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Hydrology and Earth System Sciences Discussions

Interactive comment on "Geostatistical radar-raingauge combination with nonparametric correlograms: methodological considerations and application in Switzerland" *by* R. Schiemann et al.

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1 Reply to comments by referee #1 (S. Sinclair)

1.1 Construction of the radar composite

The construction of the radar composite is documented in German et al., 2006. In particular, the radar precipitation field is adjusted to gauge measurements using a single factor for each of the three contributing radars. The factor is determined from radar-gauge agreement after integration over a large time window (6 months) and several gauges in the vicinity of the radar. This is a 'climatological' bias correction; it involves only a small subset of the gauge network considered in this study, and does not correct for the substantial biases that can occur in the radar composite on the hourly timescale.

A corresponding remark will be added to the revised manuscript (section 2.1).

1.2 Cross validation

We expect this influence to be small. Even though somewhat involved, the whole purpose of steps 1 and 2 of the KED$_{OK}$ and KED$_{KED}$methods is to yield residual fields from which the nonparametric correlograms for $Y(\mathbf{s})$ (Eqn. 13) can be estimated. The presence or absence of a single gauge should only have a minor influence on the general character of these correlograms. On a similar note, Erdin (2009) found for the combination of daily Swiss radar and raingauge data, that re-estimating a parametric semivariogram for each gauge removed in leave-one-out cross validation differs negligibly from the result obtained using the full set of raingauges. Nonetheless, the sparser gauge network used herein, the characteristics of the spatial distribution of hourly precipitation, and the ability of nonparametric correlograms to capture much of the actual spatial structure, might have some impact on how a single gauge can influence the estimated correlogram. We therefore agree with the reviewer, that this point should be double-checked explicitly and plan to do so in future implementations. We will add a corresponding remark in the concluding section of the revised manuscript.

1.3 Range of the empirical semivariogram (Fig. 8a)

The estimation of the parametric semivariograms is described in Appendix A. We restrict the calculation of the empirical semivariogram to lag distances smaller than the practical range of a first-guess one-dimensional semivariogram or 150 km (whichever smaller, Appendix A, Step 3). For test case 2, this range is smaller than for the other cases and hence the truncation in Fig. 8a. For the robust estimation of a parametric two-dimensional semivariogram from the empirical semivariogram, we found it beneficial to reduce the maximum lag even further (Appendix A, Step 4).

In complete analogy to the one-dimensional case, these thresholds are largely chosen empirically. This is a drawback of the parametric estimation and one of the reasons why we put forward the nonparametric estimation.

1.4 Technical corrections

We agree to all technical corrections suggested by the reviewer and will make corresponding changes in the revised manuscript. These changes include:

- Pg. 6937, lines 5 & 6: sentence will be removed
- Pg. 6940, line 10: reformulate to "A spatially complete rainfall field is estimated by OK_{np} using a sparse set of radar values sampled at the gauge locations."
- Pg. 6943, bullet starting at line 3: reformulate to "A representative spatial distribution of gauges is necessary to assess the average performance of a method in the study area. As far as the distribution over different parts of the country is concerned, the MeteoSwiss raingauge network reasonably meets this requirement. Remote and high-altitude locations, however, are somewhat underrepresented."

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2 Reply to comments by referee #2

2.1 Introduction

Pg. 6929, line 15, the following sentence will be added: "... radar data in Switzerland. Additionally, the present application tests in how far geostatisitical methods that traditionally rely, implicitly or explicitly, on a Gaussian data model, can be applied to highly non-Gaussian and non-continuous hourly precipitation data in complex terrain. This paper ..."

2.2 Wet-dry distinction of OK methods

As emphasized at the beginning of section 2.3 (pg. 6937, line 11), the OK methods are interpolations based on the sparse gauge values and use the radar data only for the estimation of the correlogram. Since the sparse gauge network is spatially much less representative than the spatially complete radar composite, it is not at all surprising that the distinction between wet and dry areas is better in the radar composite. This is an advantage of the radar field over the gauge data, and both this and previous studies show that the higher spatial representativity of the radar can be incorporated into the geostatistically merged fields.

2.3 Study area

Pg. 6930, line 1: The first sentence of this paragraph will be changed to "The study area is Switzerland and has a surface area of 41285 km^2."

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2.4 Wet-dry threshold

In Alpine Switzerland, flooding at different spatial and temporal scales is a major natural hazard. Accordingly, the main application of the radar-raingauge combination methods will be the near-realtime monitoring of precipitation, and the near-realtime provision of the precipitation data for impact models. With this application to abundant precipitation in mind, the threshold has been set to the value of 0.5 mm/h, which is well above the sensitivity threshold of raingauges.

Even if focus is on other applications, notably long-term hydroclimatological budget calculations, this choice is not too critical. We have calculated for a number of gauges the contribution of hourly accumulations $<$ 0.5 mm/day to the total long-term accumulation. This contribution is smaller than 10% for stations in the central/northern part of Switzerland (Swiss Plateau), and should be considerably smaller than that in the Alps and the south of the country.

2.5 Underestimation of sill and range

We agree with the reviewer and the existing geostatistical literature both emphasizing the primary importance of the correlogram near the origin. In fact, this is expressed in section 2.2.3 (pg. 6936, lines 7-14) and is one of the reasons for using nonparametric correlograms in this study.

We have not explicitly tested in how far the underestimation of the semivariogram at large lags (i.e. sill and range) might adversely affect our results. We expect this to be largely dependent on the case under consideration and find this an interesting option for future research.

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2.6 Technical corrections

See reviewer #1.

Erdin, R. (2009), Combining Rain Gauge and Radar Measurements of a Heavy Precipitation Event over Switzerland, Master's Thesis, MeteoSwiss / ETH Zurich, 108pp.

Germann, U., G. Galli, M. Boscacci, and M. Bolliger (2006), Radar precipitation measurement in a mountainous region, *Quarterly Journal of the Royal Meteorological Society*, 132(618), 1669-1692, doi:10.1256/qj.05.190.

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