WP5 Freshwater from the land

Calving modes
Calving flux
Seasonal fluctuations of tidewater glaciers
Interactions ice/water

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Factors of calving - calving modes

Fot. J.A. Jania, October 2015

Groups of factors

Combination of factors leading to different calving modes

Features of tidewater glaciers
– thermal structure
Cold type - vely slow mass turnover
Subpolar type - medium mass turnover
Temperate type - fast mass turnover

Features of glaciers - dynamics
Flow velocity mode: „normal" flow ~ balance flow
Fast flow mode – permanently fast flowing glacier
Periodic / episodic – surge type behaviour

Morphology of glaciers
(ice thickness vs. sea depth)
Grounded
Semi-floating
Floating tongue
Ice shelf

Oceanographic conditions
Presence of sea ice cover and / or ice melange (back stress and attenuation of waves)
Ocean climate (sea water temperature and currents, warm water intakes into fiords)

Sequence of processes leading to calving of grounded tidewater glaciers in Spitsbergen

Glacier movement along the valley. Tectonics of ice near the front as a „memory” of stresses history

Stretching toward terminus (widening of crevasses)

Tidal weakining of ice structure (opening of basal crevasses)

Melting of ice cliff at the contact with the sea (importance of water temperature, currents and waves)

Loose of cliff stability over the undercuted notch (collapse of slabs from lower part of the cliff)

Fall down of the upper part of ice cliff

An intermission in calving events until re-melting of the niche at the sea level

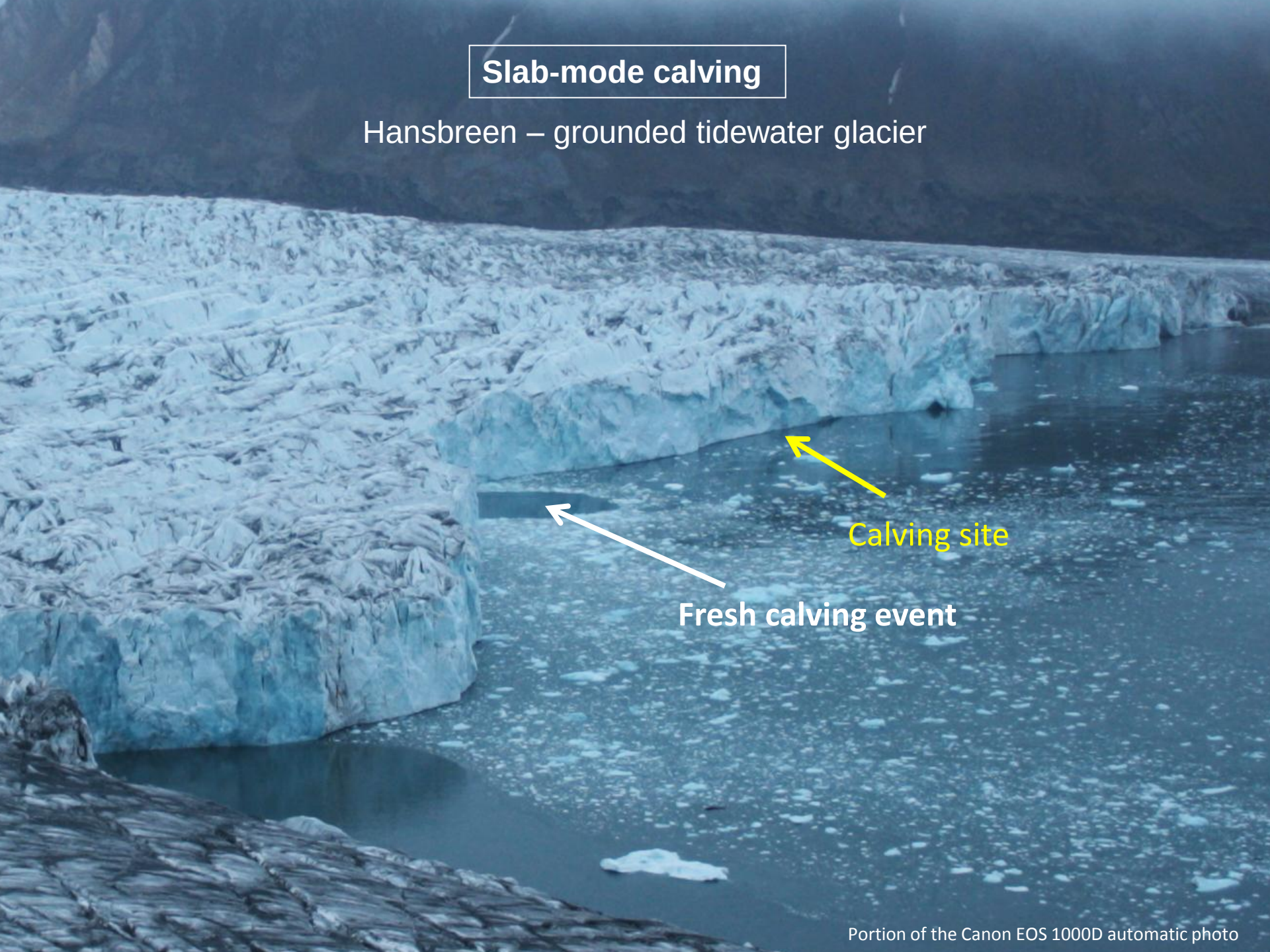
Destruction of ice horst between ice cliff and the first crevasse line

Detachment of submarine portion of the ice horst – underwater calving

Preparatory stages

Breaking off stages

Slab-mode calving of entirely grounded tidewater glacier


Slab-mode calving
Hansbreen – grounded tidewater glacier
Calving site
Fresh calving event
Portion of the Canon EOS 1000D automatic photo


9 Jul. 2011, 8:11
Loose of cliff stability over the undercuted notch
(collapse of slabs from lower part of the cliff)


10 Jul. 2011, 8:11
Stretching toward terminus
Fall down of the upper part of ice cliff

Laser scanner Riegl in use for Hansbreen in 2015

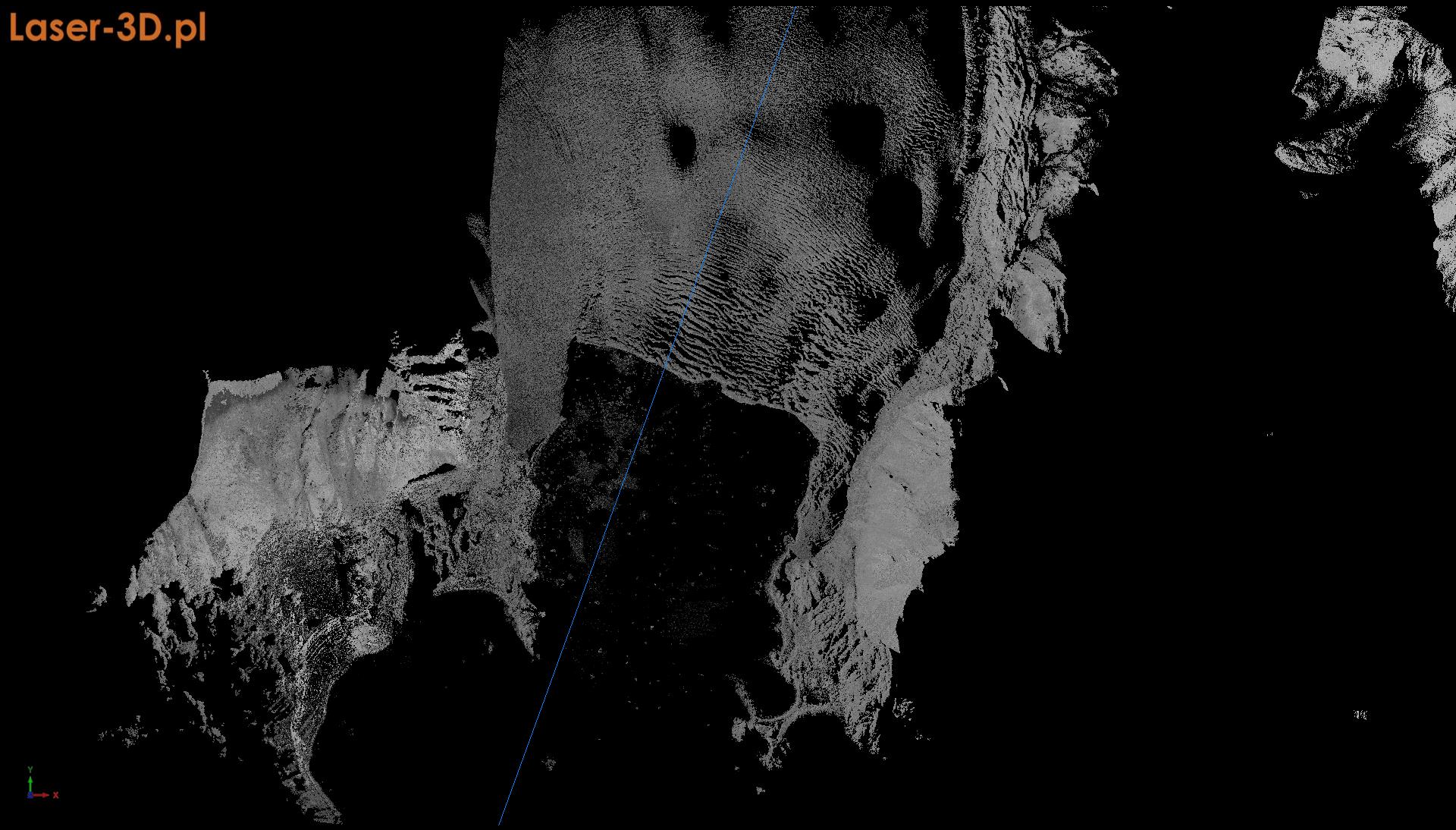
Photo: Piotr Krężel

Processes in different time-scales

Diurnal and hourly fluctuations, velocities, calving, etc.

26 Aug. 2015

Laser-3D.pl

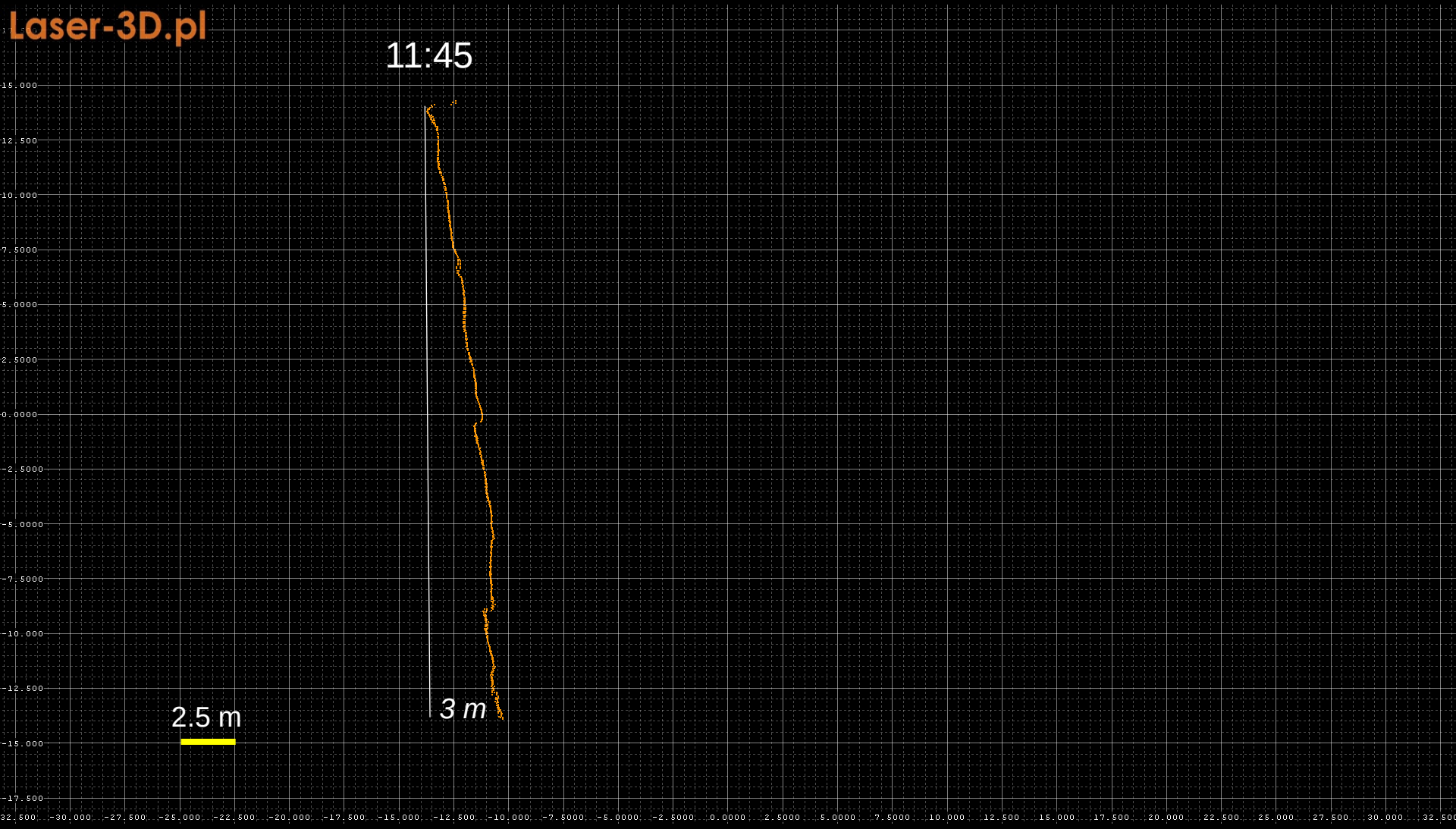


Effect of terrestrial laser scanning 20 - 27 August 2015

By Laser - 3D (Klaudia Gergont, Jacek Krawiec) & M. Blaszczyk, M. Petlicki

Ice cliff vertical profile

26 Aug. 2015



26 Aug. 2015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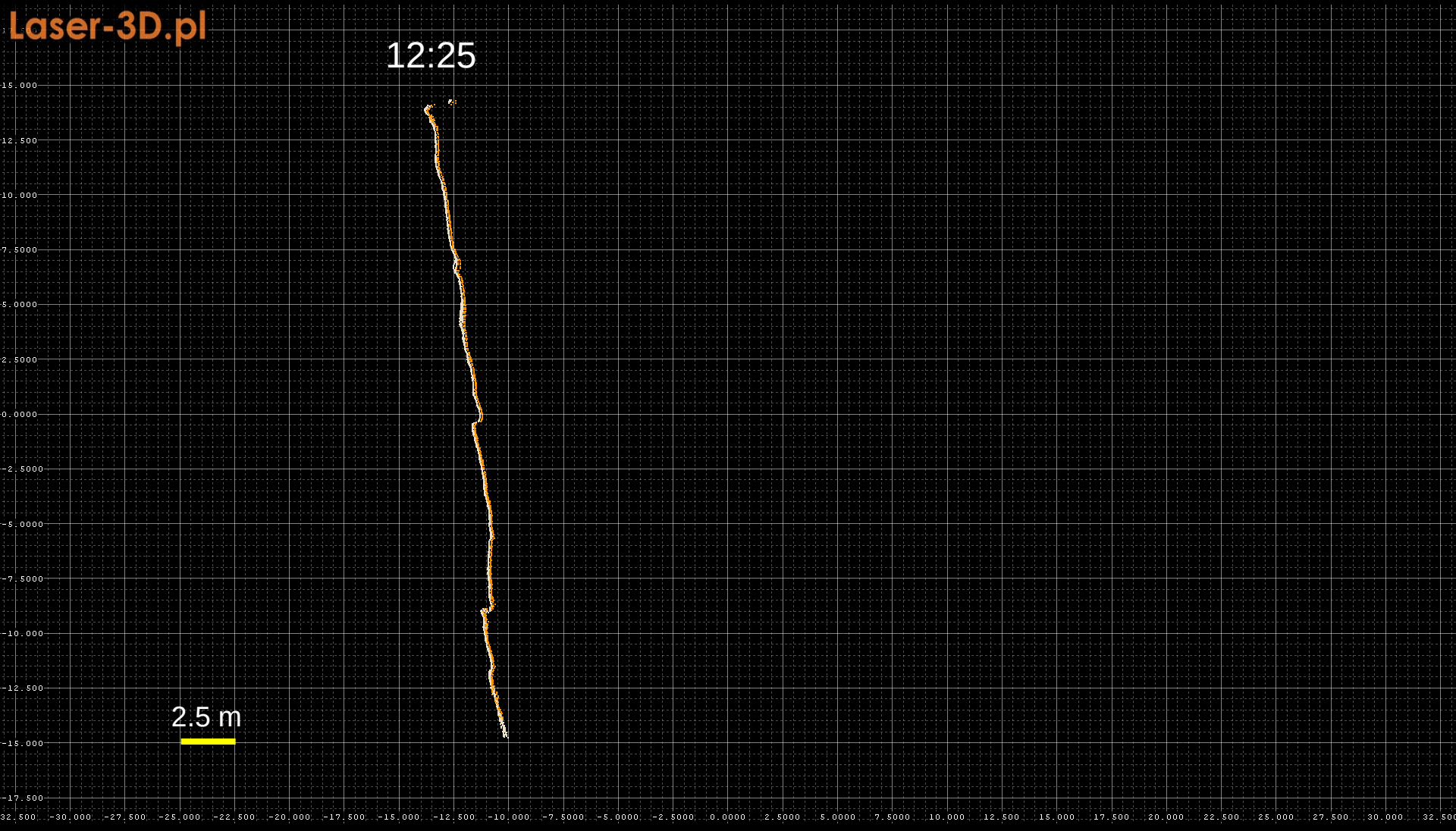

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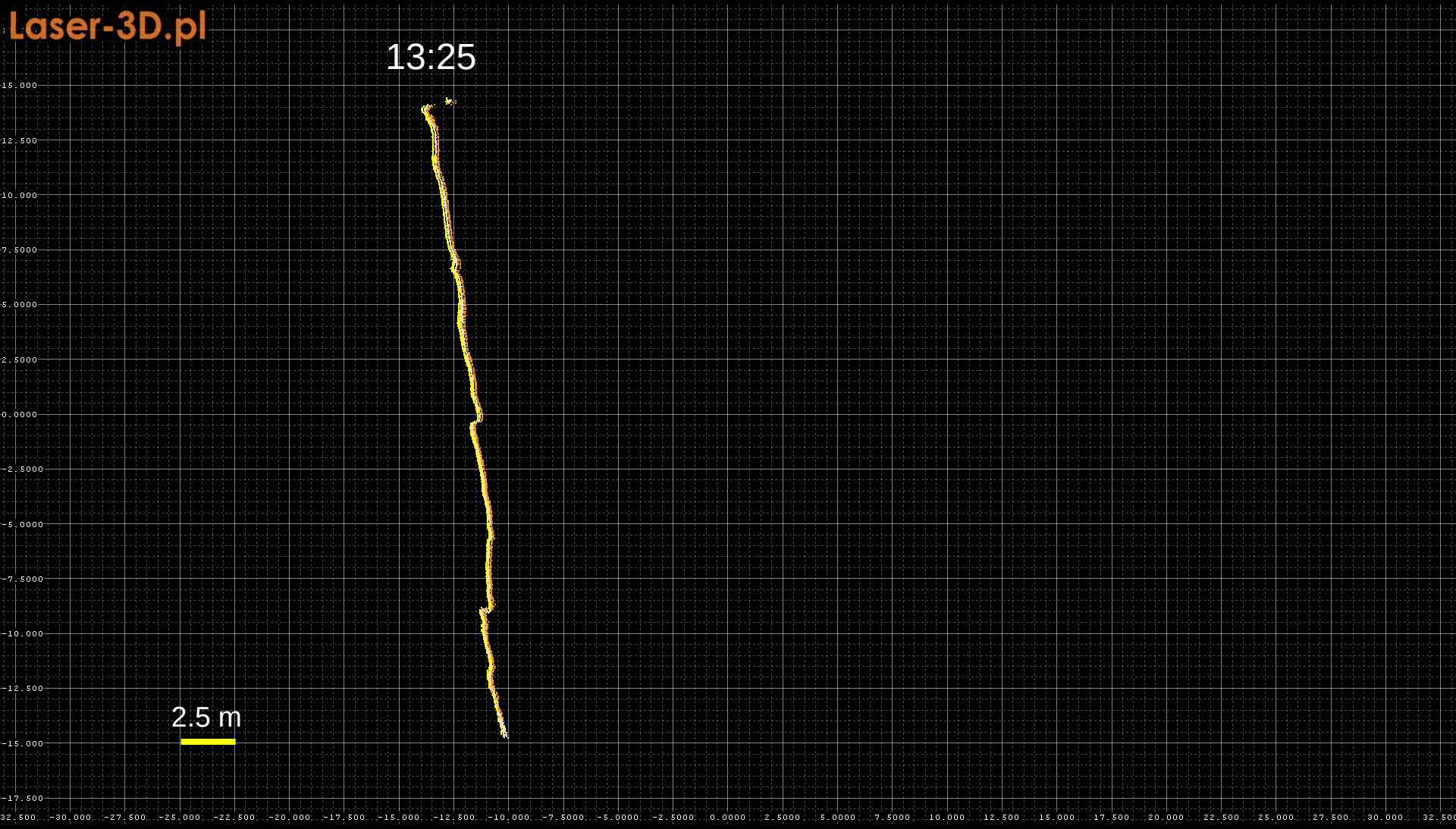
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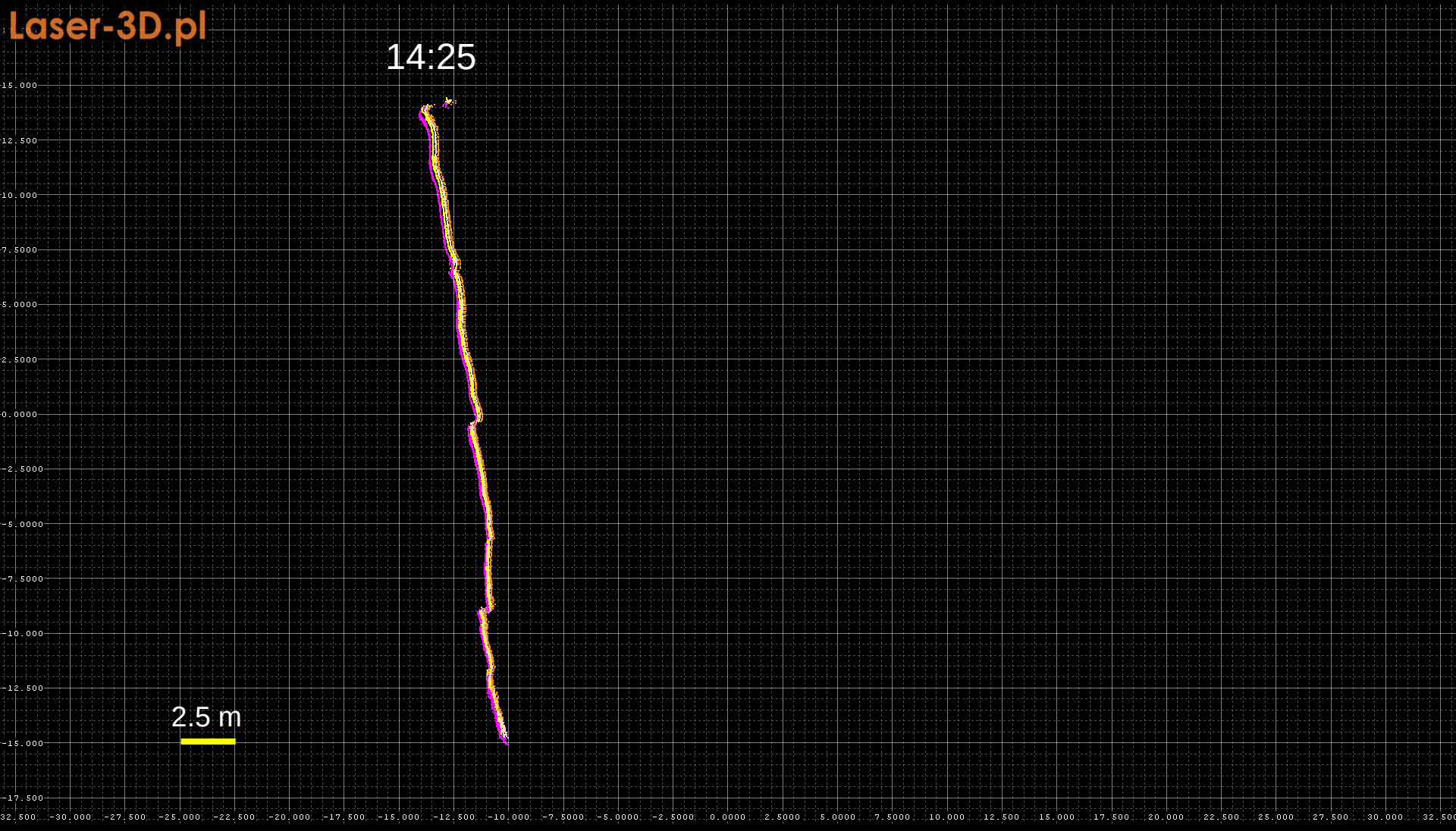

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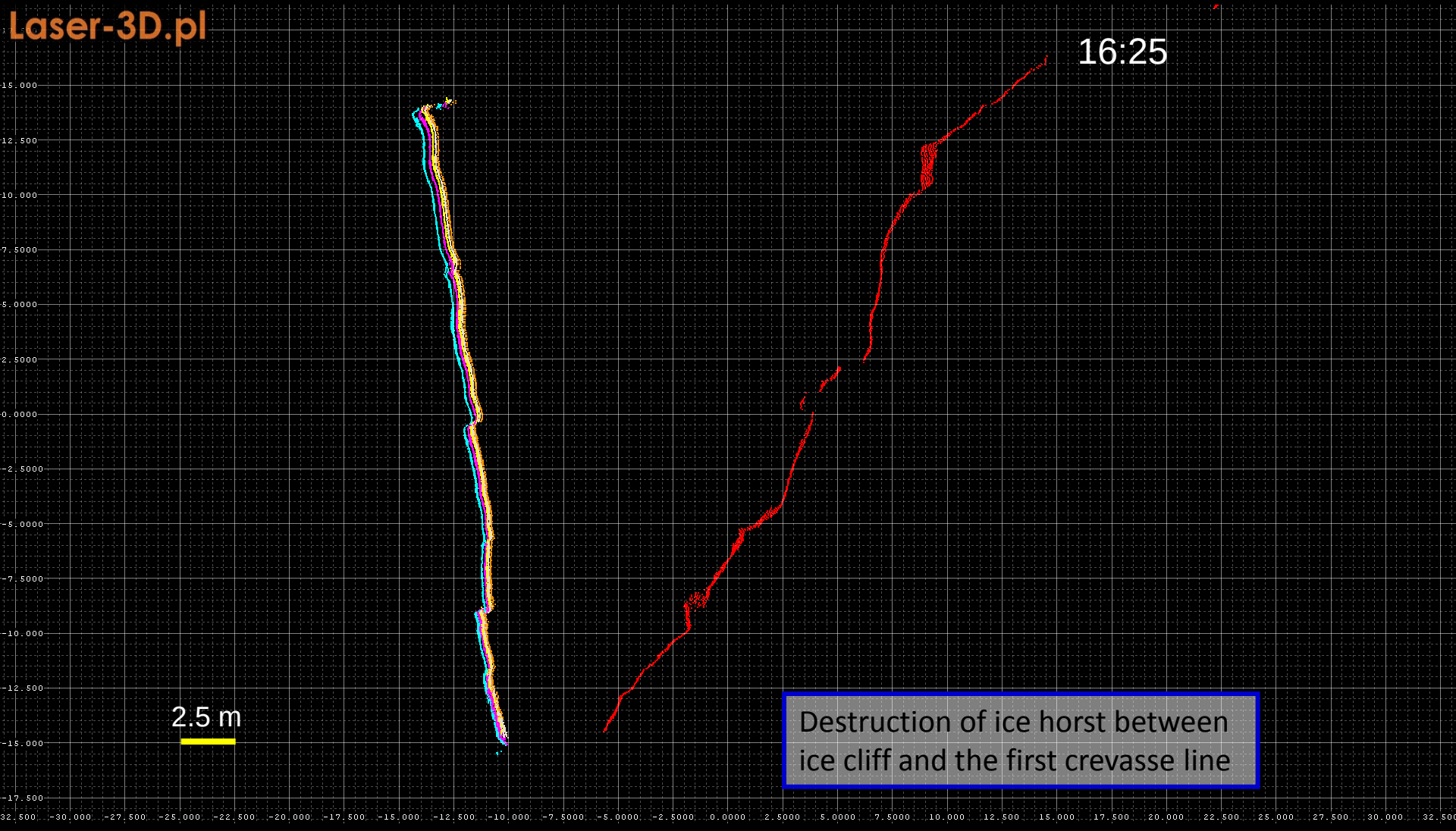
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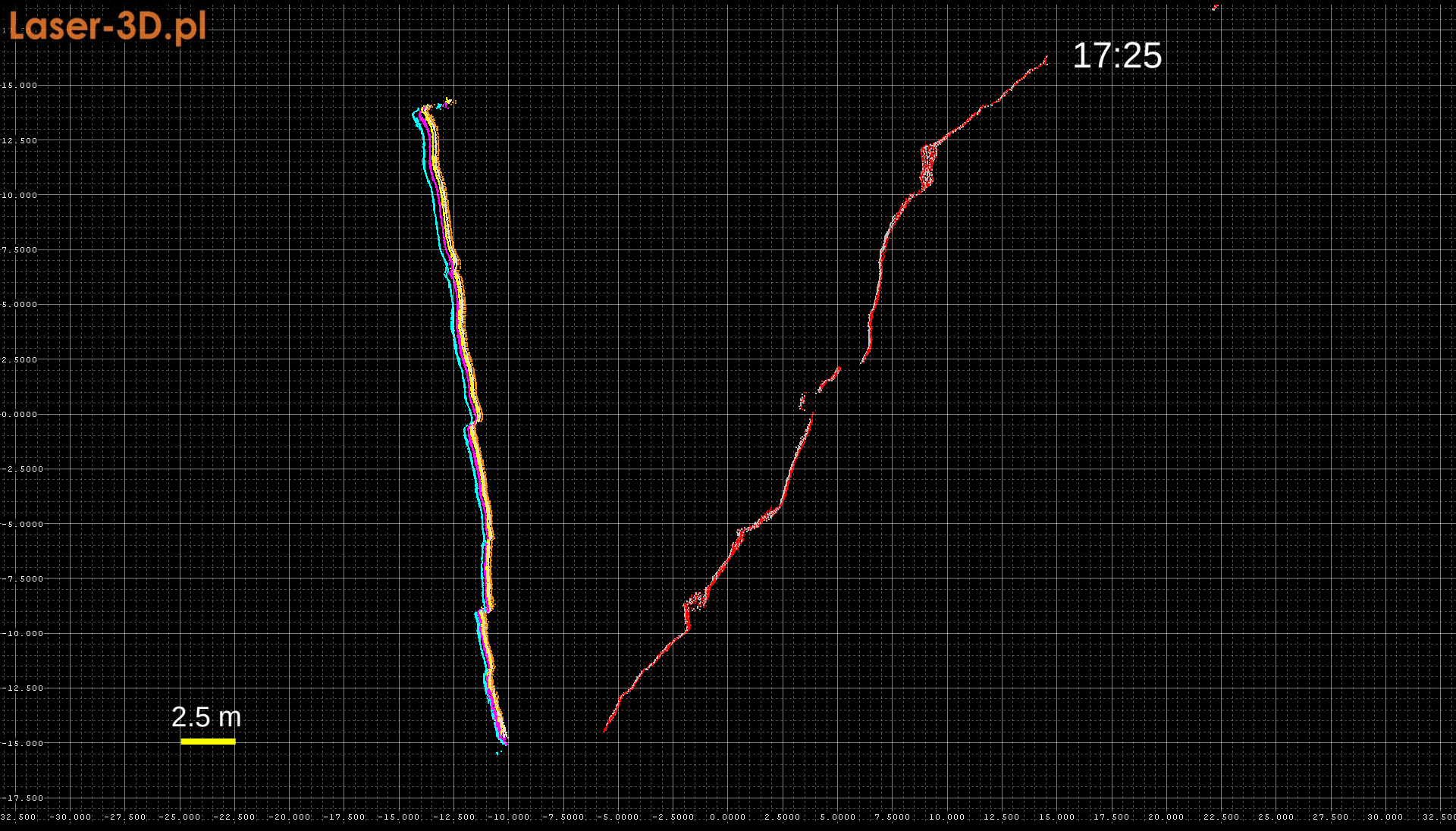
Destruction of ice horst between ice cliff and the first crevasse line

26 Aug. 2015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26 Aug. 2015


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26 Aug. 2015

Effect of terrestrial laser scanning in August 2015

By Laser - 3D (Klaudia, Jacek Krawiec) & M. Blaszczyk, M. Petlicki)

Sequence of processes leading to calving of semi-grounded tidewater glaciers in Spitsbergen

Glacier movement along the valley. Tectonics of ice near the front as a „memory” of stresses history

Stretching toward terminus (widening of crevasses)

Tidal weakening of ice structure (opening of basal crevasses)

Junction of superficial and basal crevasses

Appearance and widening of superior crevasse at certain distance from the front (50 – 100 m)

Detachment of substantial portion of frontal ice from the glacier tongue

Disintegration of the table-like iceberg into smaler ones and ice melange

Melting of ice cliff at the contact with the sea (importance of water temperature, currents and waves)

Loose of cliff stability over the undercuted notch (collapse of slabs from lower part of the cliff)

An intermission in slab type calving until re-melting of the niche at the sea level or massive calving event

Preparatory stages

Breaking off stages

Massive calving of semi-grounded tidewater glacier (with accompany by slab type calving)

Massive calving event - subsequent stages

Appearance and widening of superior crevasse at certain distance from the front (50 – 100 m)

Paierlbreen

4 Oct. 2011 - 09:11:16

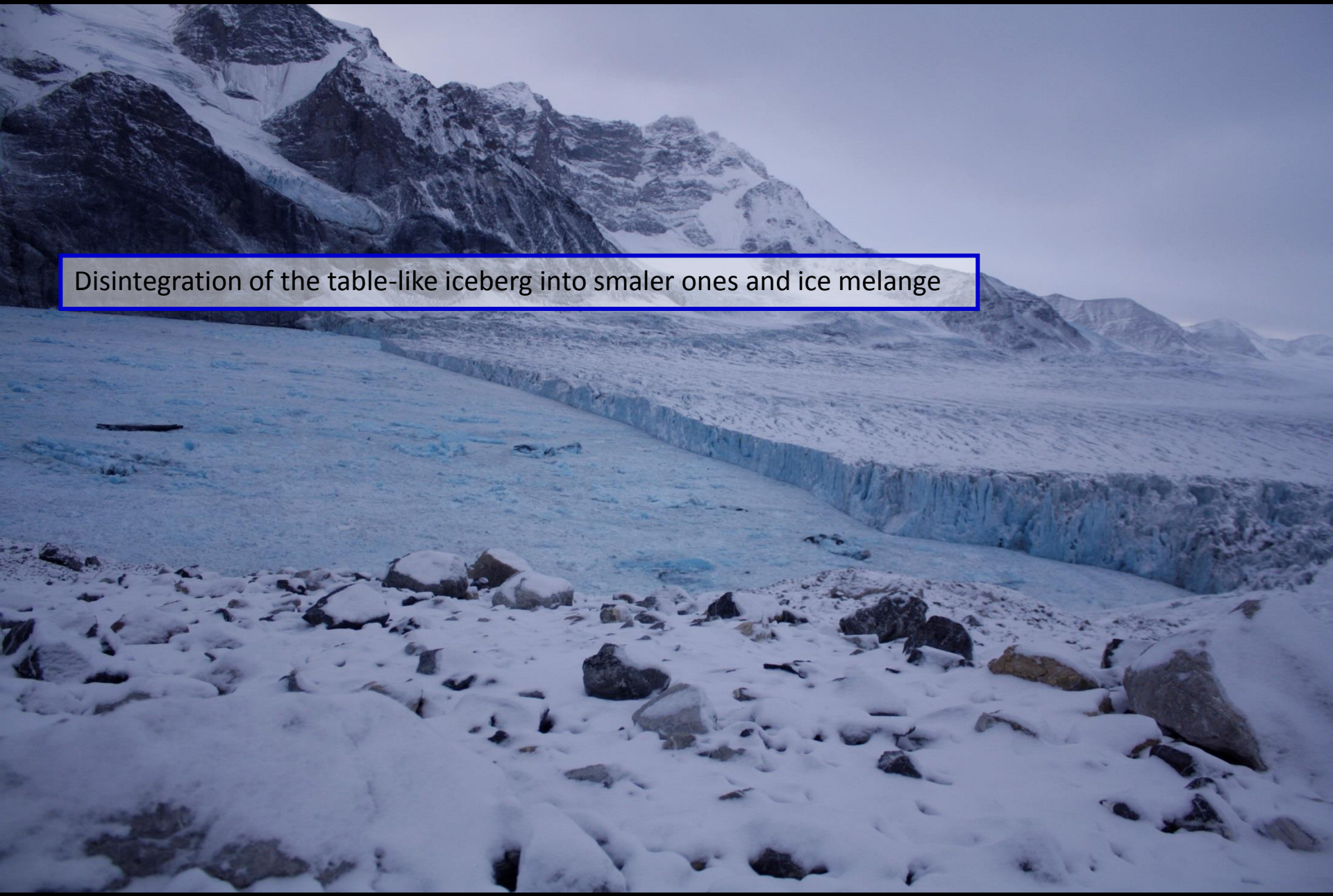
Paierlbreen

4 Oct. 2011 - 12:11:16

Paierlbreen

4 Oct. 2011 - 15:11:16

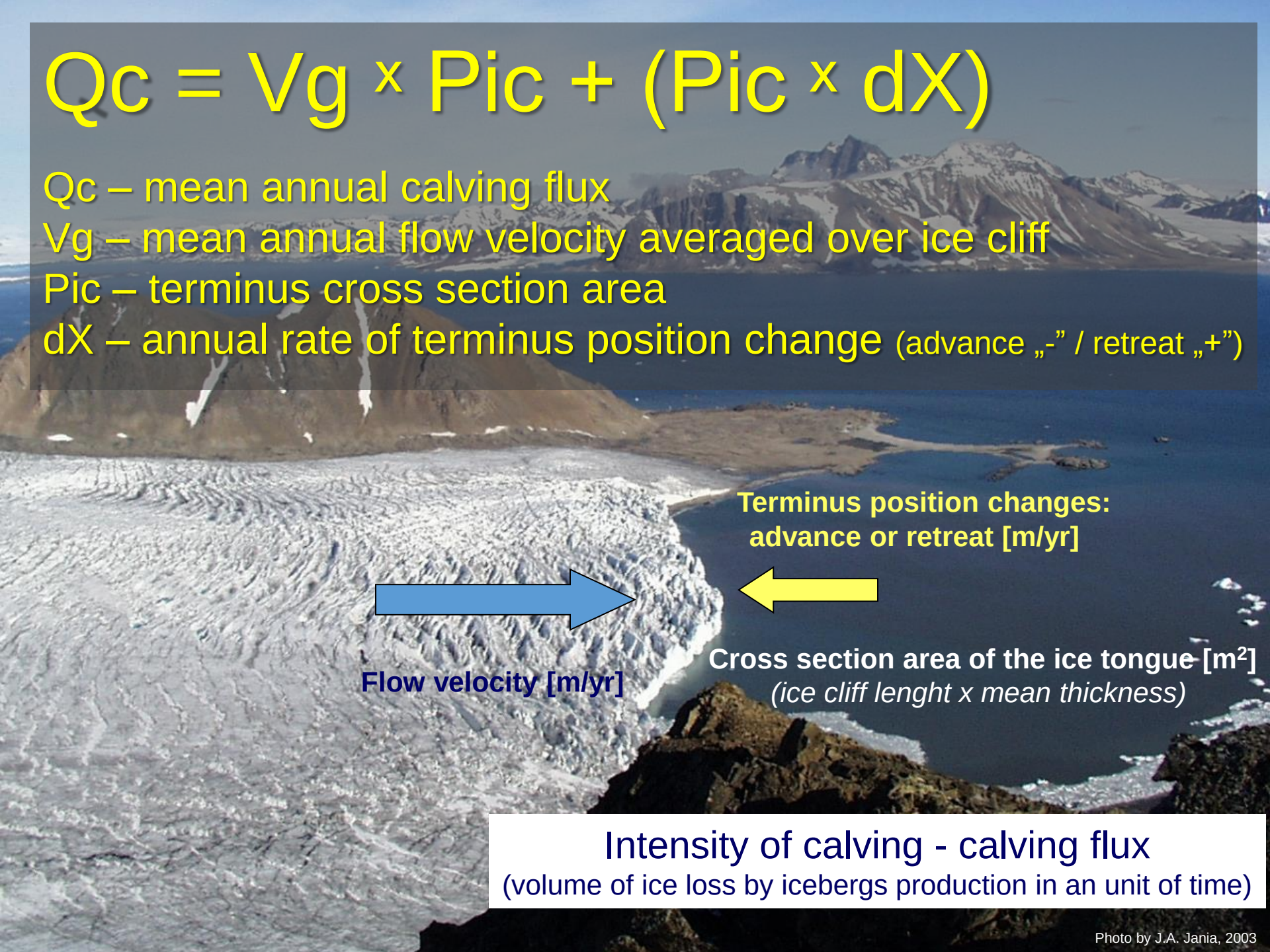
Paierlbreen



4 Oct. 2011 - 18:11:16

$Qc = Vg \times Pic + (Pic \times dX)$

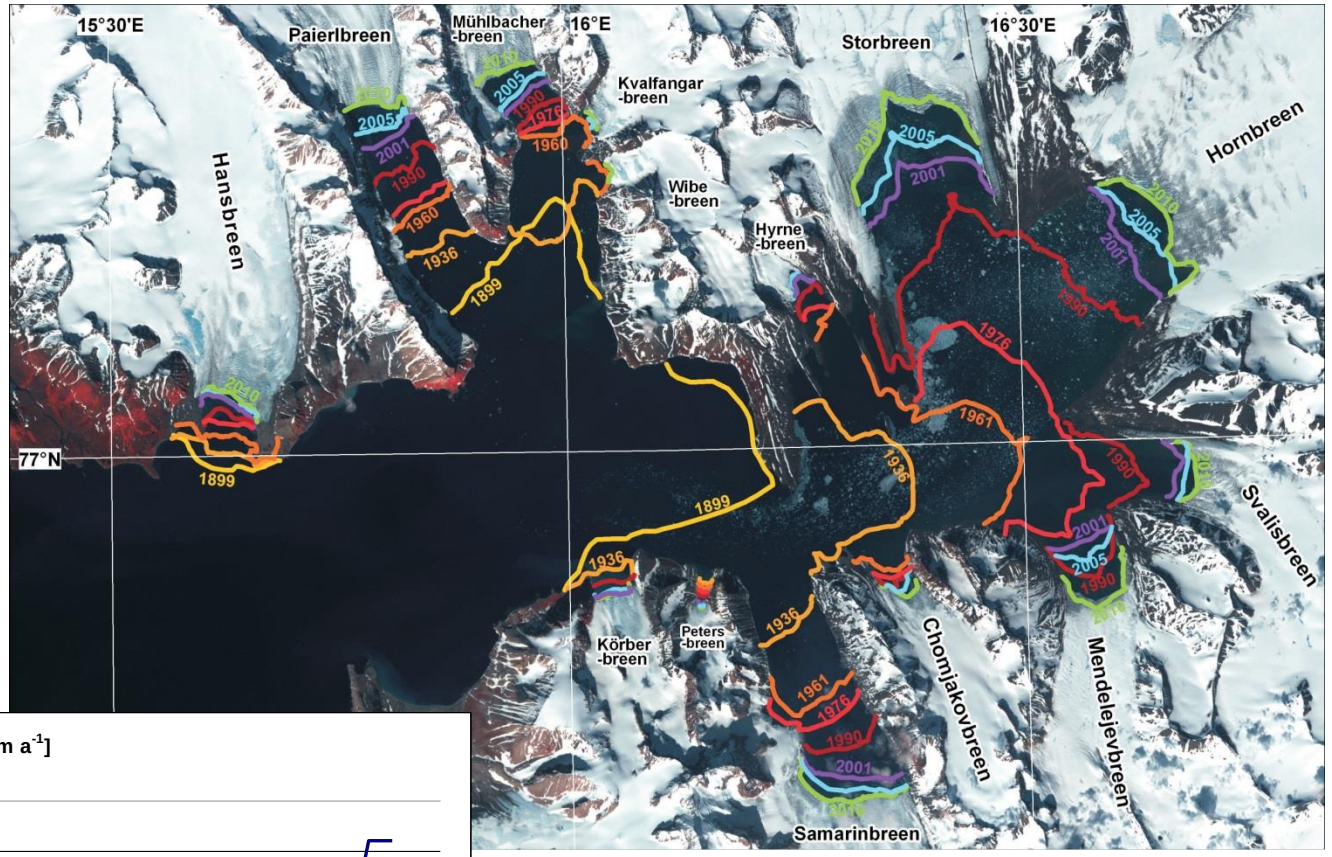
Qc – mean annual calving flux
Vg – mean annual flow velocity averaged over ice cliff
Pic – terminus cross section area
dX – annual rate of terminus position change (advance „-” / retreat „+”)



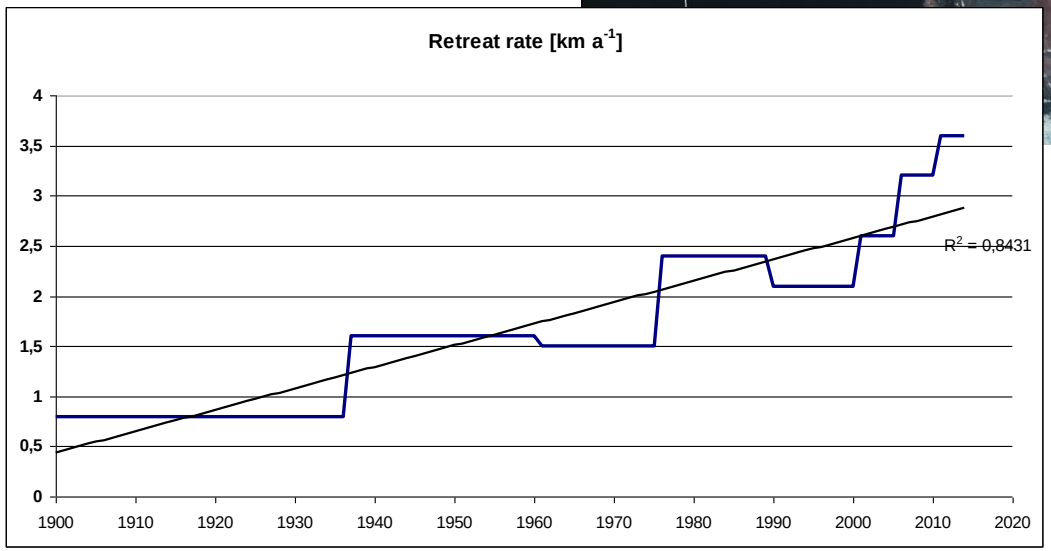
Intensity of calving - calving flux
(volume of ice loss by icebergs production in an unit of time)

Photo by J.A. Jania, 2003

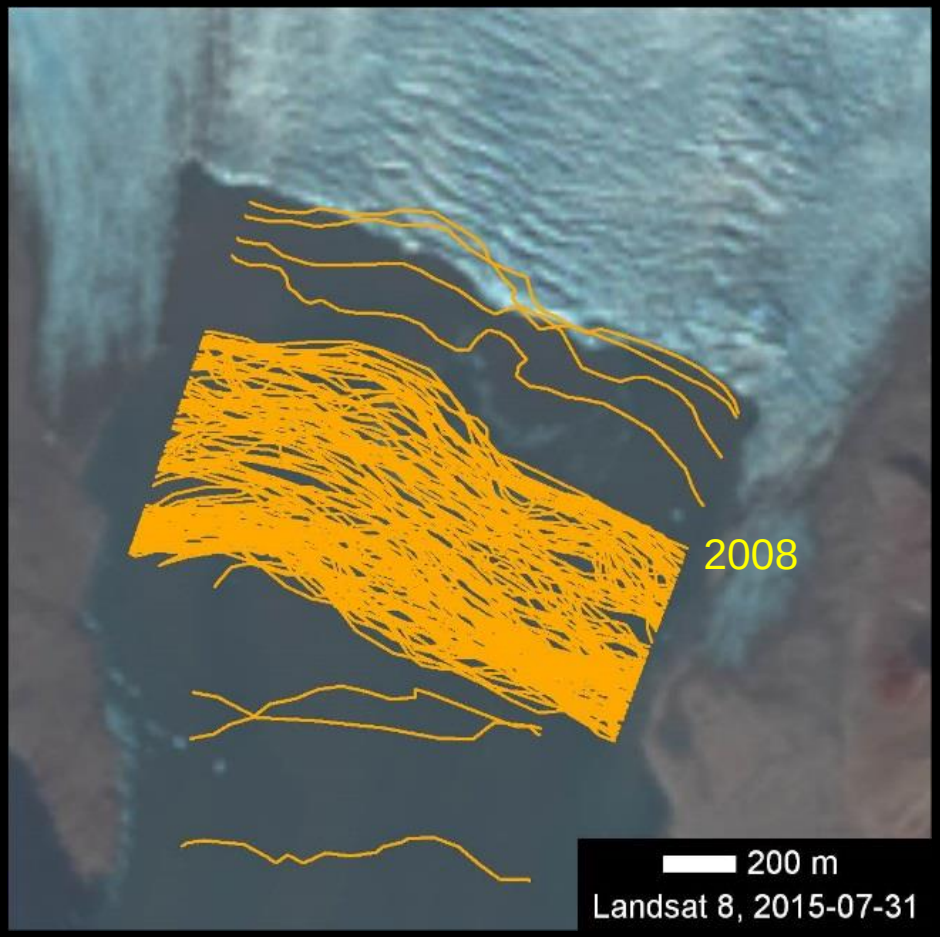
Retreat of glaciers in Hornsund since 1899



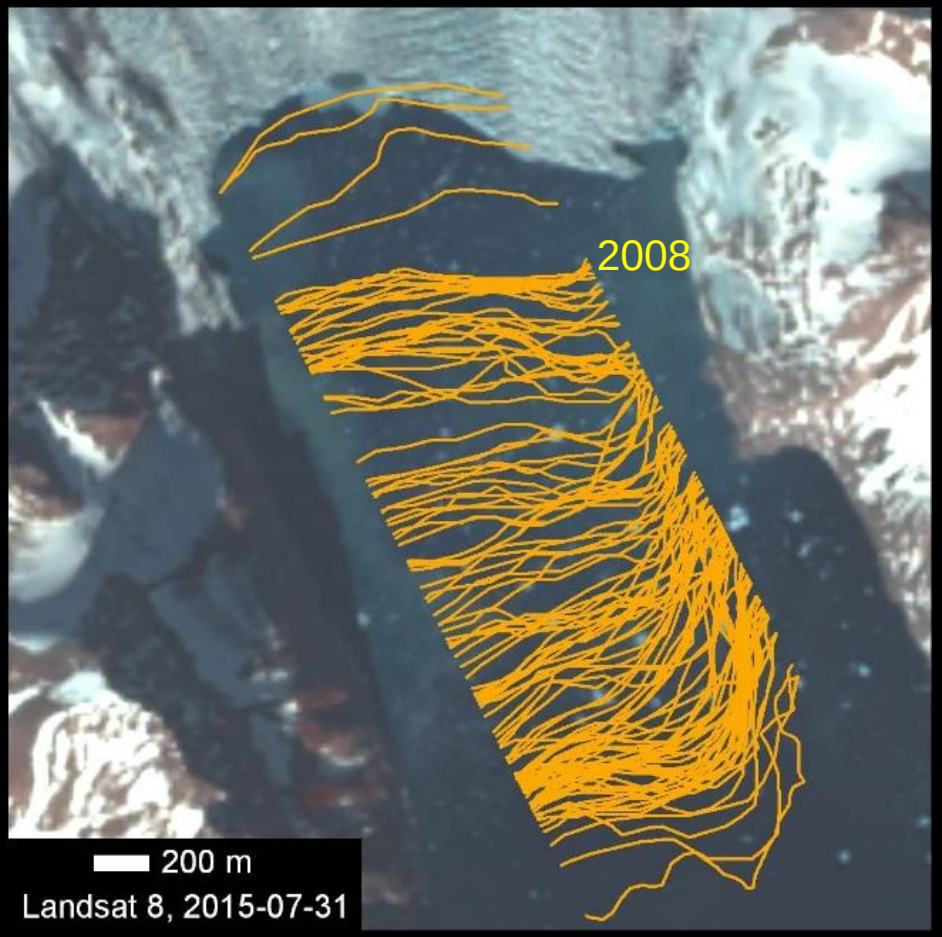
Błaszczyk et. Al. 2013



Front position changes from satellite data 1990-2014



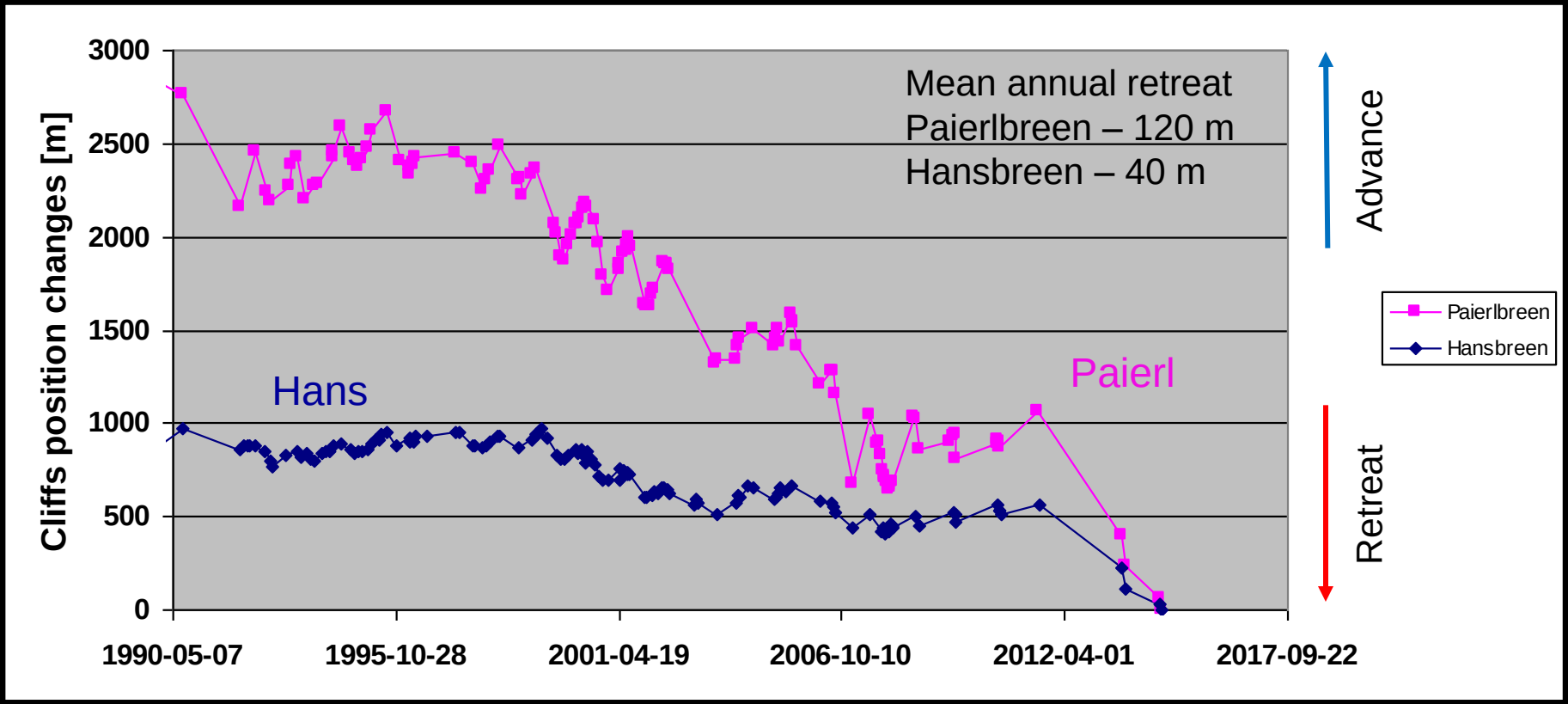
Hansbreen



Paierlbreen

Data from visible bands (Landsat 2, Terra ASTER, Landsat ETM+, Landsat 8, Alos Avnir, SPOT 5) and radar satellite data (ERS SAR, Envisat ASAR)

Front position changes from satellite data 1990-2014
(normalized to the 1 August 2014)



Hansbreen

Mean annual seasonal fluctuations: **86 m**

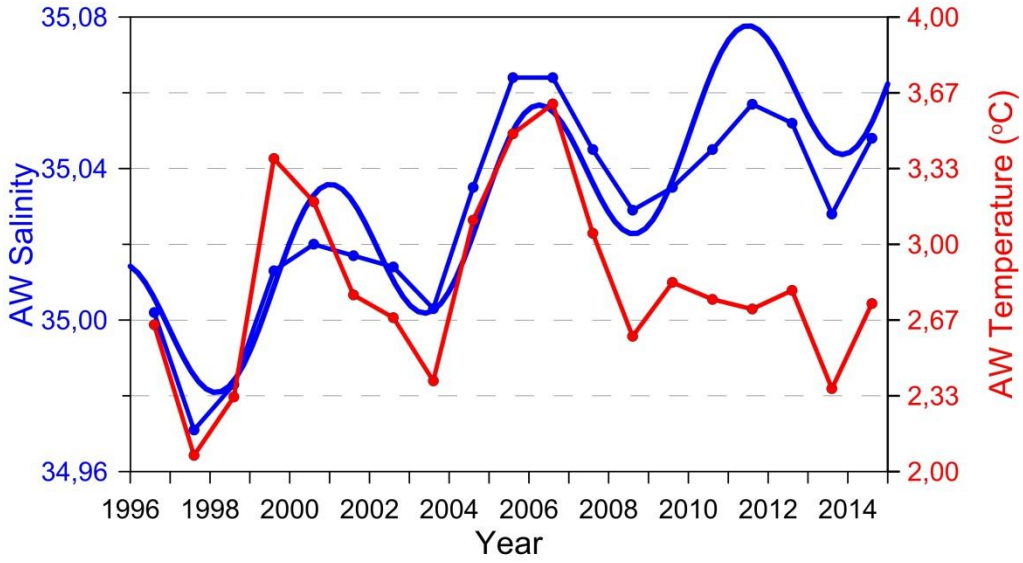
Maximal annual seasonal fluctuations: **170 m**

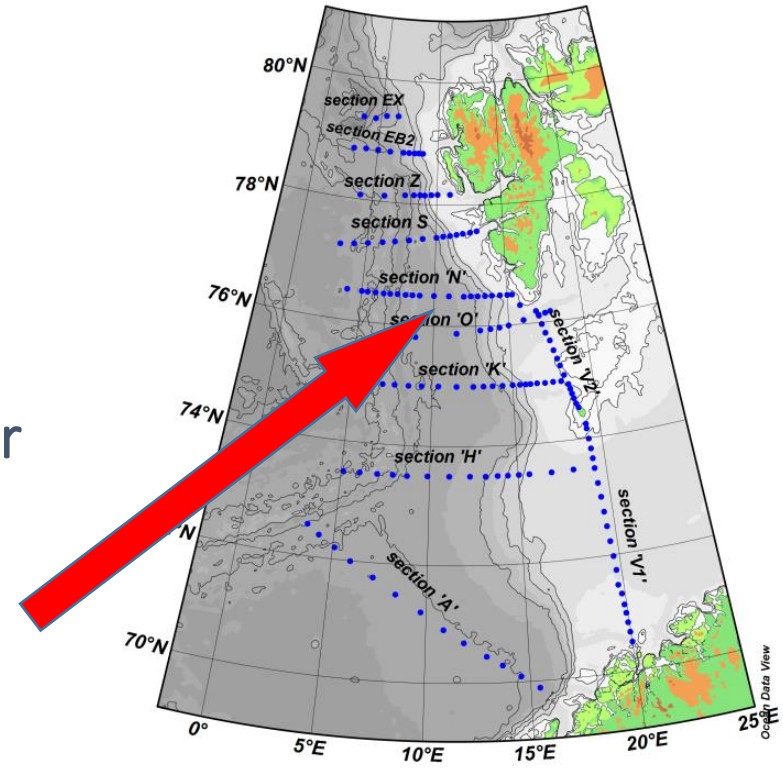
Paierlbreen

Mean annual seasonal fluctuations: **290 m**

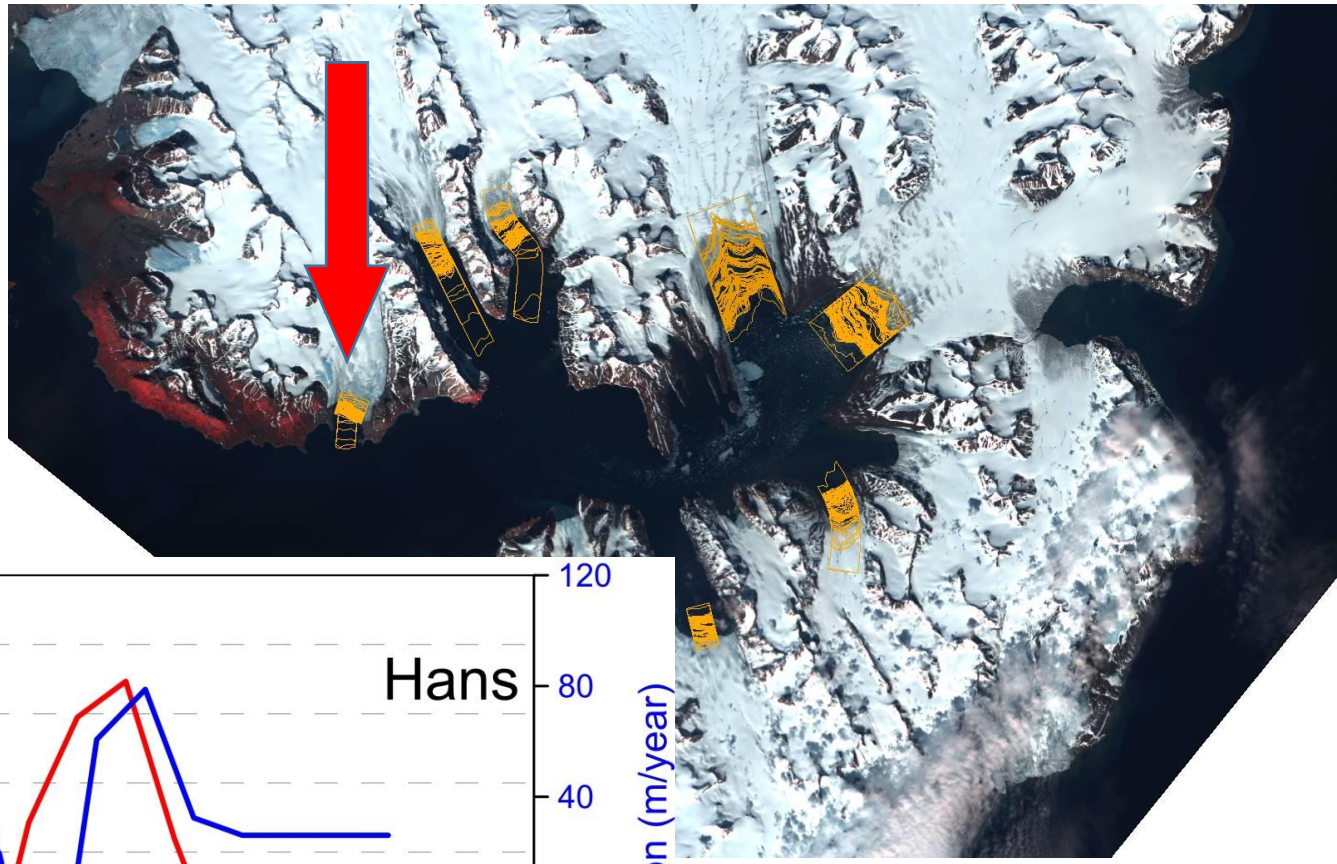
Maximal annual seasonal fluctuations: **600 m**

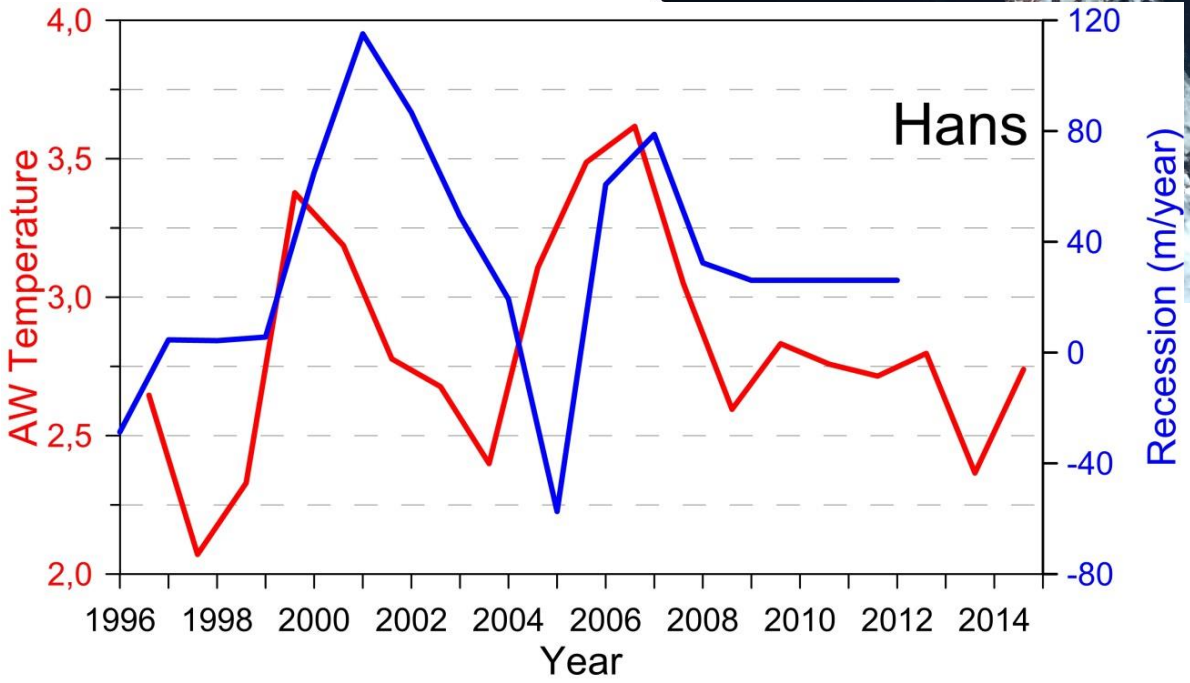
Temperature and salinity of Atlantic Water at 76° 30’ N



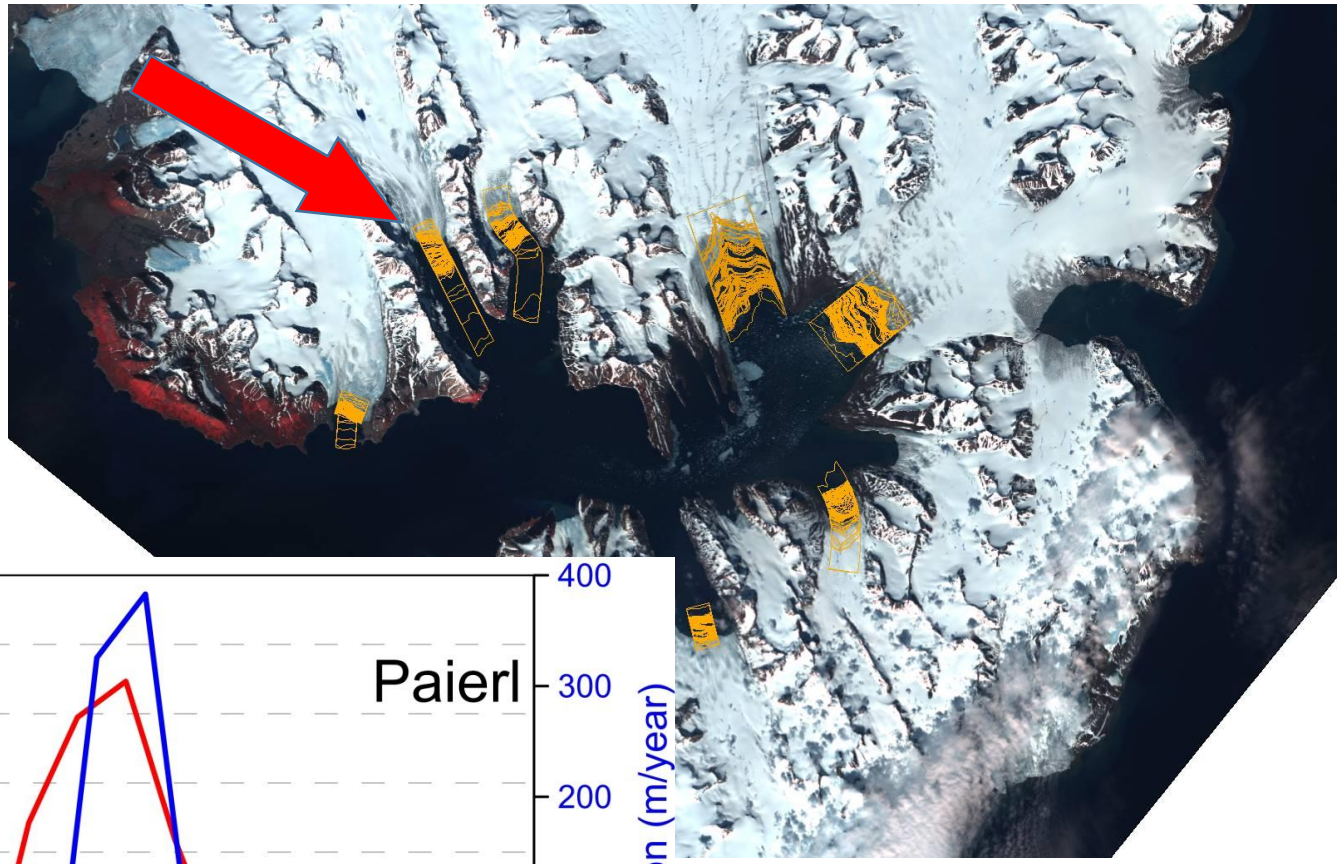


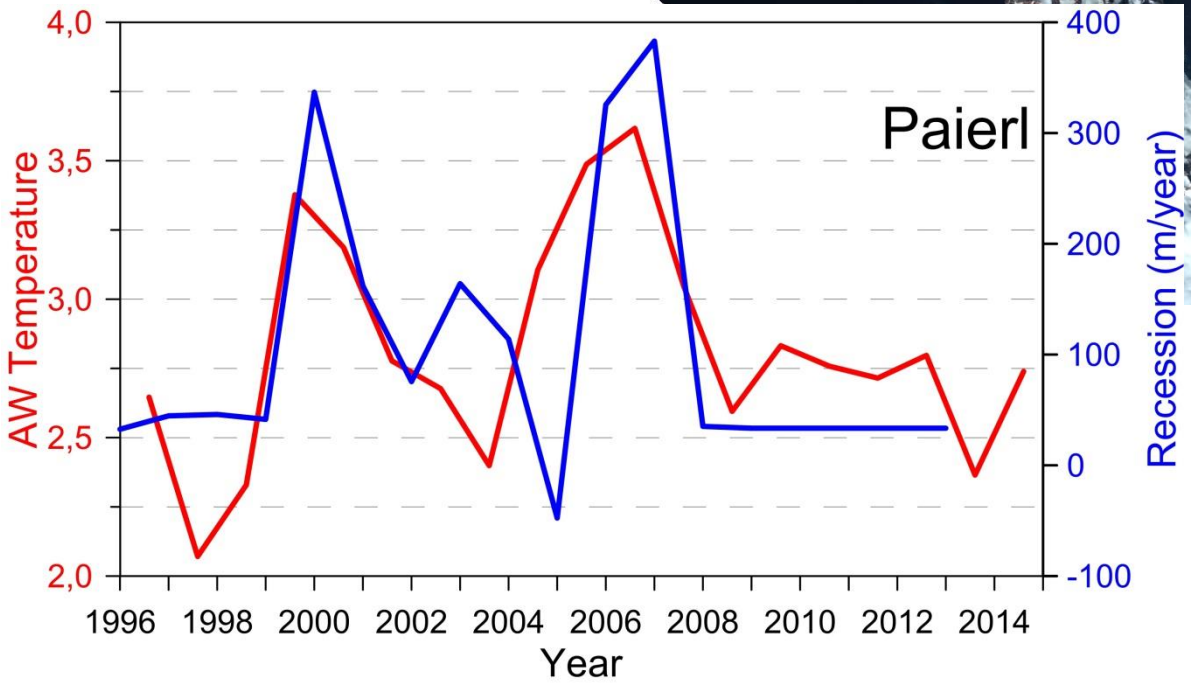
Hornsund. Glaciers recession rate



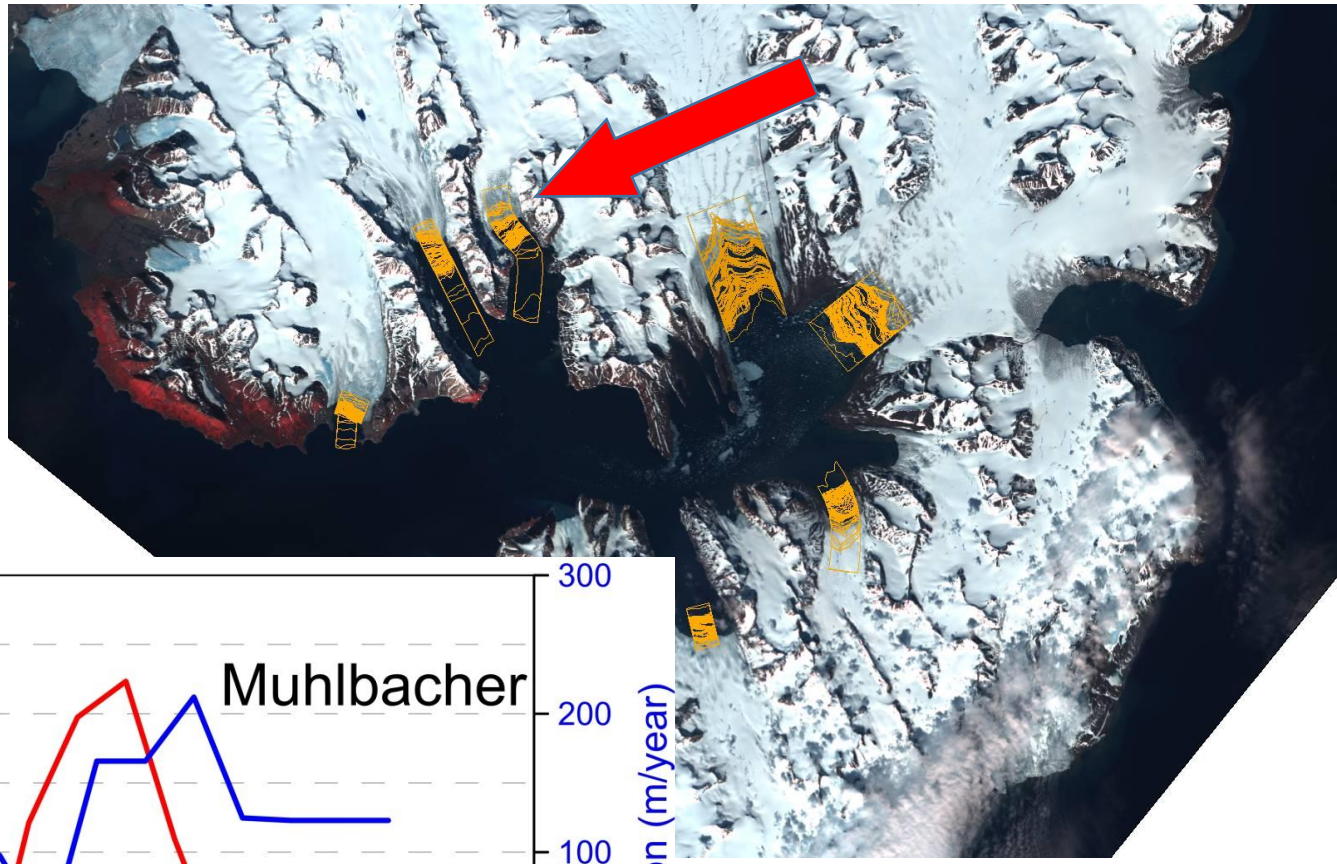


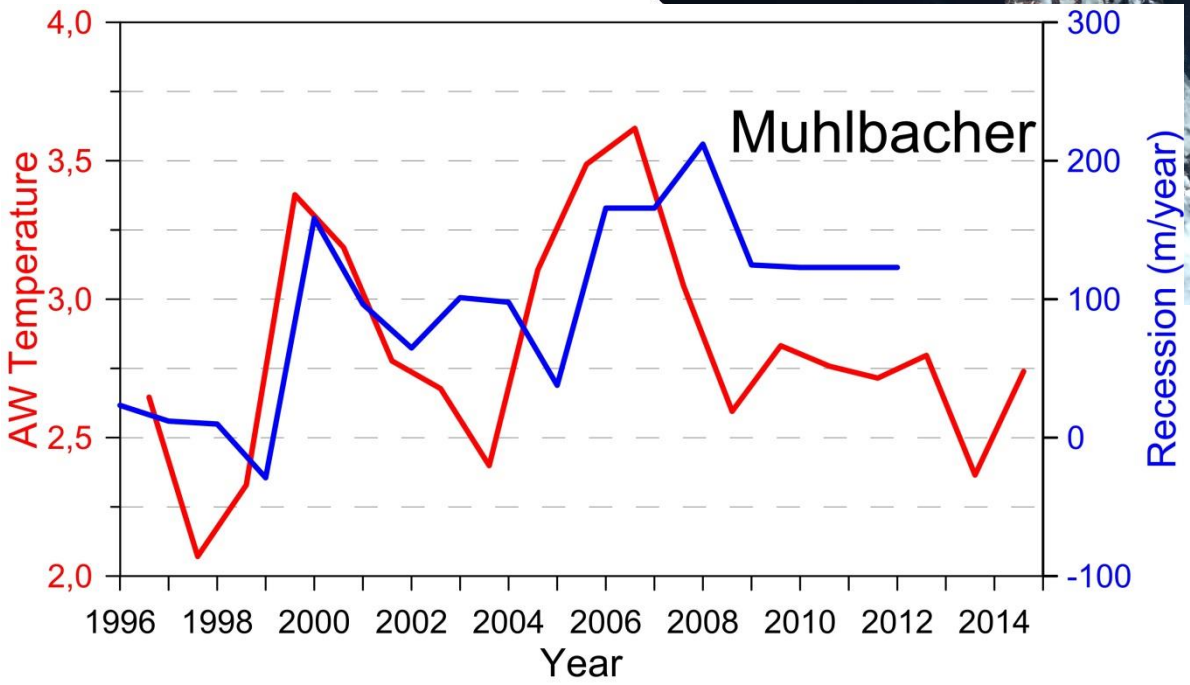
Hornsund. Glaciers recession rate



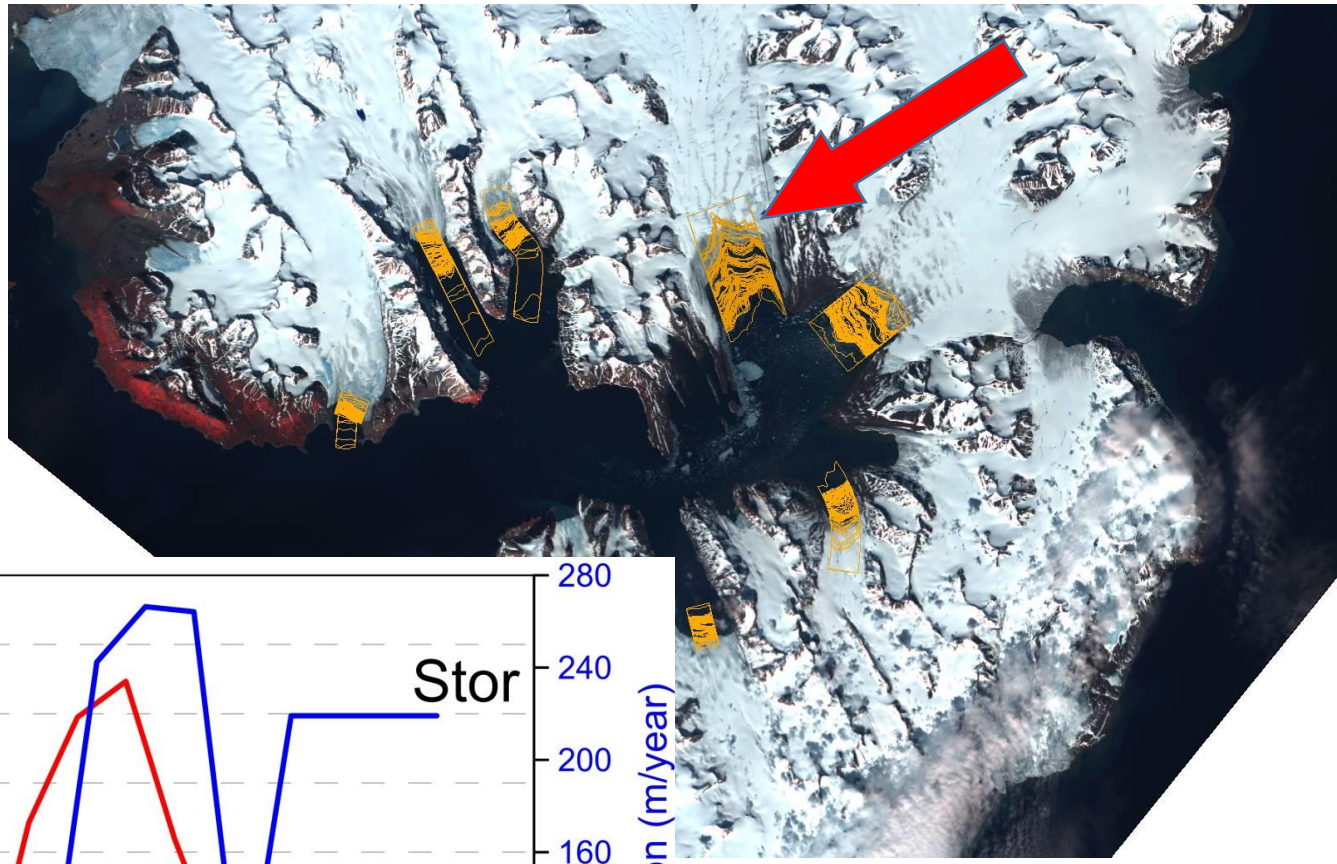


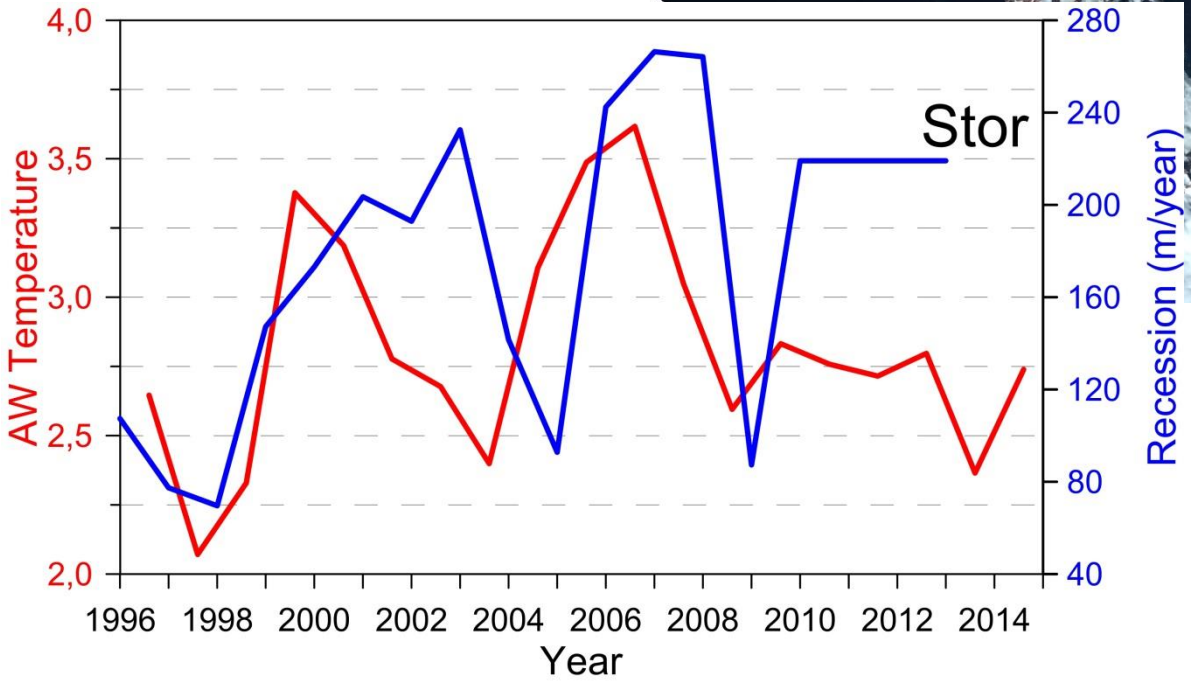
Hornsund. Glaciers recession rate



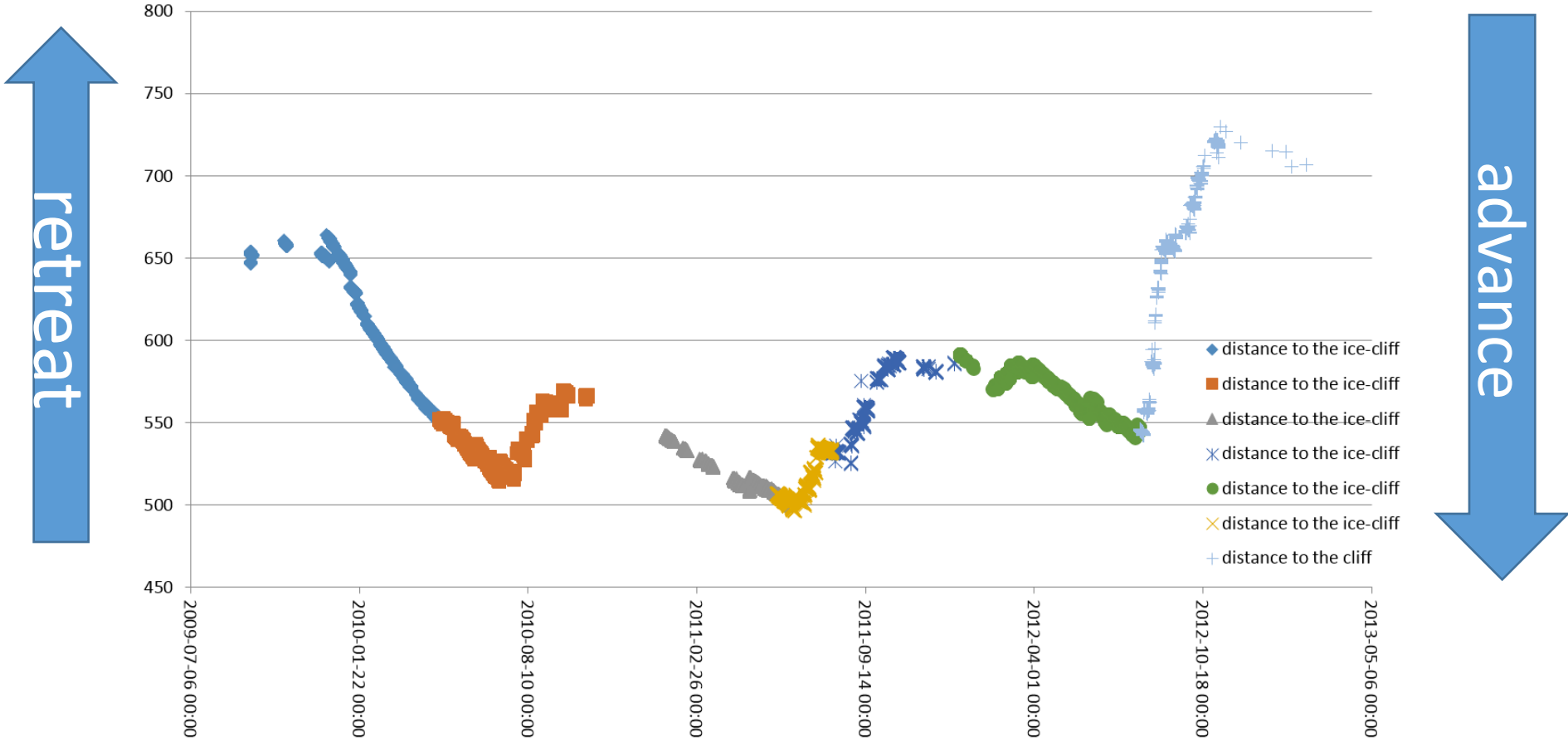


Hornsund. Glaciers recession rate

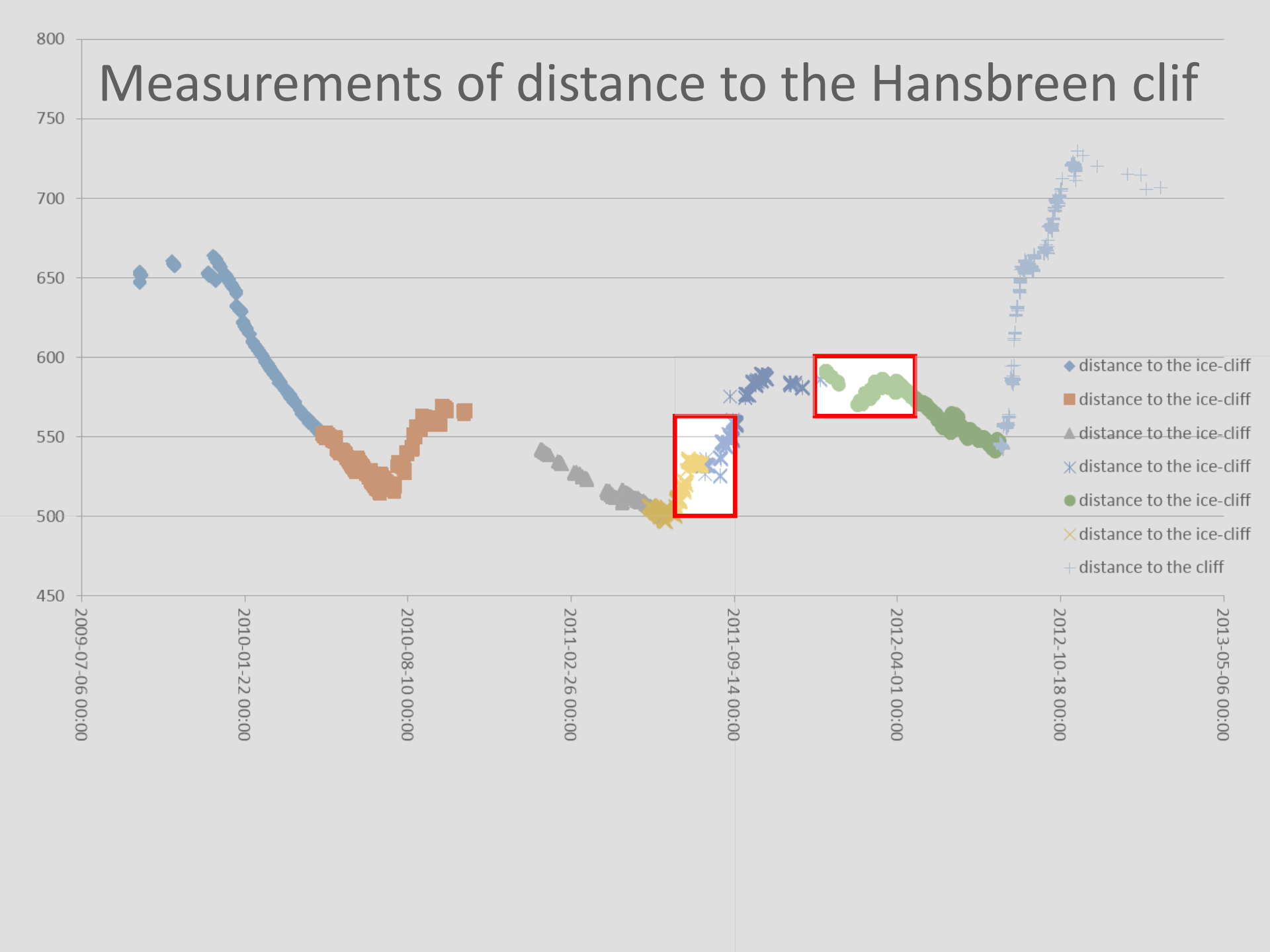




Measurements of distance to the Hansbreen ice clif



Source: University of Silesia


Measurements of distance to the Hansbreen clif
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2010-08-10 00:00
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2012-10-18 00:00
2013-05-06 00:00
distance to the ice-cliff
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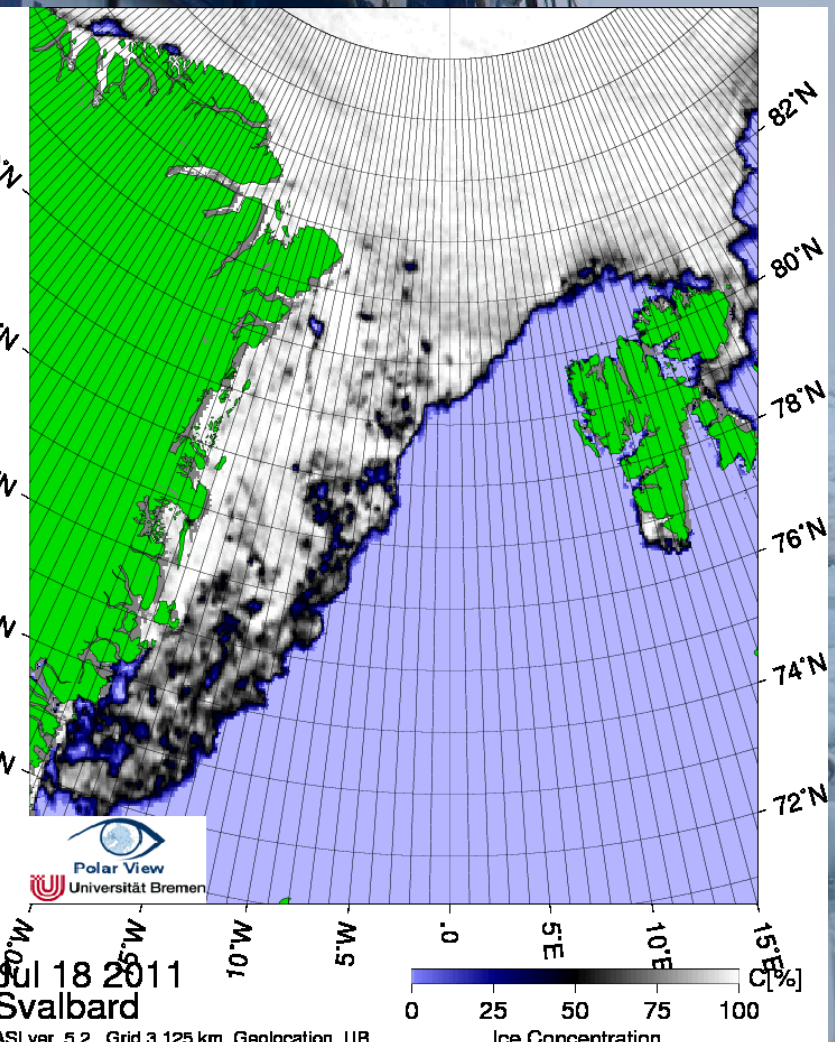
distance to the ice-cliff
distance to the cliff

Sea ice conditions in Hornsund Fjord

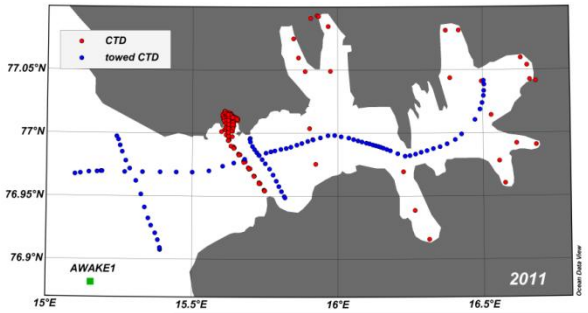


- Fast ice starts to form in late Autumn (November) – mainly in Brepollen and other bays of Hornsund
  Main basin usually covered with pack ice carried by the Sørkapp Current from the Barents Sea
  The ice season in the fjord lasts until May or beginning of June when the drifting ice is blowing out from the fjord

Extreme event: summer (July) 2011 – inflow of sea ice from the Barents Sea observed twice in Hornsund Fjord

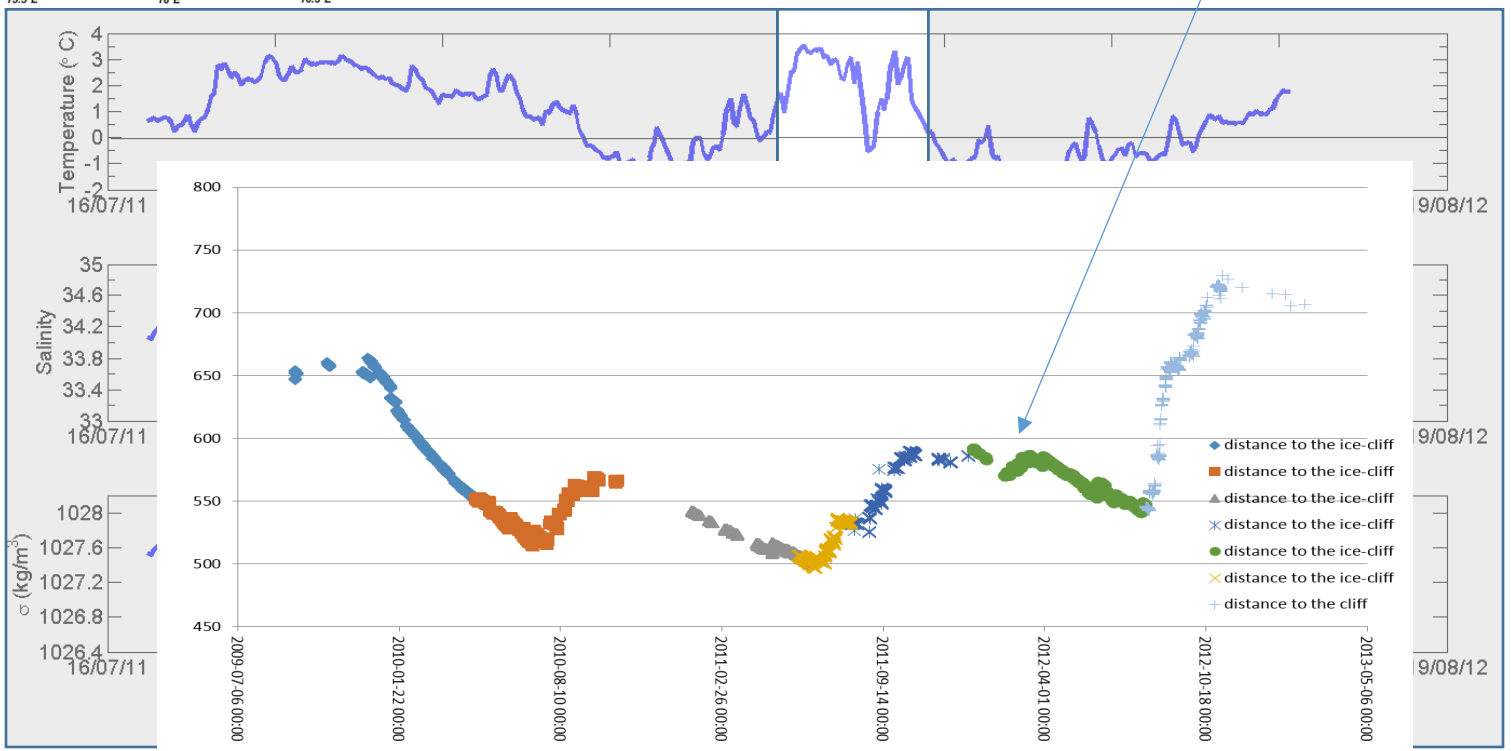
Stop of glacier calving during sea ice occupation

Daily mean temperature, salinity and density at AWAKE1 in 2011/2012



Inflow of Atlantic Water in February/March

Calving in February/March



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Thank You!
Fot. M. Błaszczyk