small spatio-temporal scales, Climatic change, 118, 783–797, doi:10.1007/s10584-012-0669-0, 2013.

Hanel, M. and Buishand, T. A.: On the value of hourly precipitation extremes in regional climate model simulations, J. Hydrol., 393, 265–273, doi:10.1016/j.jhydrol.2010.08.024, 2010.

He Z., Zhao W., Liu H., and Chang X.: The response of soil moisture to rainfall event size in subalpine grassland and meadows in a semi-arid mountain range: a case study in northwestern China's Qilian Mountains, J. Hydrol., 420–421, 183–190, doi:10.1016/j.jhydrol.2011.11.056, 2012.

Lenderink, G. and van Meijgaard, E.: Increase in hourly precipitation extremes beyond expectations from temperature changes, Nat. Geosci., 1, 511–514, doi:10.1038/ngeo262, 2008.

Prein, A. F., Langhans, W., Fosser, G., Ferrone, A., Ban, N., Goergen, K., Keller, M., Tölle, M., Gutjahr, O., Feser, F., Brisson, E., Kollet, S., Schmidli, J., van Lipzig, N. P. M., and Leung, R.: A review on regional convection-permitting climate modeling: demonstrations, prospects, and challenges, Rev. Geophys., 53, 323–361, doi:10.1002/2014RG000475, 2015.

Prein, A. F., Gobiet, A., Truhetz, H., Keuler, K., Goergen, K., Teichmann, C., Fox Maule, C., van Meijgaard, E., Déqué, M., Nikulin, G., Vautard, R., Colette, A., Kjellström, E., and Jacob, D.: Precipitation in the EURO-CORDEX 0.11° and 0.44° simulations: high resolution, high benefits?, Clim. Dynam., 46, 383–412, doi:10.1007/s00382-015-2589-

y, 2016.

Ran Q., Danyang S., Li P., and He Z.: Experimental study of the impact of rainfall characteristics on runoff generation and soil erosion, J. Hydrol., 424–425, 99–111, doi:10.1016/j.jhydrol.2011.12.035, 2012.

Schilling W.: Rainfall data for urban hydrology: what do we need?, Atmos. Res., 27, 5–21, doi: 10.1016/0169-8095(91)90003-F, 1991.

Singh, V. P.: Effect of spatial and temporal variability in rainfall and watershed characteristics on stream flow hydrograph, Hydrol. Process., 11, 1649–1669, doi:10.1002/(SICI)1099-1085(19971015)11:12<1649::AID-HYP495>3.0.CO;2-1, 1997.

Sunyer, M. A., Luchner, J., Onof, C., Madsen, H., and Arnbjerg-Nielsen, K.: Assessing the importance of spatio-temporal RCM resolution when estimating sub-daily extreme precipitation under current and future climate conditions, Int. J. Climatol., doi:10.1002/joc.4733, in press, 2016.

Svensson, C. and Jones, D.: Review of methods for deriving areal reduction factors, J. Flood Risk Manage., 3, 232–245, doi:10.1111/j.1753-318X.2010.01075.x, 2010.

Wang X.-P., Cui Y., Pan Y.-X., Li X.-R., Yu Z., and Young M.-H.: Effects of rainfall characteristics on infiltration and redistribution patterns in revegetation-stabilized desert ecosystems, J. Hydrol., 358, 134–143, doi:10.1016/j.jhydrol.2008.06.002, 2008.

Westra, S., Fowler, H. J., Evans, J. P., Alexander, L. V., Berg, P., Johnson, F., Kendon, E. J., Lenderink, G., and Roberts, N. M.: Future changes to the intensity and frequency of short-duration extreme rainfall, Rev. Geophys., 52, 522–555, doi:10.1002/2014RG000464, 2014.

Wischmeier, W. H. and Smith, D. D.: Predicting rainfall erosion losses: a guide to conservation planning, Agriculture handbook 537, Science and Education Administration, U.S. Department of Agriculture, 1978.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-283, 2016.