



The ASTER Global Emissivity Database (ASTER GED)

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1. Background

The Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Emissivity Database (ASTER GED) was developed by National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL), California Institute of Technology. The ASTER GED product provides global emissivity maps of the Earth's land surface in five spectral bands. In addition to the mean emissivity and standard deviation maps for all five ASTER thermal infrared bands, the product also provides maps for mean land surface temperature (LST) and standard deviation, a re-sampled ASTER Global Digital Elevation Model (GDEM), land-water mask, mean Normalized Difference Vegetation Index (NDVI) and standard deviation, latitude, longitude, and observation count. All maps are produced on $1^{\circ} \times 1^{\circ}$ grids at 100 meter or 1 kilometer spatial resolution (nominal).

The ASTER-GED is an extension of NAALED to the rest of the globe. The difference between ASTER GED and NAALED is that ASTER GED consists of a mean climatology of all ASTER data ever acquired over a specific region (2000-2008), while NAALED consists of a mean seasonal map (Summer and Winter) for N. America only. Data beyond 2008 is not currently being added due to problems with cloud masking without the SWIR bands. An example of the global ASTER GED band 12 emissivity resampled to 5 km resolution is shown in Fig. 1, while Fig. 2 shows an example cutout over Death Valley, CA at full native resolution (100 m). Smaller landmass regions (e.g. islands and volcanic hotspots) will be added to the collect in the future.

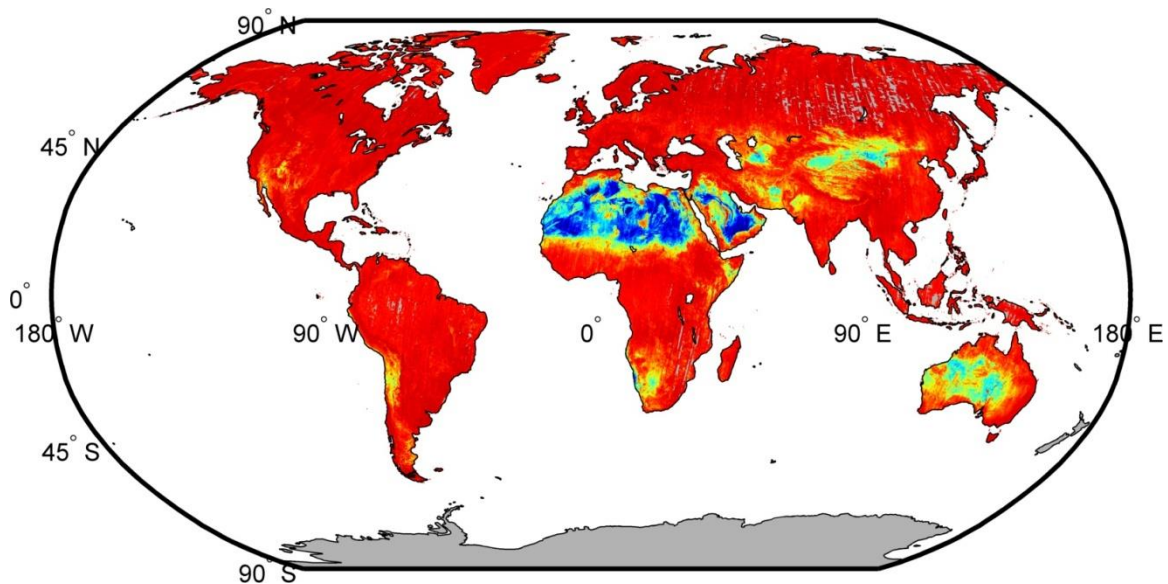


Figure 1. ASTER GED band 12 emissivity resampled from 100 m to 5 km for display purposes.

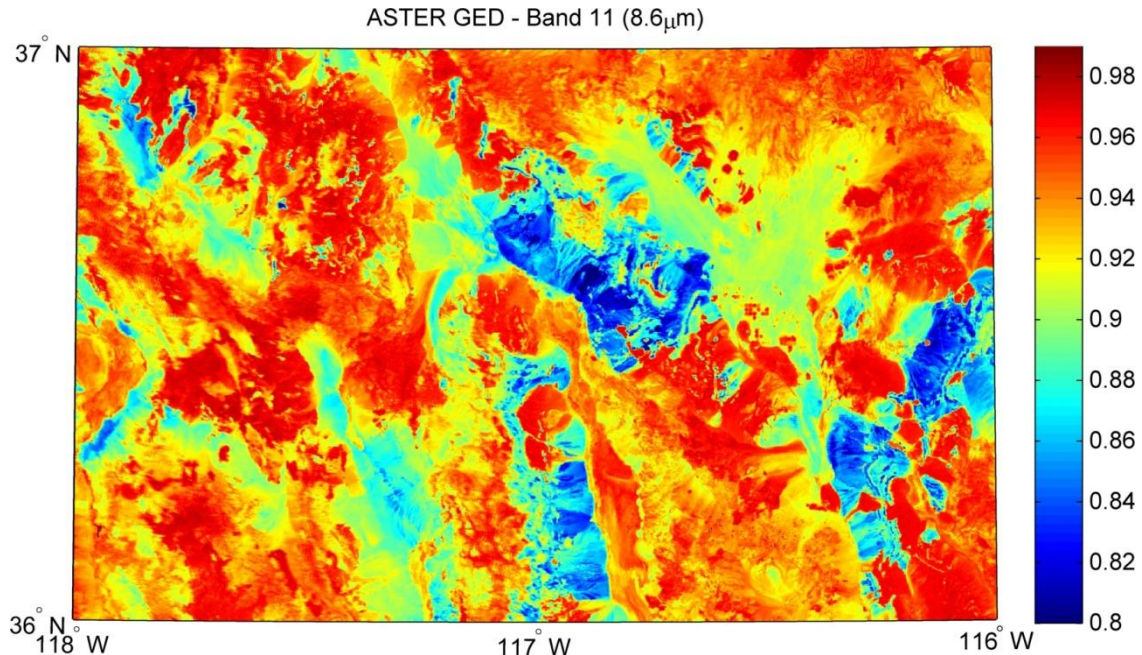


Figure 2. ASTER GED band 11 emissivity over Death Valley, CA at 100 meter spatial resolution.

2. ASTER GED Collection Details

Products within the ASTER GED collection are distributed in two spatial resolutions (100-meter and 1-kilometer) and in two output formats (HDF5 and binary). Table 1 contain information for all ASTER GED products.

Table 1: ASTER GED Products

Short Name	Collection	Community Data Product	Current Version	Temporal Extent	Spatial Resolution
AG100	ASTER GED	ASTER GED Global 100-meter HDF5	1	2000-2008	100 m
AG100B	ASTER GED	ASTER GED Global 100-meter Binary	1	2000-2008	100 m
AG1km	ASTER GED	ASTER GED Global 1-kilometer HDF5	1	2000-2008	1 km
AG1kmB	ASTER GED	ASTER GED Global 1-kilometer Binary	1	2000-2008	1 km

2.1. Product Naming Convention

The data are output on 1°x1° grids at 100 m and 1 km spatial resolution in two product formats - HDF5 and binary. Each 1°x1° grids is named according to version, geographic location, and spatial resolution as follows:

ASTER GED - 100 meter

AG100.{version}.{ northwest corner latitude }.{ northwest corner longitude }.0001.h5

Example: AG100.v003.33.-115.0001.h5

AG100B.{version}.{ northwest corner latitude }.{ northwest corner longitude }.0001.bin

Example: AG100B.v003.33.-115.0001.bin

ASTER GED - 1 kilometer

AG1km.{version}.{ northwest corner latitude }.{ northwest corner longitude }.0010.h5

Example: AG1km.v003.33.-115.0010.h5

AG1kmB.{version}.{ northwest corner latitude }.{ northwest corner longitude }.0010.bin

Example: AG1kmB.v003.33.-115.0010.bin

2.2. Product Contents

The Scientific Data Sets (SDS) contained within the ASTER GED Collection are distributed in HDF5 and binary formats

2.2.1 HDF5 Scientific Data Set (SDS) Details:

Table 2: ASTER GED product details for HDF5 SDS

SDS	Description	Data Type	Scaling factor
DEM	ASTER GDEM	int16	n/a
Emissivity	Mean Band 10 - 8.3 μm Band 11 - 8.6 μm Band 12 - 9.1 μm Band 13 - 10.6 μm Band 14 - 11.3 μm	int16	0.001
	SDev Band 10 - 8.3 μm Band 11 - 8.6 μm Band 12 - 9.1 μm Band 13 - 10.6 μm Band 14 - 11.3 μm	int16	0.0001

Geolocation	Latitude	float32	n/a
	Longitude	float32	n/a
Land-Water Map	Mean	int16	n/a
NDVI	Mean	int16	0.01
	SDev	int16	0.01
Observations	Number/pixel	int16	n/a
Temperature	Mean	int32	0.01
	SDev	int16	0.01

**Values of -9999 are assigned to missing or cloudy data.

2.2.2 Binary Scientific Data Set (SDS) File Details

The binary files are all output in 32-bit integer (long integer) and can be read in by ENVI.

Table 3: ASTER GED product details for Binary SDS

Bands		Scale Factor
1. Emissivity mean	Band 10	0.001
2.	Band 11	"
3.	Band 12	"
4.	Band 13	"
5.	Band 14	"
6. Emissivity sdev	Band 10	0.0001
7.	Band 11	"
8.	Band 12	"
9.	Band 13	"
10.	Band 14	"
11. Temperature mean		0.01
12. Temperature sdev		0.01
13. NDVI mean		0.01
14. NDVI sdev		0.01
15. Land-Water Map		n/a
16. Observations		n/a
17. Latitude		n/a
18. Longitude		n/a
19. ASTER GDEM		n/a

3. Quickstart

3.1. Binary Files

3.1.1. ENVI

Example header input for reading the **100 m** data binary file in ENVI:

Dims: 1000 x 1000 x 19 [BSQ]
Size: [Long Integer] 60,000,000 bytes.
File Type: ENVI Standard
Sensor Type: Unknown
Byte Order: Host (Intel)
Projection: None
Wavelength: None
Upper Left Corner: 1,1
Description: File Imported into ENVI.

Example header input for reading the **1 km** data binary file in ENVI:

Dims: 100 x 100 x 19 [BSQ]
Size: [Long Integer] 60,000,000 bytes.
File Type: ENVI Standard
Sensor Type: Unknown
Byte Order: Host (Intel)
Projection: None
Wavelength: None
Upper Left Corner: 1,1
Description: File Imported into ENVI.

3.2. HDF5 Files

The HDF5 files can be read and viewed by a number of tools, such as HDFView, available at http://hdf.ncsa.uiuc.edu/products/hdf5_tools/. The HDF5 files can also be easily read using MATLAB and/or Python. See below for instructions

3.2.1. MATLAB

Use `hdf5info` to get information about an HDF5 file and then use `hdf5read` to read a data set, using the information structure (`hinfo`) returned by `hdf5info` to specify the data set.

!NOTE! HDF5 describes data set dimensions in row-major order, whereas MATLAB stores data in column-major order. As a result, the first two dimensions of the data are permuted before output to HDF5 and Binary formats in order to be easily read in by other programs. When reading into MATLAB, **data have to be permuted back to the original dimension.**

```
File = asterged.v001.33N115W.0001.h5;  
hinfo = hdf5info(File);
```

% Read in resampled ASTER GDEM

```
DEM = hdf5read(hinfo.GroupHierarchy.Groups(1).Datasets(1));
```

% Read in mean emissivity 3-d array for all 5 TIR bands

```
Emis_mean = hdf5read(hinfo.GroupHierarchy.Groups(2).Datasets(1));
```

% Eg. Band 10 emissivity

```
e10 = double(Emis_mean(:, :, 1))/1000;
```

% Read in emissivity standard deviation 3-d array

```
Emis_sdev = hdf5read(hinfo.GroupHierarchy.Groups(2).Datasets(2));
```

% Read in mean kinetic temperature (K)

```
T_mean = hdf5read(hinfo.GroupHierarchy.Groups(7).Datasets(1));
```

% Read in kinetic temperature standard deviation (K)

```
T_sdev = hdf5read(hinfo.GroupHierarchy.Groups(7).Datasets(2));
```

% Read in NDVI

```
NDVI_mean = hdf5read(hinfo.GroupHierarchy.Groups(5).Datasets(1));
```

% Read in NDVI standard deviation

```
NDVI_sdev = hdf5read(hinfo.GroupHierarchy.Groups(5).Datasets(2));
```

% Read in Land/Water map

```
LWM = hdf5read(hinfo.GroupHierarchy.Groups(4).Datasets(2));
```

% Read in Latitude

```
Lat = hdf5read(hinfo.GroupHierarchy.Groups(3).Datasets(1));
```

% Read in Longitude

```
Lon = hdf5read(hinfo.GroupHierarchy.Groups(3).Datasets(2));
```

% Read in number of observation per pixel

```
obsnum = hdf5read(hinfo.GroupHierarchy.Groups(6).Datasets(1));
```

3.3. PYTHON

The example below is just instance of opening an ASTER GED HDF5 file in python. For the example, the PyTables library (<https://pytables.github.io/downloads.html>) needs to be installed.

```
'''  
Read ASTER GED HDF5 file into PYTHON using PyTables  
'''
```

```

import tables as tb

data = tb.openFile(r"...\\data\\AG100.v003.-01.-035.0001.h5")

# Browse data object tree
data.root
data.root.Emissivity
data.root.Emissivity.Mean

# Get emissivity data for band 10, 11, ...
emissivity_band10 = data.root.Emissivity.Mean[0]
emissivity_band11 = data.root.Emissivity.Mean[1]
""" ... """

# Get temperature mean and standard deviation bands
t_mean = data.root.Temperature.Mean[:]
t_sdev = data.root.Temperature.SDev[:]

# Get Lat/Lon bands
lat = data.root.Geolocation.Latitude[:]
lon = data.root.Geolocation.Longitude[:]

""" ... """

```

4. Caveats

A full description of the retrieval method including atmospheric correction can be found in this paper:

Hulley, G. C., and S. J. Hook, 2010, Generating Consistent Land Surface Temperature and Emissivity Products Between ASTER and MODIS Data for Earth Science Research, *IEEE Transactions on Geoscience and Remote Sensing*, DOI: 10.1109/TGRS.2010.2063034.

- On April 23, 2008, the ASTER SWIR detector became unstable due to rising temperatures, resulting in the SWIR bands becoming saturated. Without the SWIR bands, cloud masking becomes a challenge since bare rocks and snow show distinct features in the SWIR region which helps to filter cloud. For example, the NDSI (Normalized Difference Snow Index) is one of the primary tests used to identify snow regions and is based on SWIR band 4. A modified cloud mask algorithm was developed based on visible and TIR only bands, which works well for most conditions, however, pixels with snow/ice during the summertime period (Jul-Sep), for example Mt. McKinley in Alaska, will have no data as the cloud mask will filter out these pixels (it is set to clear-sky conservative, i.e. rather overestimate than underestimate clouds). A work-around is being developed that will use the MODIS cloud mask (MO35) to filter clouds

in all data processed post-2008.

- Artifacts will exist in some images where total scenes used to produce the mean image is low (eg. <3). This is especially apparent in the surface temperature product due to large variability in day-to-day temperatures. For example, temperature averages may be taken between scenes from different years with different atmospheric conditions, which will produce artifacts, especially if clouds were screened in one or both images. This may appear to look like incomplete cloud screening, but in fact is simply data from one scene 'filling in' the cloud gaps from the scene that contains clouds. These artifacts may not be as apparent in the emissivity product, unless the surface changed, or atmospheric conditions were challenging.
- The limit to which TES (even when using the Water Vapor Scaling (WVS) method to improve the atmospheric correction) can retrieve accurate temperature/emissivities was found to be ~5 cm total water vapor. All scenes with higher total water vapor loads higher than this value were discarded.
- The NDVI product is produced from TOA reflectances generated from the L1-B product, NOT atmospherically corrected surface reflectances. As a result, caution should be used if using this product quantitatively. The Land-Water mask was also produced from TOA reflectances, so in some cases there may be errors over some regions. The Land-Water mask has not been validated at present, but work is in progress to improve its accuracy

5. Citing ASTER GED

These data are not copyrighted; however, if you publish NASA data or results derived by using LP DAAC data products, we request that you include an acknowledgment and citation. If possible, please e-mail or send us reprints/citations of papers or oral presentations based on data obtained from the LP DAAC (see below for mailing address and e-mail address). Your input will help us to stay informed as to how the data are used.

Example LP DAAC Citation:

Hulley, G.C., and S.J. Hook. 2013. The ASTER Global Emissivity Database (ASTER GED). Data set. Available on-line [<https://lpdaac.usgs.gov>] from NASA Land Processes Distributed Active Archive Center (LP DAAC). USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota, U.S.A. doi: XXXX, Accessed XX/XX/XXXX.

Also, please reference one or more of the following papers for publishing purposes:

Hulley, G.C., and S. J. Hook (2008), A New Methodology for Cloud Detection and Classification with the Advanced Spaceborne Thermal Emission and Reflection (ASTER) Data, *Geophys. Res. Lett.*, 35, L16812, doi:10.1029/2008GL034644

Hulley, G.C., and S. J. Hook (2008), The First Gridded ASTER Land Surface Emissivity Database of California and Nevada, , *Geophys. Res. Lett.*, L13401, doi:10.1029/2008GL034507

Hulley, G. C., S. J. Hook, and A. M. Baldridge, 2009. Validation of the North American ASTER Land Surface Emissivity Database (NAALSED) Version 2.0., *Remote Sensing of Environment*, 113, 2224-2233.

Hulley, G. C., and S. J. Hook, 2009. The North American ASTER Land Surface Emissivity Database (NAALSED) Version 2.0., *Remote Sensing of Environment*, 113, 1967-1975.

Hulley, G. C., and S. J. Hook, 2010, Generating Consistent Land Surface Temperature and Emissivity Products Between ASTER and MODIS Data for Earth Science Research, *IEEE Transactions on Geoscience and Remote Sensing*, DOI: 10.1109/TGRS.2010.2063034.

Hulley, G. C., T. Hughes, and S. J. Hook (2012), Quantifying Uncertainties in Land Surface Temperature (LST) and Emissivity Retrievals from ASTER and MODIS Thermal Infrared Data, *J. Geophys. Res. Lett.*, 117, D23113, doi:10.1029/2012JD018506.

Related validation results and information can be found here:

<http://emissivity.jpl.nasa.gov/validation>

Hulley, G. C., S. J. Hook, and A. M. Baldridge, 2009. Validation of the North American ASTER Land Surface Emissivity Database (NAALSED) Version 2.0., *Remote Sensing of Environment*, 113, 2224-2233.

Göttsche, F. M., and G. C. Hulley, (2012), Validation of six satellite-retrieved land surface emissivity products over two land cover types in a hyper-arid region, *Rem. Sens. Environ.*, 124, 149-158.

Gillespie, A.R., E.A. Abbott, L. Gilson, G. Hulley, J.C. Jimenez-Munoz, and J.A. Sobrino, (2011), Residual errors in ASTER temperature and emissivity standard products AST08 and AST05, *Remote Sensing of Environment*, doi:10.1016/j.rse.2011.09.007