

Scientific research and communication skills

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- 3.1 Basic ideas
- 3.2 Scientific presentation skills
- 3.3 Scientific writing skills

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1.1 What does a scientist need to know?

- Scientific method
- How to form good questions/answers
- How to search for information (re-search!)
- How to critically assess information
- How to work in a team
- How to write up scientific reports
- How to make scientific presentations
- Other?
 - Communicate with media, policy makers etc.

1.1 The Scientific Method

- Make a **careful observation** of the world
- Ask a **question** based on what has been seen
- Propose some **tentative answers** (*hypotheses*)
- Use the hypotheses to make **predictions** about **new** as yet unobserved data/phenomena
- **Test the predictions** by making **repeated** observations of the new data/phenomena
- **Reject hypotheses** that fail to predict the new observations

1.1 Key ideas for science

- Testable **predictions** that can be **falsified** by **observation** of the real world (minimises biases caused by personal prejudice/faith)
- Needs to be **repeatable** and so methods and data have to be made **openly available** to the whole community
- **Inductive reasoning** (use a fact to make a more general hypothesis) followed by **deductive reasoning** (use a hypothesis to predict a new fact)
- **Hypothesis** = assumption to be tested
Model = hypothesis with limited validity
Theory = well-tested hypothesis that explains a lot
- **Parsimony principle (Ockham's razor)**: use the simplest model that explains the known facts (to get the most predictive power)

1.1 Common mistakes

- To selectively use data that is known not to disagree with the hypothesis
- To use unrepeatable methodology
- To use data that is not openly available
- To accept rather than reject hypotheses
- To underestimate experimental or prediction uncertainties and thereby falsely reject hypotheses
- To overestimate experimental or prediction uncertainties and thereby miss rejecting hypotheses
- To fail to formulate clear testable hypotheses BEFORE new data is observed
- To publish only successful results

1.1 Critical thinking

a **persistent** effort to examine any belief or source of knowledge in the light of **evidence** that supports it and the **conclusions** it draws. (E. Glaser 1941)

Critical evaluation of the **evidence**, **line of reasoning**, and **conclusions**.

If you would be a real seeker after truth, it is necessary that at least once in your life you doubt, as far as possible, all things.

Rene Descartes (1596-1650)

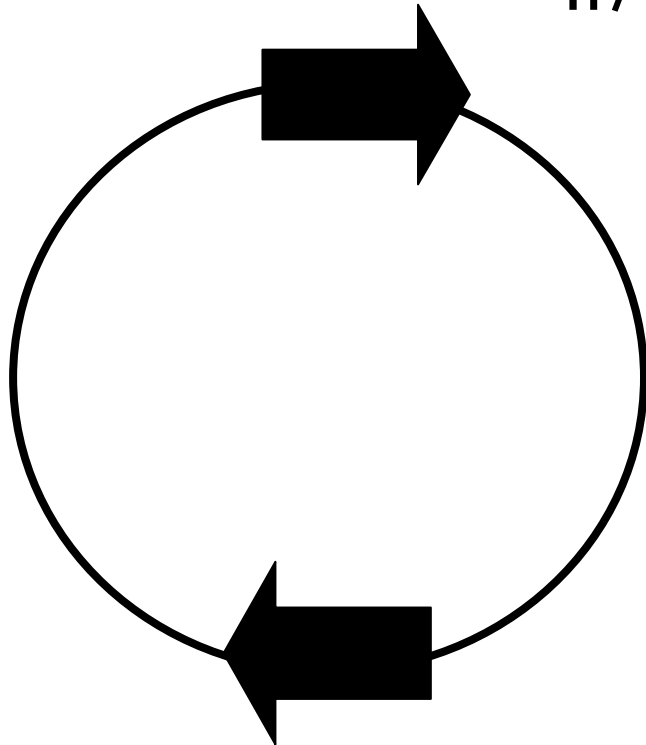


1.1 Analytical thinking

- Standing back from the information given
- Examining it in detail from many angles
- Checking closely whether it is accurate
- Checking whether each statement follows logically
- Looking for possible flaws in the reasoning, evidence, or the way conclusions are drawn
- Comparing the issue from other points of view
- Checking all the assumptions
- Searching for any contradictions

1.1 Analysis and Synthesis

Analysis - breaking things down to see if/how all the parts work.



Synthesis – putting all the parts back together again to make a consistent message.

1.1 General framework for communication

- **Aim** – what message do you want to convey?
- **Audience** – who are they? what do they know?
- **Medium** – written report, presentation, web,...
- **Content** – what should be included?
- **Structure** – logical framework for content
- **Style** – scientific and linguistic conventions
- **Feedback** – did the message get through?

1.1 The signal transmission model

transmitter → message → receiver
signal (message) + noise (clutter)

Note:

- Understanding affected by receiver's background, attitudes, beliefs, excitement
- Feedback – if you haven't received it, then you haven't communicated!
- Communication is also often **GENERATIVE** – it helps generate/clarify ideas
- Audience=set of **DIFFERENT** receivers!

1.1 General communication principle

K.I.S.S. – Keep It Short and Simple

Signal = message

All the rest is noise!
(→ so less is more)

1.2 What can go wrong in a presentation?

- Inaudible – too fast, too quiet
- Invisible – can't see images/text
- Too much material (poor selection)
- Unclear message (none or mixed)
- Poor explanation (e.g. jargon)
- Run out of time or finish too early
- Mental block – embarrassing silence
- Poor response to questions

1.2 Aims

- Why am I making this presentation?
- How will I judge whether it is a success?
- When and where will it take place?
- What would I like the audience to take away?



1.2 Audience

- Who are they exactly?
- What do they know and don't know already?
- How big is the audience?
- Small group or big venue?
- What would they like and not like to hear?



1.2 Medium

- Voice (loud, clear, slow, and deep)
- Body (relaxed and confident)
- Visual aids
 - Plastic overheads/transparencies/viewgraphs
 - Powerpoint slides – make sure you have a backup!
 - 35mm slides - expensive; reduces eye contact with audience
 - Chalkboard/whiteboard - good for building up an argument
 - Flip chart - more portable than whiteboard but doesn't work well with large audience
 - Handouts - provide helpful summary; can distract if given out before the end

1.2 Visual aids

- Allow about 1-2 minutes per slide
- Make sure you are familiar with the equipment before the talk
- Have a backup of your talk on viewgraphs in case of equipment failure



1.2 Content

- Be very clear about the message you want to get across
- What is your key message? How can you simplify it?
- Don't be too ambitious – focus on a few (<4) main points – Keep It Short and Simple
- Distinguish between opinion, facts, ideas
- Be accurate and honest about your facts
- Cite sources of information
 - (Source: www.noaa.gov/enso)
 - Sugarbarnes et al., 2003: J. Climate, 20, 1-50

1.2 Selection of material

- Think of a good story line e.g. questions, experiment, answers
- Choose the most important material that tells your story (KISS!)
- Use visuals – 80% of learning is achieved visually
- Decide whether to discuss shortcomings and difficulties
- Avoid irrelevant material and jargon

1.2 Structure

- Use a simple logical structure:
- Introduction:
 - Say who you are if necessary
 - Attention grabber (Important fact, joke, cartoon, picture,...)
 - Plan of talk (tell them what you are going to tell them)
 - Aims/objectives of the study
- Background – motivation for this work
- Main body, e.g. Methods and Results
- Summary/Conclusion – tell them what you've told them and end if possible with a bang

1.2 Visual style

- Use a horizontal (landscape) frame for each slide
- Avoid distracting backgrounds – white works well (paper!)
- Use large sans serif letters (e.g. Ariel 14 point and larger)
- Use dark font for letters (e.g. black)
- Use images and colours to keep attention and emphasise points
- K.I.S.S. – less than 10 lines per slide and less than 10 words per line
- Make sure figures are legible, including title, axis labels, contour labels, key, ...
- Make images and text as large as possible (the foot test)
- Number all your slides

Some examples of poor style

This slide contains a ridiculously small picture

The background is horrible

This text is way too small

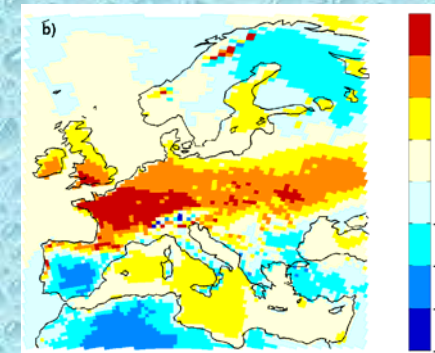
The font is not sans serif

e.g. Arial or Tahoma



I am still at kindergarten
and I like pastel shades

RM3H run T2M JJA



An inscrutable title
and as for labels?
Who needs them!

Don't take me seriously!

**This style is not appropriate for
scientific presentations!!**

1.2 Practice (makes perfect!)

- Make notes of what you want to say, e.g. on cards or post-its
- Do not write out a script to be read word for word
- Rehearse. Check the timing and refine what you will say. Less is better than too much!
- Make some material optional so that you can include it or drop it depending on how the timing goes on the day
- Check the room and visual and equipment beforehand to be sure how it works

1.2 On the day: nerves and confidence

- It's normal to be nervous. Don't worry about it!
- Physiological problems: fear → adrenalin reaction
- Establish eye contact (e.g. person at back) and smile!
- Be confident and enthusiastic (but not over-confident!)
- Dress smartly and comfortably
- Monitor your audience – try and get some feedback from them

"There are two types of speakers:
those that are nervous and those that are liars".
- Mark Twain



1.2 Voice

- Project your voice louder than normal – but don't shout
- Speak slower than normal
- Use pauses for emphasis and to help calm your nerves
- Speak to the audience, not to the screen or notes
- Drink water before and after speaking – avoid alcohol

1.2 Other things to do ...

- Keep an eye on the time; leave time for the Conclusions; be flexible if necessary.
- Point SLOWLY to items on the screen using a pointer (e.g. graph axes)
- Explain all of your points and figures fully and clearly; define technical terms and mathematical symbols
- Try to keep viewgraphs in neat piles for used and unused

1.2 Feedback after the presentation

- Feedback is good
- Anticipate likely questions
- Listen carefully to each question
- Repeat the question if necessary; rephrase difficult questions to check understanding
- Reply to the whole audience, not just the questioner. Speak loudly
- Avoid aggressive confrontation
- Don't be afraid to say you don't know
- If a question is inappropriate then suggest you speak to the questioner afterwards
- If questions are slow to come at the end of the talk then just smile and wait

1.2 Types of question

- Closed type – only one answer e.g. “Are you finding this useful?”
- Open type – many possible answers e.g. “How useful are you finding this?”
- Open usually start with “Who, what, why, where, when, or how?”
- Paraphrasing “Is what you’re saying ...?”

1.2 Answering questions

- Don't answer immediately
- Did you understand the question?
- Ask for clarification if you didn't understand
- Don't say too much – use short answers
- Don't be afraid to say you don't know
- Think about all possible questions in advance

1.3 Scientific writing

- Aim: to transfer knowledge accurately and concisely
- It is an **ESSENTIAL** scientific skill
- It is difficult and needs constant practice (start now!)
- It has style conventions that need to be learnt
- It is very creative and helps to generate/form ideas
- It can be fun! (being positive about writing helps!)
- If a report is worth writing then it is worth writing well!

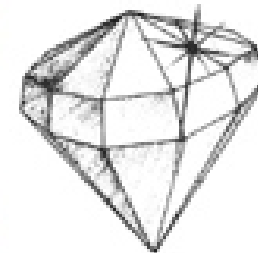
1.3 Useful books on style and usage

- W. Strunk Jr., E.B. White, and R. Angell, 2000: *The Elements of Style*. Pearson Allyn & Bacon, 105pp.
- J. Grossman 1993: *The Chicago Manual of Style: The Essential Guide for Writers, Editors, and Publishers*. Chicago University Press, 921pp.
- C. Turk and J. Kirkman 1989: *Effective Writing: Improving Scientific, Technical and Business Communication*. Routledge and Sons, 277pp.
- R. W. Burchfield (Editor) H.W. Fowler 1998 *The New Fowler's Modern English Usage* (3rd Ed). Oxford University Press, 878pp.
- J.O.E. Clark, 1990: *Harraps English Usage*. Harraps Publishers Ltd, 444pp.
- Anonymous, 1998: *Chambers Super-mini Grammar*. Chambers Harrap Publishers Ltd, 352 pp.

1.3 How to write PLAIN ENGLISH ...

- Keep It Short and Simple! (clear, concise, accurate)
- Identify and simplify your main message
- Structure your report into logical sections
- Use simple short words and avoid technical jargon
- Remove ALL useless words, sentences, paragraphs
- Use active verbs and avoid nominalization
- Keep sentences short (less than 30 words)
- Write short paragraphs each based on a single idea

www.plainenglish.co.uk



1.3 Making things clearer - lucid writing

- Remove useless words (verbal camouflage/dead wood)
- Avoid long unfamiliar words – short ones are good
- Avoid acronyms e.g. write model instead of GCM
- Rewrite ambiguous phrases e.g. light blue cheese dressing
- Avoid gratuitous variation – repeat the same phrases
- Choose new technical terms and symbols carefully
- Introduce the subject early e.g. at the start of the paragraph
- Rewrite titles and headings to be clear and informative
- Use roadmaps and signposts

Professor Michael E. McIntyre's pages on lucidity:
<http://www.atm.damtp.cam.ac.uk/people/mem/>

1.3 How to write a scientific report

1. Brainstorm – jot down lots of ideas
2. Filter the ideas to find main points – the MESSAGE
3. Construct a story line: e.g. scientific questions → answers
4. Select and prepare the **CONTENT** (best plots, tables, etc.)
(FLESH)
5. Plan a clear STRUCTURE – think of section headings
(SKELETON)
6. Start writing a section (e.g. abstract)
7. Sketch the ideas that will be in each of the paragraphs
8. Print out a draft report – double-spaced with wide margins
9. Revise carefully – remove dead wood, rewrite, check facts

Types of abstract (Turk and Kirkman 1989: Effective Writing

What's wrong with this abstract?

The report describes an apparatus built to measure the resistance to the flow of heat through various thermal-insulating reactor-vessel jackets, under conditions simulating those obtaining in practice. The effects of a variety of thick, and thin-film materials were studied, and the decrease in thermal resistivity of foam due to ageing was quantified. The relative resistance of thicker foamed polymers and glass fibre blankets is shown and the cause of enhanced resistivity of glass-fibre combinations is suggested.

What's better about this one?

Thermal-insulating reactor-vessel jackets were tested on an experimental 50 litre vessel, kept at 500K internally, and atmospheric temperature externally. Foamed polymers and glass-fibre in layers of 5 cm gave resistivities of about 2.7. Thin films of aluminium foil and PVC gave resistivities of about 1.3. With foam, ageing reduced resistivity by about 7% per year. Thicker glass-fibre blankets, up to 15 cm, were about 17% better than the same thickness of foamed polymers. We think this is because the multiple irregular surfaces within the glass-fibre blanket trap more air.

Example: excessive use of acronyms

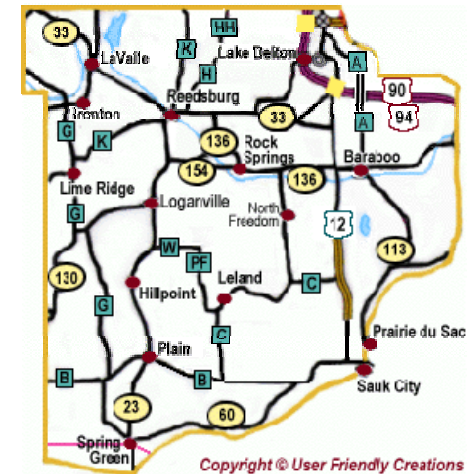
In section 4 the RDF-LGR technique (SPW) is used to estimate the rate at which small-scale features in the PV field are produced. The RDF-LGR calculation can be interpreted as an estimate of the contribution of the dissipation to the MLM mass budget. This estimate is compared to the actual contribution of SSD to the MLM mass budget. The agreement is good in a number of respects. The RDF-LGR results are also compared to the results obtained from the same model data by PWP using the CA-CG technique.

ALL acronyms should be fully defined at first use!

1.3 Road maps and signposts

Roadmap

This dissertation examines the hypothesis that the mesospheric two-day wave results from a local baroclinic instability. The hypothesis is presented in detail in chapter 2. The hypothesis leads to several predictions, in particular that the amplitude of the wave will be sensitive to the frictional drag resulting from small-scale gravity waves. Experiments designed to test these predictions are described in chapter 3.



Signpost

The following derivation assumes that the flow is in geostrophic balance. The possible breakdown of geostrophic balance will be discussed in the next section.



1.3 Scientific writing style

Scientific writing has its own specific style unlike that used elsewhere. It is concise, accurate, and rather impersonal. A more in-your-face emotional style (e.g. journalistic style) is inappropriate. So also is a chatty verbal style, ain't it?!

There are stylistic rules for

- Text
- References
- Equations
- Figures
- Tables

1.3 Tips on grammar

- Use short simple sentences: Subject verb object.
- Use the passive voice e.g. An experiment was performed ...
- Present evidence impassively but write active punchy sentences
- Keep the verb near the subject (e.g. Figure 5 shows ...)
- Be direct with verbs e.g. the model replicates ... rather than the model is replicating
- Use tenses consistently (e.g. past, present, future)
- Write in English – don't translate from other languages
- Remember readers may not be native English speakers
- Use Tools→Spelling and Grammar in Word on ALL text

1.3 Tips on punctuation

- Avoid punctuation if you don't know the rules!
- Learn the rules
www.met.rdg.ac.uk/cag/course
- Avoid underlines
 - not used in publications

Punctuation	
"	Quotation
'	Apostrophe
?	Question
.	Period
,	Comma
-	Hyphen
()	Parenthesis
/	Slash
!	Exclamation
&	Ampersand

- : Colon
- ; Semi-colon

1.3 Brief summary of punctuation

- The comma “,” is used to separate parts of a sentence; it can also be used instead of parentheses for including, in some sense incidental, remarks. Commas are also used before *which* and after words like *however*. It is NOT used to splice together lots of different ideas e.g. idea1, idea2, idea3 ... (comma splice)
- Incidental remarks can be made (a bit) stronger by using parentheses, and can be made very strong – if really necessary – by enclosing them inside dash symbols. However, too many of them scream at the reader almost as annoyingly as exclamation marks!
- The semi-colon “;” is used to separate grammatically independent but logically dependent parts of the sentence from one another; in other words, ideas that are related to one another such as items in lists: item1; item2; item3; etc. Semi-colons should not be used where a period would suffice.
- The colon is used to introduce a new clause such as a list of items or a quotation like: “that’s all for now folks”.

1.3 Capitalisation – Hart's rules

- Proper nouns e.g. names of people/places
- Prefixes and titles e.g. Sir Gilbert Walker
- Geopolitical entities e.g. South Africa but southern Africa
- Proper names of periods (Middle Ages)
- Proper names of institutions (Church of England)

1.3 References: giving credit when it is due

- Don't copy verbatim from other sources!
- Reference all sources you use
- Seek copyright permission for figures
- Don't forget yourself: "In this study, ..."
- Examples:
 - Dido (2003) showed that ...
 - ... also found in previous studies (Badboyz et al. 2003)
 - ... (Marley 1977; Sonny and Cher 1985)
 - ... similar to those shown in Fig. 1 of Pink (2003b)
 - In figure caption: Figure 1. ... [from Smith et al. (2001)].

1.3 Example of reference list entries

Andrews, D. G., and M. E. McIntyre, 1978: An exact theory of nonlinear waves on a Lagrangian-mean flow. *J. Fluid Mech.*, 89, 609-646.

Bell, J. S., 1987: *Speakable and Unspeakable in Quantum Mechanics*. Cambridge University Press. 212pp.

Gregory, A. R., 1999: Numerical simulations of winter stratospheric dynamics. PhD Thesis, University of Reading, UK.

South Bank University, 1998: Referencing electronic sources [WWW]. <http://www.sbu.ac.uk/lis/helpsheets/lrc2.html> (20 August 1999).

1.3 Mathematical equations and symbols

- Punctuate equations in the same way as normal text
- Never begin a sentence with an equation or a symbol
- Use standard notation where possible
- Define all symbols and use them consistently
- Include a glossary if you use many symbols
- Use notation sparingly – use words to explain
- Place short equations inline, e.g. $E = mc^2$ for space.
- Centre longer equations on separate lines like this:

$$\frac{\partial T}{\partial t} = -u \cdot \nabla T + Q \quad (1)$$

1.3 More on mathematic style

- Number all equations **referred** to in the text
- Refer to equations like this:
 - “Equation (2) defines ...”
 - “As can be simulated using (3) ...”
 - “inequality (2.1) leads to the bounds in (3.3)”
- Use bold face for vectors/matrices e.g. **u, M**
- Nest parentheses in this order $\langle \{ [()] \} \rangle$
- Avoid abbreviations like w.r.t, iff, etc.

1.3 Tables

State	Deforested (km ²)	Isolated (km ²)	Edge effect (km ²)	Total (km ²)
		1978		
Acre	2,612	18	4,511	7,141
Amapá	182	0	368	550
Amazonas	2,300	36	6,498	8,834
Maranhão	9,426	705	13,120	23,251
Mato Grosso	21,134	776	25,418	47,328
Pará	30,449	2,248	49,791	82,488
Rondônia	6,281	991	17,744	25,016
Roraima	196	4	812	1,012
Tocantins	5,688	337	6,584	12,609
Total	78,268	5,115	124,846	208,229
		1988		
Acre	6,369	405	23,686 (0.517)	30,460
Amapá	210	1	689 (0.537)	900
Amazonas	11,813	474	36,392 (0.582)	48,679
Maranhão	31,952	2,123	28,147 (0.626)	62,222
Mato Grosso	47,568	2,542	71,128 (0.580)	121,238
Pará	95,075	6,837	116,669 (0.633)	218,581
Rondônia	23,998	2,408	52,345 (0.657)	78,751
Roraima	1,908	1	5,236 (0.521)	7,145
Tocantins	11,431	1,437	6,760 (0.659)	19,628
Total	230,324	16,228	341,052 (0.610)	587,604

← Good example:

- clear
- no vertical lines
- just 3 horizontal lines
- well-labelled

Poor example: →

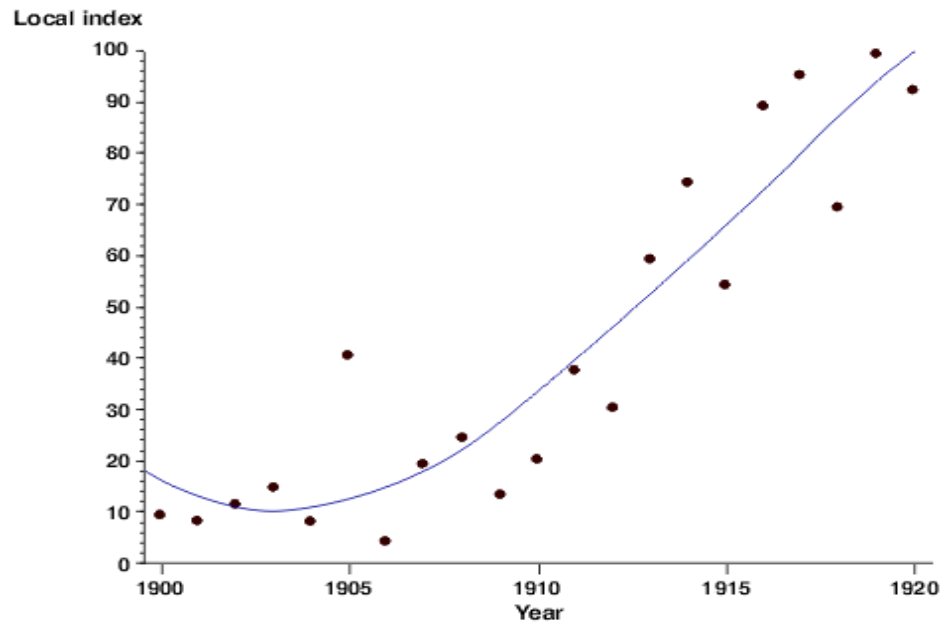
- covered in lines
- complicated
- multi-coloured

[MCL, U.S. Environmental Protection Agency maximum contaminant level; µg/L, micrograms per liter; pCi/L, picocuries per liter; U-natural, natural uranium; Cs-137, cesium-137; <, less than; -, no maximum contaminant level established]

Radionuclide and unit	Number of samples	Concentration (uranium) and activities					Number (and percentage) exceeding MCL ¹	Number of samples by county and dates of collection					
		Minimum	25th percentile	Median	75th percentile	Maximum		Berks	Bucks	Chester	Lancaster	Montgomery	York
Uranium (µg/L)	362	<0.01	<0.05	<0.4	<1	97	2 (0.5)	4 (1986-88)	7 (1986-87)	191 (1984-98)	79 (1986-94)	26 (1986-94)	55 (1986-94)
Radium-226 (pCi/L)	256	<.02	.36	.7	2.3	98	-	4 (1986-88)	8 (1986-91)	152 (1984-88)	47 (1986-88)	6 (1986-88)	39 (1986-88)
Radium-228 (pCi/L)	255	<.4	<1	<1.8	5.5	160	-	3 (1986-88)	8 (1986-91)	152 (1984-88)	46 (1986-88)	6 (1986-88)	39 (1986-88)
Radium-226 plus radium-228 (pCi/L)	253	<.6	<1.2	<2.2	8	172	81 (32)	3 (1986-88)	8 (1986-91)	150 (1984-88)	46 (1986-88)	6 (1986-88)	39 (1986-88)
Radon-222 (pCi/L)	912	49	640	1,400	2,900	53,000	809 (89)	3 (1986-88)	106 (1986-95)	555 (1986-98)	145 (1986-94)	48 (1986-94)	55 (1986-94)
Gross alpha particle activity (pCi/L as U-natural)	256	<.1	1.1	3	7.7	167	41 (16)	4 (1986-88)	7 (1986-87)	153 (1984-88)	47 (1986-88)	6 (1986-87)	39 (1986-88)
Gross beta particle activity (pCi/L as Cs-137)	258	.6	2.7	5.1	15	270	-	4 (1986-88)	7 (1986-87)	155 (1984-98)	47 (1986-88)	6 (1986-87)	39 (1986-88)

¹Includes interim and proposed MCL's.

1.3 Figures

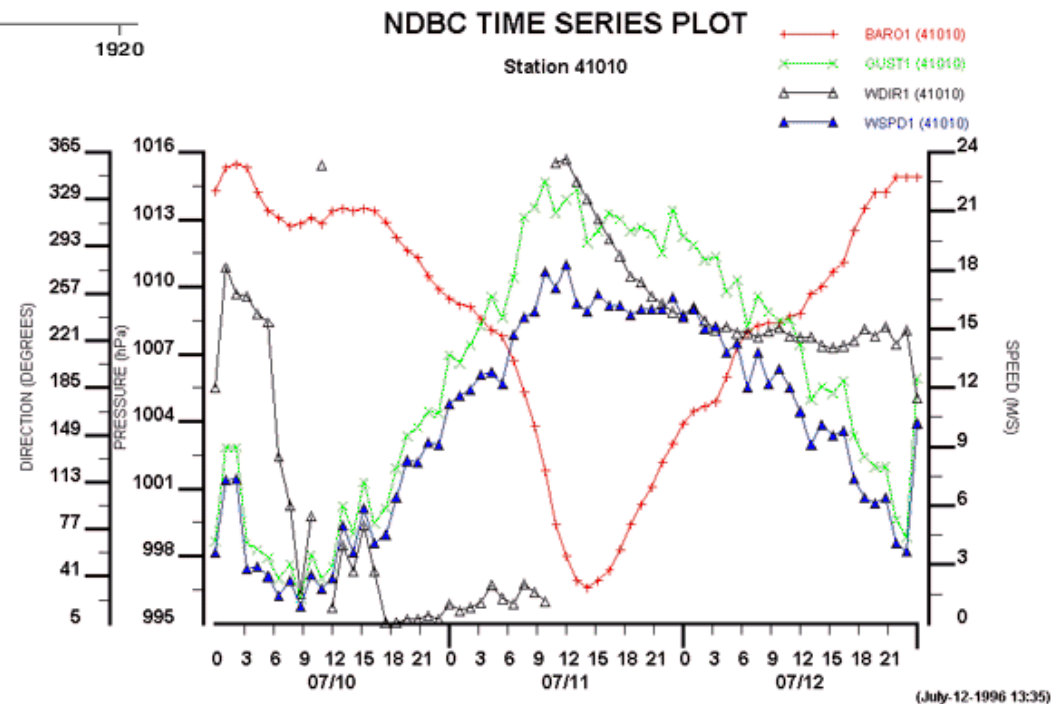


← Good example:

- clear
- good labels
- not cluttered

Poor example: →

- cluttered
- confusing
- poorly labelled
- multi-coloured
- distracting title



(July-12-1996 13:35)

1.3 How to cope with writer's block

- Don't worry – we all get it!
- Practice by writing regularly (a bit each day)
- Write anything you like for a few sentences (stretch exercise)
- Don't try and be perfect – you can revise later
- Write naturally as though talking to the reader
- Avoid outside distractions
- Imitate the style of good papers you have read
- Know when to stop – avoid being overly perfectionist

