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Predictability of Central Asia river flows: the role of regional and large-scale climate variability

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Central Asia is a semi-arid region with high societal vulnerability to fluctuations in water availability. River flows are particularly important, especially during the warm growing season, when there is little rainfall. Skillful predictions of the large year-to-year fluctuations in river flow may allow mitigation of the frequently severe socio-economic effects.

In Central Asia, precipitation occurs mainly during the winter and early spring. Because of the high mountains of the region, much of the precipitation occurs as snow and the melting of this snow provides a key source of water for agriculture and water resources during the warm season. Local observations are sparse and so a knowledge of the snow water equivalent sufficiently detailed to predict the amount of snowmelt is not available. However, previous research has shown that regional-scale patterns of climate variability are important in determining the cold season precipitation and that these regional patterns are adequately resolved in the available data. Since the precipitation falls mainly as snow, these regional winter climate patterns may provide considerable advance information about the subsequent warm season runoff and river flows.

Here, we use Canonical Correlation Analysis (CCA) to examine the patterns and assess predictability, using regional-scale patterns of precipitation and wind in Nov-Mar to predict river flows in Apr-Aug (the peak flow season). NCEP reanalysis data is used to define the regional-scale patterns as it is operationally updated and could be used to make real-time forecasts. Both upper-level zonal wind and precipitation are used to represent the cold season variability that is responsible for the snow pack, in order to include as much information as possible, given both the scarcity of observa-

tions and the limitations of the reanalysis precipitation product. 24 river flow stations are available for 1950-1985. The combination of upper-level wind and precipitation proves very able to capture the variability associated with the snow pack, as an average correlation of 0.7 for Apr-Aug is found for the 24 river flow stations from the CCA. Cross-validated correlations, which provide an estimate of expected skill in a real-time setting, show 10 of 24 stations correlated greater than 0.5, with a maximum correlation of 0.71. We have also validated the results by calculating the forecast skill for two additional stations, on the Amu Darya and Syr Darya, that were not in the original analysis. The correlations for the 1986-2003 period, also not in the original analysis, are 0.71 and 0.69, respectively, demonstrating that the approach is very stable and robust. Due to the use of reanalysis data, this forecast approach can be readily implemented in real-time.

The regional patterns of wind and precipitation are similar to previous analysis of precipitation variability and drought in the region, showing a strong link between shifts in the jet and regional precipitation variability along the windward slopes. There is also a strong link to an El Nino-like pattern in tropical Pacific ocean temperatures, also similar to that obtained in previous drought analysis, showing the importance of the large-scale variability as well. This link to the tropical ocean also suggests the possibility of forecasting at even longer lead times.

Although the region has very complex terrain and steep mountains, the success of this approach shows the primary importance of regional scale variability to even individual stations and suggests that such an approach could prove very useful in similar regions where the available local data is sparse or not available in real-time.