Geophysical Research Abstracts
Vol. 12, EGU2010-14812, 2010
EGU General Assembly 2010

Improving Rainfall and Temperature Estimations in Complex Topography: an Application in the Swiss Alps

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Within complex topography, the characteristic spatial scales of hydrological forcings are poorly captured by sparse measurements. The aim of this study is to improve temperature and precipitation interpolations during extreme precipitation events by integrating digital terrain information (DTM) and a weather forecast model (LAM) with sparse gauge data. Three previous events were analyzed to determine the factors which have the greatest influence on intense precipitation induced by orographic effects. The driver for this research was to improve the precipitation and temperature inputs to the MINERVE hydrological model. This semi-distributed model, operationally applied in the Swiss Alps, has underestimated flood peaks which have caused damage to the region on the order of millions of Swiss francs.
In this study, several interpolation techniques have been compared: Inverse Distance Weighting, Ordinary Kriging, and Kriging with External Drift (KED). Geostatistical methods relied on a robust and resilient variogram accounting for anistropy. Results indicate that using numerical weather forecast and elevation data as covariates for precipitation, KED has lower errors at the cost of higher estimation variations. Most notably, orographic effects were captured by KED at high elevations where precipitation was noted during extreme events, yet was not previously captured with measurement stations routinely used in the operational rain gauge network. Even more significantly, the use of elevation as auxiliary information in the KED of temperatures demonstrated minimal errors relative to the other interpolation methods. These results indicate that KED for temperature outperforms the other methods during extreme events due to its consideration of instantaneous lapse rates. Furthermore, the incorporation of the improved temperature and precipitation input fields into the hydrological model provided outputs in agreement with measured discharge volumes and flood peaks for the events analyzed.