Adaptation of MODIS Sea Ice Leads Detection Algorithm to VIIRS

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Background and Motivation

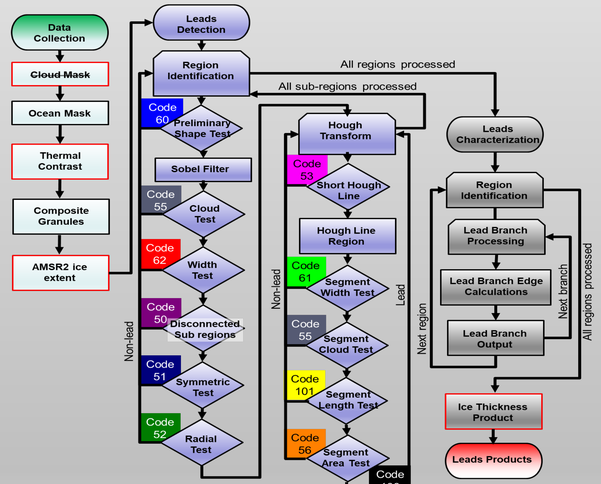
Leads are elongated fractures in the sea ice cover that form under stresses due to atmospheric winds and ocean currents. Leads provide a significant amount of heat and moisture to the Arctic atmosphere.

The purpose of this work is to extend the methodology developed to identify leads in MODIS to use VIIRS.

Algorithm Description

The method consists of the following steps:

- Acquire VIIRS level-1b imagery (SNPP & NOAA-20) from Band I5 (375m resolution 11 µm)
- Thermal contrast to identify potential sea ice leads (relatively large local brightness temperature standard deviation)
- Image processing to detect leads
- Derive object properties (length, area, width, orientation)



Notable Differences

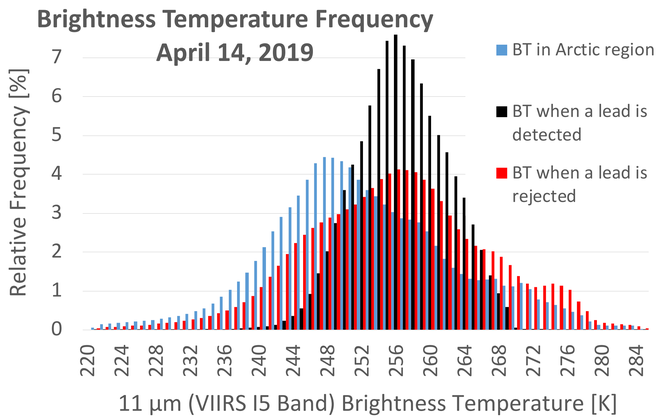
- No cloud mask applied
- Require more than 4 observations with high thermal contrast
- Thermal contrast does not include absolute temperature range
- Use AMSR2 to establish ice edge
- Lead ice thickness included

Summary

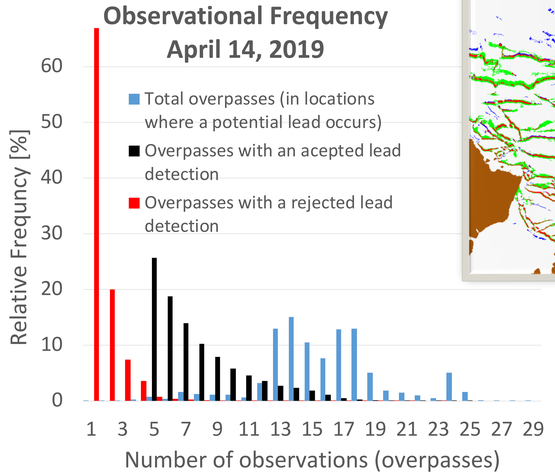
- Routine product generation began late fall 2019
- Combined VIIRS and MODIS leads detections can offer greater confidence in leads location than from a single satellite
- Future work: investigate interaction of leads with other climate processes

Project website: www.ssec.wisc.edu/leads

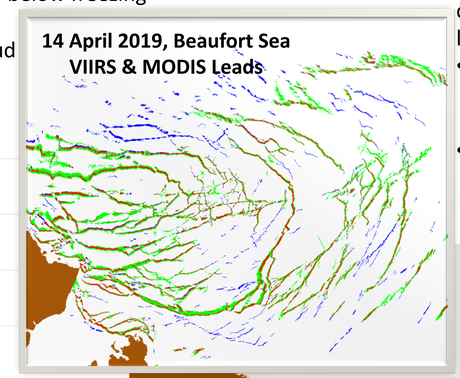
Hoffman, Jay P.; Ackerman, Steven A.; Liu, Yinghui and Key, Jeffrey R. The detection and characterization of Arctic sea ice leads with satellite imagers. Remote Sensing. 2019, 11(5), 521; https://doi.org/10.3390/rs11050521

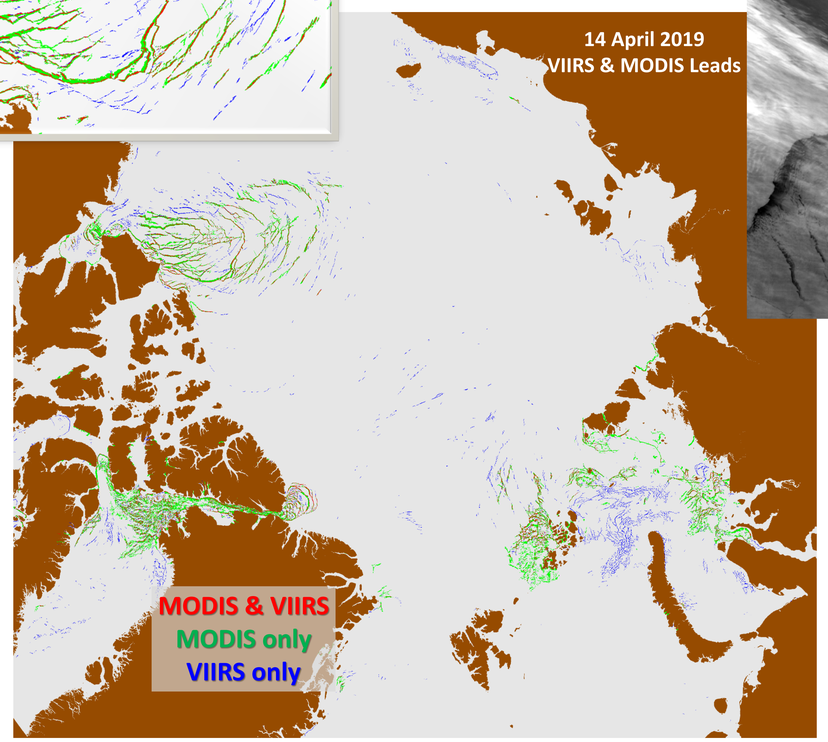


- Thermal contrast is the key to leads detection
- Brightness temperature alone is not a direct factor
- Leads brightness temperatures are usually below freezing
  - Pixels may include sea ice and water
  - Atmospheric path may include thin cloud
  - Leads may be new-ice



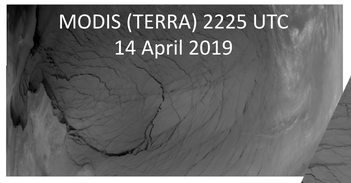
- The majority of the arctic receives more than 13 VIIRS overpasses in a day, more poleward locations receive twice as much coverage
- A VIIRS lead detection must have high thermal contrast in more than 4 overpasses. High thermal contrast is rarely detected in every (or even the majority) of the daily overpasses .
- The majority of high thermal contrast features that fail leads detection is due to infrequent repeat observations.
- Relatively few long-lasting thermal contrast features are leads are reject as leads (due to image processing for linear features)





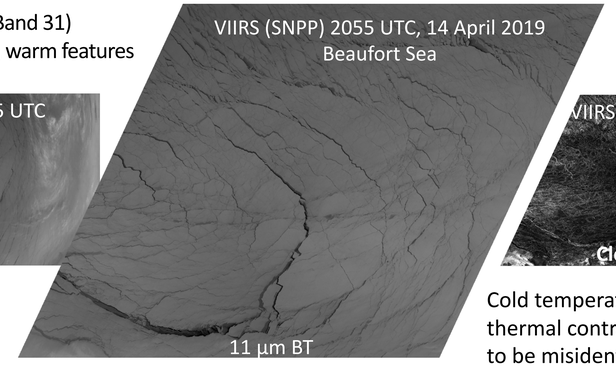
Case Study

1km resolution 11 µm (Band 31) brightness temperature, warm features are dark



Leads apparent as high thermal contrast in atmospheric window brightness temperature

375m resolution 11 µm (I5) brightness temperature, warm features are dark



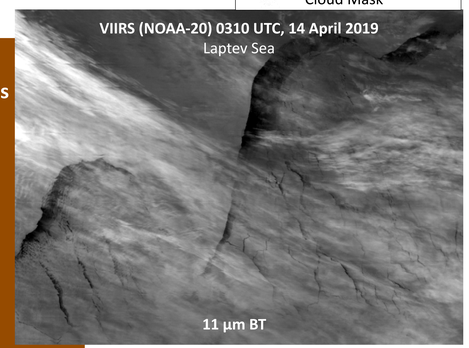
750m resolution Enterprise cloud probability, bright features are high cloud probably

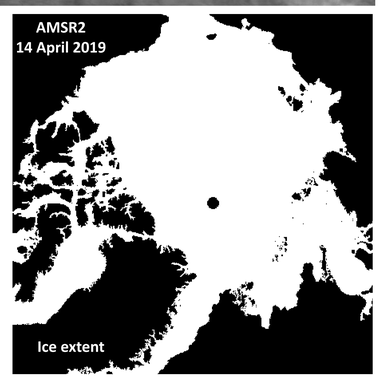
Cold temperatures and high thermal contrast can cause leads to be misidentified as clouds

For the day, 40% of the MODIS leads area corresponds with a VIIRS lead; 70% of the VIIRS lead area is collocated with MODIS.

- Due to resolution differences, VIIRS leads detections are often thinner and encapsulated by a wider MODIS detection.
- Algorithm changes, instrument difference, overpass times, and clouds contribute to differences

In a mostly cloudy example over Laptev Sea, leads thermal contrast is observed through thin clouds





Lead detection search area is bound by AMSR2 ice extent

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