# Records of past and present contamination in the Arctic


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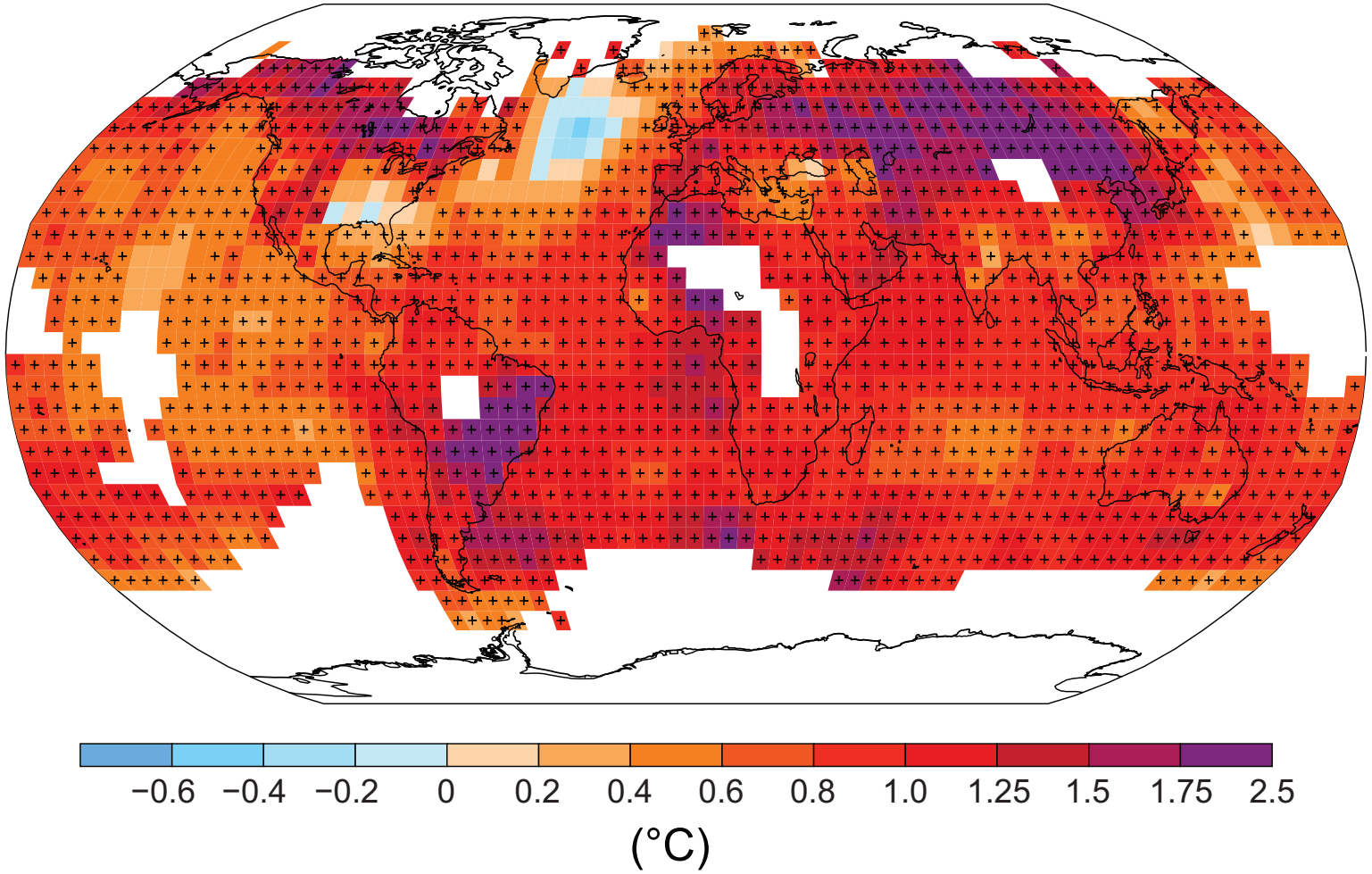
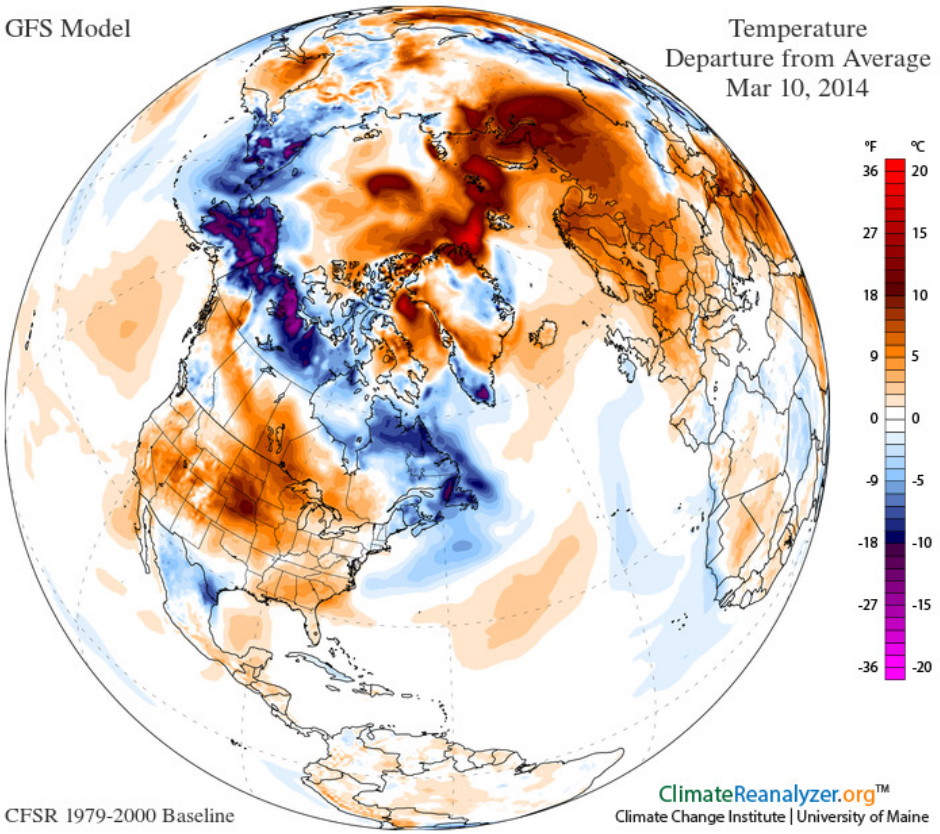
# Observed change in surface temperature 1901-2012




IPCC, 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis*.

# Arctic temperature amplification 1987-2007

## Temperature – Departure from the average
## March 10, 2014




**Arctic Heat in winter — February 2, 2014 Temperature Anomaly Hits + 6 °C for entire Arctic**

## Land-Ocean Temperature Changes

The rise in Arctic near-surface air temperatures has been **almost twice as large as the global average** in recent decades—a feature known as '**Arctic amplification**'.

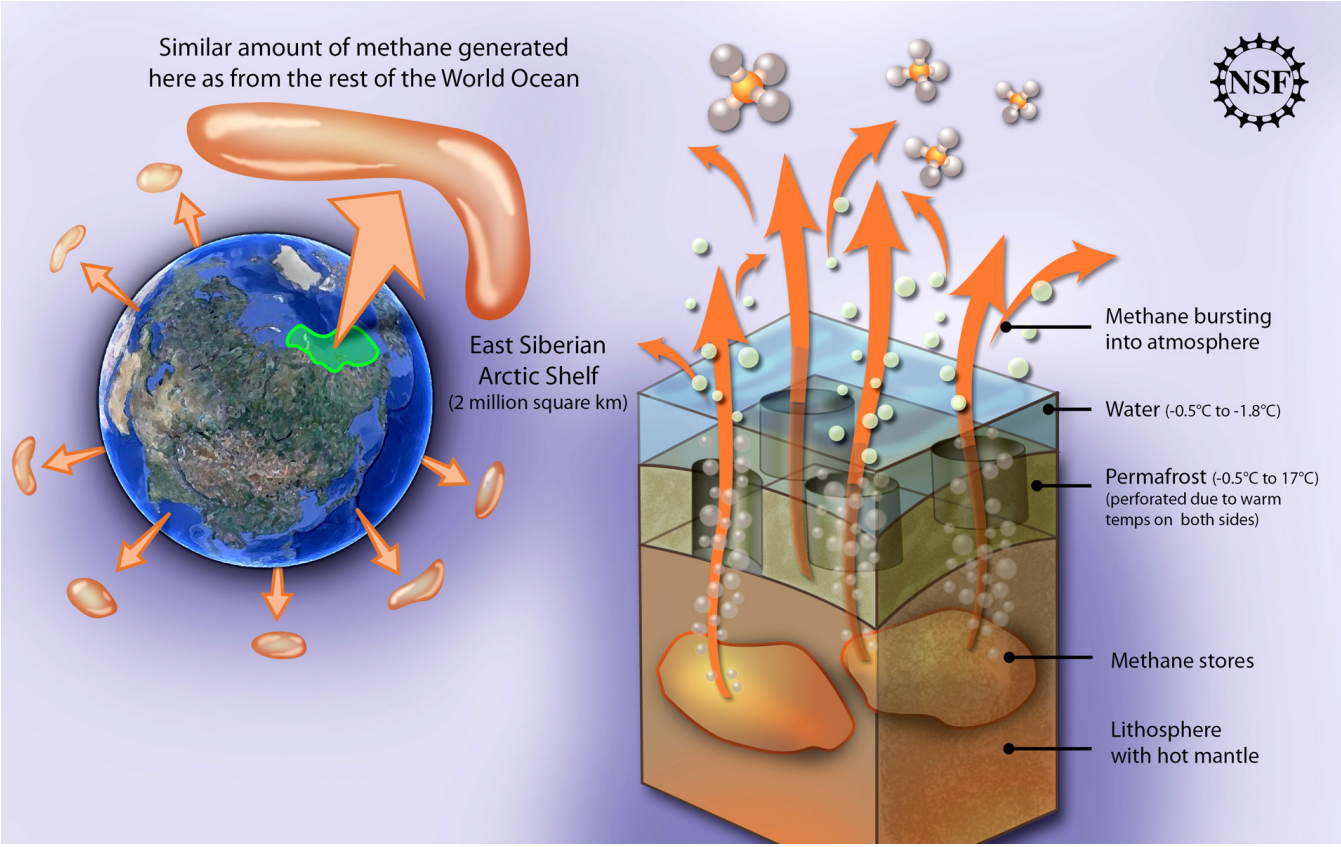
**Causes:**

1. Increased concentrations of atmospheric GHGs
2. reductions in snow and sea ice cover
3. changes in atmospheric and oceanic circulation
4. changes in cloud cover and water vapour

Screen & Simmonds, *Nature*, 2010
http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/

# Methane release from the Arctic

Arctic methane release is a long-term natural process, that may **be increased by global warming**. Large quantities of methane are stored in the Arctic in natural gas deposits, permafrost, and as submarine clathrates. This release may result in **a positive feedback effect**, as methane is itself a powerful greenhouse gas

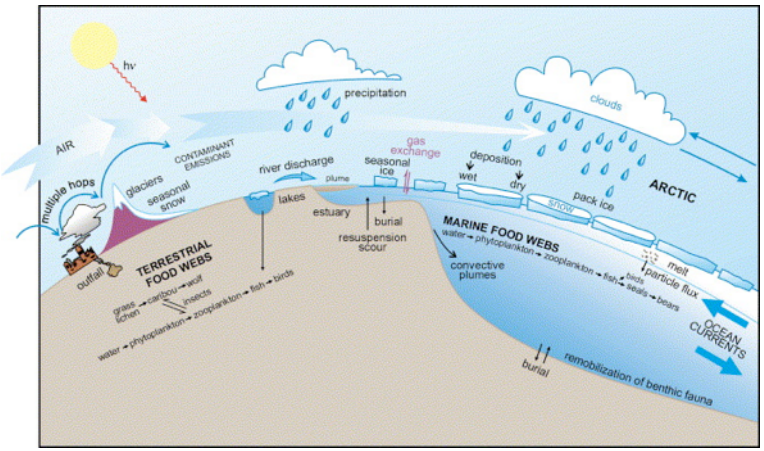


# Physical transport pathways from industrial regions to the Arctic

*Macdonnald et al., 2005*

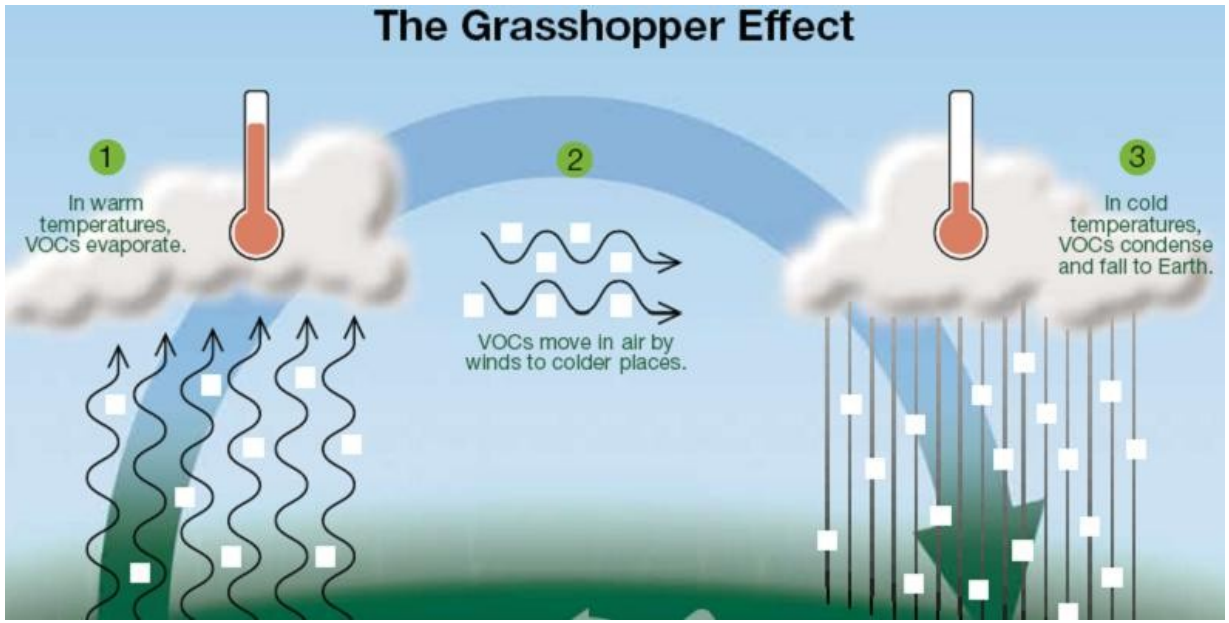

The major physical pathways (wind, rivers and ocean currents) that transport contaminants to the Arctic.

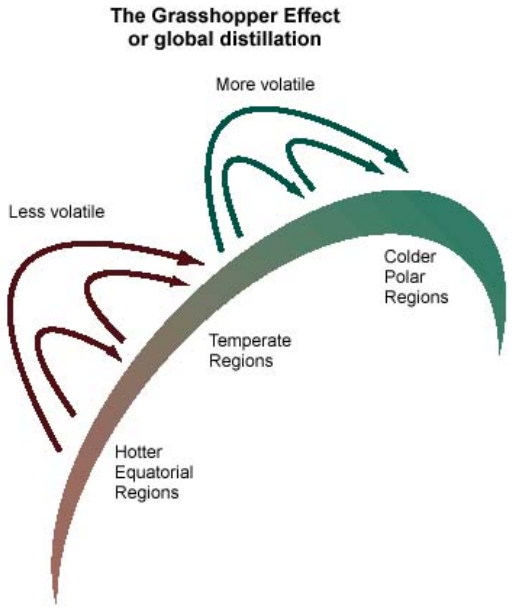
A simplified schematic diagram showing how physical pathways deliver contaminants emitted from northern industrial regions to the Arctic



# Transport of POPs to the Arctic: the Grasshopper effect

**Global distillation or the grasshopper effect** is the geochemical process by which certain chemicals, most notably persistent organic pollutants (POPs), are **transported from warmer to colder regions** of the Earth, particularly the Poles and mountain tops.



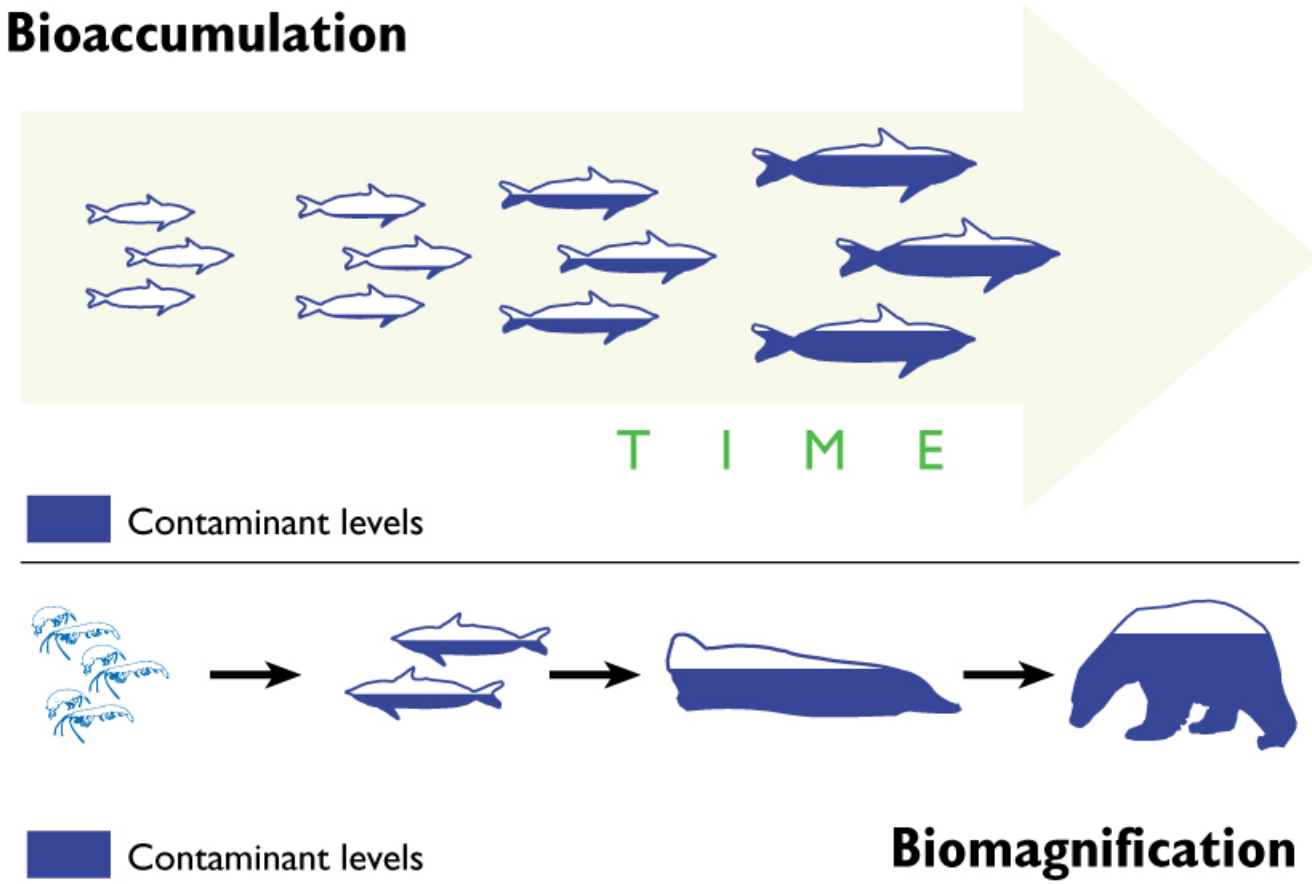

Global distillation explains why relatively high concentrations of POPs have been found in the Arctic environment and in the bodies of animals and people who live there, even though most of the chemicals have not been used in the region in appreciable amounts

# Potential consequences for POPs fate with respect to CC

| Scenario | Environmental consequence | POP associated changes | Effects on POP levels |
|---|---|---|---|
| Sea level rise | Increased erosion | Increased release of POPs from secondary sources | + |
| Coastal erosion | Loss of coastal habitats. New organisation of human settlements along coastal zones | New POP sources to be expected | + |
| Change of the atmospheric composition | Increased $CO_2$ levels, chemical composition, particulates | Changes in the global and regional transport pathways | + |
| Increasing regional weather variability | Increased average precipitation rates | Changes in the global and regional transport pathways | + |
| Increased incidents of extreme weather events including forest fires | Flooding and storm events | Increased release of POPs from secondary sources | + |
| Ambient temperature rise in the oceans | Introduction of non-native species | Introduction of new sources, increased evaporation, enhanced biotransformation | ± |
| Reduced sea ice coverage in the Polar Regions | Significant temperature rise in the Arctic ocean due to change in albedo properties | Increased POP evaporation from open surfaces (sea–land) | + |
| Reduced permafrost in polar/sub-polar and high altitude regions | Increased erosion consequences for biosphere and human infrastructures | Increased POP mobility, evaporation forms open surfaces (sea–/fresh water–land interaction) | + |

R. Kallenbhorn *J. Environ. Monit.*, 2012

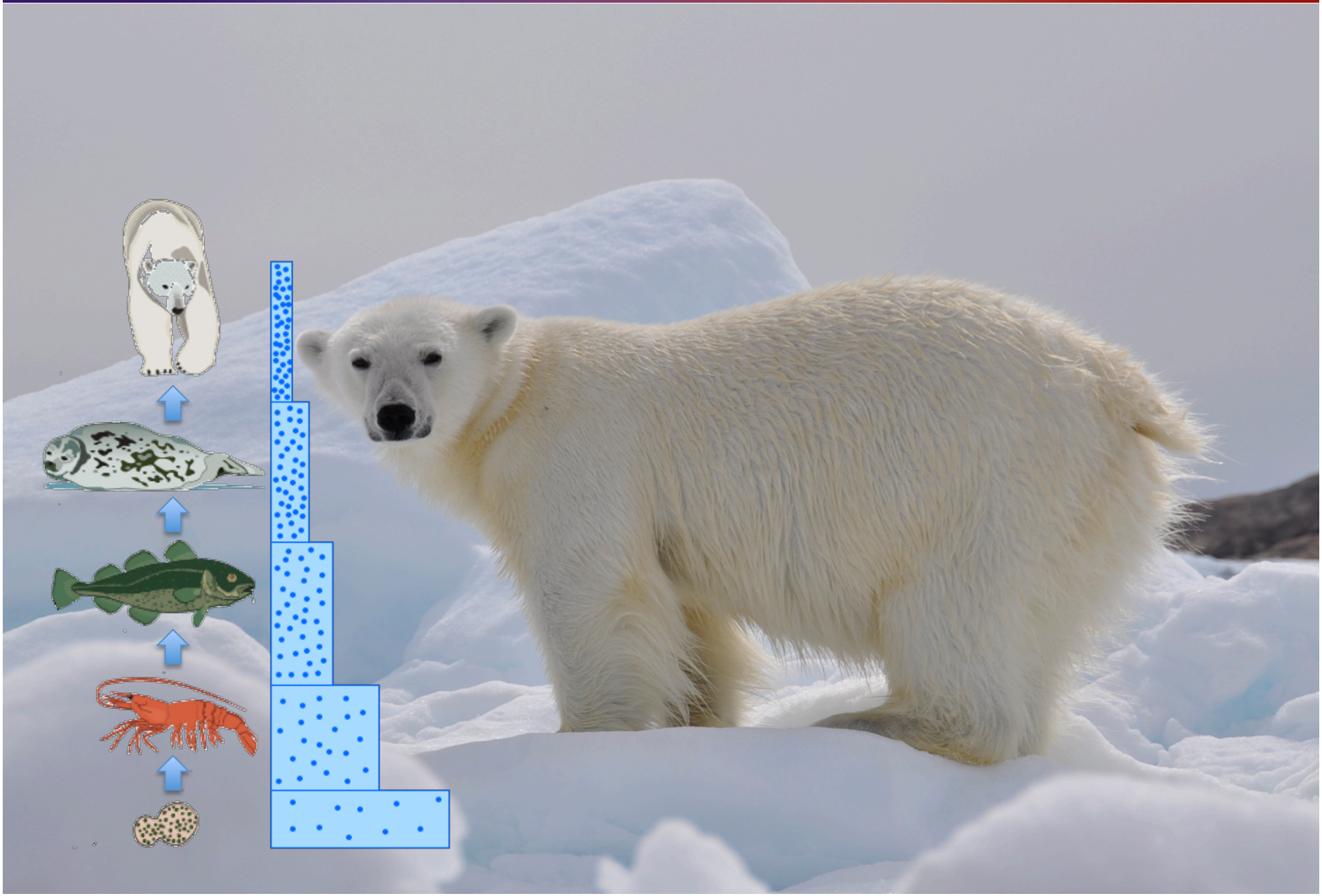
# Bioaccumulation and biomagnification of organics in Arctic




**Bioaccumulation** refers to the accumulation of substances, such as pesticides, or other organic chemicals in an organism

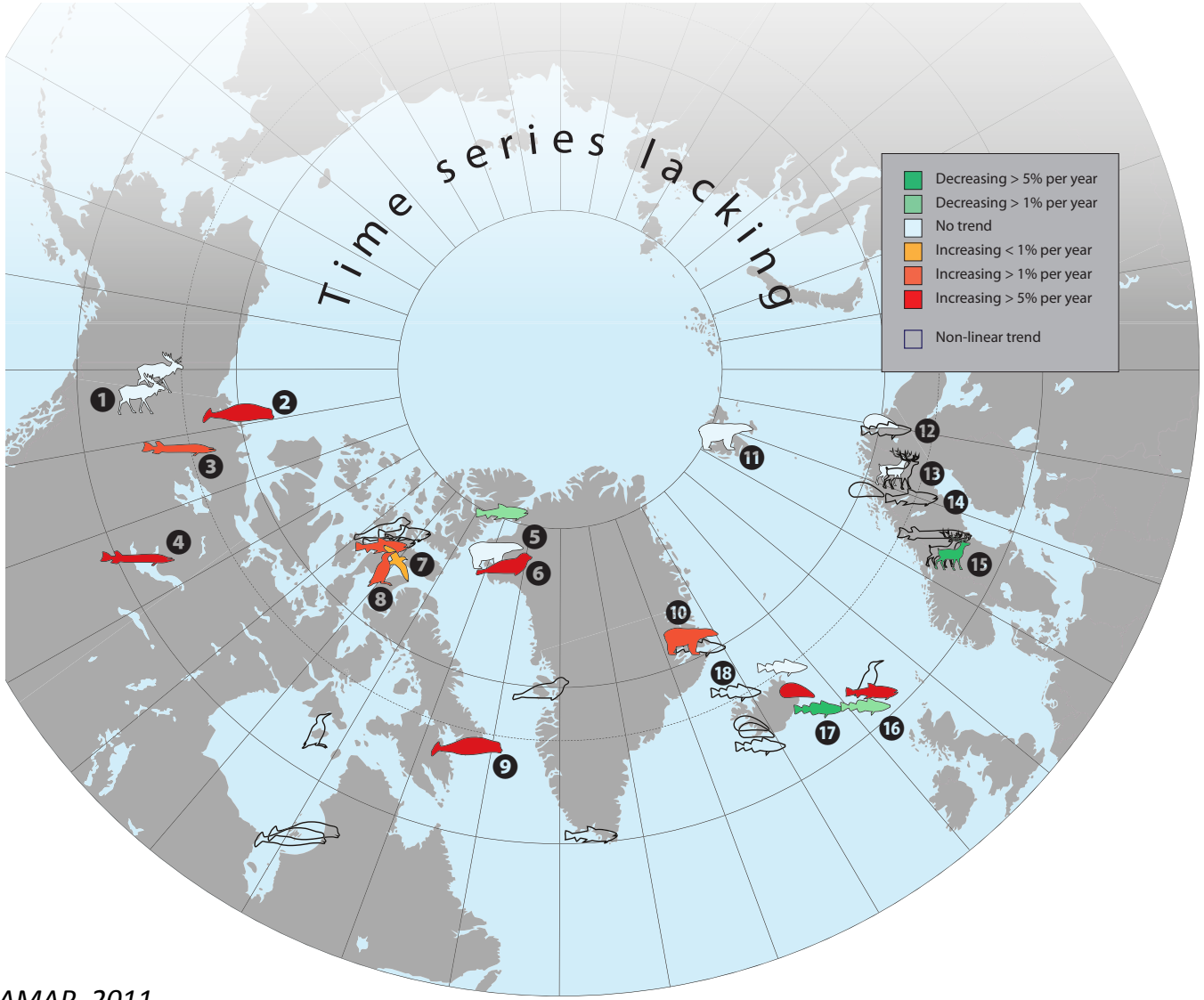
**Biomagnification** (bioamplification or biological magnification), occurs when the concentration of a substance in an organism **exceeds the background concentration of the substance in its diet**

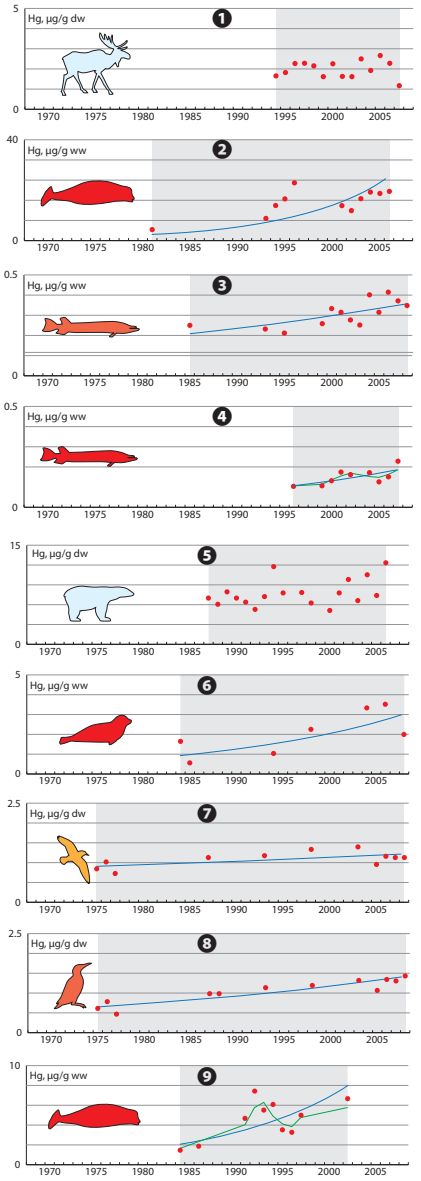
# Bioaccumulation and biomagnification of organics in Arctic



# Hg trend in different mammals and birds from 1970s to 2010

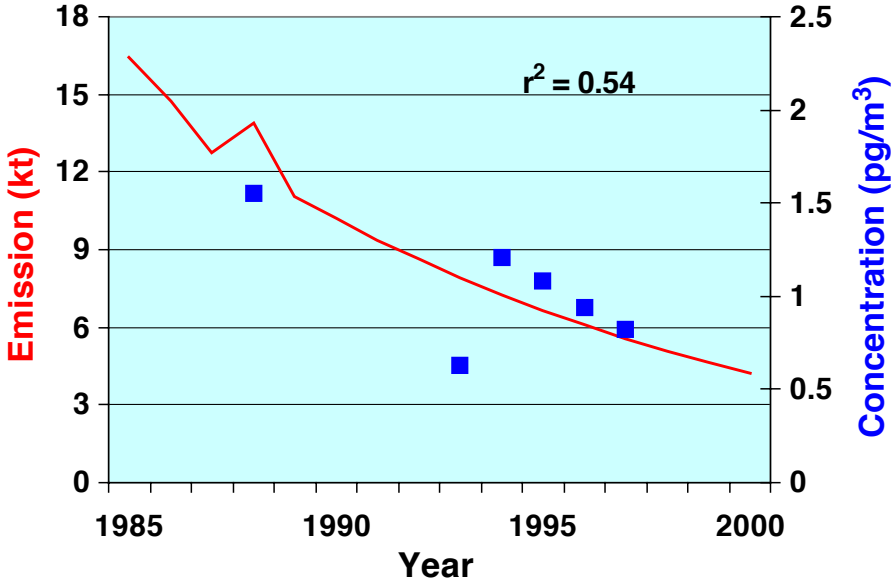
Summary of for selected time series from Canada, West Greenland, East Greenland and the European Arctic.



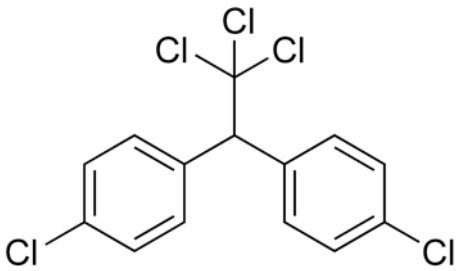



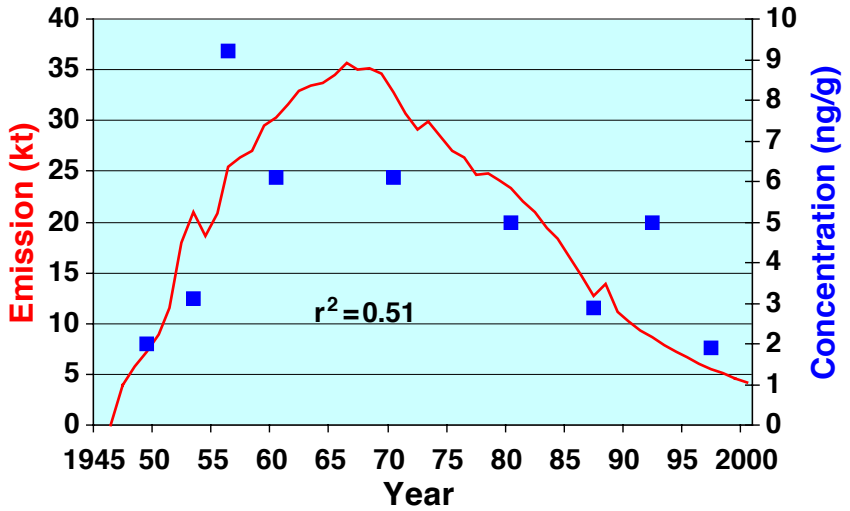

*AMAP, 2011*

# DDT emissions compared with air and lake sediments concentrations




DDT global emission (red line) and **air concentration** at Alert Station, (Nunavut, Canadian Arctic, 83°N)

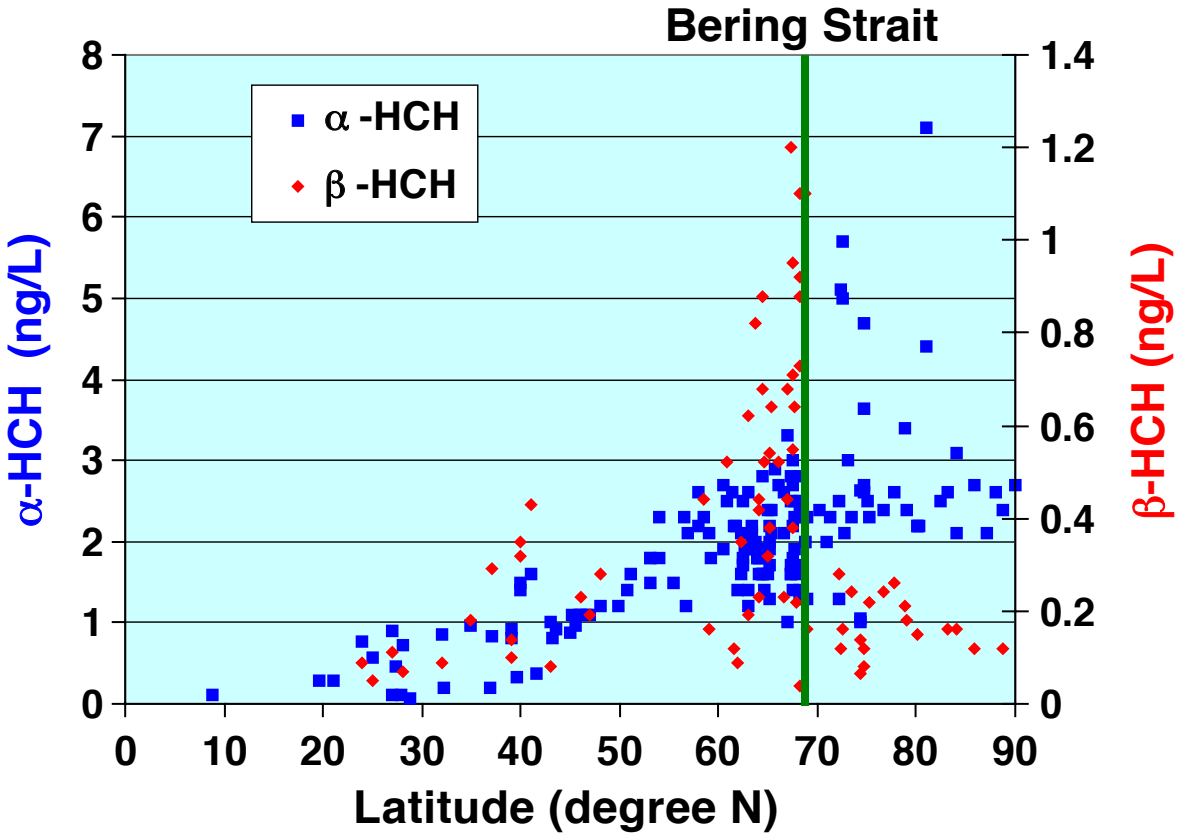


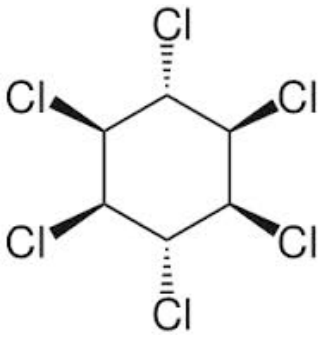




DDT global emission (red line) and concentration **in dated lake sediment**, (Devon Island, Nunavut, Canadian Arctic, 83°N)

*Li & Macdonnald, 2005*

# HCH concentrations in surface oceanic waters at different latitude

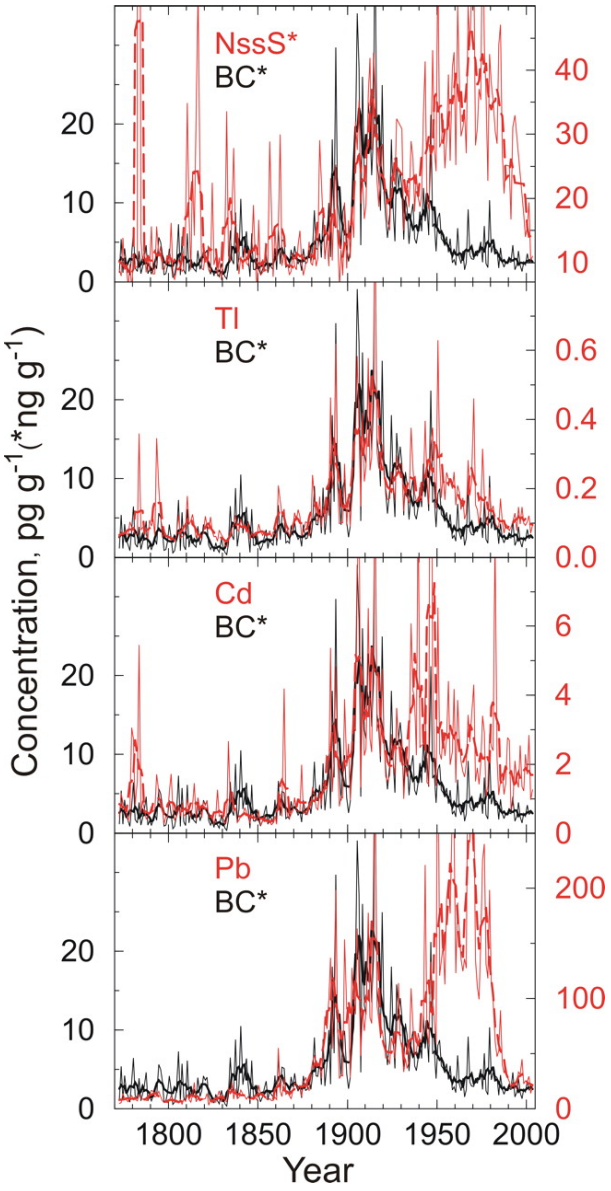


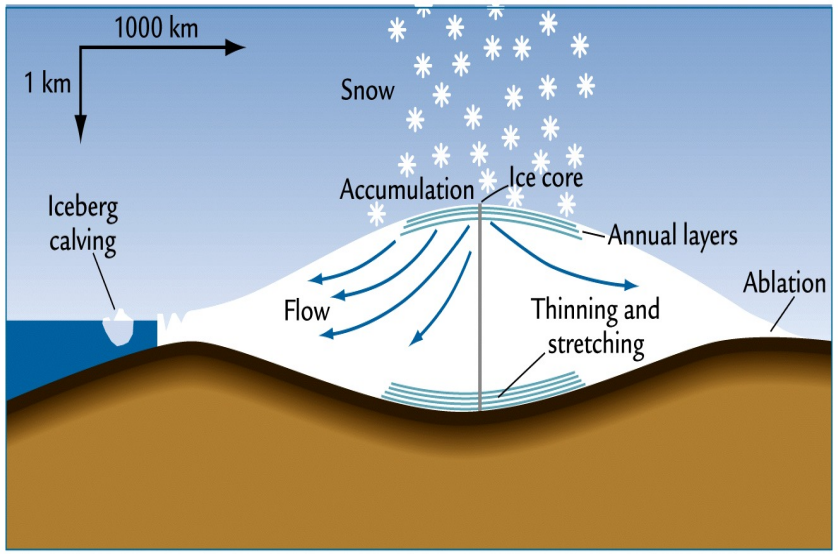




*Li & Macdonnald, 2005*

α-HCH and β-HCH concentrations in surface oceanic waters as a function of latitude from 1995 to 2005.

# Concentrations of nssS, Tl, Cd, Pb and BC in Greenland

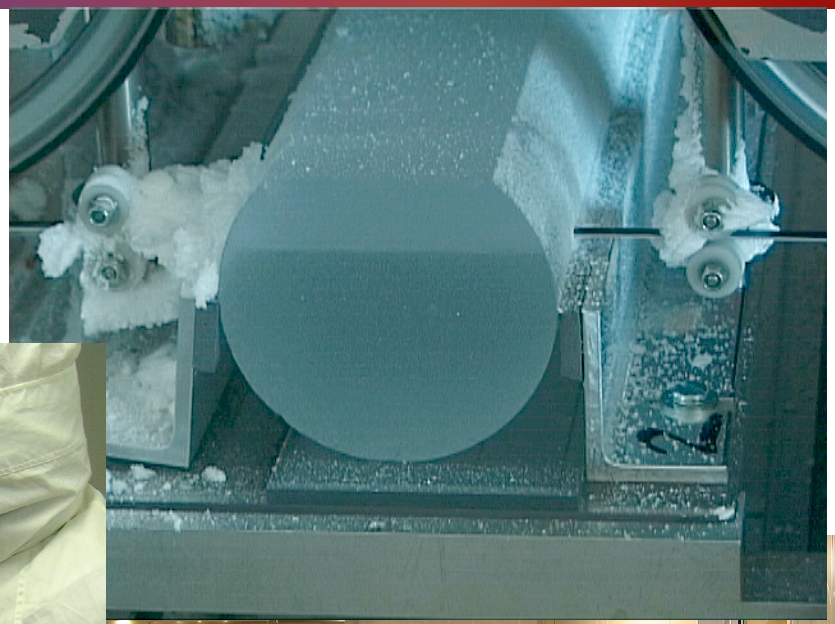



Continental ice sheets

McConnell & Edwards *PNAS*, 2008

# Ice core processing and analysis



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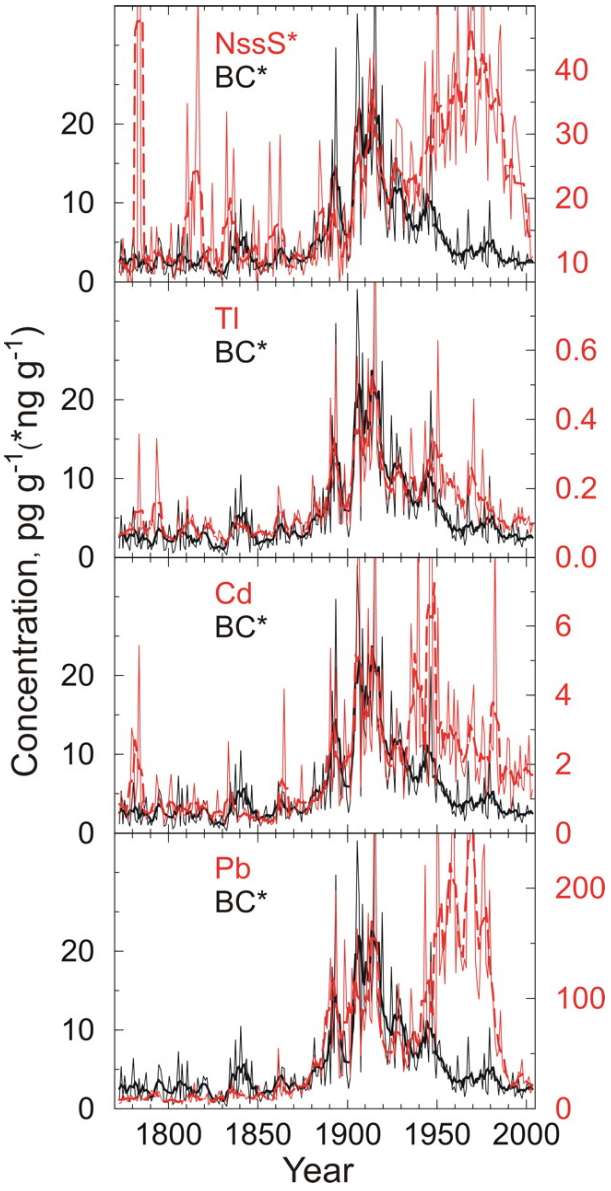
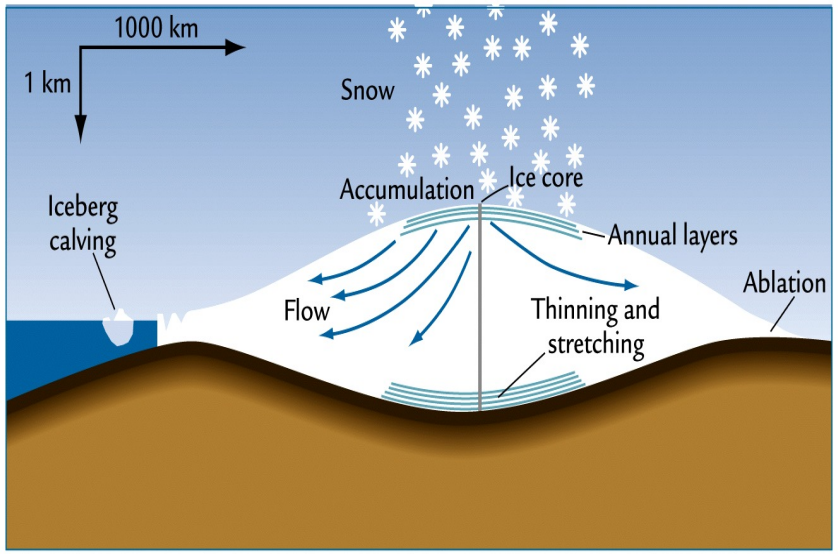



Continental ice sheets

McConnell & Edwards *PNAS*, 2008

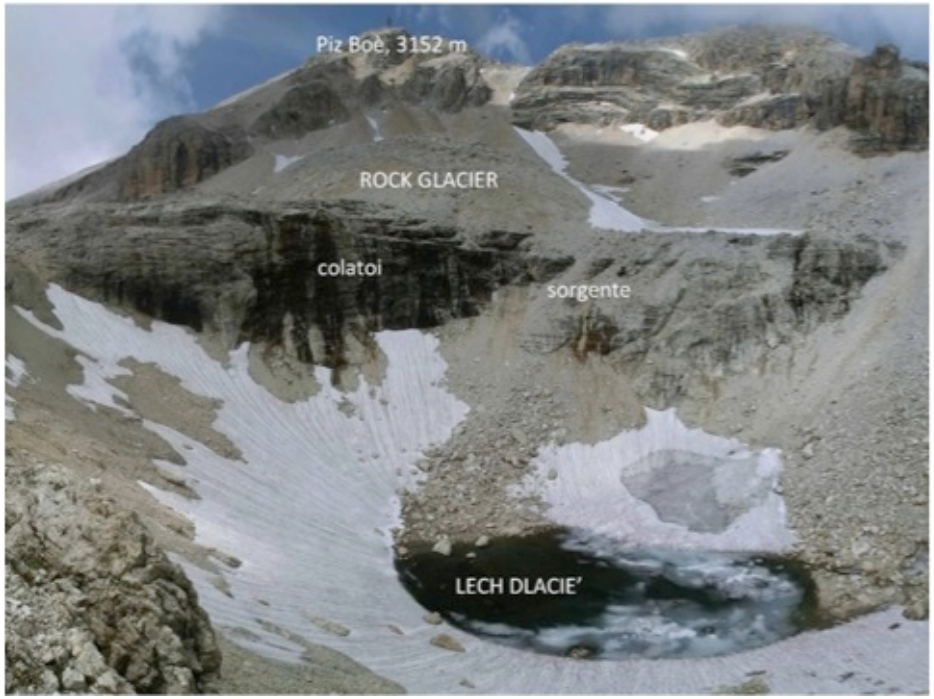
13.06.2006

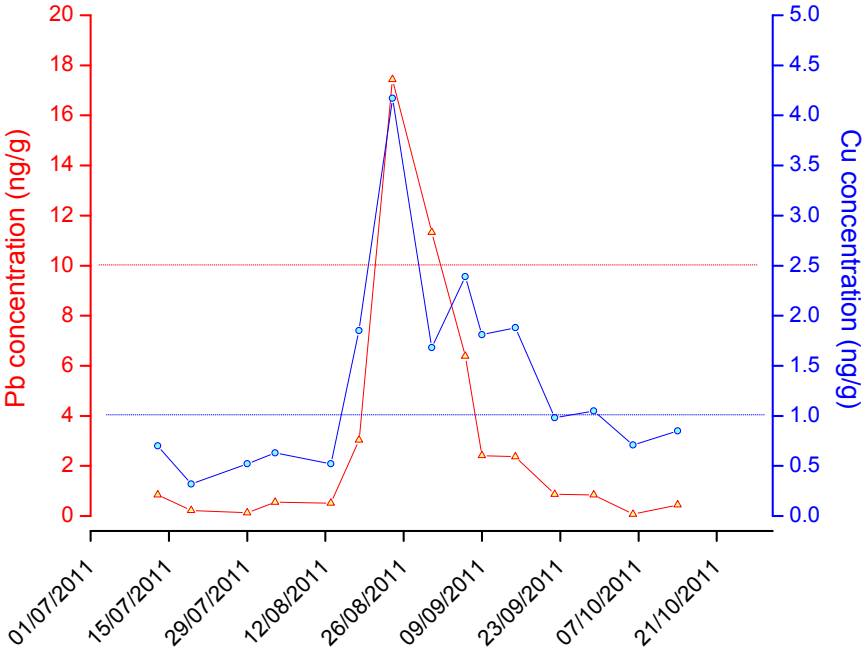
17.06.2008

12.06.2012

# Briksdalsbreen
# Norwegen

# Heavy metals release from Alpine rock glaciers and permafrost




During the melting season several heavy metals show **concentration levels higher than the legal threshold for drinkable waters.** This behaviour is not compatible with the geochemical characteristics of rocks and soil

Gabrieli, in prep. 2014

# Blast from the past !

*Environ. Sci. Technol.* **2009,** *43,* 8173–8177

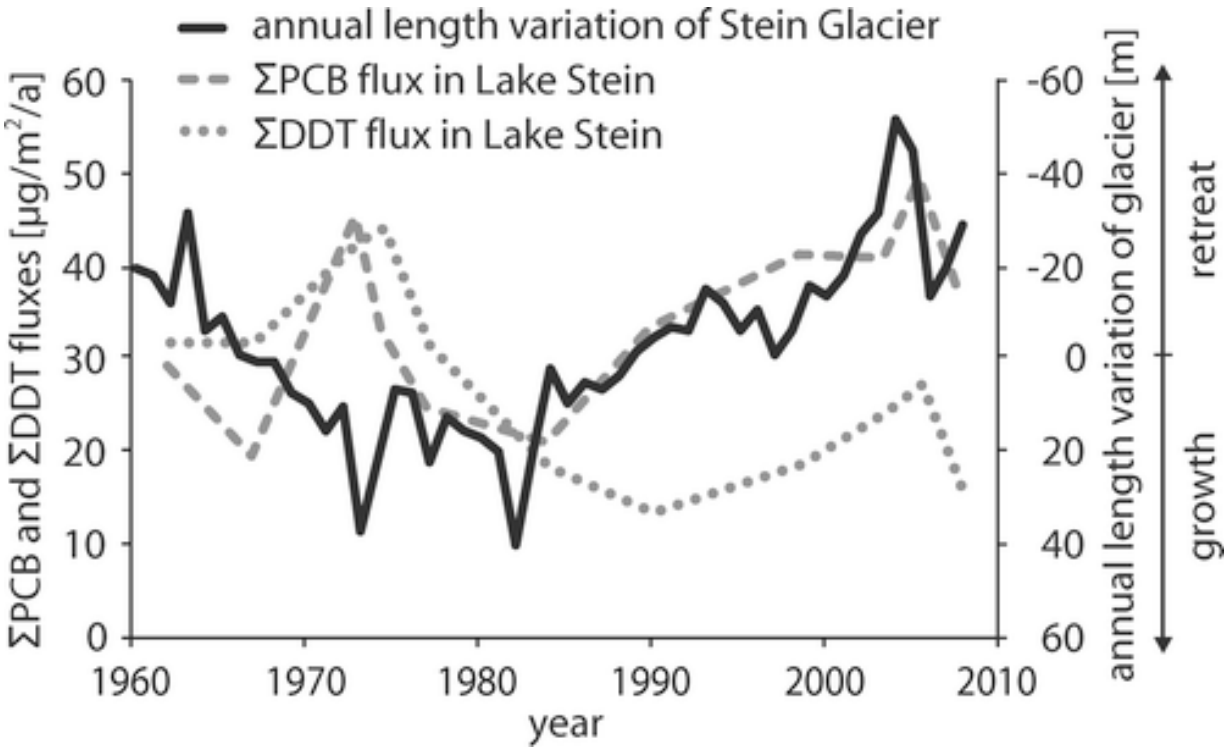
## Blast from the Past: Melting Glaciers as a Relevant Source for Persistent Organic Pollutants

C. Bogdal, 2009

*Environ. Sci. Technol.* **2011,** *45,* 203–208

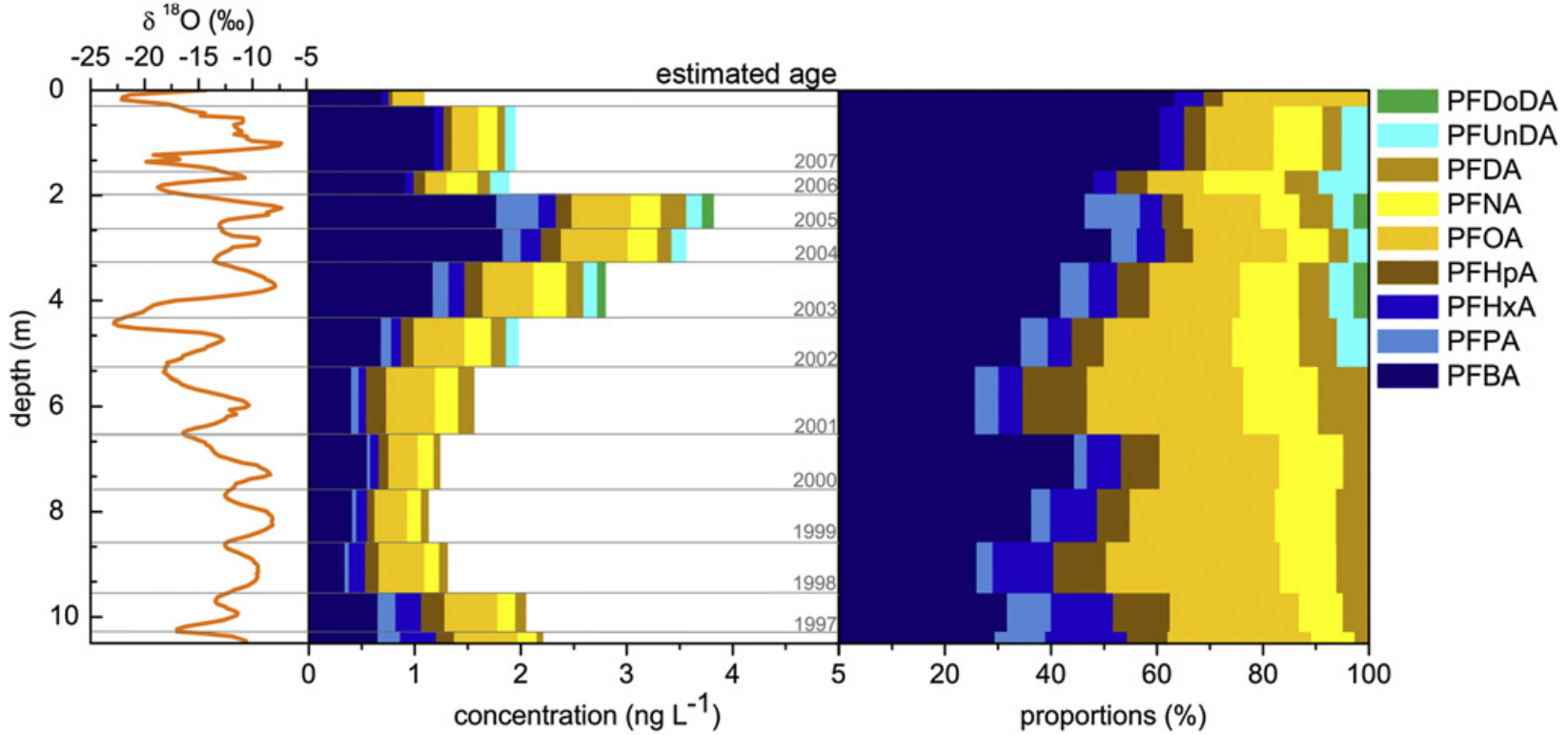
## The Missing Piece: Sediment Records in Remote Mountain Lakes Confirm Glaciers Being Secondary Sources of Persistent Organic Pollutants¶

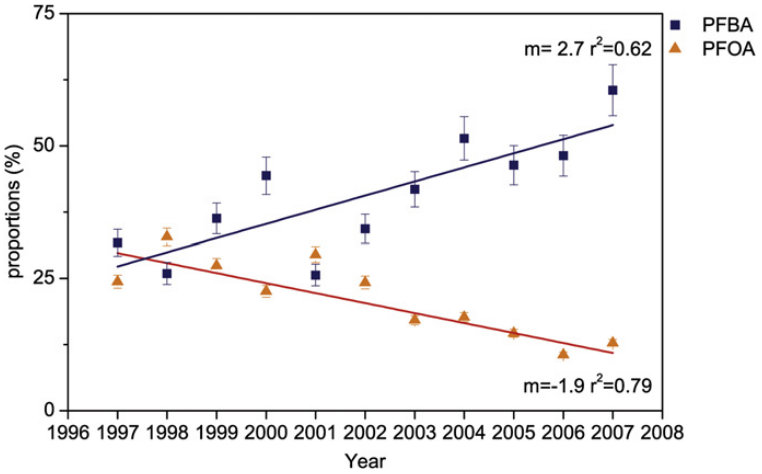
C. Bogdal, 2010




Input fluxes of ∑PCB and ∑DDT into Lake Stein and annual length variation of the Stein Glacier

# Emerging pollutants in Alpine snow and firn layers




Depth profiles of concentrations and proportions of the most frequently detected PFASs in a Colle Gnifetti shallow firn core. The orange line depicts the d18O ratio, used as a proxy for dating.

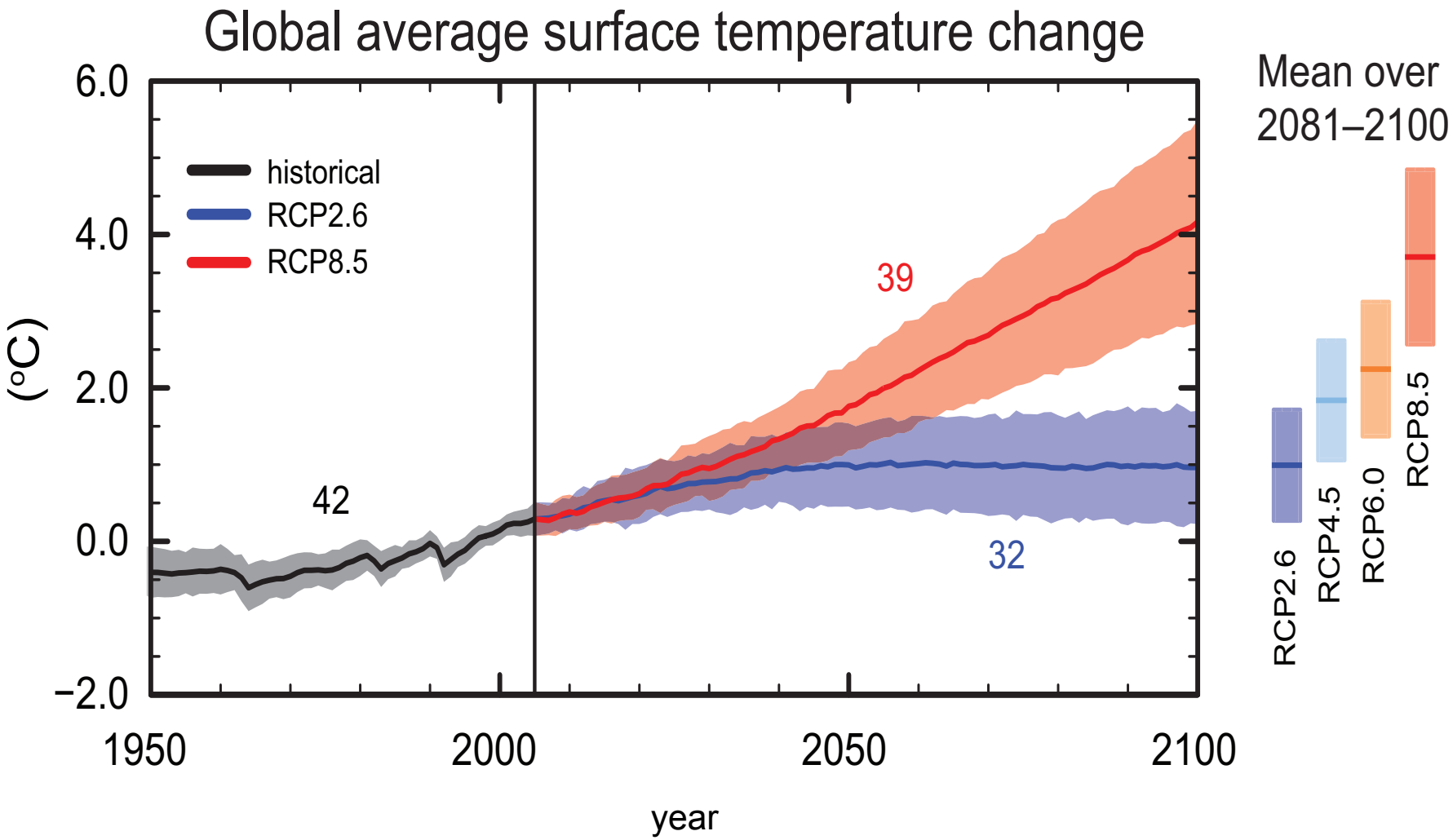
Annual proportion changes of PFBA and PFOA from 1997 to 2007

*Kirchgeorg et al, 2013*

# What do we know ….

- **Warming of the Arctic is unequivocal** and most of the observed increase in global average temperatures since the mid-20° century is very likely due to the observed increase in anthropogenic GHC concentrations. **Arctic amplification**
- Current Climate Changes are **strongly influencing the occurrence and the transport pathways** of contaminants to the Arctic. The hidden part of CC
- **Heavy Metal and POPs** are accumulated and recorded in Arctic ice dating back to several decades … millennia
- POPs and Heavy Metals accumulate along the food chain leading to **bioaccumulation and biomagnification**
- The current warming strongly influences the release of pollutants into the environment. **A blast from the Past !**

# A Look Forward to ….. 2050

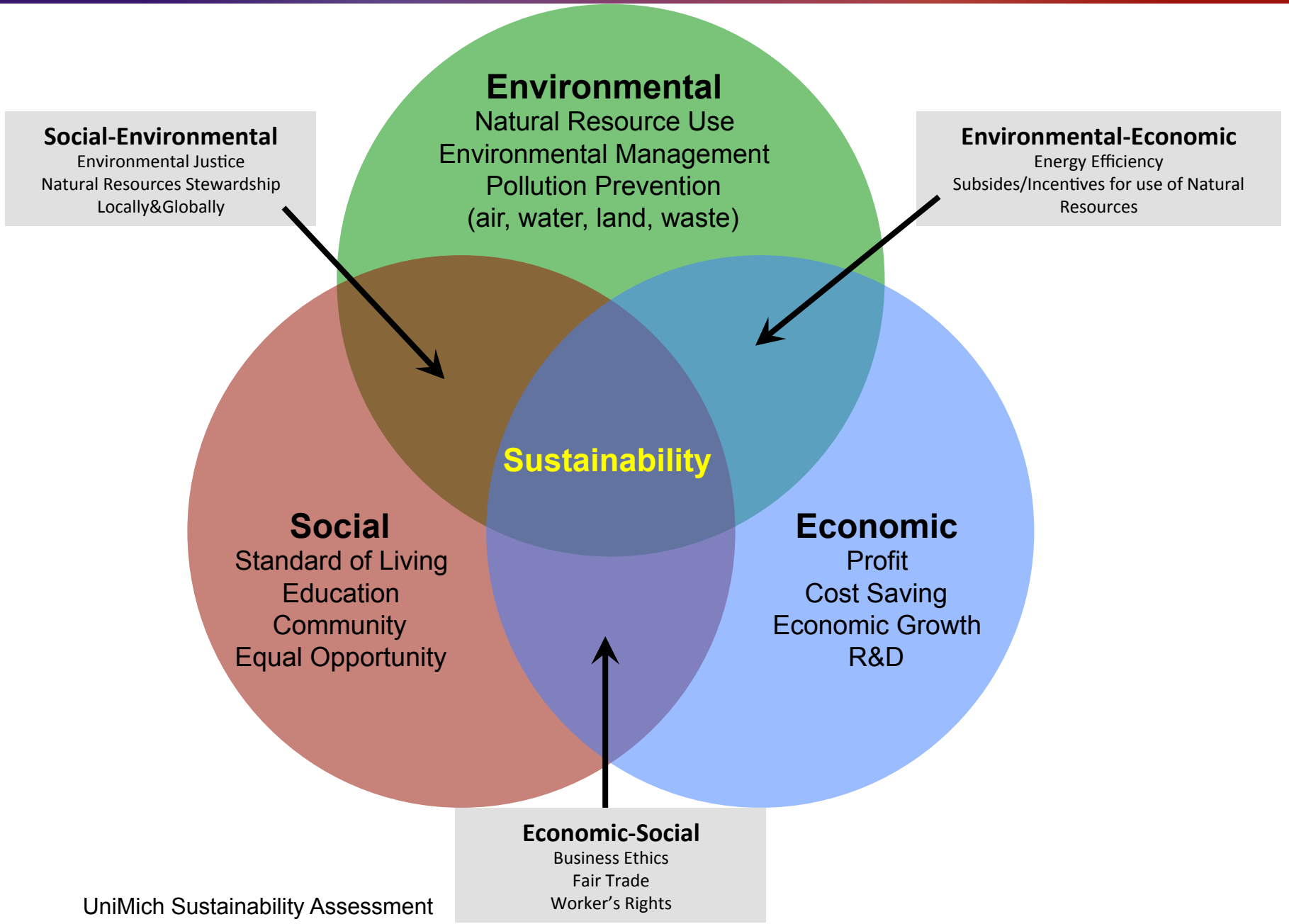



IPCC, 2013: Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis*.

# A Look Forward to ….. 2050 !

- **Increase/Improve** the climatic and environmental **observations** of the Arctic and integrate local communities in observational efforts
- **Improve climatic/environmental models** at a regional scale
- There is a new suite of **emerging pollutants** that have to be considered and monitored. Their toxicity effects are largely unknown.
- **Future local source evaluation** (off-shore activities, on-land and coastal installations).
- **Assess the impact of terrestrial warming** and permafrost thawing on the carbon cycle
- **Assess strengths and vulnerabilities of Arctic communities** facing the impacts of climate change and assist in developing adaptation strategies and tools to maximize sustainability
- **Adaptation tools for sustaining communities**

# The Three Spheres of Sustainability – the Arctic

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