Course Programme:

	MONDAY 25/09	TUESDAY 26/09	WEDNESDAY 27/09	THURSDAY 28/09	FRIDAY 29/09
08:00		MERIS Lecture	ASAR Lecture	Lecture: Measuring SST from Space	RA Lecture
				Lecture: Large-scale SST features	
10:00		*coffee break*	*coffee break*	*coffee break*	*coffee break*
10:30		MERIS Lecture	ASAR Lecture	AATSR Practical 1: IDL viewer of global SST	RA Lecture
12:00					
12:30	Registration	*lunch break*	*lunch break*	*lunch break*	*lunch break*
13:30	Welcome				
14:00	Exploitation of ESA EO missions	MERIS Practical	ASAR Practical	Lecture: SST Mesoscale ocean phenomena	RA Practical
14:30	Oceanography from Space			AATSR Practical 2: Bilko analysis of individual images	
15:30	*coffee break*				
16:00	Oceanography from Space cont.	*coffee break*	*coffee break*	*coffee break*	*coffee break*
16:30		MERIS Practical	ASAR Practical	AATSR Practical 2 (continued)	Closing
18:00	ESA Future Missions				
	Cocktail		*Boat Trip*	*Joint Dinner*	

Training Course Overview: Oceanography from Space

Prof Detlef Stammer (University of Hamburg, Germany)

Oceanography from Space

ESA has a established a series of successful satellite missions that provide data for environmental and ocean remote sensing, starting with the ERS-1/2 series that lead into the ongoing ENVISAT mission. Each mission expanded the capabilities of remote sensing of the ocean and sea ice and now covers a wide range of physical, biological and geochemical applications of societal relevance. Anticipated Earth Explorer missions of ESA will make additional contributions to the study of ocean circulation and dynamics, and the high latitude sea-ice covered oceans.

The ocean exhibits an enormous economic and social value which makes a continuous monitoring of the oceans through satellite observations mandatory. This is required to support science applications related to the ocean and clime in general terms, but also to protect our welfare, to assist everyday activities performed at sea, to aid ship routing and to support security at sea (oil spill, ship tracking, search and rescue). Benefits of satellite observations for ocean applications include increased unprecedented scientific insight, efficiency of operations at sea, improved safety to personnel and reduced damage to the environment. Observations of the ocean are especially required for the monitoring of climate and the environment on seasonal-to-interannual-to-decadal time scale. Beyond direct studies, a central objective for obtaining satellite data over the ocean is also to provide the data required by global and regional (operational) oceanography integrated systems that use in-situ and satellite observations together with models and data assimilation to provide an integrated description of the ocean. This required a seamless integration of in-situ and satellite observations together with models through data assimilation to provide an integrated description of the ocean and the coupled ocean-ice-atmosphere system.

This lecture will review the capabilities of present day Earth observing from ESA and NASA satellite missions. In particular it will discuss applications across all available ocean applications that will be addressed in more detail during the course of the week, including physical oceanography and bio-geochemical applications from the open ocean and coastal regime, and bio-geochemical applications from the open ocean and shelf regions. Moreover, the presentation will explain the goals and ongoing work of ocean data assimilation which is required to gain insight from satellite data available only at the surface about the full water column.

Training Course Overview: ESA Missions

Dr Mark Drinkwater (ESA-ESTEC, the Netherlands)

ESA's Current Missions and the Future Earth Explorer Missions for Ocean and Ice

ESA has a established a heritage in developing successful satellite missions that enable scientific study of the oceans. Importantly, the post- ERS and Envisat era will see a succession of exciting, new science- driven Earth Explorer missions developed as part of ESA's Living Planet Programme, as well as the operational series of GMES Sentinel monitoring satellites. The first three approved Explorer missions will make specific contributions to the study of ocean circulation and dynamics, and the high latitude sea-ice covered oceans. This lecture will briefly review the objectives of the GOCE, SMOS and CryoSat-2 missions, and will indicate some of the scientific applications that shall result from their data. In addition, the presentation will indicate current plans for establishing continuity in the valuable Ku-band radar altimeter, C-band SAR, ATSR and MERIS climate monitoring datastreams, in the form of the Earthwatch GMES Sentinel-3 satellite.

Training Course Overview: MERIS

Dr Roland Doerffer (GKSS, Germany) and **Dr Carsten Brockmann** (Brockmann Consult, Germany)

The MERIS session will address principles and applications of ocean colour remote sensing with special focus of the usage of MERIS data for coastal waters. The main topic is the determination of the concentrations of water constituents and optical properties from reflectance spectra of MERIS.

With its 15 spectral bands of high radiometric performance, a spatial resolution of 300 m (full resolution mode) and a revisit period of 1-3 days (latitude dependent) MERIS is in particular suited for coastal waters. However, the user of the data has to be aware of a number of problems, which are related to the variable optical properties of phytoplankton, of all kind of suspended matter and of dissolved organic compounds, all of which change the spectral reflectance. In addition these waters require a special treatment for the correction of the influence of the atmosphere.

The application ranges from water quality monitoring, determination of primary production, determination of water transparency, solar energy absorption, suspended matter transport, determination of exceptional plankton blooms etc.

Within the course all details which are necessary for a useful and critical use of MERIS data will be presented and discussed. This includes:

- Principles of ocean colour remote sensing
- Basic algorithms for open ocean and coastal waters, bio-optical models
- Basic atmospheric correction for open ocean and coastal waters
- MERIS instrument
- MERIS water algorithms for case 1 and case 2, atmospheric correction case 1 and case 2

- MERIS products overview (RR, FR, L1, L2, L3)
- MERIS flagging system
- What to find in and how to use MERIS documents: MERIS Handbook, Cyclic report, disclaimers, ATBDs, Model reference, Validation handbook
- Where are the limits of MERIS water products (e.g. concentration ranges and mixtures, atmospheric correction, sun glint)
- How to apply local algorithms
- MERIS validation procedures
- Applications - examples
- The use of BEAM software with exercises

Training Course Overview: ASAR

Prof Johnny Johannessen (Nansen Environmental and Remote Sensing Center, Norway) and **Dr Vincent Kerboal** (BOOST Technologies, France)

The Synthetic Aperture Radar - A(SAR) session will address principles and application of the imaging radars that achieve high resolution by using a synthetic aperture processing technique. Their view of the ocean is unhindered by clouds, and they have so called all-weather day and night capabilities. Via resonant Bragg backscattering from centimetre long waves the imaging radars measure the spatial distribution of sea surface roughness with a horizontal resolution of a few tens of meters. This fine- scale resolution gives the SAR the unique capability to observe a number of oceanic and atmospheric phenomena whose characteristic signatures appear in the patterns of sea surface roughness such as surface and internal waves, current fronts, surface wind variability, oil or natural slicks.

The first part of the session will present the basic principles of SAR imaging mechanisms.

The second part will explain how to interpret radar images and provide quantitative estimates of waves, near surface wind, current features, oil spill, and sea ice.

The third part of the session will include interactive practical training in which both the interpretation of oceanic signatures and the transformation of SAR images to geophysical quantities (wind, waves, current, etc.) will be demonstrated using real data from the Envisat/ERS archive.

Training Course Overview: AATSR

Prof David Llewellyn-Jones (University of Leicester) and **Prof Ian Robinson** (University of Southampton, United Kingdom)

The Advanced Along-Track Scanning Radiometer (AATSR), now flying on ENVISAT, is the third in a series of accurate infrared radiometer sensors designed to deliver sea surface temperature (SST) measurements of sufficient accuracy, better than 0.3K, combinmmed with great stability, that they can be used as climate data records. The (A)ATSR instruments are unique in terms of their design and their ability to deliver extremely accurate SST skin observations. This short introduction will provide students with an overview of the (A)ATSR, its application and practical experience handling AATSR data.

The basic principles of remote sensing in the infra-red region of the electromagnetic spectrum will first be reviewed and used to introduce and explore the innovative design of the (A)TSR series of instruments.

We will then review the modern definitions for SST including a review of the surface skin temperature deviation, SST at depth and diurnal variability. The particular SST retrieval process used by the (A)ATSR (which retrieves an estimate of the SST skin temperature) will be presented.

Finally, the (A)ATSR data set and applications of (A)ATSR will be presented.

Practicals:

Two Three practical sessions will be provided. The first will introduce the UNESCO Bilko image processing system and explore the various elements of this system using (A)ATSR data.

The second practical will consist of a Bilko lesson in which the end-to-end process of deriving SST skin from (A)ATSR Brightness temperatures will be given. If time is available, a second Bilko lesson exploring ATSR-2 monthly mean SST will be available.

A third practical lesson will introduce students to some of the basic operations of examining global data. The data to be examined will be AATSR level 3 products, in the form of monthly means of Global SST.

The operations to be demonstrated will be those of examining inter-seasonal variability, search ing for anomalies, creation of Hovmueller diagrams (time-longitude plots) to examine the progression annual or periodic phenomena such as the Tropical East Pacific upwelling. This lecture will use the ATSR Global Analyser, an IDL tool specially developed for training purposes. As an alternative, the Bilko package can also be used for this purpose and its use will be demonstrated.

Collectively, this course will provide sufficient background information, practical instruction and tools to apply (A)ATSR SST data products in a variety of applications.

Training Course Overview: RA

Prof Detlef Stammer (University of Hamburg, Germany) and

Dr Jerome Benveniste (ESA/ESRIN, Italy)

Radar altimeters have been flown on satellites for many years and have become a firm part of the climate and ocean observing system. The RA session will address principles and applications of radar altimetry with focus on open and costal ocean applications. In addition some of the emerging new applications over ice and land will also be reviewed. As for all microwave instruments, their observing capability is unaffected by the atmosphere and therefore allows to observe dynamical features of the ocean with high along- track resolution (10 km). A RA is known for its high-precision measurements of sea surface height (the shape of the surface), but provides also important information about surface wave height and about surface wind speed.

The session will present first the basic principles of RA measurements and will discuss important interaction processes of the radar pulls with the atmosphere and geophysical phenomena that need to be known in order to obtain high accuracy data.

The session will then discuss additional information that is required to use RA data for dynamical ocean studies, such as marine geoid fields or in situ data.

Finally the session will discuss various ongoing and anticipated applications of RA.

The last part of the session will include interactive practical training using the new ESA RA tool box to train students in the interpretation of oceanic signatures of RA data (SSH, waves, wind speed) using real data from the Envisat/ERS archive.

This course will provide background information, practical instruction and tools sufficient to apply RA data products in a variety of applications.