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COBBER: A Pocket Cloud Detector for Dome C

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Abstract. COBBER (ClOud OBservER), is a mid-infrared sky monitor featuring a 10μm Perkin-Elmer TPS534 thermopile detector. Radiation is focussed on to the detector through an anti-reflection coated, hemispherical ZnSe lens, providing a 30° field of view on the sky. At 10cm in length and 4cm diameter, the tiny cloud monitor was designed for ease of transportation and an extremely low power budget. Run in conjunction with ICECAM, it uses power supplied by lithium thionyl chloride ($LiSOCl_2$) batteries. COBBER is powered up by the ICECAM system once every two hours, sending its data to Sydney via the ARGOS satellite link. The instrument was installed at Dome C in January of 2003, and has been collecting data continuously from this date. In over 70 observing days, only four days of cloud have been recorded, results which have been confirmed by a webcamera installed at Dome C as part of the AASTINO project.

Key words. site testing – Antarctic astronomy – cloud monitoring

1. Introduction

COBBER was first designed in late 2001, to add to the complement of instruments on the Australian Antarctic Division's Automatic Weather Stations (AWS). At the time, an expedition to Dome A was planned for the approaching summer, and this first journey to the highest point on the Plateau was seen as ideal for the installation of an AWS to log the conditions on the dome, 4200m above sea level. A pivotal piece of information for astronomy, the percentage of cloud cover during the austral winter, could not be provided with the existing AWS system, so COBBER was designed to fill this role.

A test model of COBBER was sent to Dome C with ICECAM (Ashley et al. 2003) in the summer 2001/2002. The cloud monitor was run over the winter to complement ICECAM's data and to check COBBER's durability and performance during the winter months. However, shortly after installation a fault occurred, and the data received showed only a diurnal variation in temperature. When the team returned in late 2002, it was discovered that a loose earth wire was to blame for this malfunction. An improved model was sent down to replace the instrument in the summer 2002/2003. This second COBBER has been successfully collecting data daily from January

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Fig. 1. COBBER, lower left, installed below ICECAM. January 2003

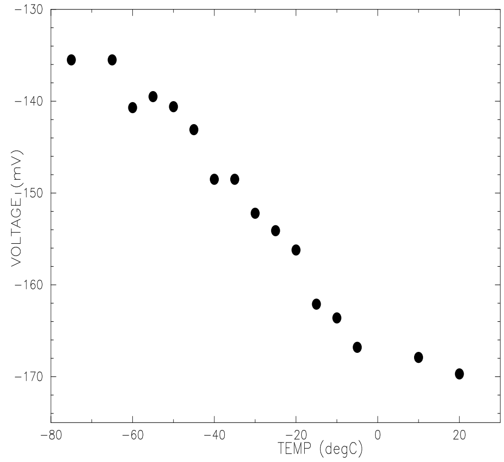

Fig. 2. Signal voltage of TPS534 detector for a source 15°C warmer than ambient, versus ambient (Detector) temperature.

2003. An image of COBBER, installed next to ICECAM, can be seen in Figure 1.

2. Design and Testing

COBBER's basic design was modelled on an instrument built by Clay et. al. (1998). The most significant alterations to this design were to adapt the instrument for the extreme temperatures of a Dome C winter (temperatures down to −80°C) and the long period without any handling or maintenance. All circuit components were carefully selected and rigorously tested in a laboratory freezer down to temperatures below −80°C. The TLC2201 op-amp's excellent stability in freezer tests and an offset drift of only $0.5\mu V/°C$ ensured satisfactory low-temperature operation. Likewise the Perkin-Elmer TPS534 detector was submitted to extensive cold-testing to determine the drop in responsivity, if any, and performance as a function of detector, and source, temperature. The results were encouraging, and can be seen in Figure 2. For a source temperature 15°C hotter than the detector, the detector was cooled from room temperature of 20°C (Responsivity = 12mV/K) down to −80°C (Responsivity = 9mV/K), causing only a 20% drop in performance. The ZnSe lens served a dual function in the design, firstly to limit the instrument's field of view to 30° to eliminate the sun. Secondly, its smooth anti-reflection coated hemispherical surface acts as a deterent to snow build-up on the instrument. The thermopile detector has an integrated IR filter with a passband of 8−12 μm. Twenty-metre long cables connect the device to the ICECAM power supply and DC/DC converter, buried in a crypt beneath the ice. Powering up once every two hours for only a few minutes, the electronics were designed to have a settling time of less than a minute.

3. Results

After installation on January 17th, 2003, COBBER took a measurement once every two hours, and returned the data via an ARGOS satellite link 12 times a day.

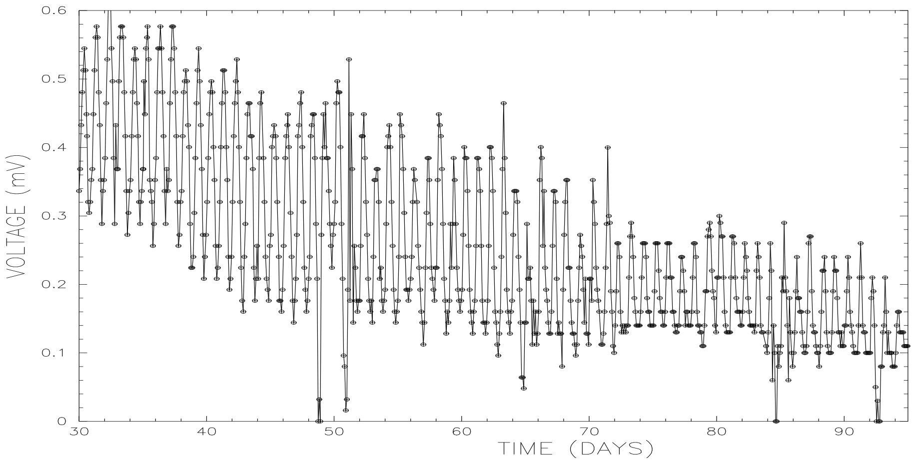

Fig. 3. Full COBBER data set from January to April 2003. Even without removing the diurnal variations caused by the sun heating the instrument, the four recorded days of cloud ($V_{signal} = 0$) are clearly seen.

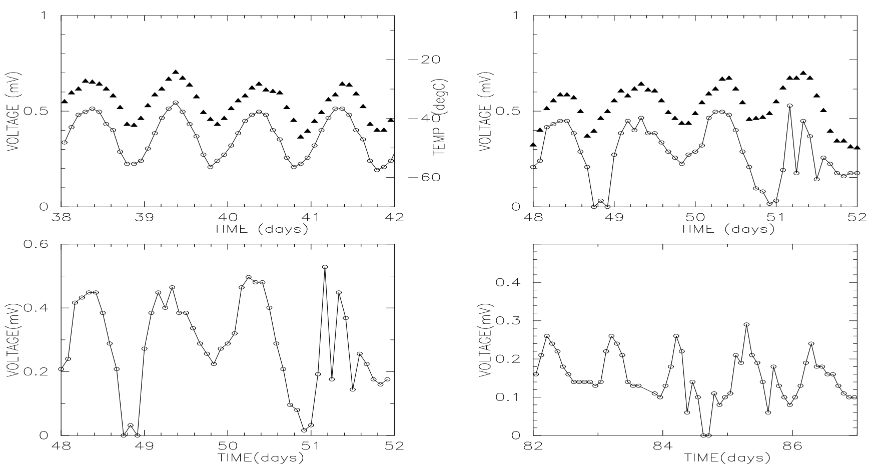

Fig. 4. Top Left: Four clear days (solid line) and $T_{ambient}$(triangles). Top Right: Two clouded days(solid) and corresponding $T_{ambient}$. Bottom Left: Signal strength in February and Bottom Right: Early April. Overcast conditions are still detectable.

Figure 3 shows the full set of data up until the middle of April. The large scale daily variation is due to the diurnal cycle of the sun heating the instrument and its detector, while the daily clear sky temperature remains constant. To show this, the ambient temperature has also been plotted in Figure 4. Cobber's signal can be described simply as

$$V_{signal} \propto T_{detector} - T_{sky} \tag{1}$$

As such, a zero level voltage indicates a completely clouded day ($T_{Detector} \approx T_{Sky}$), whilst a high signal indicates clear conditions ($T_{Detector} \gg T_{Sky}$). In the full data set to this date, only four days of complete cloud were recorded by COBBER. To confirm this encouraging result, the days in question were compared to images from the AASTINO webcamera, Travouillon et al. (2003), which showed that these days were indeed overcast. Figure 4 shows an example of a clear day, in comparison to a cloudy one, with their corresponding ambient temperatures. One detrimental effect of the declining $T_{ambient}$ has been that the ΔT between the sky and detctor is being reduced (this is the drop in signal strength in Figure 3), and so V_{signal} is declining also. The bottom two graphs in Figure 4 compare four days of data taken in early February (bottom left) with four days in early April (bottom right). Though the signal strength in the April data is weaker, overcast conditions can still be detected by a sharp drop to $V_{signal} = 0$.

4. Conclusions

COBBER has produced some useful and informative results during its current installation at Dome C. Its results can be confirmed by the a webcamera currently working at the site, however once the sun sets, only COBBER and ICECAM will be able to detect clouds. Future versions of the detector are planned for an Automated Weather Station at Dome A and other potential astronomical sites in Antarctica, and development and testing continues to improve the device for this eventuality.

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