Arctic Report Card 2011: Response to Reviews

Review #1

General comments

In general, the draft of Arctic Report Card 2011 makes a rather positive impression. The sections are generally well written and are interesting to read. The report is well-structured and nicely illustrated. ARC-2011 appropriately reflects the climate change in the recent years in the Arctic. The authors have done a good job by studying and analyzing the available data sources and publications on changes in the Arctic environment.

Response. We thank the reviewer for these general comments that recognize the overall quality and value of the Report Card.

I would like to indicate only two general drawbacks.

1) Individual chapters describing different parts of the Arctic climate system have little to do with each other. For instance, permafrost is considered as independent stand-alone phenomenon, while in fact the observed large scale variations are fully governed by the atmosphere, and on a local scale also by anthropogenic and natural disturbances, such as forest fires. Atmospheric parameters, particularly air temperature and snow, are crucial to understanding observed permafrost dynamics, and it has to be seen explicitly in the text. I may recommend writing several paragraphs describing variations of these parameters over terrestrial permafrost regions. Alternatively, permafrost chapter authors can cross-reference the atmosphere and snow sections of the ARC. So we need better coordination and cross-referencing between the report chapters or sections to have complete picture of current Arctic environment change.

Response. We agree with the reviewer's observation about the initial lack of links among the essays and sections, and regret that there was insufficient time to make the links before the documents were sent for review. During the time the documents were in the reviewers' hands, the authors, section coordinators and editors have been making those links by adding the phrase "see the essay on …". The reviewer can see where the links will be in the revised section files, including the requested links added to the *Permafrost* essay. In the online Report Card, clicking on the phrase "see the essay on …" will take the reader to the other essay for more information. Having these links helps to better integrate the Report Card and describe the Arctic environmental system rather than only the individual components.

2) There is lack of Russian data and publications used in the report. The reason is that the most of the articles are in Russian and data sources are in Russian websites. Greater involvement of Russian authors in the future reports can fix this problem. I particularly draw your attention to sea ice charts, sea ice statistics, data from "North Pole" ice drifting stations at the Arctic and Antarctic Research Institute of Roshydromet website http://www.aari.ru/. Quarterly review of the meteorology, ice conditions, oceanographic parameters in the Arctic Ocean and its coastal seas (in Russian) is also available at the AARI website (the latest is for April – June, can be found at http://www.aari.ru/resources/m0035/gm_review_2011_2.pdf).

Response. The reviewer makes a reasonable point about Russian data and literature, and of course identifies the primary difficulty, i.e., most of the data and information are in the Russian

language and thus somewhat inaccessible. We thank the reviewer for his proposed solution, to involve more Russian authors in future, and will encourage future Report Card authors to engage with their Russian colleagues to the extent that is wpossible.

Sea Ice and Ocean

P. 1, Line 12
Generally, these highlights only partly correspond with highlights for 2011 from operational meteorological services, e.g. International Ice Charting Working Group. In any case, there should be a reference to the view of operational part. Compare your highlights with those from IICWG-12 (http://nsidc.org/noaa/iicwg/IICWG_2011/IICWG-XII_News_Release.pdf):

Response. The essay highlights can only highlight what is written in the essay. In any event, the sea ice essay now refers to the IICWG news release and the fact that it includes additional information about the Northwest Passage[s], the Northern Sea Route, and sea ice in southern Greenland waters and the Baltic Sea.

• The sea ice pack in the Arctic Ocean shrank to the 2nd lowest extent on record, based on the National Snow and Ice Data Center analysis. At 4.33 million square kilometres, it was only slightly larger than the record minimum extent set in 2007.
• Significant year-to-year variability continues. For example, in 2011 sea ice persisted around Southern Greenland three weeks longer than normal.
• In February 2011, the ice in the Baltic Sea reached an extent of 309,000 square kilometers, about 3/4 of the total area of the Baltic Sea. This was the greatest extent since 1987 when it was almost completely ice covered.
• The southern hemisphere sea ice extent continued its slight increasing trend in 2011.
• Summer shipping through Russia's Northern Sea Route (NSR) is rapidly becoming more common. In 2011, the *Vladimir Tikhonov* was the first supertanker to use the NSR to transit from Europe to Asia. For the first time, the receding Arctic ice pack allowed such vessels to travel north of the New Siberian Islands, a deeper and more direct route than the traditional one to the south of the islands.
• In the Canadian Arctic, sealift operations to resupply Northern communities have increased over the last ten years. However, international transit by commercial cargo through the Northwest Passage is almost non-existent as sea ice, icebergs and meteorological conditions continue to pose significant risks to mariners.
• The 280 square kilometer ice island that calved from Northern Greenland's Petermann Glacier in 2010 broke into many fragments that are now strung along the entire east coast of Canada. The most southerly fragments are melting in the waters around Newfoundland.

P. 1, Line 14
Minimum Arctic sea ice extent in September 2011 was second lowest recorded by satellite since 1979.

P. 1, Line 43
March 7. This was about normal compared to the 1979-200 (2011?) average, but a little earlier

P. 2, Line 69
Table OSI1 summarizes September ice conditions in the southern and northern routes...

P. 2, Line 71-72
Open means the route appeared ice-free (less than 15%) in the passive microwave imagery…

P. 2, Line 74-75
All three routes have been open the past two years and the Northwest Passage southern route has been open every year since 2007.
Again, please, see note from IICWG-12 "While it was widely reported in 2011 that both the Northwest Passage and the Northern Sea Route were "open" or even "ice free", the participants in the International Ice Charting Working Group caution against misinterpreting these statements. Waters that appear "open" in satellite images can often have ice covering 15% of their surface."

P.3 Line 106
Table OSI1. Status of September ice conditions in the Northwest Passage and Northern Sea Route…

Response. The changes highlighted in yellow by the reviewer have been made, including a reference to the IICWG news release and the issue of open water versus 15% ice cover.

Permafrost

While active-layer thickness ALT variations are recognized as equally important indicator of permafrost dynamics, they largely remain beyond this report, except for the two paragraphs on lines 924-945. It would be desirable to give a broader insight into ALT dynamics on a circumpolar scale using data from the CALM observations.

Challenging task would be to include submarine permafrost, at least on the East Siberian Arctic Shelf. Recent publications on potential impact of enhanced methane emission from East Siberian Arctic Shelf on global climate, presumably related to degradation and increased perforation of sub-sea permafrost received a lot of public attention and shifted the concerns of "methane bomb" from terrestrial to sub-sea permafrost. Please, have a look to:

Shakhova, N., I. Semiletov, I. Leifer, A. Salyuk, P. Rekant, and D. Kosmach (2010), Geochemical and geophysical evidence of methane release over the East Siberian Arctic Shelf, J. Geophys. Res., 115, C08007, doi:10.1029/2009JC005602.

Shakhova, N., I. Semiletov, A. Salyuk, V. Yusupov, D. Kosmach, and Ö. Gustafsson (2010), Extensive methane venting to the atmosphere from sediments of the East Siberian Arctic shelf, Science, 327, 1246–1250, doi:10.1126/science.1182221.

Dmitrenko, I. A., S. A. Kirillov, L. B. Tremblay, H. Kassens, O. A. Anisimov, S. A. Lavrov, S. O. Razumov, and M. N. Grigoriev (2011), Recent changes in shelf hydrography in the Siberian Arctic: Potential for subsea permafrost instability, J. Geophys. Res., 116, C10027, doi:10.1029/2011JC007218.

Response. Previous Arctic Report Card essays on Permafrost did not describe active layer thickness at all. This is the first Report Card to describe active layer thickness, and we note that the data and information were provided by Nikolay Shiklomanov, who leads the CALM project and is a co-author of the Permafrost essay. We believe this is a good start on a subject that has the potential to be described in more detail in future Report Cards.

As the reviewer notes, describing submarine permafrost is a challenge. We will encourage future Permafrost essay authors to consider including submarine permafrost in future Report Cards, if there are sufficient data available. We are aware of recent reports of methane release from submarine permafrost, and note that there is, for the first time, an essay on Greenhouse Gasses in the Atmosphere section. This new essay doesn't mention submarine methane release, but we will encourage the authors to consider doing so in future, if there are sufficient data available.

Review #2

Editors' Note: The comments below correspond to the virtual 'Sticky Notes' the reviewer embedded in the original .pdf document.

Atmosphere

International authorship. We understand the value and importance of having essays written by multi-national teams, and the lead authors of each essay are encouraged, and will continue to be encouraged, to achieve this goal. It takes time to build teams and relationships, but we will aim to demonstrate progress in future Report Cards. We note that, in the aggregate, the Report Card has 121 authors, of whom 47% work in 13 different countries outside the USA.

A true 2011 report. We encourage authors to report on the most up-to-date data and information. Sometimes this is not possible because the data and information are simply not available for reasons beyond the authors' control.

Reference to previous Report Cards. In future, we will encourage authors to refer to previous Report Cards where it is appropriate to do so.

Use of laymens' terms. We encourage authors to make their essays accessible for a broad audience. Having a section summary and essay highlights is an attempt to address this issue.

Incomprehensible sentence. We agree that the sentence "In contrast to short-lived species like black carbon that change the reflective properties of the air, ice and snow, and changes in Arctic black carbon emissions directly affect Arctic climate, changes in emissions of CO_2 and CH_4 from anywhere on Earth impact Arctic climate." makes no sense. It has been changed to "In contrast to short-lived species like black carbon, whose Arctic emissions only affect Arctic climate, CO_2 and CH_4 emissions from anywhere on Earth will impact Arctic climate."

Microbial conversion. The text has been changed from "microbes can convert" to "microbes could convert".

Ozone-UV-Latitude-Season-Sun Relationship. A short paragraph that addresses this issue has been added as an Introduction to the essay.

Sea Ice & Ocean

Ice extent and ice volume. We recognize that sea ice extent does not tell the whole sea ice story, and that the sea ice volume is an important variable, as it accounts for the changing ice thickness. However, determination of the ice volume requires computer modeling, e.g., PIOMASS, and we try to minimize the use of model outputs in the Report Card.

Sequence: March vs. September. We believe the second paragraph should be about the September minimum, as that is the key event. To accommodate this, we have changed the order in the first paragraph, and now refer first to September and second to March.

Limitations of passive microwave. Another reviewer raised this issue and we have added a reference to the International Ice Charting Working Group that issued a news release that draws

attention to the fact that an ice-free area in a passive microwave image might have as much as 15% ice cover.

Ice-clogged Coronation Gulf. See previous comment.

Victoria Island sea ice. See comment about limitations of passive microwave.

Report Card time periods. The reviewer raises an important point and we recognize the problem, which is not unique to the Report Card. There is no universally agreed baseline period, some data sets are relatively short, and data for 2011, and even earlier years, might not be available.

Ocean Acidification

Cross reference. The ocean acidification essay is now cross-referenced to the essay on *Ocean Biogeophysical Conditions* (and vice-versa) in the Marine Ecosystem section. We add that during the time the Report Card has been in the hands of the reviewers, we have added many cross-references among the essays in order to better integrate the entire document and, we hope, provide some synthesis that demonstrates the links among the different parts of the Arctic environmental system.

Marine Ecosystem

Limited set of authors. This is the first time this topic has been included in the Report Card. We will encourage the authors to draw on a larger set of authors in future, including overseas authors.

Length of time series. We agree that the 2011 Report Card would benefit from having 2011 data, but if the data are not available they can't be included. Authors are generally using the most-up-to-date data and information.

Tremblay et al. (2011). Reference to Tremblay et al. (2011) has been added, to both the *Primary Productivity* essay and to the *Cetaceans and Pinnipeds* essay.

Cross reference to Grebmeier. A cross reference has been added to the essay on *Marine Ecology: Biological Responses to Changing Sea Ice and Hydrographic Conditions in the Pacific Arctic Region.* We add that during the time the Report Card has been in the hands of the reviewers, we have added many cross-references among the essays in order to better integrate the entire document and, we hope, provide some synthesis that demonstrates the links among the different parts of the Arctic environmental system.

Figure ME5 and the Ocean essay. We have added a reference to the *Ocean* essay, and, in the *Ocean* essay, added a reference to the *Cetaceans and Pinnipeds* essay.

Canadian benthic data & synthesis. We will encourage the authors to report on more data and include overseas authors in their writing team in future. Note that during the time the Report Card has been in the hands of the reviewers, we have added many cross-references among the essays in order to better integrate the entire document and, we hope, provide some synthesis that demonstrates the links among the different parts of the Arctic environmental system.

Cross reference to ocean acidification. The Ocean Biogeophysical Conditions (note the change of title) essay is now cross-referenced to the essay on *Ocean Acidification* (and vice-versa) in the *Sea Ice & Ocean* section. We add that during the time the Report Card has been in the hands of the reviewers, we have added many cross-references among the essays in order to better integrate the entire document and, we hope, provide some synthesis that demonstrates the links among the different parts of the Arctic environmental system.

Terrestrial Ecosystem

International authorship. We understand the value and importance of having essays written by multi-national teams, and the lead authors of each essay are encouraged, and will continue to be encouraged, to achieve this goal. It takes time to build teams and relationships, but we will aim to demonstrate progress in future Report Cards. We note that, in the aggregate, the Report Card has 121 authors, of whom 47% work in 13 different countries outside the USA.

Rangifer. The Rangifer essay has been significantly revised and improved in response to comments by the reviewers and editors?.

Hydrology & Terrestrial Cryosphere

Snow: seasonal asymmetry and stability. These are now mentioned in the third highlight of the snow essay.

Direct references between chapters. A number of references to other essays have been added to the Snow essay, and vice versa. We add that during the time the Report Card has been in the hands of the reviewers, we have added many cross-references among the essays in order to better integrate the entire document and, we hope, provide some synthesis that demonstrates the links among the different parts of the Arctic environmental system.

Adding diversity to the list of contributors. This is the only essay that takes this unusual approach. One of the editors (MOJ) would prefer to see the contributors listed as authors, and feels the issue should be raised with Sharp and Wolken for future Report Card essays.

Too late to include Novaya Zemlya and Iceland data? Considering that the Report Card is behind schedule and the public release has been delayed by two weeks until 1 December, we feel that it is too late to include these data.

Greenland. We agree with the reviewer's characterization of this essay and will continue to try to persuade the lead author to adopt a better approach in future essays.

River discharge – so what? An introductory paragraph that provides a rationale for studying Arctic river discharge has been added to the essay.

Review #3

Atmosphere

1. p. 11, 232-238. Check whether reference to top, centre, bottom will still be correct when printed. Is Fig. c 850 mb field for July 2011?

Response: The references to top, centre and bottom will be correct. The caption for (c, bottom) has been corrected to July 2011.

2. p.13, 261-268. Language here is complicated – could sentences be shortened.

Response: The sentence in question had already been modified and improved at the request of Reviewer #2.

3. p. 13, 278 delete "(where 1 GT = 10*15 g)"

Response: "(where 1 GT = 10*15 g)" had already been deleted in response to a request by the editors to be more consistent in the use of units.

4. p. 15, 370 delete "which posed a potential threat to ecosystems and human health" .. it seems unreasonable to include this in a summary when the main body of text explains that the low angle of incidence in the northern areas in the spring means that total UV levels are low. Better to include in the summary the last sentence in the main text, l. 493-494, which puts the spring discussions in perspective, and then perhaps expand the main text on this point.

Response: The sentence in question had already been deleted as the entire essay Summary for UV/Ozone has been deleted. UV/Ozone are now mentioned in the Section Summary. Also, a UV/Ozone essay Introduction has been added in response to Reviewer #2, who asked for a rationale for measuring Ozone & UV, and for seasonal issues to be addressed.

5. p. 22, 558. A figure where some data are deleted is not very satisfactory. At least the magnitude of the data should be indicated, i.e. something more descriptive than just writing "significantly higher".

Response: We note that data have not been deleted. Rather, very high values have been omitted as they are not necessary for this particular presentation. Nonetheless, we are waiting for information from the authors so that the magnitude of the missing values is clear. In the meantime, we note that graphs like this are published in the peer-reviewed WMO Ozone Assessments, so the authors are using standard practice.

6. p. 25, Fig. A14 is not easy to read.

Response: We will request that this figure be published at a larger size on the Web site.

Sea Ice and Ocean

1. p. 9, 228 ..”(update to ..)” is this a reminder or a reference?

Response: ”(update to Proshutinsky et al. 2009)” indicates that the information provided here is an update to information previously available in Proshutinsky et al. (2009)

2. p. 10, l303-307 – could perhaps delete the last two sentences.

Response: We prefer not to delete the sentences. They provide useful information.

Marine Ecosystem

No comments provided by the reviewer.

Terrestrial Ecosystems

1. p. 3, 124. The word “senescence” I understand to mean growing old – but perhaps it means something else in terrestrial ecology? Is there a easier understood word? If it means delayed growth then I do not understand the sentence if the shift is to earlier start. Or should line 123 say “..1 week delay in the initiation..”? Perhaps it is my lack of knowledge that is the problem – not the text!

Response: The text no longer refers to senescence at all. Instead, the first sentence reads “Bi-weekly NDVI data are used to show the yearly progression of the magnitude and timing of the photosynthetically-active period for the vegetation ..”.

2. p. 7, 270, Figs a and b have switched places in caption.

Response: The caption has been corrected so that figure references in the text correspond to the figure caption.

3. p. 8, 289, Figs a and b have switched places in caption.

Response: The figure caption is correct.

Hydrology and Terrestrial Cryosphere

1. p.4, 150-152, the Fig. text to HTC1 ought to explain the vertical scale better – what means “standardized and thus unitless”?

Response: The figure caption has been changed by the addition of the meaning of standardized (how standardized values are calculated) and thus unitless.

2. p. 5, Could Fig. HTC2 be reproduced larger? It is difficult to read.

Response: We will request that this figure be published at a larger size on the Web site.

3. p. 7 Fig HTCa a) It seems questionable to talk about – and show – a linear trend for

so few years (2004-2011). Better to say something about apparent change in trend in the text.

Response: The caption and text have been modified to address this concern.

4. p. 11, 297 Islands,

Response: "Islands" has been corrected to "islands".

5. p.16, 398 inconsistent text: "during March-June, especially in February .."

Response: This discrepancy had already been resolved before we received Review #3, i.e., "especially February and March" had simply been deleted.

6. p. 20, 558, and see fig. text and vertical caption for HTC20, l. 784.785. Text and Fig. does not correspond. What is shown - total Mass, thickness of surface layer, mass density (whatever that is)?

Response: The confusing units and labels have been corrected, such that the y-axis of the graph is labeled as Gigatons and the figure caption describes the graph as the total mass (Gigatons, Gt) of the Greenland ice sheet. This is now consistent with the text, which also refers to the total mass of the ice sheet.

7. p. 20, 576, 4th word: I presume effect is meant, or should it be affect?

Response: To make the meaning clear, "effect" has been changed to "cause".

8. P 21, 599 .."nearly 16 times the size of Manhattan Island" …delete the numbers for MH, it is implicit.

Response: The area of Manhattan Island has been deleted.

9. P 21, 602 Is the name Mittivakkat Gletscher? Should it not be Glacier, or a Greenland word, in this publication?

Response: Mittivakkat Gletscher has been used in a number of previous peer-reviewed publications. We keep the name here for consistency.

10. p. 24 Table HTC# is not readable, delete or improve

Response: The Web site developers have been given a new file that will legible when the Report Card is published.

11. p. 25/26, Tables HTC4/HTC5 should be formatted better to avoid year listed as 200 in one line and 5 in the next.

Response: The Web site developers have been provided a new file for Table HTC4 that corrects this problem. Table HTC5 has also been corrected.

12. p. 32, 742,743. "Areas where temperature anomalies.."??

Response: This is self-explanatory. We don't understand the reviewer's concern.

13. p.38, Horizontal scale to Fig. HTC19 could be improved by not marking every year, (but this change is perhaps too much effort?)

Response: The horizontal axis has been improved by marking it every two years rather than every year. The labels are now more legible.

14. p. 39, see comments to p. 20

Response: The confusing units and labels have been corrected, such that the y-axis of the graph is labeled as Gigatons and the figure caption describes the graph as the total mass (Gigatons, Gt) of the Greenland ice sheet. This is now consistent with the text, which also refers to the total mass of the ice sheet.

15. p. 41, 795, 799, see comment to p. 21, 602

Response: Mittivakkat Gletscher has been used in a number of previous peer-reviewed publications. We keep the name here for consistency.

16. p. 43, 834 .." a decrease (from..), 0.3 over 3 years is perhaps not slight?
I have not read p. 53-67.

Response: The Permafrost summary in which the temperature decrease was mentioned had already been deleted as part of a decision to consolidate all essay summaries into a single section summary. That summary still refers to the slight temperature decrease in Interior Alaska, with the qualification that the maximum decrease occurred only at some locations. Note that a graph illustrating permafrost records in Interior Alaska has been added to the essay.

17. p. 54, 1158-1160, and p. 58, FigHTC29, 1238. I understand that writing total runoff as 24 mm is a hydrological convention, but perhaps for the uninitiated it should say something like "averaged over the catchment area" if that is what is meant?

Response: The meaning is now made clearer with the sentence now reading "The results suggest that total river runoff for January to July 2011, averaged across 8 major Arctic river basins, was 24 mm (or ~17%) lower than the long-term mean observed during 1979-2010 …".

18. 1169 "…shows 17 mm w.e. less snow in 2011.."

Response: The text has been modified to make it clear that it is 17 mm water equivalent. The text now matches the figure caption.

19. p.65, 1376-78. I wonder whether the caption to Fig HTC34 could be expanded to explain better the diagrams, as there are more than one coloured circle for each year. Are these for different seasons each year, and if so when?

Response: The figure caption has been improved to make the meaning of the legend/coloured circles clearer. It now reads "Discharge-DOC concentration relationships for the six largest arctic rivers. Each point represents a single day when a DOC sample was collected. Though the relationships differ substantially among rivers, there are no clear trends across years within individual rivers."