Climate Research Activities at AWI

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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

Northern Hemisphere Extent Anomalies Aug 2012

1979-2000 mean = 7.7 million sq km

slope = -10.2 (+/-2.2) % per decade

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

EM Bird towed by Polar 5

Ice thickness north of Fram Strait

Monitoring of sea ice changes very successful!

Atmospheric monitoring at Neumayer

Timeseries of Seasonal Averaged Stratospheric Parameters (at 70hPa)

Polar Meteorology Section
Atmospheric monitoring at Ny Alesund

Ny Alesund AWIPEV station

Atmospheric Circulations Section

Oceanographic monitoring in Fram Strait

Components of the AWI ocean observing system

Monitoring in Fram Strait

Observational Oceanography Section
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

Müller et al. (2011)

**Sea ice proxies** are a very recent development!
What are the mechanisms?

Lessons from the observations (1):

Arctic Amplification

Screen and Simmonds (2010)

Lessons from the observations (2):

Increased inflow of warm Atlantic water
Candidate mechanism

Anthropogenic Emissions: Greenhouse Effect

How can we test this hypothesis? We don't have a parallel climate system without anthropogenic emissions to compare with!

Climate models

1. Step

\[ \begin{align*}
\frac{dv}{dt} &= -\alpha \nabla p - \nabla \phi - 2 \Omega \times v + F \\
\frac{dp}{dt} &= -\nabla \cdot (\rho v) \\
cp \frac{dT}{dt} &= \alpha \frac{dp}{dt} + Q \\
pT &= RT \\
\frac{dq}{dt} &= -\nabla \cdot (\rho q v) + \rho (E - C)
\end{align*} \]

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
How to get a climate model?

Model experiment

Temperatures 30°-90°N

Otzi: 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

[Graph showing ice volume and extent from NCAR CCSM 20th Century A1b model run and PIOMAS]
How good are the models?

Comparison of models with data (1)

Atmospheric Circulations Section
Comparison of models with data (2)

Polar Meteorology Section

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)
Does it matter?

SLP: Climatology  SLP: Response to ice-free Arctic

Climate Dynamics Section

Summary

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

Other questions: Antarctic sea ice
Thank you!

Sensitivity experiments
Tools III

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

„Traditional presentation“

Climate Sciences  
(Prof. Dr. F. Lauten)
Atmospheric Circulations  
(Prof. Dr. J. Dobrilla)
Polar Meteorology  
(P.Dr. U. Wacker)
Observational Oceanography  
(Komm. Prof. Dr. U. Schauer)
Climate Dynamics  
(Prof. Dr. T. Jung)
Sea Ice Physics  
(Prof. Dr. C. R. Guckes)
Paleo-Climate Dynamics  
(Prof. Dr. C. Lohmann)

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

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