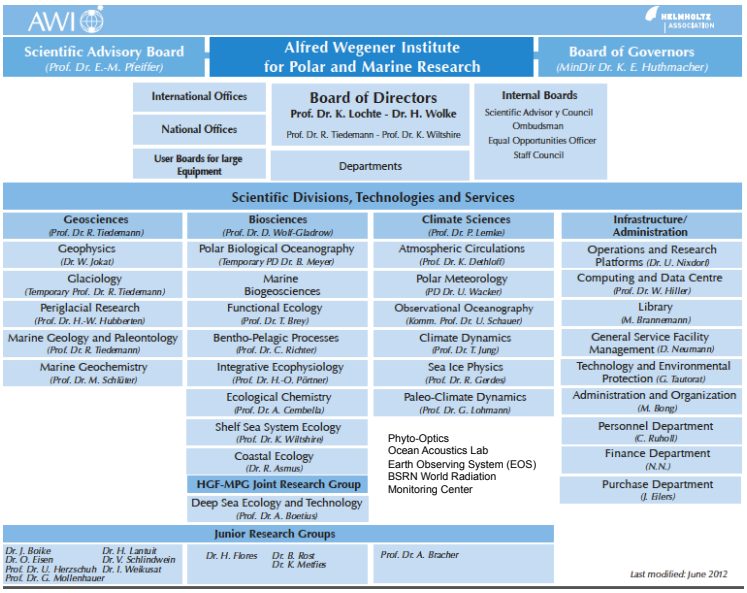
Climate Research Activities at AWI

Thomas Jung

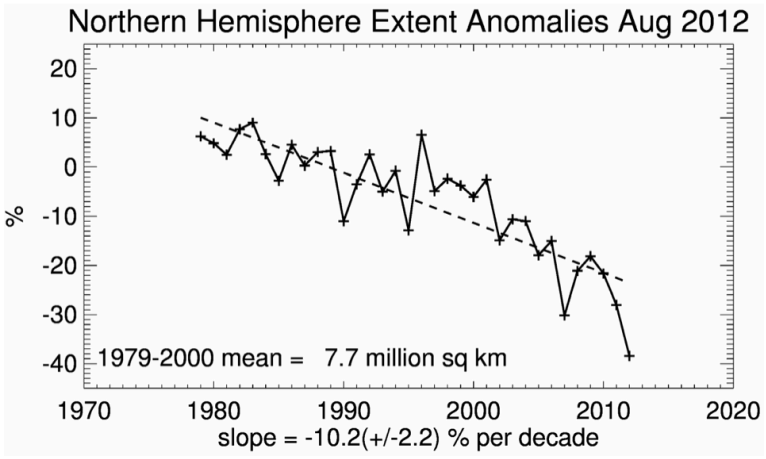
AWI's mission

- Carry out research in the Arctic and Antarctic as well as in the high and mid latitude oceans including coasts
- Coordinate German polar research
- Provide infrastructure to the national and international science community

AWI organization



Arctic sea ice decline

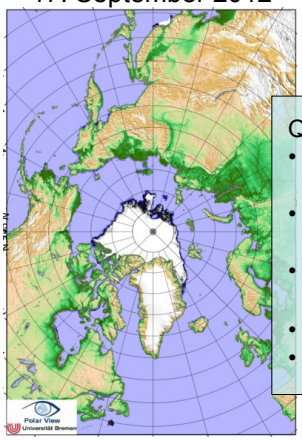


Source: NSIDC

Arctic sea ice decline

16. September 2003

17. September 2012



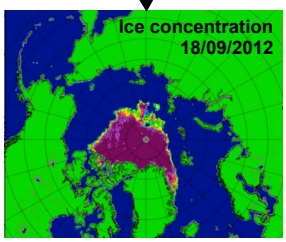
Questions:

- How do we observe sea ice?
- How unusual is the decline?
- What is driving the decline?
- What will happen next?
- Does it matter?

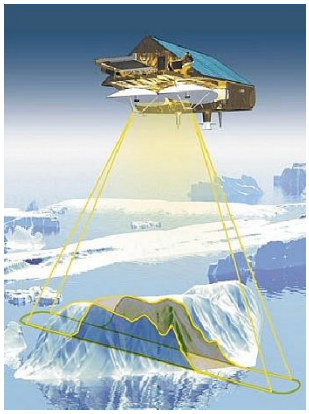
Source: Georg Heygster, University of Bremen

Satellites

DMSP SSM/I



Cryosat2

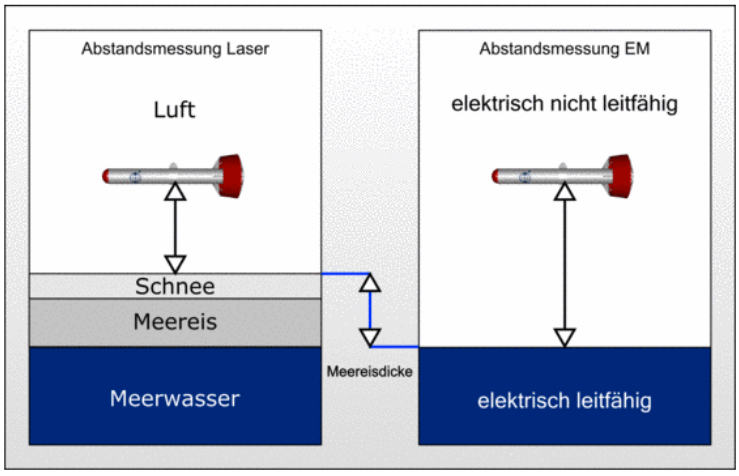


AWI Earth Observation Systems group (EOS), Polar Meteorology Section

In situ measurements

Sea Ice Physics Section

EM Bird



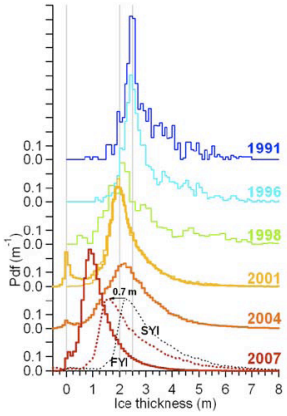
Sea Ice Physics Section

EM Bird

AWI

EM Bird towed by Polar 5

Ice thickness north of Fram Strait



Monitoring of sea ice changes very successful!

Sea Ice Physics Section

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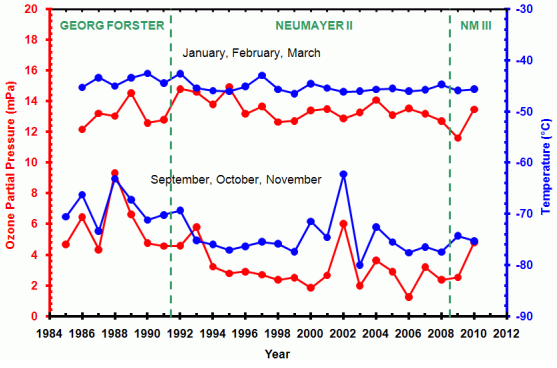
Atmospheric monitoring at Neumayer

AWI

Timeseries of Seasonal Averaged Stratospheric Parameters (at 70hPa)



Polar Meteorology Section

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Atmospheric monitoring at Ny Alesund

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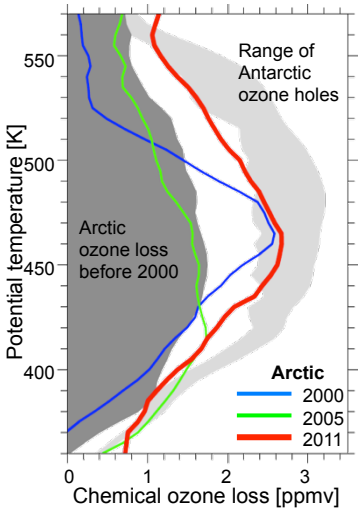
Ny Alesund AWIPEV station



Atmospheric Circulations Section

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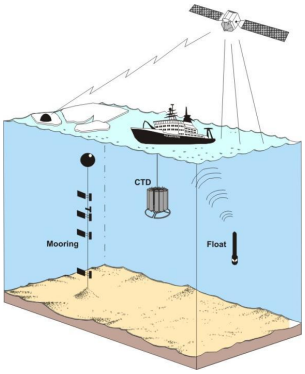
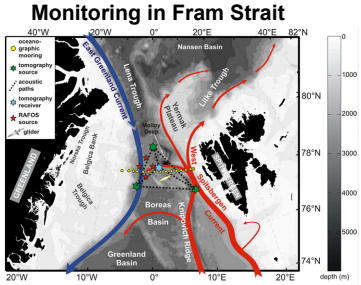
Oceanographic monitoring in Fram Strait

AWI

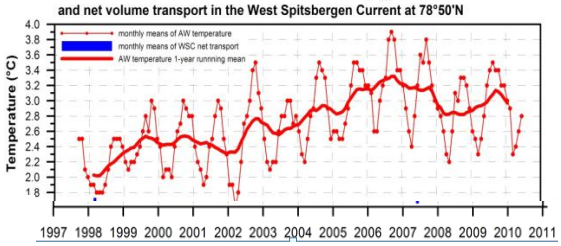
Components of the AWI ocean observing system



Monitoring in Fram Strait



Mean temperature of the Atlantic water inflow (T_{AW}>1°C) and net volume transport in the West Spitsbergen Current at 78°50'N



Observational Oceanography Section

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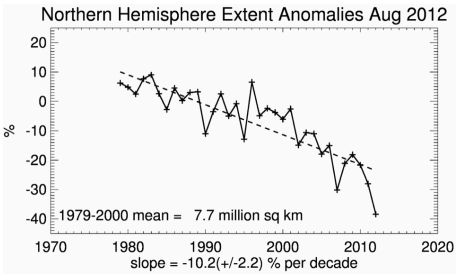
How unusual is the decline?



- How does the system behave over longer periods of time?
- Long time series are required!
- Instrumental record relatively short (a few decades worth of data)
- Proxy data are a promising way forward

Proxy data

Climate proxies are preserved physical characteristics of the past that stand in for direct measurements

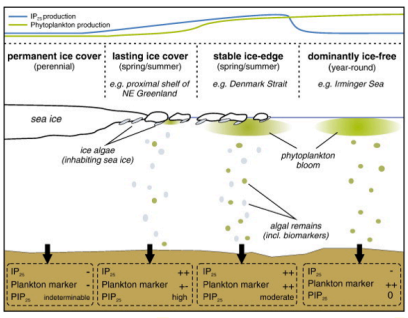


Fig. 3. Generalised scheme illustrating distinct sea surface conditions and respective (spring/summer) productivities of ice algae and phytoplankton. Overview sedimentary contents of IP_{25} and the phytoplankton-derived biomarkers and resulting PIP_{25} indices are indicated for each setting.

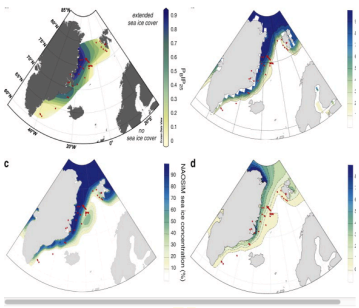


Fig. 5. Comparison of the (a) biomarker-based estimate of sea ice coverage using the P_BIP_{25} index with (b) SMMR-SSM/I satellite derived mean spring sea ice concentrations, (c) NAOSIM modelled spring sea ice concentrations, and (d) sea ice thicknesses. Both satellite and NAOSIM-based sea ice data are averaged over the period from 1979 to 2003. Red dots denote sites of sediment samples.

Müller et al. (2011)

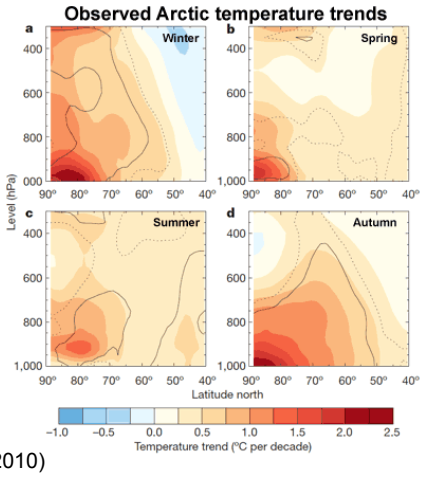
Sea ice proxies are a very recent development!

What are the mechanisms?

AWI

Lessons from the observations (1):

Arctic Amplification



Screen and Simmonds (2010)

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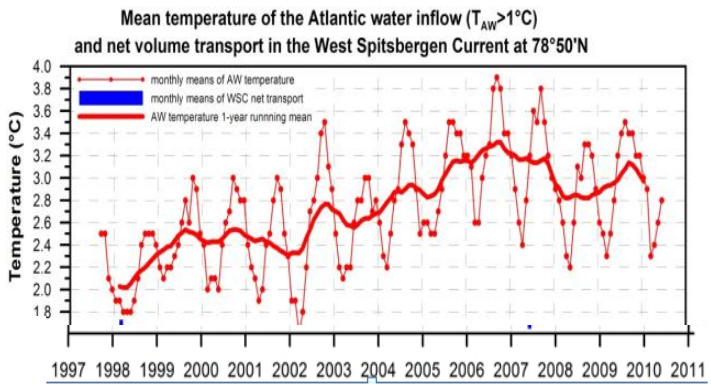
What are the mechanisms?

AWI

Lessons from the observations (2):

Increased inflow of warm Atlantic water



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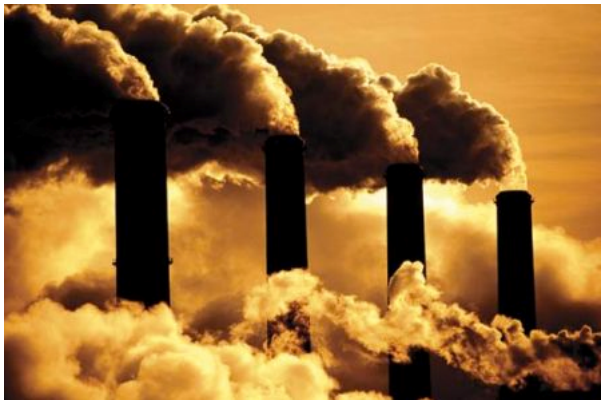
Candidate mechanism

AWI

Anthropogenic Emissions: Greenhouse Effect



How can we test this hypothesis? We don‘t have a parallel climate system without anthropogenic emissions to compare with!

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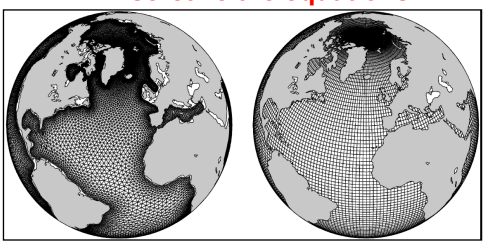
Climate models

AWI

1. Step

$$
\begin{aligned}
\frac{d\mathbf{v}}{dt} &= -\alpha\nabla p - \nabla\phi - 2\boldsymbol{\Omega}\times\mathbf{v} + \mathbf{F} \\
\frac{\partial\rho}{\partial t} &= -\nabla\cdot(\rho\mathbf{v}) \\
c_p\frac{dT}{dt} &= \alpha\frac{dp}{dt} + Q \\
p\alpha &= RT \\
\frac{\partial\rho q}{\partial t} &= -\nabla\cdot(\rho\mathbf{v}q) + \rho\,(E - C)
\end{aligned}
$$

2. Discretize the equations



3. Solve the equations numerically on supercomputers

Climate Dynamics, Paleoclimate Dynamics, Atmospheric Circulations, Scientific Computing, Sea Ice Physics, Polar Meteorology, Biogeochemistry, Glaciology

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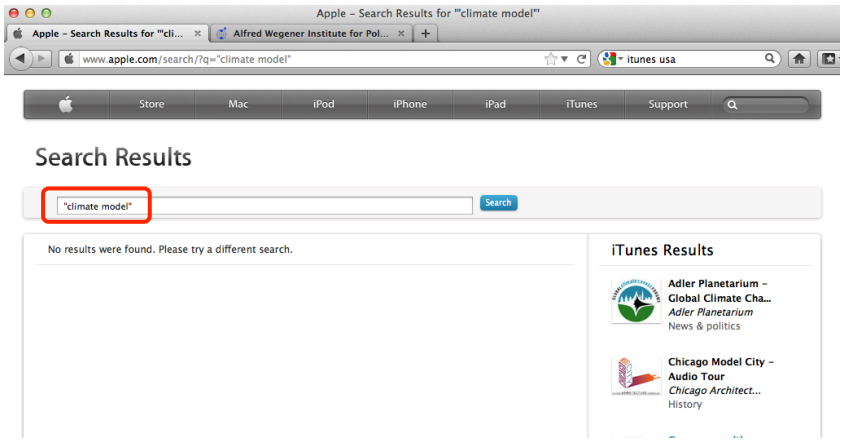
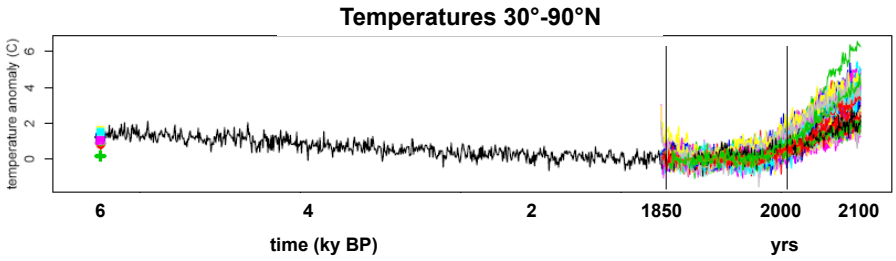
How to get a climate model?



Model experiment



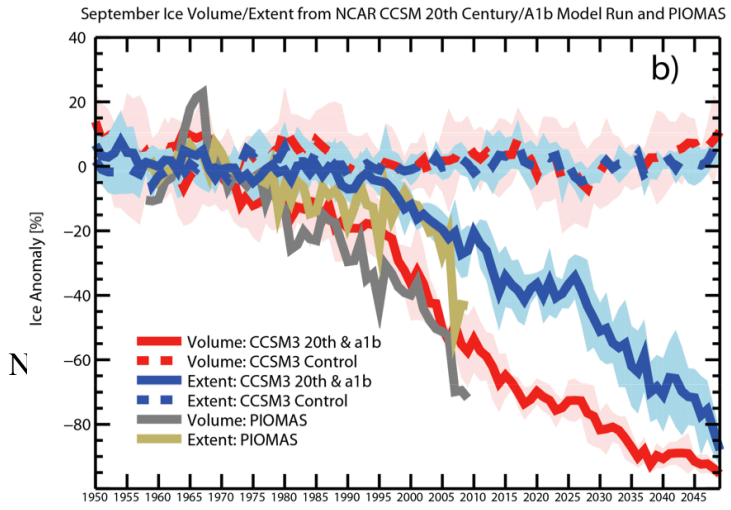
Ötzi: 5300 year old mummy from the Alps

Paleoclimate Dynamics Section

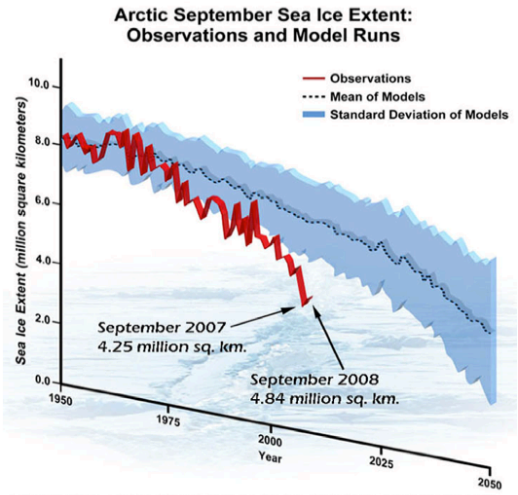
Sensitivity experiments

- Run the model without any perturbations applied (control run)
- Carry out an experiment in which a certain aspect is changed
- Look at the impact that this change has

Model experiments



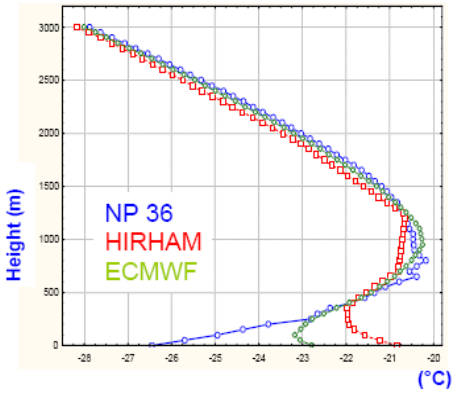
How good are the models?



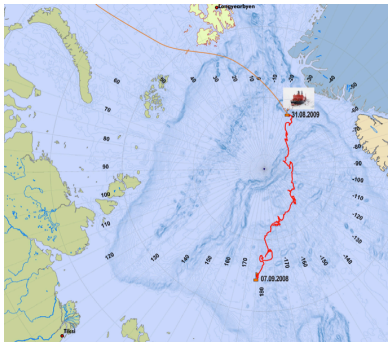
Stroeve, et. al., Arctic Sea Ice Extenet: Decline Faster than Forecast, American Geophysical Letters, February 2006, Updated with 2007 data by Bruce Melton, October 2007, 2008, National Snow and Ice Data Center.

Comparison of models with data (1)

Vertical Temperature Profiles

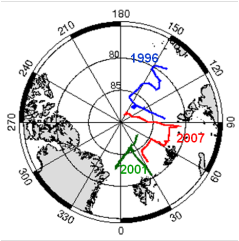


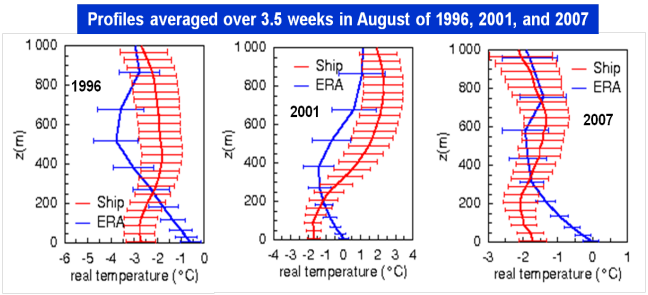
Drift of NP-36



Atmospheric Circulations Section

Comparison of models with data (2)





Polar Meteorology Section

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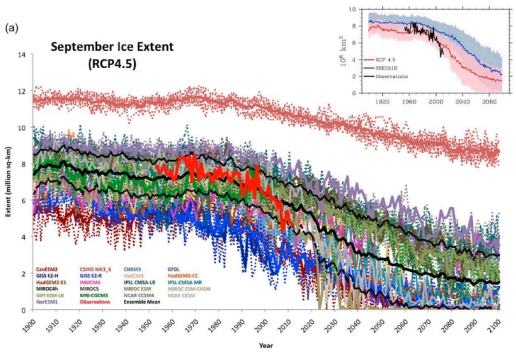
What will happen next?

"This collapse, I predicted would occur in 2015-16 at which time the summer Arctic (August to September) would become ice-free.“ (Peter Wadhams in The Guardian)

“If Arctic sea ice will follow a linear trend then ice will be vanished in 10 years.“ (Georg Heygster, University of Bremen)



Stroeve et al. (2012)

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Does it matter?

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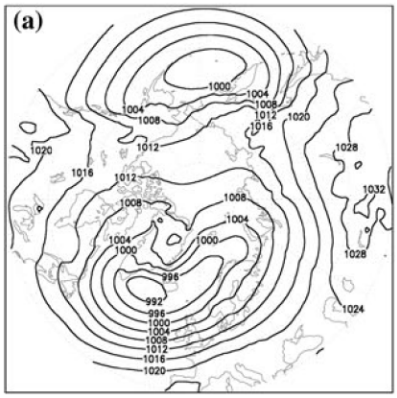
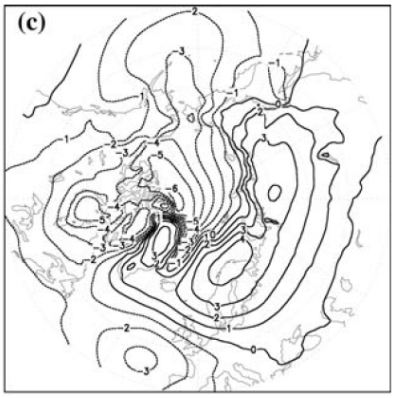
SLP: Climatology



SLP: Response to ice-free Arctic



Climate Dynamics Section

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Summary

AWI

- Polar research is very exciting
- Some central scientific challenges are linked to what happens in the polar regions
- Polar research is societally very relevant

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Thank you!

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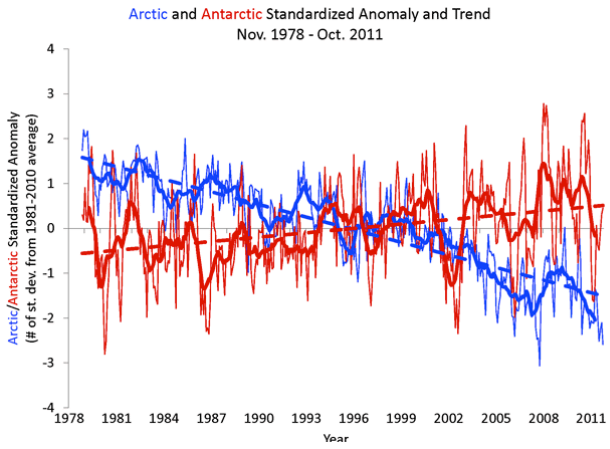
Other questions: Antarctic sea ice



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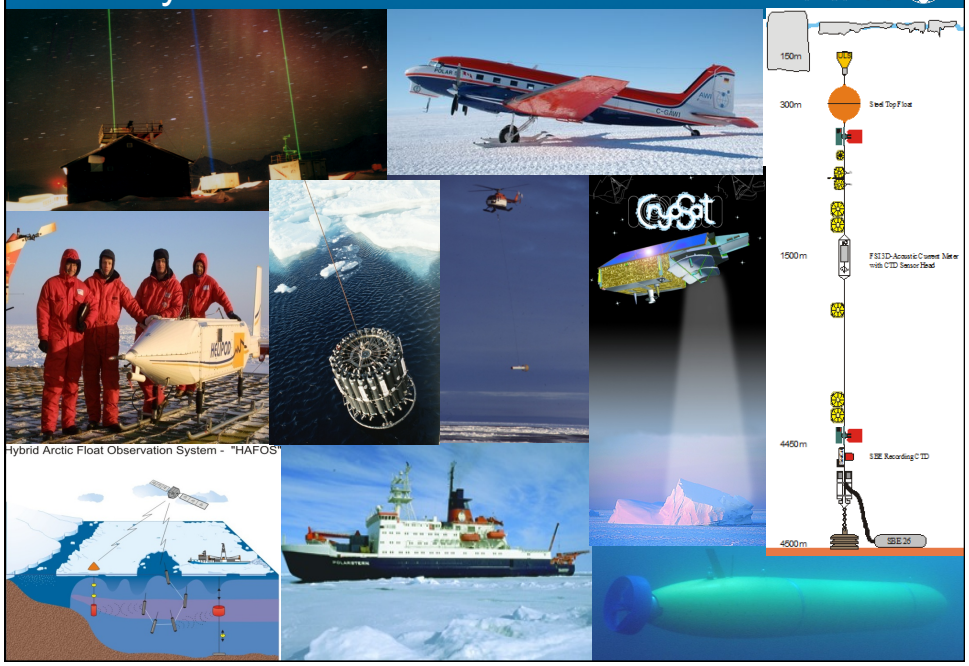
Thank you!

AWI



Hybrid Arctic Float Observation System - "HAFOS"

Sensitivity experiments

AWI

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Tools III

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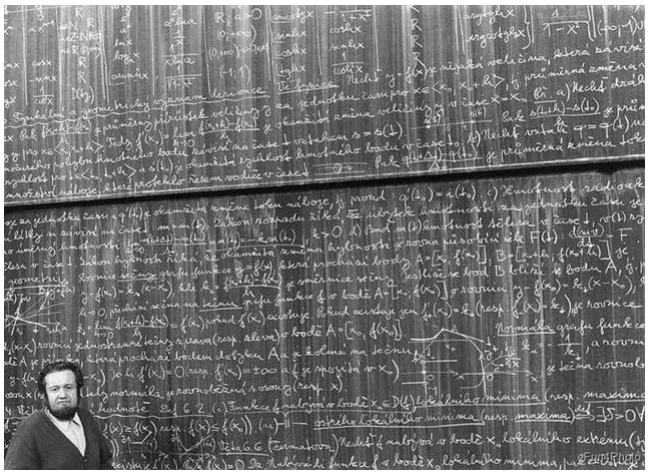

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„Traditional presentation“

AWI

Climate Sciences
(Prof. Dr. P. Lemke)

Atmospheric Circulations
(Prof. Dr. K. Dethloff)

Polar Meteorology
(PD Dr. U. Wacker)

Observational Oceanography
(Komm. Prof. Dr. U. Schauer)

Climate Dynamics
(Prof. Dr. T. Jung)

Sea Ice Physics
(Prof. Dr. R. Gerdes)

Paleo-Climate Dynamics
(Prof. Dr. G. Lohmann)

Phyto-Optics
Ocean Acoustics Lab
Earth Observing System (EOS)
BSRN World Radiation
Monitoring Center

Problems with this approach:
- Incoherent picture
- Lack of interdisciplinary

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Today‘s approach

- Focus on one high-profile issue
- Illustrate “our” activities in tackling this issue