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Evaluation of the first simulation tool to quantitatively interpret the measurements of the ExoMars mission's Wisdom GPR

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The Water Ice Sub-surface Deposits Observation on Mars (WISDOM) (500MHz - 3GHz) GPR is one of the instruments that have been selected as part of the Pasteur payload of ESA's 2018 ExoMars Rover mission. One of the main scientific objectives of the mission is to characterize the nature of the shallow sub-surface on Mars and WISDOM has been designed to explore the first 3 meters of the sub-surface with a vertical resolution of a few centimetres.

Laboratory and field tests using the prototype developed for the ExoMars mission by LATMOS (Laboratoire Atmosphère, Milieux, Observations Spatiales) in collaboration with the AOB (Bordeaux) and the university of Dresden (Germany) are regularly performed to assess and improve the radar performances. In order to quantitatively interpret the experimental data obtained, we developed a simulation tool based on ray-tracing. This code proves to be a fast practical way even if simplified to help radargrams interpretation. The WISDOM GPR, unlike most traditional GPRs, is operated approximately 30 centimetres above the surface. This configuration implies that the propagation between the antenna and the surface cannot be neglected especially because the instrument's aim is to characterise the very shallow subsurface.

As a consequence, while we can draw advantage of this specific configuration by using the surface echo's amplitude to retrieve information about the top layer's roughness and permittivity value, precise location of buried reflector becomes more complicated. Indeed, the signature distinctive of individual reflectors buried in the sub-surface is not more an exact mathematical hyperbola. When the individual reflector is buried deep enough in the subsurface, the adjustment by an hyperbolic function still allows the retrieval of the reflector's location and the permittivity value of the surrounding medium. But in case of a reflector closer to the surface, the approximation is no longer valid.

We propose a robust model adjustment that can be used for any reflector's depth. The physical assumptions taken into account are presented. Finally, results for different configurations and the validation of the limit conditions for which this adjustment method is reliable are shown.

Preliminary analyzes on real data show the good performance of the method developed. Other modelling techniques will be considered to complete a full data interpretation taking the best from the instrument capacities