Atmospheric Monitoring For The H.E.S.S. Project

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Abstract

Several atmospheric monitoring devices have been installed at the H.E.S.S. site in Namibia. Firstly, Heitronics KT19 infrared radiometers, aligned paraxially with the H.E.S.S. telescopes, measure the infrared radiation of the water in clouds crossing the telescope field of view. Correlations between the trigger rate of the telescope and these IR measurements are shown in this paper. For a general judgment of the atmosphere's transmittance, i.e. the detection of any light-attenuating aerosols, a ceilometer – a LIDAR with built-in atmospheric data reduction code – is being used. The overall status of the weather is monitored by a fully automated weatherstation.

1. Overview

The main causes of extinction of Cherenkov light are absorption and Rayleigh scattering by molecules, and Mie scattering by aerosols. The H.E.S.S. photomultipliers and mirrors are sensitive to light between 250 and 700 nm. In this range the only light-*absorbing* molecule is ozone, but the most significant loss of Cherenkov light in the case of a 'clear' sky is caused by Rayleigh *scattering* off all atmospheric molecules dominant at lower wavelengths due to its λ^{-4} dependance, and Mie scattering on aerosols which becomes dominant above approximately 400 nm [2].

2. Weatherstation

A UK Meteorogical Office approved weatherstation from Campbell Scientific has been installed at the H.E.S.S. site. It records air temperature, relative humidity, atmospheric pressure, wind speed, wind direction and rainfall 24 hours a day. The data acquisition (DAQ) is integrated in the standard DAQ scheme for the camera data and therefore allows efficient cross-checking of atmospheric

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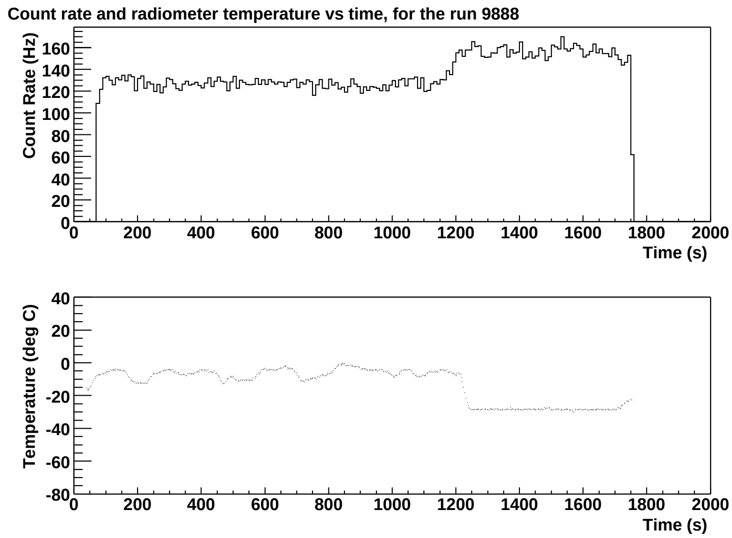

Fig. 1. Correlation between telescope count rate and radiometer temperature due to Cherenkov light absorption by cloud.

conditions and camera data. The weather data are especially important for providing input values for atmospheric models constructed with the commercially available MODTRAN package in connection with radiometer and LIDAR ("*LI*ght *D*etection *A*nd *R*anging") data.

3. The Ceilometer

A Vaisala CT25K Ceilometer has been installed at the site. A Ceilometer is a LIDAR with cloud detection and ranging facility and built in algorithms to invert the received light power to backscatter values in units of $(\mathrm{km} \cdot \mathrm{sr})^{-1}$. Using an InGaAs diode laser working at (905 ± 5)nm, the Ceilometer detects backscatter mainly due to aerosol scattering out to 7.5 km. The backscatter profile can be inverted to recreate the optical density profile for the atmosphere. This profile can be compared to profiles from model atmospheres which then can be used to calculate the extinction in the wavelength range of interest, i.e. 250 to 700 nm. Results of preliminary studies can be found in a parallel paper [1].

4. Infrared radiometer

The Heitronics KT19.82A Mark II is a radiometer designed for measuring the infrared radiation in the transmission window between 8 and 14μm [4]. We use it to measure the infrared radiation from the sky in its field of view of 2.9°. By comparing the observed quantity to a blackbody spectrum, the radiometer then calculates the 'radiative' temperature of the sky. It has been shown [3]

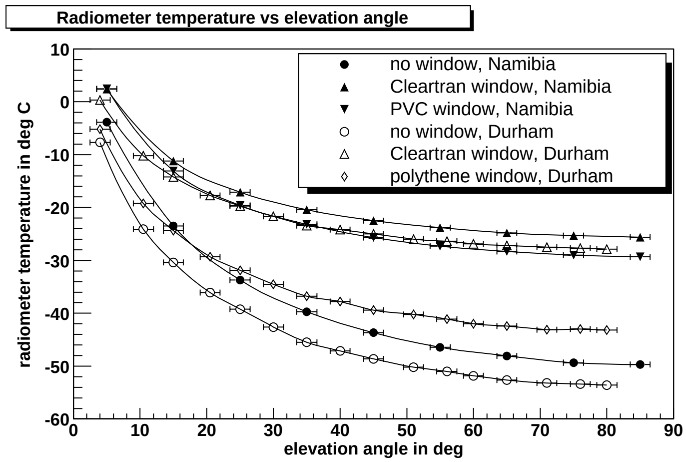

Fig. 2. The relation between sky temperature and elevation angle of the radiometer with different winow materials. Ambient conditions in Namibia: nighttime, $T = 16°C$, rel.Humidity 41%; Durham: afternoon, $T = 5°C$, rel. Humidity $(70 \pm 10)\%$

that the measured sky temperature is very sensitive to the presence of clouds and water vapour which is crucial for determining the cause of a variation in the count rate of an IACT. Although clouds are not significantly warmer than the surrounding atmosphere, they are more effective emitters of blackbody radiation than the atmosphere in this wavelength range. If there are no clouds, the temperature still can vary from night to night due to relative humidity and temperature changes which may induce ice crystallisation on aerosols and therefore change the scattering phase function of Mie scattering.

Two of the planned four telescopes of H.E.S.S Phase 1 are presently operational and on each of them a radiometer is installed paraxially to provide an immediate means of cloud detection in the field of view of the camera. Figure 1 shows the detection of the clearance of the sky after a period of high cloud. Furthermore a scanning radiometer is installed to give the shift crew an immediate overview of the sky for any presence of clouds or approaching weather fronts.

In addition to detecting clouds, the radiometer data can be used to determine the amount of water vapour contained in the atmosphere, a quantity on which the transmissivity of the latter for Cherenkov light depends. Such a measurement is not trivial. The temperature measured by the radiometer depends on several parameters: the temperature and water vapour profile of the atmosphere, the observing zenith angle, and the material of the window used to protect the instrument from the weather. Semi-empirical models like the one from Idso [5] try to relate the infrared flux detected by the radiometer to the temperature and the water vapour pressure measured at ground level in a quantitative way. Indeed, we have measured such a correlation in our data, but nevertheless this model is not satisfactory and a suitable one has yet to be found.

4.1. Zenith angle and window material dependencies

The temperature measured with the radiometer for a clear sky increases with the zenith angle due to a thicker section of the warm atmosphere being sampled [3]. In figure 2 one can see the zenith angle dependence for different window materials in front of the radiometer lens. This window protects the lens of the radiometer from weather, but as it emits in the infrared, its influence on the measured value of the radiometer is quite significant, depending on the chosen material. As one can see it not only increases the measured temperatures, but also alters the sensitivity $(T(\theta_{max}) - T(\theta_{min}))$. For this reason, the thin polyethylene film, whilst less robust than Cleartran^{TM}, is the chosen material for the protective window.

Moreover, the parametrization of the zenith angle dependence of the radiometer measurement can provide a differential estimate of the water vapour content of the atmosphere, which can in turn be related to its profile.

5. Conclusion

To conclude, we can say that the atmospheric monitoring instruments for the HESS experiment are now installed and running. Their observations have yet to be understood in some details and exploited to a fuller degree in order to let them allow us to estimate the actual transmissivity of the atmosphere to Cherenkov light to a better extent than so far.

6. References

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