

Review

GIS Open-Source Plugins Development: A 10-Year Bibliometric Analysis on Scientific Literature

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Abstract: The advent of Geographical Information Systems (GIS) has changed the way people think and interact with the world. The main objectives of this paper are: (i) to provide an overview of 10 years (2010–2020) regarding the creation/development of GIS open-source applications; and (ii) to evaluate the GIS open-source plugins for environmental science. In the first objective, we evaluate the publications regarding the development of GIS open-source geospatial software in the last 10 years, considering desktop, web GIS and mobile applications, so that we can analyze the impact of this type of application for different research areas. In the second objective, we analyze the development of GIS open-source applications in the field of environmental sciences (with more focus on QGIS plugins) in the last 10 years and discuss the applicability and usability of these GIS solutions in different environmental domains. A bibliometric analysis was performed using Web of Science database and VOSViewer software. We concluded that, in general, the development of GIS open-source applications has increased in the last 10 years, especially GIS mobile applications, since the big data and Internet of Things (IoT) era, which was expected given the new advanced technologies available in every area, especially in GIS.



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1. Introduction

The benefits of open-source software have been acknowledged for a long time in industry and academic contexts [1]. The advent of Geographical Information Systems (GIS) has changed the way people think and interact with the world. The term GIS first appeared in the United States (US) Department of the Interior in 1978 (Map Overlay and Statistical System (MOSS)). Since then, open-source software has shown promise in private and public institutions, such as industry, service and academia. The evolution of open-source software over the past 40 years has had a major impact on today's world.

The open approach (or open (source) movement) was a movement originally limited to computer engineering; however, it has spread over several other fields, such as open data, open science, open governance and open innovation [1]. Open-Source Software (OSS) is characterized by the fact that the source code is available for use, copying and redistribution with or without modification. OSS began with the political movement of Stallmann with the GNU Project (in the beginning of 1970) [2]. The OSS follows several criteria in this regard: (i) free redistribution, i.e., the license does not require a license fee or the like for such sale; (ii) source code that permits redistribution, i.e., the code should be downloadable over the Internet without charge; (iii) derivative works, i.e., the license must permit modifications and derivative works under the same terms as the original software; (iv) integrity of the author's source code, i.e., the license must not restrict the redistribution of the source code in modified form unless the license permits the redistribution of "patch files" containing the source code; (v) no discrimination against any person or group or against any field of expertise; (vi) distribution of the license; (vii) the license must not

be product-specific; (viii) the license must not restrict other software; and (ix) the license must be technology-neutral [3,4]. Open-source projects may choose a license with few restrictions (permissive licenses) or a license with no obligation to share improvements (protective licenses). There are some terms more used in the open-source and free software licenses: permissive licenses are the licenses with the minimal restrictions, only requiring that the original creators are attributed in any distribution or derivative of the software or source code. One example of permissive license is the GPL license. To guarantee the unlimited open-source access, the developers employ the concept of “copyleft”, which uses copyright’s legal framework to ensure continued open access to software and source code. These licenses are considered “restrictive”. One example of this license is the MIT [5]. The Open Source Initiative has a complete list of open-source licenses including: (i) Apache License 2.0 (Apache-2.0); (ii) 3-clause BSD license (BSD-3-Clause); (iii) 2-clause BSD license (BSD-2-clause); (iv) GNU General Public License (GPL); (v) GNU Lesser GPL (LGPL); (vi) MIT license (MIT); (vii) Mozilla Public License 2.0 (MPL-2.0); (viii) Common Development and Distribution License version 1.0 (CDDL-1.0); and (ix) Eclipse Public License version 2.0 [6].

Coetzee et al. [7] completed a review showing that open-source geospatial software and open geospatial data have been changing in the last years, concerning the way the data are collected, processed, analyzed and visualized and the improvements in these contexts, which will have more impact in the future due mostly to the innovative technologies.

MOSS and Geographic Resources Analysis Support System (GRASS) began in 1984 and were considered pioneers in terms of GIS software. GRASS software is still used today, either as stand-alone software or integrated with a GIS software [8], such as QGIS. The PROJ4 library was developed starting in 1983 and the MapServer project began in 2002 (at the University of Minnesota). In 1996, GeoTools emerged as an open-source Java GIS toolkit [9]. The Geospatial Data Abstraction Library (GDAL)/OGR library, for manipulating raster or vector geospatial data, was developed in 1998 and Python support was started in 2000. Today, GDAL/OGR is still used in several GIS software, open-source or commercial packages. QGIS and System for Automated Geoscientific Analyses (SAGA) are two examples that used the GDAL/OGR library. In 2001, the PostGIS and GeoServer projects started and, in 2002, the QGIS software was created [10]. Later, in 2004, other GIS software packages such as gvSIG and uDIG were created.

Due to the large number of open-source software packages that have been created in the last years, the leading teams of these open-source projects joined together in February 2006 to form the Open Source Geospatial Foundation (OSGeo) [6]. OSGeo is a non-profit organization with a mission to support open geospatial technology. It is a software foundation committed to an open philosophy and collaborative development. Interoperability is a high priority in OSGeo’s goals [7]. Free and Open Source Software for Geospatial (FOSS4G) is the annual recurring global event hosted by OSGeo, an annual global conference held in a different city each year since 2004, composed by a robust schedule of keynote speakers, workshops, paper sessions and talks, offering a great opportunity for newcomers and regular developers to share ideas, work and collaborate together [6]. FOSS4G conference is one of the strong initiatives of OSGeo [7]. OSGeo also implemented other initiatives such as Open Geoscience, which consists of several tiers, including Open Access, Open Data and Open Source, and enables scientists to publish and share scientific knowledge, ensuring that the results, data and methodologies are re-used and the recognition in journal publications, and the UN Initiative, which consists of a working group on Geospatial Information and Services for Disasters that was organized to support the UN migration to Open Source Geospatial software solutions. OSGeo provides all the conditions to get in contact all the GIS open-source community. With advanced Internet, technologies come new opportunities to integrate and share code between different projects [7]. As previously referred, Richard Stallman, who started the free software movement in 1983 and began developing the General Public License (GNU) operating system in 1984, defended that everyone has the freedom to copy and redistribute the source code, with or without

modifications [8]. Stallman emphasized the differences between the “free software” and “open-source” concepts. The “free software” is a movement of freedom and justice [2]. By contrast, “open-source” does not campaign for principles but only in practical advantage. This idea is realized by the OSGeo organization, which has been providing financial support to open-source geospatial software projects and initiatives since its inception [2]. Currently, there is a complex set of geospatial tools and libraries such as desktop GIS (QGIS, gvSIG, GRASS GIS, GDAL/OGR) and web GIS software [11]. However, these types of applications always require continuous improvement.

Some advantages were found when using open-source geospatial software compared to proprietary approaches, such as better utilization, better pricing (or none), compatible with modern IT and project persistence and resilience.

Given the importance of the future perspectives regarding GIS and open-source geospatial software, different types of applications have been developed, such as desktop applications, web GIS and mobile applications. Desktop GIS open-source applications are applications developed on desktop software, such as QGIS, and consequently require the installation of the main software to work. In the last 10 years, several desktop applications have been developed. For instance, in 2010, Solymosi et al. [12] created a QGIS plugin to facilitate data processing for Bayesian spatial modeling. The authors referred that, although other tools may perform some of these processes, the developed plugin allows the user to perform all steps in the same QGIS environment, without programming and with controls to avoid some possible bugs in script writing. Lee et al. [13] developed the PRISM (Parameter-elevation Regressions on Independent Slopes Model) QGIS plugin so that users can obtain gridded meteorological data of low resolutions (1 km × 1 km). Most recent studies combined existent plugins with new ones. For instance, Bittner et al. [14] integrated the LuKARS (Land use change modeling in KARSt systems) model into the already existent FREEWAT (FREE and Open Source Software Tools for WATER Resource Management) framework. With the recent advances in remote sensing techniques and Machine Learning (ML) algorithms, Bragagnolo et al. [15] presented *r.landslide*, a free and open-source add-on to the open-source GRASS software for landslide susceptibility mapping, which works with Artificial Neural Network (ANN), environmental parameters and landslide databases. Jakimow et al. [16] created the EO Time Series Viewer, a free and open-source QGIS plugin for visualization, interpretation and labeling of multi-sensor Time Series (TS) data, using satellite imagery. Other applications were developed in different contexts and combining different platforms, such as web GIS and mobile [17–22]. In the last decade, a rapid growth of web GIS applications was also observed [23–28]. The number of web mapping users has been increasing due to easy access, diversity and more integrated and intelligent geospatial applications in a web GIS environment, providing an online collaborative environment to support users and applications [29]. The development of a web GIS involves several tools and technologies, for example: (i) spatial databases (e.g., PostGIS); (ii) software clients (e.g., QGIS); (iii) command line utilities (e.g., the commands from GDAL/OGR or shp2pgsql, which allow converting ESRI shapefiles into SQL suitable for insertion into the PostGIS/PostgreSQL database); (iv) middleware, such as Geoserver and Apache tomcat server, among others; and (v) frontend JavaScript libraries and framework, such as Leaflet, MapBox GL and OpenLayers, among others [30]. According to the literature, the development of web GIS applications has been used in different areas. For instance, Kalabokidis et al. [24] developed a web-based GIS platform (Virtual Fire) for forest fire control, which allows sharing and providing information and tools among firefighting forces. Dawidowicz and Kulawiak [31] presented an implementation of the proposed concept in the form of a web GIS for analysis and visualization of risk assessment results in the context of a marine real state for the country of Poland. Cardoso et al. [32] developed a web GIS platform to support urban flood risk forecast and management providing urban analysis visualization. Other studies also developed web GIS applications considering different topics [25,26,33,34].

Regarding the development of mobile GIS applications, Gharbi and Haddadi [35] improved the traditional method of collecting road data, knowledge and management of the road network with the creation of a GIS mobile application using different solutions such as PostgreSQL, PostGIS, QGIS, IntraMaps Roam and QGIS Cloud. Hoffman et al. [36] used QGIS for Android combining with EpiCollect, a free and easy-to-use mobile data-gathering platform, to collect field data. Other studies developed mobile GIS applications [37–41]. In 2012, Steiniger and Hunter [42] identified the drivers of software projects and the different types of GIS (e.g., desktop GIS, remote sensing software and server GIS). They also listed the major projects in each software category, discussed the points that should be considered when select for use in business and research and addressed the possible future developments. In their review, Steiniger and Hunter [42] addressed some issues for generation in the FOSS context and gave relevance to: (i) emergence of new projects; (ii) consolidation in the projects existence; and (iii) collaboration among projects. With respect to the consolidation in the existent projects, the OSGeo projects is a great example, since it continues to be updated, proving that there is consolidation in the existent projects. Table 1 presents the information about OSGeo projects regarding the category, the release date and the last version date.

Table 1. OSGeo projects (release and last versions dates).

Category	OSGeo Project	Release Date	Last Version Date
Content Management Systems	Geonode [43]	2010	2020
Desktop applications	QGIS [10]	2002	2021
	GRASS [44]	1982	2020
	Marble [45]	2006	2020
	gvSIG [46]	2004	2020
Web mapping	MapServer [47]	2008	2020
	degree [48]	2002	2021
	OpenLayers [49]	2006	2020
	GeoMoose [50]	2009	2021
	Mapbender [51]	2001	2021
	PyWPS [52]	2006	2021
	GeoServer [53]	2006	2021
Geospatial libraries	PROJ [54]	1970	2021
	GeoTools [9]	1999	2021
	OrfeoToolbox [55]	2006	2021
	GDAL/OGR [56]	2000	2021
	GEOS [57]	2000	2021
Spatial Databases	PostGIS [58]	2001	2021

Table 1 shows that OSGeo projects are updated almost every year, meaning that there is a consolidation regarding the already existent projects. Several of the desktop GIS applications presented in Table 1 are also available in the form of web GIS or mobile platforms, such as QGIS (QField) and gvSIG mobile [7]. A detailed description of OSGeo projects and initiatives was presented by Coetzee et al. [7].

With respect to collaboration among the projects, the importance of collaboration in decision-making has been verified in several domains, such as urban planning, site selection and resource management, among others [59]. The fundamental goal of collaboration is to have multiple stakeholders, including experts, professional workers and administrators, working on the same data. The collaboration approach allows participants to work in different places or at different times [59]. The main relevance of collaboration is the fact that different users/developers, experts or common users, from several areas, collaborate on given issues and share data easily through a distributed framework using platforms, forums or question-and-answer sites. For example, Stack Overflow, created in 2008 by Jeff Atwood and Joel Spolsky [60,61], is a question-and-answer site for professionals and

programmers, composed of questions and answers on a wide range of topics in computer programming. According to Stack Overflow statistics, a trend was identified in the last 10 years with an increase of users [62]. The Stack Exchange, similar to Stack Overflow, was created in 2009, by Spolsky's company, Fog Creek Software, with a beta version of the Stack Exchange 1.0 platform, which did not work so well. Thus, in 2011, it was publicly launched by Jeff Atwood and Joel Spolsky, and it has grown in the years that followed. Stack Exchange is a network of question-and-answer websites on topics in diverse fields, each site covering a specific topic, including GIS [63]. According to the statistics regarding Stack Overflow, almost 82% of professional developers use GitHub as a collaborative tool [64].

Founded in 2008, GitHub is a cloud-based platform that hosts FOSS, offering to the community an opportunity to collaborate with other developers [65]. GitHub has over 56 million developers and more than 60 million repositories, with approximately 90% of developers in North America, Asia and Europe, leaving about 10% distributed in South America, Africa and Oceania [66]. GitHub uses several programming languages such as Javascript, Python, Java, TypeScript and C# [66]. GitHub platform responds to FOSS with several advantages: (i) improves the validity of research focused on software development; (ii) provides standardized data to researchers, making scientific enquiry more accessible; and (iii) improves programming education with the opportunity to engage students in the collaborative process [65]. GitHub allows developers to come together from all over the world to innovate, find connection and solve problems [66]. In fact, since 2013, the proprietary software ArcGIS collaborates with the open-source community, sharing open-source projects via GitHub [67], proving that new FOSS collaborations have been performed.

The GIS applications development requires the existence of data, in quantity and quality. Specific data are obtained mostly by companies or organizations that finance the collection of geospatial data themselves or by academia. However, over the past decade, more and more digital geospatial data have become available on several platforms. Crowdsourced data are data collected and reported by the user community. The crowdsourcing term is related to the collection of geospatial data as a contribution by non-expert users and the aggregation of these data into meaningful geospatial datasets [68]. Volunteered Geographic Information (VGI) refers to geographic content as a contribution by non-expert users [68]. OpenStreetMap (OSM) is a good example of a VGI, which is a community mapping effort that allows for free access to map images and the data are uploaded by a common user. The OSM project aims to promote participatory cartography. Other well-known crowdsourcing examples include platforms such as Wikimapia [69] and more recently the GIS Cloud Crowdsourcing Solution [68–70]. Crowdsourcing web and mobile applications are freely available applications that any user can install and allow citizens to anonymously report issues online from their desktop computers. Crowdsourcing is considered as a strategy to contribute to improve the GIS applications, since everyone benefits from collaboration, taking advantage of more effective communication, more efficient delivery of services and faster time of response in the process. Social media, with the huge amount of user's data, facilitate the collection of locations and contents, helping to contribute to crowdsourcing. Flickr, Panoramio, Instagram, Facebook and Twitter are some of the social media applications that can be used [68]. ML algorithms, as Convolutional Neural Networks (CNN) algorithms, are also used with crowdsourced data [71]. Crowdsourcing has been used in several areas. For instance, Antoniou et al. [72] presented a GIS-based crowdsourcing application launched after the first COVID-19 cases had been recorded in Greece, with the aim to locate geographical areas with increased numbers of people who felt the symptoms and determine any temporal changes in the statistics of the survey entries. Jankowski et al. [73] presented an approach to geodiversity assessment based on spatial multicriteria analysis, combining Weighted Linear Combination (WLC) with its local version called L-WLC to provide a more comprehensive assessment approach using data obtained through crowdsourcing. Krupowicz et al. [74] presented a process that transforms the spatial structure of rural areas based on a dedicated application LCCApp

(Land Consolidation-Crowdsourcing Application). Despite the success of crowdsourcing data, the reliability and fitness of the data continuous to be questionable [75]. Data quality, biases and trust issues are the challenges of crowdsourced data. Some considerations are important to follow: (i) the quality of the data; (ii) the accuracy of the data; and (iii) the reliability of the data. More recent approaches include the Linus's law (based on theories of crowdsourcing behavior), hierarchical networks of reviewers and rules-based triage of geospatial data during production [76].

GIS open-source applications can be developed in several research areas such as computer science, physical geography, geography, engineering, water resources, meteorology, atmospheric sciences, remote sensing, geology, ecology, agriculture, public administration, archaeology, urban studies and oceanography. Thus, it is clear that the GIS software is essentially used to support and provide information applied to geo-environmental sciences to improve decision making, increase the productivity of processes, provide better data and dynamic models, create predictive scenarios for impact studies and disseminate the results to the community. In the context of environmental science, the term "environment" is a very broad as it includes definitions such as "the air, water, and land in or on which humans, animals, and plants live" [77], or, in the field of ecology, it is defined as "the air, water, minerals, organisms, and all other external factors surrounding and affecting a given organism at any given time" [78]. Environmental science is considered a multidisciplinary field integrating biological, social and physical sciences to address the intractable environmental problems humans face [79]. The environmental management system requires the use of GIS tools/applications to disseminate and share georeferenced and organized information to the public sector, private organizations and interested users. GIS software provides the tools/functionalities required to manipulate the environmental variables (Figure 1). Software applications for data processing and visualization are essential and every task needs computational procedures.



Figure 1. GIS in environmental studies (adapted from <https://www.geospatialworld.net/article/gis-in-environmental-studies-an-overview/> (accessed on 20 March 2021)).

In the 1980s, GIS became a more accessible tool for researchers through programs such as GRASS, enterprises such as Intergraph and ESRI. Approaches focused on risk management, pollution and environmental monitoring emerged during the 1990s [79]. In addition, the emerging of new GIS technologies with advanced tools and algorithms that accomplish the Internet development allowed adopting integrated approaches to solve environmental issues. Many applications use GIS that cover a broad range of issues in

topics such as water resources, climate change, urban planning, environmental justice, vulnerability studies, etc. Therefore, GIS applications have become indispensable tools in the environmental management community. In addition, concepts such as crowdsourcing data have been used in environmental studies. For instance, Ghermandi and Sinclair [80] analyzed data from social media and social networking sites, such as Twitter and Flickr, to achieve a better understanding of human–environment interactions and shape future conservation and environmental management. Picaut et al. [81] developed a smartphone application and a spatial data infrastructure to collect physical data (noise indicators, GNSS positions, etc.) and perceptual data (pleasantness) in the context of environmental noise pollution.

During the last decade, significant progress has been achieved in the GIS open-source applications development, with significant contributions to mainstream geographic research and applications in several contexts. This strong impact of GIS in several contexts is related with external driving forces such as the progress in information technology, where computer sciences come to the forefront of GIS development; software, with improved Internet of Things (IoT) and 3D technologies; virtual reality technology; automation of cartographic flows; and hardware, with large-capacity optical disks and broadband optical fiber communication technology, allowing to generalize the use of GIS tools [82].

For this reason, the main objectives of this paper are: (i) to provide an overview of the last 10 years (2010–2020) regarding the creation/development of GIS open-source applications through a bibliometric analysis on scientific literature; and (ii) to evaluate the GIS open-source plugins for environmental science. The contributions of this review are divided into two main categories. In the first objective, we evaluate the publications regarding the development of GIS open-source geospatial software in the last 10 years, considering desktop, web GIS and mobile applications, so that we can analyze the impact of this type of application for different interdisciplinary research areas. In the second objective, we analyze the development of GIS open-source applications in the field of environmental sciences in the last 10 years and discuss the applicability and usability of these GIS solutions in environmental domains.

This paper highlights the huge importance of GIS open-source applications in environmental areas, giving more visibility to the community in the context of GIS applications development in the last 10 years. Future trends can be obtained from this study and future perspectives in the role of GIS open-source applications. The main contribution of this study is first to give an overview of the past research during the last decade considering the GIS open-source applications development.

This review focuses more on QGIS plugins, as it is considered the premier open-source desktop GIS software [83]. However, other desktop open-source applications are considered in the publications retrieved.

2. Bibliographic Analysis

Web of Science (WoS) and Scopus are two leading and competing citation databases in the world [84].

WoS Core Collection (renamed around 2014), through the legacy of Eugene Garfield, is considered the most powerful research engine and trusted publisher-independent global citation database [85]. It was launched in 1997 and integrates the three traditional journal citation indexes: Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) and Art and Humanities Citation Index (A&HCI).

Scopus is the largest abstract and citation database for peer-reviewed literature, including scientific journals, books and conference proceedings, providing a comprehensive overview of worldwide research output in the fields of science, technology, medicine, social sciences and arts and humanities. Scopus has intelligent tools for discovering, analyzing and visualizing research [86].

These two databases allow information to be retrieved, filtered and aggregated, and both export the data in multiple formats that allow for subsequent analysis.

For relevance in this review, the WoS database was considered. A query was defined in the database and the results were refined considering the last 10 years (2010–2020) and the type of data source, which in this case are journal publications (articles) and reviews.

The search (conducted in January 2021) was based on open-source and free GIS software. QGIS plugins or other GIS software plugins/applications, web GIS applications or GIS mobile applications were considered. To retrieve suitable publications on this topic, a query was created in the WoS database. The search was queried as follows: (“open source software” OR “open source applications” OR “GIS Web-based” OR “Web GIS” OR “GIS mobile application” OR “QGIS plugin”) AND “GIS” in the title, abstract or keyword. In the WoS database, the indices SCI-Expanded, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED and IC were included in the query by default. The period was also included concerning the last 10 years (2010–2020).

In the WoS database, the results were exported to other files separated by tab (WIN), resulting in two files as each file has a limit of 500 publications. The search considered the keywords specified in the topic. In the WoS database, the “Topic Search” field included: (i) the title of the article, review, proceeding, book, etc.; (ii) the abstract, which is a summary of the paper and includes the main points discussed, such as the research question, methodology, discussion and conclusion; and (iii) the keywords and keywords plus fields where the keywords field is the one specified by the author(s) and “tags” the main and subtopics of the content of the paper and the keywords plus field is an algorithm that provides expanded terms that come from the cited references or the bibliography of the dataset [87].

In total, 502 results were retrieved from the query submitted to the WoS database. A manual review of the 502 retrieved documents was performed by two independent researchers to solve word ambiguity issues. For instance, several terms may have similarities to concepts from other scientific fields, resulting in false positives being retrieved, such as open-source applications not being in the context of GIS. The systematic review was conducted independently by two reviewers, who have expertise in GIS and used the inclusion criteria of “any publication that relates to a GIS desktop application (as in QGIS software or other), a GIS web development, or a GIS mobile application”. The divergence between the two reviewers was solved by reaching a consensus. Only papers that were accepted by both reviewers were included in the final analysis. Only papers dealing with the development of a GIS open-source application (desktop/plugin, web GIS or mobile) were considered. The reviews considered were related to application development. After this step, only 391 publications correctly match the query, which means that about 78% of the query results are related to GIS open-source application development (see Appendix A). The result was then evaluated in VOSViewer software.

VOSViewer software focuses on the visualization of bibliometric networks [88], comprising journals, researchers or individual publications that can be constructed based on citation, bibliographic linkage, co-citation or co-authorship relationships. It provides network maps to help interpret the results obtained in the databases.

In terms of the total number of publications found, the search was refined to three main areas for evaluation: GIS open-source desktop applications (including GIS desktop applications and specifically QGIS plugins), web GIS applications and GIS mobile applications. We also evaluate the applications under the context of environmental science.

Figure 2 shows a network of co-citation regarding the journals present in the WoS database. In the network, each circle represents a different journal, with the larger circles having the highest number of citations in the GIS open-source software domain and the lines corresponding to the link strength between the different sources.

Figure 2 shows that the majority of publications are in the areas of environmental modeling software, computer geosciences, international journal of geoinformation and remote sensing of environment. Each color group represents a research area: yellow indicates ecology/environment sources; light blue, hazard/risk; green, water resources; red, GIS; purple, computer science; and blue, remote sensing. All areas are linked in terms of citations.

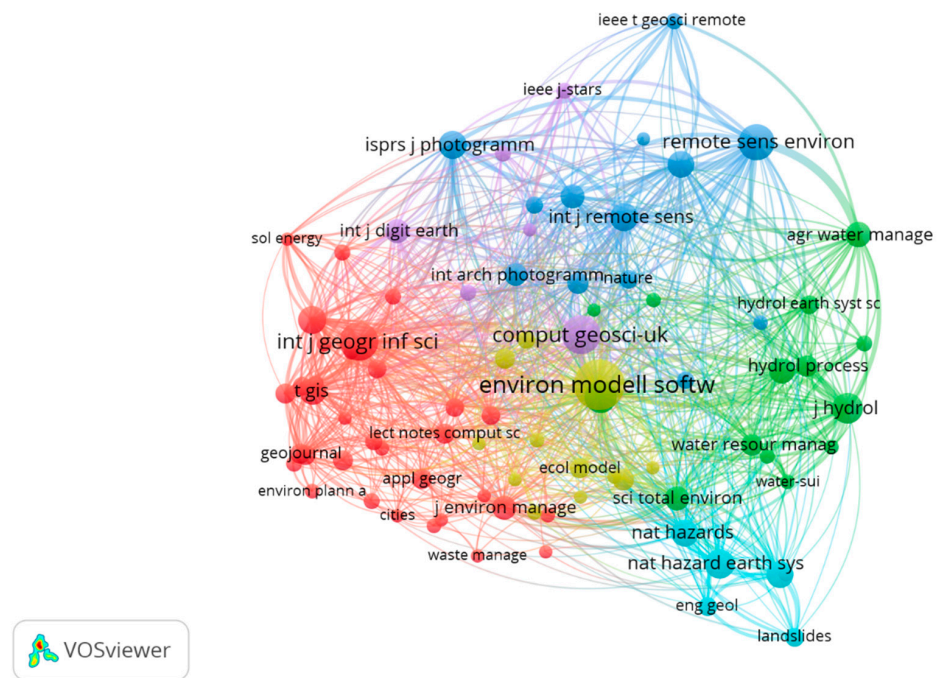


Figure 2. The network of co-citation (cited resources) relations in WoS database.

Figure 3 shows the network of keyword co-occurrences. Figure 3 shows that the keywords “gis” and “web-gis” (and other variants such as “web gis” and/or “webgis”) are the most frequent keywords appearing in the retrieved publications. Other keywords such as “management”, “open-source software”, “framework”, “information”, “remote sensing”, “geographic information systems”, “model” and “decision support system” can also be found in several publications. We can also observe some keywords are related to environmental science such as “susceptibility”, “rainfall”, “impact”, “vulnerability”, “water”, “hazard” and “landslides”.

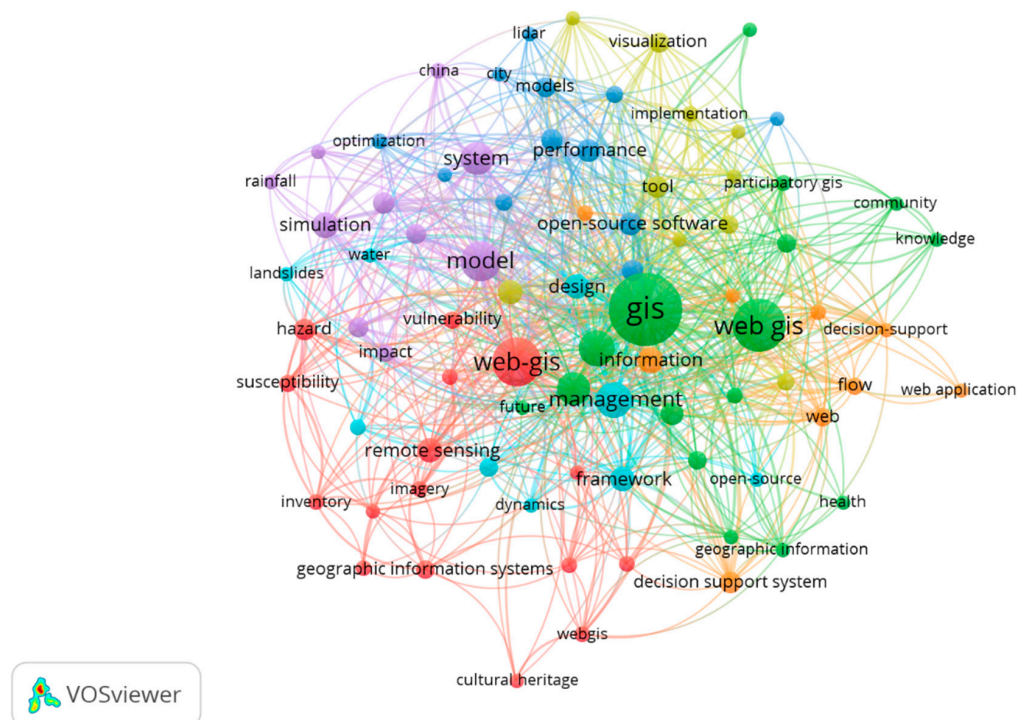


Figure 3. The network of co-occurrences of keywords in WoS database.

Regarding the 10 years analyzed, 2019 was the most productive year, accounting for 16.4% of total publications. Table 2 shows the number (and percentage) of publications per year during the 10 years analyzed.

Table 2. Occurrences of publications during 10 years (in percentage), regarding the general GIS applications, Web GIS applications and mobile GIS applications.

Year	Occurrences (GIS Applications) (%)	Occurrences (Only Desktop GIS Applications) (%)	Occurrences (Only Web GIS Applications) (%)	Occurrences (Only Mobile GIS Applications) (%)
2010	3.3	6.3	3.6	11.8
2011	2.6	0.0	2.4	0.0
2012	4.6	6.3	4.4	5.9
2013	6.7	6.3	8.0	0.0
2014	7.9	12.3	8.0	5.9
2015	10.2	6.3	8.8	5.9
2016	11.5	6.3	11.6	11.8
2017	11.5	12.3	12.0	17.5
2018	11.5	18.8	12.0	5.9
2019	16.4	6.3	14.4	11.8
2020	13.8	18.8	14.8	23.5

Analyzing Table 2, there were no occurrences in 2011, and a significant increase in the development of GIS open-source applications (desktop, web GIS or mobile GIS applications) can be observed in the last 10 years, which reflects the influence of free and open data, open-source software development and the communities' collaboration. Moreover, 2019 corresponds to the year with the highest number of publications.

In terms of the research area, publications are most evident in geosciences multidisciplinary (20.7%), remote sensing (17.9%) and environmental sciences (16.9%). However, other research areas are also covered: water resources, geography physical, computer science interdisciplinary applications, geography, engineering environmental, etc. [85].

3. GIS Open-Source Desktop Applications

The QGIS Python Plugins Repository [89] presents all plugins that have been developed and officially accepted for installation in the QGIS software. However, most of these plugins are not published and peer-reviewed. Therefore, in this review, we only consider the published and peer-reviewed studies on the development of GIS applications.

To better understand the evolution of GIS open-source applications over the last 10 years, the main query was refined to: ("QGIS plugin" OR "plugin" OR "QGIS open-source tool" OR "QGIS open source software" OR "GIS open-source application"). This new query allowed us to find QGIS plugins or other GIS open-source applications.

This refined search found 16 publications, meaning that 4% of the main query results are related to GIS desktop applications.

When analyzing the occurrence of publications per year (in percentage) regarding GIS open-source desktop applications, 2014 and 2018 stand out with 11.8% and 17.6%, respectively, of the relevant publications (Table 2). We also evaluated the number of publications based on the GIS open-source software by the author (Figure 4).

In terms of the research area and regarding the GIS desktop applications, the publications are more evident in environmental sciences, geosciences multidisciplinary and water resources, each of them with 22.2%. However, it also covers several research areas: computer science, interdisciplinary applications, geography physical, remote sensing, engineering, etc. [85]. When the QGIS plugins were considered (the same search was refined to "QGIS"), 93.8% of the previous publications were found, meaning that GIS desktop applications are mainly developed under QGIS open-source software, for instance related to health diseases [90], which also involves environmental variables, forestry [19], ground-water vulnerability [20], erosion risk/coastal management [21,91], soil consumption [92,93], meteorology [13], land use [94], Bayesian spatial models [12], geospatial data analysis and

processing [95], estimation of tree parameters [18,96] and remote sensing [16,17]. The three major research areas were: environmental sciences, water resources and physical geography.

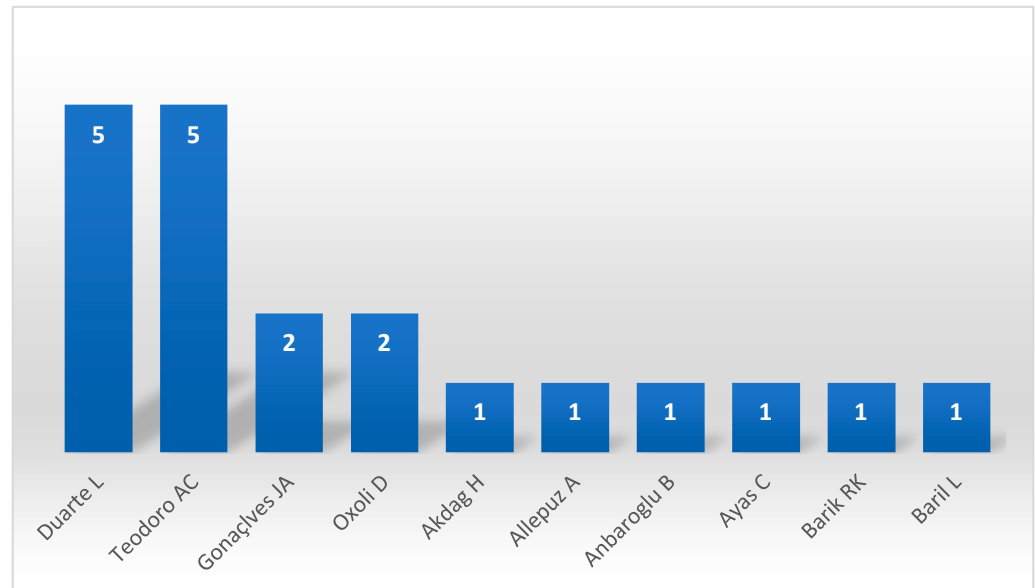


Figure 4. The number of occurrences of publications based on GIS open-source applications in the 10-year period, by author.

4. Web GIS Applications

The last decade provided rapid growth in the development of web GIS, which allows the creation of digital thematic maps with the possibility of real-time integration and dissemination of georeferenced data and is applied in several areas, such in science, commerce and government [97].

The term “web GIS” or a similar definition (“webGIS” or “web-GIS”) was applied to refine the results. The main query was refined to “webgis” OR “web-gis” OR “web gis” OR “web mapping”. In the last years, GIS evolved into the concept of data sharing and collaboration with interoperable GIS database around the world. The users and institutions share their work in several ways, using web GIS or cloud computing. Web GIS has been developed in a wide variety of areas. For instance, Aghajani et al. [98] created a web GIS to predict the future performance of a wind farm, supporting the decision for pricing policy and development of next generation of wind farms. Ahmed et al. [99] developed a web GIS-based landslide early warning system (EWS) with approaches combining static landslide susceptibility maps and rainfall thresholds and introducing a purpose-built hazard matrix. In the health area, Web GIS development has also been increasing. For instance, Delmelle et al. [100] developed an interactive web-based GIS toolkit named OnTAPP (an On-line Toolkit for the Analysis of Point Patterns), designed with the collaboration of epidemiologists from Colombia to monitor dengue fever outbreaks over the Internet and conduct spatial analysis in a limited timeframe. Several other studies involved the development of Web GIS as products for environmental sciences studies [28,101,102], remote sensing studies [23,103,104], archaeology [25], ecology and fires [24,26,33], among other research areas.

More recently, the Internet of Things (IoT) allows the integration of real-time data to every person [105]. Several studies implemented the last advances in IoT to develop new technologies. For instance, Sánchez-Aparicio et al. [106] developed a new web GIS tool to be being a digital-based preventive conservation system for the historical and cultural heritage in Southwestern Europe.

From this refined query, 250 publications were found, meaning that 63.9% of the main query results are related to web GIS development. We can conclude that there was a

significant increase (Table 2) in this area over the last 10 years, especially in the last two years (2019 and 2020, with 14.4% and 14.8%, respectively).

To better understand the use/development of web GIS applications, the network of co-occurrences of keywords related to web GIS is presented in Figure 5.

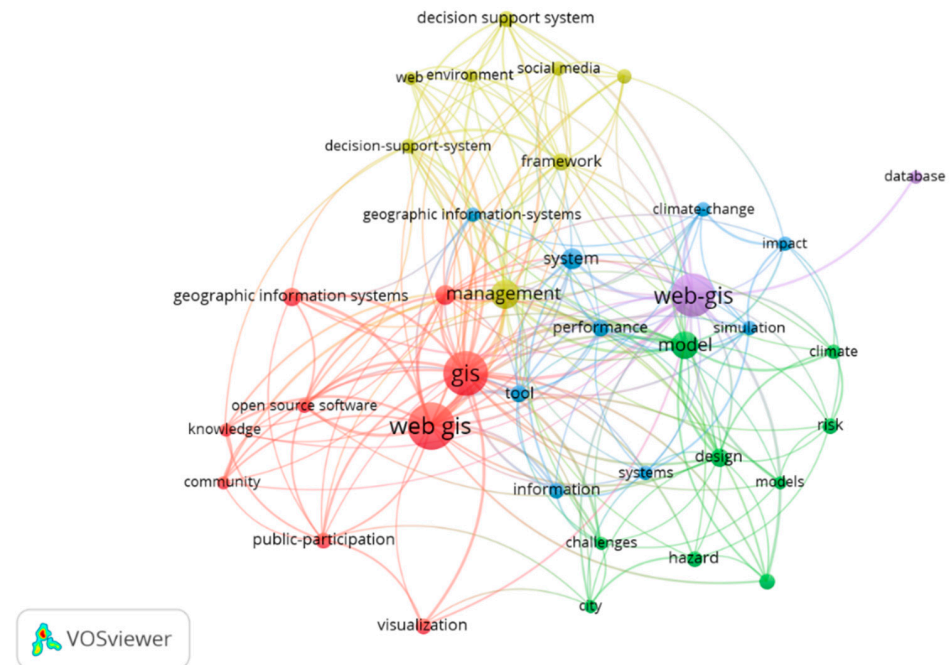


Figure 5. The network of co-occurrences of keywords related with web GIS in WoS database.

Figure 5 shows that “web gis”, “gis” and “web-gis” are the most used keywords. Other words can also be observed: “management”, “climate-change”, “system”, “model”, “information”, “geographic information systems”, etc. In addition, the term co-occurrences network map was created (Figure 6).

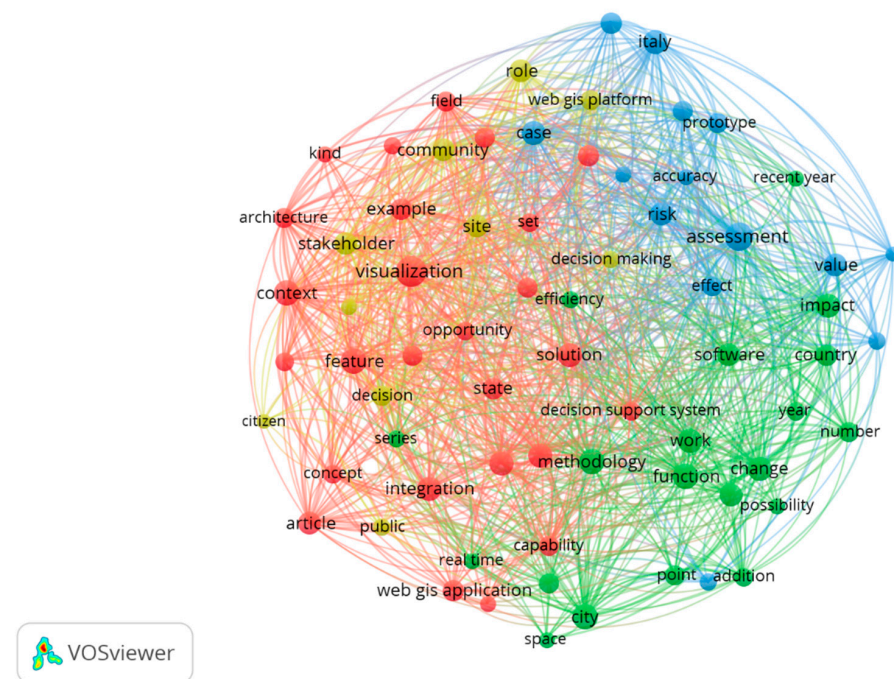


Figure 6. Term co-occurrence network map based on the text data obtained from WoS.

The different colors represent the groups of related terms. In this case, the red group represents terms related to visualization, opportunity, architecture, integration and concept. These terms can be related to the development of applications and web services. The green group represents terms related to software, impact, efficiency, methodology, etc., being terms related to software. The blue group represents terms such as assessment, accuracy, risk and effect, more related to environmental issues. The yellow group is related to decision making, community, etc., more related to the platforms and applications that are open source and thus are developed by collaboration. It can be verified that the red, green and blue groups present the strongest terms, meaning that the building of web applications or web GIS has a strong relationship with environmental applications. From the results in Figures 5 and 6, it is possible to conclude that web GIS applications have been used in a wide variety of research areas including environmental sciences.

5. GIS Mobile Applications

When the query was refined to understand the publications regarding the development of GIS mobile applications (considering “GIS mobile applications” to refine the main query), 17 results were obtained, meaning that 4.3% of the main query corresponds to publications related to GIS mobile applications. Table 1 shows that, in 2011 and 2013, there were no occurrences of publications. The development of GIS mobile applications has increased since 2015, reaching a peak in 2017. A decrease was observed in 2018 and a substantial increase is observed from 2018 to 2020 (with 23.5% of occurrences). This can be partially explained by the revolutionary IoT that, in 2013, had evolved into a system using multiple technologies, including GIS. The GIS mobile applications are related to several categories, highlighting computer sciences, information systems, physical geography, geosciences multidisciplinary, meteorology, atmospheric sciences, remote sensing and water resources, all with 16.7%. However, agriculture, dairy animal science and archaeology, among others, are also categories where this type of application is being developed [85]. Mobile GIS applications have also been combined with web GIS applications (e.g., [37–41]).

6. Environmental GIS Applications

In the main query of this study (with 391 results), 16.9% (66 publications of 391) of the publications are related to the environmental sciences category. When evaluating the percentage of occurrences considering GIS applications applied to environmental sciences, there is a slightly increase from 2010 (4.5%) to 2016 (10.6%); a slight decrease between 2016 (10.6%) and 2017 (3%); and, again, a significant increase from 2017 (3%) to 2020 (25.8%). USA (21.2%), Italy (19.7%) and Germany (13.6%) are the leading countries with more publications in this area. Regarding the source journals, 21.2% of the publications were published in Environmental Modeling Software and 9.1% in Remote Sensing and Sustainability (MDPI). Other journals were also found such as Environmental Monitoring and Assessment (6.1%) and Journal of Hydroinformatics (6.1%). GIS tools have a key role in the management, monitoring and assessment of the environmental sciences research areas, for instance in the study of environmental changes over time, indicating trends and patterns, or in the creation of 3D composites. Land degradations, forest fires, Land Use Land Cover (LULC) changes, air quality, etc. are areas where GIS can contribute more [97]. The most recent technologies allow integrating GIS with other platforms such as R software, as the development of an R Package to access free in-situ meteorological and hydrological datasets for environmental assessment [107]. The integration and interoperability of web services, such as the OGC Web Processing Service (WPS), are critical and define an interoperable protocol for process execution on the web. Thus, an approach to share environmental models on the web coupling OpenMI and WPS was suggested by Zhang et al. [108]. In addition, the constant updating of applications is required in open-source tools, and several plugins have been used and updated, such as FREEWAT (FREE and Open Source Software Tools for WATER Resource Management) that was created in 2015 [109] and integrated with a user-friendly modeling environment that integrates the LuKARS (Land use change modeling in KARSt

systems) model [14]. In addition, recent technologies regarding the Artificial Intelligence (AI) methods have been growing in this context. For instance, Razavi-Termeh et al. [110] prepared the forest fire susceptibility mapping using GIS and an ensemble of adaptive neuro-fuzzy interface systems with genetic and simulated annealing algorithms and an ensemble of radial basis function with an imperialist competitive algorithm model. The results were implemented in a web GIS and mobile application. The remote sensing imagery has also been emerging and growing, and, to overcome the issue of the software tools being limited to specific sensors or optimized for application-specific visualizations, the Earth Observation (EO) Time Series Viewer, a free and open-source QGIS plugin for interpretation and labeling of multi-sensor TS data was developed [16]. The EO Time Series Viewer allows the combination of spatial, spectral and temporal data visualization, provides maximum flexibility in terms of supported data formats, minimizes the user-interactions required to load and visualize multi-sensor TS data and speeds-up labeling of TS data based on enhanced GIS vector tools and formats. Other studies describe the development of applications using remote sensing data in several environmental areas such as water resources, flood risk, agriculture, etc. [28,90,111–113].

7. Future Trends of GIS in Environmental Sciences

Given the trends observed in the bibliometric analysis performed in this study, the main questions are: (i) What will happen in the next 10 years? (ii) What could be the future trends in GIS applications under environmental context during 2020–2030? If we consider the new technologies already emerged and applied in environmental issues, the most common applications include spatial planning, decision making and management; however, regarding IoT and Internet advancement, the future trends point to cloud technology, 3D GIS analysis and representation, real time, mobile GIS and UAVs. The easy and rapid access to information and big data can also be the future perspective in the GIS advancement. 3D GIS and mobile GIS can be combined with virtual reality or augmented reality given the capacities of the new integrated technology regarding GIS. Real-time information can be disseminated and transferred between different devices and to the back-office with the advent of fifth generation (5G) mobile communication and its ability for large amounts of data. Cloud computing will help to handle the increasing volume of data, in the way it is stored, maintained and used. Remote sensing data and the development of optimized algorithms such as ML and deep learning are also expected to be improved. The collaborative approach continues to be required to gather existing datasets from governments, the private sector and academia. The future of GIS depends on inventive thinking from capable problem-solvers and the collaboration of developers. In the next 10 years, a lot of progress will certainly be observed in GIS applications.

8. Conclusions

In this study, a bibliometric review was performed regarding the development of GIS open-source applications. A study was performed considering the scientific peer-reviewed publications where GIS open-source applications are described. Articles and reviews from the last 10 years (2010–2020) were considered. Desktop GIS, web GIS and mobile GIS applications were also considered in the evaluation. After a general evaluation, the study was focused on applications applied to environmental sciences. It was concluded that, in general, the development of GIS open-source applications has increased in the last 10 years, especially GIS mobile applications, since the big data and IoT era, which was expected given the increasing development of advanced technologies.

IoT will promote even more the development of new GIS technologies, englobing web GIS connected to mobile applications with more complex and efficient programs. The massive amount of data created every day through sensors and devices, such as the Global Positioning System (GPS), people, vehicles and objects, social media and more and more information found on the Internet will emerge as a source of valuable data. These are real-time data, and recently new advances in technologies enable incorporating them into

GIS applications. The location is crucial, and the optimization of resources and networks is fundamental in IoT, so this can be one of the reasons that GIS applications are increasing in the last years. In addition, the integration of GIS applications with other types of platforms, such as Building Information Modeling (BIM) for developing and improving infrastructure in communities around the world, promotes great changes in the data acquisition process, data management, new platforms, application development and implementation of different projects. This integration between GIS and other platforms/software and even IoT and spatiotemporal big data makes it possible to quickly acquire and process the real-world geospatial patterns knowledge and computing process, improving the geospatial analysis framework.

In the environmental sciences area, the publications found regarding the GIS applications proved that these applications have been increasingly used in different research areas regarding the environmental sciences, incorporating different methodologies that can be very useful as shared work between users. This open-source concept will help to improve and increase the use of these applications around the world, leading to more complex and efficient computational processes along with the easy management of big data. In the near future, the observed increase of GIS applications in every way should be even more disseminated, as a consequence of the free and open-source collaborative support.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

At the end of the manuscript, a complete list of all 391 publications found in WoS is presented, including the authors' names, the publisher's name, the publication year and the DOI.

Table A1. The 391 publications found in the WoS, including the authors, publisher, publication year and DOY.

Authors	Publisher	Journal Name	Publication Year	DOY
Morgan, JD; Eddy, B; Coffey, JW	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	J. Geogr. High. Educ.		10.1080/03098265.2020.1852200
Rowland, A; Folmer, E; Beek, W	MDPI	ISPRS Int. Geo-Inf.	2020	10.3390/ijgi9120753
Muller, AL; Gericke, OJ; Pietersen, JPJ	SAICE-SAISI	J. S. Afr. Inst. Civ. Eng.	2020	10.17159/2309-8775/2020/v62n4a4
Adedeji, O; Olusola, A; James, G; Shaba, HA; Orimoloye, IR; Singh, SK; Adelabu, S	SPRINGER	Environ. Monit. Assess.	2020	10.1007/s10661-020-08730-3
Casadei, S; Peppoloni, F; Pierleoni, A	MDPI	Water	2020	10.3390/w12113227
Geyer, NR; Kessler, FC; Lengerich, EJ	MDPI	ISPRS Int. Geo-Inf.	2020	10.3390/ijgi9110619
Muller, MM; Vila-Villardell, L; Vacik, H	ELSEVIER	Ecol. Inform.	2020	10.1016/j.ecoinf.2020.101151
Zhang, MD; Jiang, LC; Yue, P; Gong, JY	ELSEVIER SCI LTD	Environ. Modell. Softw.	2020	10.1016/j.envsoft.2020.104838
Perucchetti, L; Bray, P; Felicetti, A; Sainsbury, V; Howarth, P; Saunders, MK; Hommel, P; Pollard, M	WILEY	Archaeometry		10.1111/arcm.12616
Walker, JD; Letcher, BH; Rodgers, KD; Muhlfeld, CC; D'Angelo, VS	MDPI	Water	2020	10.3390/w12102928
Sanchez-Aparicio, LJ; Masciotta, MG; Garcia-Alvarez, J; Ramos, LF; Oliveira, DV; Martin-Jimenez, JA; Gonzalez-Aguilera, D; Monteiro, P	ELSEVIER	Autom. Constr.	2020	10.1016/j.autcon.2020.103304
Farnaghi, M; Mansourian, A	ELSEVIER SCI LTD	Cities	2020	10.1016/j.cities.2020.102850
Anderson, SL; Murray, SC	FRONTIERS MEDIA SA	Front. Plant Sci.	2020	10.3389/fpls.2020.511768
Schattschneider, JL; Daudt, NW; Mattos, MPS; Bonetti, J; Rangel-Buitrago, N	SPRINGER	Environ. Monit. Assess.	2020	10.1007/s10661-020-08602-w
Liang, JM; Gong, JH; Xie, XP; Sun, J	MDPI	ISPRS Int. Geo-Inf.	2020	10.3390/ijgi9090524
Yamamoto, K	MDPI	Information	2020	10.3390/info11090434
Zhang, XW; Yang, Y; Zhang, Y; Zhang, ZL	PERGAMON-ELSEVIER SCIENCE LTD	Ann. Touris. Res.	2020	10.1016/j.annals.2020.102999
Cardoso, MA; Almeida, MC; Brito, RS; Gomes, JL; Beceiro, P; Oliveira, A	WILEY	J. Flood Risk Manag.	2020	10.1111/jfr3.12663
Paul, M; Bussemaker, MJ	ELSEVIER SCI LTD	J. Clean Prod.	2020	10.1016/j.jclepro.2020.121461
Caliskan, M; Anbaroglu, B	ELSEVIER	SoftwareX	2020	10.1016/j.softx.2020.100553

Table A1. Cont.

Authors	Publisher	Journal Name	Publication Year	DOY
Sardella, A; Palazzi, E; von Hardenberg, J; Del Grande, C; De Nuntiis, P; Sabbioni, C; Bonazza, A	MDPI	Atmosphere	2020	10.3390/atmos11070700
Kalinka, M; Geipele, S; Pudzis, E; Lazdins, A; Krutova, U; Holms, J	MDPI	Sustainability	2020	10.3390/su12135293
Beyhan, B; Guler, C; Taga, H	SPRINGER HEIDELBERG	J. Geogr. Syst.	2020	10.1007/s10109-020-00325-3
Mauro, N; Ardissono, L; Lucenteforte, M	ELSEVIER SCI LTD	Inf. Process. Manage.	2020	10.1016/j.ipm.2020.102257
Agrawal, S; Gupta, RD	SPRINGER HEIDELBERG	Arab. J. Geosci.	2020	10.1007/s12517-020-05490-9
Moniz, PF; Almeida, JS; Pino, AT; Rivero, JPS	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	Water Int.	2020	10.1080/02508060.2020.1765130
De Filippis, G; Stevenazzi, S; Camera, C; Pedretti, D; Masetti, M	SPRINGER	Hydrogeol. J.	2020	10.1007/s10040-020-02176-0
Golzio, A; Bollati, IM; Luciani, M; Pelfini, M; Ferrarese, S	MDPI	Appl. Sci.-Basel	2020	10.3390/app10124243
Mussa, KR; Mjemah, IC; Machunda, RL	MDPI	Hydrology	2020	10.3390/hydrology7020028
Possenti, L; Savini, L; Conte, A; D'Alterio, N; Danzetta, ML; Di Lorenzo, A; Nardoia, M; Migliaccio, P; Tora, S; Dalla Villa, P	MDPI	Animals	2020	10.3390/ani10060983
Butt, MA; Khalid, A; Ali, A; Mahmood, SA; Sami, J; Qureshi, J; Waheed, K	SPRINGER HEIDELBERG	Appl. Geomat.	2020	10.1007/s12518-019-00282-7
Bittner, D; Rychlik, A; Kloffel, T; Leuteritz, A; Disse, M; Chiogna, G	ELSEVIER SCI LTD	Environ. Modell. Softw.	2020	10.1016/j.envsoft.2020.104682
Rakotoarison, HA; Rasamimalala, M; Rakotondramanga, JM; Ramiranirina, B; Franchard, T; Kapesa, L; Razafindrakoto, J; Guis, H; Tantely, LM; Girod, R; Rakotoniaina, S; Baril, L; Piola, P; Rakotomanana, F	MDPI	Remote Sens.	2020	10.3390/rs12101585
Razavi-Termeh, SV; Sadeghi-Niaraki, A; Choi, SM	MDPI	Remote Sens.	2020	10.3390/rs12101689
Giuffrida, S; Gagliano, F; Giannitrapani, E; Marisca, C; Napoli, G; Trovato, MR	MDPI	Sustainability	2020	10.3390/su12104022
Ghareeb, M; Seif, AK	SPRINGER INTERNATIONAL PUBLISHING AG	Innov. Infrastruct. Solut.	2020	10.1007/s41062-020-00293-z
Zhang, SR; Hou, DJ; Wang, C; Pan, F; Yan, L	ELSEVIER	Autom. Constr.	2020	10.1016/j.autcon.2020.103114

Table A1. Cont.

Authors	Publisher	Journal Name	Publication Year	DOY
Lin, NY; Chen, SP; Wang, SA; Yeh, C	EDINBURGH UNIV PRESS	Int. J. Humanit. Arts Comput.	2020	10.3366/ijhac.2020.0246
Filocamo, F; Di Paola, G; Mastrobuono, L; Roskopf, CM	MDPI	Resources-Basel	2020	10.3390/resources9030031
Kodaka, A; Kawasaki, A; Shirai, N; Acierto, RA; Zin, WW; Kohtake, N	FUJI TECHNOLOGY PRESS LTD	J. Disaster Res.	2020	10.20965/jdr.2020.p0312
Jakimow, B; van der Linden, S; Thiel, F; Frantz, D; Hostert, P	ELSEVIER SCI LTD	Environ. Modell. Softw.	2020	10.1016/j.envsoft.2020.104631
Nemoto, T; Masumoto, S; Raghavan, V; Nonogaki, S; Nakada, F	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2020	10.1007/s41324-020-00321-1
Dhiman, R; VishnuRadhan, R; Inamdar, AB; Eldho, I	SPRINGER	J. Coast. Conserv.	2020	10.1007/s11852-020-00734-y
Sejati, AW; Buchori, I; Rudiarto, I; Silver, C; Sulisty, K	BUCHAREST UNIV PRESS	J. Urban Reg. Anal.	2020	10.37043/JURA.2020.12.1.2
Frolov, A	STATE ACAD UNIV HUMANITIES	Istoriya	2020	10.18254/S207987840012436-8
Stoddart, R; Godfrey, B	UNIV ALBERTA	Evid. Based Lib. Inf. Pract.	2020	10.18438/eblip29721
Puttinaovarat, S; Horkaew, P	TAYLOR & FRANCIS LTD	Geomat. Nat. Hazards Risk	2020	10.1080/19475705.2020.1815869
Dong, YY; Xu, F; Liu, LY; Du, XP; Ren, BY; Guo, AT; Geng, Y; Ruan, C; Ye, HC; Huang, WJ; Zhu, YN	IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC	IEEE J. Sel. Top. Appl. Earth Observ. Remote Sens.	2020	10.1109/JSTARS.2020.3013340
Kostrikov, SV; Bubnov, DY; Pudlo, RA	V N KARAZIN KHARKIV NATL UNIV	Visn. V N Karazin Kharkiv Natl. Univ.-Ser. Geol Geogr. Ecol.	2020	10.26565/2410-7360-2020-52-12
Schwindt, S; Larrieu, K; Pasternack, GB; Rabone, G	ELSEVIER	SoftwareX	2020	10.1016/j.softx.2020.100438
Ishida, T; Li, HY	INDERSCIENCE ENTERPRISES LTD	Int. J. Web Grid Serv.	2020	
Czernecki, B; Glogowski, A; Nowosad, J	MDPI	Sustainability	2020	10.3390/su12010394
Afnarius, S; Akbar, F; Yuliani, F	MDPI	ISPRS Int. Geo-Inf.	2020	10.3390/ijgi9010052
Feng, QY; Flanagan, DC; Engel, BA; Yang, L; Chen, LD	ELSEVIER SCI LTD	Environ. Modell. Softw.	2020	10.1016/j.envsoft.2019.104569
Li, LQ; Ju, NP; He, C; Li, CL; Sheng, DC	SPRINGER HEIDELBERG	Landslides	2020	10.1007/s10346-019-01307-3
Jelokhani-Niaraki, M	TAYLOR & FRANCIS LTD	J. Decis. Syst.	2019	10.1080/12460125.2019.1698898
Nevistic, Z; Spoljaric, D	SCIENDO	GeoScape	2019	10.2478/geosc-2019-0011

Table A1. Cont.

Authors	Publisher	Journal Name	Publication Year	DOY
Farkas, G	UNIV TORONTO PRESS INC	Cartographica	2019	10.3138/cart.54.4.2018-0014
Sallwey, J; Schlick, R; Valverde, JPB; Junghanns, R; Lopez, FV; Stefan, C	MDPI	Water	2019	10.3390/w11112254
Hoover, B; Yaw, S; Middleton, R	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2020	10.1080/13658816.2019.1675885
Ishida, T; Hoshino, S	EMERALD GROUP PUBLISHING LTD	Int. J. Web Inf. Syst.	2019	10.1108/IJWIS-09-2018-0068
Rahmati, O; Kalantari, Z; Samadi, M; Uuemaa, E; Moghaddam, DD; Nalivan, OA; Destouni, G; Bui, DT	MDPI	Sustainability	2019	10.3390/su11205639
Kulawiak, M	ELSEVIER	Data Brief	2019	10.1016/j.dib.2019.104507
Voda, M; Graves, S; Berariu, CE	CLUJ UNIV PRESS	Geogr. Tech.	2019	10.21163/GT_2019.142.13
Quinn, S	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2020	10.1080/13658816.2019.1665672
Singh, H; Garg, RD; Karnatak, HC	SPRINGER HEIDELBERG	Earth Sci. Inform.	2019	10.1007/s12145-019-00378-z
Zhang, XQ; Zhong, M; Liu, SB; Zheng, LH; Chen, YM	MDPI	ISPRS Int. Geo-Inf.	2019	10.3390/ijgi8090364
Lee, S; Panahi, M; Pourghasemi, HR; Shahabi, H; Alizadeh, M; Shirzadi, A; Khosravi, K; Melesse, AM; Yekrangnia, M; Rezaie, F; Moeini, H; Pham, BT; Bin Ahmad, B	MDPI	Appl. Sci.-Basel	2019	10.3390/app9173495
Sismanidis, P; Keramitsoglou, I; Barberis, S; Dorotic, H; Bechtel, B; Kiranoudis, CT	MDPI	Remote Sens.	2019	10.3390/rs11172048
Lentini, V; Distefano, G; Castelli, F	SPRINGER HEIDELBERG	Bull. Eng. Geol. Environ.	2019	10.1007/s10064-018-1390-7
Mangiameli, M; Mussumeci, G; Roccaro, P; Vagliasindi, FGA	SPRINGER HEIDELBERG	Appl. Geomat.	2019	10.1007/s12518-019-00265-8
Aghajani, D; Abbaspour, M; Radfar, R; Mohammadi, A	SPRINGER	Int. J. Environ. Sci. Technol.	2019	10.1007/s13762-018-2091-2
Rossetto, R; De Filippis, G; Triana, F; Ghetta, M; Borsi, I; Schmid, W	ELSEVIER	Agric. Water Manage.	2019	10.1016/j.agwat.2019.105717
Kaya, E; Agca, M; Adiguzel, F; Cetin, M	TAYLOR & FRANCIS INC	Hum. Ecol. Risk Assess.	2019	10.1080/10807039.2018.1470896
Dabove, P	PATRON EDITORE S R L	Geam-Geoint. Ambient. Min.	2019	
Mirshafiei, P; Sadeghi-Niaraki, A; Shakeri, M; Choi, SM	MDPI	Water	2019	10.3390/w11081736
Narra, P; Coelho, C; Sancho, F	ELSEVIER SCI LTD	Ocean Coastal Manage.	2019	10.1016/j.ocecoaman.2019.104845

Table A1. Cont.

Authors	Publisher	Journal Name	Publication Year	DOY
Kulawiak, M; Dawidowicz, A; Pacholczyk, ME	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2019	10.1016/j.cageo.2019.04.011
Choosumrong, S; Humhong, C; Raghavan, V; Fenoy, G	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2019	10.1007/s41324-019-00248-2
Zou, ZQ; Cai, T; Cao, K	SAGE PUBLICATIONS LTD	Env. Plan. B-Urban Anal. City Sci.	2020	10.1177/2399808319862292
Pathak, S; Garg, RD; Jato-Espino, D; Lakshrni, V; Ojha, CSP	ACADEMIC PRESS LTD- ELSEVIER SCIENCE LTD	J. Environ. Manage.	2019	10.1016/j.jenvman.2019.04.082
Horton, P	COPERNICUS GESELLSCHAFT MBH	Geosci. Model Dev.	2019	10.5194/gmd-12-2915-2019
She, B; Hu, T; Zhu, XY; Bao, SM	TAYLOR & FRANCIS LTD	Geo-Spat. Inf. Sci.	2019	10.1080/10095020.2019.1645497
Kreklow, J	IWA PUBLISHING	J. Hydroinform.	2019	10.2166/hydro.2019.048
Siles, G; Charland, A; Voirin, Y; Benie, GB	ELSEVIER SCIENCE BV	Ecol. Inform.	2019	10.1016/j.ecoinf.2019.05.011
Mavroulis, S; Andreadakis, E; Spyrou, NI; Antoniou, V; Skourtsos, E; Papadimitriou, P; Kassaras, I; Kaviris, G; Tselentis, GA; Voulgaris, N; Carydis, P; Lekkas, E	ELSEVIER	Int. J. Disaster Risk Reduct.	2019	10.1016/j.ijdrr.2019.101169
Hansen, BD; Dahlhaus, PG; Milne, RG; MacLeod, AD; Pitfield, C	TAYLOR & FRANCIS INC	Soc. Nat. Resour.	2019	10.1080/08941920.2018.1559383
Lafrance, F; Daniel, S; Dragicevic, S	MDPI	ISPRS Int. Geo-Inf.	2019	10.3390/ijgi8060253
Muenchow, J; Schafer, S; Kruger, E	WILEY	Geogr. Compass	2019	10.1111/gec3.12441
Dolce, M; Speranza, E; Giordano, F; Borzi, B; Bocchi, F; Conte, C; Di Meo, A; Faravelli, M; Pascale, V	IST NAZIONALE DI OCEANOLOGRAFIA E DI GEOFISICA	Boll. Geofis. Teor. Appl.	2019	10.4430/bgta0254
Daras, G; Agard, B; Penz, B	SPRINGER VIEWEG-SPRINGER FACHMEDIEN WIESBADEN GMBH	Bus. Inf. Syst. Eng.	2019	10.1007/s12599-018-0548-y
Matney, JA; Slocumb, WS; Smith, JW; Bonsall, P; Supak, SK	SAGAMORE PUBL LLC	J. Park Recreat. Adm.	2019	10.18666/JPra-2019-9250
Bakibinga, P; Kabaria, C; Kyobutungi, C; Manyara, A; Mbaya, N; Mohammed, S; Njeri, A; Azam, I; Iqbal, R; Mazaffar, S; Rizvi, N; Rizvi, T; Rehman, HU; Ahmed, SAKS; Aiam, O; Khan, AZ; Rahman, O; Yusuf, R; Odubanjo, D; Ayobola, M; Fayehun, F; Omigbodun, A; Owoaje, E; Taiwo, O; Diggle, P; Aujia, N; Chen, YF; Gill, P; Griffiths, F; Harris, B; Madan, J; Lilford, RJ; Oyobode, OR; Pitidis, V; de Albuquerque, JP; Sartori, J; Taylor, C; Ulbrich, P; Uthman, O; Watson, SI; Yeboah, G	BMC	BMC Med. Res. Methodol.	2019	10.1186/s12874-019-0732-x

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Authors	Publisher	Journal Name	Publication Year	DOY
Frantz, D	MDPI	Remote Sens.	2019	10.3390/rs11091124
Kim, IH; Pow, CP; Wang, YC; Feng, CC	WILEY	Singap. J. Trop. Geogr.	2019	10.1111/sjtg.12263
Fayne, JV; Ahamed, A; Roberts-Pierel, J; Rumsey, AC; Kirschbaum, D	AMER GEOPHYSICAL UNION	Earth Interact.	2019	10.1175/EI-D-17-0022.1
Das, K; Pramanik, D; Santra, SC; Sengupta, S	ELSEVIER	Egypt. J. Remote Sens. Space Sci.	2019	10.1016/j.ejrs.2018.10.002
Goncalves, J; Pocas, I; Marcos, B; Mucher, CA; Honrado, JP	ELSEVIER	Int. J. Appl. Earth Obs. Geoinf.	2019	10.1016/j.jag.2018.11.011
Kulawiak, M; Kulawiak, M; Lubniewski, Z	MDPI	ISPRS Int. Geo-Inf.	2019	10.3390/ijgi8030144
Beyhan, B	ACAD SCI CZECH REPUBLIC, INST GEONICS	Morav. Geogr. Rep.	2019	10.2478/mgr-2019-0002
Vaitis, M; Feidas, H; Symeonidis, P; Kopsachilis, V; Dalaperas, D; Koukouroufli, N; Simos, D; Taskaris, S	SPRINGER HEIDELBERG	Earth Sci. Inform.	2019	10.1007/s12145-018-0351-9
De Donatis, M; Pappafico, GF; Romeo, RW	MDPI	ISPRS Int. Geo-Inf.	2019	10.3390/ijgi8020091
Kalpakis, V; Kokkos, N; Pisinaras, V; Sylaios, G	SPRINGER	J. Coast. Conserv.	2019	10.1007/s11852-018-0646-5
Kaku, K	ELSEVIER SCIENCE BV	Int. J. Disaster Risk Reduct.	2019	10.1016/j.ijdrr.2018.09.015
Singh, H; Karnatak, HC; Garg, RD	TAYLOR & FRANCIS LTD	Geocarto Int.	2019	10.1080/10106049.2017.1381178
Alberi, M; Baldoncini, M; Bottardi, C; Chiarelli, E; Landsberger, S; Raptis, KGC; Serafini, A; Strati, V; Mantovani, F	MDPI	Educ. Sci.	2019	10.3390/educsci9010015
Jayawardhana, UK; Gorsevski, PV	TAYLOR & FRANCIS LTD	Int. J. Digit. Earth	2019	10.1080/17538947.2017.1411535
Montagnetti, R; Rosati, P	EDIZIONI ALL INSEGNA GIGLIO SAS-ITALIAN NATL RESEARCH COUNC	Archeol. Calc.	2019	
Mariotti, S	EDIZIONI ALL INSEGNA GIGLIO SAS-ITALIAN NATL RESEARCH COUNC	Archeol. Calc.	2019	
Palombini, A; Fanini, B	EDIZIONI ALL INSEGNA GIGLIO SAS-ITALIAN NATL RESEARCH COUNC	Archeol. Calc.	2019	

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Authors	Publisher	Journal Name	Publication Year	DOY
Beconyte, G; Snezko, J; Balciunas, A; Vidugiryte-Pakeriene, I	TAYLOR & FRANCIS LTD	Cartogr. J.	2019	10.1080/00087041.2018.1533292
Montagnetti, R; Chiraz, PP; Ricci, A; Pickel, DG	ARCHEOMATICA	Archeomatica	2019	
Yermakov, V; Lunova, O; Averin, D	OLES GONCHAR DNIPRO NATL UNIV	J. Geol. Geogr. Geoecol.	2019	10.15421/111957
Calugaru, A; Leu, P; Damalan, A; Mihai, D	UNIV AGRICULTURAL SCIENCES & VETERINARY MEDICINE BUCHAREST	Sci. Pap.-Ser. E-Land Reclam. Earth Obs. Surv. Environ. Eng.	2019	
Idarraga, SAC; Vanegas, CED; Gomez, DMM	TECNOLOGICO ANTIOQUIA-INST UNIV, FAC INGENIERIA	Cuad. Act.	2019	
Sappa, G; Ferranti, F	PAGEPRESS PUBL	Acque Sotter.	2019	10.7343/as-2019-372
Onida, M; Faravelli, M; Gotti, A; Sarigiannis, D	PARLAR SCIENTIFIC PUBLICATIONS (P S P)	Fresenius Environ. Bull.	2019	
Alkazemi, BY	SCIENCE & INFORMATION SAI ORGANIZATION LTD	Int. J. Adv. Comput. Sci. Appl.	2019	
Laquidara, M	SAGE PUBLICATIONS INC	Transp. Res. Record	2018	10.1177/0361198118780834
Ahmed, B; Rahman, MS; Islam, R; Sammonds, P; Zhou, C; Uddin, K; Al-Hussaini, TM	MDPI	ISPRS Int. Geo-Inf.	2018	10.3390/ijgi7120485
Albano, R; Sole, A; Adamowski, J; Perrone, A; Inam, A	ELSEVIER SCIENCE BV	Int. J. Appl. Earth Obs. Geoinf.	2018	10.1016/j.jag.2018.06.019
Dawidowicz, A; Kulawiak, M	TAYLOR & FRANCIS LTD	Surv. Rev.	2018	10.1080/00396265.2017.1328331
Gordov, EP; Okladnikov, IG; Titov, AG; Voropay, NN; Ryazanova, AA; Lykosov, VN	PLEIADES PUBLISHING INC	Russ. Meteorol. Hydrol.	2018	10.3103/S106837391811002X
Oxoli, D; Molinari, ME; Brovelli, MA	SOC GEOLOGICA ITALIANA	Rend. Online Soc. Geol. Ital.	2018	10.3301/ROL.2018.56
Jan, JF	MDPI	ISPRS Int. Geo-Inf.	2018	10.3390/ijgi7110426
Liu, ZP; Du, GM; Cai, J; Zhou, F; Liu, J; Bian, K	SCIENCE PRESS	Rock Soil Mech.	2018	10.16285/j.rsm.2017.0221
Jeong, JS; Gonzalez-Gomez, D	ASOC ESPANOLA CIENCIA REGIONAL-AECR	Investig. Reg.	2018	
Rossetto, R; De Filippis, G; Borsi, I; Foglia, L; Cannata, M; Criollo, R; Vazquez-Sune, E	ELSEVIER SCI LTD	Environ. Modell. Softw.	2018	10.1016/j.envsoft.2018.06.007

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Authors	Publisher	Journal Name	Publication Year	DOY
Rauter, M; Kofler, A; Huber, A; Fellin, W	COPERNICUS GESELLSCHAFT MBH	Geosci. Model Dev.	2018	10.5194/gmd-11-2923-2018
Walter, SHG; Muller, JP; Sidiropoulos, P; Tao, Y; Gwinner, K; Putri, ARD; Kim, JR; Steikert, R; van Gasselt, S; Michael, GG; Watson, G; Schreiner, BP	AMER GEOPHYSICAL UNION	Earth Space Sci.	2018	10.1029/2018EA000389
McCord, P; Tonini, F; Liu, JG	ELSEVIER SCI LTD	Appl. Geogr.	2018	10.1016/j.apgeog.2018.05.001
Stefan, C; Ansems, N	SPRINGER INTERNATIONAL PUBLISHING AG	Sustain. Wat. Resour. Manag.	2018	10.1007/s40899-017-0212-6
Correia, R; Duarte, L; Teodoro, AC; Monteiro, A	MDPI	Educ. Sci.	2018	10.3390/educsci8020083
Koo, H; Chun, Y; Griffith, DA	WILEY	Trans. GIS	2018	10.1111/tgis.12452
Piedelobo, L; Ortega-Terol, D; del Pozo, S; Hernandez-Lopez, D; Ballesteros, R; Moreno, MA; Molina, JL; Gonzalez-Aguilera, D	MDPI	ISPRS Int. Geo-Inf.	2018	10.3390/ijgi7060220
Leroux, C; Jones, H; Pichon, L; Guillaume, S; Lamour, J; Taylor, J; Naud, O; Crestey, T; Lablee, JL; Tisseyre, B	MDPI	Agriculture-Basel	2018	10.3390/agriculture8060073
Seguel, IAR; Quezada, CAR; Contreras, HEDF; Reyes, PZV	UNIV BIO-BIO, DEPT PLANIFICACION & DISENO	Urbano	2018	10.22320/07183607.2018.21.37.03
Kim, J	COASTAL EDUCATION & RESEARCH FOUNDATION	J. Coast. Res.	2018	10.2112/SI85-299.1
Zhang, N; Jin, S; Ai, CF; Ding, WY	IWA PUBLISHING	J. Hydroinform.	2018	10.2166/hydro.2017.113
Rovithis, E; Makra, K; Kirtas, E; Manesis, C; Bliziotis, D; Konstantinidou, K	EARTHQUAKE ENGINEERING RESEARCH INST	Earthq. Spectra	2018	10.1193/052917EQS098DP
Yakubailik, OE; Kadochnikov, AA; Tokarev, AV	SPRINGER	Optoelectron. Instrum. Data Proc.	2018	10.3103/S8756699018030056
Mileu, N; Queiros, M	MDPI	ISPRS Int. Geo-Inf.	2018	10.3390/ijgi7050184
Bock, M; Conrad, O; Gunther, A; Gehrt, E; Baritz, R; Bohner, J	COPERNICUS GESELLSCHAFT MBH	Geosci. Model Dev.	2018	10.5194/gmd-11-1641-2018
Evangelidis, K; Papadopoulos, T	MDPI	Geosciences	2018	10.3390/geosciences8040139
Jager, D; Kreuzer, T; Wilde, M; Bemm, S; Terhorst, B	ELSEVIER SCIENCE BV	Geomorphology	2018	10.1016/j.geomorph.2015.10.008
Duarte, L; Silva, P; Teodoro, AC	MDPI	ISPRS Int. Geo-Inf.	2018	10.3390/ijgi7030109

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Authors	Publisher	Journal Name	Publication Year	DOY
Borsch, S; Khristoforov, A; Krovotyntsev, V; Leontieva, E; Simonov, Y; Zatyagalova, V	MDPI	Geosciences	2018	10.3390/geosciences8030093
Yaqot, M; Trigunarsyah, B	ICE PUBLISHING	Infrastruct. Asset Manag.	2018	10.1680/jinam.17.00009
Vacca, G; Fiorino, DR; Pili, D	MDPI	ISPRS Int. Geo-Inf.	2018	10.3390/ijgi7020049
Liao, M; Qian, XL	UNIV OSIJEK, TECH FAC	Teh. Vjesn.	2018	10.17559/TV-20170601094307
Casadei, S; Pierleoni, A; Bellezza, M	MDPI	Sustainability	2018	10.3390/su10020485
Tang, JY; Matyas, CJ	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2018	10.1016/j.cageo.2017.11.011
Quill, T; Djeno, M	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	J. Map Geogr. Libr.	2018	10.1080/15420353.2018.1628500
Godfrey, B; Stoddart, R	AMER LIBRARY ASSOC	Inf. Technol. Libr.	2018	10.6017/ital.v37i2.10208
Kulawiak, M; Chybicki, A	TAYLOR & FRANCIS INC	Mar. Geod.	2018	10.1080/01490419.2018.1469557
Van Cauwenbergh, N; Ciuro, AB; Ahlers, R	RESILIENCE ALLIANCE	Ecol. Soc.	2018	10.5751/ES-09987-230202
Castelli, F; Lentini, V; Ferraro, A; Grasso, S	IST NAZIONALE DI GEOFISICA E VULCANOLOGIA	Ann. Geophys.	2018	10.4401/ag-7705
Fonte, CC; Fontes, D; Cardoso, A	KASSEL UNIV PRESS GMBH	Int. J. Online Eng.	2018	10.3991/ijoe.v14i02.8191
Siles, G; Voirin, Y; Benie, GB	ELSEVIER SCIENCE BV	Ecol. Inform.	2018	10.1016/j.ecoinf.2017.11.005
Falco, E; Malavolta, I; Radzimski, A; Ruberto, S; Iovino, L; Gallo, F	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	J. Urban Technol.	2018	10.1080/10630732.2017.1362901
Kunapo, J; Fletcher, TD; Ladson, AR; Cunningham, L; Burns, MJ	TAYLOR & FRANCIS LTD	Urban Water J.	2018	10.1080/1573062X.2018.1424216
Ahlqvist, O; Khodke, N; Ramnath, R	ELSEVIER SCI LTD	Comput. Environ. Urban Syst.	2018	10.1016/j.compenvurbsys.2017.08.013
Phuong, NH; Nam, NT; Truyen, PT	VIETNAM ACAD SCIENCE & TECHNOLOGY-VAST	Vietnam J. Earth Sci.	2018	10.15625/0866-7187/40/3/12638
Voutos, Y; Mylonas, P; Spyrou, E; Charou, E	MDPI AG	J. Sens. Actuar. Netw.	2017	10.3390/jsan6040027
Karnatak, HC; Singh, H; Garg, RD	NATL ACAD SCIENCES INDIA	Proc. Nat. Acad. Sci. India A	2017	10.1007/s40010-017-0442-x
Agrawal, S; Gupta, RD	SPRINGER HEIDELBERG	Arab. J. Geosci.	2017	10.1007/s12517-017-3296-2
Hamylton, SM	SAGE PUBLICATIONS LTD	Prog. Phys. Geogr.	2017	10.1177/0309133317744998

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Authors	Publisher	Journal Name	Publication Year	DOY
Mikovits, C; Tscheikner-Gratl, F; Jasper-Tonnies, A; Einfalt, T; Huttenlau, M; Schopf, M; Kinzel, H; Rauch, W; Kleidorfer, M	ASCE-AMER SOC CIVIL ENGINEERS	J. Water Resour. Plan. Manage.-ASCE	2017	10.1061/(ASCE)WR.1943-5452.0000840
Huang, J; Buchanan, SM; Bishop, TFA; Triantafilis, J	WILEY	Soil Use Manage.	2017	10.1111/sum.12383
Castelli, F; Lentini, V; Grasso, S	SPRINGER	Bull. Earthq. Eng.	2017	10.1007/s10518-017-0163-1
Javadnejad, F; Gillins, DT; Higgins, CC; Gillins, MN	ASCE-AMER SOC CIVIL ENGINEERS	J. Comput. Civil. Eng.	2017	10.1061/(ASCE)CP.1943-5487.0000710
Arai, K	SCIENCE & INFORMATION SAI ORGANIZATION LTD	Int. J. Adv. Comput. Sci. Appl.	2017	
Jun, S; Lee, S	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2017	10.1007/s41324-017-0138-y
Mushongal, HT; Banda, F; Mulolwa, A	CONSAS CONFERENCE	S. Afr. J. Geomat.	2017	10.4314/sajg.v6i3.4
Barik, RK	IGI GLOBAL	Int. J. Agric. Environ. Inf. Syst.	2017	10.4018/IJAEIS.2017100104
Toschi, I; Nocerino, E; Remondino, F	REED BUSINESS-GEO	GIM Int.	2017	
Valensise, G; Tarabusi, G; Guidoboni, E; Ferrari, G	ELSEVIER SCIENCE BV	Int. J. Disaster Risk Reduct.	2017	10.1016/j.ijdrr.2017.09.014
Mizutani, Y; Yamamoto, K	MDPI AG	ISPRS Int. Geo-Inf.	2017	10.3390/ijgi6100303
Veenendaal, B; Brovelli, MA; Li, SN	MDPI AG	ISPRS Int. Geo-Inf.	2017	10.3390/ijgi6100317
He, YR; Zhang, DJ; Fang, YH	ELSEVIER SCIENCE BV	Int. J. Disaster Risk Reduct.	2017	10.1016/j.ijdrr.2017.08.007
Beccati, A; Gerken, J; Quast, C; Yilmaz, P; Glockner, FO	BIOMED CENTRAL LTD	BMC Bioinformatics	2017	10.1186/s12859-017-1841-3
Golly, A; Turowski, JM	COPERNICUS GESELLSCHAFT MBH	Earth Surf. Dyn.	2017	10.5194/esurf-5-557-2017
Lagmay, AMFA; Racoma, BA; Aracan, KA; Alconis-Ayco, J; Saddi, IL	SCIENCE PRESS	J. Environ. Sci.	2017	10.1016/j.jes.2017.03.014
Oxoli, D; Prestifilippo, G; Bertocchi, D; Zurbaran, M	PATRON EDITORE S R L	Geam-Geoint. Ambient. Min.	2017	
Baiocchi, V; Camuccio, P; Zagari, M; Ceglia, A; Del Gobbo, S; Purri, F; Cipollini, L; Mezzapesa, M; Liso, L; Vatore, F	PATRON EDITORE S R L	Geam-Geoint. Ambient. Min.	2017	
Moreri, KK; Maphale, L; Nkhwanana, N	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2017	10.1007/s41324-017-0123-5
Gong, H; Simwanda, M; Murayama, Y	MDPI AG	ISPRS Int. Geo-Inf.	2017	10.3390/ijgi6080257
Ciulli, M; Federici, B; Ferrando, I; Marzocchi, R; Sguerso, D; Tattoni, C; Vitti, A; Zatelli, P	MDPI AG	ISPRS Int. Geo-Inf.	2017	10.3390/ijgi6070225

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Farkas, G	SPRINGER HEIDELBERG	J. Geogr. Syst.	2017	10.1007/s10109-017-0248-z
Nakayama, Y; Nakamura, K; Saito, H; Fukumoto, R	MDPI	Geosciences	2017	10.3390/geosciences7020022
Favretto, A; Callegher, B	UNIV TORONTO PRESS INC	Cartographica	2017	10.3138/cart.52.2.3781
Singh, YK; Dutta, U; Prabhu, TSM; Prabu, I; Mhatre, J; Khare, M; Srivastava, S; Dutta, S	MDPI	Hydrology	2017	10.3390/hydrology4020030
Harvey, AS; Fotopoulos, G; Hall, B; Amolins, K	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2017	10.1016/j.cageo.2017.02.008
Calera, A; Campos, I; Osann, A; D'Urso, G; Menenti, M	MDPI	Sensors	2017	10.3390/s17051104
Olyazadeh, R; Sudmeier-Rieux, K; Jaboyedoff, M; Derron, MH; Devkota, S	COPERNICUS GESELLSCHAFT MBH	Nat. Hazards Earth Syst. Sci.	2017	10.5194/nhess-17-549-2017
Grippa, T; Lennert, M; Beaumont, B; Vanhuyse, S; Stephenne, N; Wolff, E	MDPI AG	Remote Sens.	2017	10.3390/rs9040358
Guenzi, D; Fratianni, S; Boraso, R; Cremonini, R	SPRINGER HEIDELBERG	Earth Sci. Inform.	2017	10.1007/s12145-016-0278-y
Albano, R; Mancusi, L; Sole, A; Adamowski, J	TAYLOR & FRANCIS LTD	Geomat. Nat. Hazards Risk	2017	10.1080/19475705.2017.1388854
Willmes, C; Becker, D; Verheul, J; Yener, Y; Zickel, M; Bolten, A; Bubenzer, O; Bareth, G	EUROPEAN COMMISSION, JOINT RESEARCH CENTRE	Int. J. Spat. Data Infrastruct. Res.	2017	10.2902/1725-0463.2017.12.art3
Cavur, M; Duzgun, HS	TAYLOR & FRANCIS LTD	J. Spat. Sci.	2017	10.1080/14498596.2016.1230837
Tora, S; Sacchini, S; Listes, E; Bogdanovic, T; Di Lorenzo, A; Smajlovic, M; Smajlovic, A; Filipovic, JV; Tahirovic, V; Sukovic, D; Beljkas, B; Xinxo, A; Maci, R; Colangeli, P; Di Giacinto, F; Conte, A	UNIV NAPLES FEDERICO II	Geospatial Health	2017	10.4081/gh.2017.593
Hu, LJ; He, ZY; Liu, JP	TAYLOR & FRANCIS LTD	Cartogr. J.	2017	10.1080/00087041.2016.1193273
Marzocchi, R; Fagandini, R; Beggiano, L; Berti, E; Ardini, R; Freddo, N; Cosso, T; Missaglia, M	MEDIAGEO SCIENCE & TECHNOLOGY PUBLISHING	GeoMedia	2017	
Ying, W	TEKNOSCIENZE PUBL	Agro Food Ind. Hi-Tech	2017	
Rahman, K; Ray, N; Giuliani, G; Maringanti, C; George, C; Lehmann, A	MAIK NAUKA/INTERPERIODICA/SPRINGER	Water Resour.	2017	10.1134/S0097807817010067
Tsai, CH	INDERSCIENCE ENTERPRISES LTD	Int. J. Comput. Appl. Technol.	2017	10.1504/IJCAT.2017.082867

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Bernardoni, S; Montanari, M; Trojanis, R	EDIZIONI ALL INSEGNA GIGLIO SAS-ITALIAN NATL RESEARCH COUNC	Archeol. Calc.	2017	
Duarte, L; Teodoro, AC; Moutinho, O; Goncalves, JA	TAYLOR & FRANCIS LTD	Int. J. Remote Sens.	2017	10.1080/01431161.2016.1259685
Sante, I; Pacurucu, N; Boullon, M; Garcia, AM; Miranda, D	WILEY-BLACKWELL	Trans. GIS	2016	10.1111/tgis.12223
Lamastra, L; Balderacchi, M; Di Guardo, A; Monchiero, M; Trevisan, M	ELSEVIER	Sci. Total Environ.	2016	10.1016/j.scitotenv.2016.07.043
Chen, XN; Elmes, G; Ye, XY; Chang, JH	SPRINGER	GeoJournal	2016	10.1007/s10708-016-9745-8
Tao, Y; Muller, JP; Poole, W	ACADEMIC PRESS INC ELSEVIER SCIENCE	Icarus	2016	10.1016/j.icarus.2016.06.017
Fujita, S; Yamamoto, K	SCIENCE & INFORMATION SAI ORGANIZATION LTD	Int. J. Adv. Comput. Sci. Appl.	2016	
Liang, JM; Gong, JH; Liu, J; Zou, YL; Zhang, JM; Sun, J; Chen, SS	MDPI AG	ISPRS Int. Geo-Inf.	2016	10.3390/ijgi5110212
Dile, YT; Daggupati, P; George, C; Srinivasan, R; Arnold, J	ELSEVIER SCI LTD	Environ. Modell. Softw.	2016	10.1016/j.envsoft.2016.08.004
Yang, BY	ELSEVIER SCI LTD	Appl. Geogr.	2016	10.1016/j.apgeog.2016.09.006
Tan, XC; Di, LP; Deng, MX; Huang, F; Ye, XY; Sha, ZY; Sun, ZH; Gong, WS; Shao, YZ; Huang, C	ELSEVIER SCI LTD	Environ. Modell. Softw.	2016	10.1016/j.envsoft.2016.07.001
Morgan, JD	WILEY	Trans. GIS	2016	10.1111/tgis.12197
Lindsay, JB	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2016	10.1016/j.cageo.2016.07.003
Suzuki, S	FUJI TECHNOLOGY PRESS LTD	J. Disaster Res.	2016	10.20965/jdr.2016.p0935
Estwick, NM; Griffin, RW; James, AA; Roberson, SG	UNIV OF WISCONSIN EXTENSION JOURNAL INC	J. Ext.	2016	
Chen, YF; Perrella, AML	UNIV TORONTO PRESS INC	Cartographica	2016	10.3138/cart.51.3.3288
Sofina, N; Ehlers, M	IEEE-INST ELECTRICAL ELECTRONICS ENGINEERS INC	IEEE J. Sel. Top. Appl. Earth Observ. Remote Sens.	2016	10.1109/JSTARS.2016.2542074
Aburizaiza, AO; Rice, MT	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2016	10.1007/s41324-016-0042-x
Zhou, JW; Yamamoto, K	SCIENCE & INFORMATION SAI ORGANIZATION LTD	Int. J. Adv. Comput. Sci. Appl.	2016	

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Authors	Publisher	Journal Name	Publication Year	DOY
Geri, F; La Porta, N; Zottele, F; Ciolli, M	MDPI AG	ISPRS Int. Geo-Inf.	2016	10.3390/ijgi5070100
Spekken, M; de Bruin, S; Molin, JP; Sparovek, G	ELSEVIER SCI LTD	Comput. Electron. Agric.	2016	10.1016/j.compag.2016.03.013
Duarte, L; Teodoro, AC; Goncalves, JA; Soares, D; Cunha, M	SPRINGER	Environ. Monit. Assess.	2016	10.1007/s10661-016-5349-5
Lee, CF; Huang, CM; Tsao, TC; Wei, LW; Huang, WK; Cheng, CT; Chi, CC	SOUTHEAST ASIAN GEOTECHNICAL SOC	Geotech. Eng.	2016	
Aye, ZC; Charriere, M; Olyazadeh, R; Derron, MH; Jaboyedoff, M	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2016	10.1007/s41324-016-0018-x
Olyazadeh, R; Aye, ZC; Jaboyedoff, M; Derron, MH	SPRINGER SINGAPORE PTE LTD	Spat. Inf. Res.	2016	10.1007/s41324-016-0017-y
Tang, JY; Matyas, CJ	AMER METEOROLOGICAL SOC	J. Atmos. Ocean. Technol.	2016	10.1175/JTECH-D-15-0118.1
Kouziokas, GN	ELSEVIER SCIENCE BV	Environ. Technol. Innov.	2016	10.1016/j.eti.2016.01.006
Jenny, B; Savric, B; Liem, J	TAYLOR & FRANCIS LTD	Int. J. Digit. Earth	2016	10.1080/17538947.2014.1002867
Aye, ZC; Sprague, T; Cortes, VJ; Prenger-Berninghoff, K; Jaboyedoff, M; Derron, MH	ELSEVIER SCIENCE BV	Int. J. Disaster Risk Reduct.	2016	10.1016/j.ijdrr.2015.12.001
Sadler, JM; Ames, DP; Khattar, R	IWA PUBLISHING	J. Hydroinform.	2016	10.2166/hydro.2015.092
Doula, MK; Sarris, A; Hliaoutakis, A; Kydonakis, A; Papadopoulos, NS; Argyriou, L	SPRINGER	Environ. Monit. Assess.	2016	10.1007/s10661-016-5139-0
Peragon, JM; Delgado, A; Diaz, JAR; Perez-Latorre, FJ	ELSEVIER SCIENCE BV	Agric. Water Manage.	2016	10.1016/j.agwat.2015.12.005
Tayyebi, A; Meehan, TD; Dischler, J; Radloff, G; Ferris, M; Gratton, C	ELSEVIER SCI LTD	Comput. Electron. Agric.	2016	10.1016/j.compag.2015.12.003
Steiniger, S; Poorazizi, ME; Hunter, AJS	COGITATIO PRESS	Urban Plan.	2016	10.17645/up.v1i2.607
Varadharajan, RB; Pavel, T; Mohan, S	PENERBIT UTM PRESS	J. Teknol.	2016	
Jamhawi, MM; Hajahjah, ZA	UNIV AGEAN, DEPT MEDITERRANEAN STUD	Mediterr. Archaeol. Archaeom.	2016	10.5281/zenodo.47541
Myers, D; Dalgity, A; Avramides, I	EMERALD GROUP PUBLISHING LTD	J. Cult. Herit. Manag. Sustain. Dev.	2016	10.1108/JCHMSD-02-2016-0010
Attorre, F; Bonacquisti, S; Francesconi, F; Sambucini, V; Martellos, S	TAYLOR & FRANCIS LTD	Plant Biosyst.	2016	10.1080/11263504.2016.1179230
Ribeiro, AM; Sousa, V; Cardoso, A	KASSEL UNIV PRESS GMBH	Int. J. Online Eng.	2016	10.3991/ijoe.v12i04.5261

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Authors	Publisher	Journal Name	Publication Year	DOY
Aye, ZC; Jaboyedoff, M; Derron, MH; van Westen, CJ; Hussin, HY; Ciurean, RL; Frigerio, S; Pasuto, A	COPERNICUS GESELLSCHAFT MBH	Nat. Hazards Earth Syst. Sci.	2016	10.5194/nhess-16-85-2016
YukseK, K; Alparslan, M; Mendi, E	COPERNICUS GESELLSCHAFT MBH	Nat. Hazards Earth Syst. Sci.	2016	10.5194/nhess-16-123-2016
Zinoviev, AT; Lovtskaya, OV; Baldakov, NA	L N GUMILYOV EURASIAN NATL UNIV	Eurasian J. Math. Comput. Appl.	2016	10.32523/2306-6172-2016-4-3-39-50
Pettygrove, MW; Ghose, R	IGI GLOBAL	Int. J. Appl. Geospat. Res.	2016	10.4018/IJAGR.2016010102
Banos, R; Wandosell, G; Parra, MC	EMERALD GROUP PUBLISHING LTD	J. Knowl. Manag.	2016	10.1108/JKM-06-2015-0218
Dolega, L; Pavlis, M; Singleton, A	ELSEVIER SCI LTD	J. Retail. Consum. Serv.	2016	10.1016/j.jretconser.2015.08.013
Kalabokidis, K; Ager, A; Finney, M; Athanasis, N; Palaiologou, P; Vasilakos, C	COPERNICUS GESELLSCHAFT MBH	Nat. Hazards Earth Syst. Sci.	2016	10.5194/nhess-16-643-2016
Afonin, AN; Sevryukov, SY; Solovyov, PA; Luneva, NN	ST PETERSBURG UNIV PRESS	Vestn. St. Petersburg. Univ. Earth Sci.	2016	10.21638/11701/spbu07.2016.408
Biljecki, F; Heuvelink, GBM; Ledoux, H; Stoter, J	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2015	10.1080/13658816.2015.1073292
Weng, Y; Cheng, WY	NADIA	Int. J. Grid Distrib. Comput.	2015	
Drypczewski, K; Stepnowski, A; Bruniecki, K	GDANSK UNIV TECHNOLOGY	Pol. Marit. Res.	2015	10.1515/pomr-2015-0066
Lichter, M; Grinberger, AY; Felsenstein, D	MDPI	ISPRS Int. Geo-Inf.	2015	10.3390/ijgi4041827
Yang, YJ; Sun, YQ; Li, SN; Zhang, SL; Wang, KY; Hou, HP; Xu, SS	MDPI	ISPRS Int. Geo-Inf.	2015	10.3390/ijgi4042078
Karashima, K; Ohgai, A; Tadamura, K	ELSEVIER	Front. Archit. Res.	2015	10.1016/j.foar.2015.08.001
Tarjuelo, JM; Rodriguez-Diaz, JA; Abadia, R; Camacho, E; Rocamora, C; Moreno, MA	ELSEVIER SCIENCE BV	Agric. Water Manage.	2015	10.1016/j.agwat.2015.08.009
Chakraborty, A; Wilson, B; Sarraf, S; Jana, A	ELSEVIER SCIENCE BV	J. Urban Manag.	2015	10.1016/j.jum.2015.12.001
Damm, B; Klose, M	ELSEVIER	Geomorphology	2015	10.1016/j.geomorph.2015.03.021
Poggio, L; Gimona, A	ELSEVIER SCI LTD	Spat. Stat.	2015	10.1016/j.spasta.2015.04.006
Zaragozi, B; Belda, A; Gimenez, P; Navarro, JT; Bonet, A	ELSEVIER SCIENCE BV	Ecol. Inform.	2015	10.1016/j.ecoinf.2015.08.001
Reed, D; Barr, WA; Mcpherron, SP; Bobe, R; Geraads, D; Wynn, JG; Alemseged, Z	WILEY	Evol. Anthropol.	2015	10.1002/evan.21466

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Authors	Publisher	Journal Name	Publication Year	DOY
Sidiropoulos, P; Muller, JP	PERGAMON-ELSEVIER SCIENCE LTD	Planet Space Sci.	2015	10.1016/j.pss.2015.06.017
Ota, M; Plews, R	TAYLOR & FRANCIS INC	Cartogr. Geogr. Inf. Sci.	2015	10.1080/15230406.2015.1031701
Delgado, F; Martinez, R; Puche, J; Finat, J	ELSEVIER	Comput. Ind.	2015	10.1016/j.compind.2015.07.012
Leidig, M; Teeuw, R	ELSEVIER	Int. J. Appl. Earth Obs. Geoinf.	2015	10.1016/j.jag.2015.05.012
Magyari-Saska, Z	CLUJ UNIV PRESS	Geogr. Tech.	2015	
Yamamoto, K; Fujita, S	SCIENCE & INFORMATION SAI ORGANIZATION LTD	Int. J. Adv. Comput. Sci. Appl.	2015	
Aye, ZC; Jaboyedoff, M; Derron, MH; van Westen, CJ	MDPI	ISPRS Int. Geo-Inf.	2015	10.3390/ijgi4031201
Duarte, L; Teodoro, AC; Goncalves, JA; Dias, AJG; Marques, JE	SPRINGER	Environ. Earth Sci.	2015	10.1007/s12665-015-4222-0
Musungu, K; Jacobs, D	CONSAS CONFERENCE	S. Afr. J. Geomat.	2015	10.4314/sajg.v4i3.2
Yue, P; Zhang, MD; Tan, ZY	ELSEVIER SCI LTD	Environ. Modell. Softw.	2015	10.1016/j.envsoft.2015.03.017
Ramirez Camargo, L; Zink, R; Dorner, W; Stoeglehner, G	ELSEVIER SCI LTD	Comput. Environ. Urban Syst.	2015	10.1016/j.compenvurbsys.2015.03.002
Larocque, GR; Bhatti, J; Arsenault, A	ELSEVIER SCIENCE BV	Ecol. Model.	2015	10.1016/j.ecolmodel.2014.08.003
Brovelli, MA; Minghini, M; Zamboni, G	TAYLOR & FRANCIS LTD	Int. J. Digit. Earth	2015	10.1080/17538947.2014.887150
Enescu, II; Vescoukis, V; Enescu, CMI; Muller, F; Panchaud, NH; Hurni, L	TAYLOR & FRANCIS LTD	Cartogr. J.	2015	10.1080/00087041.2015.1119469
Han, G; Chen, J; He, CY; Li, SN; Wu, H; Liao, AP; Peng, S	ELSEVIER	ISPRS-J. Photogramm. Remote Sens.	2015	10.1016/j.isprsjprs.2014.07.012
Yang, Y; Tang, JY; Luo, H; Law, R	ELSEVIER SCI LTD	Int. J. Hosp. Manag.	2015	10.1016/j.ijhm.2015.02.008
Swain, NR; Latu, K; Christensen, SD; Jones, NL; Nelson, EJ; Ames, DP; Williams, GP	ELSEVIER SCI LTD	Environ. Modell. Softw.	2015	10.1016/j.envsoft.2015.01.014
Rossetto, R; Borsi, I; Foglia, L	SOC GEOLOGICA ITALIANA	Rend. Online Soc. Geol. Ital.	2015	10.3301/ROL.2015.113
Bavusi, M; Bianca, M; Izzi, F; Di Leo, P; Parisi, S; Pulice, I; Schiattarella, M	SOC GEOLOGICA ITALIANA	Rend. Online Soc. Geol. Ital.	2015	10.3301/ROL.2015.46

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Authors	Publisher	Journal Name	Publication Year	DOY
Vijay, R; Sharma, A; Kumar, M; Shende, V; Chakrabarti, T; Gupta, R	WORLD SCIENTIFIC PUBL CO PTE LTD	Fluct. Noise Lett.	2015	10.1142/S0219477515500054
Zhang, DJ; Chen, XW; Yao, HX	MDPI AG	Water	2015	10.3390/w7020780
Saltenberger, J; Li, YW; Tsou, MH; Bahramzi, S	INDERSCIENCE ENTERPRISES LTD	Int. J. Healthc. Technol. Manag.	2015	10.1504/IJHTM.2015.070520
Baucic, M; Medak, D	SVENCILISTE U ZAGREBU, FAKULTET PROMETNIH ZNANOSTI	Promet	2015	10.7307/ptt.v27i2.1562
Knorchen, A; Ketzler, G; Schneider, C	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2015	10.1016/j.cageo.2014.10.003
Raco, B; Bucciatti, A; Corongiu, M; Lavorini, G; Macera, P; Manetti, F; Mari, R; Masetti, G; Menichetti, S; Nisi, B; Protano, G; Romanelli, S	PAGEPRESS PUBL	Acque Sotter.	2015	10.7343/AS-100-15-0127
Bhowmik, AK; Metz, M; Schafer, RB	ELSEVIER SCI LTD	Environ. Modell. Softw.	2015	10.1016/j.envsoft.2014.10.017
Ibrahim, WYW; Ludin, ANM	PENERBIT UTM PRESS	Int. J. Built Environ. Sustain.	2015	
Coruhlu, YE; Demir, O	YILDIZ TECHNICAL UNIV	Sigma J. Eng. Nat. Sci.	2015	
Hilde, T; Paterson, R	ACADEMIC PRESS LTD- ELSEVIER SCIENCE LTD	J. Environ. Manage.	2014	10.1016/j.jenvman.2014.05.039
Zavala-Romero, O; Ahmed, A; Chassignet, EP; Zavala-Hidalgo, J; Eguiarte, AF; Meyer-Baese, A	ELSEVIER SCI LTD	Environ. Modell. Softw.	2014	10.1016/j.envsoft.2014.08.029
Ion, S; Marinescu, D; Cruceanu, SG; Iordache, V	ELSEVIER SCI LTD	Environ. Modell. Softw.	2014	10.1016/j.envsoft.2014.09.012
Morgado, P; Gomes, E; Costa, N	ELSEVIER SCI LTD	Ocean Coastal Manage.	2014	10.1016/j.ocecoaman.2014.09.022
Kuby, M; Araz, OM; Palmer, M; Capar, I	PERGAMON-ELSEVIER SCIENCE LTD	Int. J. Hydrog. Energy	2014	10.1016/j.ijhydene.2014.08.104
Supak, SK; Devine, HA; Brothers, GL; Rich, SR; Shen, WB	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	J. Travel Tour. Mark.	2014	10.1080/10548408.2014.890153
Bortoluzzi, D; Casciati, F; Elia, L; Faravelli, L	TECHNO-PRESS	Earthq. Struct.	2014	10.12989/eas.2014.7.4.449
Larocque, GR; Bhatti, J; Arsenault, A	ELSEVIER SCIENCE BV	Ecol. Model.	2014	10.1016/j.ecolmodel.2014.06.011
Zhang, AJ; Gao, JX; Ji, C; Sun, JY; Bao, Y	ELSEVIER	Trans. Nonferrous Met. Soc. China	2014	10.1016/S1003-6326(14)63430-0

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Authors	Publisher	Journal Name	Publication Year	DOY
French, NHF; McKenzie, D; Erickson, T; Koziol, B; Billmire, M; Endsley, KA; Scheinerman, NKY; Jenkins, L; Miller, ME; Ottmar, R; Prichard, S	AMER GEOPHYSICAL UNION	Earth Interact.	2014	10.1175/EI-D-14-0002.1
Gajbe, A; Shankar, A; Rodriguez, S	WILEY-BLACKWELL	Trans. GIS	2014	10.1111/tgis.12066
Delmelle, EM; Zhu, HM; Tang, WW; Casas, I	ELSEVIER SCI LTD	Appl. Geogr.	2014	10.1016/j.apgeog.2014.05.007
Wan, ZM; Hong, Y; Khan, S; Gourley, J; Flamig, Z; Kirschbaum, D; Tang, GQ	ELSEVIER SCI LTD	Environ. Modell. Softw.	2014	10.1016/j.envsoft.2014.04.007
Wu, CI; Kung, HY; Chen, CH; Kuo, LC	PERGAMON-ELSEVIER SCIENCE LTD	Expert Syst. Appl.	2014	10.1016/j.eswa.2013.12.049
Lee, SH; Hwang, WJ; Jung, JJ; Kwon, KR	IEICE-INST ELECTRONICS INFORMATION COMMUNICATIONS ENG	IEICE Trans. Fundam. Electron. Commun. Comput. Sci.	2014	10.1587/transfun.E97.A.1595
Luan, H; Law, J	MDPI AG	ISPRS Int. Geo-Inf.	2014	10.3390/ijgi3020481
Frontoni, E; Mancini, A; Zingaretti, P; Malinverni, ES; Pesaresi, S; Biondi, E; Pandolfi, M; Marseglia, M; Sturari, M; Zabaglia, C	MDPI	ISPRS Int. Geo-Inf.	2014	10.3390/ijgi3020853
Lee, WS; Chun, JA; Kang, K	ELSEVIER	J. Hydrol.	2014	10.1016/j.jhydrol.2014.03.029
Gebel, M; Meissner, R; Halbfass, S; Hagenau, J; Duan, SH	SISEF-SOC ITALIANA SELVICOLTURA ECOL FORESTALE	iForest	2014	10.3832/ifor1169-007
Keon, D; Steinberg, B; Yeh, H; Pancake, CM; Wright, D	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2014	10.1080/13658816.2013.875548
Chen, QQ; Jia, Q; Yuan, ZW; Huang, L	INST CHEMICAL ENGINEERS	Process Saf. Environ. Protect.	2014	10.1016/j.psep.2013.01.004
Gharbi, A; de Runz, C; Faiz, S; Akdag, H	IGI GLOBAL	Int. J. Data Warehous. Min.	2014	10.4018/ijdw.2014040101
Jang, WS; Kim, J; Engel, BA; Kang, SW; Park, Y; Yoon, H; Lim, KJ; Jung, Y; Shin, Y	MDPI	Sustainability	2014	10.3390/su6041776
Kulkarni, AT; Mohanty, J; Eldho, TI; Rao, EP; Mohan, BK	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2014	10.1016/j.cageo.2013.11.002
Hansen, HS; Fuglsang, M	MDPI	ISPRS Int. Geo-Inf.	2014	10.3390/ijgi3010326
De Feo, G; Cerrato, F; Siano, P; Torretta, V	TAYLOR & FRANCIS LTD	Environ. Technol.	2014	10.1080/09593330.2013.816328
McCool, JPP	ACADEMIC PRESS LTD- ELSEVIER SCIENCE LTD	J. Archaeol. Sci.	2014	10.1016/j.jas.2013.07.037
Delipetrev, B; Jonoski, A; Solomatine, DP	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2014	10.1016/j.cageo.2013.09.012

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Authors	Publisher	Journal Name	Publication Year	DOY
Maina, MM; Amin, MSM; Yazid, MA	TAYLOR & FRANCIS AS	Acta Agric. Scand. Sect. B-Soil Plant Sci.	2014	10.1080/09064710.2014.896935
Bunting, P; Clewley, D; Lucas, RM; Gillingham, S	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2014	10.1016/j.cageo.2013.08.007
Mergili, M; Marchesini, I; Alvioli, M; Metz, M; Schneider-Muntau, B; Rossi, M; Guzzetti, F	COPERNICUS GESELLSCHAFT MBH	Geosci. Model Dev.	2014	10.5194/gmd-7-2969-2014
Zemrich, A; Schnittler, M; Hartleib, J; Busch, M; Bobertz, B; Zolitz, R	SPRINGER	Folia Geobot.	2013	10.1007/s12224-012-9149-6
Porta, J; Parapar, J; Garcia, P; Fernandez, G; Tourino, J; Doallo, R; Onega, F; Sante, I; Diaz, P; Miranda, D; Crecente, R	SPRINGER HEIDELBERG	Earth Sci. Inform.	2013	10.1007/s12145-013-0123-5
Kaku, K; Held, A	ELSEVIER	Int. J. Disaster Risk Reduct.	2013	10.1016/j.ijdr.2013.08.004
Ki, J	TAYLOR & FRANCIS LTD	Int. J. Digit. Earth	2013	10.1080/17538947.2011.631223
Karami, M; Rangzan, K; Saberi, A	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2013	10.1016/j.cageo.2013.06.007
Jiang, RG; Xie, JC; Li, JX	DISASTER ADVANCES	Disaster Adv.	2013	
Rocchini, D; Delucchi, L; Bacaro, G; Cavallini, P; Feilhauer, H; Foody, GM; He, KS; Nagendra, H; Porta, C; Ricotta, C; Schmidlein, S; Spano, LD; Wegmann, M; Neteler, M	ELSEVIER	Ecol. Inform.	2013	10.1016/j.ecoinf.2012.04.002
Lim, HS; Kim, CS; Park, KS; Shim, JS; Chun, I	SPRINGER	Acta Oceanol. Sin.	2013	10.1007/s13131-013-0352-y
Park, YS; Engel, BA; Shin, Y; Choi, J; Kim, NW; Kim, SJ; Kong, DS; Lim, KJ	MDPI AG	Water	2013	10.3390/w5031194
Skarlatidou, A; Cheng, T; Haklay, M	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2013	10.1080/13658816.2013.766336
Kalabokidis, K; Athanasis, N; Gagliardi, F; Karayiannis, F; Palaiologou, P; Parastatidis, S; Vasilakos, C	ELSEVIER	Ecol. Inform.	2013	10.1016/j.ecoinf.2013.04.007
Thiebes, B; Bell, R; Glade, T; Jager, S; Anderson, M; Holcombe, L	ELSEVIER	Eng. Geol.	2013	10.1016/j.enggeo.2013.03.004
Steiniger, S; Hunter, AJS	ELSEVIER SCI LTD	Comput. Environ. Urban Syst.	2013	10.1016/j.compenvurbsys.2012.10.003
Kunkel, R; Sorg, J; Eckardt, R; Kolditz, O; Rink, K; Vereecken, H	SPRINGER	Environ. Earth Sci.	2013	10.1007/s12665-013-2370-7
Di Felice, P; Spadoni, M	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2013	10.1016/j.cageo.2012.11.021

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Authors	Publisher	Journal Name	Publication Year	DOY
Teodoro, AC; Duarte, L	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2013	10.1080/13658816.2012.721554
Rada, EC; Ragazzi, M; Fedrizzi, P	PERGAMON-ELSEVIER SCIENCE LTD	Waste Manage.	2013	10.1016/j.wasman.2013.01.002
Chojnacky, DC; Blinn, CE; Prisley, SP	SOC AMER FORESTERS	J. For.	2013	
Gkatzoflias, D; Mellios, G; Samaras, Z	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2013	10.1016/j.cageo.2012.10.011
Lim, HS; Chun, I; Kim, CS; Park, KS; Shim, JS; Yoon, JJ	COASTAL EDUCATION & RESEARCH FOUNDATION	J. Coast. Res.	2013	10.2112/SI65-054.1
Frias, P; Horta, J; Almeida, LP; Pacheco, A; Ferreira, O	COASTAL EDUCATION & RESEARCH FOUNDATION	J. Coast. Res.	2013	10.2112/SI65-233.1
Flanagan, DC; Frankenberger, JR; Cochrane, TA; Renschler, CS; Elliot, WJ	AMER SOC AGRICULTURAL & BIOLOGICAL ENGINEERS	Trans. ASABE	2013	
Gruber, FE; Mergili, M	COPERNICUS GESELLSCHAFT MBH	Nat. Hazards Earth Syst. Sci.	2013	10.5194/nhess-13-2779-2013
Hernandez-Guzman, R; Ruiz-Luna, A	IWA PUBLISHING	J. Hydroinform.	2013	10.2166/hydro.2013.145
Ko, CH	HINDAWI LTD	Sci. World J.	2013	10.1155/2013/217972
Lhomme, S; Serre, D; Diab, Y; Laganier, R	COPERNICUS GESELLSCHAFT MBH	Nat. Hazards Earth Syst. Sci.	2013	10.5194/nhess-13-221-2013
Kang, S; Yoo, HY; Lee, K	NATL TAIWAN OCEAN UNIV	J. Mar. Sci. Technol.-Taiwan	2012	10.6119/JMST-012-0315-1
Souto, H; Gomes, N; Carvalho, R	SPRINGER	J. Coast. Conserv.	2012	10.1007/s11852-012-0188-1
Zambelli, P; Lora, C; Spinelli, R; Tattoni, C; Vitti, A; Zattelli, P; Ciolli, M	ELSEVIER SCI LTD	Environ. Modell. Softw.	2012	10.1016/j.envsoft.2012.05.016
Rota, M; Zuccolo, E; Taverna, L; Corigliano, M; Lai, C; Penna, A	SPRINGER	Bull. Earthq. Eng.	2012	10.1007/s10518-012-9369-4
Steiniger, S; Hunter, AJS	WILEY	Wildl. Soc. Bull.	2012	10.1002/wsb.168
Huang, ZJ; Das, A; Qiu, YL; Tatem, AJ	BMC	Int. J. Health Geogr.	2012	10.1186/1476-072X-11-33
Steinbach, M; Hemmerling, R	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2012	10.1016/j.cageo.2011.11.012
Gitis, V; Derendyaev, A; Metrikov, P; Shogin, A	SPRINGER	Nat. Hazards	2012	10.1007/s11069-012-0132-6
Ganci, G; Vicari, A; Cappello, A; Del Negro, C	ELSEVIER SCIENCE INC	Remote Sens. Environ.	2012	10.1016/j.rse.2011.12.021

Table A1. Cont.

Authors	Publisher	Journal Name	Publication Year	DOY
Vitti, A	ELSEVIER	ISPRS-J. Photogramm. Remote Sens.	2012	10.1016/j.isprsjprs.2012.02.005
Brovelli, MA; Minghini, M; Giori, G; Beretta, M	WILEY-BLACKWELL	Trans. GIS	2012	10.1111/j.1467-9671.2012.01311.x
Mergili, M; Fellin, W; Moreiras, SM; Stotter, J	SPRINGER	Nat. Hazards	2012	10.1007/s11069-011-9965-7
Guney, C; Girginkaya, SA; Cagdas, G; Yavuz, S	ELSEVIER SCIENCE BV	Landsc. Urban Plan.	2012	10.1016/j.landurbplan.2011.12.016
Nam, WH; Choi, JY; Yoo, SH; Engel, BA	KOREAN SOCIETY OF CIVIL ENGINEERS-KSCE	KSCE J. Civ. Eng.	2012	10.1007/s12205-012-1357-3
Eisner, WR; Jelacic, J; Cuomo, CJ; Kim, C; Hinkel, KM; Del Alba, D	WILEY	Trans. GIS	2012	10.1111/j.1467-9671.2011.01291.x
Evans, B; Sabel, CE	BMC	Int. J. Health Geogr.	2012	10.1186/1476-072X-11-2
Connors, JP; Lei, SF; Kelly, M	ROUTLEDGE JOURNALS, TAYLOR & FRANCIS LTD	Ann. Assoc. Am. Geogr.	2012	10.1080/00045608.2011.627058
Villa, P; Molina, R; Gomarasca, MA; Roccatagliata, E	TAYLOR & FRANCIS LTD	Int. J. Digit. Earth	2012	10.1080/17538947.2011.585183
Martinez-Llario, J; Gonzalez-Alcaide, M	ELSEVIER SCIENCE INC	J. Syst. Softw.	2011	10.1016/j.jss.2011.06.072
Malinverni, ES	AMER SOC PHOTOGRAMMETRY	Photogramm. Eng. Remote Sens.	2011	10.14358/PERS.77.10.1045
Lwin, KK; Murayama, Y	ELSEVIER SCI LTD	Comput. Environ. Urban Syst.	2011	10.1016/j.compenvurbsys.2011.05.002
Frigeri, A; Hare, T; Neteler, M; Coradini, A; Federico, C; Orosei, R	PERGAMON-ELSEVIER SCIENCE LTD	Planet Space Sci.	2011	10.1016/j.pss.2010.12.008
Jasiewicz, J; Metz, M	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2011	10.1016/j.cageo.2011.03.003
Li, SNA; Xiong, CF; Ou, ZQ	WILEY-BLACKWELL	Trans. GIS	2011	10.1111/j.1467-9671.2011.01250.x
Pirotti, F; Guarnieri, A; Vettore, A	WILEY	Trans. GIS	2011	10.1111/j.1467-9671.2011.01248.x
Mari, R; Bottai, L; Busillo, C; Calastrini, F; Gozzini, B; Gualtieri, G	PERGAMON-ELSEVIER SCIENCE LTD	Renew. Energy	2011	10.1016/j.renene.2010.07.005
Bogdanovic, M; Stanimirovic, A; Stoimenov, L	DRUNPP-SARAJEVO	Tech. Technol. Educ. Manag.-TTEM	2011	
Vicari, A; Bilotta, G; Bonfiglio, S; Cappello, A; Ganci, G; Herault, A; Rustico, E; Gallo, G; Del Negro, C	IST NAZIONALE DI GEOFISICA E VULCANOLOGIA	Ann. Geophys.	2011	10.4401/ag-5347

Table A1. Cont.

Authors	Publisher	Journal Name	Publication Year	DOY
Rathore, DS; Chalisgaonkar, D; Pandey, RP; Ahmad, T; Singh, Y	SPRINGER	J. Indian Soc. Remote Sens.	2010	10.1007/s12524-010-0054-2
Solymosi, N; Wagner, SE; Maroti-Agots, A; Allepuz, A	WILEY-BLACKWELL PUBLISHING, INC	Ecography	2010	10.1111/j.1600-0587.2010.06598.x
Beyer, KMM; Comstock, S; Seagren, R	SPRINGER	J. Community Health	2010	10.1007/s10900-010-9254-5
Assilzadeh, H; Levy, JK; Wang, X	MDPI	Remote Sens.	2010	10.3390/rs2092259
Kulawiak, M; Prospathopoulos, A; Perivoliotis, L; Luba, M; Kioroglou, S; Stepnowski, A	PERGAMON-ELSEVIER SCIENCE LTD	Comput. Geosci.	2010	10.1016/j.cageo.2010.02.008
Boulos, MNK; Warren, J; Gong, JY; Yue, P	BIOMED CENTRAL LTD	Int. J. Health Geogr.	2010	10.1186/1476-072X-9-14
Mantovani, F; Gracia, FJ; de Cosmo, PD; Suma, A	SPRINGER HEIDELBERG	Landslides	2010	10.1007/s10346-009-0181-4
Karnatak, H; Saran, S; Bhatia, K; Roy, PS	TAYLOR & FRANCIS LTD	Geocarto Int.	2010	10.1080/10106040802677045
Luo, K; Zheng, Z; Ma, FY; Ma, DK	TAYLOR & FRANCIS INC	Intell. Autom. Soft Comput.	2010	
Bernsdorf, S; Barsch, R; Beyreuther, M; Zaksek, K; Hort, M; Wassermann, J	TAYLOR & FRANCIS LTD	Int. J. Digit. Earth	2010	10.1080/17538940903548420
Hall, GB; Chipeniuk, R; Feick, RD; Leahy, MG; Deparday, V	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2010	10.1080/13658810903213288
Newman, G; Zimmerman, D; Crall, A; Laituri, M; Graham, J; Stapel, L	TAYLOR & FRANCIS LTD	Int. J. Geogr. Inf. Sci.	2010	10.1080/13658816.2010.490532
Becker-Heidmann, P; Heidmann, P	UNIV ARIZONA DEPT GEOSCIENCES	Radiocarbon	2010	10.1017/S0033822200046488

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