Freshwater systems in the Arctic and how they are endangered

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Arctic Hydrological Cycle

Components
- Permafrost
- Soil moisture
- Lakes/wetlands
- Rivers
- Snow cover
- Glaciers/ice sheets

[Atmosphere]

Arctic-CHAMP
http://arcticchamp.sr.unh.edu/
Quantifying freshwater

www.awi.de/en/go/sparc
Permafrost

- perennially frozen ground with an annual ground temperature at or below 0°C for at least two consecutive years

- covers about 25% of the land masses of the Northern Hemisphere

Photo: A. Morgenstern

www.awi.de/en/go/sparc
Soil moisture

Water content of the soil

• Affects land-atmosphere moisture and energy fluxes and soil heat transfer
• Important variable for crop land („green water“)

Langbein Lecture: The Soil Underfoot: Green Water and Global Food Security, AGU, 2012 (video on demand) by Garrison Sposito (University of California, Berkeley, USA)

www.awi.de/en/go/sparc
Lakes and ponds

- Arctic is dry desert (very little precipitation)
- Water stored in large lakes is mostly “fossil”
- Smaller water bodies (smaller than 10 000m²) are not accounted for!

Boike et al. 2012. Ecosystems and the Global Carbon Cycle
Wet tundra
Dry tundra
Open water

Zooming in on polygonal tundra

Few large lakes
Ponds (smaller than 1 000m²) dominate in number
Ponds need precipitation (P~ET) to sustain their water level

Muster et al. 2012 Tellus B
Abnizova et al. 2012 Global Biogeochemical Cycles
Boike et al. 2013. Biogeosciences
River runoff

- nearly all of the ungauged portion lies north of 67 degrees latitude
- total runoff not known
- many freshwater observing networks have diminished

CAFF map number 21: http://library.arcticportal.org/1347/
Thermohaline Circulation

- NADW formation is driving factor for conveyor belt
- less influx through rivers could slow this down or shut off
  → temperature drop in continental Europe (2-5°C)

Freshwater inflow Arctic ocean
Largest component of the cryosphere: mean maximum extent in the Northern Hemisphere of approximately 47 mio km² or nearly 50%.

It effects

- albedo
- energy and water exchange
- water balance (ponds, lakes, rivers)
Ice sheets contain enormous quantities of frozen fresh water!

Influence on Arctic
- Freshwater budget
- Weather
- Climate

If the Greenland Ice Sheet melted, the estimated sea level rise ~ 6 meters
Regional impacts

La Grande River
Northern Quebec, Canada

Shipping and transport, Lena River Delta, Siberia

Transport on ice roads, Alaska

Prudhoe Bay Oilfield, Alaska

https://www.flickr.com/photos/djipibi/7056868461

http://ine.uaf.edu/werc/
Global importance:

1. Albedo feedback
2. Greenhouse gas emissions/uptake (currently the Arctic is a sink)
3. Ocean circulation feedbacks (freshwater flow and energy flux into Arctic ocean as drivers of global climate change)

Regional importance:

1. Water and energy exchange
2. Resources for people (freshwater supply, industry, fisheries, agriculture, transport, leisure)
3. ....
Challenges and priorities

We are observing changes! There is a need for....

- models that are useful at scale of interest
- weather and climate data collection (with adequate spatial and temporal scales for development and validation of models)
- coordination of long term monitoring sites
- improving communication among scientists, residents, managers,...
Freshwater systems are also simply beautiful.....