Supplementary Information

Climate Change Influence on the Levels and Trends of Persistent Organic Pollutants (POPs) and Chemicals of Emerging Arctic Concern (CEACs) in the Arctic Physical Environment – A Review

Hayley Hung*[a], Crispin Halsall[b], Hollie Ball[b], Terry Bidleman[c], Jordi Dachs[d], Amila De Silva[e], Mark Hermanson[f], Roland Kallenborn[g,h], Derek Muir[e], Roxana Sühring[i,j], Xiaoping Wang[k], Simon Wilson[l]

[a] Air Quality Processes Research Section, Environment and Climate Change Canada, 4905 Dufferin Street, Toronto, Ontario M5P 1W4 Canada

[b] Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, U.K.

[c] Department of Chemistry, Umeå University, Umeå, SE-901 87, Sweden

[d] Institute of Environmental Assessment and Water Research, Spanish National Research Council (IDAEA-CSIC), Barcelona, Catalonia 08034, Spain

[e] Aquatic Contaminants Research Division, Environment and Climate Change Canada, Burlington, Ontario, Canada

[f] Hermanson & Associates LLC, 2000 W 53rd Street, Minneapolis, Minnesota 55419, United States

[g] Department of Arctic Technology, University Centre in Svalbard (UNIS), Longyearbyen, 9171, Norway

[h] Faculty of Chemistry, Biotechnology and Food Sciences, Norwegian University of Life Sciences (NMBU), Ås, 1432, Norway

[i] Department for Environmental Science, Stockholm University, 114 19 Stockholm, Sweden

[j] Department of Chemistry and Biology, Ryerson University, Toronto, Ontario M5B 2K3, Canada

[k] Key Laboratory of Tibetan Environment Changes and Land Surface Processes, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China

[l] Arctic Monitoring and Assessment Programme Secretariat, The Fram Centre, 9296 Tromsø, Norway

*Corresponding Author

Table of Contents

Text S1 Climate Variation Patterns and Indices

This paper refers to climate variation patterns and indices, including the Arctic Oscillation (AO), North Atlantic Oscillation (NAO), and the El Niño Southern Oscillation (ENSO).

These indices reflect cyclical variations in large-scale regional climate patterns. As such, they are associated with different 'climate states' that can be related to contaminant transport pathways and climate-induced changes in environmental contamination, as well as conditions that may represent possible future climate 'norms'.

In particular, the AO and NAO have been associated with changes in environmental contamination in Arctic studies and these are therefore briefly described below. Further details and illustrations can be found on the National Oceanic and Atmospheric Administration (NOAA) website: https://www.ncdc.noaa.gov/teleconnections/.

The AO index is characterized by winds circulating counter-clockwise around the Arctic at around 55°N latitude and is often considered a surface-level expression of the stratospheric polar vortex (Figure S1[1]). A positive AO phase (AO+) represents a ring of strong winds circulating around the North Pole confining colder air across polar regions. A negative AO phase (AO-) therefore represents weaker and more distorted winds, which allow an easier southward penetration of colder, Arctic air masses and increased storminess into the mid-latitudes.[2] The NAO index represents the normalized gradient in air pressure at sea level between the Azores/Lisbon, Portugal and Stykkishólmur/Reykjavik, Iceland, as per AMAP (2003). A positive phase of the NAO (NAO+) tends to be associated with above-normal temperatures in the eastern United States and across northern Europe, and below-normal temperatures in Greenland. It is also associated with above-normal precipitation over northern Europe and Scandinavia. A negative NAO phase (NAO-) is associated with the inverse situation.[2]

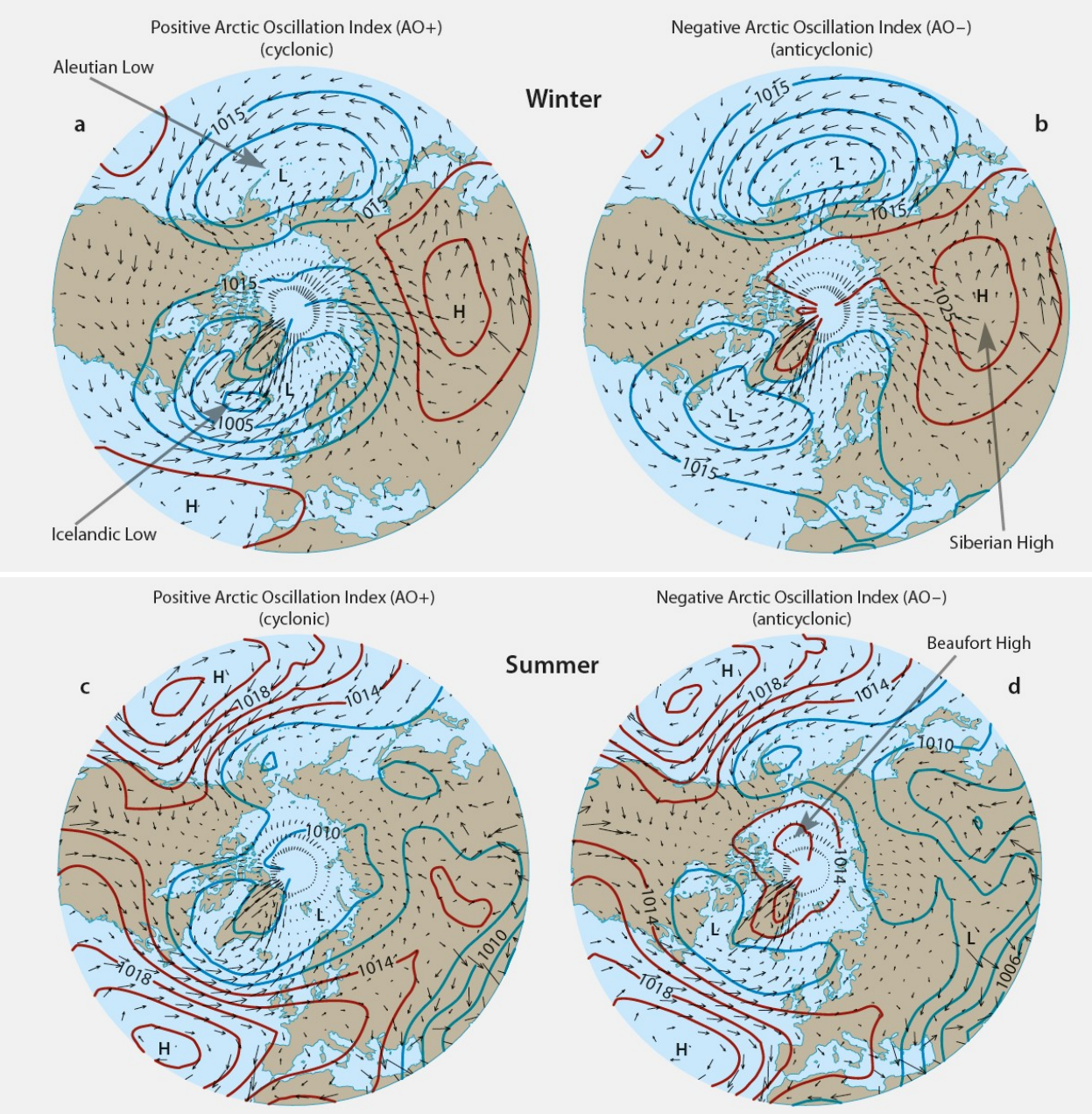

Figure S1. Atmospheric pressure fields and wind stream lines in the Northern Hemisphere for (a) strong AO+ conditions in winter; (b) strong AO- conditions in winter; c) strong AO+ conditions in summer; and d) strong AO- conditions in summer. Small arrows show the geostrophic wind field associated with the AO pattern with longer arrows implying stronger winds.[1]

References

1. AMAP, AMAP Assessment 2002: The Influence of Global Change on Contaminant Pathways to, within, and from the Arctic. By: Macdonald RW, Harner T, Fyfe J, Loeng H, Weingartner T. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 2003; xii + 65 pp.

2. NOAA, Teleconnections. National Oceanic and Atmospheric Administration (NOAA), 2019. Accessed 19 June 2019. https://www.ncdc.noaa.gov/teleconnections/