Mapping of Greenland landscape using aerial photography and orthophotography

Technical Note

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Abstract

Aerial photography is an important tool for mapping on local scale. In the paper, description of aerial photos taken over several urban and natural landscape sites in West Greenland is given as well as their processing. Using a high-resolution software, aerial photos were processed and digital terrain models (DTMs) of the sites produced. Technique of contour lines was used to check the created DTM for particular site. Finally, orthophotos of all sites were produced. In this Technical Note, several sites located on Western coast of Greenland are presented and the use of maps generated from orthophotos is discussed.

Key words: landscape, digital terrain model, aerial

***Abbreviations*:** DTM - digital terrain model, TIN - Triangulated Irregular Network

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Introduction

Greenland is a low-populated island with only several tens of towns and villages. Built-up area contains only 17 towns and 57 villages. The majority of the population lives along the western coast. Nuuk, the capital, with 15 000 inhabitants represents the most populated area. However, mapping of settlement of Greenland and surrounding land represents an important information for evaluation of settlement area increase, newly-built technical infrastructure, and changes in land use forms. That was why a mapping project started in 2005 under the tution of ASIAQ, a company organized under the home government in Greenland. ASIAQ responsibilities include mapping, geographic information, hydrology, climate, environment, and surveying and geotechnical investigation. For mapping, aerial photography was used in order to produce maps suitable for local community, technical and developmental purposes in particular.

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Compared to satellite photographs, pictures from low-flying aeroplanes are more accurate and detailed than satellite photos. On the other hand, many pictures are required as only a small section of the earth is seen in a single picture. That is why aeroplanes are used frequently for detailed surveying of towns and open land mapping. Using this approach, details of coastal line, lakes shore lines, rivers banks, glacier and nunatak can be distinguished.

In our paper, we bring an overview of the mapping project and give some suggestions for their exploitation in agricultural planning, and vegetation cover evaluation.

Material and Methods

Total area that was mapped was reached about 220 km², of which the built-up area covered 26 km². The aerial photographing has been made in scale 1:5000 with colour-photos. There were several institutions involved into the mapping project (for details *see* Table 1). The total amount of photos was 1320. Scankort (Denmark) was responsible for plane operations and the aerial photographing.

ASIAQ was responsible for Mapping, Surveying, GIS, data on hydrology, climate, local environment and geology. During the mapping period, ASIAQ established and measured new basis-points, controlled old basis-points, made a thorough and exact signalling, and transformed all points to EUREF – to a "global" net.

Task	Tool	Responsible
Signalling and basis-measuring		ASIAQ
Aerial photographing		Scankort
Scanning of aerial photos	Zeiss TD Photoscan	Geodis
Aerotriangulation	ISDM	Geodis
Construction/Data-collection	DFA/Z/I	Unico Mapping and Geodis
Orthophoto	Ortopro	Geodis
Map editing	GIS-LINE/TC-SOSI/LIFA	Unico Mapping
Quality control	DFA/GIA-LINE	Unico Mapping

Table 1. Overview of involved institutions and their fields of responsibility in Greenland mapping.

Aerial photos were provided by Scankort (Denmark). During field operations, they were taken by a specially designed aeroplane equipped with GPS/IMU navigation systems. In this paper, we bring a detailed technical information on processing of aerial photos, which was the responsibility of Geodis and Unico Mapping (recent name Rambøll). We scanned all photos provided by Scankort with high precision resolution. For processing of aerial photos, an Image Station Aerotriangulation Software (Intergraph Corp.) was used. We mapped almost all extravilan of towns and intravilan and extravilan of villages. We classified all areas denoted as vegetation cover, *i.e.* exhibiting green colour. In fact, they were rather non-rock areas. Then, we made breaklines bigger than 0.3 m into 3D models that was very difficult especially in the rock areas.

Fig. 1. Aerial photo of a quarry located north of Maniitsoq (65° 25′ 12" N, 52° 54′ 00" W) West coast of Greenland (left) and the same area on extract from NunaGIS map (*see* References).

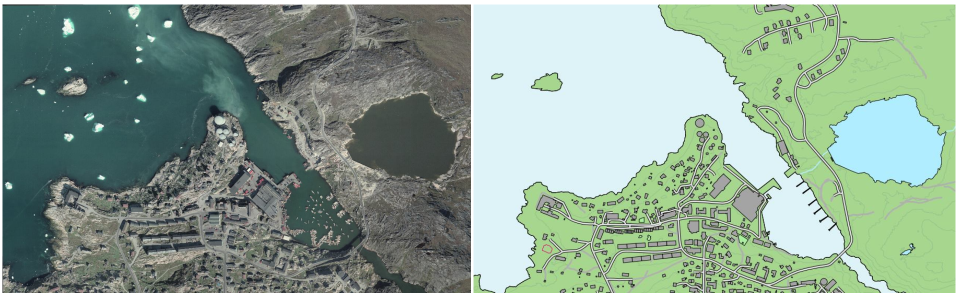

Fig. 2. Aerial photo of central part of Ilulissat (69° 13′ 18" N, 51° 05′ 47" W), a city located on western coast of Greenland (left) and the same area as extracted from NunaGIS map (*see* References).

Fig. 3. Settlement Qassiarsuk on the West coast of Greenland represents an example of agricultural land use that reflects natural relief of a land (left), and historic monument site documenting access paths in the area (right).

Subsequently, we produce DTM models combination with breaklines and automatically generated (or manually measured) grid points. To check the created DTM we used contour lines, which revealed us each notable mistake. Finally, we produced orthophoto of all the localities which we processed and delivered them along with the processed data to our Norwegian partner.

Results and Discussion

All map data were delivered according to the Danish TK3 standard and "Specification for Technical Maps – TK 99", with a supplement of Greenland specialities. Map data were delivered with DSFL-format (Danish Society of Photogrammetry and Surveying). Instead of contour lines, it has been delivered terrain-models. A terrain-model gives a better way to view the terrain than contour lines. Contour lines are products which are derivated from terrain-models. In addition a GRID has been delivered, which was generated automatically from the TIN-models and worked as a rough DTM for general view. Such maps provide a detailed graphic information on infrastructure, fixtures, technical installations and topography of the towns and settlement. They also contain a detailed picture of the shape of the terrain, displayed by means of height information. In order to obtain the same dimensions throughout the photo series, all data from an area were converted into an orthophoto. Concerning orthophoto, this was an important supplement to the map. Generally, orthophotos contain a lot of information about the terrain and may thus be used in combination with the digital maps in a GIS tool. In our project, orthophotos were delivered in GeoTiff-format, which contains both geographic placing and datum, and different levels of solutions built in the format. Here we present some examples of the aerial photo and their potential use.

Concluding Remarks

Aerial photography represents an important tool for mapping on local scale. In the paper, we reported several ways of exploitation of orthophotos and resulting maps, that may serve for local community. Recently, however, satellite technology is used for production of maps and images on regional scale to much wider extent than decades ago. Specifically for Greenland, multispectral satellite imaging may provide valuable information on area of glaciers (Stroeb et al. 2005) and changes in annual snow cover (Buus-Hinkler et al. 2006), geological (Johannessen et al. 2008, 2010) and mineral composition of rock outgrowths (Bendini 2011), vegetation area (Elvebakk 2005) and, using spectral indices such as *e.g.* NDVI, its physiological status (Hansen 1991, Loeb 1997).

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