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GOAT (Global Oxygen And Temperature) Mapping

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The $O_2(b^1\Sigma_g^+$ - $X^3\Sigma_g^-)$ Atmospheric Band system has been studied extensively since the days of Fraunhofer, who first showed that solar photoabsorption in the 762 nm region was caused by terrestrial oxygen; in this case, the 0-0 band of the $b - X$ system. The $O_2(b)$ state is generated by two different mechanisms in the atmosphere: by $O(^3P)$ atom recombination, where $O_2(b)$ is one of several excited O_2 states produced, and by the energy transfer from $O(^1D)$ to O_2, where the products are $O_2(b, v = 0, 1)$. The latter is an ionospheric process and is the case of interest here.

Recent studies at SRI International have demonstrated that $O_2(b, v = 1)$ is the predominant product of the energy transfer, with the nascent $[v = 1]/[v = 0]$ ratio being close to 4 and temperature independent. Collisional quenching of $b(1)$ by O_2, to produce $b(0)$, proceeds six orders of magnitude faster than $b(0)$ quenching [*Slanger and Copeland*, 2003]. As a consequence, the $[b - X(1\text{-}1)]/[b - X(0\text{-}0)]$ intensity ratio as a function of thermospheric altitude shows the degree to which $b(1)$ has been converted to $b(0)$, which can be interpreted in terms of atmospheric composition. Of the three colliders — O_2, $O(^3P)$, and N_2 — it is the first two that control the $b(1) \rightarrow b(0)$ relaxation rate.

To observe the $b(v = 0, 1)$ emission requires space-based measurements in the 755-780 nm region of the 0-0 and 1-1 bands. In addition to the varying intensity ratio of the two bands, the shapes will differ as a function of temperature as the rotational temperature changes. Thus, observations of the shapes and the relative intensities of the two bands will simultaneously lead to information on temperature and on the $[O_2]$ + $[O(^3P)]$ densities as a function of altitude. The technique is relevant to the dayglow and to the portion of the night when $O(^1D)$ is still detectable.

T. G. Slanger and R. A. Copeland, *Chem. Rev.* 103, 4731-65, 2003.

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