Pluto's surface albedo distribution and its evolution due to sublimation and condensation of ices

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Flyby Observations of NASA's New Horizons spacecraft of Pluto in 2015 revealed that H_2O, N_2, CH_4, CO ices coexist on the surface of Pluto and that the surface has a strong difference of reflectivity in lalitudes, middle and high latitudes are bright and low latitudes are dark, which strongly suggests a different amount of ice. However, an origin of such bright and dark color distribution on the surface is still unclear. In previous researches about a temporal changing of albedo on the Jovian and Saturnian moons, it has been shown that sublimation of H_2O ice due to an insolation affects albedo changing on their surfaces. On Pluto, condensation of ice in the atmosphere also should affect Pluto's surface albedo because Pluto has an atmosphere with surface pressure of approximately 1 Pa. In this study, we model relationship between ice behavior such as sublimation and condensation and change of albedo, and consider quantitatively about N_2 and CH_4 that is main components of atmosphere with a numerical simulation for the purpose of investigating the origin of the albedo variation on Pluto.
In our model, we assume an initial surface state that bright ice and dark non-ice material exist uniformly mixed in depth by micrometeorite bombardment and that surface has uniform albedo which can be modeled by the volume ratio between ice and non-ice materials. Subsequently, entire surface of Pluto is divided into 12 latitudinal bands by 15 degrees, and we calculate the surface temperature with thermal inertia according to a change of insolation on each latitude considering orbit, rotation cycle and precession. When the temperature exceeds the sublimation point which depends on the surface atmospheric pressure, the ice sublimes and the non-ice material remain on the surface. Sublimed ice exists as the atmospheric gas, and the gas can be condensed on the surface when the temperature of atmosphere falls below the condensation point. Moreover, we calculate a cycle that time variation of the volume ratio of ice and non-ice material due to sublimation and condensation changes albedo, and nally we examine temporal change of the Pluto's surface albedo over millions of years.
As a result, we nd that insolation varies greatly for each latitude and seasons because Pluto has the large inclination of the obliquity, and thus sublimation and condensation amount of ice change greatly for each latitude and seasons. Amount of N_2 atmosphere formed by sublimation is consistent with observation, and this suggests that Pluto has a large N_2 circulation between surface and atmosphere. In addition, we nd a possibility to reach the overall trend of the albedo on current Pluto from initial globally uniform surface albedo through this process. Also, because the changes of albedo distribution depending on the thermal inertia and initial albedo, there is a possibility that thermal inertia depending on porosity and initial albedo affects albedo distribution on current Pluto.

