Measurement of UV, visible and NIR radiation in the tropical troposphere and stratosphere with the new NILU-CUBE instrument

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Abstract

As part of the EC-funded Impact of tropical convection on the upper troposphere and lower stratosphere at global scale (HIBISCUS) project, stratospheric balloon flights were made from Bauru, Brazil in February and March 2004. The new NILU-CUBE instrument was part of the payload on two flights. The instrument measures the irradiance on the six faces of a cube. On each face the radiation is measured at 305, 312, 340 nm with a bandwidth of approximately 10 nm at full width half maximum (FWHM). In addition a PAR (photosynthetic active radiation, 400-700 nm) channel measures visible radiation and two channels in the NIR (near-infrared) is used to look for water vapour. Below the new NILU-CUBE instrument and its characteristics are presented. Furthermore, preliminary radiation data from the flights are presented.

The new NILU-CUBE instrument

A new version of the NILU-CUBE instrument described by Kylling et al. (2003) was developed for the HIBISCUS campaign. The new NILU-CUBE has six channels in each of its six heads. The heads are mounted on the faces of a cube, see Fig. 1. For each head UV radiation is measured at 305, 312, and 340 nm with a bandwidth of 10 nm at FWHM; NIR is measured at 865 nm with a bandwidth of 20 nm and 935 nm with a bandwidth of 10 nm, finally the sixth channel measures photosynthetic radiation (PAR) covering 400-700 nm. In addition to radiation measurements the new NILU-CUBE includes a GPS for position and timing information, and a magnetic compass for tilt, roll and heading information. To save weight the instrument is not temperature stabilized. However, temperature is measured for each of the six heads. Data from all sources are sampled every second. The weight of the instrument including a separate data logging unit is about 6 kg. Each head measures the irradiance. The new NILU-CUBE has improved input optics which deviates less than 5% from the ideal cosine response for zenith angles smaller than 85°. By combining the measurements from all heads, the actinic flux may be deduced as shown by Kylling et al (2003).

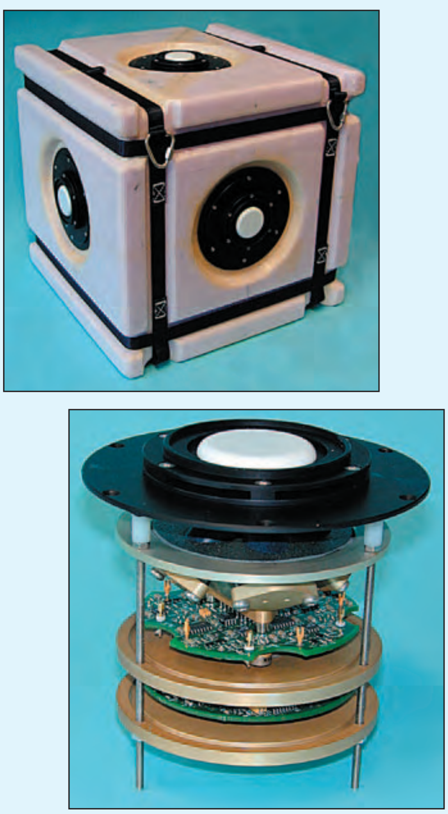

Figure 1: The new NILU-CUBE assembled (above) and a view of one of the heads. Note that detectors are not mounted.

Balloon flights

During the HIBISCUS campaign in February 2004 the NILU-CUBE was flown twice on RAVEN type balloons. The first flight took place on 13 Feb. under relatively clear sky conditions, but with some bright low altitude cumulus clouds formed under limited convection conditions. The balloon was launched at 1300 (UTC) and climbed up to about 22 km followed by a slow descent under a parachute. Solar zenith angles during the flight decreased from about 36° to 9°. The second flight was on 25 Feb. under overcast conditions with high altitude cirrus. The launch was around local noon at 1507 (UTC). Solar zenith angles increased from about 12° to 30° during the flight.

The instrument behaved well during both flights. During the first landing one detector head was detached from the body of the instrument. This was subsequently refitted and worked well during the second flight.

For the flight on the 13th the radiation increase by about 17% due to the change in the solar zenith angle between take-off and maximum altitude. On the 25th the change in the solar zenith angle cause a maximum change of about 4% in the radiation during the ascent.

Measurements

The upward and downward sensor heads may be used to calculate the transmission and reflection defined as

$$T = \frac{E^-(z)}{E^0} \qquad (1)$$

$$R = \frac{E^+(z)}{E^0}. \qquad (2)$$

Here $E^+(z)$ is upward irradiance at altitude z, $E^-(z)$ is the downward irradiance at altitude z, and E^0 is the solar irradiance at the top of the atmosphere. The transmission and reflection for two flights are shown in Figs. 2 and 3 respectively. The influence of low clouds are evident in the transmission for 13 Feb. Clouds below 4 km causes rapid changes in the transmission for 25 Feb. Above the clouds the transmission is larger than 1 due to radiation being reflected up by the cloud and subsequently downwards by the overlying atmosphere.

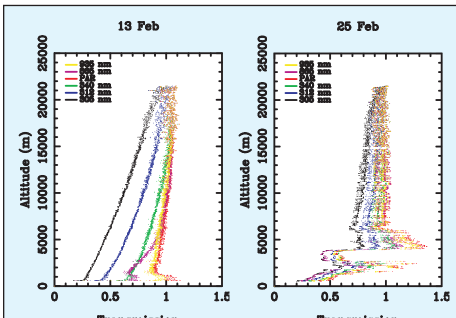

Figure 2: The transmission as defined in Eq. 1 for the two flights.

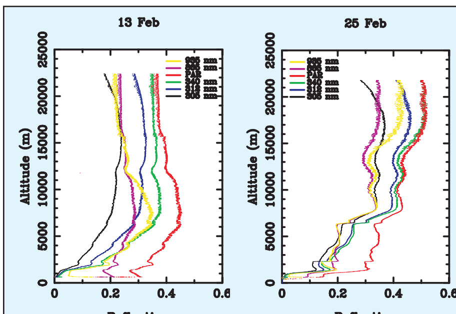

Figure 3: The reflection as defined in Eq. 2 for the two flights.

The reflection in Fig. 3 is also effected by the clouds, particularly for 25 Feb. For the two channels in the UV-B the decrease in the reflection above about 18 km indicates that the balloon is entering the ozone layer.

The signals from all heads may be combined to yield the actinic flux as described by Kylling et al. (2003). The actinic flux is needed in photochemistry applications in order to calculate photolysis frequencies. In Fig. 4 is shown the sum of the signal from all heads for each channel, normalised to the total signal at top altitude. Cloudless model simulations for all channels are included as dashed lines for 13 Feb. For the cloudless simulations the signal increases with altitude. The measurements for both days exhibit a different behaviour indicating the influence of clouds. As the clouds were truly three-dimensional in their character a fully quantitative interpretation of their radiative effects is a challenge.

Further work, including extensive radiative transfer modelling and final processing of the data, is in progress to further understand the influence of clouds on the measurements.

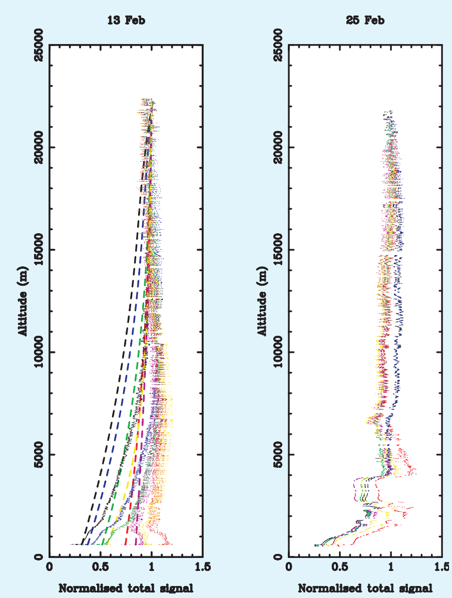

Figure 4: The sum of the signal from all heads for each channel, normalised to the total signal at top altitude. The dashed lines are cloudless model simulations by the uvspec model (www.libradtran.org).

Acknowledgments

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References

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