QUANTIFYING THE VOLUNTEER EFFORT OF SCIENTIFIC PEER REVIEWING

BY MARY GOLDEN AND DAVID M. SCHULTZ

A survey of reviewers at *Monthly Weather Review* shows how they perform their reviews and allows a calculation of how much volunteer effort goes into producing a scientific journal.

We are always amazed by the huge effort and the degree of seriousness that peer reviewers bring to the task of reading submitted manuscripts and writing reviews—a voluntary task that takes time away from their own research, other work responsibilities, and personal time. By providing written comments on manuscripts that have been submitted to journals for publication, reviewers improve the quality of manuscripts that eventually are published or they recommend rejection. In turn, reviewers benefit from having the chance to read the latest research before it is formally published, influence research that may ultimately be published, demonstrate the ability to perform high-quality reviews and become an associate editor or editor eventually, develop contacts and collaborations, and improve their own writing and science. The workload on reviewers can be tremendous. Apart from anecdotal evidence, however, quantitative measurement of the time spent on the peer-review process is largely unknown. This article presents the results of a two-year survey of reviewers at *Monthly Weather Review* and calculates the contribution of reviews by individual reviewers and collectively to the system as a whole.

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DATA AND METHODS. To improve the peer-review process qualitatively and quantitatively by gathering information that might decrease the time to editors' decisions for the benefit of authors, a brief survey was designed to find out more about how peer reviewers of *Monthly Weather Review* perform their reviews. Given that the principal impediment to timely decisions is the wait for late reviews, a decrease in the time that manuscripts reside with reviewers results in faster decisions.

This survey was conducted over a 2-yr period from 28 November 2007 to 6 December 2009. Upon

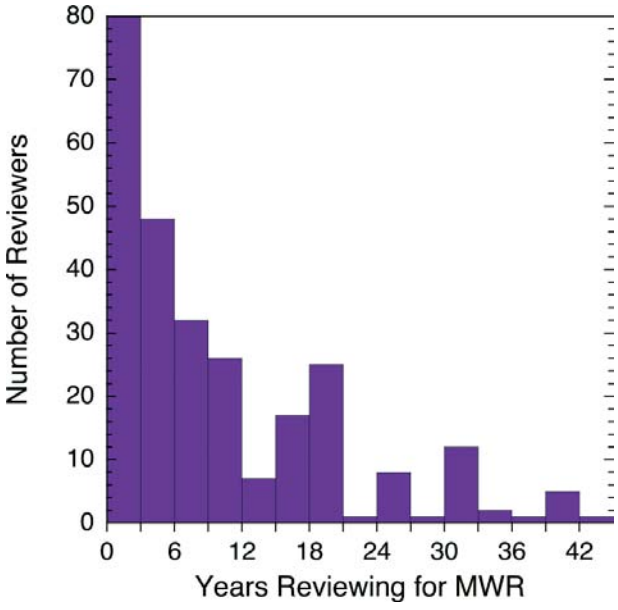

Fig. 1. Histogram of number of years reviewing for *Monthly Weather Review* by respondents to the survey.

agreeing to review a manuscript, each reviewer received a request to answer the survey questions. The survey consisted of four main questions plus an option to add suggestions or comments. (Two questions were added in March 2008, bringing the total to six. Every reviewer who had already sent in a completed survey received a follow-up email requesting answers to the two new questions.) The survey asked each reviewer for the number of manuscripts reviewed each year (for *Monthly Weather Review*, for the AMS, and for all scientific journals in total), the length of time required to perform a review, how the reviewer managed his or her time, how long the reviewer had been reviewing papers for *Monthly Weather Review*, if the reviewer was comfortable with the number of papers reviewed, and if she or he would like more manuscripts to review.

To increase the response rate, a reviewer who did not respond to the survey by the time that a final decision was rendered on the manuscript received up to two reminders. Three hundred and ten surveys were returned, which we estimate is about 15% of the 2000 invitations sent (400 manuscripts per year multiplied by 2.5 reviews per manuscript multiplied by 2 yr). Although some invitations would have gone out again to reviewers who had agreed to review manuscripts more than once during this period, responses were checked to ensure that a reviewer was not counted twice. The anonymity of the respondents was preserved as only the authors of this article have access to their identities.

The following rules were applied to code the survey responses for analysis. For questions requiring a single numerical value, responses of a range of numbers were coded as the mean of the range (e.g., "10–15 yr" was coded as "12.5 yr"). For questions requiring a frequency, responses of "usually" or "mostly" were coded as "yes," and responses of "rarely" or "occasionally" were coded as "no." Respondents who replied that this was their first review for *Monthly Weather Review* were coded as having performed one review and as having been reviewing for one year. Respondents who said anything other than a flat-out "no" on whether they wanted more reviews were coded as "yes."

RESULTS. Reviewers were asked how long they had been performing reviews for *Monthly Weather Review*. Some reviewers indicated that they had been reviewing for other journals longer than they had been for *Monthly Weather Review*, but unfortunately we did not collect that information for all respondents. Of the 280 respondents who answered this question, 24 (9%) reported that the current review was their first for *Monthly Weather Review*; of those 24, 5 (2% of the 280 respondents) reported that the review was their first ever completed for any journal. Two hundred and six (71%) respondents had been reviewing 12 yr or less, and five (2%) reviewers had been reviewing for *Monthly Weather Review* for more than 40 yr (Fig. 1).

Figure 2 shows the number of reviews that reviewers perform on average per year. The respondents performed a mean of 2 reviews each year for *Monthly Weather Review*, 4 reviews for AMS journals, and

A BRIEF HISTORY OF PEER REVIEW

Although the earliest scientific journals were published in 1665 (*Philosophical Transactions and Journal de Sçavans*), most articles submitted to scientific journals did not undergo peer review until the middle of the last century (as summarized by Weller 2001, 4–7). Before that time, the decisions at most scientific journals were usually made directly by their editors. As the founding editor of *Tellus* and *Journal of Meteorology*, C.-G. Rossby occasionally accepted a manuscript without peer review (e.g., Harper 2008, p. 131). For example, the paper describing the first numerical weather prediction (Charney et al. 1950) was accepted for publication in *Tellus* without peer review by anyone other than the journal editor (Rossby). Manuscript receipt and revision dates printed in *Monthly Weather Review* articles suggest that peer review was likely active at least as early as the 1950s, when it was published by the U.S. Weather Bureau.

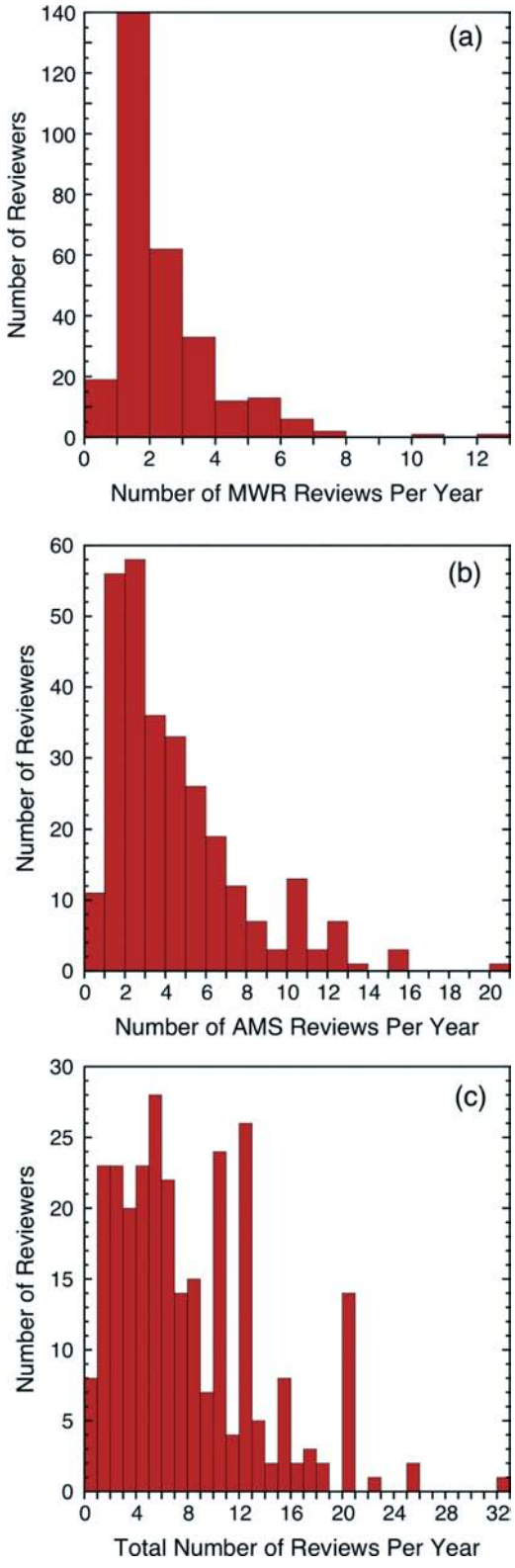

Fig. 2. Histograms of the (a) average number of *Monthly Weather Review* reviews per year, (b) average number of AMS reviews per year, and (c) average number of reviews per year from all journals performed by respondents to the survey.

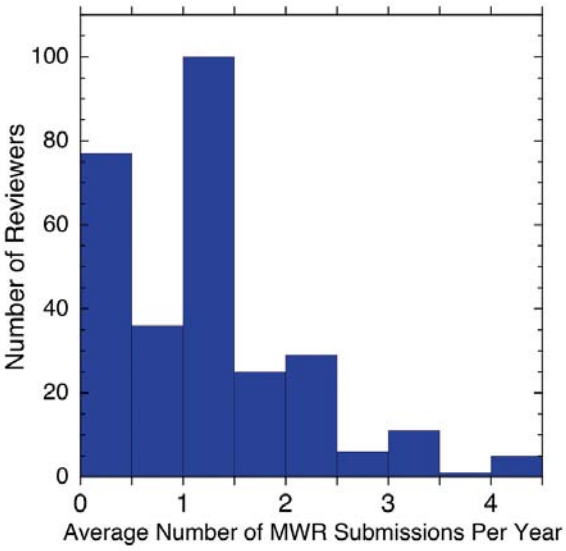

Fig. 3. Histogram of the average number of *Monthly Weather Review* submissions per year submitted by respondents to the survey.

8 reviews for all journals (medians of 1.5, 3, and 6 reviews per year, respectively). Some hearty reviewers averaged more than 20 manuscripts a year, with one reviewer undertaking 30–35 reviews a year—results that are similar to a global survey of 2,408 reviewers (Fig. 17 in Publishing Research Consortium 2008). Based on these results, *Monthly Weather Review* reviews constitute an average of 36% (median 29%) of all reviews that an individual reviewer performs.

Most reviewers (73% of those who responded to this question) averaged one or fewer submissions to *Monthly Weather Review* each year (Fig. 3). The Golden Rule of Reviewing (review at least 2–3 times the number of manuscripts that you submit) seems to be functioning at *Monthly Weather Review*. More than 58% of respondents reviewed at least twice the number of manuscripts they submitted to *Monthly Weather Review*, and 86% were within one review of meeting that goal. (Of course, this may be because the reviewers were not asked by editors to provide more reviews.) Of 252 respondents, all but 13 (5%) were comfortable with the number of reviews that they do. Of 248 respondents, 174 (70%) did not want to perform more reviews, although the remaining 30% were willing to undertake more reviews.

The number of hours that a reviewer spent on a review displays quite a range (Fig. 4). Three-quarters of respondents spent 3.5–12 h on a review (Fig. 4), with a mode of 6.0 h, a median of 8 h, and a mean of 9.6 h. Thus, based on these data, reviewing a manuscript took the better part of one or two focused

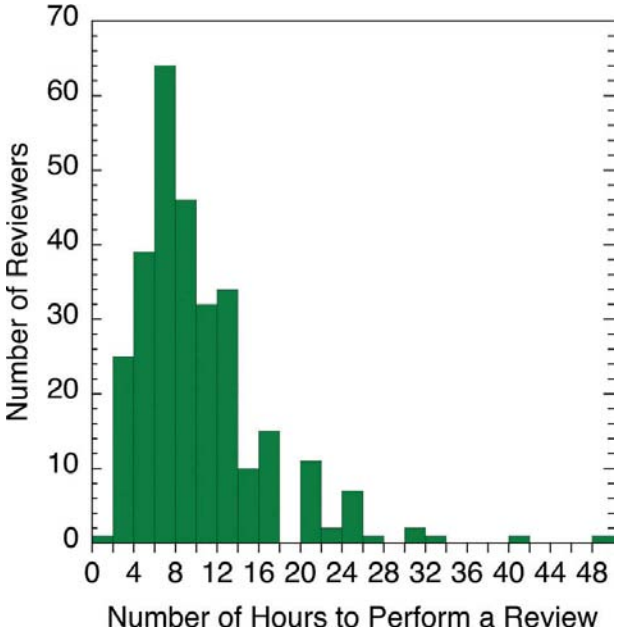

Fig. 4. Histogram of the average number of hours to perform a review for *Monthly Weather Review* by respondents to the survey.

workdays. Some reviewers read the manuscript soon after receiving it and wrote the review later after thinking about it. Other reviewers set aside time in their schedules to read the manuscript and write the review. Others spent time outside of work doing the review (e.g., Saturdays, evenings, on travel). The sidebar "How reviewers do their jobs" provides more details.

These time spans for reviews are much longer than published in previous studies (summarized by Weller 2001, p. 156), although they are similar to the mean of 8.5 h (median 5 h) found in Publishing Research Consortium (2008, Fig. 22). Specifically, medical articles (which are often only a few pages long) take 1–3 h to review (e.g., Lock and Smith 1990; Yankauer 1990; McNutt et al. 1990), whereas articles from biology and other sciences take 4–6 h (e.g., King et al. 1981). That the average *Monthly Weather Review* article published in 2010 was 18 pages long may explain the longer time required to produce a review for *Monthly Weather Review*. Indeed, Publishing Research Consortium (2008, p. 42) found that reviews in physical sciences and engineering took the longest time (10.4 h), compared to humanities and social sciences (7.9 h), life sciences (7.8 h), and clinical disciplines (5.3 h).

Although the number of hours spent reviewing manuscripts correlates negatively with both the number of years a scientist has been reviewing for *Monthly Weather Review* and the total number of reviews performed per year, this correlation is very weak (correlation coefficients of −0.17 and −0.27, respectively) and is not pragmatically significant. This result implies that the time required to perform a review depends little on experience, measured as either the number of years reviewing or the average number of reviews performed per year.

Given the number of reviews performed by each reviewer and the time required to perform a review, the number of hours each respondent spent each year performing reviews can be calculated for the 290 respondents who answered both questions. The mean number of hours spent by each respondent was 18 h yr^{-1} for *Monthly Weather Review,* 36 h yr^{-1} for AMS journals, and 63 h yr^{-1} for all journals (medians of 12, 26, and 50 h yr^{-1} respectively).

Summing up these mean numbers of hours performing reviews for *Monthly Weather Review* across all respondents, the total number of hours spent performing reviews for *Monthly Weather Review* by the 290 respondents can be calculated: 5,246 h yr^{-1}. Given that 290 respondents over two years represent about 15% of the approximately 1,000 reviews needed each year and assuming these 290 respondents are a statistically representative sample of the rest of the population of reviewers, the total effort by peer reviewers each year for *Monthly Weather Review* is estimated to be 362,179 h, or 4 years and 47.5 days. If we use the value of $64.91 (£40.40) for the hourly wage for peer reviewers in Research Information Network (2008, p. 34), the total value of volunteer labor of peer reviewers is valued at over $2.34 million.

Thus, the volunteer effort of peer reviewers requires more than 4 years of their time for every year *Monthly Weather Review* is published. This does not include the essential, but comparatively small, volunteer effort of the nine editors who read the submitted manuscripts, seek out the reviewers, and make decisions.

THE BURDEN ON REVIEWERS AND HOW TO REDUCE IT. The biggest problem with peer review, Egghe (2011) lamented, is "the workload of potential referees and, as a consequence of this, to find qualified referees who are willing to do the review job." Reviewers are committing a large amount of time to do reviews and most commonly do not want more reviews. Reviewers who are willing to take on more reviews tend to be less experienced and want to be more involved in the science and to gain experience as a reviewer. Or, these reviewers

would be willing to review more frequently, but only if the manuscript is directly related to their research interests or is "fantastically interesting," in the words of one respondent. (Sometimes editors invite reviewers who may not be experts on the topic of the manuscript to achieve balance among the reviewers or to get an outsider's perspective on the quality of a manuscript.)

Reviewers have other responsibilities (e.g., salaried job, family, community service), and these responsibilities are usually given precedence over getting reviews in on time—what one respondent referred to as "the tyranny of the urgent." Not many reviewers will admit to procrastination (at least among those who responded to the survey), although 38% of respondents admitted to submitting reviews late (see the sidebar "How reviewers do their jobs"). Speedy decisions are not the only goal of the peer-review process, however. One reviewer with more than 30 years of experience in reviewing for *Monthly Weather Review* replied as follows:

> I would be less hesitant to accept invitations to review papers (up to about six per year would be about right) if there were less of a sense of urgency involved in the process. At this stage of my career, a six-to-eight-week deadline would be preferable. I need to take my time when preparing reviews, and to proceed in a deliberate, reflective, thorough manner. This approach allows me to digest, under-

HOW REVIEWERS DO THEIR JOBS

Two questions on the survey focused on how reviewers performed their review. The first question aimed to find out how reviewers managed their time. Did they work on a review from start to finish, or did they work on it a piece at a time? Did they work on the review as soon they got it, or did they shelve it and work on it later? Did they wait to begin the review until after they received a reminder?

The results, displayed below in Fig. S1, show that respondents were roughly split on whether they worked on the review continuously or in segments. Also, respondents were roughly split on whether they worked on it when it arrived or saved it to work on later. Fewer than 10% of respondents waited until they received a reminder to start the review, according to the survey responses. Several reviewers provided written comments that they found reminders before the deadline helpful.

About 70% of the respondents self-reported getting reviews in on time, and about 30% said that they submitted reviews early (Fig. S2). Admitting to submitting reviews a week or more late was uncommon (less than 15% of responses). A small self-selection bias was inherent in the way the survey was carried out, as those reviewers who turn in reviews late may have been likely not to take the time to fill in an optional survey.

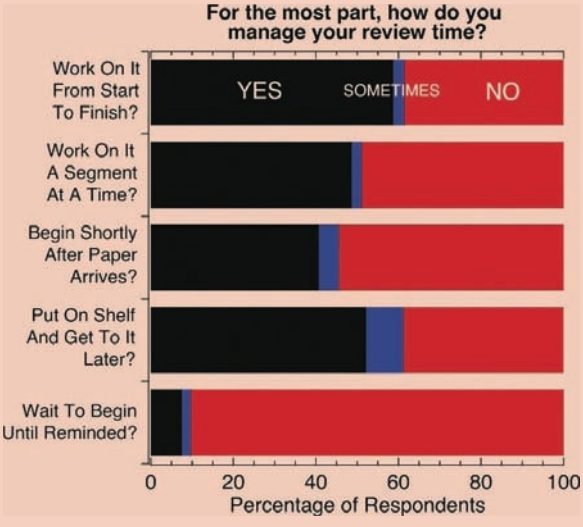

Fig. S1. Percentage of respondents to questions about how reviewers manage their review time. Black area represents "yes" answers, blue area represents "sometimes" answers, and red area represents "no" answers.

Fig. S2. Percentage of respondents to questions about when reviewers submit their reviews. Black area represents "yes" answers, blue area represents "sometimes" answers, and red area represents "no" answers.

> stand, and delve "between the lines" of a paper, and thus to achieve the scientific standard expected of reviews for leading peer-reviewed scholarly journals. My concern is that the present emphasis on minimizing the turnaround time gives the impression that speed and efficiency are valued more highly than the quality of reviews. Having stated this concern, I am well aware that journal publishing is competitive, revenue-dependent, and subject to economic pressures. Nevertheless, I still would want to advocate for the quality of reviews as critical to, and essential for, the reputation and stature of the AMS scientific journals, while fully appreciating the inherent difficulty of defining a meaningful metric for this attribute.

Editors have the ability to extend deadlines for reviewers who request extra time, and *Monthly Weather Review* grants extra time if a particular reviewer is essential for a particular manuscript or has a history of delivering high-quality reviews.

The number of reviewers needed likely will continue to increase unless mitigation efforts are put into place. The volume of submissions to journals is unlikely to decline due to several factors, including "publish or perish" (e.g., Clapham 2005); the increasing need to document productivity in universities and laboratories through publication lists and citation counts for university, national, and international metrics (e.g., Billaut et al. 2010; Dehon et al. 2010; Halilem et al. 2011); and the growing number of submissions from Asian authors (e.g., Zhou and Leydesdorff 2006; Li et al. 2007). Indeed, the number of articles in AMS journals has slowly increased over the last 50 years (Geerts 1999; Jorgensen et al. 2007). Coupled with the increasing number of proposals being submitted (e.g., Research Councils UK 2006; Natural Environment Research Council 2010, p. 33; National Science Foundation 2011), the burden of peer reviewing is growing rapidly. Anecdotal evidence from some of the editors at *Monthly Weather Review* and at other journals is that a greater fraction of prospective reviewers is declining invitations to perform reviews, citing not enough time to perform the review.

Potential solutions to the increasing burden entail either decreasing demand for reviews or increasing the supply of reviewers. Decreasing the demand for reviews can be accomplished by decreasing the number of submissions requiring review or decreasing the number of reviews per submission. Increasing the supply of reviewers can be accomplished by having reviewers spend less time per review or by increasing the number of reviewers (e.g., by recruiting more retired yet active scientists and early-career scientists).

Decreasing demand is one aspect of peer review studied by Roebber and Schultz (2011). Analyzing the peer-review system for funding using an agent-based model, Roebber and Schultz (2011) looked for ways to minimize the so-called Scientist's Dilemma, which is the situation of increasing effort required to obtain a share of decreasing funding by writing an increasing number of proposals (Roulston 2006; Carlson 2006). For scientists faced with the Scientist's Dilemma, the burden is dual—having to both write and review an increasing number of proposals as the funding rate declines. Roebber and Schultz (2011) identified strategies that program officers could employ to decrease the impact of the Scientist's Dilemma and noted that the complexity of the decision-making process may lead to unfavorable consequences, such as the declining success rate of individuals or the lower quality of the funded proposals. Although Roebber and Schultz (2011) focused on the peer-review process for *proposals*, the peer-review process for *manuscripts* could be similarly interpreted. For example, the number of reviewers could be reduced. Unfortunately, fewer reviewers per proposal submission would lower the success rate (Roebber and Schultz 2011). In contrast, whether two or three reviewers were used at *Monthly Weather Review* did not affect the decisions to accept or reject a manuscript or the number of rounds of reviews (Schultz 2010). Using fewer reviewers would reduce the volume of comments to which authors must respond as they improve a manuscript, likely resulting in slightly lower-quality published articles.

A different way to reduce the number of reviews would be to have the editor make more decisions unilaterally without sending out manuscripts for peer review, especially on those that are obvious rejections. At *Monthly Weather Review*, only 2.4% of decisions were made without peer review, and, of those, only a third were eventually published (Schultz 2010). The benefits of faster time to decision and fewer reviews are offset by authors feeling a bit cheated by not receiving peer reviews and the perception that editors may be biased in their decision making. Therefore, any move down this path should be a measured and well-considered one.

Another alternative is to increase the supply of reviewers. One approach would be to decrease the amount of time that manuscripts spend with reviewers, but this would produce the same problems as having fewer reviewers: less careful and thorough peer review. Another option would be to increase

SOME INTRIGUING PROPOSALS BY THE REVIEWERS

Our survey yielded a variety of responses in the free-form suggestions and comments section. Among the more intriguing were suggestions by the respondents for revisions to the peer-review process. Here we present some of the more inspired ones, and, for some, provide additional comments in brackets.

> In extreme cases, there should be a mechanism by which substantial reviews can warrant offers of co-authorship. I once gave a review that suggested a completely different mechanism for a set of model results and even outlined an additional set of sensitivity experiments to prove it. The authors conducted these experiments, found that my ideas were correct, and then rewrote the paper from scratch based on the revised theory. It is now a very highly cited paper, ahead of my own work on the topic. Even though my review was not anonymous, my reviewing efforts were not even mentioned in the acknowledgments. It was a frustrating experience afterwards to have people tell me about my own ideas at conferences that appeared in someone else's paper. In hindsight, I felt that in such cases, where a review completely changes the focus of the paper, that the journal editor should step in and suggest co-authorship to the authors.

> I think it would be helpful that for derivations in papers the authors send the complete derivations to the reviewers to assist in the review process even though the published paper itself will likely need to skip steps in the derivation for brevity's sake.

> I think it would be great if reviewers had a template in LaTeX or Word to follow and, as such, the response to the reviewer would also have a template.

> I think that reviews would go faster and be more beneficial if a reviewer could quickly convey questions he/she may have about the paper to the authors during the review rather than having to wait for the author responses to come back 1–2 months later. This could be accomplished by an alias email (e.g., mwr9999_revA@ametsoc.org) that would not reveal the reviewer's name. Or, perhaps a message board could be created for each paper in review.

[Authors' note: Authors can email questions for the reviewers through the editor or editorial assistant.]

> My biggest frustration is when you recommend major revision particularly for sloppy writing/style, but the science is basically acceptable trying to help someone along. Then, essentially the same paper comes back with only a few minor tweaks requiring just as much time to review as the first submission. At this point I do not feel like a reviewer but more of a proofreader.

> Does the AMS have a center for providing English composition and grammar corrections for papers submitted by non-English speakers and sometimes native English speakers? One of my most common critical comments is that the grammar and sentence structure of such-and-such manuscript needs work. Sometimes I take the time to go through grammatical errors and at other times I just let them go, including confusing sentence composition, hoping that someone can take care of it.

[Addressing the two comments above: The AMS provides a list of pre-submission editing services at www.ametsoc.org/pubs/preeditservices.html. Other services are also available.]

> Somewhere along the chain of funding sources, referees need to have a line item to charge their time for reviews, especially for those of us who are purely soft money. This is a contributor to late reviews. A paper needs a lot of time and thought, but this cuts strongly into me putting food on my table. The people with teaching positions will always have 6–9 months guaranteed, but we have zero guaranteed. Even if it never covered the full cost of refereeing articles, it would be welcome to charge off a day of time to each review.

> My supervisor does not encourage this type of activity [reviewing].

[Addressing the two comments above: Indeed, job requirements for some private-sector positions or for people on soft-money contracts may not recognize the benefits to one's career through peer reviewing. Although salaried employees often perform reviews in their "spare time outside work," hourly employees may not have that luxury. Therefore, other forms of reward should be considered. The Publishing Research Consortium (2008, p. 45) investigated incentives for reviewers and found that free subscriptions to the journal, acknowledgement in the journal, payment, or credit for accreditation were the most popular incentives for reviewers. The Research Information Network (2008, 64–67) modeled a scenario of paying reviewers as opposed to having the affiliations or the scientists donating their time as volunteer work. The increase in money to the individual researchers or their affiliations for doing the peer review is largely borne by the increased journal costs to the academic libraries. Yet, these incentives may not be worthwhile enough for some, given their financial situation.]

the size of the pool of reviewers. Early-career researchers, for example, could take on a greater share of the reviewing, as argued in Schultz (2009, p. 230). Especially when assisted by their mentors or advisors, early-career researchers engaged in the peer-review process can find it to be an educational experience that improves future submissions. Retired, but active, scientists may wish to continue or increase their activity as peer reviewers, as well.

CONCLUSIONS. This article shows that more than 4 years of volunteer peer-review effort is required to produce one year of *Monthly Weather Review*. Globally, the non-cash costs of peer review are estimated to be $3.1 billion (£1.9 billion), or nearly 30% of the total costs of publishing, and the cost per article is estimated to be $1,918 or £1,194 (Research Information Network 2008, 32 and 34). These calculations assume four hours per review (Research Information Network 2008, their Table 4.2), however, so they may be an underestimate if the results from *Monthly Weather Review* and those of Publishing Research Consortium (2008, p. 42) have greater generality.

As noted by one of the anonymous reviewers, these costs must be borne by someone. In reality, the reviewers' institutions (e.g., universities, government research laboratories and operational centers, private-sector companies) through the reviewers' salaries normally picks up this cost as part of the professional responsibilities of their employees. (Not all employers do, however, as noted by two respondents in the sidebar "Some intriguing proposals by the reviewers.") Therefore, these institutions ultimately subsidize the costs of maintaining quality within the journals. In addition, these institutions largely benefit from this scheme because their own employees reap the rewards of improvements to their submissions. Thus, untangling the direct and indirect costs of peer review may not be quite so simple.

Ultimately though, peer reviewing requires the voluntary participation of the reviewers. In tribute to this voluntary effort, Yankauer (1990, p. 1340) concluded, ". . . the scientific establishment depends not only on mutual trust and respect, but also on a substantial input of uncompensated labor. True, the donated time of reviewers is not entirely an expression of altruism; it may contribute to their own growth and critical insights, and perhaps this is sufficient payback." In fact, reviewers are not recognized for their efforts publicly by name, unless they reveal their anonymity, win an Editors Award, or are published in a year-end list of reviewers as was done for *Journal of Atmospheric and Oceanic Technology* in the 1990s and *Weather and Forecasting* during 2001–06. One author recommends the development of a "referee factor" that would be a measure of each individual's contributions to the review process, which, like other scientometric indicators, could be placed on a CV and used in promotions (Wilson and Lancaster 2006; Egghe 2011). Other suggestions for rewarding reviewers are among the ideas offered by respondents in the sidebar "Some intriguing proposals by the reviewers." Perhaps some of these are worth discussing and exploring as a possibility for the AMS journals.

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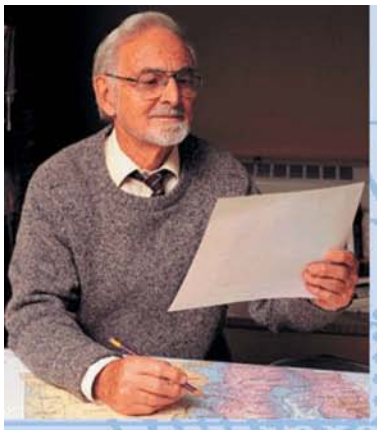

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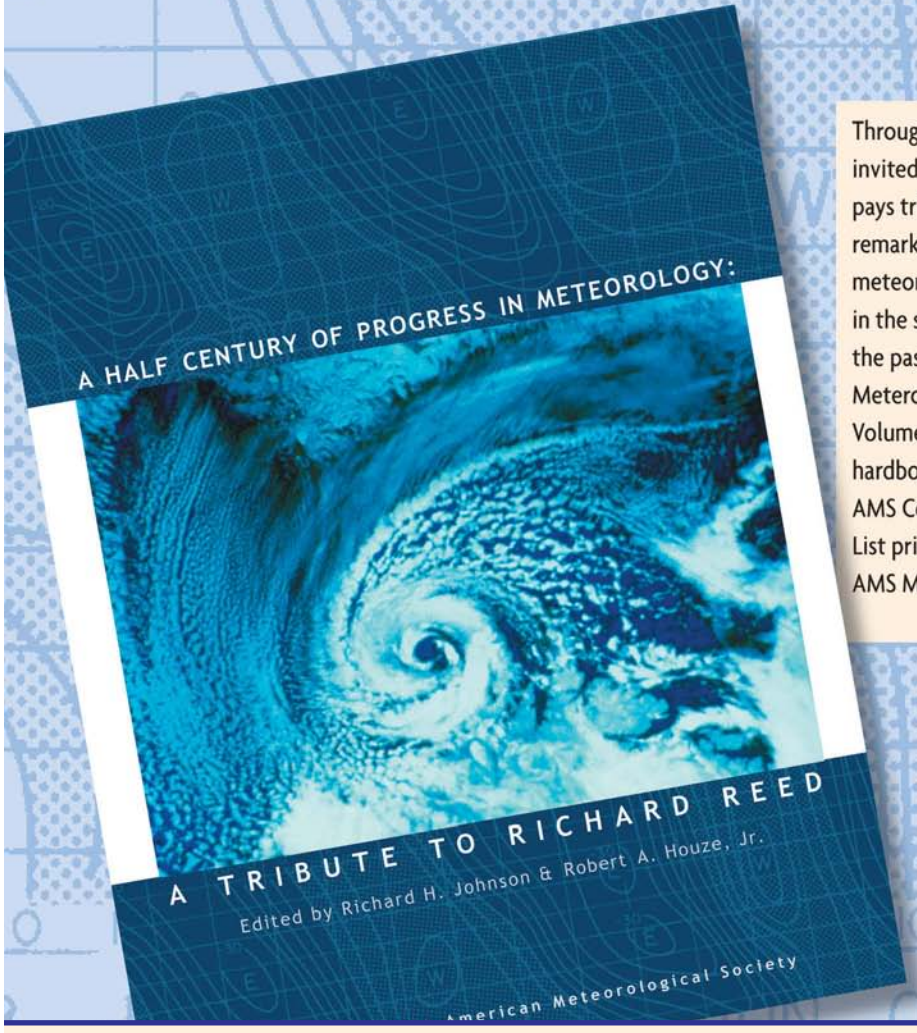

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