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#柿沼　希泉 [1), 今村　剛 [1), 青木　翔平 [1), 野口　克行 [2),Kleinboehl Armin[3)
[(1 東京大学大学院,[(2 奈良女子大,[(3NASA

Mid-latitude disturbances in the Martian atmosphere studied with MRO MCS data

#Nozomi Kakinuma[1),Takeshi Imamura[1),Shohei Aoki[1),Katsuyuki Noguchi[2),Armin Kleinboehl[3)
[(1The University of Tokyo,[(2Nara Women's University,[(3NASA

Similarly to the Earth, baroclinic waves are thought to play a significant role also on Mars in determining the climate at mid-to high-latitudes. It is known that baroclinic waves with zonal wavenumber1,2, and 3 are dominant and they become the strongest from autumn to winter in the northern hemisphere (Barnes, 1981). In addition, baroclinic waves are thought to have a connection with the meridional transport of substances in the Martian atmosphere, such as dust and water ice particles. Images taken by Mars Orbiter Camera onboard Mars Global Surveyor (MGS) revealed the possible relations between baroclinic waves and the transport of dust (Wang et al., 2005). However, previous studies considered the behavior of the waves below the 18Pa level with low vertical resolution (~10km) data set (Banfield et al., 2004). The propagation at higher altitudes has not been investigated yet. Also, the relations between baroclinic waves and the transport processes of dust and water ice particles have not been studied quantitatively.

To characterize the behavior of baroclinic waves in high altitudes, we have investigated the meridional distribution of the amplitude of the baroclinic waves and how it changes with a time resolution of 1 Martian day by using Mars Reconnaissance Orbiter (MRO) Mars Climate Sounder (MCS) limb observation data. This has a higher vertical resolution (~5km) than the data used in previous studies of baroclinic waves. To clarify how baroclinic waves have an influence on the transport processes of dust and water ice particles, we examined how the zonal distributions of dust and water ice particles vary with time and latitude and their correlations to the propagation of traveling waves seen in the temperature distribution. The retrieved data of temperature, dust opacity, and water ice opacity in MY30 within a pressure range from 200 to 1 Pa, corresponding to the altitude range from about 10 to 55 km above surface, are used in our survey. After dividing the data into time intervals with a length of 1 Martian day and subtracting the seasonal trend, fluctuations of temperature, dust opacity, and water ice opacity are analyzed. Then, we computed the amplitudes of zonal wavenumber 1-3 for each pressure surface. To examine the way of the propagation of dust and water ice particle distributions, Hovmoller diagrams were made for each substance, and we compared them with the propagation of the traveling waves.

Our results show that waves with zonal wavenumber 1 become dominant at mid-to high-northern latitudes during the perihelion season in high altitudes. Large amplitudes of zonal wavenumber 2 were also seen on several days. The region where a large amplitude appears was consistent with the region of a large temperature gradient. This result indicates that the large amplitude of traveling waves in high altitudes occurs due to baroclinic instability. Also, some zonal propagations of water ice particle distributions were seen at the same region during the same season as the propagation of traveling waves. The correlation coefficients between the zonal distributions of temperature and water ice opacity were found to be negative in most days. This result denotes a possible connection between baroclinic waves and transport of water ice particles.