NOTES AND CORRESPONDENCE

Comment on "Upper-Atmosphere Sodium and Stratospheric Warmings at High Latitudes"

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We were interested to learn of the correlation between free sodium abundance and stratospheric warmings reported by Hunten and Godson (1967). They attribute the increase of free sodium abundance associated with the stratospheric warming to vertical motions which increase the scale height of the total sodium in the lower thermosphere. Presuming that the planetary scale pressure wave patterns of the sudden warming extend into the mesosphere and lower thermosphere, there will be accompanying quasi-geostrophic horizontal and vertical motion fields. We would like to suggest as an alternative mechanism that these motions transport atomic oxygen downward producing an increase of the abundance of this constituent in the 70–90 km region. The lifetime of atomic oxygen is of the order of a day or more in this region so that vertical motions as small as 1–10 cm sec^{-1} would be expected to be an important factor in determining the atomic oxygen abundance. The proposed mechanism does not appear to have any implications which contradict the facts reported by Hunten and Godson, and it has the attraction of offering a possible explanation for the increase of ionospheric absorption which is known to accompany many stratospheric warmings.

Hunten and Godson cite as the most important reactions in the chemistry of sodium

$$NaO+O \rightarrow Na+O_2, \quad (1)$$

$$Na+O_3 \rightarrow NaO+O_2, \quad (2)$$

stating that equilibrium is quickly reached, leading to

$$n(Na)=\frac{k_1}{k_2}\frac{n(O)}{n(O_3)}n(NaO), \quad (3)$$

where k_1 and k_2 are the rate coefficients for reactions (1) and (2), respectively. They further state, for reasonable values of these rate coefficients, that $n(Na)$ increases with altitude to attain a maximum in the 85–90 km range, approaching at greater heights the curve for the distribution of total sodium, $n(Na)+n(NaO)$. The vertical motion invoked increases the total sodium by some factor (which depends on altitude) and both $n(Na)$ and $n(NaO)$ in Eq. (3) are increased by the same factor. The enhancement of atomic oxygen in the 70–90 km region, which we suggest may accompany the stratospheric warming will, on the other hand, increase the free sodium at the expense of the NaO. In either case, an increase of the free sodium content of the upper atmosphere is achieved.

The results of recent laboratory measurements of the rate coefficients for several reactions of importance in the D region of the ionosphere have been reported by Fehsenfeld *et al.* (1967). Discussion in that paper indicates that, at least during the daytime, the principal negative ions in the 70–90 km region should be O^- and O_2^-, and that the most important process responsible for the destruction of these negative ions should be detachment by atomic oxygen. (Provided the downward vertical motion is strong enough to maintain a concentration of atomic oxygen greater than that of ozone, the foregoing statement will apply also at night.) An increase of the atomic oxygen abundance in the 70–90 km region would therefore be expected to increase the number of free electrons, at the expense of the negative ions. The principal contribution to daytime vertical incidence absorption is from the free electrons in the 70-80 km region [see, for instance, Sechrist (1967)]. It has been established by Shapley and Beynon (1965), using 10-mb temperatures and daily values of ionospheric absorption, that high values of ionospheric absorption accompany stratospheric warmings. An increase of atomic oxygen abundance in the 70–90 km region can account not only for the increase in the free sodium content of the upper atmosphere, but also the increase of ionospheric absorption.

REFERENCES

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