Title (Translated from Japanese):

The studies on aerosol transport, its deposition, and its impact on climate

- the study on the surface material circulation can connect from the past to the future -

(The study on the GEOS-5 at NASA/GSFC)

Recently the issue on glacier retreats comes up and many factors should be relevant to the issue. The absorbing aerosols such as dust and black carbon (BC) are considered to be one of the factors. After they deposited onto the snow surface, it will reduce snow albedo (called snow darkening effect) and probably contribute to further melting of glacier. The Goddard Earth Observing System version 5 (GEOS-5) has developed at NASA/GSFC. However, the original snowpack model used in the land surface model in the GEOS-5 did not consider the snow darkening effect. Here we developed the new snow albedo scheme which can consider the snow darkening effect. In addition, another scheme on calculating mass concentrations on the absorbing aerosols in snowpack was also developed, in which the direct aerosol depositions from the chemical transport model in the GEOS-5 were used. The scheme has been validated with the observed data obtained at backyard of the Institute of Low Temperature Science, Hokkaido University, by Dr. Teruo Aoki (Meteorological Research Institute) et al. including me. The observed data was obtained when I was Ph.D. candidate. The original GEOS-5 during 2007-2009 over the Himalayas and Tibetan Plateau region showed more reductions of snow than that of the new GEOS-5 because the original one used lower albedo settings. On snow cover fraction, the new GEOS-5 simulated more realistic snow-covered area comparing to the MODIS snow cover fraction. The reductions on snow albedo, snow cover fraction, and snow water equivalent were seen with statistically significance if we consider the snow darkening effect comparing to the results without the snow darkening effect. In the real world, debris-cover, inside refreezing process, surface flow of lacier, etc. affect glacier mass balance and the simulated results immediately do not affect whole glacier retreating. However, our results indicate that some surface melting over non debris-covered parts of the glacier would be explained by the snow darkening effect. Further discussion and observations are necessary to assess the glacier issue.

(BC deposition estimates over Himalayan glaciers based on the submitted paper to

Atmospheric Environment)

A preliminary work on the estimate of black carbon deposition (BCD) over southern slope of the Himalayas was carried out in our last year's study (Yasunari et al., ACP, 2010) as a pioneer work. However, the study was probably "lower bound" estimate using a fixed dry deposition velocity. That is why still we have not known how much such estimate on the BCD exists at the southern slope of the Himalayas. In this study, we tried to estimate how much error range would exist on BCD and related snow albedo reduction within different methods including observation-based and global model estimates. This study is the first study on determining the error range of BCD over southern slope of the Himalayas. This study will raise an attention of error range on BCD and related snow albedo reduction so as to reduce uncertainties and be useful for many scientists working on observational and modeling studies in Himalayan glacier issues.

The snow darkening effect due to solar absorbing aerosol such as black carbon (BC) is one of the major factors attributed to the accelerated melting of Himalayan glaciers. One of the key challenges in determining the darkening effect is the large uncertainty in the estimation of the BC deposition (BCD) rate on surface snow cover. In this paper, we estimate a possible error range on dry BCD with 7 different methods during pre-monsoon 2006 using atmospheric observation at the Nepal Climate Observatory – Pyramid (NCO-P) with different dry deposition theories and outputs from two global models (SPRINTARS at NIES/AORI/JAMSTEC and GOCART at NASA/GSFC). Our results show BCD rates in the range of 270-4700 $\mu g\ m^{-2}$ during the period. Both global models overestimate BCDs due to strong model surface wind and misrepresentation of surface roughness over glacial areas. Using ice surface roughness, which affects dry deposition velocity for aerosol depositions, and observation-based meteorological data, we estimate a likely range of BCD of 900-1300 $\mu g\ m^{-2}$. Under dry and highly polluted conditions, aged snow (old snow) and sulfate-coated BC (often seen in heavy pollution) are expected to reduce visible snow albedo of 4.2-5.1%. Our results suggest that for global or regional climate modeling of aerosol-induced darkening of Himalaya snowpacks, realistic physical representation of ice or snow surface roughness and surface wind speed are critical in reducing uncertainties on the estimate of BCD over snow surface.