Expert Reviewer's Comments on the Second-Order Draft of the Contribution of the Climate Science Working Group (WG1) to the *Fifth Assessment Report* (AR5, 2013) of the Intergovernmental Panel on Climate Change

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General comments on the draft of WG1's contribution to AR5

Comment #1: *Ch. 0, from page 0, line 0, to page 0, line 0*

To restore some link between IPCC reports and observed reality, the report must address – but does not at present address – the now-pressing question why the key prediction of warming in earlier IPCC reports have proven to be significant exaggerations.

Reason: The IPCC's credibility has already been damaged by its premature adoption and subsequent hasty abandonment of the now-discredited "hockey-stick" graph as its logo; by its rewriting its *Second Assessment Report* after submission of the scientists' final draft, to state the opposite of their finding that no discernible human influence on climate is detectable; by its declaration that all Himalayan ice would be gone in 25 years; and by its use of a dishonest statistical technique in 2007 falsely to suggest that the rate of global warming is accelerating. But the central damage to its credibility arises from the absence of anything like the warming it had predicted.

Example: In 1990 the IPCC's central estimate was that warming would occur at 0.3 K/decade and that by now some 0.6 K warming would have occurred. Since then observations show warming has occurred at 0.14 K/decade and 0.3 K warming has occurred. There has been no global warming for 16 years.

Comment #2: *Ch. 0, from page 0, line 0, to page 0, line 0*

To restore lost credibility, all alterations by governments to the scientists' final draft must be visibly distinguished from it and referred back to all expert reviewers for comment before publication.

Reason: Failure to make explicit the distinction between scientific and political content weakens the *Assessment Reports* by leaving readers wondering which findings are political. For this reason, I recommend the governments I advise to exercise caution before relying on the IPCC, which was founded as a political and not a scientific body.

Example: During preparation of the *Fourth Assessment Report* (AR4, 2007), governments' political representatives decided by show of hands the "90% confidence" that more than half of the warming since 1960 was manmade. China had argued for no estimate; others had argued for 95%. Yet commentators unaware that this central decision was not scientific but political presented it as though it were a legitimate scientific finding.

Comment #3: *Ch. 0, from page 0, line 0, to page 0, line 0*

To prevent recurrence of past scientific dishonesty, all alterations to the scientists' final draft after submission are to be visibly flagged and referred back to all expert reviewers for comment.

Reason: The IPCC's Chairman, Dr. Pachauri, defended certain scientific errors in AR4 that exaggerated our influence on climate and had not been in the scientists' final draft.

Example: The scientists' final draft showed a graph of global mean surface temperature anomalies since 1850, with one linear trend-line covering the entire period. Later, someone added three additional trend-lines, starting in 1900, 1950 and 1975 respectively, and added a false conclusion that since the trend-lines that began later rose more steeply manmade warming was accelerating. The same artifice would show a sine-wave, which has a zero trend, rising (or, if desired, falling) at an ever-faster rate, depending on the chosen start-points for the added trend-lines. Dr. Pachauri did not have this error corrected when asked.

Comment #4: *Ch. 0, from page 0, line 0, to page 0, line 0*

To limit politicization of *Assessment Reports*, all material from non-peer-reviewed sources, such as environmental lobby groups, is to be excluded.

Reason: 30% of all references listed in AR4 were not from reviewed papers in the learned journals but from the "gray literature": e.g. media handouts from environmental groups. While this practice continues, I cannot recommend the IPCC's reports as scientifically credible to the governments I advise. The Inter-Academy Council was asked to ban this practice but failed to do so.

Example: For six months the IPCC's climate-science chairman, Dr. Pachauri, asserted that anyone who doubted the conclusion in AR4 that all the ice in the Himalayas would be gone within 25 years was "anti-science". Yet the conclusion had no scientific basis. It came from a polemic by a travel journalist. The lead author of the relevant chapter said he had known of the error but had decided not to correct it.

Comment #5: *Ch. 0, from page 0, line 0, to page 0, line 0*

To make explicit the magnitude and sign of any revisions to central climate-change projections compared with previous *Assessment Reports*, projections on all six original SRES emissions scenarios should be included.

Reason: In the AR5 draft the goalposts have been moved by the use of scenarios incompatible with the original SRES scenarios. Yet governments need to have a clear idea of how fast the models' key projections are changing, and in which direction. For backward compatibility, projections similar to those in Fig. 10.26 of the *Fourth Assessment Report* should be made under each of the six original scenarios.

Comment #6: *Ch. 0, from page 0, line 0, to page 0, line 0*

To respect the scientific method by enhancing the replicability of results shown in AR5, the data underlying all graphs in AR5, whether taken from cited learned papers or generated during the drafting, should be properly archived, with their data structures made explicit, and made available online to all.

Reason: The credibility of the IPCC has been damaged by its failure to verify that material it has cited had been properly archived.

Examples: The key projections on all six SRES emissions scenarios in AR4 were encapsulated in small-scale graphs at Fig. 10.26 (IPCC, 2007, p. 803). However, the data that underlay the graphs do not appear to have been archived. Also, the graph in TAR (IPCC, 2001) that purported to demonstrate the absence of the medieval warm period and the little ice age was withheld from researchers attempting to verify it for some considerable time after TAR was published.

Comment #7: *Ch. 0, from page 0, line 0, to page 0, line 0*

To clarify the process for determining climate sensitivity, the derivation and central estimate of the Planck or zero-feedback climate-sensitivity parameter should be made explicit.

Reason: The Planck parameter is that quantity in Kelvin per Watt per square meter by which, where temperature feedbacks are non-existent or have not yet begun to act or sum to zero, a radiative forcing is multiplied to give the resultant temperature change. The magnitude of the contribution of feedbacks themselves to warming is separately dependent upon it. It is, therefore, a crucial quantity.

Example: The only mention of the value of the Planck parameter in any previous Assessment Report is in a footnote on p. 631 of AR4, where its derivation is not made as clear as is desirable. It should also be expressed in Kelvin per Watt per square meter as an element in the climatic reference frame, rather than in Watts per square meter per Kelvin as though it were itself a feedback (Roe, 2009).

Comment #8: *Ch. 0, from page 0, line 0, to page 0, line 0*

To demonstrate the projected impact of temperature feedbacks over time, central estimates, with error-bars, of the evolution of the value of the climate-sensitivity parameter over the period from the instant when a forcing is applied to the time when equilibrium is attained should be evaluated, discussed, and presented as a graph.

Reason: The impact of temperature feedbacks on the fundamental equation of climate sensitivity is expressed via increase over time in the value of the climate-sensitivity parameter (~0.3 K W m – 2 in the absence of feedbacks or where they sum to zero; ~0.9 K W m^{-2} at equilibrium after 1000-3000 years following a doubling of atmospheric CO_2 concentration). A graph of the evolution of the value of the climate-sensitivity parameter over time is necessary to make explicit the rate at which the IPCC considers global warming will increase.

Comment #9: *Ch. 0, from page 0, line 0, to page 0, line 0*

To clarify the method modelers use to determine climate sensitivity, AR5 should contain a table of temperature feedbacks, linearizing non-linear feedbacks where possible, providing a central estimate and error bars

for each feedback, and making explicit the magnitudes of the respective contributions to forcing at equilibrium from direct forcings and from the feedbacks they trigger.

Reason: Almost twice as much of the projected warming at CO_2 doubling comes from feedbacks as from CO_2's direct forcing.

Example: Though it is generally accepted that the direct warming from CO_2 is <1.2 K, the multi-model mean central estimate that equilibrium warming at CO_2 doubling is 3.3 K (AR4, p. 798, box 10.2), implies an overall temperature feedback gain factor >2.8, near-tripling the direct warming caused by atmospheric CO_2 enrichment. Yet it is only in the *Fourth Assessment Report* that the principal feedbacks the IPCC considers climate-relevant are quantified for the first time, and then only by reference to a single paper. For credibility, it is essential that feedback projections be put on an explicitly quantitative footing, with multiple sources for each feedback.

Comment #10: *Ch. 0, from page 0, line 0, to page 0, line 0*

To increase credibility, the IPCC must tackle explicitly the fact that there has been no statistically-significant increase in global mean surface temperature for 16 years, and that this prolonged stasis in global warming notwithstanding record increases in CO_2 concentrations does not fall within the intervals projected either by the models or by the IPCC in previous *Assessment Reports*.

Reason: Researchers with the courage to question the official projections have long predicted that – though some warming from CO_2 enrichment is to be expected – not very much warming will occur. The 16-year temperature stasis that has now occurred must be explicitly faced.

Example: The world's leading modelers wrote in 2008 that a stasis of15 years or more would establish a discrepancy between what is modeled and what is predicted. To explain that discrepancy one might argue that the relatively weak warming signal from CO_2 has been overlain by three recent natural influences: in late 2001 we entered a ~30-year cooling phase of the ~60-year cycle of the ocean oscillations; the current ~11-year solar cycle displays near-unprecedentedly weak solar activity, implying the possibility of a Dalton or even Maunder minimum in the coming decades; and there has recently been a double-dip La Niña.

Comment #11: *Ch. 0, from page 0, line 0, to page 0, line 0*

To reduce the near-certainty that governments will ignore the IPCC's reports as irrelevant in current economic circumstances, a chapter should be added comparing the economic merits of mitigation and adaptation.

Reason: When the IPCC was established, mitigation and adaptation were assigned to separate working groups in a manner calculated to prevent direct economic comparison between them. It is now clear that adaptation would be one or even two orders of magnitude more cost-effective than mitigation.

Example: The Stern and Garnaut reports purported to set the costs of mitigation against the benefit in climate-related losses abated by focused adaptation. However, both reports were produced for governments aiming to justify substantial new sources of tax revenues. A more objective approach is now necessary. An economic chapter appropriately belongs to a physical-science assessment, since it is only when the IPCC's physical projections are combined with the standard economic methodologies of inter-temporal investment appraisal that a mature conclusion on the cost-effectiveness of mitigation can be reached.

Comments on the draft of the Summary for Policymakers

Comment #12: *Ch. SPM, from page SPM-2, line 3, to page SPM-2, line 6*

To reduce prejudice, add at the end of the first paragraph of the *Summary for Policymakers*: "Evidence that global CO2 concentrations, temperature and sea level are not increasing as rapidly as originally projected, and that other effects of global warming may not prove as damaging as had been thought, is also evaluated."

Reason: The IPCC is now seen as political rather than scientific, and as promoting an extremist viewpoint rather than objectively weighing the evidence in the reviewed literature and data. It should be seen to be making every effort – especially in the *Summary for Policymakers* – to discuss both sides.

Example: Temperature has not risen for 16 years. In the past 60 years, covering full cooling and warming phases of the ocean oscillations, warming has occurred at a rate equivalent to 1.2 K/century: yet AR4, as the mean central estimate on all six SRES emissions scenarios, projected warming of 2.8 K/century to 2100. The implausibility of the key warming projection in AR4 should now be discussed.

Comment #13: *Ch. SPM, from page SPM-2, line 8, to page SPM-2, line 8*

To restore scientific rigor, the sentence "The evidence that formed the basis for the IPCC *Fourth Assessment Report* (AR4) has further strengthened" must be rewritten or deleted.

Reason: It is not made explicit which "evidence" has "strengthened", and to what degree, and there is no mention of the key evidence which has weakened.

Example: After 16 years without global warming, and after a decade throughout which the rate of sea-level rise has been slowing, these two key indicators have weakened, and the *Summary for Policymakers* should be honest enough to say so.

Comment #14: *Ch. SPM, from page SPM-2, line 8, to page SPM-2, line 11*

To ensure balance and restore scientific credibility, the mention of the SREX report on extreme weather should be followed by the following new sentence: "The report found 'medium evidence and high agreement that long-term trends in normalized losses have not been attributed to natural or anthropogenic climate change … The absence of an attributable climate change signal in losses also holds for flood losses.'"

Reason: It is appropriate to state the principal conclusions of cited reports even when those conclusions do not endorse the alarmist message that the IPCC – rightly or wrongly – has sought to convey. The SREX report concluded that it is not yet possible to attribute extreme-weather losses to anthropogenic influence on the climate, and the *Summary for Policymakers* should be honest enough to say so.

Comment #15: *Ch. SPM, from page SPM-2, line 13, to page SPM-2, line 18*

To make explicit the magnitude and sign of any revisions to central climate-change projections compared with previous *Assessment Reports*, projections on all six original SRES emissions scenarios should be added to the new RCP projections.

Reason: In the AR5 draft the goalposts have been moved by the introduction of scenarios incompatible with the original SRES scenarios. Yet governments need to have a clear idea of how fast the models' key projections are changing, and in which direction. For backward compatibility, projections similar to those in Fig. 10.26 of the *Fourth Assessment Report* should be made under each of the six original scenarios: and, this time, the source and output data for the graphs encapsulating the projections should be made available.

Comment #16: *Ch. SPM, from page SPM-2, line 20, to page SPM-2, line 21*

To provide a fair scientific assessment of the difficulties in making reliable climate projections in the very long term, the *Summary for Policymakers* should contain a clear statement similar to §14.2.2.2 of AR4 explaining the impact of the fact that the climate object is, mathematically speaking, chaotic.

Reason: Lorenz (1936), in the celebrated paper that founded chaos theory, concluded that because the climate behaves as a chaotic object the reliable long-term prediction of future climate states was not available by any method.

Example: Predicting the future evolution of a chaotic object demands knowledge of the initial values of its defining parameters to a precision which, in the climate object is and will always be unattainable. Accordingly, it is not possible even on a global scale reliably to predict the future evolution of the climate object in response to a perturbation such as our adding CO_2 to the atmosphere. *A fortiori,* difficulties in regional-scale prediction will be greater still, and the *Summary for Policymakers* should say so.

Comment #17: *Ch. SPM, from page SPM-2, line 20, to page SPM-2, line 21*

To provide policymakers with a mature assessment of the difficulties in reliable long-term prediction of future climate states, the *Summary for Policymakers* should admit that probability density functions are still more problematic than simple central estimates flanked by error-bars.

Reason: Because the climate behaves as a chaotic object, even establishing a reliable, century-long simple central estimate flanked by error bars is not possible. *A fortiori,* providing projections by way of probability-density functions is impossible, since PDFs require more information than estimates flanked by error-bars, not less. In general, the IPCC follows the modelers in claiming too much certainty for its conclusions.

Comment #18: *Ch. SPM, from page SPM-2, line 30, to page SPM-2, line 34*

To put the IPCC's observational findings into perspective, it should make clear at the outset that the physical and biogeochemical state of the oceans and the extent and volume of snow and ice has changed throughout their history; that the changes of the past 40 years are not unprecedented; and that the changes are not necessarily harmful.

Reason: The wording in the draft to the effect that the hydrosphere and cryosphere have "changed during the past 40 years" or "changed over the latter half of the 20th century" leaves the impression that the changes are unprecedented or at least unusual, when in truth we do not have to this day any adequately long or spatially well-resolved time series for mean sea level, mean oceanic acid-base balance; Arctic or Antarctic land-ice or sea-ice extent or volume; or Northern-Hemisphere snow-cover extent.

Comment #19: *Ch. SPM, from page SPM-2, line 30, to page SPM-2, line 34*

To draw policymakers' attention to the uncertainties surrounding the IPCC's projections, it is necessary to explain that since even today's measurements of key climate indicators are problematic the difficulty in establishing what took place in the paleoclimate is still greater.

Reason: Paleoclimate reconstructions are subject to large uncertainties and are less capable of providing definitive indications of the likely future evolution of today's climate than IPCC *Assessment Report* have been willing to admit. In particular, the quantitative information they provide is uncertain.

Comment #20: *Ch. SPM, from page SPM-2, line 37, to page SPM-2, line 39*

To render the wording more neutral and scientifically credible, the words "Confidence is stronger that many changes that are observed consistently across components of the climate system are significant, unusual or unprecedented on times scales of decades to many hundreds of thousands of years" should be deleted.

Reason: Since there has been no warming since the previous *Assessment Report,* there is manifestly no observational evidence to support the offending sentence. The only potential adverse consequence of CO2 enrichment that does not follow from warming is a putative alteration of the acid-base balance of the oceans: however, no global time series of sufficient length or steric resolution to draw any conclusion is yet available. Therefore the offending sentence, scientifically speaking, is fiction.

Comment #21: *Ch. SPM, from page SPM-3, line 3, to page SPM-3, line 3*

To correct an incomplete and misleading statement, the words "Widespread warming is observed from the surface of the Earth throughout the troposphere" should be replaced by the following: "Warming of ~0.6 K has been observed over the past 60 years, but this rate of warming is within natural variability, though an anthropogenic component may be present. No warming has been observed since the *Third Assessment Report* was published in 2001: indeed, there has been no statistically significant global warming for 16 years."

Reason: The warming observed since 1900 is well within natural variability. Warming at a rate equivalent to 4 K/century was observed in central England in the 70 years 1695-1735 during the recovery of solar activity after the Maunder Minimum: historical evidence suggests this rate may have been global. It is important not to mislead policymakers: therefore, the fact that there has been no warming since the two previous *Assessment Reports* must be made explicit. The statement that "Widespread warming *is* observed" when it has *not* been observed for 16 years is calculated to deceive.

Comment #22: *Ch. SPM, from page SPM-3, line 3, to page SPM-3, line 3*

To correct an incomplete and misleading statement, the words "and cooling is identified in the stratosphere" should be replaced by the following: "During the period of lower-troposphere and surface warming from the beginning of satellite observations in 1979 until late in 2001, the stratosphere cooled. However, the stratospheric cooling ceased in 2001."

Reason: The statement that "cooling *is* identified in the stratosphere", when there has been no such cooling for well over a decade, is calculated to deceive. If the IPCC is to earn back some of the credibility it has lost, it must take exaggerated care to be precise, particularly in the *Summary for Policymakers,* which will be read largely by people with little scientific experience or knowledge of the underlying data.

Comment #23: *Ch. SPM, from page SPM-3, line 30, to page SPM-3, line 30*

To ensure scientific balance, add the following bullet point: "* In the past 60 years (covering a complete warming and cooling cycle of the ocean oscillations), the observed rate of global warming, expressed as a linear trend, was equivalent to 1.2 K/century."

Reason: The IPCC has been predicting 3 K/century for the 21st century. Given the much slower observed rate of warming, the IPCC needs to explain how its far higher predicted rate will occur, and when the first signs of it will become evident.

Comment #24: *Ch. SPM, from page SPM-3, line 30, to page SPM-3, line 30*

To give a more complete picture of temperature trends, add the following bullet point: "The maximum rate of warming that persisted for more than a decade since global surface-temperature records began in 1850 was 0.17 K/decade, equivalent to 1.7 K/century. That rate occurred from 1860-1880, 1910-1940 and 1976-2001."

Reason: It is significant that the greatest supra-decadal warming rate observed since global records began is little more than half the mean 21st-century warming rate predicted by the IPCC. It is also significant that the rapid warming from 1976-2001 was not unprecedented, having occurred twice before during the instrumental record. On the earlier two occasions, the human influence on climate was negligible, suggesting that our influence on the third period of warming may similarly have been small. Failure to discuss points such as this in the *Summary for Policymakers* is calculated to mislead the readers.

Comment #25: *Ch. SPM, from page SPM-3, line 47, to page SPM-3, line 47*

To increase accuracy, between the two sentences in this paragraph add the following sentence: "There are insufficient data to establish that the frequency, intensity and duration of extreme-weather events have increased globally."

Reason: This sentence reflects the conclusion of the SREX report on extreme-weather events.

Comment #26: *Ch. SPM, from page SPM-3, line 47, to page SPM-3, line 48*

To ensure honesty, after the sentence that reads "Overall the most robust global changes are seen in measures of temperature", add the following: "However, globally there has been no statistically-significant warming for 16 years. Such periods of stasis are not unprecedented, but they constrain the long-run rate of warming, which remains below earlier projections."

Reason: The IPCC must be seen to deal with the long-running failure of the Earth's surface to warm at anything like the previously-predicted rate.

Comment #27: *Ch. SPM, from page SPM-4, line 29, to page SPM-4, line 31*

To take due account of measurement uncertainties, delete " it is *virtually certain* that the upper ocean has warmed since 1971, and that ocean warming dominates the change in the global energy content" and substitute "it is not known to what extent the upper ocean has warmed since 1971, or what fraction of the change in the global energy content ocean warming represents."

Reason: The 3000+ Argo bathythermograph buoys show very little ocean warming since they were first deployed. They are the most comprehensive measure of upper-ocean temperature available, but they are equivalent to taking a single temperature and salinity profile at one location in Lake Superior less than once a year. Previous expendable bathythermographs also showed little warming until a correction for an imagined cooling bias was introduced. Before that, haphazard measurements were taken by passing ships. The data are altogether inadequate to allow any "virtually certain" conclusion about ocean temperatures.

Comment #28: *Ch. SPM, from page SPM-4, line 34, to page SPM-4, line 35*

To allow for the near-total absence of temperature sampling in the deep oceans, delete "It is *likely* that the deep ocean has warmed below 3000 m depth since the 1990s."

Reason: The frequency and steric distribution of ocean temperature sampling at depth is altogether inadequate to allow any conclusion to be drawn about changes in deep-ocean temperature. The conclusion is in any event greatly complicated by lack of knowledge of variability in subsea volcanic activity, which heats the deep ocean directly. Furthermore, given that the ocean is ~1100 times denser than the atmosphere, it seems implausible that over as short a period as 40 years any appreciable warming of the deep ocean attributable to anthropogenic warming of the atmosphere could have occurred.

Comment #29: *Ch. SPM, from page SPM-4, line 40, to page SPM-4, line 43*

To verify the math, some consideration should be given to the missing ocean heat implied in the statement that "Upper ocean (0-700 m) heat content *very likely* increased at a rate between 74[43 to 105] x 10^{12} W and 137 [120 to 154] x 10^{12} W for the relatively well-smapled 40-year period from 1971 to 2010."

Reason: Assuming 361.132 x 10^{12} m ocean surface area, the IPCC's estimated 74-137 x 10^{12} W represents 0.2-0.4 W m^{-2} stored in the upper ocean. The atmospheric concentration of CO2, which represents 70% of all greenhouse forcings, rose from 326.1 µatm in Jan 1971 to 390.7 µatm in Jan 2011. Over that period, overlooking the cooling effect of aerosol particulates, the additional energy retained within the coupled Earth/atmosphere system as a result of greenhouse gases was thus (10/7)[5.35 ln(390.7 / 326.1)] = 1.381 W m^{-2}, of which the IPCC regards nine-tenths, or 1.243 W m^{-2} as stored in the oceans, which represent 70.8% of the Earth's surface, giving 1.75 W m^{-2} in the oceans, or approximately six times the IPCC's value for the upper ocean alone.

Comment #30: *Ch. SPM, from page SPM-5, line 3, to page SPM-5, line 39*

To provide perspective, the *Summary for Policymakers* should indicate the sea-level rise equivalents of the observed or inferred ice-mass losses, and also the percentages of total ice mass represented by the losses.

Reason: Ice mass losses expressed in Gigatonnes are calculated to cause alarm that may be inappropriate once it is borne in mind that 400 Gt ice melt is equivalent to just 0.1 mm sea-level rise.

Examples: 210-371 Gt yr^{-1} ice loss in Greenland is equivalent to 0.5-0.9 mm yr^{-1} sea-level rise, and Antarctic ice loss of 65-112 Gt yr^{-1} is equivalent to 0.2-0.3 mm yr^{-1} sea-level rise, which, considering the very large volume of ice in the Antarctic, is a minuscule fraction of a percentage point each year.

Comment #31: *Ch. SPM, from page SPM-5, line 3, to page SPM-5, line 39*

To provide perspective, the shortness of the record should be emphasized, and observations from the early 20th century should be mentioned.

Reason: Monitoring of Arctic sea-ice extent by satellite only began in 1979, not quite a third of a century ago, and there is some evidence that the beginning of satellite monitoring coincided with an Arctic sea-ice maximum. Numerous reports from early in the 20th century, when temperatures in the North Atlantic are known to have been higher than the present, indicate that sea-ice extent in the Arctic may have been less then than today.

Example: A report by the US Meteorological Service in 1922 found an unprecedented ice-melt in the Arctic.

Comment #32: *Ch. SPM, from page SPM-5, line 32, to page SPM-5, line 35*

To take account of recent satellite data on Northern-Hemisphere snow cover extent, the draft should make plain that over the period of satellite coverage (before which the data are insufficient and unreliable and the anthropogenic influence was small) there has been no trend in fall or winter Northern-Hemisphere snow cover extent, with the downtrend (chiefly attributable to the period before 1990) confined to spring snow cover extent only.

Reason: Data from the Rutgers Snow and Ice Lab show that there was a zero trend in fall snow-cover extent; a statistically-insignificant increase in winter extent; and a decline in spring extent only.

Example: In 2010, Northern-Hemisphere winter snow cover extent reached a maximum greater than in any year since the satellite record began.

Comment #33: *Ch. SPM, from page SPM-5, line 44, to page SPM-5, line 45*

To provide historical perspective, delete the sentence "It is unequivocal that global mean sea level is rising as is evident from tide gauge records and satellite data", and substitute "Global mean sea level has been rising since at least 1850, but rates of increase since 1993 may be no greater than those observed from 1930-1950."

Reason: The current draft of the highlighted paragraph on sea level does not provide a proper historical perspective. In the *Summary for Policymakers,* highlighted paragraphs in particular must be presented in a balanced manner. It is very far from clear that there has been any significant acceleration in the rate of sea-level rise as a result of recent anthropogenic warming.

Example: In 2011-12, sea level actually fell.

Comment #34: *Ch. SPM, from page SPM-5, line 47, to page SPM-5, line 49*

To remove a false claim of near-certainty, delete the sentence "It is *virtually certain* that over the 20th century the mean rate of increase was between 1.4 to 2.0 mm yr^{-1}, and between 2.7 and 3.7 mm yr^{-1} since 1993." Replace it with the following: "Tide-gauges suggest that over the 20th century sea level rose 1.4-2.0 mm yr^{-1}. The apparent increase to 2.7-3.7 mm yr^{-1} from 1993 may in part be an artefact of the change to satellite altimetry in that year."

Reason: Sea level is sufficiently complex that claims of "virtual certainty" for rates of sea-level rise are unacceptable.

Examples: Issues such as tectonic subduction, variations in the length of the day, and isostatic recovery following the end of the Younger Dryas cooling event are among those that complicate sea-level measurement.

Comment #35: *Ch. SPM, from page SPM-5, line 51, to page SPM-5, line 52*

To make a qualitative point quantitative, after "It is *likely* that extreme sea levels have increased since 1970, and this is mainly caused by rising mean sea level", add the following sentence: "Sea level has risen by 0.1 m since 1970."

Reason: Storm surges are unlikely to be very much more serious as a result of a mean sea-level rise of only 0.1 m. This rate of increase, within natural variability, is too little to cause significant additional damage. One might with advantage omit all reference to this very limited influence on extreme storm surges.

Comment #36: *Ch. SPM, from page SPM-6, line 11, to page SPM-6, line 11*

To standardize scientific notation, remove references to "ppm" and replace them with "μatm" or "μbar".

Reason: The term "ppm" does not make it explicit whether the concentration is measured by volume or by mass (hence a footnote has had to be included). Also, it is clearer to express partial pressure as a fraction (in the present instance millionths) of the standard atmospheric pressure, and this convention is increasingly used in the scientific literature.

Comment #37: *Ch. SPM, from page SPM-6, line 25, to page SPM-6, line 28*

To restore correct use of scientific terms, the statement that "there is *very high confidence* that oceanic uptake of anthropogenic CO2 has resulted in gradual acidification of seawater evidenced by a decreasing pH in surface waters at a rate of between 0.015 and 0.024 per decade since the early 1980s" should be altered to remove the term "acidification", and the caption in Fig. SPM.2 should similarly be altered to replace the word "acidity" with "alkalinity".

Reason: The pH of the oceans has been estimated at 7.8-8.2. The oceans, therefore, are pronouncedly alkaline, since a neutral pH is 7.0. At a rate of 0.1-0.2 pH units per century, it might take as much as a millennium to render the oceans barely acid, and a further millennium or two before the oceans became as acid as rainwater at a pH of 5.4, even if one supposed that the buffering of the oceans as the flow over rocks would not be sufficient to maintain approximate homeostasis in ocean pH.

Comment #38: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore credibility, delete "Analyses of a number of independent paleoclimatic archives provide a multi-century perspective of Northern Hemisphere temperature and indicate that 1981-2010 was *very likely* the warmest 30-year period of the last 800 years. There is *medium confidence* that in the Northern Hemisphere 1981-2010 was the warmest 30-year period of the last 1300 years. There is *high confidence* that the Medieval Climate Anomaly, about 900 to 1400 CE, shows inconsistent temperature changes across seasons and regions, in contrast to the widespread temperature increase of the late 20th century." Delete references to *medium confidence* that glacier recessions and sea-ice extents are unusual in 2000 years.

Reason: This and succeeding comments list 450 papers on proxy surface temperature reconstructions by many methods from many regions showing the medieval warm period as real, global, and warmer than today. The IPCC departs from the literature on proxies and unduly favors papers based on modeling.

Examples: The following are examples of general temperature reconstructions, most of them global, that indicate the extent of the medieval warm period.

Bard, E. 2002. Climate shock: Abrupt changes over millennial time scales. *Physics Today* **55(12)**: 32-38.

Bell, B. and Menzel, D.H. 1972. Toward the observation and interpretation of solar phenomena. AFCRL F19628-69-C-0077 and AFCRL-TR-74-0357, Air Force Cambridge Research Laboratories, Bedford, MA, pp. 8-12.

Broecker, W.S. 2001. Was the Medieval Warm Period global? *Science* **291**: 1497-1499.

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Comment #39: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in the Northern Hemisphere are given below.

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To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in the Arctic are given below.

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Przybylak, R. 2000. Temporal and spatial variation of surface air temperature over the period of instrumental observations in the Arctic. *International Journal of Climatology* **20**: 587-614.

Przybylak, R. 2002. Changes in seasonal and annual high-frequency air temperature variability in the Arctic from 1951-1990. *International Journal of Climatology* **22**: 1017-1032.

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Comment #41: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Greenland are given below.

Alley, R.B., Meese, D.A., Shuman, C.A., Gow, A.J., Taylor, K.C., Grootes, P.M., White, J.C.W., Ram, M., Waddington, E.D., Mayewski, P.A., and Zielinski, G.A. 1993. Abrupt increase in Greenland snow accumulation at the end of the Younger Dryas event. *Nature* **362**: 527–529.

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Christiansen, H.H. 1998. 'Little Ice Age' navigation activity in northeast Greenland. *The Holocene* **8**: 719-728.

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Comment #42: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Iceland are given below.

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Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in North America are given below.

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Comment #44: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Europe and the Mediterranean are given below.

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Comment #45: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Russia and central Asia are given below.

Chen, F.-H., Chen, J.-H., Holmes, J., Boomer, I., Austin, P., Gates, J.B., Wang, N.-L., Brooks, S.J., and Zhang, J.-W. 2010. Moisture changes over the last millennium in arid central Asia: A review, synthesis and comparison with monsoon region. *Quaternary Science Reviews* **29**: 1055–1068.

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Xiong, F.S., Meuller, E.C. and Day, T.A. 2000. Photosynthetic and respiratory acclimation and growth response of Antarctic vascular plants to contrasting temperature regimes. *American Journal of Botany* **87**: 700-710.

Yang, B., Wang, J., Brauning, A., Dong, Z. and Esper, J. 2009. Late Holocene climatic and environmental changes in arid central Asia. *Quaternary International* **194**: 68-78.

Yoon, H.I., Park, B.-K., Kim, Y. and Kang, C.Y. 2002. Glaciomarine sedimentation and its paleoclimatic implications on the Antarctic Peninsula shelf over the last 15,000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* **185**: 235-254.

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Comment #46: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in India and Pakistan are given below.

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Comment #47: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in China are given below.

Bao, Y., Brauning, A. and Yafeng, S. 2003. Late Holocene temperature fluctuations on the Tibetan Plateau. *Quaternary Science Reviews* **22**: 2335-2344.

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Ge, Q., Zheng, J., Fang, X., Man, Z., Zhang, X., Zhang, P., and Wang, W.-C. 2003. Winter half-year temperature reconstruction for the middle and lower reaches of the Yellow River and Yangtze River, China, during the past 2000 years. *The Holocene* **13**: 933–940.

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Liu, Y., An, Z.S., Linderholm, H.W., Chen, D.L., Song, M.H., Cai, Q.F., Sun, J.S. and Tian, H. 2009. Annual temperatures during the last 2485 years in the mid-eastern Tibetan Plateau inferred from tree rings. *Science in China Series D Earth Science* **52**: 348-359.

Ma, Z., Li, H., Xia, M., Ku, T., Peng, Z., Chen, Y. and Zhang, Z. 2003. Paleo-temperature changes over the past 3000 years in eastern Beijing, China: A reconstruction based on Mg/Sr records in a stalagmite. *Chinese Science Bulletin* **48**: 395-400.

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Wen, H. and Wen, H. 1996. Winter-Half-Year Cold/Warm Change in Historical Period of China. Science Press, Beijing, China.

Wu, H.Q. and Dang, A.R. 1998. Fluctuation and characteristics of climate change in temperature of Sui-Tang times in China. *Quaternary Sciences* **1**: 31-38.

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Yafeng, S., Tandong, Y. and Bao, Y. 1999. Decadal climatic variations recorded in Guliya ice core and comparison with the historical documentary data from East China during the last 2000 years. *Science in China Series D-Earth Sciences* **42** Supp.: 91-100.

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Yang, B., Braeuning, A., Johnson, K.R. and Yafeng, S. 2002. General characteristics of temperature variation in China during the last two millennia. *Geophysical Research Letters* **29**: 10.1029/2001GL014485.

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Comment #48: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

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Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Japan are given below.

Aono, Y. and Saito, S. 2010. Clarifying springtime temperature reconstructions of the medieval period by gap-filling the cherry blossom phenological data series at Kyoto, Japan. *International Journal of Biometeorology* **54**: 211–219.

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Kudo, G. 1991. Effects of snow-free period on the phenology of alpine plants inhabiting snow patches. *Arctic and Alpine Research* **23**: 436–443.

Sakaguchi, Y. 1983. Warm and cold stages in the past 7600 years in Japan and their global sea level changes and the ancient Japanese history. *Bulletin of Department of Geography, University of Tokyo* **15**: 1–31.

Treydte, K.S., Frank, D.C., Saurer, M., Helle, G., Schleser, G.H. and Esper, J. 2009. Impact of climate and CO2 on a millennium-long tree-ring carbon isotope record. *Geochimica et Cosmochimica Acta* **73**: 4635-4647.

Yamada, K., Kamite, M., Saito-Kato, M., Okuno, M., Shinozuka, Y., and Yasuda, Y. 2010. Late Holocene monsoonal-climate change inferred from Lakes Ni-no-Megata and San-no-Megata, northeastern Japan. *Quaternary International* **220**: 122–132.

Yamanaka, H. 1979. Nivation hollows on the southeast slope of Mt Onishi, Iide Mountains, northeast Japan. *Annals of the Tohoku Geographical Association* **31**: 36–45.

Comment #49: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

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Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Africa are given below.

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Bond, G., Showers, W., Cheseby, M., Lotti, R., Almasi, P., deMenocal, P., Priore, P., Cullen, H., Hajdas, I., and Bonani, G. 1997. A pervasive millennial-scale cycle in North Atlantic Holocene and Glacial climate. *Science* **278**: 1257–1266.

Bond, G., Showers, W., Elliot, M., Evans, M., Lotti, R., Hajdas, I., Bonani, G., and Johnson, S. 1999. The North Atlantic's 1–2 kyr Climate Rhythm: Relation to Heinrich Events, Dansgaard/Oeschger Cycles, and the Little Ice Age. In *Mechanisms of Global Climate Change at Millennial Scales*, edited by P.U. Clark, R.S. Webb, and L.D. Keigwin, 35–58. Washington, DC: American Geophysical Union.

Buntgen, U., Frank, D.C., Nievergelt, D. and Esper, J. 2006. Summer temperature variations in the European Alps, A.D. 755-2004. *Journal of Climate* **19**: 5606-5623.

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Elenga, H., Schwartz, D., Vincens, A., Bertraux, J., de Namur, C., Martin, L., Wirrmann, D. and Servant, M. 1996. Diagramme pollinique holocene du Lac Kitina (Congo): mise en evidence de changements paleobotaniques et paleoclimatiques dans le massif forestier du Mayombe. *Compte-Rendu de l'Academie des Sciences, Paris, serie* **2a**: 345-356.

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Esper, J., Frank, D., Buntgen, U., Verstege, A., Luterbacher, J. and Xoplaki, E. 2007. Long-term drought severity variations in Morocco. *Geophysical Research Letters* **34**: 10.1029/2007GL030844.

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Gasse, F. and Van Campo, E. 1994. Abrupt post-glacial climate events in West Asia and North Africa monsoon domains. *Earth and Planetary Science Letters* **126**: 435–456.

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Huffman, T.N. 1996. Archaeological evidence for climatic change during the last 2000 years in southern Africa. *Quaternary International* **33**: 55-60.

Keigwin, L.D. 1996. The Little Ice Age and Medieval Warm Period in the Sargasso Sea. *Science* **274**: 1504–1507.

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Verschuren, D., Laird, K.R. and Cumming, B.F. 2000. Rainfall and drought in equatorial east Africa during the past 1,100 years. *Nature* **403**: 410-414.

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Comment #50: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in South America are given below.

Abbott, M.B., Binford, M.W., Brenner, M. and Kelts, K.R. 1997. A 3500 14C yr high resolution record of water-level changes in Lake Titicaca. *Quaternary Research* **47**: 169-180.

Binford, M.W., Kolata, A.L, Brenner, M., Janusek, J.W., Seddon, M.T., Abbott, M. and Curtis. J.H. 1997. Climate variation and the rise and fall of an Andean civilization. *Quaternary Research* **47**: 235-248.

Bird, B.W., Abbott, M.B., Vuille, M., Rodbell, D.T., Stansell, N.D. and Rosenmeier, M.F. 2011. A 2,300-year-long annually resolved record of the South American summer monsoon from the Peruvian Andes. *Proceedings of the National Academy of Sciences USA* **108**: 8583-8588.

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Cioccale, M.A. 1999. Climatic fluctuations in the Central Region of Argentina in the last 1000 years. *Quaternary International* **62**: 35-47.

Eichler, A., Brutsch, S., Olivier, S., Papina, T., and Schwikowski, M. 2009. A 750-year ice core record of past biogenic emissions from Siberian boreal forests. *Geophysical Research Letters* **36**: 10.1029/2009GL038807.

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Figueroa-Rangel, B.L., Willis, K.J. and Olvera-Vargas, M. 2010. Cloud forest dynamics in the Mexican neotropics during the last 1300 years. *Global Change Biology* **16**: 1689-1704.

Fletcher, M.-S. and Moreno, P.I. 2012. Vegetation, climate and fire regime changes in the Andean region of southern Chile (38°S) covaried with centennial-scale climate anomalies in the tropical Pacific over the last 1500 years. *Quaternary Science Reviews* **46**: 46-56.

Hansen, B.C.S., Seltzer, G.O. and Wright Jr., H.E. 1994. Late Quaternary vegetational change in the central Peruvian Andes. *Palaeogeography, Palaeoclimatology, Palaeoecology* **109**: 263-285.

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Jenny, B., Valero-Garces, B.L., Urrutia, R., Kelts, K., Veit, H., Appleby, P.G. and Geyh, M. 2002. Moisture changes and fluctuations of the Westerlies in Mediterranean Central Chile during the last 2000 years: The Laguna Aculeo record (33°50'S). *Quaternary International* **87**: 3-18.

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Kellerhals, T., Brutsch, S., Sigl, M., Knusel, S., Gaggeler, H.W., and Schwikowski, M. 2010. Ammonium concentration in ice cores: A new proxy for regional temperature reconstruction? *Journal of Geophysical Research* **115**: 10.1029/2009JD012603.

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Seltzer, G. and Hastorf, C. 1990. Climatic change and its effect on Prehispanic agriculture in the central Peruvian Andes. *Journal of Field Archaeology* **17**: 397-414.

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Wells, L.E. 1990. Holocene history of the El Niño phenomenon as recorded in flood sediments of northern coastal Peru. *Geology* **18**: 1134-1137.

Wright Jr., H.E. 1984. Late glacial and Late Holocene moraines in the Cerros Cuchpanga, central Peru. *Quaternary Research* **21**: 275-285.

Comment #51: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all

parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period in Antarctica are given below.

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Castellano, E., Becagli, S., Hansson, M., Hutterli, M., Petit, J.R., Rampino, M.R., Severi, M., Steffensen, J.P., Traversi, R. and Udisti, R. 2005. Holocene volcanic history as recorded in the sulfate stratigraphy of the European Project for Ice Coring in Antarctica Dome C (EDC96) ice core. *Journal of Geophysical Research* **110**: 10.1029/JD005259.

Comiso, J.C. 2000. Variability and trends in Antarctic surface temperatures from *in situ* and satellite infrared measurements. *Journal of Climate* **13**: 1674-1696.

Cook, A.J. and Vaughan, D. 2009. Overview of areal changes of the ice shelves on the Antarctic Peninsula over the past 50 years. *The Cryosphere Discussions* **3**: 579–630.

Cook, E., Palmer, J., and D'Arrigo, R. 2002. Evidence for a Medieval Warm Period in a 1100-year tree-ring reconstruction of past austral summer temperatures in New Zealand. *Geophysical Research Letters* **29**: 10.1029/2001GL014580.

Domack, E.W., Leventer, A., Dunbar, R., Taylor, F., Brachfeld, S. and Sjunneskog, C. 2000. Chronology of the Palmer Deep site, Antarctic Peninsula: A Holocene palaeoenvironmental reference for the circum-Antarctic. *The Holocene* **11**: 1-9.

Doran, P.T., Priscu, J.C., Lyons, W.B., Walsh, J.E., Fountain, A.G., McKnight, D.M., Moorhead, D.L., Virginia, R.A., Wall, D.H., Clow, G.D., Fritsen, C.H., McKay, C.P. and Parsons, A.N. 2002. Antarctic climate cooling and terrestrial ecosystem response. *Nature* advance online publication, 13 January 2002 (DOI 10.1038/nature710).

Goosse, H., Masson-Delmotte, V., Renssen, H., Delmotte, M., Fichefet, T., Morgan, V., van Ommen, T., Khim, B.K. and Stenni, B. 2004. A late medieval warm period in the Southern Ocean as a delayed response to external forcing. *Geophysical Research Letters* **31**: 10.1029/2003GL019140.

Hall, B. 2007. Late-Holocene advance of the Collins Ice Cap, King George Island, South Shetland Islands. *The Holocene* **17**: 1253–1258.

Hall, B.L. and Denton, G.H. 1999. New relative sea-level curves for the southern Scott Coast, Antarctica: evidence for Holocene deglaciation of the western Ross Sea. *Journal of Quaternary Science* **14**: 641-650.

Hall, B.L. and Denton, G.H. 2002. Holocene history of the Wilson Piedmont Glacier along the southern Scott Coast, Antarctica. *The Holocene* **12**: 619-627.

Hall, B.L., Hoelzel, A.R., Baroni, C., Denton, G.H., Le Boeuf, B.J., Overturf, B. and Topf, A.L. 2006. Holocene elephant seal distribution implies warmer-than-present climate in the Ross Sea. *Proceedings of the National Academy of Sciences USA* **103**: 10,213-10,217.

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Leventer, A., Domack, E.W., Ishman, S.E., Brachfeld, S., McClennen, C.E. and Manley, P. 1996. Productivity cycles of 200-300 years in the Antarctic Peninsula region: Understanding linkage among the sun, atmosphere, oceans, sea ice, and biota. *Geological Society of America Bulletin* **108**: 1626-1644.

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McDermott, F., Mattey, D.P. and Hawkesworth, C. 2001. Centennial-scale Holocene climate variability revealed by a high-resolution speleothem ð18O record from SW Ireland. *Science* **294**: 1328-1331.

Monnin, E., Indermühle, A., Dällenbach, A., Flückiger, J., Stauffer, B., Stocker, T.F., Raynaud, D. and Barnola, J.-M. 2001. Atmospheric CO2 concentrations over the last glacial termination. *Nature* **291**: 112-114.

Näslund, J.O., Fastook, J.L and Holmlund, P. 2000. Numerical modeling of the ice sheet in western Dronning Maud Land, East Antarctica: impacts of present, past andfuture climates. *Journal of Glaciology* **46**: 54-66.

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Petit, J.R., Jouzel, J., Raynaud, D., Barkov, N.I., Barnola, J.-M., Basile, I., Bender, M., Chappellaz, J., Davis, M., Delaygue, G., Delmotte, M., Kotlyakov, V.M., Legrand, M., Lipenkov, V.Y., Lorius, C., Pepin, L., Ritz, C., Saltzman, E. and Stievenard, M. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. *Nature* **399**: 429-436.

Schaefer, J., Denton, G., Kaplan, M., Putnam, A., Finkel, R., Barrell, D.J.A., Andersen, B.G., Schwartz, R., Mackintosh, A., Chinn, T., and Schluchter, C. 2009. High-frequency Holocene glacier fluctuations in New Zealand differ from the northern signature. *Science* **324**: 622–625.

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Williams, M.B., Aydin, M., Tatum, C. and Saltzman, E.S. 2007. A 2000 year atmospheric history of methyl chloride from a South Pole ice core: Evidence for climate-controlled variability. *Geophysical Research Letters* **34**: 10.1029/2006GL029142.

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Comment #52: *Ch. SPM, from page SPM-6, line 41, to page SPM-6, line 48*

To restore lost credibility, the IPCC must make a less partisan and more impartial appraisal of the extensive peer-reviewed literature from all parts of the world establishing by a variety of proxy temperature reconstructions that the medieval warm period was real, was global, and was warmer than the present. In this and succeeding comments, some 450 papers inconsistent with the IPCC's current draft are presented.

Reason: The IPCC's conclusion that today's temperatures are greater than those of the medieval warm period is inconsistent with the preponderance of the published literature on temperature proxies and relies too heavily on modeling.

Examples: Some papers indicating the reality, extent, and magnitude of the medieval warm period worldwide during the "Little Medieval Warm Period" are given below.

Baedke, S.J. and Thompson, T.A. 2000. A 4700-year record of lake level and isostasy for Lake Michigan. *Journal of Great Lakes Research* **26**: 416–426.

Barron, J.A. and Bukry, D. 2007. Solar forcing of Gulf of California climate during the past 2000 yr suggested by diatoms and silicoflagellates. *Marine Micropaleontology* **62**: 115–139.

Bartholy, J., Pongracz, R., and Molnar, Z. 2004. Classification and analysis of past climate information based on historical documentary sources for the Carpathian Basin. *International Journal of Climatology* **24**: 1759–1776.

Black, D.E., Abahazi, M.A., Thunell, R.C., Kaplan, A., Tappa, E.J., and Peterson, L.C. 2007. An 8-century tropical Atlantic SST record from the Cariaco Basin: Baseline variability, twentieth-century warming, and Atlantic hurricane frequency. *Paleoceanography* **22**: 10.1029/2007PA001427.

Blundell, A. and Barber, K. 2005. A 2800-year palaeoclimatic record from Tore Hill Moss, Strathspey, Scotland: the need for a multi-proxy approach to peat-based climate reconstructions. *Quaternary Science Reviews* **24**: 1261–1277.

Büntgen, U., Esper, J., Frank, D.C., Nicolussi, K., and Schmidhalter, M. 2005. A 1052-year tree-ring proxy for Alpine summer temperatures. *Climate Dynamics* **25**: 141–153.

Cage, A.G. and Austin, W.E.N. 2008. Seasonal dynamics of coastal water masses in a Scottish fjord and their potential influence on benthic foraminiferal shell geochemistry. In: Austin, Cage, A.G. and Austin, W.E.N. 2010. Marine climate variability during the last millennium: The Loch Sunart record, Scotland, UK. *Quaternary Science Reviews*: 10.1016/j.quascirev.2010.01.014.

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Chuine, I., Yiou, P., Viovy, N., Seguin, B., Daux, V., and Le Roy Ladurie, E. 2004. Grape ripening as a past climate indicator. *Nature* **432**: 289–290.

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Dean, J.S. 1994. The Medieval Warm Period on the southern Colorado Plateau. *Climatic Change* **25**: 225–241.

Eronen, M., Zetterberg, P., Briffa, K.R., Lindholm, M., Merilainen, J., and Timonen, M. 2002. The supra-long Scots pine tree-ring record for Finnish Lapland: Part 1, chronology construction and initial inferences. *The Holocene* **12**: 673–680.

Fleitmann, D., Burns, S.J., Neff, U., Mudelsee, M., Mangini, A., and Matter, A. 2004. Palaeoclimatic interpretation of high-resolution oxygen isotope profiles derived from annually laminated speleothems from Southern Oman. *Quaternary Science Reviews* **23**: 935–945.

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Holmgren, K., Tyson, P.D., Moberg, A., and Svanered, O. 2001. A preliminary 3000-year regional temperature reconstruction for South Africa. *South African Journal of Science* **99**: 49–51.

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Loehle, C. 2004. Climate change: detection and attribution of trends from long-term geologic data. *Ecological Modelling* **171**: 433–450.

Luckman, B.H. and Wilson, R.J.S. 2005. Summer temperatures in the Canadian Rockies during the last millennium: a revised record. *Climate Dynamics* **24**: 131–144.

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Comment #53: *Ch. SPM, from page SPM-7, line 17, to page SPM-7, line 18*

To remove a false statistical interpretation, delete the sentence "Longer-term trends of sea level change during the last few thousand years were about 10 times smaller than the trend during the 20th century."

Reason: Fluctuations over the short term will generally be greater than trends over the longer term, regardless of the causes of the fluctuations: therefore the cited sentence misleads by its implication that the order-of-magnitude difference between short-run and long-run trends is unusual, and should either be heavily qualified or preferably deleted.

Comment #54: *Ch. SPM, from page SPM-7, line 24, to page SPM-7, line 24*

To ensure scientific precision and neutrality, in the sentence "Natural and anthropogenic drivers cause imbalances in the Earth's energy budget", delete "imbalances" and insert "changes".

Reason: The atmosphere is bounded by outer space above and the ocean heat-sink below, suggesting that powerful homeostasis is likely. Indeed, reconstructions of global mean surface temperatures over the past 64 million years (e.g. Zachos *et al.,* 2001) and over the past 750 million years (e.g. Scotese, 1999) suggest that temperatures have not varied by more than 3% (8 K) in absolute terms. In such circumstances, the word "imbalances" is not scientifically plausible.

Comment #55: *Ch. SPM, from page SPM-7, line 28, to page SPM-7, line 29*

To increase scientific precision, the statement "Globally, CO2 is the strongest driver of climate change compared to other changes in the atmospheric composition, and changes in surface conditions" should be rewritten "Globally, in recent decades, increases in the atmospheric concentration of CO2 have proven more influential as forcers of global warming than increases in the concentration of other greenhouse gases."

Reason: Some papers (e.g. Murphy *et al.,* 2009) have shown the negative aerosol forcing as being equal to the entire CO2 forcing in recent decades. The redrafted sentence ensures accuracy even if this is so.

Comment #56: *Ch. SPM, from page SPM-7, line 28, to page SPM-7, line 29*

To add useful detail, insert after "changes in surface conditions" the new sentence "CO2 is thought to represent ~70% of all greenhouse-gas forcings."

Reason: The IPCC's 2001 report estimated that some 70-80% of all greenhouse-gas forcings were attributable to CO_2 alone. The 2007 report was less explicit, but analysis of Table 10.26 on p. 803 indicates that the models on which the IPCC's central projections for the present century are predicated were assuming a 70% contribution from CO_2.

Comment #57: *Ch. SPM, from page SPM-7, line 29, to page SPM-7, line 30*

To take account of the fact that natural drivers of temperature change have prevailed over anthropogenic influences over the past 16 years, rewrite "Its relative contribution has further increased since the 1980s and by far outweighs the contributions from natural drivers" to read "Its relative contribution has continued to increase since the 1980s, but it has not proven strong enough to outweigh natural cooling influences over the past decade and a half, though it is expected to outweigh such influences over the longer term."

Reason: Since there has been no global warming for 16 years, the unqualified statement that the contribution from CO_2 "far outweighs the contributions from natural drivers" will not be taken seriously.

Comment #58: *Ch. SPM, from page SPM-7, line 39, to page SPM-7, line 41*

To ensure perspective, after the sentence stating that mean CO_2 concentration has increased by a quarter since 1958 add the following: "For comparison, the atmospheric concentration of CO_2 was not less than 30% in the Neoproterozoic era; it is thought to have been 0.03% at the start of the industrial revolution in 1750; it is now 0.04%; and, in the absence of significant mitigation, it is expected to reach 0.07% by 2100."

Reason: The dolomitic limestones that were deposited in the Neoproterozoic could not have formed unless the partial pressure of CO_2 was at least 0.3 atm. Since then, formation first of dolomites, then of amagnesic limestones, then of gypsum, then of calcifying organisms has reduced the atmospheric concentration to perhaps its lowest point in the past billion years.

Comment #59: *Ch. SPM, from page SPM-8, line 1, to page SPM-8, line 5*

To increase precision, rewrite "There is consistent evidence from observations of a net energy uptake of the Earth System due to an imbalance in the energy budget. It is *virtually certain* that this is caused by human activities, primarily by the increase in CO2 concentrations. There is very high confidence that natural forcing contributes only a small fraction to this imbalance." to read "Observations indicate that the rate of radiant-energy dissipation to space has slowed. It is *virtually certain* that much of this is caused by human activities, primarily by the increase in CO2 concentrations. Short-term natural forcing has offset the warming effect of this change in the past decade and a half and may do so for another two decades, but is likely to be close to zero in the long term."

Reason: The term "energy imbalance" is imprecise. Also, there has been no warming for 16 years and it is possible that natural forcings may remain sufficiently net-negative over the coming decades to inhibit net warming.

Comment #60: *Ch. SPM, from page SPM-8, line 1, to page SPM-8, line 5*

To ensure internal consistency, delete the sentence "There is *very high confidence* that natural forcing contributes only a small fraction to this imbalance."

Reason: Later, the *Summary for Policymakers* makes the (not well justified) assertion that up to 1.4 K global warming ought in theory to have occurred since the mid-20th century as a result of our influence on climate, even though only 0.6 K warming was observed over the period. Given that the estimated negative forcing from the direct and indirect effects of anthropogenic particulate aerosols has now (rightly) been reduced, a net-negative natural forcing of some magnitude is implicit in the IPCC's current high-end estimate of the quantum of anthropogenic warming over the period, which must accordingly be countervailing the energy "imbalance" to a substantial degree.

Comment #61: *Ch. SPM, from page SPM-8, line 7, to page SPM-8, line 10*

To make the central mathematics of climate sensitivity inferred from observed temperature change plausible, reverify the [1.8,3.0] $W m^{-2}$ anthropogenic radiative forcing (for clarity the term should be spelled out in full).

Reason: Most anthropogenic radiative forcing is thought to have occurred since 1950. Accordingly, a sub-centennial-scale climate-sensitivity parameter ~0.4 K W^{-1} m^2 should be applied, for fewer than half of equilibrium feedbacks will have acted. Accordingly, the implicit interval of anthropogenic warming expected since 1750 is [0.7, 1.2] K. Warming since 1750, as a linear trend on the Central England Temperature Record (latitudinally and, in the period of overlap with the global instrumental record, observationally a good proxy for global mean warming), was 0.9 K. The IPCC's implicit [0.7, 1.2] K interval thus implies that ~100% of post-1750 warming was anthropogenic. If so, the IPCC should say so. Otherwise, it should reduce the lower bound of the anthropogenic radiative forcing interval.

Comment #62: *Ch. SPM, from page SPM-8, line 20, to page SPM-8, line 23*

To diminish a transparent fudge-factor, substantially reduce both the negative magnitude of the radiative forcing from aerosols and, in the sentence "The uncertainty in the aerosol contribution dominates the overall net uncertainty in RF, but there is *high confidence* that aerosols have offset part of the forcing caused by the well-mixed greenhouse gases", the confidence level.

Reason: The increase in particulate-aerosol emissions in Asia has largely been offset by a very substantial reduction in such emissions in the West via clean-air laws. Furthermore, even the sign of the aerosol contribution is unknown. It has long been apparent that the negative aerosol contribution has become a convenient fudge-factor allowing an unwarrantable increase in climate sensitivity inferred from observational temperature change.

Comment #63: *Ch. SPM, from page SPM-8, line 20, to page SPM-8, line 23*

To take account of the latest research on the cosmic-ray influence over aerosol nucleation and cloud condensation, delete "but there is *high confidence* that the effect is too weak to have any significant climatic influence during a solar cycle or over the last century."

Reason: From 1925-1995, peaking in ~1960, there was a 70-year period of solar activity that came close to being a Grand Maximum. Pinker *et al.* (2005) noted a substantial decrease in cloud cover from 1983-2001, which may well have contributed a substantial proportion of the warming over that period. Studies by Svensmark *et al.,* now widely replicated throughout the literature, demonstrate that the small direct solar forcing is amplified approximately sevenfold by the cosmic-ray effect, which he has recently been able to explain completely by molecular-level chemical equations.

Comment #64: *Ch. SPM, from page SPM-8, line 50, to page SPM-8, line 51*

To make explicit the central source of uncertainty in determining climate sensitivity, add after "theoretical studies of feedback processes" the clause "none of which is directly measurable".

Reason: In the IPCC's method, temperature feedbacks are imagined to near-triple the relatively small direct warming caused by anthropogenic radiative forcings. For instance, the CO2 radiative forcing implies less than 1.2 K direct warming at a CO2 doubling: yet the models relied upon by the IPCC (2007, p. 298, box 10.2) imagine 3.26 K warming will have occurred at equilibrium, implying an overall feedback gain factor >2.8. This gain factor is essentially guesswork, and is near-certainly a very substantial exaggeration. Indeed, even the sign of the contribution from temperature feedbacks is unknown, and various studies (e.g. Lindzen & Choi, 2009, 2011; Spencer & Braswell, 2010,. 2011) have found it to be negative.

Comment #65: *Ch. SPM, from page SPM-9, line 3, to page SPM-9, line 5*

To introduce some realism, delete "Development of climate models has resulted in more realism in the representation of many quantities and aspects of the climate system, including large-scale precipitation, Arctic sea ice, ocean heat content, extreme events, and the climate effects of stratospheric ozone", and insert "Climate models are inherently incapable of making reliable, very-long-term predictions of the future evolution of the complex, non-linear, chaotic climate object. Initial parameters are unknown to a sufficient resolution or precision. For example, models failed to predict the recent 16-year stasis in global warming. Major processes such as temperature feedbacks are unmeasurable and insufficiently understood."

Reason: The obsession with models is imprudent given their inescapable limitations. Models can be and have been tweaked to reproduce past climate changes but, on the whole, have been – and will probably always be – incapable of making reliable predictions for more than a week or two ahead.

Comment #66: *Ch. SPM, from page SPM-9, line 7, to page SPM-9, line 10*

To remove absurdity, delete "There is *very high confidence* that coupled climate models provide realistic responses to external forcing. This is evident from simulations of the surface temperature on continental and larger scales, and the global-scale surface temperature increase over the historical period, especially the last fifty years."

Reason: The climate is chaotic and hence inherently unpredictable; the values of initial parameters are unknown; and not one of the temperature feedbacks that contribute two-thirds of all model-predicted warming can be measured directly. None of the models predicted there would be no warming for 16 years. Claiming"very high confidence" that the models are realistic on the basis of hindcasting, when forecasting has proven so inept, is mere rodomontade. It is now time for the IPCC to admit the limitations of the models.

Comment #67: *Ch. SPM, from page SPM-9, line 18, to page SPM-9, line 20*

To remove an absurd claim, delete "There is *very high confidence* that climate models realistically simulate the annual cycle of Arctic sea-ice extent, and there is *high confidence* that they realistically simulate the trend in Arctic sea-ice extent over the past decades."

Reason: To be able to simulate the waxing and waning of Arctic sea ice with the seasons is so elementary that one does not require a coupled model to perform that task, which can be performed by a pocket calculator. And the "high confidence" that models can realistically simulate any *past* trend is simply silly. The question is whether models can reliably predict any *future* trend: and, given not only the short-term but also the multi-decadal variability of Arctic and Antarctic sea-ice extent, it is doubtful whether current models can predict those extents reliably. The models did not predict the growth in Antarctic sea-ice extent over recent decades.

Comment #68: *Ch. SPM, from page SPM-9, line 22, to page SPM-9, line 23*

To remove a further absurd claim, delete "There is *high confidence* that many models simulate realistically the observed trend in ocean heat content."

Reason: For a start, measurements of ocean heat content lack sufficient precision, and particularly resolution, to allow any meaningful determination of the trend in ocean heat content, particularly at depth. Furthermore, "high confidence" that models tweaked to reproduce past trends are capable of reproducing those trends is a self-congratulatory instance of *petitio principii*.

Comment #69: *Ch. SPM, from page SPM-9, line 31, to page SPM-9, line 33*

To remove yet another absurd claim, delete "There is *high confidence* that the global distribution of temperature extremes is represented well by models. The observed warming trend of temperature extremes in the second half of the 20th century is well simulated."

Reason: Yet again there is a claim that hindsight is working well. Yet it is foresight that matters: and there is no admission of just how badly the models have failed to predict the failure of the world to warm at anything like the predicted rate. The central implausibility in current predictions is that, after an observed warming rate equivalent 1.2 K/century since 1950 and a period of 16 years without any warming at all, the models predict 3 K/century to 2100.

Comment #70: *Ch. SPM, from page SPM-9, line 37, to page SPM-9, line 38*

To remove yet another hindcasting claim, delete "There is *high confidence* that most ESMs [Earth system models] produce global land and ocean sinks over the latter part of the 20th century that are consistent with the range of observational estimates.

Reason: Yet again, the question is not whether models can be or have been tweaked to reproduce past climatic changes but whether they are capable of reliably predicting future change.

Comment #71: *Ch. SPM, from page SPM-9, line 44, to page SPM-9, line 50*

To admit uncertainties fairly, delete "Various feedbacks associated with water vapour can now be quantified, and together they are assessed to be *very likely* positive and therefore to amplify climate changes. The net radiative feedback due to all cloud types is *likely* positive." Insert "The magnitude and sign of net temperature feedbacks is unknown. The inferred temperature stability of the past 64 Ma suggests that feedbacks are more likely to be somewhat net-negative than strongly net-positive."

Reason: No feedback can be reliably quantified by measurement or theory. Though the Clausius-Clapeyron relation says the space occupied by the atmosphere *can* hold near-exponentially more water vapour as it warms, it does not say it *must*. The primary influence of clouds is in reflecting incoming radiation and providing shade during the day, rather than in retaining at night radiation that would otherwise escape. The cloud feedback is near-certainly negative: see e.g. Spencer & Braswell (2010. 2011).

Comment #72: *Ch. SPM, from page SPM-10, line 8, to page SPM-10, line 9*

To demonstrate proper scientific caution, in the sentence "It is *extremely likely* that human activities have caused more than half of the observed increase in global average surface temperature since the 1950s", replace "*extremely likely*" with "possible".

Reason: Over a span as short as half a century, little more than the 0.3 K W^{-1} m^2 zero-feedback climate-sensitivity parameter will have operated; and, if feedbacks are significantly net-negative over the short term, as Lindzen & Choi (2009 2011) find them to be, this parameter could be as low as 0.2 K W^{-1} m^2. In that event, assuming 305 µatm CO2 concentration in 1950 and 392 µatm in 2012, warming attributable to CO2 alone would be 0.2[5.35 ln(392/305)] = 0.27 K, and, dividing by 0.7 to allow for other greenhouse gases, 0.38 K. If the aerosol negative forcing is as strong as the IPCC imagines, anthropogenic warming could have been less than 0.3 K: i.e., less than half of the 0.7 K warming since 1950.

Comment #73: *Ch. SPM, from page SPM-10, line 9, to page SPM-10, line 11*

To retain some credibility, delete "There is *high confidence* that this has caused large-scale changes in the ocean, in the cryosphere, and in sea level in the second half of the 20th century. Some extreme events have changed as a result of anthropogenic influence."

Reason: It is not clear whether "this" refers to the total warming of 0.7 K since 1950 or to the anthropogenic fraction of warming since that year, which could be less than 0.3 K. Nor is it clear what "large-scale changes in the ocean [and] in the cryosphere" are. And, since there is no evidence that sea level has risen any faster since 1950 than before 1950 (the change in the measurement method in 1993 having disturbed the record), one cannot say sea level has suffered "large-scale changes" since 1950. Furthermore, if anthropogenic warming has been less than 0.3 K, then its influence on extreme events will have been negligible. In any event, climate system changes as a result of cooling would be far more severe than changes driven by warming.

Comment #74: *Ch. SPM, from page SPM-10, line 28, to page SPM-10, line 30*

To remove a scientific absurdity, delete "The greenhouse gas contribution to the warming from 1951-2010 is in the range between 0.6 and 1.4 C°. This is *very likely* greater than the total observed warming of approximately 0.6 C° over the same period."

Reason: The 70-year period 1925-1995, peaking in ~1960, was very nearly a solar Grand Maximum. If climate sensitivity were anything like as high as the models are instructed to assume, the warming caused by the elevated solar activity would have persisted for two or three decades beyond 1960. Alternatively, if the solar influence is as small as the models posit, and if it is not amplified significantly by cosmic rays, then on any view it could not have caused as much as 0.8 C° cooling since 1951, as is implied here. This sentence, and the underlying sub-chapter, appear to be a maladroit attempt to justify continued alarm about the climate in the absence of any evidence of warming at anything like the rate the models had predicted. It must go.

Comment #75: *Ch. SPM, from page SPM-10, line 28, to page SPM-10, line 30*

To retain scientific credibility, amend "Over every continent except Antarctica, anthropogenic influence has *likely* made a substantial contribution to surface temperature increases since the mid-20th century" to read "Over every region except Antarctica and central Africa, anthropogenic influence may have made some contribution to surface temperature increases since the mid-20th century."

Reason: The warming rate equivalent to <1.2 K/century since 1950 is well within the natural variability of the climate, particularly bearing in mind the possibility of a continuing recovery of global temperatures following the very cold weather of the Grand Minimum of 1645-1715. The existing sentence, therefore, is yet another overstatement and must be toned down.

Comment #76: *Ch. SPM, from page SPM-10, line 36, to page SPM-10, line 39*

To reflect the models' limitations correctly, delete "Climate model simulations that include only natural forcings (volcanic eruptions and

solar variations) can explain a substantial part of the pre-industrial inter-decadal temperature variability since 1400 but fail to explain more recent warming since 1950."

Reason: The offending sentence, like similar statements in previous IPCC reports, is an instance of the fundamental Aristotelian logical fallacy of the *argumentum ad ignorantiam,* the fallacy of arguing from ignorance. It has no evidential value and, therefore, no place in a scientific document. Natural variability on its own is sufficient to explain all recent warming (though it is possible that some of that warming was anthropogenic). For instance, the central England temperature record shows warming at a rate equivalent to 4 K/century during the 40 years 1695-1735: yet the IPCC's very low estimate of solar forcing would render so large a warming impossible. Models underestimate natural variability.

Comment #77: *Ch. SPM, from page SPM-10, line 36, to page SPM-10, line 39*

To restore balance, amend "It is *very likely* that more than half of the ocean warming observed since the 1970s is caused by external forcing, mainly due to a combination of both anthropogenic forcing and volcanic eruptions" to read "Insofar as the ocean may have warmed since the 1970s, it is possible that some of the warming may have been caused by external forcing, such as anthropogenic and volcanic forcings."

Reason: Measurements are inadequate to establish the extent or magnitude of ocean warming: even the 3000 ARGO bathythermograph buoys do no more than the equivalent of taking a single temperature and salinity profile in the whole of Lake Superior less than once a year. Furthermore, we do not have a sufficiently long data series to tell us whether or at what rate the ocean is warming, and there is no analysis of variability the considerable direct heating of the deep ocean caused by the 6000+ subsea volcanoes. This sentence is guesswork and should be deleted.

Comment #78: *Ch. SPM, from page SPM-10, line 50, to page SPM-10, line 53*

To reflect measurement uncertainties properly, delete "There is *medium confidence* for anthropogenic contributions to an increase in atmospheric moisture content and tropospheric specific humidity, and to changes in zonal precipitation patterns over land with reductions in low latitudes and increases in northern hemisphere mid to high latitudes since 1950."

Reason: Water vapor is not a well-mixed greenhouse gas. Its concentration is highly variable seasonally, latitudinally, and altitudinally. There is altogether insufficient information to establish whether the changes mentioned in this sentence have occurred at all, still less whether the changes are beyond natural variability. This is more guesswork and it should be deleted.

Comment #79: *Ch. SPM, from page SPM-11, line 4, to page SPM-11, line 6*

To increase scientific precision, replace the sentence "There is *medium confidence* that the observed small net increase in Antarctic sea ice extent is consistent with internal variability" with "There is *medium confidence* that the observed net increase in Antarctic sea ice extent over the past three decades – a net increase equivalent to almost half of the net loss of sea ice extent in the Arctic over the period – is consistent with internal variability."

Reason: If the gain in Antarctic sea ice were "small", then the loss in Arctic sea ice would not be very great. It is better to demonstrate balance here.

Comment #80: *Ch. SPM, from page SPM-11, line 6, to page SPM-11, line 8*

To increase scientific precision and restore balance, rewrite "Human influences are the *likely* cause for a substantial reduction in glaciers since the 1960s (*high confidence*), and reductions in snow cover and permafrost since the 1970s (*medium confidence*)" to read "Anthropogenic influences may have contributed since the 1960s to the reduction in some mountain glacier lengths that began in the 1880s, and to reductions in permafrost since the 1970s, but there has been no significant reduction in glacier lengths in most of Antarctica (where nearly all of the world's 160,000+ glaciers are to be found), and no significant reduction in northern-hemisphere snow cover except during the spring."

Reason: The IPCC has consistently exaggerated the effects of warmer weather on the cryosphere. To avoid further embarrassment, it should tone down its claims and be more precise about them.

Example: In 2010, winter snow cover extent in the Northern Hemisphere reached a high only exceeded on one occasion some 30 years previously.

Comment #81: *Ch. SPM, from page SPM-11, line 10, to page SPM-11, line 11*

To reflect the literature more accurately, replace "It is *likely* that anthropogenic forcings have contributed to the increased surface melt of Greenland since 2000" with "Greenland's ice sheet may have thickened by 0.5 m except at the coastal fringes from 1992-2003, and may have thinned by 0.1-0.3 m in the decade since then, but, since there has been no global warming since 1998, the anthropogenic contribution to comparatively small loss of ice thickness in Greenland since 2003 must have been negligible."

Reason: Johannessen *et al.* (2005) found that the mean thickness of a study area of land-based ice in Greenland had increased by >5 cm/year during each of the 12 years 1992-2003. Subsequent studies have shown some thinning of the ice sheet. On these data it is not safe to attribute any significant loss of ice thickness in Greenland to anthropogenic influences.

Comment #82: *Ch. SPM, from page SPM-11, line 11, to page SPM-11, line 12*

To increase precision, replace "There is only *low confidence* of a human contribution to the observed loss of Antarctic ice sheet mass since 1990 due to limited scientific understanding of the processes involved", and with "There has been some loss of ice sheet mass in West Antarctica, notably in the Antarctic Peninsula, but Antarctica as a whole has cooled for 30 years and ice mass in East Antarctica has *very likely* increased."

Reason: East Antarctica has cooled so sharply in recent decades that environmental damage owing to the cooling has been observed in some of the Antarctic glens (e.g. Doran *et al.,* 2002). Recent attempts to maintain that East Antarctica has warmed and lost ice mass are based on questionable statistical techniques, including unduly imaginative interpolations of data over vast regions where no measurements have been taken.

Comment #83: *Ch. SPM, from page SPM-11, line 27, to page SPM-11, line 29*

To reflect uncertainties in the sign and magnitude of net temperature feedbacks, replace "Equilibrium climate sensitivity is *likely* in the range 2 C^{o} to 4.5 C^{o}, and *very likely* above 1.5 C^{o}. The most likely value is near

3 C° ” with "Sensitivity to a doubling of atmospheric CO2 concentration where temperature feedbacks are net-zero is <1.2 C°. Some studies have estimated that sensitivity may be as low as 0.7 C°, implying net-negative feedbacks. Other studies assuming net-positive feedbacks estimate that equilibrium sensitivity is 2 C° to 4.5 C°. Data are insufficient to determine either the net impact of feedbacks – the major source of uncertainty – or final climate sensitivity."

Reason: Numerous studies are finding temperature feedbacks net-negative and climate sensitivity low. These studies are not adequately reflected in the IPCC's reports, which ought to take a more neutral and honest view of the increasing likelihood that climate sensitivity is nothing like as high as it has previously suggested.

Comment #84: *Ch. SPM, from page SPM-11, line 31, to page SPM-11, line 33*

To take account of observations and of the uncertainty in climate sensitivity, rewrite "The total amount of anthropogenic emissions of long-lived greenhouse gases largely determines the warming in the 21st century. The global mean warming per 1000 PgC is *very likely* between 0.8 C°-3 C°" to read "Though there has been no global warming in the 21st century, it is *likely* that anthropogenic emissions of long-lived greenhouse gases will cause some warming in the 21st century."

Reason: In the absence of recent warming and of any significant natural cooling to countervail against the anthropogenic warming influence, it must now be questioned whether climate sensitivity to any forcing is as large as the IPCC imagines. The absence of recent warming must be explicitly faced and mentioned, and its possible implications for climate sensitivity discussed. If the IPCC is to retain any credibility, it cannot simply ignore the failure of the climate to warm as the models had predicted.

Comment #85: *Ch. SPM, from page SPM-11, line 44, to page SPM-11, line 47*

To reflect the uncertainties inherent in climate modeling, add the following after the introductory sentence describing the hierarchy of climate models: "Since the climate behaves as a chaotic object. reliable centennial-scale prediction of future climate states is not possible by any method. Also, the spatial resolution, sampling frequency, and duration of the principal climatic inputs are insufficient to permit reliable

modeling, and many processes – especially at sub-grid scale – are either insufficiently understood or not understood at all. Therefore, modeling will always be of limited value in climate prediction. Nor is it possible to overcome these defects by attempting probability distributions, which require more, not less, data than simple estimates flanked by error bars.”

Reason: Models have failed by their creators’ own criterion: a stasis of 15 or more years’ duration. Consequently, the IPCC’s model-based approach must now be modified to reduce reliance on models.

Comment #86: *Ch. SPM, from page SPM-12, line 6, to page SPM-12, line 8*

To reflect the restrictions on the utility of modeling imposed by the chaoticity of the climate object, rewrite “Projections of many quantities on the near-term horizon already provides an indication of changes later in the 21st century. The confidence in these projections is often assessed to be lower for the near-term than for later in the 21st century” to read “Near-term changes, such as the change from warming to the absence of warming in the late 1990s, do not necessarily provide an indication of changes later in the 21st century. The confidence in any projections of future climate states is necessarily lower for later in the 21st century than for the near-term.”

Reason: The obtrusion of deterministic but inherently non-determinable bifurcations in the evolution over time of any object that behaves chaotically becomes more likely as time passes, reducing the reliability of forward projections.

Comment #87: *Ch. SPM, from page SPM-12, line 13, to page SPM-12, line 14*

To reflect the failure of past IPCC projections, rewrite “The global mean surface air temperature change for the period 2016-2035 relative to the reference period of 1986-2005 will *likely* be in the range 0.4 C°-1.0 C° (*medium confidence*)” to read “In 1990 the IPCC’s *First Assessment Report* projected that in the 35 years to 2025 there would be 1 C° warming, at a rate equivalent to 0.3 C°/decade. Warming since 1990 has occurred at a rate equivalent to 0.14 C°/decade, and this far lower rate is expected to continue to 2035.”

Reason: Since there has only been 0.3 C° warming since 1990, it is extremely unlikely that warming to 2035 will be anything like the 1 C° upper bound now envisaged by the IPCC – an upper bound that is itself less than the central projection of 1 C° by 2025 that it made in 1990. If the IPCC is to retain any credibility, it must be explicit about its past over-projections of global warming.

Comment #88: *Ch. SPM, from page SPM-12, line 32, to page SPM-12, line 33*

To reflect the scientific literature accurately, replace the sentence "Models project increases in evaporation in most regions" with "Models have tended to underestimate by two-thirds the rate of evaporation and the consequent countervailing global cooling effect in response to warmer weather. Evaporation is expected to increase with warming, but global net specific humidity is *very likely* to remain constant because precipitation will tend to increase to match the evaporation."

Reason: Wentz *et al.* (2007) report that, while models project a 2% increase in evaporation for each Kelvin of warming, the observed outturn has been closer to 6%/K. Since the IPCC projects an increase in precipitation as well as an increase in evaporation, it cannot safely be said that there will be a net increase in specific humidity.

Comment #89: *Ch. SPM, from page SPM-13, line 45, to page SPM-13, line 49*

To clarify the central long-term temperature projection, rewrite "For RCP4.5, 6.0 and 8.5, global mean surface air temperatures are projected to at least *likely* exceed 2 C° warming with respect to pre-industrial by 2100, and about *as likely as not* to be above 2 C° warming for RCP2.6" as follows: "For RCP4.5, 6.0 and 8.5 it is *likely,* and for RCP2.6 it is *as likely as not,* that global mean surface air temperatures will be more than 1 C° warmer than today by 2100."

Reason: There has already been ~1 K warming compared with pre-industrial times. However, in the pre-industrial era temperatures were low thanks to the prolonged drop in solar activity during the 70 years of the Maunder Minimum (1645-1715); so the 1 K warming seen since 1750 may well be largely a continuing recovery in response to the rapid growth in solar activity since then (Hathaway, 1984).

Example: The least-squares linear-regression trend on the Central England Temperature Record since 1750 is ~0.9 K.

Comment #90: *Ch. SPM, from page SPM-13, line 51, to page SPM-13, line 54*

To simplify and strengthen the presentation of projections on the various scenarios, take their mean: thus, after the sentence "Global-mean surface temperatures for 2081-2100 (relative to 1986-2005) for the CO2 concentration driven RCPs will *likely* be in the 5-95% range for the CMIP5 climate models, i.e., 0.2-1.8 C° (RCP2.6), 1.0-2.6 C° (RCP4.5), 1.3-3.2 C° (RCP6.0), and 2.6-4.8 C° (RCP8.5)" add the following: "The mean warming interval is thus [1.3, 3.1] C°, with a central estimate in the region of 2.2 C°. This is 0.6 C° below the central estimate of 2.8 C° taken as the average of the six SRES scenarios in the *Fourth Assessment Report* (2007)."

Reason: The central estimate on the six SRES scenarios for 21st-century warming was 2.8 C°. The fact that the new central estimate is significantly below this should be made explicit.

Comment #91: *Ch. SPM, from page SPM-14, line 6, to page SPM-14, line 8*

To avoid stating the obvious, delete "It is *virtually certain* that, in most places, there will be more hot and fewer cold temperature extremes as global temperature increases. These changes are expected for events defined as extremes on both daily and seasonal timescales."

Reason: The inclusion of this sentence reads like an attempt to make a meal of future temperature change and its consequences. Better to omit it.

Comment #92: *Ch. SPM, from page SPM-14, line 22, to page SPM-14, line 23*

To avoid a probably erroneous speculation, delete "concurrent with a *likely* increase in both global mean tropical cyclone maximum wind speed and rainfall rates."

Reason: The maximum wind speeds in tropical cyclones are driven chiefly by temperature differentials, which are expected to narrow with warmer weather.

Comment #93: *Ch. SPM, from page SPM-14, line 23, to page SPM-14, line 24*

To bring projections into line with observations and with theory, delete "The frequency of the most intense tropical cyclones is projected to *more likely than not* increase substantially in some basins".

Reason: Notwithstanding a warming of ~1 K over the past century and a half, there has been no trend in landfalling Atlantic hurricanes throughout the period. In the past two or three decades, there has been a decline in the frequency of the most intense tropical cyclones and typhoons, notwithstanding the warming over the period. The current draft is accordingly at odds with observation, and also with theory, which suggests that the temperature differentials that fuel extreme tropical cyclones will diminish as the world warms.

Comment #94: *Ch. SPM, from page SPM-14, line 26, to page SPM-14, line 27*

To eliminate a further instance of systemic prejudice in the drafting, rewrite "It is *unlikely* that the global number of extra-tropical cyclones will decrease by more than a few percent due to global warming" to read "It is *likely* that the global frequency of extra-tropical cyclones will decrease by a few percent in response to global warming".

Reason: A reduction in extra-tropical cyclones – albeit small – is a good-news consequence of global warming, and should not be deliberately presented in a negative light.

Comment #95: *Ch. SPM, from page SPM-15, line 24, to page SPM-15, line 25*

To align the models' projections with elementary celestial mechanics and physics, delete "It is *very likely* that the AMOC will weaken over the 21st century with a best-estimate decrease in 2100 of about 20-30% for the RCP4.5 scenario and 36-44% for the RCP8.5 scenario."

Reason: As Professor Karl Wunsch has pointed out, while the Earth rotates and the wind blows the AMOC will circulate. The comparatively small anthropogenic warming to be expected this century will scarcely influence either mean wind speeds, still less the rotation of the Earth, so the AMOC will not be much affected by warmer weather, though there may be a small effect from modest changes in salinity distribution. Furthermore, the offending sentence has the air of a political and not a scientific point. What is meant by "weaken", and how is "weakening" objectively measured? If this point is to be retained at all (and deletion is recommended), it must be rewritten to answer these questions.

Comment #96: *Ch. SPM, from page SPM-16, line 12, to page SPM-16, line 15*

To reflect uncertainties, rewrite "It is *very likely* that the rate of global mean sea level rise during the 21st century will exceed the rate observed during 1971-2010 for all RCP scenarios" as follows: "Accurate measurement of sea-level change by satellite altimetry has only been available since 1993, and has suggested a rate of sea-level rise of 0.3 m/century. Tide-gauges in use until that year showed a sea-level rise of ~0.2 m over the 20th century. The extent to which the apparent increase in the rate of sea-level rise is an artefact of the change in the measurement method is unknown. The reliable record is too short to allow definite projections: but thermosteric expansion and land-based ice loss will be *likely* to contribute to a continuing – though not necessarily increasing – rate of sea-level rise to 2100 and beyond."

Reason: The demonstrated propensity of models to exaggerate warming trends and their consequences compared with observation and the literature should be allowed for.

Comment #97: *Ch. SPM, from page SPM-16, line 24, to page SPM-16, line 25*

To reflect a more balanced presentation of the scientific literature, and to reduce dependence upon models that have failed to predict key variables such as the rate of global warming correctly, either reduce the estimates of sea-level rise or include some reference to papers (e.g. Möerner *passim*) that suggest sea-level rise could be as little as 10-20 cm over the 21st century – if anything, rather below the rate of rise seen since the mid-19th century.

Reason: Models that have been shown greatly to exaggerate predicted warming will also greatly exaggerate sea-level rise. Here as elsewhere throughout the report, the obsession with modeling should be replaced with a more mature and balanced consideration of the published scientific literature. It is notable that in each year during the past decade the decadal rate of sea-level rise has been declining, entirely contrary to the absurdly overblown projections of sea-level rise made by the models.

Comment #98: *Ch. SPM, from page SPM-16, line 40, to page SPM-16, line 42*

To restore balance, add the words "or smaller" to the sentence "As a result, larger *or smaller* values of sea level rise cannot be excluded, but current scientific understanding is insufficient." Delete the rest of the sentence, "… for evaluating the probability of higher values".

Reason: The duration, reliability and steric resolution of ocean measurements are altogether insufficient to permit reliable modeling of the future behavior of the oceans in response to warmer weather worldwide. The absurd over-precision with which model outputs such as imagined sea-level rise are stated throughout this draft is calculated to mislead.

Comment #99: *Ch. SPM, from page SPM-16, line 44, to page SPM-16, line 48*

To restore balance, delete "Global mean sea level rise will *very likely* continue beyond 2100, with ocean thermosteric sea-level rise to continue for centuries to millennia, unless global temperatures decline. The few available model results indicate global mean sea level rise by 2300 *likely* to be less than 1 m for greenhouse gas concentrations below 550 ppm CO2-equivalent scenario but rise as much as 1-3 m for concentrations above 700 ppm CO2-equivalent" and substitute "Sea level is *likely* to rise for as long as temperature rises, though the relations between radiative forcings, warming rates and sea-level rise are uncertain."

Reason: Models have consistently over-predicted warming rates based on rates of increase in greenhouse-gas concentrations. Therefore, they are over-predicting rates of sea-level rise in consequence of greenhouse-gas-driven warming. These extreme projections may be politically attractive and financially profitable to the IPCC, but they are not scientific and must be deleted.

Comment #100: *Ch. SPM, from page SPM-17, line 10, to page SPM-17, line 14*

To adopt the correct scientific nomenclature and depoliticize the draft, rewrite "Anthropogenic ocean acidification, evidenced by a decrease in ocean pH, is projected to continue worldwide over the 21st century in all RCPs. The largest decrease in pH is projected to occur in the warmer low and mid-latitudes. It is *likely* that surface waters in the Southern Ocean become corrosive for a less stable form of calcium carbonate by 2100, and even before the Arctic Ocean" to read "A small anthropogenic

decrease in the alkalinity of the ocean (i.e., a decrease in pH) may be occurring, and may continue to occur over the 21st century. However, the sampling frequency, duration and steric resolution of ocean pH measurements on a global scale are insufficient to allow definite conclusions to be drawn."

Reason: The data are inadequate to draw the conclusions in the offending sentence.

Comment #101: *Ch. SPM, from page SPM-17, line 10, to page SPM-17, line 24*

To increase the scientific precision of the draft, delete "Many aspects of climate change will persist for centuries even if concentrations of greenhouse gases are stabilized. This represents a substantial multi-century commitment created by human activities today. Insert "Most consequences of anthropogenic global warming will manifest themselves within a century of the forcings that triggered the warming. Some consequences will persist for many centuries, but will not be significant. For instance, half of the warming from a doubling of atmospheric CO2 concentration will occur within a century: the remainder will occur over 1-3 millennia, allowing plenty of time for adjustment."

Reason: Only the decadal- to centennial-scale changes caused by anthropogenic influences are likely to prove significant. Thereafter, changes will be smaller, and will be spread over such long timescales as to be harmless.

Comment #102: *Ch. SPM, from page SPM-17, line 10, to page SPM-17, line 24*

To moderate an extreme projection, rewrite "Continuing greenhouse gas emissions beyond 2100 as in the RCP8.5 extension induces a total radiative forcing above 12 W m^{-2} by 2100 that leads to a warming of 8.7[5.0, 11.6] C° by 2300 relative to 1986-2005" to include projections for all four principal RCPs, not just the most extreme RCP, and reduce or delete the extreme and absurd warming projection.

Reason: The draft's emphasis on imagined negative effects of a warmer climate is here exemplified by a deliberate concentration only on the most extreme emissions scenario. Given the observed propensity of models greatly to overstate warming in response to a forcing, the temperature estimates should either be determined for all four principal RCPs, not just the most extreme RCP, or deleted altogether. The prediction given here is inconsistent with the homeostatic profile of temperature changes over the past 64 Ma, where absolute temperatures have varied by only 3%, or 8 K, either side of the long-run mean.

Comment #103: *Ch. SPM, from page SPM-17, line 39, to page SPM-17, line 42*

To restore balance, delete "For scenarios driven by carbon dioxide alone, global average temperature is projected to remain approximately constant for many centuries following a complete cessation of emissions. Thus a large fraction of climate change is largely irreversible on human time scales, except if net anthropogenic greenhouse gas emissions were strongly negative over a sustained period." Insert "The atmospheric residence time of CO2 in the literature is ~7 years (first-order effect) and ~40 years (second-order effect). Accordingly, a gradually decreasing fraction of the warming caused by an increase in CO2 concentration will remain present for about half a century after the increase has ceased."

Reason: The persistence of CO2-driven warming is chiefly dependent upon the atmospheric residence time which – like much else – the IPCC has exaggerated compared with the literature.

Comment #104: *Ch. SPM, from page SPM-17, line 44, to page SPM-17, line 48*

To reflect reality, delete "Surface melting of the Greenland ice sheet is projected to exceed accumulation for global mean surface air temperature over 3.1[1.9, 4.6] C° above pre-industrial, leading to ongoing decay of the ice sheet. The loss of the Greenland ice sheet is not inevitable, because surface melting has long time scales and it might re-grow to most of its original volume if global temperatures decline. However, a significant decay of the ice sheet may be irreversible." Insert "The Greenland ice sheet, amounting to some 5% of the Earth's land-based ice, may decline in thickness if warming exceeds ~3 C°, and if that warming persists. However, surface melting has millennial timescales. Even the emission of all CO2 now locked in fossil fuel reserves would not cause a long enough warming to melt much of Greenland."

Reason: The IPCC had previously admitted that the timescale for melting Greenland ice is millennial: it must continue to admit this.