COLORS OF MARTIAN FOG: OBSERVATION PLAN BY MIC. A. Inada[1], A. M. Nakamura[2], and T. Mukai[3], [1]1-1Rokkoudai Nada Kobe, Japan 657-8501, inada@komadori.planet.sci.kobe-u.ac.jp [2]1-1 Rokkoudai Nada Kobe, Japan 657-8501, amnakamu@kobe-u.ac.jp [3]1-1 Rokkoudai Nada Kobe, Japan 657-8501, mukai@kobe-u.ac.jp

Introduction: Viking Orbiter 1 observed the channel region in the west of the scarp in Memnonia (centered at 15S, 145W) at 45 min and 75 min after sunrise [1]. The later image shows the higher brightness in the most craters seen there, as well as on the floor of the channels in that region. Such brightening is not found in the preceding image. As a result, it is thought that a frost on the surface of Mars evaporated after sunrise, and then the resulting water re-condensed in the atmosphere as a fog.

It is known from Mars Pathfinder data [2] that the temperature on the surface in the mid latitude changes from 196 K to 265 K in a spring day. It is natural to assume that the temperature in the low latitudes is higher in the same season. In addition, the temperature of the atmosphere, where the fog is generated, is close to that of the surface, because of its low altitude (less than 100 meters). Therefore, we can expect that the main component of the fog is water, because carbon oxide is saturated under 150 K.

The study for the formation of fog is important to examine the water balance between the regolith and the atmosphere in Mars. Savijarvi [3] suggested the expansion of fog up to 60-80 m altitude during the night and their dispersion in two hours after sunrise, based on a simulation of fog formation performed in the case that topsoil was dry, which was detected at the Viking Lander 1 site in summer. Kahn [4] has shown that the particle size of a discrete ice haze in the upper atmosphere can grow up large enough to fall to the surface.

Referring to these results, we can propose alternative mechanisms for the formation of morning fog, *i.e.* (1) re-condensation from a frost on the surface, and (2) remaining of night fog. Evening fog may occur as (1) a precursor of night fog or as (2) a grown haze. The size of fog particle plays a key role to study the mechanism of its formation. When the water vapor saturates in the atmosphere, the size of resulting ice particles are small at the beginning time. As the vapor cools down slowly, the particle size increases. Therefore, the morning fog which was generated during night (as night fog), in general, consists of larger particles. On the other hand, the re-condensed particles in the morning fog coming from the evaporation of frost should be smaller.

We will present the angular and wavelength dependence of the scattered light by the surface fog to study the size, shape and material components of its individual particles, using the color images taken by Mars Imaging Camera (MIC).

Current Status of MIC: Mars Imaging Camera (MIC) onboard NOZOMI, the Japanese spacecraft launched on July 3rd (UT) 1998, will have a potential ability to observe diurnal phenomena on Mars. MIC consists of 3 CCD lines with a blue filter (wavelength of 440-480 nm), a green filter (520-580 nm), and a red filter (630-680 nm). Although NOZOMI was planned to reach the planet in October 1999, the arrival time will be postponed to the spring in 2003 because of the trouble in the valve in propulsion system during the earth escape kick maneuver. However, all functions of MIC instrument are well healthy.

The instrument is checked now as the first in-flight calibration by using the images taken on the orbits around the Earth and the Moon. The dark level data and their fluctuation were acquired by taking uncompressed images of the empty space. No significant change in dark level, compared with that in pre-flight calibration, appears. Since MIC has no own calibration target, the in-flight calibration of the sensitivity are done by (1) obtaining the absolute sensitivity of some CCD pixels from the detection of Jupiter and the sites on the near side of the Moon for which ground-based observation data are available, (2) calibrating the relative sensitivity of all pixels in each line, and then (3) leading to the absolute sensitivity of all pixels from the combination of (1) and (2). We will show the sensitivities of three colors in our presentation.

Reflectance from the Fog: In order to study the particle size of the fog based on the MIC images, we estimate the dependence of the reflectance of fog on wavelengths, the zenith angles of emergence and incidence, and the phase angle, where Hapke's equations for the two-layer bi-directional reflectance model are applied [5]. Our model consists of two layers which are an optically thin layer (fog) and a layer with a large optical thickness (Martian surface). The two layers model is illuminated by a distant collimated source (the Sun). The lower layer is assumed to be composed by basalt dust particles, and their single scattering albedo and the phase function are deduced from Mie theory. A radius of the particle is assumed to be 60 micron. The upper layer consists of water ice particles as the fog. The single scattering albedo and the phase function of the fog particle vary with the size parameter.

We calculated the reflectance of incident sunlight by the two-layers, when the upper layer includes the water ice particles alone. The calculations were done by changing the radius of ice particle from 0.1 micron to 10.0 micron, as a function of the optical depth of the upper layer. The wavelength of interest was set to be 0.45 micron (the center wavelength of the MIC blue filter), 0.55 micron (green), 0.65 micron (red).

It is found from our model calculations that the dependence of the resulting reflectance on the wavelength is rather weak in the case of the large particle (Fig. 1). On the other hand, the fog consisting of small particles shows a significant dependence of reflectance on the wavelength (Fig. 2). Furthermore, it is shown that no clear difference in the optical depth at different wavelengths appears in the case for the fog with large particles. However when the fog consists of small ice particles with radii of 0.1 micron, the optical depth of 1.0 at blue decreases 0.54 times of blue at green and 0.30 times of blue at red. It is expected therefore that the color images can give the information of the fog particle size.

It is worthwhile to note that the reflectance by the larger particle shows a distinct forward scattering property, and also has a diffuse structure between -50 and 50 degrees of the zenith angle of emergence. On the other hands, the reflectance by the small particle shows a dependence of the zenith angle of emergence.

Discussions: We need to image the surface without fog to obtain the information of the reflectance of the dust opacity and the surface in order to distinguish the reflectance of fog from the reflectance of the others. After that, we will be able to deduce the opacity of the fog from the intensity reflected only by the fog. Such information provides the column density of the ice particles.

The images of the different regions taken at the same local time in the same season will provide the information where the fog tends to appear and how wide the surface fog distributes. If the occurrence of fog in the outflow channels will be found, it may suggest that the surface is still wet in particular.

A set of images along local hour of the surface of the area of interest taken by MIC would provide the information for the beginning time of fog and its lasting period. The roles of temperature, water vapor abundance, and dust abundance in the atmosphere on the occurrence of fog will be examined by analyzing the images obtained in the different seasons. The annual variation of temperature of about 20 K in the global atmosphere is estimated even in the mid-low latitudes associated with the eccentric orbit of Mars [6]. It is well known that the water vapor abundance varies with the season, i.e. higher abundance in the summer and less in the winter. The dust storms or the dust devils increase the dust abundance in the atmosphere, and consequently they lead to the increase of temperature. These variations may influence on the occurrence of fog. We will try to study the parameters to control the

appearance of fog by using the multi-colors MIC observations.

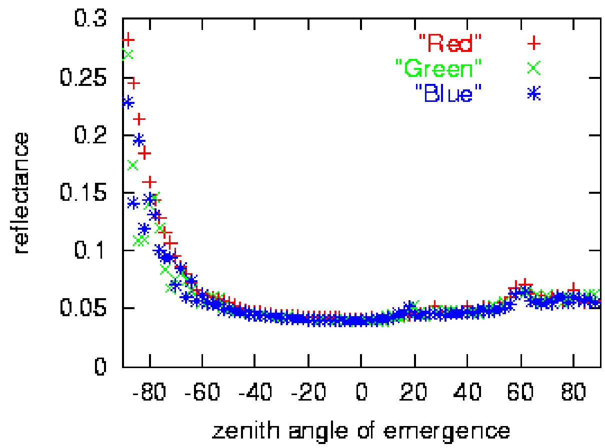

Fig. 1 Reflectance of the model for fog defined in the text when the zenith angle of incidence is 60 degrees, and where the upper layer contains the ice particles of radii a=10.0 micron. The positive zenith angle shows the reflected light toward the side of sunlit, and the negative angle shows the opposite. The red, green and blue marks show the reflectance expected at red, green, and blue filters, respectively.

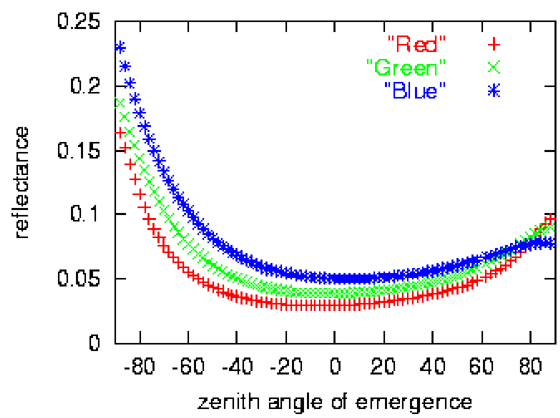

Fig. 2 The same as Fig. 1, but a=0.1 micron

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