How much variation in land surface phenology can seasonal climate oscillations explain at pasture scale in Kyrgyzstan?

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Interactions of the atmosphere with the oceans play an essential role in shaping climate and its variability. Naturally-occurring dynamical modes result in teleconnections—correlated weather patterns between remote locations—that can account for a substantial amount of large-scale climatic variability, and can play significant roles in determining seasonal weather anomalies. In developing economies, where the rural resource base relies on favorable weather, such anomalies may be very deleterious. For example, in montane Central Asia, where the regional economy is grounded in agropastoralism and the climate is cool and dry due to elevation, precipitation received outside the growing season may determine the difference between success and failure in annual production.

We sought to assess whether the impacts of teleconnections are detectable and significant in early season dynamics of highland pastures across five rayons in Kyrgyzstan from 2001 through 2017. Specifically, we focused on the explanatory and predictive power of five seasonal (winter, spring, and summer) climatic oscillations on land surface phenology (LSP) based on fine spatial resolution data. We included two sets of environmental variables already shown to influence LSP in these highland pastures: two snow cover seasonality metrics derived from the MODIS snow cover product—the last date of snow (LDoS) and the number of snow covered dates (SCD)—and three terrain characteristics derived from the NASA SRTM Digital Elevation Model—elevation, slope, and the TRASP index, a linearization of aspect.

We characterized early season vegetation growth using two phenometrics derived from the LSP model that links the normalized difference vegetation index (NDVI) derived from Landsat data at 30 m with accumulated growing degree-days (AGDD) derived from MODIS land surface temperature data at 1 km: (1) the maximum modeled NDVI or Peak Height (PH); and (2) the quantity of AGDD required to reach the PH or Thermal Time to Peak (TTP).

We used Spearman’s rank correlation to assess the strength and significance of geographic differentiation of the phenometrics’ linkages to environmental variables. PH showed significant but weak correlations with TTP (positive in western rayons but negative in eastern rayons), and moderate positive relationships with LDoS and SCD appearing only in one northeastern rayon. Of the 15 seasonal indices we evaluated, only two showed significant (positive or negative) correlation with PH. In contrast, TTP showed consistently significant strong negative relationships with LDoS, SCD, and elevation, but very weak significant positive correlations with three winter modes and only in western rayons.

Second, we used Partial Least Squares regression to investigate how much of additional variation in LSP metrics can be explained by seasonal oscillation indices. PLS modelling showed that thermal time accumulation could be explained mostly by elevation and snow cover metrics, explaining 55–70 % of the observed variation in TTP. Only three oscillation indices (two summer and one spring) had a significant relationship with TTP, but contribution of each to the model’s predictive power was negligible. PLS models were able to explain no more than 29% of PH variability. Similarly, just two oscillation indices (one spring and one summer) were significantly linked to PH, but their predictive contribution was minimal. Influences of climate oscillations were too weak to provide effective seasonal prediction of LSP at fine spatial resolution. Rather, the effects of climatic oscillations on highland pastures phenology were overshadowed by terrain features (primarily elevation) and the timing of snow cover seasonality.

Whether seasonal climate oscillation indices may provide some useful information about growing season conditions remains a provocative question, particularly given the multiple environmental challenges facing agropastoralism as a sustainable livelihood in montane Central Asia.

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