Title: Using Empirical Mode Decomposition to Identify Anomalies in Flow Data and Correlations with other Environmental Data

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We apply empirical mode decomposition (EMD) and the Hilbert-Herbert transforms, as tools to analyze streamflow data from the Yampa and Upper-Green rivers to identify environmental forcing functions, such as the 11-year solar cycle, and anomalies. We selected the Green and Yampa Rivers as they have similar head waters, but the Yampa has minimal diversions or controls while Flaming George dam on the Green River significantly affects flow. This provides two different flow regimes with similar large watersheds. In addition to flow data, we analyzed several time series data sets, such as temperature and precipitation from Northeast Utah, North Western Colorado, and Southern Wyoming. This area defines the Yampa River and Green River watersheds which stretch from Flaming Gorge Dam to Ouray Colorado for this study. The EMD method is a relatively new technique that allows any time series data set, including non-linear and non-stationary datasets that are common in earth observation data, to be decomposed into a small quantity of composite finite data series, called intrinsic mode functions (IMFs). The EMD method can decompose any complicated data into several IMFs which represent independent signals in the original data. These IMF may represent periodic forcing functions related to environmental conditions or they may be an artifact of the decomposition methods and not have an associated physical meaning. This study attempts to assign physical meaning to IMFs resulting from the decomposition of the Green and Yampa flows where possible. To assign physical meaning to the IMFs, we analyzed frequencies using Hilbert-Herbert method and then compared frequencies of the IMFs with known frequencies of physical processes. We found significant correlation in some IMFs from both the flow and temperature data series with the approximate 11-year sunspot activity cycle. Other IMFs indicated a relationship between frequencies within flow and temperature data and El Nino Southern Oscillation (ENSO) events. The EMD process also extracts a long-term trend in non-linear data sets which can provide insights into the effects of climate change on the flow system. Though in preliminary stages of research, these environmental functions may lead to further understanding the availability of water within the upper Yampa and Green River Watersheds.