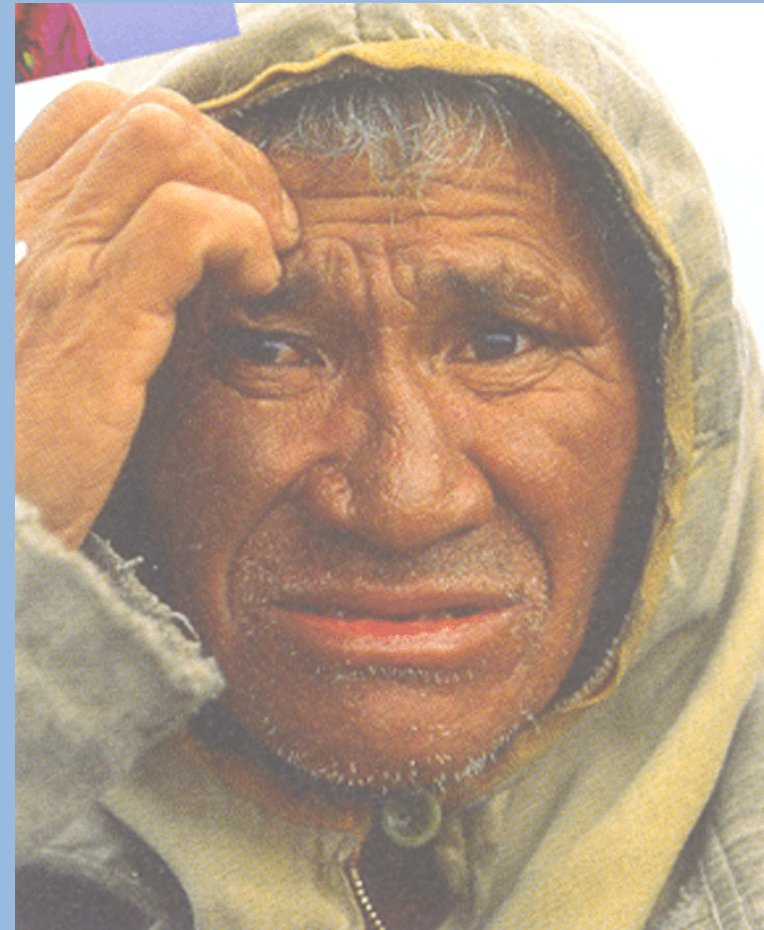


## Arctic – The Barometer of the Globe

Climate change and future scenarios in  
the Arctic Region  
11<sup>th</sup> December 2014

Lars-Otto Reiersen  
AMAP Executive Secretary



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*Arctic Monitoring and Assessment Programme*

## Thawing of the Cold war

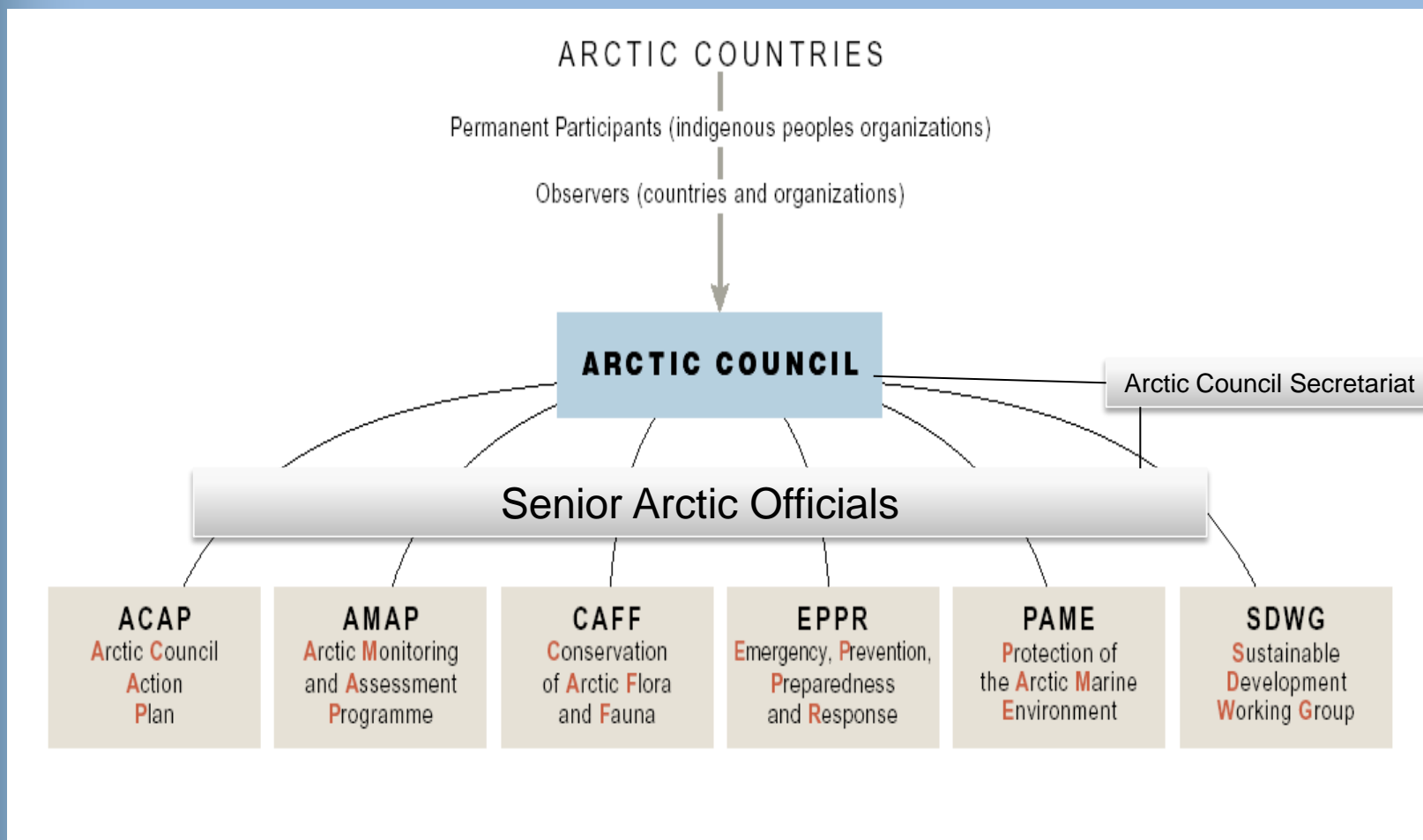




ARCTIC COUNCIL

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## Arctic Monitoring and Assessment Programme





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### Permanent Participants (6 Arctic Indigenous Orgs):

- Aleut International Association
- Arctic Athabaskan Council
- Gwich'in Council International
- Inuit Circumpolar Council
- Saami Council
- Russian Arctic Indigenous Peoples of the North (RAIPON)

### AMAP Assessment 2009: Human Health in the Arctic



Arctic Monitoring and Assessment Programme (AMAP)

# AMAP

*Arctic Monitoring and Assessment Programme*

**AMAP** initiated in 1991 to monitor and assess levels, trends and effects on Arctic ecosystems and humans:

**Pollutants** – Persistent Organics (POPs), heavy metals, radionuclides, petroleum hydrocarbons & acidification;

**Climate change**, incl. UV, ozone, black carbon, methane & ocean acidification;

**Analyzing samples** from: air, water, snow, ice, sediments, plankton, invertebrates, fish, birds, mammals & humans;

**Perform integrated assessments** of several drivers.

**Provide science based policy related Actions**

# AMAP

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## AMAP's geographical coverage



## AMAP products



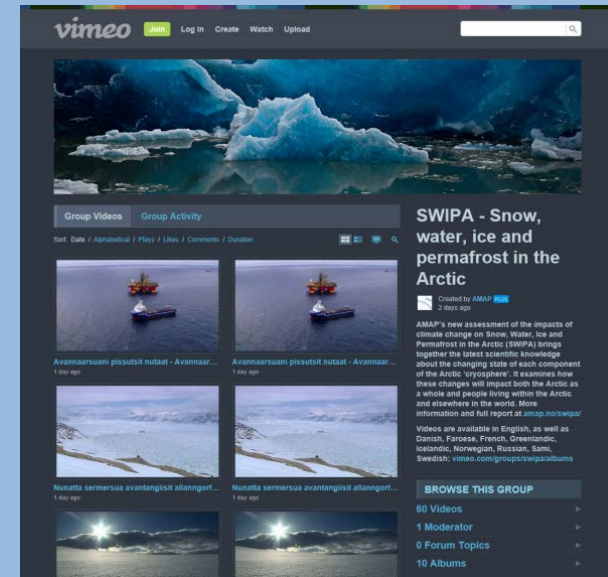
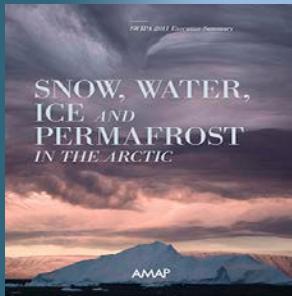
### Science assessment report

- **Made by scientists;**
- **Independent peer review;**
- **Presented at science conferences & publications;**

# Robust spin-off products



- Laymans report
- Summary for policy makers
- Layman summaries
- DVD Films
- Social media
- Technical reports





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## AMAP Assessment - leads

Persistent Organic

Pollutants (**POPs**)

Canada & Sweden

Radionuclides

Norway & Russia

Mercury

Canada & Denmark

Oil

Norway & USA

Human health

Canada & Norway

Adaptation Action for a

Changing Arctic (**AACA**)

Norway & USA

1. Barents: Finland, Norway, Russia & Sweden

2. Bering/Chukchi: Canada, Russia & USA

3. Baffin/Davis Strait: Canada & Denmark/Greenland

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## AMAP Climate Assessments - leads

Status, Feedbacks & Forecast: Russia & USA

Land ice: Canada, Denmark/Greenland,  
Russia & USA

Sea ice: Canada, Norway & USA

Permafrost: Russia & USA

Snow: Canada

Arctic Freshwater Synthesis: Canada

Ocean Acidification: Norway & USA

SLCF: - BC & Ozone: Norway & USA

- Methane: Canada & USA

# Evaluating specific episodes: PCBs at Ny-Ålesund

AMAP  
ARCTIC MONITORING and ASSESSMENT Programme



**View from the station on  
a clear day...**

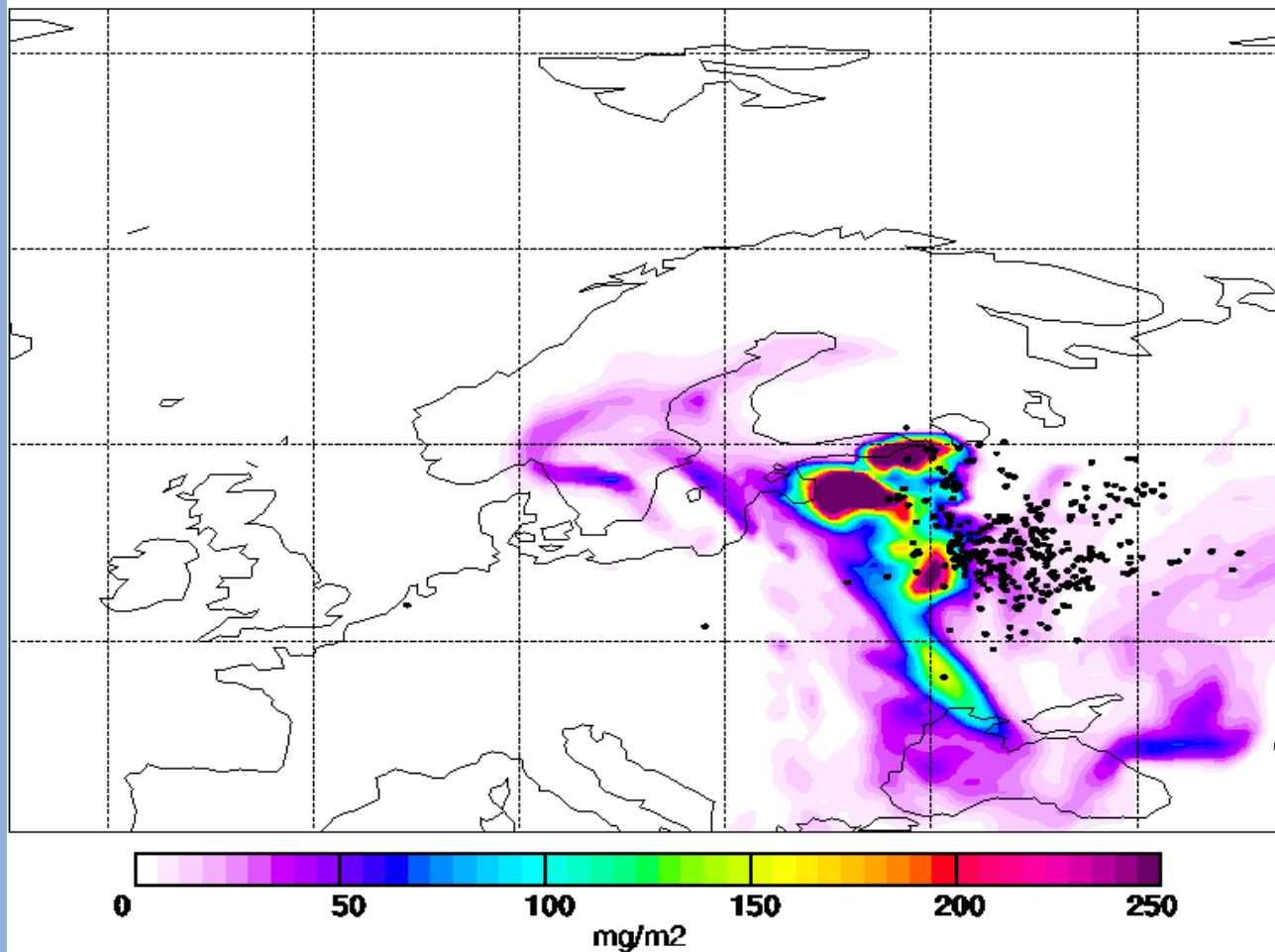
**And during the 2nd  
episode in May, 2006**



<http://www.amap.no>

# Evaluating specific episodes, e.g. PCBs at Ny-Ålesund

Simulation start 20060407. 0 Actual time 20060425. 0



### Riverine pathway

Main runoff in June

70 % of water from south of the Arctic.  
Mainly due to LRT,  
but also significant local inputs.



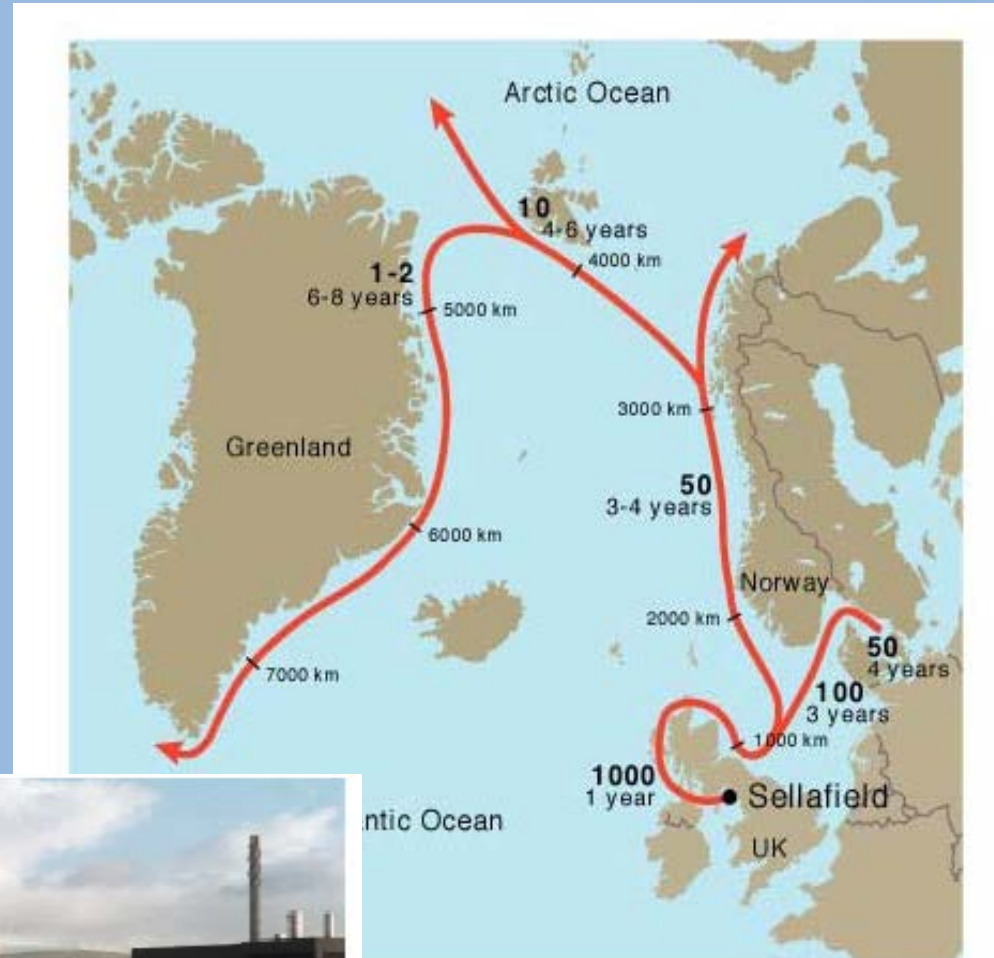
# AMAP

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### Marine pathway

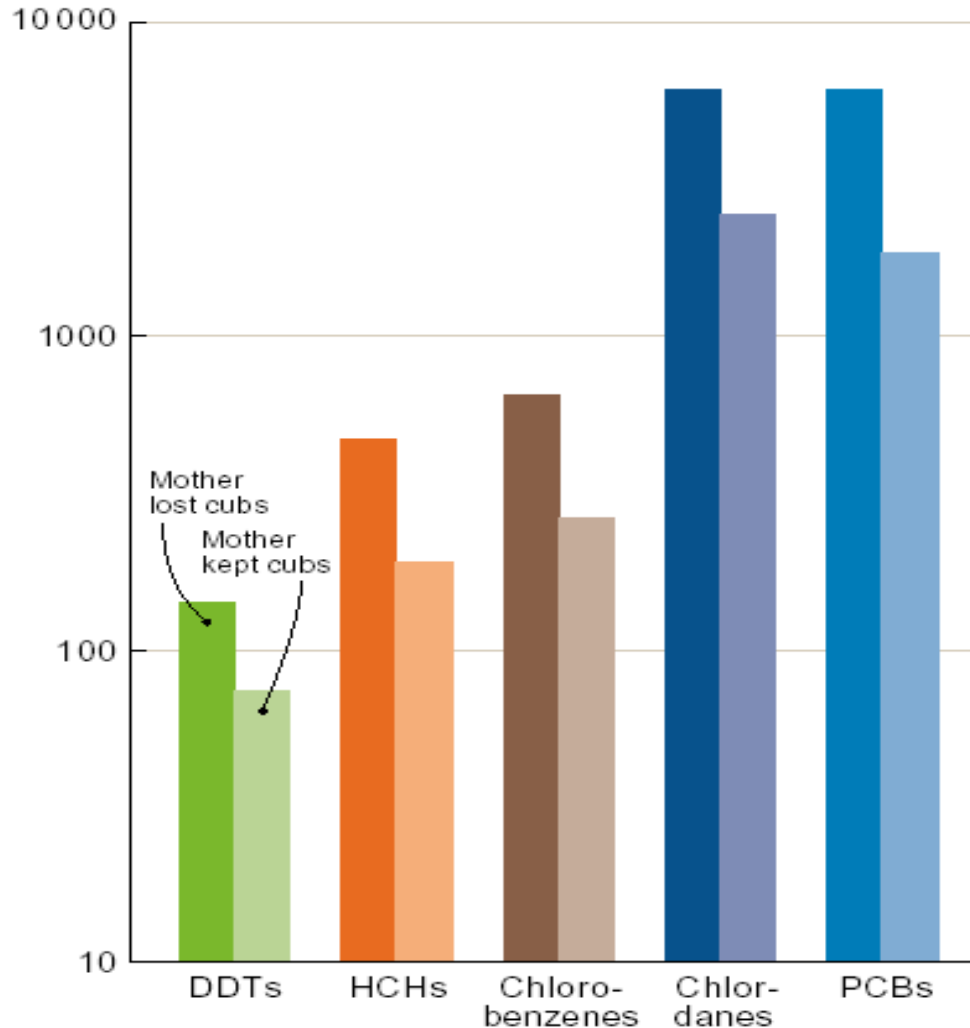
#### Radionuclides

Mainly from storage and handling of spent nuclear fuel and waste, operation of nuclear power plants and vessels and military installations. Continued concern over previous releases from 'old sins'



### Effects of POPs on Reproduction of Polar Bears

Concentrations, ng/g lipid weight



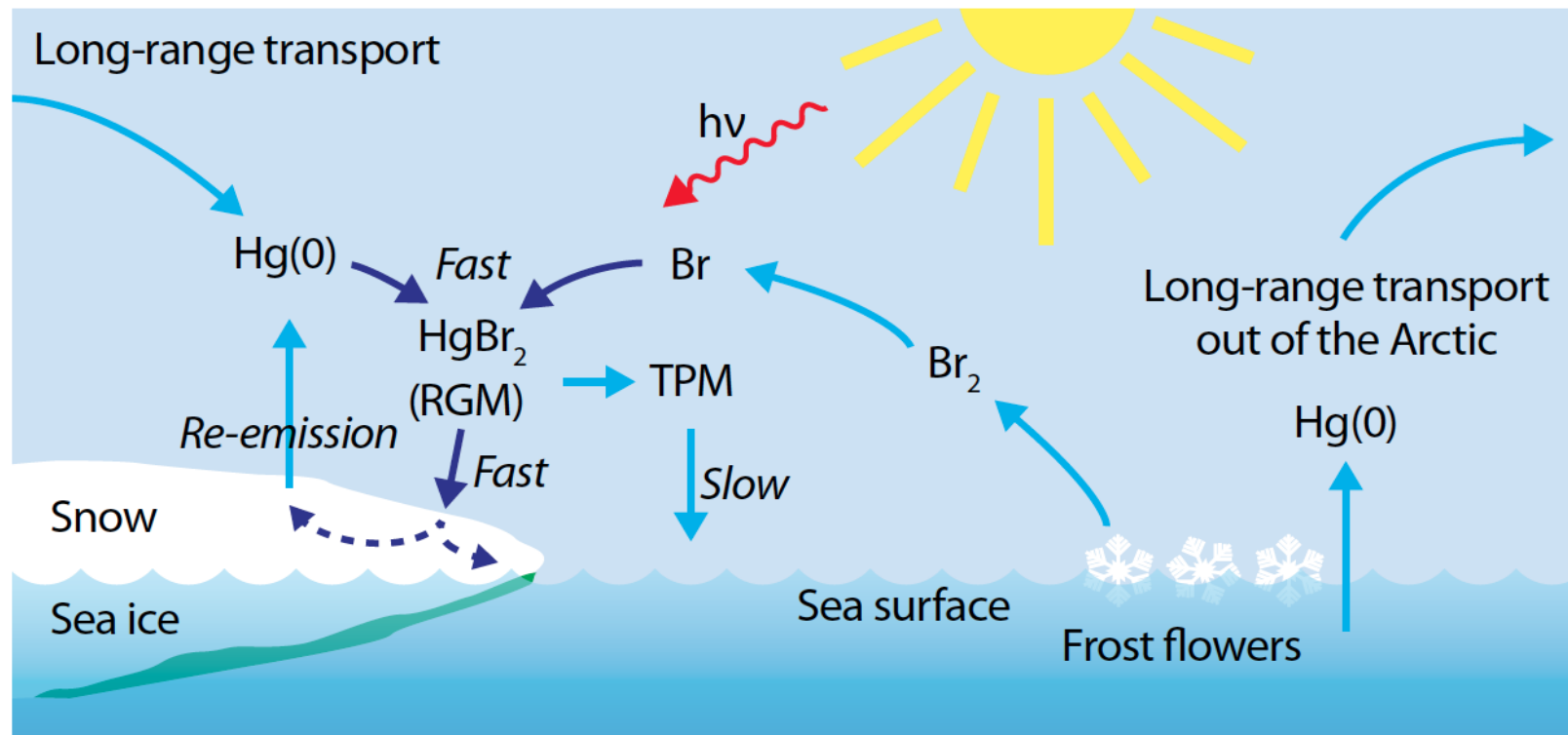
# POPs of Emerging Arctic concern

- Per-polyfluorinated compounds (PFCAs, PFSAs, etc.)
- Brominated flame retardants (BDE-209, HBCD, DPTE, etc.)
- Chlorinated flame retardants (Dechlorane plus, Dechlorane 602, etc.)
- Organophosphate-based flame retardants and plasticisers (TnBP, TCEP, TCPP, TDCPP, etc.)
- Phthalates
- Short-chained chlorinated paraffins
- **Siloxanes**
- **Pharmaceuticals and personal care products**
- Polychlorinated naphthalenes
- Hexachlorobutadiene
- **Current used pesticides** (Dicofol, Pentachlorophenol/anisole, etc.)
- Mono-dibutyltins
- PACs (e.g. nitro-PAHs, hydroxyl-PAHs, alkyl-PAHs)
- PCB11 from smelting
- Halogenated natural products (naturally formed BDEs, OH-BDEs, MeO-BDEs, brominated dioxins etc.)



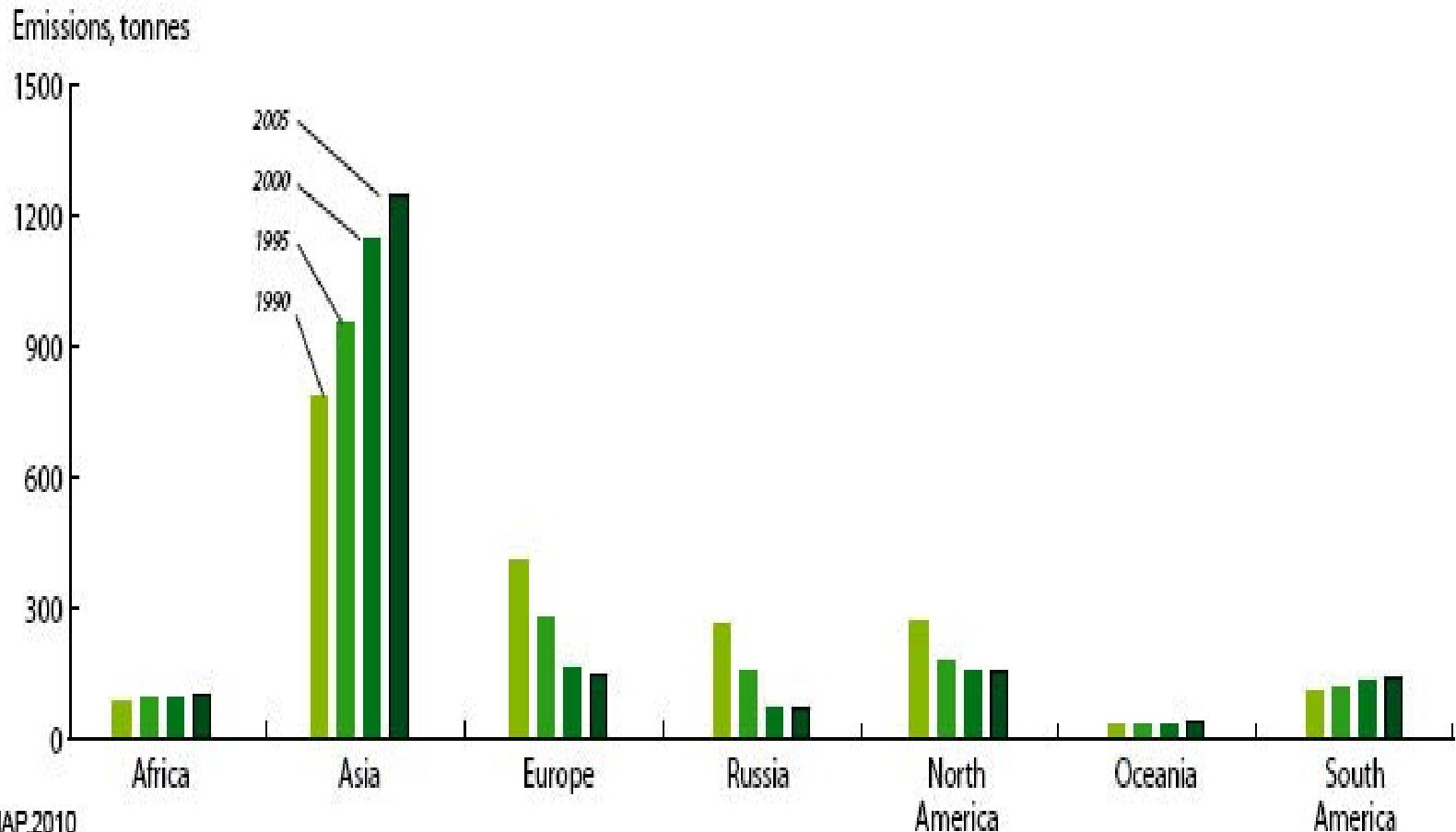


# Mercury cycle in the Arctic



Combined effects, Climate and Contaminants, (AMAP 2012).

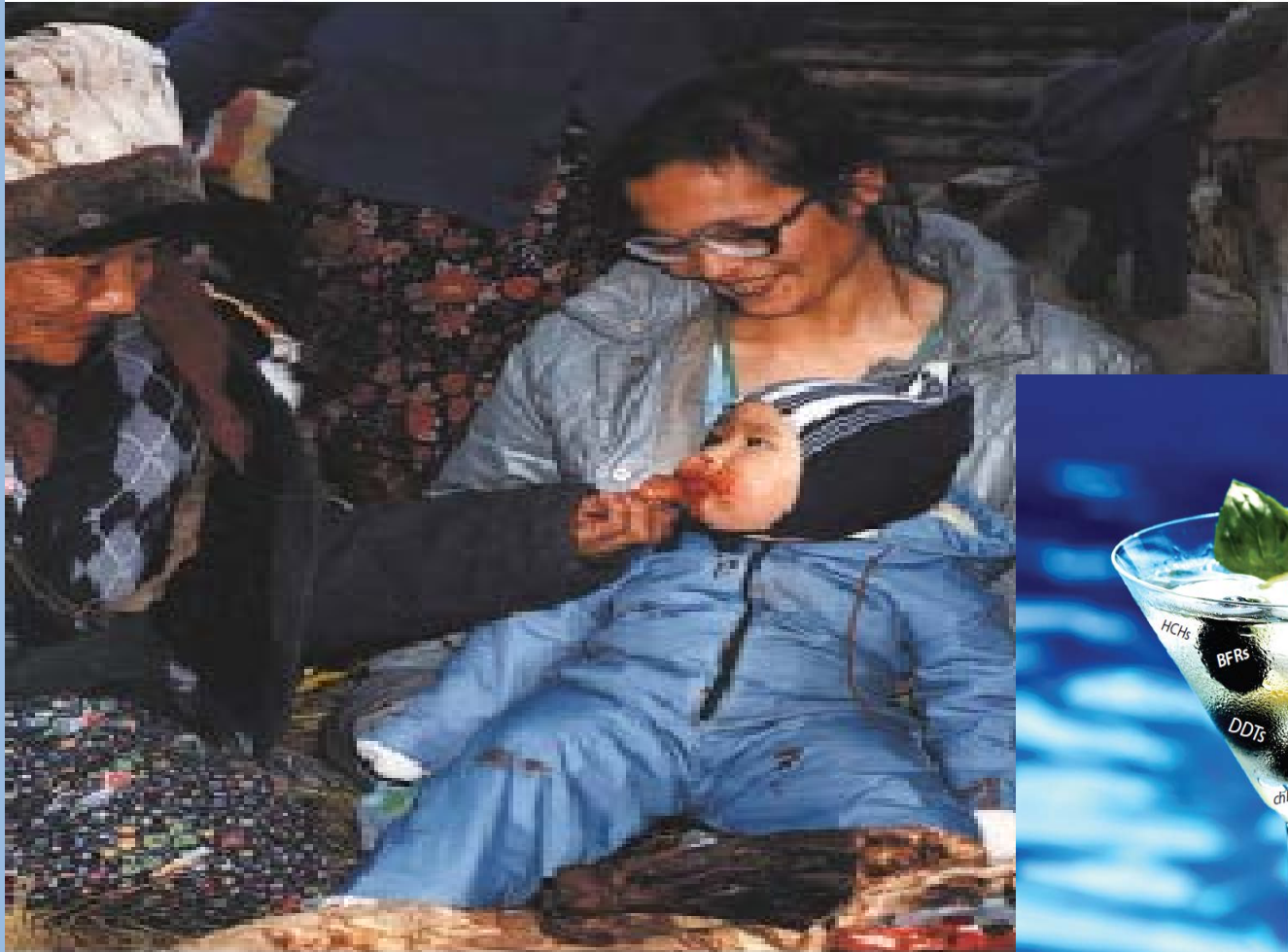
## Global emissions of Mercury 1990 – 2005 (AMAP 2011)



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**Shaken not stirred!**



# AMAP

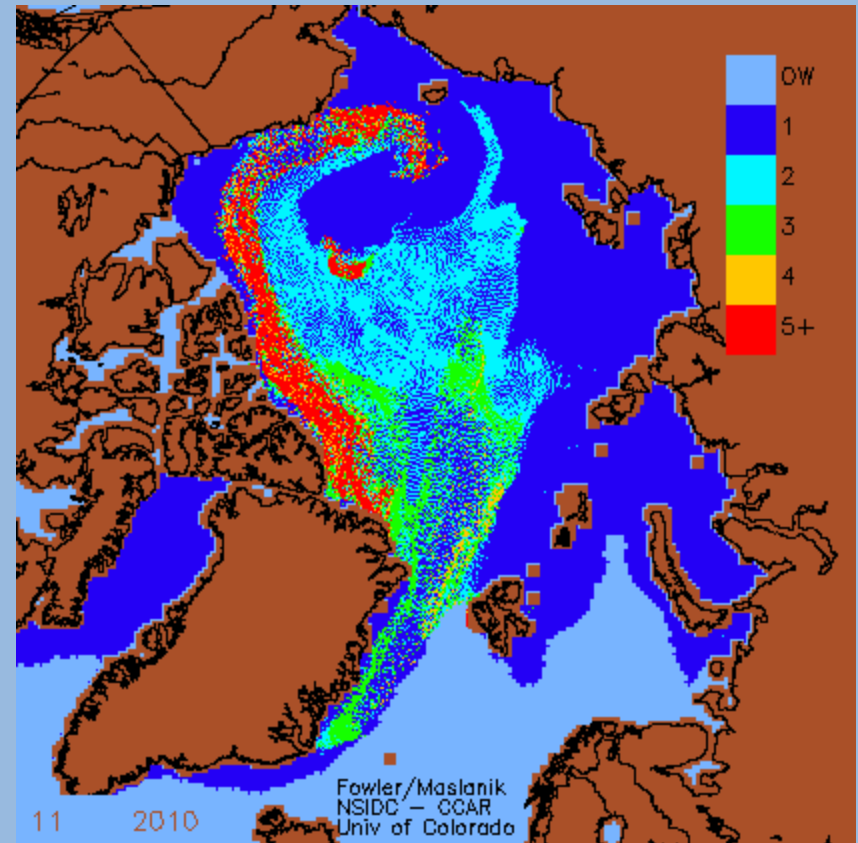
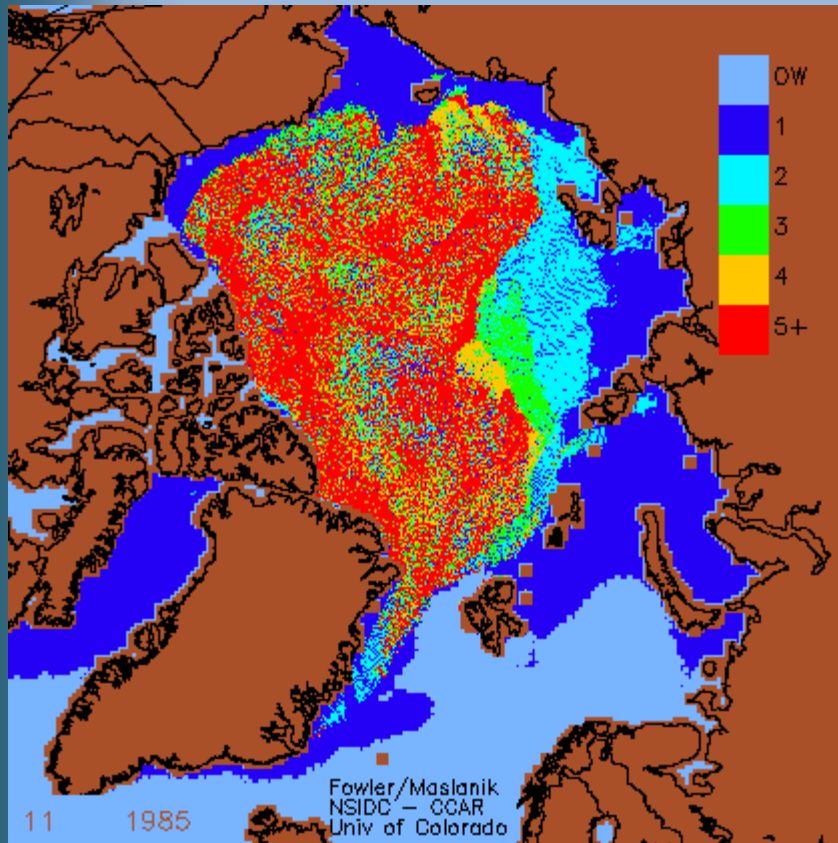
## Arctic Monitoring and Assessment Programme

### Ice is getting younger and thinner (ACIA & SWIPA)

Much of older, thicker ice north of Alaska now melting away during summer

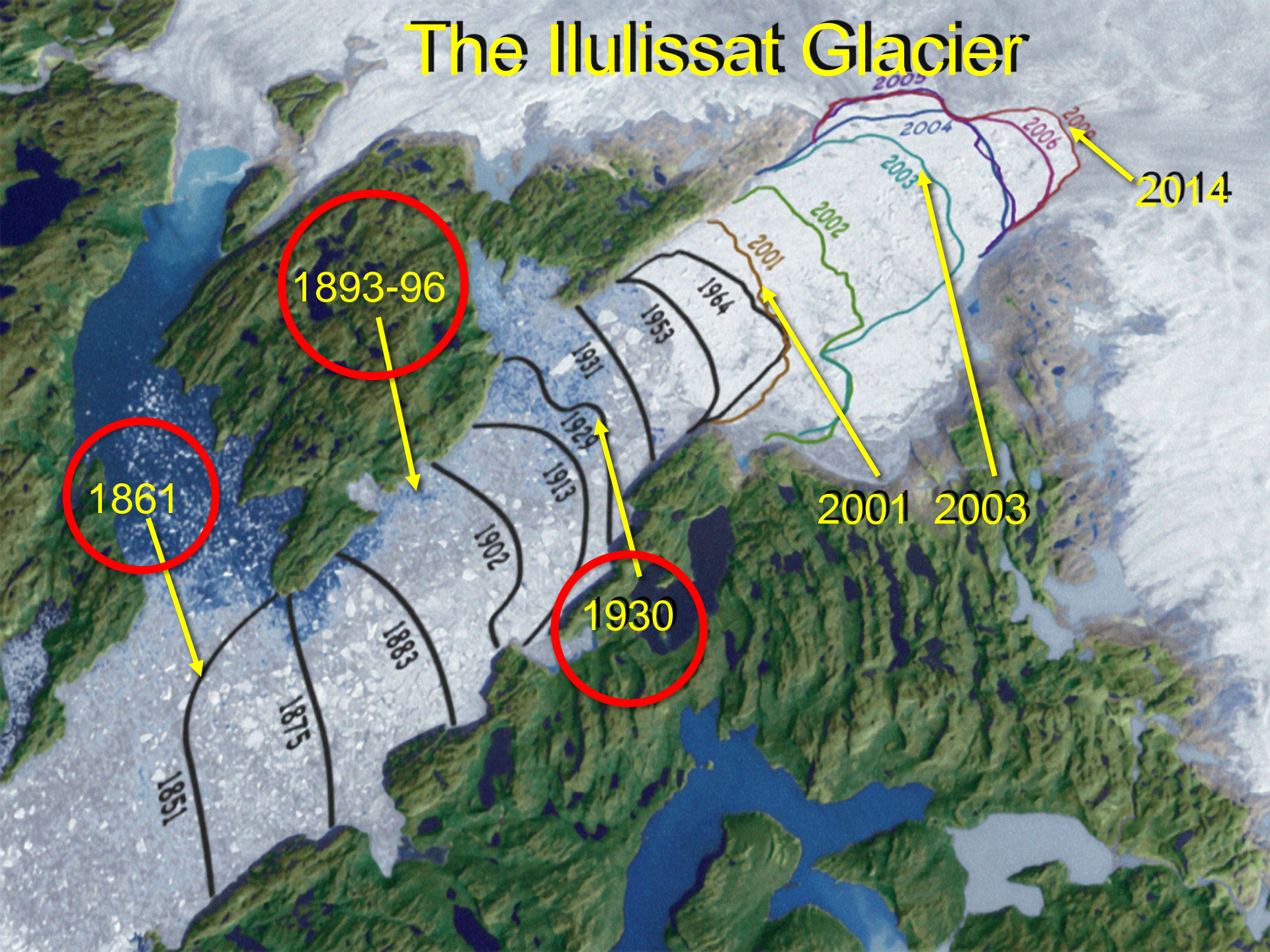
Mar 1985 – Mar 1986

Mar 2010 – Mar 2011



Based on satellite observations; from J. Maslanik, C. Fowler, Univ. Colorado

# The Ilulissat Glacier

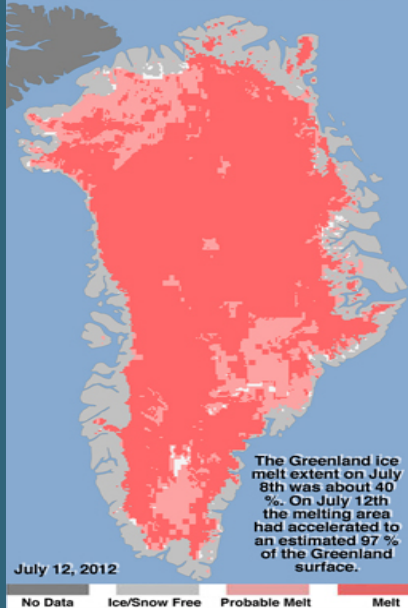


# AMAP

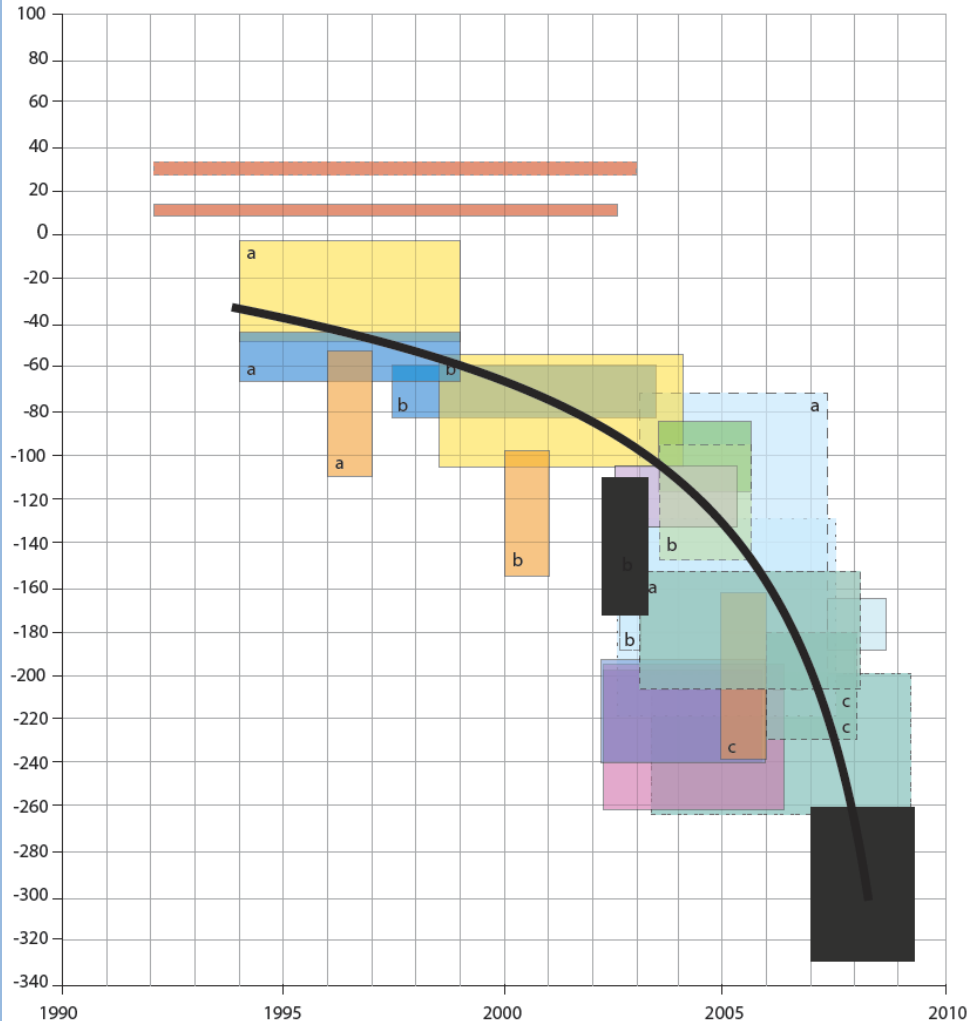
## Arctic Monitoring and Assessment Programme

# Greenland Mass Balance

### Extent of Surface Melt Greenland's Ice Sheet



Net balance, Gt/y



#### Radar Altimetry

- Johannessen et al., 2005
- Zwally et al., 2005 [SRALT]

#### Laser Altimetry

- ab Krabill et al., 2004 [ATM]
- ab Thomas et al., 2006 [ATM + GLAS]
- a Slobbe et al., 2009 [GLAS, density range  $\pm 300 \text{ kg/m}^3$ ]

#### Mass Budget

- abc Rignot and Kanagaratnam, 2006 [InSAR + SMB]
- van den Broeke et al., 2009 [SMB + InSAR]

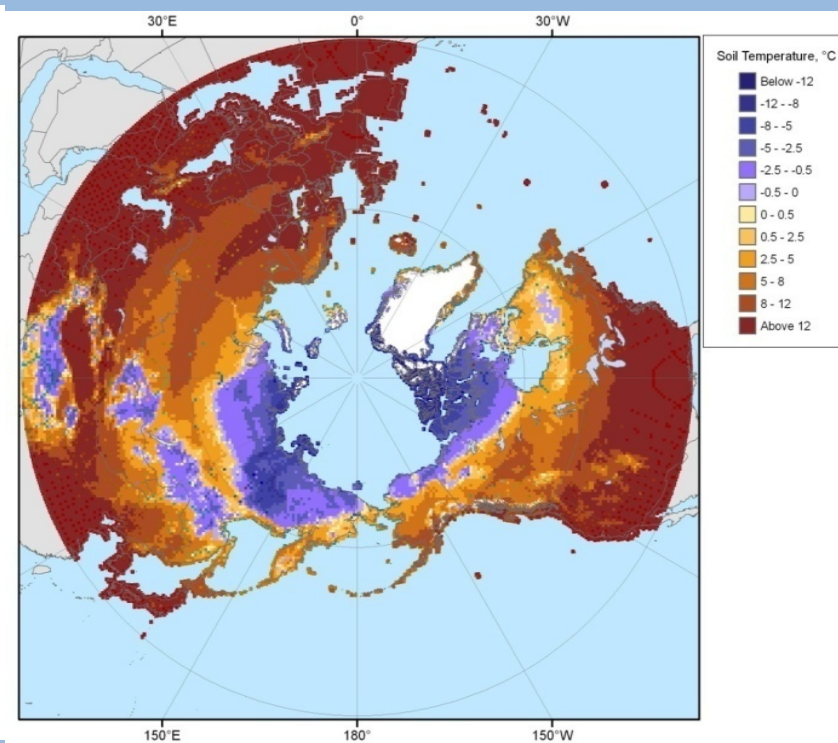
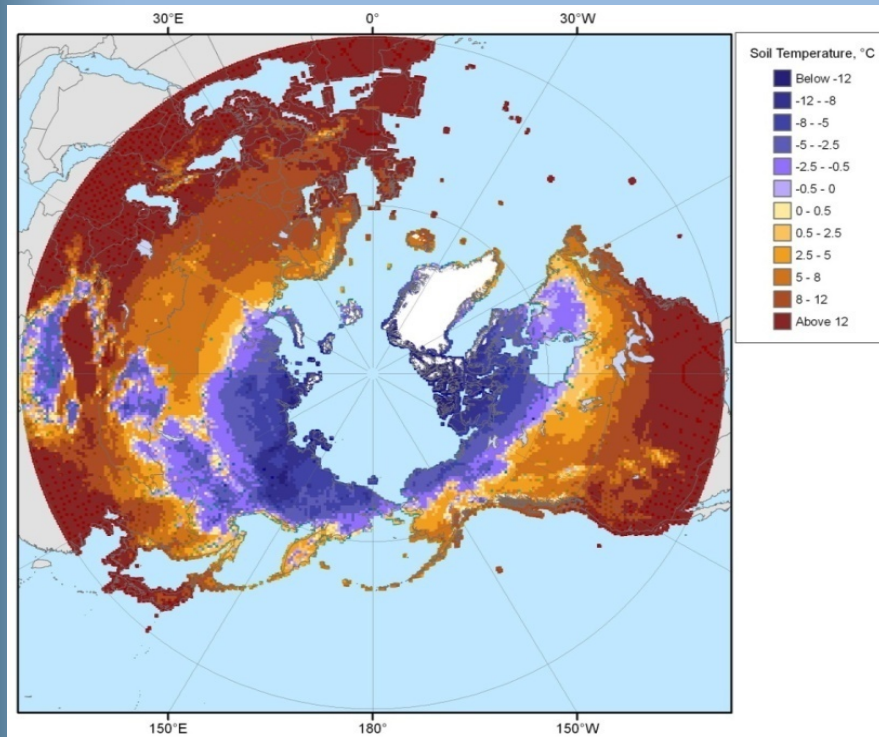
#### Satellite Gravity (GRACE)

- Luthke et al., 2006 [GRACE/MASCON]
- Chen et al., 2006 [GRACE]
- Vellicogna and Wahr, 2006 [GRACE]
- Vellicogna, 2009 [GRACE]
- Ramillien et al., 2006 [GRACE]
- Wouters et al., 2008 [GRACE/EOFfilter]
- b Slobbe et al., 2009 [GRACE, CNES/CSR/DEOS/GFZ range]
- Baur et al., 2009 [GRACE, CSR/GFZ/JPL products, see Table 8.4 for range]
- Vellicogna, GRL, 2009

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### Permafrost area, Projections for 2050 and 2090





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## Vegetation & Biodiversity Shift

Current Arctic Vegetation



©2004, ACIA / Map ©Clifford Grabhorn

Projected Vegetation, 2090-2100



- Ice
- Polar Desert / Semi-desert
- Tundra
- Boreal Forest
- Temperate Forest
- Grassland

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## Arctic Freshwater Systems (Budget)

Atmospheric – precipitation, moisture, N-S,

Terrestrial - hydrology, ecology, shifts,

Ocean – freshwater, circulation, biodiversity,  
storm tracks,

Resources – water supply, transport, hydro,  
mining, etc.

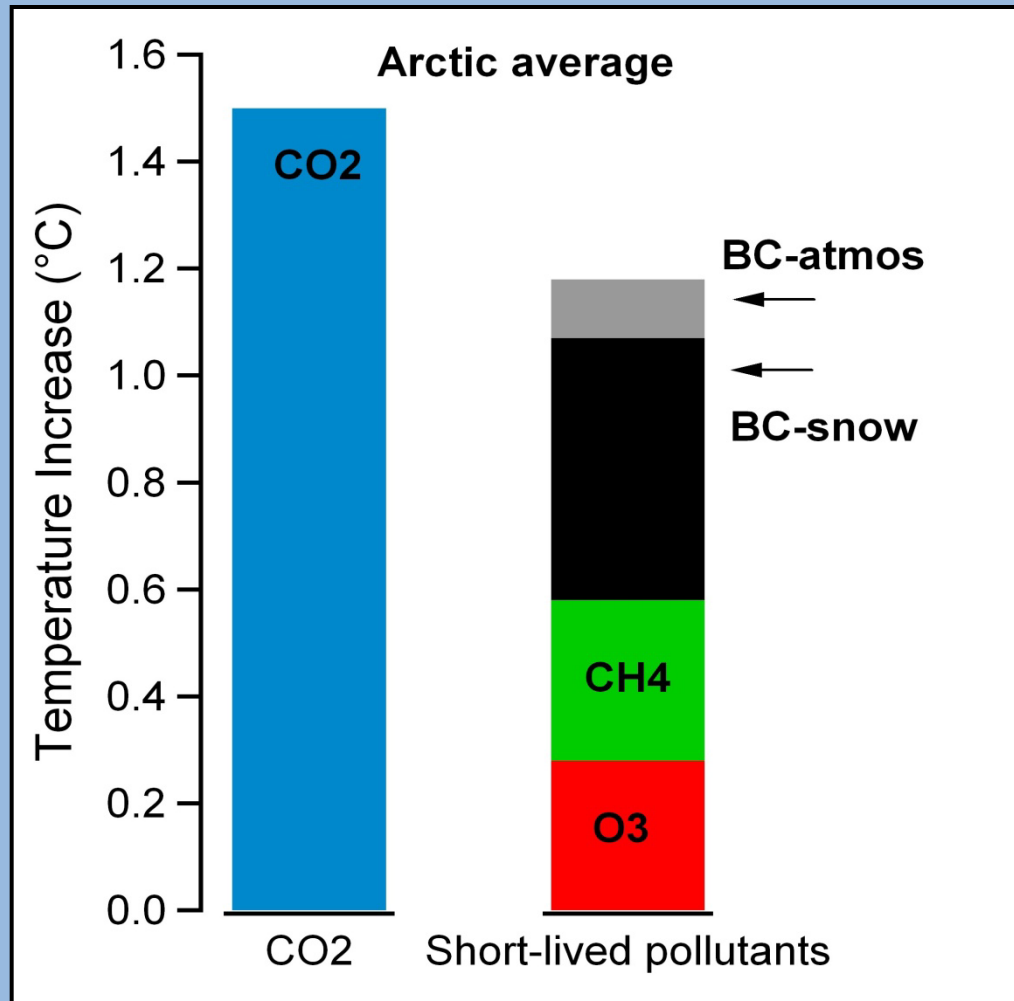
Modelling – sources, fluxes, storage,

To be presented at ICARP 3 in April 2015.

<http://www.amap.no>

A joint AMAP, CliC & IASC product

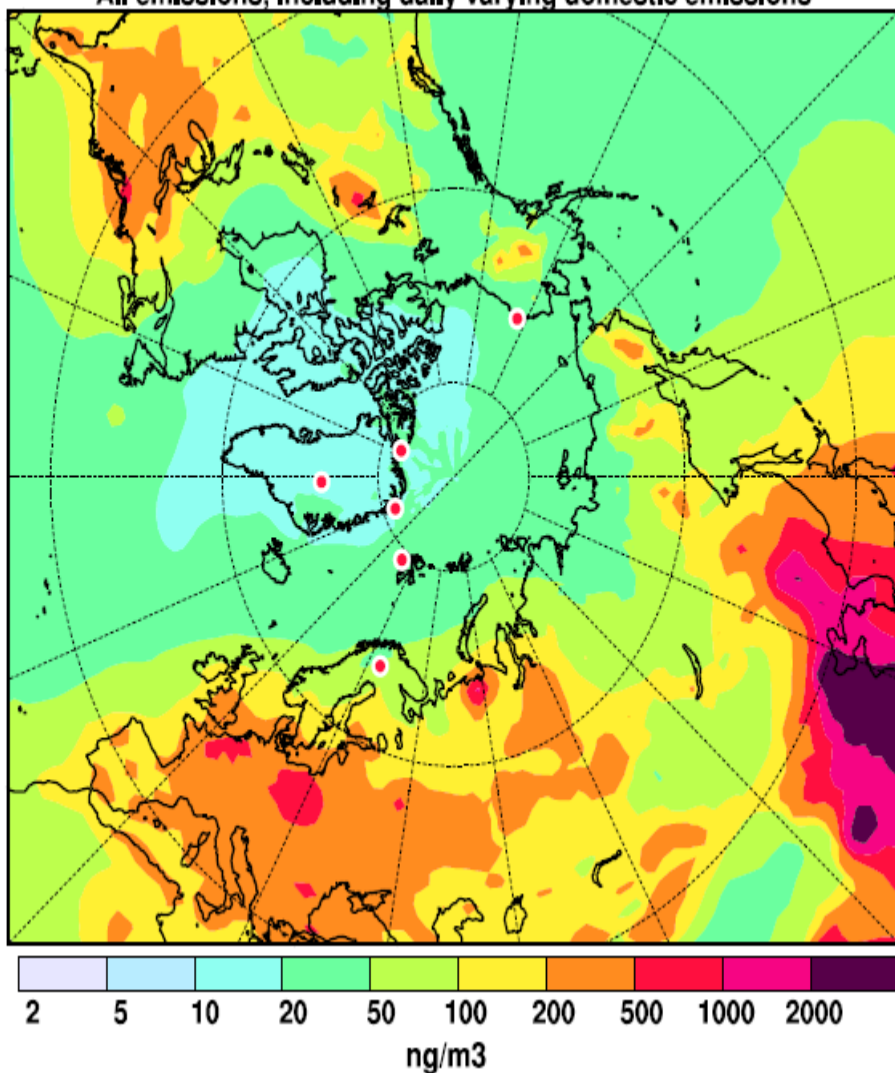
### Annually Averaged Temperature Increase due to CO<sub>2</sub> vs. Short-Lived Pollutants (relative to pre-industrial)



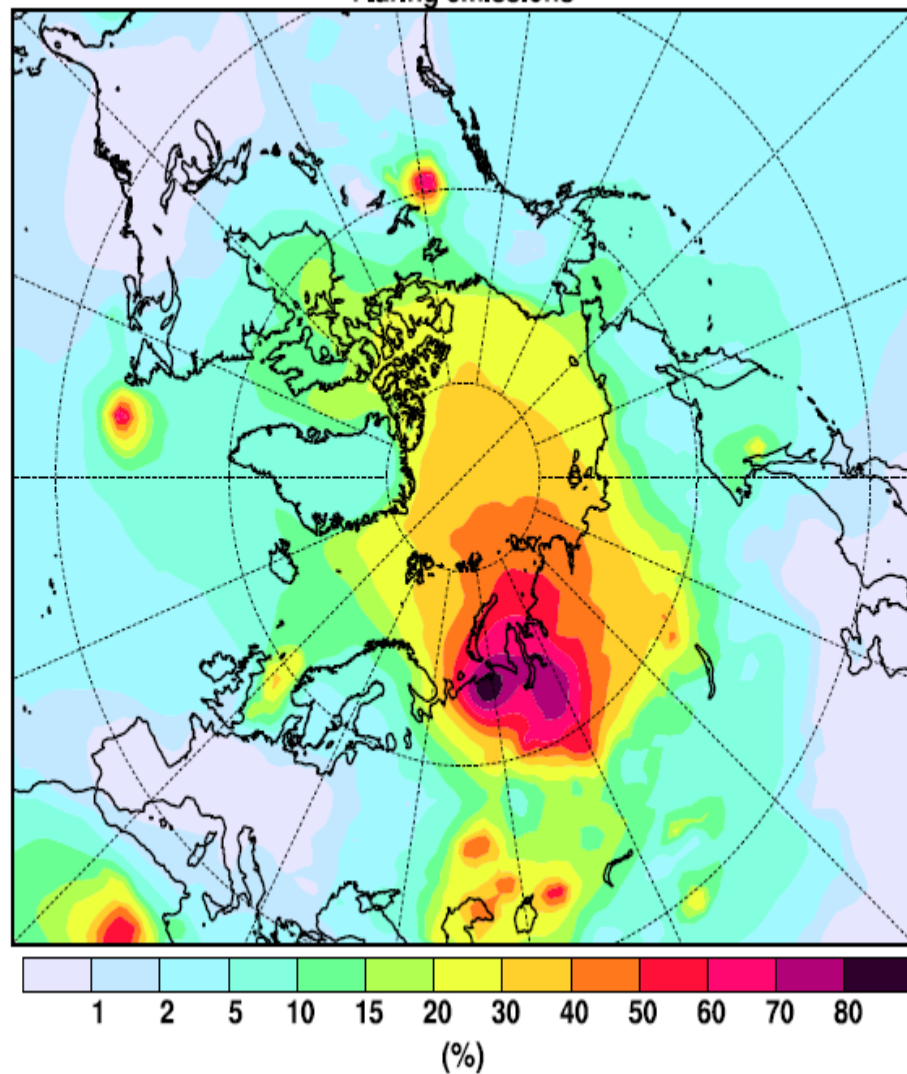
# Emissions from gas flaring contribute 42% to Arctic-mean BC surface concentrations

left panel: total BC surface concentrations; right panel: relative contribution from flaring

All emissions, including daily varying domestic emissions

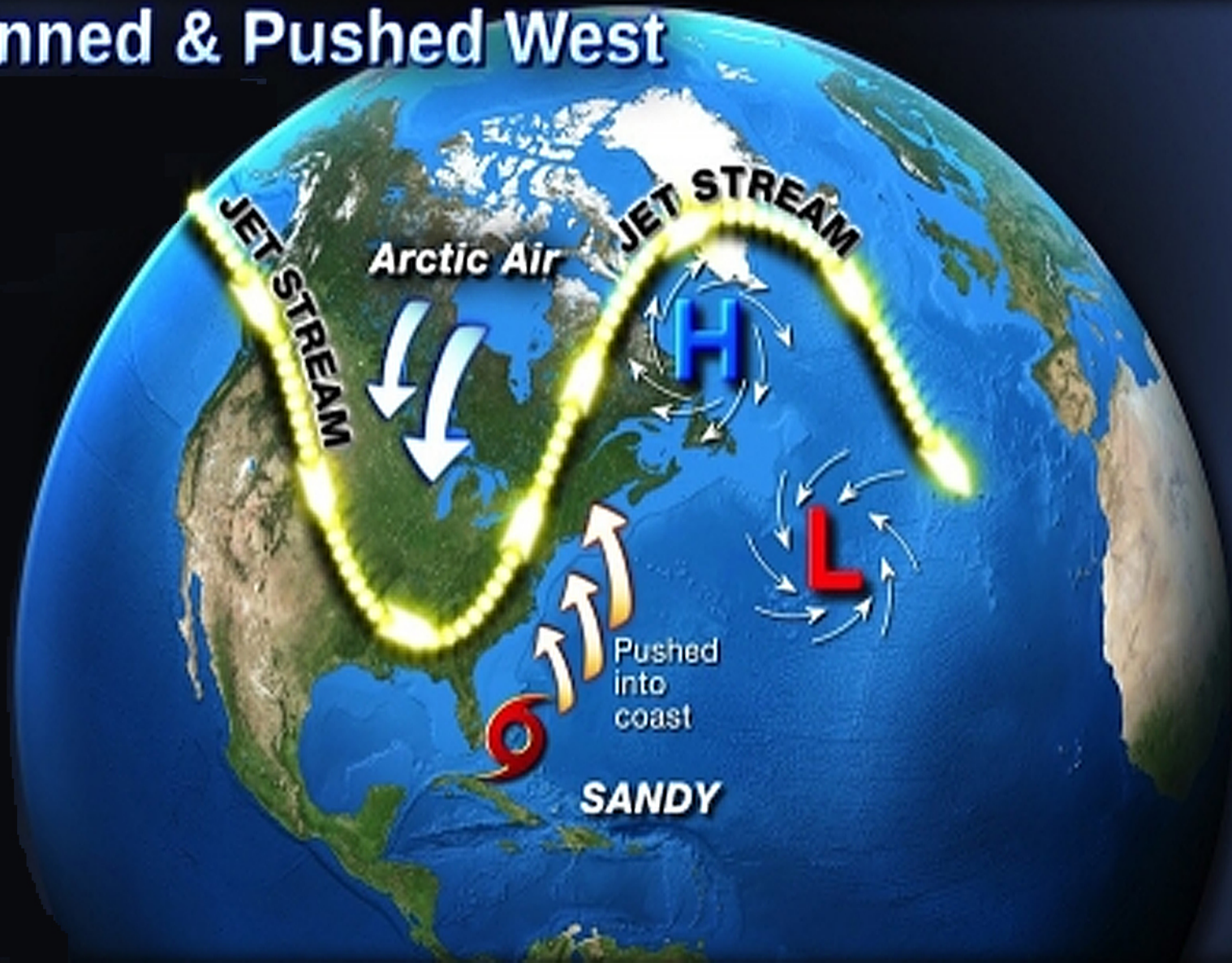


Flaring emissions

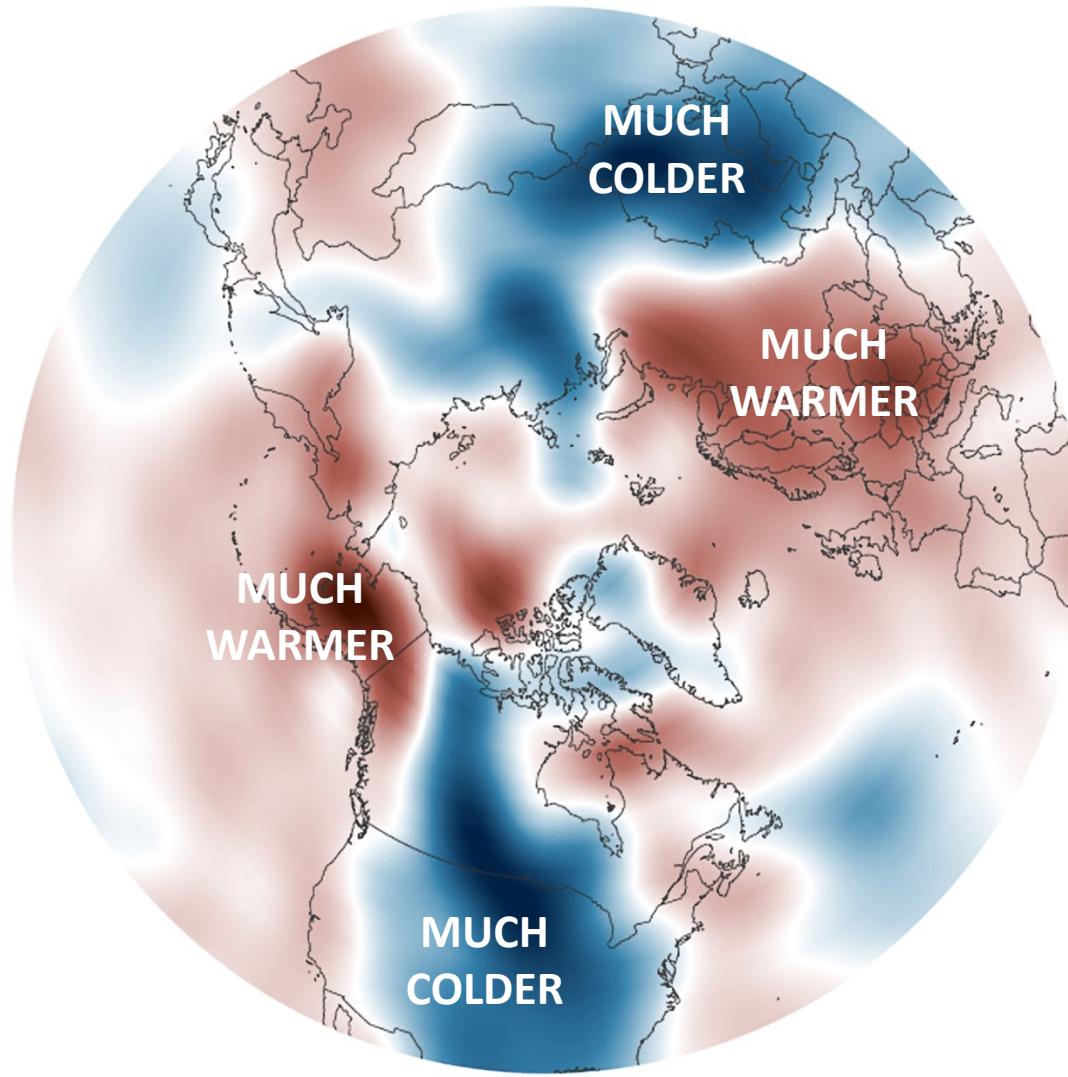


Climate changes appears to increase the north-south range of the Jet Stream and slowing, even locking sometimes, its position over the northern hemisphere

## Sandy Pinned & Pushed West

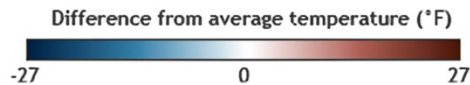


# Consequences of Changes in the Polar Vortex



- There are intra-regional temperature differences, by as much as +/- 27 °F.
- The changes polar vortices tend to drive the temperature differences over open water which provides a mechanisms that in turn influences weather systems south of the Arctic

Jan 5-7, 2014



NOAA Climate.gov

# Key Findings: Arctic Ocean Acidification

## Key finding 1

Arctic marine waters are experiencing widespread and **rapid ocean acidification**

## Key finding 2

The **primary driver** of ocean acidification is uptake of carbon dioxide emitted to the atmosphere by **human activities**

## Key finding 3

The Arctic Ocean is especially **vulnerable** to ocean acidification

## Key finding 4

Acidification is **not uniform** across the Arctic Ocean

pH	H <sup>+</sup> (moles per liter)	change in acidity
7.2	$6.3 \times 10^{-8}$	+900%
7.3	$5.0 \times 10^{-8}$	+694%
7.4	$4.0 \times 10^{-8}$	+531%
7.5	$3.2 \times 10^{-8}$	+401%
7.6	$2.5 \times 10^{-8}$	+298%
7.7	$2.0 \times 10^{-8}$	+216%
7.8	$1.6 \times 10^{-8}$	+151%
7.9	$1.3 \times 10^{-8}$	+100%
8.0	$1.0 \times 10^{-8}$	+58%
8.1	$7.9 \times 10^{-9}$	+26%
8.2	$6.3 \times 10^{-9}$	

*Average global surface ocean pH has fallen from a pre-industrial value of 8.21 to 8.10, corresponding to an increase in acidity of 28.8%. Values of 7.8–7.9 are expected by 2100, representing a 100–150% increase in acidity (NOAA/PMEL)*



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### **From Science to Policy:**

- Radioactivity reduce risk (1996 - 2014)
- Food advice to Arctic peoples
- UNECE Århus protocol (1998)
- UNEP Stockholm Convention on POPs (2001)
- UN FCCC COP & IPCC (2004 - 2014)
- UNEP Global Mercury Minamata agreement (2013)



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## Climate Change - Combined Effects



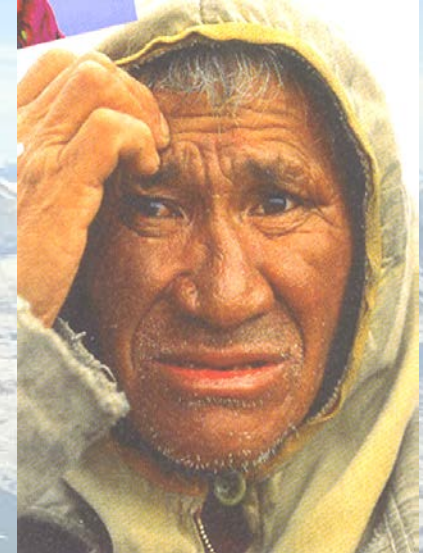
# Consequences of change ?

## Challenges

## Opportunities

Arctic residents  
*Losers?*

Insecure travel routes,  
diminishing traditional  
food sources



The global community  
*Winners?*  
(*multi-national industry*)



Sea level  
rise,  
amplified  
warming

Better access  
to resources -  
- oil and gas, -  
- mines, - -  
- fish?  
new shipping  
routes





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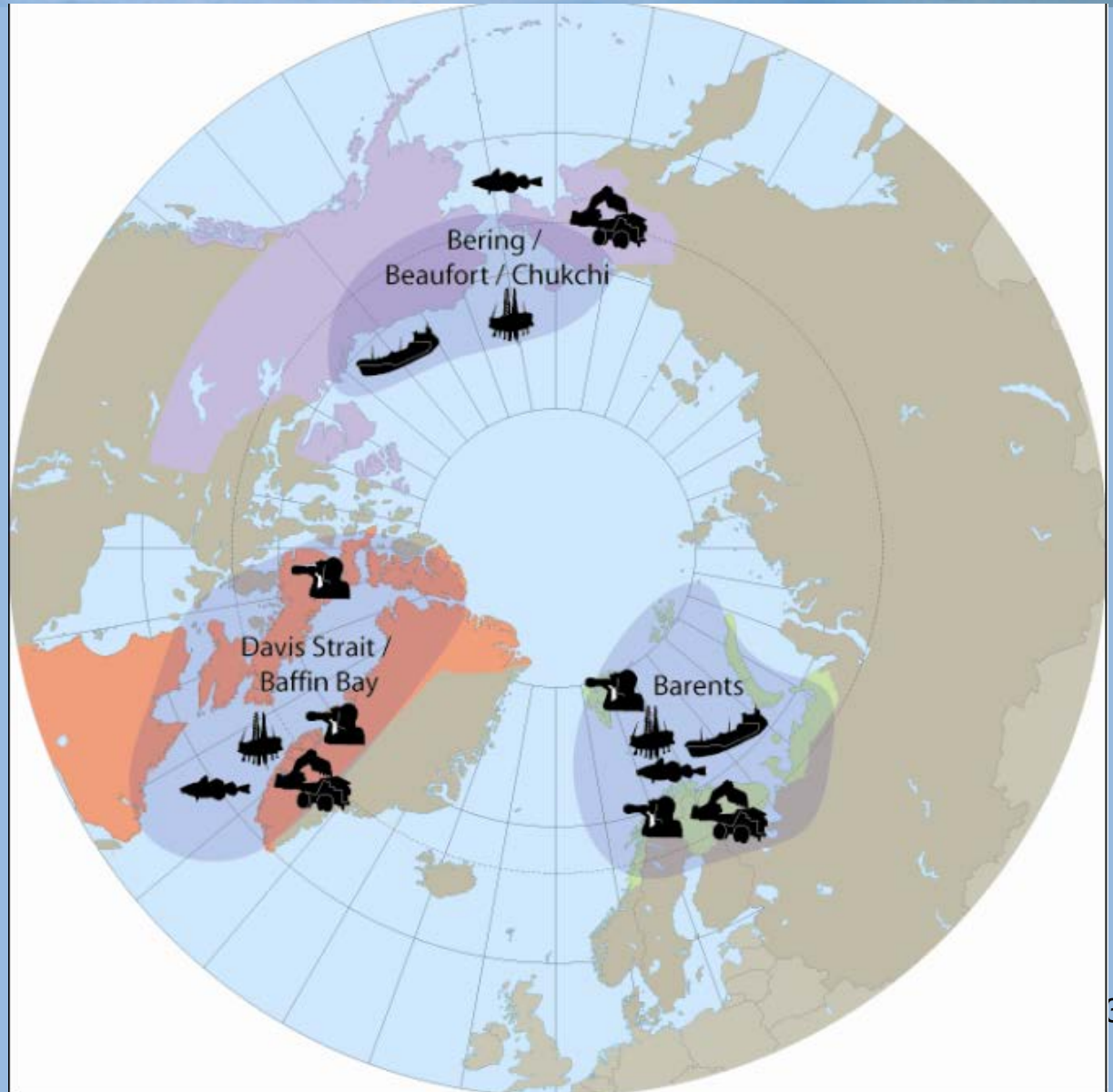
# AMAP

## Arctic Monitoring and Assessment Programme

**A**daptation  
**A**ctions for a  
**C**hanging  
**A**rctic

**Three  
regions**

**Three  
sciences**



# Arctic Unmanned Aircraft Systems (UAS) Operation Guidelines - Agreement



Implementing Scientific Data Collection  
across the Arctic Oceanic Region Utilizing  
Unmanned Aircraft Systems (UAS)

*By: The Arctic Council's Arctic Monitoring and Assessment Programme (AMAP)  
Expert Group on Unmanned Aircraft Systems (UAS).*

## Welcome Italy to:

Nominate experts to all expert groups;

Provide data/information from national research and monitoring;

Secure stations/platforms to perform observations/research (SAON);

Provide new technology/sensors for observations in the Arctic;

Provide financial support ;

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Arctic – the Barometer of the Globe

