Atmospheric ion escape: contribution to the early evolution of the terrestrial atmosphere

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Understanding the evolution of planetary atmospheres, and particularly the evolution of the composition of Earth's atmosphere, is a major challenge. The evolution of the terrestrial atmosphere is driven by its interactions with the planet's crust and oceans, the biological activity, the influx from space (e.g., meteors), and the atmospheric escape to space as neutral and as ionised species. Ions outflowing from the terrestrial ionosphere and circulating in the magnetosphere play also an important role in the magnetospheric dynamics, by loading the magnetosphere with heavy ions. Some of the outflowing ions can be re-injected into the inner magnetosphere, whereas some can completely escape to outer space. The observations of the outflowing and escaping ion populations performed by the Cluster mission will be reviewed and their dependence on the solar wind parameters and on the geomagnetic activity conditions analysed. Integrating the actual ion loss rates over geological time scales (3 to 4 billion years ago), and considering that the young Sun was much more active and that the Earth's rotation period around its axis was much shorter, provides an indication on how ion escape is adequate to change the composition of the Earth's atmosphere.