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Effects of 3-dimensional cloud structures on satellite observations of the Ring effect, trace gas absorptions and radiance

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3-dimensional structures of clouds have a strong influence on the atmospheric radiative transport. In particular, the radiance observed by UV/vis satellite instruments depends not only on the average cloud properties but also on their 3-dimensional structure. However, to date, such effects are often not considered in the retrieval of cloud properties from satellite observations. In this study, we explore the effects of 3-dimensional cloud structures using our 3-dimensional Monte-Carlo radiative transfer model TRACY-2. Besides the observed radiance we also simulate the absorptions of the oxygen molecule (O2), the oxygen dimmer (O4) and the Ring effect (the filling-in of solar Fraunhofer lines due to rotational Raman scattering). We study in detail the influence of the satellite viewing direction, the solar zenith angle, and the field of view. It is found that in many cases 3-dimensional cloud effects have a strong influence on the observed quantities. We present a systematic overview on these dependencies and quantify the associated errors made in the data retrieval if horizontal homogeneity is assumed. Besides model simulations, we also present measurement examples.