Location variability and rain attenuation in Satellite Communication

Presented by

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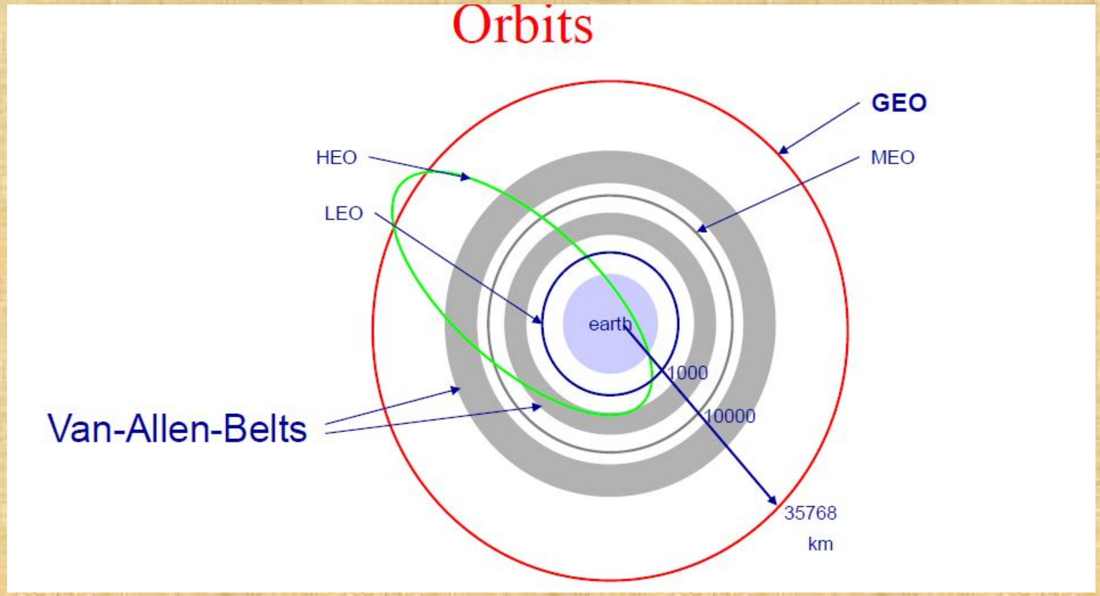
Objectives:

- Presenting a monthly prediction model for Rain attenuation using 4 years data collected from 7 earth stations in Norway.
- Modeling scintillation .
- Comparing the results with ITU-R recommendations .

Why SatComs? What is so special about them?

- Satcoms provide high reliability communication over very long distances (hundreds of kilometers).

- SatComs applications include:
  - Telecom.
  - Radio and TV Broadcasting.
  - Backbone for other networks.
  - Supervisory control and data acquisition (SCADA).
  - Earth observation .
  - Navigation (GPS , Galileo).



Source: Gerard Maral, Michel Bousquet-Satellite Communications Systems_ Systems, Techniques and Technology (2010)

- Let’s take a Geostationary Sat as an example:
  - Located 36000 km , orbiting the earth with the same angular speed as earth rotation.
  - They appear in the same position in the sky all the time.
  - Three of GeoSats can cover the whole earth.

Radio propagation effects:

- Ionospheric:
  - Interactions between the earth magnetic field and the radio waves.
  - Interactions between the layers of charged particles around the earth.
- Tropospheric :
  - Interactions between the waves and the lower atmospheric layer.
  - The effect of gases composing the air and hydrometeors such as RAIN.

Rain attenuation

Source: antennas and propagation for wireless communication systems 2nd ed

$$L_{total} = L_{Ab} + L_{Sc}$$

Where

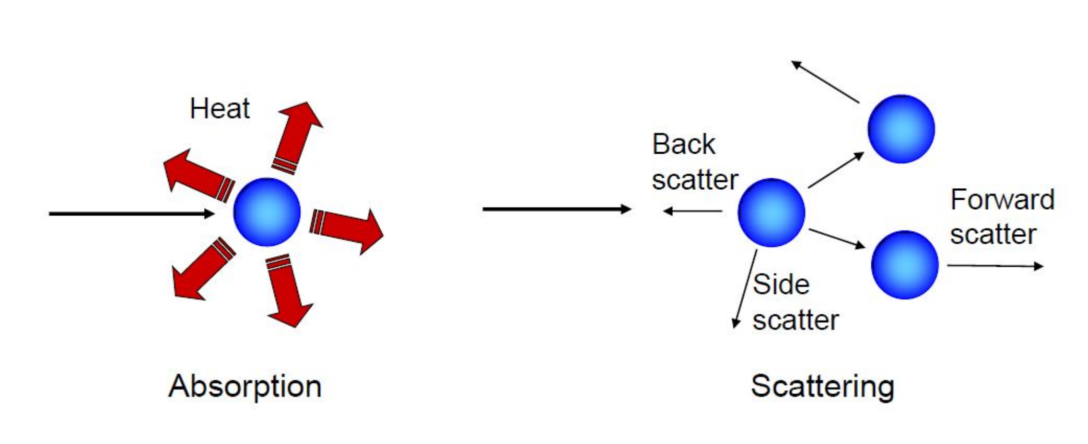
L_{Ab} is Absorption attenuation

L_{SC} is Scattering attenuation

$$\gamma = aR^b$$

Where

γ is the rain attenuation, R is the Rain rate [mm/h] , a and b are constants depending on frequency and polarization.

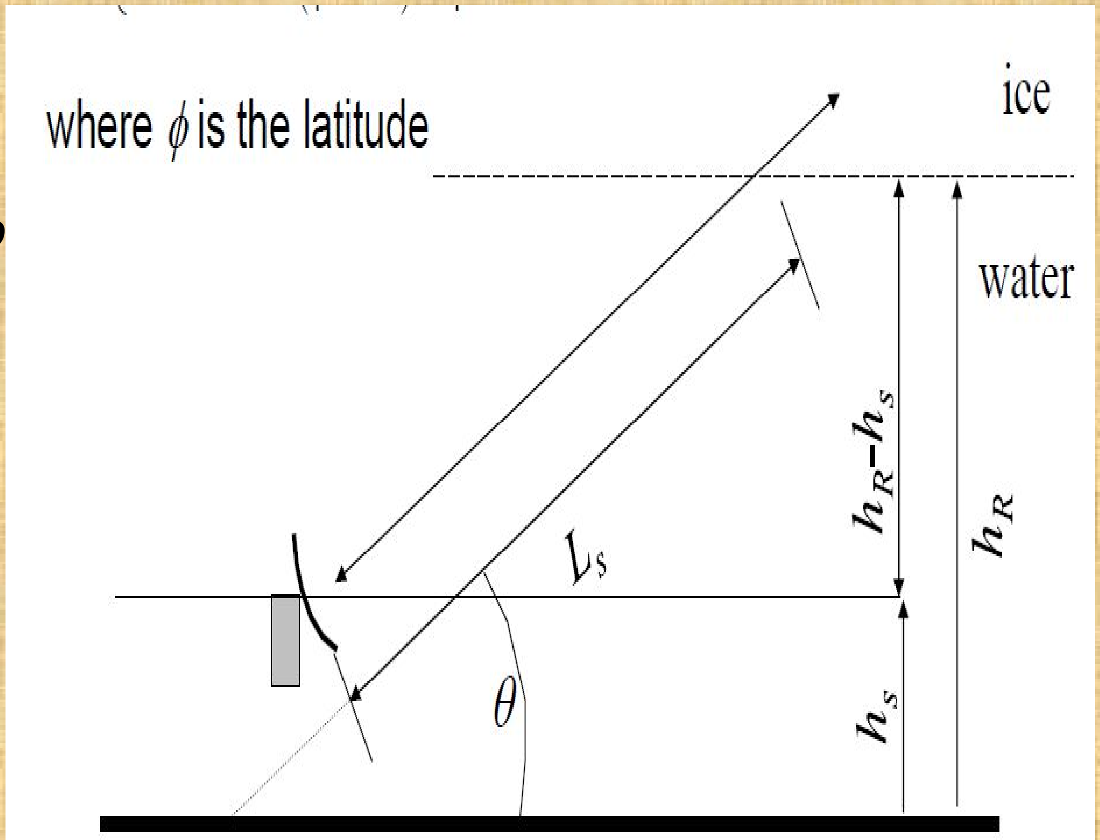


Parameters:

- Rainfall [mm/h]
- Hail [Hits/cm^2]
- Air temperature[℃]
- Air relative humidity[%]
- Atmospheric total pressure[hPa]
- Wind speed[m/s]
- Wind direction[∘]
- Signal plus noise power within the noise bandwidth[W]
- Noise floor [W/Hz]

Methodology:

- Calculating the effective rain height
- $h_R = \begin{cases} 3.0 + 0.028\phi & 0 \leq \phi < 36^o \\ 4.0 - 0.075(\phi - 36) & \phi \geq 36^o \end{cases}$
- Calculating the length throw the rain
- $L_s = \begin{cases} \frac{(h_R - h_s)}{\sin\theta} & \theta \geq 5^o \\ \frac{2(h_R - h_s)}{\sin\theta^{\,2}\,\frac{2(h_R - h_s)}{R_e}} & \theta < 5^o \end{cases}$



antennas and propagation for wireless communication systems 2nd ed

- Calculating the horizontal path

$$L_G = L_s \cos\theta$$

- Rain rate not exceeded (mm/h) at 0.01% of a year.
- Horizontal path reduction factor

$$d_{eff} = rL_G$$

- Calculating the worst month
- and finally calculating the attenuation for each month and comparing the results with ITU-R recommendations .

References:

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- [8] T. Tjelta and J. Mamen, "Climate trends and variability of rain rate derived from long-term measurements in Norway," Radio Science, Vol 49, No 9, 2014, pp. 788-797.
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