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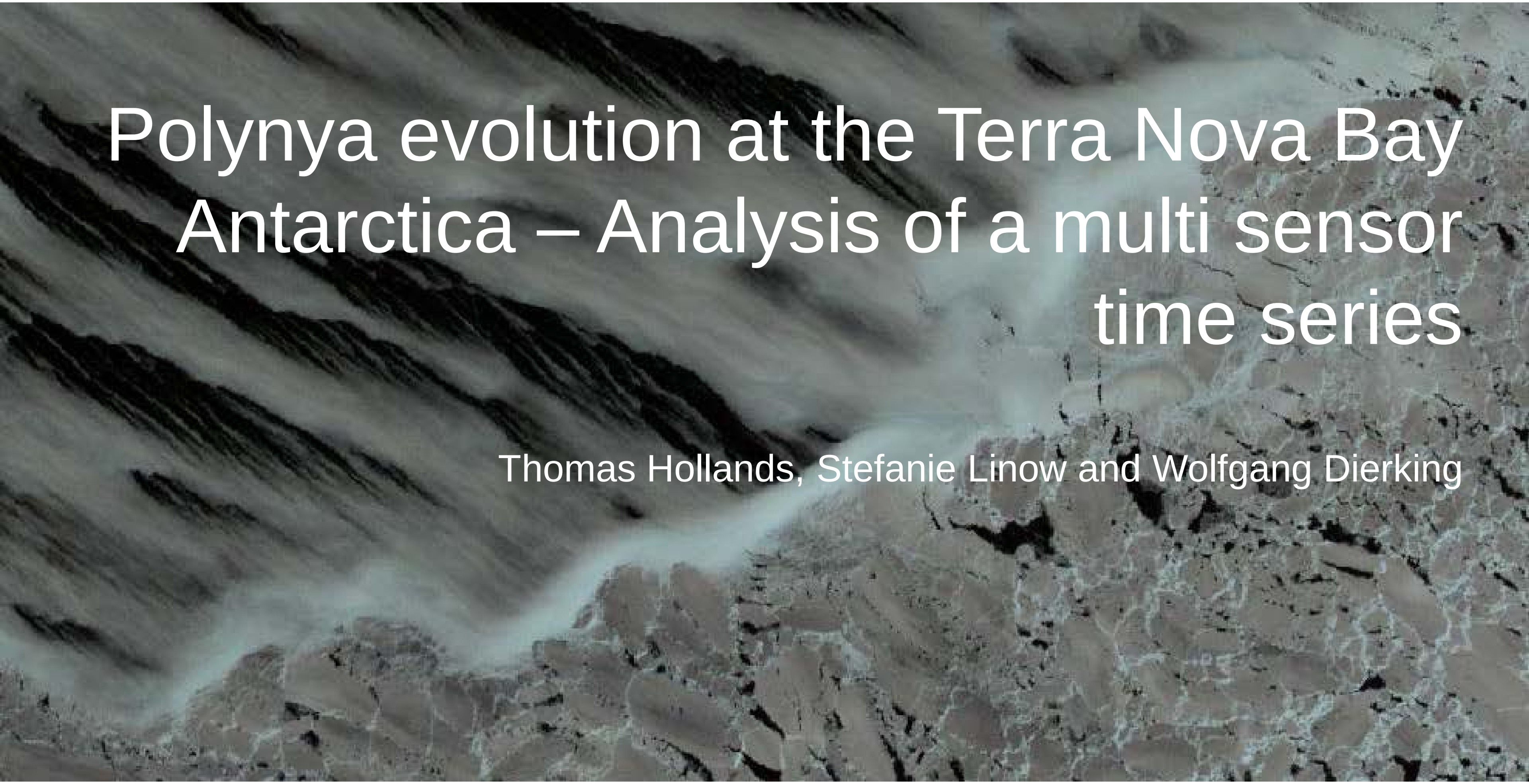

Polynya evolution at the Terra Nova Bay Antarctica – Analysis of a multi sensor time series

Thomas Hollands, Stefanie Linow and Wolfgang Dierking

HELMHOLTZ
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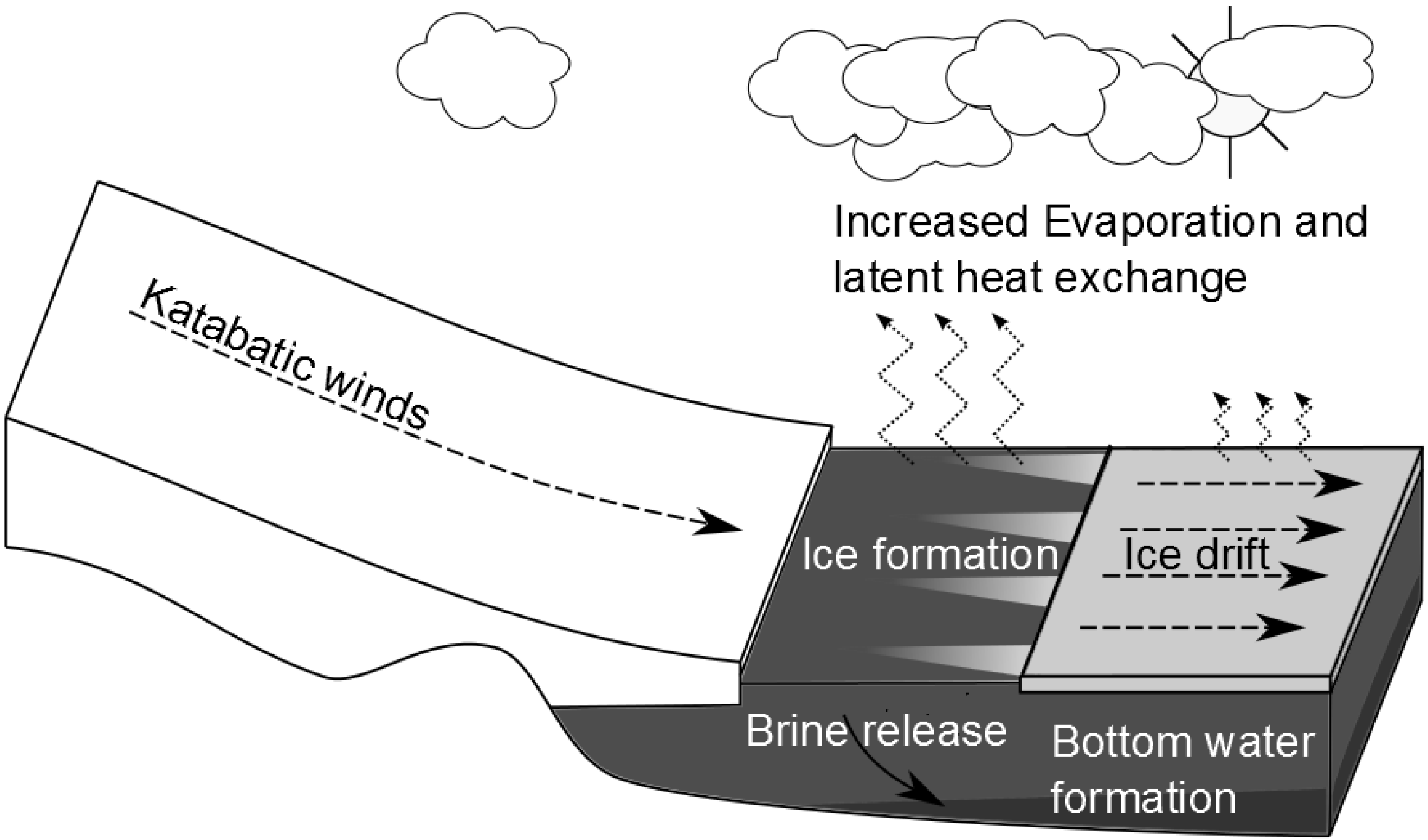
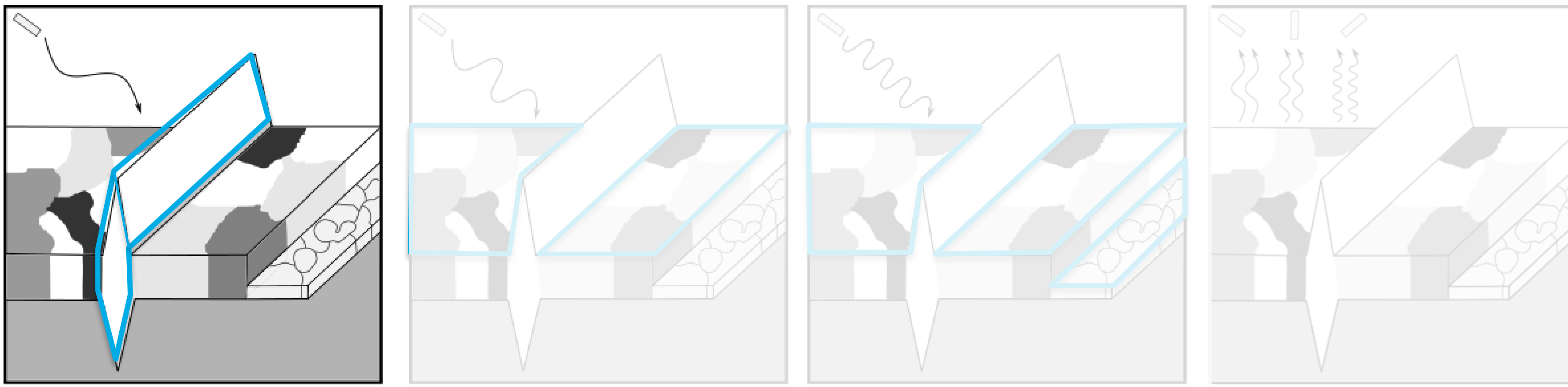
What is a polynya?



Why multi sensor missions?



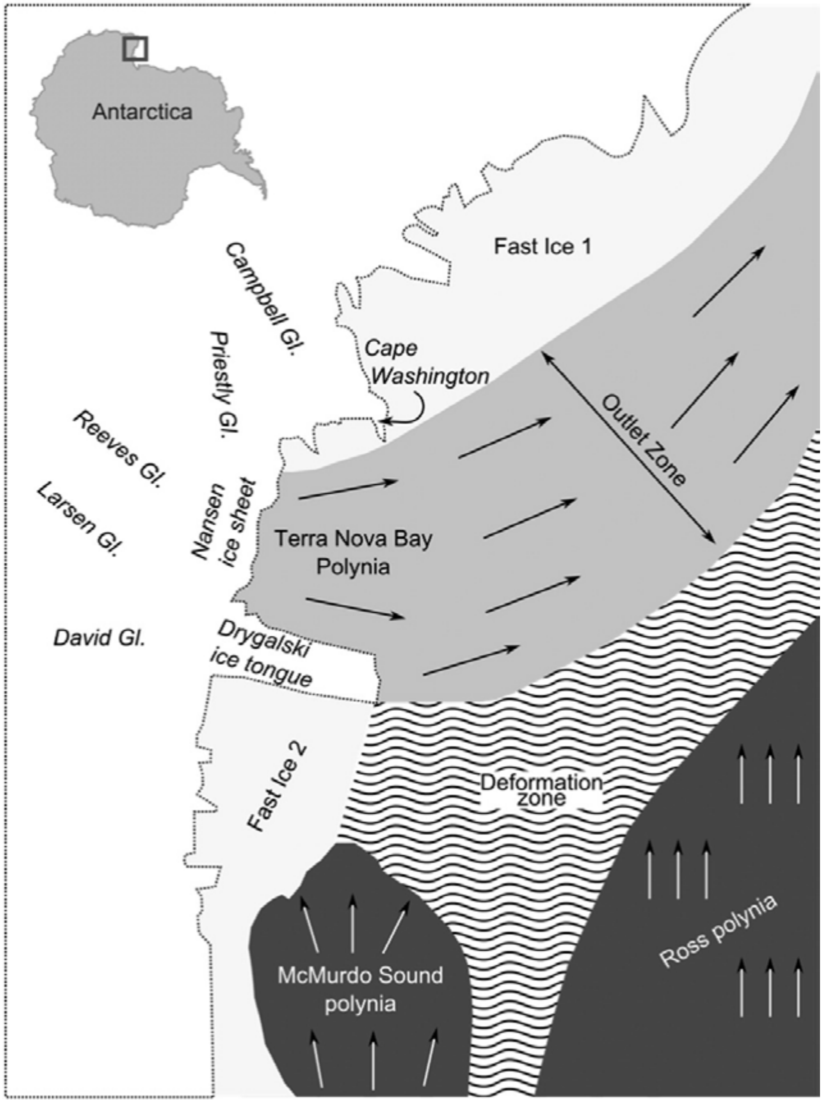
L-Band (i.e. ALOS2) C-Band (i.e. S-1) X-Band (i.e. TSX)

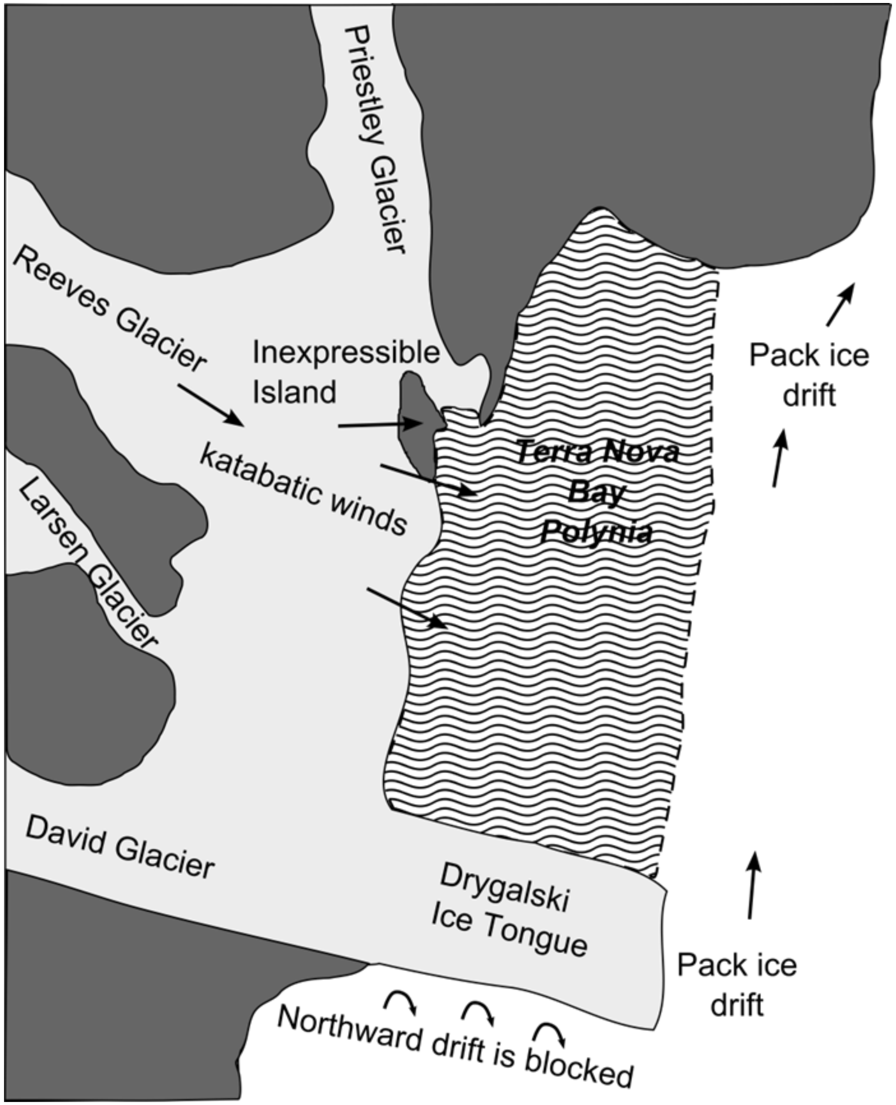
- microwaves
- optical
- Near infrared
- Thermal infrared
- …

What are the problems?

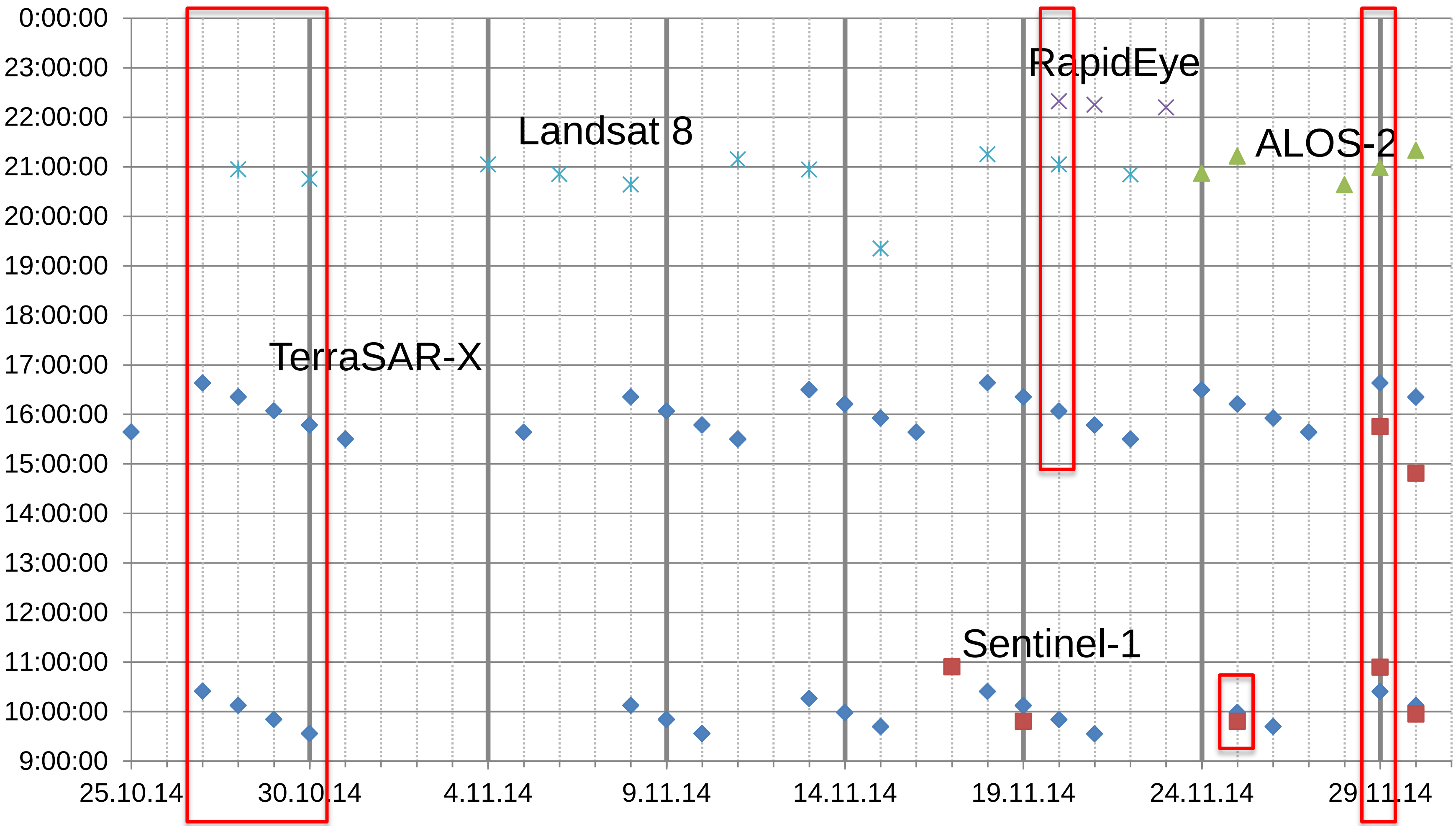
- Various catalogues for various products
- Various ordering procedures
- A variety of data formats
- Individual proposals and reports
- Coordinated ordering
- Sea ice is not land – a few hours can be crucial
- Polynya coverage (get the whole picture)

Terra Nova Bay

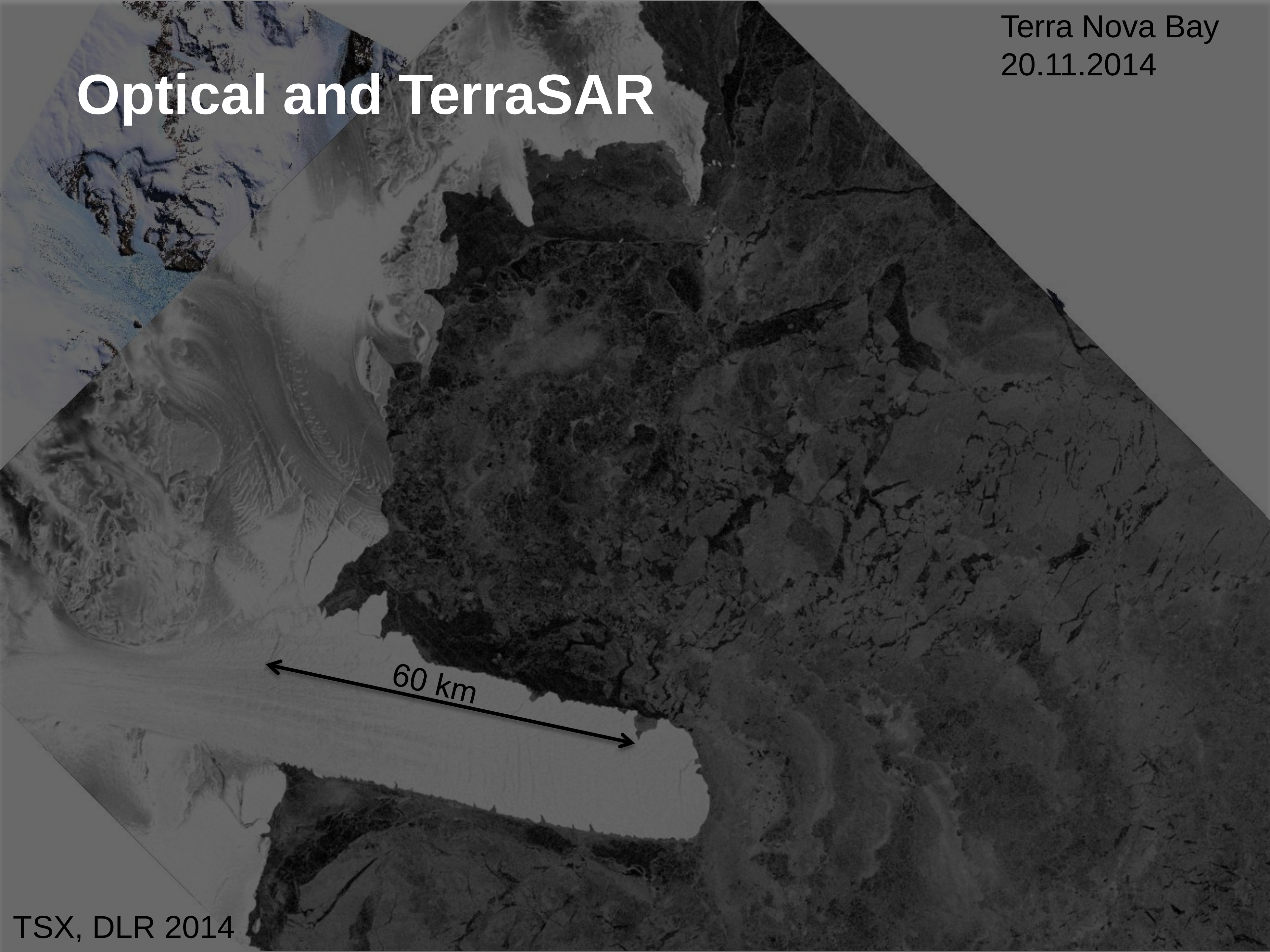


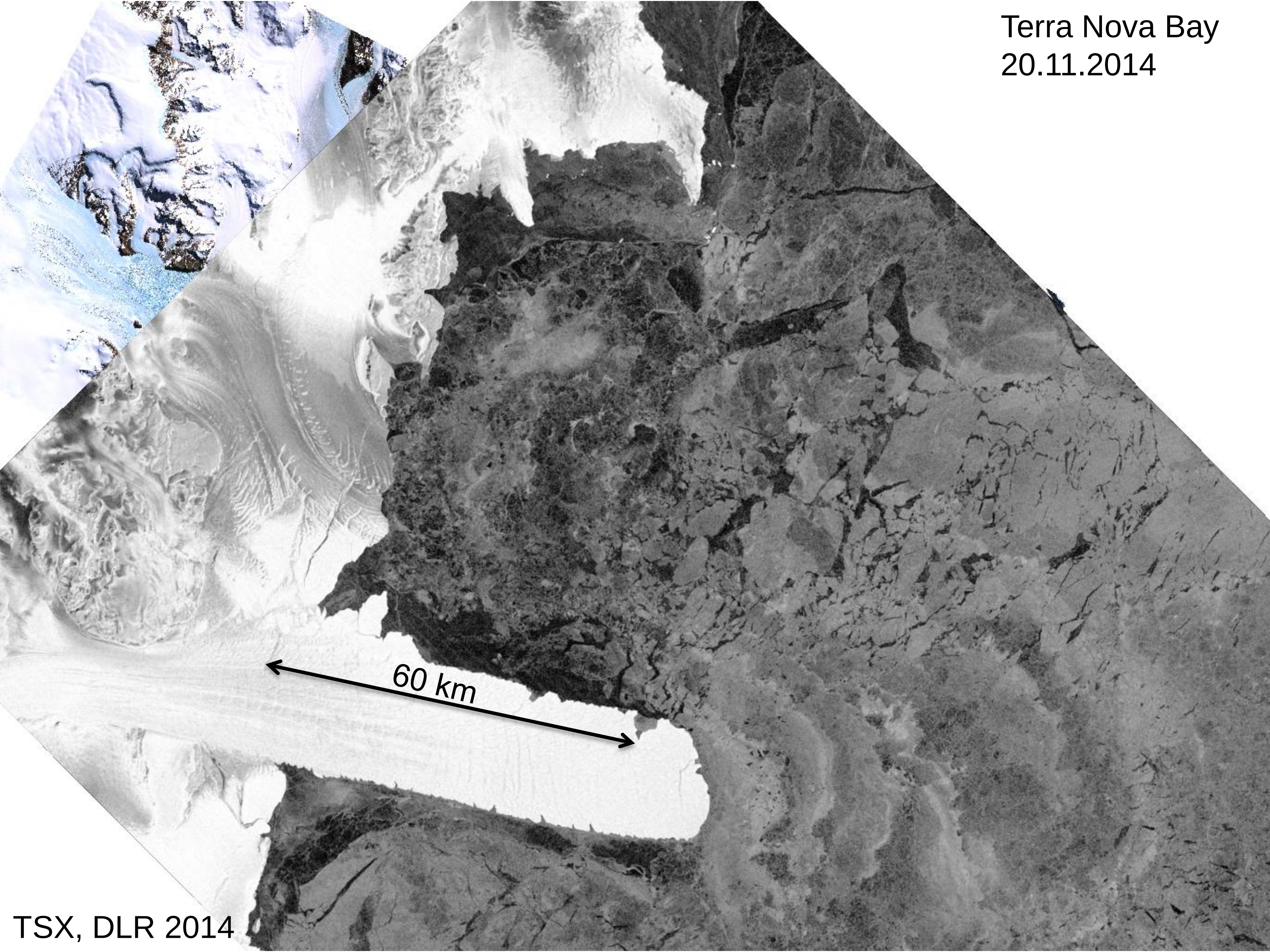


Time series Terra Nova Bay Polynja

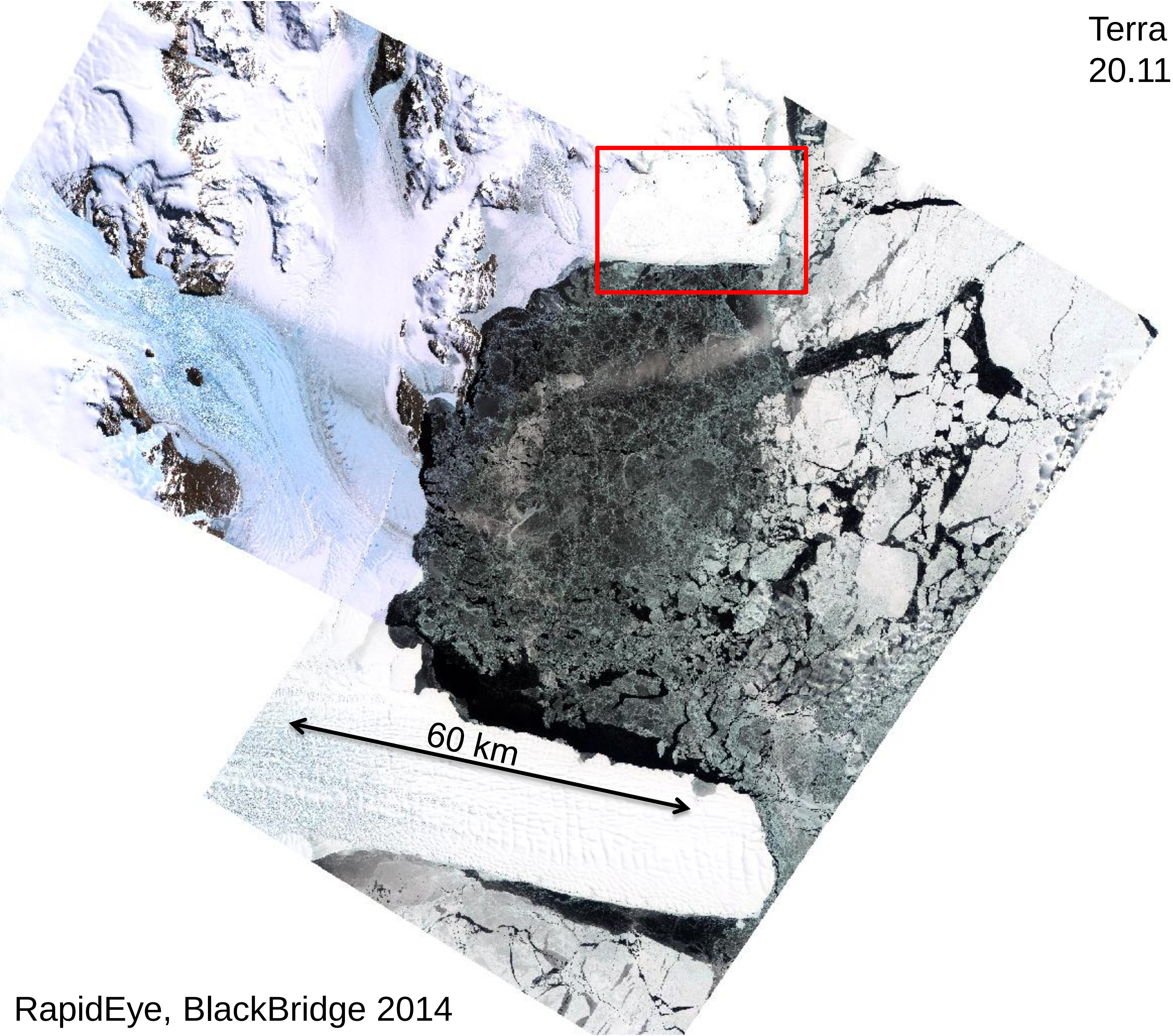


Optical and TerraSAR

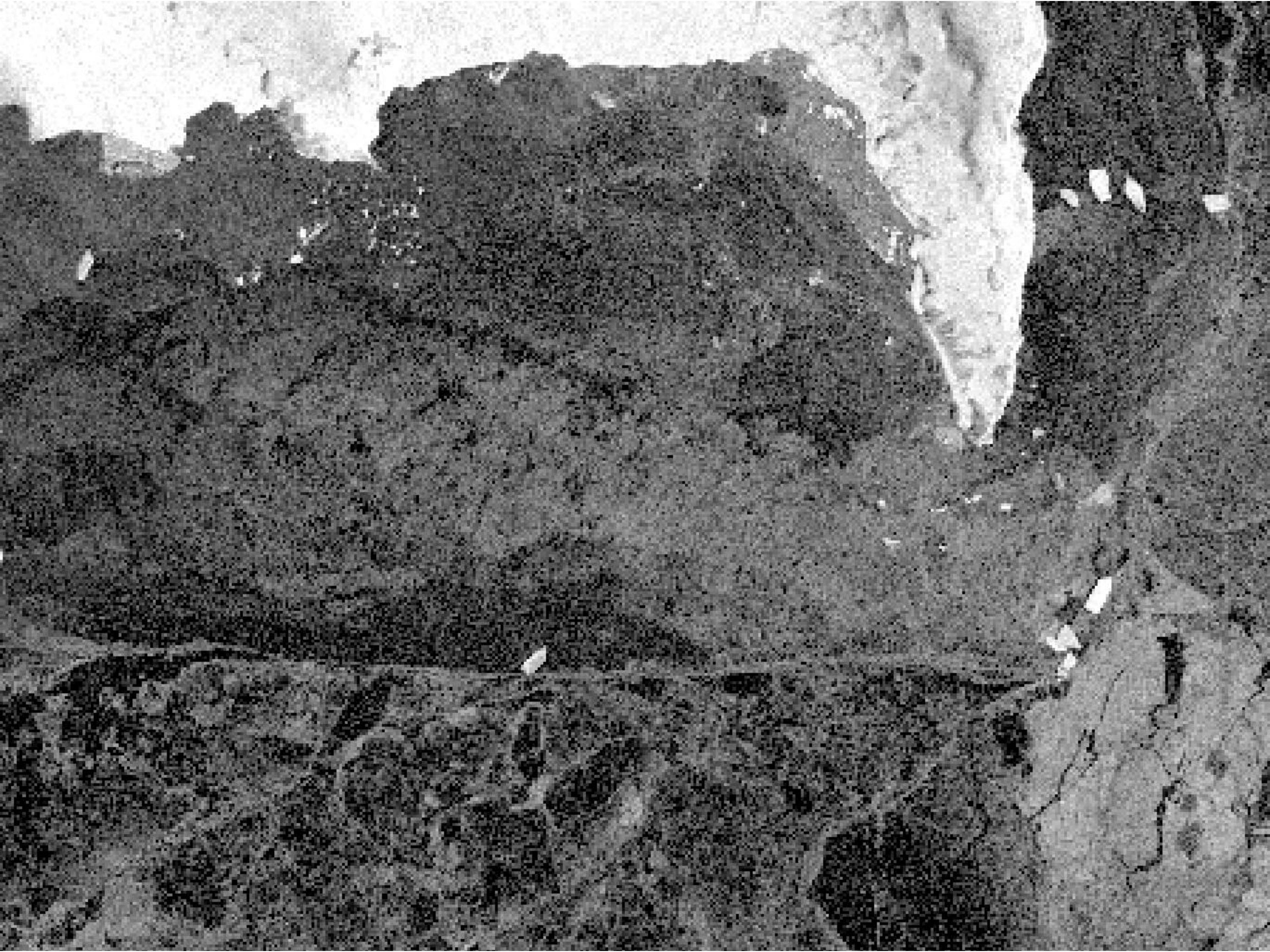


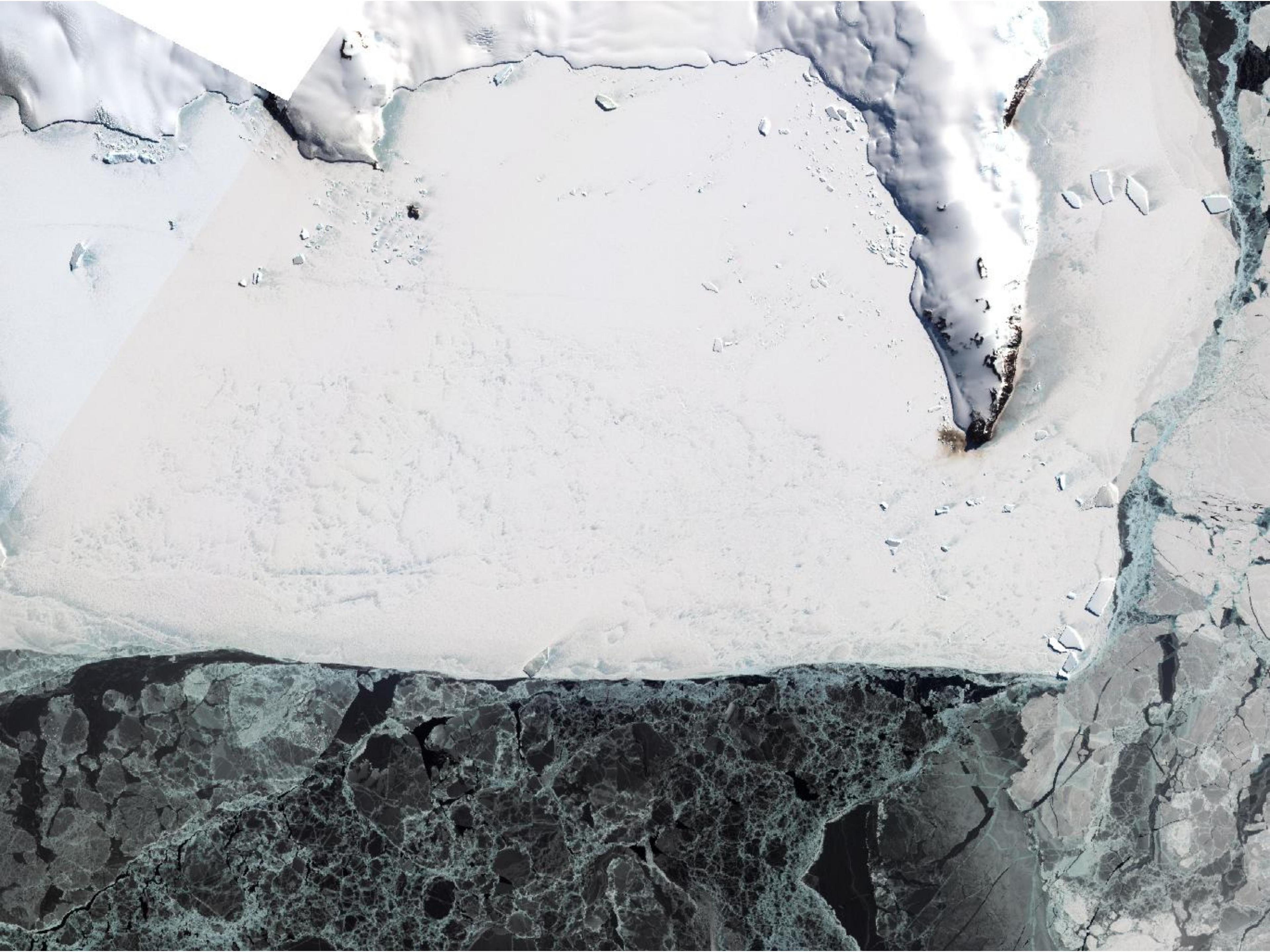

Terra Nova Bay
20.11.2014
60 km
TSX, DLR 2014

Terra Nova Bay
20.11.2014

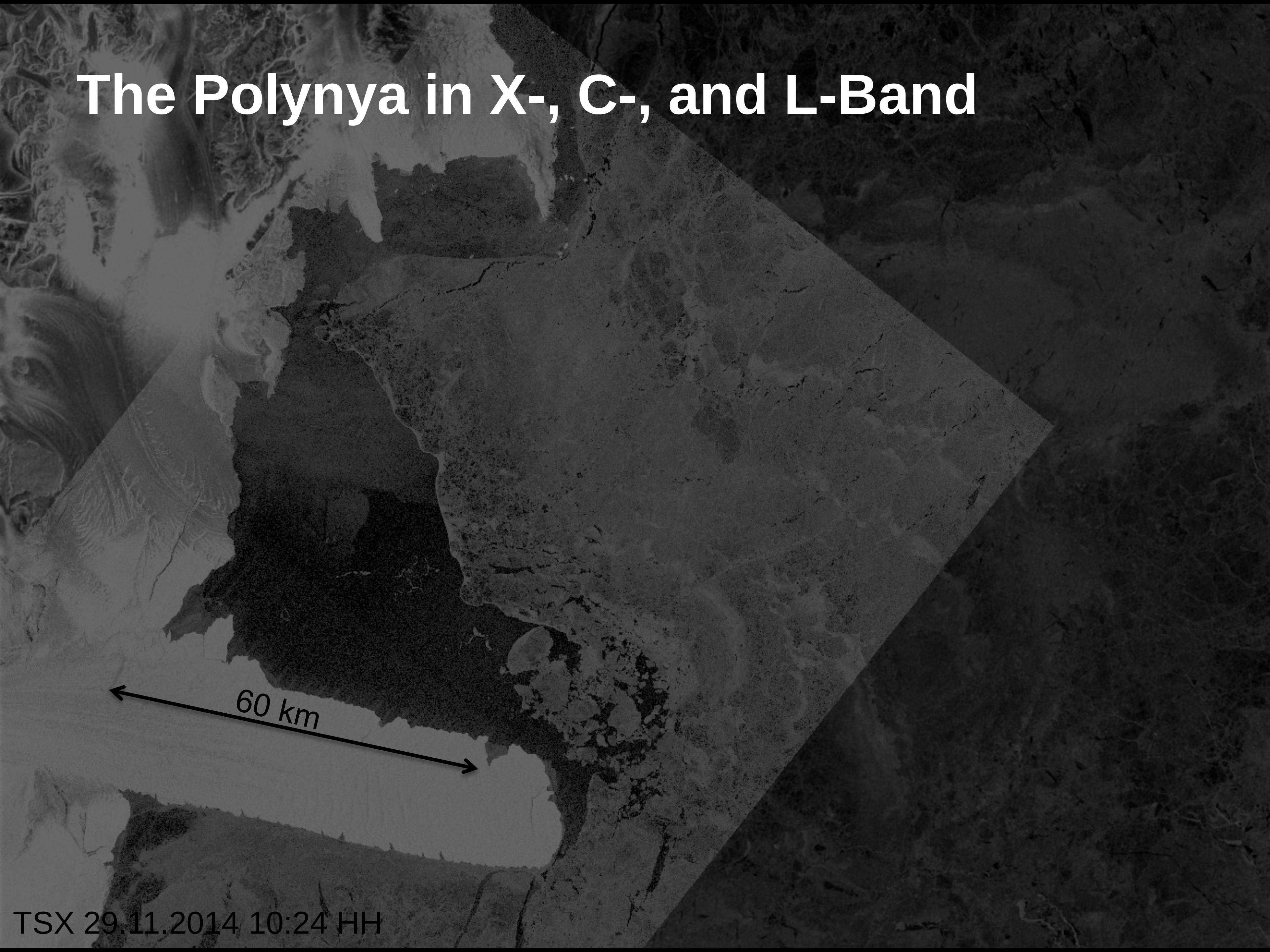


RapidEye, BlackBridge 2014





The Polynya in X-, C-, and L-Band




60 km
TSX 29.11.2014 10:24 HH

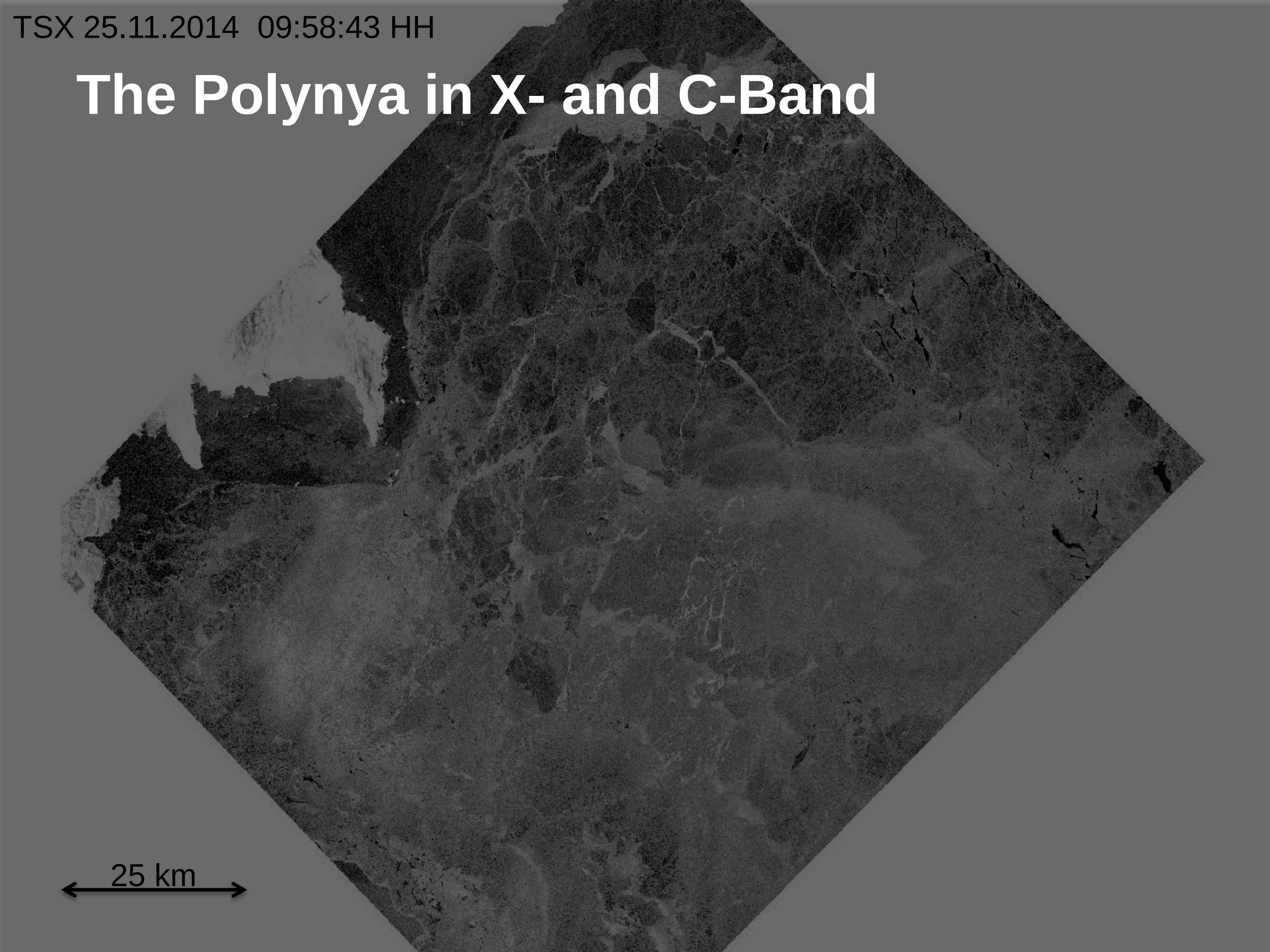
60 km
Sentinel 1 29.11.2014 15:45


60 km
TSX 29.11.2014 16:38 HH

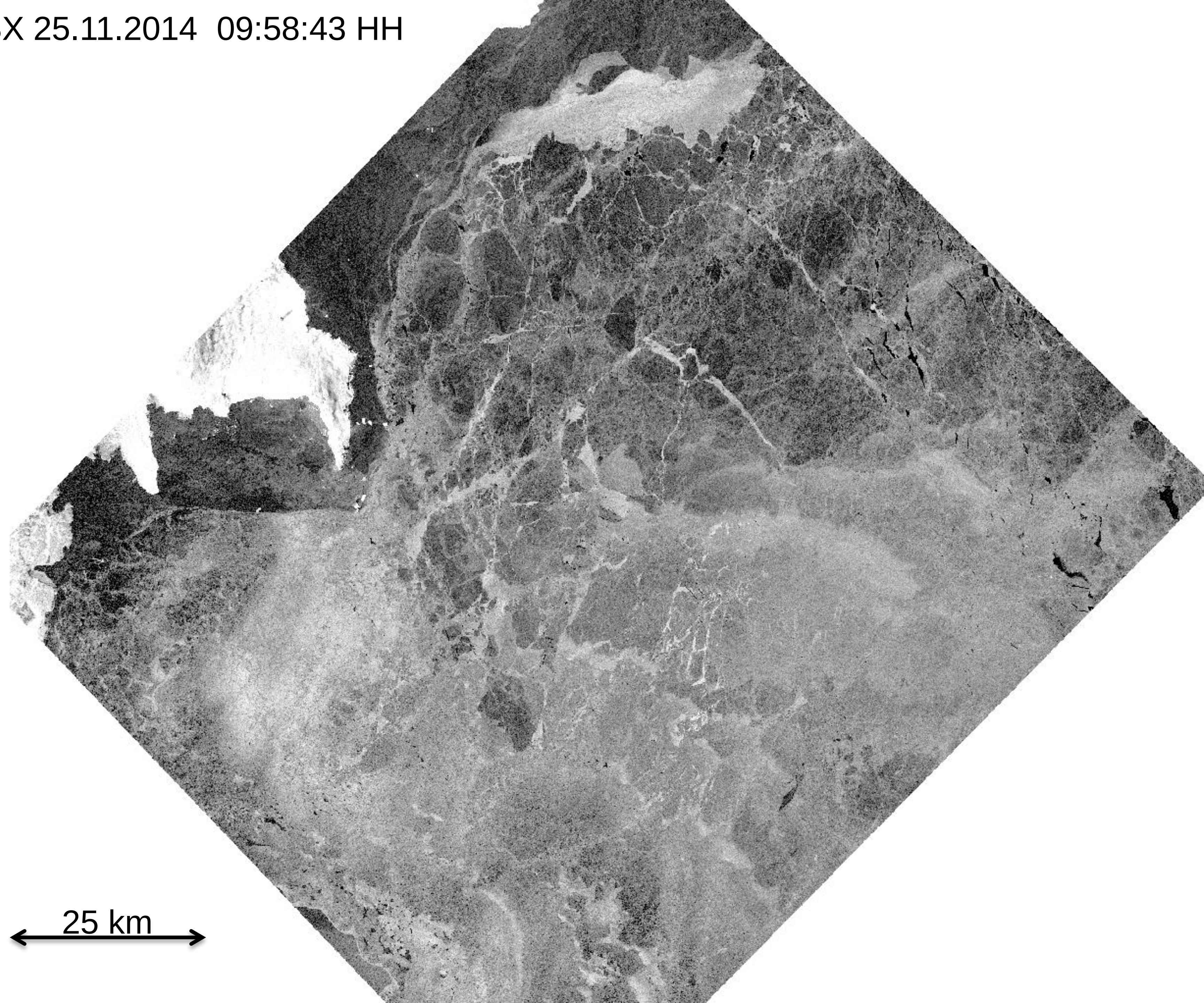

60 km
ALOS2 29.11.2014 21:00 HH

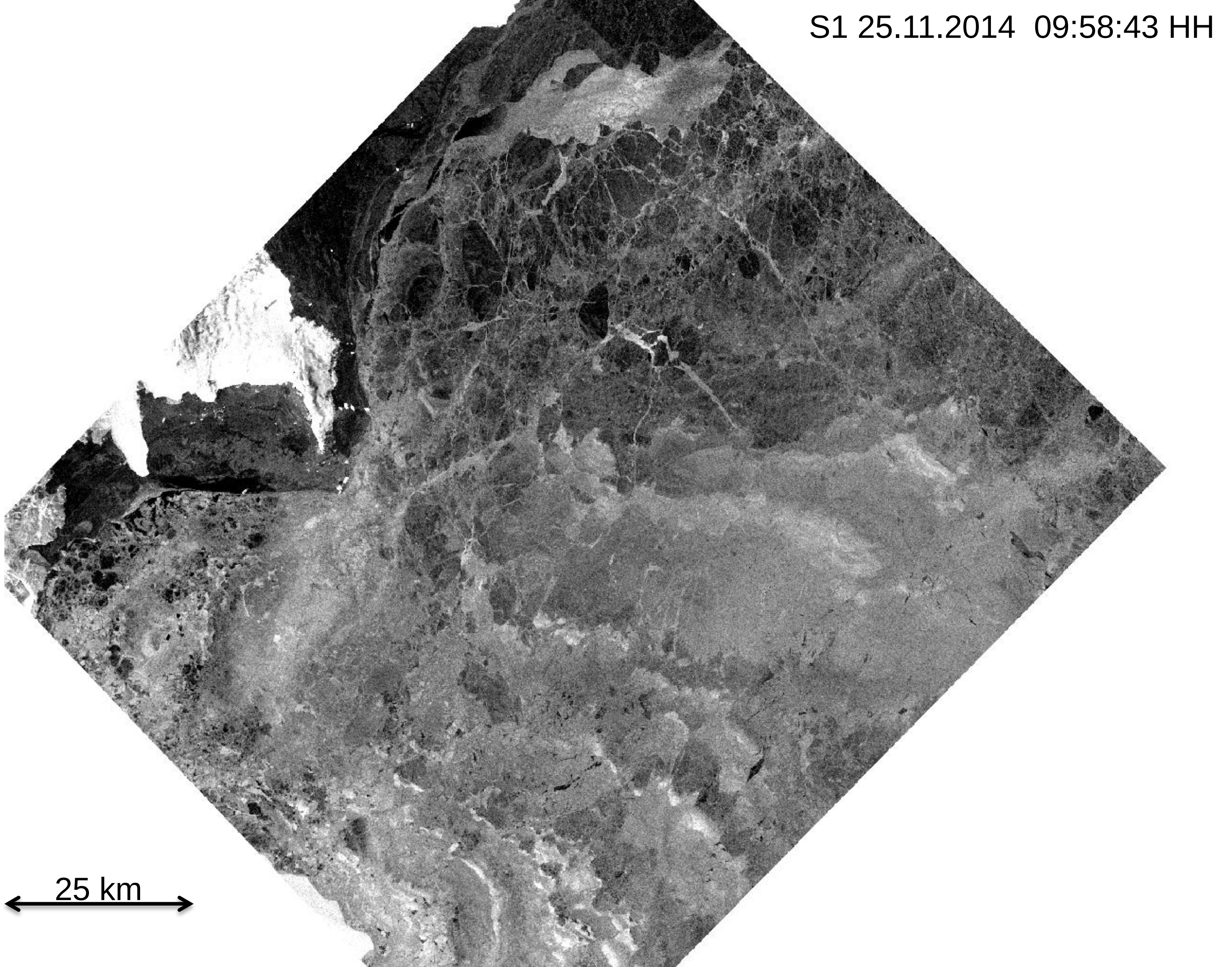
Sentinel 1 29.11.2014 15:45

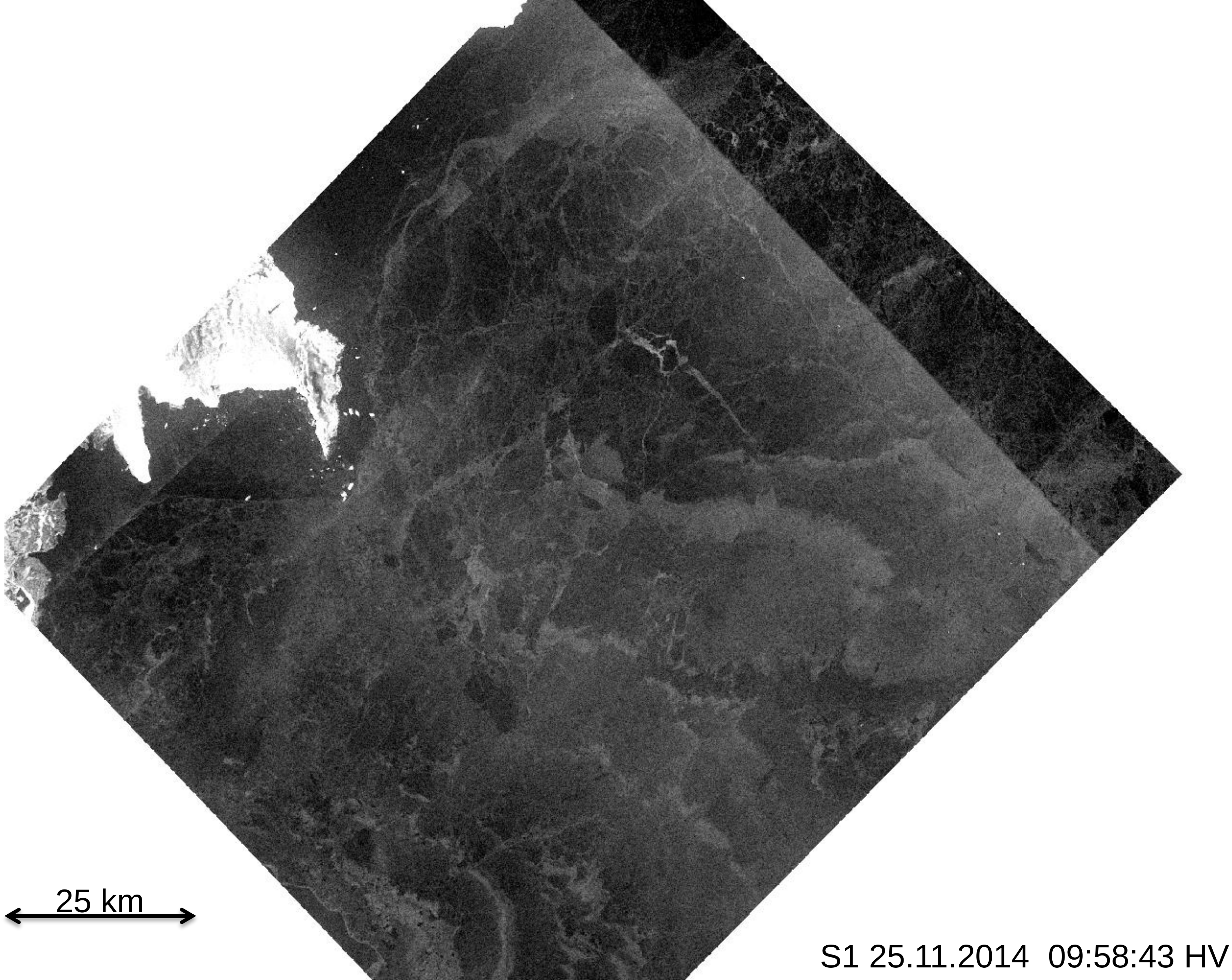
The Polynya in X- and C-Band

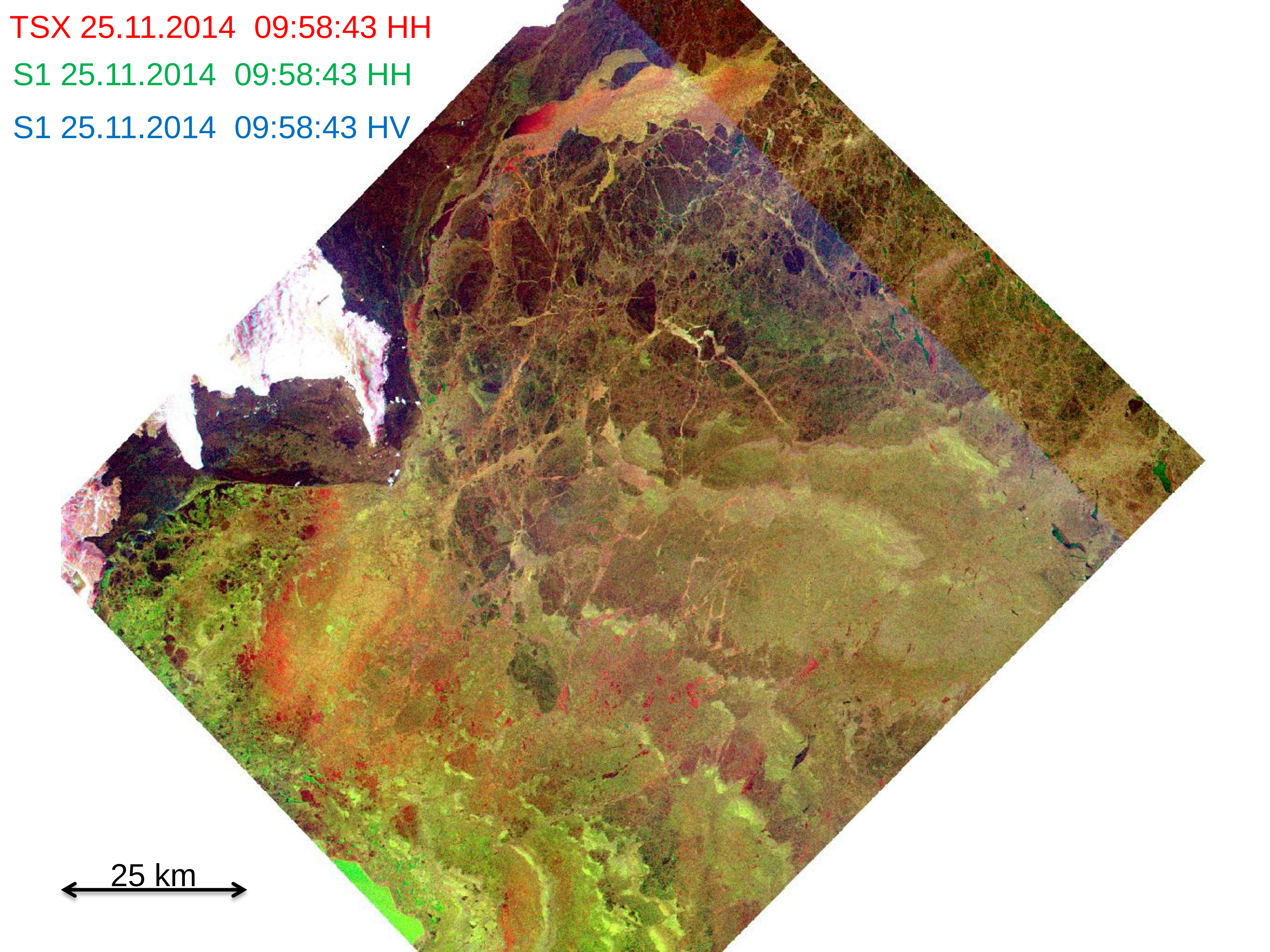


TSX 25.11.2014 09:58:43 HH

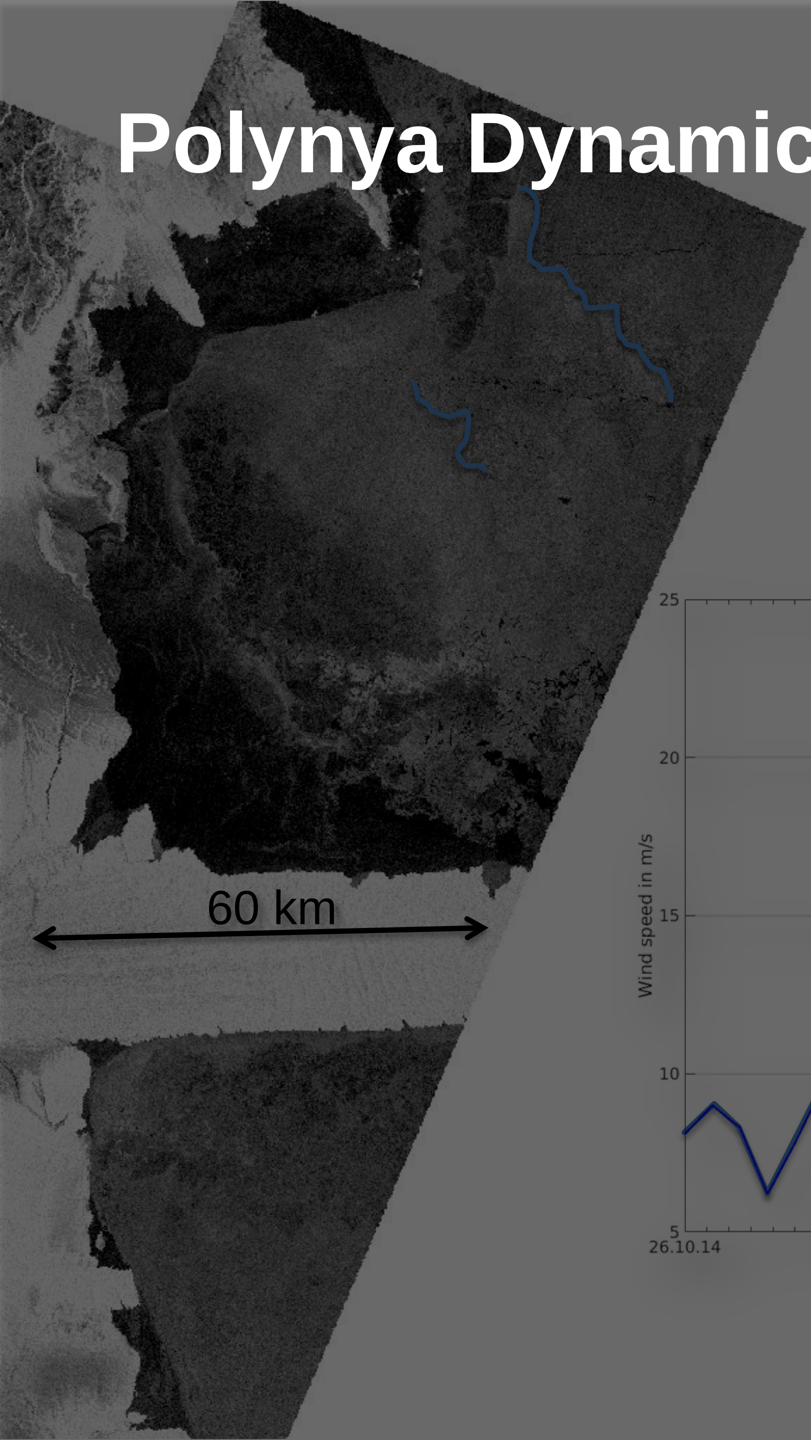


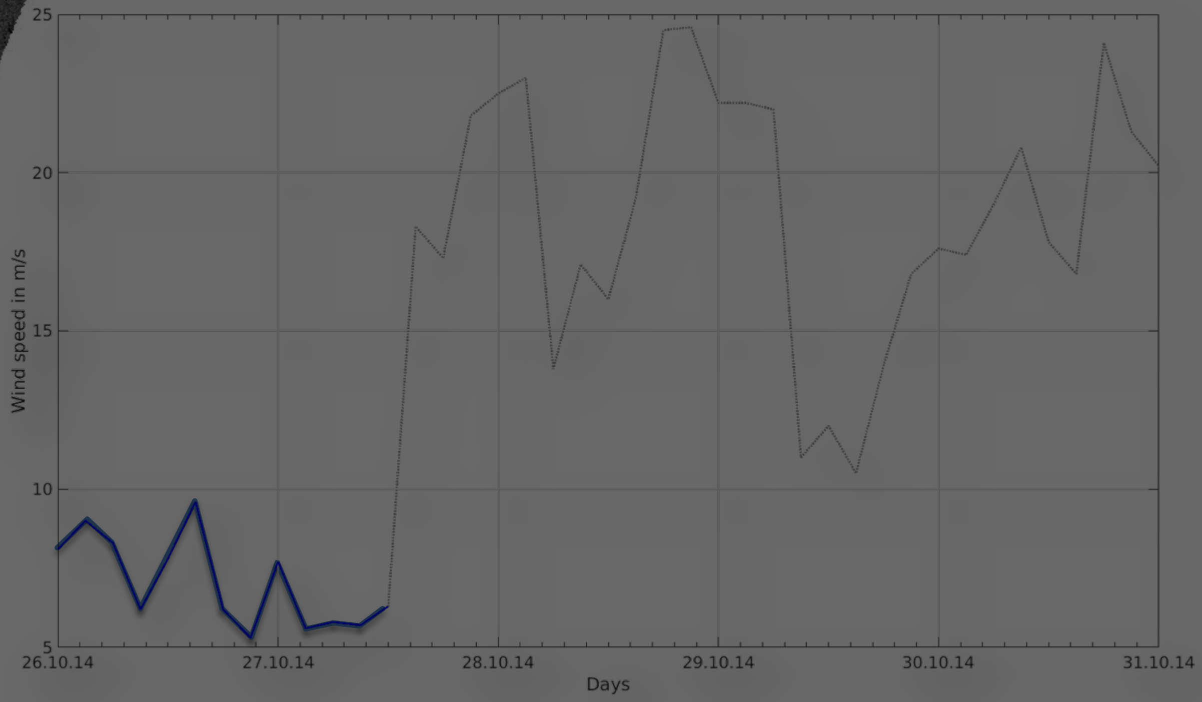

S1 25.11.2014 09:58:43 HH
25 km


25 km
S1 25.11.2014 09:58:43 HV

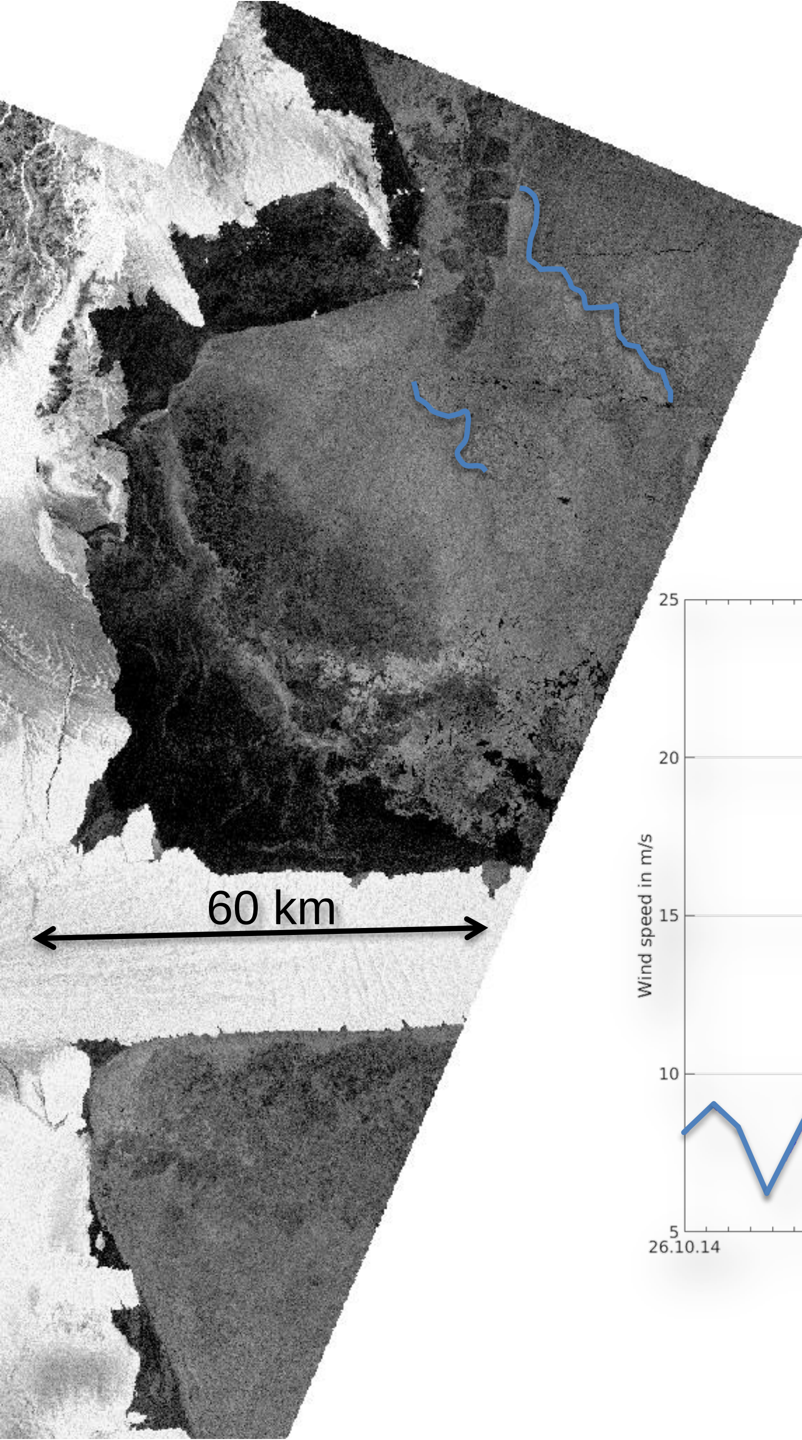

TSX 25.11.2014 09:58:43 HH
S1 25.11.2014 09:58:43 HH
S1 25.11.2014 09:58:43 HV
25 km

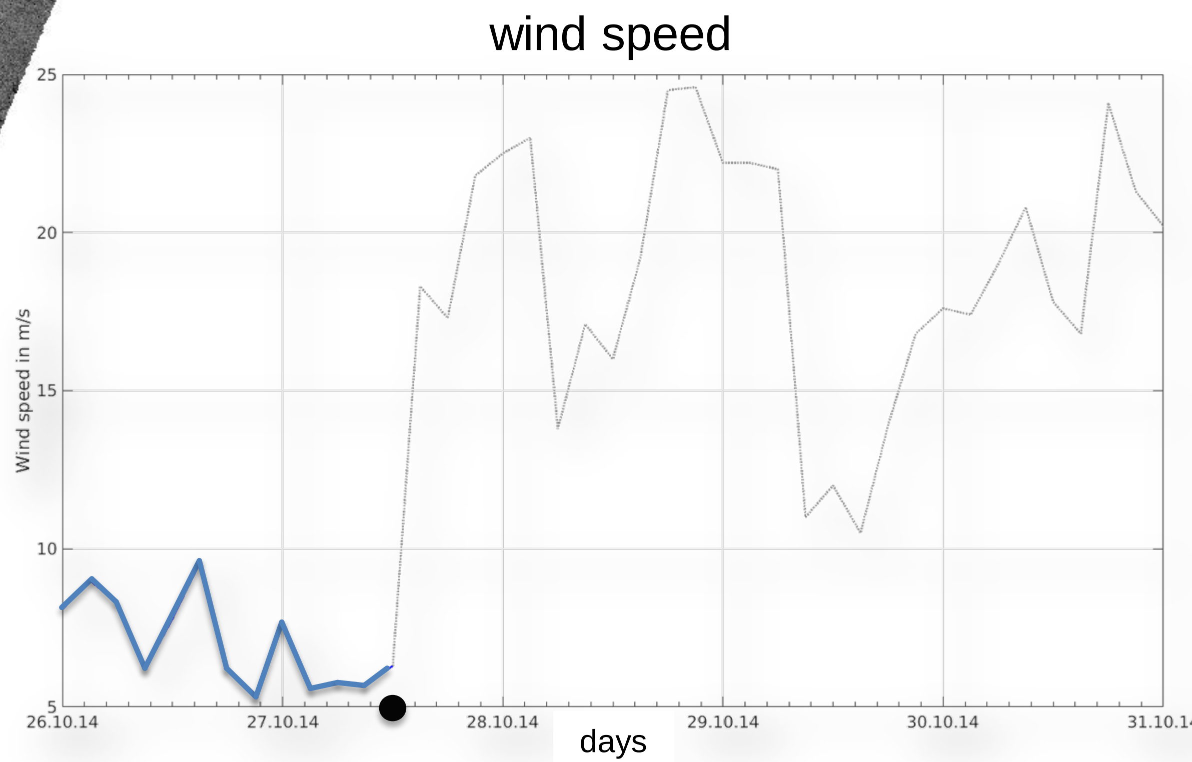
Polynya Dynamics



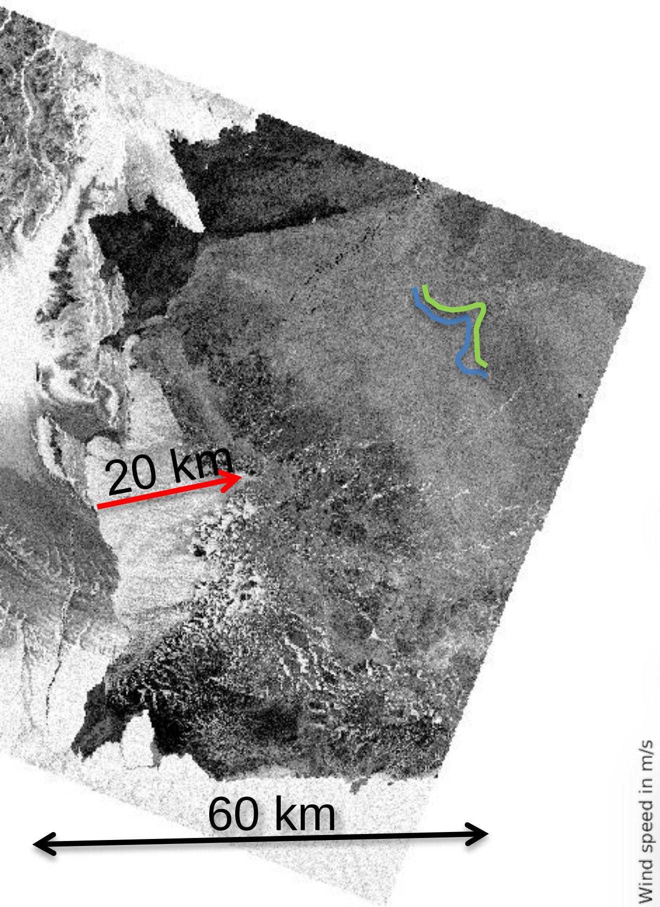


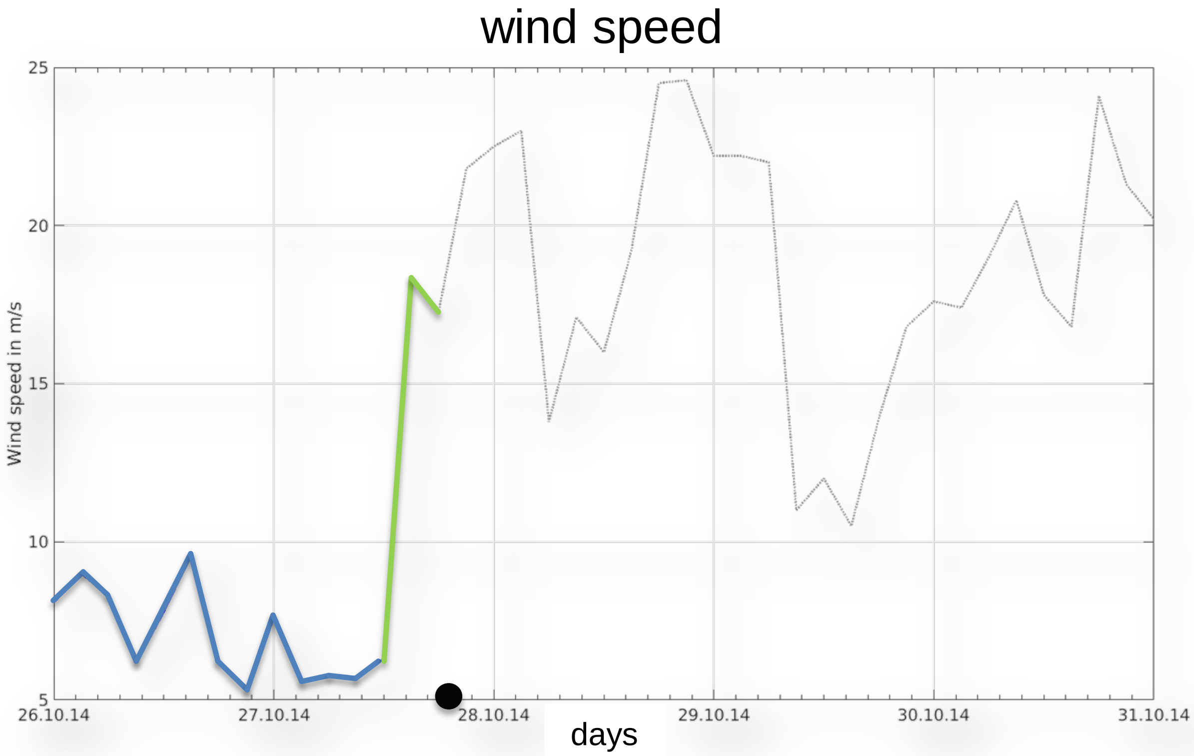
TDX 27.10.14 10:24:32



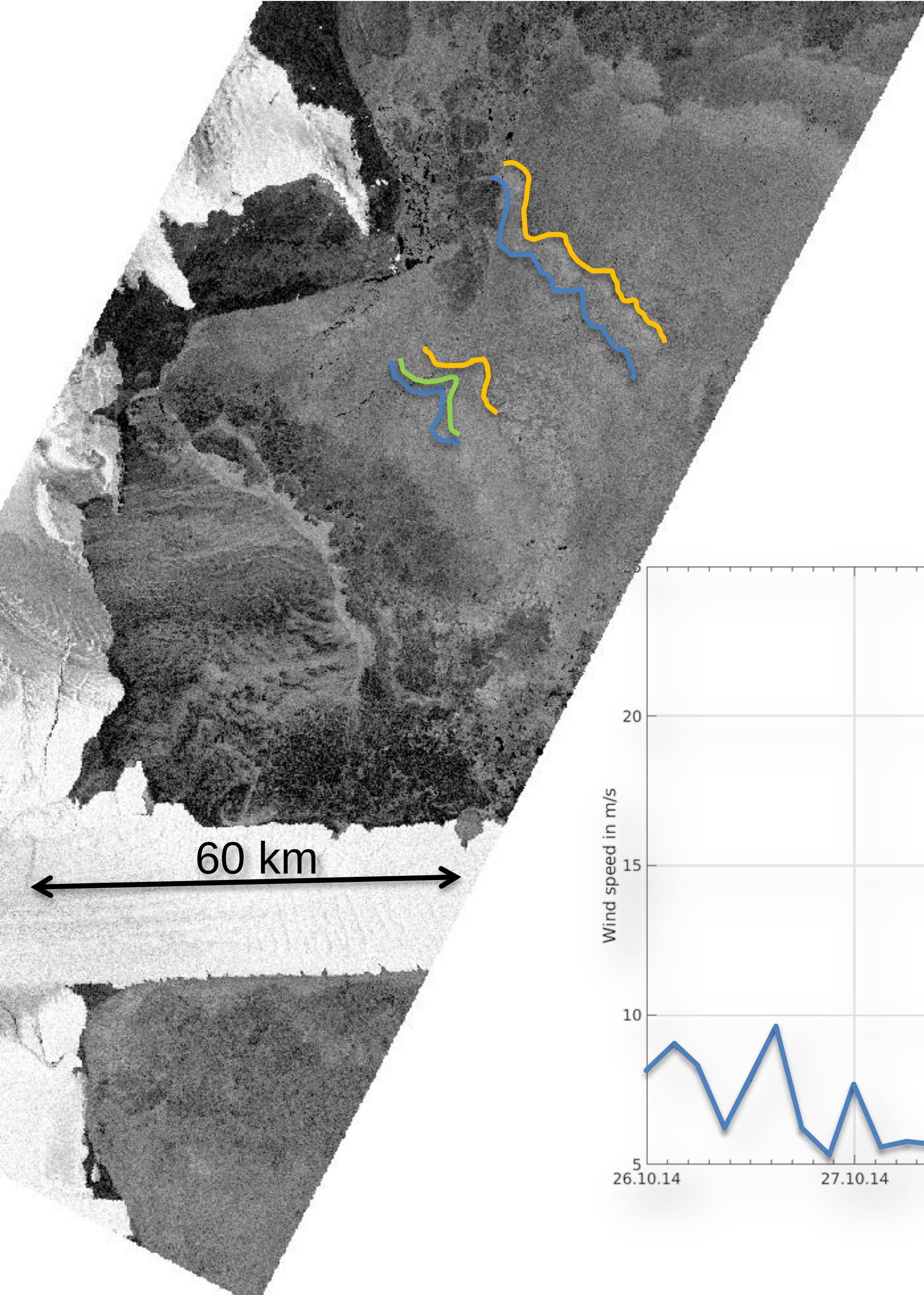


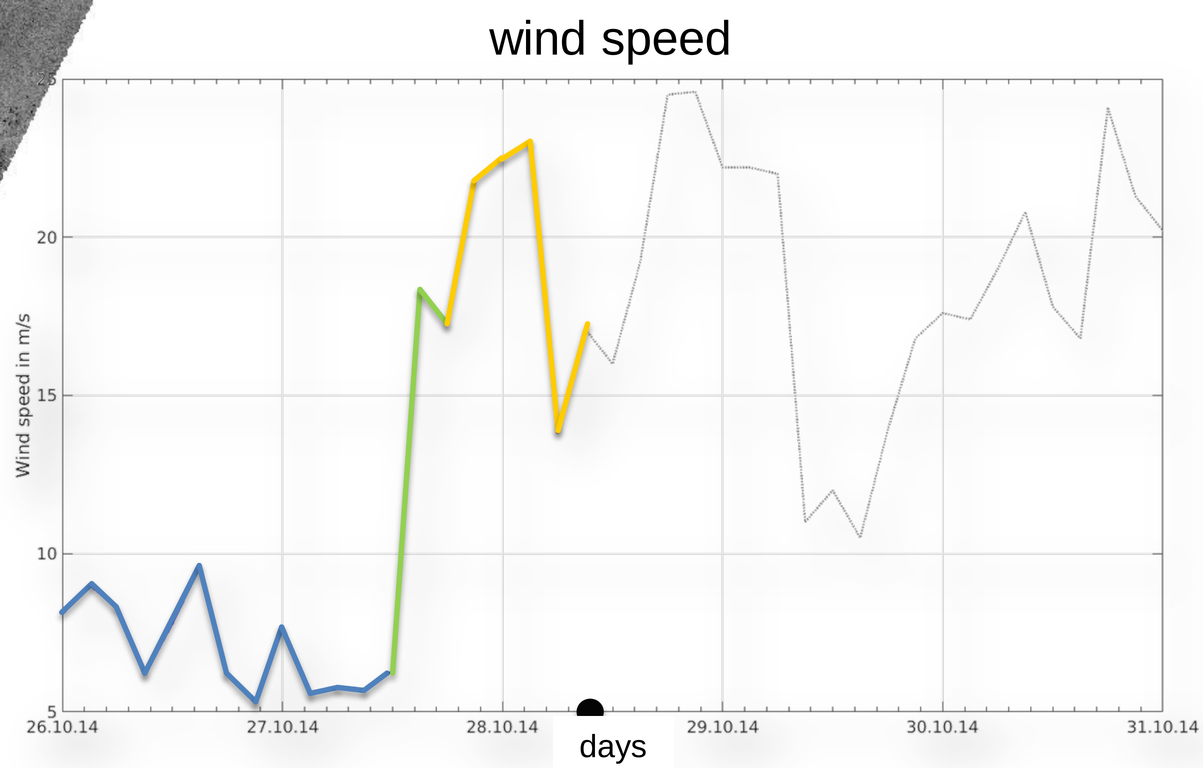
TDX 27.10.14 10:24:32



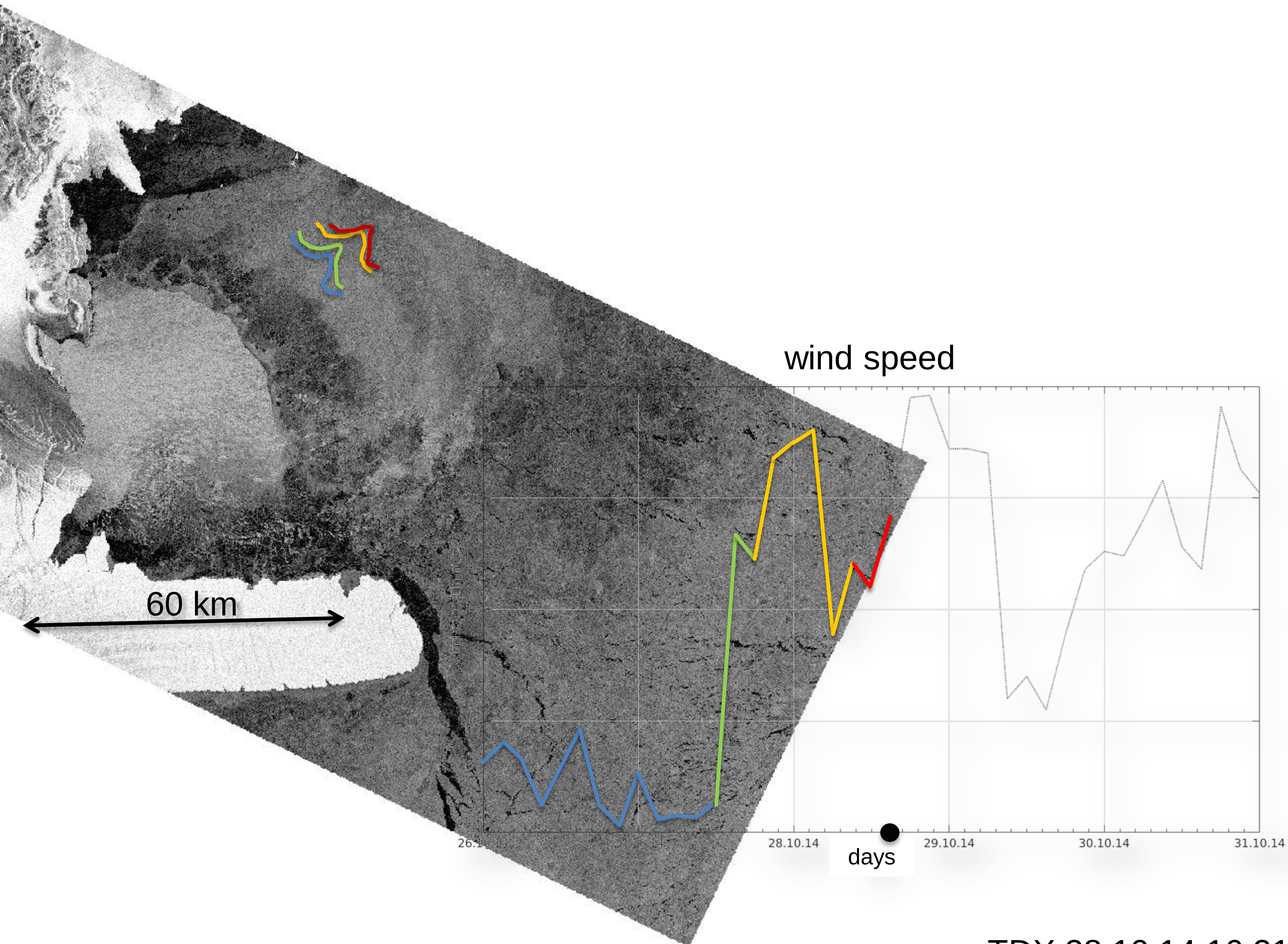


TSX 27.10.14 16:38:03

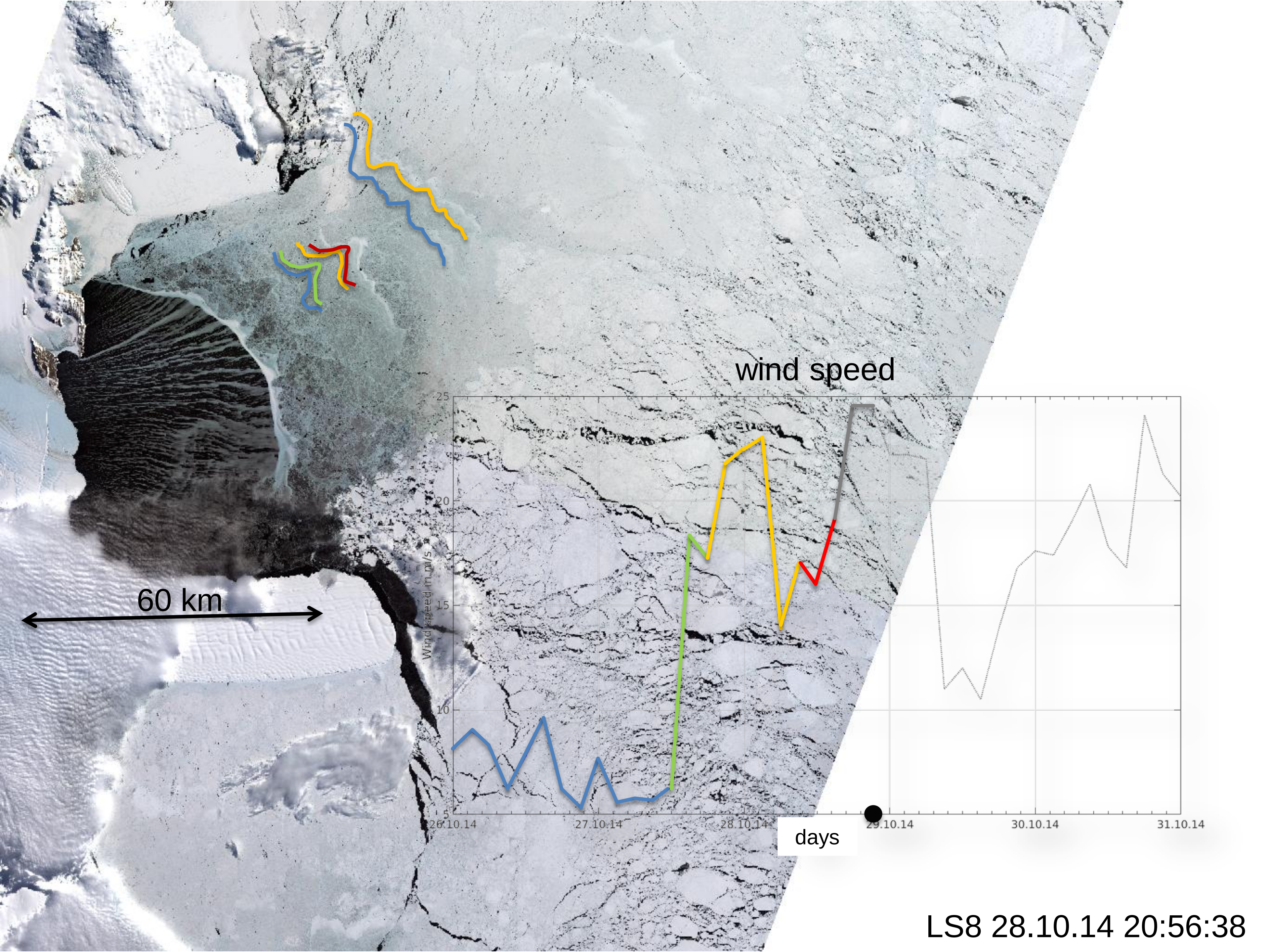


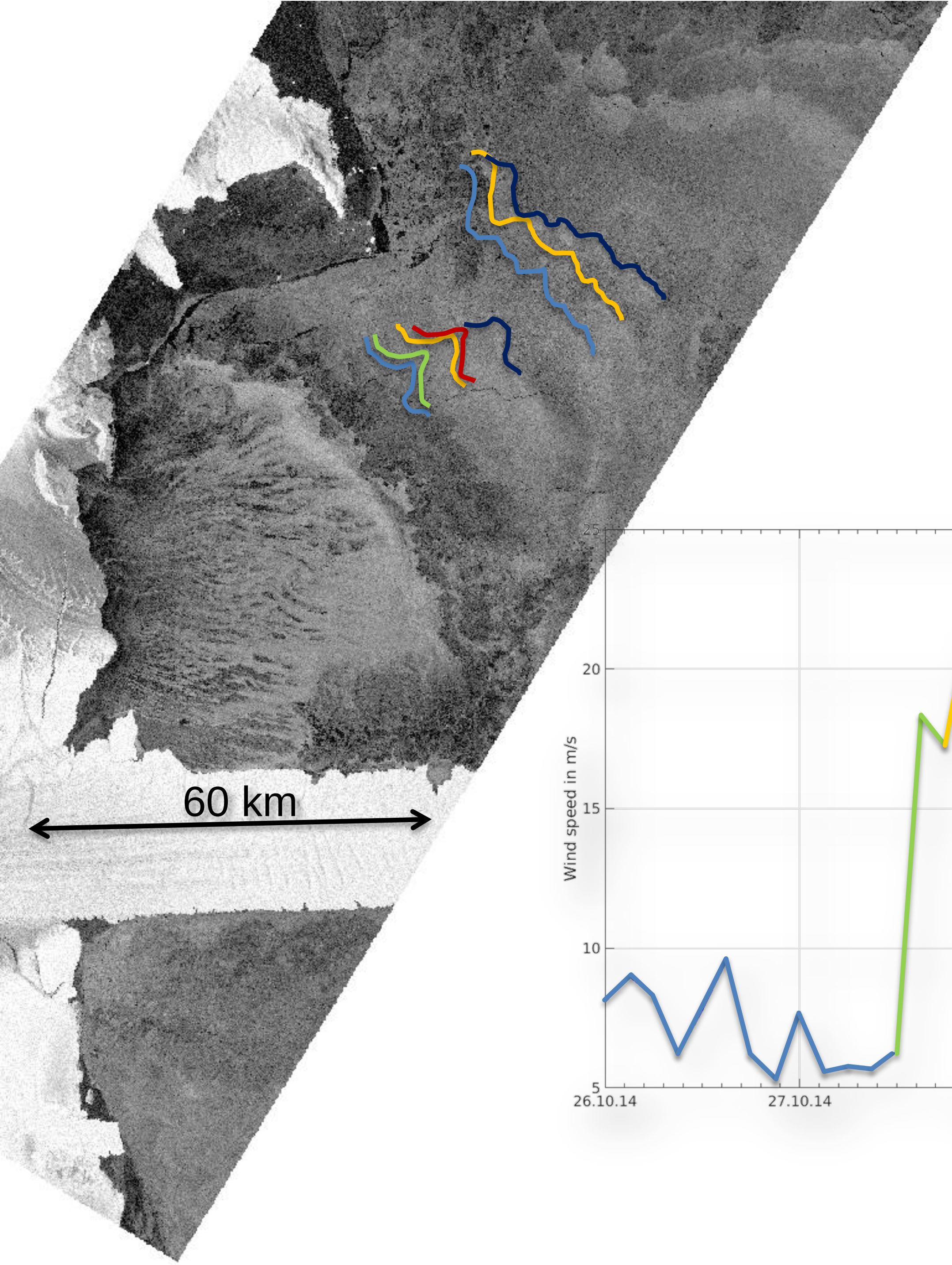


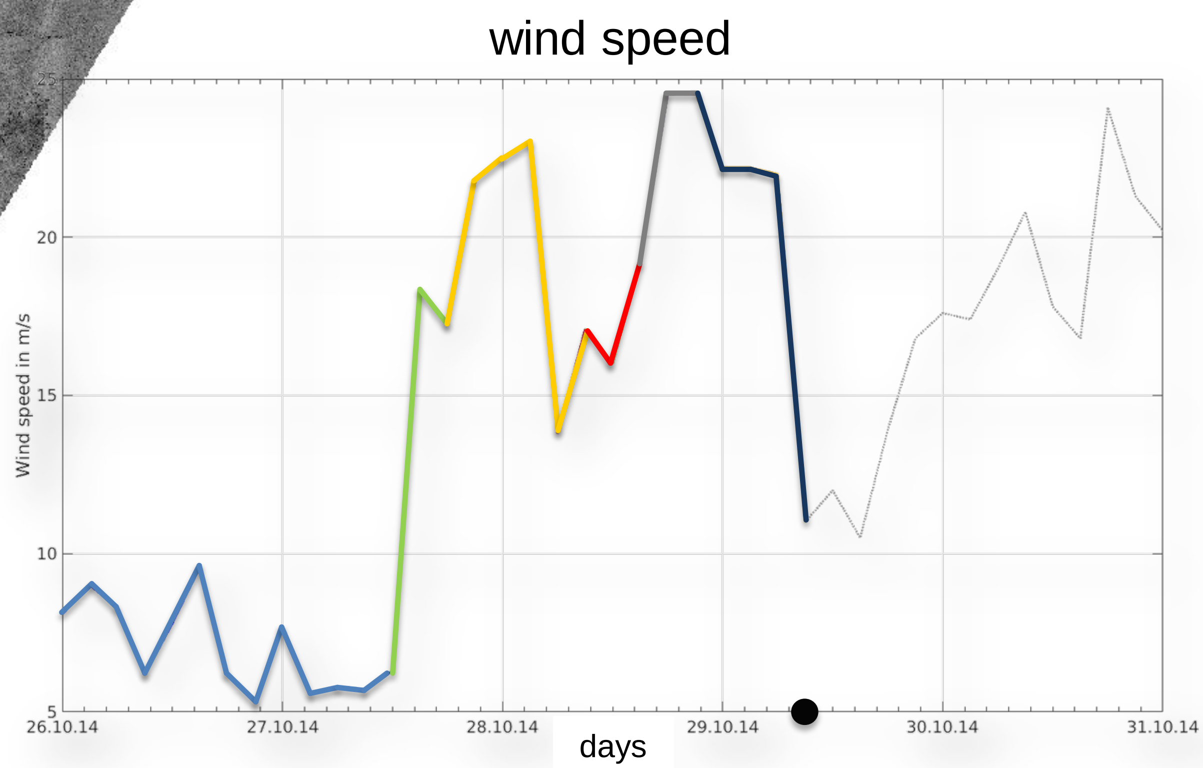
TDX 28.10.14 10:07:30



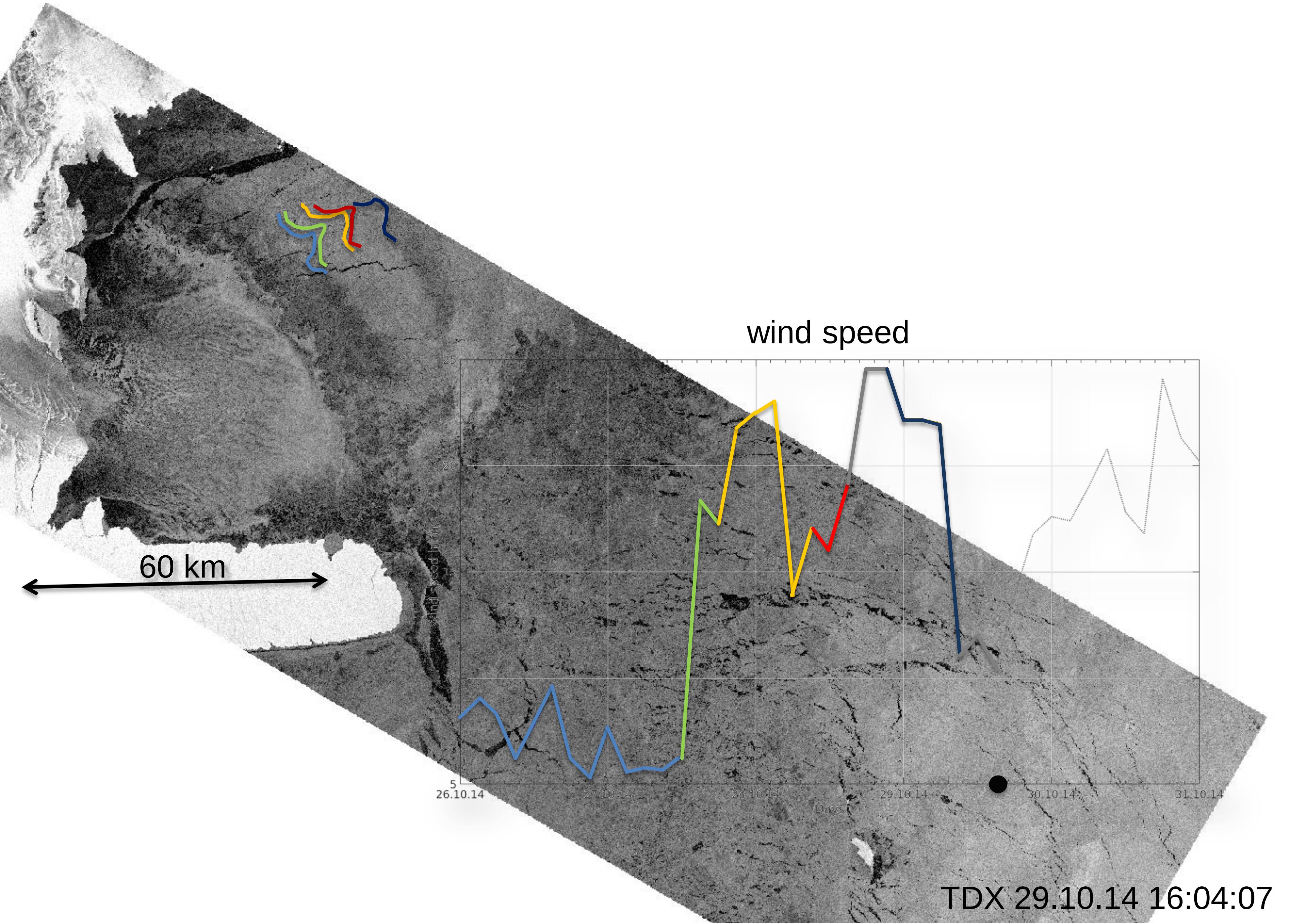
TDX 28.10.14 16:21:09

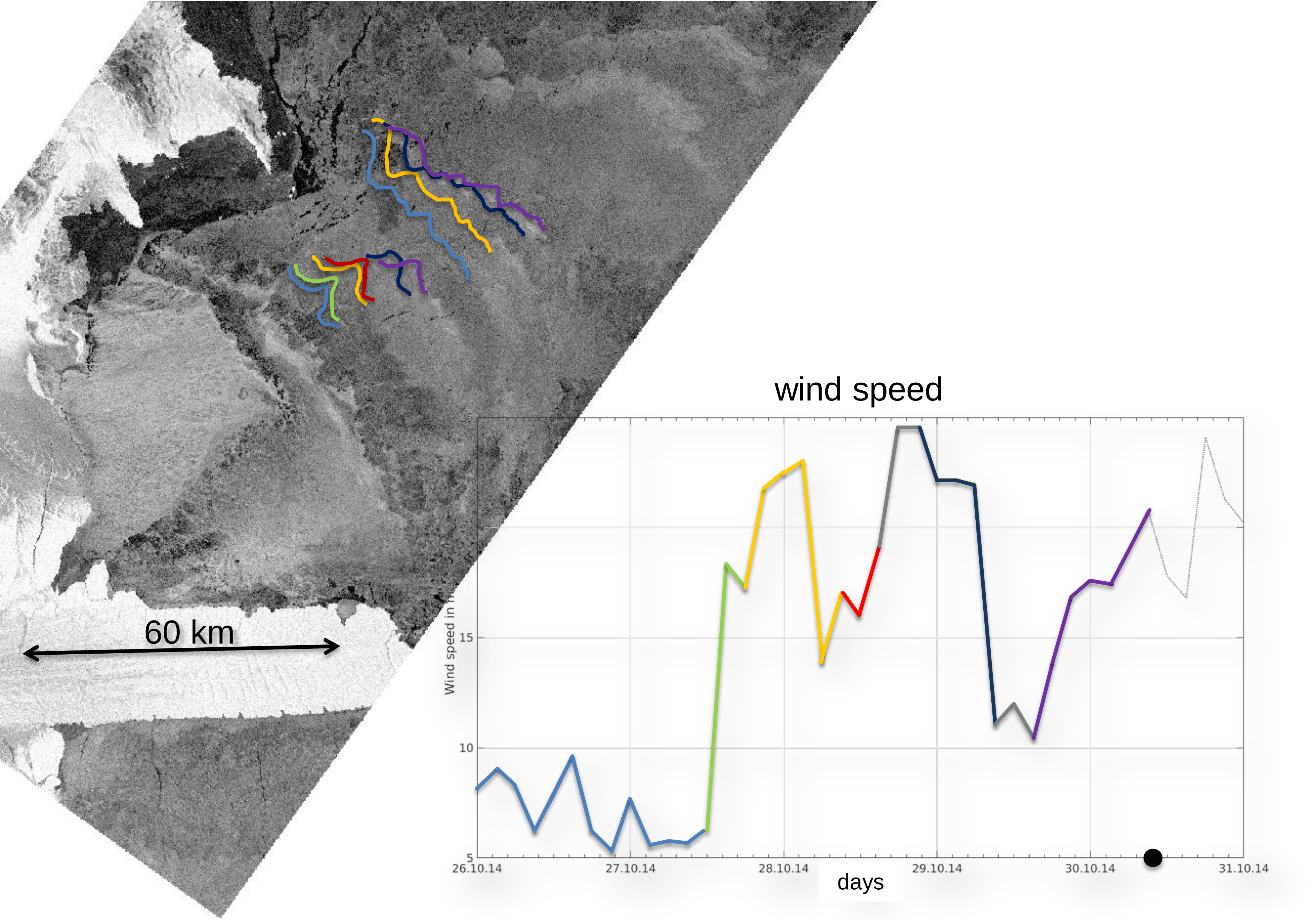

wind speed
60 km
Wind speed in m/s
25
20
15
10
5
26.10.14
27.10.14
28.10.14
29.10.14
30.10.14
31.10.14
days
LS8 28.10.14 20:56:38



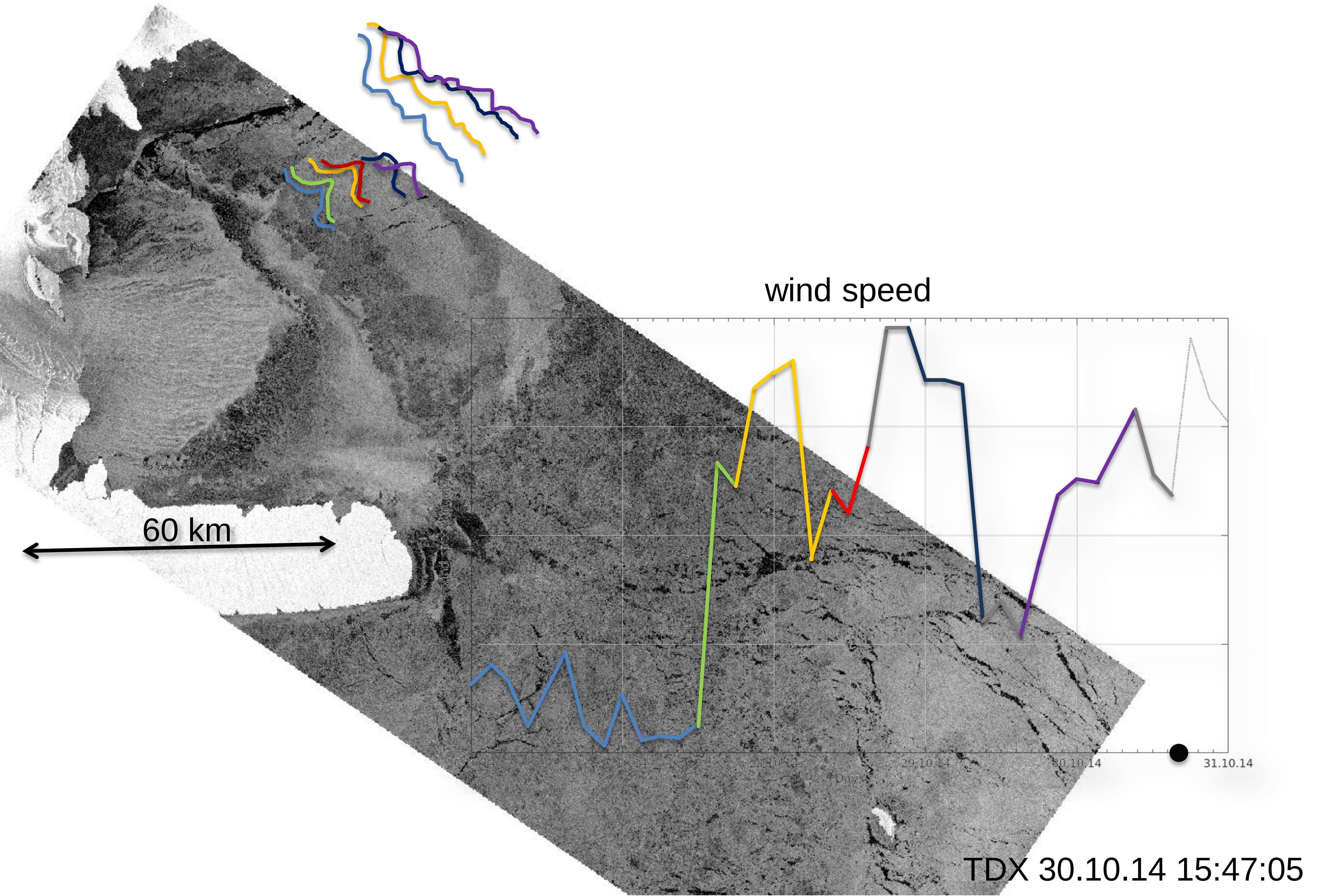


TDX 29.10.14 09:50:28

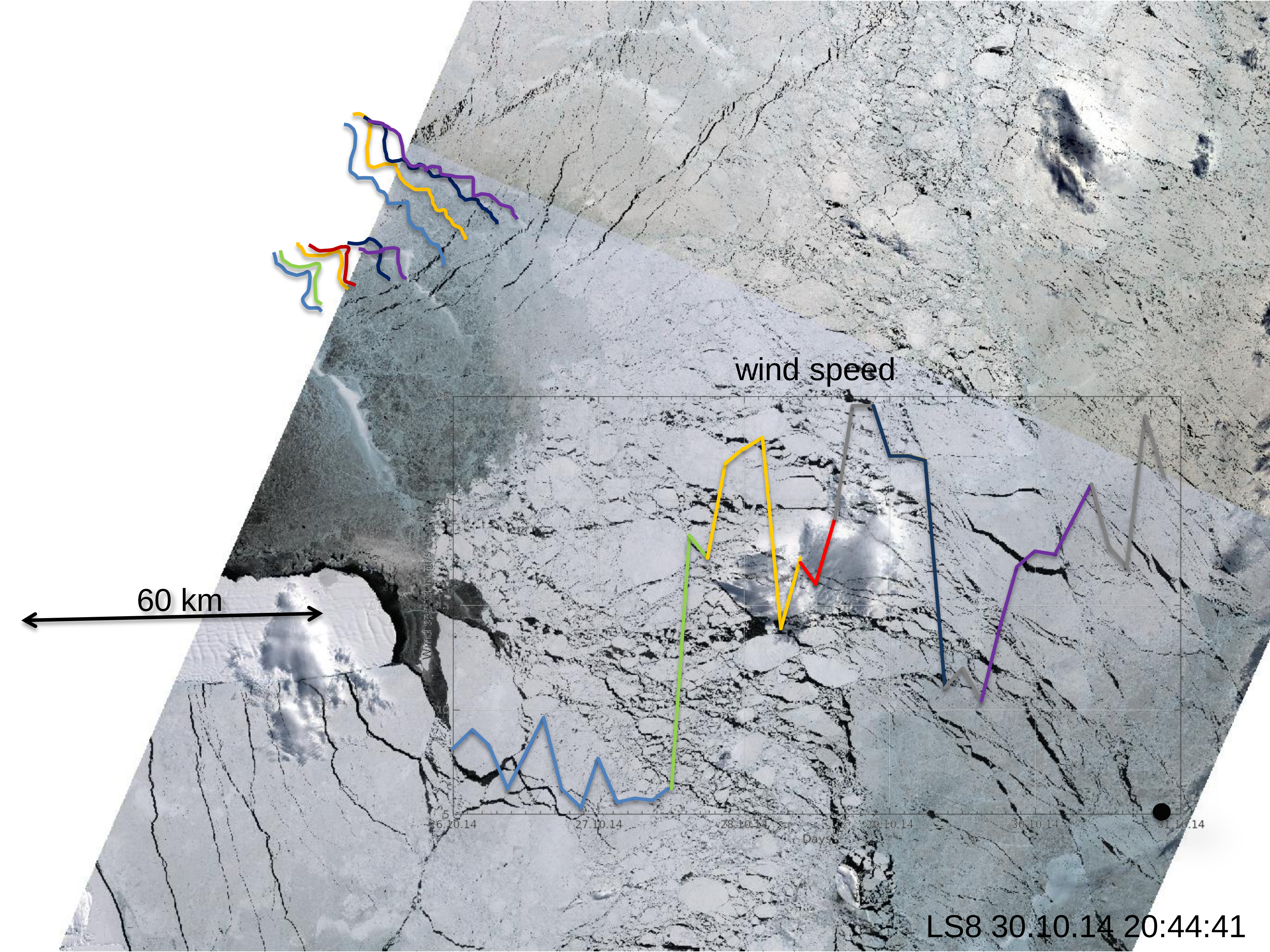

wind speed
60 km
26.10.14
29.10.14
30.10.14
31.10.14
Days
TDX 29.10.14 16:04:07



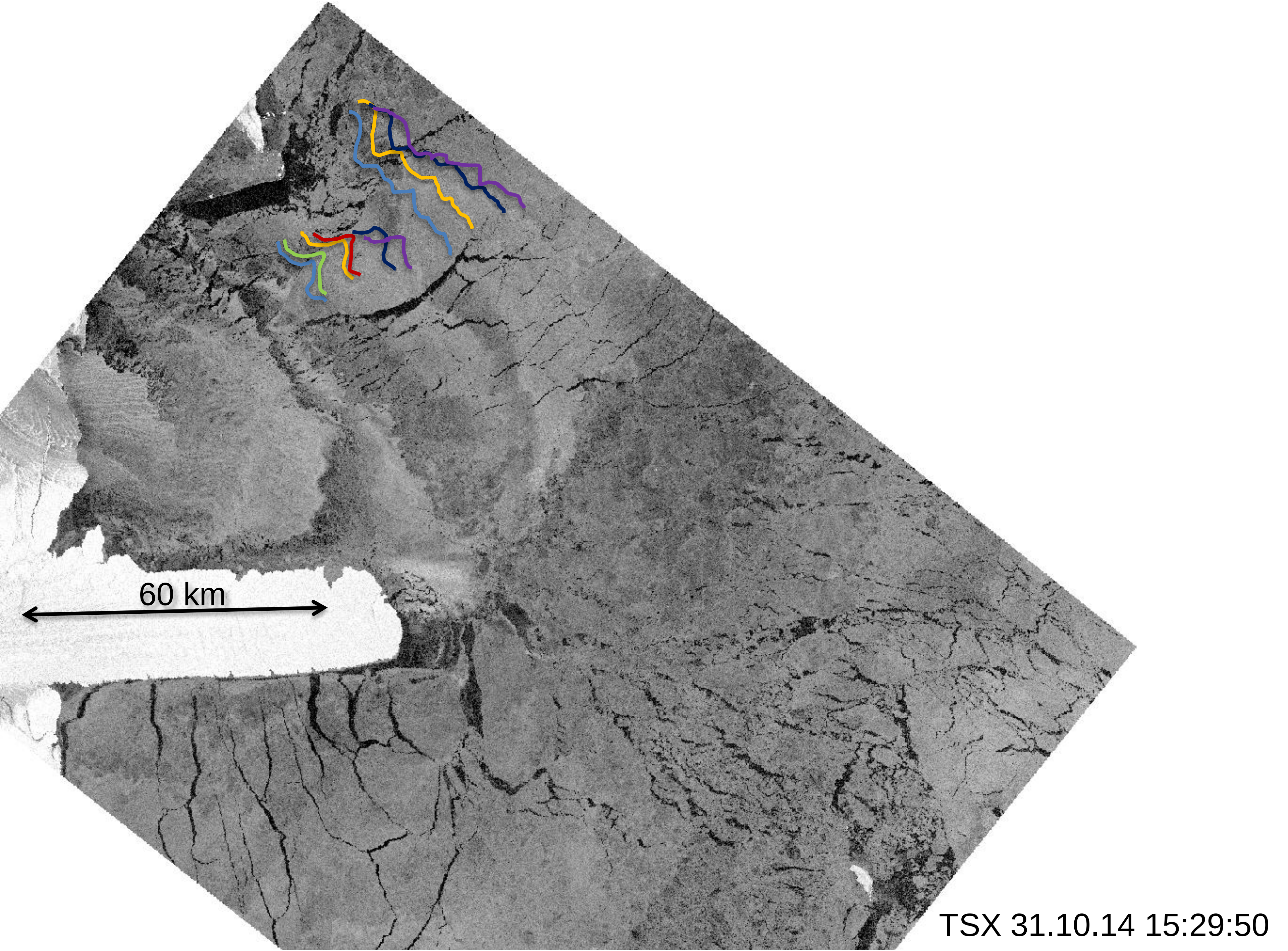
TDX 30.10.14 09:33:23



wind speed
60 km
29.10.14
30.10.14
31.10.14
TDX 30.10.14 15:47:05



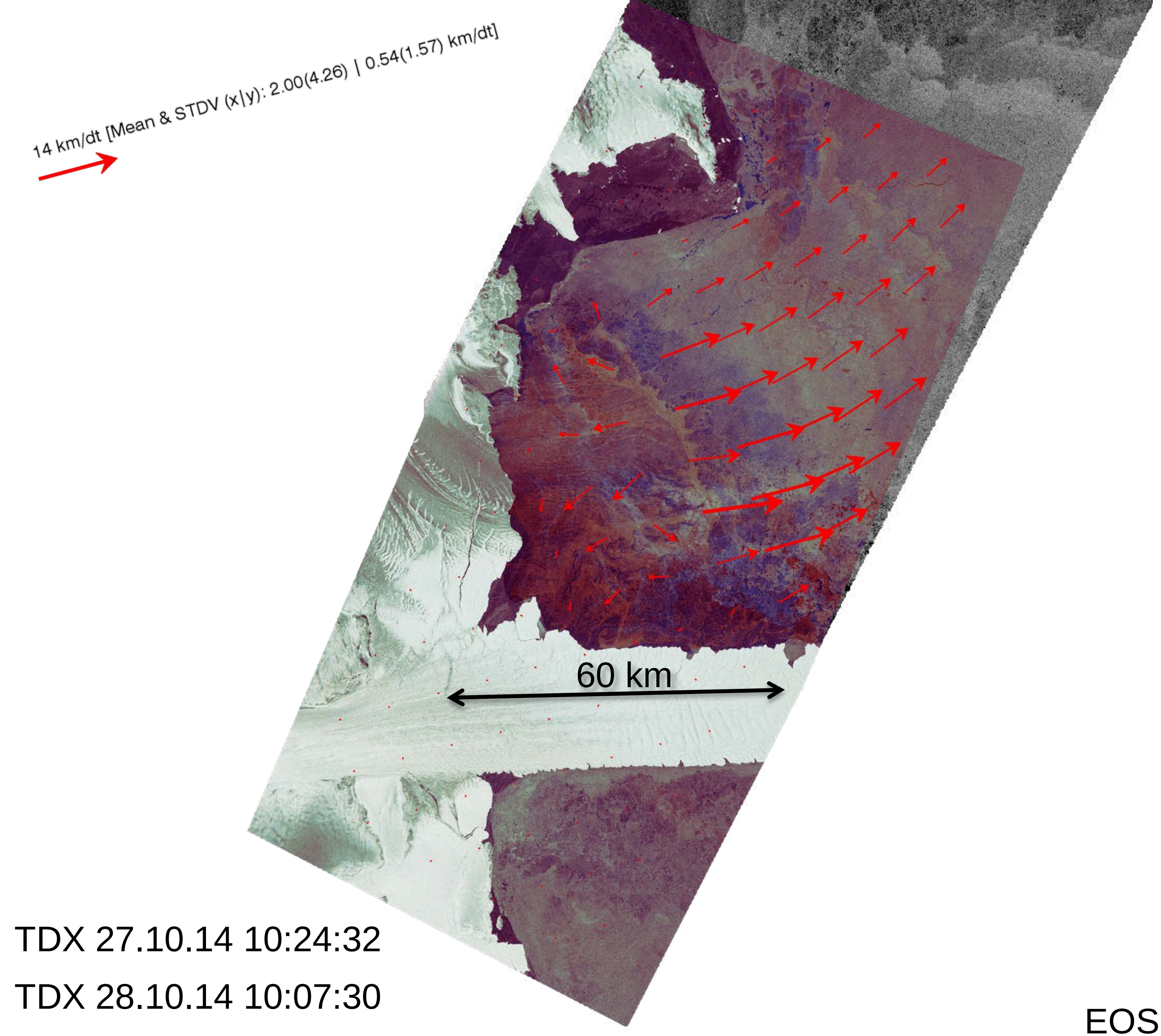
wind speed
60 km
Days
26.10.14
27.10.14
28.10.14
29.10.14
30.10.14
31.10.14
LS8 30.10.14 20:44:41


60 km
TSX 31.10.14 15:29:50

EOS AWI Drift algorithm

TDX 27.10.14 10:24:32

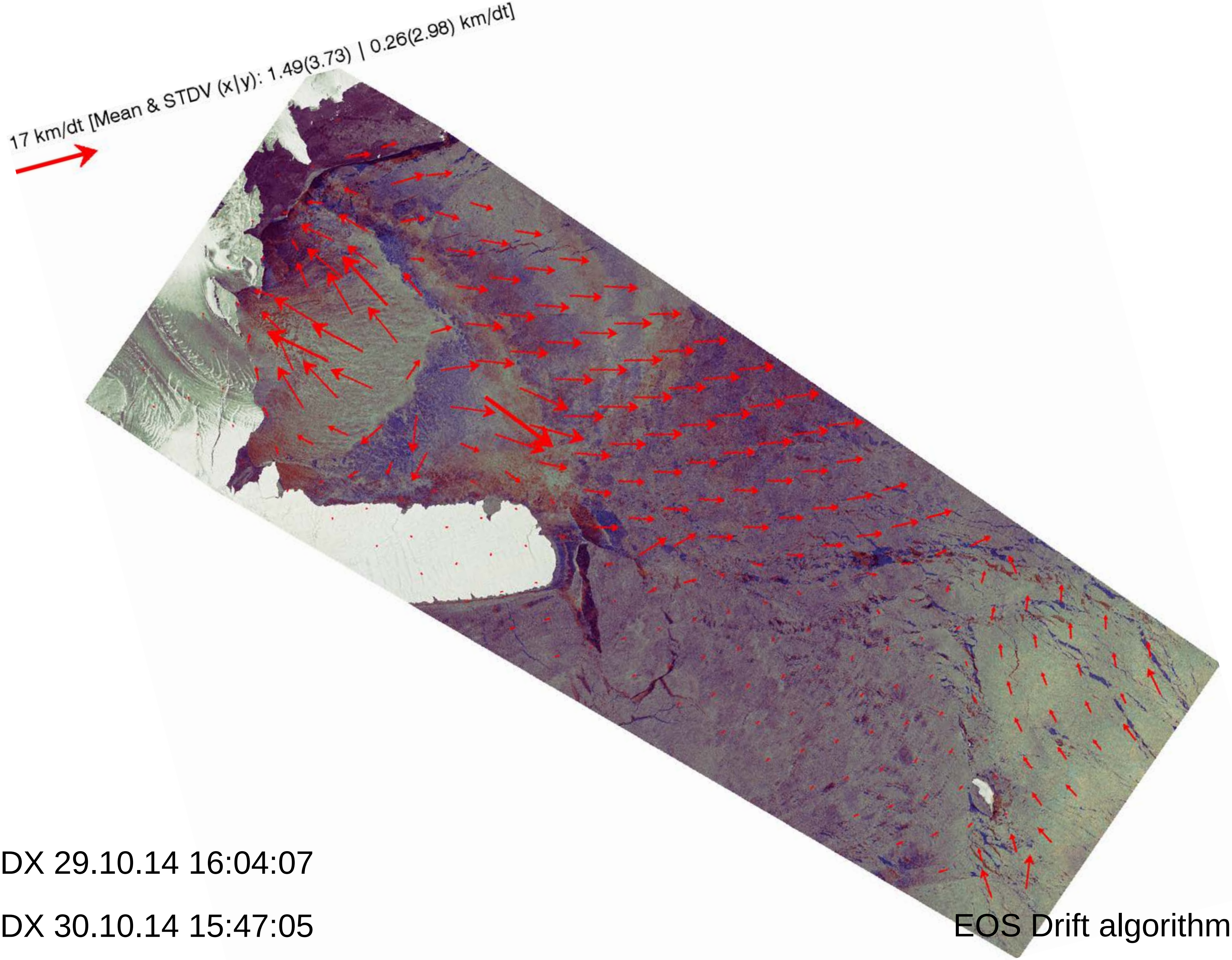
TDX 28.10.14 10:07:30



TDX 27.10.14 10:24:32

TDX 28.10.14 10:07:30

EOS Drift algorithm

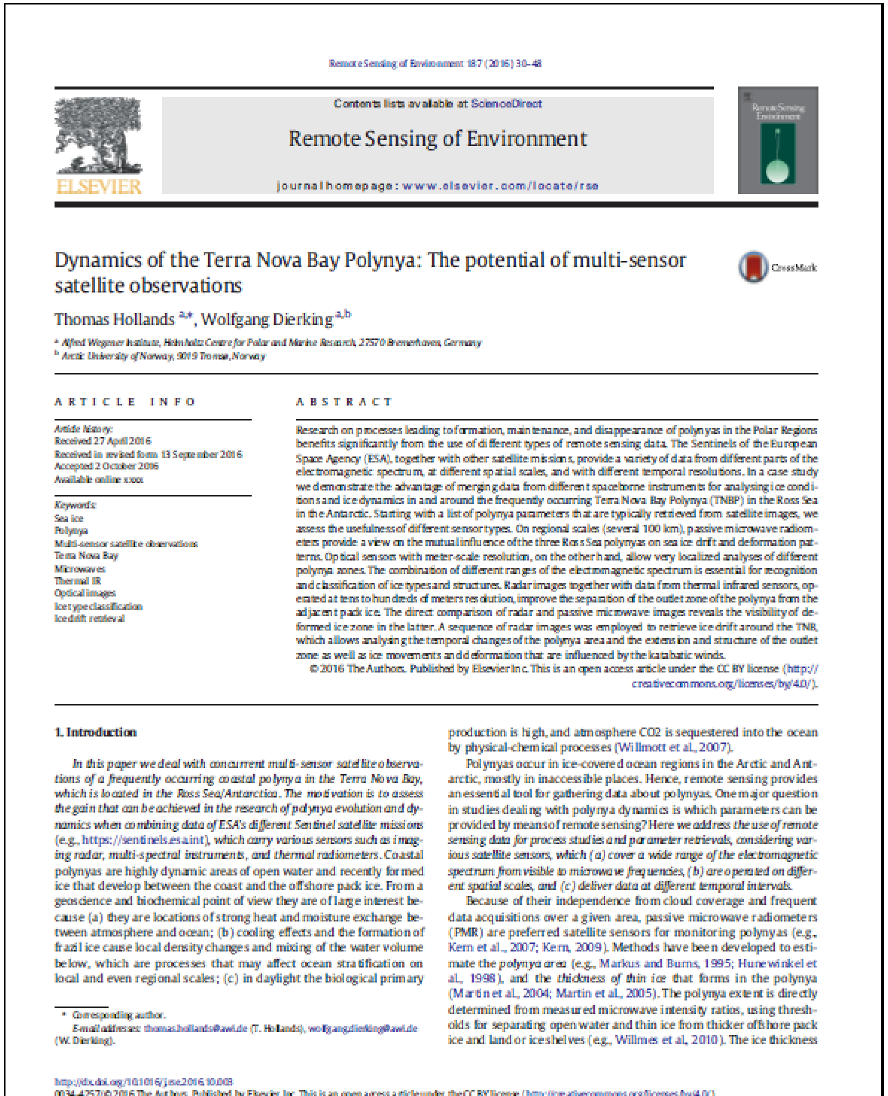


TDX 29.10.14 16:04:07

TDX 30.10.14 15:47:05

EOS Drift algorithm

Contact



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Dynamics of the Terra Nova Bay Polynya: The potential of multi-sensor satellite observations

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ABSTRACT

Research on processes leading to formation, maintenance, and disappearance of polynyas in the Polar Regions benefits significantly from the use of different types of remote sensing data. The Sentinels of the European Space Agency (ESA), together with other satellite missions, provide a variety of data from different parts of the electromagnetic spectrum, at different spatial scales, and with different temporal resolutions. In a case study we demonstrate the advantage of merging data from different spaceborne instruments for analysing ice conditions and ice dynamics in and around the frequently occurring Terra Nova Bay Polynya (TNBP) in the Ross Sea in the Antarctic. Starting with a list of polynya parameters that are typically retrieved from satellite images, we assess the usefulness of different sensor types. On regional scales (several 100 km), passive microwave radiometers provide a view on the mutual influence of the three Ross Sea polynyas on sea ice drift and deformation patterns. Optical sensors with meter-scale resolution, on the other hand, allow very localized analyses of different polynya zones. The combination of different ranges of the electromagnetic spectrum is essential for recognition and classification of ice types and structures. Radar images together with data from thermal infrared sensors, operated at tens to hundreds of meters resolution, improve the separation of the outlet zone of the polynya from the adjacent pack ice. The direct comparison of radar and passive microwave images reveals the visibility of deformed ice zone in the latter. A sequence of radar images was employed to retrieve ice drift around the TNB, which allows analysing the temporal changes of the polynya area and the extension and structure of the outlet zone as well as ice movements and deformation that are influenced by the katabatic winds.

1. Introduction

In this paper we deal with concurrent multi-sensor satellite observations of a frequently occurring coastal polynya in the Terra Nova Bay, which is located in the Ross Sea/Antarctica. The motivation is to assess the gain that can be achieved in the research of polynya evolution and dynamics when combining data of ESA's different Sentinel satellite missions (e.g., https://sentinels.esa.int), *which carry various sensors such as imaging radar, multi-spectral instruments, and thermal radiometers.* Coastal polynyas are highly dynamic areas of open water and recently formed ice that develop between the coast and the offshore pack ice. From a geoscience and biochemical point of view they are of large interest because (a) they are locations of strong heat and moisture exchange between atmosphere and ocean; (b) cooling effects and the formation of frazil ice cause local density changes and mixing of the water volume below, which are processes that may affect ocean stratification on local and even regional scales; (c) in daylight the biological primary production is high, and atmosphere CO2 is sequestered into the ocean by physical-chemical processes (Willmott et al., 2007).

Polynyas occur in ice-covered ocean regions in the Arctic and Antarctic, mostly in inaccessible places. Hence, remote sensing provides an essential tool for gathering data about polynyas. One major question in studies dealing with polynya dynamics is which parameters can be provided by means of remote sensing? Here we address *the use of remote sensing data for process studies and parameter retrievals, considering various satellite sensors, which (a) cover a wide range of the electromagnetic spectrum from visible to microwave frequencies, (b) are operated on different spatial scales, and (c) deliver data at different temporal intervals.*

Because of their independence from cloud coverage and frequent data acquisitions over a given area, passive microwave radiometers (PMR) are preferred satellite sensors for monitoring polynyas (e.g., Kern et al., 2007; Kern, 2009). Methods have been developed to estimate the *polynya area* (e.g., Markus and Burns, 1995; Hunewinkel et al., 1998), and the *thickness of thin ice* that forms in the polynya (Martin et al., 2004; Martin et al., 2005). The polynya extent is directly determined from measured microwave intensity ratios, using thresholds for separating open water and thin ice from thicker offshore pack ice and land or ice shelves (e.g., Willmes et al., 2010). The ice thickness

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