Satellite geophysics

Tentative plan, Fall 2013

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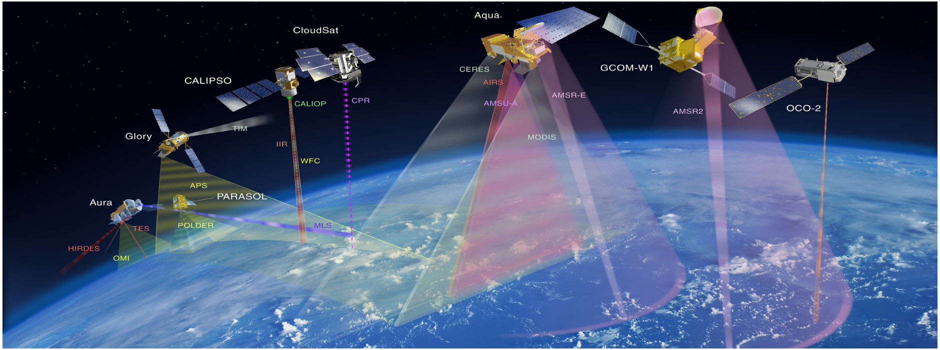
Satellite Missions (examples)



- Ørsted, CHAMP, SWARM
- GRACE, GOCE
- MetOp, METEOSAT SG
- ERS1/2, ENVISAT, CryoSat2
- GPS / radio-occultation
- NOAA series orbiting
- CloudSat, Aqua, Aura, CALIPSO, PARASOL
- Seasat SAR, SIR-A, SIR-B, SIR-C
- QuickScat, SeaWinds
- Terra, SMOS, SPOT, THEOS

Teachers and rooms

Teachers	Brian Sørensen (BS – course administrator) Carl Christian Tscherning (CCT) Assistent teachers Eigil Kaas (EK), Lars P. Prahm (DMI), Kristian Pagh Nielsen (DMI), Bjarne Amstrup (DMI), Stig Syndergaard (DMI), Ole Andersen (DTU-Space), Eigil Friis-Chrisenten (DTU-Space), Mark Falkenberg, Matilde B. Jensen.
Location	RF061 Some weeks at other places – check the *weeklies*.
Time	Monday 13:15 - 16:00 Wednesday 10:15 - 12:00 Wednesday 13:15 - 15:00 (some days 16:00)
Equipment	Bring a laptop (or share with co-students)

Teaching material

- CEOS EO (http://www.eohandbook.com/)
- Kaula: Theory of satellite geodesy, 1966. (Dover Reprint).
- Seeber: Satellite Geodesy (kun visse afsnit)
- Articles (pdf's will be available on web-site).
- Various presentations from the 2007 ECMWF seminar on the use of satellite observations in numerical weather prediction.
- Dele af kapitel 4 i J.M. Wallace og P.M. Hobbs: Atmospheric Science: An Introductory Survey. Second edition, 2006, ISBN: 13: 978-0-12-732951-2.

Description of skills and competences

- The student will obtain a fundamental understanding of satellite orbits and the consequences for the distribution of data in space and time.
- The students will have an overview of the sensors of geophysical importance which are flown on satellites, their function, utilization and calibration.
- The student will also be able to explain the relationship between satellites and satellite systems.
- The student will be able to evaluate a satellite mission, or design a new mission to obtain geophysical data both in terms of the orbital parameters (semi-major axis, inclination), mission lifetime and sensors.
- The student will be able to determine precise positions using GNSS (GPS).
- The student will be able to use a mathematical model in order to assimilate data from satellites.

This course will provide the students with a competent background for further studies within this field, i.e. a M.Sc. project

Description of knowledge

The students will be able to:

- Describe the relationship between satellite orbits, observation time and acquired data.
- Understand the use of series of solid spherical harmonics used to describe the gravity and magnetic fields, and the relationship with the satellite sensors used.
- Describe position determination using GNSS and the disturbances due to the troposphere and ionosphere and the use to map these fields.
- Describe satellites, the physics and the instruments enabling sensors to map the vertical profile of the atmosphere (circulation, chemistry, temperature and radiation)
- Understand the basics behind assimilation of satellite profiling data in numerical weather prediction models.
- Describe the principles behind SAR and InSAR.
- Give examples on how satellite systems support each other.

Week 47, Monday Nov. 18th

13:15-14:00 Introduction [BS, CCT and EK]

Overview of schedule for lectures, exercises, and company/institution visits. Internet access, required software, and teaching materials. The course evaluation is a report. At the lecture an overview of the different satellite types will be given. It will be shown that satellite measurements differ from traditional point measurements or measurements from airplanes by covering larger areas of the Earth.

Week 47, Monday Nov. 18th (cont.)

14:15-15:00 Lecture [CCT]
Basic knowledge of coordinate systems as well as Earths motion in a inertial system, e.g. rotation and orbital motions. The height concept, the gravity field, and Kepler's laws.

Materials Kaula: Theory of Satellite Geodesy.

15:15-16:00 Computer session [CCT and BS]
Installing the required software on the students own laptops and show how one can access additional software on NBI's servers, e.g. Matlab, GRAVSOFT (gravity field calculations, and CDO (Climate Data Operators), and the GUT-server (GOCE user tools).

Week 47, Wednesday Nov. 20th

10:15-12:00 Lecture [CCT]
Keplerian elements and orbits. Geostationary and variable orbits. Connection between orbit radius and orbit inclination. Polar satellites. Sun-synchronous orbits. Introduction to "strange" orbits.

Purpose Understand how orbit inclination is connected to orbital period and orbital radius.

Materials Kaula: Theory of Satellite Geodesy.

13:15-16:00 Exercises [CCT and BS]
Simple orbit examples, simple gravity field model, IERS database (International Earth Rotation and Reference Systems Service), Celestrak/NORAD (satellite orbital elements)

Week 48, Monday Nov. 25th

13:15-14:00 Lecture [Ole Andersen (OA) and CCT]
The oceans; ocean circulation, waves, sea surface temperature.

- Salinity - ENVISAT and TOPEX/POSEIDON
- Altimetry - JASON.

14:15-16:00 Exercises [OA and CCT]
CERSAT (altimetry database).

Week 48, Wednesday Nov. 27th

10:15-11:00 Lecture [CCT and BS]
Using GOCE User Tools for mapping ocean currents.
https://earth.esa.int/web/guest/software-tools/gut

11:15-12:00 Lecture [BS]
Signal propagation in the atmosphere and ionosphere.

Materials Seeber: Satellite Geodesy (p. 42-61).
Chapter 4 on radiation in Wallace and Hobbs.
Notes from the 2007 ECMWF seminar.

11:15-12:00 Exercises [BS]
Examples on the delay of signals, the Doppler effect, and ionospheric Total Electronic Density from GPS.

Week 49, Monday Dec. 2nd

13:15-14:00 Lecture [CCT]
Observation of land and sea ice.
ERS, ENVISAT (ASAR), Topex/Poseidon, Jason, CRYOSAT2, IceSAT (laser-altimetry), SAR, and GRACE.

14:15-16:00 Exercises [BS and Mark Falkenberg (MF)]
Data from ESA's EoLisa system and SAR based iceflow measurements.

Week 49, Wednesday Dec. 4th

10:15-11:00 Lecture [BS]

The atmosphere: circulation, temperature, chemistry, radiation, and climate. Basic topics such as the radiative transfer equation, the optical properties of the atmosphere, and inversion techniques used in numerical weather prediction, will be covered.

GPS, ATSR, NOAA satellites, EUMETSAT, AMSU, DOBSON (O_3), OLR (CERES), Albedo measurements, HIRS, ENVISAT (MERIS, MWR, GOMS, MIPAS, SCIAMACHY) MODIS, NOAA (AVHRR)

Materials CEOS EO Handbook

http://www.eohandbook.com/

Week 49, Wednesday Dec. 4th cont.

11:15-12:00 Exercises [BS]
EUMETSAT data analysis and using NESDIS (NOAA database).

13:15-14:00 Lecture [BS]
The Lecture on the atmosphere is continued.

14:15-15:00 Exercises [BS]
Groups will go through different instruments, data, and techniques.

Week 50, Monday Dec. 9th

13:15-16:00 Visit at DMI [Henrik Vedel (HV), Kristian Pagh Nielsen (KPN), and Bjarne Amstrup (BA)]

HV Overview of Eumetsat satellites and future plans.

KPN Satellite based measurements of optical properties of clouds and cloud liquid water content.

BA Satellite data assimilation in numerical weather prediction models.

- Mainly SEVIRI and CLOUDSAT.

Week 50, Wednesday Dec. 11th

10:15-12:00 Lecture [Eigil Friis-Christensen (EFC)]
Magnetic field.
Ørsted, CHAMP, and SWARM.

13.15-15:00 Lecture [CCT]
Gravity, solid Earth, plate tectonics, volcanism, seismic, and uplift/subsidence.
GRACE, GOCE, Starlett, GPS, and InSAR.

15.15-16:00 Exercises [CCT and BS]
Use of data from GRACE and GOCE.
GOCE User Tools.

Week 51, Monday Dec. 16th

13:15-15:00 Exercises [CCT and MF]
Examples from InSAR in the ESA database

- Before and after earthquakes.
- The susbsidence of Skagen.

Week 51, Wednesday Dec. 18th

10:15-11:00 Lecture [CCT and Joanna Levinsen (unconfirmed)]
Observations of topography: GPS, SPOT, ASTER, SAR and InSAR, and SRTM.

Tools Terrain model

`http://www2.jpl.nasa.gov/srtm/`

11.15-12:00 Exercises [BS]
Preparation for GPS measurements.

12.15-15:00 Field measurements [BS]
Measurements with GPS in the field (contact Afrifa).

Week 2, Monday Jan. 6th

12:15-13:00 Lecture [Leif Toudal (DMI)]
Methods for measuring sea ice.

13:15-14:00 Exercies [BS and Matilde Brandt Jensen (DMI)]
Retrieving data, plotting and animation of sea ice extent. Estimating time development of sea ice extent.

14:15-15:00 Lecture [Stig Syndergård (DMI)]
GPS occultation for temperature profiles.

15:15-16:00 Exercise [SS]
Working with GPS occultation data.

Week 2, Wednesday Jan. 8th

10:15-11:00 Lecture [Per Kolbeck Nielsen (ESA delegate)]
Satellite systems, international coordination: ESA (Living Earth Programme), NASA, NOAA, Japan, China, India.

11:15-12:00 Lecture [AWH (unconfirmed)]
Satellites covering the polar areas (Molnya orbits).

13:15-15:00 Exercices [Mandatory]
Brainstorming: The ideal geophysical satellite (meteorology, climate, ocean monitoring, ice, gravity field, ...).

Week 3, Monday Jan. 13th

12:15-15:00 Lectures [DTU-Space]
Visit to DTU-Space.

Week 3, Wednesday Jan. 15th

10:15-12:00 Preparation [BS and CCT]
Begin the preparation for the final reports. Decide on topics of geophysical phenomena.

Final report in Satellite Geophysics

Content Description of the chosen phenomena that must be observed and interpreted.

- Which satellites can be used.
- Their orbits and their orbital periods, time in operation.
- Which instruments. How are they calibrated.
- Where can date be found (eg. EOLiSA?)
- Data examples: as time series or as maps.
- Use of data (eg. for climate research).
- Which other satellites are interacting with these.

Length 20 pages maximum.

Ideas for observable phenomena

- Positions of points on Earth or in space.
- Topography of Earth, incl. ice heights.
- Tidal earth and tidal water.
- Gravity or magnetic field variations in time and space.
- Atmospheric profiles of temperature and water vapour. Measurements of chemical species.
- Energy budget of the planet (top of the atmosphere (TOA) net radiation).
- Measuring electron density of the Ionosphere.
- The oceans: Surface height, temperature and salinity variations, wave heights, sea ice extent, wind over oceans.
- Surface changes / Earthquakes.

Grading of the exam/report

- Requirements for obtaining "12": the grade is given for an excellent performance.
- Demonstrating a fulfilment of 5 of the teaching goals, with no or few deficiencies.