ALMA Memo 334.1 Atmospheric Transparency at 225 GHz over Chajnantor, Mauna Kea, and the South Pole

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2000 November 10
revised 2000 November 29

Abstract

Measurements of the 225 GHz atmospheric transparency with functionally identical tipping radiometers at Mauna Kea, the South Pole, and Chajnantor indicate periods of excellent observing conditions at all three sites. Conditions at Chajnantor and the South Pole are better than at Mauna Kea. The first quartile zenith transparency at Chajnantor and the South Pole are roughly equal. During the best conditions at Chajnantor, however, the zenith transparency is better than during the best conditions at the South Pole.

Introduction

Three premier sites for millimeter and submillimeter wavelength astronomy are Mauna Kea, the South Pole, and the ALMA site near Cerro Chajnantor, Chile. Functionally identical 225 GHz tipping radiometers have been operated at all three sites to gauge observing conditions. This memo compares the results from these measurements.

Instruments

The NRAO tipping radiometers (Memos 40 & 41) are DSB heterodyne receivers operating at 225 GHz. An internal chopper continuously switches the receiver input between two calibration loads (45°C and 65°C) and an offset parabolic mirror that scans the sky. The atmospheric transparency is determined by measuring the sky brightness at different zenith angles. Several tippers were constructed in the mid-1980s and operated at various sites under consideration for the Millimeter Array project (Memos 19, 45, 49, 51, 68, 79, & 118). Although different computers and software have been used to control the tippers at different sites, the radiometers are functionally identical and the measurements are directly comparable.

One tipper been in service at the Caltech Submillimeter Observatory on Mauna Kea (4100 m altitude) since 1989 August with only brief interruptions. Transparency measurements are made every 10 minutes. For the period considered in this memo, 1997 January to 2000 October, data are available 76% of the time. These data are consistent with previously reported data from 1989–1993 (Memos 79 & 118; Masson 1992).

Another tipper was deployed to the South Pole (2835 m) in 1992 (Chamberlin & Bally 1994, 1995), where it operated about 75% of the time. The interval between successive transparency measurements alternated between 8 and 36 min.

Since 1995 April, NRAO has operated a radiometer at the ALMA site (5060 m) near Cerro Chajnantor, Chile (Radford & Holdaway 1998). Transparency measurements are made every 10 min, but every 4.5 h, these are suspended for one hour while the receiver measures fluctuations in the sky brightness. Through 2000 September, this instrument has operated 81% of the time. Because of Y2K jitters and various instrument failures, however, data are sparser in 2000 than in earlier years.

Data

It comes as no surprise that all three sites have periods of excellent observing conditions. The cumulative distributions of the measured 225 GHz zenith optical depths, τ_{225}, show significant differences (Figure 1). Chajnantor and the South Pole are clearly superior to Mauna Kea. The comparison between Chajnantor and the South Pole is more complex. The distributions cross near the fortieth percentile. During the best conditions at Chajnantor, the transparency is better than during the best conditions at the South Pole. The distribution at the South Pole, however, is far sharper than at the other sites.

Conclusions

Mauna Kea, Chajnantor, and the South Pole all have periods of excellent observing conditions for millimeter and submillimeter wavelength astronomy. At 225 GHz, the atmospheric transparency over Chajnantor and the South Pole is better than over Mauna Kea. The first quartile zenith transparency at Chajnantor and the South Pole are roughly equal. During the best conditions at Chajnantor, however, the zenith transparency is better than during the best conditions at the South Pole.

Acknowledgements

Frazer Owen, Mark Holdaway, Gerry Petencin, and Scott Foster spearheaded deployment of the tipping radiometer to Chajnantor and developed the NRAO analysis software. Angel Otárola keeps the instruments functioning smoothly at Chajnantor.

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Table 1: 225 GHz optical depths (τ_{225})

		Chajnantor	Mauna Kea (CSO)	South Pole
	start	1995 Apr	1997 Jan	1992 Jan
	stop	2000 Jul	2000 Oct	1992 Dec
	25 %	0.036	0.058	0.043
at zenith	50 %	0.061	0.091	0.053
	75 %	0.115	0.153	0.066

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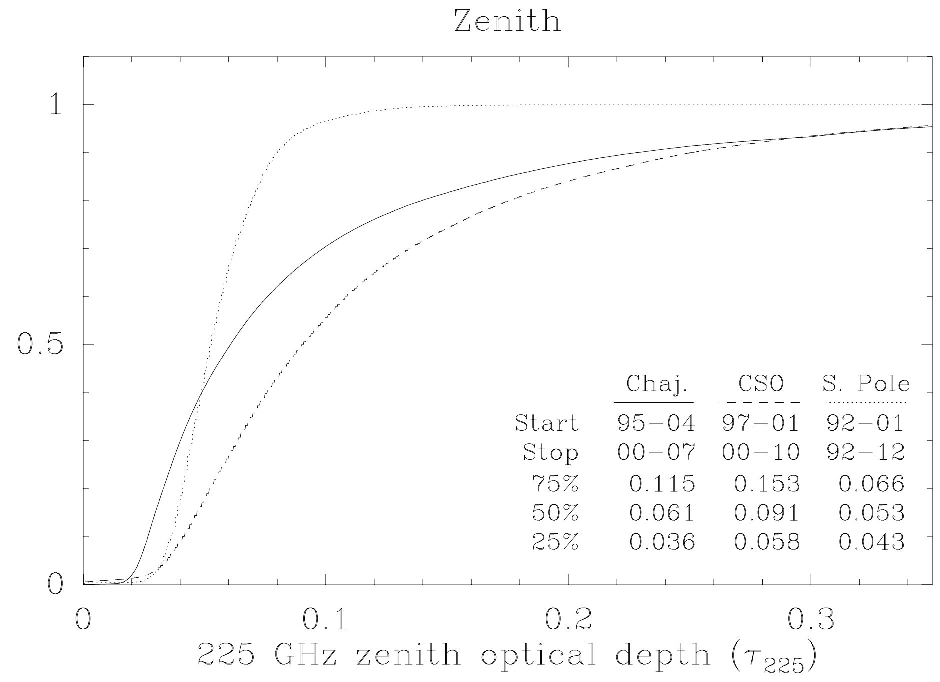

Figure 1: Cumulative distributions of the 225 GHz zenith optical depth (τ_{225}) measured at Chajnantor, at the CSO, and at the South Pole.