Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5. Temperature and Precipitation						
	Fitzpatrick					**n.b. - Reviewer c comments are found in his 'track changes' version of Chapter 5. This is a separate MSWord file that I have sent to you. You may find it easier to work from that version than to go through these comments in the spreadsheet. Please note that the line numbers recorded in red refer to those in the track changes version this reviewer sent back, not the original. Please do record your responses here in the spreadsheet.**
General	Brigham-Grette			Overall structure works well. Additional details on forcings/proxies specific to Arctic followup on more general mated in Chapter 4. Narrative on changes over time (5.4) covers appropriate evidence and topics.	b	**Noted.**
General	Brigham-Grette			This chapter is an excellent summary of our knowledge of the past climate of the Arctic regions over the last 65 million years. It presents a clear and thorough answer to the first part of the question posed in the prospectus for SAP 1.2: "What has been the extent of temperature and precipitation changes in the high latitudes in the past, and what can this tell us about how much warmer/colder, wetter/drier it may become in the future?"	k	**Noted.**
General	Brigham-Grette			The chapter is strongest in its careful and mostly accessible descriptions of the methods used to estimate past climate, and in its discussion of the record of the past hundred thousand years. It's one major conceptual weakness is in its overly simple discussion of "polar amplification," as discussed below. I have a number of suggestions for clarifications, which follow in order of occurrence in the chapter.	k	**Noted.**

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Abstract	Brigham-Grette	3	29-30	"during both warm and cold times"; (pg 5, ln 87-88), 3-4x in warm and cold departures.	b	**Accepted and wording changed.**
Abstract	Brigham-Grette	3	35-36	It's over done to say that "the forcings leading to exceptional warmth were often different than the forcings expected in the coming decades". As discussed in the text, our best guess as to the forcing that led to Eocene warmth was additional carbon dioxide. Better to say: "…because the boundary conditions (such as continental positions and topography) during past times of exceptional warmth were quite different.	k	**Accepted and text changed accordingly.**
Abstract	Brigham-Grette	3	46-48	extensive deciduous forests occupied lands now only capable of supporting polar desert tundra ("polar desert" and "tundra" are two different bioms according to many biological classifications).	c	**Accepted.**
Abstract	Brigham-Grette	4	60-61	The penultimate warm interval, ~130 to 120 ka ago, occurred when solar energy in summer in high northern latitudes - was greater	c	**Accepted.**
Abstract	Brigham-Grette	4	70-71	Solar energy in summer rose in the Arctic steadily from 20 ka to a maximum (10% higher than at present) 11 ka ago	c	**Accepted**
Abstract	Brigham-Grette	5	83	Warming over the past century and a half - VR has resulted	c	**Accepted**
Abstract	Brigham-Grette	5	91-93	the next century if global warming forecasts are correct here we have to be a bit careful because we are still within the last interglacial when climate variability and probably Arctic amplification is generally reduced .	c	**So noted.**
5.2	Brigham-Grette	7	137	It's really only on time scales of 100 Ma or more that long term solar brightening is a significant factor. It's been less than 0.5% during the Cenozoic, so not significant in the period discussed here.	k	**Accepted.**
5.2.2	Brigham-Grette	9	175 - 178	relatively warm ocean (at or above the freezing point of seawater) and cold atmosphere (which, in the Arctic winter, averages -40 °C (Chapman and Walsh, 2007). If sea ice is thinned (winter sea ice will not be removed by warming in any observable future) by warming, then the ocean heats the overlying atmosphere in winter months, amplifying warming.	c	**Accepted.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.2.3	Brigham-Grette	10	190-192	be important (these interactions represent an example of a negative fiedback to the warming climate through increasing winter surface albedo when decidious forest is replacing evergreen boreal forest as a result of warming) (Bonan et al., 1992; Rivers and Lynch, 2004).	c	**Accepted.**
5.2.4	Brigham-Grette	10	198-199	extent of permafrost (how changes in cloud cover interact with permafrost extent????).	c	**Accepted, assumiing I have the meaning right.**
	Brigham-Grette	10	201-202	As permafrost thaws under a warmer climate (Fig. 5.6) (this Figure doesn't show any permafrost thawing, just warming)	c	**Noted. But The figure shows trends in warming which can lead to thaw.**
	Brigham-Grette	10	204-206	et al. 2004, Thomas et al, 2002, Archer, 2007) (much more greenhouse gases may be released as a result of decomposition of the organic matter presently sequestered in permafrost).	c	**Accepted**
5.2.5	Brigham-Grette	10	206-207	Here is the first place, among many, where a more detailed (than Fig 5.7) map of the Arctic Ocean would be useful. In particular, one with bathymetry (e.g., a simplified version of the IBCAO map) would give the reader a better appreciation of the physical aspects of this basin.	b	**So noted for change by the USGS technical unit.**
5.2.5	Brigham-Grette	11	209	5.2.5 Freshwater balance feedbacks and thermohaline circulation (disproportionally more detailed description in comparisson with 5.2.1 - 5.2.4)	c	**So noted for change by the USGS technical unit.**
5.2.5	Brigham-Grette	13	259-263	Is there any data at all on the relative magnitudes of change in CO2 transfer and nutrient turnover? The former is spatially focused whereas the latter tends to occur over a much broader area and isn't necessarily as tightly coupled to the THC. Mentioning them both together implies near-equal changes in response to THC change.	b	**Noted.**
5.2.7	Brigham-Grette	15	317	"an unperturbed climate" – add "in balance on annual timescales". A cartoon summarizing the feedbacks would be useful here.	b	**Accepted.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.3	Brigham-Grette	17	352	Proxies of Arctic Temperature and Precipitation: Vegetation: Tree rings are not mentioned here but should be, as important indicators of Arctic climate change.	g	**Accepted -- probably best to add a page of text here now at line 363 about Tree rings as section 5.3.1 if we can't fit it into existing section.**
5.2.7	Brigham-Grette	17	360-362	Over longer times, growth of an ice sheet such as the Laurentide ice sheet on North America, or melting of an ice sheet such as that on Greenland, can occur. This in turn can influence albedo, freshwater fluxes to the ocean, broad patterns of atmospheric circulation, greenhouse-gas storage or release in the ocean and on land, and more.	c	**Accepted**
5.3.1a	Brigham-Grette	19	400	Inverse modeling and forward modeling should be defined clearly before they are used.	k	**Accepted. These are defined as they are used but both terms could be added to the glossary -- USGS tech unit.**
5.3.1b	Brigham-Grette	20-21	420-448	Section 5.3.1b seems to say oxygen isotopes in the Arctic are only good for salinity, but also mentions ice volume effects. Are the latter a factor in interpretation or not?	b	**Noted. Ice volume effects are swamped by the salinity effect.**
5.3.1b	Brigham-Grette	20	427	"meteoric waters" should be defined or replaced by "precipitation"	k	**Accepted. Could be added to the glossary since its defined in principle in the rest of the sentence.**
5.3.1c	Brigham-Grette	21-22 29-30		5.3.1c (pp 21-22) and 5.3.1g (pp 29-30): Are isotopes (5.3.1c) truly so much less dependent on multiple external factors compared to the biological proxies (5.3.1g)? I would have said that some of the confounding factors affecting biology would also affect isotopes, though the text leads to a quite different conclusion.	b	**Noted. The influence of factors on lake isotopic records is properly reported here.**
	Brigham-Grette	23	491-523	Significance of spatial versus temporal relationships of ice-core isotopes to temperature is not clearly explained. Figure 5.13 is also not used very effectively.	b	**Accepted. Text altered to clarify the meaning of figure 5.13 and address spatial temporal issues.**
5.3.1e	Brigham-Grette	25	531	Eliminate "and this almost certainly was true in the past", and insert at the beginning of 532, "If we can assume that species maintain their preferences through time, the mathematical…. "	k	**Accepted.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.3.1g	Brigham-Grette	29	632	It would be good to insert here a general sentence about what makes species “useful” for paleoclimate: abundance, robust response to climate, continuity with modern species.	k	**Accepted.**
5.3.2c	Brigham-Grette	35	776	“mathematically squeezing the air out” might be confusing. Better: “mathematically accounting for the amount of air trapped in the ice”	k	**Accepted**
5.4	Brigham-Grette	37		I found a complete absence of permafrost-related feedbacks from the discussion on the past environmental changes (Section 5.4). Some mateds on this could be found in Walter KM, Edwards M, Zimov SA, Grosse G, Chapin III FS: Thermokarst lakes as a source of atmospheric CH4 during the last deglaciation, Science, Vol. 318. no. 5850, pp. 633 – 636, 2007.	c	**Accepted. Text was added at the end of 5.2.4 about this recent work.**
5.4.1	Brigham-Grette	40	871	This paragraph should get a bold subheading, to draw attention to the transition from description of climate changes to explanation of those changes.	k	**Noted. Will have the USGS technical edits people consider this.**
5..4.1	Brigham-Grette	40	876	Expand “climate modeling” to “general circulation models of climate” or something similar.	k	**Accepted**
5.4.1	Brigham-Grette	40	882	It’s hard to compare Barron’s and Donnnadieu’s work, not only because of the difference in the experiments they performed, but also because of the huge difference in model resolution and sophistication between 1993 and 2006.	k	**Accepted. I changed the sentence to reflect the time between studies.**
5.4.1	Brigham-Grette	42	928	It should be pointed out here that the large Arctic response to CO2 during the PETM takes place in the absence of any ice, and therefore in the absence of any ice- or snow-albedo feedbacks.	k	**Accepted and sentence here was altered to reflect this comment.**
5.4.2	Brigham-Grette	45	994	Inconsistent use of bold face for species names.	k	**Rejected. Here only latin names are in bold; common names are not.**
5.4.2	Brigham-Grette	45	1001	The word “transgression” should be defined before its first use.	k	**Noted. This is a standard term but could be added to the glossary.**
5.4.2	Brigham-Grette	46	1010	Likewise, “correlative to” should be defined, or replaced with “at the same time as”	k	**Accepted and changed to "the same age as"**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.4.3	Brigham-Grette	48	1054	The problem of the 100,000 year glacial cycles is important enough that it merits listing of a few of the alternative hypotheses to the glacial lubrication idea: e.g. carbon cycle feedbacks involving the deep ocean circulation.	k	**Accepted. References added to include Southern ocean ideas and also phasing of milankovitch now at about line 1092.**
5.4.3	Brigham-Grette	48	1060-1061	After many tens of thousands of years a sufficient ice thickness was build up, trapping of the Earth's heat led to thawing of the bed and allowing faster flow.	c	**Accepted.**
5.4.3	Brigham-Grette	48	1076	...sufficiently large and thick to trap enough of the Earth's heat to thaw the ice-sheet bed	c	**Accepted**
5.4.4	Brigham-Grette	49-50	1088-1112	pp 49-50, ln 1088-1112: This section feels odd. Is it just a transition between the Mid-Pliocene section and MIS 11, etc.? Or does it have a larger purpose, e.g., explaining (or reminding?) that there are lots of complex changes we don't fully understand? Either way, it feels like it needs work and a clearer sense of purpose.	b	**5.4.4 section serves to transition into time periods where nore is know about the role of CO2 and the magnitude of change.**
5.4.4	Brigham-Grette	50	1103	"various changes produced additional dust." It's worth listing these: glacial erosive action, windy, dry conditions in advance of glaciers. Cite: Mahowald, N. M., D. R. Muhs, S. Levis, P. J Rasch, M. Yoshioka, C. S. Zender, and C. Luo (2006), Change in atmospheric mineral aerosols in response to climate: Last glacial period, preindustd, modern, and doubled carbon dioxide climates, J. Geophys. Res., 111, D10202, doi:10.1029/2005JD006653	k	**Accepted and added to the text and ref list.**
5.4.6a	Brigham-Grette	53	1183-1184	processes, although seasonality and moisture availability may influence some biological parameters?? such as dominance by evergreen versus deciduous vegetation	c	**Accepted. A word was missing from the earlier draft.**
5.4.7	Brigham-Grette	58	1298, 1300	traditional Karginskii/MIS 3 period across arctic Russia; however, stratigraphic confusion within the limits of radiocarbon-dating precludes widespread correlation of events.	c	**Accepted.**
5.4.9	Brigham-Grette	60	1354	...of climate change in response to relatively small changes in ???forcings	c	**Accepted.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.4.9a	Brigham-Grette	62	1382	Laurentide ice sheet in Canada, which depressed temperatures nearby until the ice melted back (in our earlier publication: Maximova, L. N. and c, V.E., A hypothesis of the Holocene permafrost evolution, Proceedings of the Fifth International Conference on Permafrost, Norwegian Inst. Tech., Trondheim, Norway, pp. 102-106, 1988, we proposed an explanation of the differences in the HTM timing based on a simple analysis of spatial variability in the amplitudes of specific Milankovitch cycles (41, 21, and 11 ka)	c	**Accepted and reference added.**
5.4.9a	Brigham-Grette	64	1435	Astakhov (1995) suggests that thawing permafrost was apparent north of the Arctic Circle (only in the European North, not in Siberia. In the Siberian North, partial thaw of permafrost was very local and was practically entirely confined by areas under thermokarst lakes that were actively developing there during the early to middle Holocene. There are better references on this topic – VR) during the early through middle Holocene. Areas south of the Arctic Circle in the Eoropean North of Russia and in the West Siberia appear to have experienced deep thawing...	c	**Accepted.**
5.4.9a	Brigham-Grette	64	1444	permafrost in these regions produced an extensive thawed layer sandwiched between the shallow (20 to 80 meters in thickness), more recently frozen ground, and deeper Pleistocene permafrost.	c	**Accepted.**
5.4.9c	Brigham-Grette	67	1508	The cited D'Arrigo et al. 2006 paper also emphasized the uncertainties involved in estimating Medieval Warm Period warmth relative to that of the 20th century, due in part to the more sparse proxy data coverage and the less coherent variability of tree growth temperature estimates for the MWP.	g	**Accepted -- comment inserted to line 1509**
5.4.9b	Brigham-Grette	67	1510	glacier advances (Karlén, 1988) between 2.6 and 2.0 ka ago. An extended analysis of these multiple centennial-scale warmer and colder intervals in Russia was published by Velichko et al.: Cenozoic climatic and environmental changes in Russia. Edited by A.A. Velichko and V.P. Nechaev; editors of the English edition: H.E. Wright Jr., T.A. Blyakharchuk, A.A. Velichko and Olga Borisova. Special Paper 382. The Geological Society of America, 2005. 226 p	c	**(typo corrections)**
5.4.10	Brigham-Grette	71		The various tree-ring and paleoreconstructions cited above are also relevant to the section: 5.4.10: Placing 20th century warming	g	**Accepted and citation added to that section.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.5.1	Brigham-Grette	74	1655	This would be a good place to mention a's Early Anthropogenic hypothesis: a, W. F. (2007), The early anthropogenic hypothesis: Challenges and responses, Rev. Geophys., 45, RG4001, doi:10.1029/2006RG000207.	k	**Rejected for line 1680. This hypothesis remains challenged and and work of Berger show that the current interglacial would normally last for another 10k. This is probably a better reference.**
5.5.1	Brigham-Grette	75	1688	...summer sunshine in the Arctic than in the current interglacial, with summer??? temperatures …	c	**Accepted.**
5.5.1	Brigham-Grette	75	1704	Smaller oscillations in climate	c	**Accepted.**
5.5.2	Brigham-Grette	79	1781	The apparent constancy of the Arctic amplification is really puzzling in light of the lack of albedo feedbacks in the ice-free Arctic (in the Eocene and before). Also, there's a lot of doubt about tropical temperatures in the Eocene and Cretaceous, with some reports of very high temperatures: Paul N. Pearson, Bart E. van Dongen, Christopher J. Nicholas, Richard D. Pancost, Stefan Schouten, Joyce M. Singano, and Bridget S. Wade, 2007. Stable warm tropical climate through the Eocene Epoch Geology 2007 35: 211-214	k	**The polar amplication figure does not extent to the Eocene but I added reference to accommodate this comment near the end of 5.5.2 Reference as added to the bibliography.**
5.5.3	Brigham-Grette	81	1829	but air over ice-covered water can become very cold in the dark Arctic winter (this is a trick – if air above is cold enough the sea water will freeze, it cannot stay liquid if air temperature is really cold!!! – VR), allowing sustained changes in sea-ice coverage to cause perhaps the largest temperature changes observed on the planet	c	**Accpeted. Text change made.**
Figure 5.6	Brigham-Grette			Figure 5.6: "clear warming trends" are not particularly clear in many cases. There is also no context for the different curves, in particular within each graph but also between graphs. Either a location map is needed or an abstraction of the data.	b	**Noted. My suggestion is that we add a figure with sites. The figure caption explains the context of the figure in the text.**
Figure 5.21	Brigham-Grette			Figure 5.21: Why is there no timescale on this figure? "Across the PETM" is too vague for properly appreciating time and rates of change.	b	**Noted. We can ask USGS techs to add a time scale on the left side based on the original paper.** **From Joan: Please note that there is no age-depth relationship given in the original paper. It would be inappropriate for USGS editors to create one.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
Figure 5.33	Brigham-Grette			Figure 5.33: MWP and LIA: this curve has been criticized as its origin is uncertain e.g. http://www.climateaudit.org/?p=3072#more-3072 It is also quite old, nearly 20 years or more out of date.	g	**Taken into account. We can look for a different figure. Current figure is now from the IPCC assessment 2007.**
Abstract	Brigham-Grette	4	60	line 60. northern hemisphere summer?	i	**Accepted and changed.**
5.3.1b	Brigham-Grette	20	428	line 428: 'excellent corrrelation' between d18Osw and salinity in the Arctic is a little strong. The presence of sea ice makes very large seasonal excursions. I would rather state that the correlation is worse in the Arctic than elsewhere (e.g. Tan and Strain (multiple references), Legrande and i (2006)).	i	**Noted. Legrande and i 2006 added.**
5.3.1b	Brigham-Grette	21	439	line 439: more Accepted value for the glacial ice volume change is more like 1.0 permil. Though give a range, I suggest 1.0 to 1.2 permil. (Schrag, Adkins et al)	i	**Noted. Text changed and both references added.**
5.3.1d	Brigham-Grette	23	483	line 483: 'generally Accepted to reflect annual mean temperature' is somewhat undermined by the doubling of the sensitivity (as exposed by the borehole estimtes and nitrogen isotope measurements) due in large part to seasonal effects (Werner et al 2000). I would rewrite this section to either make it clear that this	i	**Accepted. Werner et al. added to the text with note about seasonality issue. (approx line 507 in this version of mine).**
5.3.1f	Brigham-Grette	26	562	line 526: why the restriction to the Holocene? i et al 2007 show issues with even different Holocene climate changes (incl the 8.2 event, orbital and other changes).	i	**Accepted. Reference added to the End of Sec. 5.3.1d.**
5.4.1	Brigham-Grette	38	844-846	line 844-846: rewrite. I don't think that northern hemisphere summer can be prevented by a change in eccentricity.	i	**Accepted. Wording changed at now line 1178.**
5.4.1	Brigham-Grette	40	876	line 876: "Arctic temperatues" are not defined by Greenland. It is certainly expected that temperature changes at high elevations are amplified compared to sea level, and possibly changes to the inversion over Greenland itself might increase the amplification further.	i	**Noted.**
5.4.1	Brigham-Grette	40	879	line 879 (and other places). Be carreful comparing records to the "20th Century" given the changes over that period. In many cases it will matter if you are talking about the early or late part, and depending on the records, it is unlikely that the proxy will extend to the late 20th C warming. I suggest being extremely specific in each case.	i	**Noted.**

Chapter	Responder	Page	Line(s)	Comment	Reviewer	Notes
5.4.9c	Brigham-Grette	67	1489	Section 5.4.9.c heading. Might I suggest Medieval Climate Anomaly instead of MWP? The MWP lends itself to presupposing what is still to be determined and leads many authors to line any wamring from 500 to 1500 AD - however asynchronous - to the MWP. This laxity in usage could be signigifcantly corrected here.	i	**Accepted and corrected.**
5.4.1	Brigham-Grette	42	914	line 914: Shindell et al 1999 was a modelling study - not a data analysis. They showed that solar forcing could produce a moe negative phase NAO - not that this necessarily happened during the late Maunder Minimum.	i	**Accepted assuming the reviewer means Shindell et al. 2001 on line 1615. Text corrected.**
5.4.1	Brigham-Grette	42	926	line 926/7. "not extraordinarily high". Just say weak.	i	**Accepted for line 1647 in revised version.**
Fig. 5.33	Brigham-Grette	135		Figure 5.33: This has to go! The schematic from FAR (IPCC 90) is a handrawn cartoon based on a smothed version of Lamb's central England temperature with a zero line that nominally reflects 1900 temperatures. Late 20th C temperatures clearly exceed the MWP 'bump' in in the CET and this graphs's representativeness is exceedingly ambiguous. Compared to the careful synthesis in the rest of this rpeort, this figure sticks out like a sore thumb. Delete! (Use the AR4 compilations if you want something equivalent but more quantitative).	i	**Accepted with enthusiasm. Changed figure to one from Mann et al, in press, PNAS**