DOMARS24K: EXPANDING AUTOMATED GEOMORPHIC ANALYSIS ON MARS BY WIND AND ICE SHAPED LANDFORMS. T. Wilhelm, R. Nocon, S. Stepcenkov, C. Wöhler. Image Analysis Group, TU Dortmund University, 44227 Dortmund, Germany (thorsten2.wilhelm@tu-dortmund.de).

Introduction: Scientists creating geologic or geomorphic maps of planetary surfaces face immense workloads. New data of Mars arrives in a steady pace and renders a manual assessment of all data challenging. Then, automated approaches can be utilized to pre-process and summarize the incoming streams of data. In this work we focus on grouping image data from the Mars Reconnaissance Orbiter Context Camera (CTX) [1] into a set of 22 different landforms, which cover a large range of all Martian landforms. The grouping is then used to automatically derive a geomorphic map, which can be used by scientists as a starting point.

The work presented here is an extension of our automated geomorphic mapping framework and the dataset DoMars16k, which is currently the most diverse dataset of CTX captured Martian landforms. Both were recently introduced in [2]. In order to improve the framework, we added seven new landform classes with a total number of over 8000 samples to the dataset. The additionally introduced classes allow for a better geomorphic mapping of landforms formed by wind and ice. Therefore, we are able to generate improved geomorphic maps of the constantly changing Martian south polar cap [3] or from regions of the Amazonis quadrangle which commonly feature yardangs [4] and dust devil tracks [5].

Methods and Dataset: DoMars24k expands DoMars16k by seven additional landforms in two thematic groups—"Aeolian Landforms" and "Ice-Related Terrains". The latter contains the classes "Fingerprint terrain", "Ice Moats and Mesas, "Swiss cheese", and "Spiders" and the former the classes "Yardangs", "Wind Streaks", and "Dust Devil Tracks". Additionally, the "Aeolian Bedforms" of [2] are part of this thematic group. Dataset samples of the newly introduced classes are presented in Fig. 1. As in [2] each sample is 200 pixels wide and tall or roughly 1.2 km respectively. The classes are solely distinguished by their visual appearance.

As in [3] we define "Fingerprint Terrain" as areas dissected by linearly shaped depressions, which are mostly fork-like or parallel. We group images featuring large (above 500 m) quasi-circular depressions in the "Swiss Cheese" class [3]. The remaining types of depressions which commonly occur on the south polar cap are more randomly in nature and are thus summarized in an additional "Ice Moats and Mesas" class. "Spiders" [6] are another characteristic ice-related landform. They have a dendritic appearance which is formed by the interaction of ice, sunlight, and dust and sand. Spiders are also subject to seasonal effects and are often only barely visible in the Martian summer. DoMars24k contains images from all Martian seasons.

Martian wind is another agent which shapes the appearance of the planetary surface. Among others, it redistributes surface sediments and forms together with obstacles, like craters, distinctive linear to fan-shaped albedo patterns which are aligned with the wind direction. We summarize these patterns into a "Wind Streaks" class. "Yardangs" are elongated hill-like structures which are formed by erosion [4]. They appear in various shapes ranging from long ridge-like to curvilinear and varying sizes ranging from centimeters to kilometers. We only consider images as part of the "Yardangs" class if their size reasonably matches the given quadratic window size of 1.2 km. Hence, centimeter scale yardangs which are not resolved in CTX images are not considered as well as yardangs which are several kilometers large. Occasionally, wind forms dust devils on the Martian surface [5]. Their linear and meandering tracks are visible in orbital images and are summarized in the "Dust Devil Tracks" class.

The expanded dataset—DoMars24k—is then used to train an artificial intelligence (AI) to recognize all 22 different landforms. The AI is adopted from [2] and built around a DenseNet-121 [7]. Additional details regarding the AI are presented in [2].

Results: The resulting maps of a few exemplary regions of Mars highlighting the novel classes are shown in Fig. 2.

Conclusion: We introduced an improved version of our dataset DoMars16k [2] by adding seven additional landforms and over 8000 samples to the dataset. In total it now contains over 24000 samples of 22 different Martian landforms. Automatically creating geomorphic maps is greatly improved by the use of the expanded dataset. Besides, we showed how easily extensible the framework of [2] is.

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References:

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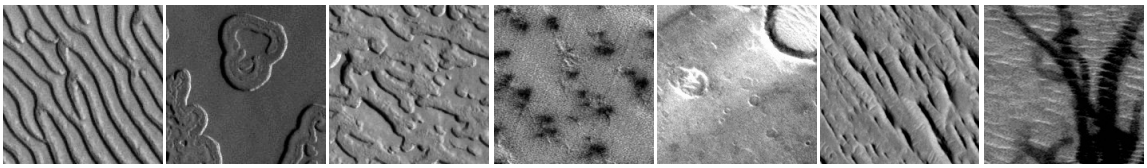

Figure 1. Dataset samples of the new classes. From left to right: “Fingerprint Terrain”, “Swiss Cheese”, “Ice Moats and Mesas”, “Spiders”, “Wind Streaks”, “Yardangs”, and “Dust Devil Tracks”.

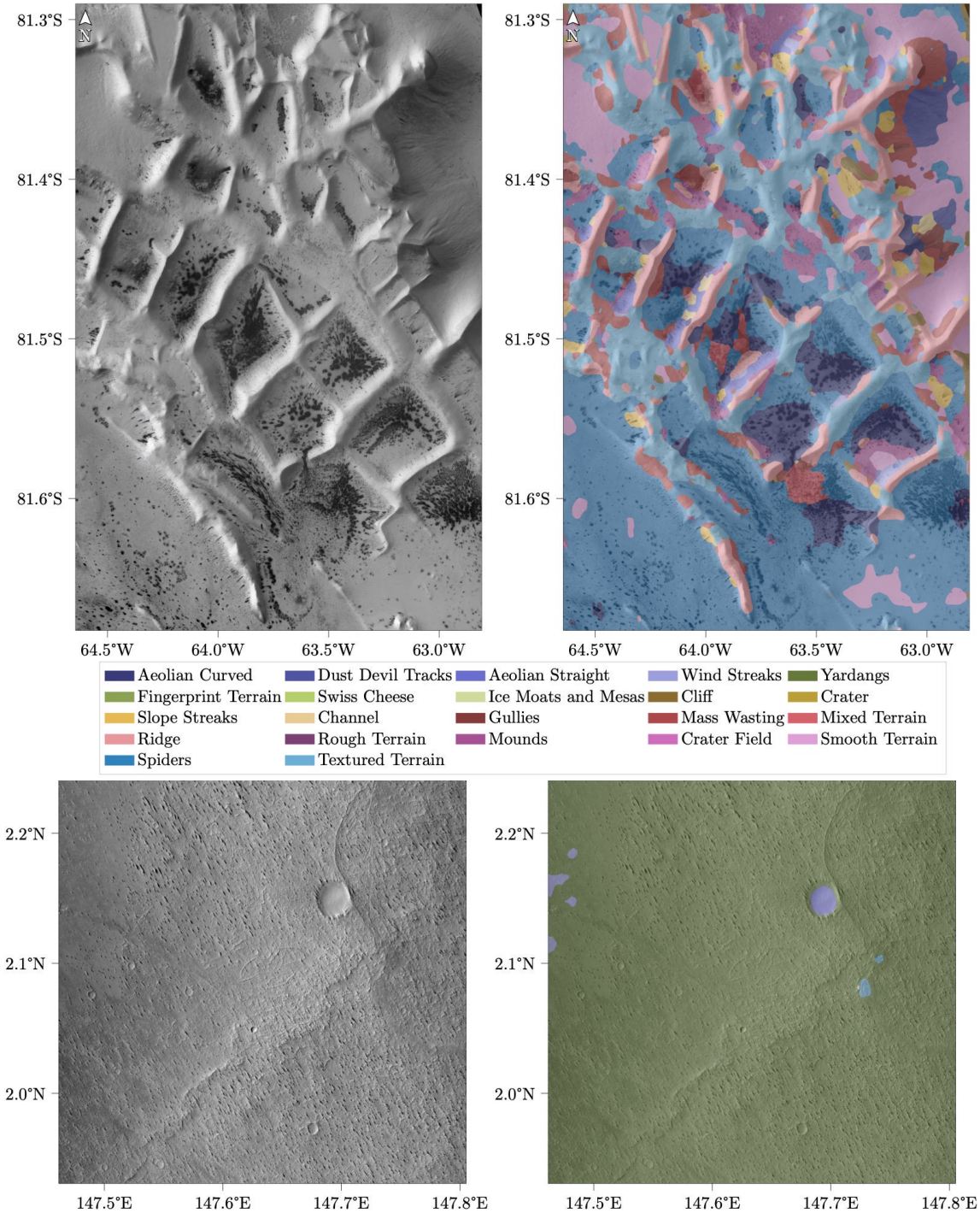

Figure 2. Geomorphic maps created by the proposed approach. Cutouts from CTX image B07_012256_0985_XN_81S063W (top) and CTX image P16_007171_1816_XI_01N212W (bottom).