# River Ice monitoring over the Susquehanna River Basin using remote sensing data

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***The ultimate goal of this study is to implement an automated approach using multi-satellite data for river ice monitoring in the Susquehanna River Basin (SRB). The approach is based on the simultaneous use of satellite images from MODIS and AVHRR in the visible and infrared channels. The developed database will be a benchmark towards the development of an ice jam warning system along the Susquehanna River.***

## Problem statement


*Example of observed ice jam on January 1996 and flooded areas (2006) in the Susquehanna River Basin (www.srbc.net)*

✓ Susquehanna River is one of the most vulnerable and flood-prone areas in the USA
✓ The ice flood in January 1996 was devastating
✓ Ice breakup processes are rapid and dangerous
✓ In the United States, the estimated cost of damages related to ice jams is in the order of $ 100 million
✓ Ice jams are local and tend to occur in relatively small scale
✓ Ice motion limits the efficiency of monitoring systems which are based on local in situ observations limited coverage is subject to significant fluctuations
✓ An automated and adaptive system capable of capturing the dynamic of ice cover along the river is needed in order to monitor in near real time an assessment of the actual extent of ice.

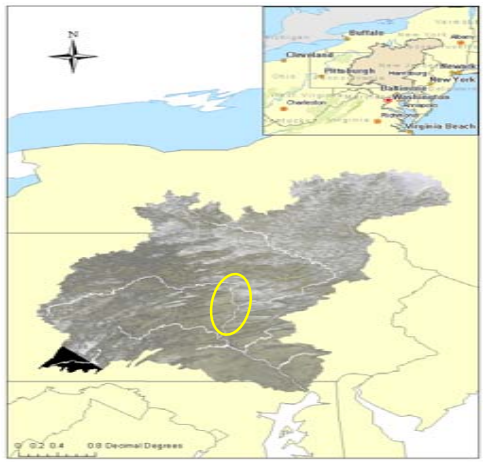
*Satellite imagery is a key alternative*

## Methodology

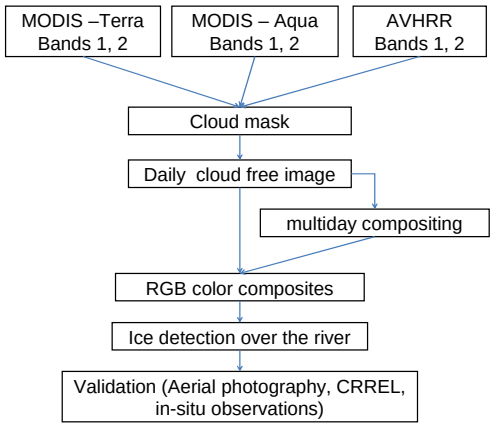
The ice detection approach makes use of the color composite (RGB) based technique to detect and monitor ice in the Susquehanna River. This technique assigns red, green and blue color to three different channels (bands). It is applied to MODIS and AVHRR data. Almost 30 years of AVHRR data (1 km) will be processed. MODIS data are available since 2000. MODIS Terra and Aqua are considered (250 m, 500 m and 1 km).

The approach consists of comparing two images (day to day difference) covering the same scene and taken at two successive acquisition dates with the same sensor (MODIS-Terra, MODIS-Aqua, AVHRR):

- Daily time series of color composites was generated within each sensor
- Band 1 (visible) is assigned to blue
- Band 2 (near infrared) is assigned to red and green
- White color in the obtained image corresponds either to ice, snow or cloud



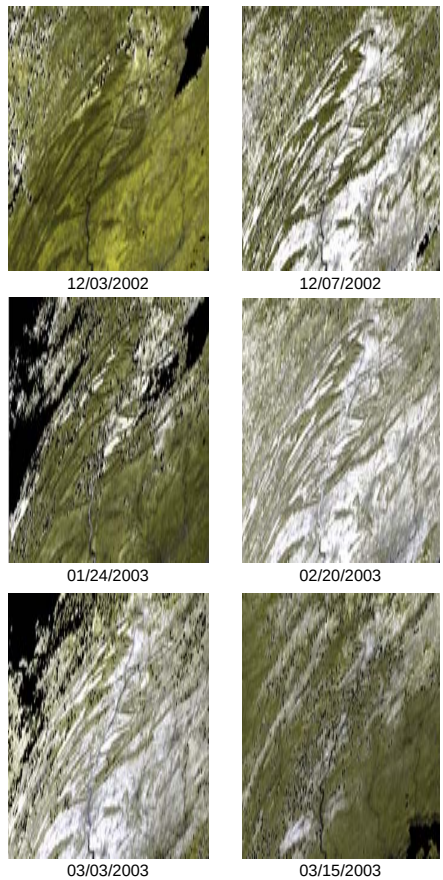
*MODIS image of the Susquehanna River Basin*




*Flowchart of the approach*

Clouds present the major factor that hamper timely detection of changes in ice cover. Cloudy pixels need to be properly identified and labeled in satellite imagery.

An automated technique was set up to systematically process daily images from MODIS and AVHRR. The technique consists of:
- Images acquisition
- Image reprojection and subsetting by applying the SRB mask
- Cloud detection
- Compositing and cloud free scenes generation
- Ice detection within cloud free areas and ice map generation




*Examples of cloud free RGB images*

## Results

The multi-band false color composite image obtained within cloud free areas shows ice coverage over the river (white color). These preliminary results show great potential for satellite imagery in visible and near infrared to monitor ice cover and to detect its dynamic.

## Future work

❖ Delineate river ice extent based on the analysis of 10 years MODIS data and 30 years AVHRR images records
❖Develop an exhaustive ice jam database
❖Investigate the relationship between flood occurrence and ice coverage spatial patterns
❖ Validate obtained results with aerial photography, CRREL and in situ observations