

## SAP 3.4 Public Comment Table

Lister of public Reviewers:

- #1 Raúl Samayoa, Tegucigalpa, Honduras
- #2 Thomas Cronin, USGS
- #3 Debra Willard, USGS
- #4 Samuel P. Williamson, NOAA/OFCM
- #5 Eric Swanson, Warrensville, NC
- #6 Michael C. MacCracken, Climate Institute
- #7 NOAA Research Council

Note: Page and line numbers associated with public comments in this table refer to the Public review draft.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
<b>General Comments</b>										
				<b>Reviewer #1</b>						
1-1	Gen			The report is a very good work however I may do just comment  As a final conclusion I will recommend to concentrate more on the Sun and their effects on the climate in the long run in the Planet Earth.				X		Where the report discusses evidence of past climate change, it clearly identifies changes that may be associated with changes in the solar forcing.
				Plus other 2 items:						
1-2	Gen			1. According to studies made some time ago and base on studies of more than 400,000 year, the temperature cycles and CO2 in the air go by cycles as the day and night, only in cycles of more			X			Correct – this comment refers to an interval long before the influence of humans, when the variations in climate and CO2 were associated with natural variability. The report makes clear distinctions in

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				than 100,000 years, must of them we as the human did not have nothing to do, only the SUN.						discussing natural variability in the past, some of which is due to solar influences. However, many experiments with global climate models demonstrate that the CO2 rise over the last 150 years due to burning of fossil fuels is required to explain the warming that the Earth has experienced over the last 50 years.
1-3	Gen			2. If we take the Changes in Mesoamerica in the last 12,000 years <sup>1</sup> and the changes to the Rise and Fall of the Mayan empire and all the changes in Mexico, Texas and South of USA it is the following, before the year 1500 ac			X			Again, these changes may be due to solar forcing (although there is still no consensus on this), it occurred before the recent interval of rise on CO2 associated with burning of fossil fuels.

<sup>1</sup> Brenner Mark, Rosenmeier Michael F., Hodell David A., and Curtis Jason H. PALEOLIMNOLOGY OF THE MAYA LOWLANDS *Long-term perspectives on interactions among climate, environment, and humans. Ancient Mesoamerica*, **13** (2002), 141–157 Copyright © 2002 Cambridge University Press. Printed in the U.S.A. DOI: 10.1017.S0956536102131063. Department of Geological Sciences and Land Use and Environmental Change Institute (LUECI), University of Florida, Gainesville, FL 32611, USA

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
1-4	Gen			<p>3. El Niño and their effect</p> <p>Some of the problems are because of the human presence, however the amount of rain the causes may be again the Sun and the ENOS presence because of the Pacific Ocean temperature.</p> <p>El Niño has been happening for at least the past 130,000 years, the strongest evidence for which comes from fossil corals and lake sediments.</p> <p>» There has been a general tendency toward an increase of El Niño events over the period of about 10,000 years ago to the present.</p> <p>» The El Niño-Southern Oscillation cycle is sensitive to changes in the Earth's orbit, and this is well documented over the past 10,000 years.</p> <p>» Changes in solar irradiance, amplified by ocean-atmosphere dynamics, may help explain drought conditions over the past millennium.</p>			X			Again, we agree that these past changes in ENSO may be a response to past solar forcing.
1-5	Gen			<p>El Nino's past</p> <p><input type="checkbox"/> <b>3000 B.C</b>-Chemical signatures of warmer sea surface temperatures &amp; increased rainfall caused by El Nino</p>	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>appear in coral specimens at least this old,some researchers claim to have found coral records that hold evidence of El Nino cycles more than a 100,000 years ago.</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <b>1500 A.D</b>-Fisherman off the coast of Peru discover that periodic warm waters hold down their anchovy catch. Peruvian farmers notice the warm waters lead to increased rainfall, transforming normally barren areas into fertile farmland. The warm current is dubbed El Nino after the child Jesus, because it usually appears around Christmas.</li> <li><input type="checkbox"/> <b>1700-1900</b>-European sailors make sporadic attempts at documenting the phenomenon. Scientists become interested in identifying its cause.</li> <li><input type="checkbox"/> <b>1891</b>-Dr.Luis Carranza,a Peruvian geographer, publishes an article associating El Nino with unusual rain patterns &amp; suggests it exerts "a very great influence on the climate conditions of (this) part of the world."</li> <li><input type="checkbox"/> <b>1923</b>-British scientist Sir Gilbert</li> </ul>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>Walker discovers that when air pressure is high in the pacific, it is low in the Indian ocean from Africa to Australia and vice versa. His find, which he names the southern Oscillation, is the first indication that weather conditions in distant parts of the tropical pacific are connected.</p> <p><input type="checkbox"/> <b>1969</b>-Professor Jacob Bjerknes of the university of California at Los Angeles comes up with the first detailed description of how El Nino--now officially known as El Nino/Southern Oscillation or ENSO for short--works.</p> <p><input type="checkbox"/> <b>1982-83</b>The strongest El Nino ever recorded wrecks havoc around the world. Related floods, droughts &amp; wildfires kill about 2,000 people worldwide. Damage is estimated at \$13 Billion. In the United States, the first widespread attempts to study the phenomenon begin.</p> <p><input type="checkbox"/> <b>1997-1998</b>An El Nino more powerful than the record 1982-83 event develops in the pacific. Warnings are issued in mid 1997,&amp; emergency preparedness conferences are</p>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>convened. By march 1998,El Nino-related flooding &amp; tornadoes have killed dozens in Florida &amp; the rest of the U.S, Georgia experienced a tornado killing over a dozen people</p> <p><input type="checkbox"/> <b>So what causes El Nino?</b> periodically, trade winds near the equator weaken or reverse direction, forcing a huge current of warm water that seesaws back &amp; forth across the pacific. The warm waters pool off the coast of Peru &amp; raise the water 3 to 5 degrees</p>						
				<b>Reviewer #2</b>						
2-1	Gen			<p>General, This review is as comprehensive as it is well done, at least for the topics chosen for focus. One could argue there are other major topics pertinent to abrupt climate change, or that each is too in depth for a general readership. But the authors emphasized their specialities, so it is very up to date.</p>	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-2	Gen			The format for each chapter seems awkward, requiring frequent “doubling back” to topics introduced earlier; this redundancy could be reduced. Graphics vary greatly in quality and appropriateness – executive decisions must be made on how to handle figures.	X					
				<b>Reviewer #4</b>						
4-1	Gen			We believe the SAP is informative and provides excellent characterizations of the four types of abrupt climate change that pose clear risks to society in terms of our ability to adapt to their impacts. The evidence presented about the significance of and impacts resulting from abrupt climate change is very convincing. The evidence also leaves the reader very uneasy because of the number and types of unknown or uncertain factors related to each of the four topics covered. For example, if one had to budget funds to conduct research in any of these areas it would be extremely difficult to decide how/where to conduct research and even more difficult to estimate what	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				results one could expect from such investments. However, the fact that the text leaves the reader with a sense that (1) decisions about allocating resources will be difficult and (2) the estimates of research results are uncertain is a testament to how well the document is written and how well the document lays out the challenges to addressing abrupt climate change and its impacts.						
4-2	Gen			Accordingly, we believe that the SAP is well-written and provides useful references to support statements made in the document. We offer general and specific comments for your consideration when updating the SAP.	X					
4-3	Gen			There are numerous typographic errors within the document. Words are needlessly repeated (e.g., "of of" on page 4-25, line 19) or misused (e.g., "year-to-tear changes", instead of "year-to-year changes" on page 4-22, line 16). Acronyms are defined and then redefined in the document. For example, Last Glacial Maximum is defined and then redefined throughout the document. Please ask a technical editor to review this document and incorporate the appropriate corrections into the next SAP draft.			X			The report is undergoing technical editing.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
4-4	Gen			There are numerous terms and associated acronyms within the body of this SAP. It might be useful to add a list of acronyms as an appendix to the SAP. Please consider adding a list of acronyms as an appendix to the SAP.			X			There will be an appendix listing all acronyms.
				<b>Reviewer #6</b>						
6-1	Gen			General Comment: Overall, this is an excellent report, focused on aspects of climate change of great interest to society and providing useful and interesting depth on each subject—and done in several ways (ES, Chapter 1, starts of each chapter, full chapters, etc). Compliments to the authors.	X					
6-2	Gen			General Comment: Although especially applicable to the Land Hydrology section starting on ES-6, line 1 and the Recommendations section beginning on page ES-10: Regarding the hydrological case, what seems to be happening is that the rapid thinning and reduction in extent and seasonal duration of Arctic sea ice is dramatically altering the timing and extent of warming of the Arctic				X		The reviewer is discussing changes that may influence weather, whereas we are discussing changes that influence climate.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>atmosphere by the underlying ocean. This appears to be leading to a significant reduction in the generation of very cold winter air (the air at -40 C) that each winter typically pushes outward, southward over North America and in so doing tends to, during most years, keep the tropical moisture to the south along the coast of the Gulf of Mexico. Without diminished generation of the very cold air and reduced extent and duration of winter air masses over North America, the moist tropical air pushes northward, and so we have, for example, the tropical air reaching Wisconsin in January 2008, causing tornadoes there when met by a cold front (wintertime air masses alone do not cause tornadic outbreaks—it takes tropical air and all the latent energy for this to happen). Similarly, all this record-breaking flooding results from the collision of the cold fronts from the north and the moist tropical air masses from the south colliding further north than normal (generally there is more cold air and the collisions occur further to the south). While some of this relocation may be due to changes in ENSO and the SST</p>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>changes that are talked about in the text and have been part of variability in the past, the really new feature is the rapidly melting Arctic and the real reduction in the air coldness brought on from the north. So, the gradual warming trend that is projected by GCMs is being manifested not as a slight warming of each type of air mass, but a rather dramatic shifting of the location where moist tropical air is meeting the reduced cold air from the north. This reduced production of cold air is also likely contributing to the increased drought in the western US, allowing the subtropical circulation to spread poleward. While I understand that present modeling capabilities (mainly analysis of their results) focuses on the multi-decadal changes, and so a focus on the likelihood of increased drought in the western US, what really does need to be done is a much greater effort to analyze the changes in weather patterns that are occurring, and what these will mean—very likely bringing abrupt changes in the patterns and frequencies of extreme weather, especially as the locations of the intersection of polar and tropical air</p>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				masses changes.						
6-3	Gen			General Comment: The numbering system for this report is a bit confusing. Figures are done by chapter and have the chapter number as the first bit of identifying information. Sections of the report, however, are redone for each chapter, but without the lead chapter number, so they repeat in each section, and references from one chapter to another can get confusing. I would urge starting each chapter subsection with the chapter number, even though this would mean that some of the subsections go to 4-number identifiers. I would also add that having so many subsections labeled summary and conclusions, etc., when this is just for a particular subsection is a bit confusing.				X		The consensus of the committee is that the current numbering system is adequate.
<b>Preface Comments</b>										

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<b>Reviewer #2</b>						
2-5	P	2	6	p. 2, line 6, elsewhere, IPCC has a proper, recommended way to cite chapters or the whole WG I volume. NOT IPCC 2007. See one of their chapters.				X		Referring generally to the entire IPCC AR4 WG 1 volume as "IPCC, 2007" is consistent with usage in other SAPs.
2-6	P	4	17	p. 4, line 17 "methane stored in..." [add stored]		X				Done.
2-7	P	5	1	p. 5, line 1 and throughout, sea-level with hyphen when used as adjective.		X				Done.
2-8	P	6	19	p. 6. FAC is used here but FACA later on		X				FAC acronym removed.
<b>Executive Summary Comments</b>										

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<b>Reviewer #2</b>						
2-9	ES	4	28-29	p. ES-4-5, lines 28, 29 etc. Is the increased mass balance gain in interior Antarctica really an "interannual" snowfall issue, or a response of the global hydrological system to warming; ie a secular trend, not just internal CLIVAR?			X			We have removed the specific explanation "result of high interannual variability in snowfall"
2-10	ES	5	15	ES-5, line 15. Velocities increasing twofold over what baseline rate?				X		This is a generalization - It is an increase of more than twofold over whatever the specific baseline rate was for the specific glacier.
2-11	ES	6	23-24	ES-6, line 23-24. I don't mind the term "boundary condition" but if the intention here is to say no change in radiative ("external" forcing like GHG, volcanic, solar, then it should be specified what exactly is meant by boundary conditions – for example, there were changes in CO2 concentrations during the LIA, solar variability is obviously		X				

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-12	ES	11		ES-11. On the deployment of an AMOC monitoring system, foreshadow the RAPID program discussed in Chapter 4; since Bryden's 2005 paper made waves.		X				We have added reference to RAPID program, as in Chap. 4.
2-13	ES	10-12		ES-10-12. The 8 recommendations emphasize monitoring and modeling, not paleo-reconstructions, even though paleo-records are the primary foundation for the majority of topics covered in the report (North American droughts, methane variability, abrupt MOC changes etc). One could in fact argue, that the abrupt SAP 3.4 report itself would not exist if it were not for paleo-evidence for abrupt climate reversals, later confirmed by climate models, and at least to some, the last few decades of satellite monitoring.			X			We have extracted what we felt to be the most urgent recommendations for monitoring the current climate system. We agree with the comment on the importance of the paleoclimate record, and such recommendations are provided in the more extended list found in each chapter. We have combined these chapter-specific paleo recommendations into one more generalized recommendation (now #9) in ES.
				<b>Reviewer #7</b>						
7-1	ES			<b>Background:</b> The Research Council, as part of its major project oversight duties for the Climate Change Science Program (CCSP), was asked to review the draft report for CCSP Synthesis and	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>Assessment Product 3.4: Abrupt Climate Change.</p> <p>The Research Council Exec Sec sent the document to all Research Council members and to specific NOAA staff that were identified to review the document. Following are the consolidated Research Council comments.</p>						
7-2	ES	1	13-15	<p><b>Comment 1 (Major): What defines a climate change as abrupt?</b></p> <p>i. Executive Summary, page 1, line 13-15. Abrupt climate change can be defined in different ways, for example when the climate system enters a new regime via irreversible mechanisms/processes at a rate faster than the cause. Alternatively, abrupt change can be viewed in terms of human or natural systems having difficulty adapting to the rate of this change. A single short-term extreme event should not be considered as abrupt</p>			X			<p>i. We agree with this comment and have taken care to ensure that our definition excludes such events, including in our prospectus. Our definition:</p> <p><i>A large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems.</i></p> <p>explicitly states that for an event to be characterized as abrupt in our report, the change must persist (or be anticipated to persist) for at least a few decades. Climate extremes are the subject of Synthesis and</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>climate change, so long as the regime characteristics are not changed.</p> <p>ii. Executive Summary, page 6, line 8-11; and Chapter 3, page 1, line 19-22. A severe drought "not reflecting a permanent change in the state of the climate system" should not be regarded as abrupt climate change. This report failed to distinguish abrupt climate change from climate variation within one regime.</p>				X		<p>Assessment Product 3.3, "Weather and Climate Extremes in a Changing Climate."</p> <p>ii. We disagree with this comment. It is not clear to us what is meant by a <u>permanent</u> change. Our definition of abrupt climate change was carefully crafted after extensive discussions at our first public meeting. Through consensus we agreed to attach a timescale to the persistence of change (longer than a few decades). We also selected to add into our definition that the change had to cause substantial disruptions to human or natural systems.</p>
7-3	ES	3	4-9	<p><b>Comment 2 (Major): How to build confidence in model scenarios?</b></p> <p>Executive Summary, page 3, line 4-9. Those conclusions derived from model projections should be considered more carefully according to recent understanding of climate prediction as a seamless problem. Multi-model consensus is not a sufficient criterion.</p>	X				X	<p>We acknowledge the importance of assessing model simulations of variability. However, SAP 3.4 (Abrupt Climate Change) is not the appropriate forum for undertaking this task. We refer the reviewer to Synthesis and Assessment Product 3.1 "Climate Models: An Assessment of Strengths and Limitations" and in particular the</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				Climate is a highly nonlinear system, in which different scale processes interact with each other. Model systematic biases, not only in climatology but also in variability, can propagate across spatial and temporal scales, contaminating long-term projections. To increase confidence in model scenarios of abrupt climate change, verification of model simulations of variability, in addition to the mean, for the current climate state should be considered in this report.						section on how well climate models simulate natural variability and how this variability changes over time.
7-4	ES	2	13-14	<b>Comment 3 (Minor): Editorial</b> Executive Summary, page 2, line 13-14. Change "extremely unlikely probability" to "extremely unlikely: <5% probability".		X				Done.
<b>Chapter 1 Comments</b>										
				<b>Reviewer #2</b>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-14	1	2		1-2. Historically, one could argue Broecker's work on abrupt climate reversals based on marine and deglacial onshore records had more or as much influence as the ice cores, though DO's were important and both emerged in the mid 80s.	X					
2-15	1	2		1-2. Am I correct to interpret the footnote to mean, the authors use the term "forcing" differently from IPCC's radiative forcing. IPCC and others view internal "unforced" variability as "noise", please clarify this important point, as the opinions of the SAP 3.4 report are important and perhaps more reasonable than IPCC>			X			As we understand it, the reviewer is raising the question as to whether there is any forcing other than radiative forcing. We have added to the footnote examples of other forcings, namely freshwater forcing and changes in sea-surface temperatures.
2-16	1	15	3	1.15, line 3 spell Herweijer		X				
2-17	1			Chapter 1. In the discussion of sea level. Shouldn't authors cite Meier's studies of alpine glaciers right here; he and others believe glaciers will be the primary ice-melt contribution to sea level rise during at least the 21st century [with Greenland and/or Antarctica playing a larger role later]			X			This point is made, but with reference to IPCC AR4. It is important to keep in mind, however, that we do not expect any abrupt changes in sea level from glaciers and ice caps.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-18	1	24		1-24. Why is this uncertainty box placed here?	X					This is just for the draft – actual placement will be in final published where Box is referred to in text.
2-19	1	31		Figure 1.1. Strictly speaking the top panel is not the true Arctic, if I am correct, it's a Greenland ice core and the O-18 is not a perfect temperature record. I also wonder why authors chose this time interval, rather than let's say the last 40,000 years in which glacial DO variability contrasts with deglacial (B/A, YD etc) and lower amplitude Holocene variations?				X		Although the Greenland record is not a perfect temperature record, it is primarily temperature, as shown by the gas records (N and Ar). Moreover, it is the best record we have for high northern latitudes, and where other high-latitude records exist, they share the same characteristics. Finally, we chose this interval to show the frequency and amplitude of the abrupt changes being discussed in the text.
2-20	1	33		Figure 1.2 in caption, mention the Gulf of Mexico, which dominates the map.		X				
2-21	1	33		Figure 1.3 Map only has red and blue line, how does this tell you # of melt days?		X				The incorrect figure caption was provided. This has been corrected.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-22	1	36-37		Figures 1.6, 1.7. There's quite a contrast in the style of graphics – the complex ocean circulation versus the wonderful picture of the Emerald Isle [this is so for other figures too]. Give some thought to the audience and which route you want to take on the types of graphics.	X					
				<b>Reviewer #4</b>						
4-5	1	3	14-16	Chapter 1, Page 1-3, Lines 14-16 The text in these lines states: “Finally, improvements in modeling of the climate systems have further reduced uncertainties in assessing the likelihood of an abrupt change.” It would be helpful to the reader to describe some of the “reduced uncertainties” at this point or at least be more specific where the discussion could be found in the SAP. In subsequent drafts of this SAP, please consider (1) incorporating within Chapter 1 examples of how uncertainties have been reduced or (2) within Chapter 1, clearly point the reader to where the discussion on reduced uncertainties occurs in later				X		This statement is made in the context of the introductory front matter, similar to the statements immediately preceding it which similarly indicate progress in other means of examining abrupt climate change. This context should be clear, and specific examples follow both in this chapter as well as in subsequent chapters. In this context, we do not see the need to provide a pointer to specific places where this discussion occurs.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				chapters within the SAP.						
4-6 <sup>2</sup>	1	6, 8, 10		Chapter 1, Page 1-6, Lines 14-17; Chapter 1, Page 1-8, Lines 27-28; Chapter 1, Page 1-10, Lines 1-7; and Chapter 2, Page 2-4, Lines 5 and 11 The text on page 1-6, lines 14-17 states that "physical processes that may be governing" dynamical responses to warming of the ice sheets were not included in the ice-sheet model projections used in the Intergovernmental Panel on Climate Change Fourth Assessment Report. However, this deficiency is not included in the recommendations (in Chapter 2) which address model deficiencies. We believe this deficiency should be included within the recommendations (in Chapter 2) to address the model deficiency noted on page 1-6. Accordingly, we recommend that the text on page 2-4, line 5 be revised to read: "... investigations of <u>physical</u> processes ..."		X				

<sup>2</sup> Comment 4-6, 4-7 and 4-8 refer to text in both chapters 1 and 2. Revisions were made in chapter 2 based on the recommendations in these comments.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
4-7	1	6, 8, 10		For the same reason, we also suggest that the recommendation text on page 2-4, line 11 be revised to read: "... modeling of ocean/ice interactions and physical processes ..."		X				
4-8	1	6, 8, 10		These changes to page 2-4, lines 5 and 11 will also help address those deficiencies described on page 1-8, lines 27-28 and on page 1-10, lines 1-7. Please consider making the suggested text amendments to page 2-4, lines 5 and 11 in subsequent drafts of this SAP.	X					
				<b>Reviewer #6</b>						
6-4	1	2	7-8	Page 1-2, lines 7-8 (and late in that section): I think it should be made clear here that just because there was not a change in radiative forcing does not mean that the abrupt change did not have a cause. For example, at least some of the abrupt changes during the glacial period were apparently due to releases of meltwater ponds, etc. What needs to be conveyed, it seems to me, is that the climate system does not seem to just spontaneously go through an			X			We have added an additional bullet later on this page to make this point.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				abrupt change—it appears that there are causal mechanisms (reasons) for such changes happening, and that these do involve aspects of the system that are at least potentially predictable—and not just random.						
6-5	1	2	16-22	Page 1-2, lines 16-22: The statements here would benefit by adding that there is no real indication that global changes occur randomly, but do, as is noted, occur as the result of interactions of processes and components.				X		We believe that the third bullet makes this point already.
6-6	1	3	3-4	Page 1-3, lines 3-4: We really do not know that the changes were unforced—this assertion should be caveated in some way—it is perfectly possible that a forcing (other than a radiative forcing) caused the change (e.g., an ice dam limiting glacial meltwater release).		X				We consider the possibility of forcings other than radiative (such as freshwater) under the general term “forcings.” We have added text to indicate that many changes appear associated with some forcing.
6-7	1	3	17	Page 1-3, line 17ff: It might be helpful somewhere to note that climate itself is defined as the average of conditions over a few decades (typically 30 years). In this regard you might also need to define climate fluctuation and/or climate variability. You might also add that a change in climate would normally involve changes in the patterns and frequencies of weather and				X		We believe that this level of clarification is not needed for this report.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				extremes.						
6-8	1	4	16	Page 1-4, line 16: You might want to note here or elsewhere that other types of hydrologic changes are also possible, even likely, in that warming globally leads to more precipitation and continuation of trends to greater extreme precipitation, and in addition, there are shifts in major precipitation bands, so an increased frequency of flooding is certainly also possible.				X		This information is addressed elsewhere in this chapter and in Chapter 3. The context of the statement in question here is that of our greatest interest for this report, namely the possibility of drought. In addition, the question of extreme events (flooding, extreme precipitation) is addressed in another SAP.
6-9	1	5	13	Page 1-5, line 13: On a recent visit to JPL, they suggested the rate of sea level rise over past year or so was up to near 4 mm/yr, so you might indicate that the trend appears to be accelerating.				X		We cannot add reference to a number that has not been published yet.
6-10	1	7	8-9	Page 1-7, lines 8-9: Given that sea level was down about 120 meters during the last glacial, and recent ice on land is near 75 meters, saying more than 2.5 times as much might be more accurate.				X		Current ice volume is ~65 m. At LGM, it was 120-130 m. So at the LGM, the excess ice volume was ~2 times greater than the present volume, as stated.
6-11	1	7	28	Page 1-7, line 28 to Page 1-8, line 6: At his AMS seminar last November, Konrad Steffen showed a plot of the depth of land underlying Greenland (included here as Figure 2.10), and				X		It is correct that the central part of Greenland is well below sea level but only a few glaciers connect the coast to the depression (i.e., Jakobshavn Isbrae). In so far as

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				quite shockingly, most of the interior part of the Greenland ice sheet is resting below sea level. Indeed, although there are only a couple of fjords connecting that depressed area to the open ocean, this report should make clear that most of Greenland is actually grounded below sea level, and so is likely very vulnerable, especially as it is at lower latitude than the West Antarctic ice sheet. The differentiation suggesting that West Antarctic is more vulnerable seems to me somewhat outdated, being based on the now-mistaken view that the Greenland ice sheet was resting on mountains above sea level. This is not the case except around the edges—so it is more than just the Jakobshavn Isbrae that is vulnerable.						we currently understand, WAIS remains more vulnerable because so much of its area grounded below sea level is directly connected to ocean.
6-12	1	10	8	Page 1-10, line 8 and following: There does not seem to be mention that precipitation bands can shift in location, making some areas much wetter. As noted in the general comment, with less cold area coming out of the Arctic, warm, moist air is going to push further north, with the heavy rains coming at the intersection of these air masses shifting to new				X		We disagree with this assessment of the controls on precipitation by collision of air masses, and instead attribute any large changes in distribution of precipitation to large-scale changes in circulation that govern moisture flux and vertical motions (large-scale uplift).

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				regions, or at least to new seasons.						
6-13	1	19	20-30	Page 1-19, lines 20-30: While the ocean circulation may not change abruptly, the atmospheric circulation can change, shifting, for example wave number or shifting position. Some mention should be made of the fact that just because the ocean is changing gradually, the atmospheric circulation, and therefore the weather affecting various regions, can shift suddenly (e.g., shifts in NAO can quite dramatically shift the weather in Europe and be indicative of weather shifts elsewhere around the NH, etc.)—and it is, after all, the weather that will be how most people experience the change in the AMOC.					X	Such potential changes in atmospheric behavior fall under the purview of changes in regime shifts, which is not within the scope of this report.
6-14	1	21	5-6	Page 1-21, lines 5-6: What is more important about methane when considering the potential for abrupt change is that on a 20-year time scale (the time during which abrupt change would happen) the GWP compared to CO2 is 72 (or something similar), so there is a very large near-term influence that fades away faster than CO2 due to			X			Our focus here is not on danger as defined by the EU, but on abrupt change. We agree that policy makers should consider this issue when considering short term emission reduction schemes, but calculating the CO2 equivalent of a methane change still requires the use of the 100 year GWP. To address

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				the chemical destruction of methane (lifetime just over a decade). So, methane is a really, really important issue for the near term. Given we are near to a CO2 equivalent now near 450 ppmv (discounting the very short-lived aerosol effect), putting us near a warming commitment that would be over the EU's "dangerous" temperature rise of 2 C over preindustrial, an increase in methane has the potential to rapidly push the temperature rise upward, not only abruptly, but to a level above "dangerous"—by their definition.						this issue, we have added the following statement: ON SHORTER TIME SCALES, METHANE'S IMPACT ON RADIATIVE FORCING IS HIGHER.
6-15	1	24	4-5	Page 1-24, lines 4-5: Given that Arctic sea ice is melting more rapidly than models have been projecting, and this is looking as if will continue, and that this really greatly shortens the period of very intense cold as the sea ice is too thin to insulate the atmosphere from the underlying ocean, can one really say with such high confidence that a quite rapid warming of permafrost areas and consequent acceleration in the loss of methane could not occur? I would suggest that the relatively rapid retreat of sea ice, the increasing deterioration of the Greenland Ice Sheet and adjacent			X			Because permafrost hydrate is relatively deep in the terrestrial sediment column the temperature signal will take a long time to get there, under any scenario. So from the perspective of hydrates this is not a concern. From the wetland perspective the uncertainties in future methane emissions from high-latitude wetlands are due more to the lack of understanding and predictive capability in how the landscape will respond to permafrost thaw (e.g. considerably more wetlands or not) than uncertainties in the extent and

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				ice bodies, and the retreating snow duration and cover, suggest that greater than projected permafrost thawing is possible, so this statement should not be indicated with such high confidence.						timing of permafrost thaw. We have addressed this issue by highlighting in the text that the pace of climate change is accelerating, particularly in the arctic.
6-16	1	33		Page 1-33, Figure 1-2 and caption: This plot shows land areas less than 6 meters. It is not at all clear that these would be the boundaries of the land with a 6-meter sea level rise. Sea level is given as a mean level, so there are tides that take sea level higher and lower than the mean. The present shoreline has become hardened to its level (with dunes being created, mangrove growth, etc.) that it is not at all clear would be duplicated at the boundaries shown, especially given that sea level will be rising so that there is little time for hardening of the new sea shores compared to the thousands of years that we have had the near preindustrial sea level. Quite likely, the new seashores will be much more vulnerable to storm surges and wind-driven waves, etc., meaning that the actual seashore could be a good bit further inland. The caption should at least somehow indicate this potential vulnerability, and that all that the map			X			We have added a sentence in figure caption to distinguish between what is shown relative to the point raised by the reviewer.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				shows is the best estimate of the 6-m elevation, which is likely the minimum amount of inundation/land loss that will occur.						
<b>Chapter 2 Comments</b>										
				<b>Reviewer #2</b>						
2-23	2	2	2	2.2, line 2 as velocities increase and ice shelves collapse drawing down interior ice from Antarctic Peninsula	X					True, as shown at Larsen B.
2-24	2	2	9	2.2, line 9 causes and mechanisms ARE [plural] not well understood [actually they are fairly well known]		X				We removed this paragraph
2-25	2	4	16-18	2.4, lines 16-18. Actually, early Cenozoic paleo-reconstructions and modeling suggest there was ice in the Eocene, is oscillated at orbital frequencies, and some authors thing the		X				We modified the text

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				Cretaceous Paleocene as well. So 35 Ma is not the onset of Cenozoic of land-based ice.						
2-26	2	5	25	2.5, line 25. the SL-equivalent of Greenland ice, be sure the same value is given throughout report [5,6,7 m]. A meter is a lot of SL rise.		X				
2-27	2	8	23	2.8, line 23 and earlier in text. Be consistent referring to Jakobshavn Isbra as a glacier, ice tongue etc		X				
2-28	2	9	1	Section 2. Other than brief mention of coral records, this sea level ice volume section misses the important source of past sea level data from paleo-shorelines – in fact the GIA models are built on paleo-shorelines for the deglacial-Holocene. Add a paragraph on shorelines at least on shorelines and emphasize the ICE GIA model is in 1000-year timesteps, not really policy relevant.				X		Sources of past sea level data as from corals are reflecting change. Paleo-shorelines – see also 2.10, lines 4-10

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-29	2	12		2.12. The Cenozoic CO2 climate linkage briefly discussed here does not do justice to the complexity of the issue, the problems with proxies and it really doesn't belong in a discussion of post-LGM and LIG ice volume.			X			We modified the title of this section: Sea level changes during the past
2-30	2	13		2.13. The deglacial rates of SL rise are cited many times in the report, eliminate redundancy.				X		True, the deglaciation rates for Antarctica were discussed in 1.1, 2.1 and 3.3.2, but in a different context (paleoracord, reconstruction of ice sheets, and uplift rates)
2-31	2	21	11-12	2.21. lines 11, 12. superscript per annum symbols		X				
2-32	2	31		2.31. Considering the in depth treatment of glaciological evidence in preceding pages, the statement we must rely on temperature to deduce past glacial growth and decay rates does not at all do justice to the many excellent regional alpine glacial studies on all continents [Alaska and Canada are some of the best studied], many with excellent chronology and independent proxy records [e.g. lake records, in addition to glacial features], some with valuable information about variability during the MWP and LIA. This section		X				Removed lines 18-23

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				gives the false impression we do not know much about glacial history, but we in fact do!						
2-33	2	36	24	2.36, line 24. Don't imply really warm water is in contact with glacier margins. Rephrase "Interaction of ocean water with the periphery"		X				Changed to: The interaction of warm ocean waters with the periphery of the large ice sheets
2-34	2	37	5-7	2.37, lines 5-7. See Domack's Holocene history of ice shelves.				X		Domack's paper in Nature (436, 2005) proposes a thinning in the Holocene, but there is no adequate observational data base against which to definitely correlate ice shelf thinning or collapse with warming of the surrounding ocean waters.
2-35	2	37	29-30	2.37, lines 29, 30 Italics for names				X		Only literature references will be in italics in this document.
2-36	2	39	30	2.39, line 30 "the global ocean"		X				

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-37	2	39-40		2.39/2.40. discussion of ocean warming and melting is simplistic, Levitus' analyses were very region/depth specific, so there is no need to imply general oceanic warming is relevant, it's the ocean system immediately adjacent to an ice sheet margin.		X	X			Correct, but ocean temperature measurements are lacking close to the ice margin.
2-38	2	41	10	2.41, line 10. "the outcome"		X				
2-39	2	47	1	2.47, line 1. Not "western half", say WAIS		X				
2-40	2	75		Figure 2.2 at end of chapter is not very useful.				X		This graph illustrates well that ice sheets (Greenland and Antarctica) might not respond to "rapid" increase of CO2 (hence warming) unless we consider ocean interaction and ice dynamics.
2-41	2			Chapter 2: General. Given the detail devoted to land-based ice, it is striking there was no attention given to sea ice which is extremely dynamic even over seasonal timescales, has several strong feedbacks [albedo, insolation, carbon-nutrient biogeochemical processes etc],		X				This will be addressed in more detail in Chapter 4, Box 4.4.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				and is implicated in many studies as important in abrupt climate transitions.						
				<b>Reviewer #4</b>						
4-9	2	2	9	Chapter 2, Page 2-2, Line 9 The text on this line reads: "The cause and mechanism of these meltwater fluxes is not well understood ..."; however, none of the Chapter 2 recommendations (about addressing deficiencies) highlights this deficiency/issue. In subsequent drafts of this SAP, please consider amending the recommendations in Chapter 2 to highlight this deficiency/issue.		X				This bullet has been deleted
				<b>Reviewer #6</b>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-17	2	1	22	Page 2-1, line 22: Shouldn't "decreased" be "increased"?		X				Thanks for spotting this error
6-18	2	2	3-6	Page 2-2, lines 3-6: To make really clear that this covers two different periods, this point should be made into two sentences (or maybe into two points). And, regarding the Eemian, it should likely be noted that these warmer summer conditions were a result of orbital changes and that globally, the average temperature was up perhaps 1 C, so significantly less than is projected for the 21 <sup>st</sup> century.		X				Text has been revised and more information was provided. However, we disagree with the statement that the global average temperature in the Eemian; in fact we suggest it was up by as much as 4 C as quoted in the revised text. The orbital changes were mentioned in the text.
6-19	2	2	9-11	Page 2-2, lines 9-11: It is not clear to what this statement applies. As noted in the comment on lines 3-6, it should be said that it was orbital element forcing that contributed to the warming during the Eemian—that is reasonably understood. If this statement applies to the melting after the Last Glacial Maximum, then this needs to be made clearer.		X				This bullet was deleted

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-20	2	2	16	Page 2-2, line 16: As noted in another comment, Konrad Steffen's visual from the AMS talk last November showed most of interior Greenland as being below sea level—not just a few (large) ice streams.				X		This bullet refers to ice masses grounded below sea level connected to the coast. It is correct that the central part of Greenland is well below sea level but only a few glaciers connect the coast to the depression (i.e., Jakobshavn Isbrae)
6-21	2	3	19-25	Page 2-3, lines 19-25: It needs to be made clearer why the GRACE observations (that give changes in mass) are so much more important than the radar observations that give only change in volume. With the volume measurements only, we had been making a serious error with regard to what was happening to Greenland, having to make the assumption that density was remaining constant. With that now indicated as a poor assumption, we absolutely have to have the gravity observations, whereas we could survive without the radar observations.				X		GRACE measurements are important as they give e to total mass change, but I would disagree that RADAR measurements are no longer needed or less important. The RADSAR derived ice velocities together with ice thickness give us mass loss at the margins of the ice sheet, hence provide us where the dynamic plays an important role. We need to understand the processes better and therefore need ice velocity (RADAR) and ice thickness.
6-22	2	4	18-21	Page 2-4, lines 18-21: What I would really also like to have is the rate of SL rise occurring leading into the Eemian rather than jumping to the rate of rise after the Last Glacial Maximum. Can you say what is known about this?	X					Unfortunately, this rate is not known.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-23	2	5	3-5	Page 2-5, lines 3-5: The phrasing here is confusing. Saying that the rate of ice loss is increasing would be clearer, especially in that it is next said that the rate is accelerating.		X				Clarified and revised: Rapid changes in ice-sheet mass have surely contributed to abrupt changes in climate and sea level in the past. The mass balance loss of the Greenland Ice Sheet increased in the late 1990s to 100 gigatonnes per year ( $Gt a^{-1}$ ) or even more than 200 $Gt a^{-1}$ for the most recent observations in 2006
6-24	2	7	7-11	Page 2-7, lines 7-11: It would help to give an indication of ice shelf and ice tongue thickness to compare these rates to.			X			Ice tongues and ice shelves are of similar thickness for large glaciers (400-800m). Small glacier tongues can be as thin as 50 m.
6-25	2	8	23	Page 2-8, line 23: Konrad Steffen's plot of underlying geography of Greenland shows two additional inward reaching fjord in the northwest and northeast coastlines of Greenland—so, with a bit more warming, there may be as many as three outlets for the main part of the Greenland Ice Sheet.		X				Added Petermann, Humboldt, and 79N glacier in this comparison
6-26	2	8	27-30	Page 2-8, lines 27-30: It would sure be helpful if ways that could block these channels could be described. Dams may be hard to construct under such conditions, but might there be a way—possibly with inflatable dams or				X		Lines 27-30 do not refer to the channels below sea level. I assume you refer to the channels leading to the interior of the ice sheet in Jakobshavn, Petermann, Humboldt and 79N glaciers. I cannot answer

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				something similar.						this geo-engineering question.
6-27	2	10	20	Page 2-10, line 20: This section does not seem to have any discussion of the inability of observations to explain the observed sea level rise of the 20 <sup>th</sup> century (or as the IPCC indicated, from the 1960s to present, except for the period since 1993. While the new Church and colleagues paper explains part of this is due to problems with ocean measurements, there should be some discussion of the differences in what has been observed and what we can explain—if not in this section, somewhere—as the problem might well be due to uncertainties in what has been happening to the ice sheets.	X					Accurate global ocean surface height observations became available from 1993 with satellite altimetry. Before that data, SLR was derived from coastal water height measurements which are known to have a regional signature. This has been discussed in the previous IPCC reports.  This section discusses past SLR of the past 100k y.
6-28	2	10	21-22	Page 2-10, lines 21-22: Though clarified a bit in succeeding sentences, this statement is seriously misleading (remember that key statements can get taken out of context—and this could be one of them). Prior to the preindustrial period, global sea level had been amazingly constant for at least several thousand years. Phoenician salt flats in		X				This sentence has been deleted as it was misleading.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				Sicily (in particular, the structures they used at that time) that are almost 3000 years old are just starting to be covered with rising sea level—seashores have been quite stable except where isostatic adjustments have been occurring (or other human influences). Indeed, on longer time scales, sea level has been quite variable, though it is really important here to differentiate between changes in global sea level (quite stable during the Holocene) and changes in relative sea level in particular places (due to isostatic effects); confounding the two points does not seem justified—in fact, is there any evidence that isostatic effects have been changing global sea level at a significant rate? Maybe start the sentence by saying “Until the unusual stability of sea level during the Holocene, ...” or something similar.						
6-29	2	11	22	Page 2-11, line 22: Earlier (page 2-2, line 3), I think the last interglacial was said to have persisted to 120 ka. Check for consistency. Then on 2-12, lines 16-17 give a different interval.		X				Corrections were made (120 ka)

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-30	2	12	9-11	Page 2-12, lines 9-11: This statement about long response time of ice sheets referred to here is the case for models—not necessarily for reality, as past abrupt changes suggest (and as is indicated in a later sentence that is confusing unless the statement on lines 9-11 is adjusted). This statement needs to make clear it is about model behavior, as models now exist, with their shortcomings.		X				Correct, this chapter is about the past. The two last sentences of this paragraph were moved to chapter 3.2
6-31	2	12	27	Page 2-12, line 27: Saying twice understates the change—SL dropped 120 m, compared to us having 75 m of SL equivalent now, so factor is 195/75, or about 2.5, which is a lot more than “twice.”		X				Changed to 2.5
6-32	2	23	3	Page 2-23, line 3: Do the indications of increased icequakes in Greenland have any significance? Should this be mentioned somewhere as an indication of increased flow rates?	X					True, but there are no publications in the open literature yet (in review only).
6-33	2	33	2-6	Page 2-33, lines 2-6: Of course, models are known to be worse on simulating precipitation than temperature, worse on simulating snow than rain, and worse on simulating in mountainous terrain than in flat terrain—and for Greenland and Antarctica, we have all		X				We added the following sentence to clarify this point: Model results predict increasing snowfall in a warming climate in Antarctica and Greenland, but only the later could be verified by independent measurements ( <i>Johannessen et al., 2005</i> )

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				three challenges. That observations are not matching models is especially troubling in that the IPCC has been relying to a large extent on model projections of increased snow over the large ice sheets to justify keeping estimates of sea level rise below what observational changes are suggesting.						
6-34	2	49	7-11	Page 2-49, lines 7-11: The underlying geography of Greenland shown in Konrad Steffen's diagram (Figure 2.10) suggests that most of the Greenland ice sheet is grounded below sea level—far more than has traditionally been thought. In this regard, might sea level affect the flows or some glacial streams that flow from the mountains inland (are these inlet glaciers?) to the depressed (below sea level) area?		X				The central part of Greenland is depressed below sea level because of the weight of the ice sheet. We added a sentence to point out the regions in the northern part of the ice sheet.
6-35	2	53		Page 2-53: This figure is misleading for Greenland. For Greenland, per the Steffen diagram, the bedrock for the center of Greenland has been pushed down well below sea level. Also, this figure would not apply to the West Antarctic Ice Sheet—so it is wrong for the two most vulnerable ice sheets, and so should be changed.	X					This graph is only a schematic carton of ice sheet, since the underside of the Greenland ice sheet is >50% above sea level, the carton is adequate.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-36	2	74		Page 2-74: This diagram does not seem to reflect the near constancy of sea level through the Holocene. Is there a reason why?	X					The SLR during the last 8ka (only part of the Holocene) was near constant which is shown in Fig. 2.1. Because we use such a long time period, the last 8ka is mid-way between the two last crosses in the graph.
<b>Chapter 3 Comments</b>										
				<b>Reviewer #2</b>						
2-42	3			Chapter 3. General. bold type is used in places for emphasis, this is OK but other chapters do not use this approach. Start chapter 3, section 2 with a clear statement about the potential causes of N American climate variability [emphasis on rainfall] over different timescales – ENSO, PNA-PDO, centennial, solar, volcanic, orbital/feedbacks etc. Then clarify the La-Nina-like conditions for droughts – most readers don't even understand teleconnections, so a little basic info at			X			Moved and combined material to create an expanded section 2.1.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				the beginning would help. You eventually get to these things on 3.34; put them earlier.						
2-43	3	10	18	3.10, line 18 delete “?”		X				Deleted.
2-44	3	11	10-11	3.11, lines 10,11 Cite Enfield 2001 for AMO and N American river flows. Kushnir has a more recent review [2002] paper.		X		X		Added citation to Enfield (2001). Kushnir (1994) is OK for the reference
2-45	3	15	15	3.15, section 2.2. It might make sense to stay away from the global context of the N American drought simply because precipitation patterns are so regionally complex, modelers and radiative people don't fully understand cloud/H2O feedbacks, most paleo work has focused on temperature, and the IPCC summary emphasizes the complexity of precip response to various forcing. This section should refer to paleorecords of progressive Holocene monsoon development and ITCZ migration in both hemispheres which in my estimation is the most				X		We disagree, and think that it is important to show that North American hydroclimatic variability is embedded in hemispheric and global anomalies. (This is specifically discussed the third paragraph of this section.) No action taken for the “global context” of this multi-part comment.  We added a forward reference to section 4 (Holocene variations) in section 2 as follows: “In a similar fashion, the Holocene drought in the mid-continent of North America

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				convincing evidence for atmospheric dynamical changes during an interglacial, and which the authors take up later in the chapter.						(Sec. 4) can be shown to be embedded in global-scale energy balance and atmospheric circulation changes."
2-46	3	22-25		3.22-3.25. The box is a little long; its aim should be a brief overview, right?		X				Agree. We moved the "water quality" section to section 7. We also attempted to shorten the remainder of the text (within losing content) by moving much of the remainder of the box to a new section following 2.1.3 and added a new, much shorter box on the Colorado R. example to Sec. 2
2-47	3	26	21	3.26, line 21, Herweijer put names in italics.		X				Done.
2-48	3	30	10	3.30, line 10. "So what differentiates..."		X				Done.
2-49	3	33	8	3.33, line 8 superscript 14 in C-14		X				Done.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-50	3	35	11	3.35, line 11 "what does "either side of" mean?"		X				Changed to "relative to."
2-51	3	61	15, 18	3.61, line 15 & 18 add degrees Kelvin symbol		X				Changed all "degree Kelvin" to "degree Celsius"
2-52	3	93-97		Figure 3.1-3.6. Give consideration to what graphics are chosen. The current ones here are not that illustrative and not really tied to the emphasis of the chapter. Why not show an ENSO teleconnection map for N American precip/temp, a time series labeling key Holocene patterns, etc/			X	X		Added a 4-panel (temp, precip, El Niño/La Niña) figure at the beginning of the chapter (as Fig 3.2) and removed the current 3.5.  Holocene time series appear in current Figs. 3-15 and 3-17. We don't know what "time series labeling ... patterns means" and have made no changes to the figures.
2-53	3	99-102		Three PDSI time series is too much. Fig 3.8 is fine. Figures also have different formats for how time axis is plotted [vertically/stratigraphically, along X-axis]. Also, are axes showing years BP, calendar years, AD/BC etc?? Be consistent. see 3.17, 3.19, others.		X				We removed existing Fig 3.9; combined 3.10 and 3.11 into a new figure (new Fig. 3.9).  We added remarks to the figure legends. Where figures were adopted from existing publications (as opposed to being newly created) we used the

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
										original figure's layout (e.g. Fig. 3.13)
				<b>Reviewer #3</b>						
3-1	3			This chapter focuses primarily on droughts in the North American West and Great Plains region, which is understandable given the authorship of the chapter. Little mention is made of the impact or history of droughts/floods in the eastern U.S., which seems inappropriate given the large human population that occupies that region.		X				Added section 3.6 entitled, "Drought in the Eastern United States."
3-2	3	3	14	Pg 151, <sup>3</sup> line 14 Change "the role soil moisture feedbacks" to "the role of soil moisture feedbacks"		X				Done.

<sup>3</sup> Reviewer #3 refers to page numbers as they appear in the toolbar of the pdf reader (e.g. Adobe Reader). The page # column in this table refers to the page numbers printed on the bottom of each page in the SAP.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
3-3	3	4	21-25	Pg 152, lines 21-25: Replace two sentences beginning with "Yet" with "However, rapidly growing human populations worldwide are increasing the stresses on currently available water supplies even before we factor in anticipated effects of a changing climate on the availability of a clean and reliable fresh-water supply."		X				We adopted the proposed sentence.
3-4	3	4	25	Pg 152, line 25: Change "These concerns follow naturally from the general devinition of drought used by the international meterological community: the' to "Changes in the frequency, intensity, and duration of droughts would have a significant impact on water supplies both for human societies and terrestrial and marine ecosystems. Droughts are defined generally by the international meteorological community as: the "		X				We adopted the proposed change.
3-5	3	5	25-26	Pg 153, lines 25-26. Change "The United States faces all of these problems. The semi-arid regions of the Southwest are projected to dry, with the model results suggesting" to "Hydroclimatic changes are likely to affect all regions in the United States. Semi-arid regions of the Southwest are projected to dry further, and model		X				We adopted the proposed change.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				results suggest”						
3-6	3	6	1	Page 154, line 1 Fig. 3.6 is the first figure cited in this chapter, yet it is the sixth figure. The numbering of the figures needs to be checked and adjusted. Its caption doesn't mention its source - was it made specifically for this volume? This figure also is unclear and difficult to read.		X				We moved the figure up to Fig. 3.1. Added URL to caption <a href="http://www.usbr.gov/water2025/report.html">http://www.usbr.gov/water2025/report.html</a> <a href="http://www.usbr.gov/water2025/images/supplylarge.jpg">http://www.usbr.gov/water2025/images/supplylarge.jpg</a>
3-7	3	6	21	Pg. 154, line 21 Change “influence of water scarcity is at best” to “influence of water scarcity on political conflict is at best”				X		Citations are to discussions of armed conflict, not political conflict. (no action) Fixed Raleigh typo in references (3-84, line 24).
3-8	3	6	23	Pg. 154, line 23 Change “variabilty” to “variability”		X				Done.
3-9	3	6	27-28	Pg. 154, lines 27-28 What do you mean by “regions that show more robust mean climate change”? Do you mean regions that have shown significant changes in the last decade or few years? Or perhaps areas that models indicate are likely to change in the short term?		X				Reworded for clarity: “Such quantitative methods need to be applied to other regions where changes in the mean state and variability of climate are occurring now and also to regions where climate change is robustly projected

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				This is unclear.						by models.”
3-10	3	7	7	Pg. 155, line 7 Change “changes in greenhouse gases and human-induced global warming” to “human-induced changes in greenhouse gases and global warming”		X				We adopted the proposed change.
3-11	3	17	8-9	Pg. 165, lines 8-9 change “assess how the ocean conditions over the 4-year period influenced climate” to “assess climate response to altered oceanic conditions during the four-year interval”		X				We adopted the proposed change.
3-12	3	18	15	Section 2.3 (beginning on page 166, line 15) In this section, the authors state that there is no clear evidence to date of anthropogenic influence on North American precipitation amounts. They then go on to discuss possible linkages between 20th century droughts and various ENSO cycles and SST patterns. The section ignores the impacts of human land-cover change on climate, although a substantial body of work exists that examines the impacts of land use and land-cover change on the radiative balance of the Earth.			X			<p>We replaced “anthropogenic” with “human-induced climate change” in section 2.3.</p> <p>We cross-referenced to SAP 3.3 on precip extremes</p> <p>We will also check into attribution of the precipitation change</p> <p>We included additional language on land-cover changes in section 2.1.2.</p> <p>Richard Seager will also check on</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				Although much of that work is focused on specific regions, it is arguable that very little of Earth's land surface is unaltered by humans. Collectively, clear-cutting of tropical rainforests, extensive growth of urban and suburban landscapes, diversion of water from rivers and wetlands, and agricultural lands across the globe combine to have significant impacts on albedo, surface thermodynamics, and other physical parameters related to precipitation and temperature distribution. There is convincing evidence that specific land-cover changes have significant influences on regional precipitation, temperature, and hydrology; its absence in this section is disappointing.						land-cover-related issues.
				<b>Reviewer #4</b>						
4-10	3	60	21-27	Chapter 3, Page 3-60, Lines 21-27 The developments listed in the bulleted text are excellent; but the modeling efforts also need to be supported by more and better computational capability. Consequently, we		X				We adopted the proposed change.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				recommend that a sentence be added on page 3-60, line 27 which would read: "Sufficient computational capability must be provided (or made available) to facilitate development and use of enhanced models." Please consider incorporating this text in the next iteration of this SAP.						
				<b>Reviewer #6</b>						
6-37	3	1	1	Page 3-1, line 1: Given the drought going on over the Southeast, it is unfortunate that it is not mentioned here. My interpretation of what is happening is that, due to the warmer Arctic, the triggering frontal movements from northern Canada are not reaching the eastern seaboard during the summer, and only getting to the NW side of the Appalachians. So, plenty of thunderstorms to the NW of the Appalachians, but the cool front is not of sufficient intensity to make it over the Appalachians and undercut the warm moist summer air in a way that can trigger thunderstorms. As a result, the moist air sits on the eastern				X		<p>Although the southeastern drought is a high-impact event, it would be premature to discuss its attribution in a synthesis document.</p> <p>Changed bullet #2 "On continental and subcontinental scales..."</p> <p>Added Box 3.2 on the control of weather by large-scale atmospheric circulation.</p> <p>Note: this also addresses comment 6-2 in the general comments on SAP 3.4</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				seaboard day after day—plenty of moisture in the air, but with precipitation virtually stopped over the mid summer, local drought develops. This type of effect might be mentioned at some point in the chapter.						
6-38	3	1	15-17	Page 3-1, lines 15-17: It seems quite insensitive, and likely unfortunate, to be downplaying the damage from floods (same comment applies to page 3-4, lines 3-4—there is no real reason to downplay flooding to play up drought—drought is indeed serious enough to be of great concern, but so are changes in chance of severe flooding, which are suggested to greatly increase in frequency). While droughts do have major effects, so do floods—and they can develop over weeks to seasons, and be devastating in days or less, and take decades to recover from. And shifts in precipitation tracks and patterns can lead to quite dramatic impacts, as is being shown in 2008 (and seems explainable in terms of a climatic impact—see my general comment). And hurricane induced flooding can also be very devastating, having long-lasting impacts.			X			We didn't intend to do downplay or play up either. We hope the change in 6-37 will suffice.  Added material on floods in the key findings, section 6.3 (Floods and Global Climate Change) section 8 (Conclusions).

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-39	3	1	23-29	Page 3-1, lines 23-29: These factors have apparently most important in the past—not at all clear they will be the dominant factors in the future, so say this is the case in the past, and it shows that changes in conditions can lead to droughts, etc.				X		The sentence is correct. We are not arguing that SSTs are “the dominant factors”
6-40	3	2	13-21	Page 3-2, lines 13-21: Might it be appropriate to indicate the change in condition of the Sahara as an indication of how climate change can lead to very large changes in the state of various regions? It is not North America, but it was a very large change. Might also do on page 3-7, line 27 (or thereabouts). I do see that this is covered on page 3-37, but it might be worth mentioning earlier to give a greater appreciation for how large the changes can be.				X		This is a general bullet, not location or region specific. We have already considered North America-centric issues in this SAP.  Addressed also in new bullet in key findings.
6-41	3	7	14	Page 3-7, line 14: You might ad that the collective changes in radiative forcing from these events were likely considerably less than projected changes in forcing due to human activities.				X		Discussed also in section 4 (“Abrupt Hydrologic Changes During the Holocene.)
6-42	3	59	11-13	Page 3-59, lines 11-13: There is another mechanism for changes in precipitation, and that is shifts in atmospheric circulation patterns, and also the new			X			Sentence changed to read: “The mechanisms underlying these changes include the increase in atmospheric moisture, the intensity

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				orographic interactions that arise. In my view, this general mechanism is likely to cause the largest changes in intense/flooding precipitation. For example, with less cold air from the poles, the moist tropical air can push further north, and cause heavy precipitation in new locations.						of the hydrologic cycle, and the changes in atmospheric circulation as the atmosphere warms."  Also see new Box 3.2
6-43	3	61	16	Page 3-61, line 16: "Given approximately fixed relative humidity" seems a strange way of putting things (it implies, in some way, that modelers have chosen to keep it constant). What about saying "With only small changes projected for relative humidity" or something similar?		X				We adopted the proposed change.
6-44	3	63	8-12	Page 3-63, lines 8-12: I think it is important to also mention wildfire as a potentially important consequence of drought for the environment and society, especially because fire leads to an extension of the impacts to many decades given how long it takes an ecosystem to recover.			X			Increased fire risk as an impact of drought is discussed in section 1.  Added "natural ecosystems" to the list of impacts in this sentence.
<b>Chapter 4 Comments</b>										

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<b>Reviewer #2</b>						
2-54	4			Chapter 4. AMOC. The chapter seems to jump around and introduces topics, leaves them, and returns to the same topic later. Consider a quick reading and some cutting and pasting. This is especially true of the "impacts" section where the distinction between proxy records as monitors of processes, causes, responses etc are blurred.			X			We have restructured and modified some of the text, especially in the "impacts" section, to try to address the reviewer's comments.
2-55	4			The big gap in this chapter is the lack of discussion of the NAO-AO, Arctic sea ice and AMOC, including "great" salinity anomalies, probably the strongest oceanographic changes ever recorded with instrumental record of the world's oceans. High latitude N Atlantic (Labrador Sea esp) salinity and temperature the last 50 years are robustly linked to atmospheric pressure, wind fields, broad climatology and circulation, storms, SST, deep water convection not to mention marine ecosystems fisheries, etc. I would include in this topic the important Arctic Ocean patterns since they are			X		X	The box on Arctic sea ice has been revised, and a new figure introduced showing model projected and observed changes in Arctic sea ice extent. The authors felt that a large additional discussion of these topics was outside the focus of the chapter on <u>abrupt</u> changes.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				definitively linked to North Atlantic Oscillation and climate. I specifically refer not only to much publicized Arctic sea ice trends simplistically linked to GHG forcing [and AO variability], but the well-documented enhanced N Atlantic Current warm water influx into the Arctic, basically melting the sea ice from below, change halocline depth (see review in Dickson et al 2000 J Climate, and many other papers). Given the robust multi-decadal scale signal, the key role in sea-ice and its feedbacks, the importance of Arctic hydrography and freshwater export for N Atlantic hydrology, density AMOC, the exceptional NAO-paleo record [compared to AMO] etc, I could make the case it is one of the most important topics for the context of this chapter and the larger question of abrupt climate change. But that's just my opinion.						
2-56	4			Early in chapter, make it a little clearer that winds, tides and bottom topography are critical factors [in addition to density-driven by S and T] in completing the entire THC system and AMOC in particular.				X		We agree these are crucial, but feel that the text on p. 4-9, lines 4-6 is fairly clear. It states "... the energy sources for the ocean are wind stress at the surface, tidal motion, heat fluxes from the atmosphere, and heat fluxes through the ocean

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
										bottom." These points are also mentioned elsewhere in the chapter (see, for example, the discussion at the bottom of page 4-10, and the winds discussion on page 4-11). We agree with the reviewer on the importance of these topics, but did not see how to make this clearer since it is mentioned in several places.
2-57	4	16		Figure 4.2 – what is Deacon?		X				A sentence has been added to the figure caption.
2-58	4	30	5	4.30, line 5. Strictly speaking you refer to both last glacial and deglacial periods in reference to paleo-records of abrupt AMOC reversals.					X	The last glacial period is defined broadly to include the last deglaciation.
2-59	4	30	16	4.30, line 16. The LGM as defined by GLAMAP, EPILOGUE, building on CLIMAP, experienced large variability, so much that it is very hard to actually define the LGM, given diachroneity of ice sheet histories and other factors.					X	EPILOG's definition (followed here) was based on identifying an "interval within which global climate was reasonably stable."

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-60	4	30	24	4.30, line 24. Marine [oxygen] Isotope Stage – define early, use MIS acronym.		X				
2-61	4	31		4.31. Earlier in report, the Holocene was defined as the last 10,000 years, here it's the last 11500. Tradition has used 10 ka for Holocene onset but more and more the post YD Preboreal warming is used and this fits the evidence from both poles.			X			We use 11,500 years, and have revised elsewhere in report.
2-62	4	31	3-4	4.31, lines 3-4. Regarding Holocene ice volume – statement is not true, even at 9 ka, there was at least 25 meters more of final deglacial SL rise still to happen. Moreover, even after ~ 6 ka when global SL reached modern levels, we simply don't know the fine scale [1-3 meters] ice volume fluctuations.		X				We have deleted the reference to near modern ice volumes.
2-63	4	31	10	4.31, line 10 – fix delta symbol for C-13 [later on too]. Mention protactinium and sortable silt (SS) as tracers in this paragraph up front. A few pages down, you introduce Pa/Th again; do it once, avoid redundancy		X				

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-64	4	32	24	4.32, line 24. Italicize Lynch-Stieglitz		X				
2-65	4	34		4.34. A little misleading regarding sediment mixing, and really refers to slow sed accumulation rates, which is not = to bioturbation, and these are much less of a problem in Cariaco Basin C-14 record of abrupt climate changes.		X				Inserted phrase "slow sedimentation rates and" before the word mixing.
2-66	4	39		4.39. Ellison had both bottom water and surface ocean proxies in the same record, so the relationships are in fact straightforward, if you accept the proxies.		X				Deleted some appropriate text on page 39.
2-67	4	43		Figure 4.10. A much better depiction of the North-South anti-phasing could be obtained from the various EPICA papers for the entire last glacial-deglacial cycle, as they compare to Greenland [ie back 130 ka or so].				X		This is true, if this is all that we wished to illustrate, but the existing figure also includes the high-resolution 13C record, which would not be possible to show for the depiction suggested by the reviewer.
2-68	4	49		4.49. Section 5.3. The quantification of proglacial lake volumes and mapping of possible outlet routes is among the most thoroughly documented aspects of paleo-abrupt climate studies. Thus, one could take issue with the statement on line 25 that this information is not easy				X		Disagree. The current wording reflects comments received during peer reviews. We agree that while there are quantitative estimates of lake volumes and routings, other important details

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				to obtain [in fact early glacial lake volume estimates were used years ago in classic model studies by Manabe, Rahmsdorf etc]						remain uncertain (e.g., whether lakes drained in one or multiple pulses and the volume of water drained in each pulse, short-term variations in runoff from ice sheet melt, the spatial distribution of freshwater anomalies in the ocean). These details are critical for the model simulations discussed in this section.
2-69	4	54	20	4.54, line 20 elsewhere, wetter or drier conditions [not wetting, drying]		X				
2-70	4			Sections 6.2, 6.3. I really wonder why the discussion of the AMO is in here. It is marginally relevant to AMOC circulation and not well represented in proxy records. It's multi-decadal timescale makes it's natural variability, persistence etc poorly constrained despite the Enfiled, Schlesinger, Delworth, Mann etc papers on multi-decadal variability based mainly on instrumental records. As a SST index, AMO cannot really be reconstructed properly from tree-rings (Gray) and				X		We appreciate the reviewer's comment, but we have included the discussion of the AMO as a possible proxy for the way that AMOC changes impact the large-scale climate system. One possible mechanism responsible for the AMO is a fluctuating AMOC; in such a scenario, supported by some modeling evidence, the climatic impacts associated with the AMO could be attributed to the AMOC. This is still a matter of scientific

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				deep-sea marine records are low resolution, though there is a large literature in the last 5 years on high-res late Holocene coastal marine records in parts of the N Atlantic providing empirical evidence for late Holocene SST; it's a really complex signal. The NAO-AMOC relationship is much better established [see below].						uncertainty, but it was our assessment that the inclusion of the AMO was relevant to the topic.
2-71	4	65		4.65, whole page Italicize authors names. Also p. 4.66, 4.67		X				
				<b>Reviewer #4</b>						
4-11	4	3	14-16	Chapter 4, Page 4-3, Lines 14-16 The text within the second bullet on this page recommends "increased collection and analysis of proxy evidence documenting the AMOC in past climates." To facilitate the reader's understanding of "proxy evidence" relative to the Atlantic Meridional Overturning Circulation (AMOC), it might be useful to provide an example. Also, providing examples		X				Specific examples have been provided.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				of proxy evidence is consistent with examples provided within the fourth bullet's text. The text in the fourth bullet on this page provides examples of "processes controlling the AMOC [such as] small-scale eddies, flows over sills, mixing processes ..." Please consider incorporating the suggested amendments in subsequent drafts of this SAP.						
4-12	4	19	11-15	Chapter 4, Page 4-19, Lines 11-15 The text in these lines provides examples of deficiencies in the "the inverse analyses for the global time-mean ocean." We believe these are excellent examples of unknowns, weaknesses, and uncertainties that create huge doubts about the value of inverse ocean models and the present state of the AMOC!	X					
4-13	4	72	1-3	Chapter 4, Page 4-72, Lines 1-3 Text on these lines discusses "development and use of improved data assimilation systems for providing estimates of the current and past states of the AMOC, as well as initial conditions for prediction of the future evolution of the AMOC." The development and use of improved data assimilation systems is well supported				X	X	The suggested report primarily deals with assimilation systems for tropical cyclones, and is thus beyond the scope of this report. Further, we do not feel it would be appropriate to advocate for a particular program.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>in the OFCM document, <i>Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead</i> (on pages 6-3 and 6-4). Therefore, to support the data assimilation statement on page 4-72, lines 1-3 of SAP 3.4, we recommend adding the OFCM document to the list of Chapter 4 references. The reference citation for the OFCM document is:            OFCM, 2007, <i>Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead</i>, Washington, D.C., USA, FCM-P36-2007, 270 pp.            Note: The link for <i>Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead</i> is:  <a href="http://www.ofcm.gov/p36-isrtc/fcm-p36.htm">http://www.ofcm.gov/p36-isrtc/fcm-p36.htm</a>.</p>						
				<b>Reviewer #5</b>						
5-1	4			<p>Thank you for the opportunity to comment on the Draft of SAP 3-4 (hereafter, the Draft Report). I will address my comments specifically to Chapter 4, "The Potential for Abrupt Change in the Atlantic Meridional</p>	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				Overturing Circulation”, as my studies have been directed toward that question.						
5-2	4			On first reading the Draft Report, I thought that the treatment of the Thermohaline Circulation(THC) was rather shallow, given the current understanding of the situation, even though the Draft Report provides many referenced. I then read several of the background papers and 2 books on the subject, including van Aken, 2007 and Dickson et al., 2008. That was in addition to my many years of study of the problem of Anthropogenic Global Warming(AGW)and climate change. Although I am not an expert, I hope my comments will be taken seriously.	X					
5-3	4			For the past decade or so, there has been a steady decline in the minimum extent and area of sea-ice found in the Arctic Ocean at the end of the melt season(Comiso, 2002). Last summer, the loss was suddenly much greater than in previous years, with records found in both extent and area computations. It has been suggested that this remarkable event was the			X			(1) Additional discussion has been added on the connections between the Arctic and the AMOC via fresh water exchanges.  (2) The authors made a very conscious decision to use the term AMOC rather than THC. The authors use the term “AMOC” to denote the mass flow in the Atlantic,

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>result of unusual wind patterns and thus not something to worry about. The sea-ice area and extent recovered somewhat during the colder months of last Winter, however, since then, the spring melting is progressing along nearly the same path seen last year. While it is too soon to know whether the sea-ice melt will again present another record minimum, the fact that this is occurring is cause for great concern as the Earth's climate system can be expected to become fundamentally different once the last of the multi-year sea-ice disappears (Lindsay et al., 2003). See: <a href="http://nsidc.org/data/seai ce_index/images/daily_images/N_timeseries.png">http://nsidc.org/data/seai ce_index/images/daily_images/N_timeseries.png</a></p> <p>I find little reference to this situation in the Draft Report with only passing mention of the impact of sea-ice noted in Box 4.4, page 77, the very last page of the Draft Report. The results of the complete loss of sea-ice in summer can be expected to have a direct impact on the THC, as the Arctic Ocean and the Nordic Seas are directly connected, exchanging waters thru the Fram Strait and Barents Sea. Indeed, the Arctic Ocean and the Nordic Seas together are</p>						<p>which is a measurable quantity of physical importance. The term "THC" refers to a specific type of mass flow associated with a driving mechanism, and is a subcomponent of the AMOC. We focus on the more general AMOC, noting its multiple driving mechanisms.</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				called the Arctic Mediterranean by some analysts in order to recognize the coupling between the two (Dickson et al., 2008.). The Draft Report focuses on the AMOC while downplaying the THC even though the THC may be said to power the AMOC in the North Atlantic and provide the mechanism for a considerable portion of the transport of warm water to the highest latitudes of the North Atlantic and the Arctic Ocean. The THC has been at the center of concerns about possible impacts of AGW and much effort has been undertaken to understand the processes involved, including intense work to measure the currents involved and to build simulations which describe both the actual measured process and to project changes which might result due to AGW. As a result, many studies have appeared in the literature, many more than I have been able to read and understand.						
5-4	4			The Draft Report presents a description of the AMOC beginning on page 4, continuing on page 5. The paragraph beginning with page 5, line 7, describes the AMOC as two "overturning cells", then continues to describe them as a				X		The authors fully acknowledge the three dimensional nature of the AMOC circulation. For example, in Figure 4-1, some of the horizontal circulation structure is articulated clearly, including the Florida

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>surface flow and a bottom return flow as the North Atlantic Deep Water (NADW). With all due respect, those flows are not “overturning cells”, but are, generally, horizontal flows. The claim that the “upper cell” is “far stronger” reflects the fact that much of the water in the Florida Current and the Gulf Stream remains near the surface and most of that water turns and flows southwards as part of the Subtropical Gyre. The source of the NADW is that portion of the Gulf Stream which turns northward as the North Atlantic Drift Current, reaching higher latitudes where the sinking process takes place. Thus, the two “cells” are not separate, as implied by the description, but are directly connected thru the THC, thus the description is misleading, to say the least. The formal definition of the AMOC (page5, line 19) looks only at the latitude-depth plane, intentionally ignoring the different driving forces of winds and THC sinking. This point of view makes the assessment of changes very difficult, as it is changes in the THC which have been suggested to be the mechanism for possible abrupt change in the AMOC. The winds will</p>						<p>current, while Figure 4-2 shows the latitude-depth structure of the circulation. The chapter fully acknowledges the different driving forces of the AMOC, including both buoyancy forcing and wind stress forcing.</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				continue to blow, pushing water westward in the North Atlantic, producing the Florida Current and Gulf Stream Western Boundary Currents, but the THC may not willingly follow our model projections.						
5-5	4			The cartoon in Figure 4.1 which is presented to show the currents misses many important details of the flow. For example, there's no Kuroshio Current, which is a western boundary current similar to the Gulf Stream. There's no recognition of the ENSO flows, such as La Nina, which can bring large quantities of water to the surface in the Pacific. As far as the AMOC is concerned, there's no link shown between the Arctic Ocean and the North Atlantic, nor is there any indication of the flow of fresher waters from the Pacific into the Arctic Ocean thru the Bering Strait, some of which is said to eventually flow thru the Canadian Arctic Archipelago and the Davis Strait into the Labrador Sea. Figure 4.4 of the Draft presents a more detailed sketch of the currents, but still misses the full Arctic Mediterranean. I suggest that another graph be included in the Final Report, such as Figure 16.1			X			The current figure focuses on the largest volume transports around the world that are associated with the global MOC. We have emphasized the connections with the Arctic through text changes to the first two sections of the chapter, and hope that those convey satisfactorily the potential importance of those connections.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				from Dickson et al., 2008, which provides a wider view than the similar graphic in Figure 4.1 or 4.4 of the Draft.						
5-6	4	13	10	On page 13 of the Draft, beginning with line 10, we find this statement: "The main influence of these surface fluxes on the AMOC is exerted on its sinking branch, i.e. the formation of deep water masses in the northern North Atlantic. This deep-water formation (DWF) occurs in the Nordic and Labrador Seas (see Fig. 4.1). Here, strong heat loss of the ocean to the atmosphere leads to a densification and subsequent sinking..."	X					
5-7	4	9		On page 9 of the Draft Report, Section 2.1 begins a discussion Sandström's experiment, in which a deep tank with a narrow profile was used to simulate the circulation in the oceans. By applying both heat and cooling at different positions in the tank, he was able to produce circulation. The Draft Report follows the discussion in Kuhlbrodt et al., 2007, which contended that the overturning circulation depended upon a source of thermal energy near the bottom in order to produce overturning	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				circulation. It is suggested that the overturning can be modeled as a Carnot Cycle, with the thermal energy driving the upwelling supplied by winds, etc.						
5-8	4			I submit that Sandström's experimental model is a rather poor model for the ocean's circulation. I think that's true because the model does not capture the correct geometry of the oceans. For example, the distance from Iceland to the southern reaches of the Atlantic Ocean extends over some 125 degrees of latitude. The distance is thus about 1.39e4 km. Assuming an average depth of about 3.7 km, the ratio of depth to surface distance is (3.7/1.39e4) or 0.00026.	X					In this report we have synthesized the available literature on the topic of the AMOC – its theoretical underpinning, observational analyses, and modeling studies. We have relied on peer reviewed literature for this. The reviewer has not provided references to peer reviewed literature to support his or her opinion. Without such supporting material we feel it would be inappropriate to modify the text.
5-9	4			My experience with aerodynamics of wind sections suggests that a proper model must include an accurate representation of the geometry. The force characteristics of a wing are greatly impacted by the ratio of thickness to chord length and airfoils are usually specified by percent of chord thickness. Wings with thicker cross sections perform well at low speeds, whereas thinner ones are better at higher velocities. Realistic physical	X					See response to 5-8.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				models of wings must maintain the same relative geometry at any scale for the results to have predictive value. I submit that the same is true for constructing models of other fluid systems, including the oceans. The oceans are very flat and thin compared with the surface which is in direct contact with the atmosphere above, thus, wind forces are likely to be the main driving forcing which causes up welling of deeper waters. The recent La Nina produced colder waters in the equatorial Pacific, water which was brought to the surface from below. Sandström's experiment did not include winds, nor did it include the impacts of the transport of fresh water between oceans.						
5-10	4			If I understand Sandström's theorem, the up welling circulation can not occur if the warming and cooling is applied at the same depth. However, if the warming is at mid level, the circulation could progress. The claim presented in Kuhlbrodt et al., 2007 is that thermal energy is not available within the oceans to provide the driving energy for up welling. I saw no discussion of the fact that there are heat sources at	X					See response to 5-8.  In addition, we are not aware of any evidence that local geothermal heating from the bottom of the ocean has a significant impact on the ocean circulation in general and abrupt climate change in particular.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				mid-depth found in some areas. The Mediterranean Sea has a higher salinity than the Atlantic Ocean and water which exits the Mediterranean Sea thru the Strait of Gibraltar is denser than the Atlantic surface water and sinks to mid depth in the Atlantic, even though the Mediterranean bottom water is warmer than the Atlantic water around it. The same is true for water exiting the Red Sea and the Persian Gulf. This warm water might drive local up welling as the thermal energy is spread to the surrounding oceans. Local hot spots and occasional undersea volcanos could also drive local up welling of bottom waters.						
5-11	4			There is almost no discussion in the Draft Report of the contribution from the Arctic Mediterranean on the THC and thus to the AMOC. The Arctic Ocean and the Nordic Seas are connected thru the Fram Strait, with a sill depth of 2600m, which is deeper than the sills on the Greenland-Iceland-Scotland rise. Surface water flows into the Arctic from the Nordic Seas and there is also flows of surface water and sea-ice from the Arctic Ocean into the Greenland Sea. The bottom waters	X					In sections 2 and 3 of chapter 4 we have added discussion emphasizing the connections between the Arctic and Atlantic.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				which exit the Fram Strait contribute to the waters which eventually exit the Greenland Sea across the sill in the Denmark Strait, which thence results in one of the flows which eventually combine to become the NADW						
5-12	4			From Dickson et al., 2008, Chapter 13, one finds this quote: "The circulation in the deeper layers is largely confined to the Arctic Ocean and the Nordic Seas and the Arctic Ocean appears at present to be a more active source of deep water than the Greenland Sea. We postulate that a production of 0.4Sv of deep water with a salinity of 34.9325 takes place in the Arctic Ocean by brine rejection on the shelves and subsequent sinking of dense saline plumes down the slope, entraining warmer intermediate water on their way to their equilibrium density levels..."	X					
5-13	4			The freezing and thawing of sea-ice tends to reject water with high salinity and this brine can sink to the bottom of the ocean. This process produces most of the cold, dense water which sinks around Antarctica, forming the deepest waters in the oceans. A similar process, as noted in the quote above, operates in the Barents and Kara seas and the	X					In sections 2 and 3 of chapter 4 we have added discussion emphasizing the connections between the Arctic and Atlantic.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				brines thus produced flow into the Arctic Ocean. I suggest that it is very likely that one consequence of a decline in the minimum extent of Arctic sea-ice would be an increase in brine production under the sea ice as it reforms during the freeze season, since the maximum extent has seen little change. Thus, the Arctic Ocean might become a "salt pump" much like that presently found around the Antarctic.						
5-14	4			The rapid decline seen in the Arctic sea-ice minimum presents a most basic question, which is, how well do the models represent this important aspect of present climate? That question has been raised by others working with one model (Holland et al., 2006), who found that the NCAR CCM3 model did not show changes in the sea-ice as seen since the 1990's, but did suggest a decline in area before the end of the century. The Draft Report, section 7, discusses the AMOC variability of several recent model experiments, yet there's no mention of changes in sea-ice or the impacts of such changes on the THC and thus on the AMOC. Where's the assessment of the accuracy of the various models' representation of			X			We agree, and have modified section 5 to emphasize how important it is that models correctly simulate the mean climate in general, and sea ice in particular.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				sea-ice?						
5-15	4			Some of the THC sinking of water in the Greenland and Labrador Seas has been shown to be thru "Convective Chimneys", which are local areas of intense downward convection (Wadhams, 2002). These regions are quite small in size and are below the resolution of most ocean models. They only occur in winter in locations which are difficult to reach from the surface, therefore there has been little information gathered about them, due to the harsh weather at that time of the year. The location in the Greenland Sea has been associated with a feature seen by satellite in the sea-ice flowing out of the Fram Strait with the East Greenland Current, called the Odden Ice Tongue (Wadhams et al., 1999). The Odden Ice Tongue was noted in all the years studied from 1979 thru 1997, except 1994 and 1995. This year, the Odden Ice Tongue could not be seen in the satellite data, which suggests that the associated Convective Chimneys were	X	X				Added text and reference in section 5.1 to note this. In addition, this is also discussed in some detail on page 13.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				also absent, thus a portion of the THC was shutdown.						
5-16	4			Also of note is recent data for the Arctic Ocean which suggests that currents from the Nordic Seas are flowing further into the Arctic Ocean and model results that suggest the Arctic Ocean is warming (Zhang, 2005). Such changes would tend to accelerate the melting of sea-ice during the polar oceans, resulting in less sea-ice at the end of the melt season.		X				Box 4.4 has been modified, including a figure showing observed and projected Arctic sea ice.
5-17	4			Furthermore, from the U.S. CCSP, 2007, there's this quote: " The persistence of near-record low sea-ice extent raises concern that Arctic sea ice may be in a continual, long-term decline. Models driven by projected increases in greenhouse gases project a decrease in summer sea ice of more than 50% over the 21st century, although such projections should be tempered by the recognition that simulations of present-day sea ice generally differ from observed seasonal and geographical distributions (emphasis added). According to	X					We agree, and have modified section 5 to emphasize how important it is that models correctly simulate the mean climate in general, and sea ice in particular. We have also modified Box 4.4 and added a figure as part of Box 4.4.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				paleoclimatic records, there is no evidence of an ice-free summer Arctic during the last 800 millennia....”						
5-18	4			<p>At the beginning of the Draft Report (page 2), one finds this statement: “The above conclusions depend upon our understanding of the climate system, and on the ability of current models to simulate the climate system. However, these models are far from perfect, and the uncertainties associated with these models form important caveats to our conclusions...”</p> <p>In spite of this admission, in the Draft Report, one of the findings was: “No current comprehensive climate model projects that the AMOC will abruptly weaken or collapse in the 21st century. We therefore conclude that such an event is very unlikely...”</p> <p>Given that the models are stated to be “FAR from perfect”, according to the Draft, how is it possible that ANY conclusion be considered to be “VERY unlikely” (emphasis added)? Section 5.1 presents a comparison between</p>	X					<p>This report adopts the IPCC terminology for expressing likelihood of future change. Within this context, a statement that an event is “very unlikely” implies that there is less than a 10% chance of this occurring. The reviewer asks why, if the models are far from perfect, can we make such a strong statement.</p> <p>This is a very good question that has received a lot of attention. We look at this from a complementary perspective. If we are to say that the chance of an AMOC collapse is “unlikely”, this would imply a chance of between 10% and 33% that this would occur. We see no evidence in the literature that there is more than a 10% chance of an AMOC collapse. Therefore we have chosen the term “very unlikely”.</p> <p>In addition, the report does not state that the models have poor</p>

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				recent model results and historical data. However, since there's no discussion of to the ability of these models to reproduce historical sea-ice data (including the recent strongly declining trend of minimum extent) I suggest that it is unreasonable to consider the use of models with poor representations of the present strength of the AMOC or of the sea-ice history when presenting the conclusions.						representations of AMOC; there is a significant range in simulated AMOIC characteristics; there is also a significant range in observational estimates.
5-19	4			<p>An example of this sort of misinterpreting of model results can be found in work reported by Seager et al., 2002, which is based on the results of two modeling efforts which simulated the results of a shutdown of the THC. The models differed in their treatment of sea-ice cover and as a result, the impact of a shutdown of the ocean heat transfer was different. The model which allowed the sea-ice to change after the ocean heat transport was cut produced a large drop in temperature over areas of northern Europe, whereas the other did not.</p> <p>Seager et al. note the different results due to the modeling of sea-ice thus: "More problematic for certain regions</p>	X					We agree that the representation of sea ice is an important factor, and have modified section 5 to emphasize this.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				is the treatment of sea ice. In CCM3 we held the ice cover fixed, but when it was allowed to vary in the GISS model removal of OHT caused a large expansion of seasonal ice cover in the Kamchatka region and in the Norwegian and Barents Seas, cooling the air above and to the east..."						
5-20	4			The results from these 2 models have since been used to justify the claim that there would be little impact on Europe due to a shutdown of the THC, even though the models were admittedly imperfect. When I read this report a few years ago, I thought the conclusions drawn from these models were not reasonable. Apparently I was not alone in my perception, as Peter Rhines offered similar objections, which may be found in Chapter 4 of Dickson et al., 2008.	X					
5-21	4			From what I've been able to learn as an observer of other people's efforts to study the question of Abrupt Climate Change, I must take exception to the conclusions presented in Chapter 4 of the Draft Report, conclusions which are repeated in the Executive Summary. The recent history of Arctic sea-ice decline points to a complete melting of	X					The models examined for this report all simulate substantial reductions or complete elimination of Arctic sea ice. These models typically simulate a gradual weakening of the AMOC. However, none of these models project an abrupt collapse of the AMOC, even with total loss of summer sea ice. This evaluation of

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>the sea-ice in the near future, perhaps by 2013 as one researcher suggested. The complete melting would of necessity imply the complete loss of the older, thicker multi-year sea-ice. Should that happen, it is difficult to conceive of a return to sea-ice conditions which were previously the norm, as there are positive feedbacks in the process which would tend to prevent the return of multi-year ice. Once the "cork" of multiyear sea-ice is removed from the passages between the Arctic Ocean and the Nordic and Labrador Seas, there will be little way to halt the flows of fresh water which may be expected to follow as the winds blow across the Arctic, pushing the water and sea-ice into the areas where THC sinking presently occurs.. Should the sea-ice be completely lost, I submit that the Earth will be switched into a new climate regime, one not experienced for more than 800 thousand years.</p>						the available model-based evidence forms the basis for our summary conclusions on the likelihood of an abrupt AMOC collapse.
5-22	4			We may awaken a monster and sorely regret having done so.	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
5-23	4			<p>References:</p> <p>Comiso, J. C. (2002), A rapidly declining perennial sea ice cover in the Arctic, <i>Geophys. Res.Lett.</i>, 29, 1956, doi:1029/2002GL015650.</p> <p>Dickson, R. R., Meincke, J., Rhines, P. (eds.) (2008), <i>Arctic-Subarctic Ocean Fluxes, Defining the Role of the Northern Seas in Climate</i>, ASFO, Springer, ISBN 978-1-4020-6773-0</p> <p>U.S. CCSP (2007), <i>OUR CHANGING PLANET, The U.S. Climate Change Science Program for Fiscal Year 2007.</i> <a href="http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-hi_clivar.htm">http://www.usgcrp.gov/usgcrp/Library/ocp2007/ocp2007-hi_clivar.htm</a></p> <p>Holland, M. M., C. M. Bitz, and B. Tremblay (2006), Future abrupt reductions in the summer Arctic sea ice, <i>Geophys. Res. Lett.</i> 33, L23503, doi:10.1029/2006GL028024.</p> <p>Lindsay, R. W., J. Zhang (2005), The Thinning of Arctic Sea Ice, 1988–2003: Have We Passed a Tipping Point?, <i>J. Climate</i>, 4879.</p> <p>Seager, R., D. S. Battisti, J. Yin, N.</p>	X					

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<p>Gordon, N. Naik, A., C. Clement and M. A. Cane (2002), Is the Gulf Stream responsible for Europe's mild winters? Quarterly Journal of the Royal Meteorological Society 128:2563-2586.</p> <p>van Aken, H. M. (2007), The Ocean Thermohaline Circulation, Springer, ISBN 9780- 38736637-1.</p> <p>Wadhams, P., and J. C. Comiso (1999), Two Modes of Appearance of the Odden Ice Tongue in the Greenland Sea, Geophys. Res. Lett., 26(16), 2497-2500, doi:10.1029/1999GL900502.</p> <p>Wadhams, P., J. Holfort, E. Hansen, J. P. Wilkinson (2002), A deep convective chimney in the winter greenland sea, Geophys. Res. Lett. 29(10), 1434, doi:10.1029/2001GL014306.</p> <p>Zhang, J. (2005), Warming of the Arctic Ice-Ocean System is Faster than the Global Average Since the 1960s, Geophys. Res. Lett. 32, No. 19, L19602, doi:10.1029/2005GL024216.</p>						

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
				<b>Reviewer #6</b>						
6-45	4	1	23-24	Page 4-1, lines 23-24: At least some of the impacts on the atmospheric circulation and weather should be described here—to really make the case that changing the AMOC is very important. Then start a new paragraph.			X			Have made additions to the text on page 4-1 along the lines suggested by the reviewer.
6-46	4	2	18-23	Page 4-2, lines 18-23: Is it not also the case that a slowdown in the AMOC will lead to an increase in global sea level rise for the ocean will be less effective at carrying cold water to the bottom and the pushing back up of the warming that is mixing downward along equal density surfaces in low and mid-latitudes. Thus, a reduced AMOC would lead to increased heat penetration downward in low and mid latitudes, and so greater thermal expansion. So why say that a slowdown in the AMOC would mainly affect the North Atlantic?				X		We are aware of studies showing regional increase in sea level in the North Atlantic in response to a weakened AMOC due to a mass redistribution. However, on a global scale, the effect of a weakened AMOC would be less uptake of heat by the ocean, and therefore less increase in global sea level attributable to thermal expansion. This is inconsistent with the mechanism proposed by the reviewer. Without a clear published reference for the reviewer's suggestion we do not feel it would be wise to alter the text in the suggested fashion.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-47	4	19	13	Page 4-19, line 13: "undoubtedly untrue" is a rather awkward phrase. How about saying this is not the case, or this is false, or something.			X			Changes made as suggested by the reviewer.
<b>Chapter 5 Comments</b>										
				<b>Reviewer #2</b>						
2-72	5			Chapter 5. Methane. This chapter is well-written, though like the others, introduces a topic and returns to it later, creating redundancies.			X			This structure allows a casual or hurried reader to get the gist of the chapter, and we view that as an important aspect of a document that may be read by busy policy makers.
2-73	5			The brief mention of deep-sea temperature variability from proxy records does not do justice to the multiple records of BWT variability over various timescales, including the Holocene.				X		We believe we have discussed the relevant aspects of deep-sea temperature variability with respect to methane hydrates. The chapter is not intended to be a review of BWT variations.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-74	5	32	24	5.32, line 24. MacDonald, line 28 use per annum superscript as in other chapters, also later in chapter for watts per square meter		X	X			Macdonald changed to MacDonald.  Use of per annum and related terms will be regularized in copy editing process and is not attempted here.
2-75	5	38	15	5.38, line 15 ppb [not pbb]		X	X			Change made.
2-76	5	40	7	5.40, line 7. I could argue Ocean Anoxic Events, similar to the PETM [an "incipient OAE] but much stronger, are better known than the PETM, certainly they have a much longer history of study.			X			Deleted "although less well documented" in the relevant sentence.
2-77	5	42		5.42. LIP [large igneous Intrusions] like the Deccan traps actually take less than 1 Ma to occur, are episodic and possible drivers of Mesozoic climate.		X	X			The statement at issue here concerned whether or not volcanic CO2 from LIPS could explain the PETM carbon isotope anomaly (line 25). The reviewer is correct that some studies suggest fast emplacement, and the sentence containing the phrase "...these events tend to take millions of years to play out" was deleted.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
2-78	5	43		5.43. Warming is inferred from many proxies, not just O18 [Tex 86, faunas floras etc]		X	X			Although we do note Mg/Ca records of temperature change, to address this comment we add reference to Sluijs et al. (2006), which is already cited elsewhere, and Sluijs et al. 2007. These papers discuss faunal evidence, and the 2007 paper discusses the Tex86 temperature proxy.
2-79	5	53	18	5.53, line 18 Tg is used, earlier Gt, line 23: is this V. Masson-Delmotte? Not in references under any name.				X		We use Tg when discussing the methane budget because this is the common unit used in the literature on this topic.  The Delmotte reference is to a paper by Mark Delmotte, V. Maisson Delmotte's husband, and the reference is in the reference list.
				<b>Reviewer #6</b>						
6-48	5	24	3	Page 5-24, line 3: Change to "extends"		X				Change made.

Comment from Peer Reviewers					Author's Response					
Reviewer ID - Comment #	Chapter #	Page #	Line #	Comment Text	Acknowledged. No further response or revisions are required.	Revisions have been incorporated as suggested.	Agree, but see "Notes on Response."	Disagree; see "Notes on Response."	Beyond scope of report/chapter	Notes on Response
6-49	5	26		Page 5-26, Figure: It just seems to me that the time axis should be going the other way—this figure time reads right to left. Quite strange—and Figure 5.12 has the direction the other way.		X				X axis reversed.