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Hydrology and Earth System Sciences Discussions

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HESSD

10, C6688–C6698, 2013

Interactive Comment

Interactive comment on "When does higher spatial resolution rainfall information improve streamflow simulation? An evaluation on 3620 flood events" *by* F. Lobligeois et al.

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The authors thank Dr Alberto Viglione for his positive and constructive comments on the manuscript. We agree with most of the points of view he expressed. We respond to his questions and we explain how we will modify the text to account for his comments.

Page 12497, line 19: maybe a rainfall movement index could be added here, such as, for example, the catchment scale storm velocity discussed in Zoccatelli et al. (2011).

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Reply: We took in consideration this relevant suggestion and we used the catchment-scale storm velocity, V_S, proposed by Zoccatelli et al. (2011) to compute the rainfall movement index of precipitation fields, I_M, shown in Eq. (1) :

(1) $I_M = \frac{\sum_{t=1}^{T} V_S(t).P_t}{\sum_{t=1}^{T} P_t}$,

where

(2) $V_S(t) = C_{bsn}.\frac{dI_{pcp}(t)}{dt}$,

(3) $I_{pcp}(t) = \frac{C_{pcp}(t)}{C_{bsn}}$,

(4) $C_{pcp}(t) = \frac{\sum_{i=1}^{N} P_i(t).A_i.L_i}{\sum_{i=1}^{N} P_i(t).A_i}$,

(5) $C_{bsn} = \frac{\sum_{i=1}^{N} A_i.L_i}{\sum_{i=1}^{N} A_i}$,

where P_t is the spatial average of the hourly precipitation field covering the basin at the time step t, T is the duration of the flood event, $P_i(t)$ is the hourly rainfall data for the pixel i at the time step t, N is the total number of rainfall pixels within the watershed, C_{bsn} is the basin's centre of mass, $C_{pcp}(t)$ is the centre of rainfall mass for each time step t, $I_{pcp}(t)$ is the rainfall centroid ratio for each time step t, A_i is the pixel area ($A_i = 1\ km^2$ in the present case) and L_i is the hydraulic distance between the pixel i and the catchment outlet calculated through the river network.

The storm movement index I_M quantifies the averaged catchment-scale storm velocity over the flood event duration: it is a velocity measure expressed in $L.T^{-1}$. As discussed by Zoccatelli et al. (2011), negative and positive values of the storm movement index respectively indicate that the precipitation field mainly moved to the upstream and downstream part of the catchment. Null I_M values indicate that the storm is stationary or moved to the upstream as well as downstream part of the catchment during the flood event duration.

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We will include the storm movement index in our discussion and Figs. 6, 7 and 11 in the discussion paper will be updated. Please, see the changes in Figure 1, Figure 2 and Figure 4 at the end of this response.

Page 12499, line 22: "hydrological truths" seems a bit too strong to me :-)

Reply: We agree. We were too enthusiast regarding the modelling results. Moreover, modelling results should not be considered as "hydrological truths". We will replace the following sentence "Some obvious hydrological truths can be observed in Fig. (. . .)" by "Some obvious modelling results can be observed in Fig. (. . .)".

Page 12499, line 28: "perfectly balanced" seems again too strong, unless "perfect balance" is somehow defined. If I were the Author, I would write "...KGE is balanced between..."

Reply: We agree we should not use the term "perfect" about criteria evaluation. We will correct it. The following sentence will be changed: "(. . .) KGE is perfectly balanced between (. . .)" will be replaced by "KGE is balanced between".

Page 12502, line 5: shouldn't "has now been further investigated" be "has been further investigated" or "is now further investigated"?

Reply: We agree. We will replace the sentence "This aspect has now been further investigated" by "This aspect is now further investigated".

Page 12506, line 7: a curiosity here. For some catchments/events the spatial variable rainfall (even with a coarse resolution) provides a better input than the lumped one. I wonder if a lumped model could make use of indices of spatial variability of the rainfall (just the indices, i.e., I_σ and/or I_L, not the spatial rainfall

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itself) to better reproduce the runoff hydrograph. Actually soft information could be retrieved for flood events on the region of the catchment more severely affected by rainfall, for example interviewing the people living there in post-event surveys. This soft information could maybe be converted into an index such as I_L and/or I_σ and used in the model. Any idea on how? PS. this discussion can be omitted from the paper, it is just my personal curiosity.

Reply: This is a relevant curiosity. Actually, this question has already been investigated by Bourqui (2008) who modified the lumped rainfall-runoff model GR4J to account for rainfall spatial variability. She tried to quantify the improvement of model performance obtained by taking into account this variability. In her work, rainfall spatial variability was evaluated using the ground network of raingauges for about 200 French basins. Two approaches were explored:

(i) The first one consisted in introducing an index of rainfall spatial variability in the structure of the lumped rainfall-runoff model. This index more or less modified the model functioning depending on the level of rainfall heterogeneity.

(ii) The second one consisted in applying a multi-model approach: several models were run in parallel, each of them being fed by the rainfall input of a single raingauge. Their outputs were then combined following different aggregation strategies.

The results of the large number of tests indicate that the gains in model performance that can be expected from introducing the information on rainfall spatial variability are very limited on average on the catchment set.

The work we proposed in the present paper is the continuation of this previous research which was limited to lumped modelling. Furthermore, we believe the GR4J lumped model (like other models) behaves like a low-pass filters, absorbing spatial variations of rainfall inputs through the routing store (see the GR4J structure in Perrin et al. (2003)

and the discussion by Oudin (2004)). As a consequence, we wonder if the lumped GR model is adequate to investigate the impact of spatial heterogeneity on catchment response. This is why, in this present study, we investigate the impact of spatial rainfall variability on catchment response using semi-distributed modelling.

However, we prefer to not include this discussion in the present paper since this is not in the scope of the researched work.

Figures 6 and 7: one panel could be added with a rainfall movement index such as, for example, the catchment scale storm velocity discussed in Zoccatelli et al. (2011).

Reply: We will present and comment the cumulative distribution of the storm movement index for the 3620 observed events. Please see Figure 1.

Figure 6: maybe a log-normal plot would result in a more readable curve (which is quite skewed)

Reply: We will correct it. Please see Figure 1.

Figure 7: switch the last 2 panels for consistency with Fig. 6

Reply: We will correct it. Please see Figure 1 and Figure 2.

Figure 7 and 8: just a suggestion, if in Fig. 7 a colour scheme is used for recognising different regions in France and the same colors are used in Fig. 8, the discussion of Fig. 8 would maybe become easier and clearer. Reply: We will take into account your suggestions. Please see Figure 2 and Figure 3.

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Figure 11: “The red points show the median values”. The median of what? I guess of the relative KGE performance index.

Reply: We will add more explanations in the figure legend. Please see Figure 4.

References

Bourqui, M.: Impact de la variabilité spatiale des pluies sur les performances des modèles hydrologiques., Ph.D. thesis, ENGREF, Cemagref, France, 2008.

Oudin, L.: Locating the sources of low-pass behavior within rainfall-runoff models, Water Resour. Res., 40(11), doi:10.1029/2004WR003291, 2004.

Perrin, C., Michel, C. and Andréassian, V.: Improvement of a parsimonious model for streamflow simulation, J. Hydrol., 279(1–4), 275–289, doi:10.1016/S0022-1694(03)00225-7, 2003.

Zoccatelli, D., Borga, M., Viglione, A., Chirico, G. B. and Blöschl, G.: Spatial moments of catchment rainfall: rainfall spatial organisation, basin morphology, and flood response, Hydrol. Earth Syst. Sci., 15(12), 3767–3783, doi:10.5194/hess-15-3767-2011, 2011.

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Figure captions

Figure 1: Cumulative distribution of flood durations, peak values, event-based amounts of precipitation, localization, spatial variability and storm movement indexes of precipitation fields for the 3620 observed events in the 181 selected catchments (values for the minimum, 0.25, 0.5, 0.75 percentiles and the maximum are indicated on the cumulative distributions).

Figure 2: Event characteristics averaged over the 20 flood events observed in each of the 181 catchments. The peak flow coefficient is the ratio between the peak flow and the mean flow. The colours refer to geographic regions.

Figure 3: Relationship between seasonality of the spatial rainfall variability (left) and spatial rainfall variability and event duration (right) for the 3620 flood events observed. The colours refer to geographic regions with the same colour scheme used in Fig. 2.

Figure 4: Relative KGE performance index in validation mode between the lumped and the semi-distributed (SD04) simulations. The relative performance indices are computed for 3620 flood events ordered by location index (top), storm movement index (middle), spatial rainfall variability index (bottom) and for three groups of 60 catchments classed by area (G01, G02 and G03). For each catchment group, the red point plotted on the axis at x=0 shows the median values of the variable of interest (I_L, I_M or I_σ). The boxplots show the distribution of the relative KGE performance index for three groups of events with the same number of events per boxplot.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 12485, 2013.

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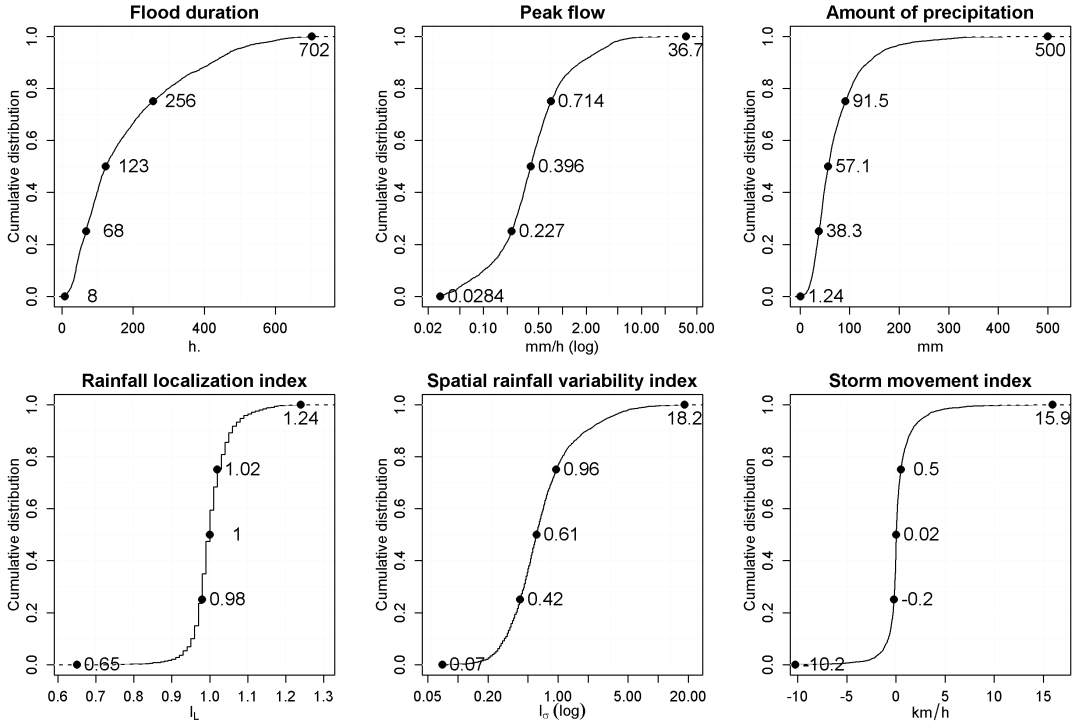

Fig. 1.

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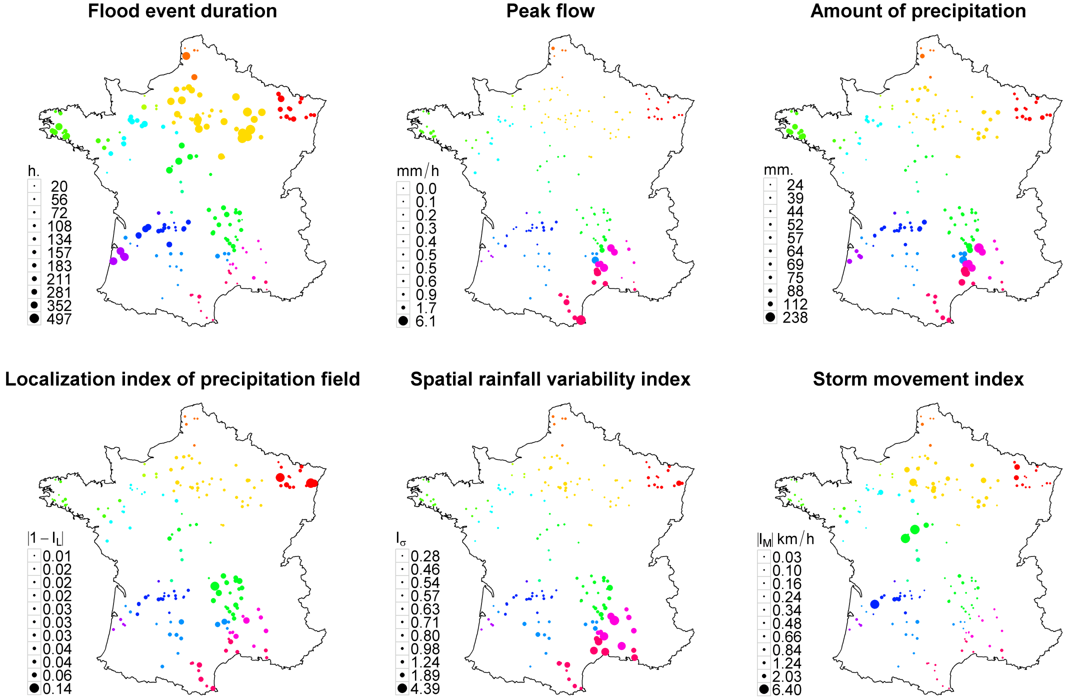
Flood event duration
h.
20
56
72
108
134
157
183
211
281
352
497
Peak flow
mm/h
0.0
0.1
0.2
0.3
0.4
0.5
0.5
0.6
0.9
1.7
6.1
Amount of precipitation
mm.
24
39
44
52
57
64
69
75
88
112
238
Localization index of precipitation field
|1 − I_L|
0.01
0.02
0.02
0.02
0.03
0.03
0.03
0.04
0.04
0.06
0.14
Spatial rainfall variability index
I_σ
0.28
0.46
0.54
0.57
0.63
0.71
0.80
0.98
1.24
1.89
4.39
Storm movement index
|I_M| km/h
0.03
0.10
0.16
0.24
0.34
0.48
0.66
0.84
1.24
2.03
6.40

Fig. 2.

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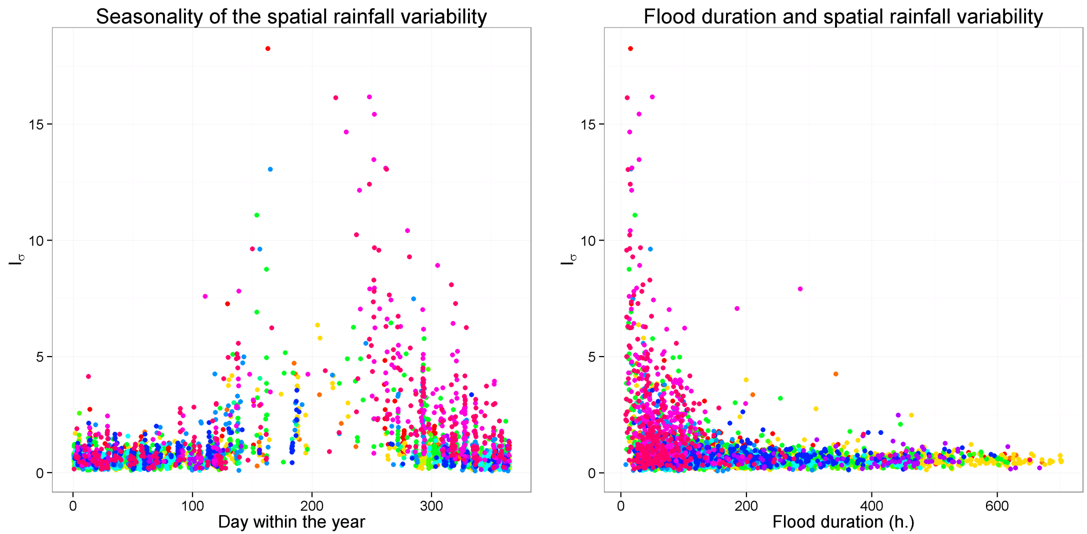
Seasonality of the spatial rainfall variability
Flood duration and spatial rainfall variability
I_σ
0
5
10
15
0
100
200
300
Day within the year
0
200
400
600
Flood duration (h.)

Fig. 3.

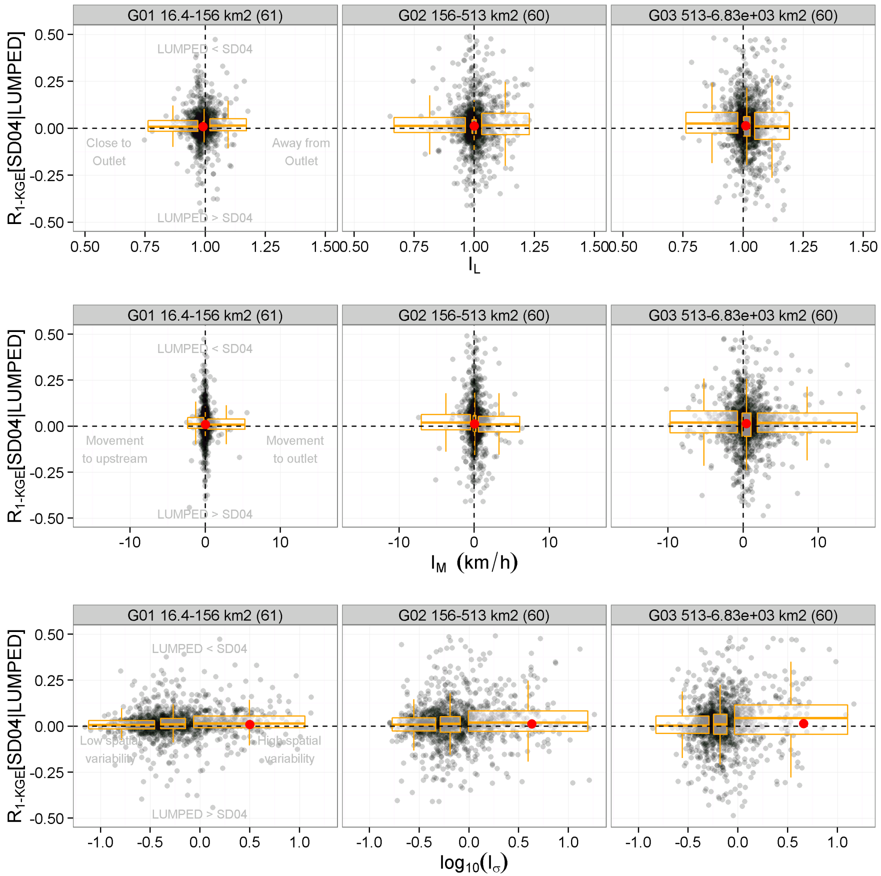

Fig. 4.

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