ECE 6390

Homework 4

Frederick Ealick

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In addition to the parameters used in the simplified ITU rain attenuation model , the full model also considers the transmission frequency and the earth station latitude. Both models use the same formula to calculate the specific attenuation (γ_R) and the predicted attenuation exceeded for 0.01% of an average year ($A_{0.01}$). The models differ in the calculations for the effective path length (L_E), which is an element in the attenuation calculation.

The code found in Appendix A uses the parameters defined in Example 8.5.2 because the results can be checked with the answers given in the book. This also means that the code only considers vertical polarization and rain attenuation for 0.01% of the average year. The difference between vertical and horizontal polarization is different values for α and k. The simplified model in class is for rain attenuation for 0.01%. While the code could be expanded to include different probabilities, the extra results could not be used to compare the full model against the simplified model.

Unlike the full model, frequency is not an input to the simplified model. However, the simplified model does use α_v and k_v, which are determined by the frequency. Figure 1 shows the calculated attenuation from both models graphed versus frequency. For both models, α_v and k_v are changed with the frequency. For frequencies greater than 10GHz, the simplified model's attenuation is greater than the full model's attenuation by approximately 10dB.

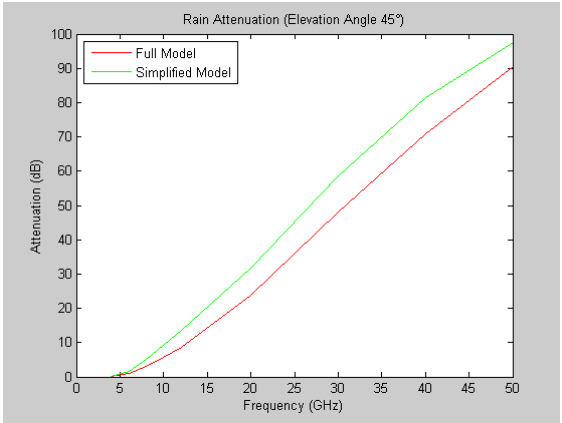

Figure 1. Changing frequency with θ=45°.

While the code uses the values given in the book's example for all of the parameters except the changing variable, the behavior of the models relative to one another is interesting for different

elevation angles. Figures 2-6 show, for low values of θ, the simplified model is much greater than the full model, but as the elevation angle increases, the difference between the outputs decreases and the full model becomes greater than the simplified model.

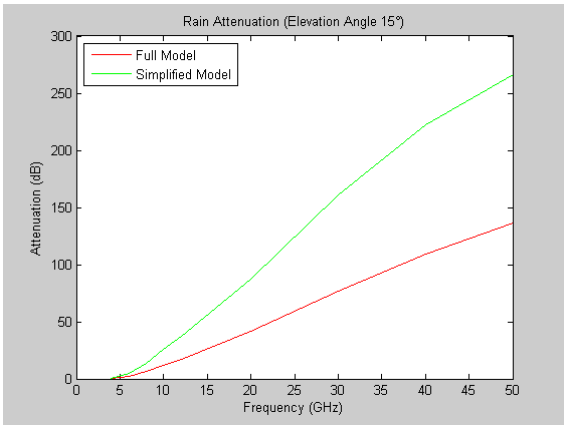

Figure 2. Changing frequency with θ=15°.

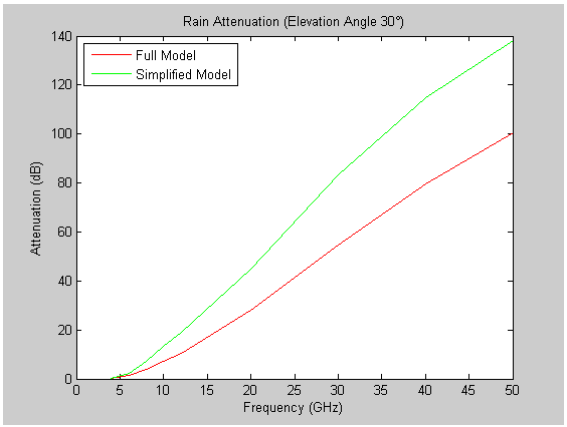

Figure 3. Changing frequency with θ=30°.

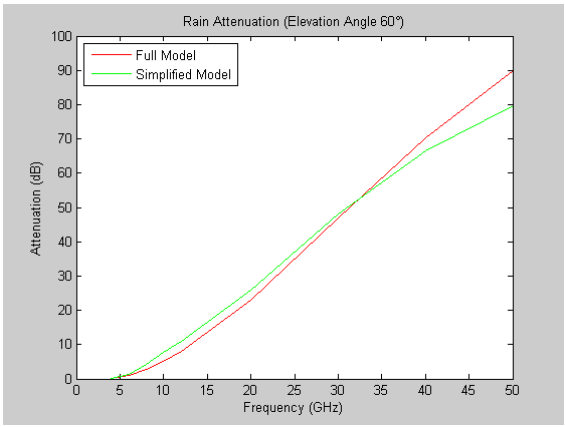

Figure 4. Changing frequency with θ=60°.

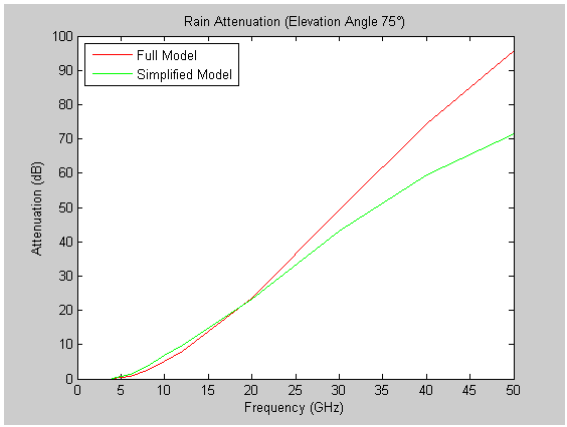

Figure 5. Changing frequency with θ=75°.

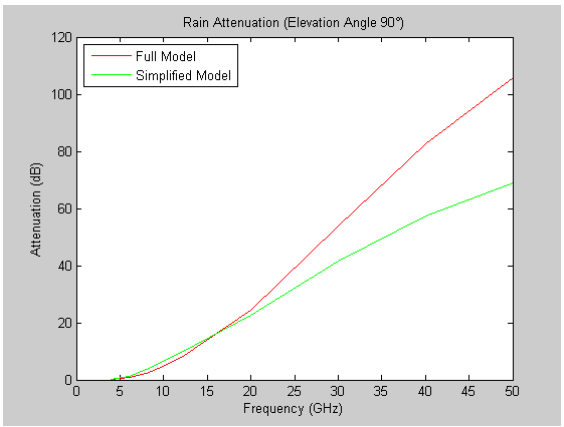

Figure 6. Changing frequency with θ=90°.

The intersection of the simplified and full models occurs at decreasing frequencies as the elevation angle increases. It is also interesting to note that before these intersection frequencies both models behave similarly, but after the intersection, the full model behaves

linearly while the simplified model has a decreasing slope. This varying relational behavior associated with changes in elevation angle is probably due to the fact that the full model includes corrections for the manner in which rain interferes with a transmission at different angles.

The other parameter that exists in the full model but not in the simplified model is the latitude of the site. Figure 7 shows the relationship between attenuation and latitude. Unlike the previous graphs, the discrepancy between the models is constant after 30° latitude. The discrepancy's magnitude is also only approximately 2.5dB, much lower than the double digit differences with varying frequencies and elevation angles. This behavior suggests that the full model's addition of the latitude parameter is not as significant as the frequency parameter.

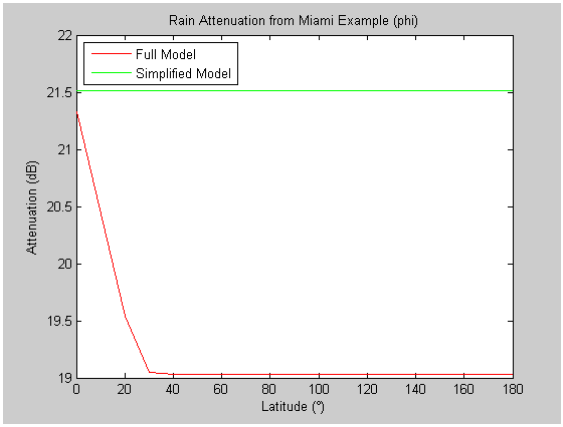

Figure 7. Changing latitude.

The earlier graphs were changing frequency, but also elevation angles. It is important to observe the models' while only changing the elevation angle. Figure 8 shows that the disagreement decreases with increasing elevation angle.

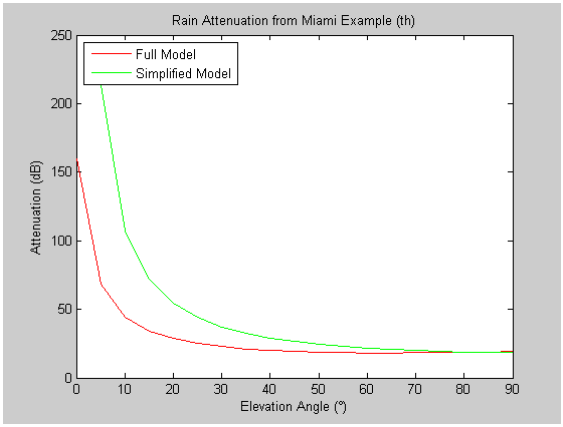

Figure 8. Changing elevation angle.

Unlike the previous parameters, the elevation angle is common to both models. The rain storm height and the rain intensity modify both models. Figures 9-10 show the relationship they have with the rain attenuation.

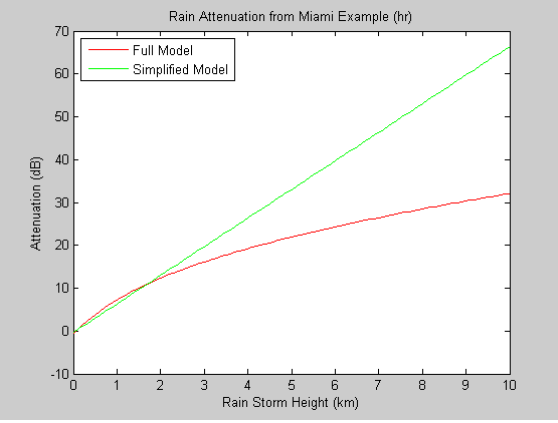

Figure 9. Changing rain storm height.

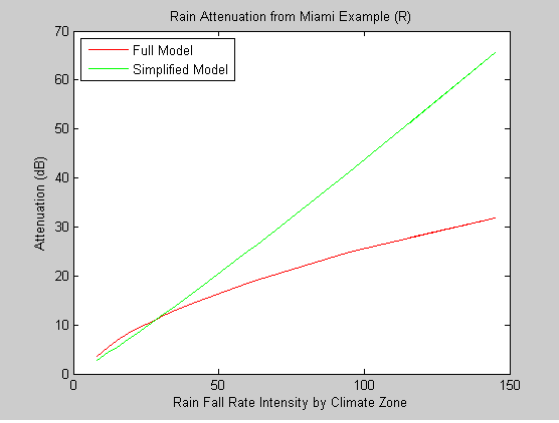

Figure 10. Changing rain fall rate intensity.

For both cases, the simplified model is only accurate at the lowest inputs. After approximately 2km, the simplified model increases linearly while the full model increases with a decreasing slope. Similar behavior occurs after a rain fall rate intensity of approximately 25. As a result, there is a double digit decibel discrepancy at the higher input values.

After studying the effects that the different parameters to the different models, the simplified model most accurately approximates the full model at low frequencies, high elevation angles, low latitudes, low rain storm heights, and low rain fall rate intensities. For example, using the parameters defined in Appendix B that follow the previous guidelines, the full model yields an attenuation of 0.0450dB and the simplified model yields an attenuation 0.0424dB. Frequency appears to have the most influence on the discrepancies of all the above parameters.