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A detection algorithm for scale analysis of post-sunset low-latitude plasma depletions as observed by the Swarm constellation mission

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ESA's constellation mission Swarm was successfully launched on 22 November 2013. The three satellites achieved their final constellation on 17 April 2014 and since then Swarm-A and Swarm-C orbiting the Earth at about 470 km (flying side-by-side) and Swarm-B at about 520 km altitude. The satellites carry instruments to monitor the F-region electron density with a sampling frequency of 2 Hz. This paper will present a detection algorithm for low-latitude post-sunset plasma bubbles (depletions), which uses local minima and maxima to detect depletions directly from electron density readings from Swarm. Our analyses were performed in the magnetic latitude (MLat) and local time (MLT) coordinate system.

The detection procedure also captures the amplitude of depletion, which is called depth in the following. The width of a bubble corresponds to the length the satellite is located inside a depletion. We discuss the global distribution of depth and width of plasma bubbles and its seasonal and local time dependence for all three Swarm satellites from April 2015 through September 2015. As expected, on global average the bubble occurrence rate is highest for combined equinoxes (Mar, Apr, Sep, and Oct) and smallest for June solstice (May, Jun, Jul, and Aug). MLT distribution of the bubble occurrence number shows a sharp increase at about 19 MLT and decreases towards post-midnight hours. Interestingly, there is an inverse relation between depth and width of bubbles as function of MLT. This is true for all seasons and for all Swarm satellites. The bubble depth (width) is decreasing (increasing) from post-sunset to post-midnight for December solstice (Jan, Feb, Nov, and Dec) and combined equinoxes with about the same amplitude values for bubbles depth (width). Therefore we suggest that at post midnight when the depletions are less steep the structures of the depletions is broader than early after sunset. However for June solstice the depletions are less deep and the bubble depth and width do not change significantly throughout the evening. Deepest depletions occur at around +/- 10° magnetic latitude that is at the inner edge of the ionisation anomaly with density maxima at around 15° MLat. Therefore, the level of background electron density does not only determine the depth of a post-sunset depletion.