Hydrology and Earth System Sciences Discussions

Interactive
Comment

Interactive comment on "Uncertainties on mean areal precipitation: assessment and impact on streamflow simulations" *by* L. Moulin et al.

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General comments

The paper deals with the assessment of mean areal rainfall uncertainties and their impact on discharges. This is a dynamic field of research, thus, new contributions can be very interesting. Authors suggest an areal rainfall error model based on ordinary kriging interpolation method and first order autoregressive models (AR(1)). Overall, the paper is rather clear and well organized, nevertheless, we have some methodological doubts, which we discuss in the next section.

Specific comments

The first point concerns the use of climatological variogram for rainfall data at daily and finer time scales. Kriging interpolation is often used for rainfall data aggregated

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to coarser time scale, such as monthly (e.g., Chen et al., 2008) or for mean of the annual rainfall averages (e.g., Pardo-Iguzquiza, 1998). For rainfall series at daily or finer time scales, Wood et al. (2000) and Villarini and Krajewski (2008) show that areal rainfall error depends on rainfall intensity. Adopting a climatological variogram such dependence is neglected, since the error standard deviation is "constant over the whole period in case of stationary network" (pp. 2075-2076). This aspect could be not much important in the interpolation process (the usual application of kriging), but it could be in simulation. In fact, as shown by Figs. 5 and 8, climatological assumption results in constant errors associated to interpolated values, since oscillations are only due to failures on data collection, and on the number of surrounding gauges used to interpolate (p. 2076). This fact could be more evident if y-axis of Figs. 5 and 8 is extended to negative values, highlighting the symmetry of errors around the interpolated values. From the text, the simulation algorithm seems to consist in adding a simulated AR(1) signal to interpolated rainfall. However, this procedure can easily generate negative rainfall values corresponding to interpolated values below about 10 mm/h, where many observations are clustered. If the above generation algorithm is correct (please, clarify in the text), it is important to point out how eventual negative values are managed. A simple removal can strongly affect both intermittency and event volumes, resulting in a bias and/or delay of hydrograms. Other correction procedures (if used) should be described and tested. We notice that the above problems do not arise when kriging is used for interpolation and one deals with data that exhibit values far from zero and/or allowing negative values.

The second issue concerns the use and validation of AR(1) hypothesis. The assumption of autocorrelated errors can be reasonable, but the validation procedure in Section 4.2 can be questionable. Authors simulate using autocorrelated errors and show (Fig. 6) that the inflated errors are closer to the observed ones than uncorrelated errors. Then, they conclude that observed errors are autocorrelated. However, the variance inflation is an analytical property of AR(1) process, as pointed out in Eq. (15). Thus,

AR(1) correction accomplishes the task of inflating variance, but it does not prove that inflation is due to autocorrelation. The reasoning should be opposite: after proving the existence of autocorrelation by computing e.g. the autocorrelation function (ACF) and assessing its significance at lag 1, then, lag-1 ACF value can be used to build AR(1) model. On the contrary, authors fix the lag-1 ACF value (= 0.6) that allows obtaining the desired variance inflation without showing the actual existence of temporal linear dependence.

Another point relates to conclusions reported in Section 5.1.2. Authors show distributions of the highest simulated MAP errors in Fig.7, and state that small errors for large catchments depend on averaging effects of the catchment area. Actually, differences between small and large catchments should be only due to rain gauge network configuration. If a dense network is available in a small basin, we could have averaging effects in spite of catchment area. Furthermore, 90% simulated confidence intervals of maximum computed MAPs at the three stations are close to each other (about 20, 14, 18 mm/h at Rieutord, Chambon-sur-Lignon and Bas-en-Basset, respectively) and do not exhibit the behaviour of maxima. Thus, conclusions could be that: (i) maxima of absolute errors decrease when the number of interpolation points increase (dependence on the area is indirect); (ii) 90% confidence bands are theoretically constant for each quantile (differences must be ascribed to lack of measurements in some site); (iii) 90% confidence bands seem rather constant for all catchments (straight lines interpolating the peaks of 90% confidence bands in Fig. 8 show rather constant width).

At lines 15-25 of page 2087 (Section 5.2.2), authors comment Table 5 and write that "For the smallest catchments (Rieutord, Chambon-sur-Lignon), the simulated 90% confidence interval contains almost 90% of the measured streamflow values when a tolerance factor of 20% is considered (Table 5)". From Table 5, this conclusion seem to be correct for the smallest and the largest basins when $Q_{obs} > Q_{10}$. In the other cases, percentages are 68.7, 53.6, 50.6, 65.0%, rather far from 90.0%.

Authors recognize that the model is far from being perfect, but some properties and aspects have to be accounted for in order to obtain reliable results. In particular, rainfall observations at daily or finer time scale represent an intermittent process difficult to be modelled with Gaussian-based tools. Perhaps, the approach proposed by authors can be more suitable for rainfall at coarser time scales.

Technical corrections

Pag. 2076, line 5: "...stationnary...","...stationary...".
Pag. 2080, line 15: "...is an weighted...", "...is a weighted...".
Pag. 2098, Table 4: Please, add a sentence in the caption explaining that column "50%" refers to NSE (as mentioned in the text).
Pag. 2103, Fig. 4: Histograms are not suitable to point out goodness of fit. Please, consider qq-plots or pp-plots for visual assessing the agreement of normal distribution and empirical one. Furthermore, it should be better to use formal goodness-of-fit tests (Kolmogorov-Smirnov, Lilliefor, Shapiro-Wilk for normality, among others).
Pag. 2104, Fig. 5: Please, extend y-axis to negative values to point out the symmetry of the errors around the interpolated values.
Pag. 2105, Fig. 6: This figure is difficult to be read. Please, increase dimensions of characters and symbols.
Pag. 2106, Fig. 7: Consider to invert axes, and to change "scenario" label with "probability of (non-) exceedance". "...higher errors...", "...the highest errors..."
Pag. 2107, Fig. 8: Please, extend y-axis to negative values (see comment to Fig. 5).
Pag. 2109, Fig. 10: Figure colours do not match with those reported in the caption.
Pag. 2110, Fig. 11: This plot is not mentioned in the text. Consider to remove it, since related information is already described in Table 5.

References

Chen Y-C, Wei C, and Yeh H-C (1998) Rainfall network design using kriging and entropy. Hydrological Processes, 22, 330-346.

Pardo-Iguzquiza E (1998) Comparison of geostatistical methods for estimating the areal average climatological rainfall mean using data on precipitation and topography. Interantional Journal of Climatology, 18, 1031-1047.

Villarini G, Krajewski WF (2008) Empirically-based modeling of spatial sampling uncertainties associated with rainfall measurements by rain gauges. Advances in Water Resources, 31, 1015-1023.

Wood SJ, Jones DA, Moore RJ (2000) Accuracy of rainfall measurement for scales of hydrological interest. Hydrology and Earth System Sciences, 4, 531-543.

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