Statistical links between seasonal hydrologic and large-scale climatic signals and their use in a nonparametric approach for daily disaggregation

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Abstract. This research examines statistical relationships between (decadal and interannual) climatic variations in the Pacific Ocean and hydrologic variability in a river basin of the Pacific Northwest region of the United States, and explores their use in a nonparametric disaggregation framework to produce synthetic sequences of daily streamflow values. The statistical approach considers linear association of the variables of interest by means of lag-time cross-covariance analysis in the period 1950 – 2007. Cross-correlation maps were generated between historical data of preceding seasonal series of both sea surface temperature and sea level pressure fields, and spring streamflow volumes at Payette, Idaho, in order to identify geographical regions in the Pacific Ocean with statistically significant correlation. Lagged links between April through July runoff volumes and three climatic indices related to large-scale ocean-atmosphere interactions are also analyzed. Preceding seasonal El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) indices, SOI and PDO, respectively, and the North Pacific Gyre Oscillation (NPGO) index are evaluated. The disaggregation scheme is conditional on predicted (or known) spring runoff volumes and the three large-scale climatic indices. The disaggregation methodology is based on nonparametric bootstrapping and multivariate techniques and it is first developed for temporal disaggregation using a stepwise procedure. A nonparametric K-nearest neighbor time series bootstrap approach is proposed for the development of the downscaling framework and Principal Component Analysis is used as a key tool in the neighbor choice. The large-scale climatic patterns are statistically significantly correlated with the spring streamflow, including the NPGO. The statistical analysis with SSTs showed that the highest levels of correlation are observed in the November-February period and located in an alternating dipole structure in regions of the North Pacific (between 40°N and 50°N, with the highest positive correlations in the longitude 178°W and negative in regions off the coast of Washington and Oregon). In the tropical Pacific, the highest correlations are located between equator and 10°N, and 160°W thru 165°W, corresponding to the region Niño 3.4. Our results also indicate that the atmospheric mechanisms that originate the correlation structure in the North Pacific Ocean persist from fall trough winter. The highest persistence observed in this region suggests that its thermal inertia influences more significantly the hydrologic variability in our study zone, explaining up to 60% of the variance of the spring streamflow. The significant correlations found are consistent with those regions in the Pacific Ocean where PDO and ENSO are defined. However, shifts are observed when the correlation analysis is based on these teleconnection indices. Results show that the highest cross-covariance is produced for lag times of about 10 months for ENSO/SOI (i.e., in the preceding summer) and half of this time for the PDO index (i.e., in the preceding transition period fall-winter). Of special interest is the shorter lag-time for the NPGO index, with values of about three months (i.e., in the preceding winter). Results of the temporal disaggregation framework are also presented.