RPC-MIP has been designed to access the plasma density of the ionized outflowing cometary atmosphere, and estimate the electron temperature under certain plasma conditions. The investigation of these plasma parameters, combined with other plasma and electro-magnetic parameters measured by the other RPC instruments, enables ~~to~~ better ~~constrain~~ extra bulk plasma parameters (such as the electron temperature and the ion bulk velocity, under certain hypothesis) and contributes to the understanding of the ionization of the cometary atmosphere, as well as the thermalization, the structure and the dynamics of the expanding cometary ionosphere (also called by some authors "induced magnetosphere") and its interaction with the incoming solar wind.

constraints of the

RPC-MIP's additional goals include defining the spectral distribution of natural plasma waves, through the measurement of the electric field projected along the direction of the instrument, in the frequency range from 7 kHz to 3.5 MHz, i.e. above the electron cyclotron frequency under cometary plasma conditions encountered around 67P/C.

The scientific rationale underpinning the RPC-MIP archive in the PSA system is as follows:

- Maximize the scientific return from the experiment by making available both the calibrated (L3) and interpreted (L5) RPC-MIP data to the world-wide scientific community,
- Ensure that the unique data set returned by RPC-MIP is preserved in a stable, long-term archive for scientific analysis beyond the end of the Rosetta mission,
- Provide this archive as a part of the valuable contribution by ESA and the Rosetta science community to the exploration of comets.

4. Instrument Operations

4.1 Instrument operational modes

The RPC-MIP in-flight operations are controlled by a configuration table sent from ground by telecommand (TC) and setting the operational parameters values.

The main operational concepts are described below.

- **Active and passive mode**

  In **active mode**, a transmission signal is injected through one electrode (T1, T2 or LAP2) or the dipole (T1 and T2) at a given frequency. Contemporarily, the signal is received on the reception dipole (R1-R2) and is Fourier transformed (DFT) at the frequency of the transmitted signal, with a 7 kHz resolution. A sweep over the selected frequency table allows the computation of the overall spectral response.

algorithm depends on the plasma regime and on the signal-to-noise ratio at the time of acquisition, resulting in a non-continuous coverage.

6.2 Electron density from cross-calibration between RPC-MIP and RPC-LAP

While absolute measurements of the electron plasma density, through the identification of the plasma frequency in RPC-MIP spectra, are believed to be accurate, scientific analyses are limited by the instrument capabilities in terms of time resolution, frequency resolution and accessible density range. Combining these products with floating potential as well as ion and electron currents and/or electric potentials measured by RPC-LAP enables to ~~validate and~~ ~~increase the~~ time resolution of the RPC-MIP derived density. This cross-calibration effort between instruments among the RPC leads to the delivery of a common L5 density dataset between RPC-MIP and RPC-LAP that complement the RPC-MIP-only L5 density dataset[2].

Cross-calibrated densities are obtained by fitting different RPC-LAP measurements to RPC-MIP electron densities over fixed-length overlapping sliding time windows.
Inputs are listed below.

- RPC-MIP derived densities obtained in SDL phased and SDL antiphased modes of operation, available as a L5 dataset on the PSA.
- RPC-LAP potential and currents obtained from probes operated in floating mode or current mode, respectively, available as L5 datasets on the PSA.

Possible issues regarding the use of RPC-MIP and RPC-LAP input datasets for such cross-calibration purpose is a priori limited by a careful selection of possible cross-calibration intervals. This is obtained through (i) a prioritization among RPC-MIP measurements that enable ~~to extract~~ the plasma density, (ii) a prioritization among possible RPC-LAP measurements to be cross-calibrated, and (iii) by discarding events where the measurements quality can be limited (such as attitude correction manoeuvers, RPC-LAP probes illumination conditions...).

Results from the cross-calibration procedures are filtered out to discard false detections, for instance time intervals when the assumptions adopted for the cross-calibration process could be doubtful.

A more detailed description of the cross-calibration procedure can be found in RD4.

[2] planned to be available in the PSA in summer 2019

- UTC time of the electron density value.
- Half of the on-board acquisition time.
- Plasma electron density value (in cm^{-3}).
- Estimated uncertainty of the plasma electron density (in cm^{-3}).
- Quality of the plasma frequency signature in the RPC-MIP spectrum (between 0 and 1).
- Quality describing the RPC-MIP spectrum complexity (between 0 and 1).
- Density detection rate in a 320 seconds window.
- UTC time of the spectrum used to extract the electron density.
- Instrument mode at the time of acquisition (SDL or LDL).
- Instrument transmission level.
- Instrument telemetry rate.

Operational parameters included in L5 dataset potentially affect the estimation process and/or quality by e.g. modifying the instrument frequency response or signal-to-noise ratio. They are repeated in L5 datasets to enable investigations on electron density without the need for L3 datasets.

Note that the times corresponding to a RPC-MIP spectrum and to the associated derived electron density are different: RPC-MIP spectra are dated at the start of acquisition while the time associated to the electron density is the time of the spectrum from which the density is extracted, corrected from half the acquisition period due to on-board processing such as transmission at different frequencies and averaging over successive spectra (which is also given in L5 datasets). The acquisition period is operational mode dependent and varies in particular with the instrumental mode and the TM rate.

RPC-MIP SDL and LDL modes ~~enable to probe~~ enables probing of plasmas with different Debye length ranges, below a few tens of centimeters or up to ~2m, respectively. When switching between SDL and LDL modes in a steady plasma, the extraction of the electron density estimation from the mutual impedance spectra in both operational modes cannot always be guaranteed, as one of the modes may not be adapted to perform a proper RPC-MIP measurement. Nevertheless, when mutual impedance spectra from both SDL and LDL modes allow the plasma density to be extracted, the plasma density does evolve continuously with time, as expected. Finally, the user should be aware that such SDL/LDL switches were not performed automatically, but instead triggered by TC defined before the scheduled operations. Furthermore, the frequency range in the LDL mode of operation is limited and does not extend beyond 168 kHz. It is quite usual than, in the comet environment, plasma frequency (thus electron density) exceeds this limit. The instrument mode of operation at the time of the density extraction is provided for each density value.

8.7.2 RPCMIP/RPCLAP electron density dataset

RPCMIP/RPCLAP cross-calibrated plasma density, as a derived product, is provided in L5 datasets. Data files contain values of the total plasma density derived from the cross-calibration of RPC-MIP densities (contained in RPC-MIP density dataset) and several possible RPC-LAP measurements. On-board operational constrains or instruments limits do not enable ~~to perform~~ the performance of the cross-calibration process over the whole mission in a continuous manner. Thus, only selected time intervals are included in this dataset. The cross-calibration process is briefly discussed in section 6.2 and more details can be found in RD4. While cross-calibration process is mainly driven by RPC-LAP operational modes and performed by RPC-LAP operational blocks, data files enclosed in this dataset are given as daily files for consistency with RPC-MIP density dataset. Each line of the file gives several information listed below.

- UTC time of the derived electron density value (sampled on RPC-LAP timings).
- Plasma density value (in cm^{-3}).
- Quality value (normalized) of the inputs used for the cross-calibration process.
- Quality describing the cross-calibration process (TBD).
- RPC-MIP operational mode.
- RPC-MIP instrument telemetry rate.
- RPC-LAP measurements used as input for the cross-calibration process (current or potential mode and used LAP probe).
- RPC-LAP operational macro.

9. Recommendations and caveats

9.1 General recommendations on RPC-MIP datasets

RPC-MIP data are usually presented as dynamic spectrograms in which the electric-field intensity is plotted as a function of time (in the X-axis) and frequency (in the Y-axis) using a color code. The spectrograms bear important information about explored regions or cometary activity. The characteristic signature of natural or actively triggered waves indicates the nature of the ambient plasma regime and, combined with the spacecraft position, reveals the position of key boundaries encountered during a specific time interval.

It is therefore strongly recommended to first look at these spectrograms when using RPC-MIP observed and derived data. In some cases, RPC-MIP spectra may be corrupted by interferences and/or overflows that make the measurements interpretation intricate. Useful supporting parameters are included in the data file to help the user in the data analysis.