# The Hebrew University of Jerusalem

## Syllabus

## REMOTE SENSING OF SOIL-PLANT-ATMOSPHERE PROCESSES - 71631

*Last update 13-09-2020*

*HU Credits:* 3

*Degree/Cycle:* 1st degree (Bachelor)

*Responsible Department:* Soil and Water Sciences

*Academic year:* 0

*Semester:* 2nd Semester

*Teaching Languages:* Hebrew

*Campus:* Rehovot

*Course/Module Coordinator:* Dr David Helman

*Coordinator Email:* david.helman@mail.huji.ac.il

*Coordinator Office Hours:* TBD

*Teaching Staff:*
*Dr. David Helman,*
*Mr. Yaron Michael*

*Course/Module description:*

*The course describes remote sensing methods for monitoring and modeling biophysical processes related to the soil-plant-atmosphere continuum, such as: evapo-transpiration, carbon fluxes, and soil water dynamics, in agricultural and natural vegetation systems. The course implements mathematical and physical calculations as well as practical exercises in Phyton. The subjects learned in the course are: (a) The theoretical basis in which we'll learn the principles of radiation (electromagnetic radiation, black body, energy balance, and radiative transfer), EOS (Earth Observation Systems), sensors (active/passive sensors), and vegetation indices (spectral and thermal); (b) Quantitative methods, which include the main remote-sensing methods used for estimating water and carbon fluxes in vegetation systems (biophysical and empirical methods); and (c) Remote sensing of soil, which will be focused on methods that assess soil properties (e.g. by hyper-spectral sensing), as well as soil water content dynamics (e.g. by SAR – Synthetic-Aperture Radar).*

*Course/Module aims:*

*The course aims at providing the students a basic knowledge of remote sensing of biophysical processes related to the soil-plant-atmosphere continuum in agricultural and natural vegetation systems. Students will learn the theoretical basis behind remote sensing and the connection to energy balances and fluxes. The course will incorporate lectures, computational exercises, and practice in python programming language where we will practice the use of data acquired from satellites and drone in flux modeling.*

*Learning outcomes - On successful completion of this module, students should be able to:*

*On successful completion of this module, students should be able to:*
*• Understand the principles of remote sensing of biophysical processes*
*• Know the main methods of remote sensing of biophysical processes*
*• Download and analyze satellite images*
*• Perform basic land use sorting and mapping using remote sensing data and GIS platforms*
*• Use remote sensing data for basic assessment of ET and carbon fluxes in a crop field*

*Attendance requirements(%):*

*85%*

*Teaching arrangement and method of instruction: Frontal lecture, reading of required materials, exercises sessions in a computer lab*

*<u>Course/Module Content:</u>*
*The wavy model, Planck’s function, brightness temperature, emissivity – Kirchhoff’s Law, Wien's displacement law, Stefan-Boltzmann Law (Python exercise at classroom, physical calculations – home exercise) Introduction: Principles of Radiation A – Electromagnetic radiation and black body radiation 1*
*Solar energy and energy balances in the spectral and thermal ranges, calculation of emissivity, Rayleigh, Mie, and non-selective scattering (Python exercise at classroom, physical calculations – home exercise) Introduction: Principles of Radiation B – Energy balances, scattering and absorption, atmospheric windows 2*
*Principles of sensors, active and passive sensors, georeferencing, image analysis, radiation and reflectance (Python exercise at classroom, practical home exercise) Introduction: Principles of Remote Sensing A – Spectral and thermal sensors and image processing 3*
*Spectral and thermal-based vegetation indices, calculation, uses, and their biophysical meaning (Python exercise at classroom, practical home exercise) Introduction: Principles of Remote Sensing B – Vegetation Index 4*
*Mid-term Exam and Phyton project 5*
*Implementation of the radiation principles learned in weeks 1-2 for the estimation of latent heat and evapo-transpiration using satellite data (physical calculations – home exercise) Sensing Processes: Evapo-transpiration and Water Use A – The energy balance method 6*
*Implementation of the Trapezoid model for soil water content & ET – combining thermal and spectral remote sensing (Python exercise at classroom, practical home exercise) Sensing Processes: Evapo-transpiration and Water Use B – The Trapezoid model 7*
*Replacing FAO’s irrigation coefficient with spectral-based vegetation index derived from remote sensing (Python exercise at classroom) Sensing Processes: Evapo-transpiration and Water Use C – The FAO-based model 8*
*Monteith-based fAPAR primary productivity model, global CO2 estimations, and hybrid models (physical calculations – home exercise) Sensing Processes: Carbon fluxes and yield A – CO2 flux models 9*
*PRI – the photochemical reflectance index and RUE, Sun-induced fluorescence (SIF) from satellites, global carbon balance (Python exercise at classroom) Sensing Processes: Carbon fluxes and yield B – Radiation use efficiency (RUE) 10*
*Python final project and Summary 11*
*Spectral signal of soils, soil spectral libraries, hyper-spectral sensing of soils, soil signal sorting (Python exercise at classroom, practical home exercise) Soil Sensing: Soil properties – Texture and composition 12*
*Thermal sensing and soil water content, spectral-based models, SAR (Synthetic-*

*Aperture Radar) Soil Sensing: Soil properties – Soil water content 13*

*Required Reading:*

*Reading material will be part of the home assignment.*

*Additional Reading Material:*

*Hanes, J.M. (Ed.). (2013). Biophysical applications of satellite remote sensing. Springer Science & Business Media.*
*Jensen, J.R. (2007). Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Ed., Upper Saddle River, NJ: Prentice Hall, 592 pages.*
*Hendriks, M. (2010). Introduction to physical hydrology. Oxford University Press.*
*van der Tol, C. & Parodi, G.N. (2012). Guidelines for remote sensing of evapotranspiration (pp. 227-250) in Evapotranspiration: Remote Sensing and Modeling. InTech.*

*Course/Module evaluation:*

*End of year written/oral examination 40 %*
*Presentation 0 %*
*Participation in Tutorials 0 %*
*Project work 0 %*
*Assignments 40 %*
*Reports 0 %*
*Research project 0 %*
*Quizzes 20 %*
*Other 0 %*

*Additional information:*

*The course implements mathematical and physical calculations and is open to students that successfully completed the course of Basic Python programing (71137).*
*The course is limited to a maximum of 35 students; therefore, students with previous knowledge in agricultural meteorology, particularly those that successfully completed the course FUNDAMENTALS OF AGRICULTURAL METEOROLOGY (71619), will be prioritized. Students without prior knowledge in agricultural meteorology should consult the instructor prior to registration.*