Sunspike Detection using Radial-by-Radial Noise Estimates

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Introduction

Using the sun as a baseline for calibration is a passive method which requires no extra equipment or expenditure; the only requirement is identifying and processing the sunspikes in the operational radar datasets. The operational reflectivity signature of a sunspike is represented on a Plan Position Indicator (PPI) display as a strobe which fills all bins down a radial with power. During calibration procedures where the sun is tracked by the radar, called solar box scans, the signature of the sun appears more intuitively as a circular disk, seen in the Fig. 2. Previously, sunspikes were detected and assimilated through the method developed by Cunningham et al. (2013). The original algorithm for detecting sunspikes considered all bins in a radial to determine admission into the usable set of sunspikes to create a composite pointing plot. The signal-to-noise ratio (SNR) was calculated at each bin, and the number of bins between 10-15 dB were summed, which ensured that the sunspike was in fact direct, and that weather did not contaminate the results. Radial-by-Radial (RxR) Noise Estimation was introduced in Software Build 14 by the Radar Operations Center in mid-2014. With the radially specific estimates, the power received from the sun essentially censors itself by raising the calculated noise floor. The algorithm was no longer able to detect sunspikes due to loss of the reflectivity strobes, seen in Fig. 2. Revisions to the algorithm were made in order to resolve the undesirable sun hit distribution; these changes are discussed here.

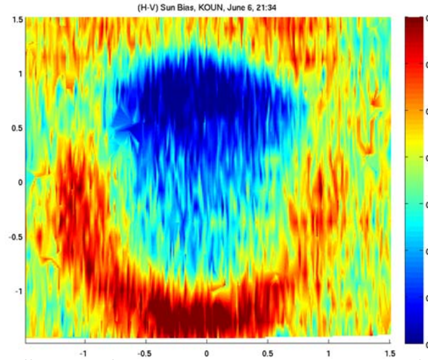

Fig. 1– Differential Reflectivity measured during a solar box scan (KOUN)

Background

Sunspikes are named as such due to the "spike" in the received power throughout the radials where the sun's radio emissions were encountered. These occurrences have proved useful in regards to the efforts of many to externally measure antenna pointing bias. Ice et al. (2014) discusses how the Radar Operations Center engineering team has taken advantage of these to improve engineering calibration practices. More specifically, the sun can be used to calibrate differential reflectivity, while at the same time monitoring the pointing bias of the antenna. This is possible due to the sun's intrinsic differential reflectivity of zero. Fig. 1 shows how the differential reflectivity tend towards zero near the origin of the pointing chart.

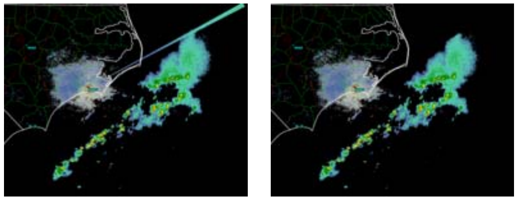

Fig. 2– Comparing the same scan with RxR estimation off (left) with on (right) (KMHX)

Methods

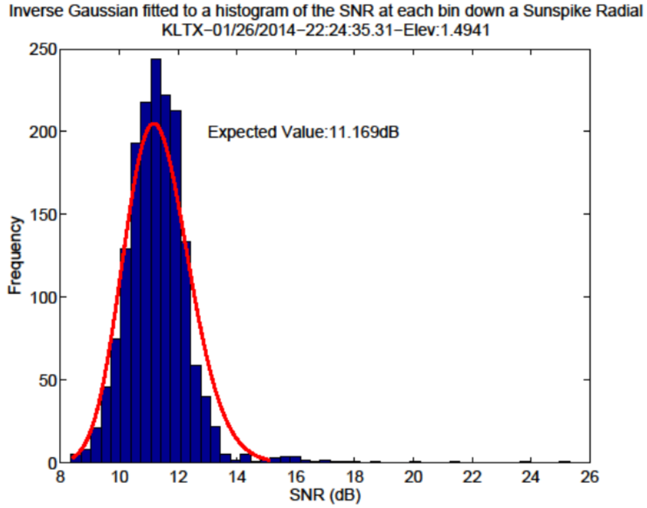

Fig. 3– Histogram of SNR at each radial (KLTX)

Two techniques for measuring the solar image are presented here. The first, which was used in the original sunspike detection method, relies on reflectivity to calculate SNR values. But in order to arrive at a single value per radial for comparison with RxR noise, the method shown in Fig. 3 was used. The second, new technique uses RxR noise power to calculate the Sunspike Noise Ratio (SPNR) values, shown in Fig. 4. The Sunspike Noise Ratio, or Spike Noise Ratio, is a new term coined to describe the ratio of a sunspike's peak RxR noise value to the noise floor. Here, the noise floor used is the 'Blue-Sky' Noise. Using MATLAB to read and process Level II data, it is shown that SNR and SPNR are nearly equivalent.

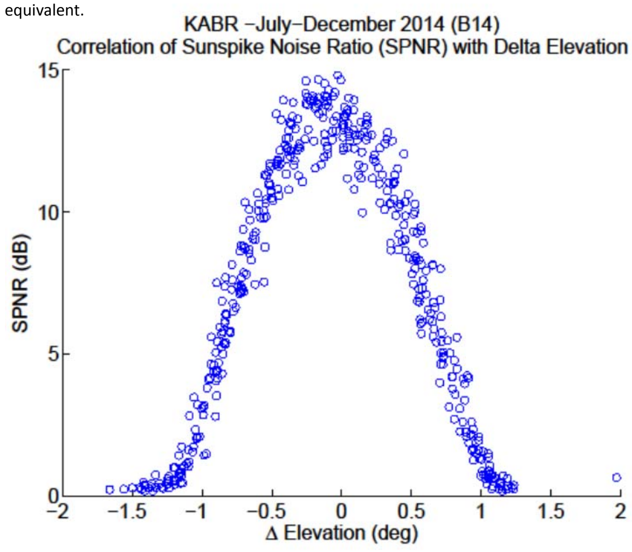

Fig. 4 – Sunspike –to-noise ratio compared to radar elevation in relation to Sun (KABR)

Results

Azimuthal precision is increased through the new RxR sunspike detection, as seen in the decrease of the angular width of the solar image as measured by RxR noise (Figs 6a-b) compared with that measured by reflectivity (Fig. 5). Figs. 6a-b show that the expected elevation distribution is accurately portrayed, but the azimuth is somewhat constrained, only reaching around 0.3°. This could be due to the convolution created by the scanning motion of the antenna, but it is most likely that the RxR noise method for detecting sunspikes increases the precision in choosing the correct radial.

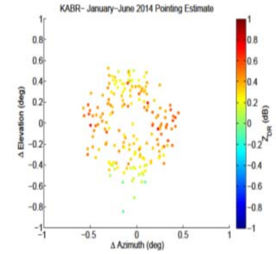

Fig. 5 – Pre Software Build 14 Pointing Estimate (previous algorithm)(KABR)

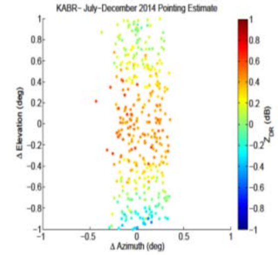

Fig. 6a – Post Software Build 14 Pointing Estimate (Before algorithm fix)(KABR)

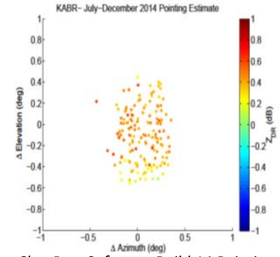

Fig. 6b – Post Software Build 14 Pointing Estimate (After algorithm fix)(KABR)

Conclusion

There are many advantages to using RxR noise for sunspike detection and validation. Since it is a measure of noise and not power, it can distinguish between weather and a sunspike, unlike SNR. In the future, the ROC may be able to incorporate more than just clear-air VCPs into the algorithm. With other VCPs included, this will also introduce sunspikes at various elevations. Furthermore, the new algorithm is not capped at 15 dB, which allows for the admission of the most direct sunspikes. This could greatly improve differential reflectivity calibration efforts, as near-perfect point hits have the most chance of measuring the sun's actual intrinsic differential reflectivity of zero.

Acknowledgements

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References

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