

Reading MOLA Map-Projected Data in ENVI and ArcGIS

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The Planetary Data System (PDS) archives many data sets containing images of planetary surfaces in various map projections. One such data set is the MOLA MEGDR data, topography maps of Mars derived from altimetry data acquired by the MOLA instrument on the Mars Global Surveyor orbiter. PDS data products are described by PDS labels (version PDS3, in this case), which contain all the metadata required to read and interpret the data.

ENVI and ArcGIS are two popular programs for working with map-projected planetary image data. While these programs are able to read some kinds of PDS-labeled data products, they do not import the map projection information from MEGDR labels. One way to get the MEGDR maps into ENVI and ArcGIS is to convert them to a GIS-ready format that the software can understand using GDAL, a format translation tool.

A problem using this method has been discovered: when GDAL-translated MEGDR maps are compared to other Mars map data, in particular Mars Express HRSC images and digital topographic maps, offsets and scale differences are observed between the MOLA and HRSC data. These differences have two root causes:

1. Different versions of GDAL appear to yield different results in terms of corner and center coordinates.
2. The value of the MAP_SCALE keyword in the MOLA MEGDR labels is not precise enough.

Four methods are given below to address this issue.

Method 1. Create an ENVI header file for the MEGDR image that provides the map projection information, including a more precise value for MAP_SCALE. (See **Computing MAP_SCALE** below.) When the header file is present in the same directory as the MEGDR image, ENVI and ArcGIS will use it to obtain the correct map projection information.

For the user's convenience, ENVI header files have been created for all MOLA MEGDR image products. They are available in the EXTRAS directory of the MEGDR archive, at http://pds-geosciences.wustl.edu/mgs/mgs-m-mola-5-megdr-l3-v1/mgs_l300x/extras/. The header files have the same name and subdirectory path as the images they describe, but with the extension ".hdr".

The ENVI header files may also be downloaded along with the data products using the Mars Orbital Data Explorer (ODE) search service at <http://ode.rsl.wustl.edu/mars/indexProductSearch.aspx>.

Method 2. Update the value of MAP_SCALE in the MEGDR label to use a more precise value, and then use GDAL to translate the MEGDR image. GDAL version 1.11.4 or higher is recommended for this method. The GDAL command is

```
gdal_translate --config PDS_SampleProjOffset_Shift -0.5 --config
PDS_LineProjOffset_Shift -0.5 Input.lbl Output.tif
```

Method 3. Calculate the map extents of the data grid corners in meters, and then use GDAL to translate the MEGDR image. Any version of GDAL may be used with this method. The GDAL command is

```
gdal_translate -a_ullr upperLeftX UpperLeftY LowerRightX LowerLeftY
Input.lbl Output.tif
```

Method 4. Call `gdal_translate` first to convert the MEGDR image to a GeoTIFF image, and then use `gdal_edit` to change the map extents. GDAL version 1.11.4 or higher is recommended for this method. The GDAL commands are

```
gdal_translate --config PDS_SampleProjOffset_Shift -0.5 --config
PDS_LineProjOffset_Shift -0.5 Input.lbl Output.tif

gdal_edit -a_ullr upperLeftX UpperLeftY LowerRightX LowerLeftY
Output.tif
```

Method 1 is recommended for beginners. Users familiar with GDAL and map projections may prefer method 2, 3, or 4.

Computing MAP_SCALE

The value for `MAP_SCALE` in kilometers per pixel in the MEGDR label is given to three decimal places, which is not precise enough to allow MEGDR data to be overlain onto HRSC data without visible mismatch of features. A more precise value can be computed using other keywords in the label, as follows.

For example, these values are specified in the MEGDR label `MEGT90N000EB.LBL`:

```
LINES = 2880
LINE_SAMPLES = 5760
MAP_PROJECTION_TYPE = "SIMPLE CYLINDRICAL"
A_AXIS_RADIUS = 3396.0 <KM>
B_AXIS_RADIUS = 3396.0 <KM>
C_AXIS_RADIUS = 3396.0 <KM>
MAP_SCALE = 3.705 <KM/PIXEL>
MAXIMUM_LATITUDE = 90.0 <DEGREE>
MINIMUM_LATITUDE = -90.0 <DEGREE>
WESTERNMOST_LONGITUDE = 0.0 <DEGREE>
EASTERNMOST_LONGITUDE = 360.0 <DEGREE>
```

In the simple cylindrical projection the map scale is the scale at the equator. The distance in kilometers at the equator divided by the number of pixels at the equator gives the scale in km/pixel. As this image covers 360 degrees of longitude, the distance in kilometers at the equator is the circumference of the

planet, computed as $2\pi R$ where R is the radius. The number of pixels at the equator is the width of the image; that is, the number of samples per line. The map scale is therefore

$$2\pi * 3396.0 / 5760 = 3.7044613374 \text{ km/pixel.}$$

Ten digits of precision should be sufficient for use in ENVI and ArcGIS.

Definitions and Resources

ARCGIS – Mapping software (commercial); <https://www.arcgis.com/>.

ENVI – Image processing software for geospatial data (commercial);
<http://www.harrisgeospatial.co.uk/ProductsServices/ENVIProducts.aspx>.

GDAL – Geospatial Data Abstraction Library, a software library for translating between various raster and vector geospatial data formats (open source); <http://www.gdal.org/>.

GDAL packages for various computer systems can be found at <https://trac.osgeo.org/gdal/wiki/DownloadingGdalBinaries>. The Windows package used in the above examples is the OSGeo4W 64-bit version 2.2.0. A MacOS X build is available as well. More details about the gdal_translate and gdal_edit commands can be found at the following links.
http://www.gdal.org/gdal_translate.html
http://www.gdal.org/gdal_edit.html

GIS – Geographic Information System

HRSC – High Resolution Stereo Camera, an instrument on the European Mars Express orbiter (2003-present); PDS archive at http://pds-geosciences.wustl.edu/missions/mars_express/hrsc.htm.

MEGDR – Mission Experiment Gridded Data Record, a Mars topography data set; <http://pds-geosciences.wustl.edu/missions/mgs/megdr.html>.

MOLA – Mars Orbiter Laser Altimeter, an instrument on the NASA Mars Global Surveyor orbiter (1999-2006); PDS archive at <http://pds-geosciences.wustl.edu/missions/mgs/mola.html>.

ODE – Orbital Data Explorer, a PDS tool for searching and downloading orbital data products including MOLA data; <http://ode.rsl.wustl.edu/mars/>.

PDS – Planetary Data System; <http://pds.nasa.gov/>.

Questions about the information in this document may be addressed to the PDS Geosciences Node at geosci@wunder.wustl.edu.