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Predictability of winter precipitation in Central Asia – The role of tropical and extratropical drivers

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Due to its highly continental climate, Central Asia is prone to drought events. More than half of the annual precipitation amount falls as snow during extended winter season (Nov-Mar) and is released during subsequent summer, allowing the irrigation of the vast cotton fields along the Syrdarja and Amudarja river systems. A robust seasonal precipitation forecast is required by governmental and non-governmental decision makers, in order to adapt the agricultural strategy to anomalous hydro-climatic conditions.
In the framework of the CAWa project (Central Asian Water), funded by the German Ministry of Foreign Affairs, the German Center for GeoSciences cooperates with the national hydro-meteorological services of Central Asia. The current project phase aims at the development of simple but efficient tools, which enable the operational prediction of cold season precipitation.

Our results show that a skillful forecast of extended winter precipitation is feasible by means of simple statistical techniques. A linear regression based model, which step-wise selects adequate predictor variables from a list of climate indices (including tropical SST-modes, Northern hemispheric pressure patterns and Eurasian snow cover anomalies) achieves cross-validated correlations of 0.37 and 0.51 between observed and predicted precipitation sums for sub-regions in Northern and Southern Central Asia, respectively. The modelling results suggest that seasonal precipitation anomalies in the Northern sub-region (including parts of Kazakhstan, Uzbekistan and Kyrgyzstan) are strongly associated with the El-Nino-Southern-Oscillation and the extent of Eurasian snow cover in previous October. The Southern sub-region (Afghanistan, Tajikistan, Pakistan) is likewise influenced by ENSO-related indices. However, while the influence of Eurasian snow cover is negligible, the Quasi-Biannual-Oscillation (QBO) is detected as an important predictor.

Against the background that pure statistical approaches are prone to overfitting and artificial correlations, we conducted a systematic analysis of the teleconnections between the above mentioned predictor variables and the winter-time circulation over Central Asia. Therefore 8 weather types (WT) were identified by means of a k-means cluster algorithm, applied to daily 500 hPa geopotential height fields. Each WT is associated with characteristic pressure anomalies, moisture fluxes, cyclone tracks and precipitation patterns. The analysis of the WT frequencies shows, that the interannual precipitation variability (and also the spatial pattern of precipitation trends) is highly related to the occurrence of WTs.
We further show that the Central Asian WTs are embedded in the large-scale circulation via Northern hemispheric wave tracks. Strong correlations are detected between the frequency of WTs and extratropical teleconnection indices, such as the Arctic Oscillation and the Scandinavian and East Atlantic/Western Russia patterns. High snow cover rates over Eurasia in autumn promote the prevalence of a negative Arctic Oscillation, which leads to an increased probability of WTs associated with strong meridional winds and the advection of dry continental air masses into Central Asia. Concurrently the ENSO-circulation affects the frequencies of Central Asian WTs, with an increased probability of low-pressure systems over Central Asia during El Nino events.