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Geostatistical combination of radar and rain gauges – does data transformation improve uncertainty estimates?

Rebekka Erdin (1), Christoph Frei (1), and Hans R. Künsch (2)

(1) MeteoSwiss, Kraehbuehlstrasse 58, P.O. Box 514, CH-8044 Zurich, Switzerland (rebekka.erdin@meteoswiss.ch), (2) ETH Zurich, Seminar for Statistics, Raemistrasse 101, CH-8092 Zurich, Switzerland

Geostatistical methods are widely used to combine radar and rain gauge data. The underlying stochastic concept not only provides an estimate of the precipitation amount but also of the estimation uncertainty. Accurate uncertainty estimates are elementary for many applications, e.g. ensemble hydrological runoff modeling. However, geostatistical combination methods assume Gaussian distributions, whereas precipitation and radar error fields are non-Gaussian. In spite of this contradiction, several studies have shown good performance of geostatistical radar-gauge combination for the precipitation estimate. Yet, the contradiction may be much more critical for the estimation uncertainty and this quantity has rarely been verified so far.

We propose to modify classical geostatistical combination methods by using Box-Cox transformed radar and rain gauge data. The goal is to better fulfill model assumptions and hence obtain more realistic uncertainty estimates. In an application over Switzerland, we compare untransformed and Box-Cox transformed data in two standard combination techniques - kriging with external drift (KED) and ordinary kriging of radar errors (OKRE). The effect of transformation is illustrated qualitatively by example cases and assessed quantitatively in a systematic evaluation of precipitation AND uncertainty estimates over one year.

Our analyses show that the Box-Cox transformation of radar and gauge data influences the probabilistic precipitation estimate in several ways. First, it restricts possible precipitation amounts to non-negative values, which is desirable for precipitation. Second, it creates skewness and dependency on precipitation amount in the uncertainty estimate, which both increase with the transformation strength. Third, it influences the linearity of the radar-gauge relationship and hence the radar coefficient in KED. The restriction to non-negative values and unrealistic skewness can lead to biases in precipitation estimates for inappropriate transformation strengths.

We conclude that the Box-Cox transformation of radar and gauge data in geostatistical combination models can improve the uncertainty estimate. Especially upper extremes of precipitation are better captured in the uncertainty range, which is a crucial quality for practical applications. However, the choice of a suitable transformation strength is not straightforward. Compromises between the quality of upper and lower quantiles as well as compromises between the linearity of the radar-gauge relationship and nearly Gaussian distribution seem unavoidable.