The Project

Can a DEM of Mars be used to find sites of ancient water flow?

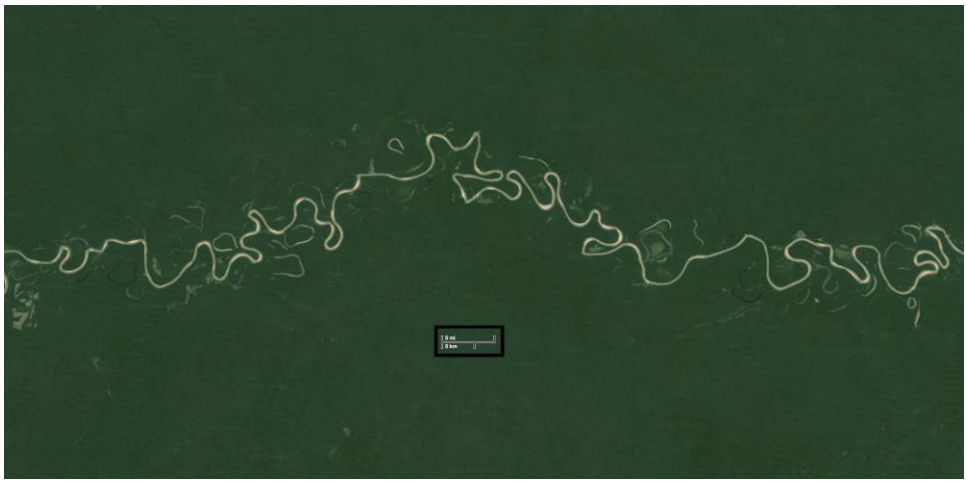
The Project

1. Find the longest flow length of the Amazon

2. Find the longest “stream” on Mars

3. Compare stream and watershed statistics

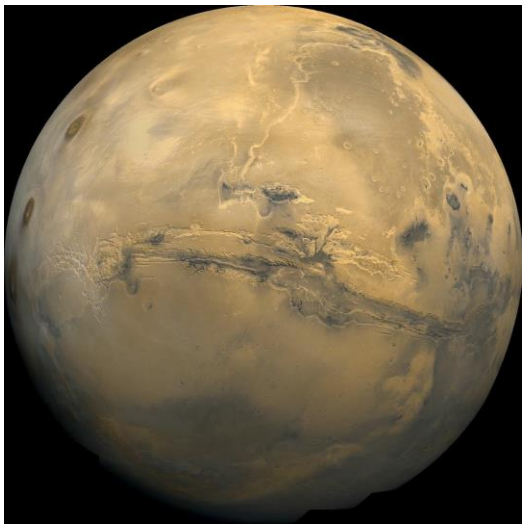
The Amazon



Google

4

Mars



NASA.gov

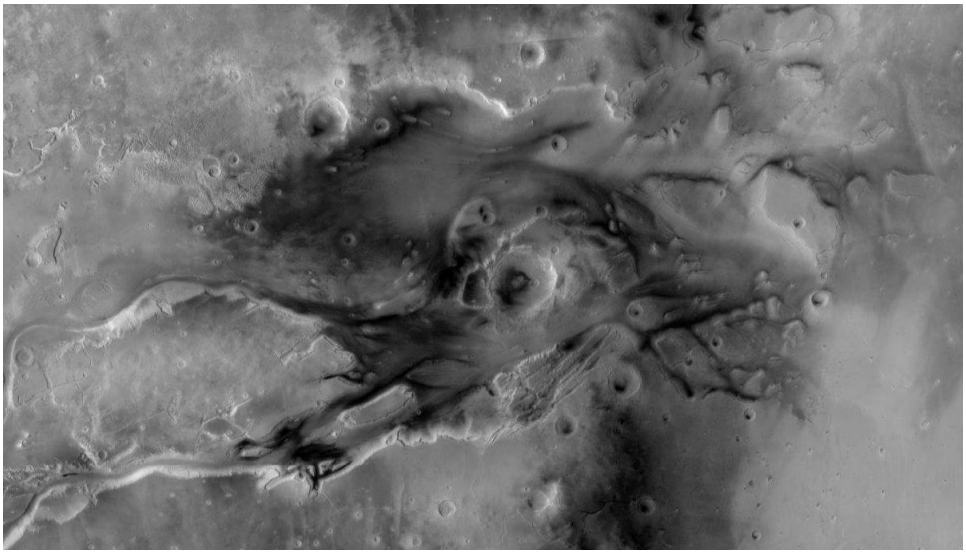
Water on Mars?

NASA.gov

Water on Mars?

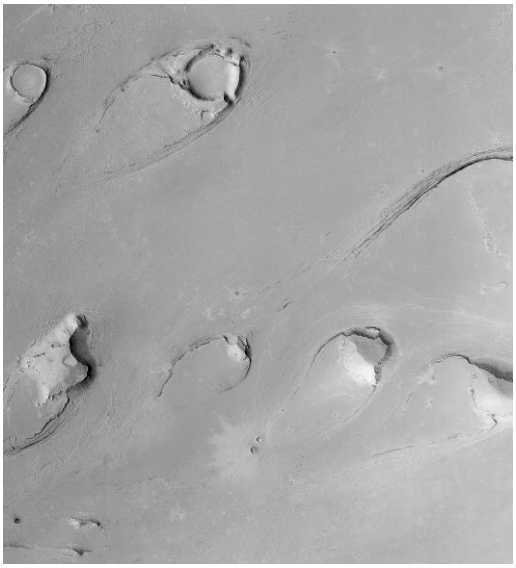
NASA.gov

Water on Mars?



NASA.gov

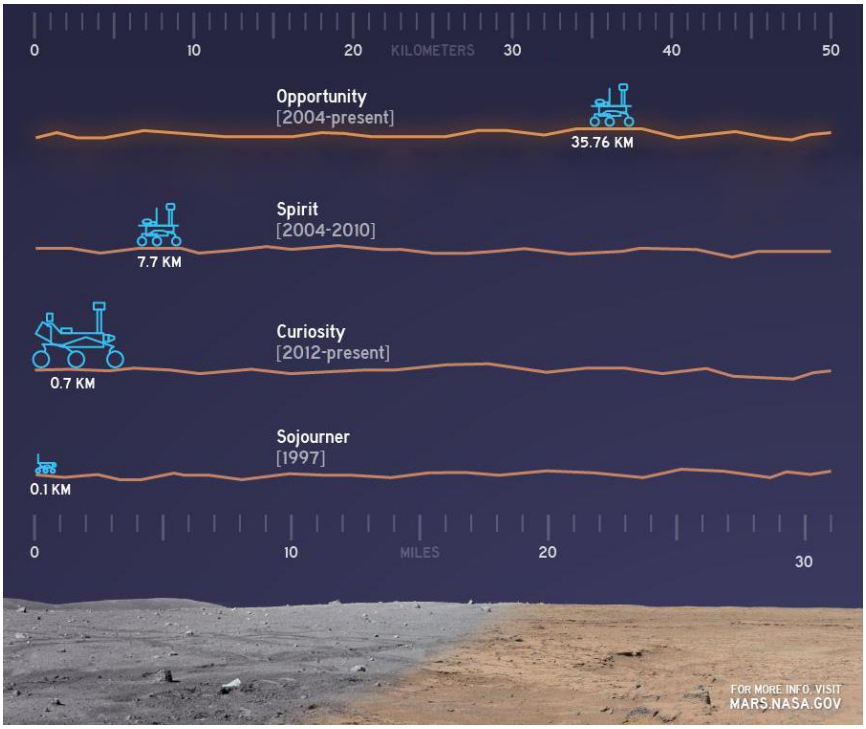
Massive Flood Events?

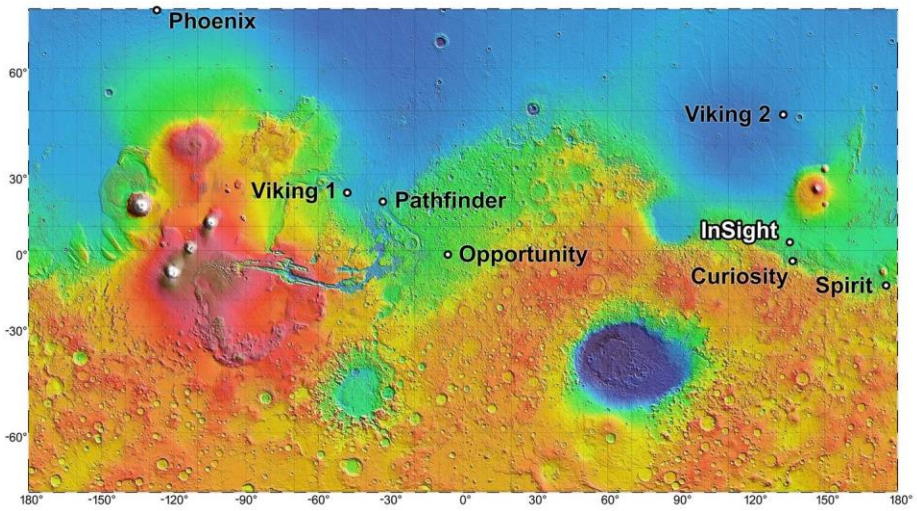


Mars Global Surveyor

Previous Investigation

Rovers





Mars Global Surveyor - NASA

Previous Investigation

Rovers

- Curiosity has found water
  - 2 pints / 1cf of soil, however not bonded to itself.

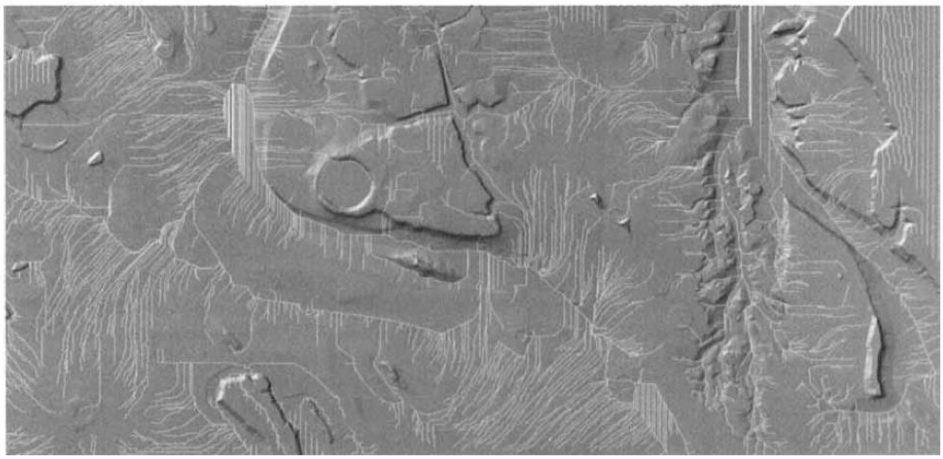
Previous Investigation

Rovers

- Curiosity has found water
  - 2 pints / 1cf of soil, however not bonded to itself.

Previous DEM Stream Work (1990)

- Based on stereogrammetry, photoclinometry, and shadow measurements of Viking images
  - 200 meter DEM



100 Kilometers

APPLICATIONS OF HYDROLOGIC INFORMATION AUTOMATICALLY EXTRACTED FROM DIGITAL ELEVATION MODELS

SUSAN K. JENSON

U. S. Geological Survey, EROS Data Center, Sioux Falls, South Dakota 57198, U.S.A.

15

Martian Geography

No Sea = No Sea Level

- Terrestrial method for setting elevation datum is inapplicable

Setting an Elevation Datum

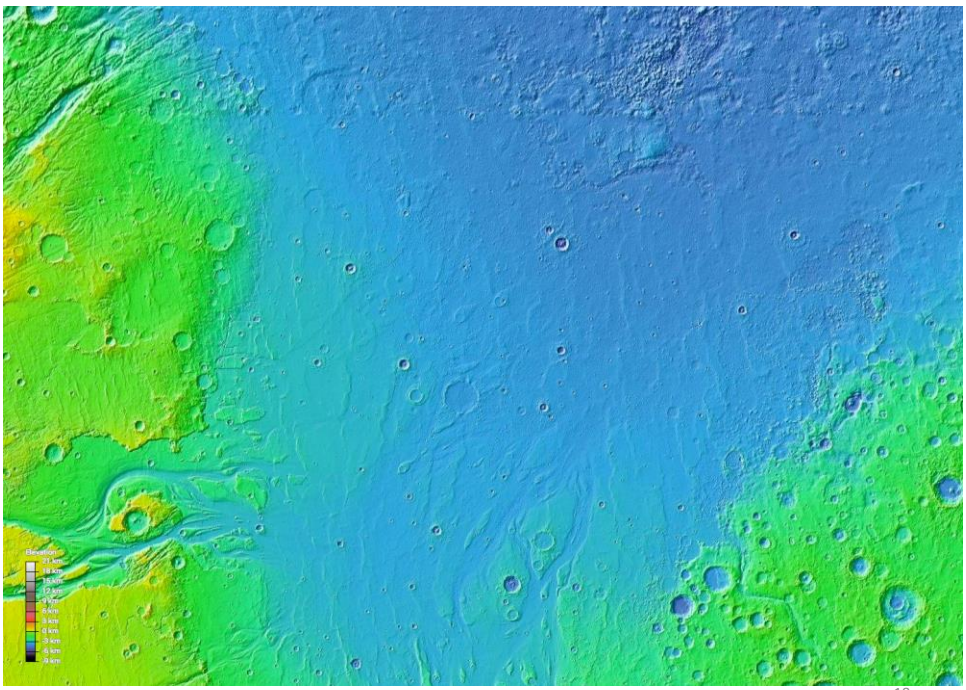
- Triple point of water
  - Potential to have all 3 phases of water at a location based on pressure and temperature
  - 6.105 millibars

Setting a "Sea Level"

Visual Interpretation

- Texture changes
- Frequency of craters
- Flow patterns

We chose -4150 meters



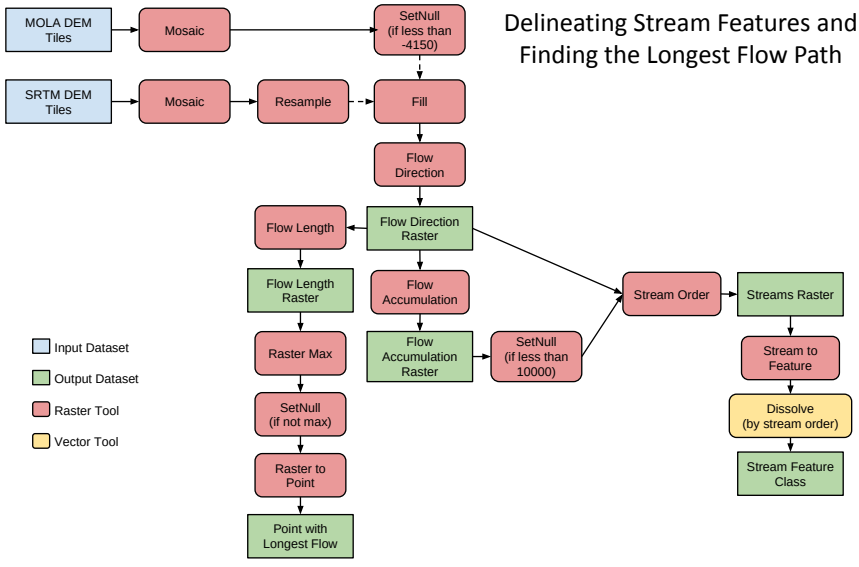
Google / NASA

Data & Methods

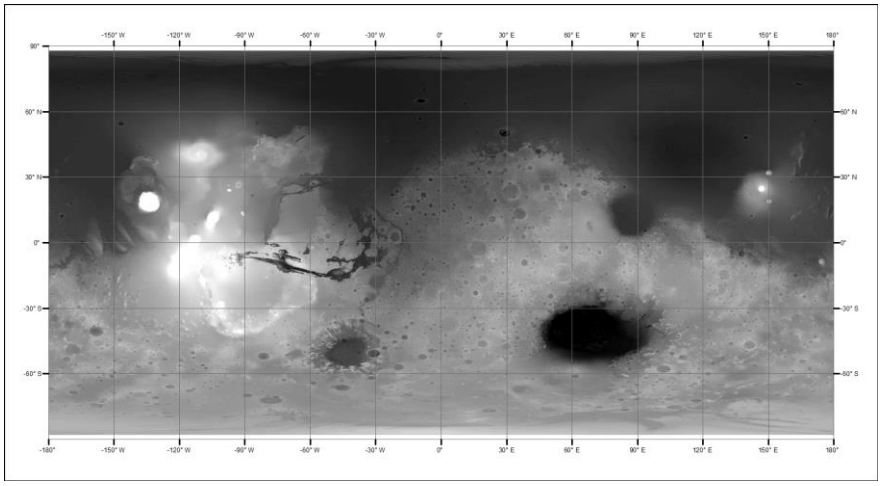
Data Sources:

- Mars Orbiter Laser Altimeter (MOLA) 128px/deg DEM
  - Tiles between 88° N and 88° S
- Shuttle Radio Topography Mission (SRTM) 3-arcsecond DEM
  - Tiles to cover the entire Amazon Basin

Data & Methods

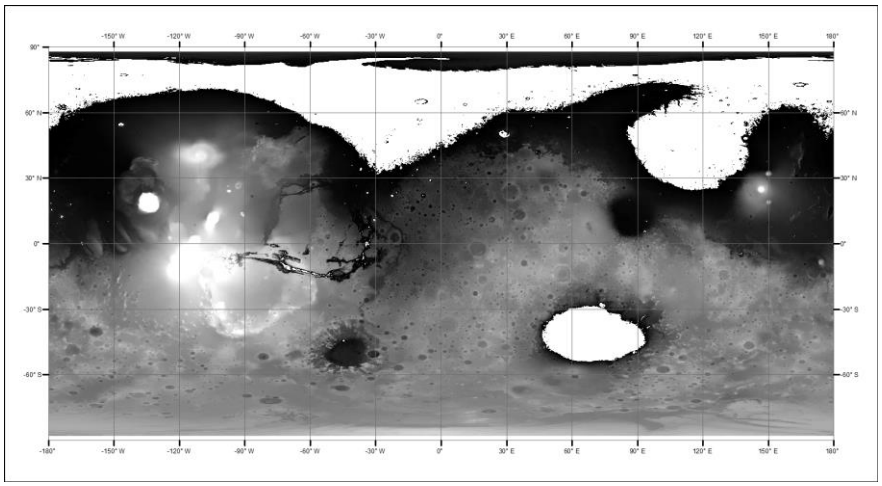


Data & Methods



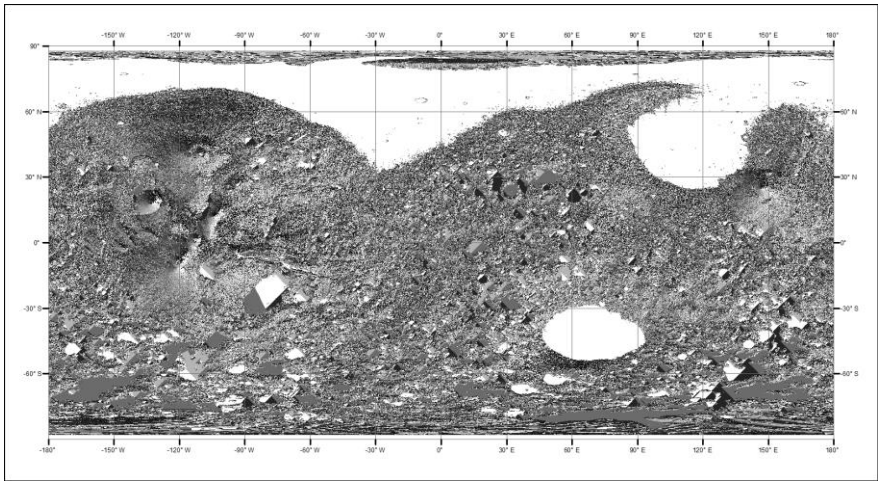
Mars DEM

Data & Methods



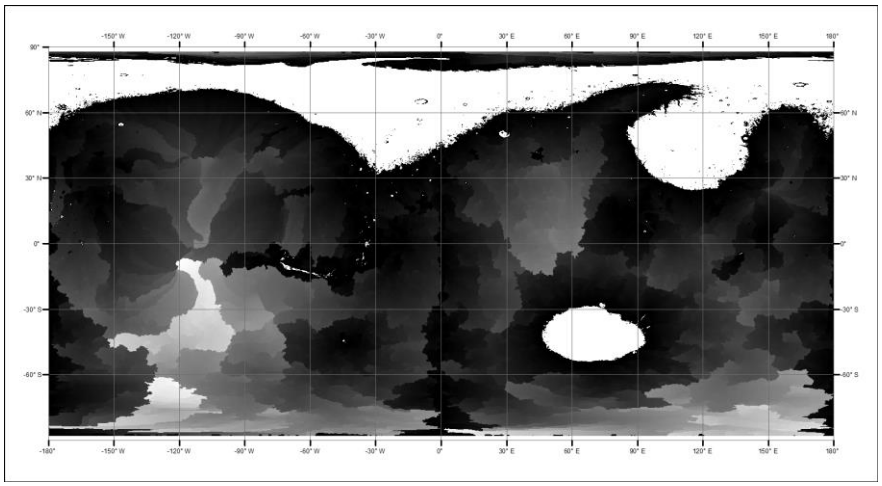
Mars DEM with < -4150m set null

Data & Methods



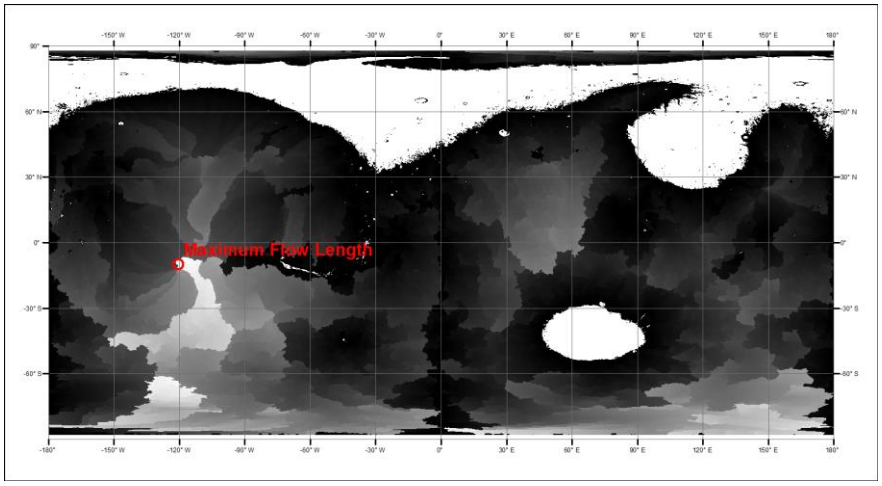
Mars Flow Direction

Data & Methods



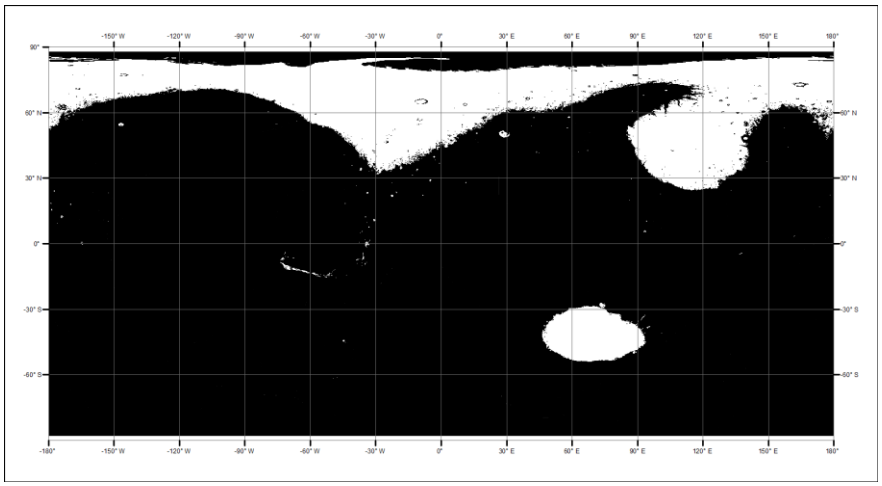
Mars Flow Length

Data & Methods



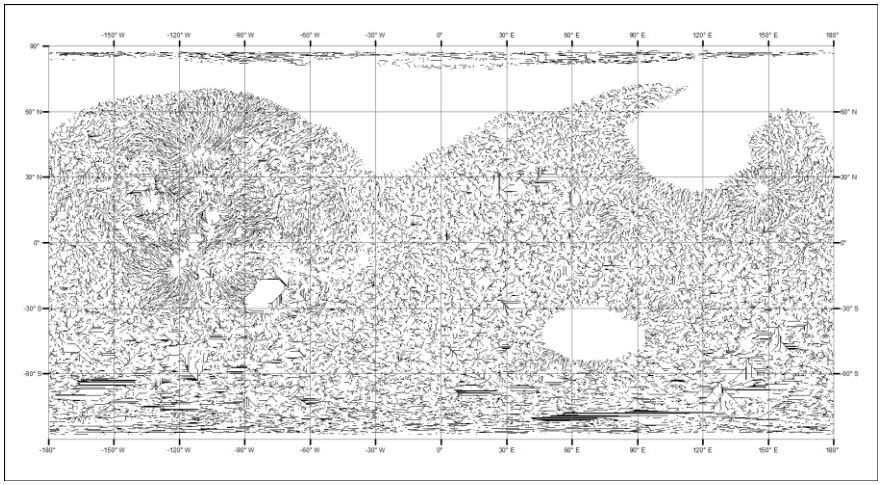
Mars Flow Length

Data & Methods



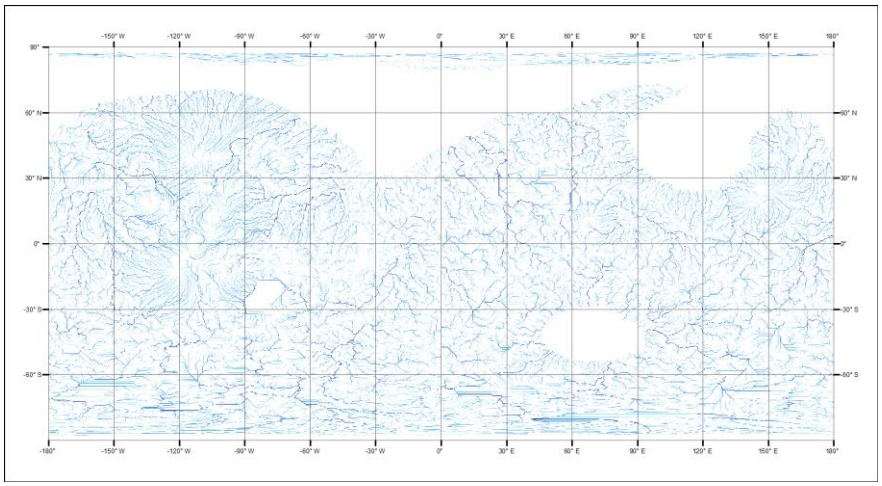
Mars Flow Accumulation

Data & Methods



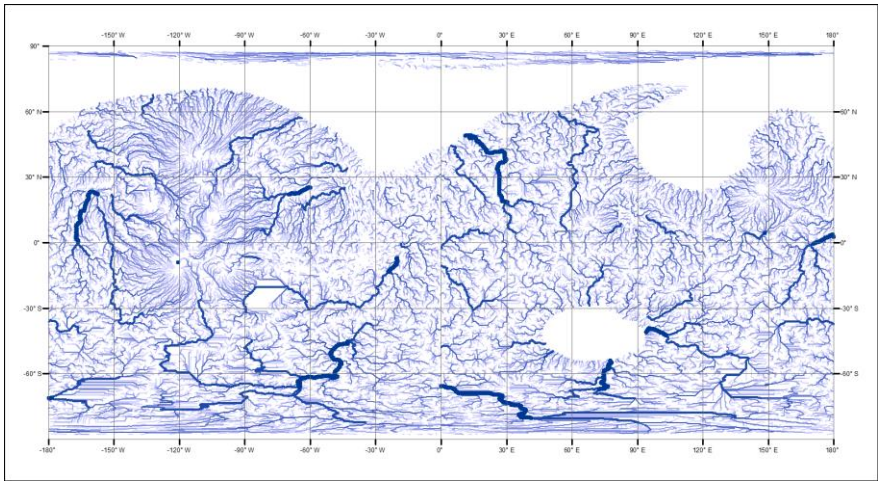
Mars Flow Accumulation with < 10000 set null

Data & Methods



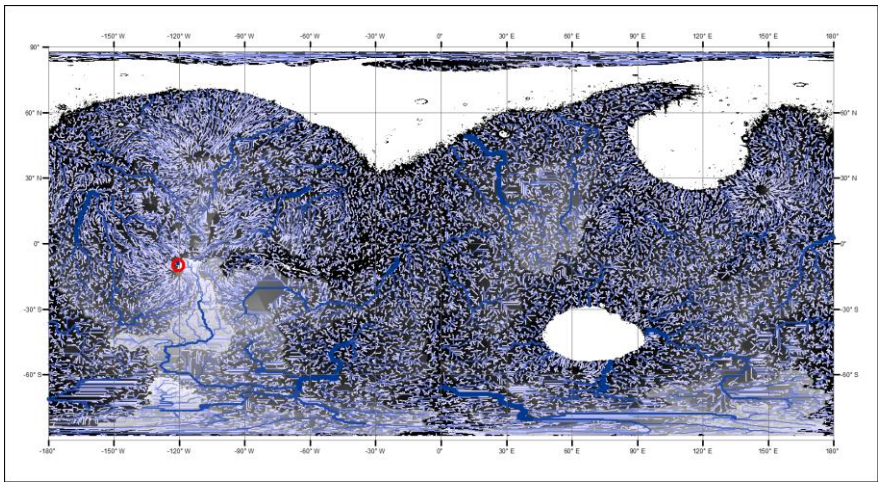
Mars Stream Order Raster

Data & Methods



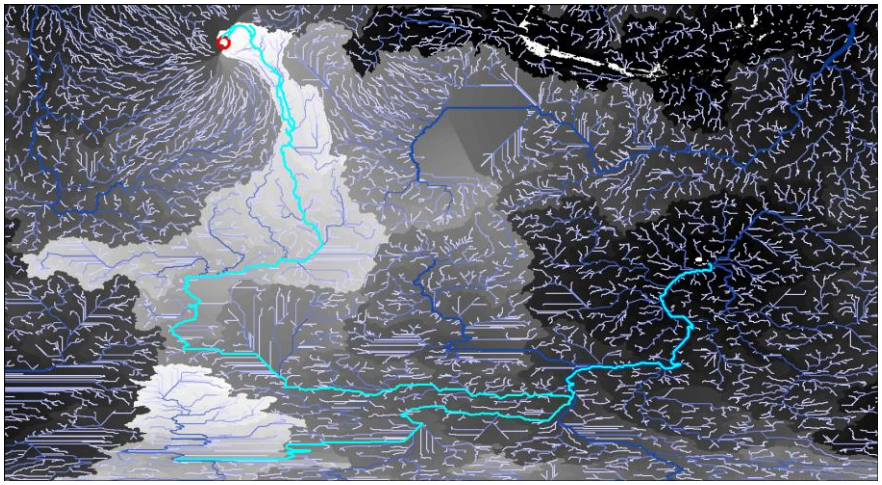
Mars Stream Features

Data & Methods



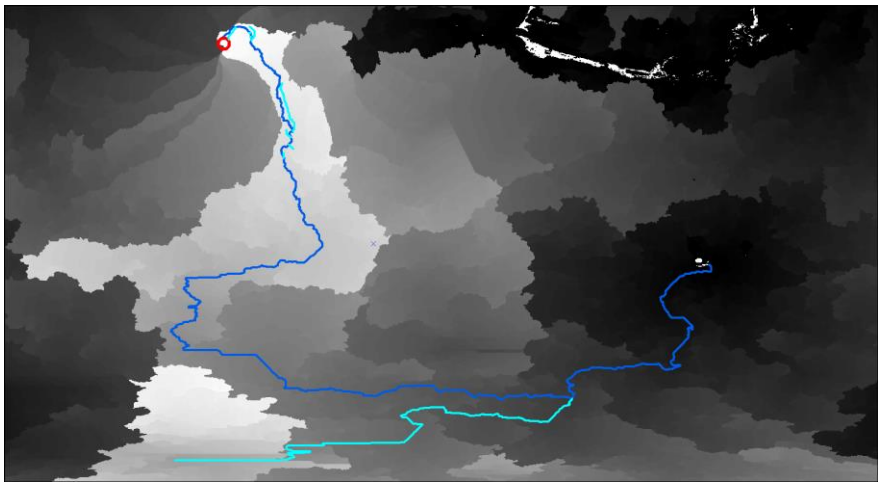
Mars Stream Features on Flow Length raster with Max Point

Data & Methods



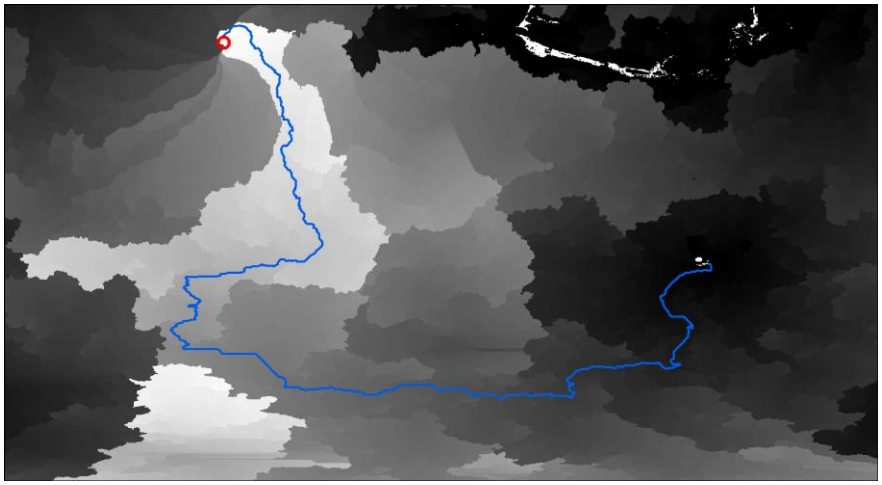
Longest Flow Length Stream Selection

Data & Methods



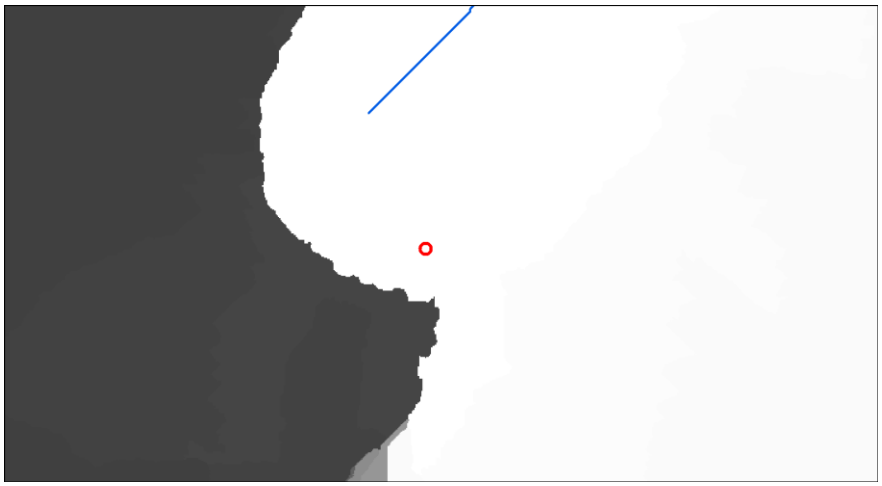
Longest Flow Length Stream Selection

Data & Methods



Longest Flow Length Stream Selection

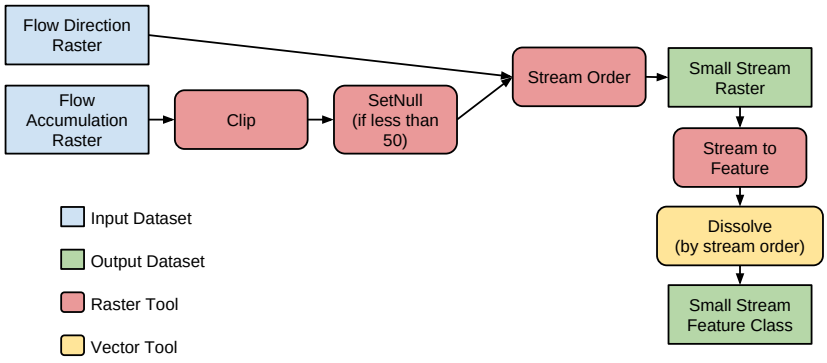
Data & Methods



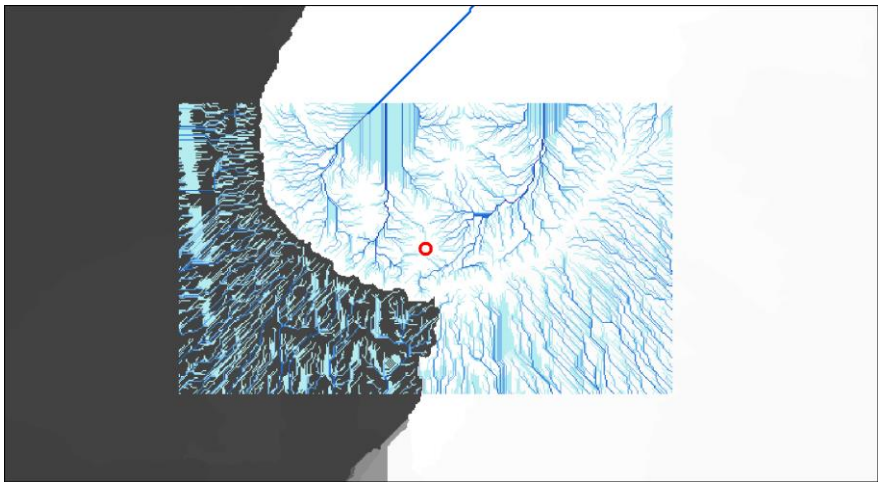
Stream Does Not Reach Max Flow Length Point

Data & Methods

Finding Smaller Tributaries

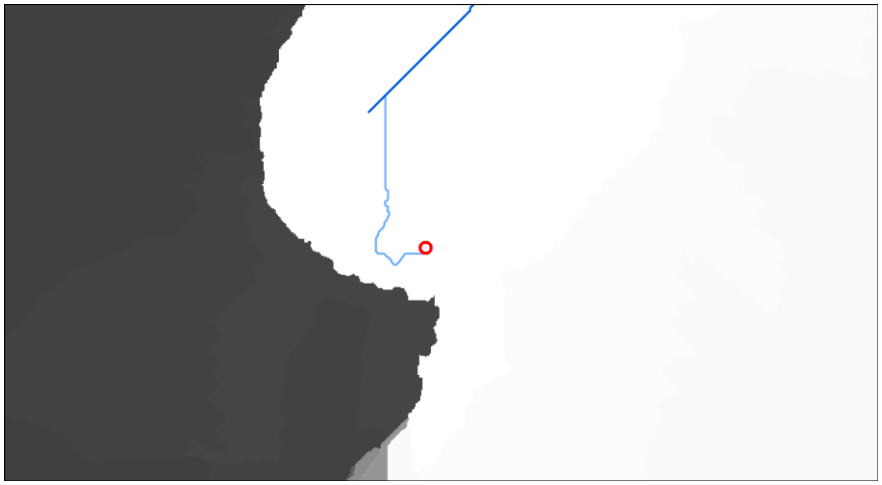


Data & Methods



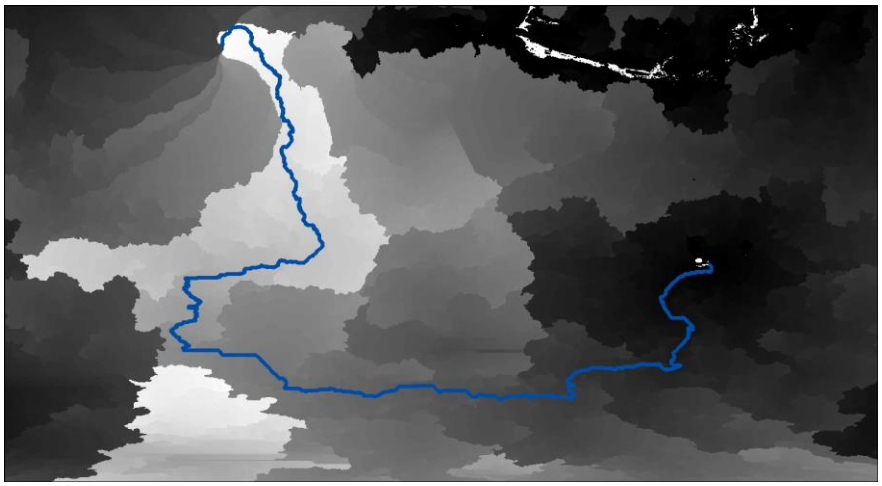
Smaller Tributaries Raster

Data & Methods



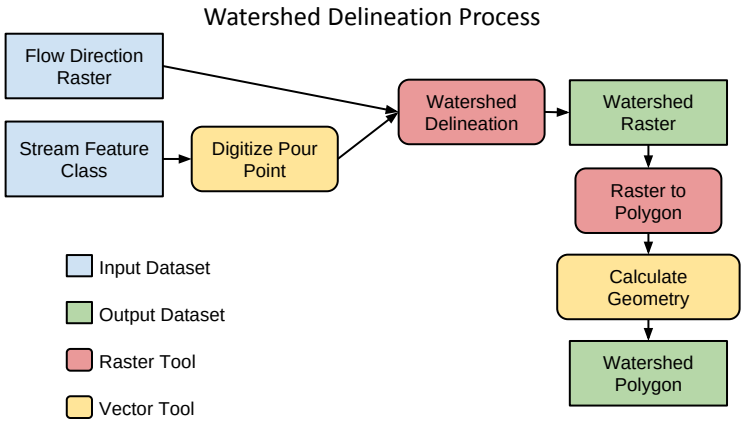
The Path to Maximum Flow Length

Data & Methods

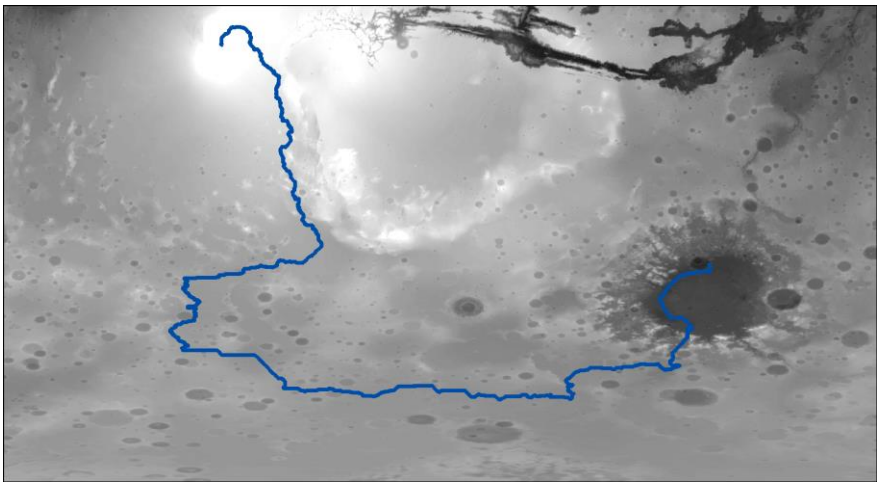


The Longest “Stream” on Mars

Data & Methods

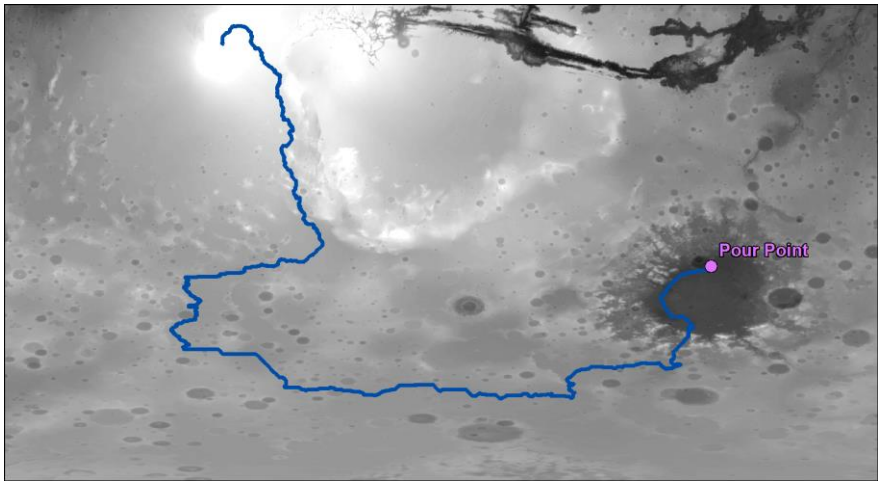


Data & Methods



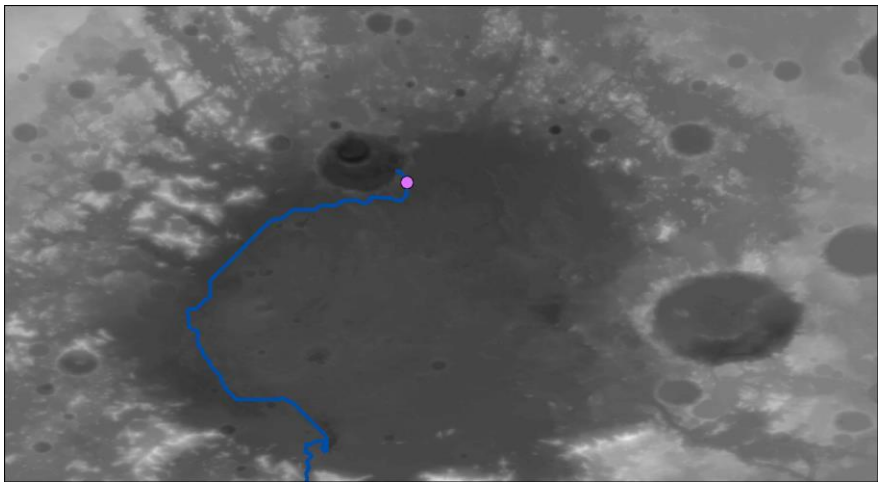
Finding the Watershed

Data & Methods



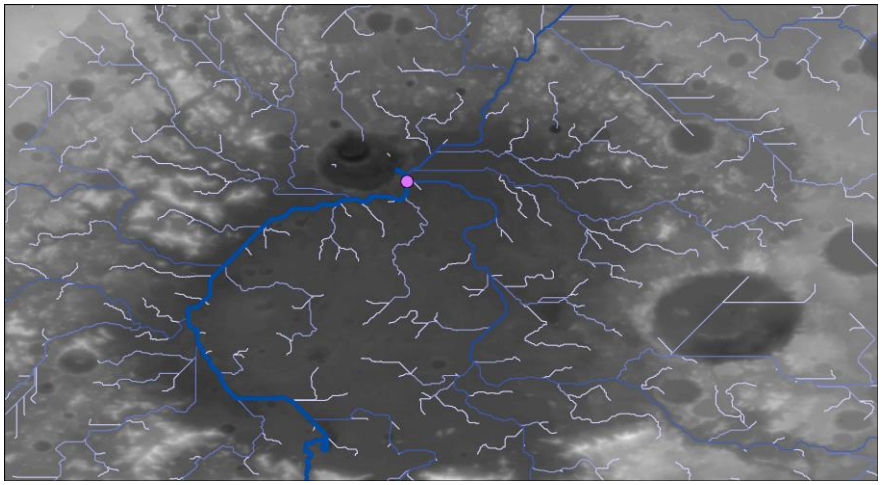
Finding the Watershed – Adding the Pour Point

Data & Methods



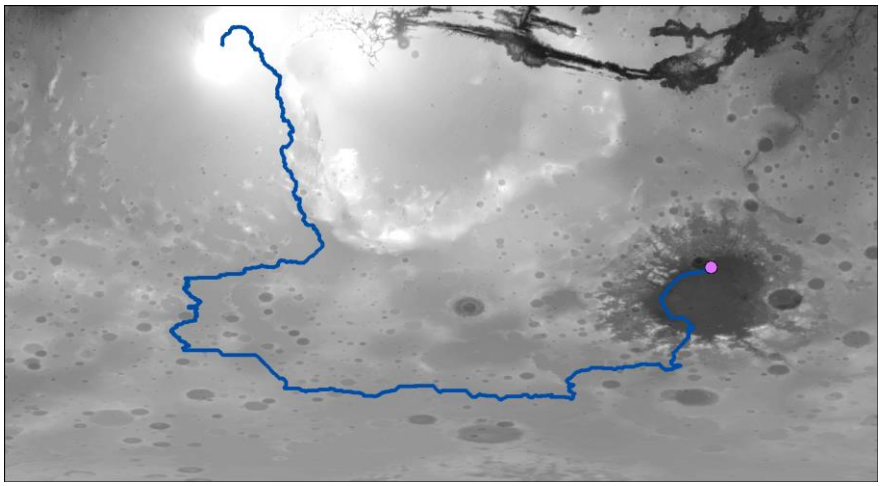
Finding the Watershed – Adding the Pour Point

Data & Methods



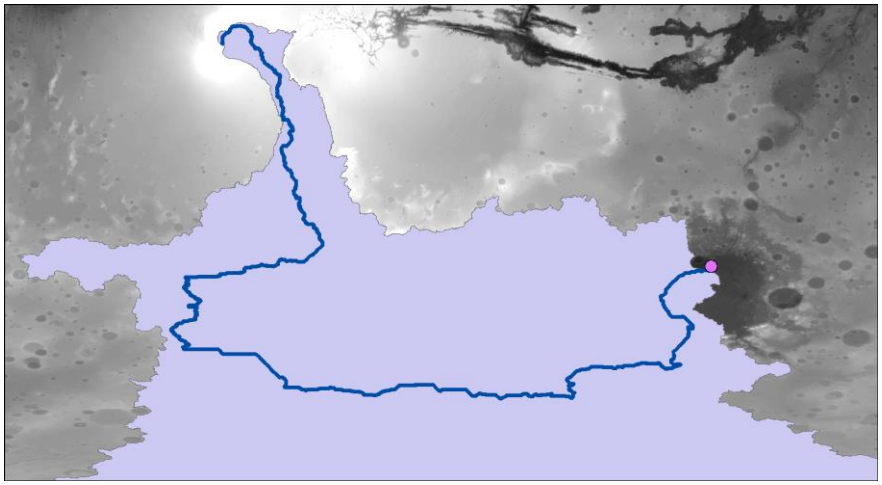
Finding the Watershed – Adding the Pour Point

Data & Methods



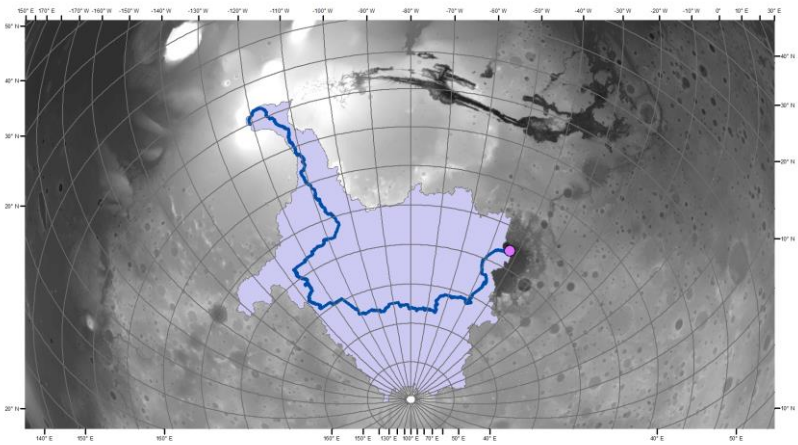
Finding the Watershed – Delineation

Data & Methods



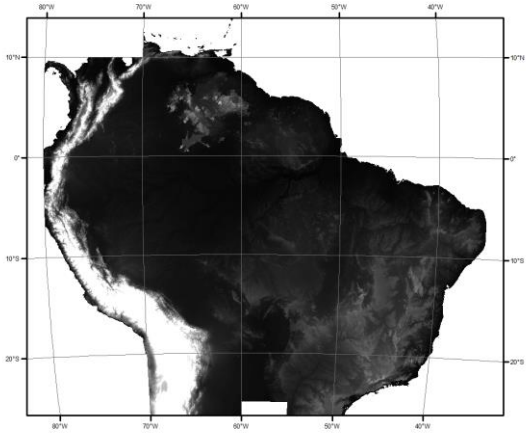
Finding the Watershed – Delineation

Data & Methods



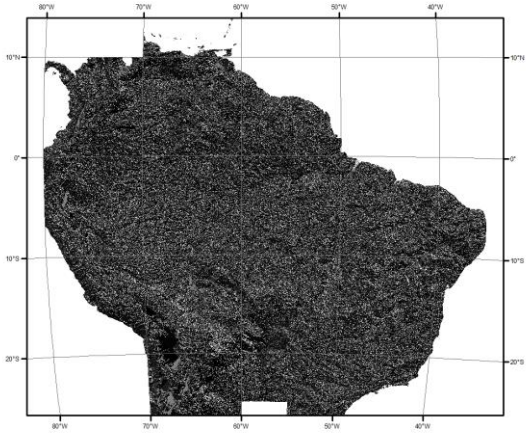
Finding the Watershed – Delineation

Data & Methods



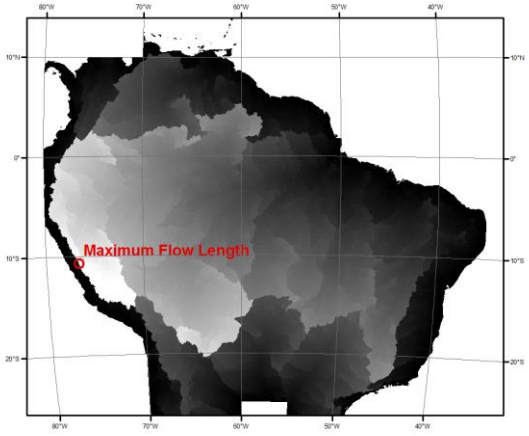
Amazon DEM

Data & Methods



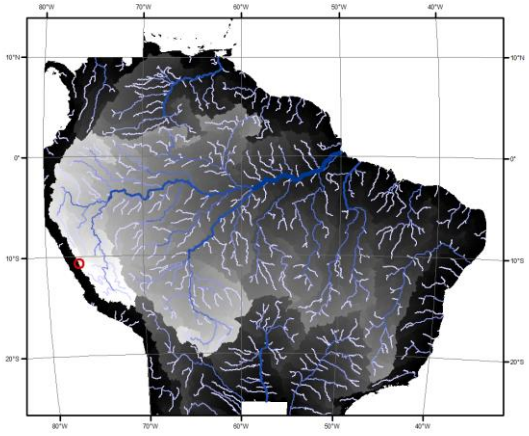
Amazon Flow Direction

Data & Methods



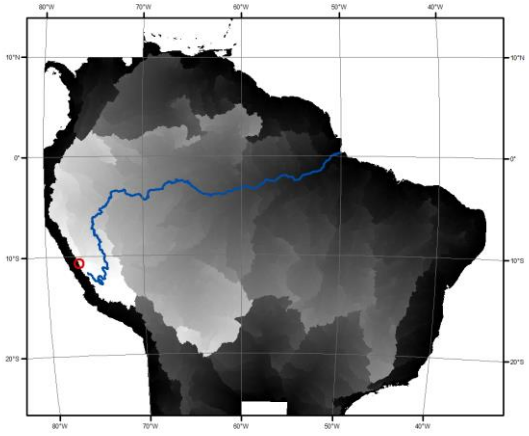
Amazon Flow Length with Maximum Point

Data & Methods



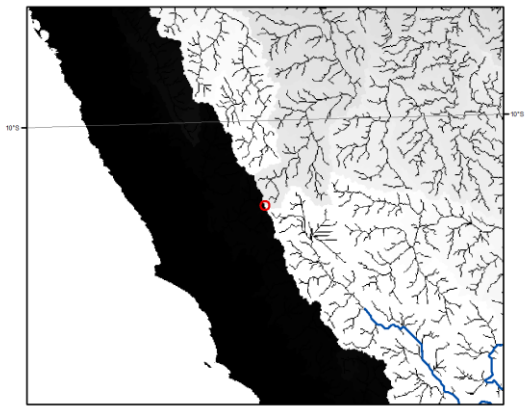
Amazon Stream Features

Data & Methods



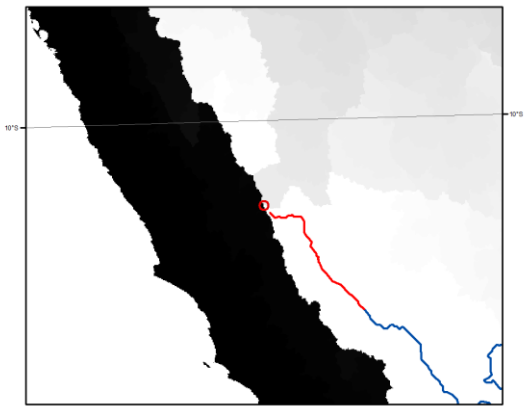
Amazon Selected Stream

Data & Methods



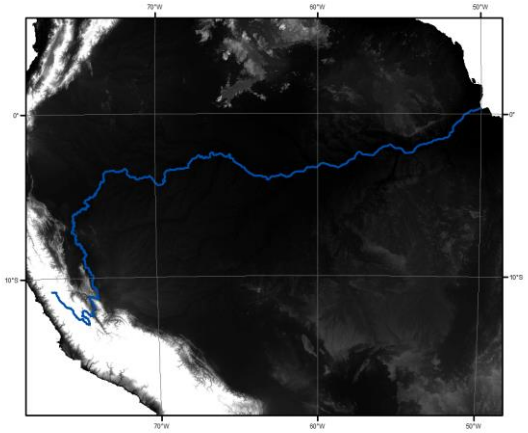
Amazon Max Flow Length and Small Streams

Data & Methods



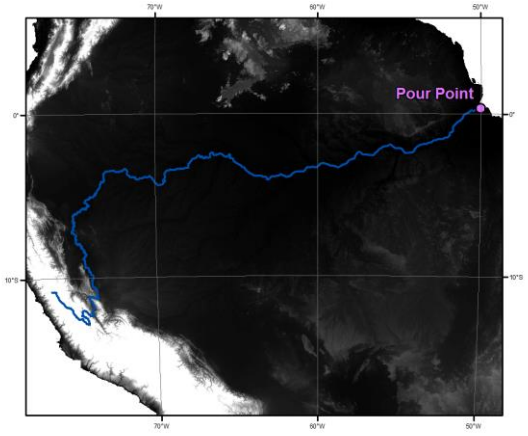
Amazon Max flow Length and Small Streams

Data & Methods



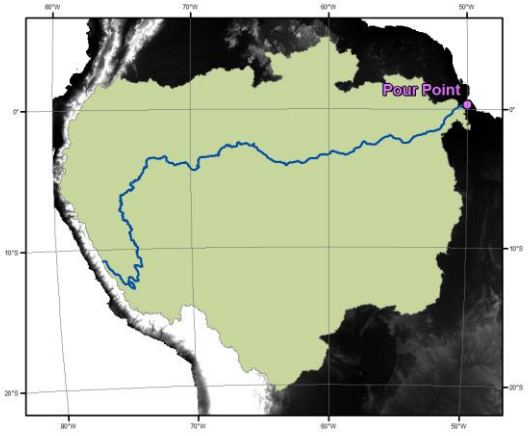
Amazon Longest Stream

Data & Methods



Delineating the Watershed Boundary

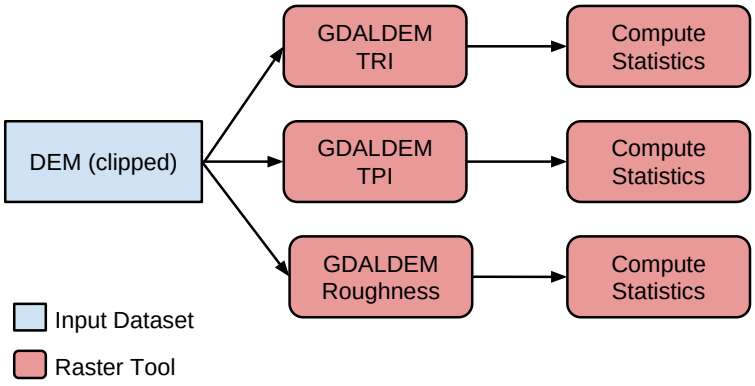
Data & Methods



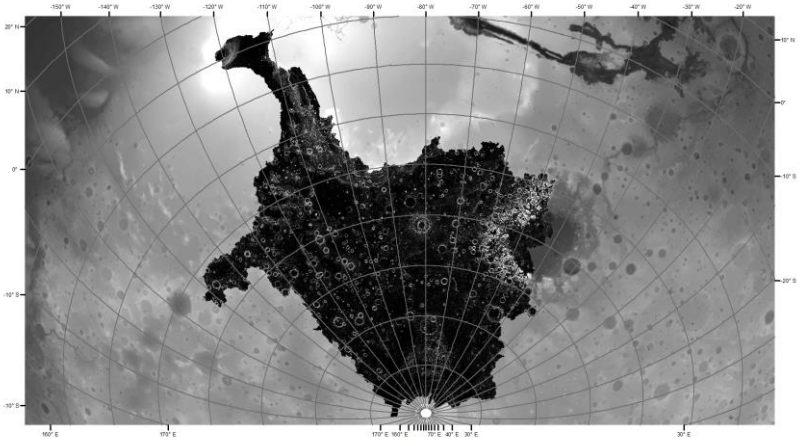
Delineating the Watershed Boundary

Data & Methods

Watershed Terrain Metrics

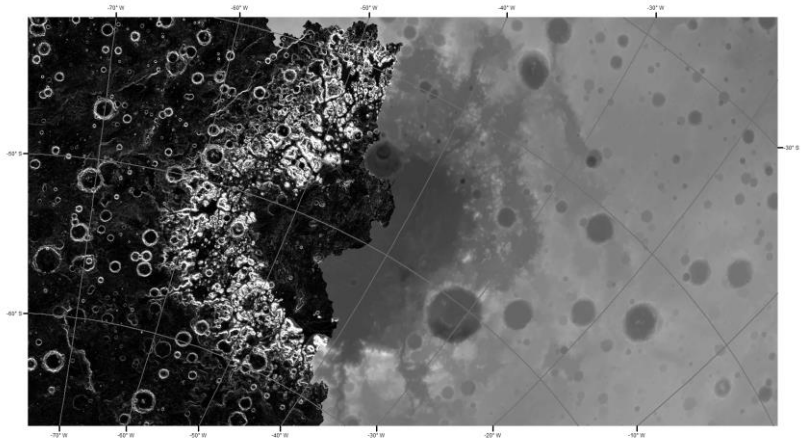


Data & Methods



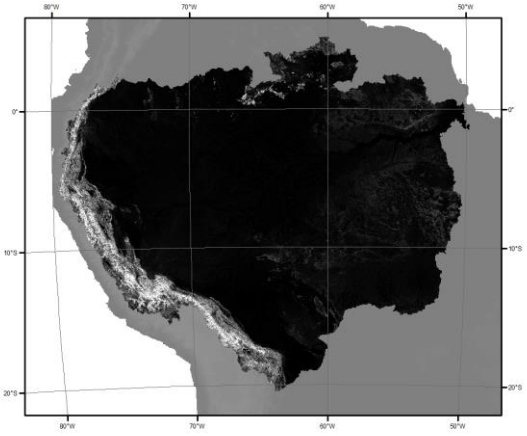
Mars Watershed Roughness

Data & Methods



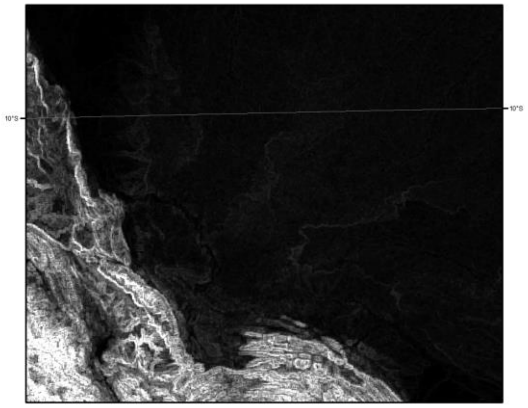
Mars Watershed Roughness

Data & Methods



Amazon Watershed Roughness

Data & Methods



Amazon Watershed Roughness

Results

Stream Lengths

	Length (km)	Percent of Planet Circumference
Mars Stream	10,336.7	48.4
Amazon	5,782.7	14.4

Results

Watershed Measures

	Area (km^2)	Perimeter (km)	Isoperimetric Quotient (Compactness)	Min Elevation (m)	Max Elevation (m)	Elevation Std. Dev.
Mars Watershed	8,767,315	29,121.8	0.13	-3807	17774	1528.6
Amazon Watershed	5,974,715	17,086.9	0.26	-11	6372	810.22

Results

Watershed Terrain Metrics – Terrain Ruggedness Index

	Min	Max	Mean	Standard Deviation
Mars Watershed	0	871.125	9.53	15.11
Amazon Watershed	0	1246.75	26.57	51.73

Watershed Terrain Metrics – Topographic Profile Index

	Min	Max	Mean	Standard Deviation
Mars Watershed	-432.75	871.125	0.004	5.29
Amazon Watershed	-1246.75	1021	0.05	38.96

Watershed Terrain Metrics – Roughness

	Min	Max	Mean	Standard Deviation
Mars Watershed	0	1270	30.38	48.25
Amazon Watershed	0	2330	77.43	151.75

Discussion

Discussion

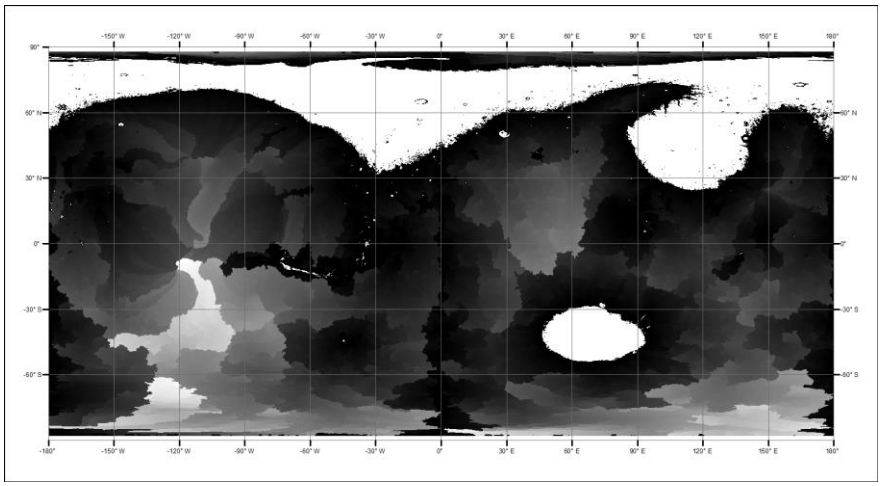
Or why everything we just told you is wrong!

Discussion

Major Problems:

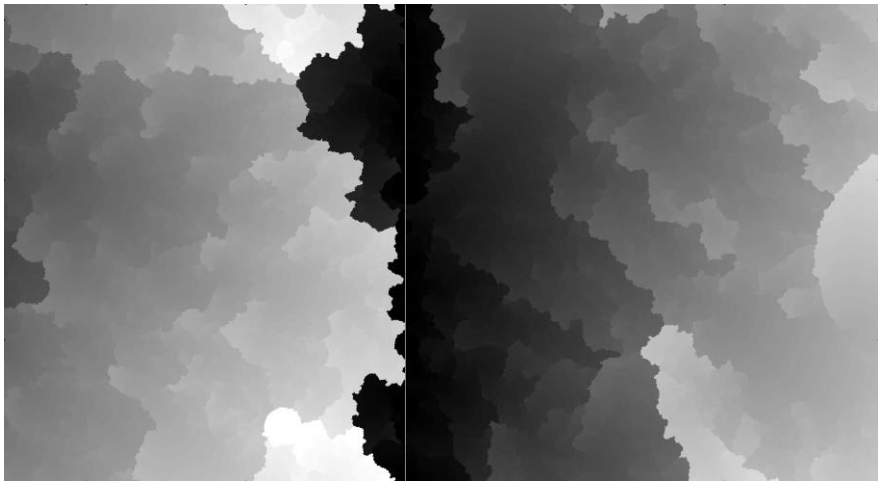
– Gaps in the Mars DEM

Discussion



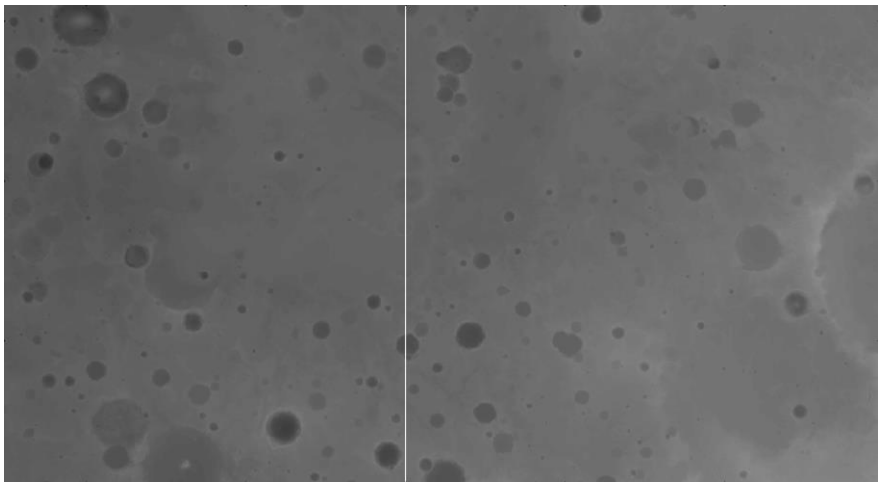
Mars Flow Length

Discussion



Mars Flow Length

Discussion



Mars Flow Length

Discussion

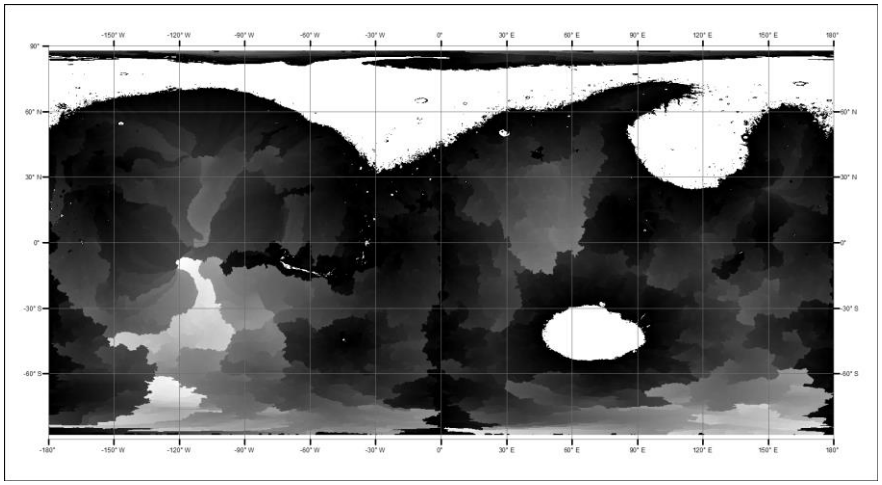
Major Problems:

- Gaps in the Mars DEM
- Planetary-scale analysis does not work

Discussion

How to model flow from edge to edge?

Discussion



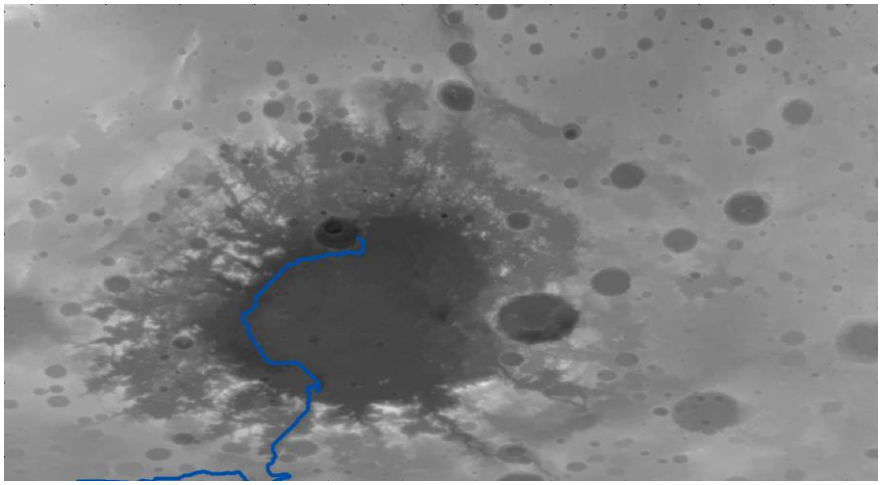
Mars Flow Length

Discussion

Major Problems:

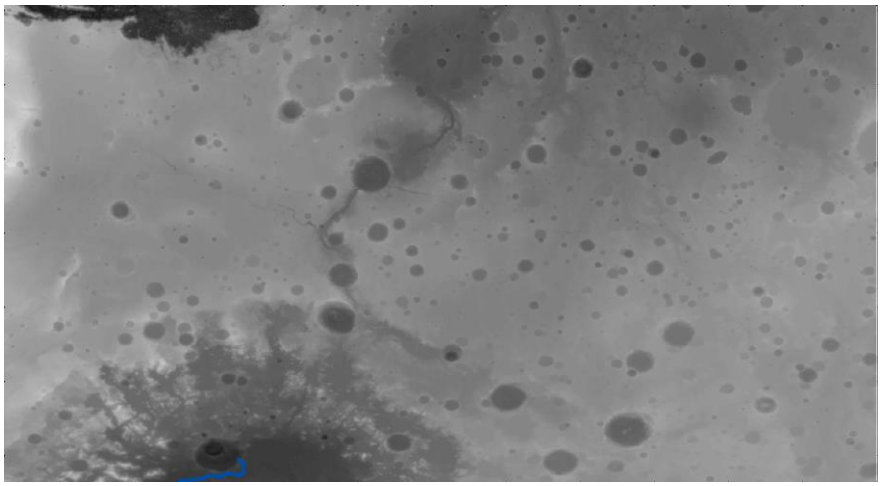
- Gaps in the Mars DEM
- Planetary-scale analysis does not work
- Setting “sea level” creates unintended sinks in the DEM

Discussion



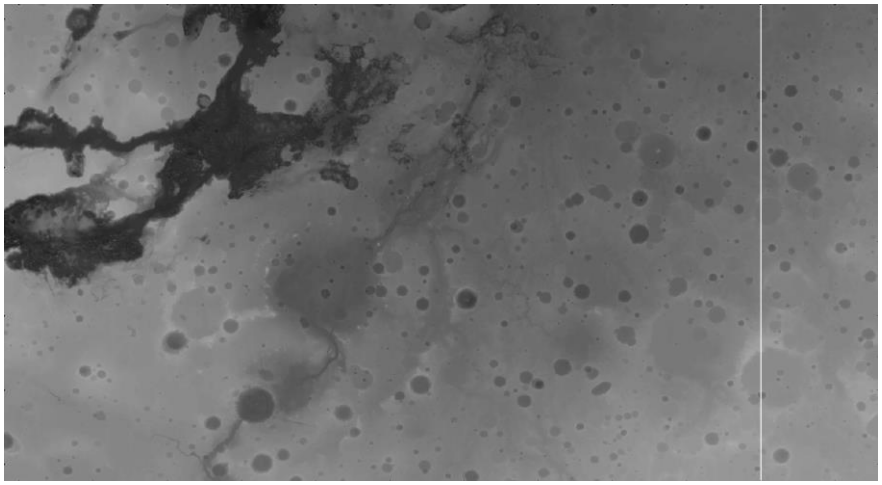
Problem with Setting Sea Level Null

Discussion



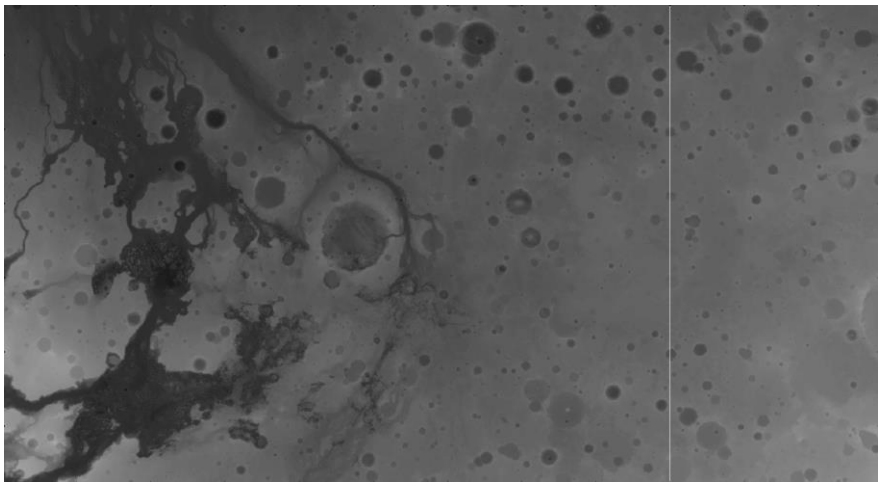
Problem with Setting Sea Level Null

Discussion



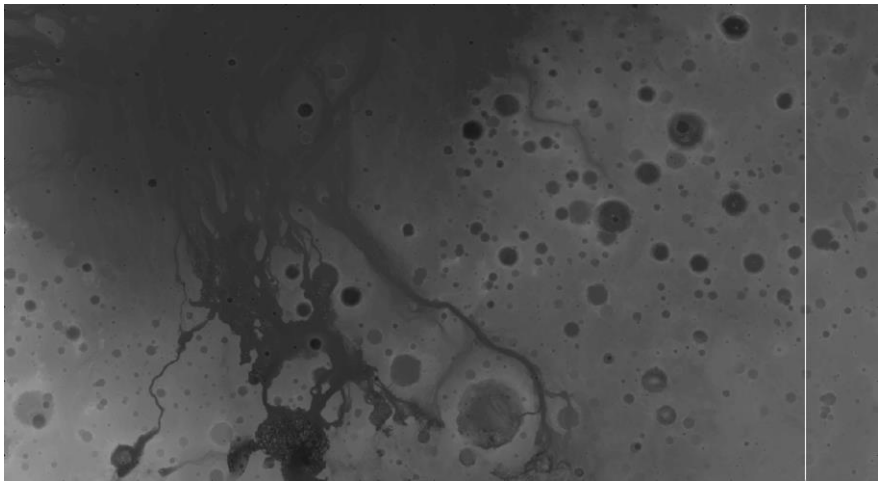
Problem with Setting Sea Level Null

Discussion



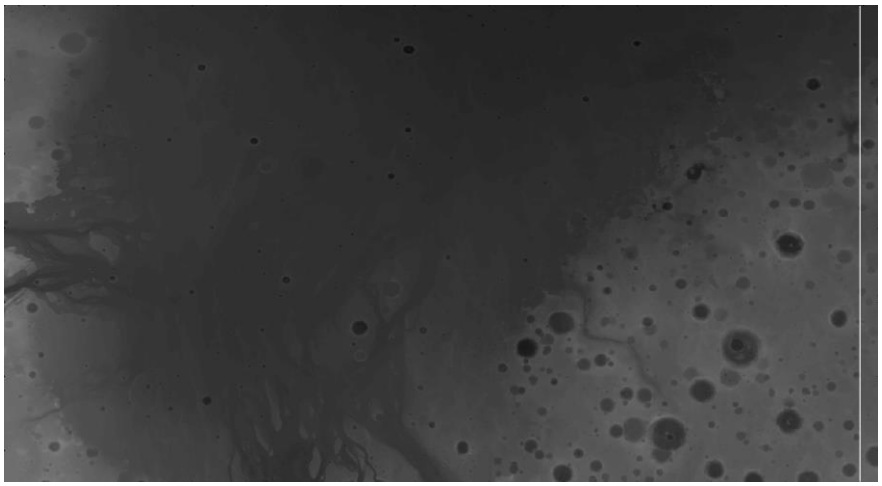
Problem with Setting Sea Level Null

Discussion



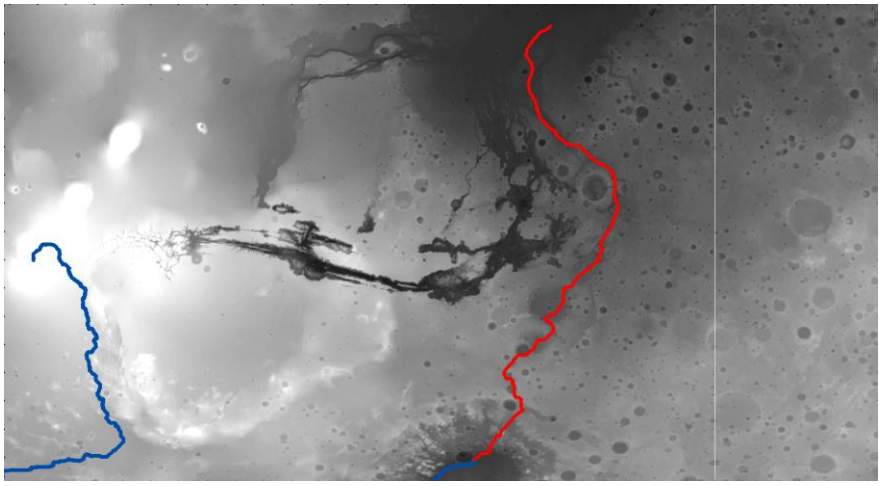
Problem with Setting Sea Level Null

Discussion



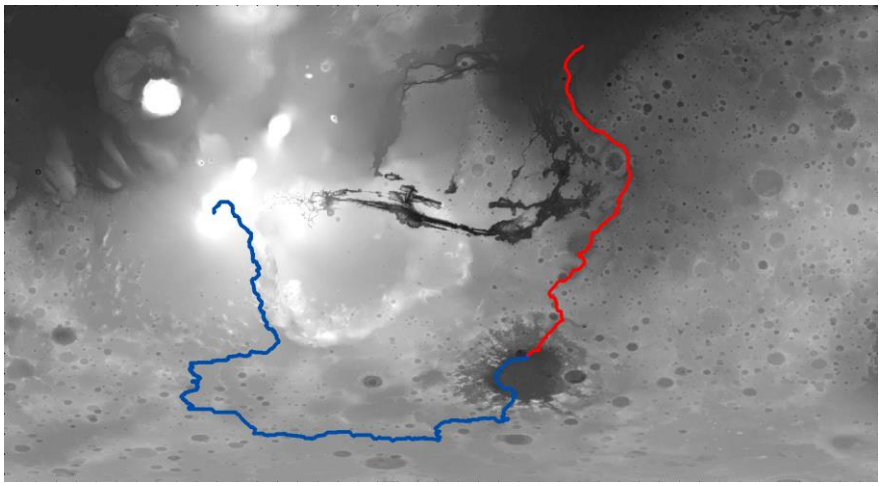
Problem with Setting Sea Level Null

Discussion



Problem with Setting Sea Level Null

Discussion



Problem with Setting Sea Level Null

Data & Methods

Length of added stream segments:

6,296.4 km

Original Length:

10,336.7 km

Total Length:

16,633.1 km

Discussion

Major Problems:

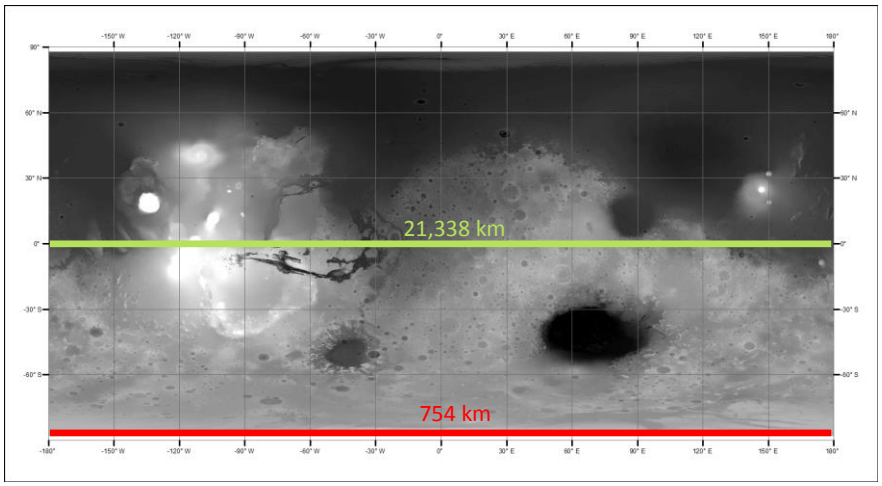
- Gaps in the Mars DEM
- Planetary-scale analysis does not work
- Setting “sea level” creates unintended sinks in the DEM
- Flow length does not find longest flow

Discussion

Flow length does not find longest flow:

- Flow length tool assumes pixels of constant linear dimension
  - Our data has pixels of constant angular dimension

Discussion



Mars DEM

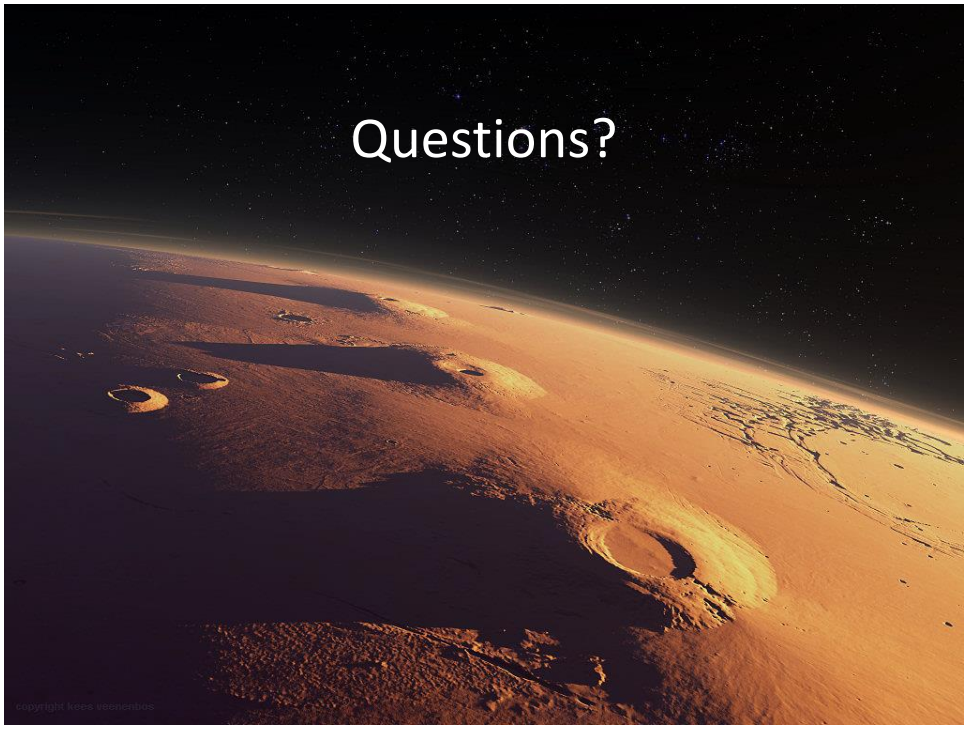
Discussion

Flow length does not find longest flow:

- Our Linear pixel dimensions are not constant
  - Length of flow of a pixel cannot be determined with flow length
  - Maximum flow length cannot be known with certainty

Conclusion

- Unable to conclude if delineated path was formed by water
- Potential for much longer streams on Mars than on Earth
- No tools exist for this scale of analysis
  - New tools required for better results


Questions?