Ka-band Propagation Measurements and Modeling

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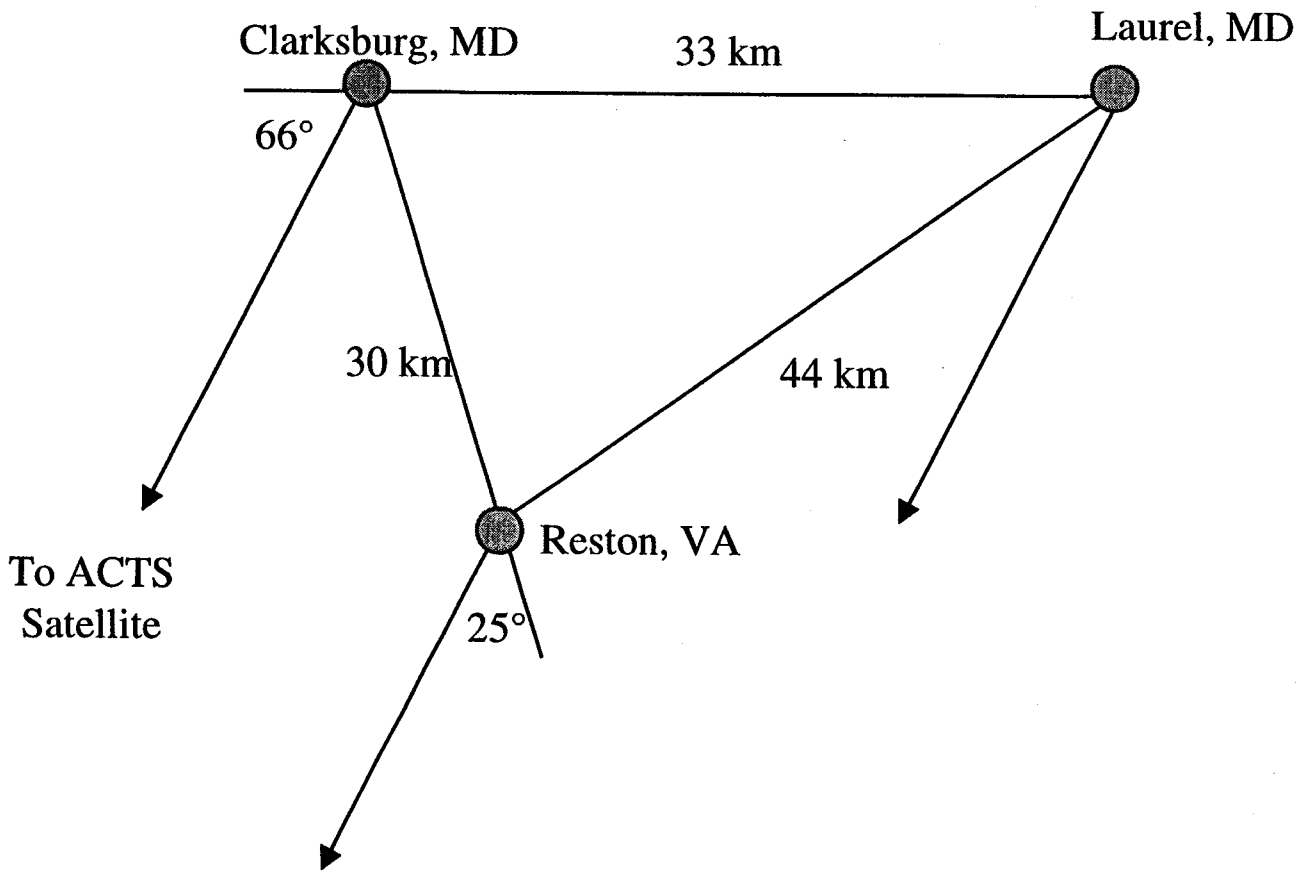
Propagation Measurements

- Using NASA ACTS satellite
- Experiments:
  - Long-term beacon measurements at 20.2 and 27.5 GHz
  - Site diversity at 20.2 and 27.5 GHz
  - Tropical propagation measurements

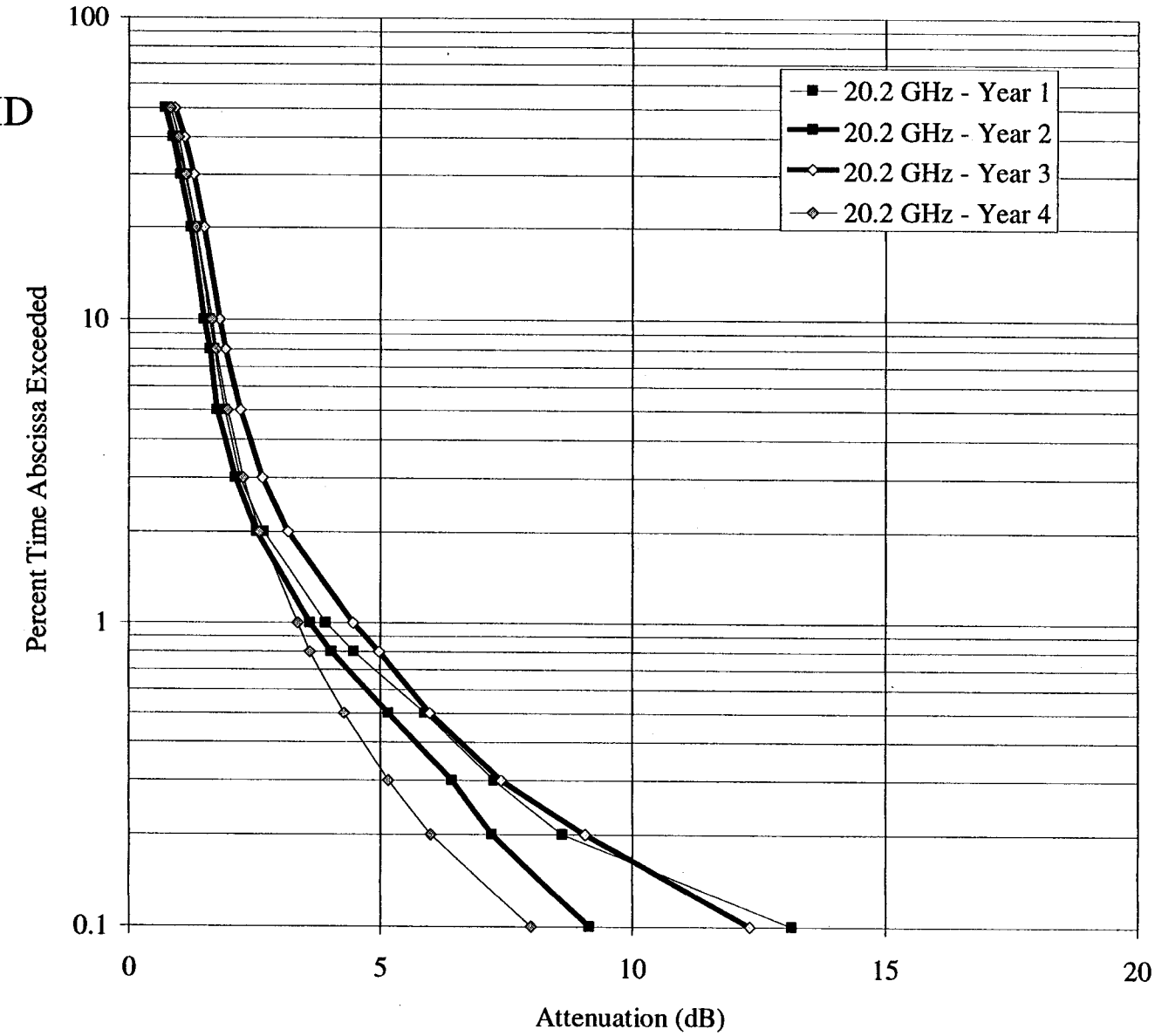
ACTS Beacon Measurements

- Measurements were conducted at three sites in Washington DC area.
- Measurement periods ranging from two to four years.
- Weather instruments and Ka-band radiometers were used to improve accuracy and quality of collected data.

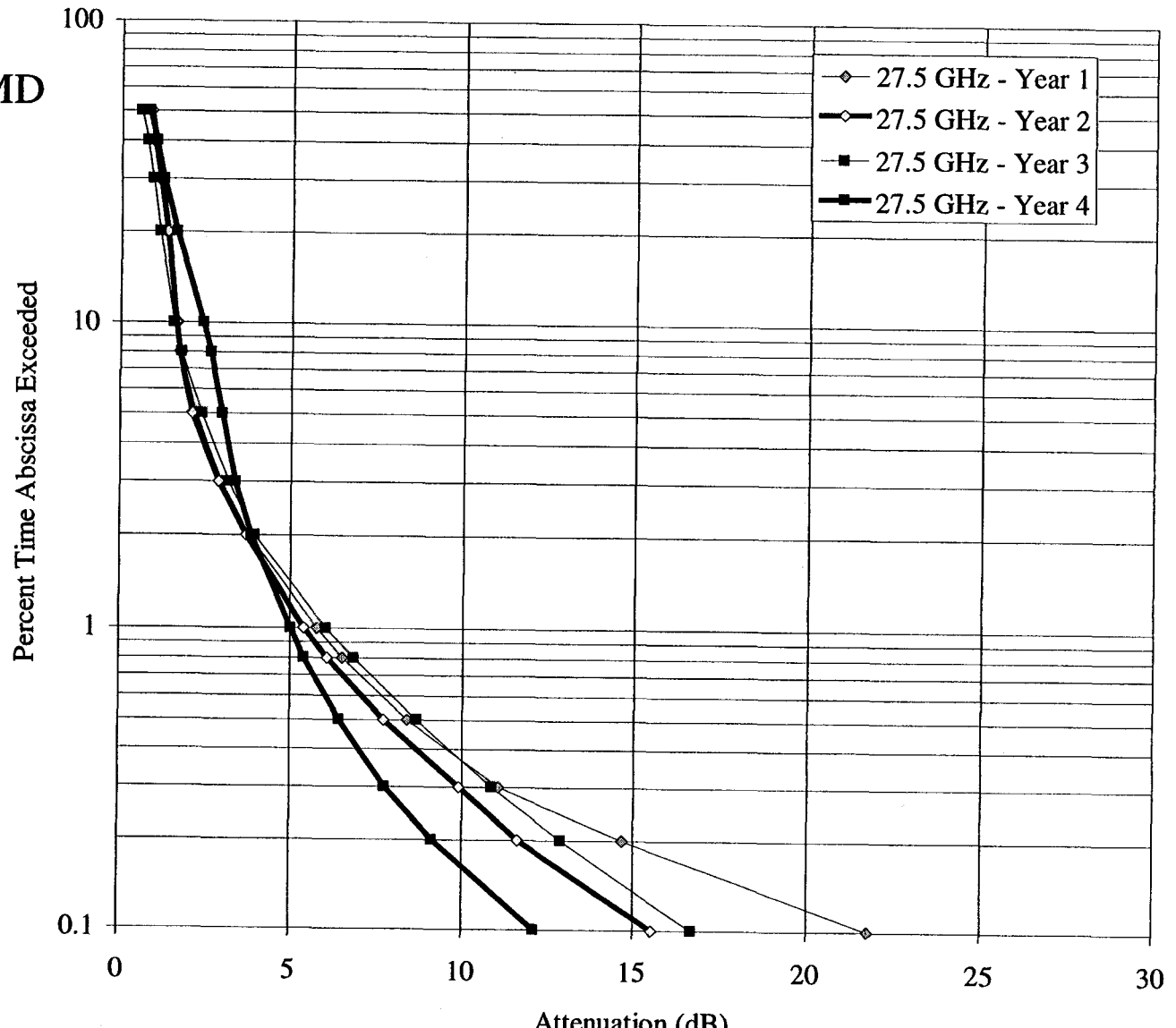
Measurement Sites in Washington DC Area



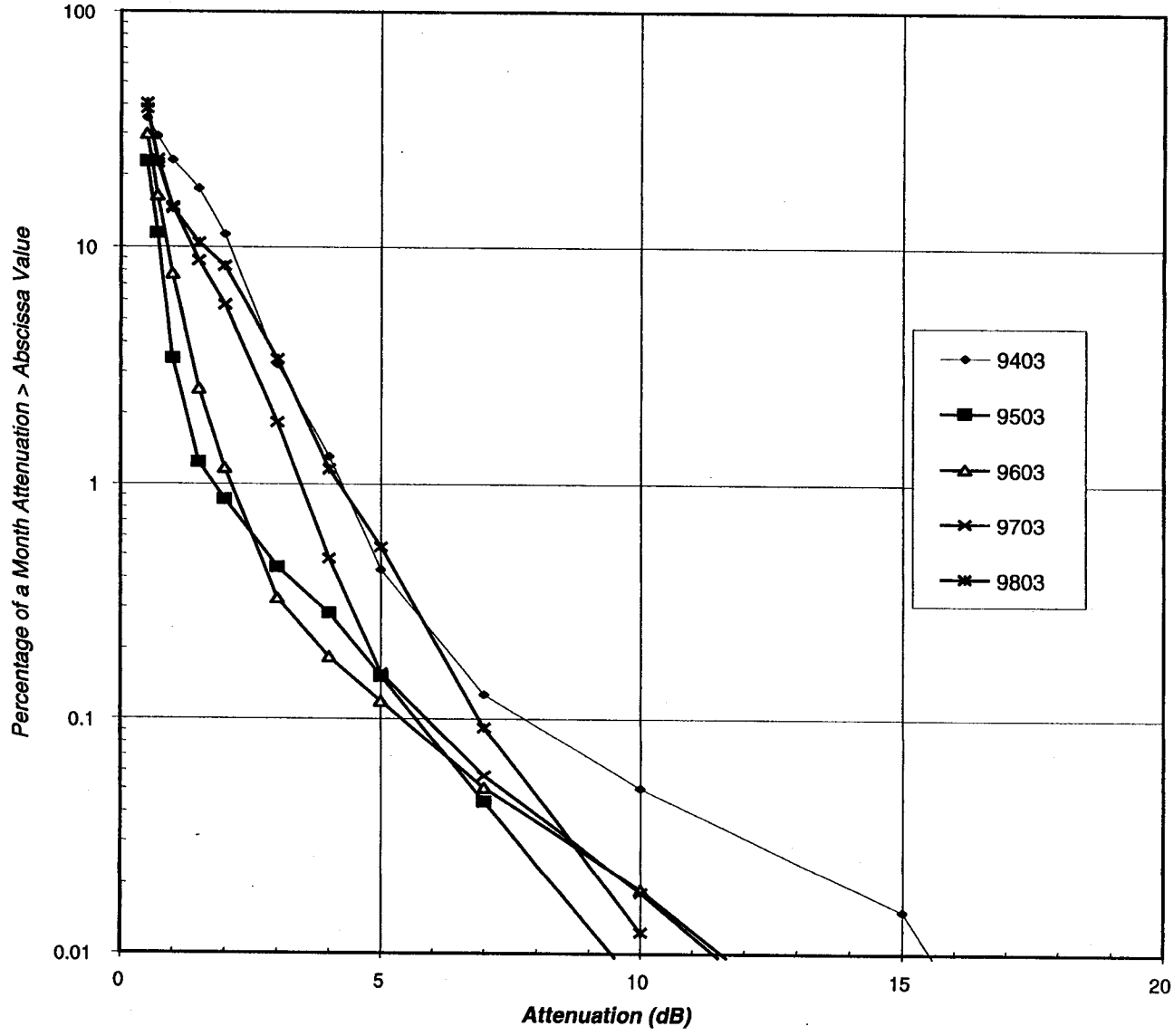
20.2 GHz Attenuation Statistics, Clarksburg, MD



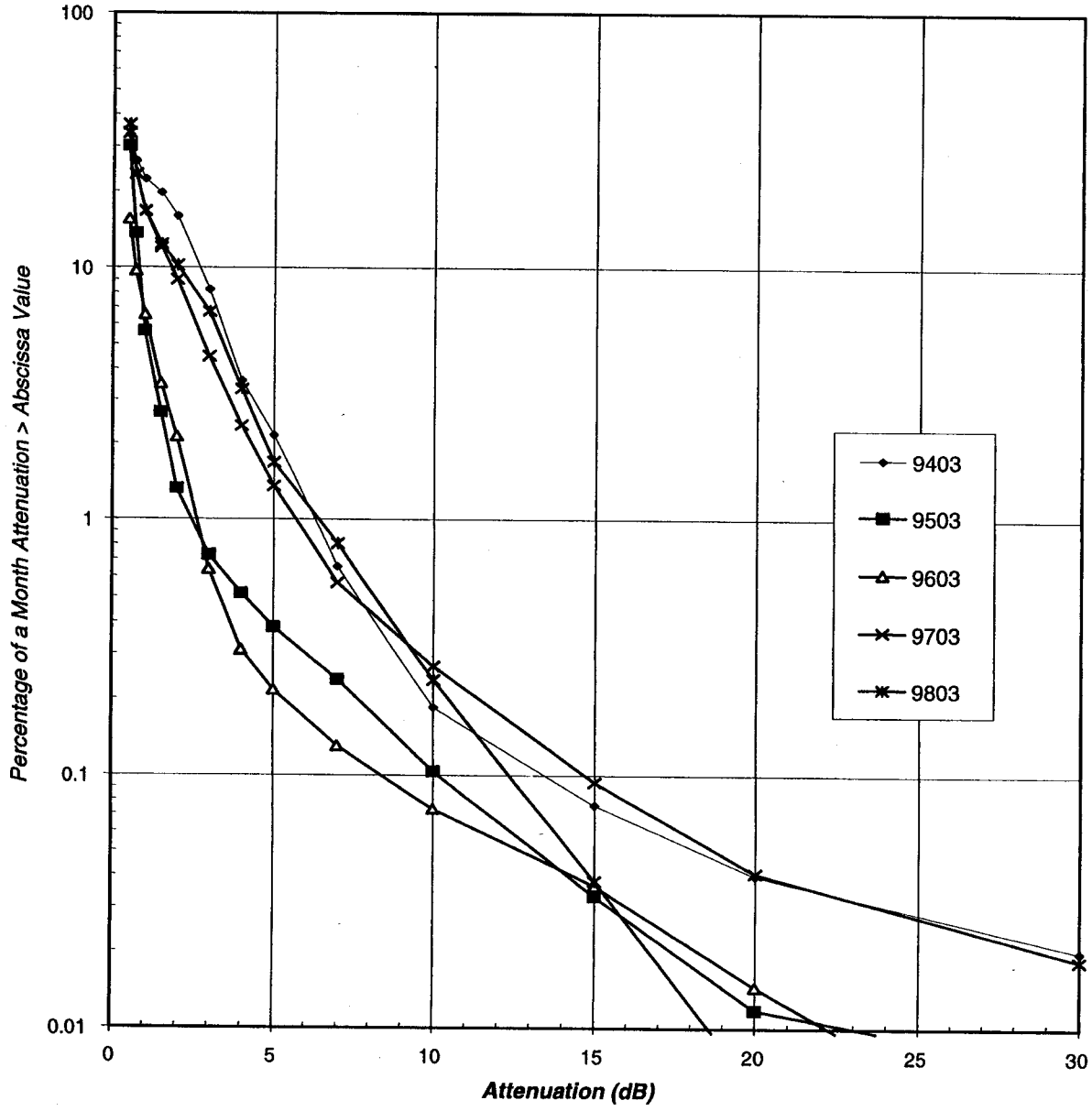
27.5 GHz Attenuation Statistics, Clarksburg, MD



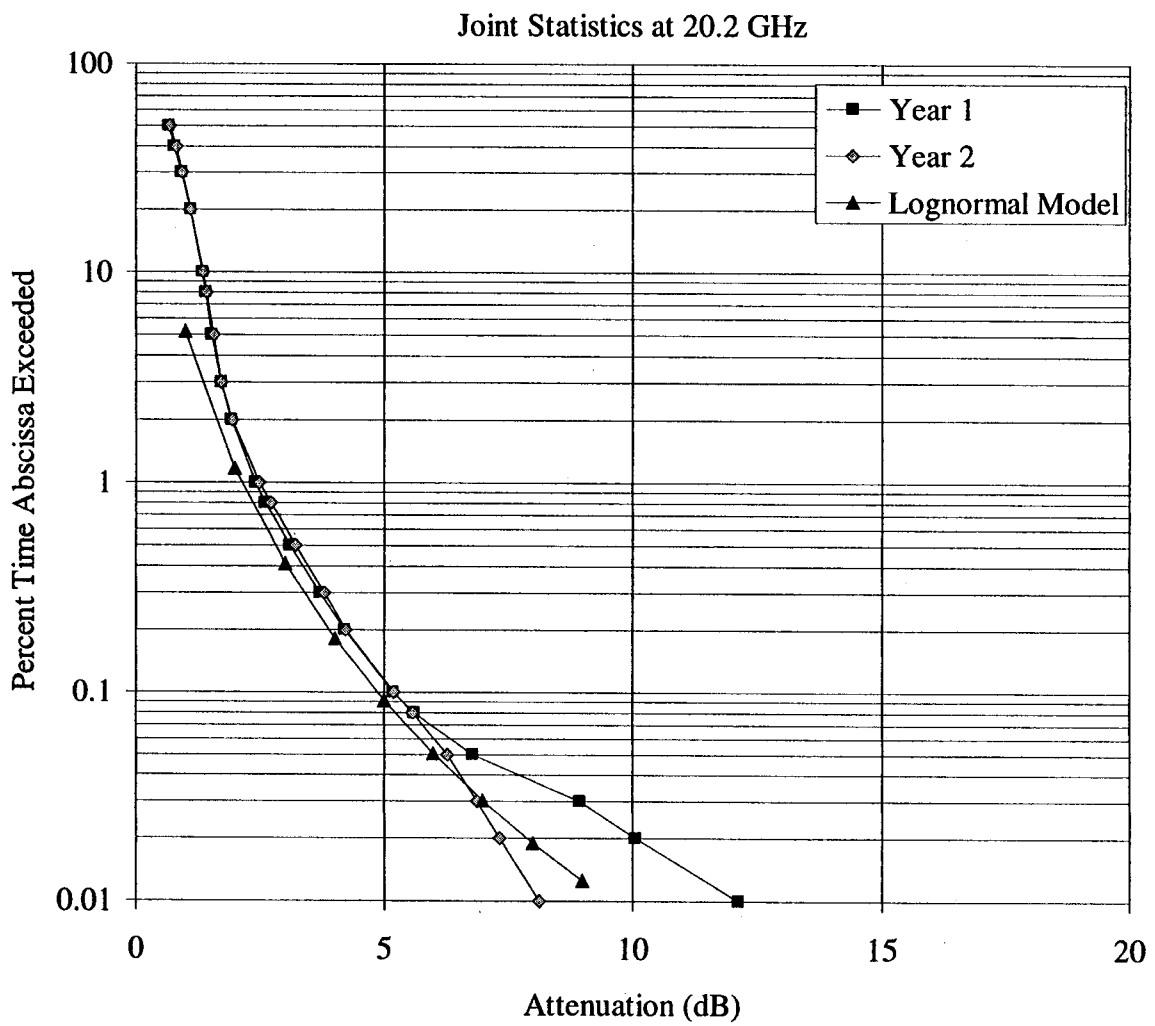
20.2 GHz Attenuation Statistics, Reston, VA



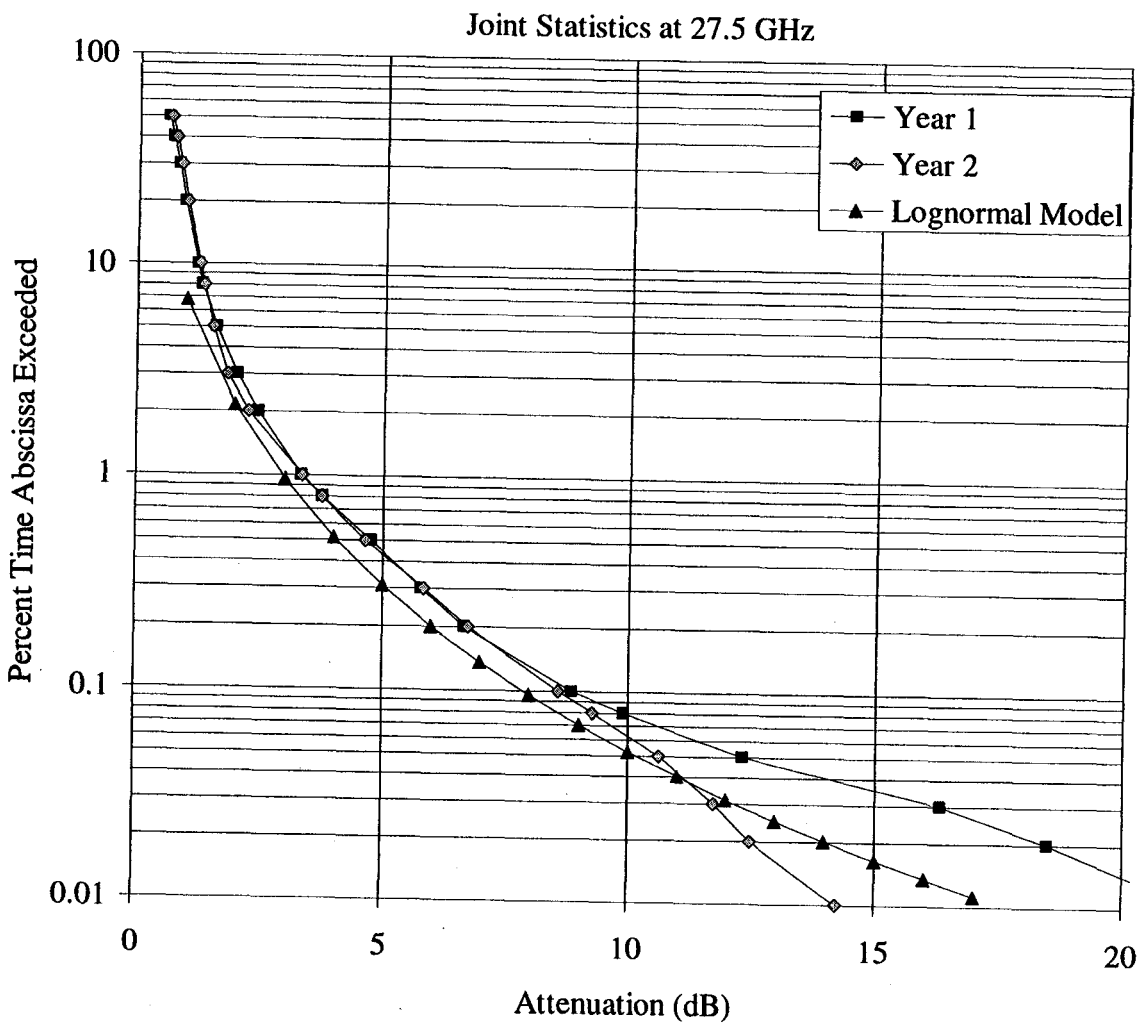
27.5 GHz Attenuation Statistics, Reston, VA



Site diversity statistics for Clarksburg, MD and Reston, VA; frequency: 20.2 GHz



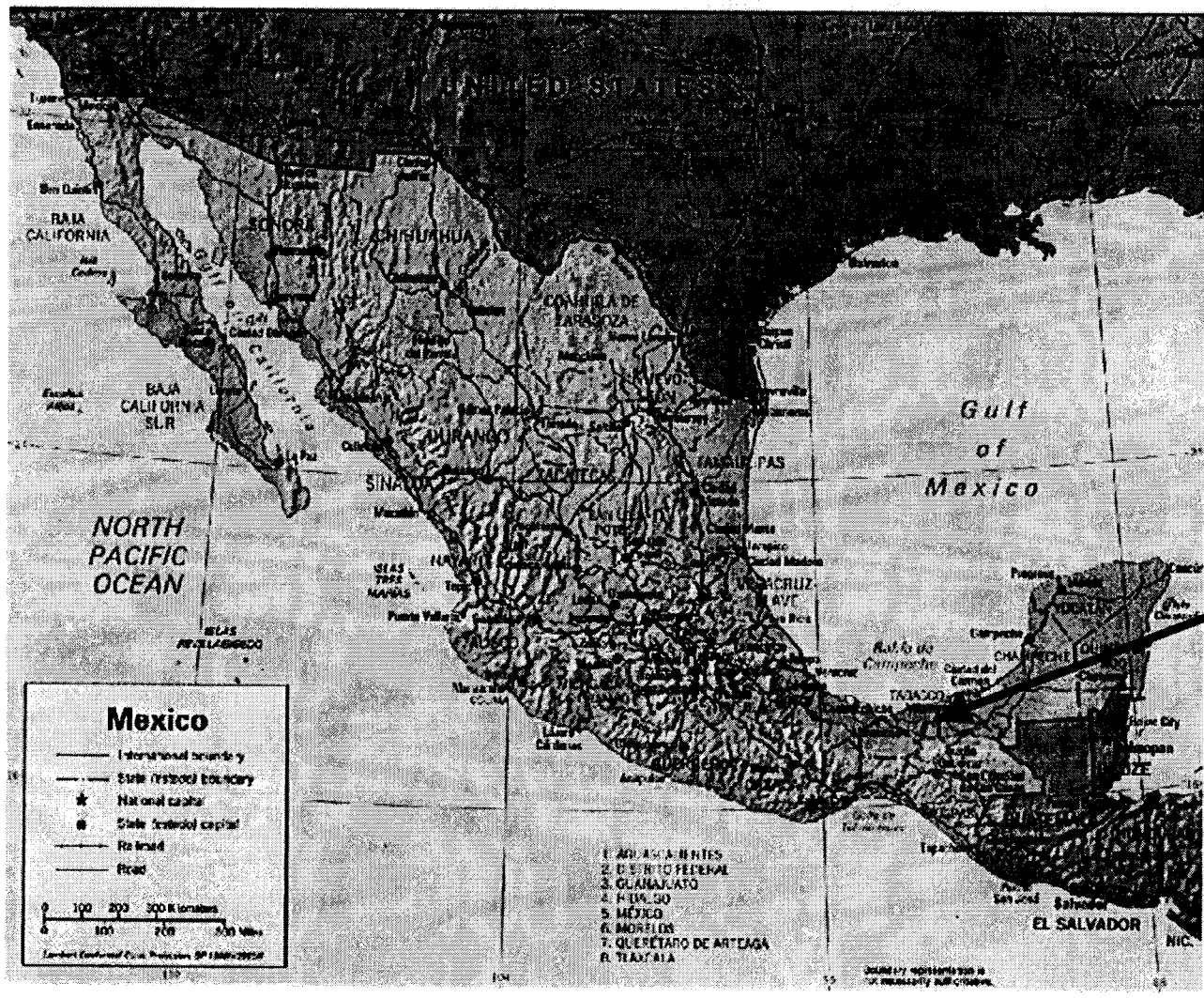
Lognormal Diversity Model: 27.5 GHz



Tropical Propagation Measurements

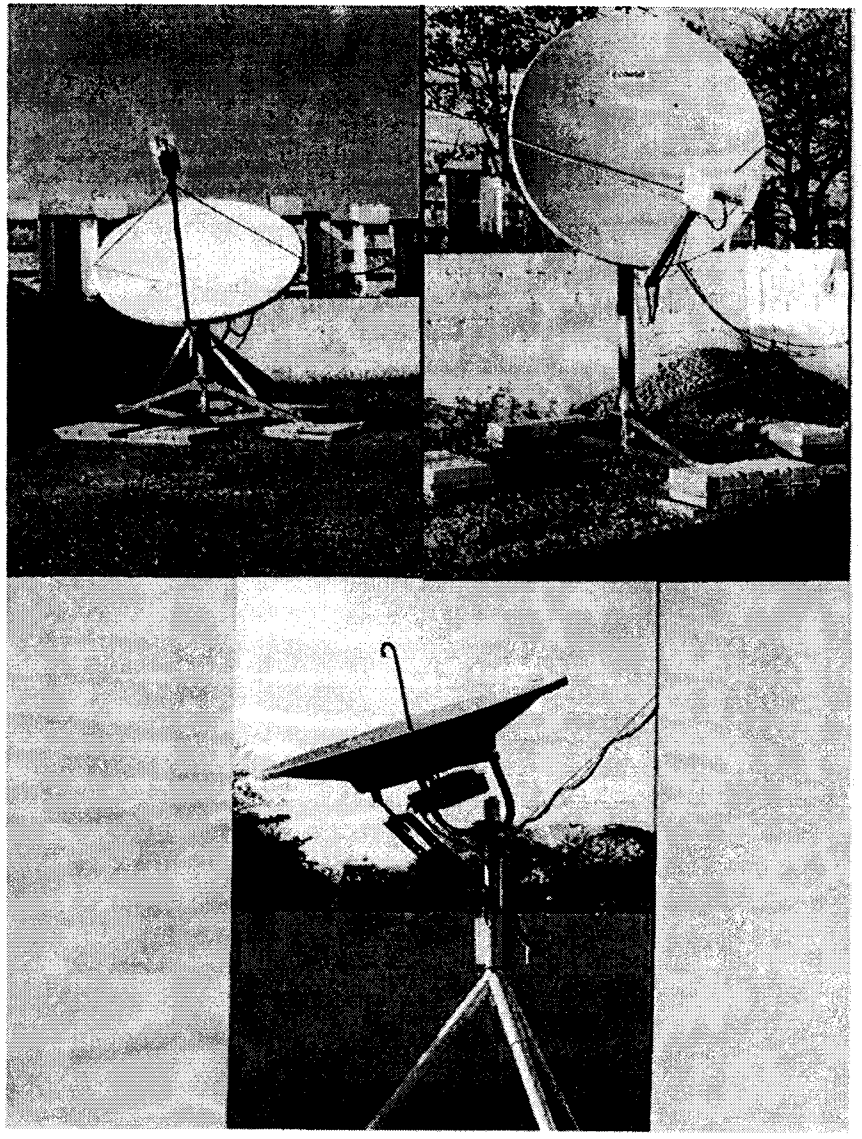
- To characterize Ka-band propagation conditions in the tropics.
- Measurements conducted using the ACTS satellite at a site in southern Mexico.
- Ancillary measurements include:
  - X-band weather radar
  - Ku-band radiometer
  - Rain drop size distribution

Measurement Site

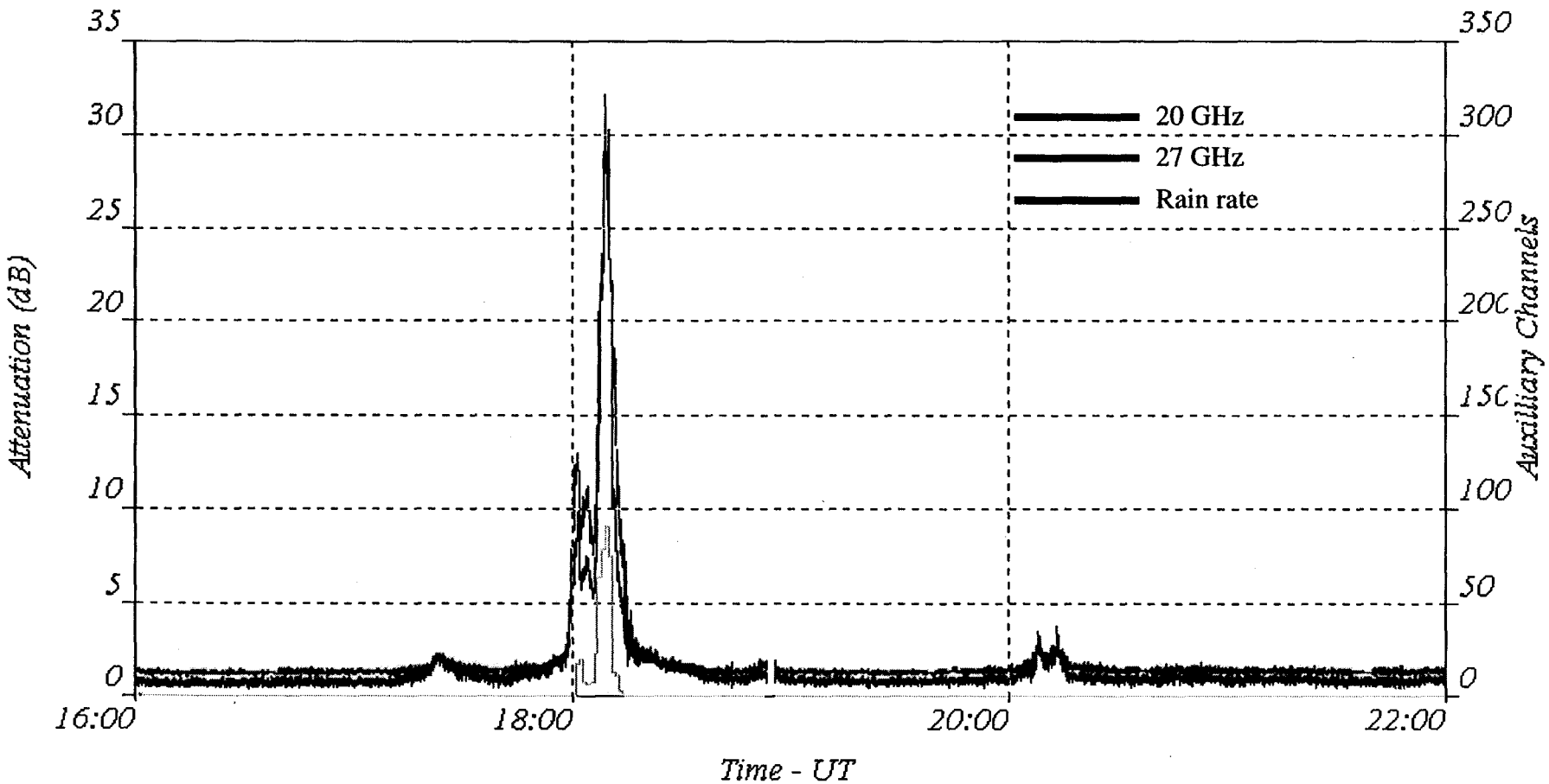


Measurement Site

Measurement System



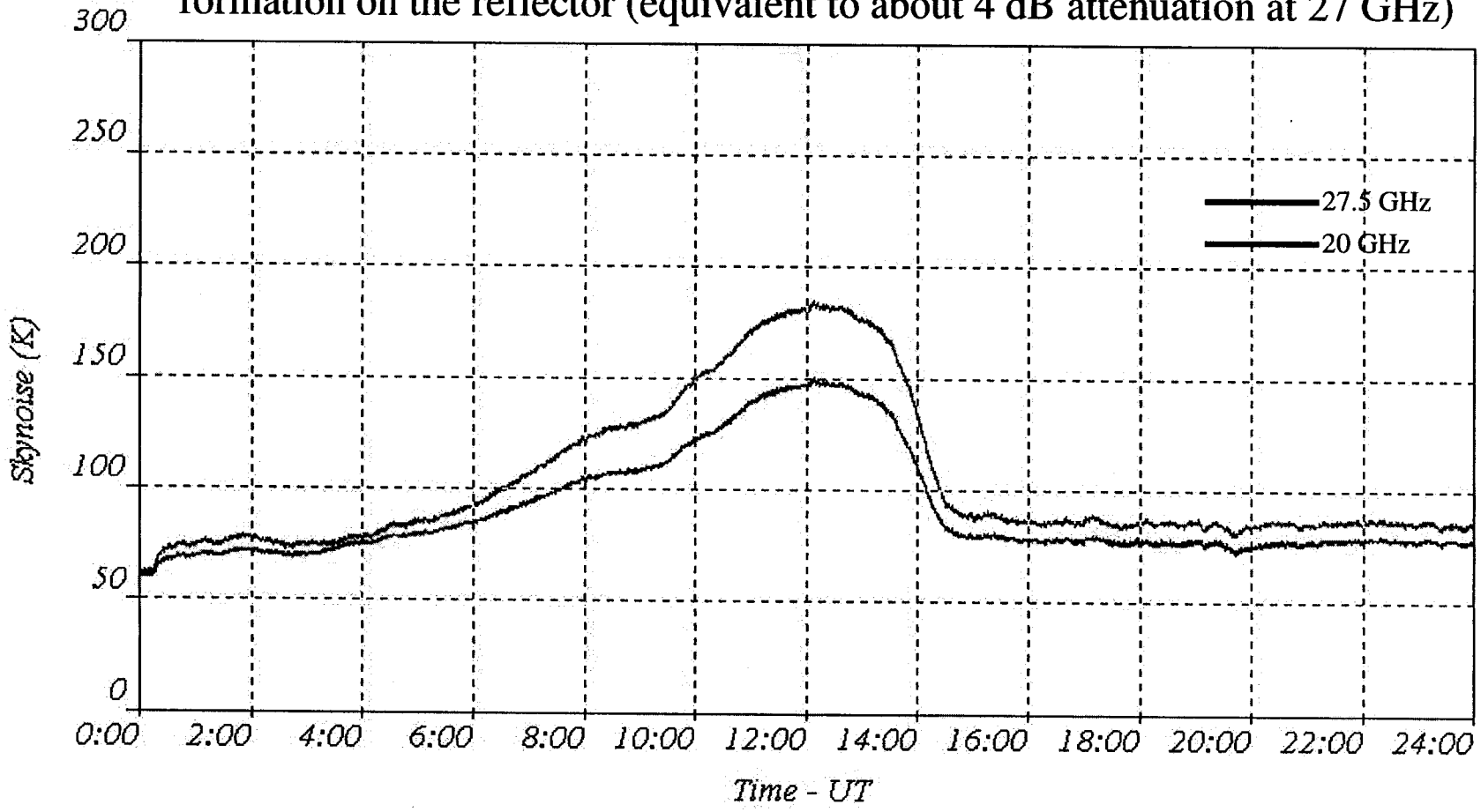
Measurement Results



Day Plot for 26 October 1998

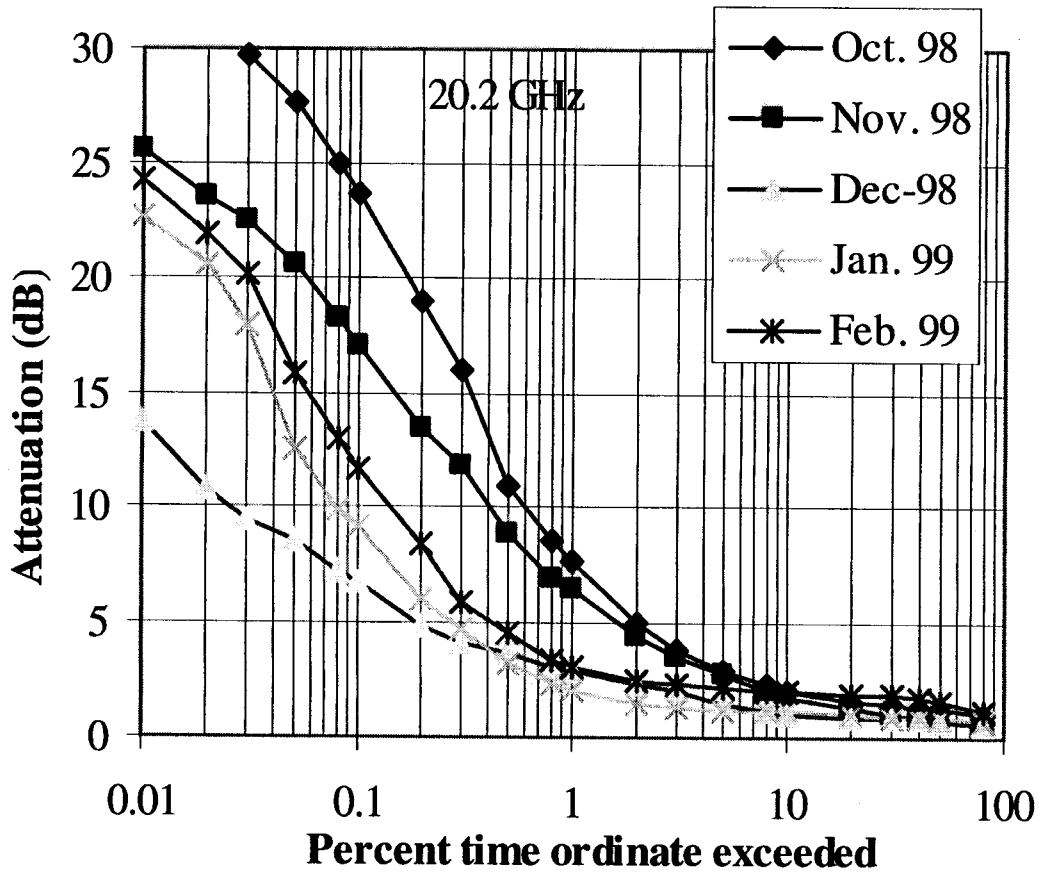
Measurement Results

Rise in antenna noise temperature due to dew formation on the reflector (equivalent to about 4 dB attenuation at 27 GHz)



Day Plot for 07 February 1999

Monthly Attenuation Distributions at 20 GHz



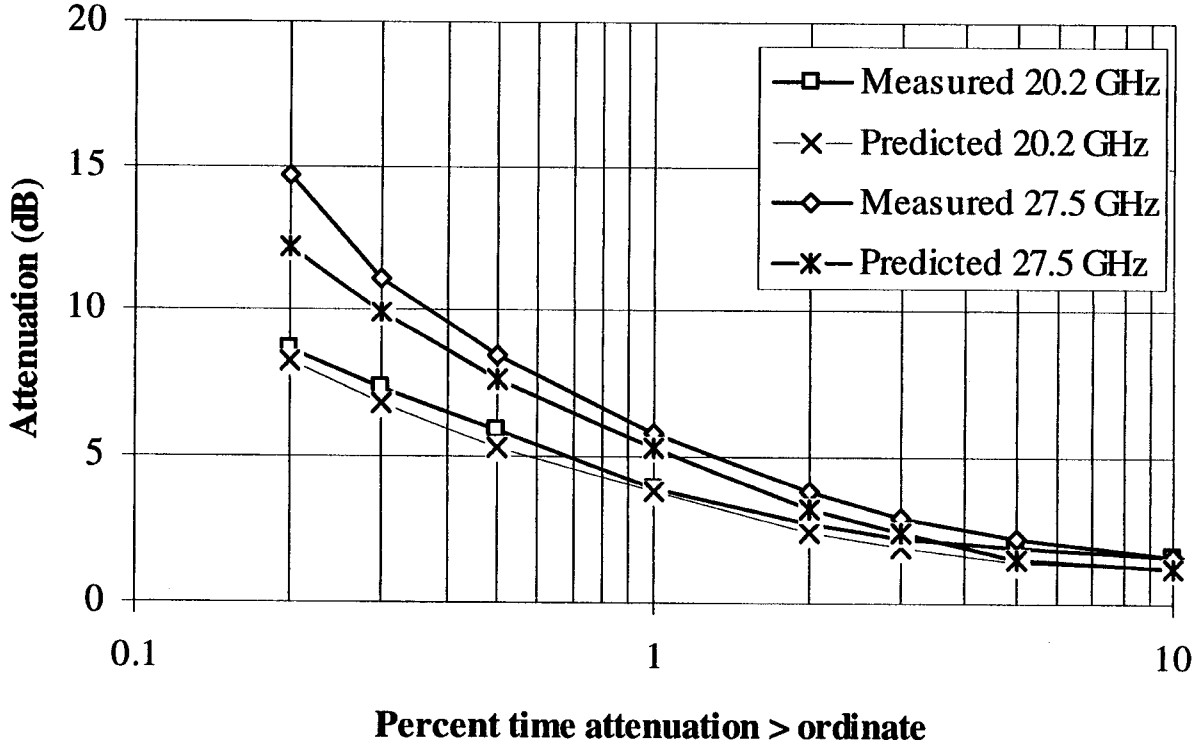
Ka-band Propagation Modeling

- Propagation models developed for:
  - rain attenuation
  - cloud attenuation
  - combining different impairments

Modeling Approach

- Models based on long standing involvement in propagation measurements throughout the world.
- Rain attenuation model based on log-normal statistics for rain attenuation and rain rate. Model parameters derived from measured slant path as well as terrestrial data.
- Cloud model based on long term observations of cloud cover.

Impairment Combining

- Comprehensive approach to combining following propagation impairments:
  - gaseous absorption
  - cloud attenuation
  - melting layer attenuation
  - rain attenuation
  - tropospheric scintillation
  - low-angle fading
- Useful in predicting propagation outages for low-availability systems.

Combined Attenuation: Measured vs. Predicted