DETAILED DESCRIPTION OF DAILY PROGRAMME OF RS PROGRAMME

Find below the set-up of the course, assuming a study time of 8 hours per day for 5 day

Day 1

Lecture 1: Electromagnetic radiation

Learning Objectives and/or Content and/or Content

RS have an unavoidable side on strict physics. Maybe the most important aspect of RS.

- Understanding of energy sources of EMR, Planck's, Stefan Boltzman's, Wien's and Kirchoff's laws.
- EMR spectrum and the EMR regions in relation to RS.
- Main: Visible, near infrared, and thermal infrared regions.
- Other regions.
- Radiances, reflectance, transmission, emission and the interaction with media (atmosphere) and surface.
- Reflectance curves
- Involves exercises.

Sources and order for study:

- RS head book: From page 29 (P2.1: "Electromagnetic energy and Remote Sensing Introduction") till page 53 (Summary - inclusive).
- RS head book: From page 205 (Chapter 12: "Thermal remote sensing") till page 211 (12.4 Thermal applications - exclusive).
- Lecture PDF: Electromagnetic radiation and units

Lecture 2: Reflective and thermal radiation

Learning Objectives and/or Content and/or Content

- Reflectance
- Theoretical reflectance types:
- Specular and Lambertian
- Light and interaction with objects
- Bi-directional reflectance
- Reflectance integration: the broadband albedo
- Emissivity vs. Reflectance (revision of the Kirchoff law)
- Solar radiation
- Terrestrial, Ground incoming and reflected solar radiance
- Spectral reflectance curves
- Electromagnetic radiation interaction with the atmosphere
- Scattering and absorption processes
- Bands and reflectance zones properties
- The remote Sensing method of using radiance

Sources and order for study:

- Lecture PDF: Reflective and thermal.
- RS head book: Start with thermal imagery. Chapter 12 from page 205 to page 211. Exclude P.14.4 from the reading

Lecture 3: Introduction to ILWIS concepts

- What is ILWIS?
- Data input
- Data management
- Data analyses
- Data output

- The data is geographically referenced: the information is identified according to its location.
- ILWIS Data types
- Spatial entities and data models
- How the spatial data types are represented in ILWIS
- Basic User-interface of ILWIS
- ILWIS Concepts
- MapCalc / TabCalc

Sources and order for study:

- Lecture of the ILWIS software (P01): Introduction to ILWIS

Practical 1: Introduction to ILWIS Software
Learning Objectives and/or Content and/or Content

- Practice with ILWIS academic 3.31
- Experience the first GIS and Remote Sensing concepts in ILWIS in a self-guided exercise.
- Understand ILWIS objects:
- raster
- vectors: points, segments and polygons
- tables
- Understand ILWIS auxiliary objects: domains, representations and georeferences

Sources for the practical:

- Guidelines of practical 1: A_Practical_Guide_Ilwis31quick.pdf
- ILWIS data of practical 1
- ILWIS academic 3.3.1

Day 2
Lecture 4: The Remote Sensing System
Learning Objectives and/or Content and/or Content

- Differentiation: Sensors on board on platforms.
- Classification of sensors: Active and passive sensors
- Image constraints: Classification of imagery capability:
- Spatial resolution: ground sample resolution, ground spatial resolution. Scale is meaningless in RS.
- Radiometric resolution.
- Revisiting time or temporal resolution.
- Overpass time.
- Expected lifetime.
- Criteria for image selection: cloudiness and angular distortions
- Summary of available platforms and imagery (selection to specializations)

Sources and order for study:

- RS head book: Chapter 4 Platforms and passive electro-optical sensors. Starting from page 61
    - P.4.1. and P.4.2.: quick look. Study main concepts only.
    - P.4.2.3: Deep study
    - P.4.2.4.: excluded
    - P.4.3.: optional. Have a quick look only
    - P.4.3.2.: excluded
    - P.4.4: Deep study
    - P.4.5.: excluded
    - P.4.6 and P.4.7.: As reference only.

Lecture PDF: "The remote sensing system": It summarizes the concepts in the book. In this presentation the information of platforms and sensors is better presented as in the book

Lecture 5+6: Coordinate system and georeferencing
Learning Objectives and/or Content and/or Content

- Basics on Coordinate Systems
- Ellipsoids and Horizontal Datum: many to one and one to many.
- Country coordinate systems
- Projections
- Coordinate conversions
- Image distortions and displacements.
- Georeferencing: (2D approaches)
- Manual georeferencing:
- Planar interpolations
- Map or GPS to image and image to image methods
- Transformations selection as related to imagery: conformal, affine and polynomial.
- How to correct a distorted imagery: From georeferencing to geocoding.
- Matching images with maps.
- Process of resampling.

Sources and order for study:

- For Coordinate Systems:
    - RS head book: Chapter 4. Start at 4.1 on page 93 till page 111. (Exclude P.4.1.4)
    - PDF from lectures: RS_INTRO-Coordinate systems
- For Georeferencing and Geocoding
    - RS head book: Chapter 6 from page 107
        - P.6.1: all
        - P.6.2: Regarding the image distortions understand: only the concepts of oblique view, earth rotation and relief displacement.
        - P.6.3.: all. Very important
        - P.6.4.: Concepts of DEM and DSM
        - P.6.4.1.: have an overview of the orientation of aerial photos. Not in detail
        - P.6.4.2. and P.6.4.3.: have an overview of mono-plotting and ortho-imagery
        - P.6.4.4.: excluded
    - PDF from lectures: RS_INTRO-Georeferencing & geocoding

Practical 2: Georeferencing and resampling (NL case)
Learning Objectives and/or Content

- Learning to acquire and read coordinate systems: datum, ellipsoids and projection.
- Learning how to georeference a toposheet with a printed grid and evaluat the georeferencing error.
- Learning how to georeference an image:
- Criteria for the selection of ground control points: fair spatial distribution and clarity
- Evaluation of GCP precision.
- GCP corrections and overall image precision.
- Learning geocoding: Right selection of the resampling method and map boundaries

This practical consists of the georeferencing of a topographic map in a GIS system. Once the topographic map is georeferenced and ready in the GIS, a remote sensing image is georeferenced by using the georeferenced topographic map and GCP selected by the student. This exercise is done using the standard example of the CORE of ITC (an image in NL).

Day 3

Lecture 7: Image visualization and enhancement

Learning Objectives and/or Content

- Understanding of “on-screen” image clustering: Histogram operations
- Interval and cumulative representations.
- Interval classification in terms of clustered reflectance.
- Visualization of on-screen-image enhancement: Contrast enhancement
- Linear stretching: bounded, percentage, piecewise.
- Non-linear: histogram equalization
- Single band color scales
- Interval construction
- The pseudo color scale
- Density slicing
- Single band classifications by bounding.
- Quick review on mathematical changes of an image for feature detection: Filter operations
- Low and high frequency images.
- Definition of filters and types:
- Linear: lowpass (smoothing) and highpass (enhancing)
- Non-linear: Median, speckle and morphological.

Sources and order for study:

- RS head book: Chapter 5 from page 83 till page 97, following these suggestions.
    - P.5.1.: overview
    - P.5.2.:
    - P.5.2.1: only RGB and IHS well understood. YMC only concept.
    - P.5.2.2.: deep study
    - P.5.3.: excluded
    - P.5.4.: deep study
- Lecture PDF: Image visualization and enhancement. Use it to study and as a reference for the book.

Lecture 8: Visual interpretation in aerial photos and RS images

Learning Objectives and/or Content

- Understanding the concepts and products of the image interpretation.
- Visualizing the common imagery: aerial photos and remote sensing
- Realizing the different deductive processes of interpretation
- Understanding the properties of the objects used for identification and mapping
- The mapping processes

Sources and order for study:

- Lecture PDF: Visual interpretation.Main concepts and review the interpretation analysis of some of the images. Perceive the properties of the image used to interpret.
- RS head book: Chapter 7 starting from page 125 till 131. Exclude P.7.4.: "Quality aspects".

Practical 3: RS Calculus. Net radiation and Vegetation indexes

This practical may be seen either as two independent practicals or as a single practical where after some common section the participant choices the net radiation or the vegetation index.

As two independent practices:

The participants have to complete **first** the practical ""AP3_ Practical_EBE_VEGINDEX_ILWIS_GP_stud.pdf"" and then they move to the document "AP3B_Vegetation_indexes.pdf". All the indexes should be calculated with the reflectance bands obtained in the first part of the assignment

As a single practice with choice:
The common part is the calculation of the radiometric calibration of remote sensing imagery. Then the student has a choice:

- A longer exercise for people interested in energy balance: Revising a basic example of calculating the simplified energy balance net radiation term from satellite imagery. That corresponds from the beginning till where it says: "Calculation of indexes". All in the document "AP3_ Practical_EBE_VEGINDEX_ILWIS_GP_stud.pdf"
- A shorter exercise for people interested in vegetation indexes: reviewing the use and calculation of different vegetation indexes in Remote Sensing. That correspond to the document "AP3_ Practical_EBE_VEGINDEX_ILWIS_GP_stud" from the beginning til the title "Calculation of broadband albedo at the top of the atmosphere" (Excluded). At that point the participant changes to the document "AP3B_Vegetation_indexes.pdf". All the indexes should be calculated with the reflectance bands obtained in the first part of the assignment

Learning Objectives and/or Content (Overall)

- The Map calculator: Interface and command line languages
- Logical and conditional operators
- Advance issues: undefined
- Concept of domains
- Image dependency
- Image attributes
- Map operation with attributes
- Experiencing the use of map calculation features with one image example: the estimation of the net radiation. (NOTE: the goal here is to understand the concepts behind the building of raster maps out of equations. For that an example on net radiation is used as it is very relevant for the understanding of quantitative Remote Sensing. It is not the goal to understand in deep the net radiation at this stage).
- Uses of map calculation for image calibration, radiances, reflectance and second other derivative.
- Calculation of radiances
- Calculation of reflectance
- Calculation of brightness temperature
- Calculation of broadband albedos
- Calculation of surface emissivity using surrogate formulae
- Calculation of air temperature using interpolation techniques
- Calculation of apparent emissivity of the atmosphere using surrogate formulae
- Calculation of net shortwave radiation
- Calculation of incoming and outgoing longwave radiation
- Calculation of net radiation
- Practice repetitive calculations in ILWIS: the batch file
- Definition and calculation of the following vegetation indexes
- Basic indexes: RVI, NDVI, IPVI, DVI, PVI, WDVI,
- Minimize soil interference: SAVI, TSAVI, MSAVI, MSAVI2
- Minimize atmospheric noise: GEMI, ARVI
- Other indices: GVI

Day 4

Lecture 9: Digital Image Classification

Learning Objectives and/or Content

- Introduction: what is it and for what can we use digital image classifications for? The limitations.
- Understanding Image space versus feature space: arrays, single band, multiband
- The analysis of feature space scatterplots
- Distances in feature space
- Decision boundaries in feature space
- Unsupervised versus supervised classification
- Supervised training
- Defining a classification algorithms: pro's and con's
- Box classification
- Minimum distance to the mean
- Maximum likelihood
- Accuracy assessment (classification validation):
- Confusion matrix
- Ground truth data set
- Problems in Image classification

Sources and order for study:

RS head book: Chapter 8 from page 135. The whole chapter well understood till the page 146 (end). (P.8.5 "Pixel based": excluded)

Lecture PDF: "Image classification". Use the material as a summary of the text book.

Lecture 10: Image Filtering

Learning Objectives and/or Content

Filters are mostly incorporated within GIS courses. here a quick overview of the Filter concept and the most common image filters will be presented and demonstrated.

- Filter operations
- Low and high frequency images.
- Definition of filters and types:
- Linear: low-pass (smoothing) and high-pass (enhancing)
- Non-linear: Median, speckle and morphological.

Sources and order for study:

Lecture “PDF”: "Filters". As reference material.

RS Head Book: From P.5.4.3 in page 97 till page 99. P.5.5: Image fusion is excluded

Lecture 11 (optional): Qualitative and Quantitative applications in hydrology

This is a presentation on (some) current topics of research at ITC WRS department and partner departments. It gives you a glance on what we are doing and your potential field of research for the MSc degree.

Learning Objectives and/or Content:

- Overview of the RS application in hydrology.
- Qualitative and quantitative products. Is always necessary to work qualitative?
- Opportunity images vs. time series:
- Image integration with models: the spatial side of a model.

Practical 4: Digital Image Classification

- Linking the image band reflectance with the spectral signatures of the main land surface characteristics.
- Analysis with different image band combinations: Color composition and detection of land features.
- Evaluation of reflectance of pixels in different bands and comparison with the feature signature.
- Clustering and sampling sets: Training sets for classification. Selection of well identified pixels.
- Classification methods. choices and evaluation of the classification results.

This exercise cover the basic aspects of the pre-processing and steps for the digital image classification using ILWIS. Some aspects of the practical will be presented with a step by step video available among the exercises data file.

Day 5

Lecture 12: Table and Databases & Remote sensing data sources

Learning Objectives and/or Content

Table and databases are seen deeper during the GIS part of the course. Here an introduction of functionalities of databases and tables related to Remote Sensing imagery with stress in the ILWIS software is given.

- Tables and databases
- Tables and databases: two different concepts
- Concept Relational databases:
- Correct design of a relational database
- Avoiding database redundancy
- Queries: spatial and non-spatial

Sources and order for study:

- RS head book: P.3.4.: It is optional as ILWIS does not have a relational database. In any case the material is all here.
- Lecture PDF: "-Tables & attributes": summarizes the content in the book. It is used as a guideline from the book. It also contains an addendum on ILWIS functionalities.

Lecture 13: Remote Sensing data sources

Learning Objectives and/or Content

This is an introductory presentation on available RS data sources of imagery in the Internet.

- Sources of Remote Sensing imagery
- The WEB: the almost infinite source of data
- Products levels: quality control of products available in the net.
- Software and toolboxes: commercial and free packages.
- ESA
- GEOSS a world wide initiative.
    - Geonetcast in ILWIS: a quick reference

Sources and order for study:

- Lecture PDF: "Remote sensing data sources"

Lecture 14: Elements of atmospheric correction

Learning Objectives and/or Content

- When atmospheric correction is needed and when it is not
- Radiometric correction:
- Sensor scaling: gain and offsets. Dual scaling. Top of the atmosphere radiance.

- Top of the atmosphere reflectance for visible bands.
- Brightness temperature for Thermal bands.
- Atmospheric interaction: scattering and absorption processes of EMR.
- Quantitative and qualitative atmospheric correction.
- Sources of atmospheric data

Sources and order for study:

- RS head book: Chapter 11 from page 193 till the end of the chapter.
- Lecture PDF: "Elements atmospheric correction".

Practical 5: Relative and absolute atmospheric correction with ground information
Learning Objectives and/or Content

- Using a crude image correction procedure for multi-temporal analysis
- Selection of pixel reflective invariant
- Understanding the linearity between top of the atmosphere imagery and atmospherically corrected images.

Distribution of the material for this training.
All the material for theory and practicals are distributed in a single self extractable file encrypted and with password. Once executed 7 folders are created:

- 1 Material: containing the e-books relevant to the course
- 2 Software: ILWIS 3.3.1 academic version and patch to make the software free. Includes the installation instructions in a readme file. The software must be installed to solve all practicals.

3-7 Day: material per day for