Correction to "Optical signatures of radiation belt electron precipitation induced by ground-based VLF transmitters"

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In the paper "Optical signatures of radiation belt electron precipitation induced by ground-based VLF transmitters" by R. A. Marshall et al. (*Journal of Geophysical Research*, *115*, A08206, doi:10.1029/2010JA015394, 2010), calculations in section 4, "Implications for Experimental Detection," were not correctly updated from an earlier draft during the production process. The correct calculations and statements are given here.

In section 4.1, the computations of the SNR contained numerous errors. Paragraph 32 should be replaced with the following.

"The best narrowband filters on the market have bandwidths of ∼12 Å and a peak transmission of ∼0.5. Integrating in our two emissions, this yields an airglow signal of 12 R in the 4278 Å channel and $(250 + 12 \times 5) = 310$ R in the 5577 Å channel. We can compute a system sensitivity as follows: 1 R (10^6 photons cm^{-2} s^{-1} $(4\pi$ sr$)^{-1}$) into an optical system with 10 cm diameter and $10^\circ \times 10^\circ$ field of view (0.03 sr), through the filter with transmission of 0.5, yields 9.4×10^4 photons s^{-1} hitting the detector. As an example detector, the Hamamatsu R5900U series of photomultiplier tubes has a quantum efficiency (QE) of ∼0.17 at 5577 Å, a dark current at the anode of ∼1 nA, and a gain of $G = 10^6$; this yields an anode signal current of 2.55 nA per rayleigh. If we use this sensitivity in our optical system, the shot noise due to the background cathode current of $I_{\mathrm{sky}} = 0.79\ \mu$A (which dominates over the 1 nA dark current) is given by

$$I_{s,\mathrm{sky}} = \sqrt{2qI_{\mathrm{sky}}B}(G), \tag{3}$$

where B is the bandwidth of the recording system and q is the electron charge. If we assume a sampling interval of 1 s or a bandwidth of 1 Hz, then $I_{s,\mathrm{sky}} = 503$ pA for the 5577 Å channel. In addition, with a feedback resistance of 1 MΩ, we have dark noise of 18 pA, signal shot noise of 3 pA, and Johnson noise of $I_{s,R_{\mathrm{sh}}} = \sqrt{4k_BTB/R_{\mathrm{sh}}} = 0.1$ pA; and, as such, we can neglect all but the background noise.

The total of 503 pA is to be compared to our signal of 10 mR, which is measured as 25.5 pA. This yields an SNR of ∼0.05, and so our signal is not likely to be detectable in a single event. Even worse, if we assume a sine pitch angle distribution, the peak intensity is only 0.1 mR, resulting in a signal current 100 times smaller and an SNR of 0.0005, making detection impossible. Note that the 4278 Å line has only an ∼12 R background intensity, resulting in a shot noise of 100 pA and an SNR of ∼0.25 for the square pitch angle distribution, assuming a similar detector QE at 4278 Å."

Note that the end result is a change in the computed SNR from 0.07 to 0.05 in the 5577 Å line and an increase from 0.16 to 0.25 in the 4278 Å line.

The SNR errors from section 4.1 propagated into section 4.2. In paragraph 34, the statement "increasing the background current to 37.5 pA and the shot noise to 10 fA and reducing the SNR to ∼0.05" should be replaced by "increasing the background shot noise to 780 pA and reducing the SNR to ∼0.03."

Similarly, in paragraph 35, the statement "increasing the SNR by a factor of $\sqrt{900} = 30$ to a best-case SNR of 2.1 for the 5577 Å line and 4.8 for the 4278 Å emission" should be modified to read "increasing the SNR by a factor of $\sqrt{900} = 30$ to a best-case SNR of 1.5 for the 5577 Å line and 7.5 for the 4278 Å emission."