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Earth-Space Propagation Research in Canada

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PROPAGATION IMPAIRMENTS AFFECTING SATELLITE COMMUNICATION SYSTEMS

Impairment	Physical Cause	Prime Importance
Signal attenuation, sky noise increases	Atmospheric gases, cloud, precipitation melting layer	Systems at f>10 GHz
Signal depolarization	Raindrops, ice crystals	Dual-polar systems at 6/4 and 14/11 GHz
Signal scintillations	Refractivity variations	Low-margin systems; low elevation angles; antenna tracking
Refraction, atmospheric multipath	Atmospheric gases	Systems operating at low elevation angles; antenna tracking
Reflection multipath, shadowing, blockage	Objects, vegetation on Earth's surface	Mobile-satellite services
Propagation delays & delay variations	Free-space, variations in troposphere	TDMA & position-location systems; adaptive control
Intersystem interference	Ducting, precipitation scatter, diffraction	6/4-GHz systems

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ACTS Measurements in Canada

I. UBC, Vancouver / ACTS Propagation Terminal:
- Path elevation 29.4°, azimuth 150.4° CWN
- ITU-R Rain Climate D (maritime)

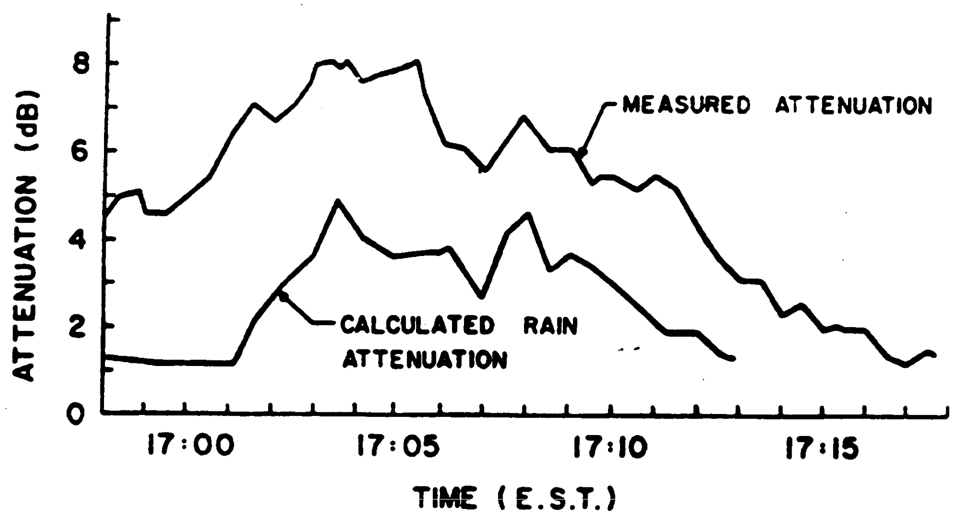
II. Teleglobe, Montréal:
- Site diversity (separation 93.6 km)
- Path elevation 31.5°, azimuth 214° CWN

III. CRC, Ottawa:
- Path elevation 32.2°, azimuth 212.4° CWN
- Radiometers at 12/20/29.5 GHz
- Possible communication experiments with RADC

Clear-Sky Link Budgets/Ottawa

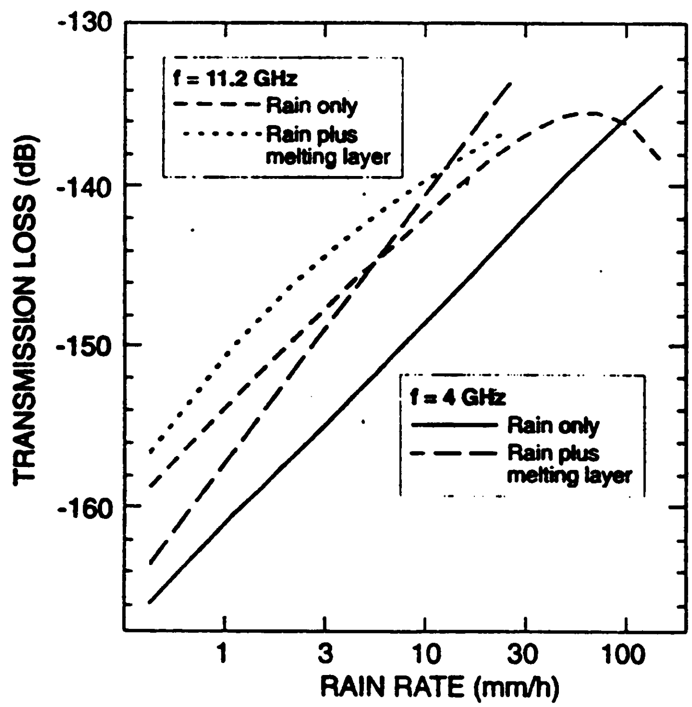
	20.2 GHz	27.5 GHz
Beacon EIRP (dBW), nominal	16.6	15.1
Free-space Loss (dB)	- 210.2	- 212.9
Clear-sky Loss (dB), nominal	- 0.8	- 0.7
Polarization Loss (dB)	- 0.2	- 0.1
Earth Terminal Pointing Loss (dB)	- 0.2	- 0.4
Modulation Loss (dB), nominal	- 3.2	0.0
Earth Terminal G/T (dB/K), nominal	20.0	20.0
Received Power (dBW)	- 177.8	- 179.0
1/k (dB-Hz K/W)	228.6	228.6
C/N_0 (dB-Hz)	50.8	49.6
C/N in 65 Hz (dB)	32.7	31.5

Melting-Layer Attenuation Event

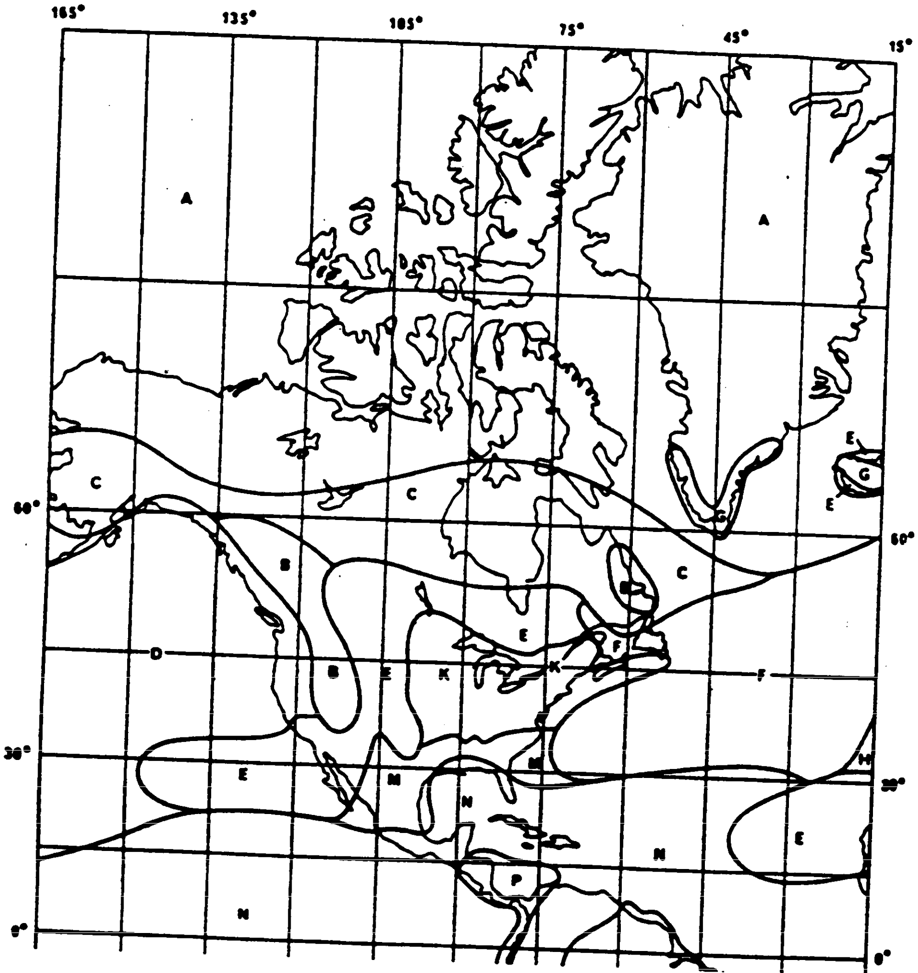


Measured at Ottawa using COMSTAR 28-GHz Beacon and
16.5-GHz Polarimetric Radar

Transmission Loss with and without Melting Layer

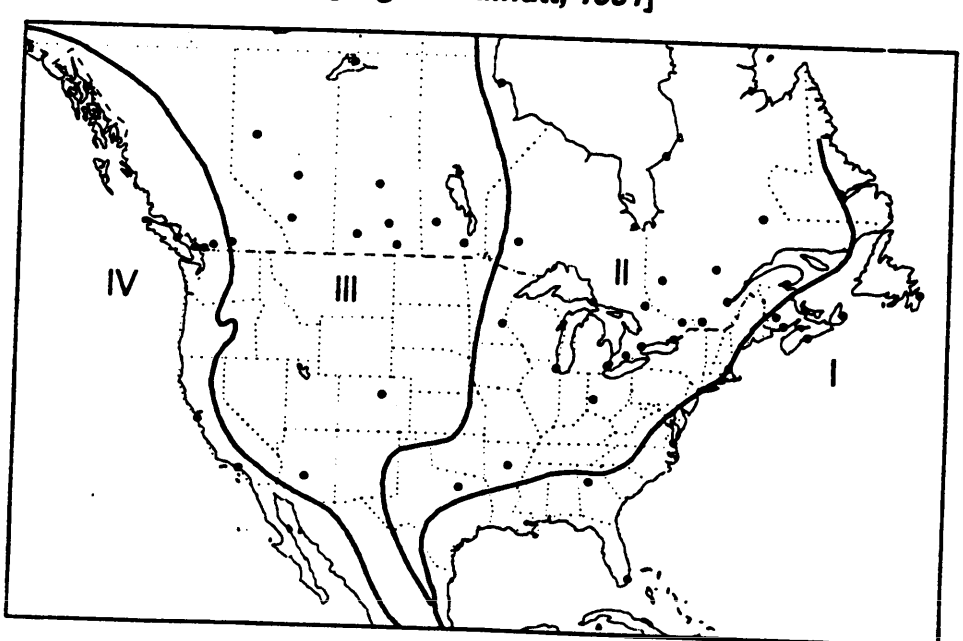


ITU-R Rain Zones



Climate Regions Based on 60-Minute Rainfall Observations

[*Segal & Allnutt, 1991*]



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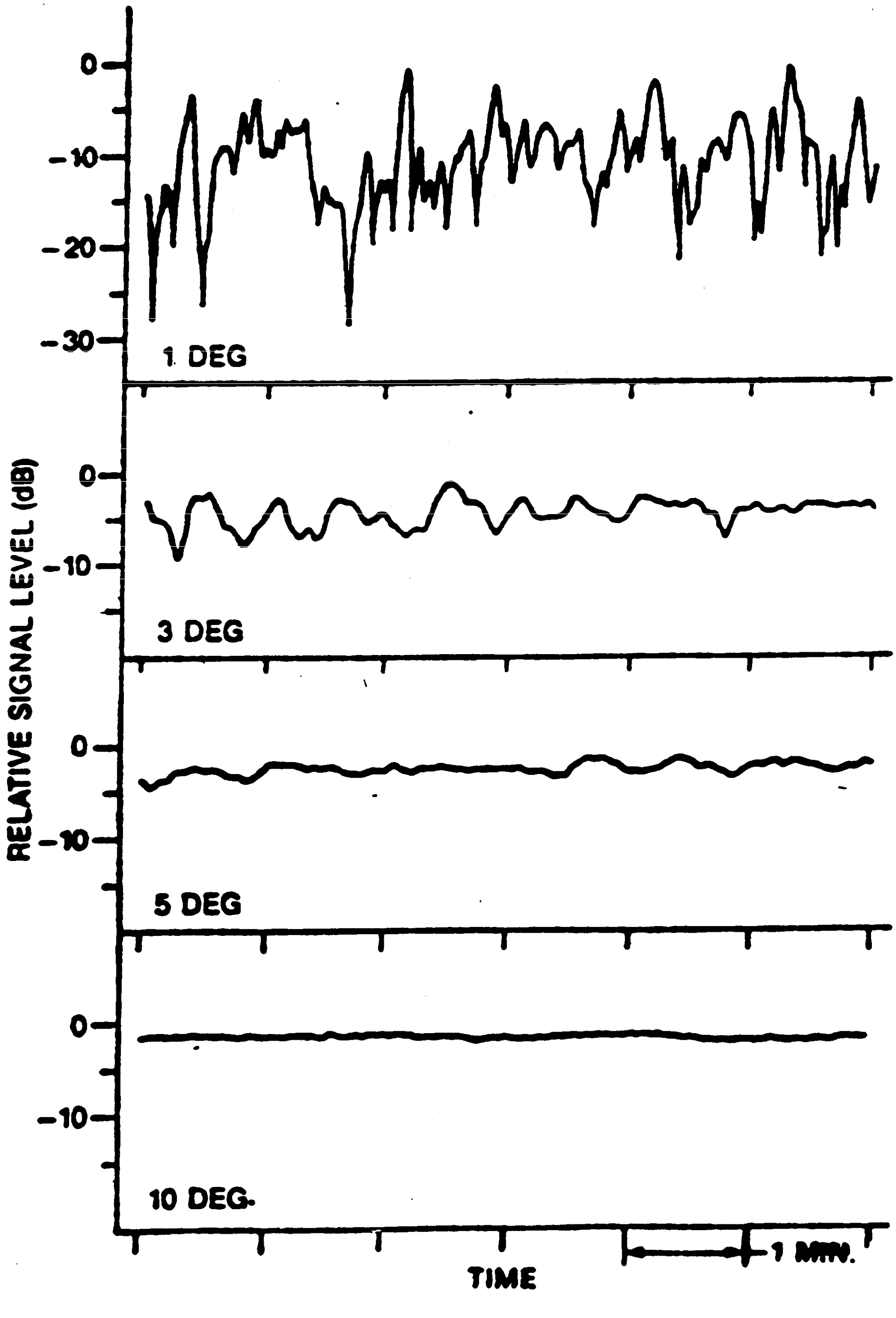
38-GHz Low-Angle Fade/Scintillation Data Measured at Alert, N.W.T.



WORLDWIDE PROCEDURES FOR PREDICTING SCINTILLATION/MULTIPATH FADING DISTRIBUTION AT VERY LOW ANGLES (<5°)

- Fade depth A (>25 dB) exceeded for p % of the time in the average worst month:

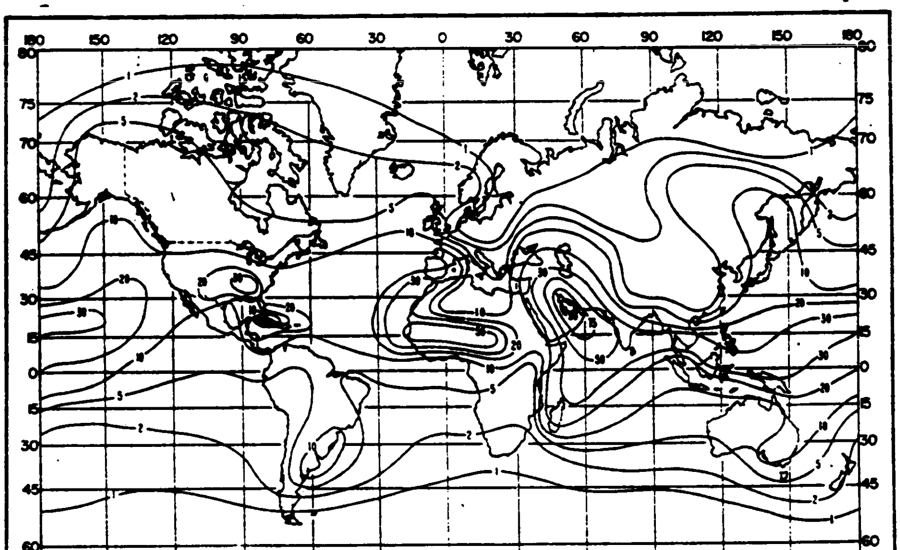
$$A = G_W + 92 + 9 \log f - 55 \log(1+\varepsilon_o) - 10 \log p \qquad \text{(dB)}$$

where $G_W = G_O + C_{Lat} + 15 \log p_L$

$$G_O = \begin{cases} -16 & \text{antenna height} \le 700 \text{ m} \\ -22 & \text{antenna height} > 700 \text{ m} \\ -10 & \text{paths over water or adjacent coastal areas} \end{cases}$$

C_{Lat} = high latitude factor

p_L: Aug



- Associated methods for shallow fading range (0-25 dB) and predictions in the average year

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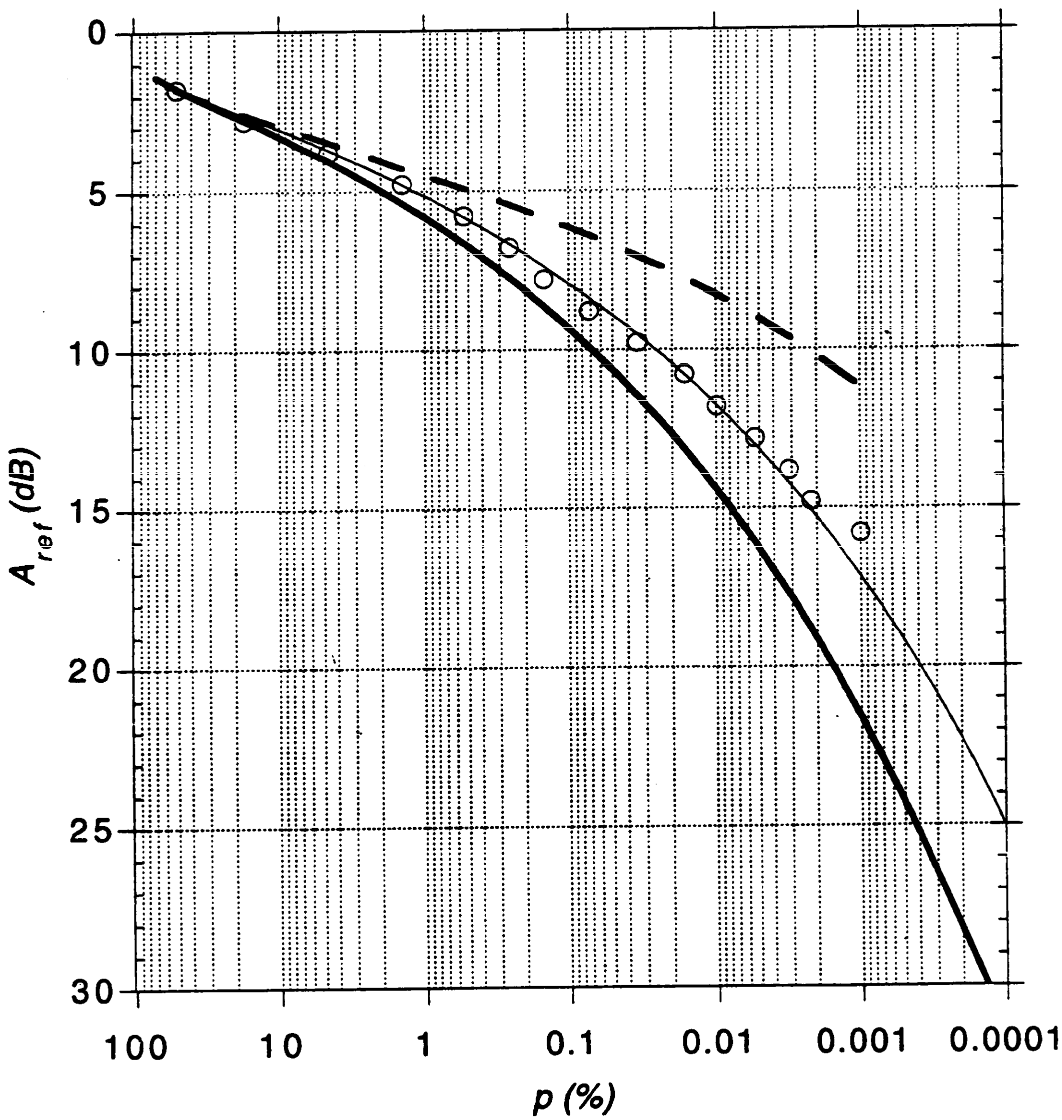
Low-Angle Fade Model Compared to Data

Comparison of model with average worst-month clear-air fading (3.2° elev. angle) Spitzbergen, Norway



Circles: measured; **Line**: fit to measured data; **Bold line**: predicted; **Dash line**: predicted with extended ITU-R scintillation model