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Atmospheric Mercury Depletion Event and Mercury Photoreduction in Snowpack of Mid-latitude Coastal Island

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The polar springtime Atmospheric Mercury Depletion Event (AMDE) is thought to be responsible for substantial atmospheric mercury (Hg) delivery (in the form of oxidized Hg^{2+}) to snowpack via active Hg photo-oxidation led by coastal halogen. While this atmospheric-snowpack exchange for mercury is well characterized in the Arctic and the Antarctic, only a few studies have characterized Hg interactions between the atmosphere and snowpack at mid-latitude coastal regions. We collected atmospheric samples of total gaseous Hg (TGM) and snow samples at Mountain Halla (elevation of 970m, 1400m and 1700m) located at a coastal island of Jeju, South Korea to characterize sources and mechanisms driving atmospheric-snowpack Hg interaction at mid-latitudes. The snow samples collected at Mountain Halla exhibited surprisingly consistent Hg isotope ratios (δ^{202}Hg = 0.02 ± 0.02‰, δ^{199}Hg = -1.07 ± 0.31‰, 1 SD) with snowfall samples affected by the AMDE in the Arctic region (δ^{202}Hg = 0.25 ± 0.42‰, δ^{199}Hg = -1.08 ± 0.18‰, 1 SD) and contrast with snow influenced by reactive surface uptake of gaseous elemental Hg (Hg^0) (δ^{202}Hg = -1.27 ± 0.22‰, δ^{199}Hg = -0.14 ± 0.14‰, 1 SD). The TGM samples collected at the same site showed a δ^{202}Hg range of –2.33 to –0.80‰. Such negative δ^{202}Hg in TGM is thought to reflect Hg evaded from the ocean surface, indicating that our snow samples are likely impacted by marine air masses containing coastal halogen and Hg. Over the course of 3-day sampling, the Hg isotopes ratios of the snow samples showed increasing trend (3rd day; δ^{202}Hg = 0.34 ± 0.03‰, δ^{199}Hg = 0.03 ± 0.02‰, 1 SD). The slope of δ^{199}Hg/δ^{201}Hg, used to differentiate between photochemically reduced Hg^{2+} and photochemically degraded methylmercury, showed a value (δ^{199}Hg/δ^{201}Hg = 1.04 ± 0.03) consistent with the aqueous Hg^{2+} photo-reduction, caused by the melting of snow. Our study provides clear evidence of the AMDE occurring at mid-latitude coastal sites, driven by the surface evaded halogen and Hg from the ocean surface.

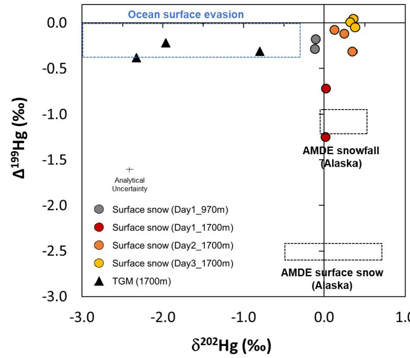

Figure 1. δ^{202}Hg and Δ^{199}Hg of surface snow and total gaseous mercury (TGM) collected at low (970m) and high altitudes (1700m) in Mountain Halla, Jeju Island, South Korea in February, 2021. Surface snow samples are presented in circles and the colors indicate varying sampling days and altitudes of sampling sites. Ambient TGM are presented in black triangles.