

Remotely Monitoring Great Lakes Coastal Wetlands Using a Hybrid Radar and Multi-Spectral Sensor Approach

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Remotely Monitoring Great Lakes Coastal Wetlands

➤ Great Lakes Remote Sensing Projects

- Satellite radar data analysis of forested coastal wetlands of the Great Lakes *sponsored by General Dynamics*
- Hybrid sensor approach to monitoring Great Lakes coastal wetlands *sponsored by the Great Lakes Commission*

➤ Goals

- Develop robust remote sensing techniques for potential operational use to evaluate landscape indicators
- Use medium resolution (~30 m) sensors
- Minimize cost but maximize effectiveness

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Remotely Monitoring Great Lakes Coastal Wetlands

➤ Focus: SOLEC Landscape Indicators

- Water Level Fluctuations 4861
- Habitat Adjacent to Coastal Wetlands 7055
- Near-shore Land-use Intensity 8132
- Area Quality and Protection of Special Lakeshore Communities 8129
- Extent and Quality of Near-shore Natural Land-cover 8136

➤ Strategy

- Combine satellite imaging radar data with classical Landsat data to:
 - monitor change in wetlands and adjacent uplands
 - Develop techniques to map wetlands with minimal *in situ* data
 - Monitor extent of inundation in wetlands

Sensors

➤ Landsat Sensor Capabilities

- Very useful for mapping vegetative cover and land use
- Can be used to map flooding in open areas and wetness in open canopied vegetative cover

➤ Synthetic Aperture Radar (SAR) Compliments Electro-Optical Data

- SAR is an active system that interacts differently with vegetative ecosystems based upon biomass, structure and moisture characteristics
- Capable of detecting inundation in closed canopy and open canopy ecosystems
- Useful for land cover and wetland classification

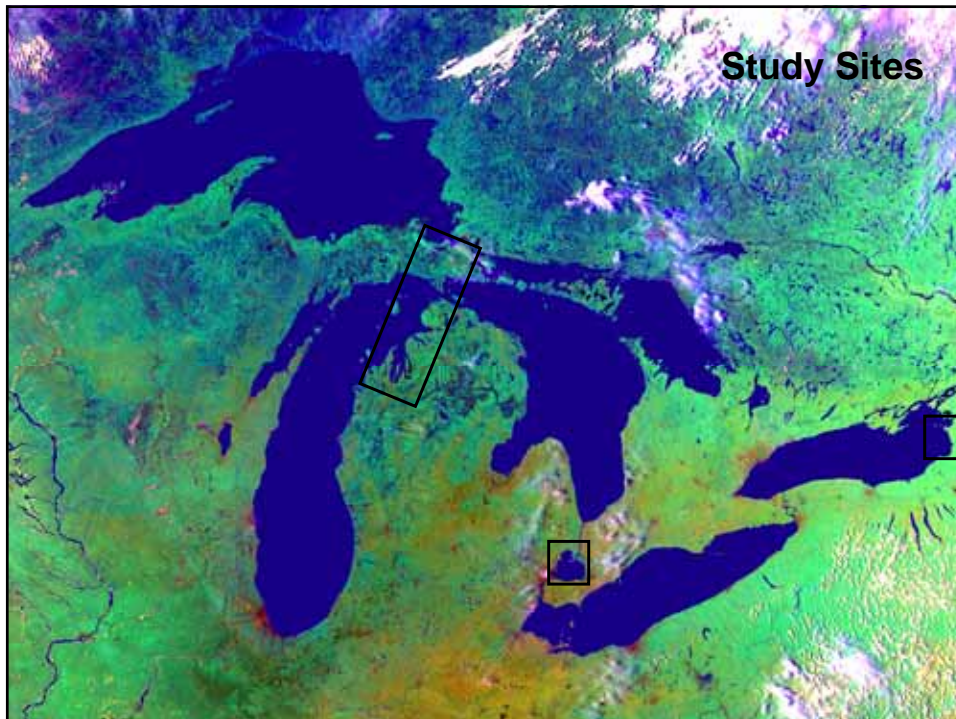
Sensors

➤ Specific Advantages of SAR over Landsat

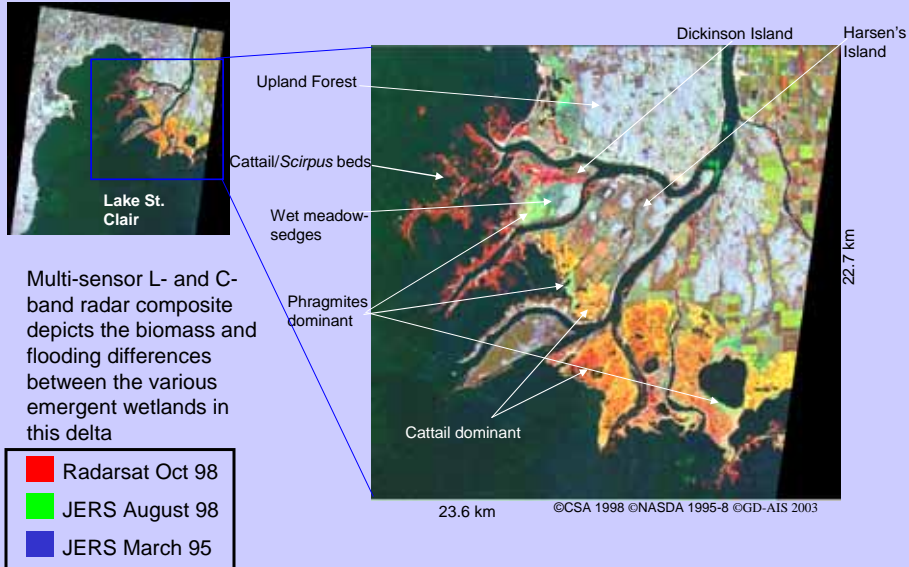
- All-Weather Day/Night Capability allowing timely collections of data
- Capable of detecting inundation beneath a vegetation canopy
 - Radarsat C-band SAR (5.7 cm wavelength) is useful for detecting flooding beneath herbaceous canopies.
 - JERS L-band SAR (23 cm wavelength) is useful for detecting forested wetlands and some high biomass herbaceous wetlands.

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SAR Multi-Sensor Composite of Lake St. Clair

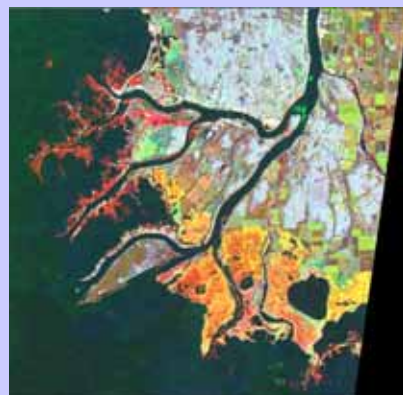


Complimentary Landsat and SAR

Landsat ETM (Aug '01) 5,4,3
False Color Composite



Radarsat (Oct '98), JERS (Aug '98), JERS (March '95) False Color Composite



Merged Landsat-SAR Land Cover Mapping

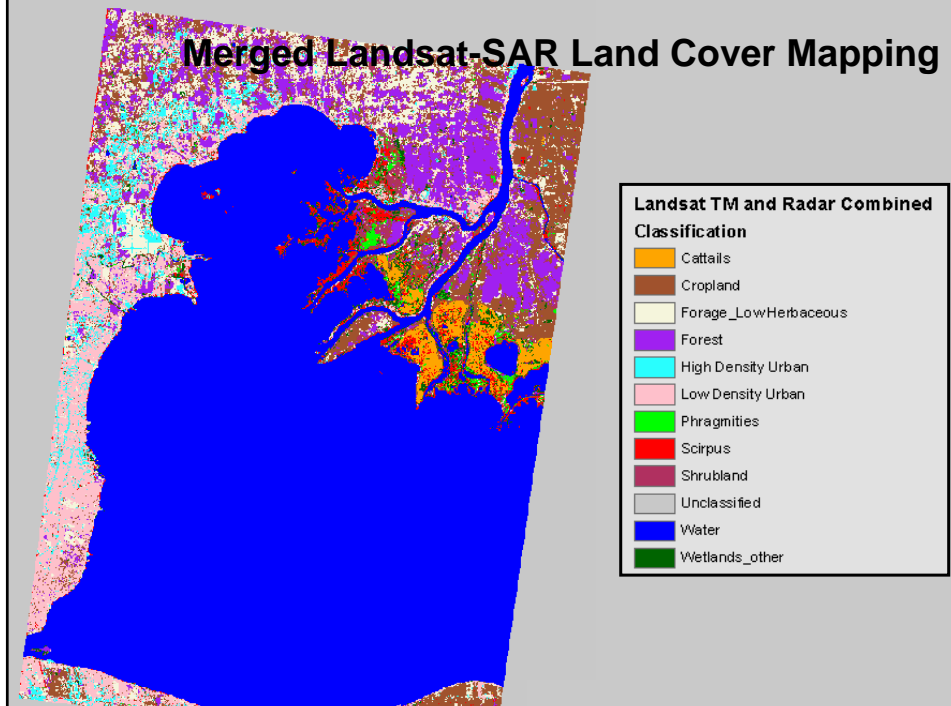
➤ Methods

- Performed separate classifications on the Landsat and then SAR imagery using multi-date radiometrically calibrated data. This resulted in some overlap of categories but also some unique categories for each individual classification.
- Fused resulting categories
 - Lake St. Clair Example
 1. Water defined by Landsat alone
 2. *Scirpus* and *Phragmites* were defined by SAR but used Landsat wetland classes for reinforcement
 3. Urban was defined by areas classed as urban in Landsat and urban/forest in SAR.

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Merged Landsat-SAR Land Cover Mapping



Merged Landsat-SAR Land Cover Mapping

➤ Results of Combined Approach at Lake St. Clair Site

- Allowed easy delineation of the invasive species *Phragmites*
- Allowed overall increased definition of wetland types over optical imagery alone
- Allowed better delineation of *Scirpus* beds on fingers of the delta, areas that were missed in IFMAP
- Greater than 70% overall accuracy when compared to IFMAP

➤ Problems

- SAR data available were not collected at optimal times for detecting woody wetlands and delineating extent of inundation. Therefore, forested wetlands are not delineated in this map.

Forested Wetland Inundation Mapping

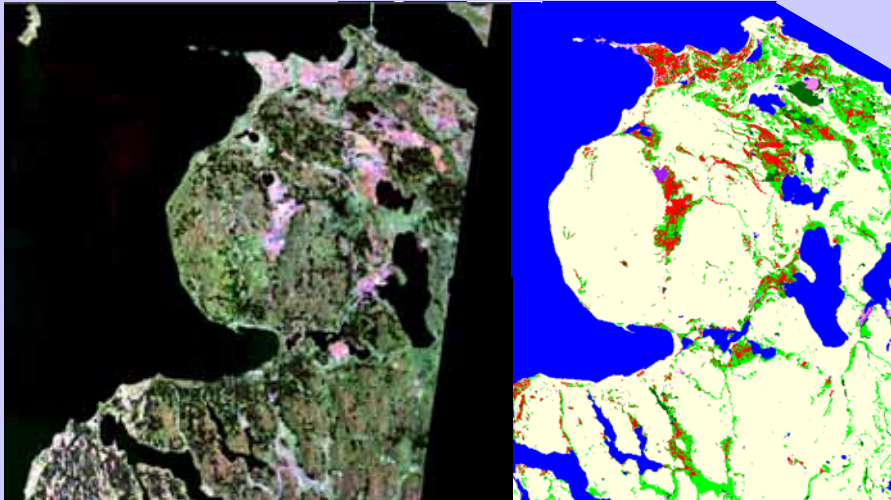
➤ Methods at UP, Mackinac, and Leelenau Study Areas

- Used four dates of JERS imagery collected between Fall of 1992 and Spring of 1994 to estimate extent of inundation during that period.
- Image classification was performed on the four image date composite to four classes: inundated woody wetland, open water/low return, medium biomass herbaceous, and coniferous forest
- Due to confusion of woody wetlands with urban areas and tree plantations, only those areas that fell within NWI areas that were labeled as woody wetland (shrub or forested) were kept.

Great Lakes Forested Wetland Inundation Mapping

Red Green Blue False Color
Multi-temporal JERS L-band Composite

NWI with SAR-derived Inundation Overlaid

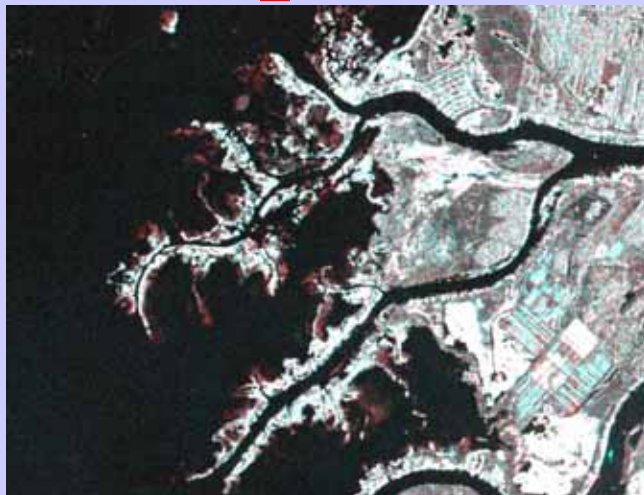


■ Extent of Inundation

Herbaceous Wetland Change in Inundation

Two date false color composite of Radarsat Imagery over Lake St. Clair

■ 3 October 1998 ■ 27 October 1998



Water level is 19 cm higher on the first date, causing specular reflection (low return-dark).
A decrease in inundation on the second date reveals the vegetation causing double bounce scattering (bright return-red).

Hybrid Change Detection of Wetlands

➤ Methods

- Categorical change between the NWI (1976) and IFMAP (2000) data.
- Radiometric change between an early MSS scene (July 1974) and recent Landsat ETM+ (August 2001)
 - Data were registered and resampled to a 60-m cell size. MSS channels were radiometrically balanced to the TM channels
- The radiometric change product was thresholded to eliminate low magnitude change and then combined with the categorical change image to produce a hybrid change product.
- Areas of change were checked in the Landsat images and then used to update the NWI.

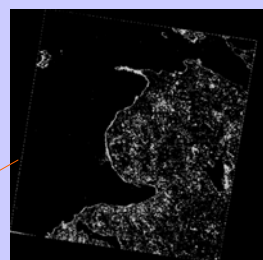
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Hybrid Change Detection with Landsat



Post-categorical
change map NWI
to IFMAP



Landsat Radiometric
Change Magnitude
(July 1974 to August
2001 Imagery)



Hybrid Change Image

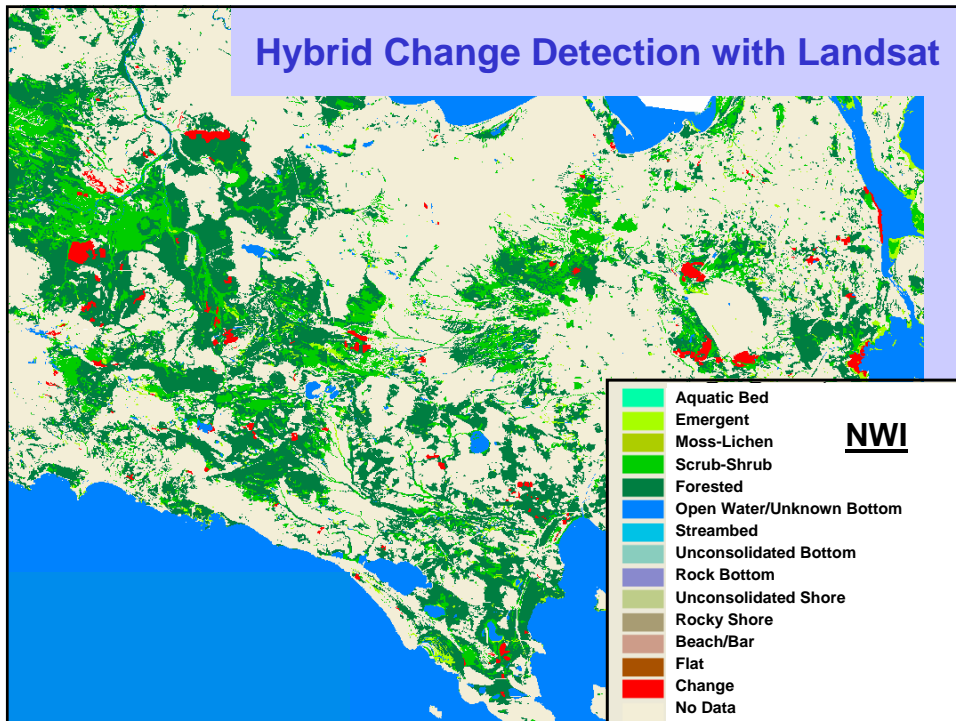
Hybrid Change Detection with Landsat



NWI



Hybrid Change Detection with Landsat



NWI

Hybrid Change Detection of Wetlands

➤ Results

The hybrid change analysis resulted in 2.6% overall change to the nine counties covered by the UP, Mac and Lee study areas.

- The total area converted from wetland to upland in the change analysis was 2546 hectares (ha).
- The area converted from upland to wetland was only 3 ha.
- 1304 ha changed from emergent to woody (shrub or forested) wetland and 7.2 ha changed from woody to emergent over the three decade change analysis.
- The area changing from wetland to open water (including aquatic bed) was 124 ha.

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Conclusions

➤ Using a combination of SAR and Landsat data in wetland mapping and monitoring:

- Takes advantage of the unique qualities of each sensor
- Allows a larger range of capabilities
- Reduces the amount of *in situ* data required when mapping wetlands with a hybrid sensor approach
- Compliments existing datasets

➤ Hybrid change detection technique

- Utilizes existing categorical datasets
- Provides a cost-effective method for monitoring change

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