MODIS/VIIRS Sea Ice Leads

2019 MODIS Science Team Meeting

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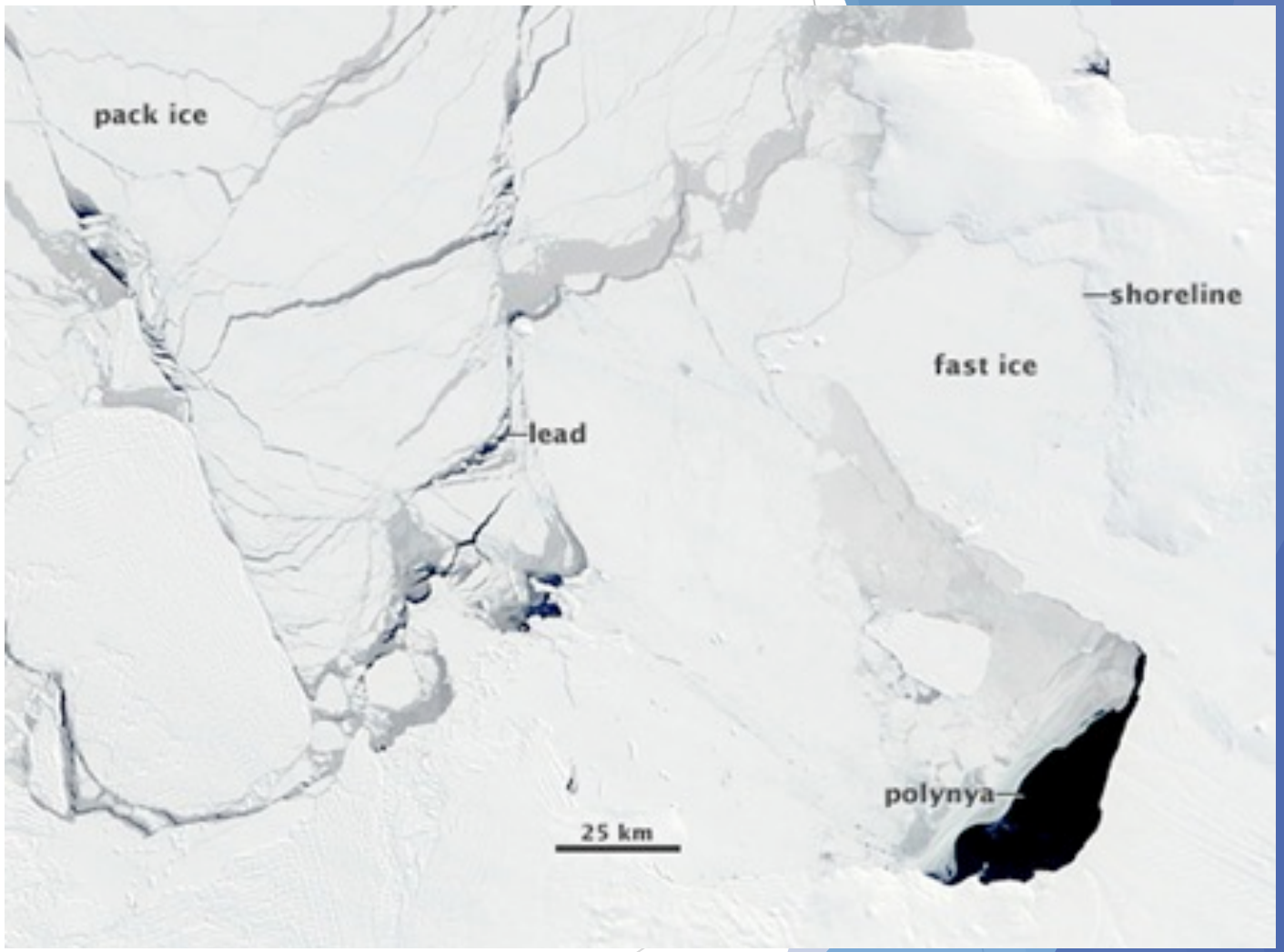
Background

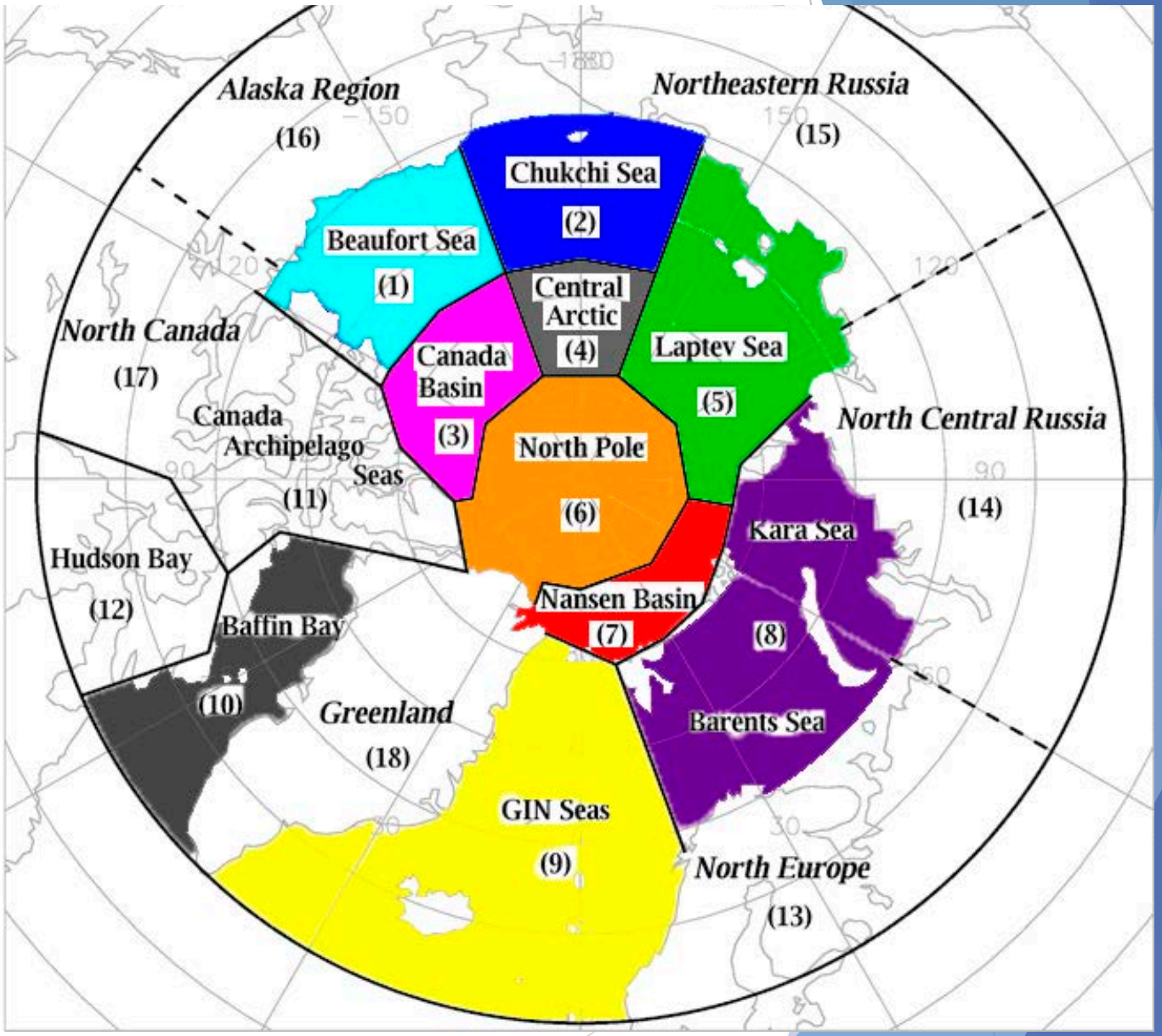
- Leads are elongated fractures in the sea ice cover. They form under atmospheric and oceanic stresses.
- Leads provide a source of heat and moisture to the Arctic atmosphere.
- Leads detection can assist navigation in the Arctic.



(From earthobservatory.nasa.gov)

Study Area

- November – April
- 10 polar regions
  - Beaufort Sea
  - Chukchi Sea
  - Canada Basin
  - Central Arctic
  - Laptev Sea
  - North Pole
  - Nansen Basin
  - Kara & Barents Sea
  - GIN Seas
  - Baffin Bay



Algorithm description

The method consists of the following steps:

- Acquire data
  - MODIS: Band 31 (1km resolution 11 μm)
  - VIIRS: Band I5 (375m resolution 11 μm)
- Cloud mask
  - MODIS: confidently clear only
  - VIIRS: no mask applied
- Thermal contrast
  - MODIS: 2+ repeat observations
  - VIIRS: 4+ repeat observations
- Image processing to detect leads (linear features)
- Derive object properties (length, area, width, orientation)

remote sensing

MDPI

Article

The Detection and Characterization of Arctic Sea Ice Leads with Satellite Imagers

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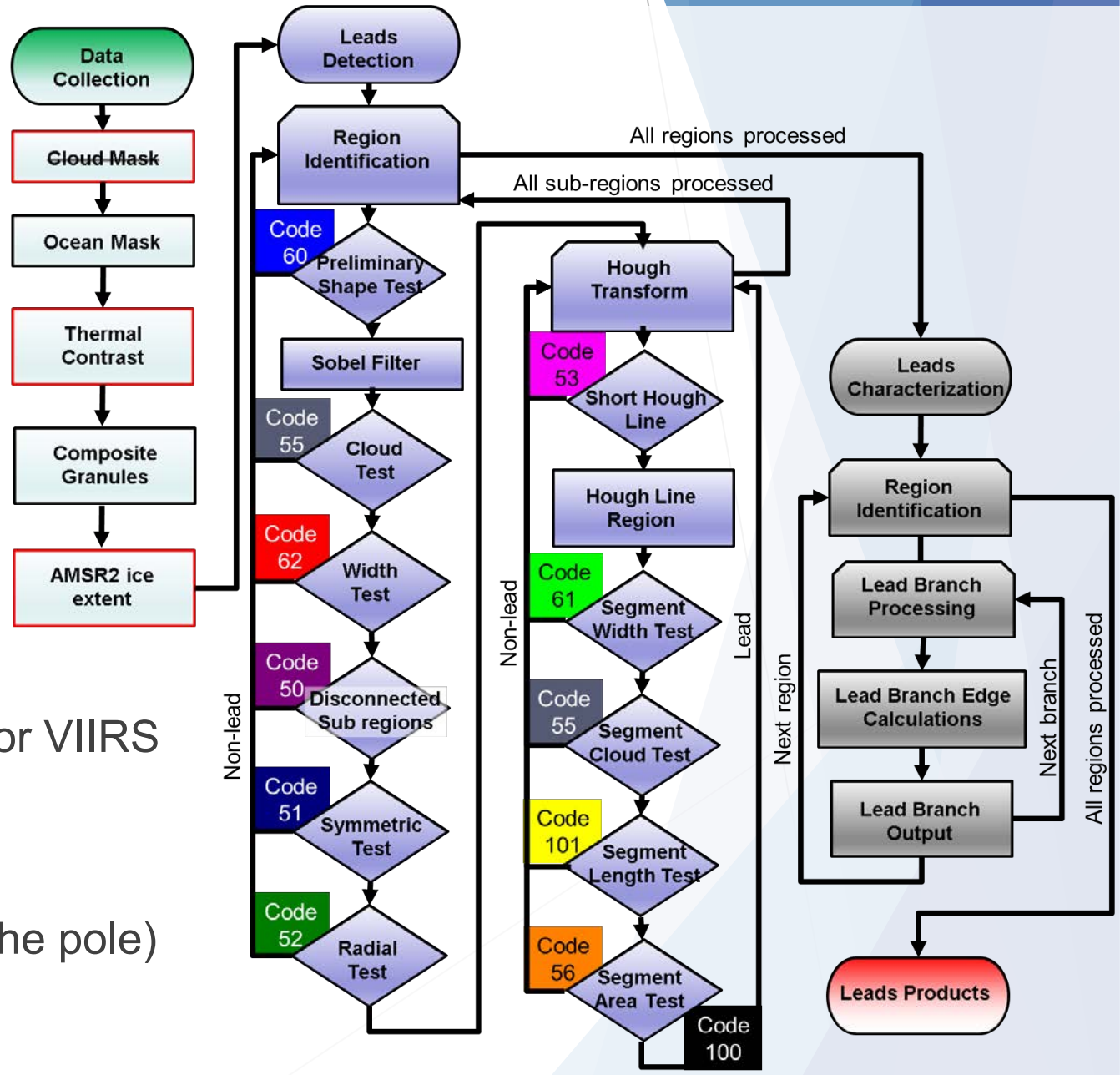
Refer to paper in Remote Sensing for more information

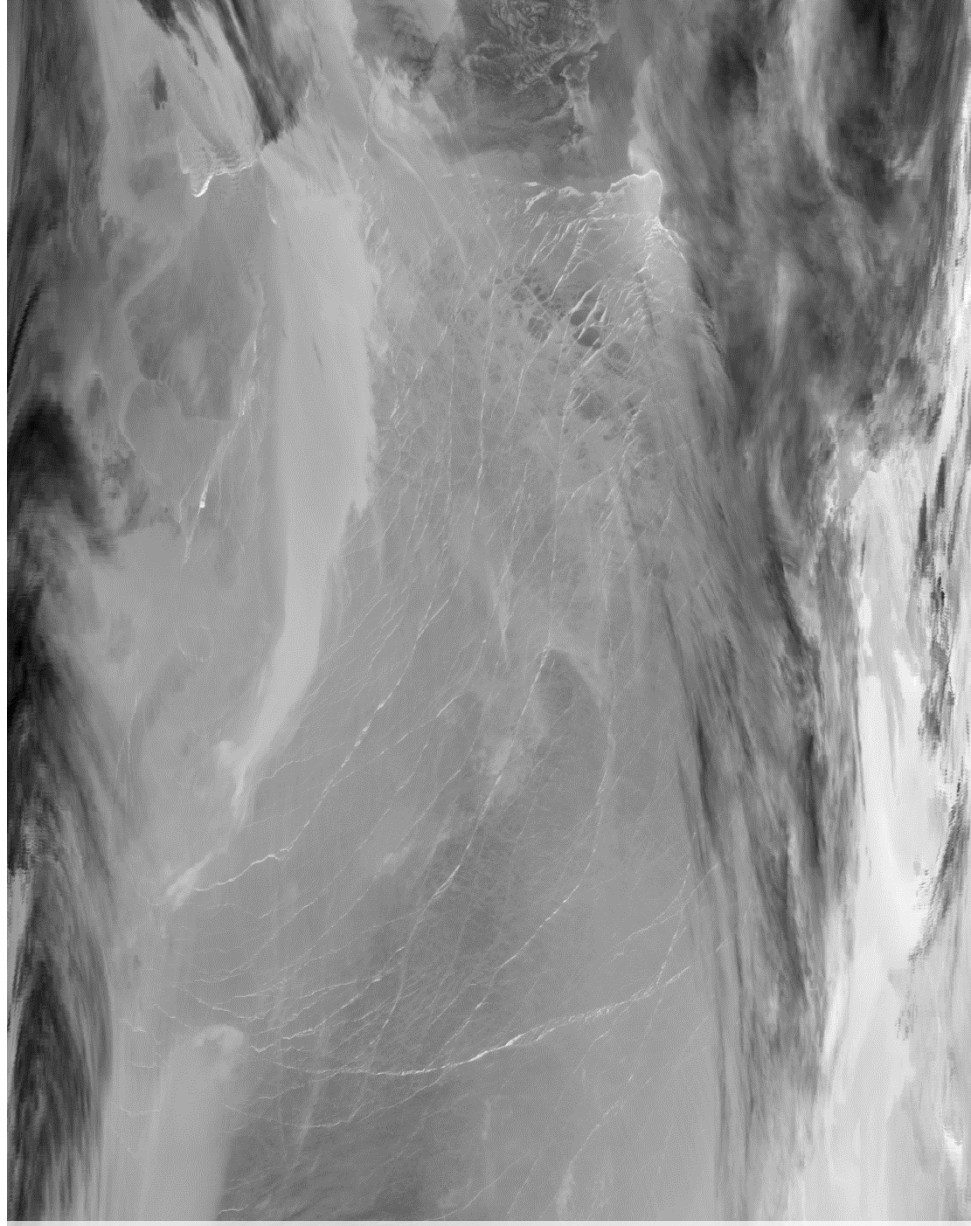
Algorithm differences

- Cloud mask
  - MODIS: confidently clear only
  - VIIRS: no mask applied
- Thermal contrast
  - MODIS: 2+ repeat observations
  - VIIRS: 4+ repeat observations
- Ice edge
  - MODIS: BT11 < 271K
  - VIIRS: AMSR2 to establish ice edge for VIIRS product
- Scan angle
  - MODIS: 30° limit (no coverage over the pole)
  - VIIRS: entire swath



Thermal Contrast

- Leads are identifiable by thermal contrast
  - Leads are warmer than the surrounding ice
  - Leads are long-lasting (relative to cloud motion)
- Criteria
  - 11 μm brightness temperature 1.5K warmer than the local mean
  - Local standard deviation of 11 μm brightness temperature greater than 1.5
  - 11 μm brightness temperature local standard deviation greater than difference from mean



MODIS-TERRA BT31 from 15 Feb 2018 at 0545UTC. Leads are readily apparent as bright (warm) features relative to the darker (colder) ice and clouds.

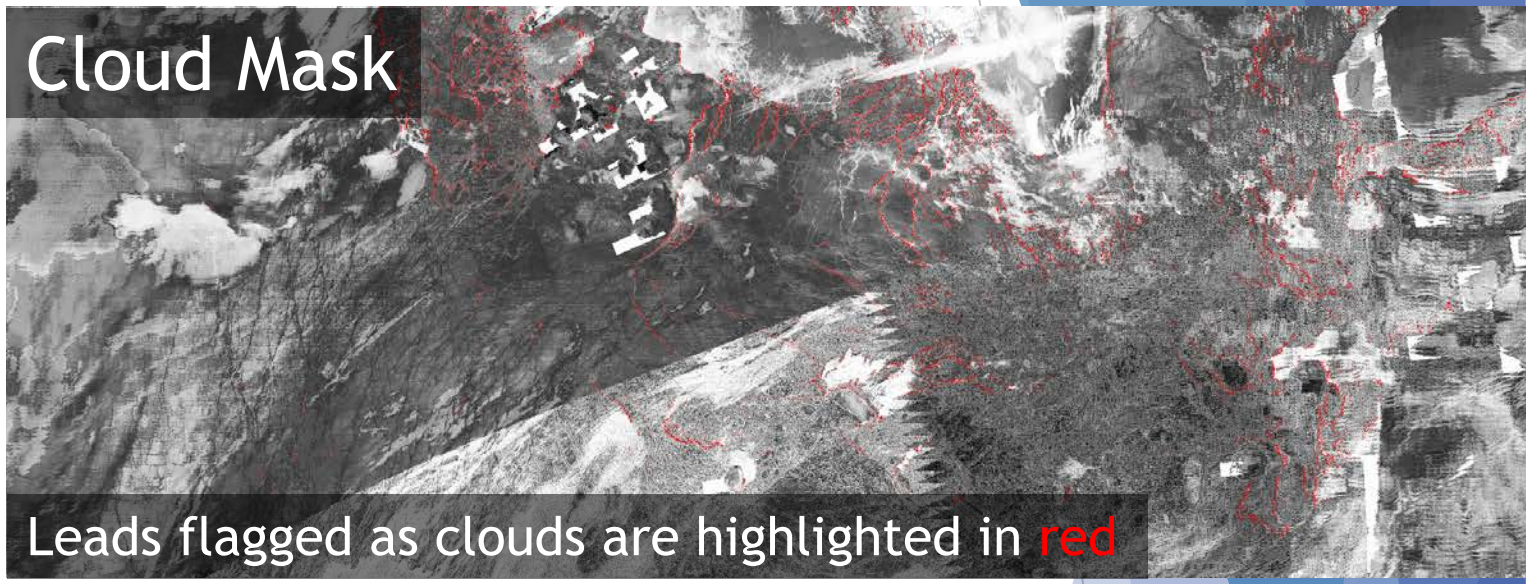
MODIS Cloud Mask

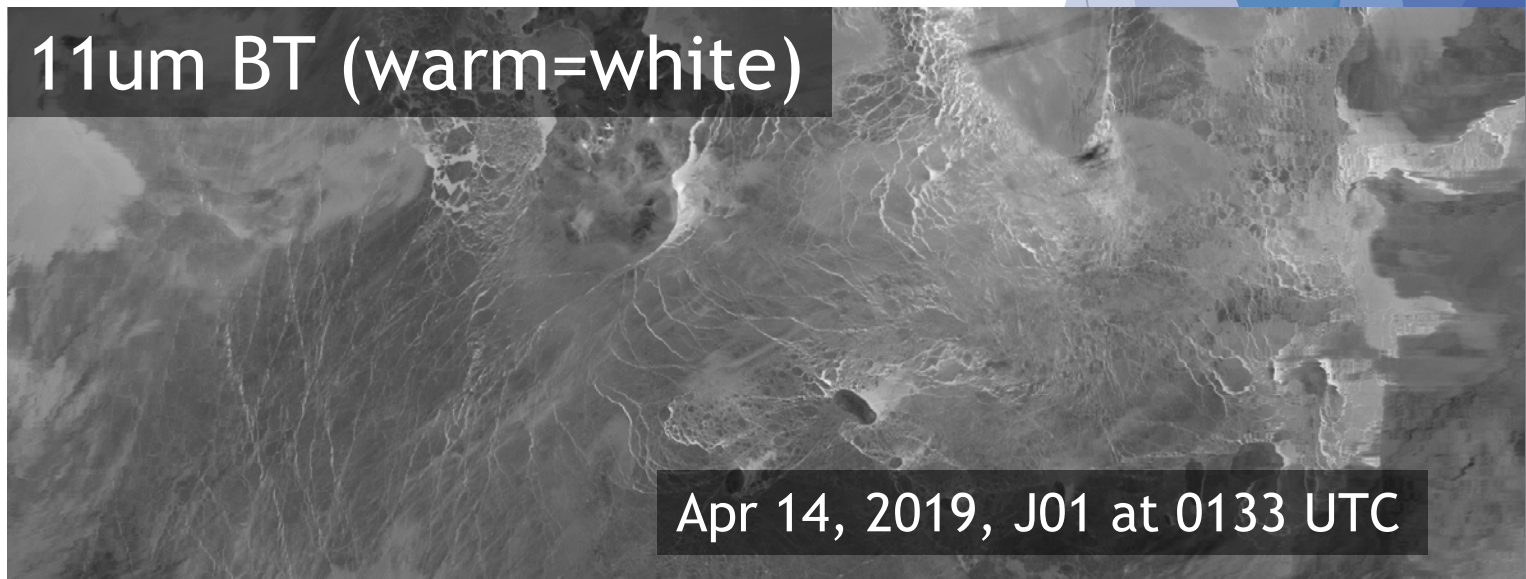
- MODIS-TERRA cloud mask image from 15 February 2016, at 0545UTC.
- The original cloud mask defines clouds as all non-black areas.
- A spatial filter is applied to remove thin features (at night) from the mask and orange in the figure reprints clouds removed.

VIIRS Cloud Mask

VIIRS cloud mask not used/needed

- Leads flagged as false clouds.
- Lead detectable through thin clouds.
- With frequent repeat coverage, leads are detectable though repeat observations; clouds are less stationary.

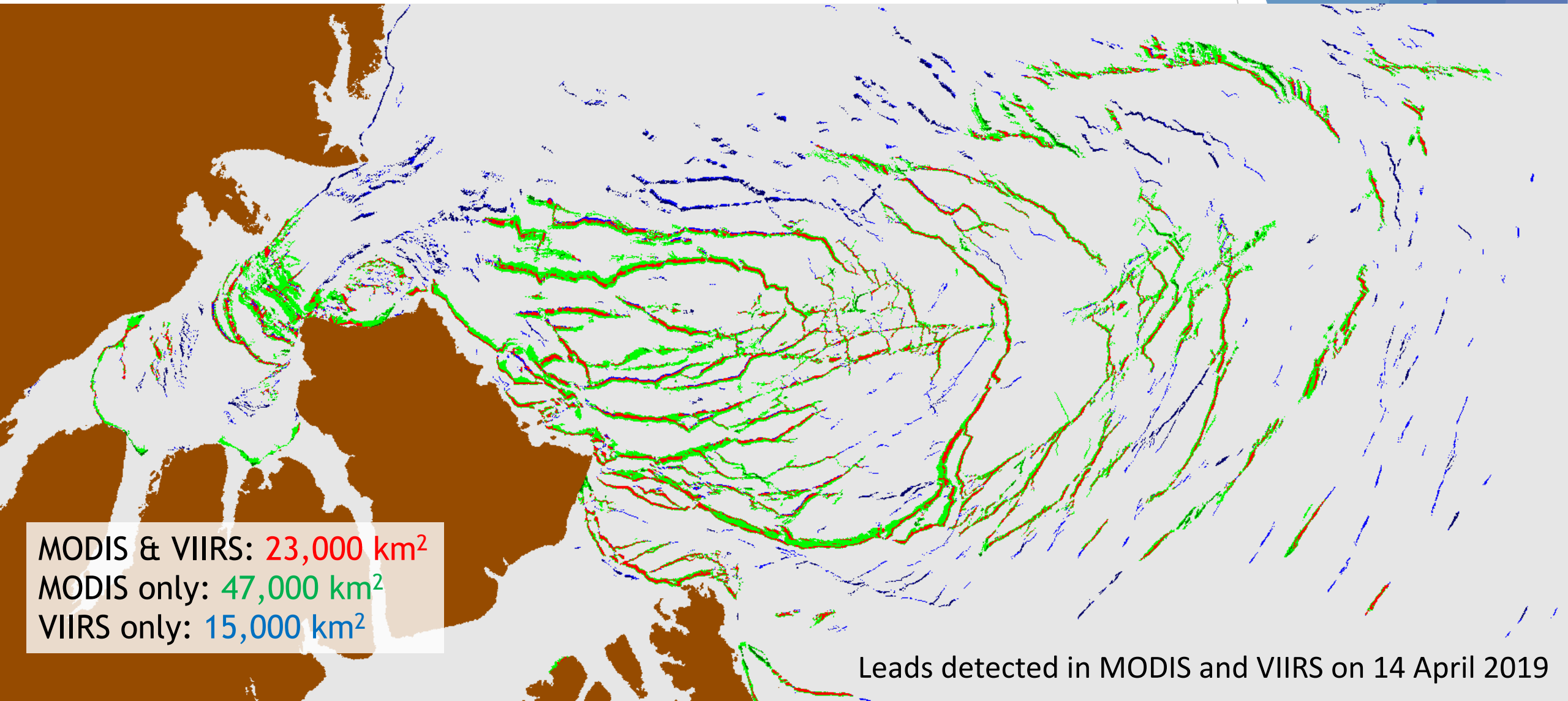




Transition to operational product

- MODIS and VIIRS products are running routinely at CIMSS
- Products are available at ftp://frostbite.ssec.wisc.edu
- Primary challenge: IDL software dependency
  - Image processing software library subroutines: Hough Transform, Sobel image filter, label region, erode, dilate, ect.

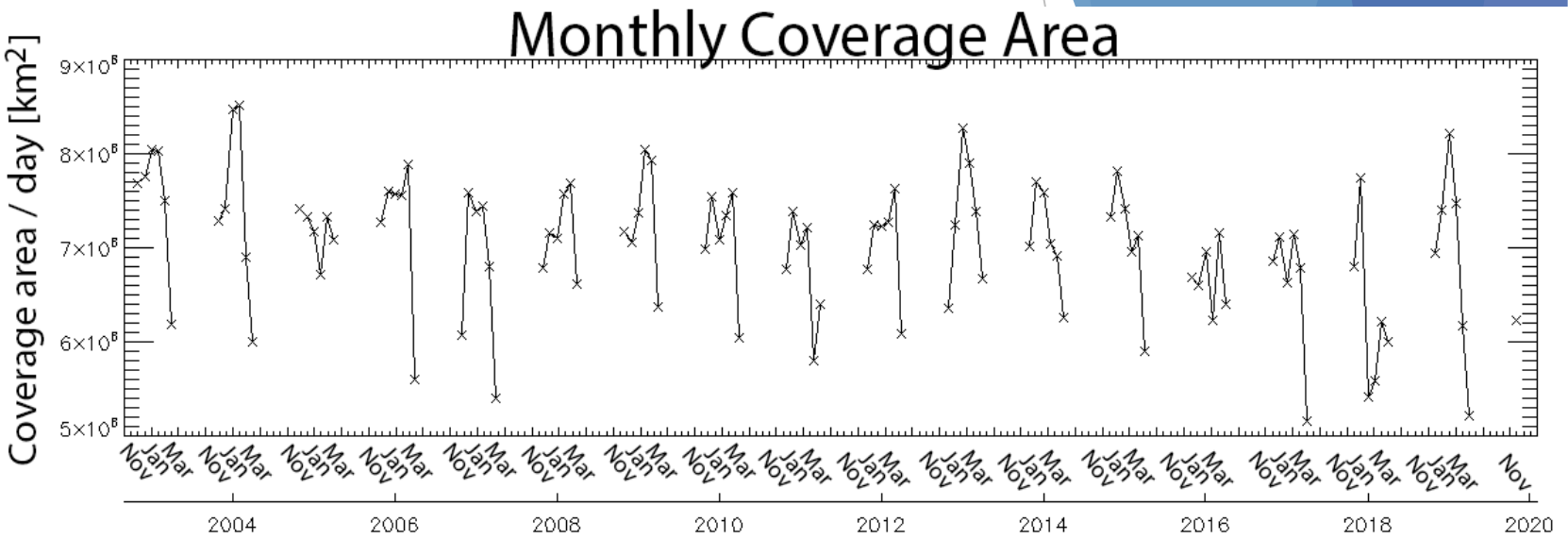
MODIS / VIIRS Leads Comparison

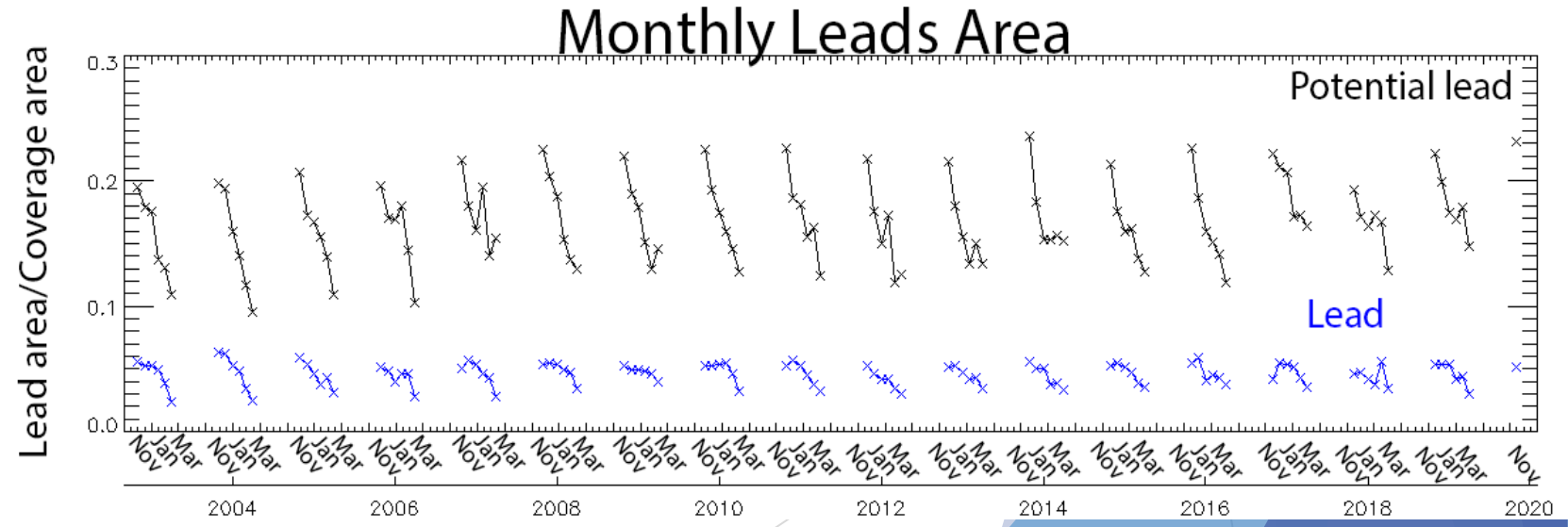


Leads detected in MODIS and VIIRS on 14 April 2019

Monthly Trends

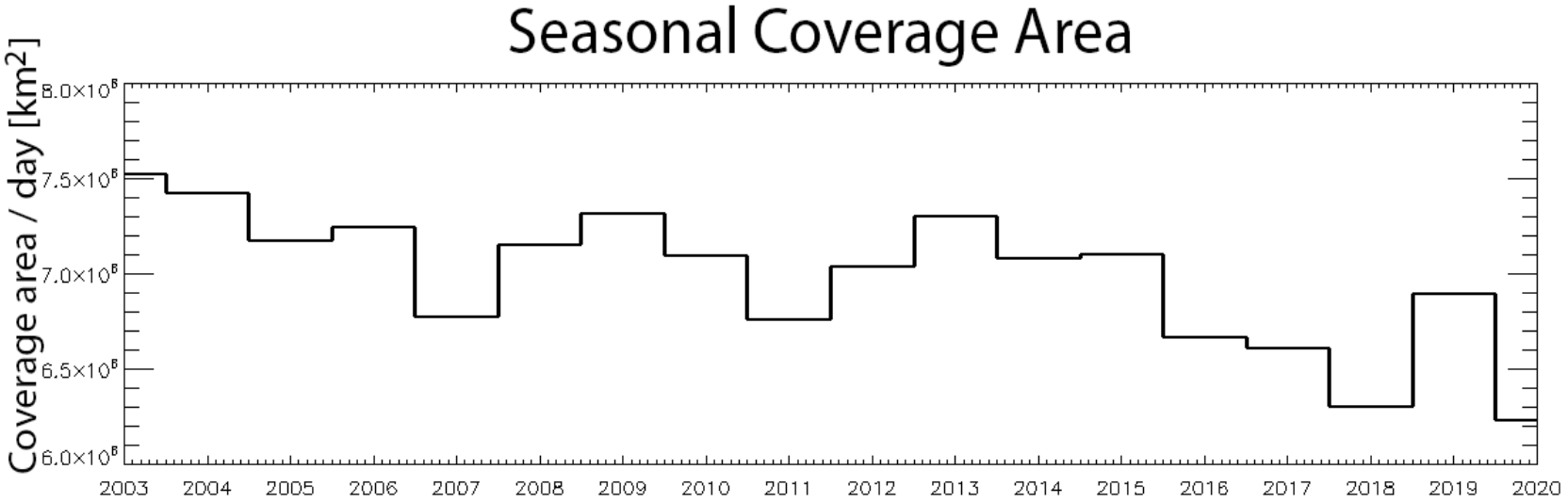
- Coverage area highest in Jan or Feb; lowest in Apr.
- Lead detection highest in Nov and Dec; decreasing through Apr.
- As ice thickens through the winter, leads become less common.

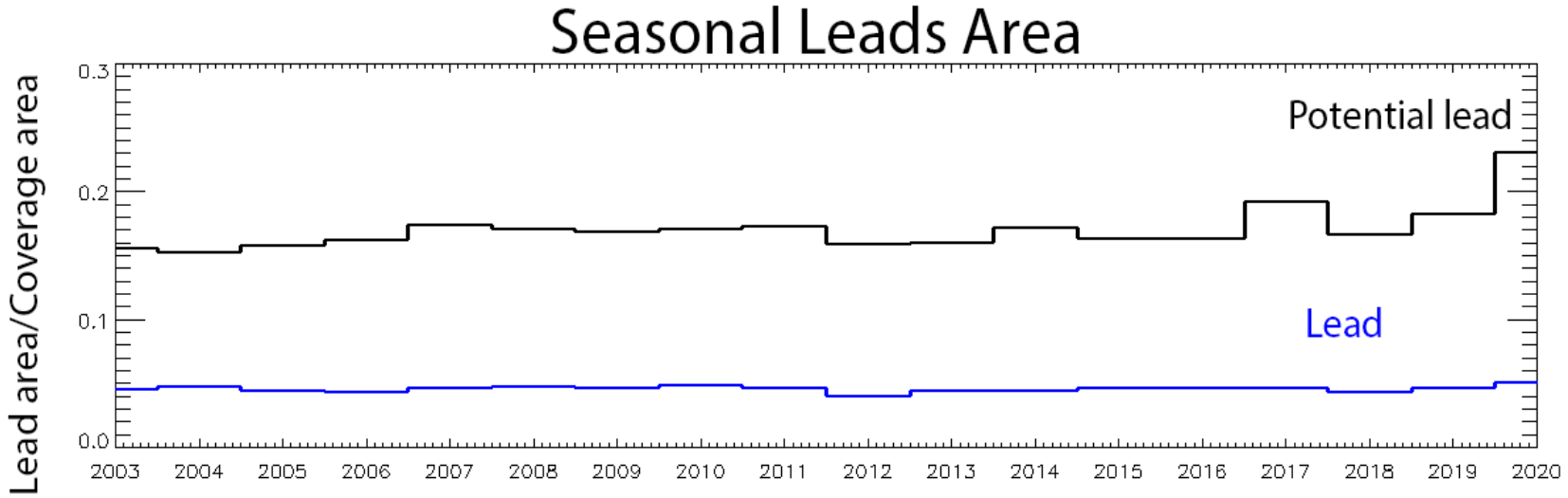




Seasonal Trends

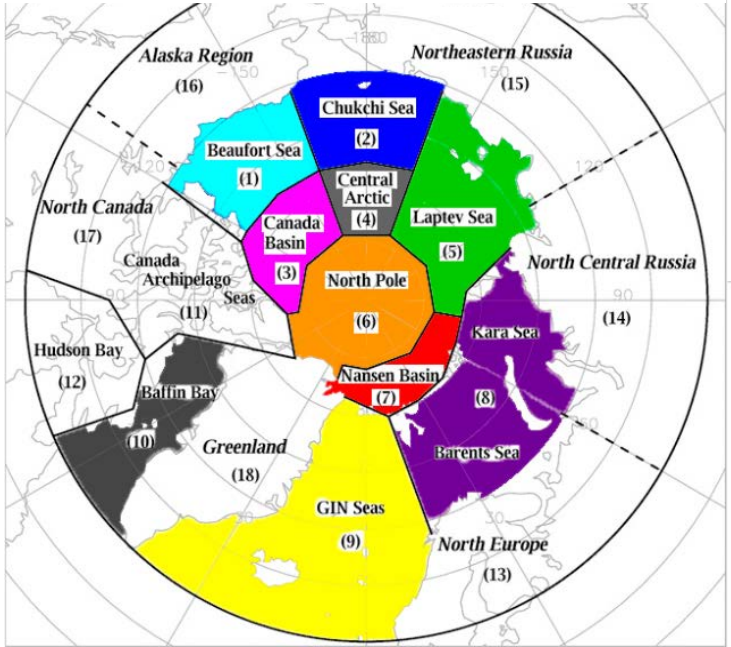
- Decreasing trend in coverage area (increasing cloud coverage).
- No statistically significant trend in leads area.
- More work to do on the relationship between clouds and lead detection.

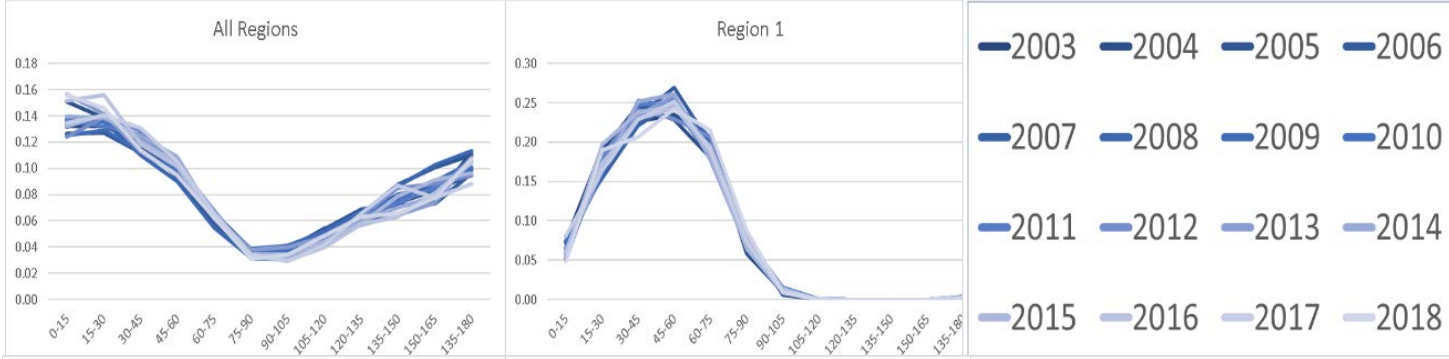


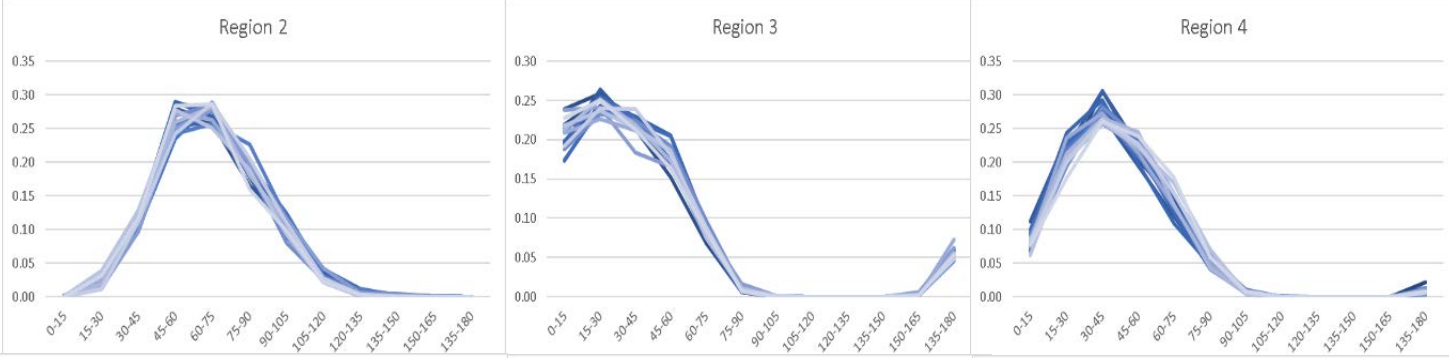


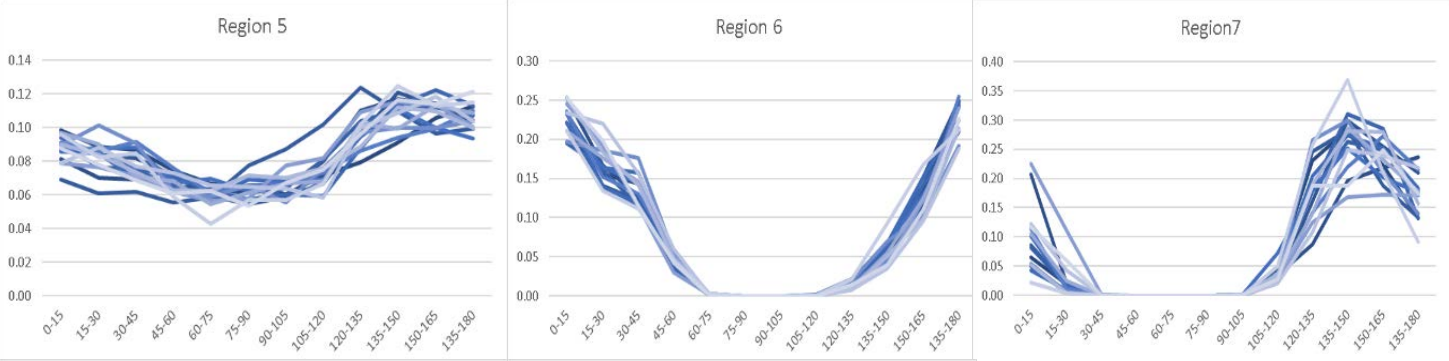
Leads Characterization

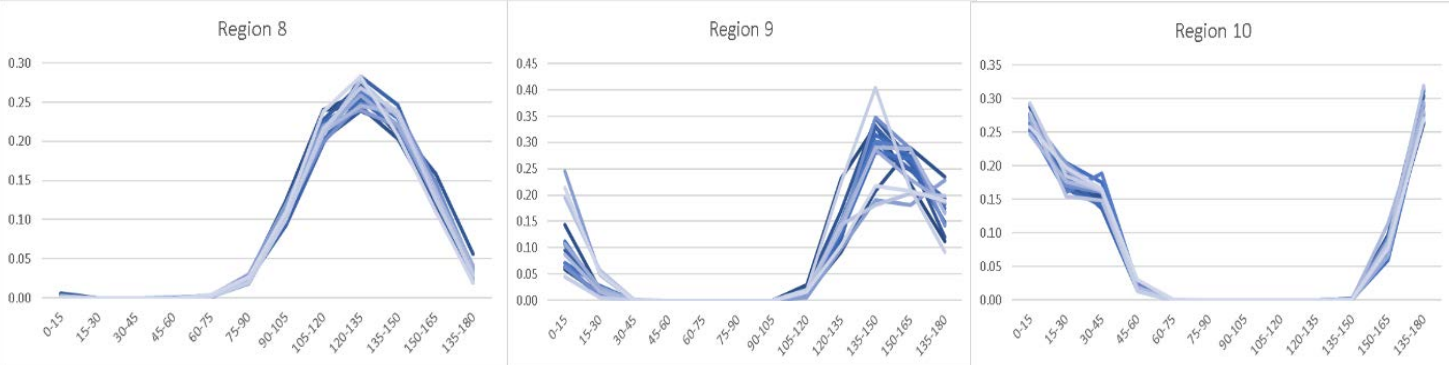
- Identify end points
  - Length (great-circle distance)
  - Orientation (shown)
- Area
  - Pixel count * pixel resolution
- Width
  - Area/length











Ongoing work

- Investigate trends
- Investigate MODIS/VIIRS similarities & differences
- Move towards operational product

Questions?

www.ssec.wisc.edu/leads

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