

# Comparison of Channel Models for Devices with Low-Height Antennas

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# Abstract

- **We provide a comparison between channel models for links determined by devices with low height antennas, i.e., H-CPE  $\leftrightarrow$  L-CPE.**
- **The comparison intends to indicate the most appropriate channel model in order to calculate such link budgets for IEEE 802.22b.**
- **Extended-Hata model [4] and the low-height antennas model in [1], [2], were compared with radio propagation measurements of low positioned devices [5], [6].**

# Motivation

- **Hata [3] and Extended-Hata [4] models were derived specifically for propagation of highly positioned antennas. In the IEEE 802.22b context, extended Hata models can be useful for link budget analysis of**
  - **BS  $\leftrightarrow$  H-CPE, BS  $\leftrightarrow$  L-CPE,**
  - **H-CPE  $\leftrightarrow$  H-CPE, provided that at least one H-CPE  $\geq 30\text{m}$**
- **Often, both H-CPE and L-CPE will be placed below 30 meters, thus rendering extended-Hata models useless in many circumstances.**

# Measurements

- **Measurements in [5], [6] present signal levels within suburban houses measured in the 800MHz band. The measurements were made with dipole antennas; the receiver positioned at 9.1 meters while the transmitter positioned at 1.8 meters above ground.**
- **The height dependence in the data is found to be consistent with the simple model of reflection from the ground.**
- **Interestingly, these experiments have demonstrated that low-height antennas links have very low frequency dependence.**

# Propagation Models being Compared

## ITU-R P529-3 Extended Hata Model [4]

Correction factor for city size: medium to small

Area type: suburban

$$b = 1;$$

$$a = (1.1 \cdot \log_{10}(f_c) - 0.7) \cdot H_r - (1.56 \cdot \log_{10}(f_c) - 0.8);$$

$$L_p = 69.55 + 26.16 \cdot \log_{10}(f_c) - 13.82 \cdot \log_{10}(H_t) - a + (44.9 - 6.66 \cdot \log_{10}(H_t)) \cdot (\log_{10}(d))^b - 2 \cdot (\log_{10}(f_c/28))^2 - 5.4;$$

$$Pr = 10 \log(P_t) + 10 \log(G_t) + 10 \log(G_r) - L_p - B;$$

Obs: ' $P_t$ ' in Watts, ' $d$ ' in kilometers, ' $H_t$ ' in meters, ' $H_r$ ' in meters, ' $f_c$ ' in MHz,  $Pr$  in dB; ' $B$ ' = 5.4 dB, ' $G_t$ ' = ' $G_r$ ' = 1.65;

## Low-Height Antennas Model [1], [2]

Area type: suburban

$$Pr = 10 \log(P_t) + 10 \log(G_t) + 10 \log(G_r) + 20 \log(H_t) + 20 \log(H_r) - 43.36 \log(d) - A - B;$$

Obs: ' $P_t$ ' in Watts, ' $d$ ' in meters, ' $H_t$ ' in meters, ' $H_r$ ' in meters,  $L_p$  in dB; ' $B$ ' = 5.4 dB, ' $A$ ' = 19.26 dB, ' $G_t$ ' = ' $G_r$ ' = 1.65;

# Considerations – part 1

## For Measurements in [5]

Suburban area of small city;

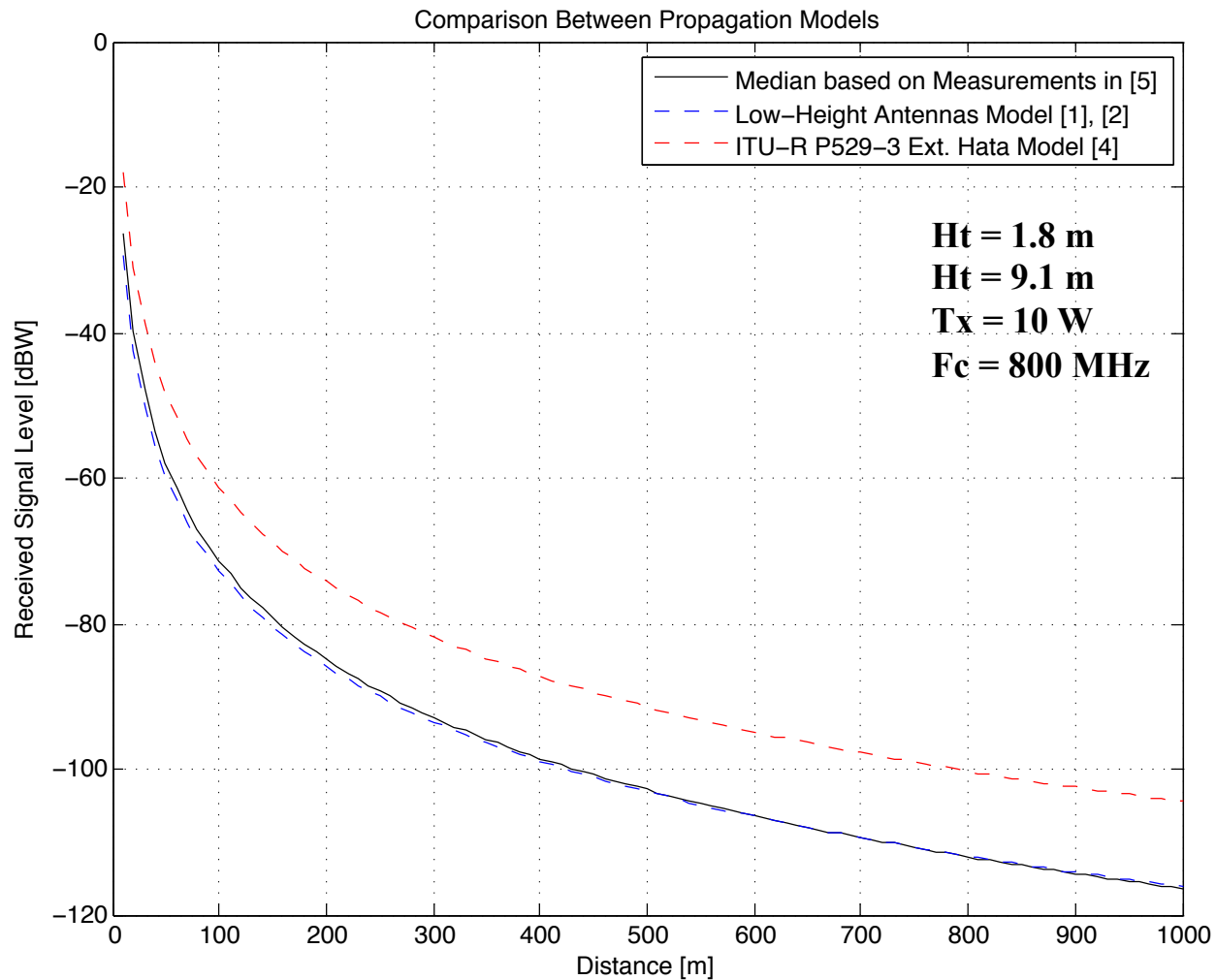
Tx @ 1.8 m (located indoors) is half-wave dipole

Rx @ 9.1 m (located outdoors) is half-wave dipole

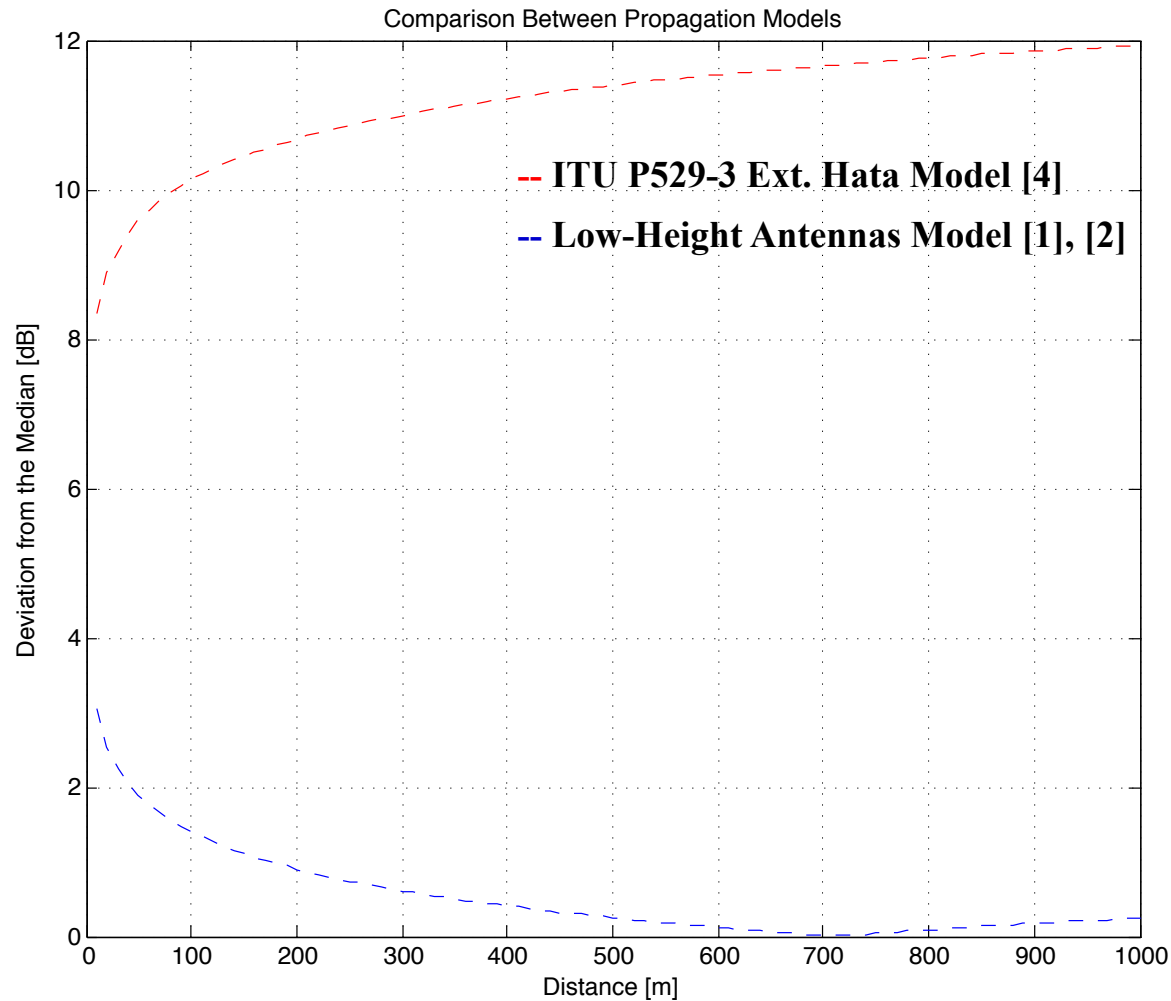
Fc = 800 MHz band

- **Low-Height Antennas Model [1], [2]**
  - Area Type: Suburban
  - Transmitter indoors
  - Receiver Outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
- **ITU-R P529-3 Extended Hata Model [4]**
  - Area Type: Suburban
  - Correction factor for city size: Medium to Small
  - Transmitter indoors
  - Receiver outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
  - Frequency is 800 MHz;

# Model vs. Measurement – part 1



# Model vs. Measurement – part 1





# Considerations – part 2

## For Measurements in [6]

Suburban area of small city;

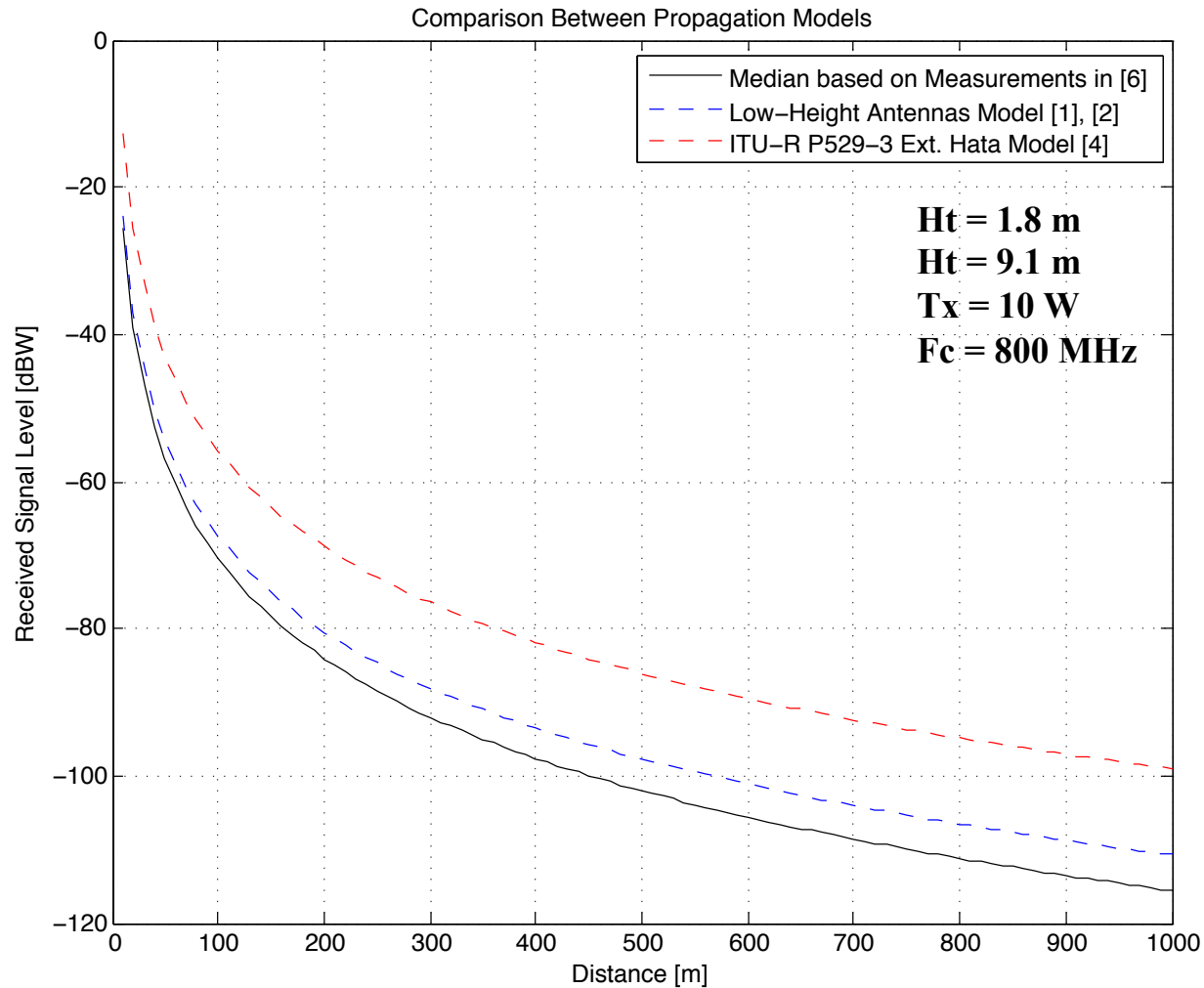
Tx @ 1.8 m (outdoors) is half-wave dipole

Rx @ 9.1 m (outdoors) is half-wave dipole

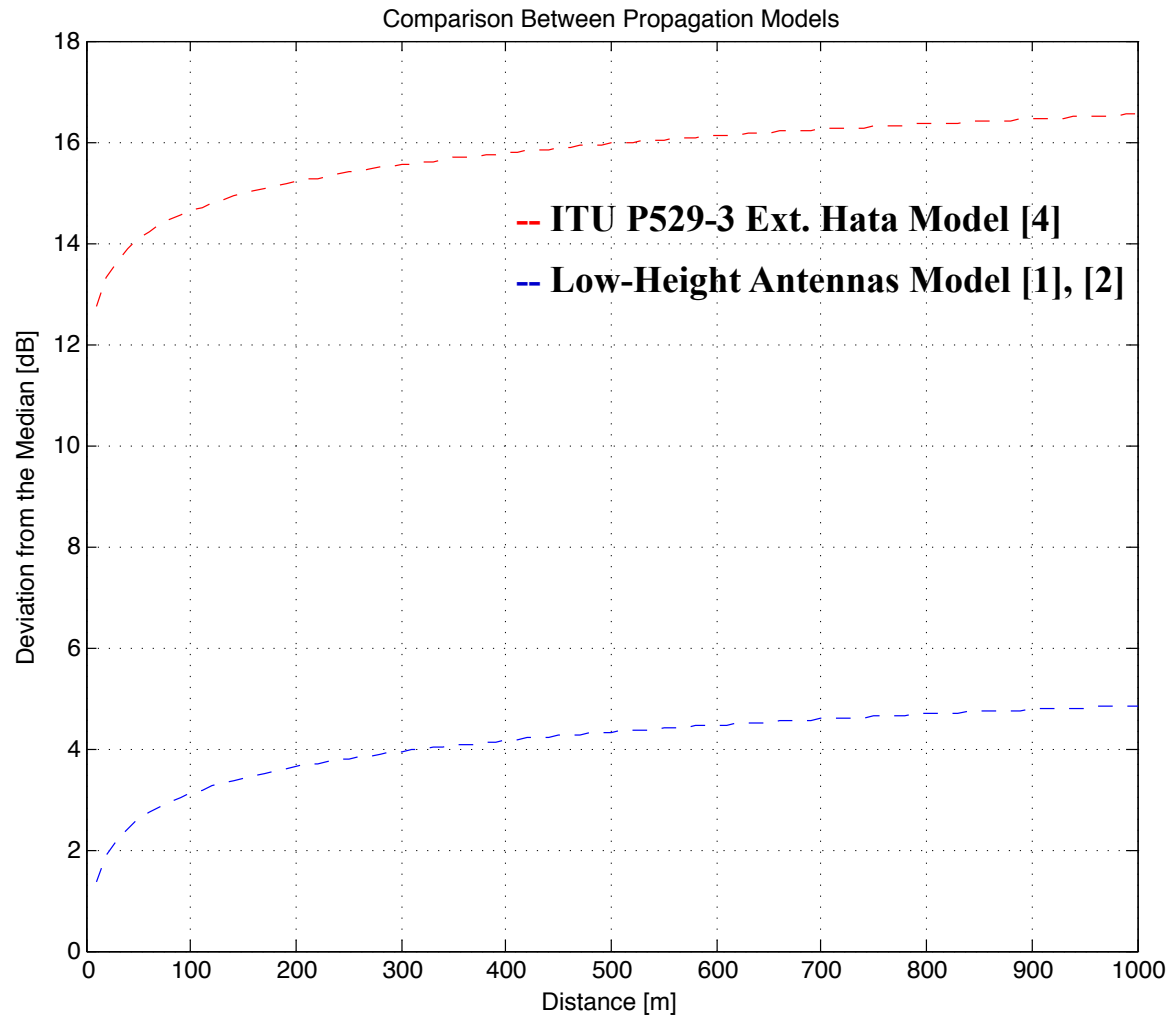
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- **Low-Height Antennas Model [1], [2]**
  - Area Type: Suburban
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  - Receiver Outdoors
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  - Area Type: Suburban
  - Correction factor for city size: Medium to Small
  - Transmitter outdoors
  - Receiver outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
  - Frequency is 800 MHz;

# Model vs. Measurement – part 2



# Model vs. Measurement – part 2



# Conclusions

- Using models developed for broadcasting services, *i.e.*, Hata [3] and Extended-Hata models [4], can provide very conservative link range estimations for applications in which antennas heights are low. This is due to the fact that the predicted path-loss is smaller than the ones obtained through measurements of low positioned devices [5], [6].
- On the other hand, the model derived for low height antennas [1], [2], has provided path-loss estimation remarkably close the the ones obtained from measurements [5], [6]. It can, therefore, be expected that ranges of links such as H-CPE $\leftrightarrow$ L-CPE will be shorter than previously predicted by the references [7], [8].

# References

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