ArcticBiomass

Final meeting and open workshop/conference

Longyearbyen, Svalbard, Norway

October 20th - 23rd 2015

The project partners of ArcticBiomass arranged the final meeting and an open workshop/conference in Longyearbyen in Svalbard from Tuesday 20th to Friday 23rd October 2015. Altogether, 26 researchers participated in the open workshop/conference (Figure 1). Thirteen participants were from Norway, eight participants were from USA of which two participated on Skype, three from Finland, one from Italy (EU JRC), and finally one from United Kingdom.

Figure 1. From the Svalbard workshop October 22nd 2015.

Wednesday October 21st 2015

Welcome and presentation of the ArcticBiomass project by Hans Tømmervik

ArcticBiomass is a Norway-USA network project funded by the Research Council of Norway. The objectives of this project are to:

• Establish a joint American-Norwegian research team dealing with research on the combination of field and satellite remote sensing based above-ground plant biomass, vegetation productivity and growing season mapping in northern Alaska and in Svalbard, as well as on a circumpolar scale.

• Compile existing plant biomass and productivity data from the North Slope of Alaska and from Svalbard, and to evaluate existing remote sensing data and remote sensing based biomass products throughout the Arctic.

Greening of the Earth – Chair: Dr. Scott Goetz

The program for the open workshop (October 21st – October 22nd) started with a key note presentation “The Greening Earth” by Professor Ranga Myneni. This presentation focused on the greening of the Earth with focus on the Arctic. He presented different studies base on AVHRR data, GIMMS-NDVI3g data and MODIS data and he dived his speech in four parts: A. AVHRR Data (1981-1999), B. Greening North (1981-2012), C. Greening Earth (1981-2014) and D. Related Studies.

For the greening North he concluded: Regarding photosynthetically active period (PAP) - mean NDVI (Np), three points are noteworthy.

First, the proportion of Arctic vegetation with a statistically significant (p < 0:1) increase in Np (greening) varied from 32 to 39% and the proportion with a statistically significant decrease in Np (browning) was <4%. In the boreal region, greening varied from 34 to 41% and browning was <5%. The ratio of greening to browning proportion is even higher at p<0:05 in both regions.

Second, the greening (Figure 2) is most prominently seen in coastal tundra and eastern mixed forests in North America, needle leaf and mixed forests in Eurasia, and shrublands and tundra in Russia. North American boreal vegetation shows a fragmented pattern of greening and browning, unlike its counterpart in Eurasia, which shows widespread contiguous greening. Further analysis reveals little evidence of widespread browning of boreal vegetation at the circumpolar scale.

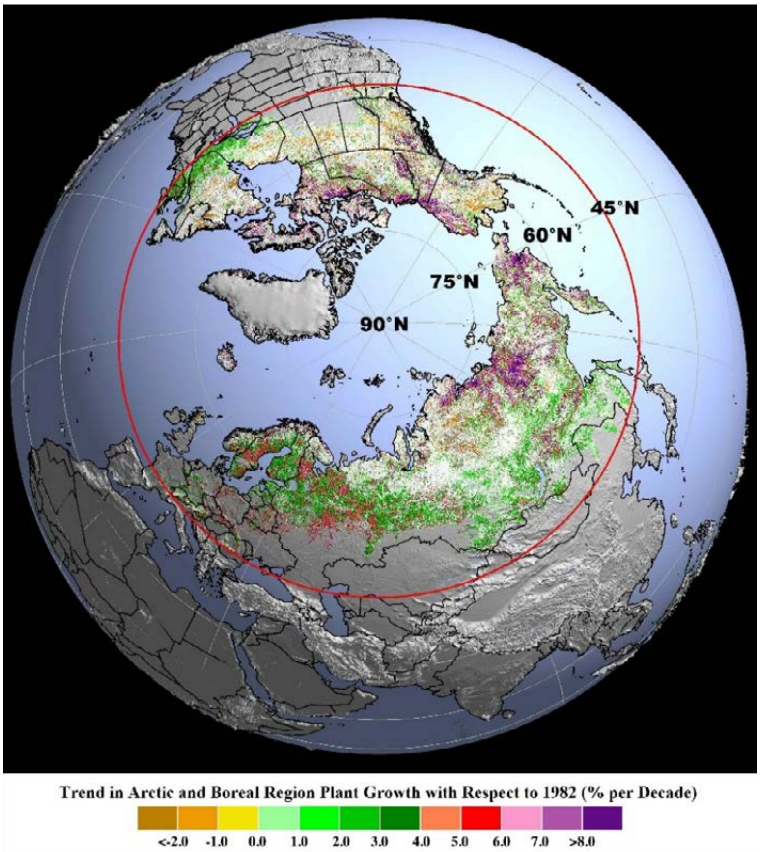

Figure 2. Trend in Arctic and Boreal Region plant growth with respect to 1982 (% per decade).

Third, about 90% of the Arctic and 70% of the boreal greening vegetation show Np increases >2.5% per decade. Trends did not oppose in 75% of the study area. Warming did not promote browning. Cooling did not promote greening

C. Greening Earth (1981-2014). This study is in preparation so following conclusions are preliminary:

- A greening trend of 2.8 to 5.1% per decade is seen in all vegetation types
- Dynamic vegetation models forced with observed CO_2, N-deposition, climate and land cover changes reproduce the observations.

The correct perspective of the Greening Earth is presented in Figure 3.

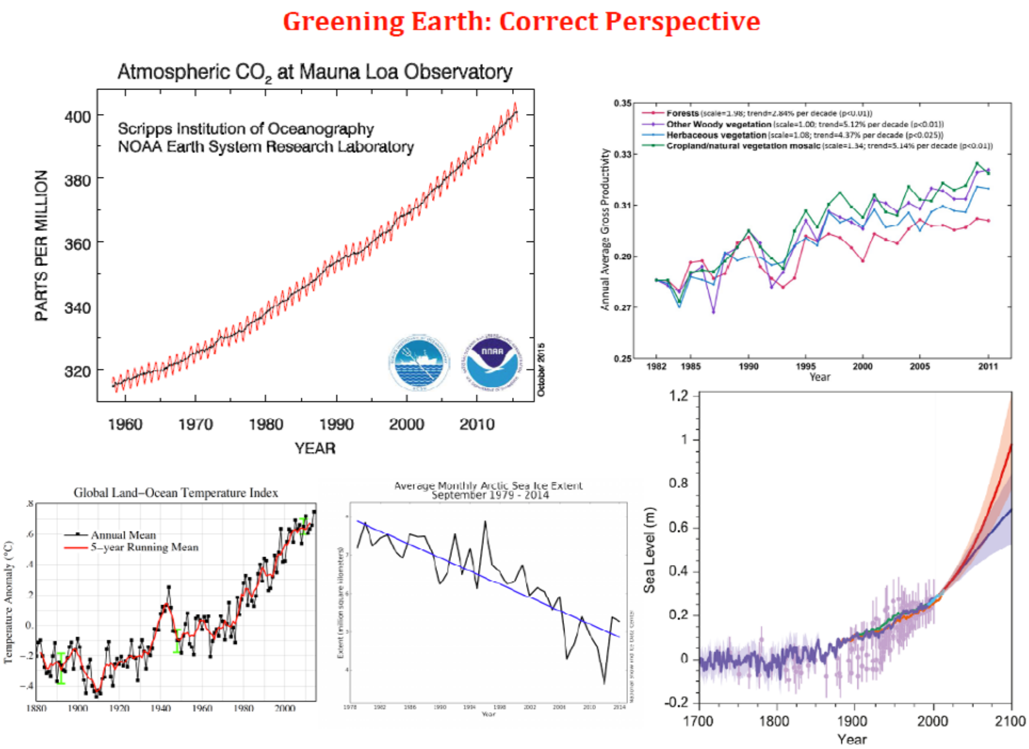

Figure 3. Greening Earth: The Correct Perspective.

Vegetation mapping and biomass change – Chair: Dr. Scott Goetz

This presentation was followed by presentations on vegetation mapping and biomass change analysis using satellite remote sensing and Unmanned Aerial Systems (UAS) on Svalbard, Yamal (Russia), USA and Fennoscandia. Presenters here were Associate Professor Lennart Nilsen (The Arctic University of Norway), Dr. Rune Storvold (Norut), Associate Professor Timo Kumpula (University of Eastern Finland), Dr. Hans Tømmervik (NINA) and Dr. Sangram Ganguly (NASA).

Associate Professor Lennart Nilsen (The Arctic University of Norway) presented a new thoughts and methology for delineation and characterizing of bioclimatic zones on Svalbard.

Rune Storvold (Norut) presented studies on use of UAS-systems (ordinary cameras, NDVI-cameras and hyperspectral cameras) which efficiently fill in the gap between field based investigations and satellite remote sensing. UAS can also act as a substitute for field work - since the resolution could be down to millimeters and the main species could be recognized and detected.

Associate Professor Timo Kumpula (University of Eastern Finland) presented studies from Yamal (Russia) and concluded that Gas development has wide impacts to reindeer pastures, migration and herding society, eg. devaluation and shrinkage of pastureland. Industrial development is just in the starting phase and is rapid. Climate change induced impacts related to land cover change are shrubification, snow-ice conditions, landslides and thawing lakes. To study land use and land cover change (LULCC) it requires multidisciplinary approach that can be combined with anthropogenic disturbances, reindeer grazing impact, shrub increase-decrease, climate change impacts, landslides, lake changes, to create synthesis of LULCC dynamics in Yamal.

Dr. Hans Tømmervik presented a study on forest and tundra biomass change in the forest-tundra ecotone of northernmost Norway during the last century (1914-2012) and he concluded that the forest coverage (included low scattered tundra forests) had increased from ca. 7000 km^2 to more than 15000 km^2.

The presentation by Dr. Sangram Ganguly (NASA) focused on topics such as NASA Earth Exchange (NEX), "Big data" and unsupervised learning/classification of satellite data using Deep Belief Network (DBN). Since labeled training data is limited, we have to resort to Unsupervised Learning and Deep Belief Networks use unlabeled data in the first phase. Since, there are ample amounts of unlabeled data, the unsupervised learning phase is able to initialize the weights and biases of the Neural Network to a global error basin. Because the neural network is initialized to a global error basin, in the supervised learning phase, it requires very little training data - which is well suited for our purpose since we already have limited training data. Deep Belief Network (DBN) provides the most powerful and state-of-the-art learning framework to address these problems and is very useful in the Arctic and the Polar regions where we often lack labeled data.

Climate change effects and ecosystem productivity – Chair: Professor Ranga Myneni

Associate Professor Eugenie Euskirchen (University of Alaska-Fairbanks) gave a presentation on "Long-term changes in carbon fluxes and pools in arctic tundra ecosystems in northern Alaska".

- Tundra ecosystems thought to be CO_2 sources, slight sinks or neutral. Generally, sources of CH_4.
- Detailed descriptions (seasonal, multiyear) of C fluxes at the landscape scale still relatively rare in tundra.

Changes in CO_2 uptake: Could observe greater uptake as vegetation biomass increases AND could also see greater release as respiration increases. Conclusions in her presentation were:

- Important to take into account landscape heterogeneity and interannual variability
- Wet sedge tundra a greater source of CO_2 in recent years with warmer late fall/ early winter
- CH_4 emissions at the wet sedge added a small component to annual CO_2 equivalent emissions
- These tundra ecosystems appear to be CO_2 sources over the long-term.

Professor Howard Epstein (Virginia University) gave a presentation on the circumpolar heterogeneity of arctic tundra vegetation responses to recent temperature dynamics. His conclusions were as follows:

- Vegetation has increased to a greater degree than temperature in the more southern Subzones (C, D and E) of the Arctic, potentially due to interactions with disturbances, precipitation and other factors. The relationship between NDVI and NDVI in the prior year increases from north to south.
- Interannual variability and responses to temperature are greatest in Subzones B, C, and D (mid-transect), potentially due to intermediate levels of vegetation and nutrient constraints, as well as a mix of High and Low Arctic plant types.

Disturbances and vulnerability – Chair: Professor Ranga Myneni

Dr. Scott Goetz (Woods Hole Research Centre) presented an update on the Arctic Boreal Vulnerability Experiment.

Finally, Dr. Jarle Bjerke (NINA) gave a presentation on the increasing climatic and biotic disturbance severity and he put forward the question: *Can we influence the direction of Arctic vegetation change, and if so, which direction should we promote?* He focused on the role of lichen coverage in keeping up the albedo as a negative feedback to climate change.

Thursday October 22nd 2015

Climate change effects and ecosystem productivity – Chair: Dr. Jarle Bjerke

Dr. Gregory Taff (Norwegian Institute of Bioeconomy Research) started the day with a presentation on the use of remote sensing to study climate change effects on cultivated grasslands a newly funded research.

Phenology and productivity – Chair: Dr. Jarle Bjerke

Dr. S.R. Karlsen (Norut) presented a study on the growing season and primary production mapped by MODIS and Landsat 8 data (Figure 4) on Svalbard and the conclusion of this presentation that there was no clear trend in onset of the growing season, 2000-2014. No increase in temperature when the growing season starts. He found a relationship between plant biomass and time-integrated NDVI (Integrated from onset of the growing season to peak of season). Two-fold variation in plant biomass between years on western Svalbard.

Figure 4. Landsat 8 image over Longyearbyen and Adventdalen from July 2014 (Norut).

PhD student Taejin Park (Boston University) contributed a study on phenological and physiological Variations on Northern Vegetation Productivity Changes over the last three decades and he concluded that NDVI3g based growing season and productivity can explain 57%, 53%, 62%, and 61% of variations in Flux-GPP based SOS, EOS, LOS and GPP, respectively. He also found that the photosynthetic and thermal potential growing season has lengthened by about 8.6 and 10.9 days ($P < 0.01$, 1982–2014), respectively. About 42% and 2.5% of study regions (Arctic and Boreal zones) showed greening (interpreted as 20.1% of productivity gain) and browning (1.2% productivity loss) trends. Finally, he found relatively higher increasing rate (8.54%) in Tundra vegetation than in forested lands (5.48%). There was also a trend to reduced greening/productivity the last three years (2012-2014).

Phenology – Chair: Professor Howard Epstein

Kjell-Arild Høgda (Norut) presented a study called "A NOAA AVHHR growing season max NDVI time series 1986-2014 for Nordenskiøldland on Svalbard" and the conclusions were as following:

- There was a significant correlation between spring/summer temperature and max NDVI value and we see a 1.6 degree spring/summer warming trend
- We see a 0.08 increasing trend (greening) in the max NDVI value during the period

Cryosphere – snow – vegetation:

Under the topic "Cryosphere – snow – vegetation", Associate Professor Marc Macias Fauria (Oxford University) presented a study on the sea ice dynamics and terrestrial productivity in Svalbard, while

Professor Elisabeth Cooper (The Arctic University of Norway) – presented the project SnoEco - Snow cover effects on High Arctic plants and soils-a study at the plot and landscape scale. Professor Cooper emphasized in her presentation that timing of snowmelt is a very important determinator of start of growing season and by manipulating snow cover and observing on the landscape scale, we can start to investigate these relationships and she presented results from a former project manipulating the snow cover starting in 2007 focusing on plot level. The new with the Snoeco project is that we introduce remote sensing for monitoring the development in vegetation using RGB-cameras and NDVI-sensors on plot level and a NDVI-camera and satellite sensors on landscape level, hence upscaling is enabled.

Monitoring of vegetation – Chair: Professor Howard Epstein

Dr. Virve Ravolainen (Norwegian Polar Institute) presented "Arctic vegetation as a component of ecosystem-based monitoring" - which emphasized on the newly funded Climate-Ecological Observatory for Arctic Tundra (COAT).

Professor Ingibjörg Svala Jónsdóttir, UNIS-Svalbard presented results from the International Tundra Experiment (ITEX). The ITEX syntheses have demonstrated that the ITEX sites in the low arctic already are relatively warm and respond more strongly to warming than colder sites in high arctic.

Dr. Hans Tømmervik (NINA) presented preliminary results from two studies using GIMMS $NDVI_{3g}$ data: 1. Catchment vegetation development and reduced S-deposition promote lake organic carbon load on decadal time scales, and 2. Large-scale interactions between migratory tundra caribou, hunting and vegetation in arctic North America.

Scaling of data – Chair: Dr. Scott Goetz

Concerning "Scaling of data", Dr. Pieter Beck (EU- JRC, Italy) presented a study called "From observations of tundra shrub expansion to Arctic greening seen by satellites: how wide is the scale gap?"

Professor D.A. Walker, University of Alaska-Fairbanks, presented a hierarchic review of circumpolar Arctic vegetation patterns, productivity, and biodiversity with a focus on the linkage between remote-sensing and plot-based studies (on skype from Alaska). His conclusions were following:

- Although space-based methods of monitoring are the only means to detect circumpolar-scale pa>erns of productivity and biomass changes, satellite data cannot detect changes to diversity of Arctic species or many of the subtle structural changes or changes to ecosystem processes that can only be observed with coordinated ground-based monitoring.
- Moving forward with our exploration, description, and analysis of the vegetation in the Arctic tundra biome will require greater attention to unified collaborative approaches to improve sampling and sharing of plot information.
- High priority should be given to developing plot-based survey methods and datasets that lend themselves to hierarchical studies at landscape, regional and panarctic scales using remote sensing.

Biomass and disturbances – Chair: Dr. Scott Goetz

Dr. Martha Raynolds, University of Alaska-Fairbanks – Landsat analysis of vegetation change on the Alaska North Slope, using NDVI and tasseled-cap indices (on skype from Alaska). Raynolds concluded that NOAA AVHRR imagery shows positive NDVI trends. Also, a simple difference study with Landsat also shows positive NDVI trends. Statistical trend analysis shows decreased NDVI trends ($p < 0.05$) in less than 10% of the area. Tasseled-Cap Indices provide additional information and this analysis showed a significant increased greenness on over 1/3 of the area. On the contrary, increased wetness counters this, leading to negative NDVI. In developed areas, changes in NDVI on and adjacent to infrastructure are evident.