Low-altitude ion heating, BBELF waves, and downflowing ions in the return current region

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The concept of wave-particle interaction is not favored in the community as an explanation of the observed ion heating in the terrestrial topside ionosphere. This is partly due to the collisional nature of ionosphere which can damp waves, and partly due to lack of simultaneous and appropriate plasma and wave observations below 1000 km altitudes. In this study, we statistically investigate ionospheric ion energization and field-aligned motion at very low altitudes (330-730 km) using simultaneous plasma, magnetic field, wave electric field and optical data from the e-POP satellite. The ion temperature and field-aligned bulk flow velocity are derived from 2-D ion distribution functions measured by the suprathermal particle imager (SEI) instrument. From March 2015 to March 2016, we've found in total 24 ion heating signatures passing across the dayside cleft or the nightside auroral regions. Most of these events have consistent ion heating and flow velocity characteristics observed from both the SEI and rapid-imaging ion spectrometer (IRM) instruments. The perpendicular ion temperature goes up to 4.5 eV within a ~2 km-wide region in some cases, in which the radio receiver instrument (RRI) sees broadband extremely low frequency (BBELF) waves, demonstrating significant wave-ion heating down to as low as 350 km. The in-phase and quadrature components in the RRI cross-dipole electric field measurements enable us to resolve the wave power spectral density and polarization after conducting Fourier analysis. These BBELF waves are found to be in general in electrostatic mode. The e-POP fast auroral imager (FAI) and magnetic field (MGF) instruments show that many events are associated with active aurora and are within downward current regions. In addition, contrary to what would be expected from mirror-force acceleration of heated ions, the majority of these heating events (17 out of 24) are associated with the core ion downflow rather than upflow. Potential mechanisms are discussed in the context of auroral downward current region. We are going to use a test particle simulation to study the wave-particle interaction processes involved given the observed plasma and wave characteristics.