New Digital Glacier Database for Svalbard

Max König[1], Christopher Nuth[1,2] , Jack Kohler[2], Geir Moholdt[2] and Rickard Pettersen[3]

[1]Norwegian Polar Institute, Fram Center, N-9296 Tromsø, Norway
[2]Dept. of Geosciences, University of Oslo, P.O.Box 1047 Blindern, 0316 Oslo Norway
[3]Dept. Of Earth Sciences, University of Uppsala, S-752 36 Uppsala

Abstract: The archipelago of Svalbard presently contains approximately 33,200 km² of glaciers, with a large number of small valley glaciers as well as large areas of contiguous ice fields and ice caps. While a first glacier inventory was compiled in 1993, there has not been a readily available digital version. Here we present a new digital glacier database, which will be available through the GLIMS project. Glacier outlines have been created for the years 1936, 1966-71, 1990, and 2001-2010. For most glaciers, outlines are available from more than one of these years. A complete coverage of Svalbard is available for the 2001-2010 dataset. Glacier outlines were created using cartographic data from the original Norwegian Polar Institute topographic map series of Svalbard as basis by delineating individual glaciers and ice streams, assigning unique identification codes relating to the hydrological watersheds, digitizing center-lines, and providing a number of attributes for each glacier mask. The 2001-2010 glacier outlines are derived from orthorectified satellite images acquired from the SPOT-5 and ASTER satellite sensors. In areas where coverage for all time periods is available, the overwhelming majority of glaciers are observed to be in sustained retreat over the period from 1936-2010.

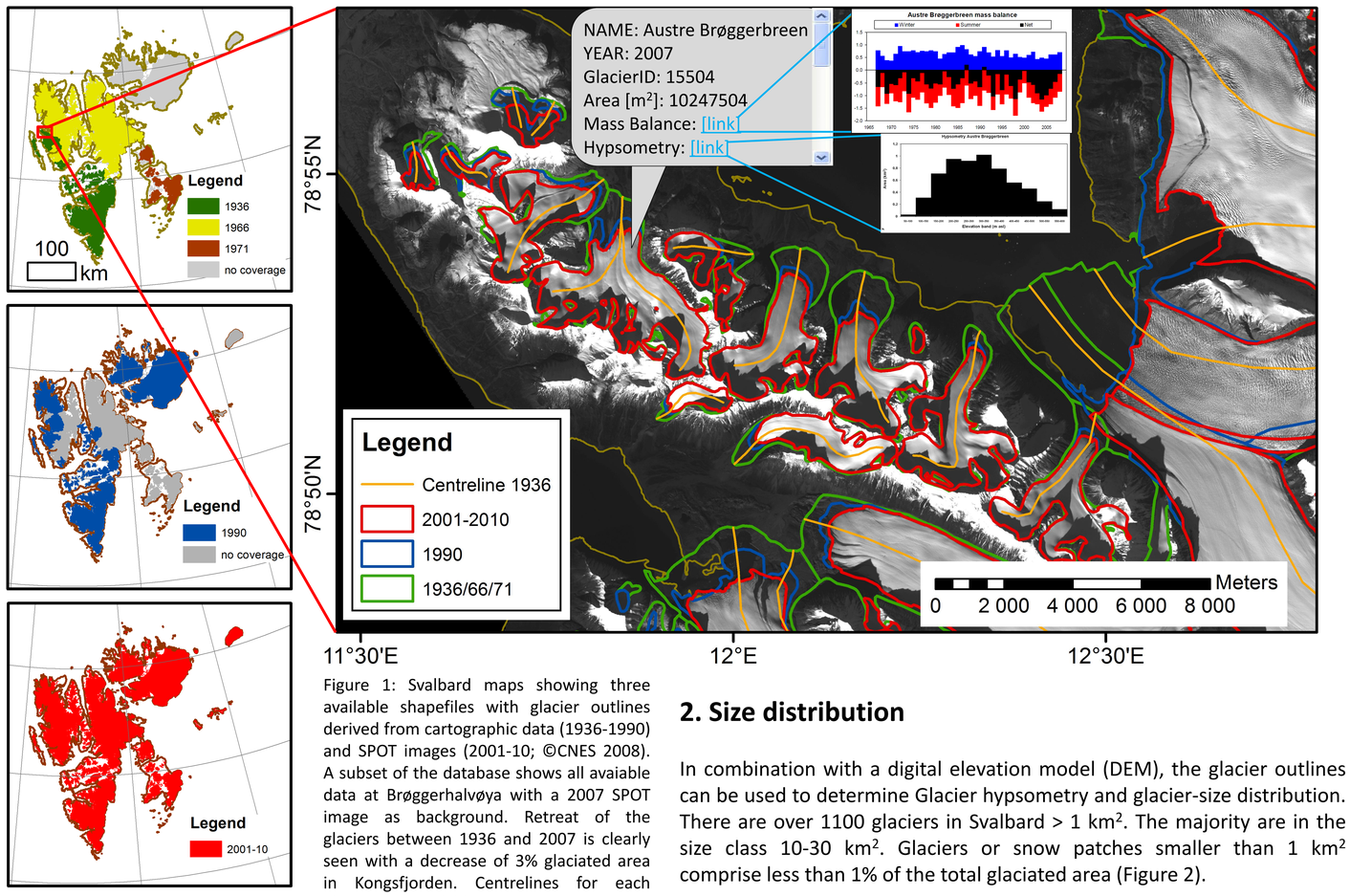


Figure 1: Svalbard maps showing three available shapefiles with glacier outlines derived from cartographic data (1936-1990) and SPOT images (2001-10; ©CNES 2008). A subset of the database shows all avaiable data at Brøggerhalvøya with a 2007 SPOT image as background. Retreat of the glaciers between 1936 and 2007 is clearly seen with a decrease of 3% glaciated area in Kongsfjorden. Centrelines for each glaciers are available.

1. Introduction

The first complete glacier inventory of Svalbard was presented by Hagen et al. (1993). This inventory was based upon the original topographic map series of Svalbard derived from aerial photographs taken over multiple years (1936/1966/1971), but has not been available in a digital format.

The new digital glacier database of Svalbard presented in this study (König et al., submitted) converts and enhances the original Hagen et al. (1993) Svalbard glacier atlas into digital format. Shapefiles describing individual glaciers with their various attributes (name, ID, size, etc.) are now available for the periods, 1936, 1966-71, 1990 and 2001-2010 (Figure 1). Not every glaciers is covered for each time period, but full Svalbard coverage is available for 2001-2010.

The glacier outlines between 1936 and 1990 have been created using cartographic data from the original Norwegian Polar Institute topographic map series of Svalbard while the 2001-2010 glacier outlines are derived from orthorectified satellite images acquired from the SPOT-5 and ASTER satellite sensors.

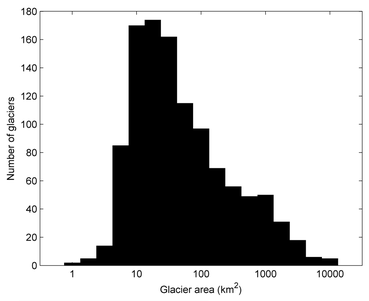
We envision a “living inventory” (dynamic inventory), which can be updated and expanded with additional glaciological data. A more complete database for example, will include glacier centerlines and lengths, glacier hypsometries, ELA and firn line estimates, thickness measurements and volume estimates as these become available.

Official publication of the dataset will occur through a digital portal operated by the Norwegian Polar Institute, the GLIMS archives at the National Snow and Ice data Center (NSIDC) and through the CryoClim data portal.

2. Size distribution

In combination with a digital elevation model (DEM), the glacier outlines can be used to determine Glacier hypsometry and glacier-size distribution. There are over 1100 glaciers in Svalbard > 1 km². The majority are in the size class 10-30 km². Glaciers or snow patches smaller than 1 km² comprise less than 1% of the total glaciated area (Figure 2).

Figure 2: Distribution of glaciers sizes for Svalbard



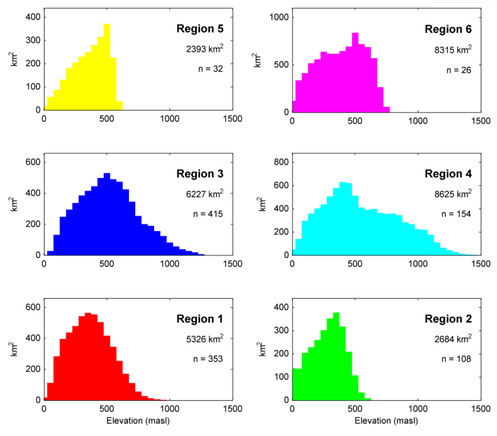
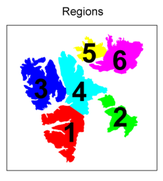


Figure 3: Glacier hypsometry for different regions



Glacier hypsometry varies considerably around the archipelago (Figure 3) and depends on the underlying terrain. Region 3 and especially Region 4 are areas of higher topography, where glaciers reach elevations above 1000 m.a.s.l.

3. Equilibrium Line Altitude (ELA)

The database and hypsometries can be used to make a rough estimate of equilibrium line altitudes for all of Svalbard. The accumulation-area ratio (AAR) is an easily-measured parameter strongly related to the long-term mass balance. Using the glacier hypsometry and assuming a uniform accumulation area ratio (AAR) of 0.6 (e.g. Moholdt et al., 2010), the equilibrium line altitude (ELA) can thus be found by choosing the elevation band delineating the upper 60% of the total area, the accumulation area.

Figure 4 shows that ELAs calculated in this way are located at higher altitudes in the northern and central part of Spitsbergen, consistent with the lower precipitation amounts in that area (Hagen et al., 1993).

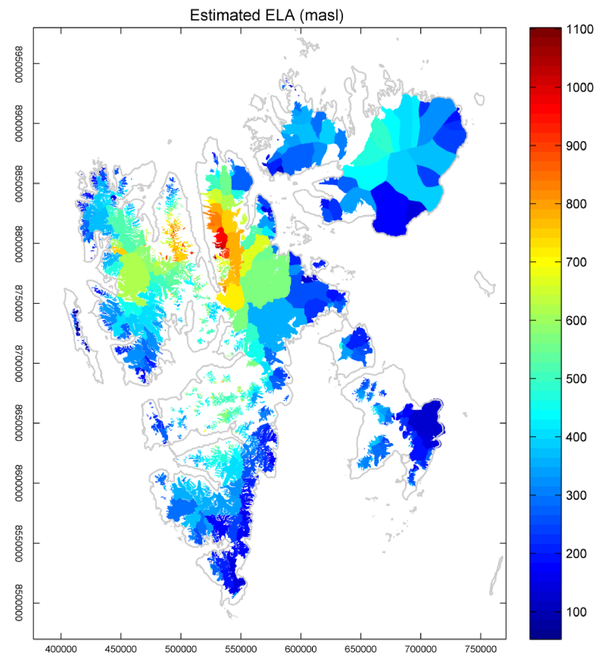


Figure 4: ELA distribution for Svalbard, estimated from individualglacier hypsometries and assuming constant AAR = 0.6.

4. Area change

In southern Spitsbergen, we have nearly complete mapping coverage for 1936, 1990, and 2008 (Figure 2), allowing us to calculate area change for the two periods 1936-1990 and 1990-2008. Figure 5 shows the area change expressed in percent change per year. The largest area changes occur for smaller glaciers in the first period. In the second period, there is an increase in the area lost for the low-altitude glaciers to the south. Some glaciers in Figure 5 are seen to have had an increase in glacier area (blue colors); these glaciers underwent a surge between the times of two map pairs.

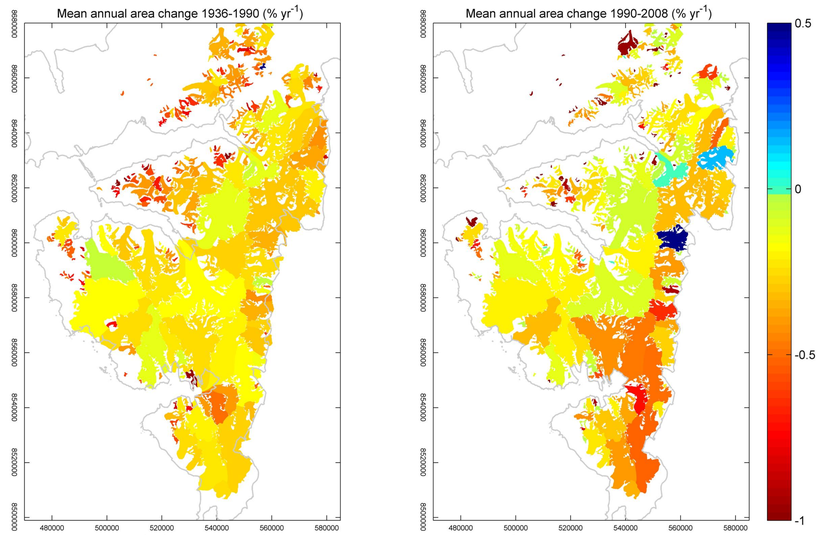


Figure 5: Annual glacier area change in percentage per year for 1936 to 1990 and 1990 to 2008.

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