

Project information

Project title

Remote sensing: Mapping and monitoring cultural heritage sites and environments in the Svalbard Archipelago (CULRES)

Year

2016

Project leader

Stine Barlindhaug, Norwegian Institute for Cultural Heritage Research

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

Longyearbyen (used as a reference point for all seven case studies): Latitude/Longitude: 78.2233400°/15.6468900°

Participants

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Flagship

MIKON

Summary of Results

In accordance with the project plan presented in the application, our focus in 2016 has been on publication. Hence, main activities in 2016 has been finalizing analyses as well as juxtaposing and discussing results.

CULRES aims to explore and evaluate Unmanned Aerial System (UAS) based techniques and sensors for mapping and monitoring cultural environments in Arctic areas, as well as assessing the applicability of such data for monitoring protocols and vulnerability assessments.

Imagery of seven cultural environments located in north-west Svalbard acquired through UAS-borne sensors have been processed to generate orthorectified mosaics and digital elevation models of the sites. Ground control points measured using a high precision geodetic GPS receiver provided centimetre accuracy for the DEMs and orthophotos. These image data, along with digital aerial photographs and high-resolution satellite imagery have been analysed with regard to detecting and documenting various impacts of human activity (mainly tourism) and natural degradation processes. On-ground surveys provide comparative data for evaluating the quality and completeness of UAS-based remote sensing data.

Cultural environments in Svalbard are not static and unchanging; they are subject to a number of transformation processes, both environmental and anthropogenic. Using high-resolution remote sensing image data we have shown that a) impacts from natural hazards are readily apparent throughout all case studies, and b) that human activity is a significant impact factor in some sites – primarily popular tourist destinations/cruise ship disembarkation sites. Svalbard's environmental conditions are, and will in the foreseeable future constitute a threat to cultural heritage. Wear and tear by tourists and other visitors on vegetation and cultural heritage features are however exacerbating the impact on cultural environments. This is made particularly clear when comparing popular tourist destinations with heritage sites that are rarely or not visited by tourists. In conjunction with a developing tourist industry, human impact on cultural heritage has increased in recent decades. Environmental and anthropogenic induced site transformation processes seem mutually reinforcing, the combined impact contributing to the ongoing deterioration of cultural heritage in Svalbard.

Using high-resolution image data we were able to detect even subtle changes in vegetation as well as deterioration of cultural heritage. An example from Smeerenburg show that during the time period covered by the imagery vegetation indexes showed a decrease and damage on vegetation. Indirectly, impact on cultural heritage could be detected, especially on and around cultural heritage features (Figure 1). The

degradation of Smeerenburg as a cultural environment is primarily attributed to coastal erosion, wind, sand drift, trampling and other damage by tourists. In Smeerenburg and other sites the UAS-based-imagery provided the highest detailed results, with regard to both mapping and monitoring changing cultural environments. Our results show notable differences concerning the various remote sensing sensors' ability to detect the full range of archaeological features present in the various case studies (Table 1). Image resolution as well as the type and state of features, vegetation on and around features proved key factors.

UAS-based imagery makes for a reliable source for mapping and monitoring cultural heritage, for monitoring general land cover and land cover changes, and to determine extent and causes of local hazard events (avalanches, soil movement) and other anthropogenic disturbances like snowmobile tracks and tourist trampling. Developing viable monitoring protocols based on the use of high-resolution remote sensing image data is proving dependent on image resolution. The centimetre resolution provided by UAS based sensors offer a highly viable basis for long-term, systematic, low-impact and cost-effective cultural heritage monitoring in Svalbard.

Master and PhD-students involved in the project

No

For the Management

Establishing long-term, systematic and cost-effective monitoring protocols capable of delivering data to MOSJ has long proved difficult. CULRES have produced data and results that show the potential usefulness of monitoring protocols primarily based on the use of UAS.

Published Results/Planned Publications

- A. E. Thuestad, H. Tømmervik, S. A. Solbø, S. Barlindhaug, A. C. Flyen, E. R. Myrvoll & B. Johansen 2015. Monitoring cultural heritage environments in Svalbard – Smeerenburg, a whaling station on Amsterdam Island. *EARSeL eProceedings* 14 (1) pp. 37-50. DOI: 10.12760/01-2015-1-04
- A. E. Thuestad, H. Tømmervik & S. A. Solbø 2015. Assessing the impact of human activity on cultural heritage sites in Svalbard: a remote sensing study of London. *The Polar Journal* Vol 5 (2), 2015 pp. 428-445. DOI: 10.1080/2154896X.2015.1068536
- R. Storbvold, S. Solbø, A. E. Thuestad, S. R. Karlsen, B. Johansen, E. R. Myrvoll, S. Barlindhaug og H. Tømmervik 2016. Bruk av ubemannede fly (UAS) i miljøovervåking på Svalbard. *Ottar* 2016 (309) pp. 3-11
- H. Tømmervik, J. W. Bjerke, S. R. Karlsen, R. Storbvold, A. E. Thuestad, B. Johansen & K. A. Høgda 2015. Monitoring human and climate change-induced plant stress in the Nordic Arctic Region and Svalbard using remote sensing and field surveys. In D. Vongraven (red.): *Assessing vulnerability of flora and fauna in polar areas. Symposium proceedings. Norwegian Polar Institute Brief Report Series 2015* pp. 50-53

Papers/reports in progress:

- A. E. Thuestad, S. Barlindhaug, E. R. Myrvoll, H. Tømmervik, S. A. Solbø, A. C. Flyen & B. Johansen (in prep.). The “life and death” of cultural heritage in Svalbard – mapping and monitoring cultural heritage in a High Arctic environment. The paper will be submitted to *Polar Research* (<http://www.polarresearch.net>).
- S. Barlindhaug, A. E. Thuestad, E. R. Myrvoll, H. Tømmervik, S. Solbø, A. C. Flyen & B. Johansen (in prep.). Monitoring cultural heritage sites and environments in the Svalbard Archipelago - Integrating cultural sites in the environmental monitoring of Svalbard and Jan Mayen (MOSJ). The paper will be submitted to *Archaeological Prospection* ([http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)1099-0763](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1099-0763)) or *Journal of the North Atlantic (JONA)* (<https://www.eaglehill.us/programs/journals/jona/journal-north-atlantic.shtml>).
- H. Tømmervik, A. E. Thuestad, S. Barlindhaug, E. R. Myrvoll, A. C. Flyen, B. Johansen & S. A. Solbø (in prep.). Feasibility study using UAS in mapping and monitoring cultural heritage environments in the Svalbard Archipelago. The paper will be submitted to *International Journal of Remote Sensing* (<http://www.tandfonline.com/loi/tres20>) or *Journal of Archaeological Science* (<http://www.journals.elsevier.com/journal-of-archaeological-science/>).
- E. R. Myrvoll, S. Barlindhaug & A. E. Thuestad (in prep.). Cultural heritage management in Svalbard – in light of legislation, goals and practices. The paper will be submitted to *Arctic Review on Law and Politics* (<https://arcticreview.no/index.php/arctic>).

The four scientific publications as well as the report listed above will be finalized and submitted for publication during the first half-year of 2017.

Communicated Results

The important target groups are primarily management authorities on both the local and national level as well as MOSJ. We deliver data and results directly to key users; the Governor of Svalbard, the Norwegian Directorate of Cultural Heritage and The Norwegian Polar Institute (MOSJ).

- UAS-based image data have been delivered to the Governor of Svalbard.

- A workshop was held on October 13 (Fram Centre) where we presented results and, not least, our work on developing indicators and parameters for MOSJ. A main aim of the workshop was to inform NP of current status and provide an opportunity to discuss the applicability of our proposed indicators and parameters.

Preliminary and final results from the CULPOL and CULRES projects have been communicated through international and national conferences, workshops and seminars.

Presentations:

- S. Barlindhaug 2016. *Kulturminner I MOSJ – en utfordring som kan overvinnes*. MOSJ workshop 13.10.2016. Fram Centre, Tromsø, Norway
- S. Barlindhaug, A. E. Thuestad and E. R. Myrvoll 2016. *Heftig vær og begeistra turister. Kulturminner under press på Svalbard*. Seminar, Department of Archaeology and Social Anthropology, University of Tromsø. 05.02.2016. Tromsø, Norway
- A. E. Thuestad 2016. *Mapping and monitoring cultural heritage sites and environments in the Svalbard Archipelago (CULRES)*. MIKON research programme meeting, Fram Centre. 10.03.2016, Tromsø, Norway
- S. Barlindhaug 2015. *Monitoring cultural heritage sites and environments in the Svalbard Archipelago - Integrating cultural sites in the environmental monitoring of Svalbard and Jan Mayen (MOSJ)*. National MOSJ Council.
- S. Barlindhaug 2014. *Remote sensing: Mapping and monitoring cultural heritage sites and environments in the Svalbard Archipelago*. Workshop, MIKON Flaggskip, 2. Oktober. 2014 Framsenteret.
- S. Barlindhaug, A.C. Flyen & E. Myrvoll 2014. *Managing cultural heritage at visitor sites in Svalbard: vulnerability and sustainability*. Paper at Polar Tourism Gateways: Past, present and future. Organized by the International Polar Tourism Research Network (IPTRN), University of Canterbury, Christchurch, New Zealand.
- A. E. Thuestad, H. Tømmervik, S. Barlindhaug and D. Hagen 2014. *Assessing the impact of human activity on cultural heritage sites and environments: a remote sensing study of London in the Svalbard Archipelago*. IPTRN IV – Polar Tourism Gateways: Past, Present and Future, 29.08-04.09-2014. Christchurch, New Zealand
- E. R. Myrvoll & M. Myrvoll 2014. *Runaway train? Escalating tourism at the tentative world heritage site Svalbard Archipelago*. Paper under IPTRN IV – Polar Tourism gateways: Past, Present and Future, Christchurch, New Zealand, 29 August 2014 – 4 September 2014
- H. Tømmervik, J. W. Bjerke, S. R. Karlsen, A. E. Thuestad, R. Storvold, B. Johansen and K. A. Høgda 2014. *Monitoring man- and climate change induced plant stress in the Nordic Arctic Region and Svalbard using remote sensing and field surveys*. Assessing vulnerability of flora and fauna in polar areas, 03-04.11.2014. Norwegian Polar Institute, Tromsø, Norway
- H. Tømmervik, B. Johansen, S. Solbø, R. Storvold, A. E. Thuestad, S. Barlindhaug, J. R. Hansen, H. F. Aas and J. W. Bjerke 2014. *Slitasje på vegetasjon ved ilandstigningsplasser og kulturminner. Fjernmåling og intensiv overvåking*. Kunnskapsseminaret – Svalbard 2014, 11-13.11.2014. UNIS, Svalbard

H. Tømmervik, A. E. Thuestad, S. Barlindhaug, B. Johansen, S. Solbø and R. Storvold 2014. *Ekstensiv overvåkning av slitasje på ilandstigningsplasser og kulturminnelokaliteter*. NP-seminar: Overvåkning av markvegetasjon på Svalbard, 23.10.2014. Tromsø, Norway

Poster

- A. E. Thuestad, H. Tømmervik, E. R. Myrvoll, B. Johansen, S. A. Solbø & S. Barlindhaug 2016. *CULRES – Remote sensing: Mapping and monitoring cultural heritage in the Svalbard Archipelago*. Framdagen. 10.11.2016. Tromsø, Norway
- A. E. Thuestad, S. Barlindhaug, E. R. Myrvoll, A. C. Flyen, H. Tømmervik, B. Johansen & S. A. Solbø 2015. *Monitoring cultural heritage in Polar Regions – a remote sensing study*. 35th EARSeL Symposium. European Remote Sensing: Progress, Challenges and Opportunities. 15-18.06.2015. Stockholm, Sweden
- A. E. Thuestad, H. Tømmervik, S. Barlindhaug & E. R. Myrvoll 2014. *Natural and human impact on cultural heritage sites and environments in the Svalbard Archipelago: a remote sensing study*. 2014 ICOMOS International Polar Heritage Committee Conference. 25-28.05.2014. Copenhagen, Denmark

A. Thuestad, M. Myrvoll, A. C. Flyen, H. Tømmervik, S. Barlindhaug & E. R. Myrvoll 2013. *Cultural Heritage in Polar Regions (CULPOL). Natural and human impact on cultural heritage sites and environments*. NAM 2013. Tromsø 07-09.11.2013.

Interdisciplinary Cooperation

The disciplines involved are: archaeology, vegetation ecology, botany and physics.

Tømmervik and Johansen (vegetation ecology/botany) (botanist) has extensive experience using remote sensing for mapping and monitoring vegetation cover as well as natural and human impact on both vegetation and cultural environments. Solbø (physics) has extensive experience with UAS, especially in Arctic/Antarctic climates. Overrein has outstanding knowledge about environmental monitoring, cruise tourism and management having worked with these issues on Svalbard for years. Barlindhaug, Thuestad and Myrvoll (archaeology) with mapping and monitoring cultural heritage, both through traditional (ground-based) surveys and through using remote sensing imagery. They are also well-versed in assessing cultural heritage vulnerability and value as well as knowledge of the challenges facing cultural heritage management in the High North.

CULRES is, in fact, based on input from multiple disciplines as interdisciplinarity has been a prerequisite throughout; for gathering data, for processing and analysing the gathered data, for assessing and validating the use of remote sensing image data as a basis for developing monitoring protocols as well as for ongoing publishing efforts. The different perspectives significantly strengthen the project; without the varied inputs we would not be able to fulfil the project objectives. As our academic backgrounds vary, our background knowledge, our perspectives as well as understanding of concepts and methodological frameworks vary. Occasionally, especially when juxtaposing and discussing analyses and results, lacking understanding of the methodological and theoretical approaches utilized by various project participants have complicated a common frame of reference. However, common understanding has evolved and improved throughout the project.

Budget in accordance to results

The funding received for 2016 was N.kr. 599.000,-

The use of high resolution remote sensing imagery is an integral part of the NRC funded project CULPOL, however, the use of UAS-based imagery was not included. As CULPOL focuses on developing a cross-scale methodological approach to mapping and monitoring cultural heritage assets in Polar Regions, CULRES have been an important addition as UAS allows collection of image data with cm resolution. The resolution, or rather high resolution, has proven to be a key factor. The funding from MIKON has thereby been crucial for strengthening the focus on exploring the applicability of image data for developing cross-scale cultural heritage monitoring protocols, as well as indicators and monitoring parameters for MOSJ. Through CULRES, NP was brought into the project which provided possibilities for discussions important for the further development of the deliveries to MOSJ

Could results from the project be subject for any commercial utilization

No

If Yes

Indirectly CULRES will benefit management authorities on both the local and national level through our contribution to MOSJ and towards establishing a knowledge base regarding vulnerability and current status of Svalbard's cultural heritage. Our work will provide a basis for recommendations on how to solve environmental issues and achieve a more sustainable governance of cultural heritage, thereby

contributing to continued tourism in Svalbard.

Conclusions

The project has provided a basis for further research on the use of UAS-based sensors for cultural heritage mapping in monitoring in Arctic environments.

Indicators and parameters intended for MOSJ are still under development/revision.