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Hydrology and Earth System Sciences Discussions

Interactive comment on "Future extreme precipitation assessment in Western Norway – using a linear model approach" *by* G. N. Caroletti and I. Barstad

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Reply to Anonymous Referee #3

Major points:

COMMENT: The description of the linear model is too short - the reader is obliged to read the previous papers in order to understand the essentials of the linear model.

REPLY: Our goal was to include the main features of the Linear Model (LM) without making the paper too cumbersome. This is just an application of a model, not a model description. However, we will go a little more into detail. This concern has been partly addressed also in our reply to anonymous referee #2.

COMMENT: A major concern is that the authors do not present any significance analysis of their results (consider e.g., analysis of variance, bootstrap methods or anything for statistical inference). In general, the manuscript would largely benefit from using some statistics.

REPLY: We understand and aknowledge the need for some statistics, especially on what is the most important result of the application, i.e. to prove the significance of the increase of precipitation in the future scenarios (Figures 4 and 5).

To evaluate a confidence interval and compare the significance of these results, we have performed bootstrapping on the scenarios results. A 1000-runs bootstrapping provided intervals of 95% confidence: [98 103] for control scenario and [108 114] and [112 119] respectively for future scenarios. The fact that there is no overlapping shows that with good confidence the increase is a real representation of physical conditions in the future, and not just a casual result.

Another way to address also the high level of noise provided by the annual variability, was to perform a Welch's t-test (independent two-sample t-test for samles with unequal sizes, since the past scenario is made of 30 yearly values, and the future ones of 20

yearly values).

The t-tests showed that there was no overlapping between the past scenario and the future scenarios, as the [future-past] interval was [+9% +12%] for 2046-2065 time-slice and [+13% +16%] for 2081-2100 with a 95% confidence.

COMMENT: Another major point concerns the validation of the linear model. Is the linear model able to represent spatial variations that are due to orographic forcing for the reference period?

REPLY: From the literature of linear model evaluation and application, it seems justified to assume the model can manage to simulate the upslope precipitation pattern in most cases (unless convection is likely). Based on this, we will use the model for our study.

COMMENT: Are there changes in the reference period that can be attributed to changes in climate parameters during the reference period (detection and attribution)?

REPLY: There is an increase in mean temperature and precipitation in the time period 1961-2000, which is the control periodo used in IPCC2007 for the GCMs. To prevent from overestimating the increase in future scenarios, we have reduced the control period to 1971-2000.

COMMENT: Is this model able to correct for systematic errors in the GCMs? How well do the GCMs represent the major parameters of the linear model?

REPLY: The model is not able to deal with how well the GCMs represent the parameters, nor with systematic errors (it gives out according to what it reads in). In our study, however, as mentioned, we have looked at the outputs from the GCMs and excluded those models that presented some systematic errors or unreasonable values for the given area in the control and/or future periods (see page 7545, lines 6-11).

COMMENT: The forcing term in the linear model is based on a Fourier transform of the topography of a limited area. What about the boundary conditions, since the assumption of periodic boundary conditions does not apply (was a pre-whitening ap-

plied/necessary)?

REPLY: The model terrain is padded inside a larger domain where results are discarded. Thus, the cyclic behaviour of FT is not present at a significant level.

Minor comments:

COMMENT p. 7540, lines 2-4: statement 'an increase in precipitation extremes' is too general - there is evidence for an increase of precipitation extremes in some regions - but uncertainty is large on the local scale

REPLY: Changed to "increase in precipitation extremes in some areas".

COMMENT p. 7544, Eq. (4): note that l and k are integer values, shouldn't Eq. (4) consist of a sum over all l and k?

REPLY: The way of writing the integral sums are short for -inf to inf. We will add this to the equation.

COMMENT Fig. 2 is not mentioned in the text.

REPLY: A mention of Figure 2 has been added in the part that describes the model domain: "The model domain is between 57°30' and 64°20' N and 4° and 10° 40' E. This includes all of southern Norway (Figure 2)."

COMMENT p. 7545: Precise whether you work with daily accumulations.

REPLY: We are not using GCM precipitation data at all in this study, only LM's daily output. This has now been specified in the paper.

COMMENT p. 7546, line 24-25: How are the days with orographic precipitation defined exactly?

REPLY: This issue has been addressed also in our replies to Anonymous Referee #1.

We have precised the matter by writing this: “Our first step is to identify OP events. The only days considered in our study are those with a relative humidity above or equal to 85%. Lower relative humidities result in relatively weak to no OP (Barstad et al., 2007). In addition, only days with wind direction between 180° and 300° (westerly winds) were considered, since they are the only ones to give significant OP (Barstad, 2002). Precipitation intensity is calculated in mm/day. “

COMMENT p. 7546ff: I wonder, whether it is wise to use the relative values, as important information is removed. How many days are there with orographic precipitation? The major signal (increase) would be visible with absolute values, but this information (model spread, uncertainty in the model, ect.) would not get lost.

REPLY: The problem with GCMs is that they tend to have large biases, and relative values removes to some extent these problems. Number of days of rain can be interesting, but not the main focus of this paper. However, we have added this information in a revised Table that also shows the relative increase in number of days.

COMMENT p. 7547: What standard deviations are shown?

REPLY: Changed and precised in the text. Now the part reads: “The standard deviations associated to the twelve models are 4% and 5% respectively (see Table 5)”.

COMMENT Fig 6: Figure not very clear (visibility of station points is weak)

REPLY: Figure 6 has been recognized as not being of the desired quality and re-drawn completely. See also replies to Anonymous Referees #1 and #2.

COMMENT: The tables of the appendix are not discussed.

REPLY: Tables have been re-organized, and the appendix have been removed. The appendix tables have been included and discussed in the main part of the paper.

COMMENT: Table 5 and Fig 7 contain same information, remove at least one.

REPLY: Figure 7 removed, see also reply to Anonymous Referee #1.