Polish-Norwegian Research Programme

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Centre for Polar Studies

Work Package 5: Freshwater from the land

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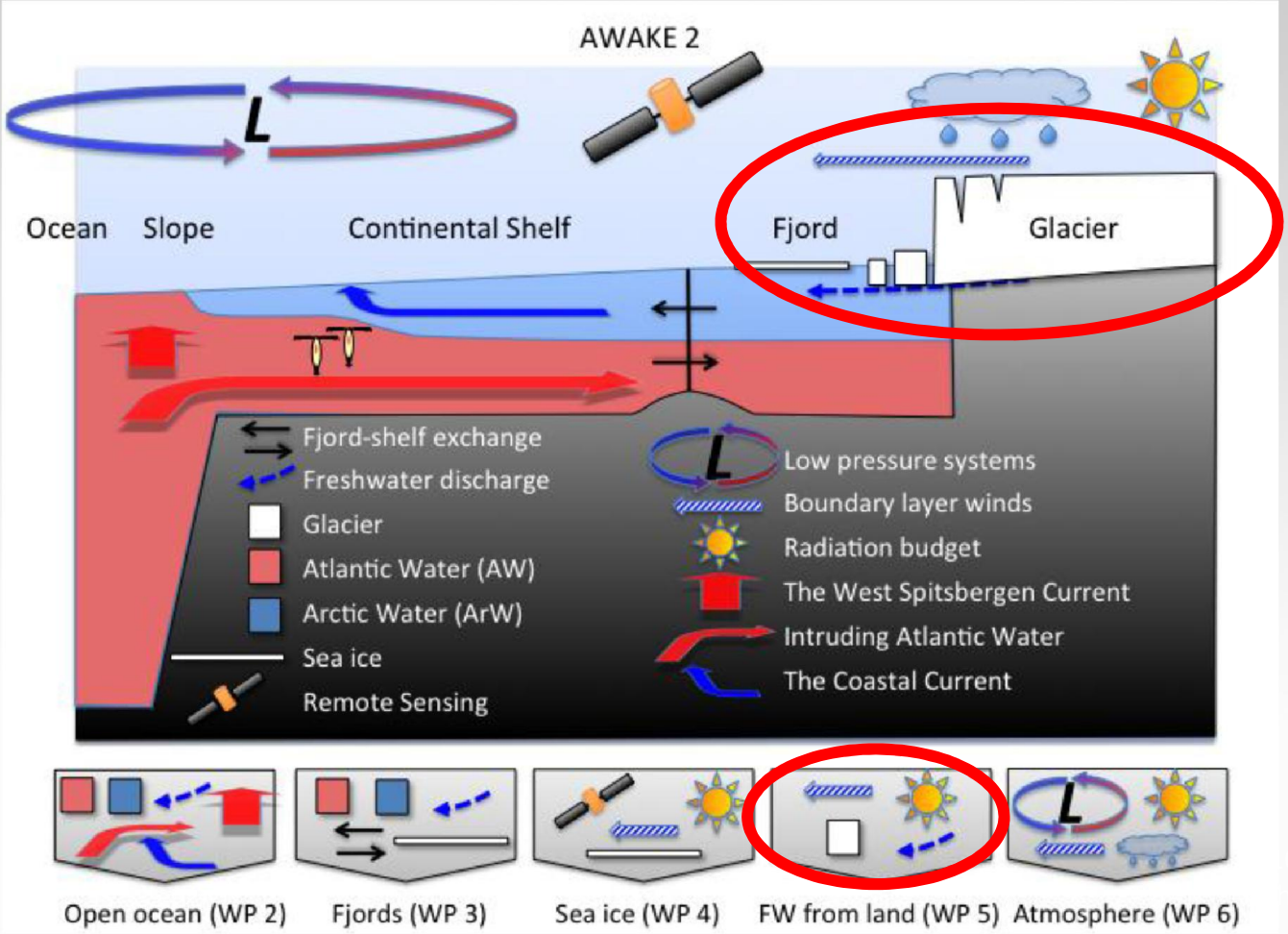
Faculty of Earth Sciences University of Silesia

AWAKE-2 Arctic climate system study of ocean, sea ice and glaciers interactions in Svalbard area.
Midterm meeting

Sopot, 27-30 September 2014

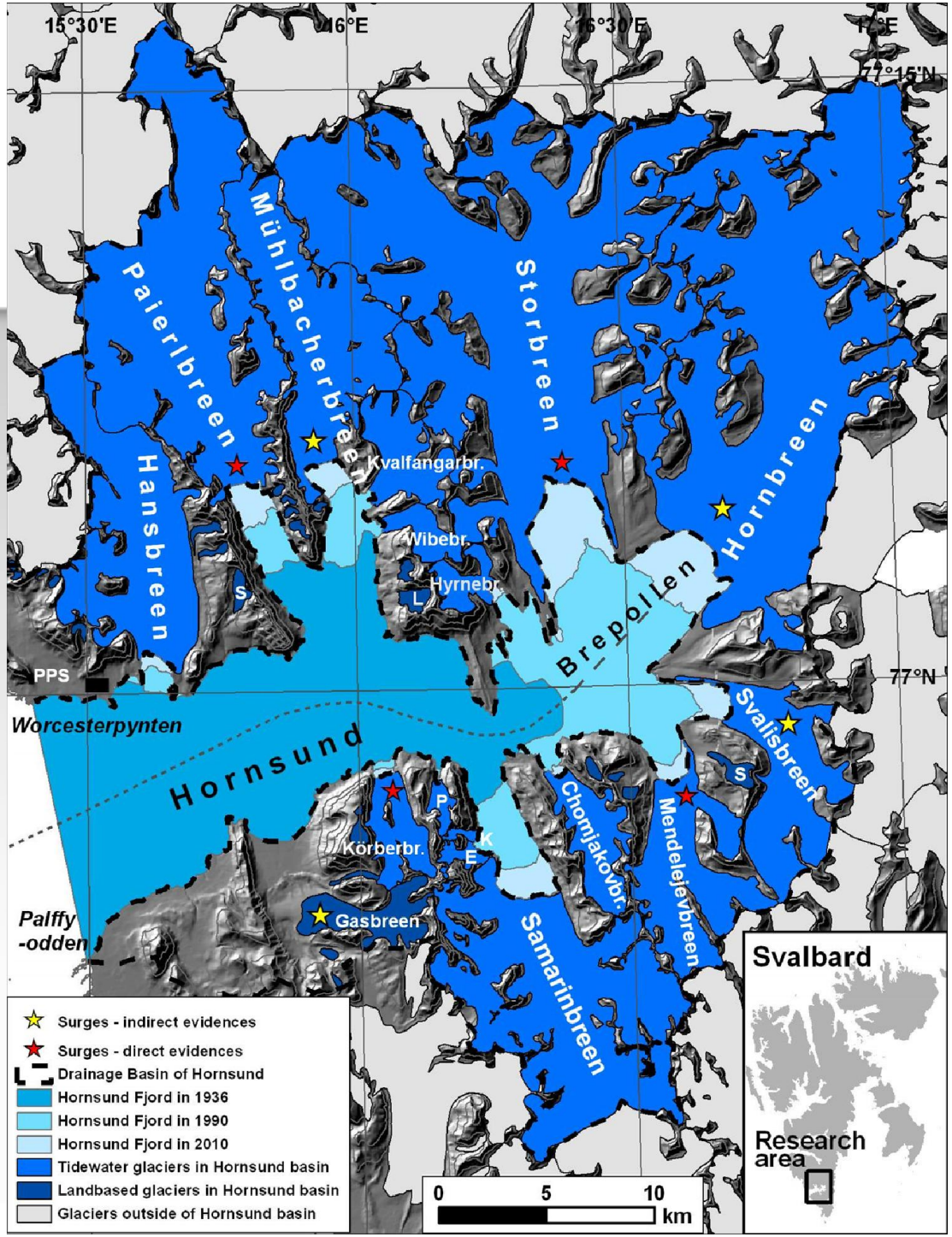
Work Package 5: Freshwater from the land

Task 5.4. Identification of key factors of the tidewater glacier's dynamics and calving intensity to the fiord
Task 5.5. Elaboration of the total water budget of the Hornsund hydro-glaciological basin including surface mass balance and icebergs production by tidewater glaciers

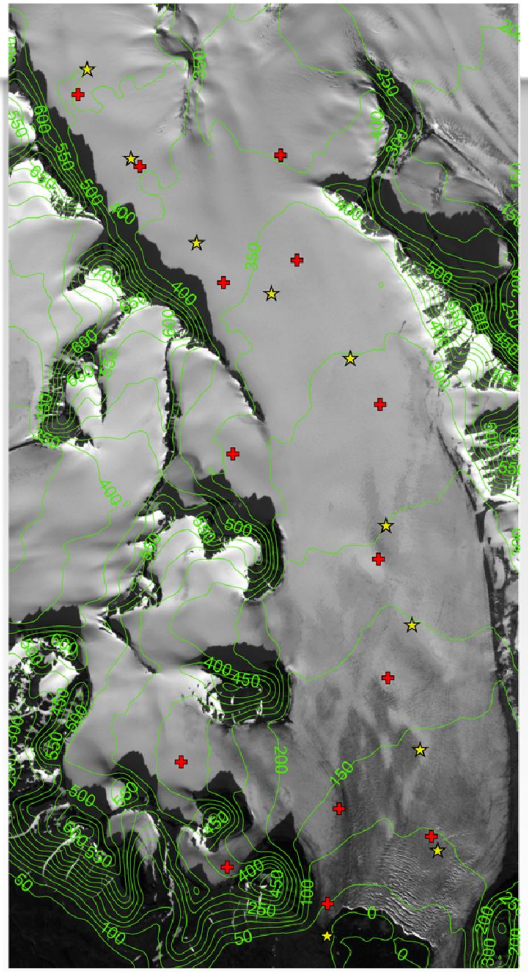


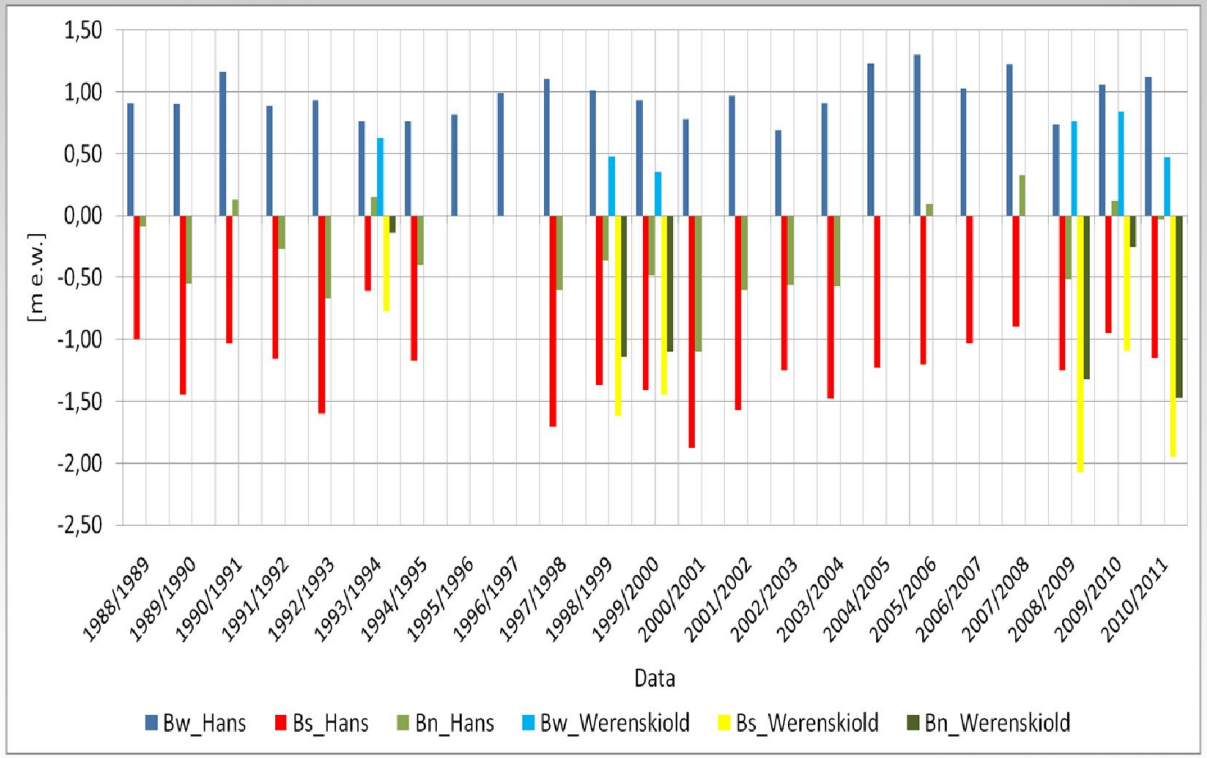
the total water budget = surface mass balance + calving flux

The entire drainage basin area of Hornsund amounts to ~1200 km2, of which ~67% (802 km2) is covered by glaciers. Tidewater glaciers constitute 97% of the glacierized area (781 km2).
Blaszczyk et al. 2013

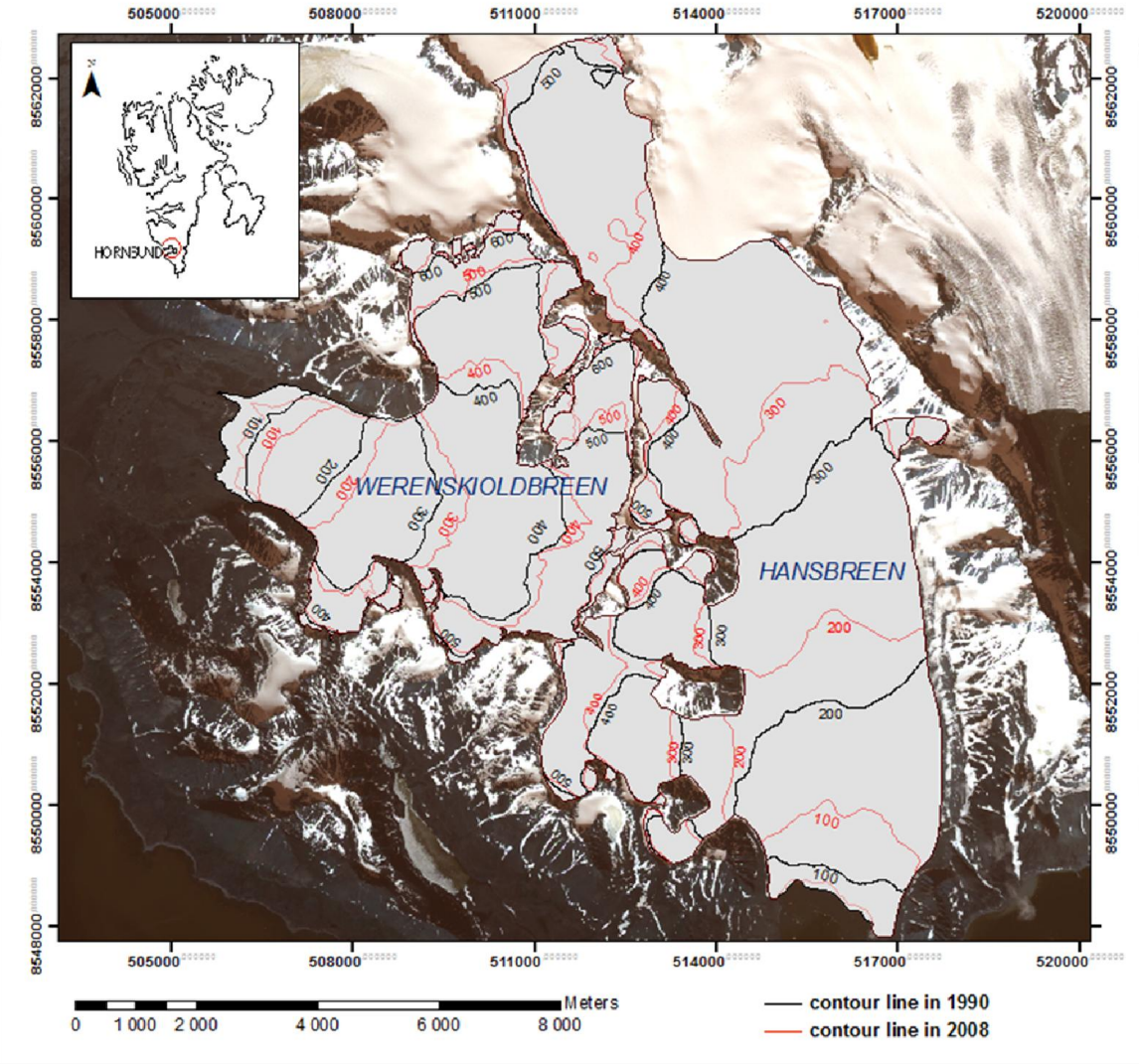


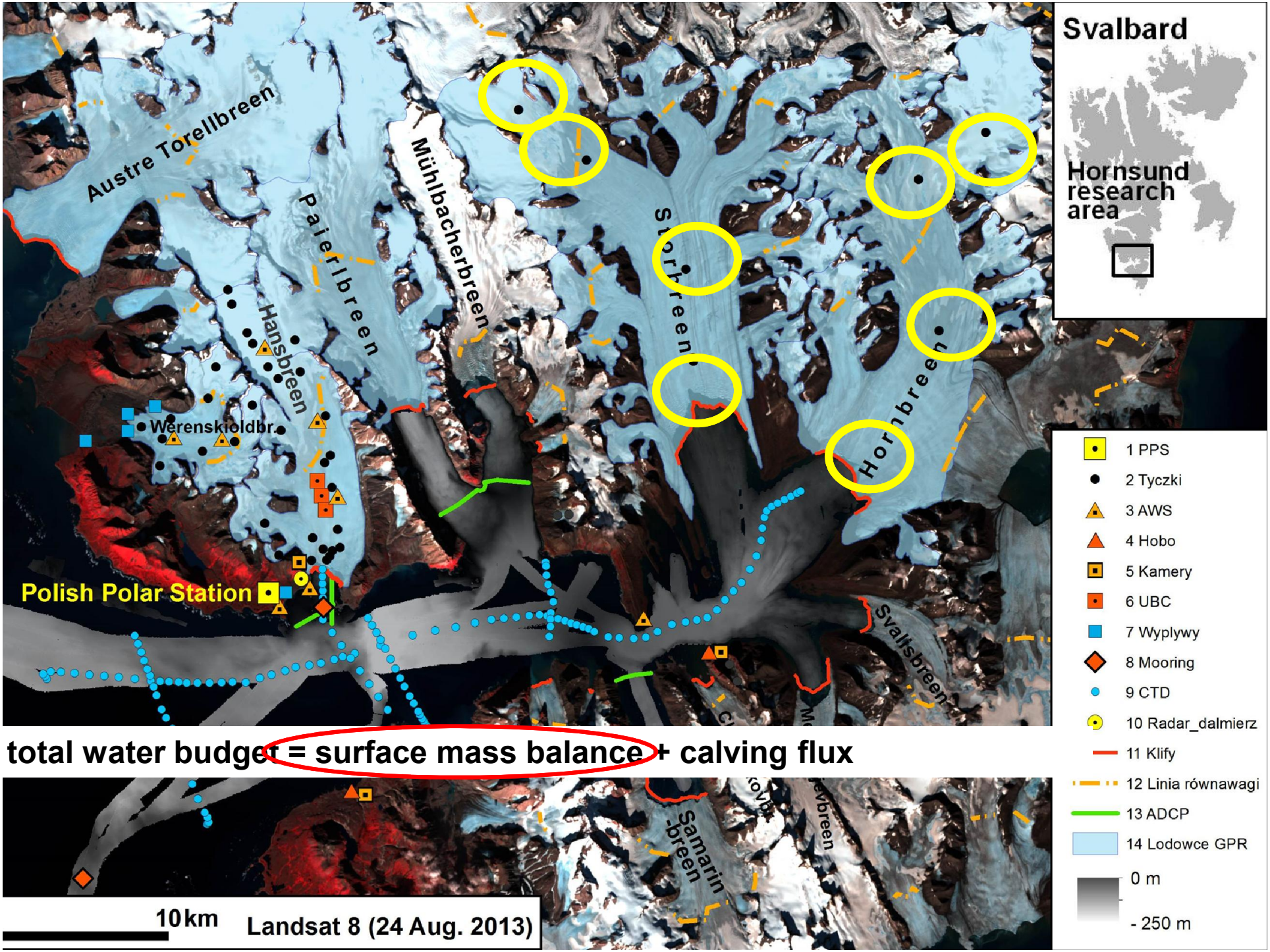
the total water budget = surface mass balance + calving flux





the total water budget = surface mass balance + calving flux




Svalbard
Hornsund research area
Austre Torellbreen
Paierlbreen
Mühlbacherbreen
Storbreen
Hansbreen
Hornbreen
Werenskioldbr.
Polish Polar Station
Svalisbreen
1 PPS
2 Tyczki
3 AWS
4 Hobo
5 Kamery
6 UBC
7 Wyplywy
8 Mooring
9 CTD
10 Radar_dalmierz
11 Klify
12 Linia równawagi
13 ADCP
14 Lodowce GPR
0 m
- 250 m
total water budget = surface mass balance + calving flux
Samarin-breen
10 km
Landsat 8 (24 Aug. 2013)

the total water budget = surface mass balance + calving flux

Calving flux - ca. 30% of the total mass loss of tidewater glaciers

the total water budget = surface mass balance + calving flux

Calving intensity of Svalbard glaciers - Qc [km^3 a^{-1}]

Ice-flux component at a fixed gate

$$Q_{c1} = V_g \cdot L_k \cdot H_l$$

Terminus fluctuations component

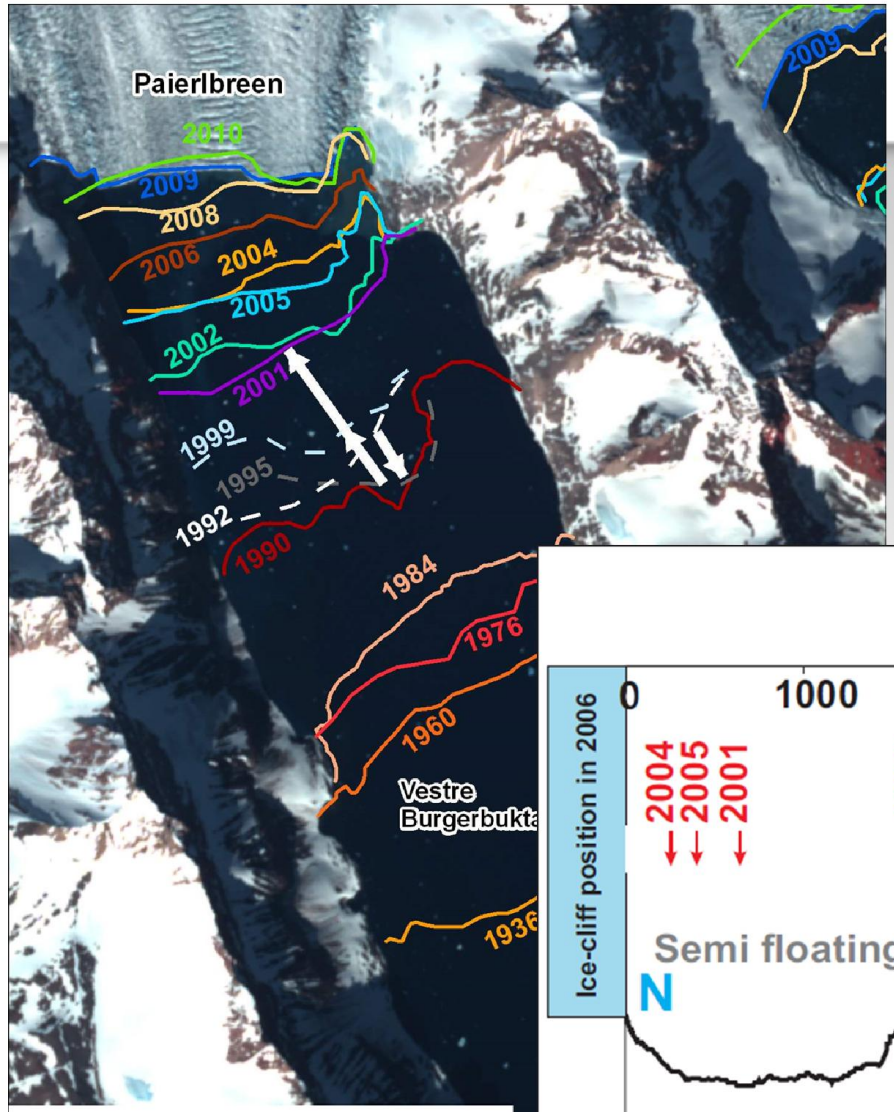
$$Q_{c2} = X \cdot L_k \cdot H_l$$

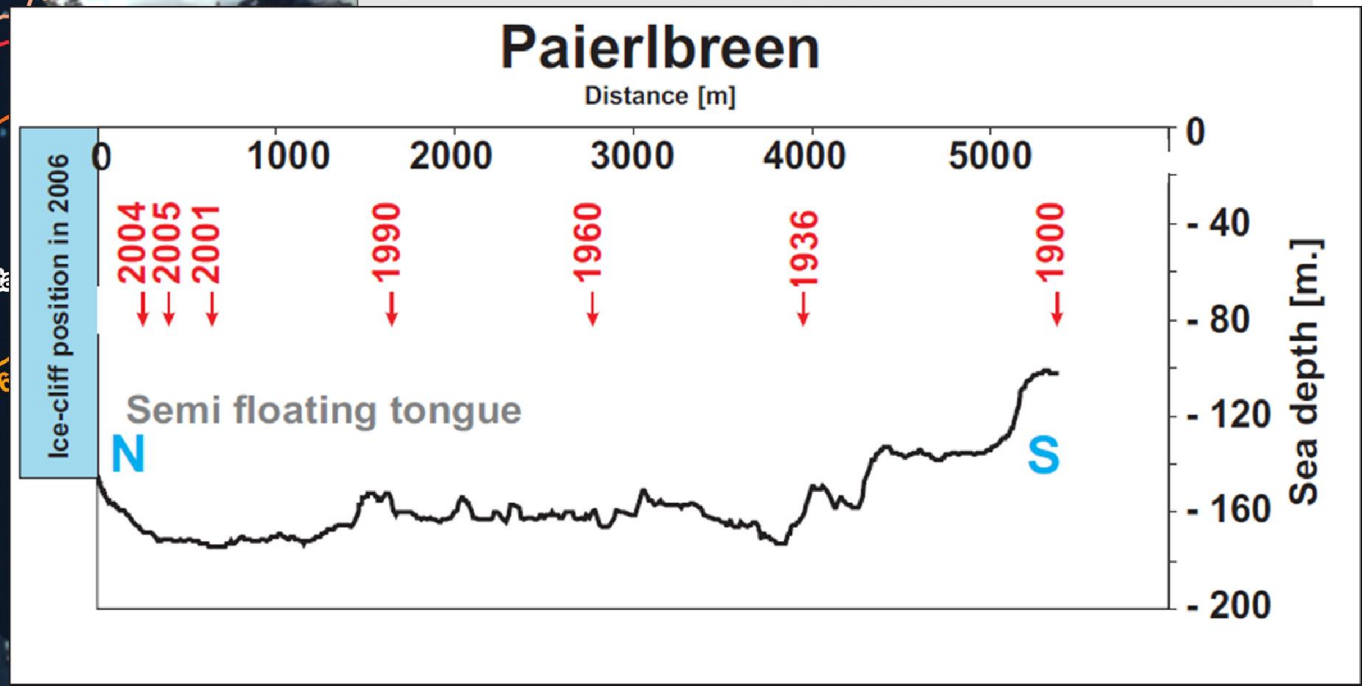
V_g – glacier velocity [m a^{-1}] => satelite data validated with field data
L_k – length of cliff [m] => satellite images
H_l – glacier thickness at the front [m] => bathymetry
X – front retreat [m a^{-1}] => remote sensing data

the total water budget = surface mass balance + calving flux

$$Q_{c2} = X \cdot L_k \cdot H_l$$

Influence of post-surge on glacier calving

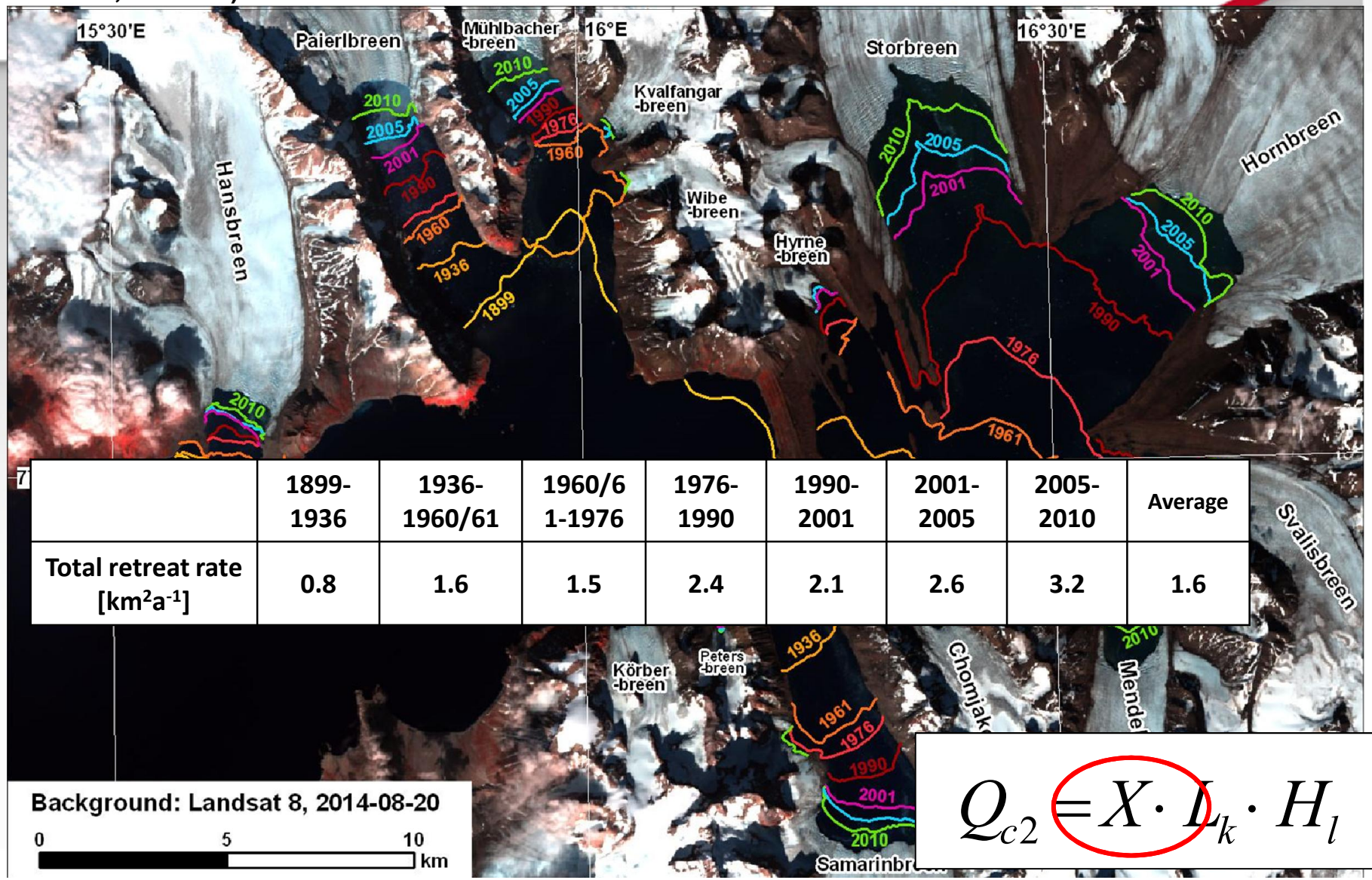




the total water budget = surface mass balance + calving flux

Post-LIE retreat of tidewater glaciers

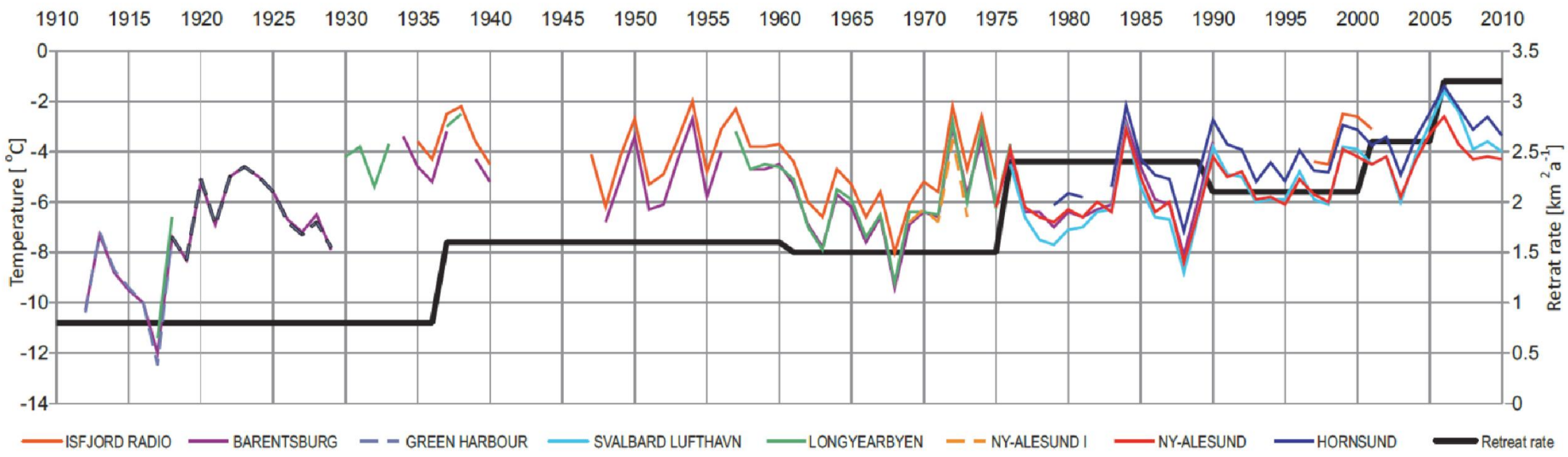
- basing upon topographical maps, field measurements and aerial and satellite images (Landsat 2, Terra ASTER, Landsat ETM+, Alos Avnir, SPOT 5)



	1899-1936	1936-1960/61	1960/61-1976	1976-1990	1990-2001	2001-2005	2005-2010	Average
Total retreat rate [km^2a^{-1}]	0.8	1.6	1.5	2.4	2.1	2.6	3.2	1.6

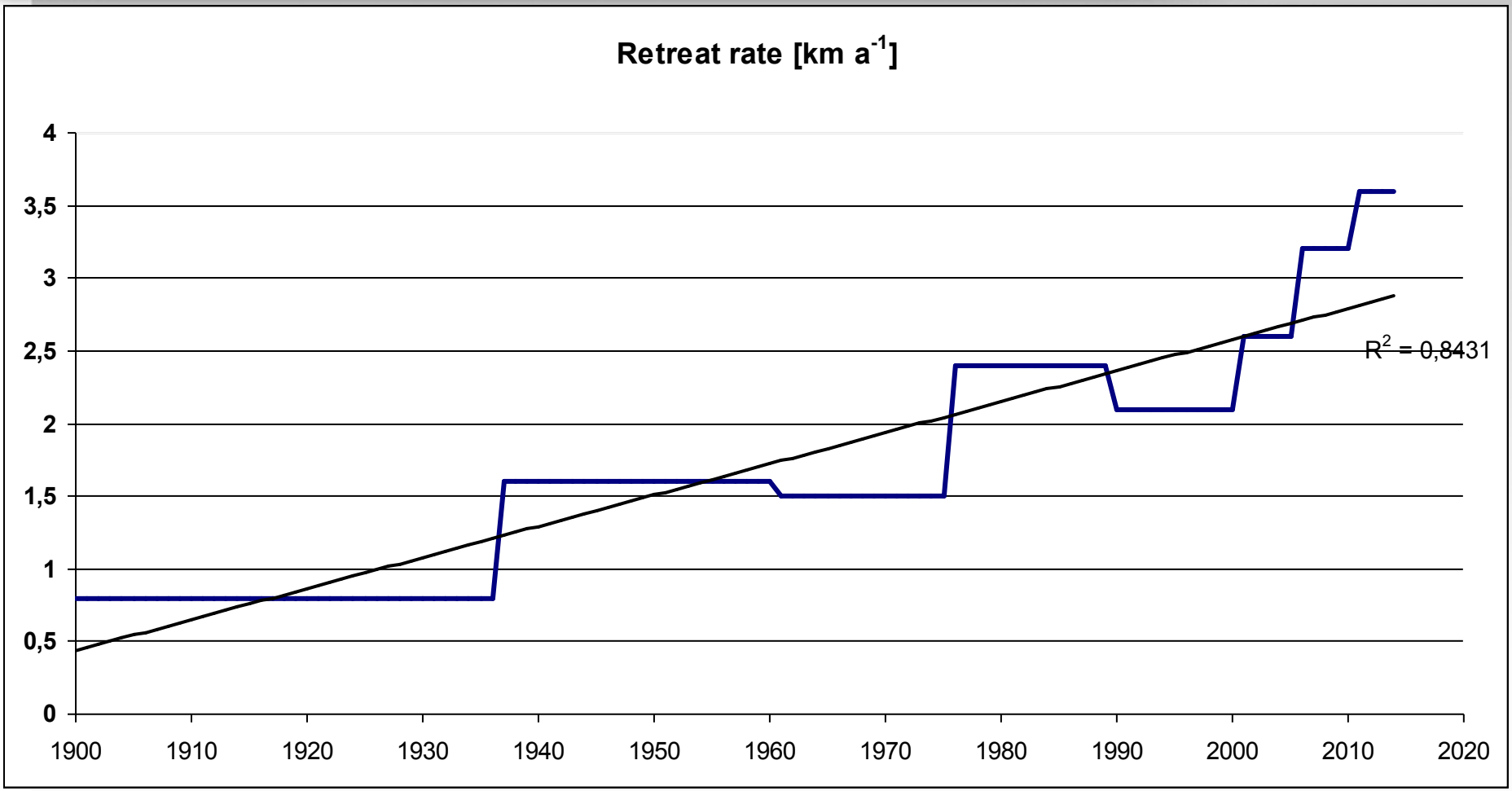
$$Q_{c2} = X \cdot L_k \cdot H_l$$

the total water budget = surface mass balance + calving flux



The course of the mean annual air temperature in Spitsbergen meteorological stations (courtesy of NPI) and the ice-marginal retreat rate of tidewater glaciers in Hornsund. Note the increase in the temperature and retreat rate during the last decade.
Blaszczyk et al., 2013

the total water budget = surface mass balance + calving flux



the total water budget = surface mass balance + calving flux

Garmin GMR 18HD panoramic radar

Angle resolution: horizontal - 5°; vertical - 25°; nominal error: 1,5%.
Survey 2 times per day.

Photo by M. Laska (May 2010)

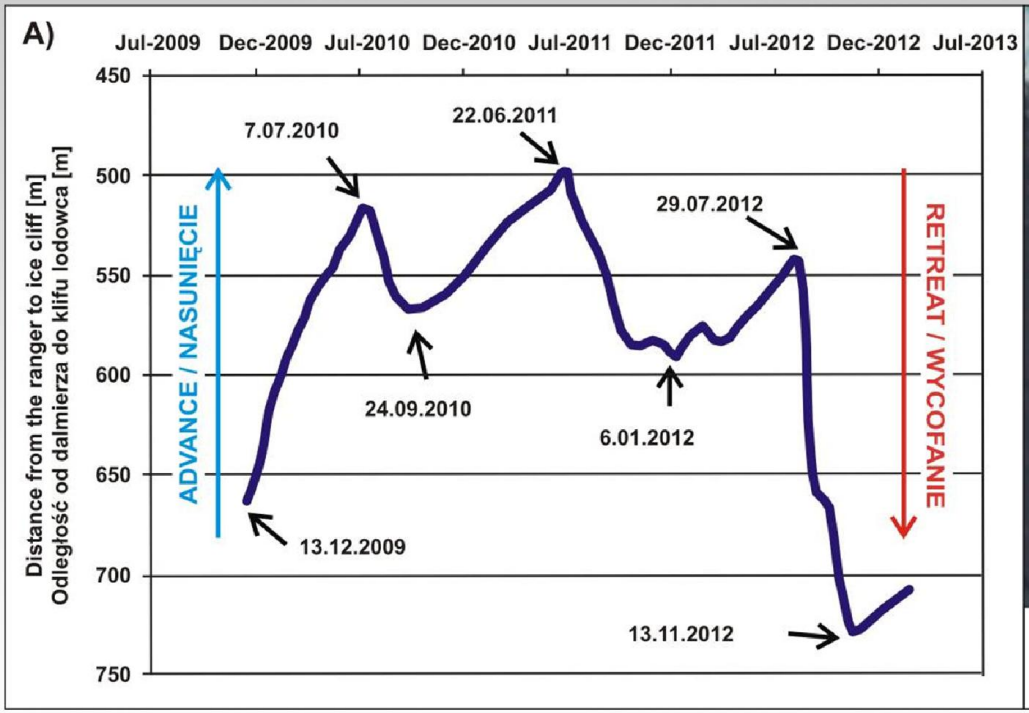
Riegl FG21-LR
Laser distance meter

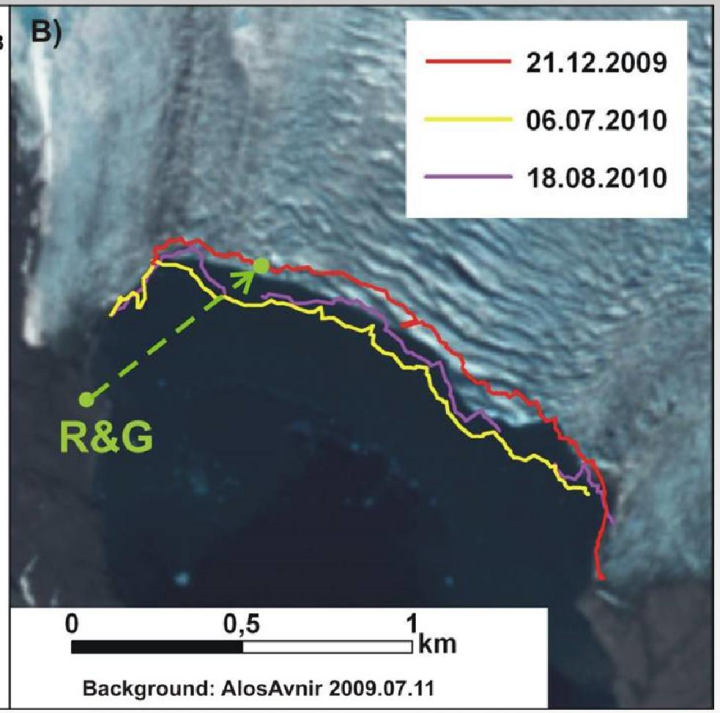
Survey every 10 min
(weather depend record)

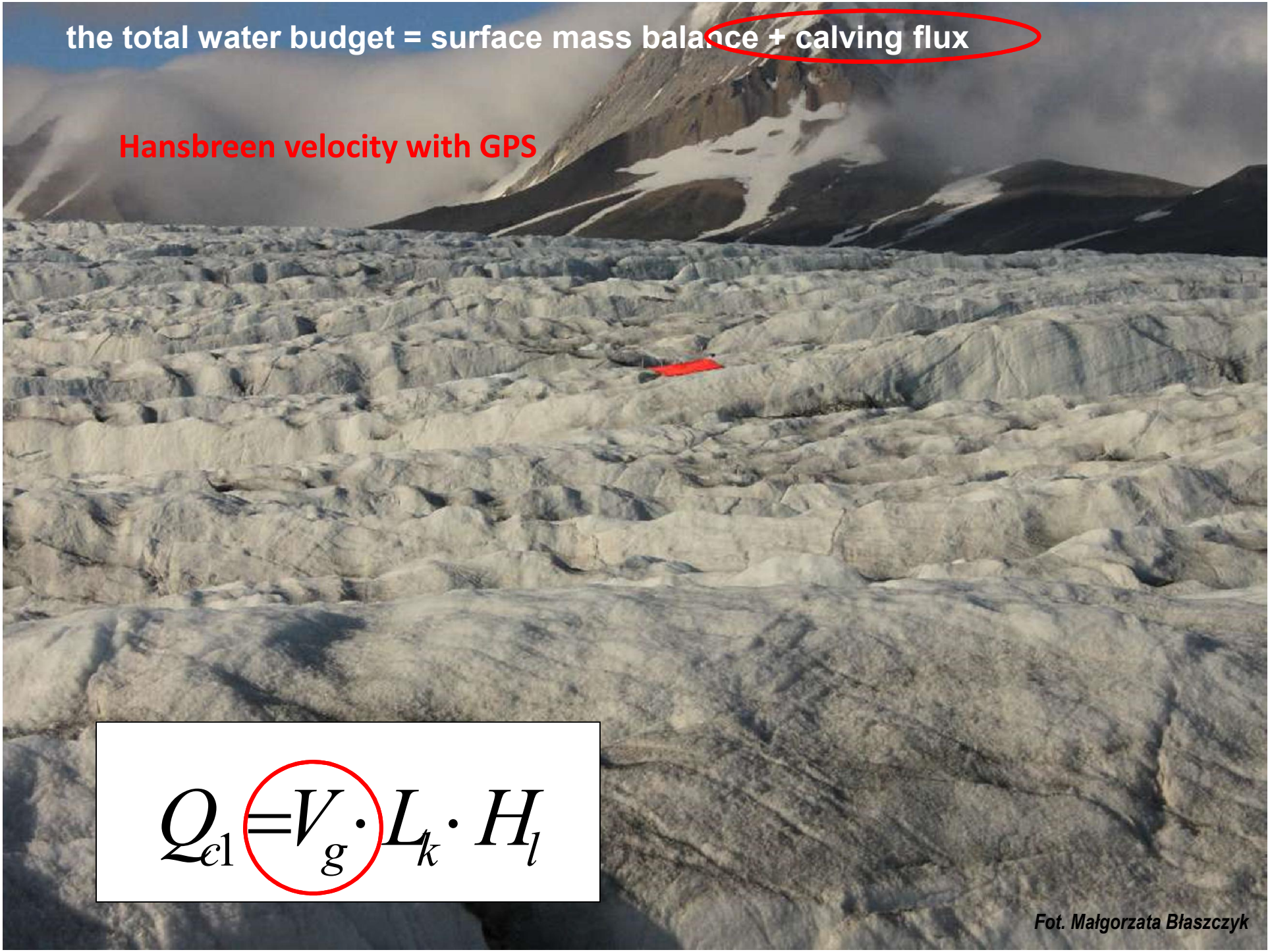
HANSBREEN

Ice cliff position survey since2009-

the total water budget = surface mass balance + calving flux



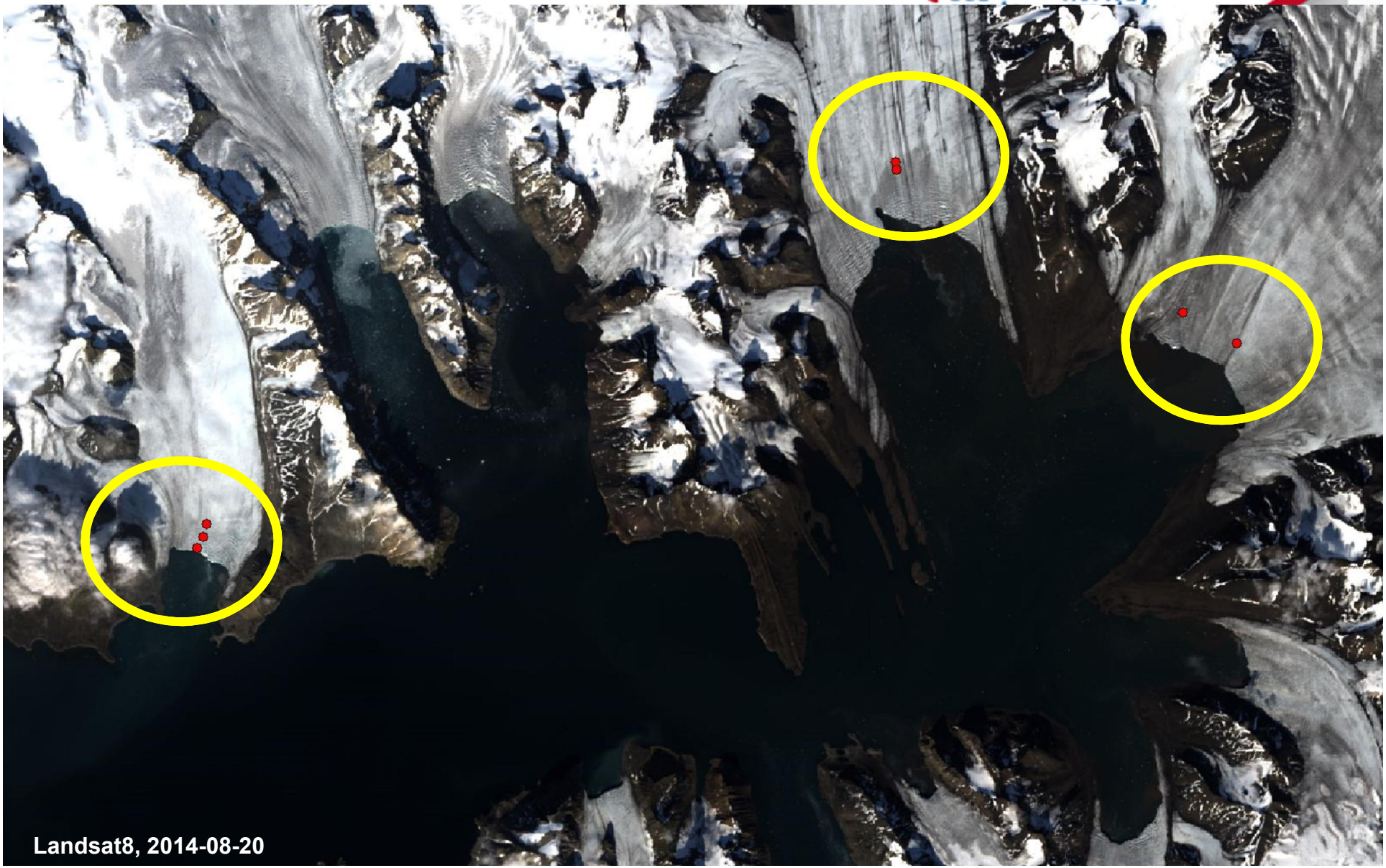



the total water budget = surface mass balance + calving flux
Hansbreen velocity with GPS
$Q_{cl} = V_g \cdot L_k \cdot H_l$
Fot. Małgorzata Błaszczyk

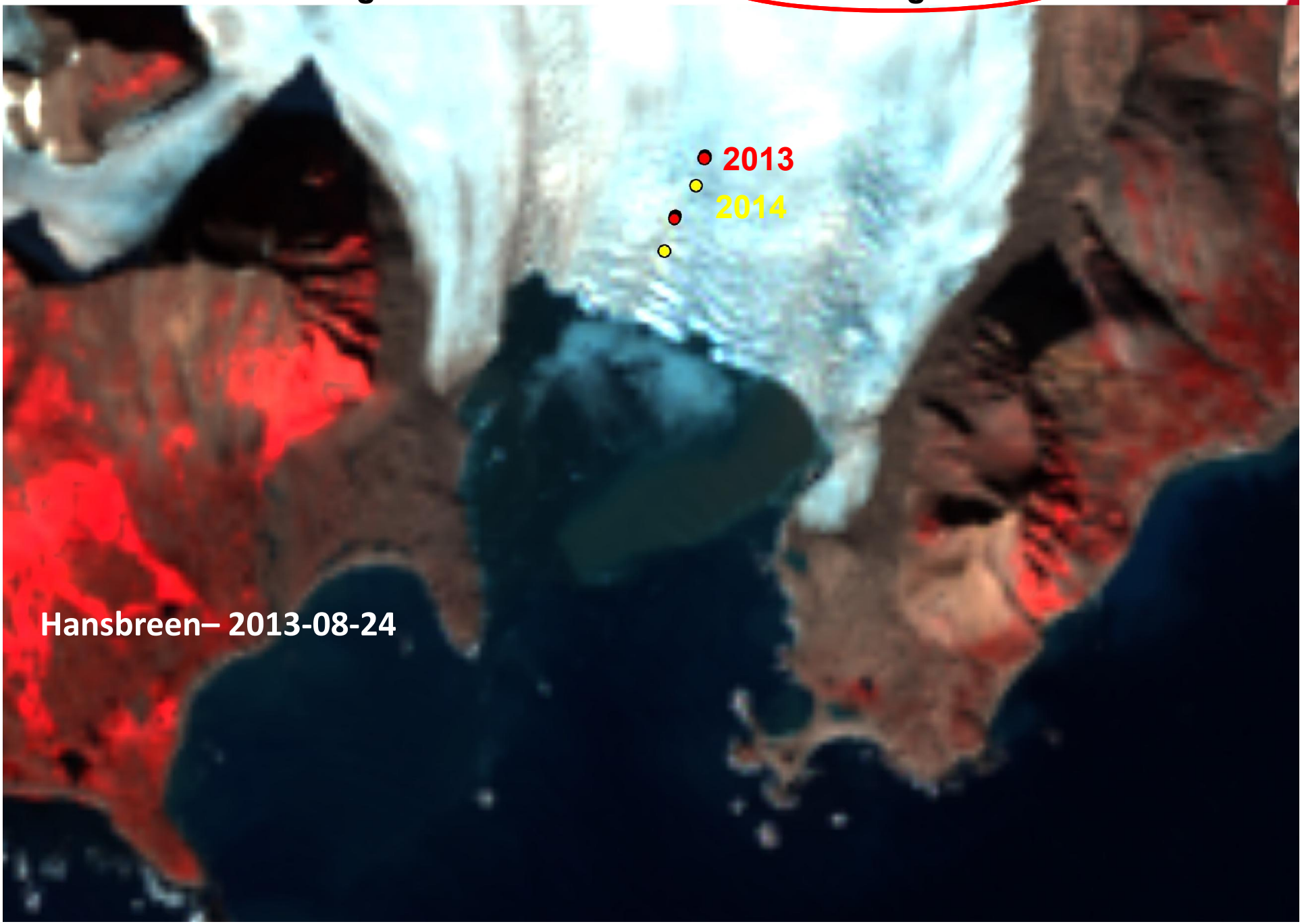
Fot. Małgorzata Błaszczyk

the total water budget = surface mass balance + calving flux

Stakes at the fronts of tidewater glaciers



the total water budget = surface mass balance + calving flux



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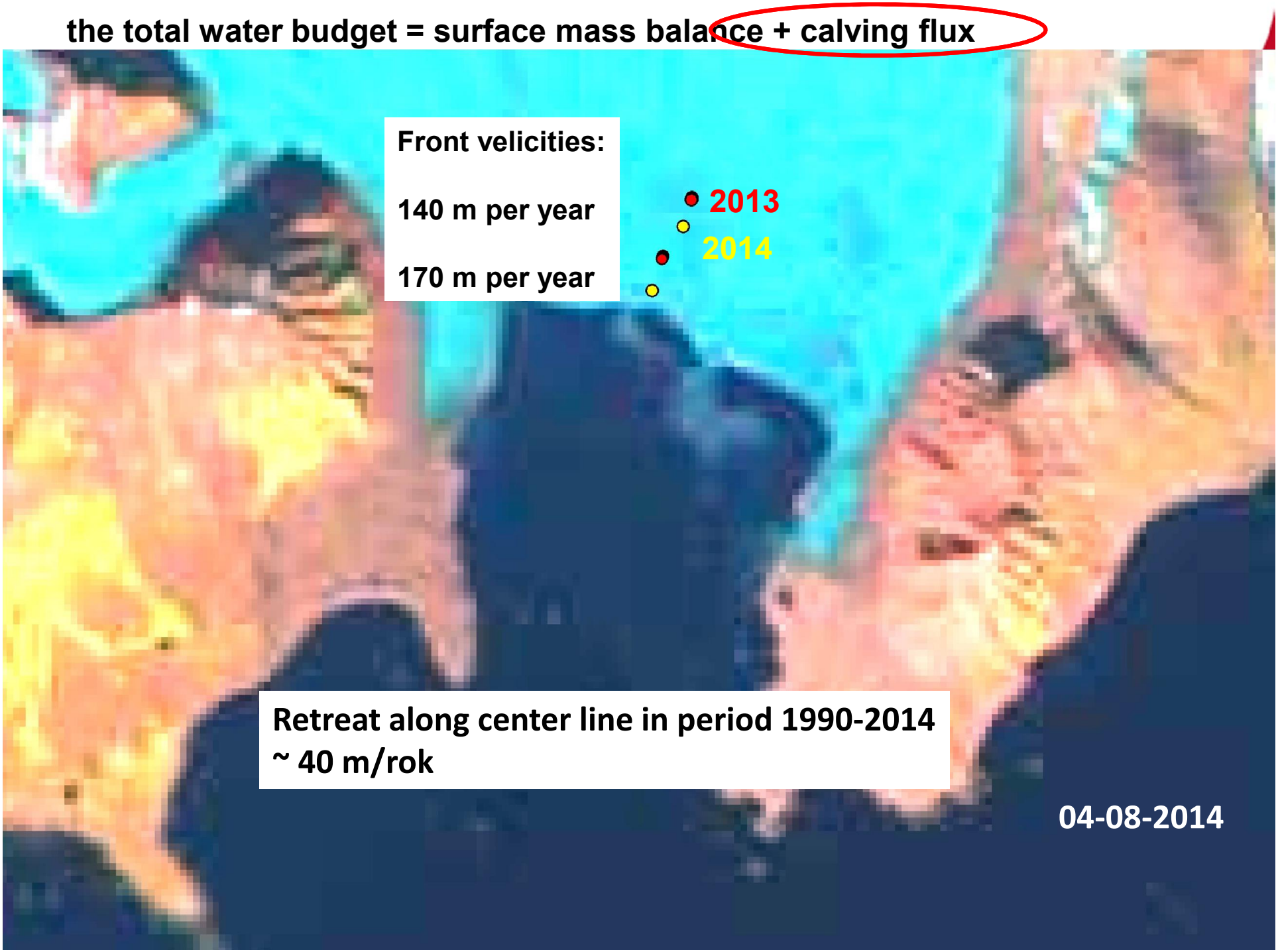
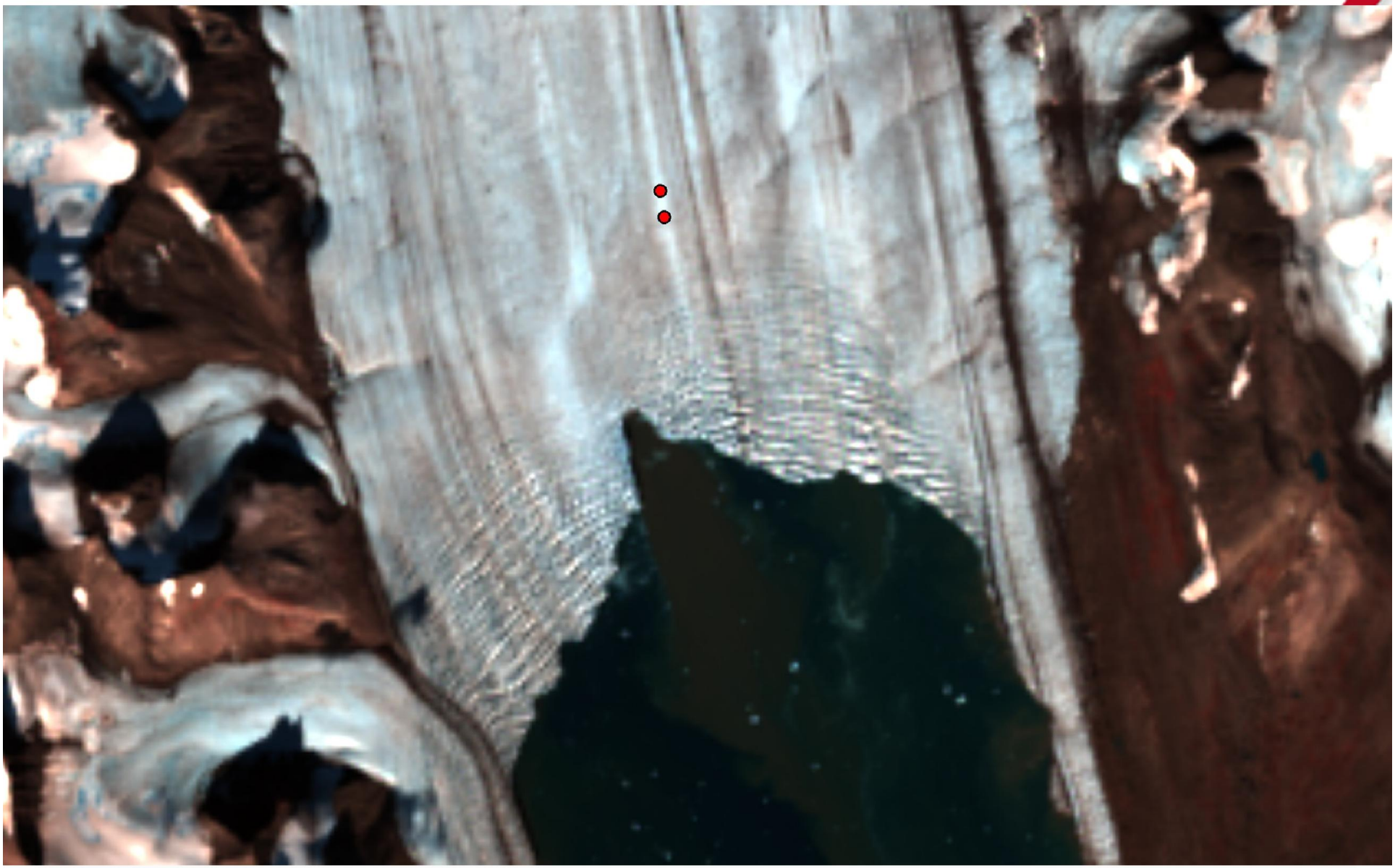


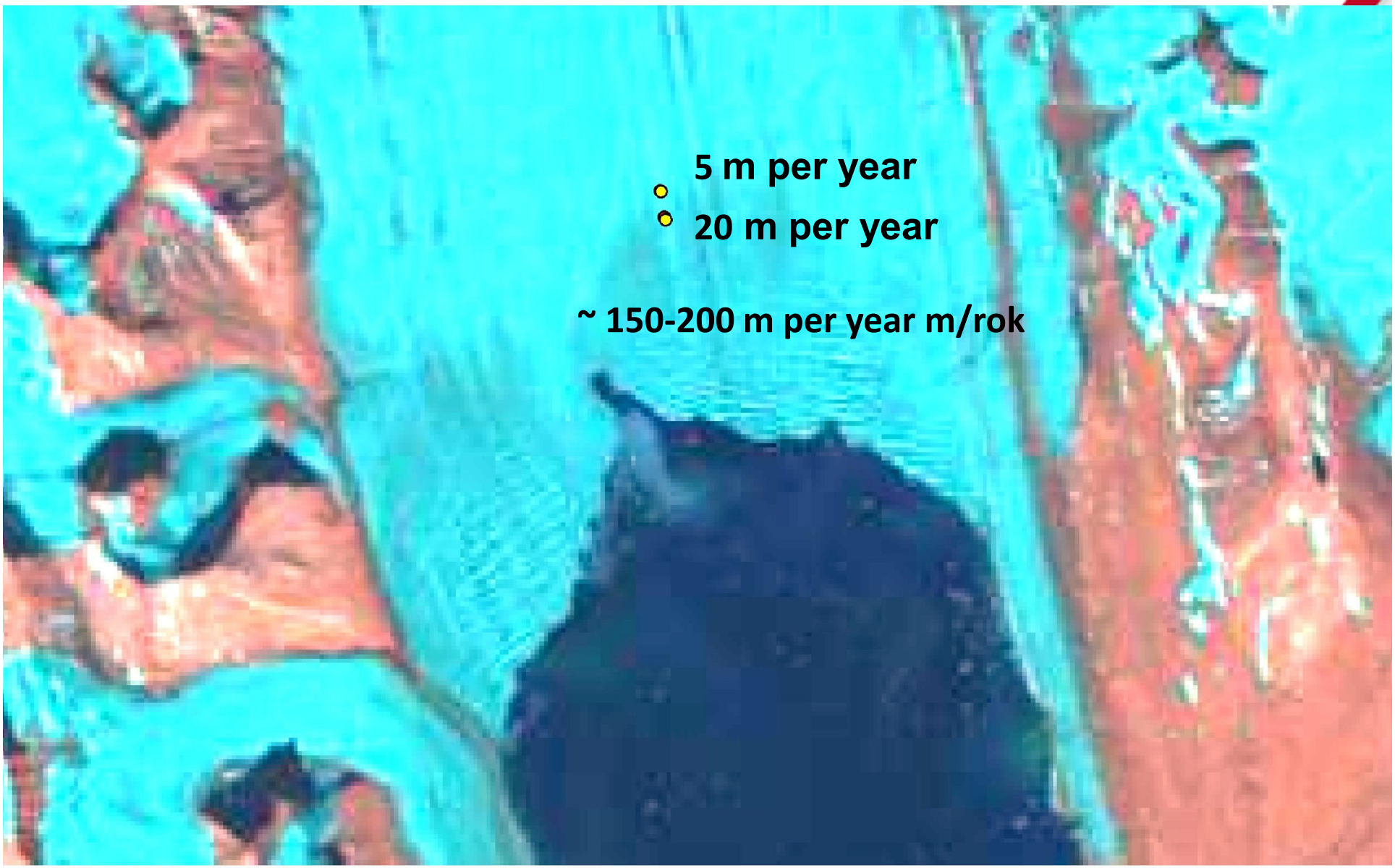
the total water budget = surface mass balance + calving flux



Storbreen – 2013-08-24

the total water budget = surface mass balance + calving flux

Lodowiec Storbreen – 2014-08-04



the total water budget = surface mass balance + calving flux

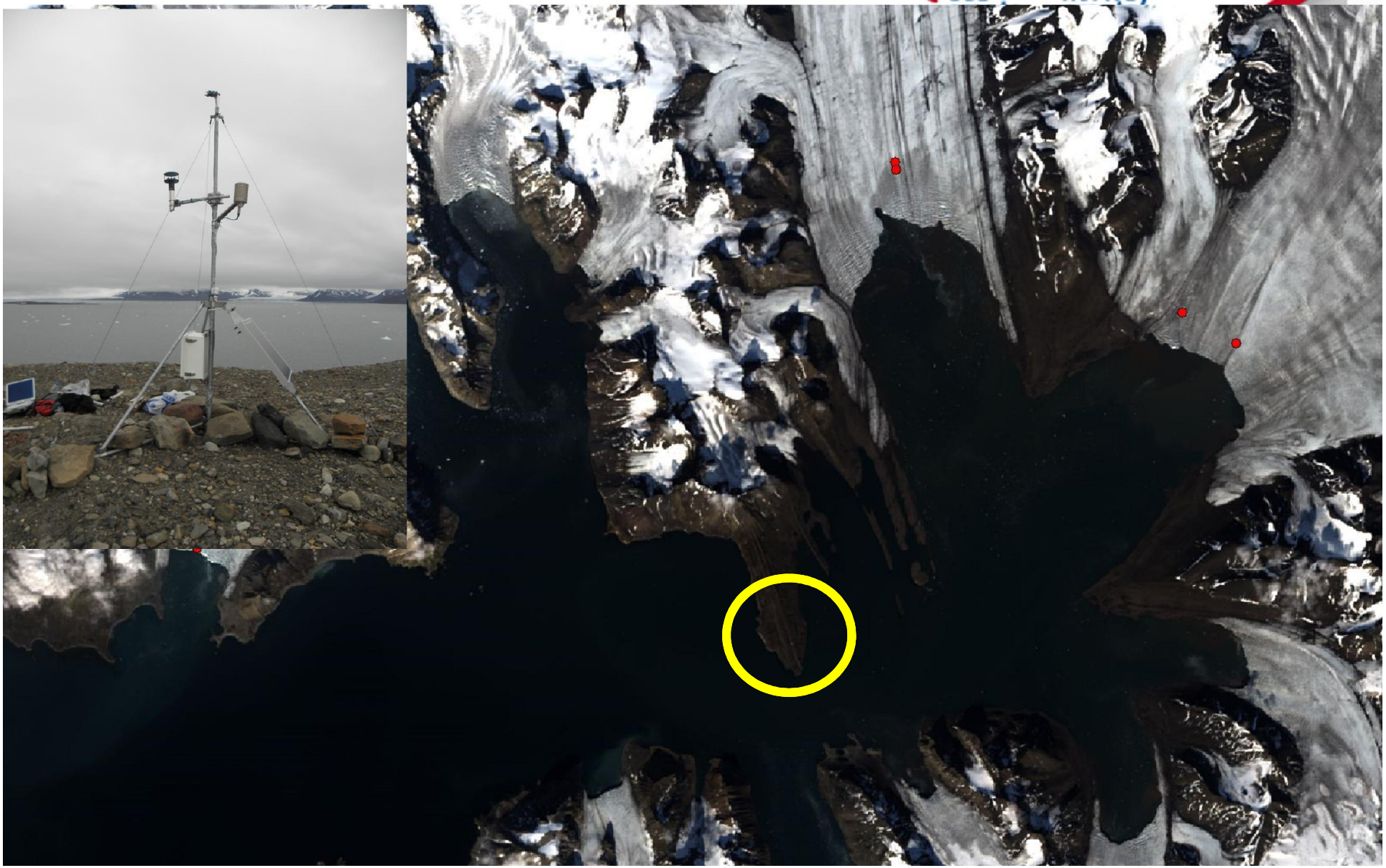
***H_l* – glacier thickness at the front [m]**

$$Q_{c1} = V_g \cdot L_k \cdot H_l$$

$$Q_{c2} = X \cdot L_k \cdot H_l$$

100 m – constant?

AWS - Treskelen

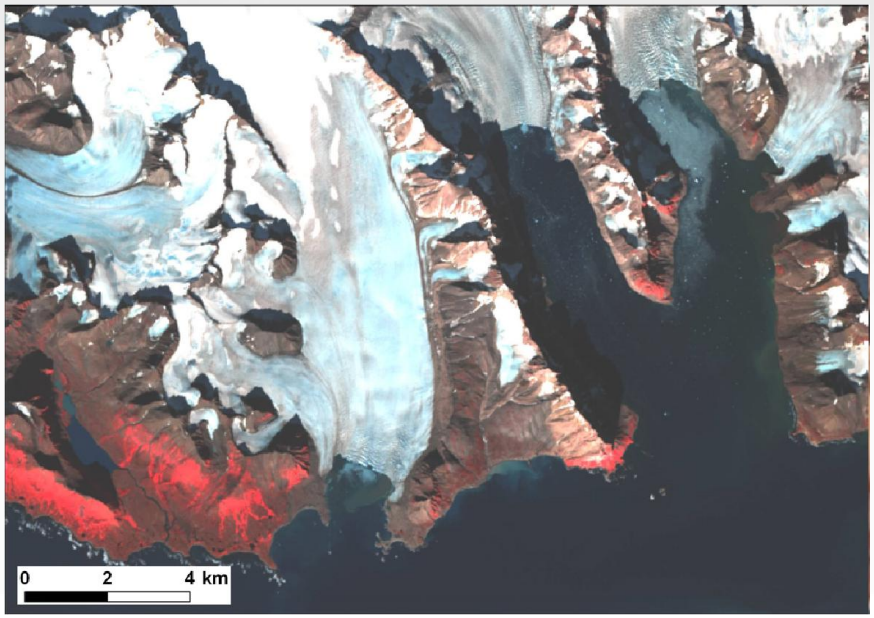


New ideas

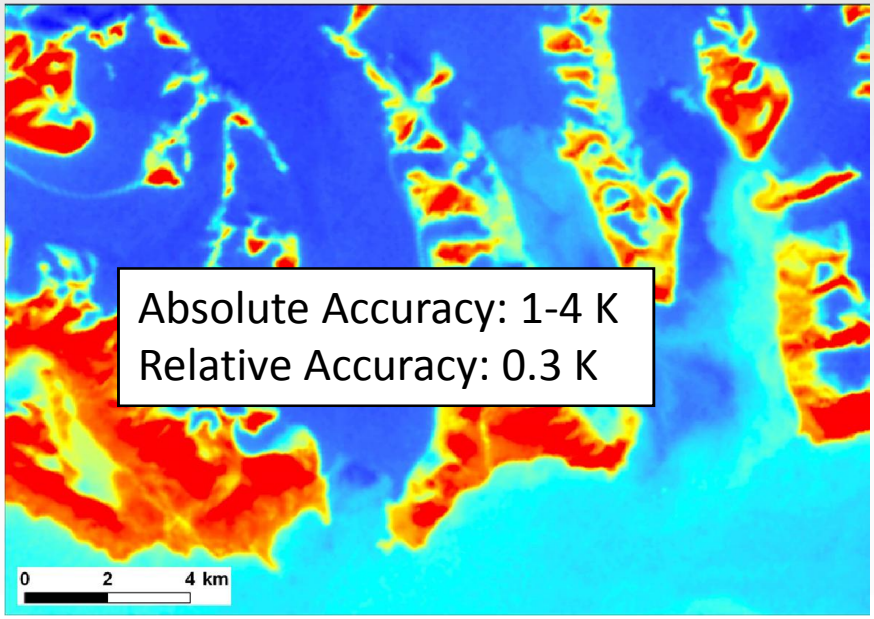
Location of subglacial water outflows from tidewater glaciers on Spitsbergen by means of satellite remote sensing

Multispectral satellite images (2000-2013):
Terra ASTER, Landsat 7, Landsat 8, Alos AVNIR

Visible and infrared bands
(spatial resolution: 10/15/30 m)



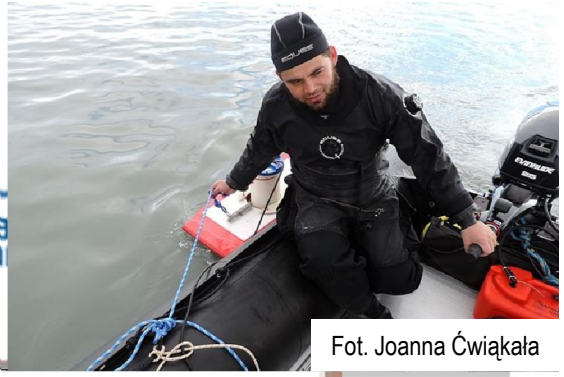
Thermal bands
(spatial resolution: 60/90/100 m)



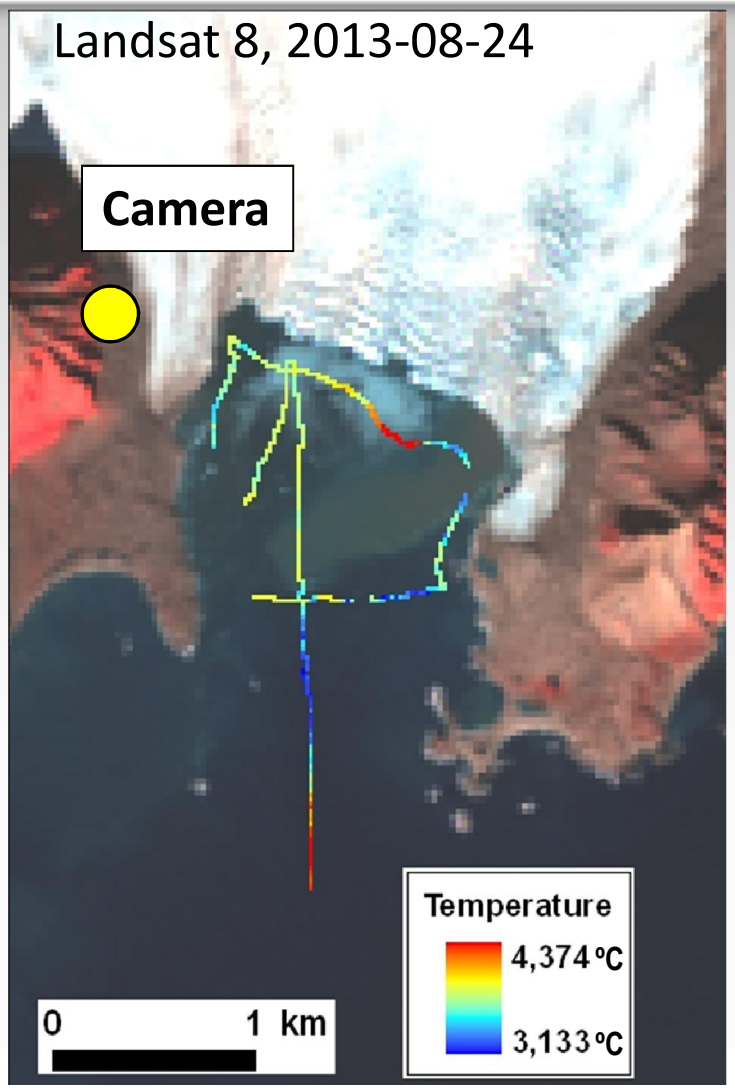
Methods – data validation

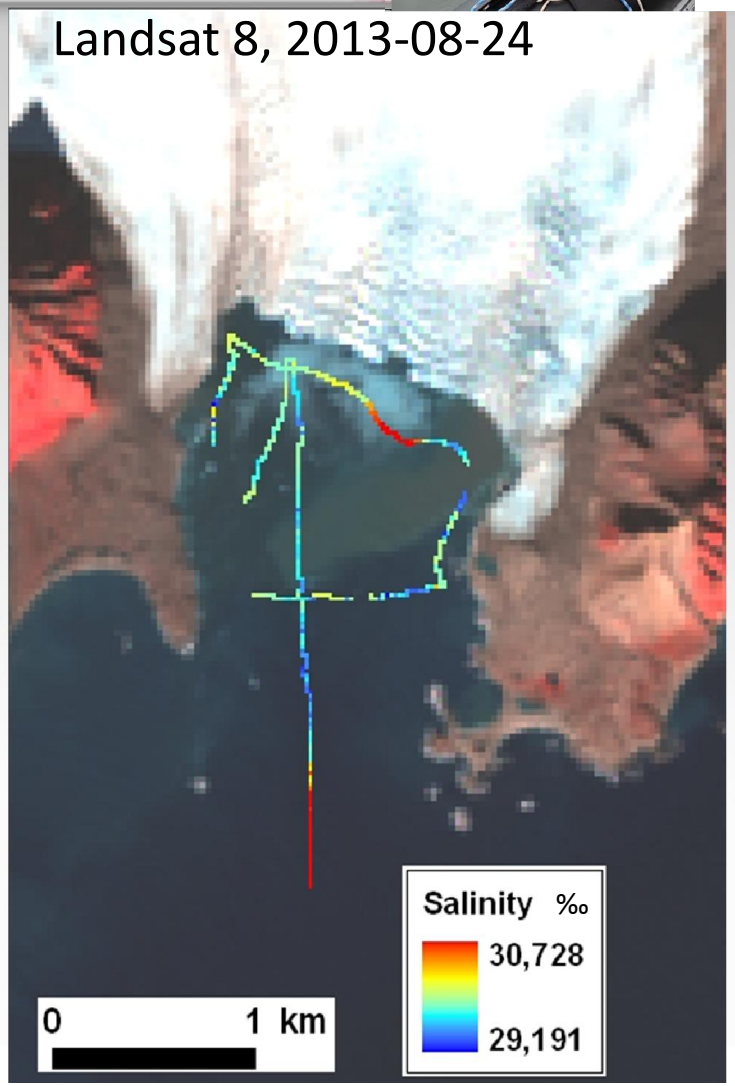
CTD (conductivity, temperature, and depth)

2013-08-12



Fot. Joanna Ćwiąkała



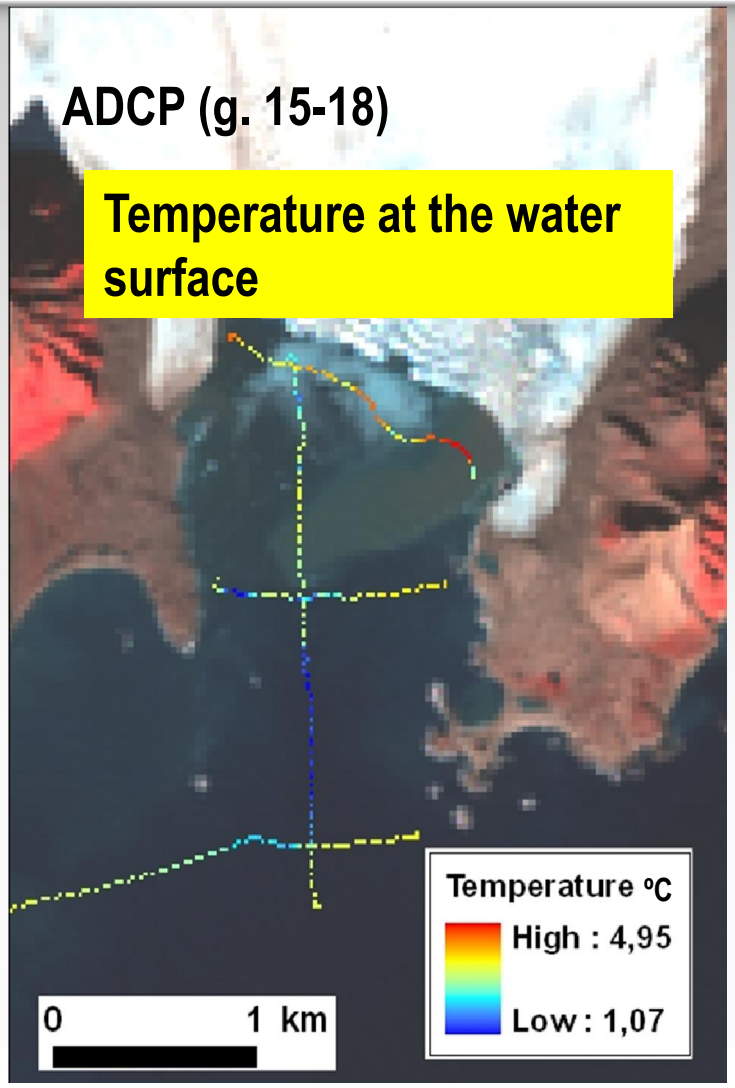


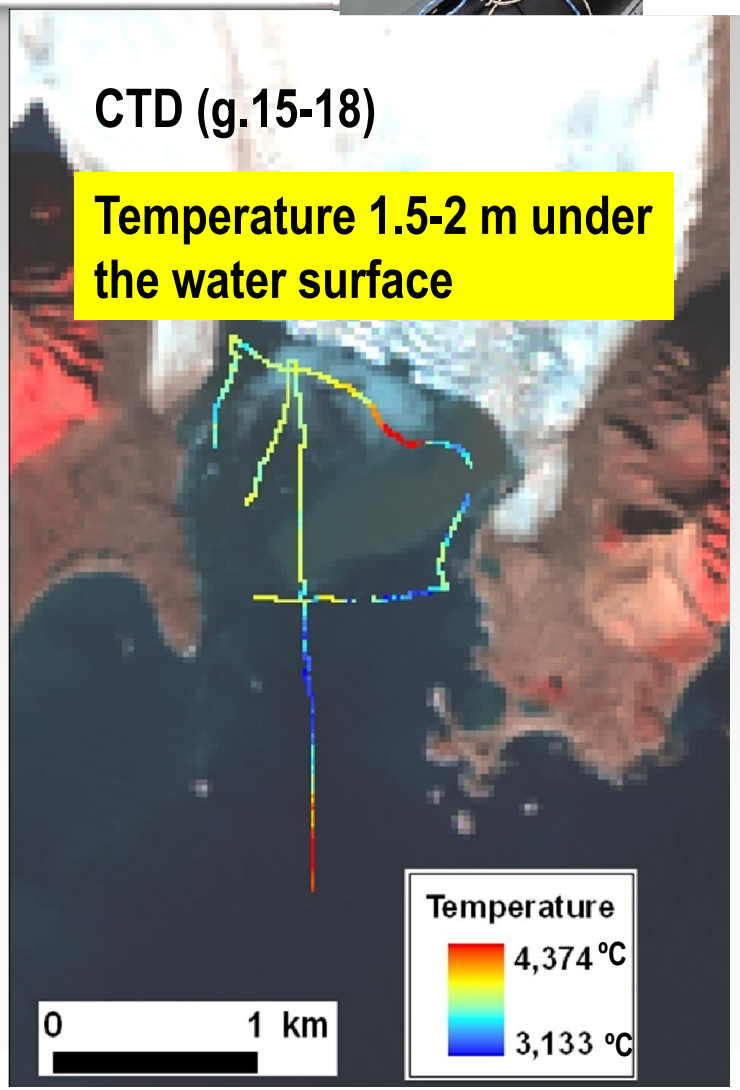
Methods – data validation

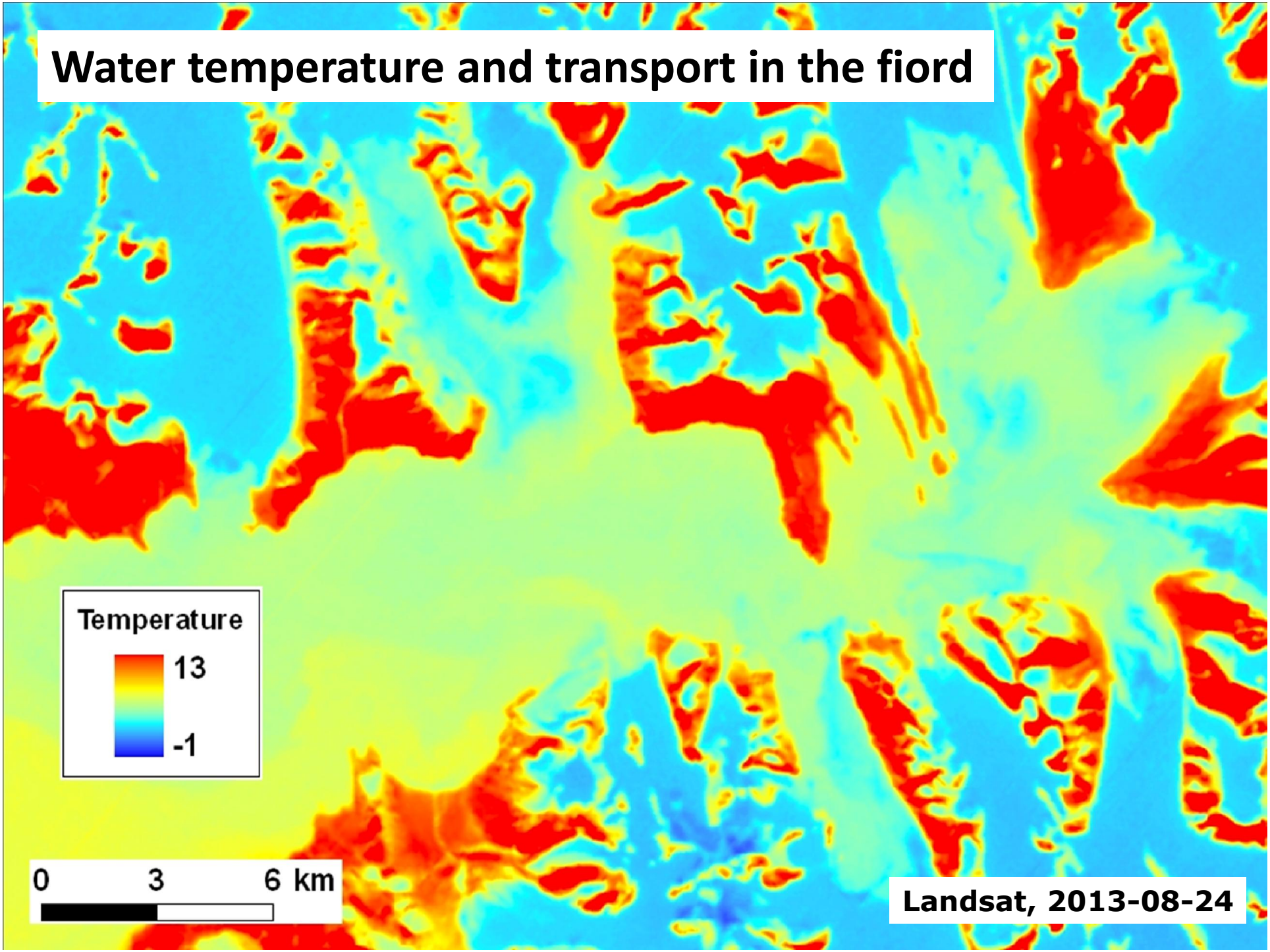
ADCP (Acoustic Doppler Current Profilers) vs. CTD

2013-08-12

Fot. Joanna Ćwiąkała

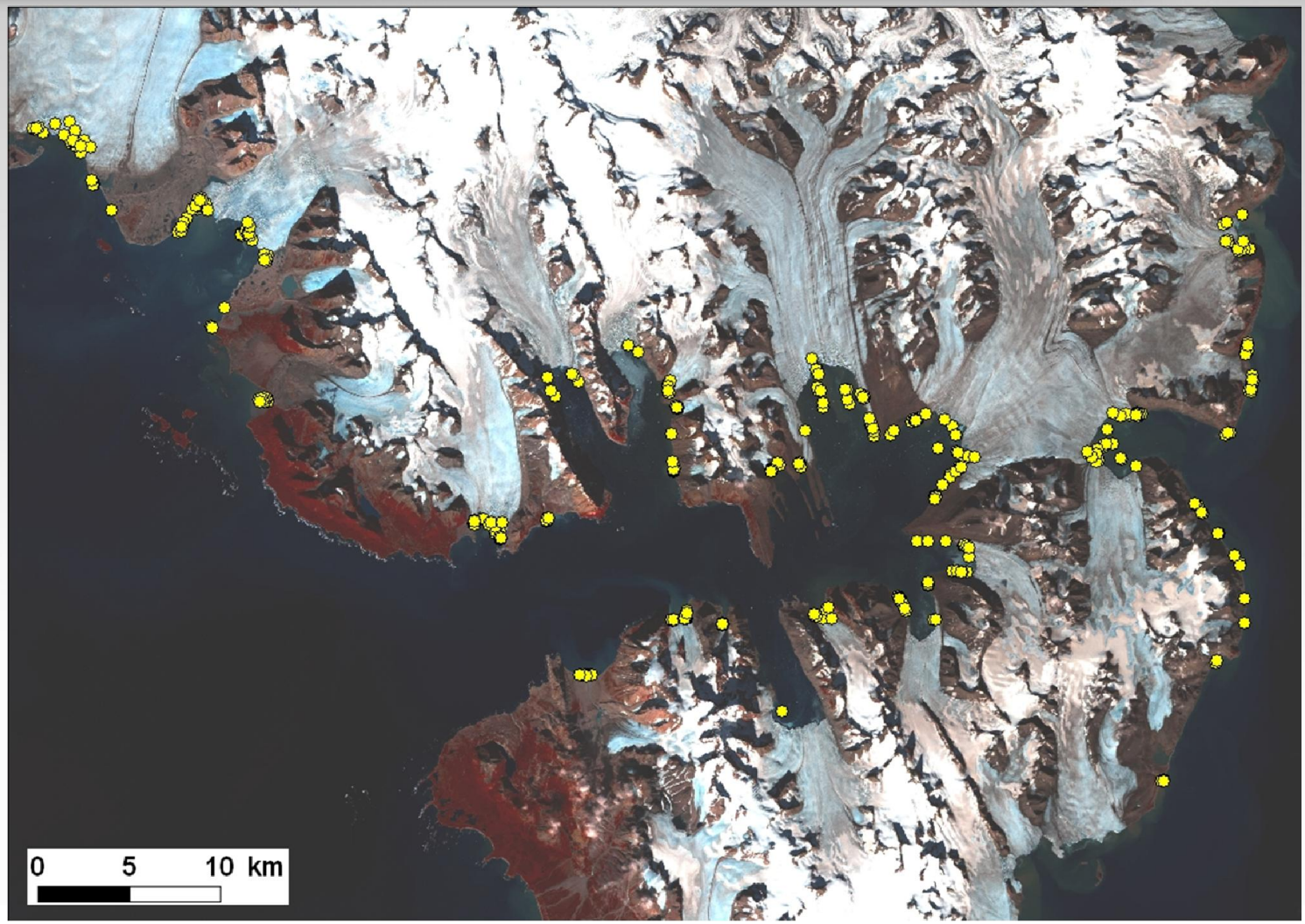





Water temperature and transport in the fiord
Temperature
13
-1
0
3
6 km
Landsat, 2013-08-24

Results

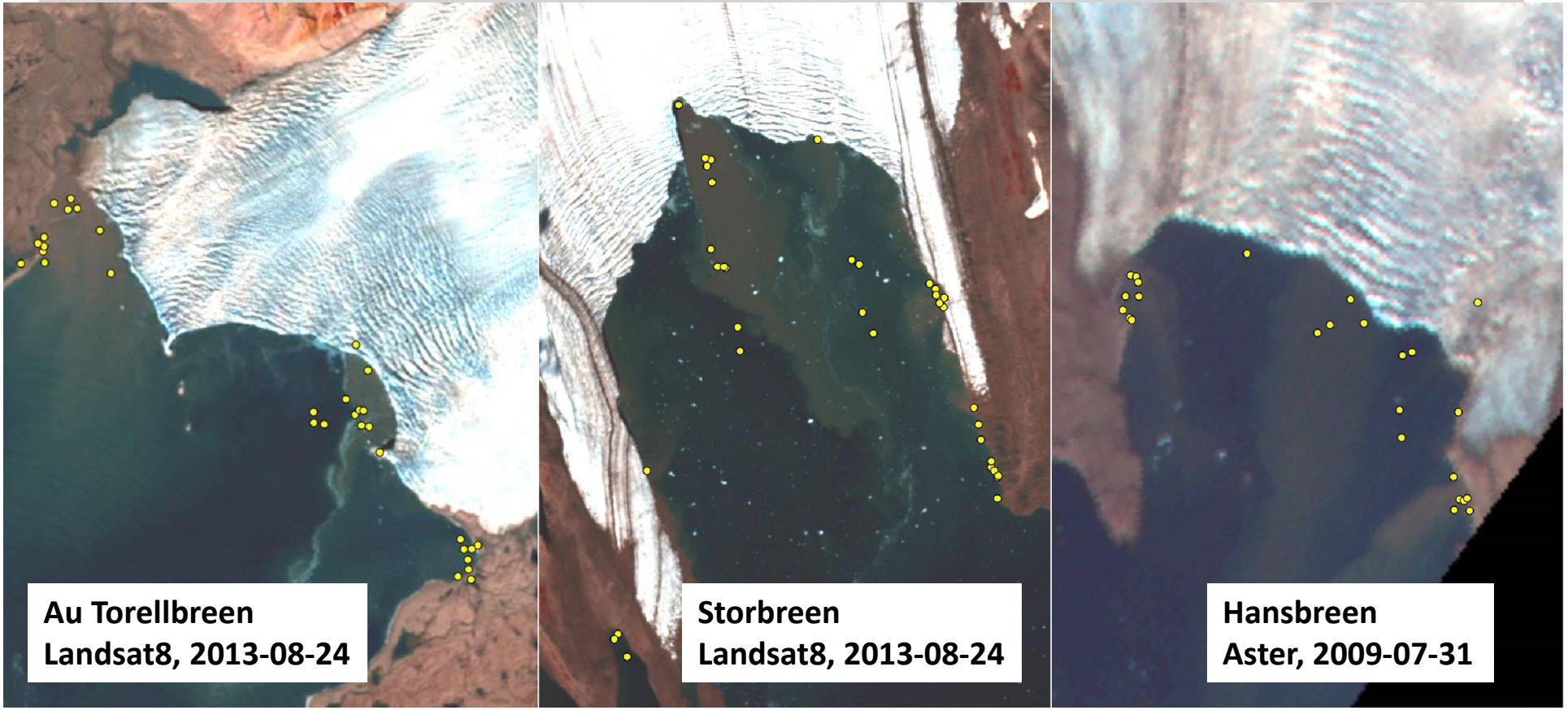
Subglacial water outflows location (2000-2013)



Results

Subglacial water outflows types

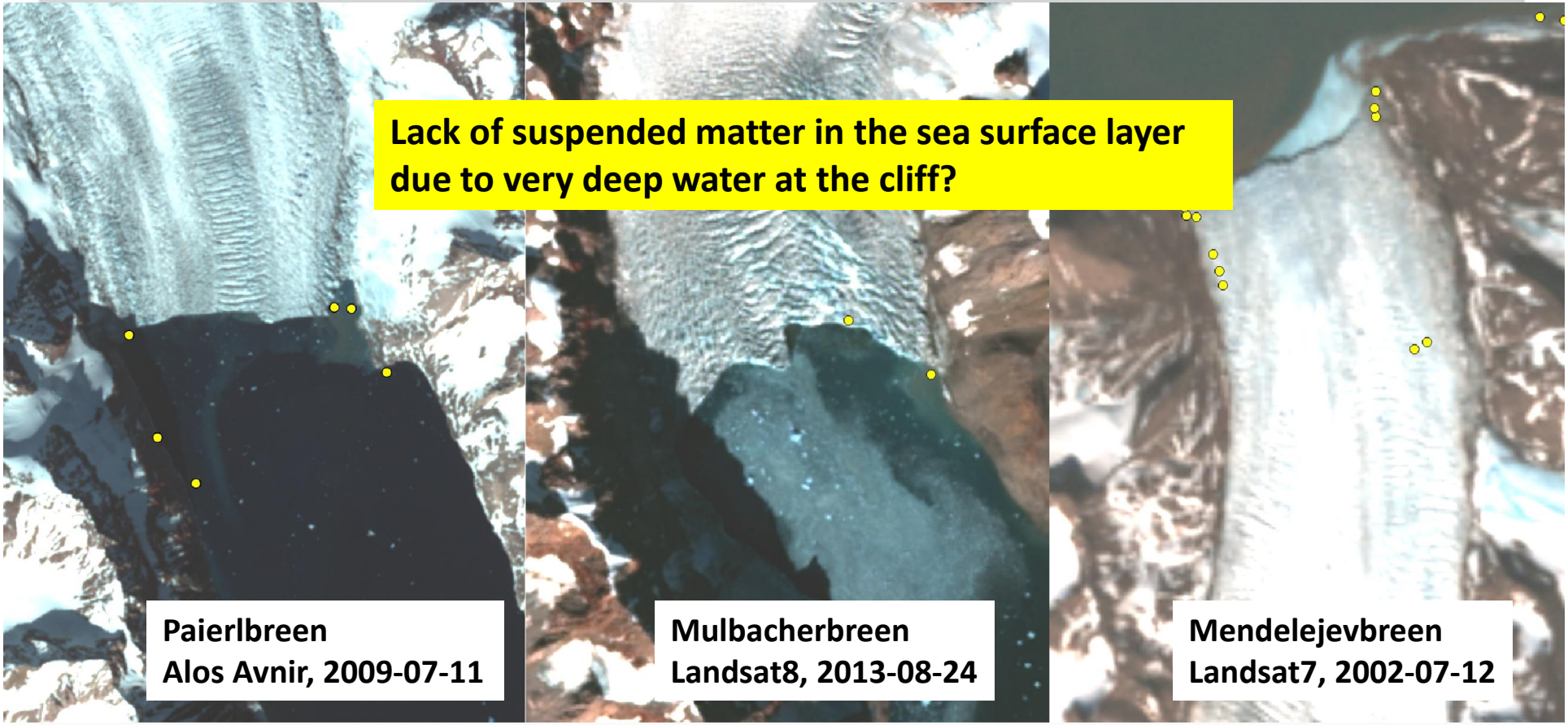
1. Glacier center + lateral outflows



Results

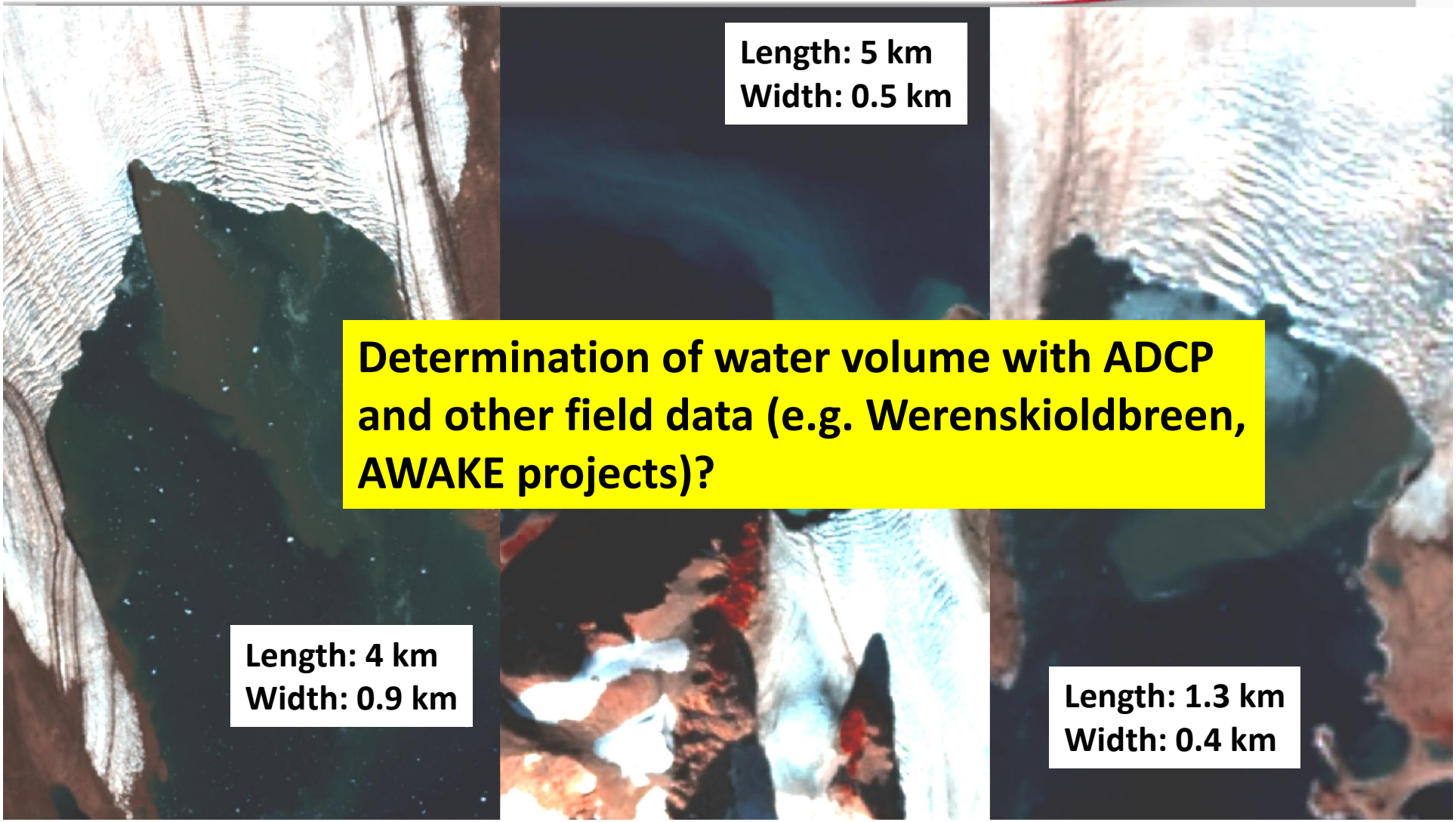
Subglacial water outflows types

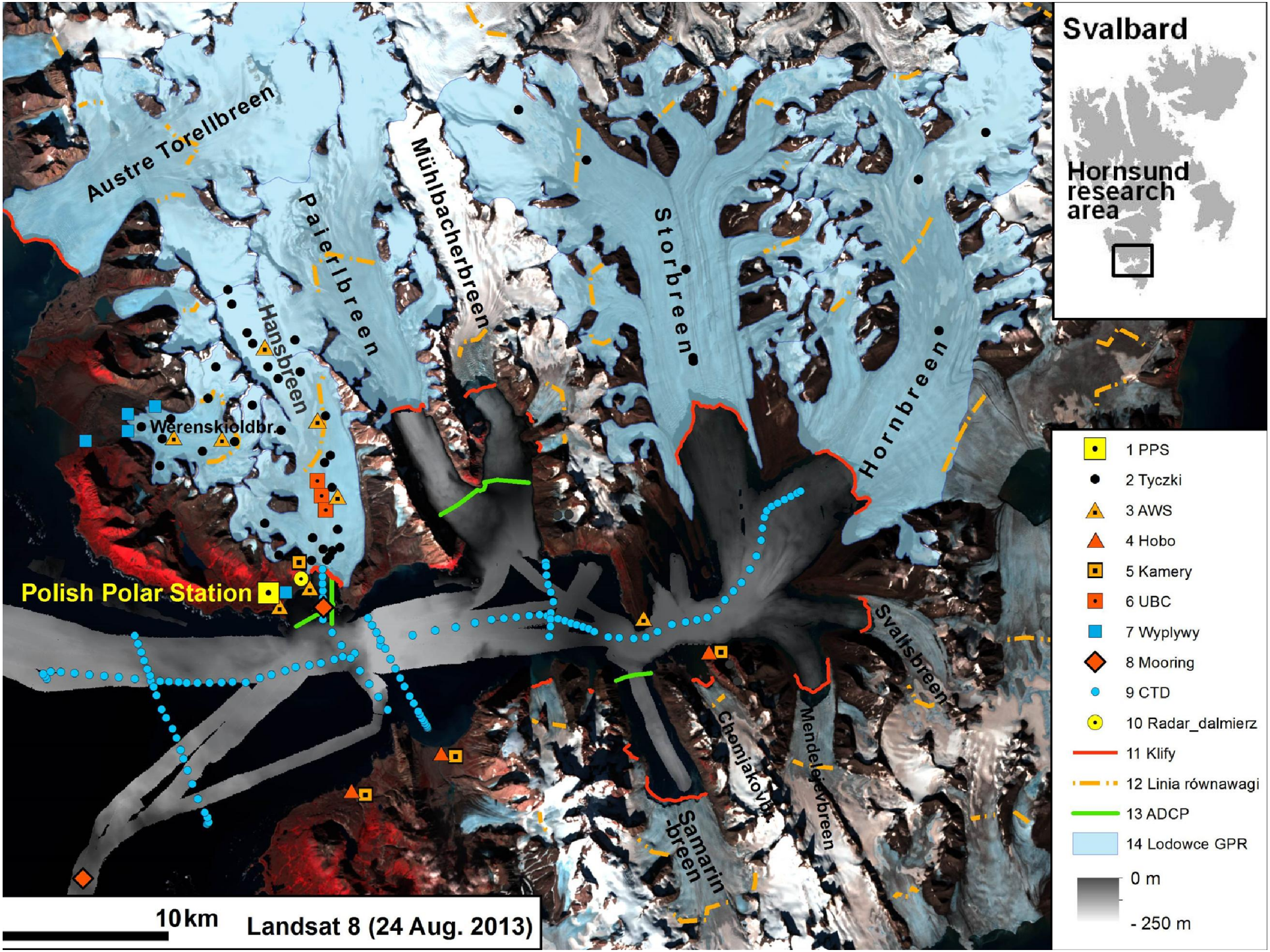
2. Lateral outflows



Results

Outflows size




Svalbard
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Chemjakovbr.
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1 PPS
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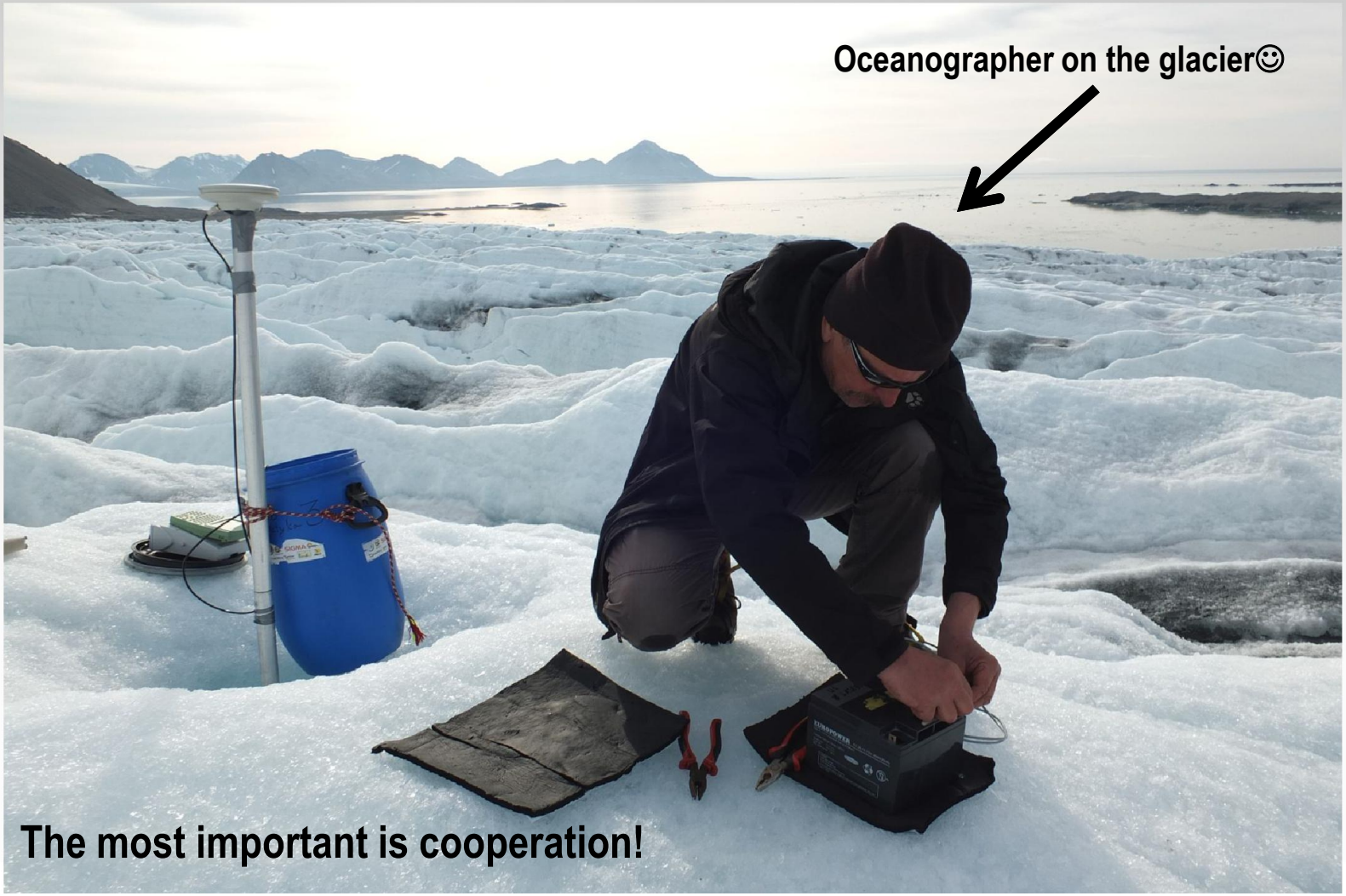
13 ADCP
14 Lodowce GPR
0 m
- 250 m
10 km
Landsat 8 (24 Aug. 2013)

Thank You!


Oceanographer on the glacier☺
The most important is cooperation!

DISSEMINATION ☺

eea grants norway grants

Easter 2014 in Polish Polar Station in Hornsund