

**Lee Wave Clouds in the Mars Colour Camera (MCC) Images: Wind Speed Measurements.** Ramdayal Singh, A. S. Arya and Prakash Chauhan, Space Applications Center, Indian Space Research Organisation, Ahmedabad – 380 015, India. (ram@sac.isro.gov.in)

**Introduction:** Lee wave clouds form by vertical deflection of wind, above a topographic obstacle. Air undergoes a wave-like oscillation in the lee of the obstacle. In the crest of the wave air rises up to the cooler region where condensation occurs due to the adiabatic cooling. In such a way a regular train of elongated clouds forms. This train of clouds is aligned orthogonal to the prevailing wind direction if the obstacle is a mountain range.

Lee wave clouds were observed by Mariner 9 in the Martian atmosphere [1]. Lee wave clouds were subsequently regularly detected by Viking Orbiter and Mars Global Surveyor [2]. MCC detected clouds over Ascræus Mons at  $L_s = 74^\circ$ , which corresponds to MCC observation dates of 27 November 2015. Benson et al. (2003), using Mars Global Surveyor Mars Orbiter Camera observations detected clouds over Ascræus Mons at  $L_s = 110^\circ$  to  $205^\circ$  [3]. Clouds observed over W, Northwest and NE slope of Ascræus Mons. NE slope of Ascræus Mons is represented by ripples in

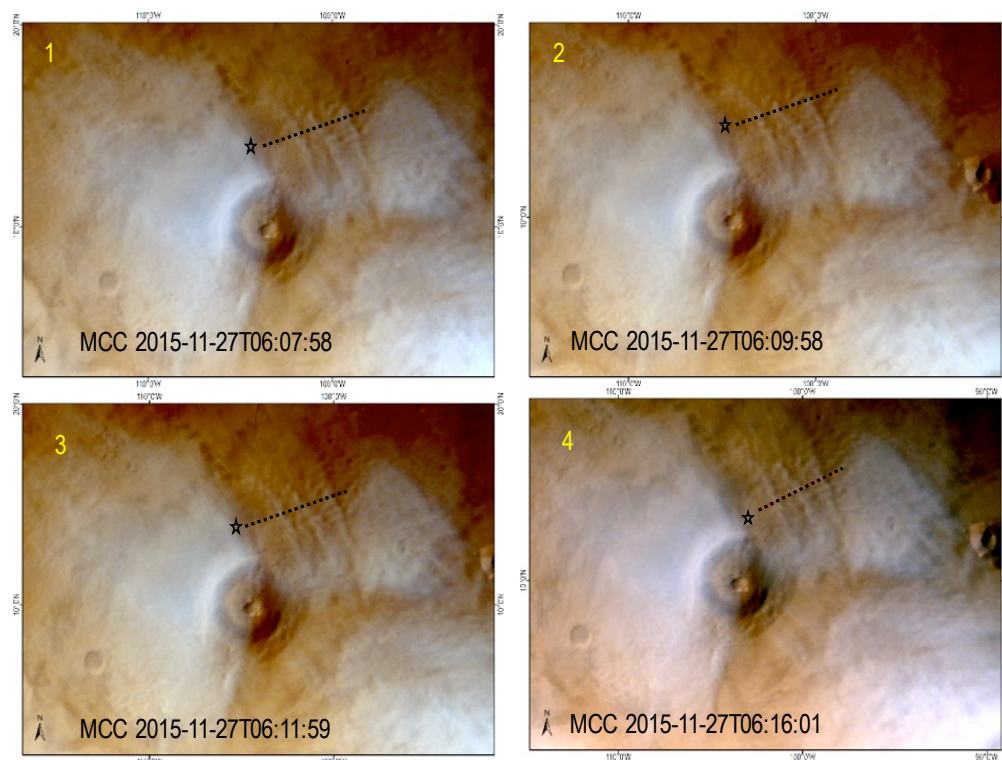
cloud, uniquely called as Lee-wave cloud. Lee wave cloud are observed toward the Lee-ward side NE slope of Ascræus Mons. The seasonal dependence of clouds at Ascræus Mons suggest that latitude is important factor in the seasonal trends of cloud activity.

**Data:** In present work we have used top of atmosphere reflectance (I/F) data [4] over Ascræus Mons (figure 1) acquired by MCC on 27 November 2015 at 06:07:58, 06:09:58, 06:11:59 and 06:16:01, respectively.

**Theory:** Speed of wind producing lee wave cloud is

$$\bar{u} = \frac{g\lambda\sqrt{\gamma-1}}{2\pi\bar{c}}, \text{ where, } \bar{u} = \text{Wind Speed, } g =$$

Martian Gravity =  $3.69 \text{ m/s}^2$ ,  $\lambda$  = Wavelength,  $\gamma = c_p/c_v = 1.3055$  and  $\bar{c}$  = Sound Speed for Mars =  $226.58 \text{ m/s}$  [5].



**Figure 1:** MCC image showing Lee Wave cloud over Ascræus Mons region. The black star point marks the position of the starting point for plots shown in figure 2.

**Table:** Summary of 27 November 2015 MCC Datasets:

S. No	Date	Time	Orbit No.	Ls	Resolution (km)	Spacecraft Height (km)	Wave-length (km)	Wind speed (m/s)	Average Wind Speed (m/s)	GCM derived Horizontal Wind Speed(m/s) at 50 km at (14.3°N, 258° E)
1	2015-11-27	06:07:58	179	73.8468	1.69	32530	37±4	53±6	56±7	56.81
2	2015-11-27	06:09:58	179	73.8474	1.68	32332	40±6	57±8		56.82
3	2015-11-27	06:11:59	179	73.8480	1.67	32207	36±4	52±6		56.82
4	2015-11-27	06:16:01	179	73.8486	1.66	32031	42±6	61±8		56.82

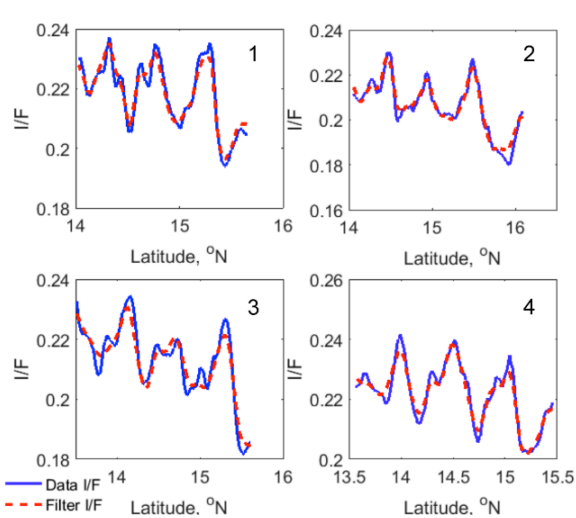


Figure 2: Wavelength determined from the plot of I/F versus latitude. Blue curve is the I/F data from MCC. Red curve is the data after applying low-pass filtering.

### Result and Discussion:

Wind speed has been derived from Lee Wave cloud using data obtained by MCC images. Average Speed of wind producing lee wave cloud was found to be 56 m/s. To confirm the lee wave cloud velocity over the Ascreaus Mons, we consulted global circulation model (GCM) at website <http://www-mars.lmd.jussieu.fr/> (a Mars climate data base) for the horizontal wind speed. From GCM horizontal wind speed at point 14.3°N, 258° E at 06:07:58, 06:09:58, 06:11:59 and 06:16:01, respectively has been computed and plotted in figure 3. Horizontal wind speed is matching at an altitude of 40-50 km. It can be concluded that cloud producing Lee wave over Ascreaus Mons may be upto 40-50 km altitude. These initial results will be further improved by analysis of more MCC datasets.

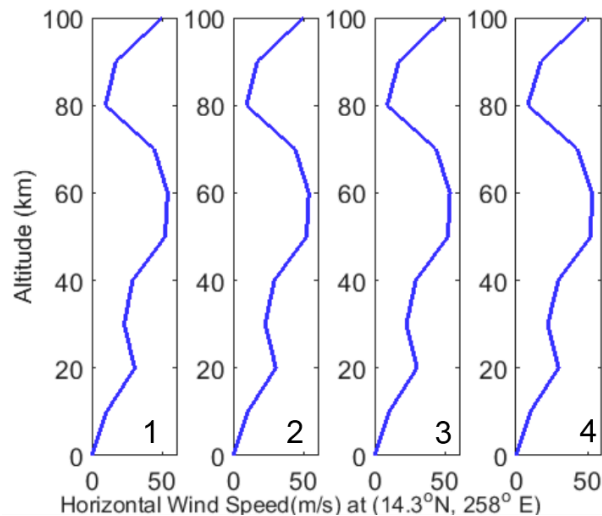


Figure 3: Horizontal wind speed determined from the GCM at point 14.3°N, 258° E at 06:07:58, 06:09:58, 06:11:59 and 06:16:01, respectively.

### References:

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