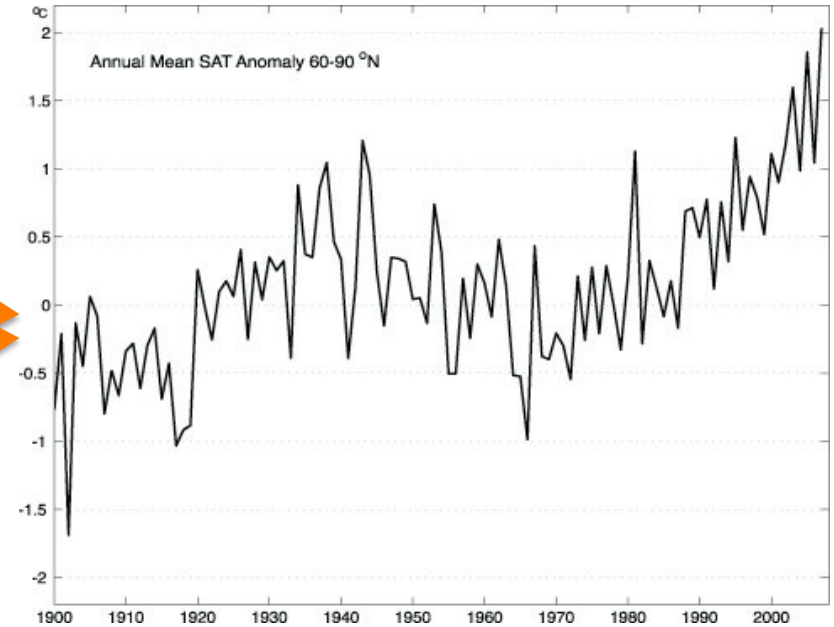
Linkages Between Trends in Arctic Sea Ice, Cloud Cover, and Surface Temperature



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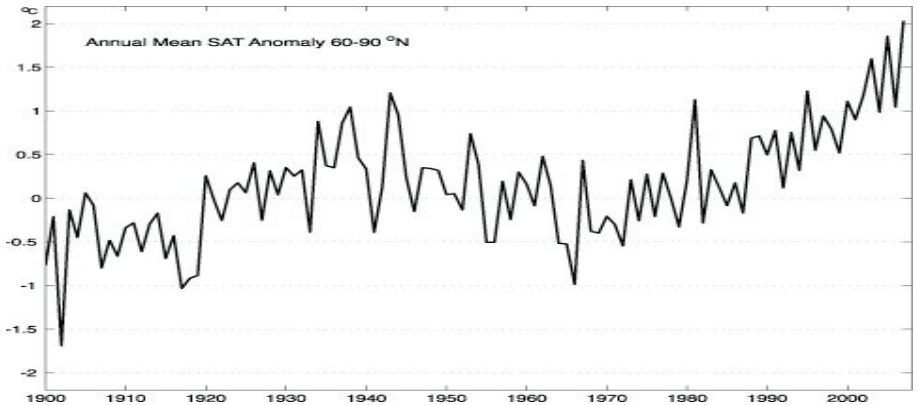
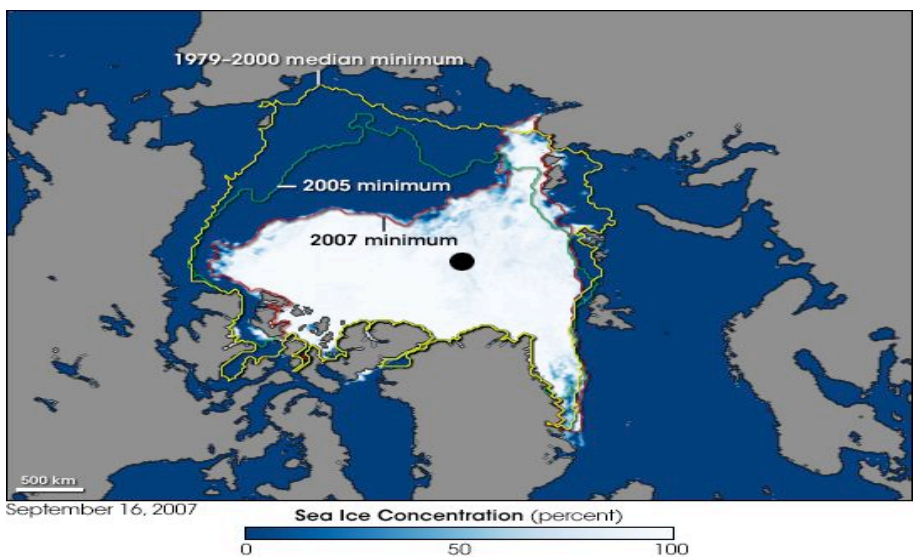
This presentation investigates the influence of trends in sea ice and cloud cover on trends in surface temperature over the Arctic Ocean from 1982 to 2004.



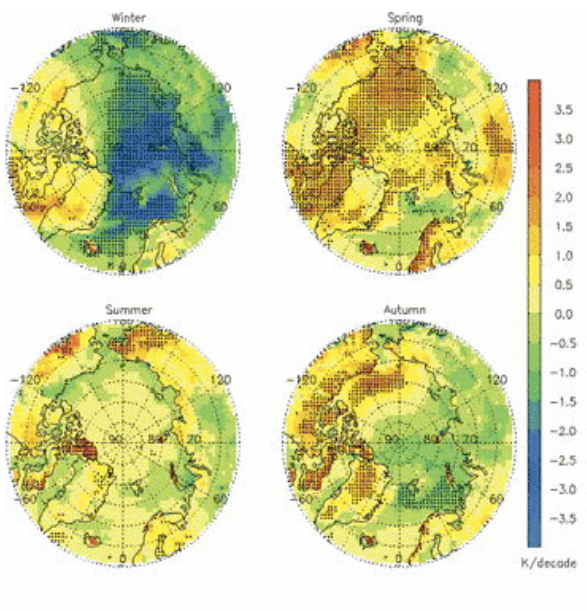
Arctic-wide annual averaged surface air temperature anomalies (60°–90°N) based on land stations north of 60°N relative to the 1961–90 mean. (Overland et al., 2008)

Will show surface temperature trends in the Arctic from various satellite surface temperature product



What are the impacts of changes in sea ice concentration (SIC) and cloud cover on the surface temperature trend?

Surface temperatures from satellites show cooling trends in winter and warming trends in other seasons in the Arctic over 25 years



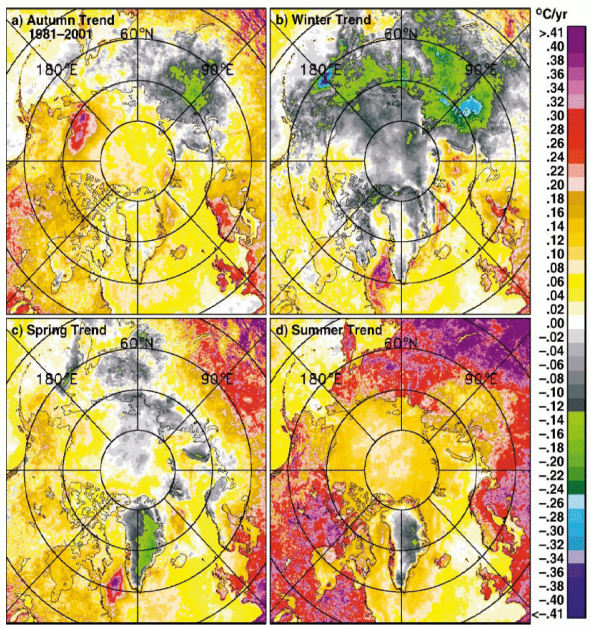


FIG. 7. Color-coded trend maps for the Arctic in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) autumn (SON) for the period 1981–2000.

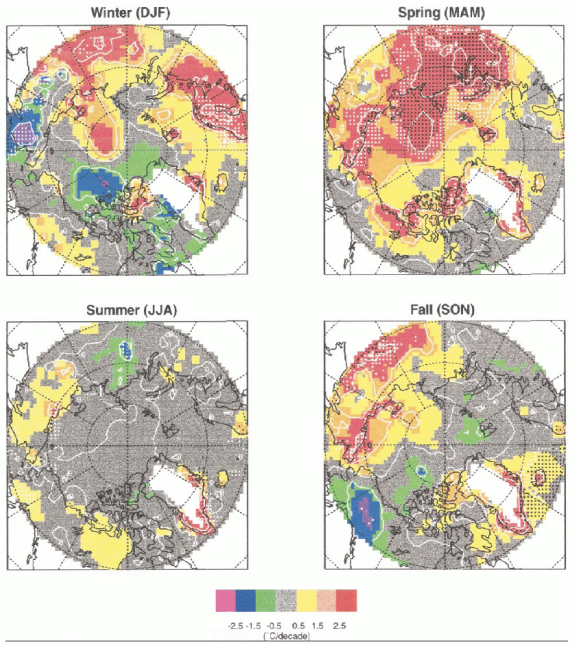


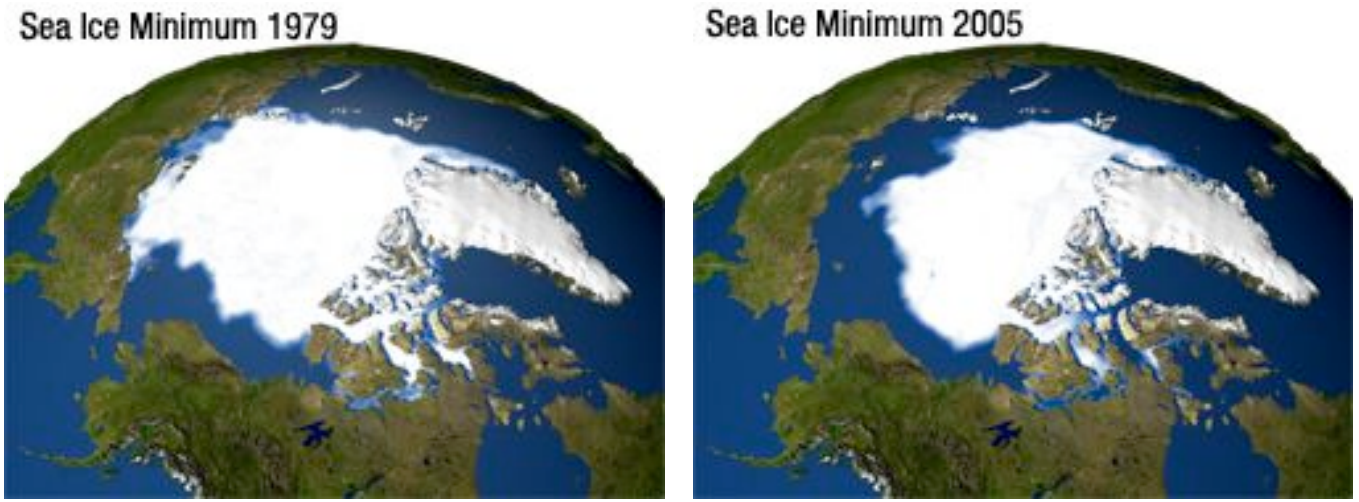
FIG. 9. Seasonal trends in SAT from IABP/POLES dataset for 1979–97.

AVHRR all-sky (APP-x)
(1982-2004)
Liu et al. (2008)

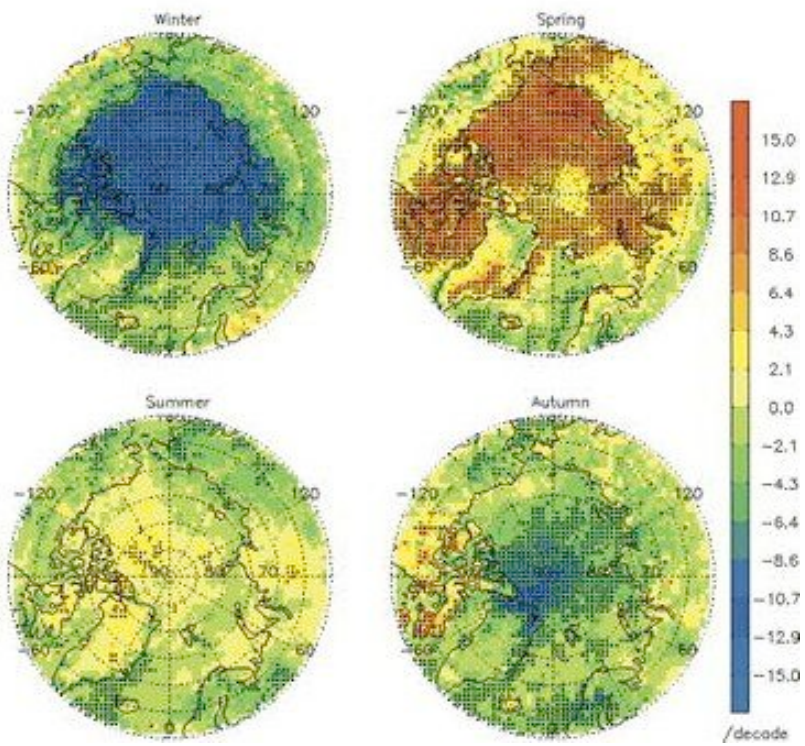
AVHRR clear-sky
(1981-2001)
Comiso (2003)

IABP/POLES (1979-97)
Rigor et al. (2000)

Decreasing sea ice extent and sea ice concentration



Meanwhile cloud cover has been changing.



Seasonal cloud cover trends from AVHRR (1982-2004).

Mathematical analysis of the influence of changes in sea ice concentration and cloud cover on surface temperature trend

$$T = F(T_{clr}, T_{cld}, F_{cld})$$

$$\frac{dT}{dt} = A + B + C$$

$$A = (T_{cld} - T_{clr}) \cdot \frac{dF_{cld}}{dt}$$

A: cloud effect

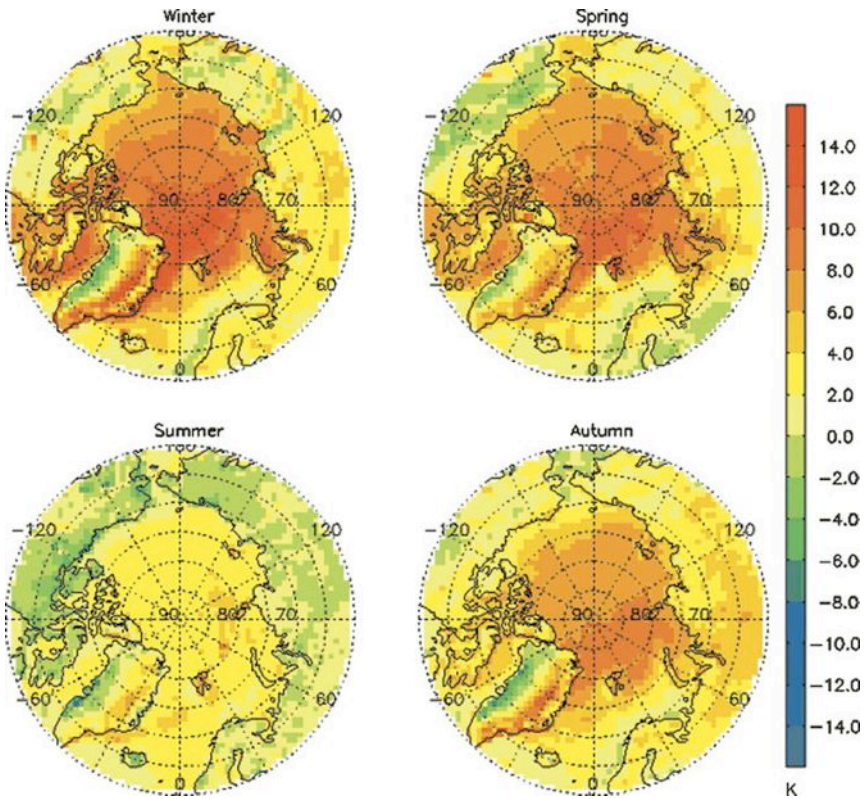
$$B = F_{clr} \cdot (T_{clr\_ice} - T_{clr\_water}) \cdot \frac{dF_{ice}}{dt} + F_{cld} \cdot (T_{cld\_ice} - T_{cld\_water}) \cdot \frac{dF_{ice}}{dt}$$

B: sea ice effect

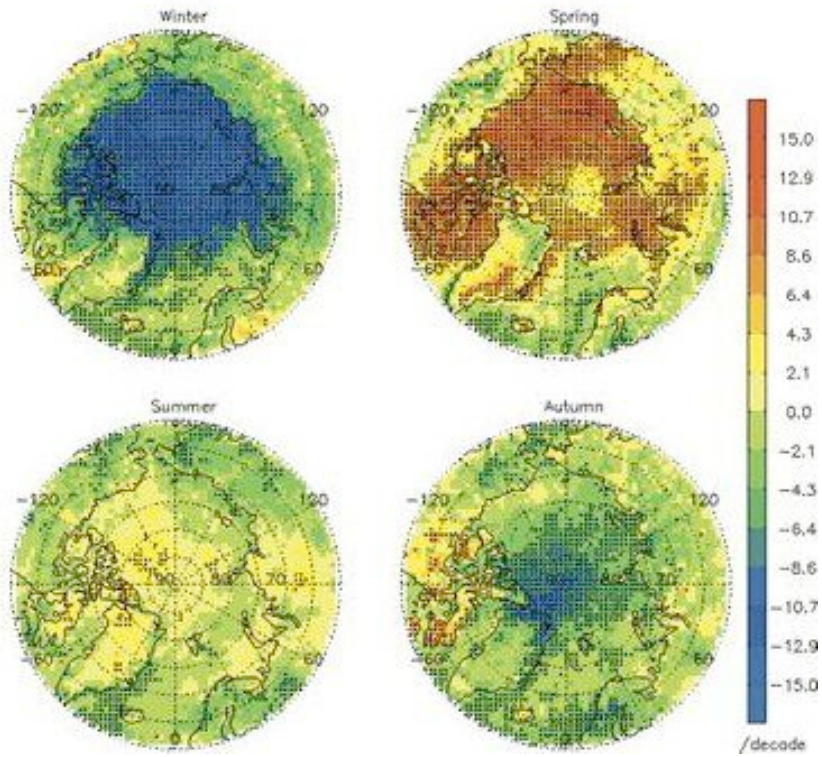
$$C = F_{clr} \cdot \left[F_{clr\_water} \cdot \frac{dT_{clr\_water}}{dt} + F_{clr\_ice} \cdot \frac{dT_{clr\_ice}}{dt} \right] + F_{cld} \cdot \left[F_{cld\_water} \cdot \frac{dT_{cld\_water}}{dt} + F_{cld\_ice} \cdot \frac{dT_{cld\_ice}}{dt} \right]$$

Calculating the influence of changes in cloud cover on the surface temperature trend

$$A = (T_{cld} - T_{clr}) \cdot \frac{dF_{cld}}{dt}$$



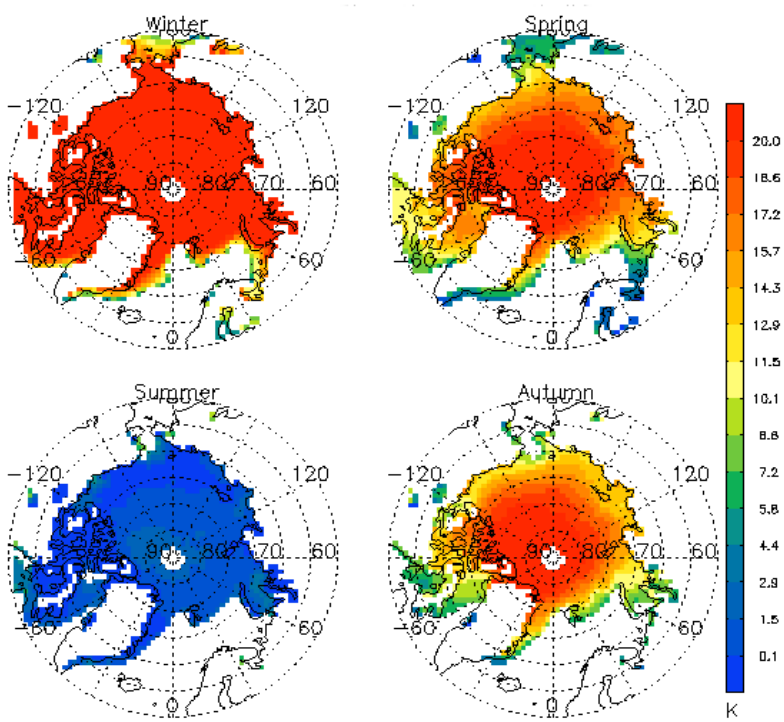
The difference between the seasonal mean surface temperature (K) under cloudy and cloud-free conditions.



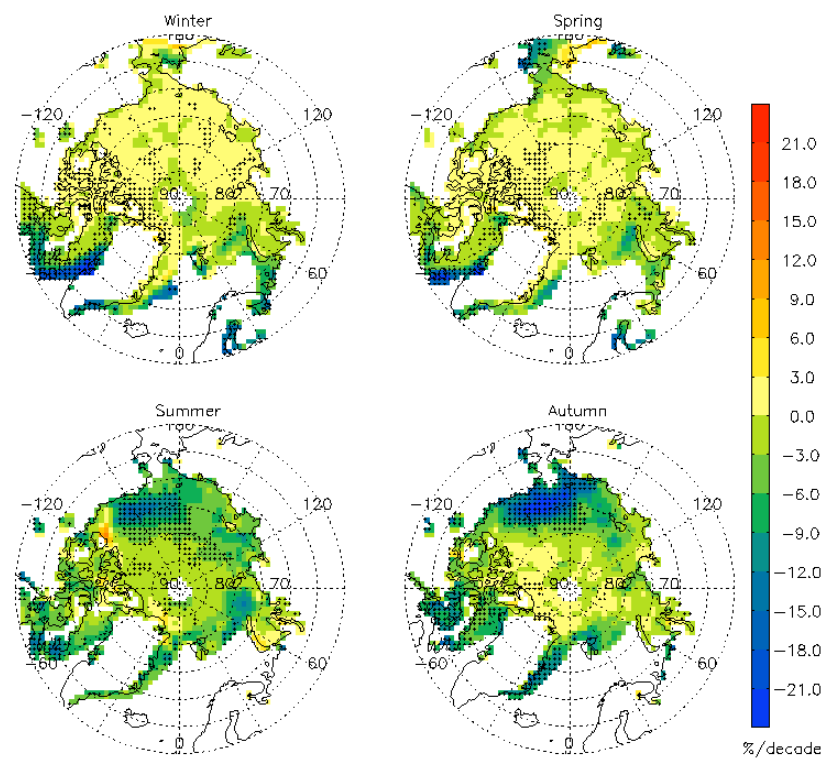
Seasonal cloud cover trends from 1982 to 2004.

Calculating influence of changes in sea ice concentration on the surface temperature trend

$$B = F_{clr} \cdot (T_{clr\_ice} - T_{clr\_water}) \cdot \frac{dF_{ice}}{dt} + F_{cld} \cdot (T_{cld\_ice} - T_{cld\_water}) \cdot \frac{dF_{ice}}{dt}$$

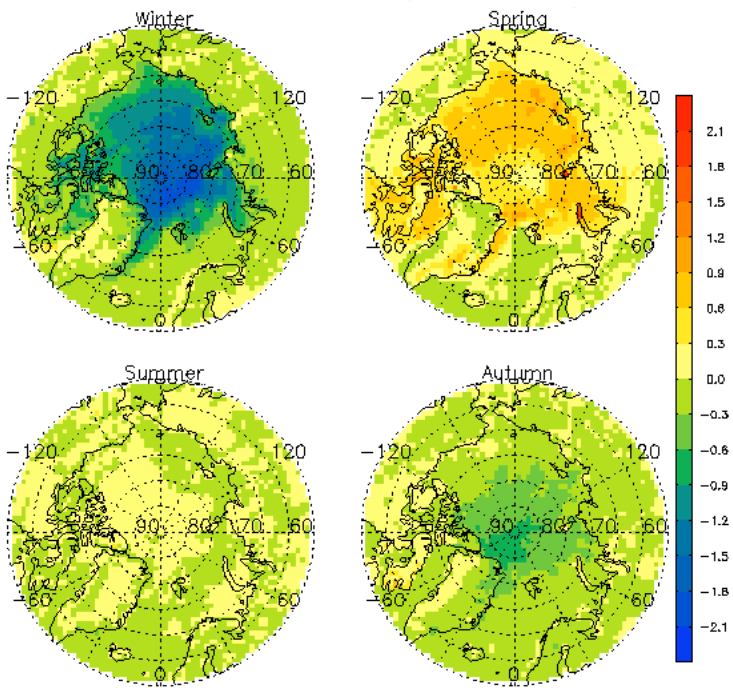


Difference of seasonal mean surface temperature over water and over ice under clear conditions (K).

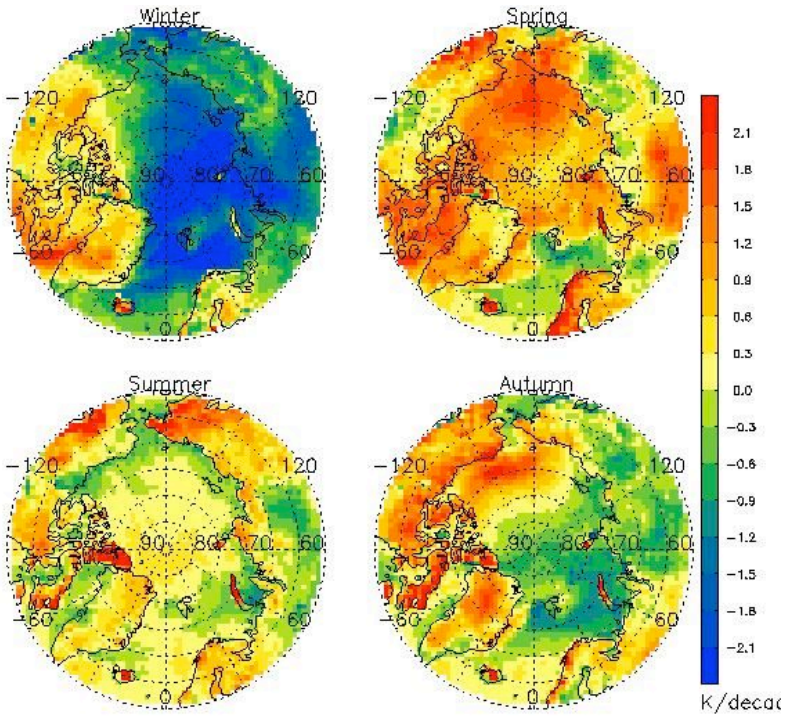


Seasonal mean sea ice concentration trends from 1982 to 2004.

Influence of changes in cloud cover on the surface temperature trend



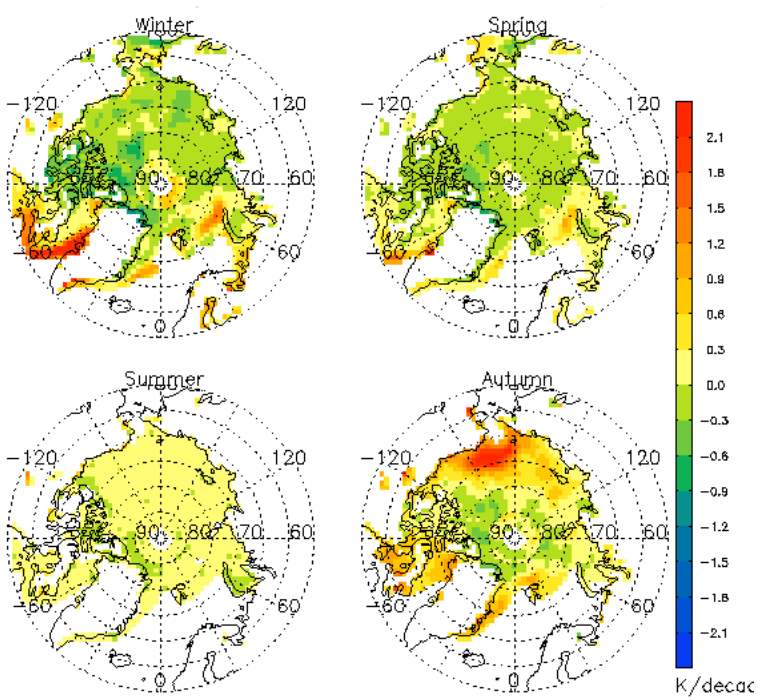
Surface temperature trends introduced by cloud amount changes (unit: K/decade).



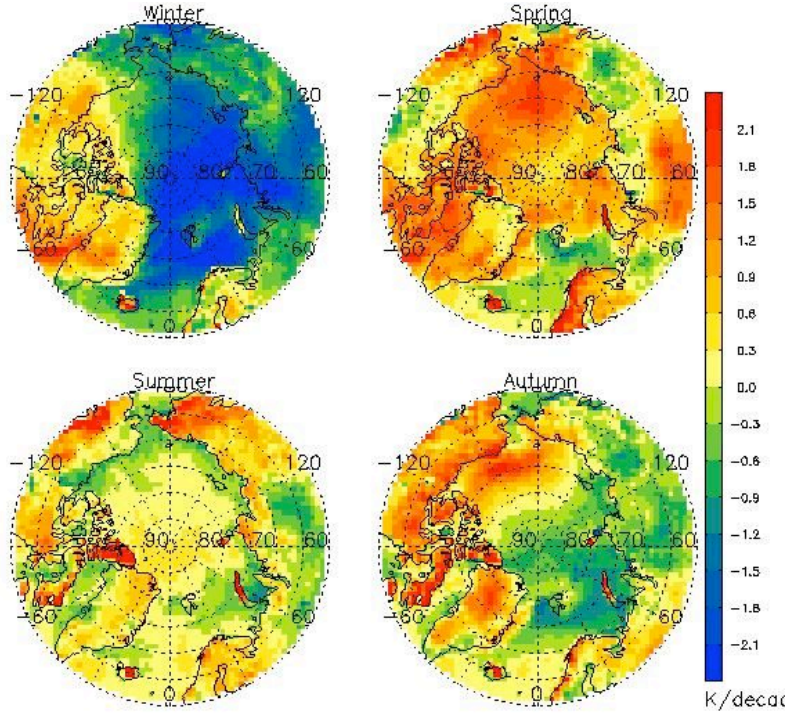
Surface temperature trends (unit: K/decade).

In winter, this trend explains -0.91 out of -1.2 K decade^{-1} of the cooling. In spring, this trend accounts for 0.55 K decade^{-1} of the total 1.0 K decade^{-1} warming.

Influence of changes in sea ice concentration on the surface temperature trend



Surface temperature trends introduced by sea ice concentration changes (unit: K/decade).



Surface temperature trends (unit: K/decade).

Surface warming due to changes in sea ice, over 0.9 K decade^{-1}, is over the Chukchi and Beaufort Seas in autumn, accounting for most of the total 1.1 K decade^{-1} warming trend.

In summary, changes in sea ice extent/concentration and cloud cover played major roles in the magnitude of recent Arctic surface temperature trends.

Cloud effect

•cooling trend in winter; warming trend in spring

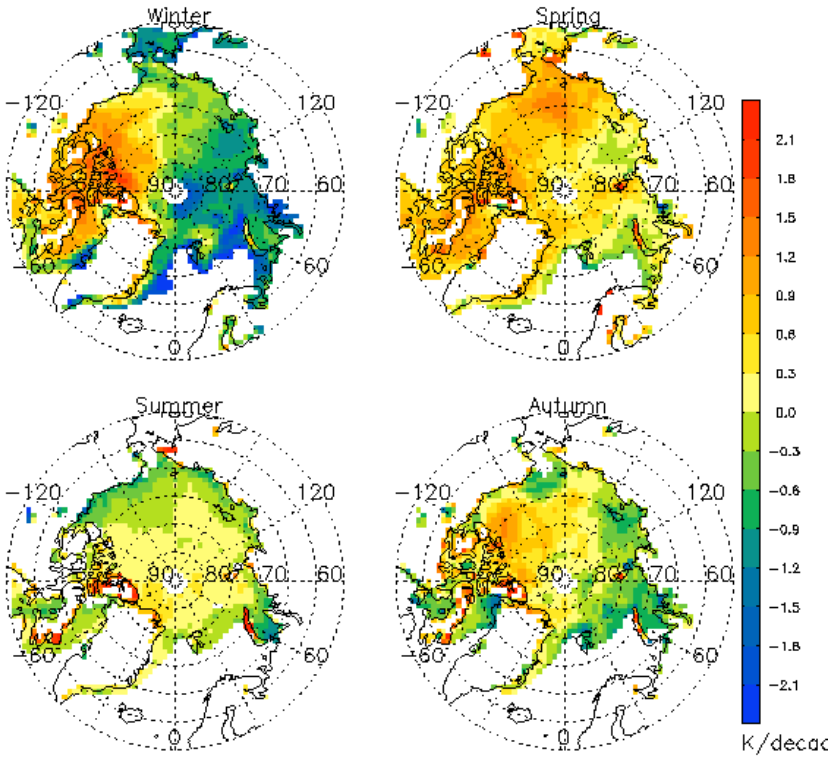
Sea ice concentration effect

•warming in autumn

Challenges and Opportunities:

1.How to explain the residual trends? What are the other parameters contributing to this residual trend?

2.Extending this analysis method to other data set and studies.



Residual trends as difference of total trends and trends introduced by changes in cloud amount and sea ice concentration.