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High-resolution Poynting fluxes derived from the ESA Swarm mission: How much are we underestimating?

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The ESA Swarm constellation of satellites have been measuring the ionospheric electric and perturbation magnetic fields since 2013. Recently, the entire dataset of Swarm electric fields has been reprocessed into a 16Hz data product, allowing the analysis of ionospheric dynamics on sub-kilometre scales.

In combination with the on-board magnetometer data, the Swarm satellites can use the electric field measurements to determine the total electromagnetic energy into and out of the ionosphere, the Poynting flux. The 16Hz dataset allows for the capturing of much smaller scale sizes than previously considered, thus presenting the opportunity to study how much Poynting flux is missed when utilizing data across typically monitored scales (usually on the order of tens to hundreds of kilometres).

We present a statistical analysis of the Swarm A and B derived 16Hz Poynting flux, utilising various low-pass filters on the electric and magnetic field data to simulate smoothing the data to larger scale sizes. We find that by increasing the width of the low-pass filters, measured Poynting flux decreases significantly and quickly. Our results show that there is an over 50% underestimation in the total hemisphere integrated Poynting flux when observing it on scale sizes of a few hundred kilometres, compared to the raw 16Hz measurements that correspond to scales of around 0.5km. Under certain circumstances, as much as a 10% underestimation in the Poynting flux is observed by increasing scale size to only 5km. These results stress the importance observing small-scale electric and magnetic fields, as they may account for a large proportion of the ionosphere-thermosphere energy budget.