EPSC Abstracts
Vol. 19, EPSC2026-946, 2026, updated on 16 Nov 2026
https://doi.org/10.5194/epsc2026-946
Europlanet Science Congress 2026
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Comparing the Galilean moon atmospheres using the DSMC method

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A range of physical and chemical processes characterises the tenuous atmospheres of the Galilean moons. Io, the innermost Galilean moon, is subject to extreme tidal forces that drive intense volcanic activity, ultimately responsible for Io's SO_2-dominated atmosphere. Next to SO_2, where the sublimation of surface frost is expected to be the main source [1], dissociation products (e.g., SO, S, O), along with compounds connected with volcanic eruptions (e.g., S_2, NaCl, KCl) have been detected in Io's atmosphere. On the contrary, the main atmospheric species of the icy Galilean moons are expected to be water-related products, such as H_2O, O_2, and H_2. Moreover, dissociation products (O, H) and non-water-related species, such as CO_2, have been detected.

In this study, we use the Direct Simulation Monte Carlo (DSMC) model ultraSPARTS (ultrafast Statistical PARTicle Simulation package) [2, 3] to compare the atmospheres of the Galilean satellites. For this purpose, we investigate the influence of various processes, including sublimation, radiolysis, and outgassing from (cryo-)volcanic plumes. To model the sublimation of SO_2 and H_2O, we apply an adapted version of the thermal model THERMPROJRS [4] to constrain the surface frost temperature on the satellites, which governs the vapour pressure and, therefore, determines whether sublimation or condensation occurs. Furthermore, we investigate the influence of different collision cross-sections and particle collisions on the macroscopic atmospheric properties.

In the 2030s, the atmospheres of the icy Galilean moons will be studied extensively by the JUICE and Europa Clipper missions using high-resolution mass spectrometry, providing an unprecedented opportunity to compare and verify our results with in-situ data.

Acknowledgements:

This work has been carried out within the framework of the National Centre of Competence in Research PlanetS supported by the Swiss National Science Foundation under grant 51NF40_205606. The authors acknowledge the use of ultraSPARTS from Plasma T.I., Taiwan.

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