Project information

Keywords
Remote sensing, grasslands, climate change, biomass estimation, timothy, flooding, Landsat

Project title
Effect of climatic changes on grassland growth, its water conditions and biomass (“FINEGRASS”)

Year
2016

Project leader
Gregory Taff

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Near Tromsø 69.57o N; 18.66o E At Holt (Tromsø) 69.65o N; 18.91o E in Harstad 68.79o N; 16.37oE in Vesterålen 68.64oN; 15.27oE

Participants

Project participants/institutions:

Dr. Marit Jørgensen and Dr. Jørgen Mølmann, NIBIO Holt;

Dr. Hans Tømmervik, NINA Tromsø;

Dr. Kari-Anne Bråthen, UiT – Dept of Arctic and Marine Biology;

Francisco Javier Ancin Murguzur (engaged with Fram centre funding through UiT – Dept of Arctic and Marine Biology);

Flagship
Terrestrial

Funding Source

EEA (Norway-Poland) 1 024 000 NOK for 2016

Summary of Results

In addition to the analyses accomplished below, time given by Fram Center funds allowed for writing up and presentation of research results in meetings, and will soon result in papers to be submitted to peer-reviewed journals.

We used data collected in 2014 and 2015 from FINEGRASS funding, and from Fram Center funding, to study how well Landsat data can estimate biomass of grass in fields in Norway, and we are in the process of extending the analysis to Poland by incorporating similar data from Poland. Ground truth of biomass from grassland fields was obtained in 2015 and 2016 in Norway by cutting, drying and weighing 0.5 x 0.5 m squares of grass in several fields throughout north Norway (in and near three regions: Tromsø, Harstad, and Versterålen). Several statistical methods were tested to estimate the biomass with the spectral data of the Landsat pixels, and Support Vector Machines proved the most successful, predicting with median R-square at 0.75 for the full model, and between 0.5 – 0.76 for analyses by region. Such results show these methods may be useful for mapping regional biomass at any time point, and examples of such mappings will be done before the end of the project. Before the end of 2016 we will test a 2-country model with multiple statistical methods using data that is now prepared from Poland.

Regarding the handheld field spectrometer data (hyperspectral data) of grasslands fields, we added data collected in summer of 2016 (from grant sources aside from this grant and the FINEGRASS grant) to the data we collected in FINEGRASS during 2014 and 2015. All these data included both field spectrometer data and ground truth biomass samples, assess through cutting, drying, and weighing. Francisco Murguzur, Hans Tømmervik, and Gregory Taff are working together to test multiple statistical methodologies and spectral indices from the spectrometer to model biomass of the grasses with the highest accuracy possible. Analyses begun only after summer 2016 data were prepared, and are therefore still ongoing.

Using the phytotron at Holt, we used Fram Center funds to study effects of waterlogging on seedlings of timothy (*Phleum pratense*, cv. Noreng) under three constant temperatures: 3°C, 7°C, 12°C, and natural light in autumn in a phytotron at Holt, Tromsø (69.7oN). After temperature treatments, all plants were further acclimated at 2°C for three weeks. Freezing tolerance was determined as LT50 and regrowth after seedlings were frozen at several predefined freezing temperatures in a programmable freezer. After freezing, survival and regrowth of new leaves was measured after three weeks at 18°C, 24h light in greenhouse. The higher temperatures had a clear negative effect on freezing tolerance. Waterlogging had no significant effect on frost tolerance of plants grown under 3°C, but had a negative effect under 7°C, and an even more pronounced negative effect under 12°C compared to non-waterlogged plants. The results indicate that waterlogging under higher autumn temperatures due to global warming may have negative implications for hardening of timothy.

Trends in meteorological data since 1985 were studied in north Norway (Troms County) and Poland (Wielkopolska and Brody), and correlations between meteorological variables that had significant trends with regional-level statistical data about annual grassland yields were studied for both north Norway and Poland. Results showed significantly increasing temperature trends during several periods in Poland, and in north Norway there were increasing temperatures in May and decreasing temperatures in January. Precipitation decreased in Poland in December, and increased in north Norway in March and April. Effects of these sets of trends were correlated in varying ways with grassland yields. A more robust study of these effects is currently underway.

Highlights:

1. We are able to estimate grassland biomass using Landsat satellite imagery in north Norway with substantial accuracy for regional-level analyses (r^2 of approximately 0.75).

2. Waterlogging of timothy grass under higher autumn temperatures due global warming may have negative implications for hardening of timothy.

Master and PhD-students involved in the project

Ilina Kamenova, PhD student, Bulgarian Academy of Sciences

For the Management

- We will be able to use Landsat imagery to make estimates (at any time point for which we can get cloud-free imagery) of standing dry biomass in grassland fields in north Norway. We hope to soon be able to extrapolate to other areas based on data from collaborators in Poland and potentially other countries to follow.

Waterlogging under higher autumn temperatures, as predicted by global warming scenarios, may have negative implications for hardening of timothy, which can reduce winter survival. Farmers in north Norway may adapt by ensuring that their fields have sufficient drainage. While longer growing seasons in the future could open up opportunities for cultivating forage species and varieties that are more productive than the timothy used in the North, this should be done with caution because a more stressful autumn and winter climate may severely damage species that are adapted for more growth in warmer summers.

Published Results/Planned Publications

Published results:

The following abstracts (attached) were published in 2016 along with these presentations, all at the conference entitled: “Impact of climate change and pollution on vegetation distribution and condition in the temperate, boreal, alpine and polar zones”, Warsaw, Poland 26-27.10.2016 hosted by the Polish-Norwegian Research Programme and the Polish National Centre for Research and Development:
1. Taff G., Murguzur F.J.A., Mølmann J., Jørgensen M., Dąbrowska-Zielińska K., Golinski P., Czerwinski M., Budzynska M., Kamenova I. *Assessing grass biomass using satellite imagery in Poland and Northern Norway.*

2. Jørgensen M., Mølmann J., Taff G. *Impact of waterlogging under different temperatures on hardening and freezing tolerance of timothy (Phleum pratense)*.

3. Dąbrowska-Zielińska K., Goliński P., Jørgense M., Taff G., Mølmann J., Twardy St., Budzyńska M., Golińska B., Tomaszewska M., Kowalik W., Czerwiński M., Kopacz M. *Climatic changes on grassland growth, its water conditions and biomass – FINEGRASS project.*

4. Goliński P., Czerwiński M., Jørgensen M., Mølmann J., Golińska B., Taff G., Dąbrowska-Zielińska K., Budzyńska M. *Impact of changing climate on grassland productivity – case study in two contrasting geographical locations.*

The following were presented as conference papers at the European Grasslands Federation conference, September 4-8, 2016:

5. Piotr Goliński, Marit Jørgensen, Marek Czerwiński, Barbara Golińska, Jørgen Mølmann, Gregory Taff, *Analysis of changing climate impact on timothy productivity in two contrasting geographical locations*.

6. Jørgen Mølmann, Marit Jørgensen, Fransisco Ancin Murguzur Javier, Gregory Taff, *Ground truthing – evaluation of different methods for estimating yields of grass fields in Norway*.

7. Marit Jørgensen, Jørgen Mølmann, Gregory Taff, *Impact of waterlogging under different temperatures on hardening and freezing tolerance of timothy (Phleum pratense).*

8. Katarzyna Dabrowska-Zielinska, Piotr Goliński, Marit Jørgensen, Jørgen Mølmann, Gregory Taff, Stanislav Twardy, Monika Tomaszewska, Barbara Golińska, Maria Budzynska, Gatkowska M. and Kopacz M., *Satellite data for monitoring of European grasslands – new tool for adaptation to climate change*.

Planned publications for peer-review journals:

Tentative titles scientific publications of the whole project:

Paper 1: Assessing grass biomass using satellite imagery in Poland and Northern Norway

Paper 2: Impact of waterlogging under different temperatures on hardening and freezing tolerance of timothy (*Phleum pratense*)

Paper 3: Impact of changing climate on grassland productivity – case study in two contrasting geographical locations.

Paper 4: Using MODIS NDVI and ground temperature products in conjunction with meteorological data to understand effects of changing climate on grassland productivity in Poland and north Norway.

Communicated Results

Fjernmåling til bruk i grovfôrproduksjon? Resultater fra “Finegrass” og Remote sensing” prosjekter. Talk at the Hurtigruteseminaret 24. November 2016

Interdisciplinary Cooperation

The project had substantial interdisciplinary collaboration. In particular, useful collaborations occurred between plant biologist (Mølmann), agronomists (Jørgensen in Norway; Golinski and Czerwinski in Poland), remote sensors/geographers/GIS (Taff in Norway; Dabrowska Zielinska in Poland), and biologist/statistician (Murguzur in Norway). This work would not have been possible if we did not have experts who understand how farmers manage their fields (agronomists), how grass productivity and biomass changes through its various growth stages stages (plant biologist), the technical aspects and limitations of satellite image interpretation (remote sensing/geography/GIS), statistical modeling (Taff and Murguzur), and how to measure the effects of waterlogging on grass growth (agronomist and plant biologist). In addition, understanding what aspects of the ground truth data are both interesting and measurable with satellite imagery required interdisciplinary collaboration, also along with the Agricultural Advisory Service which helped with knowing which fields were appropriate for collecting ground truth data, and also collecting the data.

Certainly, however extra time was required due to initial lack of understanding of the non-experts in each field, regarding issues such as field management regimes, grass growth stages, the technology regarding satellite image data, and issues around recording geographic locations.

Budget in accordance to results

The Fram Center funds were able to pay Francisco Murguzur to complete months of data preparation and analyses which would not have been possible without these funds. These analyses allowed us to experiment with multiple state-of-the-art statistical techniques to find highly appropriate, well-fitting models that could estimate biomass with Landsat data more accurately than with simpler models, which will hopefully allow us to publish this work in a higher level journal. In addition, the time given towards writing by the Fram Center funds allowed the project team to participate in 8 presentations this year, and also help us begin preparing manuscripts for submission of at least 4 articles to peer-review journals.

Could results from the project be subject for any commercial utilization

No

Conclusions

a) Indicate future research and/or perspectives which the project results have led to

Future work could focus on building similar biomass estimation models with Sentinel-2 data to get increased temporal frequency of estimation capability. Higher accuracy models could also be developed by incorporating environmental data into these models with satellite imagery as predictors. Future work could test different timothy varieties and other species in terms of the effects of waterlogging on winter hardening.

b) List and describe new methods or techniques that have been developed during the project or that the project has revealed a need for

Given the recent availability of Sentinel-2 data, new methods are in demand to harmonize Sentinel-2 data with Landsat data (already well known), but this could be applied to have more frequent estimations of grass biomass throughout the season.