A MONTE CARLO SIMULATION OF THE DIURNAL VARIATION IN SEISMIC DETECTION RATE OF SPORADIC LUNAR METEOROID IMPACTS; J. Oberst and Y. Nakamura, Institute for Geophysics and Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712.

Introduction: Meteoroid impacts detected during the operation period of the Lunar Seismic Station Network (1969-1977) (1) provide much insight into the meteoroid population near the Earth-Moon system (2). Clues as to the meteoroid types involved, their orbital distribution, and the seismic scaling laws can be inferred from the observed diurnal variation in number of impacts (2). Although it is not possible to infer these parameters directly, a comparison of the expected diurnal variations for various orbital distributions of hypothetical meteoroid populations with the observed distribution may lead to plausible parameters for the source population and to plausible seismic scaling laws.

Method: In particular, we wish to compute the diurnal variation in lunar seismic detection rate for meteoroid types known to us from terrestrial observations, namely Super-Schmidt meteors (3), fireballs (4), and meteorites (5). We use a Monte Carlo approach as described in the following steps.

a) Pick a meteoroid with orbital elements given in one of the above mentioned data sets. Meteoroids should be picked not randomly, but weighted according to their geocentric encounter speed. Meteoroids of low encounter velocity should receive a lower weight in order to account for the fact that the number of encounters with low-velocity meteoroids near Earth will be higher than near the Moon because of the enhanced gravitational crossection of Earth.

b) Randomly pick a lunar phase (i.e. time of the day at the seismic station network) at which the meteoroid is to hit the Moon.

c) Compute velocity components of the meteoroid relative to the Moon at the selected lunar phase. Determine selenographic coordinates of the point on the lunar surface located below the meteoroid's apparent radiant. Randomly pick an impact location around this point for a meteoroid approaching from the computed radiant.

d) Determine the distances from the impact point to all four seismic stations. Determine the seismic amplitudes to be observed taking into account the seismic scaling laws. Decide whether the impact is detected by the network.

e) Repeat steps b) through d)

f) Repeat steps a) through e)

For simplicity we assume the following: Earth is in a circular orbit about the sun, with the Moon in a coplanar circular orbit about Earth. Lunar orbital and rotational speeds are constant and identical, where the orientation of the lunar rotational axis is perpendicular to its orbital plane. "Zenith attraction" of the meteoroids' radiants due to gravitational focusing in the lunar gravity field is neglected. However, we do take into account increased impact speed due to lunar attraction. Angular orbital elements of the meteoroids are randomly distributed. Hence, there is an equal chance for a meteoroid to impact the lunar northern, southern, daytime or nighttime hemisphere. Deflection of meteoroids in Earth's gravity field is neglected. This effect may change the diurnal impact time of a meteoroid only in the rare case that the meteoroid approaches at extremely low geocentric velocity ($v<2$km/s) from a radiant close to the ecliptic plane during certain lunar phases.

Results and Conclusions: The computed diurnal variation of impact detections (Figure 1, a,b,c) is in good agreement with the actual observed distribution (Figure 1, d,e) provided that seismic energy is proportional to the preimpact kinetic energy of the meteoroid. In particular, the observed distribution of small lunar impacts (d) is in good agreement with what is expected if these meteoroids are in orbits like those of Super-Schmidt meteors (a). The observed distribution of large lunar impacts (e) agrees with the distribution expected from fireballs (b) (see (2) for definition of "small" and "large" impacts). The computed distribution of meteorites (c), which constitute a

subgroup of the fireballs (b) comprising about 1/3 of their total mass (6), is dissimilar to either of the observed distributions. One might expect that these higher density members of the fireballs would have higher efficiency of generating seismic waves upon impact and thus have larger contribution to the distribution of the observed lunar impacts. Our present model, however, does not support such a hypothesis. It appears that the higher density of meteorites compared with the rest of the fireballs does not produce higher seismic efficiency.

We must caution, however, that, like the lunar seismic impacts, the meteors observed by terrestrial camera networks do not represent an unbiased sample of the meteoroid population near the Earth-Moon system. Hence, further interpretation of our data must address the question of selectional bias in the terrestrial meteor catalogs in terms of meteor speed and type.

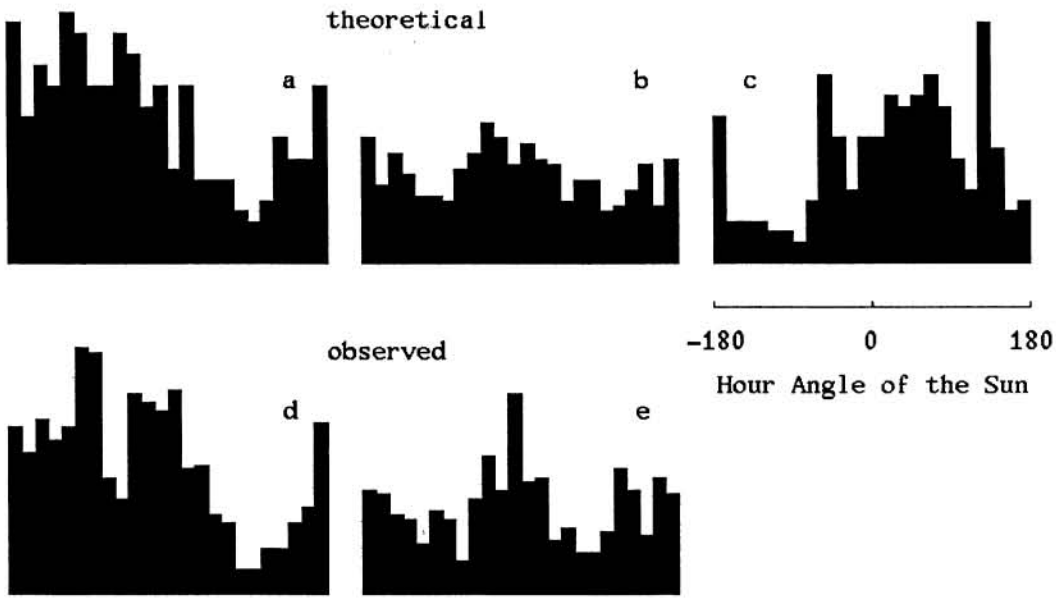

Figure 1: Theoretical and observed diurnal variations in number of seismically detected lunar impacts. The computed variations are those for meteoroids in orbits of a) Super-Schmidt meteors (3), b) fireballs (4), and c) meteorites (5). The obsered variations are for d) small and e) large impacts. The time of the lunar day is expressed in terms of the hour angle of the sun (0=midday, ±180=midnight)

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