

Automatic Mapping of valley Networks on Mars

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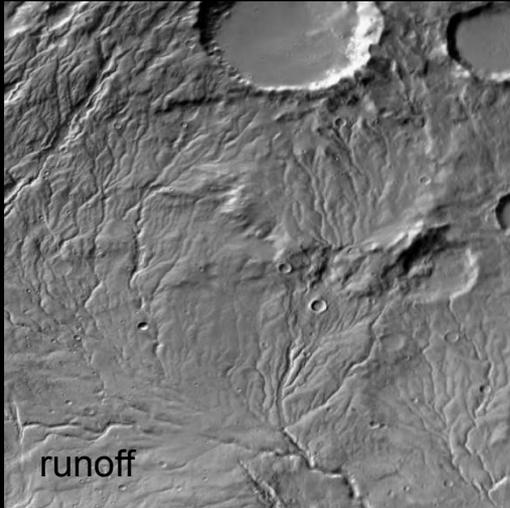
What are valley networks ?



Motivation for Studying Global Distribution of Valley Networks

- Valley networks – the search for their origin (runoff vs. groundwater sapping).
- Implications of paleoclimate on Mars
- Can we deduce the original of surface dissection from dissection pattern alone?

- Dendritic patterns
- Origin near watershed boundaries.
- Overall significant erosion.

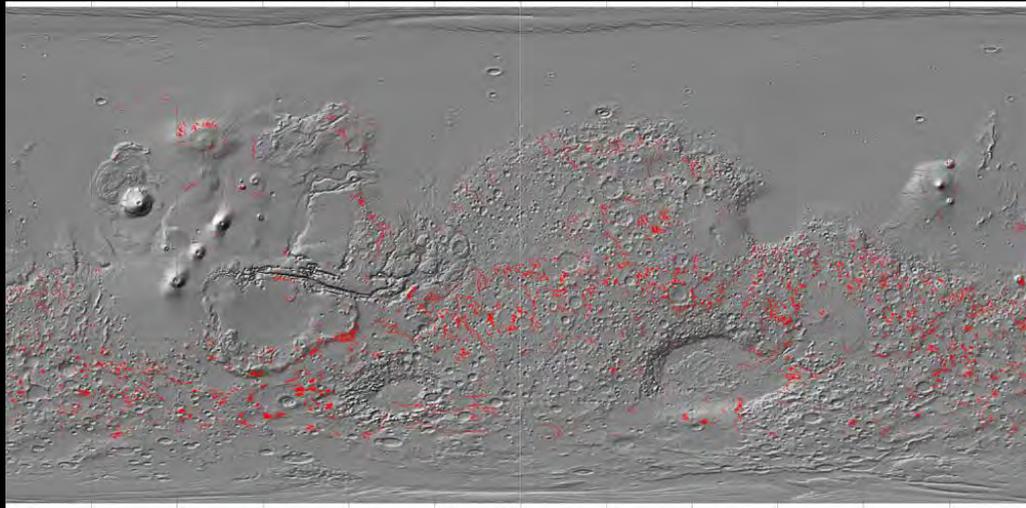


- Widely spaced tributaries with alcove-like terminations
- Constant valley width downstream
- Short, stubby tributaries
- Flat longitudinal profiles
- U-shaped cross sections

Status quo

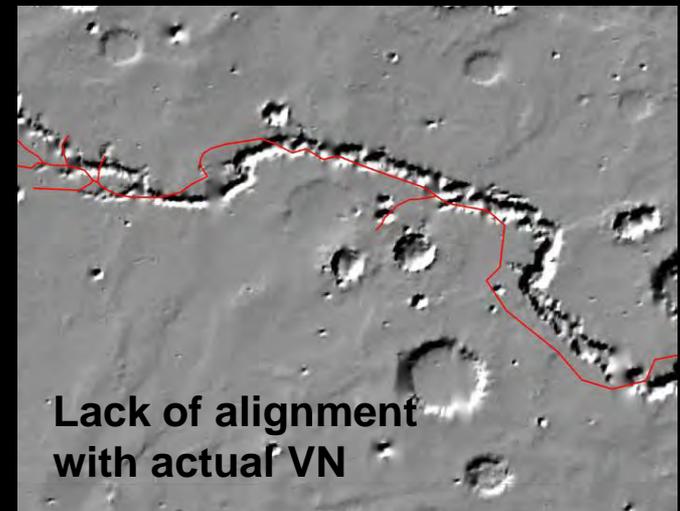
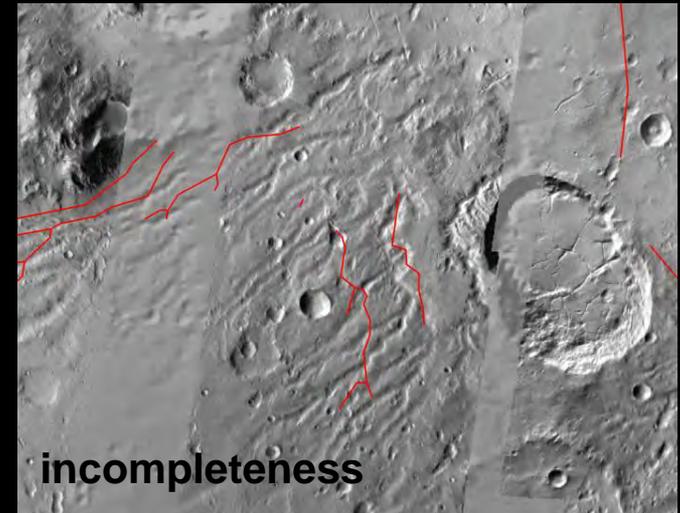


Carr's map (1997)



- Covers surface of Mars between $\pm 65^\circ$ latitude
- 11,336 segments, ~ 800 networks
- Mapped from Viking images
- Depicts immature drainage
- VN located mostly in southern highlands

Problems with Carr's map



Updating Carr's Map Using a Computer Algorithm

Don'ts

- Don't use available commercial software.
- Don't use any algorithm that extracts valleys by thresholding the D8 network.
- Don't assume it's easy.
- Don't assume you are going to get a perfect result.

Do's

- Use an algorithm that marks valleys directly from terrain morphology – this minimizes false positives.
- Expect false positives, eliminate them using either visual inspection or another algorithm.
- Expect some false negatives, learn to live with them.



Dr. Wei Luo
collaborator

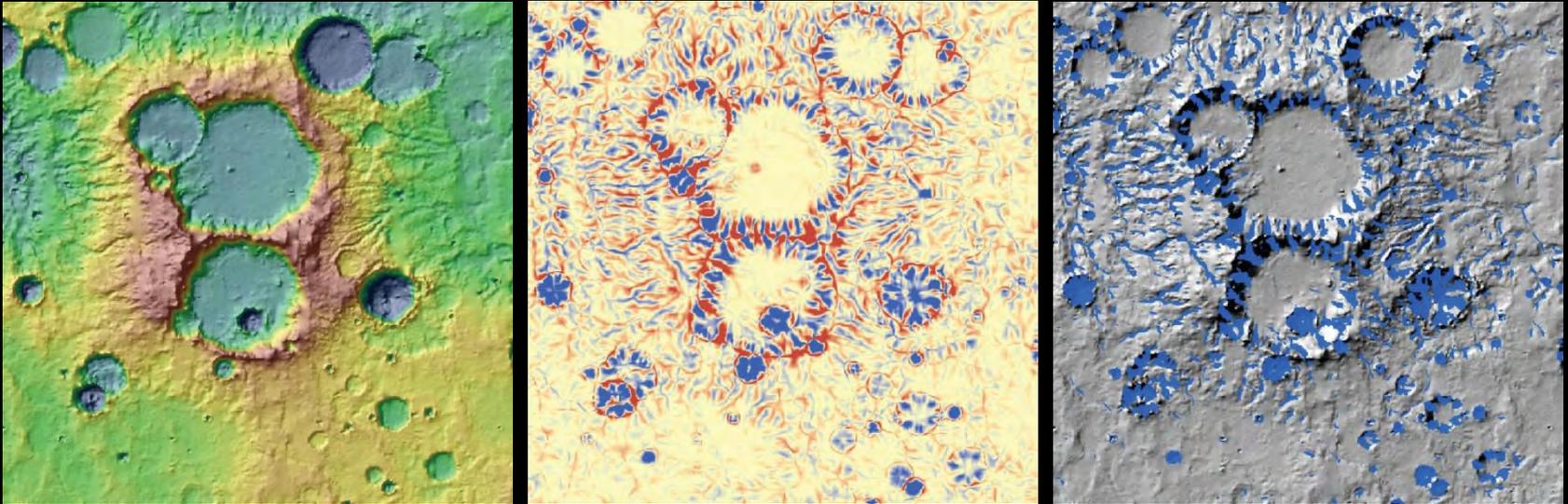


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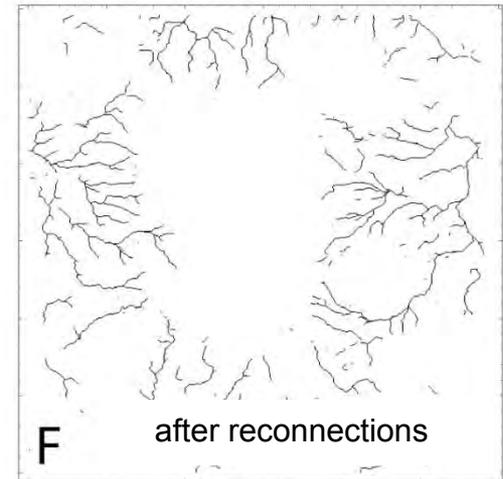
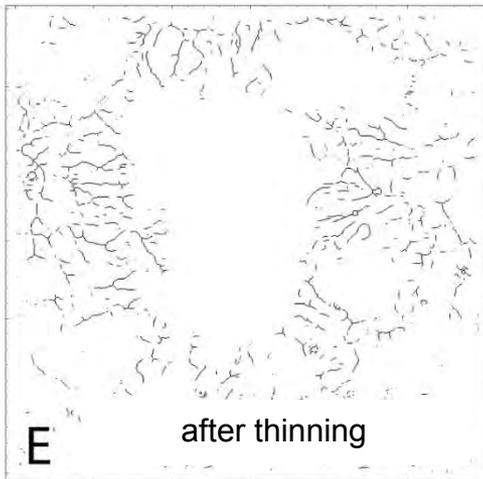
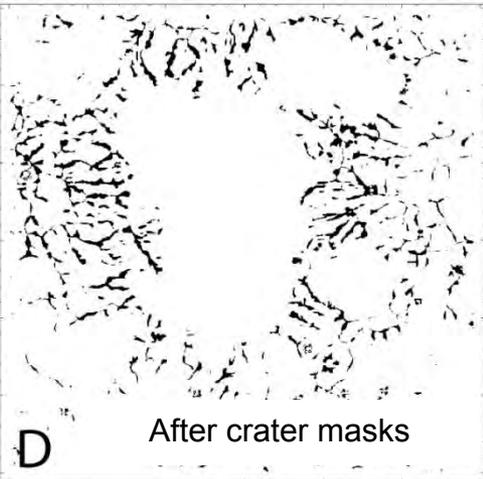
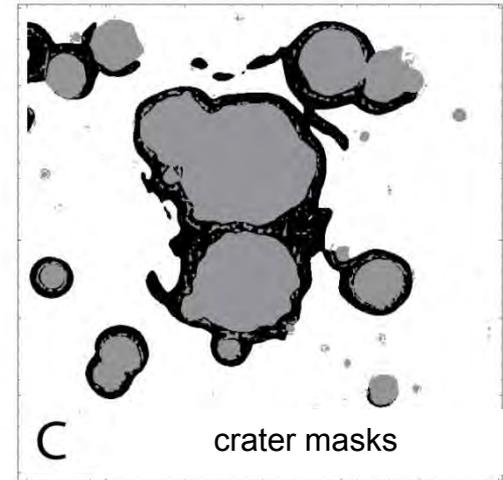
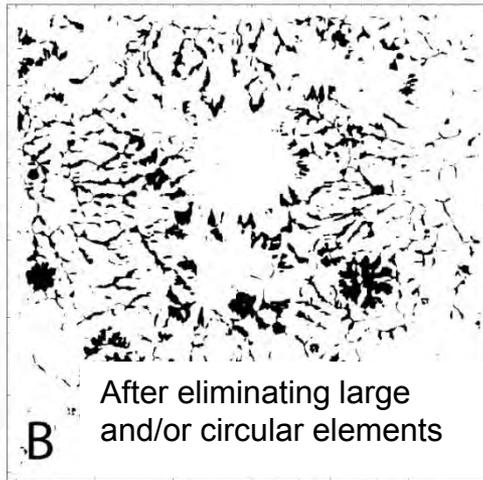
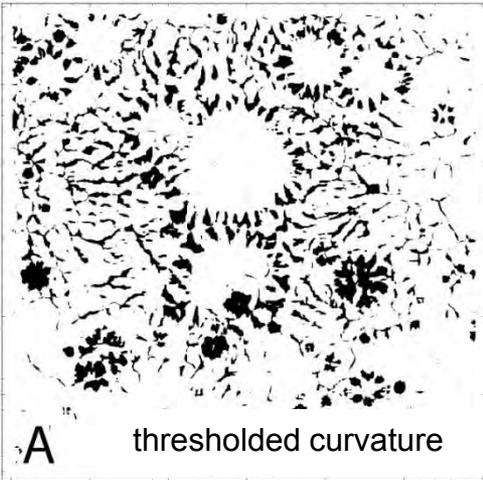
Mapping VN Using Terrain Morphology



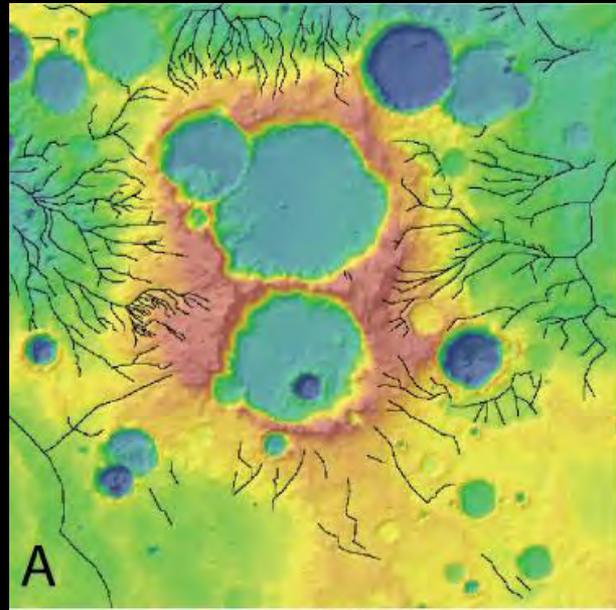
Blue: positive curvature (convergent)
Red: negative curvature (divergent)

Only pixels with curvature $>$ threshold are shown in blue

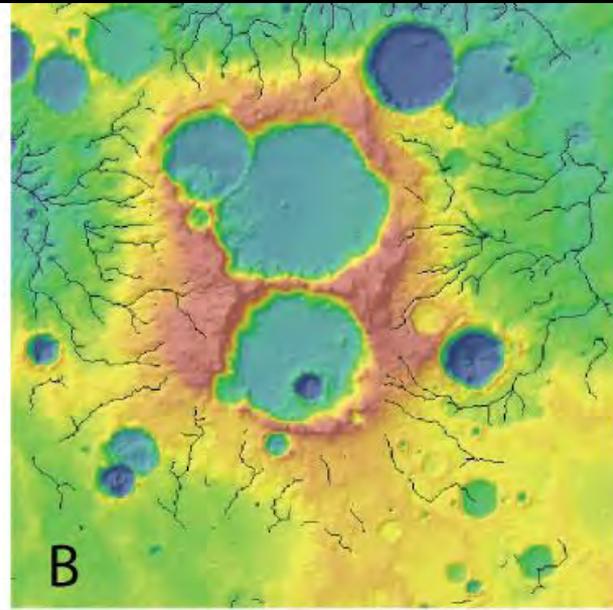
Mapping VN Using Terrain Morphology (cont.)



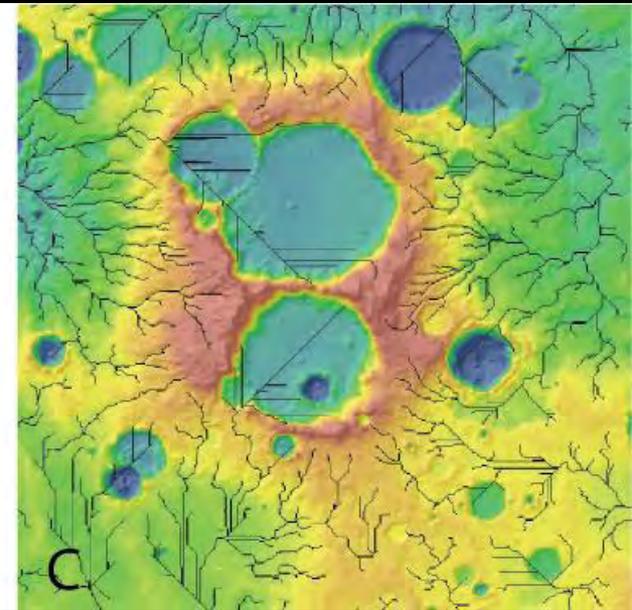
Mapping VN Using Terrain Morphology – Extraction Accuracy



manually mapped



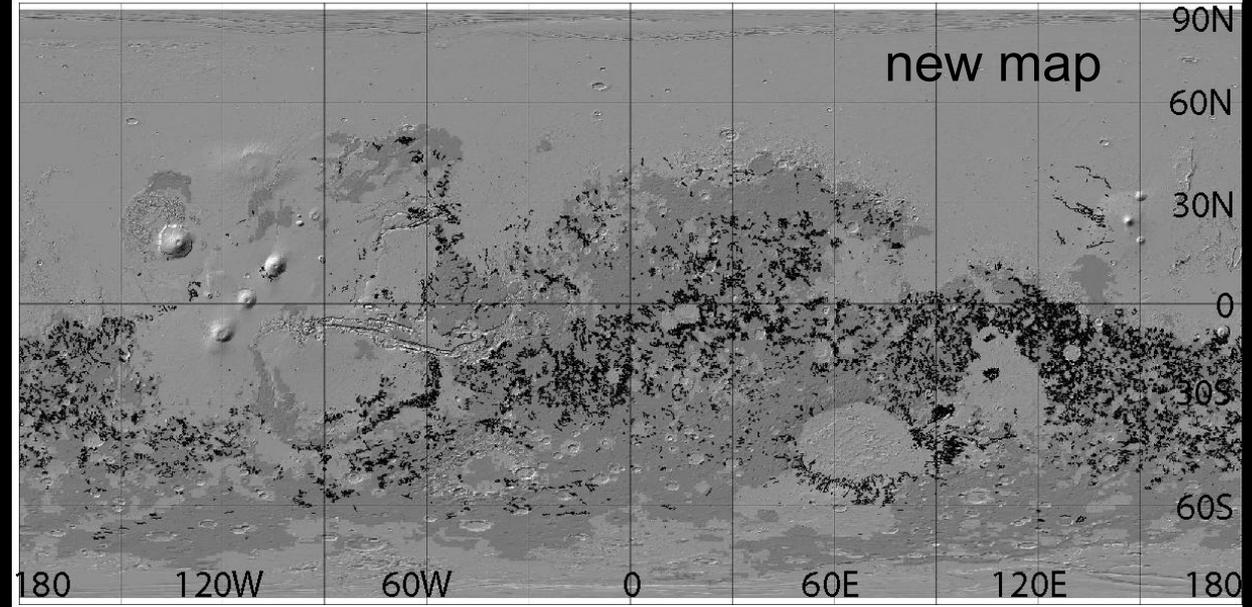
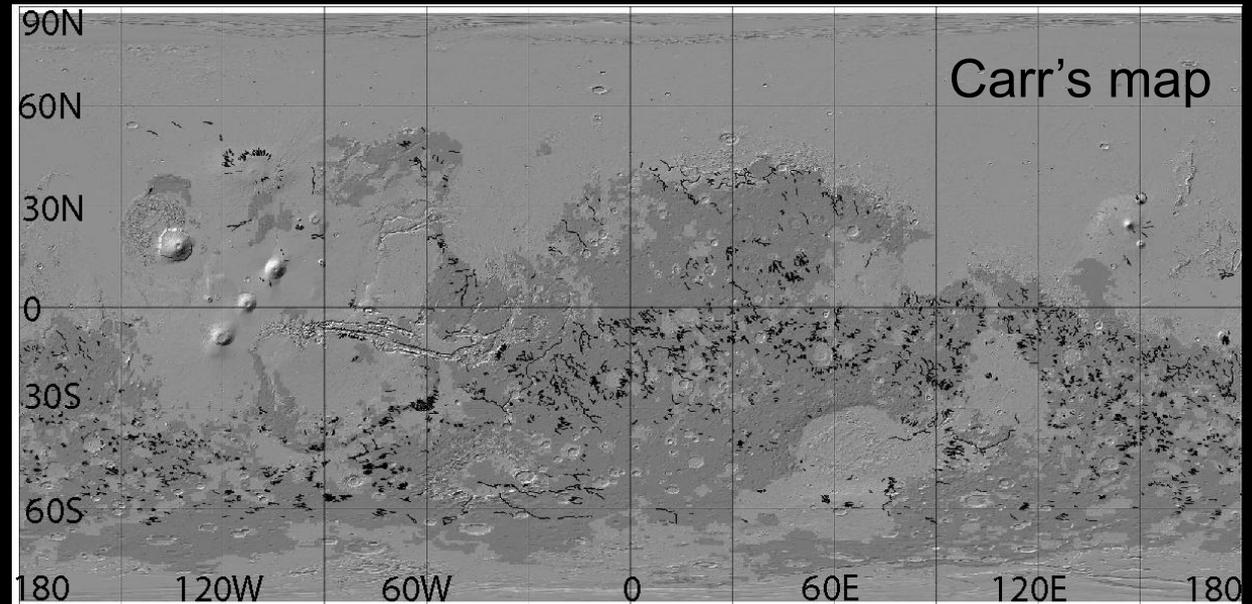
mapped by our algorithm



mapped by commercial algorithm

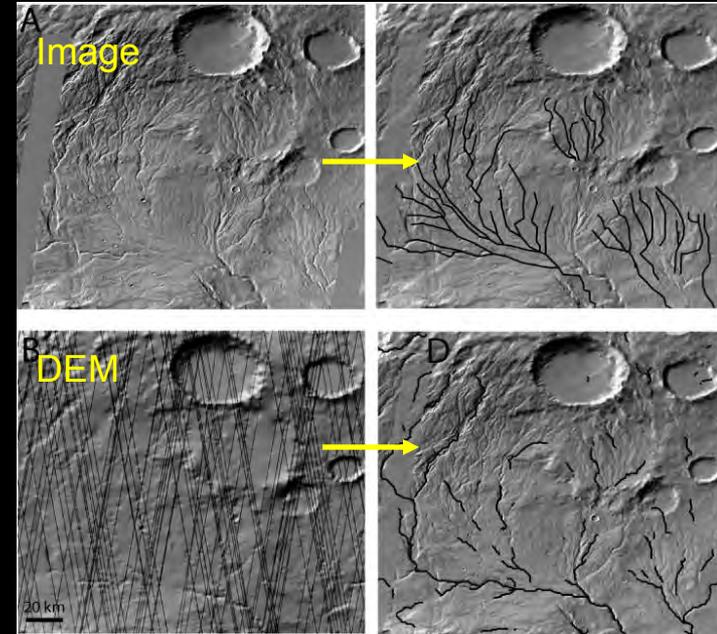
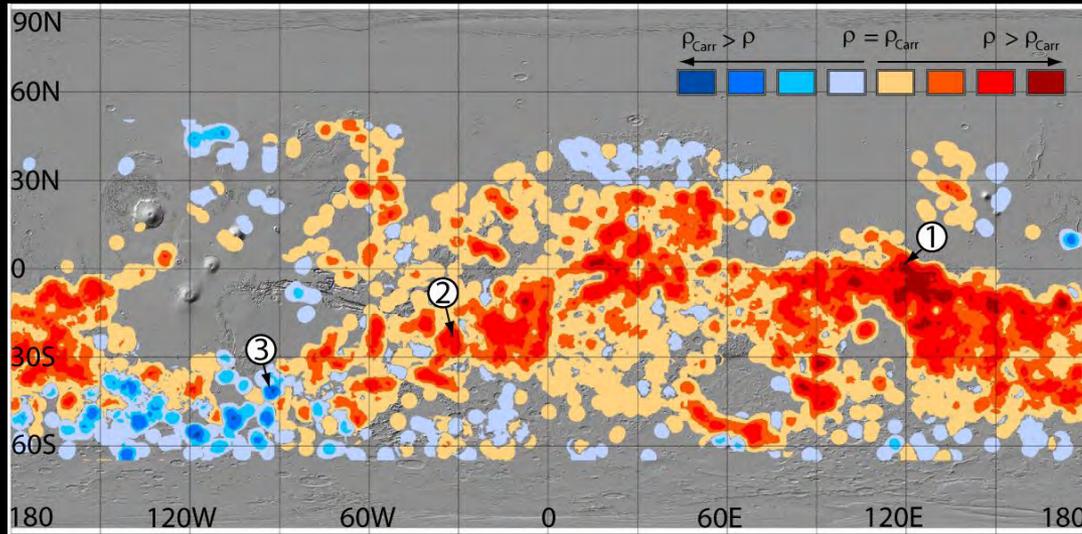
Auto-extracted map of VN

- Increase in the total length of VN by a factor of 2.3.
- Average value of DD = 0.062 km^{-1} .
- Locally the value of DD is as high as 0.12 km^{-1} .

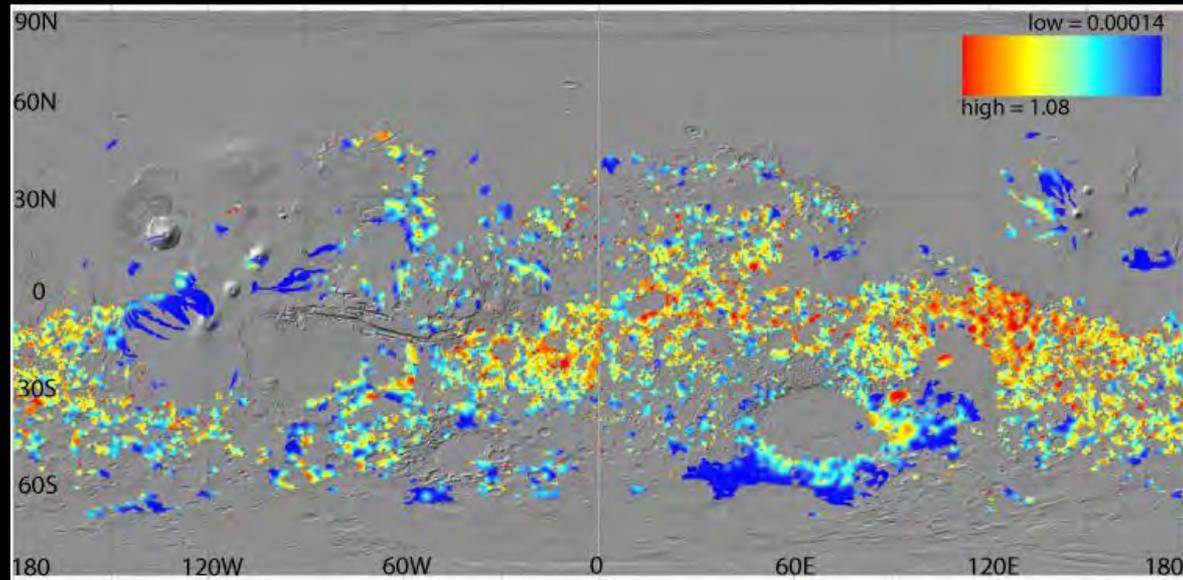


Auto-extracted Map of VN (cont.)

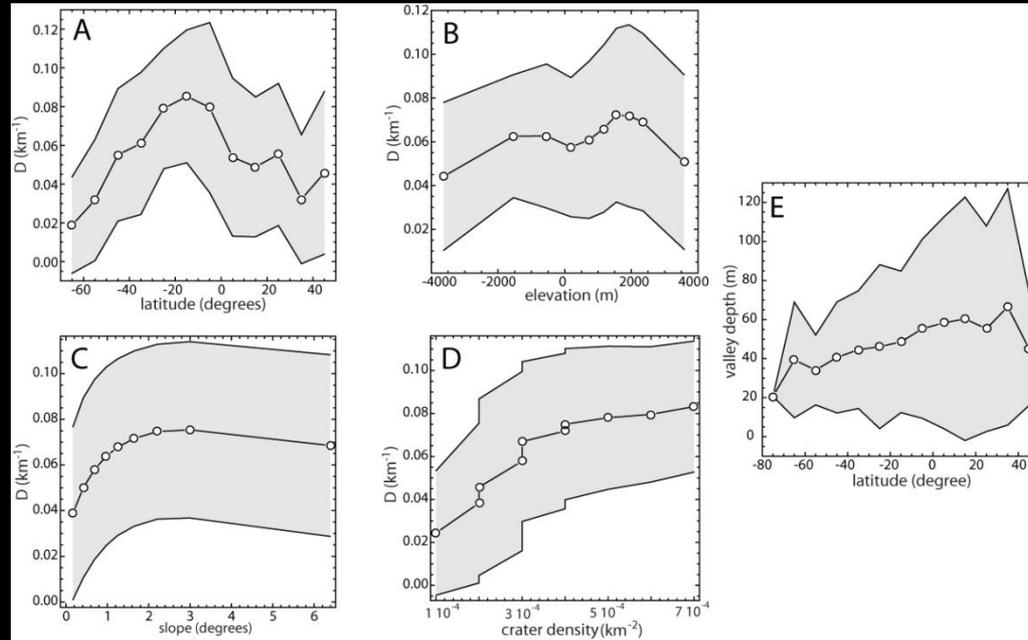
Comparison between the two maps



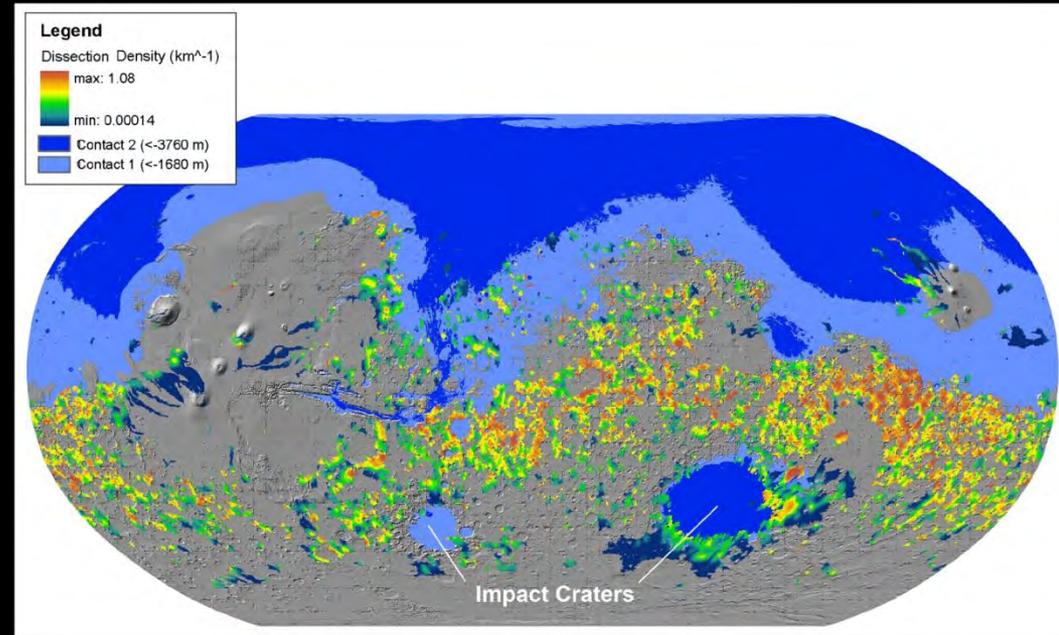
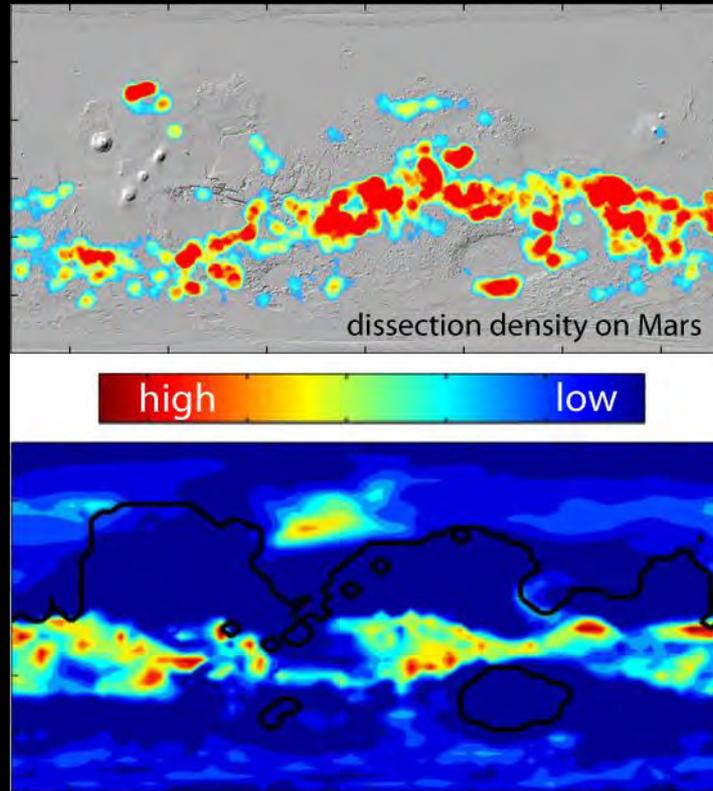
Auto-extracted Map of Drainage Density



Zonal statistics

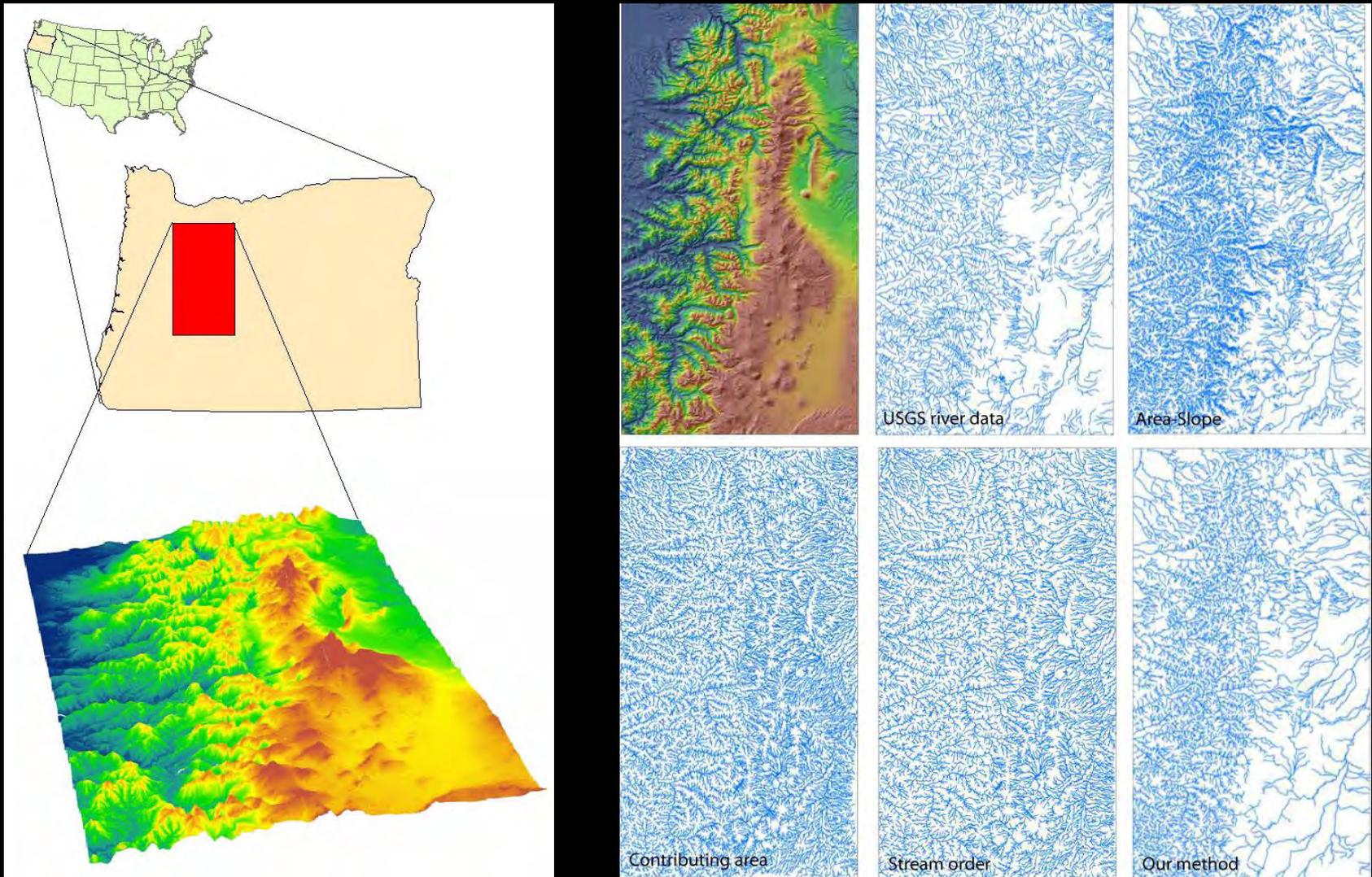


Knowledge Discovery: Martian Northern Ocean



Global distribution of VN on Mars supports existence of the Northern Ocean. In turn, existence of the Northern Ocean supports runoff origin of VN.

Application to Terrestrial geomorphology



W. Luo and T.F. Stepinski (2008) Identification of Geologic Contrast from Landscape Dissection Pattern: An Application to the Cascade Range, Oregon, USA. *Geomorphology*, 90, p90-98.

Conclusions

- Auto-mapping of VN on a global scale is a feasible technique that offers speed and objectivity.
- A new, more detailed global map of VN on Mars has been constructed and made available to the planetary community. This new map of is a significant update to the Carr map with threefold increase in the length of mapped valleys.
- Observed belt of high dissection density could be explained by existence of the northern ocean on ancient Mars. The ocean would also explain why valleys become progressively shallower toward south and why there is a southern limit to the presence of valley networks.