Geoscientific
Model Development
Discussions

Interactive comment on "Evaluation of the Plant–Craig stochastic convection scheme in an ensemble forecasting system" *by* R. J. Keane et al.

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We would like to thank Anonymous Referee #1 for the thorough and prompt review. We reply first to the Major concerns listed under GENERAL COMMENTS. We refer to figures in the paper as "Figure xx" and those added here as "RF xx".

1. In fact, rather than the large-scale precipitation between the two experiments, it is the total (large-scale plus convective) rainfall that is very similar. We shall make this point clear in the revised manuscript. Its interpretation is that, broadly speaking, the atmospheric state has a certain amount of instability, some of which is consumed by the convection scheme, and then the grid dynamics consumes what is left over.

As suggested, we have redone Figure 10 for the convective part (RF 1) and the grid

scale part (RF 2), and similarly for Figure 11 (RF 3 and RF 4). The plots are very similar whether looking only over the UK (Figure 10 and variants) or only over ocean parts of the whole domain (Figure 11 and variants). Both convection schemes are unable to produce very heavy rainfall, the highest rain rates being produced by the grid dynamics, and this effect is more pronounced with the PC scheme than with GR.

As we discussed, there is no correct partitioning between large-scale and convective rainfall in a model, and likewise it is not clear from our analysis whether the heavy rainfall events in our test period would be better accounted for by a convection scheme or by the grid dynamics. One might hope for a stochastic scheme to improve the representation of heavy rainfall, and indeed to improve extreme events generally. The PC scheme is capable of doing this, as has been demonstrated in a case study of an extreme, localized flooding event in a case study by Röhner et al. The PC scheme does not show obvious benefits for heavy rain rates in our study. However, the PC scheme does succeed in increasing the spread in the convective rainfall, and this has a knock-on effect on the grid dynamics, increasing also the spread in large-scale rainfall. This can be seen in RF 5, where we have plotted the ratio of the convective rainfall spread to the convective rainfall mean, for the two schemes (PC in red and GR in green) The same is done for large-scale rainfall in RF 6. This ratio is increased for both components using PC (although in absolute terms the spread itself is lower for PC for convective rainfall).

L Röhner, U Corsmeier and T Selz (2013). Convective heavy precipitation events (HPE) in the western Mediterranean. European Meteorological Society Conference. Presentation available at http://presentations.copernicus.org/EMS2013-663_presentation.pdf

We have also followed the suggestion to plot the convective fraction for weakly-forced cases (dashed lines), strongly-forced cases (dotted lines) and overall (solid lines) for GR (green) and PC (red). The results can be seen in RF 7. The ratio using PC is smaller for both strongly- and weakly-forced cases, although the reduction is less

severe for the weakly-forced cases. It is also true that the ratio for both schemes is higher for weakly-forced cases, suggesting that the PC scheme has a larger positive impact in those situations where it is able to produce more convection.

Finally, the effect described in the paragraph on p.10215 L10-14 is indirect: applying less input averaging over the ocean would reduce the variability in the convective rainfall and this would, in turn, reduce the variability in the large-scale rainfall and therefore the tails of the distribution.

2. We are happy to split most of these sentences into 2 or 3 parts if the Reviewer feels that would improve the readability of the text, although we would argue that the sentence on p.10200 L22-26 should remain as it is.

3. We would propose leaving "model variability" as it is on p.10201 L1 (where it really is referring to different versions of the model behaving differently), and changing it to "model spread" on p.10202 L2 and to "model error" for the other three places where it occurs.

4. The interpretation is that the PC scheme produces a better statistical distribution of rainfall, but not necessarily precisely correctly distibuted in space. The introduction of stochasticity in the convective rainfall means that the results from PC are more likely to suffer from the so-called "double-penalty" problem when assessed by a score based on grid point by grid point assessment. (For example, if very heavy localised rain is observed, a forecast showing very heavy rain at a neighbouring grid point, and no rain elsewhere may be more useful than a forecast showing light rain at all grid points, but would receive a lower score if assessed at individual grid points). This is alleviated when a larger sampling area is applied.

We reply here to the Specific Comments:

1. We used the word "verification" to emphasise that we are applying techniques that are commonly used to assess forecasts, both in the scientific literature and in routine

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forecast assessment. One argument for the use of "validation" instead, is that "verification" would apply to a longer period of at least a couple of months, and that our study is about learning more about the behaviour of the PC scheme, rather than obtaining statistical certainty that one scheme is better than the other. If this is the Reviewer's point then we are happy to accept this.

2. OK.

3. See reply to Major Concern 3.

4. We propose expanding this sentence to two sentences as follows: "Groenemeijer and Craig (2012) examined seven cases using the COSMO ensemble system with 7 km grid spacing and compared the spread in an ensemble using only different realizations of the PC scheme (i.e. where the random seed in the PC scheme was varied but the members were otherwise identical) with that in an ensemble where additionally the initial and boundary conditions were varied. They found the spread in hourly-accumulated rainfall produced by the PC scheme to be 25–50% of the total spread, when the fields were upscaled to 35 km."

5. We propose "learn" -> "reveal".

6. We propose "Of course, the two parameterizations are different in other ways than the stochasticity of the PC scheme: it is therefore possible that any differences in performance are due to other factors."

7. We propose expanding this sentence to two sentences as follows: "It is based on the Kain-Fritsch convection parameterization (citation), adapting the plume model used there and also using a similar formulation for the closure, based on a dilute CAPE. It generalizes the Kain-Fritsch scheme by allowing for more than one cloud in a grid box, and by allowing the size and number of clouds to vary randomly."

8. We shall add some text so it reads " ... core to be averaged in horizontal space and/or in time before it is input."

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9. OK (54 hours).

10. This is actually correct as the average is here over scores centred at different grid points, not over neighbouring grid points to produce a score for a single grid point. Since Reviewer #2 has asked for more motivation and clarification of this score, we shall revise this text and hopefully this point will be clearer.

11. The FSS is here calculated for each member individually and this should also be included in the angle brackets that were referred to in point 10 (i.e. equation 1).

12. Yes it would be better with a colon.

13. The lead time is mentioned at the end of the first part of this section, but we shall bring it forward to where the plots are introduced.

Figures 2-5: We shall increase the font size, according to how the figures are to be rendered in the final version.

Figures 2-4 + 8 + 10-11: For FSS see point 11. For Figure 8 this is a mean convective rainfall over all grid points, forecast starts and ensemble members, divided by a similar mean of the total rainfall. For Figures 10 & 11 we have treated each member as a separate forecast (i.e. there are simply 24 times as many data points in the PDF). We shall make sure that these points are made fully clear in the revised text.

Figure 4: This is averaged over all lead times, which we shall make clear, and we shall add a zero line.

Figures 10-11: The PDF is now plotted for all values (we have changed the calculation a little, so that the bins vary logarithmically in the same way as the graph scale, i.e. smaller widths for lower values and larger widths for higher values). We have also divided by the bin width dr, so that the quantity plotted is truely a PDF (the probability is given by $p(r)dr$ so to obtain the PDF one must divide the relative number of counts in each bin by dr).

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Interactive comment on Geosci. Model Dev. Discuss., 8, 10199, 2015.
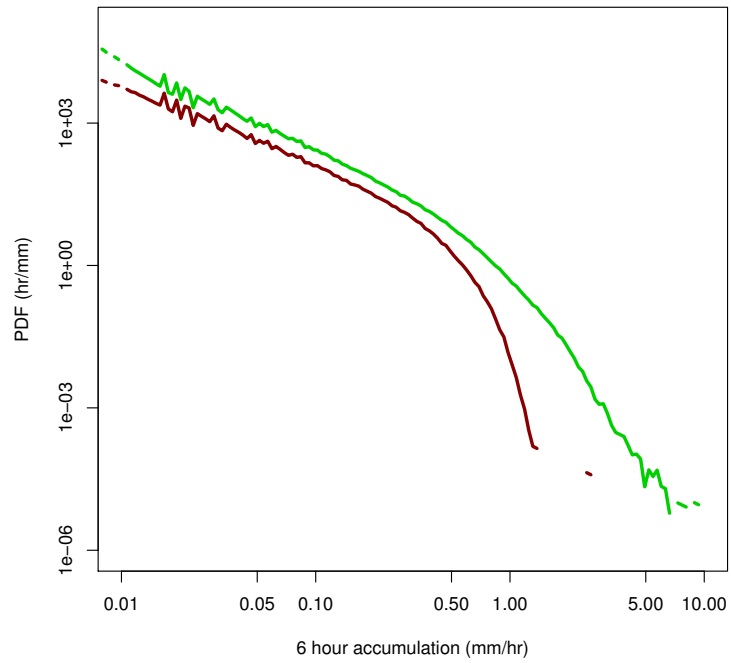
Fig. 1. PDFs of convective rainfall over the UK part of the domain, for forecasts with the Gregory–Rowntree scheme (green line), the Plant–Craig scheme (red line).
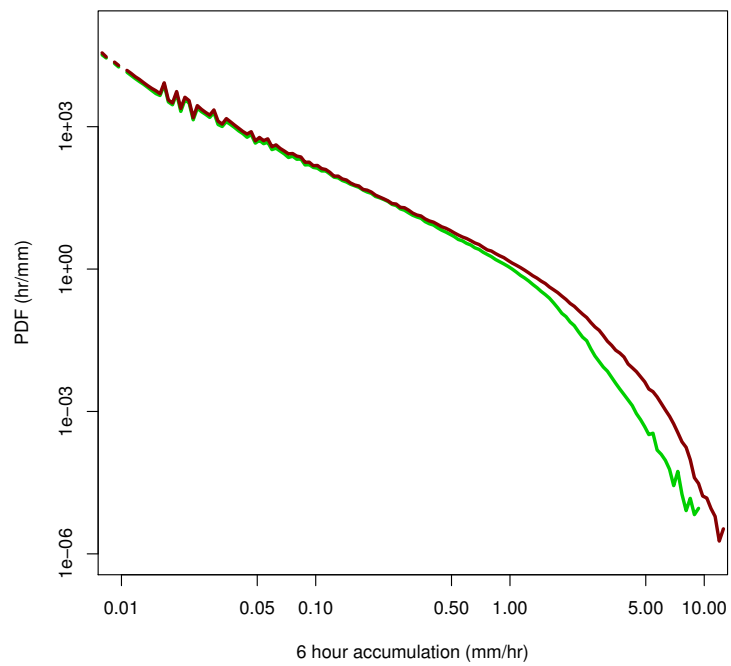
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Fig. 2. PDFs of grid-scale rainfall over the UK part of the domain, for forecasts with the Gregory–Rowntree scheme (green line), the Plant–Craig scheme (red line).
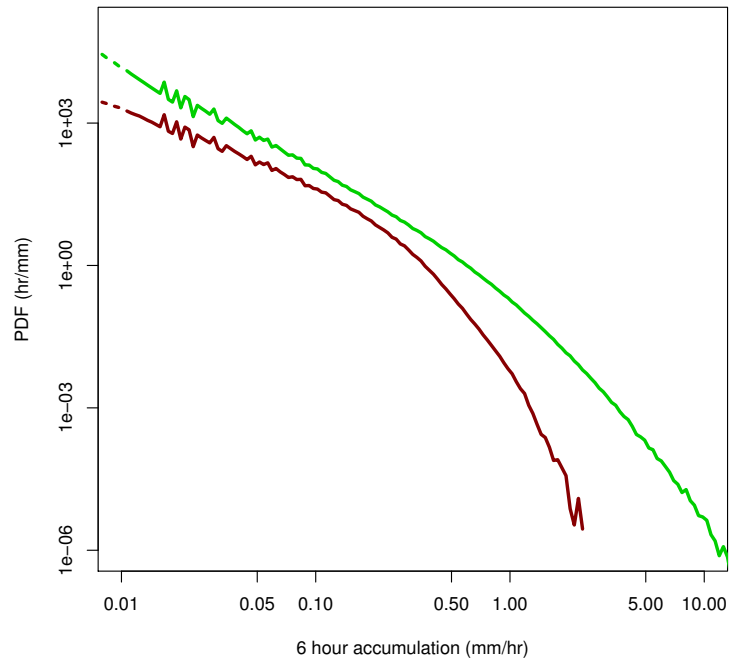
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Fig. 3. PDFs of convective rainfall over ocean, for forecasts with the Gregory–Rowntree scheme (green line), the Plant–Craig scheme (red line).

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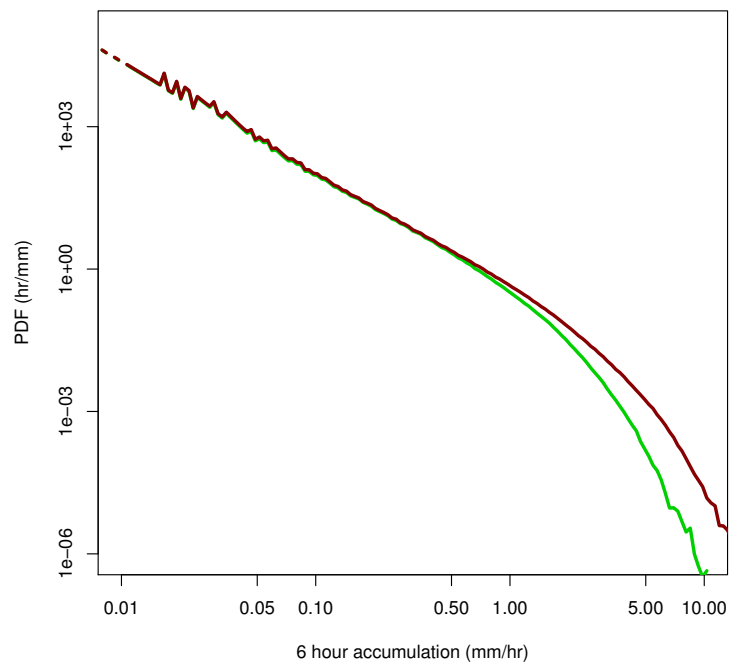
Fig. 4. PDFs of grid-scale rainfall over ocean, for forecasts with the Gregory–Rowntree scheme (green line), the Plant–Craig scheme (red line).
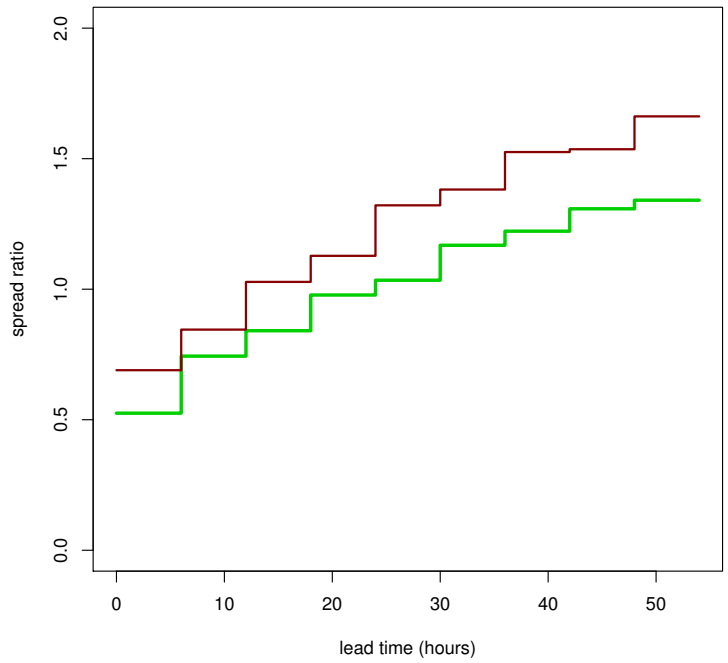
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Fig. 5. Ratio of convective rainfall spread to convective rainfall mean, for forecasts with the Gregory–Rowntree scheme (green line), the Plant–Craig scheme (red line).
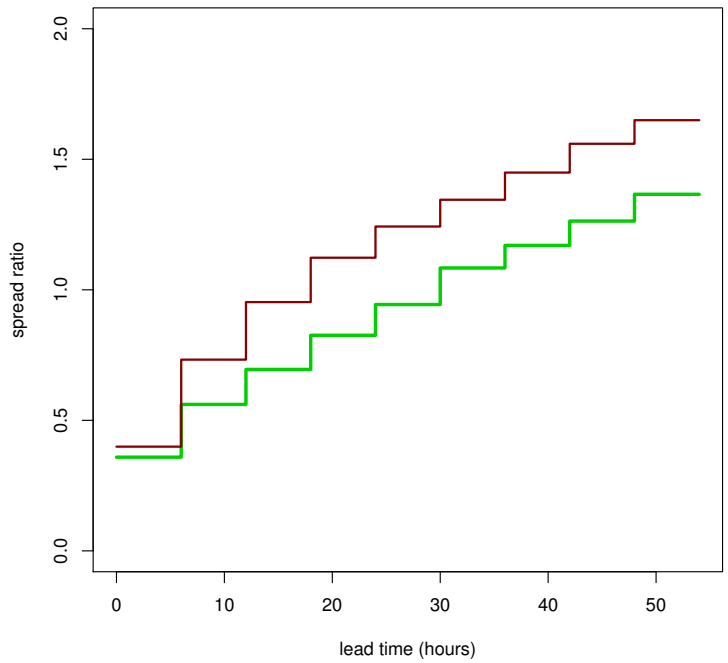
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Fig. 6. Ratio of grid-scale rainfall spread to grid-scale rainfall mean, for forecasts with the Gregory–Rowntree scheme (green line), the Plant–Craig scheme (red line).
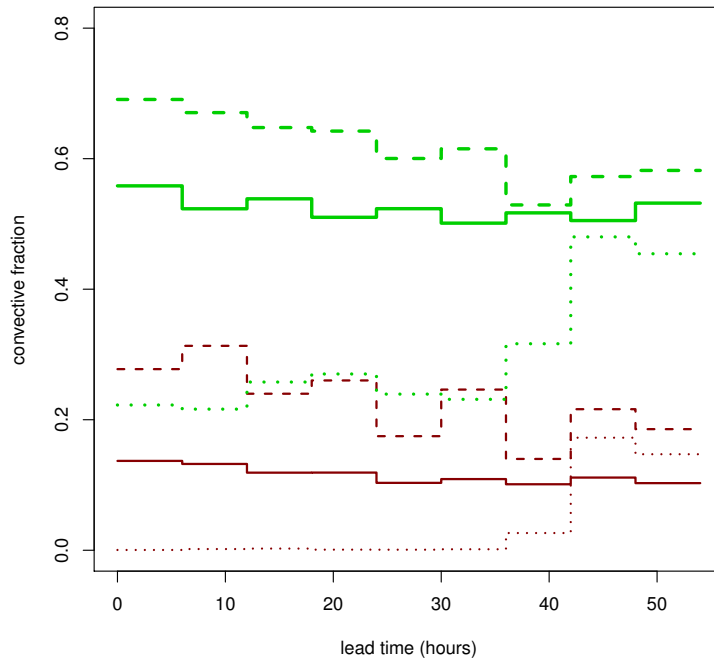
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Fig. 7. Convective fraction for weakly-forced cases (dashed lines), strongly-forced cases (dotted lines) and overall (solid lines) for GR (green) and PC (red)

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