Geophysical Research Abstracts
Vol. 12, EGU2010-5485, 2010
EGU General Assembly 2010

A Two-Step Double Filter Method to Extract Open Water Surfaces from Landsat ETM+ Imagery

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In arid and semi-arid areas, lakes and temporal ponds play a significant role in agriculture and livelihood of local communities as well as in ecology. Monitoring the changes of these open water bodies allows to draw conclusions on water use as well as climatic impacts and can assist in the formulation of a sustainable resource management strategy. The simultaneous monitoring of larger numbers of water bodies with respect to their stage and area is feasible with the aid of remote sensing. Here the monitoring of lake surface areas is discussed. Landsat TM and ETM+ images provide a medium resolution of 30m, and offer an easily available data source to monitor the long term changes of water surfaces in arid and semi-arid regions. In the past great effort was put into developing simple indices to extract water surfaces from satellite images. However, there is a common problem in achieving accurate results with these indices: How to select a threshold value for water pixels without introducing excessive subjective judgment. The threshold value would also have to vary with location, land features and seasons, allowing for inherent uncertainty.

A new method was developed using Landsat ETM+ imaginary (30 meter resolution) to extract open water surfaces. This method uses the Normalized Difference of Vegetation Index (NDVI) as the basis for an objective way of selecting threshold values of Modified Normalized Difference of Water Index (MNDWI) and Stress Degree Days (SDD), which were used as a combined filter to extract open water surfaces. We choose two study areas to verify the method. One study area is in Northeast China, where bigger lakes, smaller muddy ponds and wetlands are interspersed with agricultural land and salt crusts. The other one is Kafue Flats in Zambia, where seasonal floods of the Zambezi River create seasonal wetlands in addition to the more permanent water ponds and river channels. For both sites digital globe images of 0.5 meter resolution are available, which were taken within a few days of Landsat passing dates and which will serve here as ground truth information. On their basis the new method was compared to other available methods for extracting water pixels.

Compared to the other methods, the new method can extract water surface not only from deep lakes/reservoirs and wetlands but also from small mud ponds in alkali flats and irrigation ponds in the fields. For the big and deep lakes, the extracted boundary of the lakes fits accurately the observed boundary. Five test sites in the study area in Northeast China with only shallow water surfaces were chosen and tested. The extracted water surfaces were compared with each site's digital globe maps, respectively to determine the accuracy of the method. The comparison shows that the method could extract all completely wet pixels (water area covering 100% of the pixel area) in all test sites. For partially wet pixels (50-100% of pixel area), the model can detect 91% of all pixels. No dry pixels were mistaken by the model as water pixels.

Keywords: Remote sensing, Landsat ETM+ imaginary, Water Surface, NDVI, MNDWI, and SDD