Monitoring of the light absorbing aerosols and the impact on radiation budget of atmosphere and snow ice

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The cryosphere is one of the most vulnerable regions to climate change. Snow/ice rapidly melts in the Arctic region under global warming. The light absorbing aerosols (black carbon and mineral dust) contribute to it by absorbing solar radiation and heating the atmosphere, and the deposition of these aerosols reduces the snow/ice surface albedo. In addition, snow grain size tends to increase in the warmer environment, which further reduces snow surface albedo.Therefore, we started the project, entitled "Monitoring of the light absorbing aerosols and the impact on radiation budget of atmosphere and snow ice (FY2017-2021)", which is supported by Ministry of the Environment.

In this research project, we will monitor the snow impurities originating from the light absorbing aerosols, the snow grain size, and the related surface albedo variations. These are to be accomplished by ground-based measurements and satellite remote sensing with special focuses on East Asia, one of the major sources of the light absorbing aerosols, and the Arctic region most affected by them. Field observation of weather, radiation and snowpack in Japan and the Arctic regions will be continued to create longer datasets while observation sites are added. We will implement new measurements and devices for analysis. The results of the observation measured in more detail will be utilized to improve the process models as well as the remote sensing algorithm. Such improvements should allow us to create longer-term datasets (i.e., shape advancement of snow particle and snow impurity particle) by remote sensing over the entire Northern Hemisphere.

The numerical models should allow us to assess the impact of physical processes described above on global warming. We will improve the MRI-ESM (Meteorological Research Institute - Earth System Model) and a new model NHM-Chem-SMAP which is a regional atmospheric model that incorporates chemical processes and snow physical processes. We will also investigate the dynamics and the radiation absorption of light absorbing aerosols and the influence of its deposition and snow grain size on albedo.

This research project is composed of three sub-projects. The results of them in FY 2017 are the followings:

(1) Monitoring by ground-based observation measurements: We continued observation of the weather, radiation and snowpack in winter at three stations in Japan. In addition to the continuous observation of weather and radiation by the automatic weather station (AWS; Automatic Weather Station), periodic snow pit observation with snow sampling was performed. Snow impurity concentration was measured by analysis of the snow samples.We visited Qaanaaq in northwest Greenland and Ny-Alesund in the Arctic Ocean. In addition to continuously obtaining valuable observation data with maintenance, we started the sampling of aerosol in the Arctic atmosphere and carried out the observation of sea ice albedo. By introducing a sublimation device, we developed a method to directly observe and analyze snow impurities in snow samples with a microscope without melting snow. The results will be used for the improvement of the remote sensing algorithm.

(2) Monitoring by satellite remote sensing: Shape of real snow particles and their scattering characteristics were investigated. It was confirmed that they were consistent with those of virtual particles used for the algorithm.Using Himawari 8 with high temporal-spatial resolution, we developed an algorithm to improve the detection method of snow cover and sea ice. Therefore, high accuracy monitoring in the East Asian region including Japan became possible.

(3) Evaluation by numerical models: We improved the MRI-ESM results including the black carbon representation. The radiation effects were also investigated. We also improved the aerosol expression of NHM-Chem and investigated its effect. We also succeeded in coupling NHM-Chem with SMAP, so that we can now proceed with our research using this coupled model.

References

IPCC, 2013: Climate Change 2013: The Physical Science Basis, 1535pp.