Mars Hydrologic Environments

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There is strong evidence for the presence of surface water in Mars' past. One of the most ostensible and persuasive pieces of evidence is the channel-like features observed on the present day surface. These features suggest that water once flowed freely on the surface of Mars. Still, questions remain as to the nature of the surface flow, and the characteristics of streams and basins associated with this flow. Use Mars Orbiter Laser Altimeter (MOLA) data to uncover remnants of past fluvial activity on the Martian surface.

You will use a digital elevation model (DEM) available through the NASA Planetary Data System Node to examine three sites where water likely flowed on Mars: Kasei Valles, Lucus Planum, and Margaritifer Terra. Each of these sites represents a different hydrologic environment. Using tools available in ArcGIS, you will model stream networks, flow direction and watershed basins on Mars and examine how each different hydrologic setting yields unique results. These results will be used to produce a global scale interpretation of hydrologic processes and trends on Mars.

Martian Hydrologic Environments

Objective: Using Mars Orbiter Laser Altimeter Data, conduct surface hydrologic modeling using ArcGIS. Use your results to determine an analogous hydrologic environment on Earth. Determine if the results show evidence for a global hydrologic model.

Before the Lab:

Define the following terms: Stream, Drainage Basin, Drainage Density, Confluence, Headwater, Source, Mouth, Meander, Oxbow, Watershed.

Instructions:

Step 1: Importing the Data

A. Go to http://pds-geosciences.wustl.edu/missions/mgs/megdr.html and download the following files (MEGDR 128 data):
    a. megt44n270hb.img (Kasei Valles)
    b. megt00n180hb.img (Lucus Planum)
    c. megt00n270hb.img (Margaritifer Terra)
    d. These files are the topography data files, with horizontal resolution of 1/128 degree per pixel (or 463 m per pixel).
B. Go to http://isis.astrogeology.usgs.gov/IsisSupport/viewtopic.php?t=341 and right-click on ftp://ftpflag.wr.usgs.gov/dist/pigpen/mars/mola/megt128PDS_GISheaders_Erdas_ArcMap.zip and click "Save link as…" to save to the folder where you have placed the MEGDR data. Unzip the file to the folder with the MEGDR data. These are the headers you will be using for the topography data.
C. Import into ArcMap
    a. Open Arc Map
    b. Click Add Data
    c. Open the megt44n180hb.raw file that you unzipped
    d. The grid will appear, it may ask if you wish to create pyramids, click no
    e. Open the layer properties menu and go to Symbology
    f. Click Classified and OK
    g. Reopen the Symbology and click Stretched and OK to display the proper values
    h. In the Data Frame Properties window → General → map units and display units are meters
    i. Repeat steps a-g in separate windows for the two other tiles

Step 2: Clipping the Grid

A. Two methods
    a. Zoom so that the window shows the feature you are interested in

b. Specify the dimensions in the Properties-Data Frame window
    i. Go to Data Frame
    ii. Under extent, select Fixed extent
        1. For Kasei Valles (20N to 25N, 287.5E to 292.5E): Top = 1481600 m, Bottom = 1185280 m, Left = 6370880 m, Right = 6667200 m
        2. For Lucus Planum (2.5S to 7.5S, 205.5E to 210.5E): Top = -148160 m, Bottom = -444480 m, Left = 1511232 m, Right = 1807552 m
        3. For Margaritifer Terra (5.5S to 10.5S, 337.5E to 342.5E): Top = -325952 m, Bottom = -622272 m, Left = 9334080 m, Right = 9630400 m

B. Then go to spatial analyst → options → extent and select same as display, cell size is 463.
C. Go to raster calculator and type [lucusgrid] = [megt00n180hb.img] and repeat for each data set you are reducing. You should have three grids (lucus, kasei, and margaritifer)

Step 3. Hydrology Operations: Perform for each grid

A. Fill the grid
    a. In the Spatial Analyst → hydrology toolbox go to Fill
    b. Input raster = newgrid
    c. Output raster = fillgrid
B. Find flow direction
    a. In the Spatial Analyst → Hydrology toolbox go to Flow Direction
    b. Input raster = fillgrid
    c. Output raster = flowdir
C. Find flow accumulation
    a. In the Spatial Analyst → Hydrology toolbox go to Flow Accumulation
    b. Input raster = flowdir
    c. Output raster = flowacc
D. Extract streams
    a. Think of a good flow accumulation level, like 2000 and go to
    b. Spatial Analyst Toolbox → Extraction → Extract by attributes
    c. Input raster = flowacc
    d. Clause = value > 2000
    e. Output raster = str2000
E. Find stream order
    a. In the Spatial Analyst → Hydrology toolbox go to Stream Order
    b. Input stream raster = str2000
    c. Input flow direction raster = flowdir
    d. Output raster = streamO
F. Find basins
    a. In the Spatial Analyst → Hydrology toolbox go to Basin

b. Input flow direction raster = flowdir
c. Output raster = basins

G. Extract basins
   a. Think of a significant basin area, like 10000 pixels and go to
   b. Spatial Analyst Toolbox → Extraction → Extract by attributes
   c. Input raster = basins
   d. Clause = count > 10000
   e. Output raster = basin10k

H. Shaded relief map
   a. 3D Analyst → Surface Analysis → Hillshade
   b. Use defaults

Step 4: Analysis

A. Local Hydrologic Environment (answer these questions for each grid):
   a. Which is the major direction of flow for this grid?
   b. What % of the grid is covered by basins (10,000 pixels or greater)? By streams?
   c. What is the highest stream order you found?
   d. Does the basin shape reflect topography or stream networks?
   e. What is the drainage density for this grid? Is the drainage density value high (closer to 1) or low (closer to 0)? What does this mean?
   f. Would you say that this area has a highly developed stream network or a poorly developed network?
   g. Suggest a comparable hydrologic environment on Earth for this grid compatible with the results of your analysis.

B. Global Hydrology
   a. Where would most water on Mars drain towards?
   b. Do these systems connect?
   c. Can you suggest a global history of surface flow for Mars based on these three different hydrologic environments?