

National Aeronautics and
Space Administration



Improving Forest Management through Early Detection of Bark Beetle Outbreaks in the Southeastern United States Using Earth Observations

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Bark Beetles



Bark beetle-induced mortality:

- ▶ Causes estimated annual losses of \$43 million
- ▶ Affects 45 times more forest area than wildfires
- ▶ Increases fuel for wildfires

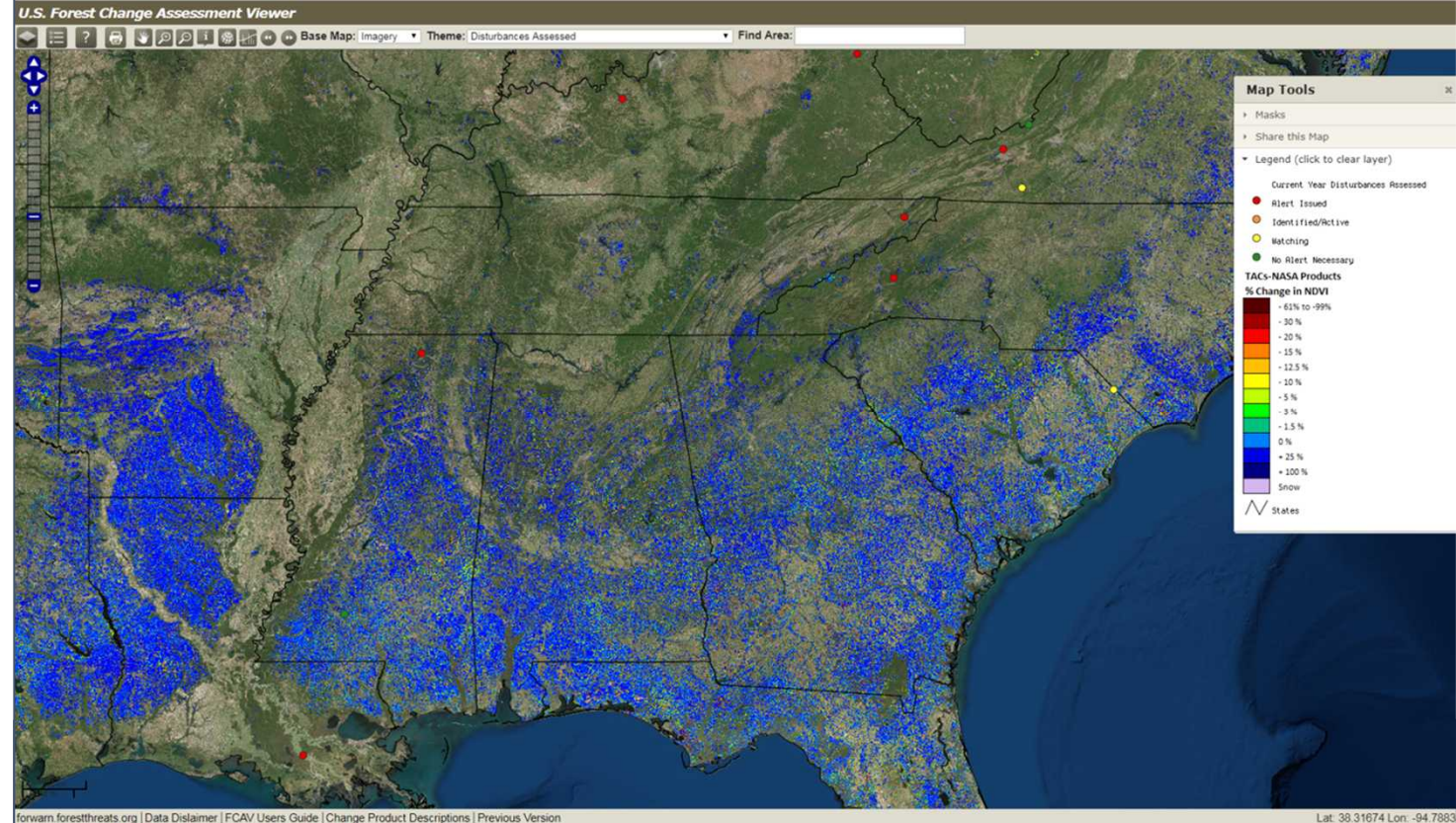
Effective intervention requires **early** detection that can be aided by remote sensing



Current Monitoring

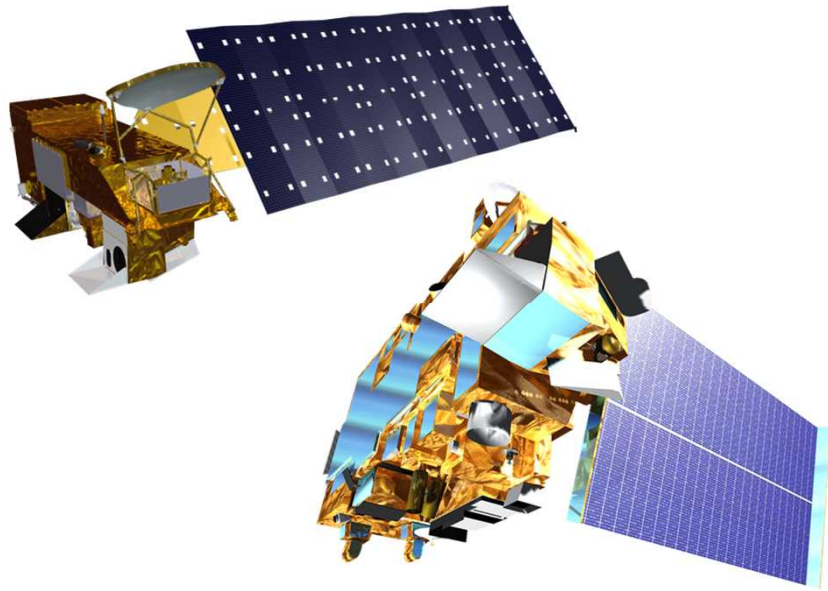
ForWarn is a counterminus US monitoring system based on MODIS NDVI data

- ▶ USFS uses MODIS NDVI data to monitor and assess biotic (e.g., bark beetle) and abiotic (e.g., drought) forest disturbances
- ▶ 250m MODIS pixels are too coarse to detect bark beetle outbreaks in time for early treatment of affected forests



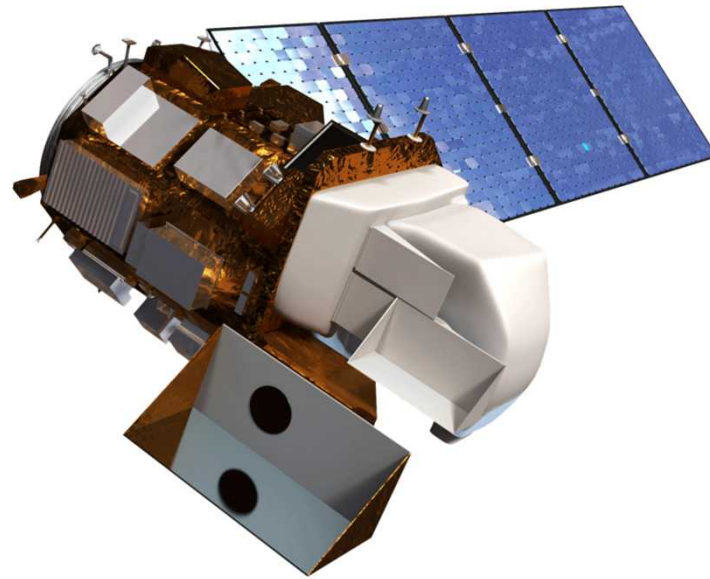


Earth Observations



Aqua & Terra MODIS

- ▶ Temporal Resolution: 8 day
- ▶ Spatial Resolution: 10 meter
- ▶ NASA



Landsat 8 OLI

- ▶ Temporal Resolution: 16 day
- ▶ Spatial Resolution: 30 meter
- ▶ NASA/USGS

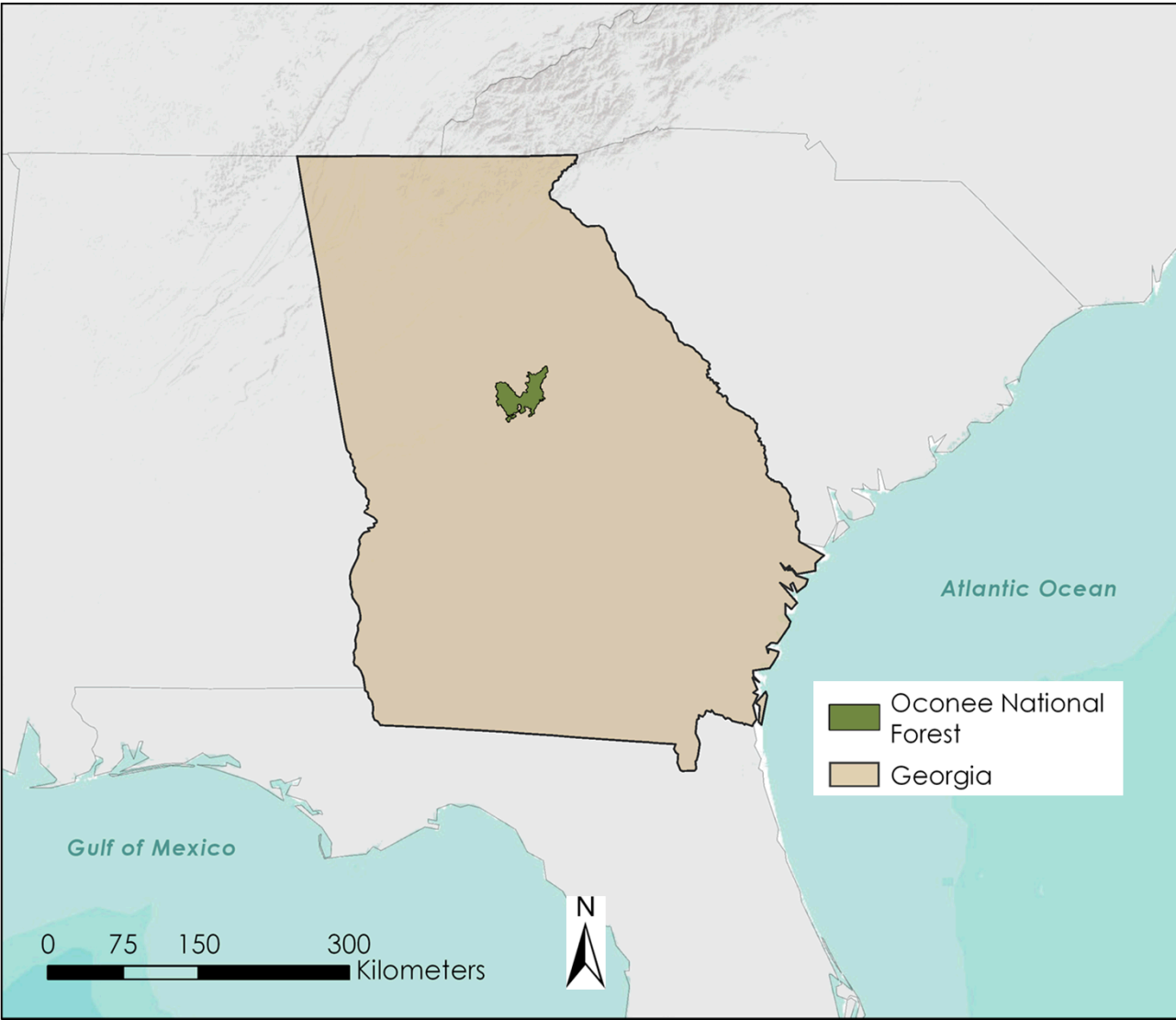


Sentinel-2 MSI

- ▶ Temporal Resolution: 5 day
- ▶ Spatial Resolution: 10 meter
- ▶ European Space Agency



Study Area & Study Period

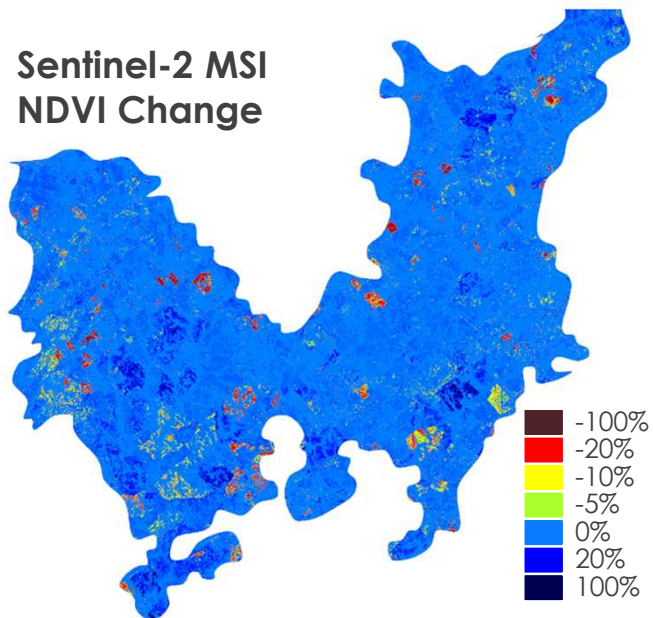


- ▶ Oconee National Forest, GA
- ▶ Analyzed high incidence of bark beetle outbreaks from 2016 to 2017 by comparing

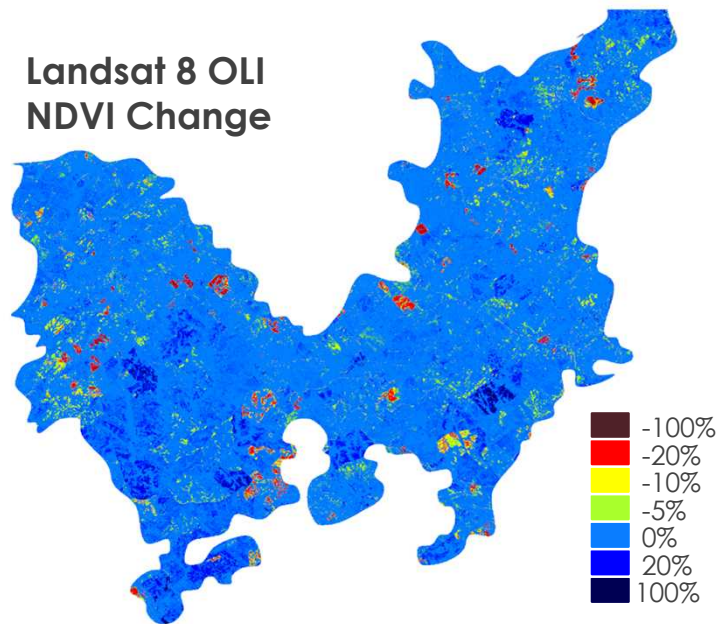


May 2016 to May 2017

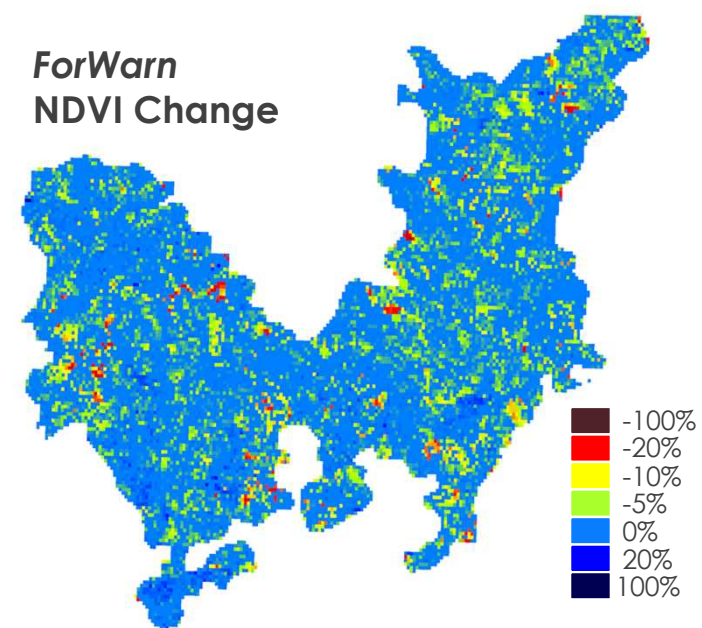
Sentinel-2 MSI
NDVI Change



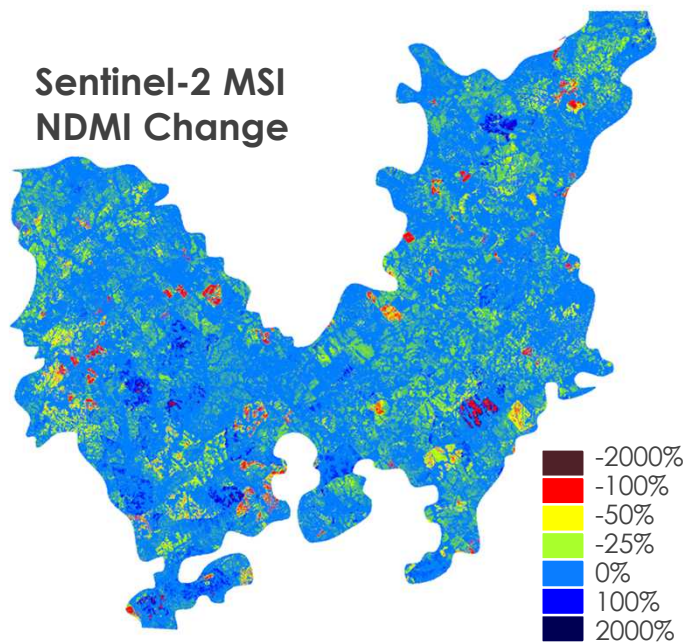
Landsat 8 OLI
NDVI Change



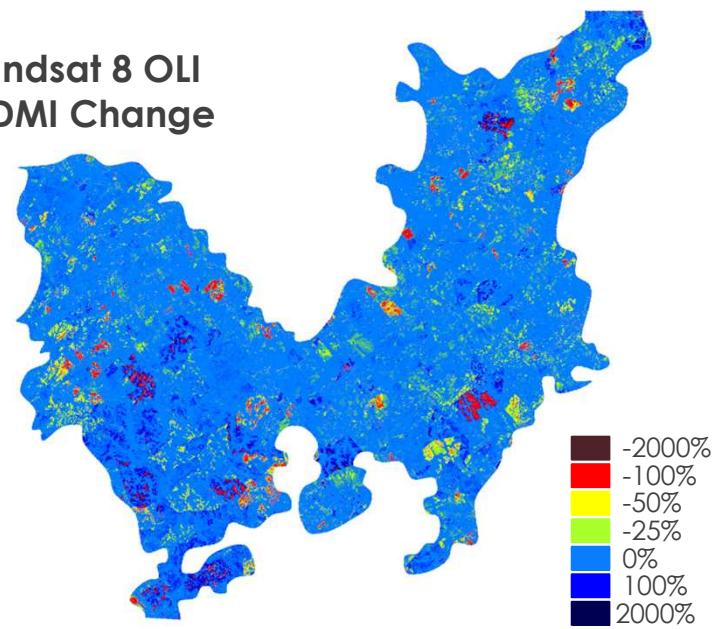
ForWarn
NDVI Change



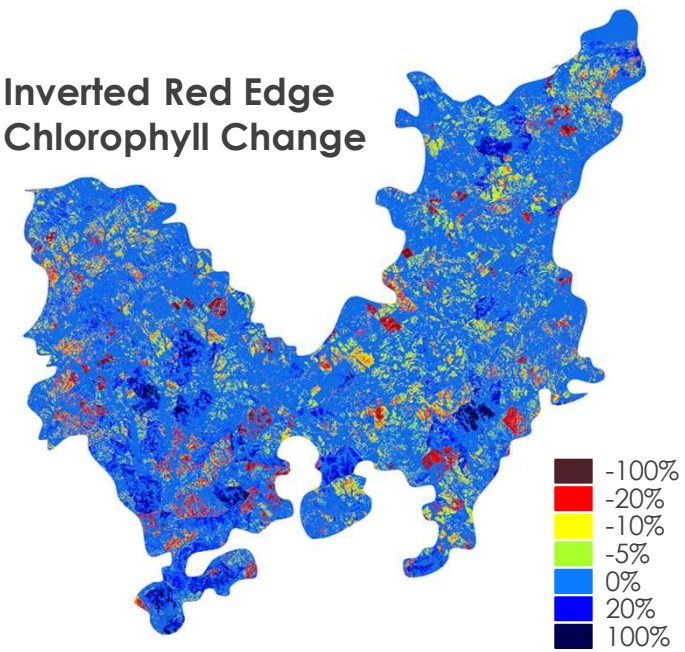
Sentinel-2 MSI
NDMI Change



Landsat 8 OLI
NDMI Change

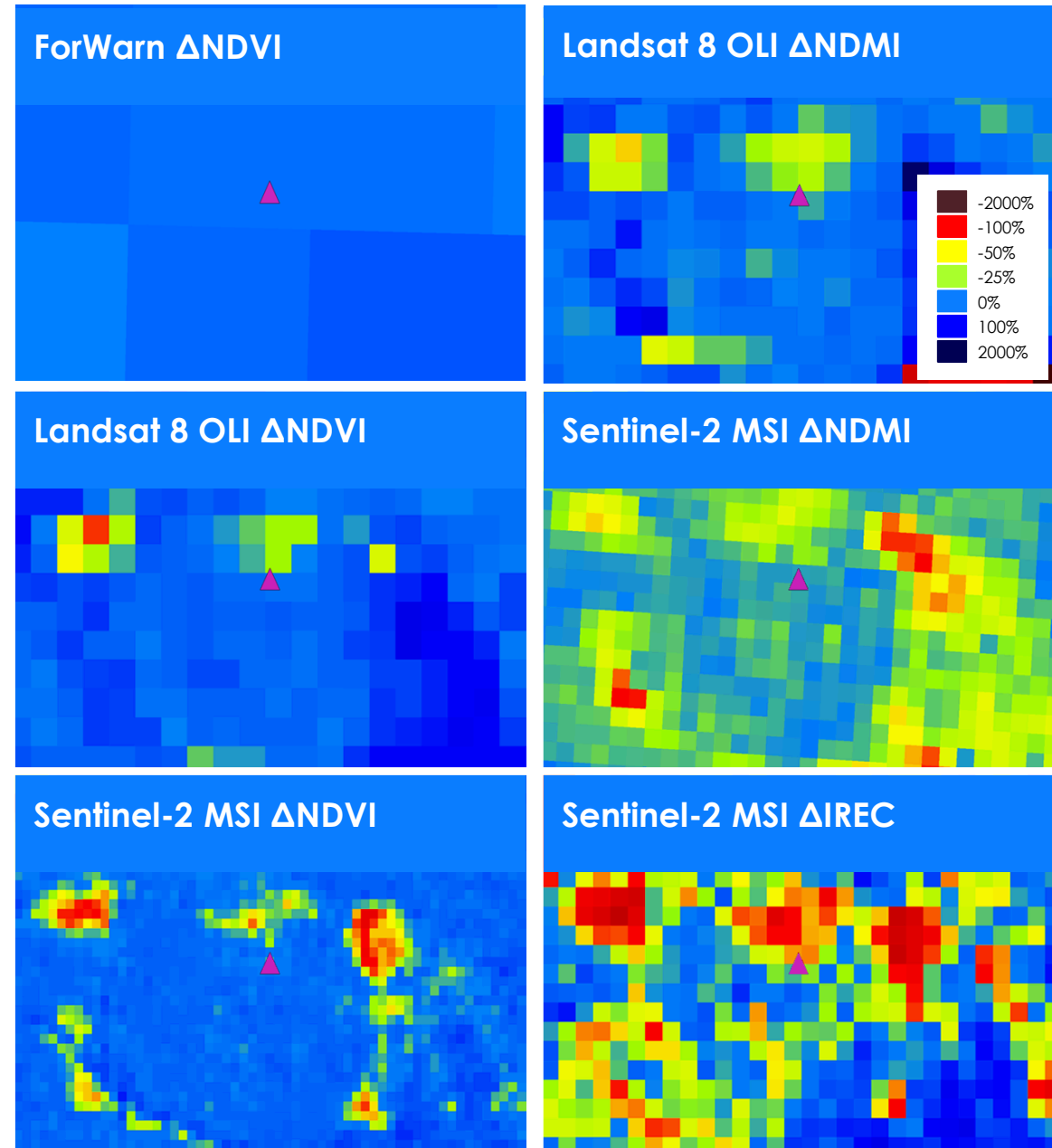


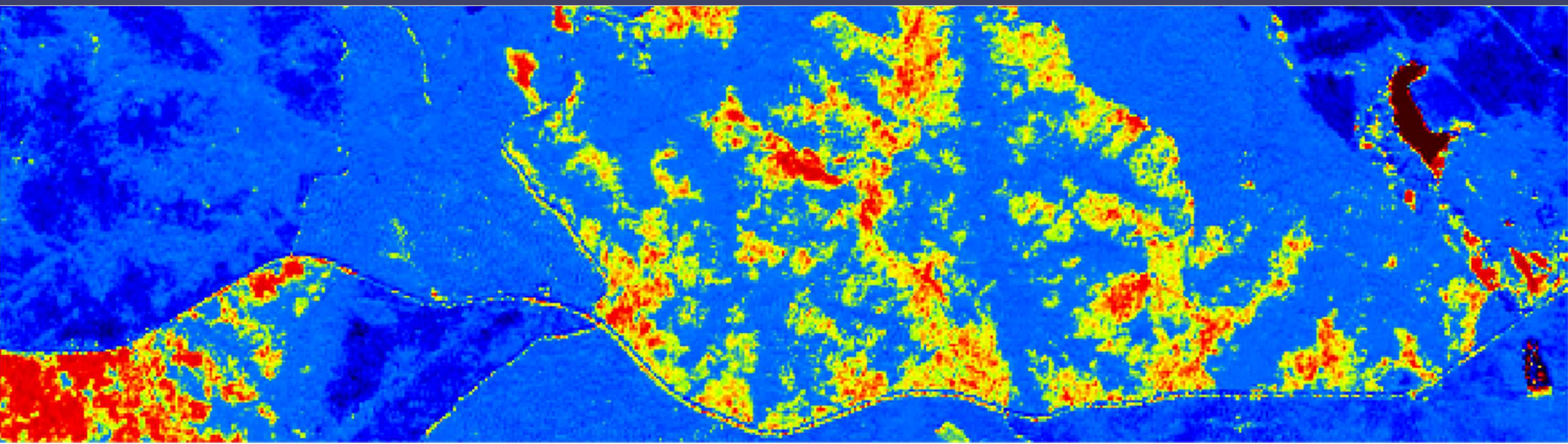
Inverted Red Edge
Chlorophyll Change



Results

- ▶ All change maps produced averaged about 70% agreement with *in situ* data
 - However, *in situ* survey data are not highly precise and may include location errors
- ▶ Higher spatial resolution change maps derived from Landsat 8 OLI and Sentinel-2 MSI provided more precision in disturbance location detection
- ▶ Some indices are more sensitive to forest canopy color changes, but all assessed indices provide some disturbance detection capability





Conclusions and Future Work

- ▶ Negative NDVI, NDMI, and IREC changes are correlated with known bark beetle activity and drought impacts.
- ▶ Landsat 8 OLI and Sentinel-2 MSI data products offer a higher spatial resolution view of bark beetle activity compared to MODIS NDVI products used by *ForWarn*.
- ▶ Sentinel-2 IREC index change maps appeared to show greater potential for identifying early indications of disturbance by bark beetles compared to non-red edge NDVI and NDMI change maps.



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