

Chapter	Responder	Page	Line(s)	GENERAL Comment	Reviewer	Notes
General Comment	Alley			<p>The CCSP assessment completely overlooks the destruction of ozone in the lower stratosphere/upper troposphere as the cause of observed cooling of in those atmospheric zones and its effect on warming of the lower troposphere and warming of the earth.</p> <p>Ozone is mentioned only once in the CCSP Product 1.2 and is mentioned only as a greenhouse gas. The primary pre-industrial 262 greenhouse gases include, in order of importance, water vapor, carbon dioxide, methane, nitrous 263 oxide, and tropospheric ozone. Concentrations of these gases are directly affected by 264 anthropogenic (human) activities, with the exception of water vapor as discussed below.</p> <p>I cannot comprehend how the destruction of ozone effect was completely overlooked. The effect was obvious to me. Why was it overlooked? It was so easy to see it makes one think it may have been ignored on purpose.</p> <p>I am an old chemical engineer and have analyzed data most of my working career. Please have your scientists review ozone destruction of ozone as the cause of recent global warming and if</p>	Ashworth	<p>Noted. IPCC assessed ozone issues in the 2007 assessment, see the Summary for Policymakers of Working Group 1 and supporting chapters. . There is a very slight effect of stratospheric ozone depletion (estimated as equivalent to a radiative forcing of -0.05 W/m2, with uncertainties ranging from +0.05 W/m2 to -0.15 W/m2) with a continental to global impact. The effect is believed largest in the Antarctic. There is also a warming influence from new production of tropospheric ozone linked to human activities, with an estimated radiative forcing of +0.35 W/m2 (asymmetric uncertainties range from +0.25 to +0.65 W/m2). Again, the effect is continental to global, and especially important in and downwind of regions with certain types of pollution. Because the report primarily deals with paleoclimatic issues, the natural changes in ozone are believed to be much smaller than the anthropogenic ones over similar time periods (there are feedbacks between stratospheric loading of aerosols from volcanism and ozone, especially since human perturbations of stratospheric chlorine, but the indirect effects of those on climate are lumped into the effects of</p>
General Comment				<p>primary cause of the recent global warming we saw up to 1998 in your CCSP assessment.</p>	(continued)	<p>volcanic eruptions), and there are not yet reliable paleoclimatic indicators of ozone, it was not treated as a focus of the report. The unsupported claim that ozone destruction is the cause of the recent warming is counter to the assessed scientific literature, and does not motivate revision of the document.</p>
General Comment	Fitzpatrick			<p>This is a comprehensive work undertaken by top researchers based on a major compilation of recent information. For example, the recent results from relic Greenland beaches showing whether summer sea ice was present was included. If other sections are this comprehensive, this report is truly encyclopedic.</p>	Feldman for NOAA/PMEL	Noted
General Comment	Fitzpatrick			<p>With the extensive background provided, the use of questions was an excellent way of providing syntheses.</p>	Feldman for NOAA/PMEL	Noted
General Comment	Fitzpatrick			<p>Particularly valuable was the amount of information and review of the early Holocene, which is probably one of the better analogs to current conditions.</p>	Feldman for NOAA/PMEL	Noted
General Comment	Fitzpatrick			<p>We believe the SAP is informative and provides excellent characterizations of and the challenges to addressing climate change associated with the Arctic region. Additionally, the evidence presented relative to the significance of and impacts from climate change in the Arctic region is very convincing and is supported by useful references, graphics, and pictures.</p>	Williamson for NOAA/OFCM	Noted
General Comment	Fitzpatrick			<p>We believe that the organization of the chapters should be rearranged to enhance reading and understanding by the general public. We believe Chapter 3 should encompass Chapter 2 which was intentionally left blank and was designated "a place holder in the event that an additional introductory chapter is deemed desirable based on the public comments." Current Chapters 6, 7, and 8 provide the substance of the report and should become Chapters 3, 4, and 5. Current Chapters 4 and 5 should be changed to Appendices, since the information in these chapters is mainly tutorial in content.</p>	Williamson for NOAA/OFCM	<p>There is now no need for a Chapter 2. All chapters have been renumbered to reflect this.</p> <p>Declined: Substance of the report includes Chapters 5, 6, 7, and 8 and not only 6, 7, and 8. The current arrangement of chapters with the background chapter leading the technical chapter was carefully crafted to ensure that lay readers would have the background information needed to provide the framework for understanding the four technical chapters that follow after.</p>

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General Comment	Fitzpatrick			There are several typographic errors within the document (e.g., “irculation” vs. “circulation” in Chapter 5, page 5, line 287; “interspersed” vs. “interspersed” in Chapter 8, page 28, Line 622; etc.). Words are erroneously omitted/inserted. There are instances of erroneous spaces and missing punctuation between words and sentences, respectively. The word “firm” is bolded in some instances and not in other instances (for example, in Chapter 6, page 26, lines 569 and 571). Additionally there are instances of subject/verb disagreement.	Williamson for NOAA/OFCM	Accepted.
General Comment	Fitzpatrick			The figures throughout the document should be reviewed for legibility and clarity. Several in Chapter 4 are not readable in their present form especially Figures 4.1, 4.2, 4.3, and 4.8. Also, having the figure descriptions separate from the figures makes interpretation and assessment of the information in the figures more difficult.	Williamson for NOAA/OFCM	Accepted. Final determination of legibility will be made by USGS editors. (Note that these comments now refer to Draft 4 Chapter 3)
General Comment	Fitzpatrick			Based on the previous discussion, please ensure that a technical editor reviews the document and incorporates the appropriate corrections into the next SAP draft	Williamson for NOAA/OFCM	Accepted
General Comment	Fitzpatrick			I looked at this primarily with reference to volcanic activity, and didn't think it's potential importance was adequately expressed in the executive summary. I also noted a couple other minor items that need correction. It's a most interesting and impressive document.	Eichelberger	Noted
General Comment	Fitzpatrick			<b>Overall Quality of Report:</b> Taken as a whole, this report is very impressive in its depth and breadth—with a bit of editing to separate it from the SAP content, this could quite easily be turned into a very useful book. However, there is a good deal of detailed work that is needed to really make it fully suitable for the wide audience that is intended.	MacCracken	Noted
General Comment	Alley			<b>Arctic Connection to Mid-Latitudes:</b> The report would benefit from some discussion of the connections of the Arctic to the global climate and to that of mid-latitudes. In particular, it would help to say more than that the change in the Arctic is roughly 2-3 times that of the globe. In particular, it would be useful to mention that the Arctic climate cannot change (other than very short-term fluctuations) in a direction opposite to the trend of the rest of the hemisphere, and related to this, the processes that are present connect the Arctic to the lower latitudes and vice-versa. It would also help to have a section relating to how the weather of the Arctic and mid-latitudes are connected (my phrasing has been that the Arctic is essentially the “air conditioner” for the Northern Hemisphere, basically creating the cold air that then leads to the weather—and warming is making it much less effective), so warming of the Arctic in the autumn will tend to warm the mid-latitudes and delay the onset of winter, etc. Basically, the atmosphere is a fluid and it cannot tolerate the creation of unusual gradients without the weather responding to moderate them.	MacCracken	Taken into account
General Comment	Alley			<b>Isostatic Effects:</b> It seems to me that a somewhat less scattered presentation is needed on the isostatic aspects. First, an introductory section on this might be useful, basically saying something like the Earth is like a ball of putty or an orange or something, and if one presses down in one area, another pops up. But, a bit more specifically, it seems to me that the issue of the Greenland Ice Sheet is quite tied to the height of Greenland itself. It seems to me the traditional view has been that Greenland is an island and the ice sheet is up on it and so it will require warmer air to melt it and meltwater will flow to the bottom and lubricate it, etc. Under this view, the ice sheet is much less vulnerable than the West Antarctic Ice Sheet, which is grounded below sea level. Actually, however, the new results (e.g., Konrad Steffen figure I have seen), indicates that a large fraction of interior Greenland is below sea level and there are some fjords connecting the inner area to the ocean. With ocean water able to transfer much more heat and to help lift the ice sheet (at least at the edge), it seems to me that the vulnerability becomes much greater. In any case, what would be useful to cover, if there is information available, is the behavior of the Greenland Ice	MacCracken	Taken into account
General Comment	Alley			useful to cover, if there is information available, is the behavior of the Greenland Ice Sheet with respect to its elevation above or below sea level, and what the effect is of having sea level down 120 meters during the last glacial, etc. One could also cover the near and far field adjustments, adjustments in length of day, etc.	(continued)	

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General Comment	Alley			<b>Early 20<sup>th</sup> Century Warming:</b> I think more needs to be said about this. It is said that this is mainly a North Atlantic phenomenon, which is helpful (though many keep citing Polyakov data set, which is mainly North Atlantic and coastal as indicating whole Arctic warmed as his record suggests). During the Arctic Climate Impacts Assessment, it became clear that Siberia, Alaska, and northwestern Canada had few stations during that time, so the Polyakov record is quite limited. To fill that in, there were efforts to discuss climate with elders and it became clear that the present warming, which is similar in the earlier warming in the North Atlantic region, is unique to these other areas—there is just no recollection, and there is no vocabulary for the types of species (e.g., birds) now in the Alaskan Arctic area. I think a bit more discussion is warranted to describe that period and what we know, sense, and don't know about it.	MacCracken	Taken into account
General Comment	Alley			<b>On Modeling of the Geological Record:</b> I think it would be very useful, though I know a good bit more work, to go over more of the modeling that has been done for paleo-periods, or at least to highlight some of the findings and refer the reader to some of the material. These results (and I mean more than the modeling of the glacial extent) suggest some interesting types of results (e.g., Berger's work indicating that orbital forcing does not seem to work above a CO <sub>2</sub> concentration of something like 400 ppm—just no way to get the glaciers building up). There have been some interesting results from PMP and other time-slice studies, etc. At least it needs to be mentioned that there is this large area of effort that is being undertaken to get at causal mechanisms, testing understanding, etc.	MacCracken	Taken into account
General Comment	Alley			<b>Length of the Eemian Interglacial:</b> The report is not entirely consistent on this issue, sometimes saying 120-130 ka and sometimes longer, and I think there are those who argue it is even shorter than 10 ka. This also comes up for some other periods as well. Explaining what the definition is and then having a table would be helpful. I'll offer a few specific comments below.	MacCracken	Taken into account
General Comment	Alley			<b>Being Precise in Statements:</b> It is really going to be important to be precise in statements, as individual ones can get pulled out of context if not said carefully. For example, there are a number of places where it is not said if what is being referred to is a summer average temperature increase or an annual one. I'll note examples that seem particularly important, but it will be important to read this to make sure each sentence can stand on its own.	MacCracken	Taken into account
General Comment	Alley			<b>On the Onset Time of Human Influences:</b> The report seems to pretty much stick to the IPCC notion that human influences have only really been significant since about 1970. I'd urge caution on this, not only because Ruddiman suggests impacts go back 8,000 years (and have several effects after that), but because the model simulations on which this is all based have yet to really include land cover change (or actually the lofting of SO <sub>2</sub> emissions that likely dramatically increased sulfate emissions in the period around 1940 and thereafter), which is perfectly capable of having caused regional changes—maybe even contributing to the Little Ice Age or warming after that. We simply do not yet know that this was natural or whether there was a human influence—and the same goes for Medieval Warming. Thus, I would urge being a bit more circumspect in reporting on these periods.	MacCracken	Taken into account
General Comment	Alley			<b>Abrupt Changes:</b> This is another area where it would help to have a bit more preliminary discussion. The really sharp changes are based on data mainly from Greenland, and could result from shifts in atmospheric circulation, etc. Given ocean thermal inertia, I would suggest that it is thermodynamically impossible for the global average temperature change to be so sharp, and there are in most cases sentences after the reporting of sharp changes that say this, but their importance seems to get lost. I would urge an opening discussion somewhere that basically makes the point about these changes that seem to start in the North Atlantic, where they do seem to be quite large, and then they spread from there, and give a sense of the cause (meltwater outbursts, etc.). But I'd urge caution in talking about sharp changes by, for example, always having the sentence say in the Arctic or in the North Atlantic or something similar.	MacCracken	Taken into account

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<b>1. Executive Summary</b>						
<b>1. Executive Summary</b>	Fitzpatrick	4	65	As written, the summary implies that the decrease in northern summer sunshine is solely responsible for the trend culminating in the Little Ice Age and that the trend since is solely due to rising CO2 concentrations. But multiple large volcanic eruptions have been implicated in contributing to the Little Ice Age, and their subsequent rarity may have enhanced the warming trend since then (Crowley, 2000; Robock, 2000). I suggest inserting: "This temperature minimum may have been augmented by multiple large volcanic eruptions, lofting a reflective aerosol layer into the stratosphere."	Eichelberger, USGS	Accepted. Sentence added.
<b>1. Executive Summary</b>	Fitzpatrick	8	164-166	This needs to be reworded - we don't recommend how policymakers should approach their job	Brouwers, USGS	Accepted.

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2. Preface						
2. Preface	Fitzpatrick		70	For clarity, I'd change "since" to "because" given you are also talking about time intervals.	MacCracken	Accepted
2. Preface	Fitzpatrick		88, 257	The reference to "Correll" should be to "ACIA"—and in any case, the spelling is "Corell"	MacCracken	Accepted
2. Preface	Alley		192	For comparative reasons, the following sentence should be added after "2007)": " By comparison, global sea levels rose by 150 meters after the melting of the last continental glaciers."	Chernoff	Declined. The sea-level rise from the end of the most recent ice age was dominated by ice other than Greenland.

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3. Concepts						
3. Concepts	Fitzpatrick			The figures throughout the document should be reviewed for legibility and clarity. Several in Chapter 4 are not readable in their present form especially Figures 4.1, 4.2, 4.3, and 4.8.	Williamson for NOAA/OFCM	Accepted. USGS editors will determine suitability of all figures.
3. Concepts	Fitzpatrick			The footer in Chapter 3 erroneously reads: “Chapter 2 Preface.”	Williamson for NOAA/OFCM	Accepted. All chapters renumbered. Headers and footers adjusted.
3. Concepts	Alley	16	339-340	The text on these lines reads: “Continents move more or less as rapidly as fingernails grow, so that a major reshuffling on the continents requires about 100 million years . . .” We believe this text is trying to use fingernail growth as an analogy to demonstrate the hundreds of millennia required for a major reshuffling on the continents. Anecdotally, some people believe that their fingernails grow quite quickly. As a result, we believe it may be more appropriate to use another analogy or delete the analogy. Please consider revising the text to more clearly reflect the author’s intent.	Williamson for NOAA/OFCM	Declined. The analogy is accurate.
3. Concepts	Fitzpatrick	23	481-482	The general public may not be familiar with the term “benthic foraminifa.” This term should be defined. In subsequent updates of this SAP, please consider defining this term.	Williamson for NOAA/OFCM	Accepted. This term has been added to the Glossary
3. Concepts	Fitzpatrick	38-41	813-877	Captions for Figures 4.1 – 4.11 are needlessly placed on these lines and pages as if the captions are part of the text. The captions also appear under each figure. Please consider deleting these captions from the body of the text.	Williamson for NOAA/OFCM	Accepted. Captions were placed as inline text solely for the convenience of the reviewers. There is no intention to retain them in this form for the final product.
3. Concepts	Fitzpatrick		41	Just as you capitalize “Earth” (yes, the planet, not the dirt), you should capitalize “Sun” as it is a specific object in the celestial sphere In fact, “Sun” is capitalized on line 72—so need to be consistent).	MacCracken	Accepted.
3. Concepts	Alley		62-66	I would like to know how “static” is defined. My sense here is that this conclusion is based on an expansion of time scales as one goes back in time. Do we really know that in times tens of millions of years ago that there were variations anything like what has happened during the Pleistocene? The statement here goes back 70 Ma—so, is the statement here saying that in the 5 Ma before the Cretaceous extinction there were also variations as during the Pleistocene? I think not—basically, “static” is the wrong word here. It is fine to say that the Earth’s climate has been very different in the past, but “static” introduces the notion of rates of change and time intervals, etc., and I don’t think the statement is justified without a good deal of clarification—and, referring to my general comment on the need to be precise, this is a statement that could well be taken out of context and used to suggest that therefore we need not do anything and that the present is not very unusual in terms of the rate of change. So, I urge a significant rewrite of this paragraph.	MacCracken	Declined. The text reflects the assessed literature.
3. Concepts	Alley		64	There is a new paper suggesting that tropical temperatures might have changed a good bit more than has been suggested—again, some qualification is needed here.	MacCracken	Declined. The text is accurate. This is discussed extensively in chapter 5 on polar amplification.

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3. Concepts	Alley		65	You might also mention that sea level was in the past perhaps 70 m higher when there was no ice on land. But also mention that these changes take time, etc.	MacCracken	Declined. Sea level is discussed elsewhere in the report.
3. Concepts	Alley		161-173	The discussion about changes in the solar output needs some elaboration as the statements in lines 161-165 seem inconsistent with those in 170-173. Basically, for millions of years, the rate of change was very small, and then it is asserted that we have had a change of 0.7% (and are there not views, such as in the new IPCC report based on calibrations with new information on changes over the sunspot cycle that this estimate might be too large?—indeed, the statement on lines 166-167 looks at odds with line 172.). What needs to be explained is that it appears over the very long term that the Sun is amazingly stable, but that there can be some variations over shorter times. Now, some of this gets said in the following subsection, so mainly what is needed is some clarification—why not move the three bullets on lines 166-173 into section 4.2.2b as these bullets have nothing to do with the aging of the Sun that is the topic covered in 4.2.2a?	MacCracken	Accepted in part. Reworded for clarity.
3. Concepts	Alley		186-189	You might add that the fact that the stratosphere is strongly cooling also would rule out a solar explanation.	MacCracken	Accepted. Text added.
3. Concepts	Alley		192	So, here we go talking about longer cycles, but section 4.2.2a talked about the amazing stability of solar output—I think a more coordinated discussion of all this solar variation and aging is needed.	MacCracken	Noted. See responses to comments 13 and 16.
3. Concepts	Alley		196	This “Little Ice Age” term is based on conditions in the North Atlantic basin—not really the globe. I think this should say “cool conditions in the North Atlantic region that are often referred to as the Little Ice Age.”	MacCracken	Accepted. Text changed.
3. Concepts	Alley		196-203	My impression has been that the lengthening satellite record is finding that the sunspot cycle variations are smaller than was assumed by a number of the earlier investigators, and so IPCC (2007) came out with a smaller estimate of the change in forcing from 1750 to the present. I would think this should be receiving primary billing and it should be said that the earlier estimates were based on outdated estimates of solar variation over the sunspot cycle.	MacCracken	Declined. Text indicates that the larger estimates are older.
3. Concepts	Alley		202-203	While this estimate for CO <sub>2</sub> is correct, the total GHG forcing is larger and just happens to be offset by aerosol forcing—which is also larger than the solar term. Basically, the IPCC now considers solar a small term among two larger terms—and so, somehow, the point might be made that if solar forcings explained the Little Ice Age, then the present much larger forcings would be expected to cause much larger responses. I would also note in all of this that methane’s effect can be quite large and rapid, so it should be mentioned as the Arctic warming could well influence it significantly.	MacCracken	Declined. Solar effect and methane contributions are discussed elsewhere in document.

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3. Concepts	Alley		229-236	It might be noted here that this explanation of having nearly no change in global forcing cause the ice age cycling rather seriously violates the IPCC paradigm that one can scale the response based on the global forcing. Basically, the orbital forcing is suggesting that regional changes in forcing can have a very large effect—so, might it be that land cover changes in the North Atlantic sector contributed to the Medieval Warming and the Little Ice Age? A bit hard to rule out.	MacCracken	Declined. The reviewer raises a fascinating topic, that some of us have worked on. However, the IPCC "paradigm" generally considers the Charney sensitivity, which involves the faster feedbacks, and the ice ages involve slower changes. An extensive critique of the IPCC methodology is beyond the scope of this report, but the IPCC has seemed to use Charney-type sensitivities for the warming from the Little Ice Age, so we follow their lead and do not address this further.
3. Concepts	Alley		246-247	Indeed, so it might be added that the sharp warming in the Arctic at present is quite unusual. It might further be argued that the natural tendency was to have cooling since the Climatic Optimum and eventually to the Little Ice Age and beyond and that there is really little basis to be thinking that the warming since the LIA was natural (except for a very small solar influence).	MacCracken	Declined. This is clearly a section on orbital forcing, and there are sub-orbital climate anomalies of both warm and cold sign during orbital cycles, which are discussed separately.
3. Concepts	Alley		259-260	This calculation is really valid only in a 1-dimensional (globally integrated) sense, and this might be said. And, despite there being no atmosphere, the calculation assumes the Earth has the same albedo it does with clouds—which would be hard if there were no water (as would snow). So, a few more caveats on this statement are needed.	MacCracken	Accepted. Caveat added.
3. Concepts	Alley		282-284	I thought Arrhenius got a climate sensitivity more like 5 C—that might be mentioned.	MacCracken	Declined. We share the reviewer's interest in historical detail, but do not believe this adds sufficiently, given the very early state of the science in Arrhenius' time.
3. Concepts	Alley		345-351	It would seem that much of this is not appropriate to this section—maybe should go in the next.	MacCracken	Noted. This serves to link the previous section to the next, and so has been left as is.
3. Concepts	Alley		192	<del>For comparative reasons, the following sentence should be added after "2007)": "By comparison, global sea levels rose by 150 meters after the melting of the last continental glaciers."</del>	Chernoff	This comment refers to the Preface not Chapter 3.
3. Concepts	Alley		35-37	No references given for cause of cooling during this period. The only place where CO2 increase precedes temperature is in the GCM models adopted by the IPCC. I consider this statement as pure speculation and cause and effect should be deleted	Chernoff	Declined. This is an abstract, and abstracts generally are not referenced, with references given in the underlying text of the chapter.
3. Concepts	Alley		150-152	delete all after " .. dust," and replace with " are the subject of intense research at this time."	Chernoff	Declined. This is a section introduction; again, the underlying text contains the references and discusses the evidence (e.g., cosmic rays on line 410).



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3. Concepts	Alley		176-203	Although CO2 forcing receives the benefit of “feedbacks”, the sun’s forcing receives no similar treatment.	Chernoff	Declined. The extensive discussion of feedbacks notes that they act on natural as well as human forcings, and indeed, much of the interest in the paleoclimatic record is to help determine the strength of feedbacks to natural forcings, as detailed in the report.
3. Concepts	Alley		284-286	The statement leaves the impression that 2 deg. Cent increase is the final answer. More recent studies have indicated increases of 1.2 deg (Hansen Houghton 2001), 1 deg. (Lindzen (1997) and Pierrehumbert (2008)) and 0.3 deg Miskolczi (2007).	Chernoff	Declined. This is clearly stated to be historical perspective, and a reference is provided immediately thereafter for more up-to-date information, much of which is also included later in the report.
3. Concepts	Alley		413-417	The increase of galactic dust between the earth and sun does not necessarily require that the dust “fall on earth”. Furthermore, the expected crossings of the galactic disk have a 34 million year period and crossings of the spiral arms may have a period of approximately 145 million years (Shaviv). Cosmic ray intensity has increased during these crossings (Shaviv).	Chernoff	Noted. The statement is quite clear about the observations.
3. Concepts	Alley		420	Shaviv , Veiser and Svensmark have made a strong case for the influence of galactic position and I believe the term “galactic positioning,” should be added after “such as” and before “drifting continents”.	Chernoff	Declined. The list clearly is headed “such as”. Adding another feature that has no discernible influence on short-term climate is not of great value.
3. Concepts	Alley		604-607	The statement should be deleted. The rise in CO2 and methane levels is mere speculation to explain the temp optimum at this time. As a matter of fact, Shellito was involved in another paper in 2004 where they invoked an 18 deg. obliquity for the earth to help explain the optimum. This is contrary to 2 deg range accepted by most scientists. Furthermore, even a doubling of GHG at this time would have elevated the temp only 1 deg. There is simply no evidence for abrupt GHG increases at this time.	Chernoff	Accepted in part. Dissolution of sea-floor carbonates, shifts in isotopic composition, and other paleoclimatic indicators strongly point to rise of CO2. Reference added.
3. Concepts	Fitzpatrick		130	“Earth” should read “the planet”. The sentence describes a hypothetical planet that is too cold, not Earth.	Eichelberger	Accepted
3. Concepts	Fitzpatrick		247	“equinoxes” should read “solstices”. The paragraph discusses the climate effect of precession with reference to solstices, but suddenly switches to equinoxes in the final sentences. This is confusing.	Eichelberger	Accepted. This sentence reworded omitting reference to equinoxes.

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<b>4. Temp &amp; Precip</b>	Brigham-Grette / Miller					
<b>4. Temp &amp; Precip</b>	Fitzpatrick	3	40	quiet --> quite	Brouwers	Accepted
<b>4. Temp &amp; Precip</b>	Fitzpatrick	17	363-364	Will tree rings be added?	Brouwers	Accepted
<b>4. Temp &amp; Precip</b>	Fitzpatrick	30	646	ice depositsed duringthe...! --> 'ice deposited during the...'	Brouwers	Accepted
<b>4. Temp &amp; Precip</b>	GHM	30	658	outline --> outlined	Brouwers	Accepted
<b>4. Temp &amp; Precip</b>	Fitzpatrick	69	1556-1558	current text does not make sense	Brouwers	Accepted
<b>4. Temp &amp; Precip</b>	Fitzpatrick	83	after 1861	add conclusions here for synthesis bullets' ????????	Brouwers	Accepted
<b>4. Temp &amp; Precip</b>	GHM		31-34	Although it might be best to cover it later in the chapter, it seems to me that it is important to distinguish two components of the summertime temperature change—having a longer time up near the freezing point, and the average summertime temperature actually rising to well above the freezing point. I think clarification is also needed about whether these are air temperatures over land or are Arctic Ocean temperatures—that is, is this statement saying that the change in Arctic Ocean surface water temperatures is greater than the average change in temperature for the globe (I would point out also that some of the ACIA model results actually showed coastal land area temperatures around the Arctic going down slightly with what is called warming because the surface temperature of melting sea ice is 0 C whereas the surface temperature of the open ocean water was lower (but, of course, above -1.8 C). Basically, I think more precision is needed in this description.	MacCracken	Accepted. Small change in abstract to indicate we are talking about surface air temperatures. A few additional clarifications elsewhere in the chapter.
<b>4. Temp &amp; Precip</b>	GHM		36-40	Using the phrase “warm times” seems to need to be changed to something like “comparatively warm times” or “warm times in the Arctic” etc. to make clear that temperatures are still quite cold in terms of what most people are used to.	MacCracken	Accepted. Text reworded
<b>4. Temp &amp; Precip</b>	GHM		43	I think it would help to indicate what the estimated CO <sub>2</sub> concentration was—making the connection early on of higher CO <sub>2</sub> and warming.	MacCracken	Accepted. Point taken; text modified
<b>4. Temp &amp; Precip</b>	GHM		45-46	I think it would be helpful to indicate in this sentence what is causing the reductions in at least the CO <sub>2</sub> concentration over this long time—so weathering of rocks and biological deposition to the ocean floor is exceeding volcanic emissions and reprocessing—or something like that. I think it would also be useful to give the pace of the change so that a comparison can be made to the present—so it must be something like a decrease of 1200 ppm over 60,000,000 years, or one part per 50,000 years—that gives a good sense of how long it will take natural processes to remove the extra CO <sub>2</sub> that we have added, which is roughly 100 ppm over 140 years or so, so about 35,000 times as fast!	MacCracken	Accepted. Text modified to include estimates of Cretaceous CO <sub>2</sub> and to describe why it decreased and compare rates with the past century.
<b>4. Temp &amp; Precip</b>	GHM		51-52	I would suggest saying “circulations were substantially different between” and then say what contributed to these changes. If one says “reorganized” then there even more strongly needs to be an explanation of how this happened.	MacCracken	Accepted. Text changed to clarify this point

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4. Temp & Precip	GHM		56	Using the phrase “ice-age time” needs a bit of caveating as at least some of the time this was not the case. It might be said this was a time when a cycling between glacial conditions and interglacials was going on—and if an interglacial is still considered as being in an ice age from a long-term perspective, then some greater explanation and definition of words is necessary.	MacCracken	Accepted. Text changed to clarify this point
4. Temp & Precip	GHM		57	I would change “changes” to “cycling” to indicate that this is periodic.	MacCracken	Accepted
4. Temp & Precip	GHM		58	After “minimum” I would insert “(causing summers to be relatively cool and winters relatively warm)”	MacCracken	Accepted
4. Temp & Precip	GHM		59	After “maximum” I would insert “(causing summers to be relatively warm, and winters relatively cold)”	MacCracken	Accepted
4. Temp & Precip	GHM		61	I don’t think it is very helpful to repeat the traditional view that interglacials are about 10 k.y. when much is later made of the lengths being very different. At the least, it should be said they have ranged greatly in length, averaging about 10 k.y. but varying from a few to roughly 40 k.y. or whatever is the case.	MacCracken	Accepted
4. Temp & Precip	GHM		61-62	Can a few reasons for the “debate” be given?	MacCracken	Accepted
4. Temp & Precip	GHM		62-63	I would start a new paragraph with the sentence starting “The relatively warm interval ...” I also think the statement on line 63 needs to be adjusted—saying that the intervals are 10 k.y. and the present one is 11.5 ka just gets one into that big to do with global cooling from the 1970s that was based on sort of a statistical average. We now know better and so we should not repeat that misimpression.	MacCracken	Accepted
4. Temp & Precip	GHM		63-65	The length of the penultimate warm interval seems to vary in the report—here being about 10 ka. First, it would help to define what an interglacial is—give some minimum—does it mean warmer than preindustrial or what. It should also be noted that while there was more solar in the summer, there was less solar in the winter for the NH so it likely got pretty cold.	MacCracken	Accepted
4. Temp & Precip	GHM		72-73	Was the 20 C warming during some season or annual? How much of it was a change in the lengths of the cold and warm fractions of the year, and how much really a change from the present minimum winter and maximum summer conditions? Is this really saying that mid-winter temperatures dropped by 20 C, or that summer never got near freezing, or what—be a bit more precise and descriptive.	MacCracken	Probably all we can say is that mean annual temperatures were 20 °C lower.
4. Temp & Precip	GHM		75 and 77	I recommend capitalizing “Sun”—but at least be consistent. See also lines 159, 160	MacCracken	Accepted. I agree... changes made throughout.
4. Temp & Precip	GHM		85-87	The wording is a bit confusing, sort of implying that glacier extent was a maximum all through the Little Ice Age, when I thought it was toward the end of it (this seems like a pretty early start—how is LIA defined?).	MacCracken	Noted
4. Temp & Precip	GHM		176-178	But the snow and ice extend down into regions where the Sun is out and what is happening there can affect what is happening elsewhere, so I would be more careful in stating the wintertime influence of melting snow and ice.	MacCracken	Declined. The statement as written is for the Arctic and is OK as is.

	Responder	Page	Line(s)	Comment	Reviewer	Notes
4. Temp & Precip	GHM		213-214	I'd suggest changing it to say "it is likely to release large quantities of CO <sub>2</sub> and CH <sub>4</sub> as a result of the decomposition ...". First, "may" is a really vague word—use the IPCC lexicon if at all possible—and it already seems to be starting to happen. And are there other gases of importance besides CO <sub>2</sub> and CH <sub>4</sub> , so be specific?	MacCracken	Accepted
4. Temp & Precip	GHM		217-223	I would just note that methane is a very powerful greenhouse gas. The traditional IPCC conversion is for the 100-year GDP and is something like 22. But for the 20-year GDP, it is 72 (and of course it is higher for even shorter periods), so if lofted and concentrated in the NH—though it likely has to have spread vertically through the troposphere—methane can have very large and very rapid effect. The change I would urge is to say on line 221 "strong and rapid"	MacCracken	Accepted in part. "rapid" added
4. Temp & Precip	GHM		236, 244, 249, 265	I am concerned that the apparent definition of "freshwater" is not the same in these three uses. Basically, there is freshwater coming out of rivers that really is fresh, and then there is freshwater in the oceans that means it has a low saline content and what is being talked about is there being a deficit of salt—but the water is not what most people would think of when hearing the term. I think the term needs to be defined and its usage in particular places made very clear.	MacCracken	Accepted
4. Temp & Precip	GHM		244-245	I would suggest deleting "the transport pathway for" on line 244 and saying "Ocean is transported by the ocean's surface layer" on line 245.	MacCracken	Accepted in part. This section has been extensively modified to make the difference between surface currents and freshwater clearer.
4. Temp & Precip	GHM		260-261	This phrase needs to say "in winter, as long as there is not much sea ice" or something similar.	MacCracken	Accepted
4. Temp & Precip	GHM		287	Correct spelling to "circulation"	MacCracken	Accepted
4. Temp & Precip	GHM		289, 478, 480, etc.	Please use IPCC lexicon instead of "may"—so say "would likely" or something similar.	MacCracken	Accepted in part. I have searched all "may" and converted those that may be changed to an IPCC term. Several may legitimately remain as "may".
4. Temp & Precip	GHM		299	I think it would help to say this a bit differently—basically, the interglacial coverage was something like 15% (i.e., Antarctica plus Greenland plus northern Canada) and so it might better be said "grew from approximately 15% (or whatever the number is) to about 30%" (and I'll ignore the fact that much of Greenland has been pushed down below sea level and so is not really part of the "modern global land area"—indeed, when the ice was a maximum, sea level was down 120 m and so land area was greater, and at 0% coverage, remaining land area would be less.	MacCracken	Accepted. Rewritten this section
4. Temp & Precip	GHM		328-333	This is very well said and is the message that should be up in the summaries.	MacCracken	Noted
4. Temp & Precip	GHM		345-346	Indeed, it might well be said that the cold season warming is mostly of the very thin surface layer, which is important for the region, but not much for everywhere else.	MacCracken	Noted
4. Temp & Precip	GHM		347	Indeed, and this damping should be mentioned earlier. The key change is the longer melt season.	MacCracken	Damping is important but this seems to be a fine place to make the statement

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4. Temp & Precip	GHM		355-357	It should be mentioned that the results of these factors is that one can get quite large changes in temperature during this period—basically causing a delayed onset of winter (so not an increase to a new annual extreme, but a large change in annual average temperature).	MacCracken	Accepted. Additional text added to describe the ice-insulation winter feedback process.
4. Temp & Precip	GHM		363-364	Add at end of sentence that thinner ice allows more heat transfer.	MacCracken	Accepted
4. Temp & Precip	GHM		370	I'd suggest saying "fall further"	MacCracken	Accepted
4. Temp & Precip	GHM		532	Change "in on" to "on"	MacCracken	Accepted
4. Temp & Precip	GHM		623-625	But might not the meltwater during the Climatic Optimum have carried the surface heating down into the ice? If not, was that period really as warm as claimed, given that present conditions are creating such meltwater flows?	MacCracken	Noted. Meltwater does not percolate through the central regions of the Greenland ice sheet, so it carries a memory of the LGM cold.
4. Temp & Precip	GHM		939	I think it would be nice to have a subsection on forcings over this period as a leadoff to the discussion starting in section 5.4.1. That is, cover the slow changes in the Sun, periods of intense volcanic activity, changes in concentrations of greenhouse gases, etc. Some of this information is relevant to the interpretation of various indicators, so that would be another reason to cover the trends in forcings.	MacCracken	I think there is a section covering forcings elsewhere.... Yes? <b>Yes Giff, we cover this in Chapter 3. JF</b>
4. Temp & Precip	GHM		1048-1049	Might not methane be another important factor—it has a very strong effect, and concentrating this forcing over several years might cause an excess melting of snow and ice that would in turn activate the albedo feedback, etc.	MacCracken	Accepted in part. I think the main point of this section is that GHG alone cannot explain Arctic warmth without getting the tropics too hot. I have changed CO2 to GHG
4. Temp & Precip	GHM		1064-1069	This suggests to me the possibility of an asteroid impact—is there some reason for not mentioning this as a possible forcing that would have very sharp onset and then slow decay?	MacCracken	Noted. Impact should result in initial cooling, not warming, and later warming, different from what is preserved in the geological record
4. Temp & Precip	GHM		1085-1088	Are there reconstructions of the methane concentration? Lines 1133-1135 seem to suggest there would be lots of potential for CH4 generation.	MacCracken	Noted. Not that we are aware of.
4. Temp & Precip	GHM		1197	I'd change "models" to "explanations" to give the average reader a clearer indication, and it would sure be nice to have a little table of what they are (to augment the text discussion).	MacCracken	Accepted. "explanations" OK; but for this summary I do not think we need to list every one of the models and evaluate there pros and cons...that's what the references are for.
4. Temp & Precip	GHM		1324	Elsewhere it is suggested that the period lasted from 120-130 ka, and some places a longer interval is used. Some uniformity or a clearer discussion would help.	MacCracken	Noted. The statement as written is not in conflict with other statements about the LIG.
4. Temp & Precip	GHM		1353	There is a note to yourselves here to be fixed.	MacCracken	Accepted.
4. Temp & Precip	GHM		1450	I thought there was also a suggestion that this could have been caused by an asteroid impact near Scandinavia?	MacCracken	Noted. There are proponents for an asteroid impact explaining the Younger Dryas, but no credible claims for the 8.2 ka that we are aware of.

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4. Temp & Precip	GHM		1721-1726	It seems to me an open question is whether the warmth might have been attributable to regional changes in land cover (deforestation or reforestation—depending on the time). Given how modest the volcanic events were during mid-20 <sup>th</sup> century, there is not much potential for even less volcanic activity causing the greater warming (and was not much of it regional?).	MacCracken	Noted. Explaining MWP remains problematic, especially when the signal is weak, as are known forcings. There is little point in adding more text here.
4. Temp & Precip	GHM		1745	It is interesting that it is a trend to cooler summers that led to increased glaciation that became called the Little Ice Age, and not so much colder winters. I doubt there is extensive understanding of this point and think it should be mentioned earlier in the text.	MacCracken	Agree that this is an important point, but it still seems to flow most cleanly in this spot,
4. Temp & Precip	GHM		1887	Change to “completed”	MacCracken	Accepted
4. Temp & Precip	GHM		1929-1932	That these small changes in global, annual forcing lead to glacial cycling is very interesting, and seems to violate the IPCC forcing paradigm that annual-average, global average forcing can be considered. That this is the case is likely in part due to the particular geography and orography of the Arctic, in part to processes not in models like isostatic adjustments, etc.—still to be determined—but it might be worth making the point that it is interesting that the climate is so sensitive to small forcings.	MacCracken	Accepted in part. I think that the case has been made many times in the past that Milankovitch forcings alone are relatively small, and averaged over the globe on an annual basis are near zero. Text modified to show this quantitatively
4. Temp & Precip	GHM		1982-1985	Berger’s model results indicate that, with enough of the feedbacks included, orbital forcing can drive ice age cycles as long as the CO2 concentration is below about 400 ppm, but above that value, the cycling does not result. While his model is not as complex as the GCMs, it is an interesting result and may well explain the Pliocene (and you might want to cite his results).	MacCracken	Accepted. Added a reference to recent Haywood and pointed to CO2 and smaller ice sheets
4. Temp & Precip	GHM		2442	Eliminate the extra “multi”	MacCracken	Accepted.
4. Temp & Precip	GHM		2536	Is the spelling of the plankton accurate?	MacCracken	Yes, it is
4. Temp & Precip	GHM		2784	It would be nice to also have such curves for sea level and amount of ice.	MacCracken	Indeed, it would. But those data are not secure enough to use in this fashion
4. Temp & Precip	GHM		45-46	No reference for the statement and there is no evidence for the link. Delete the statement.	Chernoff	This is the abstract and does not require references. There are plenty of references elsewhere that support this simple statement.
4. Temp & Precip	GHM		317-324	The lag in CO2 changes has been confirmed by many workers. In the most recent glacial and interglacials, the range in CO2 is 200 ppm to 300 ppm indicating a temp. range of perhaps 0.75 deg which is not sufficient to account for the swing in actual temperature. Too often, workers invoke CO2 without consideration of other feedbacks which may be associated with solar (orbital) changes. At the close of an interglacial, temperature begins to drop whereas CO2 continues to rise for another 800 years. This fact is not testimony to Jansen nor is it testimony to your analogy between debt and interest. The analogy is neither scientific nor relevant and in fact is very confusing. I recommend that lines 319-324 be deleted.	Chernoff	Noted. The point here is that CO2 is a key feedback and necessary to explain the reconstructed temperature changes
4. Temp & Precip	GHM		358-359	Delete everything in brackets. There are many warming agents, both known and unknown.	Chernoff	Changed to “regardless of the forcing”

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4. Temp & Precip	GHM		1014-1093	For most of this text, CO2 is implicated as the only driver which could have produced the temperature changes. Correlation does not prove cause and effect and furthermore, although the ice core records show a similar trend between CO2 and temp, we now know that CO2 follows temp and is NOT the driver. If we look back to >750 million years, we see high CO2 (up to 15 times current values) and through these values we had glacials at 750, 600 and 450 million year BP. From 450 to 300 MY BP, the CO2 values and temp values again trended in the same direction. For the Quaternary, CO2 follows temp (ice core records). To discard this relationship for the rest of geologic time is not very scientific. Yes, there appear to be correlations between CO2 and Temp at other periods but to imply CO2 drives temp is to refute solid evidence to the contrary. Therefore, implicating CO2 in this manner is disingenuous and I suggest that the entire discussion be eliminated.	Chernoff	Noted. Quaternary changes in CO2 are caused by different processes than are Cenozoic changes (rock weathering). The levels of CO2 are independently reconstructed and are consistent with our text.
4. Temp & Precip	GHM		1852-1859	CO2 and methane are invoked to explain temp changes. This is in the realm of pure speculation. There is no evidence for any of these abrupt releases. Therefore, eliminate the guessing.	Chernoff	Noted. There is an extensive literature on the cause of the PETM. A sudden release of extra greenhouse gases is the "most likely" explanation.
4. Temp & Precip	GHM		1876-1877	Check radiation absorption math – the changes in ppm are not sufficient to make a large impact on Temp. At best, speculation again.	Chernoff	Noted. This cautious statement provides a realistic assessment of a variety of positive feedbacks, GHG among many others, that can reasonably explain how the small forcing derived from orbital variations can be amplified to achieve the actual temperature changes that have been reconstructed.
4. Temp & Precip	GHM	3	36-37	The text on these lines reads "... the Arctic was either mildly or substantially warmer than at present ..." We believe quantifying what is meant by "mildly or substantially warmer" would greatly enhance the reader's appreciation for the author's point about warming. Please consider quantifying what is meant by "mildly or substantially warmer."	Williamson for NOAA/OFCM	Accepted.. Quantified as >1°C above 20th Century mean
4. Temp & Precip	GHM	7	136-137	Text in these lines is written in the first person, plural. We believe that the term "we" should not be used in a scientific document. The term "the authors" is a viable substitute. Please consider amending the text on these lines so that the use of "we" is not used.	Williamson for NOAA/OFCM	Accepted. Changed as requested; all "we: and "our" removed
4. Temp & Precip	GHM	13	274-275	The text on these lines reads: "[The global thermohaline] circulation system also is referred to as the meridional overturning circulation (MOC)." While it is true that the thermohaline circulation is referred to as the MOC, it is also true that the two are not synonymous. The MOC is distinct from the thermohaline circulation in two ways. First, the MOC is confined to the Atlantic Ocean. Secondly, there is published data on the MOC's existence. The thermohaline circulation is a concept describing the fact that colder and/or saltier water sinks because it is denser than warmer or less salty water. The colder and/or saltier water's movement happens on a global scale. Thus, the thermohaline and MOC are not the same entity. We believe that because the SAP is considered an authoritative document, it is important that the SAP not continue the misperception that the thermohaline circulation and the MOC are synonymous. Please consider altering the text to provide the appropriate name for the circulation to which the author refers.	Williamson for NOAA/OFCM	Accepted. Text added to clarify the two

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4. Temp & Precip	GHM	22	461-472	The text on these lines discusses how a tree's annual-ring width can be a response to climate change. Yet a general characterization of the relationship between changing tree-ring width and climate is not made. That is, does a narrowing of the ring width reflect a response to a warming or cooling climate? In other sections of the SAP, fundamental explanations of other climate proxy records are given; yet in this instance no such explanation is provided. We believe that providing a one- or two-sentence tutorial would greatly facilitate the reader's understanding of how tree-ring width responds to climate. Please consider adding clarifying text to the discussion on tree-ring width.	Williamson for NOAA/OFCM	Accepted. Text added
4. Temp & Precip	GHM	112	2465-2467	Text on these lines reads: "Dark objects such as the open ocean, which absorbs some 93% of the sun's energy, have low albedo (about 0.06), absorbing some 93% of the sun's energy." In these lines the text "absorbing some 93% of the sun's energy" is repeated unnecessarily. Please amend the text so that it reads: "Dark objects such as the open ocean, which absorbs some 93% of the sun's energy, have low albedo (about 0.06).	Williamson for NOAA/OFCM	Accepted.
4. Temp & Precip	GHM	102	Fig. 5.27 line 2275	...'best as assignments...' Perhaps 'best age assignments'?	Brouwers	Should be corrected both in the caption under the figure and in the text on page 102 I corrected the caption for figure 5.27 (note that there are many figures labeled 4.xx, etc not 5.xx.
4. Temp & Precip	GHM	170	3257	Willarda --> Willard	Brouwers	Corrected



Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
<b>5. Rates of Change</b>						
<b>5. Rates of Change</b>	White	2	21	line 21 longer-lived changes are ... slower than shorter-lived changes" is a tautology.	Bitz	Accepted. Words added to clarify the meaning, "but much slower to occur".
<b>5. Rates of Change</b>	White	2	35-36	line 35-36 Is this supposed to say that "slower but longer-lasting changes in the average frequency of volcanic eruptions"?	Bitz	Accepted. Sentence was edited for clarity.
<b>5. Rates of Change</b>	White	2	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. It sounds speculative to me.	Bitz	Accepted. Sentence replaced with the one suggested.
<b>5. Rates of Change</b>	White	30	882-889	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	Accepted Sentence edited for clarity. We now stress observations and note the modelling results.
<b>5. Rates of Change</b>	Fitzpatrick	13	275	rapidy --> rapidly	Brouwers	Accepted
<b>5. Rates of Change</b>	Fitzpatrick	21	460	marcofossils --> macrofossils	Brouwers	Accepted
<b>5. Rates of Change</b>	Fitzpatrick	27	610	paleothermometry --> paleothermometry	Brouwers	Accepted
<b>5. Rates of Change</b>	Fitzpatrick	37	828	...may a reasonable...' --> '...may be a reasonable...'	Brouwers	Accepted
<b>5. Rates of Change</b>	White	29	636	A better example for extreme polar warmth linked to high CO2 is provided by the remarkable 90 Ma vertebrate fossils of the High Canadian Arctic (Tarduno et al., Science, 1998; Brinkman and Tarduno, Canadian Journal of Earth Science, 2005; Vandermark et al., Palaeogeography, Palaeoclimatology, Palaeoecology 2007). This fresh water assemblage is dominated by crocodile-like champsosaurs, indicating ice-free conditions during a time of extensive global basaltic volcanism. See also recent article in NewScientists.com: When crocodiles roamed the Arctic (18 June 2008).	Tarduno	Accepted. Added Vandermark et al, 2007 and Tarduno et al, 1998.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5. Rates of Change	White	29	636	There is a difference between indications of higher CO <sub>2</sub> , and indications of high CO <sub>2</sub> explaining Eocene warmth. The reference quoted (Royer et al., 2007) is a modeling study of CO <sub>2</sub> . It would be better to quote a direct proxy record for high Eocene CO <sub>2</sub> and/or to remove this reference. The source of CO <sub>2</sub> to explain Eocene warmth is a matter of debate. There is evidence for extensive, but older (Paleocene) volcanic activity. This temporal gap is reason for examining explanations for high polar temperatures based on changes in heat transport. Your text simplifies the matter to the point of being incorrect.	Tarduno	Noted
5. Rates of Change	White	29	636	It is unclear where you determined a value of 15 degrees C for the present Arctic; in what latitude band?	Tarduno	The value in the text is -15C. The line break, which I can't change, separates the - and 15 and makes this look like 15C. <b>Jim, I have now fixed this. JF</b>
5. Rates of Change	White	29	644	The concept of a “tectonic value” is unclear and perhaps misleading. I believe you are trying to define the average long-term decrease in temperature since the Eocene. This has multiple causes; claiming it as monotonic is incorrect. Calling it “tectonic” implies plate motion is the dominant cause. This paragraph should be deleted or rewritten.	Tarduno	Declined. We do not claim it is monotonic, and note that the cooling as well as the CO <sub>2</sub> decrease both show periods of faster and slower changes. The tectonic rate is an attempt to roughly quantify CO <sub>2</sub> changes on time scales on which atmospheric CO <sub>2</sub> is clearly controlled by erosion and uplift. We do not mean to imply that the change is all tectonic, as there will of course be oceanic and plant influences at shorter time scales.
5. Rates of Change	White	69	1544	Add reference: Tarduno, J.A., D.B. Brinkman, P.R. Renne, R.D. Cottrell, H. Scher and P. Castillo, 1998: Evidence for Extreme Climatic Warmth from Late Cretaceous Arctic Vertebrates. <i>Science</i> , <b>282</b> , 2241--2244.	Tarduno	Accepted
5. Rates of Change	White	69	1559	Add reference: Vandermark, D., J.A. Tarduno, and D.B. Brinkman, 2007: A fossil chamosaur population from the High Arctic: Implications for Late Cretaceous paleotemperatures, <i>Palaeogeography, Palaeoclimatology, Palaeoecology</i> , <b>248</b> , 49-59.	Tarduno	Accepted
5. Rates of Change	White		42	By common definition, climate is an average over 30 years. I would think it clearer to say here that there was a shift over a few years in the climatic state that had persisted over many decades to a different one that then persisted. Or maybe say that the climatic state changed over a few years to a different state. (You do say on lines 52-53 that such shifts are fundamentally different, and I agree—so don't lump them in with “climate change” generally.) I would also suggest revising to make clear that evidence points to such shifts, and indeed to climate changes over very long times, being due to a forcing factor of some kind and not just a random perturbation—otherwise, why not just let what is happening happen.	MacCracken	Declined. The point is noted, but we disagree. The opening discussion is generic. We are looking at all climate changes, not specifically rapid and large, abrupt climate changes. While some scientific communities define climate as the average over 30 years, not all do, nor would all find that definition useful.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5. Rates of Change	White		43	I would urge deletion of “years”, not only because climate is defined over 30 year periods, but because if you give a rate per year people look for that much change each year, and this is just not a realistic assumption, given variability. So, use a time average over at least as long as the definitional period (you might say the average rate over a century is so much per decade, but do not imply that this is how much each decade will change).	MacCracken	The point is noted, and we agree that care must be taken not to imply uniform change. We disagree that using years in this situation invites the abuse described in the comment.
5. Rates of Change	White		49	“Earth” as the planet needs to be capitalized, along with Sun, as on the next line.	MacCracken	Accepted
5. Rates of Change	White		52-60	I’d make this a separate paragraph, and it seemed to need a bit more integrating with the paragraph starting on line 61.	MacCracken	Declined. The paragraph structure works, and we prefer keep it as is.
5. Rates of Change	White		55	Change “migrate” to “become re-established” or something similar as trees do not migrate. One might get shifts of the range of trees and say their range migrates—though I would prefer saying shifts, but trees do not migrate.	MacCracken	Changed “migrate” to “spread”
5. Rates of Change	White		57-59	I think it needs to be said that such features (abrupt changes) are characteristic of colder times and seem related to glacial melting. Are there any indications of such shifts when conditions were warmer?	MacCracken	Noted. We are talking generalities here. To state that these occur in glacial periods would imply that they couldn’t occur in warmer times. The 8.2 ka event and DO25 happened during times of less ice, and while these events were smaller than the largest events during the glacial, they do exist.
5. Rates of Change	White		59-60	Wait a minute—this rate of change is 100 times as fast for Greenland, not for the world as a whole. The whole world did not change 10 C in a short time and this needs to be made very clear. A shift in Greenland of a pretty large amount can occur from just changes in the atmospheric circulation with nearly no global temperature change.	MacCracken	We have added the word “global” to clarify the sentence and compliment the existing word “regional”.
5. Rates of Change	White		118-119	I’d rephrase to say “little effect on the projections of future weather” on line 118 and to “affected much out for a day or so” on line 119—a bit repetitive, but the time scale of statement needs to be kept in mind.	MacCracken	Accepted. Both changes made as suggested by the reviewer.
5. Rates of Change	White		121	Change to “very different weather forecasts”—there is not nearly so much effect on climatic state.	MacCracken	Accepted. Change made as suggested by the reviewer.
5. Rates of Change	White		127	Change to “theoretically predictable” and note that this does not mean the detailed local weather is so predictable—it means that what is projected shows skill relative to climatology, which is a much more limited metric.	MacCracken	Accepted. Change made as suggested by the reviewer.
5. Rates of Change	White		134-135	Be careful here—the volcanic projections are pretty generic—sort of time and general size—this does not mean that their effects on the weather or monthly anomalies is predictable in more than a pretty general way.	MacCracken	Noted
5. Rates of Change	White		138	You might add that El Nino’s have longer predictability due to knowledge of the conditions in the oceans, with their larger heat capacity. And again, the degree of predictability is pretty limited.	MacCracken	Accepted. Change made as suggested by the reviewer.
5. Rates of Change	White		151	Delete “trend”—this was a cooling over two years, not some sort of trend in 30-year averages.	MacCracken	Accepted in part. Edited to remove the word trend where possible. But we think that the word is appropriate here and where it makes sense to leave it in the text we did.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5. Rates of Change	White		152	I would suggest adding to say "of the overall trend over time"	MacCracken	Accepted
5. Rates of Change	White		159	Indeed, it is the weather that changes and the average of the weather gives the change in climate (which itself is a mathematical construct rather than something the people feel every day). Basically, this sentence has the order reversed.	MacCracken	Accepted. Edited to add "over a 30 year interval" to make the sentence clearer.
5. Rates of Change	White		822-824	It may well be that there were some forcings during this period, including changes in land cover and maybe even methane generation. Basically, we don't know the portion that is natural and what might be human—we assume they are natural until proven (generally definitively) otherwise, which is a bit of a biased assumption given that we know human activities can affect the climate (and given Ruddiman hypothesis about this starting 8000 years ago).	MacCracken	Added the sentence: Human influences on the environment were measurable at this time, and thus such as changes in land cover and small changes to greenhouse gases such as methane, may have also played a role.
5. Rates of Change	White		837-838	I am not comfortable with the phrasing here as it seems to imply that we know there was some natural recovery from the Little Ice Age. Given the changes that were going on in land cover and the start of methane rise and industrialization (so soot, etc.), etc., it is entirely possible there were human influences, and it might well be that the natural path would have kept the world quite cool as a result of the slowly changing orbital cycling.	MacCracken	See the above edit which address this concern.
5. Rates of Change	White		839	The warming in the early 20 <sup>th</sup> century in the Arctic was mainly in the North Atlantic sector, and this should be mentioned.	MacCracken	Accepted. Change made as suggested by the reviewer.
5. Rates of Change	White		871-872	I don't think this sentence is very clear—it would be better to say in a more understandable way.	MacCracken	Accepted. The sentence is lacking specifics. We changed it to read: "An Arctic-wide assessment of abrupt climate changes would yield rates of change that would plot closer to the regression lines than do either the local Greenland or global values."
5. Rates of Change	White		873-874	This statement really needs to be said more precisely. It would be much better to say here that the present warming does not reach temperatures that are outside the bounds of what has occurred over geological history, but that the rate of warming going on is faster than has been observed in the past. While coolings have occurred quite rapidly, is it the case that warmings have occurred as fast? Basically, be more precise. And keep the causes out of this at the moment, or you end up comparing apples and oranges. Sure, the Cretaceous is warmer, but its CO2 concentration was several times the present value. What is needed here is a comparison for times with similar orbital and other conditions—so, is the present rate of warming unusual compared to what has occurred during the Holocene, or other interglacials? In any case, this sentence needs reworking as it can too easily be taken way out of context.	MacCracken	Accepted. New sentence added: "While the present warming does not reach temperatures that are outside the bounds of what has occurred over geological history, the rate of warming now going on is among the faster of those observed in the past."

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5. Rates of Change	White		634-636	The referenced study (Royer) is dishonest. Firstly, they say that there are no proxies for temp whereas there is a substantial report on oxygen isotopes going back to 500 million years (Veiser). But the greatest scientific dishonesty is in the choice of the starting point , 420 MY BP which is a warm period in early Silurian time. In the opening paragraph of their report they say that their study starts at 542 MY BP and yet their title and graph presentations start at 420 MY BP. If the authors had included the previous 122 MY BP, during which there was a strong Ordovician ice-house with high CO2 (4500 PPM), there is no way that they could have produced the desired results. They must have tried this and they didn't like the results. Furthermore the results of $\Delta T = 2.8$ deg C. represents the correlation between temp and CO2 and does not prove cause and effect. The temp may have risen or fallen for many reasons and their analysis is simply an analysis of the CO2 response.	Chernoff	Noted

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
6. GIS						
6. GIS	Alley	2	26	depend --> depends	Brouwers	Declined. Subject is plural (whether changes occur, AND how fast), so verb is "depend"
6. GIS	Alley	8	156	..restrains, of buttresses...' --> '...restrains, or buttresses...'	Brouwers	Reviewer had a slightly earlier version of the manuscript than did other reviewers, and this had been fixed between versions, so this is correct in manuscript.
6. GIS	Fitzpatrick	33	676	adjusment --> adjustment	Brouwers	See previous comment.
6. GIS	Fitzpatrick	34	750	ovrer --> over	Brouwers	See previous comment.
6. GIS	Fitzpatrick	39	891	adjusment --> adjustment	Brouwers	Accepted
6. GIS	Fitzpatrick	60	1259	where's the end of the sentence?	Brouwers	See second comment in chapter.
6. GIS	Fitzpatrick	77	1756	a much --> much	Brouwers	See previous comment.
6. GIS	Fitzpatrick	88	2013	delete much	Brouwers	See previous comment.
6. GIS	Fitzpatrick	117	218	(in referrences) Bermike --> Bennike	Brouwers	Accepted
6. GIS	Alley	36	816	The discussion of crocodiles at high latitudes is incorrect, and the suggestion is mis-referenced. Markwick (1998) does not discuss Cretaceous Arctic crocodilian localities; the authors may have been confused because his graphs contain high latitude data points, but these are "vertebrate" localities, not crocodilian localities. To the best of my knowledge, the only locality relevant to this discussion is the Axel Heiberg High Arctic site. On the basis of the fossil assemblage, Tarduno et al. (1998) estimate a minimum mean annual temperature of 14.2 degrees C at approximately 90 Ma at a paleolatitude of 71 degrees N. And again, these are based on large-bodied crocodile-like champsosaur fossils.	Tarduno	Accepted
6. GIS	Alley	134	715	Remove Marwick 1998 reference.	Tarduno	Declined: Markwick does cite crocodilians to almost 65 degrees N in the Cretaceous, sufficiently close to the Arctic to be of interest, so the reference was retained as a "see also" following the primary Tarduno reference.
6. GIS	Alley	144	1024	Add reference: Tarduno, J.A., D.B. Brinkman, P.R. Renne, R.D. Cottrell, H. Scher and P. Castillo, 1998: Evidence for Extreme Climatic Warmth from Late Cretaceous Arctic Vertebrates. <i>Science</i> , <b>282</b> , 2241--2244.	Tarduno	Accepted.
6. GIS	Alley	144	1046	Add reference: Vandermark, D., J.A. Tarduno, and D.B. Brinkman, 2007: A fossil champsosaur population from the High Arctic: Implications for Late Cretaceous paleotemperatures, <i>Palaeogeography, Palaeoclimatology, Palaeoecology</i> , <b>248</b> , 49-59.	Tarduno	Accepted
6. GIS	Alley		26	"depends"	MacCracken	Declined. See first comment on chapter.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
6. GIS	Alley		42	Change “may” to “is likely to”—use the IPCC lexicon instead of such a vague word.	MacCracken	Declined. The IPCC lexicon requires that there be an assessed confidence level. In this case, the author team does not believe that the probability density function is sufficiently well known to allow such a calibrated statement.
6. GIS	Alley		44-47	This sentence seems to contradict the earlier text. What is needed is to put some limits on how big or fast or long-lasting this type of undocumented change could be. And get rid of the “may”	MacCracken	Declined. A temporary growth preceding a complete collapse is possible behavior. The report must adhere to the refereed literature.
6. GIS	Alley		52	I think it would help to say “ice mass”	MacCracken	Accepted.
6. GIS	Alley		58-59	Is this really true—Konrad Steffen’s map shows much of present Greenland has been depressed below sea level, so is this statement really valid? And should there not be some discussion of the significance of having the ice resting below sea level and there being several penetrating fjords?	MacCracken	No change needed. Reviewer is referencing a map of current topography, and the text refers both to current topography and to isostatically adjusted topography following deglaciation. Fjords are dealt with later in several places.
6. GIS	Alley		83-85	As I recall from the letter from Richard Alley, as first author out of 7 prominent US glaciologists, to the USGCRP sent in late 2000 about the IPCC TAR sea level chapter, it said that the correlation between NH temperature anomaly and snow on Greenland was negative. I’d appreciate some clarification.	MacCracken	Noted; this is commented on near line 1311 in section 7.3.3c.
6. GIS	Alley		104-106	It sure looks from the figure as if a tipping point has been reached—at least the possibility of this should be mentioned for it is a really important issue.	MacCracken	Declined. Question is raised here on the meaning of the observed trends, and is discussed subsequently.
6. GIS	Alley		187-188	It would be helpful to mention here about icequakes and whether they are an indication of warming ice.	MacCracken	Declined. Joughin et al (2008b) and subsequent work indicates that the “glacial earthquakes” are manifestations of calving rather than of flow instability. There is no paleoclimatic record of such earthquakes, and as they do not appear to be independent harbingers of ice-sheet change, the author team decided not to complicate the presentation.
6. GIS	Alley		202-203 and line 208 and material following	Is this also the case when the land has been depressed to below sea level and there are surrounding mountains and connecting fjords, etc.—that is, is this all the case for simple types of situations (e.g., once one gets above the altitudes of surrounding mountains, etc.)? This really should be clarified.	MacCracken	Noted. Clarification is given on line 226ff.
6. GIS	Alley		220-222	This all sounds as if it is for pretty ideal cases and not for a situation as complex as Greenland. I’d like to see more said about what must be the limiting assumptions.	MacCracken	Noted. Clarification given on line 226ff.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
6. GIS	Alley		232	In the preceding section, there was no mention of meltwater leading to moulons, of the decreasing ice density seen by the GRACE satellite measurements, of icequakes, of underlying orography and fjords, etc. It seems to me a bit needs to be added covering the real situation that is being faced (and maybe even some mention of how all this theoretical analysis works on simple glacial streams, etc. as I recall we have been having some glacial streams going a good bit faster than can be explained theoretically).	MacCracken	No change needed. Meltwater access to the bed is introduced in lines 142-148 although without using the technical term "moulin". GRACE does not measure density but only gravity, and the ice density is not decreasing. The GRACE data are included in figure 7.2.
6. GIS	Alley		469-476	I am confused. The "distance between the sea surface and sea bottom" measured where, and how can this possibly be applied in the past? Is this really just a measure of total ocean water mass divided by the area of the ocean? How does one deal with isostatic effects—so changing volume of the ocean? Are you sure you don't mean from the center of the Earth—and then you can explain how the shape of the Earth changes due to ice sheet formation, etc. I just do not think this explanation is very satisfactory—need a bit more explanation.	MacCracken	Accepted. Wording changed for clarity.
6. GIS	Alley		487	I assume this is because of the relative densities of the crust and the ice—if so, you might say this so people can understand how it is derived.	MacCracken	No change needed. The reviewer is correct that the relative densities are involved. Providing motivation of the physical basis was considered, but several other physical issues in this section are not so motivated (e.g., the physical basis for the response time of the system); a consistent level of detail is obtained with no change.
6. GIS	Alley		489-491	So, this is saying, it seems that the Laurentide Ice Sheet had about the same mass of ice as Antarctica has now—that might be helpful to people to understand.	MacCracken	Declined. The comparison given here is to show the reader that the local isostatic response to the loading/unloading of the ice is smaller than the global eustatic signal of the ice volume. The comparison to the modern Antarctic ice sheet (or to other modern or paleo ice sheets) would confuse the point being made.
6. GIS	Alley		498-499	It might be worth giving the rate for Chesapeake Bay as an example, it is a subsiding rate of about 0.15 cm/yr.	MacCracken	Accepted in part. "generally slower" added to line 498. The isostatic term dominates the behavior near Hudson Bay, and a numerical estimate gives clear guidance to the reader. South of the "hinge line", additional terms are important. The estimated GIA contribution to Chesapeake Bay is generally smaller than the total term cited by the reviewer (see, e.g., Sella et al., Geophysical Research Letters, 2007, L02306). A clear quantification would require an extensive discussion, not a simple example
6. GIS	Alley		503	this should say "interglacial prior to about 1900" as this is no longer the case.	MacCracken	Accepted. Text changed.
6. GIS	Alley		505	I think you need to give a bit of explanation here (and not leave to later pages) about how the equatorial Pacific could be responding so much as there was no nearby ice (or is this adjacent to South America). Is the mechanism really changing shape of the Earth in response to changing mass of high latitude ice, or maybe changing mass of water in the ocean? I believe a bit more explanation is needed.	MacCracken	No change needed. The requested material is presented in 7.2.2d.
6. GIS	Alley		586-588	But earlier it was said that the equatorial regions, or parts of them, are undergoing large isostatic adjustments, so how can such islands be used to estimate sea level change.	MacCracken	Accepted. Text reworded for clarity.



Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
6. GIS	Alley		653	Delete "a"	MacCracken	No change needed. There is no appearance of an isolated "a" in the line, and all of the "a"s within words appear to be required for proper spelling.
6. GIS	Alley		642-644	And should indicate that the rates in the early 21 <sup>st</sup> century are a good bit higher—in fact, almost twice the 20 <sup>th</sup> century rate. And, in fact, if the IPCC is right, then much of the 20 <sup>th</sup> century rise occurred during the late 20 <sup>th</sup> century, so quite an acceleration is underway.	MacCracken	Accepted. Reference added on recent sea-level changes.
6. GIS	Alley		694-695	I don't understand this sentence.	MacCracken	Accepted. Reworded for clarity.
6. GIS	Alley		716-717	I assume this is the case only if there are not moulons, so basically if there is not extensive surface melting—so what happened during the Climatic Optimum? Was it as warm as touted?	MacCracken	No change needed. Line 714 notes that this applies to the "central Greenland ice sheet", a place where moulins are not now observed and have not existed for more than 100,000 years. (The Alley and Anandakrishnan, 1995 reference on melt layers shows that meltwater in excess of 1 cm per century has not been produced in this region during the Holocene.)
6. GIS	Alley		926-933	With so much sea level rise, would at least some of the East Antarctic ice sheet not end up being grounded below sea level?	MacCracken	No change needed. Some of the East Antarctic ice sheet already is grounded below sea level. This would have slightly changed that amount. The effect on the attribution of the sea-level rise is very small, however.
6. GIS	Alley		953	It was earlier suggested that the interglacials are typically 10 ka, yet the one at 400 ka, was longer, this one is indicated as longer, and so are the ones closer to the present. So, where does that 10 ka average length come from?	MacCracken	Accepted in part. Reference added back to ch. 3.5 on chronology.
6. GIS	Alley		984	Here it is indicating that the penultimate interglacial is 74-130 ka—so quite long. Previously, it has been 125-130 and 120-130. You sure have me confused. I think "interglacial" needs a definition, and the 10 ka typical length needs to be tossed as a concept.	MacCracken	Accepted in part. Reference added back to ch. 3.5 on chronology.
6. GIS	Alley		986	Is not Greenland not depressed as much now as then, and so can't seawater indeed get at the ice? Some clarification is needed comparing the present to the past situation with respect to land depressions, etc.	MacCracken	Declined. Lines 980-981 note that the ice then was more extensive and thicker than now.
6. GIS	Alley		990-992	Well, this is the case at least so far—but global average temperature is still lower than earlier, so this conclusion needs some qualification.	MacCracken	Declined. The text specifically refers to the "end-of-ice-age forcings" and not to anthropogenic or other forcings.
6. GIS	Alley		1052-1053	So, does this not argue for a quite rapid response to present warming pulse? How much happens early on and how much is in the apparently significant tail?	MacCracken	Noted. As present warming pulse is quite different from deglacial forcing, no change needed.
6. GIS	Alley		1141-1145	For what season? Summer or annual? And just to note that here the interglacial seems to be peaking at 130 ka, so how can there not be some part of it further back in time?	MacCracken	Accepted. Clarification added that this is summertime.
6. GIS	Alley		1149-1151	For what season are these temperature changes, or are they annual?	MacCracken	Accepted. Clarification added that this is summertime.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
6. GIS	Alley		1293-1294	For what season do the temperatures apply? I would also like to know if it matters that the solar forcing has a summer peak, so the heat can be absorbed during the summer and radiated away at night, whereas for the present situation, the CO2 and CH4 are up so the forcing is applied year round and there is not really a time for the energy to be radiated out to get the situation back toward its original state.	MacCracken	Accepted. Text modified for clarity. The discussion of assessment of seasonal effects of modern CO2 and CH4 is beyond the scope of the report.
6. GIS	Alley		1306-1308 (also lines 1314-1319)	Well, the models do not match observations now, as both Greenland and Antarctica are losing mass (according to satellite observations) whereas the IPCC relied on models that have the net of the two near zero for the whole 21 <sup>st</sup> century. That seems to me is a serious disagreement. Also, the models have not been able to explain the observed amount of sea level rise over the 20 <sup>th</sup> century—that too seems serious to me.	MacCracken	Accepted. "Surface" added for clarity.
6. GIS	Alley		1313	I would note that AGCMs also tend to do least well in regions of complex orography, and for snow versus rain and rain versus temperature. It seems to me in this case, we need to be paying a lot of heed to the observations.	MacCracken	Noted
6. GIS	Alley		1387-1429	I would really like to see a model verification study for the period since the Little Ice Age or something like that—at the very least for the 20 <sup>th</sup> century. IPCC did not show such verifications, which I think was unfortunate, but it sure appears the verification is not all that good. I would hope this report would show such a verification (e.g., of simulated change in sea level).	MacCracken	Declined. A model verification study for recent changes is beyond the scope of the report.
6. GIS	Alley		1475-1483	It would be helpful to say what is happening elsewhere in the world—at least to indicate that this is not an estimate of the change in global average, or even hemispheric, temperature.	MacCracken	Accepted; qualification added that this considers the climate most relevant to the Greenland ice sheet.
6. GIS	Alley		1891	"system"	MacCracken	Accepted. Spelling corrected.
6. GIS	Alley		1902-1905	Well, IPCC could not explain the reasons for the 20 <sup>th</sup> century rise. I'd like to see a comparison of what various groups are suggesting.	MacCracken	Declined. Assessment of the 20th century sea-level rise requires assessment of primarily non-Arctic changes (groundwater storage, Antarctic ice volume, etc.) and so goes well beyond the scope of the report.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
7. Sea Ice						
7. Sea Ice	Polyak					
7. Sea Ice	Polyak		24	Change to “volume and areal extent of Arctic sea ice”	MacCracken	Accepted
7. Sea Ice	Polyak		27	spelling “incomplete”	MacCracken	Accepted
7. Sea Ice	Polyak		47	Is it really the case that the changes are controlled by temperature as opposed to by the amount of downwelling IR radiation? What do energy balance calculations show?	MacCracken	Accepted, more explanation in Section 7.2
7. Sea Ice	Polyak		286	Given the polar bear situation, I’m not sure the phrase “bear skeletons” will be understood as you intend.	MacCracken	Accepted
7. Sea Ice	Polyak		668-671	Given that the average summer temperatures were up 5 C for an extended period, this seems like not much change, given the amount of change in the early 20 <sup>th</sup> century lead to a sharp meltback in the Atlantic sector. Perhaps it should be mentioned that winter temperatures were colder. It would help to give some sense of what is going and what it means for current situation.	MacCracken	Accepted
7. Sea Ice	Polyak		536-542	The text describes a period (34 MY BP) of rapid cooling and massive Antarctic glaciation. This was a time of the solar system passing thru the centre of the galactic disk as well as a passing thru an arm of the galaxy (Shaviv). Perhaps some of these “coincidences” should be recognized and researched.	Chernoff	Noted
7. Sea Ice	Polyak		439-485	I am surprised as to the difficulty with Na aerosols and sea ice. The ice core data at Vostok clearly shows an inverse correlation between temp and Na aerosol – high Na is associated with low temp (high ice cover?) and low Na is associated with high temp (low ice cover?). This relationship is faithfully repeated through 400,000 years. (NOAA data).	Williamson for NOAA/OFCM	Accepted
7. Sea Ice	Polyak	7	134-136	The text on these lines reads: “In particular, exporting more freshwater from the Arctic may alter the Atlantic meridional overturning circulation (MOC) it increases the stability of the upper ocean and suppresses the formation of North Atlantic Deep Water.” The intent of this sentence is unclear. I believe the author’s intent is to articulate the following three changes associated with freshwater export from the Arctic: (1) an altered Atlantic MOC, (2) increased upper ocean stability, and (3) suppressed North Atlantic Deep Water. Please consider rewriting the sentence on lines 134 – 136 to adequately convey the author’s intent.	Williamson for NOAA/OFCM	Accepted
7. Sea Ice	Polyak	4	72	a --> at	Brouwers	Accepted
7. Sea Ice	Polyak	5	108	then --> than	Brouwers	Accepted
7. Sea Ice	Polyak	23, 24	523, 547	metasequoia --> <i>metasequoia</i>	Brouwers	Accepted
7. Sea Ice	Polyak	26	622	interspersed --> interspersed	Brouwers	Accepted
7. Sea Ice	Polyak	31	688	Greeland --> Greenland	Brouwers	Accepted

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
7. Sea Ice	Fitzpatrick	58	1090	U.S. Hillhouse --> J. W. Hillhouse	Brouwers	Accepted
7. Sea Ice	Fitzpatrick	76		Vinje 1999 and 2001 correct type face to not bold	Brouwers	Accepted

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
8. Summary						
8. Summary	Alley		63-65	The comments on lines 63 to 65: "The warming after the Little Ice Age began for largely natural reasons, but there is now high scientific confidence that human contributions, and especially increasing concentrations of CO2, have come to dominate the warming (Jansen et al., 2007)." This contention is highly speculative and the Jansen reference does not adequately cover the range of arctic ice forcings such as the effect of soot on the ice. Multiple papers indicate that significant amounts of melt are due to changing albedo which is not discussed.	Smith	Declined. This is a summary, and so is not fully referenced, but the summary represents the underlying text in the chapters. Note that the recent work of McConnell et al. (Science, 2007) showed soot dropping during the latter part of the referenced warming, excluding soot as the primary cause.
8. Summary	Fitzpatrick		27	I would change "recently" to "characteristic of recent decades"—otherwise the question is what is meant by "recent"	MacCracken	Accepted
8. Summary	Fitzpatrick		29	Change to "the falling"	MacCracken	Accepted
8. Summary	Fitzpatrick		31	Change to "their effects"	MacCracken	Accepted
8. Summary	Alley		33	I thought there was some thinking that the 55 Ma warming may have been caused by a methane release (that would have then chemically changed to CO2).	MacCracken	Accepted
8. Summary	Alley		37	Change to "hundreds of thousands of years indicate strong control by"	MacCracken	Accepted in part. Wording changed.
8. Summary	Alley		38	Change "features of" to 'cyclic variations in"	MacCracken	Accepted.
8. Summary	Alley		39	What is meant by "the current interglacial would continue"—so what type of conditions are meant? There have been a wide variety of conditions during this interglacial—so what is meant?	MacCracken	Declined. "Interglacial" versus "glacial" is discussed in the underlying text. Refining projections within an interglacial is beyond the scope of the report.
8. Summary	Alley		43	Change to "atmospheric concentrations of CO2"	MacCracken	Accepted.
8. Summary	Alley		45	So, is this the right length for this interglacial—lengths vary in the report?	MacCracken	Noted.
8. Summary	Alley		47	Are these summer or annual temperature differences?	MacCracken	Accepted. Text clarified.
8. Summary	Alley		49	After "glacial" insert ", which peaked 20 ka" or give the period of the interglacial.	MacCracken	Accepted. Text clarified.
8. Summary	Alley		50	It needs to say "conditions in the Arctic" if that is what is meant.	MacCracken	Declined. These events affected much of the world synchronously.
8. Summary	Alley		55-56	I'd reword to "Such abrupt changes also occurred during the current". I am also confused by the second part of sentence seems to suggest the Holocene started before the main ice sheets melted away.	MacCracken	Accepted in part. Tiny bits of the Laurentide remain, and the ice was still fairly extensive in Canada after 8 ka, well into what is normally considered to be the Holocene.
8. Summary	Alley		59-65	These are pretty strong assertions ("were linked" seems far too strong a phrasing, especially as later in the sentence other possibilities are given—and there may be more). It needs to be said that they relate mainly to the North Atlantic region. I would suggest on line 60 inserting the following phrase after "Age" saying "that are well-recorded in historical records around the North Atlantic". On line 63, saying the "Little Ice Age began for largely natural reasons"—do we know this.	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		68	I'd urge saying "larger than changes in lower latitudes and globally."	MacCracken	Declined. "Globally" might imply everywhere; globally averaged is dominated by the large lower latitudes.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
8. Summary	Alley		74-75	I would change to read “Changes in climate have many causes, occur at different rates, and are sustained for different intervals.”	MacCracken	Accepted.
8. Summary	Alley		75-77	I’d suggest changing this to “Changes in atmospheric composition, along with changes in atmospheric and oceanic circulations linked to tectonic processes over tens of millions of years, have led to large changes, including conditions so warm they are ice-free and so cold they are ice-covered year round.” Basically, that last phrase is not very clear.	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		83-89	This needs a good bit of rewriting. I’d suggest saying something like “the Arctic, make clear that more-persistent forcings have produced larger changes, but most often at a lower average rate. In addition to these general trends, abrupt changes in climate, very likely linked to shifts in oceanic conditions of the North Atlantic, have produced anomalously large and rapid temperature changes around the North Atlantic, but relatively small changes in global average temperature. Relative to the long-scale changes that have occurred over Earth history, human-linked perturbations of recent decades do not appear anomalously large (or rapid as far as coolings are concerned), but model-projected changes summarized by the IPCC would be large compared to the Arctic’s geological history and rapid compared to shifts to previous warmer conditions.”	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		93-95	The sentence seems backwards, try “existing techniques described in this report offer substantial opportunities for generation and synthesis of additional data that could extend the available results.”	MacCracken	Accepted.
8. Summary	Alley		8-99	I’d change to “Paleoclimate data indicate that the amount of ice tied up in the Greenland Ice Sheet has changed substantially in the past and that such changes have contributed to large changes in sea level.”	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		99	I’d delete “Physical understanding indicates that” as unnecessary.	MacCracken	Declined.
8. Summary	Alley		102	Change “loss” to “disappearance” as the amount of loss is not clearly specified in the current phrasing.	MacCracken	Accepted in part. Reworded for clarity.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
8. Summary	Alley		103-104	Rewrite to say “During warm periods, the available evidence indicates that there was less ice, even when snowfall rates were higher, indicating that the snowfall ...”	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		104	Change to “responses”	MacCracken	Accepted. This is line 114, not line 104.
8. Summary	Alley		117	Is this annual or summer warming of 5 C?	MacCracken	Accepted. Summertime specified.
8. Summary	Alley		127	Change to “14 Ma, so well before”	MacCracken	Declined.
8. Summary	Alley		142	I think that there needs to be another recommendation that indicates that, while there is still much to learn, the results clearly indicate that changes in forcing lead to significant changes in the Arctic, that a significant changes seems to have begun, and that projected increases in forcing that result from the IPCC scenarios would lead to very substantial changes in the climate of the Arctic and in sea level. The changes that occur would have very substantial repercussions for the global climate and sea level, and the remaining uncertainties should not be seen as a reason to delay intense consideration of the issue by decision makers.	MacCracken	Declined. This is beyond the remit of this report.
8. Summary	Alley		181-183	I’d suggest rewrite to “Changes in Arctic temperature, for both warmer and colder periods, have been approximately three to four times the globally averaged change, this being a result of processes still active and occurring around the Arctic.”	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		184-185	I would suggest a rewrite to “Arctic temperatures have changes slowly, but by large amounts, in response to persistent, long-term causes, and by lesser amounts, but more rapidly, in response to other causes.	MacCracken	Declined.
8. Summary	Alley		186-189	I think this needs to be a separate bullet, and it needs to be rewritten (also see comment on Chapter 6, lines 873-874). Basically, the point is that in the context of the Earth’s geological history, the changes are not yet unique in terms of the temperatures. As to the rate of warming, considering starting from conditions as warm as during the interglacial, have there been times when the rate has been so high, or is that a rate of change that has only occurred when conditions have been far colder? Let’s not overstate here or diminish the uniqueness of current changes unless that really applies. Also, it really is the change from the current baseline that counts (meaning same orbital elements, atmospheric composition, etc.)—make sure to be comparing apples to apples.	MacCracken	Accepted in part. Reworded for clarity.
8. Summary	Alley		194	I’d suggest saying “a commensurate rise in sea level”	MacCracken	Accepted in part.
8. Summary	Alley		20-21	The cited references for invoking CO2 as a climate driver are not definitive and at times disingenuous (eg. Royer et al picking an opportunistic starting time for their study). One cannot say that CO2 “caused” climate changes. CO2 may have been implicated as an amplifier but it was never a driver. Therefore, at least change the word “causing” (line 21) to “amplifying “.	Chernoff	Declined. Text is consistent with the assessed literature.

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
8. Summary	Alley		29-30	Effect of CO2 is pure speculation.	Chernoff	See response to comment 36.
8. Summary	Alley		33	CO2 release is pure speculation. Delete reference to CO2	Chernoff	See response to comment 36.
8. Summary	Alley		42-43	Mathematics of radiation absorption precludes CO2 as a layer. major player. [sic]	Chernoff	See response to comment 36.
8. Summary	Alley		63-65	CO2 driving temp is not convincing. Temp leads CO2 at all time scales (Kuo et al 1990). The abstract from this Study reads as follows: "The hypothesis that the increase in atmospheric CO2 is related to observable changes in the climate is tested using modern methods of time-series analysis. The results confirm that average global temperature is increasing, and that temperature and atmospheric CO2 are significantly correlated over the past 30 years. Changes in CO2 content lag those in temperature by 5 months."	Chernoff	See response to comment 36.
8. Summary	Alley		178-180	The implication of CO2 as a driver is completely without merit. For the Quaternary, this report describes often the role of the earth's orbit in causing climate change. Ice Core data analyses show that CO2 is not a driver but rather a consequence of temp movement. There is no overwhelming evidence for CO2 as a driver for the period between 65 MY BP and the Quaternary. A similar trend in temp and CO2 does not prove that CO2 is the driver. Published works indicate that CO2 follows temp at the "kyear" level and at the "30 year" level. The only place that CO2 precedes temp is in the IPCC GCM's. Therefore, there is no support for a theory that would support CO2 driving temp between 65 MY BP and now. Therefore, I recommend that "atmospheric carbon-dioxide concentrations" in line 179 be replaced with "earth's orbit, obliquity and precession". If this change is not digestible then I recommend that the text in the first bullet be terminated after the word "causes" in line 178.	Chernoff	See response to comment 36.
8. Summary	Fitzpatrick	7	123	The text on this line reads: "Chapter 8 Arctic Sea Ice." The left-justified placement of the text indicates that it is a section heading. We believe the text as a section heading is mislabeled. It should be labeled as "Chapter 9 Arctic Sea Ice." Please amend this text in subsequent iterations of this SAP.	Williamson for NOAA/OFCM	Accepted. Format corrected for all similar entries.
8. Summary	Alley	7 10	135-140 186-189	The text on lines 135 – 140 indicates that the accelerated rate of ice cover shrinking "exceeds natural declines typical of at least the most recent few millennia. This ice loss appears to be unrelated to natural climatic and hydrographic variability on decadal time scales or to multi-millennial orbital insolation changes." The text on page 10, lines 186 – 189 reads, "Human-forced changes of the most recent decades do not appear notably anomalous in rate or size for their duration when they are compared with these natural changes..." We believe the two quoted statements on page 9 and 10 potentially conflict with each other. It seems that in the first statement, the conclusion is that ice loss cannot be explained by natural climatic and hydrographic variability. However, the second statement seems to indicate that the changes are not anomalous. In subsequent iterations of this SAP, please amend this text so that the potential inconsistency between the two statements is resolved.	Williamson for NOAA/OFCM	Accepted. Text clarified on l. 187.
8. Summary	Fitzpatrick	9	172-174	This needs to be reworded. Something like - The results presented here may be of use to policy makers and science managers in the design of.....	Brouwers	Accepted. Reworded.