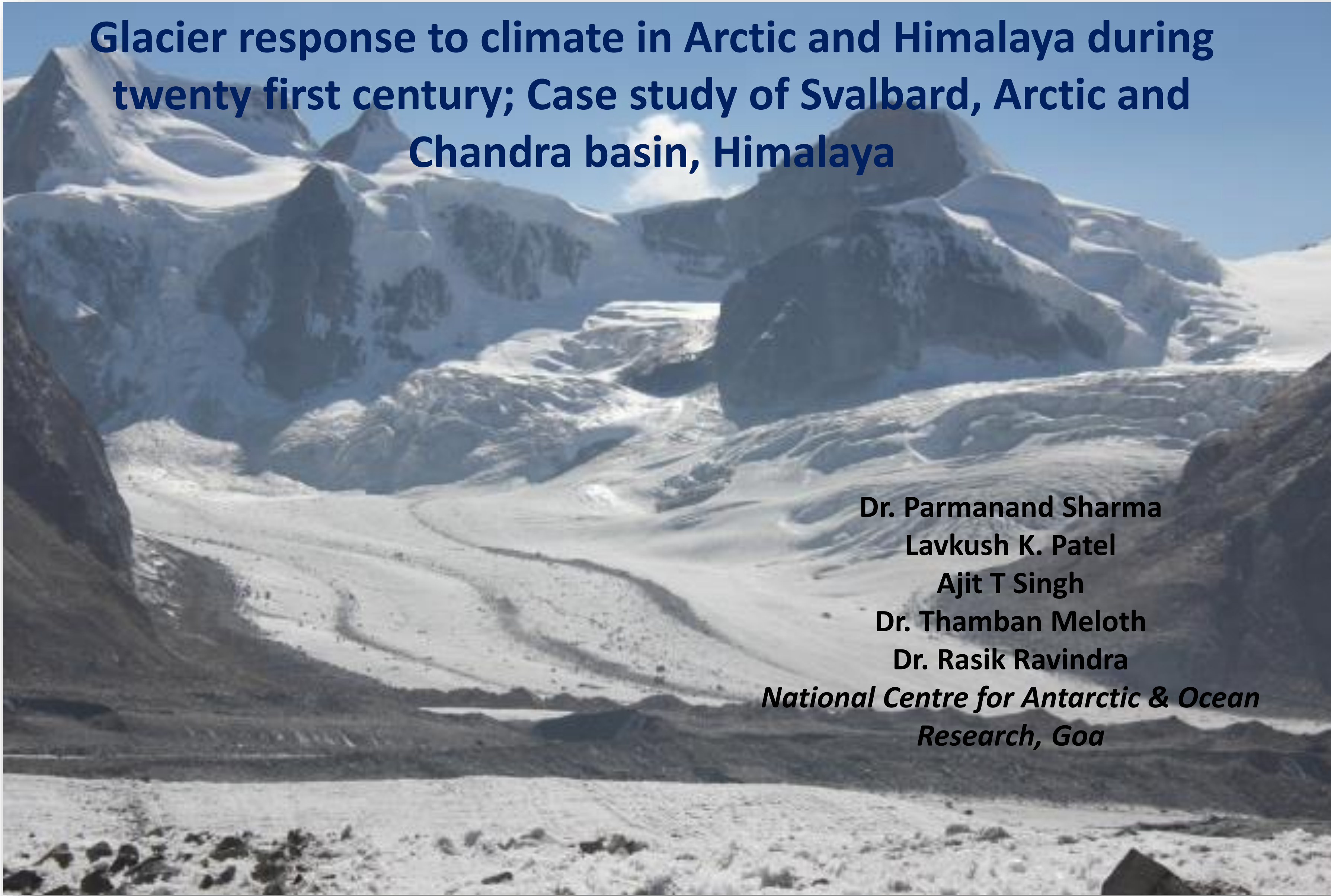


Glacier response to climate in Arctic and Himalaya during twenty first century; Case study of Svalbard, Arctic and Chandra basin, Himalaya

Dr. Parmanand Sharma
Lavkush K. Patel
Ajit T Singh
Dr. Thamban Meloth
Dr. Rasik Ravindra
National Centre for Antarctic & Ocean Research, Goa

The global threat of Polar ice melting

- Arctic and Himalaya both are abode of densely distributed snow and ice covered region other than Antarctic and Greenland.

- The Hindu Kush Himalayan (HKH) region, often referred to as the Third Pole, contains the world's greatest areal extent and volume of permanent ice and permafrost outside the polar regions.

- The process of glacier retreat has been enhanced in the Arctic and Himalayan during past one and half decades

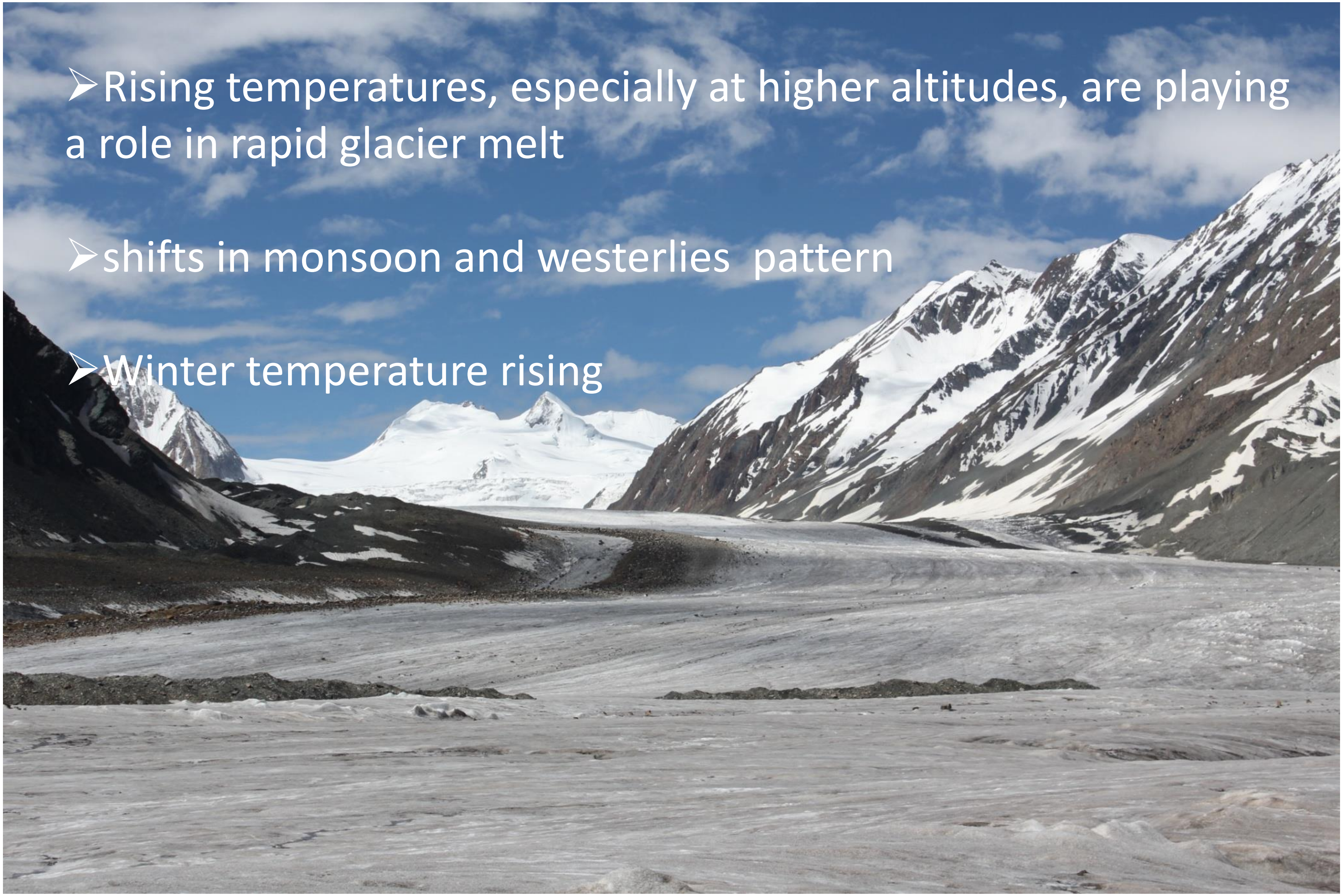
- In spite of having contrast climate set up of Arctic and Himalaya with high latitude and low latitude glacieriesed region of Northern Hemisphere respectively, their glaciers have been experiencing enhanced melting during twenty first century.

The global threat of Polar ice melting

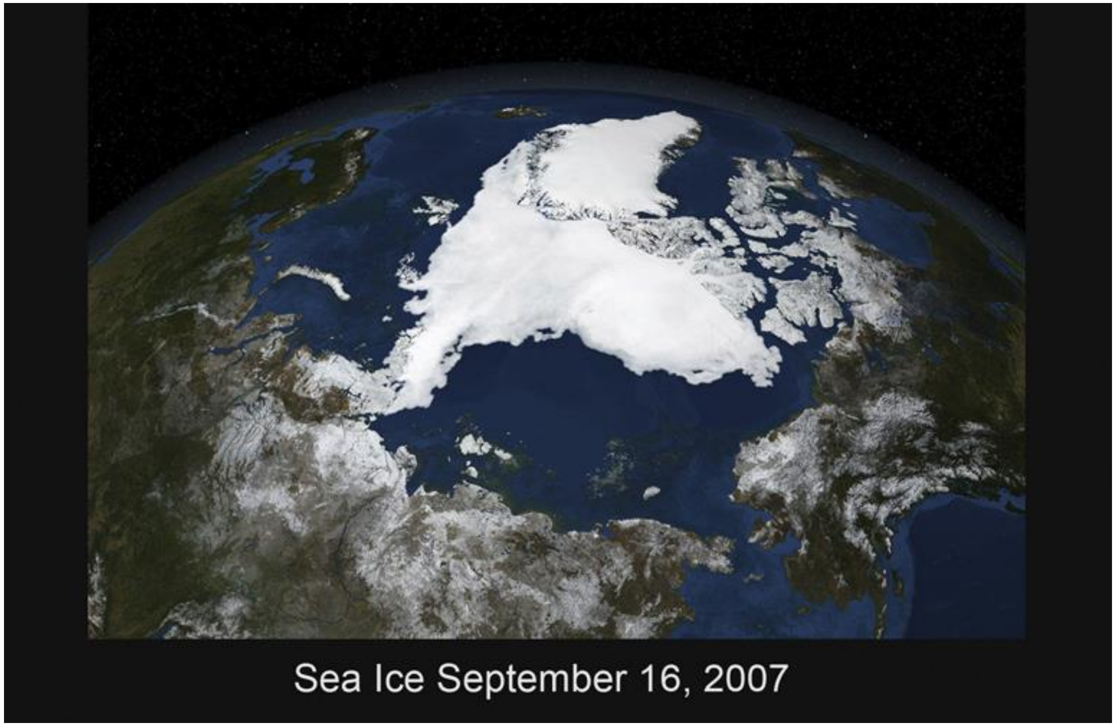
Snow and glaciers melt in Arctic enhanced significantly due to large temperature changes, changes in sea ice cover, atmospheric flow patterns and precipitation.

Ocean circulation close to fjord modulates melt rates of marine-terminating glaciers all over the Arctic

One of the Increased submarine melt due to increased discharge of surface melt at the base of glaciers,



- ➢Rising temperatures, especially at higher altitudes, are playing a role in rapid glacier melt
- ➢shifts in monsoon and westerlies pattern
- ➢Winter temperature rising



Due to GLOBAL WARMING massive amounts of Arctic and Antarctic ice are beginning to melt.

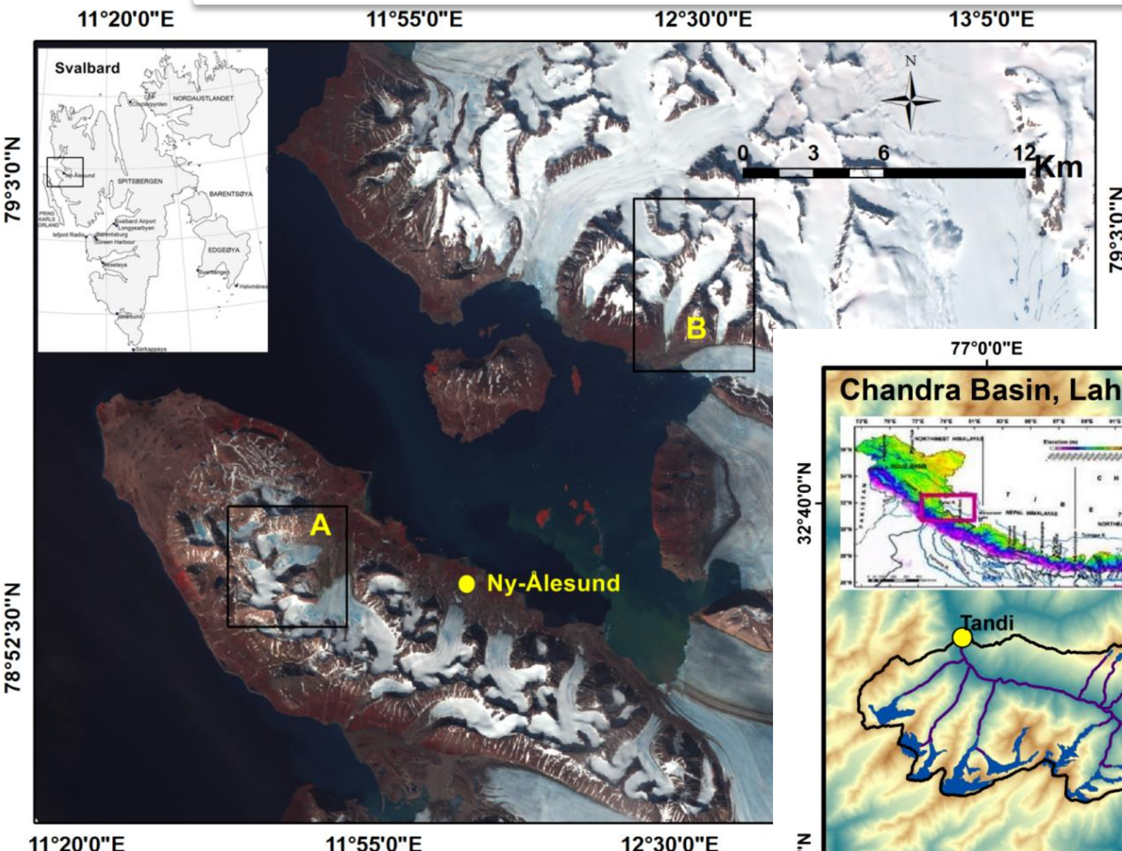
World temperatures may rise by a couple of degrees this century because of greenhouse gas emissions

- **Unlike southern Antarctica, the northern Arctic region is mostly an ocean covered with frozen ice.**
- **If this ice melts, it will not cause sea levels to rise but treat to global climate set up**

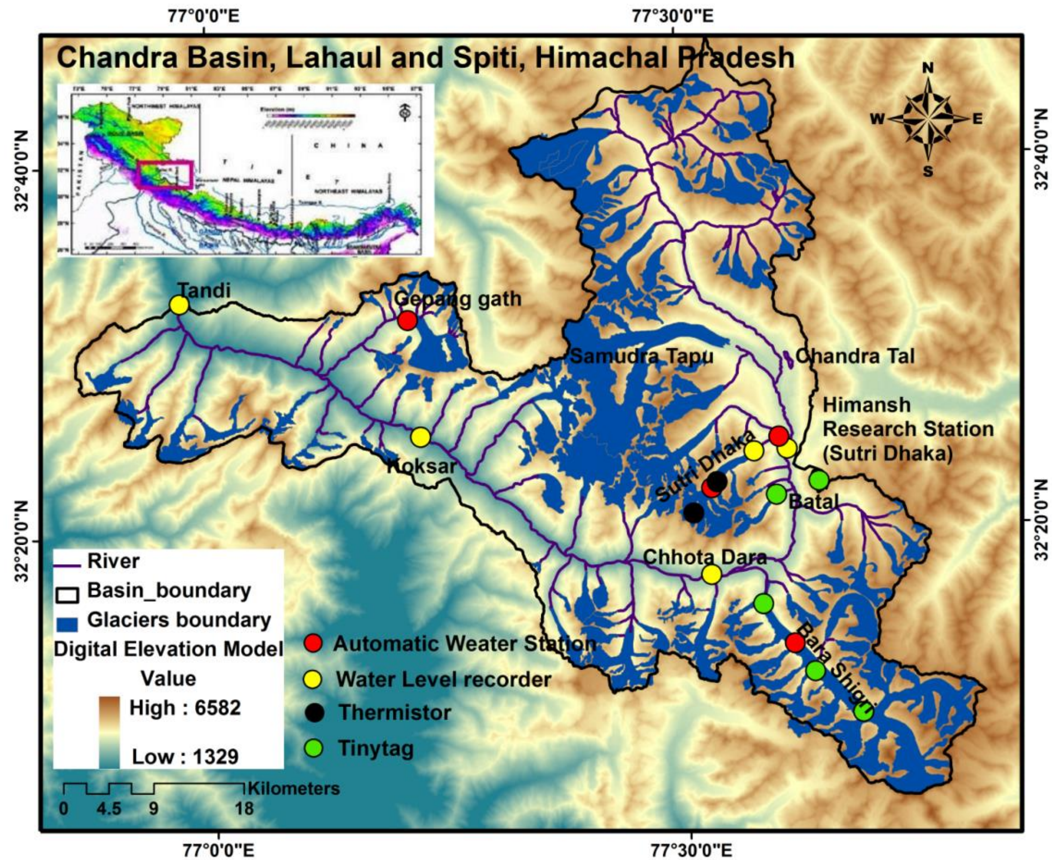
Questions to be answer

- On what timescale does Glacier respond to climate warming in Arctic and HKH region?
- Which one has the most significant control for glacier behavior in both the region - global or regional or local climates ?
- Is micro climate of glaciers effect the dynamics?
- How is glacier response regulated by changes in the rate and mechanism of ice flow? If so, what causes these changes?
- How does the local climate control the glacier health ?
- How do monsoon and westerlies effect mass balance of HKH region ?
- How do these changes amplify those caused by surface mass balance alone?
- Estimate the impact on local /regional community induced by change in glacier regime?

The Svalbard and Himalayan Glaciers



The Arctic has covering an area of 14.5 million km^2. Svalbard glaciers and ice caps cover an area of 34600 km^2 with a total ice volume of roughly 7000 km^3.



Himalaya has abode of more than 9000 glaciers and covering approx 38*10^3 km^2 glacieriesed area. Chandra basin glaciers have covering 706km^2 area with approximately ice volume of 28.3 km^3.


HIMANSH
Sutri Dhaka, Chandra Basin,
Lahaul-Spiti Valey, Himachal Pradesh
Altitude: 4080m msl17


Water Level Recorder at
Chandra River
close to the HIMANSH

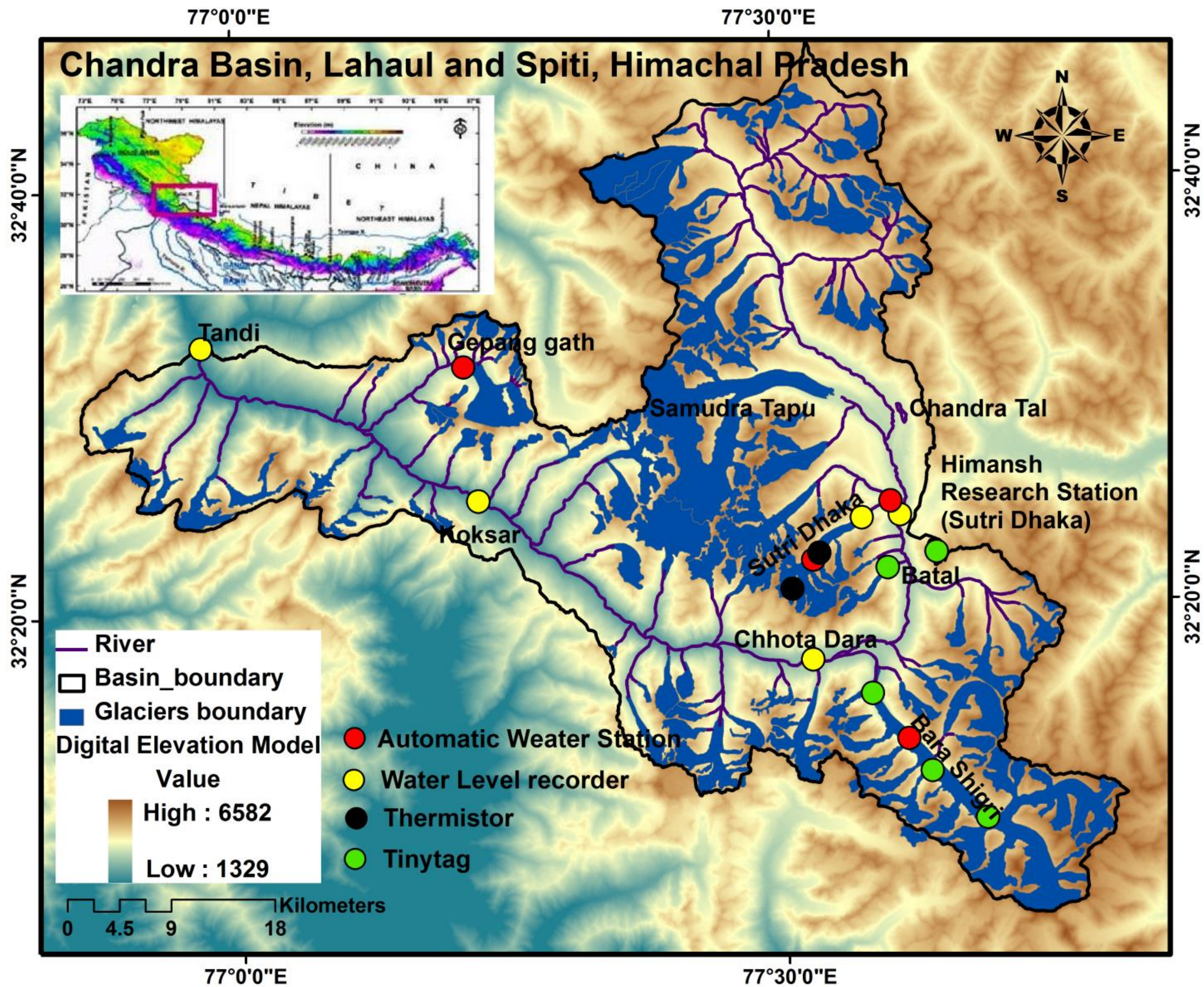
HIMADRI
Ny-Alesund, Svalbard, Arctic
Altitude: 13m msl

Study Area: Chandra basin, Lahaul & Spiti valley, Himachal Pradesh

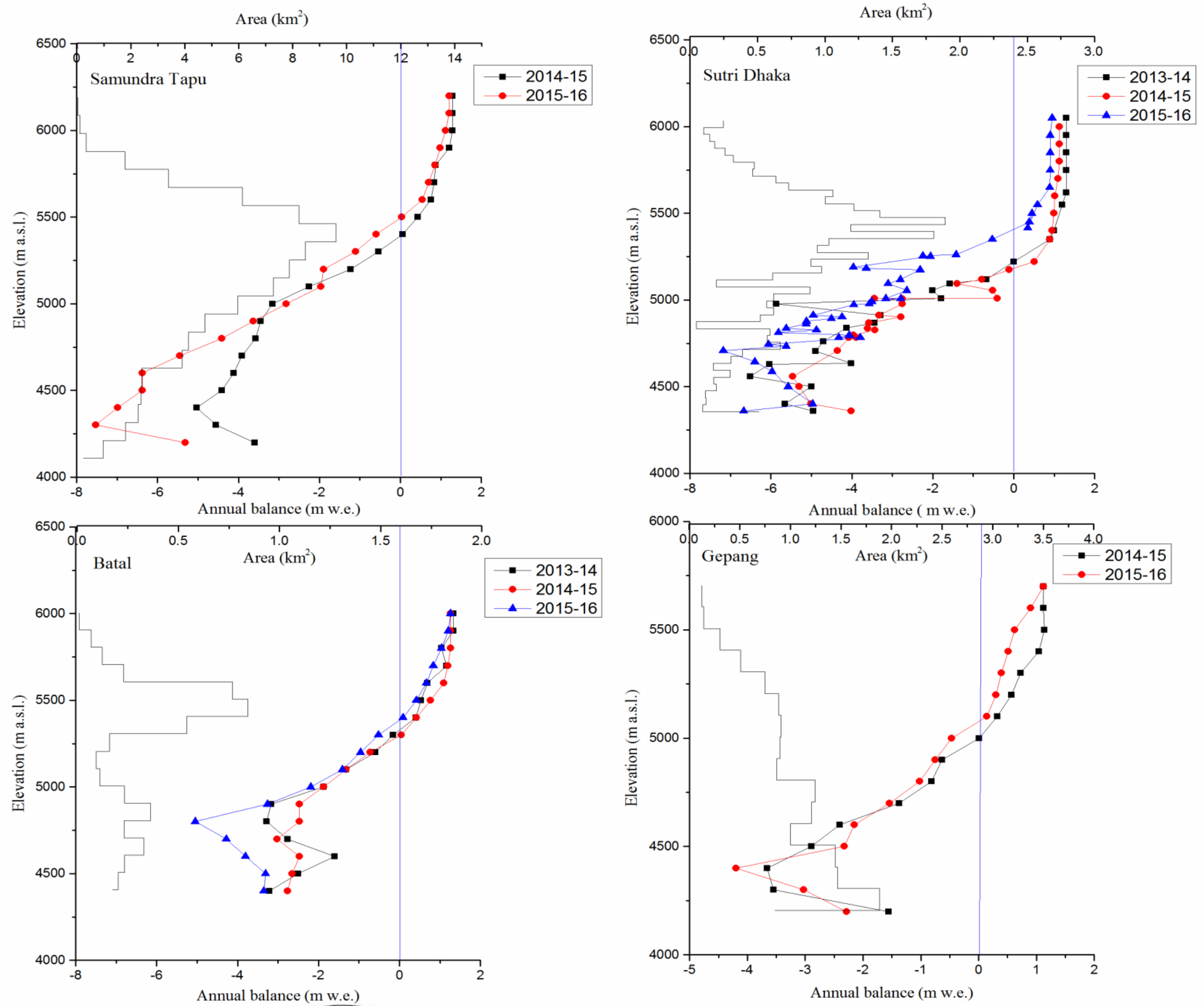
Basin Area : ~2437km^2
Total glacier Area ~ 706km^2

Six glaciers covering area ~306km^2

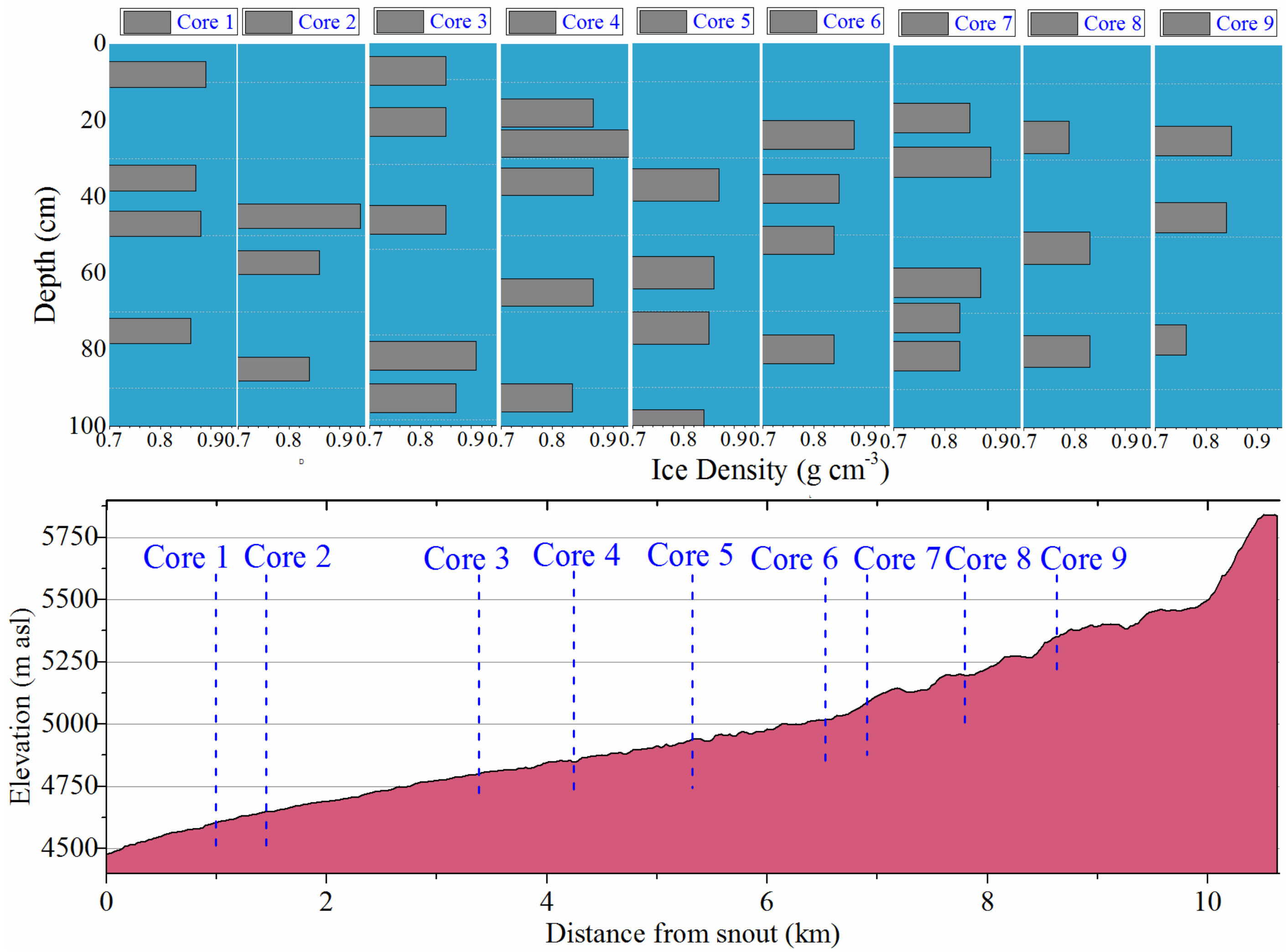
Biggest glacier in this basin: Bara Shigri (130km^2)



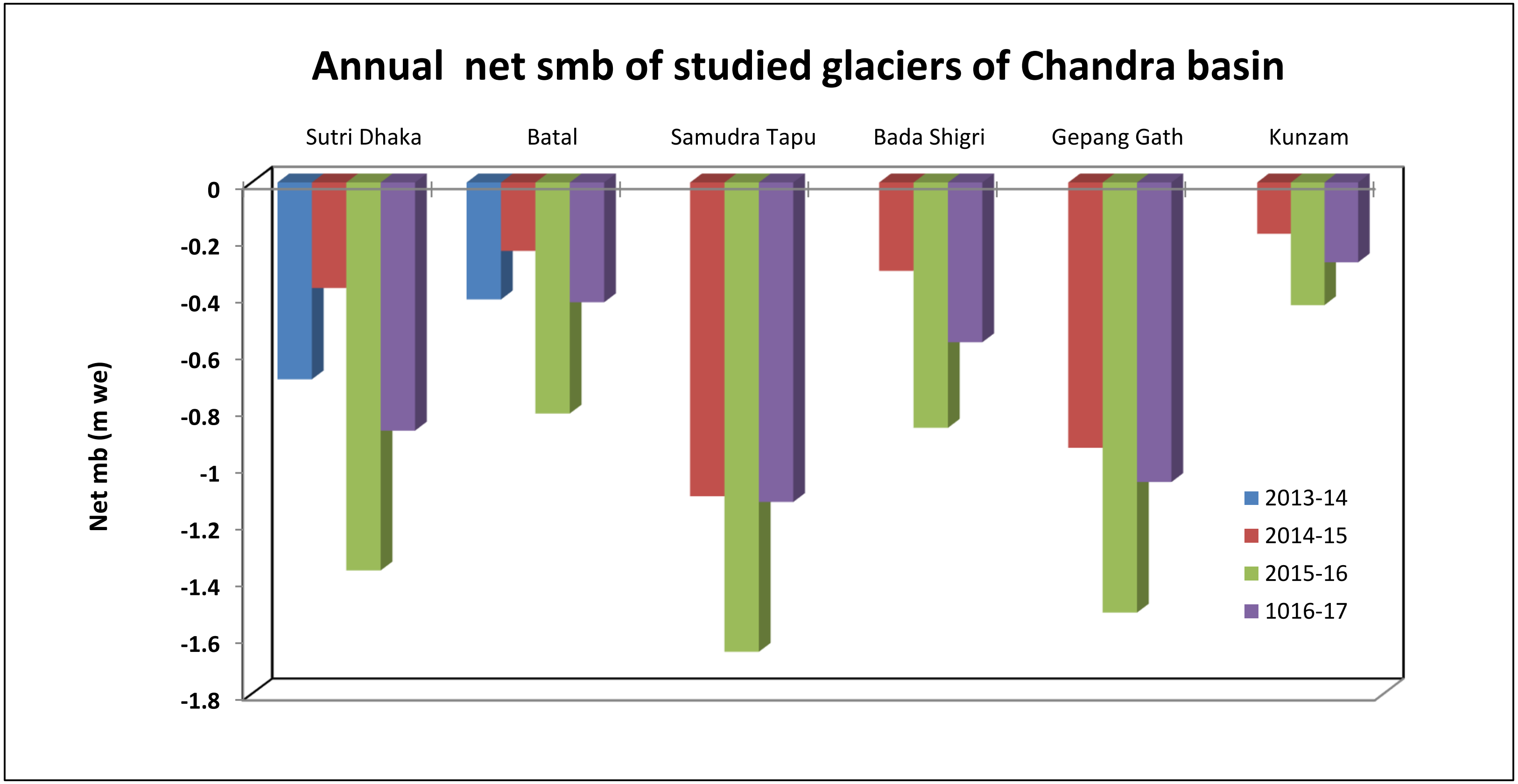
Glaciological Mass Balance in Himalaya :



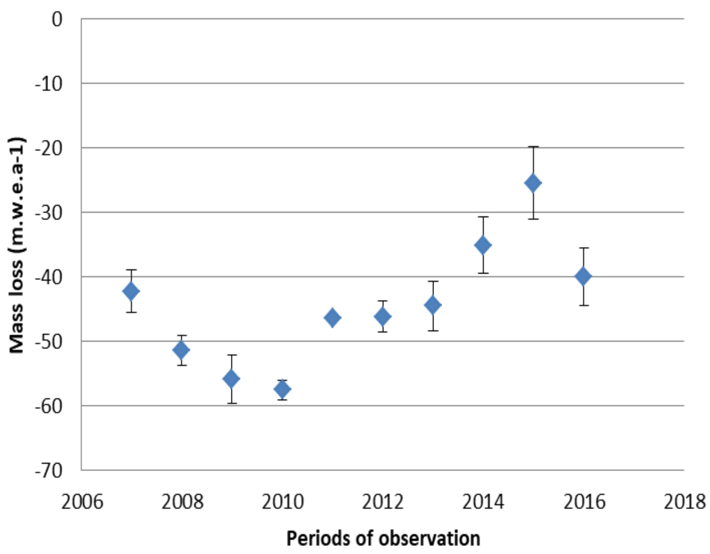
Ice Density Measurement for calculating Water equivalent

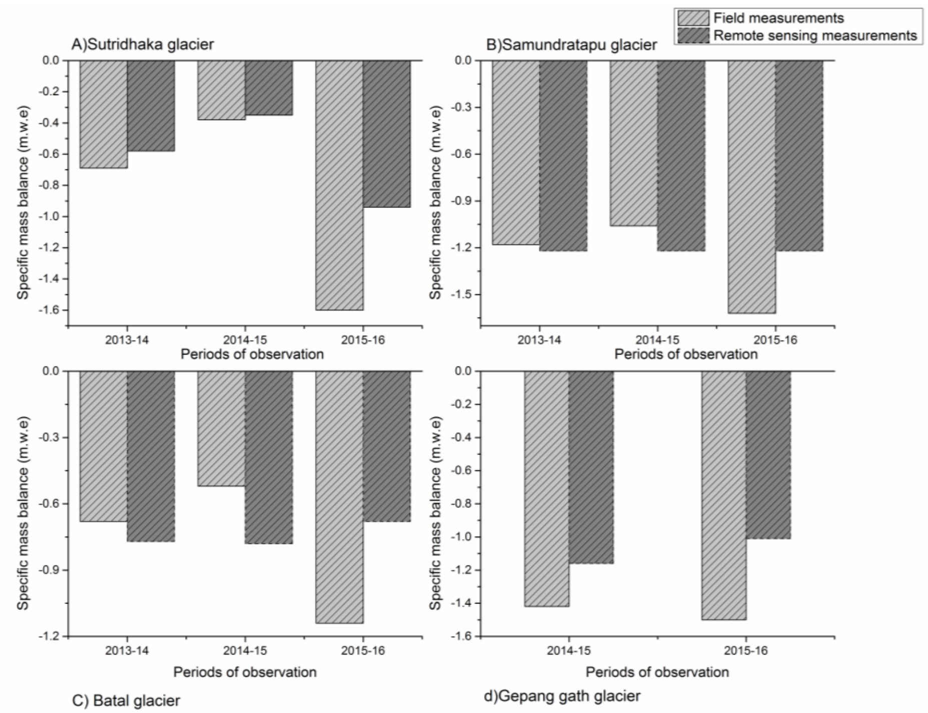


Annual Mass Balance of studied glaciers in Chandra basin



Estimation of Mass balance for last decade (2007-2016) using Accumulation Area Ratio

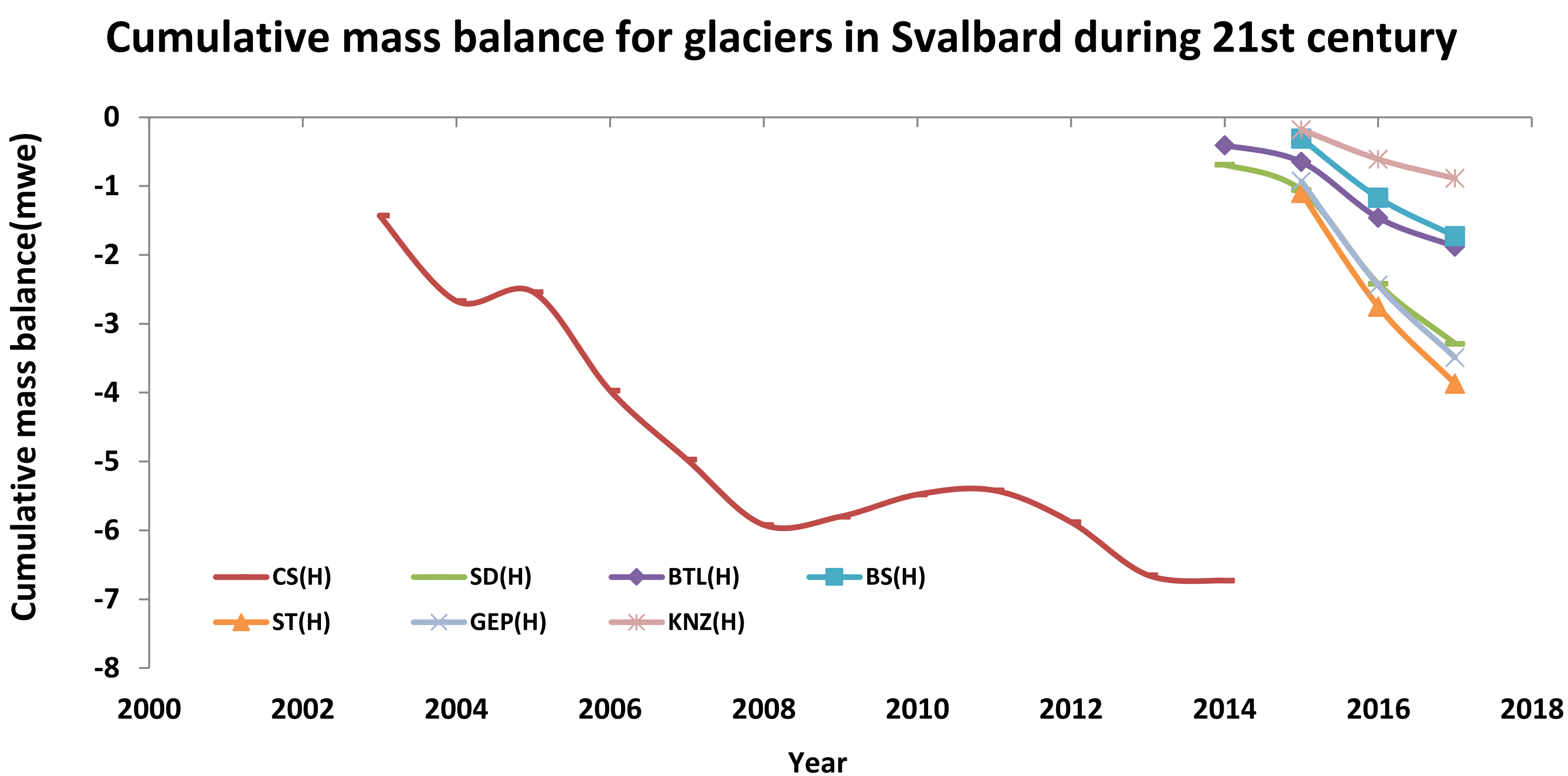




➢A loss of 0.44 ± 0.05 Gigatons of glacial mass is observed at basin scale in Chandra basin using Accumulation Area Ratio (AAR) method for a period of 10 years between 2007 and 2016.

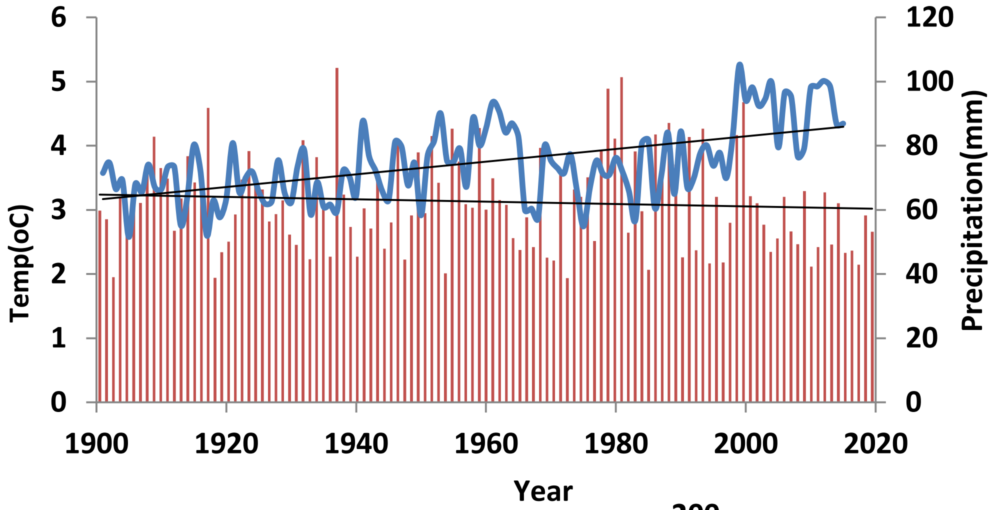
➢The glaciers have experienced both positive and negative mass balance during this period however basin scale mass loss to be varying from -0.48 ± 0.76 mwe a^{-1} to -1.09 ± 0.29 m we a^{-1}

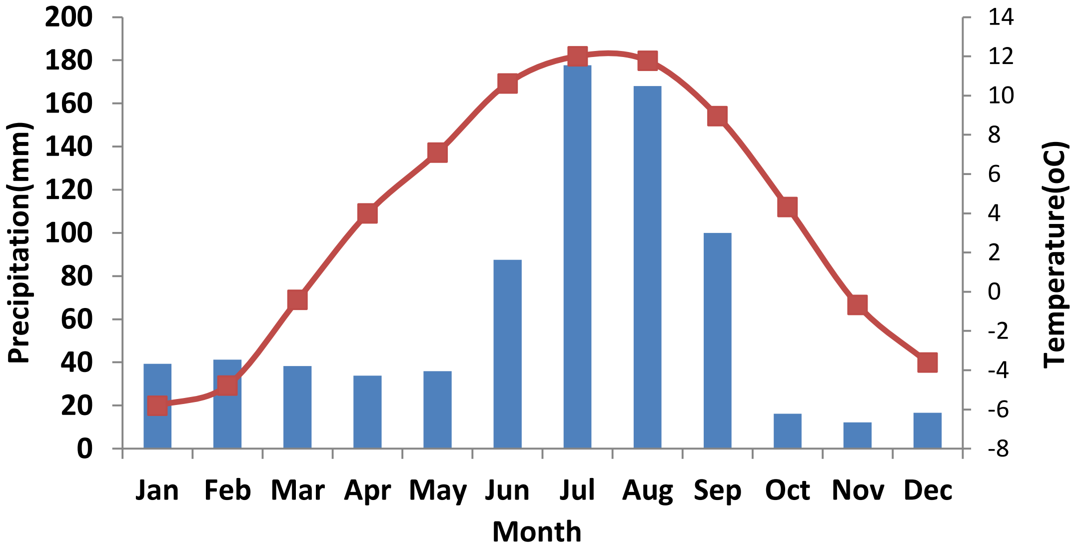
Cumulative Mass Balance of glaciers in Chandra basin

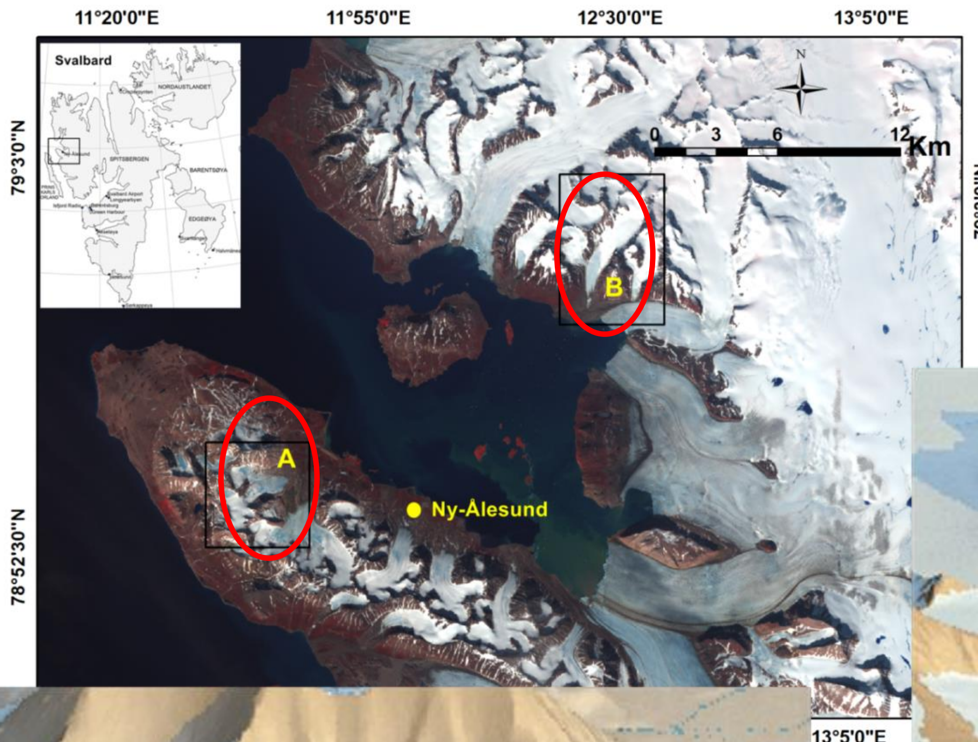


Mass loss of Chandra basin glaciers during last one and half decades is -0.56 m we/year However it was much less in nineties(1990-1999) and observed cumulative mass loss was close to zero.

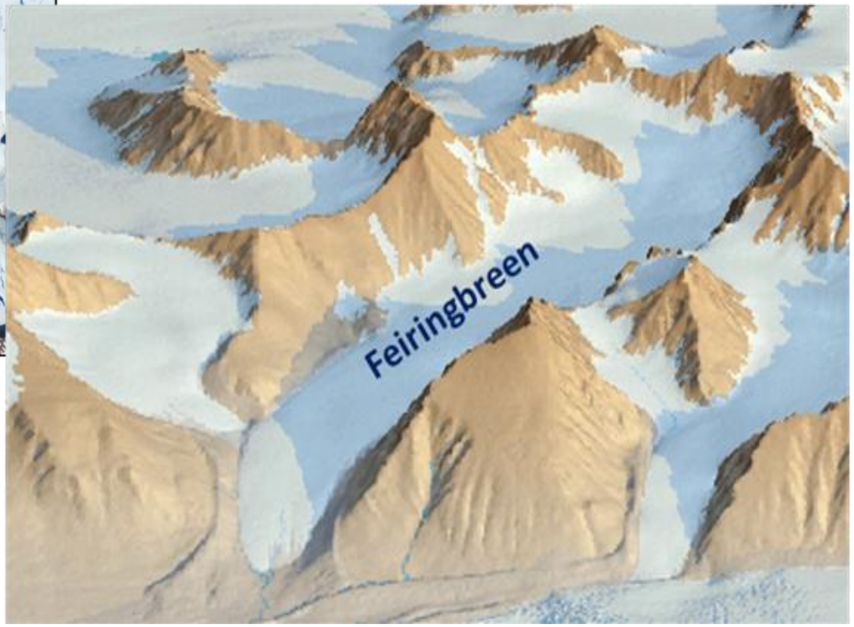
Mean annual temperature and precipitation in Chandra basin

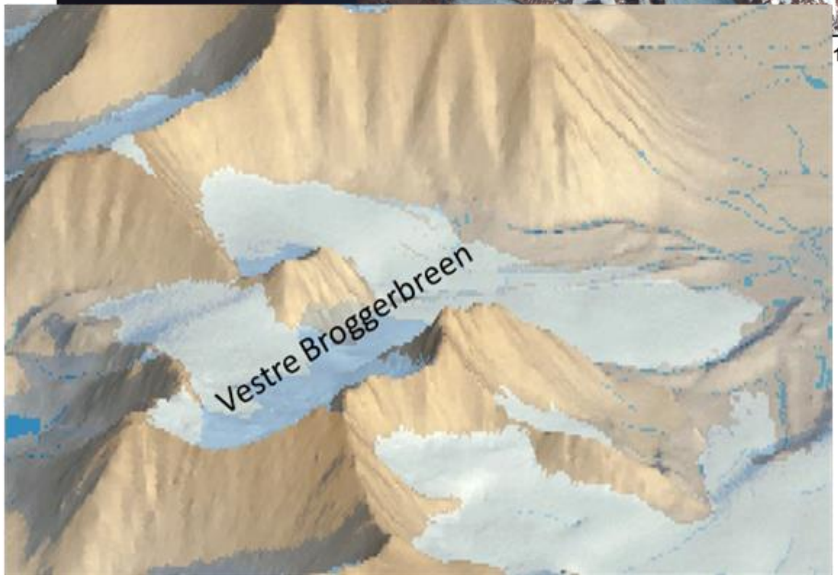






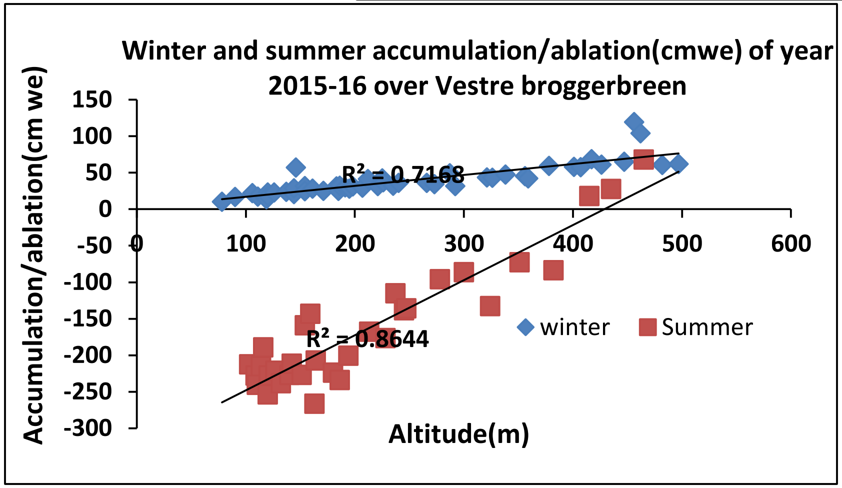
Cross the Fjord (approx. 14 km North-east to the permanent settlement Ny-Alesund
Lat. 79° 00' 59" N
Long. 12° 27' 45" E

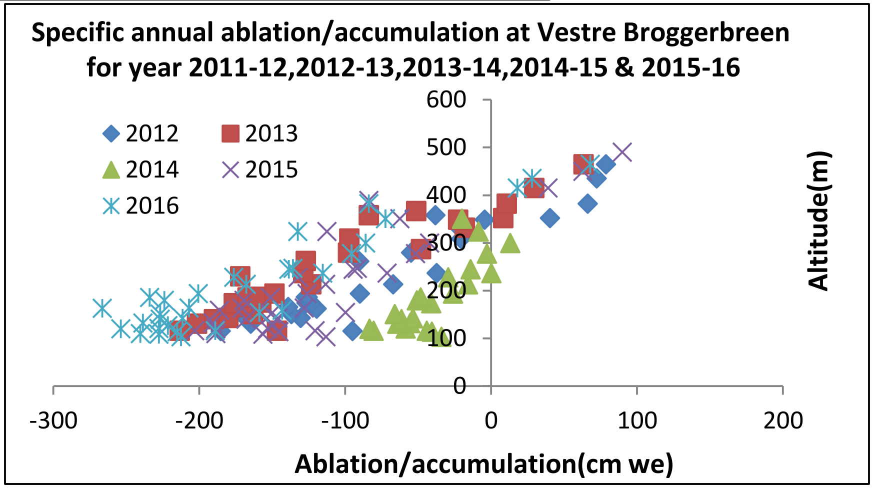


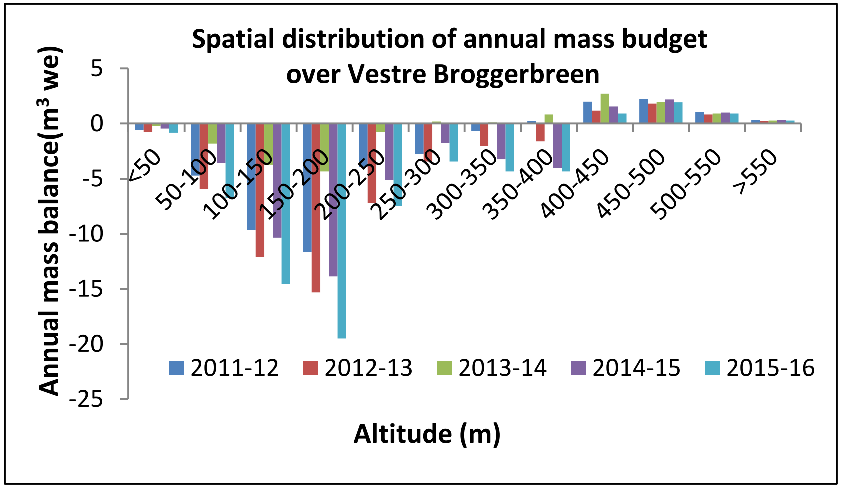


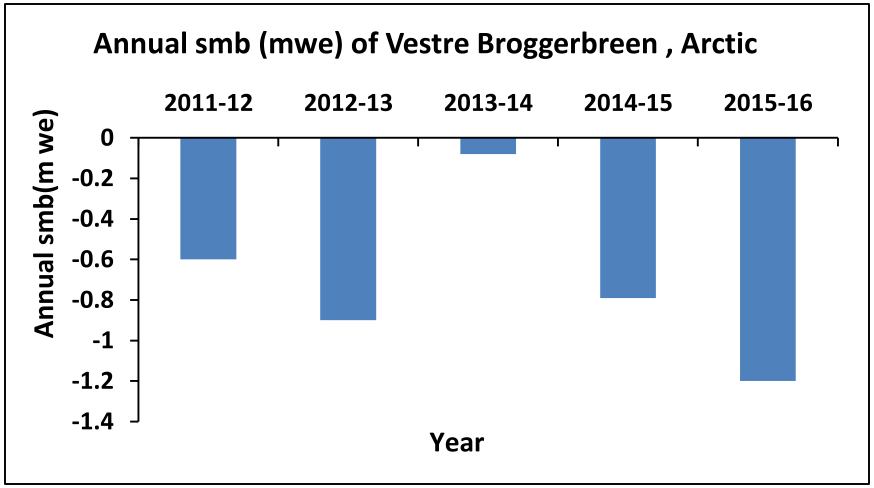
- Close to the permanent settlement of Ny-Ålesund
- Lat. 78° 55' 30" N
- Long. 11° 55' 50" E

Mass Balance of Vestre Broggerbreen glacier





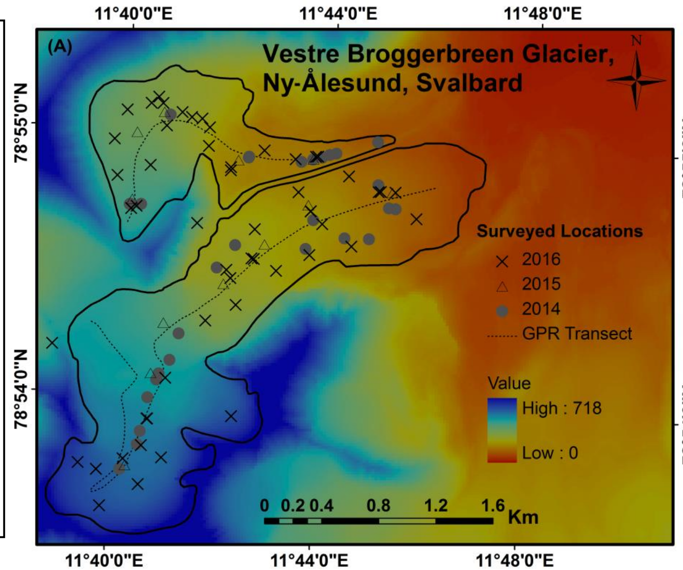


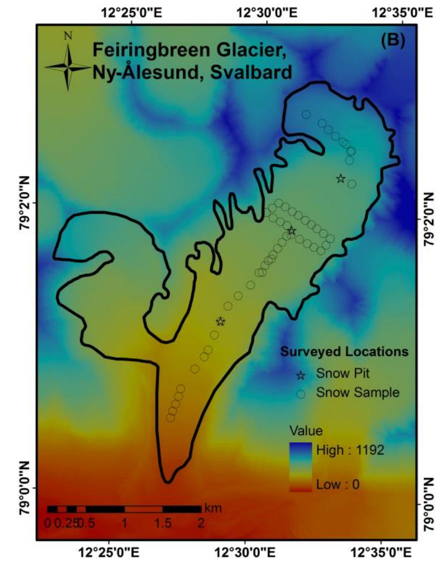


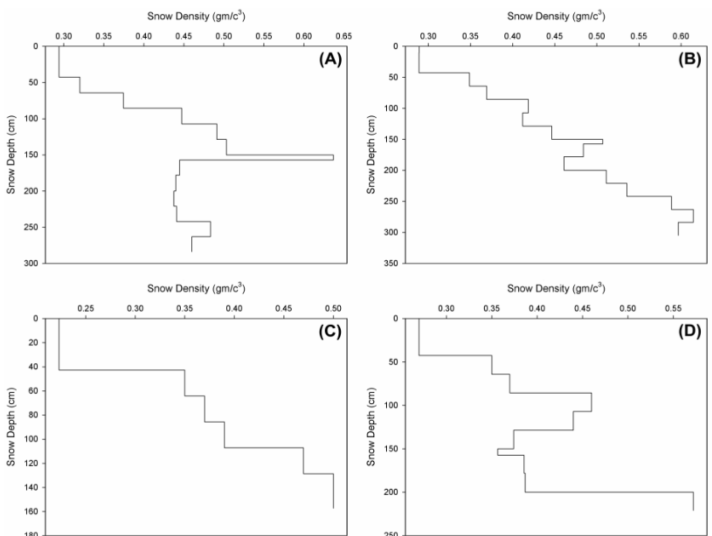
Spatial variability of Snow water equivalent in Arctic spring across Valley Glaciers, Ny-Alesund, Svalbard:

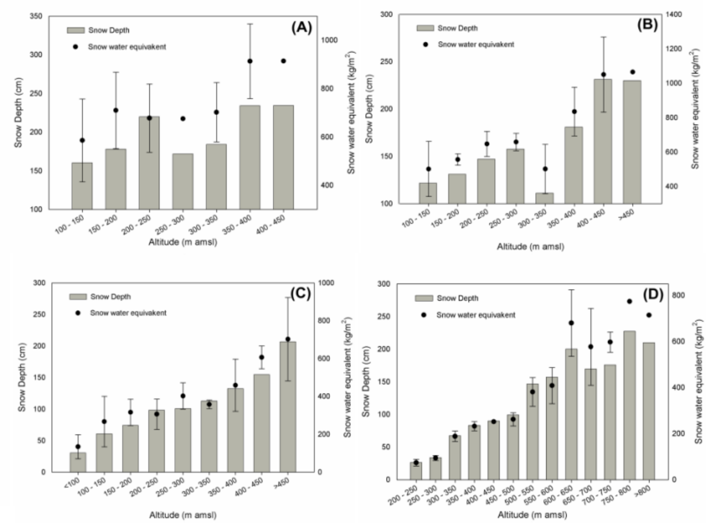
•The average SWE for the years 2014, 2015, and 2016 was 697.9 ± 185 kgm^{-2}, 603.4 ± 162 kgm^{-2}, and 376.8 ± 172 kgm^{-2} over the Vestre Broggerbreen glacier respectively, while for the Feiringbreen glaciers was 381.9 ± 187 kgm^{-2} in the year 2016.

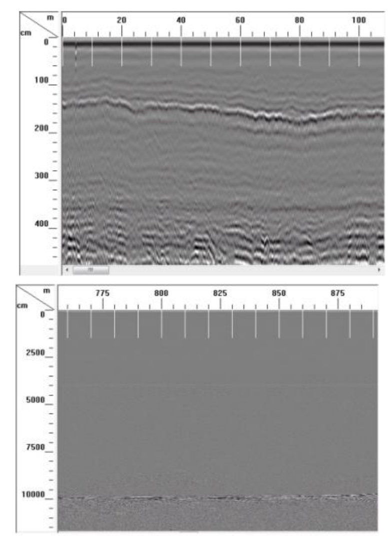
•The SWE of the selected glaciers has been decreased since 2014.



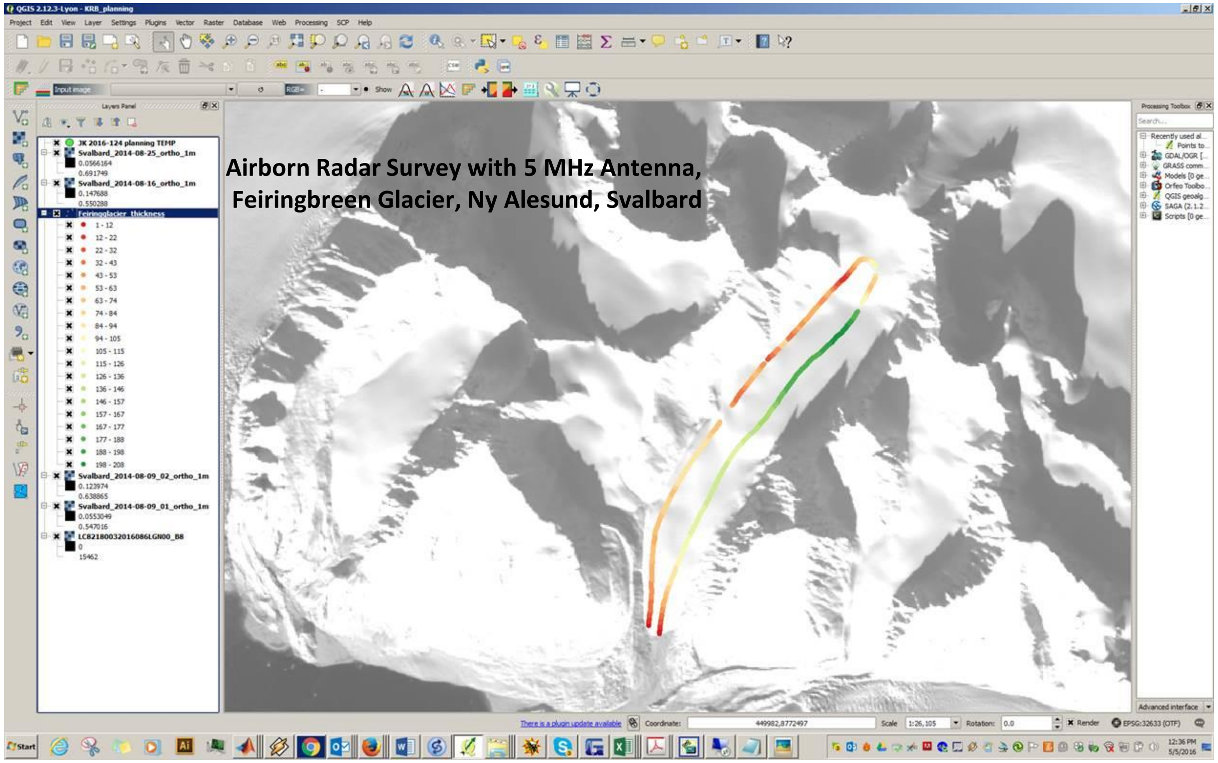


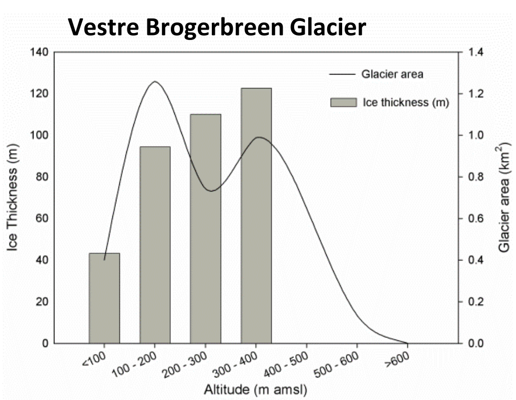


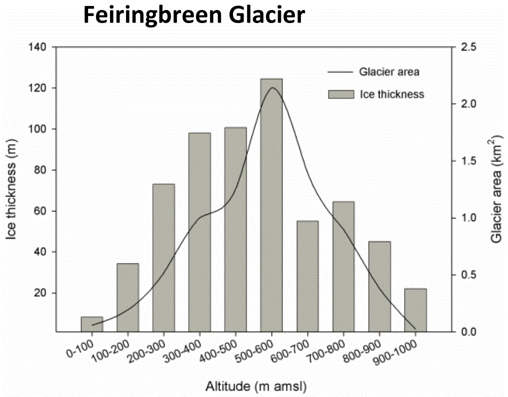




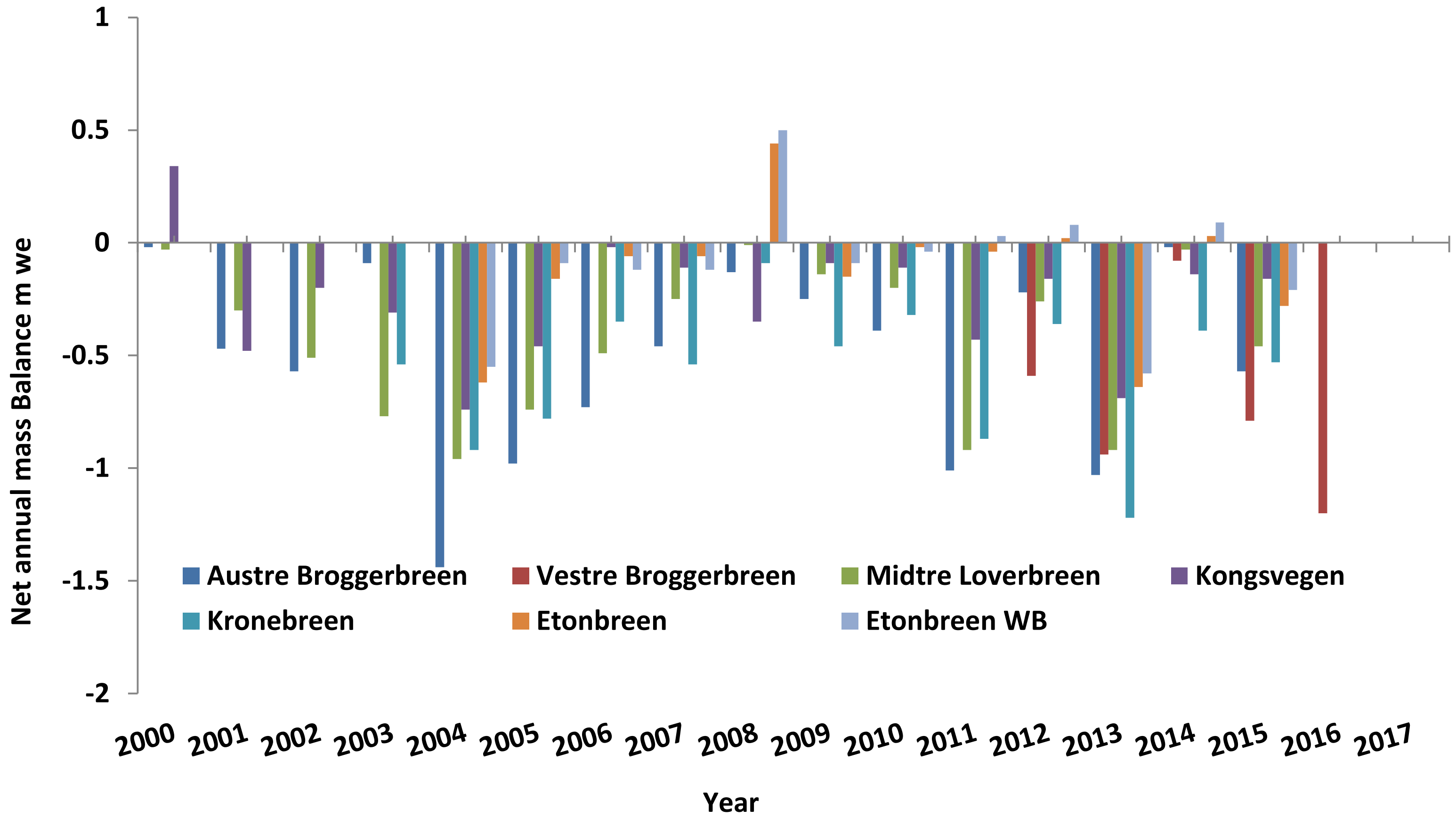
Geophysical survey over the selected glaciers of Ny-Alesund, Svalbard:



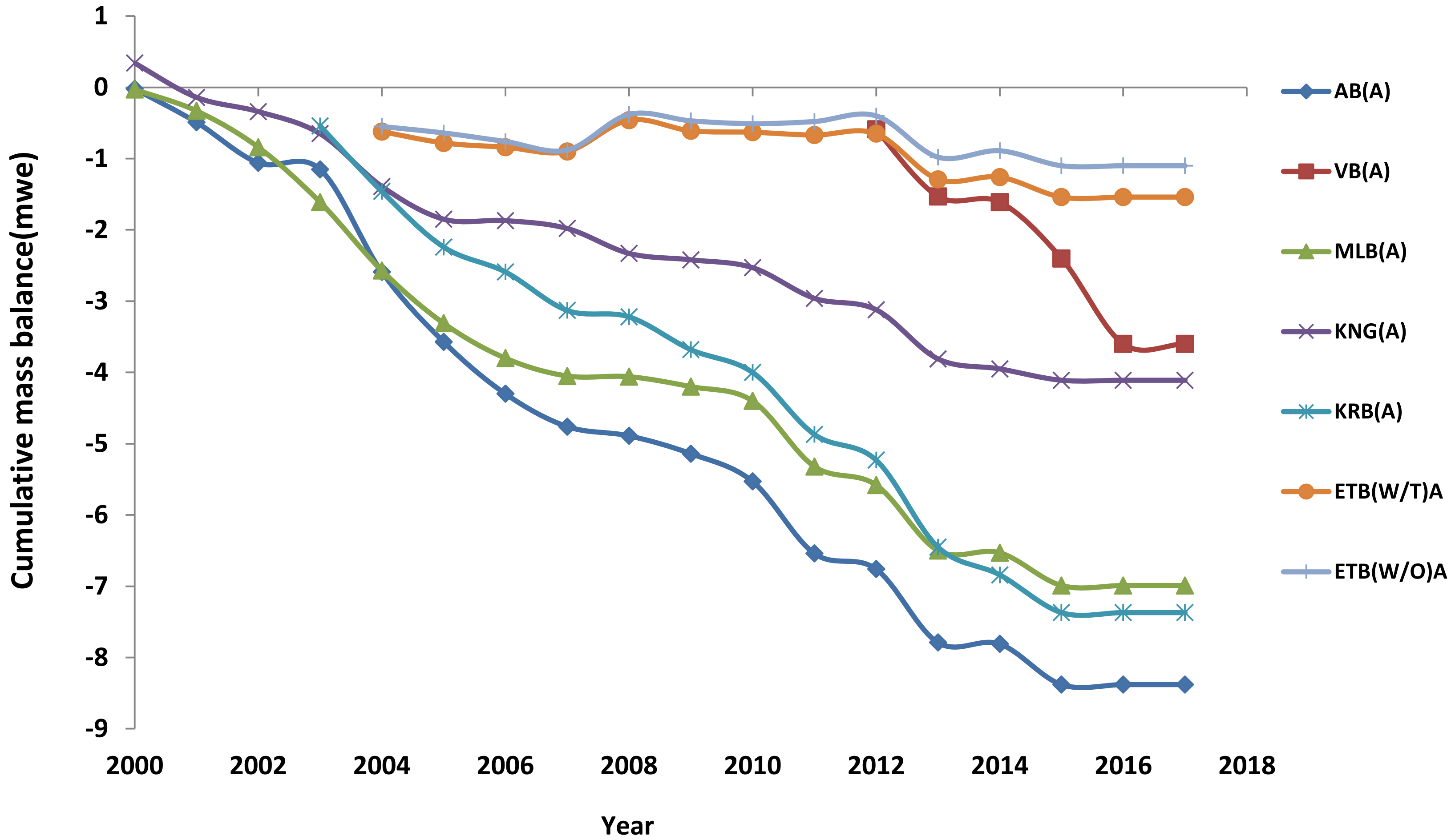




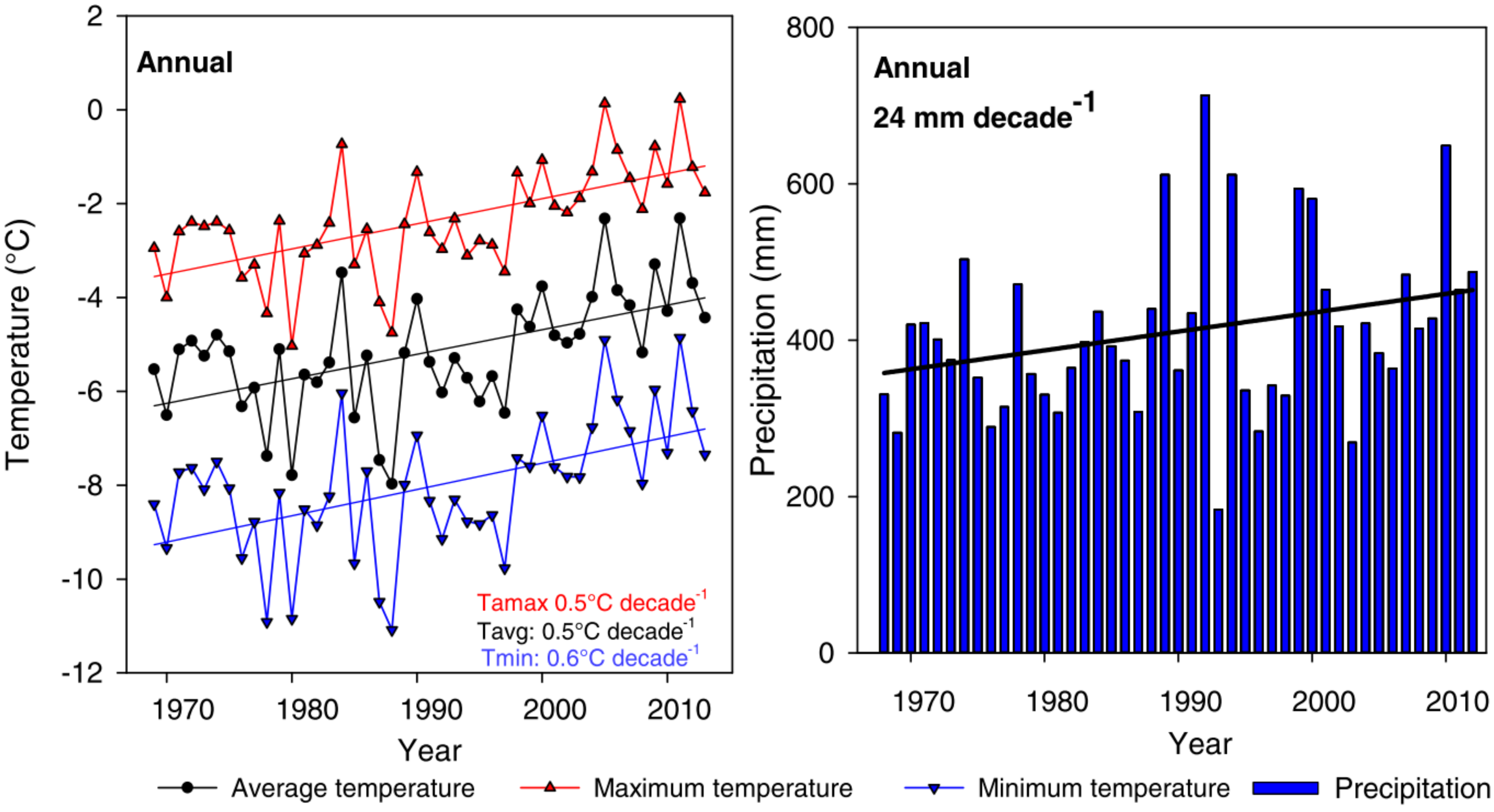
Annual Net Mass Balance of Svalbard glaciers



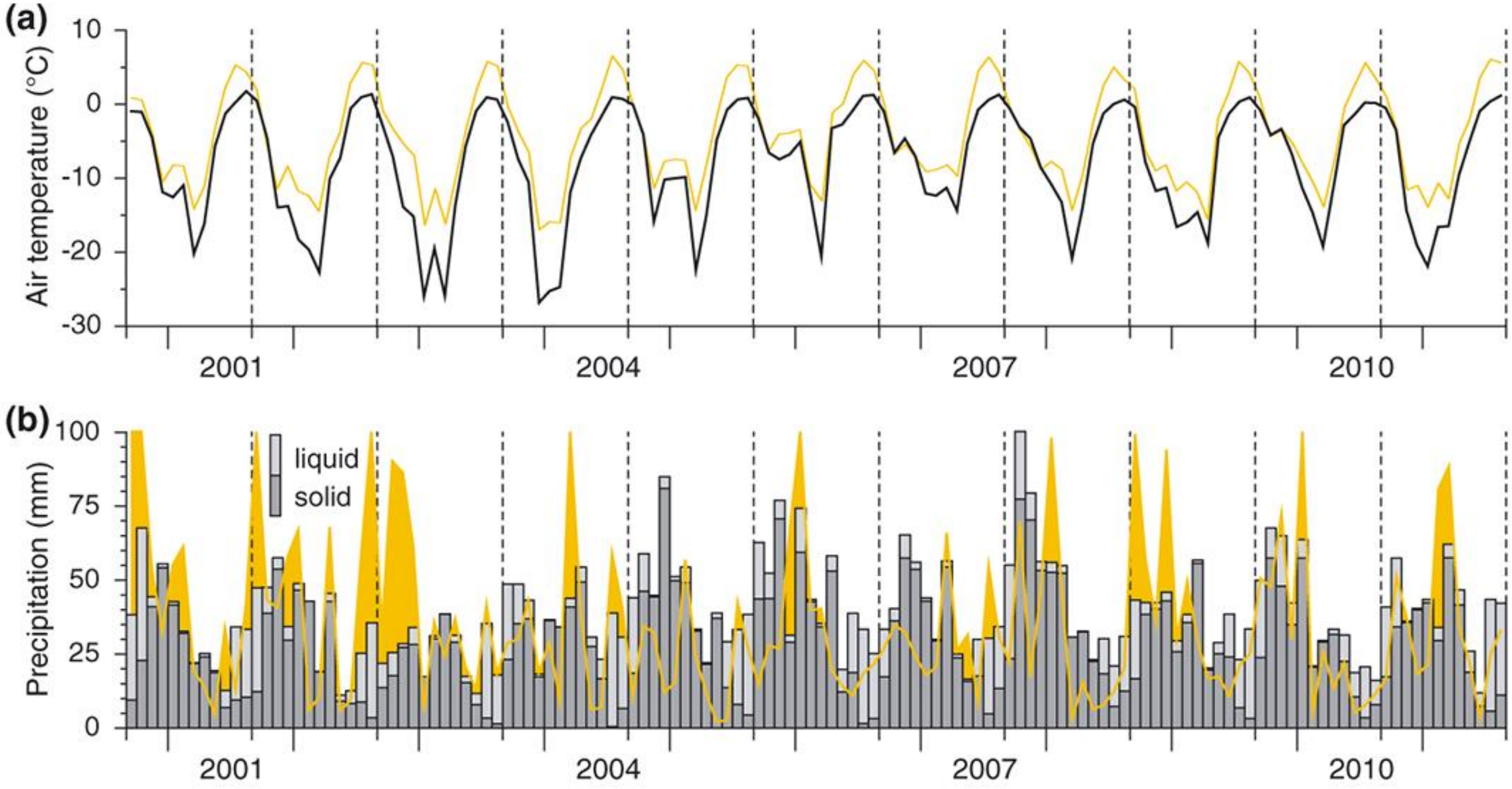
Cumulative mass balance for glaciers in Svalbard during 21st century



Temperature and Precipitation pattern over Svalbard region



Moreno et al. 2016



Monthly mean RCM a) air temperature and (b) precipitation over Svalbard for the mass balance years of 2000/2001–2010/2011 (grey bars). Measured monthly values at the meteorological station in Ny-Ålesund are shown for comparison (orange colors). The dashed vertical lines divide different mass balance years starting in September (Geir Moholdt ,2010)

- The SMB time series show a strongly negative SMB regime which is mainly controlled by the summer SMB

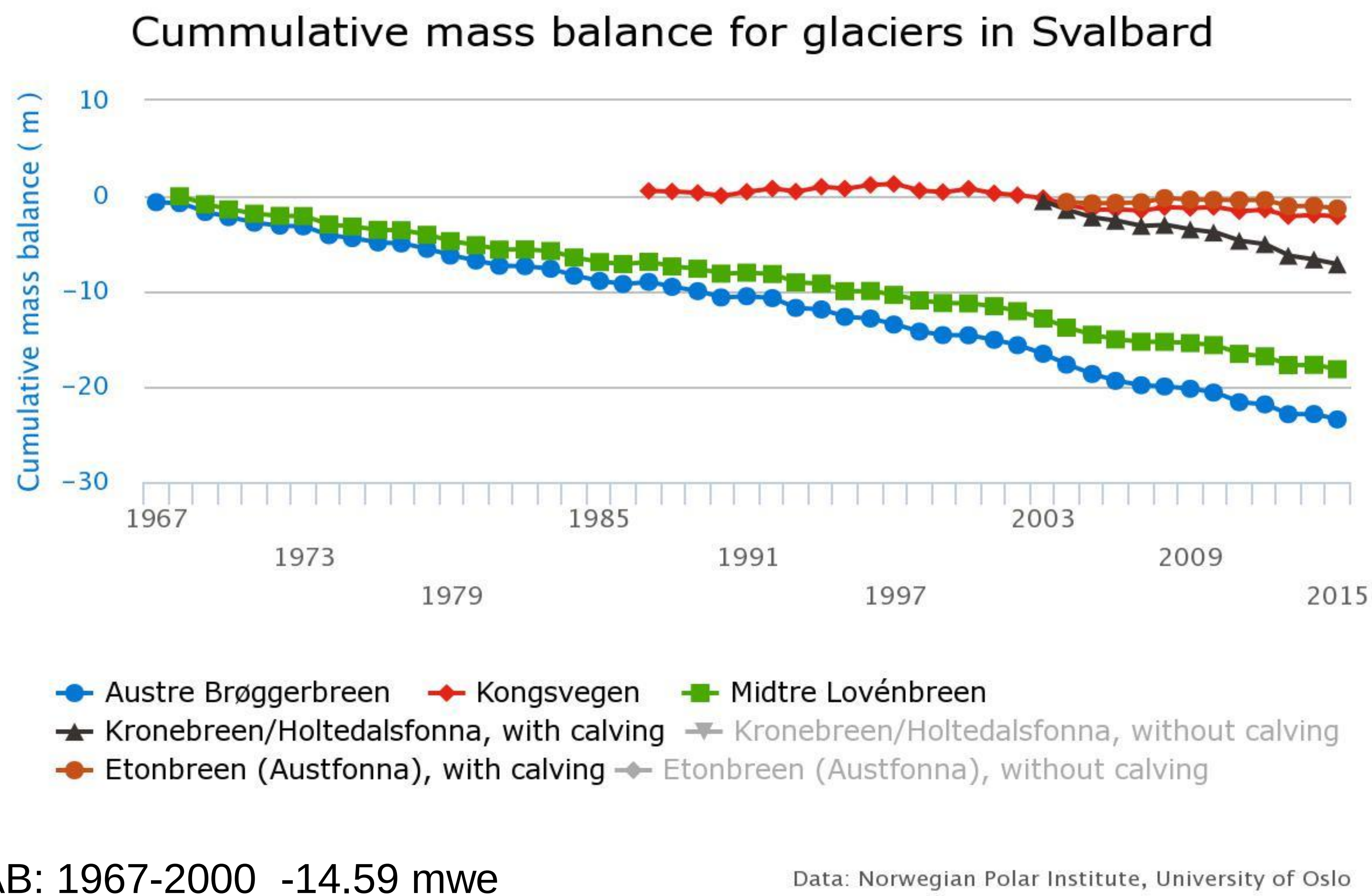
- There are no clear temporal trends in SMB although summer temperature and winter precipitation have increased slightly over the same period

- The very negative net annual balance at Austre Brøggerbreen is in contrast to similar measurements between 1987 and 2008 at Kongsvegen, a 105 km^2 quiescent surge-type glacier only ~15 km away

- The average annual net balance at Kongsvegen in this period was -0.05 m w.e. y^{-1}, while the corresponding number at Austre Brøggerbreen was -0.51 m w.e. y^{-1} (J. Kohler, pers. com.)

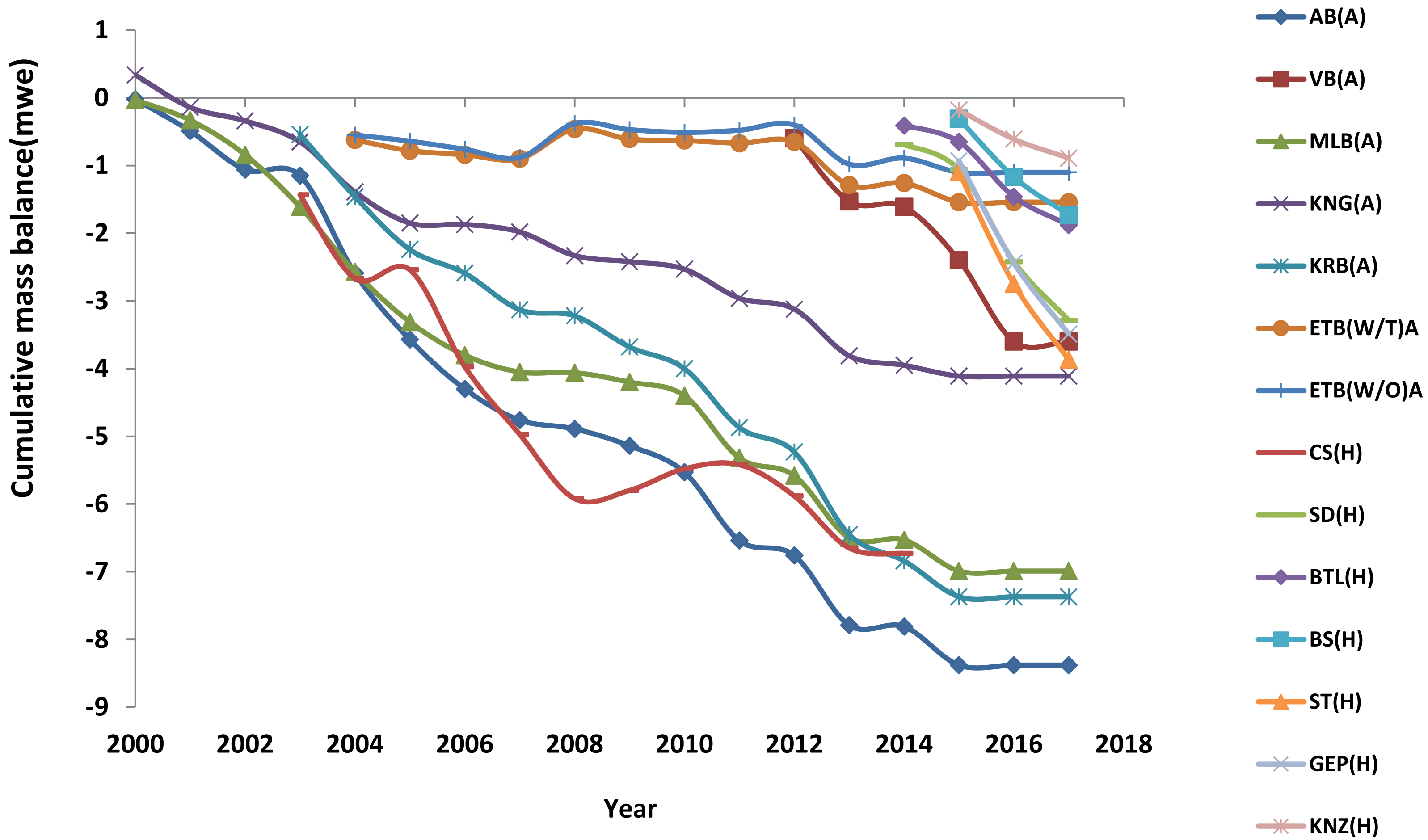
- The SMB response to a hypothetical warming of +1 K has been estimated to -0.25 m y_{-1} K^{-1} (Oerlemans et al., 1998) and -0.45 m y^{-1} K^{-1} (De Woul and Hock, 2005)

- Internal refreezing will slow down the SMB response to climate change



AB: 1967-2000 -14.59 mwe
2000-2015 - 8.85 m we

Cumulative mass balance for glaciers in Svalbard during 21st century



Conclusions

- The mean annual mass balance of Chandra basin and Svalbard Arctic are is -0.67±0.14m w.e. and -0.36±0.02 m w.e. during last one and half decades.
- Artic glaciers and ice caps have been losing more glacier mass than Himalaya in total but melting rate of Himalayan glaciers is significantly higher than Arctic.
- There has been a gradual warming with an apparent stronger trend observed both the region during the last one and half decades.
- The temperature trends are much more pronounced for the winter seasons than for the summer seasons.
- This seasonality in climate change has been observed over most of the Himalayan and Arctic region.
- Majority of the glaciers and ice caps of Arctic and glaciers of Himalaya are in state of instability and their volume may significantly reduce if the climate stabilizes at its present state.


THANK YOU

Major activities over Himalayan glaciers