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A synthesis of atmospheric mercury depletion event chemistry in the atmosphere and snow

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Abstract. It was discovered in 1995 that, during the spring time, unexpectedly low concentrations of gaseous elemental mercury (GEM) occurred in the Arctic air. This was surprising for a pollutant known to have a long residence time in the atmosphere; however conditions appeared to exist in the Arctic that promoted this depletion of mercury (Hg). This phenomenon is termed atmospheric mercury depletion events (AMDEs) and its discovery has revolutionized our understanding of the cycling of Hg in Polar Regions while stimulating a significant amount of research to understand its impact to this fragile ecosystem. Shortly after the discovery was made in Canada, AMDEs were confirmed to occur throughout the Arctic, sub-Artic and Antarctic coasts. It is now known that, through a series of photochemically initiated reactions involving halogens, GEM is

converted to a more reactive species and is subsequently associated to particles in the air and/or deposited to the polar environment. AMDEs are a means by which Hg is transferred from the atmosphere to the environment that was previously unknown. In this article we review Hg research taken place in Polar Regions pertaining to AMDEs, the methods used to collect Hg in different environmental media, research results of the current understanding of AMDEs from field, laboratory and modeling work, how Hg cycles around the environment after AMDEs, gaps in our current knowledge and the future impacts that AMDEs may have on polar environments. The research presented has shown that while considerable improvements in methodology to measure Hg have been made but the main limitation remains knowing the speciation of Hg in the various media. The processes that drive AMDEs and how they occur are discussed. As well, the role that the snow pack and the sea ice play in the cycling of Hg is presented. It has been found that deposition of Hg from AMDEs occurs at marine coasts and not far inland and that a fraction of the deposited Hg does not remain in the same form in the snow. Kinetic studies undertaken have demonstrated that bromine is the major oxidant depleting Hg in the atmosphere. Modeling results demonstrate that there is a significant deposition of Hg to Polar Regions as a result of AMDEs. Models have also shown that Hg is readily transported to the Arctic from source regions, at times during springtime when this environment is actively transforming Hg from the atmosphere to the snow and ice surfaces. The presence of significant amounts of methyl Hg in snow in the Arctic surrounding AMDEs is important because this species is the link between the environment and impacts to wildlife and humans. Further, much work on methylation and demethylation processes has occurred but these processes are not yet fully understood. Recent changes in the climate and sea ice cover in Polar Regions are likely to have strong effects on the cycling of Hg in this environment; however more research is needed to understand Hg processes in order to formulate meaningful predictions of these changes.

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