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Validation of ASIMUT-ALVL against observational data of Jupiter's atmosphere

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The study of Jupiter's atmosphere, its composition, evolution, distribution, structure, and dynamics around the planet, is of interest to the scientific community. Several missions, space observatories, and ground-based telescopes (even if limited by the telluric bands of water vapor), have studied Jupiter's atmosphere. Some of them, such as Juno, the Hubble Space Telescope (HST), and the Very Large Telescope (VLT), continue providing information about the vertical structure and distribution of the atmosphere around the planet [1-3]. Although the main chemical composition of Jupiter's atmosphere has been unraveled, many questions remain open, such as the global abundance of water, or the responsible chemistry for the coloration of the clouds [4]. Besides, a remarkable potential of VIS-NIR spectrometry for characterizing the composition and dynamics of planetary atmospheres has been demonstrated in the last years [5].

The next mission to the Jovian system from the European Space Agency (ESA) is the Jupiter Icy Moons Explorer (JUICE), to be launched in April 2023 with an arrival date on July 2031 [6]. One of the key scientific instruments onboard is the Moons And Jupiter Imaging Spectrometer (MAJIS), which will provide hyperspectral capabilities through two channels: VIS-NIR (0.5μm-2.35μm), and IR (2.25μm-5.54μm) [7]. We would like to perform simulations of different test cases with respect to the viewing geometries of MAJIS and assess its capabilities [8-9] to characterize the vertical structure of the Jovian atmosphere. For this purpose, we upgraded ASIMUT-ALVL, a Radiative Transfer (RT) code developed at BIRA-IASB, that has been extensively used to characterize Mars and Venus atmospheres [10-11].

During the implementation phase of the new Jupiter case in ASIMUT-ALVL, we applied the current knowledge of the physical and chemical characteristics of Jupiter, including the Rayleigh scattering contribution due to dominant atmospheric species, the refractive index of Jupiter's atmosphere, and the Collision-Induced Absorption (CIA) due to H_2-H_2 and H_2-He molecular systems. The typical temperature profile and atmospheric composition of Jupiter were retrieved from [12], although in our next studies we might use the CH_4 abundance from the Volume Mixing Ratio (VMR) profile from [13], which is similar to that from [14]. The required line-lists were implemented from the HITRAN online database with line parameters adequate for an H_2 and He dominant atmosphere, following the 2020 version release [15]. The extinction coefficient due to Rayleigh Scattering is obtained based on the calculation of its cross-section from [16], by considering the refractive indexes of H_2 and He, obtained from the refractivities measured by [17] and [18], respectively. The atmospheric King correction factor is obtained from an adapted version of the formula of [19], considering the depolarization ratio of H_2 as measured by [20]. To model the aerosols and hazes present in the atmosphere, we used the microphysical parameters defined by [21].

We validated the updated performances of ASIMUT-ALVL by individually comparing the main spectroscopic features of Jupiter's atmosphere in the VIS-NIR range against KOPRA, an RT code originally developed for studying Earth's atmosphere but later adapted to the atmospheres of Titan, Mars, and Jupiter [22]. We used the same geometry of observation, assuming solar occultations with a tangential altitude between 50km and 360km, a resolution of 0.3cm^{-1}, a Signal-to-Noise Ratio (SNR) of 100, and an orbit around the planet of 5000km high. The mean difference in transmittance obtained between both models is below 3%.

The next step was to validate our RT model against observational spectroscopic data, which was obtained from the Visible and Infrared Mapping Spectrometer (VIMS) observations during the Cassini flyby to Jupiter [23]. This imaging spectrometer consists of two channels: VIS (0.35µm-1.07µm) and IR (0.85µm-5.1µm). In this presentation, we will discuss the results we obtained from the complete validation of our RT model, and the perspectives for the future implementation of the performances and viewing geometries of MAJIS/JUICE.

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