POSTGRADUATION PROGRAM IN REMOTE SENSING (PGSER)

Academic Coordinator

Ieda Del'Arco Sanches

Course Counsil Members

Ieda Del'Arco Sanches (President)
Lênio Soares Galvão
Camilo Daleles Rennó
Thales Sehn Korting
Daniel Andrade Maciel (Student Representative)
Grazieli Rodigheri (alternate Student Representative)

Faculty Members

Antônio Miguel V. Monteiro, Ph.D., Univ. Sussex, 1993
Camilo Daleles Rennó, Doctor, INPE, 2003
Cláudia Maria de Almeida, Doctor, INPE, 2003
Cláudio Clemente Faria Barbosa, Doctor, INPE, 2005
Douglas Fco. Marcolino Gherardi, Ph.D., Royal Hol. Univ. London, 1996
Evlyn Márcia Leão de Moraes Novo, Doctor, USP, 1984
Fábio Furlan Gama, Doctor, INPE, 2007
Hermann Johan Heinrich Kux, Ph.D., Univ. Freiburg, 1976
Ieda Del´Arco Sanches, Ph.D., Massey Univ., Nova Zelândia, 2009
João Antonio Lorenzzetti, Ph.D., Univ. of Miami, USA, 1985
José Claudio Mura, Doctor, INPE, 2000
Leila Maria Garcia Fonseca, Doctor, INPE, 1999
Lênio Soares Galvão, Doctor, USP, 1994
Liana Oighenstein Anderson, Doctor, Univ. Oxford, Inglaterra, 2011
Luciano Ponzi Pezzi, Ph.D., Univ. of Southampton, 2003
Luciano Vieira Dutra, Doctor, INPE, 1989
Luiz Eduardo Oliveira e Cruz de Aragão, INPE, 2004
Márcio de Morisson Valeriano, Doctor, UNESP, 1999
Maria Isabel Sobral Escada, Doctor, INPE, 2003
Milton Kampel, Doctor, USP, 2003
Sidnei João Siqueira Sant´Anna, Doctor, ITA, 2009
Silvana Amaral Kampel, Doctor, USP, 2003
Thales Sehn Körting, Doctor, INPE, 2012
Waldir Renato Paradella, Doctor, USP, 1983
Yosio Edemir Shimabukuro, Ph.D., Colorado State Univ., 1987

REMOTE SENSING PROGRAM (PGSER)

FIRST PERIOD

MANDATORY COURSES (for Master degree)

SER 205-3	Introduction to Remote Sensing
SER-333-3	Physical Principles of Remote Sensing

ELECTIVE COURSES

SER-300-4	Fundamentals of Geoprocessing
SER-347-3	Introduction to Programming for Remote Sensing
SER-730-0	Master research in remote sensing
SER-780-0	Doctoral research in remote sensing

SECOND PERIOD

MANDATORY COURSES (for Master degree)

SER-413-4	Digital Image processing in remote sensing

ELECTIVE COURSES

SER-204-3	Statistics Applied to Remote Sensing
SER-311-3	Remote Sensing of Climate
SER-332-2	Radar Imaging: Principles and Applications
SER-335-3	Spectral reflectance of natural targets
SER-406-3	Agricultural Remote Sensing
SER-415-3	Detection and Analysis of Land Use and Land Cover Change Patterns
SER-457-3	Population, Space and Environment
SER-730-0	Master research in remote sensing
SER-780-0	Doctoral research in remote sensing

THIRD PERIOD

MANDATORY COURSES (for Master degree)

SER-348-3	Methodologies for study of the physical environment

ELECTIVE COURSES

SER-301-3	Spatial Data Analysis
SER-319-3	Hyperspectral Remote Sensing
SER-338-3	Spatial Dynamic Modeling
SER-339-3	Pattern Recognition and Computational Learning Methods for Remote Sensing
SER-340-3	Remote Sensing of the Oceans
SER-341-3	Remote Sensing and Spectral Data Analysis Techniques in Aquatic Ecosystems
SER-410-3	SAR image processing
SER-411-3	Advanced Topics in Digital Image Processing
SER-455-3	Special Topics in Forestry: Phytogeography and Remote Sensing Applications
SER-730-0	Master research in remote sensing
SER-780-0	Doctoral research in remote sensing

COURSES MENU

FIST PERIOD

1.   SER-205-3 – Introduction to Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Mandatory course: for the Master Degree
Prerequisite: none
Lecturers: Dr Milton Kampel (PGSER Faculty) - **Responsible**
        Dr Claudia Maria de Almeida (PGSER Faculty)
        Dr. Luiz Eduardo O. e Cruz de Aragão (PGSER Faculty)
        Dr Leila Maria Garcia Fonseca (PGSER Faculty)
        Dr Hermann Johann Heinrich Kux (PGSER Faculty)
        Dr Fabio Furlan Gama (PGSER Faculty)

PROGRAM:
Remote sensing history as an Earth Observation data acquisition system. Space programs, segments, phases, requirements, limitations, mission types, and payloads. Types of Earth Observation satellite orbits. Data acquisition levels, resolutions, sampling scales. Data and information flow, calibrations, corrections, calculation of geophysical parameters, composites, analyzes. Types and classes of remote sensors. Optical sensors in the Visible. Thermal infrared sensors. Synthetic Aperture Radar. Other remote sensors. High spatial resolution sensors. Aerophotogrammetry. Drones. Remote sensing products. Applications in vegetation, urban areas, agriculture, ocean and inland waters. Future perspectives.

REFERENCES:
Rees, W.G., Physical principles of remote sensing, 3ed., Cambridge Univ. Press, 2013.
Sabins, F.F., Remote Sensing: Principles and Applications, 3ed., Waveland Press Inc, 2007.
Sabins, F.F., Physical principles of remote sensing, 2ed., 2001.
Elachi, C., Introduction to the physics and techniques of remote sensing, Wiley-Interscience, 2ed., 2006.
Liang, S., Quantitative remote sensing of land surfaces, John Wiley & Sons, 2004.
Novo, E.M.L.M., Sensoriamento Remoto: prncípios e adplicações, 4ed., Blucher, 2010
Jensen, J. R. Sensoriamento remoto do ambiente: uma perspectiva em recursos terrestres. São José dos Campos: Parêntese, 2009. 598 p. Tradução da segunda edição.
Lillesand, T.M.; Kiefer, R.M.; Chipman, J.W. Remote sensing and image interpretation. New York, Wiley, 6th edition, 2008. 770p.
Richards, J.A. Remote Sensing Digital Image Analysis. An Introduction Springer-Verlag, 5th edition, 2013. Berlin Heidelberg.
Formaggio, A.R., Sanches, I.D. 2017. Sensoriamento Remoto em Agricultura. 1a edição, São Paulo: Oficina de Textos, 288p. ISBN 978-85-7975-277-3, eISBN 978-85-7975-282-7.

2.   SER-333-3 - Physical Principles of Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Mandatory course: for the Master Degree
Prerequisite: none
Lecturers: Dr Ieda Del'Arco Sanches (PGSER Faculty) - **Responsible**
        Dr Lino Augusto Sander de Carvalho (UFRJ)

OBJECTIVE: Enable the student to understand the basic principles surrounding the science / practice of Remote Sensing. Provide the student with a theoretical basis involving the concepts of electromagnetic radiation and its interaction with atmospheric targets and the earth's surface. Provide the student with contact with radiometric experiments that technically instruct, demonstrating and discussing the limitations and advantages of each level of acquisition of remote sensing.

PROGRAM:
Radiation fundamentals for atmospheric applications and characterization of the Earth's surface: A nature of radiant energy. Radiant energy. Electromagnetic spectrum. Radiometric quantities. Electromagnetic radiation sources (REM). Interaction of electromagnetic radiation with terrestrial targets. Radiometry: instrumentation, reflectance factor, laboratory and field radiometric practices. Electromagnetic energy emissions: Plank, Stefan-Boltzmann and Wien laws. Introduction to radiative transfer. Atmospheric composition. Atmospheric attenuation. Selective absorption and emission by atmospheric gases. Radiation transfer equation. Lambert-Bouguet-Beer Law: formulation of flux absorption. Field practice. Schwarzchild's equation and its solution. Infrared radiative transfer equation: absorption and emission. Radiation transfer equation in parallel plane atmosphere. Radiative equilibrium model. Radiation balance in the Earth-Atmosphere system: Solar radiation incident on top of the atmosphere. Solar constant. Solar irradiance distribution on the earth's surface. Radiative emission of planets from the solar system. Balance of global radiative energy flow.

REFERENCES:
Barbosa, C.C.F. Novo, E.M.L.M. Martins. V.S. Introdução ao Sensoriamento Remoto de Sistemas Aquáticos Princípios e aplicações. 2019. 178p.

Hewitt, P. G. Conceptual physics. City College of San Francisco.Twelfth edition. 2015. 819p.

Iqbal, M. An Introduction to Solar Radiation. Academic Press, 1983. 390p.

Jensen, J. R. Sensoriamento remoto do ambiente: uma perspectiva em recursos terrestres. (Tradução da Segunda Edição). José Carlos Neves Epiphanio {coordenador}... [et al.]. - São José dos Campos, SP. Parêntese. 2009.

Liou, K.N. An Introduction to Atmospheric Radiation (second edition). Academic Press, 2002, 583p.

Lorenzetti, J.A. Princípios Físicos de Sensoriamento Remoto. São Paulo. Bluecher. 2015. 293p.

Meneses, P.R. Almeida, T. Baptista, G.M.M. Reflectância dos Materiais Terrestres: Análise e Interpretação. Editora Oficina de Textos. 336p.

Mobley Curtis. Light and Water: Radiative Transfer in Natural Waters. Academic Press 1994. 592 p

Moraes, E.C.; Gama, F.F. Fundamentos de Radiometria e Comportamento Espectral. VIII Simpósio Brasileiro de Sensoriamento Remoto, Salvador, Bahia, 14-19 de Abril de 1996.

Novo, E. M. L. M. Sensoriamento remoto: princípios e aplicações. Quarta Edição. Edgard Blücher Ltda., 2010. 388p.

Slater, P.N. Remote sensing: optics and optical systems. Reading, MA, AddisonWesley, 1980. 575p.

3.   SER-300-4 – Fundamentals of Geoprocessing

Workload: 60 class hours
Total number of credits: 4 (Four)
Elective course
Prerequisite: none
Lecturers: Dr. Antonio Miguel Vieira Monteiro (PGSER Faculty) - **Responsible**
Dr. Claudio Clemente Faria Barbosa (PGSER Faculty)
Dr Maria Isabel Sobral Escada (PGSER Faculty)
Dr Silvana Amaral Kampel (PGSER Faculty)
Dr. Eymar Lopes (DIOTG)
Dr. João Pedro Cordeiro (DIOTG)
Dr. Júlio César Lima D'Álge (DIOTG)
Dr Karine Reis Ferreira (DIOTG)
Dr. Gilberto Ribeiro (DIOTG)

OBJETIVES:
The SER-300 course aims to offer an overview of the Geoprocessing area, when discussing the theoretical foundations of GeoInformation Science and Engineering, and its application areas that include environmental, urban, socio-economic, population, protective capacity, public policies, public health, among others. At the end of the course, the student should be able to develop a medium-sized geoprocessing project in an application domain, that includes from the conceptual modeling of the system, the production of results in a sgeographic information system and analysis of the results, generating an end-of-course monograph.

PROGRAM:
Computational Representations of the Geographic Space:
   The problem of computational representation of space.
   Concepts: Space, Scale, Model, Spatial Dependence
   Types of Geographic Data.
   Data Structures in GIS.
   GIS architectures.
   Data Modeling in Geoprocessing.
Spatial Data Integration:
   Cartography for Geographic Information Systems.
   Geographic Data Interoperability.
   Open Standards; Specifications - OGC
   Open Software in GIS
   Remote Sensing and GIS: What does an image contain?
Geographic Data Operations:
   Numerical Terrain Modeling.
   Introduction to Geostatistics.
   Map Algebra.
   Geographic Inference and Decision Support.
Application Examples:
   Ecological-Economic Zoning.
   Geological Prospecting.
   Public health.
   Municipal Management.
   Population Studies.

REFERENCES:
Aronoff, S. Geographic information systems: a management perspective. Ottawa: WDL Publications, 1989. 300p.
Burrough, S. Principles of geographical information systems for land resources assessment. Oxford: Oxford University Press, 1989, 200p.
Camara, G.; Casanova, M. A.; Hemerly, A.; Medeiros, C. B. M; Magalhães, G. C. Anatomia de sistemas de informação geográfica. Campinas: SBC/ Escola de Computação, 1996.
Star, J.; Estes, J. Geographical information systems: an introduction. Englewood Cliffs, NJ: Prentice Hall, 1990, 300p.

4. SER-347-3 – Introduction to Programming for Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Lecturers: Dr. Thales Sehn Körting (PGSER Faculty) - **Responsible**
Dr. Gilberto Ribeiro de Queiróz (DIOTG)
Dr. Fabiano Morelli (DIOTG)

OBJETIVES:
The huge amount and diversity of data sources from Remote Sensing has changed the way research is performed in this area. New requisites for scientists, including tools for data processing, goes beyond using only graphical interfaces. Several GIS (Geographical Information Systems) contains tools integrating programming languages with graphical interfaces. This course presents basic techniques and tools to aid the research in Remote Sensing, including data acquisition, organization and integration, analysis and visualization. The students will learn an overview on how to build small computer programs using Python programming language, for automating repetitive tasks, to extract, transform and analyse geospatial data.

PROGRAM:
Introduction to Logic Programming: The Python programming language. Data Types. Variables and atribution. Reading data. Control structures, sequences, functions. Manipulating and analysing matricial data: Layer stack. Spatial reference systems. Rater crop and mosaicking. Basic statistics from images. Band math. Visualization. Manipulating and analysing vectorial data: Spatial operations (meter, buffer, sets, topological). Manipulating shapefiles (KML, GeoJSON, ESRI shapefiles). Spatial reference systems. Integrating matricial and vectorial data: raster and geometries. Time series: obtaining time series using web services. Visualization and analysis of time series.

REFERENCES:
Rudorff, B.F.T, Shimabukuro, Y.W.E., Ceballos, J.C. O sensor MODIS e suas aplicações no Brasil. Editora Parêntese, São José dos Campos, SP, Brasil, 2007.
Mark Lutz. Learning Python. O'RELLY, CA, USA, 5th edition, 2013.
OGC. OpenGIS Implementation Specification for Geographic information – Simple feature access - Part 1: Common architecture. Technical report, Open Geospatial Consortium, 2011.
Gonzalez, R.C.; Woods, R.E. (1992) Digital image processing. Massachusetts: Addisson-Wesley, 716 pp
Jensen, J. R. Sensoriamento Remoto do Ambiente: Uma Perspectiva em Recursos Terrestres. Tradução da 2a. edição. J. C. N. EPIPHANIO (org.). São José dos Campos: Parêntese Editora. 672 p.

SECOND PERIOD

1.   SER-413-4 - Digital Image processing in remote sensing

Workload: 45 class hours
Total number of credits: 4 (four)
Mandatory course: for the Master Degree
Responsable Lecturers: Dr. Leila Maria Garcia Fonseca (PGSER Faculty)
                          Dr. Thales Sehn Korting (PGSER Faculty)

PROGRAM:
Introduction: Objective, Examples off Remote Sensing Applications, Image Processing Steps, Imagery Systems; **Mathematical Fundamentals**: Fourier Transform, Wavelet Transform (WT), Spatial Statistics, Image Normalization; **Radiometric and Geometric Corrections**: Atmospheric Correction, Radiometric Calibration, Noise Reduction, Image Registration, Geometric Transformation, Interpolation, restoration; **Spatial Transforms**: Convolution Filters; **Spectral Transforms**: Ratio, Contrast Enhancement, Principal Components (PC), Linear Mixing Model; **Color Systems**: RGB, IHS; **Color Enhancement**: color-space transform, Pseudocolor, False Color, Decorrelation; **Multi-Image Fusion**: PC, IHS, WT. **Segmentation**: Edge Detection, Region Growing, Graph-Based Segmentation, Parallel Segmentation, Classification-Based Segmentation, Multitemporal Segmentation. **Classification**: Maximum Likelihood, Euclidean Distance, Neural Networks, Self-Organizing Maps, Bhattacharrya, Isodata, K-Means, Region-Based Classification, Decision Trees, Feature Selection, Object-Based Classification.

REFERENCES:
Banon, G.J.F.; Barrera, J. Bases de morfologia matemática para a análise de imagens binárias. Recife: IX Escola de Computação, Julho de 1994.
Batschelet, E. Introduction to Mathematics for Life Scientists. 3rd Edition. Springer-Verlag. 1979.
Campbell, J.B. Introduction to remote sensing, 4th ed. Cracknell, A.P. Introduction to Remote Sensing, Second Edition Faddeeva, V.N. Computational methods of Linear Algebra. Dover, N.Y. 1959.
Feller, W. An Introduction to probability theory and its apllication. 2nd Edition. John Wiley. N.Y. 1966 (Vol. 1 e 2).
Jensen, J.R. Introductory Digital Image Processing: A Remote Sensing Perspective. Englewood Cliffs, NJ: Prentice Hall.
Kutner, M. et al., Applied Linear Statistical Models -, 5th edition Lillesand, T.M.; Kiefer, R.W. Remote Sensing and Image Interpretation. John Wiley & Sons. 6th ed.
Mascarenhas, N.D.A.; Velasco, F.R.D. Processamento Digital de Imagens. 2a. ed. EBAI. IV Escola de Computação.1989.
Matter, P.M. Computer Processing of Remotely-Sensed Images: An Introduction. New York, NY, John Wiley & Sons, 1999.
Moik, J.G. Digital Processing of Remotely Sensed Images. NASA. Washington. Muller, J.P. Digital Image Processing in Remote Sensing. Taylor & Francis. 1988.
Novo, E.M.L.M. Sensoriamento Remoto: Principios e Aplicações.
Richards, J.A. Remote Sensing Digital Image Analysis. An Introduction Springer-Verlag, 5th edition, 2013. Berlin Heidelberg.
Schowengerdt, R.A. Techniques for Image Processing and Classification in Remote Sensing. Academic Press. N.Y.
Schowengerdt, R.A. Remote Sensing: Models and Methods for Image Processing. Academic Press. N.Y.

Witten, I., & Frank, E. Data Mining: Practical machine learning tools and techniques. Machine Learning. San Francisco, CA. 2nd edition, 2005.

Wonnacott, T.H.; Wonnacott, R.J. (português). Introductory Statistics. John Wiley. 1977.

2.   SER-204-3 – Statistics Applied to Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Responsible Lecturer: Dr. Camilo Daleles Rennó (PGSER Faculty)

GOAL:
Some fundamental concepts will be discussed to improve knowledge about statistical procedures commonly used in Remote Sensing and related areas. Many examples and exercises presented during the course are related to Remote Sensing and Geoprocessing. It is highly recommended that the student already has basic knowledge of probability and descriptive statistics.

PROGRAM:
Basic statistical review: random variables, discrete and continuous distributions, and central limit theorem. Statistical inference: concepts; biased estimates; accuracy and precision, sample distributions. Confidence interval and hypothesis testing. Analysis of variance. Regression analysis. Principal components. Cluster analysis. Sampling theory. Resampling techniques. Classification evaluation: confusion matrix, total accuracy, agreement and error indices. Nonparametric statistics. Uncertainty assessment. Stochastic simulation and credibility interval.

REFERENCES:
Chatfield, C.; Collins, A.J. Introduction to multivariate analysis. London: Chapman and Hall, 1986. 246p.

Cochran, W. G. 3. ed. Sampling techniques. John Wiley & Sons, 1977.

Congalton, R. G.; Green, K. 2. ed. Assessing the accuracy of remotely sensed data: principles and practices. CRC Press, Boca Raton, 2009.

Montgomery, D.C.; Runger, G.C. Applied Statistics and Probability for Engineers. Wiley, New York, 1994.

Neter J.; Kutner, M.H.; Nachtsheim, C.J.; Wasserman, W. Applied Linear Statistical Models. 4. ed. McGraw-Hill, 1996.

Siegel, S. Estatística não paramétrica: para as ciências do comportamento. Editora McGraw-Hill do Brasil, 1977.

Venables, W.N.; Smith, D.M. An Introduction to R. 2007. (disponível em http://cran.r-project.org/doc/manuals/R-intro.pdf).

3.   SER-311-3 – Remote Sensing of Climate

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Responsible Lecturer: Dr. Milton Kampel (PGSER Faculty)

PROGRAM:
Solar radiation: physical characteristics, governing equations. Energy and radiation budget in the Earth / Atmosphere system and its climatic implications. The role of atmospheric constituents in absorption bands. Remote sensing of longwave radiation and precipitation. Satellite products time series for climate studies: vegetation indices, queimadas, sea surface temperature, ocean color, precipitation, surface wind. Time series analysis techniques for studies on spatial and temporal variability and climate connections. Applications of remote sensing and climate modeling in health.

REFERENCES:
Gurney, R.J.; Foster, J.L.; Parkinson, C.L. Atlas of satellite observations related to global change. Cambridge: Cambridge University Press, 1993, 220p.
Hartman, D.L. Global physical climatology. San Diego: Academic Press, 1994. 408p.
King, M.; Parkinson, C.L. Partington, K.C.; Williams, R.G. Our changing planet: the view from space. New York: Cambridge University Press, 2007, 390p.
Qu, J.J.; Gao, W.; Kafatos, M.; Murphy, R.E.; Salomonson, V.V. Earth science satellite remote sensing: science and instruments. New York: Springer Berlin. 2006. 418p.
Solomon, S.; Qin, D.; Manning, M.; Marquis, M.; Averyt, K.; Tignor, M.M.B.; Miller Jr., H.L.R.; Chen, Z. Climate change 2007: the physical science basis. New York: Cambridge University Press, 2007. 996 p.

4.   SER-332-2 - Radar Imaging: Principles and Applications

Workload: 30 class hours
Total number of credits: 2 (two)
Elective course
Prerequisite: none
Responsible Lecturer: Dr Fábio Furlan Gama (PGSER Faculty)

PROGRAM:
History of radar use. Radar imagering, advantages and disadvantages. Electromagnetic waves, phase, polarization, wavelength concepts. The electromagnetic and microwave spectrum. Real (RAR) and Synthetic (SAR) Aperture Radar. The radar equation. Imaging geometry. Angular quantities (depression, incidence, local incidence, azimuth). Range and Azimuth. Topographic distortions (foreshortening, layover, shadowing). Spatial resolution. Resolution cell. Digital sampling. Spatial resolution in range and azimuth. Macro topography (shape and orientation of targets / antenna). Surface roughness and surface and volumetric scattering mechanisms. Corner reflectors. Dielectric Constant. Speckle noise. Conventional, polarized and polarimetric radar. Orbital SAR systems. Polarimetry. Representation of polarimetric signatures. Interferometry, and differential interferometry. Use of SAR image processing softwares. The ALOS / PALSAR and Sentinel-1 polarimetric systems. Potential in Cartography, Geology, Forests, Agriculture, Hydrology and Urbanism Applications.

REFERENCES:
Lewis, A.J.; Henderson, F.M. 1998: Principles and Applications of Imaging Radar. Manual of Remote Sensing. Vol. 2, Third Edition.

Werle, D. 1992. Radar Remote Sensing: A Training Manual. Dendron Resources Survey.

5.   SER-335-3 - Comportamento Espectral de Alvos

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: SER-333-3 Princípios Físicos de Sensoriamento Remoto
Lecturers Responsáveis:
>   Dr Evlyn Márcia Leão de Moraes Novo (PGSER Faculty)
>   Dr. Lênio Soares Galvão (PGSER Faculty)
>   Dr. Cláudio Clemente Faria Barbosa (PGSER Faculty)
>   Dr. Yosio Edemir Shimabukuro (PGSER Faculty)
>   Dra. Elisabete Caria Moraes (DIOTG)

PROGRAM:
Interaction between the electromagnetic radiation (EMR) and Earth surface targets. Radiometric concepts and methods. Plant leaf spectral reflectance. Canopy spectral Reflectance. Canopy Reflectance Models. Spectral reflectance of pure water. Spectral reflectance of water bodies. Spectral reflectance of mineral and rocks. Soil pectral reflectance. Methods for spectral data analyses. Lectures. Laboratory and field experiments. Seminars.

REFERENCES:

Alchanatis, V., Schmilovitch, Z. and Meron, M., 2005. In-field assessment of single leaf nitrogen status by spectral reflectance measurements. Precision Agriculture, 6(1), pp.25-39.

Asrar, G. Theory and applications of optical remote sensing. New York, NY: John Wiley & Sons, 1990. 860p.

Ben-Dor, E., Inbar, Y. and Chen, Y., 1997. The reflectance spectra of organic matter in the visible near-infrared and shortwave infrared region (400–2500 nm) during a controlled decomposition process. Remote Sensing of Environment, 61(1), pp.1-15.

Binding, C.E., Jerome, J.H., Bukata, R.P. and Booty, W.G., 2008. Spectral absorption properties of dissolved and particulate matter in Lake Erie. Remote sensing of environment, 112(4), pp.1702-1711.

Boss, E.S., Collier, R., Pegau, W.S., Larson, G. and Fennel, K., 2007. Measurements of spectral optical properties and their relation to biogeochemical variables and processes in Crater Lake, Crater Lake National Park, OR. In Long-term Limnological Research and Monitoring at Crater Lake, Oregon (pp. 149-159). Springer, Dordrecht.

Bowker, D. E., Davis, R. E., Myrick, D. L., Stacy, K., & Jones, W. T. Spectral reflectances of natural targets for use in remote sensing studies, 1985.

Bowman, W.D., 1989. The relationship between leaf water status, gas exchange, and spectral reflectance in cotton leaves. Remote Sensing of Environment, 30(3), pp.249-255.

Dhanapal, A.P., Ray, J.D., Singh, S.K., Hoyos-Villegas, V., Smith, J.R., Purcell, L.C., King, C.A. and Fritschi, F.B., 2015. Association mapping of total carotenoids in diverse soybean genotypes based on leaf extracts and high-throughput canopy spectral reflectance measurements. PloS one, 10(9), p.e0137213.

Datt, B., 1999. Visible/near infrared reflectance and chlorophyll content in Eucalyptus leaves. International Journal of Remote Sensing, 20(14), pp.2741-2759.

Dekker, A. G., Detection of optical water quality parameters of eutrophic waters by high resolution remote sensing, PhD Thesis, Vrije Universiteit, Amsterdam, The Netherlands, 1993.

Effler, S.W., Perkins, M., Peng, F., Strait, C., Weidemann, A.D. and Auer, M.T., 2010. Light-absorbing components in Lake Superior. Journal of Great Lakes Research, 36(4), pp.656-665.

Gausman, H.DW. Plant leaf optical properties in visible and near-infrared light. Lubbock, TX: Texas Tech, 1985. 78p.

Gitelson, A.A., Vina, A., Ciganda, V., Rundquist, D.C. and Arkebauer, T.J., 2005. Remote estimation of canopy chlorophyll content in crops. Geophysical Research Letters, 32(8).

Goel, N. S. Models of vegetation canopy reflectance and their use in estimation of biophysical parameters from reflectance data. Remote Sensing Reviews, n.4, p.1-212, 1988.

Goodin, D. G., Han, L., Fraser, R. N., Rundquist, C., Stebbins, W. A. Schalles, J. F. Analysis of Suspended Solids in Water using Remotely Sensed High Resolution Derivative Spectra. Photogramm. Eng. Remote Sensing. Vol. 59, n. 4, pp. 505 – 510. Abr. 1993.

Gordon H. R., A. Morel, Remote assessment of ocean color for interpretation of satellite visible imagery, a review. Lecture notes on coastal and estuarine studies. Springer-Verlag ed., 114, 1983

Hoepffner, N. and Sathyendranath, S., 1993. Determination of the major groups of phytoplankton pigments from the absorption spectra of total particulate matter. Journal of Geophysical Research: Oceans, 98(C12), pp.22789-22803.

Hunt, G.R. Electromagnetic radiation - the communication link in remote sensing. In: Siegal, G. ed. Remote sensing in geology. New York, NY: John Wiley & Sons, 1980. cap.2, p.5-45. 650p.

Johnson, J.R., Achilles, C., Bell III, J.F., Bender, S., Cloutis, E., Ehlmann, B., Fraeman, A., Gasnault, O., Hamilton, V.E., Le Mouélic, S. and Maurice, S., 2017. Visible/near-infrared spectral diversity from in situ observations of the Bagnold Dune Field sands in Gale Crater, Mars. Journal of Geophysical Research: Planets, 122(12), pp.2655-2684.

Kirkpatrick, G.J., Millie, D.F., Moline, M.A. and Schofield, O., 2000. Optical discrimination of a phytoplankton species in natural mixed populations. Limnology and Oceanography, 45(2), pp.467-471.

Kirk, J. T. O. Light & Photosynthesis in Aquatic Ecosystems, London, Cambridge University Press, 1983.

Kumar, R. Radiation from plants - reflection and emission: a review. West Lafayette, IN: Purdue University, 1972. 88p. (Research project, 5543).

Lopes, M.S. and Reynolds, M.P., 2012. Stay-green in spring wheat can be determined by spectral reflectance measurements (normalized difference vegetation index) independently from phenology. Journal of experimental botany, 63(10), pp.3789-3798.

Mahlein, A.K., Steiner, U., Dehne, H.W. and Oerke, E.C., 2010. Spectral signatures of sugar beet leaves for the detection and differentiation of diseases. Precision Agriculture, 11(4), pp.413-431.

Mistele, B. and Schmidhalter, U., 2008. Estimating the nitrogen nutrition index using spectral canopy reflectance measurements. European Journal of Agronomy, 29(4), pp.184-190.

Petzold, D.E. and Goward, S.N., 1988. Reflectance spectra of subarctic lichens. Remote Sensing of Environment, 24(3), pp.481-492.

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Shenk, J.S. and Westerhaus, M.O., 1991. Population definition, sample selection, and calibration procedures for near infrared reflectance spectroscopy. Crop science, 31(2), pp.469-474.

Wynne, T.T., Stumpf, R.P., Tomlinson, M.C., Warner, R.A., Tester, P.A., Dyble, J. and Fahnenstiel, G.L., 2008. Relating spectral shape to cyanobacterial blooms in the

Laurentian Great Lakes. International Journal of Remote Sensing, 29(12), pp.3665-3672.

Wu, G., Cui, L., Duan, H., Fei, T. and Liu, Y., 2011. Absorption and backscattering coefficients and their relations to water constituents of Poyang Lake, China. Applied Optics, 50(34), pp.6358-6368.

Zhang, Y., Yin, Y., Wang, M. and Liu, X., 2012. Effect of phytoplankton community composition and cell size on absorption properties in eutrophic shallow lakes: field and experimental evidence. Optics Express, 20(11), pp.11882-11898.

6.   SER- 406-3 – Agricultural Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Responsible Lecturer: Dr Ieda Del´Arco Sanches (PGSER Faculty)

PROGRAM:
Introduction to Agricultural Remote Sensing. Spectral behavior of agricultural targets (vegetation, straw and soil). Spectral vegetation indices. Visual interpretation of agricultural targets in orbital optical images. The impact of cloud cover on satellite imagery for monitoring agricultural activity. Dynamics of Brazilian agriculture and agricultural targets. Time series analysis. Agricultural statistics in Brazil. Monitoring and mapping of agricultural crops. Productivity of agricultural crops. Precision agriculture.

REFERENCES:
Formaggio, A.R., Sanches, I.D. 2017. Sensoriamento Remoto em Agricultura. 1a edição, São Paulo: Oficina de Textos, 288p. ISBN 978-85-7975-277-3, eISBN 978-85-7975-282-7.

Jensen, J.R. Remote Sensing of the Environment: an earth resource perspective. 2000. Upper Saddle River, NJ: Prentice-Hall, 544p. (Prentice Hall Series in Geographic Information Science).

Novo, E.M.L.M. Sensoriamento remoto: princípios e aplicações. 2010. São Paulo, Edgard Blücher, 4ª edição, 387p.

Ponzoni, F.J., Shimabukuro, Y.E., Kuplich, T.M. 2012. Sensoriamento remoto da vegetação. São Paulo, Oficina de Textos, 2ª edição, 160p.

Thenkabail, P.S., Lyon, J.G., Huete, A. 2011. Hyperspectral remote sensing of vegetation. CRC Press, Taylor & Francis Group, Boca Raton, London, New York. 781p.

Articles from: Remote Sensing of Environment; ISPRS Journal of Photogrammetry and Remote Sensing; Remote Sensing; Applied Earth Observation and Geoinformation, Photogrammetric Engineering and Remote Sensing; International Journal on Remote Sensing; IEEE Transactions on Geoscience and Remote Sensing; Remote Sensing Applications: Society and Environment; Anais dos Simpósios Brasileiros de Sensoriamento Remoto (SBSR); Annals and Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences; International Geoscience and Remote Sensing Symposium (IGARSS).

7.   SER - 415-3 - Detection and Analysis of Land Use and Land Cover Change Patterns

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Lecturers: Dr Maria Isabel Sobral Escada (PGSER Faculty) - **Responsible**

Dr. Thales Sehn Korting (PGSER Faculty)
Dr. Sidnei João Siqueira Sant´Anna (PGSER Faculty)
Dr. Sérgio Rosim (DIOTG)
MSc. Luis Eduardo Pinehiro Maurano (DIOTG)
MSc. Lidiane Cristina Oliveira Costa (Collaborator)

Concerning about land use change and land cover has emerged in global research agendas a few decades ago, mainly due to its influence on climate change at local and global scales. Human activities are largely responsible for changes in land use and land cover which often result in a mosaic of fragmented landscapes and a mixture of natural and anthropogenic patches, which vary in size, shape and spatial arrangement. Understanding human intervention on the landscape and the direct and indirect consequences of it in land use and land cover spatial patterns and in ecological processes, is fundamental for land management and planning issues and land use modeling. Remote sensing multitemporal data, coupled with the use of pattern recognition techniques, landscape ecology concepts and metrics and data mining techniques represent important tools for the study of land use and land cover spatial-temporal patterns. The aim of this course is to enable students to understand and discuss concepts and methodologies for studying patterns of land use and land cover change, not only as a result of human land surface processes, but also as a component of terrestrial systems, which modify and are modified by abiotic and biotic factors.

Topics covered
1. Patterns and processes of land use and land cover change: Conceptual and theoretical framework.
2. Land use and land cover classification systems.
3. Landscape Ecology: Concepts, methodological approaches and factors that influence landscape spatial patterns and change.
4. Use of landscape metrics to detect land use and land cover change (LUCC) patterns.
5. Change detection techniques in LUCC applications
6. Utilization of spatial tools and remote sensing data for detecting land use and land cover change patterns.
7.Use of pattern recognition and data mining techniques to link LUCC patterns to socioeconomic and ecological processes
8. Landscape stratification for computational modelling of patterns and processes in LUCC.

REFERENCES
Comber A. J. The separation of land cover from land use using data primitives Journal of Land Use Science. Vol. 3, No. 4, p. 215–229, 2008.
Coppin, P.; Jonckheere, I.; Nackaerts, K.; Muys, B.; Lambin, E. Digital change detection methods in ecosystem monitoring: a review. International Journal of Remote Sensing, v. 25, n. 9, p. 1565–1596, 2004.
Food and Agriculture Organization of the United Nations - FAO Land Cover Classification System (LCCS): Classification Concepts and User Manual. Versão 2.0. Roma. Di Gregorio, A.; Jansen, L.J.M., 2004, 179 p.
Forman, R. T. T. Land Mosaics - The ecology of landscapes and regions. Cambridge: Cambridge University Press: 1997., 632 p. Jensen, J. R. Introdutory Digital Image Processing: A Remote Sensing Perspective. Pearson Prentice Hall. 3a ed. 2005. 526 p. Lambin, E. F., H. J. Geist, Et Al. Dynamics of land-use and land-cover change in Tropical Regions. Annual Review of Environment and Resources, v.28, p.205-241. 2003.
Mcgarigal, K. & Marks, B.J. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. U.S. Forest Service General Technical Report PNW, 199,5351p.

Meyer W. E Turner, B. L (EDS). Changes in land use and land cover: A global perspective, Cambridge University Press. 1994.

Silva, M. P. S.; Câmara, G.; Escada, M. I. S.; Souza, R. C. M. Remotesensing image mining: detecting agents of land-use change in tropical forest areas. International Journal of Remote Sensing, v.29, n.16, p. 4803-4822, 2008. 20

Turner, M. G. Gardner, R. H. Quantitative Methods in Landscape Ecology. Springer Verlag. 1990. 536 p.

8.   SER-457-3 Population, Space and Environment

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Responsable Lecturers: Dr Silvana Amaral Kampel (PGSER Faculty)
Dr Antônio Miguel V. Monteiro (PGSER Faculty)

RESUME:
The impacts of human activities on terrestrial systems imply significant modifications on the hydrological, ecological, geomorphologic, climatic and biogeochemical cycles. Working with environmental and socioeconomic databases, with geographical representation, is a necessary skill to the populational studies involving interactions between social and natural environments. In this context, remote sensing (RS) data, geoinformatics and spatial analysis techniques are valuable tools to integrate different data sources, enabling populational studies integrating the population and the territory where they live.

Landscape patterns and environmental profiles extracted from RS data can provide information to assist studies in migration, family arrangements, spatial distribution of the population and small area population estimates. Estimates of population counting and projections are also good opportunities for the integrated use of RS and geoinformatics techniques. Economic indicators, such as those reflecting quality of life, development indices and sustainability indices, etc., can be inferred or built from integration of remote sensing, economic databeas and demographic and agricultural census data.

OBJECTIVE:
Grounding students in theories, methodologies and technologies of geoinformatics, remote sensing, and spatial analysis appropriate for the manipulation, intergration and processing of demographic, economic and environmental databases.

PROGRAM:
Socioeconomic and demographic data: origin, indicators and spatial indexing. Spatial analysis applied to studies of socioeconomic and demographic processes. Spatial data integration: socioeconomic, demographic and remote sensing data. The Scale Effect: Inventory Scale and Integration Scale. Data aggregation / disaggregation and data structure in Geographical Information System. How to build Socio-spatial indicators.
Methods of data integration: from field data research to density probability surfaces.
Examples of applications in health, safety, urbanism, land use and land cover, demography, and others. Socioeconomic and demographic variables for scenario analysis in global climate change studies.

REFERENCES:
Martin, D. (1996). Geographic Information Systems and their Socioeconomic Applications, London: Routledge.

Martin, D. (2000) Towards the geographies of the 2001 UK Census of Population Transactions of the Institute of British Geographers 25, 321-332

Rees, P., Martin, D. and Williamson, P. (2002) The Census Data System, Chichester, UK, Wiley, 389pp. Disponível em [http://cdu.mimas.ac.uk/censusdatasystem/]

Flowerdew, R. and Martin, D. (eds.) (2005) Methods in human geography: a guide for students doing a research project Second Edition, Harlow: Pearson 366pp

Martin, D. (2006) Last of the censuses? The future of small area population data Transactions of the Institute of British Geographers 31, 6-18

Goodchild, M.F., Anselin, L.& Deichmann, U. (1993). A framework for the areal interpolation of socioeconomic data. Environment and Planning A, 25, 383-397.

Harvey, J.F. (2002). Population estimation models based on individual TM pixels. Photogrammetric Engineering and Remote Sensing, 68, 1181-1192.

Jensen, J.R. Cowen, D.C. (1999). Remote Sensing of Urban/Suburban Infrastructure and Socio-Economic Attributes. Photogrammetric Engineering and Remote Sensing, 65, 611-622.

Liverman, D., Moran, E.F., Rindfuss, R.R. and Stern, P.C. (editors) 1998. People and Pixels: Linking Remote Sensing and Social Science. National Academy Press, Washington, DC.

Dennis, R. A.; Mayer, J.; Applegate, G.; Chokkalingam, U.; Colfer, C. J. P.; Kurniawan, I.; Lachowski, H.; Maus, P.; Permana, R. P.; Ruchiat, Y., et al. Fire, people and pixels: Linking social science and remote sensing to understand underlying causes and impacts of fires in Indonesia. Human Ecology, v.33, n.4, Aug, p.465-504. 2005.

Torres, Haroldo & Costa, Heloisa (organizadores). (2000). População e Meio Ambiente: Debates e Desafios. São Paulo: Editora SENAC. ISBN: 85-7359-104-8. pp. 351.

REBEP- Revista Brasileira de Estudos de População, vol. 24, n. 2, jul./dez. 2007, número especial: População, Espaço e Ambiente. [acesso on-line em http://www.abep.org.br/usuario/GerenciaNavegacao.php?caderno_id=590&nivel=1]. ISSN 0102-3098 versão impressa.

1.   SER-348-3 - Methodologies for study of the physical environment

Workload: 45 hours
Total number of credits: 3 (three)
Mandatory course: for the Master Degree
Responsible Lecturer: Dr Márcio de Morisson Valeriano (PGSER Faculty)

Objective:
The course aims at planning skills for the development of environmental information, from the selection of data sources, analysis resources and methods for data processing up to the confection of related pre- and post-execution documents.
Contents:

1 - Introduction – remote sensing in the geosciences context: information as the main subject of geotechnologys; typical dynamics of requests; job types: survey, prospection, environmental diagnosis and planning, basic and applied research. Cartographic production and its goals; systematic and thematic cartography; temporal, spatial and thematic scales; legend specifications; generalizing and detail.

2 – Concepts – geographic data: position, attributes and dynamics; typical structures of geographic data; applications, sources and typical uses of remotely sensed imagery for landscape systems; natural structures of landscape elements; data acquisition and storing structures. The complex systems concept applied to the genesis and development of information; specific conceptual inputs from remote sensing: basic and applied research along the development of geographical information.

3 - Techniques – decomposing demands into elementary processes; survey steps and processes for developing the geographical information. Geoprocessing resources for geographic data: functional description of a GIS; basic functions: structure, analysis and query. Data integration techniques. Changes on data structure. Errors: types and sources; recommendations and control procedures; precision and accuracy measurements; scale x resolution; evaluation and qualification of remote sensing products. Communication levels in remote sensing activity and applications: image, map, map documentation, bulletin, preliminary and execution projects, technical report, oral communications, article, lesson, dissertation and thesis. Exercises.

REFERENCES:
Bonham-Carter, G. F. Geographic Information Systems for geoscientists: Modelling with GIS. In: Computer methods in geosciences, s.l: Pergamon/Elsevier, 1994.

Jensen, J. R. Sensoriamento Remoto do Ambiente: Uma Perspectiva em Recursos Terrestres. Tradução da 2a. edição. J. C. N. Epiphanio (org.). São José dos Campos: Parêntese Editora. 672 p.

Robinson, A. H.; Sale, R. D.; Morrison, J. L.; Muehrcke, P. C. Elements of Carthography. John Wiley and Sons (Ed.), New York, 106-136, 1978.

Schowengerdt, R.A. Remote sensing: models and methods for image processing. 3a. Ed. United States of America: Elsevier, 2007. 515p. ISBN: 978-0-12-369407-2

2.   SER-301-3 – Spatial Data Analysis

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: SER-300-4
Lecturers: Dr. Antonio Miguel Vieira Monteiro (PGSER Faculty) **- Responsible**
    Dr. Eduardo Celso Gerbi Camargo (DIOTG)
    Dra Silvana do Amaral Kampel (PGSER Faculty)
    Dr. Carlos Felgueiras (DIOTG)
    Dr Jussara Ortiz (DIOTG)
    Dr. Pedro Andrade (DIIAV)

OBJETIVES:
The SER-301 course presents the main techniques of Spatial Data Analysis in the context of studies of space-time phenomena, including Spatial Statistics, Geostatistics, Spatial Regression, and spatially explicit Dynamic Modeling. The purpose of using Spatial Data Analysis techniques is to seek revealing and describing existing patterns in geographic data and establish, preferably quantitatively, but not exclusively, the relationships between the different geographic variables and the phenomena under study. At the end of the course, the student should be able to establish procedures that allow to describe, in a quantitative way, the importance and contribution of each of the data used in their studies and design an experiment to test the hypothesi raised.

PROBRAM:
The problem of spatial analysis. Components of spatial analysis: exploration, consultation, manipulation and modeling. Types of spatial analysis. References. Analysis of point data: "Kernel estimation", K-function. CSR tests. Surface Analysis by Geo-Statistics: exploratory analysis, Variography, Krigeagem and its various forms; case studies. Analysis of Areal Data: proximity matrix, spatial correlation, Bayesian methods. Autocorrelation indicators (global and local). Empirical Estimation of Bayes. Spatial Regression: Ordinary regression models, autoregressive, spatial regimes. Case studies. Representation of Uncertainty: Geostatistics and Uncertainty Measures. Krigeagem by indication as estimator of the probability distribution of random variable. Uncertainty of numerical and thematic fields. Stochastic Simulation.

REFERENCES:
Bailey, T.; Gatrell, A. Interactive Spatial Data Analysis. London, Longman Scientific and
  Technical, 1995.
Câmara, G. et al., Geoprocessamento: Teoria e Aplicações. INPE, 2000 (on-line:
  http://www.DIOTG.inpe.br/livro)
Longley, P.; Batty, M. (eds) Spatial analysis: modelling in a GIS environment.
  Cambridge: Geoinformation International, 1997.

3.   SER-319-3 - Hyperspectral Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Lecturers: Dr Lênio Soares Galvão (PGSER Faculty) - **Responsible**
   Dr Ieda Del´Arco Sanches (PGSER Faculty)

PROGRAM:
Introduction and principles; multispectral and hyperspectral remote sensing; images and spectra; hyperspectral cube; airborne and orbital hyperspectral instruments; future

satellite missions; factors affecting hyperspectral data acquisition; spectral reflectance of targets (e.g., water, vegetation, rocks, soils, urban materials); hyperspectral image pre-processing; atmospheric effects; atmospheric correction of hyperspectral data; empirical, semi-empirical and physical-based methods; hyperspectral vegetation indices; band-depth calculation in images; hyperspectral image processing; target detection in hyperspectral scenes (SAM and SFF techniques); linear spectral mixture models; endmember selection: simple and elaborated methods; fraction-images; state-of-the-art of the hyperspectral studies and applications.

REFERENCES:
Borengasser, M.; Hungate, W. S.; Watkins, R. (2007). Hyperspectral remote sensing: principles and applications. New York: CRC Press. 128 pp.

Chuvieco, E. (2016). Fundamentals of satellite remote sensing - An Environmental Approach. Second Edition. New York: CRC Press. 468 pp.

Eismann, M. T. (2012). Hyperspectral remote sensing. London: SPIE. 748 pp.

Jensen, J. R. (2009). Sensoriamento remoto do ambiente: uma perspectiva em recursos terrestres. Tradução por J. C. N. Epiphanio, A. R. Formaggio, A. R. Santos, B. F. T. Rudorff, C. M. Almeida e L. S. Galvão. São José dos Campos: Parêntese. 598 pp.

Thenkabail, P. S.; Lyon, J. G.; Huete, A. (2018). Hyperspectral remote sensing of vegetation. Second Edition; volumes I to IV; Boca Raton, FL: Taylor & Francis. 1478 pp.

van der Meer, F.; de Jong, S. M. (2001). Imaging spectrometry: basic principles and prospective applications. Dordrecht, Netherlands: Springer. 426 pp.

4.   SER-338-3 - Spatial Dynamic Modeling

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: None
Responsible Lecturer: Dr Claudia Maria de Almeida (PGSER Faculty)

PROGRAM:
Theoretical issues: Historical perspective of land use and land cover dynamic models. Cellular Automata. Spatial dynamic models: Concepts, typologies, refinements, state-of-the-art. Deterministic models: BASS II, SLEUTH, SACI and others. Agent-based models: REPAST, MICE, StarLogo and others. Stochastic models: Dinamica EGO, Simlucia, Clue-S, TerraME and alike. 3-D models: PC Raster. Methodological issues in stochastic models. Statistical techniques for parameterization: Rule sets, weights of evidence, logistic regression, artificial neural networks. Calibration methods: Heuristic techniques, line generalization algorithms, fractal parameters. Validation approaches: Goodness-of-fit indices, multiple resolution methods, conventional and adapted fuzzy similarity index. Principal components in step-based modeling: Annual derivation of the global transition probabilities matrix. Statistical methods for forecasts: Stationary (Markov chain) and non-stationary (linear regression and extrapolation, time series).

BASIC REFERENCES:
Batty, M. GeoComputation using cellular automata. In: Openshaw, S.; Abrahart, R. J. ed. Geocomputation. New York: Taylor & Francis, 2000. Cap. 5, p. 95-126. Batty, M.; Longley, P. A. Advanced spatial analysis: the CASA Book of GIS. London: CASA, 2003. 275p.

Bonham-Carter, G. F. Geographic Information Systems for Geoscientists: Modelling, with GIS. Ontario: Pergamon, 1994. 305 p.

Briassoulis, H. Analysis of land use change: theoretical and modeling approaches. Lesvos, Greece. Tese (Doutorado em Geografia) - University of Aegean, 2000. Disponível em <http://www.rri.wvu.edu/W ebBook/Briassoulis/contents.htm>.

Burrough, P. A. Dynamic modelling and geocomputation. In: Longley, P. A.; Brooks, S. M.; McDonnell, R.; MacMillan, B. ed. Geocomputation: a primer. Chichester: John Wiley & Sons, 1998. Cap. 9, p. 165-192.

Parks, B. O. The need for integration. In: Goodchild, M. J.; Parks, B. O.; Steyaert, L. T. ed. Environmental Modelling with GIS. Oxford: Oxford University Press, 1993. p. 31-34.

Pedrosa, B. M.; Câmara, G. Modelagem dinâmica. In: Druck, S.; Carvalho, M. S.; Câmara, G.; Monteiro, A. M. V. (ed.). Análise espacial de dados geográficos. Brasília: EMBRAPA, 2005. Cap. 6.

Torrens, P. M.; O´Sullivan, D. Cellular automata and urban simulation: where do we GO from here? Editorial. Environment and Planning B, v. 28, p. 163- 168, 2001.

ADDITIONAL REFERENCES:

Almeida, C. M.; Gleriani, J. M.; Castejon, E. F.; Soares-Filho, B. S. Using neural networks and cellular automata for modeling intra-urban land use dynamics. International Journal of Geographical Information Science, v. 22, p. 943-963, 2008.

Câmara, G.; Aguiar, A. P.; Escada, I.; Amaral, S.; Carneiro, T. G. S.; Monteiro, A. M.; Araujo, R.; Vieira, I.; Becker, B. Amazon Deforestation Models. Science, v. 307, n. 15, p. 1043-1044, 2005.

Rennó, C. D. Construção de um sistema de análise e simulação hidrológica: aplicação a bacias hidrográficas. Tese (Doutorado em Sensoriamento Remoto) - Instituto Nacional de Pesquisas Espaciais, 2003.

Soares-Filho, B. S.; Cerqueira, G. C.; Pennachin, C. L. DINAMICA – A stochastic cellular automata model designed to simulate the landscape dynamics in an Amazonian colonization frontier. Ecological Modelling, v. 154, p. 217-235, 2002.

Verburg, P. H., Soepboer, W., Veldkamp, A., Limpiada, R., Espaldon, V., Mastura, S. S. A. Modeling the spatial dynamics of regional land use: the CLUE-S model. Environmental Management, v. 30, n. 3, p. 391-405, 2002.

White, R.; Engelen, G.; Uljee, I. Vulnerability assessment of low-lying coastal areas and small islands to climate change and sea level rise. Phase 2: Case study St. Lucia. Kingston, Jamaica: United Nations Environment Programme: Caribbean Regional Co-ordinating Unit, 1998.

5. SER-339-3 - Pattern Recognition and Computational Learning Methods for Remote Sensing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Lecturer: Dr Luciano Vieira Dutra (PGSER Faculty) - **Responsible**
Dr Marinalva Dias Soares (Collaborator)
MSc Willian Vieira de Oliveira (Collaborator)

PROGRAM:
Introduction to Pattern Recognition; Typical sequence of a computer learning system for remote sensing image analysis; Classifier types and characteristics: statistical, deterministic, hierarchical; Objects for classification: pixel and regions; Maximum likelihood and Iterative Conditional Modes (contextual); SVM- vector support machines; Decision Tree Classifiers; Methods of extraction and feature selection. Image segmentation, segment classification; Accuracy, assessment.

REFERENCES:
Bishop, C.M. Pattern Recognition and Machine Learning. 1st ed. Springer, 2006.
Duda, R.O., Hart, P.E., Stork, D.G. Pattern Classification. 2nd Ed. John Wiley & Sons, New York, NY, 2001.
Theodoridis, S., Koutroumbas, K. Pattern Recognition, 3nd ed., Academic Press, 2006.
Fukunaga, K. Introduction to Statistical Pattern Recognition. 2nd Ed. Academic Press, Boston, 1990.
Everitt, B.S., Landau, S., Leese, M. Cluster Analysis. 4th ed. Eduard Arnold, Ltd., London, UK, 2001.
Heijden, F. Image Based Measurement Systems. John Wiley & Sons, New York, NY, 1994.
Kuncheva, L.I. Combining Pattern Classifiers: Methods and Algorithms. Willey, June, 2004.
Mitchell, T. Machine Learning, McGraw Hill, 1997.
Webb, A.R. Statistical Pattern Recognition, John Wiley & Sons; 2nd edition, Oct. 2002

6.   SER-340-3 - Sensoriamento Remoto dos Oceanos

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: SER- 333-3 - Physical Principles of Remote Sensing
Lecturers: Dr. Douglas Francisco Gherardi – **Responsible** (PGSER Faculty)
          Dr. João Antonio Lorenzzetti (PGSER Faculty)
          Dr. Luciano Ponzi Pezzi (PGSER Faculty)

PROGRAM:
1) Introduction to oceanography. Forces and movement in the ocean. Large scale and mesoscale ocean processes. 2) Calibration and validation of remote sensing data. 3) Interaction of the electromagnetic radiation with ocean water. Ocean color. 4) Estimating sea surface temperature with remote sensors, principles and applications. 5) Using microwaves to monitor the ocean. Scatterometer, Synthetic Aperture Radar (SAR) and altimetry. 6) Using remote sensing data for ocean modeling. 7) Remote sensing applications for tropical coastal management. Principles of biodiversity conservation and coastal management. 8) Applications of global ocean remote sensing data bases. 9) Hands-on research project.

REFERENCES:
 Curlander, J.C.; Medonough, R.N. (1991) Synthetic Aperture Radar: systems and signal processing. New York, Wiley, 647 pp.
Green, E.P.; Mumby, P.J.; Edwards, A.J.; Clark, C.D. (2000) Remote sensing handbook for tropical coastal management (Ed. A.J. Edwards). Coastal management sourcebooks 3, UNESCO, Paris, 316 pp.
Ikeda, M.; Dobson, F.W. (1995) Oceanographic applications of remote sensing. CRC Press, Boca Raton, 480 pp.
Kirk, J.T.O. (1994) Light and photosynthesis in aquatic systems. Cambridge University Press, Cambridge, 509 pp.
Henderson, F.M.; Lewis, A.J. (1998) Principles & Applications of Imaging Radar: Manual of Remote Sensing. New York, John Wiley, 860 pp.
Martin, S. (2008) An introduction to ocean remote sensing. Cambridge University Press (UK), 426 pp.
Mobley, C., Boss, E., Roesler, C. (acessado em 09/2018) Ocean Optics Web Book <http://www.oceanopticsbook.info/>
Robinson, I.S. (2010) Discovering the Ocean from Space, the Unique Applications of Satellite Oceanography. Springer-Praxis Books in Geophysical Sciences, Chichester, 621 pp.

Robinson, I.S. (2004) Measuring the oceans from space, the principles and methods of satellite oceanography, Springer-Praxis Books in Geophysical Sciences, Chichester, 669 pp.

Martin, S. (2014). An Introduction to Ocean Remote Sensing. Cambridge: Cambridge University Press. doi:10.1017/CBO9781139094368.

Souza, R. B. (2005) Oceanografia por Satélite (segunda edição). São Paulo, Oficina de textos, 336 pp.

Ulaby, F.T.; Moore, R.K.; Fung. A 1981. Microwave remote sensing: active and passive. Boston, MA. Artech House, V. 1/3, 456 pp.

Vignudelli, S., Kostianov, A. G., Cipollini, P., Benveniste, J. (2011) Coastal Altimetry, Spinger Verlag, 565 pp.

7. **SER-341-3 - Remote Sensing and Spectral Data Analysis Techniques in Aquatic Ecosystems**

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: SER-333-3
Responsable Lecturers: Dr. Claudio Clemente Faria Barbosa (PGSER Faculty)
Dr Evlyn M. Leão de Moraes Novo (PGSER Faculty)

PROGRAM:
Physical, chemical and biological properties of continental aquatic environments. Classification of continental aquatic systems: lotic, lentic and transition systems. Interactions between the Electromagnetic Radiation (EMR) and water bodies: Analyses of the aquatic system spectral behavior analysis and the spectral characterization of different types of water bodies. Inherent and apparent optical properties. Coefficients and functions of absorption, scattering and attenuation. Upward and downward irradiance and reflectance models above the water surface and within the water column. Spectral properties of optically active components (OAC). Empirical, semi-empirical and semi-analytical algorithms for OAC estimation. Factors controling EMR / water bodies interactions. Water color simulators using analytical and semi-analytical algorithms: Hydrolight and WASI. Hyperspectral Data Analysis Techniques: Derivative Analysis, Band Ratio, Spectral Angle Mapping, Continuum Removal. Instrumentation: Operation and use of key equipment needed for monitoring and studying aquatic environments. Remote Sensing of Aquatic Environments: Concepts and modeling. Exemples of Applications.

Labs:
In situ radiometric spectral measurements and water color simulations.

Student performance in the course:
Project Proposal (20%), Monograph (40%), Review and presentation of a state of art article (40%).

REFERENCES:
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8. SER-410-3 - SAR image processing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: SER-332-2 Radar imageador: princípios e aplicações
Lecturers: Dr. José Claudio Mura (PGSER Faculty) - **Responsible**
          Dr. Sidnei João Siqueira Sant'Anna (PGSER Faculty) - **Responsible**

PROGRAM:
SAR focusing. Radar image calibration. Speckle noise. Statistical modeling of SAR images. Speckle filtering. Classification and segmentation of SAR images. SAR image polarimetry. Statistical modeling of polarimetric data. Polarimetric calibration. Polarimetric classification. Interferometry and digital elevation construction. Differential SAR interferometry.

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9.   SER-411-3 - Advanced Topics in Digital Image Processing

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: **SER-413 Digital Image Processing in Remote Sensing**
Lecturers Responsables: Dr Leila Maria Garcia Fonseca (PGSER Faculty)
                                      Dr. Thales Sehn Korting (PGSER Faculty)

PROGRAM:
Advanced topics related to image processing applied to remote sensing: object based image analysis, time series processing, image segmentation, image classification, data mining, big data techniques, pattern recognition through decision tree methods, support vector machines, neural networks, deep learning, hybrid classification methods, classification accuracy assessment, optical filtering, image radiometric correction, image restoration, super resolution, feature extraction and selection, image fusion, generalized ratios.

REFERENCES:
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10.   SER-455-3 - Special Topics in Forestry: Phytogeography and Remote Sensing Applications

Workload: 45 class hours
Total number of credits: 3 (three)
Elective course
Prerequisite: none
Responsable Lecturers: Dr Luiz Eduardo O. e Cruz de Aragão (PGSER Faculty)
                    Dr Liana Oighenstein Anderson (PGSER Faculty)

PROGRAM:
Definition and concepts. Earth's vegetation processes. Brazilian Phytogeography. Study of processes in phytogeographic domains: Amazon Forest, Atlantic Forest, Cerrado, Caatingaa Forest. Environmental and climatic impacts on vegetation. Contribution of remote sensing for detecting the impact of drought, burning and deforestation on forest functioning.

REFERENCES:
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Eden, M.J.; Parry, J.T. (eds.) Remote Sensing and tropical land management. Great Britain: John Wiley & Sons. 1986. 365 p.

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Niewwnhuis, G.J.A. Vaughan, R.A. Molenaar, M. (eds.) Operational remote sensing for sustainable development. Rotterdam, Netherlands. A. A. Balkema. 1999. 497 p.

Walter, H. Vegetação e Zonas Climáticas: Tratado de Ecologia Global. São Paulo: EPUSP, 1986. 325p.

Updates: - Photogrammetric Engineering and Remote Sensing (PERS); - International Journal on Remote Sensing (IJRS); - Remote Sensing of Environment (RSE); IEEE

Transactions on Geoscience and Remote Sensing; - Anais dos Simpósios Brasileiros de S. R.; - Anais dos Simpósios Latinoamericanos de S.R.; - Proceedings: International Symposium on Photogrammetry and Remote Sensing (ISPRS); IGARSS; ERIM;

EST – Guided Study in Remote Sensing
    Up to 4 credits

SER-730 – Master Research in Remote Sensing**
    0 credits

SER-750 - Master's Dissertation in Remote Sensing
    12 credits

SER-780 – Doctoral Research in Remote Sensing**
    0 credits

SER-800 – Doctoral Thesis in Remote Sensing
    24 credits

** Mandatory activity, in each academic period for every student in the Research phase, defined by the formalization of their Research Supervisor that will evaluate the student's performance in this activity. Compulsory, also, before the officialization mentioned for the student who is not enrolled in any discipline; in this case, the orientation and evaluation should be made by a Faculty member approved by the Academic Coordinator.

Catalog approved by the CPG in November, 29th, 2021