Climate changes at polar latitudes

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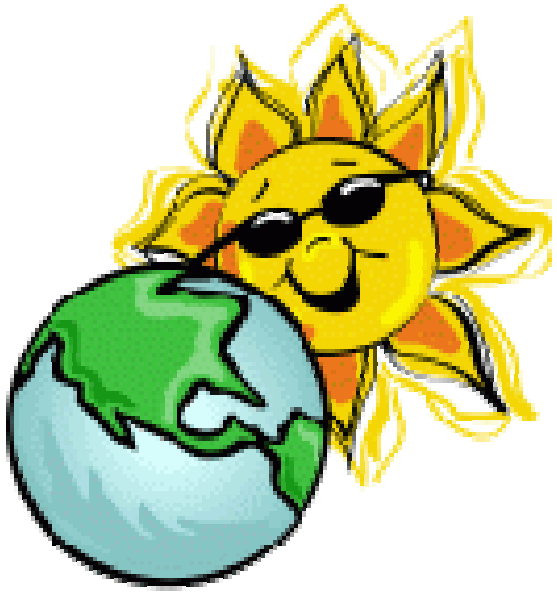

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Introduction

Since the mid-sixties, the Arctic is warmed by 1-2℃ and extended land areas even up to 4-5℃. At the same time the sea ice extent decreases by 15%. On the other hand in the East Antarctic rather a cooling is registered. Only the Antarctic Peninsula shows increasing temperatures. In the sea ice extension in the Antarctic not significant trend is observed. The reason for the differences of the Arctic and Antarctic warming are not very clear. The main explanation of the stronger Arctic warming is the ice albedo feedback.

Main goal and data used

Here the climate change impacts are studied.

Arctic and Antarctic temperature anomalies are used from GISS data

- http://data.giss.nasa.gov/gistemp/tabledata_v3/ZonAnn.Ts+dSST.txt

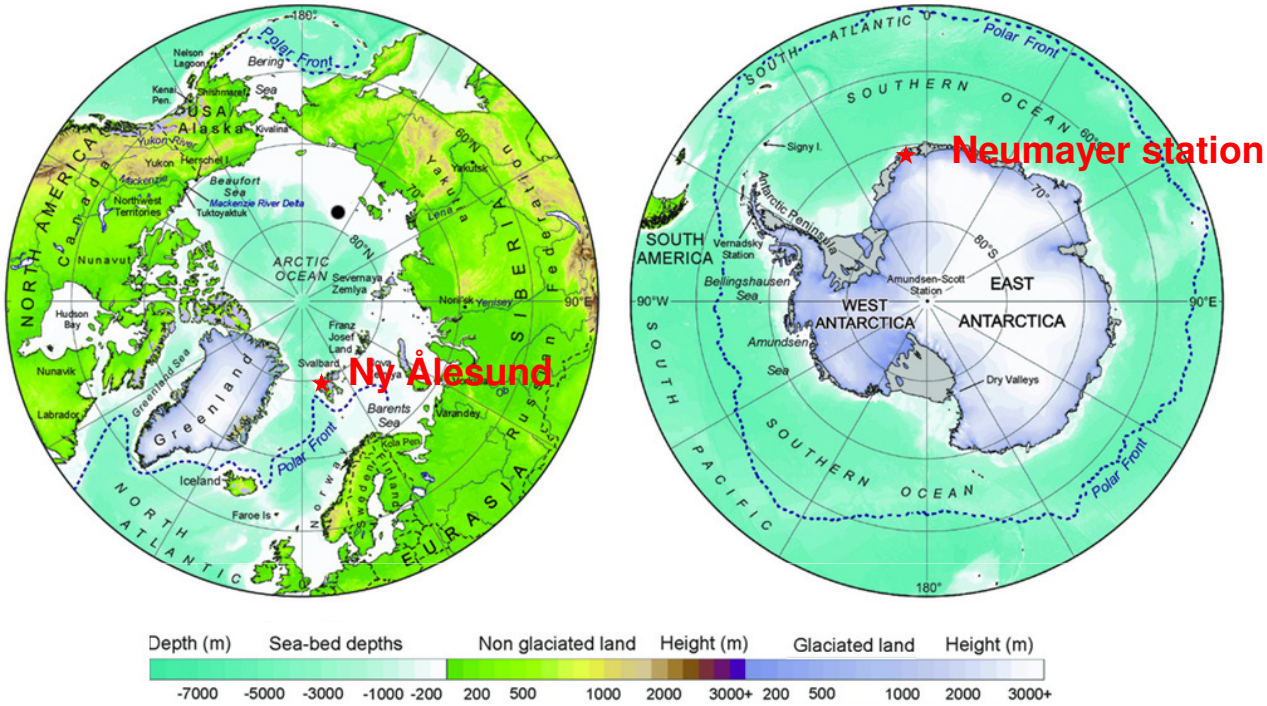
Ozone sonde data from Ny Alesund, a representative Arctic station, and from the Antarctic Neumayer station are used.

- http://www.ndsc.ncep.noaa.gov/)

The long-time temperature variations are determined by means of the concentration of carbon dioxide (CO2) in the atmosphere and the Atlantic multidecadal oscillation (AMO)

- ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_annmean_mlo.txt
- http://www.esrl.noaa.gov/psd/data/correlation/amon.us.long.data)

Arctic and Antarctic differences



Arctic

- is an ocean surrounded by land
- sea water exchange can be realized only via the European Northern Sea and the Bering strait

Antarctic

- in the Southern ocean the circum polar easterly current is dominant
- is a continent surrounded by southern parts of oceans

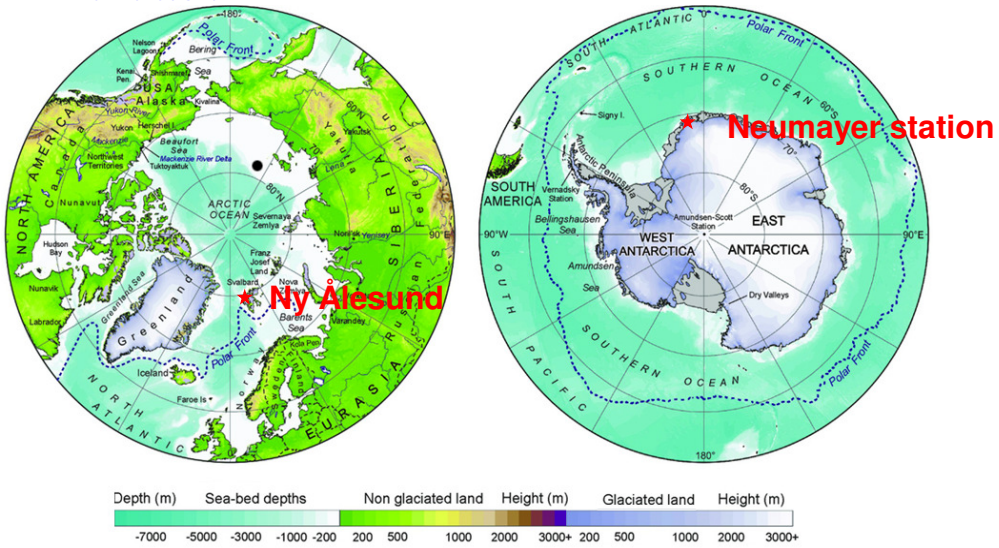
Arctic and Antarctic differences

Arctic

- is an ocean surrounded by land
- sea water exchange can be realized only via the European Northern Sea and the Bering strait
- High mountains are located in Alaska (Rocky mountains peak up to 6000 m) and in Scandinavia (up to 2000 m)
- A part of the Arctic ocean is ice covered all-the-year, the remaining part is thawing during the warm season.
- ice extension in general decreases since its first observation in 1979

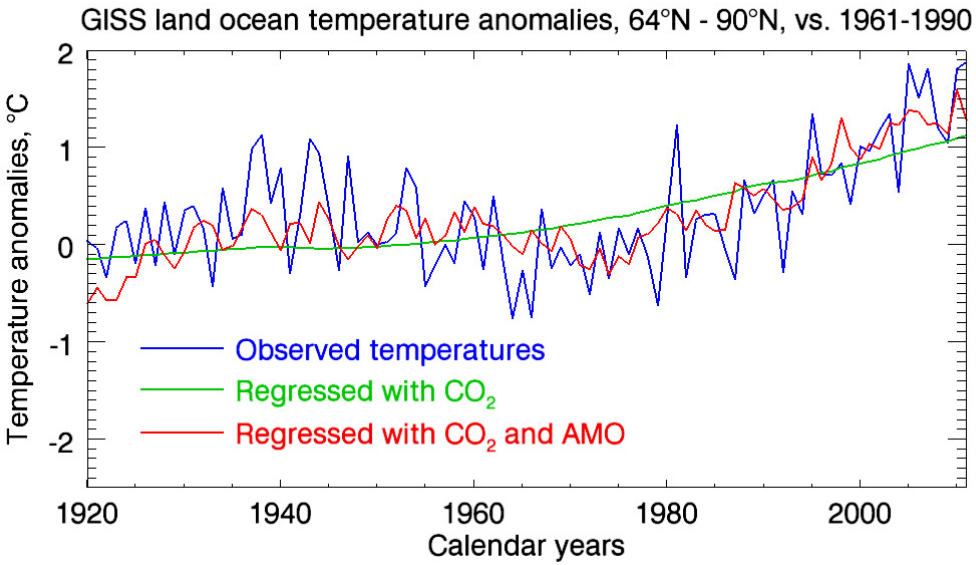
Antarctica

- land surface of approximately 13.2 Mill. km^2 is covered all year with ice
- the Transarctic mountains (up to 4600m) separates the Antarctic in a West and a East part
- ice sheets are up to 3000 m thick in the East Antarctic
- sea ice does not decrease or shows increase.



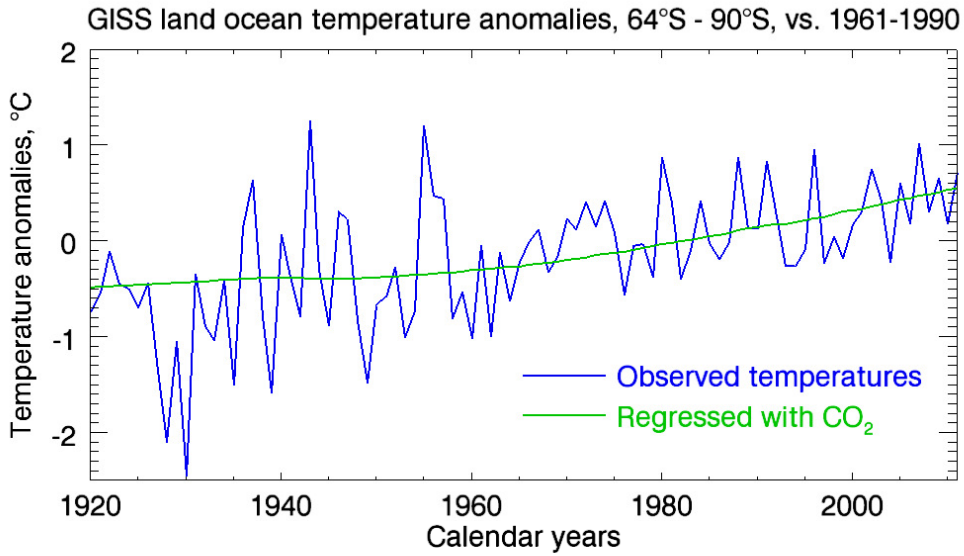
Climate change impacts

It is widely accepted, that the warming over the Arctic land is mainly a result of the sea ice/snow albedo-temperature feedback loop. That means, by reducing of the ice/snow land coverage the albedo deincrease and solar short wavelengths irradiation is more absorbed warming the surface. In the present study a very strong Atlantic multidecadal oscillation (AMO) is detected. Heat, coming from the tropics is transported to the Arctic by the Atlantic circulation. AMO significantly modulates the temperature anomalies in the Arctic. In contrast the Antarctic circum polar current prevents the inflow of warm tropical water (e.g. from the Pacific) to the high latitudes. In the Arctic the long time trend is determined only by changes of the CO_2 (and feedbacks mechanisms). The temperature increase is about 1.2°C since 1920 corresponding to 0.11°C per decade.



Comparison of the observed Arctic temperature anomalies with the modeled ones by linear regression with predictors (CO_2 and AMO) describing long time variations.

Climate change impacts

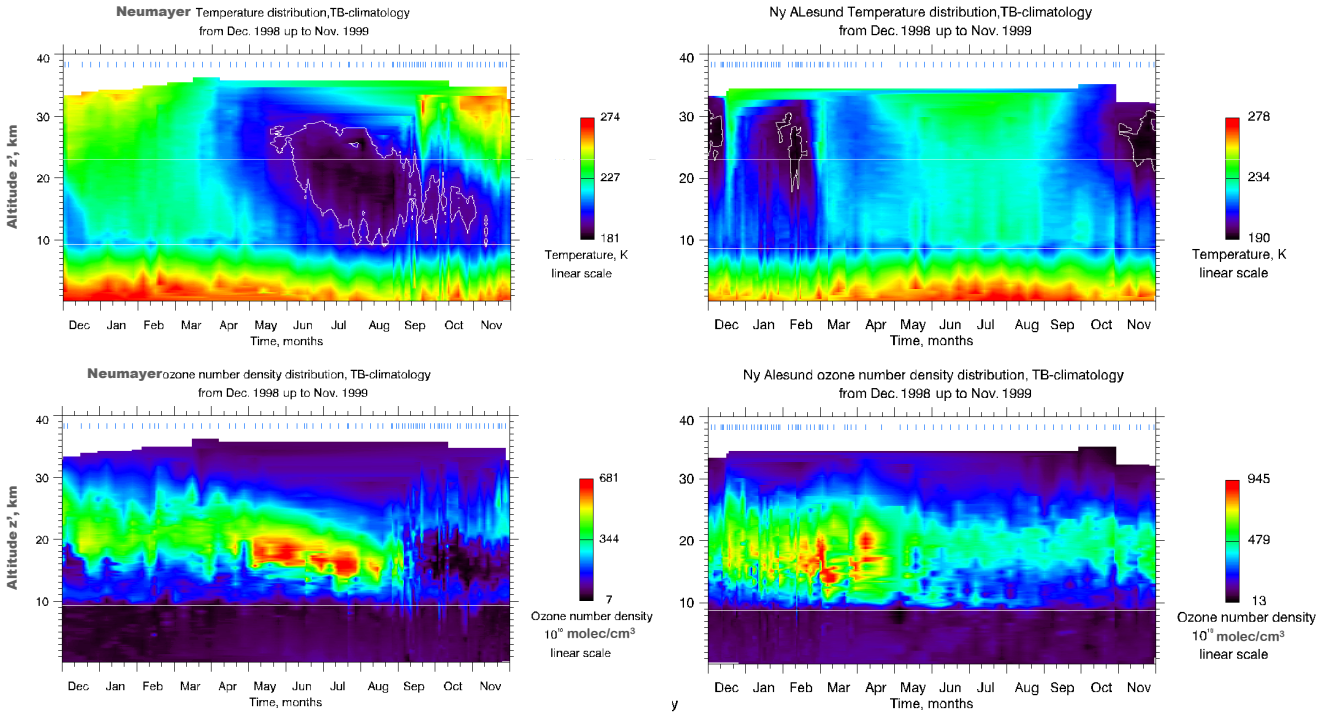


Comparison of the observed Antarctic temperature anomalies with the modeled ones by linear regression with CO_2 as predictor describing long time variations. The time series of the temperature development is not stationary. The variance after 1957, when observations in Antarctic was began, are clearly smaller than before.

In the Antarctic, here the region from 64°S to 90°S (a greater region than the continent Antarctica) not AMO influence was detected. However the temperature increase follows the development of the CO_2 amount as was observed also for the Arctic region 64°N to 90°N. The temperature increases by 1°C, approximately the same value as observed in the Arctic. The difference of the temperature development is likely caused by the different land-ocean distribution.

Climate change impacts

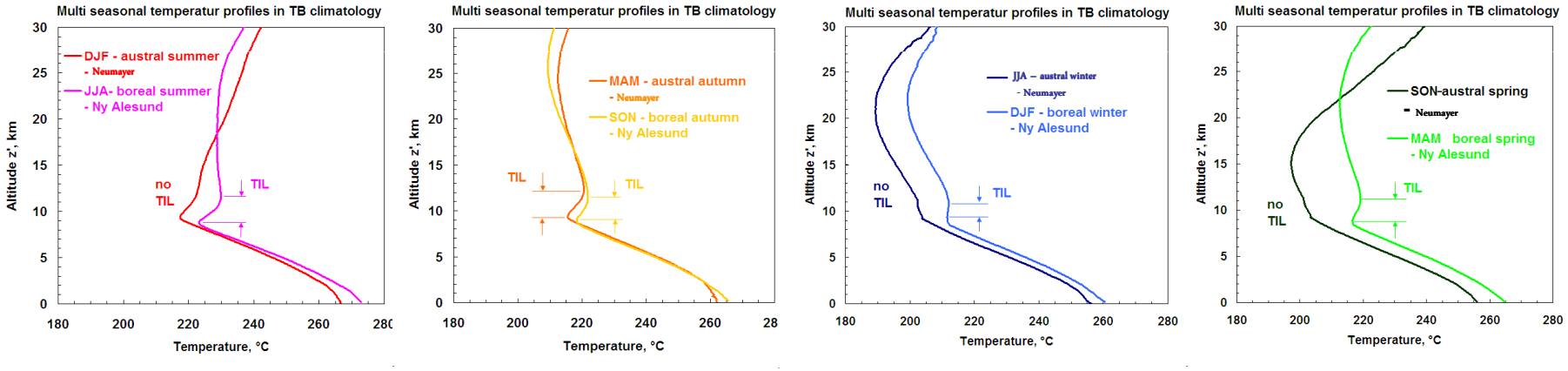
The uniform Antarctic land distribution allows the development of a strong polar vortex almost undisturbed by waves with the beginnig of the polar night by adiabatic cooling of descendent airmasses in the inner vortex. The vortex in the Antarctic is stable longer than in the Arctic and lower Antarctic temperatures enable the formation of polar stratospheric clouds of different types (Compare the fig. a and b below) generating strong ozone holes in spring. In the Arctic ozone content is



Temperature (top row) and ozone (bottom row) distribution at the Neumayer Antarctic (left column) and the Ny Ålesund Arctic (right column) station shown in tropopause-based (TB) climatology.

Climate change impacts

In the Arctic ozone content is reduced mainly in the layer up to approximately 16 km. By decreasing of the ozone content near the tropopause and by dynamic processes an inversion layer just above the tropopause is built up. In the Antarctic in the multiseasonal mean TIL is observed only in austral autumn but in the Arctic - in all seasons. Therefore the troposphere in the Arctic is more stable and isolated from the stratosphere and climate change warming processes are strongly restricted to the troposphere. In the Antarctic the cooling by descending air masses can influence the troposphere during winter/spring seasons.



Multiseasonal (1994-2004) temperature profiles measured at Neumayer station (Antarctic) in comparison with the ones of Ny Alesund station (Arctic) in TB climatology.

Conclusions

- A strongly significant AMO influence on the Arctic climate is found.
- In opposite no significant AMO signal is found in the Antarctic temperature anomalies.
- In the Arctic TIL is observed in all seasons, in the Antarctic only in autumn. The Arctic stratosphere is strong delimited from the troposphere. In the Antarctic the cooling by descending air masses can influence the troposphere during winter/spring seasons.
- In the Arctic the troposphere and stratosphere are more stable and isolated and climate warming processes are more restricted to the troposphere.
- The physical processes in the Antarctic are related to the very strong polar vortex.