Geophysical Research Abstracts, Vol. 9, 08531, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08531

What drives high flow events in the Swiss Alps? On the use of wavelet spectra to analyze observed and simulated extreme events

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The simulation of extreme high flow events in alpine catchments - for example for the estimation of design floods - is particularly difficult due to the high spatial variability of the main system inputs, i.e. of precipitation and of temperature. The performance of any simulation framework therefore strongly depends on how well the observed (or simulated) input time series capture the real catchment conditions. In the case of strongly snowmelt driven systems, not only the quality of the individual temperature and precipitation time series but also their co-variance is of prime importance.

A detailed time and frequency resolved analysis of the observed meteorological and discharge time series can give valuable information about how well they capture the mechanisms underlying observed high flow events. Wavelet spectral analysis offers a framework to analyze observed time series with respect to time and scale ($\sim$ 1/frequency) and is therefore the method of choice to analyze the non-stationary frequency content of hydrometeorological time series.

We use wavelet spectral analysis to investigate the dominant driving processes during high flow events in a catchment of the southern Swiss Alps for which design floods have recently been re-estimated based on a continuous modelling approach. The presented wavelet spectral analysis offers a powerful tool to detect potentially flood producing meteorological situations and to distinguish between different types of floods with respect to the prevailing critical hydrometeorological conditions. The gained insights will form the basis of a new methodology to assess the performance of extreme event simulation frameworks, by focusing on the hydrological model's ability to explain the *occurrence* and the *non-occurrence* of floods during potentially flood

producing situations and by testing whether the coherence of the simulated time series differ significantly from the observed pattern of coherence.

It is important to point out that the obtained results and drawn conclusions are only possible based on a sound combination of previous knowledge about the physical processes involved and a statistically rigorous wavelet analysis framework. In fact, the application and interpretation of these relatively new mathematical methods is *not as straightforward* as suggested by many authors of hydrological case studies. We will therefore shortly highlight the subtleties and potential pitfalls before presenting how wavelet spectral analysis can advance the analysis of the driving processes of extreme events.