AT Technical Data
AT/39.2/065
February 5, 1996.

THE AUSTRALIA TELESCOPE NATIONAL FACILITY

# ATMOSPHERIC NOISE CONTRIBUTION TO RECEIVER SYSTEM TEMPERATURE AT 35-50 GHZ

*Russell Gough*

## 1. INTRODUCTION.

Receiver system temperatures include a contribution from loss in the atmosphere. Fig. 1 shows the atmospheric attenuation due to oxygen and water vapour[1]. The attenuation due to oxygen and water vapour is summarized in Table 1.

| Frequency (GHz) | Attenuation due to oxygen (dB/Km) | Attenuation due to water vapour (dB/Km) |
|---|---|---|
| 10 | 0.007 | 0.004 |
| 35 | 0.02 | 0.05 |
| 50 | 0.2 | 0.08 |
| 100 | 0.05 | 0.3 |

Table 1

Below 10 GHz the atmospheric attenuation is mainly due to oxygen, but above 10 GHz there is an increasing contribution from water vapour. Between 35 and 50 GHz the attenuation due to water vapour is relatively constant but the attenuation due to oxygen increases dramatically as the frequency nears the oxygen absorbtion line at 60 GHz. At 100 GHz the attenuation due to oxygen is less, but the attenuation due to water vapour is much larger, than it is at 50 GHz. Ref. [1] also gives the equations needed to calculate the atmospheric loss and noise contribution as a function of frequency, temperature and relative humidity.

## 2. RESULTS.

Figs. 2 to 7 show the atmospheric transmission and atmospheric noise contribution, at zenith, as a function of temperature and relative humidity for six frequencies: 8.6 GHz, 35 GHz, 40 GHz, 45 GHz, 50 GHz and 100 GHz. At lower elevations the atmospheric attenuation and noise contribution increases as 1/sin(elevation).

Robin Wark supplied plots of temperature and humidity at Narrabri for a large portion of 1993. On the basis of the water vapour density inferred from the plots of temperature and humidity, I have estimated typical and best observing conditions at Narrabri in January, April and June, 1993. Figs. 8 and 9 show the temperature and humidity at Narrabri in January, 1993.

On January 8, 1993, the daytime maximum was 310 K ( 37°C ) and the relative humidity (RH) was 10%. The corresponding water vapour density, 5 $gm^{-3}$, was the lowest recorded in January, 1993. On January 25, 1993, the day time maximum was 311 K, the relative humidity was 40% and the corresponding water vapour density, 20 $gm^{-3}$, was the highest recorded in January, 1993.

On January 20, 1993, which looks typical, the day time maximum was 314 K (25% RH), in the evening it was 306 K (40% RH) and the night time minimum was 300 K (60% RH). The water vapour density is 14 $gm^{-3}$ for each of these conditions. Typical and best observing conditions at Narrabri in January, April and June, 1993, and the corresponding atmospheric noise contributions at zenith at 35, 40, 45, 50 and 100 GHz are given in Table 2.

Fig. 10 shows the water vapour density as a function of temperature and relative humidity. On Fig. 10 are also indicated the range of temperature and humidity and typical and best observing conditions at Narrabri in January, April and June, 1993.

Fig. 11 shows the atmospheric transmission and atmospheric noise contribution, at zenith, as a function frequency in the 35 to 50 GHz band for typical and best observing conditions at Narrabri in January, April and June, 1993, noted above.

| | Temperature (C) | Relative Humidity | Atmospheric noise contribution at zenith (K) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 35 GHz | 40 GHz | 45 GHz | 50 GHz | 100 GHz |
| Typical January | 35 | 0.35 | 26 | 34 | 53 | 96 | 118 |
| Best January | 37 | 0.10 | 9 | 16 | 31 | 75 | 54 |
| Typical April | 25 | 0.35 | 16 | 23 | 39 | 83 | 72 |
| Best April | 32 | 0.18 | 12 | 19 | 35 | 79 | 56 |
| Typical June | 13 | 0.60 | 14 | 22 | 37 | 80 | 64 |
| Best June | 3 | 0.80 | 12 | 19 | 34 | 77 | 51 |

Table 2

## 3. CONCLUSION.

It is clear that atmospheric attenuation is a more important factor in the 35 to 50 GHz region than at frequencies below 10 GHz. As the observing frequency increases towards the oxygen absorbtion line at 60 GHz, the atmospheric loss increases. But for typical observing conditions at Narrabri at frequencies up to 49 GHz, the atmospheric loss is lower than it would be at 100 GHz, and it is less sensitive to water vapour in the atmosphere.

## 4. REFERENCE.

[1] "Radio Systems Design for Telecommunications (1-100 GHz)", Freeman, R. L., Chapter 6.

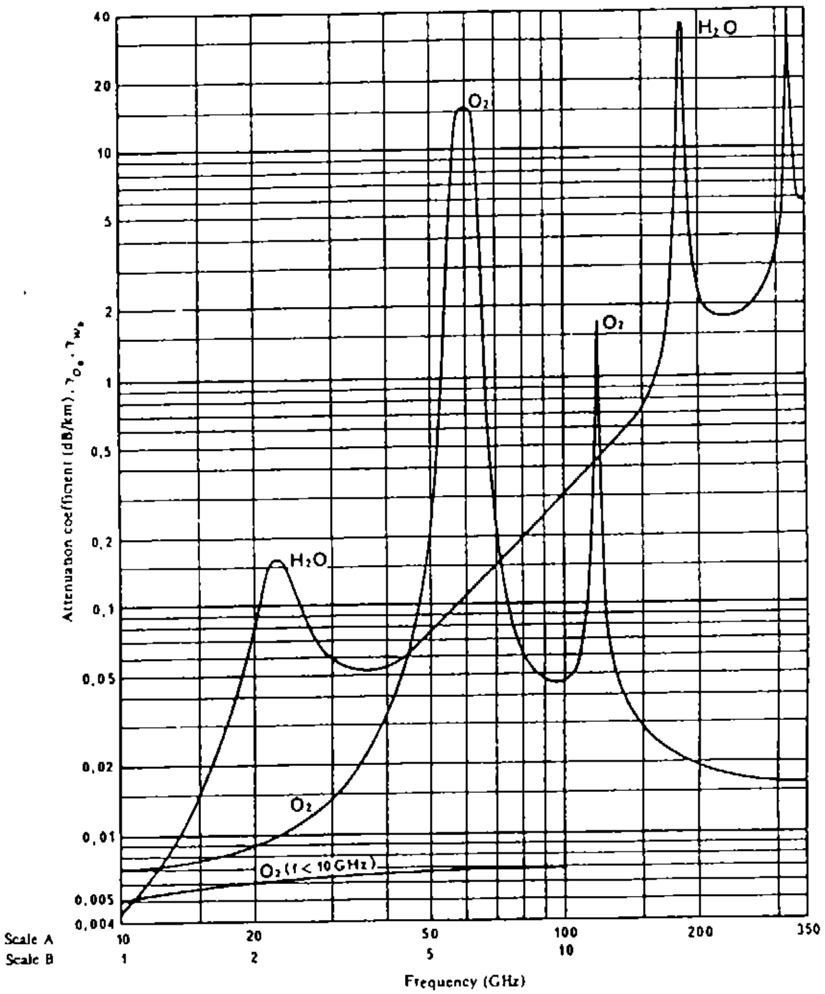



FIGURE 6.1 Atmospheric attenuation by oxygen and water vapor. Use Scale B for oxygen absorption below 10 GHz. Pressure, 1 atm (1013.6 mb), temperature, 20°C, water vapor density, 7.5 g/m³. From CCIR Rep. 719 (Ref. 2). Courtesy of ITU-CCIR, Geneva

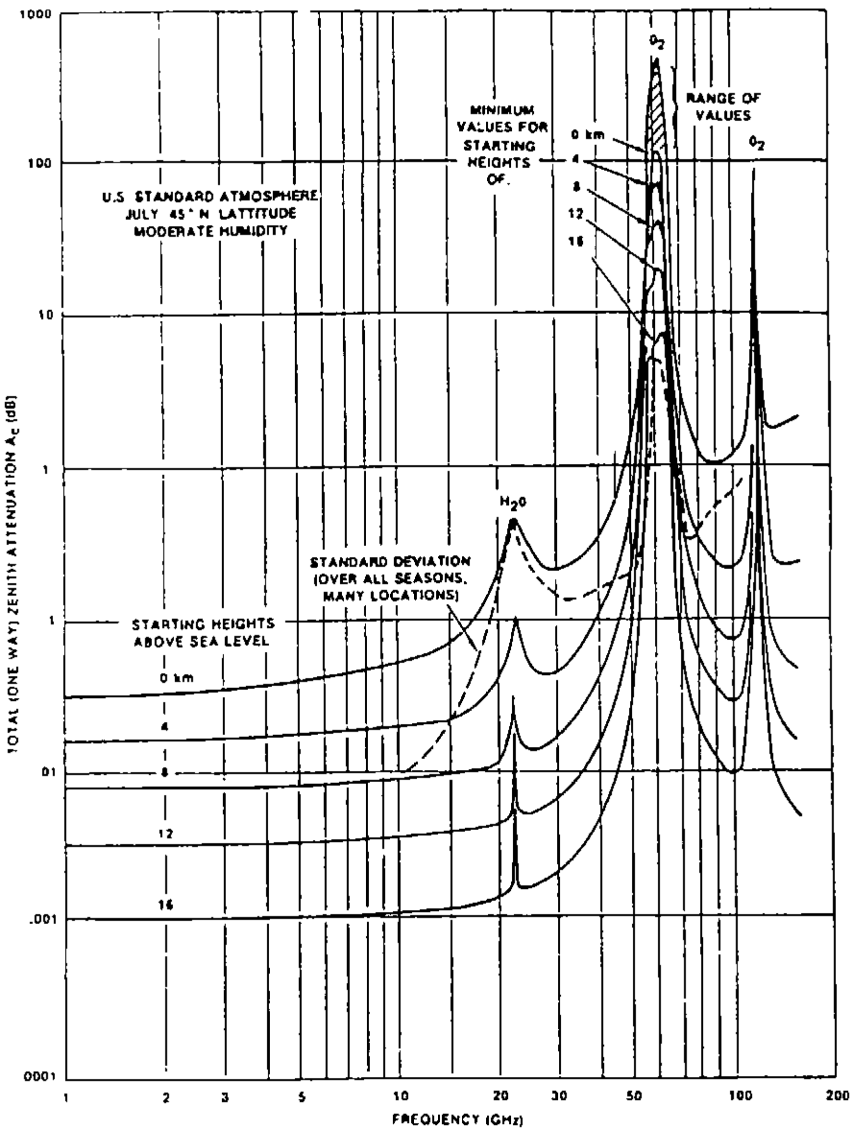
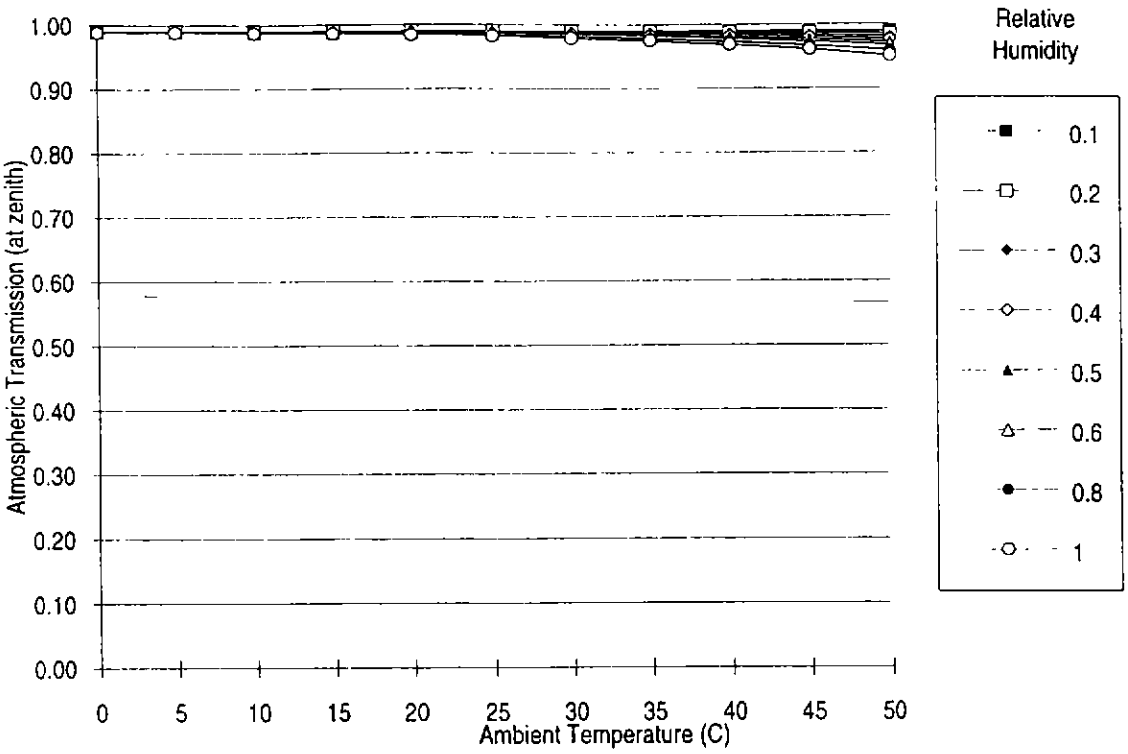
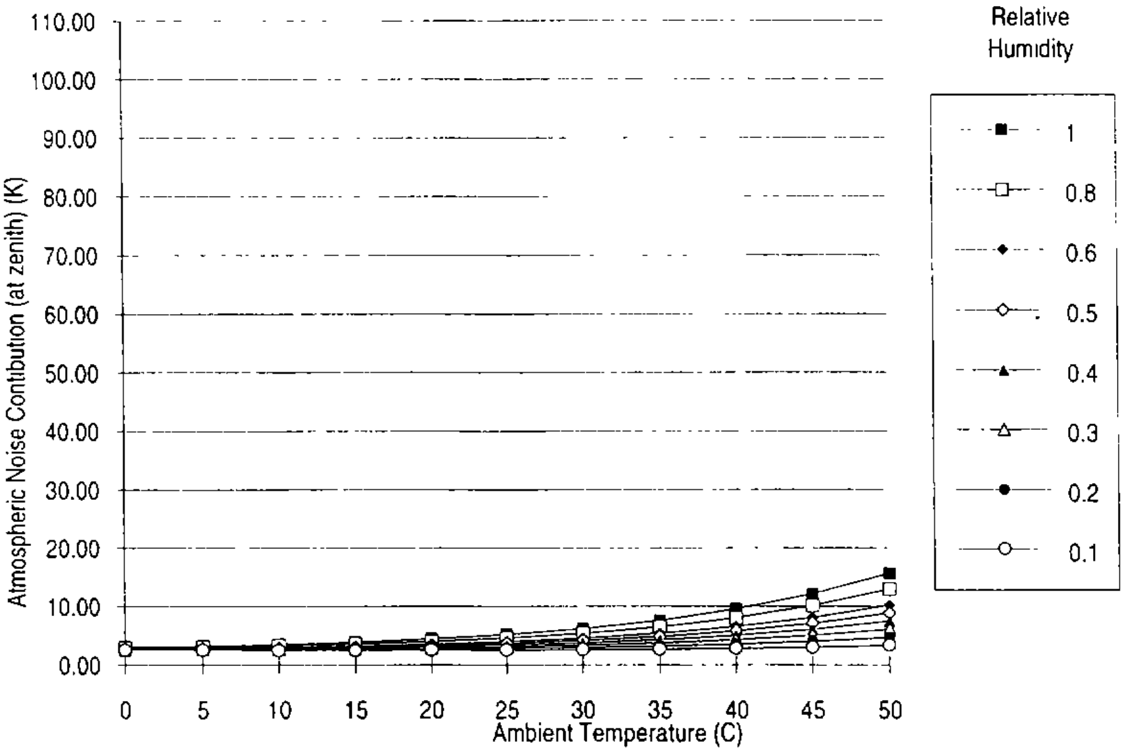



FIGURE 6.16 Total zenith attenuation versus frequency (from Ref. 11)

Fig. 1. Atmospheric attenuation by oxygen and water vapour[1].

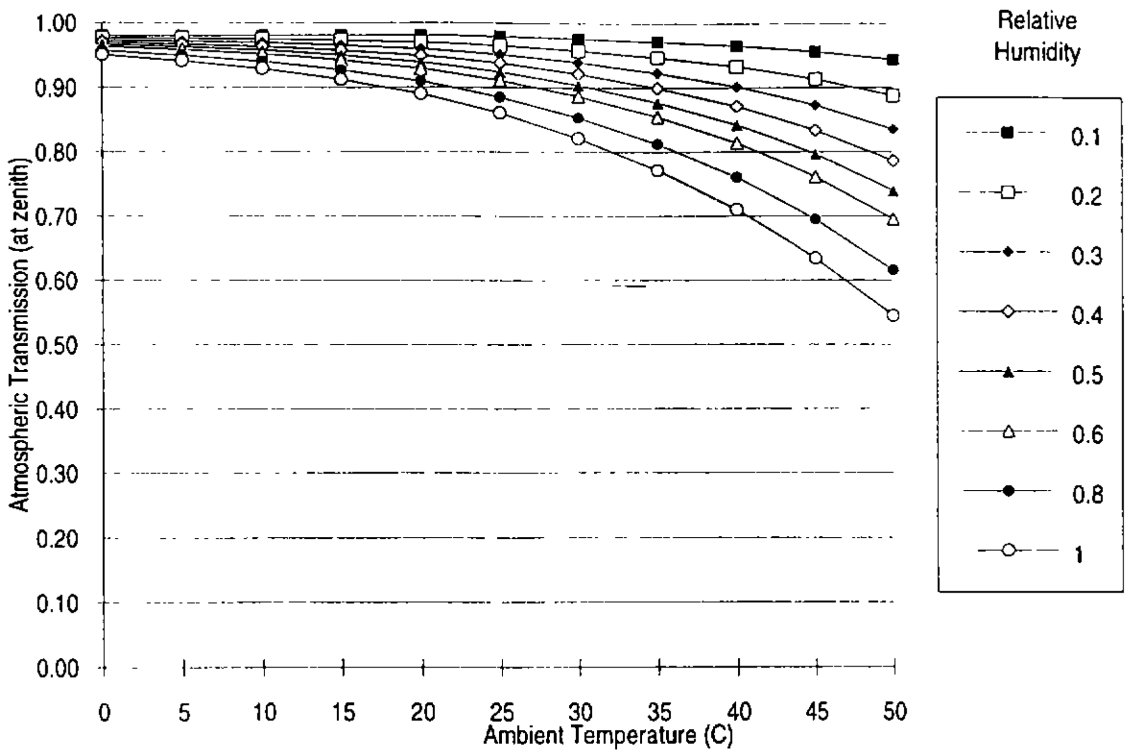



**(a)**

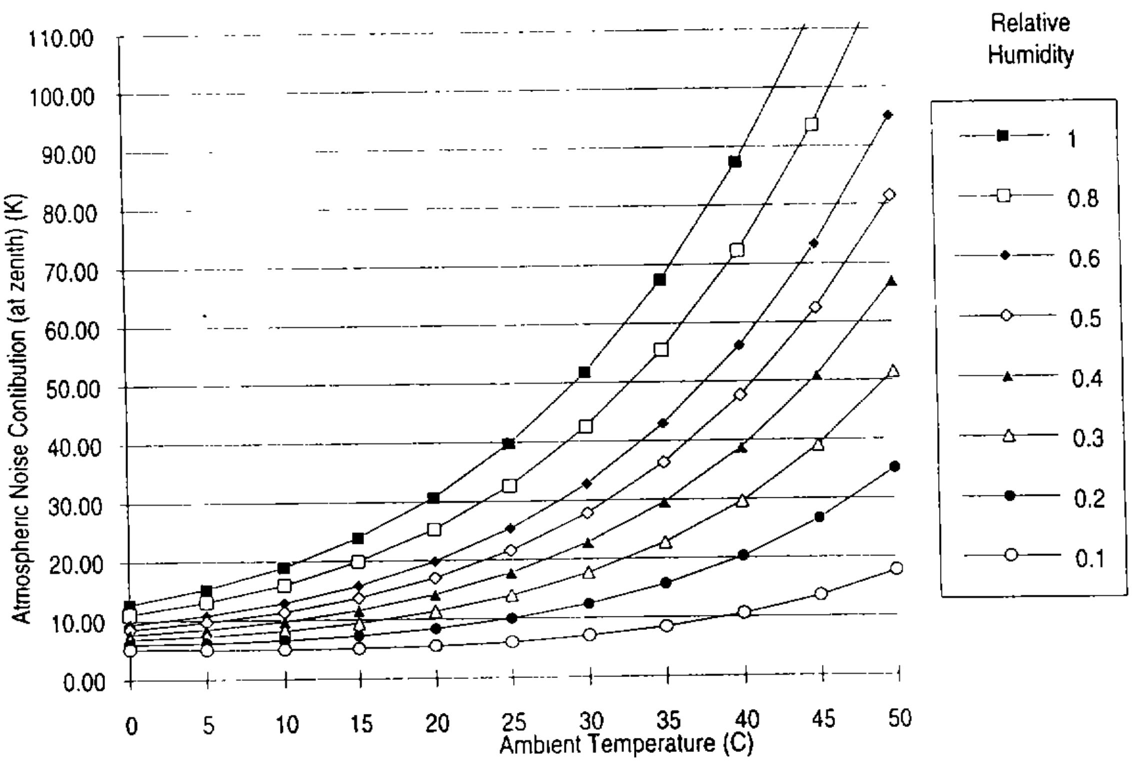



**(b)**

Fig. 2. Frequency = 8.6 GHz
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith

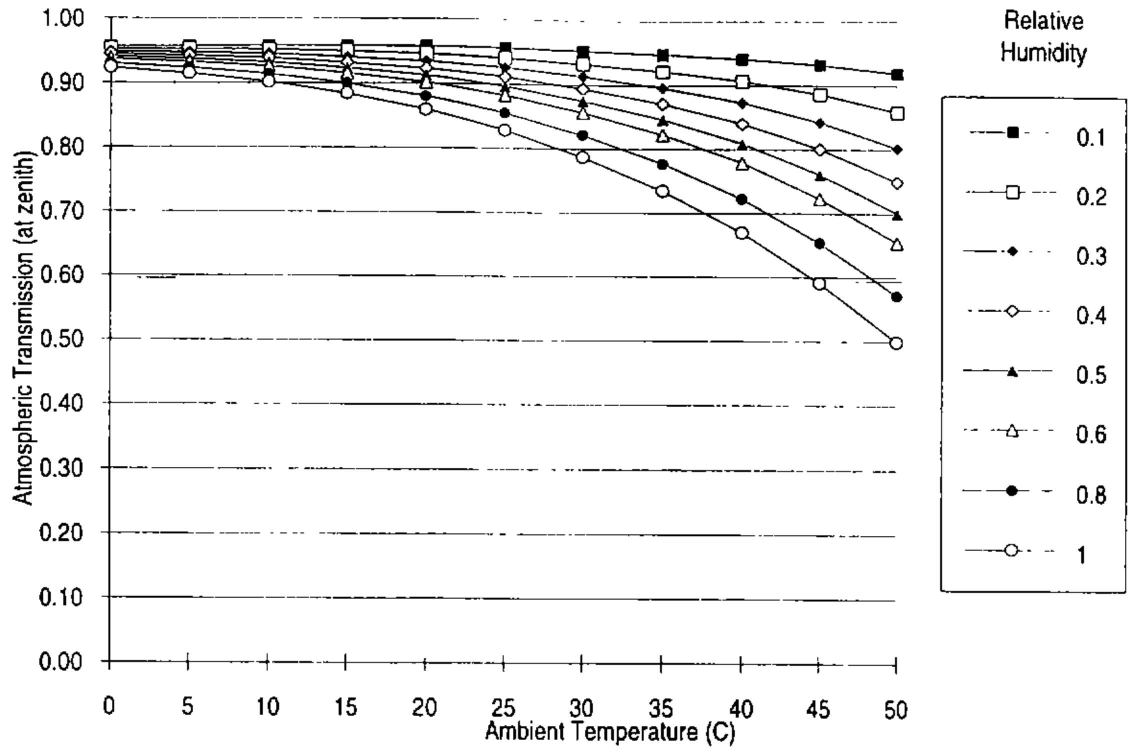



**(a)**

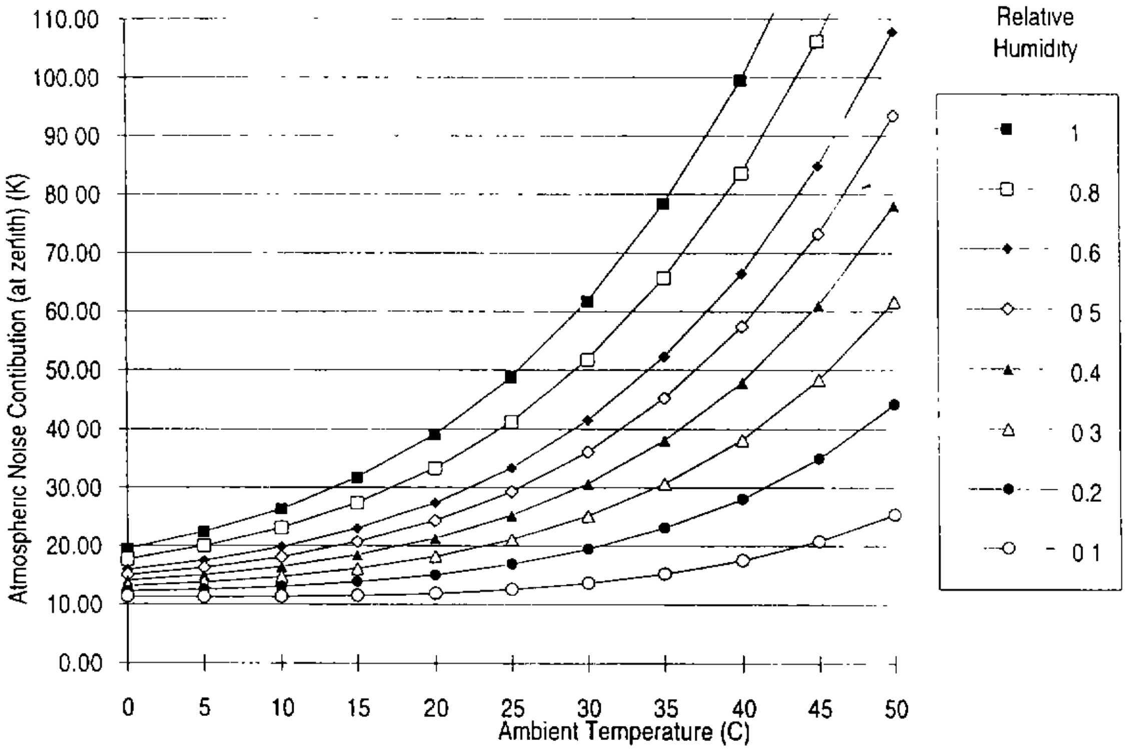



**(b)**

Fig. 3. Frequency = 35 GHz
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith

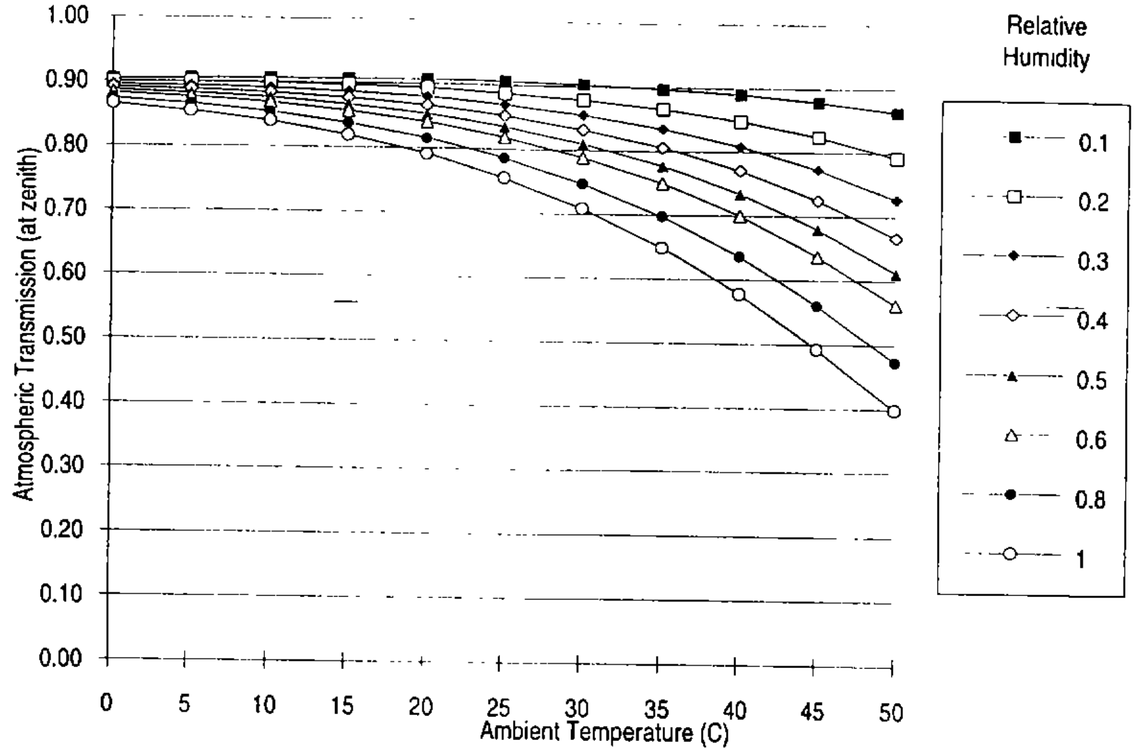



**(a)**

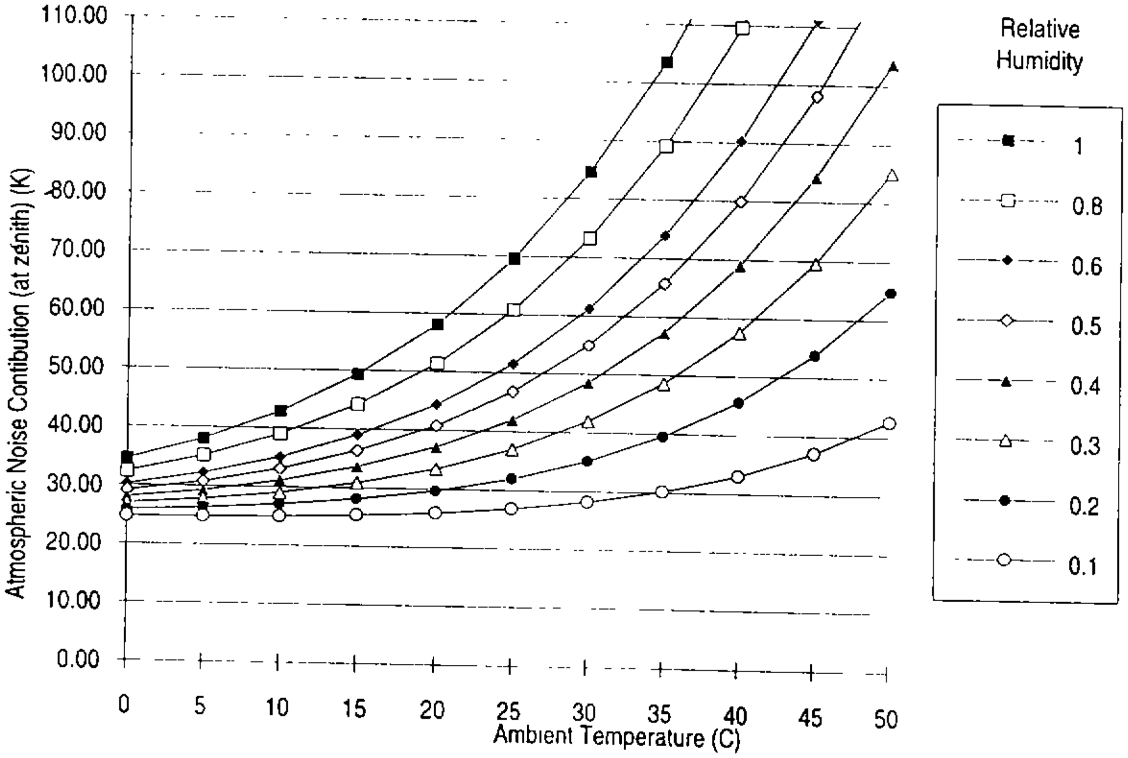



**(b)**

Fig. 4. Frequency = 40 GHz
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith




**(a)**




**(b)**

Fig. 5. Frequency = 45 GHz
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith

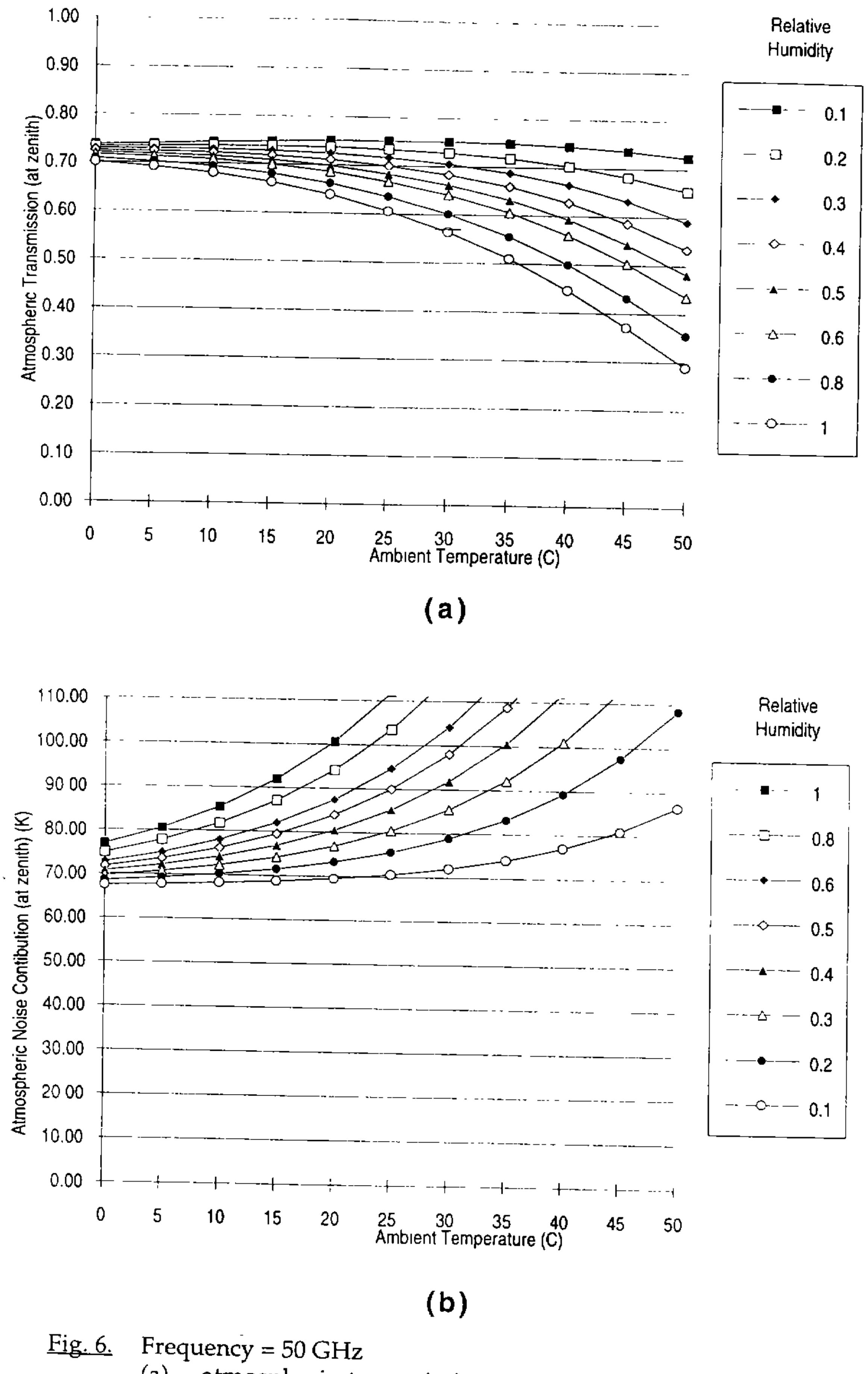
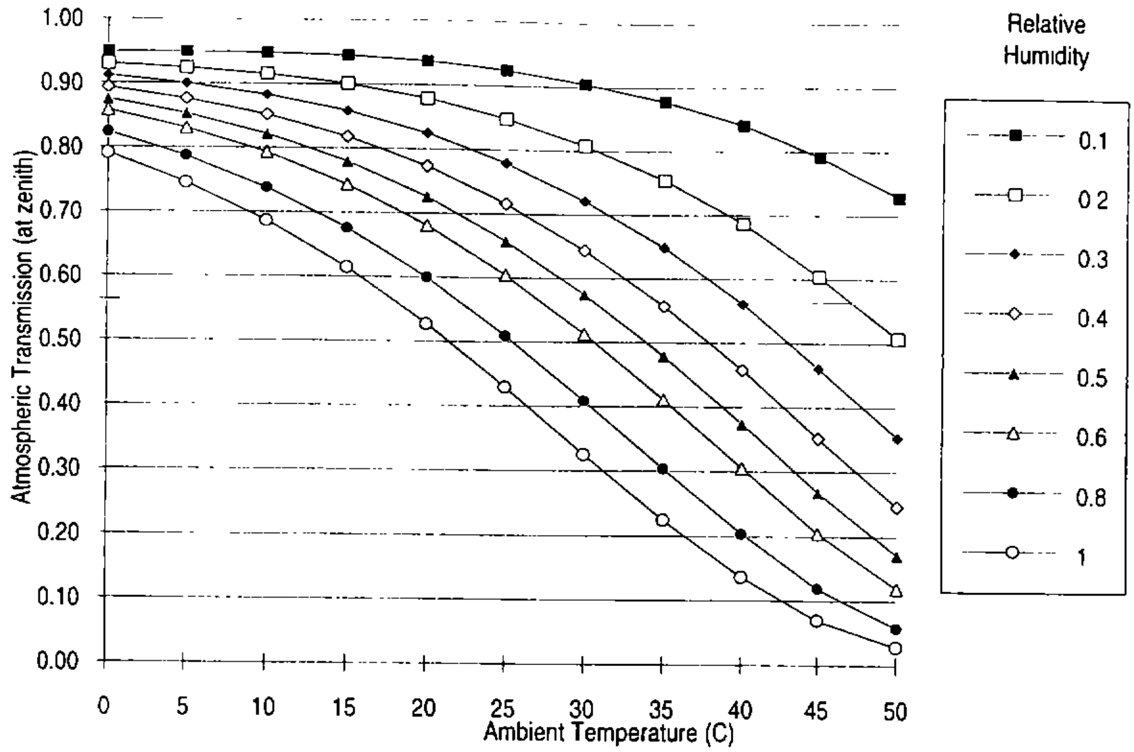
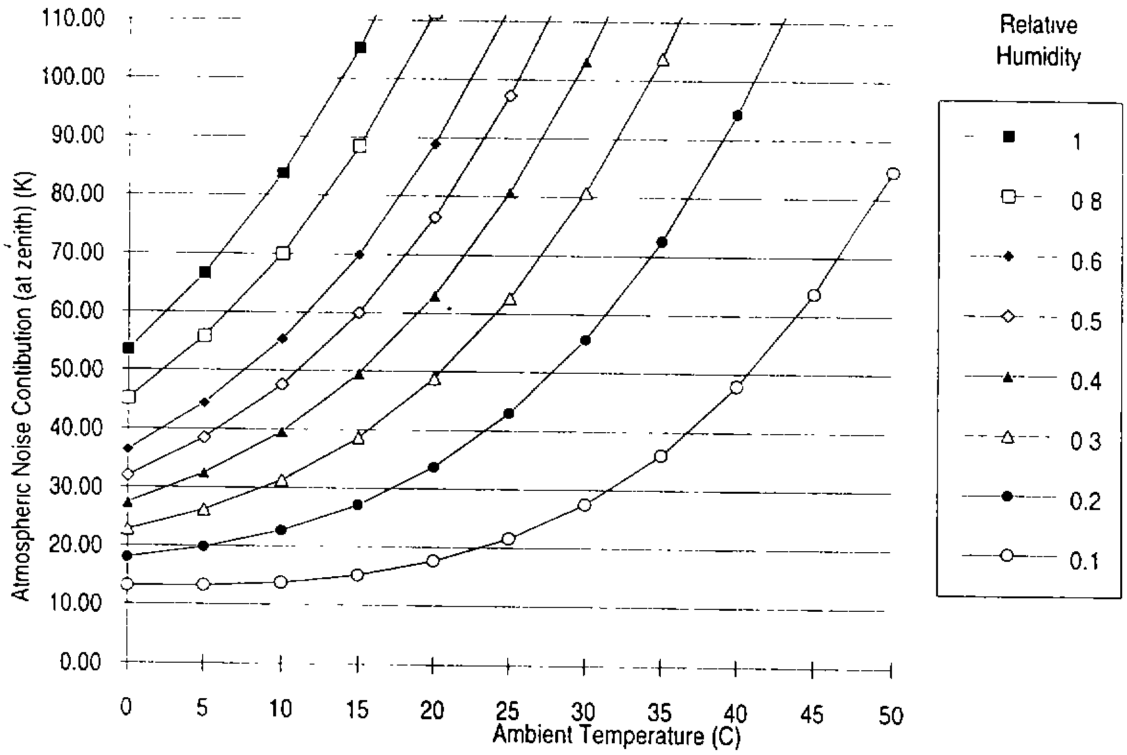



Fig. 6. Frequency = 50 GHz
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith




**(a)**




**(b)**

Fig. 7. Frequency = 100 GHz
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith

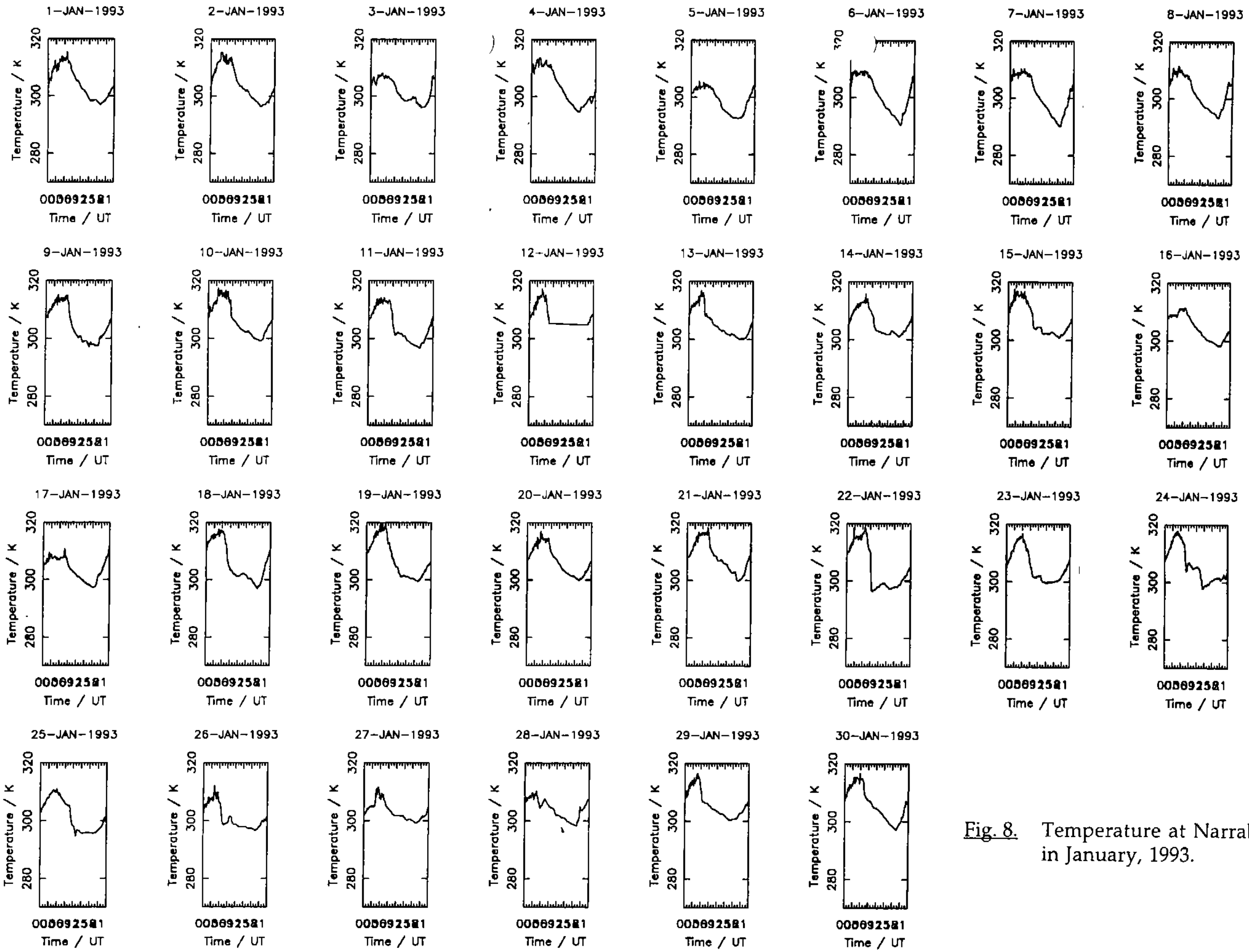



Fig. 8. Temperature at Narrabri in January, 1993.

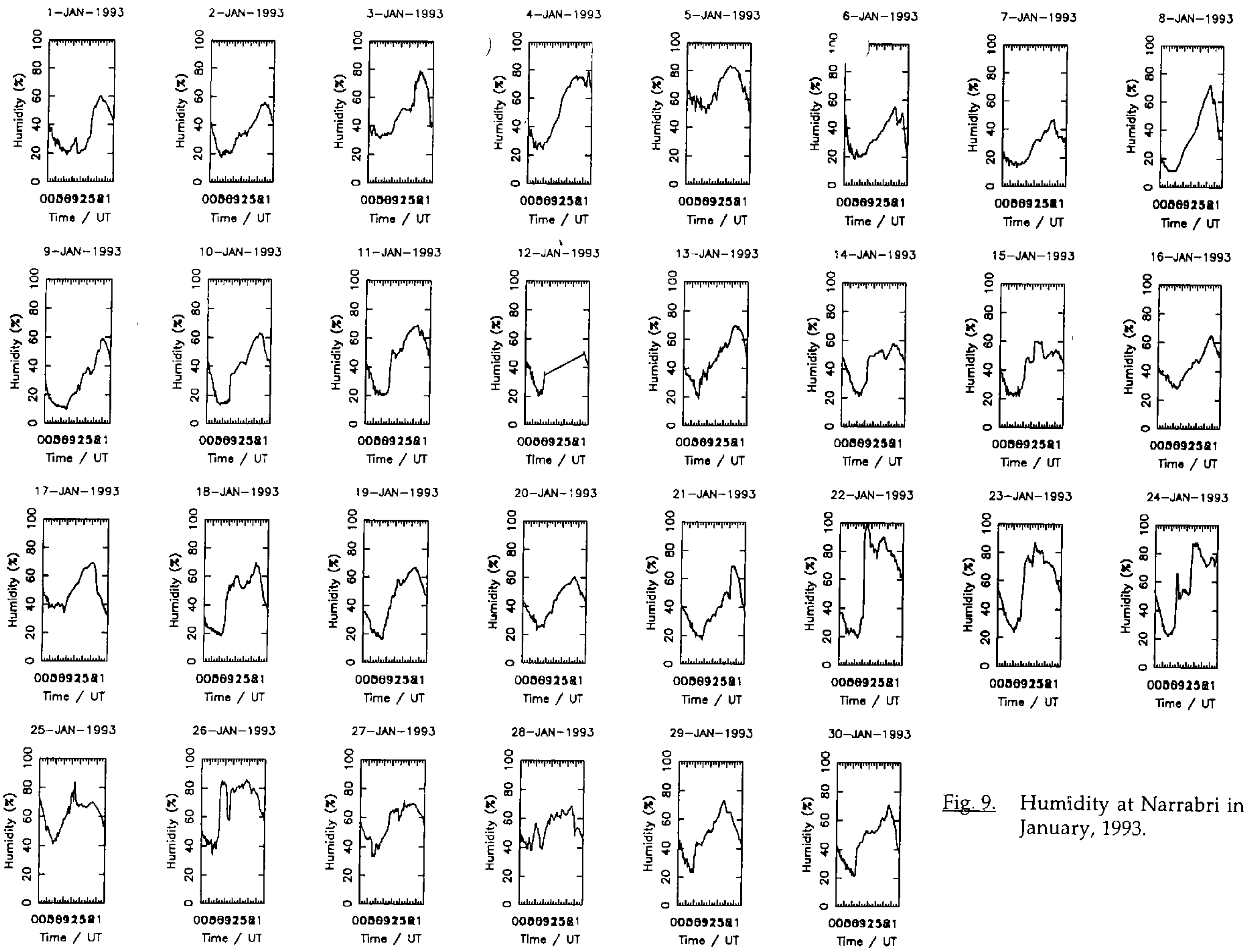



Fig. 9. Humidity at Narrabri in January, 1993.

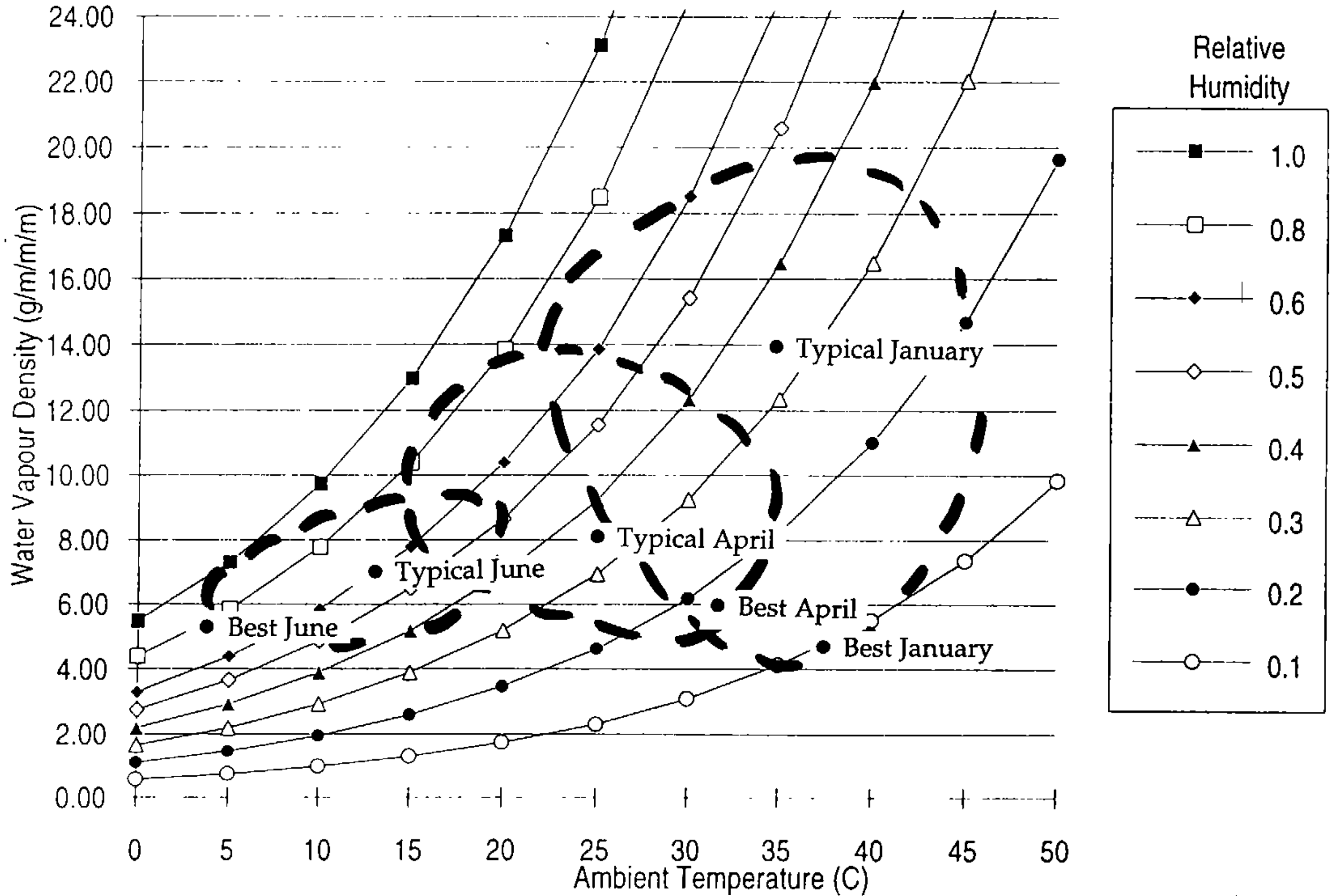
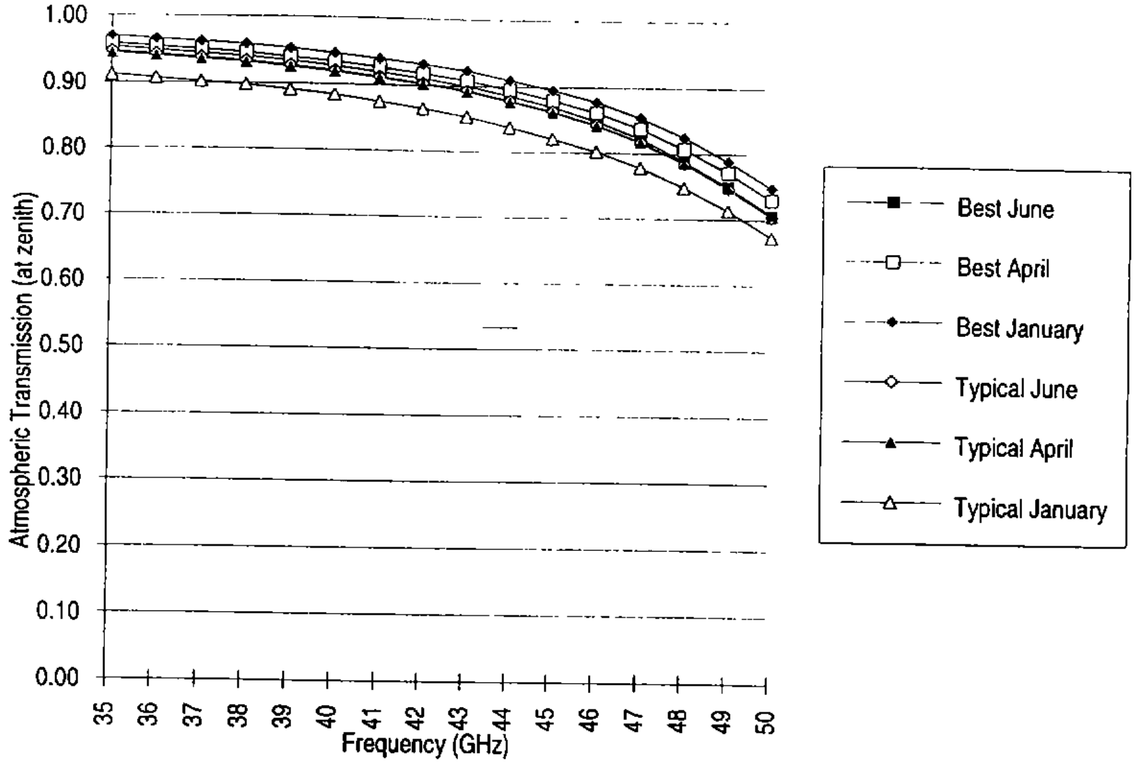
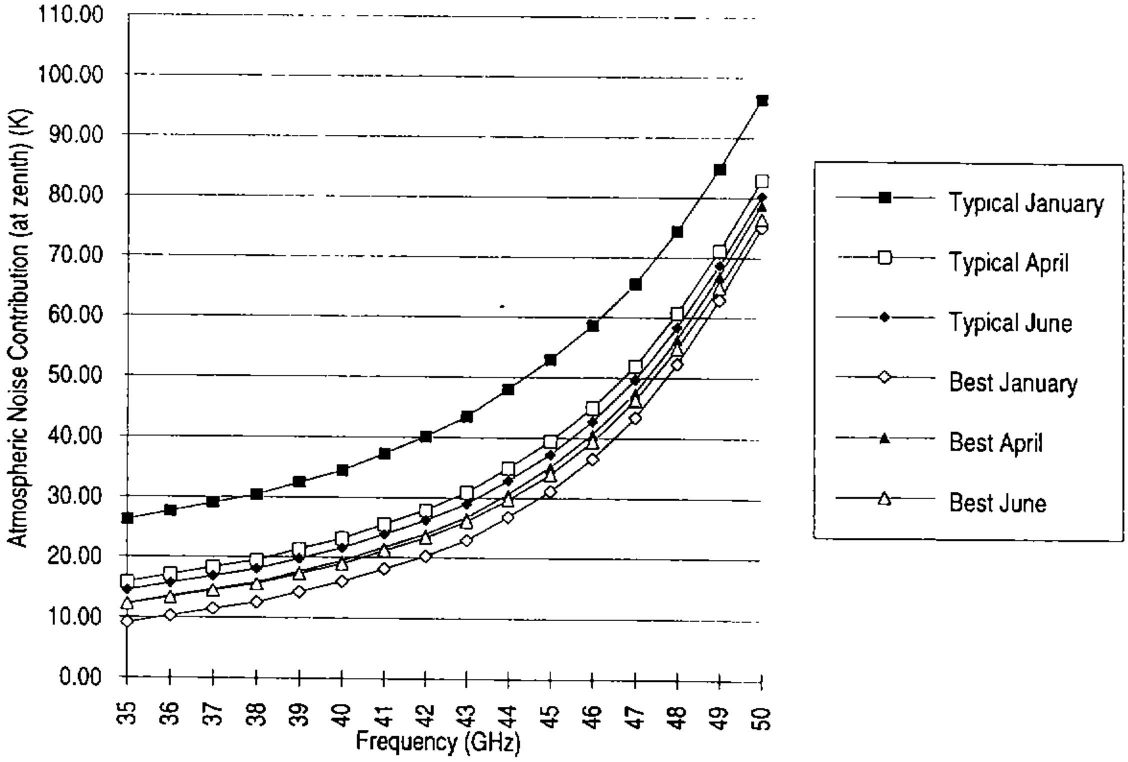



Fig. 10. Water vapour density as a function of temperature and relative humidity. Also indicated are the range of temperature and humidity, and typical and best observing conditions at Narrabri in January, April and June, 1993.




**(a)**




**(b)**

Fig. 11. Typical and best observing conditions at Narrabri in January, April and June, 1993
(a) atmospheric transmission at zenith
(b) atmospheric noise contribution at zenith