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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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Authors want to thank for the detailed comments that will help us to substantially improve our analysis. The aim of our work is to find the reasons why the Langmuir probes on board CSES and Swarm satellites show such a high discrepancy in the plasma density measurements while they track each other in the shape of the time series along the orbit (reaching a very good agreement when at almost same LT). Of course, the expected difference due to the different altitude and orbits should be considered. Although Swarm calibration obtained by Lomidze et al. shows consistent agreement between the measurements, we think that in-situ observations should be

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treated separately since these are obtained with similar procedures. The agreement in Lp measurements could be a simpler matter once the actual value of collected current is determined. For this reason, we consider very important to find a way to match in-situ measurements in order to provide the proper reference values for ionospheric plasma models. Of course, also CSES Lp data need a calibration review, especially for what concern the plasma potential detection (e.g. Rui Yan et al., The Langmuir probe on board CSES: data inversion analysis method and first results, EEP, 479-488, 2018, doi:10.26464/epp2018046). However, it is our feeling that the harmonic mode of Swarm Lp, and in particular its negative bias, could produce more important interferences in the ion collection described in OML theory. With reference to the shape and effect of a sheath around the probe, we appreciate suggestions from Swarm Lp developer which warn to consider the Chen reference and the sheath presence itself in case of fast moving objects in the plasma (i.e. S/C velocity). Still we believe in the sheath presence and in its effect on ion collection but we would rather suggest the specific results of Whipple (Potential of surface in space, 1981) for a revised evaluation of the actual current collection. To examine in depth such warnings, we have chosen Whipple (1981) results that summarize the condition in which the sheath effect on ion collection is applicable. In fact, if the relative velocity between S/C and plasma is much greater wrt the thermal velocity, this effect becomes very small with respect to the static scenario we firstly suggested. The increase in current collection, therefore, should be within few tens of % more than that collected by the probe disk area. We also discussed the “electric field effect” induced by the S/C-Lp potential difference, that is fixed at -2.5V along the orbit, to quantify an “unbalanced” probe cross-section (meaning a cross-section growing only toward the S/C but not in the outer direction). We estimate the ToF to identify how long the electric field acts pushing down towards the probe the ions that are travelling in the space between S/C and Lp. This path can be roughly considered to start at the edge of the S/C sheath and to finish while crossing the stub of the Lp. Anyway, as the sheath is the charge layer that shields electric fields around a polarized body, the electric field is confined inside the sheath. This means that, as

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long as the sheath is small, the probe polarization effects are localized very close to the probe and, in addition, they are already described by OML theory. In such cases corrections are not applicable. Nevertheless, when the plasma density becomes very low (e.g. at higher latitudes or inside plasma bubbles or Travelling Ionospheric Disturbances) and the Debye length consequently increases, the probe and the S/C sheaths could melt and the electric field between them is no longer shielded, giving rise to saturation effects due to ions amount inside the enlarged global sheath. Unfortunately, this scenario appears to be very hard to describe with a simplified model and so the relevant current collection enhancement. We are currently performing additional analysis aiming to explain and quantify the two different kind of discrepancy level observed between Swarm and CSES that are, the average difference, and the extreme difference that occur at very low density (e.g. below 109 m-3). The average ratio (about 4) could be addressed to; i) different altitude (about 35%), ii) sheath increasing collection of Swarm (within 50%), and iii) CSES plasma potential computation uncertainty (about 50%). On the other hand, the extreme discrepancy evaluation needs to model the electric field topology inside the melted sheath, still depending to density level as shown during exceptional plasma depletions where the discrepancy level reached about 3 order of magnitude. All those issue imply that the paper cannot be corrected in its current version but it needs a complete revision. We aim to carry such study out in cooperation with the Swarm Lp developer team in order to improve the feedback rate and the quality of the analysis. We decided therefore to withdraw the paper in its current form.

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