Consequences of Institutional Change: Land Cover Dynamics in Kazakhstan
~~~ A Review of Findings and Accomplishments ~~~

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What have we learned about institutional change?

The collapse of the Soviet Union in the early 1990s is now being recognized as another rapid, widespread LCLUC event. The principal mechanism of LCLUC across this region was the disintegration of the institutions of centralized control over the agricultural sector. Without planting schedules, or crop energy subsidies in the form of fertilizers, pesticides, and fuel, or access to markets, the agricultural sector contracted sharply during the 1990s throughout the Former Soviet Union and its client states. There were significant consequent changes in biogeophysical processes, including the onset and timing of land surface phenology (LSP) that links the ecological dynamics of the vegetated surface with the atmospheric dynamics of the planetary boundary layer.

Analyzing the Pathfinder AVHRR Land (PAL) NDVI dataset as a function of accumulated growing degree-day (AGDD) using two different spatial partitionings, we observed across Kazakhstan only three significant patterns of change in LSP out of 14 possible patterns: (1) increased NDVI throughout the growing season; (2) higher NDVI earlier in the growing season; and (3) earlier green-up with increased seasonal integral of NDVI (de Beurs and Henebry 2004a, 2005a).

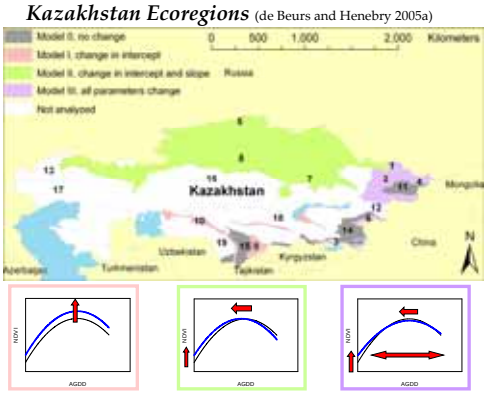
The principal mechanism behind these changes in LSP was ***widespread agricultural deintensification*** in the forms of increased proportions of fallow fields in the rain-fed grain belt and decreased grazing intensities in pastures due to declines in livestock herds.

Methods Development for LCLUC Analysis

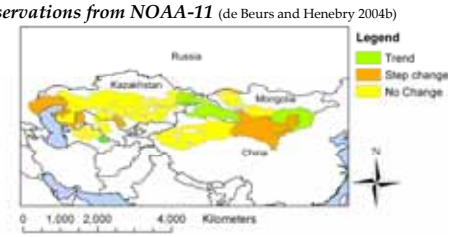
A major achievement of our project is the development of a statistical framework for change analysis in long image time series (de Beurs and Henebry 2004a,b 2005a,b). This framework evaluates for step changes, trends, and changes in temporal pattern of a biogeophysical field. While our work has focused on NDVI (AVHRR and MODIS) and AGDD (as averages, variances, and spatial pattern indices), it is possible to use the framework with other kinds of observed, retrieved, or modeled biogeophysical variables. The framework includes:

- robust techniques for post-hoc multiple comparisons (handling non-normality, missing values, unequal variances)
- robust trend identification and assessment
- linear and nonlinear parametric modeling of phenological patterns
- testing procedure to assess significant differences in model parameter coefficients
- mixture modeling using phenological endmembers

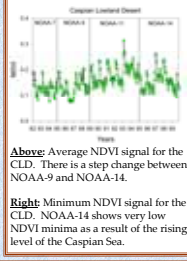
Change in LSP is Not Uniform Across Kazakhstan Ecoregions (de Beurs and Henebry 2005a)



Change Analysis of Central Asia Deserts After Omitting Observations from NOAA-11 (de Beurs and Henebry 2004b)

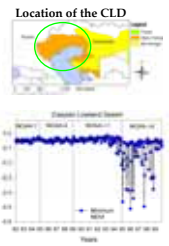


- Changes and trends are not consistent across all study regions.
- No significant 'greening' trend for the deserts of Central Asia.
- Step changes and trends may be explainable from finer resolution analyses and socio-economic literature.
- Ex: step change in Caspian Lowland Desert is due to sea level rise.

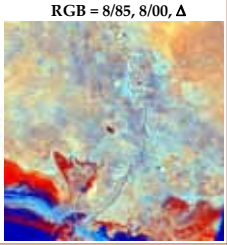


Above: Average NDVI signal for the CLD. There is a step change between NOAA-9 and NOAA-14.

Right: Minimum NDVI signal for the CLD. NOAA-14 shows very low NDVI minima as a result of the rising level of the Caspian Sea.



Atyrau, KZ
Landsat TM Band 4
RGB = 8/85, 8/00, Δ



Urban cover change analysis using Corona and Quickbird: Astana, KZ (Ratcliffe and Henebry 2004)

What's next?

How has LSP changed in other parts of Northern Eurasia? Kirsten de Beurs is pursuing this question through support from the NASA Earth System Science Fellowship. Preliminary analyses, to appear in *Global Change Biology*, were restricted to the IGBP High Latitude Transects and show differential changes in LSP depending on ecoregion and transect. Dates of peak NDVI show significant earlier shifts in most ecoregions. Comparing the 1985-88 and 1995-99 observational periods, the peak NDVI was reached 9.3 days earlier in the North America transects and 6.3 days earlier in the Eurasian transects.

How have LSP changes affected the regional hydrometeorology? If the LSP has indeed changed following the collapse of the Soviet Union, then have there been observable changes in regional precipitation patterns? What is the strength and sensitivity of the link between LSP and hydrometeorology in the semi-arid grain belt of Eurasia? Have these changes made the region's agricultural economy more vulnerable to predicted global climate changes? These questions have been proposed to be investigated using interdisciplinary observational and modeling studies in a pending NEWS proposal.

~~~ Accomplishments ~~~

A. Journal Articles (3 more in preparation)

de Beurs, K.M., and G.M. Henebry. 2004a. Land surface phenology, climatic variation, and institutional change: Analyzing agricultural land cover change in Kazakhstan. ***Remote Sensing of Environment*** 89:497-509; doi:10.1016/j.rse.2003.11.006.

de Beurs, K.M., and G.M. Henebry. 2004b. Trend analysis of the Pathfinder AVHRR Land (PAL) NDVI data for the deserts of Central Asia. ***IEEE Geoscience and Remote Sensing Letters*** 1(4): 282-286. doi:10.1109/LGRS.2004.834805.

de Beurs, K.M., and G.M. Henebry. 2005a. A statistical framework for the analysis of long image time series. ***International Journal of Remote Sensing,*** In press.

de Beurs, K.M., and G.M. Henebry. 2005b. Land surface phenology and temperature variation in the IGBP high-latitude transects. ***Global Change Biology***, accepted pending minor revisions JAN2005.

Gitelson, A. A. 2004. Wide Dynamic Range Vegetation Index for remote quantification of biophysical characteristics of vegetation. ***Journal of Plant Physiology*** 161:165– 173.

Henebry, G.M., K.M. de Beurs, and A.A. Gitelson. Land surface phenologies of Uzbekistan and Turkmenistan between 1982 and 1999. ***Arid Ecosystems,*** in review AUG2004.

Viña, A., G.M. Henebry, and A.A. Gitelson. 2004. Satellite monitoring of vegetation dynamics: Sensitivity enhancement by the Wide Dynamic Range Vegetation Index. ***Geophysical Research Letters*** 31:L04503, doi:10.1029/2003GL019034.

B. Proceedings Papers

de Beurs, K.M., G.M. Henebry, and A.A. Gitelson. 2004. Regional MODIS analysis of abandoned agricultural lands in the Kazakh steppes. ***Proceedings of IGARSS 2004***, paper 3WE_33_06.

de Beurs, K.M., and G.M. Henebry. 2004c. Analyzing land cover change in Kazakhstan: Land surface phenology, climatic variation and sensor artifacts. ***ASPRS Proceedings***, paper 14:1-12.

Henebry, G.M., K.M. de Beurs, and A.A. Gitelson. 2002. Land surface dynamics in Kazakhstan: dynamic baselines and change detection. ***Proceeding of IGARSS 2002***, II:1060-1062.

Ratcliffe, I.C., and G.M. Henebry. 2004. Using declassified intelligence satellite photographs with Quickbird imagery to study urban land cover dynamics: A case study from Kazakhstan. ***ASPRS Proceedings***, paper 198:1-10.

C. Presentations (20 at national or international mtgs)

US-IALE, Lincoln, NE, April 2002
IGARSS, Toronto, ON, July 2002
AGU Chapman Conference, Santa Fe, NM, June 2003
Regional meeting of the AAG, Manhattan, KS October 2003
ITC Invited Seminar, Enschede, The Netherlands, January 2004
US-IALE, Las Vegas, NV, April 2004
USGS EROS Data Center Invited Seminar, Sioux Falls, SD, May 2004
ASPRS, Denver, CO, May 2004
First International Workshop on Human Dimensions of Climate and Environmental Change in Central Asia, Grand Rapids, MI, May 2004
IGARSS, Anchorage, AK, September 2004
AGU Fall Meetings, 2002-2004
NASA LCLUC Science Team Meetings 2001-2005

D. Awards

Climate Change or Institutional Change? On Changes in Land Surface Phenologies in Central and Northern Eurasia. NASA Earth System Science Fellowship. 2004-2005. $24,000. (PI: Kirsten M. de Beurs, Ph.D. candidate advised by Henebry).

Honorable Mention in Best Student Presentation Competition to I.C. Ratcliffe (M.A. student advised by Henebry) for the poster "Using declassified intelligence satellite photographs with Quickbird imagery to study urban land cover dynamics: A case study from Kazakhstan" presented at the ASPRS 2004 Meeting in Denver, CO, May 24-27.

E. Proposals Generated

Robust retrievals from vegetated land surfaces: Assessing land surface phenology using next-generation vegetation indices for satellite data assimilation. NASA 2003-2006 $494K (PI: Gitelson) NOT FUNDED.

Land surface phenology, climate variability and institutional change: Analyzing land surface variation in Northern Eurasia. NASA Earth System Science Fellowship. 2003-2004. $24,000. (PI – Kirsten M. de Beurs (Ph.D. student advised by Henebry). NOT FUNDED.

Ecosystem change and variability, land surface phenology, ecoregional dynamics, and anthropogenic influences in the Great Plains grasslands. NASA IDS 2003-2006. $2,269K (PI: Henebry) NOT FUNDED.

Land surface phenology and climatic variability across Northern Eurasia: Spatio-temporal contexts for rescaling carbon dynamics. NASA Carbon 2004-2006 $589K (PI: Henebry) NOT FUNDED.

Evaluating the effects of institutional change on regional hydrometeorology: Assessing the vulnerability of the Eurasian semi-arid grain belt. NASA NEWS Step 2 proposal. 2005-2008 $600K (PI: Henebry) PENDING.

Baseline dataset of in-situ observations for extreme event studies: Long-term and near-real time data linked to remote sensing products. NASA NEWS Step 2 proposal. 2005-2009 $862K (PI: Groisman) PENDING.

F. Other Accomplishments

Project website: http://www.calmit.unl.edu/kz/

Available on website: (1) project overview; (2) paper abstracts; (3) copies of presentations; (4) bibliography on Kazakhstan and Central Asia; (5) gallery of very high resolution analysis of urban change analysis.

Co-convened special session "Phenology and Global Change: Patterns, Processes, and Dynamics" at 2004 AGU Fall Meeting.

Interdisciplinary networking leading to new collaborative research.

Two doctoral and one masters students supported in full or in part.

Fourteen student presentations at scientific meetings.