



Remote Sensing of Sea Ice

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Users of Sea-Ice Information

- ▶ Historically: people living near ice infested waters since the sea ice affected people's lives in various ways.

(In worst cases no fishing, no travel, no harvest...)

- ▶ Seafarers and fishermen for navigational safety
- ▶ Meteorologists and climatologists as the sea ice affects weather and plays a big role in climatology
- ▶ Tourist companies and others carrying out operations in icy waters
- ▶ Fish farms and other activities at sea
- ▶ The media, the public, officials and researchers.

The requirements for ice information vary greatly – concerning the parameters observed, area coverage, geometric resolution, time resolution and timeliness.

*Best to get information as close to real time as possible,
Make accessible to users but build up an archive at the same time*

Sea-Ice observations

- ▶ Marine Sediment Cores - indication of sea ice and iceberg extent (*diatoms, foraminiferas, IP25, IRD*)
- ▶ Historical Sea-Ice Information – maximum ice extent, type, consequence (*charts, logbooks, diaries*)
- ▶ Direct observations from ships, aircraft, coastal stations and submarines (thickness data)
- ▶ Satellite imagery – optical, thermal, passive and active microwave, lidar.

Again, different timescale, precision and properties are needed.

Properties of sea ice

- ▶ Sea-ice extent
- ▶ Sea-ice concentration
- ▶ Ice types and ice age
- ▶ Size and shape of floes
- ▶ Thickness, roughness, ridges
- ▶ Salinity
- ▶ Ice drift
- ▶ Surface melt
- ▶ Snow cover
- ▶ Soot, sediments, algae...
- ▶ Icebergs

Remote Sensing in regions that are frequently covered by clouds, are inaccessible and dark for considerable part of the year

Studying features that change fast, are affected by wind, currents and internal forces

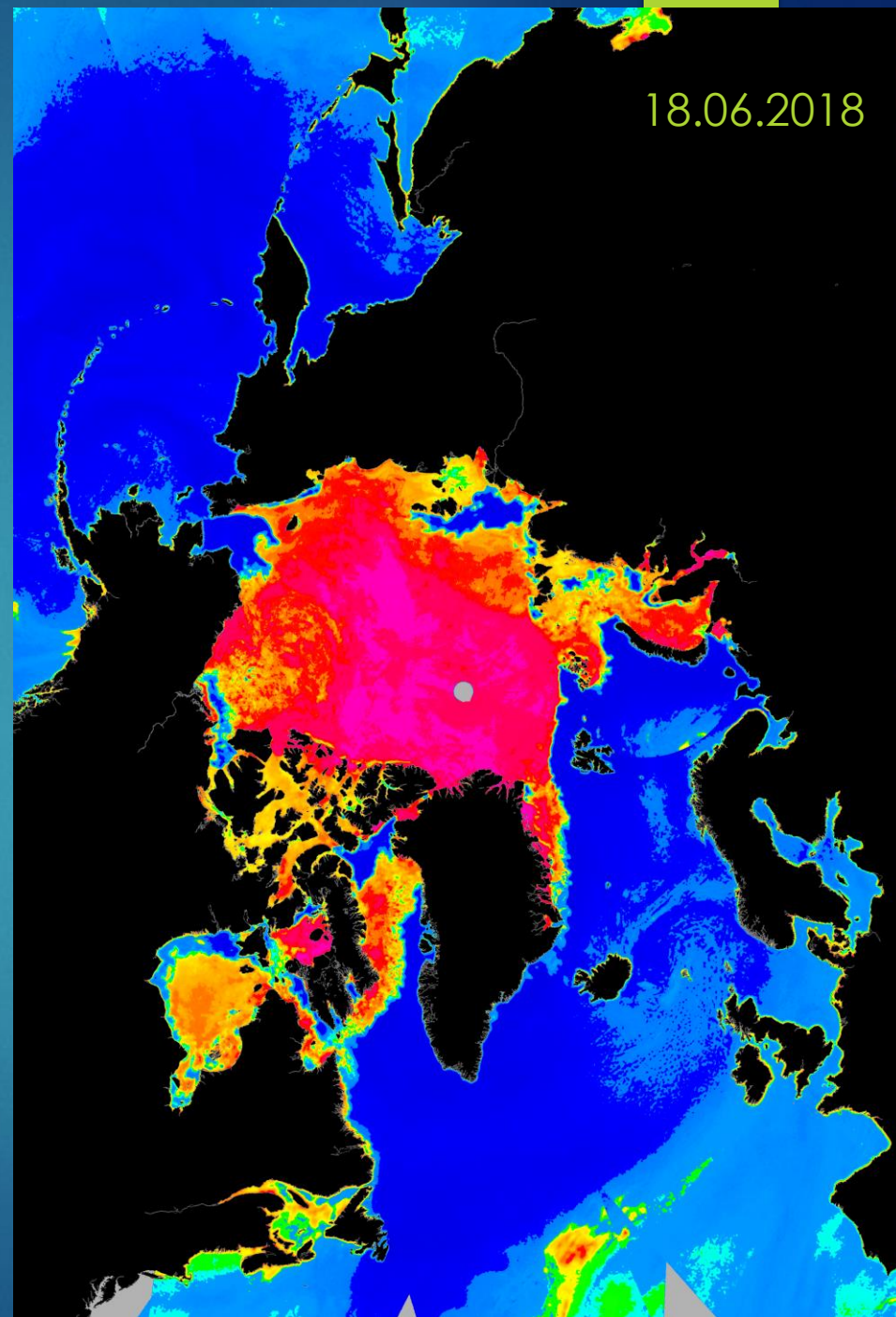
So... Remote sensing of sea ice is challenging but never boring

Data types

- ▶ Optical and multi spectral images
 - Ice extent and concentration, ice type
- ▶ Thermal images
 - SST, new ice formation
- ▶ Passive microwave images
 - Daily coverage of the hemisphere, back to 1979
- ▶ RADAR (SAR) images
 - Various ice parameters independent on clouds
- ▶ LIDAR
 - Ice thickness

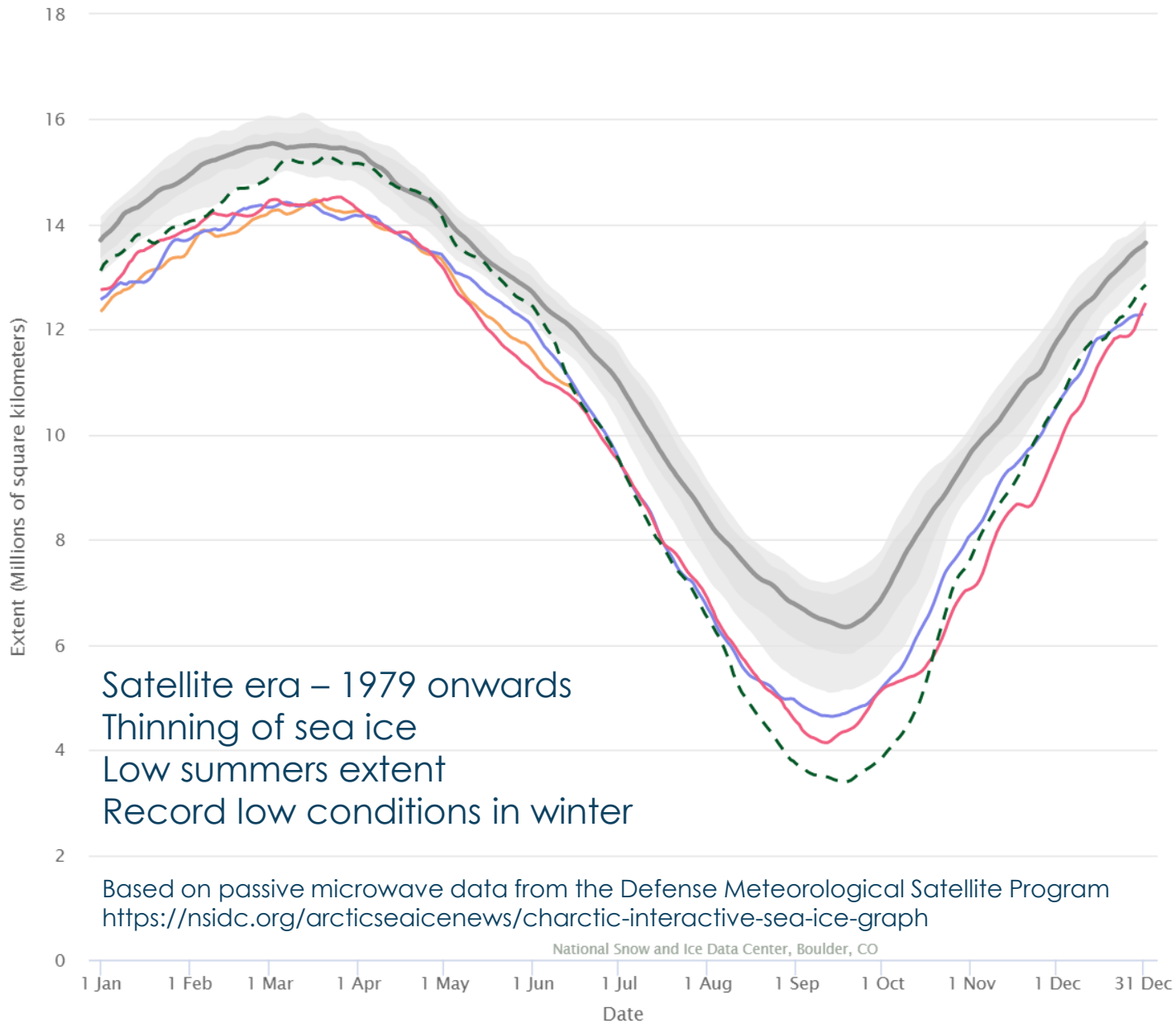
AMSR-2 data
from NASA &
seaice.dk

Daily mosaic
of the Arctic
(and Antarctic)
low spatial
resolution
various
parameters



Arctic Sea Ice Extent

(Area of Ocean with at least 15% sea ice)



Satellite era – 1979 onwards
Thinning of sea ice
Low summers extent
Record low conditions in winter

Based on passive microwave data from the Defense Meteorological Satellite Program
<https://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph>

National Snow and Ice Data Center, Boulder, CO

- Show all
- Hide all
- 1981–2010 Median
- Interquartile Range
- Interdecile Range
- 1981–2010 Average
- ±2 Standard Deviations
- 2001–2010 Average
- 1991–2000 Average
- 1979–1990 Average
- 2018
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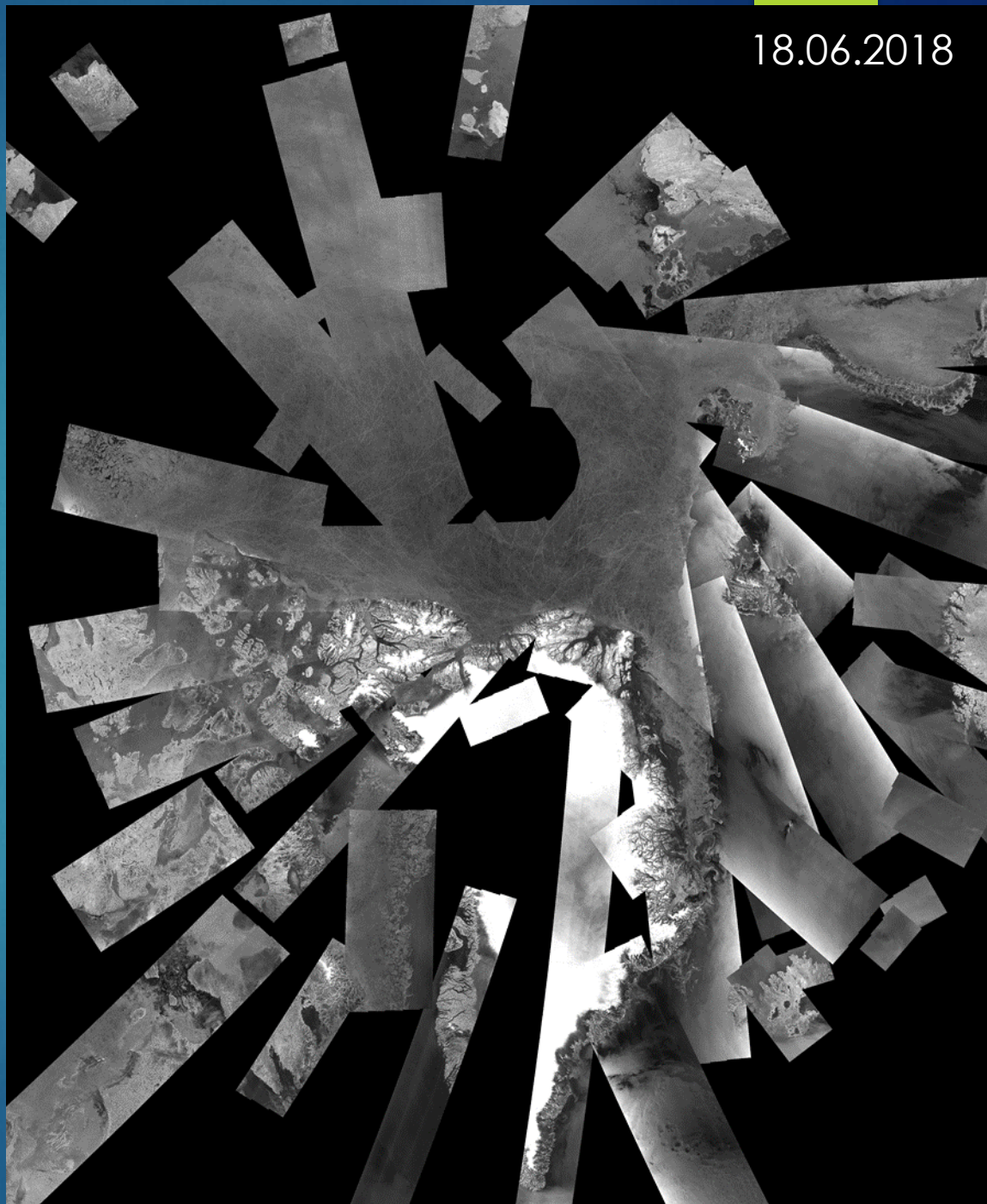
▲ 1/2 ▼

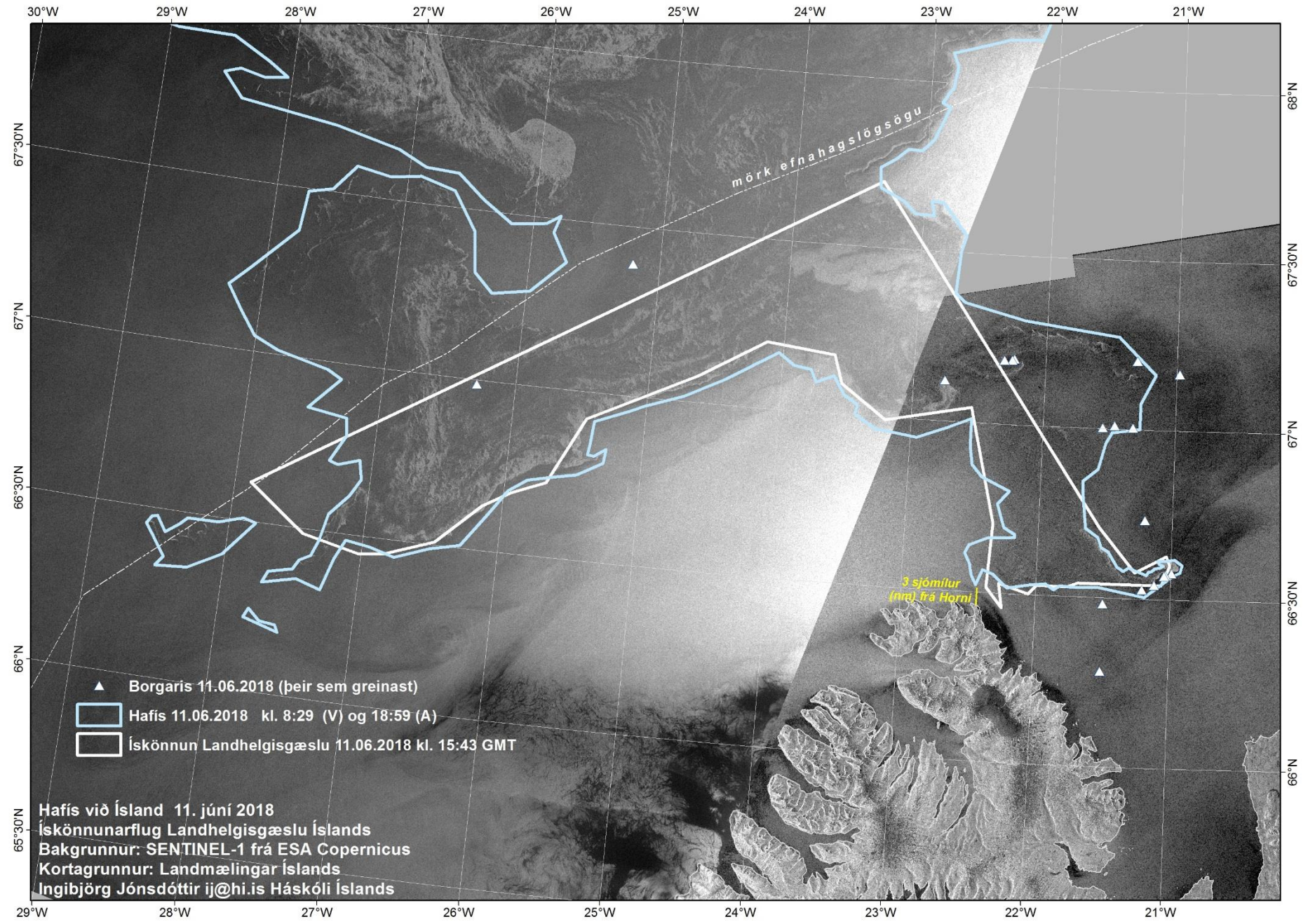
18.06.2018

SENTINEL-1 from ESA & seaice.dk

High resolution
SAR data
available in
near real time
independent
of cloudcover
and sunlight

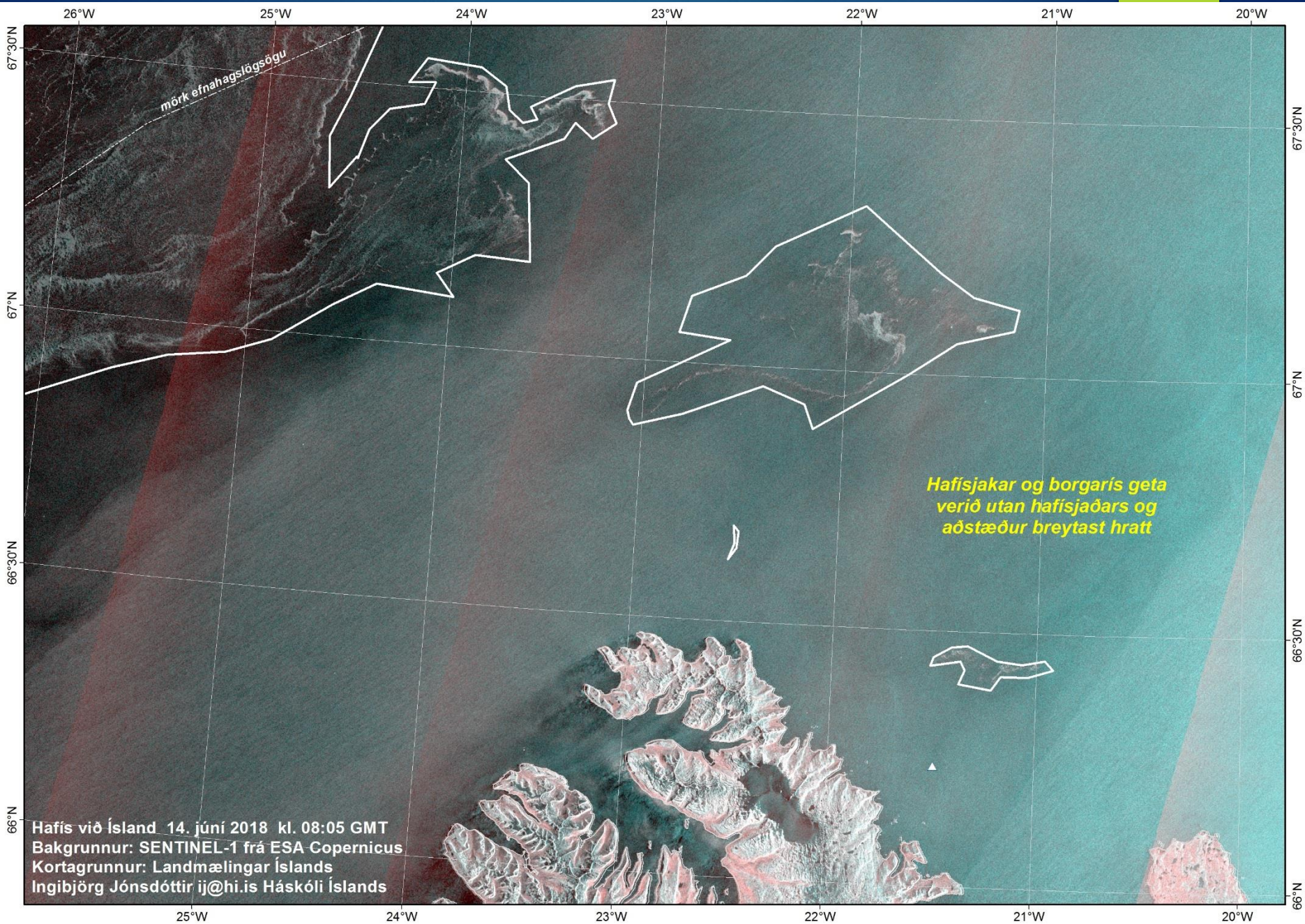
1a and 1b





- ▲ Borgaris 11.06.2018 (þeir sem greinast)
- Hafis 11.06.2018 kl. 8:29 (V) og 18:59 (A)
- Ískönnun Landhelgisgæslu 11.06.2018 kl. 15:43 GMT

Hafis við Ísland 11. júní 2018
Ískönnunarflug Landhelgisgæslu Íslands
Bakgrunnur: SENTINEL-1 frá ESA Copernicus
Kortagrunnur: Landmælingar Íslands
Ingibjörg Jónsdóttir ij@hi.is Háskóli Íslands



26°W 25°W 24°W 23°W 22°W 21°W 20°W

67°30'N

67°N

66°30'N

66°N

67°30'N

67°N

66°30'N

66°N

25°W 24°W 23°W 22°W 21°W 20°W

mörk efnahagslögsögu

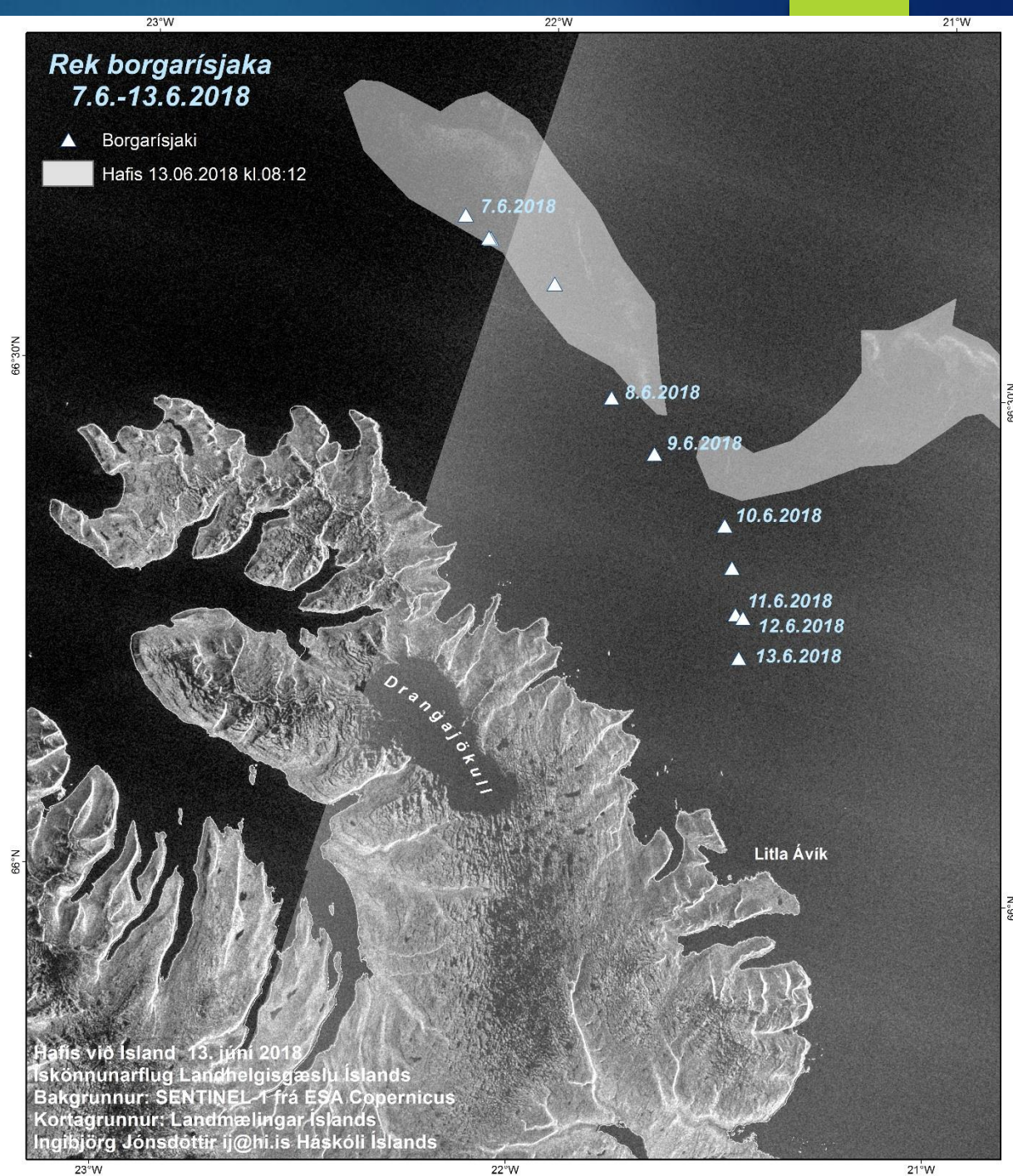
Hafisjakar og borgarís geta verið utan hafisjaðars og aðstæður breytast hratt

Hafis við Ísland 14. júní 2018 kl. 08:05 GMT
Bakgrunnur: SENTINEL-1 frá ESA Copernicus
Kortagrunnur: Landmælingar Íslands
Ingibjörg Jónsdóttir ij@hi.is Háskóli Íslands

Tracking iceberg 2018

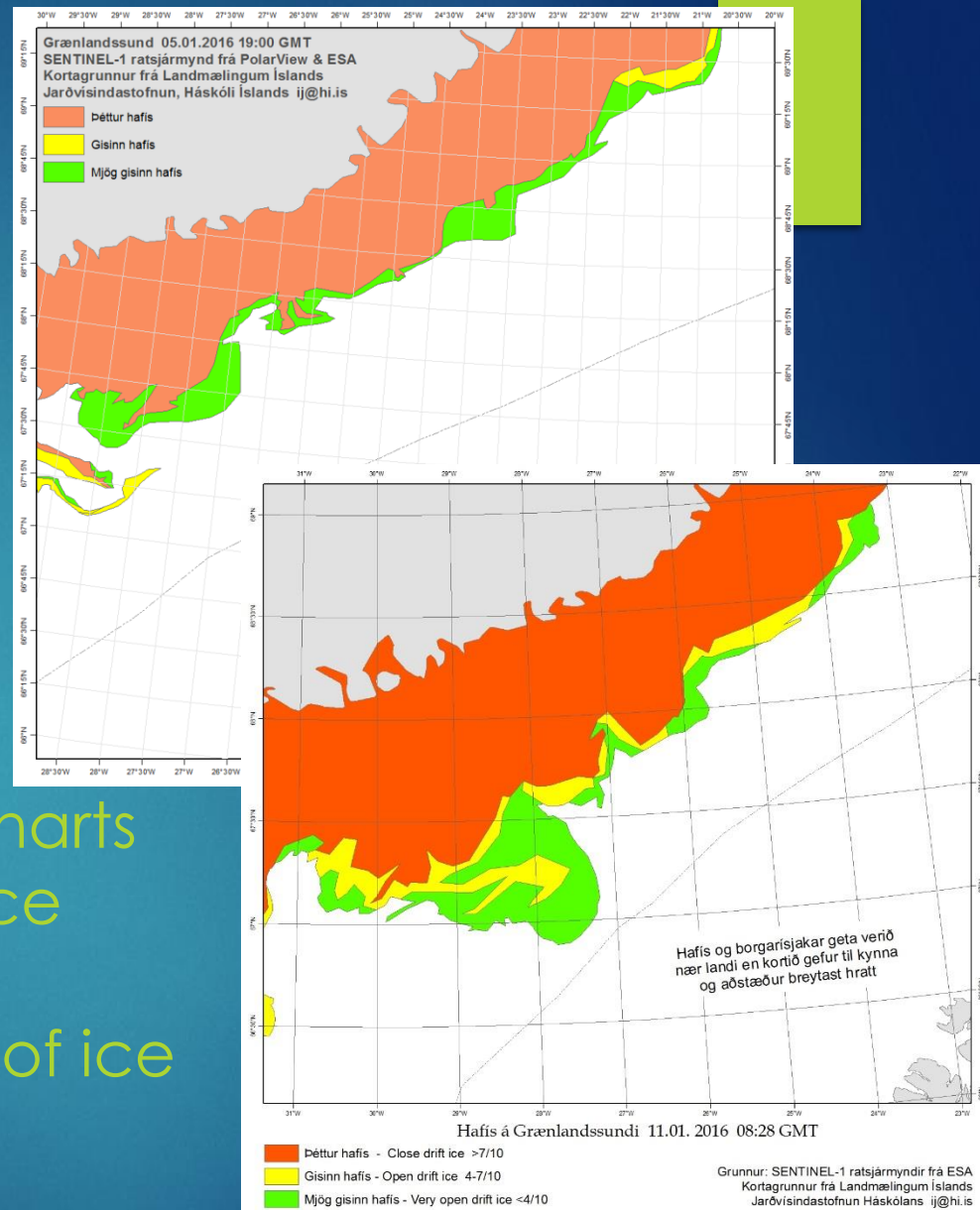
It was possible to chart the ice up to 3 times per day (June '18)

Icebergs vs ships still a problem but can be solved (AIS)



Ice charts

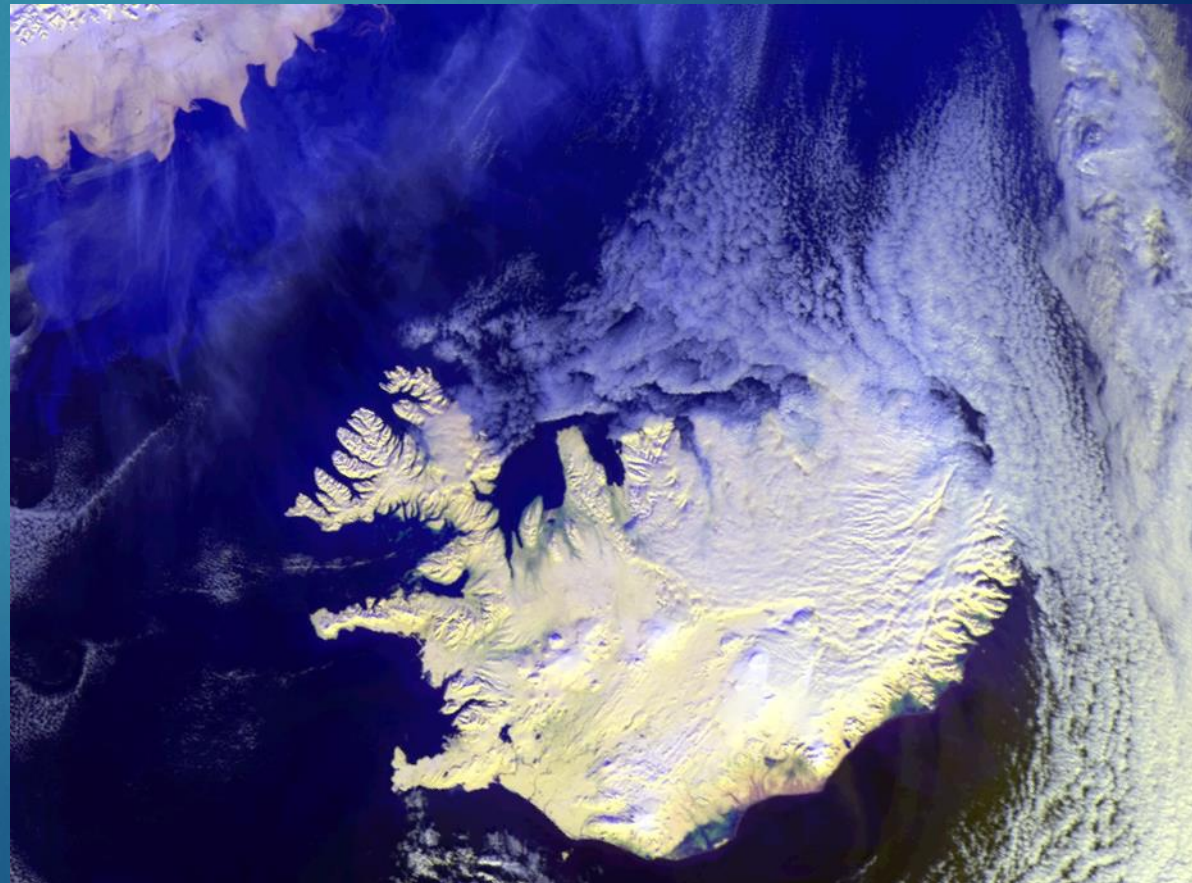
A question of accuracy and presentation?
Misleading to have the charts too accurate, since the ice changes so fast?
Direct contact with users of ice information is important.



Optical images

- ▶ NOAA AVHRR 1978-
- ▶ MODIS 2000-
- ▶ SUOMI NPP VIIRS
- ▶ SENTINEL-3
- ▶ LANDSAT-8 2013
- ▶ SENTINEL-2

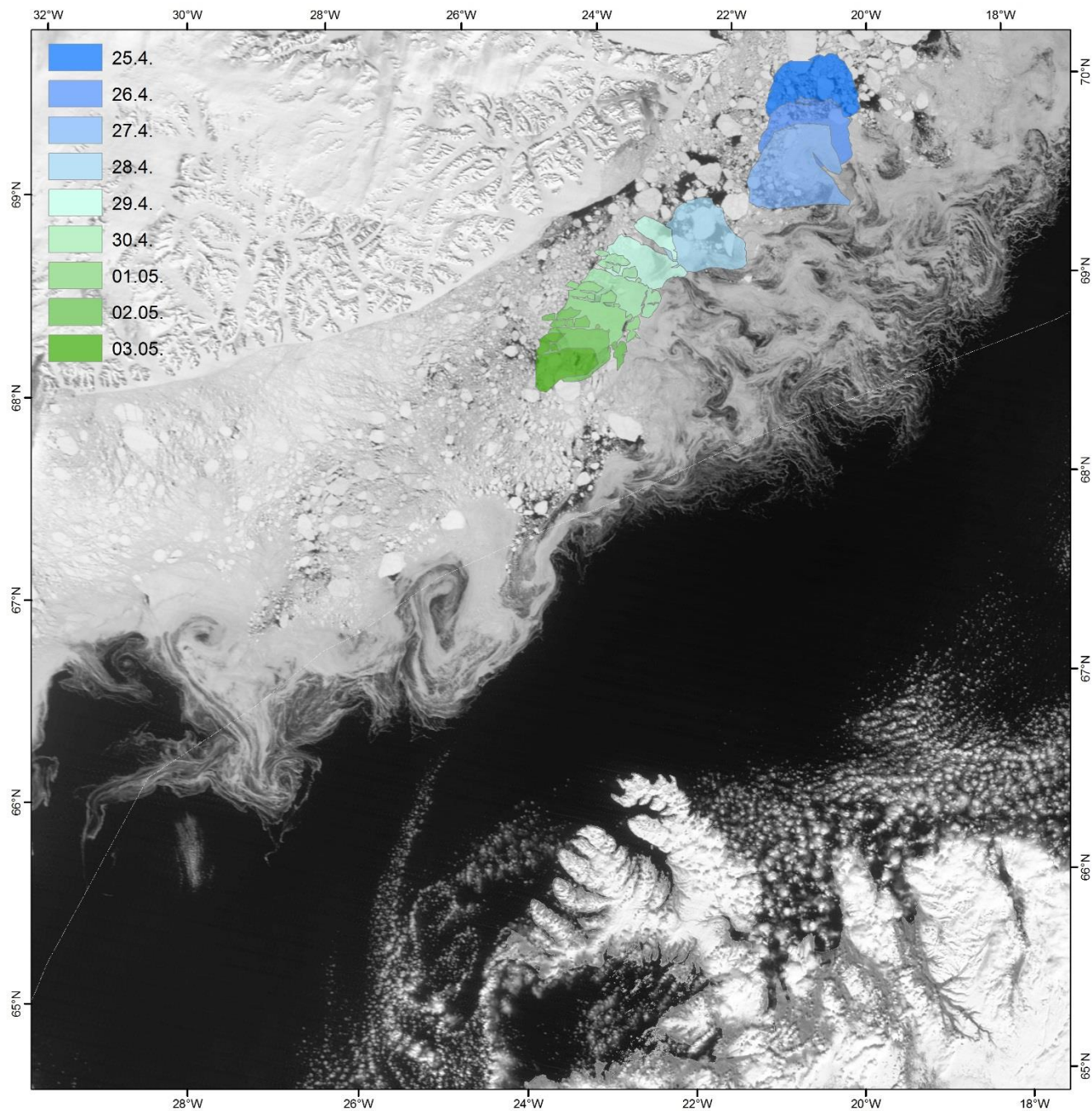
Denmark Strait 28.02.2017 12:30 GMT



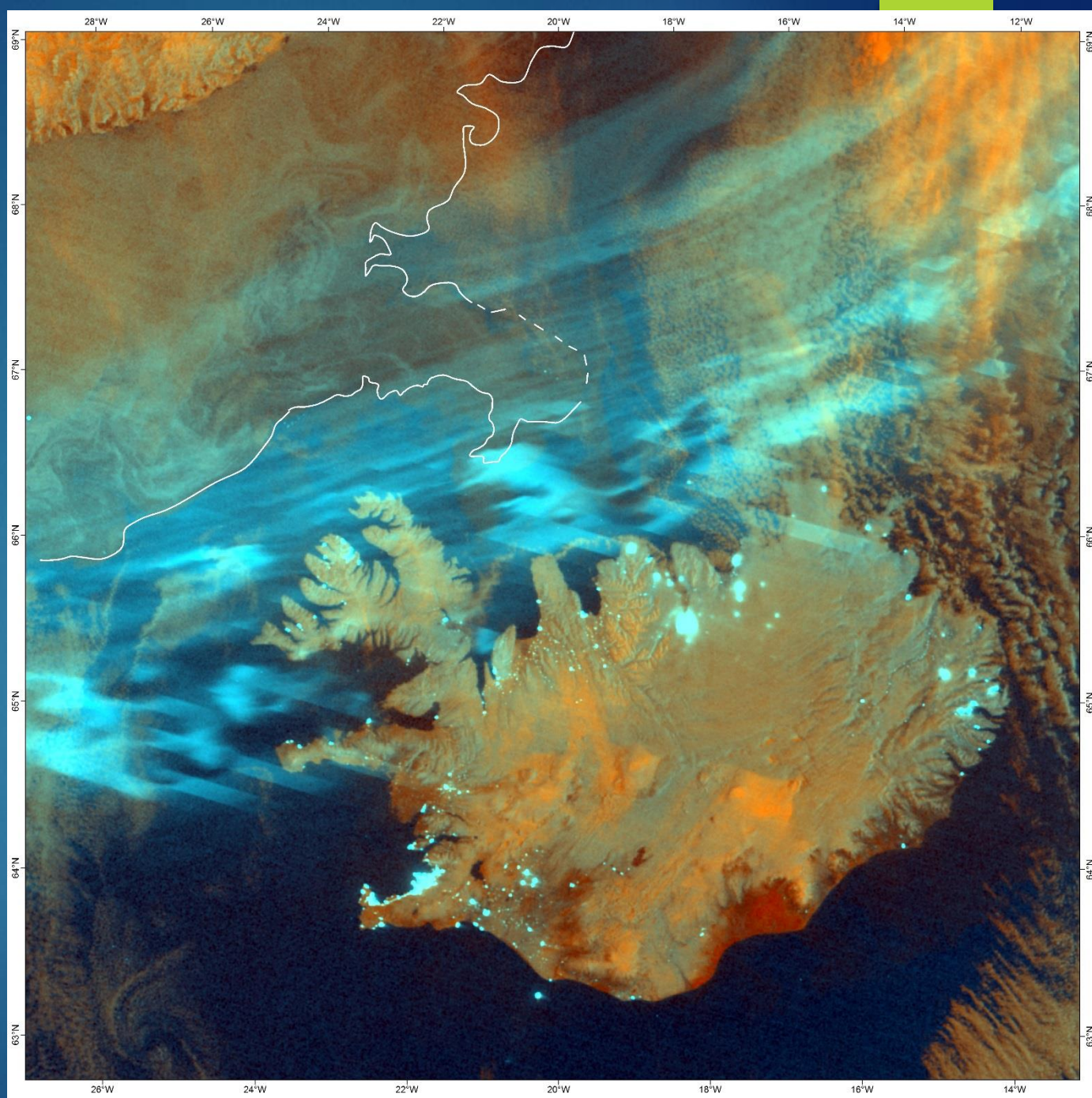
MODIS

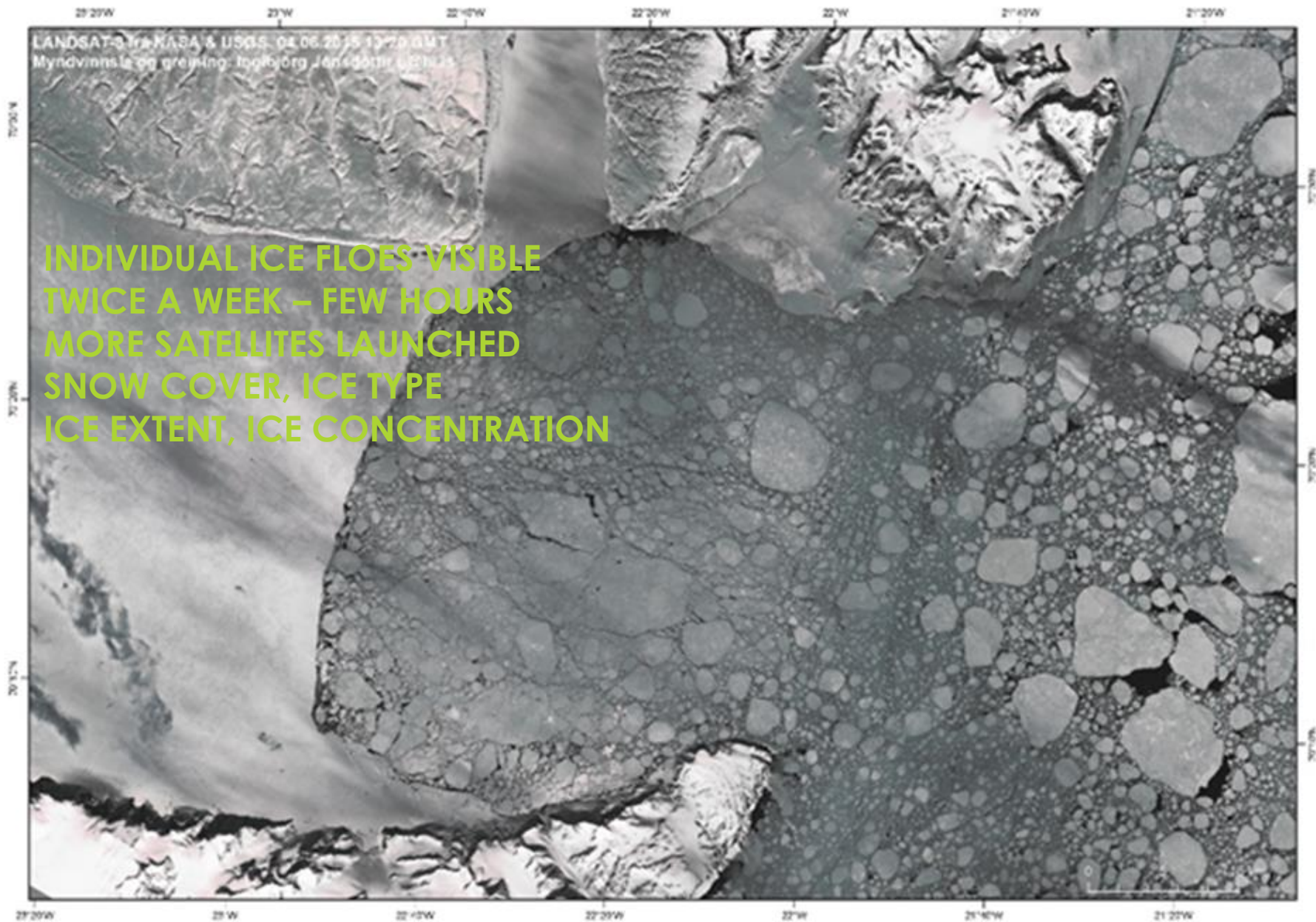
Tracking
floe drift
and break

Possible to
monitor
ice drift
~10 times
per day
(+VIIRS)

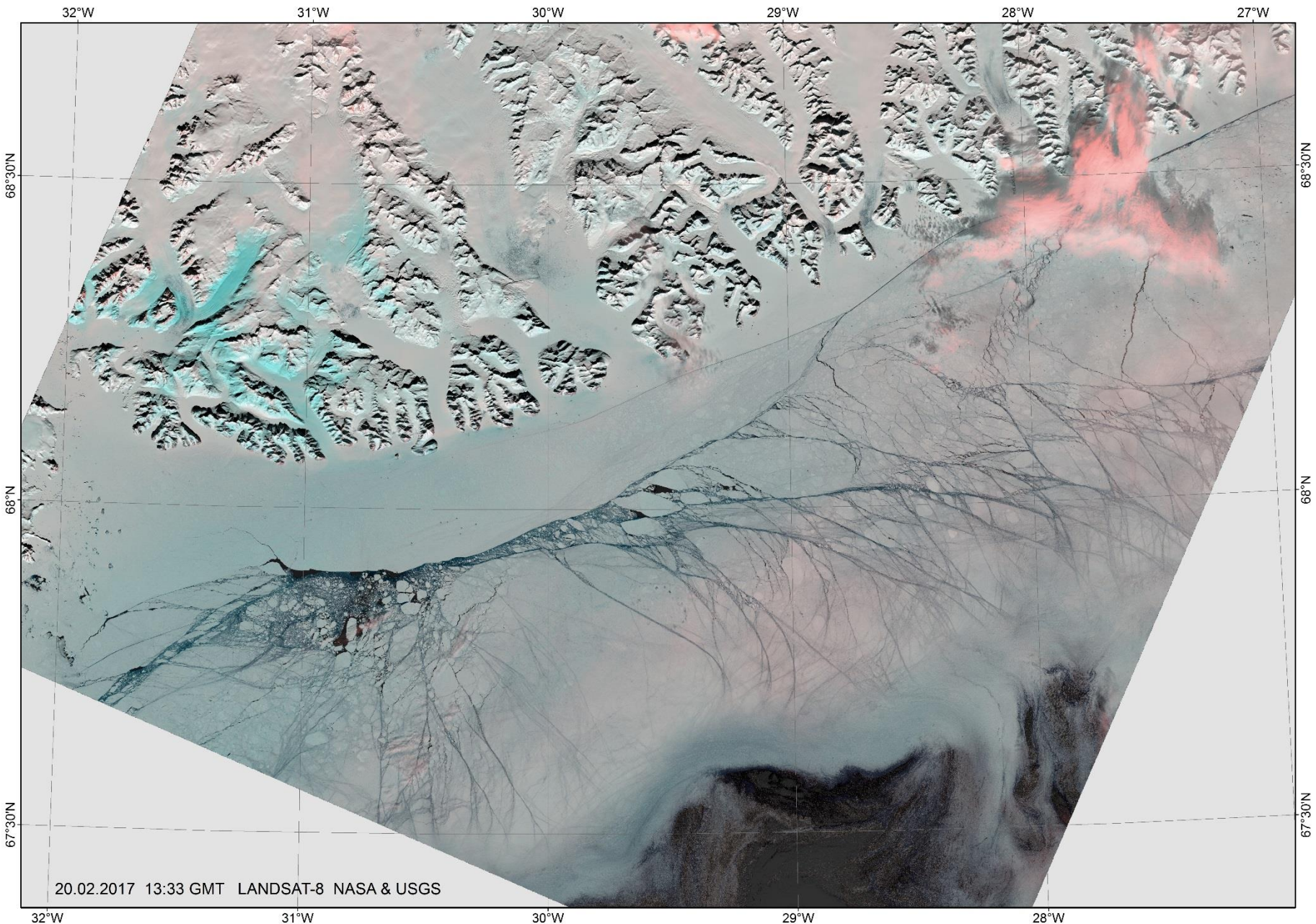


VIIRS Night time image





High resolution images – LANDSAT 8 NASA & SENTINEL -2 ESA



20.02.2017 13:33 GMT LANDSAT-8 NASA & USGS

28°W

27°W

26°W

25°W

LANDSAT-8 NASA & USGS 16.6.2018 Night time image

67°N

67°N

66°30'N

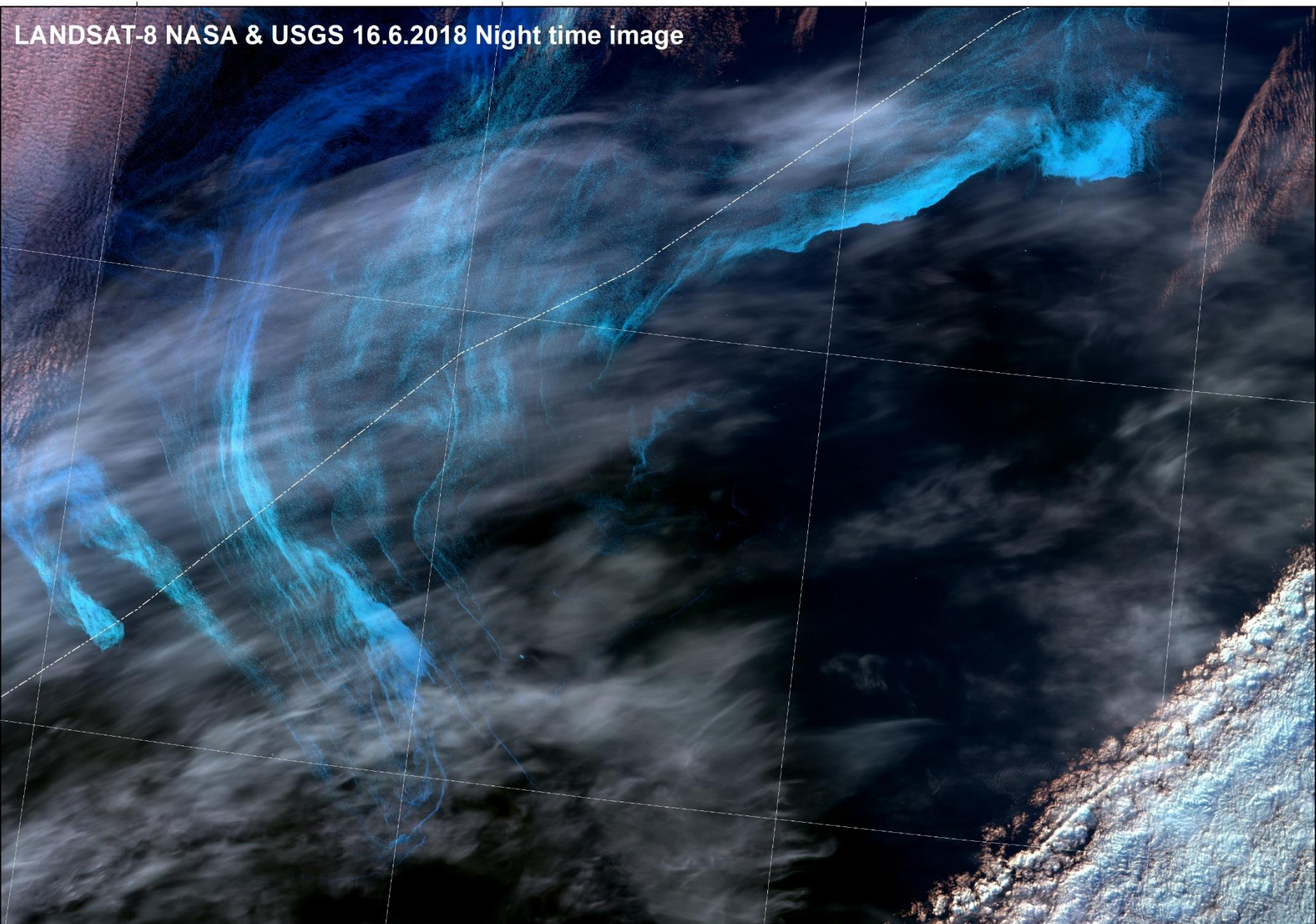
66°30'N

28°W

27°W

26°W

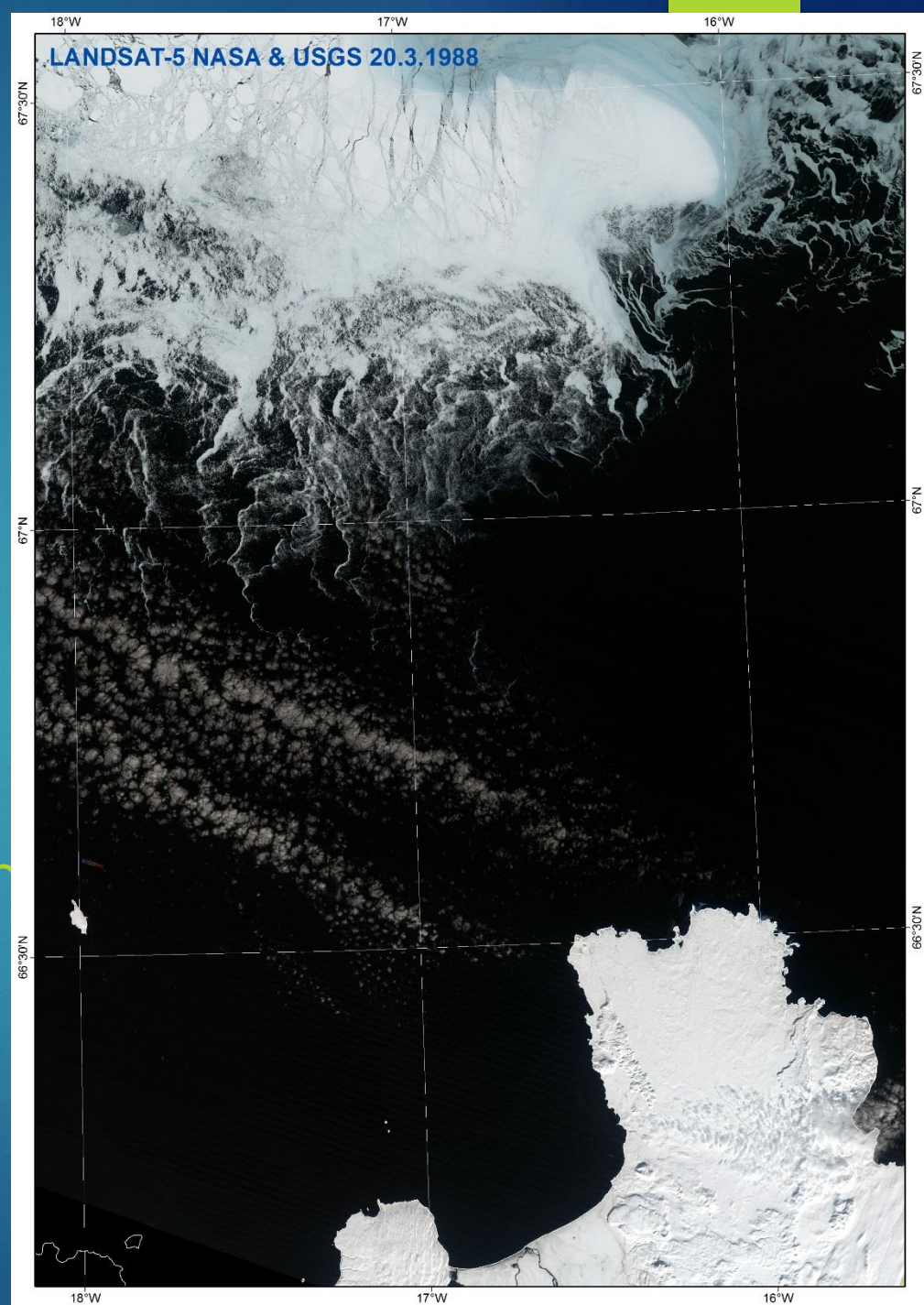
25°W

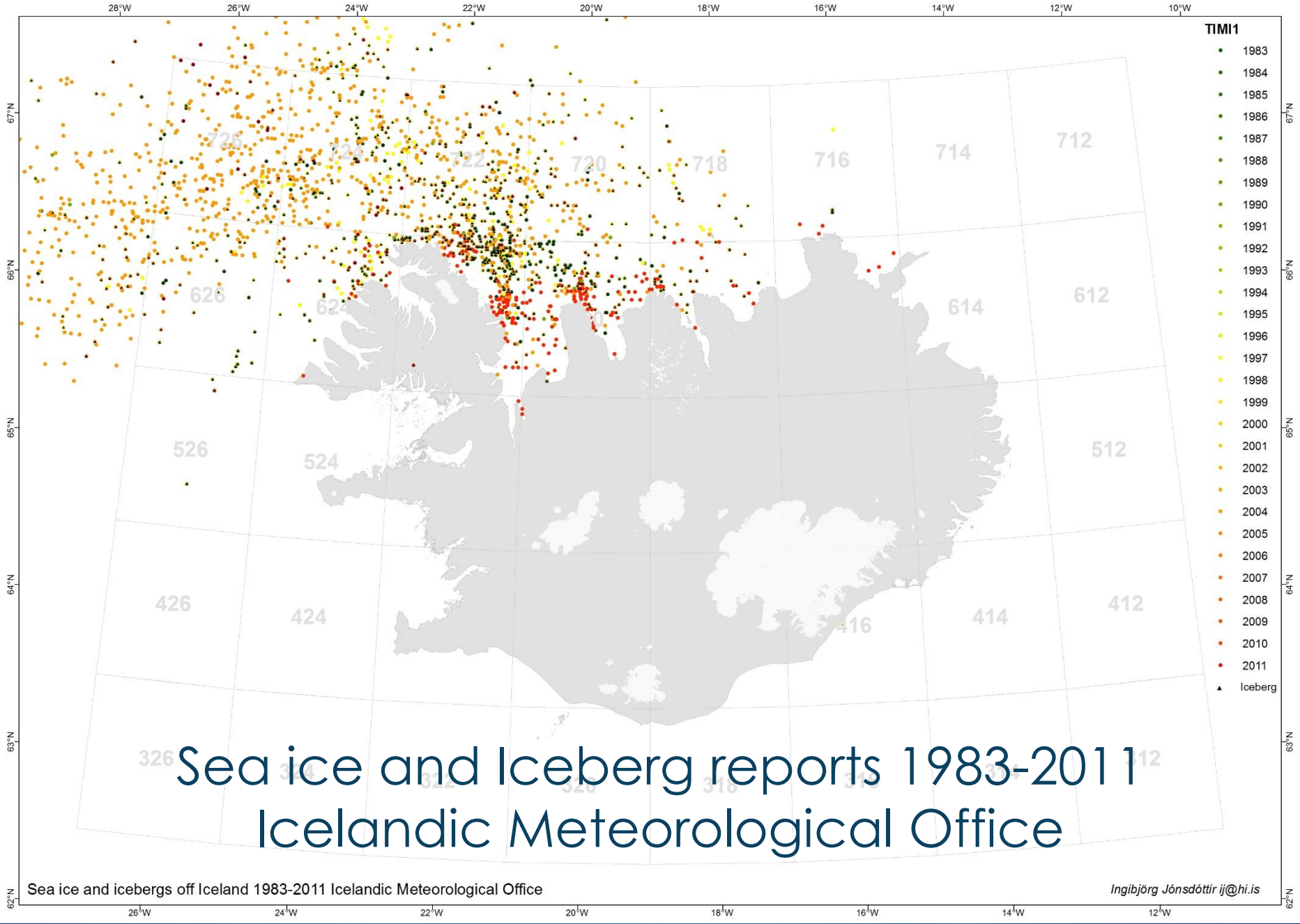


Various images
have become
available through
archives

Data that was not
available in real time
at the time but will
now allow study of
previous ice conditions
and processes

LANDSAT series





Sea ice and Iceberg reports 1983-2011

Icelandic Meteorological Office

Sea ice and icebergs off Iceland 1983-2011 Icelandic Meteorological Office

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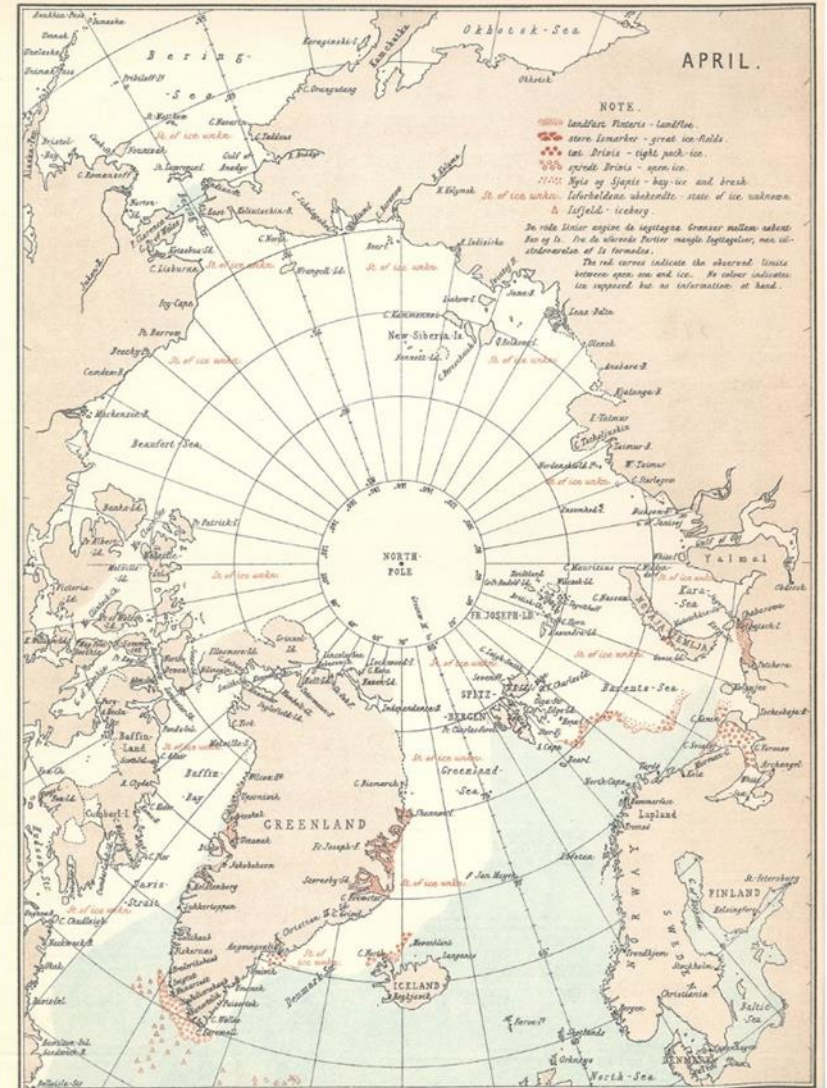
DMI Annual reports from the Arctic



Handwritten notes in Danish, likely describing ice conditions or geographical observations related to the map above. The text is written in a cursive script and includes phrases such as "Ved denne tid..." and "I den..."

ISFORHOLDENE I DE ARKTISKE HAVE 1901.

UDGIVET AF DET DANSKE METEOROLOGISKE INSTITUT.



Handwritten notes in Danish, likely describing ice conditions or geographical observations related to the map above. The text is written in a cursive script and includes phrases such as "Ved denne tid..." and "I den..."

Summary

- ▶ Many options for using satellite images to study sea ice on a long time scale as well as in real time
- ▶ For operations, using many data sources is essential to get the „full picture“
- ▶ Archives, that have become available recently, offer many possibilities to examine past conditions and processes
- ▶ The combination of high spatial, spectral and temporal resolution will enhance knowledge on sea ice properties, drift and decay