<u>ESSReS-L4:</u>
17 Aug – 20 Aug, 2009

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

“Physics and Chemistry of the Atmosphere, Remote Sensing and Phytooptics”

Editor in charge: Klaus Grosfeld,
Earth System Science Research School, 2009
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Course programme within the ESSReS Curriculum

ESSReS-L4: Introduction to the interdisciplinary field of Earth System Science Research, Part IV

Physics and Chemistry of the Atmosphere, Remote Sensing, Phytooptics
Block course: 17 - 20 August 2009, four days, 9 am - 5 pm
Location: University of Bremen, IUP; ESA/ESTEC-Noordwijk (The Netherlands)
*Responsible: **A. Ladstätter-Weißenmayer,** A. Bracher, K. Grosfeld, W. von Hoyningen-Huene, C. Melsheimer, M. Palm, A. Richter, T. Ridder, F.Wittrock*
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lad@iup.physik.uni-bremen.de

The recognition that significant changes in the composition of the Earth's atmosphere are occurring on both short and long timescales and thereby modifying our environment and climate, has resulted in scientific debate as well as public concern, and emphasises the need for global measurements of atmospheric constituents at representative spatial and temporal sampling. In order to assess the significance of such changes a detailed understanding of the physical and chemical processes controlling the global atmosphere is required. The accurate assessment of the impact of current and future anthropogenic activity or natural phenomena on the behaviour of the system, comprising the atmosphere and the Earth's surface, requires quantitative knowledge about the temporal and spatial behaviour of several atmospheric trace constituents (gases, aerosol, clouds) from the local to global scales in the troposphere, stratosphere and mesosphere, as well as surface conditions (sea ice, ocean colour). This can be gained by remote sensing techniques.

Unit 1: **Date: Monday, 17 August 2009,**

Location: University Bremen

Building: IUP

Room: NW1, S1360

9:00 – 10:30: Remote Sensing – an introduction
(Annette Ladstätter-Weißenmayer)

11:00 – 12:00: Laboratory tour (Mathias Palm, Theo Ridder)

13:30 – 15:00: Satellite observations of atmospheric trace gases
(Andreas Richter)

15:30 – 16:00: Laboratory tour (Andreas Richter, Folkard Wittrock)

Unit 2: **Date: Tuesday, 18 August 2009,**

Excursion to ESA/ESTEC (Klaus Grosfeld)

Departure: 8:00h Bremen main station

Arrival: 14:00 Noordwijk (Netherlands)

14:00 – 17:15: Visit and guided tour at ESA/ESTEC

Departure: 18:00h Noordwijk (Netherlands)

Arrival: 00:00h Bremerhaven/Bremen

Unit 3: **Date: Wednesday, 19 August 2009,**

Location: University Bremen

Building: IUP

Room: NW1, S1360

13:00 – 14:30: Remote Sensing of sea ice (Christian Melsheimer)

15:00 – 16:30: Lecture continued (Christian Melsheimer)

Unit 4: **Date: Thursday, 20 August 2009,**

Location: University Bremen

Building: IUP

Room: NW1, S1360

9:00 – 10:30: Ocean colour remote sensing (A. Bracher)

11:00 – 12:00: Exercises (A. Bracher)

13:30 – 15:00: Remote Sensing of atmospheric aerosols
(Wolfgang von Hoyningen-Huene)

15:30 – 17:00: Lecture continued + Laboratory tour
(Wolfgang von Hoyningen-Huene)

Updates of the course program and location can be found at

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

Contents:

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Ocean Colour Remote Sensing

Lecturer
Name: Astrid Bracher
Department: Climate Sciences (AWI) and Institute of Environmental Physics (IUP)
Institutes: AWI and Uni Bremen
Email: astrid.bracher@awi.de or : bracher@uni-bremen.de
Duration of lecture: 90 min. and 45 min. exercise

Lecture content (short summary with one relevant graph)

The first part of the lecture covers the principles of ocean optics. Topics included are basic physics of light and interaction of light with matter: inherent and apparent optical properties, radiative transfer equation, light fields within the ocean, water-leaving radiance and remote-sensing reflectance, effects of various seawater constituents on ocean reflectance, and optical instrumentation and measurement techniques. The second part of the lecture focuses on ocean color remote sensing. This includes the principles of ocean color remote sensing, the technology of the instruments commonly used ocean color satellite sensors (such as CZCS, SeaWiFS, MODIS, MERIS, but also sensors with high spectral but rather moderate spatial resolution (SCIAMACHY, GOME-2) and retrieval techniques of overall phytoplankton biomass and of specific phytoplankton groups.

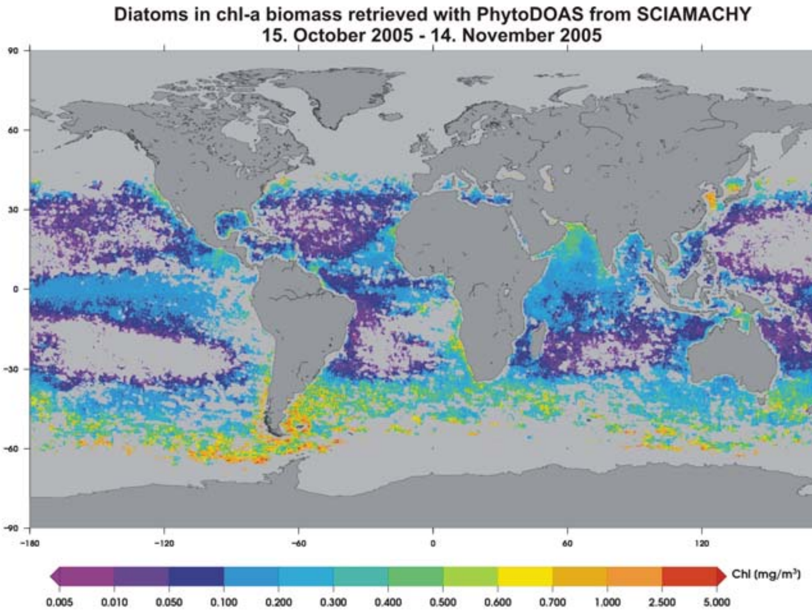


Figure: Monthly average (from 15 October to 14 November 2005) global distribution in chl-a conc. of diatoms determined by using the PhytoDOAS with SCIAMACHY data (left panel). Figure from Bracher et al., Biogeosciences 6, 751-764, 2009.

References

Mobley, C. D., 1994, Light and Water. Radiative Transfer in Natural Waters, Academic Press,
Martin, S., 2004, An Introduction to Ocean Remote Sensing" Cambridge University Press.

Excursion to the ESA/ESTEC

Organizer
Name: Klaus Grosfeld
Department: Climate Science/Paleoclimate Dynamics
Institute: AWI
Email: klaus.grosfeld@awi.de
Duration of lecture: full day

European Space Research and Technology Centre (ESTEC)

The European Space Agency (ESA) and its 18 Member States work together to pursue a wide range of ambitious and exciting goals in space. Together, they create fascinating projects that would not be feasible for the individual Member States.

These projects generate new scientific knowledge and new practical applications in space exploration, and contribute to a vigorous European aerospace industry.


from ESA web page

ESA has sites in several European countries. The European Space Research and Technology Centre (ESTEC), the largest site and the technical heart of ESA — the incubator of the European space effort — is in Noordwijk, The Netherlands. Most ESA projects are born here, and this is where they are guided through the various phases of development. More than 2000 specialists work here on dozens of space projects.

Except for launchers, nearly all ESA projects are managed from ESTEC. In Noordwijk, people work on science missions, on human spaceflight, telecom, satellite navigation, and Earth observation. ESTEC also houses a large pool of people with highly specialised technical knowledge, who are assigned to space projects when their expertise is needed for missions.

A one-day excursion and a guided tour to the ESA/ESTEC will introduce you to its working field and environment.

References

http://www.esa.int/esaCP/SEMOMQ374OD_index_0.html

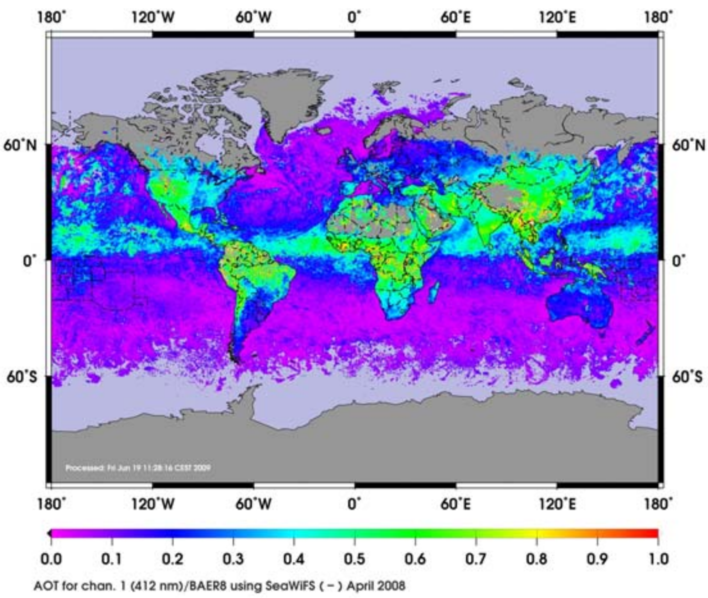
Remote Sensing of Atmospheric Aerosols

Lecturer

Name:	Wolfgang von Hoyningen-Huene
Department:	FB 1, Universität Bremen
Institute:	Umweltphysik
Email:	hoyning@iup.physik.uni-bremen.de
Duration of lecture:	3 h

Lecture content

- Introduction on atmospheric aerosols
- Principles of satellite remote sensing of atmospheric aerosols.
- Boundary conditions for the remote sensing.
- Physical properties of atmospheric aerosol, which are relevant for satellite remote sensing.
- Satellite instruments
- Applications, validation



Global map of monthly average of aerosol optical thickness derived from SeaWiFS observations.

References

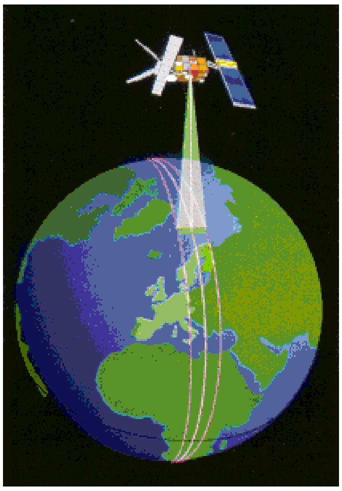
Kokhanovsky, A., de Leeuw, G.: Satellite Aerosol Remote Sensing over Land. Springer 2009.

Remote Sensing – an Introduction, Satellite Observations of trace gases

Lecturer
Name: Annette Ladstätter-Weißenmayer, Andreas Richter
Department: Institute of Environmental Physics (IUP)
Institute: University Bremen
Email: lad@iup.physik.uni-bremen.de, richter@iup.physik.uni-bremen.de
Duration of lecture: 90 minutes lecture and 60 minutes lab tour, each

Lecture content

Remote sensing measurements from satellites, aircrafts and from the ground provide a wealth of information on surface properties, the ocean, and the composition of the atmosphere. In remote sensing, information is retrieved indirectly using electromagnetic radiation and mathematical inversion techniques. The radiation measured by the remote sensing instrument can be scattered or reflected sunlight or the thermal radiation emitted by surfaces and the atmosphere. In addition, active systems can also employ their own radiation source e.g. in RADAR or LIDAR applications. Depending on both the used wavelength region and viewing geometry, the instruments probe different altitude ranges from the upper atmosphere to the surface with varying vertical resolution and sensitivity.



In the first part of this lecture, the basic physical concepts of remote sensing from space will briefly be presented with a focus on atmospheric measurements. In addition, an overview over existing satellite instruments will be given. In the second part, applications of remote sensing to trace gas observations will be discussed and recent results on measurements of atmospheric pollution from space will be shown. The lectures will be complemented by lab tours to different ground-based remote sensing instruments used at the IUP.

References

Stephens, G. L., Remote sensing of the lower Atmosphere, Oxford University Press

Remote Sensing of Sea Ice

Lecturer
Name: Christian Melsheimer
Department: Pysics, University Bremen
Institute: Institute of Environmental Physics (IUP)
Email: melsheimer@iuni-bremen.de
Duration of lecture: 90 minutes + 90 minutes

Lecture content

Sea ice on the polar (Arctic and Antarctic) seas is an important component of the global climate system. As the light-coloured sea ice reflects much more sunlight back into space than open ocean, the total extent of sea ice influences the global radiation budget. Moreover, sea ice insulates the ocean underneath from the atmosphere above, i.e., it practically prevents heat flux and evaporation. Therefore, the sea ice coverage influences local as well as regional weather and climate. In addition, global warming has turned out to be considerably stronger in the Arctic than elsewhere in the world. Therefore, the Arctic is a kind of indicator for climate change, making the monitoring of sea ice particularly important.
Since the late 1970s, daily maps of global sea ice cover can be derived from data of various satellite instruments (which is done, e.g., here at IUP). Such sea ice maps clearly show the seasonal variation of the ice cover, reaching its maximum in early spring of the respective hemisphere, and its minimum in early autumn. The time series of the total Arctic ice extent of the last 30 years shows that the maximum and the minimum have been slowly decreasing. Most notable is the dramatic and unprecedented sea ice minimum in the Arctic in September 2007, which undercut the previous "record" from 2005 by more than 20%. The Arctic sea ice minimum in September 2008 was almost as extreme (see figure next page)
The lecture covers the basics of sea ice formation and development, introduces the major methods used for remote sensing of sea ice, and presents recent results from sea ice remote sensing.

References

NSIDC (National Snow and Ice Data Center): All about sea ice, http://nsidc.org/seaice

G. Spreen, L. Kaleschke and G. Heygster 2008: Sea ice remote sensing using AMSR-E 89GHz channels, *J. Geophys. Res.* 113, C02S03, doi:10.1029/2005JC003384.

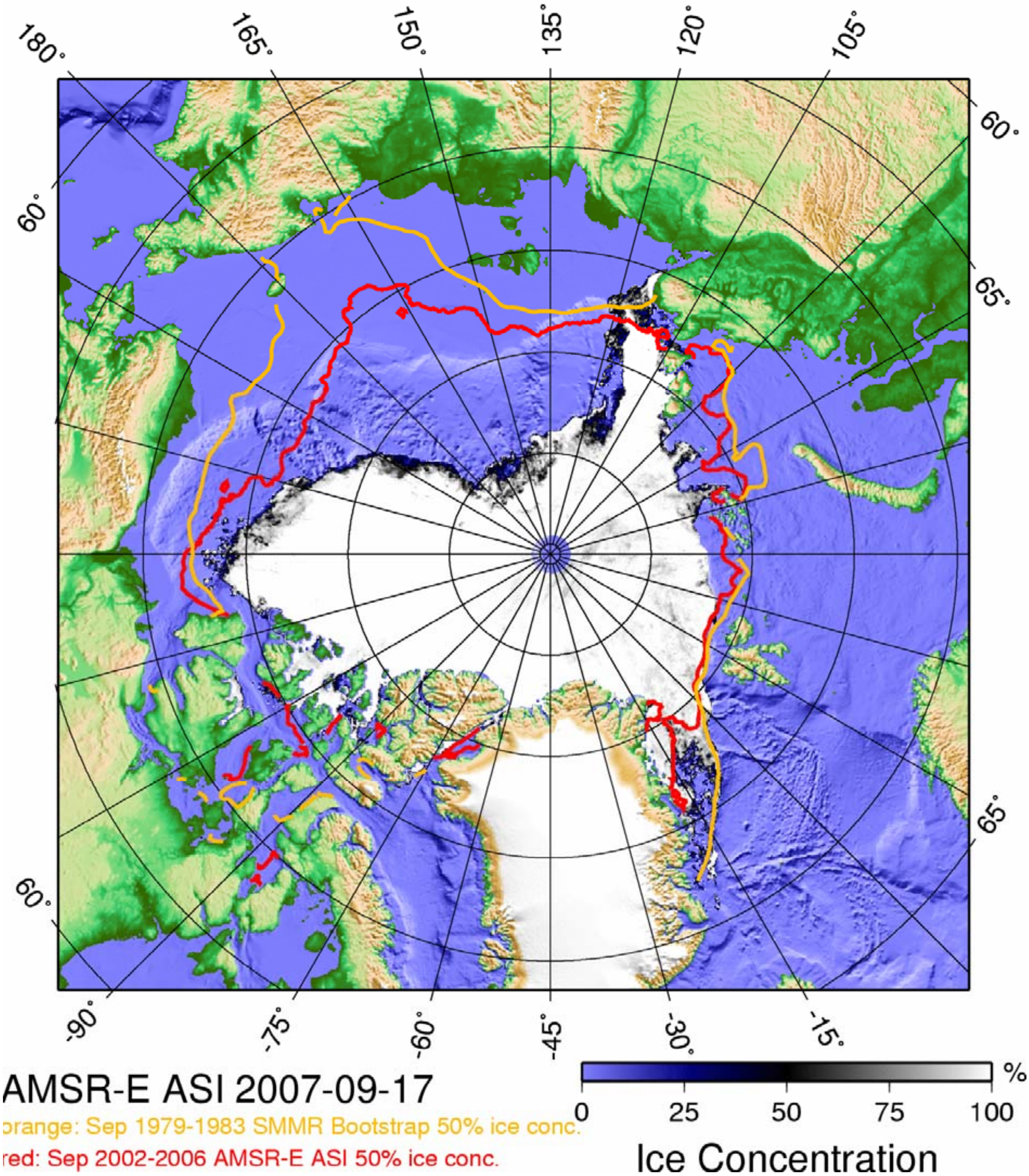


Figure: Arctic sea ice concentration during the summer minimum on 17 September 2007.