

**Processing Remote Sensing Images**

Code: 43384  
ECTS Credits: 6

| Degree                                                      | Type | Year | Semester |
|-------------------------------------------------------------|------|------|----------|
| 4314828 Remote Sensing and Geographical Information Systems | OB   | 0    | 1        |

**Contact**

Name: Xavier Pons Fernandez

Email: xavier.pons@uab.cat

**Use of Languages**

Principal working language: catalan (cat)

**Other comments on languages**

Approximately 55% of the classes are in Catalan and 45% in Spanish. Most of the bibliography are in English

**External teachers**

Jordi Cristóbal

Jordi Joan Mallorquí Franquet

Mercè Vall-Llossera Ferran

**Prerequisites**

Prerequisites are not required

**Objectives and Contextualisation**

At the end of the course, the student will be able to:

Master different tools primary processing of aerial and satellite imagery.

Dominate the physical principles that govern remote image capture and transformations of the content of the image itself.

Distinguish the different sources of image geometric deformations and possible signal interference caused by atmospheric captured or lighting effects (topography, etc.)

Correctly apply the methodologies to mitigate the different error sources in order to be able to view and extract physical parameters of the received data.

**Competences**

- Apply different methodologies for the primary processing of images obtained by remote sensors in order to subsequently extract geographic information.
- Continue the learning process, to a large extent autonomously.
- Design and apply a methodology, based on the knowledge acquired, for studying a particular use case.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

- Take a holistic approach to problems, offering innovative solutions and taking appropriate decisions based on knowledge and judgement.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
- Use different specialised GIS and remote sensing software, and other related software.

## Learning Outcomes

1. Continue the learning process, to a large extent autonomously.
2. Correctly apply methodologies to mitigate the different sources of error in order to visualise and extract physical parameters from the data received.
3. Design and apply a methodology, based on the knowledge acquired, for studying a particular use case.
4. Distinguish the different sources of geometric image deformation, and the possible interferences in the captured signal caused by atmospheric effects or illumination effects (topography, etc.).
5. Show expertise in the physics principles that govern remote image capture and transformations made to the content of the image itself.
6. Show expertise in using different primary processing tools for aerial and satellite images.
7. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
8. Take a holistic approach to problems, offering innovative solutions and taking appropriate decisions based on knowledge and judgement.
9. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

## Content

### PHYSICAL PRINCIPLES OF REMOTE SENSING

#### *Solar spectrum*

1. Concepts: radiation and electromagnetic spectrum, polarization. Fundamental relationships between frequency, length and transported wave energy.
2. Basic physical parameters (terminology and symbology, definitions, units): Radiant energy, energy flow, energy intensity, radiance energy excitance, irradiance, reflectance, albedo, transmittance, absorptance; absorbance. spectral magnitudes
3. Specular reflection, diffuse and lambertiana
4. Black body (Planck's law, Stefan-Boltzmann law, Wien's displacement law)
5. Solar radiation. Exoatmospheric characteristics and the surface of the Earth; interaction with the atmosphere and atmospheric windows
6. Spectral signatures. Main characteristics of water, soil and rocks and vegetation in the visible and infrared non thermal
7. Factors that influence the spectral signature

#### *Thermal*

1. The thermal radiation emitted by the Earth. Remote Sensing approaches
2. Physical parameters of the thermal infrared region
3. KCL. black body, white body and gray body. selective radiators. Thermal behaviour of an object-related parameters
4. Spectral behaviour of the different coverages in the thermal infrared region
5. Factors which influence the emissivity
6. Emissivity measurement. Field measurements
7. Emissivity measurement. Measured from satellite

#### Active microwave

1. Active Microwave Remote Sensing: Imaging Radar
2. Wave-Matter interaction: Radar Cross Section and
3. Backscattering Coefficient
4. Backscattering models

5. SAR polarimetry
6. SAR Interferometry

#### Passive microwave

1. Passive Sensors: Fundamentals and Physical Principles
2. Applications of passive microwave E.O
3. Microwave Radiometers:
  1. Figures of Merit: Angular Resolution and Radiometric Resolution
  2. Calibration: internal, external, use of multi-look information
4. Present and future EO Passive Microwave Mission

#### GEOMETRIC CORRECTION OF AERIAL AND SATELLITE IMAGERY

1. Geometric corrections. Deformation sources. Orthoimage, orthophoto and orthophoto of authentic orthophotomap concepts. Corrections in vectorial bases
2. Physical models (collinearity equations orbit models), semi-empirical (polynomial corrections, models of rational functions, Delaunay triangulation) and mixed. Model of radar images: determining the sampling step azimuth and distance. Relief role. Ground control points (GCP), test points, homologous points
3. Geometry of the radar image. Sampling of the image. Geometric distortion of images. Accurate geocoding images using Digital Elevation Models (DEM or DEM). Obtaining DEM and Radar Mapping. Approaches to areas of low relief. Examples
4. Basic correction process. Nearest neighbor, bilinear and bicubic interpolation: Chromatic, radiometric and geometric in image resampling. Considerations about output pixel size
5. Sources of GCP. Automatic GCP
6. Basics of physical models. Consideration of the relief
7. Basics of semi-empirical models:
  - 7.1 Polynomial models 1st and 2nd degree. Application cases
  - 7.2 Higher polynomial model degree. Application cases
  - 7.3 Polynomial models with consideration relay
  - 7.4 Models of rational functions
  - 7.5 Delaunay Triangulation
8. Mixed Models: Theory and examples ASTER, MODIS, SSM/I and SMOS.
9. Error estimate. Statistical interpretation of the RMS
10. Mosaics and geometry images
11. Practical realization of the main models

#### RADIOMETRIC IMAGE CORRECTION

1. Radiometric corrections. Calibration sensors. Sources of signal distortion. DN conversion to radiances. Interest and obtaining reflectances
2. Formulation corrections in the visible and infrared non thermal
  - 2.1 Sun and atmospheric roles. Exoatmospheric radiance, transmittance. Variation throughout the year. Spectral variation. Diffuse atmospheric radiation
  - 2.2 Relief role: incidence angle, projected shadows. Celestial sphere. Neighboring reflected radiation
  - 2.3 Combining sensors in the same study. Usability of pseudoinvariant areas (PIA)
3. Corrections based in multispectral and large amount of images: advantages and limitations

### Methodology

In this module there are 3 groups of learning activities:

Targeted activities consist of classes of theory and practices that will be carried out in a specialized computer room. At the beginning of each of the subjects that make up the module, the teachers will explain the structure of the theoretical-practical contents, as well as the evaluation method.

Supervised activities consist of classroom practices that will allow you to prepare the work and exercises of each subject, as well as tutorial sessions with the teachers in case the students request it.

Autonomous activities are a set of activities related to the elaboration of works, exercises and exams, such as the study of different material in the form of journal articles, reports, data, etc., defined according to the needs of autonomous work of each student

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

## Activities

| Title                                     | Hours | ECTS | Learning Outcomes         |
|-------------------------------------------|-------|------|---------------------------|
| Type: Directed                            |       |      |                           |
| Master classes / exhibitions              | 27    | 1.08 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Resolution exercises                      | 8     | 0.32 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Type: Supervised                          |       |      |                           |
| Classroom practices                       | 34    | 1.36 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Tutorials                                 | 4     | 0.16 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Type: Autonomous                          |       |      |                           |
| Personal study                            | 15    | 0.6  | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Reading of articles / reports of interest | 2     | 0.08 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Writing reports                           | 58    | 2.32 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |

## Assessment

The evaluation of this subject consists of the following system:

- The realization of 2 exams, that will be between 60% and 70% of the final note and that will include the theoretical and practical subject carried out.
- The accomplishment of different practical works proposed throughout the teaching of the module and delivered within the fixed term, that will be between 30 % and 40 % of the final note. A correct formal presentation and careful preparation will be assessed.

Aspects to take into account.

- Regular class attendance is highly recommended in order to follow the lessons properly. Follow on through streaming is only justified in cases of physical impossibility for face-to-face assistance, since an important part of the experiences and learning are fully achieved through contact with the teaching staff and classmates.
- If you have to deliver practical work, this delivery must be done within the deadlines for them to be evaluated.
- On carrying out each evaluation activity, Lecturers will inform of the procedures to be followed for reviewing all grades awarded, and the date on which such a review will take place.

Extraordinary exams.

- The exams or other evaluation procedures not reaching the minimum mark of 5 out of 10 must be repeated. This extraordinary exam is unique.

- Students will have the opportunity to take a extraordinary exam the day or days scheduled by the faculty.

Cheating: Copies and plagiarisms.

By copies, we refer to the evidence that the work, project, exam, etc has been partially or totally created/answered without the intellectual contribution of the author. In this definition, we also include the proven attempt to copy in the exams and delivered works and projects and the violation of the laws that assure intellectual authorship. Plagiarisms refer to the works and texts from other authors that someone pretends to be his/her own creation. It is a crime against intellectual property. In order to avoid committing plagiarism, quote all the sources that you use when writing the report of a project. According to UAB's law, copies and plagiarisms or any other attempt to alter the results of one's own evaluation or someone else's -allowing to copy, for example- implies a result in the corresponding part (theory, problems or practical tasks) of a 0 and, in this case, the student will fail the subject. This does not limit the right to take academic and legal actions against those who have participated. See UAB documentation about copies and plagiarisms

[http://wuster.uab.es/web\\_argumenta\\_obert/unit\\_20/sot\\_2\\_01.html](http://wuster.uab.es/web_argumenta_obert/unit_20/sot_2_01.html)

## Assessment Activities

| Title                          | Weighting | Hours | ECTS | Learning Outcomes         |
|--------------------------------|-----------|-------|------|---------------------------|
| Practical works                | 40% - 60% | 0     | 0    | 2, 8, 3, 4, 6, 5, 7, 1, 9 |
| Theoretical and practical exam | 60% - 70% | 2     | 0.08 | 2, 8, 3, 4, 6, 5, 7, 1, 9 |

## Bibliography

### PHYSICAL PRINCIPLES OF REMOTE SENSING

#### *Solar spectrum*

- Adams, J. (1974) Visible and near-infrared diffuse reflectance spectra of pyroxenes as applied to remote sensing of solid objects in the solar system, *Journal of Geophysical Research*, 79(32): 4829-4836.
- Baig, M. (2002) "Òptica atmosfèrica. La física del paisatge" in Jou, D.; Llebot, J.E., (eds) "Física de la quotidianitat". Edicions Caixa de Sabadell, ISBN: 84-95166-42-9. P. 115-127.
- Baldrige, A. M., S.J. Hook, C.I. Grove i G. Rivera (2009) The ASTER Spectral Library Version 2.0, *Remote Sensing of Environment*, 113: 711-715. <http://speclib.jpl.nasa.gov/> [pàgina visitada el dia 15 de novembre de 2016 a les 10:39]
- Bariou, R., D. Lecamus i F. Le Henaff (1985b) "L'atmosphère." Presses Universitaires de Rennes 2. Rennes. 77 pàgs.
- Bariou, R., D. Lecamus i F. Le Henaff (1985c) "Le rayonnement electromagnetique." Presses Universitaires de Rennes 2. Rennes.
- Barsi, J.A., J.L. Barker, i J.R. Schott. (2005) An atmospheric correction parameter calculator for a single thermal band Earth-sensing instrument, IGARSS03, 21-25 July 2003, Centre de Congres Pierre Baudis, Toulouse, France. <http://atmcorr.gsfc.nasa.gov/> [pàgina visitada el dia 15 de novembre de 2016 a les 10:40].
- Bunnik, N.J.J. (1984) in P.N. Slater (Ed.) "SPIE Critical review of remote sensing." *Proceedings SPIE*, 475:2-11.
- Caselles, V., i Sobrino, J. A. (1989) Determination of frosts in oranges groves from NOAA-9 AVHRR data, *Remote Sensing of Environment*, 29: 135-46.
- Chance, K. i Kurucz, R.L. (2010) An improved high-resolution solar reference spectrum for earth's atmosphere measurements in the ultraviolet, visible, and near infrared. *Journal of Quantitative Spectroscopy & Radiative Transfer*, 111: 1289-1295.
- Chen, H. S. (1985) *Space remote sensing systems: an introduction*. Academic Press. Orlando. 257 p.
- Dozier, J. (1989) Spectral signature of alpine snow cover from the Landsat Thematic Mapper, *Remote Sensing of Environment*, 28:9-22.
- Elachi, C. i van Zyl, J.J. (2006) "Introduction to the physics and techniques of remote sensing", John Wiley & Sons. N.Y. 584 p. 2<sup>a</sup> edició.
- Emery, W. i A. Camps (2017) "Introduction to Satellite Remote Sensing. Atmosphere, Ocean, Land and Cryosphere Applications". Elsevier. 860 pàgs.

Guyot, G. (1989) "Signatures spectrales des surfaces naturelles", Paradigme. Caen. pp. 59-112.

Van de Griend, A. A., i Owe, M. (1993) On the relationship between thermal emissivity and the normalized difference vegetation index for natural surfaces, *International Journal of Remote Sensing*, 14: 1119-1131.

Kopp, G., i Lean, J.L. (2011) A new, lower value of total solar irradiance: evidence and climate significance, *Geophysical Research Letters*, 38, L01706, doi:10.1029/2010GL045777.

Liu, B.Y.H. i Jordan, R.C. (1960) The Interrelationship and Characteristic Distribution of Direct, Diffuse and Total Solar Radiation. *Solar Energy*, 4(3):1-19.

Li, S., Zhou, X., i Morris, K. (1999) Measurement of snow and sea ice surface temperature and emissivity in the Ross sea, IEEE 1999 International Geoscience and Remote Sensing Symposium, Hamburg Germany, 28 June - 02 July, 1999.

Melià, J. (1991) "Fundamentos físicos de la teledetección: leyes y principios básicos", in Gandía, S. i J. Melià (eds.) "La teledetección en el seguimiento de los fenómenos naturales. Recursos renovables: Agricultura." Departament de Termodinàmica. Universitat de València. pp. 51-83.

Milton, E.J., Schaepman, M.E., Anderson, K., Kneubühler, M. i Fox, N. 2009 Progress in field spectroscopy, *Remote Sensing of Environment*: 113 (1), S92-S109.

McCoy, R.M. (2005) "Field methods in remote sensing", The Guilford Press, New York. 159 p.

Milman, A.S. (1999) "Mathematical principles of remote sensing", CRC Press. 406 p.

Pons, X., i Arcalís, A. (2012) "Diccionari terminològic de teledetecció", Enciclopèdia Catalana i Institut Cartogràfic de Catalunya. Barcelona. 597 pàgs. També a [http://www.termcat.cat/ca/Diccionaris\\_En\\_Linia/197/Cerca/](http://www.termcat.cat/ca/Diccionaris_En_Linia/197/Cerca/) [pàgina visitada el dia 15 de novembre de 2016 a les 10:42].

Rees, W.G. (2001) "Physical principles of remote sensing", Cambridge University Press. Cambridge. 2ª edició. 372 pàgs.

Rees, G. (1999) "The Remote Sensing Data Book", Cambridge, Cambridge University Press.

Rees, G. (2006) "Remote Sensing of Snow and Ice", CRC Press, Taylor & Francis Group: New York. 285 pàgs.

Rubio, E., Caselles, V., i Badenas, C. (1997) Emissivity measurements of several soils and vegetation types in the 8-14  $\mu\text{m}$  wave band: analysis of two field methods, *Remote Sensing of Environment*, 59: 490-521.

Schaepman-Strub, G., Schaepman, M.E., Painter, T.H., Dangel, S. i Martonchik, J.V. (2006) Reflectance quantities in optical remote sensing-definitions and case studies. *Remote Sensing of Environment*, 103: 27-42.

Salisbury, J. W., i D'Aria, D. M. (1992) Emissivity of terrestrial materials in the 8-14  $\mu\text{m}$  atmospheric window, *Remote Sensing of Environment*, 42: 83-106.

Singh, D., Srivastava, V.K., Bhatt, J. i Bhattacharya, S. (2011) Mineralogical mapping of lunar orbits of Chandrayaan - 1 Mission using Hyper Spectral Imaging Camera (HySI) and Terrain Mapping Camera (TMC) data, *Photogrammetric Engineering and Remote Sensing*, 77(1):6-12.

Slater, P.N. (1985) "Radiometric considerations in Remote Sensing", *Proceedings of the IEEE*, 73:997-1011.

Smith, J.A. (1983) in Colwell, R.N. (Ed.) "Manual of Remote Sensing." American Society of Photogrammetry. Falls Church. Virginia. Pàgs.:62-114.

Sobrino, J. A. (Ed.) (2000). "Teledetección", València, Servei de Publicacions, Universitat de València.

Sobrino, J.A., i Raissouni, N. (2000) Toward remote sensing methods for land cover dynamic monitoring: application to Morocco, *International Journal of Remote Sensing*, 21: 353-366.

Sobrino, J. A., J. C. Jiménez-Muñoz, G. Sòria, M. Romaguera, L. Guanter, J. Moreno, A. Plaza i P. Martínez (2008) Land surface emissivity retrieval from different VNIR and TIR sensors, *IEEE Transactions on Geoscience and Remote Sensing*, 46(2): 316-327. doi: 10.1109/TGRS.2007.904834.

Thuillier, G., M. Hersé, D. Labs, T. Foujols, W. Peetermans, D. Gillotay, P.C. Simon, i H. Mandel (2003) The solar spectral irradiance from 200 to 2400 nm as measured by the SOLSPEC spectrometer from the Atlas and Eureka missions, *Solar Physics*, 214(1):1-22

Valor, E. i Caselles, V. (1996) Mapping land surface emissivity from NDVI: Application to European, African and South American areas, *Remote Sensing of Environment*, 57: 167-184.

Valor, E. i Caselles, V. (2005) Validation of the vegetation cover method for land surface emissivity estimation. A Caselles, Valor i Coll (2005). Recent research developments in Thermal Remote Sensing. Research Signpost, India.

Van de Griend, A. A. i Owe, M. (1993) On the relationship between thermal emissivity and the normalized difference vegetation index for natural surfaces, *International Journal of Remote Sensing*, 14: 1119-1131.

Wittich, K.P. (1997) Some simple relationships between land-surface emissivity, greenness and the plant cover fraction for use in satellite remote sensing, *International Journal of Biometeorology*, 41: 58-64

Wolfe, W. L. (1998) Introduction to radiometry. Tutorial texts in Optical Engineering. Vol. TT29. SPIE. Washington.

Zhang, Y. (1999) MODIS UCSB Emissivity Library.  
<http://www.icess.ucsb.edu/modis/EMIS/html/em.html>. [pàgina visitada el dia 15 de novembre de 2016 a les 10:34].

### **Active and passive microwave**

F.T. Ulaby, D.G. Long (Eds.) (2014), "Microwave Radar and Radiometric Remote Sensing", Univ. Michigan Press.  
C.Oliver, S.Quegan (2004), "Understanding Synthetic Aperture Radar Images", SciTech Publishing.  
I.C. Cumming, F.H.Wong (2005), "Digital Processing of Synthetic Aperture Radar Data: Algorithms and Implementation", Artech House, Norwood, MA-USA.  
C. Elachi (1988) "Spaceborne Radar Remote Sensing: Applications and Techniques", IEEE Press.  
Elachi, C. i van Zyl, J.J. (2006) "Introduction To The Physics and Techniques of Remote Sensing." John Wiley & Sons. N.Y. 584 p. 2<sup>a</sup> edició.  
Curlander, McDonough, "Synthetic Aperture Radar", John Wiley, 1991  
Radar Polarimetry for Geoscience Application, Fawwaz T. Ulaby, C. Elachi; 1990  
Skou, "Microwave Radiometer Systems: Design & Analysis", Artech House, 1989  
Janssen, "Atmospheric Remote Sensing by Microwave Radiometry", John Wiley, 1993  
Sharkov, "Passive Microwave Remote Sensing of the Earth. Physical Foundations", Springer-Praxis, 2003

### **GEOMETRIC CORRECTION OF AERIAL AND SATELLITE IMAGERY**

Abdullah, Q.A. (2010) "Mapping Matters" Photogram. Engineering & Remote Sensing, 76(8): 885,893.  
Aguilar, M.A., F.J. Aguilar, F. Agüera, and Jaime A. Sánchez (2007) Geometric Accuracy Assessment of QuickBird Basic Imagery Using Different Operational Approaches. Photogram. Engineering & Remote Sensing, 73(12): 1321-1332  
Ardizzone, J., A. Arozarena, J. Delgado, M. Herrero, G. Villa and P. Vivas (1993), Análisis estadístico para la corrección geométrica de imágenes de satélite. Proceedings of the IV Reunión Científica de la Asociación Española de Teledetección, Sevilla, Spain (November 1991), pp.:78-85.  
Bayer, T. (2014), Estimation of an unknown cartographic projection and its parameters from the map. Geoinformatica, 18:621-669.  
Beyer, E.P. (1983), Thematic Mapper Geometric Correction Processing. Seventeenth International Symposium on Remote Sensing of the Environment, Ann Arbor, Michigan, pp.:319-334.  
Billingsley, F.C. (1983), Data Processing and Reprocessing. in Colwell, R.N. (ed.) Manual of Remote Sensing. American Society of Photogrammetry, Falls Church, Virginia, pp.719-792.  
Blanc, P. and L. Wald (1998), Validation protocol applied to an automatic co-registration method based on multiresolution analysis and local deformation models, Proceedings of the ISPRS Commission II, Cambridge, England, 13-17 July 1998, 2:11-19.  
Chen, L.-C., Teo, T.-A., Liu, C.-L. (2006) "The Geometrical Comparisons of RSM and RFM for FORMOSAT-2 Satellite Images" PE&RS 72(5):573-579  
Cristóbal, J., Pons, X., Serra, P. (2004) " Sobre el uso operativo de Landsat-7 ETM+ en Europa" Revista de Teledetección, 21: 55-59.  
Cumming, I.G., Wong F.H., "Digital processing of Synthetic Aperture Radar Data", Artech House, Norwood USA, 2005.  
Curlander, J.C. and R.N. McDonough (1991) "Synthetic Aperture Radar", John Wiley & Sons, New York.  
D'Souza, G. and T. D. G. Sandford, (1996) 'Techniques for geometric correction of NOAA AVHRR imagery' in Advances in the Use of AVHRR Data for Land Applications, D'Souza, G., A. S. Belward and J.-P. Malingreau (Eds.), Euro Courses: Remote Sensing 5, Kluwer Academic Publishers, Dordrecht, The Netherlands, 153-193.  
Emery, W. and A. Camps (2017) "Introduction to Satellite Remote Sensing. Atmosphere, Ocean, Land and Cryosphere Applications". Elsevier. 860 pàgs.  
Greve, C. (1997) Digital Photogrammetry: An Addendum to the Manual of Photogrammetry. American Society for Photogrammetry & Remote Sensing. Falls Church, Virginia  
Gugan, D.J. (1987) Practical aspects of topographic mapping from SPOT imagery. Photogrammetric Record, 12(69):349-355.  
Hu, Y. V. Tao and A. Croitoru (2004) Understanding the rational function model: methods and applications, [http://www.geoict.net/Resources/Publications/IAPRS2004\\_RFM2394.pdf](http://www.geoict.net/Resources/Publications/IAPRS2004_RFM2394.pdf) (pàgina visitada 10-Nov-2007)  
ICC (Institut Cartogràfic de Catalunya) (2005) Sistemes de captura primària de dades  
[http://www.icc.es/pdf/ca/common/icc/publicacions\\_icc/dcomercial/dcomercial\\_captura\\_camera\\_digital.pdf](http://www.icc.es/pdf/ca/common/icc/publicacions_icc/dcomercial/dcomercial_captura_camera_digital.pdf)

(explica la càmera DMC ICC) (pàgina visitada 10-Nov-2008)

- Konecny, G., P. Lohmann, H. Engel and E. Kruck (1987) Evaluation of SPOT Imagery on Analytical Photogrammetric Instruments. *Photogrammetric Engineering & Remote Sensing*, 53(9):1223-1230.
- Kratky, V. (1988) Rigorous stereophotogrammetric treatment of SPOT images. *Colloque International SPOT-1: Utilisation des images, bilan, résultats*, Paris, France, pp.1281-1288.
- Kraus, K. (1993) *Photogrammetry*. Vol. 1 Dummlers Verlag. Bonn
- Labovitz, M.L. and J.W. Marvin (1986) Precision in Geodetic Correction of TM Data as a Function of the Number, Spatial Distribution, and Success in Matching of Control Points: A Simulation. *Remote Sensing of the Environ.*, 20:237-252.
- Light, D.L. (1986) *Satellite Photogrammetry*. in Slama, C.C. (ed.) *Manual of Photogrammetry*. American Society of Photogrammetry, Falls Church, Virginia, pp. 883-977.
- Lillesand, T.M. and R.W. Kiefer (2003) *Remote Sensing and Image Interpretation*. John Wiley & Sons, New York, 784 pàgs. 5<sup>a</sup> edició.
- McGlone, J.C. (2004) *The ASPRS Manual of Photogrammetry*, 5th Edition, 1168 p. (1<sup>a</sup> edició 1940, 4<sup>a</sup> edició 1986 [Slama]).
- Marvin, J.W., M.L. Labovitz and R.E. Wolfe (1987) Derivation of a Fast Algorithm to Account for Distortions Due to Terrain in Earth-Viewing Satellite Sensor Images. *IEEE Transactions on Geoscience and Remote Sensing*, GE-25 (2):244-251.
- Minnesota Planning (1999) *Positional Accuracy Handbook: Using the National Standard for Spatial Data Accuracy to measure and report geographic data quality*. Minnesota Planning, St. Paul, MN. 33 p.
- Novak, K. (1992) Rectification of Digital Imagery. *Photogrammetric Engineering & Remote Sensing*, 58(3):339-344.
- NSIDC (National Snow and Ice Data Center) (2008) DMSP SSM/I Daily Polar Gridded Brightness Temperatures [http://nsidc.org/data/docs/daac/nsidc0001\\_ssmi\\_tbs.gd.html](http://nsidc.org/data/docs/daac/nsidc0001_ssmi_tbs.gd.html). (pàgina visitada 17-Nov-2008)
- OGC (2006), *Image Geopositioning proposed Discussion Papers*. Open Geospatial Consortium PPT document.
- Palà, V. and X. Pons (1995) Incorporation of relief into geometric corrections based on polynomials. *Photogrammetric Engineering & Remote Sensing*, 61(7):935-944
- Padró, J.-C., F.-J. Muñoz, J. Planas and X. Pons (2019) Comparison of four UAV georeferencing methods for environmental monitoring purposes focusing on the combined use with airborne and satellite remote sensing platforms. *International Journal of Applied Earth Observation and Geoinformation*, 75:130-140. <https://doi.org/10.1016/j.jag.2018.10.018>
- Palenichka, R.M. and M.B. Zaremba, (2010) Automatic Extraction of Control Points for the Registration of Optical Satellite and LiDAR Images. *IEEE Transactions on Geoscience and Remote Sensing*, 48(7):2864-2879.
- Pons, X., G. Moré and L. Pesquer (2010) "Automatic matching of Landsat image series to high resolution orthorectified imagery" *Proceedings of the ESA Living Planet Symposium*. CD-ROM edition. ESA reference document: SP-686.
- Pons, X. and A. Arcalís. (2012) "Diccionari terminològic de teledetecció" *Enciclopèdia Catalana i Institut Cartogràfic de Catalunya*. Barcelona. 597 pàgs. També a [http://www.termcat.cat/ca/Diccionaris\\_En\\_Linia/197/Cerca/](http://www.termcat.cat/ca/Diccionaris_En_Linia/197/Cerca/)
- Priebsenow, R. and E. Clerici (1988) *Cartographic Applications of SPOT Imagery*. *Colloque International SPOT-1: Utilisation des images, bilan, résultats*, Paris, France, pp.1189-1194.
- Rodríguez, V., P. Gigord, A.C. de Gaujac and P. Munier (1988) Evaluation of the Stereoscopic Accuracy of the SPOT Satellite. *Photogrammetric Engineering & Remote Sensing*, 54(2):217-221.
- Salamonowicz, P.H. (1986) Satellite Observation and Position for Geometric Correction of Scanner Imagery. *Photogrammetric Engineering & Remote Sensing*, 52(4):491-499.
- Schreier, G. (Ed.) (1993) *SAR Geocoding: Data and Systems*, Wichmann, Karlsruhe. 435 pp.
- Shen, X., Liu, B, Li, Q.-Q. (2017) Correcting bias in the rational polynomial coefficients of satellite imagery using thin-plate smoothing splines. *ISPRS Journal of Photogrammetry and Remote Sensing*, 125:125-131
- Slama, C.C. (ed.) (1986) *Manual of Photogrammetry*, 4th edition. American Society of Photogrammetry, Falls Church, Virginia, 1056 pp.
- Toutin, P. and P. Cheng (2002) QuickBird - A Milestone for High-Resolution Mapping, *Earth Observation Magazine*, Abril 2002 <http://www.eonline.com/Common/currentissues/Apr02/cheng.htm> (pàgina visitada 10-Nov-2007)
- Ulaby, F. T., R. K. Moore, and A.K. Fung (1981) *Microwave Remote Sensing: Active and Passive*, Vol. I -- *Microwave Remote Sensing Fundamentals and Radiometry*, Addison-Wesley, Advanced Book Program, Reading, Massachusetts, 456 pp.

Wong, K.W. (1986) Basic Mathematics of Photogrammetry. in Slama, C.C. (ed.) Manual of Photogrammetry. American Society of Photogrammetry, Falls Church, Virginia, pp. 37-101.

## RADIOMETRIC IMAGE CORRECTION

- Bacour, C., F.M. Breon, (2006) "Variability of biome reflectance directional signatures as seen by POLDER" Remote Sens. Environ. 98(1):80-95
- Badescu V. (2002) "3D isotropic approximation for solar diffuse irradiance on tilted surfaces" Renewable Energy, 26:221-233.
- Baraldi, A., M. Girona i D. Simonetti "Operational Two-Stage Stratified Topographic Correction of Spaceborne Multispectral Imagery Employing an Automatic Spectral-Rule-Based Decision-Tree Preliminary Classifier" IEEE Transactions on Geoscience and Remote Sensing, 48:112-146.
- Baret, F., G. Guyot, J.M. Teres i D. Rigal (1988) "Profil spectral et estimation de la biomasse." Proc. of the 4th International Colloquium on Spectral Signatures of Objects in Remote Sensing, pàgs.:93-98. Aussois, France. 18-22 gener. (ESA SP-287, abril 1988).
- Bariou, R., D. Lecamus i F. Le Henaff (1985b) "L'atmosphère." Presses Universitaires de Rennes 2. Rennes. 77 pàgs. Bariou, R., D. Lecamus i F. Le Henaff (1985c) "Le rayonnement electromagnetique." Presses Universitaires de Rennes 2. Rennes.
- Bariou, R., D. Lecamus i F. Le Henaff (1985d) "Albedo, Reflectance." Presses Universitaires de Rennes 2. Rennes. 41 pàgs.
- Bariou, R., D. Lecamus i F. Le Henaff (1986) "Corrections radiometriques." Presses Universitaires de Rennes 2, Rennes. pàgs.
- Burkart, A., Cogliati, S., Schickling, A i Rascher, U. (2014) "A Novel UAV-Based Ultra-Light Weight Spectrometer for Field Spectroscopy". IEEE Sensors Journal, 14(1):62-67.
- Cavayas, F. i P.M. Teillet (1988) "Geometric model simulations of conifer canopy reflectance." Proc. of the 3rd International Colloquium on Spectral Signatures of Objects in Remote Sensing, pàgs.:183-189. Les Arcs, France. 16-20 Des. (ESA SP-247).
- Chander, G. i B. Markham(2003) "Revised Landsat-5 TM radiometric calibration procedures and postcalibration dynamic ranges" IEEE Transactions on Geoscience and Remote Sensing, 41:2674-2677.
- Chander, G., D. L. Helder, B. Markham, J. D. Dewald, E. Kaita, K. J. Thome, E. Micijevic, i T. A. Ruggles (2004) "Landsat-5 TM reflective-band absolute radiometric calibration" IEEE Transactions on Geoscience and Remote Sensing, 42:2746-2760.
- Chander, G., B. Markham, J. A. Barsi (2007) "Revised Landsat 5 Thematic Mapper radiometric calibration" IEEE Transactions on Geoscience and Remote Sensing, 45: 490-494.
- Chander G., B. Markham, D. Helder (2009). Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+ and EO-1 ALI sensors. Remote Sensing of Environment, 113: 893-903.
- Chander G, Haque O, Micijevic E, Barsi J (2010) A procedure for radiometric recalibration of Landsat 5 TM reflective-band data. IEEE Transactions on Geoscience and Remote Sensing, 48(1): 556-574.
- Chavez, P.S. (1975) "Atmospheric, Solar, and M.T.F. Corrections for ERTS Digital Imagery." Proc. of Phoenix Meeting. American Society of Photogrammetry.
- Chavez, P.S. (1988) "An Improved Dark-Object Subtraction Technique for Atmospheric Scattering Correction of Multispectral Data." Remote Sensing of Environment 24:459-479.
- Emery, W.; Camps, A. (2017) "Introduction to Satellite Remote Sensing. Atmosphere, Ocean, Land and Cryosphere Applications". Elsevier. 860 pàgs.
- Feng, M.; Huang, C.; Channan, S.; Vermote; E, Masek, J.G. Townshend, J.R.; (2012) "Quality assessment of Landsat surface reflectance products using MODIS data." Computers & Geosciences, 38:9-22.
- Feng, M., Sexton, J.O., Huang C., Masek, J.G., Vermote, E.F., Gao, F., Narasimhan, R., Channan, S., Wolfe, R.E., Townshend J.R., (2013) "Global surface reflectance products-from Landsat-Assessment using coincident MODIS observations." Remote Sensing of Environment, 134:276-293.
- Feng, M., Huang, C., Channan, S., Vermote, E.F., Masek, J.G., Townshend, J.R. (2012) "Quality assessment of Landsat surface reflectance products using MODIS data" Computers & Geosciences, 38: 9-22.
- Forster, B.C. (1984) "Derivation of atmospheric correction procedures for LANDSAT MSS with particular reference to urban data." International Journal of Remote Sensing, 5:799-817.
- Freemantle, J. R., R. Pu, J. R. Miller (1992) "Calibration of Imaging spectrometer Data to Reflectance Using Pseudo-Invariant Features", Proceedings of the 15th Canadian Symposium on Remote Sensing, Toronto, Ontario, June 1-4th, pp. 452-455.
- Gao, M, H Gong, W Zhao, B Chen, Z Chen, M Shi (2016) "An improved topographic correction model based on

Minnaert", *GIScience & Remote Sensing*, 53: 247-264

Goel, N.S. (1988) "A perspective on vegetation canopy reflectance models." *Proc. of the 4th International Colloquium on Spectral Signatures of Objects in Remote Sensing*, pàgs.:77-85. Aussois, France. 18-22 gener. (ESA SP-287, abril 1988).

Goel, N.S. i R.L. Thompson (1984) "Inversion of vegetation canopy models for estimating agronomic variables. V. Estimation of leaf area index and average leaf angle using measured canopy reflectances." *Remote Sensing of Environment*, 16:69-85.

Guanter, L., R. Richter, H. Kaufman (2009) "On the application of the MODTRAN4 atmospheric radiative transfer code to optical remote sensing" *International Journal of Remote Sensing*, 30:1407-1424.

Gu, D., Gillespie, A., 1998. Topographic normalization of Landsat TM images of forest based on 469 subpixel sun-canopy-sensor geometry. *Remote Sens. Environ.*: 64, 166-175.

Haque, O., J.A. Barsi, E. Micijevic, D.L. Helder, K.J. Thome, D.Aaron i J.S. Czapla-Myers (2012) "Landsat-7 ETM+: 12 Years On-Orbit Reflective-Band Radiometric Performance." *IEEE Transactions on Geoscience and Remote Sensing*, 50(5):2056-2062.

Holben, B.N. i C.O. Justice (1980) "The topographic effect on spectral response from nadir-pointing sensors." *Photogrammetric Engineering and Remote Sensing*, 46:1191-1200.

Horn, B.K.P. i R.W. Sjöberg (1979) "Calculating the reflectance map." *Applied optics*, 11:1770-1779.

Hadjimitsis, D.G.; Clayton, C.R.I.; Retalis, A. (2009). "The use of selected Pseudoinvariant targets for the application of atmospheric correction in multi-temporal studies using satellite remotely sensed imagery". *International Journal of Applied Earth Observation Geoinformation*, 11:192-200.

Kotchenova, S.Y., E.F. Vermote, R. Matarrese i F.K. Klemm (2006) "Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: Path radiance." *Applied optics*, 45(26):6762-6774.

Lenot, X., Achard, V. i Poutier, L. (2009) "SIERRA: A new approach to atmospheric and topographic corrections for hyperspectral imagery". *Remote Sensing of Environment* 113:1664-1677

Li, F., D.L.B. Jupp, M. Thankappan, L. Lymburner, N. Mueller, A. Lewis, A. Held (2012) "A physics-based atmospheric and BRDF correction for Landsat data over mountainous terrain" *Remote Sensing of Environment*, 124:756-770

Liang, S., H. Fang i M. Chen, (2001), Atmospheric Correction of Landsat ETM+ Land Surface Imagery-Part I: Methods, *IEEE Transactions on Geoscience and Remote Sensing*, 39:2490-2498.

Liang, S., H. Fang, J.T. Morisette, M. Chen, C. J. Shuey, C.L. Walthall, i C.S.T. Daughtry (2002) Atmospheric Correction of Landsat ETM+ Land Surface Imagery-Part II: Validation and Applications, *IEEE Transactions on Geoscience and Remote Sensing*, 40(12):2736-2746.

López, M.J. i V. Caselles (1987) "Un método alternativo de corrección atmosférica." *Comunicaciones de la 2ª Reunión Nacional del Grupo de Trabajo en Teledetección*, pàgs.:165-175. València. 17-18 desembre.

Loew, A., R. Bennartz, F. Fell, A. Lattanzio, M. Doutriaux-Boucher, i J. Schulz (2016) "A database of global reference sites to support validation of satellite surface albedo datasets (SAVS 1.0)" *Earth Syst. Sci. Data*, 8:425-438.

McCoy, R.M. (2005) "Field Methods in Remote Sensing". The Guilford Press, New York. 159 p.

Markham, B. L. i J. L. Barker (1986) "Landsat MSS and TM post-calibration dynamic ranges, exoatmospheric reflectance and at-satellite temperatures" *EOSAT Landsat Technical Notes* 1:3-8.

Markham, B.L. i J.L. Barker (1987) "Thematic Mapper bandpass solar exoatmospheric irradiances." *International Journal of Remote Sensing*, 8:517-523.

Markham, B.; Barsi, J.; Kvaran, G.; Ong, L.; Kaita, E.; Biggar, S.; Czapla-Myers, J.; Mishra, N.; Helder, D. (2014). "Landsat-8 Operational Land Imager Radiometric Calibration and Stability." *Remote Sensing*, 6:12275-12308;

Melià, J. (1991) "Fundamentos físicos de la teledetección: leyes y principios básicos." in Gandía, S. i J. Melià (eds.) "La teledetección en el seguimiento de los fenómenos naturales. Recursos renovables: Agricultura." Departament de Termodinàmica. Universitat de València. Pàgs.:51-83.

Minnaert, M. (1941) "The reciprocity principle in lunar photometry" *Astrophysics Journal* 93:403-410.

Mobley, C.D. (1999) "Estimation of the remote-sensing reflectance from above-surface measurements" *Applied Optics*, 38(36):7442-7455.

Moran, M.S., R.D. Jackson, P.N. Slater i P.M. Teillet (1992) "Evaluation of Simplified Procedures for Retrieval of Land Surface Reflectance Factors from Satellite Sensor Output." *Remote Sensing of Environment*, 41:169-184.

Mueller, J.L., G.S. Fargion i C.R. McClain (Eds) (2003) "Ocean Optics Protocols For Satellite Ocean Color Sensor Validation, Revision 4, Volume III: Radiometric Measurements and Data Analysis Protocols." Goddard Space Flight Space Center Greenbelt, Maryland. 84 pàgs.

Naugle, B.I. i J.D. Lashlee (1992) "Alleviating Topographic Influences on Land-Cover Classifications for Mobility and Combat Modeling." *Photogrammetric Engineering and Remote Sensing*, 58(8):1217-1221.

Neville, R.A., Sun, L. i Staenz, K. (2008) "Spectral calibration of imaging spectrometers by atmospheric absorption feature matching." *Can. J. Remote Sens.*, 34(1):S29-S42.

Nicodemus, F.E., J.C. Richmond, J.J. Hsia, I.W. Ginsberg i T. Limperis (1977) "Geometrical Considerations and Nomenclature for Reflectance." U.S. Department of Commerce. National Bureau of Standards. Washington.

Padró, J.C., Pons X., Aragonés D., Díaz-Delgado R., García D., Bustamante J., Pesquer L., Domingo-Marimon C., González-Guerrero O., Cristóbal J., Doktor D. i Lange M. (2017) "Radiometric Correction of Simultaneously Acquired Landsat-7/Landsat-8 and Sentinel-2A Imagery Using Pseudoinvariant Areas (PIA): Contributing to the Landsat Time Series Legacy." *Remote Sensing*, 9(12):1319. <http://dx.doi.org/10.3390/rs9121319>

Padró, J.C., Muñoz F.J., Ávila L.A., Pesquer L. i Pons X. (2018) "Radiometric Correction of Landsat-8 and Sentinel-2A Scenes Using Drone Imagery in Synergy with Field Spectroradiometry". *Remote Sensing*, 10(11):1687. <https://doi.org/10.3390/rs10111687>

Paolini, L, F. Grings, J.A. Sobrino, J. Jiménez Muñoz, H. Karszenbaum (2006) "Radiometric correction effects in Landsat multi-date/multi-sensor change detection studies." *International Journal of Remote Sensing*, 27(4):685-704

Pons, X. i L. Solé (1994) "A Simple Radiometric Correction Model to Improve Automatic Mapping of Vegetation from Multispectral Satellite Data." *Remote Sensing of Environment*, 47:1-14.

Pons X, Cristóbal J, Pesquer L, Moré G, González O (2010) "Fully automated and coherent radiometric (atm+top) correction of Landsat tm images trough pseudoinvariant areas" In: *Proc. 2010 ESA Living Planet Symposium*, ESA, Bergen, Norway.

Pons, X. i Arcalís, A. (2012) "Diccionari terminològic de teledetecció" *Enciclopèdia Catalana i Institut Cartogràfic de Catalunya*. Barcelona. 597 pàgs.

Pons, X., L. Pesquer, J. Cristóbal i O. González-Guerrero (2014) "Automatic and improved radiometric correction of Landsat imagery using reference values from MODIS surface reflectance images", *International Journal of Applied Earth Observation and Geoinformation*, 33: 243-254,

Price, J.C. (1987) "Calibration of Satellite Radiometers and the Comparison of Vegetation Indices." *Remote Sensing of Environment*, 21:15-27.

Price, J.C. (1988) "An Update on Visible and Near Infrared Calibration of Satellite Instruments." *Remote Sensing of Environment*, 24:419-422.

Proy, C. i C. Leprieur (1985) "Influence de la topographie et de l'atmosphère sur les mesures radiométriques en region montagneuse - Test d'un model d'inversion du signal sur des données TM." *Proc. of the 3rd International Colloquium on Spectral Signatures of Objects in Remote Sensing*, pàgs.:191-197. Les Arcs, France. 16-20 Des. (ESA SP-247).

Proy, C., D. Tanré i P.Y. Deschamps (1989) "Evaluation of Topographic Effects in Remotely Sensed Data." *Remote Sensing of the Environment*, 30:21-32.

Riaño, D., E. Chuvieco, J. Salas, I. Aguado (2003) "Assessment of different topographic corrections in Landsat-TM Data for mapping vegetation types" *IEEE Transactions on Geoscience and Remote Sensing* 41(5):1056-1061.

Richter, R., F. Lehmann i S. Tischler (1991) "Corrections of Atmospheric and Topographic Effects in Landsat TM Images." *Proc. of the 5th International Colloquium on Physical Measurements and Signatures in Remote Sensing*, pàgs.:69-71. Courchevel, France. 14-18 Gener. (ESA SP-319).

Salvador, R., X. Pons i F. Diego (1996) "Validación de un método de corrección radiométrica sobre diferentes áreas montañosas". *Revista de Teledetección*, 7:21-25

Saunier, S. i Y. Rodríguez (2006). "Landsat Product Radiometric calibration. Technical note" ESA. Available in [http://earth.esa.int/pub/ESA\\_DOC/GAEL-calibration-proceeding.pdf](http://earth.esa.int/pub/ESA_DOC/GAEL-calibration-proceeding.pdf)

Schaepman-Struba, G., M.E. Schaepmanc, T.H. Painterd, S. Dangelb i J.V. Martonchik (2006) "Reflectance quantities in optical remote sensing-definitions and case studies" *Remote Sens. Environ.* 103 (1): 27-42.

Schroeder, T.A., W.B. Cohenb, C. Songc, M.J. Cantyd i Zhiqiang Yang (2006) "Radiometric correction of multi-temporal Landsat data for characterization of early successional forest patterns in western Oregon" *Remote Sens. Environ* 103(1):16-26

Slater, P.N. (1985) "Radiometric considerations in Remote Sensing." *Proceedings of the IEEE*, 73:997-1011.

Smith, J.A., T.L. Lin i K.J. Ranson, (1980) "The Lambertian Assumption and Landsat Data" (Technical Note), *Photogram. Eng. and Remote Sensing*, 46(9):1183-1189.

Smith, G.M. and Milton, E.J., (1999) "The use of the empirical line method to calibrate remotely sensed data to reflectance" (Technical Note), *International Journal of Remote Sensing*, 20(13) : 2653 -2662.

Soenen, S.A., Peddle, D.R., Coburn, C.A., (2005) "SCS + C: a modified sun-canopy-sensor topographic

correction in forested terrain" *IEEE Trans. Geosci. Remote Sens.* 43 (9): 2148-2159.

Song, C, CE Woodcock, KC Seto, MP Lenney, SA Macomber (2001) "Classification and Change Detection Using Landsat TM Data: When and How to Correct Atmospheric Effects?" *Remote Sens. of Env.* 75(2): 230-244.

Teillet, P.M., Guindon, B., Goodenough, D.G. (1982). On the slope-aspect correction of multispectral scanner data. *Canad. J. Remote Sens.* 8:84-106.

Teillet, P. M. i G. Fedosejevs (1995) "On the dark target approach to atmospheric correction of remotely sensed data" *Canadian Journal of remote Sensing*, 21:374-387.

United States Geological Survey. Product guide: Landsat climate data record (CDR). Surface reflectance. Department of the Interior U.S. Geological Survey. Version 3.4, December 2013. The Internet: [http://landsat.usgs.gov/documents/cdr\\_sr\\_product\\_guide.pdf](http://landsat.usgs.gov/documents/cdr_sr_product_guide.pdf) (accessed on 2-Jan-2014).

United States Geological Survey. (2016). "Provisional Landsat 8 Surface Reflectance Code (LaSRC) product. Version 3.0" Department of the interior.

Vanonckelen, S., S. Lhermitte, A. Van Rompaey (2013). "The effect of atmospheric and topographic correction methodson land cover classification accuracy" *International Journal ofApplied Earth Observation and Geoinformation*, 24:9-21

Vermote, E., D. Tanre, J.L. Deuze, M. Herman and J.J. Morcrette (1997), Second Simulation of the Satellite Signal in the Solar Spectrum (6S) : an overview, *IEEE Transactions on Geoscience and Remote Sensing*, 35(3) 675 - 686. El programa 6S pot ser descarregat de <http://6s.ltdri.org/> (validat el 10-11-2016).

Vermote, E.; Justice, C.; Claverie, M.; Franch, B. (2016). "Preliminary analysis of the performance of the Landsat 8/OLI land surface reflectance product." *Remote Sensing of Environment*, 185:46-56.

Vidal-Macua JJ, Zabala A, Ninyerola M, Pons X (2017) "Developing spatially and thematically detailed backdated maps for land cover studies". *International Journal of Digital Earth* 10(2): 175-206. <http://dx.doi.org/10.1080/17538947.2016.1213320>

Vicente-Serrano, S., F. Pérez-Cabello i T. Lasanta (2008) "Assessment of radiometric correction techniques in analyzing vegetations variability and change using time series of Landsat images" *Remote Sensing of Environment*, 112:3916-3934.

Whitworth, Malcolm (1997) "A physically-based model to correct atmospheric and illumination effects in optical satellite data of rugged terrain" *IEEE Trans. Geosc. Remote Sens.*, Vol. 35, No. 3, pp. 708-717

Yang, C. i A. Vidal (1990) "Combination of Digital Elevation Models with SPOT-1HRV Multispectral Imagery for Reflectance Factor Mapping." *Remote Sensing of Environment*, 32:35-45.

Zhang, Z., G. He i X. Wang (2010) "A practical DOS model-based atmospheric correction algorithm" *International Journal of Remote Sensing*, 2837-2852.

Zhang, Z, G He, X Zhang, T Long, G Wang i M. Wang (2017) "A coupled atmospheric and topographic correction algorithm for remotely sensed satellite imagery over mountainous terrain" *GIScience & Remote Sensing*, <https://doi.org/10.1080/15481603.2017.1382066>

## Software

MiraMon, ArcGIS, QGIS, MATLAB, ENVI, R, SNAP, Office Microsoft