



First simultaneous detection of terrestrial ionospheric molecular ions in the Earth's inner magnetosphere and at the Moon

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Heavy molecular ions escaping from a planetary atmosphere can contribute to the long-term evolution of its composition. The ARTEMIS (Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun) spacecraft has recently observed outflowing molecular ions at lunar distances in the terrestrial magnetotail (Poppe et al., 2016). Backward particle tracing indicated that these ions should originate from the terrestrial inner magnetosphere. Here we have examined Cluster data acquired by the CIS-CODIF (Cluster Ion Spectrometry-Composition Distribution Function) ion mass spectrometer, obtained in the terrestrial magnetosphere. An event was selected where the orbital conditions were favourable and the Cluster spacecraft were in the high-latitude inner magnetosphere a few hours before the ARTEMIS molecular ion detection. Analysis shows that the CIS-CODIF instrument detected a series of energetic ion species, including not only O⁺ but also a group of molecular ions around ~30 amu. Given the 5-7 m/Δm mass resolution of the instrument, these could include N₂⁺, NO⁺, or O₂⁺. These ions were detected by Cluster about 14 hours before the ARTEMIS observation in the lunar environment, a time which is compatible with the transfer to lunar distances. The event was during an active period followed by a northward rotation of the IMF. Although energetic heavy molecular ions have been detected in the storm time magnetosphere in the past (e.g. Klecker et al., 1986; Christon et al., 1994), this event constitutes the first coordinated observation in the Earth's inner magnetosphere and at the Moon.

Additional events of coordinated outflowing molecular ion observations are currently under analysis. Future missions, as the proposed ESCAPE mission, should investigate in detail the mechanisms of molecular ion acceleration and escape, their link to the solar and magnetospheric activity, and their role in the magnetospheric dynamics and in the long-term evolution of the atmospheric composition.