U.S. NAVAL RESEARCH LABORATORY

Integrated Remote Sensing and Modeling of Arctic Melt Ponds

Wes Moses

U.S. Naval Research Laboratory

Objective

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Characterize Arctic melt pond dynamics and their impact on sea ice using an integrated, active-passive remote sensing approach in conjunction with modeling

Key Questions

Q1. How well can multi-modal (optical, synthetic aperture radar, and lidar) remote sensing data be used synergistically to detect melt pond characteristics?

Q2. What is the impact of melt ponds on thermal conductivity and salinity gradients in sea ice?

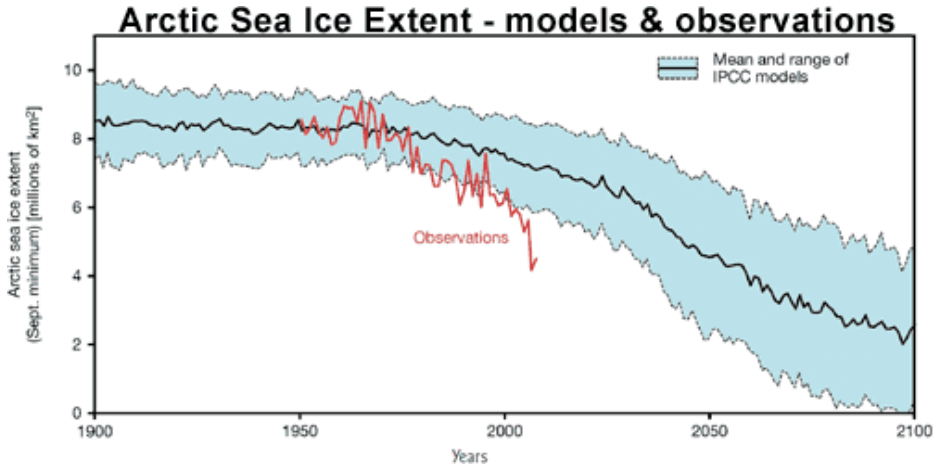
Q3. What is the impact of melt pond processes and dynamics on sea ice thickness, extent, and distribution?

Payoff

Information for an integrated remote sensing capability to potentially retrieve observational melt pond data and improve sea ice modeling

Problem Background

- Melt pond formation and dynamics affect and are affected by sea ice properties (e.g., thickness, spatial extent, etc.)
- Current sea ice models parameterize melt pond information based on
  - sea ice thickness distribution
  - assumed aspect ratio of pond height/width
- Observational melt pond information not incorporated in current sea ice models
- Inadequate treatment of melt ponds leads to inaccuracies in model predictions of sea ice
- Ability to assimilate into the model observational information on melt pond formation, evolution, and refreezing crucial for model accuracy and reliability

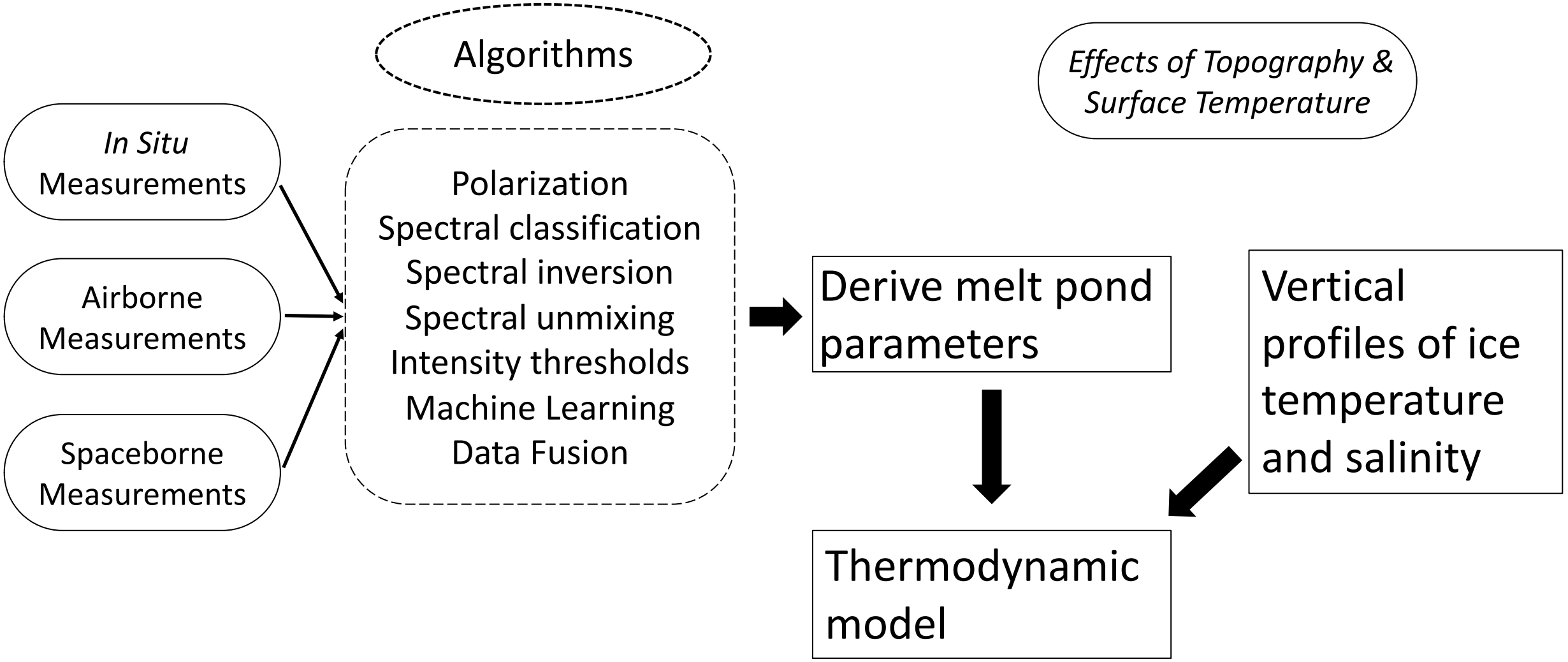


Problem Background

- Need information on
  - onset, evolution, and re-freeze
  - morphometric properties – surface area, perimeter, volume, and pond depth
  - surface roughness, freeboard, and thickness of adjoining sea ice
- Current technology – good enough to detect water on ice, but differentiating melt ponds from polynyas, leads, open-water, etc. remains a challenge
- Melt pond dynamics take place at spatial and temporal scales that are too fine to be captured by a single on-orbit sensor

- Two main questions:
  - Can we get accurate and reliable melt pond data through an integrated, multi-modal remote sensing approach?
  - How well can we assimilate observational melt pond data to improve modeling of sea ice coverage and thickness?

Technical Approach



Measurements

In Situ

- Melt pond depth
- Sea ice thickness
- Spectral reflectance
- Ice temperature and salinity profile
- Ice density
- Snow pack depth
- Snow density and temperature profile

Airborne

- Optical hyperspectral reflectance
  - HyperNano
- Topographic lidar
  - Riegl 903 nm

Spaceborne

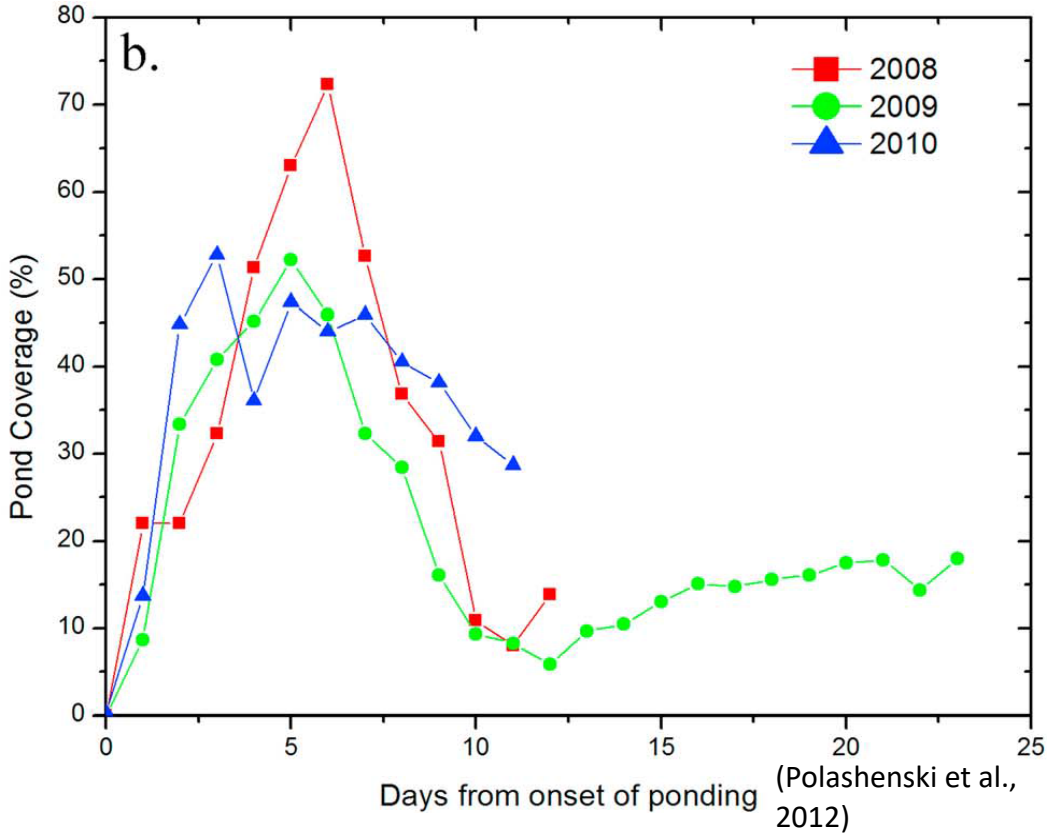
- Synthetic aperture radar backscatter
  - ICEYE
  - CAPELLA
  - TerraSAR
- Optical hyperspectral reflectance
  - WorldView-2/3
  - Planet
  - Sentinel-2
  - Landsat-8/9, PRISMA, EnMAP
- Lidar backscatter
  - ICESat-2

Credit: NASA/Kathryn Hansen

(from psc.apl.washington.edu)

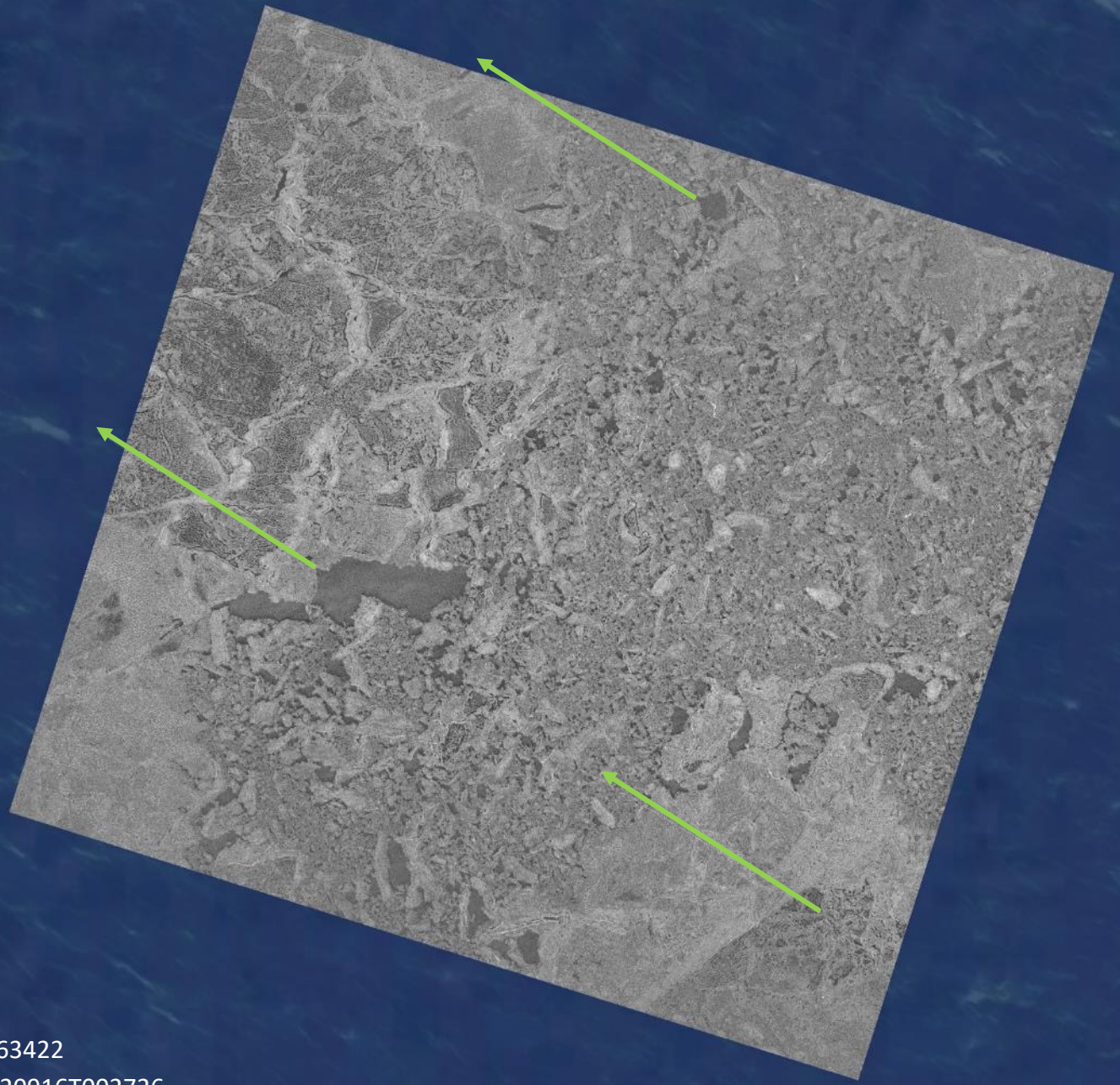
In Situ Campaign

- Landfast Ice (Barrow, AK):
  - Two three-week deployments in spring/summer (2025 & 2026)
  - Relative ease of access
  - Greater control over measurement campaign
- Sea Ice:
  - Vessels of opportunity



(Polashenski et al., 2012)

ICEYE SAR Image
Sept 16, 2022
Image ID 63422



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ICEYE SAR Image
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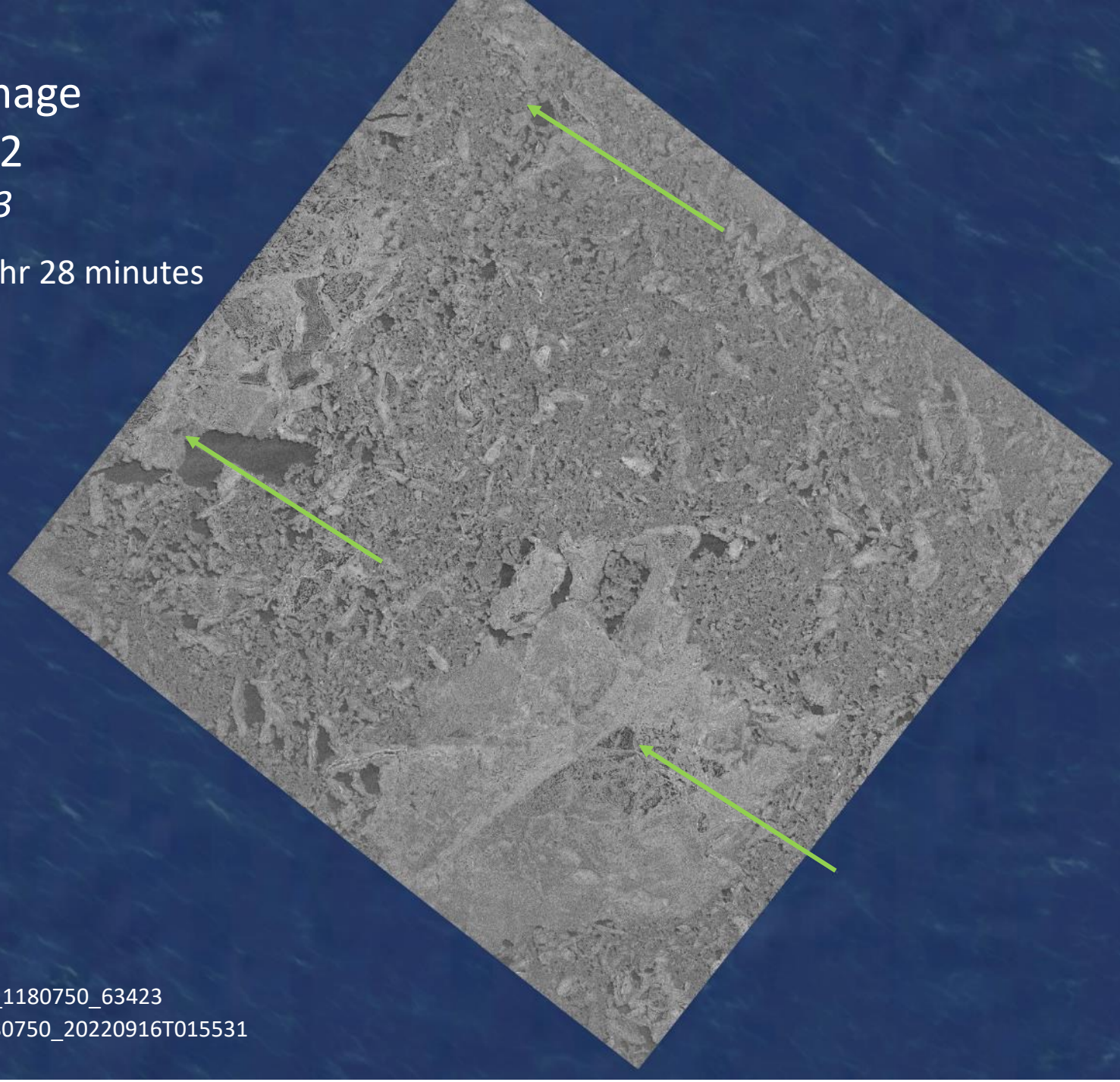
1.6 km shift in 1 hr 28 minutes
≅ 0.3 m/s



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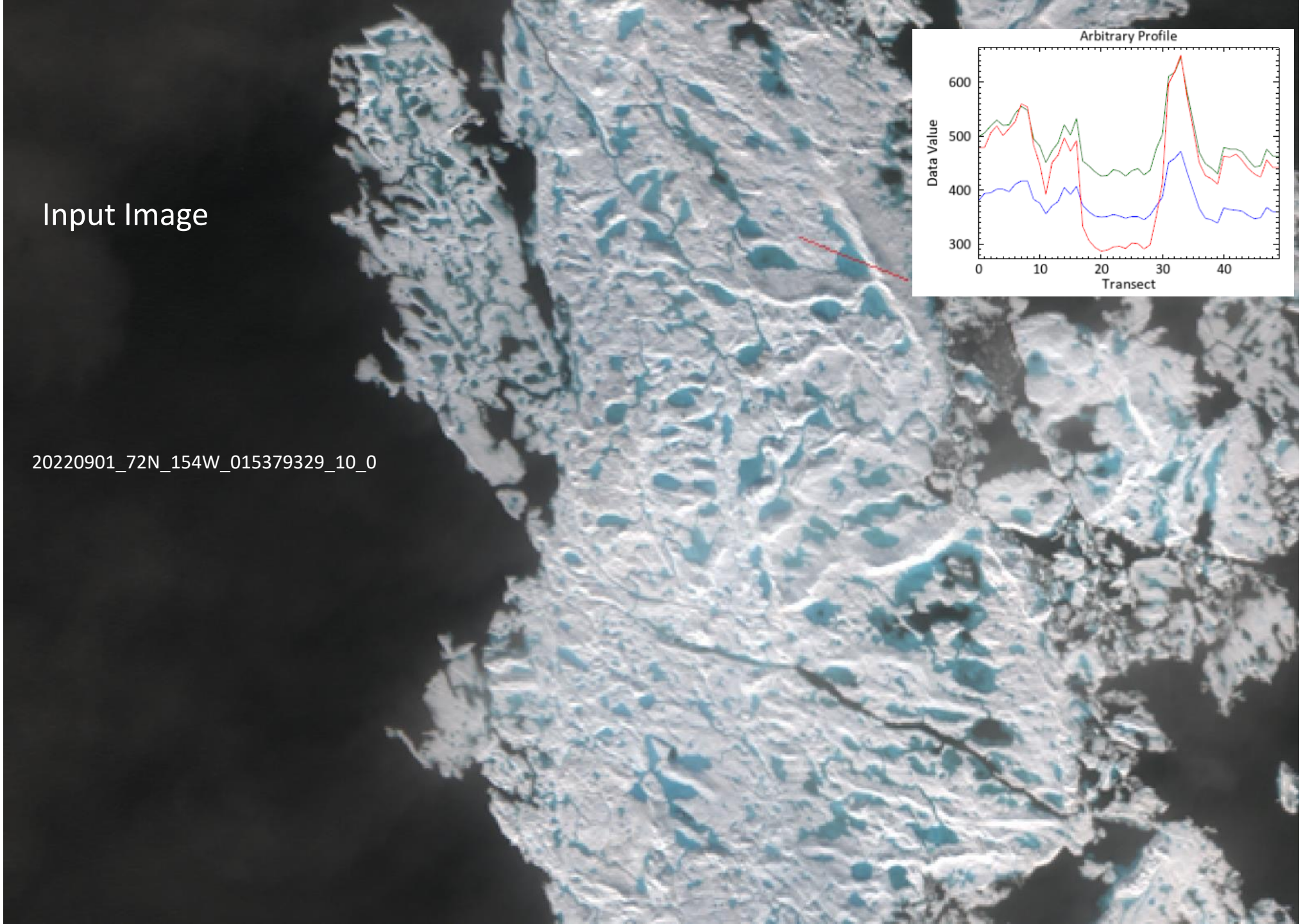

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Thank You!