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Abstract

A data-based robust ionospheric model, which computes the ion number density, has been developed in order to quantify the sources of ionization in the coma of 67P/Churyumov- Gerasimenko. The model is driven by Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA)/Cometary Pressure Sensor (COPS) neutral density. There are three ionization sources: photo-ionization by solar extreme ultraviolet (EUV) radiation, electron- impact ionization from energetic electrons (> 12 eV) and charge-exchange between solar wind protons and cometary neutrals. The EUV radiation is estimated from fluxes measured by the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED)/ Solar EUV Experiment (SEE) from Earth's orbit, taking into account the phase shift and the heliocentric distance ratio, between Earth and comet 67P. The electron-impact ionization frequencies are derived from Rosetta Plasma Consortium (RPC)-Ion and Electron Sensor (IES) integrated electron fluxes and corrected for the S/C potential from RPC/LAngmuir Probe (LAP) measurements. Charge-exchange is computed from solar wind estimated local conditions in terms of density and bulk velocity. The effect of the neutral composition of the coma on the ionization rates is assessed. Our results are compared with in-situ measurements of the plasma density from RPC-Mutual Impedance Probe (MIP) and RPC-LAP.

The ionospheric model has been used to derive the plasma densities at the location of the spacecraft at different periods during the escort phase. These densities are in agreement with in-situ plasma measurements. In addition, the relative importance of the different sources of ionization has been evaluated. Heliocentric distance, solar activity, seasonal variations, solar absorption, electron cooling and heating processes are key parameters to take into account in order to evaluate the contribution of the different ionization sources. At high heliocentric distances, the two main sources contributing to local plasma densities are photo-ionization and electron-impact ionization. As the mission progressed, the relative importance of photo-ionization declined due to the decrease in solar activity and electron-impact happened to become the main source of ionization. However, at low heliocentric distances, when the outgassing rate is the highest, photo-ionization is the dominant process. Charge-exchange is never observed to be the main ionization source in the periods that we studied but its contribution is highly variable and depends on the solar wind local conditions.