U.S. National/Naval Ice Center (NIC)
Ice Information Needs

National Academies TRB/MB Workshop:
Safe Navigation in the Arctic
Seattle, WA
15 October 2012

Dr. Pablo Clemente-Colón
Chief Scientist, National Ice Center

UNCLASS

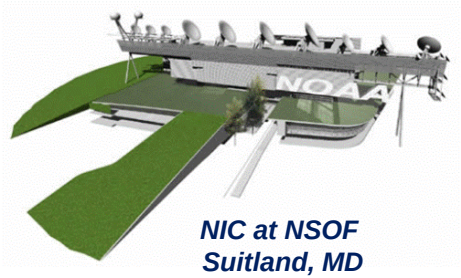
USCG

USN

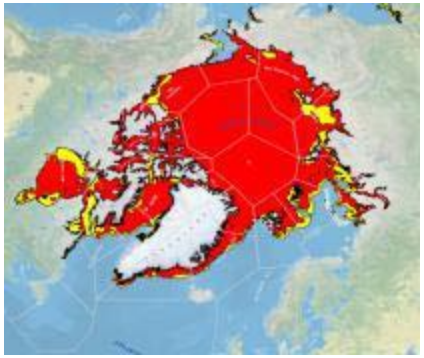
NOAA

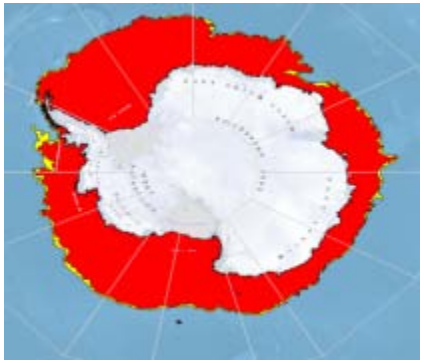
NIC Mission

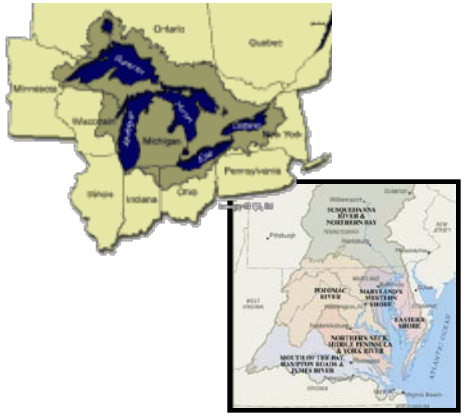
- A multi-agency operational center operated by the United States Navy, National Oceanic and Atmospheric Administration, and United States Coast Guard.
- Located in Suitland, Maryland and employs military and civilian personnel.
- GLOBAL sea and lake ice analysis and forecasting.
- Over 140 International Customers, including SUBFOR, ONI, NOAA, NWS, NSF, USCG, MSC, and NASA.



NIC at NSOF
Suitland, MD







<u>Mission</u>: Provide the highest quality, timely, accurate, and relevant snow and ice products and services to meet the strategic, operational, and tactical requirements of U.S. national interests across a global *area of responsibility*.

The National Ice Center (NIC)

Command Structure

- United States Fleet Forces Command
- Commander Naval Meteorology & Oceanography Command (CNMOC)
- Naval Oceanographic Office Stennis Space Center, MS (NAVOCEANO)
- **NAVICECEN Naval Ice Center**

- NOAA
- National Environmental Satellite, Data & Information Service (NESDIS)
- Office of Satellite Data Processing & Distribution (OSDPD)/ Center for Satellite Applications & Research (STAR)
- **National Ice Center**

- COMMANDANT United States Coast Guard
- Operations Directorate (CG-3)
- Waterways Management Directorate (CG-3PW)
- Office of Maritime Transportation System (CG-3PWM)
- Mobility & Ice Operations Division (CG-3PWM-3)
- **National Ice Center**

International Partnerships

- ***North American Ice Service (NAIS)***
  - ***Multi-agency partnership formed in 2003 between U. S. National Ice Center, Canadian Ice Service and International Ice Patrol.***
  - ***Mission: Transform individual organizational strengths into a unified source of ice information and meet all marine ice information needs and obligations of the United States and Canadian governments.***

- ***International Arctic Buoy Programme (IABP) and International Programme for Antarctic Buoys (IPAB)***
  - ***Working together with global participants since 1991 to maintain the international drifting buoy networks and co-manage with UW/PSC the U.S. components in the Arctic and Antarctic regions in support of real-time operational and research requirements including those of the World Climate Research Programme and the World Weather Watch Programme.***

- ***International Ice Charting Working Group***
  - ***Formed in 1999 to promote cooperation between the world's ice centers on all matters concerning sea ice and icebergs.***

International Partnerships

International Ice Charting Working Group http://nsidc.org/noaa/iicwg/

NEWS RELEASE

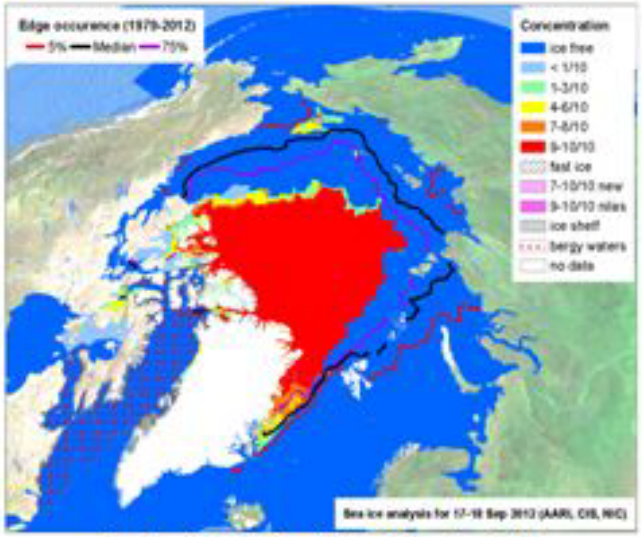
DRAFT 3

Ice Information Services of the World Prepared to Meet Demands of Increased Arctic Shipping and Resource Development

Tromsø, Norway, October 2012 –Hosted by the Norwegian Meteorological Institute this month, experts from the International Ice Charting Working Group (IICWG) held their 13th meeting in Tromsø, Norway. The IICWG issued the following statement:

"Arctic sea ice extent reached a record minimum in September of this year, surpassing the previous record set in 2007 by an outstanding 18%. Much of the remaining Arctic pack is highly deteriorated and thinner than in the past. It seems probable that the Arctic Ocean is destined to become free of sea ice during the summer months at some time in the not-too-distant future.

The retreat of the sea ice during the last two decades is facilitating a striking increase in oil and gas and mineral development accompanied by increased shipping activity. The members of the IICWG that provide information on sea ice and iceberg conditions for the safety of maritime operations are committed to the continued improvement of their services to meet the needs of expanding Arctic development."



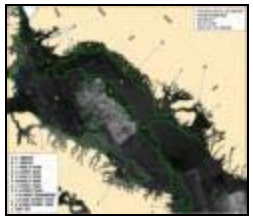
Sea Ice Analysis for 17-18 September 2012

Prepared by the Arctic and Antarctic Research Institute based on U.S., Canadian and Russian Ice Charts

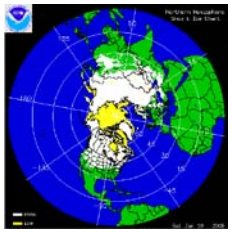
Operations and Product Generation

Human, Derived, Automated, and Reconfigured

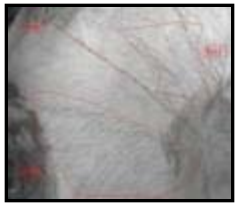
Products (Routine/Special Support)



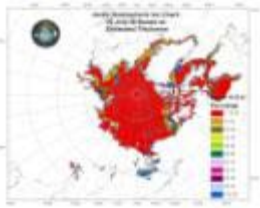
Annotated Images



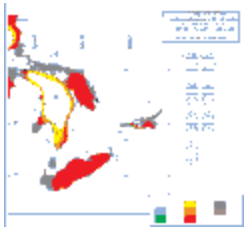
IMS snow and ice maps



Fractures, Leads and Polynyas (FLAP)



Ice Thickness Estimations



Ice Forecasts & Outlooks

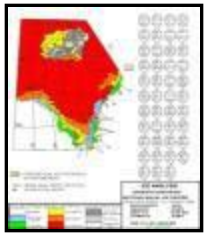
Expert Ice Analyses, Forecasting, and Quality Control

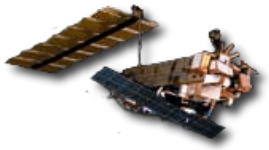
Ingest 100GB Daily

Data Fusion

Derived Data Automation

Direct Data Dissemination

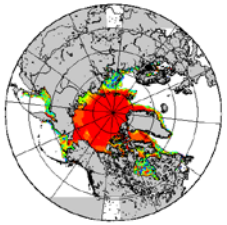




Satellites

Airborne

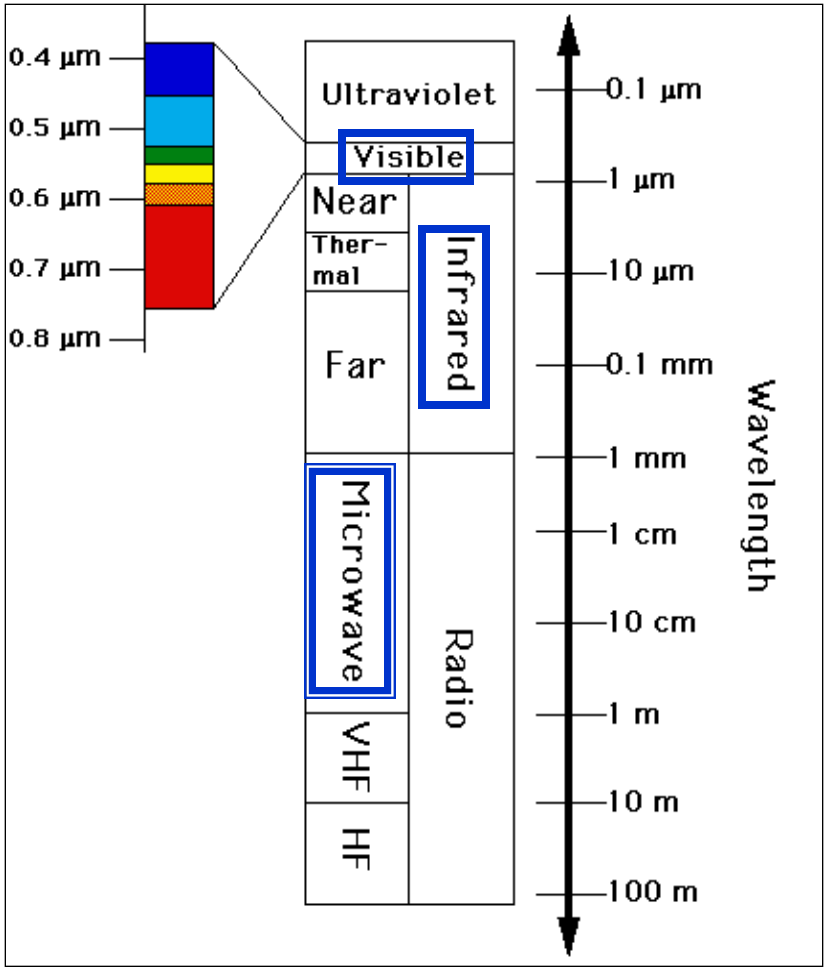
Surface



Models

Buoys

Electromagnetic Spectrum



Short Wave
High Frequency
High Energy

Visible: 0.3 – 0.7 µm

Infrared: 0.7 – 20 µm

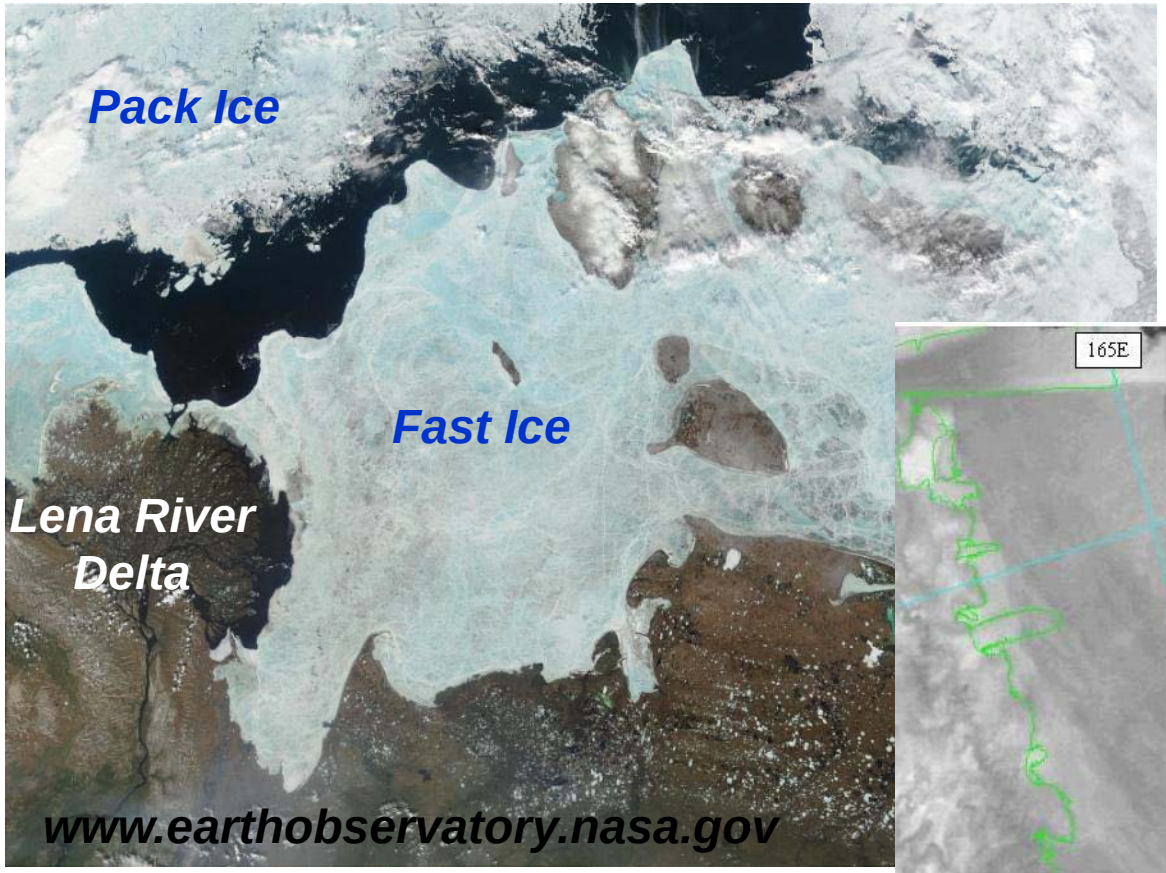
Microwave: ~1 - 10 cm

Long Wave
Low Frequency
Low Energy

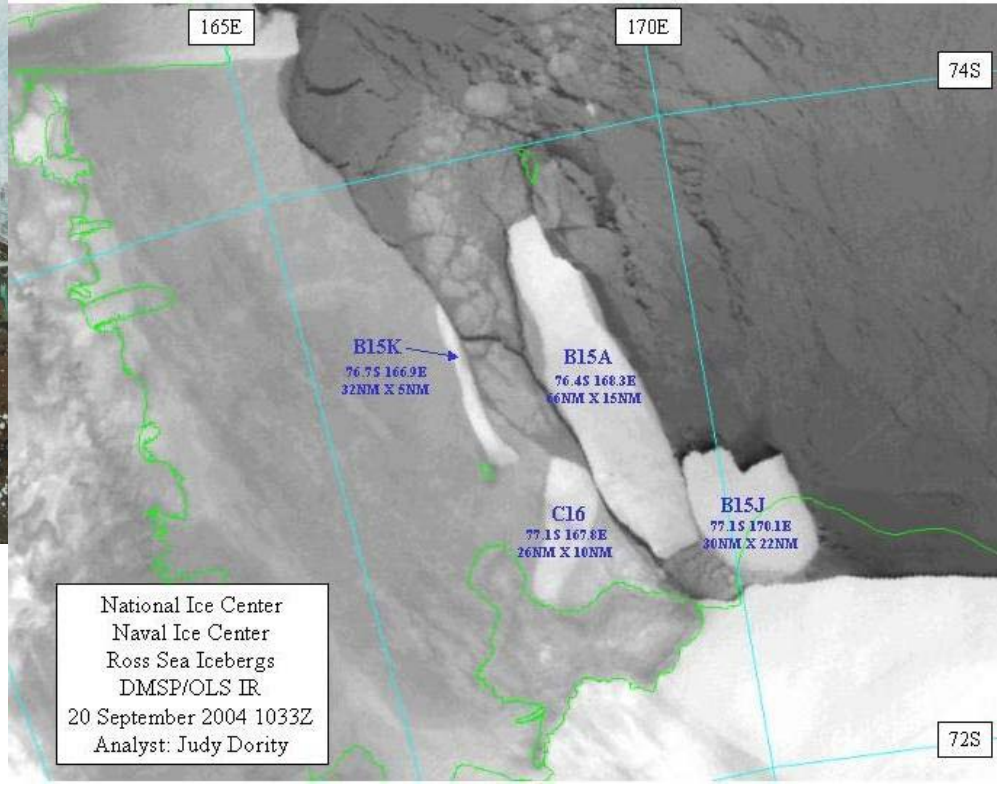
Satellites/Sensors Presently Available for Sea Ice and other Polar Observations

- **Defense Meteorological Satellite Program**
  - Visible and Infrared (VIS/IR) - Operational Line Scanner (DMSP OLS)
  - Passive Microwave (PM) – Special Sensor Microwave Imager (SSM/I)
- **NOAA Polar Orbiting Environmental Satellites (POES)**
  - Visible and infrared – Advanced Very High Resolution Radiometer (AVHRR)
  - (NPP VIIRS VIS/IR soon to be operationally available)
  - (AMSR-2 PM aboard GCOM-W1 soon to be operationally available)
- **NASA Terra and Aqua**
  - Visible and Infrared - Moderate Resolution Imaging Spectrometer (MODIS)
  - Passive Microwave - Advanced Special Microwave Radiometer (AMSR-E)
- **OSCAT and ASCAT (QuikSCAT suffered major failure on 11/2009)**
  - Active Microwave – Scatterometers
- **RADARSAT (Envisat recently lost), TerraSAR-X, COSMO/SkyMed**
  - Synthetic Aperture Radar (SAR)
- **Altimeters (Limited use)**
  - ICESAT Laser Altimeter
  - CryoSat-2 Radar Altimeter

Visible and IR Sea ice Detection

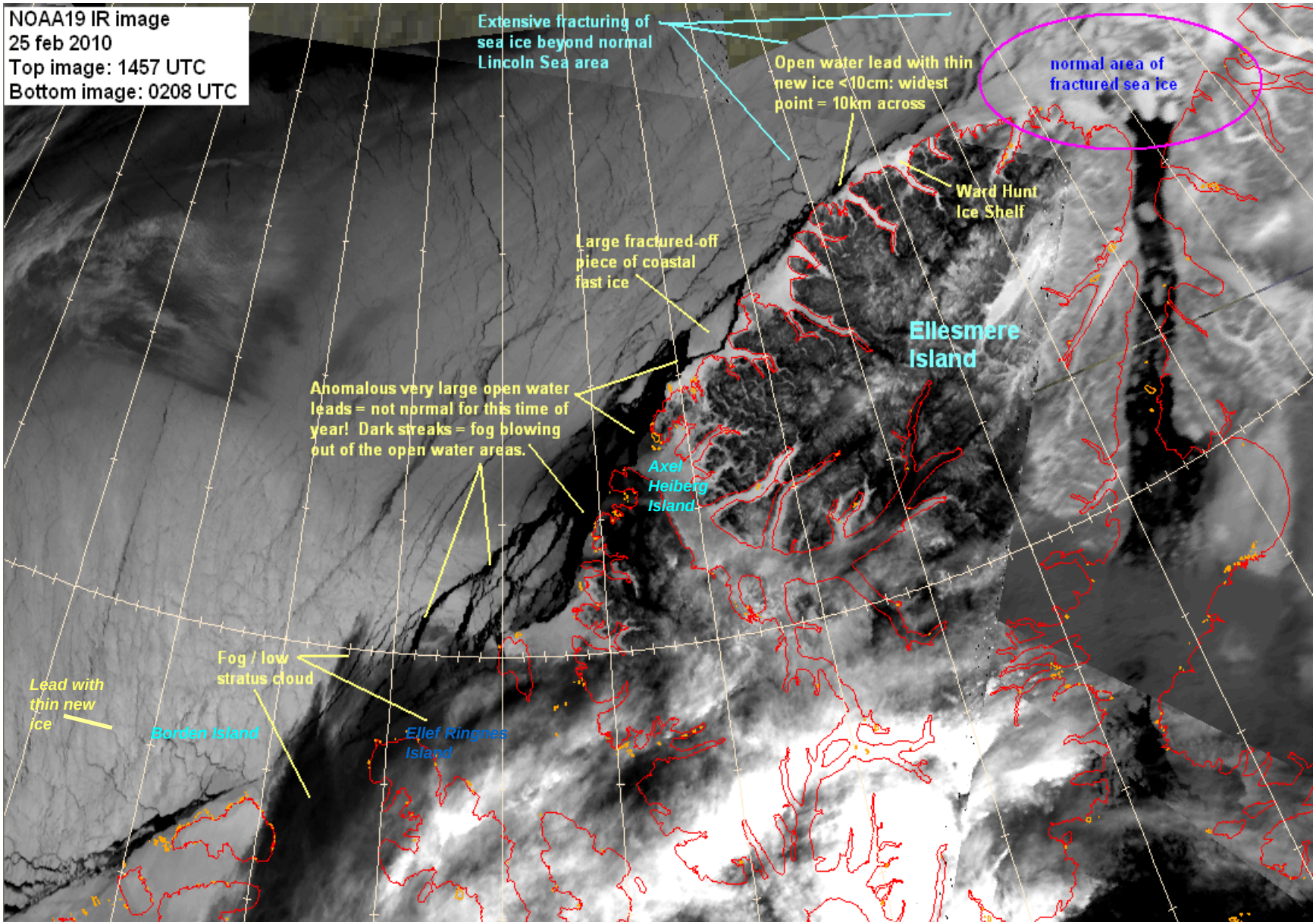


MODIS true color image

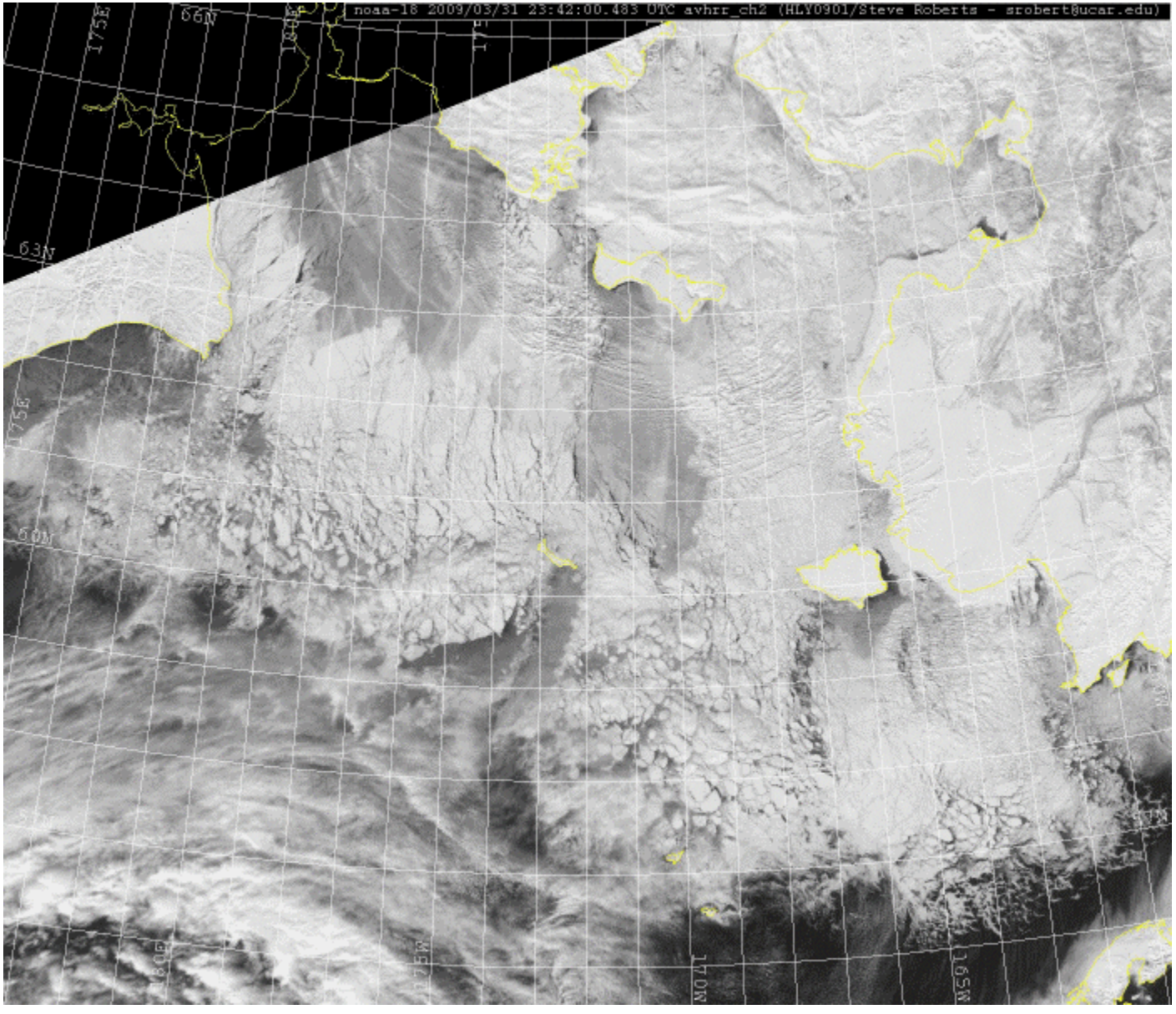


AVHRR infrared image

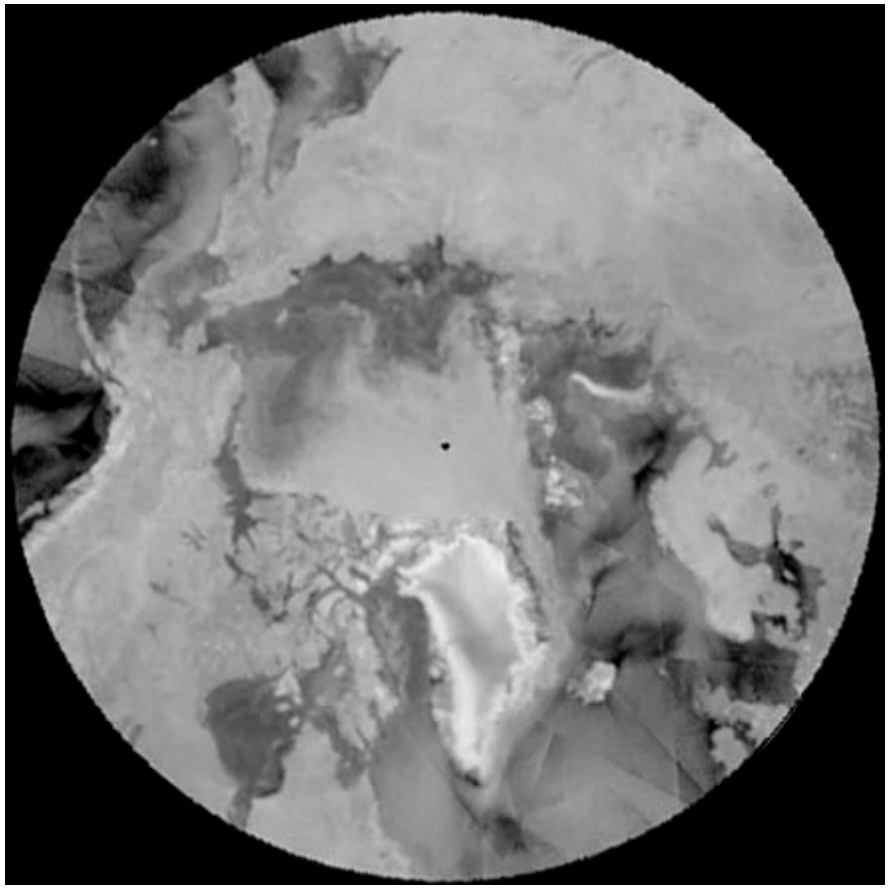
Arctic IR Sea ice Detection



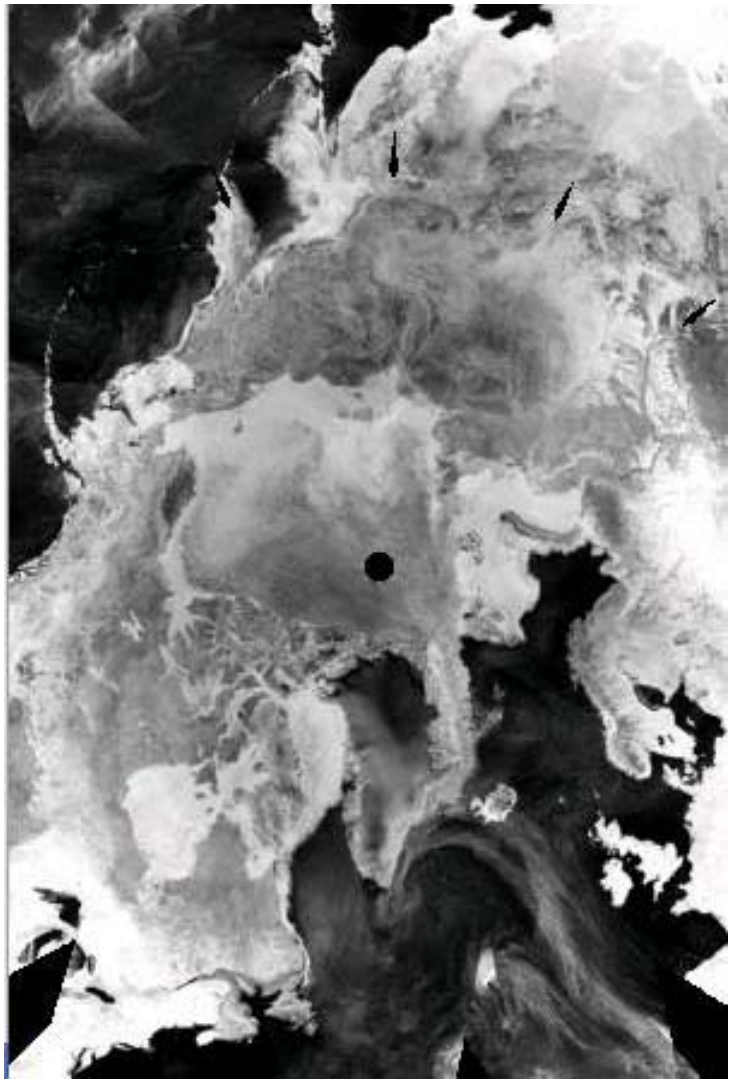
Cloud Impact on Visible (and IR) Sea ice Detection



Active and Passive Microwave Sea Ice Detection

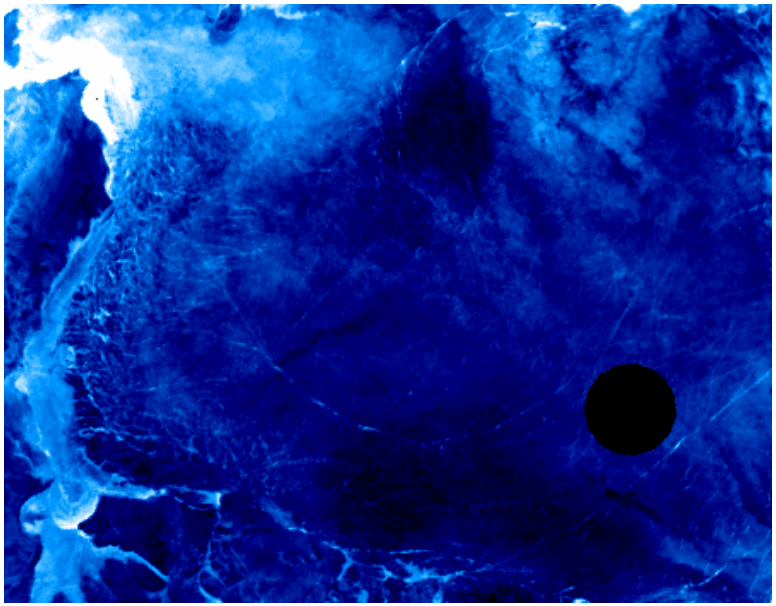


Active: Quikscat Scatterometer Ku-band - March 1, 2004



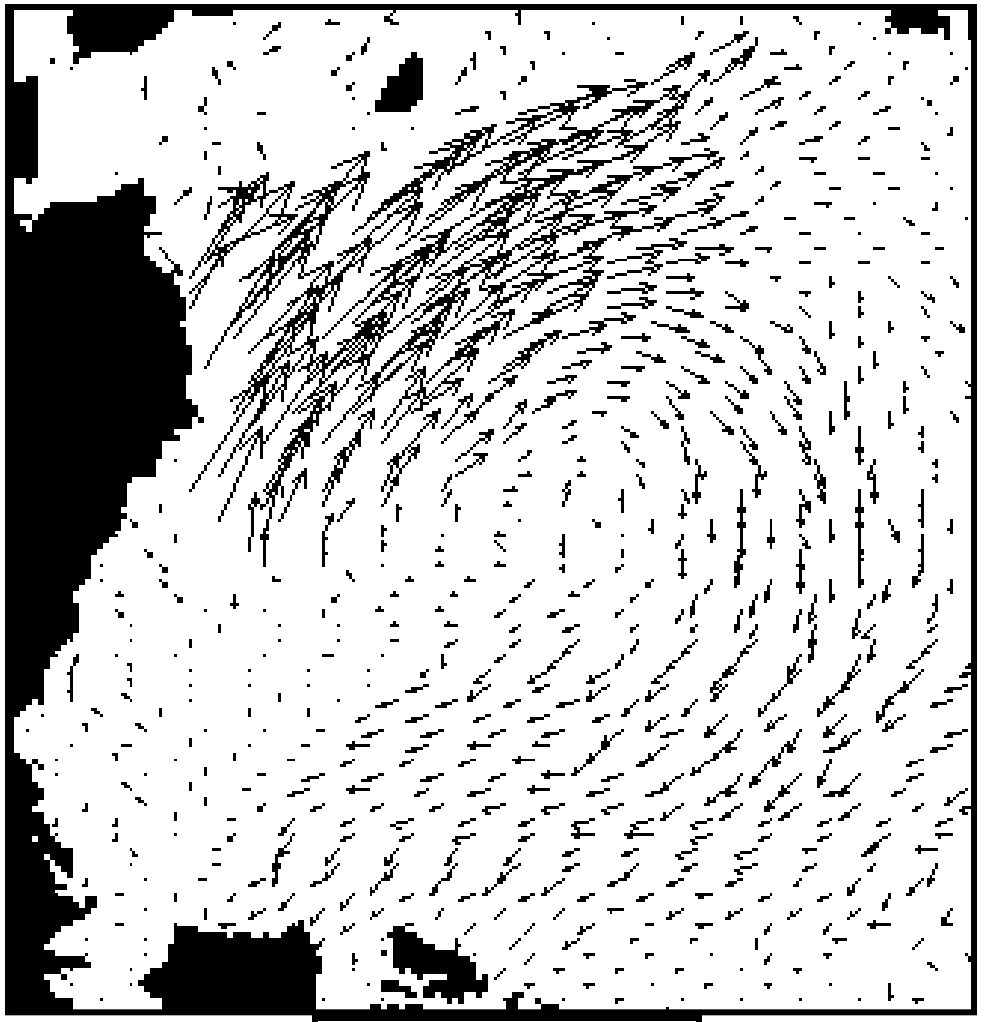
Passive: AMSR-E 85.23 GHz (V-pol)

Sea Ice Dynamics From AMSR-E Ice Drift Vectors



89V GHz T_Bs, 1 – 31 March

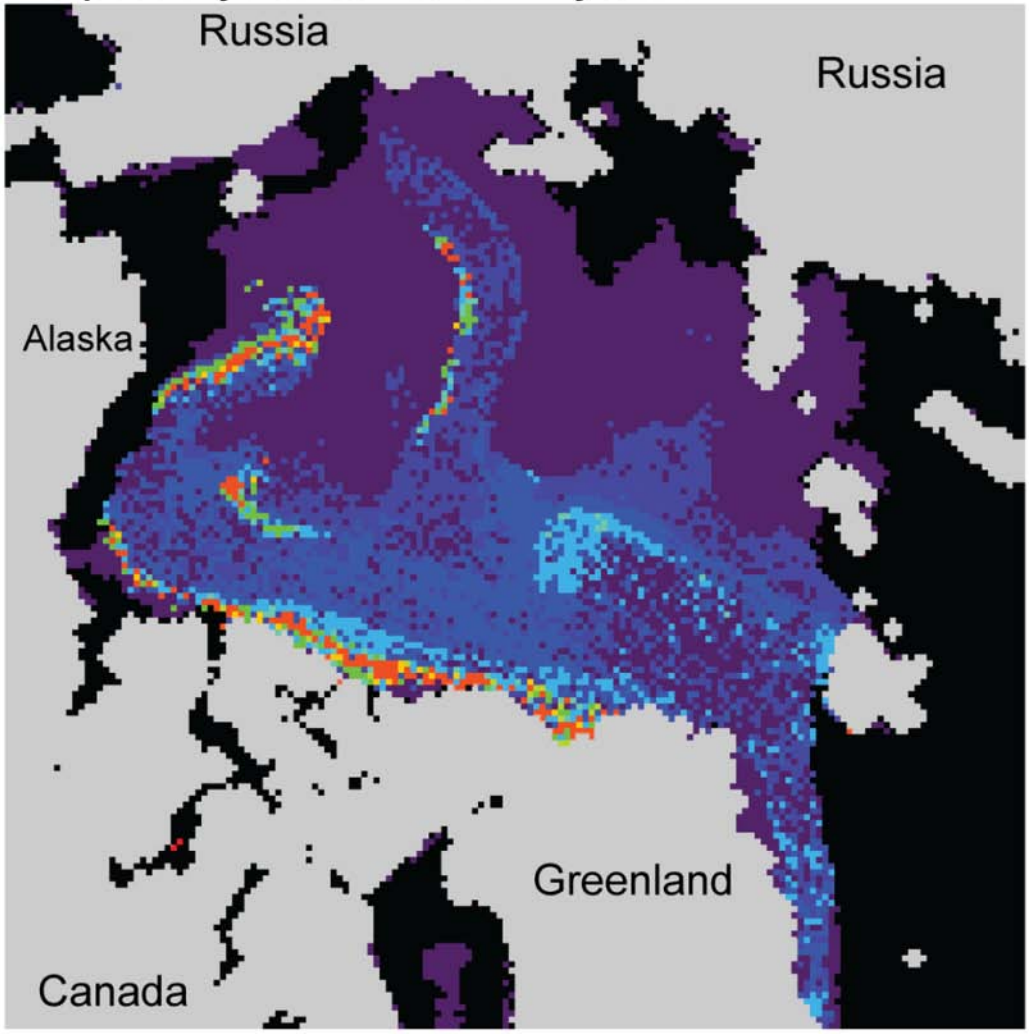
Drift vectors at 6.25 km Resolution



Passive Microwave Drift-Based Sea Ice Age

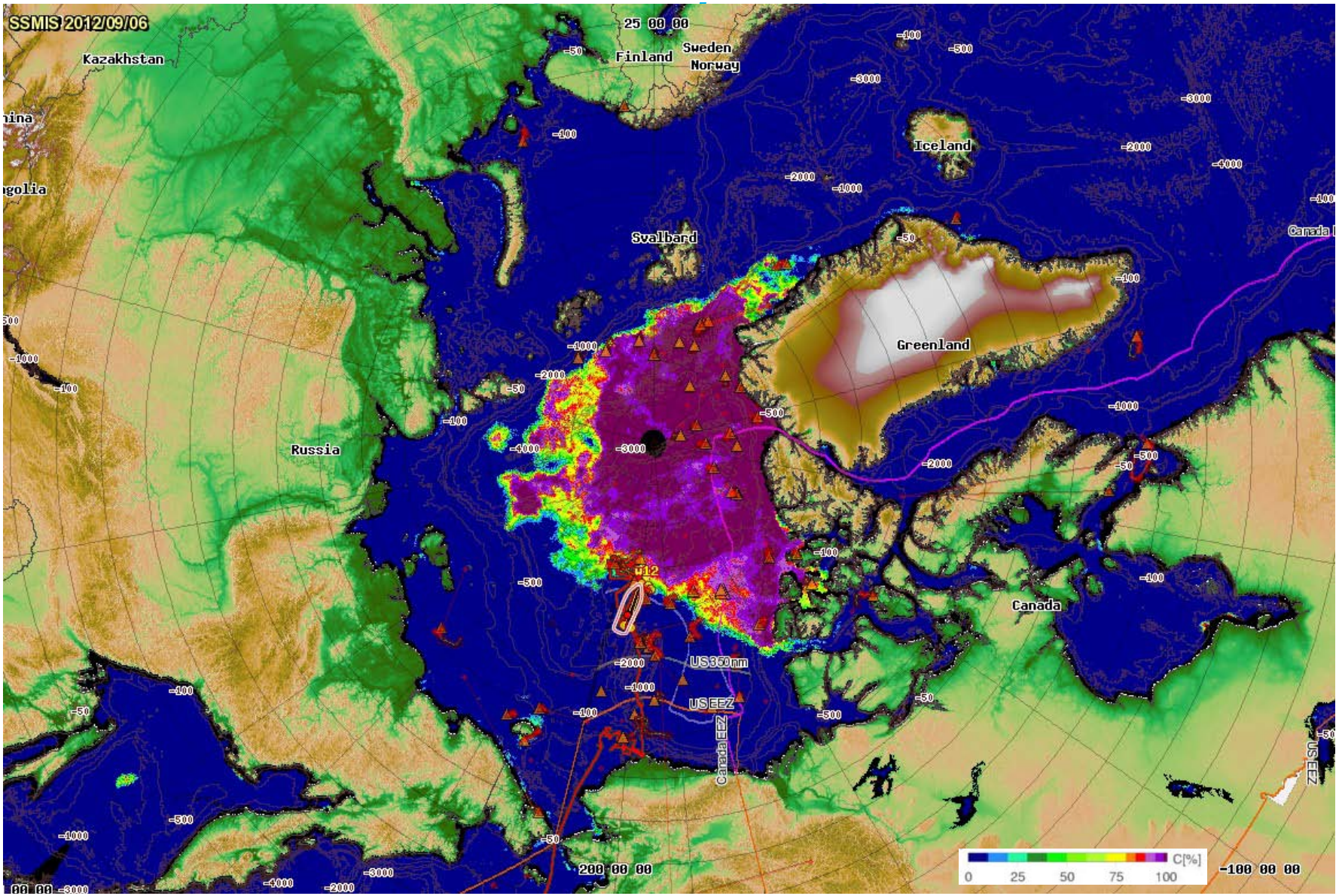
Ice Age **03 August 2011**

Purple: 1 year to Red: 5+ years

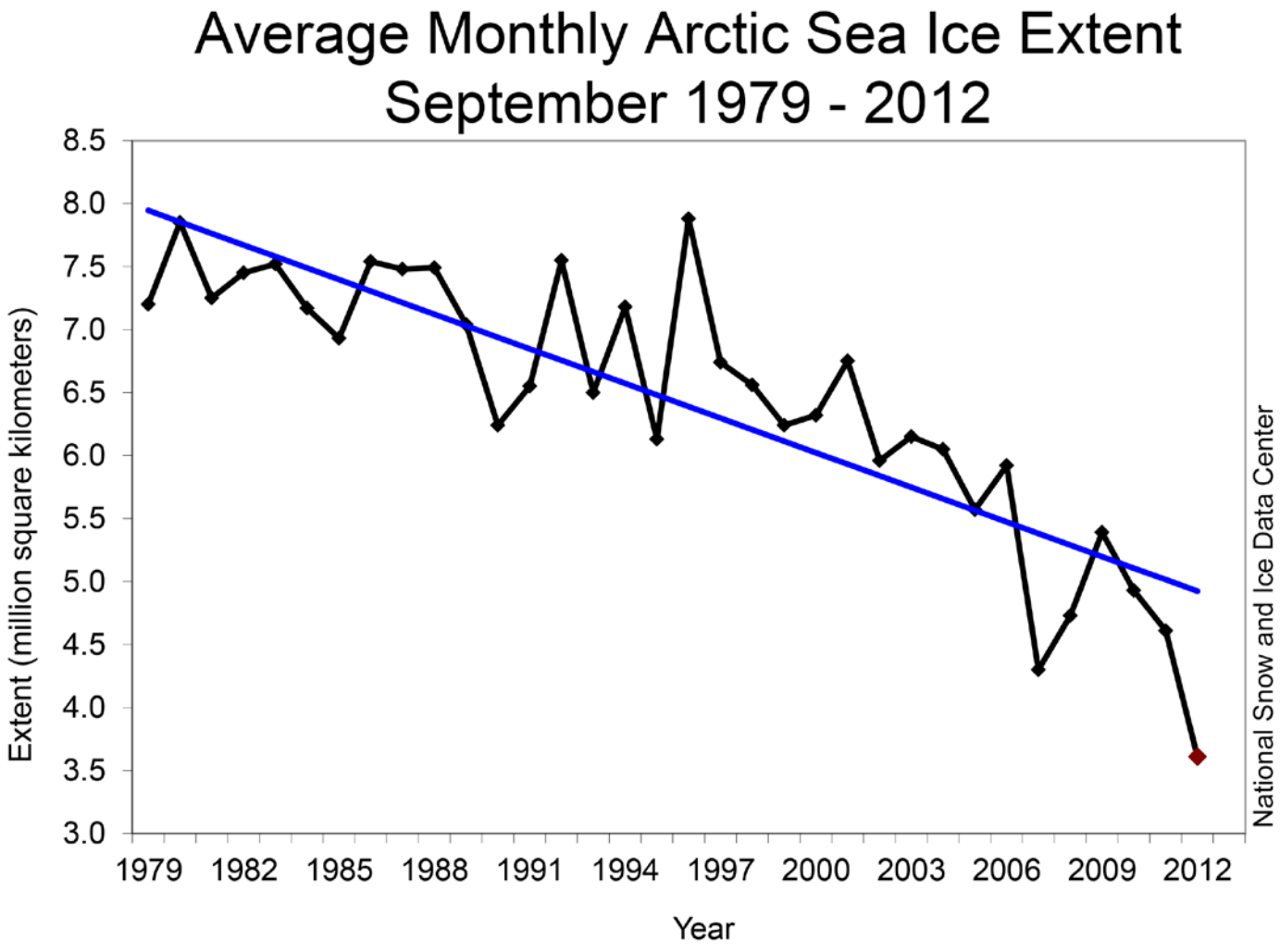


National Snow and Ice Data Center, data courtesy M. Tschudi

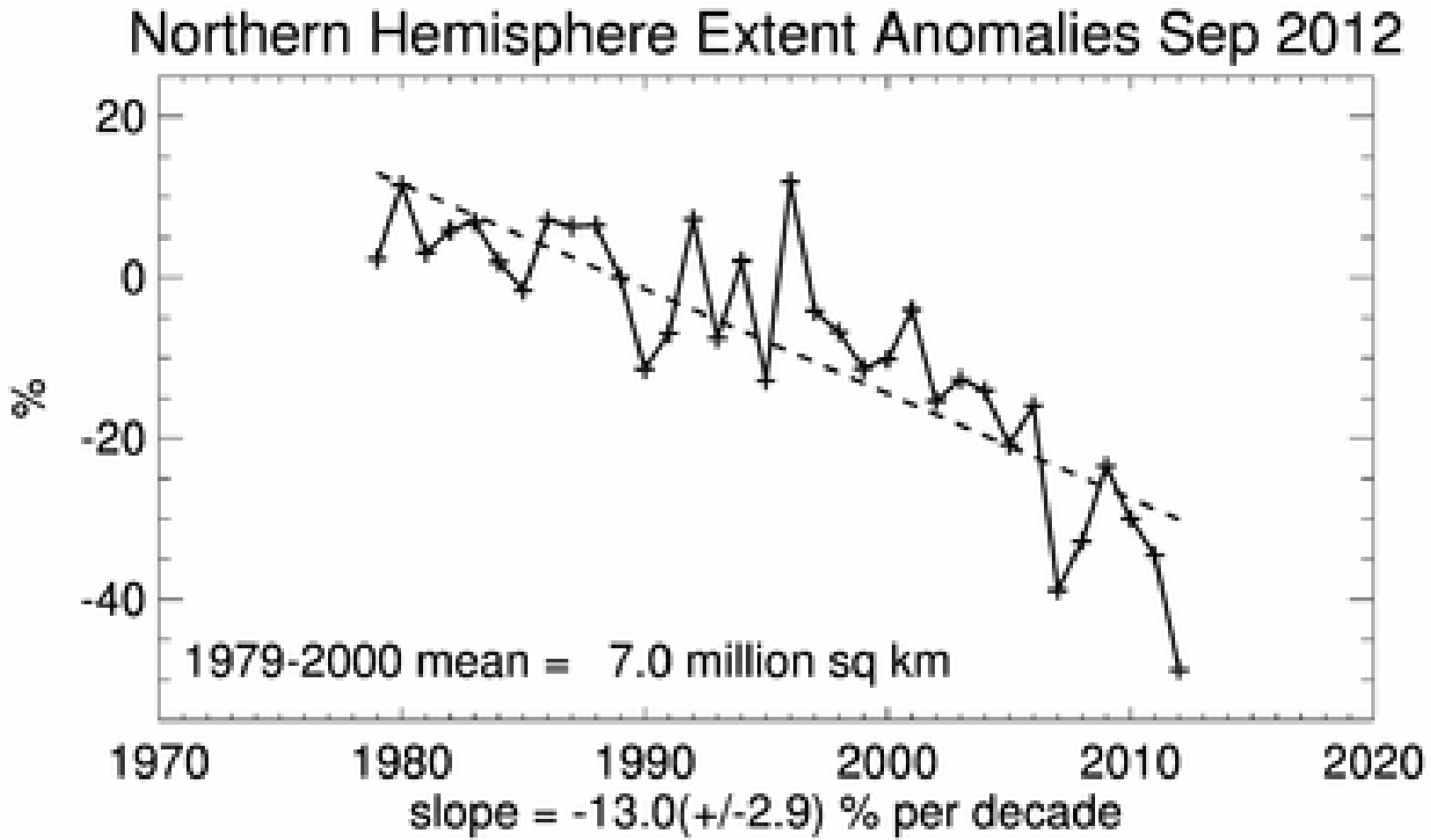
SSMIS Passive Microwave Sea Ice Concentration



NSIDC Sea Ice Index (SII)



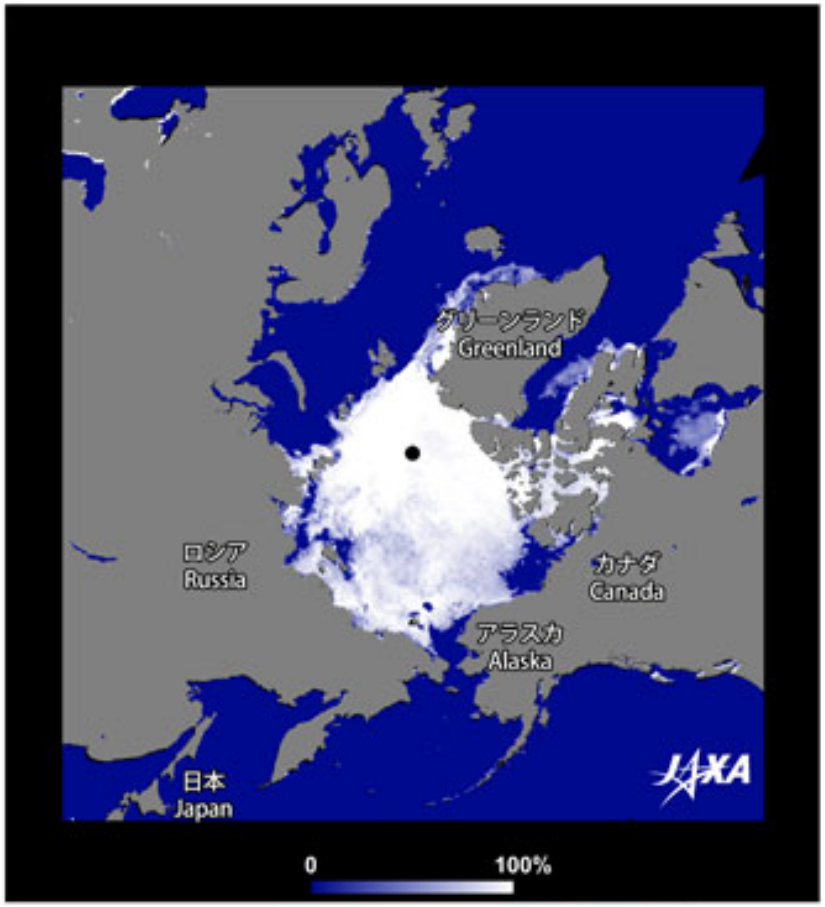
NSIDC Sea Ice Index (SII)



1st AMSR-2 Passive Microwave Sea Ice Concentration Image

第一期水循環変動観測衛星「しずく」
Global Change Observation Mission 1st-Water "SHIZUKU"

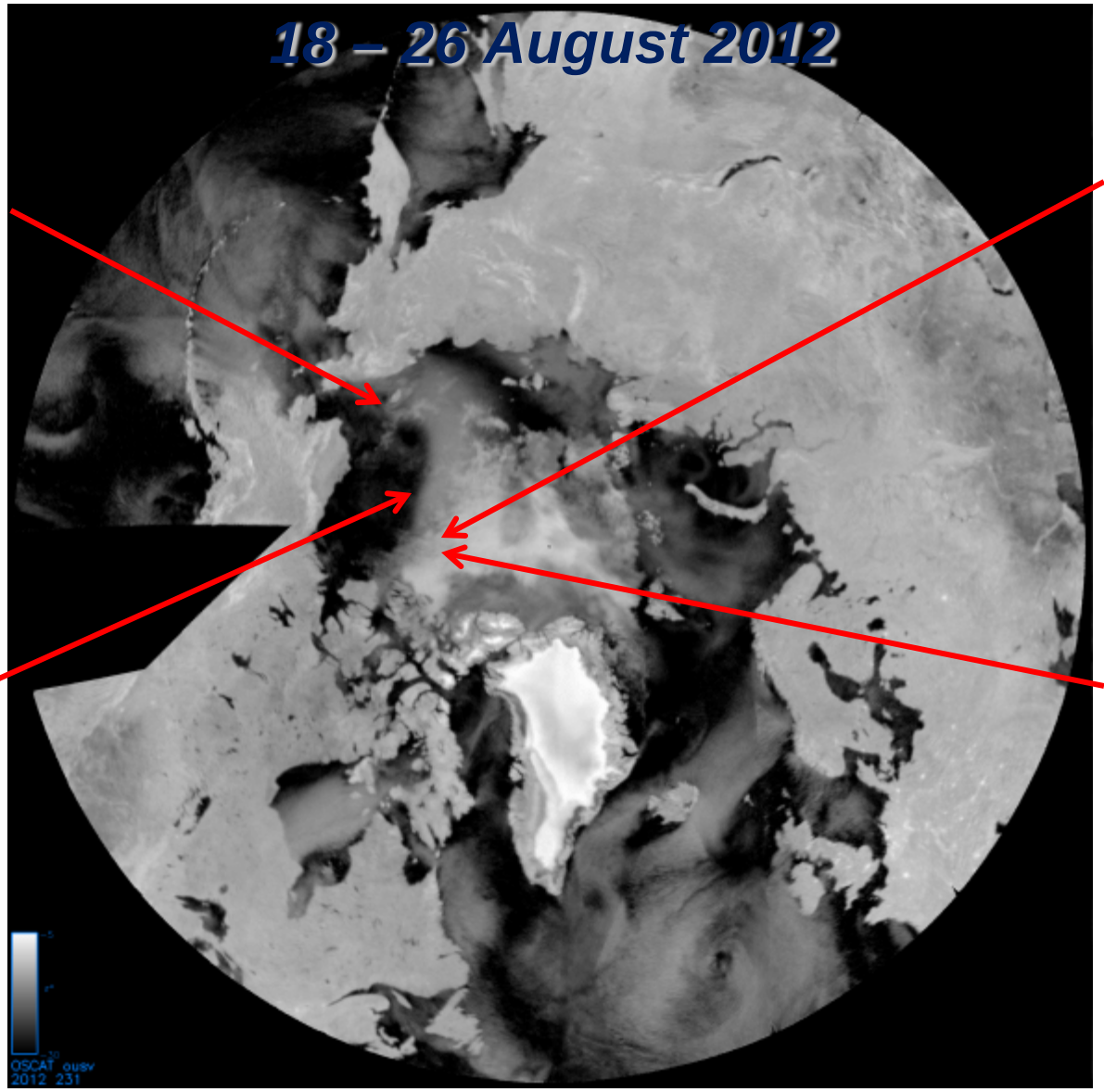
AMSR2 による北極域の海氷分布
Distribution of Arctic sea ice concentration by AMSR2



図は、平成 24 年 7 月 3 日午前 8 時頃～4 日午前 9 時頃（日本時間）の北極海の海氷分布図です。「しずく」は極地方上空を 100 分に 1 回通過するため、北極海全体を毎日観測することが可能です。白色が濃い領域は海氷に覆われていることを示し、海は青色、陸地は灰色、観測されていない領域は黒色で表されています。近年北極海航路が注目されていますが、ロシア沿岸を航行する北東航路、およびカナダ・アラスカ沿岸を航行する北西航路のいずれについても、すでに一部の海域で海氷がなくなっている様子が捉えられています。

Figure shows the distribution of sea ice concentration from 8:00 a.m. on July 3 to 9:00 a.m. on July 4, 2012 (JST). Since the SHIZUKU flies over polar regions every 100 minutes, the entire area of the Arctic Ocean can be observed daily. Colors from white to blue indicate the sea ice concentration. Areas of ocean, land, and no-observations are indicated by blue, gray, and black colors. The Arctic sea routes are getting a lot of attention during recent years. Along both the Northeast Passage and the Northwest Passage, which are running along the Russian Arctic coast and the northern coast of the North America, respectively, some sea areas are already free of sea ice.

Active Microwave Sea Ice Observations From OSCAT During HLY1202



More Persistent Ice Observed Around Wrangle Island

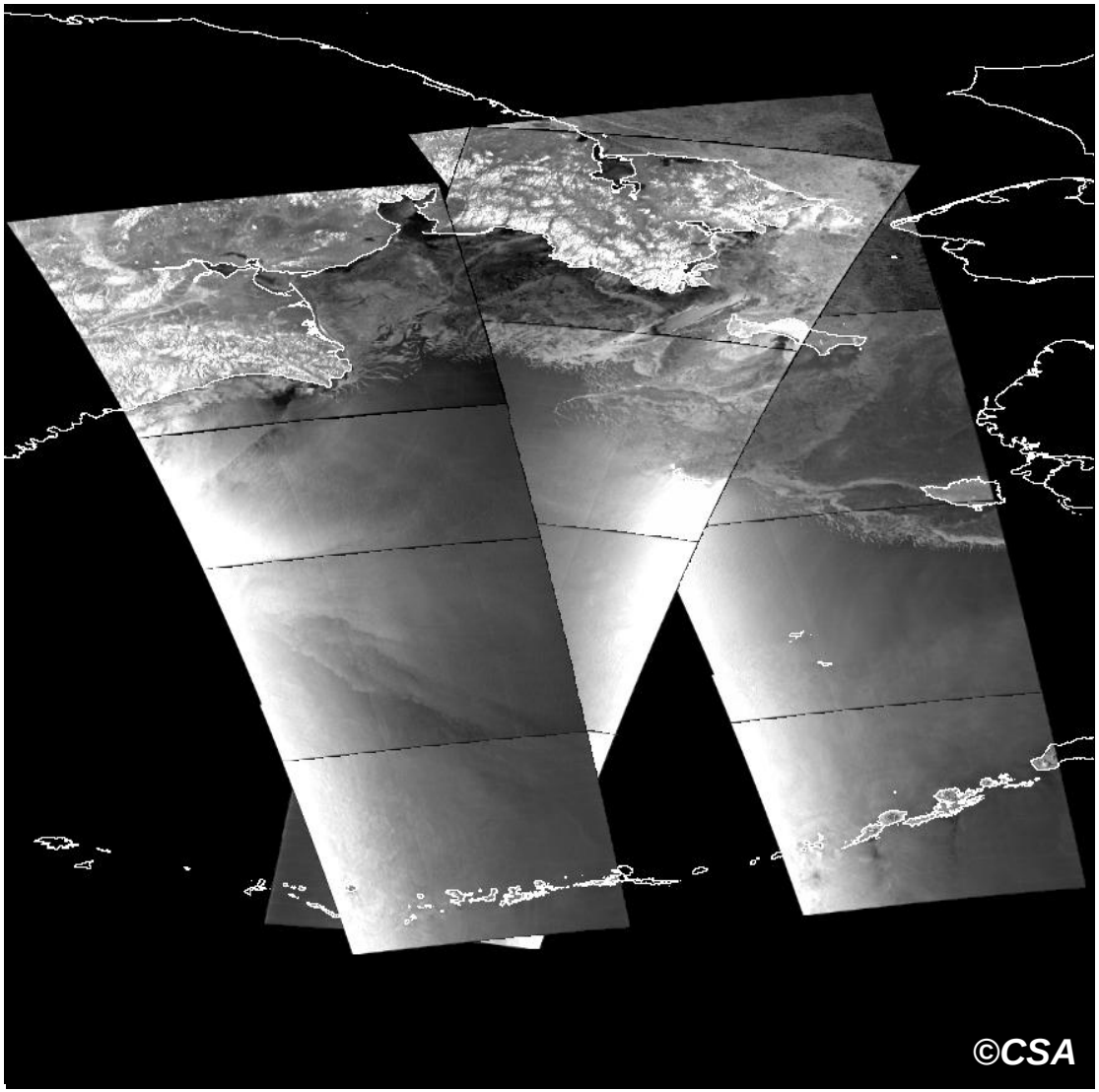
Belts. Strips or Filaments of MYI

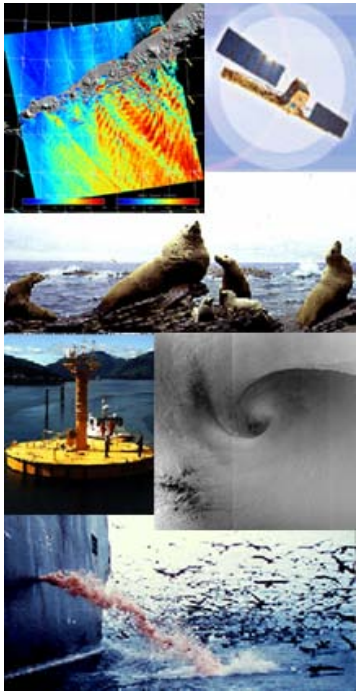
Stressed FYI Pack

MYI Traces within FYI Cover

Tactical Support Imagery of Choice
High-Resolution Active Microwave

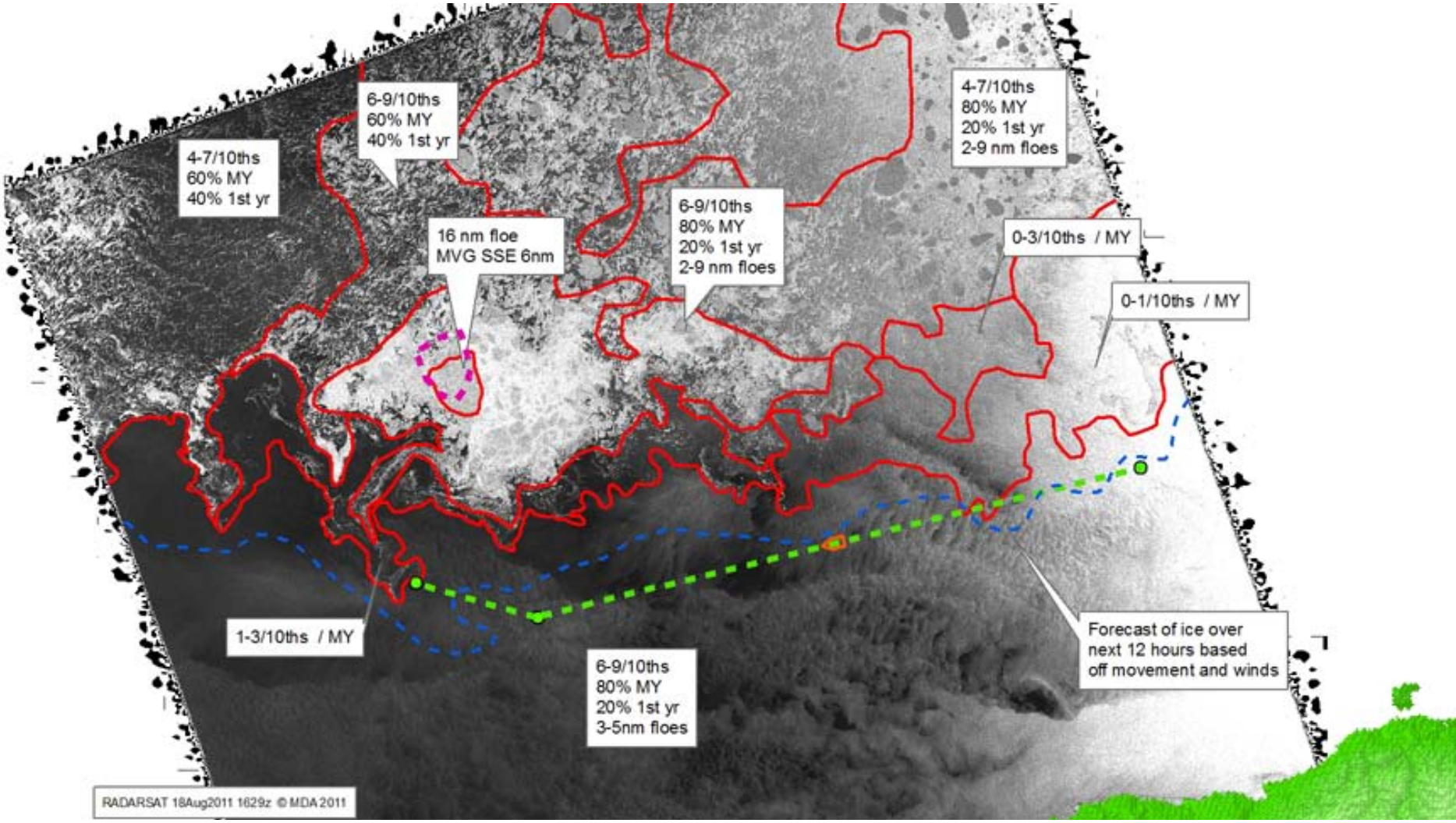
The Other SAR (Synthetic Aperture Radar)





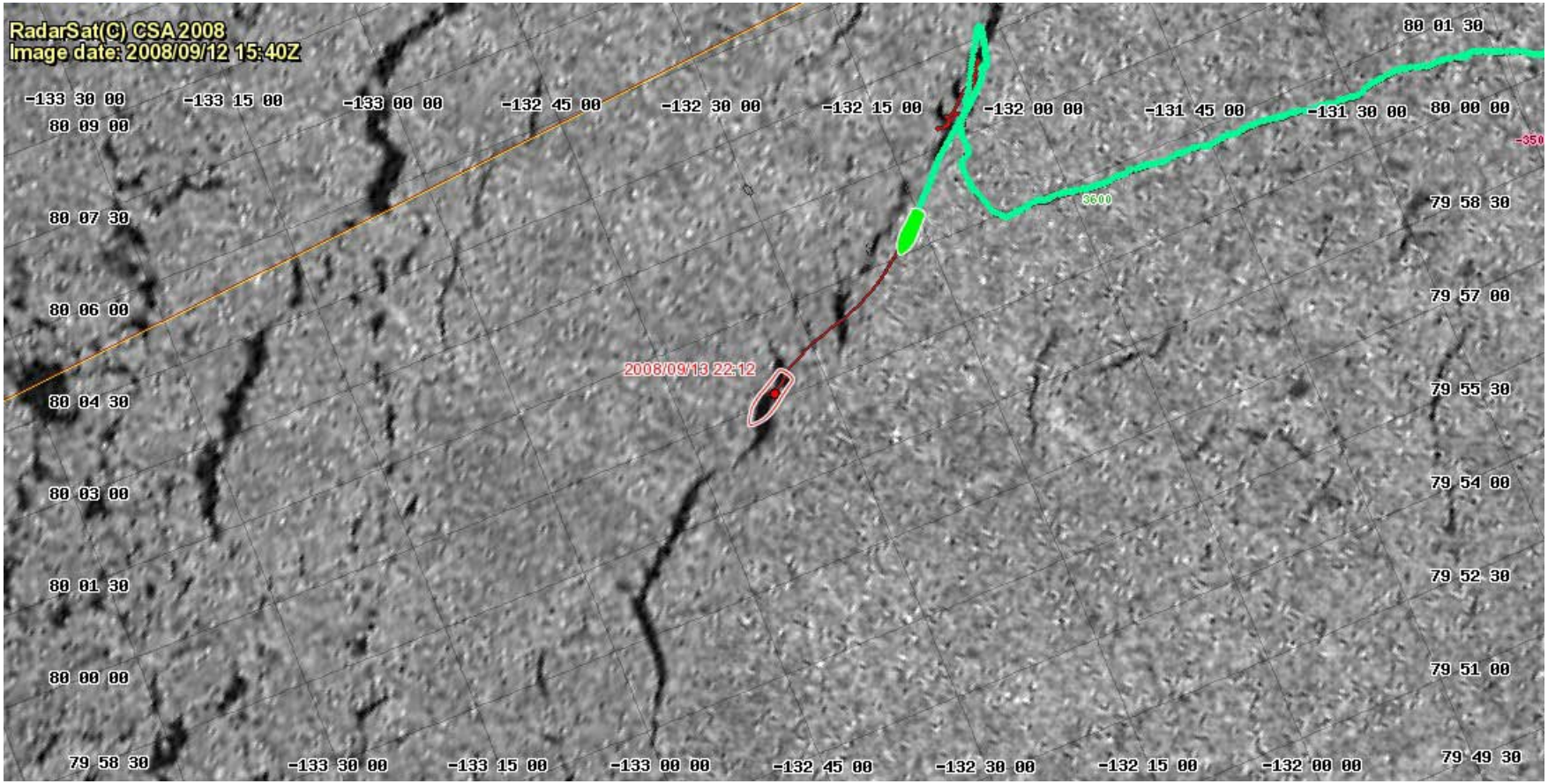
NIC SAR Imagery Sea Ice Analysis

18-19 August 2011



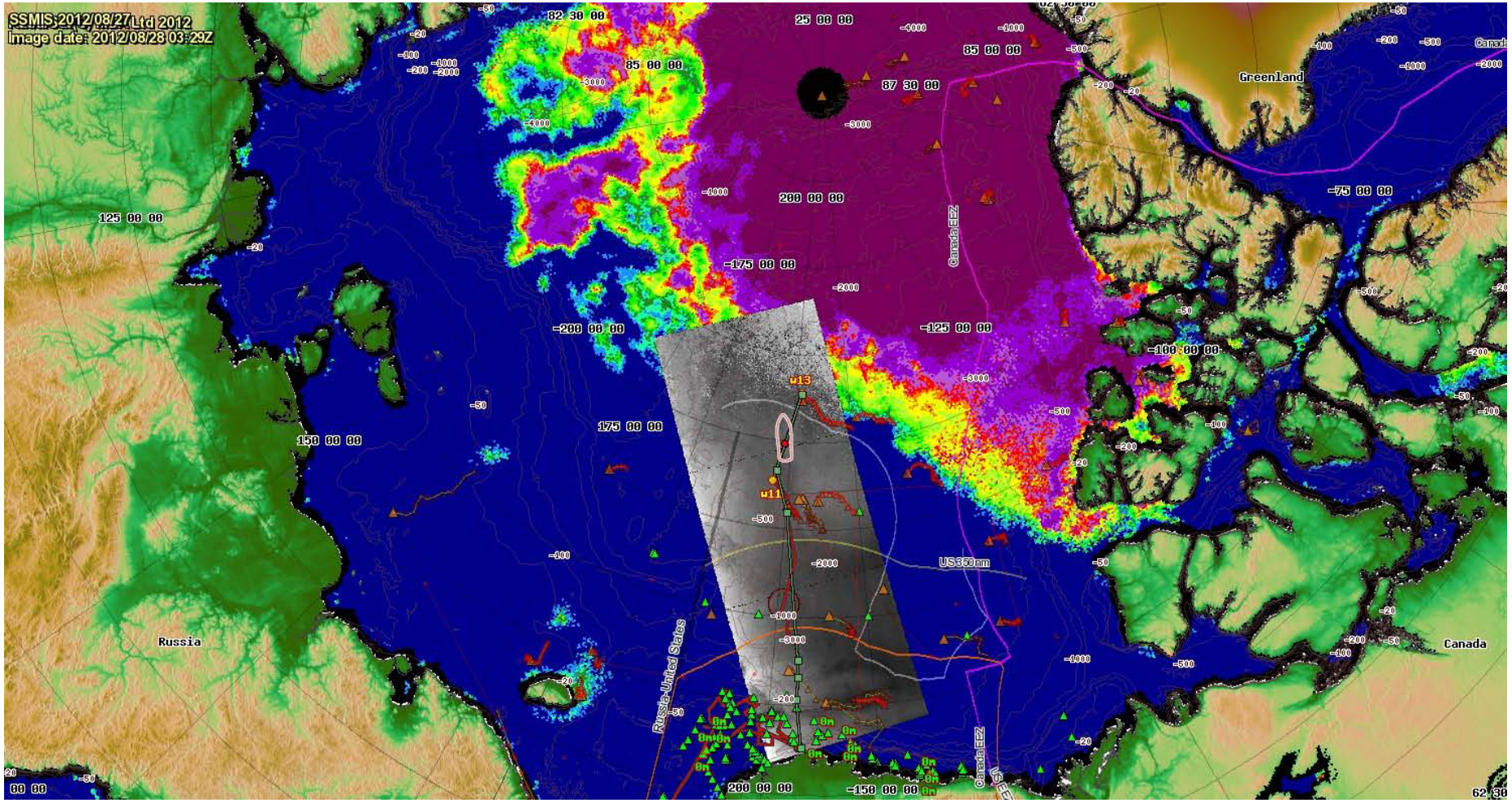
NIC Analyst: Steve Lilgreen

Exploiting Leads and Polynyas in SAR Imagery



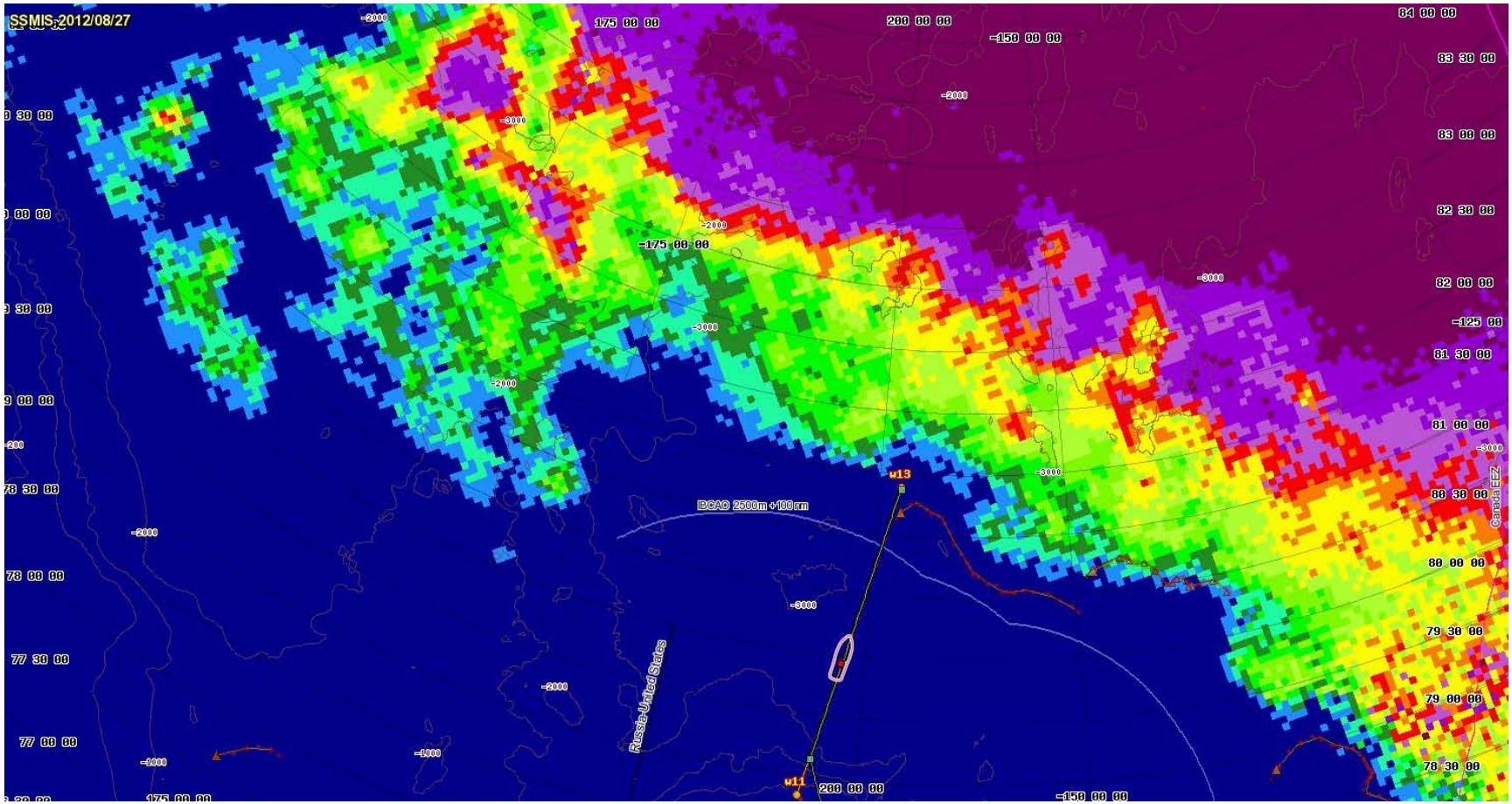
HLY1202 Sea Ice Conditions
27-28 August 2012

RADARSAT-2 SAR over SSMIS Concentrations



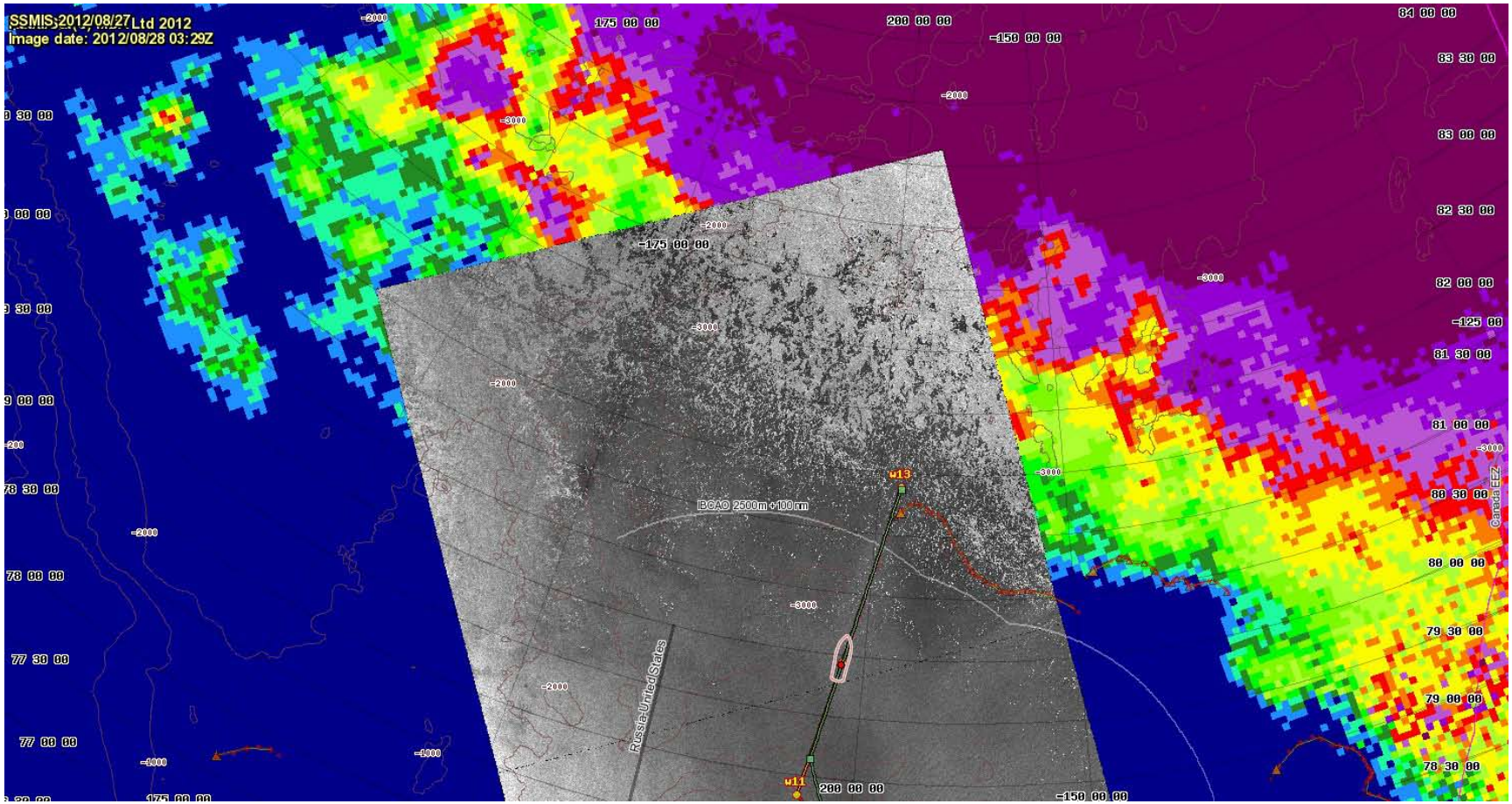
HLY1202 Sea Ice Conditions
27-28 August 2012

SSMIS Concentrations



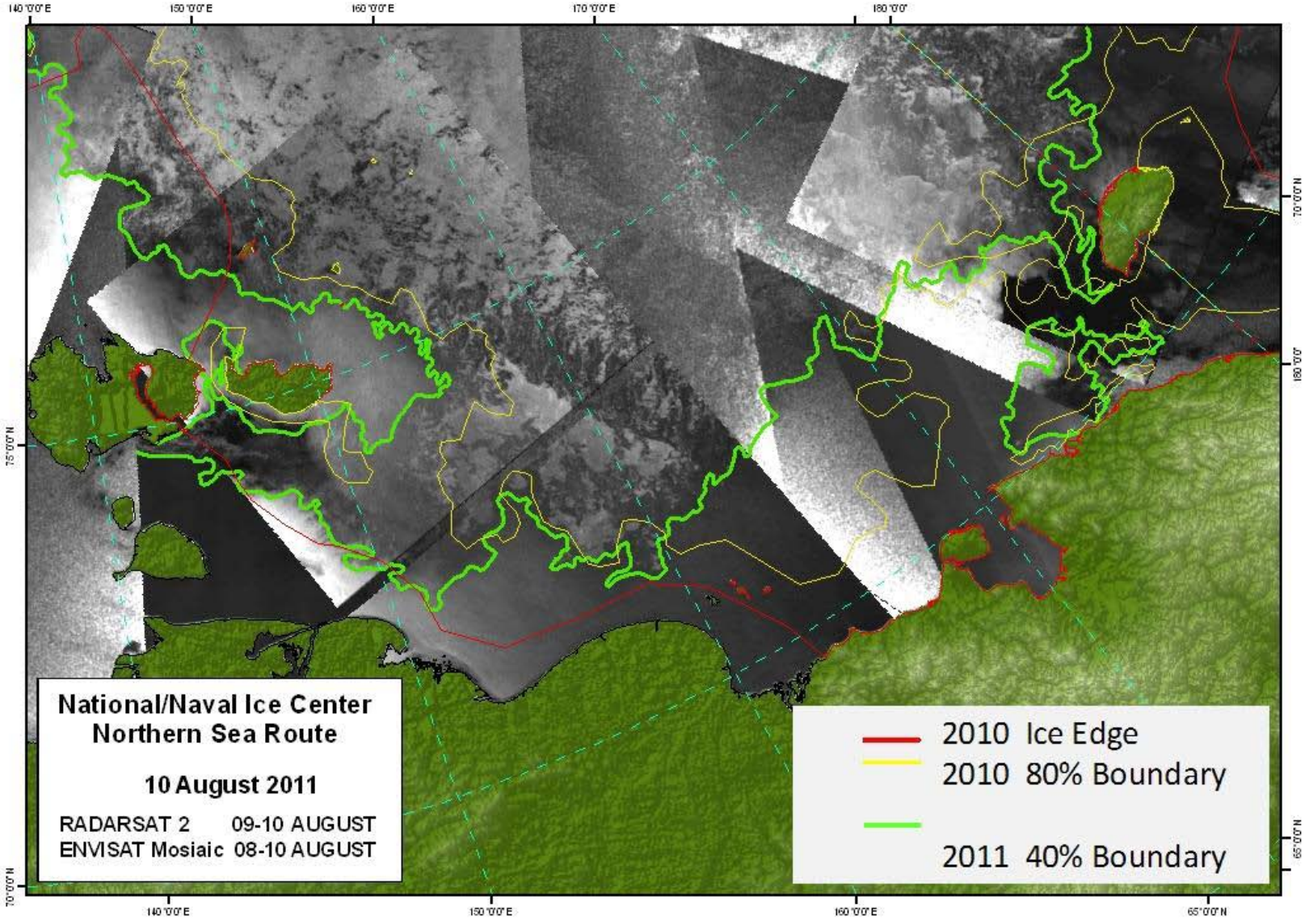
HLY1202 Sea Ice Conditions
27-28 August 2012

RADARSAT-2 SAR over SSMIS Concentrations

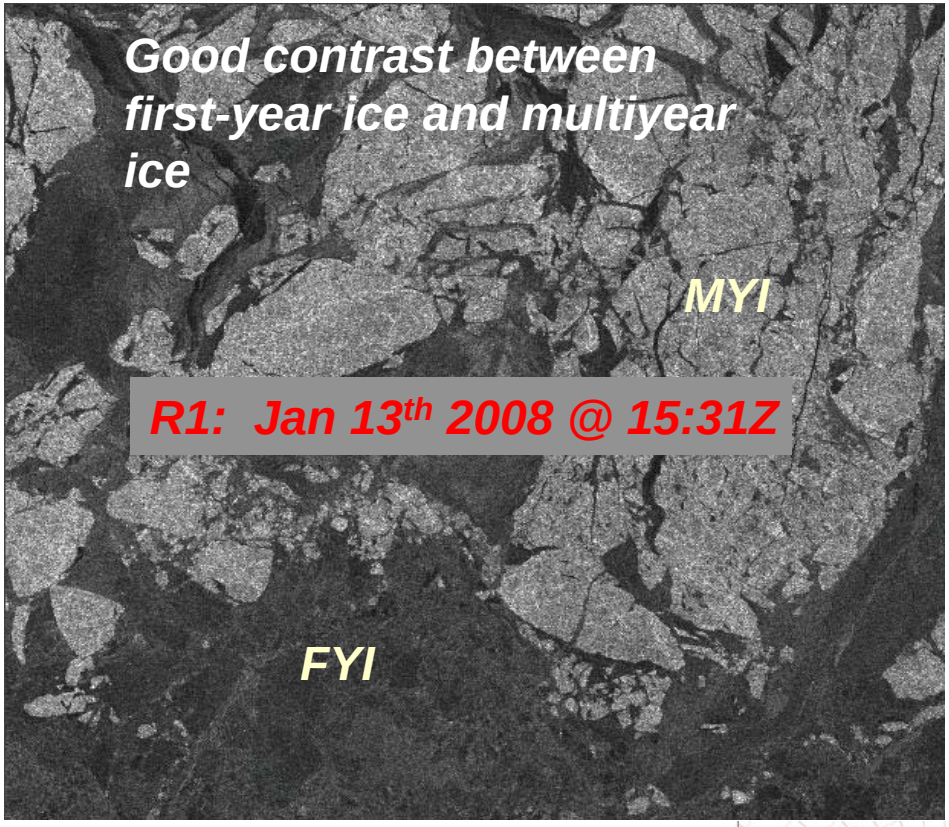


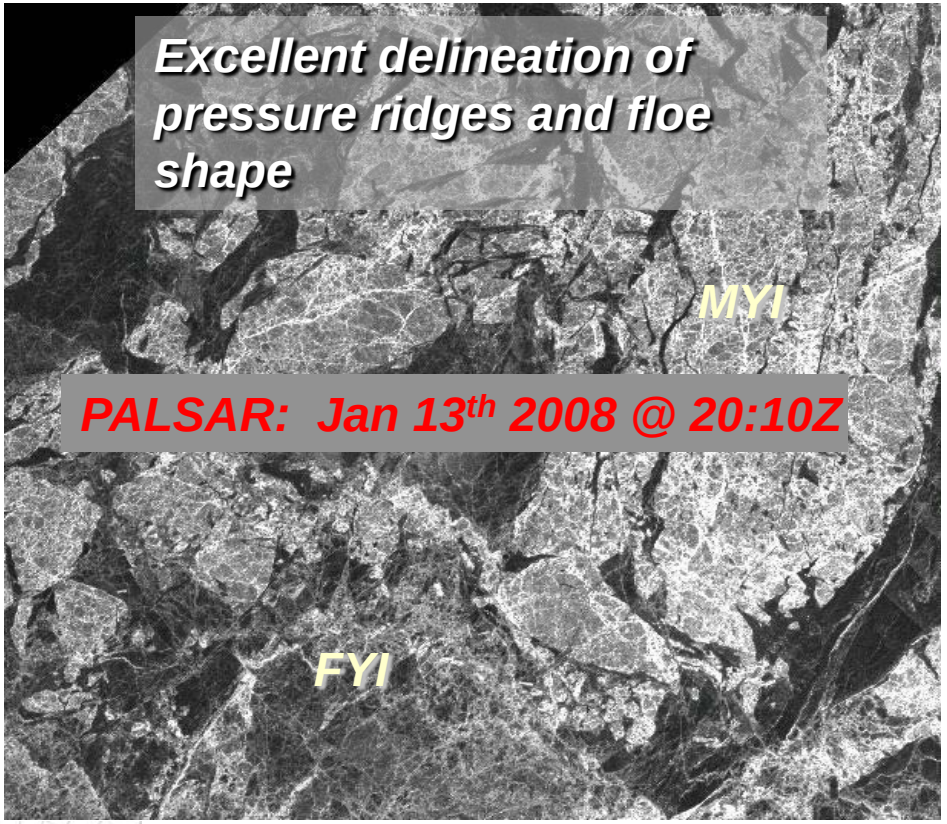
NIC Declared the NSR Open

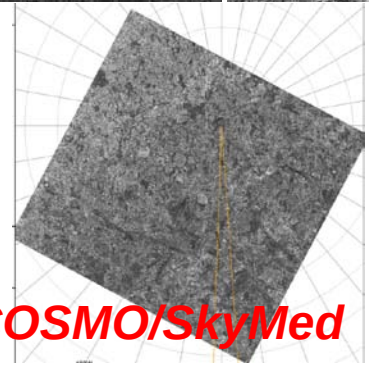
10 August 2011

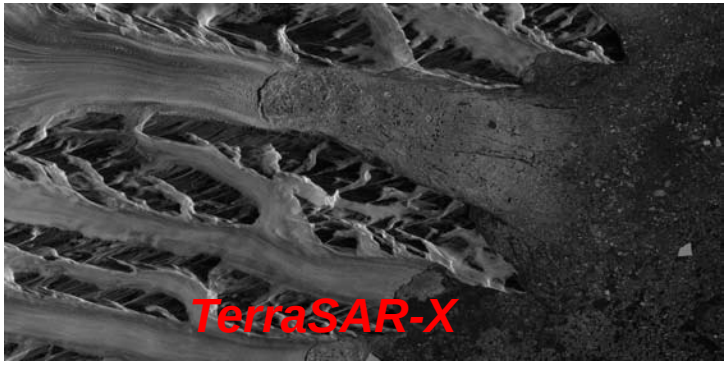


SAR Multiband/Multi-Pol Capabilities

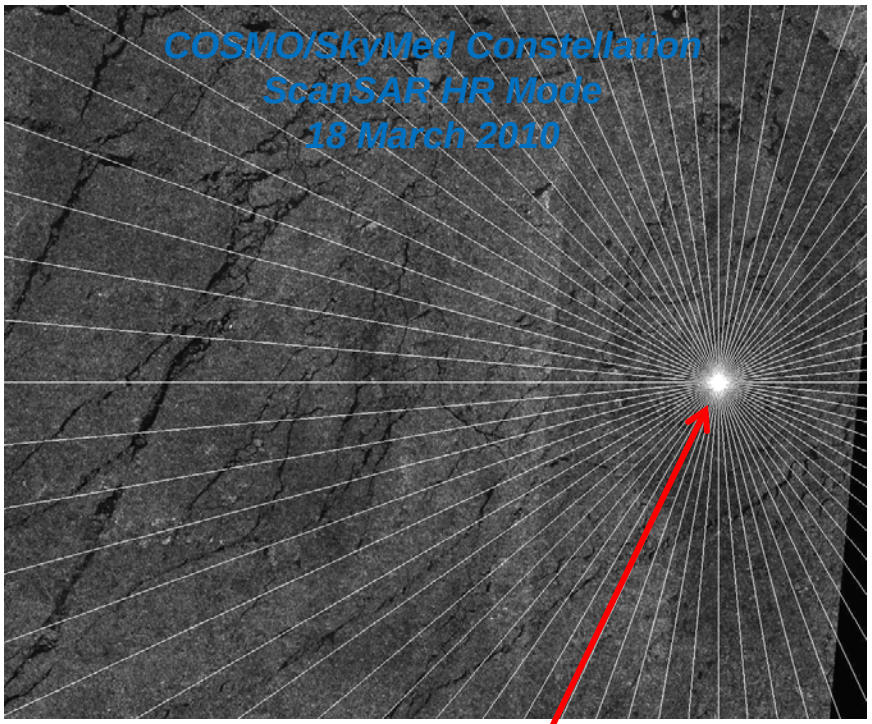


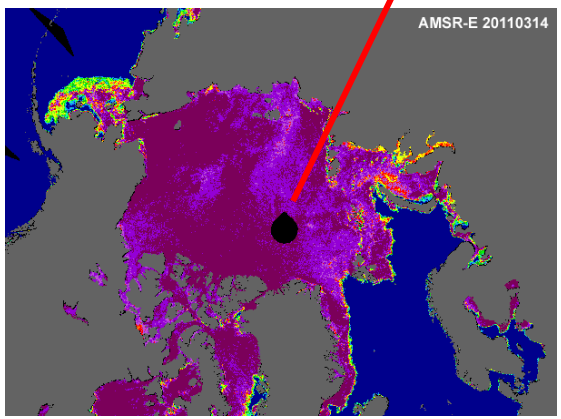


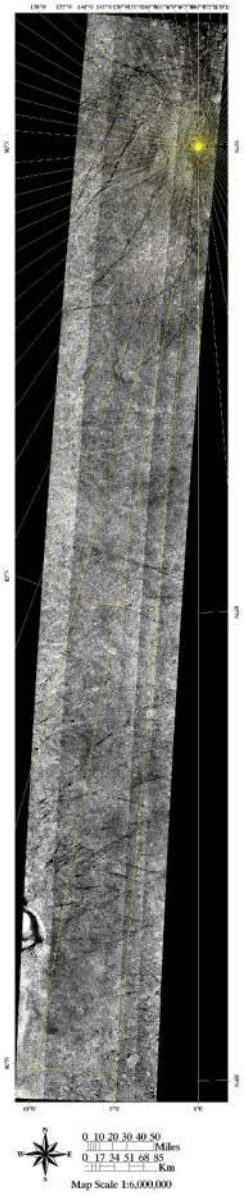


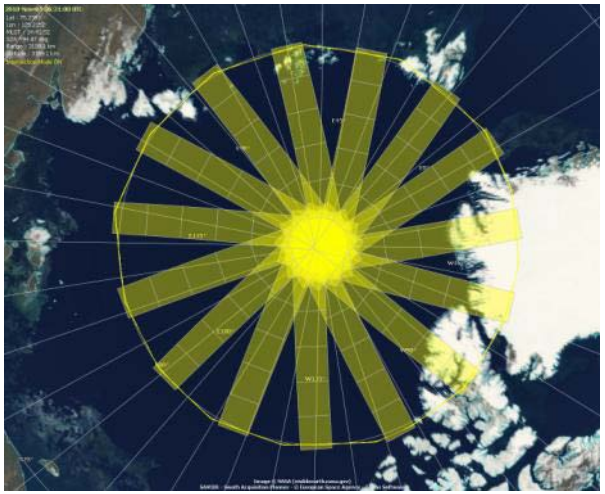


North Pole Region Blind Spot Coverage

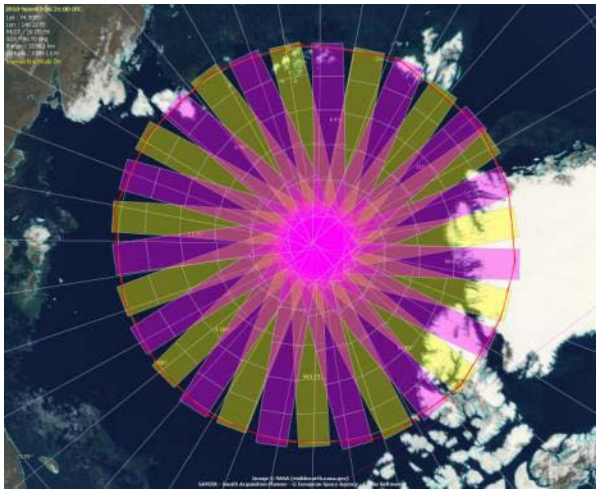








1 day collection with 1 satellite



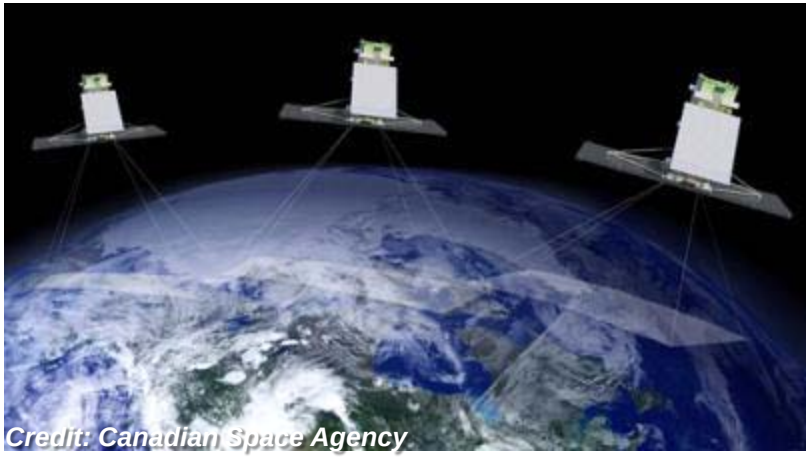
1 day collection with 2 satellites

FUTURE SATELLITE MISSIONS FOR ARCTIC MONITORING

ESA Sentinel-1

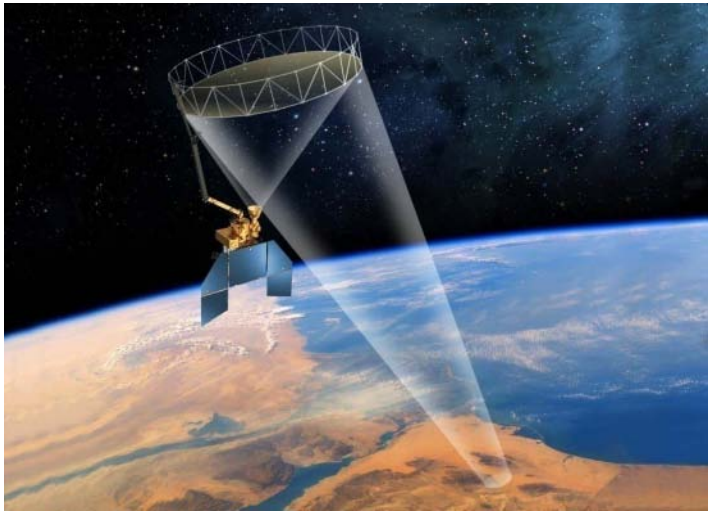
LAUNCH PLANNED FOR 2013-2015

CSA RADARSAT Constellation Mission (RCM)



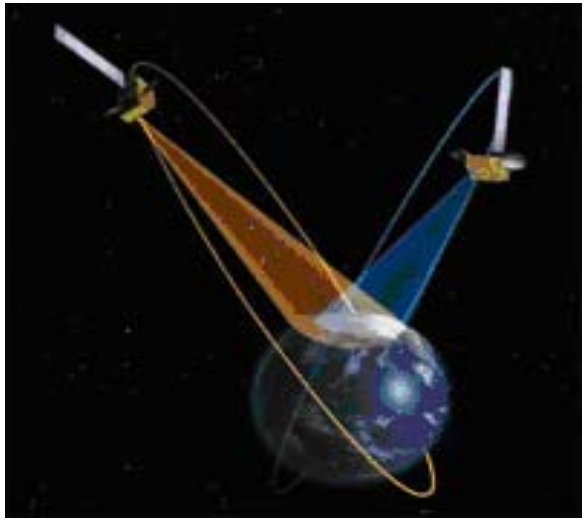
LAUNCH PLANNED FOR 2014-2015

NASA Soil Moisture Active and Passive (SMAP)



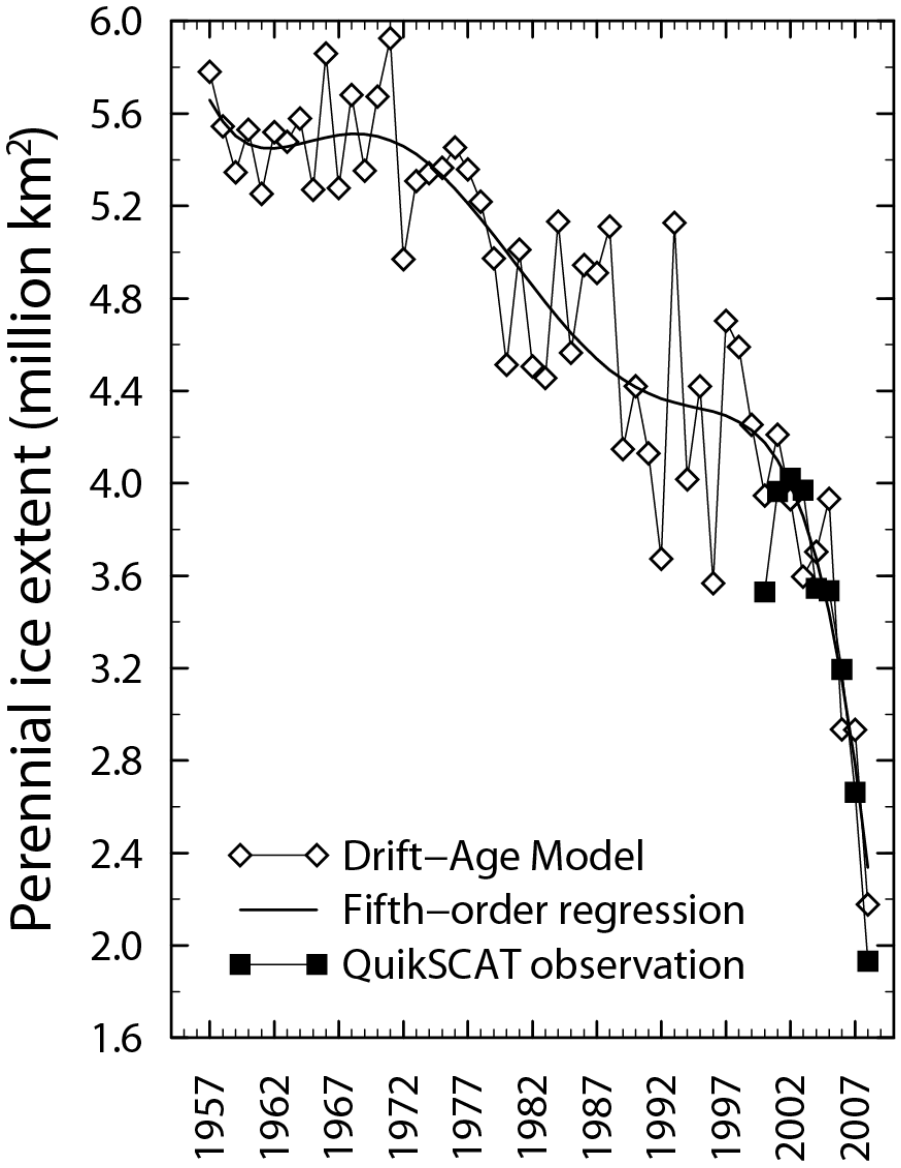
LAUNCH PLANNED FOR 2014

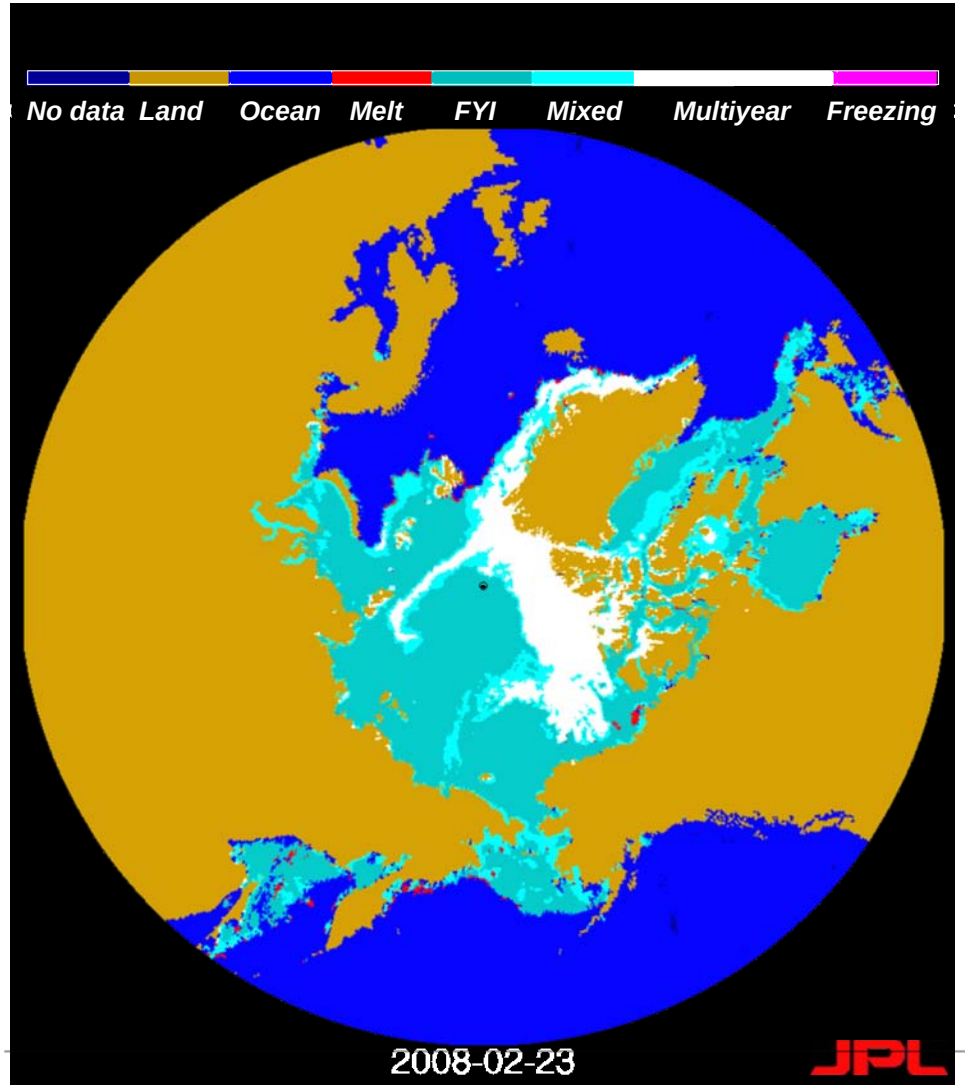
CSA Polar Communication and Weather (PCW)



TENTATIVE LAUNCH PLANNED FOR 2016

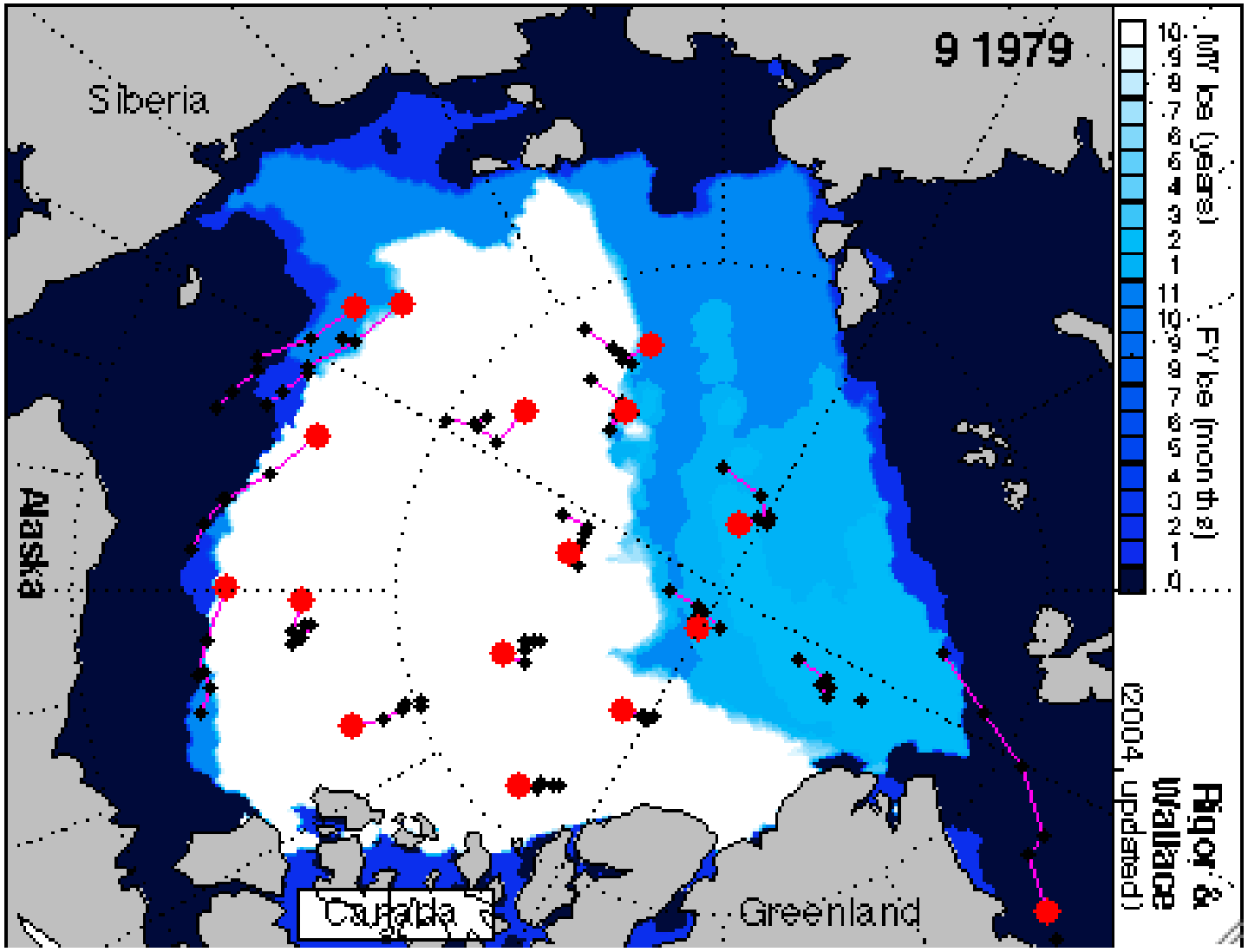
Arctic Perennial Sea Ice Change from 1957 to2008





Rigor, Nghiem, Clemente-Colón, Perovich, Richter-Menge, Neumann, and Ortmeyer GRL, 2008.

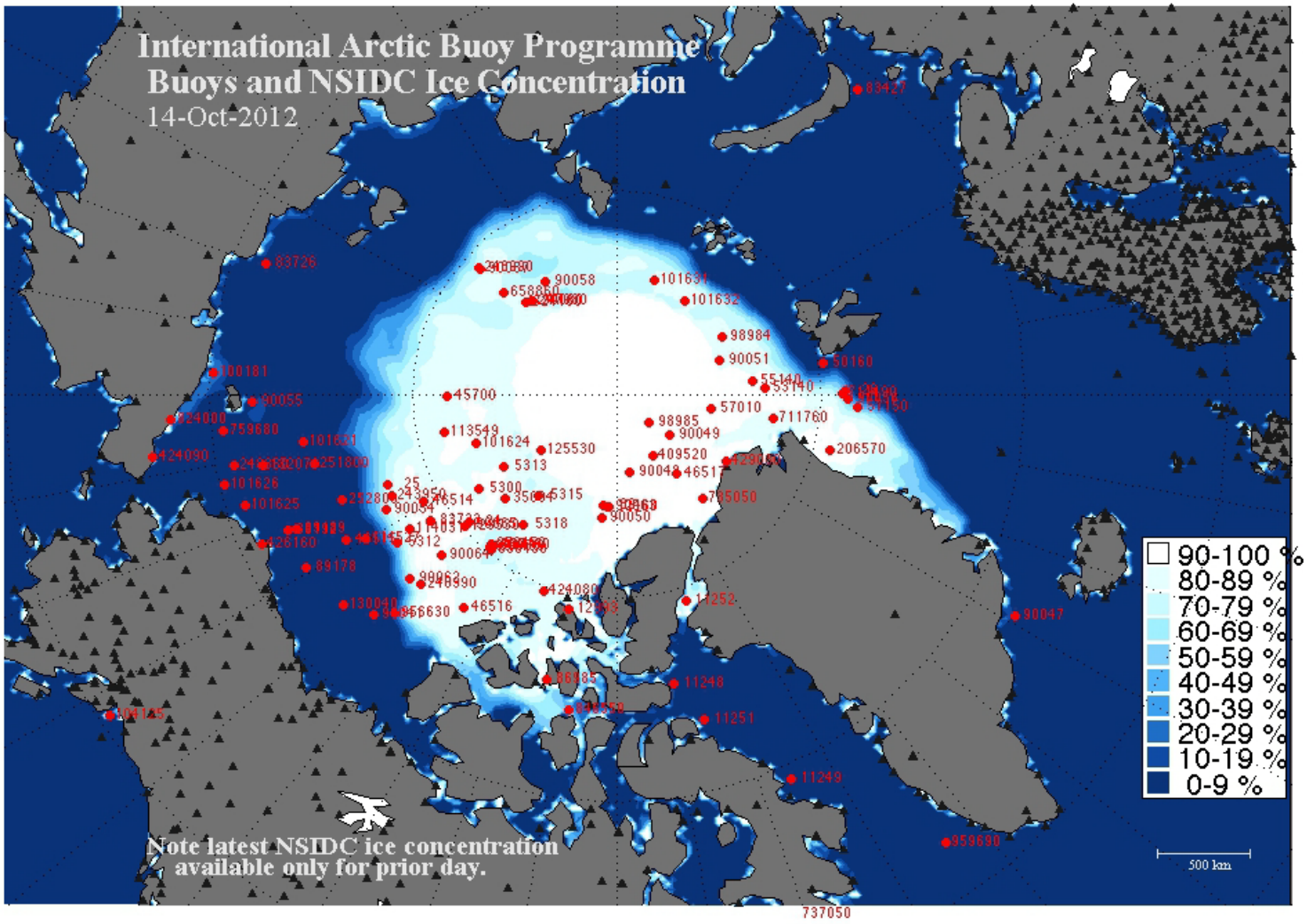
Buoy Ice Drift Sea Ice Age Model



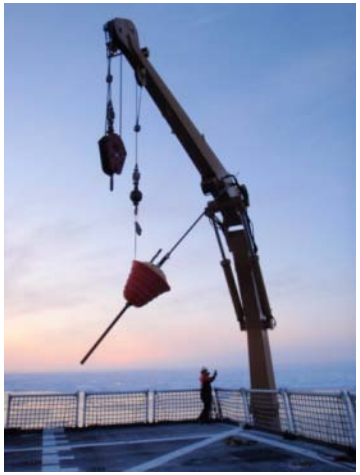
- *Sea ice grows thicker with age.*
- *Prior to 1989, ice over 80% of the Arctic Ocean is at least 10 years old.*
- *High Arctic Oscillation (AO) conditions from 1989-1991 blew most of the older, thicker sea ice out of the Arctic Ocean.*
- *Younger (thinner) Ice persist through today despite "normal" AO conditions.*

Present IABP Buoy Distribution

Distribution of the IABP network is improving but still impacted by increasing Arctic Ocean seasonal ice and openwater as well as by the decrease in perennial ice extent .



Deployment of Seasonal Buoys



Vessels that Deploy Buoys for the IABP

***Oden,* Sweden**

***Louis S St Laurent,* Canada**

***Healy,* U.S.**

***Mirai*, Japan**

***Polarstern,* Germany**

***Amundsen* , Canada**

***Araon,* Korea**

***Polar Star,* U.S.**

***Sir Wilfred Laurier,* Canada**

***Dranitsyn* and others, Russia**

***Xue Long,* China**

Thoughts For Discussion

- **Significant changes in the seasonality and thickness of Arctic sea ice as well as associated increased vessel presence in Arctic waters pose new challenges to present operational ice services.**
  - Need for increased tactical support, which heavily depends on high-res imagery, particularly from synthetic aperture radar data
  - Need for more frequent and higher resolution analyses
  - Need for improved or new forecasting capabilities from daily, weekly, seasonal, intrerannual, to even climate time-scales
- **An ice-diminishing Arctic Ocean does not translate into an ice "risk-free" ocean.**
  - Less ice = More Traffic = Increased Requirements for Ice Support
- **New strategies for the deployment of in-situ air-sea-ice observing platforms, improvements of systems to operate in high-latitude and through new seasonal conditions, better communications, and the incorporation of new technologies, including UAS/AUVs, are needed.**

Any Questions For Now?

USCGC HEALY conducts operations in support of the International Arctic Buoy Programme