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Observations of the Oxygen Green Line Airglow during the Winter Anomaly Campaign 1975/76

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Abstract. Airglow emission of the E-layer has been observed from the ground during the Winter Anomaly Campaign 1975/76. It has been established by earlier *in situ* measurements that the brightness of the oxygen green line is proportional to the second power of the oxygen density. A ground-based photometer was used for monitoring the oxygen density. A relationship between emission rate $B_{\lambda=557,7\ nm}$ and radio wave absorption was found.

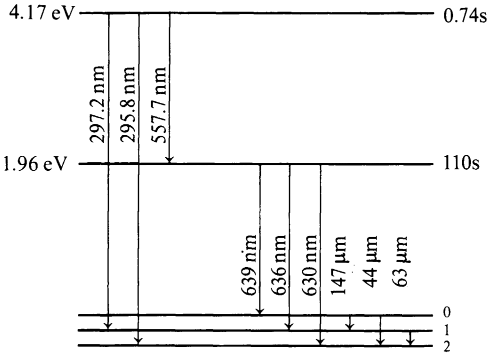
Key words: Airglow – Radio wave absorption.

Red and green oxygen emission from the upper atmosphere was measured from the ground by means of a 4-channel all-sky scanning photometer at Arenosillo, Spain, during the winter anomaly campaign 1975/76. Two of these channels were tuned to the emitted wavelength; the other channels were used to measure simultaneously the background continuum. The line channels and the background channels were matched to give the same response over a wide range of incident photon rate. The photon rate from the background channel was subtracted automatically.

Even when the background brightness was more than 20 times stronger than the line emission, it was possible to measure the line intensity. The sensitivity of this photometer was very stable and checked daily (29 ± 3 counts per Rayleigh). In this way it was possible to make reliable observations even under hazy conditions close to full moon. The great number of measured points in the sky permitted a fairly good approximation to the transmission of the lower atmosphere. The loss of light can be recalculated when the vertical transmission is better than 0.5.

The oxygen green light is emitted from ^1S state. This state is produced by the Chapman or the Barth mechanism [Chapman, 1931; Barth et al., 1961]. Both mechanisms give approximately the same production rate of 0 (^1S).

Due to the long lifte time of this state (see Fig. 1) exited atoms are partly quenched by collisions. Recent measurements have shown that atomic oxygen



	Wavelength	Transition	Einstein coefficient
^1S			
	297.2 nm	$^1S \rightarrow {}^3P^1$	$7.8 \cdot 10^{-2}\ s^{-1}$
	295.8 nm	$^1S \rightarrow {}^3P^2$	$8.0 \cdot 10^{-4}\ s^{-1}$
	557.7 nm	$^1S \rightarrow {}^1D$	$1.28\ s^{-1}$
	639.2 nm	$^1D \rightarrow {}^3P^0$	$2.2 \cdot 10^{-6}\ 2^{-1}$
^1D	636.4 nm	$^1D \rightarrow {}^3P^1$	$2.2 \cdot 10^{-3}\ s^{-1}$
	630.0 nm	$^1D \rightarrow {}^3P^2$	$6.9 \cdot 10^{-3}\ s^{-1}$
	147.0 µm	$^3P^0 \rightarrow {}^3P^1$	$1.7 \cdot 10^{-5}\ s^{-1}$
	44.2 µm	$^3P^0 \rightarrow {}^3P^2$	$1.8 \cdot 10^{-9}\ s^{-1}$
^3P	63.1 µm	$^3P^1 \rightarrow {}^3P^2$	$8.9 \cdot 10^{-5}\ s^{-1}$

Fig. 1. Exitation terms of Oxygen

is the most important quencher [Offermann and Drescher, 1973; Slanger and Black, 1976]. Quenching by O_2 and N_2 can be neglected.

The rate of emission $I_{\lambda = 557,7\ nm}$ obeys the following equation:

$$I_{\lambda\, 557,7\,nm} = \frac{K_1 [0]^3}{1 + K_2 [0]} \qquad [\text{Photons cm}^{-3}\,\text{s}^{-1}]$$

$$K_1 = 1,4 \times 10^{-30}\, e\left(\frac{-1300}{RT}\right) \qquad [\text{cm}^6 \text{ molecule}^{-2}\,\text{s}^{-1}]$$

$$K_2 = 5 \times 10^{-11}\, e\left(\frac{-610}{RT}\right) \qquad [\text{cm}^3 \text{ molecule}^{-2}\,\text{s}^{-1}]$$

Variations of the emission rate are caused by changes of either the oxygen density or the neutral gas temperature.

When starting airglow observations at the beginning of the winter anomaly campaign, we expected higher quenching after times of anomalous high absorption, due to heat flux from lower layers.

Upon comparing variations of airglow intensities and of radio wave absorption, correlated periodic variation of about 1 to 2 h were observed with both methods, (see Fig. 2); the correlation coefficient was 0.73 with absorption lagging about 12 h behind the airglow.

The regular behaviour of both effects makes it possible to predict radio wave absorption from the observed nightglow. A typical example is shown in Figure 4.

During the night a strong increase of emitted light was measured and about half a day later strong radio wave absorption was observed.

Changes of oxygen density are probably one important source winter anomaly effects.

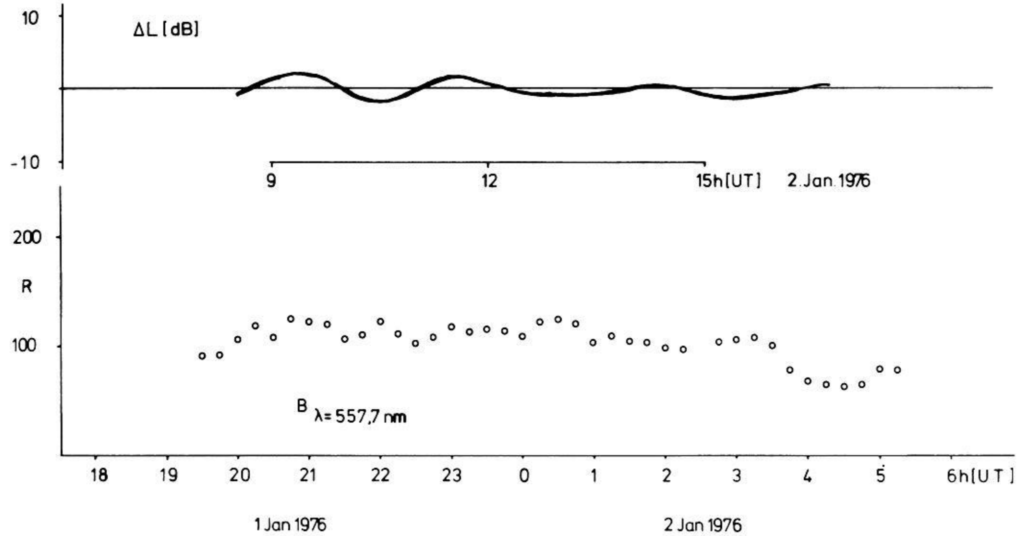


Fig. 2. Periodic variations of airglow and radio wave absorption

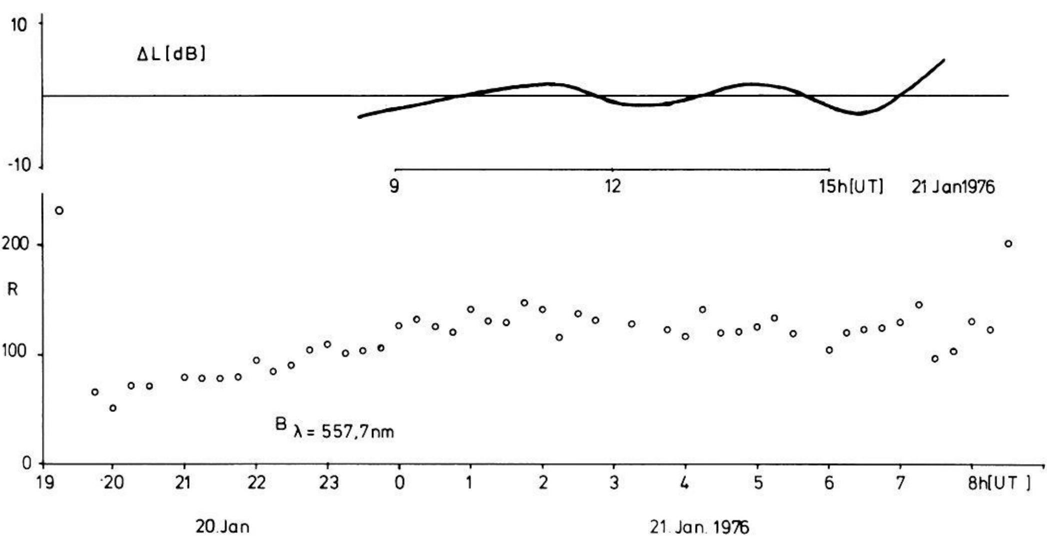


Fig. 3. Variation of radio wave absorption compared with the brightness of the night before

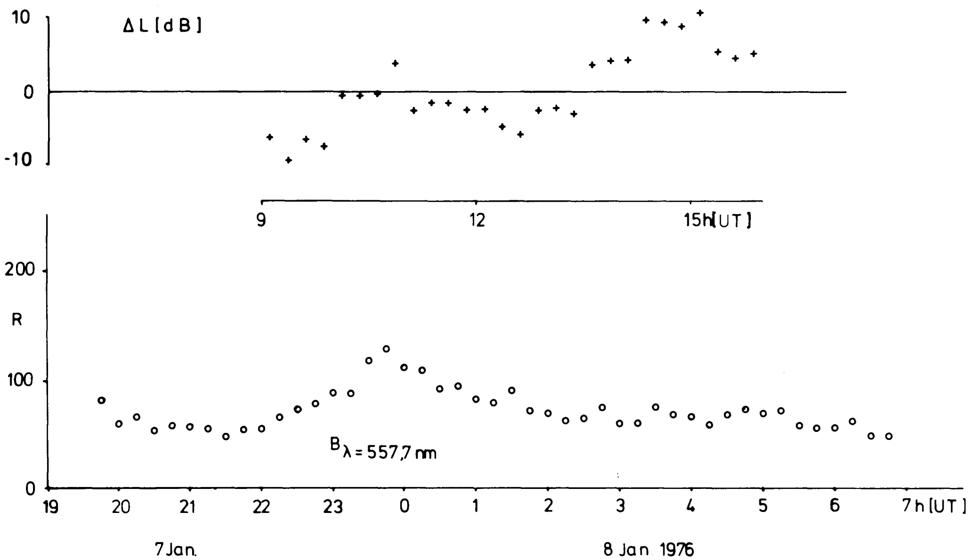


Fig. 4. Strong variation of airglow brightness indicating changes of radio wave absorption during the following day

For future experiments, ground-based equipment capable of determing temperatures in the emitting region would be very helpful.

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