Geophysical Research Abstracts,
Vol. 10, EGU2008-A-03753, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-03753
EGU General Assembly 2008

Minimalist models of Alpine hydrological processes and their relation to climate

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Understanding Alpine hydrological processes and their relation to climate has been increasing in the past years along with the need of planning future good management strategies of the water resources. Bringing the impact of climatic changes into play means to extend the process understanding over time horizons going from decades to centuries. This requires for modelling approaches able to couple the main physical basis of the process being investigated together with a sufficient level of simplification. We analyse two exemplary processes occurring at different spatial scales, and formulate related minimalist quasi-physical models thereof. In particular, at the point scale we study the interannual dynamics of snow accumulation and melting. We show that our approach leads to a stochastic model eventually explaining the probabilistic character of the End of Summer Snowlines in relation to hydroclimatic fluctuations, and offers the basis for reconstructing the past precipitation events from recorded snowpack fluctuations. At the catchment scale we propose a lumped interpretation of glacierized basins hydroclimatic behaviour and obtain a smooth nonlinear 2D differential model (ODE) that can be studied by means of dynamical system theory. We show the model flexibility to describe both the stored water and the runoff dynamics of both swiss and Italian alpine glacierized catchments with very different hydrogeomorphological characteristics, also in relation to foreseen climatic changes. Finally, we point out the role of the model nonlinearities when interacting with long-term climatic oscillations due, for instance to Milankovitch forcing time scales.