The development of a subglacial lake monitored with radio echo sounding and comparison with water volumes released during jökulhlaups: Case study from the Eastern Skaftá Cauldron in the Vatnajökull ice cap, Iceland

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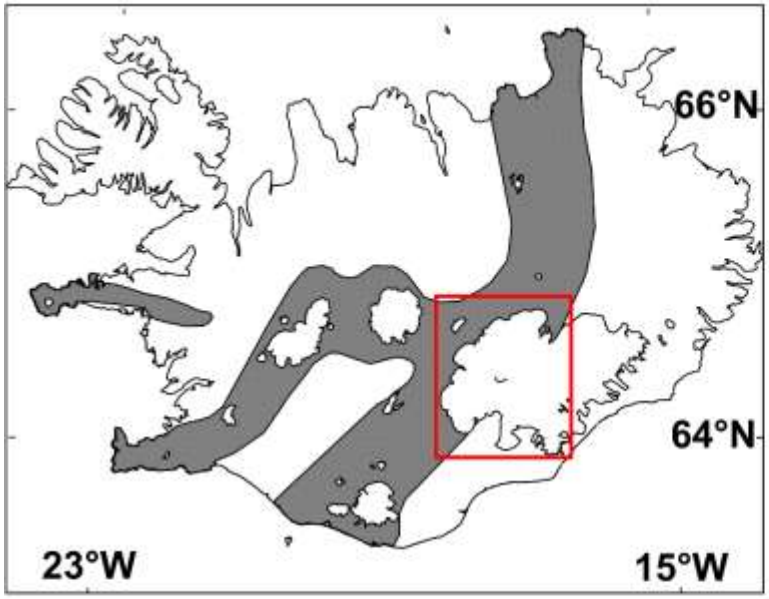
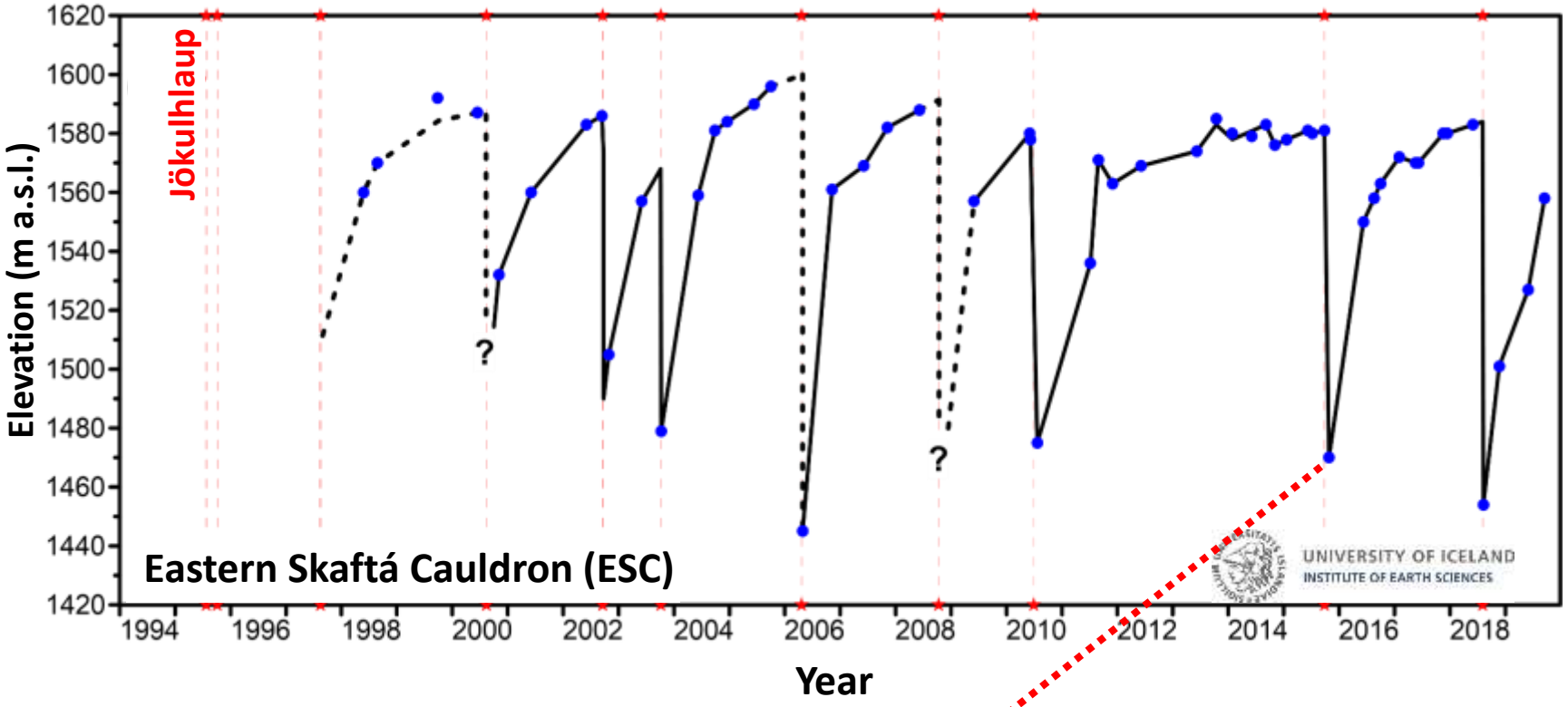
Introduction



Picture by Benedikt G. Ófeigsson

Estimated geothermal power beneath the Eastern Skaftá Cauldron (red box) is ~1 GW
(Guðmundsson et al., 2018)

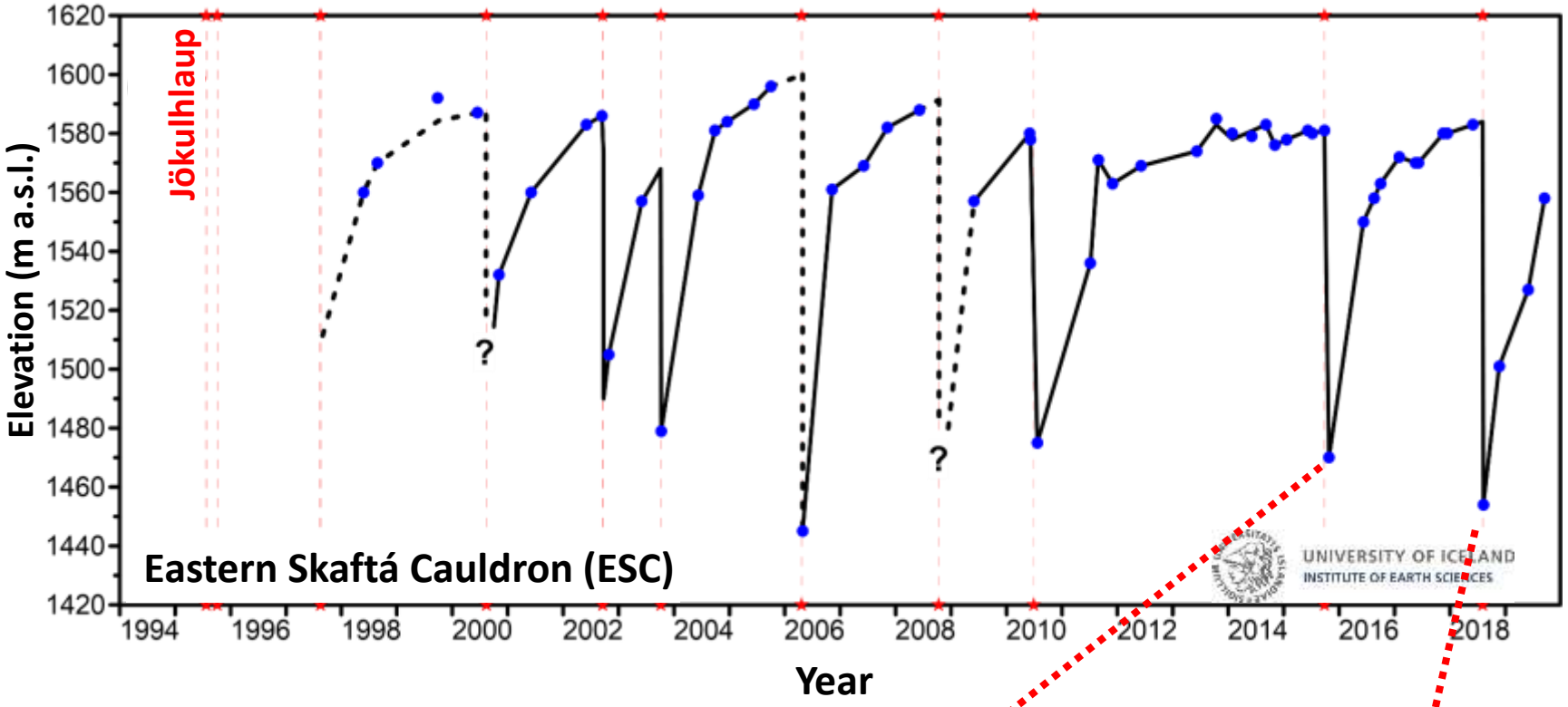
Introduction



~3000 $m^3 s^{-1}$ peak flow near glacier front

Check: https://www.youtube.com/watch?v=4NiDe2Wb5QU to see what this looks like!

Introduction



~3000 $m^3 s^{-1}$ peak flow near glacier front

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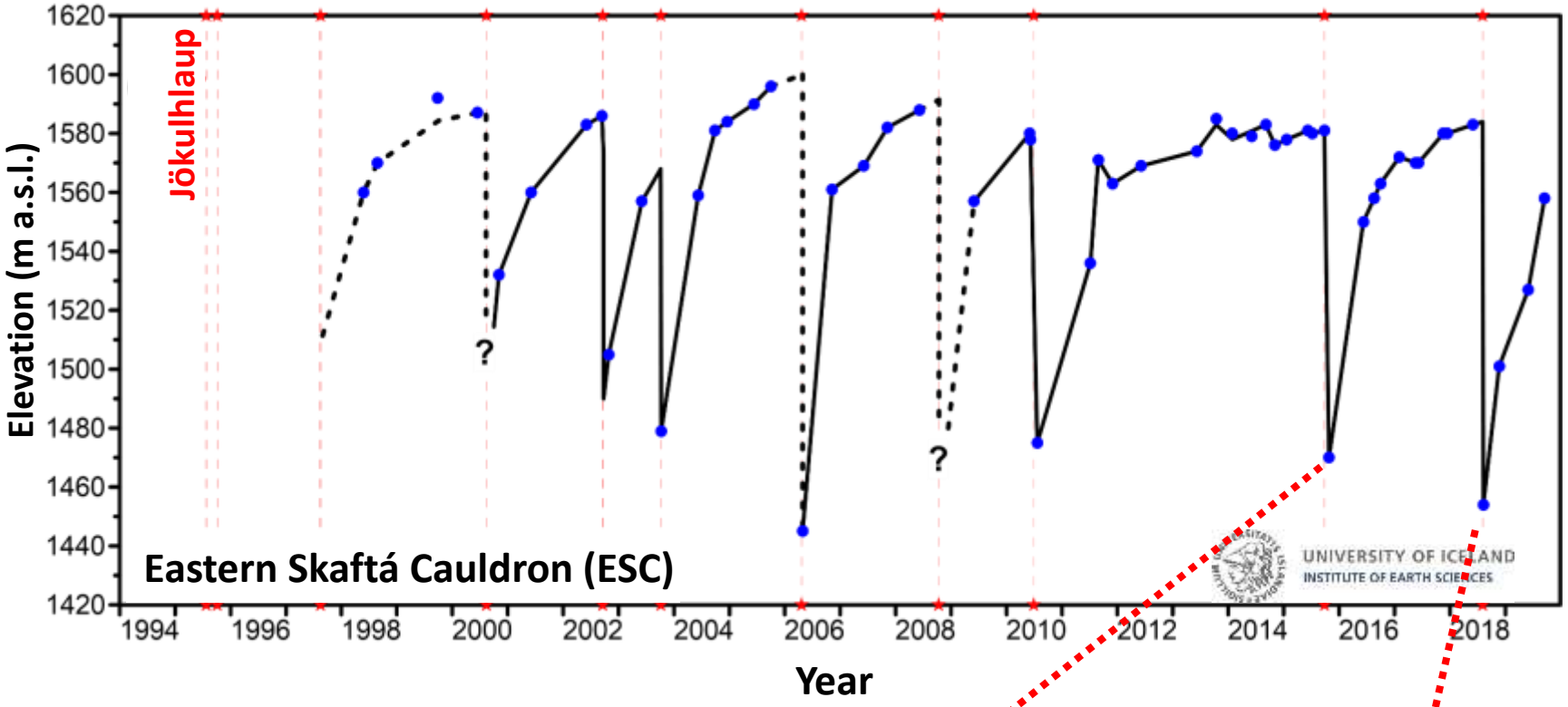


320±20 Gl (million m^3) released from ESC

210±25 Gl released from ESC

Introduction

Surface elevation measurements not good indicator of water stored beneath the cauldron and magnitude expected jökulhlaup

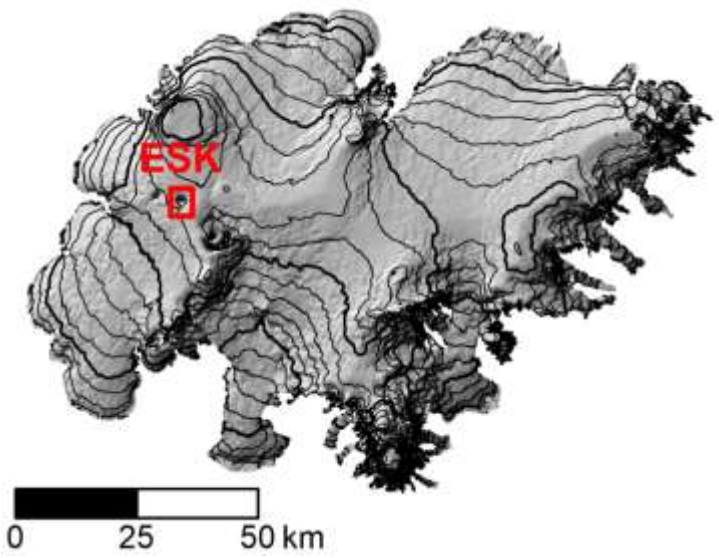
Picture by Benedikt G. Ófeigsson

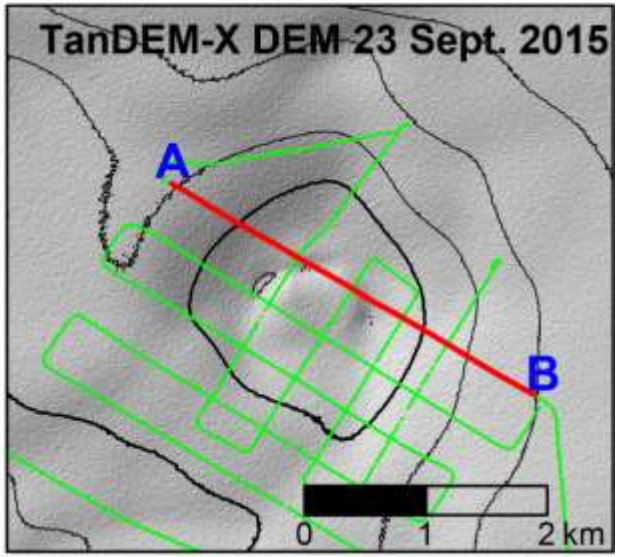
Introduction

Could low frequency radio echo sounding help?

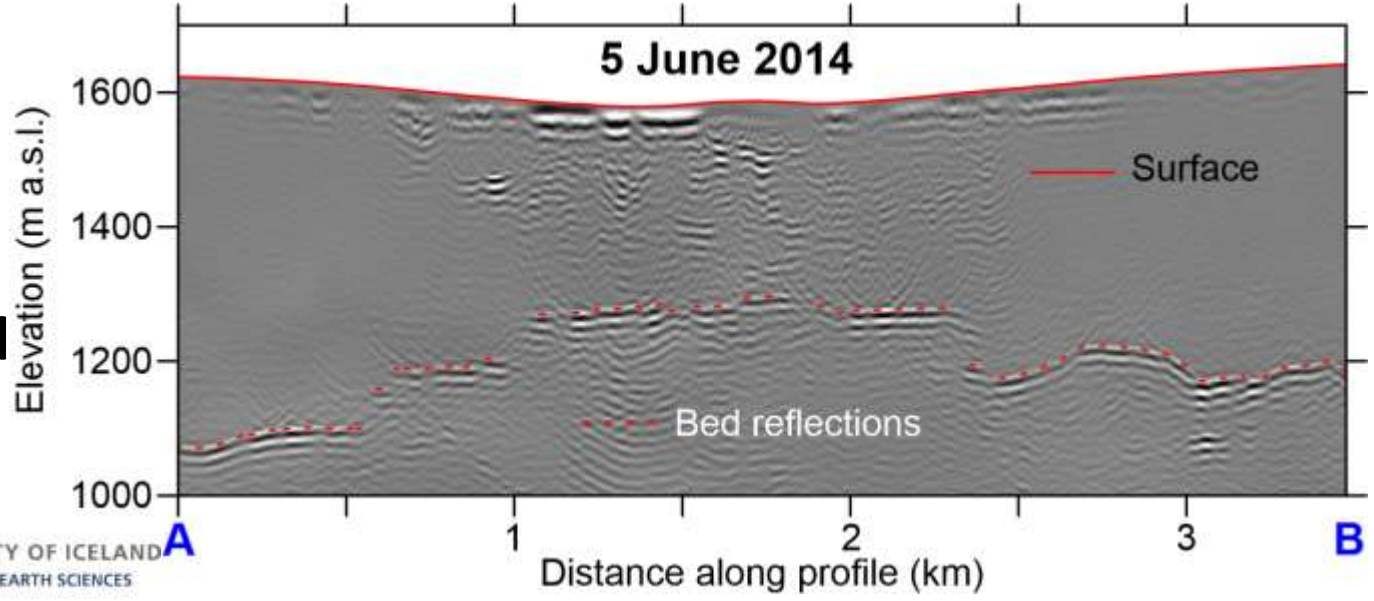
Picture by Benedikt G. Ófeigsson

The RES (~3 MHz) survey of the Eastern Skaftá cauldron 2014-2019

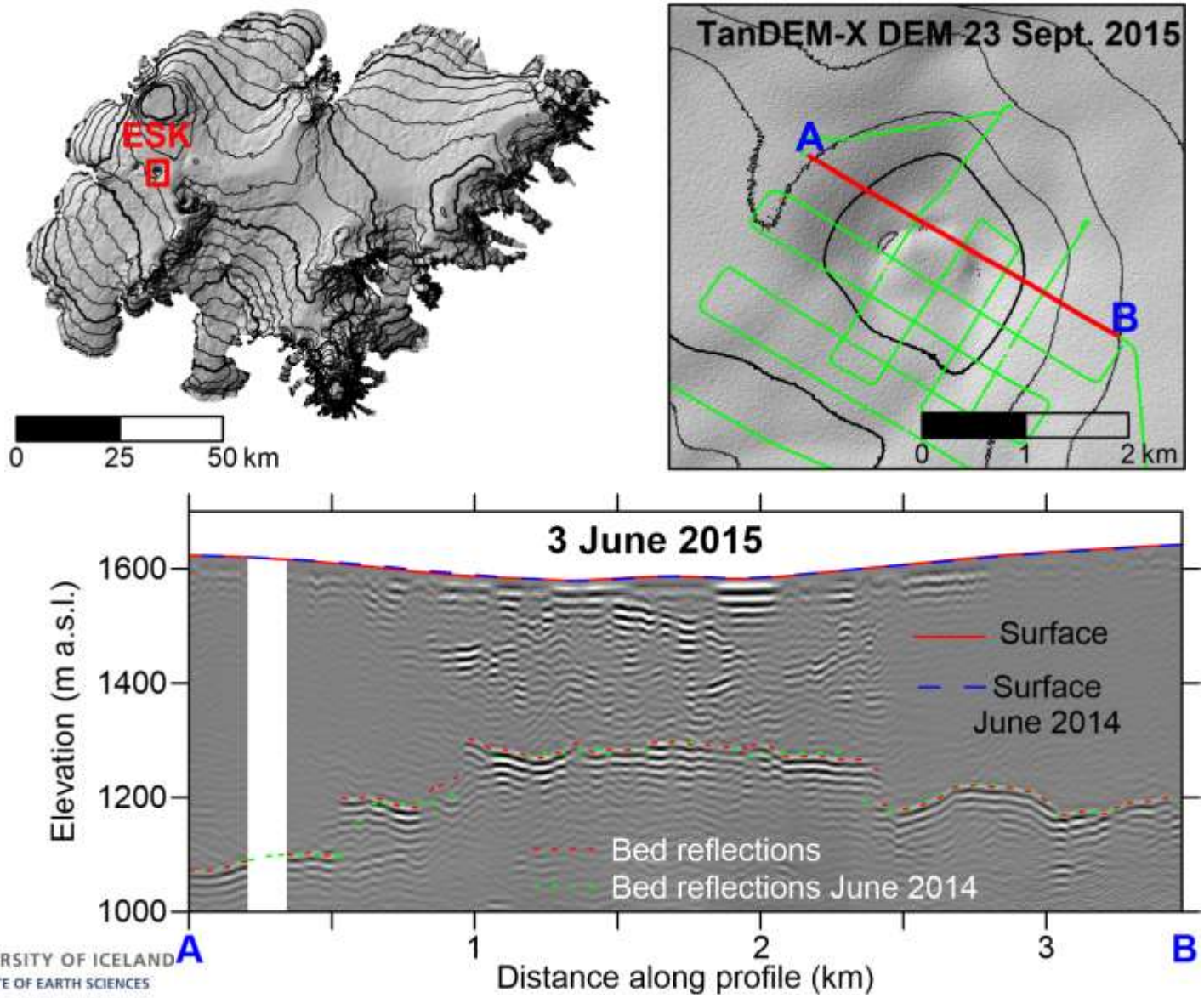




All profiles 2D migrated



The RES survey of the Eastern Skaftá cauldron 2014-2019



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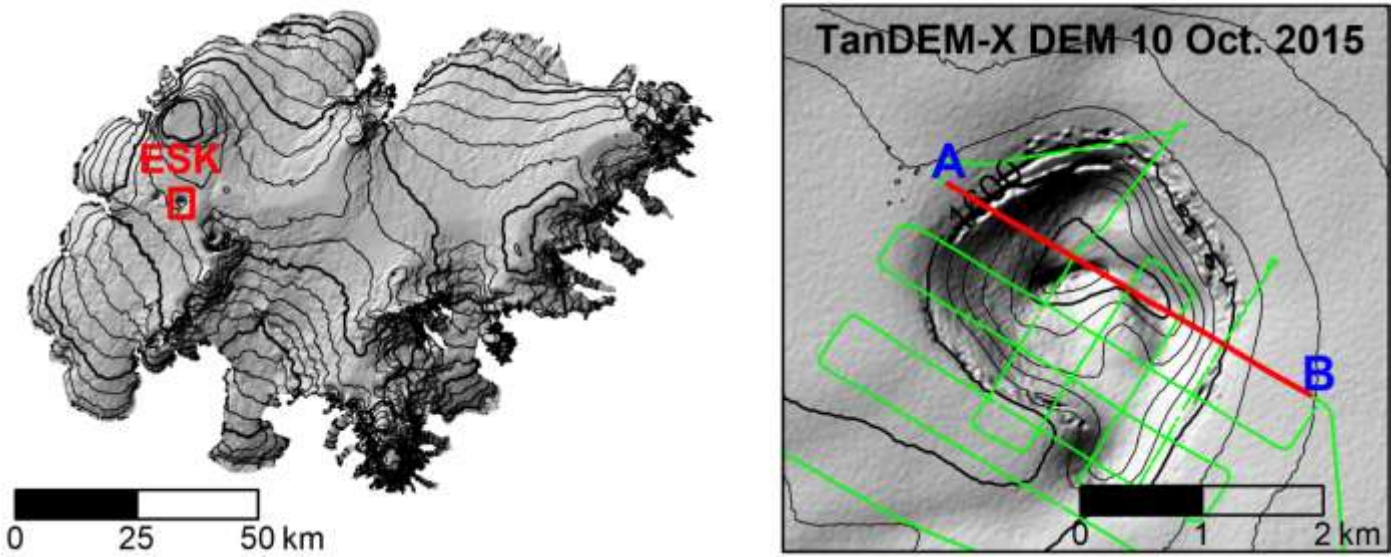

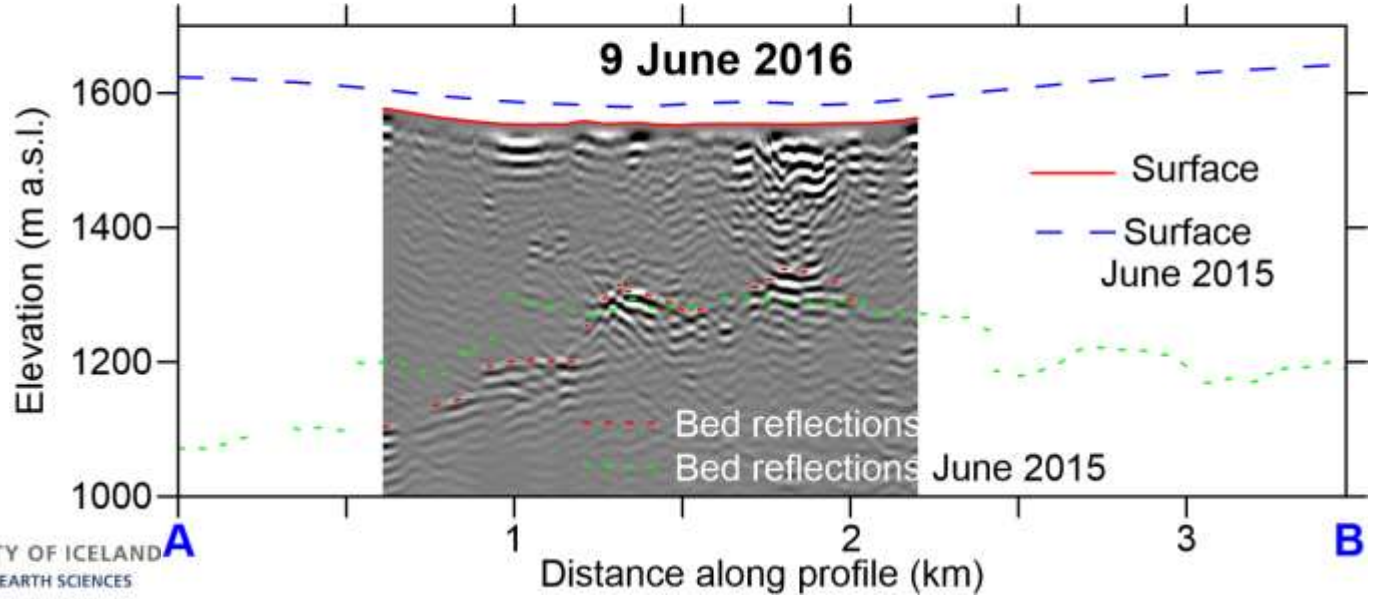

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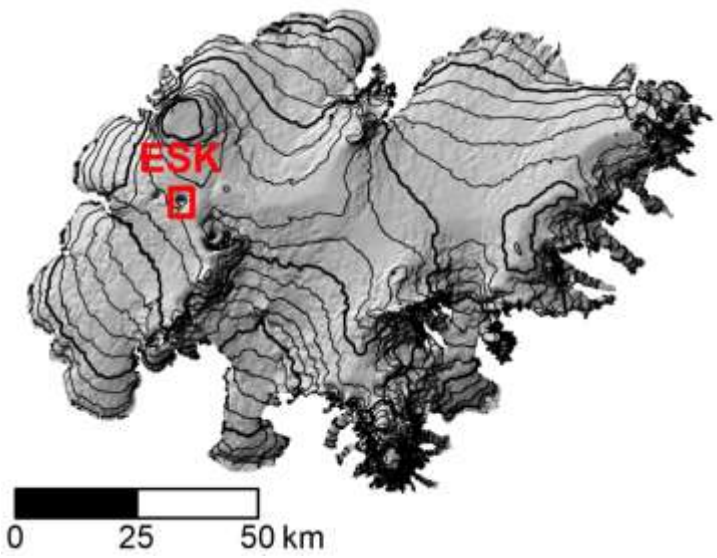

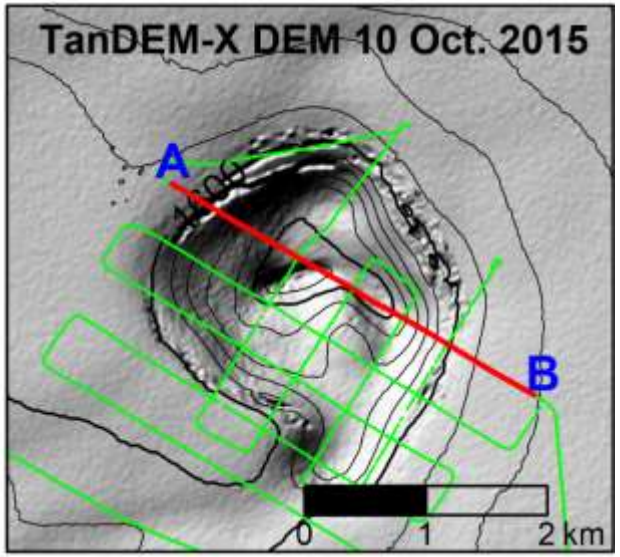

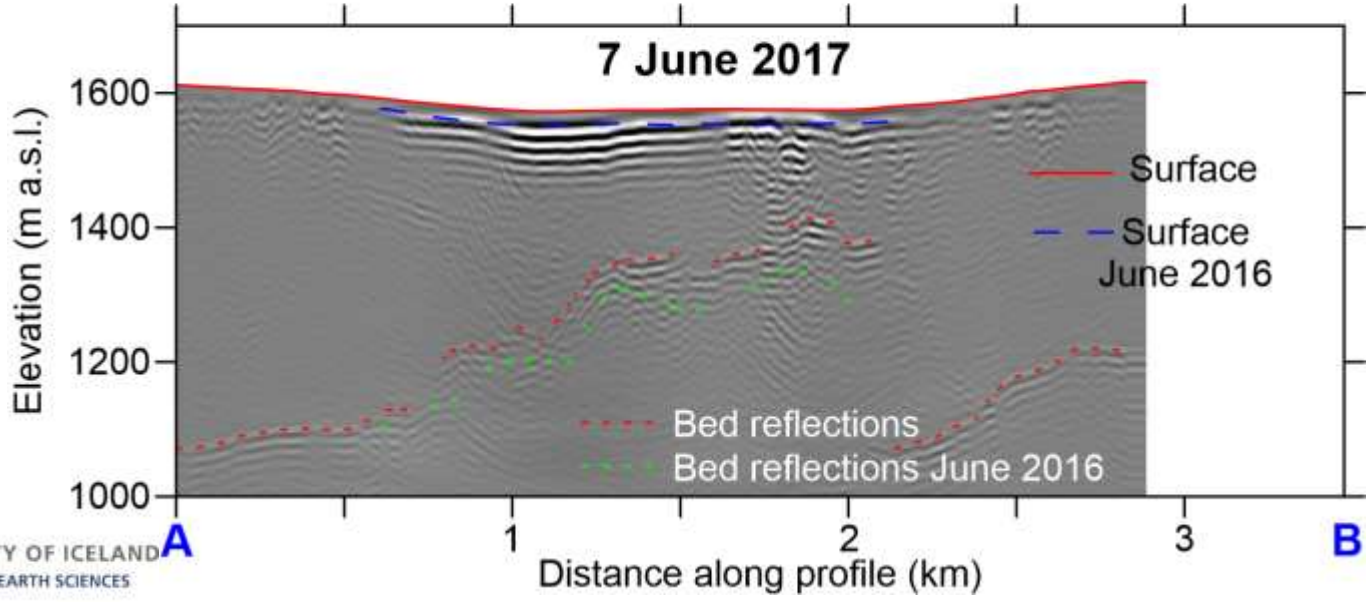

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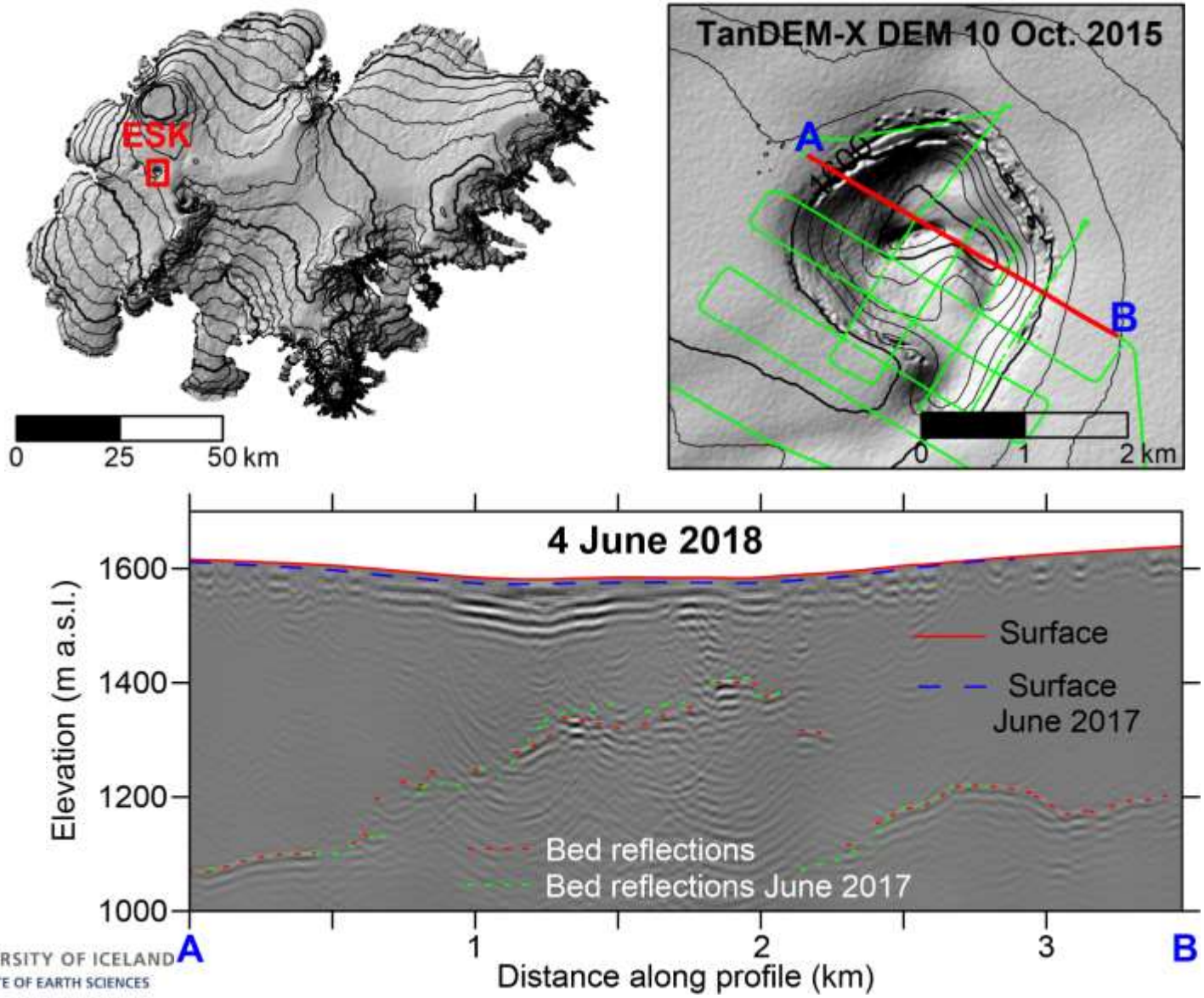

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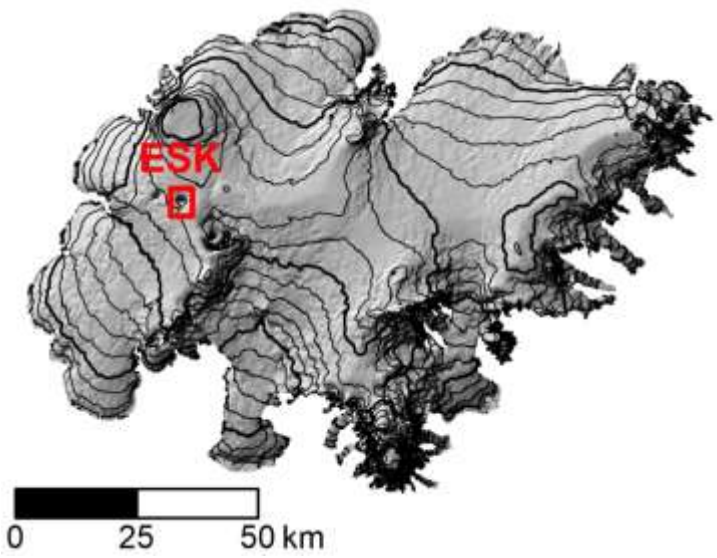

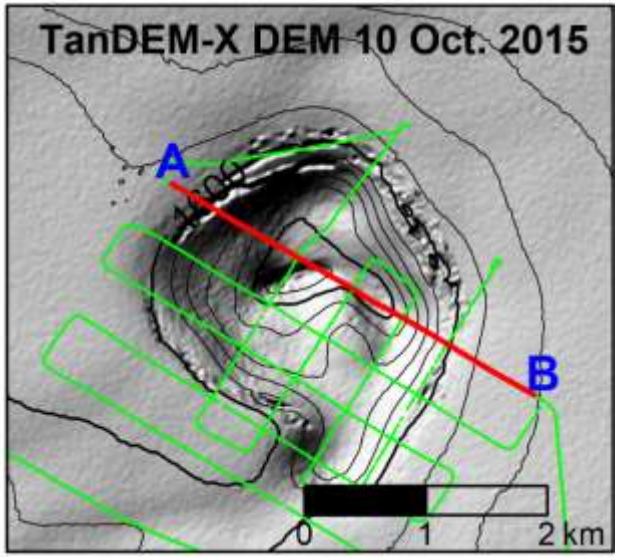

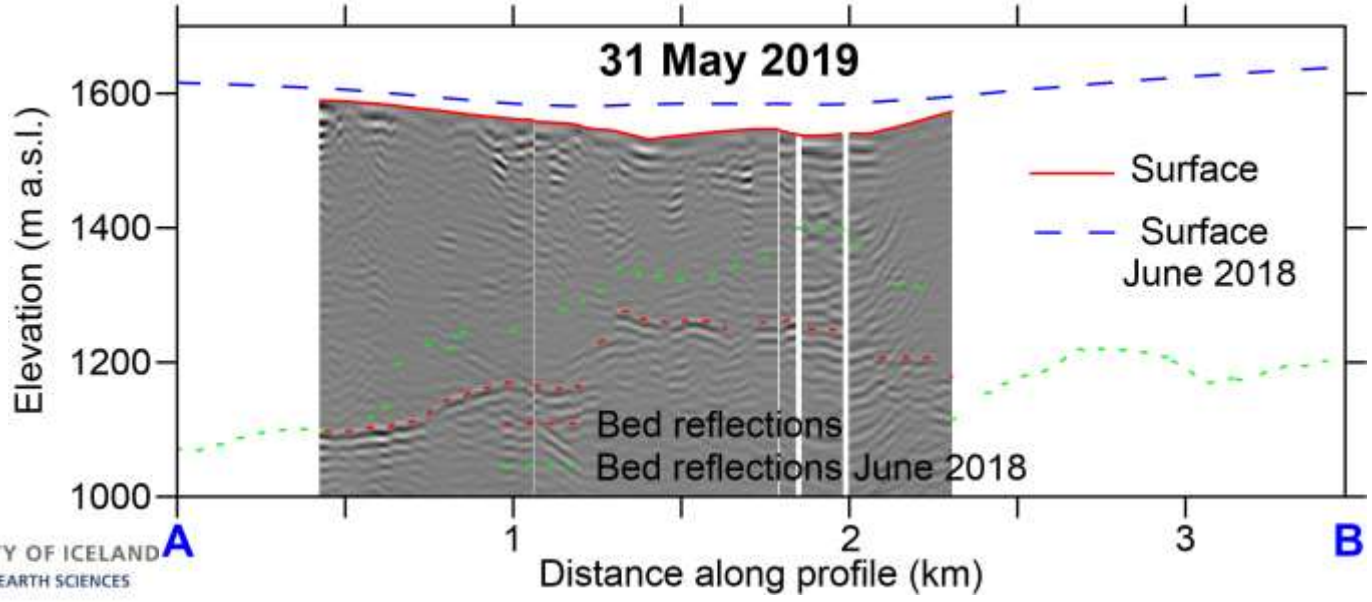

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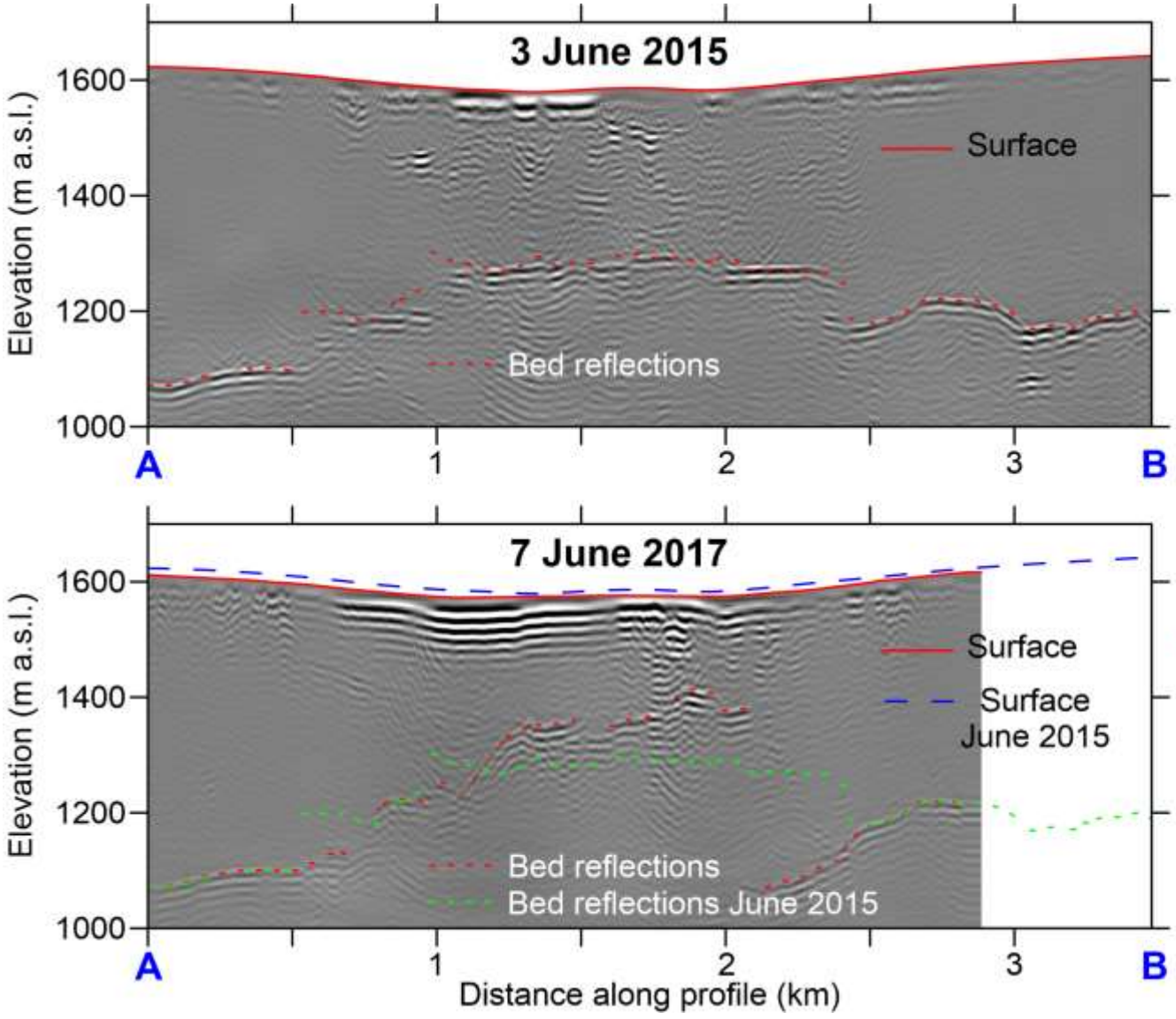

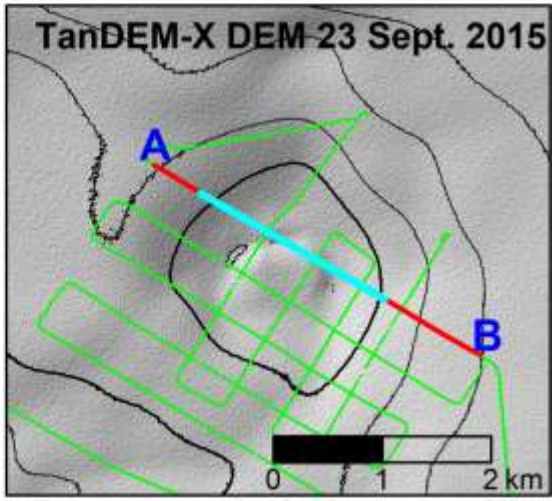

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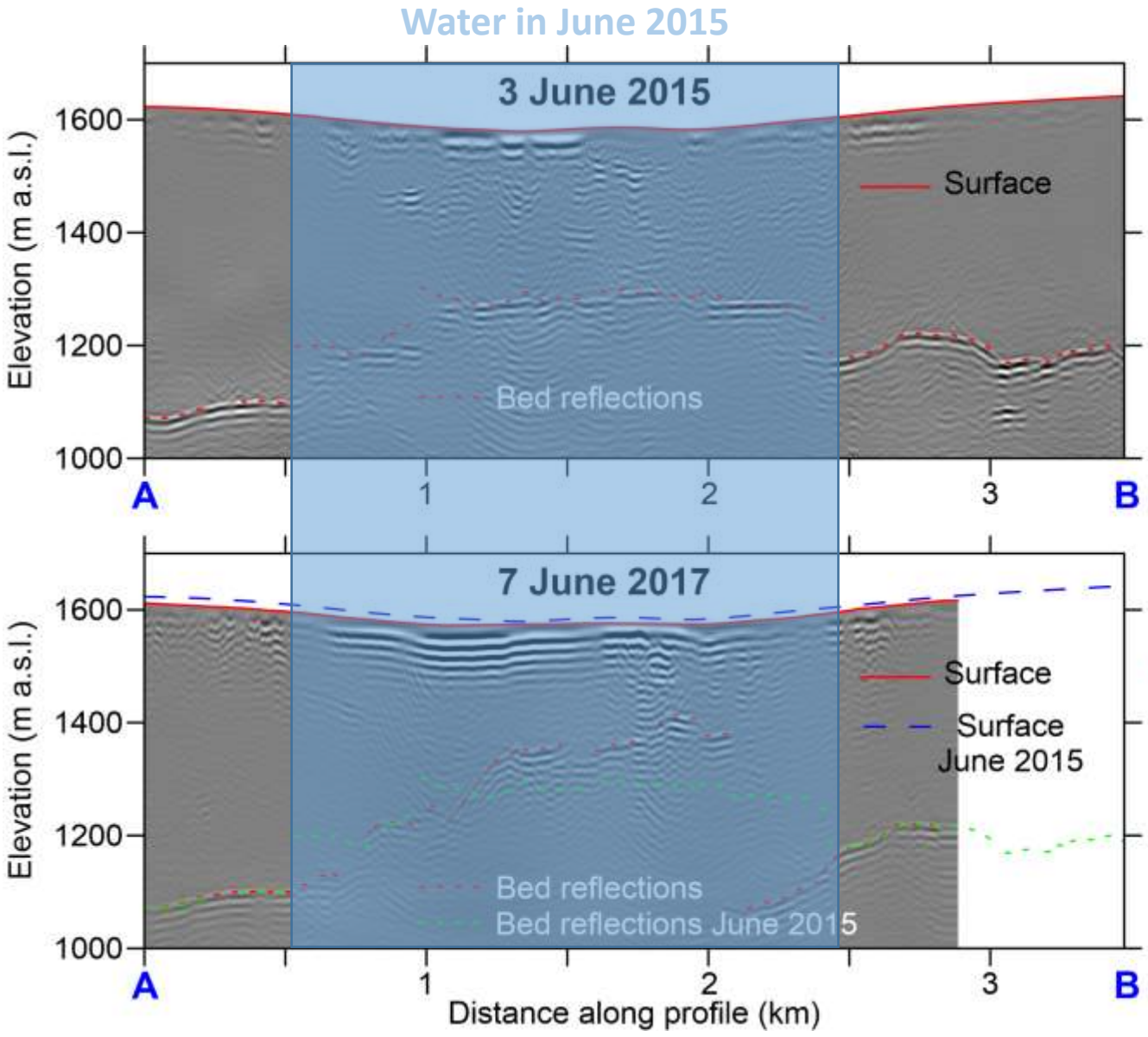

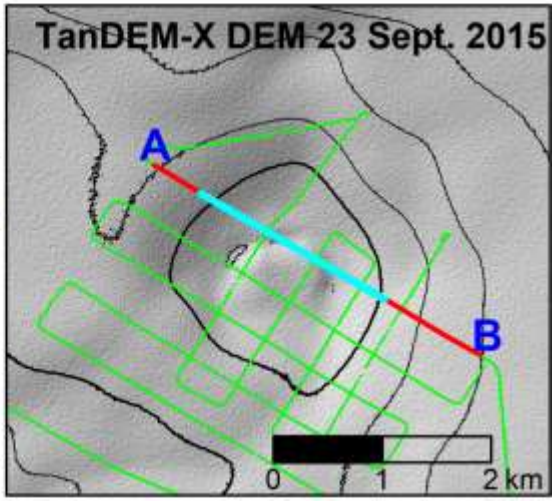

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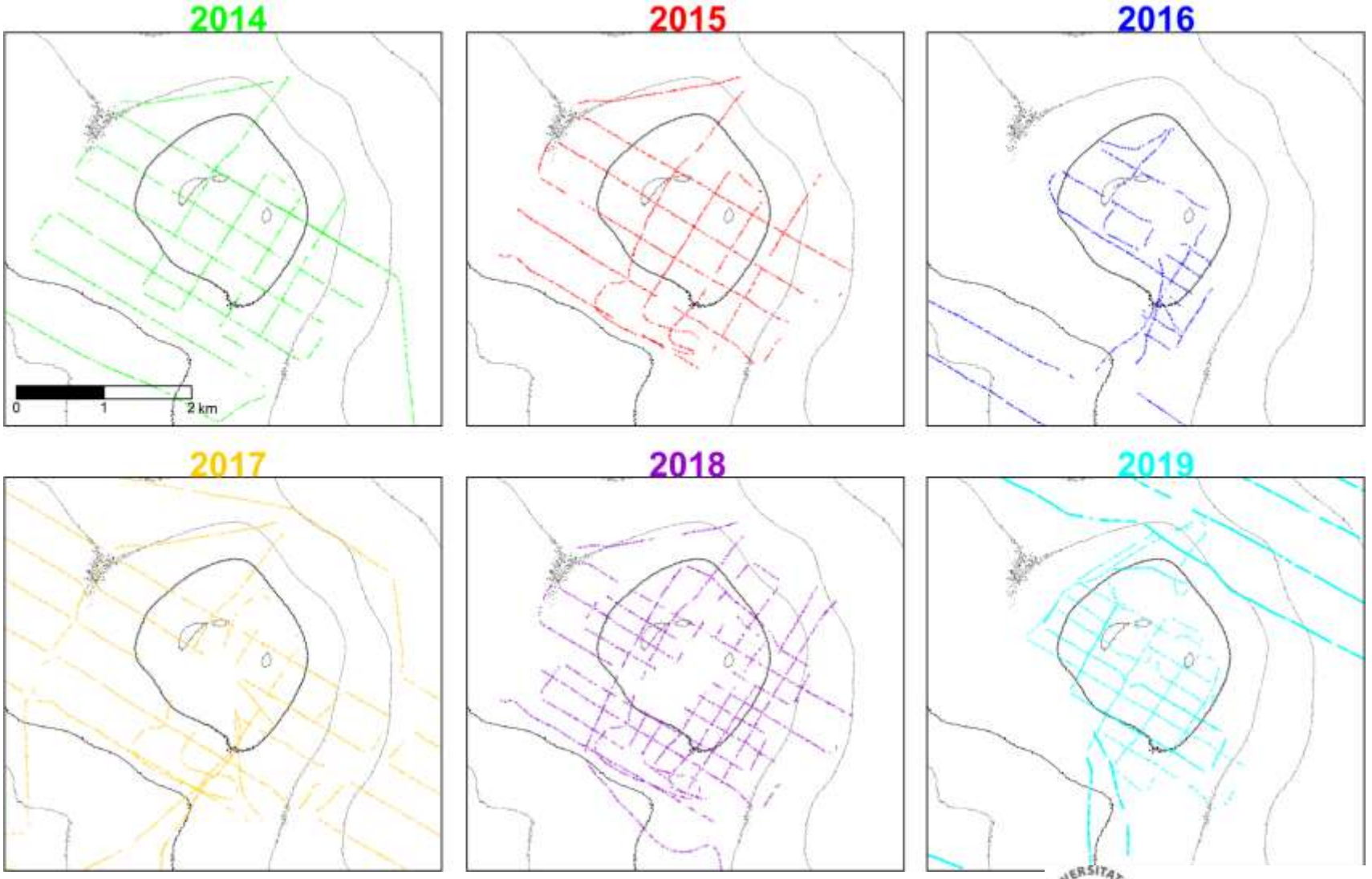

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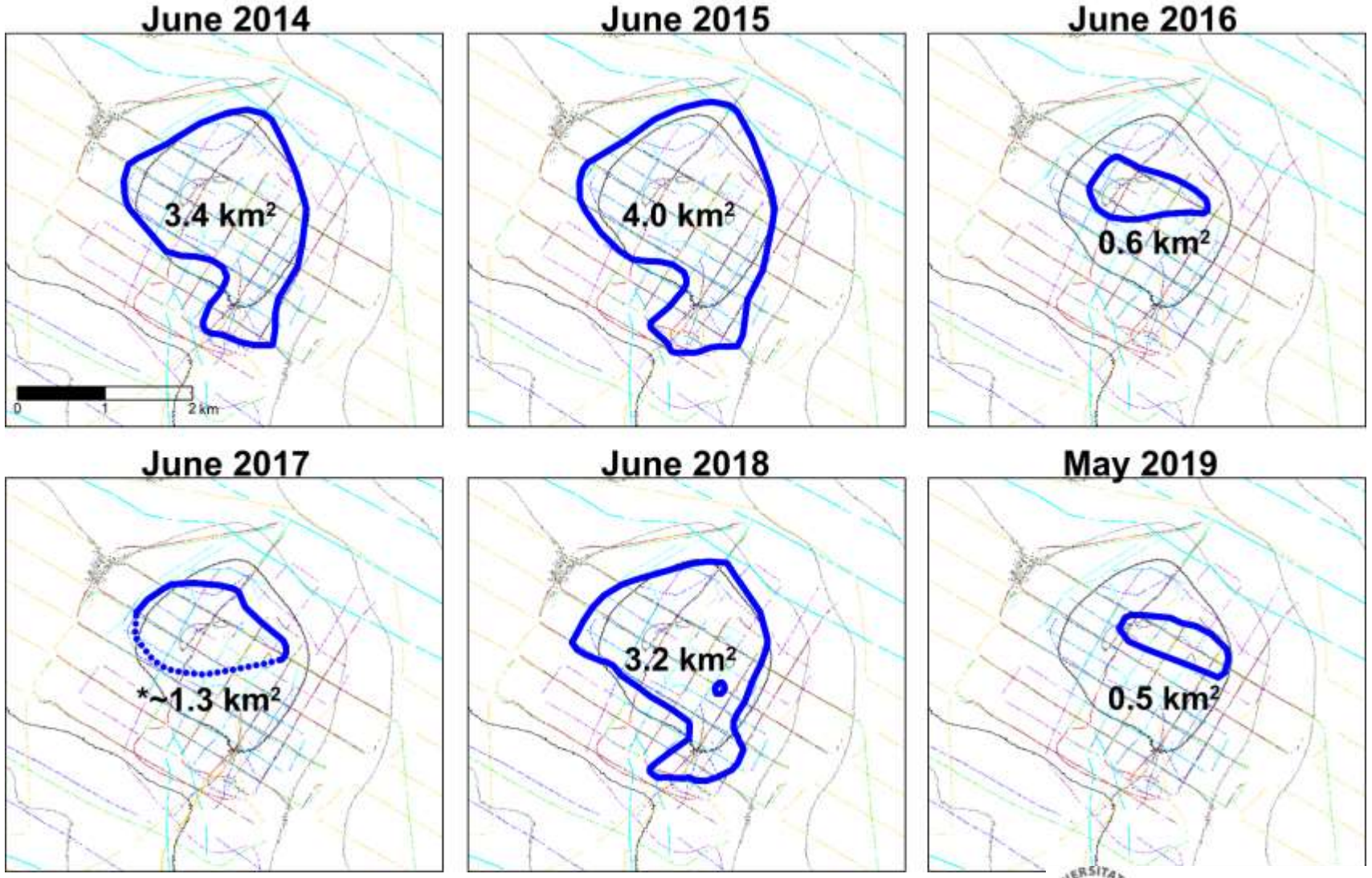
Co-interpretation of all data reveals lake margin and size for each year



* Southern margin uncertain

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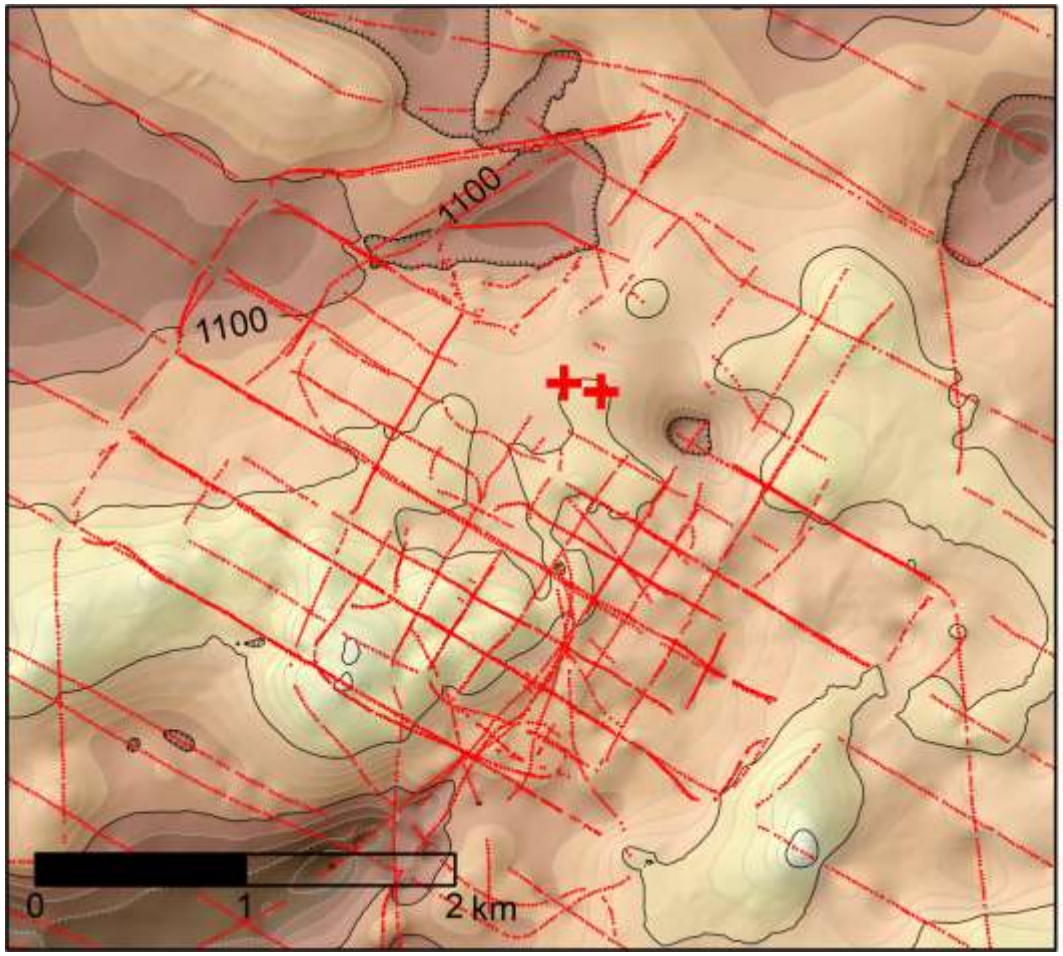
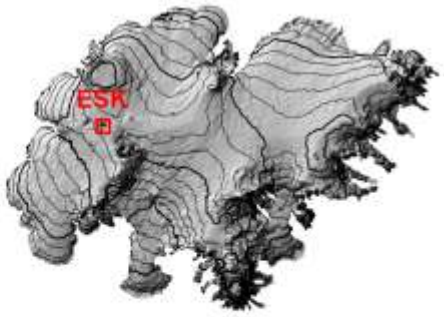
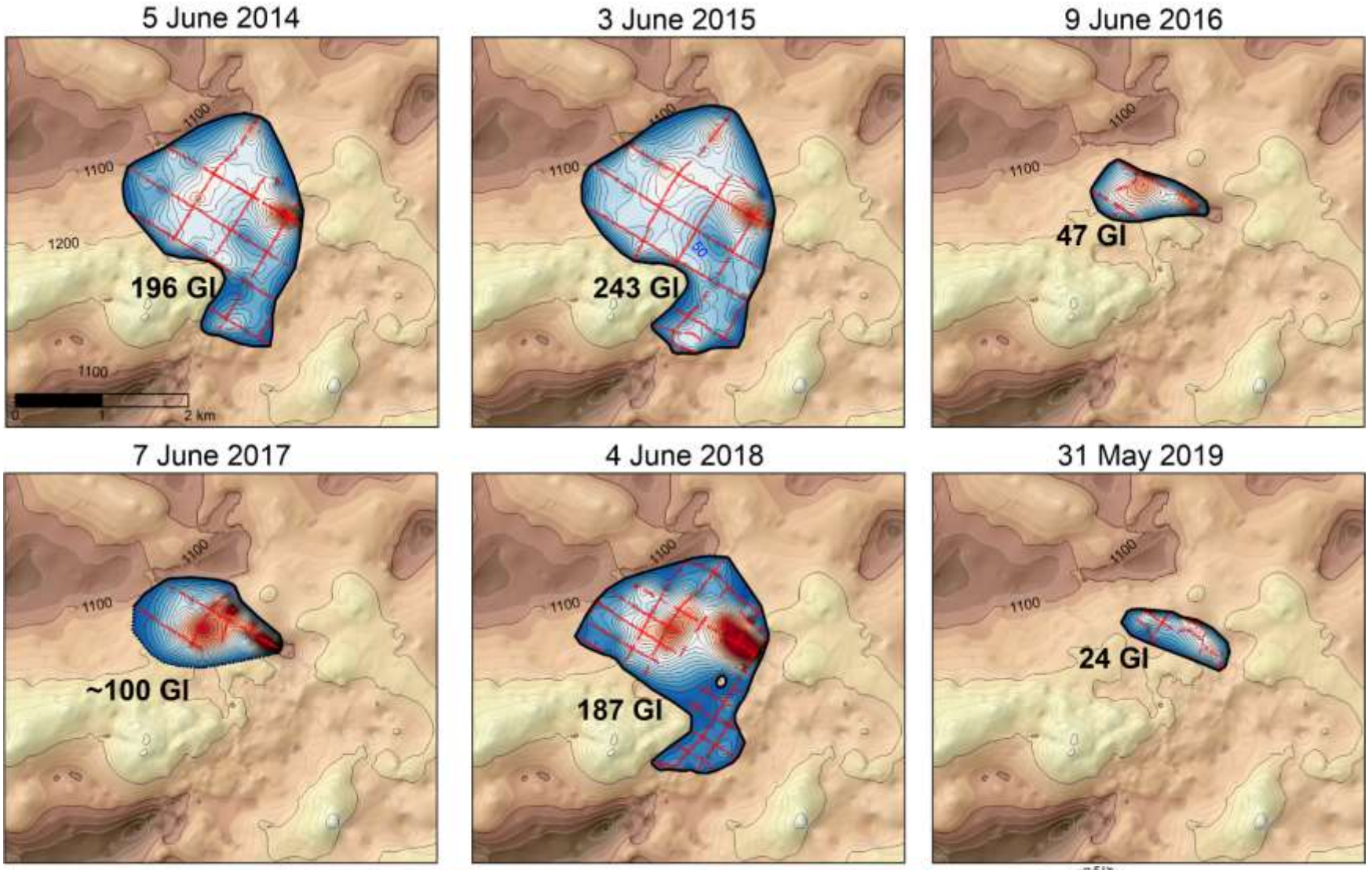
Bedrock DEM interpolated with kriging method from RES-data outside lake margins (combined data set for all years)





Bed elevation from borehole measurements

The development of the subglacial lake. Lake depth obtained by comparing bedrock DEM and res within lake margin



1 Gl = 1 million m^3

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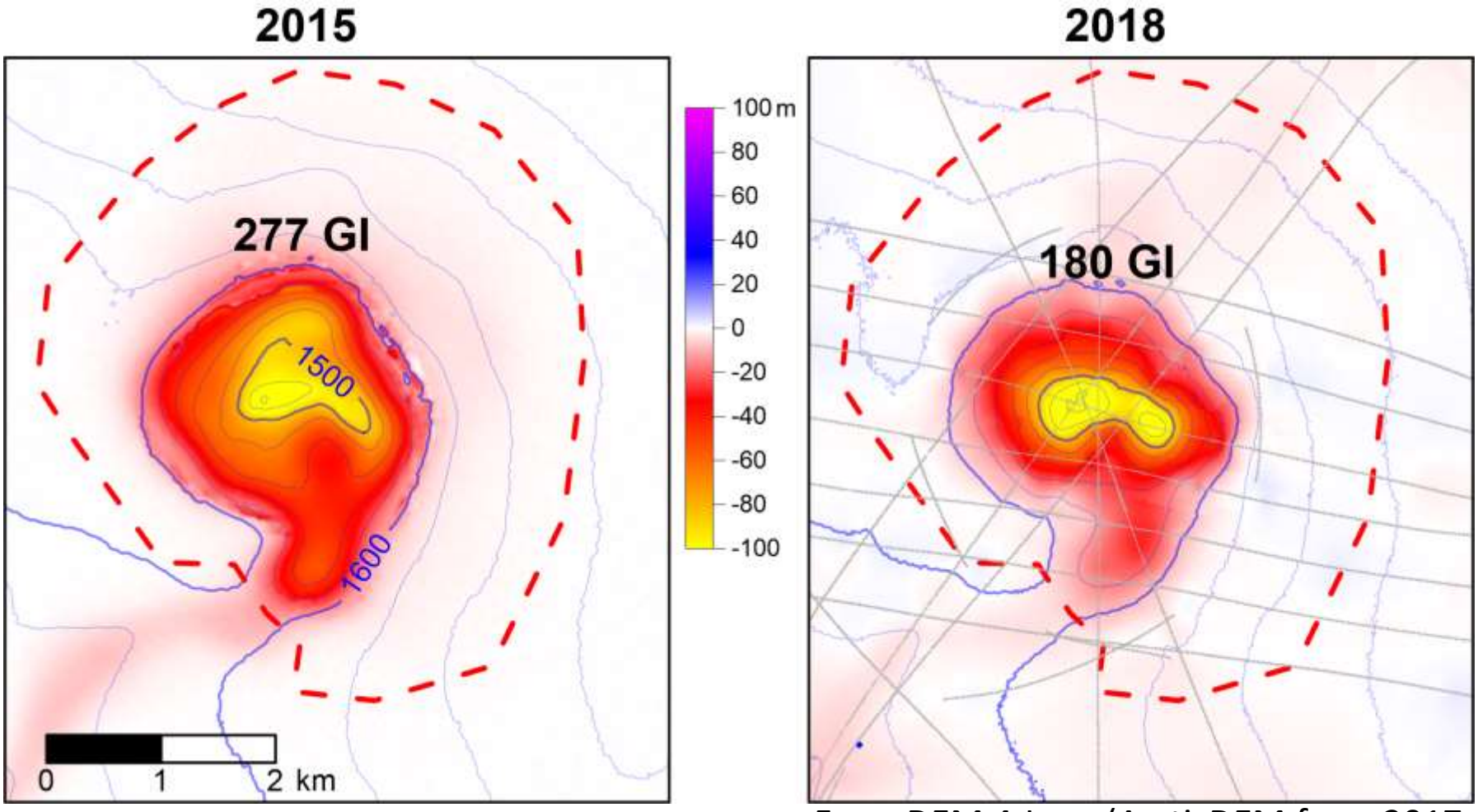
Lowering in jökulhlaups



From TanDEM-X DEMs
23 Sept. and 10 Oct. 2015

From DEM 4 June (ArcticDEM from 2017 adjusted with GPS profiles in June 2018) and airborne radar profiles (grey) 9 August 2018

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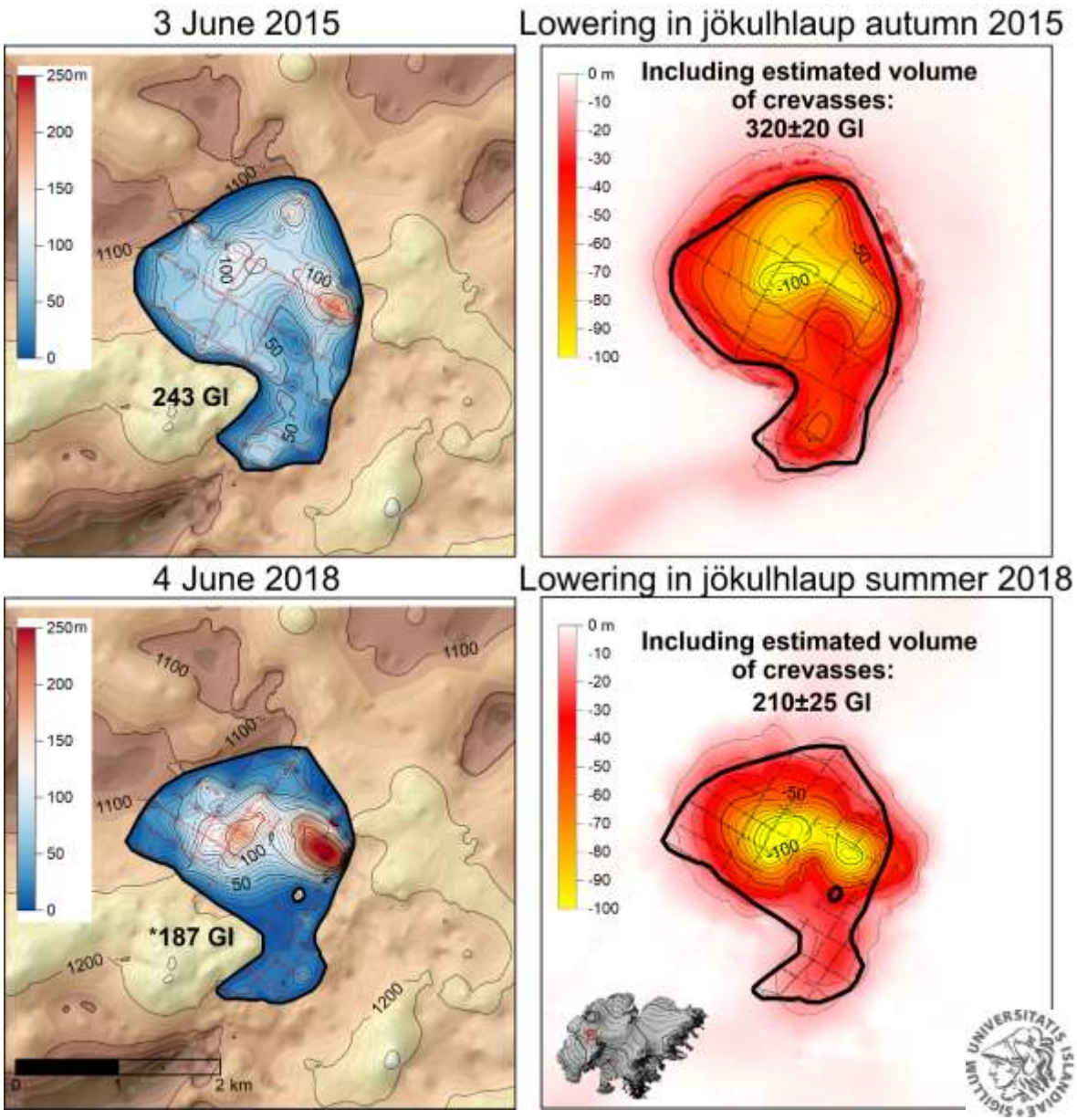
Lake vs. lowering in jökulhlaups



* The 2018 volume was estimated as 180 Gl in the summer 2018 prior to the jökulhlaup (without using the 2019 RES data set)

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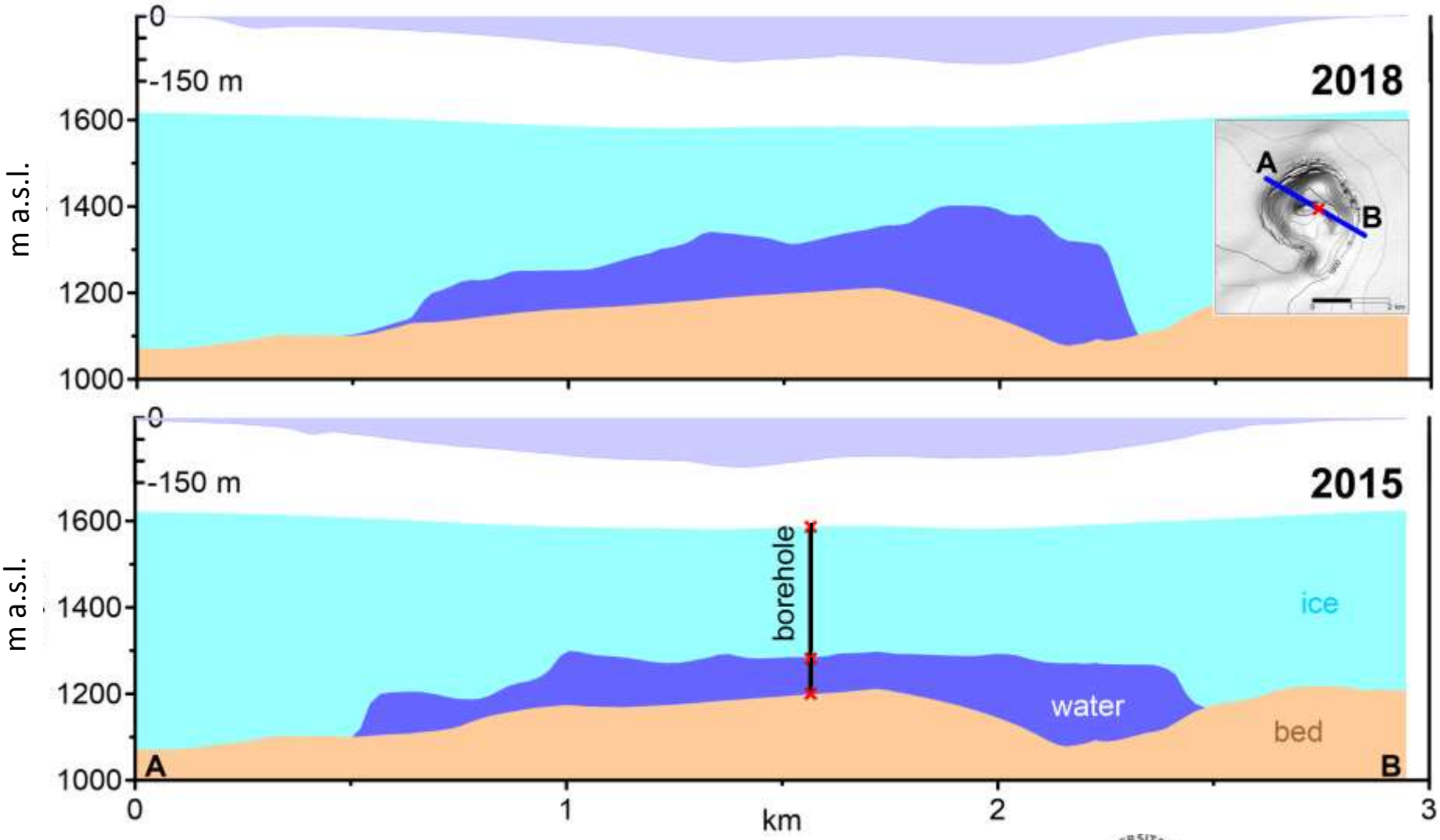
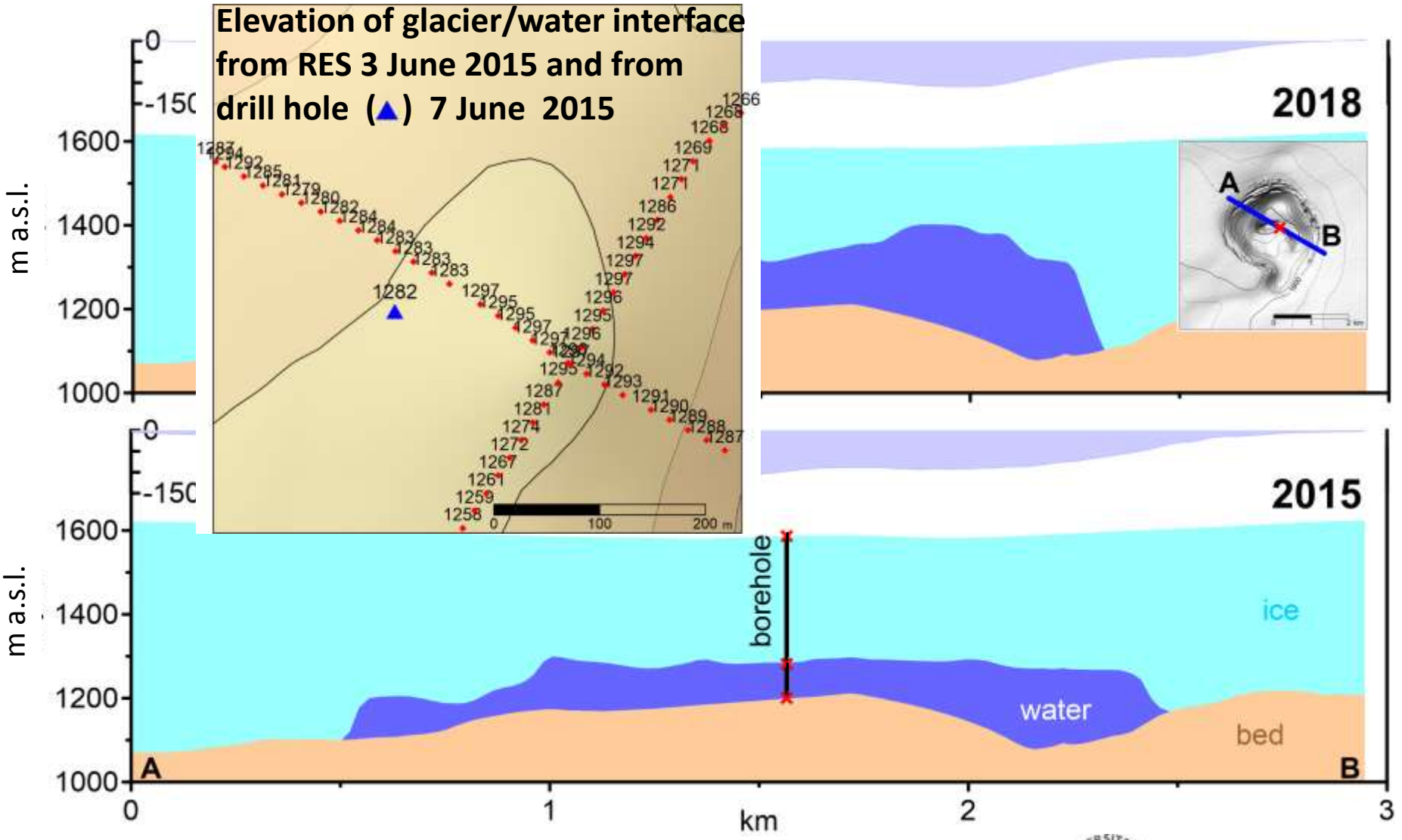
Lake vs. lowering in jökulhlaups



No vertical exaggeration!

Lake vs. lowering in jökulhlaups



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Conclusions

- RES gives new insight into the shape and the development of the subglacial lake beneath the Eastern Skaftá cauldron

- It is currently the only available monitoring tool that can give us an idea on the amount water stored in the lake

- Based on this RES data we were able to give fairly accurate estimate on how much water was beneath the Eastern Skaftá cauldron when a jökulhlaup started in 2018

Acknowledgements

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Picture by Þorsteinn Cameron