Predicting Fading on Microwave Links caused by Rain and Wet Snow.

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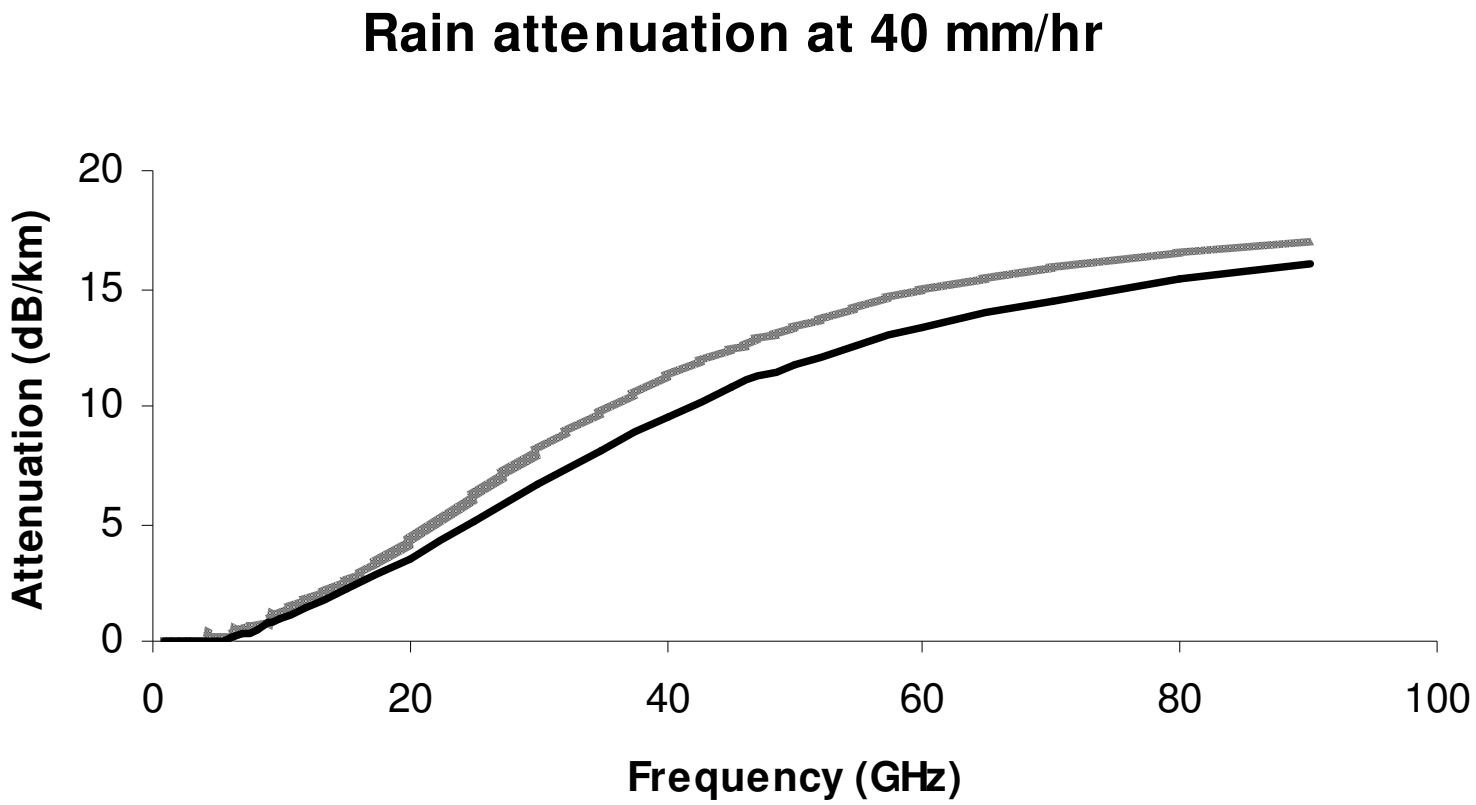
Rain Fading

- Rain fading is the most significant factor limiting achievable link length:
  - If high availability (>99.99%) is required
  - At “high” microwave frequencies (> about 13 GHz)
  - In temperate or monsoon climates (0.01% rain rate > 20 mm/hr)

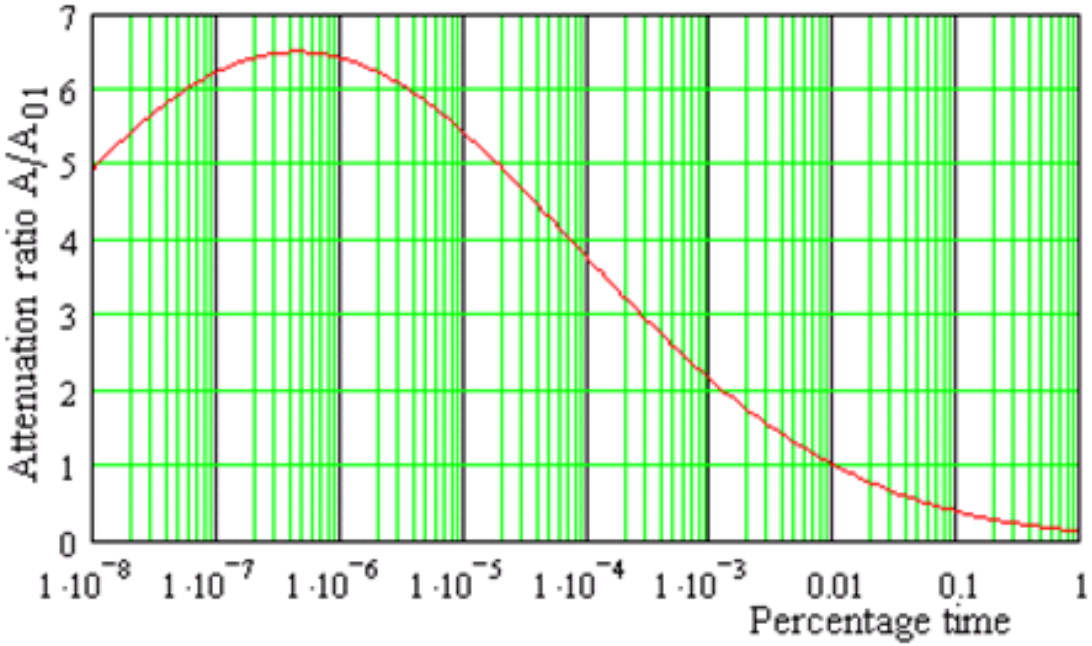
Fading due to wet snow (sleet)

- Incidences of large fades in Scotland suggest that predicting signal fade depth based on rain alone is insufficient to deliver acceptable performance
  - Greater fading when precipitation falls as wet snow may be responsible for this

Rain Fading

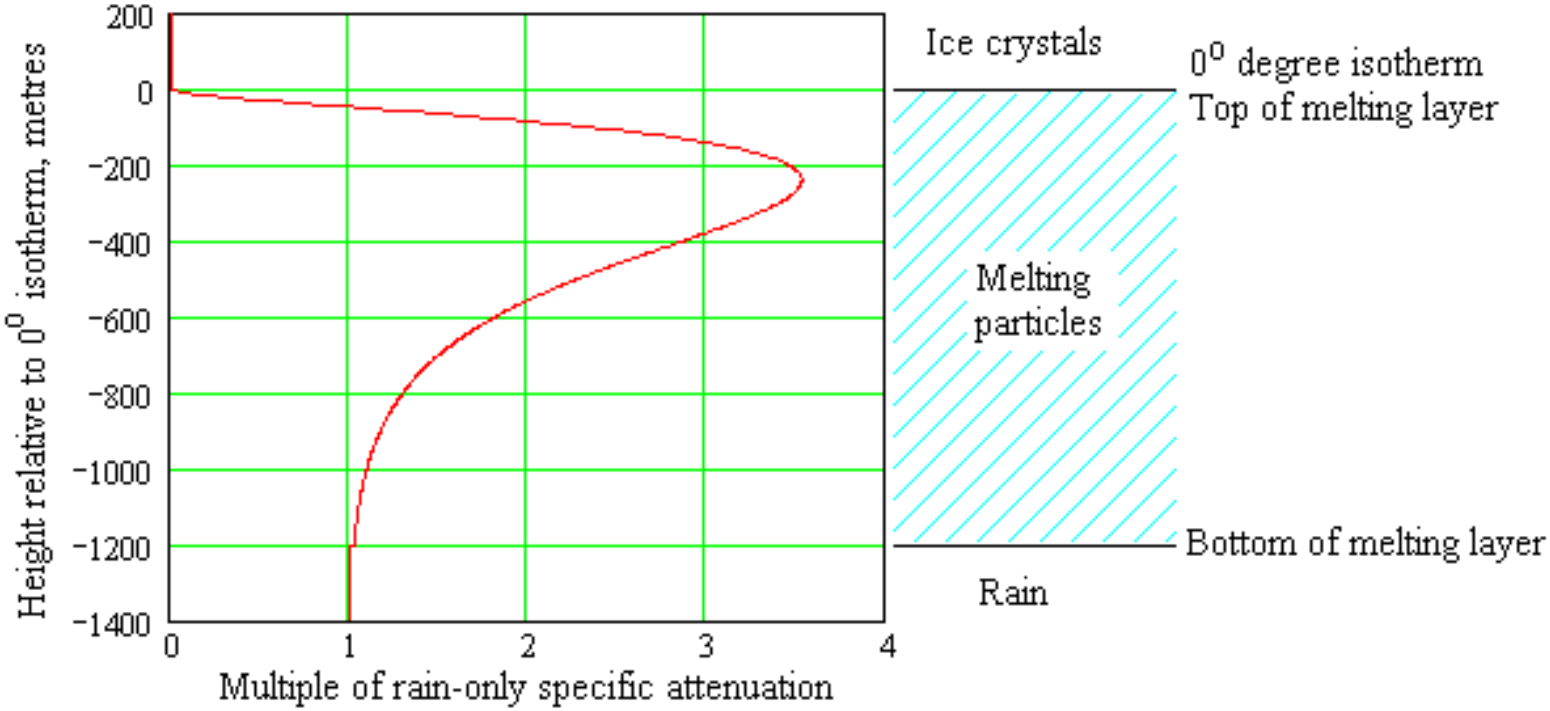

Rain attenuation at 40 mm/hr
Attenuation (dB/km)
20
15
10
5
0
0
20
40
60
80
100
Frequency (GHz)

Attenuation and Time Percentage

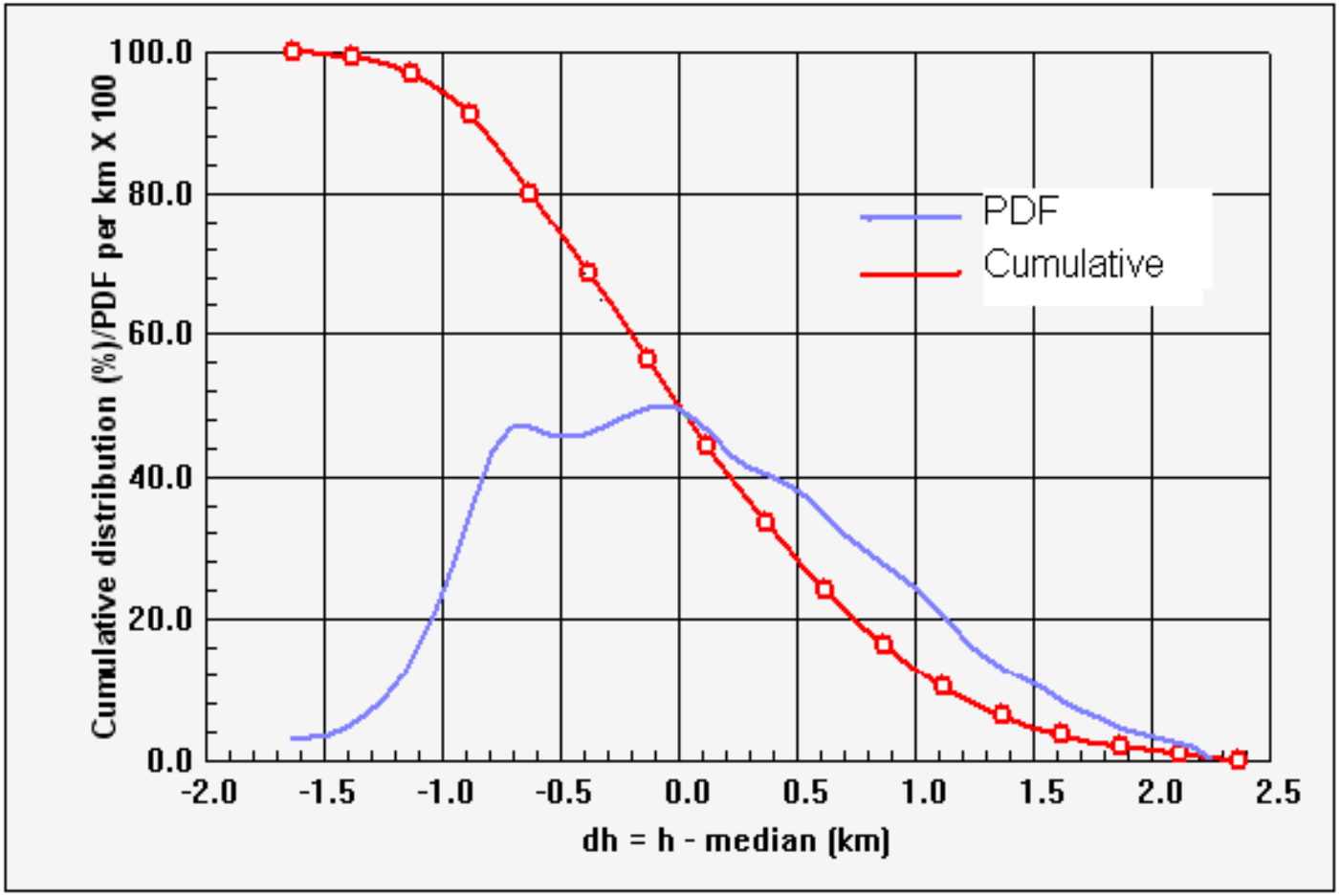


Time-dependency of rain attenuation ratio given in P.530

The Sleet Problem



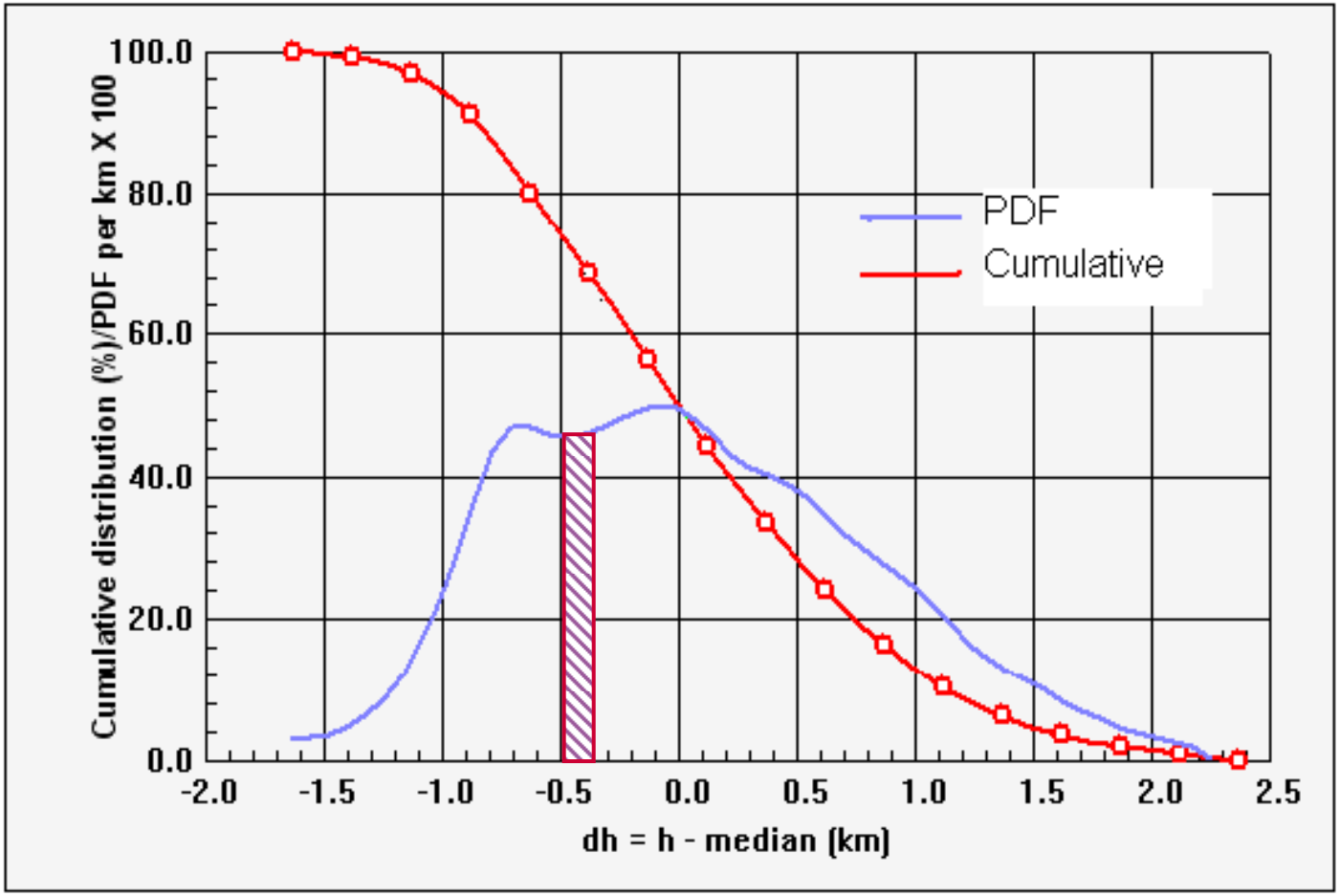
The Zero Degree Isotherm – height variation



The process of predicting fading due to rain and/or wet snow.

- Determine 0.01% rain rate and height of zero degree isotherm for location of link
- Determine the rain only fade margin required
- “Guess” a fade margin and imagine that to be implemented
- Then:
  - Divide the p.d.f of isotherm height into bins

The Zero Degree Isotherm – height variation



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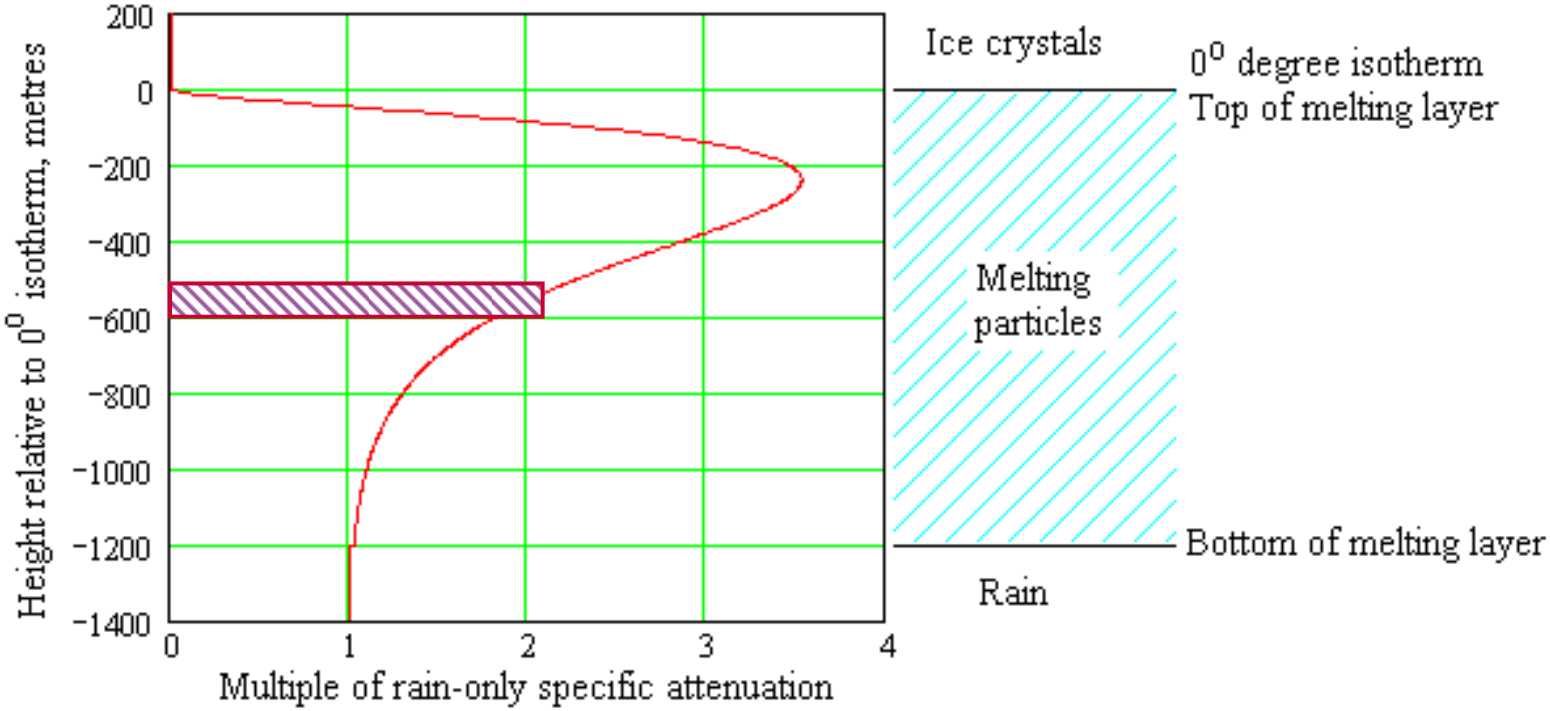

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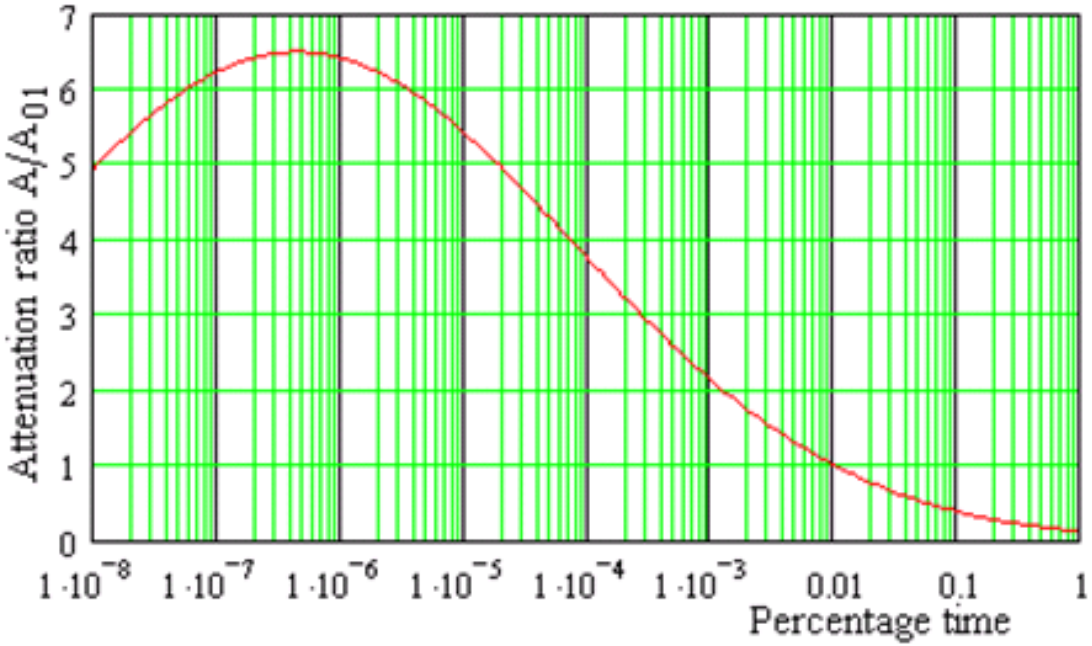
- Then:
  - Divide the p.d.f of isotherm height into bins
  - Determine position of bin height relative to 0 degree isotherm
  - Determine “rain only” attenuation needed to produce an outage
  - Determine probability of this attenuation exceeded

Attenuation and Time Percentage



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- Determine the rain only fade margin required
- “Guess” a fade margin and imagine that to be implemented
- Then:
  - Divide the p.d.f of isotherm height into bins
  - Determine position of bin height relative to 0 degree isotherm
  - Determine precipitation rate needed to produce an outage
  - Determine probability of this rate being exceeded
  - Multiply this probability by probability of bin being at that height
  - Aggregate over the p.d.f. of isotherm height

The process of predicting fading due to rain and/or wet snow.

- Output is a predicted outage for a “guessed at” fade margin
- Trial and improvement results in the required fade margin to deliver a required performance
- Note that the “sleet correction” is a multiplier of the original “rain only” fade margin

One problem: output is extremely sensitive to accurately knowing height of zero degree isotherm at times of intense precipitation

Height of the zero-degree isotherm

RECOMMENDATION ITU-R P.839-2

RAIN HEIGHT MODEL FOR PREDICTION METHODS

(Question ITU-R 201/3)

(1992-1997-1999)

The ITU Radiocommunication Assembly,

considering

a) that information is required regarding the height to which rain extends during periods of precipitation,

recommends

1 that for areas of the world where no specific information is available, the mean rain height, h_R, may be approximated by h_0, the mean 0° C isotherm height:

$$h_0 = \begin{cases} 5 - 0.075\,(\varphi - 23) & \text{for } \varphi > 23 \text{ Northern Hemisphere} \\ 5 & \text{for } 0 \le \varphi \le 23 \text{ Northern Hemisphere} \\ 5 & \text{for } 0 \ge \varphi \ge -21 \text{ Southern Hemisphere} \\ 5 + 0.1\,(\varphi + 21) & \text{for } -71 \le \varphi < -21 \text{ Southern Hemisphere} \\ 0 & \text{for } \varphi < -71 \text{ Southern Hemisphere} \end{cases}$$

where h_0 is in km above mean sea level and φ is the latitude in degrees;

2 that for North America and for Europe west of 60° E longitude, the following model for the mean 0° C isotherm height during rainy conditions may be used as an estimate of the mean rain height:

$$h_R = 3.2 - 0.075\,(\varphi - 35) \quad \text{for} \quad 35 \le \varphi \le 70$$

where h_R is in km above ground.

P.839-2

RECOMMENDATION ITU-R P.839-3

Rain height model for prediction methods

(Question ITU-R 201/3)

(1992-1997-1999-2001)

The ITU Radiocommunication Assembly,

considering

a) that information is required regarding the height to which rain extends during periods of precipitation,

recommends

1 that for areas of the world where no specific information is available, the mean 0° C isotherm height above mean sea level, h_0, be obtained from the data file ESA0HEIGHT.TXT (the data file may be obtained from the ITU Radiocommunication Bureau (BR));

2 that the mean rain height above mean sea level, h_R, may be obtained from the 0° C isotherm as:

$$h_R = h_0 + 0.36 \text{ km}$$

3 that for easy reference, values can be taken from Fig 1.

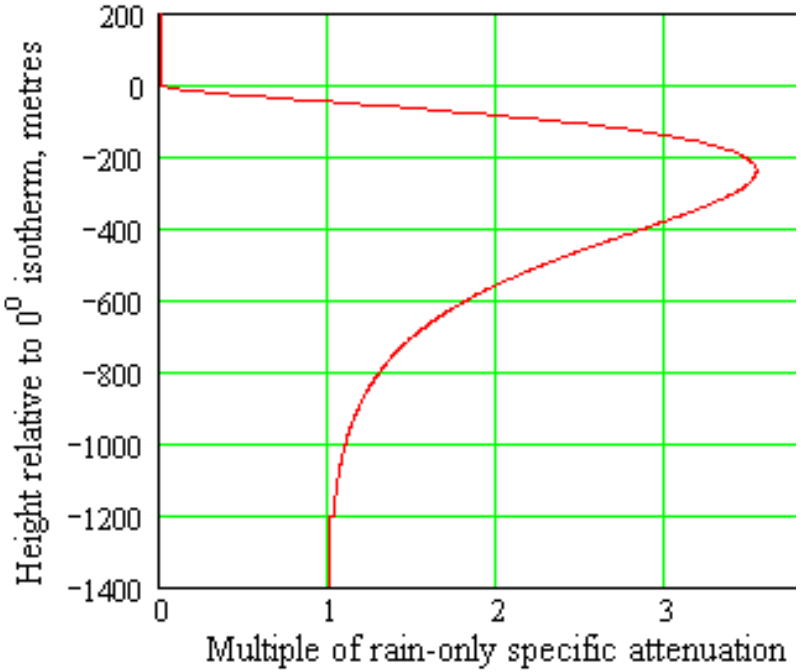
NOTE 1 – The data file ESA0HEIGHT.TXT contains the 0° C isotherm height above mean sea level (km) with a resolution of 1.5° in both latitude and longitude. The companion data files ESALAT.TXT and ESALON.TXT contain respectively the latitudes and longitudes of the corresponding entries (gridpoints) in data file ESA0HEIGHT.TXT.

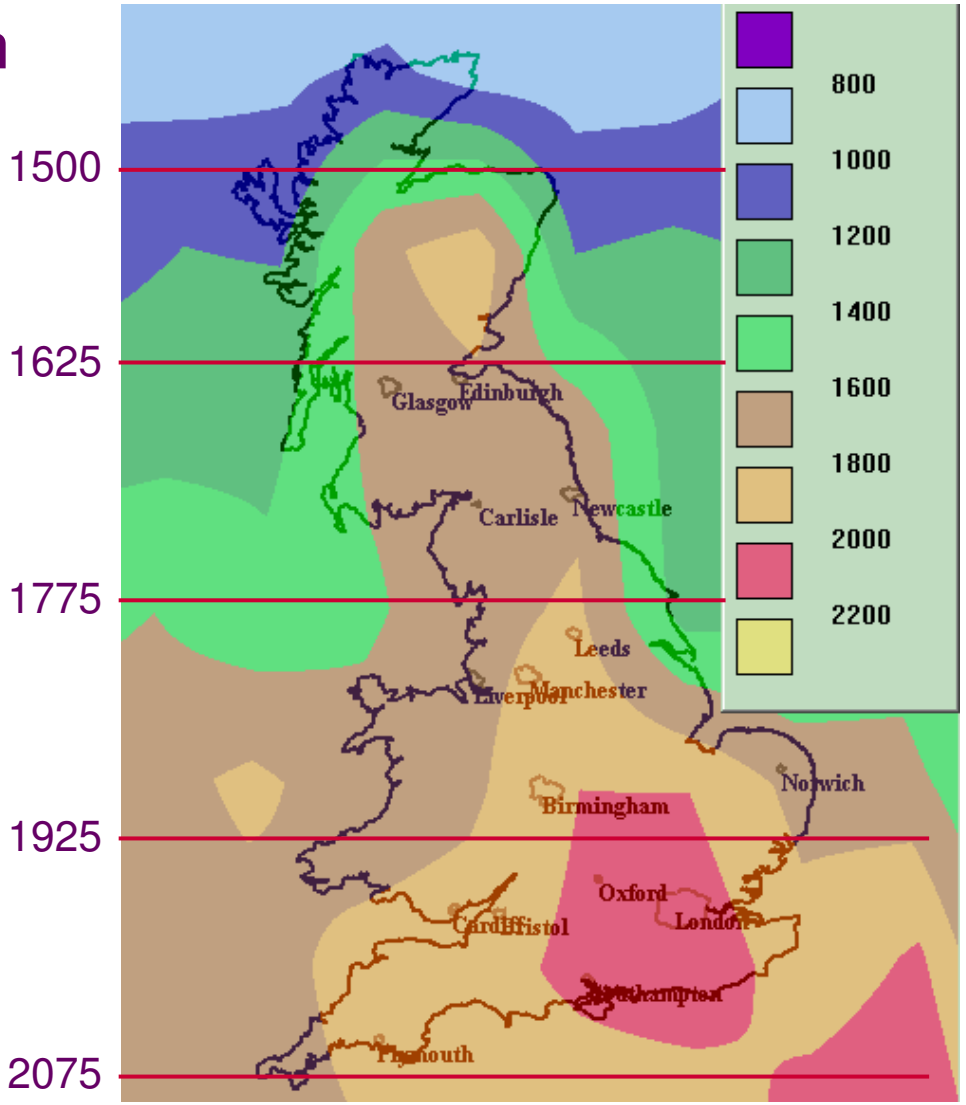
The data are from 0° to 360° in longitude and from +90° to –90° in latitude. For a location different from the gridpoints, the 0° C isotherm height above mean sea level at the desired location can be derived by performing a bilinear interpolation on the values at the four closest gridpoints.

The data files can be obtained from the BR.

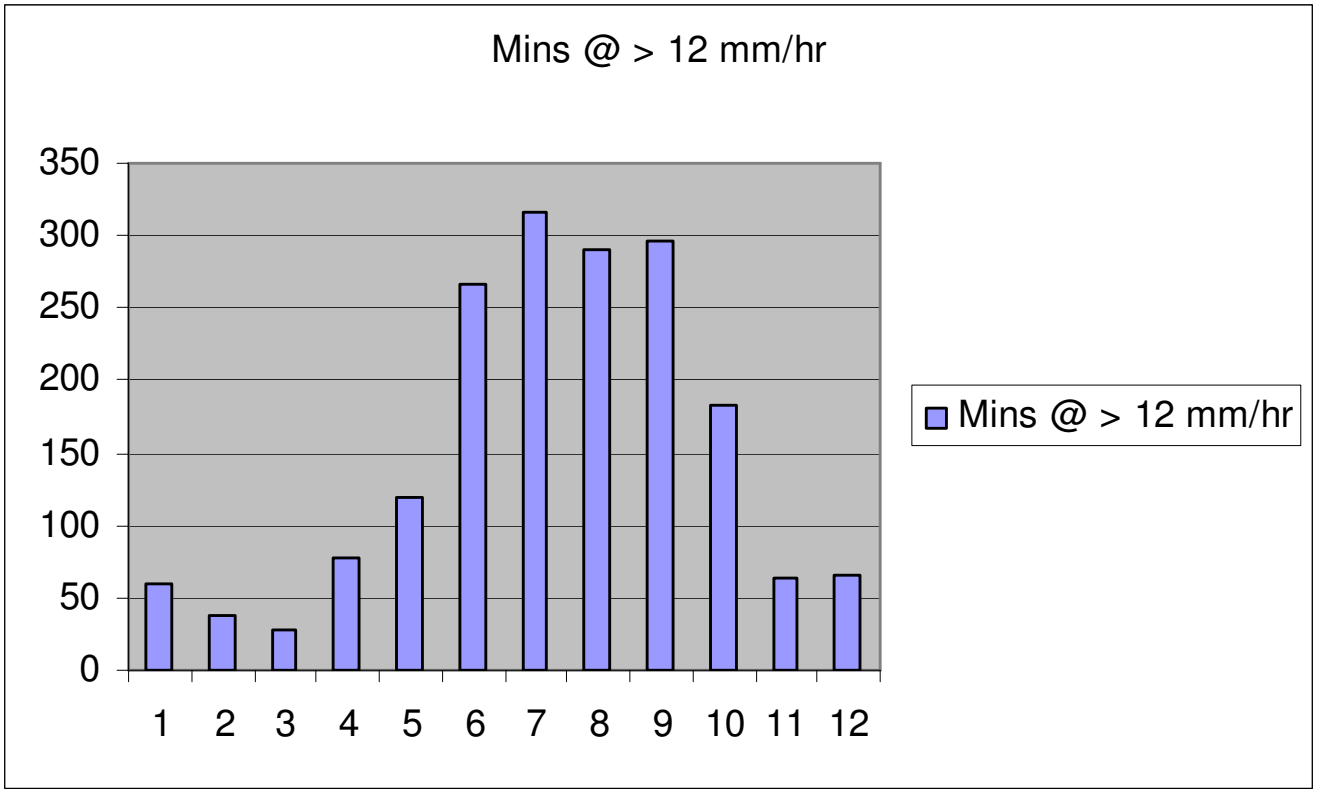
P.839-3

The Zero Degree Isotherm

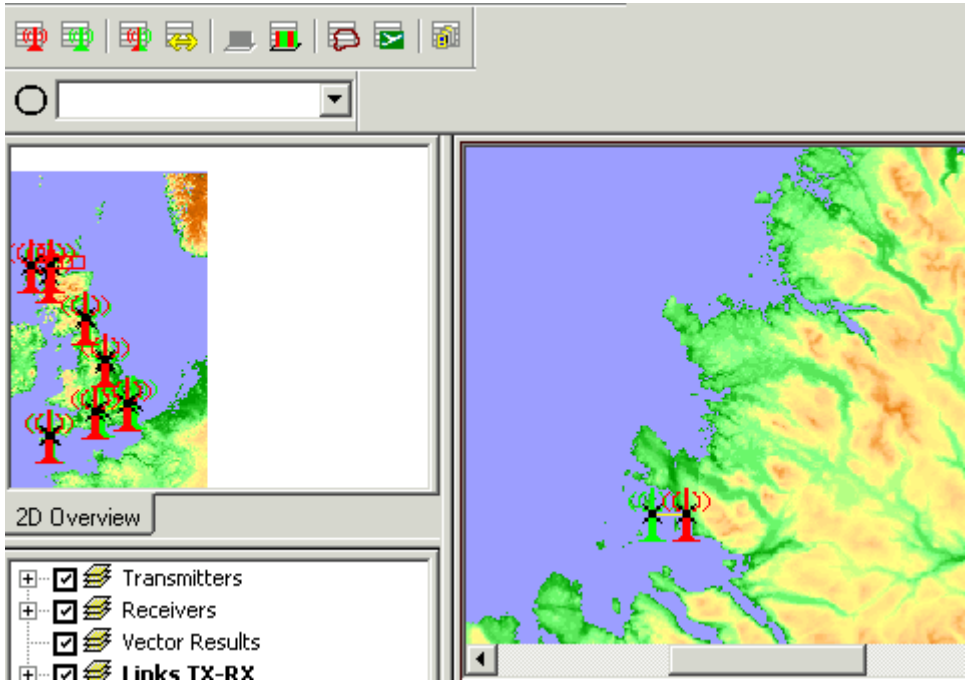




Seasonal variation of rainfall: where is the zero-degree isotherm when there is high precipitation?



Examples:



Northern UK. 58 deg N

Rain only: 24.1 dB

839-2 (+360 m): 27.9 dB

839-3 (+360 m): 34.0 dB

Ofcom
OFFICE OF COMMUNICATIONS

Examples:

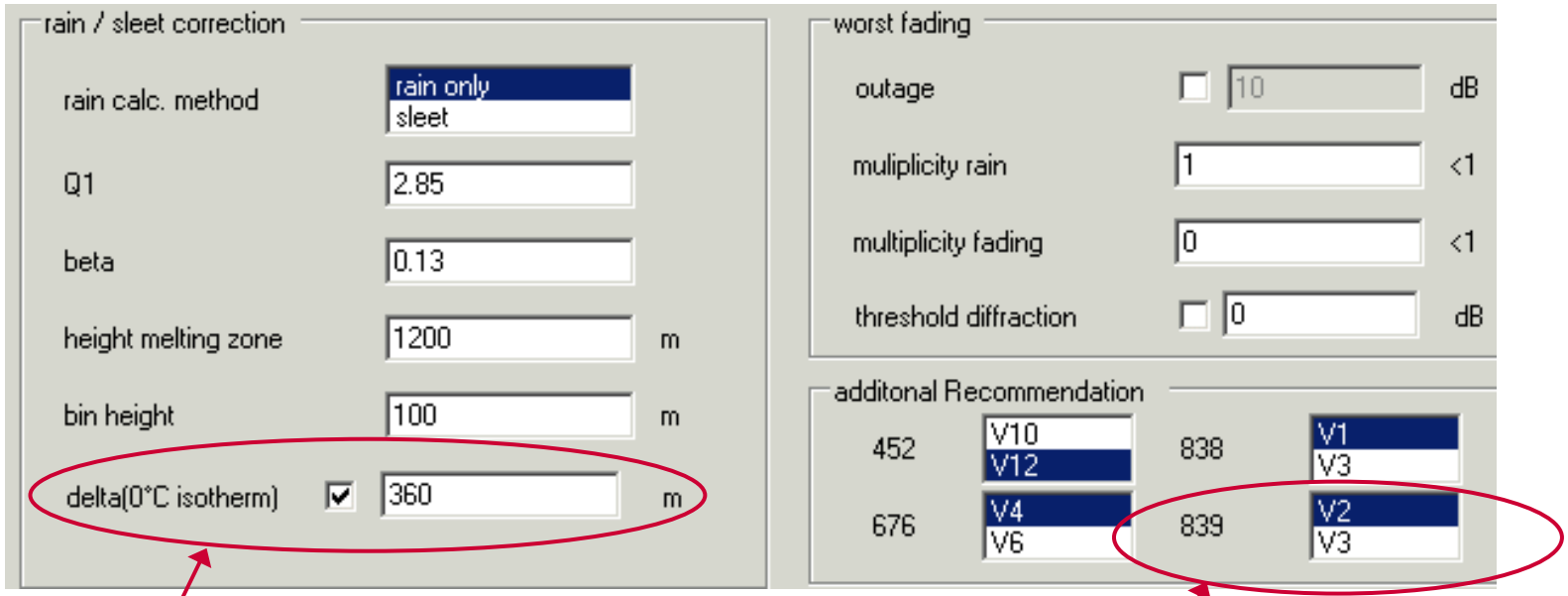
Budapest. 47.5 deg N

Isotherm Ht. 839-2: 2270 m

Isotherm Ht: 839-3: 2680 m

No sleet effect at these heights. It is necessary to reduce isotherm height to 2000 m (or increase height of link) before any sleet effect is noticed.

The LStelcom P.530-10 propagation model dialog box



Height of isotherm can be adjusted

Version of P.839 can be selected

Conclusions

- The effect of wet snow can significantly increase the attenuation of microwaves compared with that produced by rain
- The result is that the required fade margin calculated for rain only must be multiplied by a factor “gamma”
- The value of gamma is greatly influenced by, for example, the height of the zero degree isotherm
- Predictions using ITU-R recommendations can be different from local experience
- SpectraEMC allows user to adjust height of isotherm to provide predictions that the user is comfortable with