

**International PhD Course in**

# **Space-borne and ground based geodetic techniques for hydrology**

**March 1 - 5, 2010**

**DTU Environment**

**Kgs. Lyngby, Denmark**

## *Lecturers*

**Philippa A. M. Berry, De Montfort University, Leicester**

**John Wahr, University of Colorado**

**Shimon Wdowinski, University of Miami**

## *Organizers*

**Ole B. Andersen, DTU Space**

**Peter Bauer-Gottwein, DTU Environment**

## **Background and objective**

Water is mankind's most critical natural resource and must be managed carefully. Hydrological models are key scientific decision support tools in water resources management. Hydrological modellers generally lack data to calibrate and validate their models. Space-borne and ground based geodetic observations provide valuable calibration and validation datasets for surface and groundwater flow models and constrain important hydrological parameters, such as aquifer specific yield, actual evapotranspiration and runoff coefficients.

This course will cover the following techniques: Space-borne and ground based time-lapse gravity observations, Radar altimetry, and Interferometric Synthetic Aperture Radar (InSAR). Time-lapse gravity gives estimates of total water storage change in the earth system. Radar/Lidar altimetry provides time series of water level elevations in rivers, lakes and reservoirs. InSAR can be used to map soil moisture and wetland water levels.

The course will focus on the theoretical basis of the methods, data acquisition and processing. We will put emphasis on the quantitative use of the data in a generalized hydrogeophysical approach. In this approach, hydrological models are run and the output of the hydrological models is converted to synthetic geodetic signals. Subsequently the synthetic and observed geodetic signals are compared and hydrological model parameters are adjusted to produce an optimal fit.

**Form and Content**

The course will have a duration of five days. Four of the days will be a class room course with up to 20 course participants. On the fifth day we will organise a Mini-Symposium where research findings from the field are presented and discussed.

*Course Programme*

***DAY 1, Monday, March 1<sup>st</sup>, 2010***

**Using time-variable gravity from the GRACE satellite mission to recover hydrological signals (J. Wahr)**

9.00	–9.15	Welcome, introduction
9.15	–10.45	Lecture: Timevariable gravity from GRACE for hydrology (Wahr, Part 1)
10.45	–11.15	Coffee/tea break
11.15	–12.45	Lecture: Timevariable gravity from GRACE for hydrology (Wahr, Part 2)
12.45	–13.45	Lunch
13.45	–15.15	Hands on exercise Timevariable gravity from GRACE for hydrology (Wahr, Part 1)
15.15	–15.45	Coffee/tea break
15.45	–17.00	Hand on exercise Timevariable gravity from GRACE for hydrology (Wahr, Part 2)
18.30		Social dinner hosted by FIVA. Venue: To be determined

***DAY 2, Tuesday, March 2<sup>nd</sup>, 2010***

**The use of satellite radar altimetry to monitor the earth's inland water resources (P. Berry)**

A series of satellite radar altimeters has been launched over the past 15 years. As well as gathering information over the earth's oceans, these instruments also make extensive measurements over inland water. These data can be processed to yield time series of river and lake heights, and to monitor the earth's inland water resources in near-real-time. This lecture will asses the currently available products, and show how these data can be utilized for a wide range of hydrological applications. It will also include a first look at the next generation of interferometric altimeters, and will consider the enhancement in measurement capability that this innovation may provide.

9.00	–10.30	Lecture – Satellite Altimetry. (Berry, Part 1)
10.30	–11.00	Coffee/tea break
11.00	–12.30	Lecture – Satellite Altimetry. (Berry, Part 2)
12.30	–13.45	Lunch
13.45	–15.15	Hands on exercises. Using satellite altimetry in hydrological applications (Berry, Part 1)
15.15	–15.45	Coffee/tea break
15.45	–17.15	Hands on exercises. Using satellite altimetry in hydrological applications (Berry, Part 2)

**DAY 3, Wednesday, March 3<sup>rd</sup>, 2010**

**High spatial resolution hydrological monitoring using InSAR observations (Wdowinski)**

Space-based Interferometric Synthetic Aperture Radar (InSAR) is a very powerful technique for detecting cm-level displacements of the Earth’s surface over wide swaths (5-400 km) with high spatial resolution (1-100 m pixel resolution). The method compares pixel-by-pixel SAR phase observations of the same area acquired at different times from roughly the same location in space to produce high spatial-resolution displacement maps. Such maps, termed interferograms, are widely used in studies of earthquake and magmatic induced crustal deformation and glacier flow. InSAR is also very effective in hydrological studies, as it provides high spatial resolution observations of (i) wetland surface water level changes, (ii) surface subsidence and uplift induced by alluvium aquifer deformation in response to groundwater pumping and recharge, (iii) variations in soil moisture content, and (iv) estimates of snowpack mass distribution. In this special class we will cover the following topics: SAR satellites, SAR data, InSAR data processing (interferogram production), post-processing (phase unwrapping, filtering, and conversion to elevation change), hydrological applications (wetlands, aquifer-system response, soil moisture, and snowpack), validation and calibration (ground truthing), and hydrological interpretation. The class will also introduce the more advanced InSAR time series techniques, which include: Persistent Scatterers Interferometry (PSI), Short Baseline Subset analysis (SBAS), and Short Temporal Baseline Subset analysis (STBAS). If time permit, we will cover hydrological usage of SAR amplitude observations for monitoring soil moisture changes, flooding extent, and characterizing snowpack properties.

9.00	–10.30	Lecture. Hydrological monitoring using InSar (Wdowinski, Part 1)
10.30	–11.00	Coffee/tea break
11.10	–12.30	Lecture. Hydrological monitoring using InSar (Wdowinski, Part 2)
12.30	–13.45	Lunch

13.45	–15.15	Hands on Exercise: Hydrological monitoring using InSar (Wdowinski, Part 1)
15.15	–15.45	Coffee/tea break
15.45	–17.15	Hands on Exercise Hydrological monitoring using InSar (Wdowinski, Part 2)

***DAY 4, Thursday, March 4<sup>th</sup>, 2010***

9.00	–10.30	Lecture: Using ground-based time-lapse gravity observations to calibrate groundwater models (Bauer-Gottwein)
10.30	–11.00	Coffee/tea break
11.00	–12.30	Hands-on exercise: Groundwater model calibration with time-lapse gravity (Bauer-Gottwein)
12.30	–13.45	Lunch
13.45	–14.30	Lecture: Using GRACE data to calibrate regional-scale hydrological models (Andersen)
14.30	–15.15	External lecture TBA
15.15	–15.45	Coffee/tea break
15.45	–17.15	Hands-on exercise: Regional-scale model calibration with GRACE data. (Andersen and Krogh)

***DAY 5, Friday, March 5<sup>th</sup>, 2010***

Research Symposium: “Applications of Ground-based and Space-borne Geodetic Techniques in Hydrology”

**Background of participants**

Participants are expected to have a basic understanding of geodesy and hydrology.

**Course material**

- Course handouts
- Course exercises and computer practical
- Journal papers

**Work load and credit points**

Approximately 125 hours in total including lectures and exercises during the course and preparatory reading before and during the course.

The work load corresponds to 5 ECTS.

A course diploma will be issued upon satisfactory completion of the course.

### **Registration and admission**

Registration on FIVA's website: [www.fiva.dk](http://www.fiva.dk).

Deadline: February 1, 2009. Information on admission to the course will be forwarded shortly after.

The total number of participants is limited to 20. PhD students are given first priority but depending on the number of registrants we also welcome post-graduate participants.

International students are requested to provide a very short description of their research interests and background when they register. Additionally, a letter of recommendation needs to be forwarded from the research advisor.

All students are requested to submit a presentation for the Research Symposium on March 5<sup>th</sup> as part of the course preparation on their research topics - relating it to the scope of the course.

### **Fee**

The course is free for PhD students enrolled at universities. Post-graduate participants will be charged a course fee of DKK 5.000 (€675).

### **Accommodation and travel**

FIVA will provide accommodation for PhD students near the university free of charge. Participants are requested to cover travel expenses and per diem from their own funding.

Other participants are requested to make their own arrangements. Hotel suggestions:

1. Hotel Postgaarden (cheap)

<http://www.post-pub.dk/>

Transport via bus to the DTU Lyngby Campus

2. Hotel Fortunen (a little more expensive)

<http://www.fortunen.dk/>

Within walking distance (30 min) from the DTU Lyngby Campus

3. Hotel Scandic Eremitage (more expensive)

<http://www.hotel.dk/scandicermitage.html>

Transport via bus to the DTU Lyngby Campus

### **Further information**

Please contact course organizers Ole B. Andersen ([oa@space.dtu.dk](mailto:oa@space.dtu.dk)) and Peter Bauer-Gottwein ([pbg@env.dtu.dk](mailto:pbg@env.dtu.dk)) or Frederik Uldall (email: [fu@geo.ku.dk](mailto:fu@geo.ku.dk), phone: +45 3532 2414).