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Introduction and motivation

A large proportion of scientific publications are careless, useless or false, and inhibit scholarly communication and scientific progress. This statement may sound provocative, but unfortunately is not an exaggeration.

The spectacular recent cases of scientific fraud (e.g. *Nature* 2003:422, 92–3; *Nature* 2002:419, 419–21; *Science* 2003:299, 31; *Science* 2002:298, 961) are only the tip of the iceberg. Many scientific papers fail to provide sufficiently accurate and detailed information to ensure that fellow researchers can efficiently repeat the experiments or calculations and directly follow the line of arguments leading to the presented conclusions. Even in reputable peer-reviewed journals with high impact factors many contributions exhibit a lack of scientific rigour and thorough discussion. All too often papers fail to reflect the actual state-of-the-art and do not take into account related studies in a critical and constructive way.

Many papers reflect a mentality of publishing just as much and as fast as possible, rather than participation in vital scientific exchange and discussion. The inflationary increase of scientific publications is fuelled by the habit of evaluating scientific productivity by the number of papers. In many research areas scientists have to spend an excessive amount of time to maintain an overview of the information dispersed and diluted in the increasing flood of publications. These nuisances and aberrations lead to an enormous waste and misallocation of resources: researchers invest lots of time and effort in the reconstruction of poorly described methods and results; useless activities and erroneous conclusions are repeated and propagated; and scientists and projects are misvaluated.

Central to the problems outlined above is

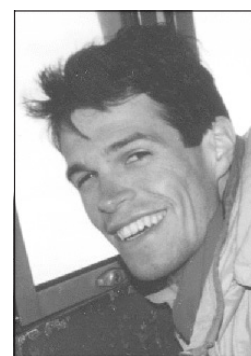
Interactive journal concept for improved scientific publishing and quality assurance

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ABSTRACT: Many scientific publications are careless, useless or false, and inhibit scholarly communication and scientific progress. This is caused by the failure of traditional journal publishing and peer review to provide efficient scientific exchange and quality assurance in today's highly diverse world of science. The most promising way to improve matters is a two-stage (or multi-stage) publication processes with interactive peer review and public discussion in new and traditional scientific journals. A concept for such interactive scientific journals is outlined, and its applicability is demonstrated by the open access journal Atmospheric Chemistry and Physics.



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*the
best-qualified
referees for a
particular
manuscript
may often not
be known to
the editor*

the failure of the traditional ways of journal publishing and peer review to provide efficient scientific exchange and quality assurance in today's fast-developing and highly diverse world of science.

The traditional closed peer-review process is hampered by limited competence and the sometimes conflicting interests of editors and referees. It frequently leads to a retardation and loss of scientific information. Because of the high degree of specialization and the enormous variety of research activities, institutions and interdisciplinary aspects, even scientists within the same discipline are frequently not aware of all the details relevant for a critical and thorough review. The best-qualified referees for a particular manuscript may often not be known to the editor. Even if very well-qualified referees are known, they often do not have enough time and motivation to evaluate thoroughly all the manuscripts they are asked to review. They usually get little or no public recognition of their efforts and contributions, which effectively disappear 'behind the curtains'. Critical, supportive and complementary referee comments are sometimes as interesting as the reviewed paper, but in traditional scientific journals these comments are generally not available to the public. On the other hand, revisions imposed on authors can dilute the impact of original manuscripts and inhibit scientific innovation. Last but not least, the closed peer-review process allows referees to delay and obstruct the publications of their competitors. It also facilitates hidden plagiarism. These and other aspects of peer review in scientific journals have been discussed in detail by Campanario.^{1,2}

Because of the large number of publications and the slow and time-consuming review and publication process of commentaries in traditional scientific journals, individual papers rarely face critical public discussion once they have passed the peer-review process. Incomplete, unbalanced or plainly unsustainable presentations are rarely complemented or corrected by public commentaries. In traditional journals the publication of a commentary requires almost as much effort as the publication of a regular research paper, and few scientists are ready

to invest a lot of time and effort in it. Errico³ gives a detailed analysis of the problems outlined above and shows for a couple of atmospheric science journals that the ratio of commentaries to regular research articles has decreased from about 1:20 to about 1:100 from the mid-1970s to the late 1990s. Similar developments and deficiencies of critical discussion and quality assurance are evident in most, if not all, fields of science. Most colleagues from physics, chemistry and the life sciences concede that the phenomena outlined above are a serious problem which substantially inhibits scientific progress.

Scientific publishing faces a dilemma between important and conflicting needs which the traditional ways of journal publishing and peer review cannot resolve: rapid publication and dissemination versus thorough review and discussion of novel ideas and results.

Rapid publication is required for efficient exchange of new findings, and it is widely pursued in current scientific publishing. Most successful journals in physics, chemistry and life sciences push for very short peer-review times (2–4 weeks), and short papers with a lack of detailed information and scientific rigour are often treated preferentially. The legitimate quest for rapid exchange and the regrettable trend towards ever-shorter peer review, shorter articles and an increasing number of publications have resulted in the scientific information market being flooded by journal articles, preprints and proceedings with little or no quality control. Thorough review and discussion are essential for the detection and minimization of flawed and useless research activities and results, but under the existing conditions this is hard to achieve.

Resolution of the dilemma of rapid scientific exchange versus thorough quality assurance requires a two-stage (or multi-stage) publication process. Efficient quality assurance in the highly diverse world of science requires interactive forms of peer review and public discussion.

Interactive scientific journal concept

The most promising, if not the only practicable way to substantially improve mainstream

scientific publishing and quality assurance on a short to medium timescale (years to decade) is the implementation of a two-stage publication process comprising interactive peer review and public discussion.

The basic principle of the interactive scientific journal concept is illustrated in Figure 1. In the first stage, manuscripts that pass an efficient access peer review or pre-selection by the editor are immediately published in a scientific discussion forum on the Internet. Then they are made available for full interactive peer review and public discussion, during which the comments of referees (anonymous or attributed), additional short comments by other scientists (attributed) and the authors' replies are published alongside the discussion paper. The interactive comments are published without peer review and revision, but can be censored in case of abusive commenting (personal offence, etc.). The access review (pre-selection by the editor with optional advice from referees) is meant to avoid a potential overload of the discussion forum with papers that are clearly deficient or out of scope. In case of doubt, however, editorial decisions should be predisposed in favour of publication in the discussion forum. To ensure publication precedence for authors and to provide a lasting record of scientific discussion, the discussion papers and interactive comments are permanently archived and fully citable.

In the second stage, the peer-review process is completed and final revised papers are published in the scientific journal. Completion of peer review and the final editorial decision to publish are performed as in traditional scientific journals (with iterative review and revision if required), taking into account the comments from the preceding public discussion.

The interactive scientific journal concept with its two-stage publication process (Figure 1) offers an all-win situation for authors, referees and readers. The primary positive effects and advantages compared to traditional scientific journals with closed peer review are:

- The discussion paper offers 'free speech' and rapid dissemination of novel results (authors' and readers' advantage).

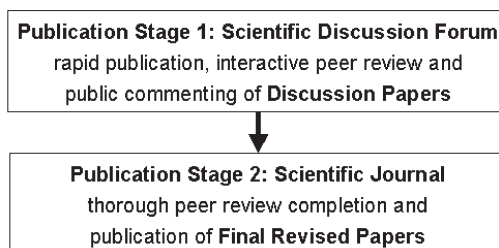


Figure 1 Basic principle of the interactive scientific journal concept: two-stage publication process with interactive peer review and public discussion.

- The interactive peer review and public discussion offer direct feedback and public recognition for high-quality papers (authors' advantage); they prevent or minimize the opportunity for hidden obstruction and plagiarism (authors' advantage); they provide complete and citable documentation of critical comments, controversial arguments, scientific flaws and complementary information (referees' and readers' advantage); they deter submissions of careless, useless and false manuscripts (referees' and readers' advantage).
- The final revised paper offers a maximum of scientific information density and quality assurance through full peer review, public discussion and final revision based on the referee comments and additional comments from other interested scientists (readers' advantage).

*all-win
situation for
authors,
referees and
readers*

Readers who are primarily interested in the quintessence of manuscripts that have been fully peer reviewed and approved by referees and editors can simply focus on the final revised paper (or, indeed, its abstract) published in the journal and neglect the preceding discussion papers and interactive comments published in the discussion forum. Thus the two-stage publication process does not inflate the amount of time required to maintain an overview of final revised papers. On the other hand, readers who want to see original scientific manuscripts and messages before they are influenced by peer review and revision, and who want to follow the scientific discussion between authors, referees and other interested scientists, can browse

the
transparent
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prevents
authors from
abusing the
peer-review
process

the papers and interactive comments in the discussion forum.

The possibility to compare a final revised paper with the preceding discussion paper and to follow the interactive peer review and public discussion facilitates the evaluation of individual publications also for non-specialist readers and scientific evaluation committees. The style and quality of interactive commenting and argumentation provide insights that go beyond, and complement, the information contained in the research article itself.

The two-stage publication process stimulates scientists to prove their competence via individual high-quality papers and their discussion, rather than just by pushing as many papers as possible through journals with closed peer review and no direct public feedback and recognition for their work.

Authors have a much stronger incentive to maximize the quality of their manuscripts prior to submission for peer review and publication, since experimental weaknesses, erroneous interpretations, and relevant but unreferenced earlier studies are more likely to be detected and pointed out in the course of interactive peer review and discussion

open to the public and all colleagues with related research interests.

Moreover, the transparent review process prevents authors from abusing the peer-review process by delegating some of their own tasks and responsibilities to the referees during review and revision behind the scenes. Referees often make substantial contributions to the quality of scientific papers, but in traditional closed peer review their input rarely receives public recognition. The full credit for the quality of a paper published in a traditional journal generally goes to the authors, even when they have submitted a carelessly prepared manuscript that has taken a lot of time and effort on the part of the referees to turn it into a good one.

Atmospheric Chemistry and Physics

Figure 2 illustrates the two-stage publication process with interactive peer review and public discussion as practised in the international scientific journal *Atmospheric Chemistry and Physics* (ACP), which was launched in September 2001. ACP and its discussion forum ACPD (*Atmospheric Chemistry and Physics Discussions*) are produced

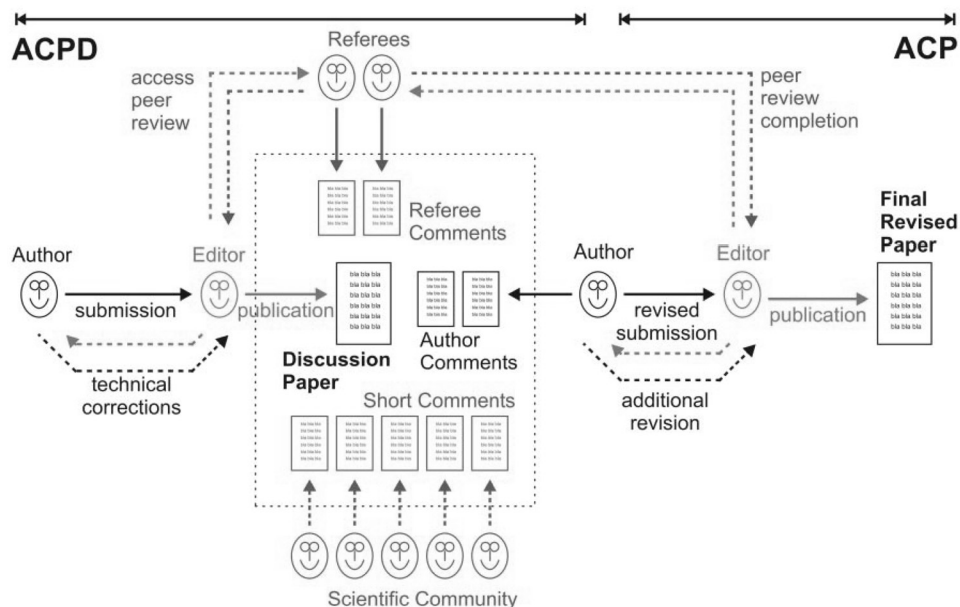


Figure 2 Two-stage publication with interactive peer review and public discussion practised in the interactive scientific journal *Atmospheric Chemistry and Physics* (ACP) and its discussion forum ACPD (bold arrows: basic processes; dashed arrows: optional processes).

and published by the European Geosciences Union (EGU, www.copernicus.org/EGU/EGU.html) and the Copernicus Society (www.copernicus.org). Both ACP and ACPD are ISSN-registered and freely accessible via the Internet (www.atmos-chem-phys.org). Paper copies and CDs are printed and sold on demand; for archiving purposes, free paper copies are distributed to several major libraries around the world. A globally distributed network of about 70 editors, co-ordinated by an executive committee and a chief executive editor, cover 32 major subject areas (research subjects and activities) within the scope of the journal. Manuscripts are normally handled by an editor with a high degree of specialist knowledge in the subject area of the submitted work. Details about the efficient and largely automated handling and editor-assignment of submitted manuscripts, as well as other technical aspects and answers to frequently asked questions, are given on the journal website.

The publication market in the atmospheric sciences currently comprises approximately 40 traditional journals publishing about 4,000 papers per year. Well-established traditional journals competing with ACP are the *Journal of Geophysical Research – Atmospheres* (American Geophysical Union, ~1,000 papers/year), *Atmospheric Environment* (Elsevier, ~500 papers/year), *Journal of the Atmospheric Sciences* (American Meteorological Society, ~200 papers/year), *Atmospheric Research* (Elsevier, ~100 papers/year), and *Journal of Atmospheric Chemistry* (Kluwer, ~50 papers/year). Two years after its launch ACP is already very well positioned among its traditional competitors. It publishes over 150 high-quality papers per year with an increasing trend, and it has been positively evaluated and is fully covered by the major citation indices: ISI (Institute of Scientific Information) and CAS (Chemical Abstracts Service). Moreover, ACP has received widespread public recognition as a promising scientific publishing initiative.^{4,5}

In late 2003 the rate of regular manuscript submissions was about 15 per month (and increasing). In addition to the regular submissions, over 100 manuscripts have been submitted to several 'special issues', i.e.

series of papers arising from a particular conference or measurement campaign. In ACP such special issues are handled in an efficient new way, which offers several advantages compared to special issue publications in traditional print journals (e.g. no publication delays by waiting for the last paper), and is described in detail on the journal homepage.

The fraction of submitted manuscripts rejected by the editors or withdrawn by the authors after the access review (before publication in ACPD) was ~15%. The fraction of manuscripts that were published as discussion papers in ACPD but for which a revised version for publication in ACP was not submitted by the authors or not accepted by the editors was less than 10%. Thus the overall fraction of manuscripts submitted but not accepted for publication in ACP (~20%) was much lower than in traditional atmospheric science journals (~50%), although the quality standards of ACP are by no means lower. These results confirm that interactive peer review and public discussion indeed deter deficient submissions and counteract the flooding of the scientific publication market.

The time from submission of a research article to its publication as a discussion paper in ACPD was typically 1–2 months, including access review and typesetting of the discussion paper. The time from publication in ACPD to publication in ACP was typically 2–4 months, including interactive peer review and public discussion, revision, peer-review completion and typesetting. Accordingly, the complete time from initial submission of a research article to its final publication in ACP was typically 3–6 months. Full automation of the editorial and production processes are expected to further reduce processing times in the near future. The absolute minimum time from submission to final publication in an interactive journal is given by the duration of the open discussion. In ACP this was set to 8 weeks, with an option for flexible extension if required, and this has proved to be a suitable arrangement.

A publication alert service informing interested scientists about new discussion papers is obviously desirable for lively public

*interactive
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indeed deter
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submissions*

a substantial amount of complementary information not available for traditional journal publications

discussion and was foreseen from the beginning of ACP. For technical reasons this service has not yet been activated (hopefully it will be in 2004), which has limited the visibility of new discussion papers up to now. Nevertheless, an average of four interactive comments are published per discussion paper, and the total number of interactive comment pages amounts to ~40% of the total number of discussion paper pages, which is a substantial amount of complementary information not available for traditional journal publications. Most interactive comments were published by referees and authors, but on average one in four papers received an additional short comment by other interested members of the scientific community, which is much more than the rate of commentaries in traditional atmospheric science journals (about one in 100 papers). A further increase of comments from interested members of the scientific community is expected upon activation of the ACPD publication alert service. Note, however, that such additional comments are neither expected nor required for every

discussion paper published in an interactive journal. Also, for papers that receive no comments from the public, full peer review by the referees and editors is guaranteed, and the transparency of the referees' comments and authors' replies, combined with the option for public commenting, assures most of the advantages of the interactive journal concept outlined above.

An example of interactive discussions in ACPD is illustrated in Figure 3. Note that in this case the discussion paper was a peer-reviewed commentary, which is analogous to the commentaries published in traditional journals and allows scientific discussions to go beyond the limits of interactive commenting. The interactive comments published in ACPD comprise compliments and plaudits (e.g. *Atmos. Chem. Phys. Discuss.* 2003:3, S1107–8), constructive supplements (e.g. *Atmos. Chem. Phys. Discuss.* 2002:2, S530–2), and harsh criticism and controversy (e.g. *Atmos. Chem. Phys. Discuss.* 2003:3, S448–51 and S912–18). So far, however, no personal or abusive comments have occurred, and there has been no need for the editors to

Atmospheric Chemistry and Physics Discussions (ACPD): Interactive Discussion

Discussion Paper

Publication Date **Title, Authors, Reference**






















01.07.2003 **Comment on evidence for surface-initiated homogenous nucleation**
J. E. Kay, V. Tsemekhman, B. Larson, M. Baker, and B. Swanson
Atmos. Chem. Phys. Discuss., 3, 3361-3372, 2003

Online Access

[Abstract \(HTML, 3 KB\)](#)
[Full Text Online Version \(PDF, 311 KB\)](#)
[Full Text Print Version \(PDF, 222 KB\)](#)
[Final Revised Version \(ACPD\)](#)

Interactive Discussion

Status: Closed

RC S1124 : 'Referee Comment on Kay et al.', Anonymous Referee #2, 28.07.2003, 19:06  
 — **AC** S1176 : 'Response to Anonymous Referee #2', Jennifer Kay, 05.08.2003, 20:05  
RC S1126 : 'Referee comment on Kay et al.', Paul DeMott, 28.07.2003, 22:59  
 — **AC** S1201 : 'Author response to referee Pa...', Jennifer Kay, 07.08.2003, 10:02  
SC S1134 : 'Comment on Kay et al. paper', Azadeh Tabazadeh, 29.07.2003, 21:33   
 — **AC** S1374 : 'Author Response to Tabazadeh ...', Jennifer Kay, 24.08.2003, 20:21  
 — **SC** S1393 : 'Reply to Kay et al.', Azadeh Tabazadeh, 26.08.2003, 18:11  
 — **AC** S1507 : 'Author Response to A. T...', Jennifer Kay, 12.09.2003, 0:41  
RC S1407 : 'review of Kay et al', Anonymous Referee #1, 28.08.2003, 9:46  
 — **AC** S1504 : 'Response to Anonymous Referee #1', Jennifer Kay, 11.09.2003, 23:53  



AC: Author Comment (on behalf of all co-authors)
RC: Referee Comment (anonymous or attributed)
SC: Short Comment (attributed)
 Online Version (PDF)
 Print Version (PDF)

Figure 3 Screenshot of an interactive discussion in ACPD (*Atmos. Chem. Phys. Discuss.* 2003:3, 3361–72).

intervene. About two-thirds of the referee comments are published anonymously. The rate of attributed referee comments is much lower among experimentalists (~20%) than among modellers (~50%). Apparently the referee comments on modelling studies contain more suggestions and ideas, for which the referees like to claim authorship.

During the start-up phase, ACP has been financed by the Copernicus Society, the European Geophysical Society (EGS) and the EGU. To maintain open access, future manuscript processing will be financed by moderate service charges levied on the authors (http://www.copernicus.org/EGU/guidelines_for_manuscript_and_article.htm). Interactive commenting will of course remain free of charge.

Key features of the ACP interactive journal concept and comparison with other initiatives

The key features of the ACP interactive journal concept for maximum efficiency of scientific exchange and quality assurance are:

- Publication of discussion papers before full peer review and revision: rapid publication, 'free speech', and public accountability of authors for their original manuscript (leads to reduction of careless submissions).
- Interactive peer review and public discussion: support of peer review, revision and editorial decision by comments from interested members of the scientific community (leads to maximum quality assurance and information density for final revised manuscripts).
- Optional anonymity for referees: enables critical comments and questions by referees who might be reluctant to risk appearing ignorant or disrespectful.
- Archiving and citability of every discussion paper and interactive comment: enables documentation of controversial scientific innovations or flaws, and the public recognition of commentators' contributions.

During the initiation and planning of ACP and its interactive journal concept in

the years 2000 and 2001, I was looking for – but was unable to find – similar initiatives to compare with and learn from. It was only at an e-publishing workshop of the Max Planck Center for Information Management in May 2002 that I learned of a similar initiative launched as early as 1996. That initiative was the *Journal of Interactive Media in Education* (JIME, <http://www-jime.open.ac.uk>). Coming from a different scientific background, the founders of JIME had designed and realized a similar concept of interactive peer review and public discussion. Unfortunately, however, JIME has not grown as fast as ACP and seems not to have inspired the foundation of similar journals in related fields of science and humanities. Despite the overall conceptual similarities, JIME does not show some of the key features of the ACP interactive journal concept. In particular, the 'private open peer review' of JIME foresees a non-public exchange of arguments between referees and authors, which is opened to the public only after approval by the editor. This seems to limit the publication and documentation of controversial scientific innovations or flaws much more than the 'access peer review' of ACP (quick go/no-go decision essentially without non-public exchange of arguments between authors and referees). Moreover, all referees are named and no anonymous referee comments are allowed in JIME, which is likely to limit and inhibit critical review and discussion. These differences may appear subtle at first sight, but they are highly relevant for the practical operation of a scientific journal and may be decisive for its success and acceptance in the target scientific community. Nevertheless, the basic aims and principles of ACP and JIME are very similar, and both have successfully demonstrated the applicability and advantages of interactive peer review and public discussion.

Alternative approaches to improved scientific publishing and quality assurance are being pursued by several journals that provide access to the 'pre-publication history' and/or offer the opportunity for open 'peer commentary' only after completion of the actual peer review and publication of the final revised manuscript. Examples are the medical journals published by BioMed Central

successfully demonstrated the applicability and advantages of interactive peer review and public discussion

(www.biomedcentral.com) and the journals *Behavioral and Brain Sciences* (www.bbsonline.org) and *Psychology* (psycprints.ecs.soton.ac.uk). The features offered by these journals are very useful and represent an improvement over traditional scientific publishing, but they miss some of the key features and fall short of the advantages of the ACP interactive journal concept. Controversial scientific innovations or flaws in papers rejected after peer review are not documented for the public and scientific community. Moreover, the completion of peer review and revision before publication and public discussion of a manuscript does not allow interested members of the scientific community to have any input to the revision and the final editorial decision. There is thus suboptimal quality assurance and information density.

As long as pre-print servers or e-print archives (e.g. arXiv) are not involved in a process of interactive peer review and public discussion but just serve as repositories for manuscripts that are later peer reviewed in traditional journals, they do not efficiently improve scientific quality assurance and information density. If, on the other hand, they were embedded in an open access publishing environment, they could serve as the basis for quality assurance by interactive peer review and public discussion. Plans for open access scholarly communication systems, which allow flexible distribution of the individual processes involved in scholarly communication and quality assurance among different parties in a global network of open access repositories, do already exist and are being pursued.⁶⁻⁸ Such novel communication systems could and should certainly include two-stage or multi-stage publication processes with interactive peer review and public discussion; their creation, however, will probably take more than just a few years. In the meantime, the implementation of the interactive journal concept in new and existing journals appears to be the most promising way to achieve the urgently needed improvement of scientific quality assurance.

The interactive journal concept can be very flexibly adapted for implementation in present and future forms of scientific

publishing, and the two-stage publication process with interactive peer review and public discussion can be easily combined with other innovative publishing concepts. For example, ACP is considering the introduction of separate journal sections for final revised manuscripts of different general relevance or for different audiences. This approach would be analogous to the quality rating system of the Berkeley electronic press journals in economics (www.bepress.com/bejeap, www.bepress.com/bejm, http://www.bepress.com/bejte), and support the implementation of quality assurance feedback loops by comparison of editorial ratings with statistical ratings of individual papers (citation, commenting and download statistics).

Perspectives and propositions

The vision behind the interactive journal concept of ACP is to promote scientific progress by the introduction of a two-stage (or multi-stage) publication process with interactive peer review and public discussion as a general new standard of scientific quality assurance and evaluation.

Based on the principles and experiences outlined above, the general introduction of interactive peer review and public discussion should lead to: (i) re-evaluation and higher information density of scientific literature (better and fewer papers); (ii) improved documentation and evaluation of scientific quality and competence; (iii) faster scientific innovation and more efficient disclosure of scientific flaws.

The success of ACP has motivated colleagues from the geosciences community to start a journal based on the same concept. This new journal, *Biogeosciences*, will be launched in 2004, and more interactive journals are being planned.

To pave the way for a substantial large-scale improvement of scholarly communication and scientific quality assurance and evaluation the following measures are proposed:

1. Promotion of the implementation of two-stage (or multi-stage) publication processes with interactive peer review and public

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discussion, including discussion forums in new scientific journals and adding them to existing journals, and moving from the (obsolete) media-oriented terminology of pre-prints and (r)e-prints to a quality-oriented terminology of (original) discussion papers and (final) revised papers.

2. Promotion of open access publishing to enable unrestricted interactive peer review and public discussion as well as other innovative forms of improved scientific publishing, supporting open access by appropriate guidelines and funding for scientific institutions and publishers, and moving funding from subscription charges to publishing service charges to create a more dynamic and innovative market for the exchange of scientific information (see <http://www.zim.mpg.de/openaccess-berlin> and related websites/publications).
3. Fostering the evaluation of scientists and scientific projects by individual publications rather than just publication numbers, encouraging evaluation committees to complement mere publication counts by looking into interactively discussed papers, and the weighting of statistical evaluation parameters (e.g. citation or download frequencies) by quality assurance factors (no peer review < closed peer review < interactive peer review and public discussion).

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