The Changing Polar Ionosphere: A Comparative Climatology of Solar Cycles 23 and 24

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The polar ionosphere is a dynamic region that readily responds to changes in solar irradiance, the solar wind, the magnetosphere, and the neutral atmosphere. The most recent solar minimum brought to light gaps in the current understanding of the relationship between ionospheric structure and solar irradiance. The Super Dual Auroral Radar Network (SuperDARN), a High Frequency (HF) over-the-horizon radar network that provides continuous coverage of the northern and southern poles, offers an invaluable dataset for studying long-term ionospheric variability. SuperDARN has been providing extensive coverage of the polar ionosphere in both hemispheres since 1995 (the solar minimum preceding the 23rd solar cycle).

HF radars are capable of observing both the disturbed and quiescent ionosphere. An under-utilized portion of the SuperDARN dataset is the groundscatter: the backscatter that returns from a reflection point on the ground instead of from an irregularity in the ionosphere. The apex of the groundscatter propagation path can originate anywhere below the plasma density peak, and will vary depending on the transmission frequency of the radar signal. Backscatter from the ground and ionosphere is observed from both in front of and behind the radar, despite radar designs to minimize contributions from the rear field-of-view. This study uses novel analysis techniques to improve the radar angle-of-arrival calculations, determine whether the backscatter originates from the front or back field-of-view, and separate groundscatter from ionospheric backscatter. The height and plasma density at the peak of the groundscatter propagation paths are then calculated during the day for equinox over the 23rd and 24th solar cycles. Using these measurements, a geographic distribution of the height of the bottomside, polar ionosphere is constructed for discrete bands of plasma density.

Examination of the distributions over a single solar cycle shows the expected lowering of the bottomside ionosphere as solar maximum approaches, reflecting the widening of the plasma density peak that occurs as the height of the plasma density peak increases. Comparing the two solar cycles reveals marked differences due to the lower levels of solar Extreme Ultraviolet (EUV) irradiance seen during the 24th solar cycle. This study explores these differences in the northern hemisphere