Reconstructing the Calving Front History for Helheim Glacier, Greenland

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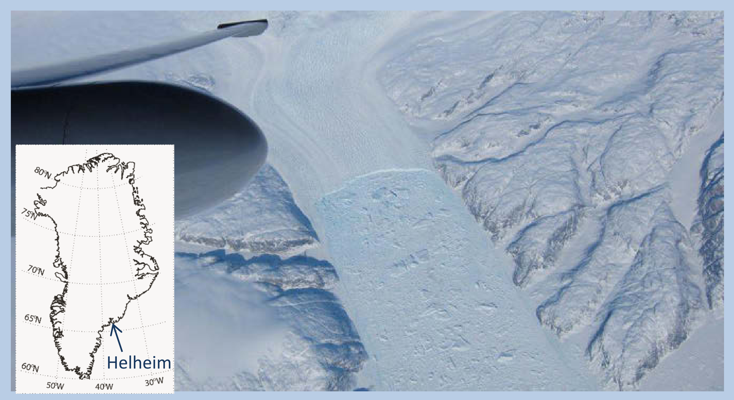
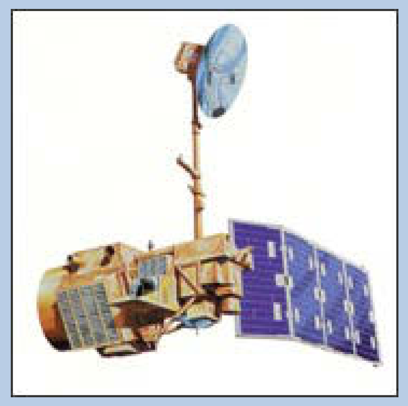
Introduction

- Over the last decade, the Southeast region of the Greenland Ice Sheet thinned at a higher rate than other regions
- Some major outlet glaciers exhibit varying levels of dynamic thinning and thickening, despite an overall warming climate
- **Helheim glacier** is used here as a case study of the behaviors of one outlet glacier



Aerial oblique image of Helheim from MABEL validation flight from 65,000 feet ***Credits: NASA / Stu Broce***



Landsat 5 drawing from NASA Landsat Science Website

Methodology

- Landsat and Corona downloaded from the United States Geological Survey Earth Explorer
- Natural Color composite images made in Environment for Visualizing Images Classic 5.0
- Advanced Spaceborne Thermal Emission and Reflection Radiometer images downloaded from Reverb ECHO
- National Aeronautics and Space Administration Airborne Topographic Mapper Images from National Snow and Ice Data Center
- Calving fronts digitized in ArcGIS 10
- Compared calving front history to elevation data

Table 1: Year, Satellite Sensor, Image type, and Bands used in the Calving front reconstruction of Helheim Glacier

Year	Sensor/Image type	Bands/Colors
1938	US Army Topo map	-
1965	Corona 1022-2	BW
1972	Landsat 1	754
1981	Aerial	BW
1985	Landsat 5	321
1986	Landsat 5	321
1987	Landsat 5	321
1988	Landsat 5	321
1989	Landsat 5	321
1990	Landsat 5	321
1992	Landsat 5 TM	321
1994	Landsat 5	321
1998	Landsat 5	321
1999	Landsat 7	321
2000	Landsat 7	321
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2005	Landsat 7	321
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2007	Landsat 7	321
2008	Landsat 7	321
2009	Landsat 7	321
2010	ASTER	321
2011	Landsat 7	321
2012	Landsat 7	321
2013	Landsat 7	321
2014	Landsat 8	321
2015	Landsat 8	321

Table 2: Year, Date, Satellite Sensor, and Bands used in the Seasonal Calving front Reconstruction of Helheim Glacier

Year	Date	Sensor	Bands/Colors
1990	25_Jun	Landsat 5	321
1990	19_Aug	Landsat 5	321
1990	24_May	Landsat 5	321
2005	29-Aug	Landsat 7	321
2005	22-Aug	Landsat 7	321
2005	4-Aug	Landsat 7	321
2005	19-Jul	Landsat 7	321
2005	2-May	Landsat 7	321
2005	17-Jun	Landsat 7	341
2005	28-Jul	Landsat 7	321
2006	29-Jun	Landsat 7	321
2006	19-May	Landsat 7	341
2006	22-Jul	Landsat 7	321
2015	8-Aug	Landsat 8	321
2015	14-Jun	Landsat 8	321
2015	5-Jun	Landsat 8	321
2015	16-Jul	Landsat 8	321

Results

- Various equilibrium oscillation points (Fig. 1)
  - 1992-2001
  - 2007-2014
- Maximum retreat in 2005 (Fig. 1)
- Retreated near to 2005 extent in 2015 (Fig. 1)
- Considerable seasonal variations for 1990, 2005, 2006, 2015 (Fig. 2)

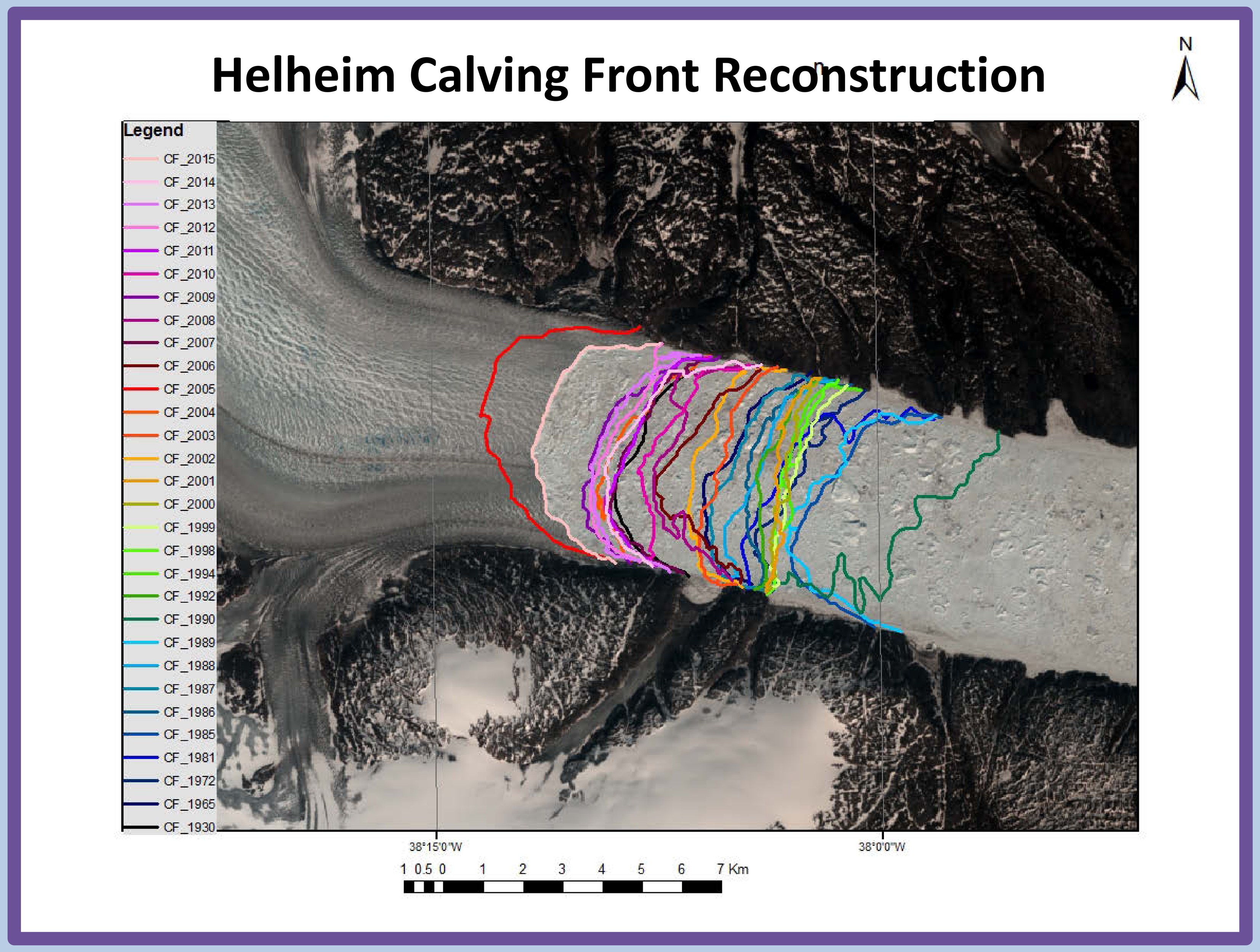

Figure 1: Reconstruction of Helheim Glacier calving fronts during summer from 1930 to 2015

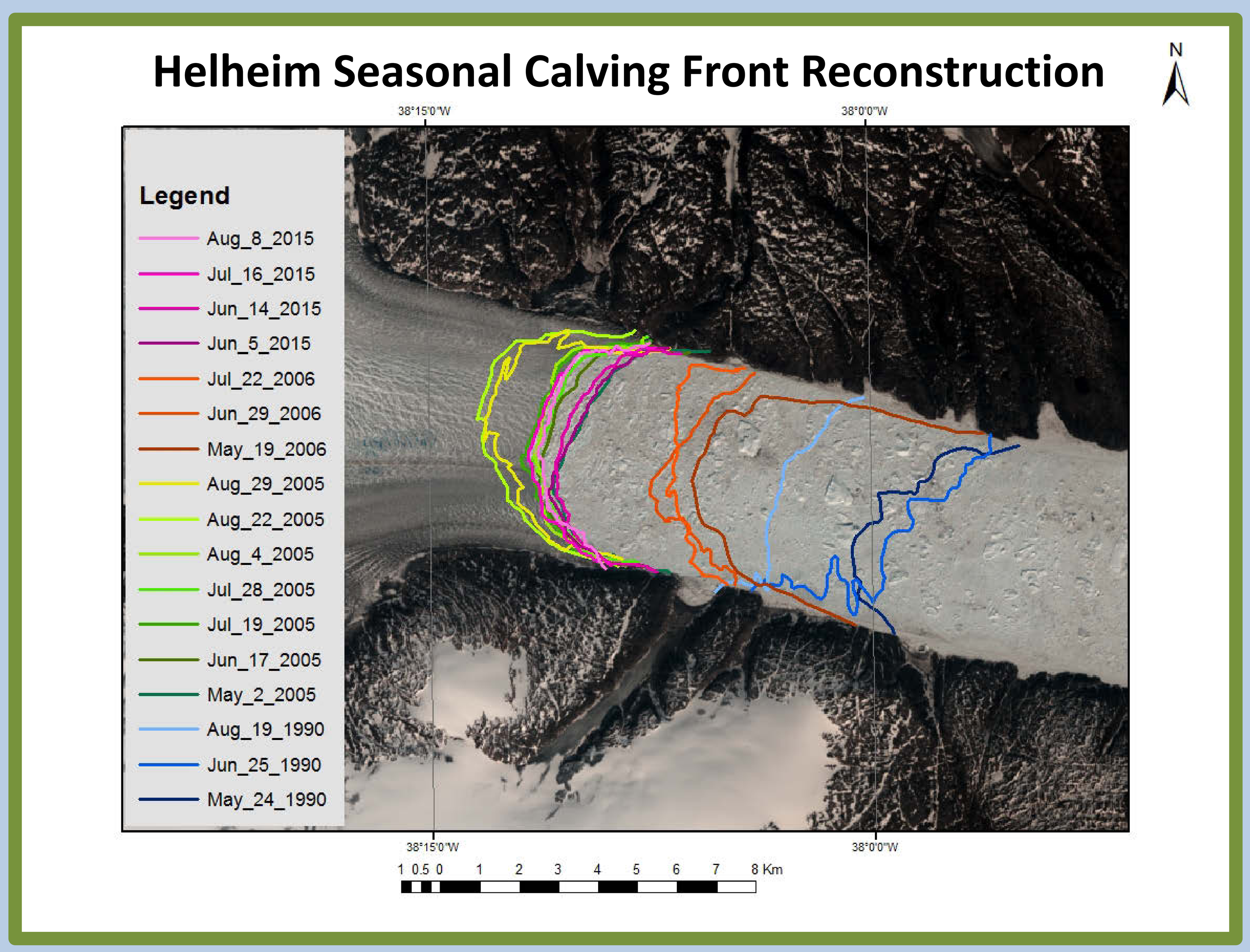

Figure 2: Seasonal variations in calving front positions in 1990, 2005, 2006, and 2015

Discussions

- Helheim exhibits calving front changes, especially after rapid retreat in 2005
- Calving front history presented is consistent with and temporarily extends results from Miles et al. (2016)
- Calving front history mirrors elevation changes after 2004 (Fig. 3)
- Further research will be done using calving front and elevation positions in the Ice Sheet System Model (NASA/JPL) to investigate different climatic forcings at Helheim (Larour et all., 2012)

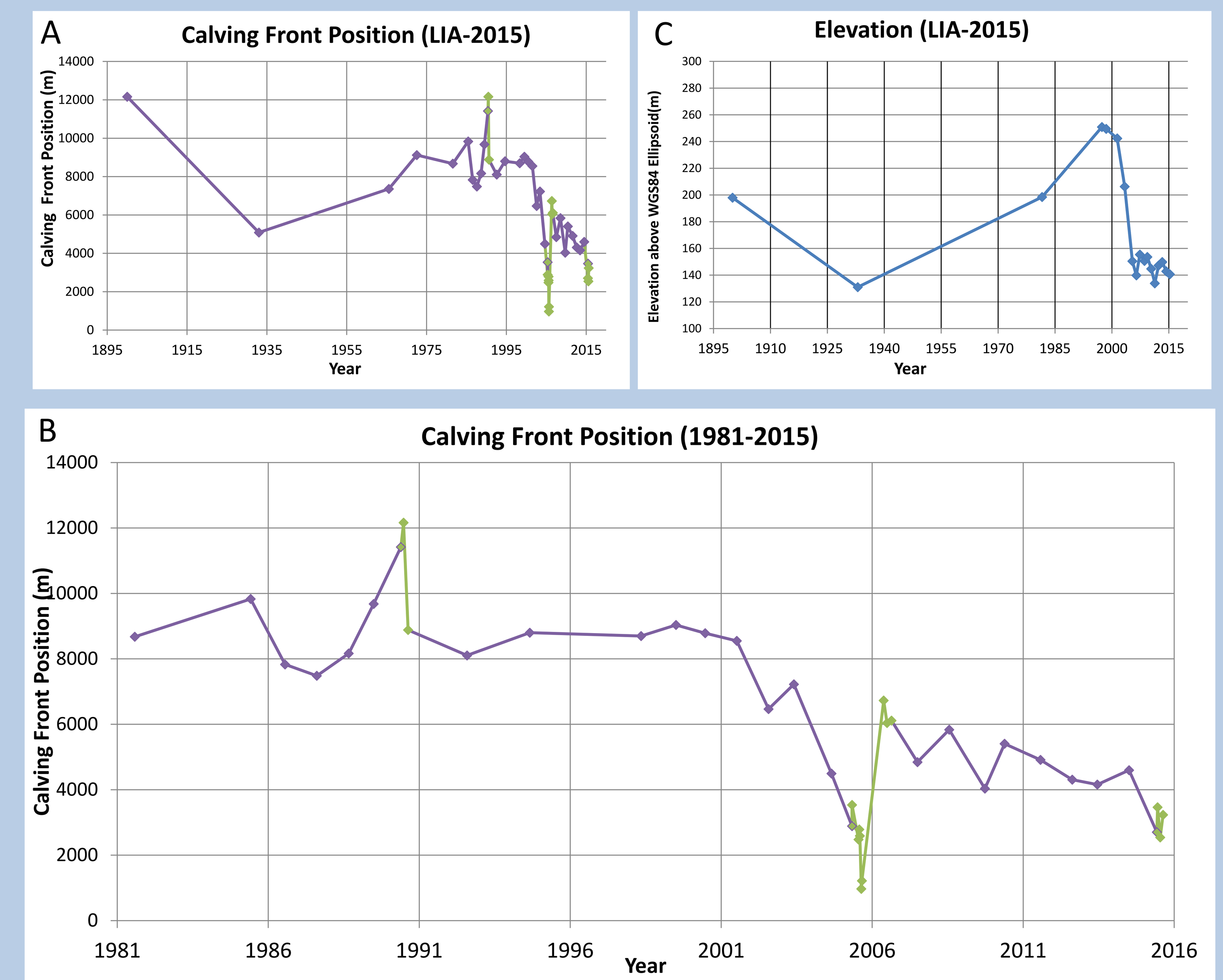

Figure 3 a,b: Calving positions measured from the center of the glacier at the fjord head. Calving front changes are shown from the Little Ice Age (LIA) to 2015 (A) and from 1981 to 2015 (C). Distance increases down-glacier

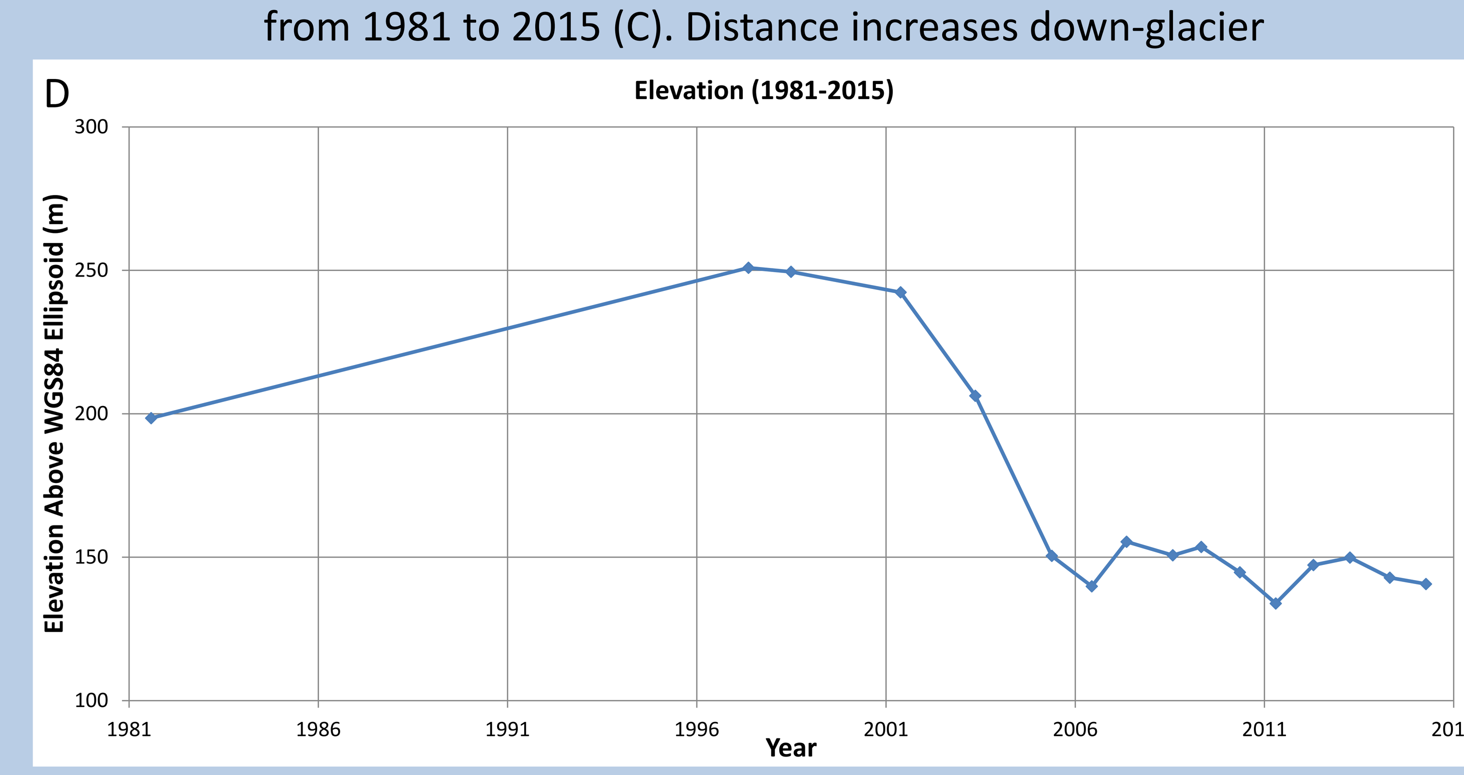

Figure 3 c,d: Glacier surface elevation changes reconstructed by SERAC method from LIA to 2015 (B) and from 1981 to 2015 (Csatho et al., 2014). Elevations are measured at the center of the glacier at the fjord head and are relative to Aug. 31, 2006

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