Hydrology and Earth System Sciences Discussions

Interactive
Comment

Interactive comment on "The spatial variability of snow water equivalent" *by* T. Skaugen

T. Skaugen

Received and published: 2 August 2007

The basic questions that this paper seeks to answer are: 1.If the spatial distribution of a unit snowfall is gamma distributed in space, what is the spatial distribution of the sum of, say 10 units of snowfall 2.If the equivalent of, say, 2 unit snowfalls are melted from the sum of, again, 10 units of snowfall, what is the spatial distribution of the remaining snow? In the paper there is acknowledged that there is a correlation in time between the stochastic unit fields when accumulating and when melting. This temporal correlation prevents us from treating the stochastic fields as independent events, which would otherwise greatly simplify the algebra of the distributions.

Referee #1 (R#1):"However the model proposed by the author describes the process of snow accumulation and melting in a point, while the spatial coordinates are not mentioned anywhere in the paper." Reply: This is not correct, but the confusion is entirely the fault of the author. y, in this paper refers to a realisation of a stochastic field, and we should have written y as y(x), where x is the spatial coordinate. This will

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be clearly stated in the text at the beginning of section 2 in the revised version. We have at all times derived the spatial distribution, as sums and differences of correlated (in time), gamma distributed (in space) stochastic unit fields of snowfall and melt.

R#1:"The passage from the temporal distribution of SWE in a point to the spatial distribution over the area is based on the misinterpreted notion of ergodicity and is unconvincing". Reply: y is distributed in space with parameters "alfa" and "ny", which, however are estimated from a time series positive point precipitation. In doing so there is an assumption of ergodicity involved (which is discussed in the paper, p1475 l. 26-27 and p.1476, l. 1-7). These estimates of "alfa" and "ny" gave very good results (which are, in fact, quite convincing). I must stress that the assumption of ergodicity is not a part of the model, but of its application. When there is no available quantitative information on the spatial distribution of the units, we used the temporal distribution of positive point precipitation as our best guess, believing that the variability found in the time series was to some degree reflected in the spatial variability. The confirmation of this being a reasonable approach comes from comparing the distribution of the sum of the spatial distributions (of the units) with the observed spatial distribution of SWE. And they compare very well.

R#1:"As applied to this case, the ergodicity would roughly mean that averaging over the area can be replaced by time averaging over some trajectory that covers the area well in some sense. Thus the spatial coordinates are involved in the process of calculations" Reply: The use of ergodicity is limited here to guess at the parameters of the spatial distribution of the units. One should bear in mind that the actual spatial distribution of SWE, and its parameters, changes continuously as accumulations and melting occur. When the method is implemented in a hydrological model, the spatial average will be derived from values obtained at a point or at points, which is exactly what happens in most rainfall-runoff modelling applications. The spatial distribution of SWE and thus its spatial variability will be estimated by the proposed model.

R#1:"Anyway, it is clear that the type of correlation within the time series measured in a

point is essentially different form the type of spatial correlation within the area" Reply: Agreed, but we do not estimate the temporal correlation from the time series in a point. The value of c is tuned in order to get an optimal fit of the spatial standard deviation (p. 1475, l.10). Furthermore, the spatial correlation is not an issue in this paper as there is no attempt to interpolate or otherwise place certain values of SWE at particular places within the area of interest. It is quite clearly stated in the paper (p. 1466, l. 13, and in section 2) that we consider only the temporal correlation between the ys (stochastic fields), and the correlation coefficient c represents the temporal correlation averaged over the number of events.

R#1:"..therefore, there can be no method to allow one to derive some spatial regularities from measurements made in a single point. Thus, unfortunately the author failed to solve the problem posed, and the paper should be rejected." Reply: I disagree. Trough developing a model that considers the snowpack as a history of accumulation and melting events, represented by spatial distributions, we are able to estimate the distribution of the sum and differences of these distributions, and thus the spatial distribution of SWE at all times. It is difficult to understand how the referee can say that the model is unconvincing and fails to solve the problem in light of the very good fits obtained when comparing simulated and observed spatial standard deviation and CDFs.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 1465, 2007.

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