Arctic potential natural vegetation changes driven by a RCAO climate scenario

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Introduction

A number of environmental changes due to high-latitude climate warming have been observed in the Arctic over the recent decades. These changes have affected the structure, composition and functioning of Arctic terrestrial ecosystem. Meanwhile, Arctic vegetation also responds to climate differently when its land surface albedo and surface energy partitioning are influenced.

The ***objectives*** of this study are:

a. To characterize future vegetation changes forced by RCAO climate scenario in terms of dominant species distribution, tree-line shift and leaf area index (LAI) change

b. To discuss vegetation feedback to climate in terms of albedo change and latent heat flux change.

Method and data

What is RCAO and LPJ-GUESS?

RCAO is a state of the art regional climate model, which has coupled two component models RCA (atmosphere) and RCO (ocean). Its domain can be seen in Figure 1.

LPJ-GUESS is a modular framework to explicitly model physiological, and biogeochemical process in the growth and competition of woody-plant individuals [2].

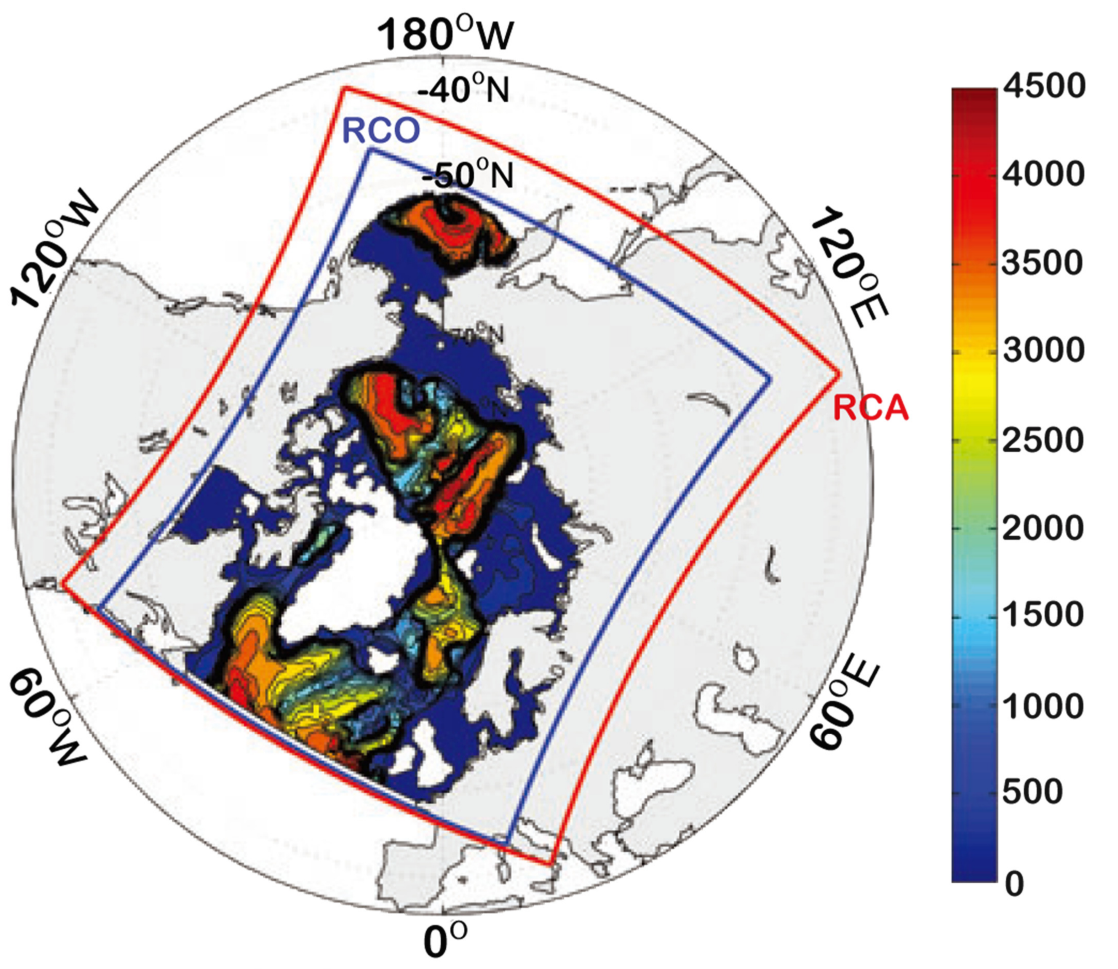


Figure 1. RCAO domain and orography (depth in m, taken from Döscher et al., 2010).

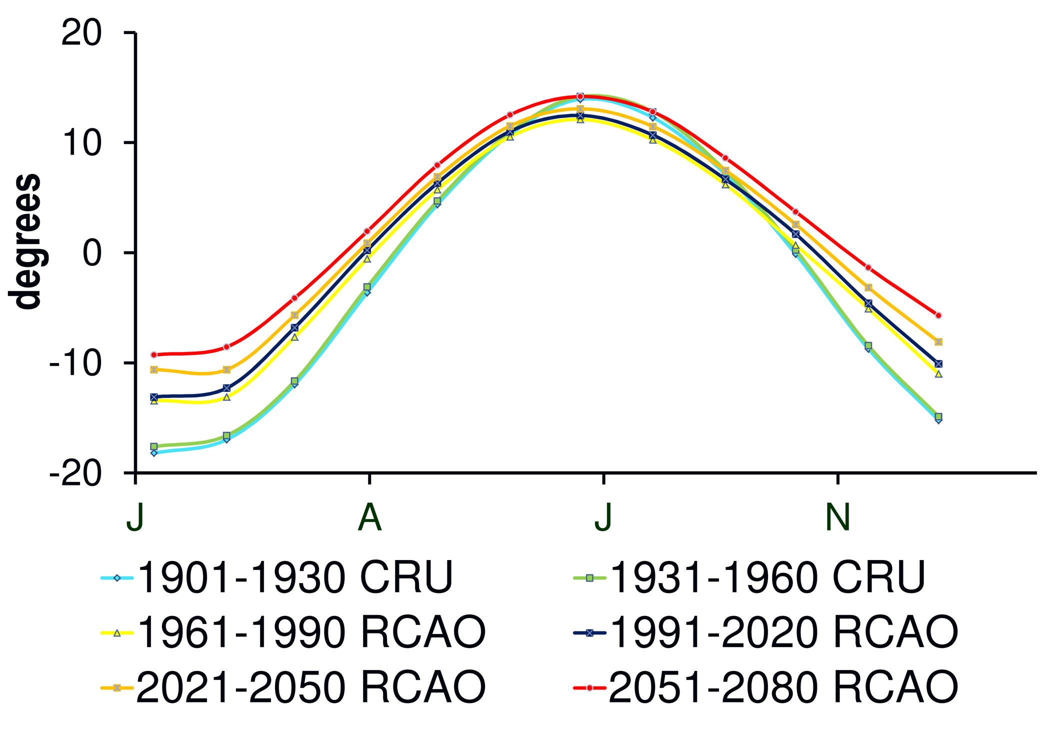


Figure 2. 2m forest land temperature data, 30 years' average, First 60 years' data is using climate research unit (CRU) database.

Results

(1) Dominant vegetation changes

Simulation of present day's vegetation distribution has been benchmarked by comparing to Kaplan potential vegetation map and MODIS land cover type data [3].

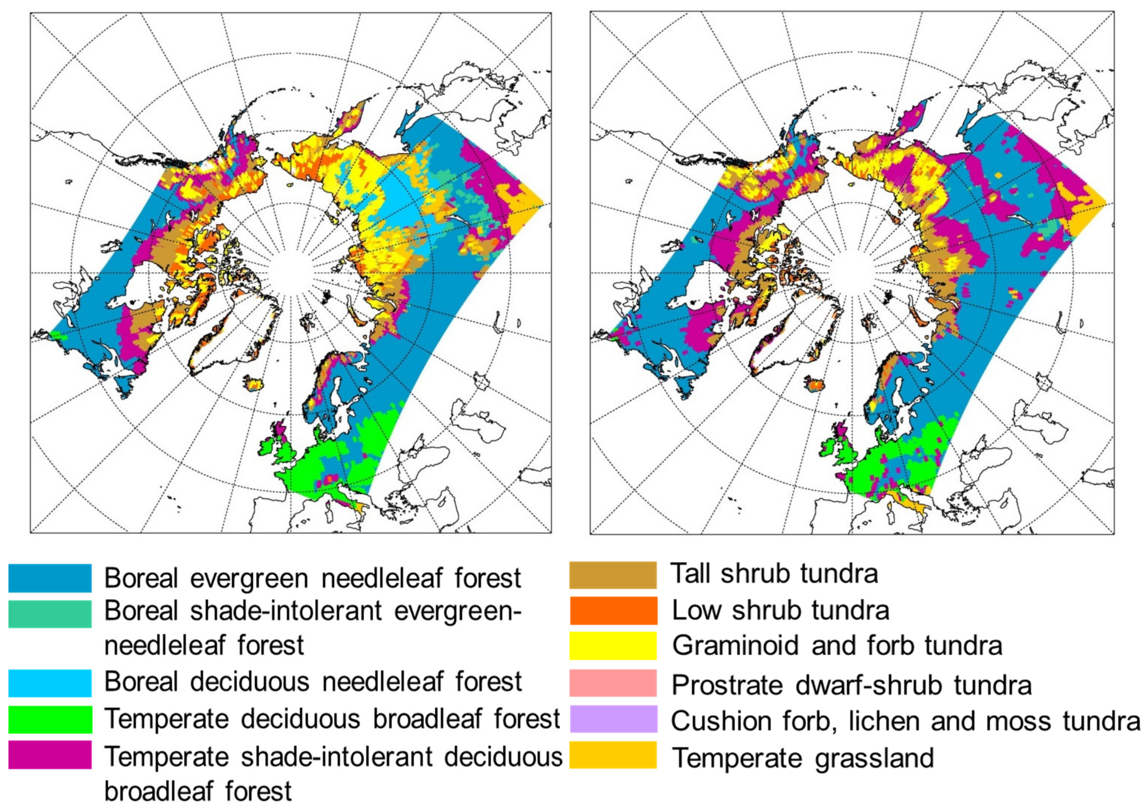


Figure 3. Dominant vegetation distribution (Left: present day 1961-1990; Right: future 2051-2080)

(2) Tree-line shift

The tree line is depicted by using the biomass of tree species.

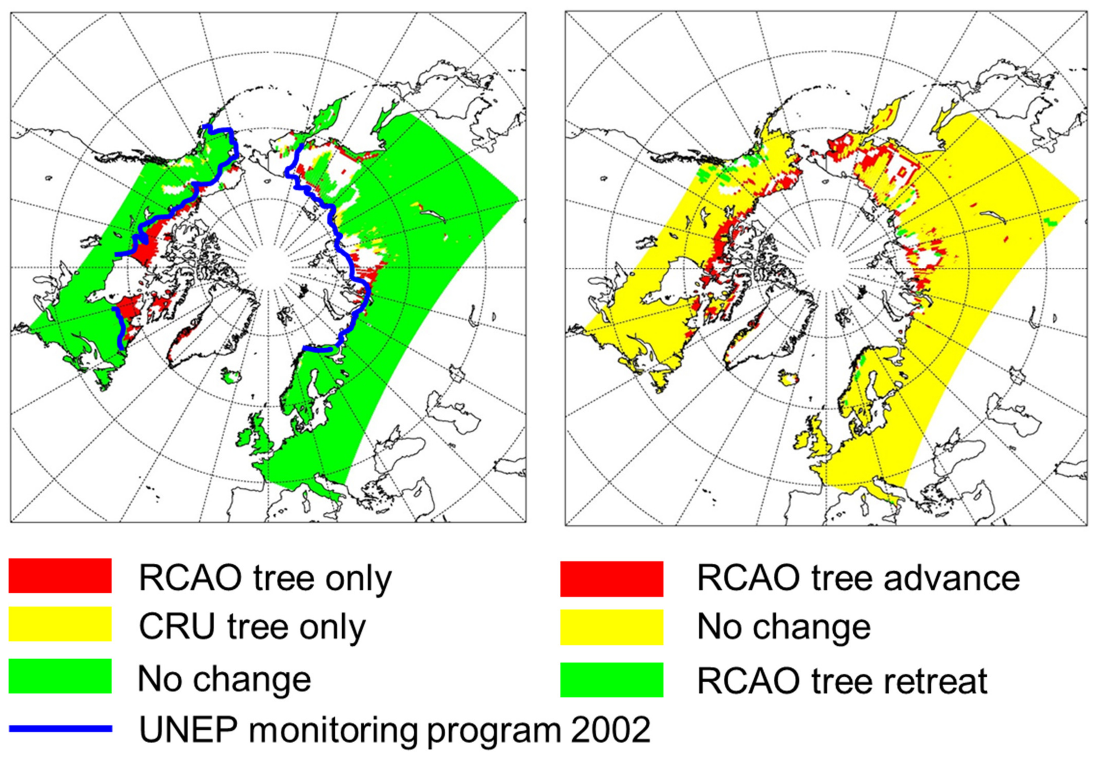


Figure 4. Tree-line validation (left, 1961-1990) and prediction (right, 2051-2080) UNEP: United Nation Environmental Program Monitoring tree-line.

(3) Seasonal LAI changes

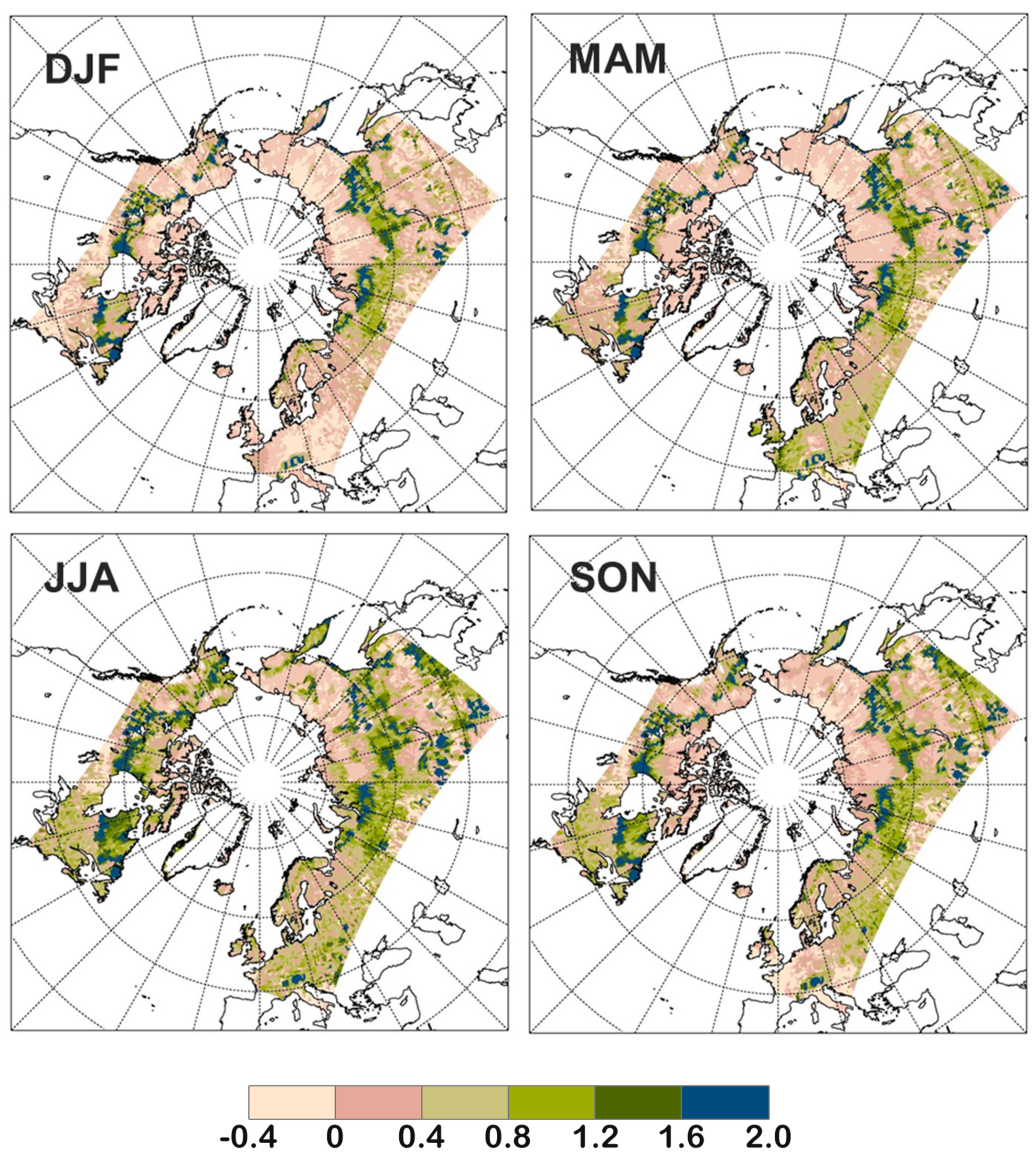
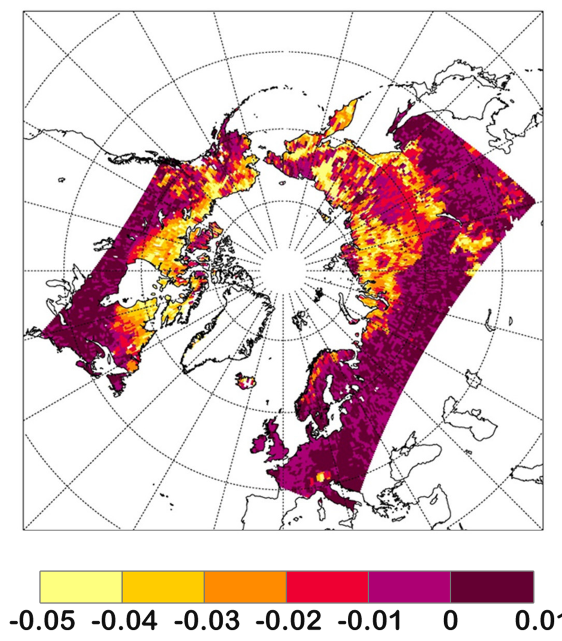


Figure 5. LAI change from 1961-1990 to 2051-2080. LAI increase is more pronounced in summer than other seasons.

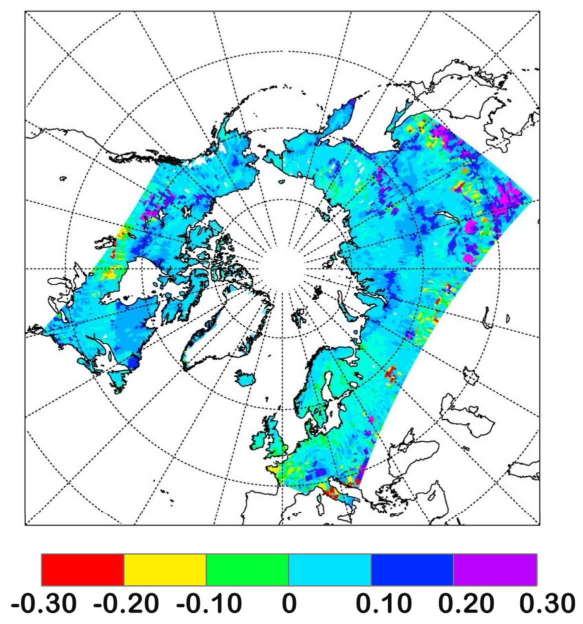
(4) Albedo changes



Biome albedo:
Cool conifer forest:0.13
Cold deciduous forest:0.14
Temp deciduous forest:0.15
Cold mixed forest:0.15
Xerophyte woods/shrub:0.18
Warm grass/shrub:0.20
Cool grass/shrub:0.19
Tundra:0.25

Figure 6. Albedo change by (2051-2080)-(1961-1990) Albedo is calculated by simulated LAI (Lambert Beer´Law)..

(5) Latent heat flux changes



$\lambda = 2.501 - 0.00236 \times T$
$E = \lambda * \rho * ET$ (10^3 MJ/m^2/y)

Figure 7. Latent heat flux change is difference between two periods' average (2051-2080) and (1961-1990).

Conclusion

RCAO-forced simulation shows that in future, boreal trees will expand northward by taking up some tundra land and shrub land. In east Siberia, warmer climate will allow evergreen conifers to dominate larch sites, and this conforms to another forest gap model (Fareast) experiment. Tree-lines are found to advance northwards especially in the north America. Seasonal LAI change shows that summer vegetation increase is more pronounced than winter in general.

As for vegetation feedback, albedo will reduce substantially in the current tundra area and further reinforce climate warming. However, increased latent heat will exert an negative feedback through reducing the share of sensible heat and cooling the climate.

References

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