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The role of electrical conductivity measurements to investigate streamflow generation in Alpine catchments

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The relationship between streamwater electrical conductivity (EC) and water discharge (Q) has found wide applications in hydrology. In this work, we perform a systematic analysis of the temporal correlation between these two signals at the gauging station of Vermiglio, in the lower portion of the Vermigliana, an Alpine headwater stream in North-Eastern Italy. The analysis is limited to the period June-November of 2012 and 2013. First, we analyze the known hysteresis relating EC and Q, showing how rain-on-snow events occurring in early autumn fall apart from this cycle. Then we perform wavelet analysis of the two signals investigating the scales with the highest power spectrum. In addition, we investigate the coherence between EC and Q wavelet spectra, showing that the two signals are strongly correlated at a scale of 24 hours during the melting period and in particular when glacier melting is significant, i.e. from July to August. The cross-correlation of the two signals allows to identify a statistically significant time lag of 1-2 hours between Q and EC during the melting period, while in early spring and autumn the time lag is masked by the stronger influence of rainfall events. Moreover, the analysis of the diurnal cycles of EC and Q evidenced clear patterns in the timing of occurrence of minimum and maximum values during the melting season. In addition, we show how the amplitude of the electrical conductivity signal can be used to estimate the contribution to streamflow due to snow-melting in absence of rainfall events. Overall, the analyses show that despite their correlation, EC and Q signals are characteristic of different aspects of the hydrological response of the catchment and support the hypothesis that they should be described using different transfer functions.

Keywords: Electrical conductivity; Alpine catchment; streamflow generation; hysteresis; wavelet analysis; cross-correlation; diurnal streamflow cycles.