Analysis of HF radar observations of ionospheric backscatter during geomagnetically quiet periods

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1. Introduction: The amount of backscatter detected by HF radars during quiet times is important for consideration of the effects of disturbances such as those considered in previous studies by *Kane and Makarevich* [2010] and *Kumar et al.* [2011]. The occurrence of HF backscatter depends on two main factors: propagation conditions and existence of irregularities. In this study, occurrence of the F-region backscatter detected by the SuperDARN TIGER Bruny Island radar during geomagnetically quiet periods (|Dst| < 30 nT) is analysed and compared to the background NmF2 and underlying E-region conductance.

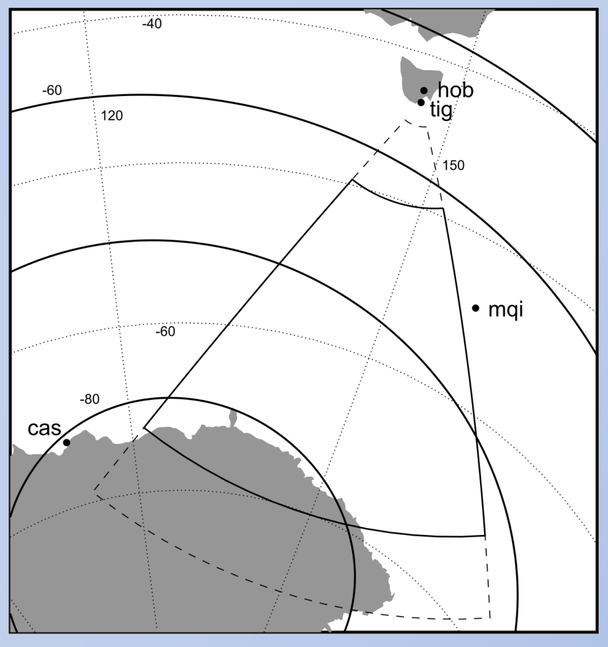


Figure 1: *TIGER FoV and nearby ionosondes. The dashed lines are the restricted ranges used here*

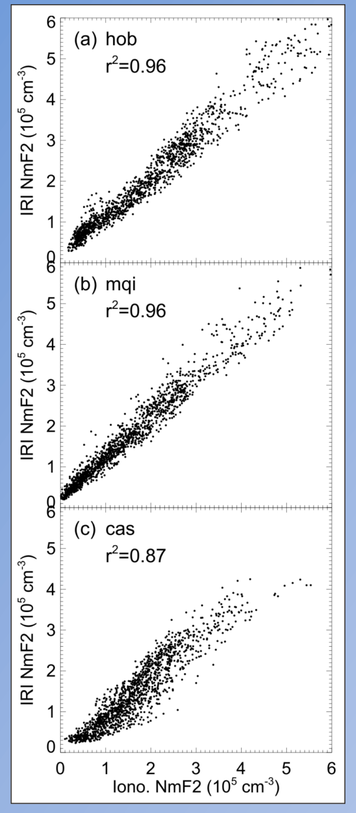


Figure 2: *Ionosonde vs. IRI-2007 NmF2, with correlations*

2. IRI-2007 Model: An empirical model (IRI-2007) was used to validate the use of (non-coincident) ionosonde data. The model was run at the ionosonde locations and compared with the NmF2 measurements for quiet days within our study interval (2002-2006). The scatter patterns and high correlation shown in Fig. 2 indicates that the IRI model provides accurate values for NmF2 near the radar's FoV.

3. E-region conductance:

The Pedersen conductance of the underlying E-region ionosphere was determined using the *Robinson and Vondrak* [1984] solar-illumination model: $\Sigma_P^E = 0.88 \times (S_a \cos\chi)^{\frac{1}{2}}$

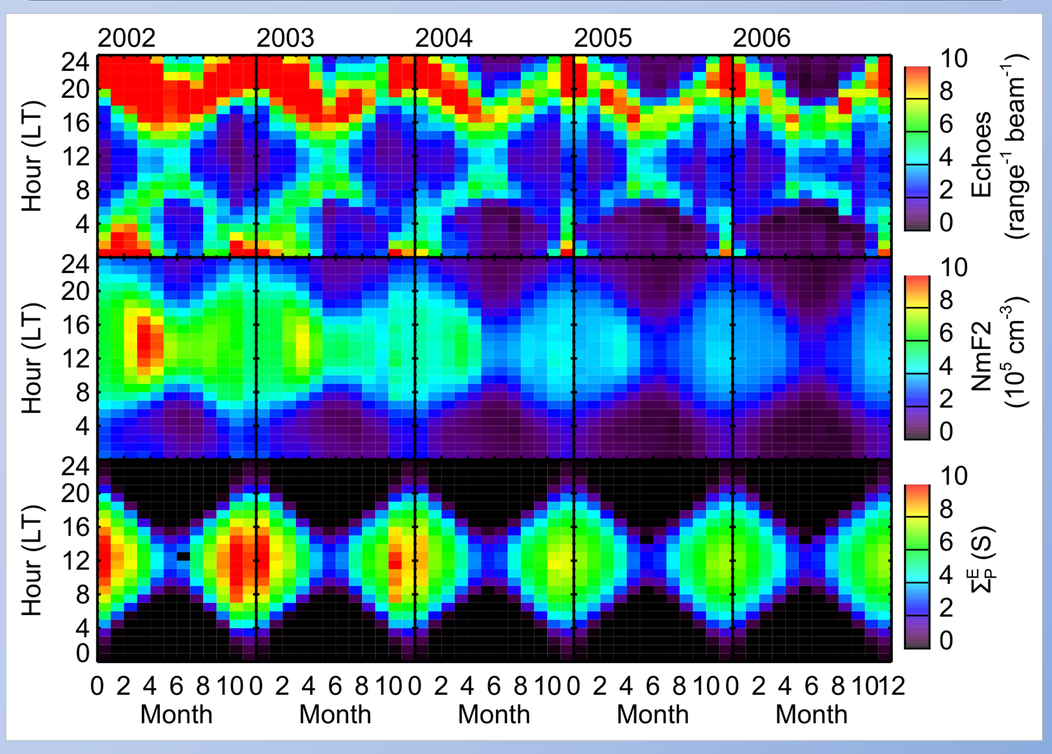
Vickrey and Kelley [1982] showed that large-scale (>1 km) irregularities should be reduced by a highly conducting E region. The assumption that this also holds for decametre-scale irregularities is to be tested here.

Figure 4: *Occurrence vs. conductance and density for the day time.*

4. Occurrence, Density and Conductance: In Fig. 3 we present the statistical quiet-time variations of the three parameters considered. Diurnal and seasonal variations in NmF2 and Σ_P^E are obvious, and are clearly controlled by zenith angle conditions. The decrease in magnitude of both parameters over the study interval is due to the decrease in solar EUV flux as the solar cycle declines.

The backscatter occurrence shows a noon minimum in summer, and a band of high occurrence in the afternoon-evening sector. The backscatter occurrence in the midnight-morning sector decreases with solar cycle and expands in local time and month. This night-time minimum is also observed in NmF2.

Figure 3: *Statistical quiet-time variations of HF backscatter occurrence (top), modelled NmF2 (middle) and modelled Σ_P^E (bottom) with values calculated hourly for each month for 2002-2006.*



5. Day-time occurrence: In Fig. 3, the day-time occurrence minima appear to correspond to the day-time conductance maxima. The absence of data points in the upper right of Fig. 4 supports this, as for high values of E-region conductance, only small amounts of backscatter are detected. Density appears to play an important role for low conductances.

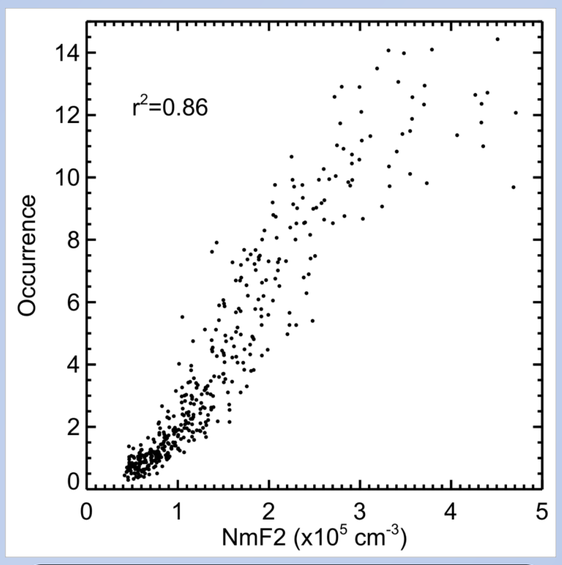


Figure 5: *Night-time occurrence vs. NmF2*

6. Night-time occurrence: At night, the amount of backscatter detected varies linearly with NmF2. Fig. 5 highlights the agreement between the night time "bite-out" of both occurrence and density observed in Fig. 3. The decrease in density could either lead to a decrease in irregularities or under-refraction.

Milan et al. [1997] showed a midnight minimum in both ionospheric and ground scatter. The decrease in ground scatter would suggest that it is under-refraction leading to the decrease in ionospheric backscatter.

7. Summary and Conclusions:

A comparison of IRI model NmF2 with ionosonde measurements shows that the IRI-2007 model accurately represents the average variations in NmF2 in the vicinity of the radar's FoV during quiet periods.

The electron density is predominantly controlled by solar illumination during quiet periods.

During the day, the amount of backscatter is decreased when the conductance of the underlying E-region is high. This is in agreement with previous theoretical studies of F-region irregularity generation.

During the night, the amount of backscatter detected is directly proportional to the background electron density. Similar studies have reported that this dependence is also present in the ground scatter data, suggesting that it is due to the decreased electron density leading to under-refraction.

References:

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