Arctic and Global Climate Responses to Ecosystem-induced Summer Albedo Changes

Debasish PaiMazumder, Nicole Mölders
email: debasish@gi.alaska.edu

Motivation

- High latitude terrestrial ecosystems may modulate climate
- The changes in climate also have consequences on ecosystems and ecosystem carbon fluxes
- A difference in temperature of ±1K can be decisive for the survival or death of plants

Methods

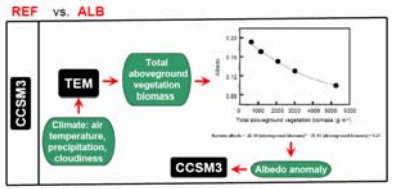

Fig. 1. Schematic view of the CCSM3 simulations performed without (REF) and with (ALB) consideration of TEM-simulated summer-albedo anomalies for 2003 to 2053. The climate data in TEM base on a B2 scenario

- Investigate regional and global consequences of summer albedo changes by comparing ALB and REF
- Perform Student's t-tests for significance of climate changes at the 95% or higher confidence level

Model simulations

- The fully coupled community climate system model CCSM3 consists of an atmosphere, land, sea-ice and ocean model that exchange data by a coupler
- The TEM is a process-based, global-scale ecosystem model that incorporates spatially explicit data pertaining to climate, vegetation, soil, and elevation to estimate monthly pools and fluxes of carbon and nitrogen in the terrestrial biosphere
- CCSM3 is run for 2003 to 2053 without and with TEM simulated albedo anomalies that occur north of 50°N

Results

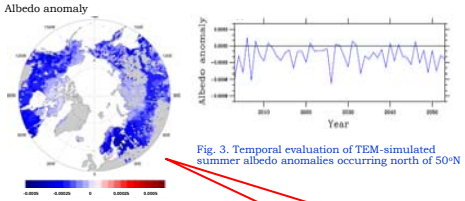

Fig. 3. Temporal evaluation of TEM-simulated summer albedo anomalies occurring north of 50°N

Fig. 2. Spatial distribution of 50y averaged TEM-simulated summer albedo anomalies occurring north of 50°N

Albedo anomalies are negative over the Pan-Arctic

Near-surface temperature significantly decreases over Alaska, western and southern Siberia central Asia, the Middle East, China, the eastern and the western part of Africa and South America.

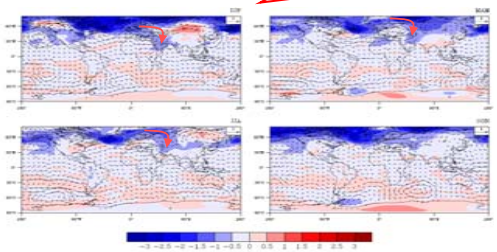

Fig. 4. Global distribution of seasonal differences (ALB-REF) in near-surface temperature (K) and wind speed (m/s) averaged over 2003-2053 for winter (DJF), spring (MAM), summer (JJA), and fall (SON)

Cloudiness increases over the North Atlantic and western Siberia up to 12% and up to 6% over the area north of 50°N during the period 2020-2031 in response to increasing evapotranspiration

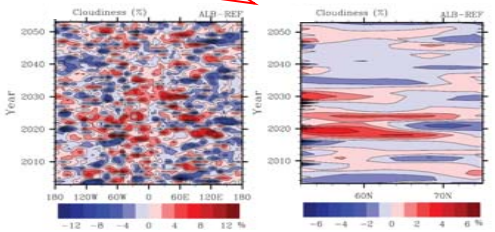

Fig. 5. Hovmüller diagram of longitudinal (left) and latitudinal (right) variation of summer differences in cloudiness (%).

Lower level cyclonic and upper level anticyclonic circulations are enhanced in response to the Pan-Arctic summer albedo anomalies

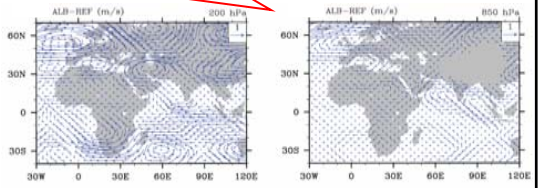

Fig. 6. 50y average wind-speed difference (ALB-REF) at 200 hPa (left) and 850 hPa (right) over the region between 70°N-40°S and 30°W-120°E

The intensification of the tropical easterly jet (TEJ) is responsible for the teleconnection between the high latitudes and eastern and western Africa and South America

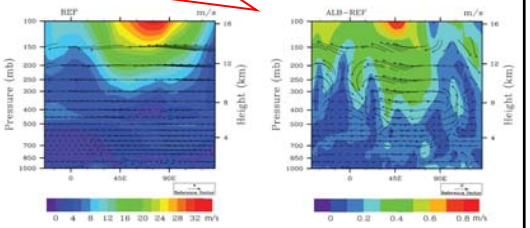

Fig. 7. Vertical distribution of 50y average summer wind speed as obtained by REF and 50y average wind-speed differences (ALB-REF) averaged over 30°N-40°S

Conclusions

- Increase in cloudiness increase planetary albedo leading to significant decreases of near-surface temperature over Alaska and Siberia
- Changes in soil temperature follow the same pattern as near-surface air temperature
- Intensification of TEJ advects relatively cooler air from southern Siberia to eastern and western Africa and South America

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