

Title: air Pollution in the Arctic: Climate, Environment and Society (PACES)

Authors: S.R. Arnold¹ (s.arnold@leeds.ac.uk), C.A. Brock², K.S. Law³

1. Institute for Climate and Atmospheric Science, School of Earth & Environment, University of Leeds, UK; 2. Sorbonne Universités, UPMC Univ. Paris 06, Université Versailles St-Quentin, CNRS/INSU, LATMOS-IPSL, Paris, France. 3. NOAA Earth System Research Laboratory, Chemical Sciences Division, Boulder, CO, USA.

Arctic air pollution, including aerosol particles such as black carbon and trace gases such as tropospheric ozone, has impacts on climate change, ecosystems, regional air quality, and human health. Rapid changes to and complex interactions within the Arctic environment due to global warming and socio-economic drivers mean that there is an urgent requirement to improve understanding of sources of Arctic air pollutants, which both contribute to and are driven by Arctic environmental change. Changes in atmospheric aerosol particles and tropospheric ozone have likely contributed substantially to recent rapid warming of the Arctic (Shindell and Faluvegi, 2009). The balance between Northern Hemisphere mid-latitude pollution sources and local Arctic sources is changing, the latter being already important in some regions, and likely to grow rapidly in the future. Reducing sea-ice is leading to increased accessibility and local emissions from activities such as oil and gas extraction or shipping. Improved quantification of the relative contributions of different pollutant sources is needed to provide a sound scientific basis for sustainable solutions and adaptive strategies. Deficiencies in predictive capability and a lack of observations at high latitudes present major challenges to advancing this understanding, and to making credible near- and long-term projections of Arctic environmental change. This Short Statement describes a new international initiative - air Pollution in the Arctic: Climate Environment and Societies (PACES) (see www.igacprojects.org/PACES), recently launched under the auspices of the International Global Atmospheric Chemistry project (under Future Earth) and the International Arctic Science Committee (IASC/Atmosphere WG). PACES addresses several AOS themes, aiming to promote and spin-up new observational efforts to reduce uncertainties in process-level understanding and improve predictive capability of impacts related to Arctic air pollution. In particular, PACES addresses Theme 1 (international strategies), Theme 6 (citizen-based science), Theme 5 (links to global programs), and Theme 2 (e.g. development of miniaturised sensors).

Despite recent progress in understanding sources, processing, fate and impacts of Arctic air pollution, through extensive and unprecedented observations from aircraft, surface and satellites during the International Polar Year (IPY) (Law et al., 2014), there remain important

uncertainties and unknowns regarding processes controlling Arctic air pollution and its impacts. Models display diverse and often poor skill in simulating pollution enhancements at the surface and throughout the depth of the troposphere in the Arctic (Monks et al., 2015; Eckhardt et al., 2015), suggesting deficiencies in diagnosing pollutant contributions from local and remote sources. Long-term Arctic surface observations provide information on seasonal cycles and pollutant trends, however these are most sensitive to local and Eurasian emissions. Pollution from North American and Asian sources enters the Arctic at higher altitudes but regular vertical profile information is severely lacking. Poor understanding of pollutant deposition fluxes is a likely driver of poor model skill. There are significant uncertainties associated with sources and impacts of local emissions from e.g. oil and gas extraction and shipping (e.g. Stohl et al., 2013). An understanding of how natural processes will be modified by pollution in a changing Arctic is also essential. Moreover, projections of Arctic air pollution must account for ever-changing human activities and evolving governance and socio-economic responses. Partnership between Northern communities and atmospheric scientists to expand and exchange knowledge about Arctic air pollution will be invaluable, through community-based observations and benefiting from local knowledge to improve assessment of air pollution risks and explore sustainable solutions in Northern communities.

PACES aims to advance Arctic air pollution research over the coming decade. Longer-term goals are being addressed in the short-term (2016/17) via a series of planning and discussion workshops to identify specific PACES actions and to foster new collaborative efforts that will be developed for the mid/longer term and contribute to the PACES Implementation Plan. PACES makes the following key recommendations:

- 1) Advancement of Arctic air pollution research should be trans-disciplinary exploiting collaborative platforms for observations across linked aspects of the Earth system (atmosphere, cryosphere, ocean, land surface, society), foster community-based monitoring approaches, and take account of societal and economic drivers and responses to Arctic change.
- 2) Improve process understanding via developments in regular long-term monitoring and intensive field observations (surface/vertically; in-situ/satellite). Use of commercial transport platforms (shipping and aircraft) and new technologies (e.g. unmanned aerial vehicles) should be explored.
- 3) Improve predictive capability across a range of scales to diagnose impacts of Arctic air pollution on regional/global climate and air quality and the wider Earth system exploiting new capabilities in Earth system modelling, and coupled regional-scale modelling.

Quantification of impacts on societies and economic response requires development of physical models informed by social and economic drivers.

Following a recent workshop, several actions have been identified and Working Groups are being developed to plan for coordinated airborne & modelling activity on transport of (Asian) pollution to the Arctic (2018-2020 timeframe) and to improve observational capacity in the Russian Arctic. A further workshop is planned at ASSW to discuss natural-social science initiatives.

References

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