The Importance of Geodetically Controlled Data Sets: THEMIS Controlled Mosaics of Mars, A Case Study

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Why Control?

- Geodetically controlled products are foundational data products.
  - Errors / uncertainties are quantified at local scales.
  - Tied to a legitimate base map.
  - Updated kernels are generated
- When do you want to use a controlled product?
  - Geologic mapping
  - Entry, landing, and descent evaluations for lander mission
  - Mission planning and coordination
  - Change detection studies
  - Fusion of multiple data sets

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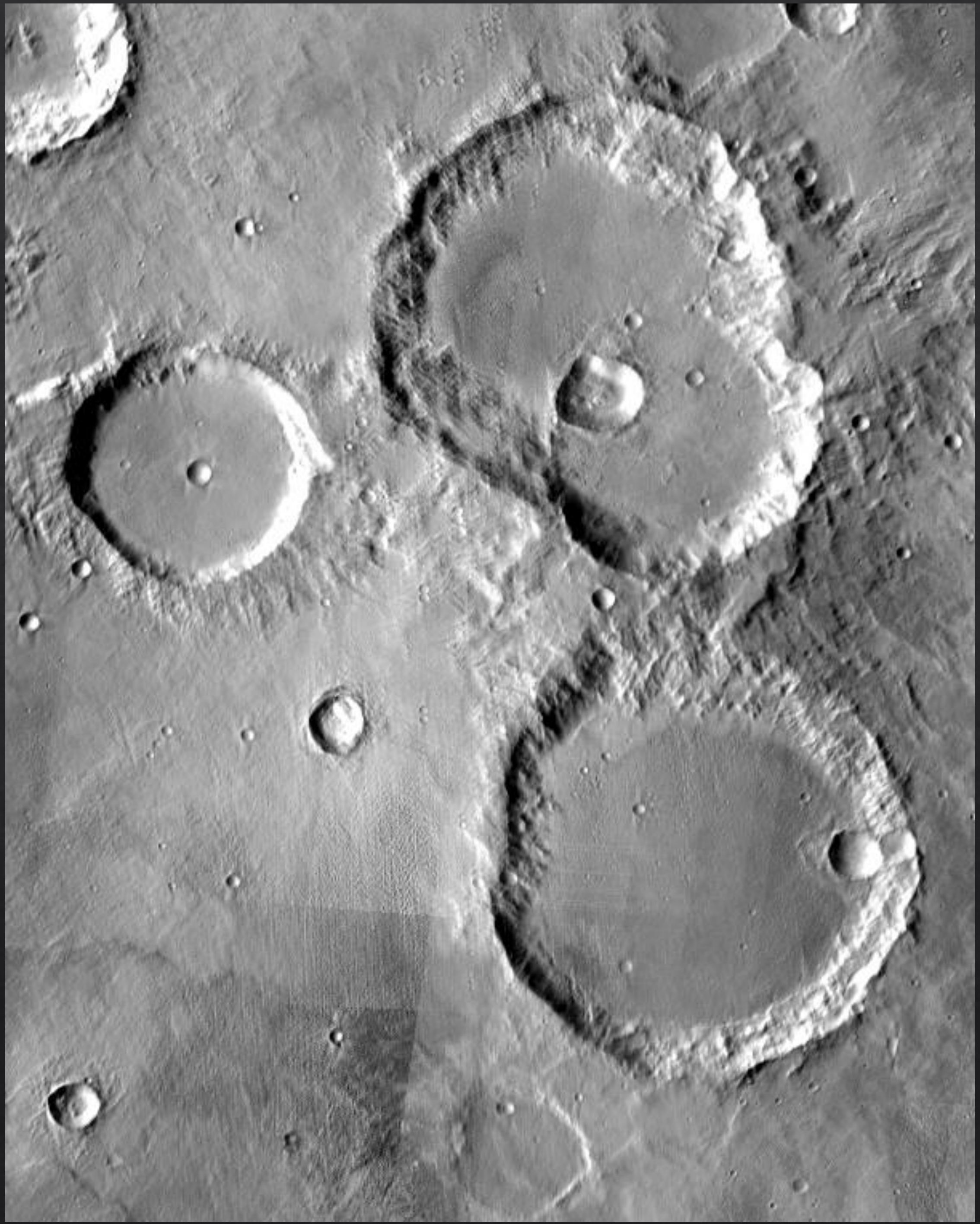
Iapygia
14.8 S, 72.9 E

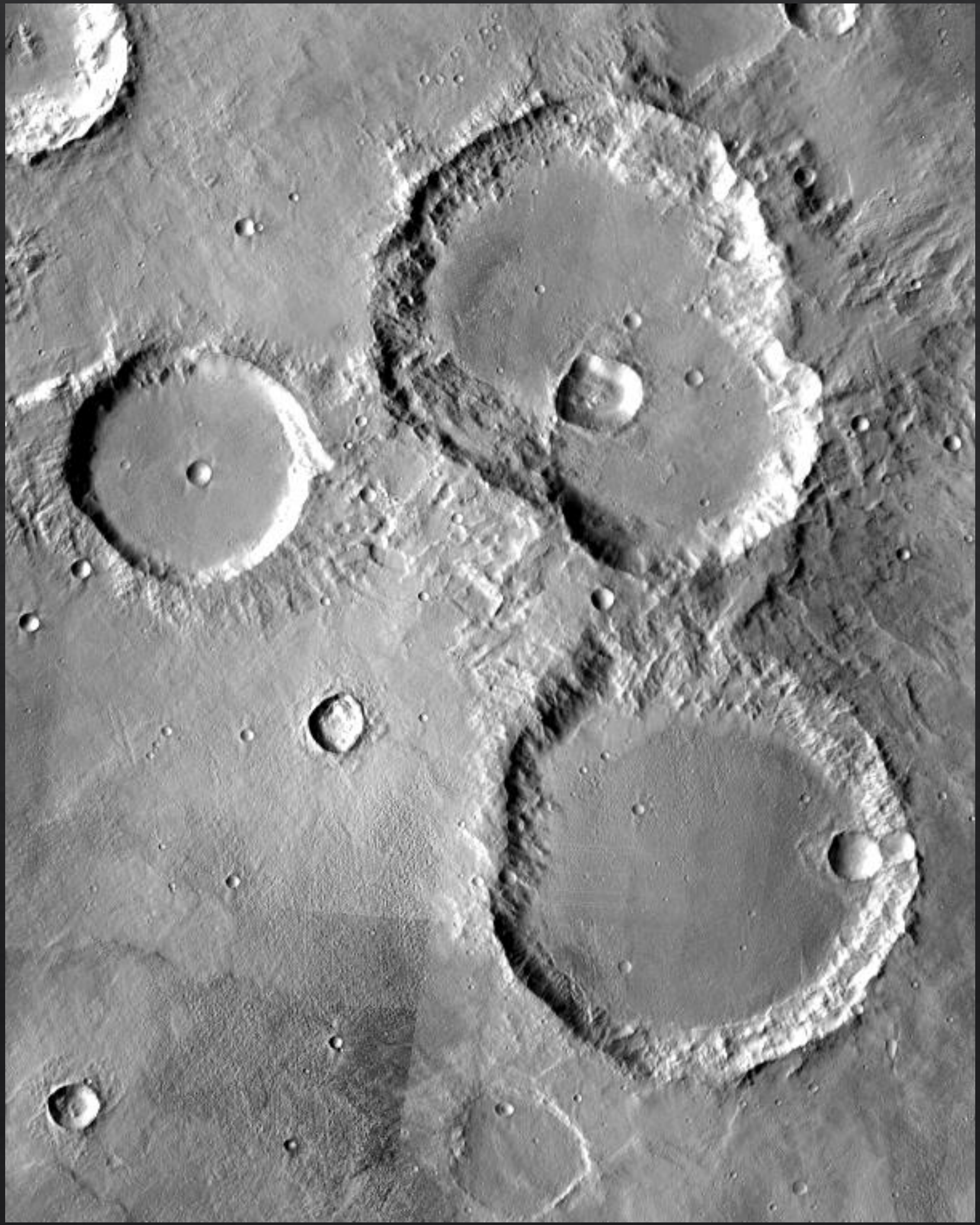
10 pixel (~1 km) shift



30 km

Iapygia
14.8 S, 72.9 E

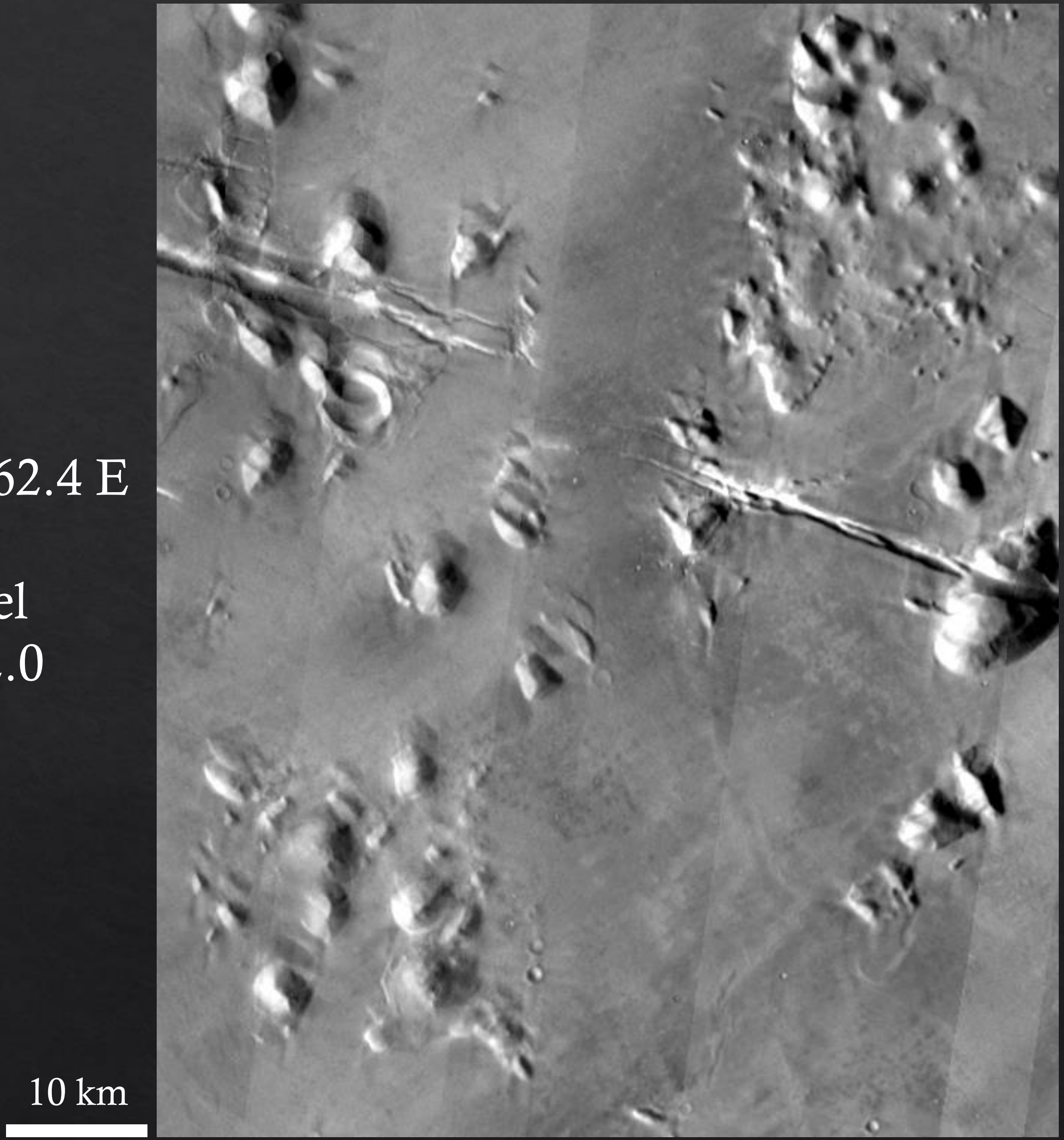
10 pixel (~1 km) shift



30 km

Elysium
15.4 N, 162.4 E

16-20 pixel
(~1.6 to 2.0
km) shift



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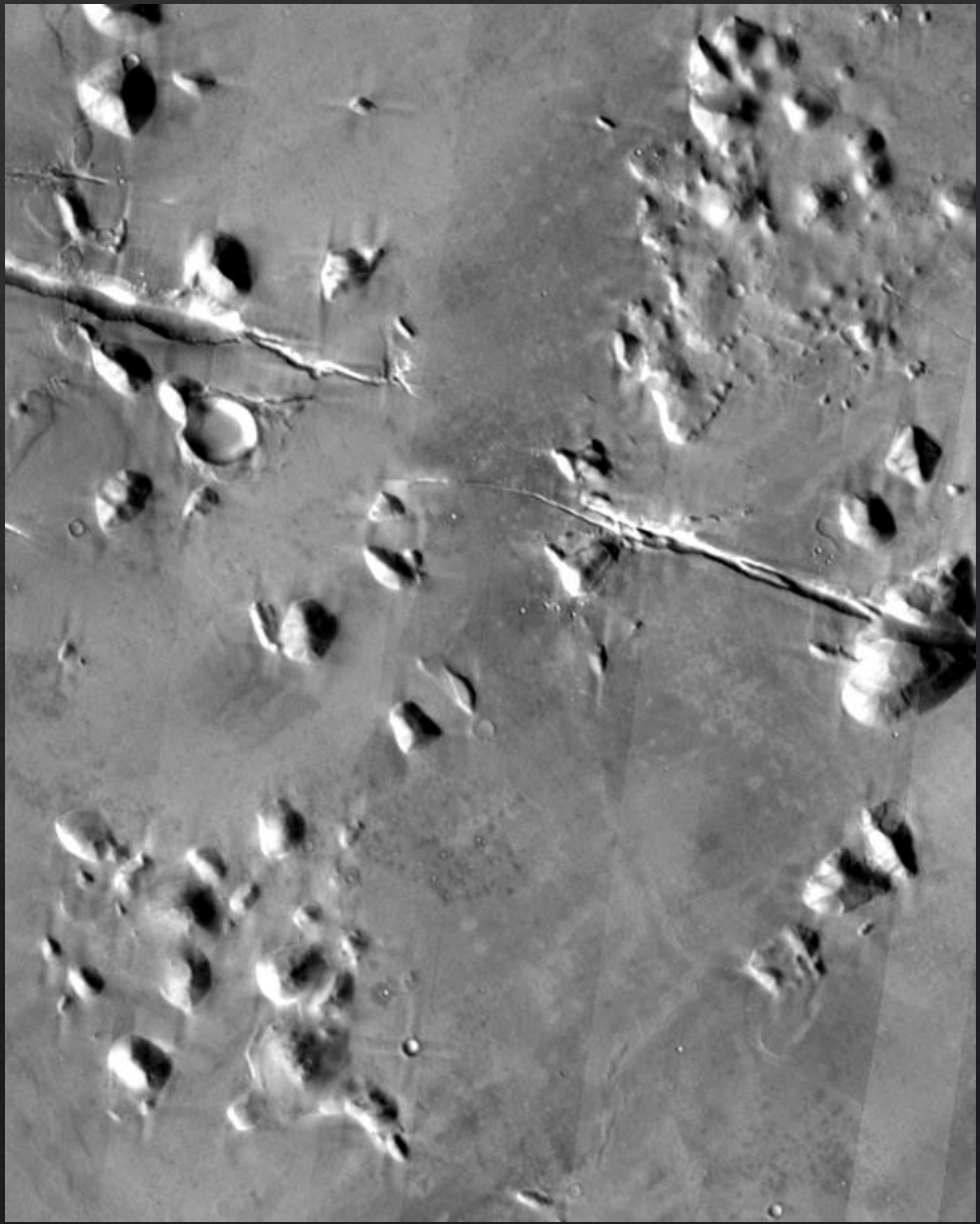

10 km

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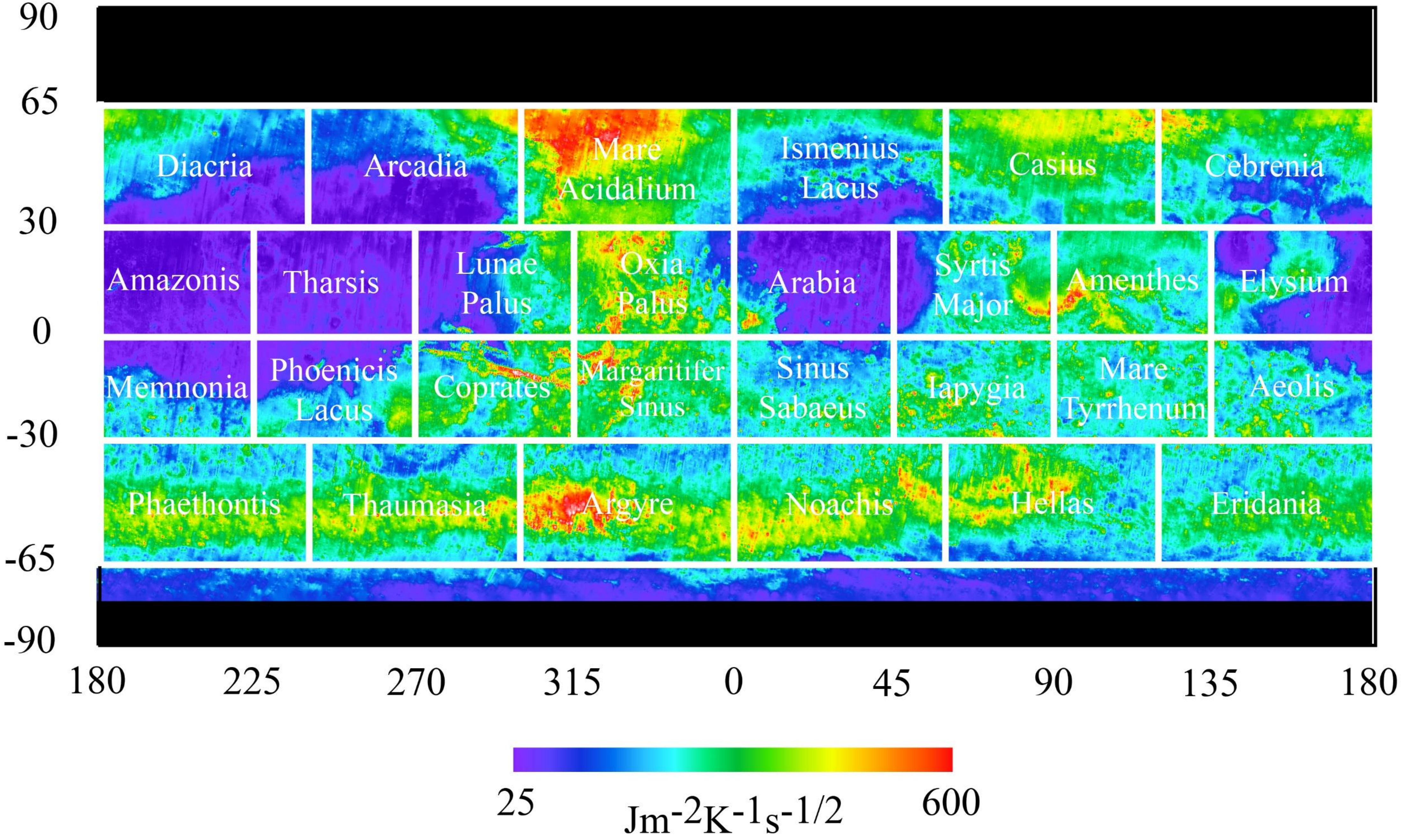
THEMIS Instrument

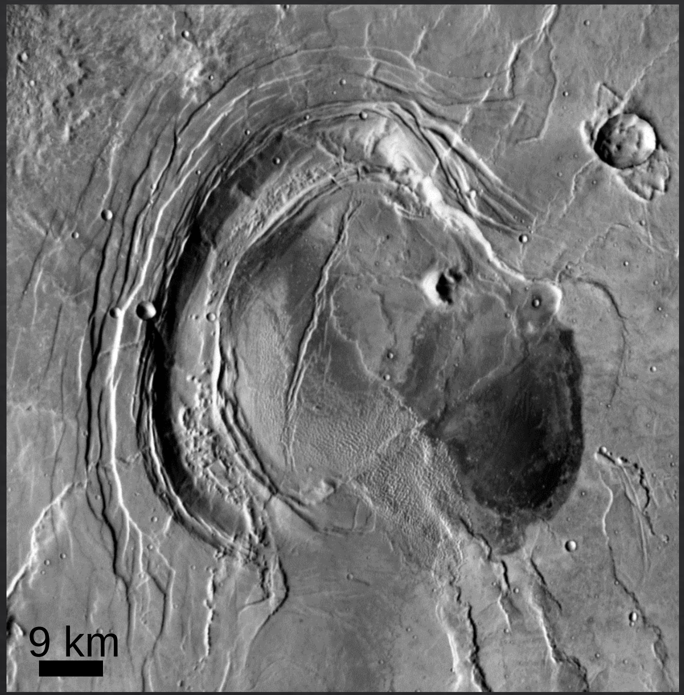
- Spatial scale of 100 m per pixel
- Sensor type = Line-scan imager
- Mapping priority was to obtain global coverage, not with the intention of generating a controlled product.
- Images were acquired both during the day and at night.

Image credit: ASU/Christensen et al., 2004



90
65
30
0
-30
-65
-90
Diacria
Arcadia
Mare Acidalium
Ismenius Lacus
Casius
Cebrenia
Amazonis
Tharsis
Lunae Palus
Oxia Palus
Arabia
Syrtis Major
Amenthes
Elysium
Memnonia
Phoenicis Lacus
Coprates
Margaritifer Sinus
Sinus Sabaeus
Iapygia
Mare Tyrrhenum
Aeolis
Phaethontis
Thaumasia
Argyre
Noachis
Hellas
Eridania
180
225
270
315
0
45
90
135
180
25
600
$Jm^{-2}K^{-1}s^{-1/2}$

Methods and Data



Nili Patera - Daytime IR (upper) and nighttime IR (lower); 8.9 N, 67.2 E

- This is one of the first global controlled products made with ISIS3
- Software
  - Jmars to identify and constrain THEMIS image list.
  - ISIS3 to generate the control network.
  - Davinci to process THEMIS data and generate the controlled mosaics.
  - ArcGIS to visually inspect each mosaic.
- Ground Control
  - Current accepted ground data source for Mars is the MOLA DEM.
  - Tied to the Viking MDIM network, which is tied to the MOLA DEM.

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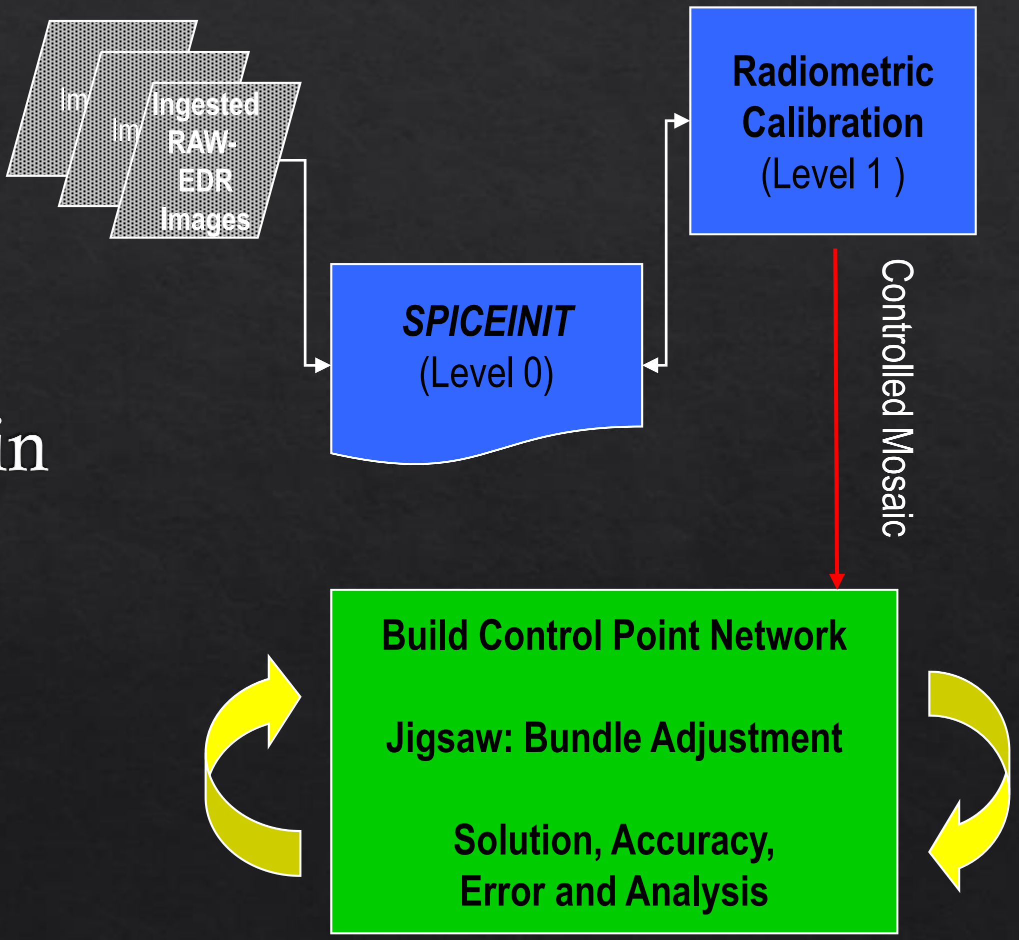
Workflow Overview

- Identify suitable images by constraining on various parameters (Jmars)
- THEMIS image processing (ISIS3/Davinci)
- Assemble the control network (ISIS3)
- Run bundle adjustment (iterative process in ISIS3)
- Tie to ground (ISIS3)
- Write out updated image and spacecraft kernels (ISIS3)
- Generate controlled mosaics (davinci)



Workflow: Control Network Assembly

- Two processes were used to generate the control networks:
  - Utilizing existing points in the merged network
  - Creating new points and measures

- Merge these two networks into a single, cohesive network that we pass to the bundle adjustment program.

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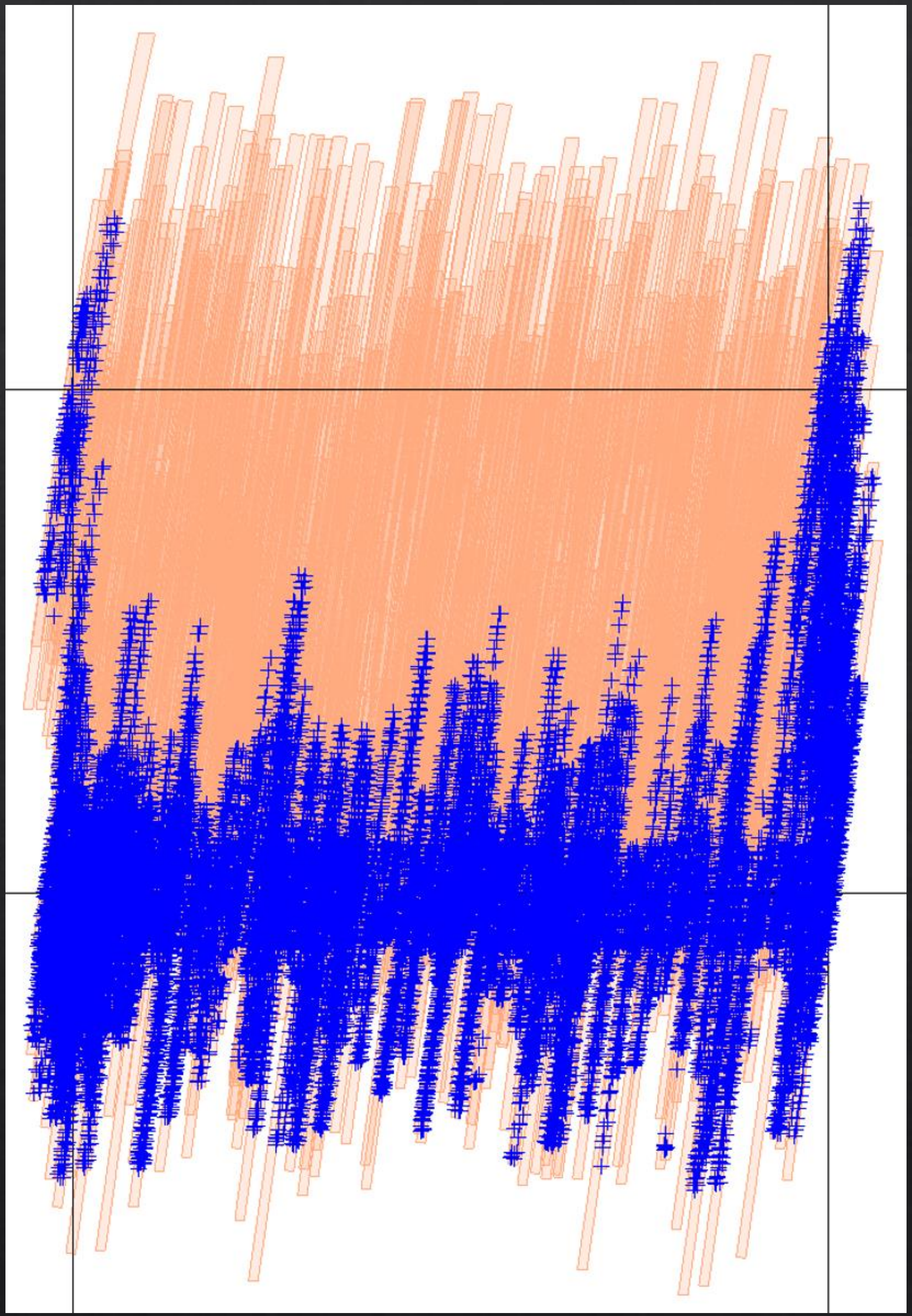
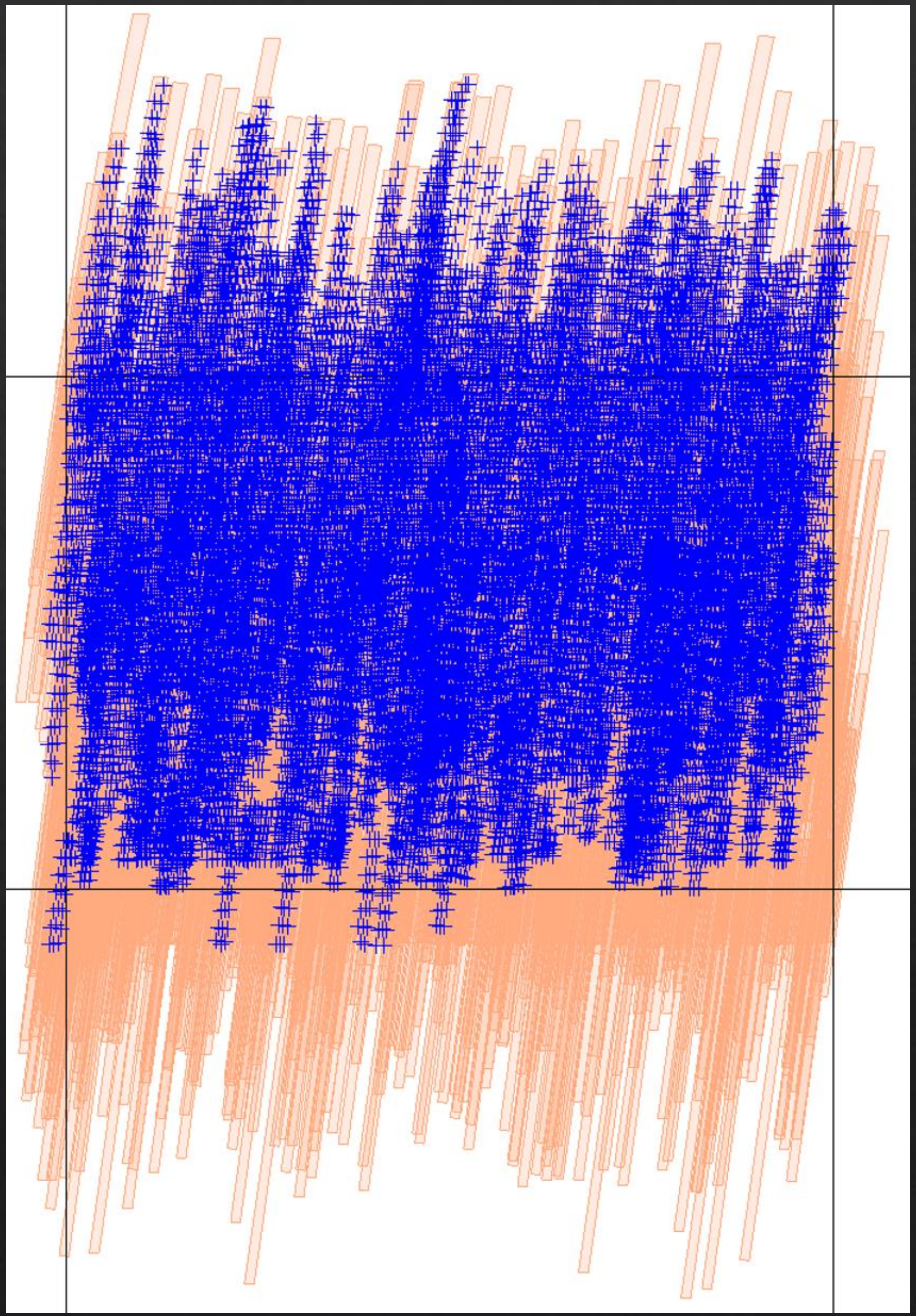


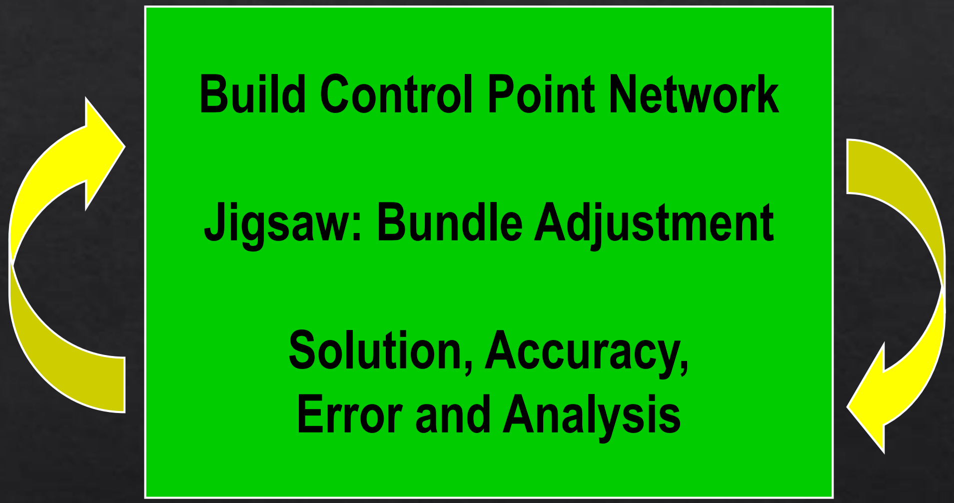
Utilizing Existing Points from the Merged Network



Creating New Points and Measures

Workflow: Bundle Adjustment

- Evaluate the health of the network
  - Identify images with zero or few points
  - Identify islands
- Run bundle adjustment
  - Evaluate the results
  - Remove high residual measures
  - Re-evaluate the health of the network
  - Re-run bundle adjustment
- We tie the network to the Viking MDIM, which is tied to MOLA.



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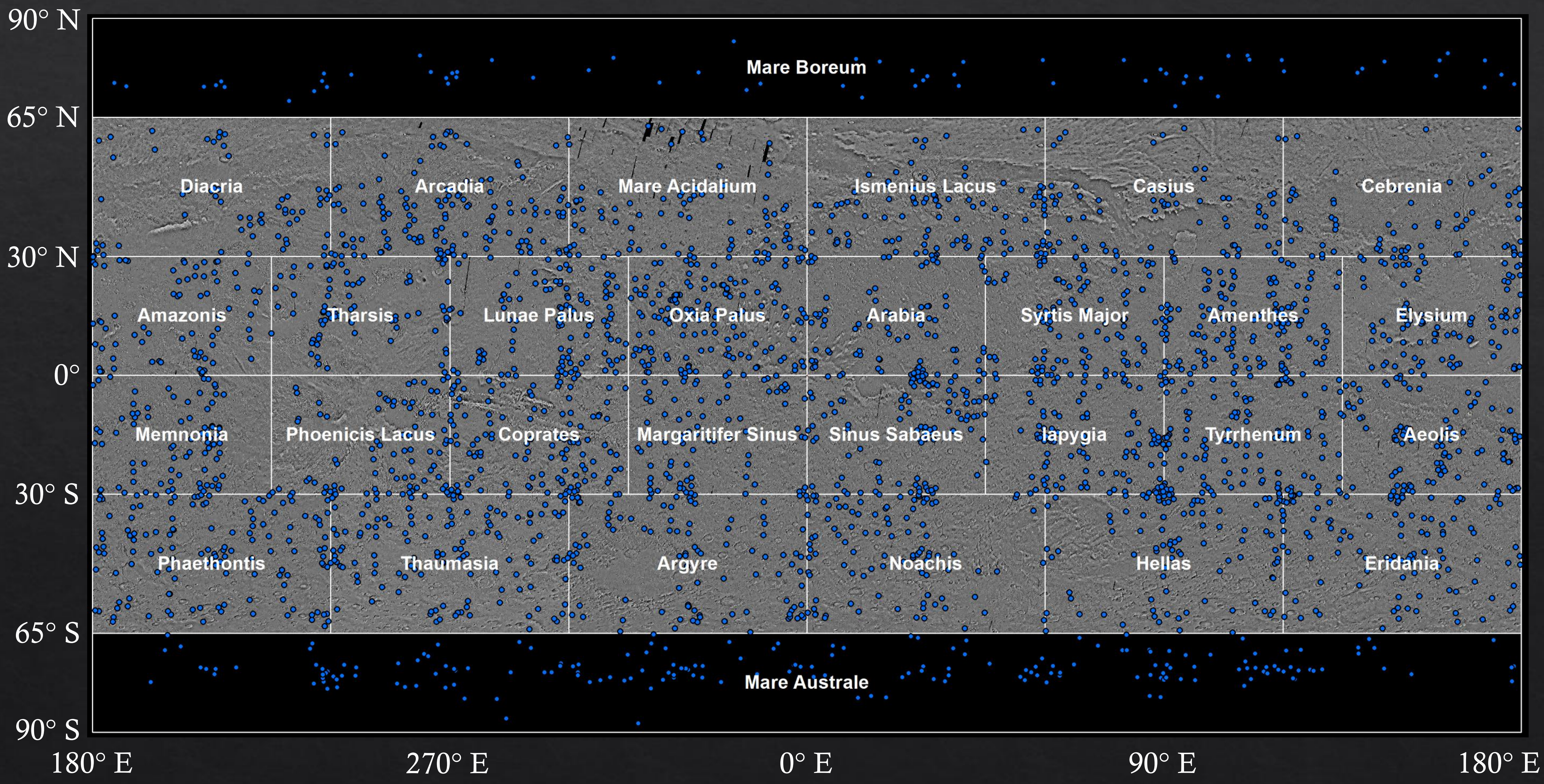
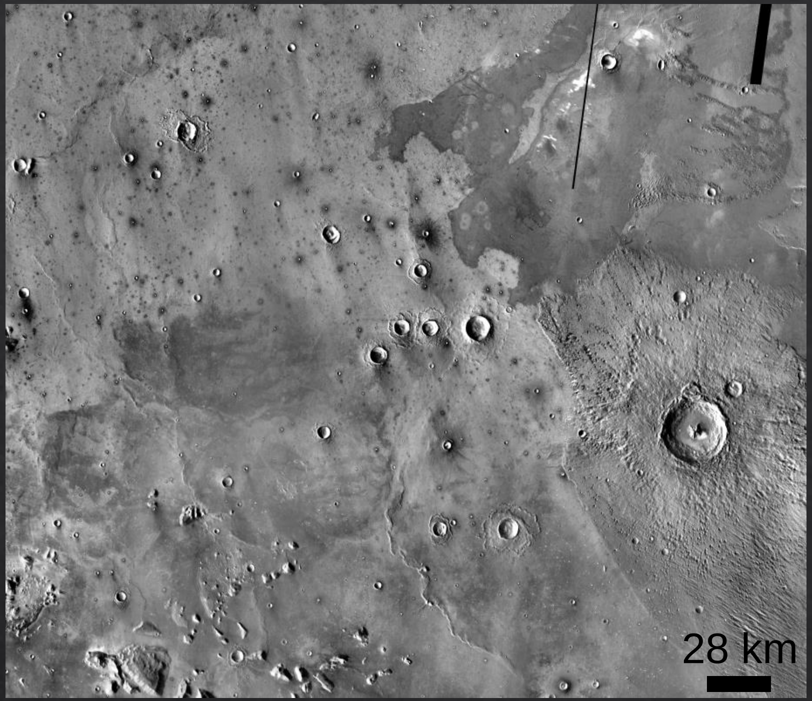
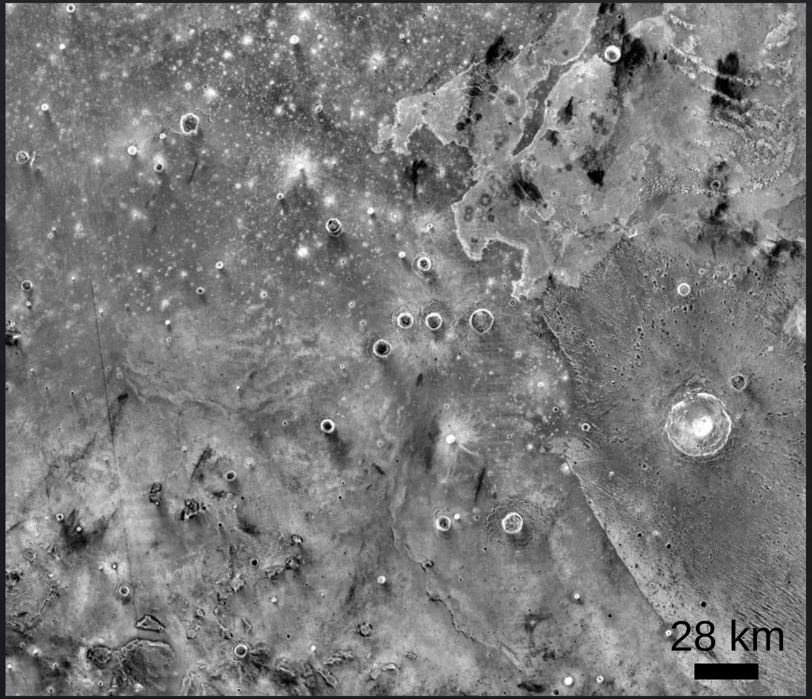


90° N
65° N
30° N
0°
30° S
65° S
90° S
180° E
270° E
0° E
90° E
180° E
Mare Boreum
Diacria
Arcadia
Mare Acidalium
Ismenius Lacus
Casius
Cebrenia
Amazonis
Tharsis
Lunae Palus
Oxia Palus
Arabia
Syrtis Major
Amenthes
Elysium
Memnonia
Phoenicis Lacus
Coprates
Margaritifer Sinus
Sinus Sabaeus
Iapygia
Tyrrhenum
Aeolis
Phaethontis
Thaumasia
Argyre
Noachis
Hellas
Eridania
Mare Australe



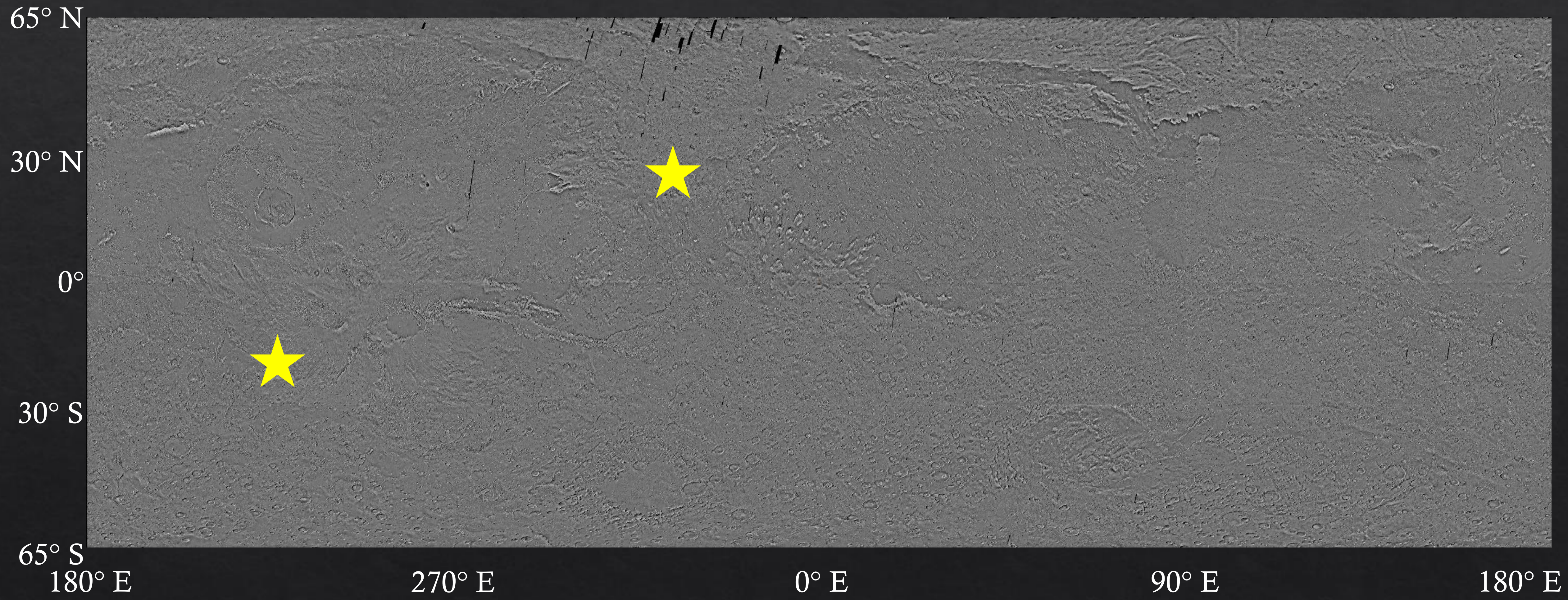


Accuracy

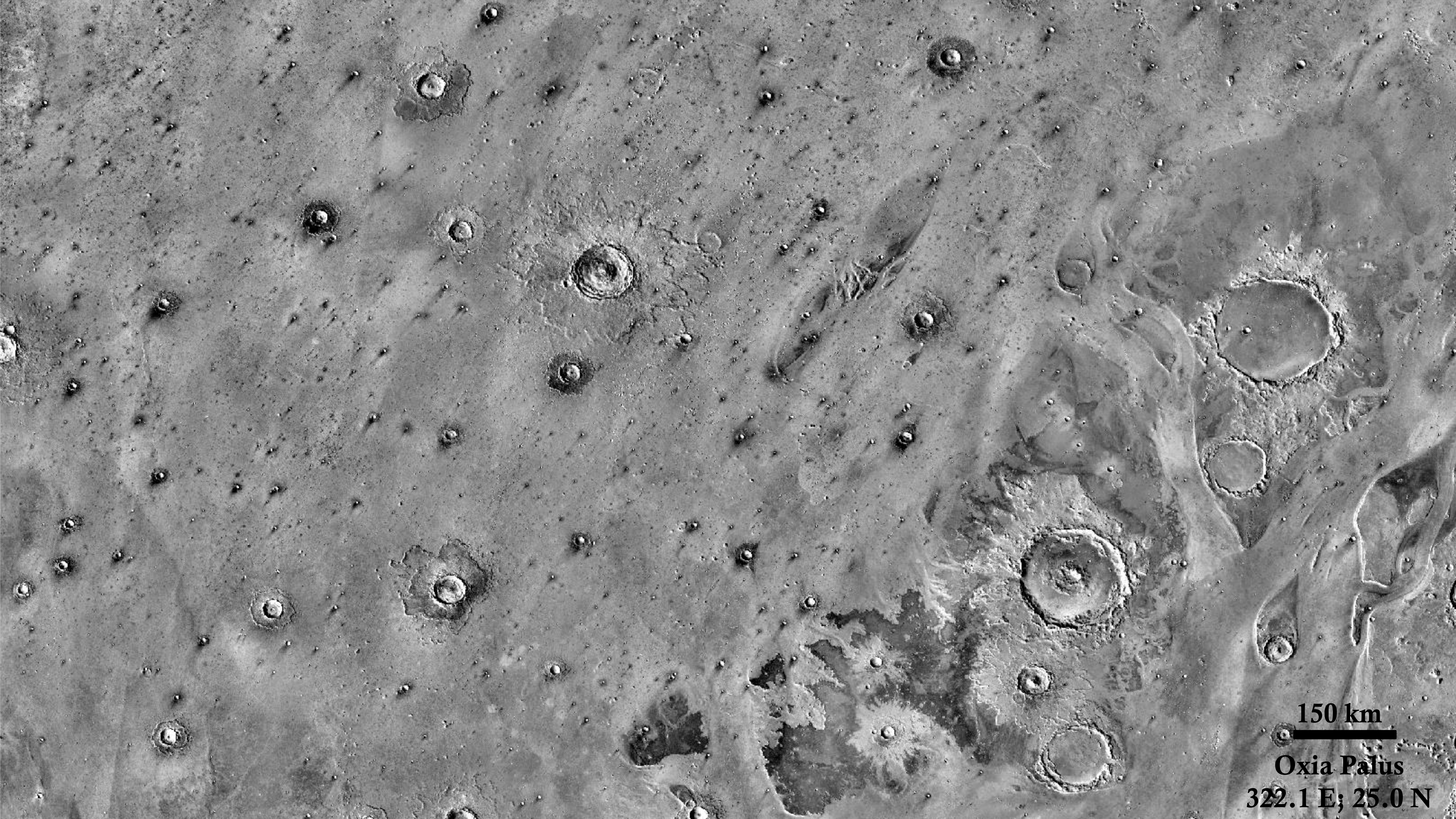
- Horizontal accuracy is ***60-390 meters***
  - 0.6 to 3.9 pixels

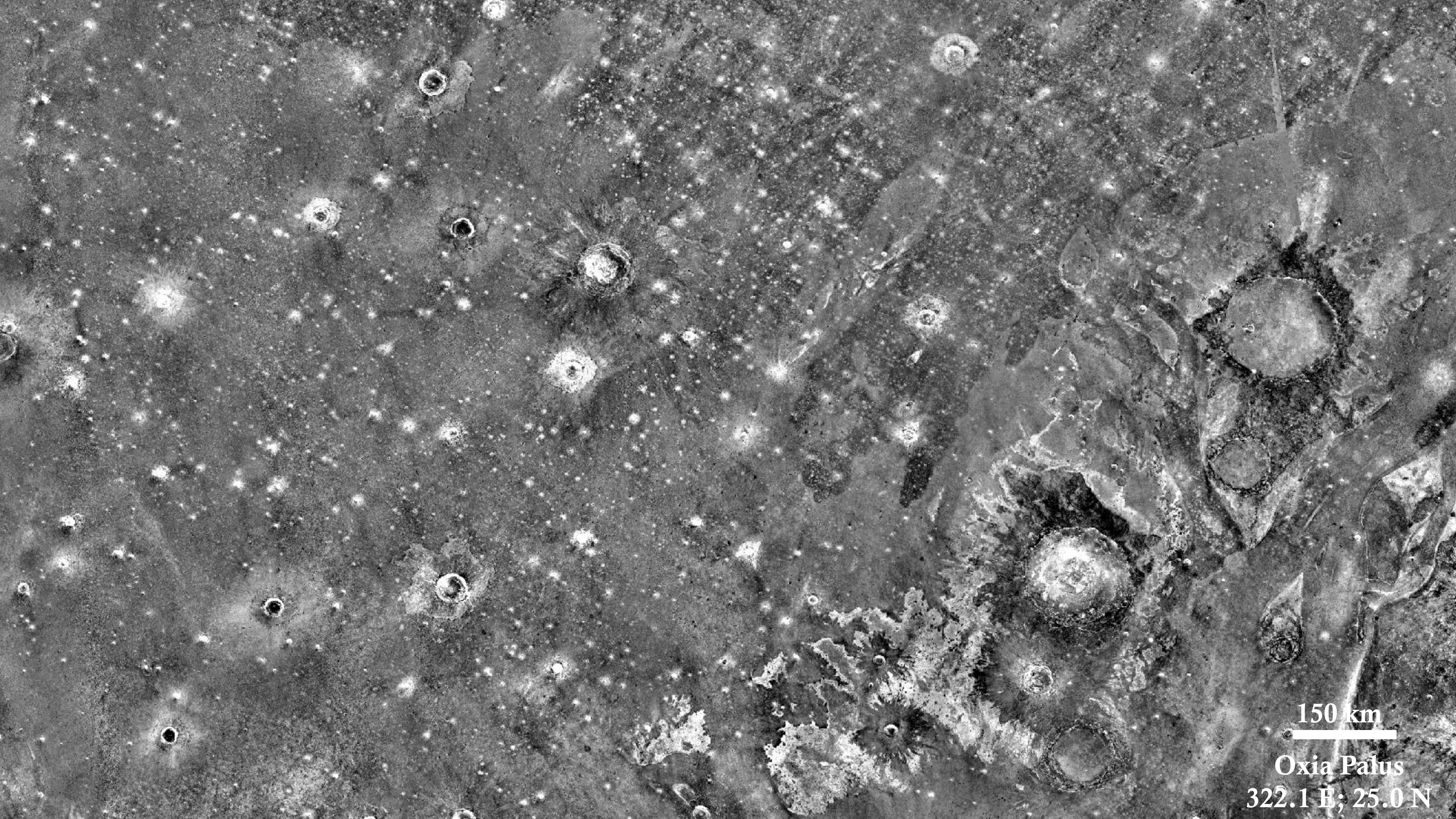
If you do not control your data, you have no idea about the accuracy of your product.

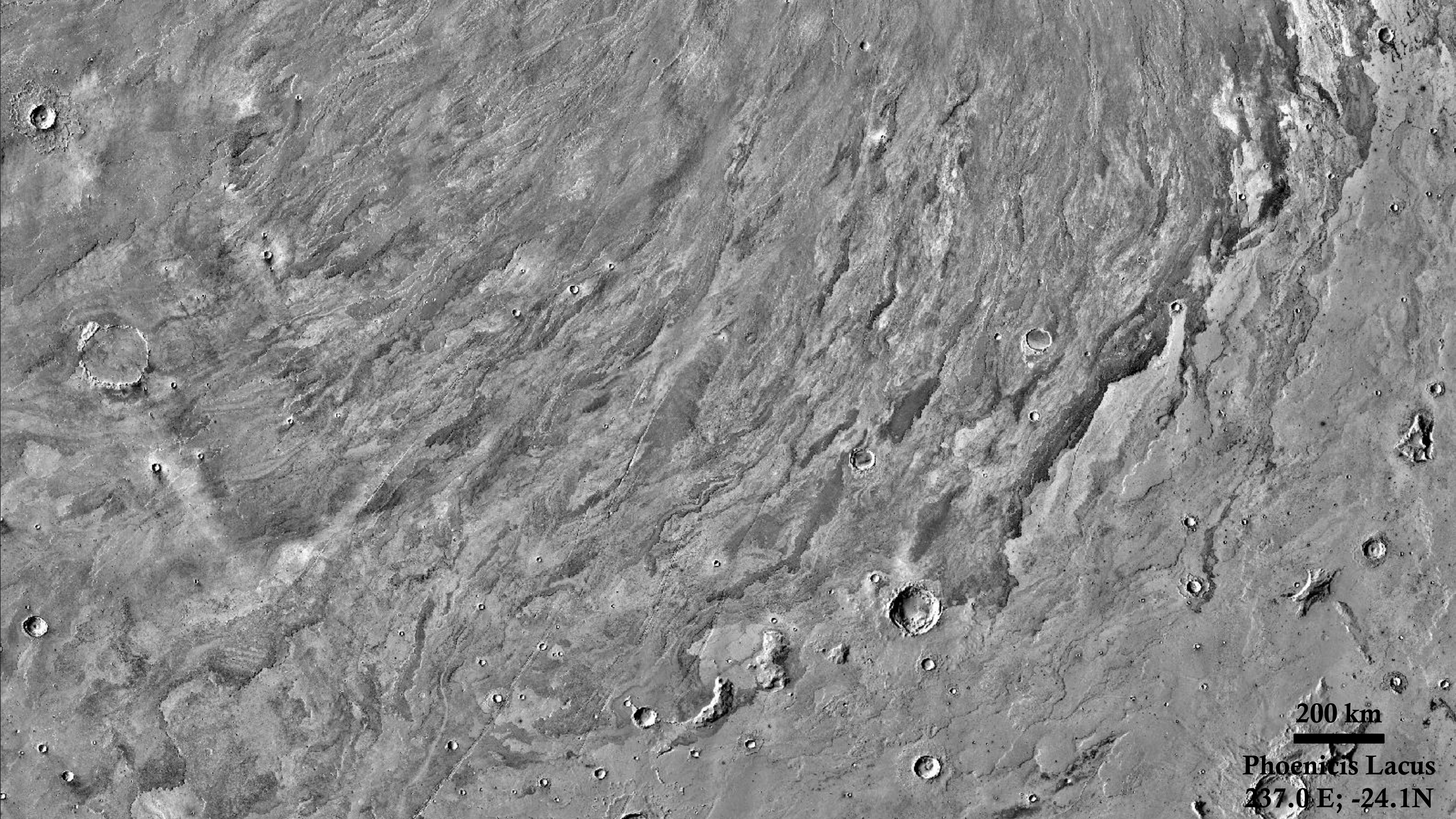
Elysium Planitia - Daytime IR (upper) and nighttime IR (lower); 3.7 N, 138.0 E

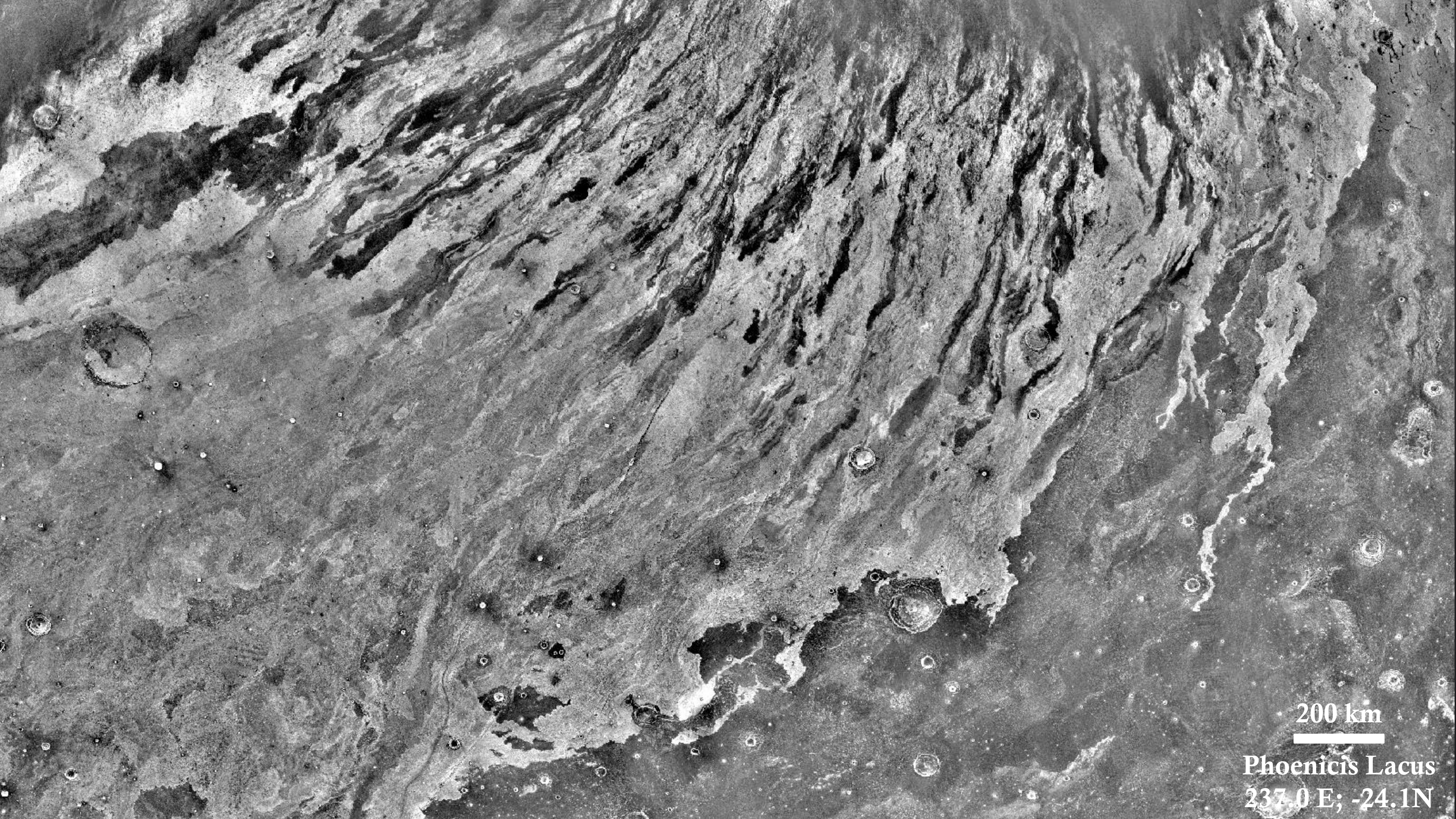


65° N
30° N
0°
30° S
65° S
180° E
270° E
0° E
90° E
180° E


150 km
Oxia Palus
322.1 E; 25.0 N

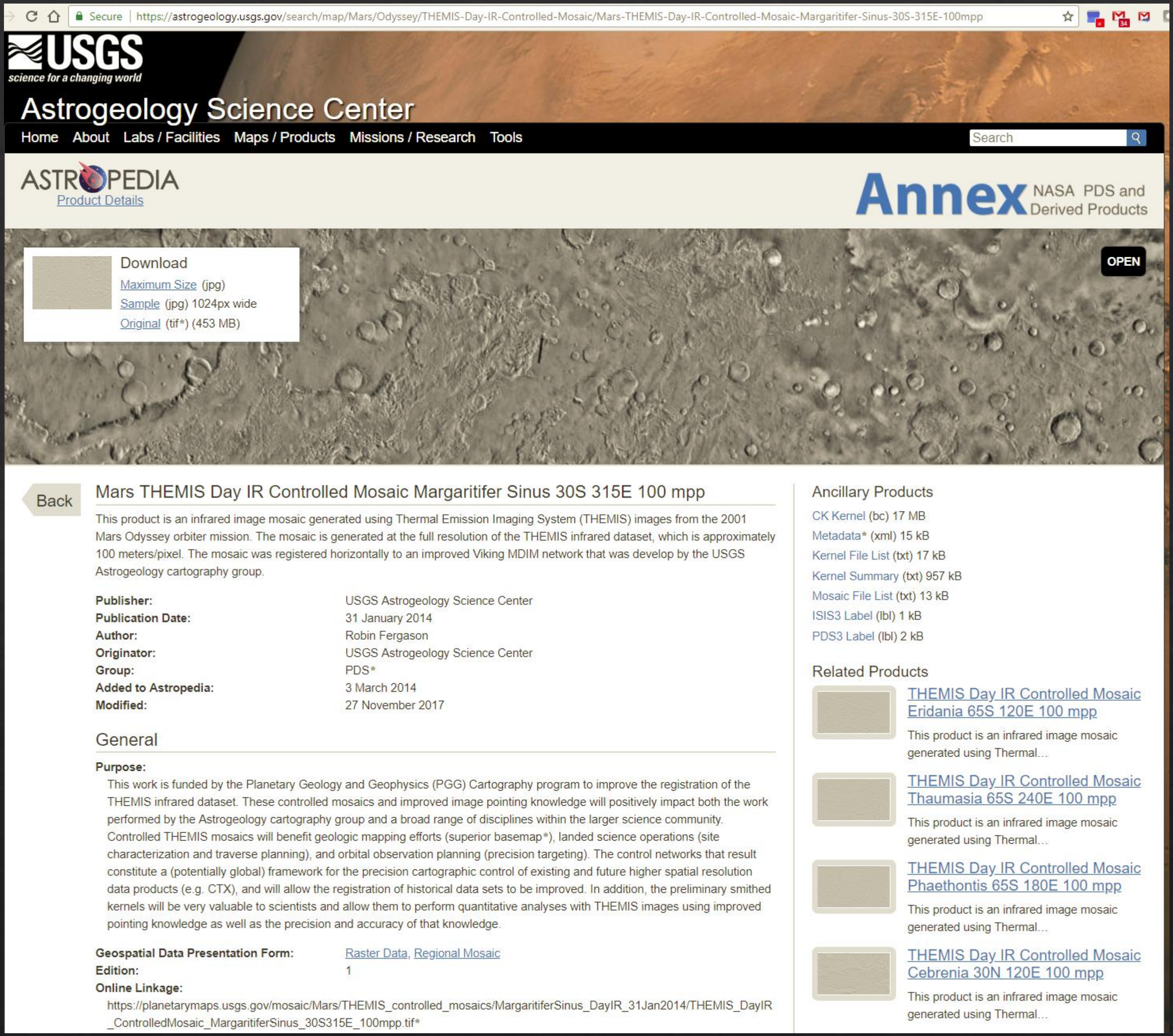

150 km
Oxia Palus
322.1 E; 25.0 N


200 km
Phoenicis Lacus
237.0 E; -24.1N


200 km
Phoenicis Lacus
237.0 E; -24.1N

Product Availability

- Products that are available from:
  - PDS Annex http://astrogeology.usgs.gov/
  - Custom layer in Jmars.
- Products:
  - Kernel files describing these improvements for each image in the control network.
  - Controlled, orthoprojected daytime IR and nighttime IR mosaics of Mars at 100 m/pixel scale for the ±65° latitude region of Mars.
- Image mosaic formats:
  - GeoTiff format with available ISIS3 and PDS3 labels.
- Final mosaics will be available in September 2018.



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