Landscape dynamics in Kazakhstan: seasonal baselines for land cover change detection

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OVERVIEW
At 2.72 million km², Kazakhstan is more than one-third the size of the conterminous US or roughly equal in area to all of Western Europe including the British Isles. It is bounded by China on the east, Kyrgyzstan and Uzbekistan on the south, the Caspian Sea and a small section of Turkmenistan on the west, and Russia in the north. Since the collapse of the Soviet Union in the early 1990s, Kazakhstan has reportedly undergone extensive land-cover changes[1].

Few details are known about the past extent of land cover change, due to the collapse of regional environmental monitoring networks in the early 1990s. Marked decreases in livestock and meat production accompany increases in productive rangelands, as measured vegetation indices, suggesting that institutional change and the socio-economic consequences are primary drivers of the region’s land-cover change.

To be able to assess the significance of changes in vegetation indices, it is necessary to examine the observational record and to place this episode within the larger context of interannual climatic variability and landscape dynamics. We used a standard global dataset to characterize the expected and actual spatio-temporal dynamics of the vegetated land surface.

Data Source
- Pathfinder AVHRR Land (PAL) maximum Normalized Difference Vegetation Index (NDVI) for May through September (276 images) was submitted to an unsupervised K-means clustering (D=0.05, 18 dates with outlying values, 104 random walks were used for each image date).
- April images were excluded from the clustering due to high interannual variation in extent of land cover change.

Processing Methods
A: Identification of Kazakhstan Ecoregions
- To segment Kazakhstan into broad ecoregions, the image time series from May through September (276 images) was submitted to an unsupervised K-means clustering (D=0.05, 104 random walks were used for each image date).
- April images were excluded from the clustering due to high interannual variation in extent of land cover change.
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- Apical images were excluded from the clustering due to high interannual variation in extent of land cover change.
- Three ecoregions were obtained: North, West, and South.

B: Seasonal Baselines
- The seasonal trend for the Scale of Fluctuation (SOF) and the trend for the NDVI are not similar (Fig. 1).
- The North ecoregion is characterized by very low climatic variability. In the first phase of a multi-year investigation, we have developed a seasonal baseline for land cover change detection.
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C: Outlier Identification
- Plots of CV% of SOF show the most frequent outliers were identified, e.g., D4 in North and C3 in South.

D: Interannual Variation Assessment
- Interannual variation assessment for the CV% of SOF and NDVI and its spatial structure for three ecoregions. Each region manifests distinctive dynamics which are a complex result of climate and land use.
- Few details are known about the pace or extent of land cover change, due to the collapse of regional environmental monitoring networks in the early 1990s. Marked decreases in livestock and meat production accompany increases in productive rangelands, as measured vegetation indices, suggesting that institutional change and the socio-economic consequences are primary drivers of the region’s land-cover change.

References

OUTLOOK
- Detecting land cover change is easier than assessing its significance, especially in regions with high climatic variability. In the first phase of a multi-year investigation, we have developed a strategy to characterize spatio-temporal variation in complementary aspects.
- Applying this strategy to the PAL imagery of Kazakhstan has led to the determination of seasonal baselines of NDVI and its spatial structure for three ecoregions. Each region manifests distinctive dynamics which are a complex result of climate and land use.
- We are currently investigating how precisely these baselines are observed in the metrics can be explained by meteorological forcing and passed into different climate regimes.
- We have found in related work that the variability in spatial structure in some ecosystems is significantly different before and after 1993.
- The next phase involves examining sites at finer spatial and shorter temporal resolution.

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