Position and dynamics of the circumboreal forest boundary

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Background: the 'Attention-grabbing paper'

3-pronged approach

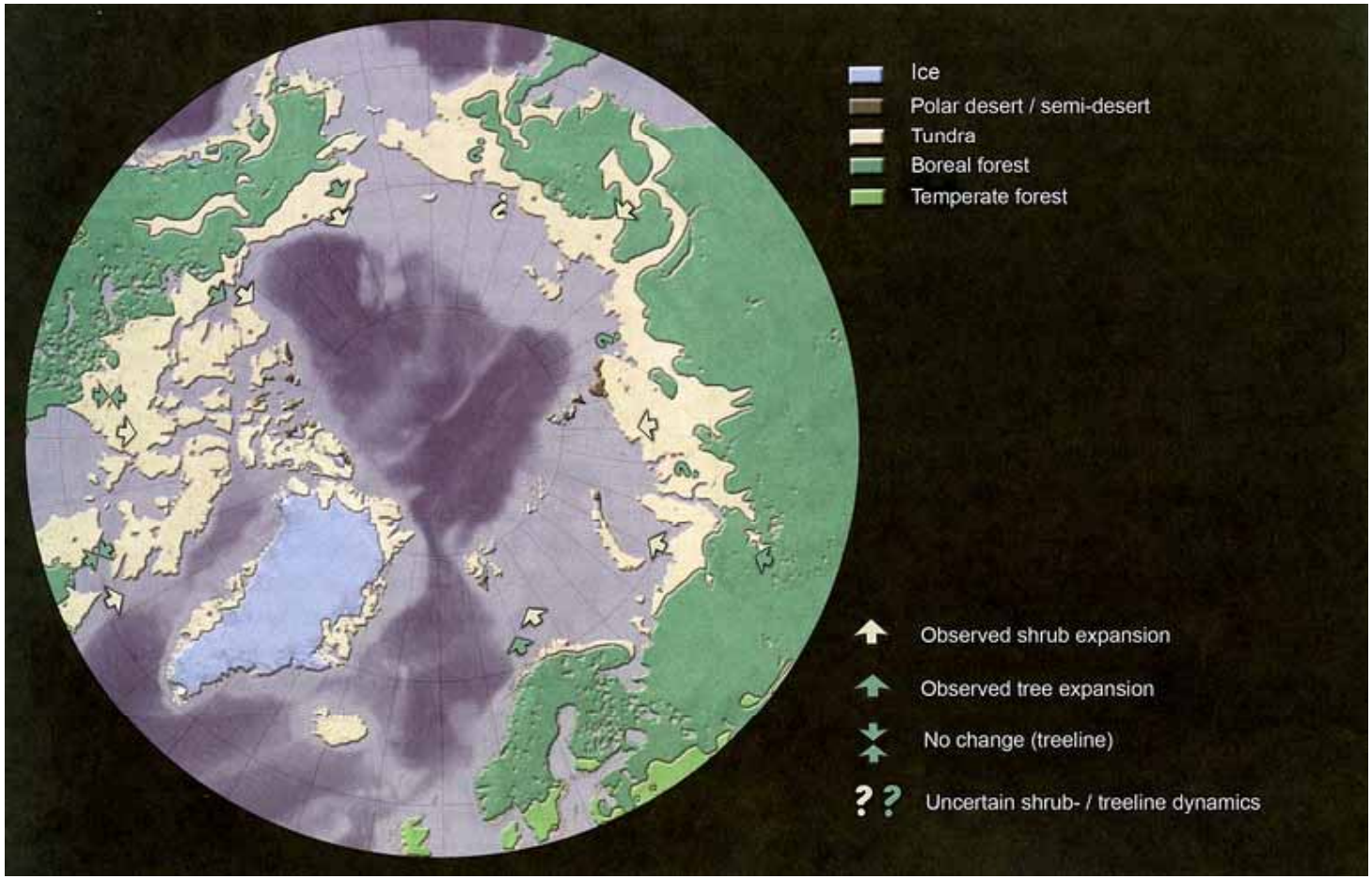
a) where is the 'treeline' now?

b) how fast is it predicted to be moving/changing its structure, on the basis of climate-driven models?

c) what evidence do we have of movement/structural change from our study sites around the Arctic?

a) Needs satellite RS data for timely and consistent picture, but methodology not yet firmly established

b) Can be answered from a) over a timescale of ≈ 25 years. For longer timescales (past and future) depends on modelling vegetation distribution as a response to actual or projected climate.



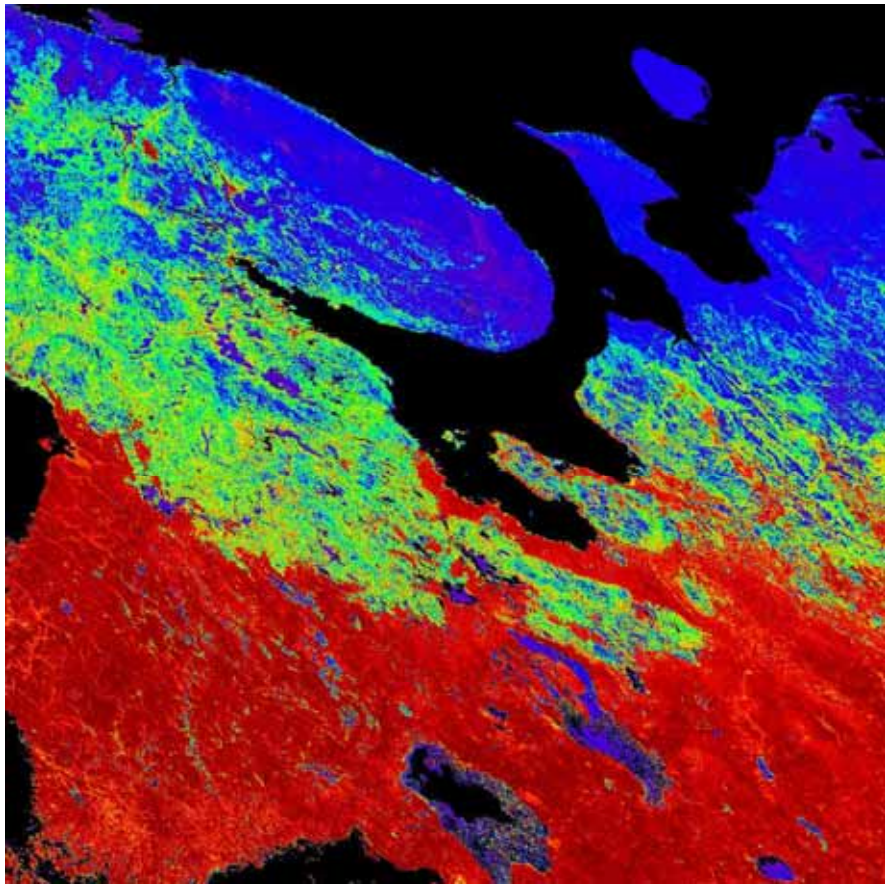
http://www.arctic.noaa.gov/report07/essay_vanbogaert.html

Why should we use a spatial resolution of ≈ 1 km?

Tundra-taiga ecotone is ≈ 4 x 10^6 km^2.

Resolution	30 m	1000 m
Data volume	12 GB	12 MB
No of images	250	10
Data acquisition	1 year +	1 month

Normalised difference vegetation index

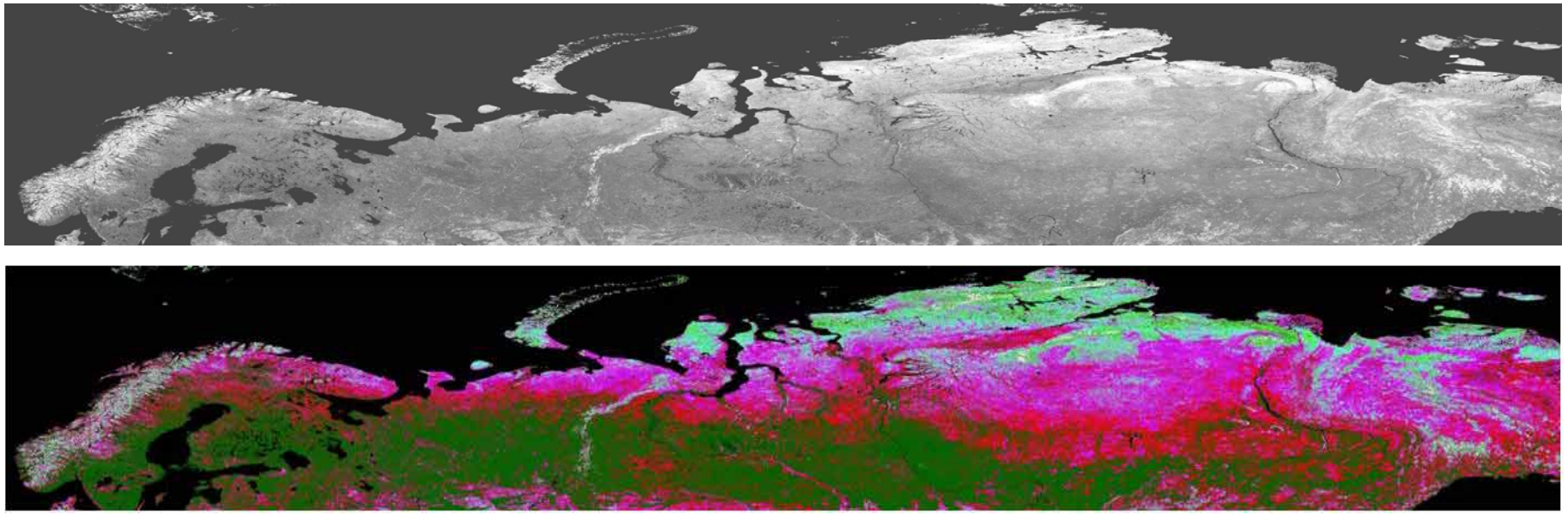


MODIS NDVI March 2008

NDVI is a mathematical transformation of the ratio of surface reflectance in near infrared and red wavebands. In temperate regions the ratio is correlated with green leaf biomass. In the past, NDVI has been used to estimate inter-seasonal and inter-annual land cover change in northern latitudes.

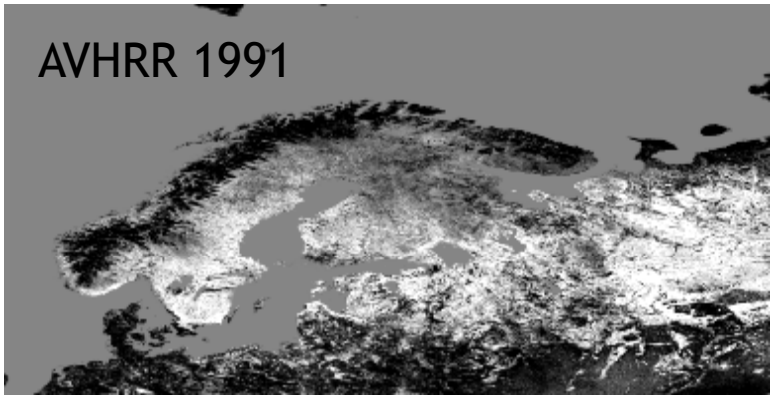
Albedo

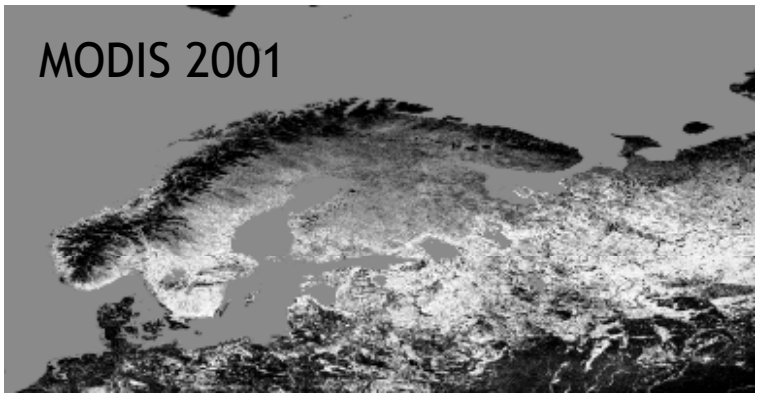
MODIS albedo July 2001

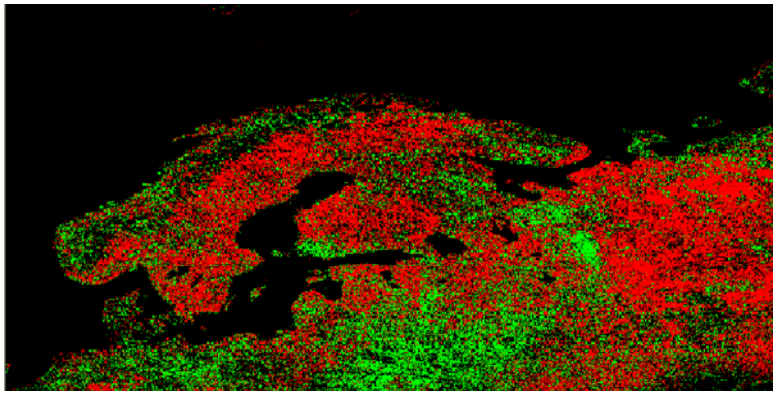


In temperate regions the surface albedo is inversely correlated with vegetation cover density, inter-seasonal variation being particularly apparent. As such, albedo might be used, along with NDVI, to estimate tree cover change.

Vegetation Continuous Fields







Differences >5%

Main problem: don't know if the AVHRR and MODIS products are consistent. Need stable calibration areas to resolve this.

The VCF is an estimate of the proportion of each pixel occupied by trees. We are investigating the scope of these derived products to give consistent agreement with other definitions of the position of the treeline, and (with appropriate intersensor calibration) to identify changes to the position of the treeline over the last few decades.

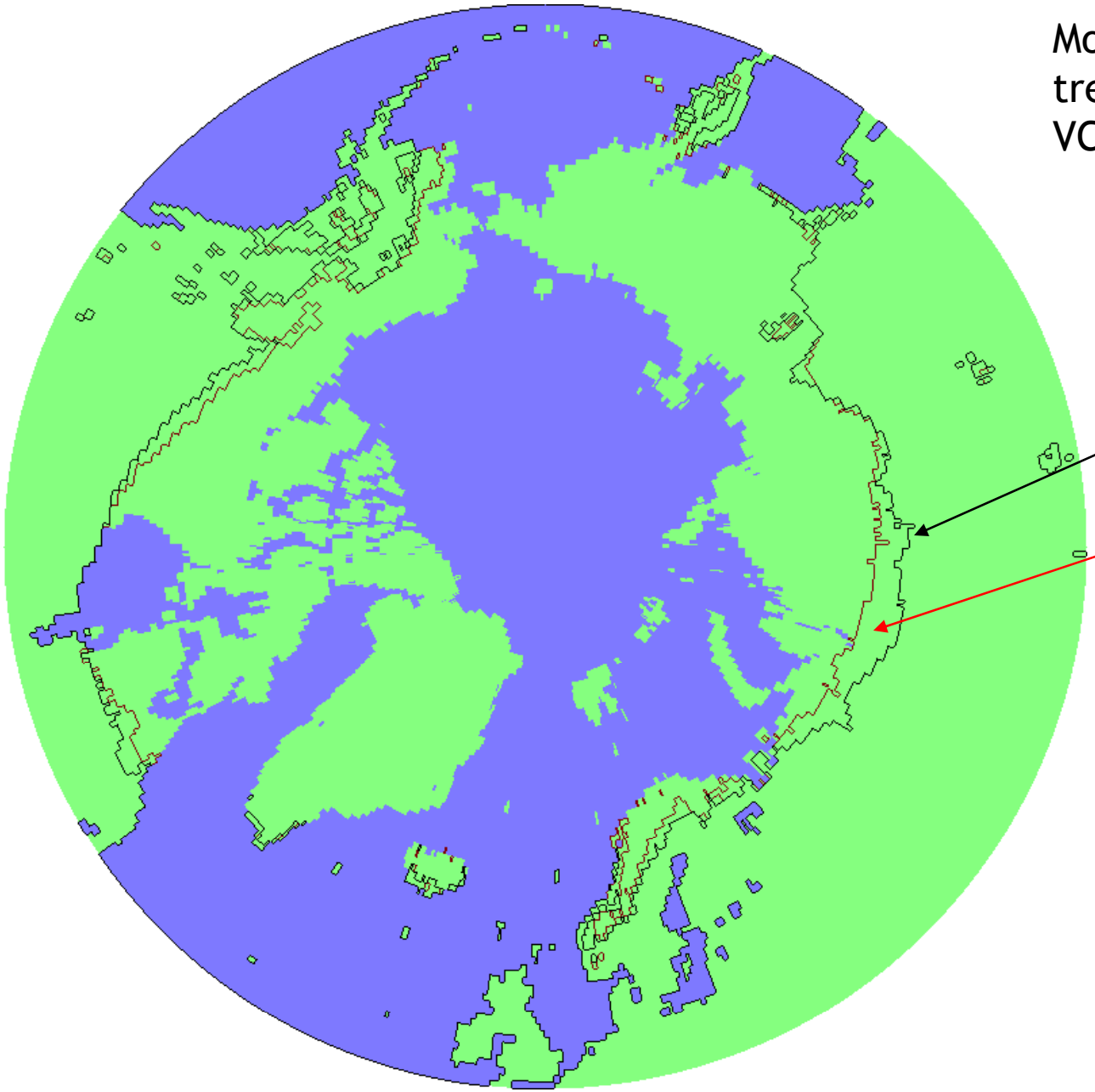
Modelling changes in treeline position

Idea is to relate current position of the 'treeline' to a simple set of variables *that can also be estimated for dates say 100 years in the past or future* and then to use the same relationship to estimate the century-scale change in position - provides context for more detailed observations.

Method 1: use seasonal climate variables (temperature and precipitation) from CRU. Spatial resolution 0.5 degree (≈ 55 km).

Use multiple linear regression to 'explain' MODIS VCF data from TT ecotone.

Best fitting model: $V = 2.5 + 5.68\ T_1 - 0.34\ T_2 + 1.41\ T_3 - 2.80\ T_4 + 0.134\ P_1 - 0.014\ P_2 + 0.029\ P_3 - 0.092\ P_4$ with $r^2 = 0.49$. (1234 = spring,…, winter, T in °C, P in mm)



Model used to estimate treeline as 20% contour in VCF

1901-1910

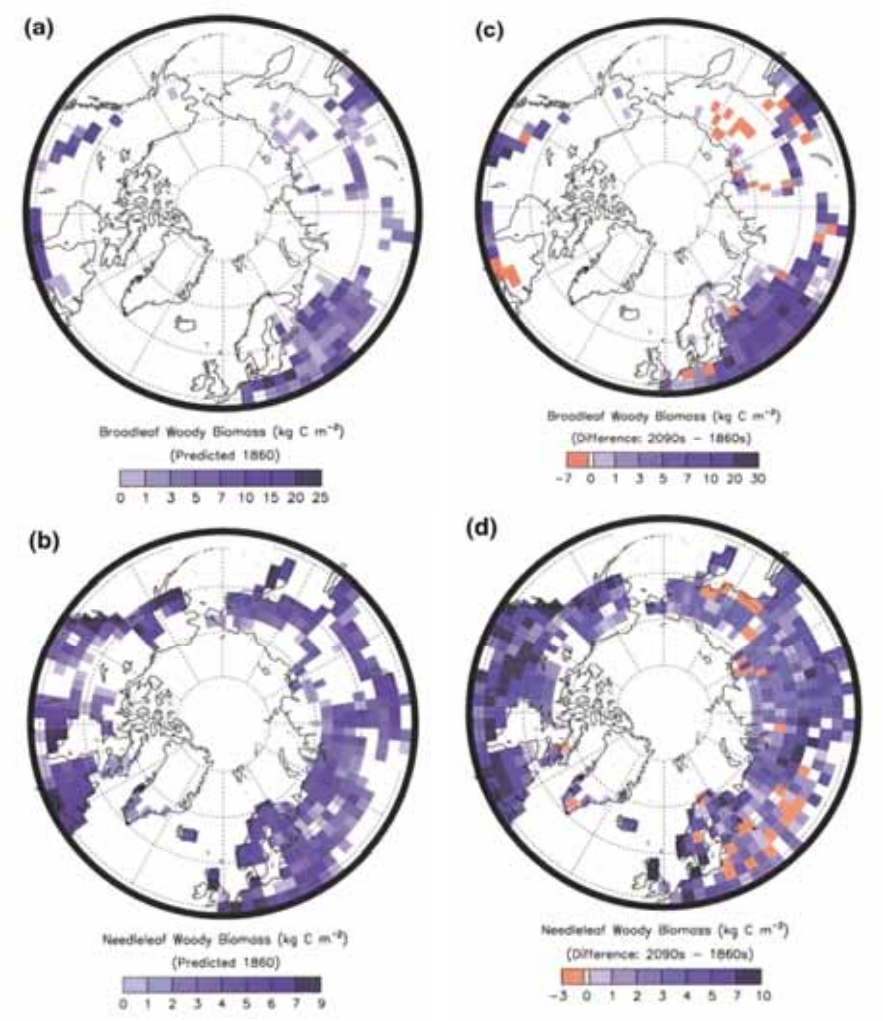
1991-2000

Predicts ‘expected’ N shift but too big – 300 km in W Siberia

Model 2: Same idea but using photosynthesis variables derived by Frank Berninger.

Does not fit quite as well (r^2 = 0.47), gives essentially same result for rate of movement of treeline

Method 3: Use dynamic global vegetation model to predict biomass distribution in different plant functional types



White A et al. *The high-latitude terrestrial carbon sink: a model analysis.* Global Change Biology (2000) 227-245

… in progress

Tasks remaining (most need input from as many of you as possible!)

- Select and optimise treeline algorithm
- Intercalibration of AVHRR and MODIS VCF data
- Improve treeline modelling for century-scale prediction
- Media paper!