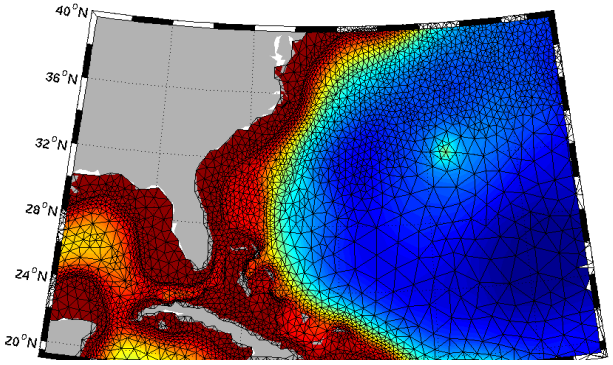
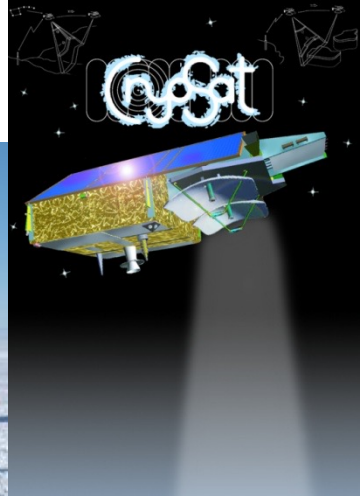
AWI Klimawissenschaften

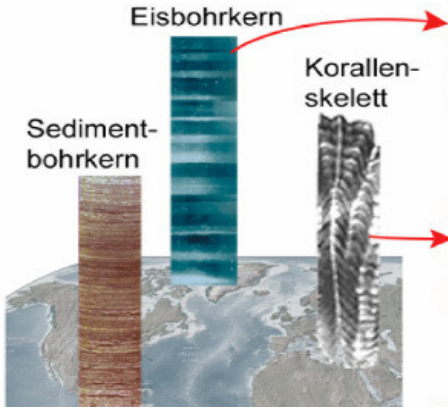


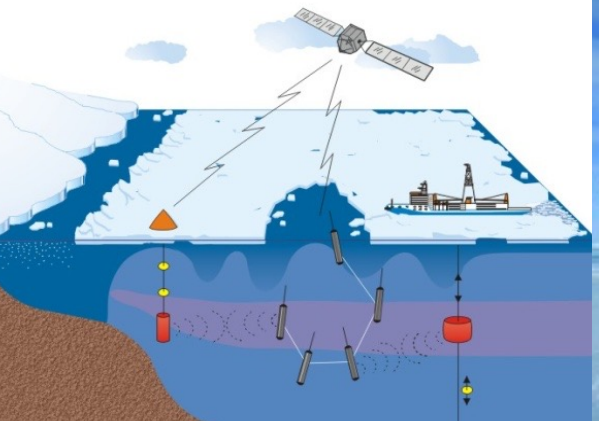


Beobachtungen, Datenanalyse & Modelle

Veränderungen im Klima & Ökosystem

Zeitskalen: Wetter bis Millionen Jahre





9:45	Start in the Glaskasten with coffee and tea
10:00-11:00	AWI and the challenges of climate research (GL), Glaskasten
11:15-12:30	Lab tour in Building D
12:45-13:45	Lunch break in the Mensa of the University of applied Science
14:00-15:00	Dynamics of tipping points, Glaskasten
15:15-16:00	Tutorium of Dynamics II related to Exercise 7, Exercise 9 distributed

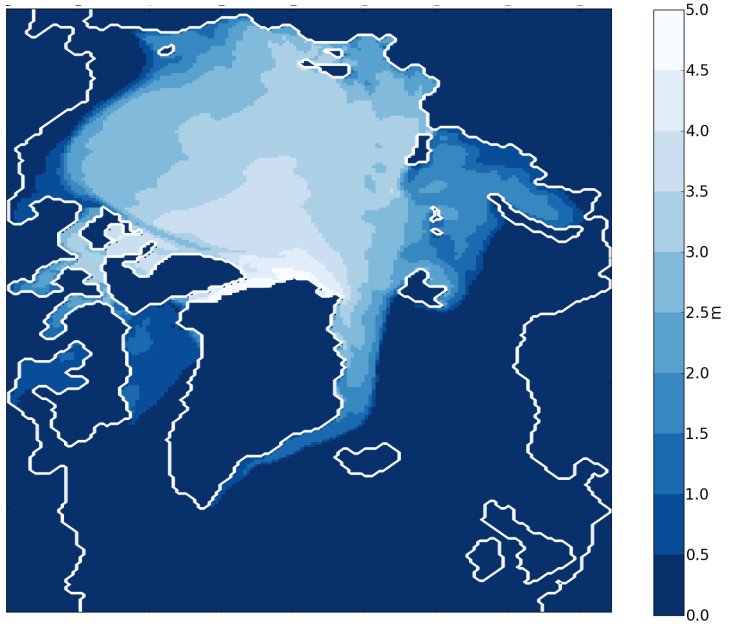
Fachbereich Klimawissenschaften

Forschungsziel:

Untersuchung des gekoppelten Systems Ozean-Eis-Atmosphäre und dessen Einfluss auf das globale Klima

- **Expeditionen: Schiffe, Flugzeuge, Helikopter, Stationen, Satelliten**
- **Numerische Simulationen: Atmosphäre, Ozean, Eis - global & regional**

Foto: Martin Schiller



simulierte Arktische Meereis-Dicke in m

AWI in Germany

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

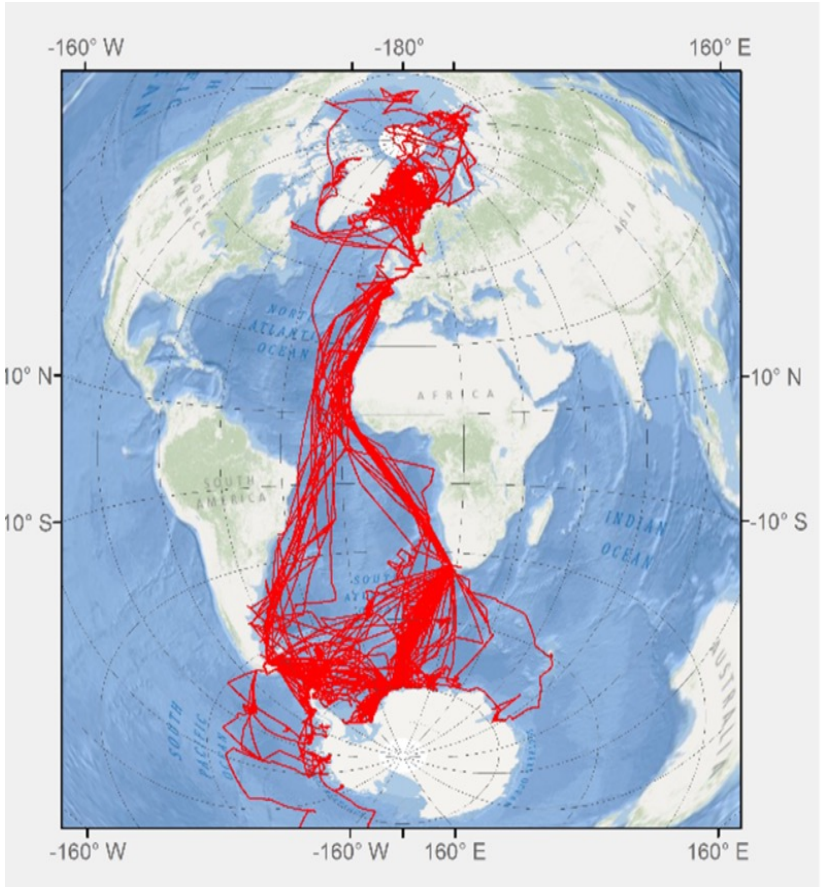
Bremerhaven

Research infrastructure

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Research Icebreaker „POLARSTERN

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

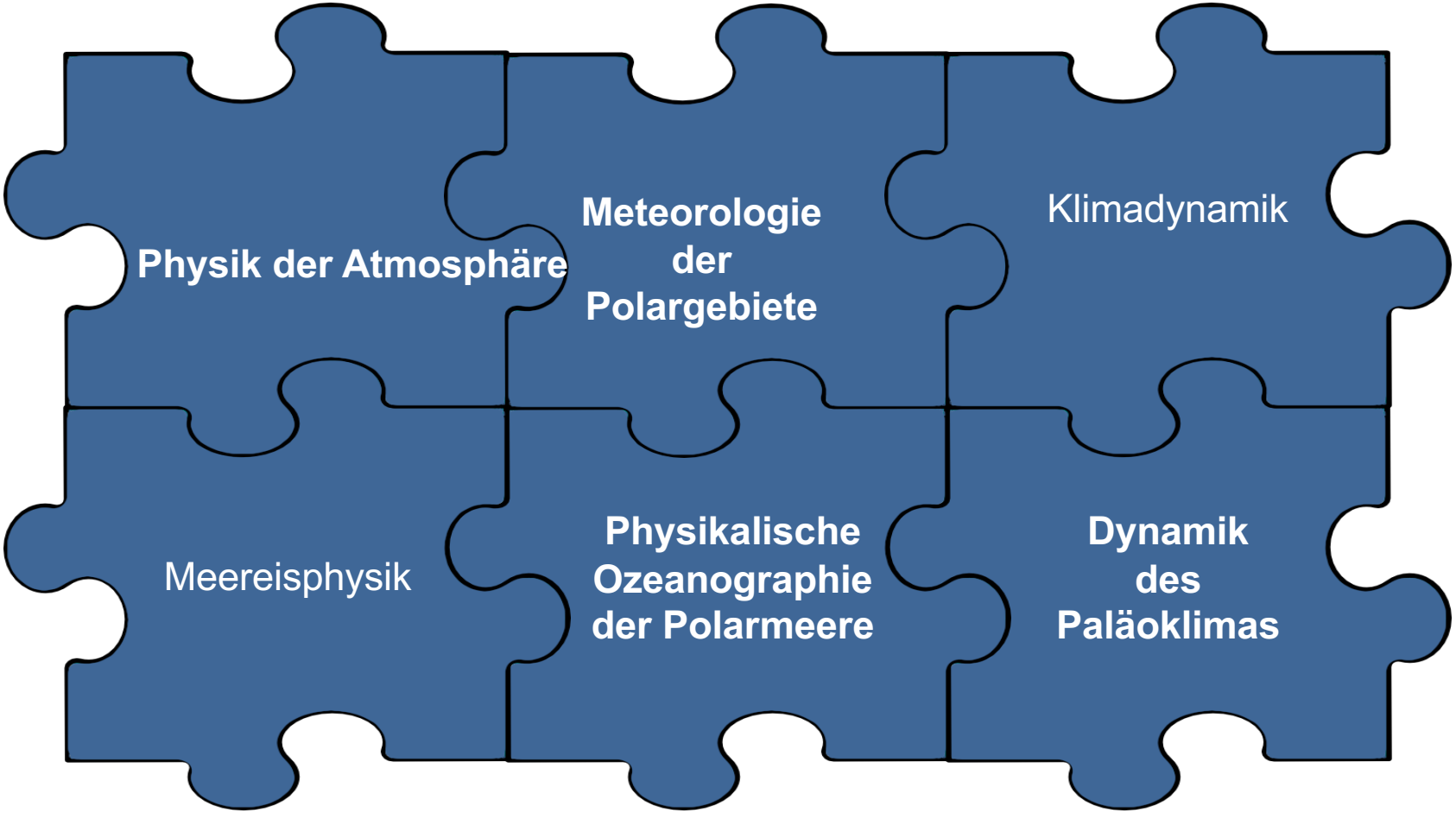


https://www.awi.de/expedition/schiffe/polarstern.html
Mosaic Expedition: https://mosaic-expedition.org/
https://mosaic-expedition.org/expedition/

Fachbereich Klimawissenschaften

Forschungsziel:

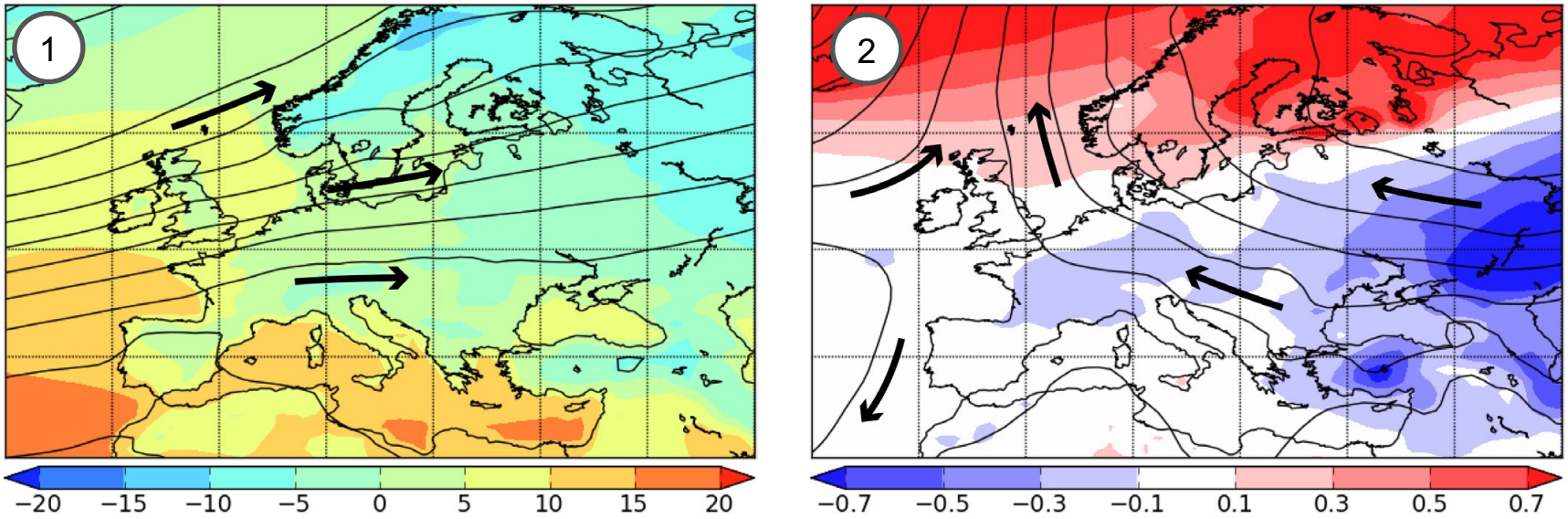
Untersuchung des gekoppelten Systems Ozean-Eis-Atmosphäre und dessen Einfluss auf das globale Klima



Klimadynamik

(Leitung: Prof. Dr. Thomas Jung)

- **Verständnis und Vorhersagbarkeit unseres Klimasystems; Veränderungen durch natürliche und anthropogene Ursachen**
- **Vorhersagbarkeit des Klimasystems auf kurzen und langen Zeitskalen**
- **Entwicklung und Optimierung von Klimamodellen**

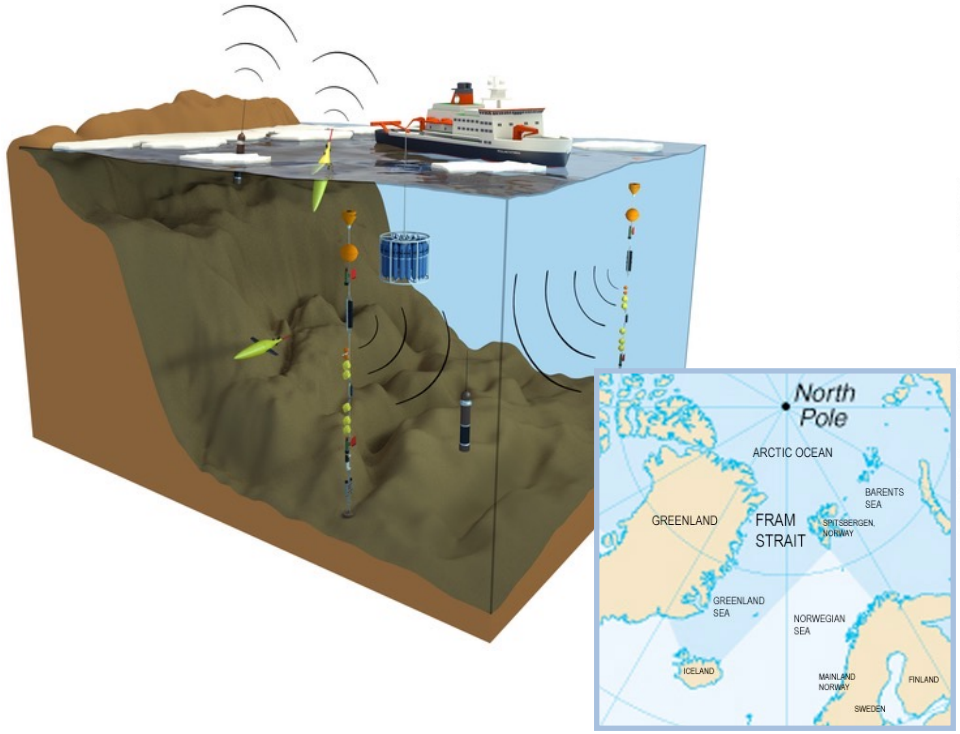


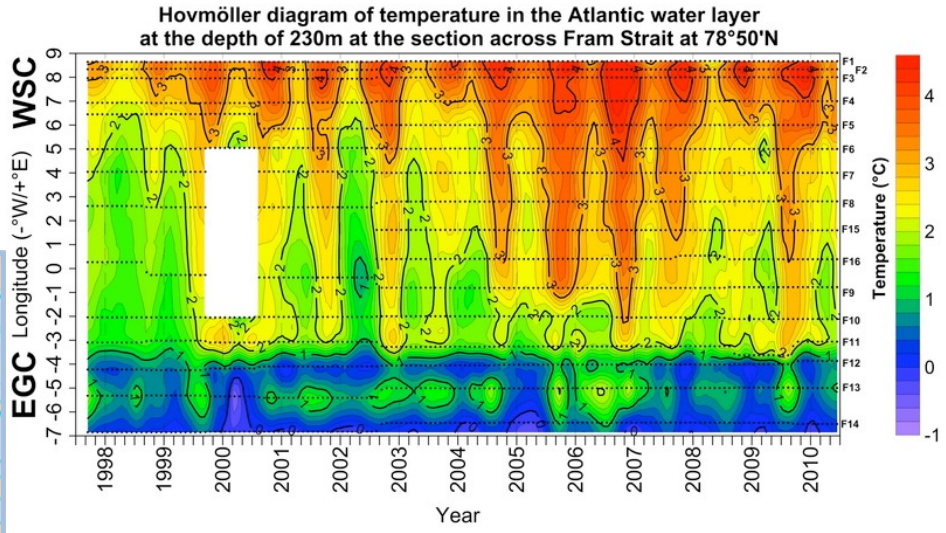
1) Winter-Klima in Europa unter normalen Meereis-Bedingungen in der Arktis
2) Mögliche Klimaänderungen bei Reduzierung der Meereis-Dicke um 50%

Physikalische Ozeanographie der Polargebiete

(Leitung: Prof. Dr. T. Kanzow)

- **Identifizierung und Quantifizierung relevanter physikalischer Prozesse, welche die Rolle des Ozeans für das Klima bestimmen**
- **Untersuchung der Variabilität im (sub)polaren Ozean auf unterschiedlichen Zeitskalen**
- **Verwendung unterschiedlichster Messinstrumente und Verfahren**



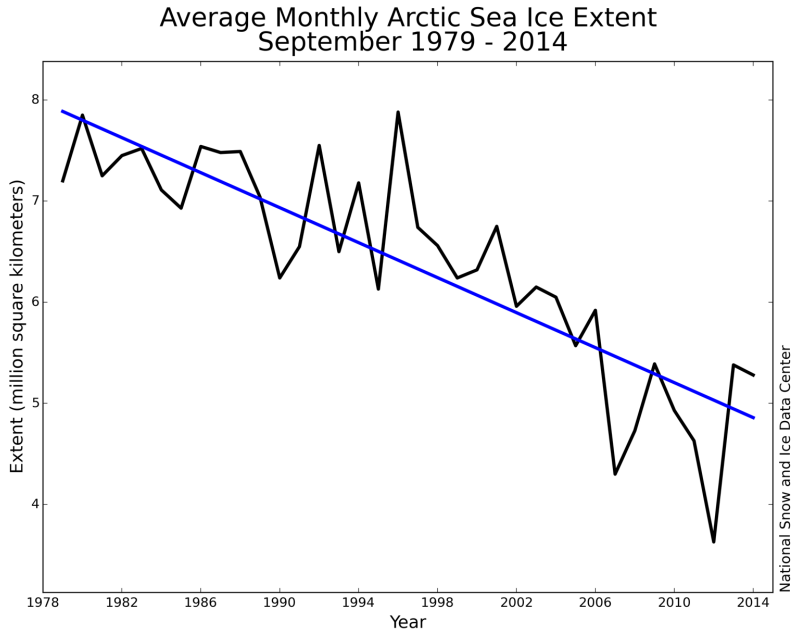


Meereisphysik

(Leitung: Prof. Dr. C. Haas)

- **Fokus auf der Rolle von Meereis im Klimasystem**
- **verbessertes Verständnis von physikalischen Eigenschaften von Meereis und relevanten Prozessen bei der Meereis-Bildung**
- **Austausch von Energie, Massen und Impuls über Meereis-Flächen; Änderung der Frischwasserbilanz**

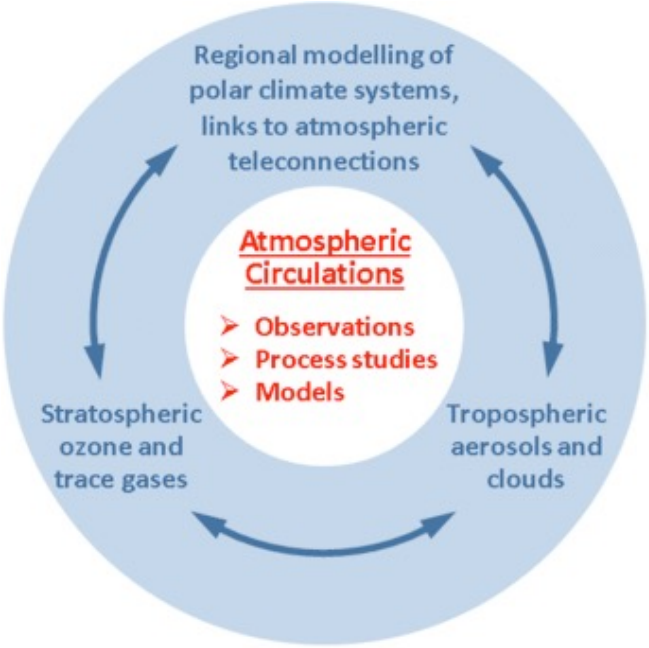
Fotos: Marcel Nicolaus

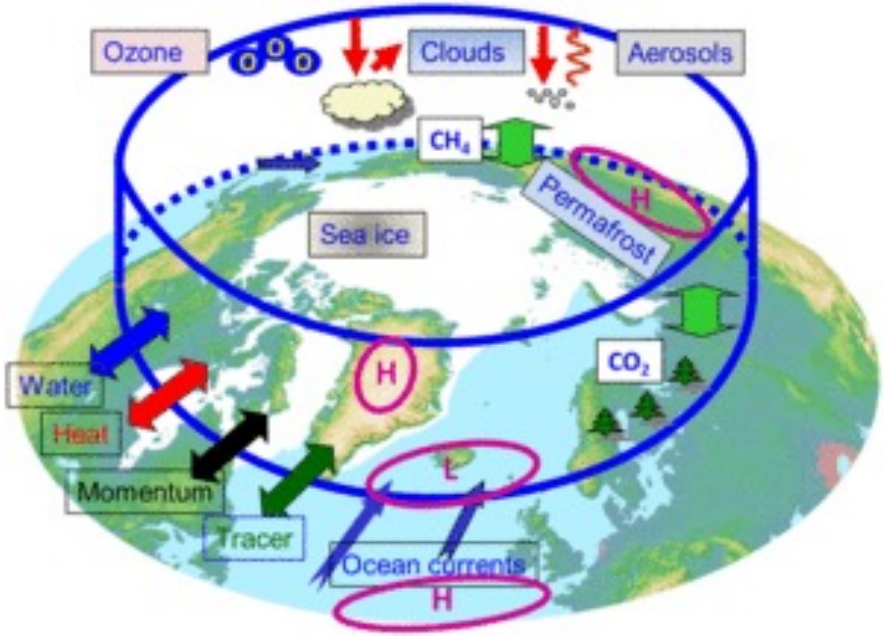


Physik der Atmosphäre (Potsdam)

(Leitung: Prof. Dr. Markus Rex)

- **verbessertes Verständnis von Klimaänderungen in den Polargebieten durch Beobachtungen, Prozeßstudien und Modellierung**
- **Analyse von Aerosol-Wolken-Wechselwirkungen**
- **Messungen und Modellierung von Ozon in der polaren Stratosphäre**



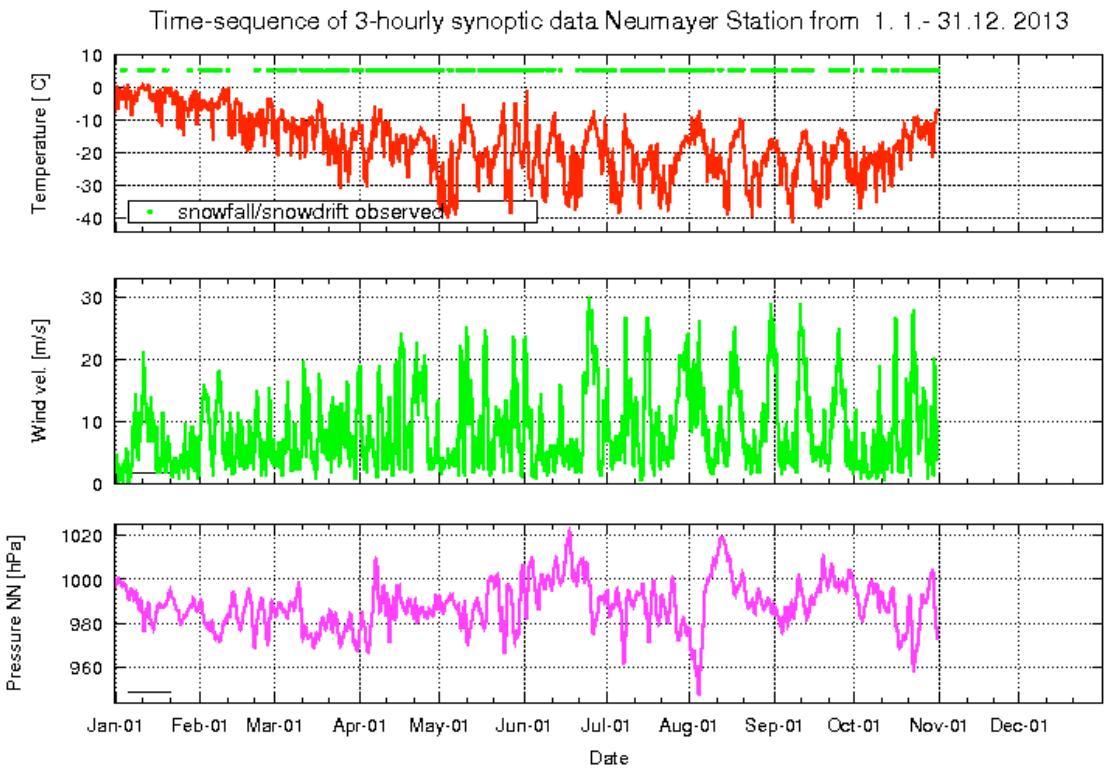


Meteorologie der Polargebiete

(Leitung: Dr. C. Lüpkes)

- **Analyse von physikalischem Prozesse in der polaren Troposphäre**
- **Wechselwirkungen zwischen Atmosphäre und Meereis sowie Ozean**
- **Schwerpunkt der Forschung:**
  Prozesse mit räumlichen Abmessungen von ca. 1 bis 50 km

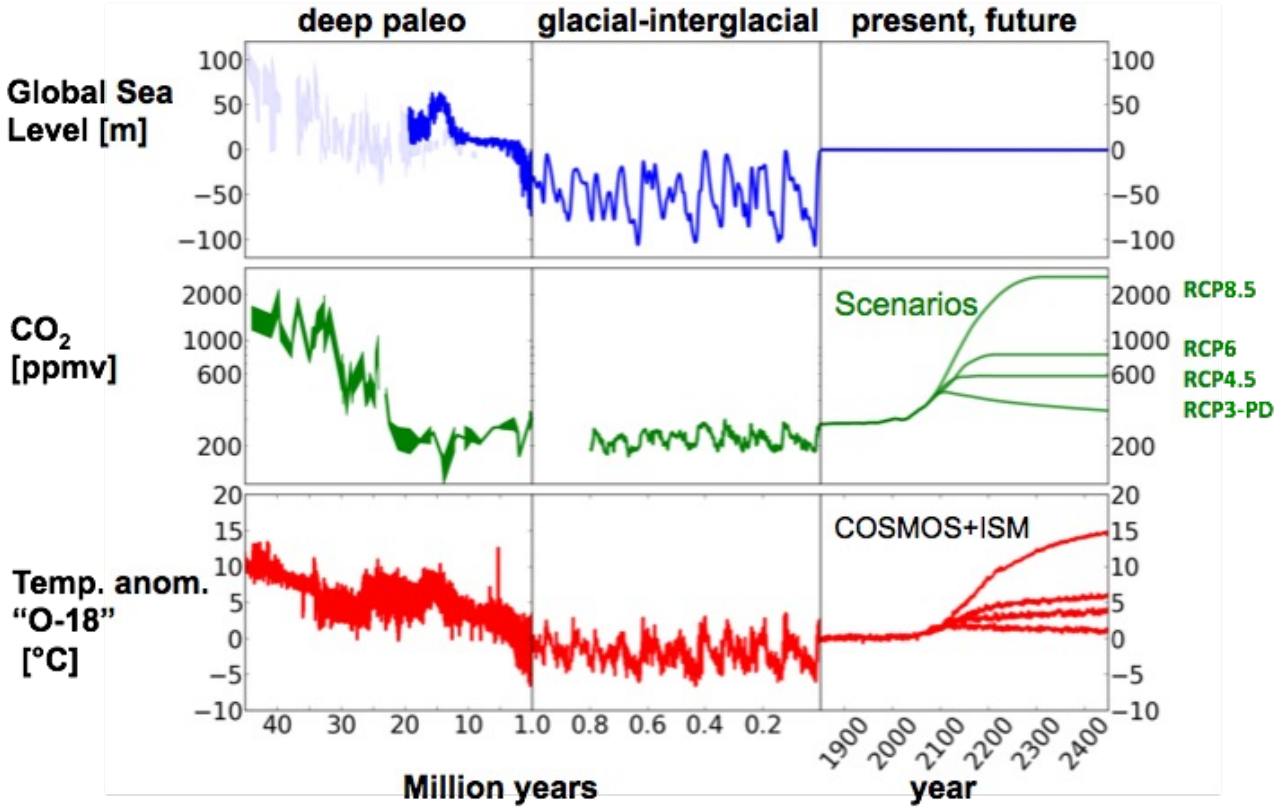
Foto: Bernd Loose



Dynamik des Paläoklimas

(Leitung: Prof. Gerrit Lohmann)

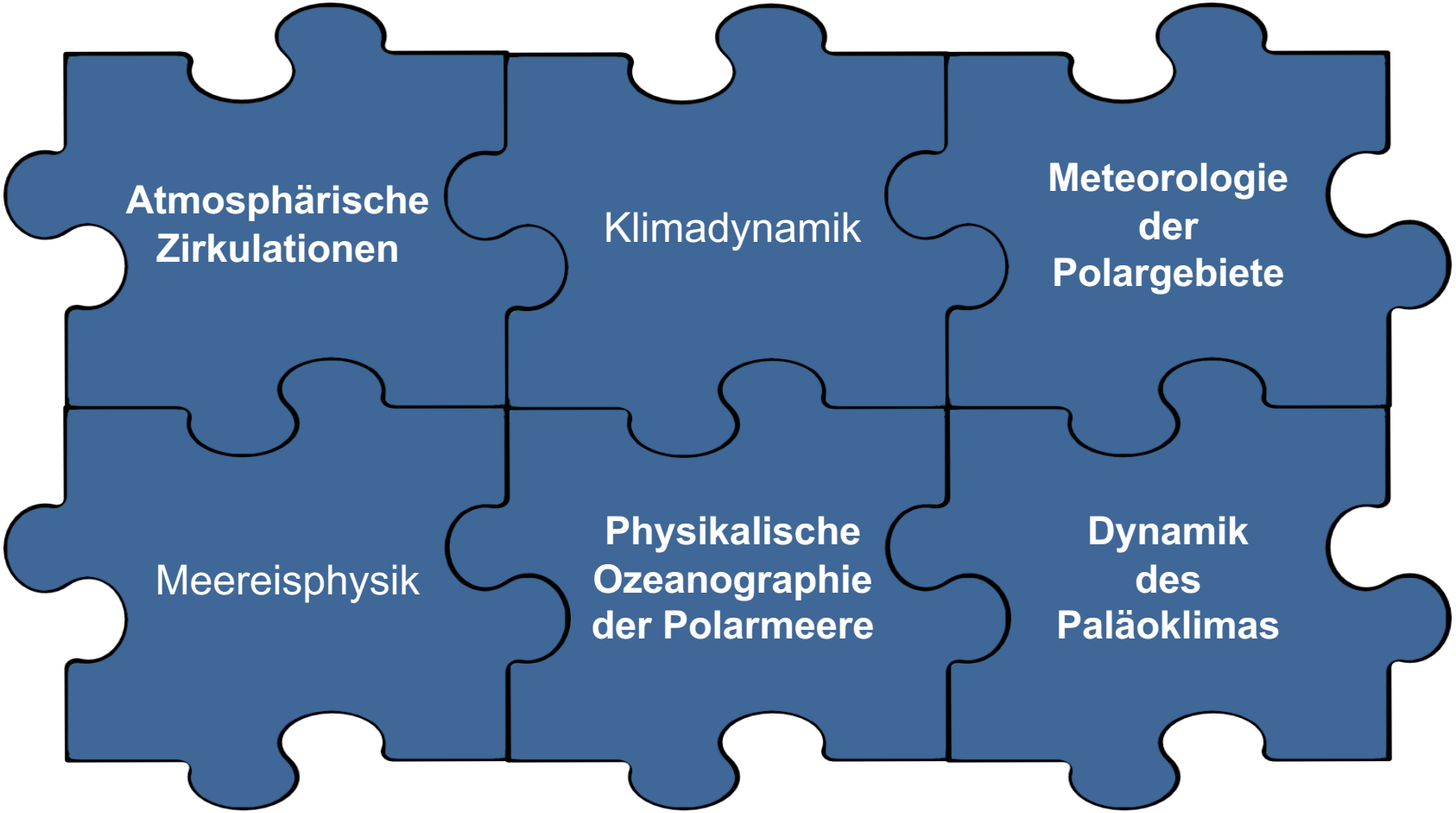
- **Analyse von verschiedenen Klimazuständen der Vergangenheit;**
- **Identifikation von Mechanismen, die Klimaänderungen verursachen**
- **Verwendung von numerischen Modellen und statistischen Methoden zur Erklärung vorhandener Messdaten (z.B. aus Eisbohrkernen)**



Fachbereich Klimawissenschaften

Forschungsziel:

Untersuchung des gekoppelten Systems Ozean-Eis-Atmosphäre und dessen Einfluss auf das globale Klima



Sea Ice Physics

Supervision: Christian Haas

- Impact of sea ice morphology on formation of melt ponds
- Sea ice melt in the marginal ice zone (MIZ)
- Surface energy balance of Arctic and Antarctic sea ice
- Requirements: Good programming and English language skills, good grades, (experience with oceanography is of advantage)

Contact:

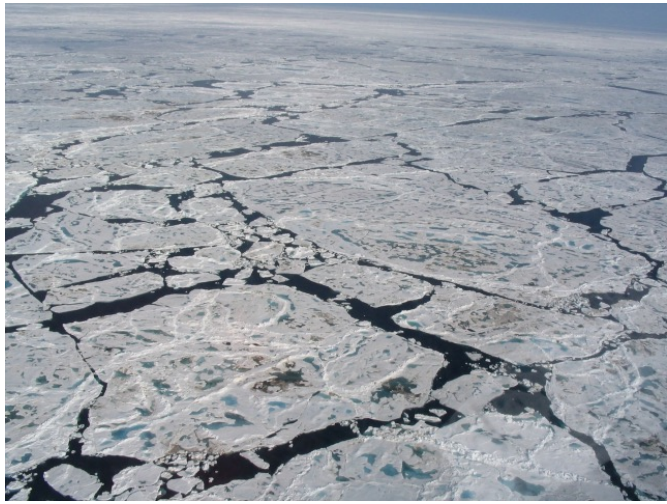
Dr. Christian Haas

christian.haas@awi.de

Surface energy balance of Arctic and Antarctic sea ice

- Compare the surface energy balance over sea ice in the Arctic and Weddell Sea with the main objective to understand **why Arctic sea ice is shrinking while Antarctic sea ice is not,** and why there are no melt ponds on Antarctic sea ice, or only under specific conditions
- Use radiosonde data from Arctic and Antarctic Polarstern cruises (e.g., Mosaic and PS124/COSMUS)
- Use ERA5 atmospheric reanalysis data
- Requirements: Good programming and English language skills, good grades, (experience with atmospheric physics is of advantage)

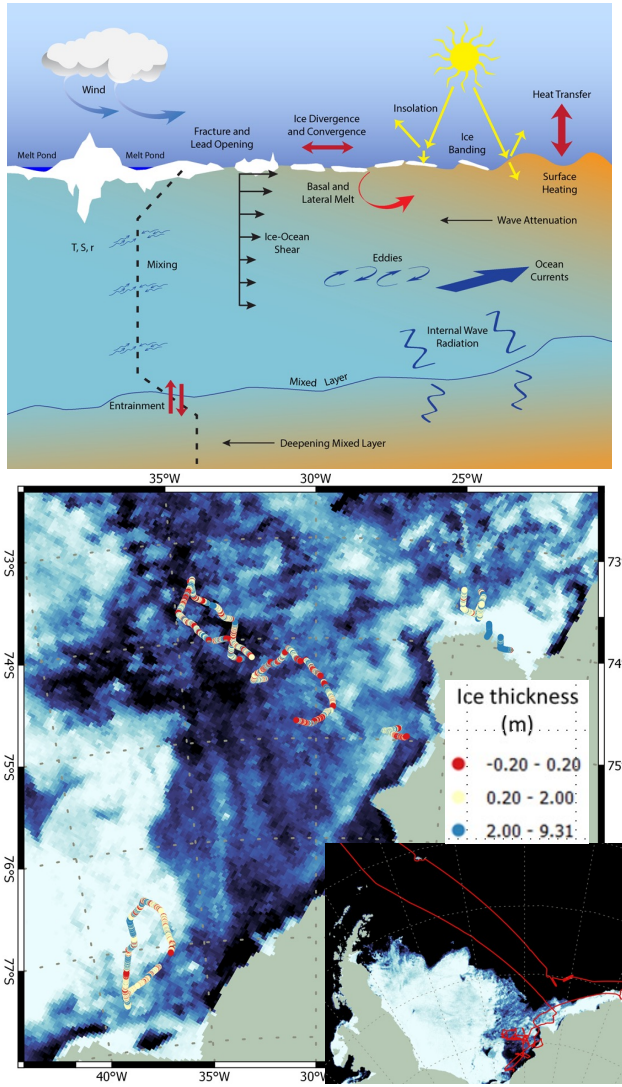
Christian.Haas@awi.de



Sea ice melt in the marginal ice zone (MIZ)

- Sea ice melt results in freshwater deposition in the mixed layer. The goal of the MSc thesis is to compute the freshwater budget for the melting season 2020/21 in the southwestern Weddell Sea.
- Use of ship-based CTD and underway-thermo-salinograph data from the 2021 Cosmus cruise
- Use of airborne and satellite sea ice data from the 2021 Cosmus cruise
- Potentially use of results of an ice-ocean-model
- Requirements: Good programming and English language skills, good grades, (experience with oceanography is of advantage)

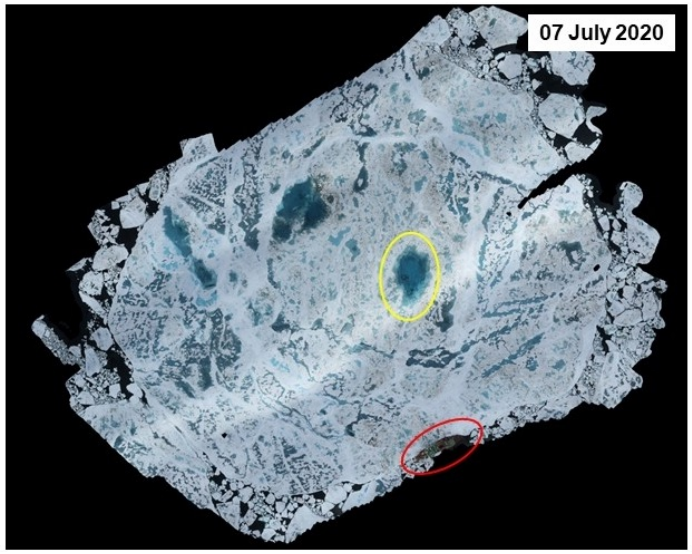
Christian.Haas@awi.de

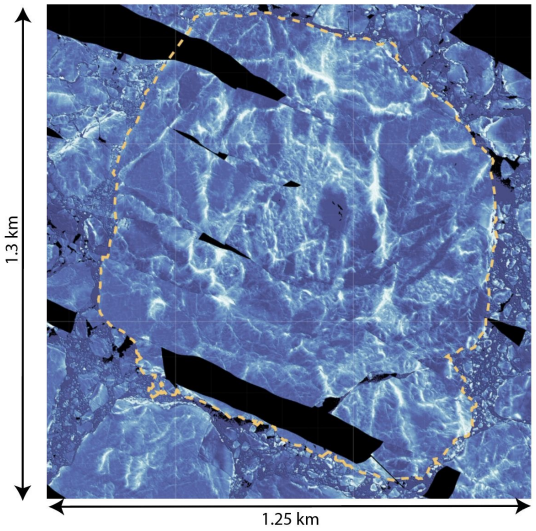


Impact of sea ice morphology on formation of melt ponds

- In the Arctic, intensive surface melt happens every summer, and the melt water accumulates in topographic depressions, where it strongly affects feedbacks of continues, accelerated ice loss. The distribution and geometry of melt ponds therefore strongly depend on the initial surface morphology
- The goal of this MSc thesis is to compare melt ponds in different ice roughness regimes.
- Processing and use of airborne laser scanner and photography (DLR MACS system) data acquired during the IceBird 2020 summer campaign
- There is also an opportunity to use similar data from Mosaic
- Requirements: Good programming and English language skills, good grades, (experience with working with large geographic data sets is of advantage)

Christian.Haas@awi.de





Physical oceanography

Supervision: Dr. Mario Hoppema

Role of the Central Intermediate Water (CIW) of the Weddell Sea, Southern Ocean

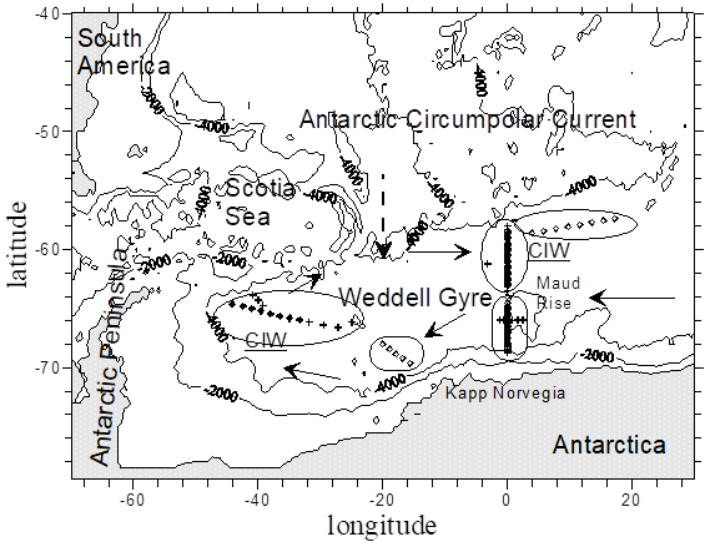
Contact:

Dr. Mario Hoppema

Mario.hoppema@awi.de

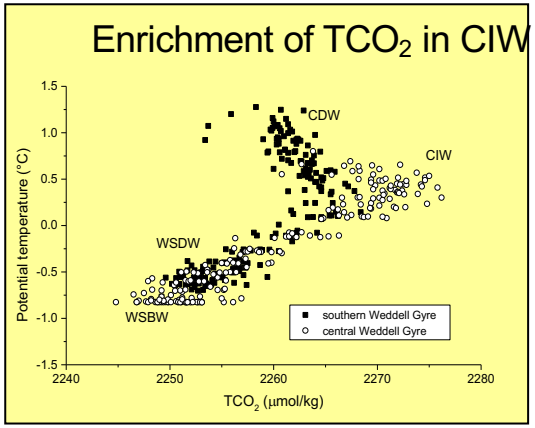
Role of the Central Intermediate Water (CIW) of the Weddell Sea, Southern Ocean

Mario Hoppema (Mario.Hoppema@awi.de)



About Central Intermediate Water

- One of the extreme water masses in the gyre: lowest Temp-max/Sal-max, lowest oxygen minimum; highest CO_2 & nutrients concentrations
- Efficient conduit for transferring nutrients and gases to the ocean abyss
- Sub-surface water mass: not well-ventilated
- Global significance at abyssal scales



Aims

- Optimize description and definition of CIW
- Variability of the CIW – lateral & seasonal
- Compute magnitude of attenuation of characteristics
- Compute enrichment of CO_2 and nutrients in CIW
- Determine pathway of CIW through the Weddell Gyre
- Role of upwelling versus lateral transport

Hydrographic data from cruises in the Weddell Sea will be used. Many of those were collected with **RV Polarstern**. Data are available from few sources, so no need to perform time-intensive data retrieval.

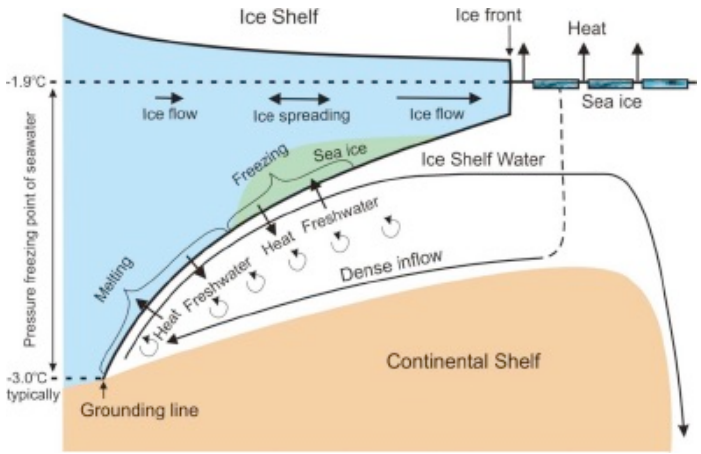
Physical oceanography

Supervision: Dr. Hartmut Hellmer & Dr. Ralph Timmermann

Parametrization of basal melting in a shallow grounding zone using FESOM

Contact:
Hartmut.hellmer@awi.de
Ralph.timmermann@awi.de

Parametrization of basal melting in a shallow grounding zone using FESOM



Conceptual picture of sub-ice shelf overturning, where the layer interacting with the ice shelf is assumed to be sufficiently thin that friction dominates over rotation in the force balance.

Background

- Ocean-driven ice-shelf basal melting is one of the two dominant terms in the mass balance of the Antarctic Ice Sheet.
- Basal melting affects the flow of inland ice towards the ocean (buttressing effect), thus, has an impact on global sea level rise.
- The buttressing effect is most pronounced near the grounding line where the water column is only a few tens of meters thick.
- Numerical models fail to resolve this shallow area due to numerical stability constraints.
- A new parametrization of basal melting in shallow grounding zones has been proposed but still needs to be tested in an ocean-ice-model applied to the Filchner-Ronne Ice Shelf.

Goal

- Implement the new parametrization in FESOM
- Test the applicability of the new parametrization.
- Determine the impact of the new parametrization on cavity circulation and ice-shelf-wide basal melting.
- Assess the impact of the new parametrization on ice sheet dynamics (**Optional**).

Physical oceanography

Supervision: Dr. Benjamin Rabe

- Arctic upper ocean phyiscs and biophysics: in-situ observations by ice-tethered buoys
- Horizontal velocity in the central Arctic from in-situ observations

Contact

Dr. Benjamin Rabe

Benjamin.rabe@awi.de

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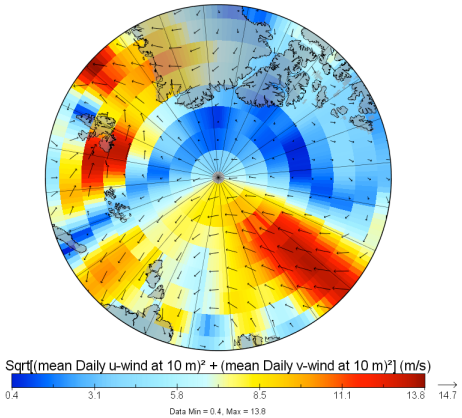
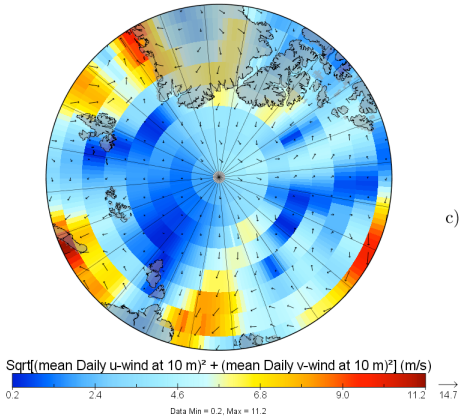
Horizontal velocity in the central Arctic from in-situ observations

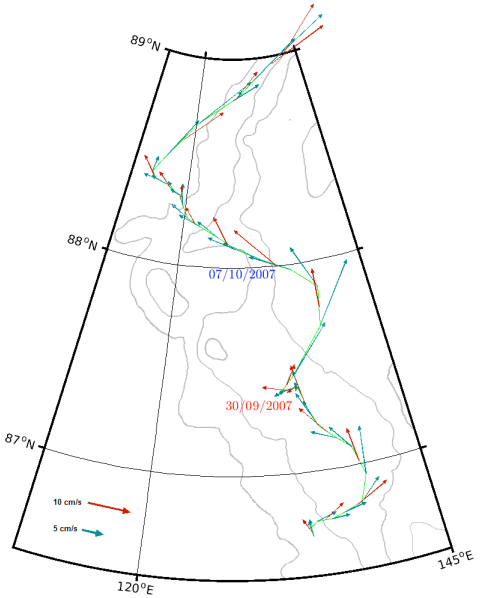
a) Wind vectors 07/10/2007



b) Wind vectors 30/09/2007



B. Recinos (2015)



c) Ice velocities and surface water velocities (23m) averaged daily

Ice drift track

Ice velocity

Ocean velocity (23 m)

Main question:
What is the vertical atmosphere-ice-ocean coupling and Arctic Ocean regional upper ocean circulation?

Data:
In-situ velocity
(Acoustic Doppler Current Profiler)

- **vessel-mounted (ships, various years)**
- **autonomous buoy (ITAC, 2007)**

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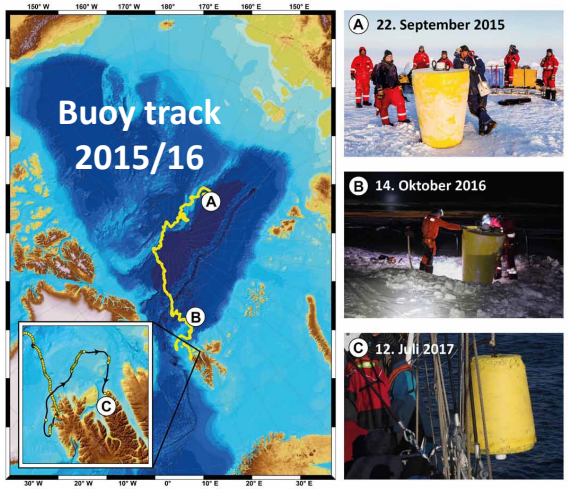
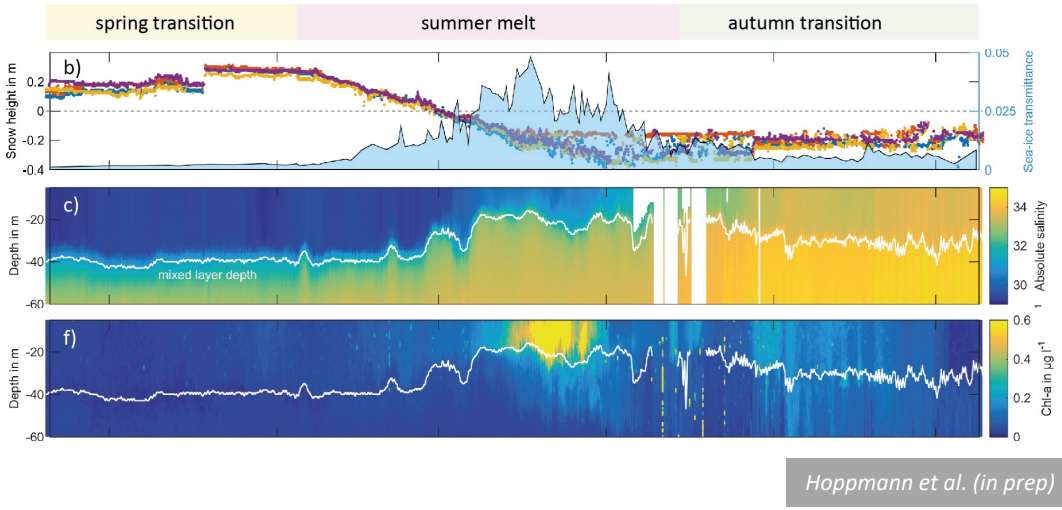
Arctic upper ocean physics and biophysics: in-situ observations by ice-tethered buoys





Sea-ice
Snow

Salinity

Chl a

Hoppmann et al. (in prep)

Main question:
What is the influence of seasonal variability on ocean physics and the upper Arctic Ocean ecosystem?

Data:
Autonomous buoys (in-situ) (MOSAiC)
Sea-ice and surface temperature (satellite)

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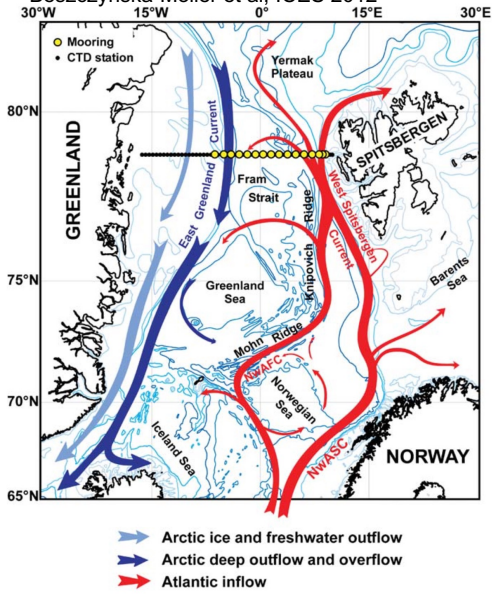
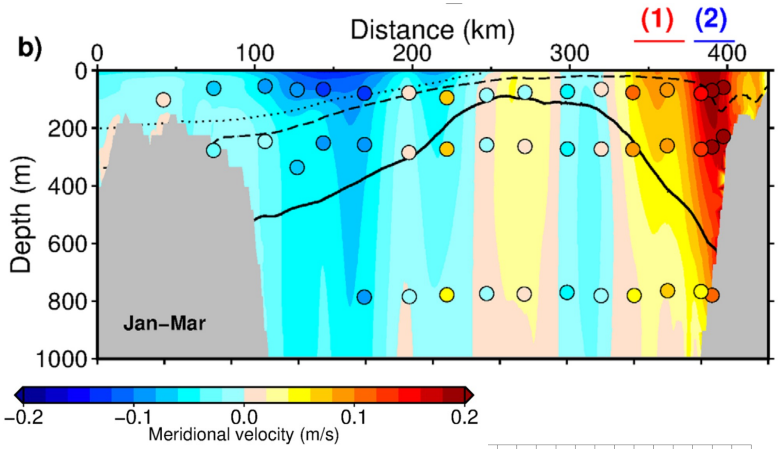
Advisors:
Wilken-Jon.von.Appen@awi.de,
Torsten.Kanzow@awi.de

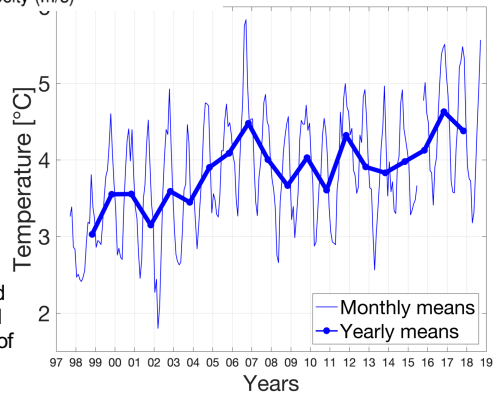
Beszczynska-Möller et al, ICES 2012



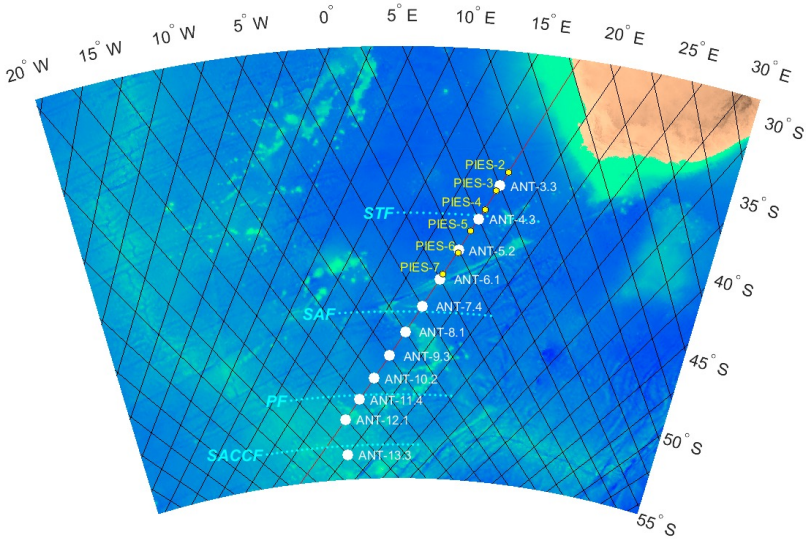
- WSC transports warm salty water northwards into the Arctic Ocean and drives change there
- Moored observations: Temperature, velocity, and (for shorter duration) salinity from six moorings (F1-F6) that slightly changed in configuration over almost 2.5 decades
- Goal: Determine interannual variability and trends; investigate their drivers



Numerical model overlaid by moored observations (circles):
Wekerle et al, JGR 2017



Mooring temperatures averaged over the inner (2) baroclinic and the outer (1) barotropic branch of the WSC:
von Appen et al, unpublished



Distribution of PIES array across the ACC

Goal of thesis:

- Calculate transport fluctuations of the Antarcitic Circumpolar Current at frontal resolution

Available data

- Four years of bottom pressure and travel time data from an array of 11 PIES (pressure inverted echosounder) spanning the ACC between 2010 and 2014.

Supervision: Olaf.Boebel@awi.de & Torsten Kanzow

Atmospheric Physics, Group Polar Meteorology

MAIN TOPICS:

1) Investigation of small-scale air-ice/ocean interaction processes with a focus on the atmospheric boundary layer in flow regimes like cold air outbreaks, warm air intrusions (mean and turbulent structure dependent on synoptic forcing, sea ice characteristics, clouds, location)

2) Study of the spatial distribution and trends of aerosol and Black Carbon in atmosphere and snow and their feedback to cloud formation and climate.
includes the influence of local pollution (like ship emissions), based on shipborne/aircraft measurements.

3) Longterm met. observations (Neumayer, RV Polarstern)
Study of trends of meteorological variables. Focus on standard meteorology, radiation, and precipitation.

4) Remote sensing of sea ice with a focus on radar satellites

Main Tools for Process Studies

T-Bird, tethered sonde for aircraft

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Master themes

Sensor technology of a mobile measurement box for the detection of ship emissions - implementation and calibration

MOTIVATION:
Development of a mobile measuring box for the detection of emissions during ship operation, since shipping contributes significantly to global environmental pollution.

OBJECTIVE:
Equipment of a mobile measuring box with different sensors (for trace gases, black carbon, aerosol particles) to determine finally the emission factors.

WORKING PLAN:
Calibration of the existing sensors in the aerosol laboratory as well as preparation of the sensor system with regard to data recording, transmission (data protocol), implementation in the mobile measuring box and first test measurements using the box.

CONTACT:
Dr. Andreas Herber * AWI Bremerhaven * andreas.herber@awi.de * 01752262215

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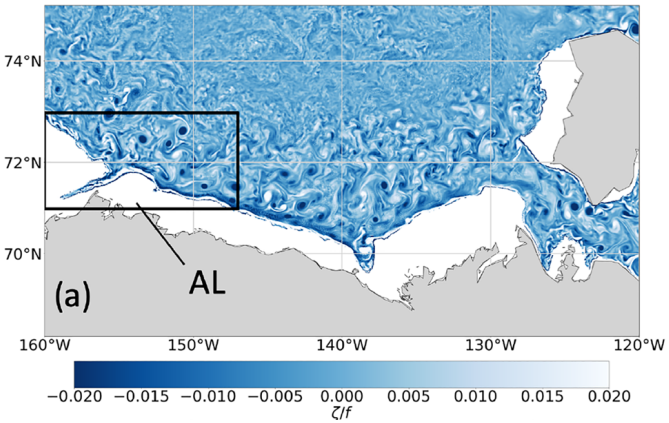


Relative vorticity in model simulations (Wang et al. 2020). Anticyclonic (dark) and cyclonic (light) eddies are responsible for lateral mixing. They are formed as a result of baroclinic instability.

Goal of thesis:

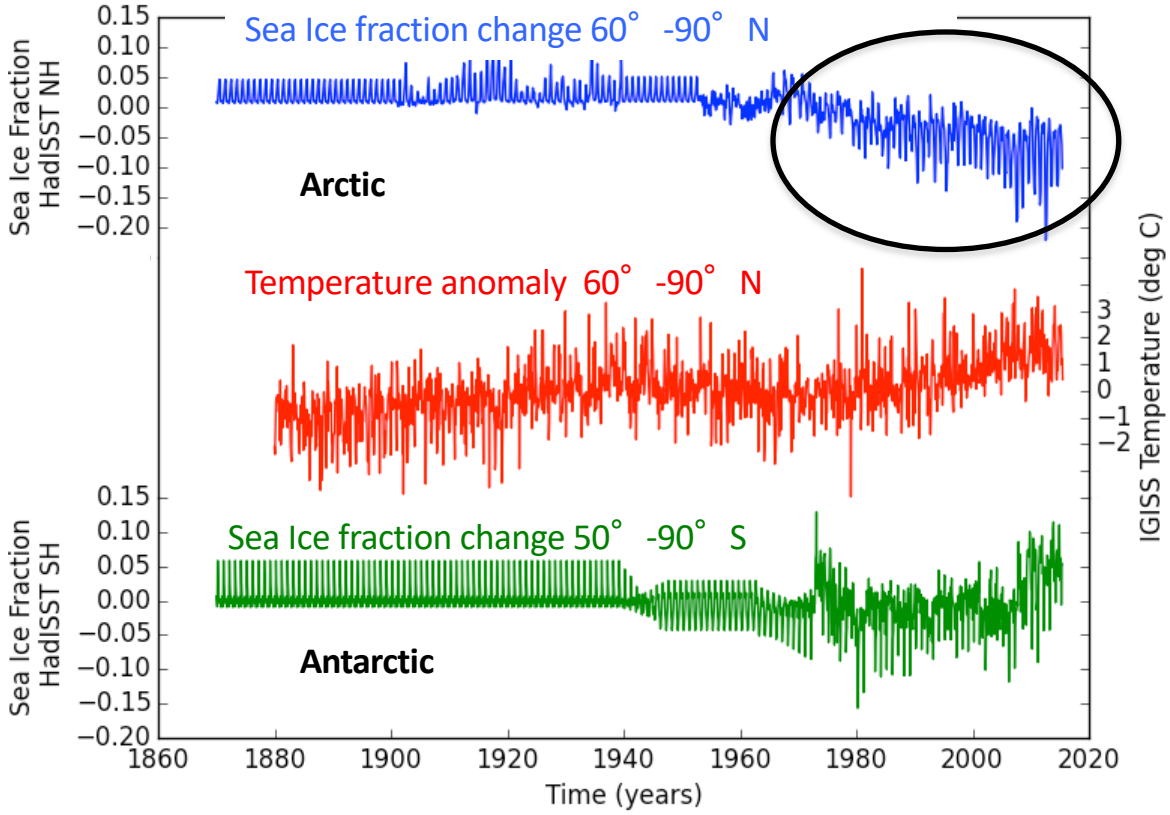
- Create a map of the wavelength and growth rate of baroclinic instability in the Arctic Ocean based on linear stability theory, using climatological and model data on temperature and salinity.
- Compare the size and distribution of eddies simulated by a high-resolution numerical model with the theory and observational data available in the literature.

Requirements

- Good knowledge of ocean dynamics, experience with Matlab or Python

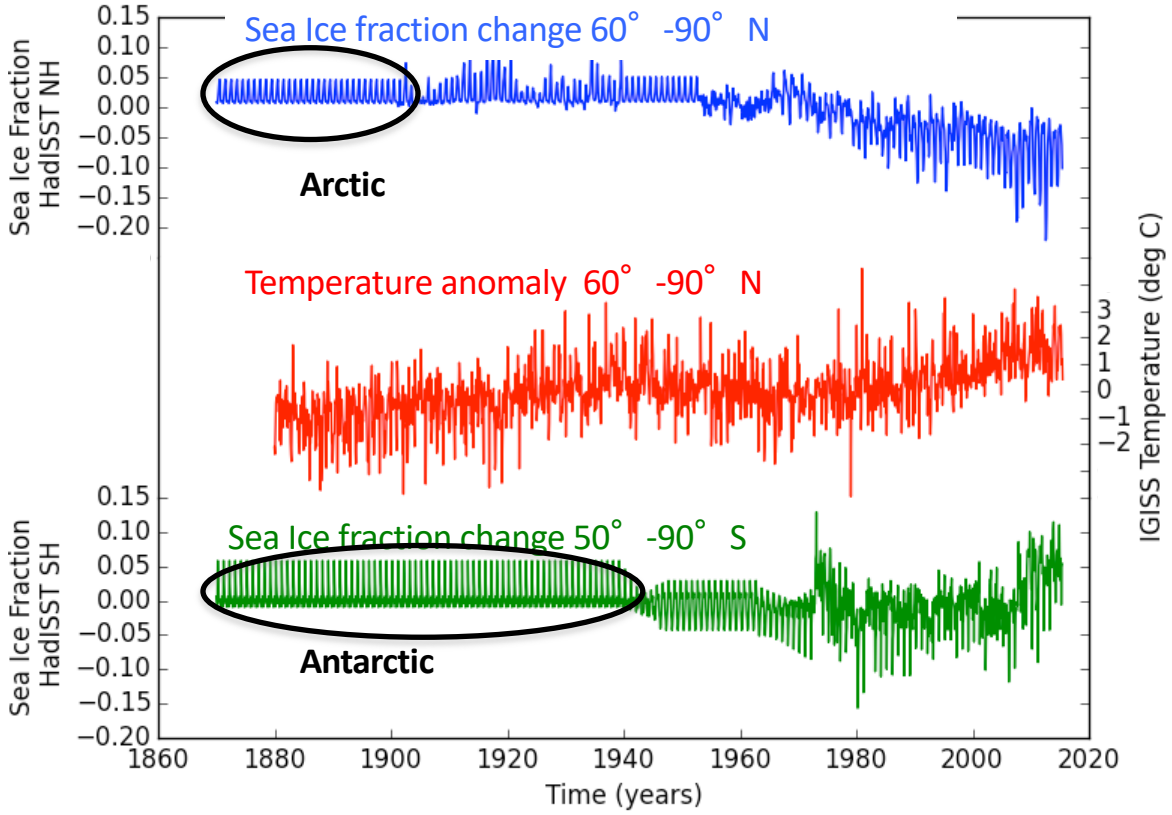
Supervision: Sergey.Danilov@awi.de & Qiang Wang

Arctic Sea Ice retreat



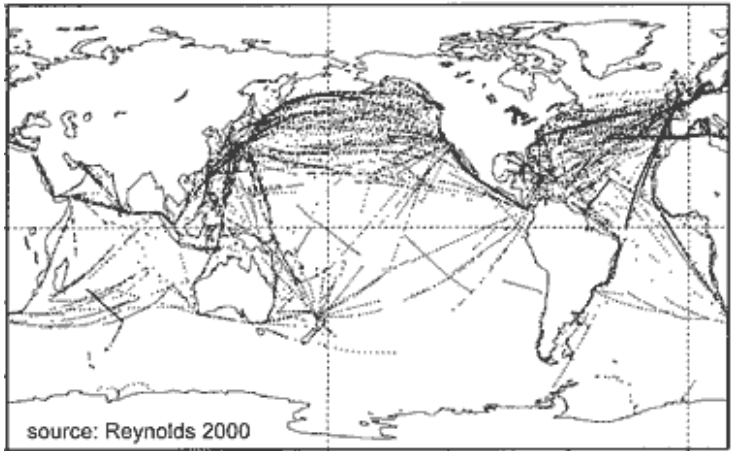
Arctic Sea Ice retreat

Missing Information about Sea Ice



The “Climate dilemma“

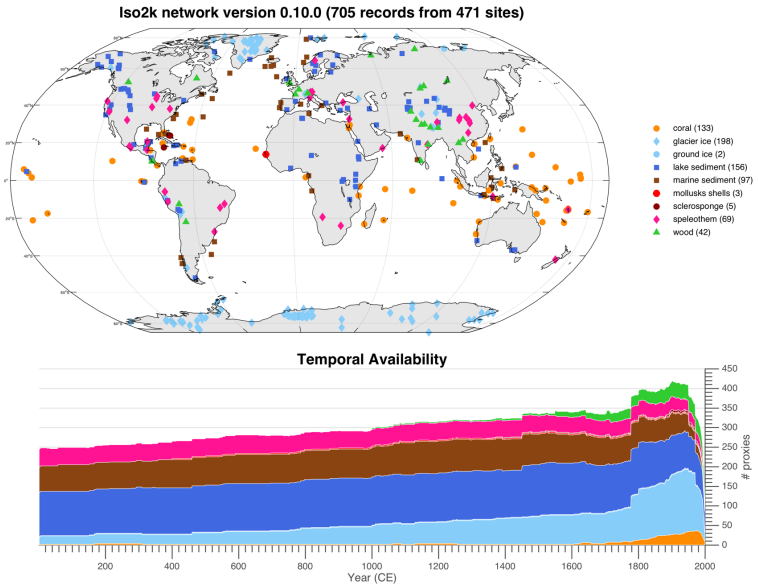
- Instrumental data are **sparce**



- The records of direct temperature measurements are **short** and already fall in the phase of strong **human influence**.

- **For the time before instrumental records, one has to rely on information from proxy data and modeling.**

Climate change recorded in water isotopes during the last 2,000 years



Compilation of isotope records covering the past 2,000 years
(figure by: PAGES Iso2k project)

Goal of thesis:

- detect and analyze climate changes as recorded in stable water isotopes over the last 2,000 years

Available data

- transient climate simulation including stable water isotope diagnostics covering the last two millennia
- various climate proxy records of $\delta^{18}O$ changes in precipitation from PAGES Iso2k project (e.g., ice cores, corals, speleothems, lake sediments)

Supervision: Martin.Werner@awi.de & Gerrit Lohmann

Section marine biogeosciences

Our question:

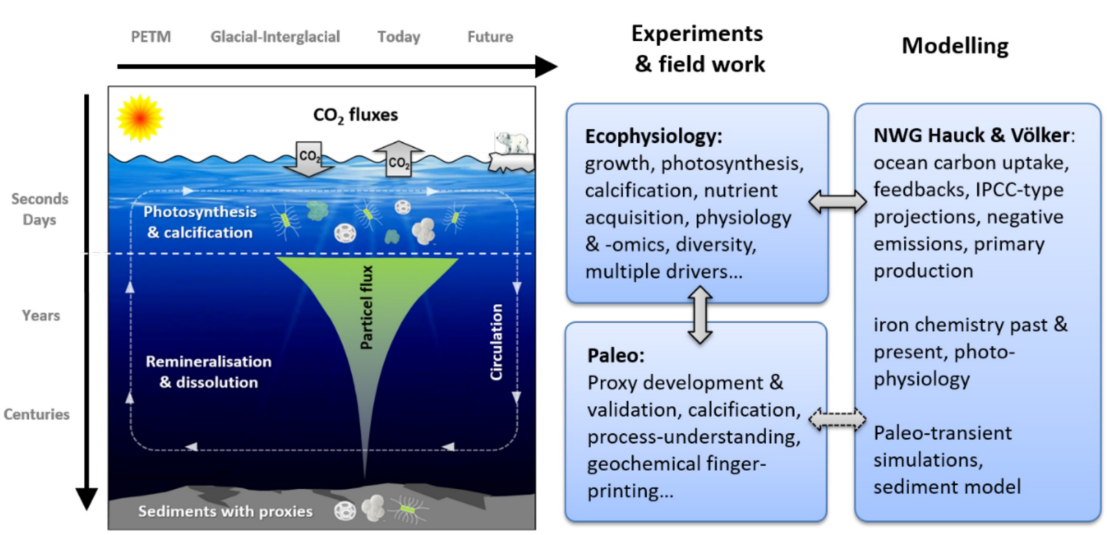
- CO_2 increase and climate change affect marine biology, both directly and through changing ocean circulation
- This affects the storage of carbon in the ocean
- This feeds back on CO2 in the atmosphere and climate

Our people:

- We are a mixed group of experimental biologists, geologists and modellers, attempting to work together.

Our method:

- We modellers take insights on mechanisms from the others, translate them into models, and use that to make predictions



HELMHOLTZ

Possible masters theses in marine biogeochemistry

Some ideas, but many others possible:

- **Model emissions of N_2O (a greenhouse gas) from the ocean**

N_2O is produced when oceanic bacteria convert nitrate to N_2 gas (denitrification); these bacteria need low oxygen values. Low-oxygen zones are predicted to expand under climate change: effect on N_2O in the atmosphere?

- **Study the effects of the vertical migration of zooplankton on the marine carbon cycle**

Many species of copepods (small crustaceans) feed at the surface, but retreat to deeper parts of the water column during the day to avoid being seen and eaten; by doing so, they effectively move carbon away from the surface: effect on carbon storage in the ocean?

Contact

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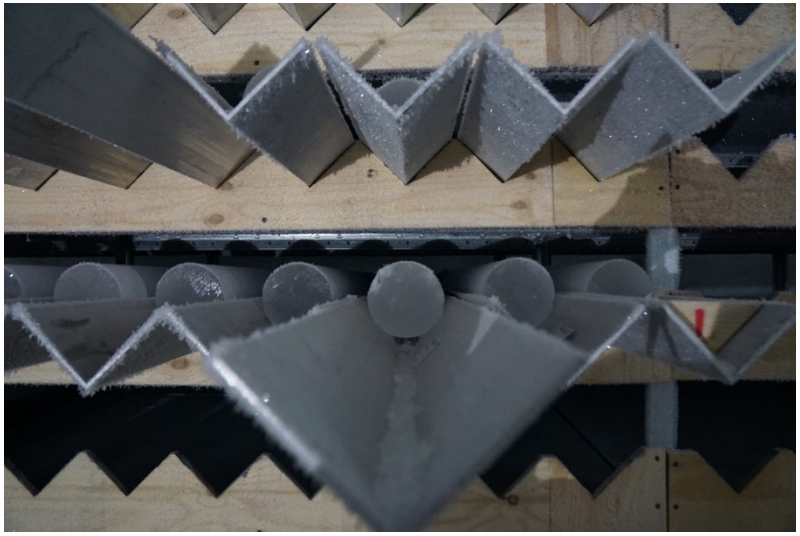
Master Thesis Projects

In the section of Glaciology
Ice core proxies

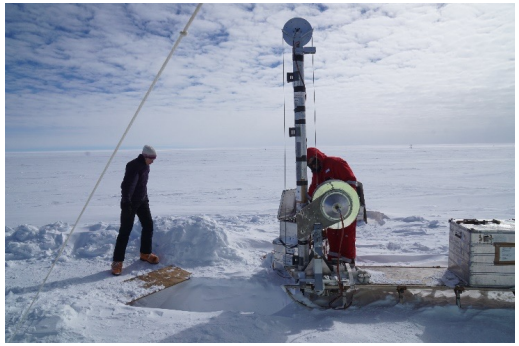
Supervisors:
Maria Hörhold together with Gerrit Lohmann and Martin Werner

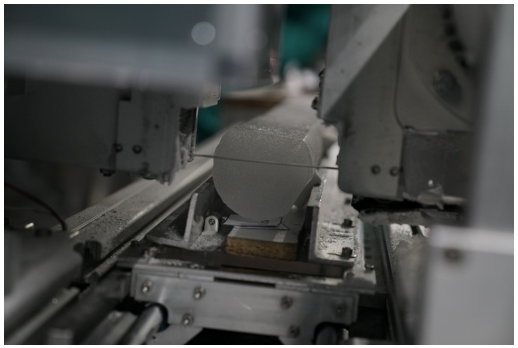


Picture: Ole Zeising

Ice cores

Ice cores – full of hot stories from the cool past





Project 1

How much does it snow?
Derive age and accumulation rate of Greenland firncores

→ 4 firn cores from North-East Greenland, 30-40m long, 50-100 years old (you have to figure out)

→ Use a Python-based „tool box“ to date the cores

→ Challenge: short cores, look out for modern absolute age markers

→ Derive the accumulation rate records of these cores

→ Place the accumulation rate in a larger context

What is available:

- Data over depth of the firn cores,
- Python Tool Box for dating the firn cores
- a Masterthesis on the tool box and its application to a firn core – so a good example to follow

Project 2

Isotopes or Isotopes?

How to best measure stable water isotopes with respect to uncertainty?

→ 1 firn core, three different ways of measuring stable water isotopes

→ Derive the measurement uncertainty (based on a provided theoretical approach) for the three different methods

→ Compare the three methods

→ Derive and test different combinations of measurement techniques, in order to get the best measurement uncertainty

What is available:

- Stable water isotope data/samples of the same core partly measured by three different techniques
- Theorectical background and approach for determining uncertainty for one of the methods
- A Masterthesis on different aspects of uncertainty, experiments etc (in German)
- A Masterhesis on the comparison of 2 methods, with theoretical concepts, (using R, in english)

Project 3

Is it getting warmer in the snow?
How has the isotopic composition of surface snow at Neumayer station changed in the past years?

→ Measure the „new snow“ samples collected at Neumayer station over the past years

→ Connect these data to the already existing time series of „new snow“ covering the past 20 and more years

→ Compare the results to in-depth snow and vapor analysis of the past 3-5 years to assess the meaning of the „new snow“ sample with respect to variability

→ Derive and test trends and variability of this time series

What is available:

- Snow samples „new snow“ from Neumayer of the past 10 years to be measured
- Time series of „new snow“ from earlier years
- Isotope data of the intensive snow sampling campaigns over three years throughout the year
- Possibiliy to compare these snow data to vapor

Project 4

How does storage changes ice cores?
How much is the stable water isotopic composition of firn and ice cores changing during storage?

→ Analyse data from different samples over different time periods

→ Utilize R-tool to look into theoretical diffusion due to storage

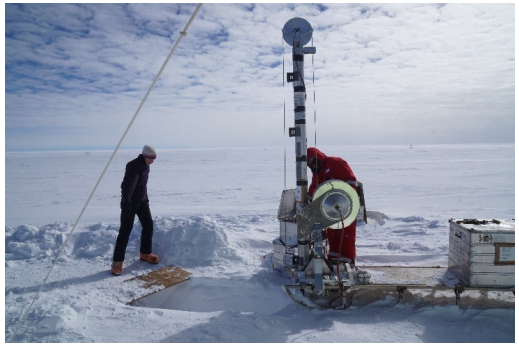
→ Compare model and data

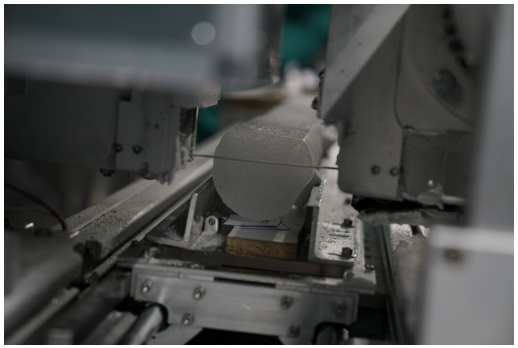
→ Quantify the effect of storage on the isotopic composition of firn and ice core samples with time

What is available:
- R-tool to model firn diffusion (needs probably some adjustment)
- Different data sets, where an effect has been observed

Ice cores

Ice cores – full of hot stories from the cool past





Questions?

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