Review of Cerberus Fossae (HiRISE, HRSC, CTX) and Crater Aristarchus (LROC-NAC) datasets

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Contents

1 Info

1.1 From Sebastien

Below you would be able to find two datasets proposed by Jan-Peter...CEP and Ar istarchus. We should probably have a look first at the CEP. I have asked them not to write two PUGs, one for CTX and one for Hirise. However, it looks like they have used the CTX approach in this dataset, thus that should look familiar.

It would be great if we could validate the CTX before mid December. If you can do both before end of the year, that would be even better!

Let me know if you have any questions.

1.2 From Jan-Peter

This is a mail to me:

> I have sent your nominated email addres an invitation to share the "For-ESA-GSF" folder in which there are 2 sub-directoies, one called "Cerberus-Fossae-3D-products" and the other "Crater-Aristcrhus-products".
>
> Inside the former you will find 3 sub-folders with the DTM, ORI and Metafiles: HiRISE HRSC CTX
>
> Inside the latter, you will find 2 sub-olders named Crater-Aristarchus-mosaic-products Crater-Aristarchus-strip-products Inside the former you will find DTM and ORI products at 10m and 0.5m respectively
>
> Inside the latter, you will find 13 directories of stereo DTM cropped and height-adjusted products as well as ORIs and Metafiles (as described in the PUG I sent yesterday) and 7 additional ORI files and Metafiles (ditto).

Please don't hesitate to contact me if there is anything which is unclear

This is from an earlier mail to Sebastien:

Please note that the PUG should be the CTX one previously delivered. Kiky still needs to send you a PUG for HiRISE.

My recent complain:

The files UCL-Aristarchus-ORI-JPL-AOI..tif and UCL-Aristarchus-ORI-JPL-AOI-10m.tif (just different resolution versions) both look like the attached. Besides that this just looks "odd", some pixels have the strange value -1.666661e+34 (cut off in my plot). Could you please double check if these files look OK for you?

Then I cannot access the image content of the file M1191003838LE-M1191017895LE-ORI-UCL.tif, while the meta information in the GeoTIFF looks OK to me. The file size seems to be too small for the content as described in the meta information. Could you check if the file on the server is really OK? There is also a version v2 of this file, which works fine for me. By the way, what is the purpose of the several v2 files? They are not mentioned in the PUG.

There are several *ORI*.tif and *Meta.txt files in the base directory Crater-Aristarchus-strip-products, without matching DTM files. These are also not mentioned in the PUG. Are they really intended to be there?

Then I have a general question about DTMs and ORIs. I was thinking that the coverage of related DTM and ORI should match exactly, or is it OK for you if they only match approximately?

Peter's reply:

I note that the 10m version has strange values down to -e05 which the 5m ORI does not and the 1m version also has some strange values. I have computed the histograms for the 10m before and after chopping the lower limit to 0 and there is negligible difference (1st & 2nd screenshots) and I have done the same for the 1m version (screenshots 3 & 4) and again chopping at 0m. I am not sure why the max and min are different at the 2

resolutions and different again to the one at 5m. I have included a screenshot of the whole area including the basemap (SELENE), the gap-filler (Change'2) and the 3 mosaics for context, it also lists the names of all the files.

Please download v2 of M1191003838LE-M1191017895LE-ORI-UCL-v2.tif, which is in the directory of the same name. It is 7.63Gb which is correct.

The v2 were replacements for the originals. I have deleted the originals in M1191003838LE-M1191017895LE and in M1129787722LE-M1129801944LE

The new ORIs in the base directory for the strip products are supplementary replacements. Please do include them. They used the DTM for orthorectification. They are discussed in the paper.

2 Cerberus 'CTX'

2.1 Dataset content

Let's see what we have:

```
system2( 'ls', args = '../dat/CTX', stdout = TRUE )
```

```
## [1] "F22_044514_1831_XN_03N195W-GO2_018853_1837_XN_03N195W-DTM_coregistered_aligned_cropped.tif"
## [2] "F22_044514_1831_XN_03N195W-GO2_018853_1837_XN_03N195W-DTM_coregistered_aligned_cropped.tif.aux.xml"
## [3] "F22_044514_1831_XN_03N195W-GO2_018853_1837_XN_03N195W-Meta.txt"
## [4] "F22_044514_1831_XN_03N195W-GO2_018853_1837_XN_03N195W-ORI_coregistered_aligned_cropped.tif"
## [5] "F22_044514_1831_XN_03N195W-GO2_018853_1837_XN_03N195W-ORI_coregistered_aligned_cropped.tif.aux.xml"
```

The '`.aux.xlm`' files are probably superfluous; in the other CTX dataset they were. They are also present in '`HRSC`' (4.1) but not in '`HiRISE`' (3.1).

2.2 Meta information

This is the content of the '`Meta.txt`' file:

```
Object = AutoDTM
  Object = ProductInfo
    Object = Processing
      SoftwareName = CASP-GO
      SoftwareVersion = 2.0
      OperatingSystem = "RHEL v7.2"
      ProcessingStartTime = 2020-06-09T02:30
```

```
    ProcessingEndTime = 2020-06-09T03:43
    ProcessingOrganisation = UCL/MSSL
    ProcessingResource = "Imaging Group Blades"
    ContactPerson = "Yu Tao"
    ContactEmail = "yu.tao{at}ucl.ac.uk"
  End_Object

  Object = Data
    ID = F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W
    Format = GeoTiff
    Band = 1
    BitDepth = 32f
    DTMResolution = 6
    ORIResolution = 6
    Unit = Metre
    NodataValue = 3.40282346600000016e+38
    Projection = Sinusoidal
  End_Object
End_Object

Object = Algorithm
  Group = ASP
    Name = "Ames Stereo Pipeline Function Parameters"
    InitialCorrKernel = 35
    RefinementCorrKernel = 75
    RefinementIteration = 3
  End_Group

  Group = sGotcha
    Name = "Adaptive Least Squares Correlation and Region growing Parameters"
    ALSCIteration = 8
    MaxEigenValue = 80
    ALSCKernel = 11
    GrowNeighbour = 8
  End_Group

  Group = ML
    Name = "Fast Maximum Likelihood Matching Parameters"
    MLKernel = 25
    MLIter = 3
  End_Group

  Group = ORS
    Name = "Outlier Rejection Schemes Parameters"
    MaxDiff = 1.5
    PercentDiff = 60
    DiffKernel = 21
    PatchThreshold = 7.5
    PercentReject = 25
    Erode = 1
  End_Group

  Group = coKriging
    Name = "Co-Kriging Interpolation Parameters"
```

```
      NeighbourLimit = 21
      DistLimit = 500
      SpatialResRatio = 1
    End_Group

    Group = MSA-SIFT
      Name = "Mutual Shape Adapted Scale Invariant Feature Transform Co-registion Parameters"
      nOctave = 8
      EdgeThreshold = 10
      MatchCoeff = 0.6
      nLayer = 3
    End_Group
  End_Object
End_Object
End
```

We load the `rgdal` package to access the geo tags in the GeoTIFF files:

```
library('rgdal')


## Loading required package:  sp

## rgdal:  version:  1.5-16, (SVN revision 1050)
## Geospatial Data Abstraction Library extensions to R successfully
loaded
## Loaded GDAL runtime:  GDAL 2.2.3, released 2017/11/20
## Path to GDAL shared files:  /usr/share/gdal/2.2
## GDAL binary built with GEOS: TRUE
## Loaded PROJ runtime:  Rel.  4.9.3, 15 August 2016, [PJ_VERSION:
493]
## Path to PROJ shared files:  (autodetected)
## Linking to sp version:1.4-2
```

This is the georeferencing information in the DTM file:

```
GDALinfo('../dat/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-DTM_coregistered_aligned_cropped.tif')


## rows        612
## columns     612
## bands       1
## lower left origin.x        13266.08
## lower left origin.y        231800.7
## res.x       6
## res.y       6
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
```

```
## projection  +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m
## +no_defs
## file        ../dat/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-DTM_coregistered_aligned_cropped.
## apparent band summary:
##    GDType hasNoDataValue  NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE 3.402823e+38          3        612
## apparent band statistics:
##        Bmin      Bmax     Bmean      Bsd
## 1 -3110.461 -2833.457 -2883.762 33.77199
## Metadata:
## AREA_OR_POINT=Area
```

And this is the one in the ORI file:

```
GDALinfo('../dat/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-ORI_coregistered_aligned_cropped.tif')
```

```
## rows        612
## columns     612
## bands       1
## lower left origin.x        13266.08
## lower left origin.y        231800.7
## res.x       6
## res.y       6
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m
## +no_defs
## file        ../dat/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-ORI_coregistered_aligned_cropped.
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          3        612
## apparent band statistics:
##          Bmin     Bmax     Bmean        Bsd
## 1 -0.07142207 1.058812 0.7155491 0.09045935
## Metadata:
## AREA_OR_POINT=Area
## DataType=Generic
```

2.3 Image data

We load the `raster` package to access the acutal image content in the GeoTIFF files:

```
library('raster')
```

Now we load the actual image content of the DTM and the ORI file:

```
dtm=raster('../dat/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-DTM_coregistered_aligned_cropped.tif
dtm
```

```
## class      : RasterLayer
## dimensions : 612, 612, 374544  (nrow, ncol, ncell)
## resolution : 6, 6  (x, y)
## extent     : 13266.08, 16938.08, 231800.7, 235472.7  (xmin, xmax, ymin, ymax)
## crs        : +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-
## names      : F22_044514_1831_XN_03N195W.G02_018853_1837_XN_03N195W.DTM_coregistered_aligned_cropped
## values     : -3110.461, -2833.457  (min, max)


ori=raster('../dat/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-ORI_coregistered_aligned_cropped.tif
ori


## class      : RasterLayer
## dimensions : 612, 612, 374544  (nrow, ncol, ncell)
## resolution : 6, 6  (x, y)
## extent     : 13266.08, 16938.08, 231800.7, 235472.7  (xmin, xmax, ymin, ymax)
## crs        : +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/CTX/F22_044514_1831_XN_03N195W-G02_018853_1837_XN_03N195W-
## names      : F22_044514_1831_XN_03N195W.G02_018853_1837_XN_03N195W.ORI_coregistered_aligned_cropped
## values     : -0.07142207, 1.058812  (min, max)
```

This is a statistical summary of the DTM data:

```
summary(dtm)


## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (26.7% of all cells)


##         F22_044514_1831_XN_03N195W.G02_018853_1837_XN_03N195W.DTM_coregistered_aligned_cropped
## Min.                                                                          -3110.367
## 1st Qu.                                                                       -2883.004
## Median                                                                        -2880.029
## 3rd Qu.                                                                       -2875.357
## Max.                                                                          -2833.457
## NA's                                                                              0.000
```

This is a statistical summary of the ORI data:

```
summary(ori)


## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (26.7% of all cells)


##         F22_044514_1831_XN_03N195W.G02_018853_1837_XN_03N195W.ORI_coregistered_aligned_cropped
## Min.                                                                         -0.06615452
## 1st Qu.                                                                       0.70562193
## Median                                                                        0.72691527
## 3rd Qu.                                                                       0.74576461
## Max.                                                                          1.05881155
## NA's                                                                          0.00000000
```

If we wanted to write the data to a file in text format, we needed to convert it to a data frame. So we do it for the DTM data:

```
dtm_df <- as.data.frame(dtm, xy = TRUE )
str(dtm_df)
```

```
## 'data.frame': 374544 obs. of  3 variables:
##  $ x                                                                                : num  13269 13275 13
##  $ y                                                                                : num  235470 235470
##  $ F22_044514_1831_XN_03N195W.G02_018853_1837_XN_03N195W.DTM_coregistered_aligned_cropped: num  -2878 -2878 -2
```

And then we do it also for the ORI data:

```
ori_df <- as.data.frame(ori, xy = TRUE )
str(ori_df)
```

```
## 'data.frame': 374544 obs. of  3 variables:
##  $ x                                                                                : num  13269 13275 13
##  $ y                                                                                : num  235470 235470
##  $ F22_044514_1831_XN_03N195W.G02_018853_1837_XN_03N195W.ORI_coregistered_aligned_cropped: num  0.731 0.719 0.
```

A plot of the DTM image is shown in Fig. 1, a plot of the ORI image in Fig. 2.

We can also make histograms, the one of the DTM data is shown in Fig.3 and the one for the ORI data is shown in Fig. 4

2.4 Conclusions

- We can confirm the integrity of the data products.
- Image content is compatible with the HiRISE and HRSC datasets, cf 3.3, 4.3.
- There are two spurious files with '`.aux.xml`' extension that should be removed.

  JPM: ACTION ESA#1: remove spurious files

  BG: Created a new folder '`REMOVED_BY_BG`' in '`For-ESA-GSF`' and moved the '`.aux.xml`' files into there.

- The file names are looooong. All file names contain

  `_coregistered_aligned_cropped`

```
plot(dtm)
```

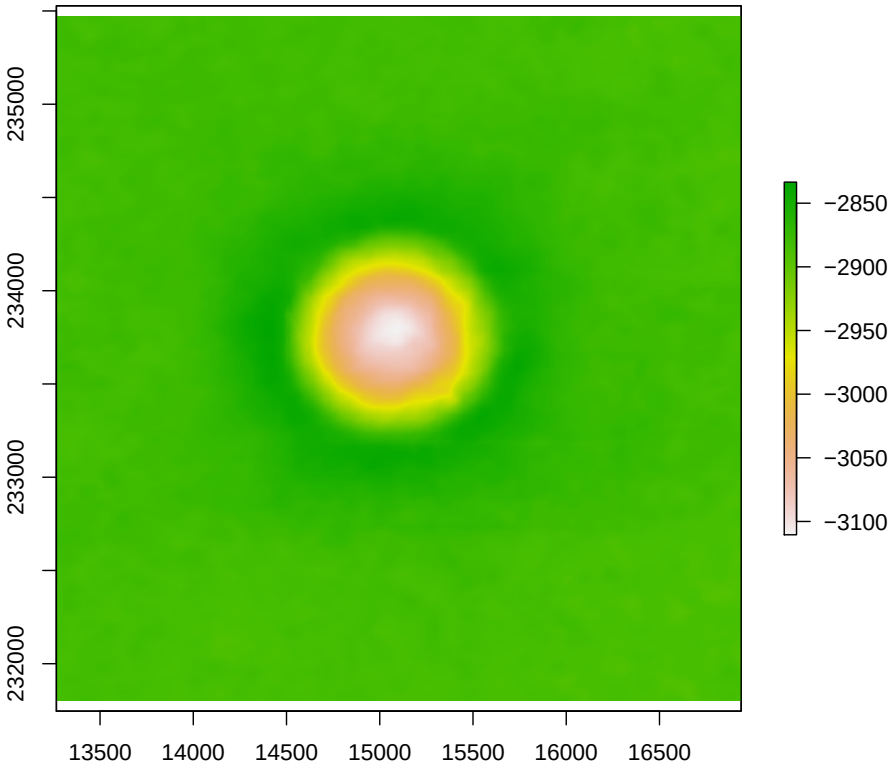

Figure 1: Plot of the CTX DTM data.

```
plot(ori)
```

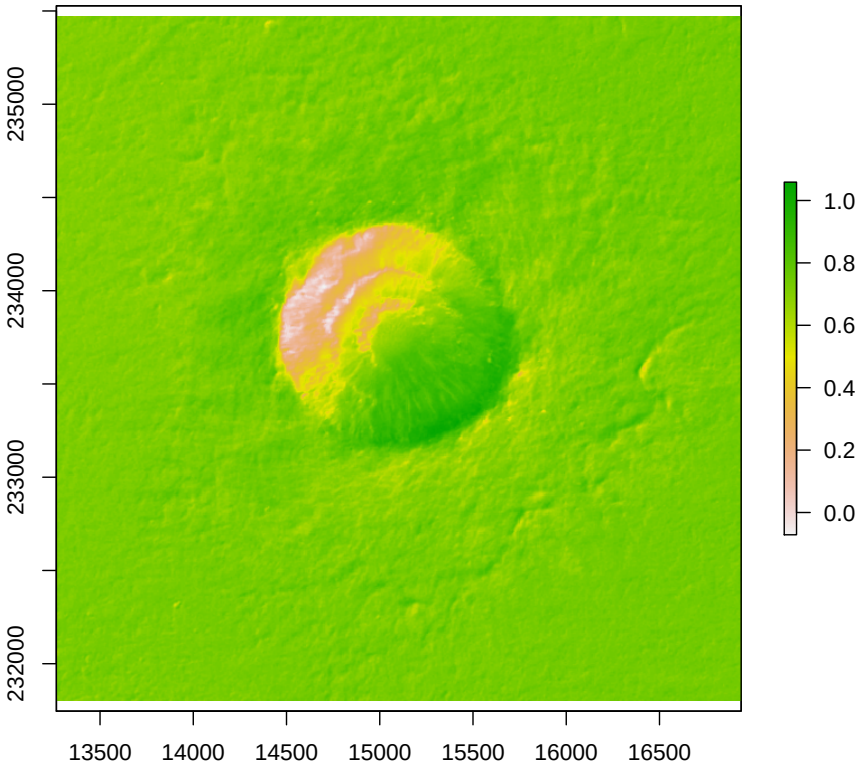

Figure 2: Plot of the CTX ORI data.

```
hist(dtm)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  27% of the raster cells were used.  100000
values used.
```

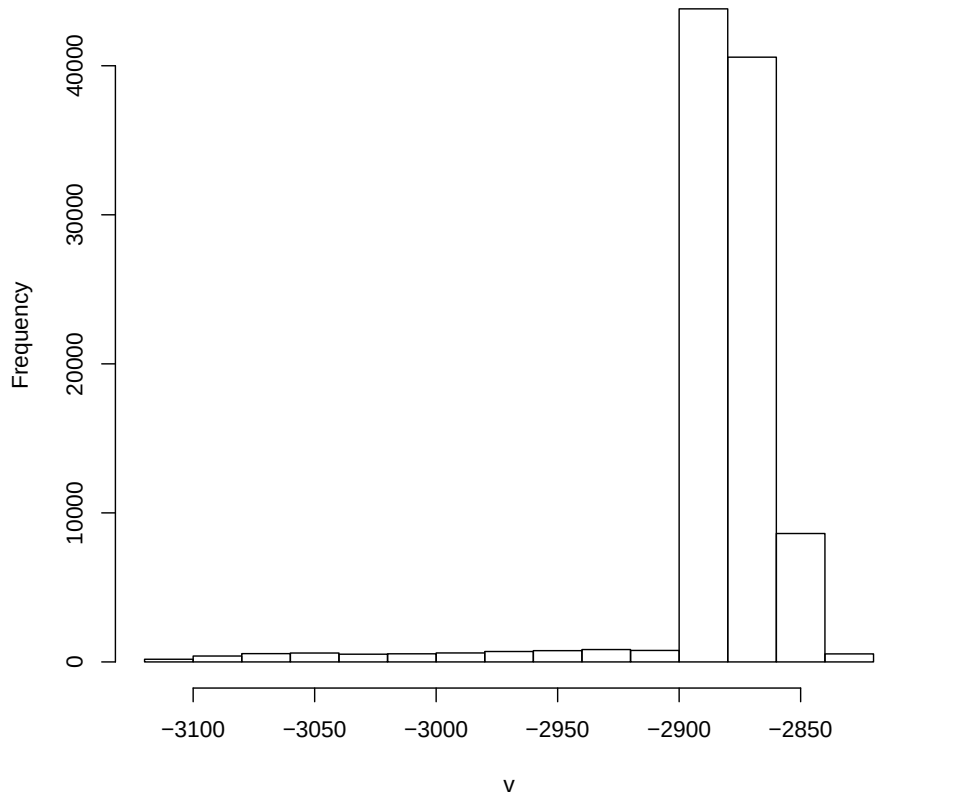

Figure 3: Histogram of the CTX DTM data.

```
hist(ori)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  27% of the raster cells were used.  100000
values used.
```

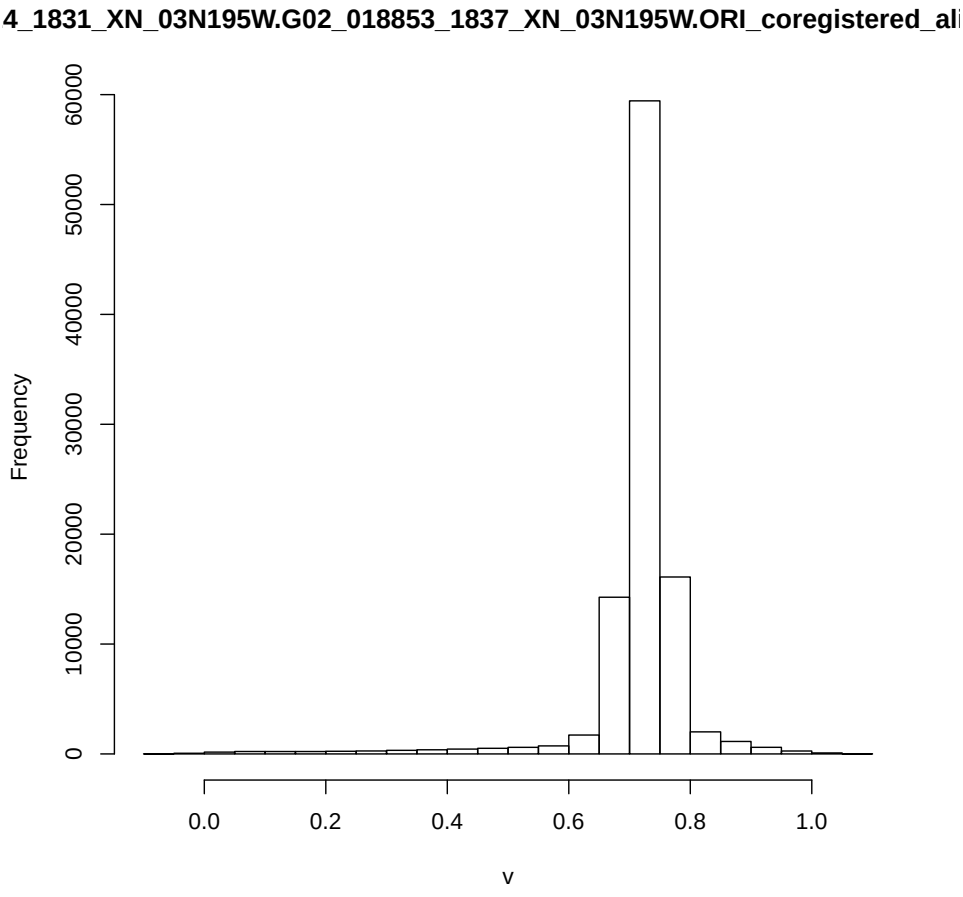

Figure 4: Histogram of the CTX ORI data.

This might have been helpful where the images were created to distiguish between different version, but in the published dataset, where only one version resides, it seemed to be unnecessary clutter. So, I was first thinking that this part should be removed from the file names. However, the PUG stated and explains this part of the file names. It reads like different files without this extra part in the name are available elsewhere. If this is really the case, we should probably keep the extra part.

JPM: Yes, this is true that it was the case as it was a lot of effort to ensure that all the CTX images were co-registered to overlapping HRSC, where available (co-registered) and co-aligned in height with MOLA and cropped as far as that was feasible to remove any rubbish that might have crept into the processing. How about shortening this to an extension of "_crac" and I modify the "PUG" ACTION UCL#1: modify the PUG

BG: Renamed the two '`.tif`' files accordingly.

3 Cerberus '`HiRISE`'

The HiRISE data is quite similar to the CTX data, so we follow a similar path.

3.1 Dataset content

Let's see what we have:

```
system2( 'ls', args = '../dat/HiRISE', stdout = TRUE )
```

```
## [1] "ESP_043815_1840-ESP_044514_1840-DTM_coregistered_aligned_cropped.tif"
## [2] "ESP_043815_1840-ESP_044514_1840-Meta.txt"
## [3] "ESP_043815_1840-ESP_044514_1840-ORI_coregistered_aligned_cropped.tif"
```

The looks very similar to the '`CTX`' content, however, the spurious '`.aux.xlm`' files we saw there (2.1) are nore present here.

3.2 Meta information

This is the content of the '`Meta.txt`' file:

```
Object = AutoDTM
  Object = ProductInfo
    Object = Processing
      SoftwareName = CASP-GO
      SoftwareVersion = 2.0
      OperatingSystem = "RHEL v7.2"
      ProcessingStartTime = 2020-06-10T06:30
      ProcessingEndTime = 2020-06-10T07:29
      ProcessingOrganisation = UCL/MSSL
      ProcessingResource = "Imaging Group Blades"
      ContactPerson = "Yu Tao"
      ContactEmail = "yu.tao{at}ucl.ac.uk"
    End_Object

    Object = Data
      ID = ESP_043815_1840_RED-ESP_044514_1840_RED
      Format = GeoTiff
      Band = 1
      BitDepth = 32f
      DTMResolution = 0.25
      ORIResolution = 0.25
      Unit = Metre
      NodataValue = 3.40282346600000016e+38
      Projection = Sinusoidal
    End_Object
  End_Object

  Object = Algorithm
    Group = ASP
      Name = "Ames Stereo Pipeline Function Parameters"
      InitialCorrKernel = 25
      RefinementCorrKernel = 35
      RefinementIteration = 1
    End_Group

    Group = sGotcha
      Name = "Adaptive Least Squares Correlation and Region growing Parameters"
      ALSCIteration = 8
      MaxEigenValue = 80
      ALSCKernel = 11
      GrowNeighbour = 8
    End_Group

    Group = ML
      Name = "Fast Maximum Likelihood Matching Parameters"
      MLKernel = 25
      MLIter = 3
    End_Group

    Group = ORS
      Name = "Outlier Rejection Schemes Parameters"
      MaxDiff = 1.5
      PercentDiff = 60
      DiffKernel = 21
```

```
      PatchThreshold = 7.5
      PercentReject = 25
      Erode = 1
    End_Group

    Group = coKriging
      Name = "Co-Kriging Interpolation Parameters"
      NeighbourLimit = 21
      DistLimit = 500
      SpatialResRatio = 1
    End_Group

    Group = MSA-SIFT
      Name = "Mutual Shape Adapted Scale Invariant Feature Transform Co-registion Parameters"
      nOctave = 8
      EdgeThreshold = 10
      MatchCoeff = 0.6
      nLayer = 3
    End_Group
  End_Object
End_Object
End
```

This is the georeferencing information in the DTM file:

```
GDALinfo('../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-DTM_coregistered_aligned_cropped.tif')
```

```
## Warning in GDALinfo("../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-DTM_coregistered_aligned_cropped.tif"):
statistics not supported by this driver
```

```
## rows        13400
## columns     13320
## bands       1
## lower left origin.x        13319.98
## lower left origin.y        232290
## res.x       0.25
## res.y       0.25
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m
## +no_defs
## file        ../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-DTM_coregistered_aligned_cropped.tif
## apparent band summary:
##    GDType hasNoDataValue  NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE 3.402823e+38          1      13320
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
```

We did not get this warning about `statistics not supported` for the CTX

file.

And this is the georeferencing informatikon in the ORI file:

```
GDALinfo('../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-ORI_coregistered_aligned_cropped.tif')
```

```
## Warning in GDALinfo("../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-ORI_coregistered_aligned_cropped.tif"):
statistics not supported by this driver
```

```
## rows        13400
## columns     13320
## bands       1
## lower left origin.x        13319.98
## lower left origin.y        232290
## res.x       0.25
## res.y       0.25
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m
## +no_defs
## file        ../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-ORI_coregistered_aligned_cropped.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1      13320
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
## DataType=Generic
```

We get the same warning here, which we did not get for the respective CTX file.

The reason for these warnings is probably that the values for `Bmean` and `Bsd` were explicitely given as TIFF tags in the CTX files, while here the reading software has to compute them by looping over the values, and appearently this version of GDALinfo does not do this. Possibly it just refuses to do so because the images are so large. But this does not really matter.

3.3 Image data

We load the actual image content of the DTM and the ORI file:

```
dtm=raster('../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-DTM_coregistered_aligned_cropped.tif')
dtm
```

```
## class      : RasterLayer
```

```
## dimensions : 13400, 13320, 178488000  (nrow, ncol, ncell)
## resolution : 0.25, 0.25  (x, y)
## extent     : 13319.98, 16649.98, 232290, 235640  (xmin, xmax, ymin, ymax)
## crs        : +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/HiRISE/ESP_043815_1840-ESP_044514_1840-DTM_coregistered_al
## names      : ESP_043815_1840.ESP_044514_1840.DTM_coregistered_aligned_cropped
```

```
ori=raster('../dat/HiRISE/ESP_043815_1840-ESP_044514_1840-ORI_coregistered_aligned_cropped.tif')
ori
```

```
## class      : RasterLayer
## dimensions : 13400, 13320, 178488000  (nrow, ncol, ncell)
## resolution : 0.25, 0.25  (x, y)
## extent     : 13319.98, 16649.98, 232290, 235640  (xmin, xmax, ymin, ymax)
## crs        : +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/HiRISE/ESP_043815_1840-ESP_044514_1840-ORI_coregistered_al
## names      : ESP_043815_1840.ESP_044514_1840.ORI_coregistered_aligned_cropped
```

This is a statistical summary of the DTM data:

```
summary(dtm)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.06% of all cells)
```

```
##         ESP_043815_1840.ESP_044514_1840.DTM_coregistered_aligned_cropped
## Min.                                                          -3111.268
## 1st Qu.                                                       -2882.162
## Median                                                        -2880.241
## 3rd Qu.                                                       -2874.712
## Max.                                                          -2828.348
## NA's                                                              0.000
```

This is a statistical summary of the ORI data:

```
summary(ori)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.06% of all cells)
```

```
##         ESP_043815_1840.ESP_044514_1840.ORI_coregistered_aligned_cropped
## Min.                                                         -0.6644432
## 1st Qu.                                                       0.4752889
## Median                                                        0.5291723
## 3rd Qu.                                                       0.5789162
## Max.                                                          1.1491894
## NA's                                                          0.0000000
```

We skip here the conversion to data frames as it is quite time consuming, even with `cache=TRUE`.

A plot of the DTM image is shown in Fig. 5, a plot of the ORI image in Fig. 6.

We can also make histograms, the one of the DTM data is shown in Fig. 7 and the one for the ORI data is shown in Fig. 8

3.4 Conclusions

- We can confirm the integrity of the data products.
- Image content is compatible with the CTX and HRSC datasets, cf 2.3, 4.3.
- The file names are looooong (same as for the CTX, same remark applies).

  JPM: Same solution except that CTX_crac is usually used as the height reference

  BG: Renamed the two '`.tif`' files similarlarly.

4 Cerberus '`HRSC`'

The HRSC data is quite similar to the CTX and the HiRISE data, so we follow a similar path.

4.1 Dataset content

Let's see what we have:

```
system2( 'ls', args = '../dat/HRSC', stdout = TRUE )
```

```
## [1] "h5154_0000_da4_cropped.tif"         "h5154_0000_da4_cropped.tif.aux.xml"
## [3] "h5154_0000_nd4_cropped.tif"         "h5154_0000_nd4_cropped.tif.aux.xml"
```

The looks very similar to the '`CTX`' and the '`HiRISE`' content, although it is here not directly obvious which is the DTM and which is the ORI. A '`Meta.txt`' file like in '`CTX`' (2.1) and '`HiRISE`' (3.1) is not provided here. The spurious '`.aux.xlm`' files we saw in '`CTX`' are also present here.

```
plot(dtm)
```

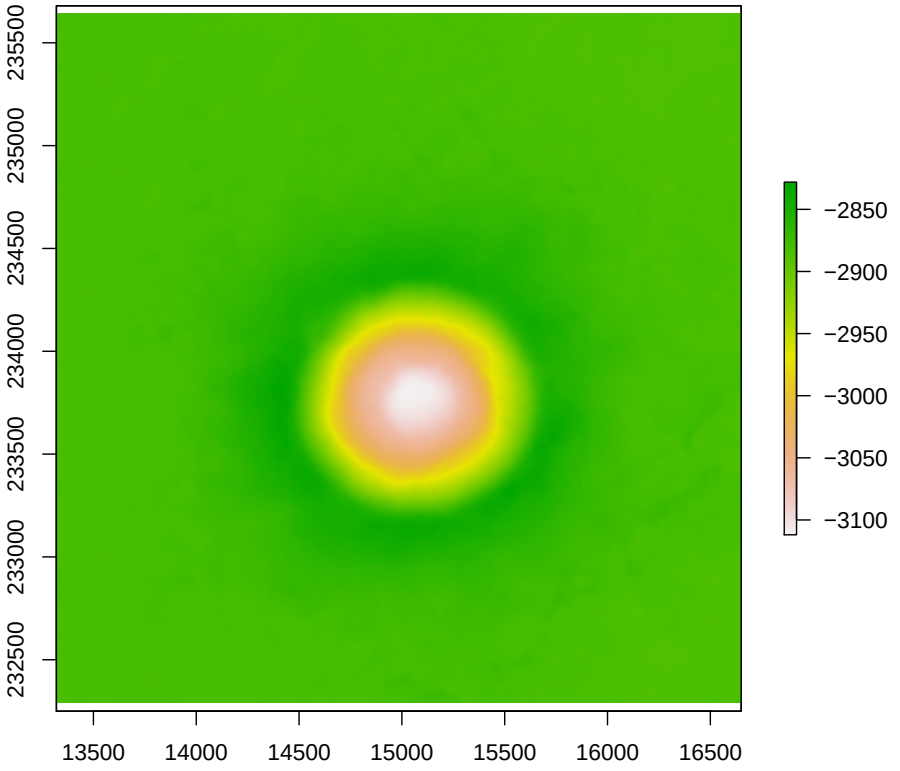

Figure 5: Plot of the HiRISE DTM data.

```
plot(ori)
```

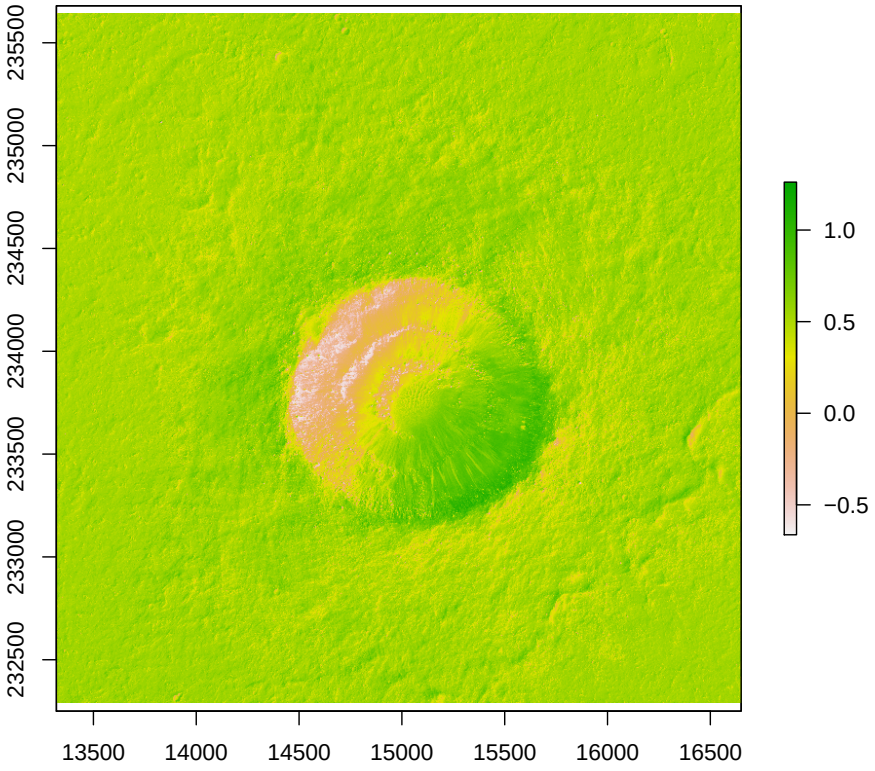

Figure 6: Plot of the HiRISE ORI data.

```
hist(dtm)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  0% of the raster cells were used.  100000
values used.
```

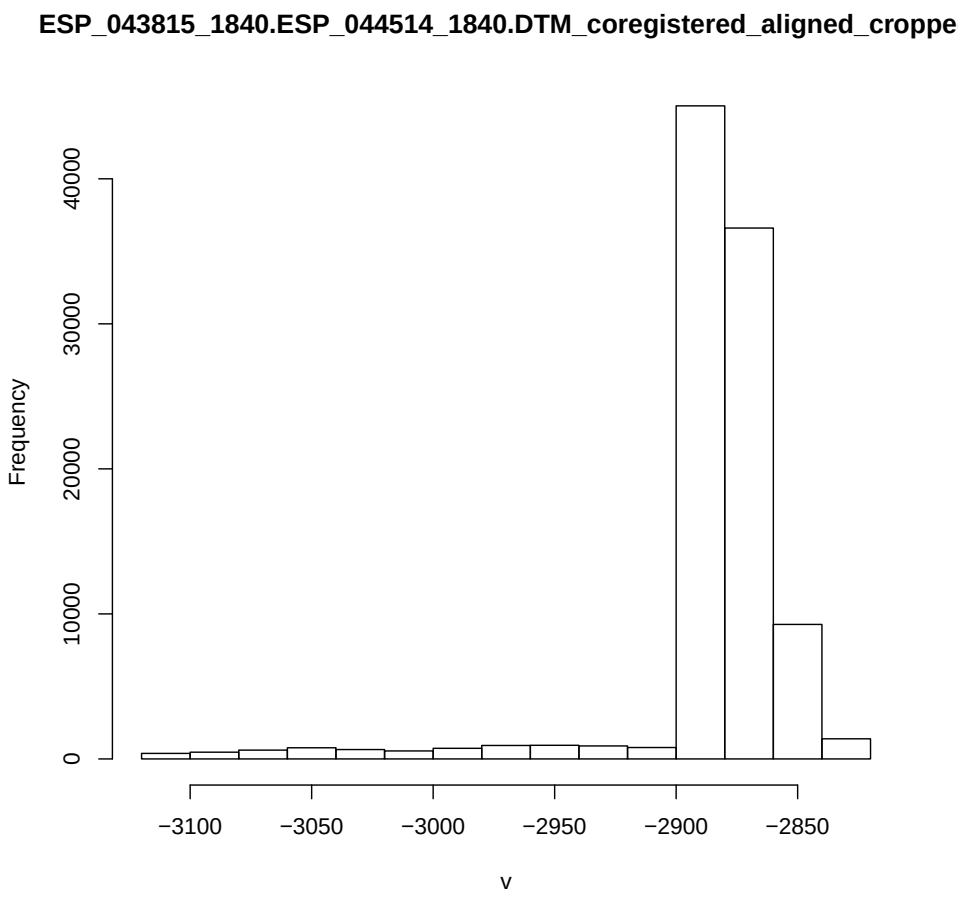

Figure 7: Histogram of the HiRISE DTM data.

```
hist(ori)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  0% of the raster cells were used.  100000
values used.
```

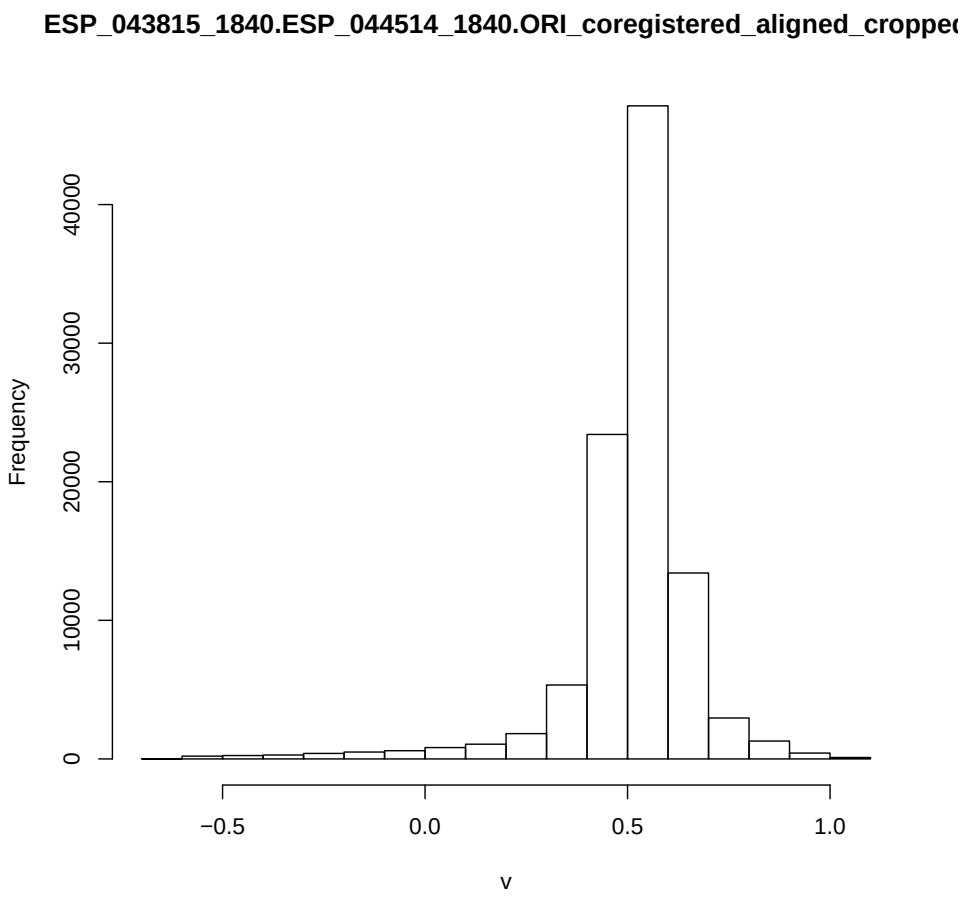

Figure 8: Histogram of the HiRISE ORI data.

4.2 Meta information

This is the georeferencing information in the first file (which turns out to be the DTM):

```
GDALinfo('../dat/HRSC/h5154_0000_da4_cropped.tif')
```

```
## rows        120
## columns     140
## bands       1
## lower left origin.x        11977.5
## lower left origin.y        230002.5
## res.x       50
## res.y       50
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m
## +no_defs
## file        ../dat/HRSC/h5154_0000_da4_cropped.tif
## apparent band summary:
##   GDType hasNoDataValue NoDataValue blockSize1 blockSize2
## 1  Int16           TRUE      -32768         29        140
## apparent band statistics:
##    Bmin  Bmax     Bmean      Bsd
## 1 -3043 -2846 -2888.013 16.50659
## Metadata:
## AREA_OR_POINT=Area
## CREATOR=Conversion from VICAR Format by Sebastian Walter, swalter@zedat.fu-berlin.de
## DTM.DTM_A_AXIS_RADIUS=-1e+32
## DTM.DTM_B_AXIS_RADIUS=-1e+32
## DTM.DTM_C_AXIS_RADIUS=-1e+32
## DTM.DTM_DESC=Height above equipotential surface described by potential model GMM3 (PDS dataset MGS-M-MOLA-5-ME
## DTM.DTM_MAXIMUM_DN=-1115
## DTM.DTM_MINIMUM_DN=-3304
## DTM.DTM_MISSING_DN=-32768
## DTM.DTM_OFFSET=0.0
## DTM.DTM_SCALING_FACTOR=1.0
## PRODUCT_TYPE=DTM
## SPACECRAFT_NAME=MARS_EXPRESS
```

And this is the georeferencing informatikon in the second (the ORI) file:

```
GDALinfo('../dat/HRSC/h5154_0000_nd4_cropped.tif')
```

```
## rows        480
## columns     560
## bands       1
## lower left origin.x        11990
## lower left origin.y        230002.5
## res.x       12.5
## res.y       12.5
## ysign       -1
## oblique.x   0
## oblique.y   0
```

```
## driver      GTiff
## projection  +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m
## +no_defs
## file        ../dat/HRSC/h5154_0000_nd4_cropped.tif
## apparent band summary:
##   GDType hasNoDataValue NoDataValue blockSize1 blockSize2
## 1   Byte           TRUE           0         14        560
## apparent band statistics:
##   Bmin Bmax    Bmean      Bsd
## 1   22  199 123.0968 10.45148
## Metadata:
## AREA_OR_POINT=Area
## CONVERSION_DETAILS=http://www.lpi.usra.edu/meetings/lpsc2014/pdf/1088.pdf
## DLRTO8.RADIANCE_OFFSET=2.74122
## DLRTO8.RADIANCE_SCALING_FACTOR=0.014268
## DLRTO8.REFLECTANCE_OFFSET=0.0824048
## DLRTO8.REFLECTANCE_SCALING_FACTOR=0.000428916
## FILE.EVENT_TYPE=MARS-REGIONAL-MAPPING-Vo-Te-Mw
## HRCONVER.ERROR_FRAMES=0
## HRCONVER.MISSING_FRAMES=0
## HRCONVER.OVERFLOW_FRAMES=0
## HRFOOT.BEST_GROUND_SAMPLING_DISTANCE=0.013
## HRORTHO.DTM_NAME=h5154_0000.dt4.50
## HRORTHO.EXTORI_FILE_NAME=h5154_0000.nd2.50_ext
## HRORTHO.GEOMETRIC_CALIB_FILE_NAME=h2gnd_02.cal
## HRORTHO.SPICE_FILE_NAME=pck00009.tpc
## M94_CAMERAS.MACROPIXEL_SIZE=1
## M94_INSTRUMENT.DETECTOR_ID=MEX_HRSC_NADIR
## M94_INSTRUMENT.MISSION_PHASE_NAME=ME_Phase_11
## M94_ORBIT.START_TIME=2008-01-06T10:31:10.853Z
## M94_ORBIT.STOP_TIME=2008-01-06T10:33:51.708Z
## PIXEL-SHIFT-BUG=CORRECTED
## PRODUCT_TYPE=IMAGE
## SPACECRAFT_NAME=MARS EXPRESS
```

We see that the DTM has 120×140 pixels with 50 m resolution while the ORI has 480×560 pixels with 12.5 m resolution. The different resolution is of course acceptable, but both should have identical corners. This would only be possible if the ORI had 481×561 pixels (cf. **??**).

4.3 Image data

We load the actual image content of the DTM and the ORI file:

```
dtm=raster('../dat/HRSC/h5154_0000_da4_cropped.tif')
dtm
```

```
## class      : RasterLayer
## dimensions : 120, 140, 16800  (nrow, ncol, ncell)
## resolution : 50, 50  (x, y)
## extent     : 11977.5, 18977.5, 230002.5, 236002.5  (xmin, xmax, ymin, ymax)
## crs        : +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/HRSC/h5154_0000_da4_cropped.tif
## names      : h5154_0000_da4_cropped
## values     : -3043, -2846  (min, max)
```

```
ori=raster('../dat/HRSC/h5154_0000_nd4_cropped.tif')
```

```
ori
```

```
## class      : RasterLayer
## dimensions : 480, 560, 268800  (nrow, ncol, ncell)
## resolution : 12.5, 12.5  (x, y)
## extent     : 11990, 18990, 230002.5, 236002.5  (xmin, xmax, ymin, ymax)
## crs        : +proj=sinu +lon_0=164 +x_0=0 +y_0=0 +a=3396000 +b=3396000 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/HRSC/h5154_0000_nd4_cropped.tif
## names      : h5154_0000_nd4_cropped
## values     : 22, 199  (min, max)
```

This is a statistical summary of the DTM data:

```
summary(dtm)
```

```
##         h5154_0000_da4_cropped
## Min.                    -3043
## 1st Qu.                 -2896
## Median                  -2887
## 3rd Qu.                 -2880
## Max.                    -2846
## NA's                      120
```

This is a statistical summary of the ORI data:

```
summary(ori)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (37.2% of all cells)
```

```
##         h5154_0000_nd4_cropped
## Min.                        22
## 1st Qu.                    120
## Median                     124
## 3rd Qu.                    127
## Max.                       197
## NA's                         0
```

If we wanted to write the data to a file in text format, we needed to convert it to a data frame. So we do it for the DTM data:

```
dtm_df <- as.data.frame(dtm, xy = TRUE )
str(dtm_df)
```

```
## 'data.frame': 16800 obs. of  3 variables:
##  $ x                    : num  12002 12052 12102 12152 12202 ...
##  $ y                    : num  235978 235978 235978 235978 235978 ...
##  $ h5154_0000_da4_cropped: int  -2888 -2887 -2887 -2887 -2887 -2887 -2887 -2887 -2887 -2887 ...
```

And then we do it also for the ORI data:

```
ori_df <- as.data.frame(ori, xy = TRUE )
str(ori_df)
```

```
## 'data.frame': 268800 obs. of  3 variables:
##  $ x                     : num  11996 12009 12021 12034 12046 ...
##  $ y                     : num  235996 235996 235996 235996 235996 ...
##  $ h5154_0000_nd4_cropped: int  118 126 137 126 122 123 121 128 127 127 ...
```

A plot of the DTM image is shown in Fig. 9, a plot of the ORI image in Fig. 10.

We can also make histograms, the one of the DTM data is shown in Fig. 11 and the one for the ORI data is shown in Fig. 12

4.4 Conclusions

- We can confirm the integrity of the data products.
- Image content is compatible with the CTX and the HiRISE datasets, cf 2.3, 3.3.
- There are two spurious files with '`.aux.xml`' extension like for CTX that should be removed.

  JPM: ACTION ESA#2 : remove spurious files

  BG: Moved the '`.aux.xml`' into '`REMOVED_BY_BG`'.
- A text file with meta information like for CTX and HiRISE is missing.

  JPM: This is because the HRSC is a copy of the file that is already in the ESA-PSA site.
- The file names are a bit long (albeit not as long as for CTX and HiRISE). All file names contain

  `_cropped`

  Same remark as for CTX aplies, however, like for CTX and HiRISE, the PUG may explain and justify these file names (which it currently does not).

  JPM: Yes, we cropped out of a full strip just the piece covering the crater. Best if this stays as is.

```
plot(dtm)
```

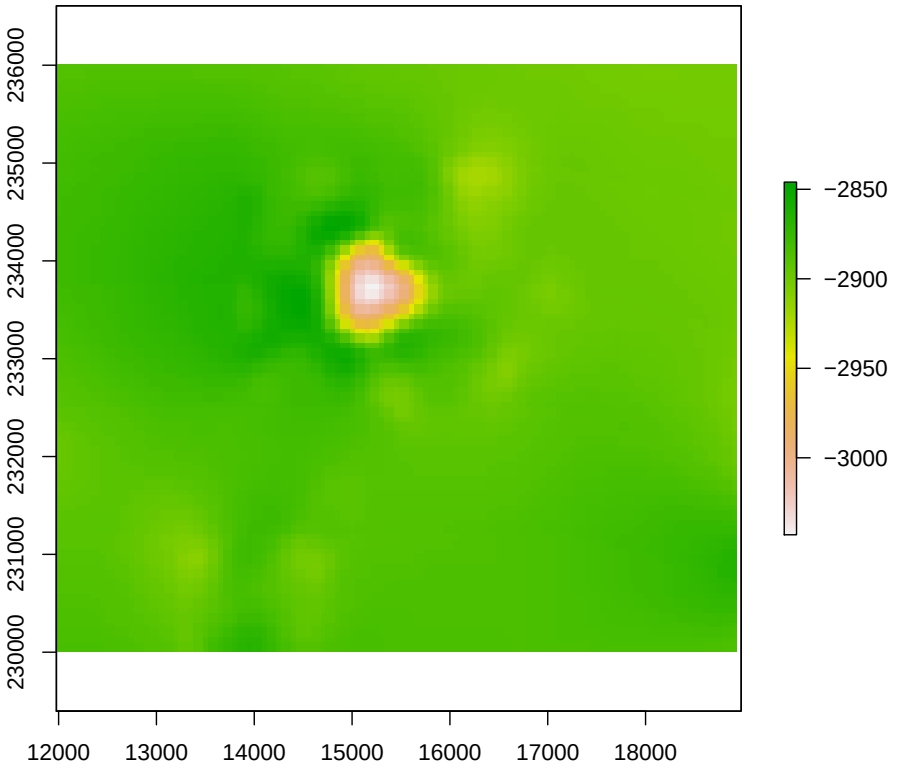

Figure 9: Plot of the HRSC DTM data.

```
plot(ori)
```

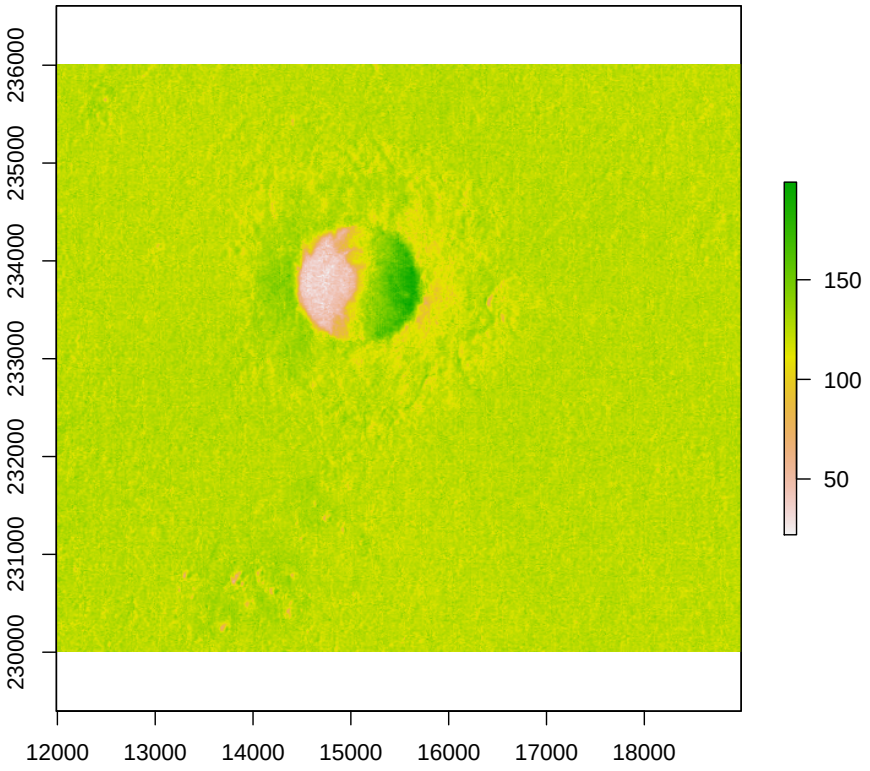

Figure 10: Plot of the HRSC ORI data.

```
hist(dtm)
```

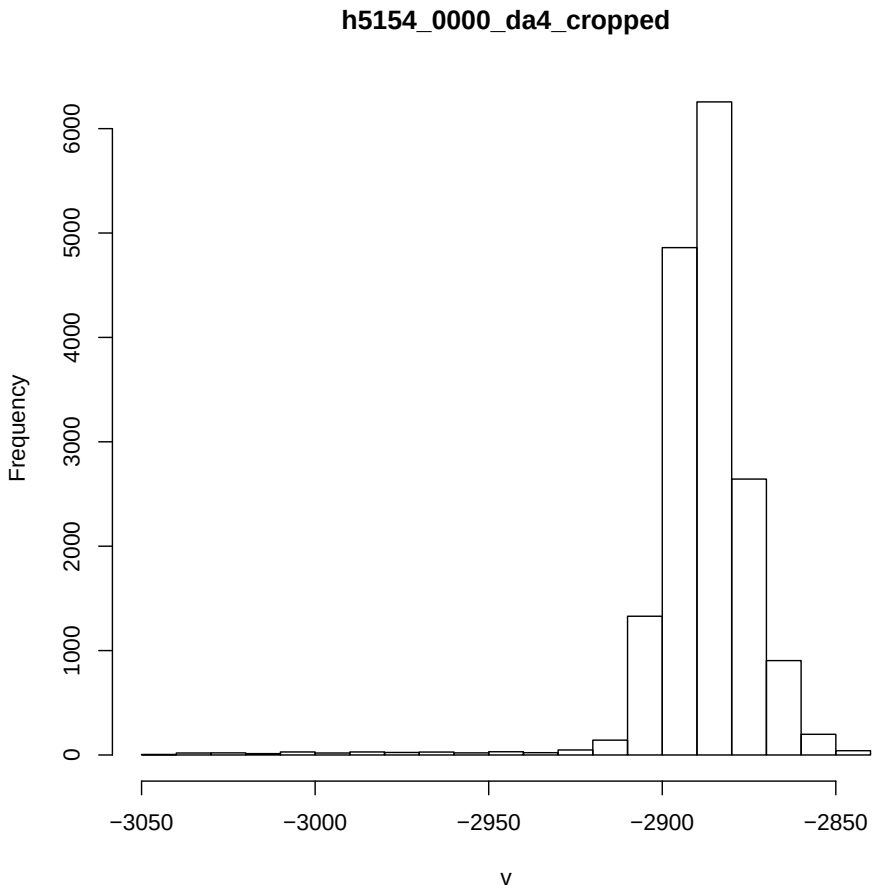

Figure 11: Histogram of the HRSC DTM data.

```
hist(ori)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  37% of the raster cells were used.  100000
values used.
```

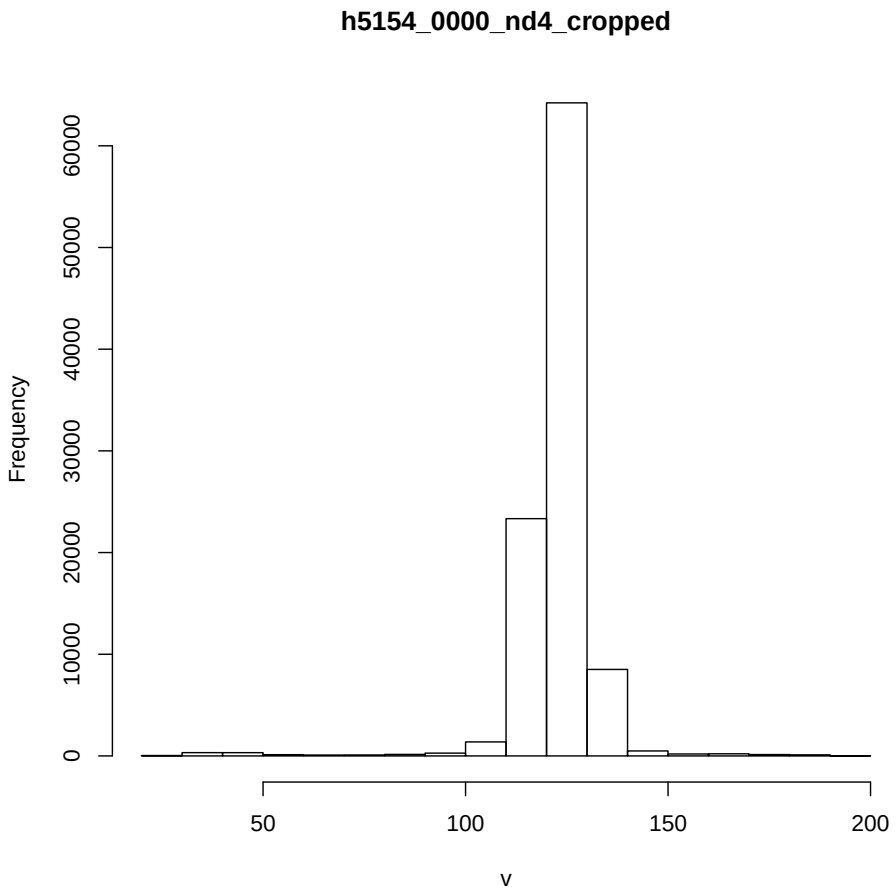

Figure 12: Histogram of the HRSC ORI data.

5 'Crater-Aristarchus-mosaic-products'

5.1 Dataset content

What do we have here:

```
system2( 'ls', args = c( '-ohH', '../dat/mosaic' ), stdout = TRUE )
```

```
## [1] "total 35G"
## [2] "-rwxrwxrwx 1 bgrieger  71M Oct 27 05:37 UCL-Aristarchus-DTM-JPL-AOI-10m.tif"
## [3] "-rwxrwxrwx 1 bgrieger 7.0G Jan  5 17:07 UCL-Aristarchus-DTM-JPL-AOI.tif"
## [4] "-rwxrwxrwx 1 bgrieger  71M Oct 27 05:36 UCL-Aristarchus-ORI-JPL-AOI-10m.tif"
## [5] "-rwxrwxrwx 1 bgrieger  28G Jan  7 12:58 UCL-Aristarchus-ORI-JPL-AOI..tif"
```

We notice a spurious extra dot in the last file name.

We have two moderate size files, one DTM and one ORI, and two very large files, also one DMT and one ORI.

5.2 Meta information

Let's begin with the moderate size files:

```
GDALinfo('../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI-10m.tif')
```

```
## Warning in GDALinfo("../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI-10m.tif"):  statistics
not supported by this driver
```

```
## rows        4203
## columns     4415
## bands       1
## lower left origin.x        -1456580
## lower left origin.y        699236
## res.x       10
## res.y       10
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI-10m.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1       4415
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
```

```
GDALinfo('../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI-10m.tif')
```

```
## Warning in GDALinfo("../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI-10m.tif"):  statistics
not supported by this driver
```

```
## rows        4203
## columns     4415
## bands       1
## lower left origin.x        -1456580
## lower left origin.y        699236
## res.x       10
## res.y       10
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI-10m.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1       4415
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
## BUNDLE_ADJUST_PREFIX=*
## CAMERA_MODEL_TYPE=*
## DEM_FILE=*
```

This looks fine. The resolution from the meta information matches the one in the file tags.

Now the two large files:

```
GDALinfo('../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI.tif')
```

```
## Warning in GDALinfo("../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI.tif"):  statistics not
supported by this driver
```

```
## rows        42028
## columns     44148
## bands       1
## lower left origin.x        -1456580
## lower left origin.y        699238
## res.x       1
## res.y       1
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI.tif
```

```
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1      44148
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
```

```
GDALinfo('../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI..tif')
```

```
## Warning in GDALinfo("../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI..tif"):  statistics
not supported by this driver
```

```
## rows        84057
## columns     88297
## bands       1
## lower left origin.x        -1456580
## lower left origin.y        699237.5
## res.x       0.5
## res.y       0.5
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI..tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1      88297
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
## BUNDLE_ADJUST_PREFIX=*
## CAMERA_MODEL_TYPE=*
## DEM_FILE=*
```

We see from the meta information that the resolution of the DTM is 1 m, while that of the ORI is 0.5 m.

In x as well as in y direction, the number of grid points of the ORI is one more than double the number of grid points of the DTM. This means that the corners of DTM and ORI could (and should) be identical (which was not the case in 4.2), however, there is, as we see, an offset of 0.5 m in y direction. This is most probably not intended.

It would be helpful if the resolution was also indicated in file tags, maybe for these two files by adding a '`-HIRES`'. A numerical value might raise doubts whether the two images belong together. For consistency, the tag '`-10m`' in the other two images could be replaced by '`LORES`'.

5.3 Image data

5.3.1 Lower resolution files

We load the actual image content of the smaller DTM and ORI file:

```
dtm=raster('../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI-10m.tif')
dtm
```

```
## class      : RasterLayer
## dimensions : 4203, 4415, 18556245  (nrow, ncol, ncell)
## resolution : 10, 10  (x, y)
## extent     : -1456580, -1412430, 699236, 741266  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-mosaic-prod
## names      : UCL.Aristarchus.DTM.JPL.AOI.10m
```

```
ori=raster('../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI-10m.tif')
ori
```

```
## class      : RasterLayer
## dimensions : 4203, 4415, 18556245  (nrow, ncol, ncell)
## resolution : 10, 10  (x, y)
## extent     : -1456580, -1412430, 699236, 741266  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-mosaic-prod
## names      : UCL.Aristarchus.ORI.JPL.AOI.10m
```

These are the statistical summaries of the DTM and ORI data:

```
summary(dtm)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.54% of all cells)
```

```
##         UCL.Aristarchus.DTM.JPL.AOI.10m
## Min.                        -3313.4575
## 1st Qu.                     -2899.0649
## Median                      -1693.2552
## 3rd Qu.                      -774.6746
## Max.                          402.5629
## NA's                       4106126.0000
```

```
summary(ori)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.54% of all cells)
```

```
##         UCL.Aristarchus.ORI.JPL.AOI.10m
```

```
## Min.                       -1.666661e+34
## 1st Qu.                     4.485982e-02
## Median                      6.801222e-02
## 3rd Qu.                     1.053317e-01
## Max.                        3.881542e-01
## NA's                        4.105940e+06
```

The statistics of the ORI looks a bit odd. Let's see how it looks like, but first we do the conversion to data frame, so that we could write the data to a text file:

```
dtm_df <- as.data.frame(dtm, xy = TRUE )
str(dtm_df)
```

```
## 'data.frame': 18556245 obs. of  3 variables:
##  $ x                              : num  -1456575 -1456565 -1456555 -1456545 -1456535 ...
##  $ y                              : num  741261 741261 741261 741261 741261 ...
##  $ UCL.Aristarchus.DTM.JPL.AOI.10m: num  NA NA NA NA NA NA NA NA NA NA ...
```

```
ori_df <- as.data.frame(ori, xy = TRUE )
str(ori_df)
```

```
## 'data.frame': 18556245 obs. of  3 variables:
##  $ x                              : num  -1456576 -1456566 -1456556 -1456546 -1456536 ...
##  $ y                              : num  741261 741261 741261 741261 741261 ...
##  $ UCL.Aristarchus.ORI.JPL.AOI.10m: num  NA NA NA NA NA NA NA NA NA NA ...
```

Now we make the plots. The one of the DTM image is shown in Fig. 13, a plot of the ORI image in Fig. 14. As suspected from the statistical summary, the ORI data (Fig. 14) contains some data points with extreme negative magnitude which spoil the contrast. A plot of the ORI data with manually adjusted stretch is shown in Fig. 15. The ORI data is obviously corrupted.

We also make the histograms. The one of the DTM data is shown in Fig. 16. For the ORI data, we make two histograms, one for the positive data values shown in Fig. 17 and one for the negative datavalues shown in Fig. 18. The ORI histogram in Fig. 18 confirms the presence of extreme outliers.

5.3.2 Higher resolution files

Now we turn to the larger DTM and the ORI files and load their actual image content:

```
dtm=raster('../dat/mosaic/UCL-Aristarchus-DTM-JPL-AOI.tif')
dtm
```

```
plot(dtm)
```

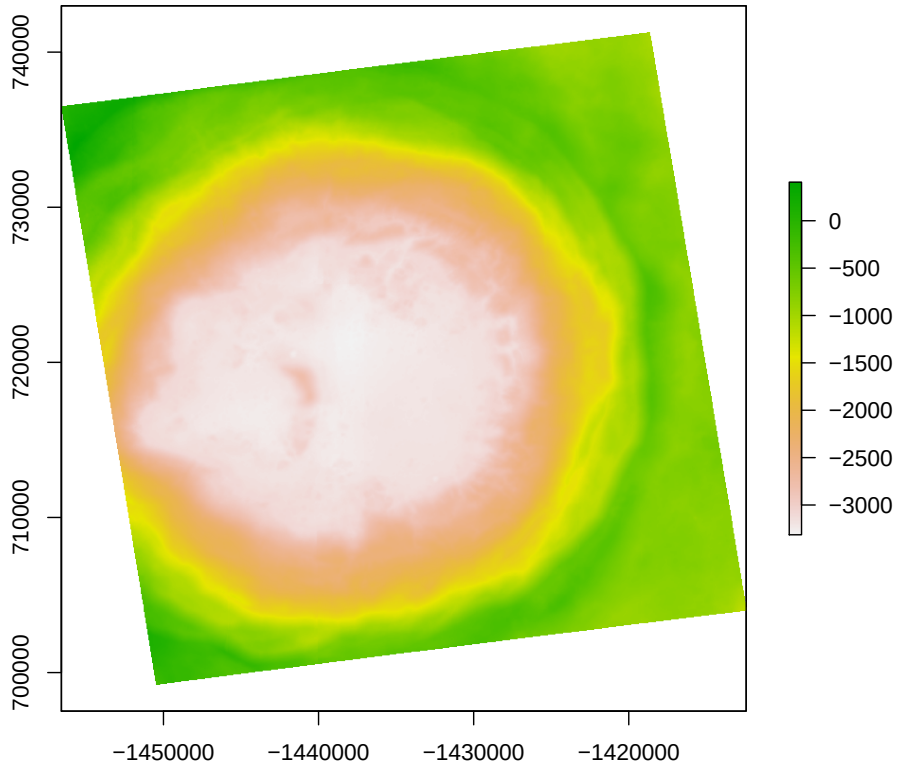

Figure 13: Plot of the Aristarchus mosaic lower resolution DTM data.

```
plot(ori)
```

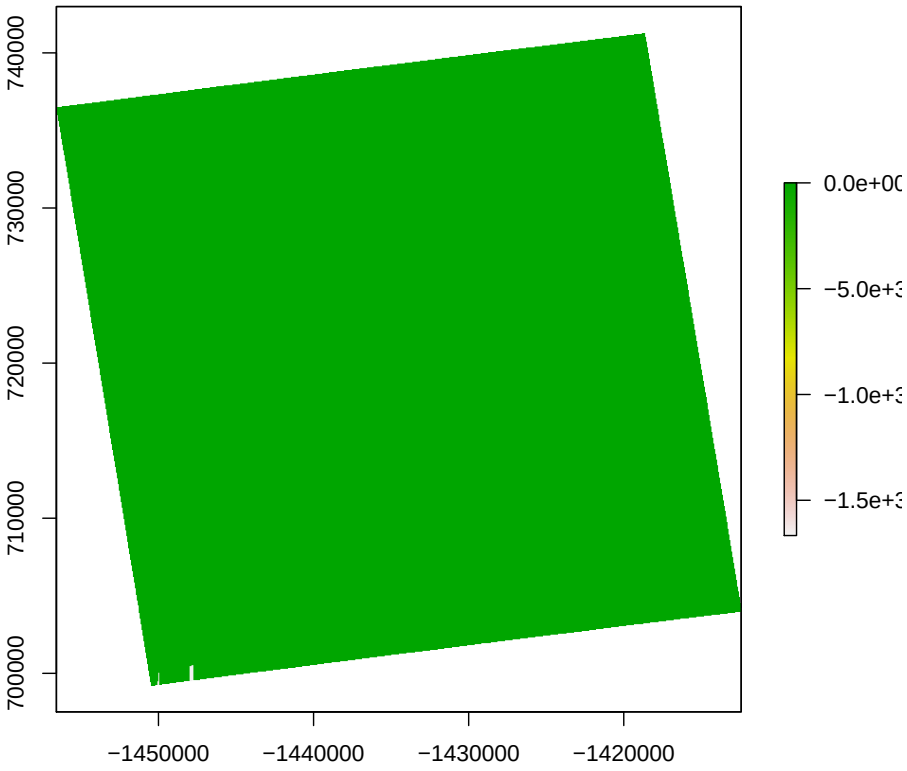

Figure 14: Plot of the Aristarchus mosaic lower resolution ORI data with automatic stretch.

```
zmin = 0
zmax = 0.4
plot( ori, zlim = c( zmin, zmax ) )
```

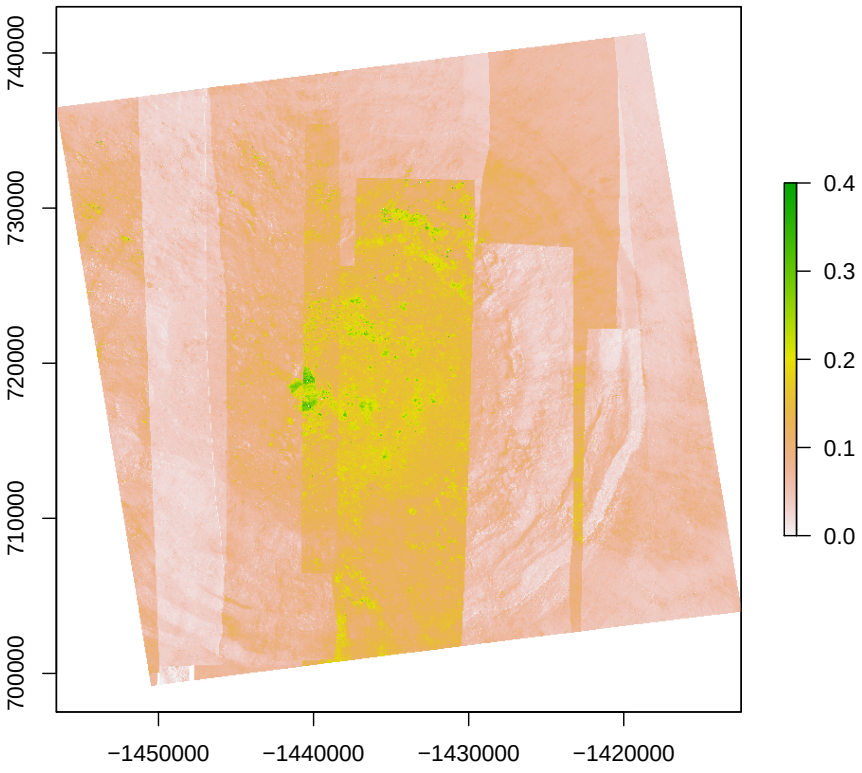

Figure 15: Plot of the Aristarchus mosaic lower resolution ORI data with minimum and maximum value set to 0 and 0.4, respectively.

```
hist(dtm)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  1% of the raster cells were used.  100000
values used.
```

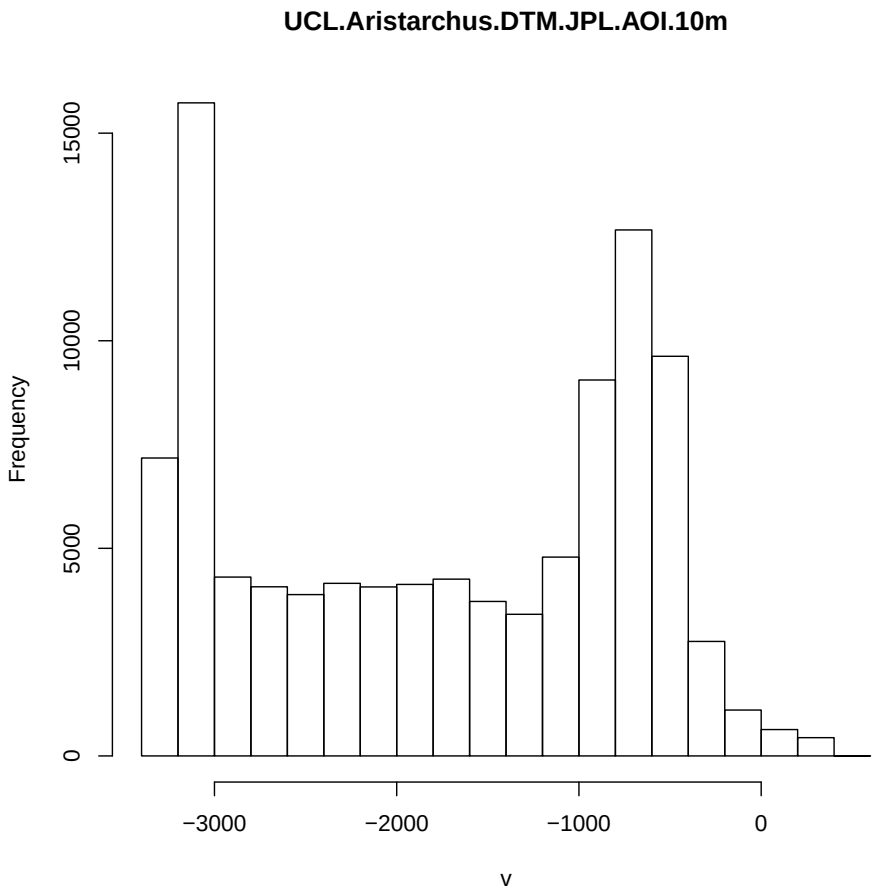

Figure 16: Histogram of the Aristarchus mosaic lower resolution DTM data.

```
hist( ori[ ori >= 0 & ori < 0.4 ],
      breaks = seq( 0, 0.4, by = 0.0004 ) )
```

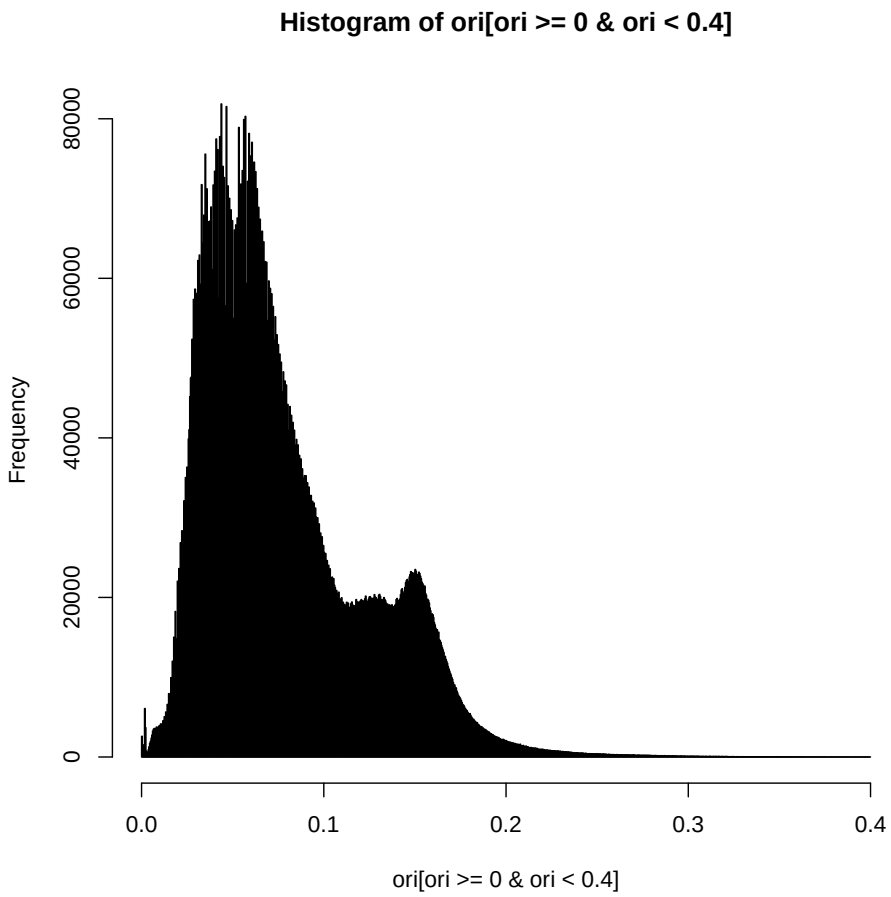

Figure 17: Histogram of the Aristarchus mosaic lower resolution ORI data, only positive values.

```
hist( ori[ ori < -1 ],
      breaks = seq( -1.7e34, -1.6e34, by = 0.0001e34 ) )
```

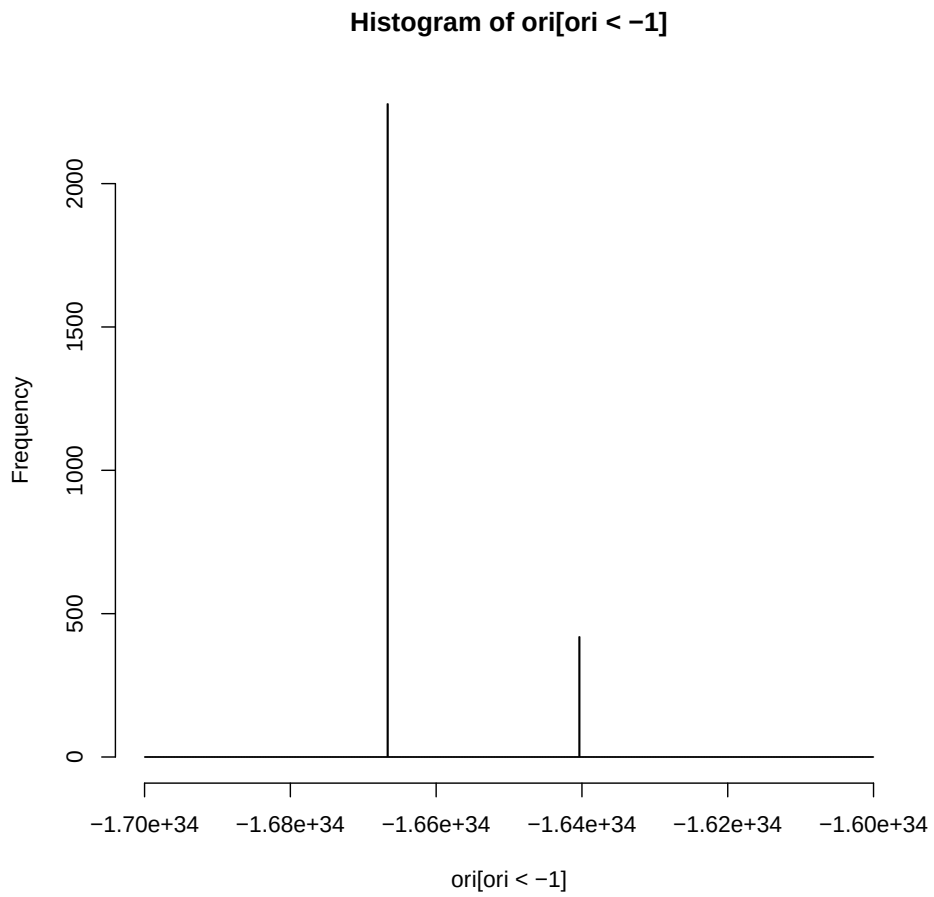

Figure 18: Histogram of the Aristarchus mosaic lower resolution ORI data, only negative values.

```
## class      : RasterLayer
## dimensions : 42028, 44148, 1855452144  (nrow, ncol, ncell)
## resolution : 1, 1  (x, y)
## extent     : -1456580, -1412432, 699238, 741266  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-mosaic-prod
## names      : UCL.Aristarchus.DTM.JPL.AOI
```

```
ori=raster('../dat/mosaic/UCL-Aristarchus-ORI-JPL-AOI..tif')
ori
```

```
## class      : RasterLayer
## dimensions : 84057, 88297, 7421980929  (nrow, ncol, ncell)
## resolution : 0.5, 0.5  (x, y)
## extent     : -1456580, -1412432, 699237.5, 741266  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-mosaic-prod
## names      : UCL.Aristarchus.ORI.JPL.AOI.
```

These are the statistical summaries of the DTM and ORI data:

```
summary(dtm)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.01% of all cells)
```

```
##         UCL.Aristarchus.DTM.JPL.AOI
## Min.                  -3.314143e+03
## 1st Qu.               -2.899296e+03
## Median                -1.693351e+03
## 3rd Qu.               -7.747059e+02
## Max.                   4.007527e+02
## NA's                   4.104446e+08
```

```
summary(ori)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0% of all cells)
```

```
##         UCL.Aristarchus.ORI.JPL.AOI.
## Min.                   -1.666661e+34
## 1st Qu.                 4.501600e-02
## Median                  6.788058e-02
## 3rd Qu.                 1.052764e-01
## Max.                    4.042948e-01
## NA's                    1.641742e+09
```

The statistics look similar to those of the lower resolution files, with some odd values for the ORI data.

We skip the conversion to data frames for the large files to save computation resources.

So we make the plots now. The one of the DTM image is shown in Fig. 19, a plot of the ORI image in Fig. 20. Like for the lower resolution ORI data, the higher resolution ORI data (Fig. 20) contains some data points with extreme negative magnitude which spoil the contrast. A plot of the ORI data with manually adjusted stretch is shown in Fig. 21. The higher resolution ORI data is corrupted similarly to the lower resolution data.

We also make the histograms. The one of the DTM data is shown in Fig. 22 and the one for the ORI data is shown in Fig. 23 The ORI histogram (Fig. 23) confirms the presence of extreme outliers, similarly to the lower resolution data.

5.4 Conclusions

- We can confirm the integrity of the two DTM files.
- For the two ORI files, I was first thinking they are corrupted as they look so patchy, but this is OK. These are *mosaics* of different images, taken by different instruments under different conditions, and no effort was made wo blend them seemlessly into each other. They were just used as they are for DTM estiation. However, there is a problem with these files: they contain (a few) extreme outliers with pixel values $\approx -1.65 \cdot 10^{34}$.
- The filename of the higher resolution DTM file contains a spurious extra dot.

  JPM: ACTION ESA#3 : remove spurious ”.”

  BG: Done.
- The lower resolution files have a tag ‘`10m`’ in the file name, while the higher resolution files have no such tag. The resolution of the DTM and the ORI is 1 m and 0.5 m, respectively. I would suggest to put the tag ‘`1m`’ and ‘`50cm`’ into the lower resolution file names.

  JPM: Agreed ACTION ESA#4 : add resolution into the filename

  BG: Done.
- For the higher resolution files, the corners of DTM and ORI do not match, but according to Jan-Peter, this is a “feature”.

```
plot(dtm)
```

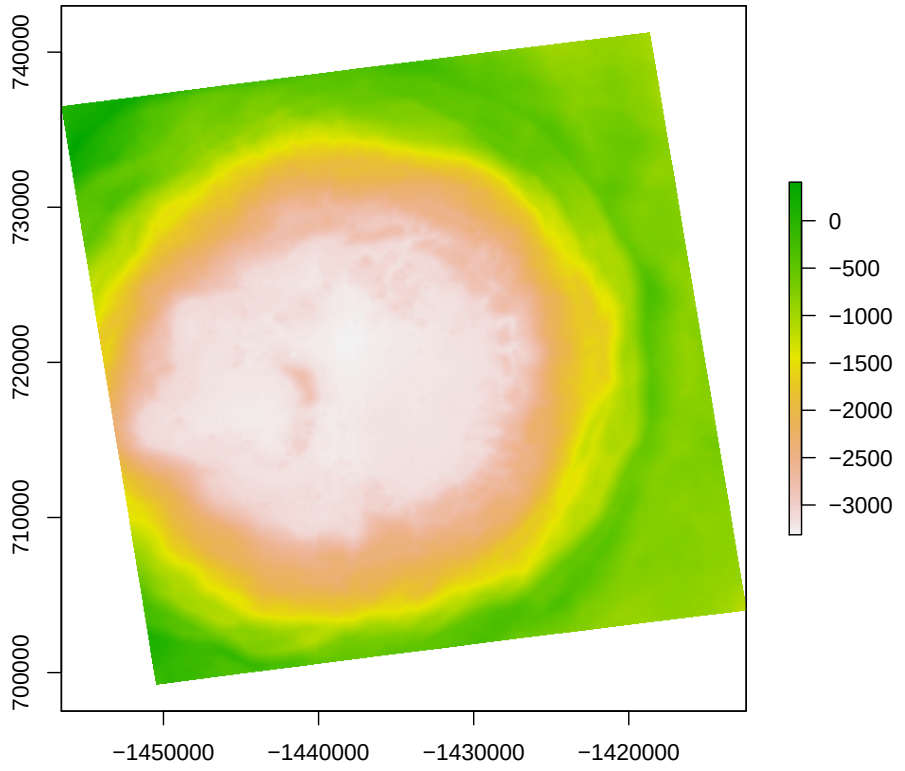

Figure 19: Plot of the Aristarchus mosaic higher resolution DTM data.

```
plot(ori)
```

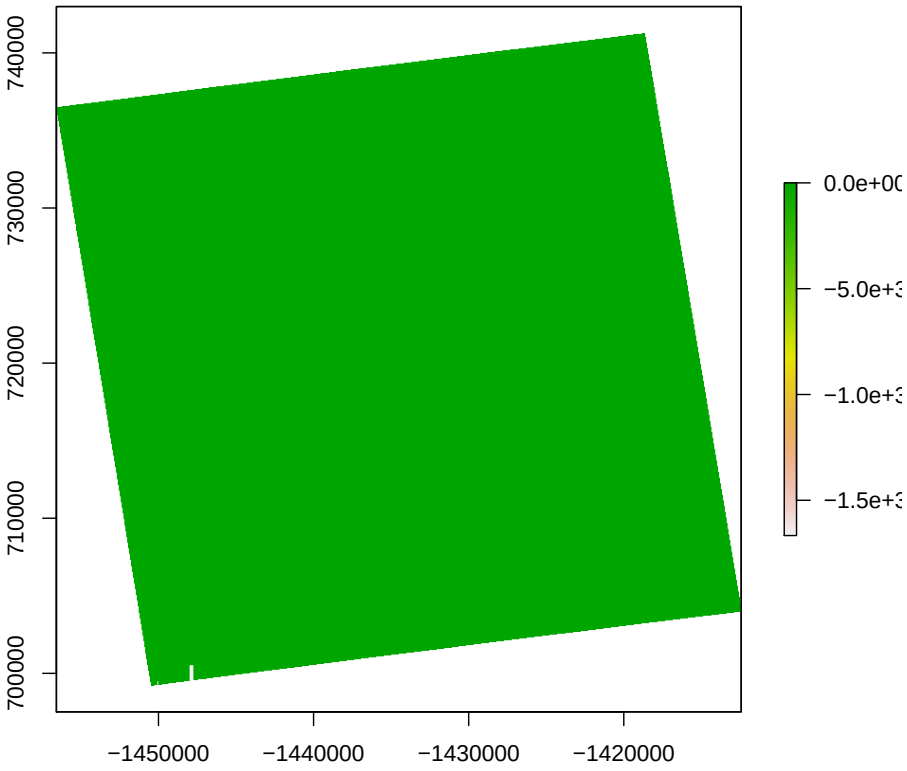

Figure 20: Plot of the Aristarchus mosaic higher resolution ORI data with automatic stretch.

```
zmin = 0
zmax = 0.4
plot( ori, zlim = c( zmin, zmax ) )
```

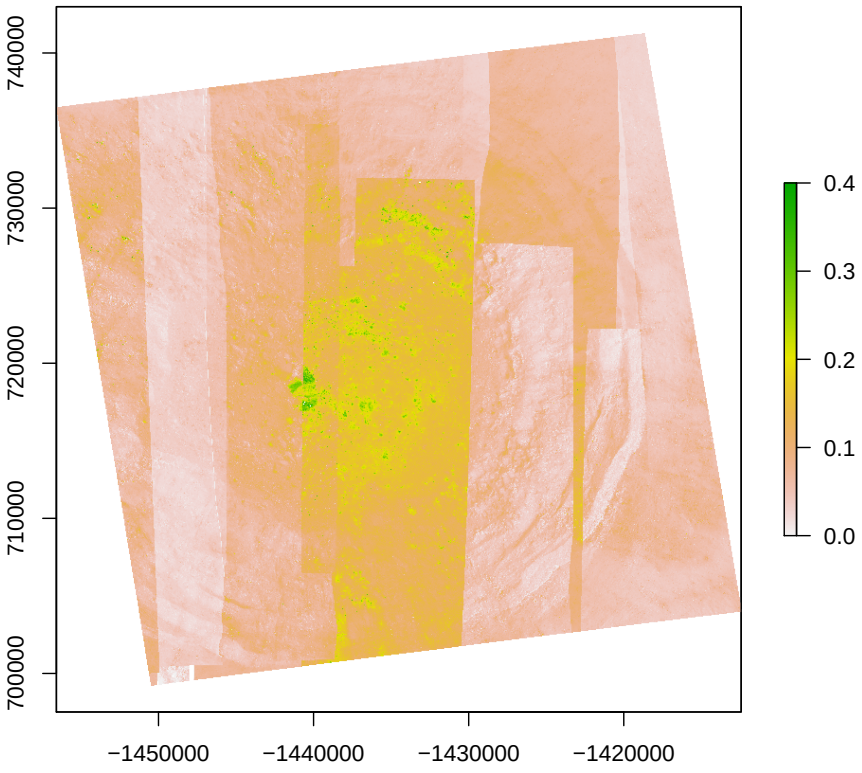

Figure 21: Plot of the Aristarchus mosaic higher resolution ORI data with minimum and maximum value set to 0 and 0.4, respectively.

```
hist(dtm)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  0% of the raster cells were used.  100000
values used.
```

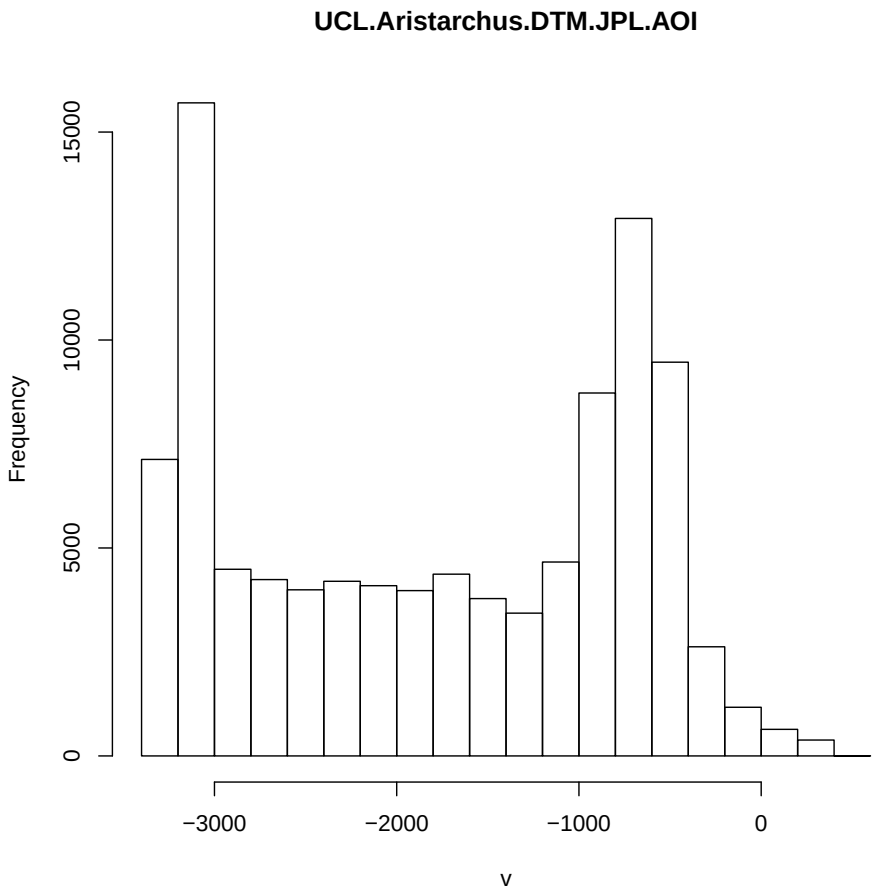

Figure 22: Histogram of the Aristarchus mosaic higher resolution DTM data.

```
hist(ori)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  0% of the raster cells were used.  100000
values used.
```

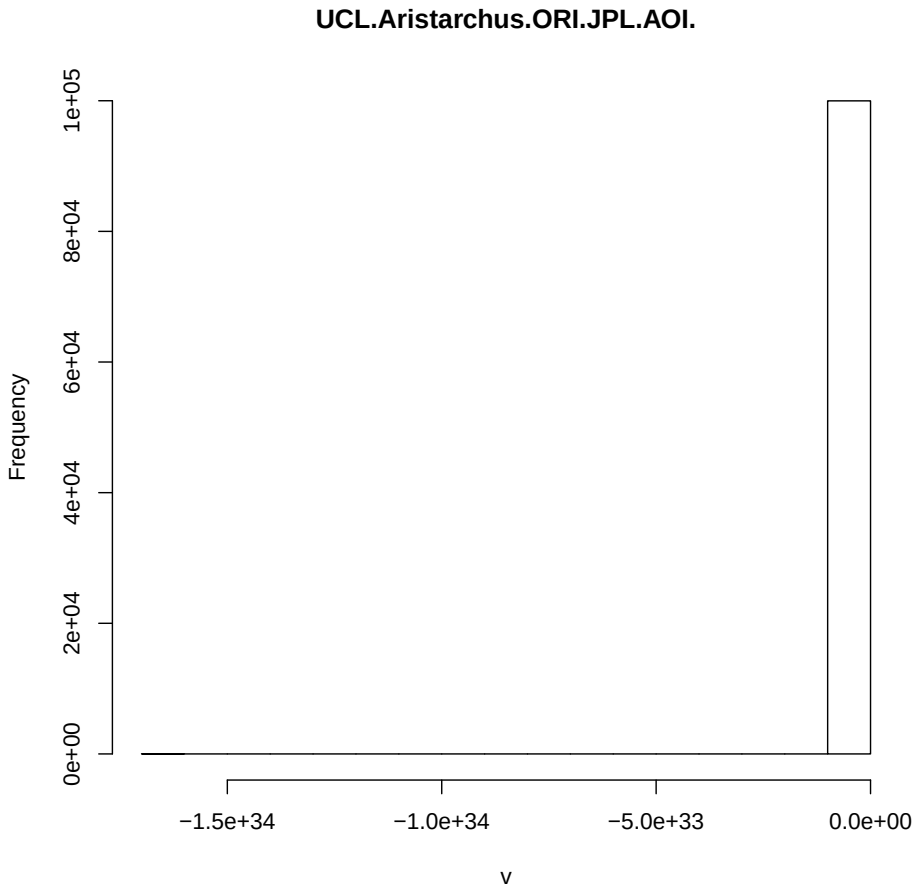

Figure 23: Histogram of the Aristarchus mosaic higher resolution ORI data.

6 'Crater-Aristarchus-strip-products'

6.1 Dataset content

Downloading big datasets from Google Drive is really a pain. In principal, the content of a folder selected to download is zipped, however, if the zip file would get large, it is splitted into several zip files. Moreover, individual large files are not zipped but downloaded as is and just put in the working directory, not where they belong in the directory tree. So restoring the original file tree requires a lot of manual work. In addition, many of the some 20 individual downloads crash without completion, therefore the downloaded dataset is just a subset of the original dataset. For the final delivery of the dataset, other means than fetching from Google Drive have to be employed. I suggest to deliver the strip folder to the GSF FTP.

Note that the naming convention given in the PUG gives '`*-DTM_UCL.tif`', '`*-ORI_UCL.tif`', and '`-Meta.txt`'.

This is what we locally have available in the base directory:

```
system2( 'ls', args = c( '-ohH', '../dat/strip' ), stdout = TRUE )
```

```
##  [1] "total 4.4G"
##  [2] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 08:39 M1106216804LE-M1106238239LE"
##  [3] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 08:40 M1106216804RE-M1106238239RE"
##  [4] "drwxrwxrwx 1 bgrieger    0 Jan 26 08:18 M1106238239LE-M1241627890LE"
##  [5] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 08:27 M1129787722LE-M1129801944LE"
##  [6] "drwxrwxrwx 1 bgrieger    0 Jan 26 08:18 M1129787722RE-M1129801944RE"
##  [7] "drwxrwxrwx 1 bgrieger    0 Jan 26 08:18 M1129794833LE-M1254550518RE"
##  [8] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 08:29 M1129794833RE-M1129801944RE"
##  [9] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 08:44 M1129801944RE-M1129787722RE"
## [10] "-rwxrwxrwx 1 bgrieger  764 Nov  3 07:31 M1147467461RE-ORI-UCL-Meta.txt"
## [11] "-rwxrwxrwx 1 bgrieger 3.4G Jan 19 15:23 M1147467461RE-ORI-UCL.tif"
## [12] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 17:30 M1191003838LE-M1191017895LE"
## [13] "drwxrwxrwx 1 bgrieger    0 Jan 26 08:31 M1191003838RE-M1191010858LE"
## [14] "drwxrwxrwx 1 bgrieger 4.0K Feb  2 07:42 M1191017895RE-M1191003838RE"
## [15] "-rwxrwxrwx 1 bgrieger  764 Nov  3 07:20 M1267502401RE-ORI-UCL-Meta.txt"
## [16] "-rwxrwxrwx 1 bgrieger  763 Nov  3 07:33 M157906985LE-ORI-UCL-Meta.txt"
## [17] "-rwxrwxrwx 1 bgrieger 1.1G Oct 27 05:25 M157906985LE-ORI-UCL.tif"
## [18] "-rwxrwxrwx 1 bgrieger  763 Nov  3 07:21 M157906985RE-ORI-UCL-Meta.txt"
## [19] "drwxrwxrwx 1 bgrieger 4.0K Jan 26 08:25 M160261901LE-M1305118300RE"
## [20] "drwxrwxrwx 1 bgrieger    0 Jan 26 08:18 M186198825LE-M1114483609LE"
## [21] "-rwxrwxrwx 1 bgrieger  763 Nov  3 07:33 M186198825RE-ORI-UCL-Meta.txt"
## [22] "-rwxrwxrwx 1 bgrieger  763 Nov  3 07:07 M188543434RE-ORI-UCL-Meta.txt"
## [23] "-rwxrwxrwx 1 bgrieger  763 Nov  3 07:32 M188557729LE-ORI-UCL-Meta.txt"
```

We have 13 subdirectories while in the original dataset on Goolge Drive there are 14 subdirectories. Besides the subdirecgtories, we have seven '`txt`' files and one '`tif`' file, while on Google Drive there are seven of each.

In each subdirectory on Google Drive, there are supposedly three files, a

'-DTM-UCL.tif', an '-ORI-UCL.tif', and a '-Meta.txt'. There are deviations from this in the following directories:

'M160261901LE-M1305118300RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M190916653RE-M190909505RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'
- two versions of '-ORI-UCL.tif'
- missing '-Meta.txt'

'M1106216804LE-M1106238239LE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1106216804RE-M1106238239RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'
- two versions of '-ORI-UCL.tif'

'M1106238239LE-M1241627890LE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1129787722LE-M1129801944LE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'
- two versions of '-ORI-UCL.tif' (now older version deleted)
- file names start with 'Copy of '

'M1129787722RE-M1129801944RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1129794833LE-M1254550518RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1129794833RE-M1129801944RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1129801944RE-M1129787722RE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1191003838LE-M1191017895LE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'
- two versions of '-ORI-UCL.tif' (now older version deleted)

'M1191003838RE-M1191010858LE'

- '-DTM_UCL.tif' instead of '-DTM-UCL.tif'

'M1191017895RE-M1191003838RE'

- file names start with 'Copy of '
- There is an empty subfolder 'M1191017895RE-M1191003838RE.pvl'

So, in total in these subdirectories there are 14 DTM files, 18 ORI files (four second versions), and 13 meta files (one missing). Successfully downloaded are 9 DTMs, 5 ORIs, and 13 Metas. Peter wrote that the 'v2' versions should replace the older version and that he has deleted two older version (noted above) but two more are still present.

The seven bare ORIs and Metas in the base directory seem not to be mentioned in the PUG, however, I have locally only one ORI, so I will just check this one. Peter wrote that these files should be included in the dataset and that they are discussed in the paper.

6.2 Meta information

We look first at some '-Meta.txt' files. This is a bare one in the base directory (the one to which we also have the successfully downloaded ORI):

```
Object = ORI
  Object = ProductInfo
    Object = Processing
      SoftwareName = ASP
      SoftwareVersion = 2.7
      OperatingSystem = N/A
      ProcessingStartTime = 2020-03-28T22:42
      ProcessingEndTime = 2020-04-04T08:40
      ProducerInstitutionName = "University College London"
      ProcessingOrganisation = "UCL/MSSL"
      ContactPerson = "Alfiah Rizky Diana Putri and Jan-Peter Muller"
      ContactEmail = "alfiah.putri.15{at}ucl.ac.uk and j.muller{at}ucl.ac.uk"
    End_Object

    Object = Data
      ID = M157906985LE
      Format = GeoTiff
      Band = 1
      BitDepth = 32f
```

```
      ORIResolution = 0.5
      Unit = Metre
      NodataValue = -3.4028234663852886e+38
      Projection = Equirectangular
    End_Object
  End_Object
End_Object
End
```

I would like to inspect also a version 2 ORI file. None was successfully downloaded. This is probably related to the fact that they are larger. In subdirectories where these files are missing, something else is also always missing. I have downloaded

```
M1191003838LE-M1191017895LE-DTM_UCL.tif
```

which is about 2 GB into the directory 'M1191003838LE-M1191017895LE', and also

```
M1191003838LE-M1191017895LE-ORI-UCL-v2.tif
```

which is about 7 GB.

This is the meta file in this directory:

```
Object = AutoDTM
  Object = ProductInfo
    Object = Processing
      SoftwareName = CASP-GO
      SoftwareVersion = 2.1
      OperatingSystem = N/A
      ProcessingStartTime = 2020-04-04T12:52
      ProcessingEndTime = 2020-04-07T23:02
      ProducerInstitutionName = "University College London"
      ProcessingOrganisation = "UCL/MSSL"
      ContactPerson = "Alfiah Rizky Diana Putri and Jan-Peter Muller"
      ContactEmail = "alfiah.putri.15{at}ucl.ac.uk and j.muller{at}ucl.ac.uk"
    End_Object

    Object = Data
      ID = M1191003838LE-M1191017895LE
      Format = GeoTiff
      Band = 1
      BitDepth = 32f
      DTMResolution = 1
      ORIResolution = 0.5
      Unit = Metre
      NodataValue = -3.4028234663852886e+38
```

```
    Projection = Equirectangular
  End_Object
End_Object

Object = Algorithm
  Group = ASP
    Name = "Ames Stereo Pipeline Function Parameters"
    InitialCorrKernel = N/A
    RefinementCorrKernel = N/A
    RefinementIteration = N/A
  End_Group

  Group = sGotcha
    Name = "Adaptive Least Squares Correlation and Region growing Parameters"
    ALSCIteration = 8
    MaxEigenValue = 150
    ALSCKernel = 30
    GrowNeighbour = 8
  End_Group

  Group = ML
    Name = "Fast Maximum Likelihood Matching Parameters"
    MLKernel = 25
    MLIter = 3
  End_Group

  Group = ORS
    Name = "Outlier Rejection Schemes Parameters"
    MaxDiff = 1.5
    PercentDiff = 60
    DiffKernel = 21
    PatchThreshold = 7.5
    PercentReject = 25
    Erode = 0
  End_Group

  Group = coKriging
    Name = "Co-Kriging Interpolation Parameters"
    NeighbourLimit = 21
    DistLimit = 500
    SpatialResRatio = 1
  End_Group

  Group = MSA-SIFT
    Name = "Mutual Shape Adapted Scale Invariant Feature Transform Co-registion Parameters"
    nOctave = 8
    EdgeThreshold = 10
    MatchCoeff = 0.6
    nLayer = 3
  End_Group
End_Object
End_Object
End
```

This looks much more exhaustive than the bare meta file in the base directory.

This is the meta information in the bare bone ORI file:

```
GDALinfo('../dat/strip/M1147467461RE-ORI-UCL.tif')
```

```
## Warning in GDALinfo("../dat/strip/M1147467461RE-ORI-UCL.tif"):  statistics not supported
by this driver
```

```
## rows        62983
## columns     16746
## bands       1
## lower left origin.x        -1429229
## lower left origin.y        692388.2
## res.x       0.5
## res.y       0.5
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/strip/M1147467461RE-ORI-UCL.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38        256        256
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
## BUNDLE_ADJUST_PREFIX=ba
## CAMERA_MODEL_TYPE=isis
## DEM_FILE=/data1/imaging/lunar/align/arismerge1mnew2.tif
```

This is the meta information in the DTM file:

```
GDALinfo('../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-DTM_UCL.tif')
```

```
## Warning in GDALinfo("../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-DTM_UCL.tif"):
statistics not supported by this driver
```

```
## rows        57128
## columns     8342
## bands       1
## lower left origin.x        4031034
## lower left origin.y        702218.6
## res.x       1
## res.y       1
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=180 +x_0=0 +y_0=0 +a=1737400
```

```
## +b=1737400 +units=m +no_defs
## file        ../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-DTM_UCL.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1       8342
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
```

And this is the meta information in the ORI file:

```
GDALinfo('../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL.tif')
```

```
## Warning in GDALinfo("../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL.tif"):
statistics not supported by this driver
```

```
## rows        114254
## columns     16684
## bands       1
## lower left origin.x        4031034
## lower left origin.y        702219.2
## res.x       0.5
## res.y       0.5
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=180 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38        256        256
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
## BUNDLE_ADJUST_PREFIX=ba
## CAMERA_MODEL_TYPE=isis
## DEM_FILE=/unsafe/arp2/M1191003838LE-M1191017895LE-final-DEM-shift.tif
```

Like we have seen before, not all corners are exactly aligned between DTM and ORI.

This is the meta information in version 2 of the ORI file:

```
GDALinfo('../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL-v2.tif')
```

```
## Warning in GDALinfo("../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL-v2.tif"):
statistics not supported by this driver
```

```
## rows        114254
## columns     16685
## bands       1
## lower left origin.x        -1427169
## lower left origin.y        702218.7
## res.x       0.5
## res.y       0.5
## ysign       -1
## oblique.x   0
## oblique.y   0
## driver      GTiff
## projection  +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400
## +b=1737400 +units=m +no_defs
## file        ../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL-v2.tif
## apparent band summary:
##    GDType hasNoDataValue   NoDataValue blockSize1 blockSize2
## 1 Float32           TRUE -3.402823e+38          1      16685
## apparent band statistics:
##          Bmin       Bmax Bmean Bsd
## 1 -4294967295 4294967295    NA  NA
## Metadata:
## AREA_OR_POINT=Area
```

While version two has a much larger file size (7.6 GB instead of 2.9 GB), the resoloution is exactly the same. The origin is very different in x and slightly different in y. The projection is defined with `+lon_0=0` instead of `+lon_0=180` and the values for `blockSize1` and `blockSize2` are different.

6.3 Image data

We first load the image content of the bare bone ORI file:

```
ori1=raster('../dat/strip/M1147467461RE-ORI-UCL.tif')
ori1
```

```
## class      : RasterLayer
## dimensions : 62983, 16746, 1054713318  (nrow, ncol, ncell)
## resolution : 0.5, 0.5  (x, y)
## extent     : -1429229, -1420856, 692388.2, 723879.8  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-strip-produ
## names      : M1147467461RE.ORI.UCL
```

Now we load the actual image content of the DTM and the two ORI files:

```
dtm=raster('../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-DTM_UCL.tif')
dtm
```

```
## class      : RasterLayer
## dimensions : 57128, 8342, 476561776  (nrow, ncol, ncell)
## resolution : 1, 1  (x, y)
```

```
## extent     : 4031034, 4039376, 702218.6, 759346.6  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=180 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-strip-produ
## names      : M1191003838LE.M1191017895LE.DTM_UCL


ori=raster('../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL.tif')
ori


## class      : RasterLayer
## dimensions : 114254, 16684, 1906213736  (nrow, ncol, ncell)
## resolution : 0.5, 0.5  (x, y)
## extent     : 4031034, 4039376, 702219.2, 759346.2  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=180 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-strip-produ
## names      : M1191003838LE.M1191017895LE.ORI.UCL


ori2=raster('../dat/strip/M1191003838LE-M1191017895LE/M1191003838LE-M1191017895LE-ORI-UCL-v2.tif')
ori2


## class      : RasterLayer
## dimensions : 114254, 16685, 1906327990  (nrow, ncol, ncell)
## resolution : 0.5, 0.5  (x, y)
## extent     : -1427169, -1418827, 702218.7, 759345.7  (xmin, xmax, ymin, ymax)
## crs        : +proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0 +a=1737400 +b=1737400 +units=m +no_defs
## source     : /media/bgrieger/Seagate Portable Drive/Crater-Aristarchus-products/Crater-Aristarchus-strip-produ
## names      : M1191003838LE.M1191017895LE.ORI.UCL.v2
```

They seem to load well.

These are the statistical summaries of the four DTM and ORI files:

```
summary(ori1)


## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.01% of all cells)


##         M1147467461RE.ORI.UCL
## Min.             1.815576e-02
## 1st Qu.          8.974634e-02
## Median           1.124424e-01
## 3rd Qu.          1.392811e-01
## Max.             3.188095e-01
## NA's             1.821701e+08


summary(dtm)


## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.02% of all cells)


##         M1191003838LE.M1191017895LE.DTM_UCL
```

```
## Min.                          -2.400012e+03
## 1st Qu.                       -1.236911e+03
## Median                        -1.077261e+03
## 3rd Qu.                       -8.059728e+02
## Max.                          -1.358885e+02
## NA's                           1.595386e+08
```

```
summary(ori)
```

```
## Error in rgdal::getRasterData(con, offset = offs, region.dim = c(1, nc), :  Failure
during raster IO
```

```
summary(ori2)
```

```
## Warning in .local(object, ...):  summary is an estimate based on a sample of 1e+05
cells (0.01% of all cells)
```

```
##         M1191003838LE.M1191017895LE.ORI.UCL.v2
## Min.                                8.928000e-04
## 1st Qu.                             1.964160e-02
## Median                              2.589120e-02
## 3rd Qu.                             4.196160e-02
## Max.                                1.348128e-01
## NA's                                4.599398e+08
```

Looks like `summary(ori) does not work.`

Now we make the plots. First the bare bone ORI file, shown in Fig. 24.

The one of the DTM image is shown in Fig. 25. This looks OK.

For the ORI file for which the `summary` did not work, plotting does also not work.

Finally, we try the version 2 of the ORI file, shown in Fig. 26. This looks in principle OK, but the coverage does not match the DTM file. Peter had said that it is a "feature" of their software that DTM and ORI does not match exactly, but here the coverage of the ORI is significantly larger. I suppose that the DTM strip has been computed from a pair of iamges, so its coverage is the intersection of the two images. Then the ORI for the images has been computed using the full mosaic, thus its coverage is the union of the two images. This should be discussed in the PUG.

We also try to make the histograms. The one of the DTM data is shown in Fig. 27. For the ORI it does also not work, like the plot. The version 2 of it is shown in Fig. 28.

I tried to write the ORI file for which all this did not work into a data frame.

```
plot(ori1)
```

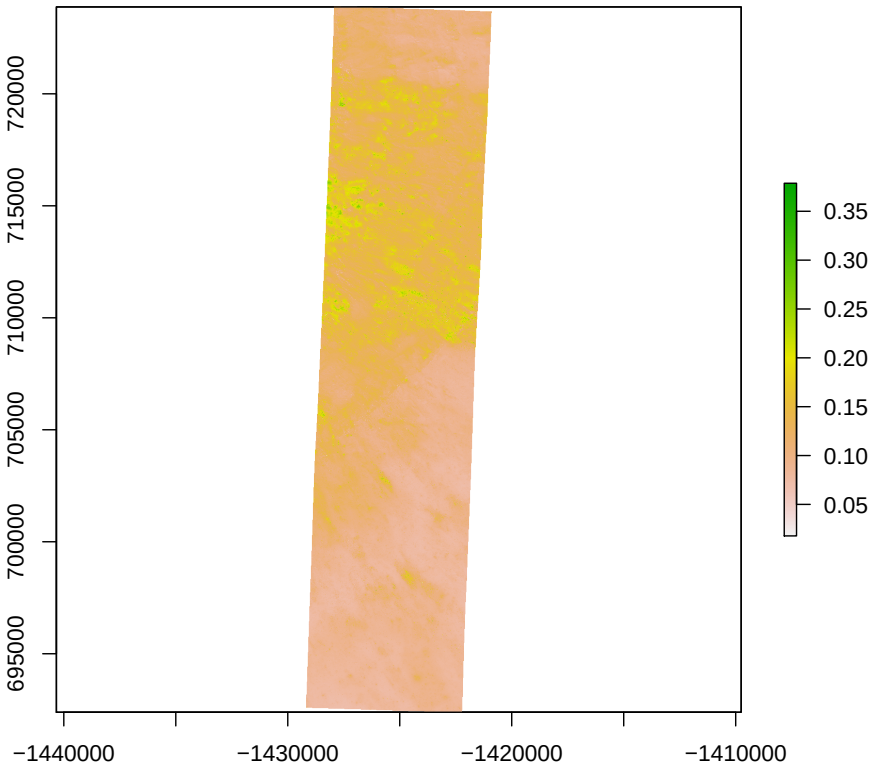

Figure 24: Plot of an example Aristarchus strip bare bone ORI file (without related DTM).

```
plot(dtm)
```

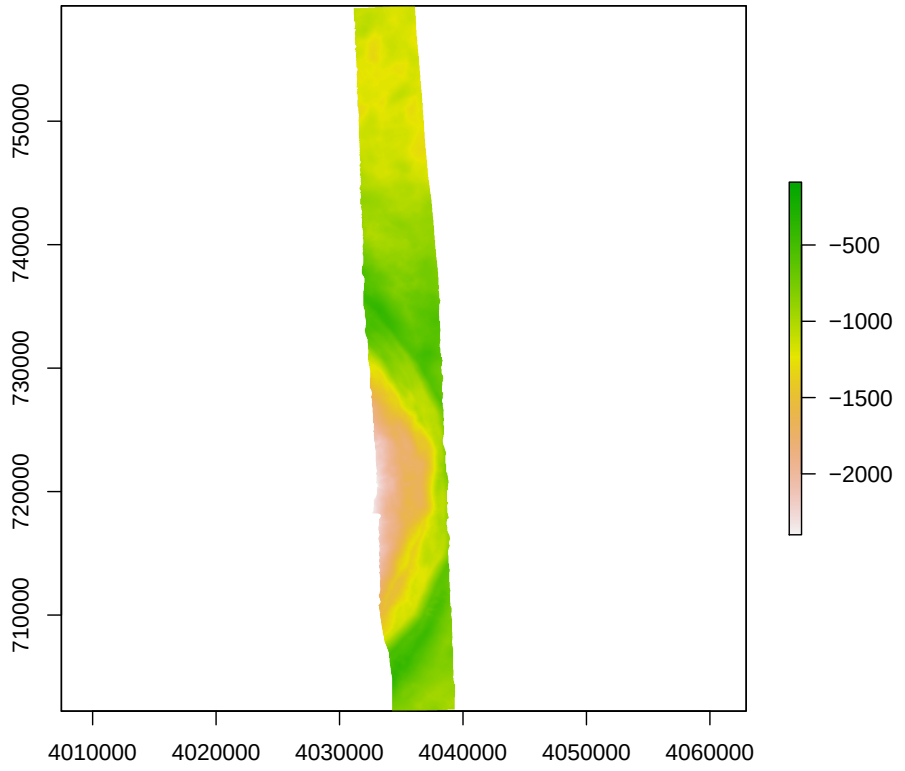

Figure 25: Plot of an example Aristarchus strip DTM file.

```
plot(ori2)
```

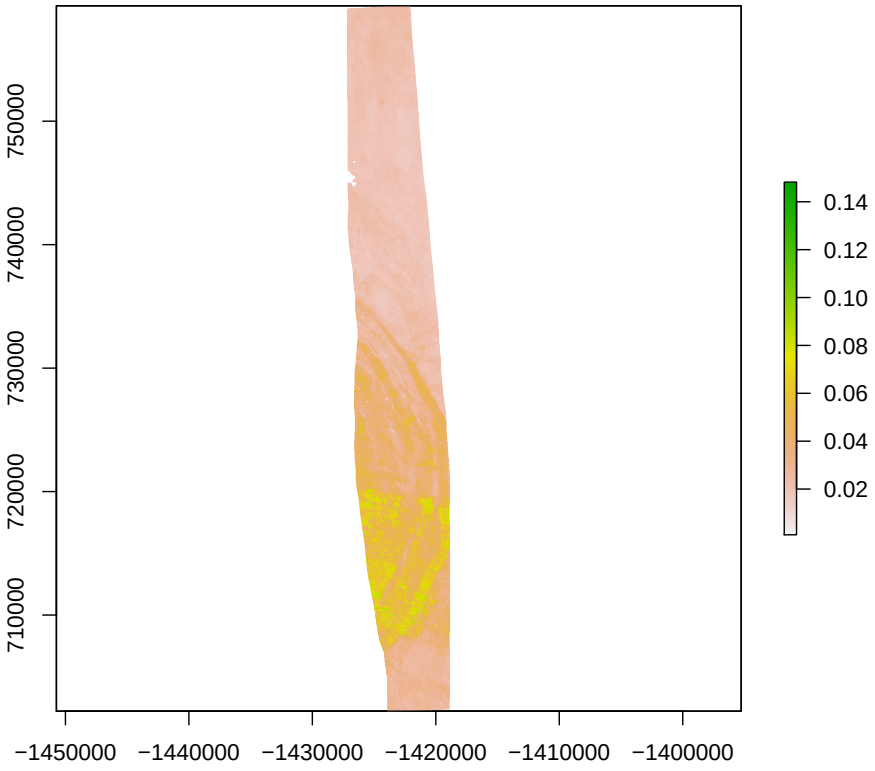

Figure 26: Plot of an example Aristarchus strip version 2 ORI file.

```
hist(dtm)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  0% of the raster cells were used.  100000
values used.
```

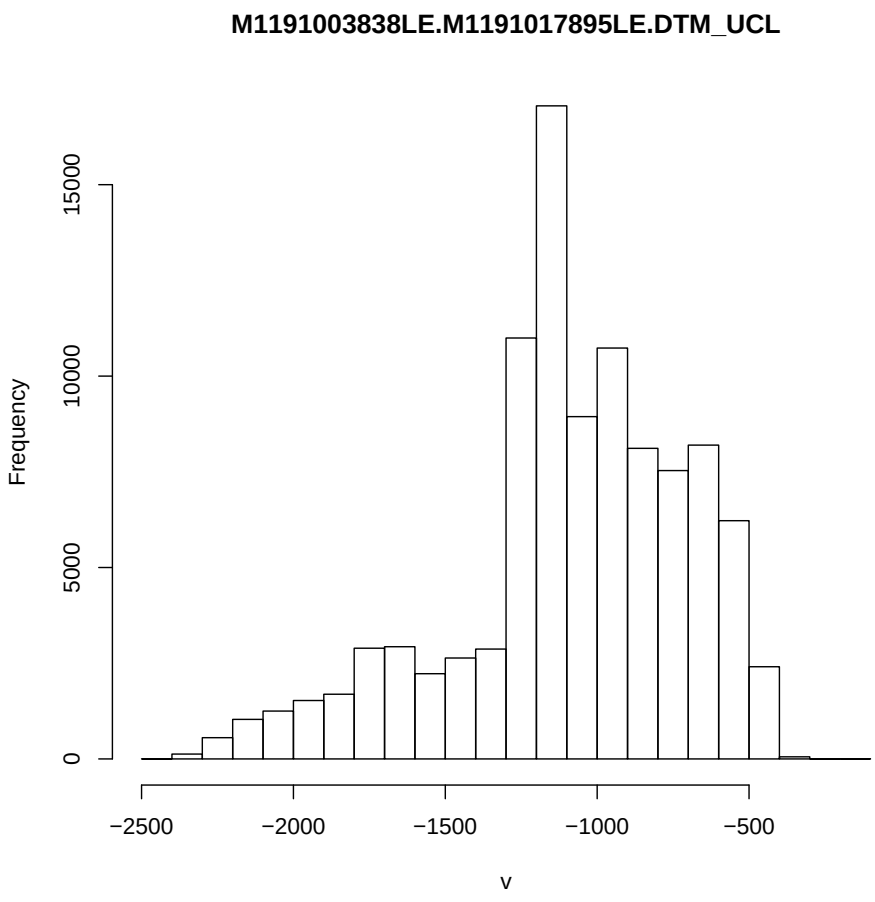

Figure 27: Histogram of example Aristarchus strip DTM data.

```
hist(ori2)

## Warning in .hist1(x, maxpixels = maxpixels, main = main,
plot = plot, ...):  0% of the raster cells were used.  100000
values used.
```

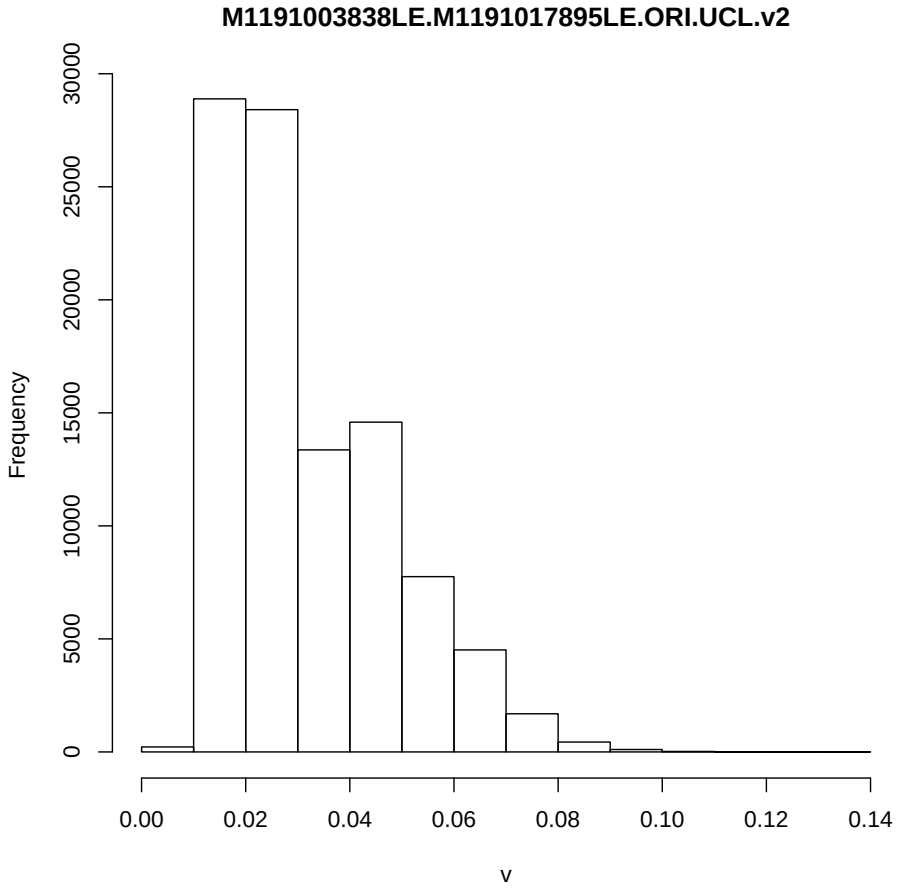

Figure 28: Histogram of example Aristarchus strip version 2 ORI data.

This did also not work.

I have downloaded the file a second time and compared it with the one I had used; they don't `diff`. I had noticed before that the resolution is the same as for the much larger '`v2`' version. Probably the file is incomplete (on the server, the size there matches my local file).

Peter wrote that the '`v2`' versions are the ones to be used (and maybe renamed). Therefore it does not matter that the old version is broken.

6.4 Checking georeferencing information

We take the ORI shown in Fig. 26 and try to plot it with longitude and latitude coordinates in equidistant cylindrical projection. So we reproject it:

```
ori2eqc = projectRaster(ori2 ,
                        crs='+proj=longlat +lat_0=0 +lon_0=0 +R=257500',
                        method='bilinear' )
ori2eqc


## class      : RasterLayer
## dimensions : 114187, 16684, 1905095908  (nrow, ncol, ncell)
## resolution : 1.65e-05, 1.65e-05  (x, y)
## extent     : -47.06511, -46.78983, 23.15761, 25.0417  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +lat_0=0 +lon_0=0 +R=257500
## source     : /tmp/RtmpK4YUIn/raster/r_tmp_2021-02-16_103413_32436_34907.grd
## names      : M1191003838LE.M1191017895LE.ORI.UCL.v2
## values     : 0.0008928, 0.1994173  (min, max)


crs( ori2eqc )


## CRS arguments:
##  +proj=longlat +lat_0=0 +lon_0=0 +R=257500
```

The result is shown in Fig. 29.

Wikipedia gives the crater center coordinates as 23.7°N 47.4°W. This seems pretty much to match.

6.5 Conclusions

- '`Meta.txt`' file is missing for

  `M190916653RE-M190909505RE`

```
plot( ori2eqc )
```

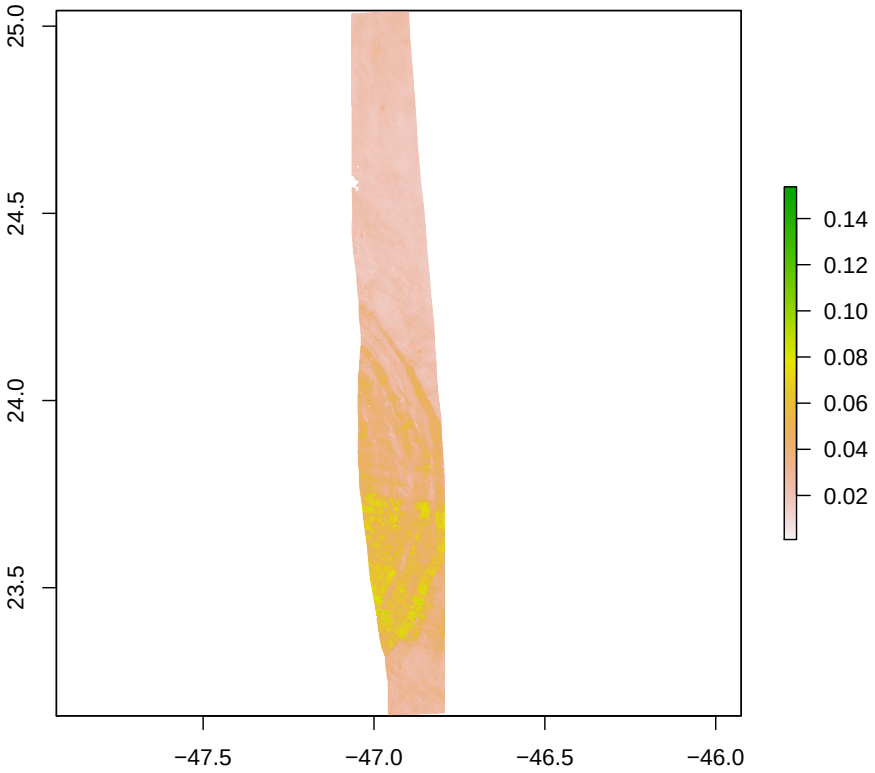

Figure 29: Plot of the reprojected ORI from Fig. 26 with longitude and latitude coordinates.

JPM: ACTION KP#3: provide missing metadata file or explanation

- The orphan files in the base folder should go in a new parent folder of their own, maybe named

  `Supplementary-strip-ORIs`

  BG: Created a new folder

  `Supplementary-strip-ORIs`

  in the directory

  `Crater-Aristarchus-strip-products`

  and moved all files in the latter into the former.

- Where version '`v2`' files are present, they have to be ranamed to replace the older version (without '`v2`').

  JPM: ACTION ESA#5 : remove v2 in the filenames

  BG: Moved the non-'`v2`' versions to '`REMOVED_BY_BG`' and removed the '`v2`' tag from the file name for the following files:

  - '`M190916653RE-M190909505RE-ORI-UCL.tif`'
  - '`M1106216804RE-M1106238239RE-ORI-UCL.tif`'

- All should consistently be renamed to

  - '`*-DTM_UCL.tif`'
  - '`*-ORI_UCL.tif`'
  - '`*-Meta.txt`'

  Currently, hyphens '`-`' are randomly interchanged with underscores '`_`'. Note also that some file names start with '`Copy of`'.

  JPM: ACTION ESA#6 : make the filenames consistent and remove "Copy of" which is an artefact of gdrive copying.

  BG: Renamed files to the following names:

  - '`M160261901LE-M1305118300RE-ORI_UCL.tif`'
  - '`M186198825LE-M1114483609LE-DTM_UCL.tif`'
  - '`M186198825LE-M1114483609LE-ORI_UCL.tif`'
  - '`M190916653RE-M190909505RE-ORI_UCL.tif`'
  - '`M1106216804LE-M1106238239LE-ORI_UCL.tif`'
  - '`M1106216804RE-M1106238239RE-ORI_UCL.tif`'
  - '`M1106238239LE-M1241627890LE-ORI_UCL.tif`'
  - '`M1129787722LE-M1129801944LE-DTM_UCL.tif`'

- 'M1129787722LE-M1129801944LE-Meta.txt'
- 'M1129787722LE-M1129801944LE-ORI_UCL.tif' (also removed 'v2' from the file name)
- 'M1129787722RE-M1129801944RE-ORI_UCL.tif'
- 'M1129794833LE-M1254550518RE-ORI_UCL.tif'
- 'M1129794833RE-M1129801944RE-ORI_UCL.tif'
- 'M1129801944RE-M1129787722RE-ORI_UCL.tif'
- 'M1191003838LE-M1191017895LE-ORI_UCL.tif' (also removed 'v2' from the file name)
- 'M1191003838RE-M1191010858LE-ORI_UCL.tif'
- 'M1191017895RE-M1191003838RE-DTM_UCL.tif'
- 'M1191017895RE-M1191003838RE-Meta.txt'
- 'M1191017895RE-M1191003838RE-ORI_UCL.tif'

Also removed empty folder

M1191017895RE-M1191003838RE.pvl.

I did not rename the files which are now in the folder

Supplementary-strip-ORIs.

Their naming scheme differs anyway from the other files and at least they are consistent among themselves.

> Working in a GUI is like a behavioral test for monkeys. Working on the command line is like magic.

7 Summary

7.1 Cerberus dataset

7.1.1 CTX

- There are two spurious files with '.aux.xml' extension that should be removed.

  JPM: ACTION ESA#1: remove spurious files

  BG: Created a new folder 'REMOVED_BY_BG' in 'For-ESA-GSF' and moved the '.aux.xml' files into there.

- The file names are looooong. All file names contain

  _coregistered_aligned_cropped

This might have been helpful where the images were created to distiguish between different version, but in the published dataset, where only one version resides, it seemed to be unnecessary clutter. So, I was first thinking that this part should be removed from the file names. However, the PUG stated and explains this part of the file names. It reads like different files without this extra part in the name are available elsewhere. If this is really the case, we should probably keep the extra part.

JPM: Yes, this is true that it was the case as it was a lot of effort to ensure that all the CTX images were co-registered to overlapping HRSC, where available (co-registered) and co-aligned in height with MOLA and cropped as far as that was feasible to remove any rubbish that might have crept into the processing. How about shortening this to an extension of "_crac" and I modify the "PUG" ACTION UCL#1: modify the PUG

BG: Renamed the two '`.tif`' files accordingly.

7.1.2 HiRISE

- The file names are looooong (same as for the CTX, same remark applies).

  JPM: Same solution except that CTX_crac is usually used as the height reference

  BG: Renamed the two '`.tif`' files similarlarly.

7.1.3 HRSC

- There are two spurious files with '`.aux.xml`' extension like for CTX that should be removed.

  JPM: ACTION ESA#2 : remove spurious files

  BG: Moved the '`.aux.xml`' into '`REMOVED_BY_BG`'.

- A text file with meta information like for CTX and HiRISE is missing.

  JPM: This is because the HRSC is a copy of the file that is already in the ESA-PSA site.

- The file names are a bit long (albeit not as long as for CTX and HiRISE). All file names contain

  `_cropped`

Same remark as for CTX aplies, however, like for CTX and HiRISE, the PUG may explain and justify these file names (which it currently does not).

JPM: Yes, we cropped out of a full strip just the piece covering the crater. Best if this stays as is.

7.2 Aristarchus dataset

7.2.1 Mosaic folder

Could you solve the issue with the extreme outliers in the two ORI files? In fact, I am not so much concerned about the few outliers but more about the fact that the histogram you sent me looks completely different from mine, even if we just look at regular values. Do you have an idea what's going on?

JPM: I think you mean the NULL DATA flag. However, I hope that Kiky can explain this

- ACTION KP#1: provide explanation for these outliers in the ORI datasets

I suspect this was because we set the limits to ignore these in QGIS

- ACTION KP#2: provide explanation for why histogram plots are different

- The filename of the higher resolution DTM file contains a spurious extra dot.

  JPM: ACTION ESA#3 : remove spurious "."

  BG: Done.

- The lower resolution files have a tag '`10m`' in the file name, while the higher resolution files have no such tag. The resolution of the DTM and the ORI is 1 m and 0.5 m, respectively. I would suggest to put the tag '`1m`' and '`50cm`' into the lower resolution file names.

  JPM: Agreed ACTION ESA#4 : add resolution into the filename

  BG: Done.

7.2.2 Strip folder

Downloading big datasets from Google Drive is really a pain. In principal, the content of a folder selected to download is zipped, however, if the zip file would get large, it is splitted into several zip files. Moreover, individual large files are not zipped but downloaded as is and just put in the working directory, not where they belong in the directory tree. So restoring the original file tree requires a lot of manual work. In addition, many of the some 20 individual downloads crash without completion, therefore the downloaded dataset is just a subset of the original dataset. For the final delivery of the dataset, other means than fetching from Google Drive have to be employed. I suggest to deliver the strip folder to the GSF FTP.

- '`Meta.txt`' file is missing for

  `M190916653RE-M190909505RE`

  JPM: ACTION KP#3: provide missing metadata file or explanation

- The orphan files in the base folder should go in a new parent folder of their own, maybe named

  `Supplementary-strip-ORIs`

  BG: Created a new folder

  `Supplementary-strip-ORIs`

  in the directory

  `Crater-Aristarchus-strip-products`

  and moved all files in the latter into the former.

- Where version '`v2`' files are present, they have to be ranamed to replace the older version (without '`v2`').

  JPM: ACTION ESA#5 : remove v2 in the filenames

  BG: Moved the non-'`v2`' versions to '`REMOVED_BY_BG`' and removed the '`v2`' tag from the file name for the following files:

  - '`M190916653RE-M190909505RE-ORI-UCL.tif`'
  - '`M1106216804RE-M1106238239RE-ORI-UCL.tif`'

- All should consistently be renamed to

  - '`*-DTM_UCL.tif`'
  - '`*-ORI_UCL.tif`'

– '*-Meta.txt'

Currently, hyphens '-' are randomly interchanged with underscores '_'. Note also that some file names start with 'Copy of'.

JPM: ACTION ESA#6 : make the filenames consistent and remove "Copy of" which is an artefact of gdrive copying.

BG: Renamed files to the following names:

- 'M160261901LE-M1305118300RE-ORI_UCL.tif'
- 'M186198825LE-M1114483609LE-DTM_UCL.tif'
- 'M186198825LE-M1114483609LE-ORI_UCL.tif'
- 'M190916653RE-M190909505RE-ORI_UCL.tif'
- 'M1106216804LE-M1106238239LE-ORI_UCL.tif'
- 'M1106216804RE-M1106238239RE-ORI_UCL.tif'
- 'M1106238239LE-M1241627890LE-ORI_UCL.tif'
- 'M1129787722LE-M1129801944LE-DTM_UCL.tif'
- 'M1129787722LE-M1129801944LE-Meta.txt'
- 'M1129787722LE-M1129801944LE-ORI_UCL.tif' (also removed 'v2' from the file name)
- 'M1129787722RE-M1129801944RE-ORI_UCL.tif'
- 'M1129794833LE-M1254550518RE-ORI_UCL.tif'
- 'M1129794833RE-M1129801944RE-ORI_UCL.tif'
- 'M1129801944RE-M1129787722RE-ORI_UCL.tif'
- 'M1191003838LE-M1191017895LE-ORI_UCL.tif' (also removed 'v2' from the file name)
- 'M1191003838RE-M1191010858LE-ORI_UCL.tif'
- 'M1191017895RE-M1191003838RE-DTM_UCL.tif'
- 'M1191017895RE-M1191003838RE-Meta.txt'
- 'M1191017895RE-M1191003838RE-ORI_UCL.tif'

Also removed empty folder

M1191017895RE-M1191003838RE.pvl.

I did not rename the files which are now in the folder

Supplementary-strip-ORIs.

Their naming scheme differs anyway from the other files and at least they are consistent among themselves.

> Working in a GUI is like a behavioral test for monkeys.
> Working on the command line is like magic.

8 The PUGs

8.1 Cerberus PUG

- Besides HiRISE, also CTX and HRSC should be in the title.
- The region should be constrained in the title, as only "a terraced crater in Elysium Planitia" is covered, and not all Mars.
- Alternatively, the title could just be "PSA product user guide for <DATA_SET_NAME>". The <DATA_SET_NAME> will probably be something like

  `UCL-MSSL_MARS-CERBERUS_CTX-HIRISE-HRSC_V1.0`

- In the section **Instrument and datasets**, only HiRISE is described. CTX and HRSC should be described also.
- From section **SCIENTIFIC OBJECTIVES**, it seems that only HiRISE and CTX products have been created by CASP-GO, and that HRSC products are only provided for reference. If this was the case, it should be more clearly stated in section **Instrument and datasets** and **SCIENTIFIC OBJECTIVES**.
- The HRSC files are not described in the **Naming convention**. They should also be described there, including the (currently missing) Meta file.
- In the **DTM/ORI specification**, the projection is given as Equirectangular. This is incorrect. It is in fact sinusoidal with a reference longitude of 164°.
- In the **DTM/ORI specification**, the resolution given is that of HiRISE. The (lower) resolution of CTX and (even lower of) HRSC are not given.

8.2 Aristarchus PUG

- The dataset name (which may be given in the PUG title) will probably be something like

  `UCL-MSSL_MOON-ARISTARCHUS_LROC-NAC_V1.0`

- In **Reference and Applicable Documents,** the references Barker et al. (2016) and Walter et al. (2018) are listed, but not cited anywhere.
- In **ARCHIVE FORMAT AND CONTENT**, the two folders

`Crater-Aristarchus-mosaic-products`

and

`Crater-Aristarchus-strip-products`

and their relation to each other should be explained.

- The orphan files in the base folder (which should get a parent folder of their own) and their relation to the other files should be described.
- In the **Naming convention**, the files in the

  `Crater-Aristarchus-mosaic-products`

  folder are not described correctly. Note that I propose to add '`-1m`' and '`-50cm`' file name tags for the higher reolution files, like the '`-10m`' file tags for the lower resolution files.
- Typo in **DTM/ORI specification:** Mars → Moon
- In **Product Example and Usage,** it is stated that projection and mapping information is also embedded in the PVL metadata files, which is not correct. It is stated two times, at the beginning and the end of the section.

9 Consolidation

After some action taken, I have written an e-mail to Jan-Peter Muller on 2021-04-06, stating that the Cerberos dataset is fine and listing the pending actions for the Aristarchus data set.

Created a new folder

`UCL-MSSL_MARS-CERBERUS_CTX-HIRISE-HRSC_V1.0`

and downloaded (separately) the subdirectories '`CTX`', '`HiRISE`', and '`HRSC`' into it.

Then rsynced this folder into

`ssols01.esac.esa.int:/PSA/PSA02/WORKING_AREA/GUEST_STORAGE_FACILITY/CERBERUS/`

and double checked that the name of the landing page is consistent with the data set name. Then tarred it up there and ftped it to the GSF delivery area. Asked Sebastien for **GO** to email Angel.