すばる望遠鏡観測による火星における水循環の解明

青木 翔平 [1]; # 中川 広務 [1]; 笠羽 康正 [2]; 佐川 英夫 [3]; 黒田 剛史 [2]
[1] 東北大・理・地球物理; [2] 東北大・理; [3] NICT

Water cycle on mars obtained by Subaru observations

Shohei Aoki[1]; # Hiromu Nakagawa[1]; Yasumasa Kasaba[2]; Hideo Sagawa[3]; Takeshi Kuroda[2]
[1] Geophysics, Tohoku Univ.; [2] Tohoku Univ.; [3] NICT

With increased knowledge on our 'neighbor' planet, Mars, based on recent successful exploration by the US and Europe, our image on Mars is changing significantly. Mars is now called 'a frozen water planet'. It is almost certain that Mars once had an era with warm and wet climate. Where has a large amount of liquid water gone? - Some of the water is thought to have escaped into space, and other is thought to have been deposited underground. In fact, Mars Odyssey Neutron Spectrometer suggests that still a large amount of water ice is conserved underground (less than 1 m below the surface) in wide areas at nonpolar latitudes, and it sometimes appears on the surface as water ice or seepage identified from the images taken by spacecrafts and landers. This fact indicates a land-atmosphere coupling of water. How does the water behave on present Mars? It will bring a deep insight into the planetary environment and its habitability on a dry and frozen water planet.

In the terrestrial case, the global measurements from space and ground of atmospheric deuterium water (HDO) in the middle to lower troposphere enables us for the first time to visualize the water cycle and its dynamic processes. Water cycle as condensation-sublimation processes deplete heavy water in the gas phase, and a strong evaporation source resulting in relatively HDO-enriched vapor. Water-ice clouds are also commonly observed in the Martian atmosphere. The condensation-sublimation cycle of the polar caps is well known to have an important impact on the atmospheric dynamics and circulations on Mars. However, highly complex interactions via cloud formation and release of latent heat, impacting convection, complicate matters and are not well represented in climate models. Land-atmosphere coupling adds further uncertainties, in particular on Mars. Furthermore, in paleoclimate applications, the isotopic composition of water in the ancient ice sheets should have a lower HDO/H_2O ratio than in the water-ice clouds, i.e. it has become a key issue of the atmospheric evolution.

We already have plenty of data for daytime column density of water vapor, including horizontal distributions and seasonal changes through several Martian years, observed using space missions. However, due to the limited local time coverage of the orbit of past satellites, information on variances with local time has been less investigated. In addition, it is not possible to detect the Martian minor constituents, HDO, from spacecraft observations due to their low spectral resolution. Thus, Martian HDO distribution has only been investigated in the dayside from a few limited observations at near infrared wavelength from ground-based facilities so far. Villanueva et al. (2008) briefly discussed local-time dependence of HDO/H_2O in northern spring-summer (Martian Solar longitude, Ls=49 deg). They suggested that the cause of the enhancement after sunrise could possibly be the sublimation of ground-frost or water-ice clouds accumulated during the nighttime, or a release from the subsurface.

In order to advance our understanding, we performed Martian HDO/H_2O observations on December 2011, January and April 2012 using 8m-Subaru telescope. Owing to the wide bandwidth of Subaru/IRCS, the absolute simultaneous observations of H_2O and HDO were performed for the first time. Our preliminary results suggested the HDO concentration in the mid-latitude region in northern hemisphere in the same season (Ls=52 deg) and the same geometry. Here we use a state-of-the-art general circulation model together with new observation to investigate key factors in the water cycle on Mars.