Project information

Keywords

Biology, agronomy, grassland yield and quality, climate change, technology, remote sensing, Geographic Information Systems, statistical modelling.

Project title

Use of remote sensing for increased precision in forage production (“Remote sensing”)

Year

2018

Project leader

Marit Jørgensen

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

9011The thirty study fields in Tana are located north and south of the village Rustefjelbma, at about 28°12’E and 70°17’-70°26’N. In Tromsø at 18°65’ – 18°90’ E and 69°58’- 69°65’N, in Harstad 16°16’ - 16°37’ E and 68°74’ - 68°79’ N, in Vesterålen 15°27’ - 15°34’ E and 68°64’ - 68°66’ N. in Malangen 18.90° – 18.92°E and 68.45° – 68.46°N As the project was national, there were also fields in the south, but those are not listed here.

Participants

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Flagship

Terrestrial

Funding Source

Norwegian Research Council (NRC) - Forskningsmidlene for jordbruk og matindustri (Matfondet)

Fram Centre

NIBIO in Kind

Summary of Results

Forage is a key resource for ruminant meat and milk production. More precise information on variation in yields and forage quality can link this information with agricultural practices, and therefore help farmers make appropriate management decisions. Remote sensing technology (with sensors mounted on tractors, drones and satellite or portable sensors) can help quickly estimate forage yields and quality at field or regional/national levels. Optical remote sensing instruments measure the electromagnetic radiant energy reflected or emitted from an object to indirectly determine properties about it. Based on the relationship between reflection from the plant canopy and precisely measured characteristics of yield or quality, models can be developed to estimate these properties by remote sensing measurements only. In this project, we investigated how sensor technology on different platforms, and analysis methodology, can be used to build systems adapted to both regional interests and the individual farmer to acquire useful information for managing forage production.

We investigated whether we can distinguish different forage species based on their spectral signatures of reflected electromagnetic radiation (reflectance) measured by the sensors. We used a handheld sensor (ASD FieldSpec3) and a hyperspectral camera (Rikola) mounted on a drone (UAV) to measure reflectance of several grass species and clover just before harvest. Analyses of reflectance of different species showed clover had a different signature than grass species. There were minor differences between grass species, but it was still possible to distinguish timothy from meadow fescue and perennial ryegrass.

To investigate whether remote measurements can be used to estimate yield and feed quality, we established field trials at Holt (Tromsø), Kvithamar (Stjørdal) and Apelsvoll (Kapp), with a mixture of timothy, meadow fescue and some red clover at three fertilizer levels. We measured reflectance with a handheld sensor just before harvest in all three trials, and with a sensor mounted on a drone at Apelsvoll and Kvithamar. Thereafter we harvested and measured yield and analysed feed quality. Results showed remote sensing is suitable for estimating crop and feed quality in forage production, but drone-based measurements are better than handheld. Results show an effect of botanical composition (e.g., clover or herb content) on spectral signature, and further studies on modelling different species compositions are recommended.

We attempted to estimate field-level forage yields in farms with drone and handheld sensors. Preliminary results with data from drones clearly show the variation within the fields. However, the correlation with yield levels is poorer than for experimental fields, probably due to greater variation in botanical composition, soil conditions and other environmental effects. Preliminary results with the handheld sensor show yields can be estimated satisfactorily using parts of the available spectral range (350-900 nm). Damp weather during measurements (especially in 2017), common in north Norway, affected the spectra and created significant noise in the data. The low sun angle in north Norway relative to southern latitudes also seems to affect measurements, requiring further investigation to manage this extra source of

error.

We investigated whether satellite data can be used to map extent of winter damages. Areas with and without winter damage from Målselv in Troms from 2017 were identified and available Landsat and Sentinel-2 satellite images were downloaded from the start of the growing season in 2017. These areas were used as training data for modelling spectral signals associated with fields with and without winter damage. The results showed significant correlation between areas of winter damage estimated with satellite data and areas reported to have winter damage. Satellite data can thus be used to estimate regional extent of winter damage, but cloud-free satellite images at start of growing season, and local reporting of date of growth start and some local reference data are necessary. The method cannot be used on historical data without good reference data.

We estimated crop and botanical composition in fields of different age in mountain areas in Møre og Romsdal, and in north Norway by measuring field area, counting bales and weighing three bales per field and harvest. Samples for the determination of dry matter and feed quality (NIRS) were also taken. The surveys show a large variation in yields with a clear yield decline with age in the mountains. In Møre og Romsdal there were small differences between the age groups. In north Norway, yield was reduced in older meadows. Sown species declined with increasing age and were replaced with couchgrass (Elytrigia repens) and smooth meadowgrass (Poa pratensis). Feed quality was not affected by age of the fields, but was lowest in Finnmark. Dry matter content and weight of the bales were generally higher than the norms used by Statistics Norway and NIBIO.

Published Results/Planned Publications

Submitted October 2018: Ancin-Murguzur Francisco Javier, Taff Gregory, Davids Corine , Tømmervik Hans , Mølmann Jørgen, Jørgensen Marit. Yield estimates by hyperspectral measurements in grasslands at high latitudes (submitted to Remote sensing)

Refereed scientific papers

Geipel J. & Korsaeth A. 2017. Hyperspectral Aerial Imaging for Grassland Yield Estimation, *Advances in Animal Biosciences* **8**(2), 770-775.

Refereed proceedings

1. Davids C. Karlsen S. R., Ancin Murguzur, F.J. and **Jørgensen M. 2018** UAV based mapping of grasslands yields for forage production in northern Europe. Proceedings of the 27th General Meeting of the European Grassland Federation, Cork, Ireland, 17-21 June 2018. *Grassland Science in Europe*, EGF23: 845-847, ISBN 978-1-84170-643-6

2. Lunnan T., Todnem, J. and **Jørgensen, M.** Botanical composition of grassland for silage in mountain districts of Norway. Proceedings of the 27th General Meeting of the European Grassland Federation, Cork, Ireland, 17-21 June 2018. *Grassland Science in Europe*, EGF23: 274-276, ISBN 978-1-84170-643-6

Planned scientific papers

Geipel, J., Bakken, A. K., Korsaeth, A., 2018 - "UAV-based forage yield estimation by means of hyperspectral imaging". to be sent to *Precision Agriculture*.

Davids, C, Karlsen, SJ, Jørgensen, M, Ancin Murguzur, FJ. "UAV and satellite based mapping of grassland yield at high latitudes". Remote Sensing eller Remote Sensing of Environment.

Shao Y, Taff G., Jørgensen M. "Use of satellite remote sensing to detect winterkill on grasslands in Norway" in preparation for Remote Sensing Letters.

Communicated Results

Formidling 2015-2018

1. Allmennretta og brukerretta formidlingstiltak

Aviser, media, web

2018

«Ny teknologi for miljøvennlig produksjon». Presentasjon av prosjektet i «Grønn kunnskap – 36 smakebiter fra NIBIOs virksomhet i 2017. NIBIO bok, 4(2) 2018.

2017

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2016

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2015

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Fagblad

2017

Lunnan, T og Jørgensen M. Avlingsregistreringar i eng. Buskap 03-2017, s 70-72, 3 s.

Foredrag

2018

19. November 2018. Bruk av fjernmåling til overvåking av engareal i Nord-Norge – kan det komme bonden til nytte? Marit Jørgensen NIBIO.
Hurtigruteseminar https://nibio.pameldingssystem.no/hurtigruteseminar-2018

Presentasjoner på sluttseminar «Bruk av fjernmåling til økt presisjon i fôrproduksjon», 20. mars 2018, Tromsø

20.03.2018 - Davids, C, og Karlsen, SR. "Sentinel-2 satellittdata for overvåking av engareal".
20.03.2018 - Davids, C, Riise, T, og Kjellstrup, A." Kan vi bruke fjernmåling fra UAV for å estimere fôrproduksjon og avling i eng hos bonden?"
20.03.2018 - Geipel, J. "Estimering av avling og fôrkvalitet med droner og håndholdte instrument".
20.03.2018 - Korsæth, A. «Hva er fjernmåling og hvilke muligheter kan det gi i fôrproduksjon?».
20.03.2018 - Murguzur F.J.A. «Fjernanalyse med håndholdt sensor i eng – resultat og erfaringer»
20.03.2018 – Jørgensen M. «Botanisk sammensetning, avling og fôrkvalitet i eng i Nord-Norge.»
20.03.2018 – Lunnan T., Todnem J., Jørgensen M. «Engregistreringer i Sør-Norge»
20.03.2018 – Taff G. Shao Y. «Methods to use satellite imagery to locate grasslands with winterkill in Norway"

2017

27.10.2017 - Jørgensen M. "Use of remote sensing for increased precision in forage production". Foredrag for besøk fra Agricultural University of Athens, 27. oktober 2017, Holt

2016

25.08.2016 – Jørgensen M. Rådgiversamling Nibio Holt – presentasjon av prosjektet «Bruk av fjernanalyse for økt presisjon i grovfôrproduksjonen". Holt Tromsø

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Mølmann J. 2015. "Field measurements and handheld field spectroscopy, methods and experience". Foredrag ved møte med Statistisk Sentralbyrå, Polen og Statistisk Sentralbyrå, Norge, NIBIO, Tromsø, Holt 22-23.09.2015.

Nasjonale møter og konferanser

2018

13.02.2018 - Jørgensen M. "Fjernanalyse i engdyrkinga". Presentasjon på Nibio-konferansen 2018, Hellerudsletta.

13.02.2018 - Geipel J. "Avlingsestimering i eng ved hjelp av UAV". Presentasjon på Nibio-konferansen 2018, Hellerudsletta.

13.02.2018 - Davids, C., Karlsen, S.R., Ancin Murguzur, J.F. og Jørgensen, M. "Can we use UAVs and satellites to improve efficiency in forage production in northern Norway?" Poster på Nibio-konferansen, 2018, Hellerudsletta.

07.02.2018 - Jørgensen M., Geipel J. Davids C. og Ancin Murguzur F. J. «Fjernmåling av avling og kvalitet - akademisk leketøy eller til praktisk nytte for bonden?» Presentasjon på Grovfôrkonferansen 2018, Stjørdal, 7. - 8. februar.

2017

02.11.2017 - Geipel, J. «Research in precision agriculture and its demand for diverse types of data». Presentation at NIBIO Food and Society division meeting, Gardermoen.

08.08.2017. Korsæth A. «Highlights from NIBIO Center for Precision agriculture». Oral presentation at the 4th Norwegian-Sino Forum on Sustainable Agricultural Development, Ås

08.03.2017 - Korsæth A. «Senter for presisjonsjordbruk og relevante prosjekter». Workshop i EU-prosjektet SOILCARE. Oslo

2016

15.12.2016 – Jørgensen M. Remote sensing. Foredrag ved Framsenteret - Årsmøte i det terrestre flaggskipet 15. Desember.

24.11.2016 – Jørgensen M. "Kan vi bruke fjernmåling til å få oversikt over avlinger i engdyrkinga"? Foredrag ved Hurtigruteseminaret 2016 – Landbruk i hele landet.

22.11.2016 - Korsæth A. «Kan presisjonsjordbruk redusere jordbrukets klimautslipp». Presentasjon på konferansen Klimasmart landbruk, Gjennestad.

International meetings, seminars, proceedings

2018

Davids, C, Karlsen, SR, Ancin Murguzur, FJ, og Jørgensen, M., 2018 akseptert. "UAV based mapping of grassland yield for forage production in northern Europe". Poster ved 27th European Grassland Federation general meeting, Cork. Proceedings med fagfelle i Grassland Science in Europe Vol. 23.

Lunnan T., Todnem J. and Jørgensen M. 2018 akseptert. Botanical composition of grassland for silage in mountain

districts of Norway". Poster ved 27th European Grassland Federation general meeting, Cork. Proceedings med fagfelle i Grassland Science in Europe Vol. 23.

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Geipel, J. 2017. "Underlag för webbaserat beslutsstödesystem för smart växtodling". EU-Interreg project meeting (Innovationer för hållbar växtodling). 7 November 2017, Apelsvoll, Kapp, Norway

Geipel J. 2017. "Hyperspectral Aerial Imaging for Grassland Yield Estimation". Presentation at the 11th European Conference on Precision Agriculture (ECPA 2017), John McIntyre Centre, Edinburgh, UK, July 16–20 2017

Shao Y, Taff G, Jørgensen M. 2017. "Detection of winterkill in grasslands in Norway using spatial-temporal satellite data mining". Abstract and presentation at the annual meeting of the American Association of Geographers, 5-9 April 2017, Boston, MA, USA.

2015

Taff G. 2015. Research grants on northern cultivated grasslands" at Arctic Biomass Final Workshop, October 20-23, 2015, Longyearbyen, Svalbard.

Interdisciplinary Cooperation

This project has been a collaboration between researchers form different fields (plant production/agronomy, ecology, statistics, geography and technology). We have also had collaboration with agriculture advisory services.

Budget in accordance to results

With the Fram Centre funding, we could engage Francisco Javier Ancin Murguzur who has led the paper "Yield estimates by hyperspectral measurements in grasslands at high latitudes" which was submitted recently to Remote Sensing. The funding is also essential for accomplishing the processing and analysis of Sentinel-2 data and Rikola data for Norut. In addition, the time used by Hans Tømmervik at NINA .

Could results from the project be subject for any commercial utilization

No

If Yes

More data is needed for better calibration of models for yield estimation, but remote sensing technology has great potential to be used as tools for increasing precisicion in farming and for planning/advisory services and administration

Conclusions

The project has largely been carried out according to plan. The funds from Framsenteret were important for carrying out more data collection, and processing data. Data retrieval and processing takes a very long time and a three-year project is basically very short time to produce good results, especially since this is a new area for most of the researchers (at least those based here in the north).

The project shows that remote sensing technology has great potential as a tool for grassland production in precision farming, but also as a tool for more regional estimates of productivity and crop damage. However, more research is needed to develop the methodology to cope with varying conditions in terms of both botanical composition and light / weather conditions. Technical solutions that are robust and reasonable must also be developed.