ESSReS-L1:
06 Oct – 10 Oct, 2008

Introduction to the interdisciplinary field of Earth System Science Research, Part I

“The Earth system and its components, an overview”

Editor in charge: Klaus Grosfeld,
Earth System Science Research School, 2008
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Course programme within the ESSReS Curriculum

ESSReS-L1: Introduction to the interdisciplinary field of Earth System Science Research, Part I

The Earth system and its components, an overview
Block course: 06.-10.10.2008, 9 am – 4 pm,
Location: AWI, IUP, Jacobs University
Responsible: G. Lohmann, P. Baumann, T. Brey, A. Ladstätter-Weißenmayer, J. Kipfstuhl, P. Lemke, L. Linsen, F. Lamy, C. Melsheimer, D. Olbers, C. v. Savigny, A. Schaefer, B.-M. Sinnhuber, G. Uenzelmann-Neben, V. Unnithan, C. Völker, D. Wolf-Gladrow

Email: info@earth-system-science.org
Gerrit.Lohmann@awi.de

This course gives an introduction and provides a broad overview about the interdisciplinary field of Earth System Science, comprising the atmosphere, ocean, cryosphere and solid earth, which at the same time determine the conditions experienced by the biosphere. Basic knowledge of processes and mechanisms of the individual Earth system components will be taught in order to sensitize for problems when bridging the gap between disciplines.

Unit 1: **Date: Monday, 06 October 2008,**
Location: AWI
Building: F
Room: Glaskasten

9:00 – 10:30: Paleoclimate dynamics – identifying driving mechanisms of climate change (G. Lohmann)
11:00 – 12:30: How the ocean circulation works (D. Olbers)
14:00 –15:30: Ice in the climate system (J. Kipfstuhl)

Unit 2: **Date: Tuesday, 07 October 2008,**
Location: AWI
Building: F
Room: Glaskasten

9:00 – 10:30: Global Cycles of Biogenic Elements (D. Wolf-Gladrow)
11:00 – 12:30: Putting it together: How global biogeochemical models work (C. Völker)
14:00 – 15:30: The living ocean – a simple look at a complex system (T. Brey)

Unit 3: **Date: Wednesday, 08 October 2008,**

Location: Jacobs University Bremen

Building: *Research IV, II, III*

Room: *Conference Room, Lecture Hall, Lecture Hall*

9:00 – 10:30: Web GIS in marine geoscience (A. Schaefer, V. Unnithan)

11:00 – 12:30: Geo-scientific data management and Web service (P. Baumann)

14:00 – 15:30: The impact of data visualization (L. Linsen)

Unit 4: **Date: Thursday, 09 October 2008,**

Location: AWI

Building: F

Room: Glaskasten

9:00 – 10:30: The Earth climate system and its components (P. Lemke)

11:00 – 12:30: Climate development – what information can we gather using geophysical methods (G. Uenzelmann)

14:00 – 15:30: Marine geology: Introduction to paleoceanography (F. Lamy)

Unit 5: **Date: Friday, 10 October 2008,**

Location: IUP/University Bremen

Building: IUP, PEP lecture room

Room: *S-3032*

9:00 – 10:30: How does remote sensing work and how this does help to understand our climate (C. Melsheimer)

11:00 – 11:45: Solar interactions and the mesosphere (C. v. Savigny)

11:50 – 12:30: Key aspects of atmospheric dynamics (B.-M. Sinnhuber)

14:00 – 15:30: Environmental chemistry (A. Ladstätter-Weißenmayer)

Updates of the course program and location can be found at

http://www.earth-system-science.org/en/courses/

Contents: page

Geo-scientific data management & Web services

Lecturer
Name: Peter Baumann
Department: EECS
Institute: Jacobs University Bremen
Email: p.baumann@jacobs-university.de
Duration of lecture: 90 min

Lecture content

This course provides an introduction to design and application of information systems using database systems and Web technology. Emphasis is on aspects which are of immediate importance for the professional life of geo scientists, addressing the key question "how does it help me in my scientific work?".
In the database section, the Entity-Relationship (ER-) Model will be introduced as a convenient means for information modeling. Next, the relational model will be covered because relations (i.e.: tables) in the end are stored and queried in a concrete database. Conversion from ER to relational schemata will be addressed briefly. Further, the SQL language will be presented as a means for flexibly extracting information from databases.
In the Web section we will introduce to HTML and XML. A glance will be given to dynamic content creation. The 3-tier architecture will be presented as a common model for Web applications.
Finally, an outlook will be given on large-scale geo-scientific raster services.

Literature

"Unfinished business used to mean going back as a ghost. Now, thanks to the Web, you can work from here."

- Jeffrey Ullman, Jennifer Widom: [A first course in database systems](). Prentice Hall, 2002.
  a good database primer
- Hector Garcia-Molina, Jeffrey Ullman, Jennifer Widom: [Database system implementation](). Prentice Hall, 2000.
  advanced material
- Stefan Stanczyk: [Theory and practice of relational databases](). Taylor & Francis, 2001.
  relational foundations
- James Lee, Brent Ware: Open source Web development with LAMP: using Linux, Apache, MySQL, Perl, and PHP. Addison-Wesley, 2003.
  a good LAMP textbook
- Hugh E. Williams, David Lane: Web Database Applications with PHP and MySQL, Second Edition. O'Reilly, May 2004 , ISBN: 0-596-00543-1
  your friend in your PHP life
- https://teamwork.jacobs-university.de:8443/confluence/display/cocoweb/Intro+to+HTML
  HTML intro (only accessible from Jacobs campus)
- http://oreilly.com/pub/topic/python
  Python books at O'Reilly

The living ocean – a simple look at a complex system

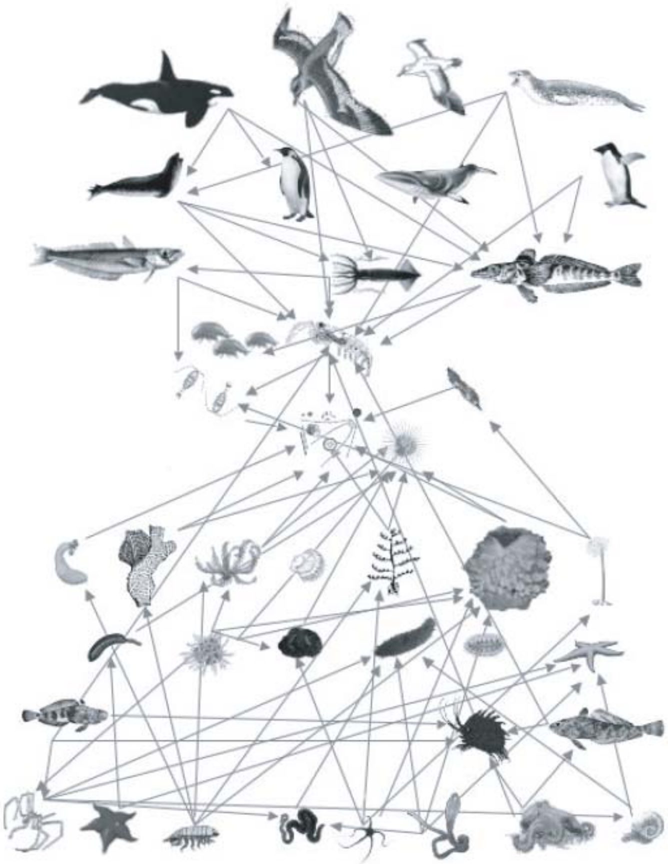
Lecturer

Name: Thomas Brey
Department: Marine Animal Ecology
Institute: AWI
Email: Thomas.Brey@awi.de

Duration of lecture: 90 min

Lecture content

One might see the living Ocean as a solar energy powered machine that cycles and re-distributes CO_2 by synthesizing high-energy molecules from CO_2 and H_2O and breaking them down again. The interesting part is that this "machine" is of awesome complexity and that it has particular border conditions, is subject to immense spatial and temporal variability and features intrinsic self-regulating and self-adapting properties. We will look at key-compartments, key-processes and key-properties of the living ocean to enhance our understanding of function and dynamics of marine ecosystems.



Simplified food web around Bouvetoya Island, Antarctica. (Jacob et al. 2006)

Literature

Belgrano A et al., 2005. Aquatic food webs – An ecosystem approach. Oxford Univ. Press,

Hurrell JW et al., 2000. The North Atlantic Oscillation – Climate Significance and environmental impact. AGU, Washington, USA.

Valiela I, 2009. Marine Ecological Processes. Springer, N.Y., Heidelberg

Ice in the climate system

Lecturer

Name: Sepp Kipfstuhl
Department: Glaciology
Institute: Alfred Wegener Institute for Polar and Marine Research
Email: sepp.kipfstuhl@awi.de

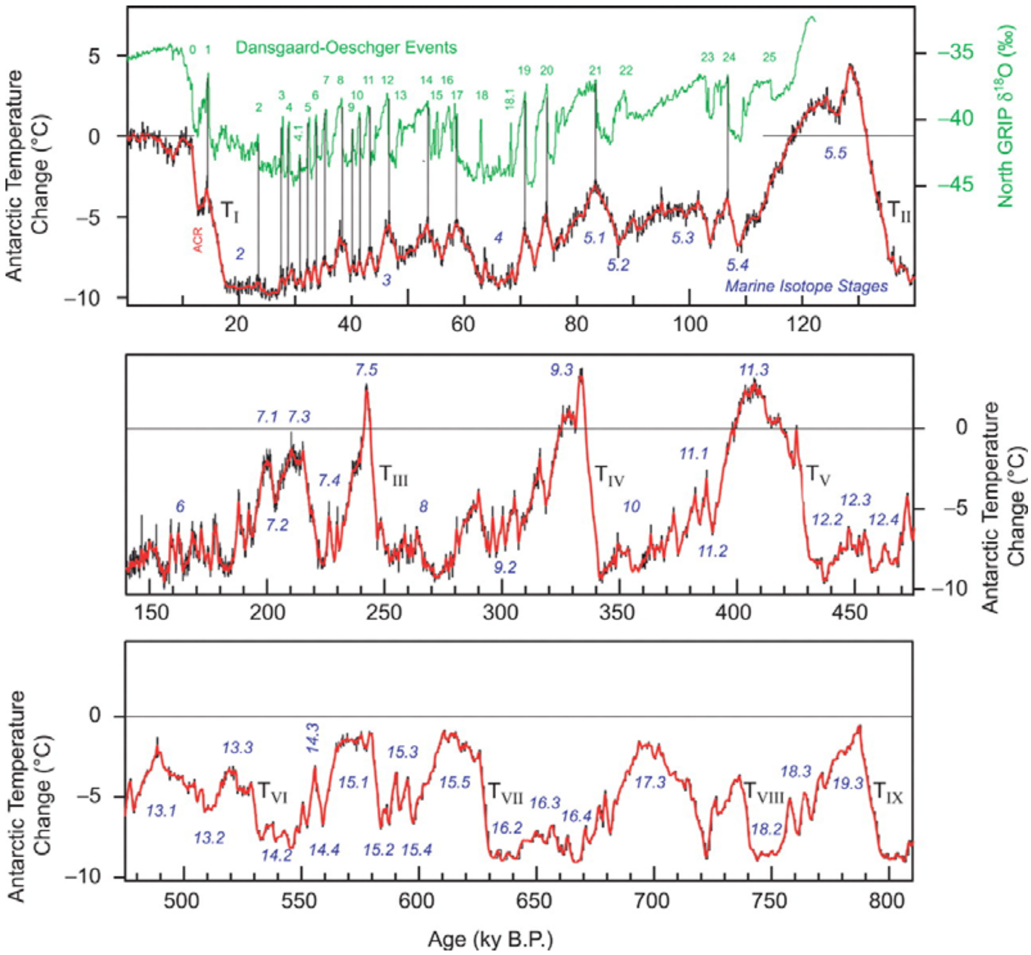
Duration of lecture: 90 min

Lecture content

Snow, frozen ground, sea ice, glaciers and the large ice sheets, in other words the cryosphere is an important component of the climate system. Snow and ice are relevant for the climate because of their special thermal and radiative properties. In the solar spectrum snow and ice are nearly white, but in the infra-red spectrum they are almost black. These properties together with the low heat capacity and conductivity and large amounts of latent associated with phase changes make ice to the major heat sink in the energy budget of our planet.

Ice - mainly the large ice sheets in Greenland and Antarctica - accounts for about 2 % of Earth's water (~65 m of sea level) and about 70 % of the fresh water. Most of the ice is frozen water vapor which forms the seasonal snow cover, glaciers and large ice sheets in Greenland and Antarctica. Sea ice forms from freezing sea water, covers about 7 % of the ocean surface and affects significantly the energy exchange over the ocean. Brine expulsion during freezing leads to the formation of dense water masses which drive the thermohaline circulation in the ocean. Another cold, dense water mass originates from the interaction of the ocean with the ice shelves. The role of ice within the climate system and for the more recent climate history is expressed in the terms "glacials" and "interglacials". They indicate that the climate of the last millions of years was characterized by glacial climate conditions. Warm climatic periods like the Holocene were more relatively short episodes between the glacial periods.

In high altitudes and latitudes where snow survives the melt season glaciers and ice sheets built up over time and created an unique archive for the climatic and environmental conditions of the past. Ice cores drilled into an glacier or ice sheet open this archive for a wide variety of atmospheric tracers and trace gases. Amongst all climate archives only ice cores can tell the story of greenhouse gases like carbon dioxide or methane from direct measurements of their concentrations. During the last 20 to 30 years ice core improved significantly our knowledge and understanding of the paleoclimate. The oldest ice core, the EPICA ice core drilled at Dome C in Antarctica, contains 8 glacial cycles.
In my presentation I will discuss the role of ice in the climate system and how ice cores contribute to decipher the climate of the past.



Dome C temperature anomaly as a function of time over the past 810 ky. From Jouzel et al., Science 2007)

Literature

EPICA, community members (2006). One-to-one coupling of glacial climate variability in Greenland and Antarctica, Nature, 444, 195-198., doi:10.1038/nature05301.

EPICA, community members (2004).Eight glacial cycles from an Antarctic ice core, Nature, 429, 623-628., doi:10.1038/nature02599.

Jouzel, J. et al. (2007). Orbital and Millennial Antarctic Climate Variability over the Past 800,000 Years, Science 317, 793.

Lemke, P. and J. Ren IPCC Report 2007, Chapter 4, Observations: Changes in Snow, Ice and Frozen Ground

North Greenland Ice-Core Project members (2004). High-resolution record of the Northern Hemisphere climate extending into the last interglacial period, Nature, 431, 147-151.

Parrenin et al., (2007). The EDC3 chronology for the EPICA Dome C ice core, Clim. Past, 3, 485–497.

IPICS White papers (oldest Ice Core and others), http://www.pages-igbp.org/ipics/index.html

Environmental chemistry

Lecturer

Name: Annette Ladstätter-Weißenmayer

Department: University of Bremen

Institute: Institute of Environmental Physics

Email: lad@iup.physik.uni-bremen.de

Duration of lecture: 90 min

Lecture content

In the recent past human activities have led to significant changes in biogeochemical cycles and have caused numerous ecological changes and problems. Many of the questions related to these problems can be interpreted by applying fundamental laws of chemistry. With the lecture in 'Environmental Chemistry' an introduction including stratospheric and tropospheric processes was presented. An overview of reactions, sources and sinks of substances relevant for the environment and about analytical methods for the determination of such substances were shown.

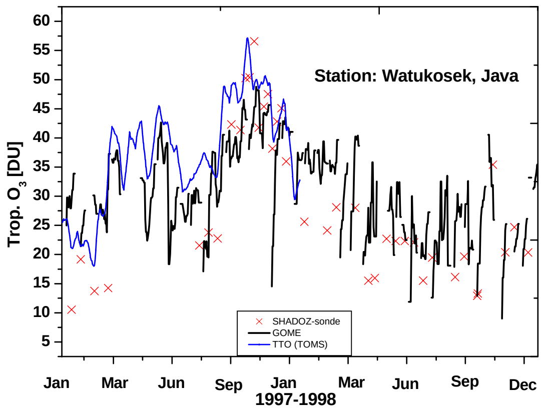


Fig. 1.: An increase of tropospheric ozone during El Niño in 1997 over Watukosek, Java as retrieved from GOME (Global Ozone Monitoring Experiment)- and sondes- and model output data.

Literature

Finlayson-Pitts, B., J., Chemistry Of The Upper And Lower Atmosphere: Theory, Experiments, and Applications, Academic Press, San Diego, London, 2000.

Wayne, R. P., Chemistry of Atmospheres, Oxford University Press, ISBN10: 019850375X, 806 p., 2000.

Environmental Chemistry, Colin Baird, Freeman and Company, ISBN 0-7167-2404-9.

Atmospheric Chemistry and Global Change, Eds Guy P. Brasseur, John J. Orlando and Geoffrey S.Tyndall Oxford University Press, ISBN 0-19-510521-4.

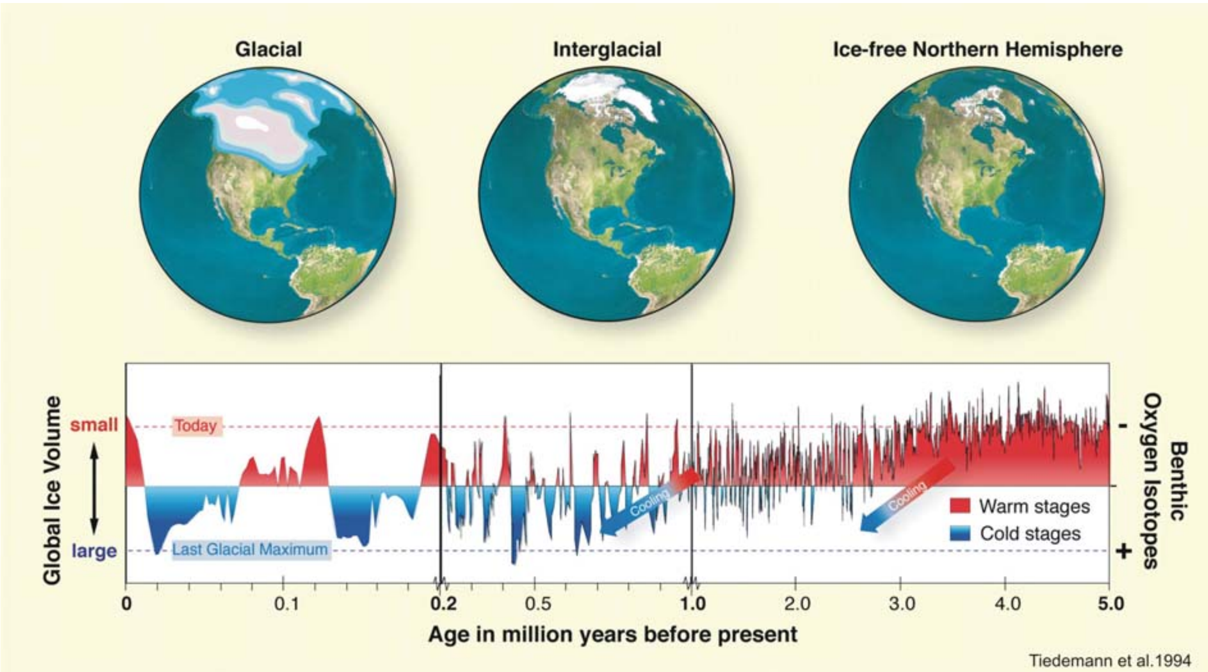
Marine Geology: Introduction to Paleoceanography

Lecturer

Name:	Frank Lamy
Department:	Marine Geology
Institute:	AWI
Email:	Frank.Lamy@awi.de
Duration of lecture:	90 min

Lecture content

The lecture will give a brief introduction to the major research topics of paleoceanography focussing on the past few million years. We will first discuss the role and importance of paleoceanographic and paleoclimatic data for improving our understanding of processes, thresholds and feedbacks in our climate system. Next we will go through the different possibilities for reconstructing climate variables in the past (proxy data). A major part of the lecture will then deal with a synopsis of past climate and ocean variations on different time-scales ranging from millions of years to decades or even years.



Literature

William F. Ruddiman, Earth's Climate: Past and Future. W.H. Freeman and Company, New York. 2001.

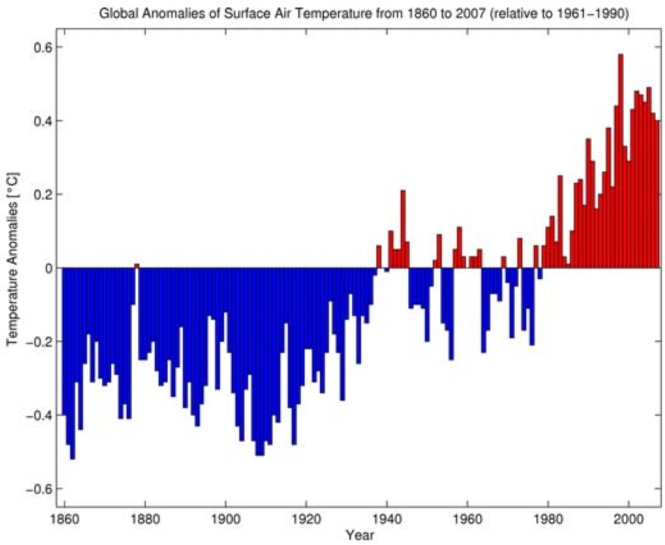
The Climate System and its Changes

Lecturer
Name: Peter Lemke
Department: Climate Sciences
Institute: Alfred Wegener Institute
Email: peter.lemke@awi.de
Duration of lecture: 90 min

Lecture content

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

This statement in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007 is based on a wide variety of climate observations and model simulations. The present characteristics of the climate system are a product of a long-term evolution determined by external forcing (sun, volcanoes) and internal interactions within the climate system, which is composed of atmosphere, ocean, cryosphere, land surfaces, and the marine and terrestrial biosphere. Until 250 years ago, the interference of man was negligible, and climate variations were a product of natural processes and interactions alone. Since the beginning of industrialisation the composition of the atmosphere, especially the concentrations of greenhouse gases like carbon dioxide and methane, have significantly increased. In addition, the character of the land surface has been largely modified through land-use and land-cover change through human activities. Part of the observed global warming during the past 100 years is attributed to these anthropogenic impacts. This lecture provides the evidence of climate variations on all time-scales, and presents an introduction to the physics of the climate system.



Literature

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. (All chapters and the Technical Summary are available under http://www.ipcc.ch)
McGuffie, K. and A. Henderson-Sellers: A Climate Modelling Primer (3rd ed.), Wiley, Chichester, 2005
Peixoto, J.P. and A.H. Oort: Physics of Climate, American Institute of Physics, New York, 1992

The impact of visualization

Lecturer

Name:	Lars Linsen
Department:	Computational Science & Computer Science
Institute:	Jacobs University
Email:	l.linsen@jacobs-university.de
Duration of lecture:	90 min

Lecture content

In geosciences, analysis and interpretation of data plays an important role. Today's devices allow for generation or collection of a massive amount of data, which are beyond of what can be handled and understood by observing individual numbers or samples. Data Visualization has become an important tool to support intuitive and interactive analysis of data in a global as well as local fashion. Scientific visualization deals with the visualization of data with a natural spatial interpretation such as computer-generated data from numerical simulations or measured data using scanning or sensor techniques. In geosciences, one typically deals with height-field data (data values defined over a 2D spatial support) or volume data (data values defined over a 3D spatial support). Time may add another dimension to the visualization problem. In case of height-field data, surface rendering and color mapping are most commonly been used to display the data field. In case of volume data, volume visualization methods such as segmentation, surface extraction, and direct volume rendering for structured and unstructured gridded as well as scattered data are being used. These include techniques for scalar field, vector field, and tensor field visualization. The lecture will give an introduction to the field of scientific visualization and will give an overview over existing methods and concepts.

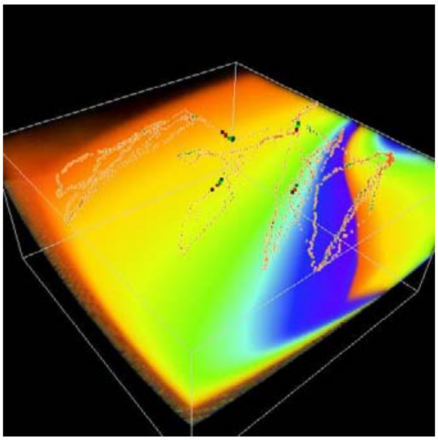


Figure 1: Visualization of a time-varying volumetric temperature field in the Monterey Bay off the coast of California. Data was collected using five autonomous underwater vehicles.

Literature

Alexandru Telea: *Data Visualization: Principles and Practice*, Wellesley, Mass.: AK Peters, 1st edition, 2008.

Charles D. Hansen & Christopher R. Johnson: *Handbook of Visualization*. Academic Press, 2004.

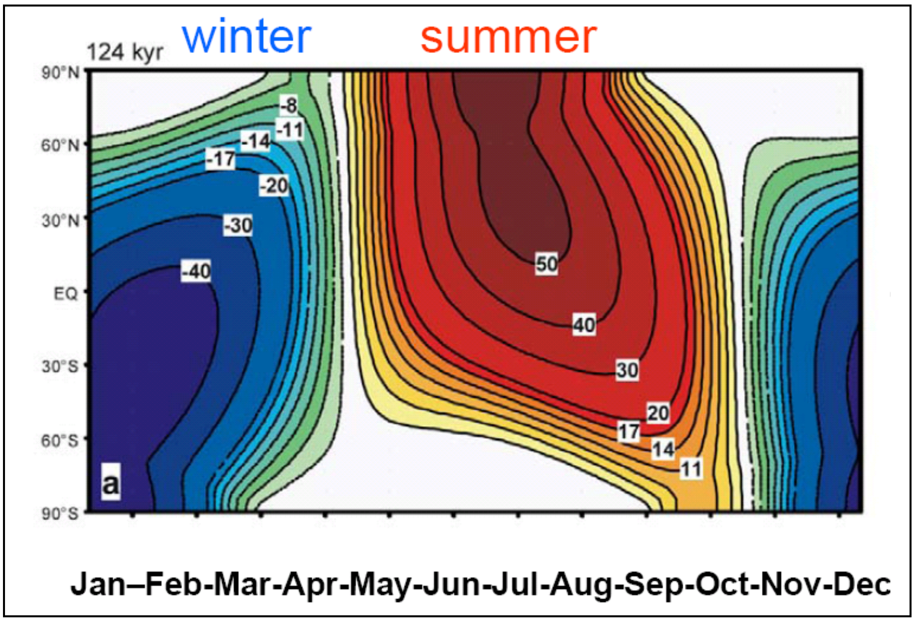
Paleoclimate dynamics

Lecturer
Name: Gerrit Lohmann
Department: Climate Science
Institute: AWI
Email: Gerrit.Lohmann@awi.de
Duration of lecture: 90 min

Lecture content

In attempting to account for long-term paleoclimatic variations, we are led to broaden our view of the climate system and to restructure our approach to a fuller theory of climate. We begin by describing the external forcing of the climate system and the observed response, as represented by proxy evidence for paleoclimatic variations. One focus of the course is to identify driving mechanisms for climate change. This is done through numerical models of the Earth system and statistical analysis of instrumental and proxy data.

Special areas: feedback mechanisms in the climate system; the role of the global oceanic thermohaline circulation for paleo and recent climate variations; deglaciation; Glacial climate; Climate modes like ENSO and NAO; Milankovitch theory of the ice ages.



Insolation anomaly at 124,000 years before present day. Units are Wm^{-2} .The anomaly is caused by variations in the Earth orbital parameters. Note an increase of max. 60 Wm^{-2} during boral summer and a reduction up to 45 Wm^{-2} during boreal winter in the Southern Hemisphere and parts of the Northern Hemisphere during that time.

Literature

Dynamical Paleoclimatology - a generalized theory of global climate change, B. Saltzman, Academic Press, San Diego, 2002, 345 pp.
The nature of mathematical modeling, N. Gershenfeld, Cambridge University Press, Cambridge, 2003, 344 pp.
William F. Ruddiman: Earth's Climate past and future http://bcs.whfreeman.com/ruddiman/
Physics of Climate by Jose P. Peixoto, Abraham H. Oort, American Institute of Physics, 1992. 520 pp.

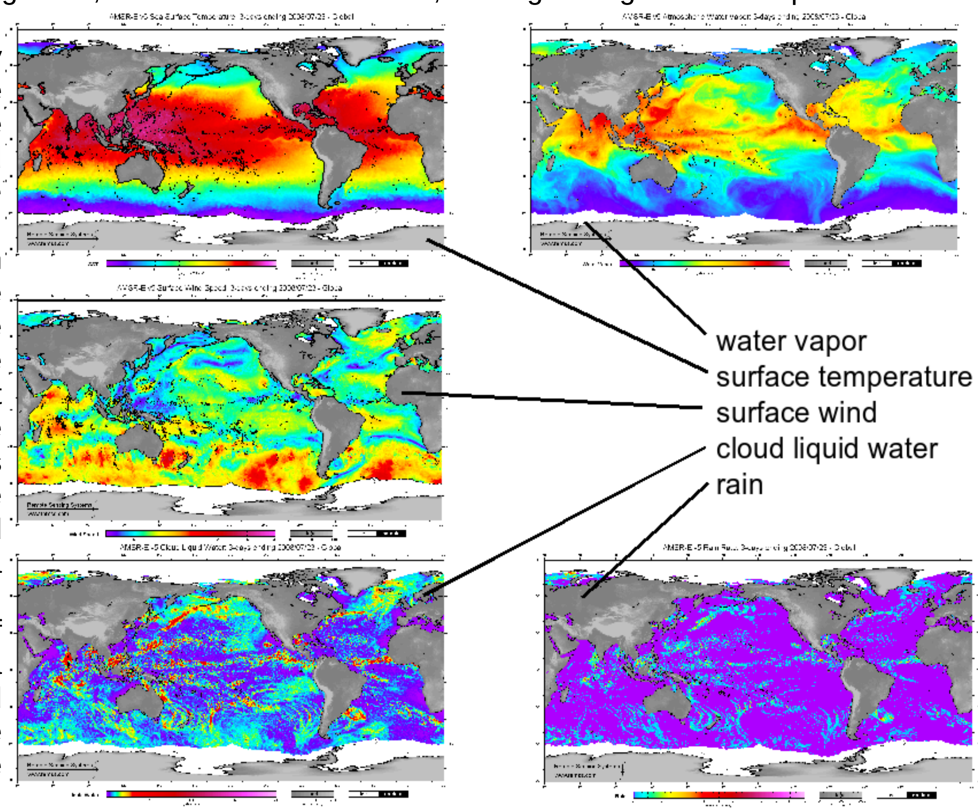
How does remote sensing work and how does this help to understand our climate

Lecturer

Name: Christian Melsheimer, Justus Notholt
Department: Physics, University of Bremen
Institute: Institute of Environmental Physics
Email: melsheimer@uni-bremen.d, jnotholt@iup.physik.uni-bremen.de
Duration of lecture: 90 min

Lecture content

The term “remote sensing” means measuring from a distance, without actually being in direct contact with the object measured. This is typically done by measuring electromagnetic radiation emitted, scattered, reflected or transmitted by the object of interest. The “object of interest” here is, of course, the Earth, i.e., the atmosphere and the land and sea surface. This lecture gives an overview of the basic principles of remote sensing of the Earth and gives some examples for applications relevant in climate research.
Remote sensing instruments can be either ground-based, looking up into and through the atmosphere, or can be based on airplanes and satellites, looking down through the atmosphere toward the ground, or can be satellite-based, looking through the atmosphere at the Earth's limb. Such instruments typically use light in the ultraviolet and visible range, infrared radiation, or microwave radiation.
The quantities that can be measured by remote sensing are, e.g., the temperature of the atmosphere at different heights, the concentration of various trace gases in the atmosphere, cloud cover, rain, the sea surface temperature, the concentration of chlorophyll near the sea surface, the wind speed, the sea surface elevation, or the sea ice cover.



Literature:

T.M. Lillesand, R.W. Kiefer: Remote Sensing and Image Interpretation. Wiley, 2000.
C. Elachi: Introduction to the physics and techniques of remote sensing, Wiley, 1987.
M.A. Janssen: Atmospheric Remote Sensing by Microwave Radiometry, Wiley, New York,1993.

How the ocean circulation works

Lecturer

Name: Dirk Olbers
Department: Climate Science
Institute: Alfred Wegener Institute
Email: dirk.olbers@awi.de

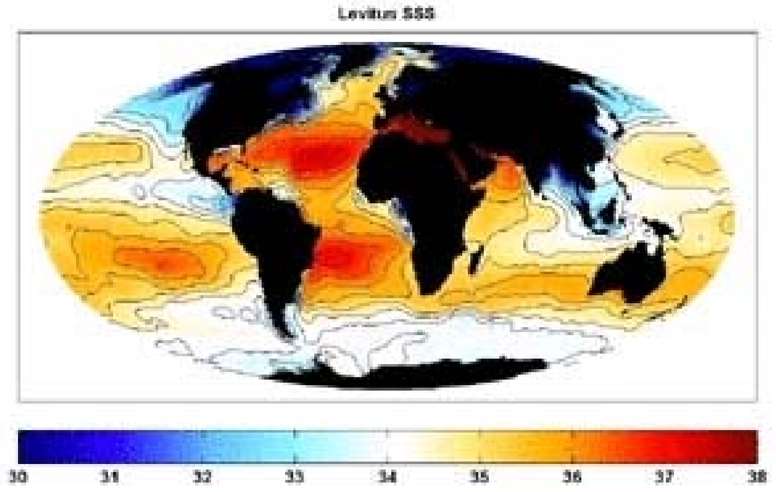
Duration of lecture: 90 min

Lecture content

The Earth is a 'water planet'. A good two-thirds of its surface is covered with water. The large oceans are an essential prerequisite for the existence of the biosphere. They were the cradle of the first life on Earth and provide an indispensable habitat for numerous organisms

It is generally accepted that the oceanic circulation has a profound influence on the mean state of the earth's climate and on climate changes on decadal and longer time scales. Large-scale transports of heat and fresh water by ocean currents are key climate parameters. The stratification and circulation in the upper ocean is crucial for the penetration of heat and substances into the ocean. Vertical motions and water mass formation processes in high latitudes are an important controlling factor for the oceanic uptake of carbon dioxide through the sea surface and thus directly influence the radiative forcing in the atmosphere.

In this lecture provides an overview about the role of the ocean in the climate system, how ocean circulation works, the processes of turbulence and mixing, and what kind of observing systems we use today.



The world ocean sea surface temperature distribution (°C) after Levitus (1994).

Literature

Bryan, K. (1978). The ocean heat balance. Oceanus 29, 18-26.
Levitus, S., Boyer, T.P. (1994). World Ocean Atlas 1994 Volume 4: Temperature, number 4.
Olbers, D., Gouretsky, V., Seiß, G., Schröter, J. (1992). Hydrographic Atlas of the Southern Ocean, Alfred-Wegener-Institut, Bremerhaven,
Olbers, D., Ivchenko, V. O.(2001). On the meridional circulation and balance of momentum in the Southern Ocean of POP, Ocean Dynamics, Vol. 52, 79-93.
Schmitz,W. J. (1996). On the World Ocean Circulation. WHOI-96-03, Volume I and II.

Solar interactions and the mesosphere

Lecturer
Name: Christian von Savigny
Department: Fachbereich 1, University of Bremen
Institute: Institute of Environmental Physics
Email: csavigny@iup.physik.uni-bremen.de

Duration of lecture: 45 min.

Lecture content

The mesosphere is the atmospheric layer between the stratosphere and the thermosphere and extends in altitude from about 50 km to about 90-100 km. Mesospheric physics and chemistry differs significantly from stratospheric and tropospheric processes in many respects. Different dynamical processes drive the meridional circulation in the mesosphere, many chemical constituents exhibit strong diurnal variations, and this atmospheric layer is also more subject to variations in solar irradiance or intermittent events such as solar flares or solar proton events, than the lower atmosphere. This lecture will provide an overview of the most important features of this interesting atmospheric layer in terms of its chemical composition, specific dynamical features, and its high sensitivity to extra-terrestrial (in particular solar) influences. Unique mesospheric phenomena such as noctilucent clouds/polar mesospheric clouds will also be discussed.

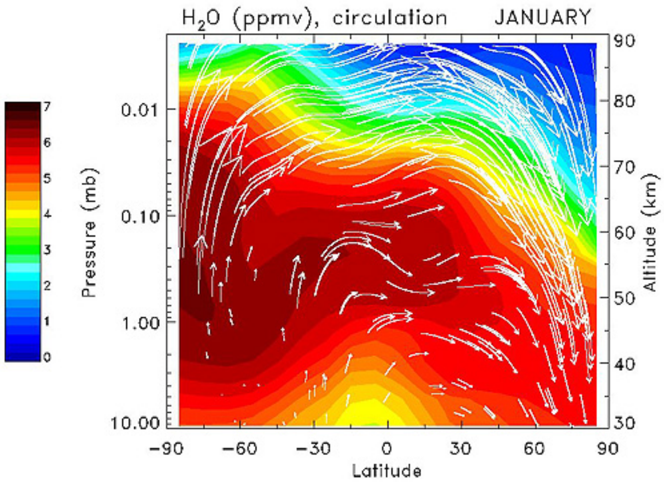


Fig. 1: Middle atmospheric H_2O (observed by HALOE) and circulation for the month of January (Stratospheric ozone online textbook)

Literature

Brasseur, G. P., Solomon, S., Aeronomy of the Middle Atmosphere, Springer Netherlands, ISBN: 1402032846, 2005.

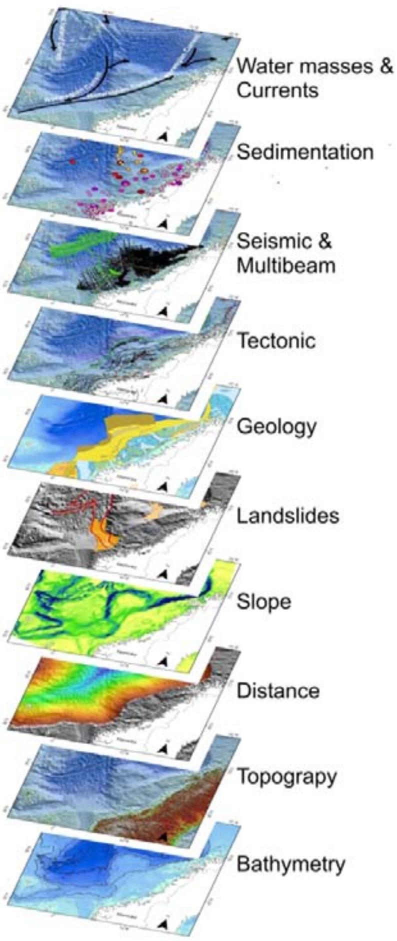
Internet data mining & Web GIS in marine geoscience

Lecturer

Name: Angela Schaefer, Vikram Unnithan
Department: Earth & Space Scinces
Institute: Jacobs University
Email: a. schaefer@jacobs-university.de
Duration of lecture: 90 min

Lecture content

This lecture will introduce you to the principles of Geographic Information System (GIS) and its application in marine geosciences. In this context we will give examples of processing and analysis techniques for marine geoscience data. A GIS allows us to combine data visually and computationally for spatial correlation, analysis, modelling and calculation. In this context, GIS has become the universal tool to integrate, analyse, manage and visualize large volumes of spatial data from multiple sources at a variety of scales. Examples of applications to various fields in marine geo- and bio-sciences, data management, habitat mapping will be discussed. A major part of this course will introduce you to role of the Internet in data mining as well as to web-based access and data retrieval from worldwide established data archives for Earth Scientists.



Literature

Dawn Wright, 2002: Undersea with GIS, 240 pages, ESRI Press, Redlands
ISBN: 9781589480162

Key aspects of atmospheric dynamics

Lecturer

Name: Björn-Martin Sinnhuber
Department: University of Bremen
Institute: Institute of Environmental Physics
Email: bms@iup.physik.uni-bremen.de

Duration of lecture: 45 min.

Lecture content

The lecture will provide an introduction into atmospheric dynamics with a particular emphasis on the large scale circulation of the stratosphere, i.e., in the region from about 10 to about 50 km altitude in the Earth atmosphere. The large scale stratospheric circulation, also known as the Brewer-Dobson circulation, is characterized by upwelling motion in the tropics and a poleward and downward transport in the extra-tropics of both hemispheres. The Brewer-Dobson circulation has direct implications for the transport of trace gases and thus the chemistry of the ozone layer and there is an increasing body of evidence that it may even have an impact on surface weather and climate.

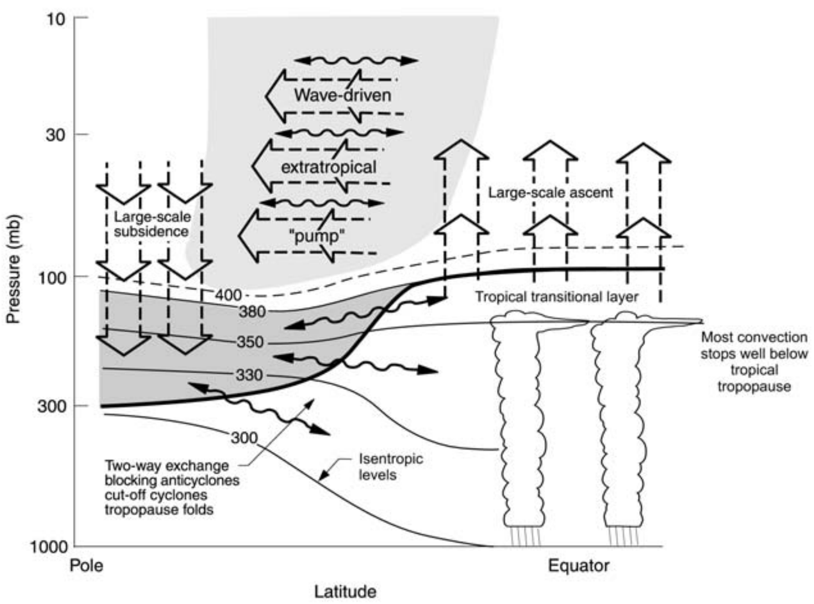


Fig. 1: Schematic representation of the stratospheric Brewer-Dobson circulation. The driving force for the circulation are dissipating planetary scale waves in the stratosphere. Modified, after Holten et al., 1995.

Literature

Garcia, R., P. Hess, and A. Smith, Atmospheric Dynamics and Transport, in **G. P. Brasseur et al., Atmospheric Chemistry and Global Change**, Oxford University Press, 1999.

Climate development – what information can we gather using geophysical methods?

Lecturer
Name: Gabriele Uenzelmann-Neben
Department: Geophysics
Institute: AWI
Email: Gabriele.Uenzelmann-Neben@awi.de
Duration of lecture: 90 min

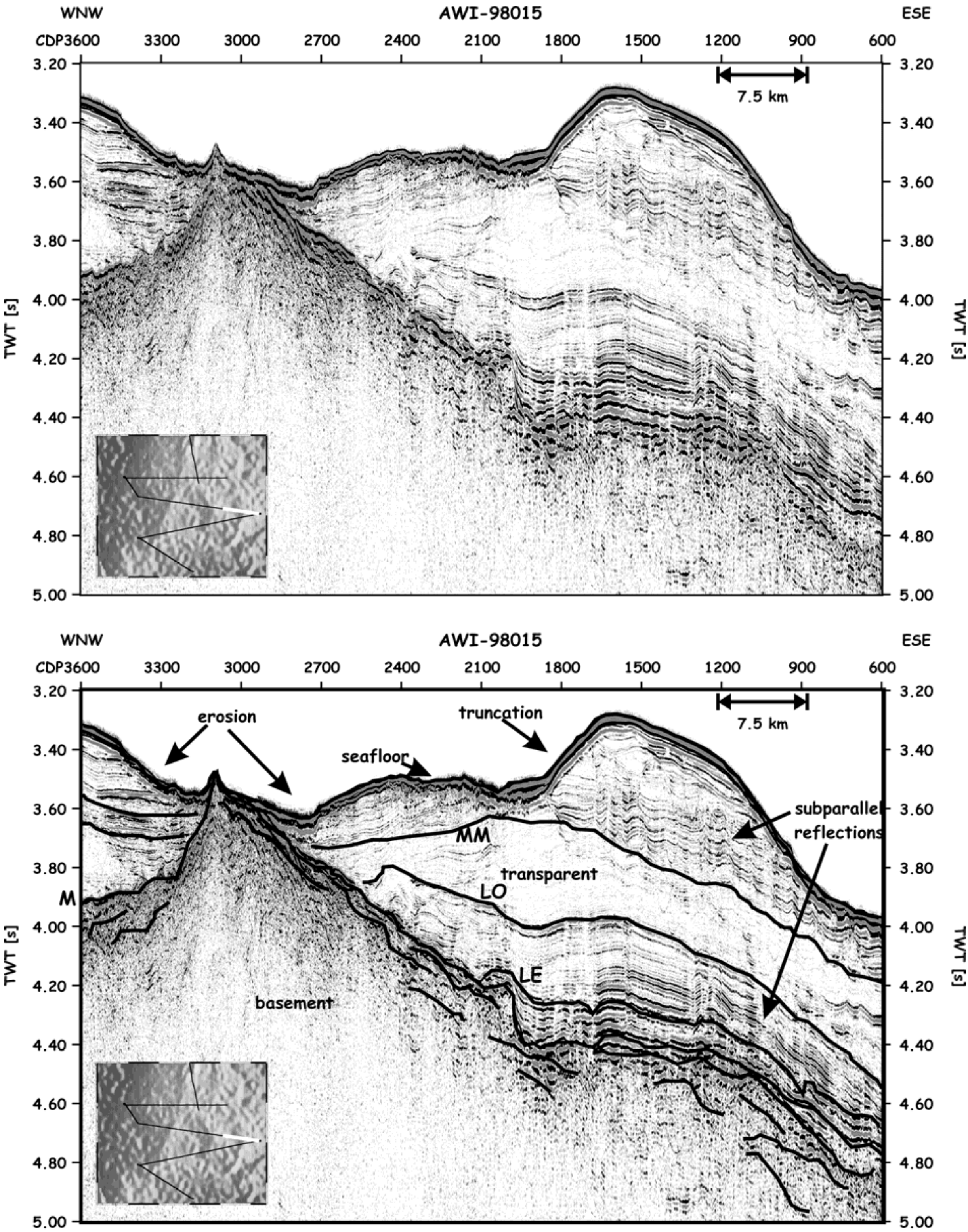
Lecture content

Thermohaline-driven bottom currents (contour currents) and their related deposits, generally termed contourites, gained an increasing amount of attention during the last three decades. This is due to the fact that drift deposits contain a record of palaeoenvironmental information about climate development and oceanography, and this archive is hence used to gain knowledge on the palaeoclimatic development of a certain region. "Drift" is a more general term compared to "contourite" and refers to larger sediment deposits with an often complex internal architecture, which are generated by persistent currents of thermohaline origin (Pickering et al., 1989). Publications of the last years concentrated on the recognition and classification of bottom-current-controlled deep-sea deposits in sediments and seismic data (Viana et al., 1998) and their interaction with turbidities (Faugères and Stow, 1993; Stow et al., 1998; Faugères et al., 1999; Stow et al., 2002). A recent publication by (Shanmugam, 2000) critically reviewed the facies models proposed for deep-water processes during the last 50 years. This discussion shows that the interplay between contour and turbidity currents is not yet fully understood (Faugères and Stow, 1993; Faugères et al., 1999). Nevertheless, it has become increasingly clear that both down-slope and along-slope processes play crucial and interactive roles in the construction and shaping of continental margins.

Transport, erosion and deposition of sedimentary particles are fundamental processes in the benthic boundary layer because they represent the link between oceanographic processes in the water column and the documentation of these processes in the sedimentary record. Harris et al. (2001) proposed that the sea ice regime and production of bottom water are closely related and thus the amount of deposited material in a sediment drift is connected to glacial-interglacial cycles. Sedimentary structures and textures hence constitute archives of the depositional and re-depositional environment and processes. By an inversion of those features into the generating process, the analysis of sedimentary structures can lead to a deciphering of the acting oceanographic conditions and thus to a better understanding of the development of both oceanographic currents and the climate in a particular area.

Seismic methods are used to image the sedimentary structures. Sediment drifts are characterised by discontinuities marking distinct changes in reflection pattern (transparent, subparallel, chaotic). Truncation of internal reflectors can be observed at the seafloor and at the discontinuities. The discontinuities correspond to significant changes in flow pattern, links to ice sheet formation or to periods of major growth of Antarctic ice (Faugères and Stow, 1993; Stow et al., 2002). Hydrological events changed the physical (salinity, density, velocity) and chemical properties of water masses thus modifying the biological productivity as well (Faugères and Stow, 1993; Faugères et al., 1999; Scher and Martin, 2006). Water masses such as Antarctic Bottomwater and the Agulhas Current with specific physical and chemical properties lead to erosion. Those erosional patches bear traces of the currents' paths and intensities.

The investigation of sedimentary structures as imaged by seismic reflection methods provides information on the current systems responsible for the generation of those structures. We are thus enabled to construct a model for the chronological evolution of the currents in a particular region. This model contains important information on the climatic evolution of the region.



Uenzelmann-Neben et al., Fig. 4

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Putting it together: how global biogeochemical models work

Lecturer

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Lecture content

Global Cycles of Biogenic Elements

Lecturer

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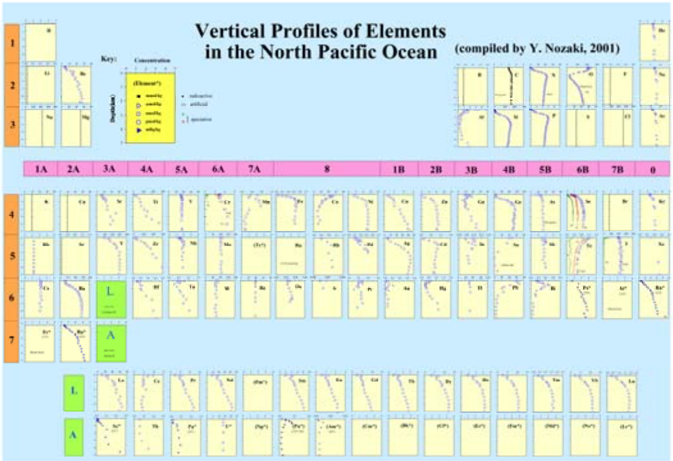
Duration of lecture: 90 min

Lecture content

The global carbon cycle and its relation to climate; the physical and the biological carbon pump; the marine carbonate system. How important is biology?
Organisms couple the cycles of various elements (C, N, P, O, Si, Ca).
Natural variations and anthropogenic perturbations of elemental cycles.



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