



AI-driven surface mapping and explainable AI for climate insights on Mars

Lida Fanara¹, Shu Su², Oleksii Martynchuk¹, Ernst Hauber¹, and Klaus Gwinner¹

¹DLR, Planetary Geodesy, Berlin, Germany (lida.fanara@dlr.de)

²Technical University of Berlin, Berlin, Germany

We are deriving insights about the climate evolution of Mars by automating surface mapping and monitoring with AI models. We are also analysing these models' uncertainty and decision-making process with explainable AI and uncertainty estimation techniques. We focus on ice block fall detection at the north polar region and polygon detection globally.

The north polar ice cap on Mars is comprised of ice layers relating to the climate cycles of Mars and this way it preserves a $\sim$ 4 million years climate change record of the planet. These layers are exposed at the marginal steep scarps of the cap, that are currently active with avalanches and block falls. We are monitoring the mass wasting activity at the north polar region by detecting ice blocks [1] and their sources [2]. We estimate the current erosion rates of all scarps resulting in a detailed map of how this extensive ice-layered dome is being shaped today.

At the mid-latitude regions, where large volumes of excess ice exist, young patterned ground resembles glacial and periglacial patterns on Earth. Can freeze-thaw cycles have recently thawed the permafrost on Mars to produce these landforms? This would have implications for the recent hydrologic past of the planet. We detect young ice-wedge polygons to determine their distribution and relationship to the topography with the potential of elucidating the formation mechanism and the role of liquid water in the recent past of Mars.

We use AI models to automate surface mapping and monitoring, because they outperform all other methods. However, they are treated as black box systems. We want to know why a model produces a specific response and how certain it is about the correctness of each result. To answer these questions, we put together an application-independent framework that deploys uncertainty estimation and explainable AI methods to provide insights into the decision-making process and assess the uncertainty of the results [3], in this project the uncertainty of the surface mapping.

References:

[1] Martynchuk O. et al., Computer vision model for monitoring mass wasting activity in the Martian North Polar region. EPSC 2024.

[2] Su S. et al., Current mass wasting on icy scarps of Mars: A comprehensive mapping of ice-fragments in the north polar area. AGU 2023.

[3] Fanara L. et al., W²: How Certain and Why? Uncertainty Estimation and Explainable AI Applied

on Mars Projects. AGU 2023.