LET NOT THAT ICE MELT IN SVALBARD

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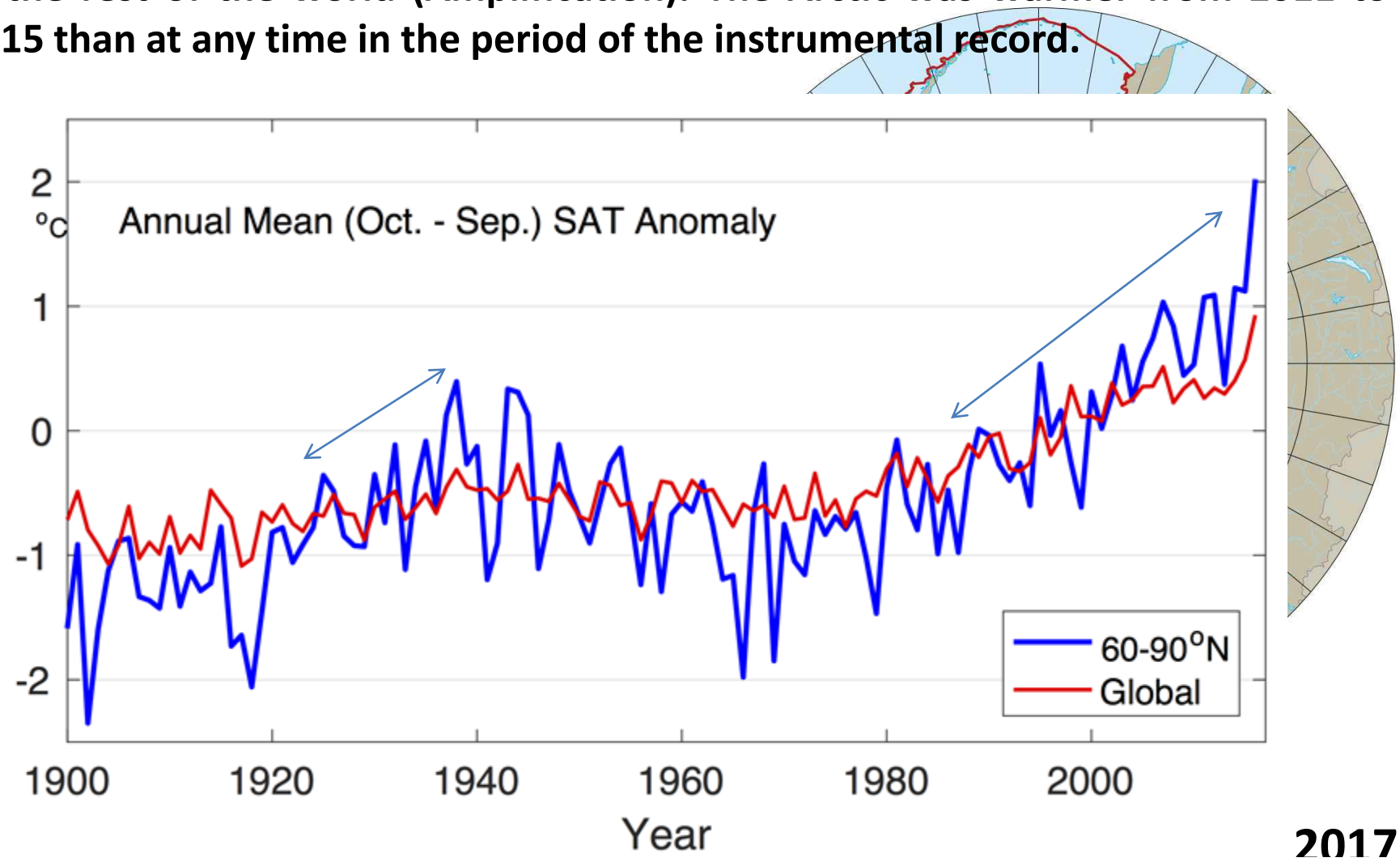
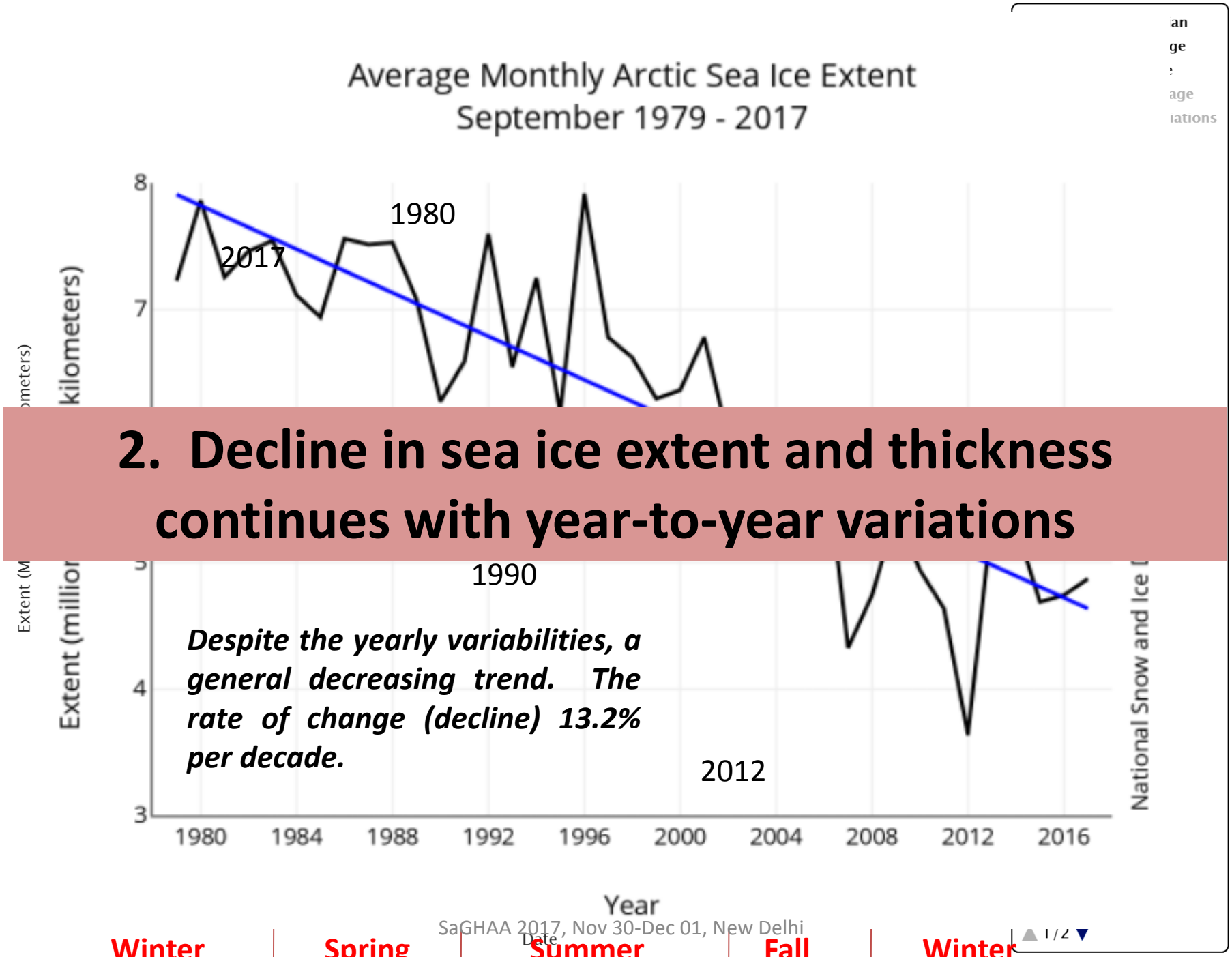
1. Arctic (surface air) temperatures are rising twice as fast as the temperatures in the rest of the world (Amplification). The Arctic was warmer from 2011 to 2015 than at any time in the period of the instrumental record.



Trends in average global (red line) and Arctic (blue line) temperature relative to the 1981-2010 mean, 1900-2016. Source: NOAA Arctic Report Card, 2016



2. Decline in sea ice extent and thickness continues with year-to-year variations

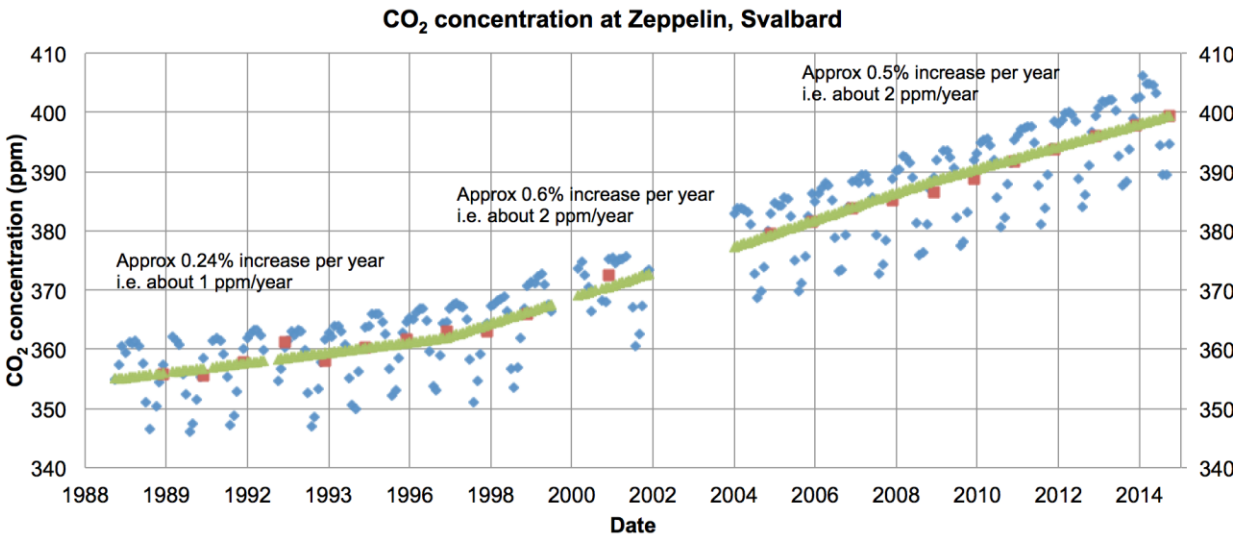
Winter | Spring | Summer | Fall | Winter

CAUSATIVE FACTORS FOR THE VARIABILITY

ANTHROPOGENIC Vs. NATURAL

" the decline in Arctic sea ice extent and its thinning over the past three-odd decades appears to be largely, but not wholly, due to greenhouse gas forcing " [IPCC, 2007].

Black carbon and tropospheric ozone have contributed ~0.5–1.4 ◦C and ~0.2–0.4 ◦C, respectively, to Arctic warming since 1890

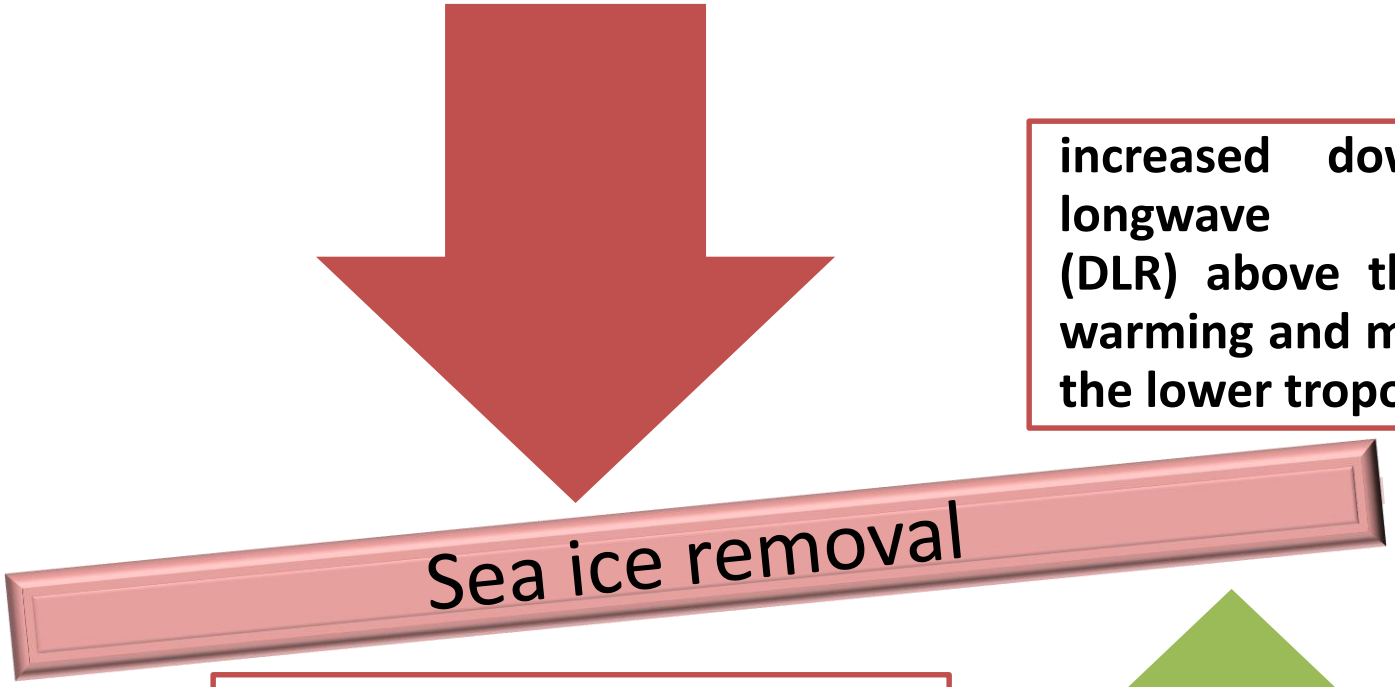


http://www.aces.su.se/zeppelin/data_co2.html

blue dots are the monthly averages, the red dots the yearly averages and the green dots show a fitted curve

If so, what are the other forcing factors?

1. Summer atmospheric circulation and sea ice removal



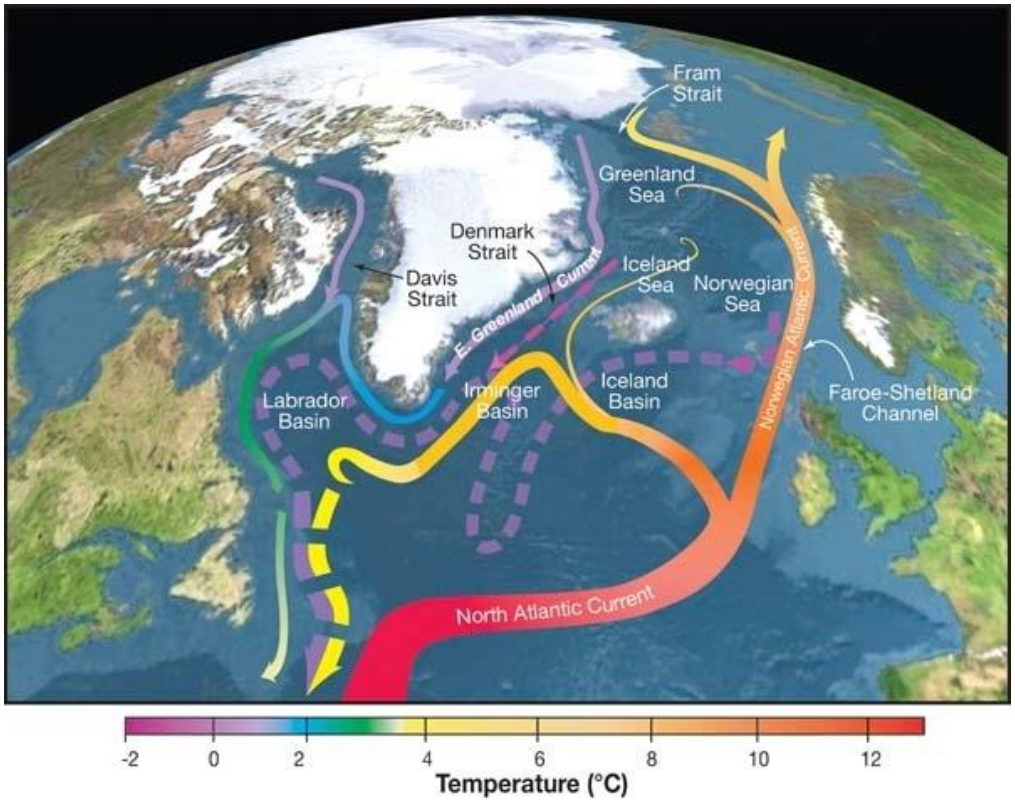
increased downwelling longwave radiation (DLR) above the ice by warming and moistening the lower troposphere

Removal of sea ice also can increase surface air temperature, clouds, low-level water vapour and thus affect the atmospheric circulation

Ding et al. 2017

3. Oceanic variabilities

Multiple simulations for 1979–2005 show that 44% of the observed September SIE trend can be explained by natural variability such as Atlantic Multidecadal Oscillation (AMO) with expression in NA SST which in turn is driven by Atlantic Meridional Overturning Circulation (AMOC) [*Kaye et al. 2011*]

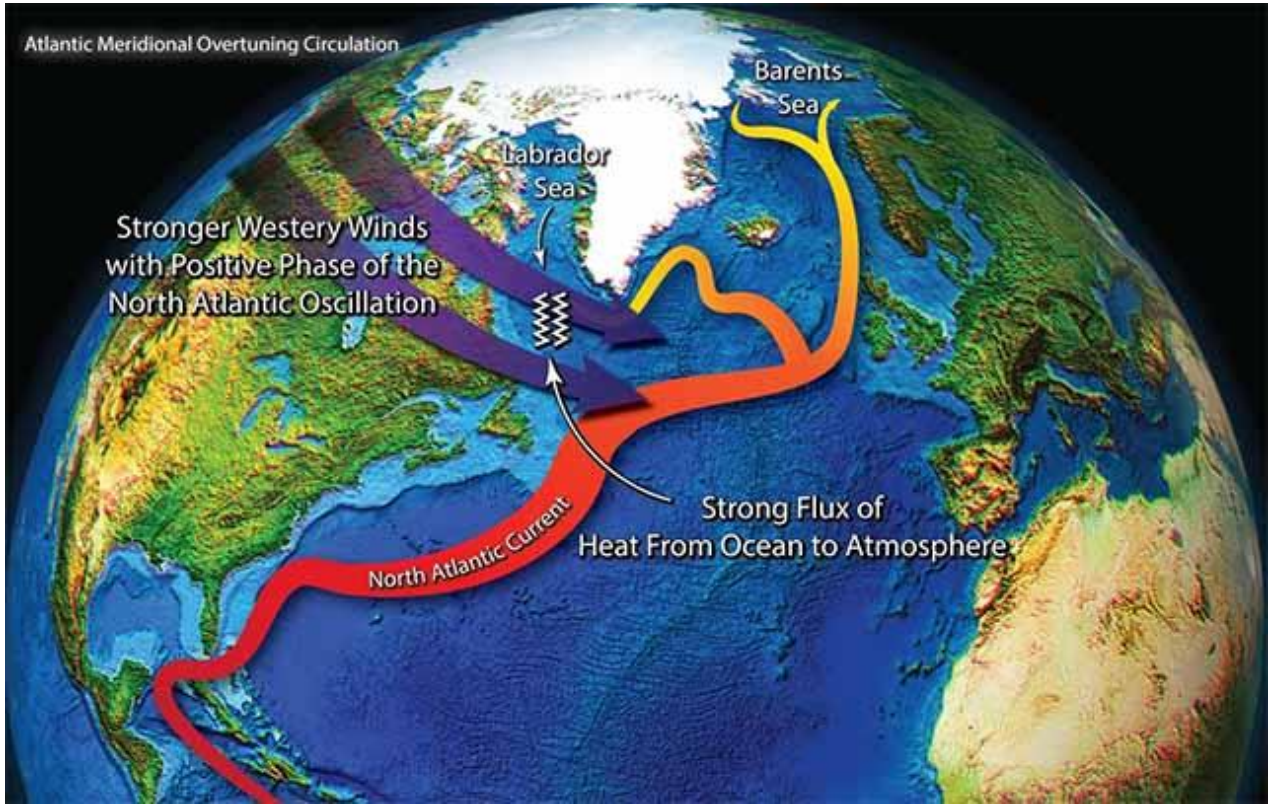


The response of SIE to AMO is larger in March than Sept. Probably because in March sea ice extends into the North Atlantic and is thus more affected by anomalous northward heat transport in the NA than September sea ice

CAUSATIVE FACTORS FOR THE VARIABILITY (contd.)
ANTHROPOGENIC Vs. NATURAL

Atmosphere-Ocean [NAO-AMO (?)-AMOC]

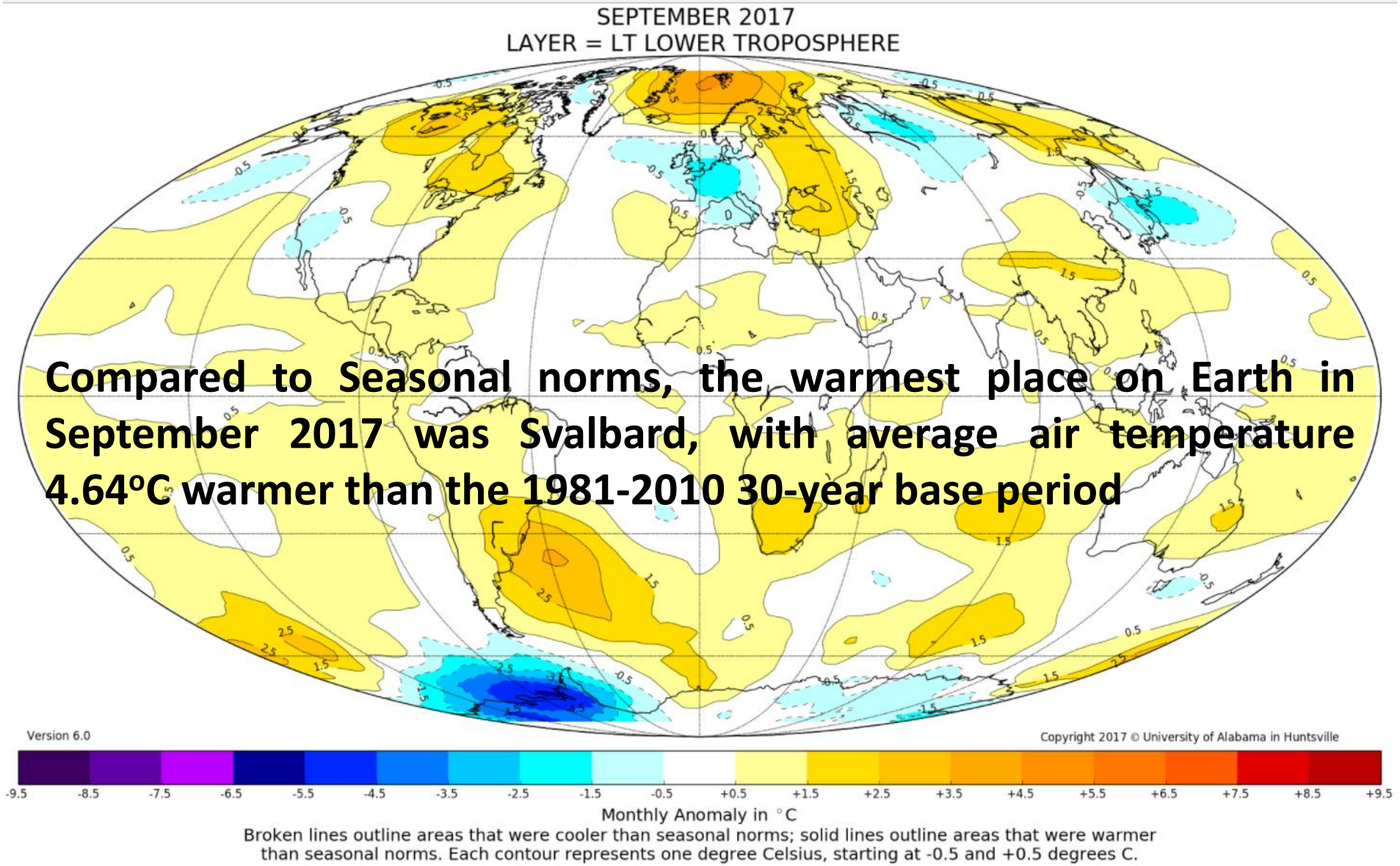
Multi-decadal variations of the North Atlantic Oscillation can induce variations in the AMOC and poleward ocean heat transport, contributing to the rapid loss of Arctic sea ice and changing Atlantic tropical storm activity (*Delworth et al. 2016*)



***Positive phase of the NAO results in stronger westerly winds that extract heat from the Labrador Sea and subpolar gyre. Heat is transported in the North Atlantic toward the pole, reducing Arctic sea ice and warming the Northern Hemisphere* (*Delworth et al. 2016*)**

What makes Svalbard so special as regards climate variability?

SVALBARD AIR TEMPERATURE, SEPTEMBER 2017



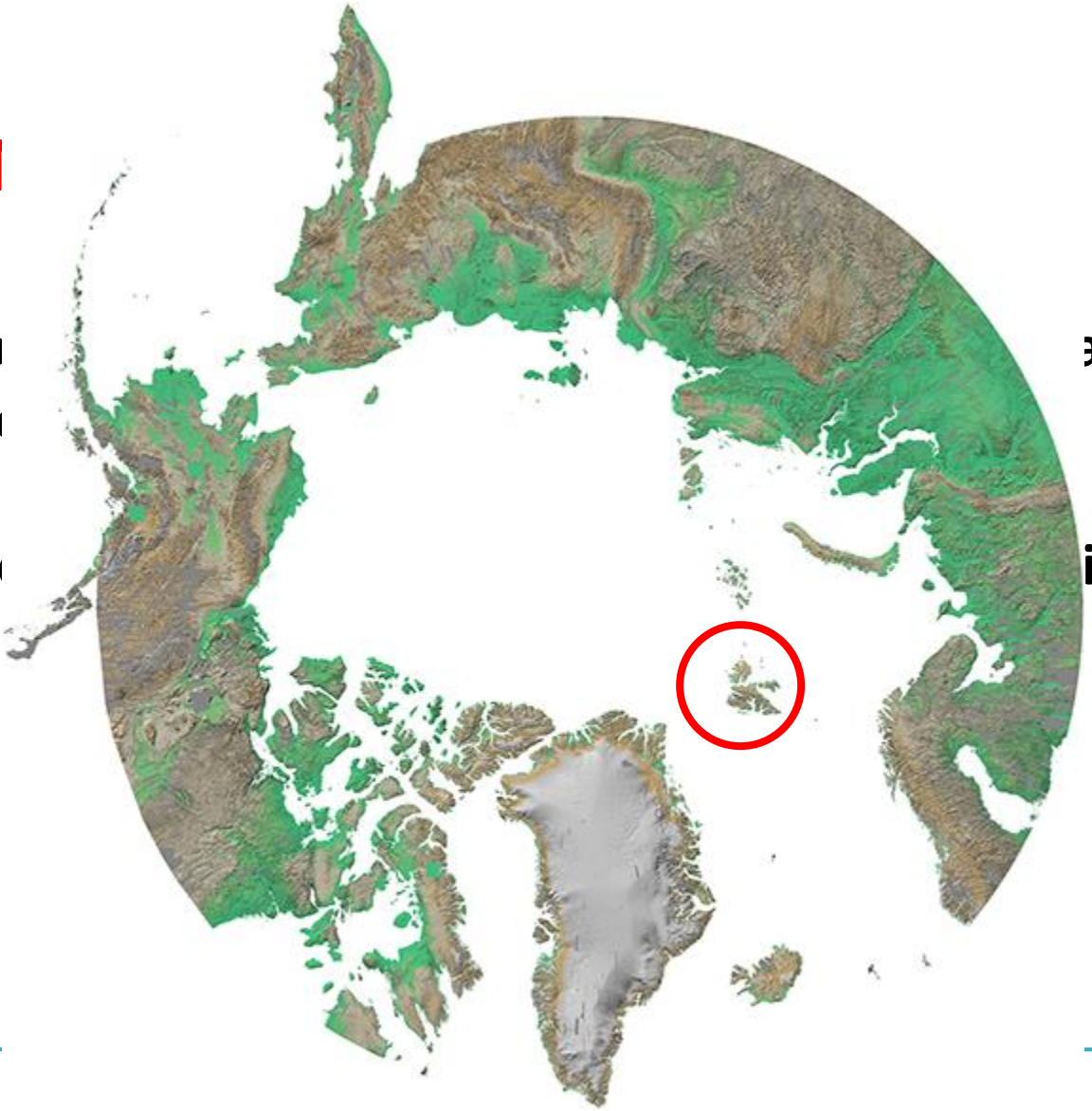
Compared to Seasonal norms, the warmest place on Earth in September 2017 was Svalbard, with average air temperature 4.64°C warmer than the 1981-2010 30-year base period

Svalbard. A natural laboratory for climate change studies?

LOCATIOI

1. **Po** **ates the polar and extra-tr**

2. **A** **ial route for seawater to**

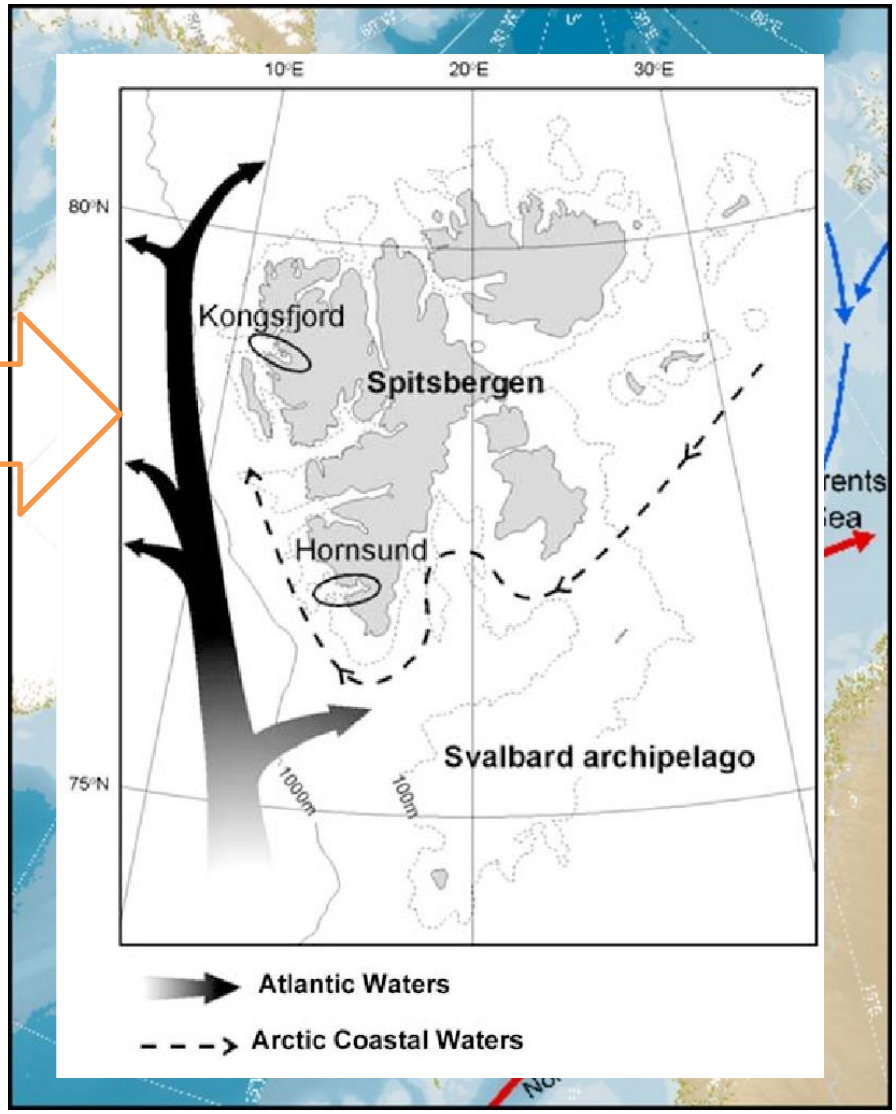


Svalbard. A natural laboratory for climate change studies?

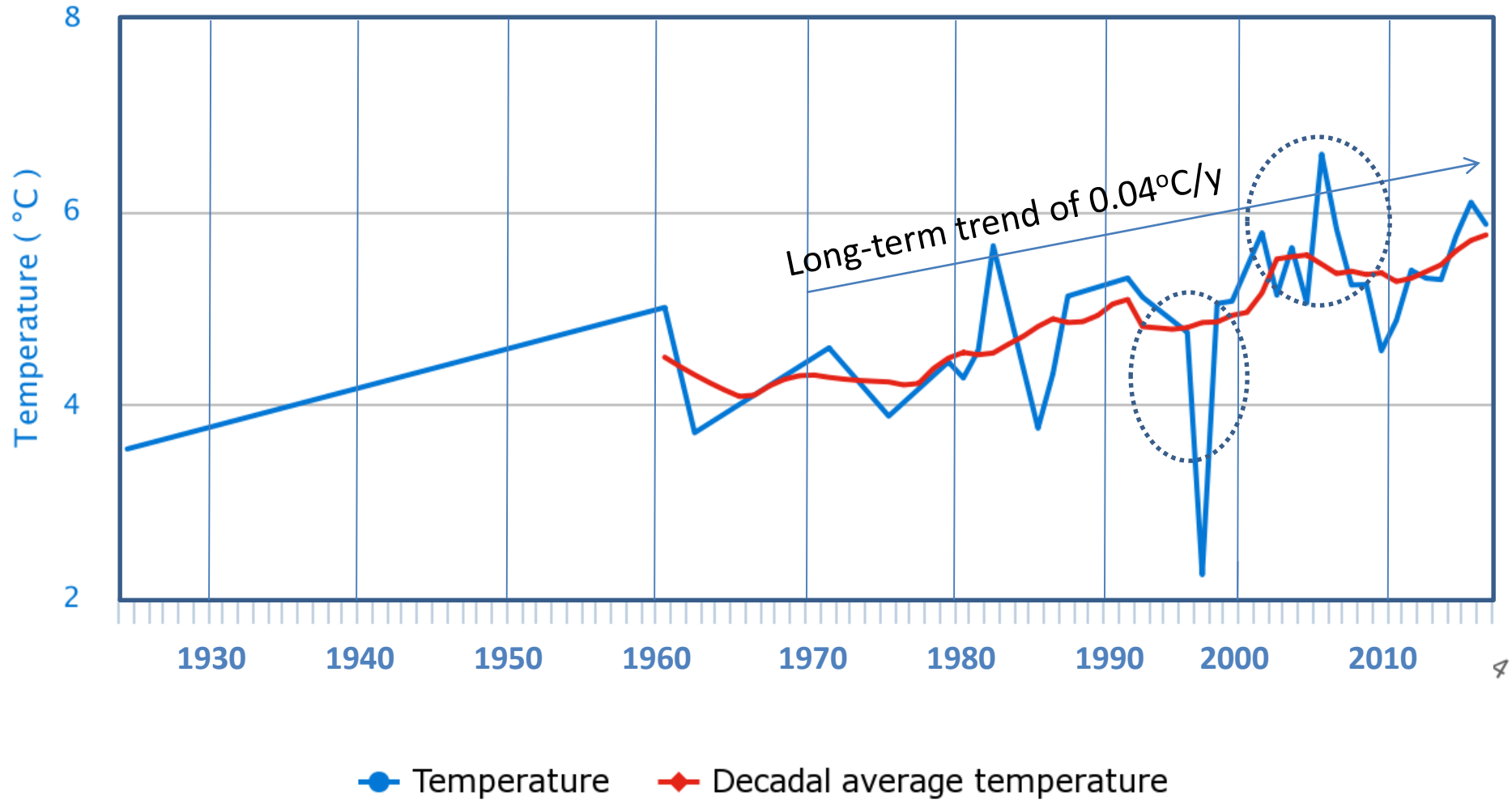
In the middle of one of the important oceanic gateways to the Arctic.

Presence of the North Atlantic drift, a powerful contributor of heat to the Arctic Ocean. The northern branch of the drift splits at Svalbard, and *almost 60 % of the water entering the Arctic Ocean comes with this*.

On the West Spitsbergen Shelf warm saline Atlantic Water, cold fresh Arctic Water of the coastal Sørkapp Current (SC) and riverine and glacial waters are in a dynamic balance.



Annual maximum temperature in the West Spitsbergen Current

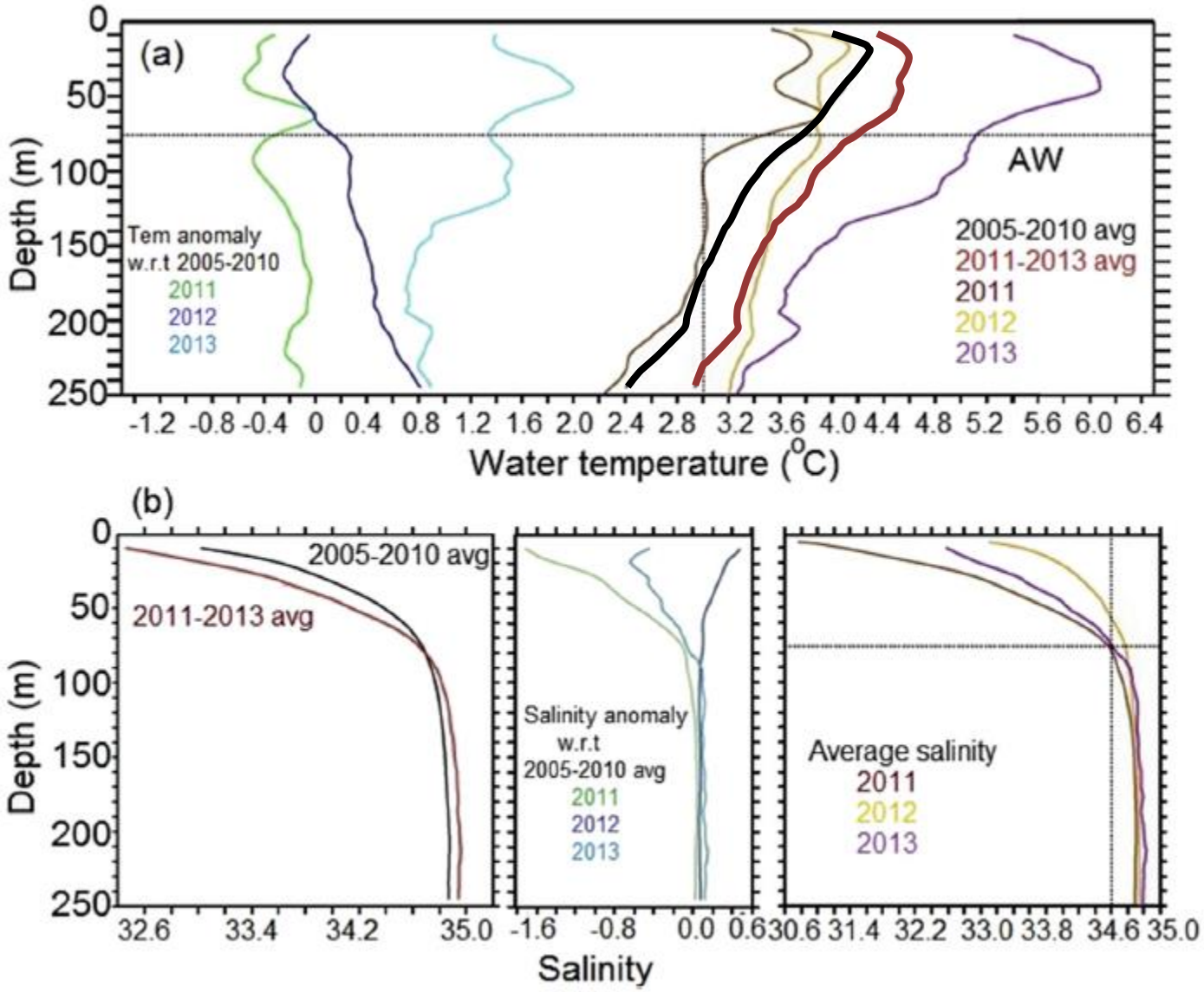


Data: Norwegian Polar Institute

What makes Svalbard special? A natural laboratory for climate change studies?

- **Fjord systems which respond to inter-annual variabilities.**
- **Fjords which are "Arctic" the year-round or "Arctic-Atlantic" over an annual cycle.**
- **Diverse habitats in the ecosystems over relatively small spatial scales exposed to various dynamic driving forces of regional and distant origins**
- **Clearly visible effects of short-term climate variability in landscape, ecosystem and humans.**

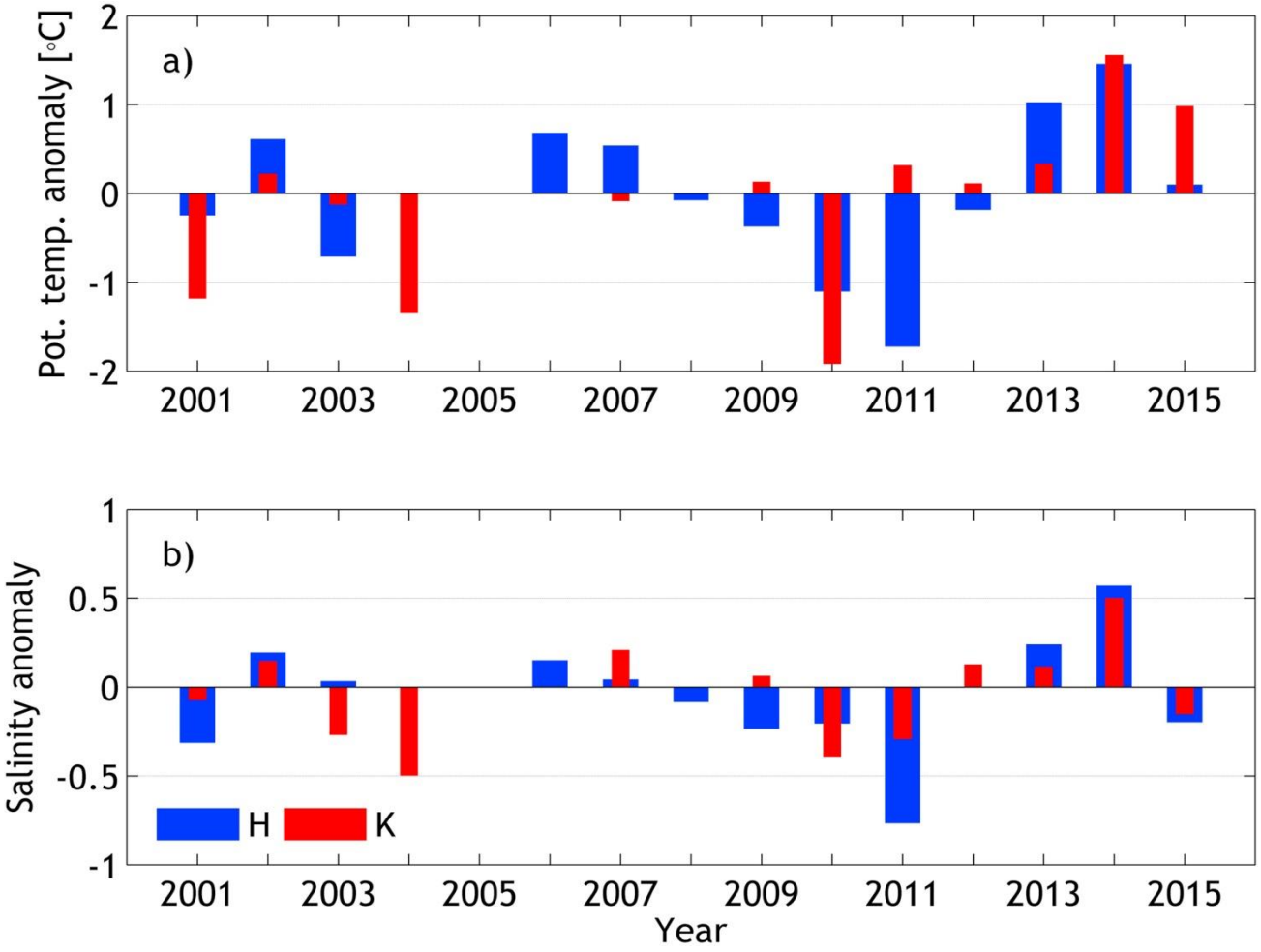
KONGSFJORDEN WATERS 2005 THROUGH 2015



Depth profiles of basin average and anomalies of (a) temperature and (b) salinity from the gridded CTD data in September for the period 2005 to 2013.

[Divya David & Krishnan, 2017]

KONGSFJORDEN & HORNSUND 2001 THROUGH 2015



Time series of temperature (a) and salinity (b) anomalies in Hornsund (blue) and Kongsfjorden (red). *Prominska et al. 2017*

- **Kongsfjorden is on average 1°C warmer and its salinity is higher by 0.5 compared to Hornsund.**
- **Kongsfjorden is characterized by two times greater transport of AW and heat delivery to the fjord.**
- **Hornsund is marked by two times more FWC as compared to Kongsfjorden**

Of polar bears, seals and reindeers (among others)

- **Reindeer are shrinking in both size and numbers : the amount of winter food available and ROS (1999-2010, Hansen et al. 20130**
- **Svalbard Rock Ptarmigan: Decrease in population growth rate- ROS (1997-2010)**
- **Decreasing numbers of Ringed seals (2002-12, Hamilton et al. 2016)**
- **Northward migration of species from Atlantic (Atlantic cod, mackerel) (Renaud et al. 2012)**
- **Disappearance of Arctic species (blue mussels) since 2005**

Wrangel Island, Russia, Sept. 19, 2017 *[Credit: Alexander Gruzdev]*

- **Polar bears population which is very dependent on sea ice has decreased around 15% in both average weight and number of cubs during recent years (2009-12), Aras, 2013**
- **Shifting of marginal sea ice and locale of PP**

Some concluding thoughts…..