GEOPHYSICAL INSTITUTE
UNIVERSITY OF ALASKA
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The Hydroxyl Emissions in Relation to the Dynamical Processes of the Atmosphere

FINAL REPORT
NGR 02-001-066
February 1, 1970-December 31, 1972

Prepared for

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

January 1973

Approved by:

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ABSTRACT

Ground and airborne hydroxyl emission observations have been made in the northern polar regions. The ground observations were made at Ester Dome, Alaska, and the airborne observations were made during the 1969 NASA Airborne Expedition. The analysis of some of the data that were acquired has lead to the following conclusions:

(a) Airglow OH measurements show no appreciable change with latitude or longitude.

(b) Diurnal changes at northern latitudes are similar to those observed in midlatitude regions.

(c) Two types of OH enhancements have been observed photometrically in the 9370 A region - one associated with visible aurora, and the other uncorrelated with visible aurora. High resolution spectra under both inactive and active conditions indicate that the OH enhancements seen photometrically in active aurorae are probably due to contamination of the filter pass bands by the unexpected enhancement of the NI multiplet lines at 9387 A and 9393 A. All previously reported aurorally associated enhancements are consequently suspect. No conclusions have as yet been reached on the mechanism associated with the non-aurorally associated enhancements.

Continuation of the study of the hydroxyl emission should concentrate on correlations of its variation with measurements of the neutral winds, joule heating and meteorological modifications of the mesosphere.

INTRODUCTION

The Geophysical Institute of the University of Alaska operated a 3/4 meter Ebert spectrometer (Brown, 1966) at Ester Dome, Alaska, in 1970 and 1971 under both active and inactive auroral conditions in an attempt to measure the dynamical and morphological changes in the hydroxyl emissions. Although many excellent spectra have been obtained, the limitations of weather, instrument sensitivity, and spectral resolution (15-20A) in the near infrared precluded its application for the basic tenets of this study. Subsequently, and in conjunction with another NASA program, the 1969 NASA auroral airborne expedition, a multifilter scanning photometer was constructed to look at various auroral emissions as well as the Q branch of the 8-4 hydroxyl band near 9370 A. This region had been studied with the aforementioned Ebert spectrometer and under the available spectral resolution deemed void of auroral emissions. The details of the aircraft operation and analyses have been reported in the Final Reports under NASA grants NGR-02-001-048, NGR-02-001-058, NGR-02-001-060 and NGR-02-001-082. Following the aircraft operation the instrument was operated at the Ester Dome observatory to acquire additional information on the diurnal variation of the hydroxyl emissions. The complete analysis and discussion of the details of these observations are available in the Master's degree thesis by R. Henderson (1972). Consequently, only a brief review of these results will be presented here. During the Spring of 1971 and 1972, the Los Alamos Scientific Laboratories operated an image intensifier infrared spectrograph at the Ester Dome observatory under the guidance of Dr. K. Mitchell.

During inactive and active auroral conditions, exposures were made to spectrally resolve the OH emissions in the 9370 A region. It is from these high resolution (less than 10A) data that clarification of the reported aurorally associated enhancements have been made.

The possibilities for future studies and the relationship of the OH measurement to other observed phenomena will be also discussed.

DISCUSSION OF THE ANALYSES

The analysis of the data has been primarily concerned with the intensities and the latitude and longitude variations of the hydroxyl emissions observed on many of the 1969 NASA Airborne Expedition flights. A preliminary description of these data were given by Brown (1970). The complete discussion is presented in the Master's degree thesis of R. Henderson (1972).

The most salient points can be discussed in terms of the anticipated dynamics.

Latitude Variations

The plot of average intensities as a function of geographic latitude appeared at first to show a slight latitude change. The average times for the observations at the various latitudes were 0500 LT, 0041 LT and 1845 LT for 48.6°N, 58.5°N and 71.6°N, respectively. The diurnal investigations of Bertheir (1955) at low latitudes and the current investigation at high latitudes suggest that the same type of temporal behavior occurs in both regions. Since the average latitudinal intensity values covered a rather large diurnal period, the average diurnal variations were compared

with the observed deviations with latitude. The observed latitudinal changes easily fit into the intensity ranges found for the diurnal variation. Therefore, the existence of a significant latitude effect is doubted for the range of latitude from 48.6°N to 71.6°N during December.

Longitude Variations

Almost no prior data are available on longitudinal variations. However, we have two flights of interest, #11 and #15. A portion of Flight #11 is entirely within the polar cap region within a latitudinal range of 0.58°. Despite the 33° changes in longitude, the average OH and O_2 levels remained uniform. Again, on Flight #15 no particular pattern was established over an 18° change in longitude.

Diurnal Variations

The diurnal variations that were observed fell into four types. They were: (1) a minimum at or before local midnight, (2) a maximum during the night, (3) constant from local midnight to about 0400 LT, followed by a sharp decrease and (4) constant through the night. Types (1) and (2) were observed most often with each being seen as often as the other. Type (3) was observed once as was type (4). These are consistent with those data reported in the literature. The results of 103 observations made throughout the year by Bertheir (1955) also showed type (1) (minimum near midnight) as the predominant type. Bertheir, observing at a latitude of 44°N, observed some of the same types of diurnal changes as we find at high latitudes. Therefore, since there seems to be no general latitude effect on the intensity of either OH or O_2 in December, the data indicate that OH and O_2 both at high and at low latitudes during this month are very similar both

in form and intensity.

OH-Enhancements

Two different types of enhancements were observed in the course of the current investigation. The first type occurs at or near the time of an intense aurora and is characterized by a quick rise and fall of intensity with the corresponding auroral changes. The second is a general increase in OH intensity over a three- or four-hour interval. During this interval there were no intense auroras at the zenith, and the general intensity level of the auroral background remained unchanged.

During the spring observing periods in 1971 and 1972, an image intensifier spectrograph was operated at Ester Dome under the direction of Dr. K. Mitchell of the Los Alamos Scientific Laboratories. Figure 1 shows a composite spectra obtained, covering the near infrared region between 8600 A and 10,000 A. Under airglow conditions (upper spectrum) and active aurora (lower spectrum) the excellent resolution available here illustrates that there is no OH enhancement but only an enhancement of auroral emissions, predominantly the NI lines at 9387 A and 9393 A. With many spectra taken in the two spring periods in which the instrument was operated under many different auroral situations, no aurorally associated enhancement of the OH emissions has been noted. Consequently, the previous conclusions (Brown and Belon, 1969) concerning aurorally associated hydroxyl enhancements must be based on the enhancement of the auroral emissions (NI) rather than OH. However, under conditions of low auroral activity the photometer measurements will correctly monitor the hydroxyl emissions and consequently the enhancements observed which are not associated with auroral activity changes are real OH variations. The causes for these changes are as yet unexplained.

FUTURE STUDIES

This study has indicated that the major changes in the hydroxyl emission are diurnal with superimposed enhancements which occur unassociated with the variation in auroral emission. To understand the causes for these changes will require future studies connected to other similar phenomena. Much of the behavior of the OH emission resembles that described for the $O_2\,^1\Delta$ emission in the polar regions (Noxon, 1970). The altitude profile of $O_2\,^1\Delta$ peaks in the region of the mesopause and lower E layer (Evans et al., 1972). This is also the region of OH emission and consequently these emissions may covary. Both emissions must somehow be associated at least partly with the meteorology of the mesopause which in turn may be effected by energy exchange from joule heating produced by electric fields. Thus, the morphology of the oval and perhaps even the ionospheric trough may bear on the diurnal variation and even the sporadic enhancements of the hydroxyl emissions.

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FIGURE CAPTION

Figure 1. Airglow and auroral spectra obtained at Ester Dome, Alaska, in the wavelength region 8600 A to 10,000 A. The spectral resolution is approximately 10 A. The exposure length for the airglow spectrum is much longer than that for the auroral spectrum.

Los Alamos Scientific Laboratory
Image Intensifier Spectra
Ester Dome, Alaska