

# Arctic, Antarctic, and Alpine Research

An Interdisciplinary Journal

ISSN: 1523-0430 (Print) 1938-4246 (Online) Journal homepage: <http://www.tandfonline.com/loi/uaar20>

## Environmental change and impacts in the Kangerlussuaq area, west Greenland

Jacob C. Yde, N. John Anderson, Eric Post, Jasmine E. Saros & Jon Telling

To cite this article: Jacob C. Yde, N. John Anderson, Eric Post, Jasmine E. Saros & Jon Telling (2018) Environmental change and impacts in the Kangerlussuaq area, west Greenland, Arctic, Antarctic, and Alpine Research, 50:1, S100001, DOI: [10.1080/15230430.2018.1433786](https://doi.org/10.1080/15230430.2018.1433786)

To link to this article: <https://doi.org/10.1080/15230430.2018.1433786>



© 2018 The Author(s). Published by Taylor & Francis.



Published online: 05 Mar 2018.



Submit your article to this journal [↗](#)



Article views: 713



View Crossmark data [↗](#)



## Environmental change and impacts in the Kangerlussuaq area, west Greenland

Jacob C. Yde<sup>a</sup>, N. John Anderson<sup>b</sup>, Eric Post<sup>c</sup>, Jasmine E. Saros <sup>d</sup>, and Jon Telling<sup>e</sup>

<sup>a</sup>Department of Environmental Sciences, Western Norway University of Applied Sciences, Sogndal, Norway; <sup>b</sup>Department of Geography, Loughborough University, Loughborough, UK; <sup>c</sup>Department of Wildlife, Fish and Conservation Biology, University of California, Davis, California, USA; <sup>d</sup>Climate Change Institute & School of Biology and Ecology, University of Maine, Orono, Maine, USA; <sup>e</sup>School of Natural and Environmental Sciences, Newcastle University, Newcastle upon Tyne, UK

### Background

During the past four decades there has been a growing interest in research on climate-induced environmental change and impacts in the Arctic. This is a response to acknowledging that a disproportional increase in surface air temperature is expected in the Arctic throughout the twenty-first century, owing to climatic feedbacks related to changes in sea ice and snow cover referred to as Arctic amplification (e.g., Serreze and Francis 2006). Not only will this Arctic amplification contribute to enhanced global sea-level rise because of accelerated melting and calving from glaciers (Church et al. 2013), rapid climate changes will also affect Arctic terrestrial and marine ecosystems and the linkage between these ecosystems and ecosystems located further south (Hawkings et al. 2015). Entire Arctic landscapes may change as glaciers recede, flood events become more frequent, the active layer deepens, and the duration of the growing season increases.

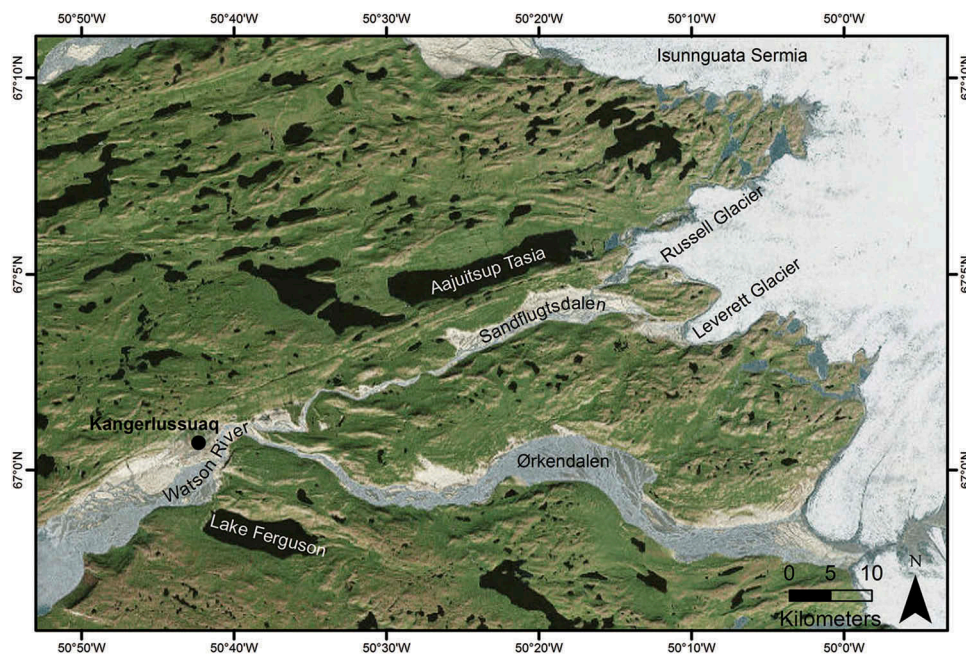
In the Arctic, ecological, geomorphic and climatic changes are closely linked and occur across a range of spatiotemporal scales (Anderson et al. 2017). Current research efforts focus on documenting the contemporary state of individual parts of the Arctic system and the rates of ongoing changes, and on providing new knowledge on responses and feedbacks of the underlying dynamic processes and biotic community structures in Arctic environments. These findings are used to refine models of future changes and to quantify available resource pools (water, nutrients, carbon) and their transport across glacial landscapes. In order to achieve a cross-system understanding of how climate-driven changes and impacts affect the linkages between ecosystem and geomorphological processes, it is of

utmost importance to have study sites in the Arctic with a long history of multidisciplinary research and monitoring.

Although the geographical range of research locations is spreading across the Arctic, logistic constraints mean that long-term research has been limited to relatively few sites. This has enhanced our appreciation that one explanation (e.g., warming) for recent environmental change at high latitudes does not fit all areas. The most notable of these are the Toolik Lake long-term ecological research (LTER) site (O'Brien 1992), which is located north of the Brooks Range, northern Alaska; the Abisko Research station, which straddles the ecotone boundary between birch forest and subarctic tundra in Swedish Lapland (Jonasson et al. 2012); and the Zackenberg facility located in the high Arctic landscape of northeast Greenland (Melfo et al. 2008). Research at these sites is diverse (e.g., meteorology, aquatic and terrestrial ecology, soils and geomorphology) but it is, perhaps, not as broad as that undertaken around Kangerlussuaq, as highlighted in this special section, in part because of the diverse ecological and physical systems located in a small spatial area.

### The Kangerlussuaq area

One of the most studied areas in the Arctic is the Kangerlussuaq area in southern west Greenland (Figure 1). This landscape extends from the Greenland Ice Sheet (GrIS) in the east to the inner part of the 190-km long fjord Kangerlussuaq in the west. The area between the GrIS and the fjord consists of floodplains with dunes, braided and meandering river systems, raised marine terraces, moraine ridges, numerous lakes with various morphologies and



**Figure 1.** Map of the Kangerlussuaq area (based on ESRI world imagery).

geochemical composition (e.g., ice-dammed, fluvial, and endorheic lakes), low mountains and an extensive marine delta where the main river, Watson River, enters the fjord. The climate is dry polar, and the permafrost is continuous. Deciduous shrubs, forbs, and graminoid species characterize the tundra vegetation. The geology comprises granitic and gneissic rocks with basic intrusions (Escher and Watt 1976). In many ways, the Kangerlussuaq area is a representative site for studying a continental Arctic landscape under transition.

The research history in the Kangerlussuaq area began with the University of Michigan Greenland expeditions of 1926–1933 (Hobbs 1926, 1927a, 1927b, 1941; Fergusson 1931). The primary purpose of the expeditions was to study anticyclones based on meteorological observations on the GrIS and near the head of the fjord, but members of the expedition were also dedicated to botanical, zoological, and glaciological studies. Many of the local place names derive from this expedition, such as the two outlet glaciers: Russell Glacier and Leverett Glacier (named after the University of Michigan geology professors Israel Cook Russell [1852–1906] and Frank Leverett [1859–1943]) and Lake Ferguson (named after U.S. Weather Bureau meteorologist Sterling Price Fergusson [1868–1959], who participated on the expedition). With the establishment in 1941 of the air base Blue West Eight (BW-8) at the head of the fjord by the U.S. Army Air Force, this part of Greenland became more accessible for pioneering researchers such as Tyge Böcher (1949) and Anker

Weidick (1968). The Kangerlussuaq area was a good choice for an airfield in Greenland because of its dry and stable weather conditions. After World War II, a civilian community developed adjacent to the air base and the airport became the main international entry point to Greenland from the 1960s to the present. The military air base was closed in 1992 and the facilities were transferred to the Danish and Greenlandic authorities. One of the former barracks now serves as a logistic support center for international researchers.

### Scope and content

The scope of this special section, *Environmental Change and Impacts in the Kangerlussuaq Area, West Greenland*, is to compile and present process studies and cross-system analyses within a broad range of bio- and geoscience disciplines. Together, these articles contribute to a better understanding of how processes and linkages within an Arctic landscape are connected.

Knowledge of past, present, and future climate change is fundamental for understanding the climatic impacts on ecosystems, nutrient transport, and landscape development. In this context, Utrecht University has done commendable work in maintaining weather stations along a transect on the Kangerlussuaq sector of the GrIS for more than two decades since 1993. This transect is known as the K-transect, and data from these stations have been vital for modeling of GrIS surface mass balance changes. Here, Smeets et al. (2018) present a summary and trend analysis of

twenty-three years of K-transect weather data, while Kuipers Munneke et al. (2018) examined variability and trends in the surface energy balance along the K-transect. With respect to past climate change, the deglaciation history in west Greenland during the early Holocene is well known, but it is very patchy during the mid- and late Holocene; especially after the Holocene Thermal Maximum (9000–5000 years BP) when the ice-sheet margin receded further inland than the present ice-sheet margin. Two articles by Levy et al. (2018) and Carrivick et al. (2018) now provide new insights into the dynamics of the ice-sheet margin during the Holocene based on  $^{10}\text{Be}$  dating of boulders and bedrock and  $^{14}\text{C}$  dating of roots and leaves in sediment profiles from drained ice-marginal lakes. Future climate change simulations are presented by Boberg et al. (2018), who used the climate scenarios to suggest that by the end of the twenty-first century the mean annual air temperature in the Kangerlussuaq area will be similar to the temperature in south Greenland today, and that the huge, local ice caps south of the fjord will almost disappear entirely by the end of the twenty-first century.

The best visual evidence of regional climate warming is the peripheral thinning of the GrIS. Ross et al. (2018) measured the ice thickness at Leverett Glacier to determine the present situation and obtain knowledge on the subglacial drainage pattern at the margin of the GrIS. Mernild et al. (2018) simulated surface mass balance and runoff from the Kangerlussuaq sector of the GrIS during a thirty-five-year period from 1979–1980 to 2013–2014. The nearby presence of the GrIS has a dominant influence as a source for sediment and nutrients to foreland and fjord systems, and both field observations and modeling of the GrIS are important to elucidate the magnitude and change of these fluxes. Based on runoff monitoring and sample collection at the outlet of Watson River, Hasholt et al. (2018) quantified the export of sediment and solutes into the fjord. Van As et al. (2018) used air temperature data from Kangerlussuaq and runoff data from lake Tasersiaq, located south of the Kangerlussuaq area, to extrapolate the Watson River runoff time series back to 1949. The runoff record shows that the recent extreme runoff years in 2010, 2012, and 2016 had longer and more intense melt seasons.

Wind acts as a key distributor of glacier-derived sediment and nutrients in dry polar regions. Bullard and Mockford (2018) analyzed the seventy-year record of dust observations from the Kangerlussuaq area and find that the magnitude of dust events has increased over the years. Aeolian processes are also an important geomorphic agent. Heindel et al. (2018) used Structure-

from-Motion photogrammetry to estimate erosion rates of deflation patches formed by strong katabatic winds from the GrIS. Dust events, dunes, and aeolian erosion are topics that must receive more attention in our effort to improve our understanding of fluxes within glacial landscapes.

Arctic ecosystems are very diverse. One of the ecosystems that has received increasing focus in recent years is the supraglacial ecosystem on the GrIS because of the impact of pigmented microorganisms on surface darkening, which enhances ice melting (Stibal et al. 2017). The ice-sheet margin in the Kangerlussuaq area is likely the most investigated glacial ecosystem worldwide. The most active microbial habitat on glacier surfaces is within cryoconite holes, and this special section presents two novel studies on cryoconite holes. Cook et al. (2018) show that ice-surface topography has implications for the morphology of cryoconite holes and carbon exchange, while Poniecka et al. (2018) explore microscale anaerobic environments in cryoconite holes.

Climatic changes affect both the physical and ecological characteristics of the many lakes in the Kangerlussuaq area (Saros et al. 2016; Osburn et al. 2017; Whiteford et al. 2016). In this special section, several studies analyzed the environmental change and impacts on Arctic lakes. Mariash et al. (2018) show that benthic and pelagic primary production decrease as the dissolved organic carbon (DOC) content increases in lakes, while Fowler, Saros, and Osburn (2018) conducted experiments to evaluate potential mechanisms, such as dust addition, bacterial activity, and photodegradation, responsible for changing DOC concentrations and quality in lakes. These findings can be applied to predict how changing DOC concentrations can affect the aquatic food web. Thompson, White, and Pratt (2018) investigated spatial variations in the stable isotope composition of macrophyte species and littoral and profundal sediments and found that the organic matter in an endorheic lake primarily derive from primary production of macrophytes within the lake. Henkemans et al. (2018) combined geochemical analyses and a range of environmental isotopes to examine the geochemical processes along a transect of lakes. They found that evaporation is the dominant control on lake chemistry, while groundwater interaction has little impact. Burpee et al. (2018) compared the ecological, chemical, and physical characteristics of glacier-fed lakes with the characteristics of nonglacial lakes. Their study shows how glacial meltwater from the GrIS impacts the ecology of Arctic lakes.

Climate-induced changes are also evident in terrestrial ecosystems (Post and Pedersen 2008). For example, previous monitoring of plant phenology and



herbivore production in the Kangerlussuaq area show that the growing season has advanced by approximately twenty days, while the timing of caribou calving has not (Kerby and Post 2013; Post and Forchhammer 2008). Radville, Post, and Eissenstat (2018) examined recent plant phenological responses to climate warming, and they find that the growing season is no longer advancing. Urbanowicz, Virginia, and Irwin (2018) analyzed pollination and plant reproduction across an air-temperature transect. Their results demonstrate that interactions between pollinators and plants may mediate the consequences of climate warming on plant reproduction. Another topic that has received much research interest in recent years is the carbon cycle in Arctic tundra soils. Bradley-Cook and Virginia (2018) quantified the spatial variation in soil carbon stocks in the Kangerlussuaq area and estimated carbon fluxes in different vegetation types. They expect a possible trend toward decreasing soil carbon storage and increasing carbon dioxide emissions.

The fjord system in the Kangerlussuaq area is characterized by a turbid meltwater plume during the summer (Lund-Hansen et al. 2010; McGrath et al. 2010) and sea ice and snow cover during the winter and spring. Lund-Hansen et al. (2018) determined a series of ecological, chemical, and physical parameters in the water column during two cruises in late summer and early spring. Their results show that turbid glacial meltwater is the primary control on primary production during the summer. The authors conclude that increasing future meltwater runoff from the GrIS will lead to reduced primary production due to increased turbidity and reduced light transmittance.

## Synthesis

As well as rapid warming, the Arctic is subject to a range of stressors, ranging from long-range atmospheric pollutants, including reactive nitrogen (e.g., Zou et al. 2017), metals such as mercury and lead (e.g., Bindler et al. 2001a), and changing hydrology (e.g., Ahlström et al. 2017). How these factors will influence the different components of the wider Arctic system will undoubtedly be complex and vary at a range of spatial and temporal scales: compare, for example, the contrasting response of weathering rates in recently deglaciated landscapes with the stratification of regimes in adjacent lakes. The range of ecological and physical processes covered in this special section illustrates the diverse nature of environmental change in the Arctic and the importance of a holistic overview. With this special section, we hope that we can stimulate Arctic researchers to include a broader landscape-scale

approach in their research as well as combine and exchange ideas with researchers working on adjacent environments within the same study area and elsewhere in the Arctic.

## Acknowledgments

We express our sincere thanks to the many contributing authors and reviewers who have made this special section possible. We are very grateful to the editors and staff of *Arctic, Antarctic, and Alpine Research*, who have provided efficient assistance throughout the entire publication process even though the journal has been through a period of change. Finally, we are in debt to the brilliant support that we have received from different managers at Kangerlussuaq International Science Support (KISS) over the years.

## ORCID

Jasmine E. Saros  <http://orcid.org/0000-0002-7652-9985>

## References

- Ahlström, A. P., D. Petersen, P. L. Langen, M. Citterio, and J. E. Box. 2017. Abrupt shift in the observed runoff from the southwestern Greenland ice sheet. *Science Advances* 3: e1701169. doi:10.1126/sciadv.1701169.
- Anderson, N. J., J. E. Saros, J. E. Bullard, S. M. P. Cahoon, S. McGowan, E. A. Bagshaw, C. D. Barry, R. Bindler, B. T. Burpee, J. L. Carrivick, et al. 2017. The Arctic in the twenty-first century: Changing biogeochemical linkages across a paraglacial landscape of Greenland. *BioScience* 67:118–33.
- Bindler, R., I. Renberg, N. J. Anderson, P. G. Appleby, O. Emteryd, and J. Boyle. 2001a. Pb isotope ratios of lake sediments in West Greenland: Inferences on pollution sources. *Atmospheric Environment* 35:4675–85.
- Bindler, R., I. Renberg, P. G. Appleby, N. J. Anderson, and N. L. Rose. 2001b. Mercury accumulation rates and spatial patterns in lake sediments from west Greenland: A coast to ice margin transect. *Environmental Science and Technology* 35:1736–41.
- Boberg, F., P. L. Langen, R. H. Mottram, J. H. Christensen, and M. Olesen. 2018. 21st century climate change around Kangerlussuaq, west Greenland: From the ice sheet to the shores of Davis Strait. *Arctic, Antarctic, and Alpine Research* 50:S100006.
- Böcher, T. W. 1949. Climate, soil, and lakes in continental West Greenland in relation to plant life. *Meddelelser Om Grønland* 147 (2):60–61.
- Bradley-Cook, J. I., and R. A. Virginia. 2018. Landscape variation in soil carbon stocks and respiration in an Arctic tundra ecosystem, west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100024.
- Bullard, J. E., and T. Mockford. 2018. Seasonal and decadal variability of dust observations in the Kangerlussuaq area, west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100011.

- Burpee, B., D. Anderson, and J. E. Saros. 2018. Assessing ecological effects of glacial meltwater on lakes fed by the Greenland Ice Sheet: the role of nutrient subsidies and turbidity. *Arctic, Antarctic, and Alpine Research* 50: S100019.
- Carrivick, J. L., J. C. Yde, N. T. Knudsen, and C. Kronborg. 2018. Ice-dammed lake and ice margin evolution during the Holocene in the Kangerlussuaq area of west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100005.
- Church, J. A., P. U. Clark, A. Cazenave, J. M. Gregory, S. Jevrejeva, A. Levermann, M. A. Merrifield, G. A. Milne, R. S. Nerem, and P. D. Nunn. 2013. Sea level change. In *Climate change 2013: The physical science basis*, ed. T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, P. M. Midgley, et al., Chapter 13, 1137–216. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, and New York, NY: Cambridge University Press.
- Cook, J. M., M. Sweet, O. Cavalli, A. Taggart, and A. Edwards. 2018. Topographic shading influences cryoconite morphodynamics and carbon exchange. *Arctic, Antarctic, and Alpine Research* 50:S100014.
- Escher, A., and W. S. Watt. 1976. *The geology of Greenland*. Copenhagen, Denmark: Geological Survey of Greenland.
- Fergusson, S. P. 1931. *Reports of the Greenland expeditions of the University of Michigan (1926–1931). Part I. Aerology*. Ann Arbor: University of Michigan Press.
- Fowler, R. A., J. E. Saros, and C. L. Osburn. 2018. Shifting DOC concentration and quality in freshwater lakes of the Kangerlussuaq region: An experimental assessment of possible mechanisms. *Arctic, Antarctic, and Alpine Research* 50:S100013.
- Hasholt, B., D. van As, A. B. Mikkelsen, S. H. Mernild, and J. C. Yde. 2018. Observed sediment and solute transport from the Kangerlussuaq sector of the Greenland Ice Sheet (2006–2016). *Arctic, Antarctic, and Alpine Research* 50:S100009.
- Hawkings, J. R., J. L. Wadham, M. Tranter, E. Lawson, A. Sole, T. Cowton, A. J. Tedstone, I. Bartholomew, P. Nienow, D. Chandler, et al. 2015. The effect of warming climate on nutrient and solute export from the Greenland Ice Sheet. *Geochemical Perspectives Letters* 1:94–104.
- Heindel, R. C., J. W. Chipman, J. T. Dietrich, and R. A. Virginia. 2018. Quantifying rates of soil deflation with Structure-from-Motion photogrammetry in west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100012.
- Henkemans, E., S. K. Frape, T. Ruskeeniemi, N. J. Anderson, and M. Hobbs. 2018. A landscape-isotopic approach to the geochemical characterization of lakes in the Kangerlussuaq region, west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100018.
- Hobbs, W. H. 1926. The University of Michigan Greenland expedition of 1926–1927. *Geographical Review* 16 (2):256–63.
- Hobbs, W. H. 1927a. The first Greenland expedition of the University of Michigan. *Geographical Review* 17 (1):1–35.
- Hobbs, W. H. 1927b. The second Greenland expedition of the University of Michigan. *Nature* 120:920–22.
- Hobbs, W. H. 1941. *Reports of the Greenland expeditions of the University of Michigan (1926–1933). Part II. Meteorology, physiography, and botany*, 287. Ann Arbor: University of Michigan Press.
- Jonasson, C., M. Sonesson, T. R. Christensen, and T. V. Callaghan. 2012. Environmental monitoring and research in the Abisko area: An overview. *Ambio* 41:178–86.
- Kerby, J. T., and E. Post. 2013. Advancing plant phenology and reduced herbivore production in a terrestrial system associated with sea ice decline. *Nature Communications* 4:1–6.
- Kuipers Munneke, P., C. J. P. P. Smeets, C. H. Reijmer, J. Oerlemans, R. S. W. van de Wal, and M. R. van den Broeke. 2018. The K-transect on the western Greenland Ice Sheet: Surface energy balance (2003–2016). *Arctic, Antarctic, and Alpine Research* 50:S100003.
- Law, A. C., A. Nobajas, and R. Sangonzalo. 2018. Heterogeneous changes in the surface area of lakes in the Kangerlussuaq area of southwestern Greenland between 1995 and 2017. *Arctic, Antarctic, and Alpine Research* 50: S100027.
- Levy, L. B., M. A. Kelly, P. A. Applegate, J. A. Howley, and R. A. Virginia. 2018. Middle to late Holocene chronology of the western margin of the Greenland Ice Sheet: A comparison with Holocene temperature and precipitation records. *Arctic, Antarctic, and Alpine Research* 50:S100004.
- Lund-Hansen, L. C., T. J. Andersen, M. H. Nielsen, and M. Pejrup. 2010. Suspended matter, chl-a, CDOM, grain sizes, and optical properties in the Arctic fjord-type estuary, Kangerlussuaq, west Greenland during summer. *Estuaries and Coasts* 33:1442–51.
- Lund-Hansen, L. C., I. Hawes, M. H. Nielsen, I. Dahllöf, and B. K. Sorrell. 2018. Summer meltwater and spring sea ice primary production, light climate and nutrients in an Arctic estuary, Kangerlussuaq, west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100025.
- Mariash, H. L., M. Cazzanelli, M. Rautio, L. Hamerlik, M. J. Wooller, and K. S. Christoffersen. 2018. Changes in food web dynamics of low Arctic ponds with varying content of dissolved organic carbon. *Arctic, Antarctic, and Alpine Research* 50:S100016.
- McGrath, D., K. Steffen, I. Overeem, S. H. Mernild, B. Hasholt, and M. van den Broeke. 2010. Sediment plumes as a proxy for local ice-sheet runoff in Kangerlussuaq Fjord, west Greenland. *Journal of Glaciology* 56:813–21.
- Meltofte, H., T. R. Christensen, B. Elberling, M. C. Forchhammer, and M. Rasch. 2008. *High-Arctic ecosystem dynamics in a changing climate*, Vol. 40, 596. Advances in Ecological Research, Elsevier, Amsterdam, The Netherlands.
- Mernild, S. H., G. E. Liston, D. van As, B. Hasholt, and J. C. Yde. 2018. High-resolution ice sheet surface mass-balance and spatiotemporal runoff simulations: Kangerlussuaq, west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100008.
- O'Brien, W. J. (ed.). 1992. Toolik Lake: Ecology of an aquatic ecosystem in Arctic Alaska. In *Developments in Hydrobiology*, Vol. 78, 269. Dordrecht: Kluwer Academic Press.
- Osburn, C. L., N. J. Anderson, C. A. Stedmon, M. E. Giles, E. J. Whiteford, T. J. McGenity, A. J. Dumbrell, and G. J. C. Underwood. 2017. Shifts in the source and composition of dissolved organic matter in southwest Greenland lakes along a regional hydro-climatic gradient. *Journal of Geophysical Research: Biogeosciences* 122:3431–45. doi:10.1002/2017JG003999.
- Poniecka, E. A., E. A. Bagshaw, M. Tranter, H. Sass, C. J. Williamson, A. M. Anesio, and Black and Bloom Team.

2018. Rapid development of anoxic niches in supraglacial ecosystems. *Arctic, Antarctic, and Alpine Research* 50:S100015.
- Post, E., and M. C. Forchhammer. 2008. Climate change reduces reproductive success of an Arctic herbivore through trophic mismatch. *Philosophical Transactions of the Royal Society B* 363:2369–75.
- Post, E., and C. Pedersen. 2008. Opposing plant community responses to warming with and without herbivores. *Proceedings of the National Academy of Science* 105 (34):12353–58.
- Radville, L., E. Post, and D. M. Eissenstat. 2018. On the sensitivity of root and leaf phenology to warming in the Arctic. *Arctic, Antarctic, and Alpine Research* 50: S100020.
- Ross, N., A. J. Sole, S. J. Livingstone, A. Igneczi, and M. Morlighem. 2018. Near-margin ice thickness and subglacial water routing, Leverett Glacier, Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100007.
- Saros, J. E., R. M. Northington, C. L. Osburn, B. T. Burpee, and N. J. Anderson. 2016. Thermal stratification in small arctic lakes of southwest Greenland affected by water transparency and epilimnetic temperatures. *Limnology & Oceanography* 61:1530–42.
- Serreze, M. C., and J. A. Francis. 2006. The Arctic amplification debate. *Climate Change* 76:241–64.
- Smeets, C. J. P. P., P. Kuipers Munneke, D. van As, M. R. van den Broeke, W. Boot, J. Oerlemans, H. Snellen, C. H. Reijmer, and R. S. W. van de Wal. 2018. The K-transect in west Greenland: Automatic weather station data (1993–2016). *Arctic, Antarctic, and Alpine Research* 50:S100002.
- Stibal, M., J. E. Box, K. A. Cameron, P. L. Langen, M. L. Yallop, R. H. Mottram, A. L. Khan, N. P. Molotch, N. A. M. Christmas, F. C. Quaglia, et al. 2017. Algae drive enhanced darkening of bare ice on the Greenland Ice Sheet. *Geophysical Research Letters* 44:11463–47. doi:10.1002/2017GL075958.
- Thompson, H. A., J. R. White, and L. M. Pratt. 2018. Spatial variation in stable isotopic composition of organic matter of macrophytes and sediments from a small Arctic lake in west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100017.
- Urbanowicz, C., R. A. Virginia, and R. E. Irwin. 2018. Pollen limitation and reproduction of three plant species across a temperature gradient in west Greenland. *Arctic, Antarctic, and Alpine Research* 50:S100022.
- van As, D., B. Hasholt, A. P. Ahlstrøm, J. E. Box, J. Cappelen, W. Colgan, R. S. Fausto, S. H. Mernild, A. B. Mikkelsen, B. P. Y. Noël, et al. 2018. Reconstructing Greenland Ice Sheet meltwater discharge through the Watson River (1949–2017). *Arctic, Antarctic, and Alpine Research* 50:S100010.
- Weidick, A. 1968. *Observations on some Holocene glacier fluctuations in West Greenland*. Vol. 165 of *Meddelelser om Grønland*, 202, C. A. Reitzels Forlag, Copenhagen, Denmark.
- Whiteford, E. J., S. McGowan, C. D. Barry, and N. J. Anderson. 2016. Seasonal and regional controls of phytoplankton production along a climate gradient in southwest Greenland during ice-cover and ice-free conditions. *Arctic, Antarctic, and Alpine Research* 48:139–59.
- Zou, Y., Y. Wang, Y. Zhang, and J.-H. Koo. 2017. Arctic sea ice, Eurasia snow, and extreme winter haze in China. *Science Advances* 3:e1602751. doi:10.1126/sciadv.1602751.