Applicant: Christian Walther
Email: christian.walther.87@gmail.com

March 17, 2016

Research proposal

Modelling the Circumpolar Taiga-Tundra Ecotone Using ALOS PALSAR and Optical Earth Observation Data.

Aim of Research Project

The goal of this research project is the ecological modelling of the circumpolar taiga-tundra ecotone using various satellite data. My master thesis forms the basis for the modelling, since good results could be achieved for a study area in northern Siberia. On pan-Arctic scale, the model result could serve as a baseline for detecting spatiotemporal vegetation changes within the Arctic. Thus, vulnerable areas could be detected and utilized for further analyses.

State of the Art

On global scale there are very few studies available for characterizing the Arctic transition zone between taiga and tundra. Walker et al. (2005) defined the treeline by using different maps from 1976 to 1990. Ranson et al. (2014) used averaged MODIS VCF data of collection 4 from 2000 to 2005. For defining the taiga-tundra ecotone, image objects of similar tree canopy cover were derived. Thus, the product only contains patchy information about the land surface.

The approach I developed contains various statistics of multisource/ multisensor state of the art data products of MODIS and ALOS PALSAR (land surface temperature, albedo, NDVI, EVI, Vegetation Continuous Fields, PALSAR HV-Polarization and LAI) as input for a random forest model. Sampling was conducted based on bioclimatic subzones (Walker et al. 2005). In order to characterize the full complexity of the transition zone, continuous probability values were computed. This allows the unique allocation per class (typical tundra, southern tundra or taiga) for each grid cell. The model was tested for a large study site in northern Siberia.

The advantage of my approach over the existing CAVM treeline by Walker et al. (2005) and the taiga-tundra ecotone delineation by Ranson et al. (2011), is the derivation of continuous probability values for the full latitudinal extent of the ecotone. Instead of defining sharp distinctions between the classes, the naturally occurring transitions are captured using continuous probability values.

Benefits of Applying the Model to the Circumpolar Region

Applied to the entire circumpolar region, the model would display the position of the transition zone between taiga and tundra. In terms of climate change, vulnerable areas could be detected and be explored further. The final product could serve as a basis for the evaluation of tree cover simulations of LPJmL DGVM (Lund-Potsdam-Jena Dynamic Global Vegetation Model for managed Land) and perhaps replace the existing MODIS VCF data used by Forkel et al. (2014). Additionally, the continuous taiga-tundra ecotone values could possibly be used for optimization of the tree cover simulations.

Model Transferability

Since the model results look promising for the designated study site in northern Siberia (overall map accuracy of 93% and a Kappa of 0.89), the developed approach is suitable for characterizing the complexity of the taiga-tundra transition zone. Thus, the model could be used for vegetation modelling of the entire circumpolar region, because all data used is available for the pan-Arctic region.

Methodological Approach

Applying the model to the entire Arctic may be feasible as the bioclimatic subzones are defined for the entire circumpolar region. First, a subset located in North America could be used for testing the model robustness and assuring its transferability. If promising results can be achieved, data for the entire pan-Arctic region could be used for modelling the circumpolar taiga-tundra ecotone.

All required datasets must be preprocessed (download, mosaicked, statistical computation).

Duration of the Research Project

The modelling should be finished within six months.

Required Computing Power

An area of approximately 23 million km² needs to be taken into account for modelling the transition zone. This would require around 900 GB of working memory (RAM) and 45 cores (2.8 GHz) if processing is conducted parallel.

The number of parallel calculations can be reduced or increased accordingly.

Literature

Forkel, M., Carvalhais, N., Schaphoff, S., v. Bloh, W., Migliavacca, M., Thurner, M., & Thonicke, K., 2014. Identifying environmental controls on vegetation greenness phenology through model–data integration. Biogeosciences 11 (23):7025-7050. doi: 10.5194/bg-11-7025-2014.

Ranson, K.J., Montesan, P.M., & Nelson, R., 2014. Tree Canopy Cover for the Circumpolar Taiga-Tundra Ecotone: 2000-2005. Data set. Available on-line [http://daac.ornl.gov] from ORNL DAAC, Oak Ridge, Tennessee, USA. doi: 10.3334/ORNLDAAC/1218.

Walker, D.A., Raynolds, M.K., Daniëls, F.J.A., Einarsson, E., Elvebakk, A., Gould, W.A., Katenin, A.E., Kholod, S.S., Markon, C.J., Melnikov, E.S., Moskalenko, N.G., Talbot, S.S., & Yurtsev, B.A., 2005. The Circumpolar Arctic vegetation map. Journal of Vegetation Science 16 (3):267-282. doi: 10.1111/j.1654-1103.2005.tb02365.x.

Appendix

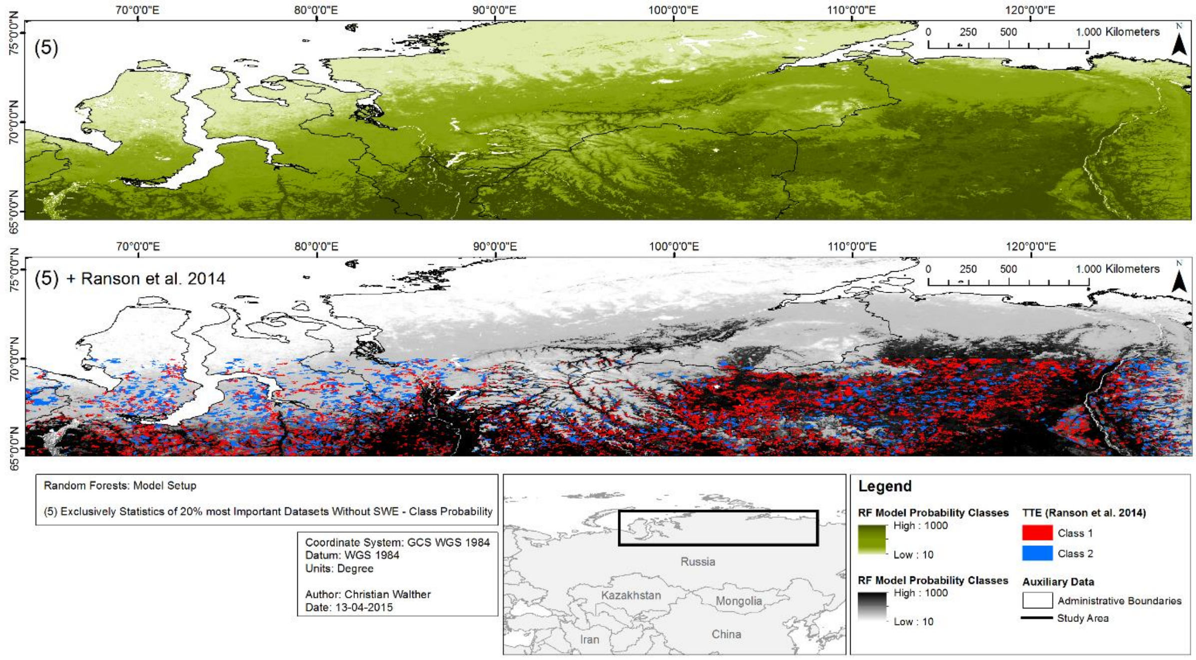

Figure 1: The upper map shows the modelled result of my approach. Light green represents typical tundra, southern tundra is visualized by green and taiga is colored in dark green. The lower map shows the comparison with the results by Ranson et al. (2014).

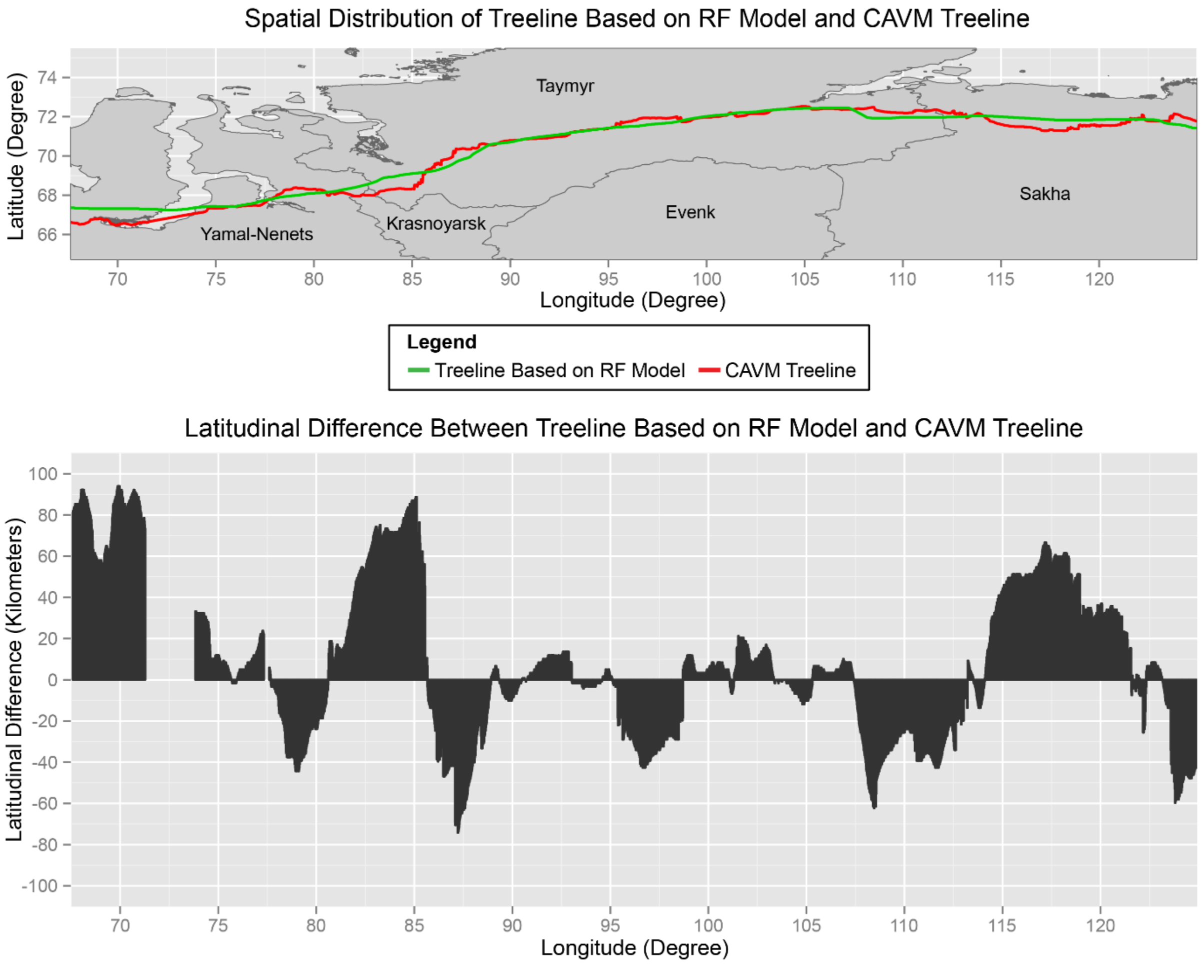

Figure 2: The upper map illustrates two treelines, whereas the red one was defined by Walker et al. (2005) and the green one was derived within my study. Both lines are representing the northern limit of tree growth. The lower graphic indicates latitudinal differences between the lines, wherefore in terms of comparison, x-axes of both illustrations are scaled equal.