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Nordic Forest Research
Co-operation Committee (SNS)

Project no: 108

Send the report to SNS-secretary Katrine Hahn Kristensen (hahn@life.ku.dk)

FINAL REPORT for PROJECT

Please notice that the size of text sections in the form can be adjusted if needed.
The length of the final report should not exceed 3 pages. **Supplementary information can be attached**

1. Projekt titel	Satellittbasert kartlegging av vekstsesongen i nordlige Fennoskandia og tilgrensende områder i nordvest Russland
2. Project title	Satellite-based mapping of the growing season in northern Fennoscandia and neighbouring parts of NW Russia
3. Coordinator (name, address, telephone, e-mail)	Anne Tolvanen Finnish Forest Research Institute, Oulu Unit P.O. Box 413, 90014 University of Oulu, Finland tel. +358 50 391 3782, anne.tolvanen@metla.fi
4. Duration	1.1.2009-31.08.2012
5. Cost	SNS-funding: 150 000 eur Other funding: 150 000 eur

6. The purpose of the project / main problems / hypotheses addressed)	The main aim is to develop and apply reliable methods for mapping the onset and end of the growing season in northern Fennoscandia and neighbouring parts of NW Russia. Mapping of the growing season helps to evaluate the timing and potential of forest growth and regeneration in the future. These predictions will be essential for the planning of regeneration practices in forests, and for ecological research evaluating species composition and location of treelines in the future. The sub-aims are to: • Develop the existing phenological networks by strengthening the intensive monitoring on a few monitoring sites. This will increase the cost-efficiency of the monitoring. The sites will be selected at the beginning of the project. • Evaluate the best calibrating method of MODIS-NDVI data. • Develop methods to model new circumstances, such as the end of growing season. • Map the average, trends, and cycles of the onset, end, and length of the growing season • Evaluate ecological changes occurring in northern Fennoscandia based on long-term monitoring, field experiments, and modeling developed in the project. • Increase public awareness and provide information on the importance of research in northern latitudes.
7. Brief description of the research plan and of possible larger deviations from the plan	The research plan focuses both on the development of methods to map phenological events in northern Fennoscandia and on ecological changes and plant phenological events occurring in the region. These topics together provide the newest information directly tailored to regions, where the impacts of climate change are predicted to be most significant. Besides that new methods and scientific results are disseminated to researchers working with related topics, the project disseminates actively on its achievements to managers, officers, media and general public. The project was launched with a kick-off meeting at Muhos on June 8th, 2009. The second project meeting was organized in Tromso on the 8th September 2010. Third project meeting was organized in Svalbard on 27-28th June 2011. In each meeting, the group members presented their ongoing work, achievements reached by that time, studies closely related to the project, project budget, and forthcoming activities. Deadlines were set to fulfil the aims set in the project schedule. There were no larger deviations from the research plan.

8. Results (max 2 pages)	**WP 1. Field Data** Phenological observations were carried out throughout the project, and monitoring was standardized between countries where possible. In Russia, species and phenophases were photographed along with phenological observations each year. Monitoring of the end of winter was intensified in Finland. Timing of snow melt is recorded now, whereas data on the first snow and soil frost can be achieved from the Finnish Environment Centre. In Norway, a new observation area of about 1x2 km was established to explore the local differences in autumn phenology. The study area includes an altitude gradient of about 250 m from sea level to the forest line. A general autumn index was produced by compiling existing field data on autumn phenophases of Sorbus and Betula. This index can be correlated with satellite data to test whether a better fit with field and satellite data can be achieved. Since there are only two common species monitored both in Finland and Russia, Metla and Pasvik also generated their own autumn indexes based on the mean values of autumn observations of all observed species. In Russia, information for identifying key-factors of the beginning of autumn phenomena was collected for a review arcticle. Lund University, Sweden, established a measurement site for monitoring reflected radiation from the ground. Optical sensors were mounted on masts of varying height (8 – 70 m), depending on the vegetation type. Despite initial technical difficulties, five systems (four in Sweden, one in Finland) now report data on half-hourly basis. The systems measure incoming and reflected radiation in visible and near-infrared bands to enable calculation of reflected PAR (photosynthetically active radiation), NDVI (normalized difference vegetation index), and PRI (photochemical reflectance index). All systems operated as they should and data was compiled into a summary report. In Finland, studies on the impacts of climate warming on tundra plants continued throughout the project, and the results were published in many highly ranked publications. For example, Finnish data were pooled with data from similar projects from across the circumpolar region to produce large-scale evaluation concerning ongoing vegetation changes in arctic-alpine regions. New information was also achieved concerning the impacts of nutrient addition and disturbance on the vegetation composition and regeneration of subarctic plants. Hence the intensity and type of disturbances should be considered in forthcoming predictions on plant responses to climate change. **WP 2. Processing satellite data** Lund University focused on developing models for phenology of coniferous tree species (pine and spruce). A study was conducted, evaluating the relationship between temperature-dependent phenology parameters and remotely sensed vegetation index data. Data from 186 coniferous monitoring sites in Sweden covering boreal, southern-boreal and boreo-nemoral conditions were analyzed with the objective to analyze the possibility to track seasonal changes in coniferous forests by time-series of Terra/MODIS eight-day vegetation indices, testing the hypothesis that satellite monitored vegetation indices (VI) are influenced by temperature-dependent phenology. The relationships between two vegetation indices (NDVI and WDRVI) and temperature dependent phenological indicators (length of snow season,

	modelled onset of vegetation period, tree cold hardiness level and timing of budburst) were analyzed. The annual curves produced by smoothening of seasonal changes in NDVI and WDRVI were to a large extent characterized by the occurrence of snow, producing stable seasonal oscillations in the northern part and irregular curves with less pronounced annual amplitude in the southern part of Sweden. Measures based on threshold values of the VI-curves, commonly used for determining the timing of different phenological phases, were not applicable for Swedish coniferous forests. Evergreen trees do not have a sharp increase in greenness during spring in comparison with winter values not influenced by snow, and the melting of snow can influence the vegetation indices at the timing of budburst in boreal forests. The VI-values for specific eight-day periods were correlated with the temperature dependent phenological indicators, and this relationship can potentially be used for satellite monitoring of northern coniferous phenology. **WP 3. Linking field and satellite data and new mapping methods** The spectral reflectance of the eight MODIS band of different land cover types was studied during the growing season to identify, which band combinations are best to monitor the onset and end of the growing season. A workshop was held in Muhos in November 2010 where we identified homogeneous forest types in the surroundings of the phenological stations in northern Finland, and the spectral properties of these forest types in spring and autumn has been analyzed. In particular sites with dense spruce forest were marked out, and in addition was field work carried out in northernmost Finland to detect areas with very dense spruce forest and open lichen rich pine forest – vegetation types with supposed small variation in spectral reflectance during the growing season. The results show that the Normalized Difference Vegetation Index (NDVI) maps the onset of the growing season well. In autumn, indices based on combination of a band in the visible part with a band in the short-wave infrared part best map the end of the season. New satellite based maps of northern areas were produced. The maps show trends and mean date in onset and length of the growing season at different scales north of 50° N. The maps indicate large temporal and local variation in onset of the growing season.
9. What advantages have been gained by the Nordic collaboration	Project funding helped to carry out phenological observations, hire people, purchase necessary equipment, and disseminate results in international and domestic meetings. Through SNS funding, project group meetings became possible, and they were necessary for exchanging information, setting goals and providing experience on the research carried out in the partner countries. Generally, a considerable amount of communication is carried out through email and internet meetings. However, these communication methods can not compensate for personal meetings and discussions, which became possible through the funding achieved from SNS.
10. Publications and other communication activities (International scientific peer reviewed journals, other scientific publications, short communications, web etc.)	See attachment “SNS project 108 publications and products” In summary, the funding from this project contributed to producing 17 articles in international scientific peer reviewed journals, and 23 other scientific publications and abstracts. Project results were disseminated through media, press releases, web columns, interviews, conference presentations, lectures, and training courses organized for schoolchildren.

11. Project summary (about 1/3 page) for possible use in the News & Views section of Scandinavian Journal of Forest Research	An advancement in the onset of growth has been observed in many studies in Europe. The high local variation calls for sufficient coverage of phenological observations and for a sufficient time period for monitoring in order to make reliable estimates on future trends in the length of growing season. Phenological field observations are expensive, whereas satellite image-aided analysis of phenology provides a means to interpolate traditional ground-based phenological observations over larger areas. Satellite analysis of the length of growing season is based on the normalized difference vegetation index (NDVI) value. The project tailored new methods for mapping the onset and end of the growing season in northern Fennoscandia and NW Russia. Phenological mapping of these regions is particularly difficult due to their high coverage of evergreen forests, where phenological variations are less pronounced than for broadleaf trees further south. The project also developed existing phenological monitoring networks in northern Fennoscandia, evaluated ecological changes occurring in the region, and increased public awareness concerning phenological changes in high latitude areas. New satellite based maps of northern areas were produced. The maps show trends and mean date in onset and length of the growing season at different scales north of 50° N. The maps provide practical information on the timing of growing season for primary industries, and they can be used to predict species distribution patterns, for pollen forecasts and to improve climate change models.
12. Date and signature	Date: August 31th, 2012 Signature of project leader/coordinator: Anne Tolvanen