Response to CEI Request of 14 April 2014 to OSTP under the Data Quality Act

Summary

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Points (a) and (b) are not in dispute by anybody, as far as OSTP knows, not even by CEI. Propositions (c) and (d) are readily substantiated by reference to the peer-reviewed scientific literature, as will be shown below. Of course, a growing body of evidence does not mean that everyone in the climate-science community is convinced that the case is proven, and Dr. Holdren was clear about that in the video when he said “Computer models tell us that there are many different factors influencing these patterns and, as in all science, there will be continuing debate about exactly what is happening.”

Note that there is virtually nothing about climate science that isn’t disputed by somebody. If the criterion for communications from the White House about climate science were that nobody disagrees on any point, there could be no such communication at all. Dr. Holdren made it clear in the video that I was offering my personal judgment on the balance of the evidence when he said “I believe the odds are that we can expect, as a result of global warming, to see more of this pattern...”.

Relevant points from the scientific literature

The most relevant points of science (which underpin the video and are needed to understand many of the points made in the literature) are:

1. Under greenhouse-gas induced “global warming”, the Arctic is warming more rapidly than the mid-latitudes. This is called “Arctic amplification”. The reasons for it are well understood. They include the “ice-albedo feedback”, in which warming reduces the area covered by sea ice, which in turn reduces the amount of sunlight that is reflected back to space and, thus, accentuates warming.

2. That the Arctic is warming faster means that the temperature difference between the relatively cold Arctic and the relatively warm mid-latitudes is shrinking. This temperature gradient is known to be an important driver of atmospheric circulation patterns that affect both the Arctic and the mid-latitudes. A change in the gradient will therefore affect those patterns (although other factors affect them, as well).

3. A plausible hypothesis is that one of the changes in circulation patterns resulting from the reduced temperature gradient is a weakening of the circumpolar jet stream, which delimits
the circumpolar vortex. A weakened jet stream is associated with both a slowing and increased waviness (larger “Rossby waves”) in the boundary of the vortex. That means larger southward excursions of relatively cold Arctic air, accompanied, in the other phase of the wave, by larger northward excursions of relatively warm mid-latitude air; it also means that those waves move from west to east relatively slowly, causing the unusual conditions associated with them to persist.

4. There is observational evidence that this behavior has been becoming more frequent and more pronounced in recent decades, although the data are incomplete in ways that ongoing research seeks to remedy.

5. Phenomena that characterize the relevant atmospheric circulation patterns, their links to ocean conditions, and their variations include the Arctic and North Atlantic Oscillations (AO, NAO), and the El Niño / La Niña cycle. While these phenomena are part of what is usually termed “natural variability” in the weather/climate system and are sometimes offered as alternatives to anthropogenic climate change as explanations for unusual weather, there is increasing evidence that their frequencies and/or intensities are now intertwined with anthropogenic climate change.

With that background, one is in a position to appreciate the support offered for points made in Dr. Holdren’s video by the following examples from the peer-reviewed scientific literature over the period 2008-2014. (Order is chronological. Italicized material is quoted exactly from the indicated sources.)


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Observational evidence shows that significant cold anomalies over the Far East in early winter and zonally elongated cold anomalies from Europe to Far East in late winter are associated with the decrease of the Arctic sea-ice cover in the preceding summer-to-autumn seasons. Results from numerical experiments using an atmospheric general circulation model support these notions.

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Here we demonstrate that the decrease in autumn Arctic sea ice is linked to changes in the winter Northern Hemisphere atmospheric circulation that have some resemblance to the negative phase of the winter Arctic oscillation. However, the atmospheric circulation change linked to the reduction of sea ice shows much broader meridional meanders in mid-latitudes and clearly different interannual variability than the classical Arctic oscillation. This circulation change results in more frequent episodes of blocking patterns that lead to increased cold surges over large parts of northern continents.


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The NAS summary (Linkages Between Arctic Warming and Mid-Latitude Weather Patterns: Summary of a Workshop, http://www.nap.edu/catalog.php?record_id=18727, 70 pp, 2014) begins as follows:

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The essence of the 50-page March 2014 review paper [Timo Vihma (Finnish Meteorological Institute), “Effects of Arctic sea ice decline on weather and climate: A review”, *Survey of Geophysics, DOE 10.1007/s10712-014-9284-0* (9 March 2014)] is conveyed by the following quote from its abstract:

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This paper, like the NAS workshop summary, calls for more data and more research in order to sort out more definitively the roles of the various (and interacting) natural and human-driven changes in explaining the observed increase in prolonged winter cold spells in the context of a world that is warming on a global-average basis. In the meantime, Dr. Holdren’s characterization of the issue in his two-minute polar-vortex video—complete with language conveying what “a growing body of evidence suggests” (emphasis added) and providing his personal scientific judgment about the probable outcome of further research (“I believe the odds are that we can expect...”)—fully satisfies the requirement that information provided by the government meet “basic standards of quality, including objectivity, utility, and integrity”.

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The NAS summary ([Linkages Between Arctic Warming and Mid-Latitude Weather Patterns: Summary of a Workshop](http://www.nap.edu/catalog.php?record_id=18727, 70 pp, 2014) begins as follows:

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The NAS summary goes on to discuss in a balanced way the challenges of establishing degrees of responsibility of the different relevant phenomena for what is being observed and, of course, calls for more data and more research.

The essence of the 50-page March 2014 review paper [Timo Vihma (Finnish Meteorological Institute), “Effects of Arctic sea ice decline on weather and climate: A review”, Survey of Geophysics, DOI 10.1007/s10712-014-9284-0 (9 March 2014)] is conveyed by the following quote from its abstract:

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This paper, like the NAS workshop summary, calls for more data and more research in order to sort out more definitively the roles of the various (and interacting) natural and human-driven changes in explaining the observed increase in prolonged winter cold spells in the context of a world that is warming on a global-average basis. In the meantime, Dr. Holdren’s characterization of the issue in his two-minute polar-vortex video—complete with language conveying what “a growing body of evidence suggests” (emphasis added) and providing his personal scientific judgment about the probable outcome of further research (“I believe the odds are that we can expect…”)—fully satisfies the requirement that information provided by the government meet “basic standards of quality, including objectivity, utility, and integrity”.
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Summary

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The CEI petition is without merit. The video was intended to, and does, inform the viewer that (a) no single extreme-weather event, hot or cold, either proves or disproves global climate change; (b) climate-change dynamics are more complex than most people imagine; (c) in that connection, there is a plausible mechanism, linked to behavior of the polar vortex, by which a world that is warming on the average could include an increase in prolonged winter cold spells in the Northern Hemisphere mid-latitudes; and (d) there is “a growing body of evidence” suggesting that this mechanism is indeed operating.

Points (a) and (b) are not in dispute by anybody, as far as OSTP knows, not even by CEI. Propositions (c) and (d) are readily substantiated by reference to the peer-reviewed scientific literature, as will be shown below. Of course, a growing body of evidence does not mean that everyone in the climate-science community is convinced that the case is proven, and Dr. Holdren was clear about that in the video when he said “Computer models tell us that there are many different factors influencing these patterns and, as in all science, there will be continuing debate about exactly what is happening.”

Note that there is virtually nothing about climate science that isn’t disputed by somebody. If the criterion for communications from the White House about climate science were that nobody disagrees on any point, there could be no such communication at all. Dr. Holdren made it clear in the video that he was offering his personal judgment on the balance of the evidence when he said “I believe the odds are that we can expect, as a result of global warming, to see more of this pattern...”.

Relevant points from the scientific literature

The most relevant points of science (which underpin the video and are needed to understand many of the points made in the literature) are:

1. Under greenhouse-gas induced “global warming”, the Arctic is warming more rapidly than the mid-latitudes. This is called “Arctic amplification”. The reasons for it include the “ice-albedo feedback”, in which warming reduces the area covered by ice or snow, which in turn reduces the amount of sunlight that is reflected back to space and, thus, accentuates warming.

2. That the Arctic is warming faster means that the temperature difference between the relatively cold Arctic and the relatively warm mid-latitudes is shrinking. This temperature gradient is known to be an important driver of atmospheric circulation patterns that affect both the Arctic and the mid-latitudes. A change in the gradient will therefore affect those patterns (although other factors affect them, as well).

3. A plausible hypothesis is that one of the changes in circulation patterns resulting from the reduced temperature gradient is a weakening of the circumpolar jet stream, which delimits the circumpolar vortex. A weakened jet stream means that southward excursions of the jet
that bring cold Arctic air to mid-latitudes and the northward excursions that bring warm air from lower latitudes move from west to east more slowly, causing cold and warm temperature conditions to persist for longer. There is also evidence that the extent of northward and southward meanders of the jet has increased in certain seasons and locations.

4. There is observational evidence that this behavior has been becoming more frequent and more pronounced in recent decades, although currently available data and model results are incomplete in ways that ongoing research seeks to remedy.

5. Phenomena that characterize the relevant atmospheric circulation patterns, their links to ocean conditions, and their variations include the Arctic and North Atlantic Oscillations (AO, NAO) as well as the El Niño / La Niña cycle. While these phenomena are part of what is usually termed “natural variability” in the weather/climate system and are sometimes offered as alternatives to anthropogenic climate change as explanations for unusual weather, there is increasing evidence that their frequencies and/or intensities are now intertwined with anthropogenic climate change.

With that background, one is in a position to appreciate the support offered for points made in Dr. Holdren’s video by the following examples from the peer-reviewed scientific literature over the period 2009-2014. (Order is chronological. Italicized material is quoted exactly from the indicated sources.)

Jennifer A. Francis, Wei Han Chan, Daniel J. Leathers, James R. Miller, and Dana E. Veron (Institute of Marine and Coastal Sciences, Rutgers University; Department of Geography, University of Delaware; College of Marine and Earth Studies, University of Delaware), “Winter Northern Hemisphere weather patterns remembers summer Arctic sea-ice extent”, Geophysical Research Letters, vol. 36, pp 1-5 (11 April 2009).

*By combining satellite measurements of sea-ice extent and conventional atmospheric observations, we find that varying summer ice conditions are associated with large-scale atmospheric features during the following autumn and winter well beyond the Arctic’s boundary. Mechanisms by which the atmosphere “remembers” a reduction in summer ice cover include warming and destabilization of the lower troposphere, increased cloudiness, and slackening of the poleward thickness gradient that weakens the polar jet stream.*


*Observational evidence shows that significant cold anomalies over the Far East in early winter and zonally elongated cold anomalies from Europe to Far East in late winter are associated with the decrease of the Arctic sea-ice cover in the preceding summer-to-autumn seasons. Results from numerical experiments using an atmospheric general circulation model support these notions.*

Recent loss of summer sea ice in the Arctic is directly connected to shifts in northern wind patterns in the following autumn, which has the potential of altering the heat budget at the cold end of the global heat engine. ... The most important conclusion of this and several recent papers is that loss of summer Arctic sea ice can have an impact on the larger Northern Hemisphere atmospheric circulation.

Jiping Liu, Judith A. Curry, Hjijun Wang, Mirog Song, and Radley M. Horton (School of Earth and Atmospheric Sciences, Georgia Institute of Technology; Institute of Atmospheric Physics, Chinese Academy of Sciences; and Columbia University Center for Climate Systems Research), “Impact of declining Arctic sea ice on winter snowfall”, Proceedings of the National Academy of Sciences, vol. 109, pp 4074-4079 (13 March 2012).

Here we demonstrate that the decrease in autumn Arctic sea ice is linked to changes in the winter Northern Hemisphere atmospheric circulation that have some resemblance to the negative phase of the winter Arctic oscillation. However, the atmospheric circulation change linked to the reduction of sea ice shows much broader meridional meanders in mid-latitudes and clearly different interannual variability than the classical Arctic oscillation. This circulation change results in more frequent episodes of blocking patterns that lead to increased cold surges over large parts of northern continents.


Two effects are identified that each contribute to a slower eastward progression of Rossby waves in the upper-level flow: 1) weakened zonal winds, and 2) increased wave amplitude. These effects are particularly evident in autumn and winter consistent with sea-ice loss, but are also apparent in summer, possibly related to earlier snow melt on high-latitude land. Slower progression of upper-level waves would cause associated weather patterns in mid-latitudes to be more persistent, which may lead to an increased probability of extreme weather events that result from prolonged conditions, such as drought, flooding, cold spells, and heat waves.


During the boreal winter 2009/2010, i.e., the period from December 2009 to February 2010, extreme conditions were recorded in many places across the northern hemisphere. Strong negative temperature anomalies and prolonged snowfall events over Europe, the Russian Federation, parts of North America, particularly the USA, and Asia, while many other larger areas registered above-normal temperatures for this season. ... According to the “Arctic Report Card: Update for 2010” (Richter-Menge, Overland, 2010), the boreal winter 2009/10 showed new connectivity between mid-latitude extreme cold and snowy events on the one hand and changes in the wind patterns in the Arctic on the other. This so-called warm Arctic — cold continents pattern has happened only three times in the last 160 years.

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the circumpolar vortex. A weakened jet stream is associated with both a slowing and increased waviness (larger “Rossby waves”) in the boundary of the vortex. That means larger southward excursions of relatively cold Arctic air, accompanied, in the other phase of the wave, by larger northward excursions of relatively warm mid-latitude air; it also means that those waves move from west to east relatively slowly, causing the unusual conditions associated with them to persist.

4. There is observational evidence that this behavior has been becoming more frequent and more pronounced in recent decades, although the data are incomplete in ways that ongoing research seeks to remedy.

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James E. Overland and Mu Yin Wang (NOAA Pacific Marine Environmental Laboratory; Joint Institute for the Study of the Atmosphere and Ocean, University of Washington), “Large-scale

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