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Simulating spectra of Jupiter's atmosphere based on MAJIS VIS-NIR characteristics

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From Pioneer 10 to Juno, which is still active, several missions and space observatories have studied Jupiter's atmosphere. Complementary, although limited by the telluric bands of water vapor, ground-based observations continue providing information about its vertical structure and its distribution around the planet. The main chemical composition of Jupiter's atmosphere has been unraveled but lots of questions still remain open, such as the global abundance of water, the responsible chemistry for the coloration of the clouds, or what drives the aurora [1-2]. Moreover, observations by NIMS/Galileo [3-4] and VIMS/Cassini [5], have demonstrated the remarkable potential of VIS-NIR spectrometry for characterizing the composition and dynamics of planetary atmospheres [6].

The Moons And Jupiter Imaging Spectrometer (MAJIS) instrument is part of the science payload of the ESA L-Class mission JUICE (Jupiter ICy Moons Explorer) [7] to be launched in 2022 with an arrival at Jupiter in 2031. MAJIS combines two spectral channels able to cover the 0.5 – 2.35 μm range (VIS-NIR channel) and the 2.25 – 5.54 μm range (IR channel) [8]. As part of its scientific objectives, MAJIS will investigate the composition, structure, dynamics and evolution of Jupiter's atmosphere at different levels, trace tropospheric cloud features, and characterize major and minor species, aerosols properties, and hot spots [9]. As explained by Langevin et al. [9], the spectral resolving power of MAJIS exceeds by three times that of NIMS or VIMS, with a spatial resolution four times better than NIMS, so it will efficiently track tropospheric processes such as clouds and hazes. Moreover, the close to equatorial orbit of JUICE for most of the mission will provide a comprehensive coverage of Jupiter in local time complementary to JIRAM/Juno [9].

We are interested in the scientific analysis of the MAJIS observations regarding the composition of Jupiter's atmosphere, specifically on the H_2O and CH_4 contents, which are the most abundant species in the troposphere as a whole, after H_2 and He [1]. Although it is expected that water vapor has a higher global volume mixing ratio than CH_4 in the deep troposphere, this has yet to be observed [1]. Additionally, the strong spectral features due to crystalline water ice (1.5 μm and 2.0 μm) require a large abundance of water to be explained [10]. Therefore, we would like to perform simulations of different test cases with respect to the viewing geometries of MAJIS and the technical properties of its Flight Model VIS-NIR detector [11].

To proceed, we need to adapt the Radiative Transfer code developed at the Belgian Institute for

Space Aeronomy (BIRA-IASB), ASIMUT-ALVL. It has been extensively used to characterize Mars and Venus atmospheres [12-19]. This tool is able to perform forward model simulations and atmospheric spectrum retrievals in nadir and limb geometries. To apply it to Jupiter's atmosphere, some changes need to be done, such as implementing Jupiter's physical parameters and adding the Rayleigh scattering contribution due to the dominant atmospheric species H_2 and He. A more demanding modification to the code concerns the treatment of the Collision-Induced Absorption (CIA) due to H_2-H_2 and H_2-He molecular systems.

A typical atmosphere's vertical structure of Jupiter has been retrieved from [20-21]. The molecular line-lists and cross-sections have been implemented from the HITRAN online database with line parameters adequate for an H_2-dominant atmosphere. Additionally, the microphysical parameters of the clouds and aerosols have been obtained from [22]. The different contributions to the spectra are being identified then simulated and finally validated through comparison with previous works [20-21]. This methodology ensures that each radiative contribution is well-understood and correctly implemented into ASIMUT-ALVL before assessing the performances of the MAJIS VIS-NIR channel to characterize the vertical structure of the Jovian atmosphere.

In this presentation, we will describe the different contributions and the challenges we faced for their implementation. A preliminary sensitivity analysis of MAJIS VIS-NIR will be discussed.

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