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Interactive comment

Interactive comment on "Ionospheric Plasma Density Measurements by Swarm Langmuir Probes: Limitations and possible Corrections" *by* Piero Diego et al.

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Manuscript: angeo-2019-136 Title : Ionospheric Plasma Density Measurements by Swarm Langmuir Probes: Limitations and possible Corrections Authors : Piero Diego, Igino Coco, Igor Bertello, Maurizio Candidi, and Pietro Ubertini
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This manuscript is definitively an interesting paper as it rightly points out some potential weaknesses of Swarm's Langmuir probe. This concerns in particular its mounting at the front bottom side, the relatively small stubs and therefore small distance (∼10 cm) from the spacecraft body, which locates them most likely within the shielding layer

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Discussion paper

(Debye-sheath) of the spacecraft, at least during some parts of the orbit.

The paper contains however some serious flaws or misinterpretations despite the good and detailed introduction of the theoretical basis of the Langmuir probe measurement principle in OML approximation. Together with a quite questionable comparison to CSES-01 Langmuir probe observations at a roughly coincident orbit in about the same meridional plane, the conclusions drawn are very doubtful.

The Swarm Langmuir probe plasma density measurements are certainly much better and reliable, than this paper tries to suggest. Several studies of comparisons with radar measurements during direct overflights (e.g., Lomidze et al., 2017, also cited in the paper) or the systematic comparison with the International Reference Ionosphere (IRI) have shown, that the relative error is of the order of a 10-15% UNDERestimation. This study exemplifies with a comparison to CSES-01 measurements during August 2018 about half to one order of magnitude (factor $\sim$4 and more) OVERestimation (Fig. 4).

The key points of the study are the two items on the actual current collection of the Langmuir probes listed and discussed in section 3. They represent a trial to quantify the effects of the probe's sheath effect and the influence of the spacecraft body and its surrounding potential distribution on the measurements.

A sheath size of about 5 Debye lenghts (line 166), referred to the papers of Chen (1984, 2001), and the deduction of a corresponding Correction Factor CF within equations (5) to (7) is certainly an overestimation for the context of the Swarm satellites. The equations for the CF are hardly comprehensible, but rely probably on the papers cited. They might be valid for Langmuir probes at rest in a laboratory environment (which is the object of study in Chen's book of 1984 and the paper of 2001), but not for a supersonic plasma stream in the OML approximation, that is applied for the Swarm LP data analysis.

The second effect to be corrected, is similarly questionable. It is founded with an electric field, that "is created between the probes and the S/C body" (lines 207-208). This electric field is understood as the difference between the fixed bias voltage in the ion current regime and the spacecraft potential, as measured by the LP. To illustrate that electric field, Fig. 3 shows their variation during an example of one daytime and one night-time orbital part.

Contrary to the author's statement, the bias potential is meant with regard to the satellite ground potential, i.e., S/C body's floating potential, fixed to -2.5 V (plus/minus the small voltage of the harmonic mode). It is quite cryptic, why the authors think, that this leads to an "unbalanced enhancement of the ion flux toward the probes" (lines 213-214). The estimations of the time of flight (ToF) of the ions between the LP and the S/C body (line 215- 216) are irrelevant, as the LPs are mounted at the bottom side, the bulk flow therefore perpendicular to this distance line. Any movement toward (or away) from the probes should consider the accelerations of the ions within the potential distribution around the spacecraft and the probes.

A plasma density of $\sim$1E5 cmˆ-3 at $\sim$510 km during daytime afternoon hours at low latitudes (CSES-01 in Fig. 4b) are assumed to be correct. The Swarm-A measurements at 440-460 km and approximately the same local time are corrected toward this value, although the height difference of about 50-70 km alone (disregarding the local time and latitude/longitude differences) suggest already a difference in density of up to a factor two, as it is almost one scale height (at least during nighttime).

Finally a few minor remarks.

The plots and/or the headlines of Fig. 4a,b and Fig. 5 seem to be messed somehow. Fig. 5 shows descending orbits, which was a daytime ($\sim$15 LT) passage between, e.g., between $\sim$ 12:30 and 13:15 UT for Swarm A. The time labels in the headlines of Fig. 4a,b should be switched.

Lines 26-27: What do you mean by "free polar orbit"? Maybe: "near polar orbit"?

Line 68: The reference is Diego et al., 2017a or 2017b?

Lines 147-148: The "amount of H+ contamination" is not increasing toward high latitudes and geomagnetically active periods, rather on the contrary.

Line 251: "electronic density" -> electron density

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