気候変動が群落フェノロジーを介して地表面アルベドに与える影響
－落葉広葉樹林における事例研究－
Impact of canopy phenology on surface solar albedo in a deciduous broad-leaved forest under climate change

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The solar albedo of the land surface, which is ratio of upward shortwave radiation to downward shortwave radiation, influences surface and near-surface energy partitioning and land surface temperature, and therefore serves as one of the key regulators of ecosystem, atmospheric, hydrological, and biogeochemical processes in Earth’s climate system. For a vegetated surface, solar albedo can change with changes in snow cover, fractional canopy cover, and plant phenology as well as in response to changes in solar elevation and moisture conditions. Temperate deciduous broadleaved forests in most of eastern Asia are subject to snow cover during winter and heavy rain during early summer, and changes in forest canopy phenology such as leaf expansion during the spring and leaf fall during the autumn. It is therefore important to identify the main factors that control solar albedo in these forests and to clarify the possible impact of snow-melt and canopy phenology on solar albedo under ongoing climate change. To achieve these aims, we (1) conducted multi-year measurements of solar albedo, meteorological factors, and canopy phenology in a cool-temperate deciduous broadleaved forest in Takayama, Japan, and (2) simulated the impact of surface conditions such as snow cover and plant phenology in solar albedo and surface radiation under global warming.

The study was carried out in the Takayama cool-temperate deciduous broadleaved forest site (TKY; 36° 08′N, 137° 25′E, 1420 m a.s.l.). This region belongs to the cool-temperate zone and is under the influence of the Asian monsoon climate.

The solar albedo and LAI were significantly positively correlated during the leaf expansion and leaf fall periods. Solar albedo increased rapidly from 0.12 to 0.17 with increasing LAI during the leaf expansion period and decreased more slowly from 0.16 to 0.13 with decreasing LAI during the leaf fall period in all three years. The rate of increase of the albedo as a function of LAI (i.e., the slope of the regression line) was clearly higher during the leaf expansion period (0.023) than during the leaf fall period (0.010). During the snow cover period, the albedo fluctuated widely, but generally decreased with decreasing snow depth during the spring snow melt period and increased with increasing snow depth during the winter snow fall period.

We simulated solar albedo under future climatic conditions by referring to the climate projection data based on A1B scenarios from CMIP3 Multi-Climate Models. Under the near future condition (2046 – 2065) as compared to the current condition (2002 – 2007), the beginning of leaf expansion was 10-13 days earlier and the end of snowmelt in spring was 8-12 days earlier. As a result, early snow-melt reduced solar albedo and early leaf-expansion increased solar albedo. Our estimation suggested that absolute value of increased reflected solar radiation by earlier leaf expansion explained about 50% of that of decreased reflected solar radiation by earlier snow-melt. The results suggest that we should pay the attention to cooling effect of land surface by canopy phenological change under global warming.