Project information

Keywords
Arctic, climate change, winter disturbance, pollutants, multistress, Svalbard, Poland, vegetation

Project title
Ecosystem stress from the combined effects of WInter CLimate change and Air Pollution - how do the impacts differ between biomes? (WICLAP)

Year
2016

Project leader
Jarle W. Bjerke, Norwegian Institute for Nature Research (NINA)

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Five localities provided as indicated in the guidelines. 1: Ny-Ålesund area, 78.9115 °N 12.0593 °E (example from Gluudneset). 2: Longyearbyen area, 78.2494 °N 15.4353 °E (example from Hotellneset-Vestpynten). 3: Hornsund, 76.9373 °N 15.8892 °E. 4: Tromsø, 69.6544 °N 18.9099 °E (Example from Holt Climate Laboratory). 5: Beskid Zywiecki (alpine parts of Poland) 49.4489 °N 19.0782 °E.

Participants

Current project participants from Fram Centre institutions: Dr. Hans Tømmervik, NINA; Dr. Dagrun Vikhamar Schuler and coworkers, Meteorologisk institutt. Associated partner: Stein Rune Karlsen, NORUT. In addition, partners from the Polish Institute of Geodesy and Cartography (IGiK), Warsaw University, Opole University and University of Sheffield. Administrative responsibility: Research Director Sidsel Grønvik, NINA.

Flagship
Terrestrial

Funding Source

The Polish-Norwegian Programme of the EEA Norway Grants (project ID 198571)

Summary of Results

For the academic communication of results, we have already published parts of our findings in peer-reviewed journals; see list under “Published/Planned publications”. We have also shared our findings in conference presentations and proceedings. For example, the project recently organized, together with other EEA Poland-Norway projects, an open conference, which attracted many Polish and Norwegian scientists (http://polar.uw.edu.pl/). We are also currently preparing additional articles based on results gathered during this project. These are also listed under “Published/Planned publications”.

Here follow some highlights from our recent findings. These adds to the summary of results provided in our 2015 report to the flagship. See that report for summaries for articles published in 2014 and 2015.

Our results from the climatological work package was recently published in the *Journal of Climate*. To identify historical frequencies of winter warming events, we applied the longest available high-quality observation series from Nordic weather stations north of the Arctic Circle. We show that all stations had very high frequencies of warm winter weather events during the 1920s and the 1930s,

corresponding to the Early 20th Century Warming period. High frequencies were also detected for the last 15 years. Our projections for the next 100 years suggest a doubling of winter warming events in mainland Scandinavia and a tripling on Svalbard. We also assessed how this increase of winter warming events will affect society and nature. Obviously, these changes will have potentially large negative impacts.

Bjerke contributed to an editorial commentary in the journal *Global Change Biology*, together with associated WICLAP partner Gareth K. Phoenix from the University of Sheffield. We comment on the unexpected observation the vegetation greenness of Arctic regions was reduced in recent years, a process commonly known as 'browning'. We develop a conceptual framework showing how trend-based and event-based effects of climate change may drive plant development in different directions. Further, we point out the challenges of observing and assessing events and their potential impacts, especially in vast Arctic regions.

Bjerke and Vikhamar-Schuler contributed to an article reviewing changing Arctic snow cover and assessing future needs for observations, modelling and impacts. First author was Stef Bokhorst from NINA's Tromsø department. This article was published in the journal *Ambio*. We conclude that interdisciplinary activities are required to resolve the current limitations on measuring and modelling snow characteristics through the cold season and at different spatial scales to assure human well-being, economic stability, and improve the ability to predict manage and adapt to natural hazards in the Arctic region.

Currently published only in the *Geophysical Research Abstracts* is our study of carbon balance of high-Arctic and boreal vegetation. Net Ecosystem Exchange and ecosystem respiration was calculated. We identified substantial site-level impacts, with heavily damaged vegetation converted from a net $CO_2$ sink to a net source. Plot-level spectral data were then used to establish a relationship between Leaf Area Index (LAI), as predicted from Normalised Differenced Vegetation Index (NDVI), and GPP. These results will make up an important part of Rachael Treharne's PhD thesis (see under "Master and PhD-students involved in the project") and will be included in a manuscript for an international journal. We are also preparing a manuscript on the damage ratios of various vegetation types following some recent extreme events in boreal and Arctic Norway, with Bjerke as first author.

Tømmervik and Karlsen contributed to a study on the changes in vegetation productivity at Spitsbergen, as estimated using a 30-year dataset on maximum NDVI. This study was published in the journal *Environmental Research Letters*. This study shows that there is a positive correlation between primary productivity and summer temperature, but that this relationship has weakened in the most recent 10-year period. This indicates that other factors than summer temperatures have played a stronger role for vegetation productivity in this period. For instance, winter warming events harming the vegetation during the last decade may have influenced vegetation productivity negatively, a topic

discussed in this article.

Tømmervik and Karlsen also contributed to a study on the applicability of optical sensors and normal digital cameras for monitoring of phenological changes of high-Arctic vegetation. This study was published in the journal *Remote Sensing*. This study shows that the Green-Red Vegetation Index (GRVI) derived from the digital camera images is well-correlated with NDVI, and concludes that inexpensive digital cameras could be used with passive and active NDVI devices to establish a near remote sensing network for monitoring changing vegetation dynamics in the high-Arctic.

In a study of heavy metals and radionuclides recently submitted to an international journal, we show that biological samples from the Longyearbyen area have high contents of nickel compared to other areas at Spitsbergen. It is suggested that legacy and current coal dust from mining activities is the main source of nickel. The first authors of this manuscript are from Opole University, while Bjerke and Tømmervik are contributing authors.

Several additional manuscripts are under preparation, and we hope to have some ready for submission soon. Results from these studies will be reported to the flagship later.

Master and PhD-students involved in the project

Bjerke and Tømmervik are co-supervisors for a PhD student at the University of Sheffield through the ACCE doctoral training partnership funded by the British Natural Environment Research Council, to which NINA is a so-called CASE partner (https://acce.shef.ac.uk/people/case-partners/). The student is associated with WICLAP and did much fieldwork at Svalbard in 2015. Warsaw and Opole Universities use this project for educating students. Opole University brought one PhD student to Svalbard, and both universities have additional master and PhD students working on the Polish test sites. One Polish master student completed her thesis in 2015.

For the Management

This project addresses several priorities of international climate and pollution agendas. The studies contribute to our knowledge on an understudied, but highly important, element of climate change, namely the frequency, magnitude and spatial extent of winter warming events and their impacts on ecosystem health at different latitudes. Parallel studies of ecosystem pollution by heavy metals and other types of pollutants, and temporal variability in ecosystem pollution, enhance our knowledge of the combined stressors of climate change and air pollution on different biomes. Knowledge of biological and societal consequences of these phenomena is enhanced, and the most vulnerable and stressed areas and ecosystems are being detected and identified.

As the project relates to climate and pollution at several levels – from extremes histories, via impacts on natural ecosystems and agroecosystems, to impact projections for the future – the results are of high relevance to the population at large in both countries involved and the entire EU, the nature management and agricultural sectors, and to the development of industry and livelihood.

Published Results/Planned Publications

WICLAP partners in bold.


**Vikhamar-Schuler D.**, Isaksen K., Haugen J.E., **Tømmervik H.**, Luks B., Schuler T.V. & **Bjerke J.W.** 2016: Changes in winter warming events in the Nordic Arctic Region. *Journal of Climate* 29: 6223–6244. doi: 10.1175/JCLI-D-15-0763.1.

Anderson H.B., Nilsen L., **Tømmervik H.**, **Karlsen S.R.**, Nagai, S. & Cooper, E.J. 2016: Using ordinary digital cameras in place of near-infrared sensors to derive vegetation indices for phenology studies of High Arctic vegetation. *Remote Sensing* 8: 847 (17 pp.). doi: 10.3390/rs8100847.

Phoenix G.K. & **Bjerke J.W.** 2016: Arctic browning: events and trends as drivers. *Global Change Biology* 22: 2960-2962. doi: 10.1111/gcb.13261.

Vickers H., Høgda K.A., Solbø S., **Karlsen S.R.**, **Tømmervik H.**, Aanes R. & Hansen B.B. 2016: Changes in greening in the high Arctic: insights from a 30 year AVHRR max NDVI dataset for Svalbard. *Environmental Research Letters* 11: 105004. doi: 10.1088/1748-9326/11/10/105004.

Bokhorst S., Pedersen S.H., Brucker L., Anisimov O., **Bjerke J.W.**, Brown R.D., Ehrich D., Essery R.L.H., Heilig A., Ingvander S., Johansson C., Johansson M., Jónsdóttir I.S., Niila I., Luojus K., Macelloni G., Mariash H., McLennan D., Rosqvist G.N., Sato A., Savela H., Schneebeli M., Sokolov A., Sokratov S.A., Terzago S., **Vikhamar-Schuler D.**, Williamson S.N., Qiu Y. & Callaghan T.V. 2016: Changing Arctic snow cover: A review of recent developments and assessment of future needs for observations, modelling and impacts. *Ambio* 45: 516–537. doi: 10.1007/s13280-016-0770-0.

**Treharne R., Bjerke J.W.,** Emberson L., **Tømmervik H.** & Phoenix G.K. 2016: Arctic browning: vegetation damage and implications for carbon balance. *Geophysical Research Abstracts* 18: EGU2016-8838.

**Kłos A., Bochenek Z., Bjerke J.W., Zagajewski B., Ziołkowski D., Ziembik Z., Rajfur M., Dołhańczuk-Śródka A., Tømmervik H., Krems P., Jerz D.** & **Zielińska M.** 2015: The use of mosses in biomonitoring of selected areas in Poland and Spitsbergen from 1975 to 2014. *Ecological Chemistry and Engineering S* 22: 201–218. doi: 10.1515/eces-2015-0011.

**Tømmervik H., Bjerke J.W., Karlsen S.R.,** Storvold R., Thuestad A., Johansen B. & Høgda K.A. 2015: Monitoring human and climate change-induced plant stress in the Nordic Arctic Region and Svalbard using remote sensing and field surveys. *Brief Report Series* (Norwegian Polar Institute) 32: 50–53.

**Tømmervik H., Karlsen S.R.**, Nilsen L., Johansen B., Storvold R., Zmarz A., Beck P.S., Johansen K.S., Høgda K.A., Goetz S., Park T., **Zagajewski B.,** Myneni R.B. & **Bjerke J.W.** 2014: Use of unmanned aircraft systems (UAS) in a multi-scale vegetation index study of Arctic plant communities in Adventdalen on Svalbard. *EARSeL eProceedings* 13, S1: 47–52. doi: 10.12760/02-2014-1-09.

**Zagajewski B., Wietecha M., Ochtyra A., Kycko M., Orlowska K., Bochenek Z., Ziółkowski D., Bartold M., Tømmervik H., Bjerke J.W., Kłos, A., Ziembik Z., Vikhamar-Schuler D., Jarocińska A.M., Romanowska E., Marcinkowska A., Sabat A., Robak A.** & **Golenia M.** 2014: Spectral properties and condition of dominant forest tree species. In: European remote sensing - new opportunities for science and practice. 34th EARSeL Symposium, abstract and programme book, pp. 214-215. ISBN 978-83-63245-57-3.

**Bjerke J.W.** 2014: Winter warmer. *International Innovation* 151: 116–118.

**Planned publications:**

**Kłos A., Ziembik Z., Rajfu M., Dołhańczuk-Śródka A., Bochenek Z., Bjerke J.W., Tømmervik H., Zagajewski B., Ziółkowski D., Jerz D., Zielińska M., Godyń P.** & **Krems P.**: The origin of heavy metals and radionuclides in soil and vegetation near Longyearbyen, high-Arctic Norway. IN REVIEW.

**Bjerke J.W., Treharne R., Vikhamar-Schuler D., Karlsen S.R., Zagajewski B., Kłos A., Ziembik Z., Bochenek Z., Ziółkowski D., Tømmervik H**. et al.: Understanding the drivers of extensive plant damage: insights from field surveys in the aftermath of dieback in boreal and Arctic ecosystems.

**Tømmervik H., Bjerke; J.W** et al.: Winter warming effects on growing season productivity of northern vegetation (Poland to Svalbard) inferred from long-term remote sensing data.

**Vikhamar-Schuler D.** et al.: Changes in winter warming events in a temperate region.

**Tømmervik H, Bjerke, J.W.** et al. Applicability of different sensors for in-situ measurements of plant health in high Arctic tundra.

**Bjerke J.W., Bochenek Z., Zagajewski B., Kłos A., Ziembik Z.,** Elverland E., Jaakola L. & & **Tømmervik H**.: The high-Arctic plants *Salix polaris* and *Luzula confusa* are tolerant to winter icing, but less tolerant to late frost.

**Bjerke J.W., Tømmervik H.** et al.: Spatiotemporal variation in physiological performance of Arctic plants.

**Zagajewski B.** et al.: Intraspecific differences in hyperspectral reflectance curves as indicators of reduced vitality in High-Arctic plants.

**Bartold M., Bochenek Z.** et al.: Application of low-resolution satellite images for studying the impacts of changeable climatic conditions on forest development.

**Zielińska M., Godyń P.** et al.: Accumulation of heavy metals in biological samples of the forest areas of southern and north-eastern Poland: a 3-year temporal study.

**Zagajewski B**. et al.: Assessment of hyperspectral vegetation indices for impact assessments of heavy metal contamination in plants.

**Bochenek Z.** et al.: Use of high-resolution optical satellite images for analyzing forest biodiversity and vulnerability to variable climatic conditions.

**Ziółkowski D.** et al.: Studies of impact of changeable climatic conditions on forest development using remote sensing data from various acquisition levels.

**Jerz D., Kłos A**. et al.: The use of the Comparison Factor (CF) in forest and tundra biomonitoring.

Communicated Results

**Bjerke J.W. & Tømmervik H**.: Understanding the drivers of extensive plant damage: insights from field surveys in the aftermath of damage in boreal and Arctic regions. *Lecture at: Impact of climate change and pollution on vegetation distribution and condition in the temperate, boreal, alpine and polar zones.* Poland-Norway projects & Warsaw University, Warsaw, 26-27 October 2016.

**Vikhamar-Schuler D.**, **Isaksen K., Haugen J.E., Tømmervik H.**, Luks B., **Mezghani A.** & **Bjerke J.W.**: Changes in winter warming events in the Nordic Arctic Region and in Poland. *Lecture at: Impact of climate change and pollution on vegetation distribution and condition in the temperate, boreal, alpine and polar zones.* Poland-Norway projects & Warsaw University, Warsaw, 26-27 October 2016.

**Tømmervik H.**, **Karlsen S.R.**, Vickers H., Høgda K.A. & **Zagajewski B**.: Changes in growing season productivity of northern vegetation inferred from long-term remote sensing data. *Lecture at: Impact of climate change and pollution on vegetation distribution and condition in the temperate, boreal, alpine and polar zones.* Poland-Norway projects & Warsaw University, Warsaw, 26-27 October 2016.

**Isaksen K.** 2016. Arktis smelter, og jeg er hverken betenkt eller bekymret. Jeg er skremt. *Feature article published in* Aftenposten, p. 13, 15 November 2016. (Includes a description of main results from our article in *Journal of Climate*).

**Treharne R., Bjerke J.W.,** Emberson L., **Tømmervik H.** & Phoenix GK.: Arctic Browning: vegetation damage and implications for carbon balance. Poster at: European Geosciences Union General Assembly 2016, Vienna, 17-22 April 2016.

Markusson H.M. & **Bjerke J.W.**: Hvorfor blir Arktis brunere? *News report published at* Forskning.no, 29 April 2016.

**Tømmervik, H.:** Klimautfordringer og konsekvenser for reindrifta - Hva skjer med reinbeitene i Nordland når vintrene blir mildere og vekstsesongen lengre? *Reindriftsseminar for Nordland*, Fauske, 10-11 February 2016.

**Bjerke J.W.**: Increasing climatic and biotic disturbance severity – can we influence the direction of Arctic vegetation change, and if so, which direction should we promote? *Lecture at: 'ArcticBiomass' Final Workshop, open programme*, 21 October 2015, Longyearbyen.

**Bjerke J.W.**: Impacts of contrasting snow, ice and soil frost conditions on northern primary productivity – insight from manipulative and observational studies. *Lecture at: Fram Centre, the terrestrial flagship's thematic day on snow: Measuring, remote sensing and modelling snow properties important for northern ecosystems*, 28 November 2014, Tromsø.

**Karlsen S.R.**: Growing season and primary production mapped by MODIS and Landsat 8 data on Svalbard. *Lecture at: 'ArcticBiomass' Final Workshop, open programme,* 22 October 2015, Longyearbyen.

**Treharne R., Bjerke J.W., Tømmervik H.**, Emberson L. & Phoenix GK.: Arctic browning: vegetation damage and implications for carbon balance. *Poster at: UK Arctic Science Conference 2015*, 16 September 2015, Sheffield.

**Tømmervik H., Bjerke J.W., Karlsen S.R.**, Thuestad AE., Storvold R., Johansen B. & Høgda K.A.: Monitoring man- and climate change-induced plant stress in the Nordic Arctic Region and Svalbard using remote sensing and field surveys. *Lecture at: Assessing vulnerability of flora and fauna in polar areas*. Norwegian Polar Institute, 3 November 2014, Tromsø.

**Tømmervik H.**, Johansen B., Strand O., Park T., Fauchald P., Myneni R.B. & **Bjerke J.W.** Arctic biomass: Greening and browning in the Arctic – implications for reindeer and caribou. *Lecture at: 14th International Arctic Ungulate Conference*, 16 August 2015, Røros.

**Vikhamar-Schuler D.**, Isaksen K., Haugen J.E., **Tømmervik H.**, Luks B. & **Bjerke J.W.**: Changes in winter warming events in the Nordic Arctic Region. *Lecture at: EGU General Assembly Conference*, 14 April 2015, Vienna.

**Vikhamar-Schuler D**., Isaksen K., Haugen J.E., **Tømmervik H.**, Luks B. & **Bjerke J.W.**: Changes in winter warming events in the Nordic Arctic Region. *Lecture at: 3rd Conference on Modelling Hydrology, Climate and Land Surface Processes*, 7 September 2015, Lillehammer.

**Bjerke J.W.**: Highlights from the Fram Centre flagship projects WINNIT and WICLAP. *Lecture at: Årsmøte for Framsenterets terrerstre flaggskipprogram, Uit –Arctic University of Norway, Tromsø,* 16 December 2015.

WICLAP consortium: WICLAP website: www.wiclap.eu (frequently updated project website with news)

NINA: Vinterforstyrrelser og luftforurensning: http://www.nina.no/Forskning/Prosjekter/Vinterklima/WICLAP (frequently updated website in Norwegian).

Interdisciplinary Cooperation

The project consortium includes researchers from several disciplines: meteorology-climatology, physical geography – especially related to earth observation, chemistry, ecology, and physiology. This interdisciplinary cooperation is running smoothly and has already been manifested in research articles. An interdisciplinary approach was a prerequisite for the EEA call. We are currently placing much emphasis on integration of results for multidisciplinary research articles, and we may also involve researchers from social sciences for further expansion of the interdisciplinary approach.

Budget in accordance to results

The entire funding from the Terrestrial Flagship for 2016 was used this year, and funding was allocated between the three Norwegian institutes according to the budget provided in the proposal. The funding obtained allowed us to undertake more extensive field data sampling than would have been possible without this funding. This is an quintessential addition, especially in light of the slightly reduced funding from EEA without allowing to reduce ambitions of the project plan, and the steadily increasing costs of undertaking fieldwork at Svalbard. We arranged three field campaigns at Svalbard during the 2016 growing season. With the increase of available working hours, we have been able to involve more young researchers in the project, including the UK PhD student Rachael Treharne and the Tromsø-based plant biologist Leif Einar Støvern. The added funding also allowed us to allocate more time to assess vegetation outside of our established plots; hence, we were able to do more careful surveys of the local variation in damage rates of some Svalbard plants and bryophytes. This has improved our knowledge on how anoxia and frost drought affects Arctic vegetation, and these results will be summarized in upcoming publications. In 2016, we have given numerous lectures at scientific meetings and undertaken some public outreach activities, including one article published at forskning.no. We expect a news feature to be published soon on our recent findings published in the *Journal of Climate*. Bjerke was also recently interviewed by a Norwegian nature magazine, and the article based on this interview will probably appear in one of the upcoming issues.

Could results from the project be subject for any commercial utilization

Yes

If Yes

The enhanced competence on drivers of environmental change and nature vulnerability gained by the Norwegian institute researchers make the personnel more attractive for consultancy assignments in environmental sciences. Know-how consulting is in such a context a commercial product. For example, Bjerke was recently assigned as member of a national expert committee for testing the international IPBES framework for assessment of a Norwegian habitat system. Norut and Meteorologisk Institutt also apply their acquired research results and increased competence in development of services of potential commercial utilization. Our Polish partners at the Institute for Geodesy and Cartography (IGiK) have as one of their main role to develop commercial products relevant for environmental and agricultural sectors. This project helps them to improve their earth observation-based products, and this is in line with the EEA call, namely to enhance the competence of Polish institutions in their fields of expertise.

Conclusions

There is to our knowledge no guideline to this section of the report form. Thus, we are not sure what type of information is expected in this section. Nevertheless, we conclude as follows:

The added funding from the flagship has been invaluable for the project. Without it, we would probably not have been able to undertake all field studies as assigned in the project description.

With the published and planned results and the implications of these results, we provide a clearer picture of the future climate of Arctic, boreal and temperate regions and the consequences of climatic and environmental changes to vegetation and society.