

Sea Ice Science Team

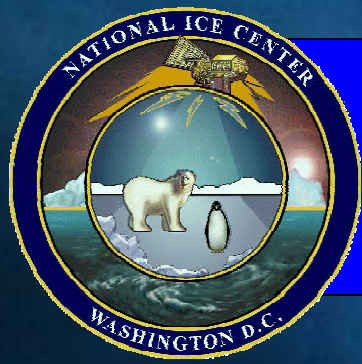
NIC – NESDIS STAR



STAR Science Forum

20 February 2007

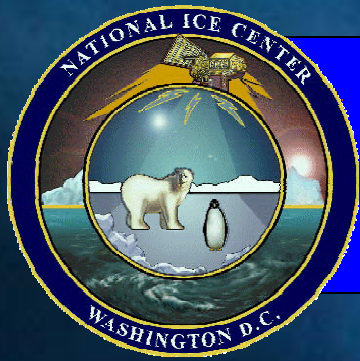
Pablo Clemente-Colón, Chief Scientist



Science and Applied Technology

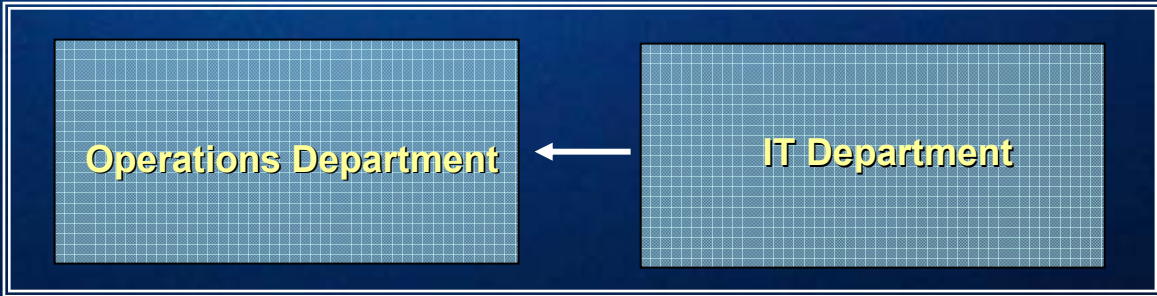
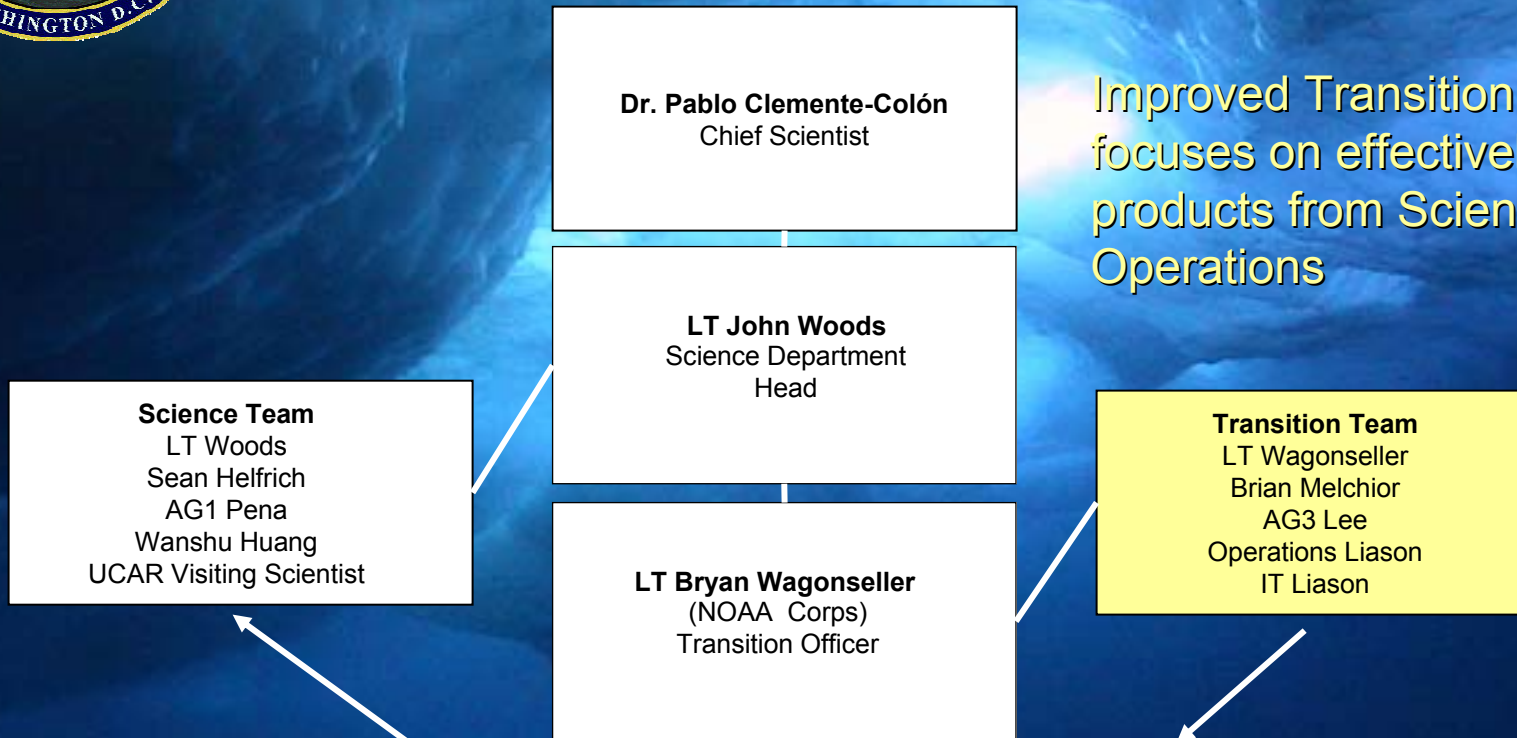
Outline

1. Organizational Overview
2. Update on Ongoing Research
3. IPY Activities
4. USIABP/IABP



Science and Applied Technology Organization

Improved Transition Process focuses on effectively moving products from Science to Operations





NIC Science and Applied Technology Personnel Changes

New Personnel Onboard

Mr. Sean Helfrich – NESDIS Physical Scientist hired (re-hired)

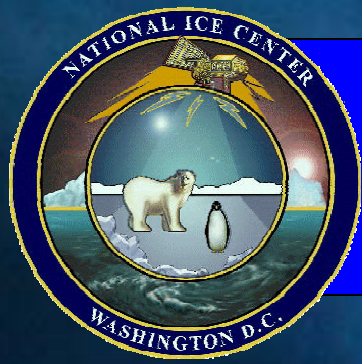
AG3 Lee – operations transition support (formerly in production)

**Dr. Todd Arbetter – Has just signed UCAR offer to fill NIC – PSC
Visiting Scientist Position**

Open Positions

Physical Scientist/Oceanographer (STAR FTE) still not fulfilled

**NOAA Corps Officer departing in May w/ replacement not earlier
than September**



NIC Science Participation in Committees and Working Groups

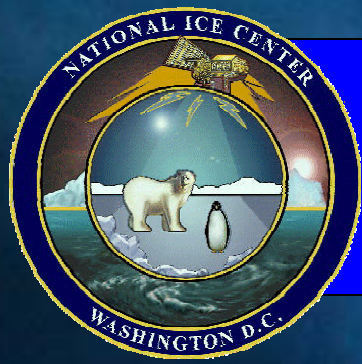
- Antarctica IPY SI Thickness WG
- Antarctica IPY Air/Sea/Ice Interaction WG
- GCOS/GOOS/JSC AOPC/OOPC WG-SST/SI
- GIIPSY Remote Sensing Data IPY Coordinating Group
- IABP Partnership
- IGARSS TPC/Ocean & Cryosphere Sessions Coordination
- IICWG Science and Technology Committee
- IICWG International Polar Year (IPY) Ad-hoc Committee
- IPAB Steering Committee
- NAIS Science Committee
- NAVO Technical Advisory Board (TAB)
- OceanSAR 2006 Science Committee
- SeaSAR Science Committee (next workshop September 2008)
- USIABP Coordination
- WindSat/CMIS-SIAWG under development



RADARSAT-1 Mission Status

RADARSAT-1 SAR (CSA and MDA)

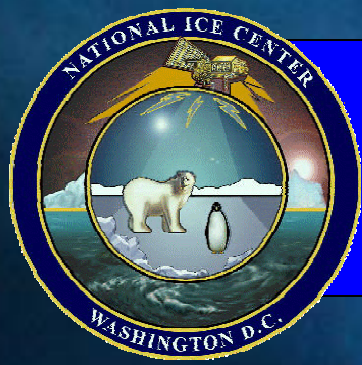
- **Present NASA-NOAA-CSA agreement in force until NOV07 or R-2 commissioning**
- **NASA negotiating agreement extension including research access to R-2 – Draft agreement prepared by Craig Dobson, Eric Madsen Representing NOAA**
- **CSA has funding for continued R-1 operations through IPY**



RADARSAT-2 Data Missions

RADARSAT-2 SAR (MDA)

- **Commercial mission**
- **New C-band polarimetric modes**
- **Launch planned for a 3 months window starting in March 2007**
- **Operational data in R-1 legacy modes available 2-3 months after launch**
- **No intergovernmental agreements in place for data access**
- **Potential for NOAA, NASA, ASF ground segment contribution in exchange for data access under consideration**



Envisat Mission Status

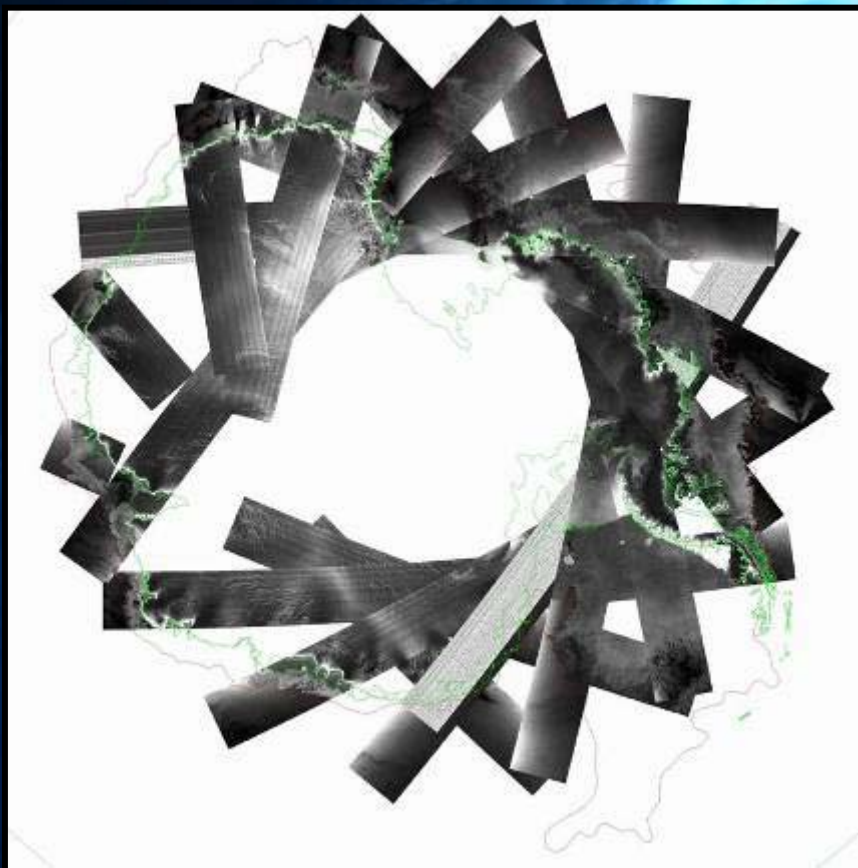
Envisat ASAR (ESA)

- **GMM mosaics available through PolarView project**
- **GMM swath data access through rolling archive**
- **Research-only access to ASAR high bit rate imagery through ESA Envisat rolling archive**
- **ASF investigating commercial acquisition of ASAR high bit rate through Envisat consortia (EMMA, SARCOM)**
- **No sharing of commercial acquisitions between NIC and CIS under the NAIS umbrella presently allowed**



Envisat Global Monitoring Mode

ENVISAT ASAR: Global Monitoring Mode (GMM) - 1 km

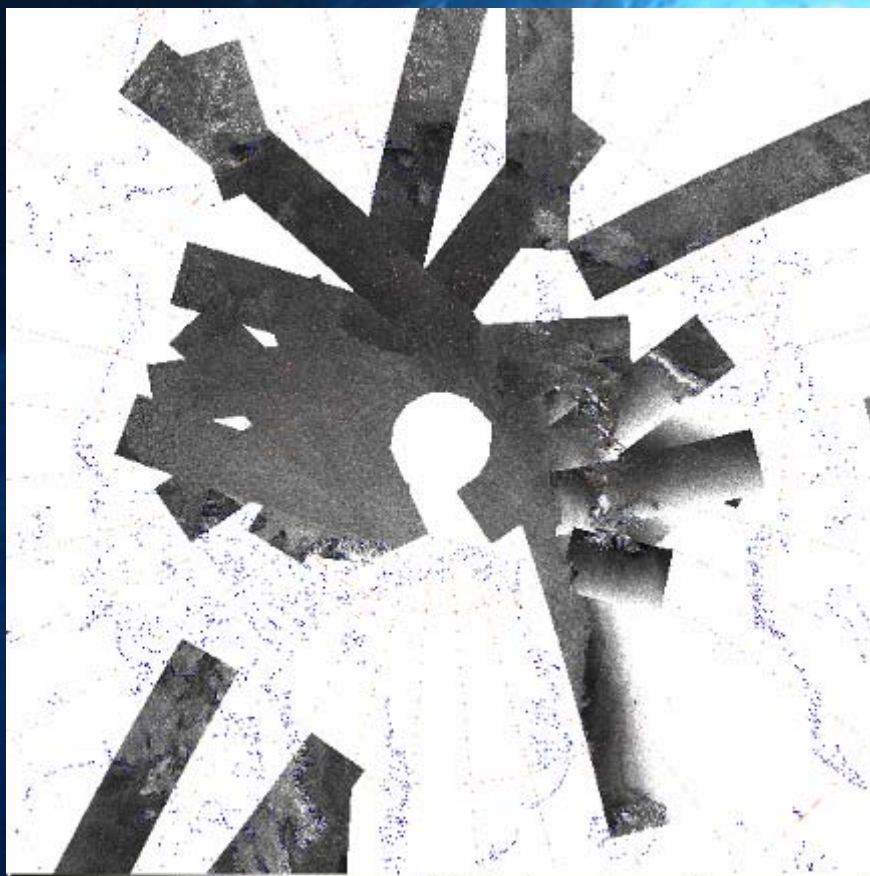


- Daily Mosaic; free access
- Very Useful for Antarctic Iceberg database
- Additional data source for the North and South daily ice edge and analyses

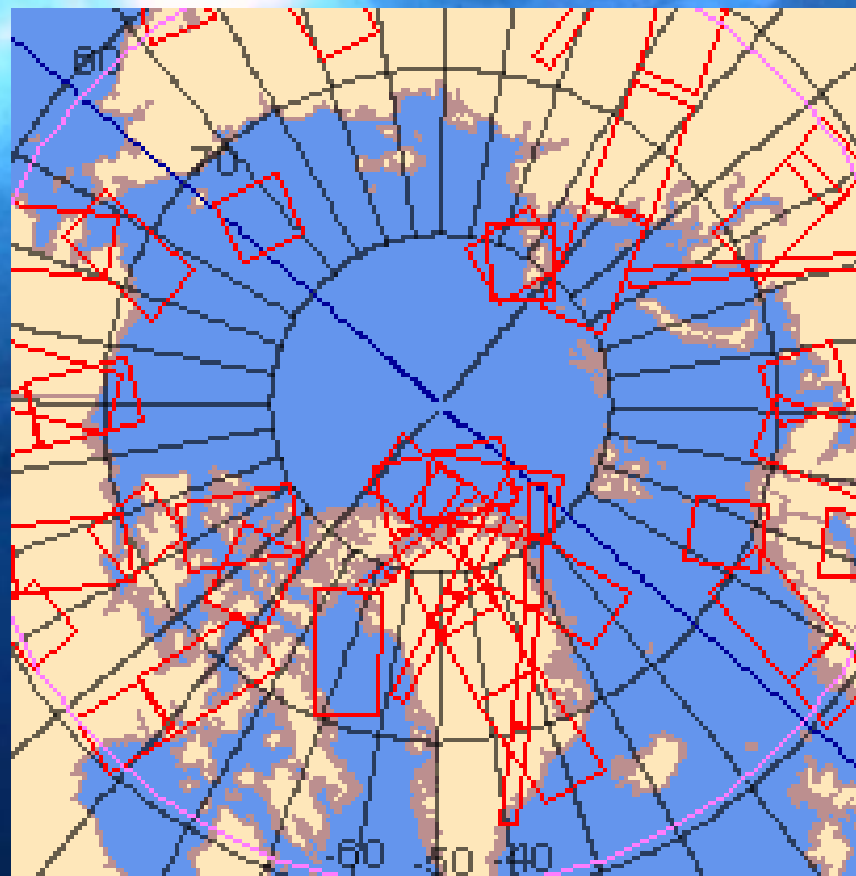


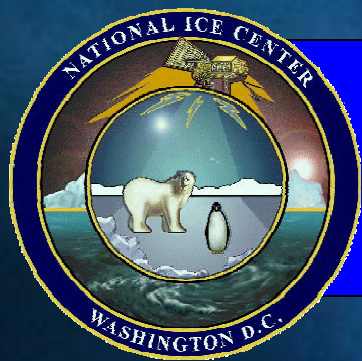
Arctic ASAR Coverage One day: 16 Jan 2006

Global Monitoring mode



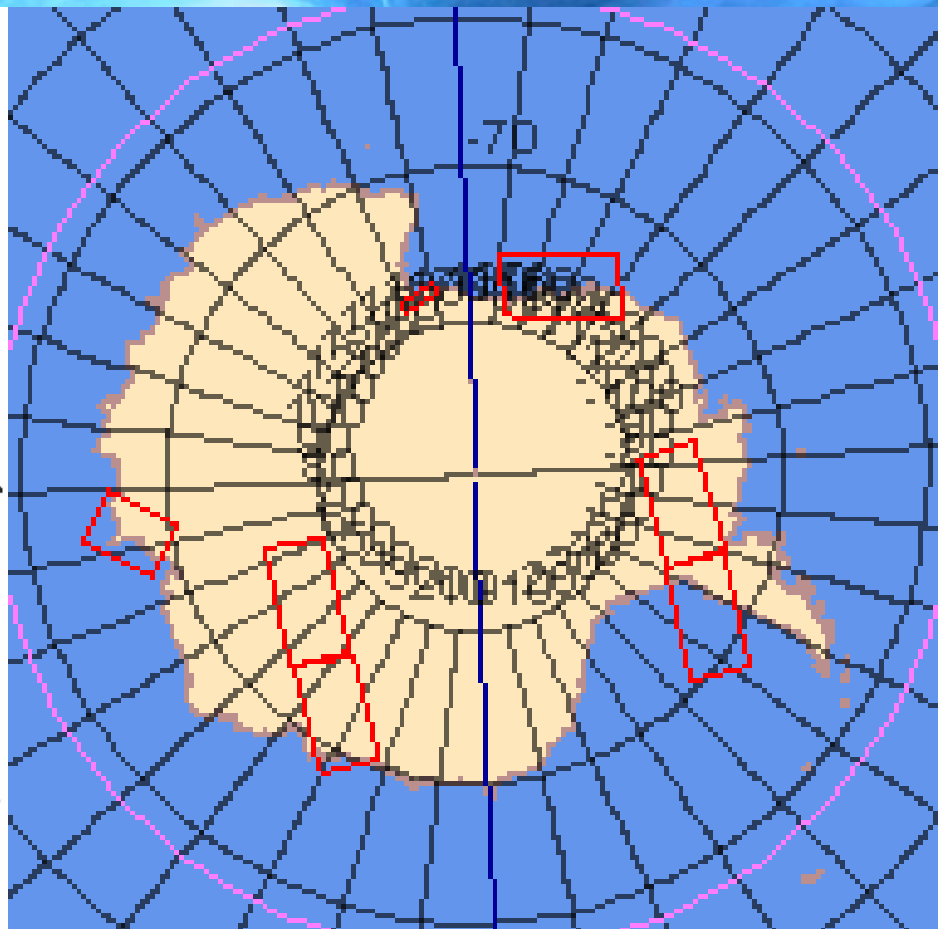
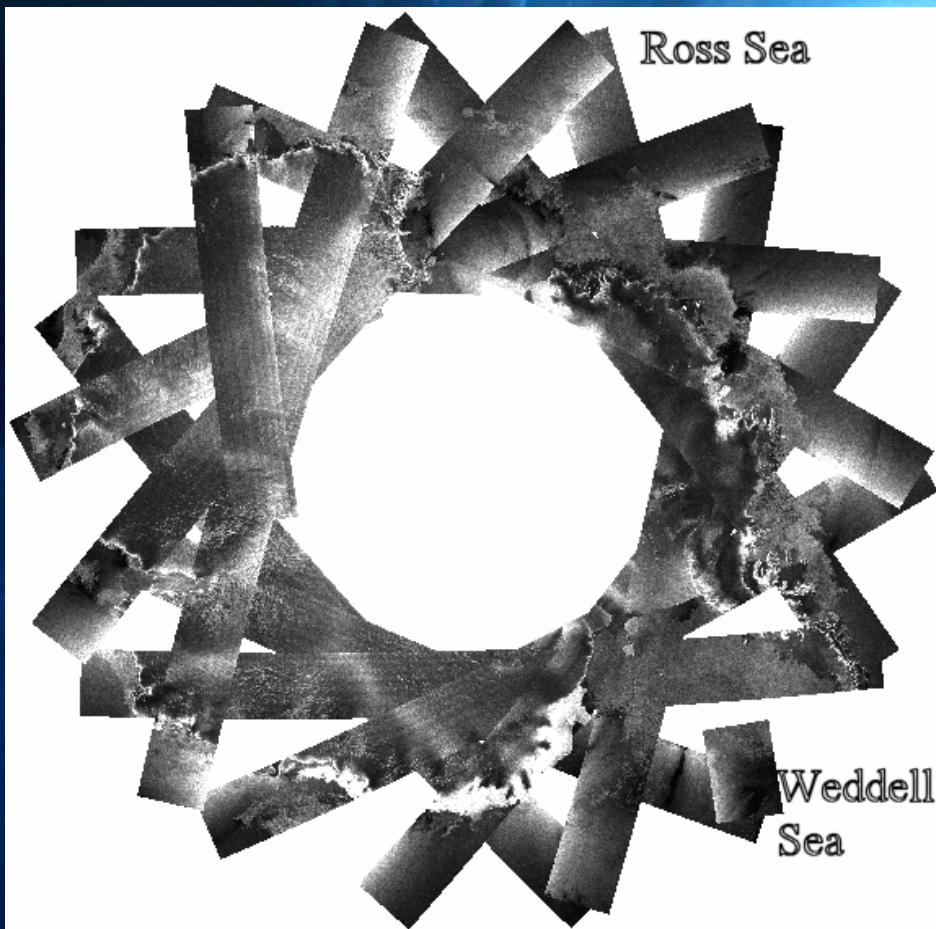
High resolution ASAR modes

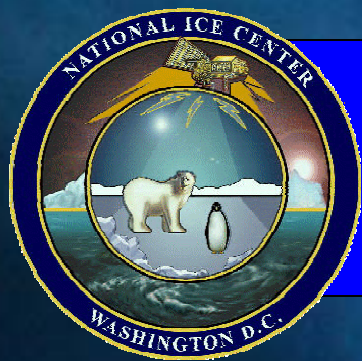




Antarctic ASAR coverage

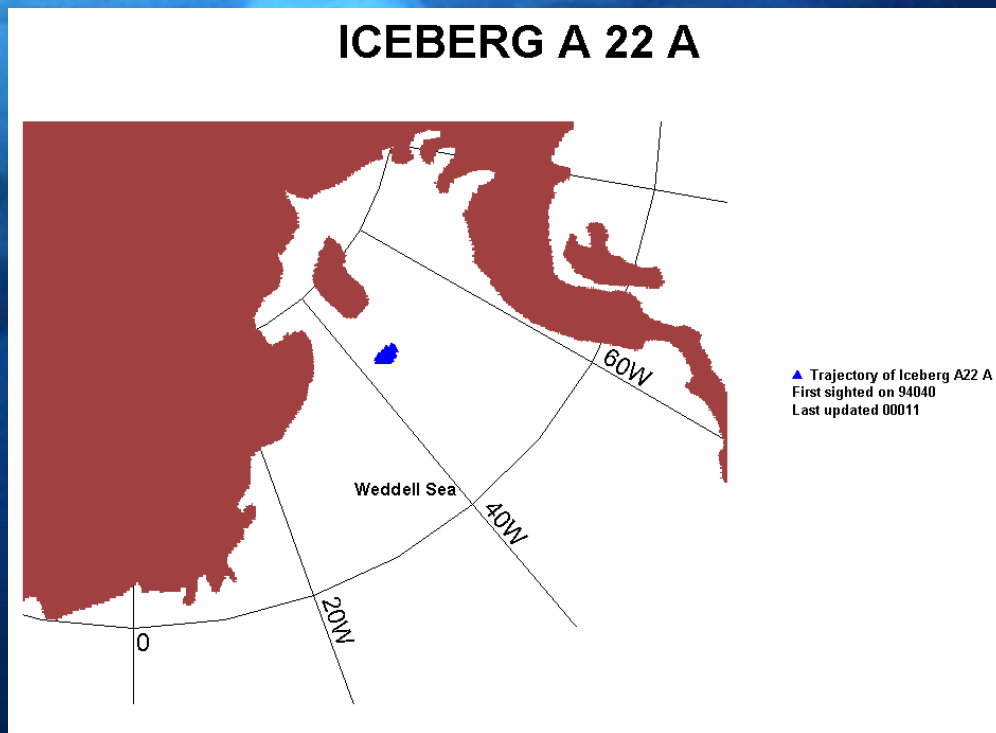
One day: 16 Jan 206

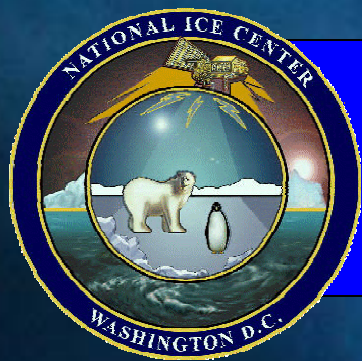




NIC Antarctic Bergs

- NIC website currently logs 44 icebergs in the Antarctic region
- Last updated position given by source used (as of 2/20/07)
- Envisat ASAR GMM: 31
- DMSP OLS: 4
- MODIS: 9

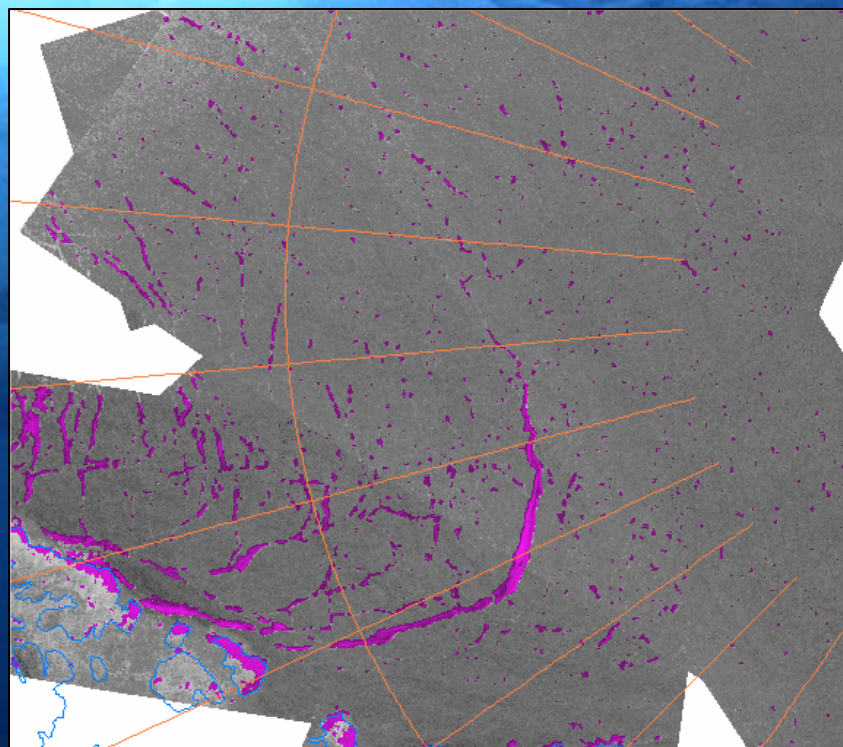




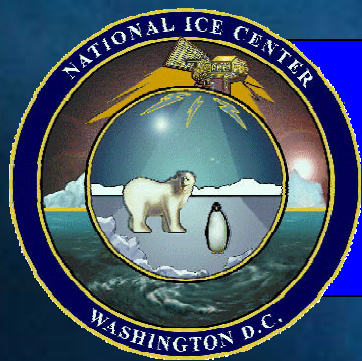
NIC Fractures, Leads and Polynyas Product and GMM



NIC FLAPS Product



Vexcel UK lead detection for 20th November 2004

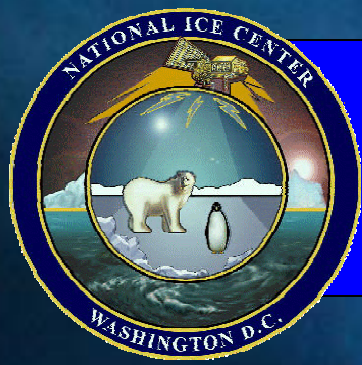


GMM Ice motion

- **GM mode ice motion algorithm:**
- Comparison with International Arctic Buoy Programme (IABP).
- RMS differences between the u- and v- components of drift amounts to 2.3 and 2.4 km respectively. This represents an improved accuracy over ice drift derived from QuikSCAT or SSM/I.

• Vexcel UK Ice motion computed between data acquired on 7th & 9th Jan 2006





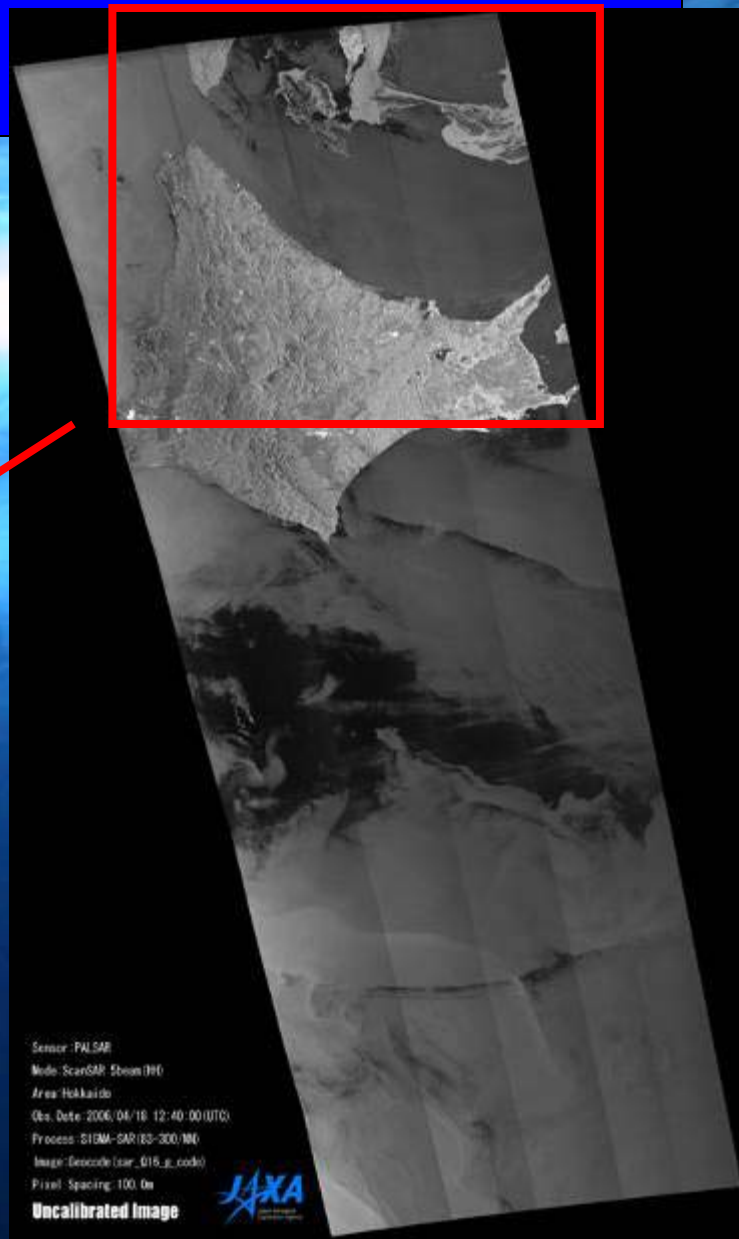
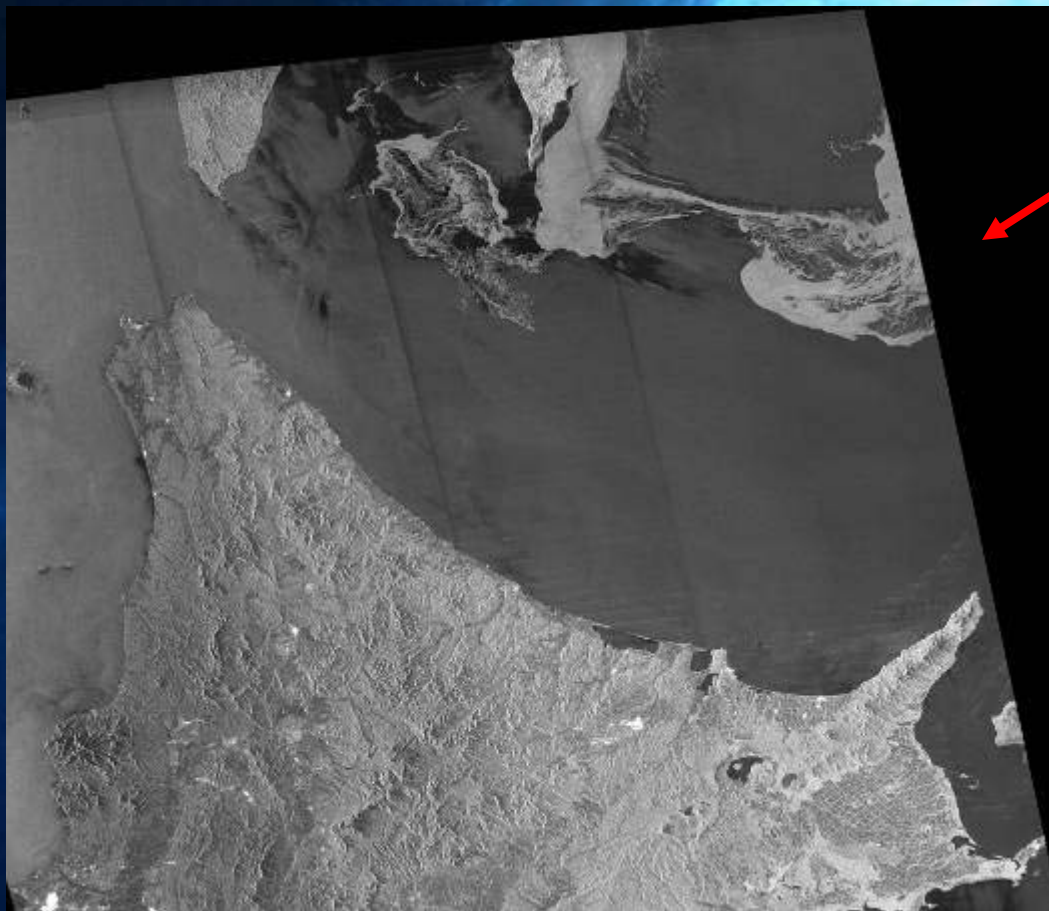
ALOS Mission Status

ALOS PALSAR (JAXA)

- L-Band w/ polarimetric modes
- Some calibrated data available since October 2006
- ASF Reception – ALOS Americas Data Node to provide for NRT data over Alaska mask
- Only non-NRT data available as of now
- Access to ASF data order desk provided
- NOAA agreement for 5 frames/day for NIC
- NASA-lead interagency ALOS consortium formed to get bulk data pricing
- NOAA (NESDIS/OSDPD) to join consortium
- JPL L-band sea ice characterization study funded



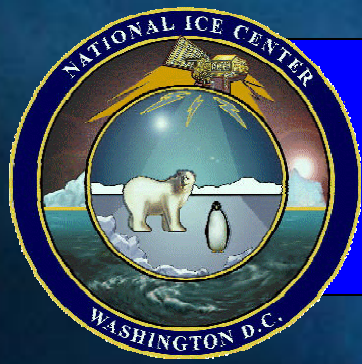
ALOS Data



Sensor: PALSAR
Mode: ScanSAR: StripMap
Area: Hokkaido
Obs. Date: 2006/04/16 12:40:00 (UTC)
Process: S10M-SAR/IS-300/104
Image Geocode (sar_016_g_code)
Pixel Spacing: 100.0m

Uncalibrated Image



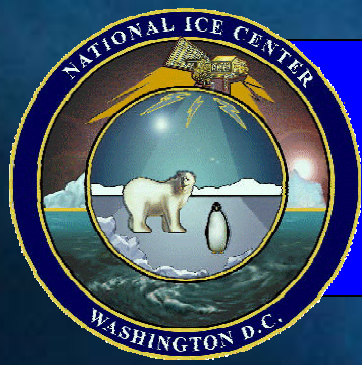


Sentinel-1 Mission Status

Sentinel-1 SAR (ESA)

- Mission Study input provided
- 2-satellite baseline constellation considered
- 1st launch scheduled for 2011
- Continuity for ASAR, Backup for RADARSAT-2
- ESA coordinating with RADARSAT-Constellation and Canadian Stations*

* Should the U.S. join the discussion?



RADARSAT-Constellation Mission Status

RADARSAT- Constellation SAR (CSA)

- **C-band 3 satellite constellation**
- **Mission Study / User Requirements input provided**
- **Launches start on 2011**
- **Multiple SAR satellites in constellation**
- **Follow-on to RADARSAT-2**
- **Meet government operational monitoring requirements***
- **International Workshop Spring 2007**

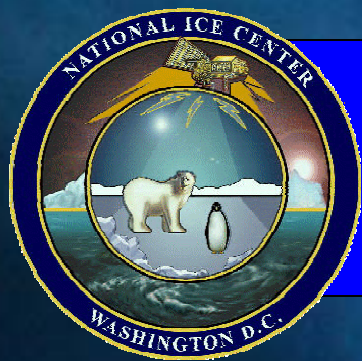
*** Shouldn't the U.S. express interest in partnering?**



U.S. SAR Mission Status

InSAR (NASA)

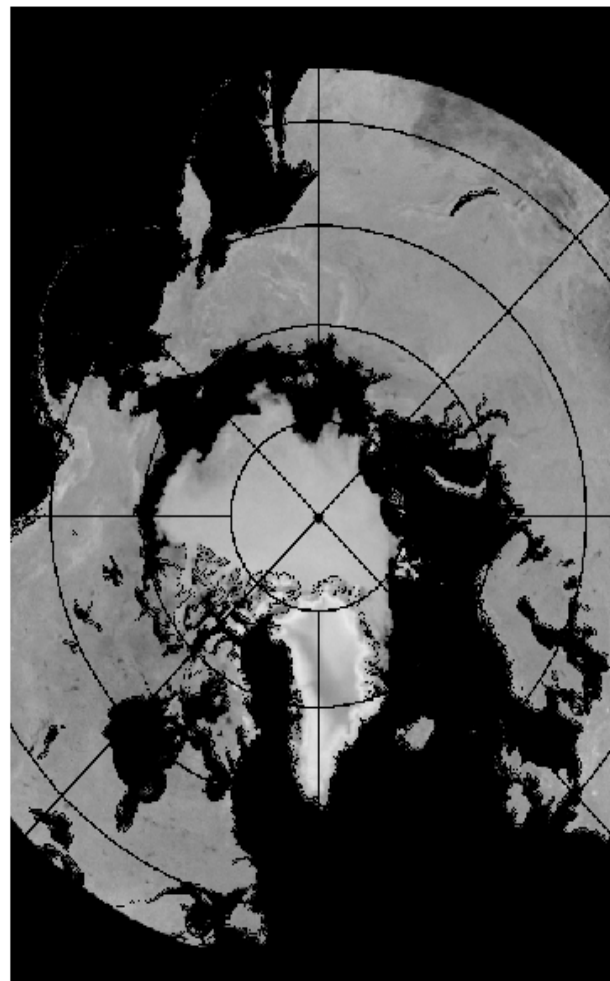
- Decadal Study Recommendations are published
- L-band interferometric SAR combined with a Laser altimetry mission recommended
- NASA-NOAA discussions on new technologies
- Exploitation of NPOESS SafetyNet ground system



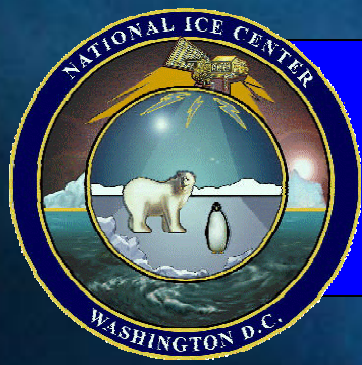
Scatterometer - QuikSCAT

- **QuikSCAT images are routinely available and used on the Operations' floors**
- **Guaranteed coverage**
- **Used similarly to Passive Microwave – large scale ice edge mapping, some typing in winter**
- **Detects concentration of about 10% -- close to SAR ice edge**

Northern Hemisphere Quikscat
00z 9/18/2005



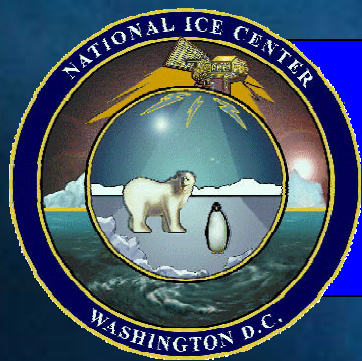
Ice Mask



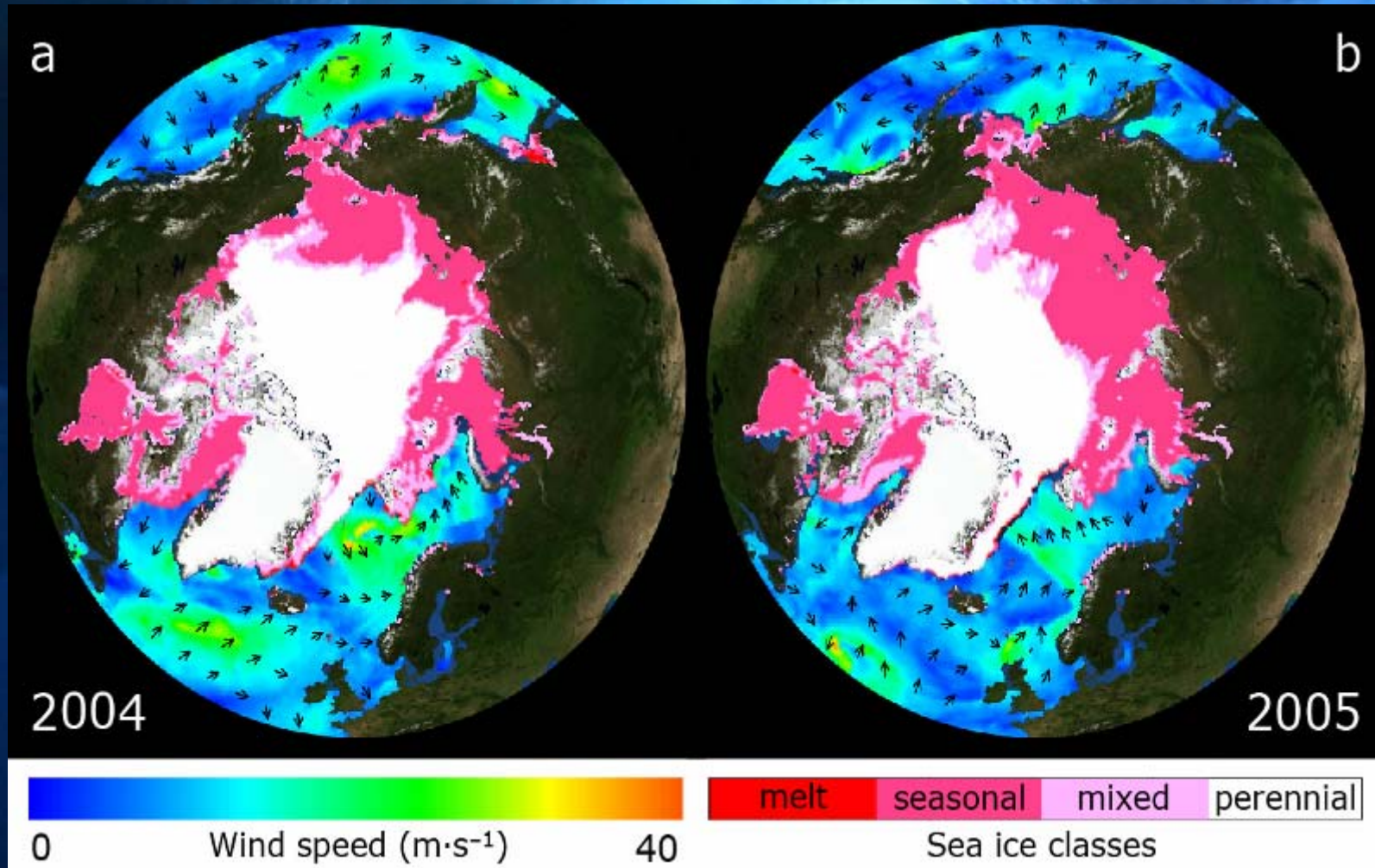
Scatterometer Missions

- **QuikSCAT Automatic ice detection – MYI, FYI, Melt, Freeze-up (Nghiem 2005 & 2006 - JPL)**
- **QuikScat Integration of winds and ice observations**
- **METOP's ASCAT**
 - **C-band scatterometer**
 - **Launch delayed**
- **Indian Oceansat -2 – May provide continuity to QuikSCAT observations**





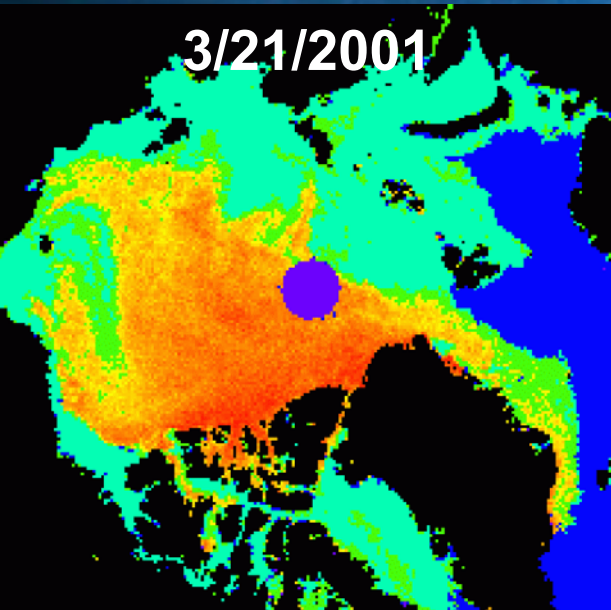
QuikSCAT Sea Ice and Wind Vectors



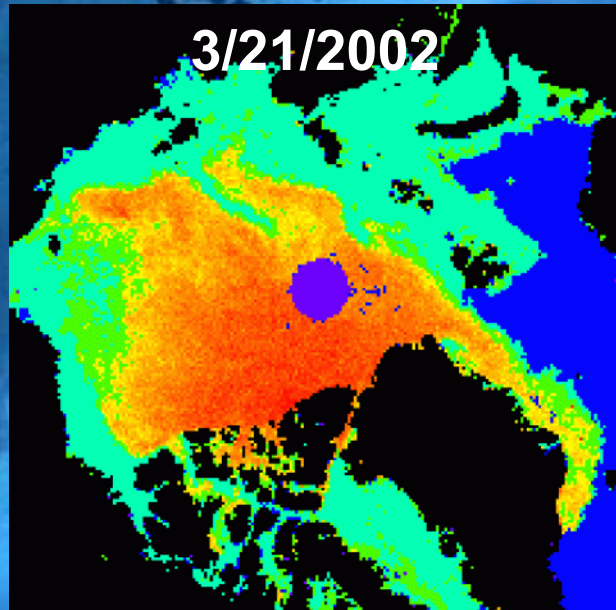
Sea Ice Classes on Spring Equinoxes

Ice classes: **Perennial (yellow-red)**, **seasonal (cyan)**, **mixed (green)**

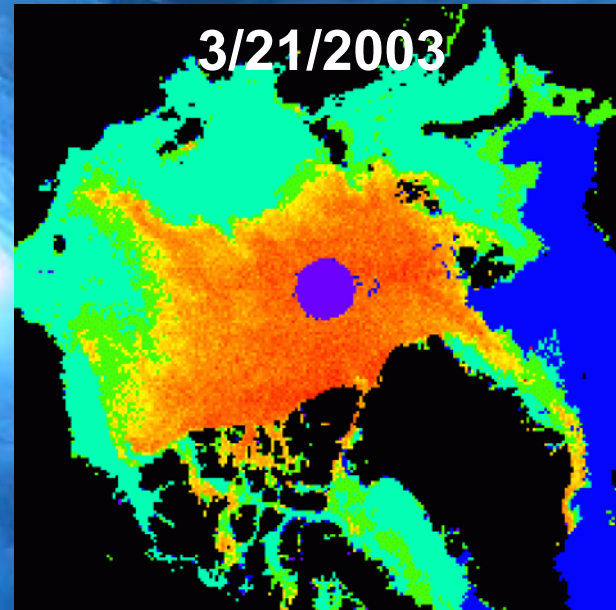
3/21/2001



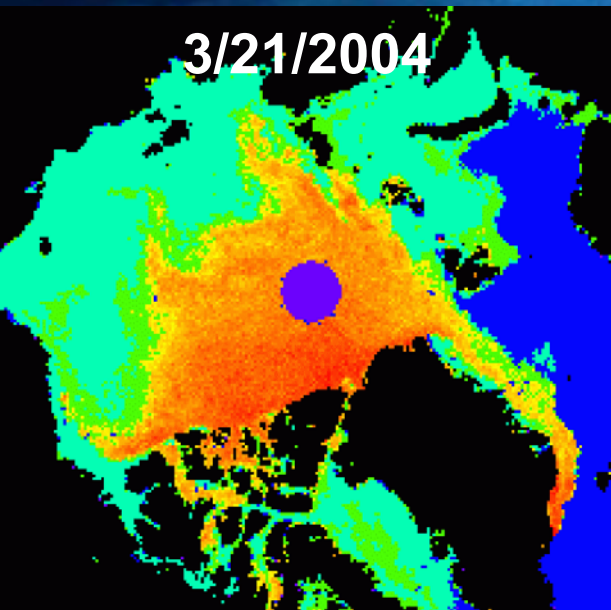
3/21/2002



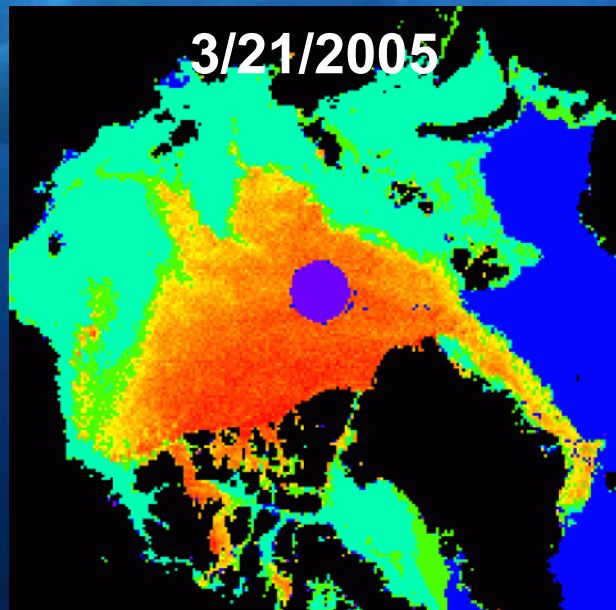
3/21/2003



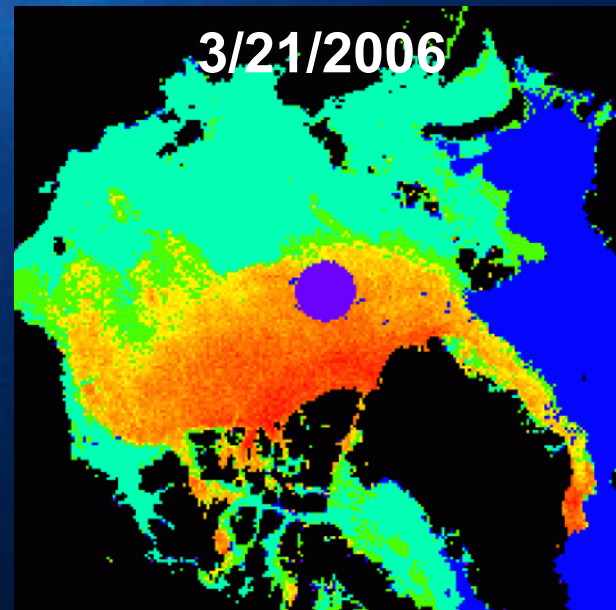
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3/21/2005

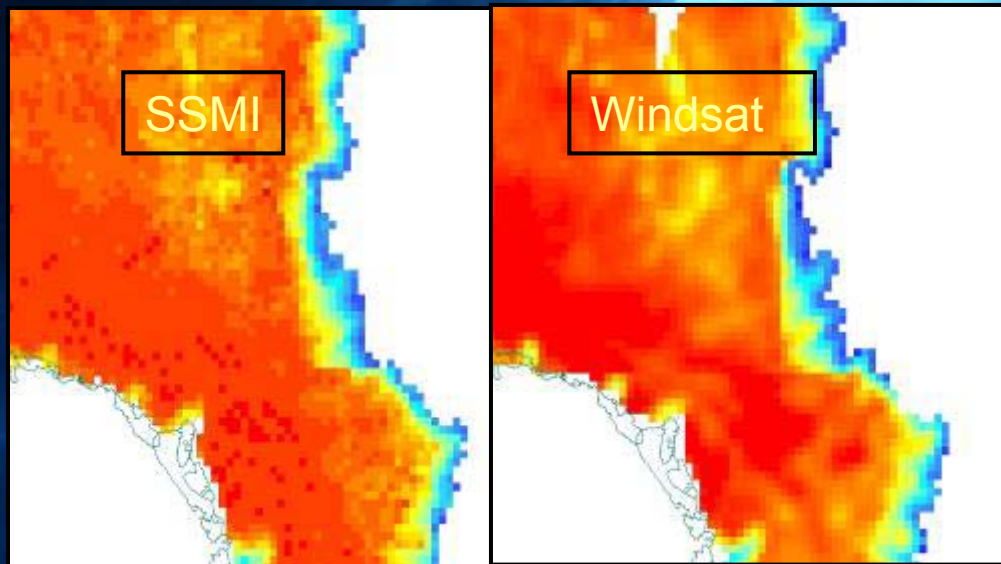


3/21/2006





WINDSAT Sea Ice Products Supplement SSM/I



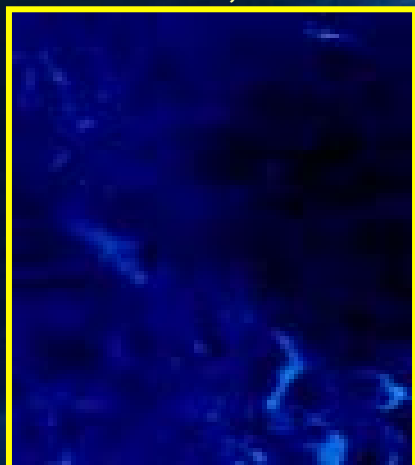
- Transitioning NRL-DC implementation of SSM/I-like sea ice algorithms on WindSat
- Outperforms SSM/I in certain areas for identifying Ice Edge
- Improved concentrations
- Area Specific
- Validation in progress



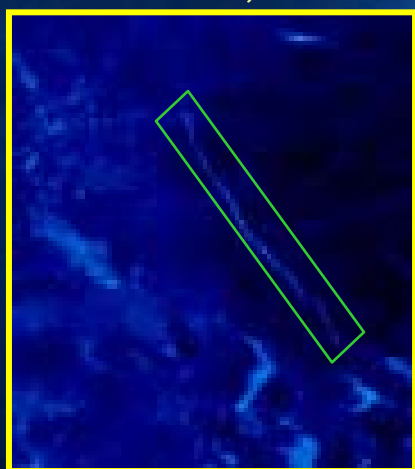
AMSR-E Motion Products

Univ. of Colorado / National Snow and Ice Data Center
(NSIDC)

89V GHz, 8 Mar

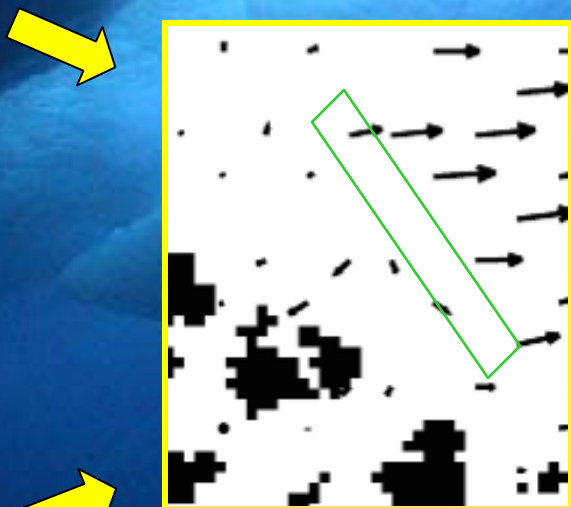


89V GHz, 9 Mar

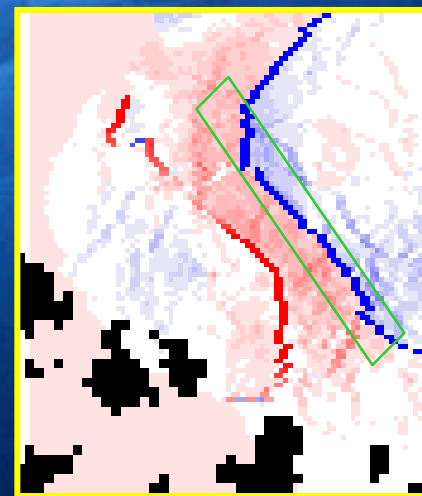


A simple thermodynamics and ice redistribution model can estimate ice growth in the lead and the amount of ridging to the southeast.

Sea Ice Motion, 8-9 Mar



24-hour Divergence
8-9 Mar



Divergence

Convergence

Divergent ice motion results in the formation of the lead.

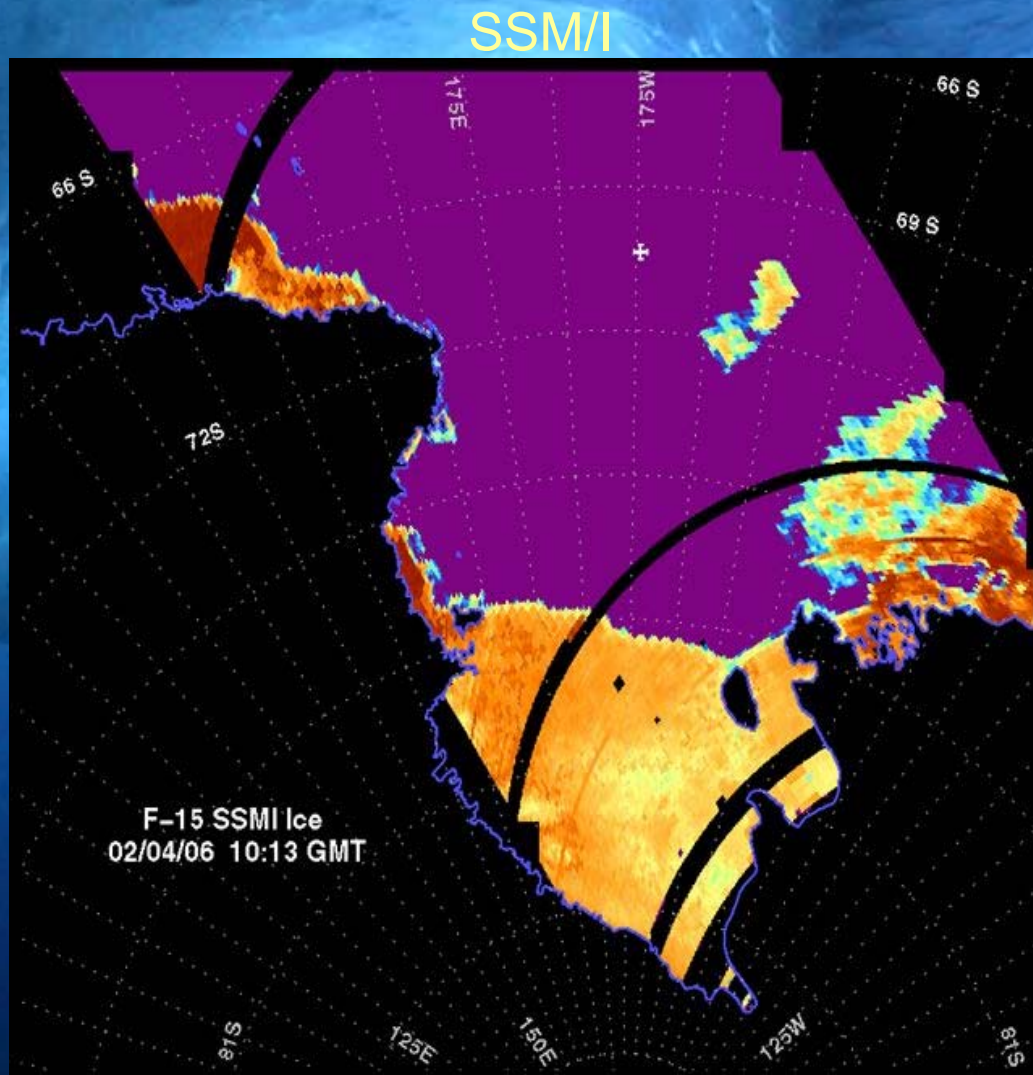
Convergent motion (red) to the southeast (left in the image), is an area where ridging is occurring.



Passive Microwave Observations

Seasonal limitations well-known – limits tactical use during the most critical operational season

Cross indicates the location of R/V Palmer over an SSM/I sea ice concentration product near the time when it encountered MY ice in the Ross Sea and lost a magnetometer.

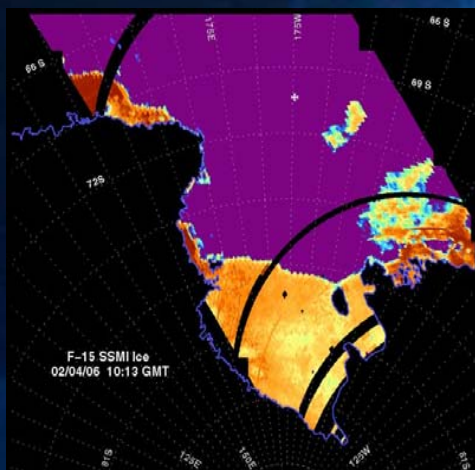




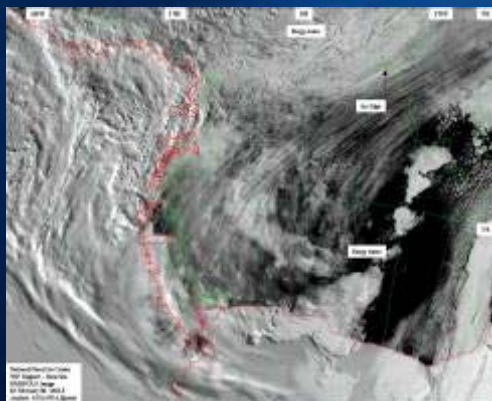
Passive Microwave Observations

Seasonal limitations well-known – limits tactical use during the most critical operational season

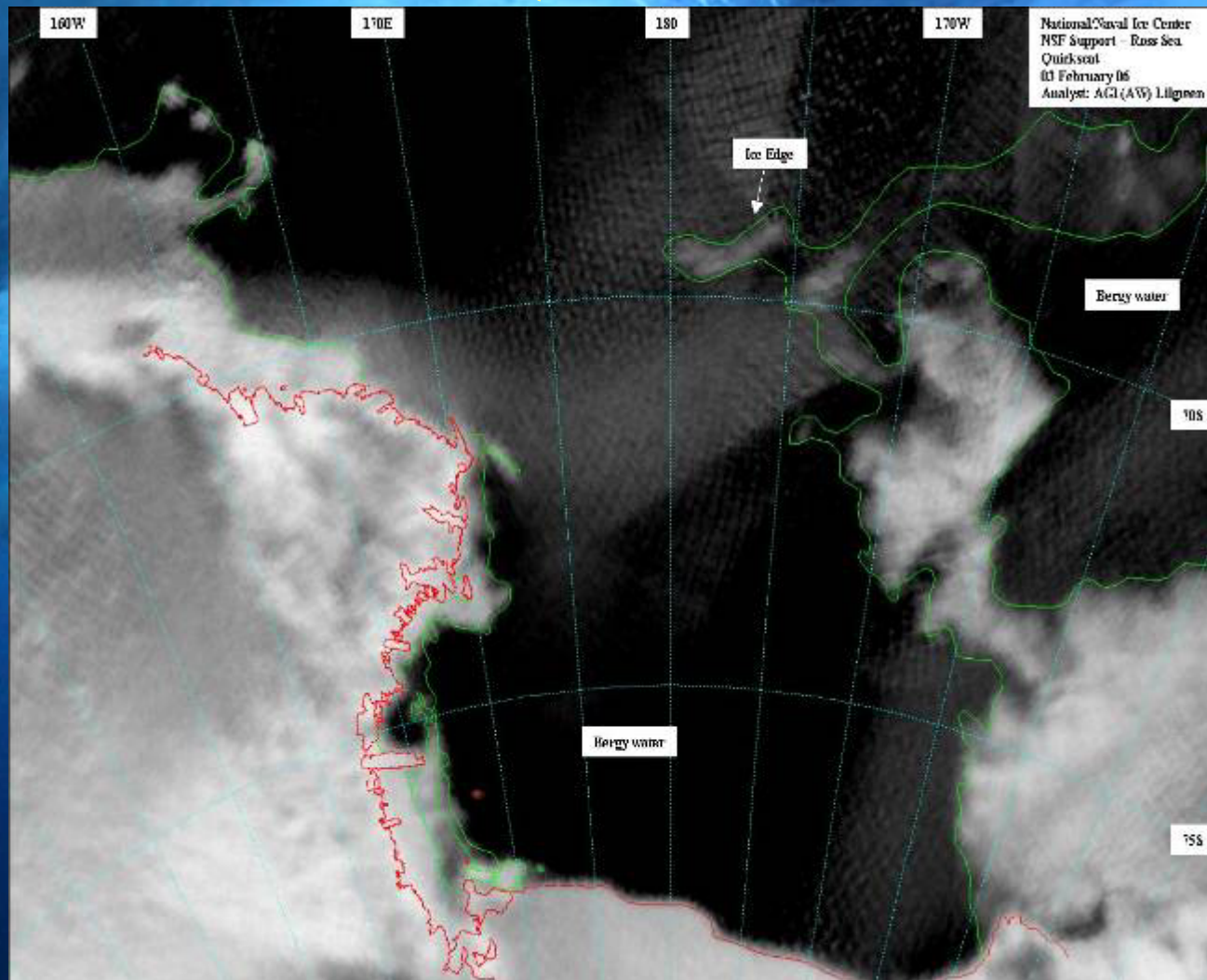
SSM/I

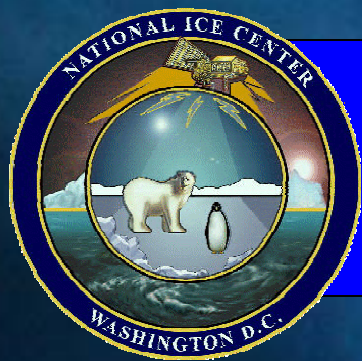


OLS

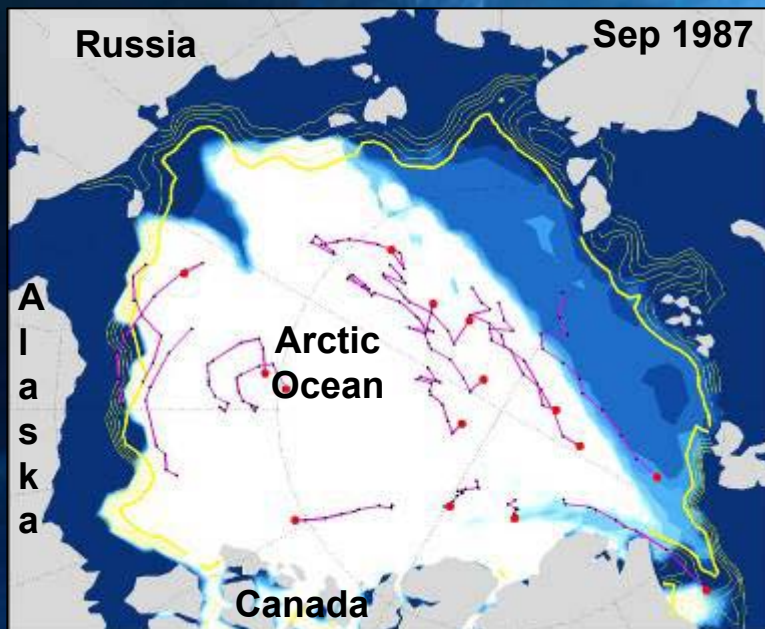


QuikSCAT

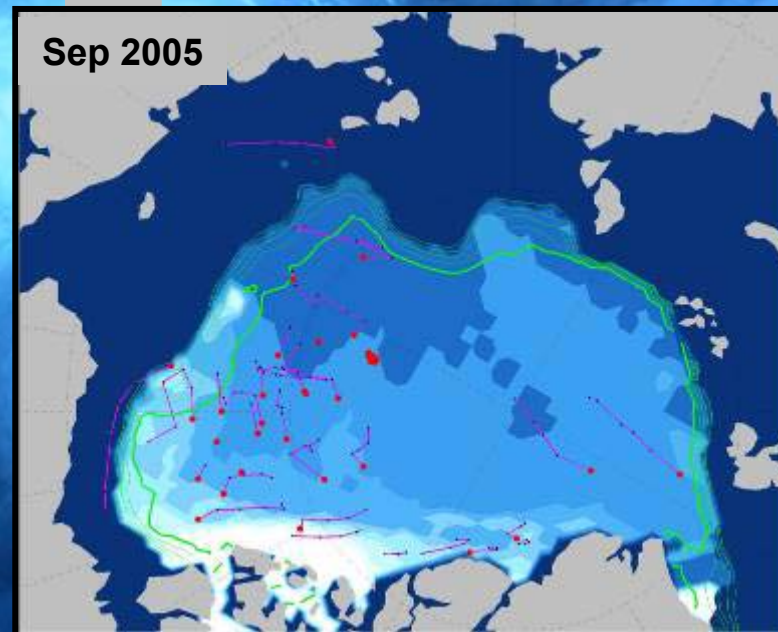




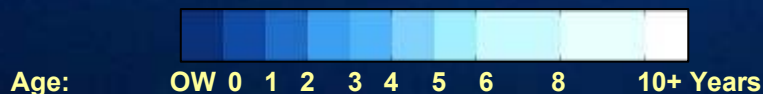
Buoy-based Age of Sea Ice



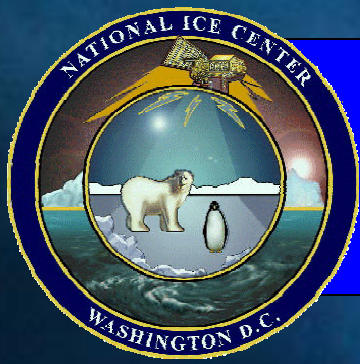
- More older, thicker ice.
- Later onset of melt, earlier onset of freeze.
- Winter and summer forcing is more important.



- Less older, thicker ice.
- Earlier onset of melt, more absorbed insolation, later onset of freeze, longer melt season...
- **POSITIVE FEEDBACKS!**

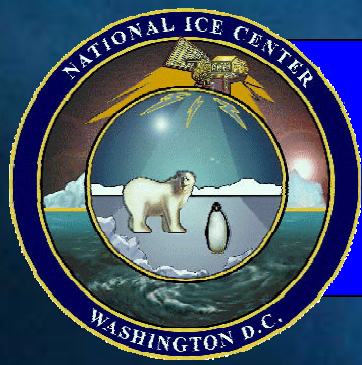


(Rigor et al., 2004)



US Interagency Buoy Program (USIABP) International Arctic Buoy Program (IABP)

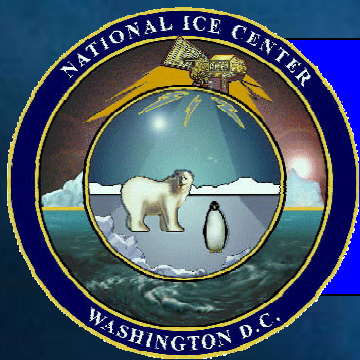
- **NIC co-manages the US Interagency Buoy Program with UW/PSC and coordinates US Arctic buoy activities within the IABP**
- **Arctic buoy data are critical to NWS and many other users providing weather forecasts, NWP, and climate modeling**
- **Arctic buoy data are used by NIC for operational ice chart analysis and supports the validation of satellite observations and sea ice models**
- **As of January 2, 2007, there are 48 buoys reporting from 35 different locations across the Arctic**
- **White Trident Mission deploys buoys for USIABP/IABP over the Arctic from a C-130 (Possible final drop AUG07 / exploring alternatives)**



USIABP Funding

- **NOAA (variable \$\$, SVP buoys, Argos costs, SBIR, NCTP and NESDIS research support)**
- **NASA funding (\$100k/year Cryospheric Program)**
- **NSF funding (\$200K USIABP/IABP funded proposal now under NSF AON)**
- **ONR funding (being re-established at \$25K/year and proposal to Ice-Diminished Arctic BAA under review)**
- **NAVO (White Trident Mission buoy deployments)**

IABP Annual Meeting to be hosted by NIC tentatively on 24-25 May 2007



Buoy Deployments and Distribution

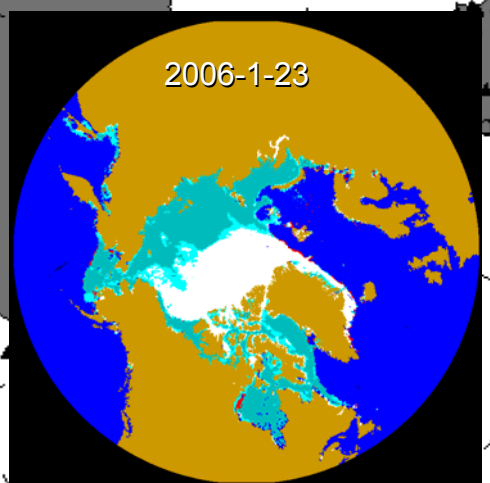
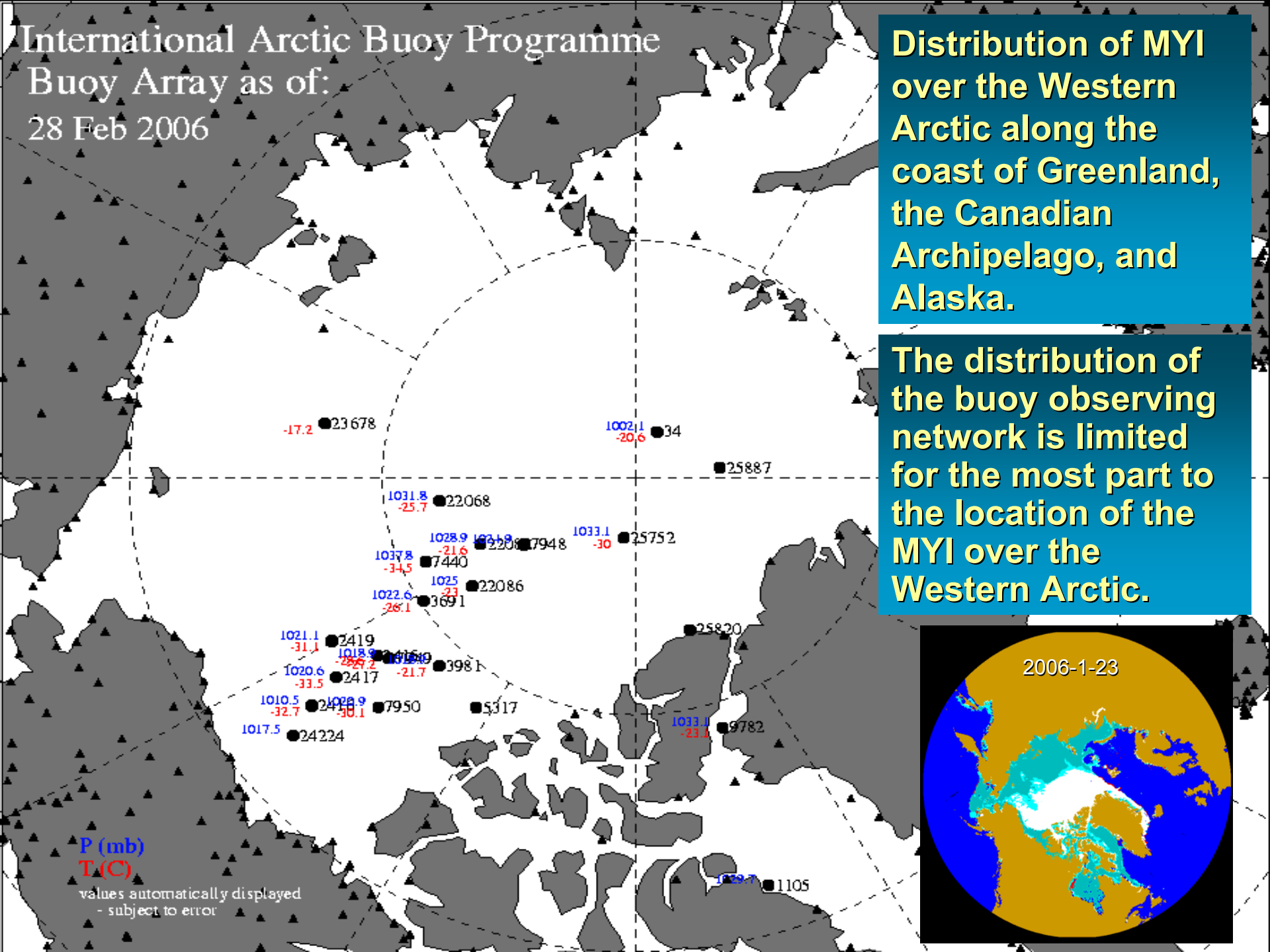
Weather Reporting Arctic Buoys



International Arctic Buoy Programme Buoy Array as of: 28 Feb 2006

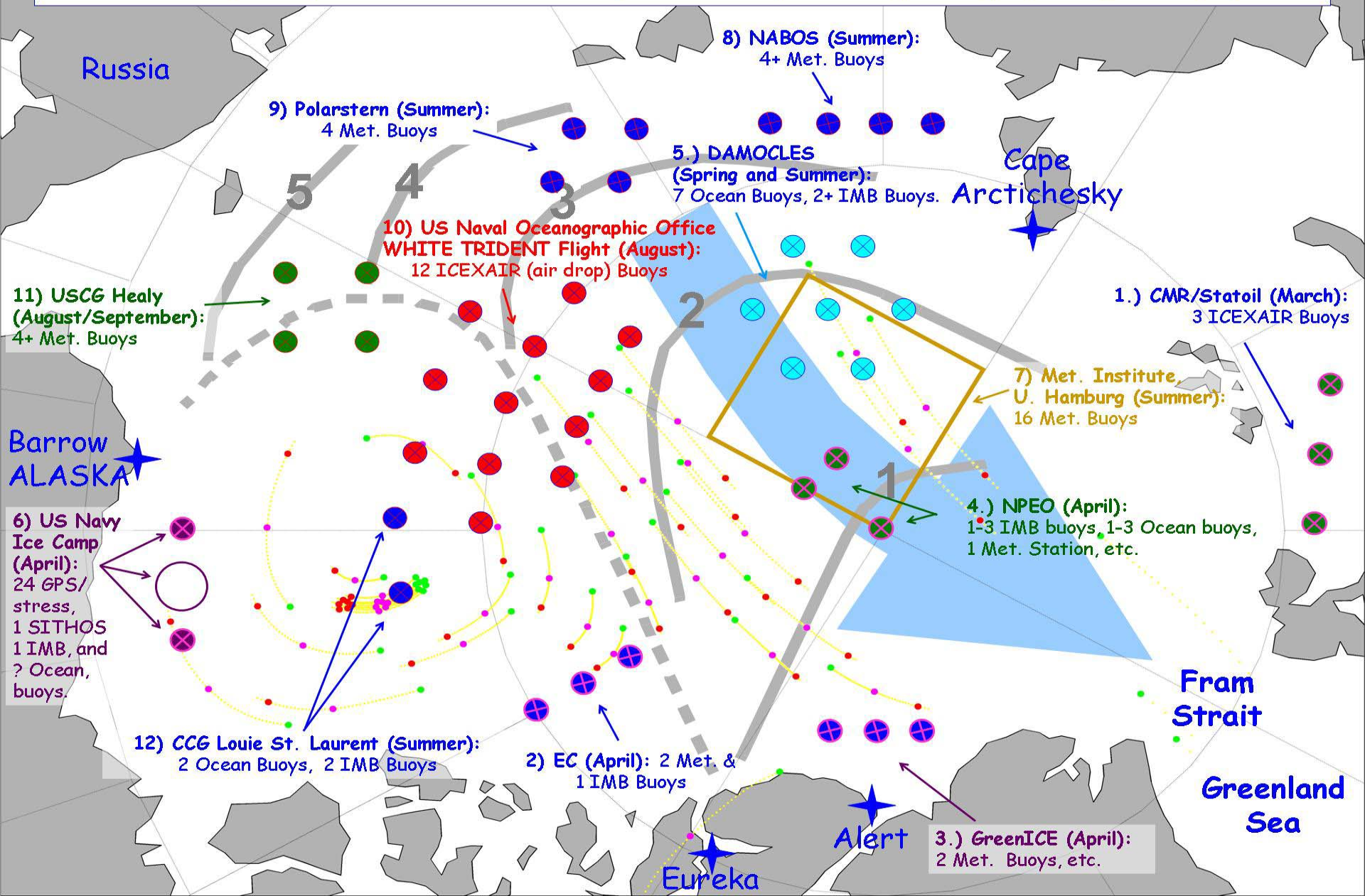
Distribution of MYI over the Western Arctic along the coast of Greenland, the Canadian Archipelago, and Alaska.

The distribution of the buoy observing network is limited for the most part to the location of the MYI over the Western Arctic.



IABP Deployment Plans for 2007 & IPY

The small green dots show the location of drifting buoys reporting on November 6, 2006. The yellow tracks show the expected drift of these buoys to September 1, 2007, with dots showing their estimated positions on April 2007 (pink) and August 2007 (red).



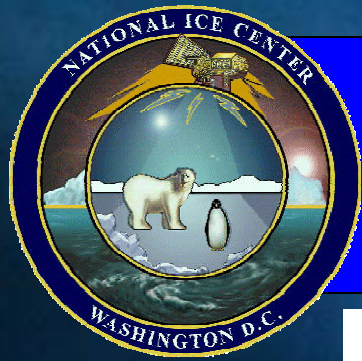


SBIR Inexpensive Airborne Expendable Ice Buoys (AXIB)

- Provides a low cost aircraft droppable seasonal buoy (with also surface deployment capability)
- Sensors/measurements include surface air temperature, surface pressure, GPS location, and Argos transmitter
- Operation in ice and open water through freeze/thaw cycles
- LBI, Inc. submitting proposal for phase II SBIR funding



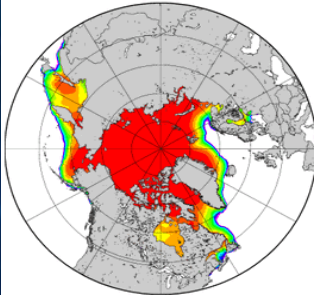
Provide alternatives to White Trident C-130 drops over MYI



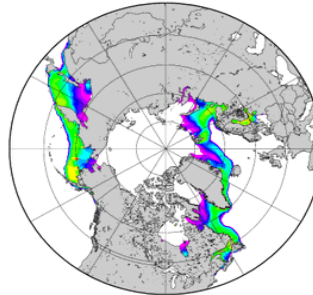
Operational Transition and Validation PIPS 3.0 Underway

PIPS 3.0 Ice Concentration (%)

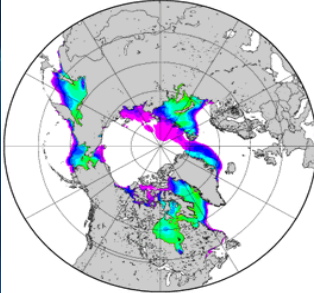
Total



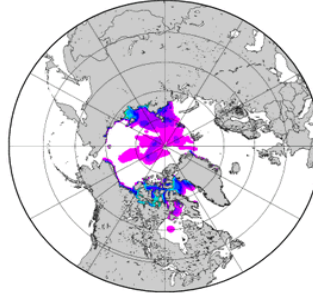
Category One



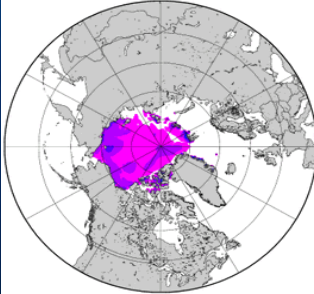
Category Two



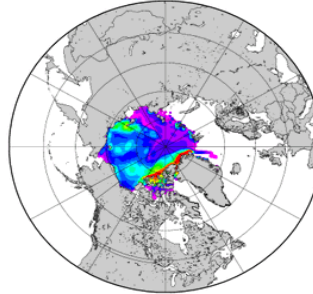
Category Three



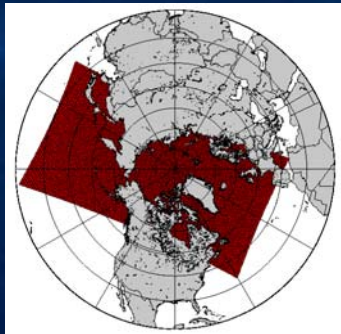
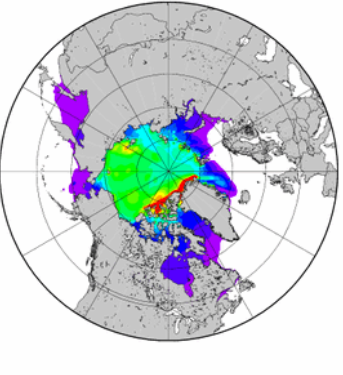
Category Four



Category Five



PIPS 3.0 Ice Thickness (m)



PIPS 3.0 improvements

- Multi-category, linearly remapped ice thickness
- Energy-based ice ridging
- New ability to predict areas of lead opening/closing for the warfighter, ice edge location, ice thickness and ice drift

NIC and CIS (under NAIS) are providing validation of PIPS 3.0 output for operational use

Category 1 0.000 – 0.644

Category 2 0.645 – 1.391

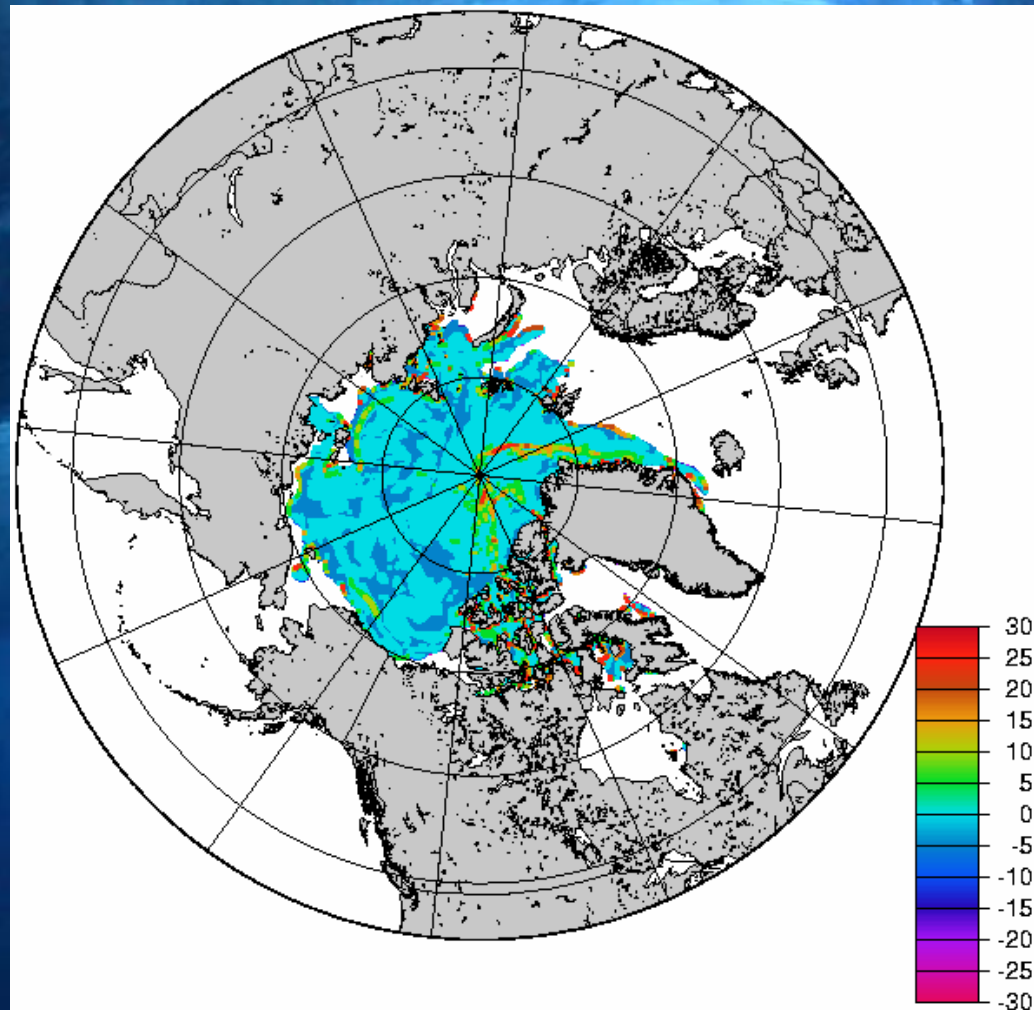
Category 3 1.392 – 2.470

Category 4 2.471 – 4.567

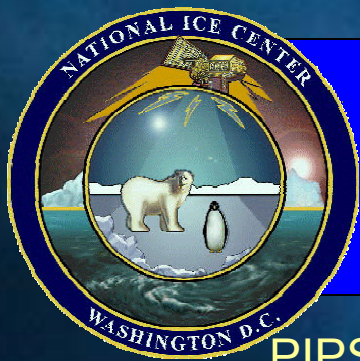
Category 5 4.568 – 9.333



PIPS 3.0 Divergence/Convergence



Will help identify areas where ridging, leads, or fractures may occur.

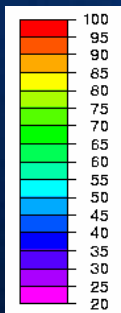
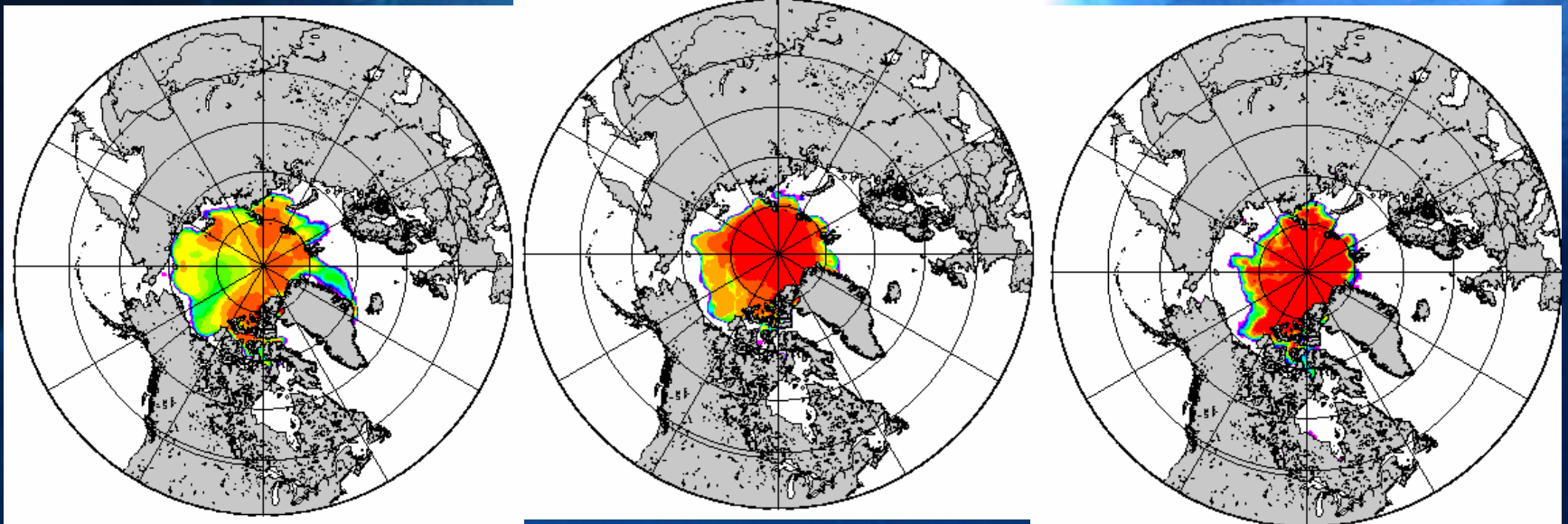


Ice Concentration – September 2003

PIPS 2.0
(w/o SSMI assimilation)

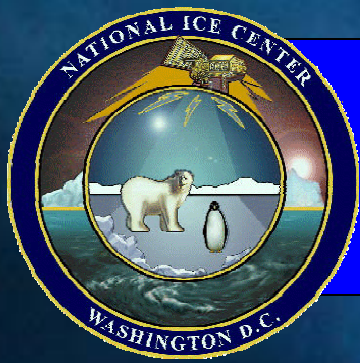
PIPS 3.0
(w/o SSMI assimilation)

SSMI
(observations)



Better agreement between PIPS 3.0 and SSMI ice concentration versus PIPS 2.0 and SSMI is consistent across all months of 2003

PIPS 2.0 receives T, S and currents from Bryan-Cox ocean model while PIPS 3.0 testing uses global NCOM T&S inputs only.



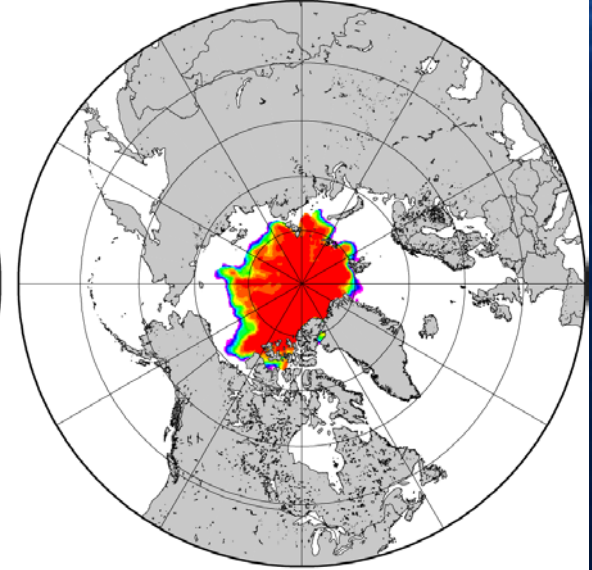
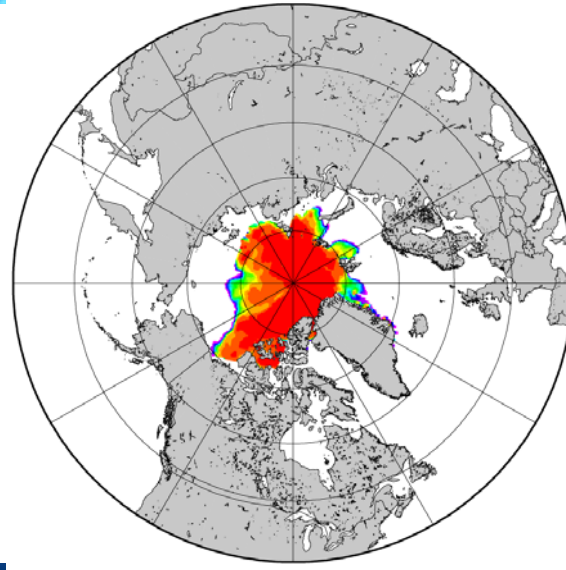
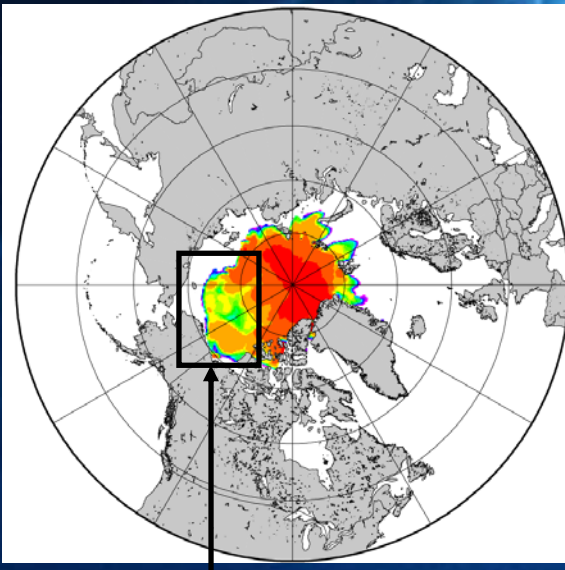
HYCOM and PIPS 3.0 Coupling (35 km)

Sea Ice Concentration
September 2003

PIPS 3.0 stand-alone
(no ocean)

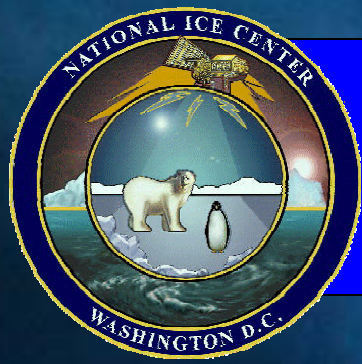
PIPS 3.0 one-way
Coupled of T&S

SSMI
observations



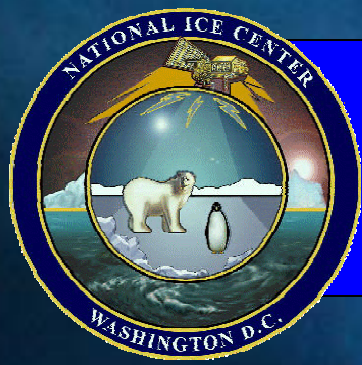
Too much ice

Coupling between the ocean and ice models more properly accounts for the momentum, heat and salt fluxes across the air/sea interface



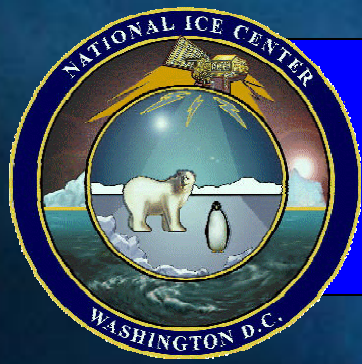
NIC Recent Accomplishments

- **Conducted an International Sea Ice Modeling Workshop At National Ice Center in September 2006**
- **33 Year Arctic Climatology released and recognized as outperforming climatologies based mainly on passive microwave**
- **Developed initial Sea Ice Thickness products for Arctic Submarine Lab**
- **NIC Science historical charts preservation and declassification project have secured paper charts at the National Archives**



Arctic Sea Ice Climatology

- **Arctic climatology from: 2006 National Ice Center (NIC) Arctic sea ice charts**
 - **Data Set 1972 – 2004**
- **NIC 33 year climatology charts published at the National Snow and Ice Data Center (NSIDC)**
- **Data derived from variety of imagery:**
 - **Radar, Visible, Infrared, Passive Microwave**
- **Relatively coarse products in early 1970s**
- **Increase in accuracy with increase in imagery resolution over time**
 - **Digital imagery mid 80s**
 - **RADARSAT Synthetic Aperture Radar (SAR) 1995**



Arctic Sea Ice Climatology

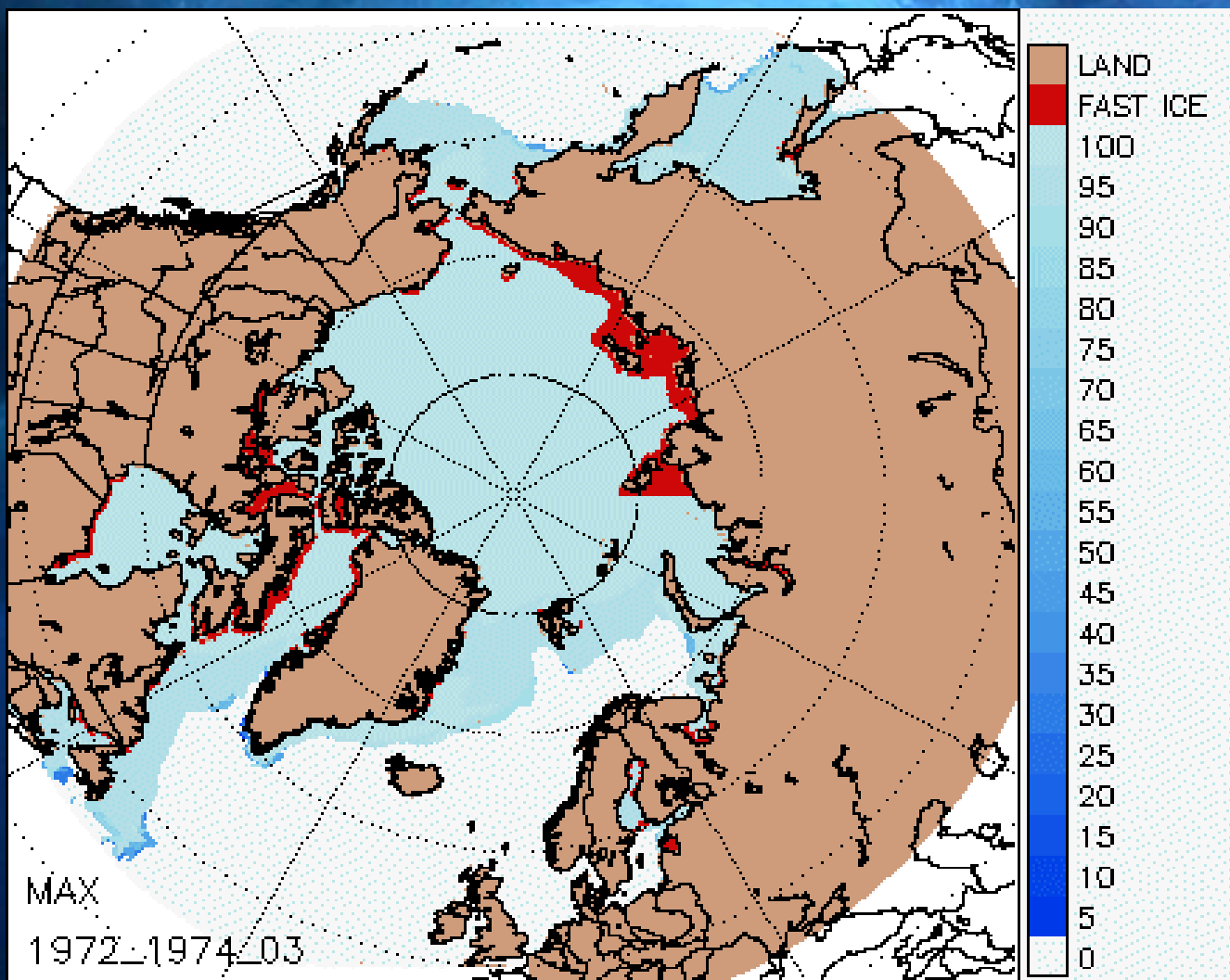
- **Sea Ice Trends**

- Ice extent “. . . Falling below pre-1950 minima after about 1975.”
- Rate of decline in ice extent of “about 3.6% per decade” documented by satellites over the past 20 years
- 35 years of submarine ice draft (ice thickness below waterline) data shows a decline of 35% at the end of summer
- Abrupt loss of 14% of multiyear (older than 1 year) sea ice between 2004 and 2005

- **Maximum ice extent normally occurs in March**
- **Minimum ice extent normally occurs in September**

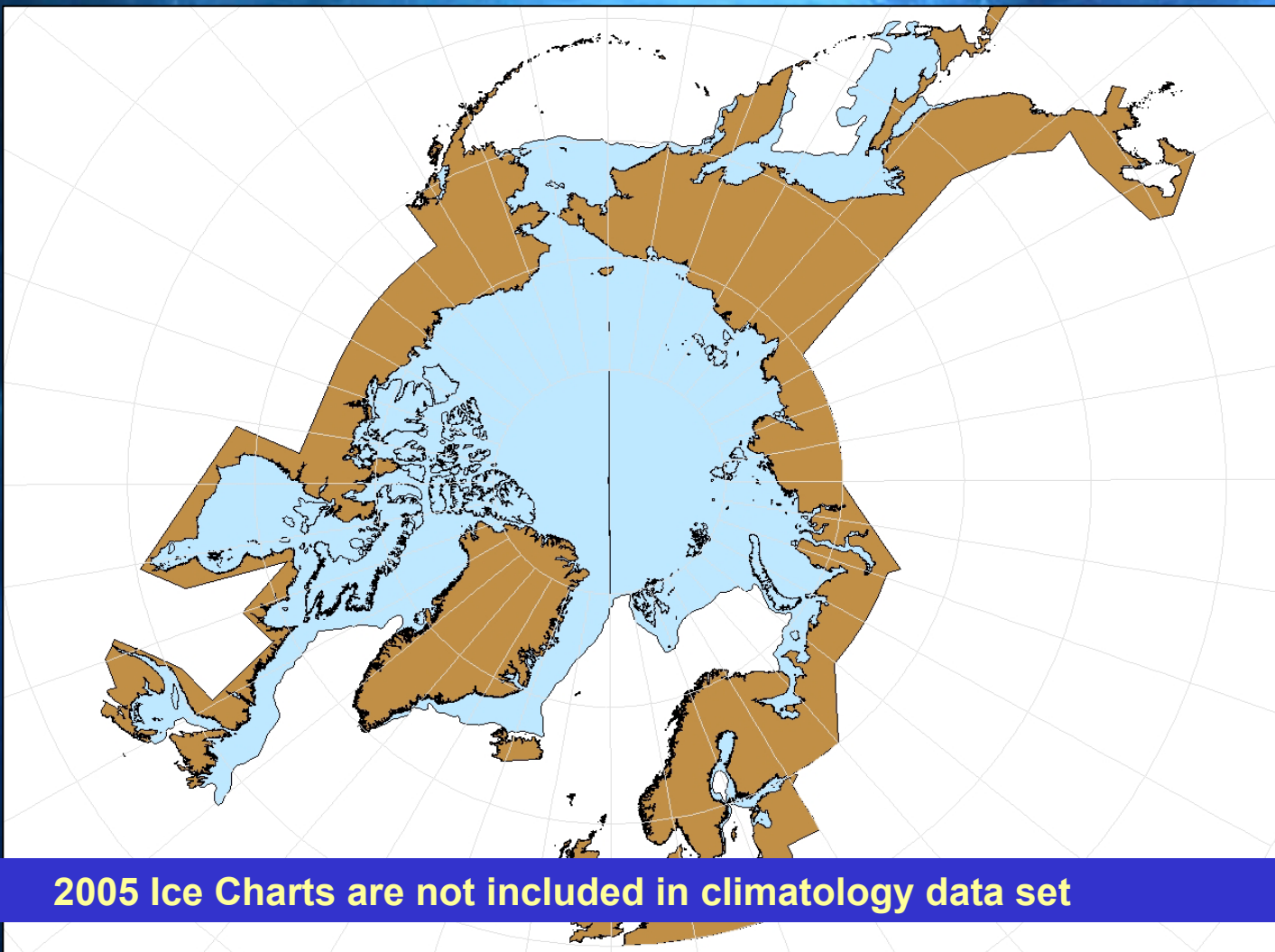


Absolute Maximum Ice Extent animation using entire NIC dataset for March 1972-2004





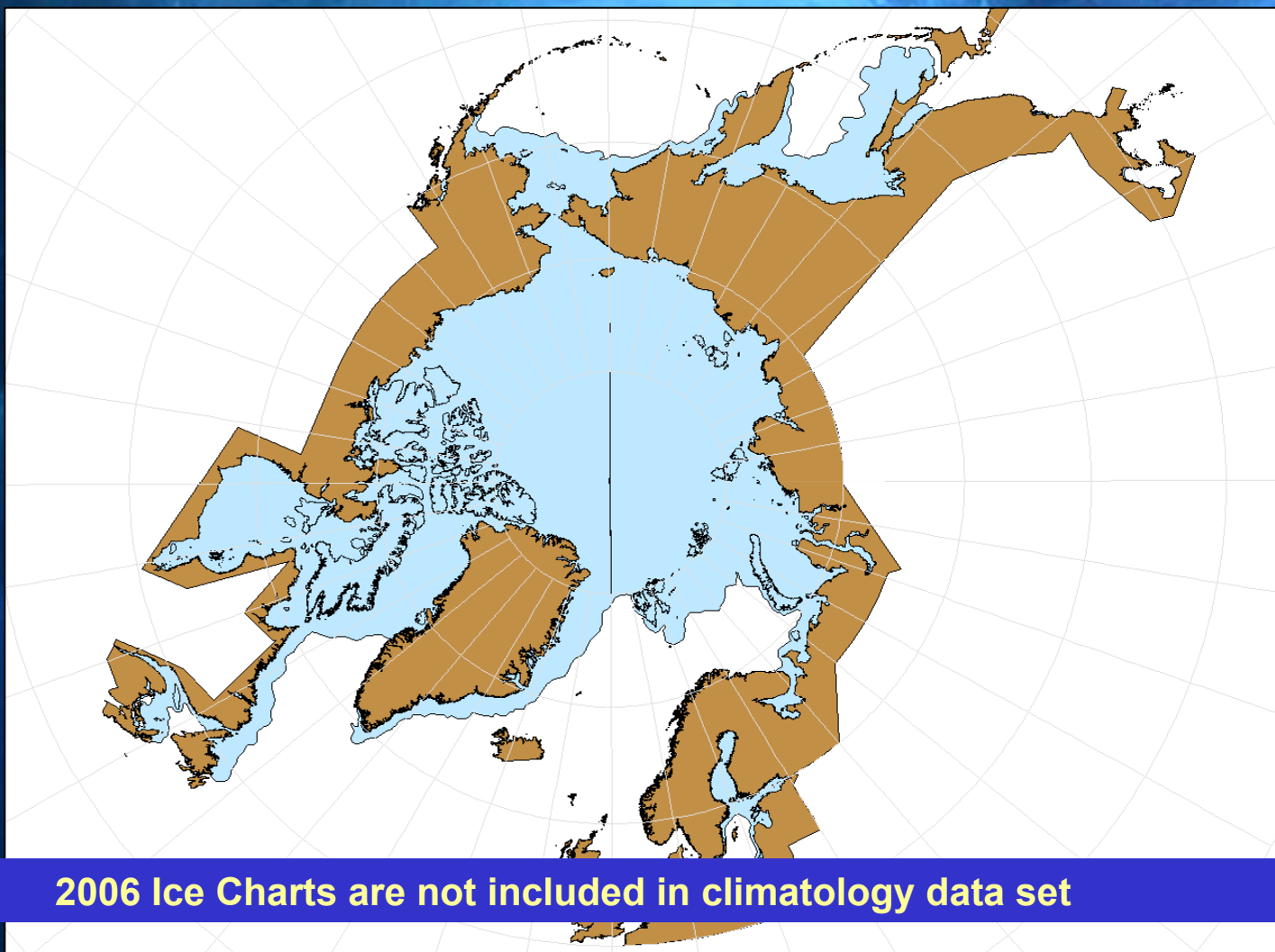
March Ice Extent 2005



2005 Ice Charts are not included in climatology data set



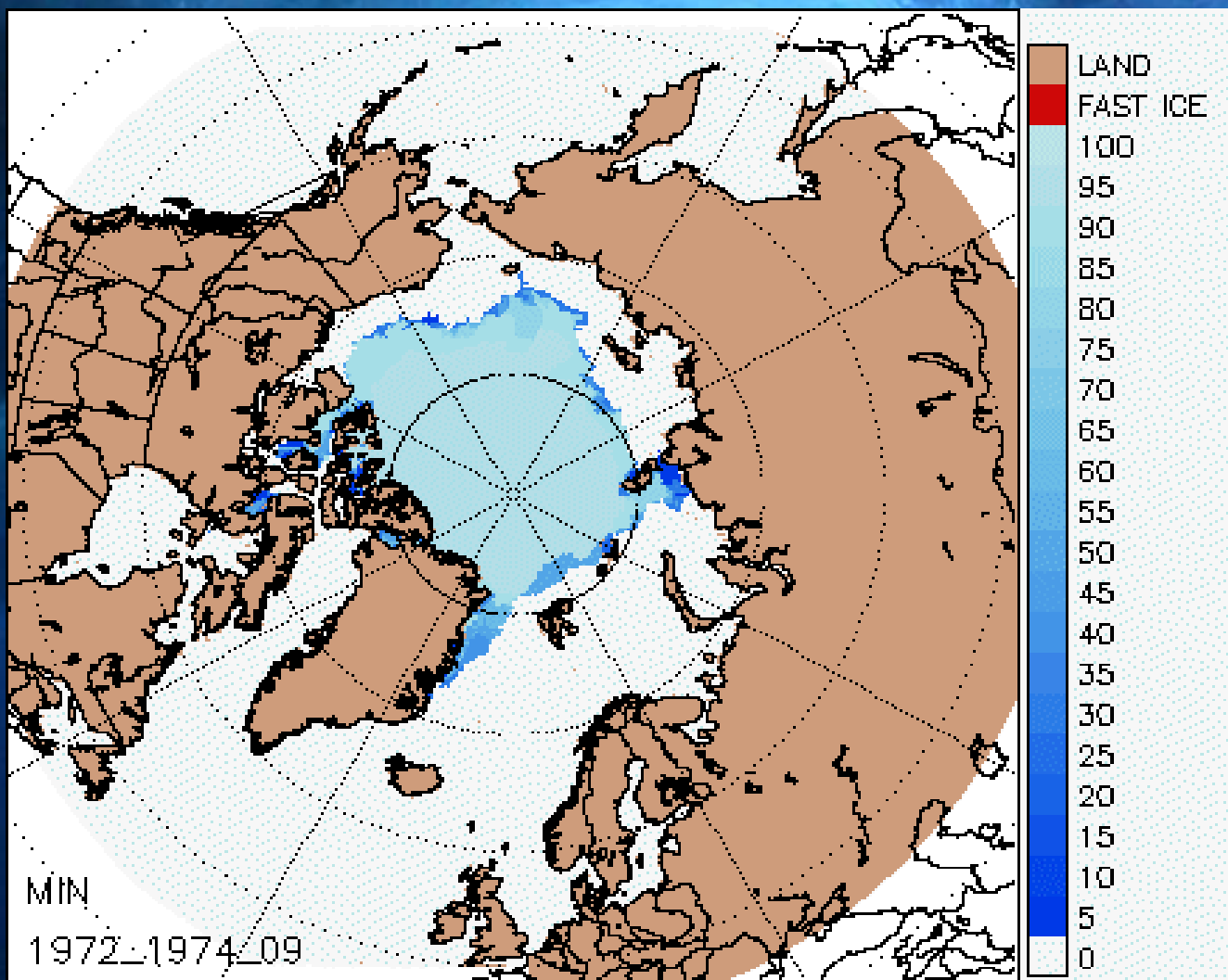
March Ice Extent 2006



2006 Ice Charts are not included in climatology data set

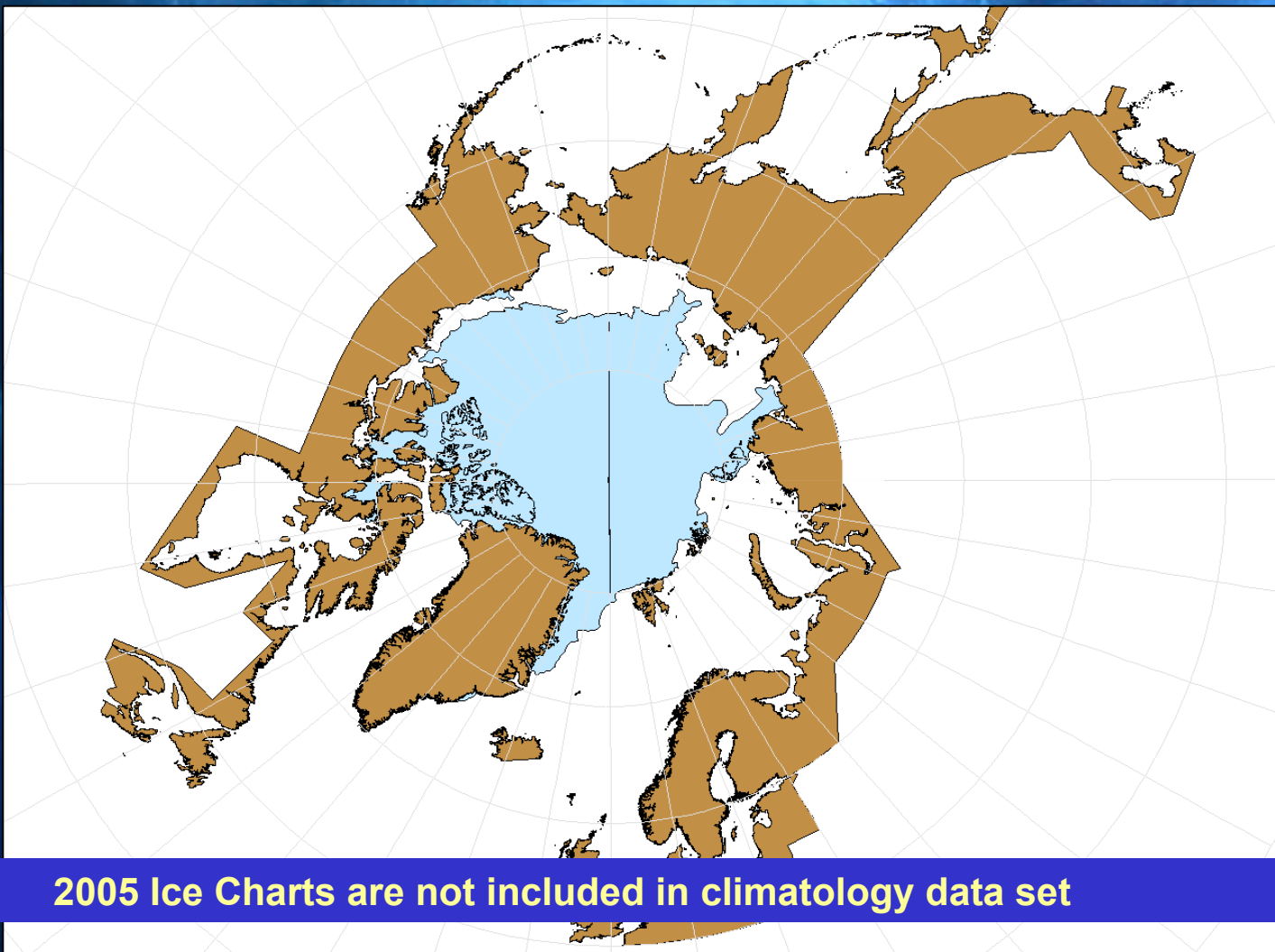


Absolute Minimum Ice Extent animation using entire NIC dataset for September 1972-2004





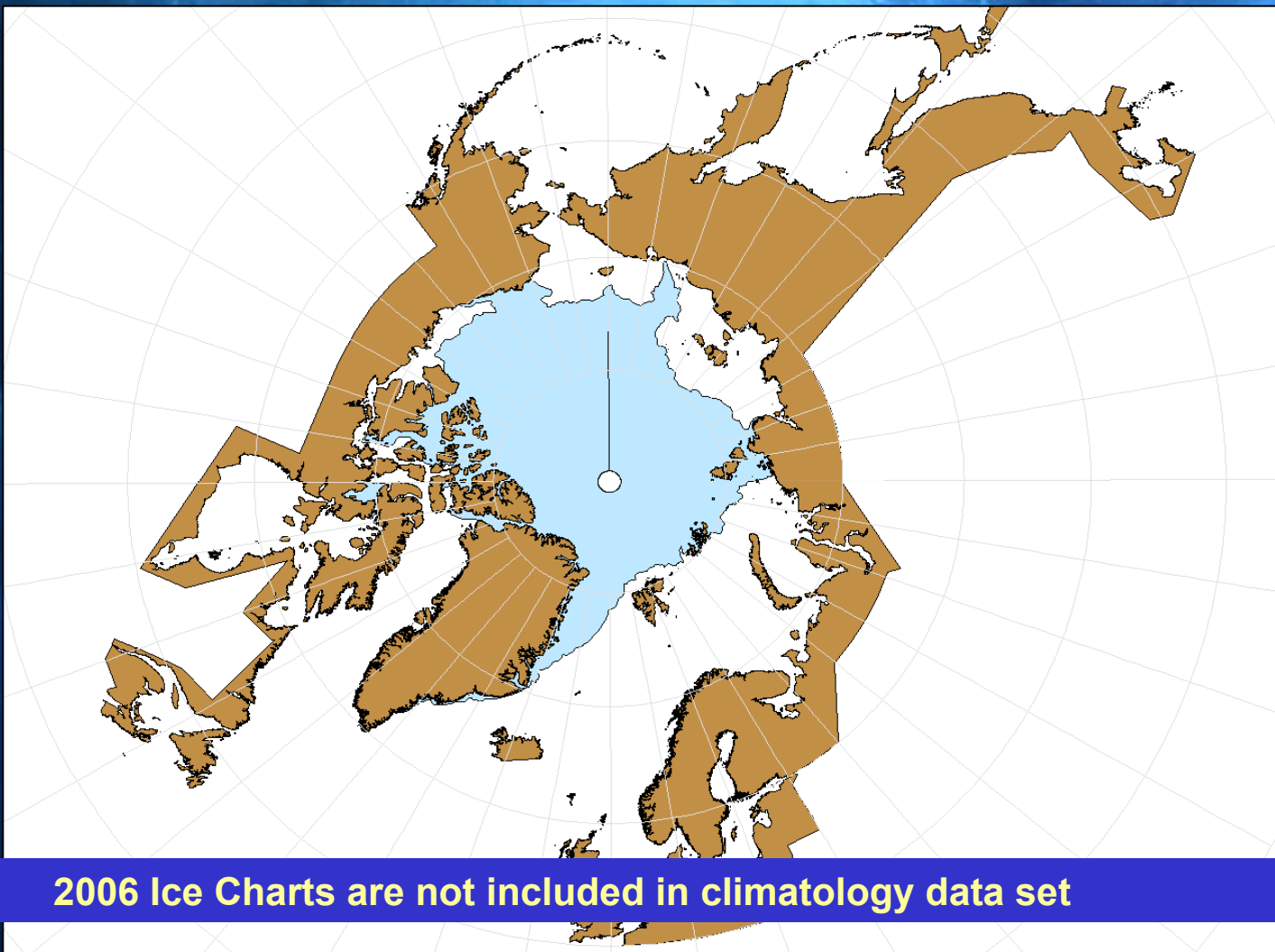
September 2005 Ice Extent



2005 Ice Charts are not included in climatology data set



September 2006 Ice Extent



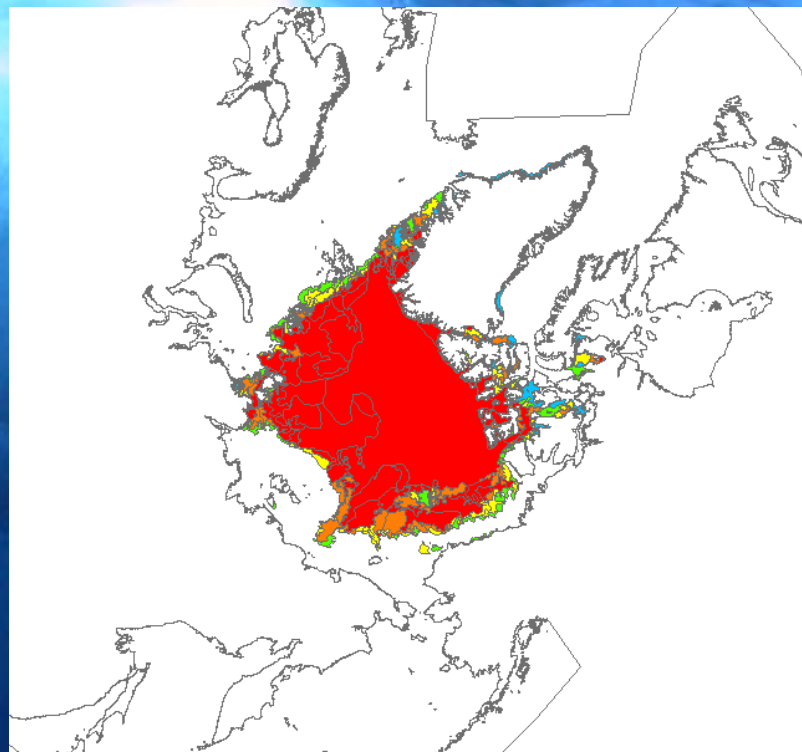
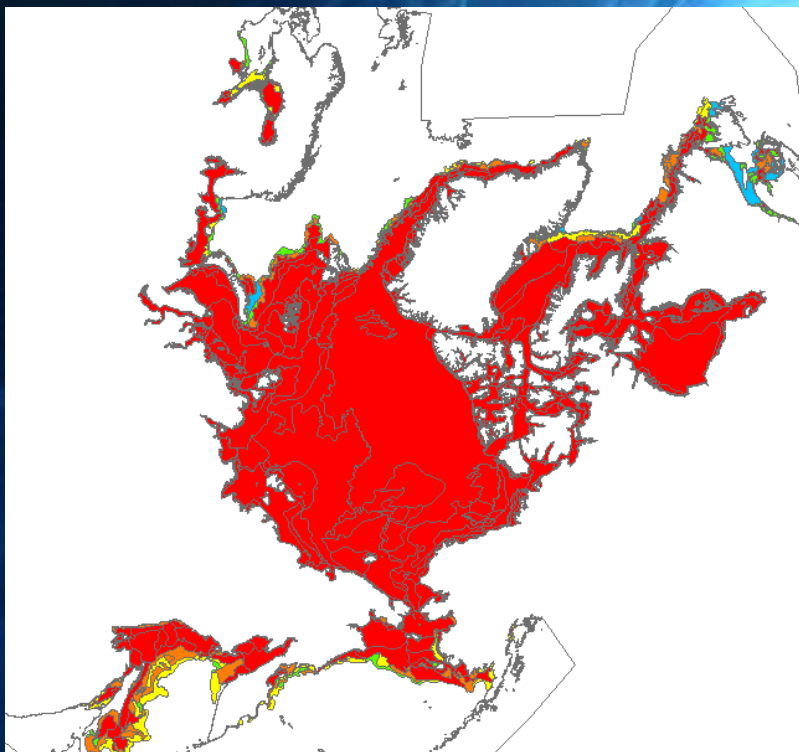
2006 Ice Charts are not included in climatology data set












NIC Hemispheric Ice Charts Seasonal Change

13 March 2006

28 September 2006



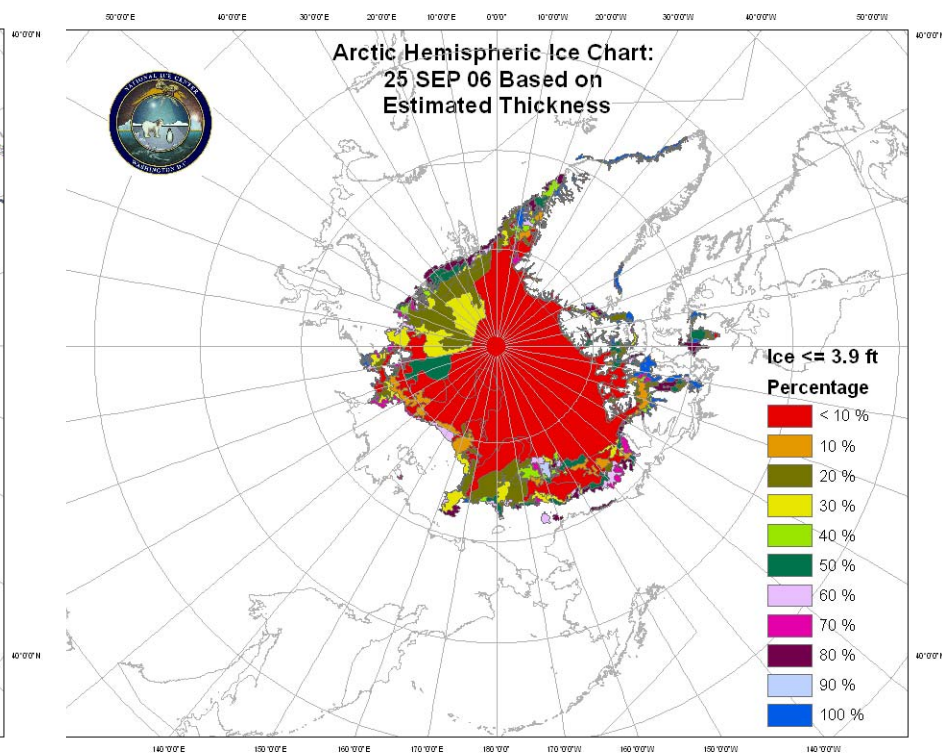
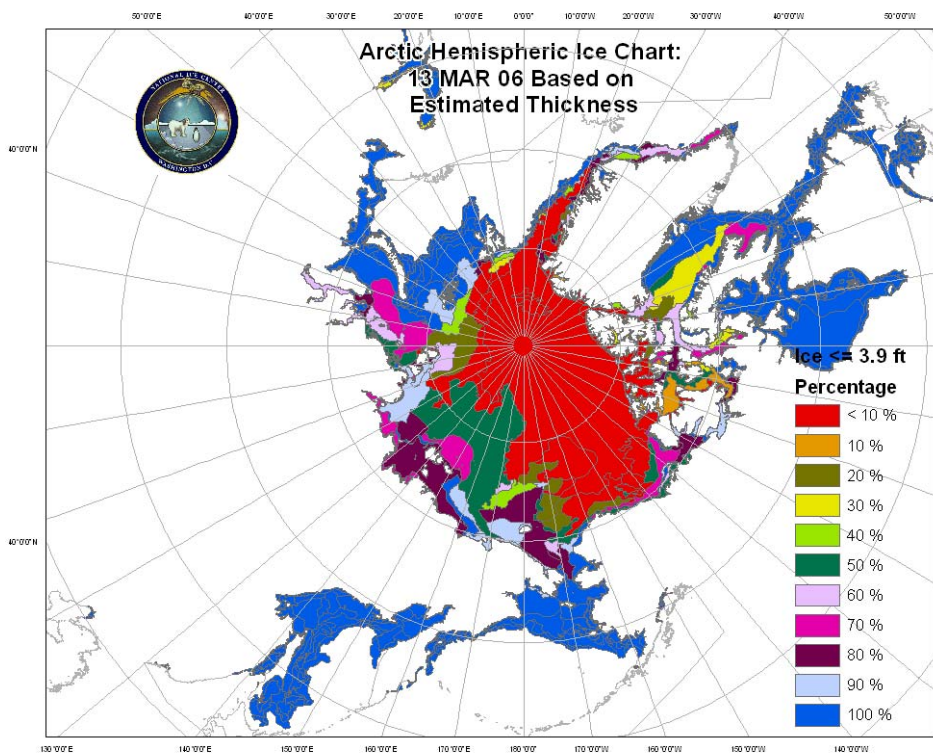
COLOR CODES BASED ON TOTAL CONCENTRATION					
	ICE FREE		4-6 TENTHS		FAST ICE (TEN TENTHS)
	LESS THAN 1 TENTH		7-8 TENTHS		ICE SHELF
	1-3 TENTHS		9-10 TENTHS		UNDEFINED ICE

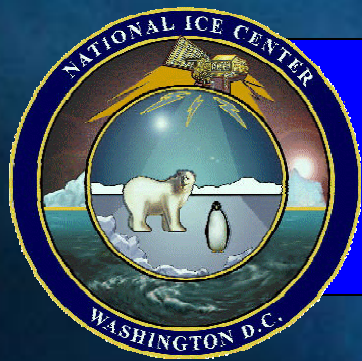


NIC Ice Thickness Proxy Seasonal Change

13 March 2006

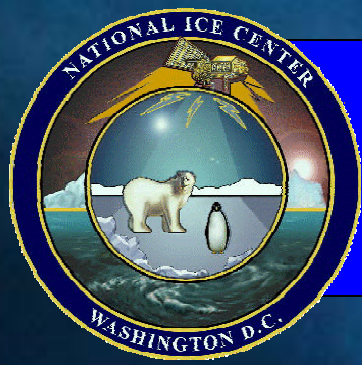
25 September 2006





NIC IPY Activities

- **Providing sea ice charting and remote sensing support to the Arctic Submarine Lab Ice Camp 2007, which is expected to provide a unique multi-sensor sea ice thickness cross-validation dataset**
- **Providing similar remote sensing support and coordination with other field activities in both the Arctic and Antarctic regions.**
- **Hosting a follow-on symposium on the Impact of an Ice-diminishing Arctic on Naval and Maritime Activities (July 2007)**
- **Producing of 33-Year Antarctic and Yellow Sea Climatologies**
 - Antarctic Climatology is being funded by NOAA
 - Requesting funding from NAVO for the Yellow Sea climatology
- **Coordinating the development of an Inexpensive Airborne Expendable Ice Buoys (AXIB) To provide a low cost aircraft droppable (also surface deployable) seasonal buoy**

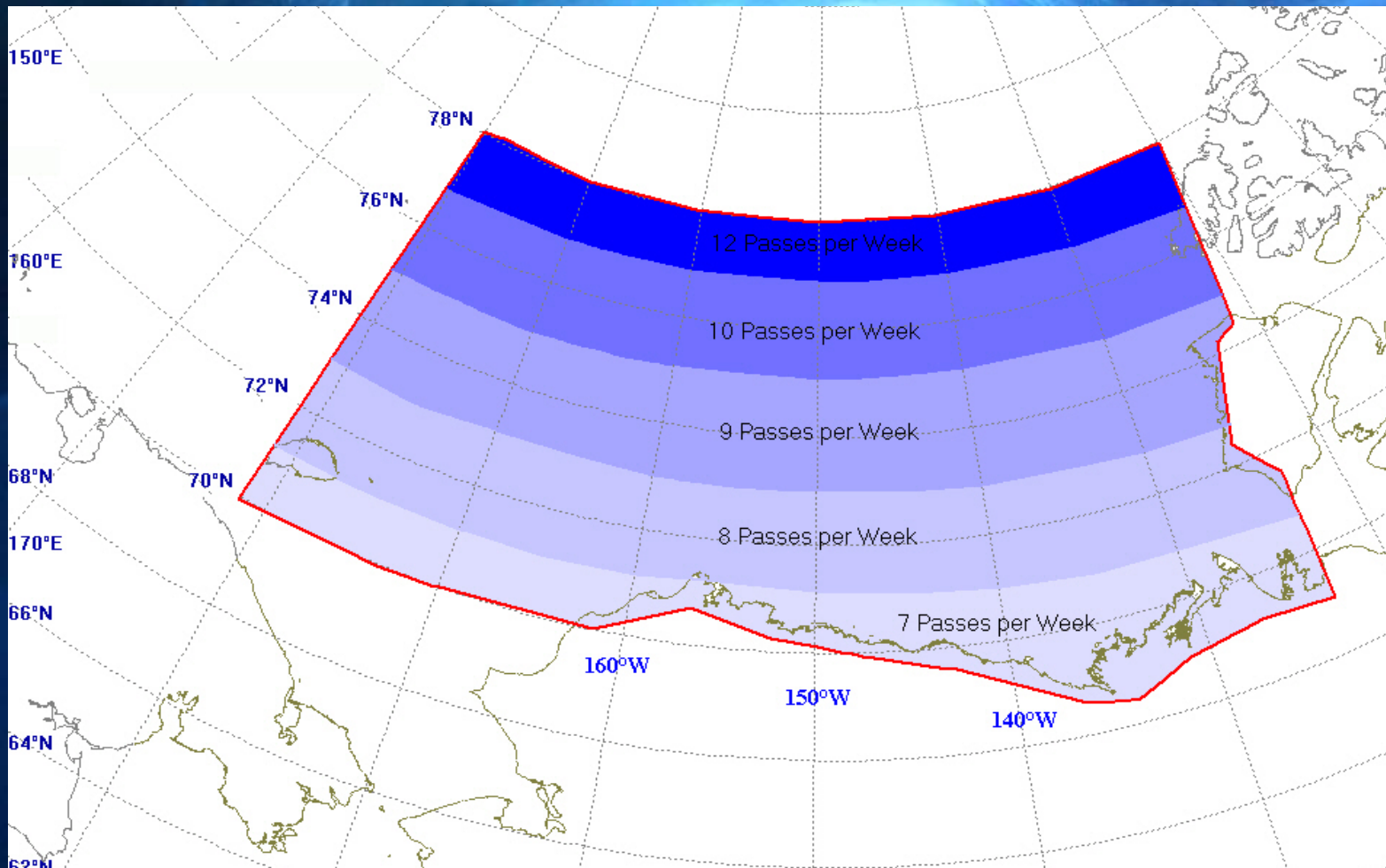


2007 APL Ice Station (APLIS)

- **An Ice Camp is being established 200 NM Northeast of Prudhoe Bay, Mid-March to Mid-April**
 - **UW Applied Physics Laboratory (APL) in charge of ice camp logistics in support of a 2 weeks classified (ASL) and a 2 weeks unclassified (NSF) camp.**
 - **Unique collection of sea ice measurements under, over, and on the sea ice.**
 - **NIC Science is providing coordination of remote sensing observations and imagery support during the camp.**
-
- An aerial photograph of an ice camp on sea ice. The camp consists of several yellow and red containers, some of which are stacked. There is also a large red and black striped container. A person is visible walking on the ice near the containers. The background shows a vast expanse of sea ice under a clear sky.



R1 SWB Frequency in Beaufort Sea



Daily coverage will support operational RGPS during the ice camp

Global Inter-agency IPY Polar Snapshot Year (GIIPSY)

Spaceborne Observations of the Polar Regions during IPY

- The IPY provides an international framework for understanding high-latitude climate change and predicting world wide impacts.
- Spaceborne technology offers unique capabilities for obtaining essential data for predictive models.
- Use of current and soon to be launched earth observing satellites to develop broad spectral, medium and high resolution snapshots of the polar regions.
- IPY era spaceborne instrumentation represents a technological leap beyond the capabilities of the IGY



NIC Science Focus for 2007 & Beyond

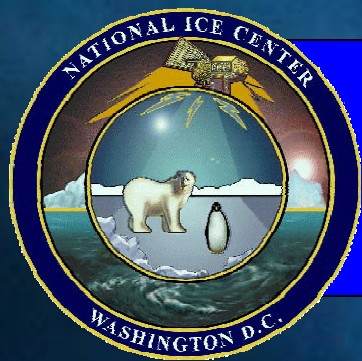
- Support International Polar Year activities.
- Consolidation of NOAA's Snow and Ice Operational IMS Product at NIC.
- Promote assimilation of NIC ice products into atmospheric, ocean, and ice forecast analyses and models.
- Enhance the Antarctic Analysis (weekly/partial concentrations).
- Explore Joint / Interagency snow & ice center of excellence with Army, Air Force.
- Further define and coordinate efforts to meet North American Ice Service (NAIS) sea ice remote sensing requirements.



Sea Ice Conditions Outlook

Continuing Changes in a Dynamic Environment

- Multi-year sea ice shrinking / compressing to western Arctic.
- Most of first-year ice will melt during summer.
 - Result: vast region of ice-free ocean in the east Arctic
- Diminished ice conditions may allow a seasonal trans-arctic sea route (Polar Passage)
 - Avoids territorial issues with either NW or NE Passage
- Daily mapping of sea ice (ice extent, ice coverage, ice type, surface melt) and wind over ice-free ocean necessary for sea ice forecasting.
- Increased uncertainty of ice conditions will complicate the development and validation of automated product generation.
- Monitoring of ice islands (Arctic tabular icebergs) may become more critical
- An increase in the number of icebergs in the Antarctic could affect sea ice forecasting and navigation in the Southern Ocean.



Questions?

