DESCRIPTION

The International Journal of Approximate Reasoning is intended to serve as a forum for the treatment of imprecision and uncertainty in Artificial and Computational Intelligence, covering both the foundations of uncertainty theories, and the design of intelligent systems for scientific and engineering applications. It publishes high-quality research papers describing theoretical developments or innovative applications, as well as review articles on topics of general interest.

Relevant topics include, but are not limited to, probabilistic reasoning and Bayesian networks, imprecise probabilities, random sets, belief functions (Dempster-Shafer theory), possibility theory, fuzzy sets, rough sets, decision theory, non-additive measures and integrals, qualitative reasoning about uncertainty, comparative probability orderings, game-theoretic probability, default reasoning, nonstandard logics, argumentation systems, inconsistency tolerant reasoning, elicitation techniques, philosophical foundations and psychological models of uncertain reasoning.

Domains of application for uncertain reasoning systems include risk analysis and assessment, information retrieval and database design, information fusion, machine learning, data and web mining, computer vision, image and signal processing, intelligent data analysis, statistics, multi-agent systems, etc.

The journal is affiliated with the Society for Imprecise Probability: Theories and Applications (SIPTA), and Beliefs functions and Applications Society (BFAS).

Benefits to authors
We also provide many author benefits, such as free PDFs, a liberal copyright policy, special discounts on Elsevier publications and much more. Please click here for more information on our author services.

Please see our Guide for Authors for information on article submission. If you require any further information or help, please visit our Support Center

AUDIENCE

Computer Scientists, Mathematicians, Statisticians, Engineers.
ABSTRACTING AND INDEXING

INSPEC
Current Contents
Pascal Francis
MathSci
UnCover
El Compendex
Social Science Search
Energy Science and Technology
Inside Conferences
Encyclopedia of Associations
Science Citation Index
Scopus
Zentralblatt MATH

EDITORIAL BOARD

Editor-in-Chief

Thierry Denoeux, Universite de Technologie de Compiegne, Compiegne, France
Uncertainty, Belief functions, Dempster-Shafer theory, Classification, Clustering, Machine learning, Evidence theory

Senior Area Editors

Davide Ciucci, University of Milan-Bicocca, Department of Informatics Systems and Communication, Milano, Italy
Rough Sets

Inés Couso, University of Oviedo, Oviedo, Spain
Fuzzy sets and Possibility theory

Anthony Hunter, University College London, London, England, United Kingdom
Logical approaches to uncertainty

Helge Langseth, Norwegian University of Science and Technology, Trondheim, Norway
Deep learning, probabilistic AI, explainable AI, Bayesian networks, decision support systems

Christoph Lauter, The University of Texas at El Paso, El Paso, Texas, United States of America
Probabilistic reasoning, Probabilistic machine learning, Probabilistic graphical models, Reasoning under uncertainty

Yiyu Yao, University of Regina, Department of Computer Science, Regina, Saskatchewan, Canada
Rough sets

Marco Zaffalon, Dalle Molle Institute for Artificial Intelligence, Lugano, Switzerland
Imprecise probabilities, Machine learning, Causal inference

Area Editors

Alessandro Antonucci, Dalle Molle Institute for Artificial Intelligence, Lugano, Switzerland
Machine Learning, Probabilistic Graphical Models, Causal Analysis, Reinforcement Learning, Explainable AI

Thomas Augustin, Ludwig Maximilians University Munich, München, Germany

Michal Baczynski, University of Silesia, Katowice, Poland
Fuzzy logic, Fuzzy connectives, Reasoning under uncertainty, Computational intelligence

Gleb Beliakov, Deakin University, Burwood, Victoria, Australia

Fernando Bobillo, University of Zaragoza, Zaragoza, Spain
Fuzzy ontologies, fuzzy Description logics, fuzzy knowledge graphs

Alberto Bugarin-Diz, University of Santiago de Compostela, Santiago de Compostela, Spain
natural language generation, linguistic descriptions of data, natural language processing, explainable AI, trustworthy AI

Martine Ceberio, The University of Texas at El Paso, El Paso, Texas, United States of America

Chris Cornelis, Ghent University, Gent, Belgium

Pierpaolo D’Urso, University of Rome La Sapienza, Department of Social and Economic Sciences, Roma, Italy
fuzzy clustering, clustering of spatial data, clustering of time series, clustering of spatio-temporal data, clustering of complex structures of data, imprecise data science

Sébastien Destercke, University of Applied Sciences for Technology Compiegne, Compiegne, France
Uncertainty
Fabrizio Durante, University of Salento, Lecce, Italy
Copulas, Clustering, Machine Learning

Tommaso Flaminio, Spanish Scientific Research Council, Madrid, Spain
logic, uncertainty, fuzzy logic, probability logic, uncertain reasoning, modal logic

Van-Nam Huynh, Japan Advanced Institute of Science and Technology, Nomi, Japan
Machine Learning, Data Mining, AI Reasoning, Argumentation, Decision Making, Kansei Information Processing

Anne-Laure Jousselme, Centre for Maritime Research and Experimentation, La Spezia, Italy

Vladik Kreinovich, The University of Texas at El Paso, Department of Computer Science, El Paso, Texas, United States of America
Uncertainty quantification, Mathematical foundations, Interval uncertainty, Fuzzy uncertainty.

Tufan Kumbasar, Istanbul Technical University, Istanbul, Turkey
fuzzy logic, intelligent systems

Sergei Kuznetsov, National Research University Higher School of Economics, Moskva, Russian Federation
Granular computing, Formal concept analysis, Rough set, Concept lattice, Three-way decision, Concept-cognitive learning

Zhunga Liu, Northwestern Polytechnical University, Xian, China

Sara Magliacane, University of Amsterdam, Amsterdam, Netherlands
Causality, causal discovery, causal inference, causality-inspired ML

Sebastia Massanet, University of the Balearic Islands, Palma de Mallorca, Spain
Fuzzy implication functions, aggregation functions, fuzzy mathematical morphology, functional equations

Denis Mauá, University of Sao Paulo, SAO PAULO, Brazil
machine learning, probabilistic reasoning, knowledge representation, bayesian networks, tractable inference, complexity theory

Enrique Miranda, University of Oviedo, Oviedo, Spain
Imprecise probabilities, Random sets, Stochastic processes, Non-additive measures

Ignacio Montes, University of Oviedo, Oviedo, Spain
Imprecise probabilities, Non-additive measures, Stochastic orderings

Serafín Moral, University of Granada, Granada, Spain

Frédéric Pichon, Artois University, Faculty of Applied Sciences, Bethune, France
belief functions

Cassio Polpo de Campos, Utrecht University, Utrecht, Netherlands

Luciano Sanchez, University of Oviedo, Oviedo, Spain
Condition monitoring, Remaining Useful Life, Battery modeling, Artificial Intelligence, Neural Networks, Uncertain data

Martin Stepnicka, University of Ostrava, Ostrava, Czechia
Fuzzy Rule-Based Systems

Barbara Vantaggi, University of Rome La Sapienza, Roma, Italy
Uncertainty, Probabilistic reasoning, AI reasoning and knowledge representation, Decision theory

Jiří Vomlel, Czech Academy of Sciences, Praha, Czechia
Uncertainty in Artificial Intelligence, Probabilistic Graphical Models, Bayesian networks

Christian Wagner, University of Nottingham, Nottingham, United Kingdom

JingTao Yao, University of Regina, Regina, Saskatchewan, Canada

Xiaodong Yue, Shanghai University, Shanghai, China

Associate Editors

Jose Maria Alonso Moral, University of Santiago de Compostela, Santiago de Compostela, Spain

Gert de Cooman, Ghent University, Gent, Belgium

Fabio Cozman, University of Sao Paulo, SAO PAULO, Brazil

Fabio Cuzzolin, Oxford Brookes University, Oxford, United Kingdom

Bernard De Baets, Ghent University KERMIT, Gent, Belgium

Graça Líz Dimuro, Federal University of Rio Grande, RIO GRANDE, Brazil
Fuzzy Logic, Fuzzy Sets, Fuzzy Systems, Aggregation Functions, Overlap Functions, Fuzzy Integrals, Deep Learning, Neural Networks, Brain Computer Interface, Machine Learning, Fuzzy Rule Based Classification, Image Processing

Javier Fernández, Public University of Navarre, Pamplona, Spain
Data uncertainty, artificial intelligence

Maria Brigida Ferraro, University of Rome La Sapienza, Roma, Italy
Clustering, Fuzzy data, Bootstrap

Scott Ferson, University of Liverpool, Liverpool, United Kingdom
Hamido Fujita, Universiti Teknologi Malaysia Malaysia-Japan International Institute of Technology, Kuala Lumpur, Malaysia
Machine learning and health care system analytics

Michel Grabisch, Sorbonne University, Paris, France

Salvatore Greco, University of Catania, Department of Economics and Business, Catania, Italy
Multiple Criteria Decision Aiding, Evolutionary Multiobjective Optimization, Rough Set Theory, Non additive integrals, Artificial Intelligence, Decision Sciences

Larry Hall, University of South Florida, Tampa, Florida, United States of America
Machine Learning, Pattern Recognition, Deep Learning, Fuzzy approaches in Learning, Medical image analysis

Eyke Hüllermeier, Ludwig Maximilians University Munich, München, Germany
Artificial Intelligence, Machine Learning

Balasubramaniam Jayaram, Indian Institute of Technology Hyderabad, Hyderabad, India
Aggregation operations, Fuzzy Inference Systems, Approximate Reasoning, High Dimensional Data Analysis, Appropriateness of Distance Functions

Richard Jensen, Aberystwyth University, Aberystwyth, United Kingdom
Honda Katsuhiro, Osaka Metropolitan University, Osaka, Japan
Soft Computing

Gabriele Kern-Isberner, TU Dortmund University, Dortmund, Germany
Jonathan Lawry, University of Bristol, Bristol, United Kingdom

Churn-Jung Liu, Academia Sinica, Taipei, Taiwan
applied logic, knowledge representation and reasoning, reasoning about uncertainty

Jesus Medina, University of Cadiz, Faculty of Sciences, Puerto Real, Spain

David Mercier, Artois University, Faculty of Applied Sciences, Bethune, France

Radko M Mesaric, Slovak University of Technology in Bratislava, Bratislava, Slovakia
Aggregation Functions

Duqian Miao, Tongji University, Shanghai, China
Machine Learning, Big Data Analysis, Granular Computing, Rough Set, Artificial Intelligence

Fan Min, Southwest Petroleum University, Chengdu, China
Machine learning, Active learning, cost-sensitive learning, granular computing, multi-label learning, multi-instance learning, recommender systems, seismic data analysis, three-way decision

Daniela Mundici, University of Florence, Firenze, Italy

Hung T. Nguyen, New Mexico State University, Las Cruces, New Mexico, United States of America

Nikhil Pal, Indian Statistical Institute, Kolkata, India
Fuzzy Pattern Recognition, Machine Learning, Neural Networks

Witold Pedrycz, University of Alberta, Department of Electrical and Computer Engineering, Edmonton, Alberta, Canada

Teddy Seidenfeld, Carnegie Mellon University, Pittsburgh, Pennsylvania, United States of America

Prakash Shenoy, The University of Kansas, Lawrence, Kansas, United States of America
Uncertain Reasoning

Songsak Sriboonchitta, Chiang Mai University, Chiang Mai, Thailand
Zhigang Su, Southeast University School of Energy and Environment, Nanjing, China
Pattern recognition, Machine learning, Evolutionary optimization, Control theory, Power engineering, Theory of belief functions

Paolo Vicig, University of Trieste, Trieste, Italy

Guoyin Wang, Chongqing University of Posts and Telecommunications, Chongqing, China

Zhihua Wei, Tongji University, Shanghai, China

Marcin Wolski, Maria Curie-Sklodowska University, Lublin, Poland

Changhe Yuan, City University of New York, New York, New York, United States of America

Advisory Board

Bernadette Bouchon-Meunier, Sorbonne University, Paris, France
Artificial intelligence, fuzzy systems

Arthur P. Dempster, Harvard University, Cambridge, Massachusetts, United States of America

Didier Dubois, Toulouse Institute of Computer Science Research, Toulouse, France

Rudolf Kruse, Otto-von-Guericke-University Magdeburg, Faculty of Computer Science, Magdeburg, Germany

Sankar Pal, Indian Statistical Institute, Kolkata, India
pattern recognition, image preprocessing, machine intelligence, soft computing, video tracking, deep learning

Henri Prade, Paul Sabatier University, Toulouse, France

Glenn Shafer, Rutgers University Newark Graduate School, Newark, New Jersey, United States of America

Michio Sugeno, Doshisha University, Faculty of Culture and Information Science, Kyotanabe, Japan

Ronald R. Yager, Iona University Machine Intelligence Institute, New Rochelle, New York, United States of America
Fuzzy logic, aggregation operations, neural modelling of symbolic systems

Former Editors-in-Chief
J.C. Bezdek, The University of Melbourne, Department of Computing and Information Systems, Melbourne, Australia
P. Bonissone, GE Power, Schenectady, New York, United States of America
GUIDE FOR AUTHORS

Your Paper Your Way
We now differentiate between the requirements for new and revised submissions. You may choose to submit your manuscript as a single Word or PDF file to be used in the refereeing process. Only when your paper is at the revision stage, will you be requested to put your paper in to a 'correct format' for acceptance and provide the items required for the publication of your article.
To find out more, please visit the Preparation section below.

INTRODUCTION
The *International Journal of Approximate Reasoning* is intended to serve as a forum for the treatment of imprecision and uncertainty in Artificial and Computational Intelligence, covering both the foundations of uncertainty theories, and the design of intelligent systems for scientific and engineering applications. It publishes high-quality research papers describing theoretical developments or innovative applications, as well as review articles on topics of general interest.

The journal collaborates with the Society for Imprecise Probability: Theories and Applications (SIPTA) and the Beliefs functions and Applications Society (BFAS) (http://www.bfasociety.org/).

Types of Paper
Relevant topics include, but are not limited to, fuzzy sets and systems, possibility theory, probabilistic reasoning and Bayesian networks, imprecise probabilities, random sets, belief functions (Dempster-Shafer theory), rough sets, decision theory, non-additive measures and integrals, qualitative reasoning about uncertainty, comparative probability orderings, default reasoning, nonstandard logics, elicitation techniques, philosophical foundations and psychological models of uncertain reasoning.

Domains of application and related technical areas include engineering and expert systems, information retrieval and database design, risk analysis and assessment, information fusion, machine learning, data and web mining, modeling and prediction, uncertainty in financial markets, evolutionary computation, computer vision, image and signal processing, pattern recognition, intelligent data analysis, statistics, robotics, hybrid soft computing systems, etc.

This journal encourages and enables you to share software that supports your research publication where appropriate, and enables you to interlink the software and data with your published article. You have the option to convert your open source software into an additional journal publication in *Software Impacts*, a multi-disciplinary open access journal that provides a scholarly reference to software that has been used to address a research challenge. It ensures that your software is actively reviewed, curated, formatted, indexed, given a DOI and publicly available to all upon publication. You are encouraged to submit your article to *Software Impacts* as an additional item if your research article is accepted. Please note an open access fee of 250 USD is payable for publication in *Software Impacts*. Full details can be found on the *Software Impacts* website. Please use this template to write your Software Impacts article.

Submission checklist
You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:
- E-mail address
- Full postal address

All necessary files have been uploaded:
*Manuscript:*
- Include keywords
- All figures (include relevant captions)
- All tables (including titles, description, footnotes)
- Ensure all figure and table citations in the text match the files provided
- Indicate clearly if color should be used for any figures in print
Further considerations
• Manuscript has been 'spell checked' and 'grammar checked'
• All references mentioned in the Reference List are cited in the text, and vice versa
• Permission has been obtained for use of copyrighted material from other sources (including the Internet)
• A competing interests statement is provided, even if the authors have no competing interests to declare
• Journal policies detailed in this guide have been reviewed
• Referee suggestions and contact details provided, based on journal requirements

For further information, visit our Support Center.

BEFORE YOU BEGIN

Ethics in publishing
Please see our information on Ethics in publishing.

Declaration of competing interest
Corresponding authors, on behalf of all the authors of a submission, must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. All authors, including those without competing interests to declare, should provide the relevant information to the corresponding author (which, where relevant, may specify they have nothing to declare). Corresponding authors should then use this tool to create a shared statement and upload to the submission system at the Attach Files step. Please do not convert the .docx template to another file type. Author signatures are not required.

Declaration of generative AI in scientific writing
The below guidance only refers to the writing process, and not to the use of AI tools to analyse and draw insights from data as part of the research process.

Where authors use generative artificial intelligence (AI) and AI-assisted technologies in the writing process, authors should only use these technologies to improve readability and language. Applying the technology should be done with human oversight and control, and authors should carefully review and edit the result, as AI can generate authoritative-sounding output that can be incorrect, incomplete or biased. AI and AI-assisted technologies should not be listed as an author or co-author, or be cited as an author. Authorship implies responsibilities and tasks that can only be attributed to and performed by humans, as outlined in Elsevier’s AI policy for authors.

Authors should disclose in their manuscript the use of AI and AI-assisted technologies in the writing process by following the instructions below. A statement will appear in the published work. Please note that authors are ultimately responsible and accountable for the contents of the work.

Disclosure instructions
Authors must disclose the use of generative AI and AI-assisted technologies in the writing process by adding a statement at the end of their manuscript in the core manuscript file, before the References list. The statement should be placed in a new section entitled ‘Declaration of Generative AI and AI-assisted technologies in the writing process’.

Statement: During the preparation of this work the author(s) used [NAME TOOL / SERVICE] in order to [REASON]. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

This declaration does not apply to the use of basic tools for checking grammar, spelling, references etc. If there is nothing to disclose, there is no need to add a statement.
Submission declaration and verification
Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify compliance, your article may be checked by Crossref Similarity Check and other originality or duplicate checking software.

Preprints
Please note that preprints can be shared anywhere at any time, in line with Elsevier's sharing policy. Sharing your preprints e.g. on a preprint server will not count as prior publication (see 'Multiple, redundant or concurrent publication' for more information).

Preprint posting on SSRN
In support of Open Science, this journal offers its authors a free preprint posting service. Preprints provide early registration and dissemination of your research, which facilitates early citations and collaboration.

During submission to Editorial Manager, you can choose to release your manuscript publicly as a preprint on the preprint server SSRN once it enters peer-review with the journal. Your choice will have no effect on the editorial process or outcome with the journal. Please note that the corresponding author is expected to seek approval from all co-authors before agreeing to release the manuscript publicly on SSRN.

You will be notified via email when your preprint is posted online and a Digital Object Identifier (DOI) is assigned. Your preprint will remain globally available free to read whether the journal accepts or rejects your manuscript.

For more information about posting to SSRN, please consult the SSRN Terms of Use and FAQs.

Use of inclusive language
Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Content should make no assumptions about the beliefs or commitments of any reader; contain nothing which might imply that one individual is superior to another on the grounds of age, gender, race, ethnicity, culture, sexual orientation, disability or health condition; and use inclusive language throughout. Authors should ensure that writing is free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions. We advise to seek gender neutrality by using plural nouns ("clinicians, patients/clients") as default/wherever possible to avoid using "he, she," or "he/she." We recommend avoiding the use of descriptors that refer to personal attributes such as age, gender, race, ethnicity, culture, sexual orientation, disability or health condition unless they are relevant and valid. When coding terminology is used, we recommend to avoid offensive or exclusionary terms such as "master", "slave", "blacklist" and "whitelist". We suggest using alternatives that are more appropriate and (self-) explanatory such as "primary", "secondary", "blocklist" and "allowlist". These guidelines are meant as a point of reference to help identify appropriate language but are by no means exhaustive or definitive.

Reporting sex- and gender-based analyses
Reporting guidance
For research involving or pertaining to humans, animals or eukaryotic cells, investigators should integrate sex and gender-based analyses (SGBA) into their research design according to funder/sponsor requirements and best practices within a field. Authors should address the sex and/or gender dimensions of their research in their article. In cases where they cannot, they should discuss this as a limitation to their research's generalizability. Importantly, authors should explicitly state what definitions of sex and/or gender they are applying to enhance the precision, rigor and reproducibility of their research and to avoid ambiguity or conflation of terms and the constructs to which they refer (see Definitions section below). Authors can refer to the Sex and Gender Equity in Research (SAGER) guidelines and the SAGER guidelines checklist. These offer systematic approaches to the use and editorial review of sex and gender information in study design, data analysis, outcome reporting and research interpretation - however, please note there is no single, universally agreed-upon set of guidelines for defining sex and gender.
Definitions
Sex generally refers to a set of biological attributes that are associated with physical and physiological features (e.g., chromosomal genotype, hormonal levels, internal and external anatomy). A binary sex categorization (male/female) is usually designated at birth ("sex assigned at birth"), most often based solely on the visible external anatomy of a newborn. Gender generally refers to socially constructed roles, behaviors, and identities of women, men and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Gender influences how people view themselves and each other, how they behave and interact and how power is distributed in society. Sex and gender are often incorrectly portrayed as binary (female/male or woman/man) and unchanging whereas these constructs actually exist along a spectrum and include additional sex categorizations and gender identities such as people who are intersex/have differences of sex development (DSD) or identify as non-binary. Moreover, the terms "sex" and "gender" can be ambiguous—thus it is important for authors to define the manner in which they are used. In addition to this definition guidance and the SAGER guidelines, the resources on this page offer further insight around sex and gender in research studies.

Author contributions
For transparency, we require corresponding authors to provide co-author contributions to the manuscript using the relevant CRediT roles. The CRediT taxonomy includes 14 different roles describing each contributor's specific contribution to the scholarly output. The roles are: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; and Writing - review & editing. Note that not all roles may apply to every manuscript, and authors may have contributed through multiple roles. More details and an example.

Changes to authorship
Authors are expected to consider carefully the list and order of authors before submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only before the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the corresponding author: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed. Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors after the manuscript has been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

Article transfer service
This journal uses the Elsevier Article Transfer Service to find the best home for your manuscript. This means that if an editor feels your manuscript is more suitable for an alternative journal, you might be asked to consider transferring the manuscript to such a journal. The recommendation might be provided by a Journal Editor, a dedicated Scientific Managing Editor, a tool assisted recommendation, or a combination. If you agree, your manuscript will be transferred, though you will have the opportunity to make changes to the manuscript before the submission is complete. Please note that your manuscript will be independently reviewed by the new journal. More information.

Copyright
Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see more information on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has preprinted forms for use by authors in these cases.
For gold open access articles: Upon acceptance of an article, authors will be asked to complete a 'License Agreement' (more information). Permitted third party reuse of gold open access articles is determined by the author's choice of user license.

**Author rights**
As an author you (or your employer or institution) have certain rights to reuse your work. More information.

**Elsevier supports responsible sharing**
Find out how you can share your research published in Elsevier journals.

**Role of the funding source**
You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement, it is recommended to state this.

**Open access**
Please visit our Open Access page for more information.

**Elsevier Researcher Academy**
Researcher Academy is a free e-learning platform designed to support early and mid-career researchers throughout their research journey. The "Learn" environment at Researcher Academy offers several interactive modules, webinars, downloadable guides and resources to guide you through the process of writing for research and going through peer review. Feel free to use these free resources to improve your submission and navigate the publication process with ease.

**Language (usage and editing services)**
Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possible grammatical or spelling errors and to conform to correct scientific English may wish to use the English Language Editing service available from Elsevier's Author Services.

**Submission**
Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

**PREPARATION**

**Queries**
For questions about the editorial process (including the status of manuscripts under review) or for technical support on submissions, please visit our Support Center.

**NEW SUBMISSIONS**
Submission to this journal proceeds totally online and you will be guided stepwise through the creation and uploading of your files. The system automatically converts your files to a single PDF file, which is used in the peer-review process. As part of the Your Paper Your Way service, you may choose to submit your manuscript as a single file to be used in the refereeing process. This can be a PDF file or a Word document, in any format or layout that can be used by referees to evaluate your manuscript. It should contain high enough quality figures for refereeing. If you prefer to do so, you may still provide all or some of the source files at the initial submission. Please note that individual figure files larger than 10 MB must be uploaded separately.

**References**
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the article number or pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct.
**Formatting requirements**

There are no strict formatting requirements but all manuscripts must contain the essential elements needed to convey your manuscript, for example Abstract, Keywords, Introduction, Materials and Methods, Results, Conclusions, Artwork and Tables with Captions. If your article includes any Videos and/or other Supplementary material, this should be included in your initial submission for peer review purposes.

Divide the article into clearly defined sections.

**Figures and tables embedded in text**

Please ensure the figures and the tables included in the single file are placed next to the relevant text in the manuscript, rather than at the bottom or the top of the file. The corresponding caption should be placed directly below the figure or table.

**Peer review**

This journal operates a single anonymized review process. All contributions will be initially assessed by the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editor is responsible for the final decision regarding acceptance or rejection of articles. The Editor’s decision is final. Editors are not involved in decisions about papers which they have written themselves or have been written by family members or colleagues or which relate to products or services in which the editor has an interest. Any such submission is subject to all of the journal's usual procedures, with peer review handled independently of the relevant editor and their research groups. More information on types of peer review.

**REVISED SUBMISSIONS**

**Use of word processing software**

Regardless of the file format of the original submission, at revision you must provide us with an editable file of the entire article. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier). See also the section on Electronic artwork.

To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

**LaTeX**

You are recommended to use the Elsevier article class elsarticle.cls to prepare your manuscript and BibTeX to generate your bibliography.

Our LaTeX site has detailed submission instructions, templates and other information.

**Article structure**

**Subdivision - numbered sections**

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to ‘the text’. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

**Essential title page information**

- **Title.** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- **Author names and affiliations.** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
- **Corresponding author.** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.
• **Present/permanent address.** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

**Highlights**

Highlights are mandatory for this journal as they help increase the discoverability of your article via search engines. They consist of a short collection of bullet points that capture the novel results of your research as well as new methods that were used during the study (if any). Please have a look at the examples here: example Highlights.

Highlights should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point).

**Abstract**

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

**Keywords**

Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

**Acknowledgements**

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

**Formatting of funding sources**

List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, it is recommended to include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Footnotes**

Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes in the text and present the footnotes themselves separately at the end of the article.

**Artwork**

**Electronic artwork**

**General points**

- Make sure you use uniform lettering and sizing of your original artwork.
- Preferred fonts: Arial (or Helvetica), Times New Roman (or Times), Symbol, Courier.
- Number the illustrations according to their sequence in the text.
- Use a logical naming convention for your artwork files.
- Indicate per figure if it is a single, 1.5 or 2-column fitting image.
• For Word submissions only, you may still provide figures and their captions, and tables within a single file at the revision stage.
• Please note that individual figure files larger than 10 MB must be provided in separate source files.

A detailed guide on electronic artwork is available.

You are urged to visit this site; some excerpts from the detailed information are given here.

Formats
Regardless of the application used, when your electronic artwork is finalized, please 'save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):
EPS (or PDF): Vector drawings. Embed the font or save the text as 'graphics'.
TIFF (or JPG): Color or grayscale photographs (halftones): always use a minimum of 300 dpi.
TIFF (or JPG): Bitmapped line drawings: use a minimum of 1000 dpi.
TIFF (or JPG): Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.

Please do not:
• Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); the resolution is too low.
• Supply files that are too low in resolution.
• Submit graphics that are disproportionately large for the content.

Color artwork
Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF), or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color online (e.g., ScienceDirect and other sites) regardless of whether or not these illustrations are reproduced in color in the printed version. For color reproduction in print, you will receive information regarding the costs from Elsevier after receipt of your accepted article. Please indicate your preference for color: in print or online only. Further information on the preparation of electronic artwork.

Figure captions
Ensure that each illustration has a caption. A caption should comprise a brief title (not on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Text graphics
Text graphics may be embedded in the text at the appropriate position. If you are working with LaTeX and have such features embedded in the text, these can be left. See further under Electronic artwork.

Tables
Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References
Citation in text
Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Reference links
Increased discoverability of research and high quality peer review are ensured by online links to the sources cited. In order to allow us to create links to abstracting and indexing services, such as Scopus, Crossref and PubMed, please ensure that data provided in the references are correct. Please note that incorrect surnames, journal/book titles, publication year and pagination may prevent link creation. When copying references, please be careful as they may already contain errors. Use of the DOI is highly encouraged.
A DOI is guaranteed never to change, so you can use it as a permanent link to any electronic article. An example of a citation using DOI for an article not yet in an issue is: VanDecar J.C., Russo R.M., James D.E., Ambhe W.B., Franke M. (2003). Aseismic continuation of the Lesser Antilles slab beneath northeastern Venezuela. Journal of Geophysical Research, https://doi.org/10.1029/2001JB000884. Please note the format of such citations should be in the same style as all other references in the paper.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

Data references
This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

Preprint references
Where a preprint has subsequently become available as a peer-reviewed publication, the formal publication should be used as the reference. If there are preprints that are central to your work or that cover crucial developments in the topic, but are not yet formally published, these may be referenced. Preprints should be clearly marked as such, for example by including the word preprint, or the name of the preprint server, as part of the reference. The preprint DOI should also be provided.

Reference management software
Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support Citation Style Language styles, such as Mendeley. Using citation plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal’s style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide. If you use reference management software, please ensure that you remove all field codes before submitting the electronic manuscript. More information on how to remove field codes from different reference management software.

Reference formatting
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the article number or pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct. If you do wish to format the references yourself they should be arranged according to the following examples:

Reference style

Text: Indicate references by number(s) in square brackets in line with the text. The actual authors can be referred to, but the reference number(s) must always be given.
Example: '..... as demonstrated [3,6]. Barnaby and Jones [8] obtained a different result ....'

List: Number the references (numbers in square brackets) in the list in the order in which they appear in the text.
Examples:
Reference to a journal publication:
Reference to a journal publication with an article number:
Reference to a book:
Reference to a chapter in an edited book:
Reference to a website:
Reference to a dataset:
Reference to software:

Research data
This journal requires and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refers to the results of observations or experimentation that validate research findings, which may also include software, code, models, algorithms, protocols, methods and other useful materials related to the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. When sharing data in one of these ways, you are expected to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing, sharing and using research data and other relevant research materials, visit the research data page.

Data linking
If you have made your research data available in a data repository, you can link your article directly to the dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect with relevant repositories, giving readers access to underlying data that gives them a better understanding of the research described.

There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For more information, visit the database linking page.

For supported data repositories a repository banner will automatically appear next to your published article on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).

Research Elements
This journal enables you to publish research objects related to your original research – such as data, methods, protocols, software and hardware – as an additional paper in a Research Elements journal.

Research Elements is a suite of peer-reviewed, open access journals which make your research objects findable, accessible and reusable. Articles place research objects into context by providing detailed descriptions of objects and their application, and linking to the associated original research articles. Research Elements articles can be prepared by you, or by one of your collaborators.

During submission, you will be alerted to the opportunity to prepare and submit a manuscript to one of the Research Elements journals.

More information can be found on the Research Elements page.

Elsevier accepts electronic supplementary material to support and enhance your scientific research. Supplementary files offer the author additional possibilities to publish supporting applications, high-resolution images, background datasets, sound clips and more. Supplementary files supplied will be
published online alongside the electronic version of your article in Elsevier Web products, including ScienceDirect [http://www.sciencedirect.com]. In order to ensure that your submitted material is directly usable, please provide the data in one of our recommended file formats. Authors should submit the material in electronic format together with the article and supply a concise and descriptive caption for each file. For more detailed instructions please visit our artwork instruction pages at [https://www.elsevier.com/artworkinstructions](https://www.elsevier.com/artworkinstructions).

**Data statement**

To foster transparency, we encourage you to state the availability of your data in your submission. This may be a requirement of your funding body or institution. If your data is unavailable to access or unsuitable to post, you will have the opportunity to indicate why during the submission process, for example by stating that the research data is confidential. The statement will appear with your published article on ScienceDirect. For more information, visit the Data Statement page.

Elsevier accepts electronic supplementary material to support and enhance your scientific research. Supplementary files offer the author additional possibilities to publish supporting applications, high-resolution images, background datasets, sound clips and more. Supplementary files supplied will be published online alongside the electronic version of your article in Elsevier Web products, including ScienceDirect [http://www.sciencedirect.com]. In order to ensure that your submitted material is directly usable, please provide the data in one of our recommended file formats. Authors should submit the material in electronic format together with the article and supply a concise and descriptive caption for each file. For more detailed instructions please visit our artwork instruction pages at [https://www.elsevier.com/artworkinstructions](https://www.elsevier.com/artworkinstructions).

**AFTER ACCEPTANCE**

**Proofs**

One set of page proofs (as PDF files) will be sent by e-mail to the corresponding author (if we do not have an e-mail address then paper proofs will be sent by post) or a link will be provided in the e-mail so that authors can download the files themselves. To ensure a fast publication process of the article, we kindly ask authors to provide us with their proof corrections within two days. Elsevier now provides authors with PDF proofs which can be annotated; for this you will need to [download the free Adobe Reader](https://www.adobe.com/reader), version 9 (or higher). Instructions on how to annotate PDF files will accompany the proofs (also given online). The exact system requirements are given at the [Adobe site](https://www.adobe.com). If you do not wish to use the PDF annotations function, you may list the corrections (including replies to the Query Form) and return them to Elsevier in an e-mail. Please list your corrections quoting line number. If, for any reason, this is not possible, then mark the corrections and any other comments (including replies to the Query Form) on a printout of your proof and scan the pages and return via e-mail. Please use this proof only for checking the typesetting, editing, completeness and correctness of the text, tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor. We will do everything possible to get your article published quickly and accurately. It is important to ensure that all corrections are sent back to us in one communication: please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely your responsibility.

**Offprints**

The corresponding author will, at no cost, receive a customized Share Link providing 50 days free access to the final published version of the article on ScienceDirect. The Share Link can be used for sharing the article via any communication channel, including email and social media. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is accepted for publication. Corresponding authors who have published their article gold open access do not receive a Share Link as their final published version of the article is available open access on ScienceDirect and can be shared through the article DOI link.

**AUTHOR INQUIRIES**

Visit the [Elsevier Support Center](https://www.elsevier.com/support) to find the answers you need. Here you will find everything from Frequently Asked Questions to ways to get in touch. You can also [check the status of your submitted article](https://www.elsevier.com/locate/ijar) or find out [when your accepted article will be published](https://www.elsevier.com/locate/ijar).

© Copyright 2018 Elsevier | [https://www.elsevier.com](https://www.elsevier.com)