Innovative progress in ground observation of snow crystals and weather conditions by citizen science

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To improve forecasts of snowfall events, a better understanding of the horizontal distribution of precipitation types and the microphysical properties of snow clouds is required. Observations of cloud microphysical properties, however, has been limited because of the sparse observation network. Recently, ground observations of precipitation types are performed by citizen science approaches especially in United States. In this study, ground observations of snow crystals and weather conditions are conducted by citizen science in Japan, and we would like to introduce recent progress in ground observation study and discuss the potentialities and challenges of citizen science big data.

The Meteorological Research Institute (MRI) has conducted the "#KantoSnowCrystal Project" to collect images of snow crystals from citizens during snowfall events in the Kanto and Koshin regions in Japan from November 2016. Smartphone cameras were used to capture the images, which were mainly collected through social networking services. Through the project, we were able to establish an easy method for snow crystal observation and data collection. More than 10,000 snow crystal images were gathered throughout the 2016-2017 winter, of which 73% were analyzable. In the case of heavy snowfall event in the Kanto plain on 22 January 2018, more than 40,000 snow crystal images were gathered in only a day. The #KantoSnowCrystal Project thereby realized spatiotemporally ultra-dense observations of snow crystals in these metropolitan areas, and the observation dataset should contribute to investigations of snowfall mechanisms in these areas and the verification and improvement of numerical weather models, etc. The amount of data, however, varied considerably between heavily populated central urban areas and less-populated inland areas. As the number of the data became enormous, it was also a challenge to efficiently collect and analyze the big data.

To investigate the characteristics of citizen science data, an existing dataset obtained from citizens of the "10-minute weather report" provided by Weathernews Inc. was examined. In this data, weather types are classified into 15 categories based on citizens' experiences. From the result of the examination of about 60 million weather reports from 2012 to 2017, it was found that the number of citizen science data and the population were proportional and the number of the data highly depended on human activity. The number of the data tended to increase in the case of rare and severe storm events in the metropolitan areas, such as heavy snowfall events in Tokyo in winter. From the comparison of the data between citizen science and the Japan Meteorological Agency, about 90 % of the weather types of rain and snow agreed in each data. The coincidence rate of weather type, however, declined for graupel and mixed rain and snow. These results indicate that citizen science data is effective in the snowfall study in the metropolitan areas and greatly contributes to the snowfall study if there is objective information such as photographs of precipitation.

Based on the results of these studies, the #KantoSnowCrystal Project of the MRI has started to use the App "SoraWatch by 3D AmagumoWatch" (https://sora-watch.3d-amagumo.com/) for smartphone and tablet devices and to gather the information of weather type and snow depth images in addition to snow crystals from all over Japan from February 2019. Citizen scientists are able to select 16 weather types (sunny, cloudy, rain, mixed rain and snow, snow, ice pellet, hail, thunder, tornado, fog, frost, burnt sky,

rainbow, cloud iridescence, halo and arc, and the other), 11 snow crystal types, and snow depth with these photographs on the App. The database is also available for the purpose of scientific research and education. Big data obtained from citizen scientists through the App has possibility to contribute to not only the snowfall study but also various meteorological research fields, educations, commercials, etc.

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