Rapid Response Flood Water Mapping

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Since the beginning of operation of the MODIS instrument on the NASA Terra satellite at the end of 1999, an exceptionally useful sensor and public data stream have been available for many applications including the rapid and precise characterization of terrestrial surface water changes. One practical application of such capability is the near-real time mapping of river flood inundation.

With the launch of the MODIS sensor aboard the NASA Aqua satellite in 2002, the two MODIS sensors provide nearly global daylight acquisitions twice daily of calibrated multispectral optical radiance and reflectance values at three spatial resolutions: 250 m, 500m, and 1000 m. The primary obstacles to using these data for surface water characterization are: 1) cloud cover obstruction, and 2) the lack of higher spatial resolution. Other properties of these data are, however, exceptionally useful: including the wide area, frequent-repeat coverage (twice daily, on a global basis), and the precise geolocation information provided by the well-characterized orbital geometry (positional accuracies of the image pixels are at a nominal +/- 50 m with reference to a global datum and geoid).

We have developed a surface water mapping methodology based on using only bands 1 (620-672 nm) and 2 (841-890 nm). These are the two bands at 250 m, and the use of only these bands maximizes the resulting map detail. In this regard, most water bodies are strong absorbers of incoming solar radiation at the band 2 wavelength: it could be used alone, via a thresholding procedure, to separate water (dark, low radiance or reflectance pixels) from land (much brighter pixels) (*1, 2*). Some previous water mapping procedures have in fact used such single band data from this and other sensors that include similar wavelength channels. Adding the second channel of data (band 1), however, allows a band ratio approach which permits sediment-laden water, often relatively light at band 2 wavelengths, to still be discriminated, and, as well, provides some removal of error by reducing the number of cloud shadow pixels that would otherwise be misclassified as water.

The most desirable outcome of a water mapping algorithm for flood surveillance is complete coverage from one image: because floods are a dynamic phenomenon, and surface water extent can change over a few hours of time. On the other hand, cloud cover commonly obscures significant land areas during flooding, so that accumulating data from more than one image is necessary in order to expand spatial coverage. Also, cloud shadow removal can be facilitated by combining data from at least two images (cloud shadows that vary in location can be distinguished from surface water present in both images). Our procedure provides a flexible approach in which raster image processing of at least four MODIS images is the initial input, and then, once the water area data are translated into GIS vector format (water polygons), accumulation of water area can be extended over several days, or more, in time: in the case when cloud cover is heavy and only relatively small areas of the ground surface are captured in even four images.

The resulting GIS files, outlining surface water, are then best used in comparison to other data obtained through identical processing but on dates prior to flooding and when surface water was at approximate mean conditions. This constitutes a change detection approach, but occurs within the GIS environment: one flood water layer, perhaps colored red, can be displayed below a normal water layer, perhaps colored light blue. All areas of visible red then represent defined parcels of land that are under water in the flood image and were not in the comparison scene.

In our mapping, we normally superimpose these GIS water layers over reference map information, such as shaded relief and cultural feature files such as cities and towns, and over all of these layers we superimpose a layer showing the persistent cloud cover.

Because of the importance of having the latest information for disaster management applications, we are developing a prototype automated system to implement the processes described above. We expect to draw on near real time data from the recently implemented NASA MODIS LANCE system to provide MODIS based flood maps with a latency time of less than six hours.

We expect to focus our future work in this area toward developing a global near real time capability, and investigating the addition of satellite radar data and higher resolution optical data sources as available.

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