Temperature and vegetation seasonality diminishment over northern lands

Xu, L. et. al. Nature Climate Change. Published online: 10 Mar, 2013. DOI: 10.1038/NCLIMATE1836

Objectives

- This letter provides a summary of a detailed analysis of the relationship of temperature seasonality (S_T) and vegetation seasonality (S_V) in Arctic and boreal regions, including change over time and projected change in the future.
- The relationships between S_T and S_V are critically examined with newly improved ground and satellite data sets.
- The study analyzes 17 state-of-the-art climate models to project future changes in seasonality.
- The apparently unchanging slope of the relationship between S_V and S_T in the north is tested with four statistical models.

New Science

- The study reports an observed diminishment of S_T and S_V equivalent to 4°and 7° (5°and 6°) latitudinal shift equatorward during the past 30 years in the Arctic (boreal) regions.
- Analysis of simulations from numerous climate models indicates that an additional S_T diminishment equivalent to 20°equatorward shift could occur this century.
- The proportion of Arctic vegetation with a statistically significant increase in greening varied form 32 – 39% and the proportion with statistically significant decrease in browning was less than 4%.
- Greening is most prominently seen in coastal tundras and eastern mixed forests in North America, needleleaf and mixed forests in Eurasia, and shrublands and tundra in Russia.
- North American boreal vegetation shows a fragmented pattern of greening and browning, while in Eurasia there is widespread contiguous greening.
- Tests of three of four statistical models support the tight coupling between the relationship of S_V and S_T.

- The test of the fourth model indicates that the slope of the relationship between S_V and S_T varies with time and between the Arctic and boreal regions, with greening in the Arctic accelerating over time, whereas boreal greening is decelerating over time.
- The Arctic S_V decline accelerated (green rate increased) over time, from 2.15° latitude between the early 1980s and the mid 1990s to 4.9° latitude between the mid 1990s and the last 2000s; in the boreal regions it decelerated from 5.7° to 0.6°latitude in the same period.
- Definitions used in this study, including temperature seasonality (S_T) and vegetation seasonality (S_V), have been defined, tested and justified. A detailed analysis is found in the supplement.

Significance

- The initiation, termination and performance of vegetation photosynthetic activity are tied to threshold temperatures; trends in the timing of these thresholds and cumulative temperatures above them may alter vegetation productivity or modify vegetation seasonality (Sv) over time.
- If the changes continue, significant increases in productivity may be expected in boreal/Arctic regions during this century, based on the climate model projections of large S_T diminishment, even as insolation seasonality remains unchanged. This would have major ecological, climatic and societal impacts.
- The large diminishment of S_T (20° equatorward) which is projected over this century will generate a response in S_V as well; however the S_V response to such a large projected S_T decline, as well as the impact of such changes, are not well understood.
- Empirical evidence suggests that in addition to direct effects of warming, several other factors influence the relationship between S_V and S_T. These include warming-induced disturbances and recovery (summertime drought and mid-winter thaws, fire frequency, pest outbreak, shrinking and draining of lakes, thawing permafrost, etc.), interactions of temperature and precipitation, complex feedbacks that influence and result from snow cover, anthropogenic influences, and changes in populations of wild herbivores.
- The northern lands need to be carefully monitored and studied in order to assess the impact of the seasonal temperature profile changes as they move towards those found in more southerly latitudes.

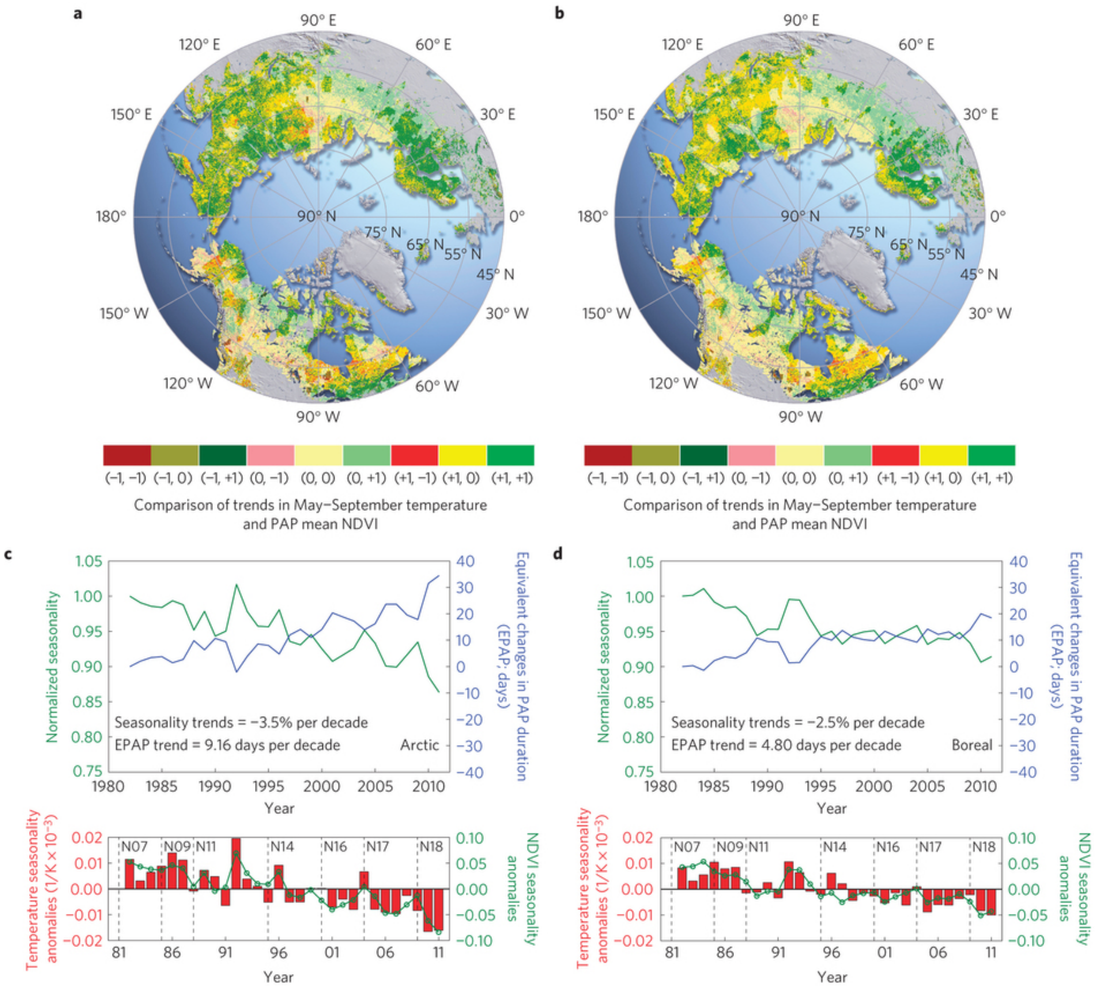

Figure 3: Relationship between temperature and vegetation seasonality (*S_T and SV*). **a.** Comparison of trends of May–September (warm-season) average temperature, TWS and PAP-mean NDVI, Np. Statistically significant (p<0:1) positive trends are denoted as +1, negative trends as -1 and insignificant trends as 0. The first character in each pair below the color bar denotes TWS trend and the second character denotes Np trend. Statistical Model 3 was used to assess statistical significance and trend magnitudes. Temperature data were downscaled to the spatial resolution of NDVI data using the method of nearest-neighbor interpolation. As this may potentially create artifacts, only the changes in sign of the respective trends are compared. **b.** The same as in a but using Vogelsang's t-PS_T method. Grey areas correspond to lands not considered in this study. Similar maps from all statistical models are shown in Supplementary Fig. S9. **c.** Time series of Arctic S_V with respect to S_V in year one (1982) of the NDVI data series and corresponding equivalent changes in PAP duration. These time series are from pixels exhibiting statistically significant trends in Np as determined by statistical Model 3. The lower panels show ST and SV anomaly time series (statistics in Supplementary Table S5). The dates of different AVHRR sensors are indicated as N07 (NOAA 7), N09 (NOAA 9) and so on. **d.** The same as in c, but for the boreal region. NOAA NCEP CPC temperature data were used.