where

$$\bar{h}_1 = 5.74\,(f^2/a_1)^{1/3}\;h_{e1},\quad a_1 = d_{L1}^{\;2}/\,2\,h_{e1},\quad \text{and} \tag{5a}$$

$$\bar{h}_2 = 5.74\,(f^2/a_2)^{1/3}\;h_{e2},\quad a_2 = d_{L2}^{\;2}/\,2\,h_{e2}. \tag{5b}$$

When $$h_{e1,2} > 0.5\sqrt{\lambda\, d_{L1,2}}\qquad \text{let } G(\bar{h}_{1,2}) = 0; \tag{6}$$

otherwise $G(\bar{h})$ is read from figure 7.2, volume 1 of Rice et al. (1967). Mathematical functions have been fitted to these curves for use in the computer method. In equations (4) through (6) all heights and distances are in km and the frequency is in MHz. The predicted value of basic transmission loss L_{bc} is then obtained by adding the free space loss L_{bf} to the calculated attenuation A_{cd}, as shown in equations (3a) and (3b).

A cumulative distribution of the differences between observed values and those calculated using this revised prediction method show excellent agreement.

Figures 55 and 56 show that both the earlier method and the computer method agree well with observed long-term median values for both two-horizon diffraction and forward scatter paths.

4. CONCLUSIONS

Several conclusions may be drawn from these comparisons of prediction methods with a large number of spot measurements and long-term recordings.

The "area" predictions, that do not require individual path profiles, define the medians of data as a function of distance either when the antenna sites are chosen at random, or the rules for site selection are clearly defined. The scatter of measured values about their median at each distance depends on site selection and the range of terrain irregularity in the group of paths considered. For homogeneous terrain the scatter of measured values is considerably less than for groups of paths with widely varying terrain characteristics.

In the current computer model terrain irregularity is characterized by a single parameter Δh. This can not completely describe the terrain characteristics of an area as, for instance, it gives no indication as to whether the irregularity consists of a few large hills and valleys or numerous small ones. Such differences would affect the parameters $h_{e1,2}$, $d_{L1,2}$, and $\theta_{e1,2}$ that are derived from Δh in the area-prediction model. Further studies to develop a more complete model of terrain irregularity are in progress.

In areas with a large proportion of line-of-sight and one-horizon paths we tend to predict too much transmission loss, particularly with the higher antenna heights. For example, figures 1 to 4 and 6 to 9 show that for the R-1 and R-2 data the area predictions calculate somewhat more than the median measured loss. Table 1 shows that 25 of the 48 R-1 paths and 15 of the 43 R-2 paths are line-of-sight or single-horizon paths. Figures 33 to 36 show that the point-to-point method also predicts somewhat too much loss for these paths, especially with the higher receiver heights. Similar results are shown for the mountainous area in Washington, where 16 of the 53 paths are line-of-sight and single-horizon paths. Figures 21 and 22 for the area predictions and 46 and 47 for the point-to-point predictions show that we overestimate the transmission loss, especially for the 3 m antennas. These results indicate that the prediction models for line-of-sight and one-horizon diffraction paths tend to overestimate the attenuation caused by reflections from terrain. Tests of the point-to-point predictions against long-term medians of data over established communication links confirm this. Figures 54 and 55 show that the computer model, Longley and Rice (1968), overestimates the transmission losses for some

30 percent of the line-of-sight and all of the one-horizon paths. The point-to-point prediction models were revised to provide much better agreement with these measured values as shown. Figures 56 and 57 show excellent agreement between measured and predicted values for transhorizon diffraction and scatter paths.

In each group of measurements some deviation of predicted from observed values for individual paths occurs. For the single spot measurements this deviation may result in part from differences in diurnal and seasonal propagation conditions and in part from path-to-path differences. Variability in time may be appreciable, especially over the longer paths, but location or path-to-path variability is probably greater. The prediction method calculates a reference value that represents the long-term median transmission loss. Figures 54 to 57 compare calculated values with the long-term median of measurements for each path. In these groups the distributions of ΔL show path-to-path or location variability. The figures show this location variability to be normally distributed with a standard deviation σ_{La} of 8 to 10 dB.

The results of comparisons with the Virginia data (figs. 11 to 14) indicate that we tend to overestimate transmission loss at the lowest frequency and underestimate it at the two highest frequencies. In this area the terrain is partly covered by deciduous trees that would cause considerably more attenuation at the higher than at the lower frequencies. The effects of vegetation and man-made structures should be further investigated.

The computer model used to calculate median basic transmission loss as a function of distance was originally developed and tested against the measurements at VHF made in Colorado and Ohio. The present comparisons show that for all frequencies, distances, antenna heights, and terrain types tested these area predictions describe the medians of data, with the exception of areas with an unusually large proportion of line-of-sight and single-horizon paths, as previously noted. In areas where most of the measurements are over transhorizon paths the present model gives excellent results.

The point-to-point predictions, based on individual path profiles, agree well with data except for line-of-sight and single-horizon paths. Modifications of the computer method have been developed that agree well with the median values recorded over established paths. These modifications will be incorporated into the computer model and tested against measurements in the various areas.

These comparisons of predicted values of transmission loss, using the computer methods of Longley and Rice, with a large amount of data from measurement programs, show excellent agreement for transhorizon paths throughout the frequency range from 20 to 10, 000 MHz for all tested antenna heights from less than 1 m to 2700 m and for terrain types ranging from very smooth plains to extremely rugged mountains. For known line-of-sight and single-horizon paths the predicted attenuation is greater than that observed. Modifications of the prediction model are described that provide excellent agreement with measurements for such paths.