A Comparison of the Mid-latitude Nickel and Sodium Layers in the Mesosphere

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Abstract

A dual-wavelength resonance fluorescence lidar facility, operating at 341 nm and 589 nm, was used to observe simultaneously the Ni and Na layers in the upper atmosphere over Yanqing station, Beijing (40.41°N, 116.01°E). Lidar measurements were performed on 126 nights (1090 hours in total) from April 2019 to March 2020, and April 2021 to August 2021, so that the full seasonal cycle of the Ni layer was observed for the first time. The Ni and Na layers exhibit a similar annual cycle, increasing by a factor of ~3 from a mid-summer minimum to a mid-winter maximum. The annual mean column densities of Ni and Na are 3.1×10^8 and 2.5×10^9 cm^{-2}, respectively, giving a mean Na:Ni ratio of 8.1, which is significantly larger than their CI chondritic ratio of 1.2. This is explained by the more efficient ablation of Na from cosmic dust particles by a factor of 3, and the more rapid neutralization of Na^+ between 90 and 100 km, where the measured Na^+:Ni^+ ratio is only 2.2. The Ni layer peak occurs around 84 km, 8 km below that of Na. These features are simulated satisfactorily by the Whole Atmosphere Community Climate Model (WACCM), and are explained by significant differences in the neutral chemistry of the two metals below 90 km, and their ion-molecule chemistry between 90 and 100 km.