



Eurasian Arctic Land-Cover and Land-Use Change in a Changing Climate

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The world climate
is changing and changes
in the Arctic are among
the most prominent
features of this change

Arctic Land Cover and Land Use In a Changing Climate: Focus on Eurasia

- **NASA LCLUC Program contribution to IPY - a compilation of the studies focused on the Arctic region of Northern Eurasia**
- **The region of interest is land ecosystems north of 60°N latitude, specifically transitional forest-tundra and tundra zones**
- **Twelve chapters written by international teams including US, Russian, and Scandinavian scientists**
- **Scheduled for submission to Springer in about 1 month**

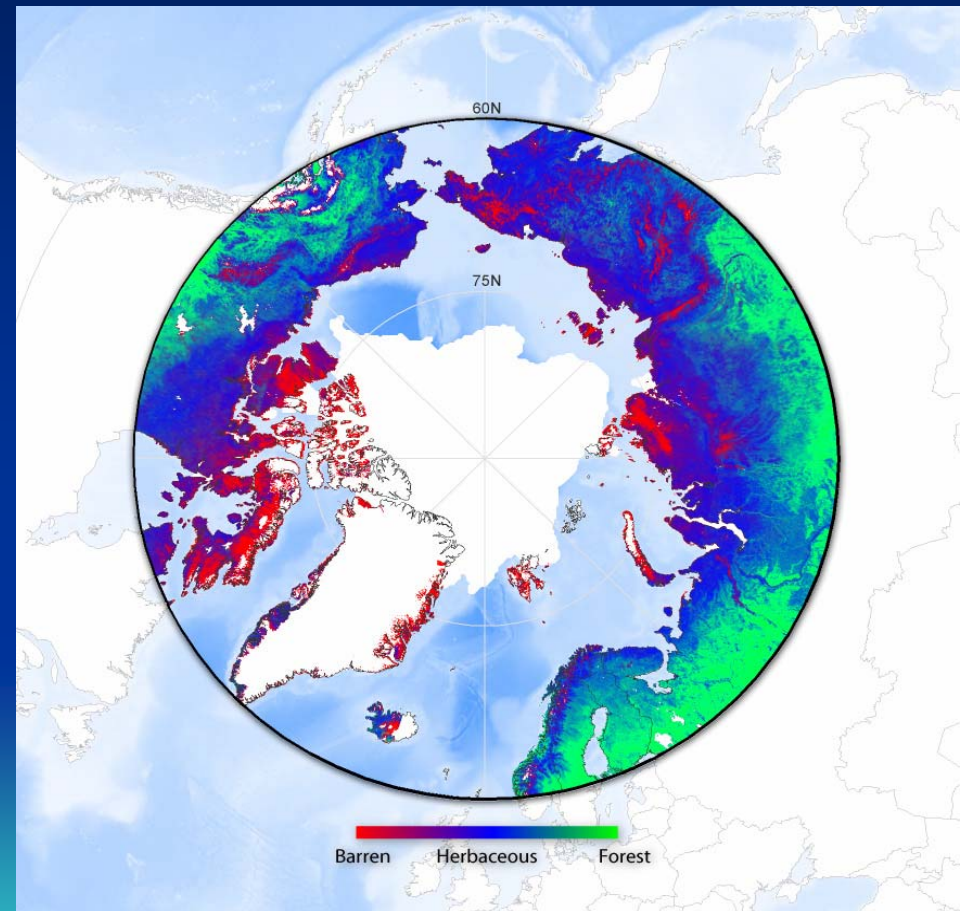
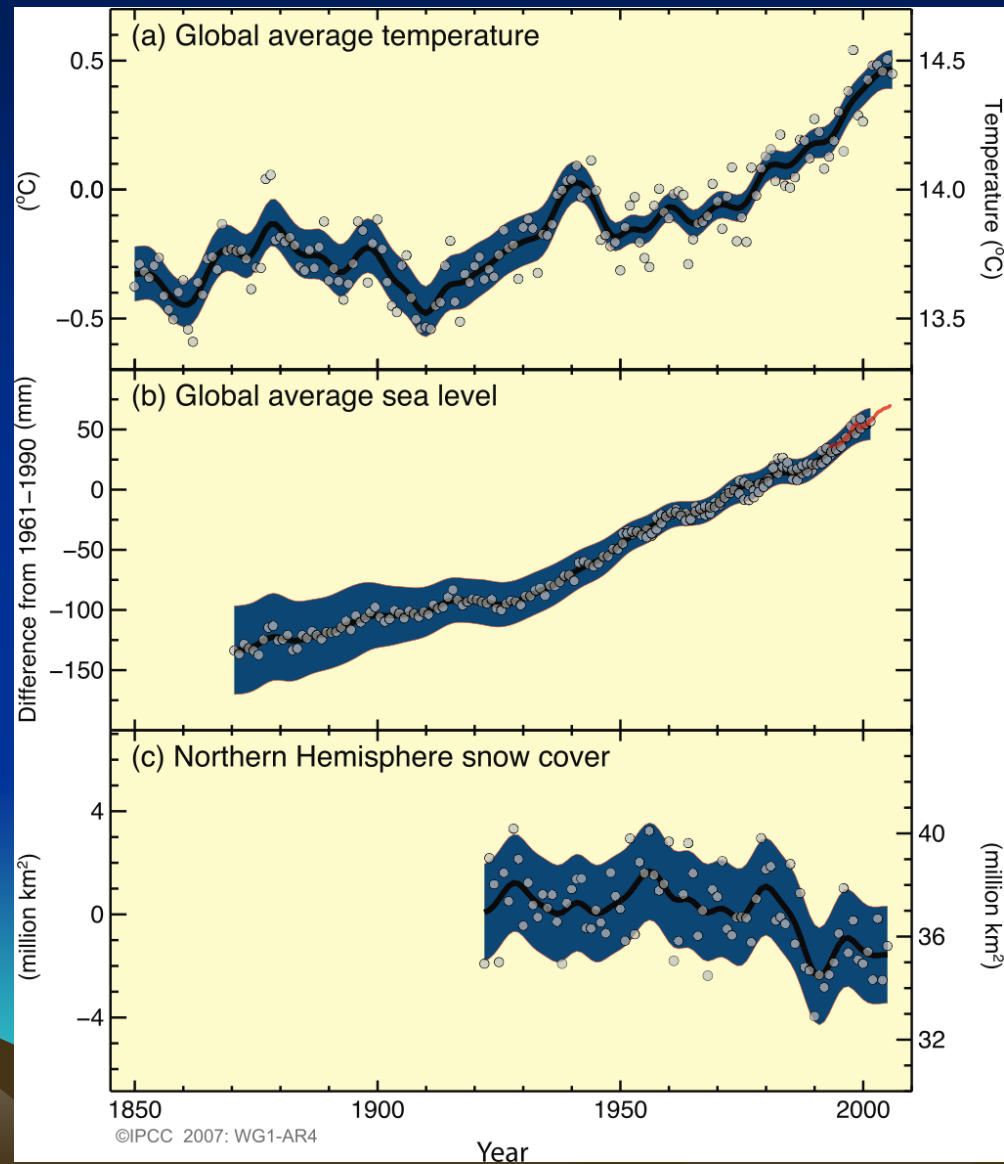


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Long-Term Large Scale Climate Trends

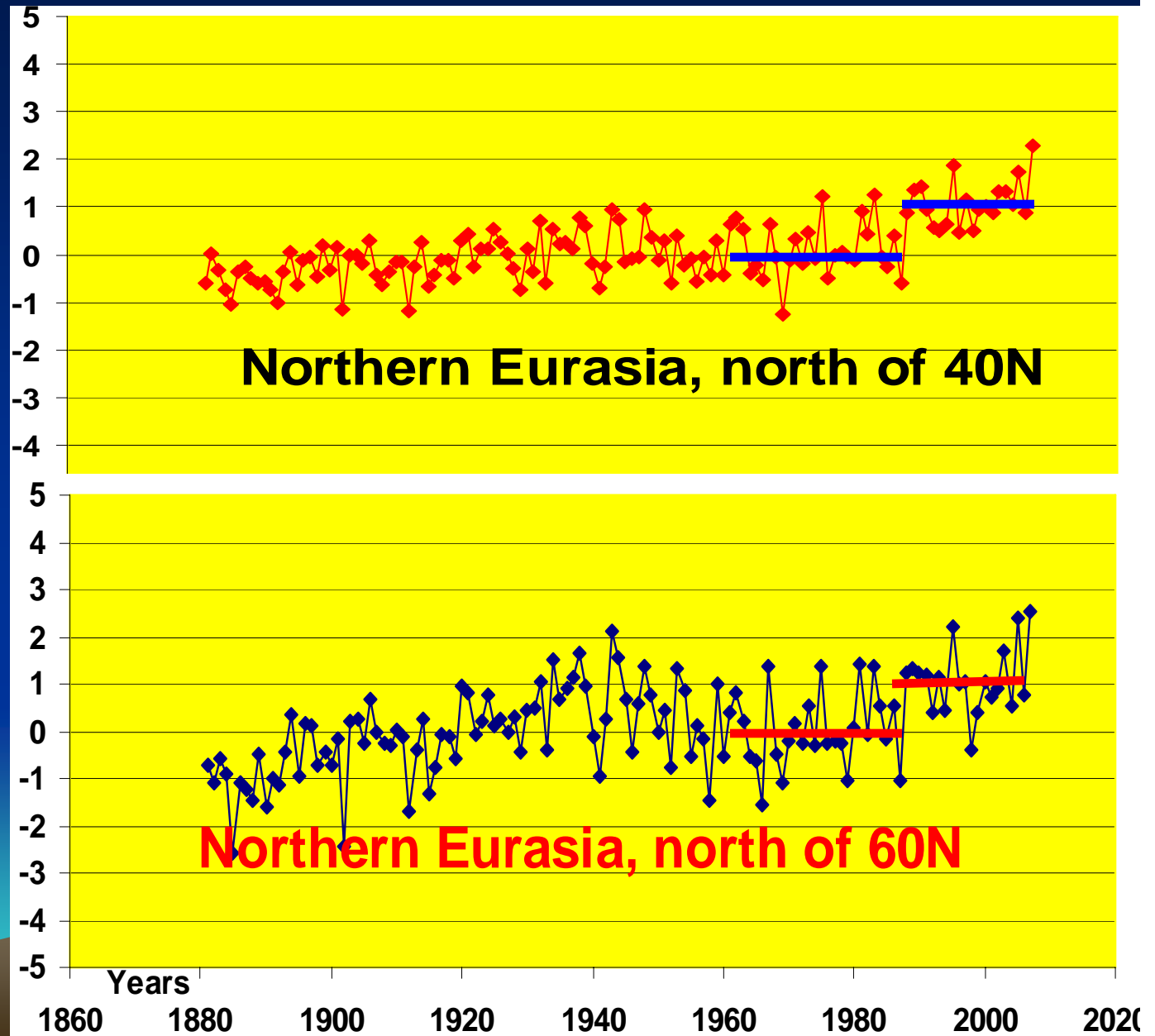


From IPCC Fourth
Assessment
Report, 2007 - Fig.
SPM.3

Annual surface air temperature anomalies, °C, area averaged over Eurasia north of 40°N and north of 60°N for the 1881-2007 period.

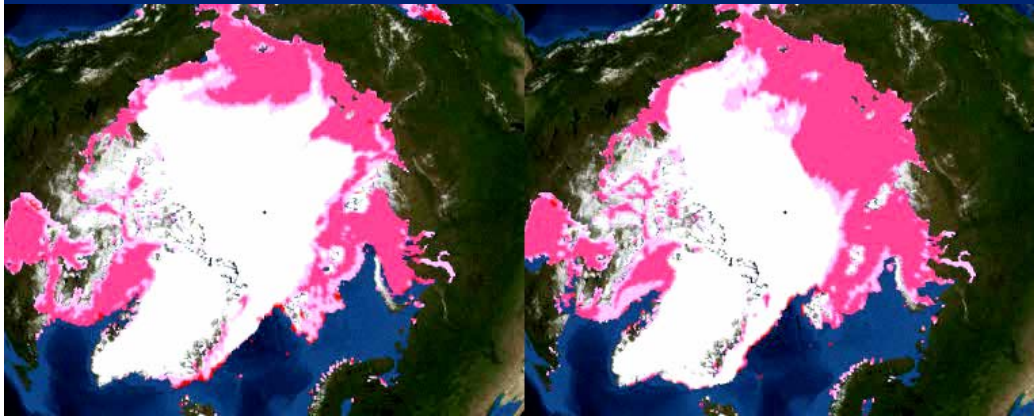
Data source:
Archive of Lugina
et al. (2007).

Statistically
significant
temperature
increases
(estimated by
linear trends)
were equal to
1.4°C and
1.7°C per 127
years
respectively.



Drastic Arctic Sea Ice Reduction

Loss in perennial sea ice extent was as large as Texas



12/21/2004

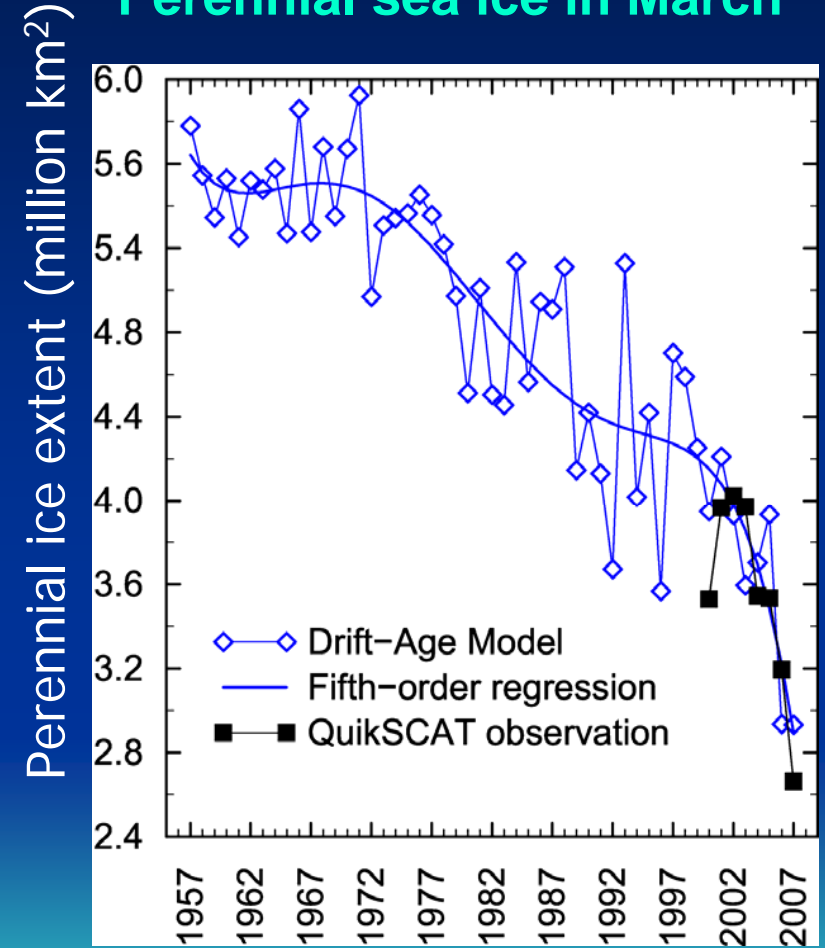
12/21/2005

seasonal mixed perennial

thin ice

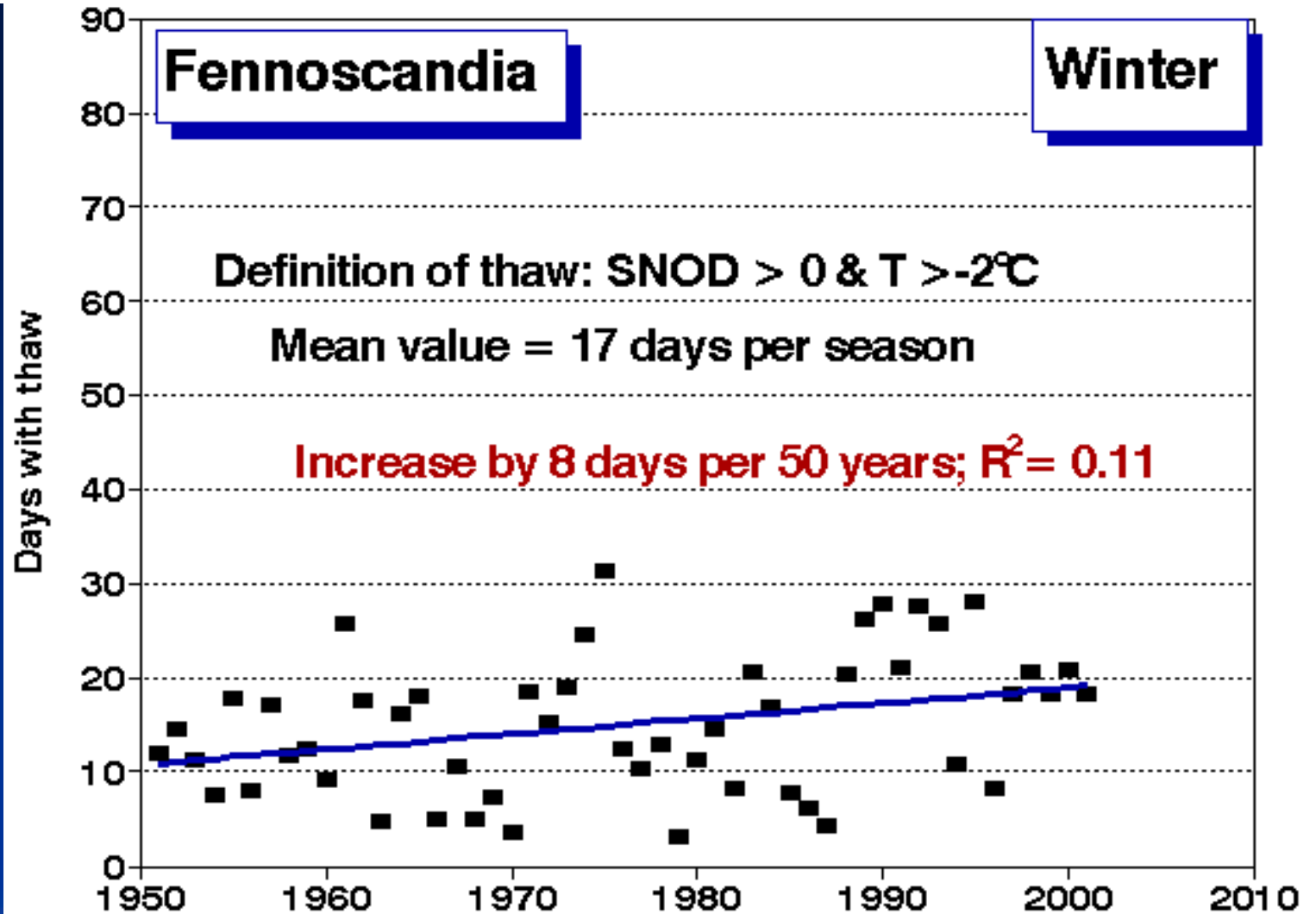
thick ice

Perennial sea ice in March



Archive of the Arctic Climate Impact Assessment Report (McBean et al. 2005).

Day with thaw is defined as a day with snow on the ground and daily temperature above -2°C).



Changes of the frequency of days with thaw

Changes in the Arctic

- The last 10 years have been the warmest in the Arctic during the 120-year period of instrumental observations
- If this warming trend continues, it will significantly affect the Arctic land cover and land use, also causing impacts on the global scale. The changes will occur in the natural land cover, with perhaps the greatest effects in that part of the Arctic where the land cover has already been modified by human activities
- In many Arctic areas there has been a clear shift from the land use practiced by indigenous peoples to intensive exploitation of the land for commercial and industrial uses

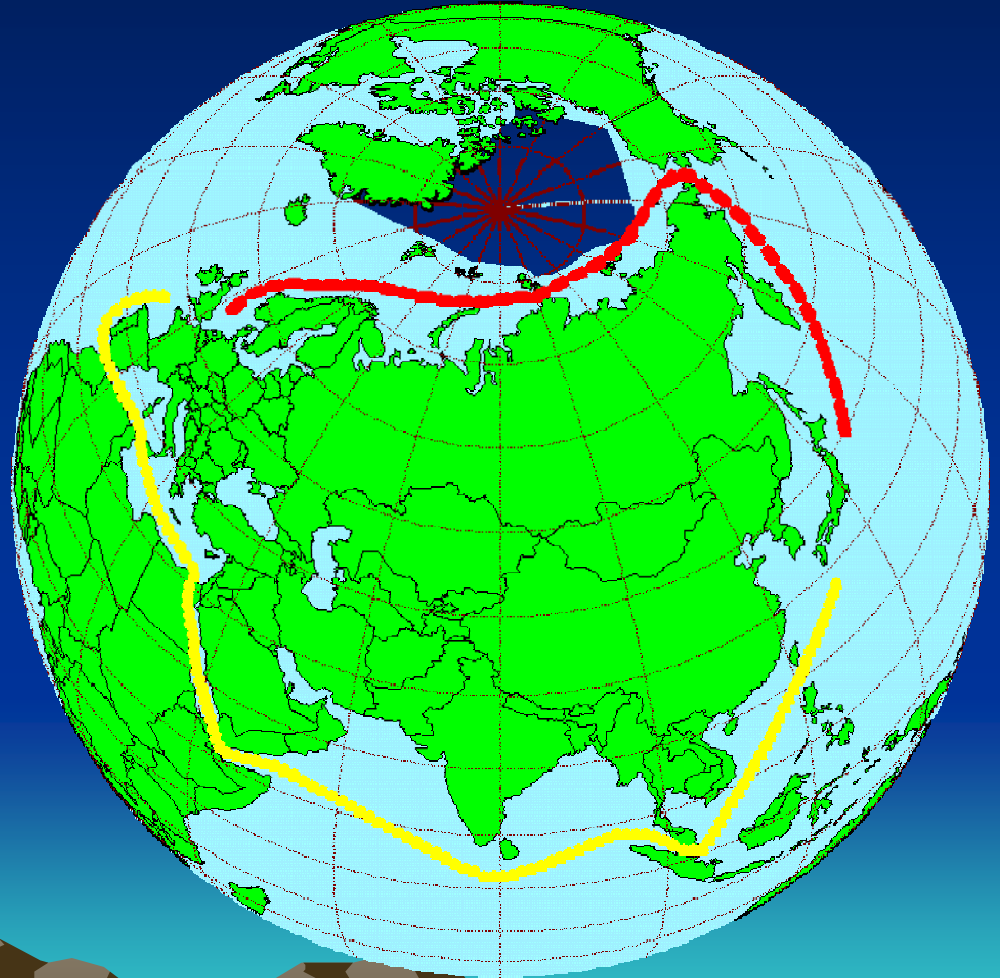
Some Impacts of Ice-Free Arctic Ocean in Summer



- More heat absorbed by the planet
- New climate patterns
- Change in wildlife habitat

Some Impacts of Ice-Free Arctic Ocean in Summer

- Trans-pole shipping becomes possible via Northern Sea Route
- Improved access to resources
- New political issues



LCLUC Processes Producing Positive and Negative Climate Feedback Effects

+? – Changes in the reflectivity and the water cycle at the surface following melting of snow and ice cover

+ – Snow cover replacement by a vegetation cover, and/or a changes in the underlying vegetation cover itself (e.g., due drier/wetter weather conditions)

+ Land-cover changes due to the permafrost thaw, e.g. changes in the amounts of greenhouse gases emitted to the atmosphere from land, especially peatlands as warming progresses

Using Satellite Time Series in the Arctic

- The current satellite data record is now of sufficient duration (over 30 years for the AVHRR and over 35 years for Landsat) to conduct meaningful analyses of inter-annual variability land-cover changes in the Arctic
- Optical and microwave data used synergistically is the key for success

Source or sink of Carbon ?

- Shift in terrestrial ecosystem C balance from a sink to a source may be occurring in the boreal forests of northern Eurasia as a result of changes in climate and an increase in fire activity in recent years



Characterizing the Water Cycle

- Remote sensing is limited in terms of resolution and sub-surface penetration =>
 - Large-scale hydrologic models should be used via assimilation of remotely sensed data
- NEESPI task for the future: We need to learn how to combine *in situ* and remotely-sensed observations, modeling, and process studies into a more coherent analysis system

Human Dimension: Land Management

- Human population of the Arctic and their associated livelihood will be impacted and will need to adapt (ACIA 2004)
- Specially designed systems, such as the EALAT Reindeer Mapper Information System will assist in the ongoing analysis of trends and detection of emerging events and conditions
- Systems like this will enhance early warning and management of responses and adaptation to external stresses



Polluting the Arctic

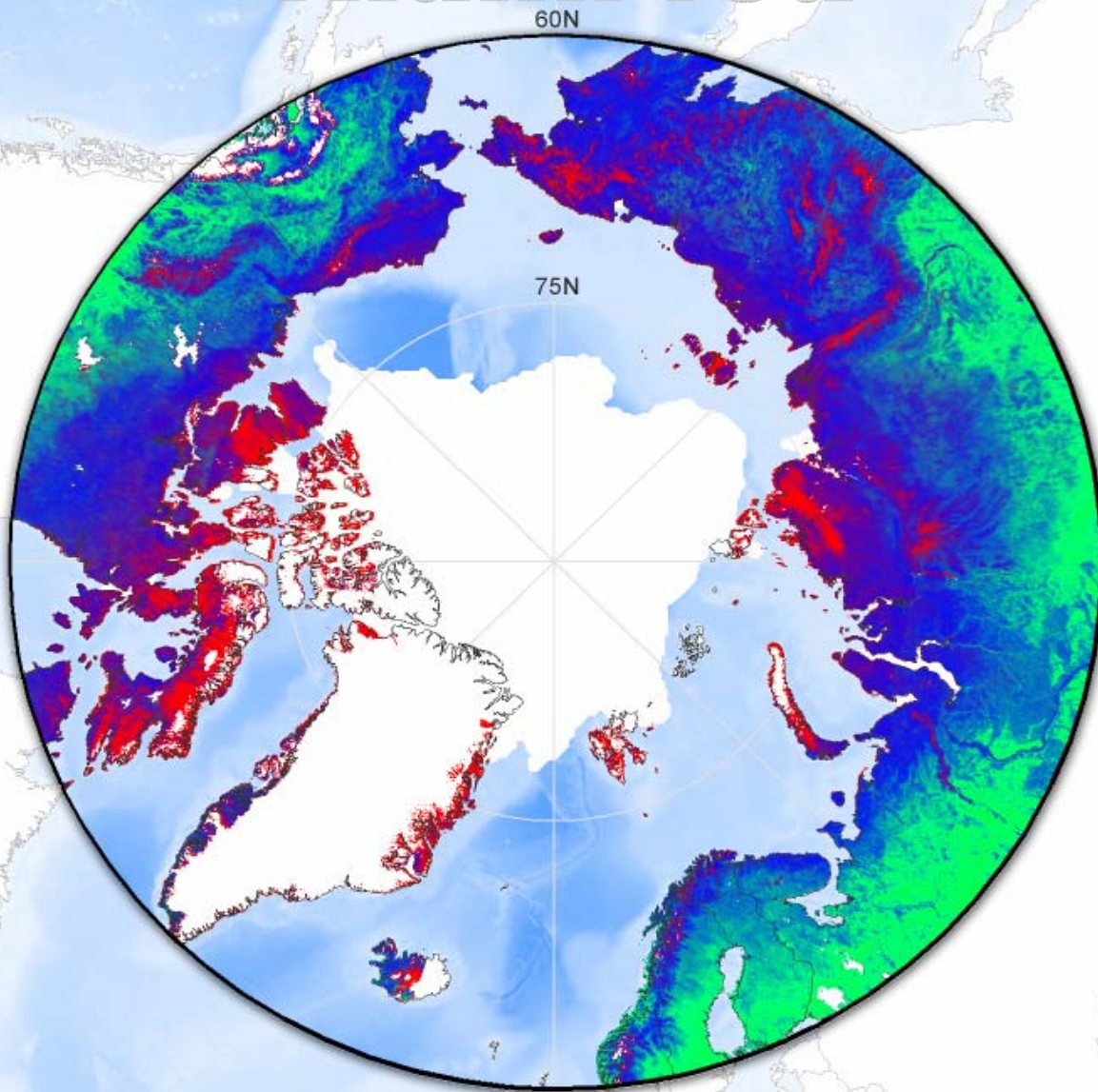
- Environmental pollution originating from oil and gas exploration and extraction activities in the Arctic is expected to increase considerably
- Heavy metal, SO₂, mercury, and sulphate deposition originating from non-ferrous metal smelting and mining activities are the main threat to the prevailing land cover
- Forest and tundra fires serve as an additional source of aerosols to the Arctic



Compound Effect of Climate Change and Pollution

- **Global warming may aggravate the effects of environmental pollution on land cover, and the extent and mechanisms through which pollutants can amplify climatic stress**
- Temperature increase =>
 - accelerate soil mineralization and decomposition processes =>
 - increased mobility/availability of heavy metals & radionuclides =>
 - higher concentrations in mushrooms, berries, reindeer, fish, birds
- Precipitation increase =>
 - increase the deposition of pollutants, and associated leaching =>
 - increased accumulation of pollutants in traditional foodstuff.
 - Higher pollutant availability will also be one consequence of their release from permafrost

Thank You



Barren Herbaceous Forest