**AMPLIFIED GREENHOUSE EFFECT SHAPING NORTH INTO SOUTH**

A new study published in *Nature Climate Change* reports decreasing temperature difference between the seasons in the North is increasing plant growth and blurring the distinction between the normally more-seasonal North and abutting less-seasonal South.

A greenhouse effect initiated by increased atmospheric concentration of heat-trapping gasses, such as water vapor, carbon dioxide, methane, etc., causes the Earth's surface and nearby air to warm. The warming reduces the extent of polar sea ice and snow cover on the large land mass girdling the Arctic ocean, which increases the amount of solar energy absorbed by the now somewhat less-white surface. This sets in motion a cycle of positive reenforcement between warming and loss of sea ice and snow cover – the amplified greenhouse effect.

This amplified warming in the North, roughly above the border between Canada and the USA for example, is reducing temperature seasonality over time because the colder seasons are warming more rapidly than the summer.

Consequently, the total amount of heat available for plant growth in these cold climes is increasing from enhanced level of warming overall and a lengthening thaw season. The result is numerous large patches of vigorously productive vegetation, totaling more than a third of the Northern landscape, in resemblance of their lusher and less-seasonal Southern counterparts.

This linked diminishment of temperature and vegetation seasonality was reported by an international team of 21 authors from 17 institutions in 7 countries. They used a new 30-year satellite data set of vegetation greenness developed by coauthors Drs. Compton Tucker and Jorge Pinzon of NASA Goddard Space Flight Center in Greenbelt, USA, in addition to two independent data sets of temperature. To determine the growing season, the authors used 20 years of twice-daily satellite observations of freeze/thaw state of the ground developed under NASA's auspices.

The authors cast seasonality changes using latitude as a yardstick because total growing season warmth and plant growth of circumpolar belts of land monotonically decrease poleward from about 50$^{o}$N latitude. This allowed definition of reference latitudinal profiles of these quantities and translation of their changes over time as shifts along these reference profiles.

As an example, consider the Arctic, the far northern tree-less circumpolar belt of shrubs, grass and sedge meadows. Arctic plant growth during the early 1980s, the reference period, equaled that of lands north of 64$^{o}$N, while now, 30 years later, it equals that of lands north of 57$^{o}$N during the reference period – a reduction in vegetation seasonality of about 7$^{o}$N in latitude. This manner of analyses suggested a decline in temperature and vegetation seasonality of about 4 to 7$^{o}$ latitude over the past 30 years.

The diminishment of vegetation seasonality, or increased greenness, in the Arctic is visually evident on the ground as increasing abundance of shrubs, their height and also tree incursions in several locations. The greening in the adjacent Boreal areas is much less conspicuous in North America than in Eurasia, reasons for which are not known, but likely involve increasingly divergent precipitation patterns between the continents.

Indeed a key finding of this study is the accelerating decline of vegetation seasonality, that is, increasing greening rate over time, in the Arctic and a decelerating decline of vegetation seasonality in the Boreal region, in the face of nearly-constant rate of temperature seasonality diminishment in these regions over the past 30 years. Perhaps this portends a decoupling between growing season warmth and vegetation productivity in the North, as the ramifications of amplified greenhouse effect, such as permafrost thawing, increased risks of fires and pest infestations, summer time aridity, etc., come in to play.

The future does indeed look disturbing. The authors report diminishment of temperature seasonality in the North of over 20$^{o}$ latitude during the last decade of this century, relative to the reference period 1951-1980, based on analysis of 17 state-of-the-art climate model simulations. The prediction of temperature seasonality decline by these models for the decade 2001-2010 is actually less than the observed decline. As we do not know the actual trajectory of atmospheric concentration of various agents capable of forcing a change in climate, such projections should of course be interpreted cautiously.

The soils in the North can release significant amount of greenhouse gases, such as carbon dioxide and methane, which are currently locked up in the permanently frozen ground. Any large-scale deep-thawing of these soils has the potential to further amplify the overall greenhouse effect.

The way of life of many organisms on Earth is tightly linked to seasonal changes in temperature and availability of food, and all food on land comes first from plants. Think of migration of birds to the Arctic in the summer and hibernation of bears in the winter. Any significant alterations to temperature and vegetation seasonality are likely to impact life not only in the North but elsewhere in ways that we do not yet know.