

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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The collapse of the Soviet Union in the early 1990s is now being recognized as a rapid, widespread LCLUC event. The principal mechanism of LCLUC in these regions 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. Changes in surface water quality in the wake of the collapse have been

Questions to be answered

- What are the significant, observable linkages between LCLUC and reservoir water quality?
- Can inland water quality be effectively monitored using SeaWiFS and MODIS standard data products and new value-added products?

Bio-optical model

$$R_{rs}^{-1}(red) \propto \frac{Q}{f} a_{Chl}(red)$$

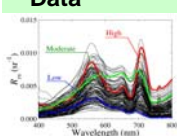
$$R_{rs}(NIR) \propto \frac{f}{Q} b_b$$

$$\frac{R_{rs}(NIR)}{R_{rs}(red)} \propto a_{Chl}(red)$$

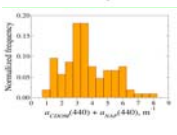
SeaWiFS: bands 6 (670 nm) and 7 (765 nm)

MODIS: bands 13 (667 nm), 14 (678 nm), 15 (748 nm)

US inland waters Data



| Calibration data set (2003, N=133) | | | | |
|------------------------------------|------------------------|---------------------------|--|----|
| Chl (mg m ⁻³) | Secchi Disk depth (cm) | Turbidity (NTU) (-b(550)) | Total Suspended Solids (mg L ⁻¹) | |
| Median | 20 | 71 | 10 | 14 |
| Min | 4 | 27 | 1 | 2 |
| Max | 236 | 308 | 67 | 45 |



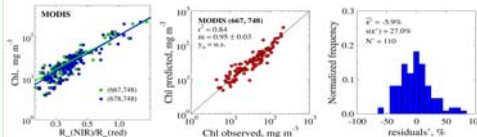
| Validation data set (2001-2002, N=115) | | | | |
|--|------------------------|---------------------------|--|-----|
| Chl (mg m ⁻³) | Secchi Disk depth (cm) | Turbidity (NTU) (-b(550)) | Total Suspended Solids (mg L ⁻¹) | |
| Median | 37 | 63 | 17 | 14 |
| Min | 4 | 18 | 3 | 0.2 |
| Max | 217 | 290 | 71 | 213 |

Model calibration and validation

MODIS (667 & 748 nm)

$$Chl = 10^{[2.05 + 1.37 * \log_{10}(R_{rs,15}/R_{rs,13})]}$$

$$STE = 11.2 \text{ ma Chl } m^{-3} \quad r^2 = 0.90$$



Project Hypotheses

- Significant changes in surface water quality following the collapse of the Soviet Union can be linked, in part, to the significant changes in land cover and land use.
- SeaWiFS and MODIS data can be used to create value-added products that enable monitoring of key surface water quality variables.

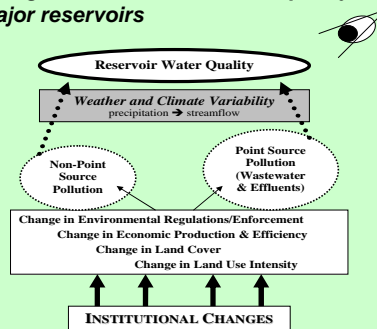
Objectives

- To assess the magnitude and variability of the linkage between LCLUC and dynamics of surface water quality, within the larger context of climatic variability.
- To develop the capability to use SeaWiFS and MODIS data to retrieve chlorophyll-a in turbid productive waters, to evaluate the uncertainties in the retrievals, and to demonstrate its efficacy by monitoring chlorophyll-a distributions in reservoirs of the Dnieper and Don rivers and in the upper portion of the Gulf of Taganrog Bay. If successful, this approach could be widely applied in many surface water monitoring programs.

Methodology

- We developed and tested the applicability of an inversion technique to retrieve chlorophyll-a concentrations from reflectance spectra of turbid productive waters. We will test developed algorithms using SeaWiFS and MODIS data to monitor chlorophyll-a and total suspended matter concentrations in reservoirs of Dnieper and Don river basins.
- We will apply a statistical framework developed in one of our previous projects to partition the variation arising from interannual climatic variability, changes in sensors, and institutional change. We will apply change analysis approach to both the terrestrial and aquatic image time series used in the project.

Conceptual linkages between institutional change and observable water quality in major reservoirs



Ancillary data

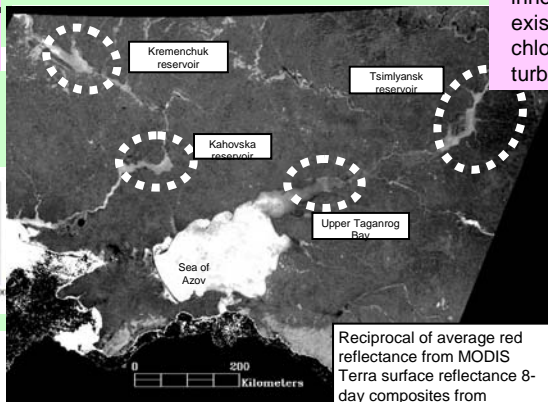
Ancillary data that are necessarily for calibration and validation of algorithms for chlorophyll-a and total suspended matter concentrations retrieval from MODIS and SeaWiFS data in reservoirs of Dnieper and Don river basins:

- Chlorophyll-a concentrations
- Total suspended matter concentrations
- Secchi disk depth

These data will be collected during satellite overpasses three times in season (April, August, and October) in the second year of the project the calibration of the algorithms and in the third year three times per year for the validation of the algorithms in Tsimlyansk and or Taganrog Bay (Russia) and in the Kahovska and Kremenchuk reservoirs

Expected Results

1. Quantitative evaluation the effects of LCLUC on the water quality and sensitivity of reservoirs water quality to climatic variability
2. Application of the existing satellite data to monitoring of chlorophyll distribution in inland waters. This aspect is particularly innovative because it will allow the use of existing ocean color sensors to estimate chlorophyll-a concentrations accurately in turbid productive waters.
3. Establishment of an interdisciplinary network of collaborators across five leading institutions in Russia and Ukraine. This capacity building effort helps to advance the programmatic goals of NEESPI and will increase the transfer of technology and knowledge between the US, Ukraine, and Russia. The approach we are taking here applied to two distinct river basins, can be implemented in other major temperate and boreal river systems of the northern hemisphere.



Reciprocal of average red reflectance from MODIS Terra surface reflectance 8-day composites from 01/27/2001

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