INTERPLANETARY CONDITIONS DURING THE APOLLO MISSIONS: IMPLICATIONS FOR THE STATE OF THE LUNAR ENVIRONMENT.

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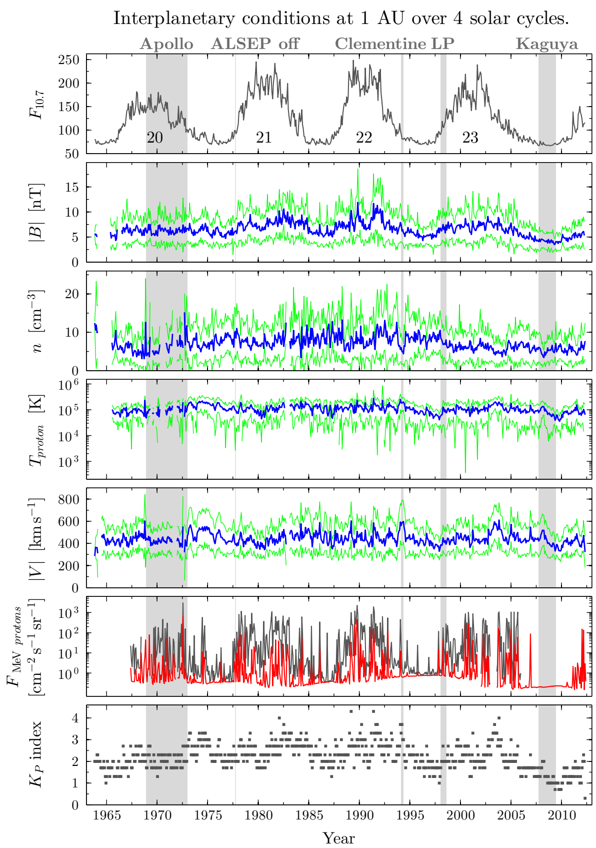
Introduction: The interplanetary conditions coinciding with the Apollo missions had important implications for the state of the lunar environment experienced by the astronauts, and measured by the many scientific investigations carried aboard the command modules and deployed on the Moon's surface. The first comprehensive overview is presented of the space plasma, solar ultraviolet, energetic particle, geomagnetic, and meteoroid stream conditions encountered by the Moon during Apollo. This includes an investigation of the location of the Moon with respect to the Earth's bow shock and magnetopause boundaries in order to assess whether it encountered either the magnetosheath or the hot tenuous plasmas of the magnetosphere, respectively, during these missions. The interplanetary conditions during the Apollo missions are placed into the context of the last four solar cycles, and subsequent lunar missions, as well as extreme events, such as occurred during August 1972.

Data Sources: We use the OMNIWeb dataset of interplanetary conditions at 1 AU. The parameters examined are: $F_{10.7}$ (solar UV proxy); interplanetary magnetic field $|B|$; the concentration n, proton temperature T_{proton}, and flow speed $|V|$ of the solar wind; the flux of energetic protons $F_{\mathrm{MeV}\ protons}$; and the K_P index (as a proxy for solar wind conditions). The $F_{\mathrm{MeV}\ protons}$ used here are good for characterizing the high fluxes during episodic solar energetic particle events, as opposed to the galactic cosmic ray background.



Space Age Overview: The figure shows parameters averaged over a 27-day solar rotation period. In the panels showing $|B|$, n, T_{proton}, and $|V|$, the blue lines indicate the average and the green lines the standard deviation. $F_{\mathrm{MeV}\ protons}$ for energies >1 MeV and >10 MeV are shown by gray and red lines, respectively. The solar cycle modulation is seen in all parameters to some extent, but especially $F_{10.7}$. Indicated at the top are important intervals for lunar science and exploration: the Apollo era (1968–1972), Apollo Lunar Surface Experiments Package (ALSEP) switch off, and the Clemetine, Lunar Prospector and Kaguya missions. The Apollo missions were the only ones to fly during a solar maximum (from the peak through the declining phase). However, Cycle 20 was typically less active than later solar cycles.

Radiation Hazards: The Apollo missions were fortunate to fly during relatively benign conditions, which is reflected in the average radiation measured by passive dosimeters flown on each mission. A maximum skin dose of 1.14 rads (rem) was measured during Apollo 14 – this is very low when compared to the maximum operational dose, which was set at 400 rads. If an Apollo mission had flown during the August 1972 solar flares and coronal mass ejections, then the crew could have experienced moderate acute radiation sickness without effective counter-measures.

Meteoroid Streams: All missions, except Apollo 13, coincided with established IAU meteoroid streams. In particular, Apollo 12 flew during the peak of the 1969 Leonids, which had an exceptionally high zenithal hourly rate of 400. Similarly, Apollo 15 and 17 flew during the Persieds and Geminids, respectively, both of which are strong annual streams. This may be related to observations of lunar horizon glow reported during those missions, whether related to resonant scattering by exospheric neutrals or sunlight scattered from exospheric dust.