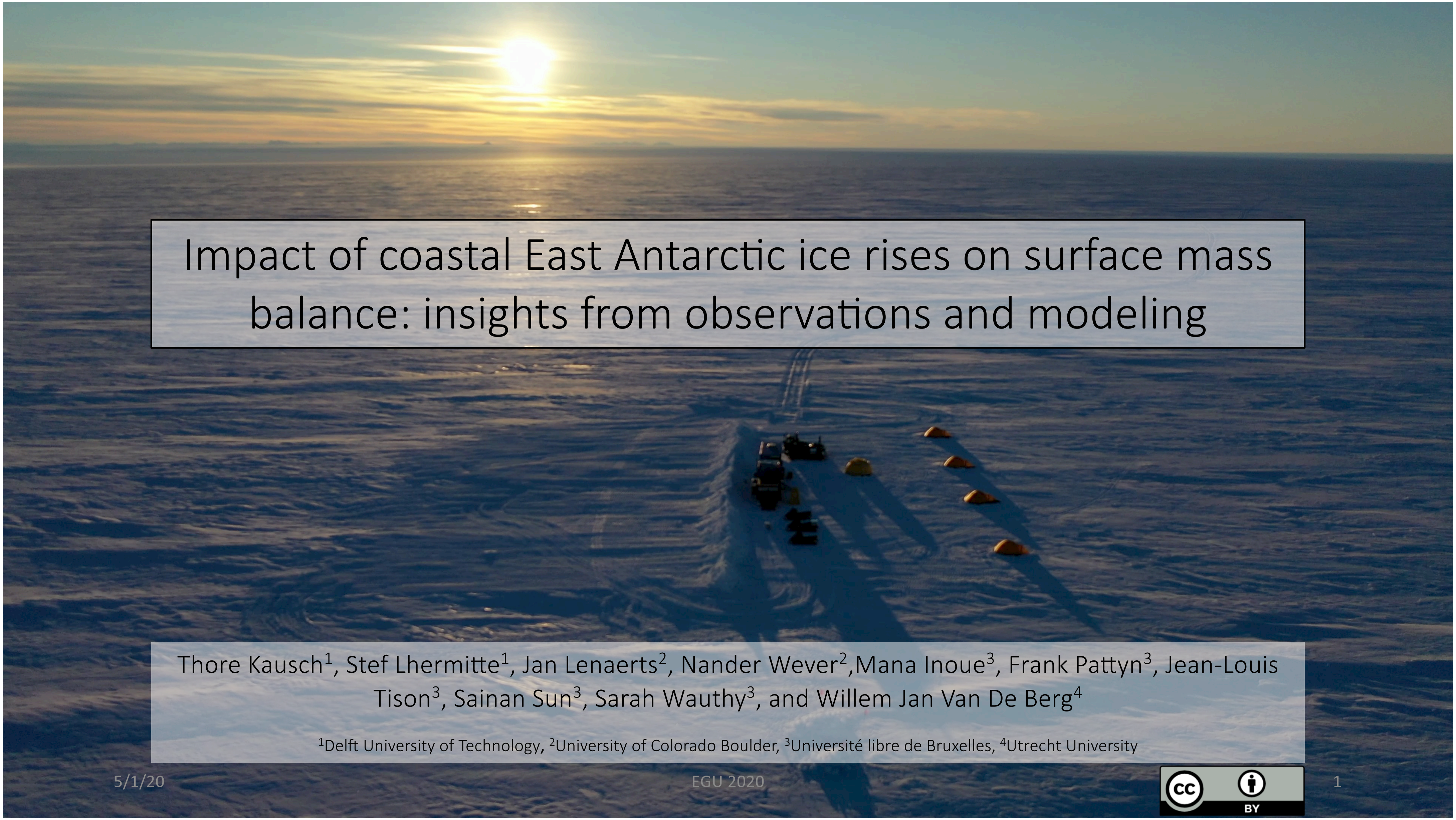

# Impact of coastal East Antarctic ice rises on surface mass balance: insights from observations and modeling

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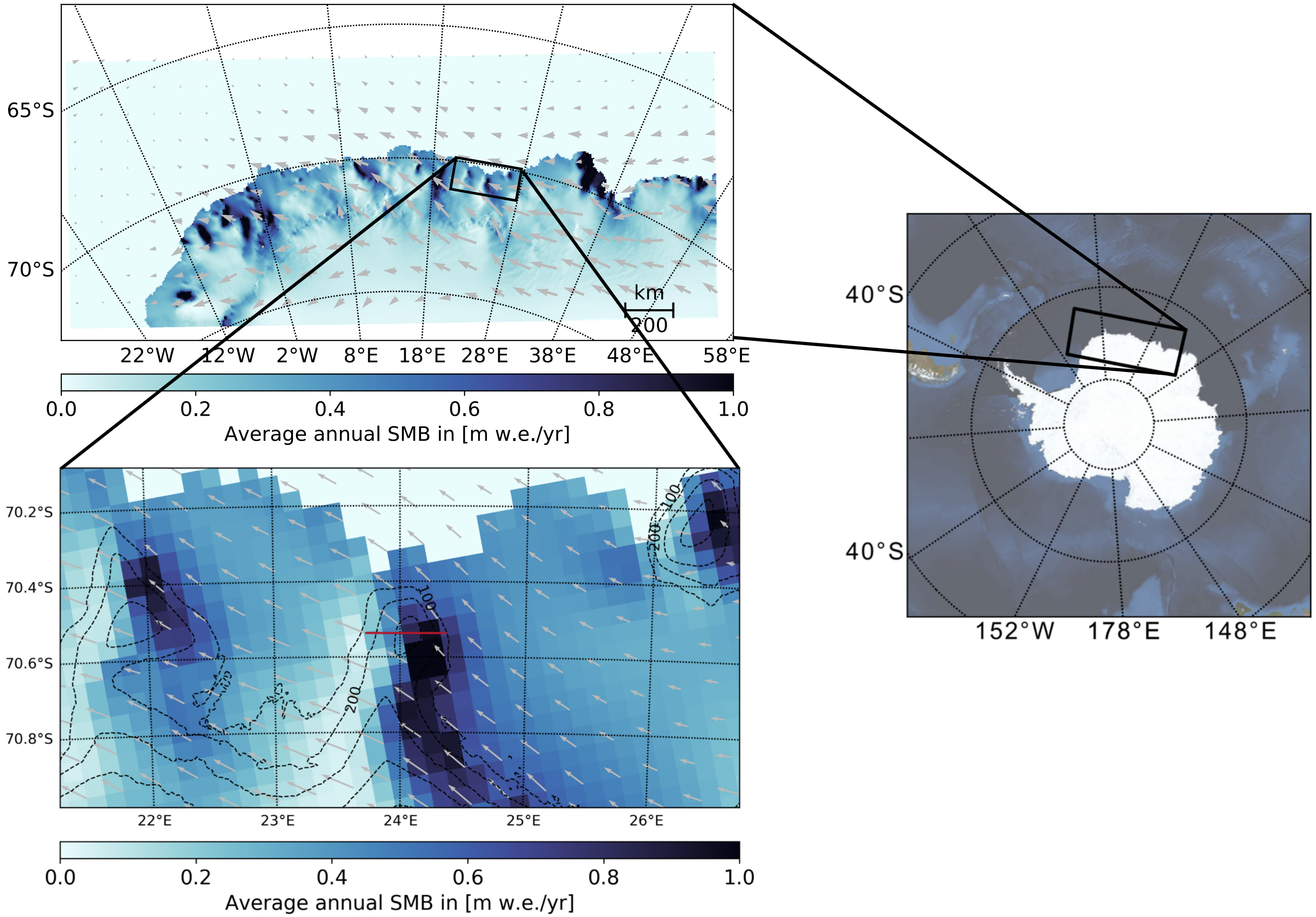
# Introduction

- About 20 % of all snow accumulation in Antarctica occurs on the ice shelves
- Ice rises control the spatial surface mass balance (SMB) distribution of the ice shelfs
- Ice rises represent ideal drilling locations for ice cores
- Here we assess the connection between snowfall variability and wind erosion across an ice rise to provide a better understanding of :
    1. How ice rises impact SMB variability
    2. This is captured in the regional atmospheric climate model RACMO2.3 (van Wessem et al., 2018)
    3. What are the implications of this SMB variability for ice rises as an ice core drilling site
- By:

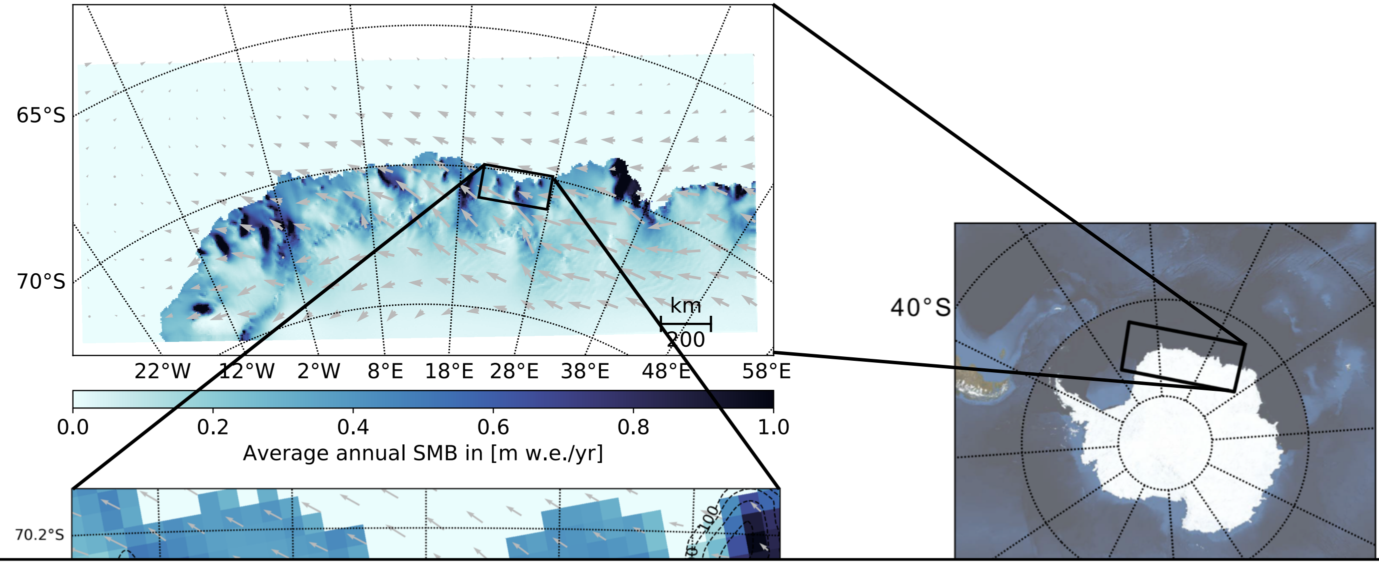
  1. Combining ground penetrating radar (GPR) profiles from an ice rises in Dronning Maud Land with ice core dating

  2. Reconstruct spatial and temporal SMB variations from 1982 to 2017 and compare the observed SMB with output from RACMO2.3 and SnowModel (Liston and Elder, 2006).

# SMB variability in Dronning Maud Land

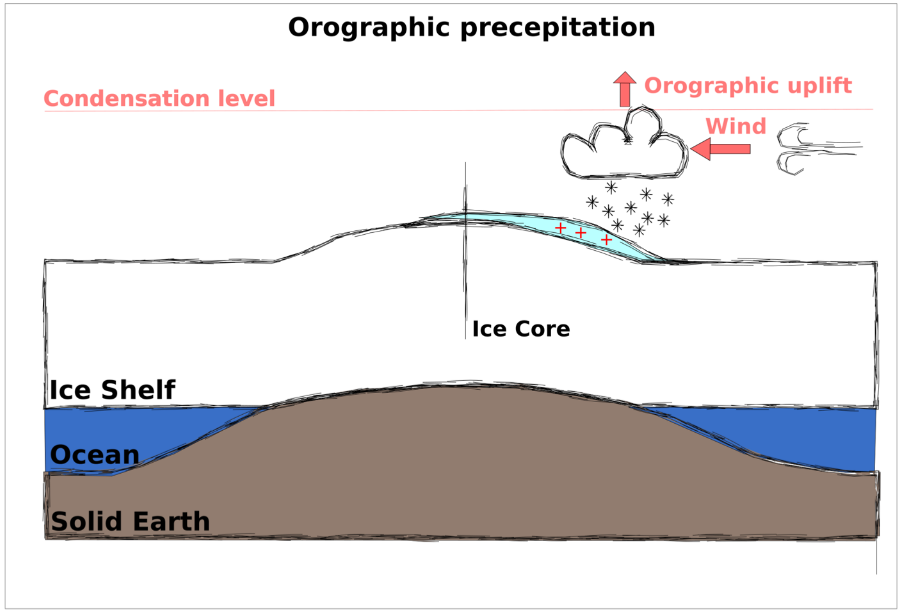


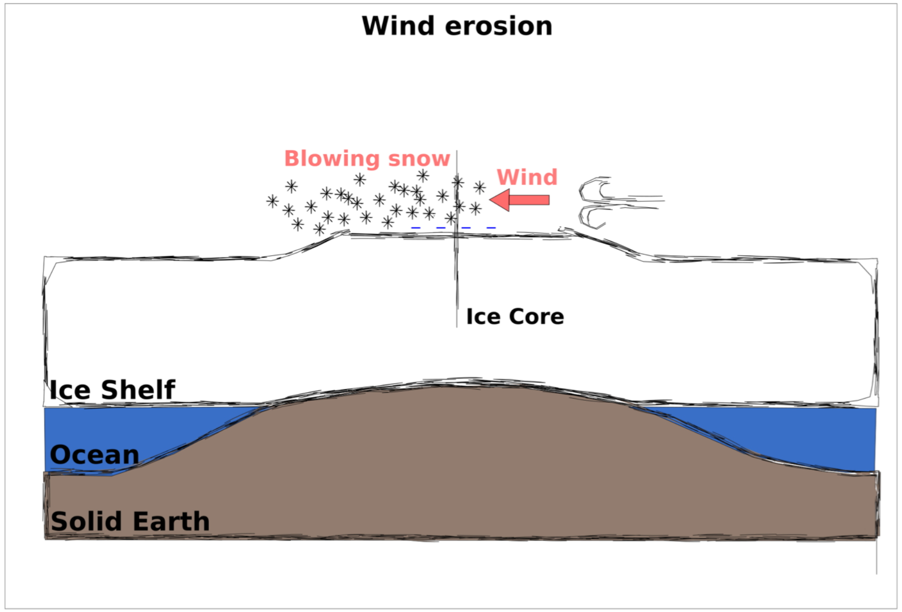
# SMB variability in Dronning Maud Land



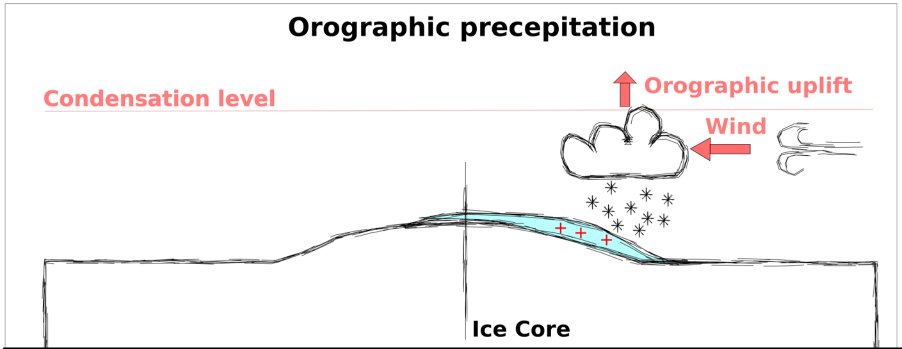

- SMB modelled by RACMO2.3 (van Wessem et al., 2018) for the time period of 2011 to 2017
- grey arrows show RACMO2.3 wind vectors
- Topography contour lines are based on the 90m TanDEM-X DEM (© DLR 2018)
- The red line shows the location of the recorded GPR tracks.

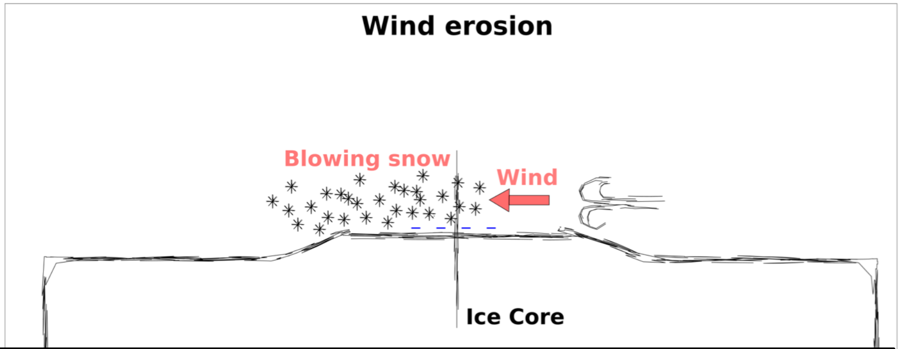
# SMB processes at ice rises



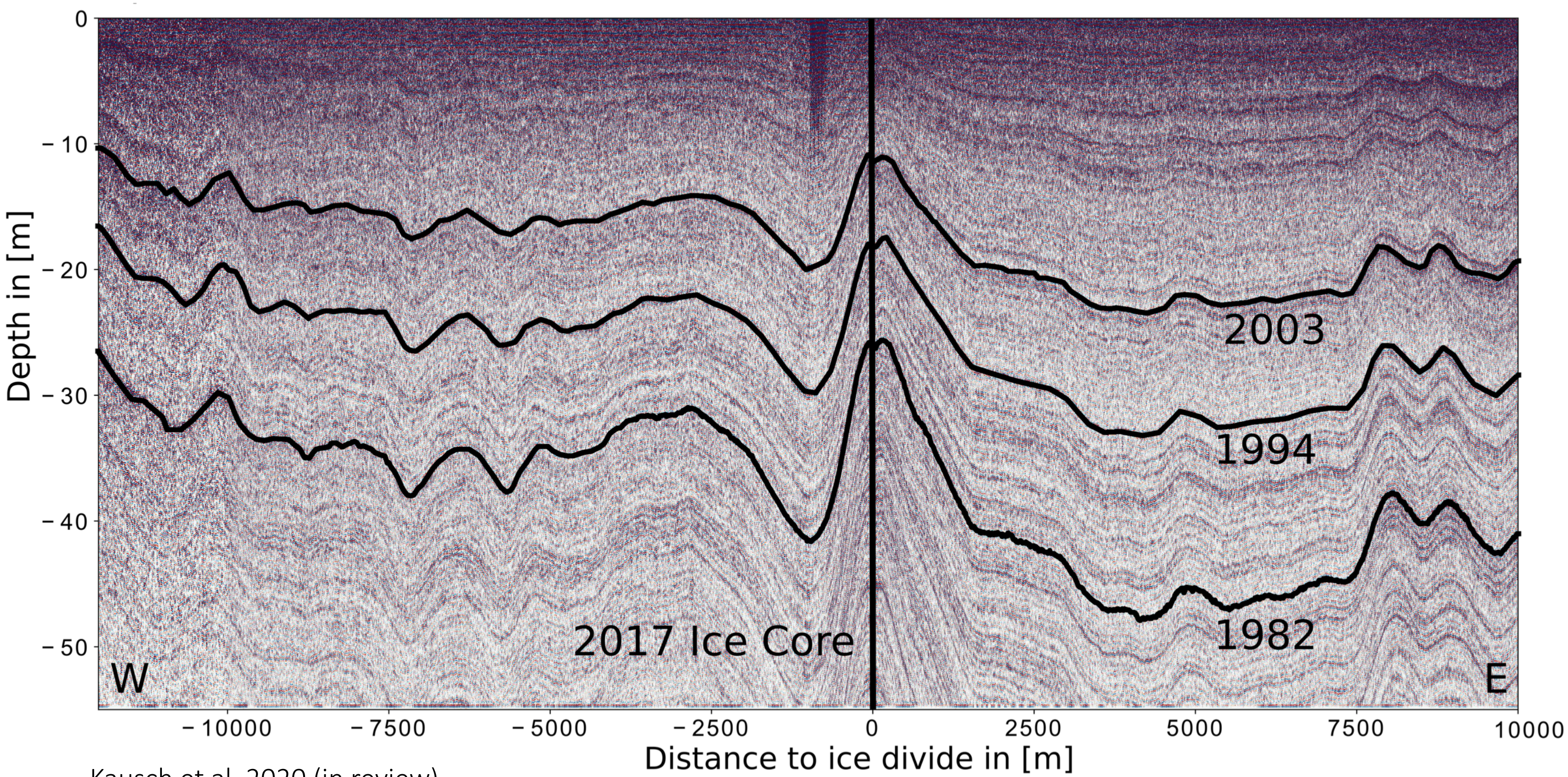
# SMB processes at ice rises



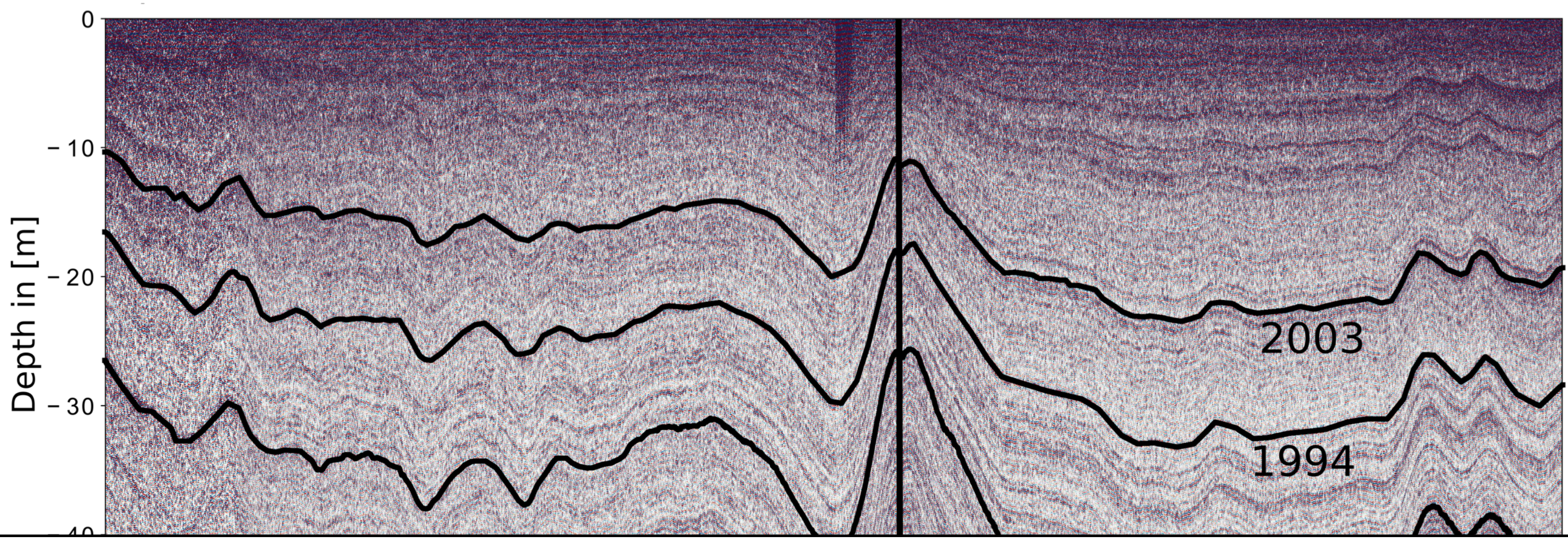

- Sketch of the two most important processes controlling the SMB of an ice rise
- Precipitation due to orographic uplift creates a snowfall surplus on the windward site of an ice rise (left)
- Wind erodes exposed snow on the peak of the ice rise and redistributes the snow downwind (right)

# Ground penetrating radar profile



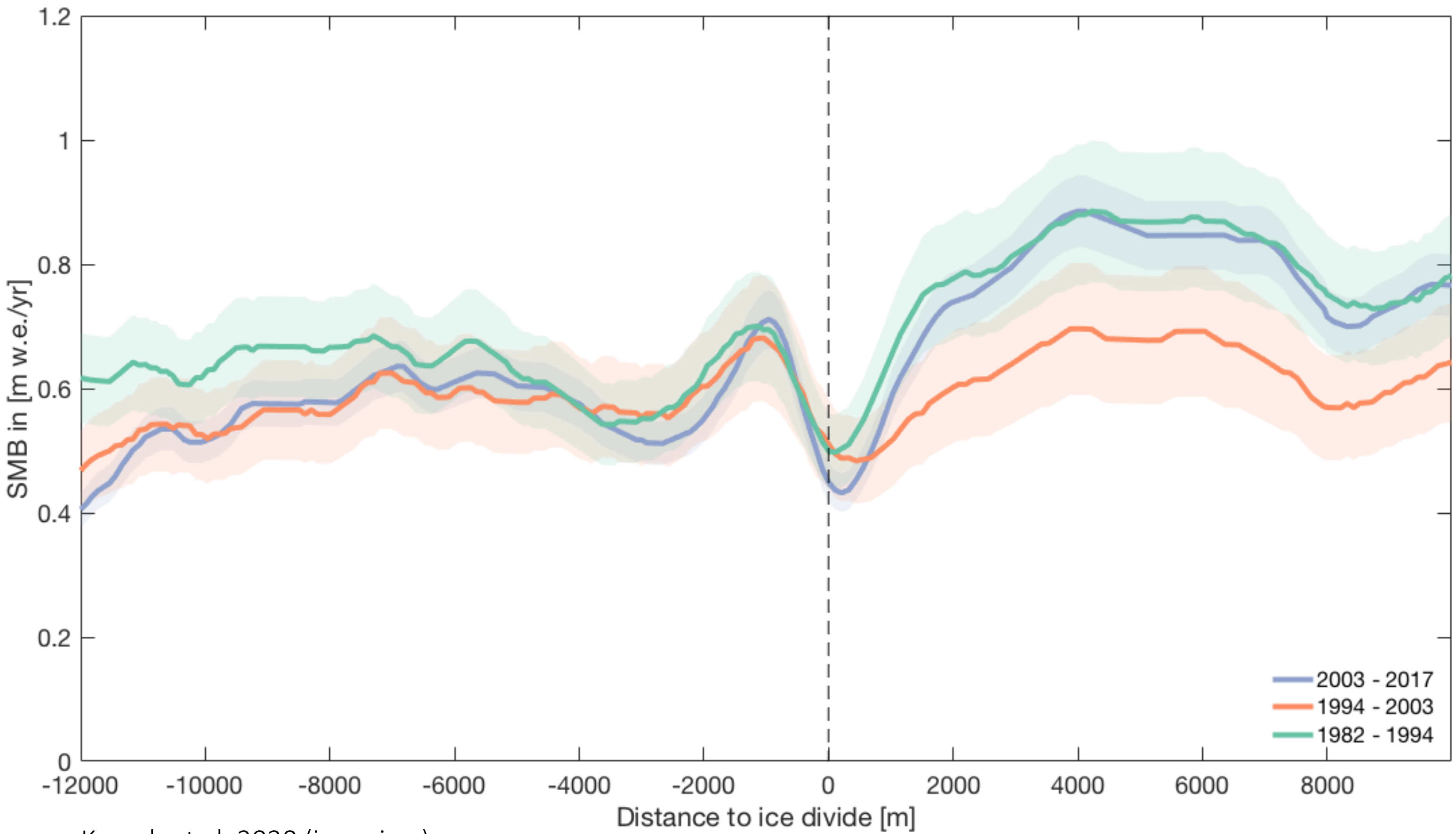

Kausch et al. 2020 (in review)

# Ground penetrating radar profile



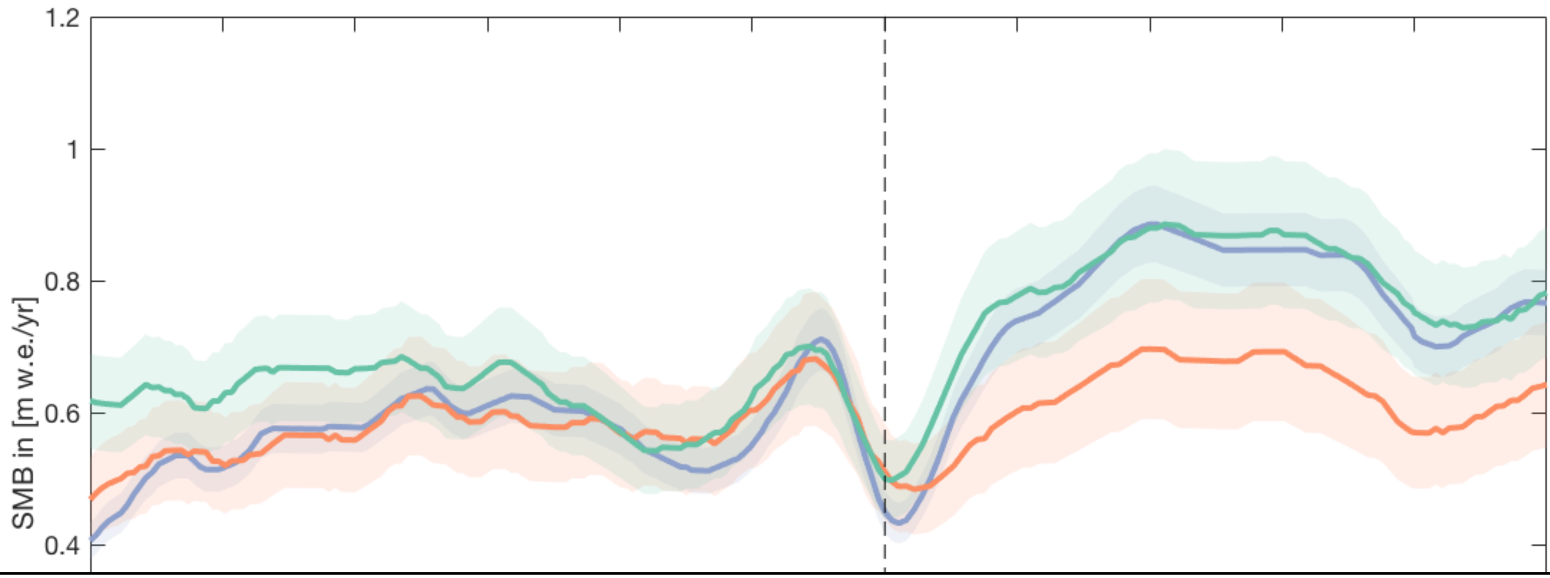

- GPR profile across the ice rise from west to east (red line on the map view)
- The black lines in show the three tracked horizons together with their dating and the vertical black line shows the location of the FK17 ice core.
- The dating of the horizons is based on the ice core dating

# SMB across the ice rise



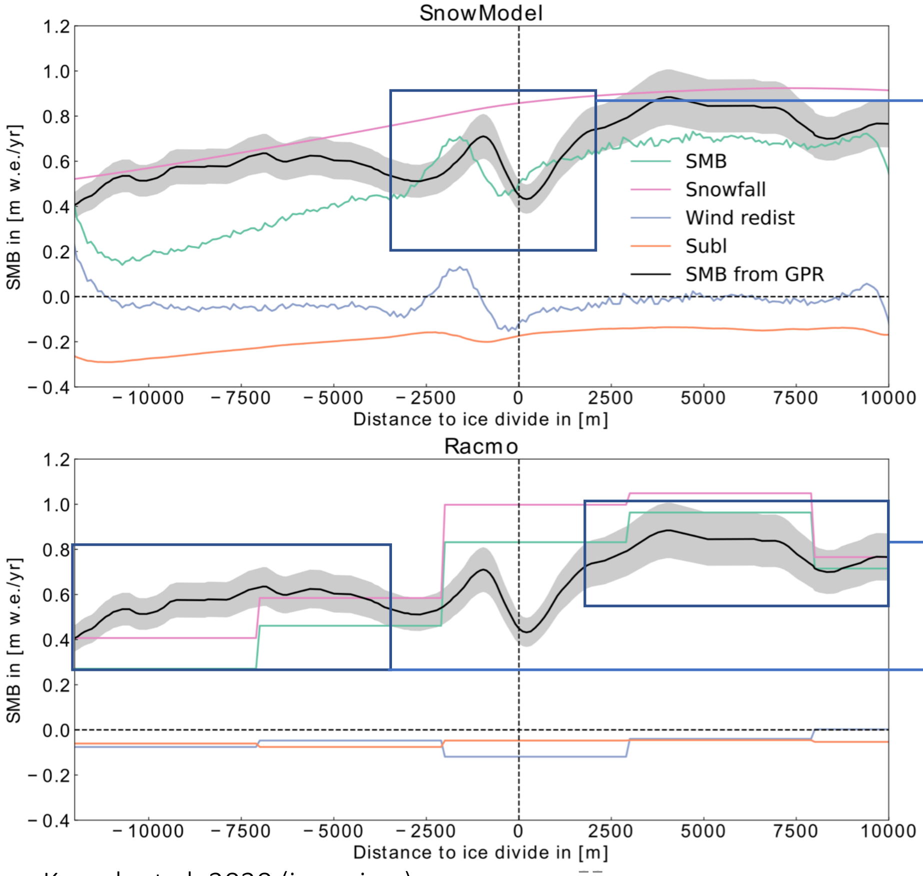

Kausch et al. 2020 (in review)

# SMB across the ice rise




- SMB reconstructed from the GPR profile for 3 different time intervals
- The SMB was reconstructed using the layer depth of the three horizons tracked in the GPR data, their age from the ice core dating and a firn densification model (Herron and Langway, 1980)

# SMB components across the ice rise

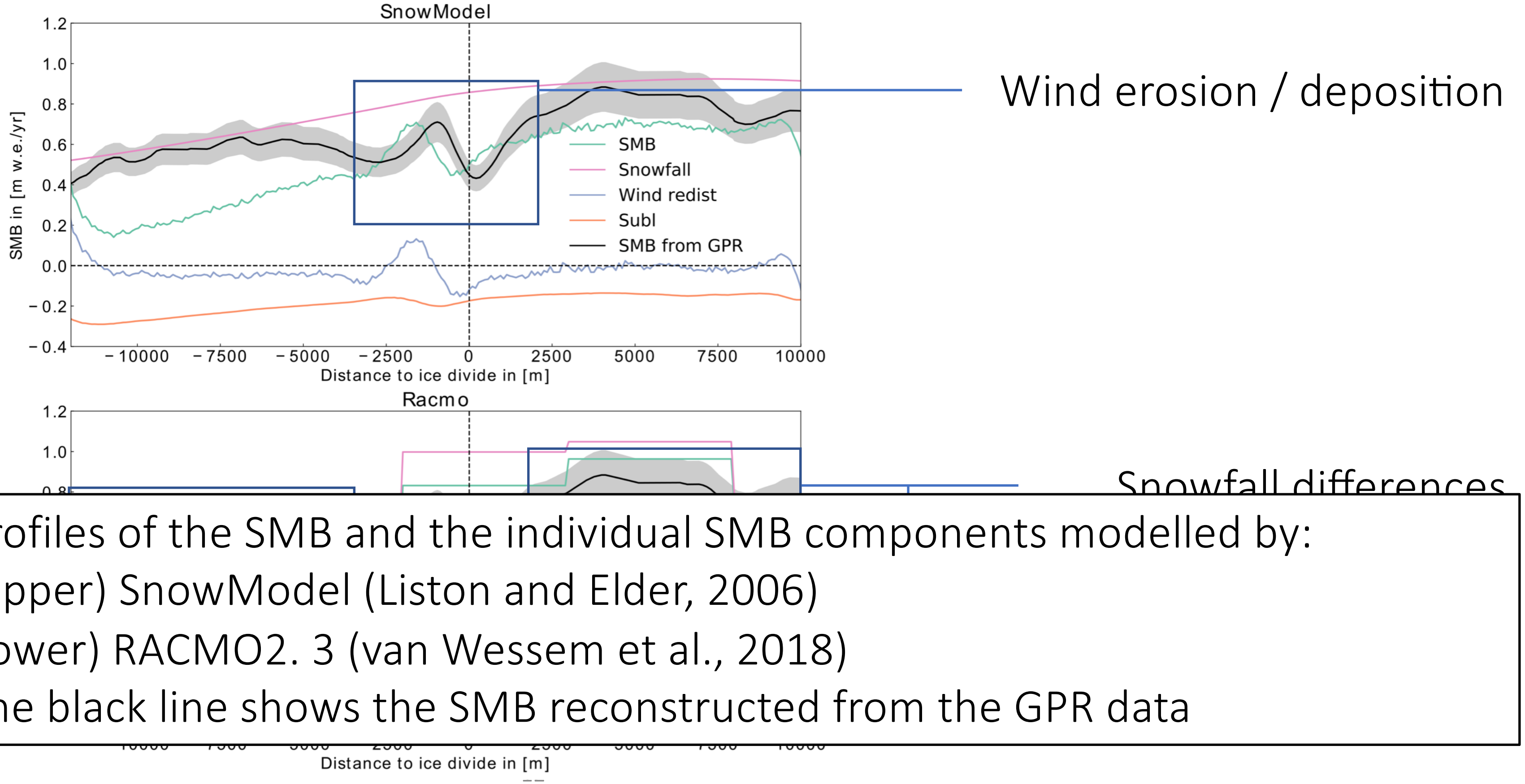



Wind erosion / deposition

Snowfall differences

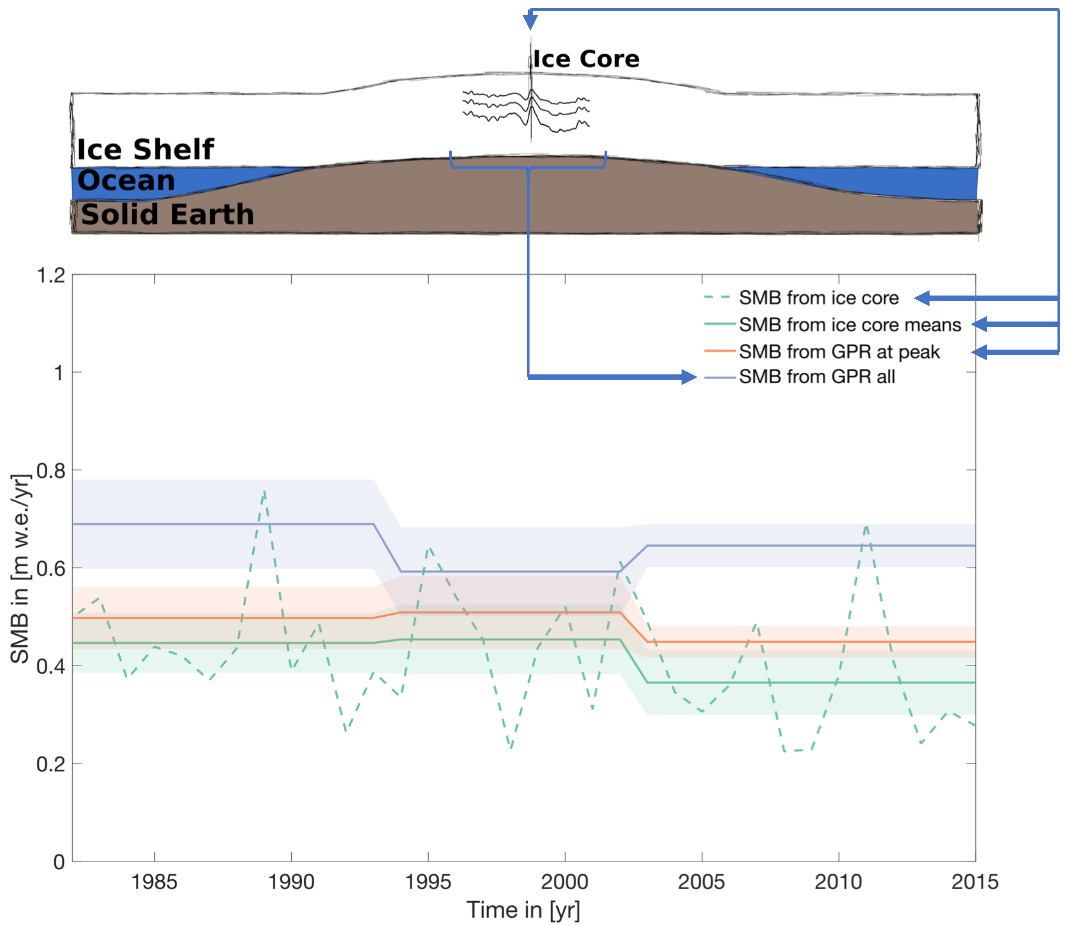
Kausch et al. 2020 (in review)

# SMB components across the ice rise



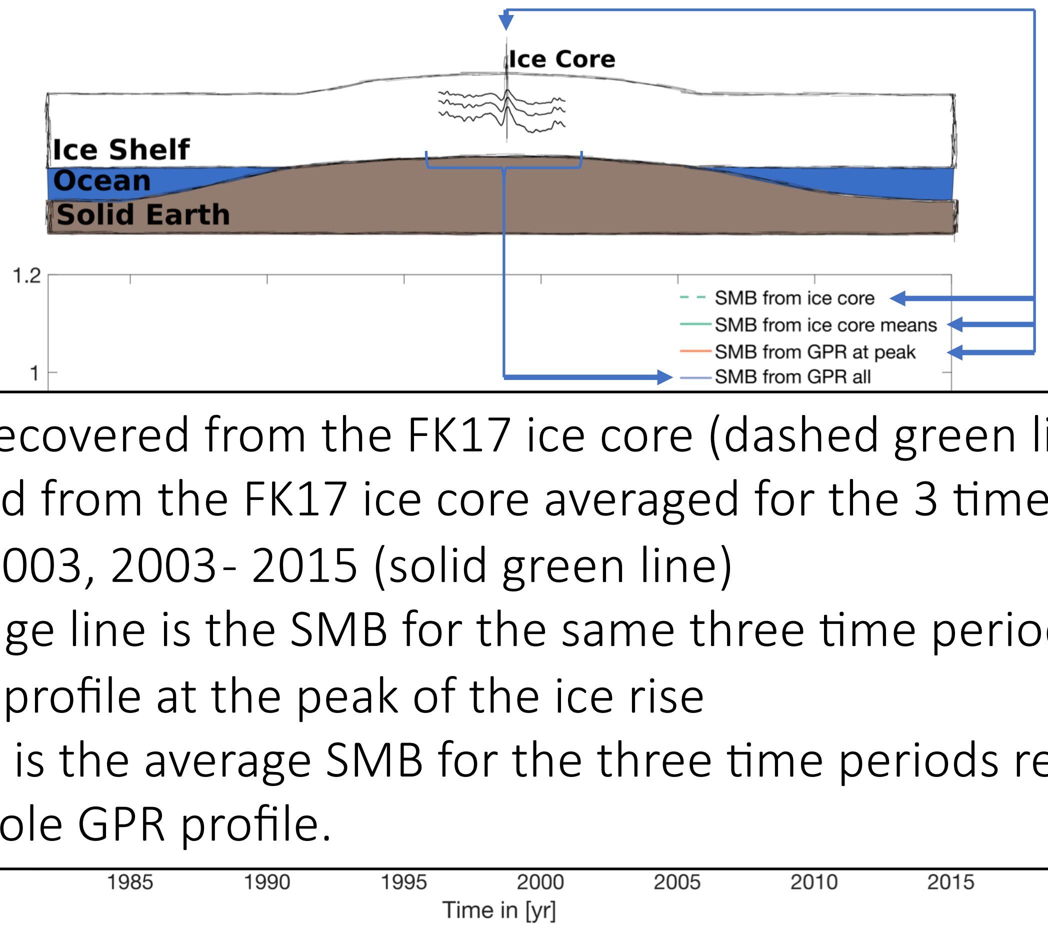

- Profiles of the SMB and the individual SMB components modelled by:
- (upper) SnowModel (Liston and Elder, 2006)
- (lower) RACMO2. 3 (van Wessem et al., 2018)
- The black line shows the SMB reconstructed from the GPR data

# SMB in time




Kausch et al. 2020 (in review)

# SMB in time




- SMB in time recovered from the FK17 ice core (dashed green line)
- SMB recovered from the FK17 ice core averaged for the 3 time periods 1982-1994, 1994-2003, 2003-2015 (solid green line)
- The solid orange line is the SMB for the same three time periods reconstructed from the GPR profile at the peak of the ice rise
- Solid blue line is the average SMB for the three time periods reconstructed across the whole GPR profile.

# Main Findings

- Snowfall driven differences of up to 1.5 times higher SMB on the windward side of the ice rise than on the leeward side (page 9)
- Local erosion driven minimum at the ice divide (page 9)
- RACMO2.3 captures the snowfall driven differences, but overestimates their magnitude (page 11)
- Erosion on the peak can be reproduced by SnowModel with RACMO2.3 forcing (page 11)
- Low temporal variability of the average SMBs (from the GPR data) for four time intervals in the 1982-2017 range at the peak of the ice rise (~ 0.03 mw.e./yr) (page 9)
- Three times higher (~ 0.1 mw.e./yr) on the windward side of the ice rise (page 9)
- At the peak of the ice rise, higher snowfall, driven by orographic uplift, is balanced out by local erosion
- SMB recovered from the ice core matches the SMB from the GPR at the peak of the ice rise, but not at the windward side of the ice rise (page 13)

-> SMB signal is dampened in the ice core.

Thank you for reading this

For more information please check out our corresponding research article, which is currently in discussion with The Cryosphere.

https://doi.org/10.5194/tc-2020-66

# References

Herron, M. M. and Langway, C. C.: Firn densification: an empirical model, Journal of Glaciology, 25, 373–385, https://doi.org/10.3189/S0022143000015239, 1980.

Kausch, T., Lhermitte, S., Lenaerts, J. T. M., Wever, N., Inoue, M., Pattyn, F., Sun, S., Wauthy, S., Tison, J.-L., and van de Berg, W. J.: Impact of coastal East Antarctic ice rises on surface mass balance: insights from observations and modeling, The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-66, in review, 2020.

Liston, G. E. and Elder, K.: A Distributed Snow-Evolution Modeling System (SnowModel), Journal of Hydrometeorology, 7, 1259–1276, https://doi.org/10.1175/JHM548.1, 2006.

van Wessem, J. M., Jan Van De Berg, W., Noël, B. P. Y., van Meijgaard, E., Amory, C., Birnbaum, G., Jakobs, C. L., Krüger, K., Lenaerts, J. T. M., Lhermitte, S., Ligtenberg, S. R. M., Medley, B., Reijmer, C. H., Van Tricht, K., Trusel, L. D., van Ulft, L. H., Wouters, B., Wuite, J., and Van Den Broeke, M. R.: Modelling the Climate and Surface Mass Balance of Polar Ice Sheets Using RACMO2 : Part 2: Antarctica (1979-2016), https://doi.org/https://doi.org/10.5194/tc-12-1479-2018, 2018.