The sodium nightglow: a continuing puzzle

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The Na D-line component in the nightglow was first reported 80 years ago. Sydney Chapman proposed 67 years ago that the origin of the emission was a cycle of two reactions: Na + O_3 to produce NaO; followed by the highly exothermic reaction NaO + O to produce Na(^{2}P). In the last 20 years, laboratory experiments established that the kinetics of both reactions are fast enough to support Chapman's hypothesis. However, ascertaining the branching ratio of the second reaction (i.e., the probability of producing Na(^{2}P) rather than ground-state Na(^{2}S)), has proved difficult, firstly because it is a challenging laboratory measurement to make, and secondly because it turns out that the NaO from the first reaction is produced in both the ground and a low-lying excited state. Field experiments involving rocket and lidar measurements have yielded conflicting estimates of the branching ratio. In the last 5 years, it has emerged that the ratio of the two D-lines is not 2, as had been widely assumed, but actually varies from $\sim$ 1.3 – 2.2 [Slanger et al., *JGR* 2005]. Airborne measurements reveal that the variation occurs over a horizontal distance of 10s of km, and may thus be gravity-wave driven. In this paper we will describe the results of a campaign at the ALOMAR observatory (Norway), where the D-line ratio and the Na density profile were measured simultaneously. The results appear to confirm the hypothesis that the variation is caused by the vertical redistribution of Na by waves and tides. A wave-driven model of the MLT, combined with the results of a recent laboratory study on the dependence of the D-line ratio on the atomic O mixing ratio, will then be used to demonstrate this effect.