Dome C, Antarctica:
the best accessible submillimeter site on the Planet?

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Abstract

The French-Italian station of Dome Concordia (lat. 76° S; long. 123° E; alt. 3,205 m) will be operating winter over since January 2005, offering a new outstanding opportunity for the deployment of instrumentation for submillimeter astronomy. In summer 2003, SUMMIT, a tipper operating at 350 μm, has been deployed at the site. A preliminary analysis of the winter submillimeter opacity data obtained is presented.

1. SUMMIT and the NRAO Submillimeter Tippers

The submillimeter tippers were originally developed at NRAO and Carnegie-Mellon University to monitor the sky opacity at submillimeter 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 submillimeter data from this site [2]. 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 black bodies, 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 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.

2. Opacity and Atmospheric Noise at 350 μm

Because water vapor lines cause the majority of the atmospheric attenuation at submillimeter 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 kilometer or more.

The sky opacity variability in the submillimeter 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 μm with the Viper submillimeter 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-mm 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-mm site in the world.

3. Data analysis and results

The first data obtained during summer 2000–01 at Dome C were encouraging, and shown 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, in the average, even better. However, simulations shown that the ice should not affect the shape of the distribution at low ($\tau \leq 2$) opacity values.

Acknowledgments

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References

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[2] Calisse, P, G. et al., 2003, PASA, accepted.
[3] Calisse, P. G., 2003, submitted to PASA.

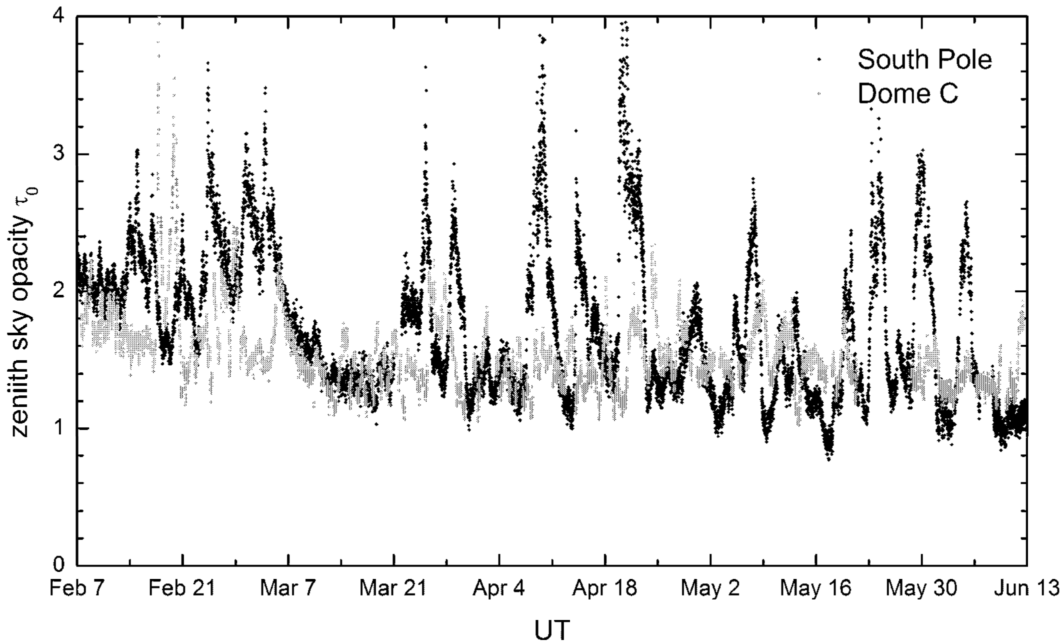

Figure 1 – Data acquired at Dome C by the SUMMIT compared to data acquired by the NRAO tipper at South Pole during the same period in winter 2003.

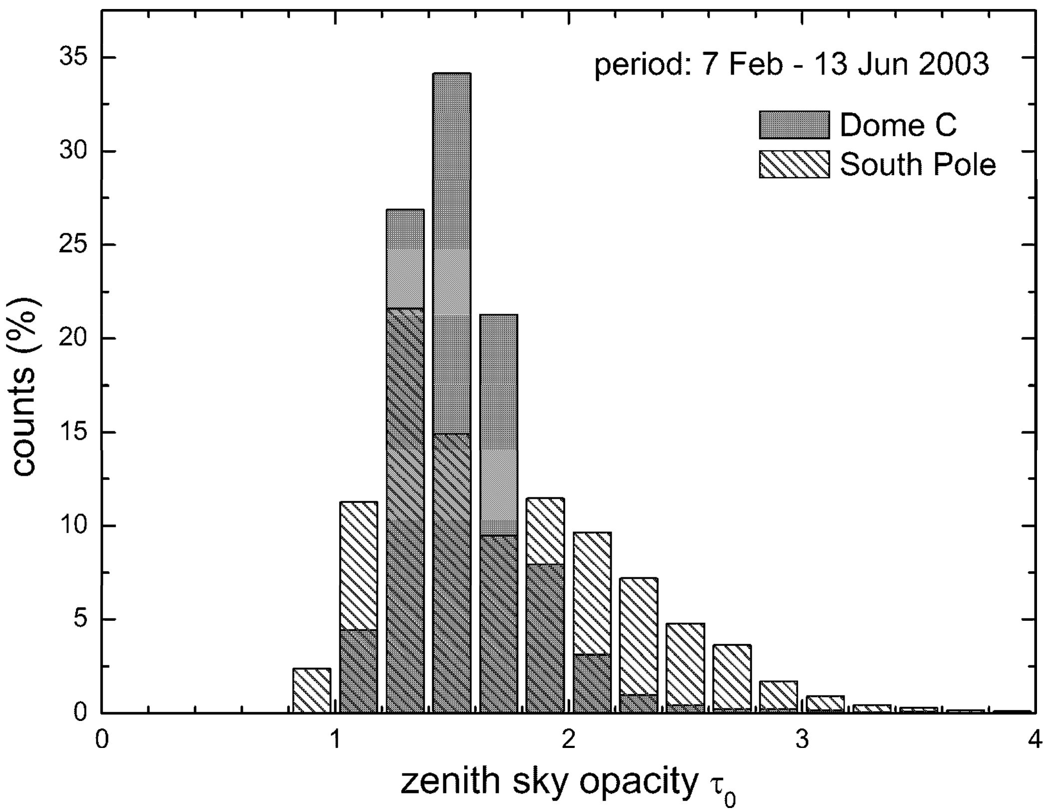

Figure 2 – Histogram of opacity data as obtained by the previous figure data.