

Report from the Kick off-Meeting/Workshop/Field campaign - Arctic Biomass - July 12th – 19th 2013

Adventdalen, Longyearbyen and Isfjord Radio, Svalbard

The Kickoff-meeting/Workshop and field campaign was held jointly with the UAS_Ecology campaign (UAS = Unmanned Aerial Systems) funded by the Svalbard Science Forum in Adventdalen-Svalbard. In the following report we present the main activities during this meeting/workshop and field campaign.

Friday 12th - Tuesday 16th of July - Field campaign and field excursions

Tests and demonstration of UAS in Adventdalen: A lot of RGB-imagery, NDVI-imagery and video were sampled using micro helicopters (Figure 1) and the Crywing UAS (Figure 2). In addition vegetation descriptions, spectrometer measurements imagery using proximal NDVI camera imagery, data on nitrogen balance content (NBI), chlorophyll content and flavonide status were gathered. Spectrometer measurements over selected vegetation entities using the spectrometer constructed by Professor Fred Sigernes were carried out.



Figure 1. Field campaign using a mini helicopter survey the vegetation in the Adventdalen (Endalen) on Svalbard.



Figure 2. Field campaign using the Crywing micro UAS in surveying of the vegetation in the Adventdalen on Svalbard.



Figure 3. Demonstration of the UAS systems in Adventdalen, Svalbard. From left to right: Bernt Johansen, Pieter Beck, Kjell Sture Johansen (UAS pilot), Stein Rune Karlsen, Lennart Nilsen, Taejin Park and Scott Goetz.



Figure 4. Left: NDVI image from Adventdalen imaged using the Cryowing Micro UAS. Right: The Cryowing Micro UAS in action in Adventdalen. Photos by Norut.

Wednesday 17th of July - Kick-off meeting and Workshop:

09.00– 09:45 Presentations of, Norut (KAH), Boston University (TP), Wood Hole Research Center (SG), UiT (LN) and NINA (HT/OS)

09:45 -10:15 ArcticBiomass - The several work packages and milestones – Hans Tømmervik, NINA

The establishment of the network group, meetings, seminars and field campaigns/field work is a result in itself, but we will also publish least 3-4 scientific papers of which one is submitted.

10:15 –10:45 Presentation of the Geese Habitat Map of Svalbard and applications of it Hans Tømmervik, NINA

The Geese Habitat Map is so far used as a basis for different reports to EU (FRAGILE project), 5 articles and the vegetation map of Svalbard.

10:45 – 11:30: Presentation of the Vegetation Map of Svalbard – Bernt Johansen, Norut

The map is presented on the Norwegian Polar Institute web-site MOSJ. One NINA-report is produced and one article is based on this map. One ptarmigan habitat report is based on this map.

Abstract: "The overall objective of this paper is to present and discuss the most recently developed vegetation map for Svalbard, Arctic Norway. The map is based on satellite images in which several Landsat TM/ETM+ images were processed through six operational stages involving: (1) automatic image classification, (2) spectral similarity analysis, (3) generation of classified image mosaics, (4) ancillary data analysis, (5) contextual correction, and (6) standardization of the final map products. The developed map is differentiated into 18 map units interpreted from 37 spectral classes. Among the 18 units separated, six of the units comprise rivers, lakes and inland waters, glaciers, as well as non- to sparsely vegetated areas. The map unit 7 is a result of shadow effects and different types of distortions in the satellite image. The vegetation of the remaining eleven units varies from dense marshes and moss tundra communities to sparsely vegetated polar deserts and moist gravel snowbeds. The accuracy of the map is evaluated in areas where access to traditional maps have been available. The vegetation density and fertility is reflected in computed NDVI values".

Source: Bernt Johansen, Stein Rune Karlsen & Hans Tømmervik. 2012. Vegetation mapping of Svalbard utilising Landsat TM/ETM+ data. *Polar Record* 48: 47–63. doi:10.1017/S0032247411000647

11: 30 – 12.15: Presentation of the Biomass Map of Nordenskiöld Land – Bernt Johansen, Norut

A satisfactory relationship between satellite based NDVI (Landsat) and biomass using the harvest-clip method is established and is one of few studies on this topic in the Arctic. One article is produced and will be soon online and printed.

Abstract: "The relationship between phytomass, NDVI and vegetation communities on Svalbard: "The overall aim of the present study was to test the correlation between NDVI and field-recorded phytomass on Svalbard, Arctic Norway. During the field study the clip-harvest method was conducted on 104 plot sites in the areas of Adventdalen and at Kapp Linné. Every sites recorded was geo-located using GPS. In the image processing part, the available Landsat 7/ETM+ image from 17th of August 2000, was converted into an NDVI-image. From this image NDVI data at the plot sites were recorded. The NDVI data were recorded inside a circle of 100 m around the measurement center. The correspondence between the point-recorded phytomass and correspondent NDVI data show a correlation of $R^2 = 0.68$. Comparable comparison of NDVI extracted from vegetation communities and recorded phytomass show a correlation of $R^2 = 0.74$. The recorded correlation of community based NDVI and the plant phytomass were used to estimate the total plant phytomass for the entire Nordenskiöld peninsula. The overall phytomass for the entire Nordenskiöld peninsula (3972 km²) is estimated to 604.4 ton × 10³ giving an average amount of 152 ton/km² or 152 g/m². Correspondent values for lowland and upland areas are 239 ton/km² (239 g/m²) and 94 ton/km² (94 g/m²), respectively. Svalbard Miljøfond has funded the project with some support from the NCoE/Tundra project."

Source: Bernt Johansen & Hans Tømmervik, The relationship between phytomass, NDVI and vegetation communities on Svalbard. *Int. J. Appl. Earth Observ. Geoinf.* (2013), <http://dx.doi.org/10.1016/j.jag.2013.07.001>



Figure 5. Reindeer grazing in Adventdalen.

12.15 – 12.30 Artic Boreal Vulnerability Experiment ABOVE – Scott Goetz, Woods Hole Research Center

SG presented the ABOVE program and our group could have a connection/cooperation with this program.

13.30- 15.00: Field visit Kapp Linne' Discussion in the field about the flora and vegetation.

15:00 – 15:30: Phenological monitoring in Svalbard – Stein Rune Karlsen, Norut

Presentation of results using flowering of the Salix polaris as a key species for determination of the spring - NDVI is satisfactory. What is happening in the moist moss tundra? Reports/maps to the Norwegian Polar Institute are produced. In-situ measurements on the productivity of the tundra together with Rene Van der Wal are established.

15:30 – 16:00: *Trends in the Start of the Growing Season in Fennoscandia 1982–2011* - Kjell Arild Høgda, Norut

Several articles are published on previous versions of GIMMSg and MODIS. The first manuscript on GIMMS3g data is submitted to Remote Sensing special edition on GIMMS3g.

Abstract: Trends in the Start of the Growing Season in Fennoscandia 1982–2011

A good relationship between spring temperature and the onset of the spring was found. A trend towards earlier start of the growing season all over Fennoscandia,

- *Most significant in the southern regions.*
- *Weaker trend in the northern regions.*

- *The trend varied between:*
 - 2.2 ± 2.0 days in northern oceanic to
 - 19.3 ± 4.5 days in the southern oceanic region.
 - For the whole area the trend was 11.7 ± 2.0 days earlier start of the growing season.
- *Looking at the trends at a decadal scale:*
 - significantly more change/trend towards earlier start of the growing season in the first period compared to the last two periods.
- *In two of the regions, the northern and southern oceanic, the trend towards earlier start of the growing season was even reversed in third period.*
- *Correlation between temperature and start of the growing season varied from*
 - -0.56 (April) in southern oceanic region to
 - -0.79 (16th May-15th June) in northern intermediate region.
- *The warming in the 4-week period before the start of the growing season varied from*
 - $0.7 \pm 1.1^{\circ}\text{C}$ in the northern intermediate region to
 - $1.8 \pm 0.9^{\circ}\text{C}$ in the southern intermediate region

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Source: Kjell Arild Høgda, Hans Tømmervik & Stein Rune Kalsen 2013. Trends in the Start of the Growing Season in Fennoscandia 1982–2011. *Remote Sens.* 2013, 5, 4304-4318; doi:10.3390/rs5094304. The article is the first product from the ArcticBiomass project.

Commentary: Work on the peak and end of growing season has begun and Taejin Park and Ranga Myneni will be co-authors. Work on the growing season trends 1982-2011 on Svalbard involving the ArcticBiomass project team will soon begin.

16:00 – 16:35 Vegetation and biomass mapping in Alaska - Pieter Beck, Woods Hole Research Center.

Why are we interested in biomass in such an area as Svalbard? Feedback: Biomass change/vegetation cover change also needed In Svalbard for reindeer – biomass interaction studies, climate change studies

Several vegetation and biomass maps were presented using various methods and imagery including GLASS (lidar). Good relationship between NDVI maps and tree-rings (dendro) concerning productivity studies. Tree-height is an important key parameter in biomass studies. The divergence between the GIMMSg and GIMMS3g concerning browning and greening was presented and there were large regions with divergence.

16:35 – 17:05 Biomass studies in Alaska - Scott Goetz, Woods Hole Research Center.

Shadow-fraction method is a method for determination of the biomass/productivity in forests in the Arctic as well as tree height measurement from LIDAR is important parameters. Landsat disturbance mapping could be of

interest in order to explain phenology and biomass variation in the Arctic. Available GLASS tracks in Fennoscandia have to be checked out!

17:05 – 17:35 Use of GIMMS NDVI3g data sets in biomass studies – Taejin Park, Boston University

Taejin Park presented results from Fennoscandia + Denmark based on a global study.

Abstract: Taejin Park, Ranga B. Myneni, Zaichun Zhu, Jian Bi, Sungho Choi- Use of GIMMS NDVI3g data sets in biomass studies

The purpose of this presentation was to show the applicability of Global Inventory Modeling and Mapping Studies (GIMMS) Normalized Difference Vegetation Index (NDVI) 3g data set for monitoring vegetation productivity trends. GIMMS NDVI3g data set is a new version of GIMMS NDVI product and its temporal and spectral qualities were improved by several refining process. Therefore, 30 years newly constructed global NDVI dataset can be used for monitoring vegetation productivity. In the pilot study, growing season integrated NDVI (GSINDVI) which strongly correlated into Gross Primary Productivity (GPP) was used as proxy of vegetation productivity and its trend represent 30 year vegetation productivity trend. The GSINDVI was calculated from cumulative NDVI within growing season determined from threshold (15% of amplitude) in annual NDVI cycle and freeze/thaw condition. In the case of pilot study in Northern European area, observed phenological events showed advancing onset and delayed end of growing season. In other words, annual growing season period was gradually lengthened. From these changes, approximately 38.7%, 0.5% and 60.9% of vegetated area shows greening, browning and no-change trend over last 30 years based on Vogelsang trend analysis with 10% significant level. When separately looked into each vegetation criteria (forest, other woody vegetation, herbaceous vegetation and cropland/natural vegetation mosaic), productivity of cropland/natural vegetation mosaic showed the highest increasing productivity trend (6.5% per decade), on the other hand, herbaceous vegetation showed the lowest increasing trend (3.5% per decade). From this study, we observed phenological changes and dominant greening trend of Northern European area over last 30 years using GIMMS NDVI3g dataset. In further study, we will explore causal factors and its contribution on greening trends.

Commentary: *The start of the growing season was significant earlier than the study presented by Kjell Arild Høgda. Kjell Arild Høgda suggested using another threshold on the basis on mean of the different growing season and not the peak as used in the TIMESAT-program. Suggestion on use of the European Forest Map or the Corine Land cover map instead of the global MODIS based map.*

18:00 – 18:40 UAS campaigns Rune Stovold, Norut

Different campaigns using UAS were presented and results from test flights of UAS in Svalbard, Norway and Greenland were presented during the meeting and the campaign.

18:40 – 19:10 Estimating lichen volume and reindeer winter pasture quality from LANDSAT imagery - Olav Strand, NINA.

A new method for estimation of the lichen volume using the lichen index/Water moisture index based on Landsat imagery was presented and will be published in the journal *Remote Sensing of Environment* soon.

Abstract

"Reindeer and caribou are keystone species in the circumpolar region, and rely on lichens as their main winter forage to survive in some of the most extreme environments on Earth. Lichen mats, however, can be heavily overgrazed at high deer densities, triggering area abandonment or population declines. Although the species' management and conservation require precise information on the quality of winter grazing areas, no reliable and cost-efficient methods are available to date to measure lichen volume across wide and remote areas. We developed a new Lichen Volume Estimator, LVE, using remote sensing and field measurements. We used a Landsat TM land cover mask to separate lichen heath communities from other vegetation types and, therein, we predicted lichen volume from a two dimensional Gaussian regression model using two indexes: the Normalized Difference Lichen Index, NDLI (Band 5 – Band 4/Band 5 + Band 4), and the Normalized Difference Moisture Index, NDMI (Band 4 – Band 5 / Band 4 + Band 5). The model was parameterized using 202 ground measurements equally distributed across a gradient ranging from 0 to 80 lichen dm³/ m² (R² = 0.74 between predicted and observed ground measurements), and was validated with a ten-fold cross validation procedure (R² = 0.67), which also showed a high parameter stability. The LVE can be a valuable tool to predict the quality of winter pastures for reindeer and caribou and, thus, help to improve the species' management and conservation."

Source: Tobias Falldorf, Olav Strand, Manuela Panzacchi, & Hans Tømmervik. Estimating lichen volume and reindeer winter pasture quality from LANDSAT imagery. Remote Sensing of Environment. In press.

Thursday 18th of July - Kick-off meeting and Workshop:

09:00– 09:30 Classification of Svalbard vegetation - Lennart Nilsen, University of Svalbard

Abstract:

Many different classification systems have been applied to Norwegian vegetation. On Svalbard the use of classification systems becomes even more diverse, as many botanists from all over Europe have been collecting data and tried to delineate vegetation types on the archipelago.

However, two projects have recently been initiated, aiming to bring more consensus to the application of vegetation classification systems. The Norwegian Biodiversity Information Centre (<http://www.biodiversity.no/frontpage.aspx?m=23>) was established in 2005 on the initiative of the Ministry of Education and Research. In 2006 the Centre decided to develop a classification system called Nature types in Norway (NiN), which major aims were to act as a tool for documenting and classifying all Norwegian nature variation. In 2009 version 1.0 of NiN was completed, containing 385 basic nature types and 68 main nature system types. At the same time an internet based user interface was presented as a tool for navigating and searching for nature type's documentation (<http://www.naturtyper.artsdatabanken.no/>). In spring 2012 it was decided to make a revision of NiN based on feedback from users of the system, new knowledge and deficiencies. It is quite evident that the revision will make changes to the Svalbard vegetation classification, where several vegetation types and areas are poorly described or classified. The process of revising NiN is on the track and planned to be completed by the end of 2014.

Another initiative arises from Prof. D.A. Walker and his research group at the Alaska Geobotany Center, University of Alaska, Fairbanks. They took the lead in the establishment of the Arctic Vegetation Archive (AVA (<http://www.geobotany.uaf.edu/ava/>)). This Arctic vegetation data are especially valuable because of the large time, cost, and even risk associated with their collection in remote areas of the Arctic. However, the data are scattered across many countries, institutions and available in a variety of formats. The major goal of AVA is to combine and harmonize the vegetation data from the Arctic tundra biome. There is a rich source of species-distribution information in Arctic vegetation-plot (relevé) data collected and organized according to traditional phytosociological methods. Gathering these data in an open access database would be the first to represent an

entire global biome. AVA will be used to develop and improve the pan-Arctic vegetation classification and act as a resource for climate-change and biodiversity research.

NIN needs to document and describe the selected nature types, and AVA data can act as a guideline for delineating nature types on Svalbard and Jan Mayen. Many of the phytosociological studies also contain geographical located information, and some are even supplied with maps. Thus they can be used as ground truth data for remote sensing purposes, such as the Arctic Biomass project. Applying a uniform circumpolar plant community classification system will also ensure a more consistent comparability of biomass measurements across the Arctic. A preliminary survey of Svalbard phytosociological literature has been undertaken and so far 60 phytosociological published and unpublished studies have been recognized. Together they contain more than 6000 data points (relevés) with description of vascular plants, bryophytes and lichens. Many of these studies also include recordings of environmental variables. Considering Svalbard's small size and remote location the archipelago appear as one of the best studied areas of the Arctic biome.

09:30 – 10:00 Animal borne cameras and collection of reference data in wild reindeer pastures – Olav Strand, NINA

A speech on "Rudolph as fieldworker" for greening studies and collection of reference data using an animal borne camera was presented and many ideas were brought forward and is at present time in development.

10:00– 10:30 Wrapping up – High lights and Summary - Meeting plan and plan for publications - Hans Tømmervik, NINA

Hans Tømmervik presented high lights concerning the presentations from the meeting. He also stressed following topics:

Deliverable 1.1 A joint American-Norwegian research team on remote sensing based plant biomass and productivity studies in the Arctic and a program for exchange of researchers and students: *This is now in development and this meeting/field campaign is an evidence for this.*

ArcticBiomass Project team:

<i>Scott Goetz, Woods Hole Research Center, USA</i>
<i>Pieter Beck, Woods Hole Research Center, USA</i>
<i>Taejin Park, Boston University, USA</i>
<i>Ranga Myneni, Boston University, USA</i>
<i>Kjell-Arild Høgda, Northern Research Institute - Norut, Norway</i>
<i>Stein-Rune Karlsen, Northern Research Institute - Norut, Norway</i>
<i>Rune Storvold, Norut, Northern Research Institute - Norut, Norway</i>
<i>Bernt Johansen Northern Research Institute - Norut, Norway</i>
<i>Lennart Nilsen, University of Tromsø, Norway</i>
<i>Olav Strand, Norwegian Institute for Nature Research - NINA, Norway</i>
<i>Jarle Werner Bjerke, Norwegian Institute for Nature Research - NINA, Norway</i>
<i>Hans Tømmervik, Norwegian Institute for Nature Research - NINA, Norway</i>

Exchange of data: The Norwegian part of the team has so far received the GIMMS NDVI3g data set covering Fennoscandia and Svalbard from the project partner at Boston University (Professor Ranga Myneni). The data set has been so far analyzed for the onset of the growing season and one paper is already published (Høgda et al. 2013). Analysis concerning the whole growing season has started for Fennoscandia and will further on also cover Svalbard. We will include our American partners in this work. Exchange of in-situ/field data from Fennoscandia and Svalbard to the American partners will be carried out the coming winter.

Exchange of PhD students and visiting scientists: *PhD student Taejin Park from Boston University plan to visit NINA/Norut in Tromsø for a longer stay in 2014-2015. A further plan for exchange and visits will be developed during winter 2013-2014.*

Kick-off meeting/Workshop/Field campaign in Svalbard 2013 was arranged July 12th – 19th 2013: *Kick-off meeting/Workshop/Field campaign in Svalbard 2013 was arranged July 12th – 19th 2013 in Adventdalen, Longyearbyen and Isfjord Radio.*

Workshop/Field campaign in Alaska 2013: *The site (Toolik Field Station) and time for the next field campaign in Alaska was discussed and Scott and Pieter will check out the different possible dates.*

Deliverable 1.2: 3 Workshops and 2 field campaigns: *One workshop and field campaign in Longyearbyen, Adventdalen and Isfjord Radio is completed.*

Deliverable 1.3 Field protocol: *Field protocol will be developed the coming months using experience from the field campaign in Adventdalen.*

Deliverable 1.4 Establishment of field sites: *One field site is decided to be in Adventdalen (Svalbard) another in Toolik (Alaska). Additional field sites will be decided later.*

Articles:

Deliverable 2.1: Scientific paper on improved remote sensing based mapping of biomass in the Arctic combining in-situ and remote sensing data. One paper on the biomass of Nordenskiöld land on Svalbard funded by Svalbard Miløfond and NCoE Tundra is in press and online: Johansen & Tømmervik 2013. <http://dx.doi.org/10.1016/j.jag.2013.07.001>.

Status July - October: *Above mentioned work (Johansen & Tømmervik 2013 in press) from Nordenskiöld land will be expanded in order to cover the entire Svalbard by the ArcticBiomass project team.*

Also the method in the "Lichen biomass" paper (Falldorf et al. In press) will be further developed in order to fit with Sentinel 2 sensor data and MODIS data in order to monitor the lichen biomass in more detail (Sentinel 2: 10 meter spatial resolution) and in coarser spatial resolution (MODIS and Sentinel 3) for circumpolar studies. Papers are planned but this is dependent on additional funding. The whole ArcticBiomass project team will be invited to contribute.

Deliverable 2.2: Scientific paper on the relationship between the changes in plant biomass and the fauna in the Arctic. Status July-October: *We are planning a paper on the relationship between biomass and reindeer in Fennoscandia, Svalbard and Alaska.*

Deliverable 3.1: Scientific paper on mapping of plant productivity in the Arctic.

Status: *When the biomass paper from Svalbard is ready (Deliverable 2.1) is finished we will continue with this paper and cover Svalbard, Northern Norway and Alaska.*

Deliverable 4.1: Scientific paper on improved mapping of growing season in the Arctic. Already one on the start of growing season is submitted to the journal *Remote Sensing*. **Status October:** *This paper is now published online: Høgda et al. 2013. doi:10.3390/rs5094304. This work will be expanded to cover the whole growing season with help from the ArcticBiomass project team. Also a paper from Svalbard is planned to be produced dependent on additional funding.*

15:00-16:00 Field campaign and field excursion continues in Adventdalen

Excursion to the phenological field sampling plots in Endalen and near by the EISCAT station in Adventdalen was carried out (Figure 5).

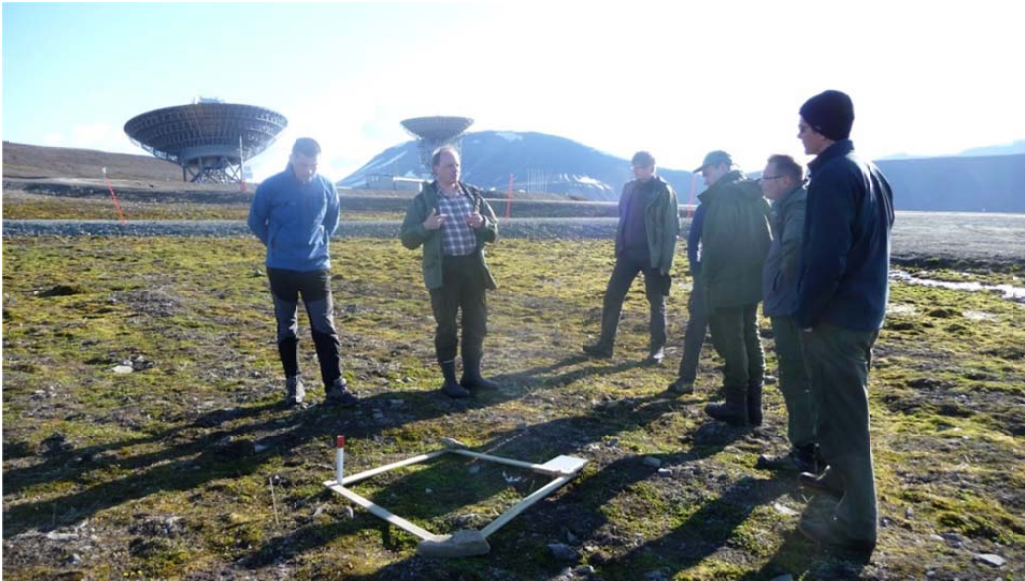


Figure 5. Excursion to the phenological field sampling plot near by the EISCAT station in Adventdalen Thursday 18th of July.

Friday 19th of July :

09:00 – 19:00 Field campaign and excursions in Adventdalen and Bjørndalen.

Spectrometer measurements (Figure 6) and field excursion continued in Adventdalen and Bjørndalen.



Figure 6. Spectrometer measurements in Adventdalen - Friday 19th of July.

Participants on the Kick-off meeting /Workshop and field campaign in Svalbard

Scott Goetz, Woods Hole Research Center, USA
Pieter Beck, Woods Hole Research Center, USA
Taejin Park, Boston University, USA
Kjell-Arild Høgda, Northern Research Institute - Norut, Norway
Stein-Rune Karlsen, Northern Research Institute - Norut, Norway
Rune Størvold, Norut, Northern Research Institute - Norut, Norway
Bernt Johansen Northern Research Institute - Norut, Norway
Lennart Nilsen, University of Tromsø, Norway
Olav Strand, Norwegian Institute for Nature Research - NINA, Norway
Hans Tømmervik, Norwegian Institute for Nature Research - NINA, Norway
Additional participants in the UAS_ecology campaign:
Kjell-Sture Johansen, Northern Research Institute - Norut, Norway
Anna Zmarz, University of Warsaw, Poland