

Arctic Change in the Flow of Global Warming

- Need for Long-term Monitoring Observations

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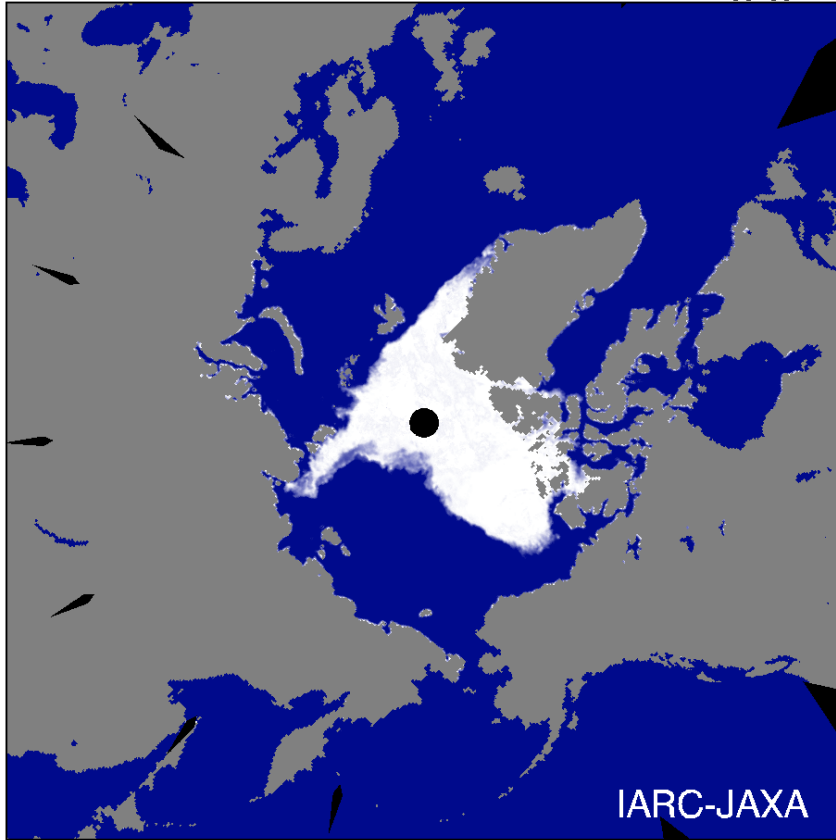


Ny-Alesund (79° N, 12° E), Svalbard

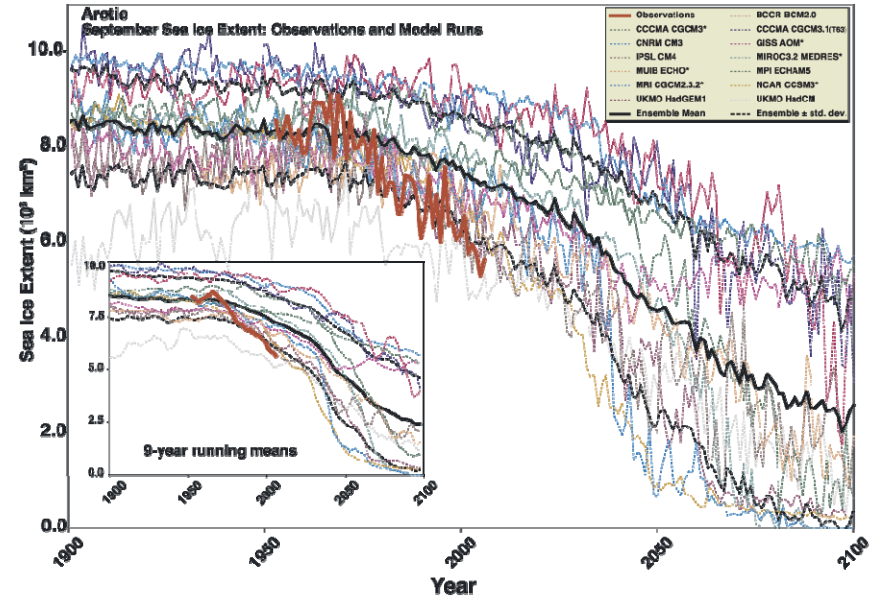
Arctic change

- abrupt decrease of sea ice extent

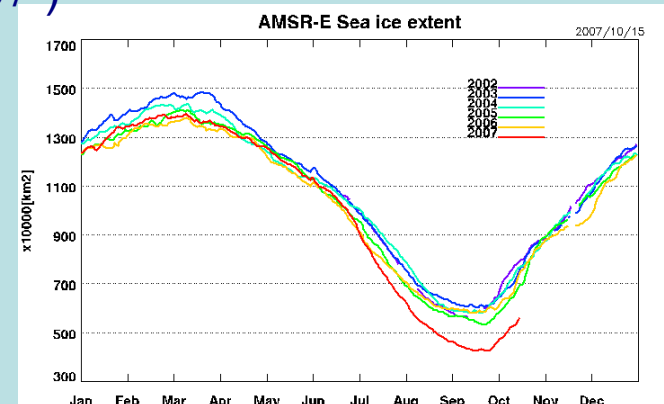
AMSR-E Sea Ice Concentration 20070924



Satellite observation of sea ice extent, 24 September 2007, minimum.

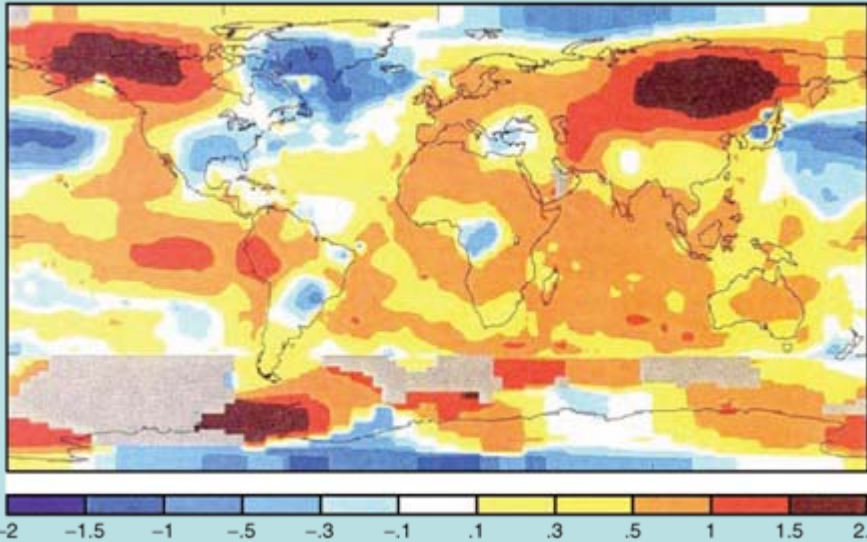


Climate model and observation (Stroeve et al., 2007)

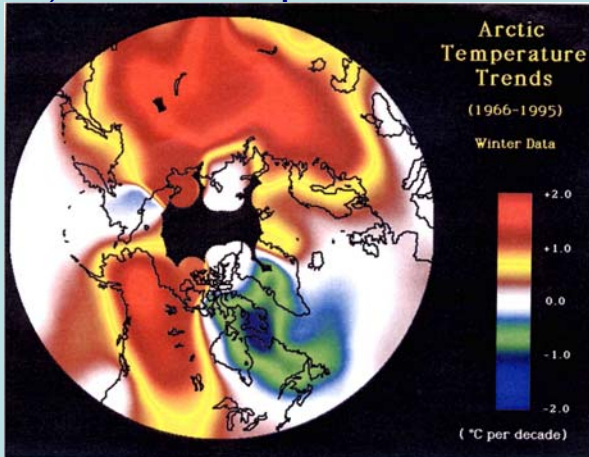


Sea ice area in the recent (IARC-JAXA)

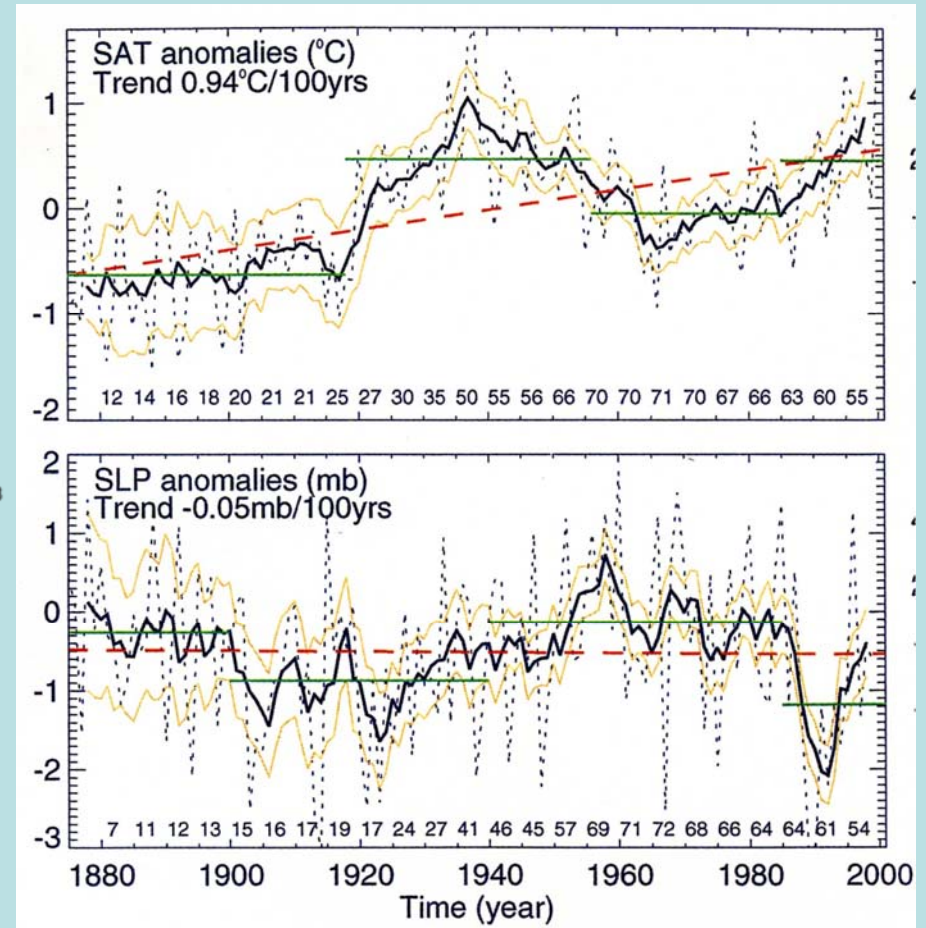
Arctic change - temperature rise



Annual surface temperature trends for 1950 to 1998 (Turner et al., 2007; after Hansen et al., 1999). “Polar amplification”



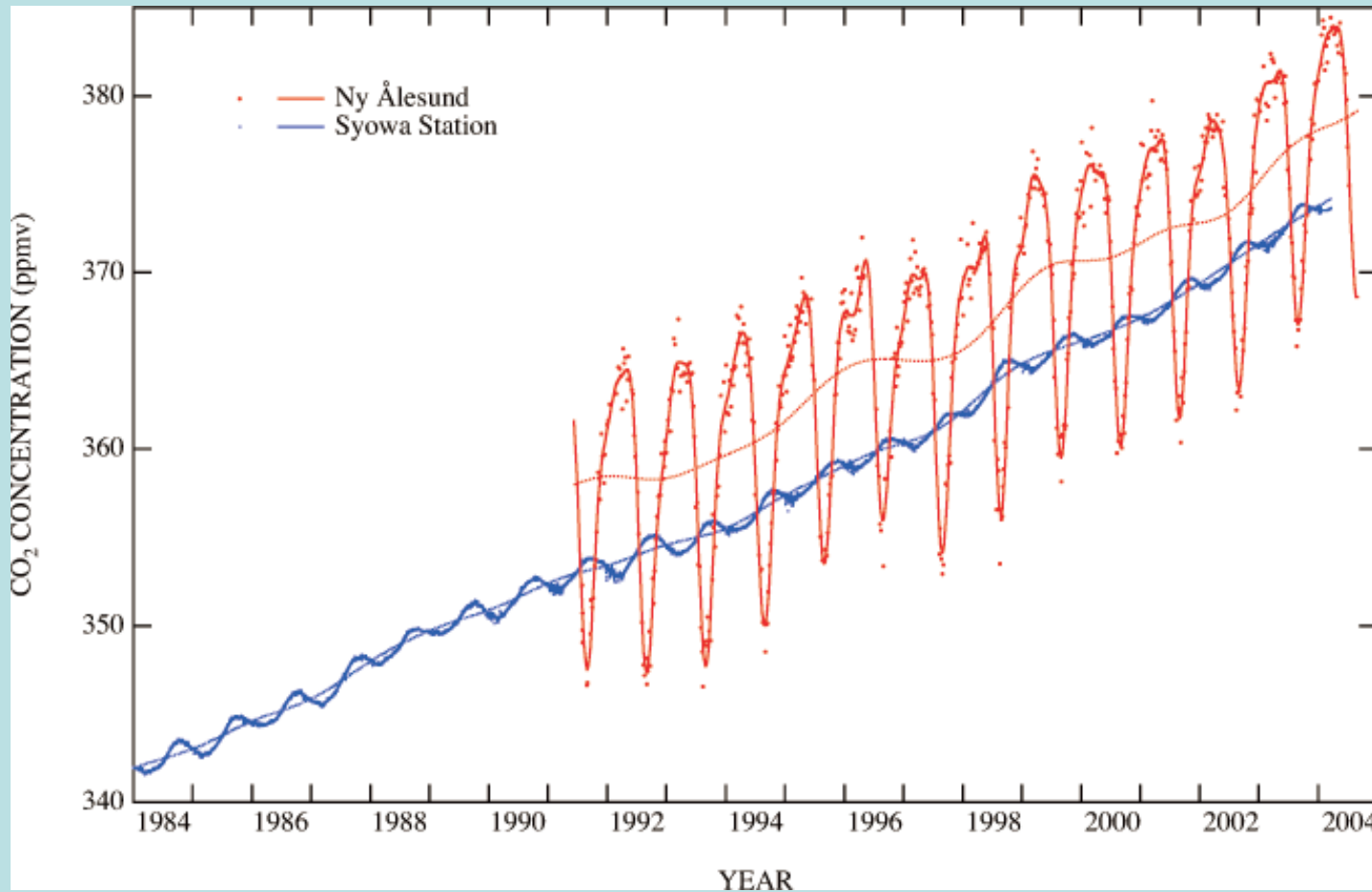
Distribution of Arctic temperature rise (Serreze et al., 2000)



Surface air temperature in the Arctic (Polyakov et al., 2003).

1920s - 40 warming and 1940 - 60 cooling!

CO₂ concentration in the Arctic and Antarctic



North-south
difference of
amplitude of
seasonal
variation

Annual increase
rate (~1.5 ppmv/
a)

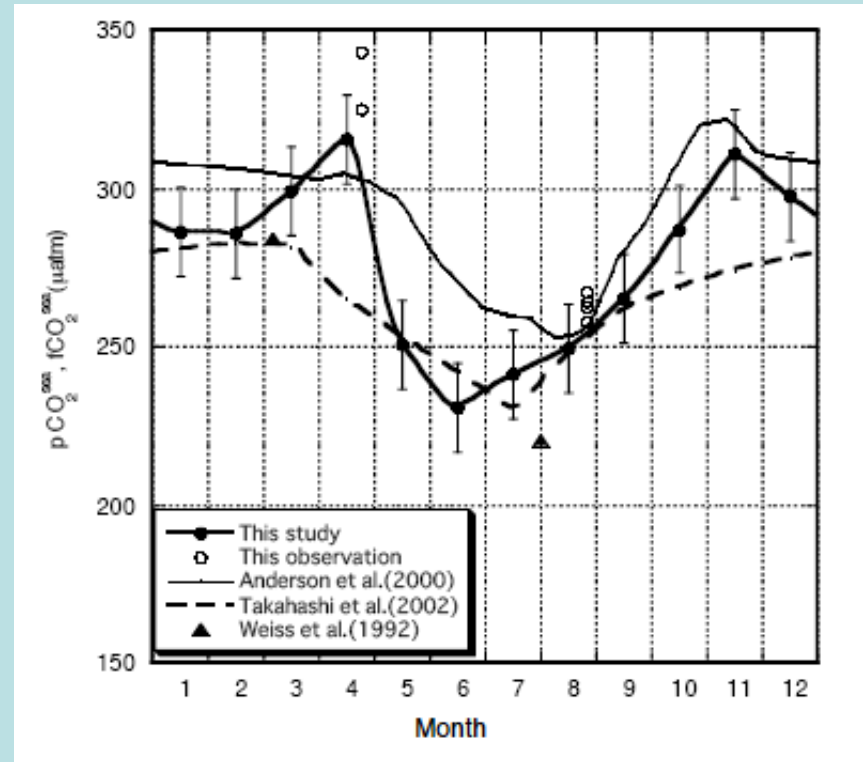
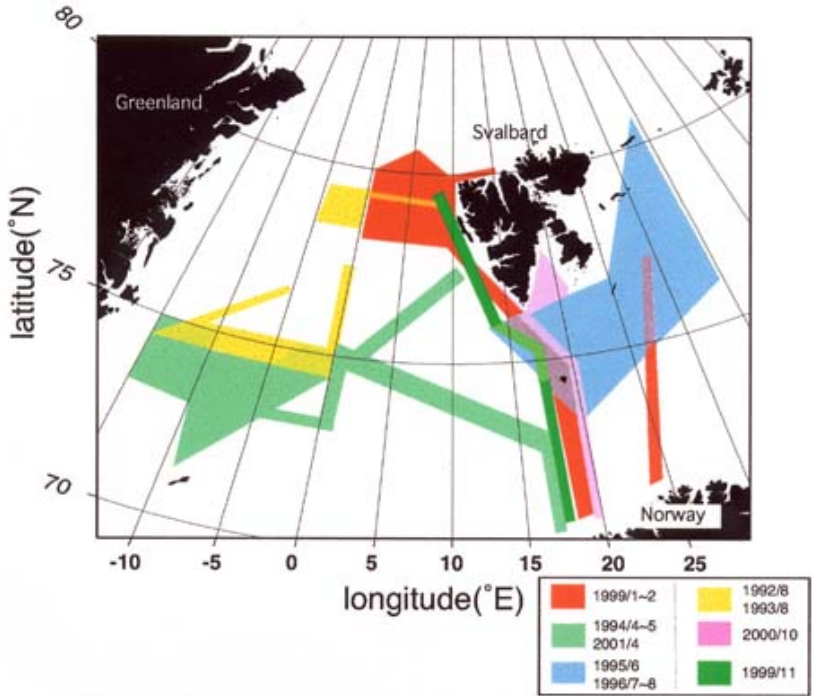
North-south
difference of
inter annual
variation

North-south
difference of
absolute amount

Comparison of CO₂ concentration at Ny-Ålesund, Svalbard (red) and Syowa, Antarctica (blue)

Partial pressure of CO₂ (pCO₂) of the surface waters in Greenland and Barents Seas

Area of shipborne observations(1992-2001) → $pCO_2 = a(t)*SST + b(t)$

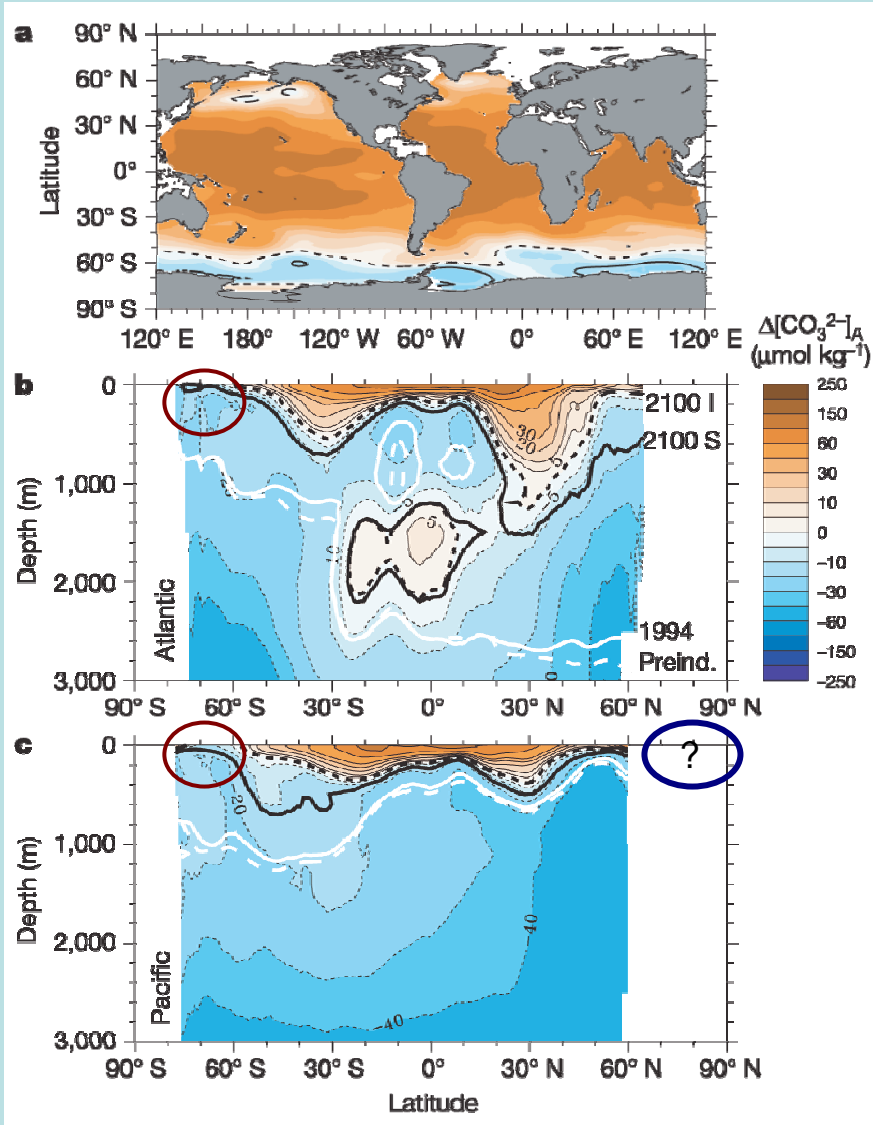


R/V Lance

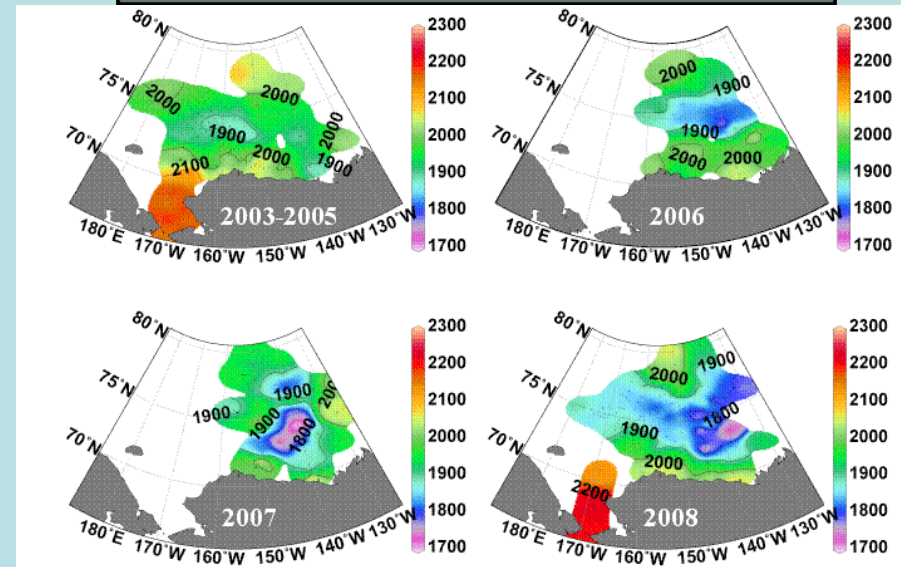
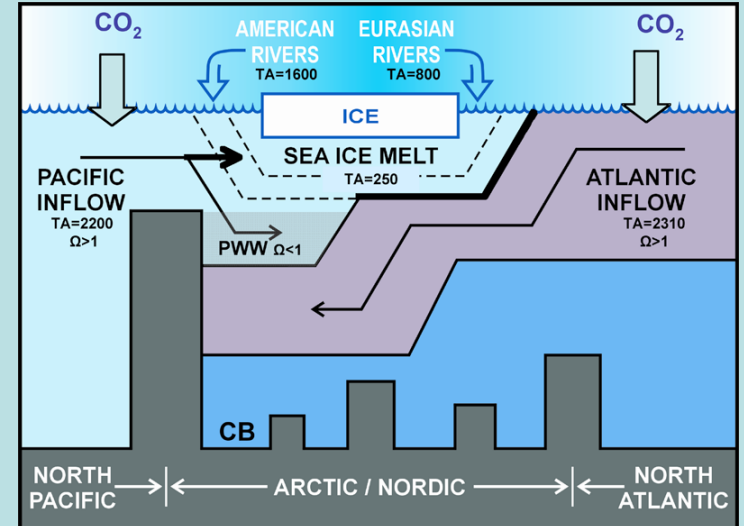


Seasonal variation of pCO₂ at the center of Greenland Sea (75°N, 0°E; thick line), Anderson et al. (2000; thin line) and Weiss et al. (1999; ▲). Sudden decrease in spring is noticeable (Nakaoka et al., 2006).

CO₂ increase to ocean acidification

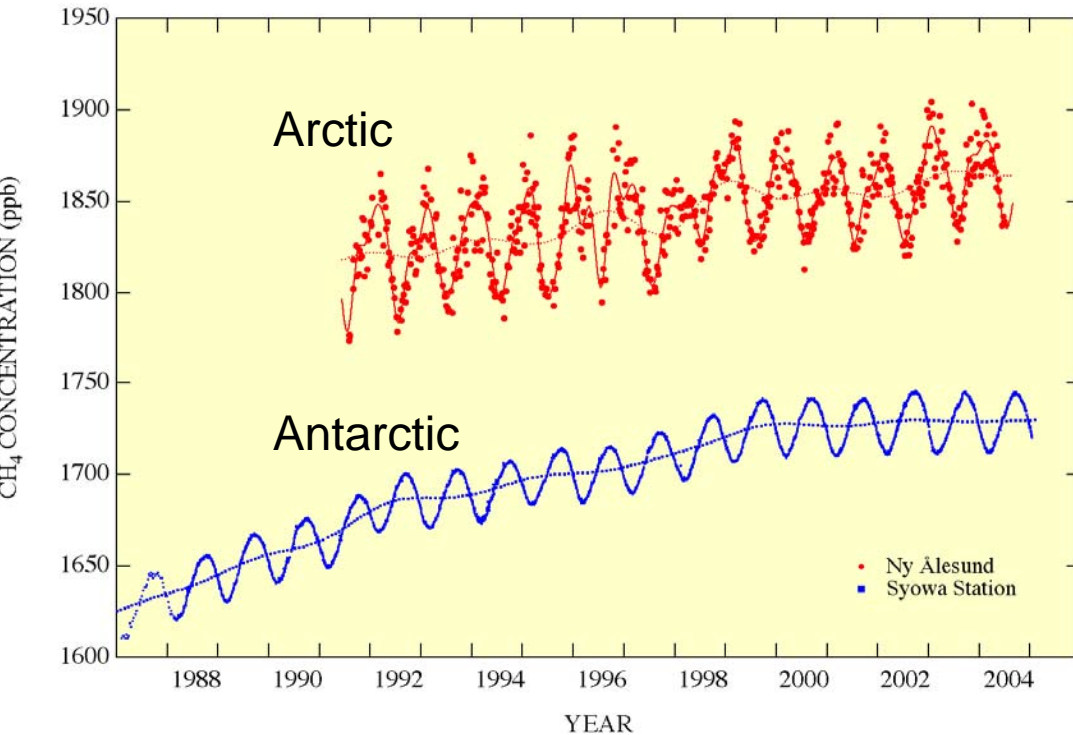


Saturation state in 2100 $\Delta[\text{CO}_3^{2-}]_A$
(Orr et al., 2005, Nature)



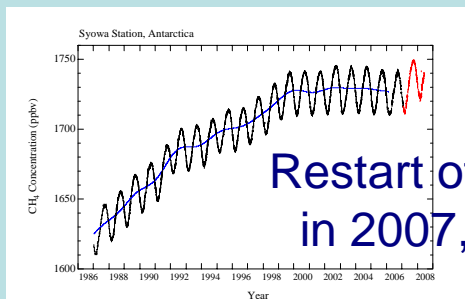
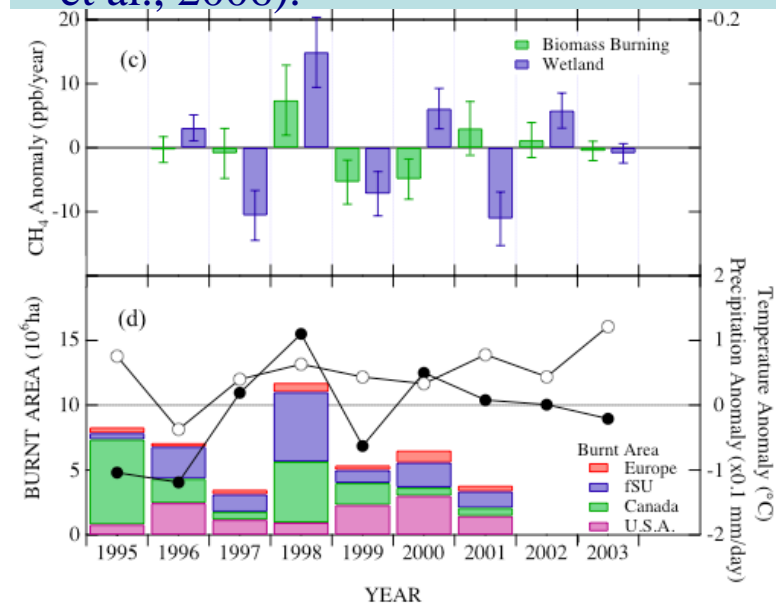
Total Alkalinity in surfaces waters of the
Canada Basin (Yamamoto-Kawai, 2009)

Methane (CH₄) concentration



Comparison of CH₄ concentration at Ny-Ålesund, Svalbard (red) and Syowa, Antarctica (blue).

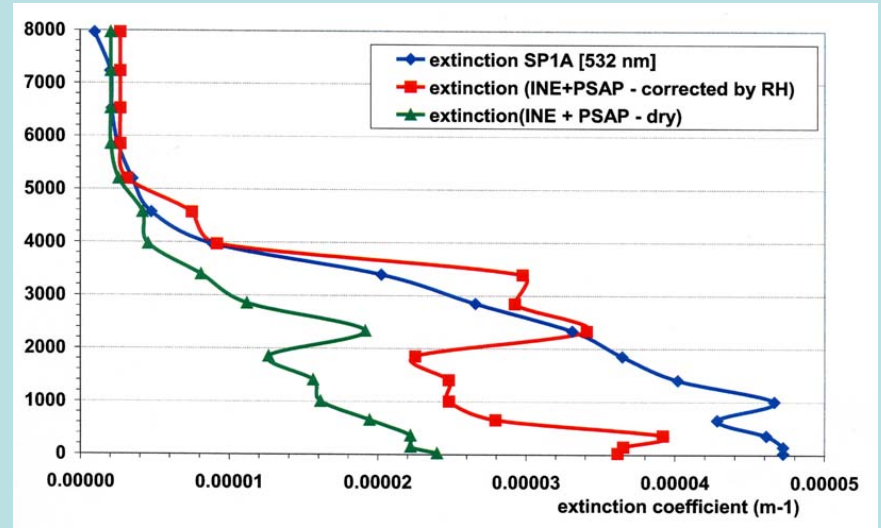
From measurements of CH₄ and $\delta^{13}\text{C}$ in the Arctic, sources of CH₄ are assumed. Contribution of **wetland** is affecting year to year variation of increase rate (Morimoto et al., 2006).



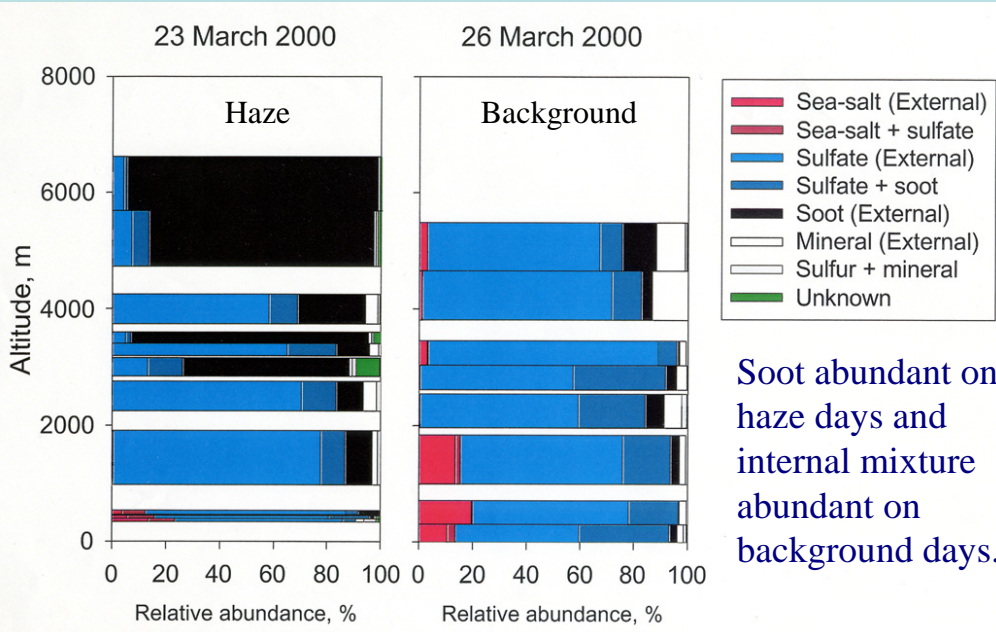
Arctic haze at ASTAR 2000 airborne observation



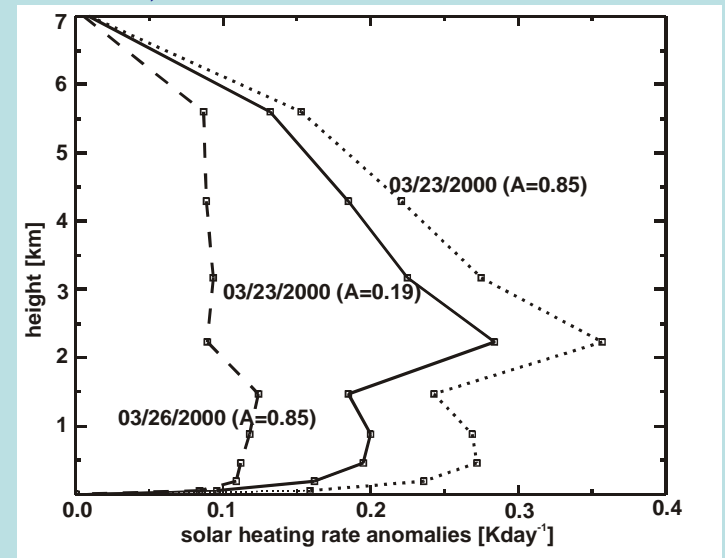
AWI Polar 4 (Dornier 228)



Extinction coefficient (sunphotometer, IN+PSAP); Arctic haze



Soot abundant on haze days and internal mixture abundant on background days.

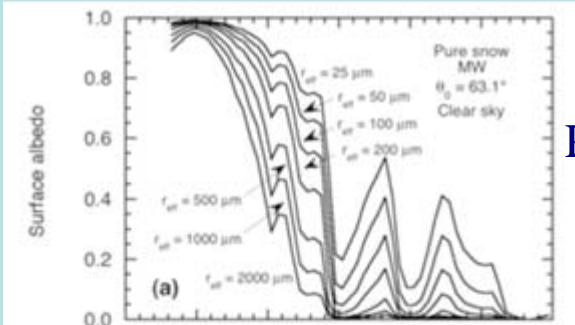


Radiative effect of Arctic haze (Treffeisen, 2005)

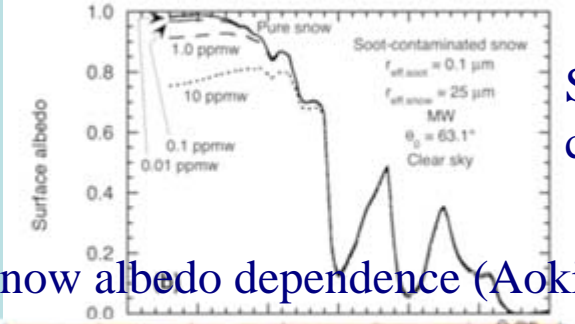
Chemical composition of particles

Amplification of aerosol radiative forcing

Snow albedo increase by black carbon

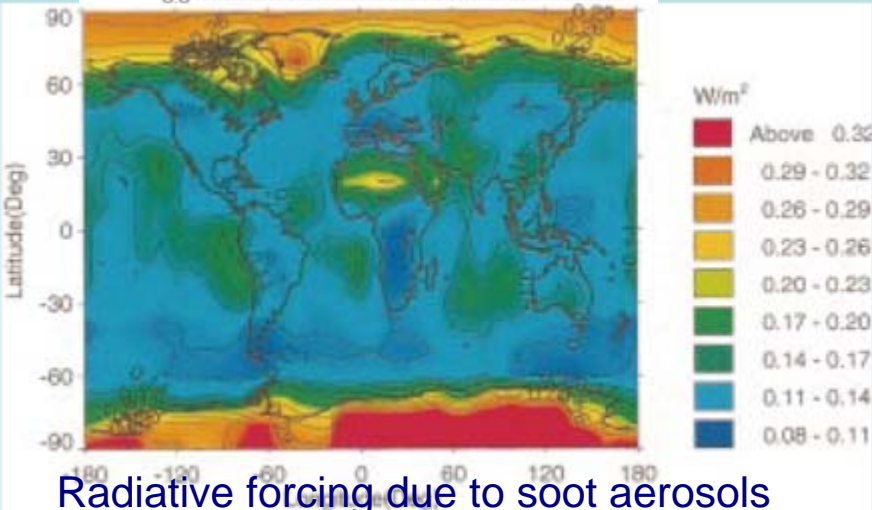


Particle size

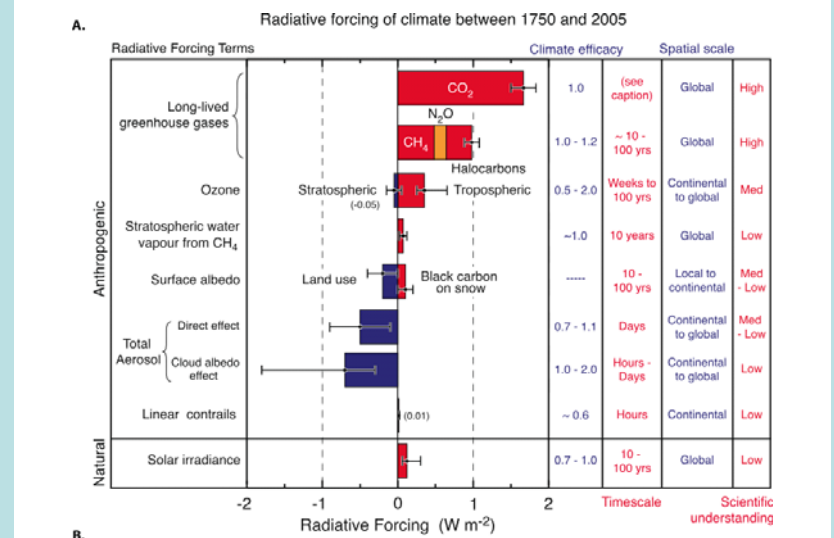


Soot contamination

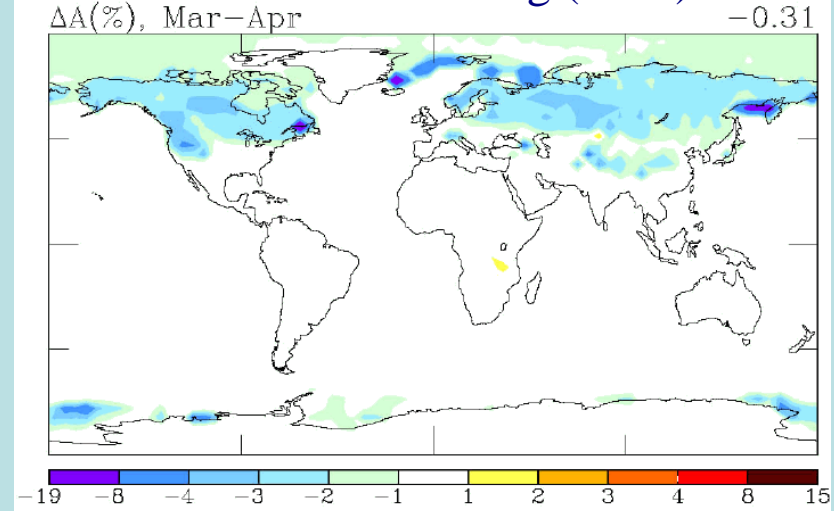
Snow albedo dependence (Aoki, 2007)



Radiative forcing due to soot aerosols (Myhre et al., 1998, Tellus)

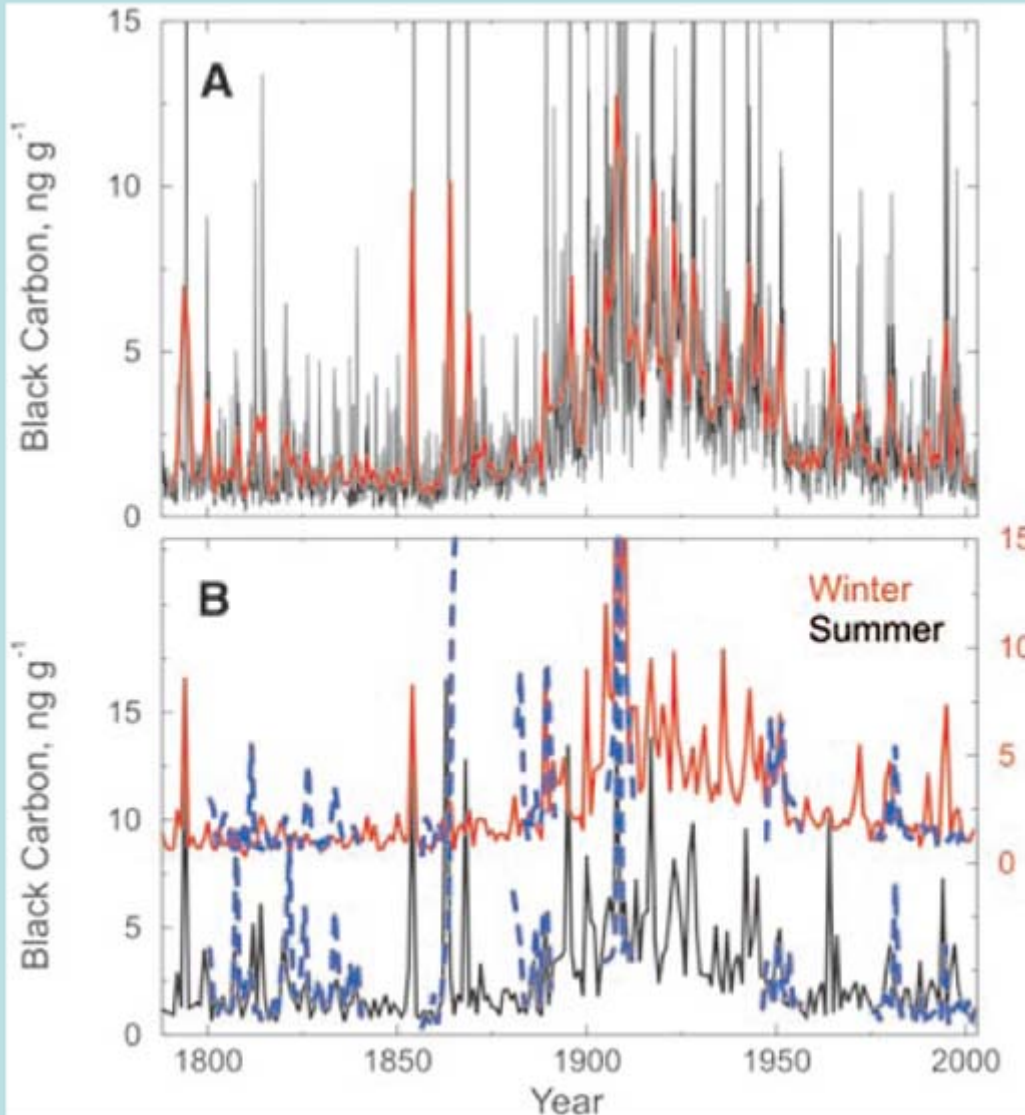


IPCC Radiative forcing (2007)



Surface albedo change (%) by BC 1880 - 2002 (Hansen et al., 2005, JGR)

Black carbon from Greenland ice core



Monthly (black) and annual (red) black carbon (BC) concentrations from 1788 through 2002 measured in the Greenland D4 ice core.

1920s increase!

Winter and summer BC concentrations show that long-term changes in BC were greater in winter (red) than in summer (black) during the late 19th and 20th centuries.

McConnell et al. (2007), *Sci.*

Early 20th C warming concentrated in high latitude: observation and model

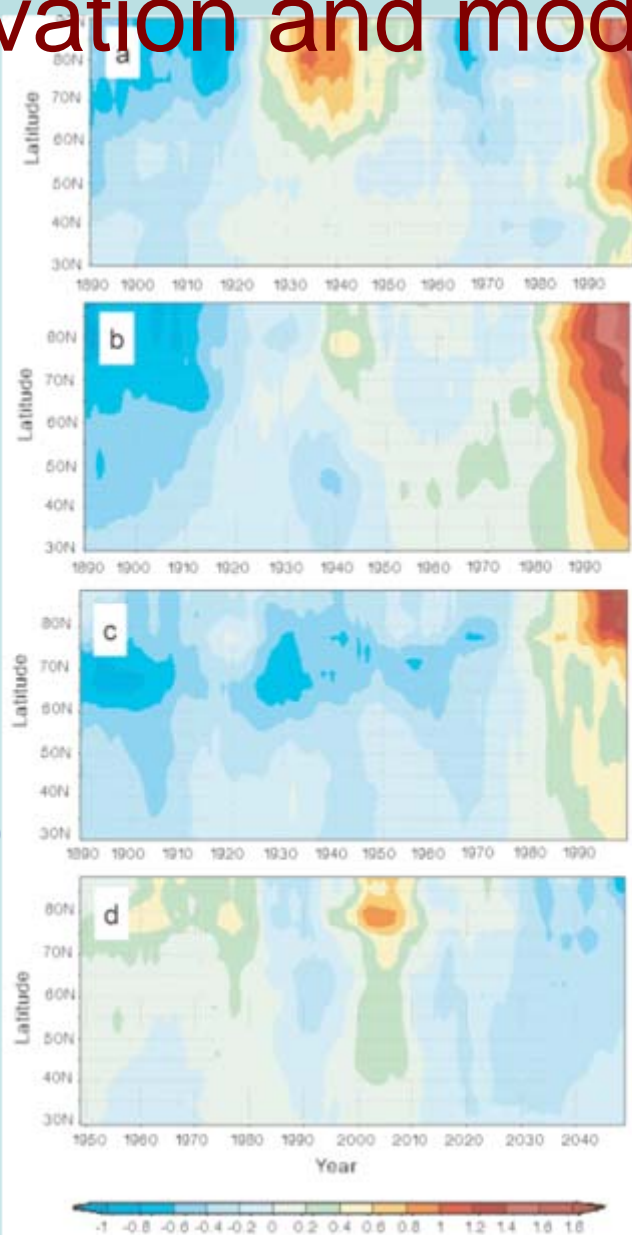
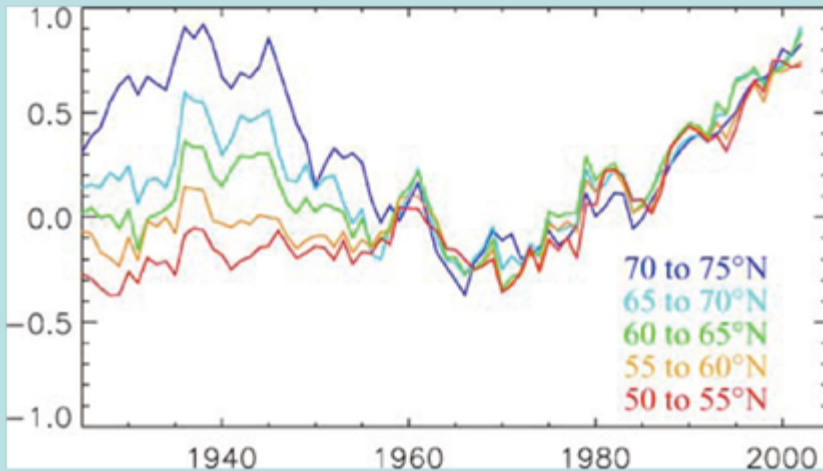
Obs. AARI data, Alekseev et al. (1999) + α

Modelled, GHGs only

Modelled, GHGs+sulfate aerosols

Modelled control run, variability

Johannessen et al. (2004)

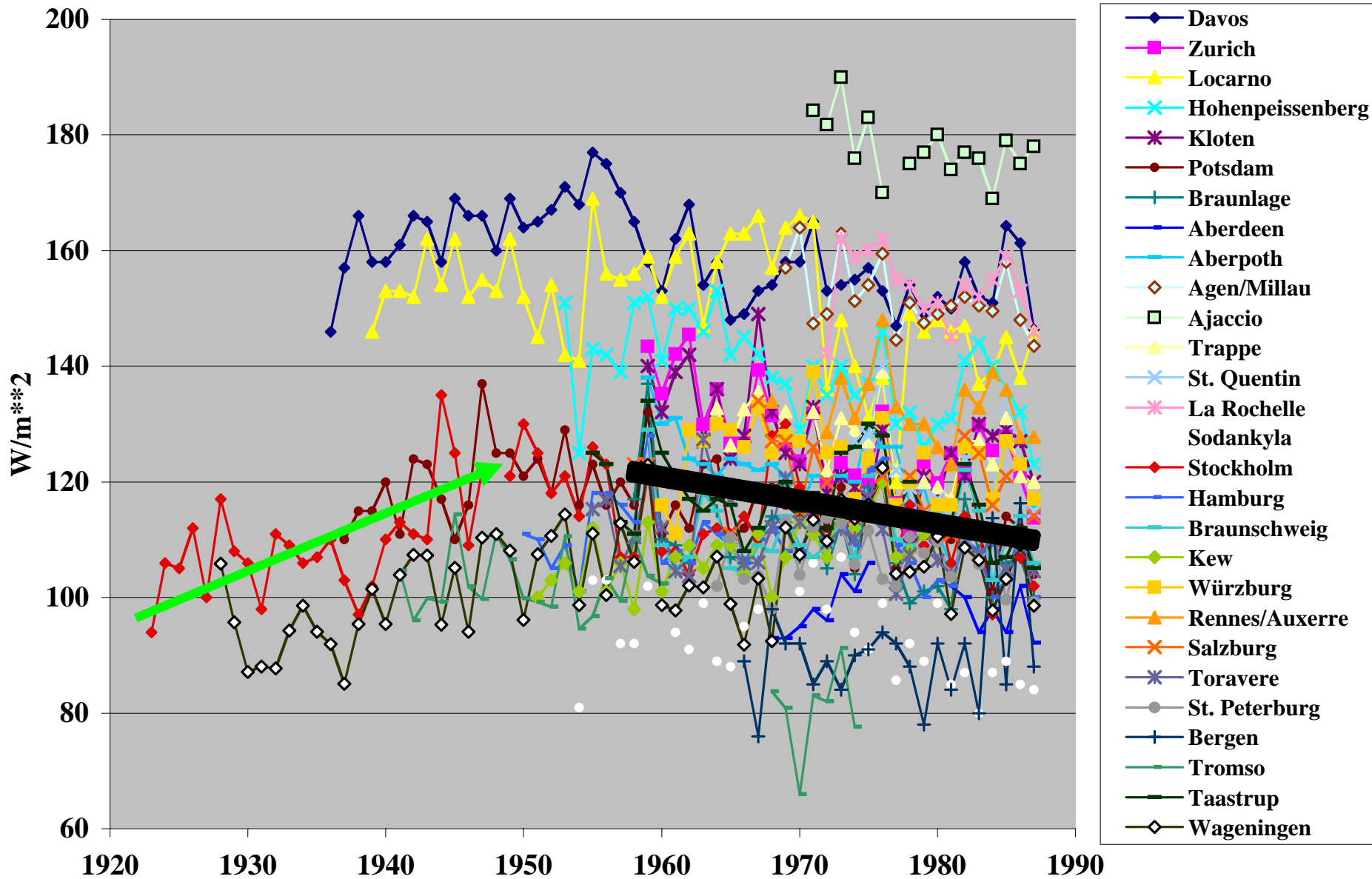


Annual mean SAT anomalies ($^{\circ}\text{C}$), data from Jones et al. (2003), Serreze and Francis (2006)

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Global radiation for Europe to 1987

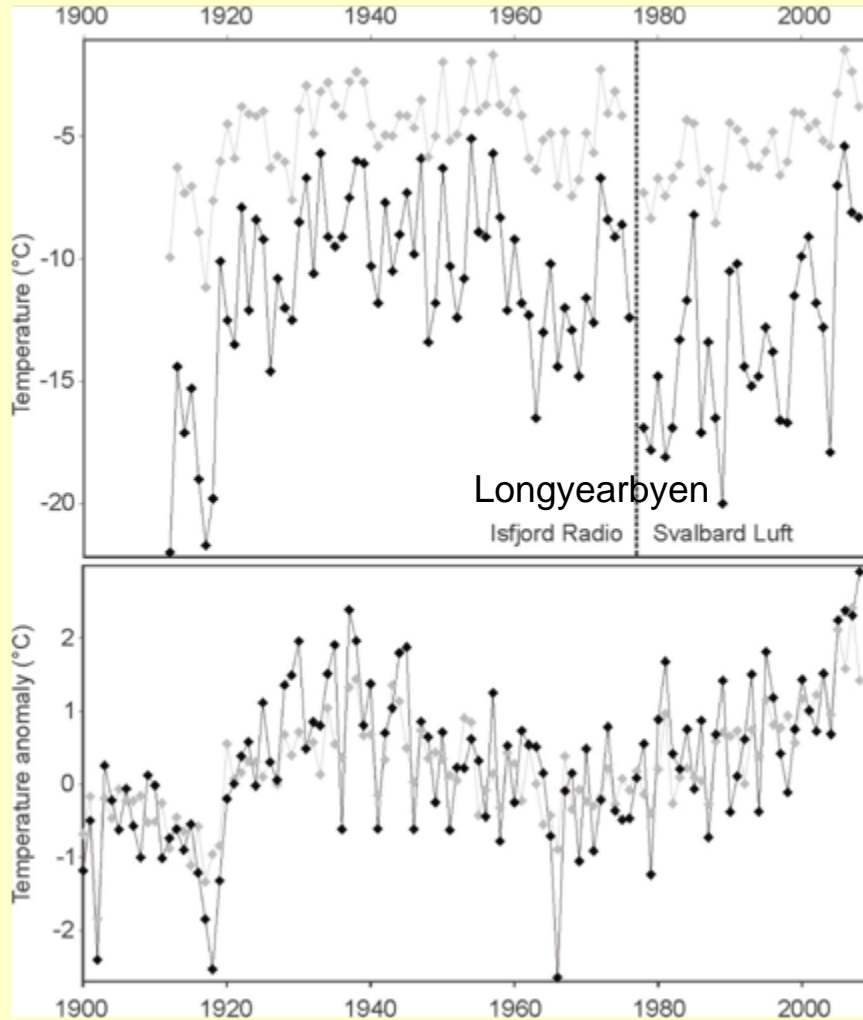
By Ohmura, 2008



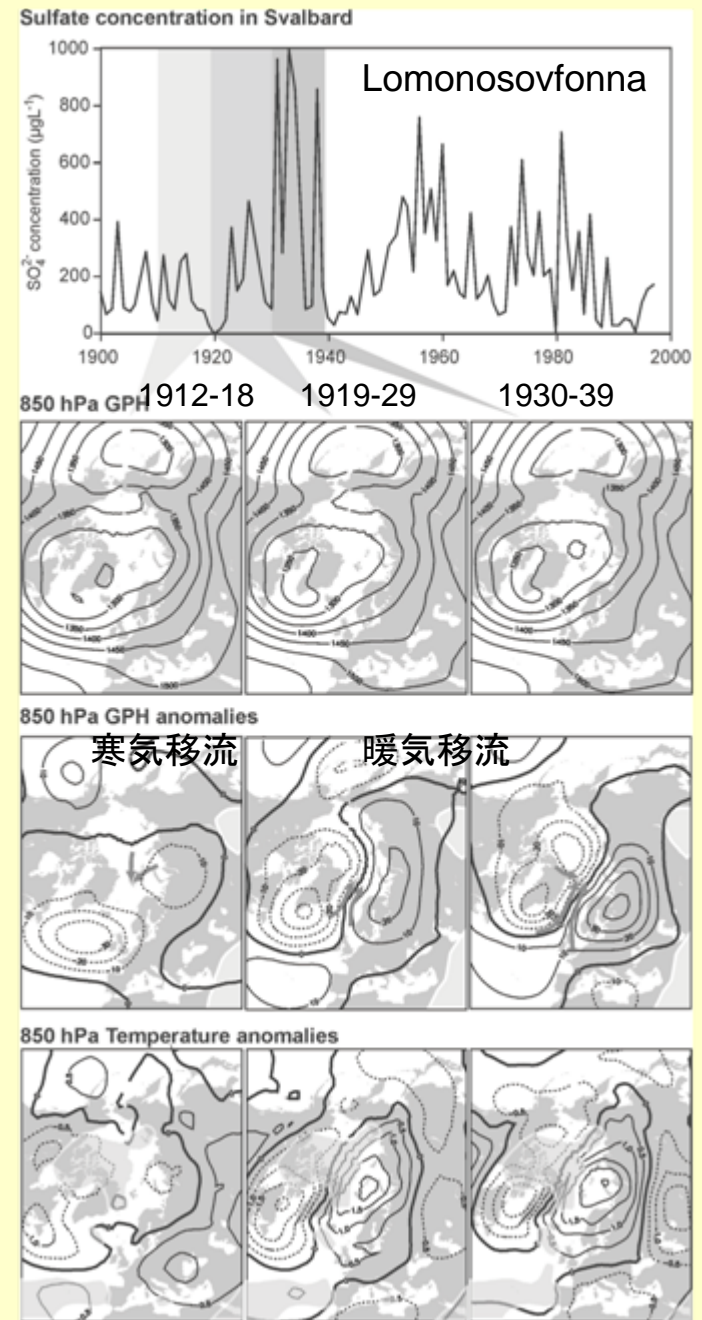
Increasing trend 1920s - 40s; by Yamanouchi

Early 20c warming

Grant et al. (2009)



Surface air temperature in Spitsbergen and average for the Arctic north of the polar circle for the winter and annual (grey)



Anomalous transport, winter (DJF)

International Polar Year (IPY) 1882-83

Inspired by Carl Weyprecht and proposed by Georg von Neumayer

12 Principal research stations
established in the Arctic during
the first IPY, 1881-84.



Map of 12 stations

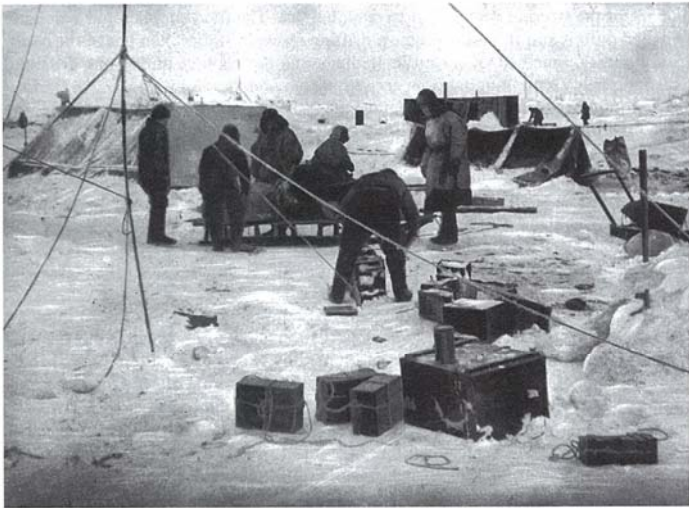
12 stations

IPY-2 (1932-33)

Drifting Station North Pole (USSR/Russia) 1937~1991 and 1993~present



(a)



(b)

Figure 1.2. (a) The ship *Cheluskin* is beset in the ice of the Chukchi Sea in 1933; (b) ice camp and crew of the *Cheluskin* in March 1934.

(a) Photo by Ya. Gakkel. (b) Photo by P. Novitsky.



(a)



(b)

Figure 1.6. (a) Aerologists Vasily Kanaki (on the left) and Igor Tsigelnitsky prepare for launching a radiosonde at the 'North Pole-3' drifting station (1954); (b) general view of the construction of the 'NP-3' drifting station (April 1954).

(a) Photo from V. Savostianov. (b) Photo from the RGMMA archives.

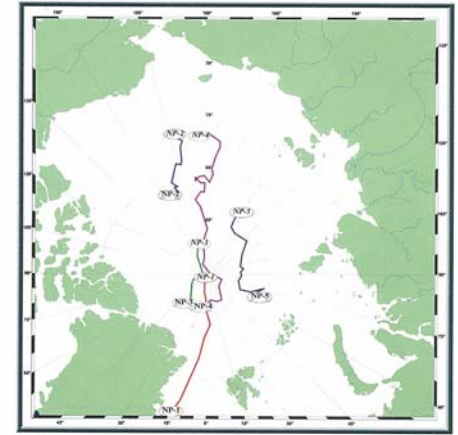


Figure 1.12. Layout of the drift of the 'NP-1'-'NP-5' stations. (Initial positions in italic.)

Ny-Alesund, Svalbard International Research Site

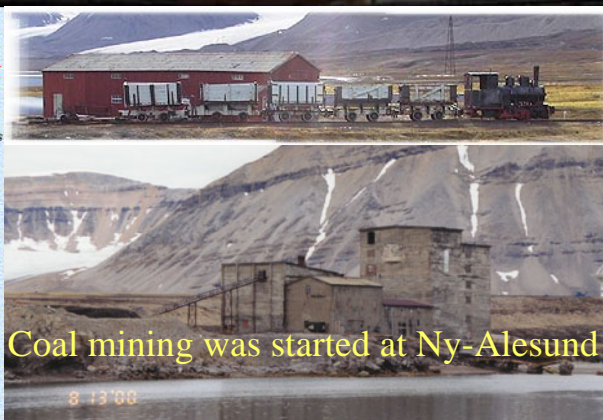
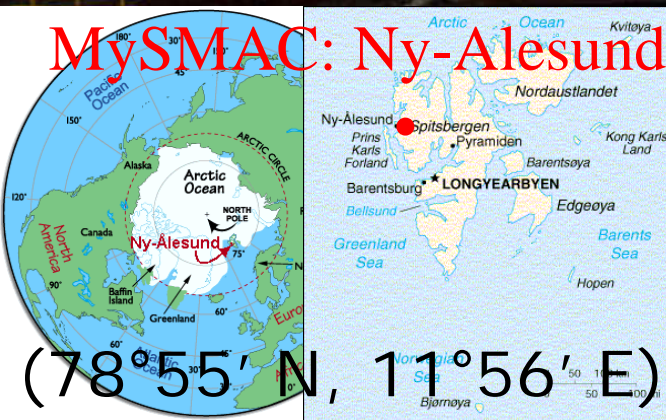


Established in 1990s by Norwegian Polar Institute (NP) and operated by Kings Bay AS (originally, KBKC).

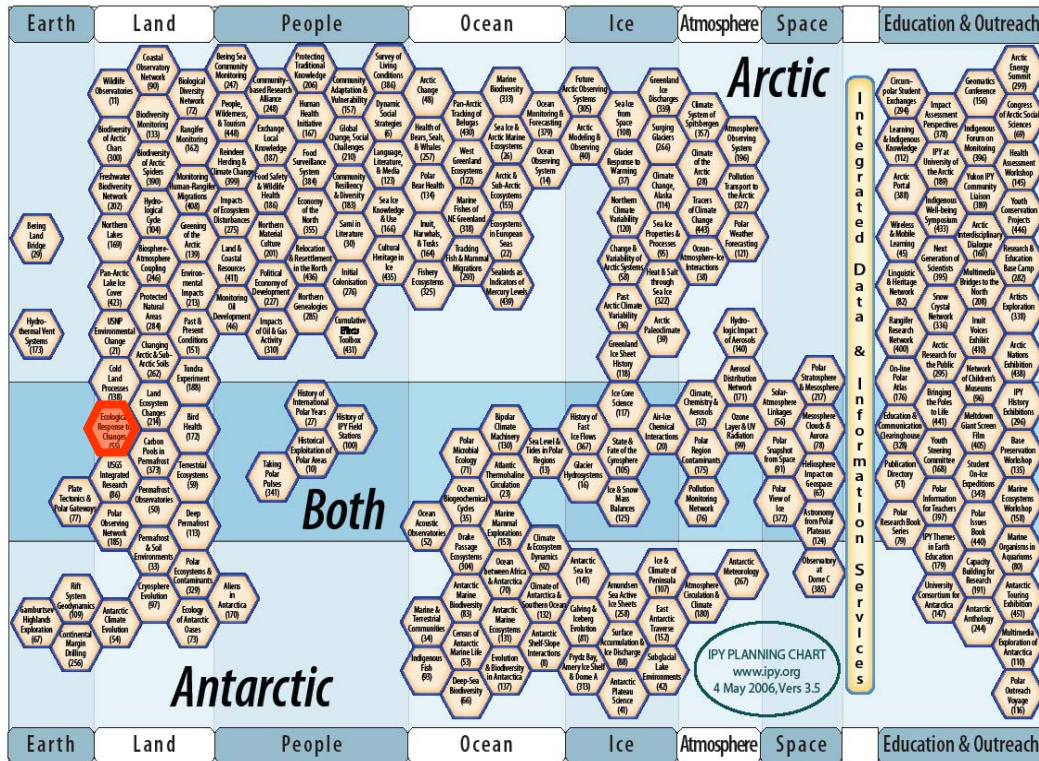
Germany (AWI), China (CAAA), Italy (CNR), France (IPEV), Korea (KOPRI), Japan (NIPR), UK (NERC), Norway (NILU, NMA, NP, NSC, UNIS, UiT), Sweden (SU), Netherland (UoG)

北極観測の活発化<----- 冷戦構造の崩壊 (ゴルバチョフ宣言 1989)

我が国も観測基地設置(1991) Svalbad Treaty (1920) 第一次大戦後



International Polar Year (IPY) 2007-2008



International Symposium
Asian Collaboration in IPY 2007 - 2008
Science Council of Japan, Tokyo,
1 March 2007

Officially endorsed IPY projects (228)

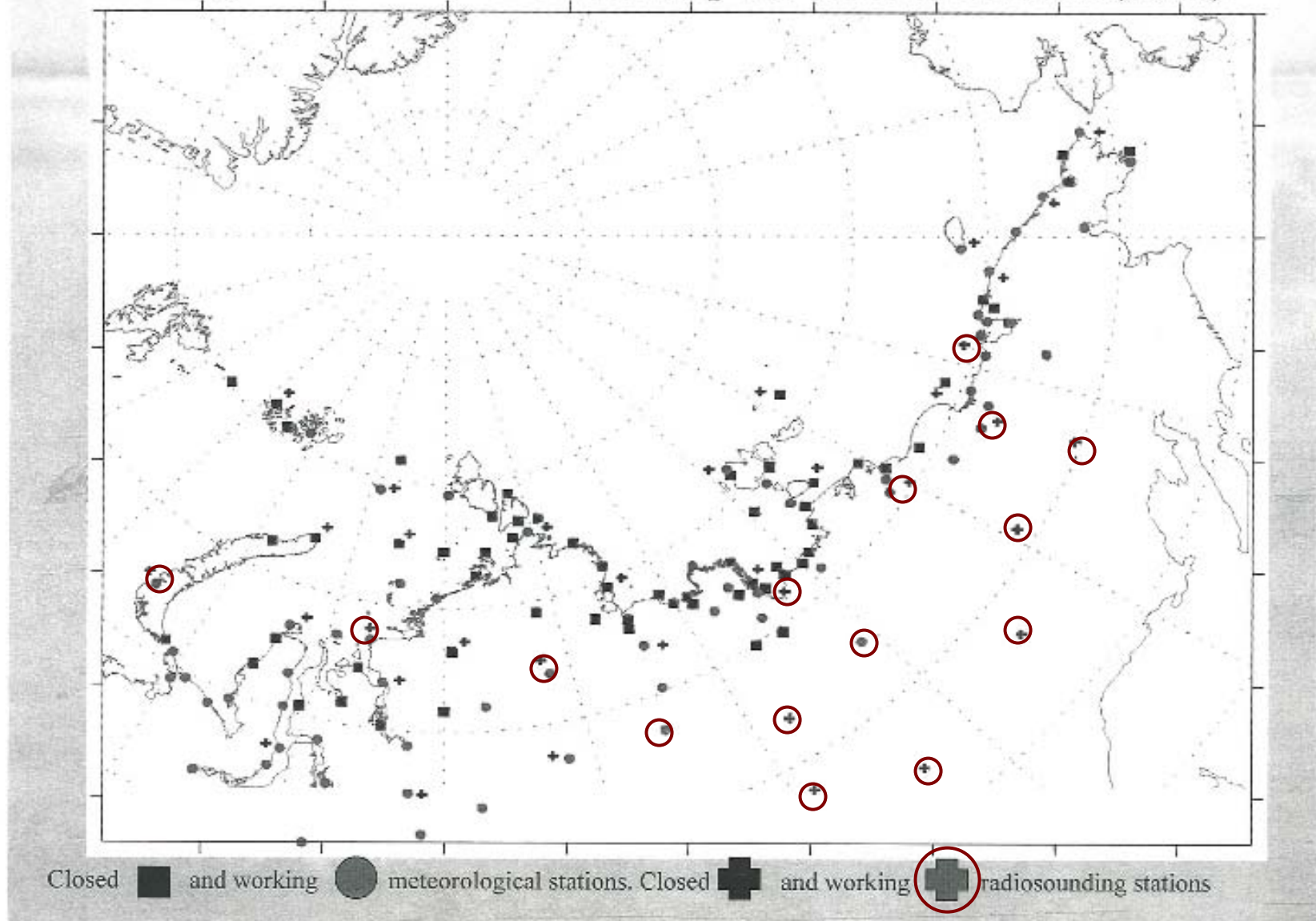


Asian collaboration among five countries,
China, Japan, Korea, India and Malaysia



Observation stations network?

Past and present state of the Russian polar stations network (2008)



22 closed and 15 existing

Conclusion

Abrupt changes are seen in the Arctic related to global warming; however, all are not well understood, especially for the atmosphere. It is indispensable to study early 20 C warming in order to understand the recent abrupt warming and to predict future change in the Arctic.

Recommendations

- Establish, enhance and maintain multidisciplinary sustained long-term observing systems in the Arctic
- Establish and maintain drifting ice or ship stations in the central Arctic Ocean
- Collect and analyze historical data archives in the Arctic, especially of early 20th century
- Increase communication between scientists and politicians about the Arctic change and keep the Arctic safe, peaceful and free area for science (need for “Arctic Treaty” just similar as the “Antarctic Treaty”