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# Long-term Change Detection from Historical Photography


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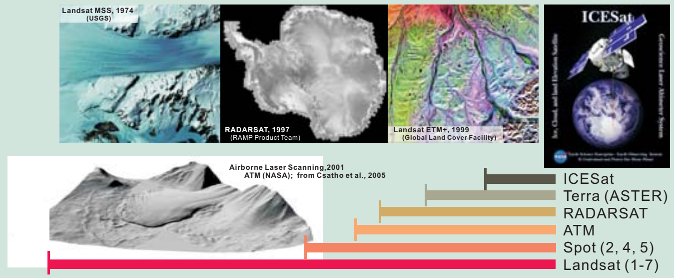
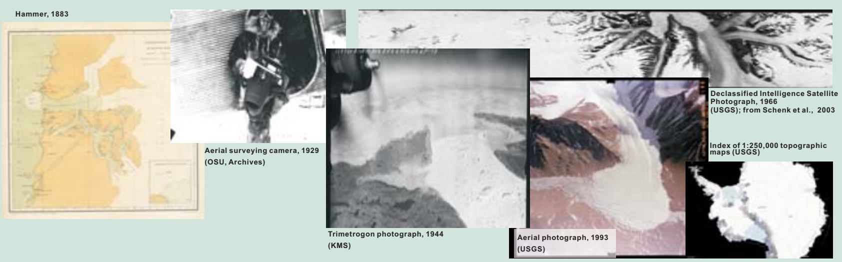
## Modern Era Data Sources

The advent of GPS and satellite remote sensing revolutionized the way of data collection, particularly in remote and hostile areas. Various sensor types, including electro-optical imagers, multi/hyperspectral sensors, SAR/InSAR, and LIDAR, produce a wealth of data and information that led to numerous publications documenting recent changes in the polar regions.

To better understand the significance of these changes it is highly desirable to analyze them in a broader temporal context. We promote to extend the time line as far back as possible and include historical data sources that can be quantitatively analyzed.




1890 | 1930 | 1940 | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010




## Historical, Quantitative Data Sources

Historical data sources that allow quantitative analysis date back to photographs obtained with terrestrial cameras used on expeditions in the early 20th century, to maps produced in 1930s, aerial photographs from reconnaissance flights during 2nd WW, and on to declassified satellite imagery (DISP) and near vertical aerial photography taken by modern mapping cameras.

## Combining Historical and Modern Data Sources using Feature Based Digital Photogrammetry

**Principle:** quantitative analysis of information extracted from modern and historical data sources requires the establishment of a common reference system. WGS-84 is the system of choice because modern sensor data are geocoded in it. Registering historical photography to WGS-84 is accomplished by extracting features from modern sensor data and old photography. Such features (sensor-invariant features) are common in both data sources (sensor-invariant features) and are used to register historical photography to WGS-84 with newly developed algorithms of feature-based photogrammetry (Schenk et. al., 2005).

**Example:** registering aerial photography to ICESat laser points. Fig. 1.(a) shows a transect along a section of an ICESat trajectory across Byrd Glacier, Antarctica. The same footprint location was measured stereoscopically on the photographs. The registration (orientation of photographs) was computed by minimizing the elevation differences between the two data sets. Fig. b) shows 3 linear features extracted from images (ridge line and valley). The same features are also extracted from ICESat laser points (see Fig. 1.(a) and are used to perform the registration.

Figs. 2.(a) and (b) depict two stereo image patches and back-projected laser points. If properly registered, the laser points in the stereopairs must be at the same location. This is not the case as a closer inspection of Figure 2.(a) reveals. The difference in the image location is used to compute better registration parameters. The result is shown in Figure 2.(b): laser points are now exactly at the same image locations.

Figure 1.

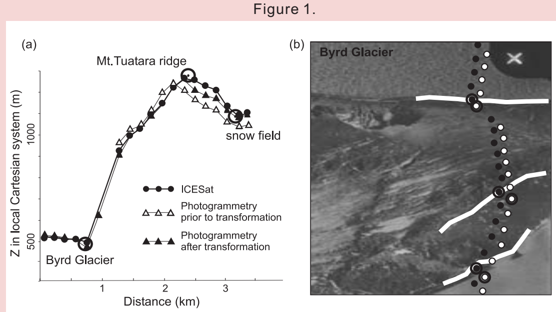
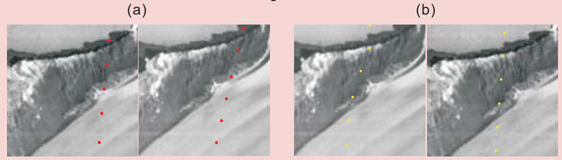


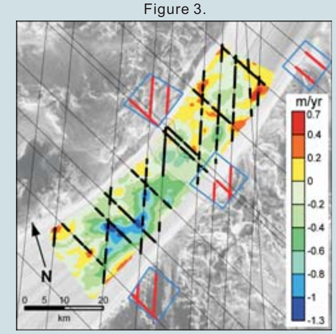

Figure 2.




## Changes from Satellite Laser Altimetry and Photogrammetry, Byrd Glacier, Antarctica (1979-2004)

Elevations determined photogrammetrically on photographs from 1979 have been compared with ICESat data acquired from 2003 to 2005. Fig. 3 shows average surface elevation change rates of Byrd Glacier plotted on a AMM-1 SAR mosaic. Black dashed lines show ICESat ground track segments used for change detection and the red lines indicate those tracks that have been used for registering the photographs. The results confirm previous research that the Byrd Glacier is in balance during the last half century (Schenk et. al., 2005).

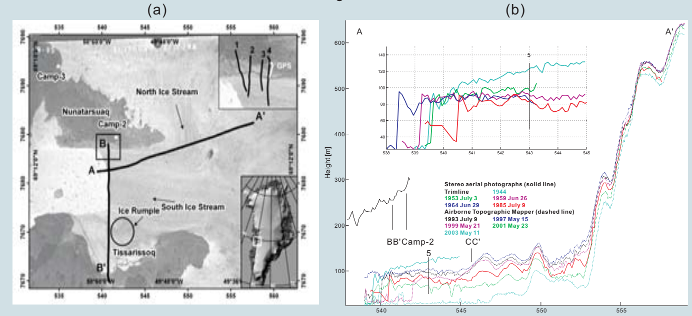
Figure 3.




## Intermittent Thinning of Jakobshavn Isbrae from Photogrammetry and Airborne Laser Altimetry, Jakobshavn Glacier, Greenland (1944 to present)

Historical photographs acquired in 1944, 1953, 1959, 1964 and 1985 have been combined (fused) with modern ATM data to analyze surface elevation changes over Jakobshavn Glacier. Fig. 4 (a) shows the location of the transects and the elevations at different time epochs are plotted in Fig. 4 (b). The quantitative incorporation of historical data puts the recently observed rapid thinning of the Jakobshavn Glacier into a broader temporal context, allowing longer-term comparisons with the climate changes since the Little Ice Age (Csatho et al., 2006).

Figure 4.





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