Observing Pole to Pole – A virtual observing system

Global Inter-agency IPY Polar Snapshot Year (GIIPSY)
WMO Space Task Group

NASA ICEsat

Participating International Agencies: ASI, CSA, CMA, CNES, DLR, ESA, EUMETSAT, INPE, JAXA, NASA, NOAA, ROSHYDROMET, WMO, WCRP-CLiC

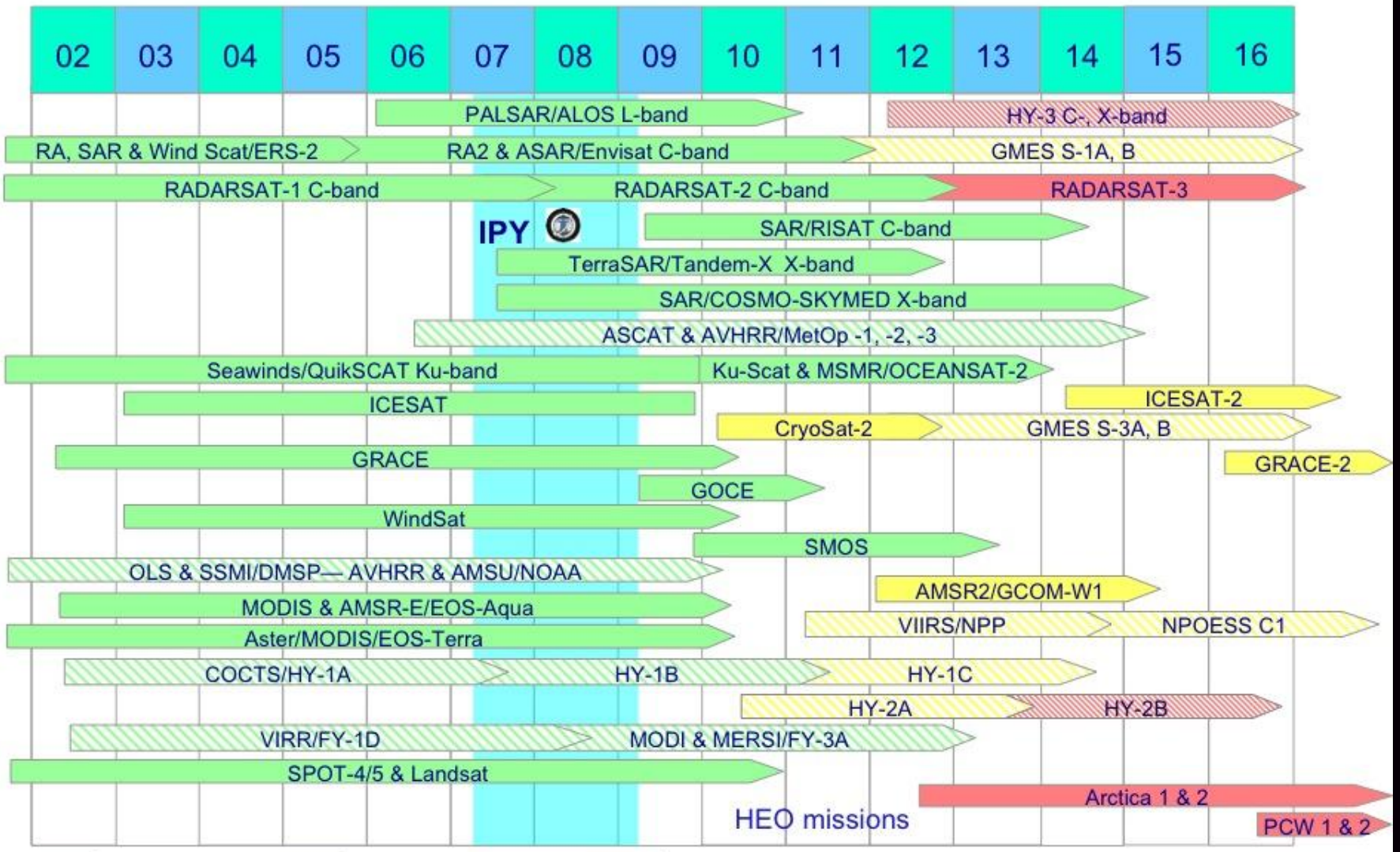
IGOS Theme on Cryosphere

Climate Change and the IPY 2007-2008

- *The IPY provided an international framework for understanding polar processes and high-latitude climate.*
- *Spaceborne technology offered unique capabilities for obtaining essential data for predictive models.*
- *IPY era spaceborne instrumentation represented a technological leap beyond the capabilities of the IGY*

2000 Modified Antarctic Mapping Mission ice velocity model. A precursor activity to GIIPSY and the STG (K. Jezek)

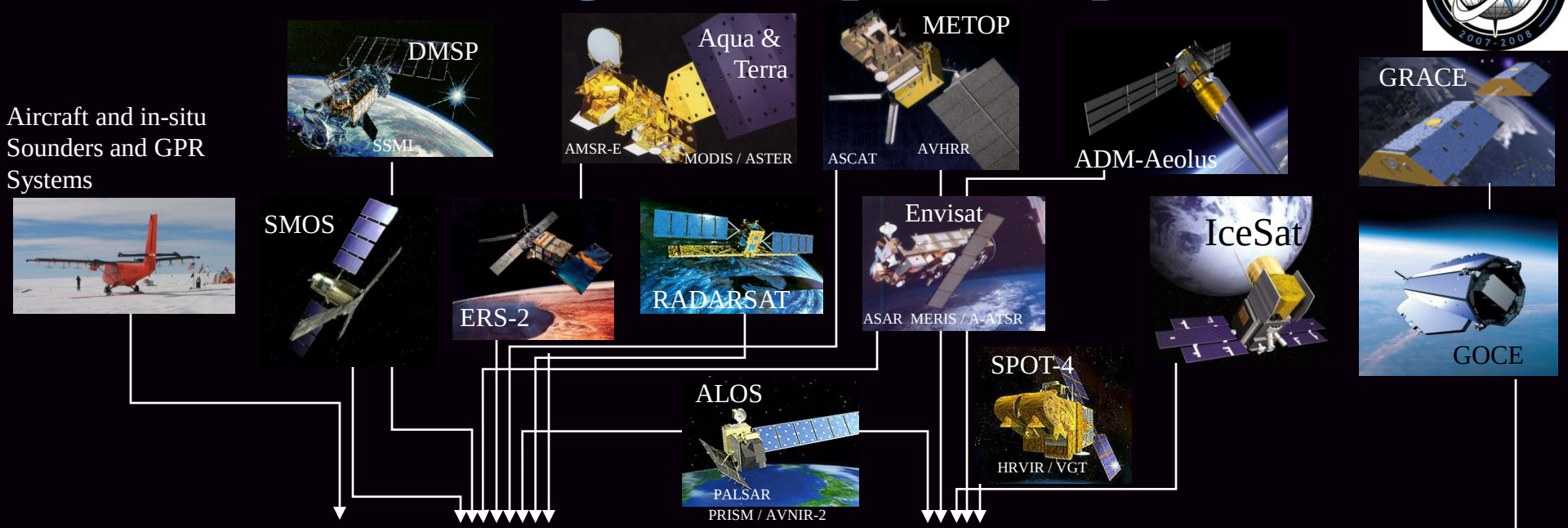
Cryosphere Satellite Missions

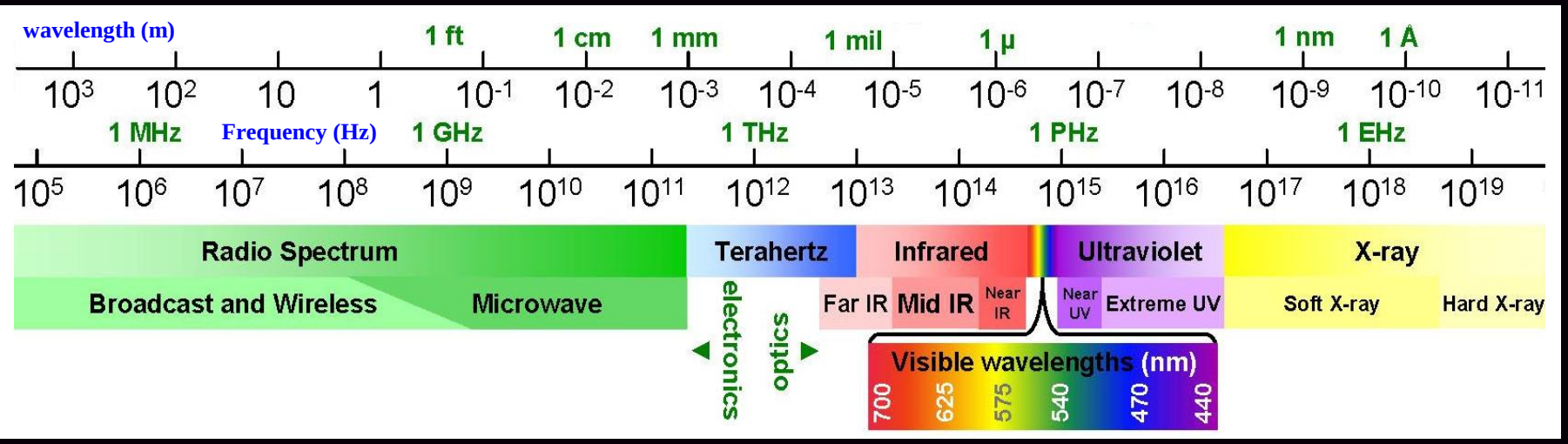


Solid color = R&D mission; hatched = operational mission

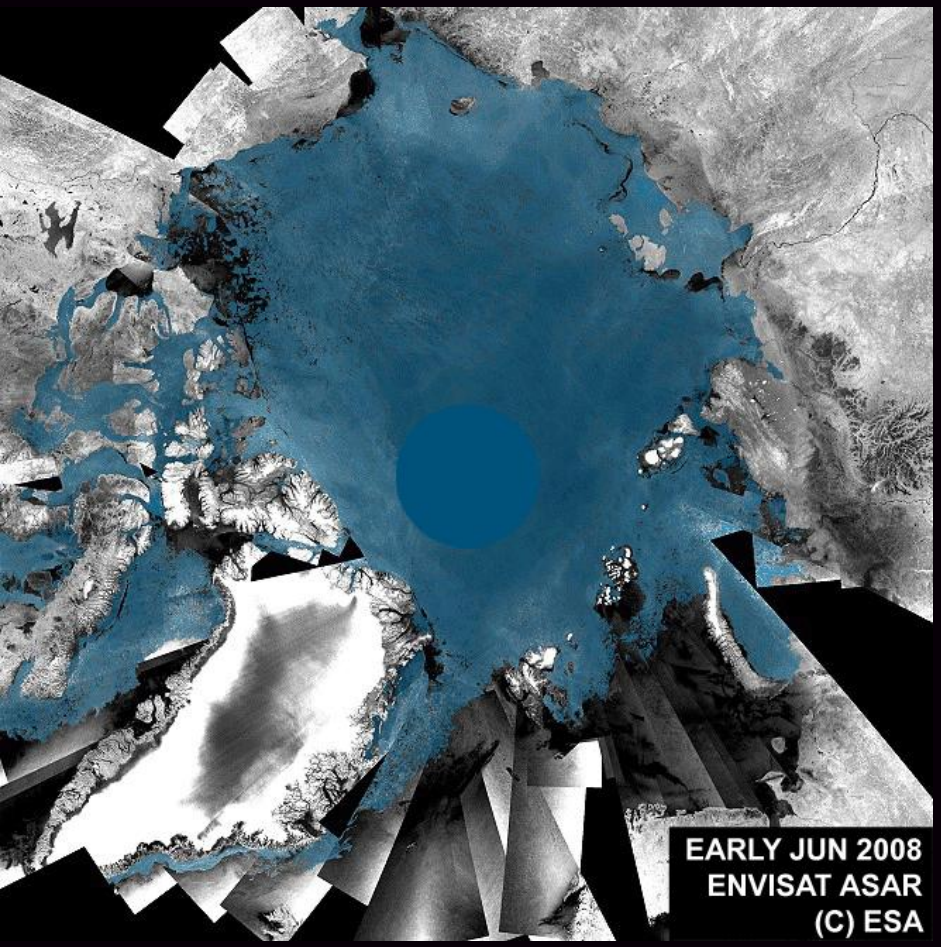
(Courtesy of M. Drinkwater)

Collecting satellite polar snapshots





Gravity



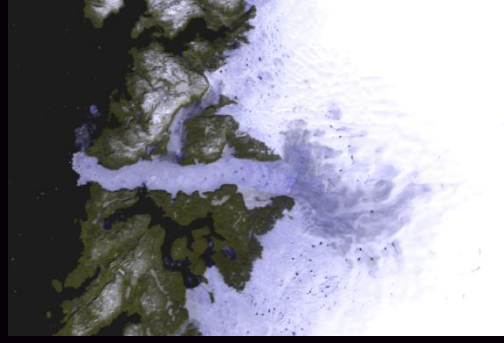
GIIPSY

The 1957 IGY began the rigorous scientific investigation of the Polar Regions.

The 2007-08 IPY goes beyond the IGY through the numbers and capabilities of earth observing satellites. These systems can routinely observe the poles and cast polar processes within the context of the global environment.

In November 2005, the Global Interagency Polar Snapshot Year (GIIPSY) project was established to develop consensus requirements on polar science objectives that could best and perhaps only be met with Earth observing satellites

GIIPSY Strategy



- Work with the science community to compile IPY science data requirements
- Identify those requirements which will be satisfied through routine operations (eg MODIS, MERIS)
- For routine observations, work with flight agencies to assure that data are available/archived in some standardized fashion
- Identify those requirements that can only be satisfied by non-routine tasking, processing and distribution. Work with the flight agencies to acquire these data in a fashion that distributes the operational load.
- Following selection of projects through the national A.O.'s, identify whether any legacy data sets are absent from the acquisition plans. Make necessary requests.
- GIIPSY science requirements and related documentation are posted at www.bprc.osu.edu/rsl/GIIPSY

WMO IPY Space Task Group (STG)

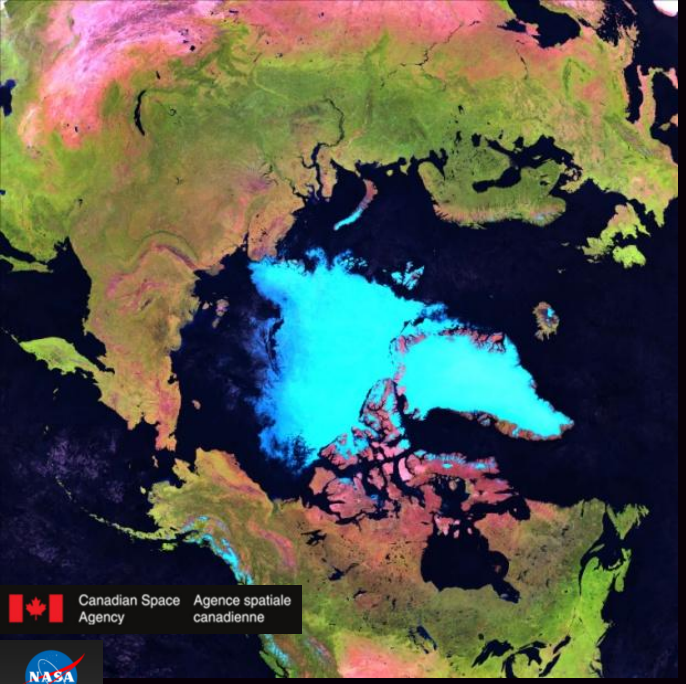
The STG is the body convened by the WMO tasked with addressing how to meet the IPY space observation requirements developed by GIIPSY.

The STG was established to coordinate agency planning, processing and archiving of IPY Earth observation legacy data sets.

It is comprised of nominated representatives from Brazil, Canada, China, France, Germany, Italy, Japan, Russian Federation, United Kingdom , United States, and both the European Space Agency and The European Organization for the Exploitation of Meteorological Satellites, the later two of which alone represent 26 nations.

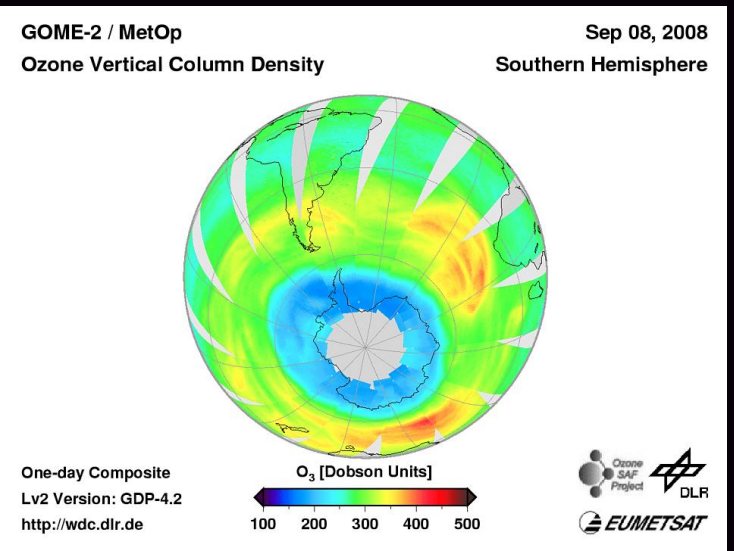
STG coordinates across CEOS and CGMS Agencies.

World Meteorological Organization
Working together in weather, climate and water

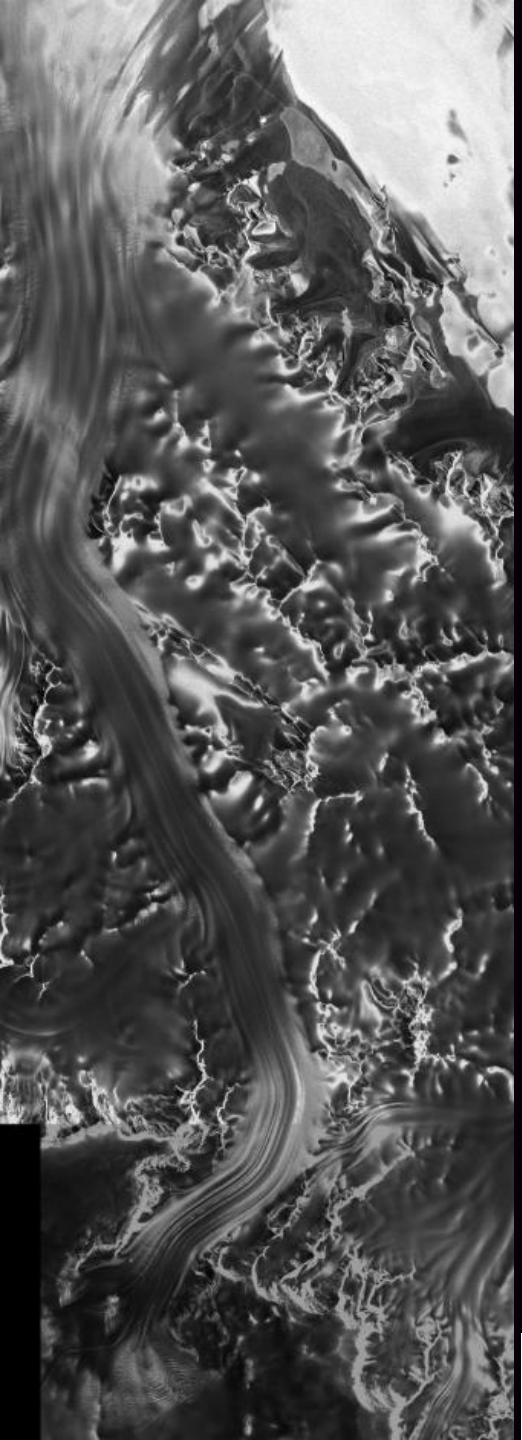


STG Strategy

- Satisfy GIIPSY science requirements in a fashion that distributes the acquisition and processing loads across agencies
- Select projects that are compatible with the operational mandates of individual agencies and commercial partners
- Encourage participation of other nations as additional polar observation capabilities are developed
- Identify a limited number of the most important scientific objectives achievable within the STG framework and within the IPY time period.



Participating International Space Agencies:
ASI, CSA, CMA, CNES, DLR, ESA, EUMETSAT, INPE, JAXA, NASA, NOAA, ROSHYDROMET, WMO, WCRP-CLiC



STG Goals

The STG initially accepted 4, primary objectives based on the GIIPSY requirements. Polar meteorology and atmospheric chemistry goals were later added.

- Pole to coast multi-frequency InSAR measurements of ice-sheet surface velocity.
- Repeat fine-resolution SAR mapping of the entire Southern Ocean sea ice cover for sea ice motion.
- One complete high resolution visible and thermal IR (Vis/IR) snapshot of circumpolar permafrost.
- Pan-Arctic high and moderate resolution Vis/IR snapshots of freshwater (lake and river) freeze-up and break-up.

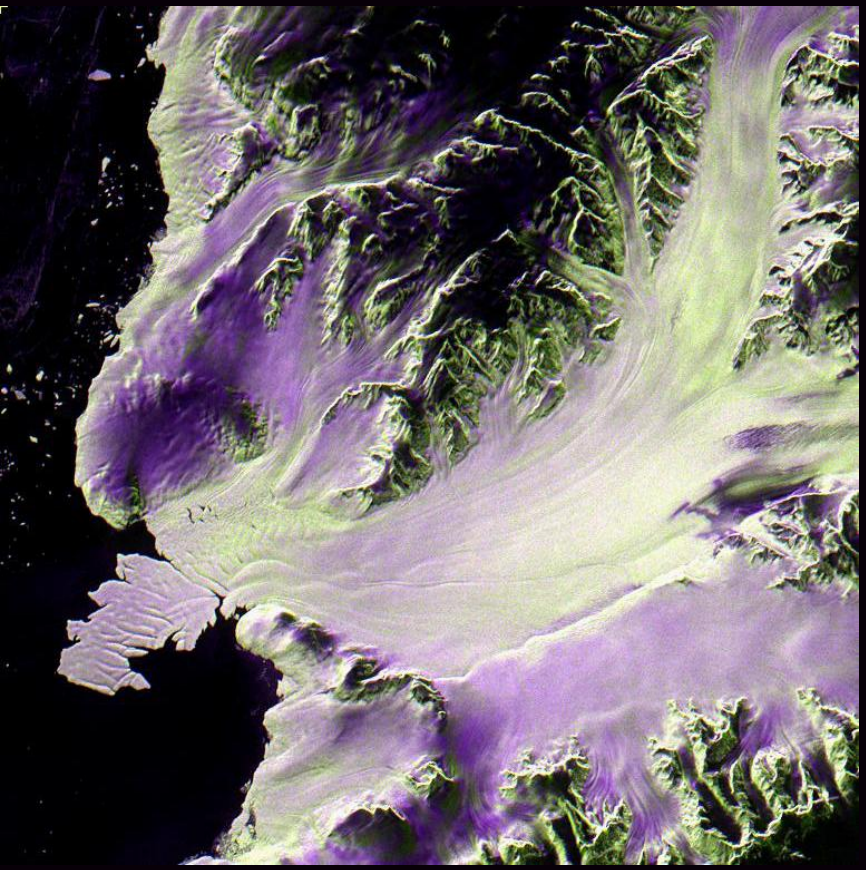
TerraSAR-X image of Leverett Glacier and the South Pole Traverse Route

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

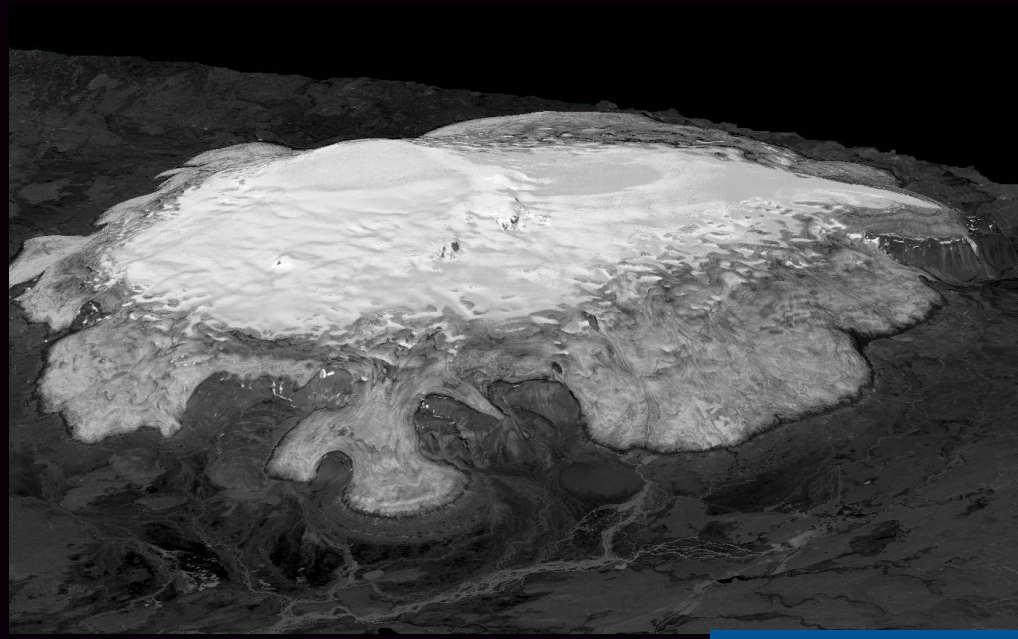
Ice Sheets

Multisensor data provide new views of the polar ice sheets

RADARSAT 2 Multi-pol color composite of Antarctic outlet glaciers
HH, HV, HH-HV

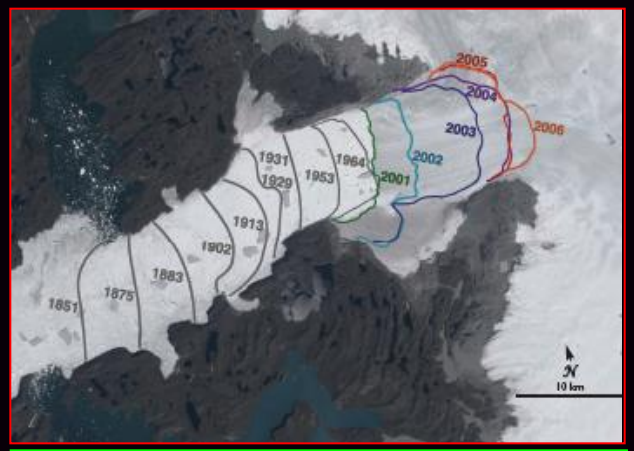


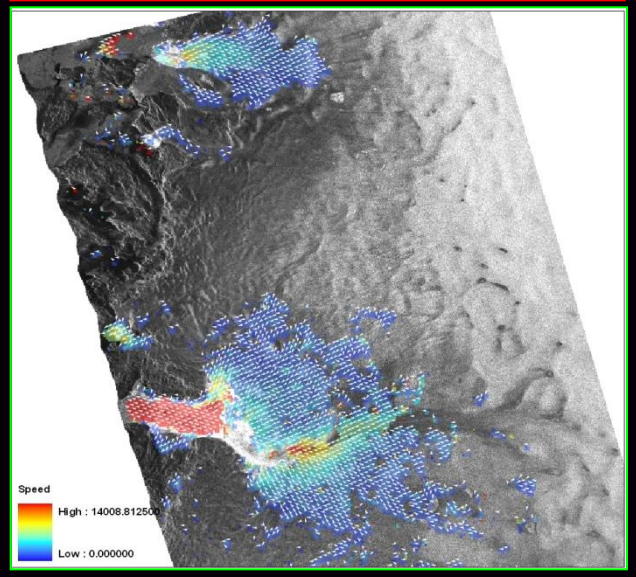
SPOT stereo digital elevation model from CNES SPIRIT project. Hoffsjökull Ice Cap, Iceland



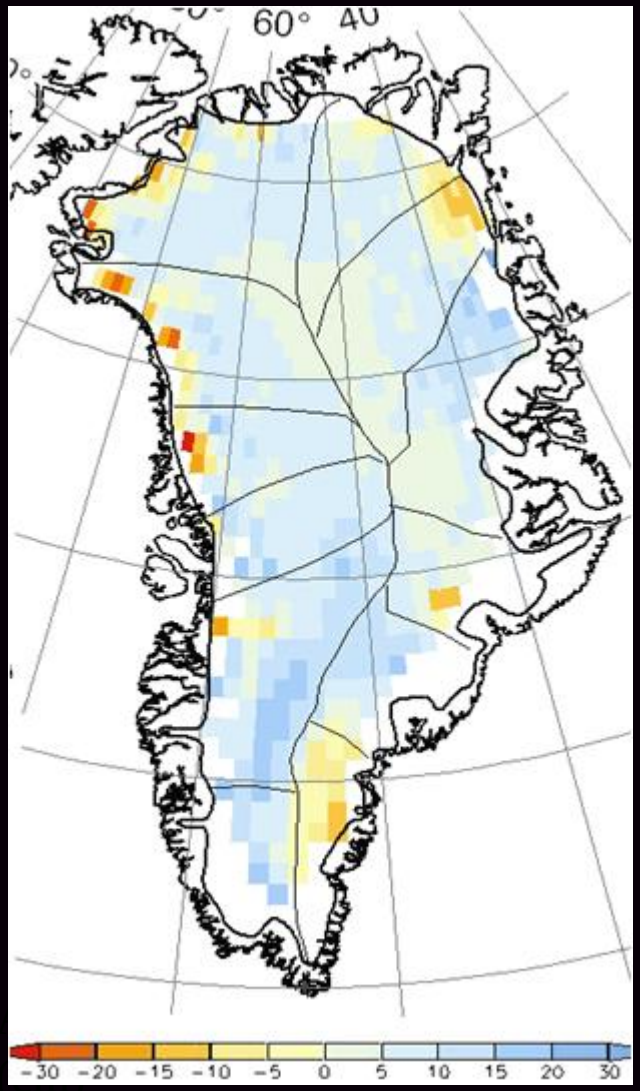
Canadian Space Agency | Agence spatiale canadienne

Greenland ice-sheet dynamics & change

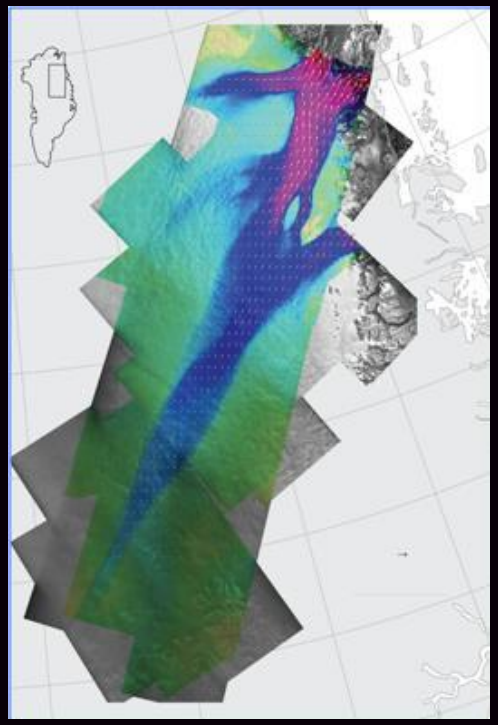




Courtesy Jezek et al



Courtesy Johannessen et al

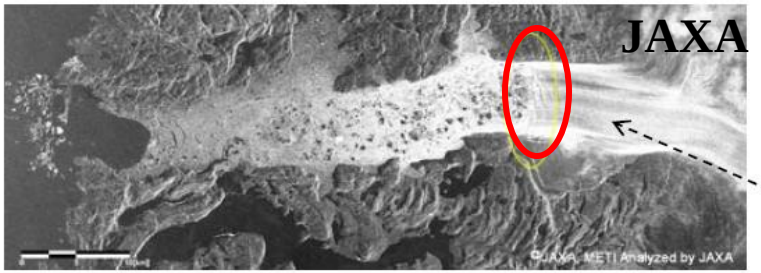


Courtesy Joughin et al

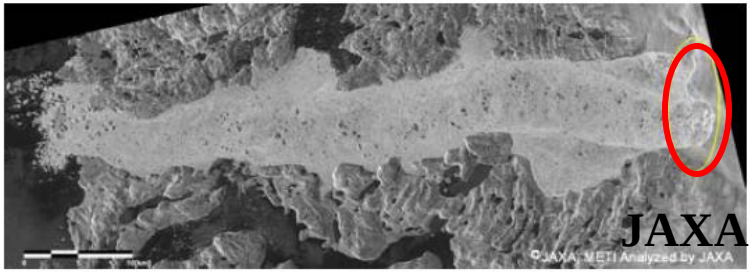
Canadian Space Agency
Agence spatiale canadienne

Greenland ice-streams

JERS-1
Oct. 4, 1994



PALSAR
Aug. 3, 2007

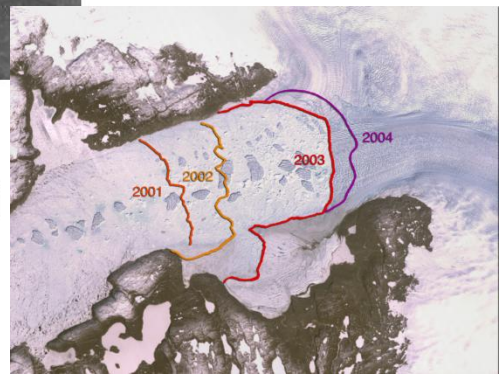


Japan Aerospace Exploration Agency

TerraSAR Sites

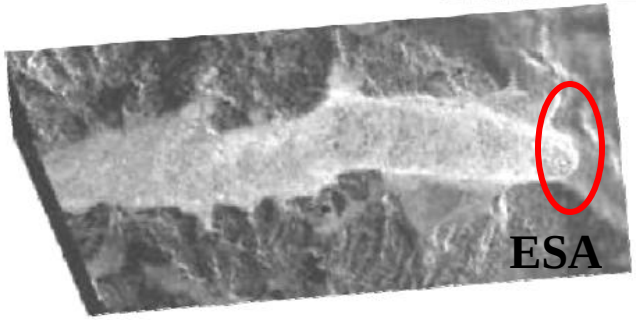
Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

TerraSAR -X
June, '08

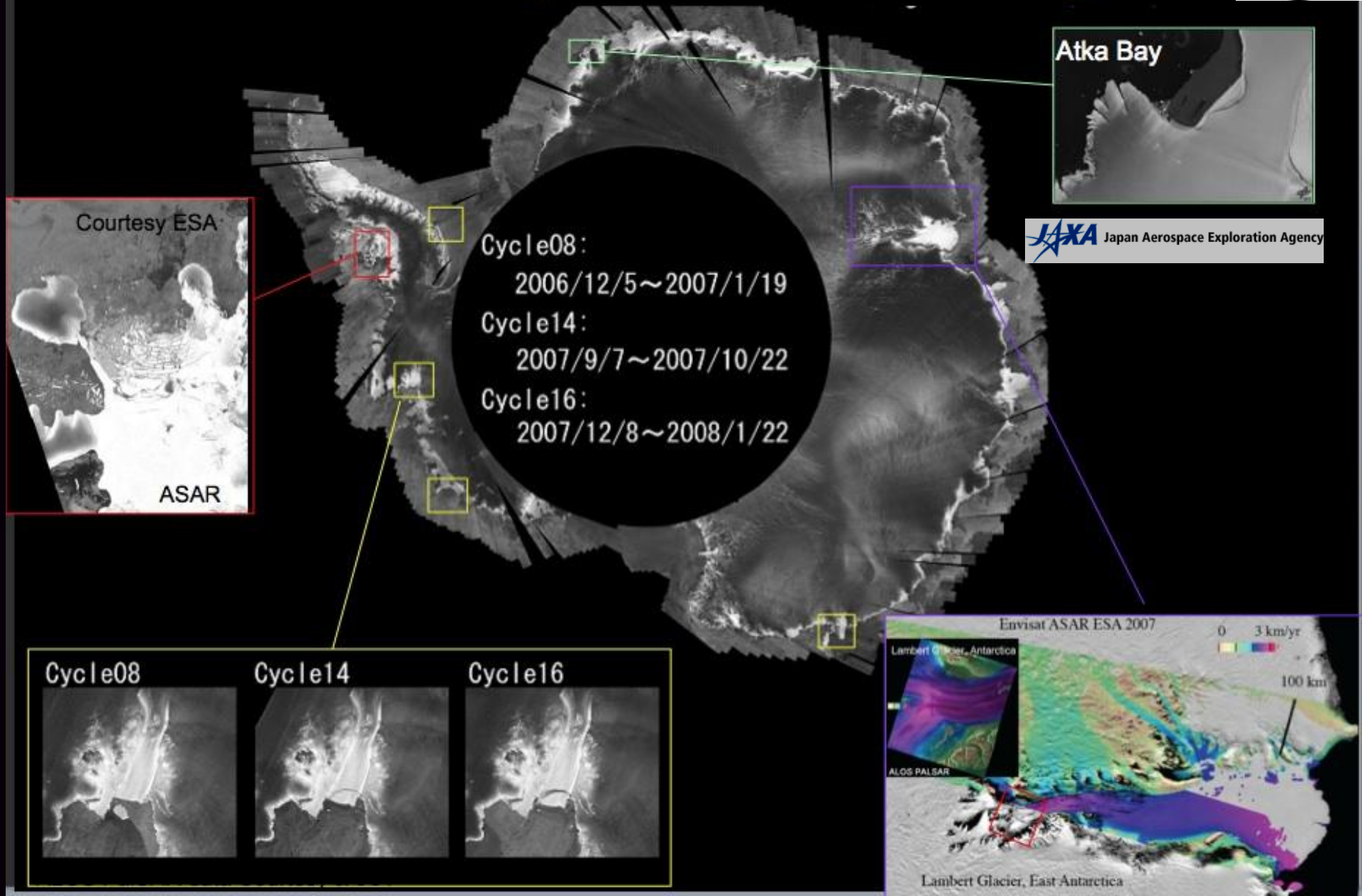


Fast

ASAR Browse
Sep. 18, 2008



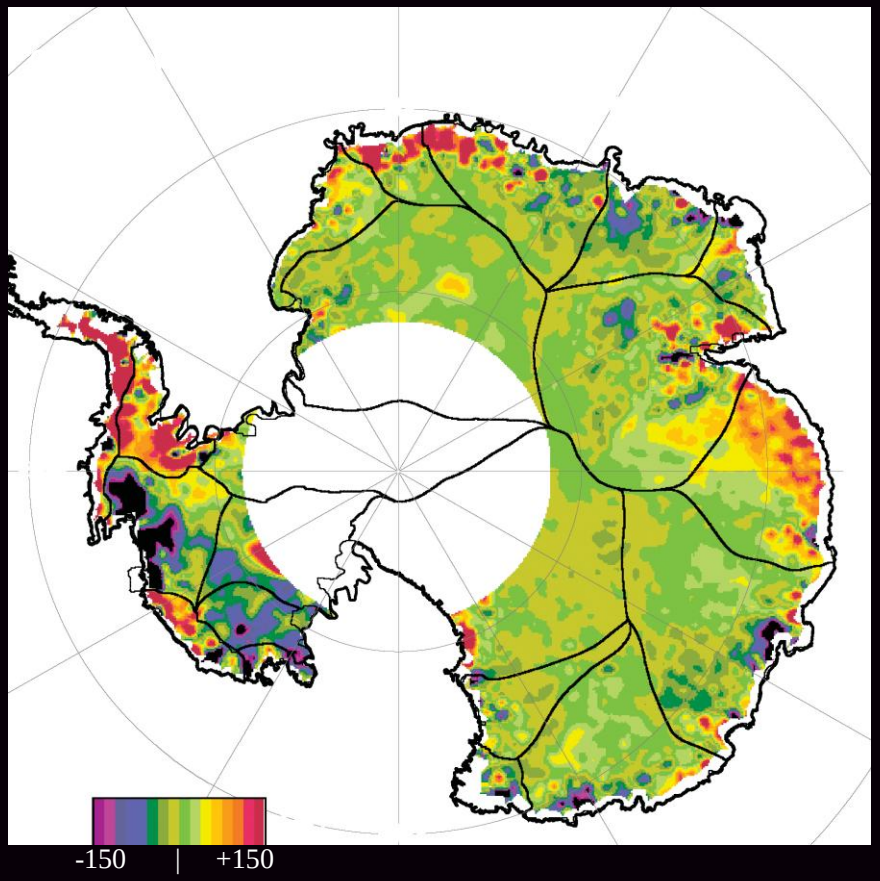
Monitoring Antarctic changes



Japan Aerospace Exploration Agency

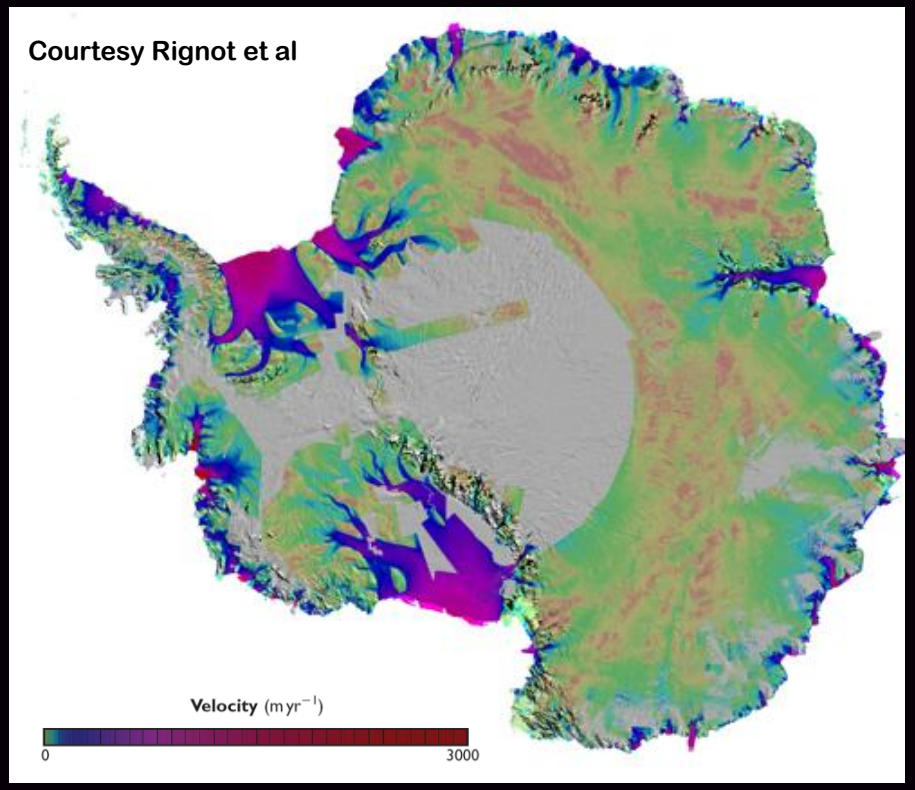
Ice-sheet change in Antarctica

Altimeter – Topographic Change



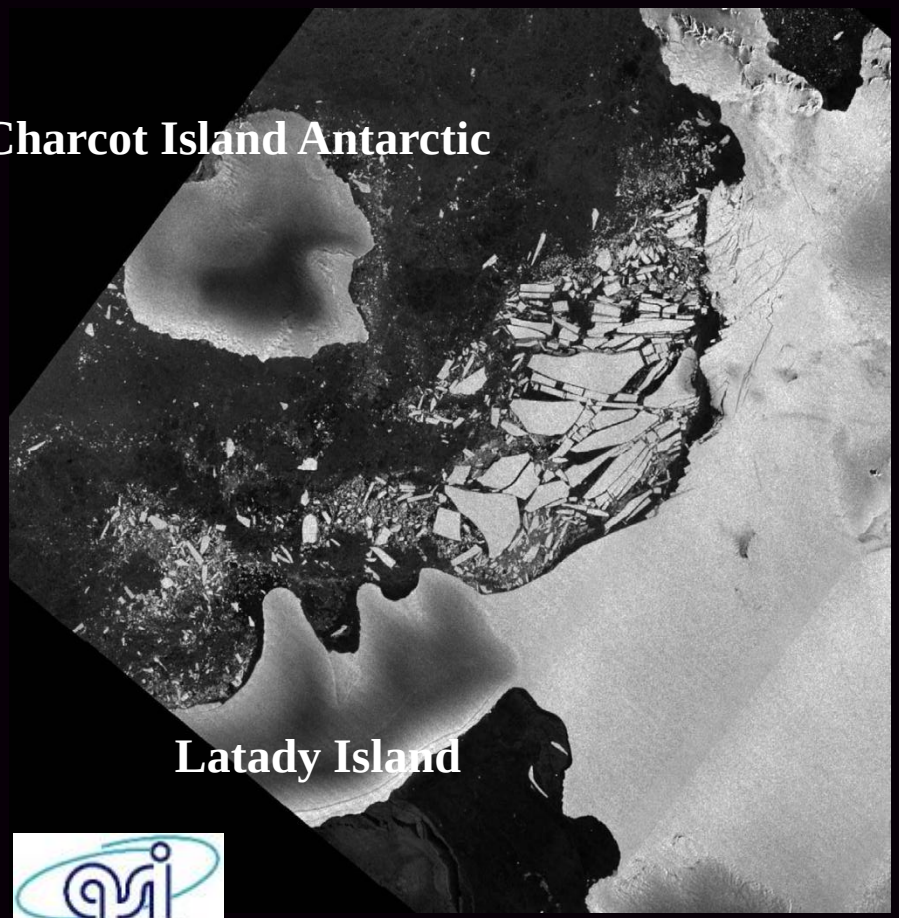
Rate of change of elevation (mm/yr)

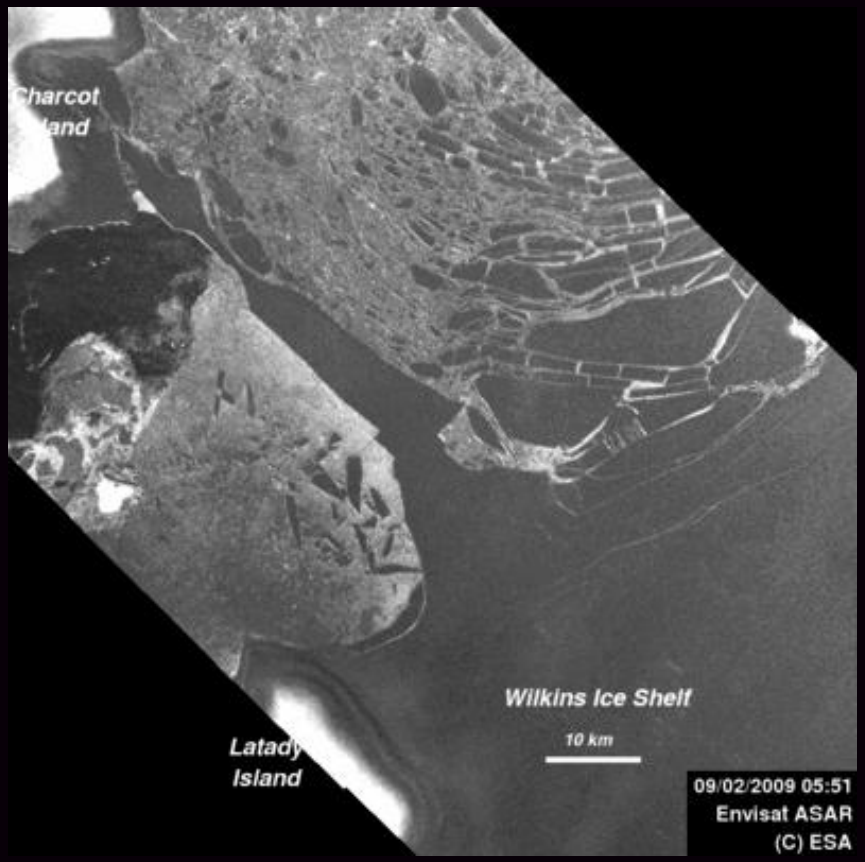
SAR – Ice Flow Dynamics



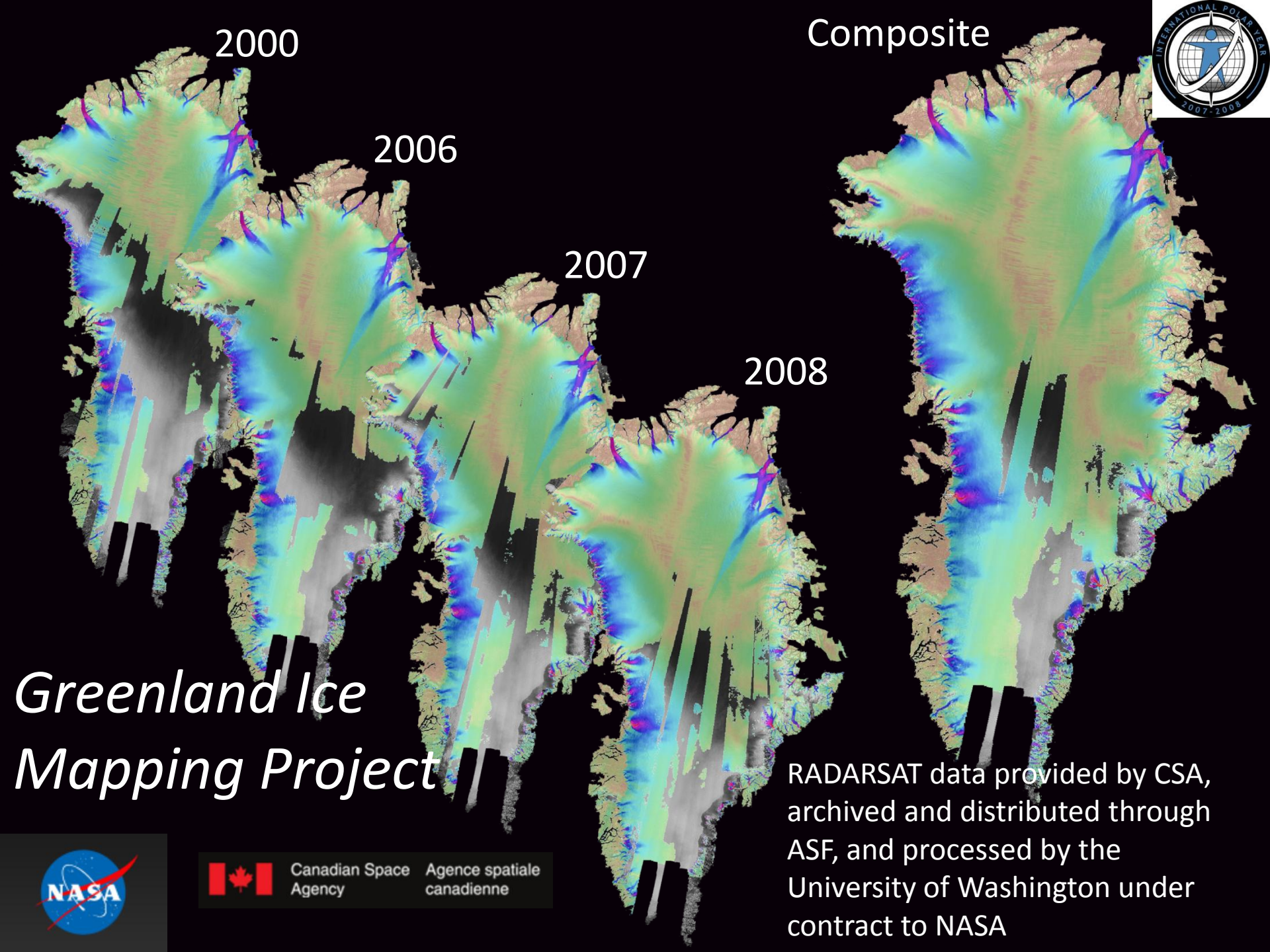
Wilkins Ice Shelf disintegration

2009-09-04 HR
ASI Cosmos Skymed

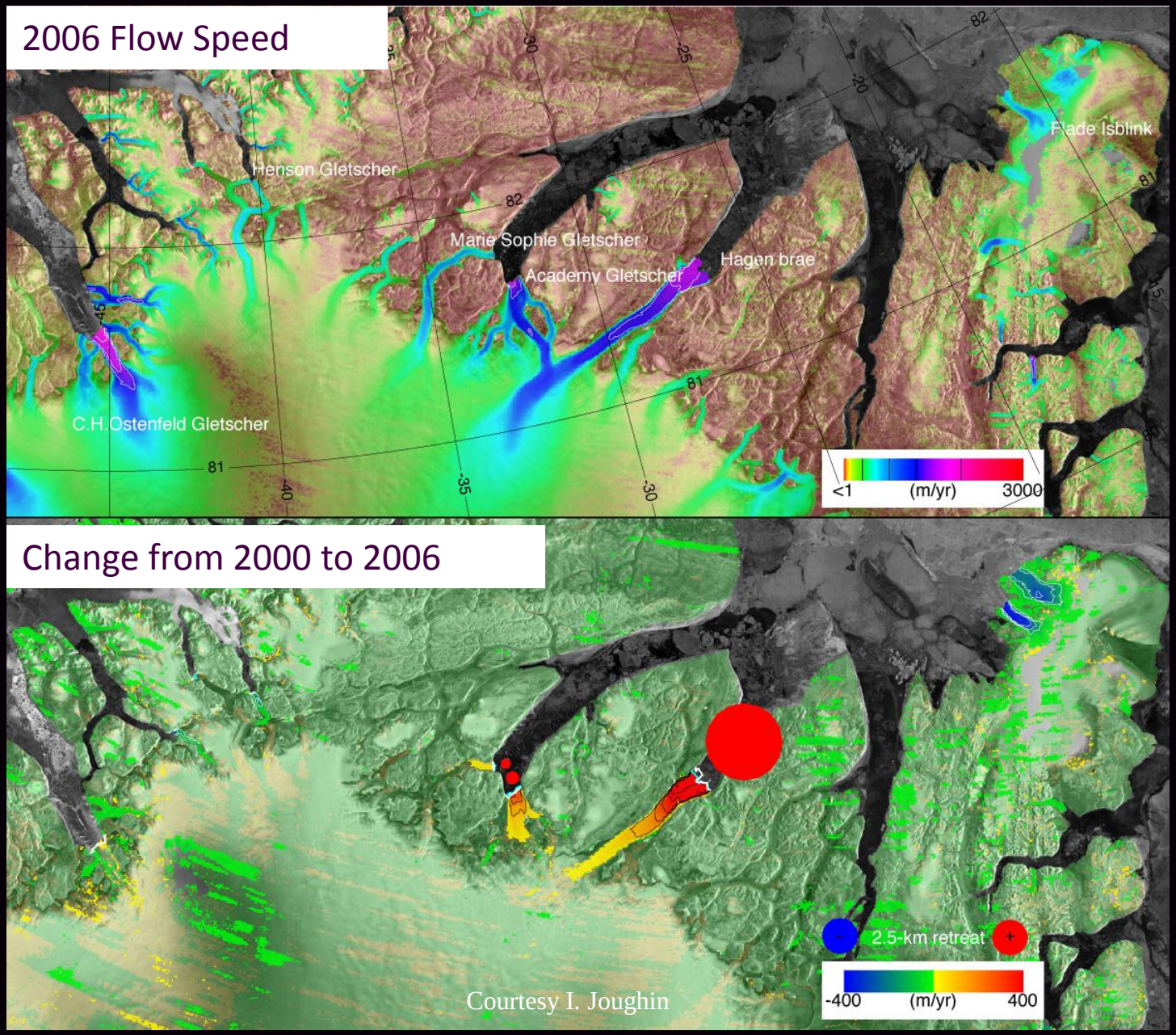




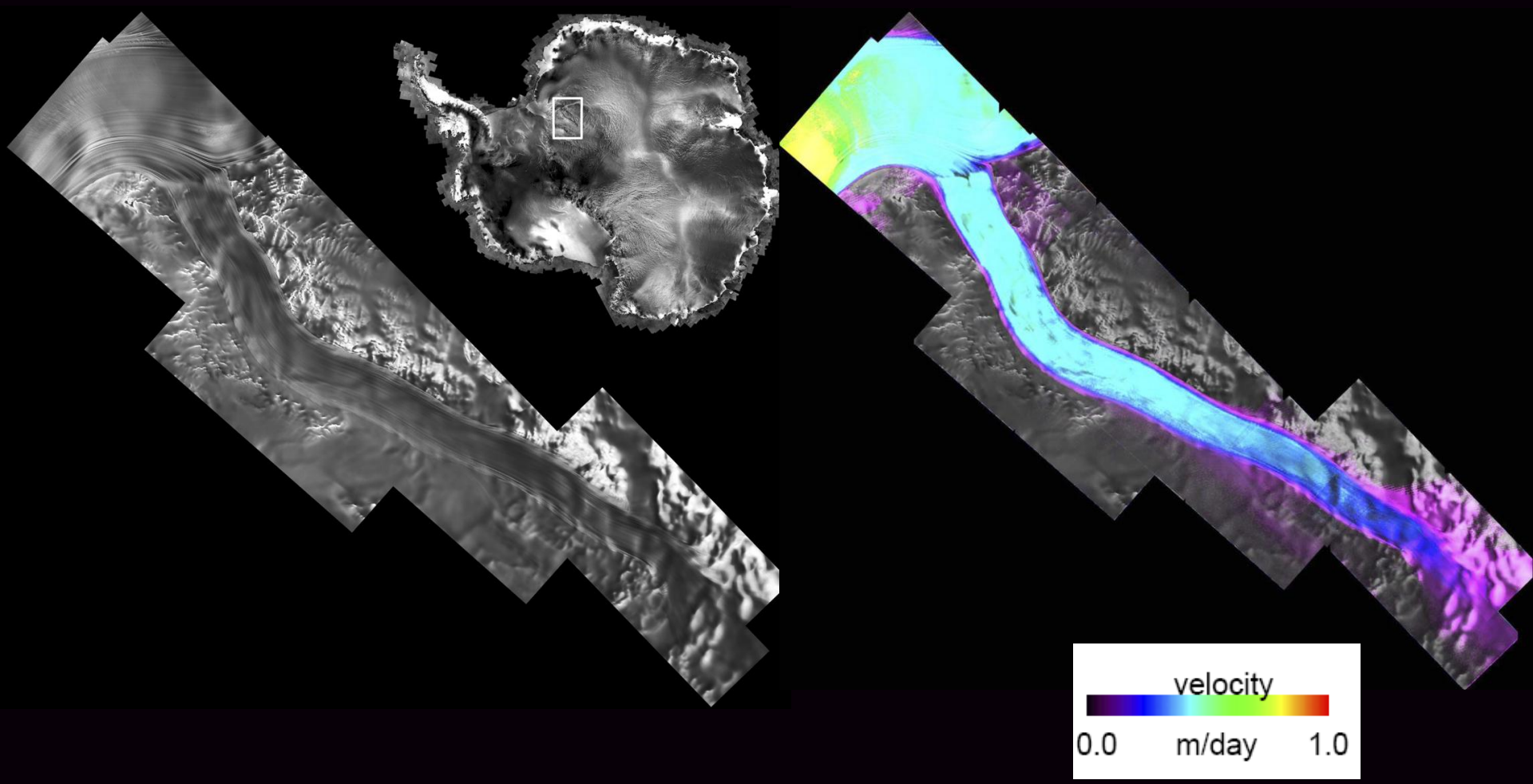
For the first time, pole to coast multi-frequency InSAR measurements of ice-sheet surface velocity


2000
2006
2007
2008
Composite
Greenland Ice Mapping Project
RADARSAT data provided by CSA, archived and distributed through ASF, and processed by the University of Washington under contract to NASA
Canadian Space Agency
Agence spatiale canadienne

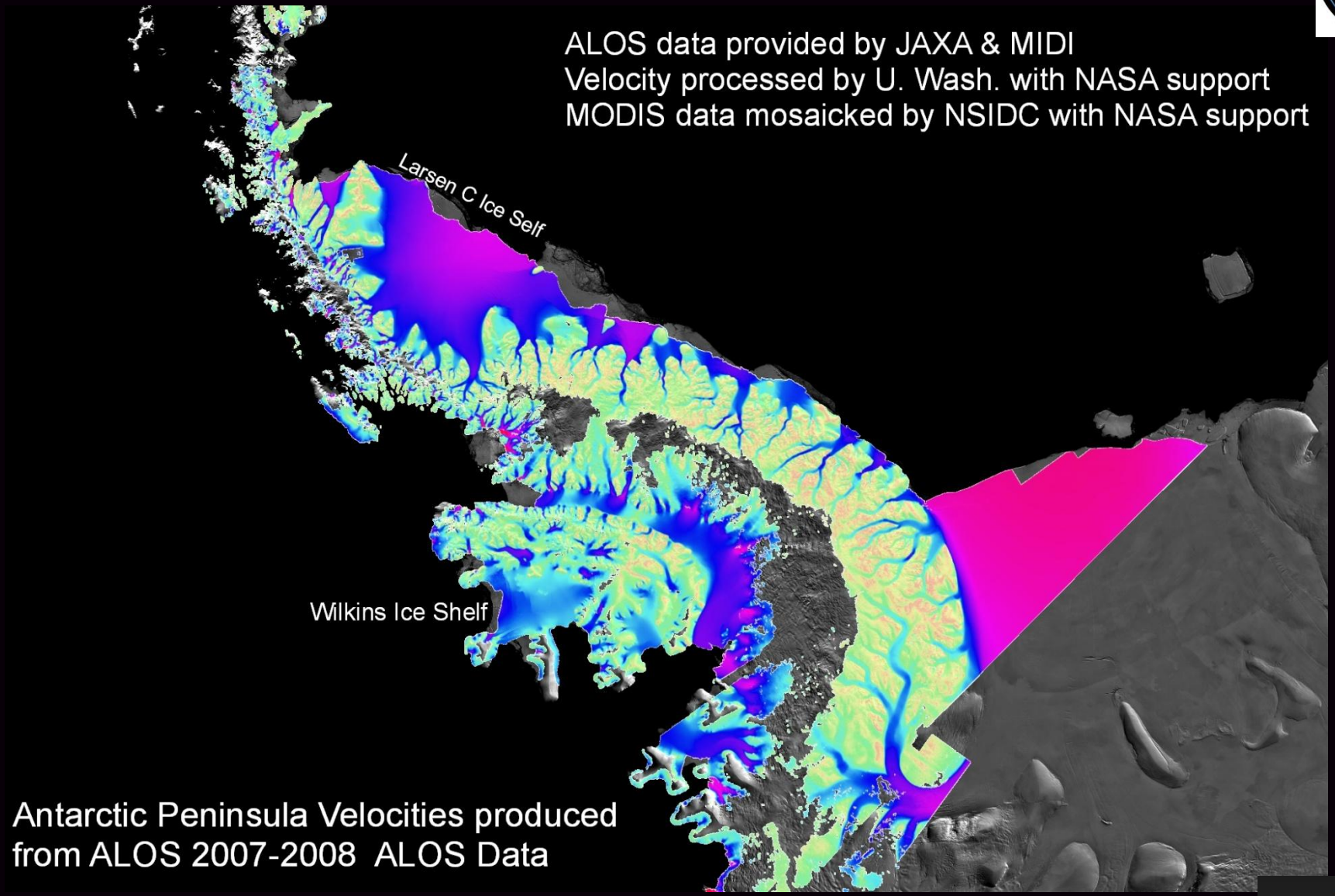
Northern Greenland Glacier Speed Change – 2000 to 2006



Recovery Glacier – T-SAR-X



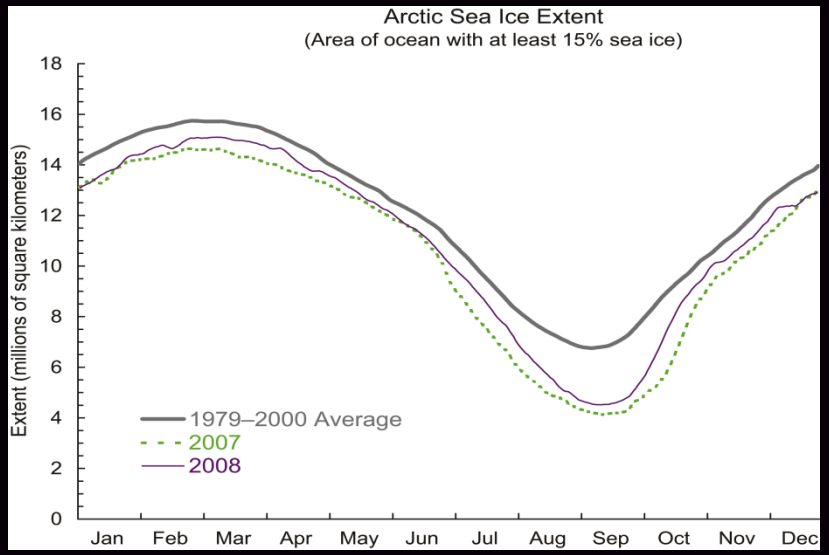
Japan Aerospace Exploration Agency

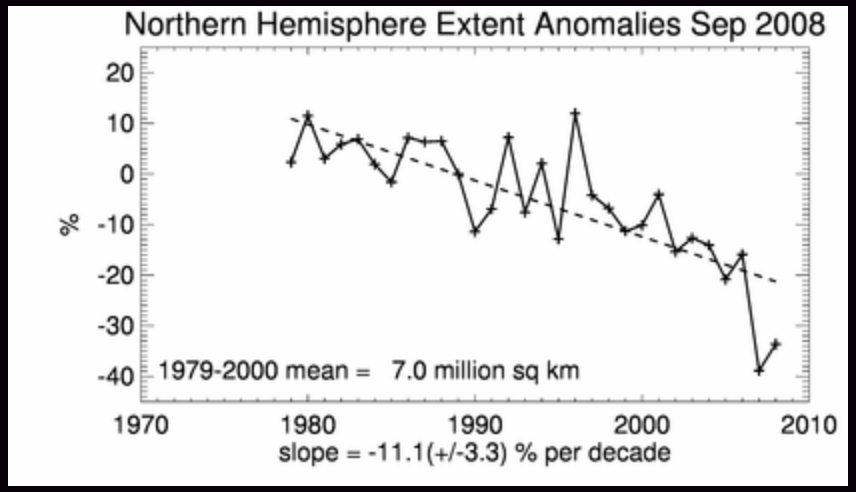


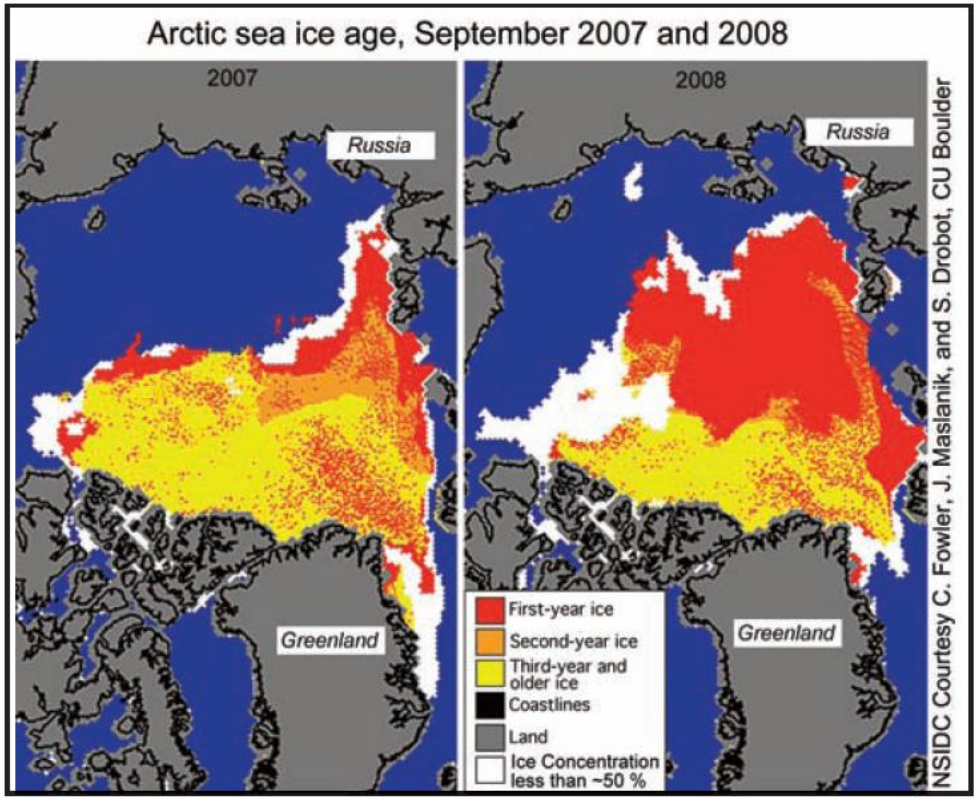
Antarctic Peninsula Velocities produced from ALOS 2007-2008 ALOS Data

Sea Ice

Arctic sea ice changes



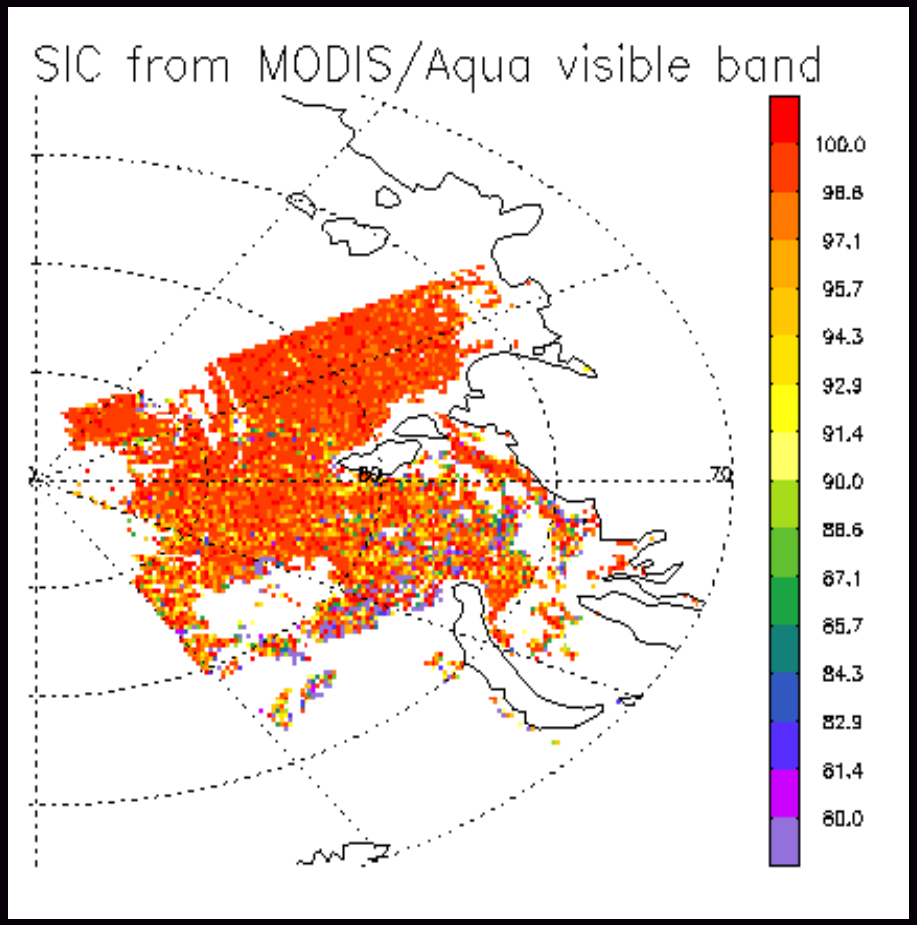




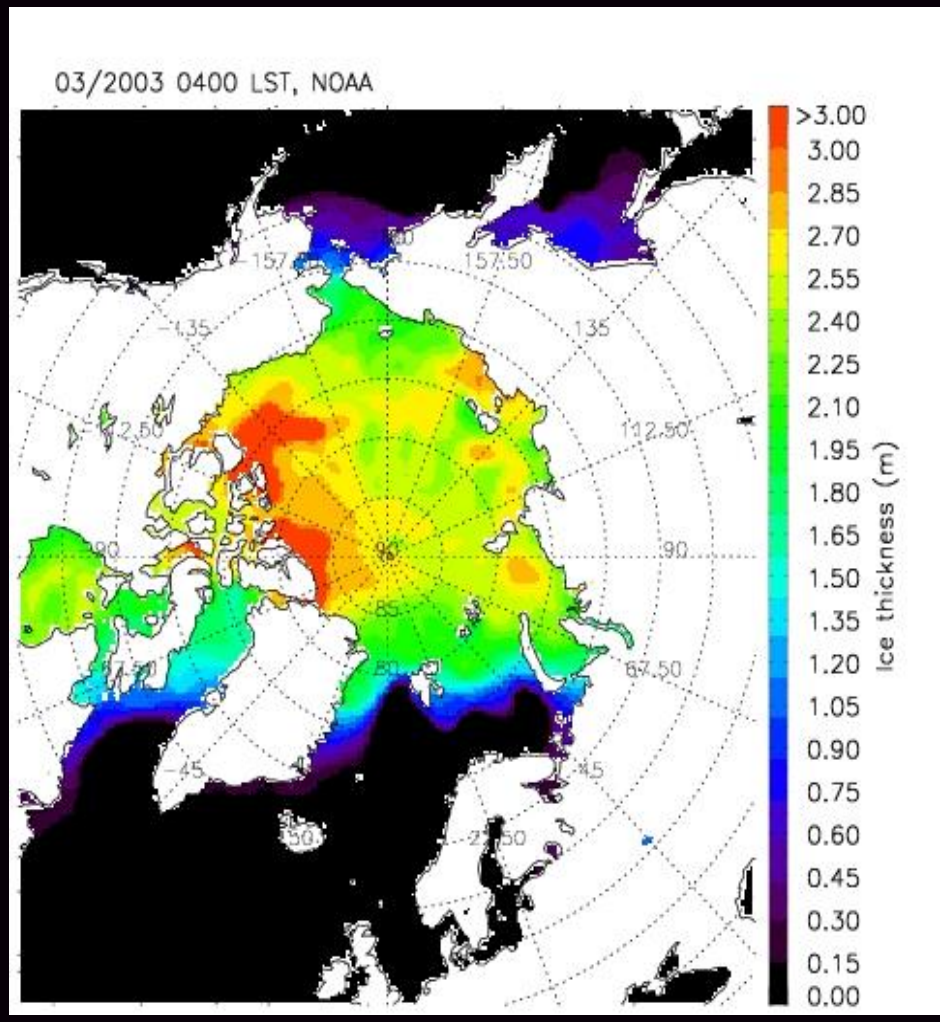
A comparison of ice age in September 2007 (left) and September 2008 (right) shows the increase in thin first-year ice (red) and the decline in thick multi-year ice (orange and yellow). White indicates areas of ice concentration below ~50 percent, for which ice age cannot be determined. AVHRR, SMMR SSM/I, and IABP buoy data were used

New Ice Products from AVHRR, MODIS, SEVERI

Sea Ice Concentration

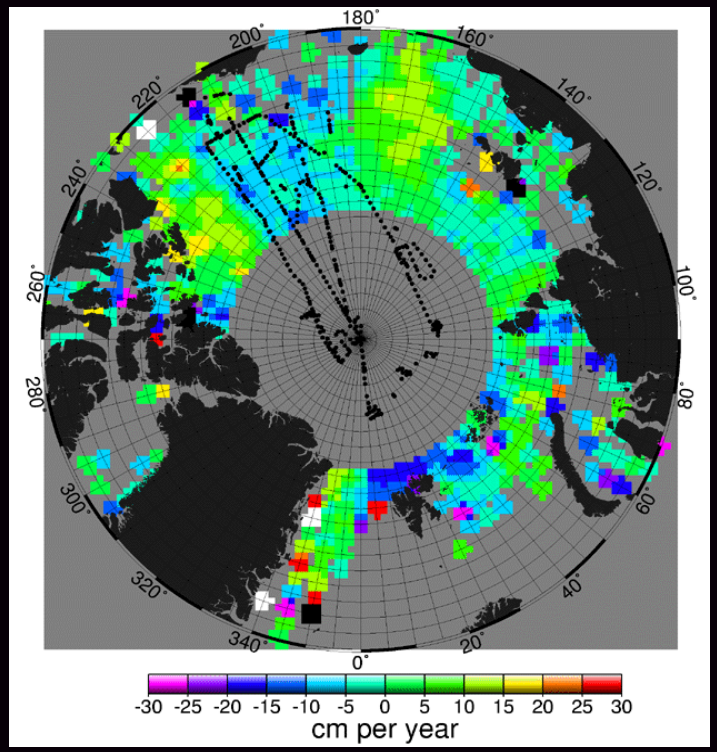


Sea Ice Thickness



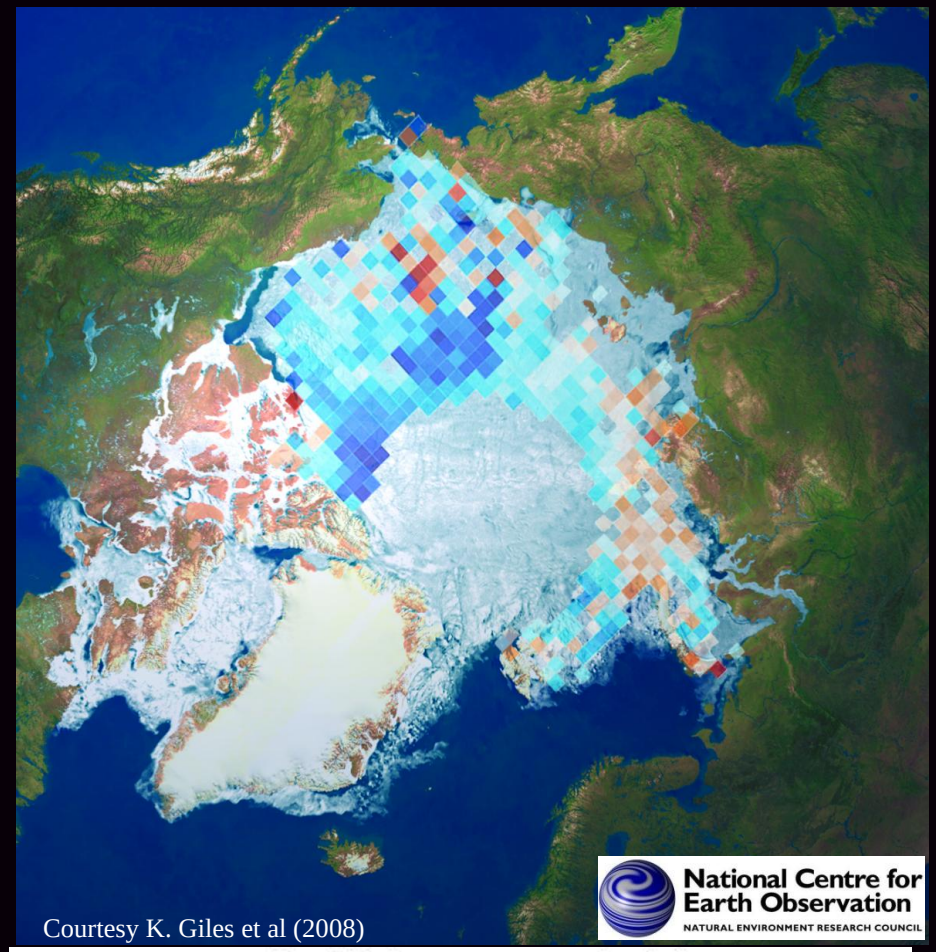
Arctic Sea-Ice Thickness Change

ERS-1/2: 1993-2002

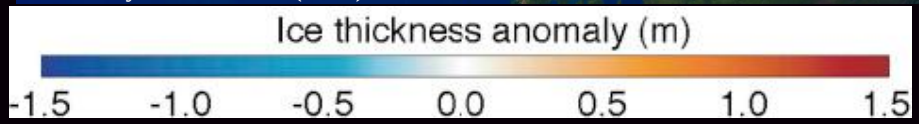


Courtesy S. Laxon

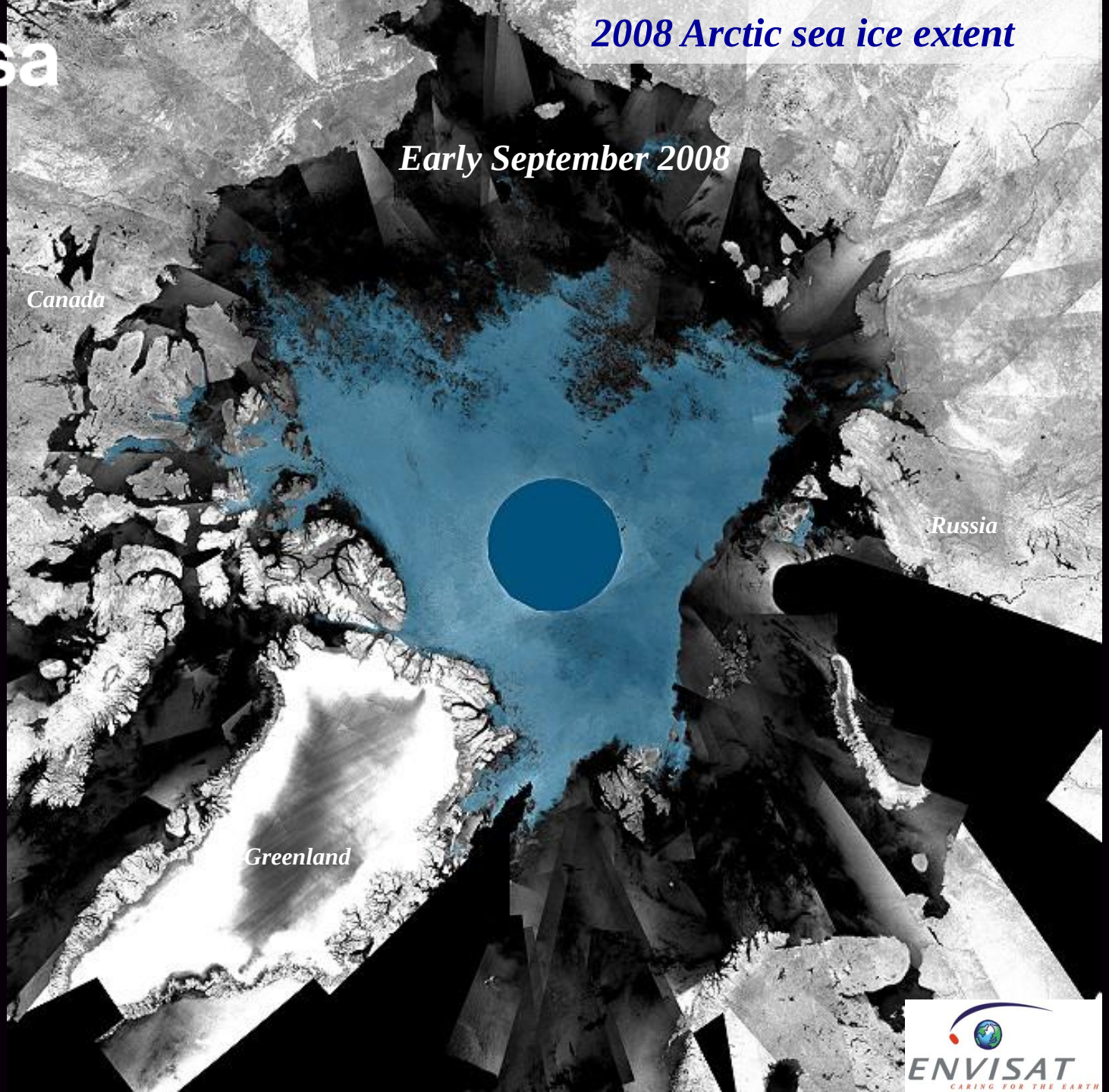
Envisat: 2008 ice anomaly



Courtesy K. Giles et al (2008)

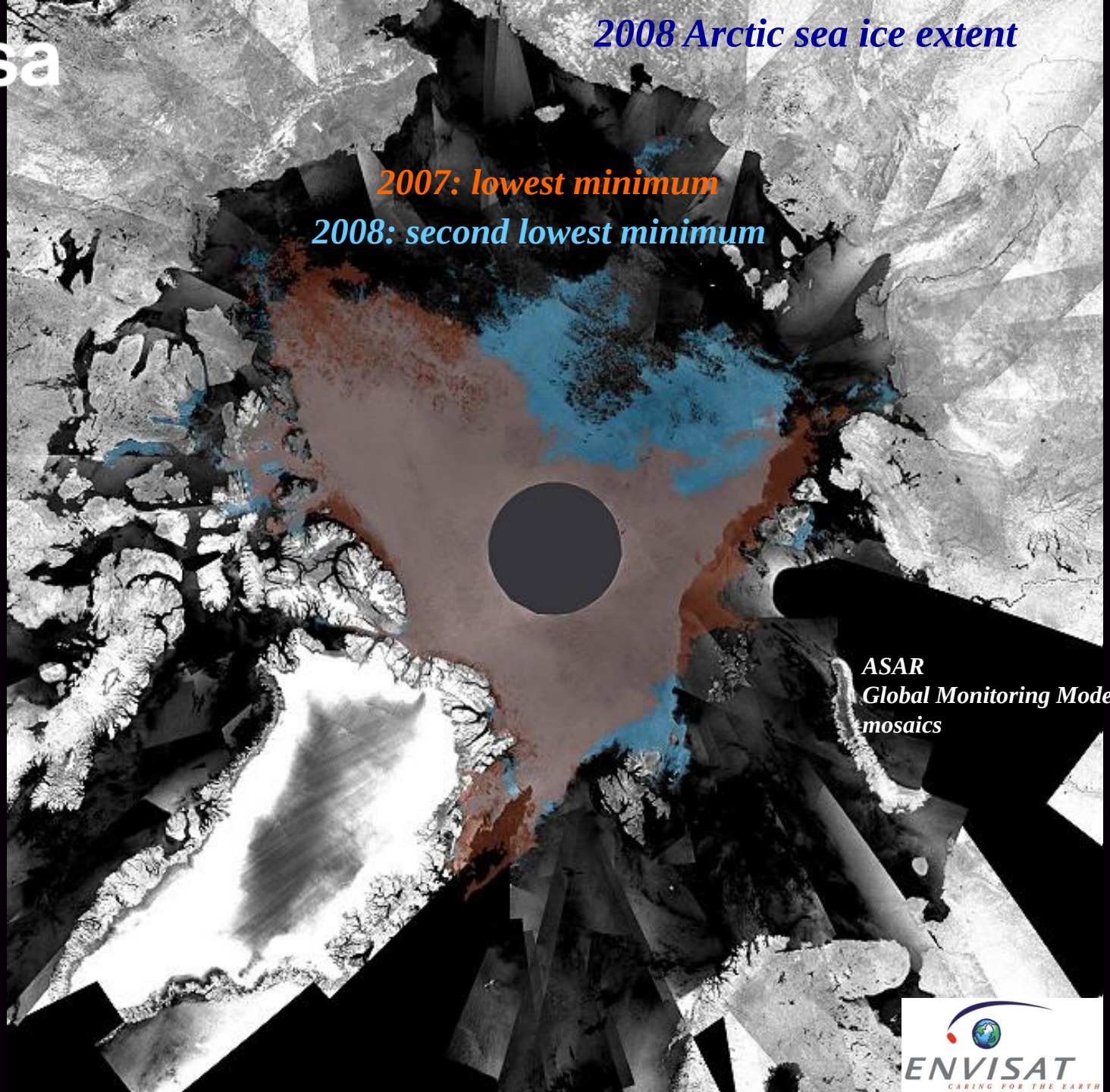


2008 Arctic sea ice extent

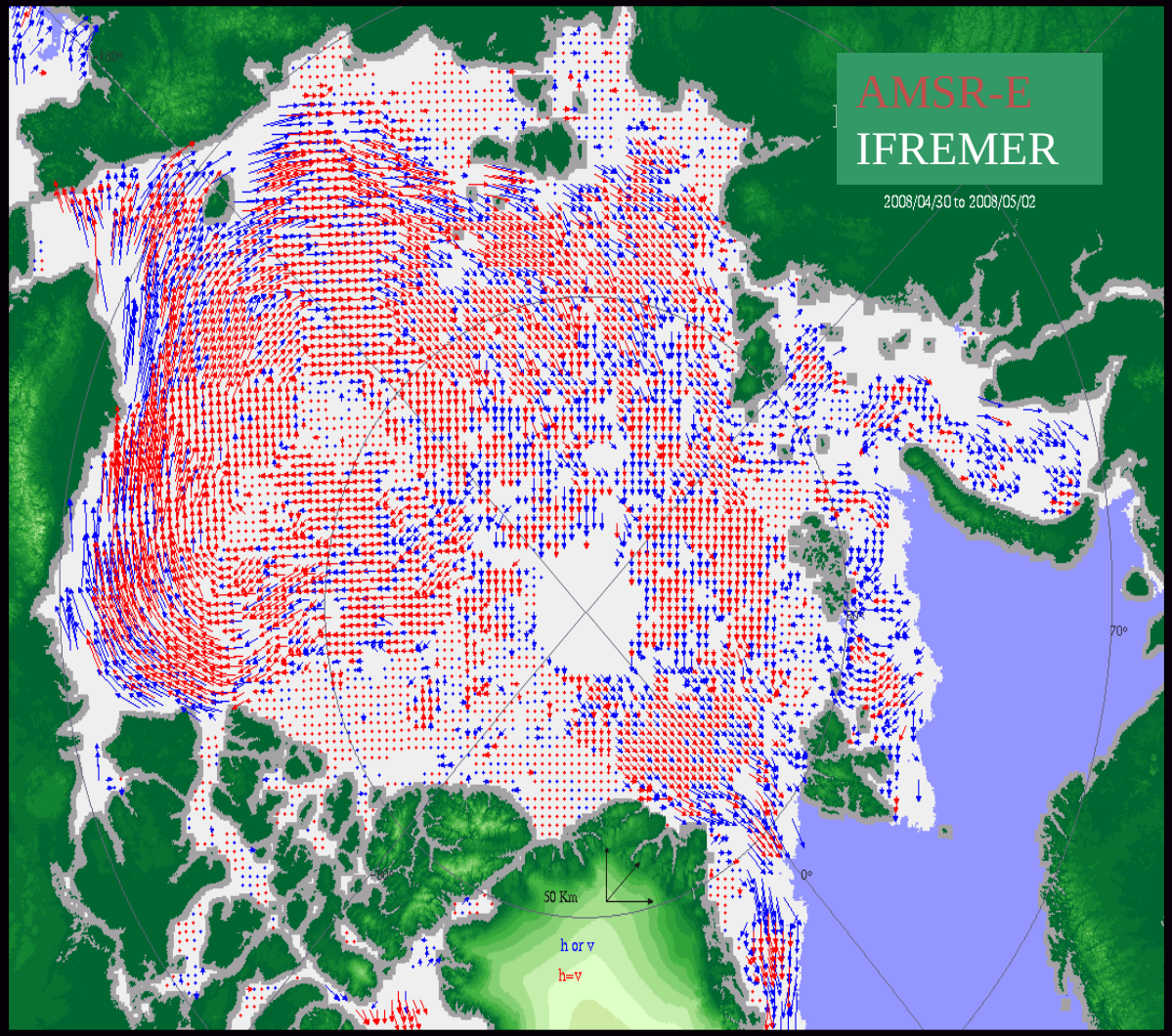


ASAR GMM mosaic

2008 Arctic sea ice extent



Arctic Sea-Ice Drift



2-day ice drift: April 30, 2008 → May 02, 2008

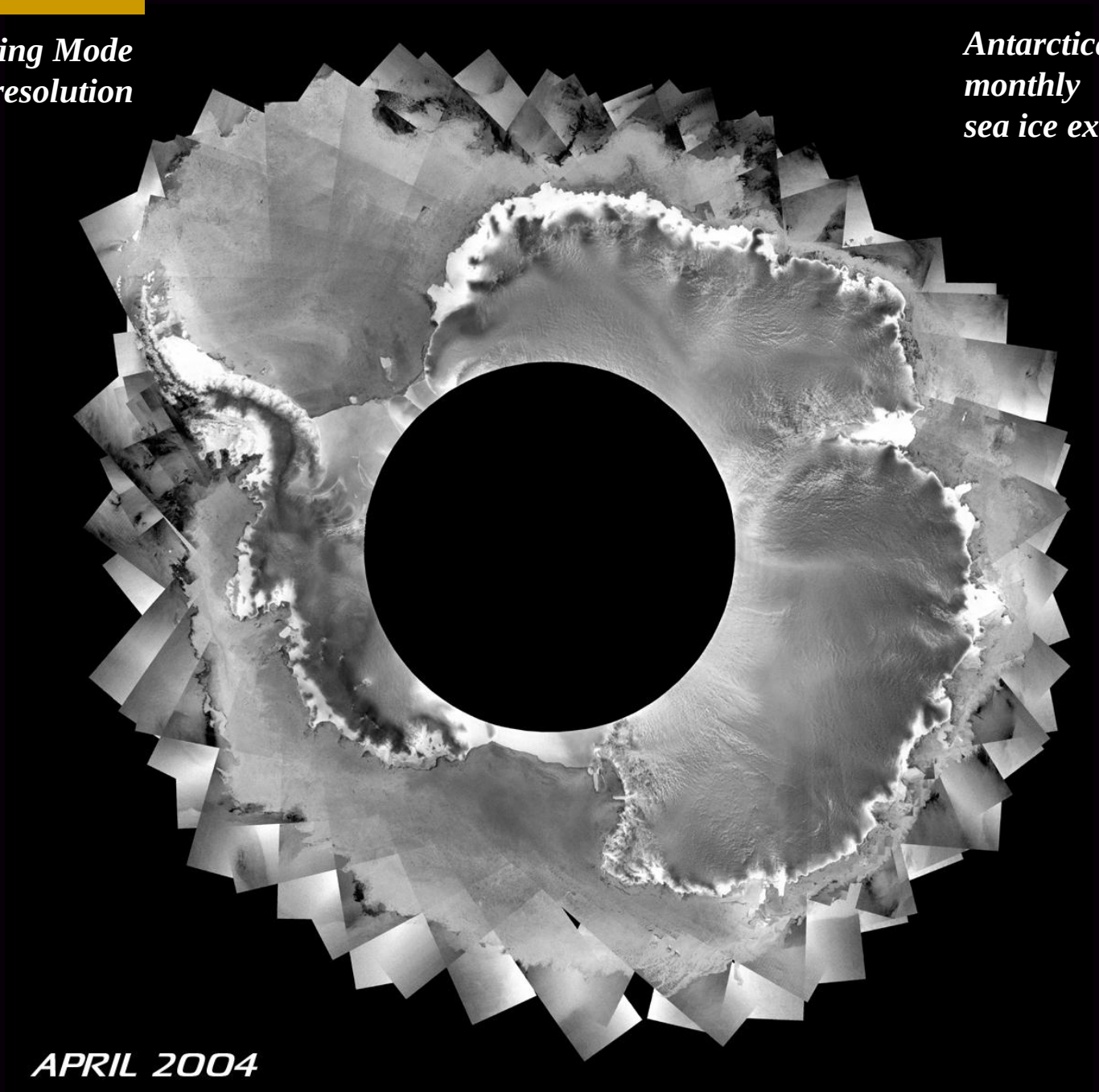
http://www.seaice.dk/test.N/

For the first time, repeat fine-resolution SAR mapping of the entire Southern Ocean sea-ice cover for sea ice motion

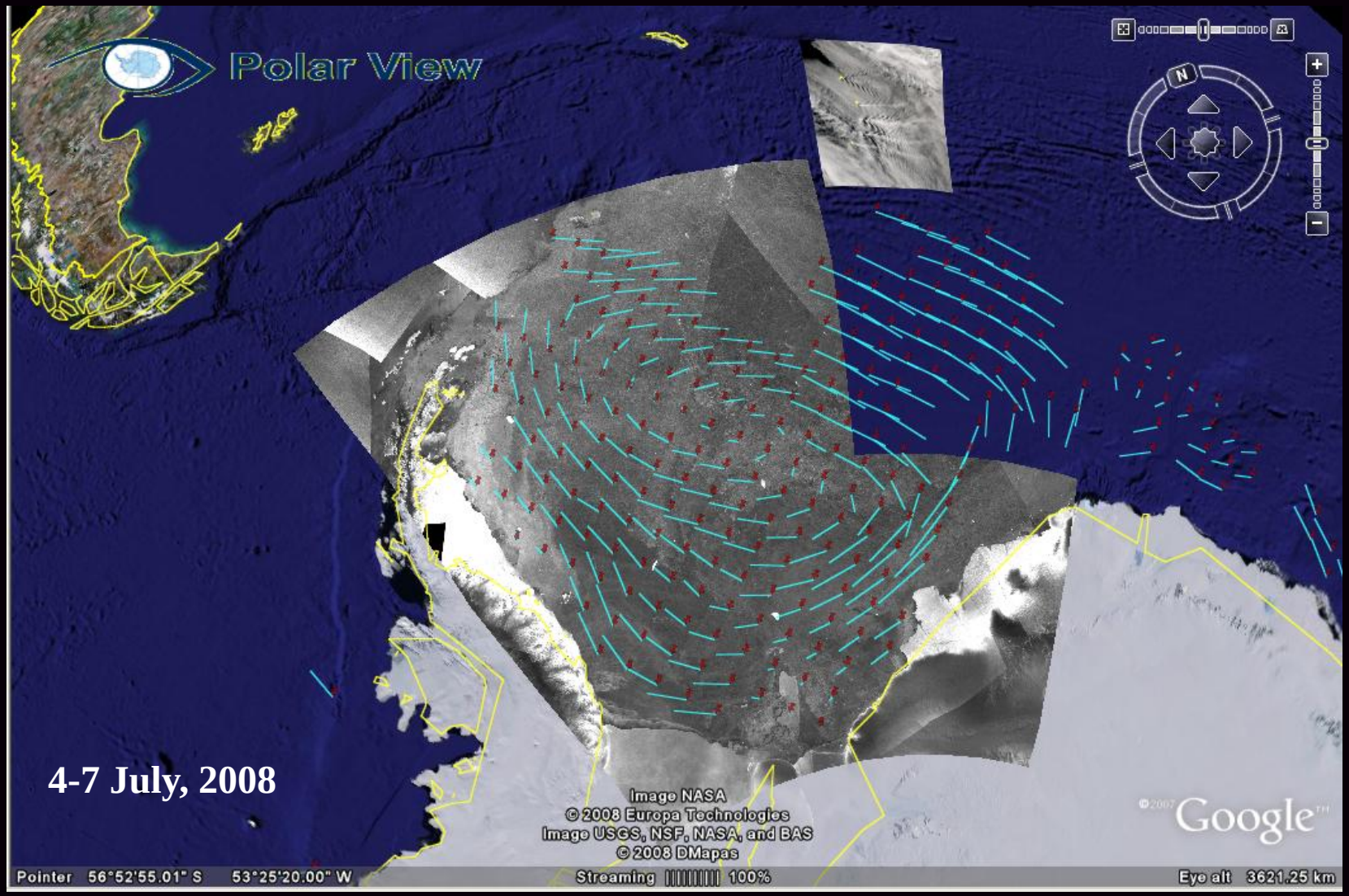
ASAR

Global Monitoring Mode (GMM) – 1km resolution

Antarctica monthly sea ice extent

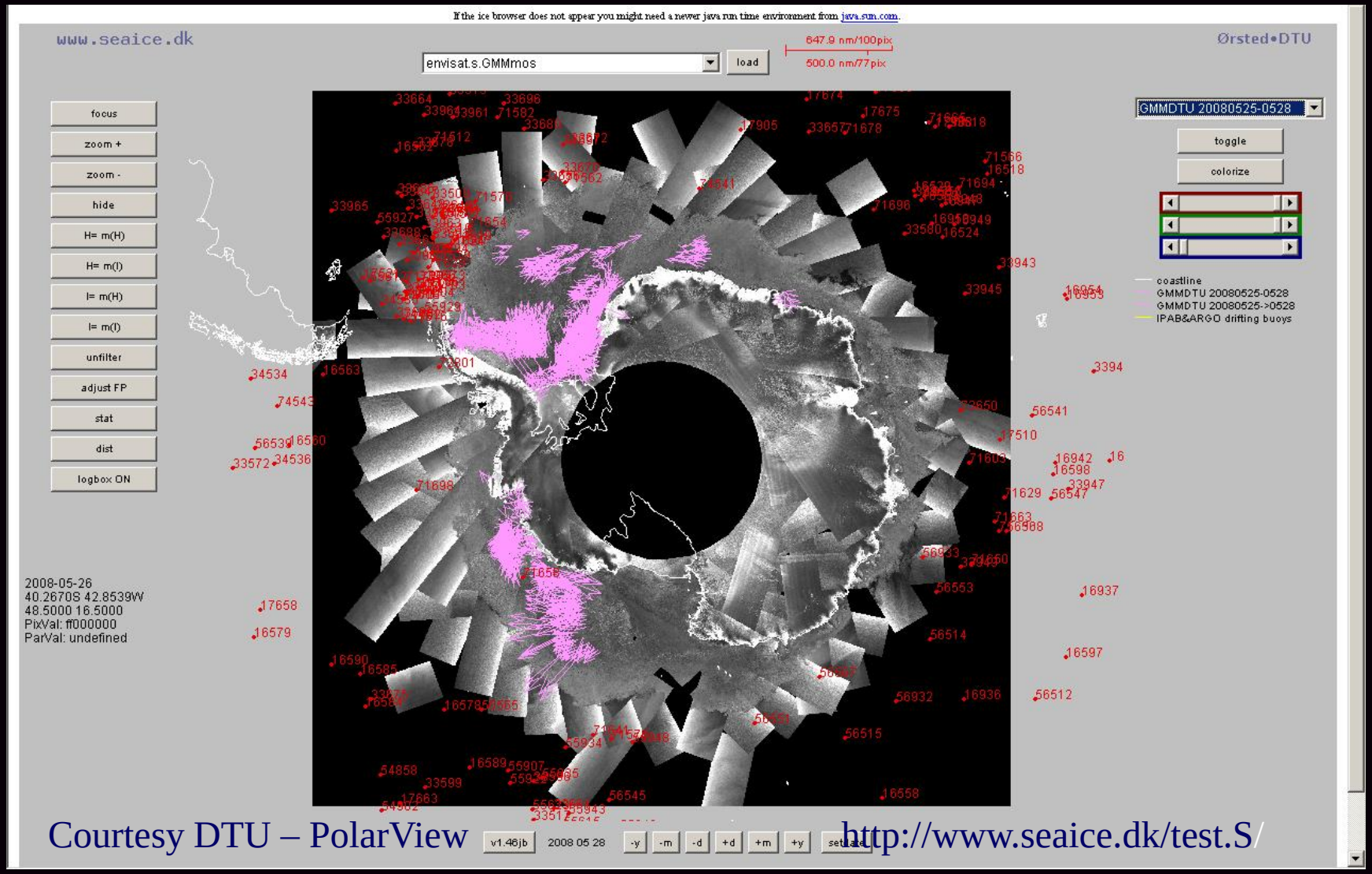


Envisat ASAR 3-day sea ice drift



http://www.seaice.dk/polarview/google.s/latest.GMMdrift.kml

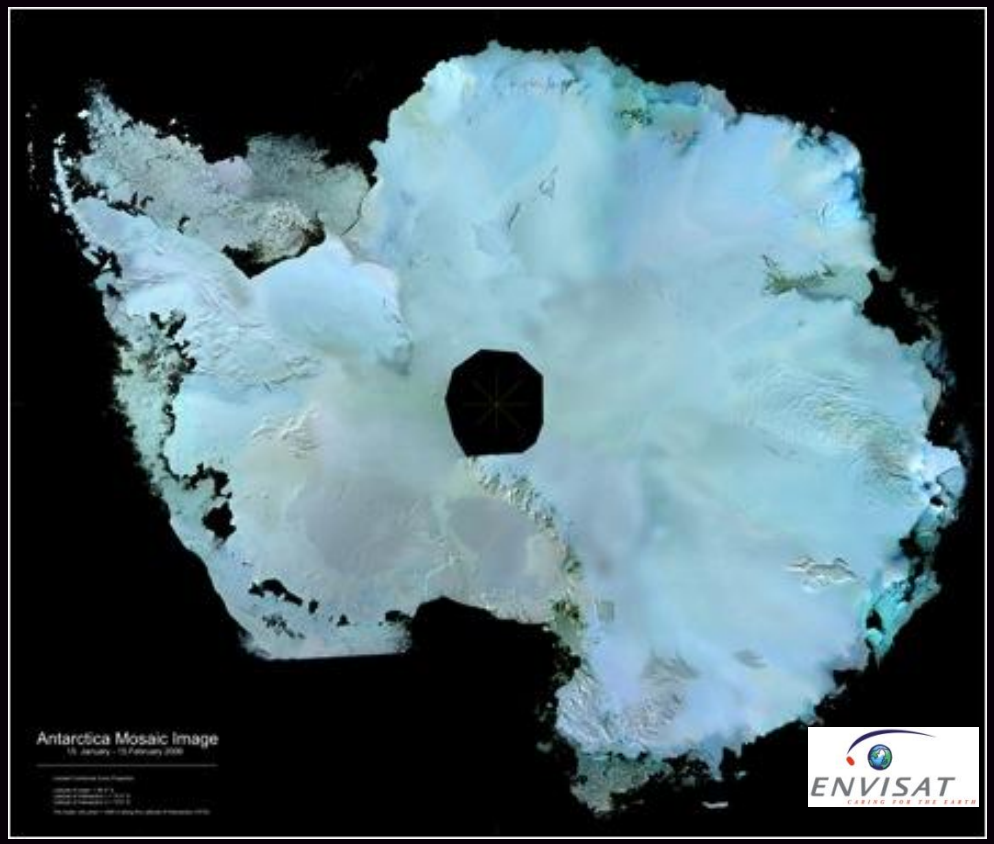
Routine Antarctic Sea ice Drift

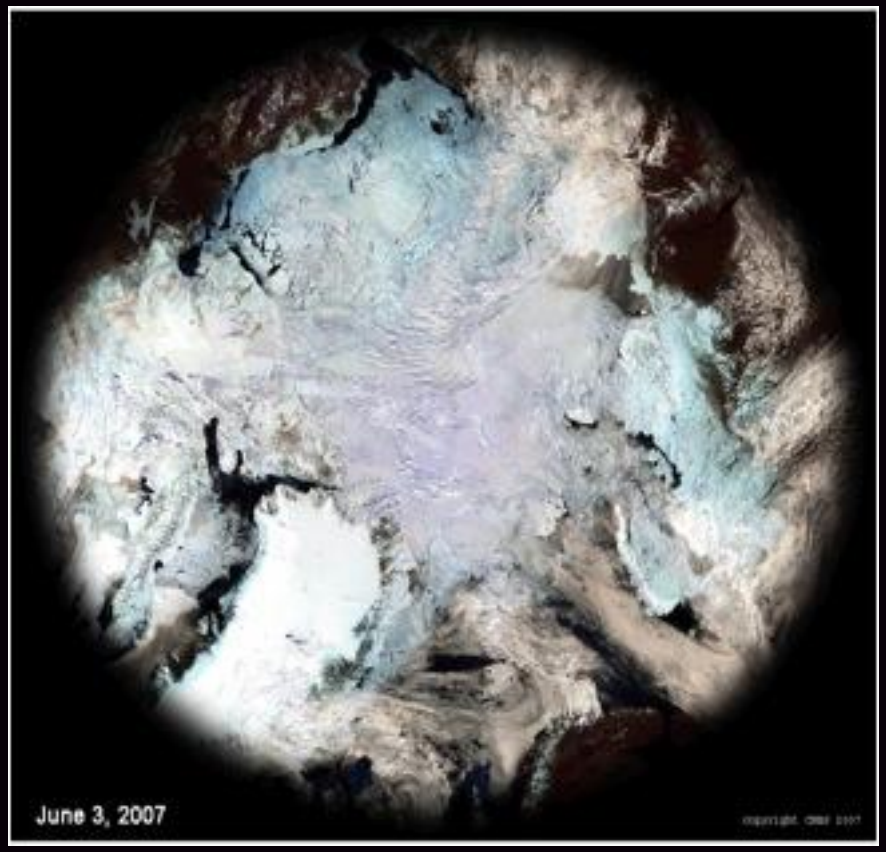


Courtesy DTU – PolarView http://www.seaice.dk/test.S/

For the first time, one complete Bipolar high & moderate resolution visible and thermal IR and SAR snapshot - for ice sheet, circumpolar snowcover and permafrost applications

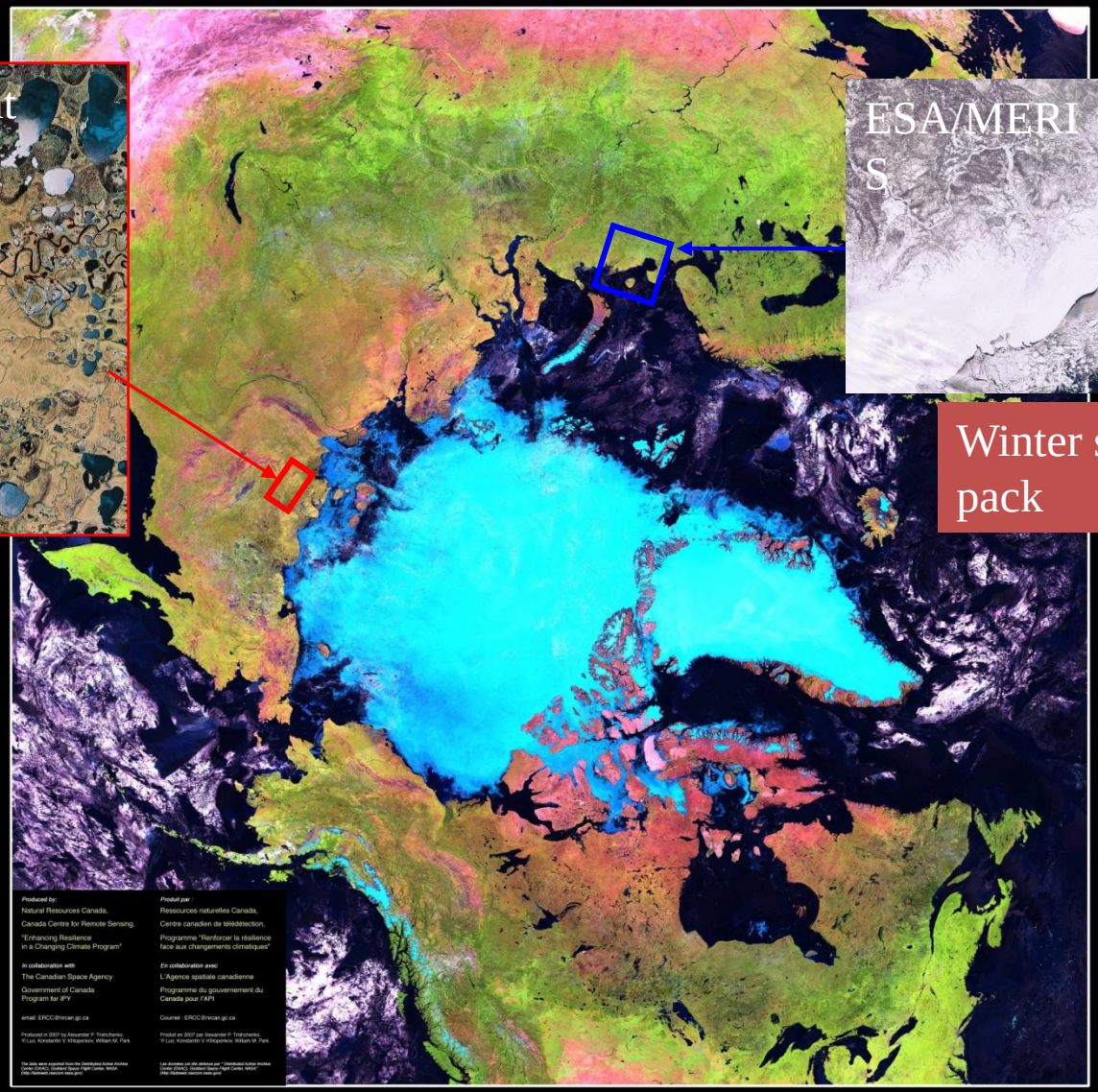
Visible/IR Image Mosaics of the Poles





SPOT VGT 1km daily mosaics (courtesy CNES)

Circumpolar Clear Sky Composites



Winter snow pack

Spring thaw – Siberian Thermokarst

Canadian Space Agency | Agence spatiale canadienne

NASA

INTERNATIONAL POLAR YEAR 2007-2008

Gouvernement du Canada | Government of Canada

MODIS Mosaic - Courtesy NRCan & NASA

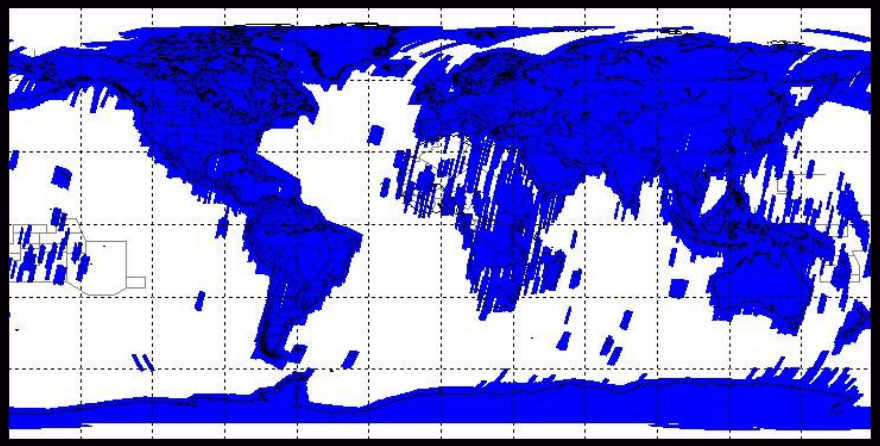
Canada

River and Lake Ice

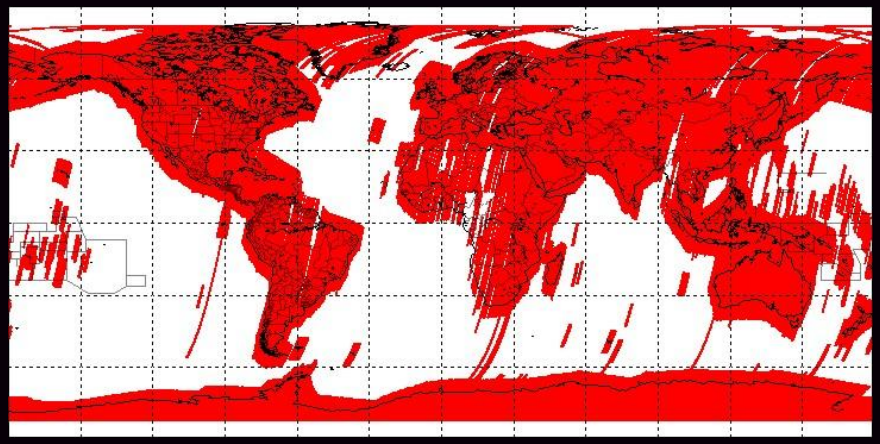
For the first time, Pan-Arctic high resolution Vis/IR and SAR snapshots - for lake and river freeze-up and break-up and other applications

ALOS: AVNIR-2 (10m) & PRISM (2.5m)

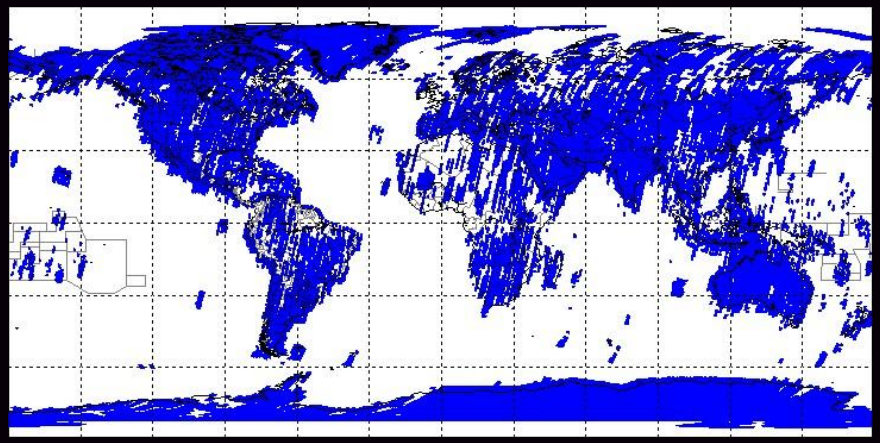
Acquired



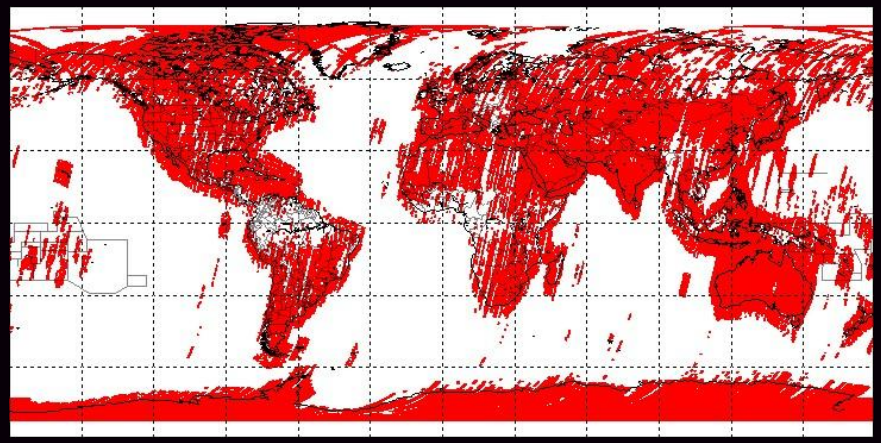
Acquired



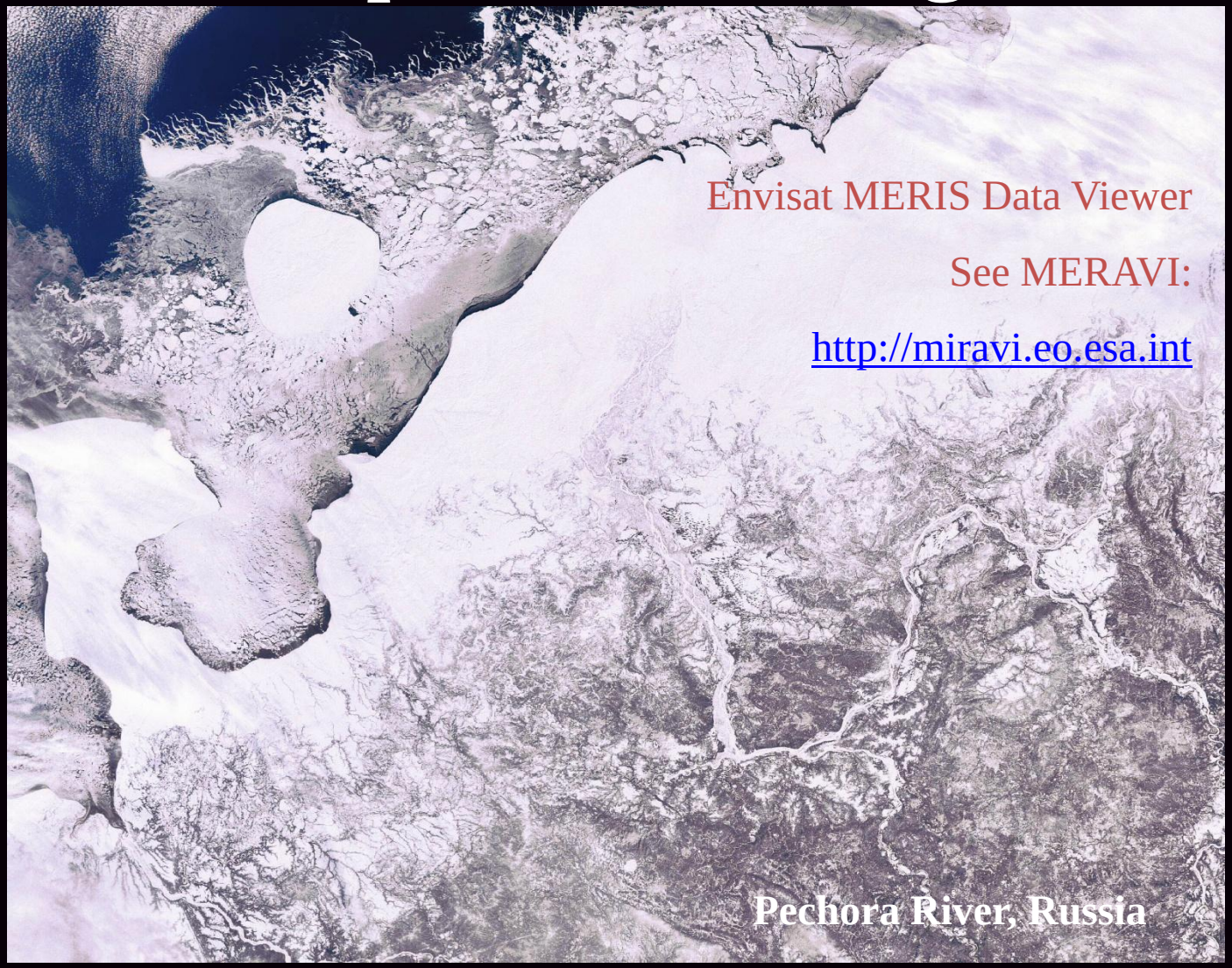
Cloud Free



Cloud Free

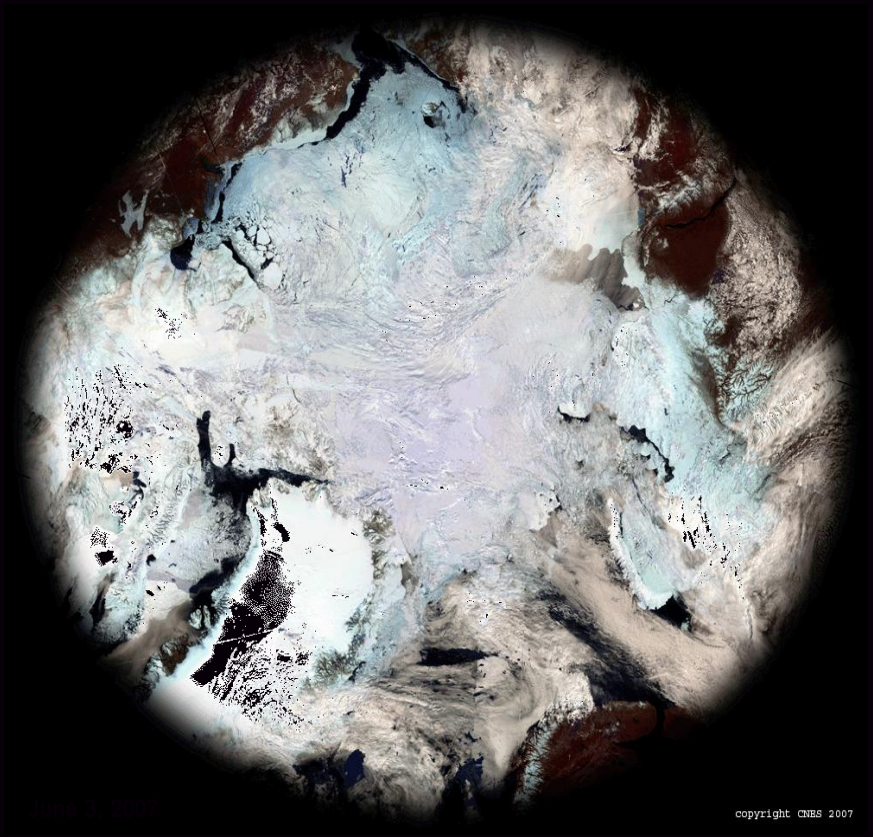


Arctic Optical Coverage



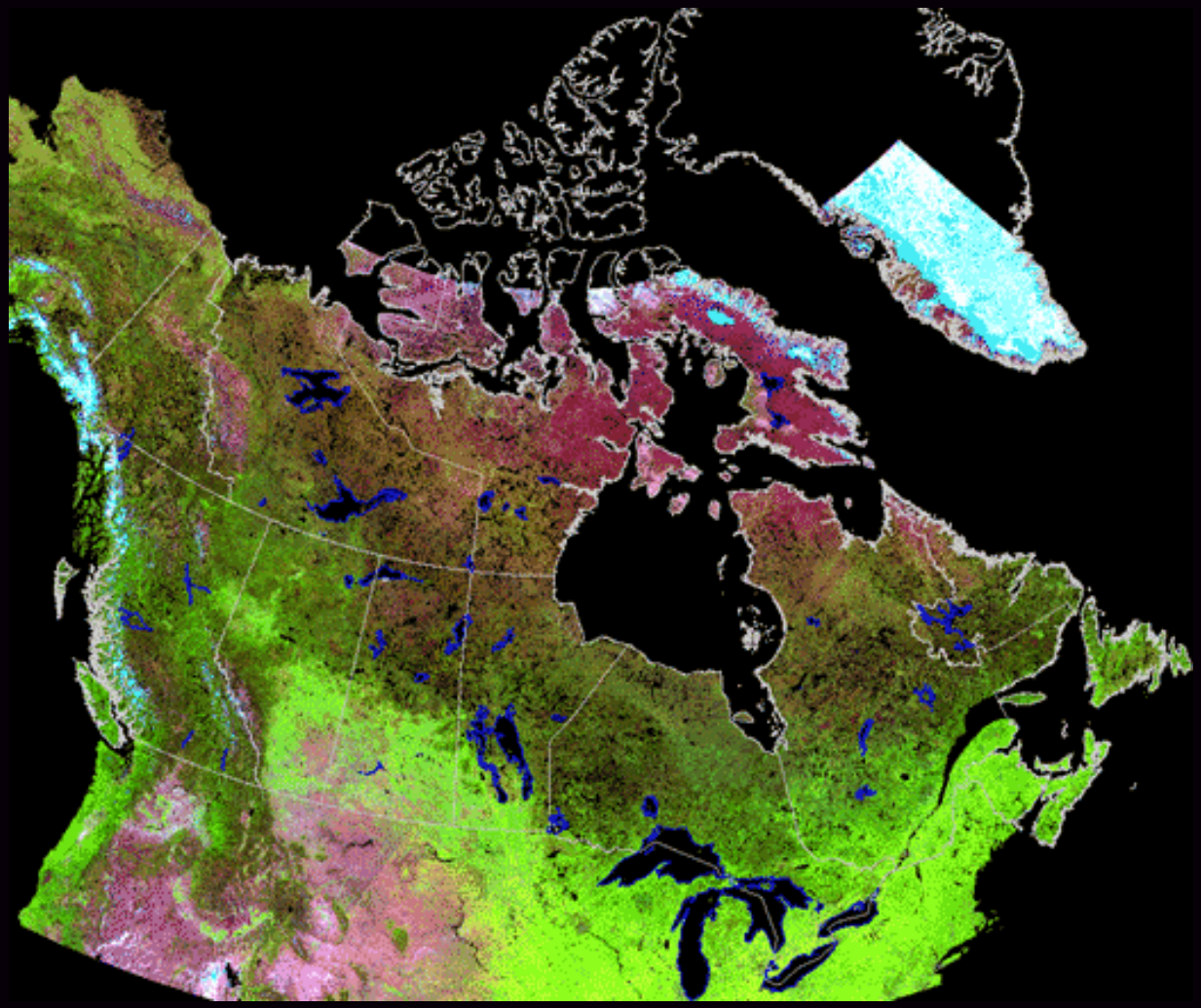
Envisat - MERIS – 300m optical image of Arctic tundra

Daily Optical (Visible/InfraRed)



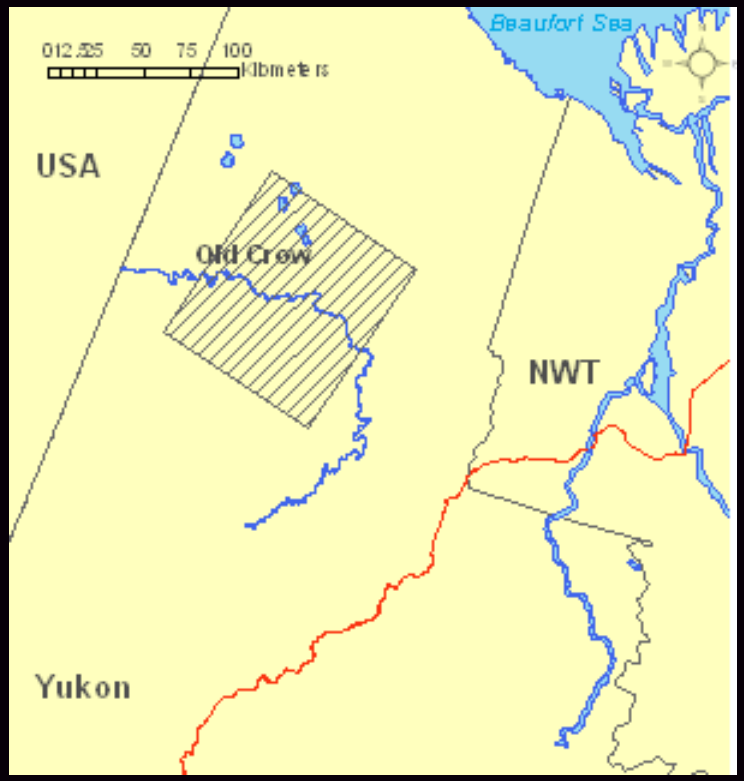
SPOT VGT 1km daily mosaics (courtesy CNES)

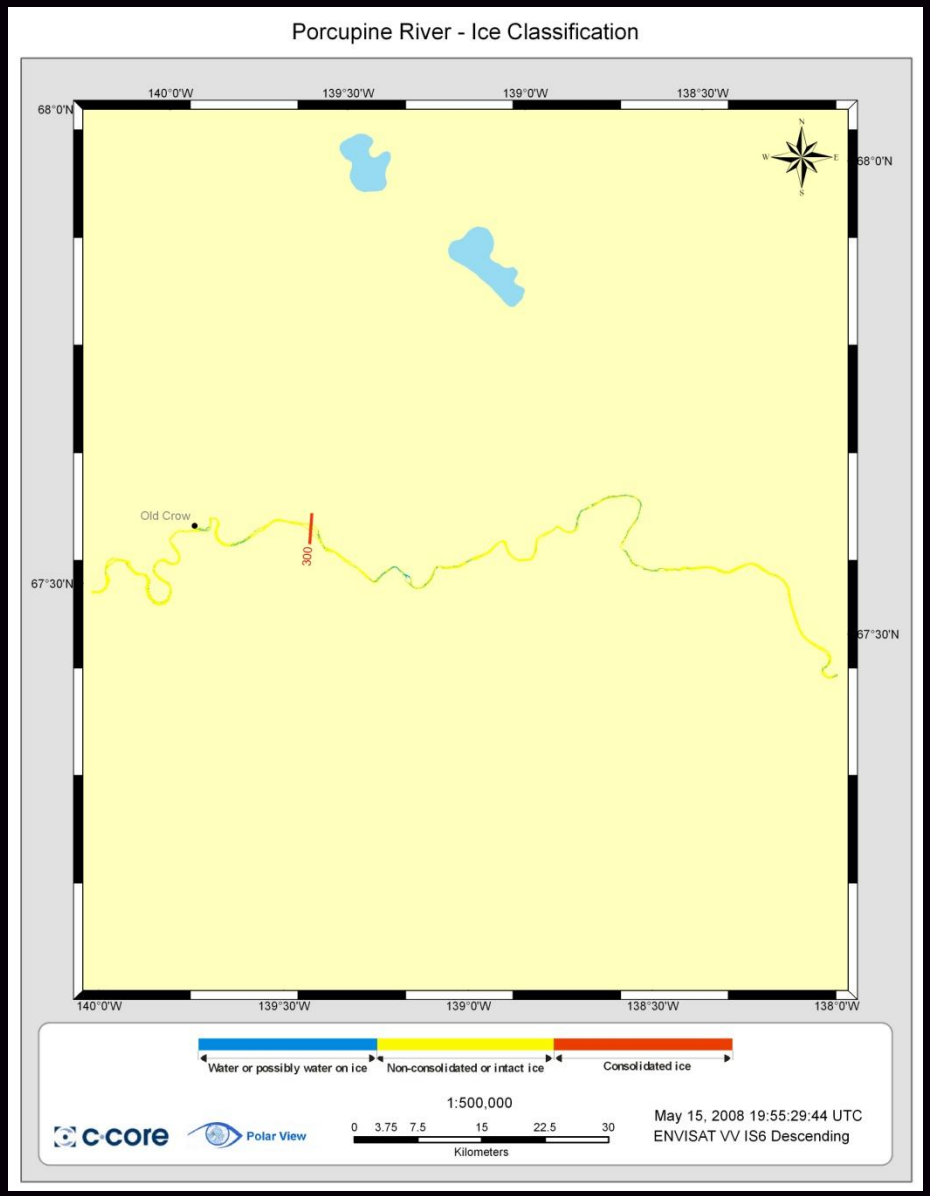
NRCan VGT mosaics



Corrected for BRDF & cloud effects (courtesy, Government of Canada, Natural Resources Canada, Earth Sciences Sector and Canadian Space Agency)

River Ice monitoring - Porcupine River, YK

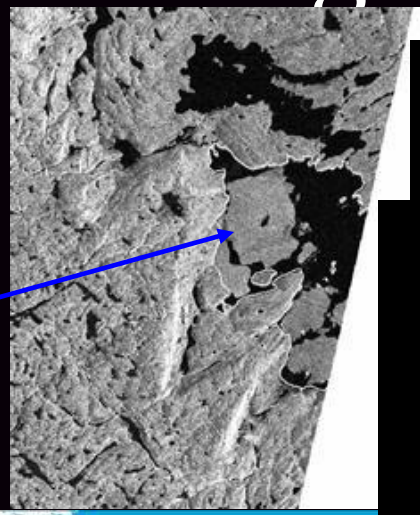




May 15, 2008

Envisat ASAR VV -IS6 – Desc.

Lake Ice Monitoring



Radarsat Image of Tasirjuakuluk for Jun 28, 2008:

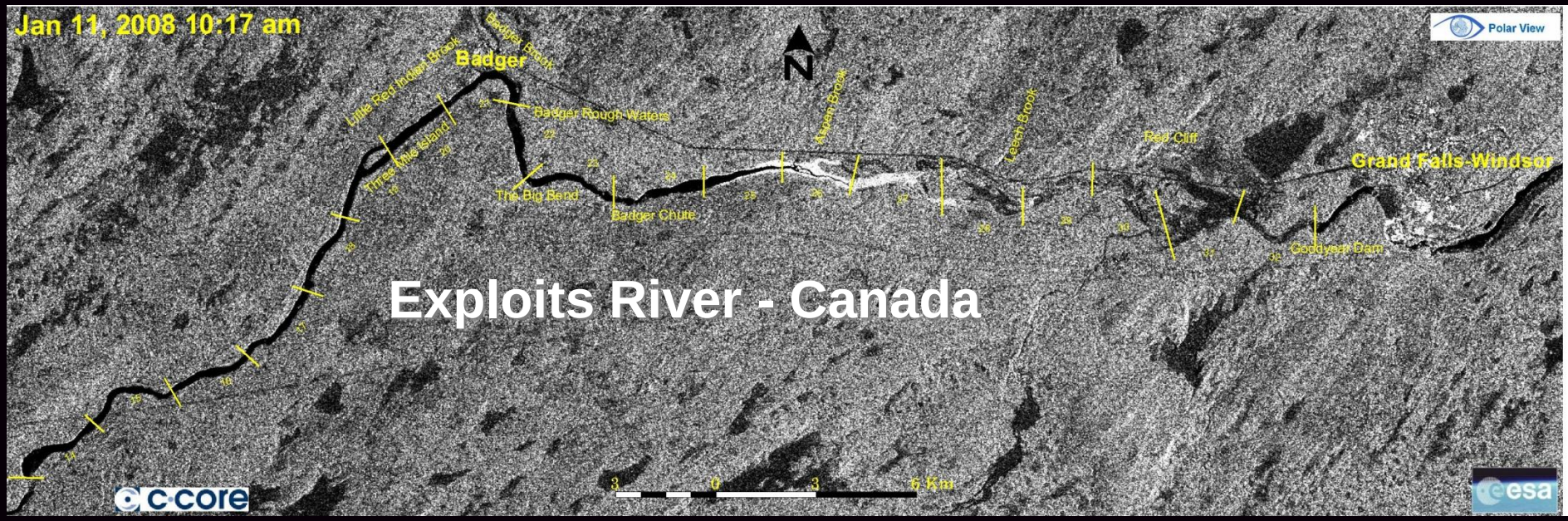
Ice Status: **Initial Ice Break-up**

Percent Area Frozen: **25 - 50%**

http://www.polarview.org/services/lim.htm

River Ice &
Ice Jam Monitoring

Alternating polarisation mode ASAR data



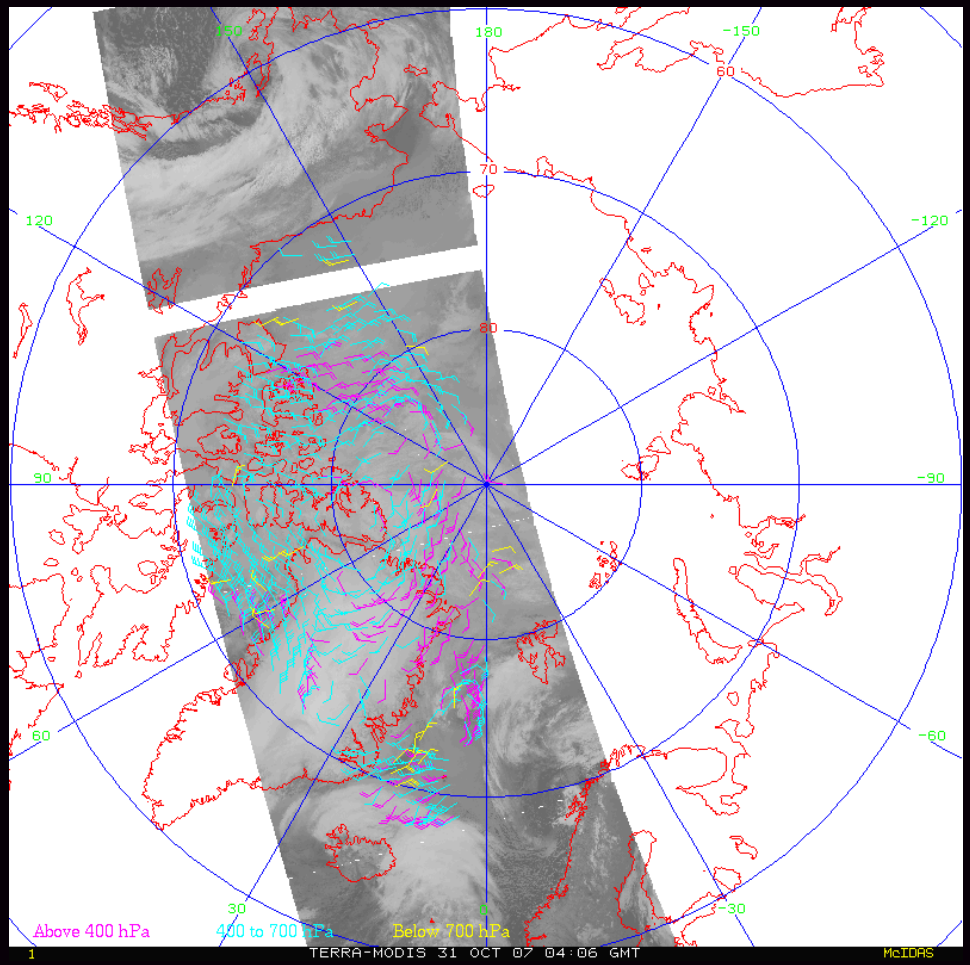
January 11, 2008

Courtesy PolarView

http://www.polarview.org/services/rim.htm

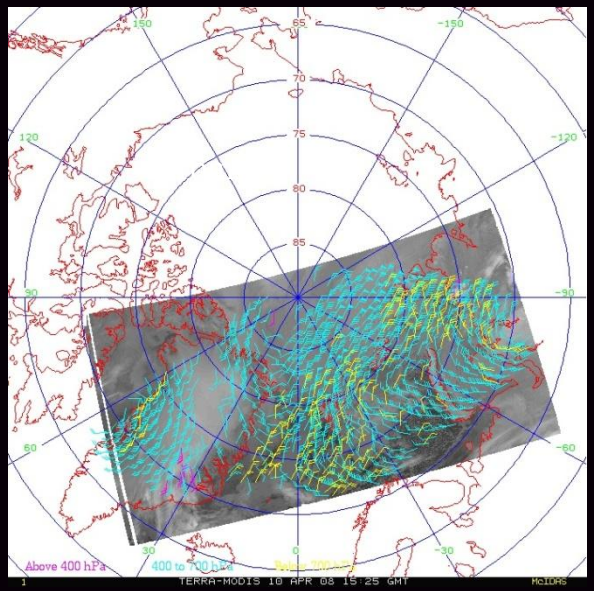
Atmosphere

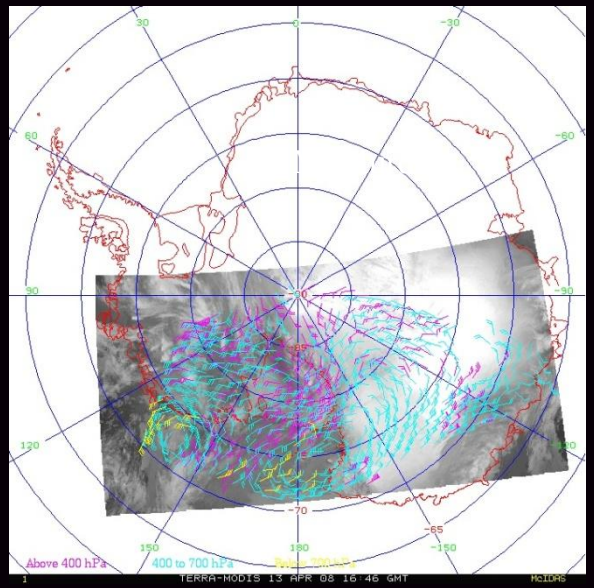
Cloud tracking : Upper atmosphere Winds

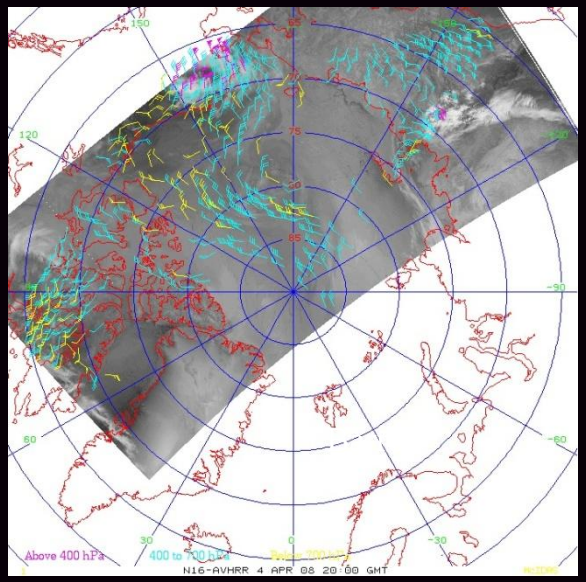


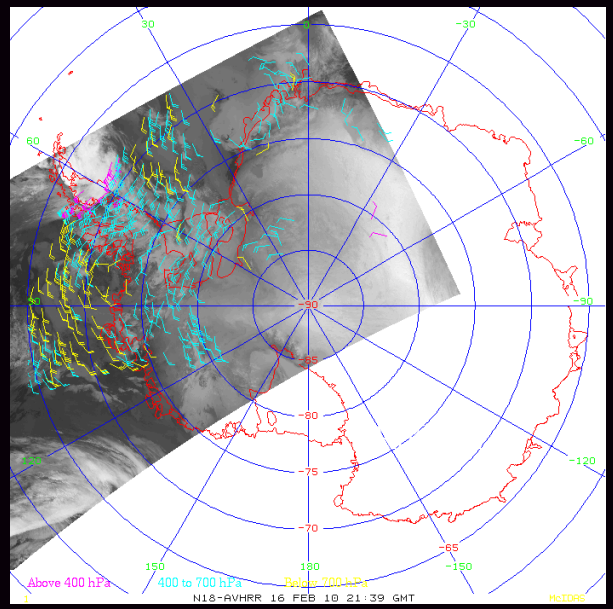
Polar Winds (courtesy NOAA/NESDIS)

Direct Broadcast (Readout) MODIS and AVHRR Winds



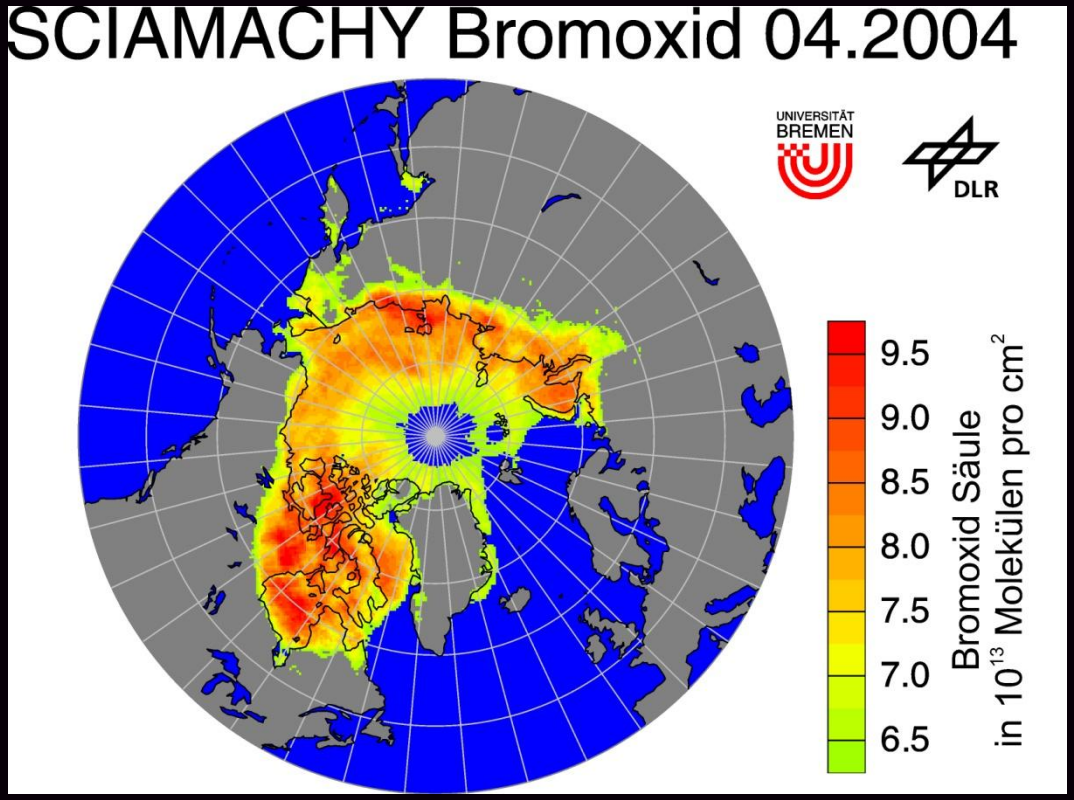






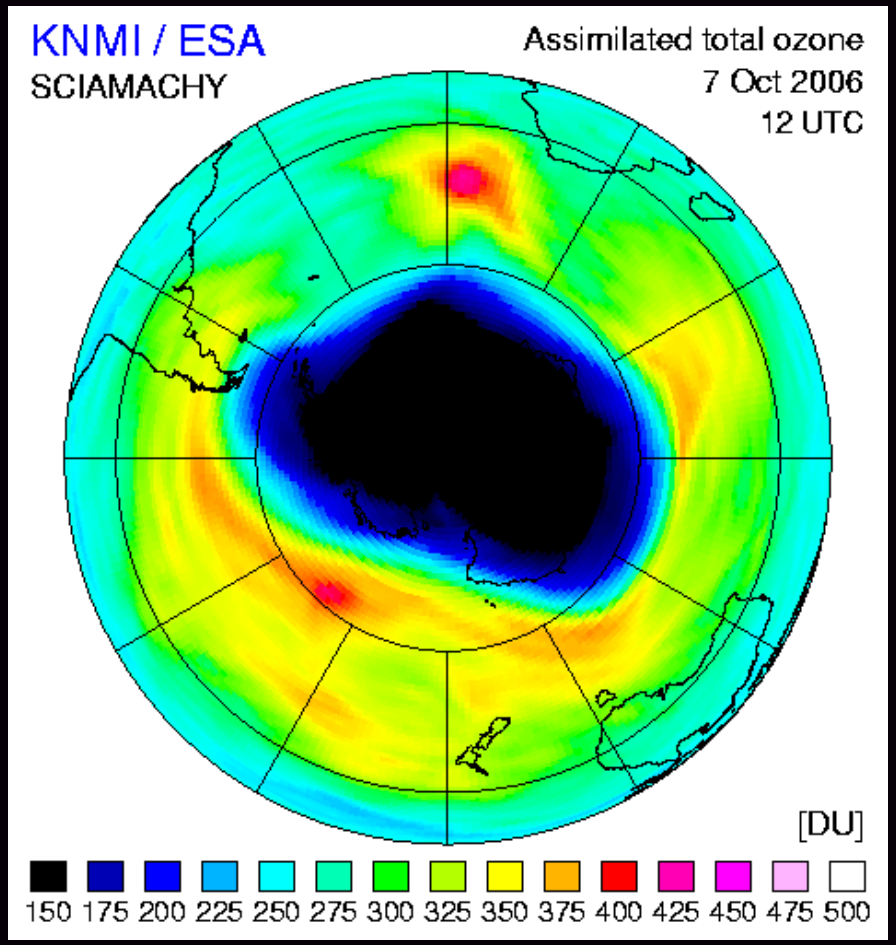
- Aqua, Terra, AVHRR winds are generated separately
- Data source is direct readout (broadcast)
- 1 km MODIS and AVHRR remapped to 2 km.
- Cloud-track and water vapor (MODIS) winds
- NCEP's GFS is used as the background.
- Pros: Low latency; high resolution.
- Cons: Incomplete polar coverage.

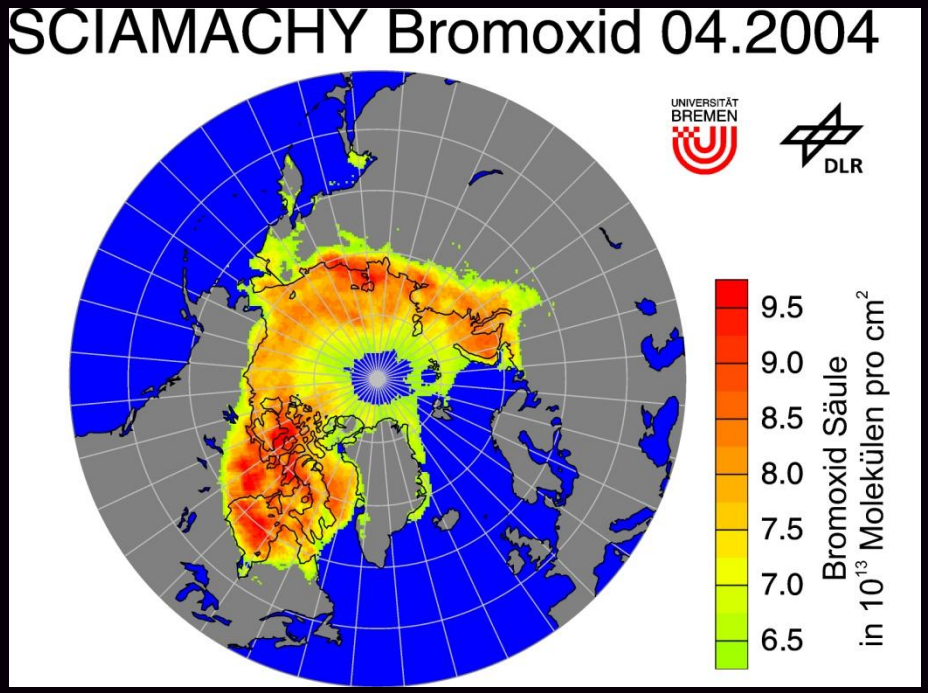
Atmospheric composition measurements, e.g. Bromium Monoxide (BrO)

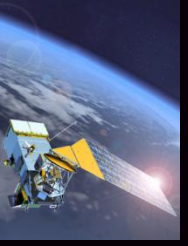


Courtesy S. Kern

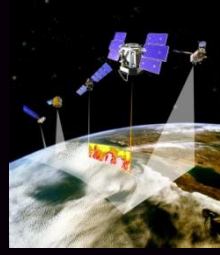
Continued atmospheric composition measurements, e.g., ozone (O3) and bromium monoxide (BrO)







Summary



- The STG has contributed fundamentally to IPY by ensuring inter-Agency coordination needed to acquire a critical 21st century climate benchmark dataset necessary to meet IPY Science goals
- IPY satellite Legacy dataset is multi-dimensional and spans data from 14 space agencies.
- The Space Task Group mechanism is itself a legacy for organizing future coordinate earth observing campaign as appropriate.

What Next?

GIIPSY/STG:

A legacy of IPY

A component of WIGOS

A legacy of WCRP/CliC in the area of observations

A contribution to GEOSS

Establish a path for securing future collections of spaceborne snapshots of the poles through development of a virtual constellation

The WMO Global Cryosphere Watch could be a vehicle for achieving that objective.

How would a reconstituted STG operate in a new framework? Would there be expanded scientific objectives? What would be the extent of the planning window?

What would be the new functional link to the science community.

GIIPSY/STG Related Publications

- Drinkwater, M.R., K. C. Jezek and J. Key, 2008. Coordinated satellite observations during the International Polar Year: Towards Achieving a Polar Constellation. Space Research Today, no. 171, p. 6-17
- Floricioiu, D. and K. Jezek, 2009. Antarctica during the IPY: TerraSAR-X images the Recovery Glacier System. Environ. Geol., DOI 10.1007/s00254-009-1743-4, 58:457-458
- Goodison, B., J. Brown, K. Jezek, J. Key, T. Prowse, A. Snorrason, and T. Worby, 2007. State and fate of the polar cryosphere, including variability in the Arctic hydrologic cycle. WMO Bulletin 56 (4), p. 284-292
- Gottwald, M. and C. von Savigny, 2009. Exploration of noctilucent clouds in the polar mesosphere with SCIAMACHY, Environmental Earth Sciences, DOI 10.1007/s12665-009-0308-**x**, 59:949-950
- IGOS, 2007. Integrated Global Observing Strategy Cryosphere Theme Report - For the Monitoring of our Environment from Space and from Earth. Geneva: World Meteorological Organization. WMO/TD-No. 1405. 100 pp.
- Jezek, K.C., and M. Drinkwater, 2006. Global Interagency IPY Polar Snapshot Year, EOS, Vol 87, Issue 50, p. 566.
- Jezek, K. and M. R. Drinkwater, 2008. Global interagency IPY polar snapshot year: an update. Environ Geol., DOI 10.1007/s00254-008-1393-y
- Jezek, K, and M. Drinkwater, 2010. Satellite Observations from the International Polar Year. EOS, vol 91, no. 14, p. 125-126.