Geoscientific and Navigation Applications of GNSS and InSAR - BMEEOAFDT84

I. Subject Specification

1. Basic Data

1.1 Title

Geoscientific and Navigation Applications of GNSS and InSAR

1.2 Code

BMEEOAFDT84

1.3 Type

Module with associated contact hours

1.4 Contact hours

Type	Hours/week / (days)
Lecture	2

1.5 Evaluation

Exam

1.6 Credits

3

1.7 Coordinator

name	Dr. Rózsa Szabolcs
academic rank	Associate professor
email	rozsa.szabolcs@emk.bme.hu

1.8 Department

Department of Geodesy and Surveying

1.9 Website

https://epito.bme.hu/BMEEOAFDT84
https://fiek2.mywire.org/course/view.php?id=3447

1.10 Language of instruction

english

1.11 Curriculum requirements

Ph.D.

1.12 Prerequisites

1.13 Effective date

1 September 2022

2. Objectives and learning outcomes

2.1 Objectives

This course aims at conveying up-to-date knowledge on the research and applications of the satellite navigation technologies, especially GNSS and satellite radar imagery in Geosciences, including geophysics, tectonophysics, meteorology, atmospheric sciences and hydrology.
Moreover, the recent developments and advances in satellite navigations are also introduced in the course, including global and regional navigation satellite systems, augmentation systems, ground based radionavigation systems and the fusion of satellite navigation observations with other positioning and attitude determination sensors (e.g INS, barometer, etc.).

2.2 Learning outcomes

Upon successful completion of this subject, the student:

A. Knowledge

1. has an overview of the error effects of the GNSS observations;
2. understand the various GNSS processing techniques;
3. understands the concepts of geodetic reference frames;
4. understands the principles of satellite orbit determination;
5. has an overview of the global and regional GNSS infrastructure;
6. understands the link between satellite navigation and other geosciences;
7. understands the principles of positioning, navigation and timintg (PNT) applications
8. understands the varios interferometric SAR processing techniques (DInSAR, PSInSAR, DSInSAR, etc.)

B. Skills

1. able to process GNSS observations with a scientific level GNSS processing software (Bernese, GIPSY)
2. able to retrieve various geophysical/geodetic parameters from satellite navigation observations, like atmospheric water vapour, sea (or water) level, total electron content of the ionosphere, earthquake parameters, crustal deformations;
3. able to estimate precise orbits for satellites
4. able to use the observations and products of the International GNSS Service
5. able to process interferometric SAR observations and retrieve post seismic deformations
6. able to analyse the GNSS time series

C. Attitudes

1. is keen on discovering the latest advances in satellite navigation
2. presents her/his ideas, individual works in efficient and aesthetic presentations

D. Autonomy and Responsibility

1. She/he is able to process literature on her/his own, and present the main points to other students.
2. She/he collaborates with other students in small groups to solve the project work.

2.3 Methods

Lectures including practical demonstrations, individual projects with consultation. Presentation of the results.

2.4 Course outline

Week	**Topics of lectures(and/or exercise classes)**
1.	Geodetic Reference Systems. Terrestrial and Celestial Reference Systems. Transformation between Reference Systems.
2.	GNSS positioning techniques (relative positioning using double differences, precise point positioning, single point positioning).
3.	Systematic error sources of GNSS positioning (orbit and clock error, inter system biases, atmospheric effects and modelling, antenna PCO and PCV, multipath, etc.). Linear combinations and their role in retrieving geoscientific information.
4.	Structure and operation of GNSS reference stations. The European Permanent Network, the IGS network. Products, reference frames. Realtime data transfer, tools to automatic data collection (RTKLIB, bash scripts, etc.)
5.	Introduction to the rigorous GNSS data processing. The structure and modules of the Bernese Software. Orbit integration, receiver clock synchronization, preprocessing phase observations.
6.	Parameter estimation using Bernese Software. The Bernese Processing Engine. Workflows for coordinate estimation, tropospheric delay esti ation, total electron content estimation, orbit parameter and Earth Rotation Parameter estimation.
7.	Definition of the individual project work in GNSS (**P1**).
8.	Principles and the theoretical background of interferometric SAR data processing
9.	DInSAR, PSInSAR, DSInSAR techniques.
10.	Introduction to the InSAR data repositories and the SNAP software. DInSAR workflow.
11.	Case study of estimating post-seismic surface deformations using DInSAR technique.
12.	Definition of the project work in InSAR (**P2**)
13.	Time series analysis of GNSS coordinate time series. Extracting hydrological signals from GNSS coordinate time series.

14.	Summary. Individual student project demonstrations.

The above programme is tentative and subject to changes due to calendar variations and other reasons specific to the actual semester. Consult the effective detailed course schedule of the course on the subject website.

2.5 Study materials

- B. Hofmann-Wellenhof, H. Lichtenegger, E. Wasle: GNSS - Global Navigation Satellite Systems (GPS, GLONASS, Galileo and more). Springer Verlag Vienna, 2008, ISBN 978-3-211-73017-1
- P.J.G. Teunissen, O. Montenbruck: Handbook of Global Navigation Satellite Systems. Springer Nature Switzerland AG, 2017, ISBN 978-3-030-73172-4
- V.B.H. Ketelaar: Satellite Radar Interferometry, Subsidence Monitoring Techniques. Springer Science+Business Media B.V. 2009, ISBN 978-1-4020-9427-9
- ESA: inSAR Principles: Guidelines for SAR Interferometry Processing and Interpretation. Eurpean Space Agency, 2007, https://esamultimedia.esa.int/multimedia/publications/TM-19/TM-19_InSAR_web.pdf
- EO College website: https://eo-college.org/resource-spectrum/radar/

2.6 Other information

2.7 Consultation

Appointments: as specified on the department's website. Additional appointments can be made via e-mail to the lecturer(s).

This Subject Datasheet is valid for:

Inactive courses

II. Subject requirements

Assessment and evaluation of the learning outcomes

3.1 General rules

3.2 Assessment methods

Evaluation form	Abbreviation	Assessed learning outcomes
GNSS Project	P1	A.1-A.4; B.1-B.4; C.2; D.1-D.2
InSAR Project	P2	B.5; D.1-D.2
Exam	E	A.1-A.8; B.6; C.1

The dates of deadlines of assignments/homework can be found in the detailed course schedule on the subject's website.

3.3 Evaluation system

Abbreviation	Score
P1	20%
P2	20%
E	60%
Sum	**100%**

3.4 Requirements and validity of signature

Submission of both individual projects and their acceptance by the course coordinator.

3.5 Grading system

Grade	Score (P)
excellent (5)	4.501-5.00
good (4)	3.501-4.500
satisfactory (3)	2.501-3.500
pass (2)	1.501-2.500
fail (1)	<1.501

3.6 Retake and repeat

P1 and P2 projects can be submitted after its deadline specified in the detailed course programme until 11:59 pm on the last day of the completion week. In this case, the student must pay the pre-determined fee.
2. Submitted and accepted homeworks can be corrected until the deadline given in point 1) without paying a fee.

3.7 Estimated workload

Activity	Hours/semester
Contact hours	14×2=28
Preparation of the projects (P1, P2)	42
Preparation for the exam	20
Sum	**90**

3.8 Effective date

1 September 2022

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