

Dome C, Antarctica: the Best Accessible Sub-millimetre Site on the Planet?

P.G. Calisse¹, M.C.B. Ashley¹, M.G. Burton¹, J.S. Lawrence¹, T. Travouillon¹, J.B. Peterson², M.A. Phillips¹, S.J.E. Radford³, and J.W.V. Storey¹

¹ School of Physics, University of New South Wales, Sydney, NSW 2052 Australia
pcalisse@phys.unsw.edu.au

² Department of Physics, Carnegie Mellon University, PA, 15213 USA

³ National Radio Astronomy Observatory, Tucson, AZ 85721-06625 USA

Abstract

The French-Italian station of Dome Concordia (lat. 76° S; long. 123° E; alt. 3,260 m) will be operating year-round from January 2005, offering a new outstanding opportunity for the deployment of instrumentation for sub-millimetre astronomy. In early 2003, SUMMIT, a tipper operating at 350 μm , was deployed to the site. A preliminary analysis of the winter sub-millimetre opacity data obtained is presented.

1 SUMMIT and the NRAO Sub-millimetre Tippers

The sub-millimetre tippers were originally developed at NRAO and Carnegie-Mellon University to monitor the sky opacity at sub-millimetre wavelengths at different remote sites. They have been installed at Atacama (Chile), Mauna Kea (Hawaii, US), and South Pole (Antarctica). A rugged, low power version, designed to operate unattended on the Antarctic Plateau has been developed at the University of New South Wales. It operated originally at Dome C over the summer of 2000–01, gathering the first sub-millimetre data from this site [1]. The instrument then spent two years at the South Pole, to perform a cross-calibration with the NRAO tipper permanently installed at that site. This calibration demonstrated consistency between the two instruments.

The tippers operate at a central frequency of about 350 μm (857 GHz) with a bandwidth of 108 GHz. A rotating 45° parabolic off-axis mirror allows measurement of the flux received from the atmosphere at different airmasses from 0 to 90 degrees zenith angle. Two blackbodies, maintained at different temperatures, allow an absolute calibration of the instrument. The two blackbodies are respectively maintained in thermal contact with the external environment (cold) and the inside of the supporting module AASTINO (warm), kept warm by the waste heat generated by the electrical power generator.

A radome with a transmission of 78–80% protects the system from the atmospheric agents. The beam from the sky (or from the blackbodies) is directed through a chopper, and then to a blocking filter, to an 857 GHz mesh filter and finally to a Barnes pyroelectric detector. Since February 2003 SUMMIT has been operating on the roof of the AASTINO (Automated Astrophysical Site Testing International Observatory), an automated, self powered module installed by UNSW at Dome C. The instrument continuously acquired data until communication with the AASTINO stopped on the 1st of July 2003.

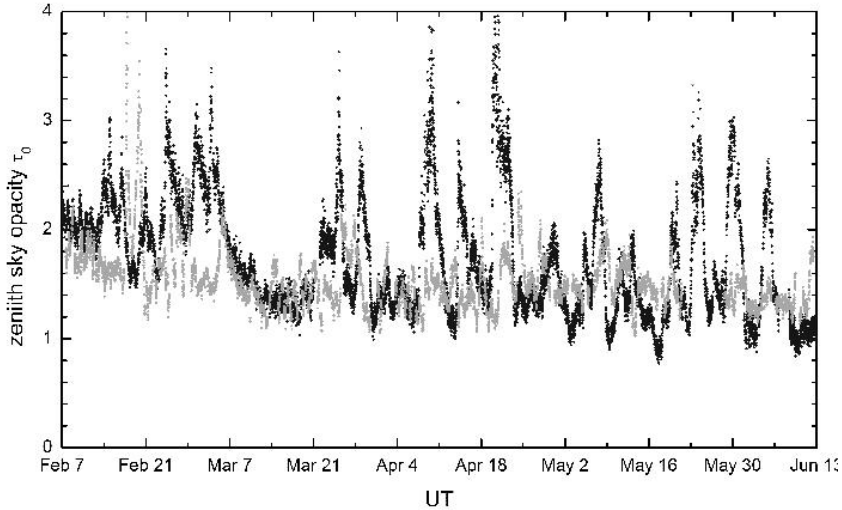


Fig. 1. Data acquired at Dome C by the SUMMIT (grey data points) compared to data acquired by the NRAO tipper at South Pole (black data points) during the same period in winter 2003

2 Opacity and Atmospheric Noise at 350 μm

Because water vapor lines cause the majority of the atmospheric attenuation at sub-millimetre wavelengths, the ideal observing site will be very high and very dry. In addition, the requirement for long integration times implies a site with stable atmospheric conditions – preferably for many hours at a time. Finally, interferometry demands good atmospheric phase stability for as long as possible and over spatial scales of a kilometre or more.

The sky opacity variability in the sub-millimetre regions depends principally on fluctuations in the precipitable water vapor content of the atmosphere. The residual zenith opacity, estimated to be about 0.7–0.8 at the

elevation of Dome C for broadband instruments like the tippers, is described as dry-air opacity. However, observations carried out at South Pole at 450 m with the Viper sub-millimetre telescope, suggest that the atmospheric noise at this wavelength is not completely correlated with the zenith opacity, but can vary over a wide range – more than a factor of 10 – even when the sky opacity reaches very low values.

Dome C, Antarctica, is potentially an outstanding sub-millimetre site. With a pressure altitude approaching 4,000 m in winter, significantly lower precipitable water vapor than even the South Pole, and a remarkably stable troposphere with very low wind speeds at all altitudes, it is possibly the best accessible sub-millimetre site in the world.

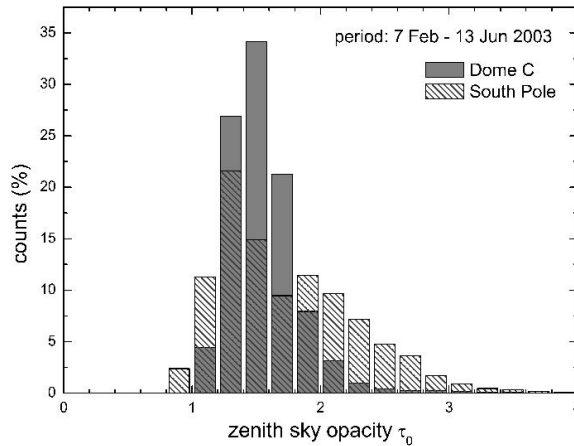


Fig. 2. Histogram of opacity data as obtained by the previous figure data

3 Data Analysis and Results

The first data obtained during summer 2000-01 at Dome C were encouraging, and show a significantly lower overall opacity than the South Pole [2, 3]. A preliminary analysis of data acquired at Dome Concordia during winter 2003 (see Figure 1) shows a more stable atmosphere than the South Pole and indeed any other site tested so far. Only in a few cases does the zenith sky opacity exceed 2 (see Figure 2).

However, because of the possible formation of a thin layer of ice on the inner surface of the SUMMIT radome, data in Figure 1 and 2 may contain an opacity offset of about 0.2 and the real opacity at the site could be, on average, even better. Simulations have shown that any such ice layer should not affect the shape of the distribution at low ($\tau = 2$) opacity values.

Acknowledgments

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References

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