Satellite Monitoring of Chlorophyll-a Concentration in the Water Bodies of the Dnieper and Don River Basins

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Introduction
The work presented here is a part of a larger project involving the use of remotely sensed data to investigate and understand the effects of the bio-physical characteristics of the water bodies in the Dnieper and Don River basins due to changes in the land use and land cover in the surrounding regions.

The specific objective was to estimate the concentration of chlorophyll-a (Chl-a) from MODIS and MERIS data using two-band and three-band spectral algorithms specially developed for turbid and productive Case II waters.

The data were processed with different atmospheric correction procedures available for MODIS and MERIS data. No one particular procedure was consistently and systematically better than the rest.

The results highlight promises as well as challenges in using satellite data for remote monitoring of such dynamic water bodies.

Data
The in-situ data were collected by the field crews at the Southern Scientific Centre of the Russian Academy of Sciences, Rostov-on-Don, Russia and Institute for Environmental Quality, Kiev, Ukraine.

The MODIS data were processed using the default neural network procedures for MODIS data, the retrievals from NIR (near infrared) band models are not representative of the whole pixel area. The figure above shows significant variations of Chl-a Fluorescence within each 300 m and 1 km lengths along a transect measured on the Azov Sea in 2005.

The MODIS and MERIS estimates were compared with measured data from the fluorometer, the reflectance spectra for the same station illustrate the sensitivity of the algorithm to differences in the type of data processing.

Study Area

Data Processing
Level-1A MODIS AQUA data were downloaded from NASA’s LAADS website and processed using the software SeaDAS to derive Level-2 reflectance products.

The MODIS data were processed using four different atmospheric correction procedures:

- NIM Processing: Atmospheric correction by using the radiance at 443 and 555 nm for aerosol correction
- SWIR Processing: Atmospheric correction by using the radiance at 1240 nm and 2130 nm for aerosol correction
- MUMM Processing: A method proposed by Rudnicki et al. (2009) wherein the assumption of zero-water-leaving radiance in the NIR bands is replaced by the assumption of spatial homogeneity of the 748/865 reflectance ratio for aerosol and water reflectance within an image. This ratio calculated for aerosol and water reflectance is used to determine the aerosol model
- Wang-Shi Processing: Same as the SWIR processing method but with different calibration coefficients for the SWIR bands.

The MERIS data were obtained as Level-1 and Level-2 images from the European Space Agency. The Level-1 images were processed using the POEMBEAM toolbox through the interface, VISAT.

The MERIS data were processed using the default neural network procedure for atmospheric correction, which was developed from a broad training dataset chosen to be globally applicable for Case II waters, and also a special neural network procedure developed with a limited training dataset that was specifically targeted for coastal and inland waters. Both these types of processing are options available through VISAT.

Results

The plots above correspond to in-situ data collected on 18 and 19 June 2005 and satellite images acquired on 19 June 2005. The calibration curves were drawn using different sets of Chl-a and MODIS reflectance data.

The MODIS estimates were compared with measured data from the fluorometer, the reflectance spectra for the same station illustrate the sensitivity of the algorithm to differences in the type of data processing.

Key Conclusions
- The results were encouraging. However, problems persist due to two primary factors which pose a big hurdle in deriving reliable calibration coefficients for the algorithm.
- Spatial heterogeneity in water within satellite pixels: The pixel in-situ measurement may not be representative of the whole pixel area. The figure above shows significant variations of Chl-a Fluorescence within each 300 m and 1 km lengths along a transect measured on the Azov Sea in 2005.
- Time difference between in-situ and satellite observations: Coastal and inland waters are very dynamic and the time lapse between the acquisitions of in-situ and satelite data may result in actual changes in the bio-physical characteristics of water in-between the data acquisitions, which are not accounted for.

In-situ data with measures of spatial variability within satellite pixel-areas that were collected truly simultaneously with satellite data will help better assess the accuracy of the NIRRadiative algorithm.

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