Skills of Writing a Scientific Paper

(Jeffrey T. Freymueller)

Abstract: A critical aspect of the scientific process is the reporting of new results in scientific journals in order to disseminate that information to the larger community of scientists. Most journals accept papers for publication only after a peer review by a small group who work in the same field and who recommend publishing the paper. In this session, Prof. Jeffrey Freymueller talks about how to write an excellent paper and how to make your paper easily accepted by journals.

Host:

Good afternoon. Welcome to attend English GeoScience Café session 19. The topic of today is Skills of Writing a Scientific Paper. The speaker is Professor Jeffrey T. Freymueller served as a member of the US National Committee from 2003-2016. He was the chair of the committee and the USA representative to the IUGG Council from 2011-2016. In addition, he was a US National Representative to the International Association of Geodesy (IAG). He is also currently the Director of the Earth Scope National Office.

His research interests include the kinematics and dynamics of active processes that shape the Earth. He has made great contributions to the realm of geodesy and geophysics and has published more than 110 scientific papers that were issued in the journals Nature, Science, Journal of Geophysical Research, Geophysical Research Letters, and so on. Professor Freymueller is a Fellow of the American Geophysical Union (AGU). Let us welcome him!

Jeffrey T. Freymueller: Thank you. When we talk about writing a scientific paper, the hardest part is to organize it. Some of the organization issues are true for any language. We will talk specifically about English and discuss common problems that Chinese-speaking writers have in English. Then, we try to go through about the basic rules of English – maybe this is just a reminder for you of what you already know, but think about it anyway. Finally, I will try to give you some ways to improve your written English.

Fig.1. Professor Jeffrey T. Freymueller is giving the Talk of EGSC Session.19 (photo by by Ahmed Reda)

1. Importance of Communication

Communicating what you do in science is very important. If you do not write up your work and publish it, nobody will ever know what you did. You have to communicate your work; what you have done. After you finished your work, it is your responsibility to write about your work clearly.

We really focus on all the kinds of scientific and technique writing, and it is a little bit different if you write a story. We do not worry about the same things people writing fiction, poetry, or something else focus on. What is the most important in scientific and technical writing is organization, writing clearly, and so on.

Writing clearly requires.
1) Proper organization of the material.
2) Logical ordering of text and figures because you are discussing work you have done and making an argument about what you found.
3) Correct use of language.

The last point is important. I have read many papers from people whose native language was not English. Some of them are excellent, and some of them are impossible to read. Using language correctly is very important, because you must make the job of understanding easy for your readers.

Today, our topics cover three parts, the general structure about scientific paper, outlining, basic organization and methods that put your thoughts in order, and writing clearly in English, thus avoiding common mistakes.

It is good to look at some texts and try to look at them critically and spot errors. It is important to be able to spot errors, because at least when you can do that, you know it it is not right and you may ask someone specifically for help.

2. General Structure

A typical paper organized by several sections, as follows in figure 2. I have read many papers that mixed sections up. Those writers did not fully organize all their thoughts. They started writing, and then they realized that they needed to say something so they just said it at the point that they realized that. But maybe that is not the best place for that information. It is very easy to do that, but it is an easy way to make a paper hard to read.

General Structure of a Scientific Paper

The typical paper is organized something like this:
1. Introduction
2. Data
3. Methods
4. Results
5. Discussion
6. Conclusions
- *Look at good papers to find a model that best matches what you want to say.*

Fig. 2The General Structure of a Scientific Paper

The first step is making order. You decide how to put structure of your paper, and whether you need an introduction, regional background or not. You may have a slightly different organization structure, and the structure tells you what parts you are with and keep following that. The key point is finding a couple of good papers with good basic structure, which are easy to read and understand. Starting out with learning good structure will lead to a good start.

3. Outlining

Let us look at how we make sure that we put things into right place in our text. A very effective way is called making an OUTLINE. The idea of an outline is to start out by making a well ordered list of the topics that we are going to discuss. We might have some subtopics, and then we might have some points we want to make under each sub-topic. The outline is hierarchical, with multiple levels.
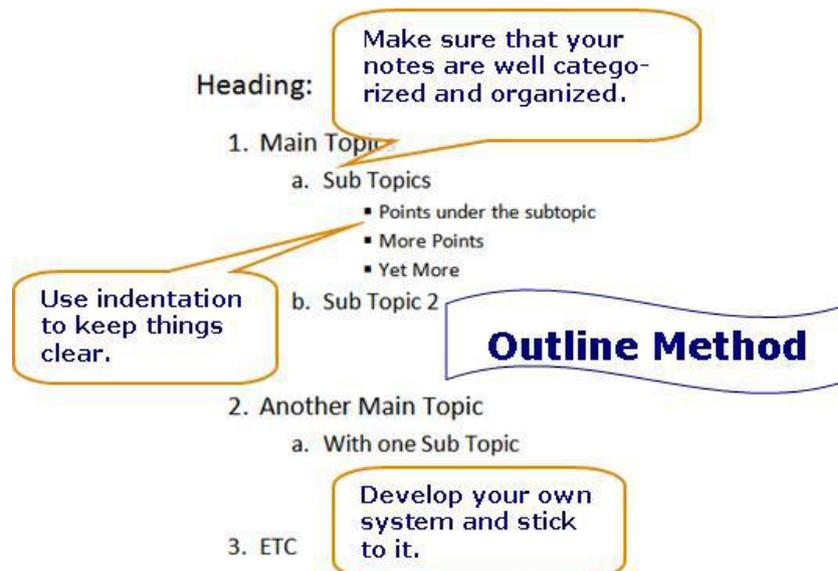
Make sure that your notes are well categorized and organized.

Heading:

1. Main Topic
   a. Sub Topics
      • Points under the subtopic
      • More Points
      • Yet More
   b. Sub Topic 2

Use indentation to keep things clear.

Outline Method

2. Another Main Topic
   a. With one Sub Topic

Develop your own system and stick to it.

3. ETC

Fig .3 The Format of Outline

The first level might be the sections to the paper, and then you go down and detail more and more. You make the whole frame first, then you can see if everything fits in place, and adjust it

before you start writing the actual text.

The outline puts your ideas into a structure that starts with main topics, and then lists sub-topics. There are rules you should follow when making an outline:

1) You should make outline to your paper including references to the figures, before you start writing anything.

2) You should detail the outline's whole structure first, once the outline is complete, then you can start writing parts of your paper, and following the outline will keep everything in order.

When you make the outline and follow it, all the parts will be in the right place. Sometimes, when you start writing, you find that some parts of your outline need to be modified, and you can make small changes in the outline.

It is also good to develop your own system and stick to it. There are some good examples. So finding a header, you just make an indentation or something, or you can just use indentation with numbers, letters, and so on.

Here is an example. This was a case where we developed our outline before we actually got down to writing the paper.
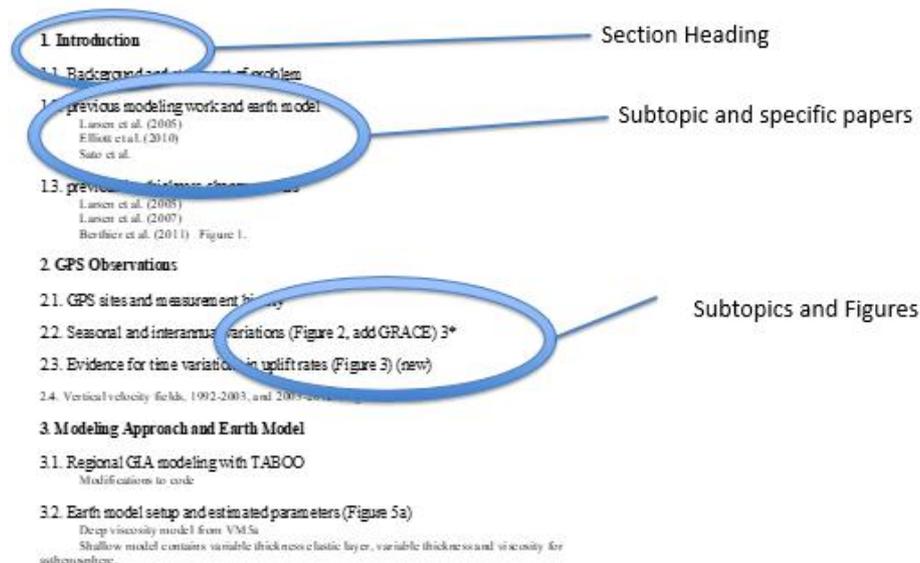

Fig. 4 Example of Outline

Here, I know where I am going to need to first reference each figure. This helps make sure that you reference the figures in the right order, and also helps you determine if your presentation of the results is complete. It is very easy to do while you develop the whole paper, and look through it to the end.

Having the outline and figures makes the text much easier to write, because each piece you are going to write is a self-defined piece when you ultimately write down. If you do not have that structure, then trying to keep whole thing in your head is much harder. When you are writing one piece at a time, you only need to be thinking about that one piece and the outline tells you where to put it in then structure. Doing this the right way then it makes much easier.

If you do computer programming, you might see that the outlining is like a top-down program design. You start at top place, forming the big structure, and then you work narrowly,

smaller and smaller. How many outline levels when you build it? You can have section, subsection, topics or points within subsections, as deep as you want to go. The lowest level that makes sense is the paragraph level. When I write a section, I outline the subsections, writing out the topic sentence of each paragraph that is going to be in that sub-section. Once I am satisfied with that, I go back and add the rest of each paragraph. The first sentence in each paragraph is what that paragraph is about, the topic sentence. Once I know what that is going to be, then each paragraph has a structure and it is easier to fill in the details and also to know when to stop.

Some problems can be avoided though outlining. The most common problem in papers is that material is put in the wrong place, for example, the presentation of data mostly being in the data section, but some parts being added in the modeling section. It is also easy to end up with figures that are referenced out of order, especially if you write without planning. Outlining will help you minimize that. The other thing is making decisions early on about the structure of your text that makes it easier to write each part. The solution is to give yourself the structure, and then you can focus on each topic one by one and know whether you put them in the right time of structure.

4. Paragraph Structure

As the slide shows, a paragraph is a group of sentences about one main idea. It can be short or long, depending on the topic or idea. A paragraph generally should be no longer than about 10 lines, because if it gets too long it gets hard to read. This is just a guideline for readability, not a strict rule. But if you have some topic that needs a lot of discussion, then it will be easier to read if you break it up into smaller, logical pieces and have one paragraph for each of these pieces. Once you feel happy that you have nothing further to say on that particular subject, you should move on to a new paragraph.

It is very common that inexperienced writers will write a paragraph that somewhere halfway through completely switches to a very different topic and just continue. A paragraph should be about one topic. The idea behind writing in paragraphs is that paragraphs make the text much easier to read.

Breaking the text up into pieces makes it easier to read. Each paragraph should have one topic and should start with a topic sentence, which makes it clear. Do not suddenly change to another topic in the middle of a paragraph.

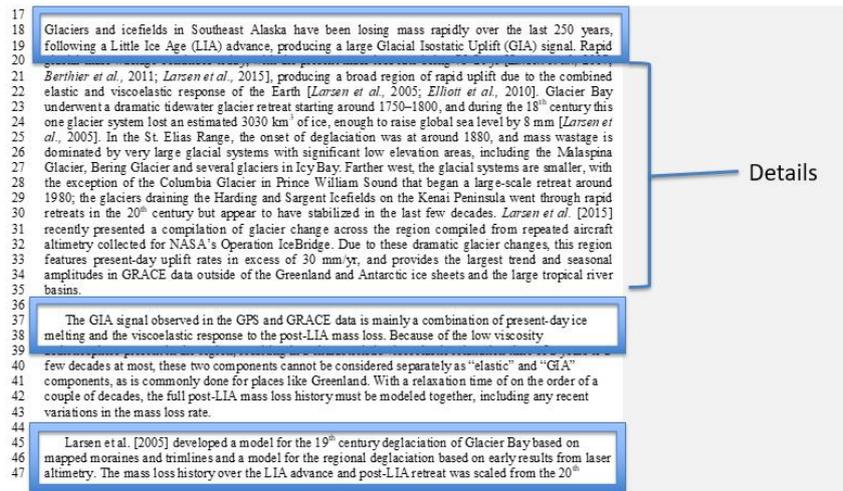Here are some examples, and I just want to highlight the first sentence of each paragraph.

Fig. 5 Example of Topic Sentence

Those topic sentences are the three main points on this page, and the rest of the text are details. If somebody just read the first sentence in every paragraph in your paper they should have a basic idea of what you did and what the paper is about. That is your goal with the topic sentences.

5. Writing Clearly in English

Anybody who wants to write in another language has the challenge that the languages do not match one to one, and there are some concepts that are described by one word in one language but require a sentence of explanation in other languages. Here are some points you need to take care with, when writing English:

5.1 Types of Words：

The main types of words are as follows:
- ✧ A noun is a person, place, thing, idea, etc.
- ✧ A verb is an action.
- ✧ An adjective is a modifier for a noun.
- ✧ An adverb is a modifier for a verb; usually it ends in –ly.
- ✧ A preposition is a word to define a relationship, such as *of*, *for*, *with*, etc. Therefore, you can find the relationship between some things through the preposition.

The main type of words is very basic. What is important is that you know how to identify what type of word it is. If you use the wrong type of words, you will destroy the sentence structure and make it hard to understand.

5.2 Do Not Mix Up Adjectives and Adverbs

Here is an example of a wrong sentence:

He is a quickly runner.

It mixes the modifier, because quickly should be modifying a verb, but here the writer tries to

use it to modify a noun and it does not make sense. The correct sentence is:

He runs quickly or *He is a quick runner.*

For some reason, this specific error is very common for Chinese speakers; maybe there are some differences with the writer's mother language.

5.3 Learn to Identify the Main Words and Modifiers

The example is:

I saw the small gray cat.

The words *small* and *gray* are modifiers. They just give more description of the cat. However, the core meaning is preserved if the modifiers are removed, and "*I saw the cat*" is the core. The modifier does not change the sentence structure.

Here is another sentence: *I saw two cats.* One thing is singular, and two or more are plural. Most of the time, the plural form has an additional –s, however some words in English are irregular, such as *goose-geese.*

5.4 Subject and Verb

Xiaohui gave the small gray cat some food.

In this sentence, the subject is the person or thing doing the action – **Xiaohui**. The ***verb*** is the action taken – ***gave.***

We need to take care of the following regulations:

✧ The verb form must match the subject.

The verb form also indicates the time of the action: past, present, future.

✧ Verb forms in English are sometimes irregular (especially for some very common words).

Most European languages have even more different verb forms than English.

The verb indicates that who is taking the action and when do they take the action. The verb will have different forms in each different case. When we use wrong verb tense in a sentence, our reader may have to stop and think about what the meaning is supposed to be, because the sentence as written does not make sense.

5.5 Verb Tenses

Verb tense refers to the time of an action; here are some examples:

✧ Present: *Hypothesis A states that …*
It means that the statement is made right now.

✧ Simple Past: *Hypothesis A was proposed by Dr. Xu.*
It refers to the Hypothesis was *proposed* in the past.

✧ Future: *My hypothesis will be tested by a future study.*
It means the hypothesis has not been tested yet, and it will be done in the future.

Verb tense is important and mixing them causes difficulty in understanding. When writing scientific papers, people have different habits; whether to write in present tense or past tense. I like using past tense to describe things that were done, but you are making an argument or result, it refers to right now, that is present tense.

5.6 Actions in the Past

There are many different ways to describe actions happening in the past in English and other languages. Here are some examples:

✧ *The hypothesis was proposed by Dr. Xu.*

It tells you that some time ago Dr. Xu proposed the *hypothesis*. The action (proposing) is actually completed, he is not proposing right now; he already proposed it.

✧ *I have been testing this hypothesis*

That means I have spent some time already testing it and actually I still am testing it. When I say I have been doing something; it does not imply an ending, it is still going on. Therefore, the action starts in the past and continues to the present.

✧ *Dr. Xu's hypothesis had been favored by some authors in the 1990s, but was rejected by Dr. Wang's 2003 study.*

What does it tell you when you see something like this? *"had been favored"* means it was favored at one time in the past but not any more; it is no longer favored. On the other side, "*have been testing"* means, I started to do it in past and I am continuing it.

In fact, if you want to keep it simple, you can describe it by using the past tense. It is okay for most typical writing, more complicated in scientific writing.

5.7 Active Voice VS Passive Voice

Passive voice is a sort of a thing that as happened without saying who did it.

✧ *Active voice: I made a mistake.*

✧ *Passive voice: Mistakes were made.*

When using active voice, the subject performs the action noted by the main verb. When using the passive voice, the subject is acted upon by another agent or an unknown something.

Active voice is always stronger and more direct than passive voice and it often better for scientific writing. Sometimes in the scientific papers, people are accustomed to say "I did this" "I did "that" or "we did this" "we did that", some people do not like that style, but I think it is actually fine, it is a kind of description to say what you and your professor have done, which is much stronger and easier to understand.

You should try to develop something with simple and direct sentence and make it easy to understand. You had better to favor clear and direct language in scientific papers, and do not use novel or obscure words.

5.8 The and a

The words "the" and "a" are called articles. Most of the time, *a* noun will be preceded by an article unless the noun is a name.

✧ "The" is used in talking about a specific case (noun).

✧ "A/An" is used for a non-specific case.

For instance*,*

<p align="center">*I saw the small gray cat.*</p>

Let us suppose that we are talking about a cat, and the cat is the specific one we have been talking about. Then I would say *the cat*. If I say, *I saw a grey cat,* that might be the cat we talking about or maybe some other cat. Using *a* in this case actually creates ambiguity in the

interpretation.

Whether to use "the/a" depends on the context. For example, if we are talking about a specific cat that I make a statement about, I will use "the", because I am confirming that we are talking the same cat. When I say *a small cat*, then that could be about some other cat.

If you do not know if the noun is the specific one or already has been discussed in the previous sentence, the non-specific case usually going to be "a/an". If the first letter of the next word is vowel, then you should use "an" instead of "a".

When you are talking about a specific thing in scientific paper, but you say *a something*, it actually can add ambiguity to your content. The readers may wonder that whether you are suddenly talking about a different thing. Remember that readers will assume that you chose your words intentionally, not by accident or by guessing!

We will finish up with few examples of errors. Fig.6 is shown below, I took the photo this morning in my hotel. Hotels in China are a wonderful place to find bad English translations. It is almost like they use a bad English translation service.

Fig.6 Errors in the hotel

For this particular case, I suspect that the Chinese text says much more than English text does. Now, can somebody tell me here what's the error in English? "*bathed*" is past tense. If you say please do something, you need to use present tense.

Ok here is another one:

The hydrological loading deformations have significance annual cycle.

Tell me; where is the error here? In this sentence, *significance and deformations* are incorrect. Therefore, the correct sentence is "*The hydrological loading deformation has a significant annual cycle.*"

Q&A

Q: I found some difficulties when working with tables and figures. How to explain the table in a better way and how can the figure make sense?

A: It is hard to say in journal, because sometimes a figure shows very specific things that refer to something deeper. It is needed, because you have to demonstrate the point. I guess that when you have a figure, the figure caption should have the basic information to inform the reader what is in it. When you reference a figure, if you describe what does the data mean and show, the reader will

understand more easily. But put those details in the main text, not in the figure caption. The figure and table caption should just define what the lines, symbols, colors, etc in the figure mean so that the reader can read the figure.

To sum up, put the figure in the right place, do not just put the table or figure here, tell readers what does the data show and what is the key point.

Q: Could you talk about conclusions? I found that many people have the problem that mixed discussion and conclusion up.

A: There is a simple rule I can give you about conclusion: I do not like put the discussion and conclusion in one section, and the conclusion should be separate. Do not mention anything for the first time in the conclusion, except for the plan. The Conclusion is just the summary of your key points; it is like a long version of the abstract.