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This Week's Citation Classic

Booker H G & Gordon W E. A theory of radio scattering in the troposphere.
Proc. IRE **38**:401-12, 1950.
[School of Electrical Engineering, Cornell University, Ithaca, NY]

The theory of scattering of radio waves by atmospheric turbulence in the troposphere shows that, at SHF, UHF, and VHF, the scattered field dominates the diffracted field at receivers located substantially beyond the horizon. This is the basis of tropospheric scatter communication. [The *SCI*® indicates that this paper has been cited over 120 times since 1961.]

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"In 1949 it was known that, in the SHF, UHF, and VHF bands, the field received beyond the horizon often exceeds that due to diffraction and that, on many occasions, this is caused by atmospheric refraction. However, there were some observations that did not fit the refraction theory. The received field in these circumstances was Rayleigh distributed and suggested a scattering mechanism.

"In 1949, theories of scattering by atmospheric and oceanic irregularities existed for light and for sound. A theory of scattering also existed in wave mechanics, particularly the Born approximation. Moreover, under the direction of Jack Ratcliffe, a theory of radio scattering had just been developed at Cambridge for irregularities of ionization in the ionosphere.[1] When, at that time, I arrived at Cornell from Cambridge, William Gordon suggested that we apply these ideas to the troposphere. This paper is what emerged. One might perhaps imagine that Gordon was the professor and that I was a candidate for the PhD degree, but in fact the reverse was true.

"In ionospheric scattering it was customary at that time to use a Gaussian autocorrelation function for the irregularities; this incorrect notion persisted in ionospheric scattering for many years thereafter, and for an even longer period in radio astronomy. It was again Gordon who realized in 1949 that, at least for the troposphere, the exponential autocorrelation function is much closer to the truth. It was the switch from the Gaussian autocorrelation function to the exponential autocorrelation function that made possible the scattering explanation of what came to be known as tropospheric scatter communication.

"The paper almost certainly played a timely role in the development of tropospheric scatter communication. Applied to the E region of the ionosphere, it also played a timely role in the development of ionospheric scatter communication.[2] Applied to missile wakes, it played a role in identifying the cause of enhanced radar echoes. Applied to irregularities in the ionospheric F region aligned along the Earth's magnetic field, it has contributed to our understanding of 'spread F.'[3] Even recently, this development of the theory has been used to generate a quantitative treatment of transequatorial propagation at VHF.[4]

"The basic theory presented in 1950 has stood the test of time reasonably well. However, the exponential autocorrelation function, while vastly superior to the Gaussian autocorrelation function, has needed some modification to bring it into agreement with the Kolmogoroff spectrum of turbulence. On the other hand, the numerical values used in 1950 have not stood the test of time. No inner scale of turbulence was then used; it is not important for tropospheric scattering, but it is needed for ionospheric scattering. The scale used in 1950 was in fact the outer scale of turbulence. Its magnitude was grossly underestimated, as also was the mean square fluctuation of the refractive index. The two errors roughly balanced because it is only a combination of the two parameters that is actually important."

1. **Booker H G, Ratcliffe J A & Shinn D H.** Diffraction from an irregular screen with applications to ionospheric problems. *Phil. Trans. Roy. Soc. London A* **242**:579-609, 1950.
2. **Bailey D K, Bateman R, Berkner L V, Booker H G, Montgomery G F, Purcell E M, Salisbury W W & Wiesner J B.** A new kind of radio propagation at very high frequencies observable over long distances. *Phys. Rev.* **86**:141-5, 1952.
3. **Booker H G & Ferguson J A.** A theoretical model for ionospheric spread F echoes in the HF and VHF bands. *J. Atmos. Terr. Phys.* **40**:803-29, 1978.
4. **Ferguson J A.** *A scattering theory of transequatorial propagation at VHF.* PhD dissertation. La Jolla, CA: University of California, 1982.