

The impact of the 2020 COVID-19 lockdown and 2021 heavy snowfall on atmospheric conditions from the Mt. Tateyama snowpack point of view

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The rapid economic development of the Asia continent is affecting atmospheric conditions such as air pollution. Air pollution also causes damage to surrounding areas due to wind action. Airborne pollutants from the Asia continent are carried by the monsoon and westerlies to Toyama Prefecture in Japan, which has one of the heaviest snowfalls in the world. It has been reported that they are captured in the snowpack of the Tateyama Mountain range and stored during the winter. This feature is used to assess the impact of transboundary pollution. Recent interesting events include 1) significant changes in atmospheric conditions on the Asia due to the COVID-19 lockdown in 2020 and 2) record snowfall in the Toyama Plain in winter 2021. To assess how these events affect atmospheric conditions, this study compared the chemical composition (e.g., $\delta^{18}\text{O}$, δD , $\delta^{34}\text{S}$, REEs) of the Mt. Tateyama snowpack and Toyama Plain precipitation (rainfall and snowpack) in 2020, 2021, and 2022, assuming that the 2022 samples are from normal conditions. The location of the loess layer and d-values were used to estimate the timing of snow accumulation on a monthly scale. High $\delta^{34}\text{S}$ and $\text{nss-SO}_4^{2-}/\text{NO}_3$ values were found in the 2020 sample. This result indicates anthropogenic emissions in the Asian continent during the lockdown period (January to March 2020). These values can be attributed to the increased rate of major sulfate emissions from households without extensive desulfurization rather than from plants in Asia. The total deposition of the major chemical components in Mt. Tateyama was much smaller in winter 2021 than in 2020. On the other hand, the amount of deposition in the plain area was higher in winter 2021 than that in 2020. This indicates that intensive heavy snowfall deposited a large amount of chemical constituents in the plain area, thus reducing the deposition in the Tateyama area. Aerosol has been reported to be an important source of nutrients to the ocean. This study highlights the threat of reduced nutrient delivery to the ocean via aerosol due to increased extreme weather events and the importance of continuous monitoring of snow accumulation in the Tateyama region.