

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
General	Fitzpatrick			<p>All three chapters (6,7, and 8) are very well done and based on solid science, as might be expected from the high caliber of the authors (who are to be thanked for such monumental efforts). All three chapters surpass the criteria set forth for the reviews. I was especially pleased to see appropriate doubts expressed about several issues I see as contentious:</p> <p>---The (probably small) role of solar changes in the warming of the last 100 years ---The sense that human impacts on climate have only recently begun to emerge from natural variability. ---Uncertainties about Bond's work on Fe-stained quartz, the inferred 1500-year cycle, and a possible link to solar forcing. The authors of both chapters 7 and 8 expressed this uncertainty in an appropriate way.</p>	Ruddiman	Noted
General	Ch. 4 Fitzpatrick Ch. 5 Brigham-Grette / Miller			Numerous places refer to slow, long-term processes changing CO ₂ but the background seems a bit brief (Ch 4, pg 15, ln 297-307: plate tectonics, weathering and volcanoes; Ch 5, pg 3, ln 41-42: cooling attributed to GHG decrease; Ch 5, pg 14, ln 282-284: complex changes in ocean-atm changed CO ₂ ; Ch 5, pg 40, ln 872-875). A slightly more extensive primer on this topic would be helpful.	Reusch	Noted
General	Fitzpatrick			Location maps are much needed, both for basic geography but also topography and bathymetry (in particular, Chapter 7). It is very difficult to appreciate the shallowness of peripheral Arctic seas or the relative position of shelf fans to Greenland outlet glaciers with no supporting	Reusch	Accepted. Figures will be supplied during the technical edit.
General	Leads as indicated in individual chapters please.			Continental drift vs plate tectonics: Usage of "drifting continents" feels fuzzy, especially since "continental drift" has effectively been replaced by "plate tectonics". "Drift" may also have implications of randomness that don't really apply. This comment applies in numerous places in the document: Ch 3 (pg 7, ln 152), Ch 4 (pg 5, ln 77-78; pg 14, ln 290; pg 16, ln 333; pg 19, ln 407), Ch 5 (pg 41, ln 897, 927), Ch 6 (ph 2, ln 22, 28; pg 22, ln 645-646).	Reusch	Taken into account in chapters
General	Alley			Might it be useful to summarize how this report has advanced what is known about this material beyond what was published by IPCC in 2007? A summary of open research questions/topics would also add value.	Reusch	Accepted. Section added.
General	Fitzpatrick			For the most part, the text should be accessible to a reasonably informed non-specialist, though there are still a few tough spots here and there. With respect to the goals of the Prospectus, I believe all the questions can be answered positively.	Reusch	Noted
General	Fitzpatrick			There is always a fine line between providing too little and too much information when describing particular results/conclusions/recommendations, but I feel the authors have overall managed to keep within a reasonable distance of the desired level of detail. Thorough references to the literature (past and present) provide more than adequate additional opportunity for the reader to delve more deeply.	Reusch	Noted

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General	Fitzpatrick			I found, that the scope of the report reflects very well the intent of the Prospectus and all materials are clearly described in the report. All aspects of this charge are fully addressed. The authors do not go beyond their expertise.	Romanovsky	Noted
General	Fitzpatrick			Evidences, analyses, and arguments adequately support the conclusions and recommendations of the report. Uncertainties or incompleteness in the evidence are explicitly recognized	Romanovsky	Noted
General	Fitzpatrick			In my opinion, the report is not always appropriately balanced. Different sections have a very different level of complexity and comprehensiveness. For example, the use of a loan example to explain positive feedbacks and the discussion of the use of biomarkers for seawater temperature estimates have a very different level of comprehensiveness and addressed to a different level of the readership.	Romanovsky	Noted, will be addressed by USGS in technical edit
General	All leads please take note!			Throughout the entire document it is important to be more specific when warming or cooling is mentioned: is this warming/cooling just for the summer time or for the entire year? Most of the time it is just for the summer and it should be specifically mentioned every time.	Romanovsky	Taken into account - see individual chapters.
General	Fitzpatrick			Some of the report's findings are based on the collective opinions of the authors. Every time it was acknowledged, and the scientifically defensible reasons were given how those conclusions were made	Romanovsky	Noted
General	Fitzpatrick			The scope and intent are within the intent of the Prospectus and are clearly described in the report.	Rial	Noted
General	Fitzpatrick			2) Are all aspects of this charge fully addressed? Do the authors go beyond this charge or their expertise? All the aspects seem to be addressed. It is difficult to judge whether the authors have gone beyond their expertise without knowing all authors or having read their contributions.	Rial	Noted
General	Fitzpatrick			3) Are the conclusions and recommendations adequately supported by evidence, analysis, and argument? In general, conclusions are well supported by evidence or by references to the literature. The analyses and argumentation are essentially uneven throughout, and this is the obvious consequence of having many authors each contributing their part. There is an obvious need for a main editor to bring continuity to the text, to make an effort to bring unity to the narrative. I have marked sections that I believe require this effort more than others in chapters 4,6, and 7.	Rial	Taken into account as noted in individual chapters

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General	Fitzpatrick			4) Are the information and analyses handled completely? Completely is difficult to say, but information and analyses are plentiful throughout, though their quality is not uniform. To be more specific, the authors often seem to lose sight of who their audience is. Within the same page or chapter the narrative switches from heavily specialized, full of lingo, and profusely referenced, to the most pedestrian analogy or 'explanatory' argument that seems directed to a very unsophisticated audience. Most of these otherwise well-intentioned attempts fail or fall short of their mark. To paraphrase Einstein, things can be made as simple as possible, but not simpler. The use of analogies and similes is always welcome, but it has to be done intelligently and precisely. In order for an analogy to work it has to invoke some familiar event and then link it with the unfamiliar; and it needs to do it in a way that motivates further interest in the subject. (continued...)	Rial	Noted, will be addressed by USGS in technical edit
General	Fitzpatrick			The risk is to hopelessly confuse the reader by creating an 'understanding' that not only is wrong, but that will persist for a long time creating unsolvable contradictions. Since the authors use many of these throughout (including one especially bad that uses credit card debt as analogy) it is important that these are carefully revised. Even an intelligent, well educated scientifically literate reader can be totally misled by a bad analogy.	Rial (continued)	(see above)
General				5) Are uncertainties or incompleteness in the evidence explicitly recognized? Not always, and not uniformly. Again, the most obvious flaw is the lack of uniformity in the narrative/emphasis/discussion details. This is not surprising in a collective effort, but in order to be effective it needs a thorough editing job. I have noted a case in which the uncertainties in the aerosol forcing are not discussed (section 4.2.2). This is of great importance and the report should fairly handle this uncertainty least it becomes easy target of politically motivated criticism.	Rial	See comment in Chapter 4 for response.
General	Fitzpatrick			6) Are the report's exposition and organization effective? No. The organization makes one lose bearings quite quickly. Is the title appropriate? Yes, but it could be shorter and sexier.	Rial	Noted. Organization addressed in USGS technical edit. Title mandated by CCSP.
General	Fitzpatrick			7) Is the report appropriately balanced? Is the report's tone impartial and devoid of special pleading? It is not clear what is meant here by "balanced" The tone, in most of what I read, is impartial.	Rial	Noted

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General	Fitzpatrick			<p>. 8) Are any of the report's findings based on value judgments or the collective opinions of the authors? If so, is this acknowledged, and are scientifically defensible reasons given for reaching those judgments?</p> <p>I did not find any glaring examples of personal opinion trumping science. But, there is an obvious insistence on citing just a small group of authors and ignoring others who may have contributed as much to the synthesis and argument discussed. It is clear that there are only relatively few Arctic specialists, so it is expected that some will be cited profusely. On the other hand the report usually makes general statements with global implications without really making an effort to summarize the abundant literature on many subjects that are not necessarily Arctic-based. Specifically, there is constant referencing of articles by members of particular research groups, e.g., Penn State, whether or not the reference is relevant. This is somewhat disturbing.</p>	Rial	Noted
General	Fitzpatrick			In general I find the report highly stimulating, very informative, securely based on relevant science, but poorly organized, way too long and poor in illustrations (both number and relevance).	Rial	Noted
3. Preface						
3	Fitzpatrick			The Preface reads well.	Barry	Noted
3	Fitzpatrick			Quite acceptable as is, well-suited to being the Preface of this document.	Reusch	Noted
3	Fitzpatrick	15	330	Ch 3 References, line 330: Quart. J. Roy. Met. Soc.	Barry	Accepted. Complete title of journal entered.
3.2.2	Fitzpatrick	4	79-81	As mentioned first in Ch 3 (pg 4, ln 79-81), the Arctic has warmed at 2x rate of rest of globe, how does this compare during cooling periods? Is this covered elsewhere already?	Reusch	Taken into account in Chapters 6 and 7
4. Concepts						
General	Fitzpatrick			Chapter 4 is comprehensive and well written.	Barry	Noted
General	Fitzpatrick			The chapter as a whole is generally well written. The conclusions are adequately supported by evidence, it is appropriately balanced, the tone is "impartial and devoid of special pleading", and none the reports findings are based on value judgments. My specific suggestions for improvements are detailed below. Note that I only read this chapter, not the whole report. Some of my comments may reflect this.	Alexander	Noted
General	Alley			Brief conclusions would be useful (especially when an Introduction is given).	Reusch	Accepted. Synopsis added.
General	Alley			Otherwise does well with covering all the main forcings/feedbacks that matter on these timescales, rules out those that don't, and gives a quick intro to the role proxies play in the science (with most details appropriately left to later chapters where specific applications are discussed). A hint that more details on proxies lie in Ch 5 would help.	Reusch	Accepted. Paragraph added at end of introduction, setting the stage for this and subsequent chapters.

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Abstract	Alley	2		The last sentence of the abstract is vague, and could easily be misread. How have the sun, volcanic eruptions and other factors been influential? Influential in what? In recent warming trends observed? Someone might read this as saying that changes in the sun may be a significant cause for the recent observed climate change. Later in the report it says that the changes in the forcing from the sun over time are small compared to recent increases in greenhouse gas concentrations, but the abstract could be read as saying something very different. The authors should be more specific.	Alexander	Accepted. Text changed for clarity.
Abstract	Fitzpatrick	2	19	As in the prospectus, the use of “sedimentary deposits” here is inappropriate. Note: this reviewer provided the following comment on this topic in response to the Prospectus: <i>"This sentence could be misinterpreted to read as though all paleoclimate records are derived from sediment, which is incorrect. I disagree with the use of the term "sediment" to encompass all proxy data, as it can be misleading."</i>	D'Arrigo	Rejected. Use of the term 'sediment' or 'sedimentary deposits' encompasses any medium that records a temporally resolvable climate signal - not just sedimentary deposits, which is the interpretation the reviewer seems to have adopted.
Abstract	Fitzpatrick	2	21	suggest inserting “tree rings” here.	D'Arrigo	Accepted
Abstract	Fitzpatrick	2	28	as in the prospectus, the use of “sedimentary deposits” here is inappropriate	D'Arrigo	See Note above
4.2.1	Alley	7	134-137	What is a “too-cold” and “too-warm” planet? I get the point, but this may be confusing to a lay person. I would leave these two sentences out.	Alexander	Accepted. Clarification added.
4.2	Alley	5 - 19	85-411	Regarding the different subsections of 4.2, it is not always clear whether the topic being discussed is a forcing, feedback or just an aspect of (natural) variability. This being a somewhat long section, it's important to not lose track that these are the topics being covered here.	Reusch	Noted.
4.4	Alley	26 - 30 30-35	568 - 649 651-766	The flow of ideas would probably be improved if these two sections were swapped. In this way, the history would follow the coverage of chronology and cap the chapter.	Reusch	Rejected. Text optimized to current order.
4.1	Alley	5	77-78	“continental drift”, see Ch 3.	Reusch	Accepted. Reworded.
4.1	Alley	5	81-82	Isn't “developing scientific explanations” also a part of “paleoclimatology”?	Reusch	Accepted. Reworded.
4.2	Alley	6	105	“blocked by that carbon dioxide” is inappropriate. Better terminology needed (as done in 4.2.4 246-249). Also see pg 8, ln 137-140.	Reusch	Accepted. Reworded.
4.2.1	Alley	7	134-137	Discussion of energy balance is unclear. “Too cold” planets <i>retain</i> more energy rather than <i>receiving</i> it. Description for “too warm” planets seems to get it right. Consider a slightly more detailed treatment including why there's a balance.	Reusch	Rejected. Text is correct as stated; a planet colder than equilibrium receives more energy than it radiates. The retained energy may be a tiny fraction of the received.
4.2.1	Alley	8	145-146	I would substitute the word “return” for the word “emit”. “Return” suggests that the Earth emits radiation back to where it came from, the sun, when it really emits radiation in all directions into space.	Alexander	Accepted.

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4.2.1	Alley	8	153-155	Again, this last sentence is vague. I would reword something like "... may have a small effect but are not as important as the forcings mentioned above."	Alexander	Accepted. Reworded.
4.2.2a	Alley	9	175	Replace the words "more significant" with "larger".	Alexander	Accepted. Reworded.
4.2.2b	Alley	10	184	Replace the word "changes" with "variability".	Alexander	Accepted.
4.2.2b	Alley	10	187	Replace the word "their" with "the".	Alexander	Accepted. Removed in rewording.
	Alley	10	195-197	Where is "radiative forcing" introduced? How do the forcings listed compare to the average solar output?	Alexander	Accepted. Introduction now provided.
4.2.4	Alley	13	258-270	This paragraph does not make a wholly compelling argument for why water vapor can be ignored (more or less) as a greenhouse gas. Need to strengthen and clarify.	Reusch	Noted. The text has been clarified. However, the text does not, should not, and cannot make a case that water vapor can be ignored as a greenhouse gas, but only that water vapor is more of a feedback than a forcing.
4.2.4	Alley	13	258-270	Perhaps it would be more explicit to emphasize that water vapor is a feedback, rather than an external forcing (especially since these were defined previously).	Alexander	Accepted. Text reworded.
4.2.4	Alley	12	282-287	This paragraph seems out of place. For example, what is the relationship between climate and greenhouse gases? Why is climate change in the Arctic amplified? These seem to come out of nowhere and are not backed up. Both are important points, but they should be substantiated.	Alexander	Accepted. Text reworded, with reference to more-complete treatment in chapter 5.
4.2.6	Alley	16	335-341	It is probably not clear to the lay person how volcanic activity is related to continental drift. As such it seems out of place. Perhaps put this into the following section on volcanic eruptions.	Alexander	Accepted. Text added at the end of section 4.42.5 to introduce the concept.
4.2.6	Alley	16	329-341	<i>Some</i> evolution is certainly on the same timescales as continental reorganizations, but is it accurate to prohibit evolutionary change from being significant on millennial (or multimillennial) scales? Bringing the long-term aspects of plate tectonics and evolution together is sensible but current headings blur timescales. There are both long- and short-term aspects to biology but (generally) only long-term aspects to plate tectonics.	Reusch	Noted. MAJOR evolutionary change is referenced.
4.2.7	Alley	18	383	Is this a 1°C global cooling, or just a cooling over Greenland?	Alexander	Noted. Specification is clearly made of Greenland ice-core records, which are described in the text as providing records solely of local climate.
4.2.7	Alley			Could end this paragraph whether or not there is a trend over time in the number or strength of volcanic eruptions.	Alexander	Rejected. This is already included in the previous sentence.
4.2.8	Alley	19	409-411	Don't changes in the sun's output also affect the planet's temperature directly? Isn't the key difference here trends in forcing over time (e.g. there is no trend in explosive volcanic eruptions)? I'm not sure what the point of these last two sentences is.	Alexander	Accepted. Wording clarified.
4.3.1	Alley	22	468-469	The following would make more sense. "... reflects glacial (colder – more ice) ... reflects interglacial (warmer – less ice)..."	Alexander	Accepted.

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4.3.1	Alley	22	473	Paragraph beginning on line 473. Paragraph seems out of place. Should this be moved up one paragraph?	Alexander	Accepted in part. Text clarified that one example is followed by general issues and then specific materials.
4.3.1	Alley	21 -22 24	455-460 514-519	Discussion of isotopes is not fully developed until second occurrence. The earlier, oxygen-oriented section is short on the details delivered in the later, carbon-oriented section. Suggest revising former to add details; latter could be modified as well, to avoid repetition.	Reusch	Accepted in part. Text clarified that one example is followed by general issues and then specific materials.
4.3.1	Alley	23	482-484	This belongs in the first paragraph of this section.	Alexander	Accepted in part. Text clarified that one example is followed by general issues and then specific materials.
4.3.2	Alley	25 - 26	541-566	Suggest adding a caveat as to how dating precision declines with age. This is more or less implied in the discussion of annual layer counting but could be more explicitly addressed (especially with the back-reference at line 625).	Reusch	Accepted.
4.3.2	Alley	26	561	The statement in parentheses is not grammatically correct.	Alexander	Accepted in part. Reworded for clarity.
4.2.1	Alley	8	148	Add ref to Serreze et al. 2007: The large-scale *energy budget* of the Arctic. J Geophys Res, 112.	Barry	Accepted
4.2.2b	Alley	10	191	why just colder summers here, rather than cold on an annual basis	D'Arrigo	Accepted. Text Modified.
4.2.7	Alley	18	371	Perhaps qualify this sentence – that these three eruptions have been studied in detail using climate models, which I think is the point of the paragraph – since other volcanoes (e.g.Tambora) have been studied as well in a general sense and are not mentioned.	D'Arrigo	Accepted -- we added the note about modeling and point out that Tambora is mentioned in Figure 4.5
4.2.7	Fitzpatrick	18	382	The extensive studies on tree rings and volcanism are not even mentioned here. For example: LaMarche, V. & Hirschboeck, K. Frost rings in trees as records of major volcanic eruptions. Nature 307, 121-126 (1984). Briffa, K., Jones, P., Schweingruber, F. & Osborn, T. 1998. Influence of volcanic eruptions on Northern Hemisphere summer temperature over the last 600 years. Nature 393, 450-455 (1998). Salzer, M. & Hughes, M. Bristlecone pine tree rings and volcanic eruptions over the last 5000 yr. Quat. Res. 67, 57-68 (2007). D'Arrigo, R. & Jacoby, G. Northern North American tree-ring evidence for regional temperature changes after major volcanic events. Climatic Change 41, 1-15 (1999).	D'Arrigo	Accepted
4.3.1	Fitzpatrick	21	440	as in the prospectus, the use of “sedimentary deposits” here is inappropriate	D'Arrigo	See note above
	Fitzpatrick		502-504	Tree-ring references needed here: e.g. Cook, E. & Kairiukstis, L. Methods of Dendrochronology (Kluwer, Dordrecht, 1990). Fritts, H. 1976. Tree Rings and Climate. Academic, London.	D'Arrigo	Accepted

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	Alley		530-533	Ditto references just above; also note that interpretation of tree growth variations in tree rings requires understanding of site history; can optimize the signal of interest depending on site selection.	D'Arrigo	Noted.
4.3.1	Fitzpatrick	25	533	'the temperature of the growing season'	Barry	Accepted
	Alley		549	the nature of tree-ring cross-dating makes it almost uniquely accurate relative to other proxies, with precise annual resolution.	D'Arrigo	Rejected. Cross-dated and achieve precise annual resolution.
4.3.2	Alley	25-26	541-566	This section seems incomplete. What about dating beyond 40 or 100 ka? I know it's complicated, but perhaps it can be summarized in a separate paragraph. It seems suspiciously absent.	Alexander	Accepted. Text modified.
4.4	Alley	27	582-588	Replace "has been" with "was".	Alexander	Accepted.
4.4	Alley	29	633-634	I don't know what this sentence means.	Alexander	Accepted. Reworded.
4.4	Alley		General	All of these different timescales may be confusing to a lay person. A figure may help. Perhaps start with Figure 4.9, then "blow up" the last 3 ma, then the last 0.9 ma, then the last 10 ka.	Alexander	Rejected. Preparation of a figure that worked proved impractical.
4.5	Alley	31	680	'and in north-central Labrador until about 6,000 years ago.'	Barry	Accepted.
4.5	Alley	35	General	The ending seems very abrupt. Maybe it is appropriate in the context of the larger report, which I did not read. But as a stand alone chapter, it at least needs a conclusions section.	Alexander	Accepted. Synopsis added.
	Alley	9	174-177	which is estimated to have had the same warming effect globally as an increase in solar output (there is still no good way to estimate the effect of changes in the solar irradiance! – VR) of 0.5% (Forster et al., 2007) and thus is more significant than solar irradiance changes over this time (see the previous comment – VR).	Romanovsky	Noted.
	Alley	10	198-199	as high as 0.6 Watts per m ² , still well below (what is "radiative forcing" of the Milankovitch cycles? - VR) the estimated radiative forcing of increased greenhouse gases of the past century (~1.7 Watts per m ²)	Romanovsky	Noted. This is described in next section.
	Alley	22	462	isotopes oxygen-16 to oxygen-18 (not vise verse? – VR) in seawater	Romanovsky	Relative abundance can be expressed either way.
	Alley	30	647-648	The "shape" of the climate records is interesting, with northern records typically showing abrupt warming, gradual cooling, abrupt cooling, near-stability or slight gradual warming, and then repeating (this discussion is not clear. A good figure can help here – VR).	Romanovsky	Accepted in part. Figure call added.
	Alley	30	654	These include broad warming and then cooling over millennia, abrupt events probably linked to the older abrupt changes????, and additional events with various spacings and sizes????? that have a range of causes, which will be described more in chapters 5 and 6 (The same comment as for the previous paragraph – VR).	Romanovsky	Accepted in part. See note in previous comment.

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4.2.2b	Alley	10	196-199	with the estimated minimum level of at least 0.2 Watts per m2, and some estimates as high as 0.6 Watts per m2, still well below the estimated radiative forcing of increased greenhouse gases of the past century (~1.7 Watts per m2) (IPCC, 2007). The radiative forcing range of uncertainty is large (~ ±1 W/m2) and should be given here since the lower end of the error bar is around 0.7 W/m2. The uncertainty is due mostly to our lack of understanding of the aerosol effect (IPCC 2007, FAQ 2.1, Fig 2.). Also, the source of the “as high as 0.6 W/m2” estimate should be singled out for the same reason.	Rial	Accepted in part. Text has been clarified. Text notes radiative forcing of greenhouse gases, not total anthropogenic radiative forcing including aerosols, etc.
4.2.2b	Alley	14	282	The direct relationship between climate change and greenhouse gases such as CO2 and methane is clearly described by the recent IPCC report (IPCC, 2007). Both the pattern of observed warming in the direct observational record, especially the record of the past 30 years, as well as climate model simulations (needs definition or short description of climate models), suggest that the Arctic will be more impacted by increases in greenhouse gas concentrations than any other region on Earth (Figure 4.4).	Rial	Accepted in part. Text modified.
4.4	Alley	29	621	Please add Clark et al 2006 Clark, P.U., D. Archer, D. Pollard, J. Blum, J.A. Rial, V. Brovkin, A. Mix, N.G. Pisis, and M. Roy (2006): The Middle Pleistocene Transition: Characteristics, Mechanisms, and Implications for Long-term Changes in Atmospheric pCO2, Quaternary Science Reviews, Special Issue in honor of Nick Shackleton ; 25, pp. 3150-3184 A brief discussion of the ‘much research’ involved here is important. The reader is now intrigued that the Milankovitch periodicities do appear in the record, but the narrative has not yet offered a comforting explanation or some of the possibilities the research over the last 30 years has produced.	Rial	Accepted in part. Reference added. Discussion of research pathways is beyond the scope of the chapter.
4.5	Alley	35	746	It should be clearly noted that tuning can in fact destroy important information about the nature of the forcing and the nature of the climate system response. It should also be noted that relying on tuning is tantamount to assuming that the climate system response is proportionate (linearly related) to the input, which is probably a pretty bad assumption, given all that has been said previously about the complexity of the climate system.	Rial	Accepted. Text modified.
	Alley	35	756	Recognizing that there are probably faulty assumptions inherent in the use of the.....	Rial	Accepted. Text modified.
	Alley	35	756-766	Please explain the origin and need at this time of the MIS nomenclature. Also, the above rationale to support using SPECMAP is weak and for a non-specialist sounds inconsequential.	Rial	Rejected. Some nomenclature is needed, and this one is widely Accepted. The reader can judge the strength of the reasoning.
Figure 4.5	Fitzpatrick			Average deposition of what? What are the units?	Alexander	No change necessary: Caption states that it is the distribution of volcanic sulfate aerosols in kg/km2 referred to in the figure.
Figure 4.6.	Fitzpatrick			This does not show the isotopic record as the caption implies. It is derived from the isotopic record though.	Alexander	Accepted. Caption re-written to clarify.

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4.2.2	Alley			section 4.2.2: note that more recent estimates are all on the low end. In particular the logic that supported 0.6 W/m ² at the Maunder Minimum has evaporated in the light of newer information.	Schmidt	Accepted.
4.2.3	Alley			section 4.2.3: (out-of-roundness) => (departure from circularity)	Schmidt	Accepted.
4.2.4	Alley			section 4.2.4: 33 deg C warmer is 59.4 deg F warmer, not 57 deg F.	Schmidt	Accepted.
4.2.7	Alley			section: 4.2.7: tropical eruptions interact with the Brewer Dobson circulation to produce a longer timescale response than high latitude eruptions. Cite Shindell et al (2004, JGR) and Fischer et al (2007) on the dynamical response to large tropical volcanoes in recent centuries.	Schmidt	Accepted in part. (Brewer Dobson circulation a bit technical for this section, so omitted.)
4.2.8	Alley			section 4.2.8: "the climate did not track the beryllium-10" - unclear, rephrase to state that there was no related climate response.	Schmidt	Accepted. Wording changed.
	Alley			trained historians - remove qualifier - it's patronising	Schmidt	Accepted.
4.3.1	Alley			section 4.3.1: "Climates Proxies" => Climate Proxies Neither tree-rings nor pack rat middens are 'sediments' in any sense of the word, and even stalagmites are a stretch. Please reconsider this framing.	Schmidt	Rejected. The text notes that sediment is "broadly defined" here. We have not found a single label that is more useful than "sediment" for the purposes here.
4.3.1	Alley			4.3.2: "other times with less precision." => other examples with less precision "the damage that accumulates from cosmic rays" - increased 10Be on an exposed rock can't really be described as 'damage'. Use 'effect'.	Schmidt	Accepted. Wording changed.
4.4	Alley			4.4: "rapid decreases in foraminifera 18O at about 34 Ma ago..." The previous sentence seems to imply this was a time of warming - some confusion here. "decades to years" - drop 'years' - this is not replicatable across ice cores nor does it make sense in a noisy series.	Schmidt	Accepted. Text changed.
	Alley			All text and captions: W/m ² is the standard unit description for climatically relevant energy fluxes over the Earth. Please use this consistently.	Schmidt	Noted. Changes made as appropriate.
General	Alley			ch 4 The chapter title should be "climate concepts" because it is not only about paleoclimate. The first exclusively paleoclimate concept doesn't appear until page 11. The abstract is not representative of the generality of much of the chapter.	Bitz	Accepted in part. Abstract has been reworded somewhat. Title of chapter maintained.
General	Alley			ch 4 I don't think this chapter is a good idea overall. It is too long and abstract to hold the attention of the nonscientists. I think the information would be more useful if distributed as introductions and in text boxes throughout the other chapters. In addition, the material could be tightened and made less flowery, and more references are needed.	Bitz	Noted. Additional extensive referencing is provided in chapters 5-8, and a pointer to the material in those chapters has been added.
	Alley		87-88	line 87-88 the first and third categories are not separable - in contradiction with the sentence wording. The section text correctly indicates their connection.	Bitz	Accepted. Reworded for clarity.
	Alley		104-105	line 104-105 change to "from those volcanoes in a couple of years following an eruption, and the Earth's surface will be warmer on average in response."	Bitz	Rejected. The sentence refers to the number of eruptions per century, not the output of ash per eruption.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
	Alley		185	line 185 I don't think it is necessary or true to call the 11-yr solar induced climate change small. It has been argued that global warming in the past 5 years has eased owing to the 11 yr solar cycle. It would be better to emphasize the difference in forcing on timescales. The 11-yr solar	Bitz	Accepted. Numerical values added rather than qualitative terminology.
	Alley		189	line 189 Be specific here and indicate that the solar variability may have contributed only weakly to long-term (near century-scale) temperature trends early in the 20th century. Presently the time-scale of the variability is not mentioned.	Bitz	Accepted. Reworded.
	Alley		193-194	line 193-4 A reference is needed for these longer solar cycles. I have never heard of them and doubt their significance.	Bitz	Accepted. Reference to Frohlich and Lean (2004) added.
	Alley		276	line 276 What focus? Do you mean with regard to anthropogenic GHG emissions? The statement is not true for many times in the past.	Bitz	Accepted. Reworded for clarity.
	Alley		281	line 281 Assessment is misspelled.	Bitz	Accepted.
	Alley		329	line 329 decompose should be combust, I think	Bitz	Accepted. Changed.
	Alley		402	line 402 this section title should be improved	Bitz	Accepted. Title changed.
	Alley		405	line 405 what does "it" refer to?	Bitz	Accepted. Reworded for clarity.
	Alley			line 610-611 presumably it is meant that methane is released from ocean sediments, not the ocean.	Bitz	Accepted. Wording changed.
5. Temp & Precip						
						n.b. - Romanovsky comments are found in his 'track changes' version of Chapter 5. This is a separate MSWord file that I have sent to you. You may find it easier to work from that version than to go through these comments in the spreadsheet. Please note that the line numbers recorded in red refer to those in the track changes version Vladimir sent back, not the original. Please do record your responses here in the spreadsheet.
General	Brigham-Grette			Overall structure works well. Additional details on forcings/proxies specific to Arctic followup on more general material in Chapter 4. Narrative on changes over time (5.4) covers appropriate evidence and topics.	Reusch	Noted.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
General	Brigham-Grette			This chapter is an excellent summary of our knowledge of the past climate of the Arctic regions over the last 65 million years. It presents a clear and thorough answer to the first part of the question posed in the prospectus for SAP 1.2: "What has been the extent of temperature and precipitation changes in the high latitudes in the past, and what can this tell us about how much warmer/colder, wetter/drier it may become in the future?"	Kirk-Davidoff	Noted.
General	Brigham-Grette			The chapter is strongest in its careful and mostly accessible descriptions of the methods used to estimate past climate, and in its discussion of the record of the past hundred thousand years. It's one major conceptual weakness is in its overly simple discussion of "polar amplification," as discussed below. I have a number of suggestions for clarifications, which follow in order of occurrence in the chapter.	Kirk-Davidoff	Noted.
Abstract	Brigham-Grette	3	29-30	"during both warm and cold times"; (pg 5, ln 87-88), 3-4x in warm and cold departures.	Reusch	Accepted and wording changed.
Abstract	Brigham-Grette	3	35-36	It's over done to say that "the forcings leading to exceptional warmth were often different than the forcings expected in the coming decades". As discussed in the text, our best guess as to the forcing that led to Eocene warmth was additional carbon dioxide. Better to say: "...because the boundary conditions (such as continental positions and topography) during past times of exceptional warmth were quite different.	Kirk-Davidoff	Accepted and text changed accordingly.
Abstract	Brigham-Grette	3	46-48	extensive deciduous forests occupied lands now only capable of supporting polar desert tundra ("polar desert" and "tundra" are two different bioms according to many biological classifications – VR).	Romanovsky	Accepted.
Abstract	Brigham-Grette	4	60-61	The penultimate warm interval, ~130 to 120 ka ago, occurred when solar energy in summer in high northern latitudes - VR was greater	Romanovsky	Accepted.
Abstract	Brigham-Grette	4	70-71	Solar energy in summer rose in the Arctic - VR steadily from 20 ka to a maximum (10% higher than at present) 11 ka ago	Romanovsky	Accepted
Abstract	Brigham-Grette	5	83	Warming over the past century and a half - VR has resulted	Romanovsky	Accepted
Abstract	Brigham-Grette	5	91-93	the next century if global warming forecasts are correct here we have to be a bit careful because we are still within the last interglacial when climate variability and probably Arctic amplification is generally reduced - VR.	Romanovsky	So noted.
5.2	Brigham-Grette	7	137	It's really only on time scales of 100 Ma or more that long term solar brightening is a significant factor. It's been less than 0.5% during the Cenozoic, so not significant in the period discussed here.	Kirk-Davidoff	Accepted.
5.2.2	Brigham-Grette	9	175 - 178	relatively warm ocean (at or above the freezing point of seawater) and cold atmosphere (which, in the Arctic winter, averages -40 °C (Chapman and Walsh, 2007). If sea ice is thinned –VR (winter sea ice will not be removed by warming in any observable future – VR) by warming, then the ocean heats the overlying atmosphere in winter months, amplifying warming.	Romanovsky	Accepted.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.2.3	Brigham-Grette	10	190-192	be important (these interactions represent an example of a negative feedback to the warming climate through increasing winter surface albedo when deciduous forest is replacing evergreen boreal forest as a result of warming – VR) (Bonan et al., 1992; Rivers and Lynch, 2004).	Romanovsky	Accepted.
5.2.4	Brigham-Grette	10	198-199	extent of permafrost (how changes in cloud cover interact with permafrost extent???? – VR).	Romanovsky	Accepted, assuming I have the meaning right.
	Brigham-Grette	10	201-202	As permafrost thaws under a warmer climate (Fig. 5.6) (this Figure doesn't show any permafrost thawing, just warming – VR)	Romanovsky	Noted. But The figure shows trends in warming which can lead to thaw.
	Brigham-Grette	10	204-206	et al. 2004, Thomas et al, 2002, Archer, 2007) (much more greenhouse gases may be released as a result of decomposition of the organic matter presently sequestered in permafrost – VR).	Romanovsky	Accepted
5.2.5	Brigham-Grette	10	206-207	Here is the first place, among many, where a more detailed (than Fig 5.7) map of the Arctic Ocean would be useful. In particular, one with bathymetry (e.g., a simplified version of the IBCAO map) would give the reader a better appreciation of the physical aspects of this basin.	Reusch	So noted for change by the USGS technical unit.
5.2.5	Brigham-Grette	11	209	5.2.5 Freshwater balance feedbacks and thermohaline circulation (disproportionally more detailed description in comparison with 5.2.1 - 5.2.4 – VR)	Romanovsky	So noted for change by the USGS technical unit.
5.2.5	Brigham-Grette	13	259-263	Is there any data at all on the relative magnitudes of change in CO2 transfer and nutrient turnover? The former is spatially focused whereas the latter tends to occur over a much broader area and isn't necessarily as tightly coupled to the THC. Mentioning them both together implies near-equal changes in response to THC change.	Reusch	Noted.
5.2.7	Brigham-Grette	15	317	“an unperturbed climate” – add “in balance on annual timescales”. A cartoon summarizing the feedbacks would be useful here.	Reusch	Accepted.
5.3	Brigham-Grette	17	352	Proxies of Arctic Temperature and Precipitation: Vegetation: Tree rings are not mentioned here but should be, as important indicators of Arctic climate change.	D'Arrigo	Accepted -- probably best to add a page of text here now at line 363 about Tree rings as section 5.3.1 if we can't fit it into existing section.
5.2.7	Brigham-Grette	17	360-362	Over longer times, growth of an ice sheet such as the Laurentide ice sheet on North America, or melting of an ice sheet such as that on Greenland, can occur. This in turn can influence albedo, freshwater fluxes to the ocean, broad patterns of atmospheric circulation, greenhouse-gas storage or release in the ocean and on land, and more.	Romanovsky	Accepted
5.3.1a	Brigham-Grette	19	400	Inverse modeling and forward modeling should be defined clearly before they are used.	Kirk-Davidoff	Noted. These are defined as they are used but both terms could be added to the glossary -- USGS tech unit.
5.3.1b	Brigham-Grette	20-21	420-448	Section 5.3.1b seems to say oxygen isotopes in the Arctic are only good for salinity, but also mentions ice volume effects. Are the latter a factor in interpretation or not?	Reusch	Noted. Ice volume effects are swamped by the salinity effect.
5.3.1b	Brigham-Grette	20	427	“meteoric waters” should be defined or replaced by “precipitation”	Kirk-Davidoff	Noted. Could be added to the glossary since its defined in principle in the rest of the sentence.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.3.1c	Brigham-Grette	21-22 29-30		5.3.1c (pp 21-22) and 5.3.1g (pp 29-30): Are isotopes (5.3.1c) truly so much less dependent on multiple external factors compared to the biological proxies (5.3.1g)? I would have said that some of the confounding factors affecting biology would also affect isotopes, though the text leads to a quite different conclusion.	Reusch	Noted. The influence of factors on lake isotopic records is properly reported here.
	Brigham-Grette	23	491-523	Significance of spatial versus temporal relationships of ice-core isotopes to temperature is not clearly explained. Figure 5.13 is also not used very effectively.	Reusch	Accepted. Text altered to clarify the meaning of figure 5.13 and address spatial temporal issues.
5.3.1e	Brigham-Grette	25	531	Eliminate “and this almost certainly was true in the past”, and insert at the beginning of 532, “If we can assume that species maintain their preferences through time, the mathematical.... “	Kirk- Davidoff	Accepted.
5.3.1g	Brigham-Grette	29	632	It would be good to insert here a general sentence about what makes species “useful” for paleoclimate: abundance, robust response to climate, continuity with modern species.	Kirk- Davidoff	Accepted.
5.3.2c	Brigham-Grette	35	776	“mathematically squeezing the air out” might be confusing. Better: “mathematically accounting for the amount of air trapped in the ice”	Kirk- Davidoff	Accepted
5.4	Brigham-Grette	37		I found a complete absence of permafrost-related feedbacks from the discussion on the past environmental changes (Section 5.4). Some materials on this could be found in Walter KM, Edwards M, Zimov SA, Grosse G, Chapin III FS: Thermokarst lakes as a source of atmospheric CH ₄ during the last deglaciation, <i>Science</i> , Vol. 318. no. 5850, pp. 633 – 636, 2007.	Romanovsky	Accepted. Text was added at the end of 5.2.4 about this recent work.
5.4.1	Brigham-Grette	40	871	This paragraph should get a bold subheading, to draw attention to the transition from description of climate changes to explanation of those changes.	Kirk- Davidoff	Noted. Will have the USGS technical edits people consider this.
5.4.1	Brigham-Grette	40	876	Expand “climate modeling” to “general circulation models of climate” or something similar.	Kirk- Davidoff	Accepted
5.4.1	Brigham-Grette	40	882	It’s hard to compare Barron’s and Donnadieu’s work, not only because of the difference in the experiments they performed, but also because of the huge difference in model resolution and sophistication between 1993 and 2006.	Kirk- Davidoff	Accepted. I changed the sentence to reflect the time between studies.
5.4.1	Brigham-Grette	42	928	It should be pointed out here that the large Arctic response to CO ₂ during the PETM takes place in the absence of any ice, and therefore in the absence of any ice- or snow-albedo feedbacks.	Kirk- Davidoff	Accepted and sentence here was altered to reflect this comment.
5.4.2	Brigham-Grette	45	994	Inconsistent use of bold face for species names.	Kirk- Davidoff	Rejected. Here only latin names are in bold; common names are not.
5.4.2	Brigham-Grette	45	1001	The word “transgression” should be defined before its first use.	Kirk- Davidoff	Noted. This is a standard term but could be added to the glossary.
5.4.2	Brigham-Grette	46	1010	Likewise, “correlative to” should be defined, or replaced with “at the same time as”	Kirk- Davidoff	Accepted and changed to “the same age as”

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.4.3	Brigham-Grette	48	1054	The problem of the 100,000 year glacial cycles is important enough that it merits listing of a few of the alternative hypotheses to the glacial lubrication idea: e.g. carbon cycle feedbacks involving the deep ocean circulation.	Kirk-Davidoff	Accepted. References added to include Southern ocean ideas and also phasing of milankovitch now at about line 1092.
5.4.3	Brigham-Grette	48	1060-1061	After many tens of thousands of years a sufficient ice thickness was build up, trapping of the Earth's heat led to thawing of the bed and allowing faster flow.	Romanovsky	Accepted.
5.4.3	Brigham-Grette	48	1076	...sufficiently large and thick to trap enough of the Earth's heat to thaw the ice-sheet bed	Romanovsky	Accepted
5.4.4	Brigham-Grette	49-50	1088-1112	pp 49-50, ln 1088-1112: This section feels odd. Is it just a transition between the Mid-Pliocene section and MIS 11, etc.? Or does it have a larger purpose, e.g., explaining (or reminding?) that there are lots of complex changes we don't fully understand? Either way, it feels like it needs work and a clearer sense of purpose.	Reusch	5.4.4 section serves to transition into time periods where none is know about the role of CO2 and the magnitude of change.
5.4.4	Brigham-Grette	50	1103	"various changes produced additional dust." It's worth listing these: glacial erosive action, windy, dry conditions in advance of glaciers. Cite: Mahowald, N. M., D. R. Muhs, S. Levis, P. J Rasch, M. Yoshioka, C. S. Zender, and C. Luo (2006), Change in atmospheric mineral aerosols in response to climate: Last glacial period, preindustrial, modern, and doubled carbon dioxide climates, J. Geophys. Res., 111, D10202, doi:10.1029/2005JD006653	Kirk-Davidoff	Accepted and added to the text and ref list.
5.4.6a	Brigham-Grette	53	1183-1184	processes, although seasonality and moisture availability may influence some biological parameters?? such as dominance by evergreen versus deciduous vegetation	Romanovsky	Accepted. A word was missing from the earlier draft.
5.4.7	Brigham-Grette	58	1298, 1300	traditional Karginiskii/MIS 3 period across arctic Russia; however, stratigraphic confusion within the limits of radiocarbon-dating precludes widespread correlation of events.	Romanovsky	Accepted.
5.4.9	Brigham-Grette	60	1354	...of climate change in response to relatively small changes in ???forcings	Romanovsky	Accepted.
5.4.9a	Brigham-Grette	62	1382	Laurentide ice sheet in Canada, which depressed temperatures nearby until the ice melted back (in our earlier publication: Maximova, L. N. and Romanovsky, V.E., A hypothesis of the Holocene permafrost evolution, Proceedings of the Fifth International Conference on Permafrost, Norwegian Inst. Tech., Trondheim, Norway, pp. 102-106, 1988, we proposed an explanation of the differences in the HTM timing based on a simple analysis of spatial variability in the amplitudes of specific Milankovitch cycles (41, 21, and 11 ka) – VR)	Romanovsky	Accepted and reference added.
5.4.9a	Brigham-Grette	64	1435	Astakhov (1995) suggests that thawing permafrost was apparent north of the Arctic Circle (only in the European North, not in Siberia. In the Siberian North, partial thaw of permafrost was very local and was practically entirely confined by areas under thermokarst lakes that were actively developing there during the early to middle Holocene. There are better references on this topic – VR) during the early through middle Holocene. Areas south of the Arctic Circle in the European North of Russia and in the West Siberia appear to have experienced deep	Romanovsky	Accepted.
5.4.9a	Brigham-Grette	64	1444	permafrost in these regions produced an extensive thawed layer sandwiched between the shallow (20 to 80 meters in thickness), more recently frozen ground, and deeper Pleistocene permafrost.	Romanovsky	Accepted.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.4.9c	Brigham-Grette	67	1508	The cited D'Arrigo et al. 2006 paper also emphasized the uncertainties involved in estimating Medieval Warm Period warmth relative to that of the 20 th century, due in part to the more sparse proxy data coverage and the less coherent variability of tree growth temperature estimates for the MWP.	D'Arrigo	Accepted -- comment inserted to line 1509
5.4.9b	Brigham-Grette	67	1510	glacier advances (Karlén, 1988) between 2.6 and 2.0 ka ago. An extended analysis of these multiple centennial-scale warmer and colder intervals in Russia was published by Velichko et al.:	Romanovsky	(typo corrections)
5.4.10	Brigham-Grette	71		The various tree-ring and paleoreconstructions cited above are also relevant to the section: 5.4.10: Placing 20 th century warming in long-term (millennial) perspective.	D'Arrigo	Accepted and citation added to that section.
5.5.1	Brigham-Grette	74	1655	This would be a good place to mention Ruddiman's Early Anthropogenic hypothesis: Ruddiman, W. F. (2007), The early anthropogenic hypothesis: Challenges and responses, Rev. Geophys., 45, RG4001, doi:10.1029/2006RG000207.	Kirk-Davidoff	Rejected for line 1680. This hypothesis remains challenged and work of Berger show that the current interglacial would normally last for another 10k. This is probably a better reference.
5.5.1	Brigham-Grette	75	1688	...summer sunshine in the Arctic than in the current interglacial, with summer??? temperatures ...	Romanovsky	Accepted.
5.5.1	Brigham-Grette	75	1704	Smaller oscillations in climate	Romanovsky	Accepted.
5.5.2	Brigham-Grette	79	1781	The apparent constancy of the Arctic amplification is really puzzling in light of the lack of albedo feedbacks in the ice-free Arctic (in the Eocene and before). Also, there's a lot of doubt about tropical temperatures in the Eocene and Cretaceous, with some reports of very high temperatures: Paul N. Pearson, Bart E. van Dongen, Christopher J. Nicholas, Richard D. Pancost, Stefan Schouten, Joyce M. Singano, and Bridget S. Wade, 2007. Stable warm tropical climate through the Eocene Epoch Geology 2007 35: 211-214	Kirk-Davidoff	The polar amplification figure does not extent to the Eocene but I added reference to accommodate this comment near the end of 5.5.2 Reference as added to the bibliography.
5.5.3	Brigham-Grette	81	1829	but air over ice-covered water can become very cold in the dark Arctic winter (this is a trick – if air above is cold enough the sea water will freeze, it cannot stay liquid if air temperature is really cold!!! – VR), allowing sustained changes in sea-ice coverage to cause perhaps the largest temperature changes observed on the planet	Romanovsky	Accepted. Text change made.
Figure 5.6	Brigham-Grette			Figure 5.6: “clear warming trends” are not particularly clear in many cases. There is also no context for the different curves, in particular within each graph but also between graphs. Either a location map is needed or an abstraction of the data.	Reusch	Noted. My suggestion is that we add a figure with sites. The figure caption explains the context of the figure in the text.
Figure 5.21	Brigham-Grette			Figure 5.21: Why is there no timescale on this figure? “Across the PETM” is too vague for properly appreciating time and rates of change.	Reusch	Noted. We can ask USGS techs to add a time scale on the left side based on the original paper. From Joan: Please note that there is no age-depth relationship given in the original paper. It would be inappropriate for USGS editors to create one.
Figure 5.33	Brigham-Grette			Figure 5.33: MWP and LIA: this curve has been criticized as its origin is uncertain e.g. http://www.climateaudit.org/?p=3072#more-3072 It is also quite old, nearly 20 years or more out of date.	D'Arrigo	Taken into account. We can look for a different figure. Current figure is now from the IPCC assessment 2007.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
	Brigham-Grette			line 60. northern hemisphere summer?	Schmidt	Accepted and changed.
	Brigham-Grette			line 428: 'excellent correlation' between $\delta^{18}O_{sw}$ and salinity in the Arctic is a little strong. The presence of sea ice makes very large seasonal excursions. I would rather state that the correlation is worse in the Arctic than elsewhere (e.g. Tan and Strain (multiple references), Legrande and Schmidt (2006)).	Schmidt	Noted. Legrande and Schmidt 2006 added.
	Brigham-Grette			line 439: more Accepted value for the glacial ice volume change is more like 1.0 permil. Though give a range, I suggest 1.0 to 1.2 permil. (Schrag, Adkins et al)	Schmidt	Noted. Text changed and both references added.
	Brigham-Grette			line 483: 'generally Accepted to reflect annual mean temperature' is somewhat undermined by the doubling of the sensitivity (as exposed by the borehole estimates and nitrogen isotope measurements) due in large part to seasonal effects (Werner et al 2000). I would rewrite this section to either make it clear that this is a historical view or raise issues with seasonality and sources straight away.	Schmidt	Accepted. Werner et al. added to the text with note about seasonality issue. (approx line 507 in this version of mine).
	Brigham-Grette			line 526: why the restriction to the Holocene? Schmidt et al 2007 show issues with even different Holocene climate changes (incl the 8.2 event, orbital and other changes).	Schmidt	Accepted. Reference added to the End of Sec. 5.3.1d.
	Brigham-Grette			line 844-846: rewrite. I don't think that northern hemisphere summer can be prevented by a change in eccentricity.	Schmidt	Accepted. Wording changed at now line 1178.
	Brigham-Grette			line 876: "Arctic temperatures" are not defined by Greenland. It is certainly expected that temperature changes at high elevations are amplified compared to sea level, and possibly changes to the inversion over Greenland itself might increase the amplification further.	Schmidt	Noted.
	Brigham-Grette			line 879 (and other places). Be careful comparing records to the "20th Century" given the changes over that period. In many cases it will matter if you are talking about the early or late part, and depending on the records, it is unlikely that the proxy will extend to the late 20th C warming. I suggest being extremely specific in each case.	Schmidt	noted.
	Brigham-Grette			Section 5.4.9.c heading. Might I suggest Medieval Climate Anomaly instead of MWP? The MWP lends itself to presupposing what is still to be determined and leads many authors to line any warming from 500 to 1500 AD - however asynchronous - to the MWP. This laxity in usage could be significantly corrected here.	Schmidt	Accepted and corrected.
	Brigham-Grette			line 914: Shindell et al 1999 was a modelling study - not a data analysis. They showed that solar forcing could produce a more negative phase NAO - not that this necessarily happened during the late Maunder Minimum.	Schmidt	Accepted assuming the reviewer means Shindell et al. 2001 on line 1615. Text corrected.
	Brigham-Grette			line 926/7. "not extraordinarily high". Just say weak.	Schmidt	Accepted for line 1647 in revised version.
	Brigham-Grette			Figure 5.33: This has to go! The schematic from FAR (IPCC 90) is a hand-drawn cartoon based on a smoothed version of Lamb's central England temperature with a zero line that nominally reflects 1900 temperatures. Late 20th C temperatures clearly exceed the MWP 'bump' in the CET and this graph's representativeness is exceedingly ambiguous. Compared to the careful synthesis in the rest of this report, this figure sticks out like a sore thumb. Delete! (Use the AR4 compilations if you want something equivalent but more quantitative).	Schmidt	Accepted with enthusiasm. Changed figure to one from Mann et al, I press, PNAS

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
6. Rates of Change						
General	White			There are many examples of figures comparing different weather/climate phenomena on spatial versus temporal extent scales. It might be useful to include such a figure in this chapter (near the beginning). (This would be <i>different</i> from Fig 6.5.)	Reusch	Accepted. We will look for an appropriate figure.
General	White			Overall, sets the context well for discriminating between “weather” and “climate”, “brief but locally large/globally small” and “long but locally small/globally large”, along with an excellent perspective on types of change.	Reusch	Noted: no change necessary
General	Fitzpatrick			This chapter has almost no results or citations about climate modeling, which have inform a great deal about climate variability and change in the Arctic. The word model doesn't even appear before the figure captions. There is a strong reliance on referencing the IPCC, when it would be better to cite the original papers.	Bitz	Deferred to public comment period (received after deadline)
6.2.1 6.2.2	White			Similarly, a brief figure/study showing how averaging period (length and start/end) may affect conclusions about means, trends and other statistics would be a useful supplement to the material in sections 6.2.1 and 6.2.2.	Reusch	Accepted: a figure has been added
6.3.2	White	13-21		Section 6.3.2 (pp 13-21) is fine in spirit (all the right topics) but feels rough in practice. Perhaps this material can be reorganized to reduce the subheadings.	Reusch	Noted
	White, Alley	6-7	164-167	pp 6-7, ln 164-167: As much as Alley has come to be associated with the phrase “tipping point”, at least among his colleagues, I'm not sure it's appropriate to credit him with coining either this term or its usage. (A search on “tipping point” at the NY Times web site quickly reveals just how widespread usage is.)	Reusch	Accepted: wording changed to avoid exclusive credit.
	White	8	197-204	pg 8, ln 197-204: A mention of the time-transgressive nature of change and the complexites introduced by the varying time-resolution of proxies seems appropriate here. The former is alluded to but could be expanded; the latter is expanded on greatly in 6.3 but deserves at least brief mention here.	Reusch	Accepted: text added for clarity
6.2.4	White	7	197-204	A graph (time series) showing the Younger Dryas record in Greenland and its correlation to other proxies in other geographical locations would help immensely the reader at this point. Also, an illustrative example of the chaoticity of the weather system, its predictability range, would help the reader understand that these are not mere speculations. The foregoing explanation (section 6.2) is needed but the prose is somewhat convoluted and unless one has some understanding of nonlinear dynamics, chaos, weather predictability, El Nino, etc. the text is difficult to follow, the point of the whole section is lost. For someone not in the loop, the above paragraphs are cryptic at best.	Rial	Noted
Figure 6.1	White			Figure 6.1: Are there two time series for each core in the left-hand figure? Would it be possible to reduce the detail without losing the message? (Also, the caption and the subfigures do not match positionally.)	Reusch	Accepted: the caption has been fixed. Yes, there are two time series. No, reducing the detail would make the figure less clear.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
	White			Abstract: "1-10 years" I'm not sure this casual statement is helpful. Many of the claims of sub decadal climate change in these abrupt events are a bit of a stretch in time series that have significant interannual variability and this statement does not qualify this at all. I think you'd get more argeement if you said "decades or possibly faster" instead.	Schmidt	Rejected: Note that sub-decadal changes have been documented in Dansgaard et al (1989) an din Alley et al (1993).
6.1	White, Alley			6.1 bracketing is incorrect - temperature is associated with Celcius, not time period.	Schmidt	Accepted: wording changed for clarity.
	White			I don't know if I even agree that '10 deg C in 10 years' has been truely described in regional records in the NRC report, but the appropriate comparison should be to regional warmings in recent decades (not the global mean). These have, in places (the Arctic, Antarctic Peninsula etc.) reached 3 deg C in 30 years, a factor of only 10 smaller than the claim for paleo-climate (which you need to check).	Schmidt	Accepted: changed 10 deg C in 10 years to 10 deg C in 50 years.
6.2.1	White			6.2.1 volcanic eruptions are predictable beyond two weeks? I'm sure the volcanologists would be happy to hear that if it were true.	Schmidt	Accepted: added "some day" to add clarity.
	White			The 8.2 kyr event temperature estimate from Leeunberger et al is for Greenland only and is pretty tentative (extrapolating a long term calibration to shorter timescales and not making any allowances for possible meltwater effects (i.e. Legrande et al, 2006). This kind of sentence might go some way to explaining why colleagues often mistake regional claims for global ones.	Schmidt	Accepted: added "Greenland" to add clarity.
	Fitzpatrick		21	line 21 longer-lived changes are ... slower than shorter-lived changes" is a tautology.	Bitz	deferred to public comment period (received after deadline)
	Fitzpatrick		35-36	line 35-36 Is this supposed to say that "slower but longer-lasting changes in the average frequency of volcanic eruptions"?	Bitz	deferred to public comment period (received after deadline)
	Fitzpatrick		37-40	line 37-40 This sentence is very awkward. It would be better to say something like "It is highly probable that recent anthropogenically forced changes are larger in terms of overall size and rate of change than natural climate change over the past 1000 years. However, substantially different climatic conditions appear to have permitted even larger changes than in the more distant past." I know of no projections with climate models that ever yield changes as rapid and large in magnitude as Dansgaard-Oeschger events. Models cannot even produce large enough changes with melt water added artificially. So I wonder what was meant by the last part of the sentence. <i>It sounds speculative to me.</i>	Bitz	deferred to public comment period (received after deadline)
	Fitzpatrick		891-897	line 891-897 Delworth and Knutson did not reconstruct temperature. They ran a model of the 20th century and compared it to observations (not a reconstruction). They found that the early century warming could have resulted from natural variability but the late-century warming must result at least partly from anthropogenic greenhouse gas emissions. The current text appears to have the wrong reference or the text needs to be revised.	Bitz	deferred to public comment period (received after deadline)
7. GIS						
General	Fitzpatrick			What of the drawbacks/compromises of the current generation of ice flow models?	Resuch	Noted
General	Alley			This chapter especially needs good site maps, for land, ice and ocean (surface, deep and currents, perhaps even a cross-section).	Resuch	Accepted; Figure will be added in technical edit. added as ending plate.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
7.1	Alley			Section 7.1 is a very nice introduction to the main topics and ideas needed for the rest of the chapter. A veritable micro-primer on the field of glaciology.	Resuch	Noted
	Alley	8	161-163	A bit too brief of an overview of ice shelf buttressing, especially since the term comes in later (166) without explicitly being connected to what it is.	Resuch	Accepted; reworded for greater clarity.
	Alley	36-37	816-832	The goal of this paragraph seems to be to cover a bunch of topics that are related only in that they each help to explain climate, but that goal is not made clear on its own. Further, the paragraph start implies it will just be about recovering accumulation rates, but goes on into a string of other topics.	Resuch	Accepted; introductory sentence added to paragraph.
7.3.2	Alley	41-51		If reliable evidence is only available from MIS 11 onward, might this section be better named "the last 500ka"? It would also be useful to note that more details on MIS 5, etc., follows in subsequent sections. This could be done here or in a new introductory paragraph after the 7.3 heading.	Resuch	Accepted; sentence added to clarify the times covered in 7.3.2.
	Alley	59-60	1339-1351	Is the "sliding over the bed" mechanism being proposed as a way to preserve past ice (permafrost) or as a way to "advect" ice from elsewhere to Dye3 and reestablish the ice sheet in that region?	Resuch	Accepted; text added to introduce both ideas at the start of the paragraph, and again within the paragraph.
	Alley	64	1443-1444	What exactly is meant by "best available"? The narrowest range? The "best" model dynamics, etc.?	Resuch	Accepted; wording changed.
	Alley	70	1583-1588	A cartoon of the cooling/warming cycles would help interpret and appreciate Figure 7.9 more.	Resuch	Accepted in part. Alley (1998) provided a cartoon of this, and is now referenced. However, here reliance is placed on the data rather than the cartoon.
	Alley	71	1600-1602	"The complexity observed" is rather an understatement. I'm also more interested in the correlations between the ice core record and each marine core than amongst the marine cores (though the latter is still interesting).	Resuch	Noted
	Alley	81	1836-1837	The event timings mentioned in the text would be much easier to follow in Figure 7.9 if the latter had a more detailed x-axis scale (unlabelled ticks at 2k intervals would be very helpful).	Resuch	Accepted, tics will be added in technical edit. <i>Later note by JF: unable to obtain high resolution version of this image to edit. Will need to redraft during layout to accomplish this.</i>
7.1.2	Alley	11	231	Because of this insensitivity of the inland thickness to many controlling parameters, changes in ice-sheet volume are controlled more by changes in the areal extent of the ice sheet than by changes in the thickness in central regions. It'd help here to have either a figure or scheme (perhaps a few equations) that show the nonlinear relationships discussed above. Though the discussion is very clear and flows well, it always help to illustrate.	Rial	Accepted in part. Additional referencing added in lieu of equations.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
7.3.4a	Alley	71	1612	The slower tens-of-millennial cycling of the climate records is well explained by features of Earth's orbit and by associated influences of Earth-system response to the orbital features (especially changes in atmospheric carbon-dioxide and other greenhouse gases, ice-albedo feedbacks, and effects of changing dust loading), with strong modulation by the response of the large ice sheets (e.g., Broecker, 1995). The faster changes are rather clearly (these are likely linked to the THC, not clearly linked to them) linked to switches in the behavior of the north Atlantic, with colder intervals during times of more-extensive wintertime sea ice, and with warmth when such sea ice was reduced (Denton et al., 2005), coupled to changes in deepwater formation in the north Atlantic and thus to the "conveyor-belt" circulation (e.g., Broecker, 1995; Alley, 2007). Yet, a detail mechanism of the possible processes acting in the north Atlantic is still debated, including the origin of the forcing that presumably generates the D-O. (see for instance AGU Geophysical Monograph 173 –Ocean Circulation- or Stastna and Peltier, 2007, JGR-Oceans)	Rial	Accepted in part. Text and reference added on mechanistic understanding. The faster changes are clearly linked to changes in behavior of the north Atlantic (reference added); whether this extends into the larger-scale issues of the THC is addressed in the added text.
				or Stastna and Peltier, 2007, JGR-Oceans).	(cont.)	
Synopsis	Alley	95		I have one suggestion, for the authors of chapter 8. It concerns melting of Greenland ice, a highly charged issue. The introduction and text of chapter 8 (<i>sic</i>) delve appropriately into the paleo evidence of changes in Greenland ice. The authors mention the longer response time of the north-central ice dome compared to the marginal areas. They cite probably incomplete melting during the last interglaciation (isotopic stage 5e). And they mention the lack of really firm constraints on future ice shrinkage. All this is fine. In the chapter summary, however, this complexity is reduced to a statement to the effect that warming of a few degrees is sufficient to cause ice-sheet loss. Taken in isolation, such a statement is at least semi alarmist. Based on what the body of the chapter shows, I would have said something like: "Warming of a few degrees, if sustained over several millennia, would be sufficient to melt a sizeable fraction, and possibly all, of the Greenland ice sheet."	Ruddiman	Accepted in part. Text changed to more clearly emphasize the uncertainties on the threshold warming required for ice-sheet loss.
8. Sea Ice						
General	Fitzpatrick			The chapter is well written and provides a comprehensive overview of geological, historical and recent ice conditions in the Arctic.	Barry	Noted
General	Fitzpatrick			Very thorough and interesting compilation of paleoclimate information, especially the section 8.3 is very fluently and easy to read and understand. Be consistent by using either sea ice or sea-ice	Skourup	Noted
Abstract	Polyak	2	31-33	Sea ice less under warmer climate events associated with changes in the Earth's orbital parameters on the time scale of tens of thousands of year; a reference would be nice	Skourup	Taken into account (discussed in Section 8.4.2 and in Chapter 4)
	Polyak	6	117-120	It would be useful to say more about why altered winter sea ice affects circulation like the NAO, especially since this is likely to include feedbacks between the two systems (it's highly unlikely they exist in isolation).	Reusch	Taken into account. Explained on lines 119-120.
8.3.6	Polyak	20	439	higher (not warmer) temperatures	Barry	Accepted

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
8.4.4	Polyak	24		I noted the omission of reference to Vinje's work in the Barents Sea: Vinje, T. 1999. Barents Sea ice edge variation over the past 400 years. Extended Abstracts, Workshop on Sea-ice Charts of the Arctic, Seattle, WA, World Meteorological Organization, WMO/TD No. 949, 4-6. Vinje, T.. 2001 Anomalies and Trends of Sea-Ice Extent and Atmospheric Circulation in the Nordic Seas during the Period 1864–1998. Journal of Climate 14: 255–67. Also, the recent work on the Russian sea ice record for 1933-2006 by Mahoney et al. Mahoney, A.R., Barry, R. G., Smolyanitsky, V. M. and Fetterer, F. 2008. 20th century Russian sea ice extents from observations. 38th International Arctic Workshop, Program and Abstracts, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO. pp. 84-86.	Barry	Accepted
8.4.3	Polyak	36	809	explain 'seesaw' effect	Barry	Accepted
8.4.3	Polyak	36	815	give approx dates for Little Ice Age and Medieval Warm Epoch	Barry	Taken into account (see explanations on lines 749 and 827)
8.4.3	Polyak	37	825	Dark Ages applies only to western Europe; give time range	Barry	Corrected
	Polyak	7	151-156	September extent is certainly the most dramatic but it would also be useful to have a visual of the other months (though not necessarily all) to emphasize that change has been occurring year-round.	Reusch	Taken into account (contributors contacted for a respective figure)
8.1	Polyak	3	49	is the thinning also accelerating ?	Skourup	Corrected (wording changed)
8.1	Polyak	3	50	seasonally ice free in 2030 ... change to 2040 according to text	Skourup	Accepted
8.2.1	Polyak	4	70	(provide) Reference to the numbers of sea ice extent ...	Skourup	Accepted
8.2.1	Polyak	4	81	3m peak is this a number covering all Arctic sea ice ?? Here again it would be nice with a reference	Skourup	Accepted
8.2.1	Polyak	4	84-86	Here it would be nice to include WMO definition first-year ice < 2m in thickness, Multi-year ice > 2m in thickness, for people who do not have a clue about sea ice	Skourup	Accepted
8.2.2	Polyak	7	134-147	What is the conclusion ... it is a little vague. What if areas of newly formed sea ice which are believed to contribute to the deep water formation due to brine rejection disappears, e.g. the Oden area East of Greenland which are formed now and then and are believed to have a big influence on the NAO?	Skourup	Accepted
8.3.1	Polyak	12	257	include the abbreviation ACEX (ACEX: Beckman et al., 2006) The Holocene section there is a lot of information ...	Skourup	Accepted
8.4.1	Polyak	24	541	Cenozoic – a definition of which time it covers	Skourup	Taken into account (see Chapter 4)
8.4.1	Polyak	28	632	A more complete or a more detailed It will probably never be complete	Skourup	Accepted
8.4.2	Polyak	29	644	It would be nice with a reference	Skourup	Accepted (reference to Chapter 4 inserted)
	Polyak	31	695	Historical limit – is it the same sea ice limits as shown in figure 8.1	Skourup	Accepted

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
	Polyak		696	Is it the Bering Strait	Skourup	Accepted
8.4.3	Polyak	32	714	which records ?	Skourup	Accepted
	Polyak	33	752	3 C above mid-twentieth conditions ... which are characterized as ??	Skourup	Accepted
	Polyak	34	757	briefly, met coinciding with the Atlantic bowhead penetrating into the central channels.	Skourup	Accepted
	Polyak	34	762-771	But how does this correlate to migration of the bowhead between the Atlantic and Pacific ??	Skourup	Corrected
	Polyak	34	769	wouldn't changes in forest composition and extent need a longer timespan than evident by the rapid decline 7 ka BP	Skourup	No change necessary (discussed in Chapter 5)
	Polyak	34	770	Peaked during the early Holocene ... isn't it late Holocene according upper graph of figure 8.11	Skourup	Accepted, corrected to mid Holocene
	Polyak	34	777	Fig 8.12 does not cover 8.5 only 6.5 ka	Skourup	Accepted
	Polyak	35	786	what is progressively shorter from south to north ?	Skourup	Accepted. Text corrected
8.4.4	Polyak	38	871-876	Even the thorough report I still find it unproven if similar events have occurred in the past, especially the speed of the process. This might be "hidden" in poorer resolution of drilling sites in the past ?	Skourup	Noted
8.5	Polyak	39		Here again ... it would be nice to point out that more data is needed from the past, drilling etc. in different regions to get a clearer picture of the past sea ice changes. The data available now on which the sea ice history rely on are very sparse.	Skourup	Taken into account (see last two sentences of the Synopsis)
Figure 8.1	Polyak			Maksimum [<i>sic</i>] and minimum extent from which period ??	Skourup	Not clear which sentence is commented upon
Figure 8.7	Polyak			Figure 8.7: I find the reference to Vostok temperature to be more distracting and confusing than of any use to understanding the rest of this figure. For one thing, it implies that Vostok provides a multi-million year record, which obviously it does not.	Reusch	Figure deleted
Figure 8.8	Polyak			Figure 8.8: As in the previous figure, I find it awkward to be extrapolating the Vostok calibration to such a great temporal extent. This figure also implies that our understanding of temperature over the last 5+ Ma is based on a relatively recent calibration with the Vostok ice core, and that's clearly not true.	Reusch	Figure deleted
Fig 8.10	Polyak Fitzpatrick			It would be nice to have the timescale reversed to fit the timelines of the previous graphs going from old times (left) to today (right)	Skourup	Can be done, but is this really important? Leonid, I'll see what we can do with this during technical edit but this will probably have to wait until we go to layout. JF
Fig. 8.11	Polyak Fitzpatrick			Here again it would be nice to have the timescale reversed to fit the timelines of the previous graphs going from old times (left) to today (right) – but at least it is important to have it the same as fig 8.10	Skourup	Can be done, but is this really important? See previous comment J
	Polyak		68-78	lines 68-78 The numbers here need references.	Bitz	Taken into account (discussed in Section 8.4.2 and in Chapter 4)

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
	Polyak		94	line 94 A range should be given on the amount of ice export. I suspect this number is relative to the end of summer area, while the area relative to the winter maximum is more like 10%. A reference should be given as well.	Bitz	Taken into account. Explained on lines 119-120.