Studying the day-to-day variability of 150-km echoes

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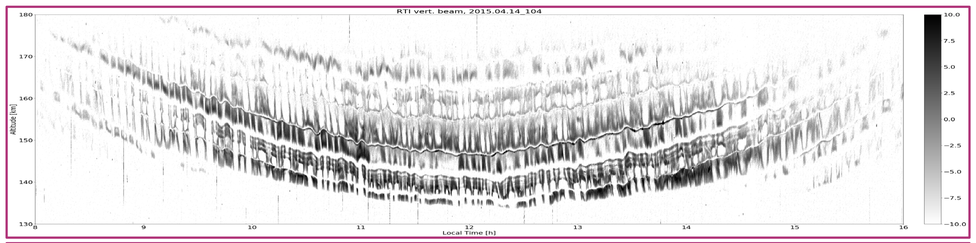
Abstract: Daytime VHF echoes from the lower F region (also known as 150-km echoes) are an everyday, normal occurrence in the ionosphere at Jicamarca. Many vertically stacked layers ("necklace") descending in the morning and ascending in the afternoon are detected separated by narrow gaps of no backscatter in the 150 km echoes [1]. We have found that the characteristic arrangement of these layers is very similar every day, but the absolute height shifts vertically and in local time and the apparent slopes change from day to day. We have traced at several of these gap layers and compare their diurnal height-vs-time shapes with virtual-height-vs-time contours for specific plasma frequencies from simultaneous observations with the VIPIR ionosonde operated at the radar site.



Idea:

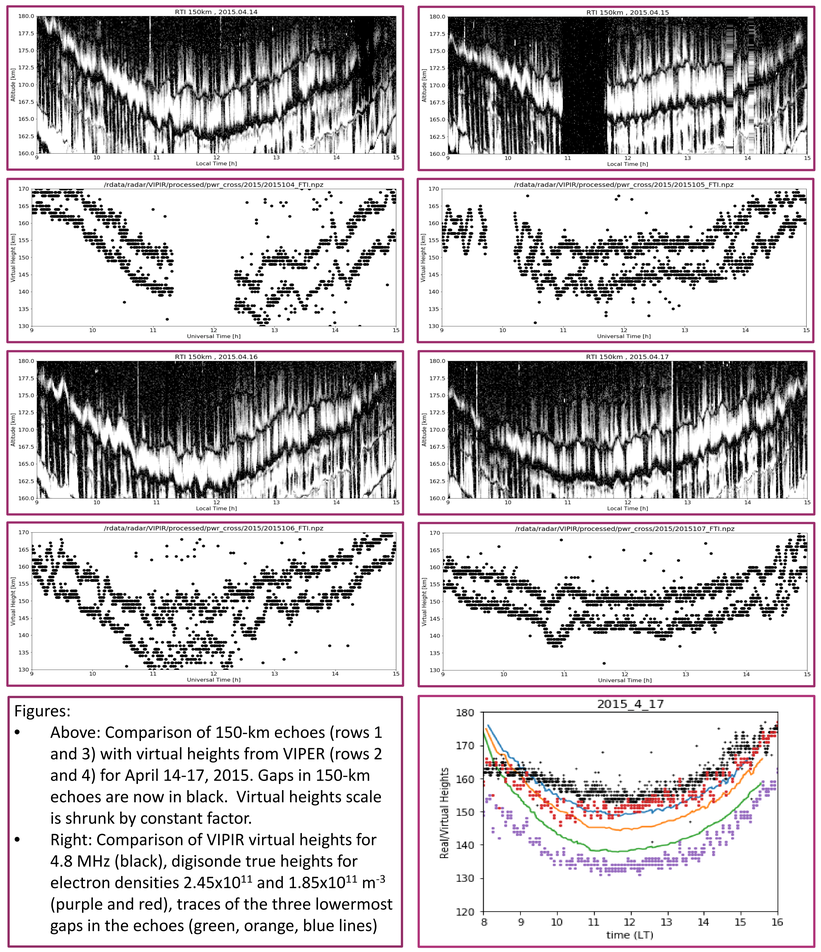
- Periodic gaps in the echoes (white curves in the figures on the left) exist at specific height intervals, e.g., at 140 and 170 km.
- Gaps may occur for certain values of the electron density which show similar behavior from morning to afternoon.
- Occurrence may be related to the upper hybrid resonance in the lower F region excited by suprathermal photoelectrons [2,3,4].

Method of Approach:

- Comparison of 150 km echoes with VIPER data (Vertical Incidence Pulsed Ionosphere Radar) for 4.5 MHz and 4.8 MHz (figures on the right) for four consecutive days in April 2015.
- Height pattern of the gaps is compared to the virtual heights obtained at specific frequencies between 9 and 15 LT.
- We also compared true-height electron density profiles derived from the Jicamarca digisonde with echo gaps and VIPIR data.

Findings:

- Solar parameters as proxy for ionization rate showed relatively small variation during the four days shown here. F10.7 was 147.7, 155.7, 151.3 and 150.8, and sun spot number was 105, 96, 100, 107.
- On the other hand, the gap height pattern and electron density (plasma frequency contours) vary more significantly from day to day suggesting other important local or global drivers.
- The contours for 4.5 and 4.8 MHz track well the gap layers near 170 km. Specific electron density values seem to be an important factor in determining the necklace pattern.
- Plasma frequencies of 4.02 and 4.71 MHz (electron density 2.01×10^{11} and 2.76×10^{11} m^{-3}) correspond to the 6th and 7th Bernstein wave which do not propagate where $\omega_p^2 = (n^2-1)\Omega^2$ with $\Omega = eB/m$ and could be a reason for the regular gaps structure.



Figures:

- Above: Comparison of 150-km echoes (rows 1 and 3) with virtual heights from VIPER (rows 2 and 4) for April 14-17, 2015. Gaps in 150-km echoes are now in black. Virtual heights scale is shrunk by constant factor.
- Right: Comparison of VIPIR virtual heights for 4.8 MHz (black), digisonde true heights for electron densities 2.45×10^{11} and 1.85×10^{11} m^{-3} (purple and red), traces of the three lowermost gaps in the echoes (green, orange, blue lines)

References:

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- [4] Oppenheim and Dimant (2016), Photoelectron-induced waves: A likely source of 150 km radar echoes and enhanced electron modes, Geophys. Res. Lett., 43.

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