Universitat Autònoma de Barcelona

2020/2021

Spatial Analysis

Code: 43379
ECTS Credits: 9

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

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

Name: Xavier Pons Fernández

Email: Xavier.Pons@uab.cat

Use of Languages

Principal working language: spanish (spa)

Other comments on languages

Approximately 25 % of the classes are in Catalan and 75 % in Spanish. Most of the literature is in English

Teachers

Joan Pino Vilalta

Lluís Pesquer Mayos

Pere Serra Ruíz

External teachers

Fernando Pérez

Oscar Mora

Prerequisites

Prerequisites are not required

Objectives and Contextualisation

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

Dominate at the practical level the different tools related to the interpolation and terrain analysis.
Use the main applications for the generation of new information from GIS data.
Identify the concepts associated with spatial analysis, its applications and its limitations.

Competences

- Analyse and exploit geographic data from different sources to generate new information from pre-existing data.

- Communicate and justify conclusions clearly and unambiguously to both specialist and non-specialist audiences.
- 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.
- Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
- Use different specialised GIS and remote sensing software, and other related software.
- Use different techniques and concepts for generating useful information in spatial analysis.
- Write up and publicly present work done individually or in a team in a scientific, professional context.

Learning Outcomes

1. Communicate and justify conclusions clearly and unambiguously to both specialist and non-specialist audiences.
2. Continue the learning process, to a large extent autonomously.
3. Design and apply a methodology, based on the knowledge acquired, for studying a particular use case.
4. Exploit geographic data through map algebra, layer combination, network analysis and other techniques, taking the right decisions for each problem area based on the knowledge acquired.
5. Identify the concepts associated with spatial analysis, their applications and their limitations.
6. Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
7. Show expertise in using the different tools of terrain analysis and interpolation.
8. Use the main applications for generating new information from GIS data.
9. Write up and publicly present work done individually or in a team in a scientific, professional context.

Content

ANALYSIS IN GIS

1. General Concepts of GIS Analysis
1.1 Introduction
1.2 Specifications regarding the data model
1.3 Combining raster-vector analysis
2. Layers combinations
2.1 Variants and possibilities
2.2 Vector overlay
2.3 Transfer of attributes
2.4 Categorical data
3. Map algebra
3.1 Previous conditions
3.2 Characteristics
3.3 NODATA
3.4 Multicriteria decision analysis
4. Propagation of errors
4.1 Geometric quality criteria
4.2 Thematic quality criteria
4.3 Elimination of results by criteria of geographical insignificance
5. Analysis of the landscape
5.1 Introduction to the conceptual and methodological framework of landscape ecology
5.2 Calculation and analysis of landscape indexes at various scales
5.3 Analysis of the ecological connectivity of the landscape
6. Space interpolation
6.1 Concepts
6.2 Polygons of Thiessen
6.3 Trend surfaces
6.4 Kriging
7. Logistic regression

7.1 Characteristics
7.2 Spatial applications
7.3 Limitations and adjustments of models
8 Analysis of distances
8.1 Cartesian distances and geodesic distances
8.2 Generation of continuous and buffer maps
8.3 Anisotropic distances and cost analysis
8.4 Introduction to network analysis

DIGITAL TERRAIN MODELS

1. Concepts
1.1 Fundamental concepts and terminology (DTM, DEM, DSM, etc.)
1.2 Models of data: raster, TIN, isolines, etc
1.3 Vertical and geoid duck
2. Collection ofdata. Primary (field, photogrammetry, lidar, InSAR, etc.) and Secondary
3. Generation of DTM
3.1 Interpolation from points: Inverse of the weighted distance (IDW), splines, kriging
3.2 Interpolation from isolines
3.3 Generation of TIN models
4. Quality of MDT
4.1 Altimeter quality
4.2 Control of the error in the DTM
4.3 Propagation of error in derivative models
5. Derived models
5.1 Slope, orientations, curvatures, etc.
5.2 Hydrographic basins, drainage network
5.3 Illumination, shading and solar radiation
6. Applications
6.1 Applications in the processing of remote sensing images: geometric and radiometric image rectification.
6.2 Topographical profiles and visibility analysis
6.3 Three-dimensional perspectives

INTERFEROMETRY

1 Introduction
1.1 Classification of sensors
2 SAR concept
2.1 Formation of the image
3 SAR image
3.1 Geometric and radiometric characteristics
3.2 Geocoding
4 SAR interferometry
4.1 Concept and topographic applications
5 Differential Interferometry SAR (DInSAR) classical
5.1 Advanced DInSAR (Persistent Scatterer Interferometry)

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

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Master classes / exhibitions	51	2.04	3, 7, 4, 5, 6, 1, 2, 9, 8
Type: Supervised			
Oral presentation	1	0.04	3, 7, 4, 5, 6, 1, 2, 9, 8
Practical works	58	2.32	3, 7, 4, 5, 6, 1, 2, 9, 8
Tutorials	2	0.08	3, 7, 4, 5, 6, 1, 2, 9, 8
Type: Autonomous			
Personal study	15	0.6	3, 7, 4, 5, 6, 1, 2, 9, 8
Reading of articles / reports of interest	3	0.12	3, 7, 4, 5, 6, 1, 2, 9, 8
Writing reports	94	3.76	3, 7, 4, 5, 6, 1, 2, 9, 8

Assessment

The evaluation of this subject consists of the following system:

a) The realization of 2 exams (a test and an oral presentation), that will be between 60 % and 70 % of the final note and that will include the theoretical and practical subject carried out. The exam that has not reached the minimum mark of 5 out of 10 must be repeated the day assigned by the teacher of the subject.

b) 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.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Theoretical exam and oral presentation	60 %-70 %	1	0.04	3, 7, 4, 5, 6, 1, 2, 9, 8
Writing reports	40 %-60 %	0	0	3, 7, 4, 5, 6, 1, 2, 9, 8

Bibliography

ANLYSIS IN GIS

Manuals

Barredo, J.I. (1996) "Sistemas de Información Geográfica y evaluación multicriterio en la ordenación del territorio" Ra-ma. Madrid.
Bonham-Carter, G.F. (1994) "Geographic information systems for geoscientists modelling with GIS" Pergamon. Kidlington. 398 p.
Burrough, P.A. i R.A. McDonnell (1998) "Principles of Geographical Information Systems" Oxford University Press. 333 p.
Cebrián, J.A. (1992) "Información geográfica y sistemas de información geográfica (SIGs)" Servicio de publicaciones. Universidad de Cantabria. Santader. 85 p.
Chilès, J.-P., Delfiner, P.(1999). Geostatistics: Modelling Spatial Uncertainty. Wiley, New York, 687 p.
Cressie N.A.C. (1993) "Statistics for SpatialData" (Wiley Series in Probability and Mathematical Statistics) Johm Wiley & Sons New York 900 p.
Fischer, M.M. i P.Nijkamp (eds.) (1993) "Geographic information systems, spatial modelling and policy evaluation" Springer-Verlag. Berlin. 280 p.
Forman R.T.T. (1995). "Land mosaics. The ecology of landscapes and regions" Cambridge University Press, Cambridge.
Fotheringham, S. y P. Rogerson (eds.) (1994) "Spatial analysis and GIS" Taylor & Francis. London. 281 p.
Gámir, A, M. Ruiz y J.M. Seguí (1995) "Prácticas de análisis espacial" Oikos-Tau. Barcelona. 384 p.
Geoderma (1994). El volum 62 de la revista és un especial dedicat a interpolació espacial.
Jovell, A.J. (1995). "Análisis de regresión logística. Cuadernos metodológicos", 15. Madrid, Centro de Investigaciones Sociológicas
Kitanidis P.K. (1997) "Introduction to geostatistics: applications to hydrogeology". Cambridge University Press. 249 p.
Kleinbaun, D.G. (1994). "Logistic regression". New York, Springer-Verlag.
Laurini, R. i Tompson, D. (1992)"Fundamentals of Spatial Information Systems" Academic Press. Londres. 680 p.
Lloyd, C. D. (2006) "Local Models for Spatial Analysis", CRC Press, Belfast, 244 p.
Maguire, D.J., M.F. Goodchild i D.W. Rhind (eds.) (1991) "Geographical Information Systems. Principles and Applications" 2 Vol. Longman Scientifical & Technical. Essex. 649+447 p.
McGarigal, K., S.A. Cushman, i E. Ene. (2012) "FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical and Continuous Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst". Disponible a: http://www.umass.edu/landeco/research/fragstats/fragstats.html
O'Sullivan, D. and D. Unwin, (2002) "Geographic Information Analysis". John Wiley & Sons, Hoboken NewJersey, 436 p..
Pavlidis, T. (1982) "Algorithms for graphics and image processing." Springer-Verlag. Berlin. p. 180-189.
Santos Preciado, J.M, Cocero D. (2006) "Los SIG ráster en el campo medioambiental y territorial. Ejercicios prácticos con Idrisi y MiraMon" UNED. Madrid. 167 p.
Santos Preciado, J.M. (2004) "Funcionamiento del programa MiraMon. Aplicación para la realización de ejercicios prácticos de carácter medioambiental y/o territorial. Cuaderno de Prácticas". UNED. Madrid. 430 p.
Tomlin, C.D. (1990) "Geographic Information Systems and Cartographic Modeling", Pretince Hall. Englewood Cliffs. 249 p.
Worrall, L. (1991) "Spatial analysis and spatial policy using geographic information systems edited" Belhaven. London. 236 p.

Papers

Aangeenbrug, R.T. (1991) "A critique of GIS" In Maguire, D.J., M.F. Goodchild, y D.W. Rhind (eds.) "Geographical Information Systems. Principles and Applications" Vol 1. Longman Scientifical & Technical. Essex. p. 101-107.
Anselin, L. (1995) "Local Indicators of Spatial Association - LISA,"Geographical Analysis 27(2): 93-115.
Cooper W. i C. Jarvis (2004) "A Java-base intelligent advisor for selecting a context-appropiate spatial interpolation algorithm" Computers & GeoSciences, 30:1003-1018.
Curtin, K.M. (2007) "Network analysis in geographic information science: Review, assessment, and projections", Cartography and Geographic Information Systems, 34(2),103-111.
Ding Y., Fotheringham A.S. (1992) "The integration of spatial analysis and GIS" Comput., Environ. and Urban Systems, 16: 3-l 9.
Forman, R.T.T. (1995) "Some General Principles of Landscape and Regional Ecology" Landscape Ecology, 10: 133-142
Franke R. (1982), "Scattered data interpolation: tests of some methods", Mathematics of Computation, 38:

181-199.
Getis A. Ord J.K. (1992). "The Analysis of Spatial Association by Use of Distance Statistics". Geographical Analysis 24 (3).
Grimes, D. I. F. and Pardo-Igúzquiza, E. (2010) "Geostatistical Analysis of Rainfall". Geographical Analysis, 42: 136-160. doi: 10.1111/j.1538-4632.2010.00787.x
Goodchild M.(2004) "A general framework fo error analysis in measurement-based GIS" J. Geograph. Syst. 6:323-324.
Hancock, P.A., Hutchinson, M.F., Spatial interpolation of large climate data sets using bivariate thin plate smoothing splines. Environmental Modelling and Software 21, 1684e1694, 2006.
Hengl T. (2006) "Finding the right pixel size". Computers & Geosciences (vol. 32, Pag 1283-1298).
Kratzera, J. F, Hayesa D. B., Thompson B E (2006) "Methods for interpolating stream width,depth, and current velocity" Ecological modelling, 196: 256-264
Li, J., Heap A.D. (2011) "A review of comparative studies of spatial interpolation methods in environmental sciences: Performance and impact factors" . Ecological Informatics 6: 228 - 241.
Limin J.,Yaolin L.(2012) Analyzing the spatial autocorrelation ofregional urban datum land price. Geo-spatialInformation Science 15(4), 263-269.
Mitasova, H., Mitas, L. (1993) "Interpolation by regularized spline with tension: I. Theory and implementation" Mathematical Geology 25:641-656.
Mitasova, H., Hofierka, L. (1993) "Interpolation by regularized spline with tension: II. Application to terrain modeling and surface geometry analysis" Mathematical Geology, 25: 657-667.
Malczewski, J. (2006). "GIS-based multicriteria decision analysis: a survey of the literature". International Journal of Geographical Information Science, 20(7), 703-726.
Mordechai H. "Map Calculus in GIS: a proposal and demonstration" Int. J. Geographical Information Science (vol. 18, no. 2).
Narumalami, S., Jensen, J.R., Althausen, J.D., Burkhalter, S., Mackey, H.E (1997). "Integration of GIS and logistic multiple regression for aquatic macrophyte modeling" PERS, 63(1): 41-49.
Oliver, M. A., Webster, R. (1990), Kriging: a method of interpolation for geographical information systems. International Journal of Geographical Information Science, 4(3): 313 - 332
Pardo-Igúzquiza E. i P.M. Atkinson (2007) "Modelling the semivariograms and cross-semivariograms required in downscaling cokriging by numerical convolution-deconvolution". Computers & GeoSciences, 33:1273-1284.
Pesquer L., Cortés A., Pons X. (2011) "Parallel ordinary kriging interpolation incorporating automatic variogram fitting". Computers & Geosciences, 37, 464-473.
Pino J., Rodà F. (1999). "L'ecologia del paisatge: un nou marc de treball per a la ciència de la conservació". Butlletí de la Institució Catalana d'Història Natural, 67: 5-20.
Pino, J., Rodà, F., Basnou, C., Guirado, M, (2008) "Canvis en la superficie i el grau de fragmentació del bosc a la plana del Vallès entre els anys 1993 i 2000". Documents d'Anàlisi Geogràfica, 51: 59-77.
Saura, S. Torné, J. (2009) "Conefor Sensinode 2.2: a software package for quantifying the importance of habitat patches for landscape connectivity" Environmental Modelling &Software, 24: 135-139.
Shoji T. Kitaura H. (2006) "Statistical and geostatistical analysis of rainfall in central Japan" Computers & Geosciences (vol. 32, no 8, Pag 1005-1234).
Turner, H. (2005) "Landscape ecology: what is the state of the science?" Annual Review of Ecology, Evolution and Systematics, 36: 319-344.
Varas, A. J. (2002). "Modeling the potential distribution of forests with a GIS". PERS, 68(5): 455-461.

DIGITAL TERRAIN MODELS

Manuals

Bonham-Carter, G.F. (1994) "Geographic Information Systems for Geoscientists: Modelling with GIS" Pergamon, 398 p.
Burrough, P.A. i R.A. McDonnell (1998) "Principles of Geographical Information Systems" Oxford University Press. Oxford. 333 p.
Depraetere C. (1992) "DEMIURGE: Chaîne de production et de traitement des MNT" ORSTOM, Laboratoire d'Hydrologie. París. 225 p.
Eastman, J.R. (2001) "IDRISI32 Release 2: Guide to GIS and Image Processing". Clark University . Worcester. (2 vol.) 161+144 p.
Geoderma (1994). El volum 62 de la revista és un especial dedicat a interpolació espacial.
Felicísimo, Á.M. (1994) "Modelos digitales del terreno. Introducción y aplicaciones en las ciencias ambientales" Biblioteca de Historia Natural, 3. Pentalfa Ediciones. Oviedo. 220 p.

Fra, U. (2011) "Diccionari terminològic de fotogrametria" Enciclopèdia Catalana i Institut Cartogràfic de Catalunya. Barcelona. 350 p.
Kitanidis P.K. (1997) "Introduction to geostatistics: applications to hydrogeology". Cambridge University Press. 249 p.
Martínez-Casasnovas,J.A. (1999) "Modelos digitales de terreno: Estructuras de datos y aplicacionesen el análisis de formas del terreno y en Edafología" QUADERNS DMACS Núm. 25, Departament de Medi Ambient i Ciències del Sòl, Universitat de Lleida, Lleida.
Maune, D.F. (2007) "Digital Elevation Model Technologies and Applications: The DEM Users Manual" American Society for Photogrammetry and Remote Sensing. Bethesda. 620 p. + DVD. (1ª edició: 2001)
Mitas, L., Mitasova, H. (1999) "Spatial Interpolation". In: Longley, P., M.F. Goodchild, D.J. Maguire, D.W.Rhind (Eds.), Geographical Information Systems: Principles, Techniques, Management and Applications, Wiley, p. 481-492.
PE&RS (2006) . El volum 72, número 3 corresponent al mes de març, de la revista és un especial dedicat a Shuttle Radar Topography Mission.
Pons, X., Arcalís. A. (2012) "Diccionari terminològic de teledetecció" Enciclopèdia Catalana i Institut Cartogràfic de Catalunya. Barcelona. 597 p.
Renslow, M. (2012) "Manual of Airborne Topographic Lidar" ASPRS, 528 p.
Wilson, John P.; Gallant, John C. (2000) "Terrain Analysis. Principles and Applications." John Wiley & Sons: New York. 479 p

Papers

Achilleos, G.A. (2011) "The Inverse Distance Weighted interpolation method and error propagation mechanism - creating a DEM from an analogue topographical map" Journal of Spatial Science, 56(2):283-304.
Aguilar, F.J., Aguilar, M.A., Agüera, F. (2007) "A Theoretical Approach to Modeling the Accuracy Assessment of Digital Elevation Models" PE&RS, 73(12):1367-1379.
Aguilar, F.J., Agüera, F, Aguilar, M.A., (2007) "Accuracy assessment of digital elevation models using a non-parametric approach" Int. J. Geographical Information Science, 21(6):667-686.
Arnold, J.G., Moriasi, D.N., Gassman, P.W., Abbaspour, K.C., White M. J.,Srinivasan, R., Santhi, C., Harmel, R.D., van Griensven A., Van Liew, M. W., Kannan, N., Jha, M.K. (2012) SWAT: Model Use, Calibration, and Validation. Transactions of the ASABE, 55(4):1491-1508.
Baella, B., Pla, M. (2002) "Some generalization practices on relief representation derived from the Topographic Database of Catalonia at scale 1:5000" Institut Cartogràfic de Catalunya http://www.icc.es/pdf/bienni0102/I_cartografia/pla.pdf.
Carrara, A., Bitelli, G., Carala, R. (1997) "Comparison of techniques for generating digital terrain models from contour lines" Int. J. Geographical Information Science, 11(5):451-473.
Chen, Q. (2007) "Airborne Lidar Data Processing and Information Extraction" PE&RS, 73(2):109-112. [bon article introductori].
Chen, C., Li, Y., Cao, X., Dai, H.(2014) "Smooth Surface Modeling of DEMs Based on a Regularized Least Squares Method of Thin Plate Spline". Mathematical Geosciences, 46:909-929.
Chou, Y.H., Liu, P.S., Dezzani R.J. (1999) "Terrain complexity and reduction of topographic data" Journal of Geographyical Systems, 1(2):179-198.
Douglas, D.H. (1983) " The XYNIMAP family of programs for geographic information processing and thematic map production" In, Wellar, B.S., (Ed.) Auto-Carto Six, International Symposium on Automated Cartography 6th, Ottawa Canada, Proceedings: II:2-14.
Douglas, D.H. (1986) "Experiments To Locate Ridges And Channels To Create A New Type Of Digital Elevation Model" Cartographica, 23(4):29-61.
Felgueiras, C., Goodchild, M.F. (1995) "Two Papers on Triangulated Surface Modeling". "A comparison of three tin surface modeling methods and associated algorithms" and "An incremental constrained Delaunay triangulation". National Center for Geographic Information and Analysis. University of California, Santa Barbara. Technical Report 95-2. 47 p.
Felicísimo, Á.M. (1994) "Parametric statistical method forerror detection in digital elevationmodels" ISPRS Journal of Photogrammetry and Remote Sensing, 49(4):29-33.
Felicísimo, Á.M. (1995) "Error propagation analysis in slope estimation by means of digital elevation models" Proceed. 17th Internat. Cartographic Conference, 1:94-98. Barcelona.
Ferraz, A., Bretar, F., Jacquemoud, S., Gonçalves, G. (2009). "The Role of Lidar Systems in Fuel Mapping" Instituto de Engenharia de Sistemas e Computadores de Coimbra. 37 p.
Gràcia, E., Díez, S. (2013) "Com s'explora el fons i el subsòl marí?" Revista Mètode. 20-5-2013 https://metode.cat/revistes-metode/monografics/com-sexplora-el-fons-i-el-subsol-mari.html

Gonga-Saholiariliva, N., Gunnell, Y., Petit, C., Mering, C. (2011) "Techniques for quantifying the accuracy of gridded elevation models and for mapping uncertainty in digital terrain analysis" Progress in Physical Geography, 35(6): 739-764
Horn, B.K.P. (1989). "Obtaining shape from shading information". In: Horn, B. K. P., Brooks, M. J. (Eds.) "Shape from Shading", p. 121-171. MIT Press.
Hugentobler, M. (2004) "Terrain Modelling with Triangle Based Free-Form Surfaces". PhD dissertation. Universität Zürich. 145 p.
Hui Lu, Y., Trinder, J.C., Kubik, K. (2006) "Automatic Building Detection Using the Dempster-Shafer Algorithm" PE&RS, 72(4):395 -403.
Jenson, S.K., Domingue, J.O. (1988) "Extracting Topographic Structure from Digital Elevation Data for Geographic Information System Analysis" PE&RS, 54(11):1593-1600.
Lindsay, J. B. (2006) "Sensitivity of channel mapping techniques to uncertainty in digital elevation data". International Journal of Geographical Information Science, 20(6):669-692.
Lindsay, J. B., Creed, I.F. (2006) "Distinguishing actual and artefact depressions in digital elevation data". Computers & Geosciences,32:1192-1204.
Li, J., Heap, A.D., (2014) "Spatial interpolation methods applied in the environmental sciences: A review". Environmental Modelling & Software, 53, 173-189.
Lu, Z., Kwoun, O., and Rykhus, R. (2007) "Interferometric Synthetic Aperture Radar (InSAR): Its Past, Present and Future" PE&RS, 73(3):217-221. [bon article introductori].
Mallet, C. and Bretara, F. (2009) "Full-waveform topographic lidar: State-of-the-art" ISPRS Journal of Photogrammetry and Remote Sensing, 64(1):1-16.
Meisels, A., Raizman, S. Karnieli A. (1995) Skeletonizing a DEM into a drainage network. Computers & Geosciences, 21 (1) 187-196.
Miliaresis, G.CH., Argialas, D.P. (1999) "Segmentation of Physiographic Features from the Global Digital Elevation Model / GTOPO30" Computers & Geosciences, 25(7):715-728.
Mitasova, H., Mitas, L. (1993) "Interpolation by regularized spline with tension: I. Theory and implementation" Mathematical Geology, 25:641-656.
Mitasova, H., Hofierka, L. (1993) "Interpolation by regularized spline with tension: II. Application to terrain modeling and surface geometry analysis" Mathematical Geology, 25:657-667.
Moriasi, D.N., Arnold, J.G., Van Liew, M. W., Bingner, R. L., Harmel, R.D.and Veith, T.L. "Model evaluation guidelines for systematic quantification of accuracy in watershed simulations." (2007) Transactions of the American Society of Agricultural and Biological Engineers 50(3): 885-990.
Mukherjee San., Joshi P.K. , Mukherjee Sam., Ghosh A., Garg R.D., Mukhopadhyay A. (2013) Evaluation of vertical accuracy of open source Digital Elevation Model (DEM) International Journal of Applied Earth Observation and Geoinformation, 21:205-217.
O'Callaghan J.F. and Mark D.M. (1984) "The extraction of drainage networks from digital elevation data". Computer Graphics and Image Processing 28:323-344.
Pierce, L, Kellndorf, J., Walker, W., Barros,O. (2006) "Evaluation of the Horizontal Resolution of SRTM Elevation Data" PE&RS, 72(11):1235-1244.
Podobnikar, T., Vrečko, A. (2012) "Digital Elevation Model from the Best Results of Different Filtering of a LiDAR Point Cloud" Transactions in GIS, 16(5):603-617
Pons, X. (1996) "Estimación de la radiación solar a partir de modelos digitales de elevaciones. Propuesta metodológica" In Juaristi, J., Moro, I. "Modelos y Sistemas de Información en Geografía" (458 p) p. 87-97.
Pons X., Ninyerola M. (2008) "Mapping a topographic global solar radiation model implemented in a GIS and refined with ground data" International Journal of Climatology, 28 (13):1821-1834. DOI: 10.1002/joc.1676.
Pons, X., Dalmases, C., Pesquer, L., Marcer, A., Masó, J. (2004) "ISOMDE: Una nueva aproximación a la generación de Modelos Digitales del Terreno." In Conesa, C., Martínez, J.B. "Territorio y Medio Ambiente. Métodos cuantitativos y Técnicas de Información Geográfica", p. 27-38 (404 p). Universidad de Murcia. Murcia. ISBN: 84-8371-484-1.
Rabus, B., Eineder, M., Roth, A., Bamler, R. (2003) "The shuttle radar topography mission- a new class of digital elevation models acquired by spaceborne radar" ISPRS Journal of Phototgrammetry & Remote Sensing, 57:241-262.
Romano, M.E. (2015) "Commercial geiger mode lidar". Harris presentation at www.asprs.org/wp-content/uploads/2015/05/5H[4]-slides.pdf
Slater, J. A., Heady, B., Kroenung, G., Curtis, W., Haase J., Hoegemann, D., Shockley, C., Tracy, K. (2011) "Global Assessment of the New ASTER Global Digital Elevation Model," Photogrammetric Engineering & Remote Sensing, 77 (4), 335-350.
Stoker, J.M., Greenlee, S.K., Gesch, D.B., Menig, J.C. (2006) "CLICK: The New USGS Center for Lidar

Information Coordination and Knowledge" PE&RS, 72(6):613-616.
Tarboton D.G. (1997) "A new method for the determination of flow directions and upslope areas in grid digital elevation models" Water Resources Research, 33(2):309-319.
Tarquini, S., Vinci, S., Favalli, M., Doumaz, F., Fornaciai, A., Nannipieri, L. (2012) "Release of a 10-m-resolution DEM for the Italian territory: Comparison with global-coverage DEMs and anaglyph-mode exploration via the web" Computers and Geosciences, 38(1):168-170.
Taud, H., Parrot, J.F., Alvarez, R. (1999) "DEM generation by contour line dilation" Computers and Geosciences, 25(7):775-783.
Toutin, T. (2006) "Comparison of 3D Physical and Empirical Models for Generating DSMs from Stereo HR Images" PE&RS, 72(5):597-604.
Vaze J., Teng J., Spencer G. (2010) "Impact of DEM accuracy and resolution on topographic indices" Environmental Modelling and Software, 25, pp. 1086-1098
Webster T. L., Diasb, G. (2006) "An automated GIS procedure for comparing GPS and proximal LIDAR elevations" Computers & Geosciences 32(6):713-726.
Wechsler, S.P., Kroll, C.N. (2006) "Quantifying DEM Uncertainty and Its Effect on Topographic Parameters" PE&RS, 72(9):1081-1090.
Wise, S. (2011) "Cross-validation as a means of investigating DEM interpolation error" Computers & Geosciences, 37 (2011) 978-991.

INTERFEROMETRY

Lu, Z., Kwoun, O., and Rykhus, R. (2007) "Interferometric Synthetic Aperture Radar (InSAR): Its Past, Present and Future" PE&RS, 73(3):217-221.