Radio Wave Propagation by Marcel H. De Canck, ON5AU
A Review

L. B. Cebik, W4RNL

For many years, I have had the privilege of pre-reading Marcel De Canck's "Propagation" column before *antenneX* readers get their chance. From the very start, Marcel had designed his work to form a book—actually several books in a series. I watched avidly as he progressed from the very basic elements of ionospheric propagation and moved in two directions. One direction added refinement to the reader's understanding of the very diverse phenomena that go into conveying radio-wave energy from one point to a distant second point (or set of points). The other direction of his work guided readers into the world of computerized prediction of propagation. In both directions, his work shows patience and attention to detail, the hallmarks of a true craftsman and expert. At the same time, his style of presentation shows the spirit of amateur radio as he takes his readers step by step through ideas and through computer use as if he were speaking to a novice visiting his shack.

I cannot say it better than did his friend, the renown John Devoldere, ON4UN, of *Low-Band DXing* fame: "Marcel has studied everything that's available on the subject of radio propagation, knows the ins and outs, and has worked with all of the related computer tools that float around. He's an expert on these matters. Being able to explain, in simple words, to the non-experts, how it works makes him a good teacher as well." One day, Marcel's work will become as well known as John's volume, now in its 4th edition. I do not know if there is something special in the Belgian water or simply the Belgian spirit that produces two men who share the ability to be systematic, thorough, and able to serve their colleagues so well.

Radio Wave Propagation is a series of books (with 3 having appeared and the fourth in the works) to which paper cannot do justice. The CDROM is the perfect venue for Marcel's

presentations. Of course, they include a text, but they major on illustrations that bring life to the many subjects within the field of propagation. If Marcel's text and static illustrations were not enough to distinguish his work, his animation "Wizards" mark the volumes as unique in the field. Marcel is able to set propagation into motion to show the signal flow around the globe. Volume 1 alone contains 10 Wizard files, each keyed to the relevant portion of the text. As well each is self-contained. However, the most important feature of the Wizards is that they demonstrate vividly how dynamic radio wave propagation is in virtually all of its facets.

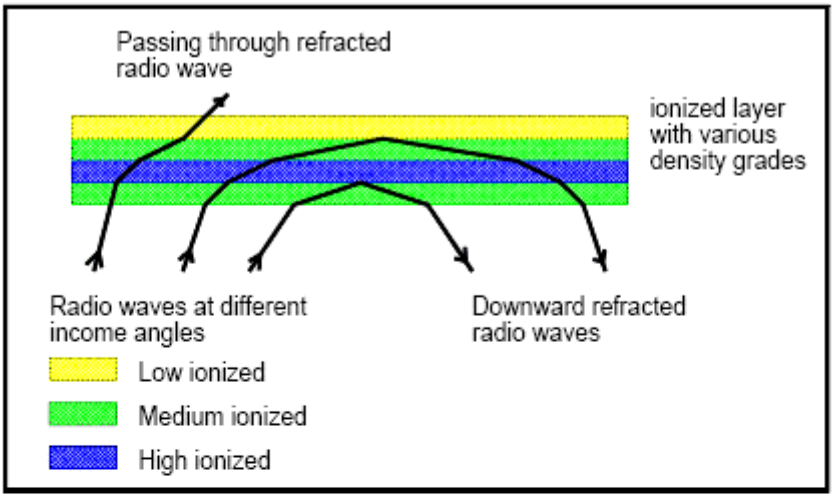


Fig 2.5. Different refraction phenomena with different sub-layer properties and different incoming angles.

The Snell law (By Dutch scientist Willebrord Snell van Royen 1591 - 1626)

Eq. 2.1

$$\text{Snell's Law} = \frac{\sin\theta i}{\sin\theta r} = n = \frac{v1}{v2}$$

Chapter 2 ~ Wave Propagation Direction Changes

The format used in the volumes allows easy reading via the standard Adobe PDF reader. The page size and print size allow the reader to keep an entire page on the screen with excellent graphic definition and minimal eyestrain. The simple illustration above gives a sample that may go a small way toward converting "paper-only" readers into CDROM readers. (Please note that the illustrative page is a reproduction of the Adobe PDF page, which is in fact sharper.) In short, the volumes are designed to let the reader progress through the text as comfortably as any book, that is, any book that also included motion pictures.

Marcel does not presume that his readers know anything more about propagation than we might have to memorize to obtain an amateur radio license. Volume 1 contains 12 chapters designed to bring us up to speed on the fundamental properties of propagating radio waves, the ionosphere, and how the two interact. His treatment, however, is quite refined and contains the most important equations used to calculate various propagation phenomena. As early as Chapter 2, he has his readers sorting out such radio-wave terms as bending, reflection, diffraction, and refraction. By Chapter 7, on the idea of the critical frequency, we can distinguish the height of virtual reflection from the height at which actual refraction occurs, and understand how--for each layer of the ionosphere--the height differs.

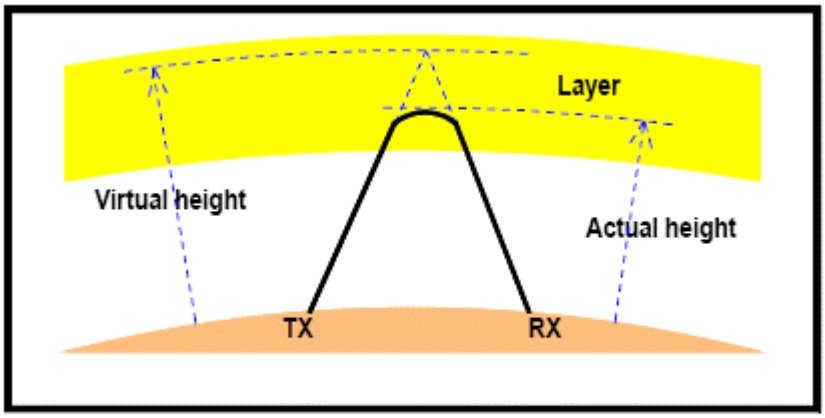


Fig 7.1 The actual height is the height where the refraction happens. The virtual height is the height the wave should have reached to span the same distance, if it had been purely reflected.

By the end of Volume 1, Marcel has given us an appreciation of the relationship between frequency of operation and the effects of the ionosphere in terms of the signal take-off angle (TOA) and the idea of critical frequency. Although my embellishments of this review make use of static graphics from the text, Marcel provides both wizards and series of graphics, gathered from his many computer resources, to provide the reader with a full sense of the dynamics of these conditions, dynamics that include the time of day, the month or season, and the numerous other variables that mark propagation,

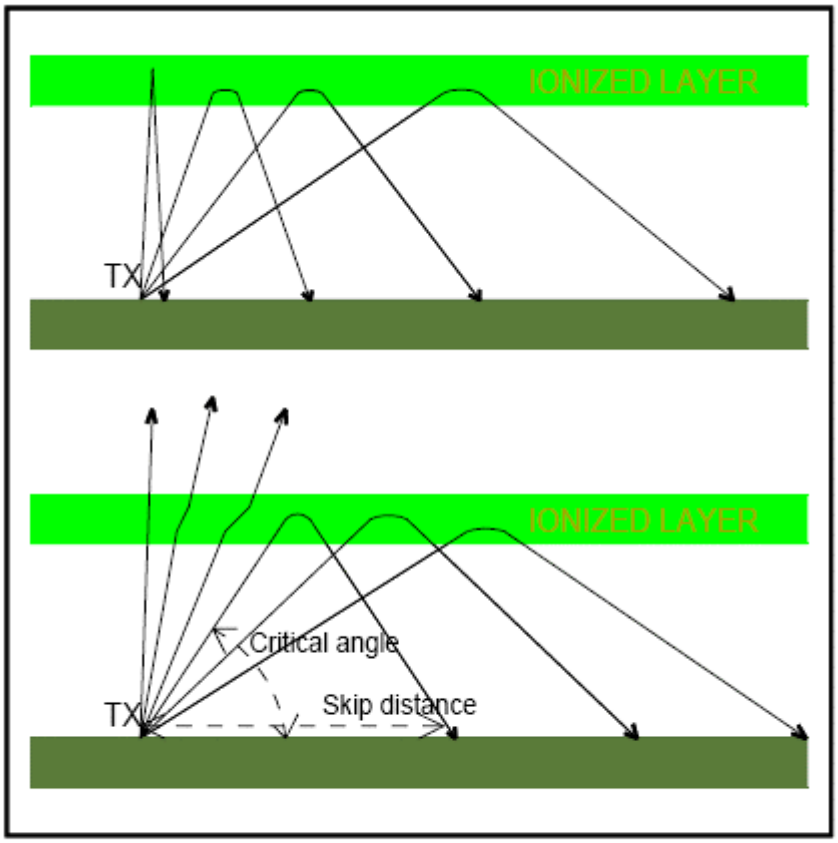
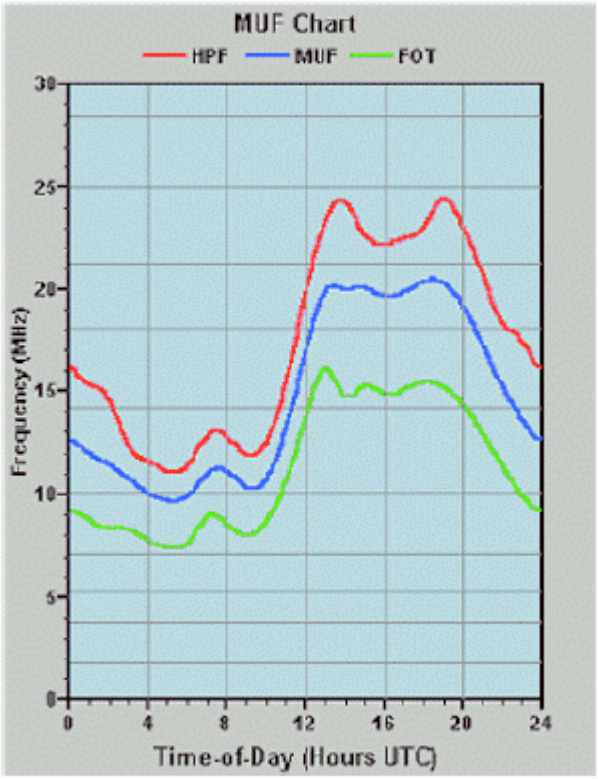
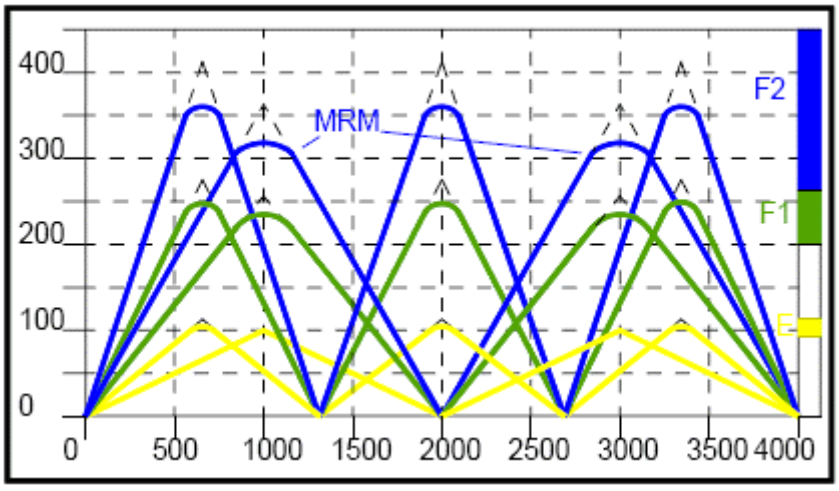


Fig. 12.1. *Simplified picture, only one layer is taken into account. The top sketch illustrates propagation with radio waves frequencies lower than the critical frequency; all the sky waves return back to the earth. The bottom sketch illustrates propagation with radio waves frequencies higher than the critical frequency.*

Volume 2 of *Radio Wave Propagation* contains 9 chapters divided into 3 parts. The first part deals in MUF, the maximum usable frequency. Most of us believe that we have a good idea of what this term means. Marcel provides the basic computations that go into what turns out to be a cluster of terms related to MUF, such as basic, operational, and standard MUF. As well, we discover the MUF 3000 (the conventionalized MUF for a 3000-kM path). Although his main tools at the computer include Proplab-Pro-2 and ITS-VOACAP, he provides samples of MUF calculations from a variety of propagation programs available to students of the phenomena (including avid Dxers and international contesters). Included in the samples of HFX, W6EL-Prop, Wincap Wizard, ACE-HF, and VOACAP itself. The sample graph below is from ACE-HF and introduces us to other common terms related to MUF. HPF is the highest possible frequency for communications, while FOT is the frequency for optimum traffic. Missing from the graphs is LUF, the lowest or minimum usable frequency. Lest we come to believe that we must allow the computational equations to lie in mystery, shrouded behind the compiled computer programming, Marcel (in Chapter 15) outlines the fundamental equations used to graph the MUF on an hourly basis. Indeed, he defines a number of calculation modes of single and multi-hop paths along with MUF calculations for the E, F1, and F2 layers.

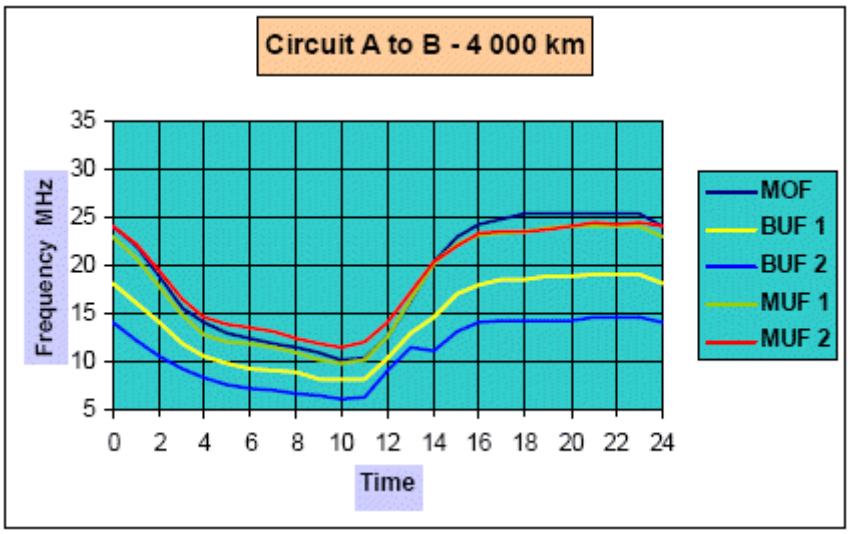


The determination of values for the MUF and related numbers requires a calculating engine (or a cadre of graduate students) to produce hourly projections along various paths. VOACAP (where the VOA part means Voice of America) has long been a standard for calculating a wide variety of propagation phenomena, both as an overall view and in detail. The program can calculate potential hops between points, with an indication of the MRM or most reliable mode.



Theoretical calculations do not form the only basis for propagation predictions. Ionosonde data provides an alternative set of inputs and results in alternative measures, such as MOF (maximum observed frequency) and BUF (best usable frequency). Marcel's advanced

propagation software allows him to produces comparisons among the alternative outputs, as the graphic sample suggests.



The final part of Volume 2 is devoted to an examination of the types of input data used in predictions, that is, the empirical information upon which propagation software makes is predictive calculations. At this juncture, Marcel notes that investigators found the best correlation to lie between monthly median ionospheric parameters and the smoothed sunspot number. He then lays out extensive comparisons of data and their results. It is at this point that I must leave the trail of concepts, since they become too intricate to capture in a brief review. However, the progression of text, graphics, and Wizards in Marcel's patient account makes good sense of them all, and provides a ready resource for future reference.

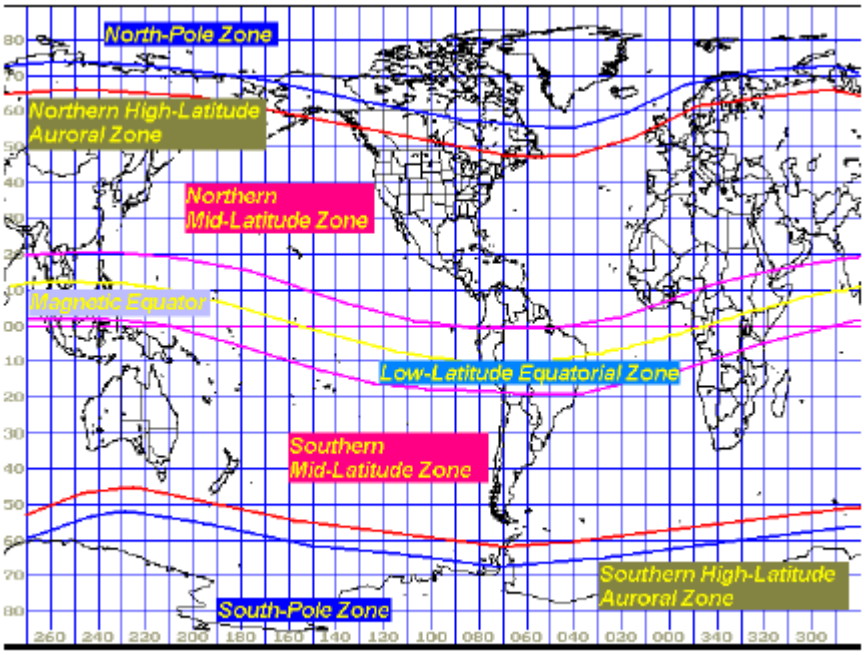
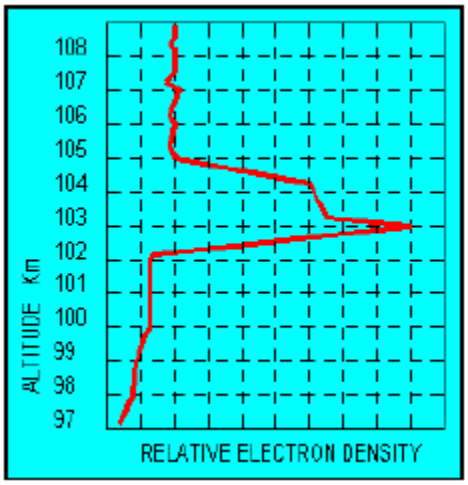


Fig. 22.1. Worldwide different Sporadic-E zones

Volume 3 is devoted to a study of one of the more mysterious aspects of radio wave propagation, sporadic E skip. Most of us accept the phenomenon as a blessing when it occurs without ever really understanding what is at stake. The 8 chapters of the 3rd volume provide a progressively more intense understanding of Es, beginning with the sample map that outlines sporadic-E zones. Sporadic E occurs because within the region of the E-layer, thin clouds of dense ionization can form. Although the norm for daily E-layer cloud critical frequencies is from 2 to about 3.5 MHz, the value can climb above 5 MHz, at which times we may experience short-range skip on 10 or 6 meters. (When I lived in Athens, GA, an AL channel-2 TV station would compete in strength with the marginal direct signal I received from Atlanta on that channel.) The record of relative electron density from a sounding rocket passing through the E-layer (100-110 km up) provides a sense of the layer's potency.



Generally, we have the greatest interest in Es contacts on 10 through 2 meters, because the effects of an E cloud and a suitably high critical frequency are so noticeable. As Marcel's map indicates, one might even make NVIS 10-meter contacts.

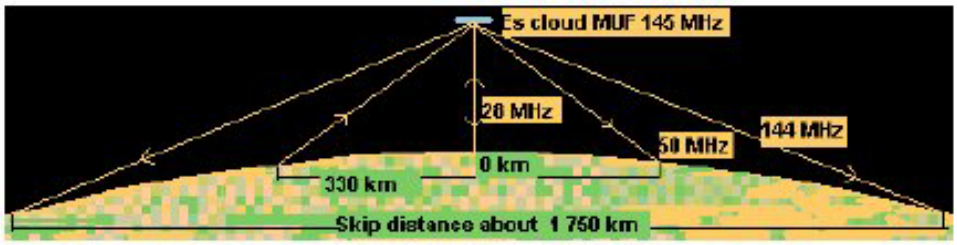


Fig. 23.1. Illustrates the minimum skip distance of the 10-, 6- and 2 meters band with an Es cloud having a MUF of 145 MHz. With such a cloud overhead or nearby, you are able to make the closest 10-meter contacts right into your neighborhood.

Marcel's treatment, however, does not stop at the basic phenomenon. He recommends the use of SEP-Win-Prop for evaluating Es potentials, and even includes a discussion of tilted Es clouds and multiple Es clouds. However, in his evaluation of empirical data, he is not afraid to admit that numerous unknowns still remain.

In the lower HF and the MF regions, we are familiar with D-layer absorption. Marcel takes up the questions surrounding the effects of the E-layer in these frequency regions, noting both their propagating and their blocking effects.

Due to the intricacies of the subject, along with the mass of interlaced terminology common to the field, I have been ably only to follow the general course of the discussions and the studies within *Radio Wave Propagation*. My sample graphics have simply illustrated the profusion of illustrations, but have not attempted to copy any of the more complex graphs and maps. Each of those requires textual context and explanation, which is available within the book, but not easily summarized in a review.

All in all, *Radio Wave Propagation* is not only a well-planned and executed journey through the fundamental and the more advanced ideas in propagation and its prediction. It is also an exciting safari into a part of antenna work that we too often neglect in the attempt to develop the hardware of antennas. The Wizards give life to the constant changes that occur in the 3-dimensional region between antennas.

If we simply ride along with Marcel on the journey, we shall all learn a great deal. However, mastering some of the software that enables us to perform our own analyses and create our own predictions can convert passive learning into active involvement. Volume 4 of the series, yet to come, will ease our software entry by providing step-by-step instructions in setting up and using propagation prediction programs.

The three volumes so far published are available on CDROM from *antenneX*. **–30-**

For more info on these books

To Biography of the Author, LB Cebik, W4RNL: Click Here

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