# Overview

- The Canadian Arctic
- Present and Future Capabilities
  - Ship position information
  - Synthetic Aperture Radar: RADARSAT-2 and Polar Epsilon
  - RADARSAT Constellation Mission
  - Challenges
- Situational Awareness
  - Historical data
  - Decision support
  - Trends
- Summary

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# The Canadian Arctic

- Increasing accessibility
- Canadian investment in new capabilities:
  - On land – facilities, ports
  - In sea – Arctic/Offshore Patrol Ship (AOPS)
  - In space – RADARSAT Constellation Mission (RCM)


- Arctic includes many departments: Environment Canada – Canadian Ice Services, Canadian Coast Guard, Fisheries and Oceans, National Defence
- Focus in this work is on maritime situational awareness primarily from a National Defence aspect (NGMC2S)

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# Present and Future Capabilities (1)

- Sources for ship information includes…
- Regulatory reporting (and voluntary)
  - Northern Canada Vessel Traffic Services Zone (NORDREG)
- Transponders
  - Commercial Space-based AIS (S-AIS) Class A/ Class B
    - Satellite reception of Class-B AIS of high interest
  - Long Range Identification and Tracking (LRIT)
  - Commercial GPS-based systems
- Open source
  - E.g. Social Media and websites

# Present and Future Capabilities (2)

- Active sensing
  - Possibility to detect a larger set of vessels, including non-cooperative vessels
  - Today: Space-Based Synthetic Aperture Radar (SAR): Radarsat-2 and Polar Epsilon
  - Ship-Iceberg discrimination is a challenge
  - Sparse data (very few ships, very many icebergs) – signal/noise

- RADARSAT Constellation Mission (RCM) and Polar Epsilon 2
  - 3 smaller satellites in formation
  - Include AIS receivers

# Challenges for Space Based SAR

- Ship-Iceberg Discrimination, can be improved through:
  - Improved image processing
  - Association with AIS/LRIT
  - Radar polarization
    - HH/HV/Quad
    - 92%-96%-98% discrimination performance using HH/HV/Quad can be achieved[1]
- Targeting
  - Land interference
  - Imagery ordering (Cued acquisition/tracking) requires predictive capabilities

1 Howell, C, Power, D, Lynch, M, Dodge, K, Bobby, P, Randell, C, Vachon, P, Staples, G (2008) Dual polarization detection of ships and icebergs – recent results with ENVISAT ASAR and data simulations of RADARSAT-2. Proc. of IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pp.206-209

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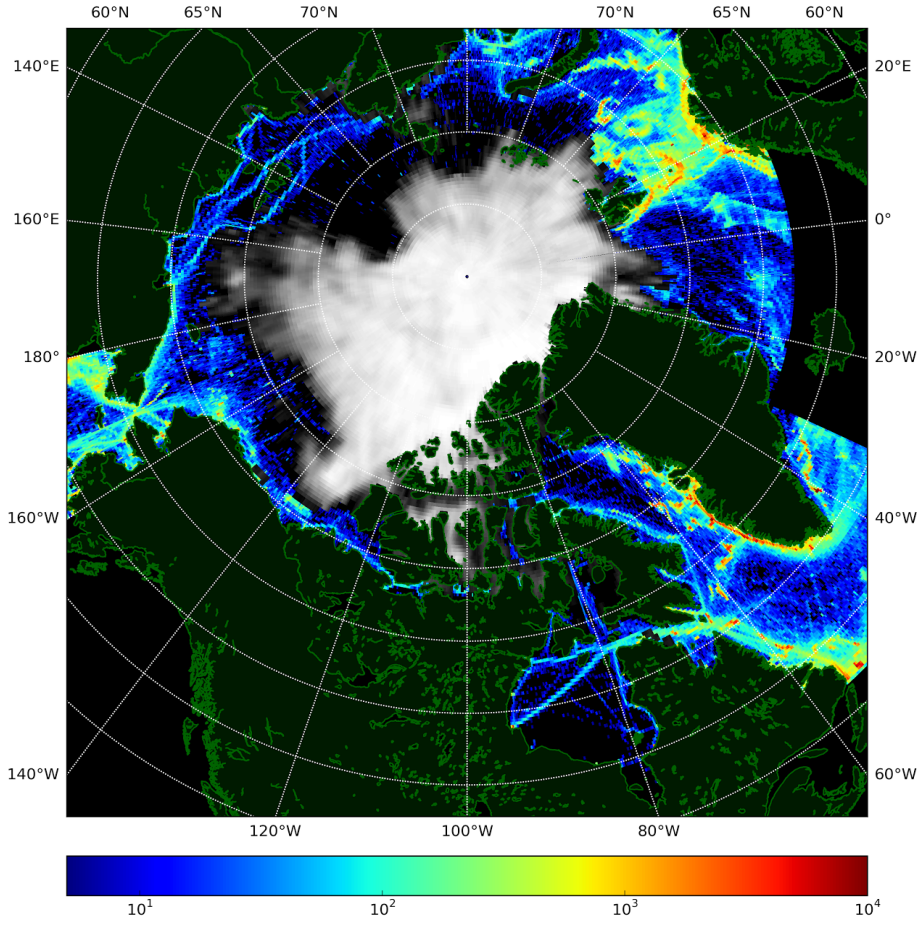
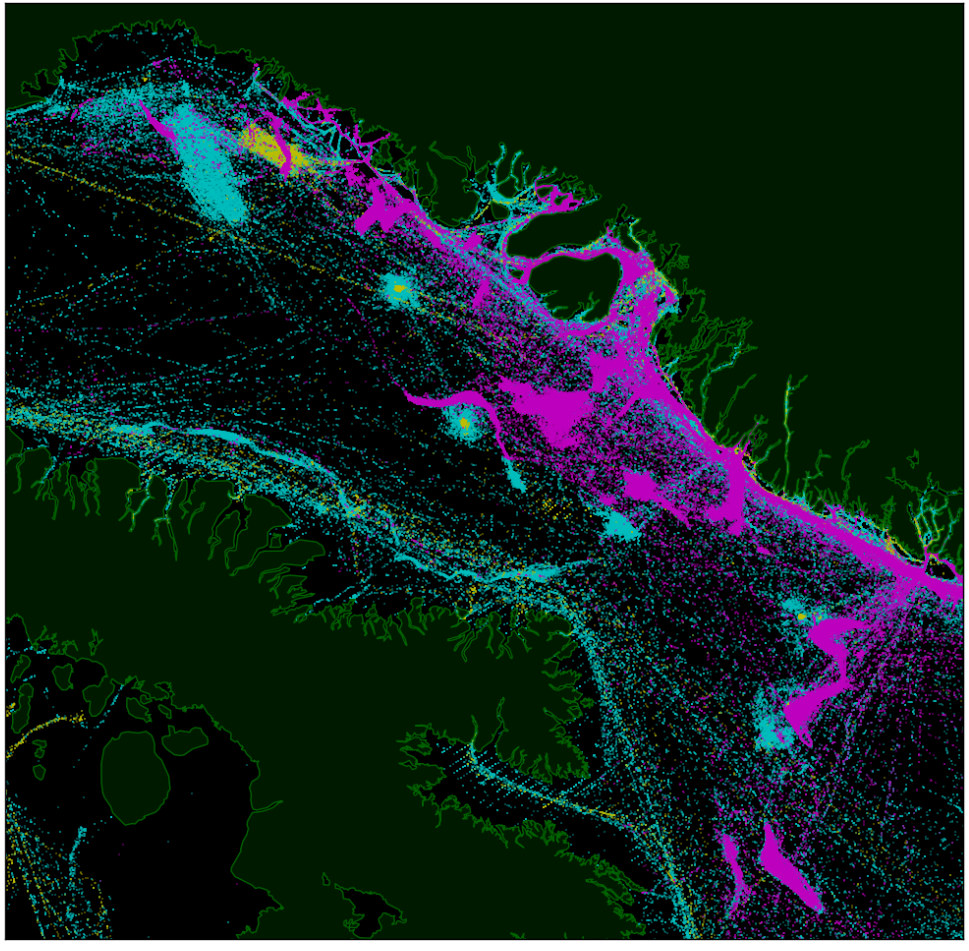
# Situational Awareness (A Macroscopic View)

- Data from Royal Canadian Navy's Unclassified Global Position Warehouse (GPW)
  - May 1, 2011 – July 1, 2015
- Significant amount of activity
- Some patterns/routes emerge in data
- Density of reports
  - Convolved traffic + sensor access



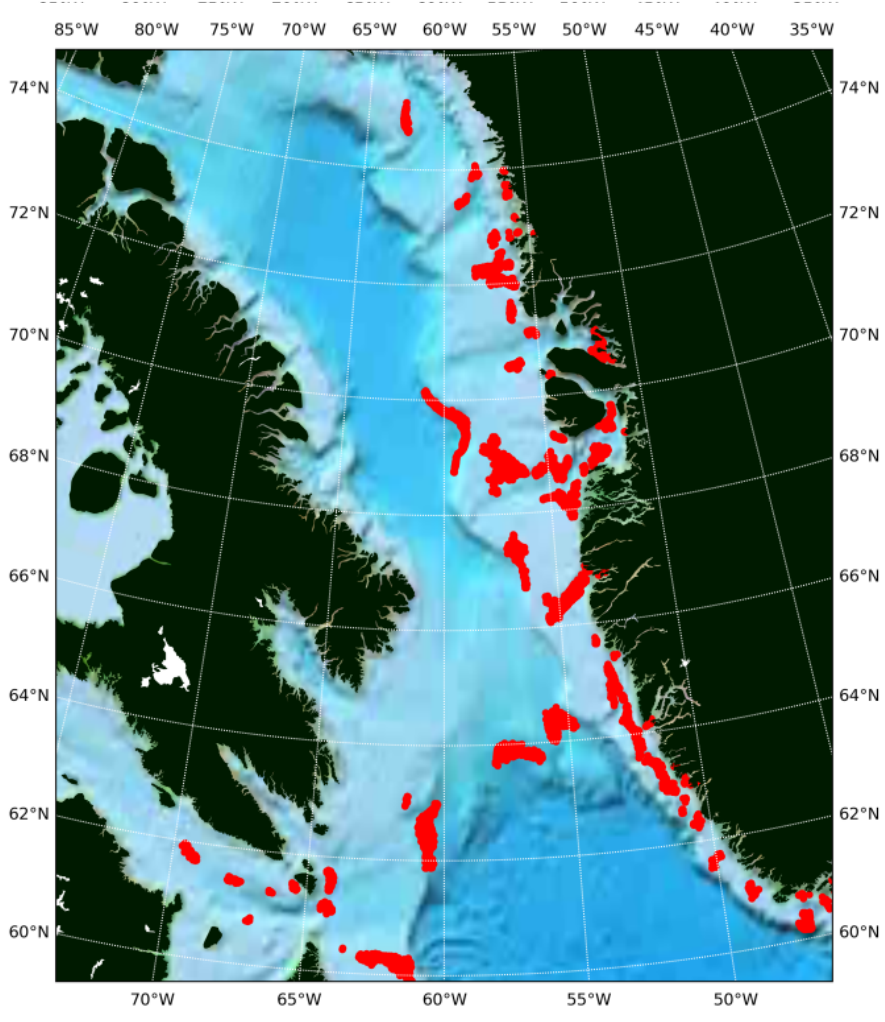
# Patterns of Life

- Baffin Bay
  - Cyan – Merchant
  - Yellow – Government
  - Magenta – Fishing
- Interesting features apparent

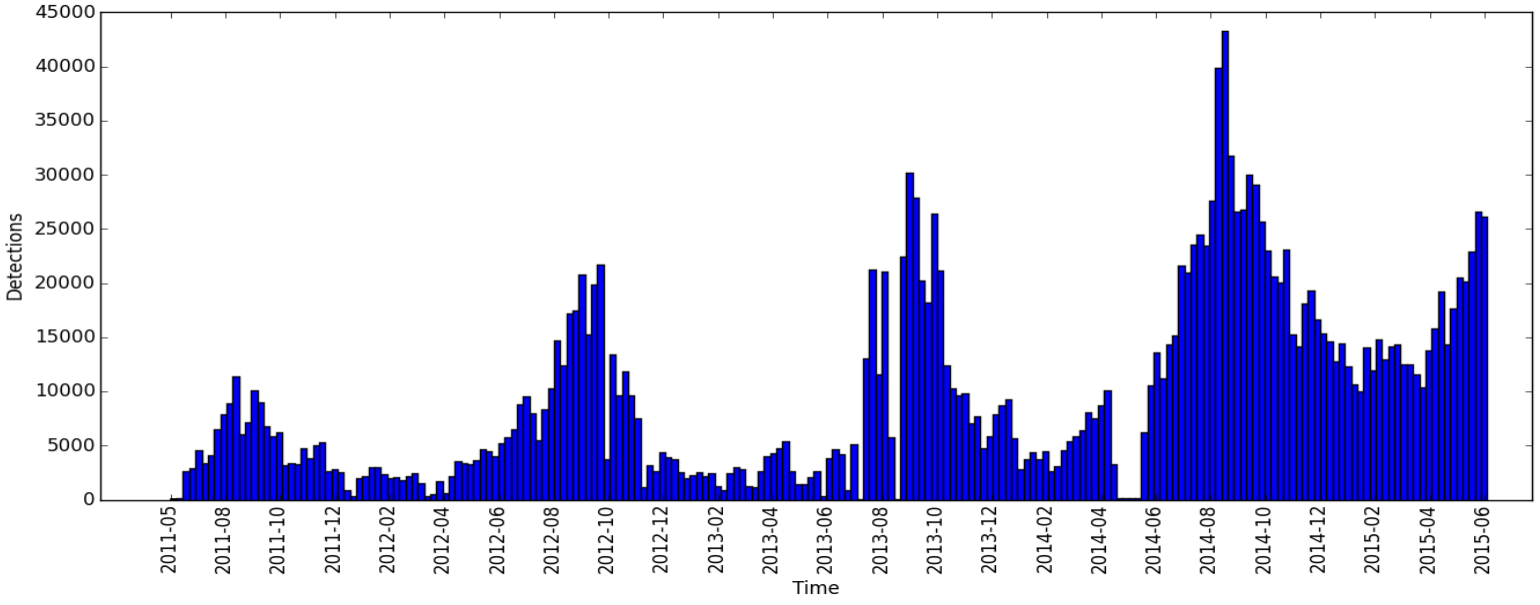


# Patterns of Life (2)

- Example investigation of traffic reported as fishing ships
  - Features in distribution of fishing ship position reports
- Cluster on fishing-like behaviour
  - i.e. Slow and loitering
- Overlaid on bathymetry
- Possibility to use this knowledge as context for prediction and decision support



# Trend in Data




- Combination of increased traffic and increased sensing
- Seasonality

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- Canada is investing in arctic development
- Capability to detect and track vessels in the arctic is a challenge, but the amount of information is increasing.
- Space Based SAR has potential to enhance maritime security, but there are some challenges to overcome.
- Increasing amount of data to be used for operational decision support. The specifics of arctic maritime operations are to be included in development of the next generation maritime Command and Control Systems.

# Thank you

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