Land cover land use change effects on surface water quality: Integrated MODIS and SeaWIFS assessment of the Dnieper and Don River basins and their reservoirs

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Overview

Our questions:

1. Can we see the significant changes in land cover and land use following the collapse of the Soviet Union using satellite data?
2. Can we use satellite data to generate new products that enable monitoring of key surface water quality variables?

First, we analyzed land surface phenology within specific land cover categories using the non-parametric seasonal Mann-Kendall trend test adjusted for autocorrelation to NDVI image series from AVHRR (PAL and GIMMS) for the Soviet (1982-1988) and post-Soviet (1993-2000) epochs. This analysis identified the spatial location and extent of temporal trends and assessed their direction and statistical significance. About 56% of croplands and forested land in Don Basin showed significant trends during the Soviet epoch, and there was little [much] area in significant negative trends during the post-Soviet epoch.

During the recovery epoch, forested lands in the Don Basin exhibited fewer significant positive trends than in the Dnieper Basin. Second, we calibrated and validated the three-band model as well as its special case, the two-band model, using datasets collected over a considerable range of optical properties, trophic status, and geographical locations in turbid, productive lakes and reservoirs. We evaluated the extent to which the two-band model could be applied to the MODS and NDVI image series from AVHRR (PAL and GIMMS) data taken over Ukrainian and Russian test sites.

1. Changes in Land Use Intensity Within the Don and Dnieper River Basins

Data Sources, Data Processing and Methodology

Following data sources were used:

- MODIS NDVI reflectance MODIS NDVI 16 Days (0.5 km) from AVHRR (PAL and GIMMS) data from http://www.earthenginepartnership.org/members/glimpses.html and http://modis.gsfc.nasa.gov/data/granules/index.html

Data Processing Steps:

- 27 GSP land cover classes from MODIS-LC 1992 were aggregated to 6 classes.
- Each super class was masked separately for each river basin and reclassified to a common spatial resolution (4 km).
- Analyses were monitored in the Forests, Shrublands, and Mixed-Cover Transition Areas.
- Analyses were monitored in the composite periods from April to October in each study area.
- Satellite data from NOAA-11 were selected due to sensor artifacts (due to Beurs and Henebry, 2006).
- Trends were assessed using the non-parametric Seasonal Mann-Kendall test adjusted for autocorrelation (de Beurs and Henebry, 2006).

Methodology

Generalized Mann-Kendall (GKM) non-parametric trend test was computed for incoherent temporal autocorrelation (de Beurs and Henebry, 2006).

- Data were analyzed using a version of the GKM in R by Dr. K. M. de Beurs and P. de Beurs.
- The resulting test results were reclassified to 6 to 8 classes based on confidence intervals, directions, and attitudes of optical reflectance to determine the extent of changes LSP (see legend below).

LSP Trend Change Intensity and Direction

The trend change intensity and direction maps show a predominant pattern of negative trends across both basins during the transition between Soviet and post-Soviet epochs. Negative trends are more pronounced in the Dnieper basin than in the Don basin. The most common trend direction is decrease in area of cropland and increase in forested land.

Concluding remarks:

- The trend analysis and the probability of changes in trend direction and the presence of negative trends is as shown in the LSP maps.
- The results showed agreement in capturing the area of persistent negative changes that stretches from the western side of Dnieper into the Ul'yanov region in the vicinity of the Don (the area near the west of Ukraine coasts where agricultural practices changed dramatically during the Soviet epoch).
- Change in trend from positive to negative may be due to increased instances of disturbance, especially after 1990.

Key Findings from the Change Analysis:

- Roughly 50% of croplands and forestland in Dnieper Basin showed significant trends during Soviet epoch; Don Basin exhibited more significant positive trends than Dnieper Basin during Soviet epoch.
- Recovery epoch showed presence of significant trends in croplands; Dnieper Basin exhibited more significant positive trends than Don Basin during Soviet epoch.
- The magnitude and direction of change in cropland areas during Soviet epoch was about 8% in Dnieper Basin and 12% in Don Basin.
- Insignificant area in significant negative trends during the post-Soviet epoch.
- Less area in significant negative trends during Soviet epoch.
- Significant area in significant negative trends during post-Soviet epoch.
- Significant trends in forested areas during the post-Soviet epoch.
- Significant area in significant positive trends than Don Basin during the recovery epoch.

2. Surface Water Quality Assessment In the Don and Dnieper River Basins

Semi-analytical three-band model for chlorophyll-a estimation in turbid waters

The optimal bands are determined by performing the calibration for a continuous range of NIR red bands, selecting one band at a time, and choosing each of the 3 bands according to a minimal mean squared error (RMSE) on the calibration dataset.

The model was calibrated and validated using MODIS spectral bands, a 186,740 km² and λ = 658-757.5 nm. The three-band model was used for estimating Chlorophyll-a concentrations in turbid waters using 3-band MODIS reflectance values.

The accuracy of chlorophyll-a concentration in four independent datasets was assessed without parameterization after initial calibration investigations. The validation data were obtained using the three-band model (λ = 658-757.5 nm) and Chl with a relative error on the order of 20-25%.

Ukraine: Donier-Bug Estuary

Satellite data were taken (29 June and 1 July, 2005) of stations along the Don and Dnieper river basins on the Dnieper River. Chlorophyll-a and other parameters were estimated from MODIS imagery (June 30th, 2005). Three MODIS images were compared with measured chlorophyll-a concentrations.

References


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