A guide to effective geophysical writing and presentation

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ABSTRACT

Much of the value of our geophysical work follows from conveying it to others, either orally or in writing. Geophysical studies are often communicated, both in print and presentation, in a general structure that includes introduction, methods and results, discussion, and conclusions. The use of standard writing and presentation rules-of-thumb can greatly enhance the appreciation, adoption, and further application of our geophysical work.

INTRODUCTION

James Michener (1992) wrote, "The writer who sits at his or her desk with an empty piece of paper staring back is like the explorer who stands at the edge of a new continent, uncertain of how to proceed" – an exciting but perhaps difficult position. The goal of this article is to provide that intrepid explorer with some additional tools, strategies, and thoughts to aid in the exploration and development of the new realm. In addition, the explorer will likely want (or have) to go back and tell others the fascinating story of the adventures had. So we'll also discuss how our brave speaker can enthuse, persuade, and educate the audience (after Stewart et al., 1995).

As much of the value of our geophysical work follows from conveying it to others, we must communicate, both accurately and compellingly, in writing and in speaking. This paper presents some standards, practices, and rules-of-thumb that we (and others – see References for General Reading) have found useful. A number of pitfalls are also described – mostly from our personal experience.

The communication process really starts early in the work or study itself; the deeper our understanding of the problem, the more clearly we will be able to describe it. During the work, it is essential that we continue to ask ourselves probing questions on the truth, completeness, and relevance of our solutions. Critical self-questioning will not only lead to better answers and greater confidence, but will help us to anticipate and respond to questions from associates or an audience.

The development of a geophysical technique or case history is not truly complete without presentation, review, and revision. There are many reasons for this. Presentation is where we communicate our work to others. In the subsequent review, comments, praise, and criticism come back to us. This is essential. Praise is important to let us know that we're on the right track, that our work is useful. It's warm and fuzzy and motivates us. Constructive, even stinging, criticism and suggestions are often necessary: for example, our study can have implicit but inappropriate assumptions that we don't recognize but others may; it may have unrecognized inefficiencies. Furthermore, it may use less than ideal methods compared to those used, perhaps obscurely, elsewhere. Review by colleagues, both junior and senior, internal and external to our organization, may help with these problems. In revision, we upgrade and enhance our work by taking into account the review discussion.

In all stages of the technical development, it is important to keep notes, references, figures, plots, etc. These should be organized, perhaps loosely, in files, notebooks, and electronic documents. As the study progresses, much of the final presentation can already be underway because we have kept snippets of writing, have jotted down references, drafted a few figures, generated some plots, and captured relevant information from the web or conference CDs. This evolutionary approach to the final paper or talk will minimize the amount of work required at its conclusion: most of a paper (structure, graphs, discussion, references) can already have been done before writing begins in earnest! Furthermore, keeping complete records will safeguard our accuracy in discussing them – the study might last longer than the precision of our memories.

Perhaps the most important aspects of communicating or transmitting technical information rely on personal qualities: patience, empathy, and energy. We need to have patience with an audience because they generally aren't as familiar with our work as we are. They will require adequate background information about the study, our motivation for doing it, and an appropriate rate of information delivery. We need to have empathy with the audience, to present our results not as we think of them but as the audience can understand them. Furthermore, people will likely try harder to follow us, if they know that we are attempting to present to them in a considerate way. Communication is close to teaching; and the value of instruction is more about what the 'receiver' has learned rather than what the 'transmitter' has broadcast. Finally, all of this takes energy. We have to want to communicate, to enthuse, to be accurate, and be understood. For many reasons (scientific, personal, financial, inspirational), we believe that good communication is eminently worth it.

WRITING A TECHNICAL PAPER

There are many different forms of technical writing including: e-mail, memos, letters, abstracts, short notes, posters, proposals, articles, reports, course notes, webpages, refereed papers, and books. These various forms have different lengths and depths, but all share a similar structure and intent. They must be clear, credible, and enlightening. The following gives a possible procedure for going about your writing:

The Eight-fold Writing Path

1) Define the subject
2) Decide on form and deadline
3) Gather and review material
4) Draft an outline (major ideas, sections)
5) Ferment, review, finalize the outline
6) Start writing (free flow)
7) Reorganize
8) Edit

Following a route something like the above can help one avoid writer's block, stalling, and slow progress. Further ways to prevent writer's block are: Start writing any part of the report... front, back, headings, references, introduction; anyplace...; don't worry about spelling, grammar, or anything editorial – that comes later – just get some words down; make associations freely; talk about the subject then return to writing. Keep moving ahead, even if only slightly.

There are also numerous variations in the style of scientific writing. The style depends on the subject matter, the purpose (in-house report, journal paper, agency document, etc.), the nature of the content (quantitative with data analysis, qualitative or descriptive, review of previous work, etc.) and other factors. However, summarized below are the major common elements of most geophysical papers:

Title
Author(s) and their affiliation(s)

Abstract

Introduction
Geology/Study area
Data Acquisition
Derivations/Methods
Data Analysis
Interpretation
Results

Discussion
Conclusions or Summary
Future Work
Acknowledgements

References
Appendices
Figure Captions
Figures
Tables and Captions

Let's expand a bit on some of the headings given above.

Title: It should be as brief as possible while still conveying the topic or problem treated. The title should contain significant words suitable for classifying or indexing the paper.

Author(s): The name(s) of author(s) should be followed by affiliation(s) and address(es).

Abstract: The abstract or summary is critically important as it is likely to be read by 10 to 500 times more people than is the entire paper (Landes, 1966). It is not an introduction, nor a table of contents, and not a list of what will be discussed in the paper. It is a summary of the essential results of the work described in the paper, including its principal conclusions. Enough background information should be included in the Abstract to make the results meaningful to the reader. Abstracts vary in length depending on the nature and length of the paper. However, they usually range from about 75 to about 400 words. The Abstract is similar to the Conclusions section. Short notes or commentaries may not need an abstract.

Introduction: This should set the stage for the paper so that, at the Introduction's end, it is clear to the reader just what the problem is, what progress has been made in the area previously, why you are pursuing this work, and how you are going to tackle the problem and enhance or advance the general state of knowledge in that area. This may include a brief literature review, statements of the area of study, the type of data gathered, the method of analysis, and/or some other indication of what the reader will encounter if indeed he/she is moved to read further.

Main Body: This is extremely variable but usually is comprised of several sections. They may deal with, for instance: the survey area, geologic setting, experimental set-up and procedure, data acquisition, mathematical derivations, methods, data analysis, error analysis, interpretation, results, etc.

Discussion: Often it is suitable, or even necessary, to discuss the significance or limitations of your study rather than just presenting it without comment. Sometimes this discussion may be incorporated into various sections of the main body; sometimes it may be combined with the Conclusions. We are provided an opportunity in the Discussion section to be a bit editorial, qualitative, or even speculative.

Conclusions: The important results or conclusions of your paper should be synthesized here into a several concisely phrased sentences. Point form may be suitable in some cases. New ideas or comments should not be introduced in the Conclusions as you are summarizing what has been shown previously in the paper. Recall that the Conclusion section will resemble the Abstract.

Future Work: Frequently, the study may have some unresolved issues or might raise new ideas which could be the subject of future research. You may have some great thoughts to pursue, which could be useful to interested readers, but there just wasn't time (or energy or funding, etc.) to do so in this piece of writing. These points can be briefly outlined in the Future Work section.

Acknowledgements: In the process of conducting our work and writing about it, we've often been helped by a range of people and organizations. It is thoughtful to express our appreciation to these individuals or groups. Sometimes agreements or contracts concerning the work may require a formal acknowledgement, especially if there was funding involved.

If an individual has contributed significantly to the technical content of a paper, via observational data, analysis, ideas regarding methodology, procedures, or detailed writing, then coauthorship may be more appropriate than just an acknowledgement.

References: All statements of an assertive nature that are not more or less axioms should be proved or referenced. Unfortunately, most ideas aren't new, so we need to acknowledge their creators. As we are usually building on the work of others or using their efforts, it is essential to acknowledge these sources as completely as possible. This is fair treatment of others' work and can avoid any intimation of plagiarism or theft.

A complete bibliography is a kind service to your reader and a conscientious author's responsibility. Those references cited in the text, usually by author and year, are generally listed alphabetically (then chronologically). Sometimes they may be provided as footnotes or, especially in the engineering literature, numbered in the order that they occur in the text. Background literature that is not explicitly cited can be listed separately under some heading like References for General Reading.

Appendices: An appendix contains material that is important enough to be included in the paper but not critical to understanding the main thrusts of the study. Similarly, if a secondary point requires lengthy or separate discussion that could detract from the continuity of the text, it could be better placed in an Appendix. Supporting mathematics or derivations are often put in an Appendix.

Figures and Tables: These should have captions or headings which enable them to be understood, in their essentials, independently of the text of the paper. Imagine a busy reader thumbing quickly through your article, stopping only at an interesting figure and trying to understand it. Figures may be embedded in the text close to their discussion place, usually closely following first mention, as in a published journal paper. Or they may be grouped in order at the end of the paper as in a report or manuscript that will undergo further review before journal publication.

In tables or plots, numbers without units are of very limited use unless they are, in fact, dimensionless. Otherwise, always provide units. The use of clear and complete annotations on the axes, lines, or data points of graphs will help the reader decipher what can be complicated information. Commentary about a figure, apart from essential annotation (units, labels, legends, north arrows, etc.) should largely be put into the figure caption.

Tone and style

Boldly state assumptions and limitations. This contributes to the honesty of a paper and helps with clarity and understanding. It also pre-empts the critic's strike. Most scientific readers will be more receptive to a reasonable theory, perhaps understated and qualified, than one with hidden problems that is pushed like a sales pitch.

Use correct, moderately formal but nonflowery grammar, and spell properly! There are spell-checking and grammar-assisting word processors to help in these regards. Beware though, word processors don't necessarily have a good grasp of meaning (e.g., the classic, "know more miss steaks that ewe can knot sea"). One word processor of ours didn't have the word geophysics in its dictionary and came up with its best replacement - goofiness.

Be careful with long sentences (more than about 3 lines) or run-on sentences. They're hard to follow and understand. Having colleagues read and critique your paper will likely help it considerably. A plain style of writing which uses well understood words, avoids repetition, and uses active tenses will probably be most appreciated. William Safire in his book *Fumblerules* calls attention to some issues of style, "Never, ever use repetitive redundancies; Avoid trendy locutions that sound flaky; Never use a long word when a diminutive one will do; Last but not least, avoid clichés like the plague." There are a number of useful guidebooks on syntax, word-choice, style, etc. (e.g., Cochran et al., 1979; Bernstein, 1981; Venolia, 1983; Buckley, 1992; PW&GSC, 1997).

Use appropriate technical standards (like SI and SEG in our case) in referencing, spelling, and stating units. The January issue of GEOPHYSICS gives a detailed guide to these.

Attempt to be concise. There is a movement in journals and trade magazines toward shorter papers. These are often easier to grasp and digest. In fact, some journals have page limitations or charges beyond a certain number. Also, a paper has more impact if it has one or two main points to convey. Important, new ideas can become diluted or even lost in a long, structurally complex paper. For better or worse, most people are busy and only have a short time for your paper.

The final, written paper must have a logical, coherent flow; it will frequently start with the simplest and most basic ideas, then develop in complexity. Often, the order to best present the work is not the same as the chronological order in which the work was done.

For most people (even some of the great authors), writing is not easy. Don't be alarmed if you go through 20 drafts of a paper – your computer won't mind. It is important to continue reworking sentences and concepts until they are clear. Revising is easier than writing the original script, so don't try for the perfect paper in the first draft. In the end, the critical matter is to get your work evaluated and appreciated by others. Hopefully, the paper will be good; realistically, it won't be perfect.

Finally, enjoy your paper! As geophysicists, our production is often in the form of a report or document. It can be exceedingly satisfying to produce a paper which has met your literary and technical goals. Your work and writing is something of which you should and can be proud.

PRESENTING A TECHNICAL PAPER

The structure of a technical talk is often very similar to that of a written paper. However, in giving an oral presentation, it is critical to be selective about what you include. There is almost always a time limit specified for a presentation. Most technical meetings have a presentation time of 10 to 20 minutes, a formal lecture perhaps 40 to 50 minutes, a news broadcast - a sparse 30 seconds! Many people can concentrate for only short periods even with the most engaging of orators. Better to be a little under the time given than over. This can give extra time for discussion or questions. A possible presentation structure is shown below:

Overview – introduction, motivation	] What you're going to say
Anecdotes Basic ideas, methods Results, examples, applications, limitations	] Say it
Summary, the future, acknowledgements	] What you've said

Visual aids and their presentation

As a general guideline, we suggest using about one graphic or slide per minute. This gives the audience adequate time to digest the information on the slide but provides new material rapidly enough that interest isn't lost. The title slide should include authors and their affiliations. It is also helpful to use an outline slide to ease yourself and the listeners into the talk. Each slide should be completely described, including, for example, the axes on plots. Remember that you are familiar with your slides but the audience won't be. To finish the talk it is helpful to include a conclusion slide – this is the information that the audience will be left with.

There are many tastes in slide design. Using a dark background and bright colors for lettering on your slides can help their readability. Some people prefer a white background and dark letters to keep the room well lit. Seismic sections are often best seen as black traces on a white background. Remember, in some halls, viewers may be half a football field length away from the screen – give them a chance to read the slides by using large slide-filling letters and figures. Four or five lines of text on a slide are usually plenty. If you are using two screens, try to arrange your slides so that they step through sequentially in pairs. PowerPoint presentations have largely displaced slides and transparencies that were prone to being upside down, out of order, or even melted.

It has been said that mathematics should be kept in your office, with the lights down, and the door closed. Viewers of talks with dozens of equations would likely agree. However, mathematics can be effectively communicated in a talk. It just takes time. The audience will be lost unless every variable in the equations, limits of the integration, etc. are described and explained. One or two equations per slide are generally all that can be assimilated by viewers. An audience of processors might like equations more than geologically oriented interpreters.

As mentioned before, plan your talk carefully to fit the available time. This is critical at most meetings, but especially at large gatherings where there may be many simultaneous sessions and a tight schedule. It's embarrassing to everyone if a session chairman has to give you 'the hook' - terminate your talk. Know where in your talk you should be at half time; slow down or speed up accordingly. Revise the talk until you feel that there is a logical, compelling flow to it. Practice your talk and know the order of your slides. The continuity of a talk is increased greatly if you introduce the next slide before it is displayed. Visit the room before you talk, stand at the podium to get a feel of the room. See where the laser pointer and the audio and slide controls are. It is useful to have your talk burned onto a CD or memory stick as back-up.

Standard public speaking rules

Many books and organizations tell us that good speakers are not just born, they are made. Practice works. Some of the following points may help improve your presentations. Attempt to modulate your voice (this helps maintain an audience's interest in your talk, and perhaps their consciousness). Speak loudly enough for the whole room to hear you. Rather than “um”, “ah”, etc., try to say nothing. Brief silences or pauses in the talk give the audience time to think about what you have said. It is important to maintain eye contact with the group at large and to avoid talking to the screen. People don't listen well if they’re not being spoken to directly. Avoid reading the text of your talk, except the introduction and conclusions (if necessary). Try not to read from your slides; the audience reads them visually faster than you do verbally.

Most people who perform publicly (whether musicians, actors, or geophysicists) experience some degree of stage fright or performance anxiety – a first talk in front of a luncheon of 900 colleagues is a stressful experience. Knowing that you are prepared and practiced minimizes this concern. Expecting a credible, but not brilliant performance from yourself can help too. Being less critical of the performance of others seems to allow one to let up on oneself too. Remembering that you have been asked to talk, and thus are giving to others, may make the situation less difficult for you. If you are nervous, have small cue cards or a written outline with you at the podium. We suggest adopting a fairly formal stance (e.g. hands out of pockets, standing straight, moderate use of gestures). There are other radical and valid styles, but generally in science we want to communicate technical points not theatrical excess.

If using a laser pointer, turn it off when moving between places on the screen to be emphasized. The eye follows the pointer and excessive pointer movement, especially circles, potentially causes whiplash or motion sickness! Using both hands to hold the pointer can prevent jitter, which is very distracting for the audience (perhaps revealing your anxiety level or a previous evening’s activities).

Don't pace (particularly in circles). If there's a stage, be careful not to step off it inadvertently (as happened to a colleague, pulling the microphone cord and laser pointer apparatus off in unison. This surprised, but undaunted, speaker stepped back onto the stage, said “oops”, and continued). If there's a podium, don't assume it to be so well anchored as to support the full weight of a leaning body.

In spite of the best preparations, accidents as above do happen: Additionally, a projector may quit or catch on fire as occurred to one of us, your computer hangs, or a jackhammer starts up next door. For such eventualities, immediately try to resolve the problem yourself or request assistance. Remain pleasant and polite. If a time gap ensues, try relating a suitable anecdote, ask for questions from the audience, or ask about the audience's experience. If the problem is persistent or will require some time to fix, suggest reconvening after an appropriate interval. Most public speakers have a whole library of their disasters. They are not the end of a career nor the world.

There are also rare occasions when you will encounter a hostile questioner. Most people don’t like belligerence, so the audience will probably be on your side. It is wise to answer the assertions calmly and concisely. Using phrases that acknowledge the question, but don't capitulate or insult can turn the attack into a learning experience for the audience or at least allow you to escape less wounded: "That's an interesting point" or "I understand what you're suggesting, but…", or "I can't really agree with that view because … ." If the questioner is persistent and unswayed by your answers, you might need to say that there is a difference of opinion and you would be happy to discuss it in detail later.

It's true, there's a lot to remember. But, by working at several points each time you present, you will eventually do them more naturally with less effort. It helps to appreciate that, by and large, the audience is sympathetic to you (they likely want to learn something from you, have devoted time to do so, and may have been in the spotlight themselves before). In other words, pretty well everyone wants your talk to be enjoyable and successful. Some organization, use of standard rules as well as practice will assist you a great deal in communicating your geophysics.

SUMMARY

Geophysical studies are often presented in a general structure that includes introduction, methods and results, discussion, and conclusions. The use of standard writing and presentation rules-of-thumb can greatly enhance the impact of your geophysical work.

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