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Initial GMES Service for Geospatial Reference Data Access

Full report on data processing performed and the transfer to the data base D2.1

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1. INTRODUCTION

1.1 OBJECTIVE

This document aims at describing the production chains and work flows applied for the production of EU-DEM and EU-HYDRO, providing enough detail to replicate the processes if necessary.

1.2 SCOPE

This document presents the production chains and workflows for the data components of this project: DEM (EU-DEM) and hydrography database (EU-HYDRO).

The description of the processes comprises all the stages from the acquisition and quality control of the input data to the delivery of the final databases. A brief description of the QC procedures involved is given.

1.3 APPLICABLE DOCUMENTS

AD-01 Call for Tenders No ENTR/2009/27

AD-02 Proposal Nr. 1143-09/IE

AD-03 Implementation of an Initial GMES Service for Geospatial Reference Access – Offer N.1143-09/IE – Technical & Management Proposal

AD-04 EC GMES Service Project Plan D09024.S - PM.FRM.0002 (Intermap internal document)

AD-05 GSGRDA Quality Control Plan - GSGRDA-PLN-002

1.4 REFERENCE DOCUMENTS

RD-01 Building the EEA European Catchment and Rivers Network System (ECRINS) from CCM v2.1. Part 1: Setting and implementing rules and producing the watershed layer (βv2)

RD-02 Building the EEA European Catchment and Rivers Network System (ECRINS) from CCM v2.1. Part 2: Setting and implementing rules for river main drains layer building.

RD-03 Building the EEA European Catchment and Rivers Network System (ECRINS) from CCM v2.1. Part 4: Setting and implementing rules for lakes and dams layer bulding.

RD-04 EuroRegionalMap. Pan-European Database at Medium Scale. Specification and Data Catalogue.

1.5 ACRONYMS AND TERMS

CLC	CORINE Land Cover
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AOI	Area of Interest
ARC	Applied Research Centre
DEM	Digital Elevation Model
ERM	Euro Regional Map
GIS	Geographic Information Systems
GMES	Global Monitoring for Environment and Security
HW	Hardware
PD	Photogrammetry Department
QC	Quality Control
SRTM	Shuttle RADAR Topography Mission
SW	Software

2. EU-DEM

2.1 PROCESS FLOW

The following figures show the overall process flow for the production of the EU-DEM. The next sections will describe each of the work steps considered.

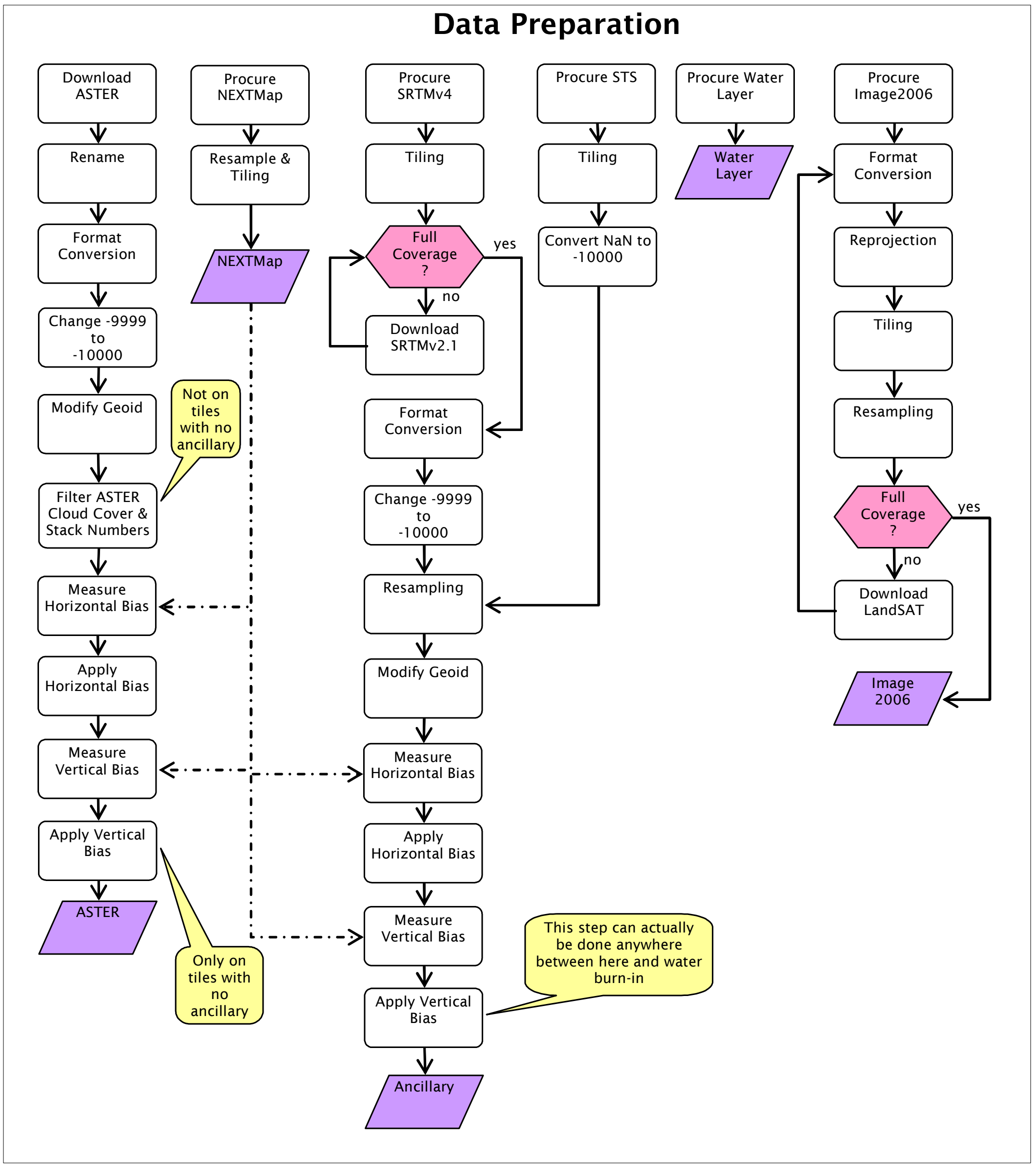


Figure 2-1. Work flow for data preparation.

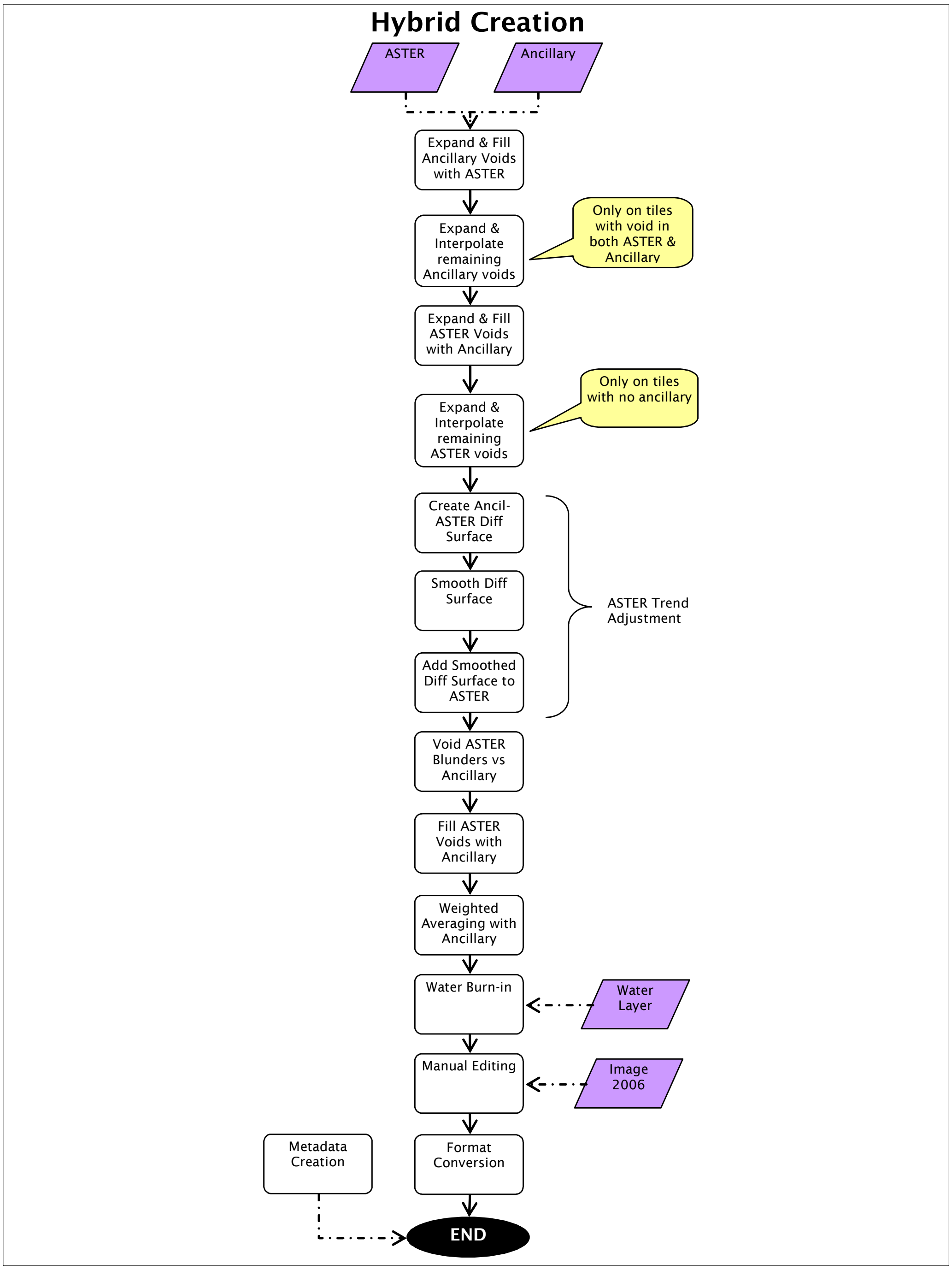


Figure 2-2. Work flow for hybrid creation.

2.2 DATA PROCUREMENT

In the GMES Project Plan, the area of interest (AOI) is described as being comprised of 1,165 1°x1° tiles covering the 38 countries comprising the European Environment Agency (EEA38).

Intermap Engineering (Sub-contractor for the production of the EU-DEM) received a KML file from the prime contractor (Indra Espacio) containing the boundaries of all these tiles and their tile names. This KML file can be loaded into Google Earth to view the expected ground coverage for each tile as well as being loaded into GlobalMapper to view the tile outlines.

In order to QC the data downloads, the KML file was used to create a list of tiles for the GMES project. The following method was used to create this tile list.

1. Load the KML file into GlobalMapper
2. Export the vector data to a CSV file
3. Load the CSV file into Microsoft Excel
4. Remove all columns except the tile name column and save back to a new CSV file
5. Rename the CSV file to *list.txt*

Now at this point there is a text file called *list.txt* which contains the name of all the tiles in the KML file on a separate line. A small check was done to ensure that the number of lines in this file was 1165 and indeed they were.

The problem with this text file is that the tile names in the KML file are named in the format E###N## whereas the actual ASTER and SRTM tiles and the expected EU-DEM output tiles are named N##E###. Additionally, the KML tiles are named according to the top-left corner of the tile whereas the actual ASTER and SRTM are named according to the bottom-left corner of the tile.

6. To overcome this last problem, a windows batch file was written to rename all the tiles and output to a file called *tilelist.txt*. The batch file contents are shown below:

```
@echo off

:: Run through all tiles in the list.txt file and for each call the Process function
type NUL > tilelist.txt
for /f %%i in (list.txt) do call :Process %%i
exit /b

:Process
setlocal enableextensions

set name=%1
set eastingletter=%name:~0,1%
:: Ensure the output will be lowercase
if %eastingletter%==W set eastingletter=w
if %eastingletter%==E set eastingletter=e
set easting=%name:~1,3%

set northingletter=%name:~4,1%
if %northingletter%==N set northingletter=n
if %northingletter%==S set northingletter=s
set northing=%name:~5,2%

:: Parse leading zeros from the northing
if %northing:~0,1%==0 set northing=%northing:~1,1%

:: Subtract one degree from the northing to move from top to bottom of tile
:: If the tile is in the southern hemisphere you need to add to the northing instead
if %northingletter%==n set /a northing=%northing%-1
if %northingletter%==s set /a northing=%northing%-1

:: Add back in the zero padding where necessary
if /i %northing% LSS 10 set northing=0%northing%
```

```
:: Write the tile name back to a new tilelist.txt file
echo %northingletter%%northing%%eastingletter%%easting%>>tilelist.txt

endlocal
exit /b
```

After running this batch file new *tilelist.txt* file is provided, which contains all the tiles named properly to the bottom-left corner of the tile. After running, this file was checked again to ensure that the tile names were indeed renamed properly and that it still contained 1165 lines.

An example of this check is shown in the following table where the original file contents are on the left and the new tile contents are on the right. You can see that the tiles were renamed properly.

Original Tile List	Final Tile List
E000N39	n38e000
E000N40	n39e000
E000N41	n40e000
E000N42	n41e000

Table 2-1. Example of original tile list and final tile list.

An additional step which is not required is to sort the text file by name just to keep similar tiles together. This was done using the sort function in Notepad++

2.2.1 ASTER

ASTER data was downloaded from the Internet at http://asterweb.jpl.nasa.gov/gdem-wist.asp

The data comes in zip file format. After unzipping the files, there are two resultant files in GeoTiff format. One is the DEM and the other is the QA File which identifies the number of DEM stacks used for each pixel as well as the areas which were infilled using alternate data sources.

The DEM file is named ASTGTM_N##E###_dem.tif where N## is the latitude of the south-west corner of the tile and E### is the longitude of the south-west corner of the tile. The files were renamed to remove the ASTGTM_ prefix so that they would match the name in the tilelist.txt file.

QUALITY CONTROL CHECK

A QC check was needed in order verify that all the required tiles were downloaded and if not, which were missing. To perform this check, all DEM files were placed into a single folder and the following batch script was run.

```
@echo off

type nul > missingtiles.txt
for /f %%i in (tilelist.txt) do (if not exist ASTER\dem\%%i_dem.tif (echo %%i >> missingtiles.txt))
```

for the QA Files, the batch script was modified as follows:

```
@echo off

type nul > missingtilesNUM.txt
for /f %%i in (tilelist.txt) do (if not exist ASTER\num\%%i_num.tif (echo %%i >> missingtilesNUM.txt))
```

This checks the list of tiles in the tilelist.txt file already created (see above) and ensures that there is a DEM file (or NUM file) for each tile and outputs the list of missing tiles to a text file called missingtiles.txt (or missingtilesNUM.txt).

The results of running this batch file gave the following tiles in the *missingtiles.txt* file:

- n28w019
- n34e023
- n36w009
- n40e012
- n41e011
- n53w006
- n54e007
- n57e006
- n66e011

Of course, the missingtilesNUM.txt file had the same contents which confirmed there was a QA File for each DEM file. After checking these manually, we confirmed that these tiles were indeed missing from the ASTER data set. We tried to re-download them, but they did not exist. We determined that it is most likely because all of these tiles are right on the edge of the data set and they contain less than 0.01% land cover. The ASTER specifications indicate that anything with this low amount of land cover is not included.

2.2.2 Ancillary

2.2.2.1 SRTMv4

SRTMv4 data was obtained from JRC. The data set arrived in three 30° square tiles with 3" pixel size in 16-bit elevation grid format. They also came with header files describing the contents.

In order to use these files, they were renamed with .bil file extension and a .hdr file was manually created in standard GridFloat format using the information in the provided header. The .hdr files are attached here:

N30w030.hdr N30e000.hdr N30e030.hdr

Once the tiles were in proper format, Matlab was used to load them and write them out to 1° tiles in 32-bit float bil format with proper hdr files. The Matlab script used is attached here

splitintotiles.m

QUALITY CONTROL CHECK

Now that the data was tiled appropriately, a QC check was done using the same manner as above for ASTER tiles to compare with the listfiles.txt to ensure all tiles were found. The following batch file was used.

```
@echo off

type nul > missingtilesSRTM4.txt
for /f %%i in (tilelist.txt) do (if not exist SRTM4\%%i.bil (echo %%i >> missingtilesSRTM4.txt))
```

The results of running this batch file gave the following tiles in the *missingtilesSRTM4.txt* file:

- n27w016
- n27w017
- n27w018
- n27w019
- n28w014
- n28w015
- n28w016
- n28w017
- n28w018
- n28w019
- n29w014
- n39w032

Additionally, all tiles above 60°N were missing, but this was expected since this was SRTM data.

2.2.2.2 SRTMv2.1

All missing SRTMv4 tiles as found in the *missingtilesSRTM4.txt* file were downloaded as SRTMv2.1 (non void filled) as alternate. It was downloaded from http://dds.cr.usgs.gov/srtm/.

Since there were so few of these, no QC was needed to ensure all were obtained (aside from a quick glance at the list).

2.2.2.3 STS

JRC also provided ancillary data for above 60°N. This data set is derived by digitization of Russian topo maps and covers the Scandinavian countries.
This data arrived in the same format as the SRTMv4 data and was prepared in the same manner. The one difference was that they were already in 32-bit float format so they did not need to be converted. The manually created .hdr file is attached here:

Sts.hdr

Also, the Matlab script used to split the file into tiles is here:

splitintotiles.m

Although there was no alternate data for missing tiles, hence no QC necessary, a similar QC was performed using the following batch file. Any missing files found meant that only ASTER could be used.

```
@echo off

type nul > missingtilesSTS.txt
for /f %%i in (tilelist.txt) do (if not exist STS\%%i.bil (echo %%i >> missingtilesSTS.txt))
```

The results of running this batch file gave all tiles below 60°N of course, but additionally the following tiles. This list of tiles represents tiles which will be comprised of only ASTER and no Ancillary data.

n60w001	n64w015	n65w018	n66w019
n60w002	n64w016	n65w019	n66w020
n60w003	n64w017	n65w020	n66w021
n63w017	n64w018	n65w021	n66w022
n63w018	n64w019	n65w022	n66w023
n63w019	n64w020	n65w023	n66w024
n63w020	n64w021	n65w024	
n63w021	n64w022	n65w025	
n63w022	n64w023	n66w015	

n63w023	n64w024	n66w016	
n64e030	n64w025	n66w017	
n64w014	n65w017	n66w018	

Table 2-2. List of tiles only comprised of ASTER data

2.2.3 NEXTMap® Europe

The NEXTMap data was procured directly from Intermap's data delivery/distribution department.

2.2.4 image2006

The imagery was provided by JRC via AGI to Intermap in INSPIRE compliant European Grid Coding System (EGCS) Level 17 cells. These are 250km x 250km tiles with a 25m pixel size. The imagery came in quad band 32-bit GeoTiff format and was in the ETRS-LAEA projection.

2.3 FILE FORMAT CONVERSION

2.3.1 ASTER

ASTER tiles come in 16-bit GeoTiff format when downloaded. In order to use them in our tools they needed to be converted to 32-bit BIL/HDR format. This was accomplished using the GlobalMapper batch conversion tool.

QUALITY CONTROL CHECK

Only minor QC was necessary for the file conversion. The steps for the QC checks are as follows:

1. Open the unconverted file in GlobalMapper
2. Open the converted BIL file in GlobalMapper
3. Use GlobalMapper to create a difference surface between the two and ensure that this difference surface is 0 everywhere.

This QC check was done on a random sampling of the tiles and it passed the testing.

2.3.2 SRTM v2.1

The SRTMv2.1 tiles come in 16-bit HGT format when downloaded. These also need to be converted to 32-bit BIL/HDR format. Like ASTER data, the GlobalMapper batch conversion tool was used to convert these.

QUALITY CONTROL CHECK

Only minor QC was necessary for the file conversion. The steps for the QC checks are as follows:

1. Open the unconverted file in GlobalMapper
2. Open the converted BIL file in GlobalMapper
3. Use GlobalMapper to create a difference surface between the two and ensure that this difference surface is 0 everywhere.

This QC check was done on a random sampling of the tiles and it passed the testing.

2.3.3 IMAGE2006

See section 2.6.1 since the format conversion, reprojection, resampling, and tiling for Image2006 data was all done in one step.

2.3.4 Product

Since the last step in the process is to perform manual editing of the data in IES, the data coming out of this step is in the IES DIG/ImageInfo format. These files are first converted to BIL/HDR format. This is done using the Intermap dig2bil utility. In a last step those BIL files need to be converted into 32bit GeoTIFF file format. This is done also in GlobalMapper.

2.4 REPROJECTION

2.4.1 Image2006

Since the imagery was delivered in ETRS-LAEA projection, it was more difficult to resample and tile the data. However, since it is imagery, nearest neighbor resampling is sufficient so GlobalMapper was used to perform the entire process of reprojection, resampling, tiling, and reformatting the data. A GlobalMapper script was used for this process.

Note that the Coverage 1 MOS imagery was used since a pre-screening showed that these images provided the best balance of limited cloud and high dynamic range.

The GlobalMapper script used is attached here along with the Matlab script used to create the GlobalMapper script and the projection files used by the script:

GMESReproject.gms ETRS-LAEA.prj Wgs84.prj GMScriptCreator.m

QUALITY CONTROL CHECK

After the data was reprojected and tiled appropriately, two difference QC checks were done. First, a random sampling of tiles was opened in GlobalMapper and checked to ensure that the before and after aligned. Additionally, the ASTER data for the same tiles was opened to ensure they matched up.

Another QC check was done using the same manner as for ASTER tiles to compare with the listfiles.txt to ensure all tiles were covered by imagery. The following batch file was used.

```
@echo off

type nul > missingtilesImagery.txt
for /f %%i in (tilelist.txt) do (if not exist Image2006\%%i.bil (echo %%i >> missingtilesImagery.txt))
```

Running this batch file showed that no imagery was missing and there was full coverage.

2.5 VOID VALUE CONVERSION

2.5.1 ASTER and SRTM

The ASTER and the SRTMv2.1 data sets used -9999 as the void value (SRTMv4 contained no voids). However, Intermap tools use -10000. Therefore, voids were all converted to -10000.

To perform the conversion the Intermap raw2raw tool was used. A windows batch file was created in order to run on all tiles at once.

```
@echo off
if "%1"=="" goto Usage

:: Run through all bil files
FOR %%i IN (%~f1\*.bil) DO call :Process %%i

exit /b

:Process
setlocal enableextensions

::Convert using raw2raw
raw2raw %~f1 %~f1.tmp -i f -o f -v -9999 -10000 -x

::Replace the original file with the converted one
del %~f1
rename %~f1.tmp %~nx1

endlocal
exit /b

:Usage
ECHO.
```

```
ECHO %~n0 v1.0 - Changes the NULL value of all 32-bit float bil and hdr files in a
ECHO   folder from -9999 to -10000
ECHO.
ECHO Usage: %~n0 folder
ECHO.
ECHO Required:
ECHO   folder  Location of the bil and hdr files
ECHO.
exit /b
```

Additionally, the HDR files needed to be updated to reflect the new void value. Intermap's hdr2hdr tool was used for this. Again, the following batch file was used to run on all tiles.

```
@echo off
:: One parameter, the input path
if "%1"=="" goto :EOF

:: Run through all hdr files
FOR %%i IN (%~f1\*.hdr) DO (hdr2hdr %%i %%i_new -void -10000 & move /y %%i_new %%i)
```

QUALITY CONTROL CHECK

A simple check was done on random tiles in the data sets. Tiles with voids were opened in GlobalMapper both before and after the conversion to ensure that voids were still voids in the output. The hdr files were also checked to ensure that they contained -10000 as the void value.

2.5.2 STS

The STS data was unique in that it contained NaN values around the edges where there was no data. This includes where there was water.

The tile boundaries were observed in Google Earth using the tile boundaries KML file and it was determined that the tiles with NaN values were either entirely ocean, or entirely void. Therefore, the NaN values were changed to either 0 for ocean or -10000 for void. This was done using the attached Matlab script. Note that it makes use of an existing Intermap Matlab function called listfiles which is not attached. It simply creates a cell object containing all the files in a directory.

Fixnan.m

The script was modified manually for each case of changing to 0 or -10000.

The void values in the HDR files was set in the same manner as for the ASTER & SRTM files using hdr2hdr.

QUALITY CONTROL CHECK

A simple check was done on all edge tiles in the data set. Tiles with NaN values were opened in GlobalMapper both before and after the conversion to ensure that they were now either water or void as they should be. The hdr files were also checked to ensure that they contained -10000 as the void value.

2.6 RESAMPLING

2.6.1 SRTM and STS

Since the SRTM (both versions) and STS data came in 3” resolution, they needed to be resampled to 1” to match the ASTER and to match the final output resolution.

This was accomplished using Intermap’s Coarse Grid Resampler tool with the bilinear resampling algorithm.

After the tiles are run through the Coarse Grid Resampler, unfortunately their file names are changed to be referenced to the upper-left corner of the tile rather than the lower-left corner. Therefore, they had to be renamed. Intermap’s TileNameFromHdr tool was used. This tool reads the HDR file and renames the bil and hdr files appropriately to the desired origin. The tool was run in batch as follows:

```
 @echo off
:: One parameter, the input path
if "%1"=="" goto :EOF

:: Run through all bil files
FOR %%i IN (%~f1\*.bil) DO (TileNameFromHdr %%i -c ll)
```

<u>QUALITY CONTROL CHECK</u>

A simple check was done on random tiles in the data sets. Tiles were opened before and after the conversion and compared in GlobalMapper. They were observed to ensure that the resampling was done correctly and that no shifts or other anomalies were introduced. Profiles were drawn over the same area in both and they were compared.

2.6.2 NEXTMap

In order to use NEXTMap data for doing measurements of horizontal and vertical biases in the ASTER and ancillary data, the NEXTMap tiles needed to be resampled to 1” and tiled to 1° tiles. This was accomplished using Intermap’s Coarse Grid Resampler tool using a bilinear resampling algorithm.

2.7 GEOID UPDATE

The ASTER, SRTM, and STS data were all provided referenced to the EGM96 geoid model. However, the expected output geoid model is the EGG08 geoid model. Therefore, the EGM96 model needed to be removed and the EGG08 model added back in.

The geoid model update was prepared using all Intermap command line tools and the following batch script for running on an entire folder of bil/hdr files.

EGM96toEGG08.bat

QUALITY CONTROL CHECK

A random sampling of tiles was used for verification of the programs and batch script results.

The verification was done by running part of the same batch script, but only the part that creates the Geoid surfaces. Then we were able to load both these geoid surfaces into GlobalMapper and perform a difference between them. We also loaded the tile before and after the geoid update and performed a difference between them.

Therefore, you get the following equation:

EGG08-EGM96=after-before

Meaning that the difference between the two geoid surfaces should equal the difference between the before and after tile results. We were able to confirm that these were the same for all the sample tiles using the GlobalMapper differences.

2.8 ASTER CLOUD COVER AND STACK NUMBER FILTERING

Previous studies on the ASTER data set have indicated that when the number of scene-based DEMS (stack number) is less than 5 that the quality of the ASTER decreases very rapidly. Therefore, in order to improve the EU-DEM results, these areas were filtered out so that they could be replaced by SRTMv4 data.

Additionally, the cloud covered areas in the ASTER data set were mostly filled using SRTM already. However, the filling method is unknown and may be unreliable. Therefore, these areas were also filtered out so that we could re-fill them ourselves.

Filtering out these areas just required setting them to the void value of -10000 so that void filling can be used later in the process to fill them with SRTM.

Voiding of the areas was done using Intermap command line tools and the attached batch script for running on multiple tiles in a folder. Note that this utilizes the ASTER QA File which contains the stack number or cloud fill type for every pixel in the ASTER data set.

SceneMask.bat

*Note: This step must be done prior to any horizontal bias adjustment is done to the ASTER data otherwise resampling of the stack number files would also need to be done and this would potentially cause issues with movement of the stack number boundaries.

QUALITY CONTROL CHECK

A random sampling of tiles was used for verification of the programs and batch script results.

The tiles were loaded into GlobalMapper along with the QA file. A visual check was done to ensure that wherever the QA file showed an area to be filtered that the resulting file was void.

Additionally, the following image was created which shows visually the areas which were voided out due to cloud cover and low number of stacks. White areas are void.

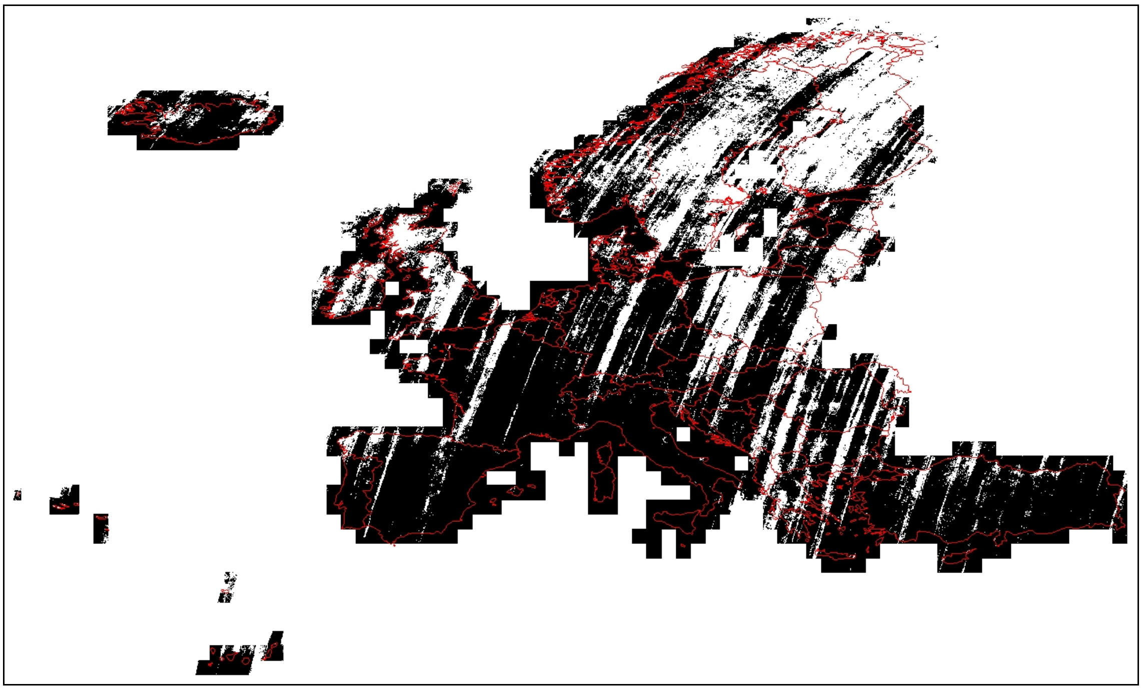


Figure 2-3. ASTER voided areas due to cloud cover.

2.9 HORIZONTAL ADJUSTMENT

In order to determine if there was a horizontal adjustment to be applied to the ASTER and/or SRTM data sets, they were compared to the NEXTMap data wherever it existed. The comparison was made by automatically correlating features in the data sets and measuring the offset of this correlation. This was done using the attached Matlab script.

Measurehorizontalshift.m

After running this tool, it was possible to generate statistics on the differences as well as geographic plots to visualize any geographic trends if they existed. The results of these measurements are shown in the next sections.

2.9.1 ASTER X shift (East – West)

The histogram and LE90 plots for the ASTER shift in X direction do not show a nice clean distribution. However, they do show a general bias to the left (negative). Note that the images indicate shifts in units of **pixels** and not meters. The mean shift is about -0.7 pixels or approx. -14m.

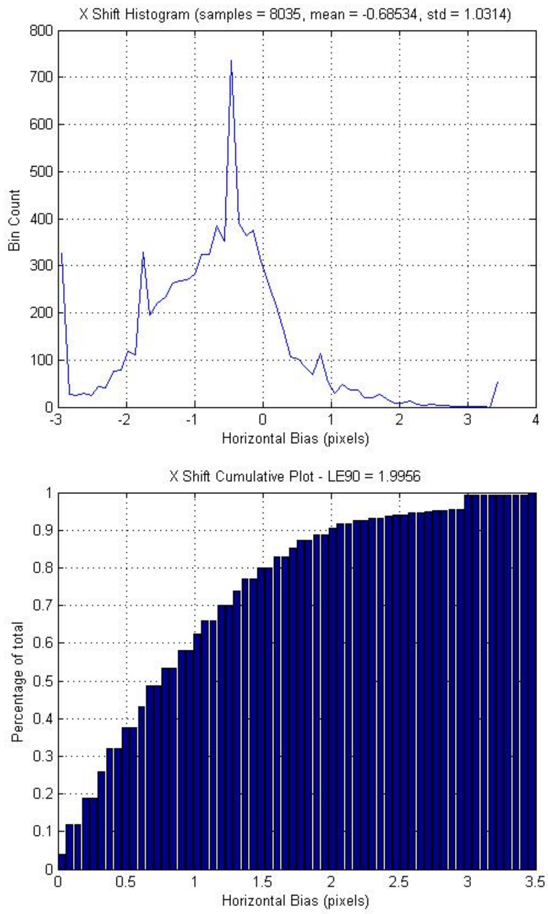


Figure 2-4. Shift histogram and LE90 plots for ASTER in X direction.

The geographic plot shows the reason for the poor distribution. There appears to be a general trend of the shift value from South to North and it is generally a shift to the left.

Note: The units shown in the legend of the following maps are in pixels and not meters. The white areas are where there was either no NEXTMap data, or the data was void due to low stack number or cloud cover.

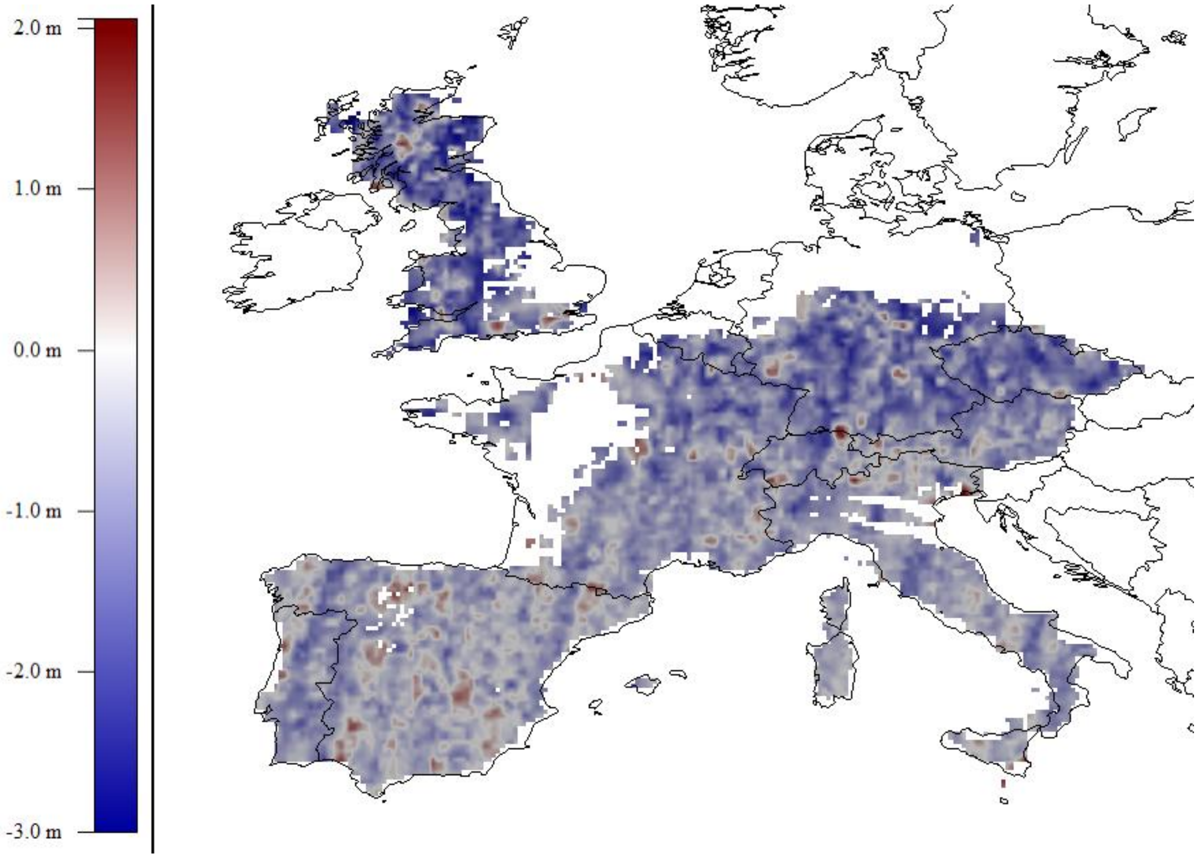


Figure 2-5. Geographic distribution of ASTER x shift.

2.9.2 ASTER Y shift (North – South)

The histogram of the ASTER shift in the Y direction appears to be a much more normal distribution. It also appears to be centered roughly on zero. From these, we would conclude that ASTER does not have a shift in the Y direction.

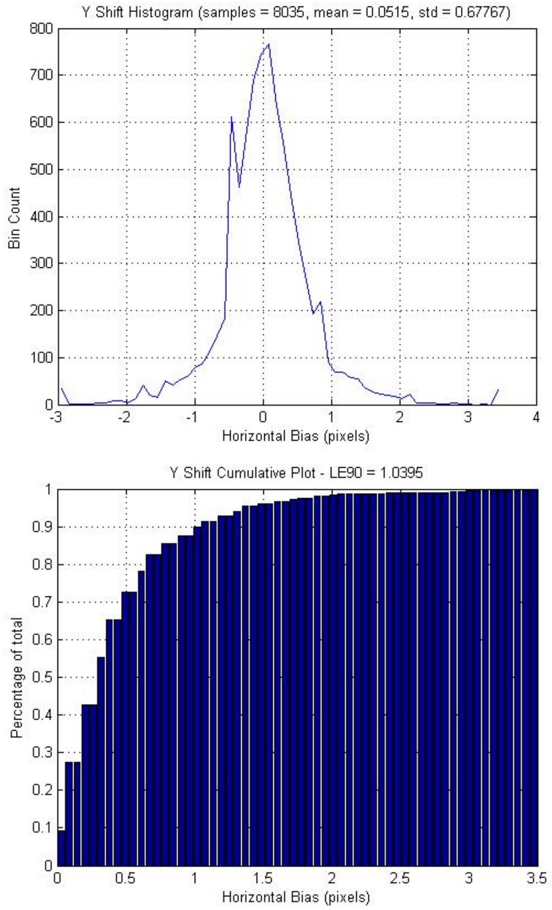


Figure 2-6. Shift histogram and LE90 plots for ASTER in Y direction.

The geographic plot of the Y direction also appears to indicate values closer to zero (lighter colour) and no apparent geographic trend.

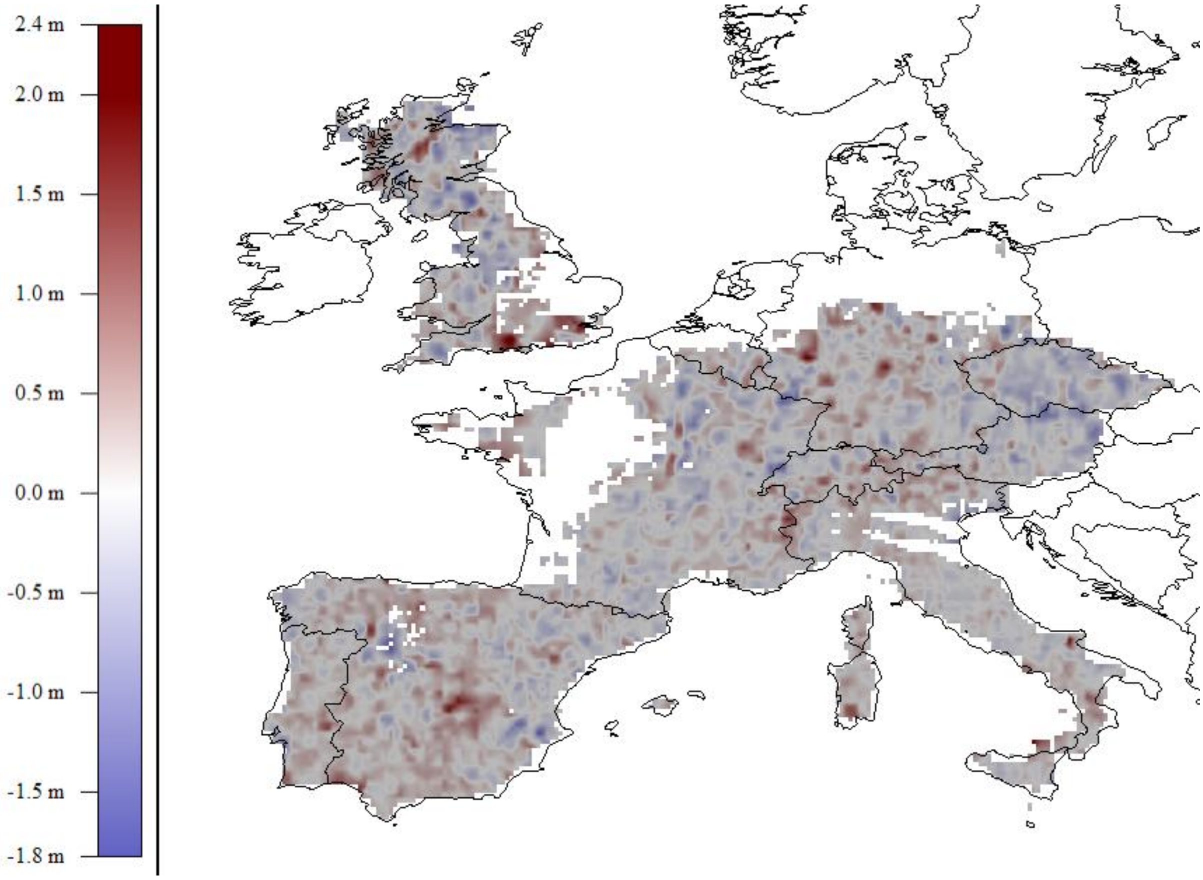


Figure 2-7. Geographic distribution of ASTER y shift.

2.9.3 SRTM X shift (East – West)

The histogram and LE90 plots for the SRTM shift in X direction show a nice clean distribution. It is also centered closely around zero. You could argue for about a quarter pixel shift to the left, but when considering the accuracies of the data, this is most likely in the noise.

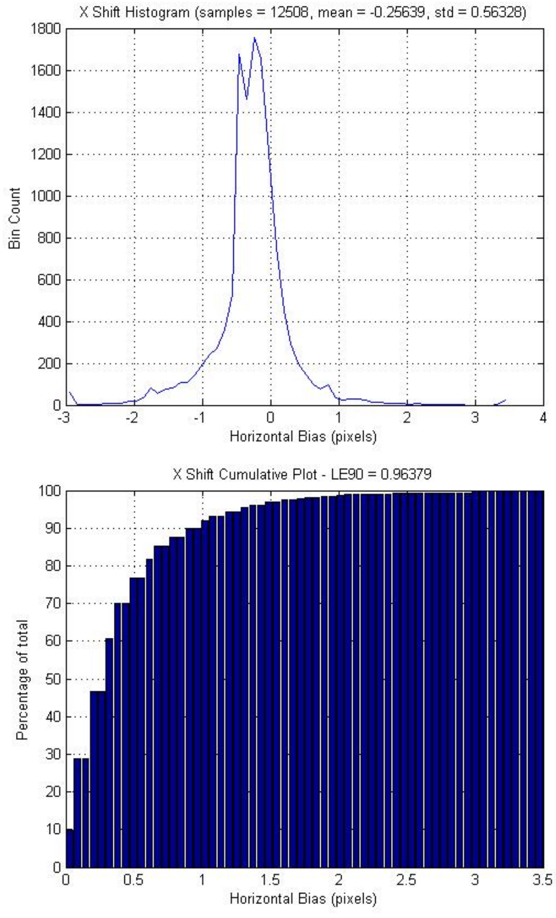


Figure 2-8. Shift histogram and LE90 plots for SRTM in X direction.

The geographic distribution also appears to be quite well distributed with a possible slight shift to the left (more blue than red). However, it is very minor.

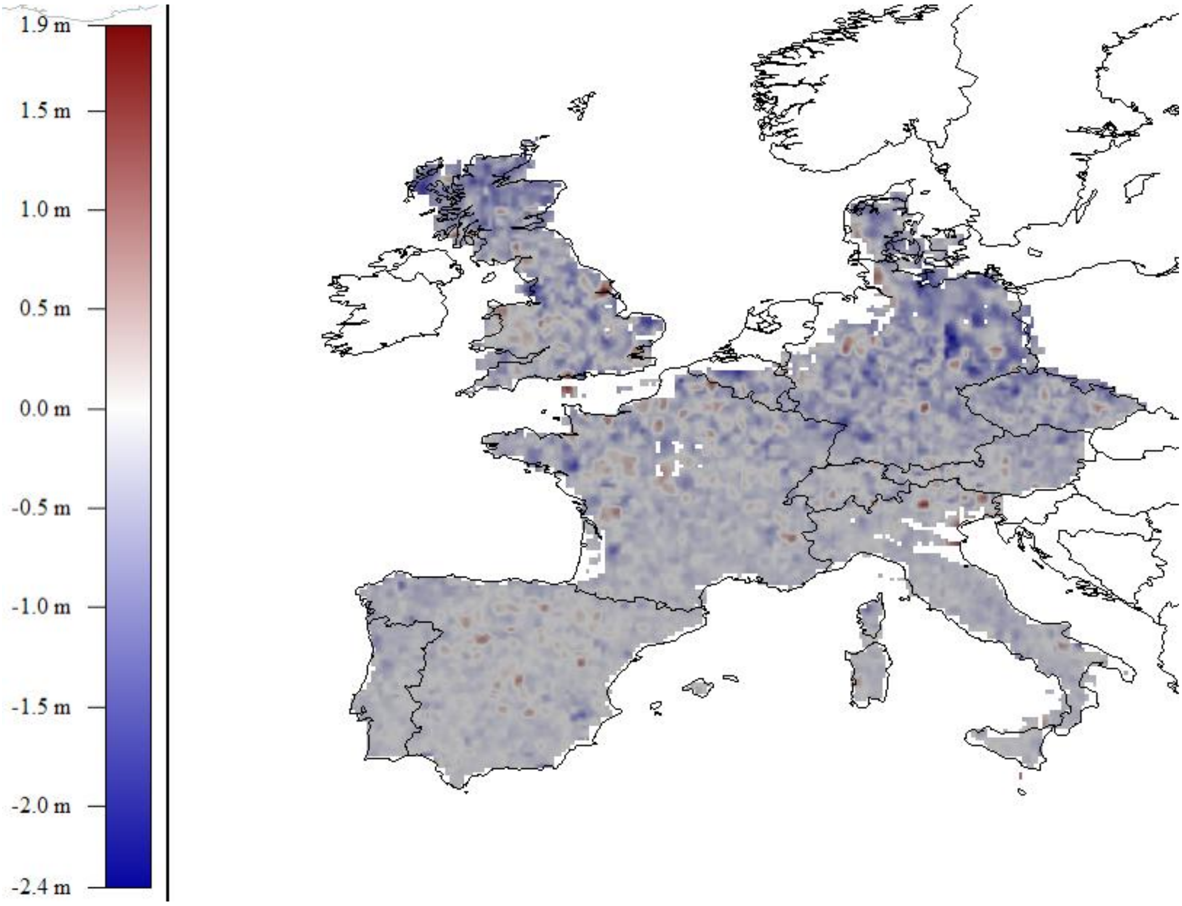


Figure 2-9. Geographic distribution of SRTM x shift.

2.9.4 SRTM Y shift (North – South)

The histogram and LE90 plots for the SRTM shift in Y direction show an extremely tight distribution around zero. Therefore, no shift is apparent.

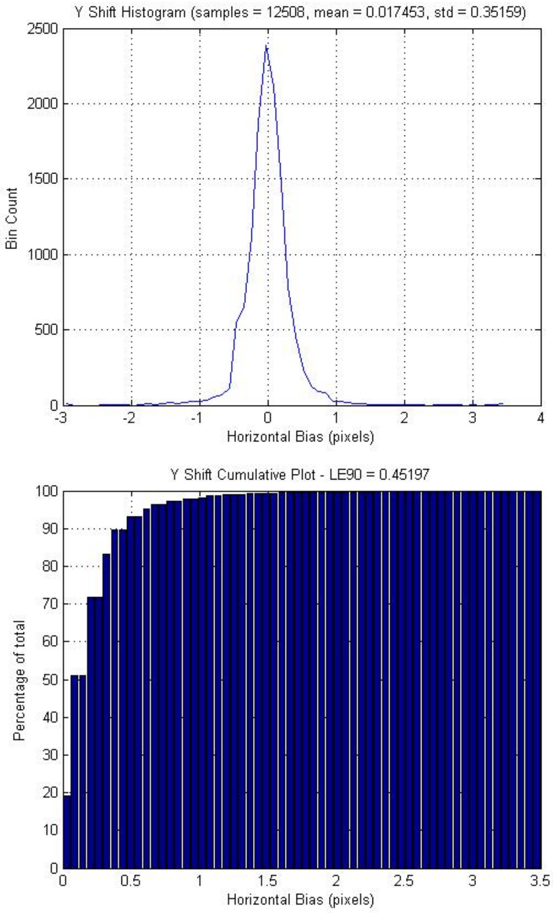


Figure 2-10. Shift histogram and LE90 plots for SRTM in Y direction.

The geographic plot shows the same tight distribution with no geographic trends.

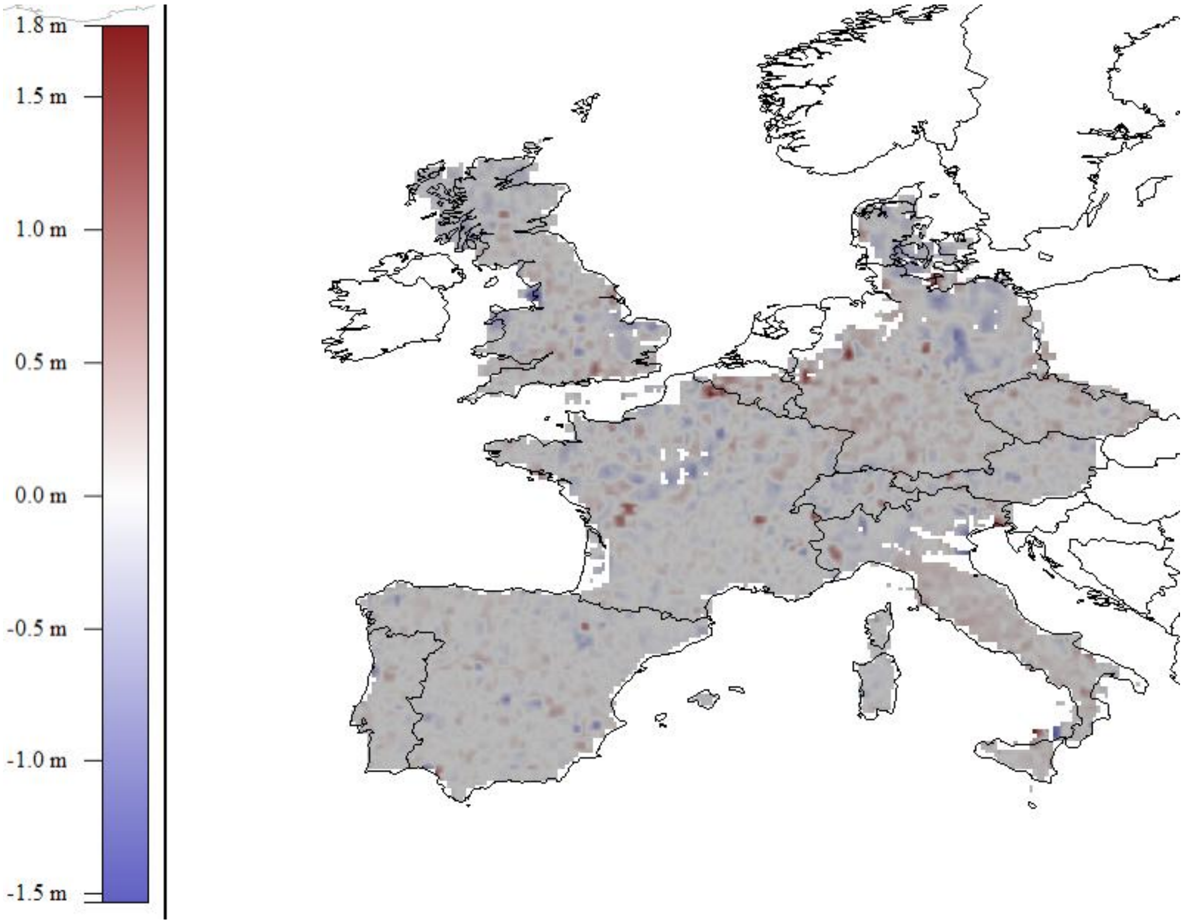


Figure 2-11. Geographic distribution of SRTM y shift.

2.9.5 Shift application

Based on the statistics, it was decided that we would apply an X shift to the ASTER data only. The SRTM data would not be shifted at all.

Unfortunately, the shift was not a single value which could be applied over the entire data set. This was the initial hypothesis and it is what the initial proposal was for. However, it was determined that we could apply a planar adjustment to the data in a relatively quick fashion and this was what was eventually done.

To apply the planar adjustment, a plane was fit to the X shift values using GMT.

The equation of the plane is **Shift = A + B*longitude + C*latitude**

Where A = 7.98376E-05, B=8.14442E-07, and C=1.66904E-06

These values were used to calculate a single shift value for each tile based on the center latitude and longitude of the tile.

The shift values were applied to the HDR files for each tile and then Intermap's Coarse Grid Resampler tool was used to resample the tiles back to the original grid posts using a bilinear resampling algorithm.

2.9.6 Shift results

After applying the shift, the horizontal alignment was measured again versus NEXTMap. The results for the ASTER X-Shift show a more normal distribution centered around zero as we would hope.

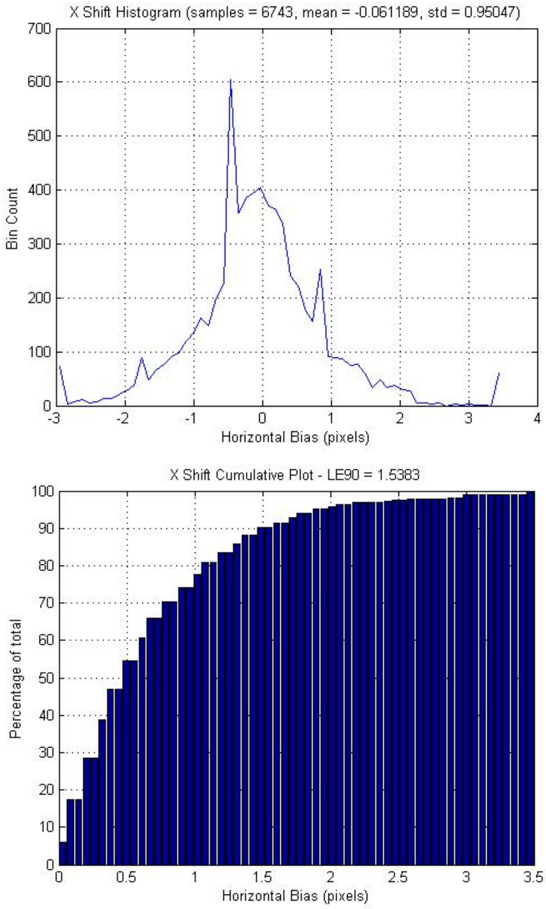


Figure 2-12.Shift histogram and LE90 plots for ASTER in x direction after shifting.

The geographic plot no longer shows a trend and appears more as noise centered around zero.

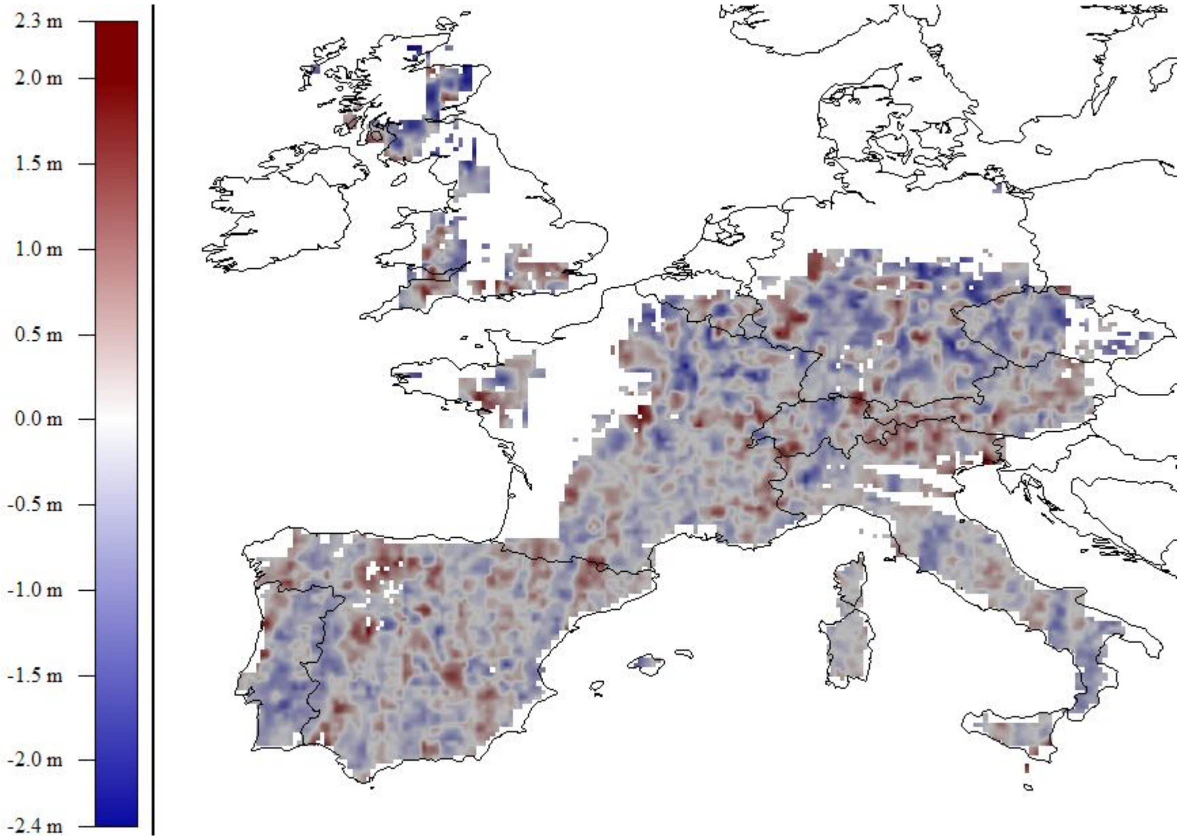


Figure 2-13. Geographic distribution of ASTER x shift after applying shift.

In addition to recalculating the horizontal bias, the vertical errors versus vertical check points (VCPs) were measured both before and after the horizontal shift was applied. The results are as follows:

	Unshifted	Shifted
Number of VCPs	7389	7414
Min	-45.89	-42.92
Max	23.65	31.36
Mean	-10.47	-10.44
Std dev	6.58	6.57
RMSE	12.37	12.33
95 Percentile	21.04	21.08
Blunder (3x Std dev)	19.73	19.70

Table 2-3. Comparison of figures unshifted vs shifted.

It can be seen that, although the horizontal statistics improve, the vertical statistics are virtually unchanged due to the horizontal shift. There are a couple of possible explanations for this. It is partially due to the fact that for most tiles the shift is sub-pixel. Therefore, to realign with the original postings, a re-sampling of the points are needed. However, the most significant reason for little change in vertical statistics most likely due to the fact that the VCPs were all points in unobstructed areas with relatively flat terrain. Therefore, a shift by even a couple of pixels would in most cases not make a major impact.

2.10 VERTICAL ADJUSTMENT

To measure whether there is a vertical bias adjustment to apply to the ASTER and SRTM data, a set of over 8000 vertical check points (VCPs) measured using GPS, and other means were obtained. These points are spread over all of Europe and are located in unobstructed terrain with low slope. The difference between the DEMs and the VCPs was obtained at every VCP point. The resulting statistics were as follows:

	NEXTMap DSM	NEXTMap DTM	SRTM	ASTER
Number of VCPs	8296	8296	8296	7414
Min	-3.95	-5.74	-27.96	-42.92
Max	4.77	4.43	15.76	31.36
Mean	0.03	-0.27	-3.06	-10.44
Std dev	0.61	0.63	3.19	6.57
RMSE	0.61	0.69	4.42	12.33
95 Percentile	1.22	1.41	8.84	21.08
Blunder (3x Std dev)	1.83	1.90	9.56	19.70

Table 2-4. Figures of vertical accuracies of the different Dem datasets.

These statistics indicate an approximately -3.0m bias in SRTM and -10.4m bias in ASTER. Note that the ASTER statistics are all given after the horizontal shift was applied. The measurements were calculated for before and after, but they changed very little which is why this section will only use the after statistics.

Additional statistics are shown in the next few sections.

2.10.1 ASTER vertical bias

The histogram and cumulative plot for ASTER data is shown below. They show a well behaved normal distribution with quite large side lobes on the histogram. However, the mean is just below -10m.

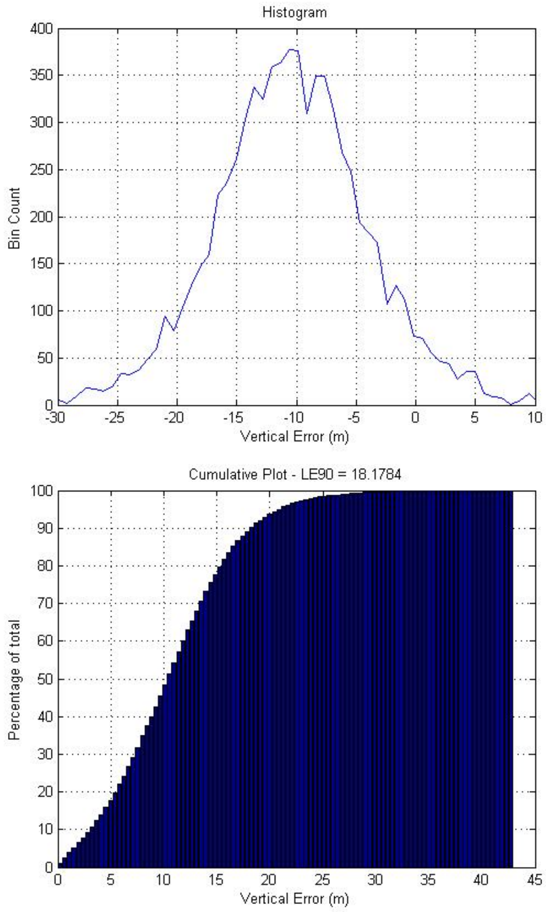


Figure 2-14. Histogram and cumulative plot for ASTER vertical bias.

From all the points, a surface was created to identify if there were any geographic trends in the vertical bias. This geographic plot is shown below. Note that the color map is centered about -10. There is no obvious geographic trends which could be expected to be modeled from this plot.

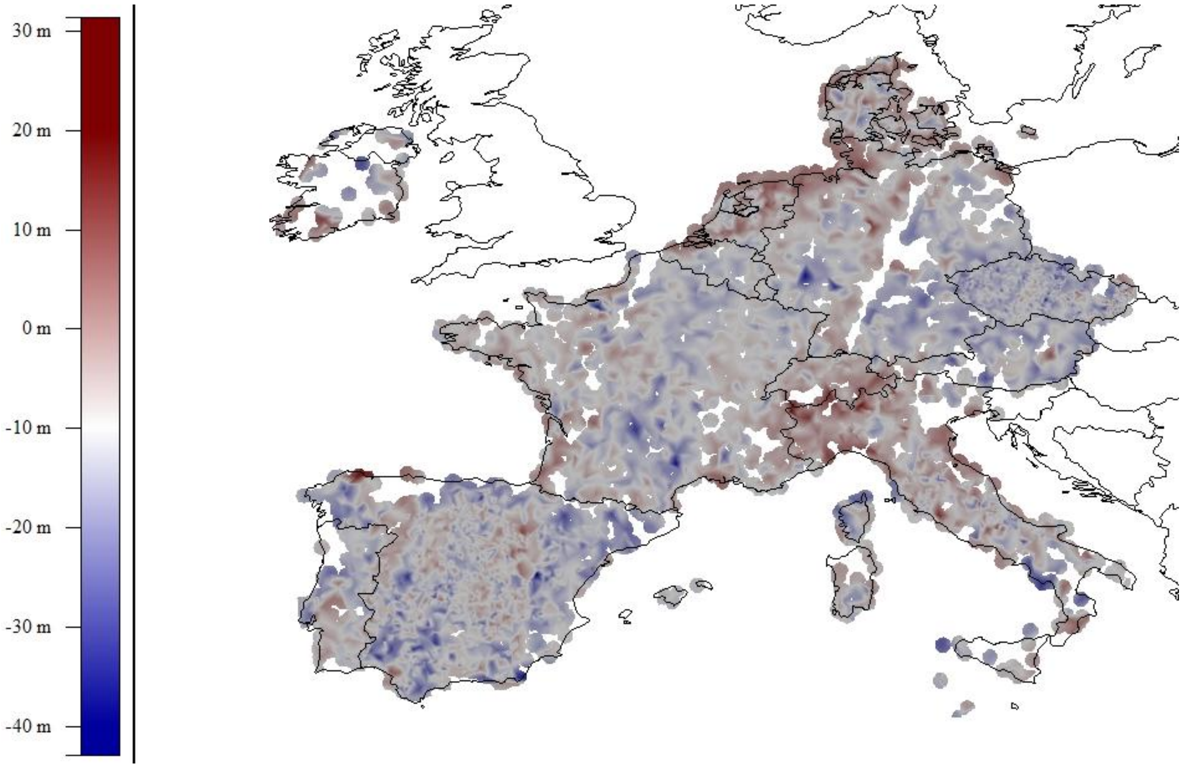


Figure 2-15. Geographic distribution of ASTER vertical bias.

The distribution of the points is shown below for reference:

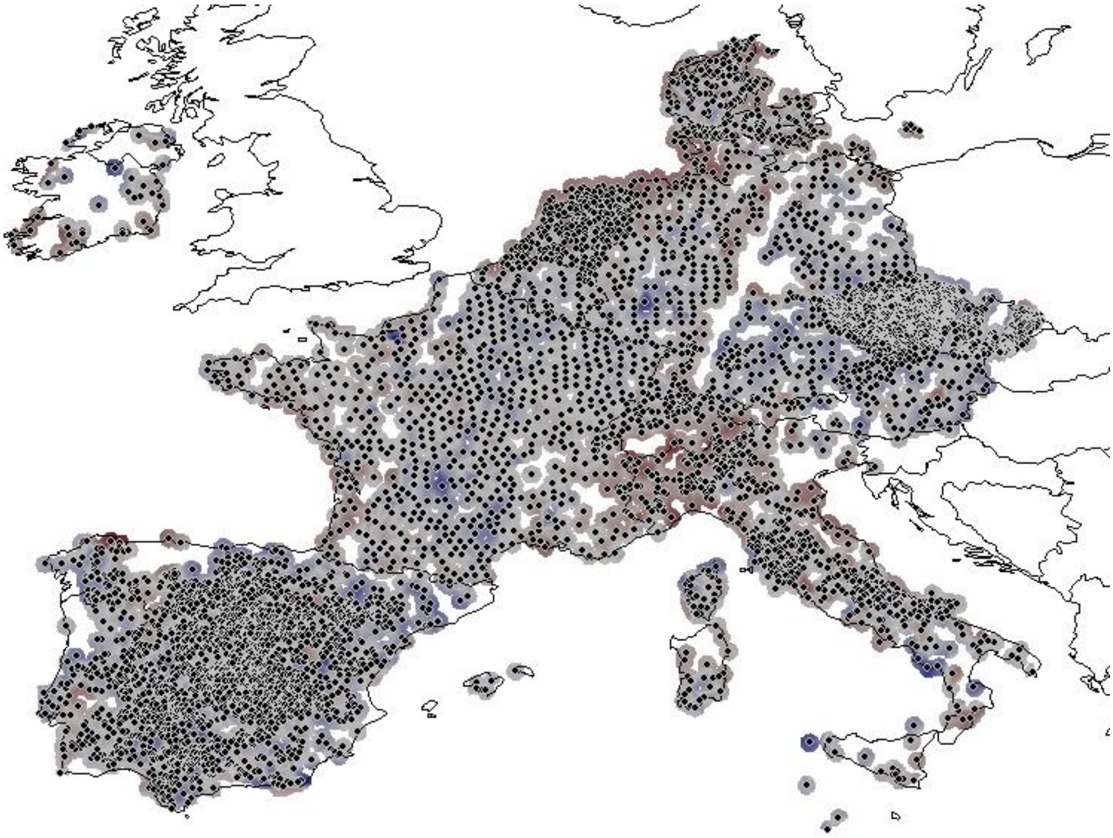


Figure 2-16. Distribution of control points.

2.10.2 SRTM vertical bias

The histogram and cumulative plot for the SRTM is shown below. They show a normal distribution in the histogram with a mean near -3m.

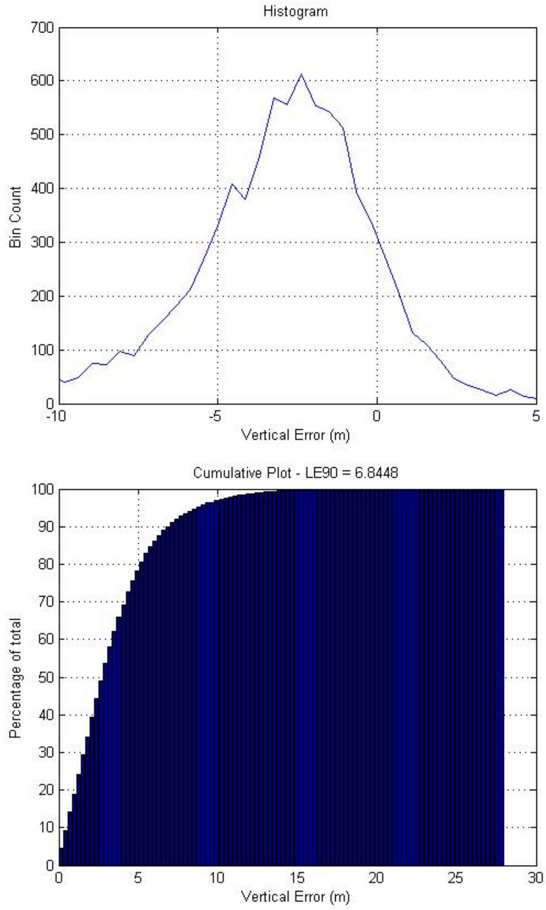


Figure 2-17. Histogram and cumulative plot for SRTM vertical bias.

The geographic plot for SRTM does not appear to have any trends that could be easily modeled. There are spots of higher and lower bias values, but it does not appear to be a model which is predictable. Note that the colour map is centered about -3m.

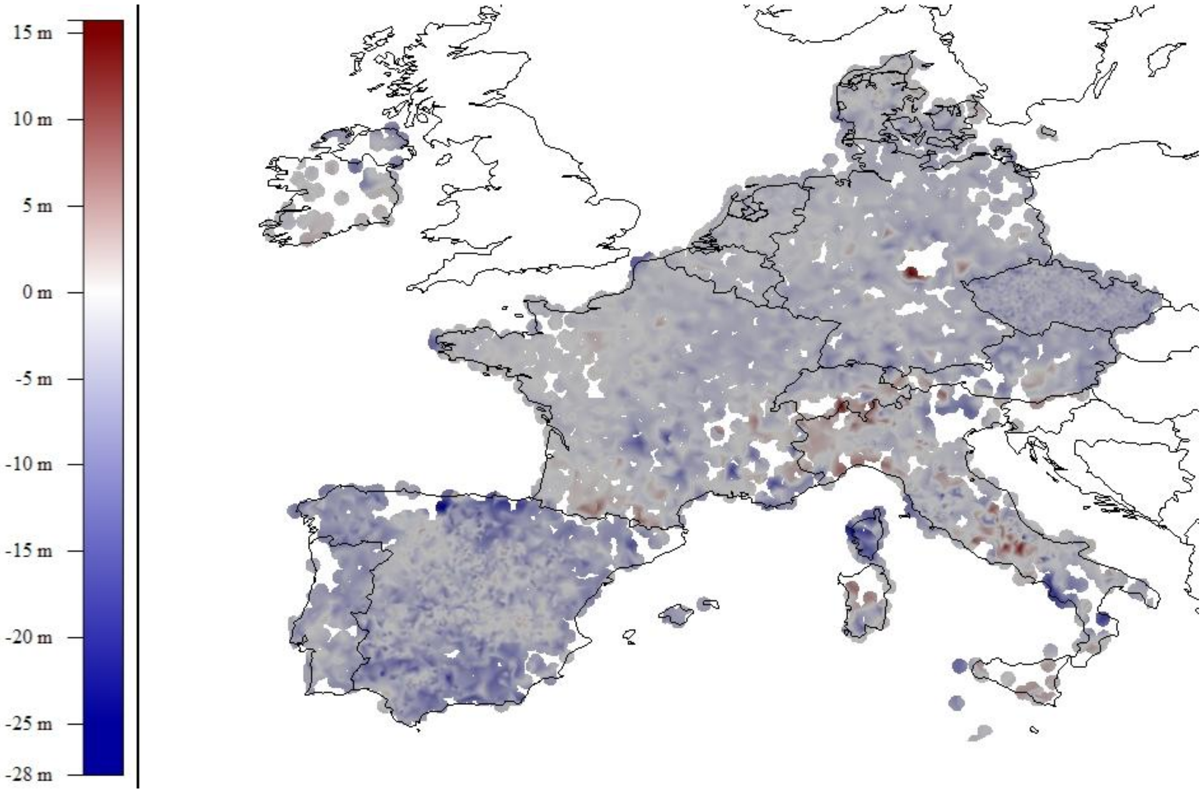


Figure 2-18.Geographic distribution of SRTM vertical bias.

Again, it is shown the VCP distribution for SRTM.

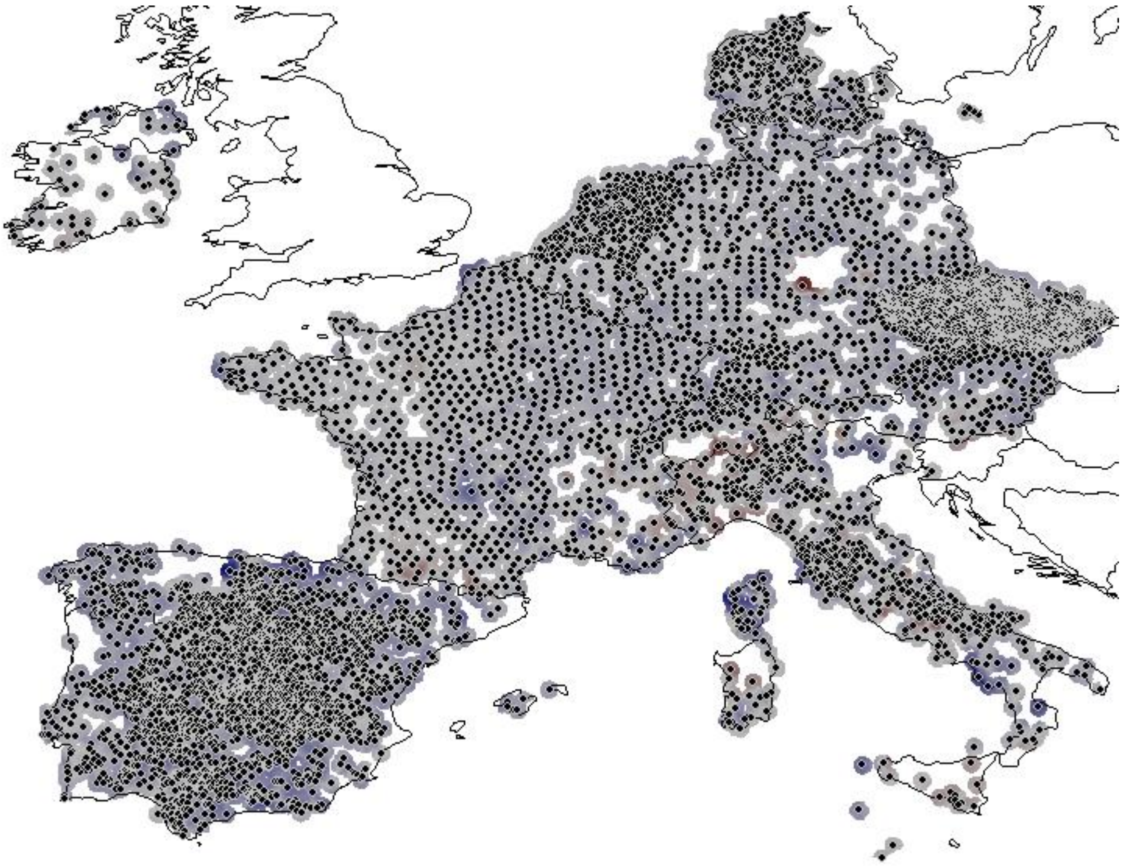


Figure 2-19. Distribution of control points.

2.10.3 Shift application

The previous sections have indicated a bias in ASTER of -10.4m and a bias in SRTM of -3.0m. These are the values applied to the data.

However, since later in the process we will be performing an adjustment of the ASTER data to match it up to SRTM (ASTER Trend Adjustment step), we only need to apply the ASTER shift on tiles where there is no SRTM data (46 tiles).

For the SRTM, the vertical bias can be applied at pretty much any point in the process, including after the hybrid has been generated, but before the water has been burnt in.

To apply the shift, the following batch script was created. It utilized existing Intermap utilities to perform the shift while keeping the void values at -10000. Although water will be shifted as well, it should not make a difference since a water mask will be used to burn in water elevations later.

Shiftelevations.bat

QUALITY CONTROL CHECK

A simple check was done on random tiles in the data set. Tiles were opened in GlobalMapper from before and after the shift and a difference surface was created to ensure it was equal to the shift value everywhere. Also, voids were checked to ensure they remained as void.

Finally, the VCP statistics were calculated again to ensure the shift was done in the correct direction.

2.11 VOID FILLING

The desire is to have a final product which is free of voids. Therefore, voids need to be filled. Wherever there is void in ASTER data, the SRTM/STS data is used to fill the voids. Additionally, some SRTM tiles may contain voids because SRTMv2.1 was used. Therefore, there is a chance that there will be areas which are void in both the ASTER and the STRM/STS data sets. In this case, interpolation will be used to fill the voids. Interpolation will also be used on tiles where there is no SRTM/STS data at all.

Additionally, for the process, the SRTM/STS tiles must all be void free. Therefore, the opposite process will be done to fill any voids found in these tiles (there should not be many). ASTER will be used to fill voids when it exists and interpolation will be used where it does not.

It is also important to note that prior to filling the voids, the area immediately surrounding the void will also be filled (2 pixels wide). This is because it has been observed that poor data is commonly found surrounding voids.

Void filling is done using Intermap's Interferometric Editing System (IES).

*NOTE: Because the SRTM was resampled to 1" pixels from 3" pixels, there was evidence of interpolation artifacts. When using this to fill voids in the ASTER, the result ends up with a rough appearance around the voids. Therefore, the SRTM was smoothed using a standard Gaussian 3x3 kernel smoothing before it was used to fill the ASTER voids.

QUALITY CONTROL CHECK

To ensure voids were filled, a simple Matlab script was written which searches all tiles for void values and writes out a text file indicating the number of void posts found within each tile. The script is attached here.

findvoids.m

This script was run before void filling to identify tiles which needed to be filled and then run again afterwards to ensure they were filled.

Also, a random sampling of tiles was opened to ensure that the void filling appeared reasonable.

2.12 ASTER TREND ADJUSTMENT

Because the SRTM vertical bias measurements showed a much tighter distribution versus the ASTER, a method was devised to bring the ASTER more in line with the SRTM in terms of vertical accuracy without sacrificing the details provided in the ASTER data. The method used was as follows:

1. Create a difference surface by subtracting the ASTER from the SRTM/STS
2. Smooth the difference surface using a large Gaussian kernel smoother
3. Add the smoothed difference surface back to the ASTER tiles

The first step was done using Intermap's rawdiff utility.

The second step was done using Intermap's IES software. This was used because it has a built in smoother with allows for adjustment of the kernel size, and it smoothes over the boundary of the tiles into the neighboring tiles to eliminate tile edge seams.

The last step was done using Intermap's rawdiff utility again, but this time Intermap's raw2raw utility was run first to negate the difference surface so it would be added rather than subtracted to the ASTER.

QUALITY CONTROL CHECK

To validate the trend adjustment process, random tiles were opened before and after the adjustment in GlobalMapper. A difference surface was created between the two surfaces and the SRTM/STS to ensure the low frequency differences were removed in the after tiles.

The following images show examples of this for tile n42e000.

NEXTMap

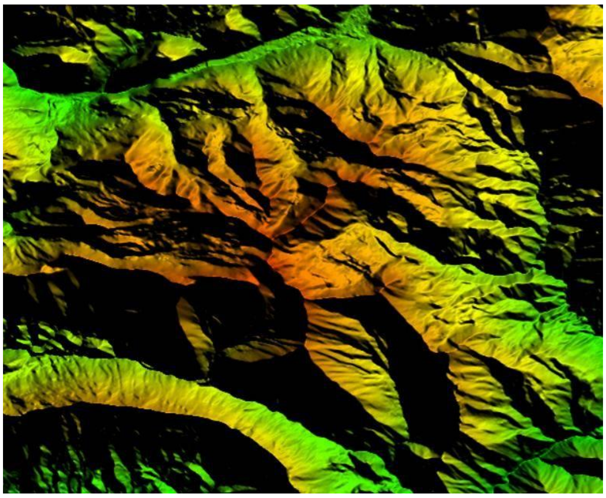


Figure 2-20. Tile n42e000, NEXTMap.

SRTM

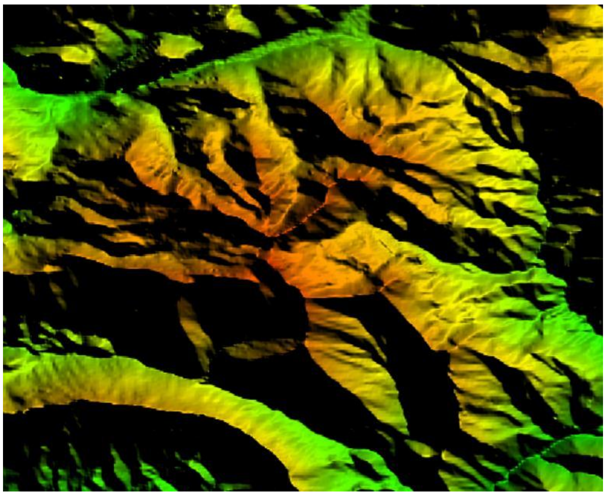


Figure 2-21. Tile n42e000, SRTM.

ASTER – Before Adjustment

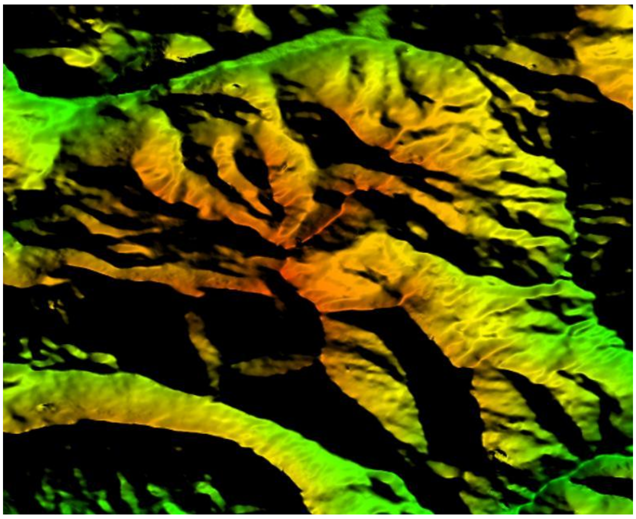


Figure 2-22. Tile n42e000, ASTER before adjustment.

ASTER – After Adjustment

Minor changes apparent in DEM, but most changes are only noticeable in the difference image.

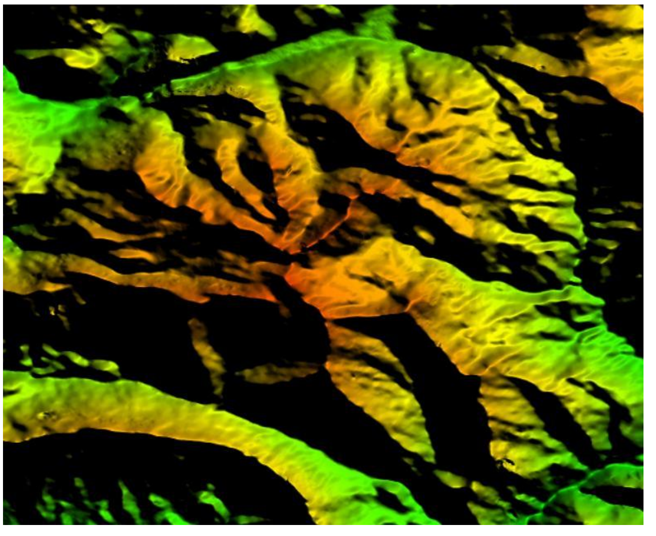


Figure 2-23. Tile n42e000, ASTER after adjustment.

SRTM - ASTER – Before Adjustment

Blue tones indicate negative values (SRTM higher) and red tones indicate positive values. Lighter tone indicates values closer to zero. The difference image indicates that the ASTER is in general lower than the SRTM.

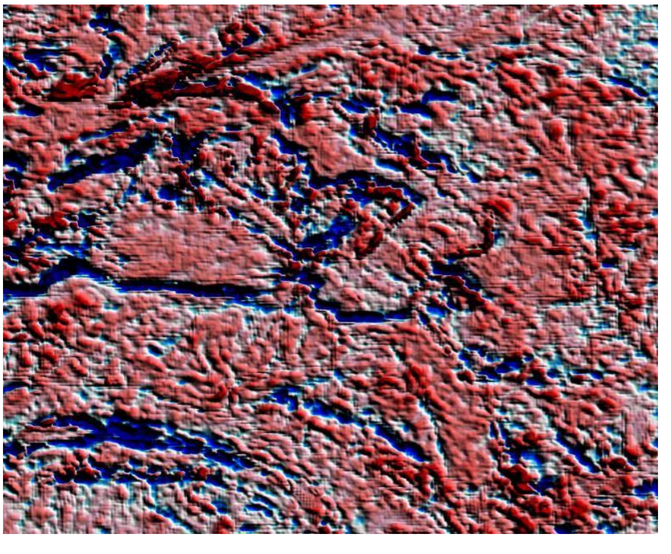


Figure 2-24. Difference image SRTM – ASTER before adjustment.

SRTM - ASTER – After Adjustment

After the adjustment there is much less difference in elevation between the SRTM and ASTER.

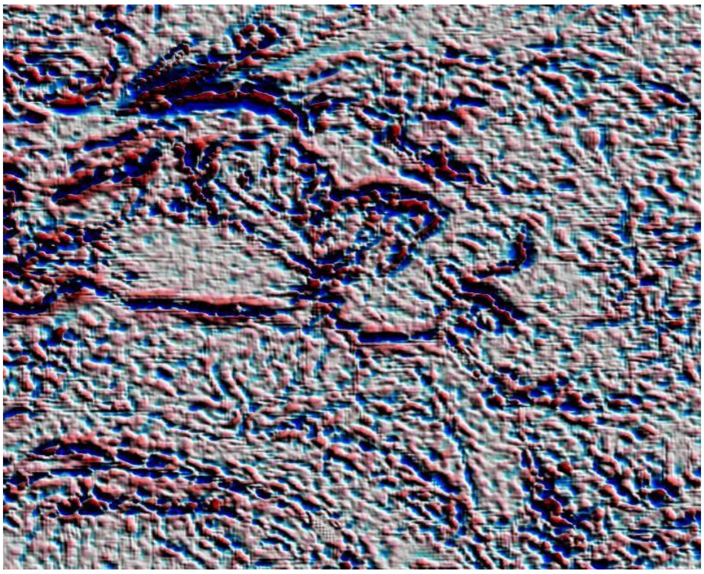


Figure 2-25. Difference image SRTM – ASTER after adjustment.

Additionally, in order to validate the theory that the ASTER is being vertically adjusted without losing terrain shape, some profiles over the terrain were created. The location of the profile is the red line below.

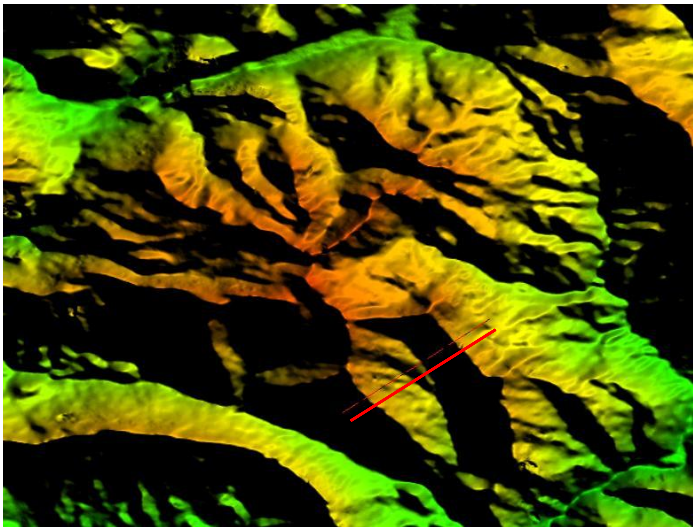


Figure 2-26. Location of profile (red line).

NEXTMap

From Pos: 0.3279839776, 42.4782676878 To Pos: 0.3672131108, 42.5033176163

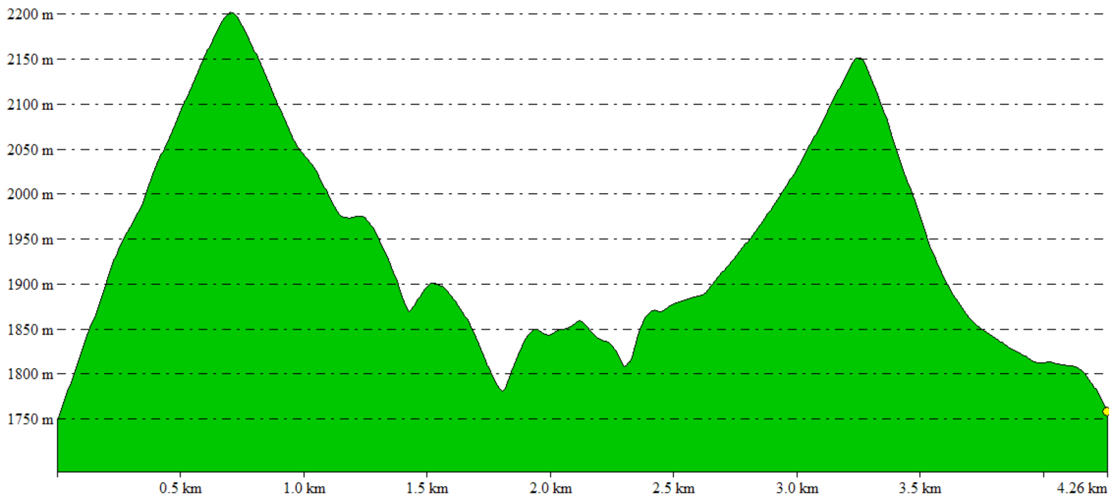


Figure 2-27. Profile in NEXTMap.

SRTM

The SRTM rounds off the peaks and valleys due to low resolution.

From Pos: 0.3279839776, 42.4782676878 To Pos: 0.3672131108, 42.5033176163

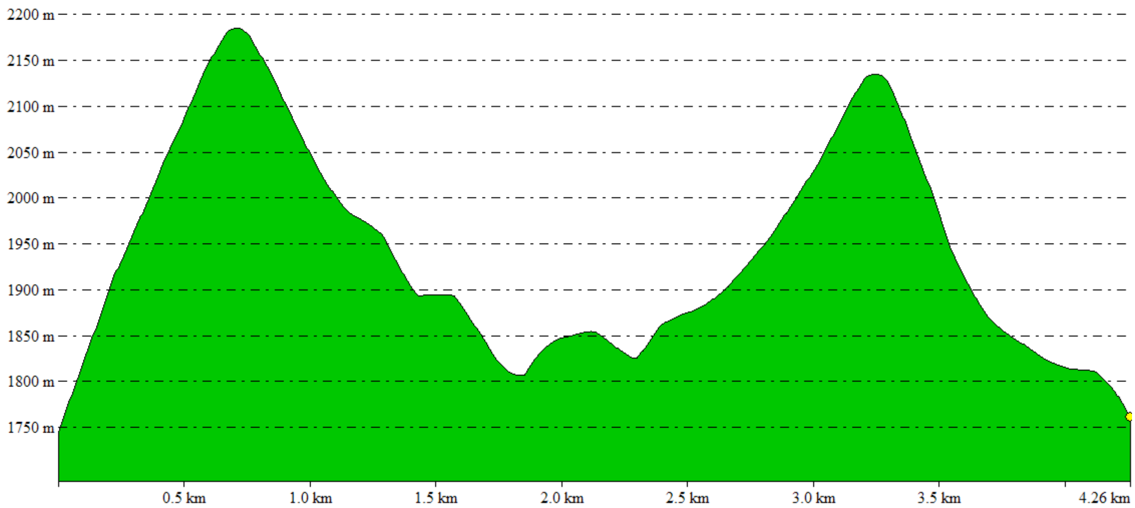


Figure 2-28. Profile in SRTM.

ASTER

The ASTER is also rounded off, but the peaks are sharper. Additionally, it is overall lower than the other two.

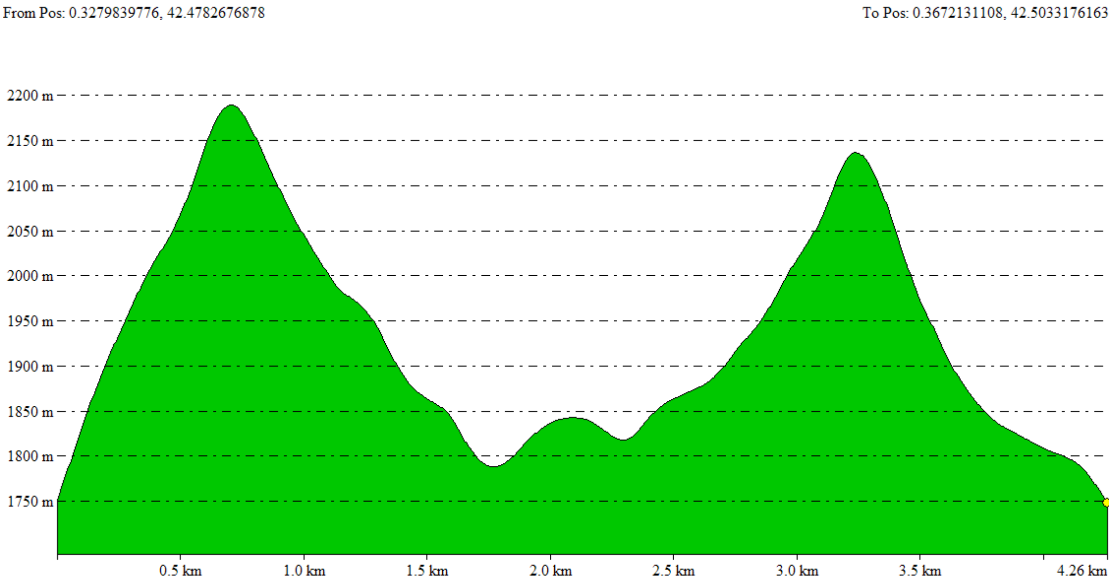


Figure 2-29. Profile in ASTER.

ASTER Adjusted

After Adjustment, the ASTER keeps its general shape, but the bias is removed.

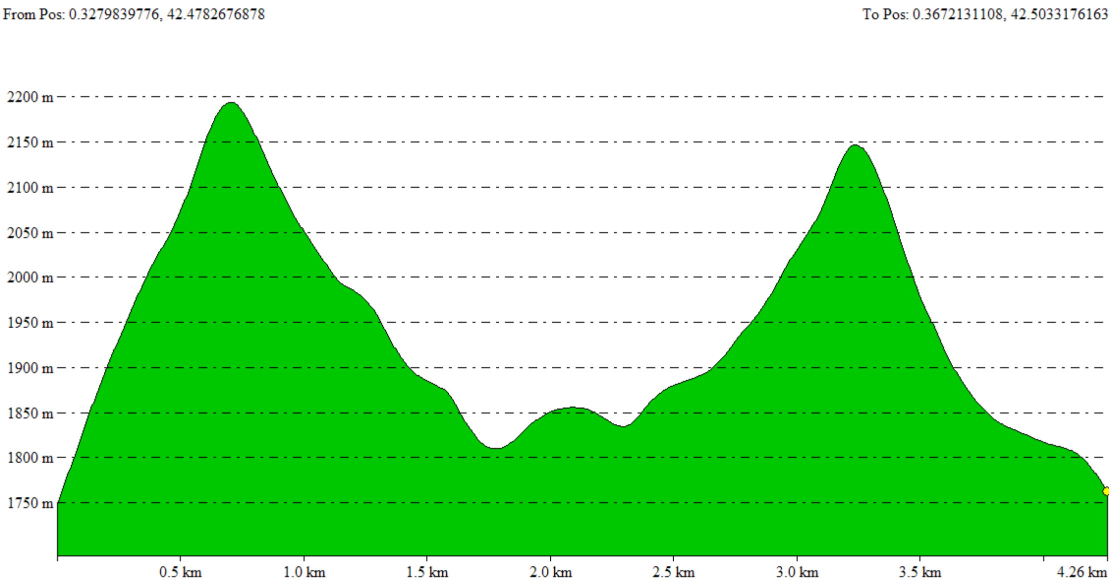


Figure 2-30. Profile in ASTER adjusted.

2.13 ASTER BLUNDER REMOVAL

Now that the ASTER is at a common height frame with the SRTM/STS, we can detect blunders in the ASTER by locating where it is different from the SRTM/STS by more than 15m. Wherever these differences are found, the ASTER is set to void. This is done using a batch script to call various Intermap utilities. The script is attached here:

Diffmask.bat

Once the blunders were voided out, the voids were filled again using the same method described in Section **¡Error! No se encuentra el origen de la referencia.**. Again, the smoothed SRTM/STS were used for void filling to reduce void boundary artifacts.

QUALITY CONTROL CHECK

To validate the blunder removal, a difference surface was created in GlobalMapper and differences greater than 15m were highlighted. The voided surface was opened in the same GlobalMapper instance to ensure voids were created in the correct locations. This was done on a random sampling of tiles.

The void filling was validated through global inspection by opening the results for random tiles in GlobalMapper to ensure the filling appeared normal, without any major artifacts introduced.

2.14 WEIGHTED AVERAGE BLENDING

The weighted average blending was done using a modified version of Intermap's DEM Merge tool created for similar means. The tool performs the blending by creating a slope map based on the ancillary tiles. Then, for all areas where the slope is very low, the ancillary data is used. For all areas with high slope, the ASTER data is used. And for all areas in between, a distance weighted average is used.

This allows us to take advantage of ASTER's detail in the high slopes, while being able to reduce the number of artifacts visible in the ASTER in low slopes.

The tool actually performs a smoothing on the slope map before applying the averaging. This is done so that the transitions between each slope level are smooth rather than jagged. This provides cleaner results in the transition areas. The single slope areas can be thought of as contours on the slope map. These contours are made smoother by performing a smoothing of the slope map.

The smoothed slope values used by the tool are 1 degrees at the low end and 5 degrees at the high end. It must be pointed out that these are not true slopes due to the smoothing. These values were arrived at by trying different parameters and performing a visual inspection to see which parameters seem to best balance keeping the ASTER detail in high slope and removing ASTER artifacts in low slope.

QUALITY CONTROL CHECK

To validate the weighted average blending, visual inspection was first used to ensure the results were acceptable in terms of expected appearance.

Then, difference surfaces were created with respect to the ASTER and SRTM/STS to ensure that there is no difference from ASTER in high slope and no difference from SRTM/STS in low slope with gradually changing differences in between.

Sample images follow:

SRTM

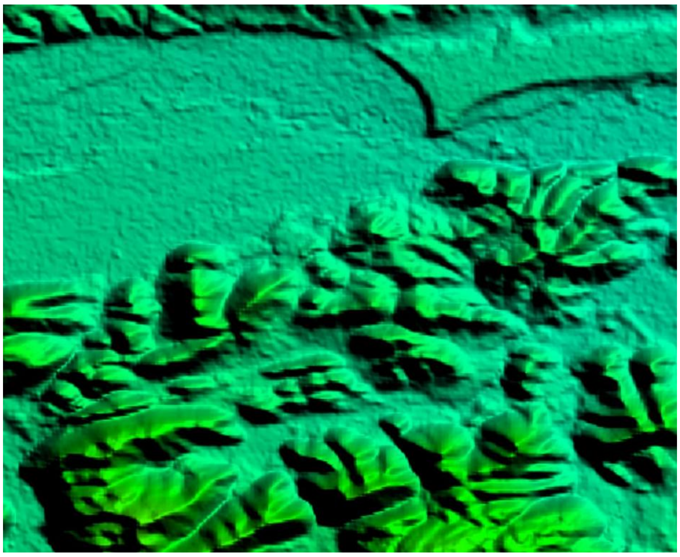


Figure 2-31. Detail of SRTM shaded relief.

ASTER

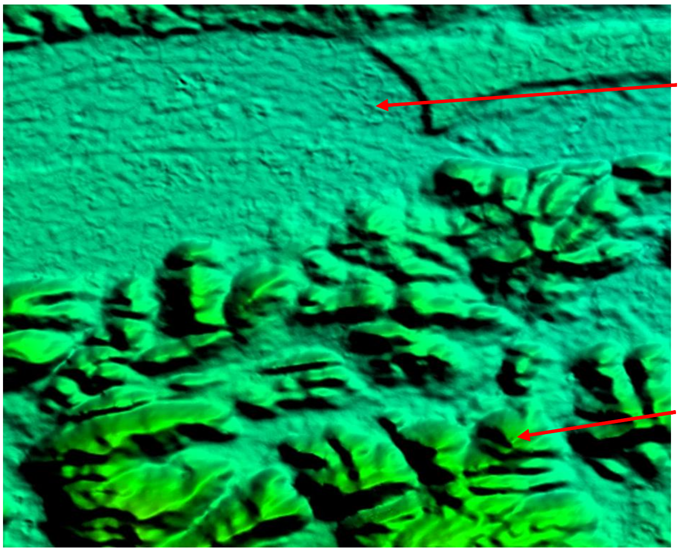


Figure 2-32. Detail of ASTER shaded relief.

BLENDED

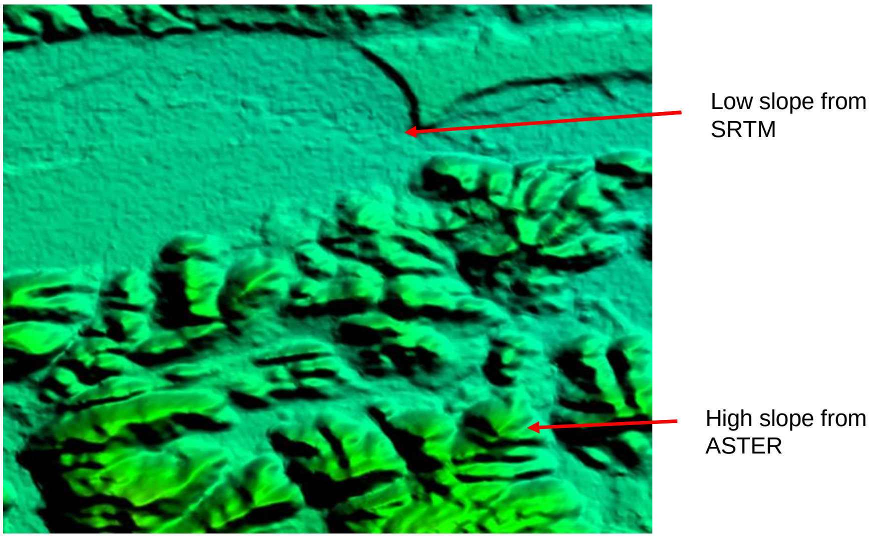


Figure 2-33. Detail of DEM shaded relief after blending.

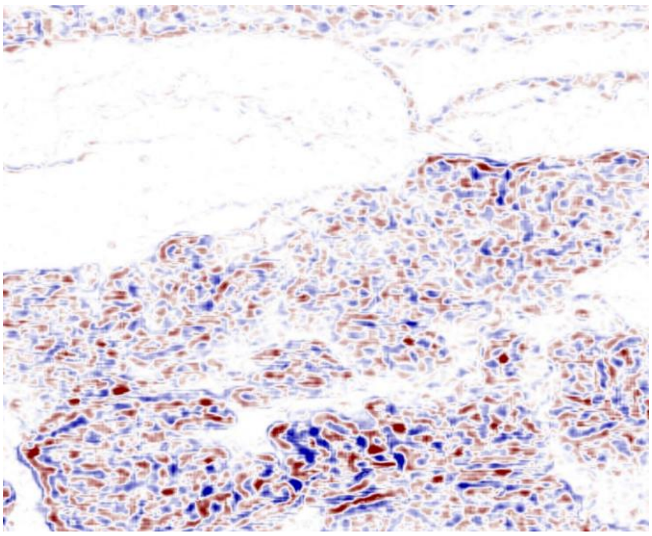


Figure 2-34. Differences all in high slope. SRTM-blended.

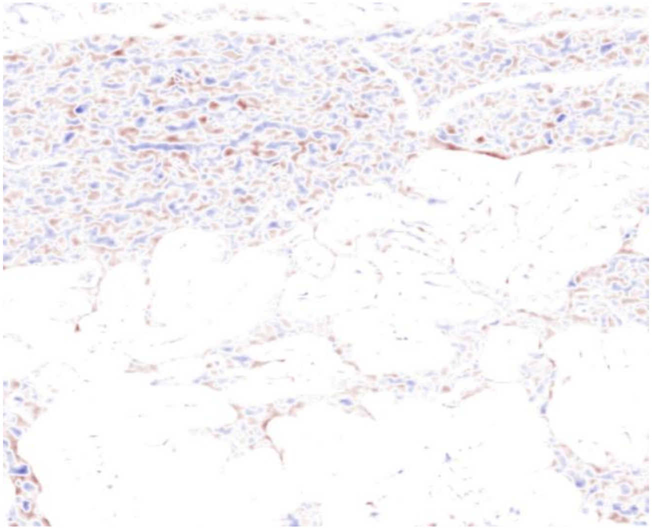


Figure 2-35. Differences all in high slope. ASTER-blended.

2.15 WATER BURN-IN

Water burn-in was done using a combination of methods.

For ocean, the elevation was set to 0.

For the lakes and reservoirs, the elevation was set to the minimum shoreline elevation so that “flooding” into the shoreline would not occur.

For rivers and canals, an Intermap standard mask file used by the IES application was created. Then, the tiles were opened in IES and the standard IES river stepping tools were used to step the rivers to create a flow in the correct direction.

QUALITY CONTROL CHECK

To validate the water burn in, the files were opened along with the water mask in order to visually inspect that the burn in took place over all water features.

Sample imagery is shown below.

Water Mask – Sample 1

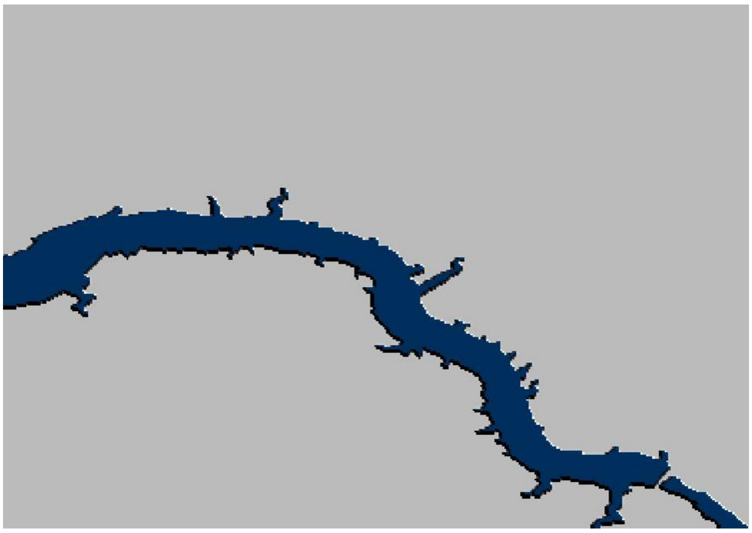


Figure 2-36. Example of water mask (sample 1).

Before Water Burn In – Sample 1

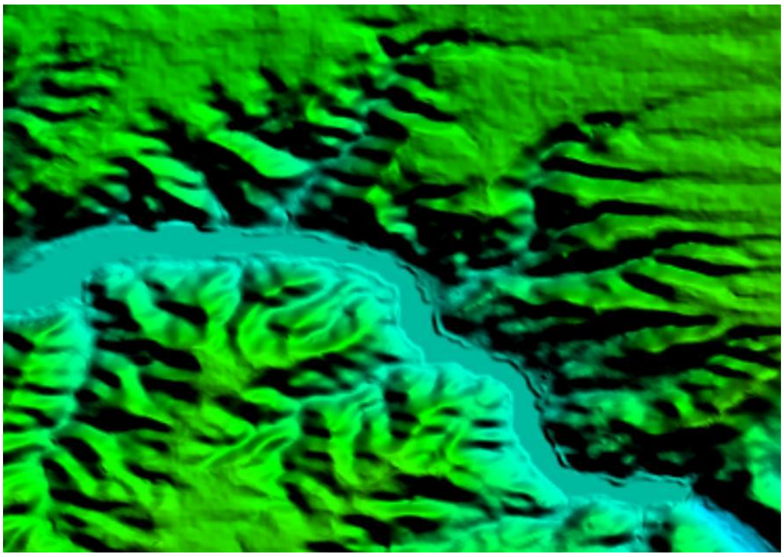


Figure 2-37. DEM before water burn-in (sample 1).

After Water Burn In – Sample 1

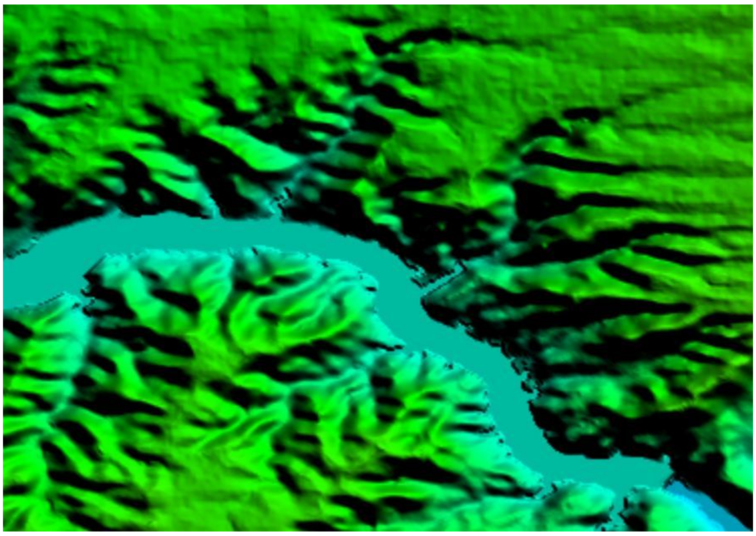


Figure 2-38. DEM after water burn-in (sample 1).

Water Mask – Sample 2

Figure 2-39. Example of water mask (sample 2).

Before Water Burn In – Sample 2

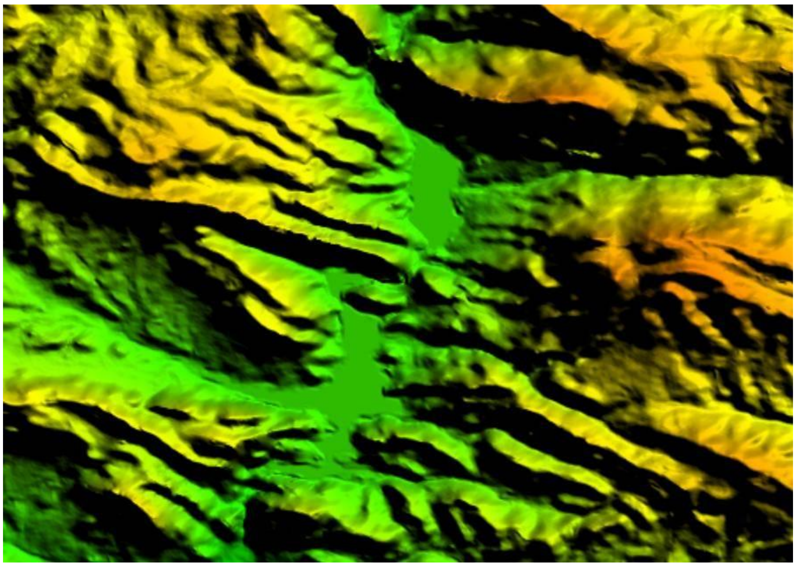


Figure 2-40. DEM before water burn-in (sample 2).

After Water Burn In – Sample 2

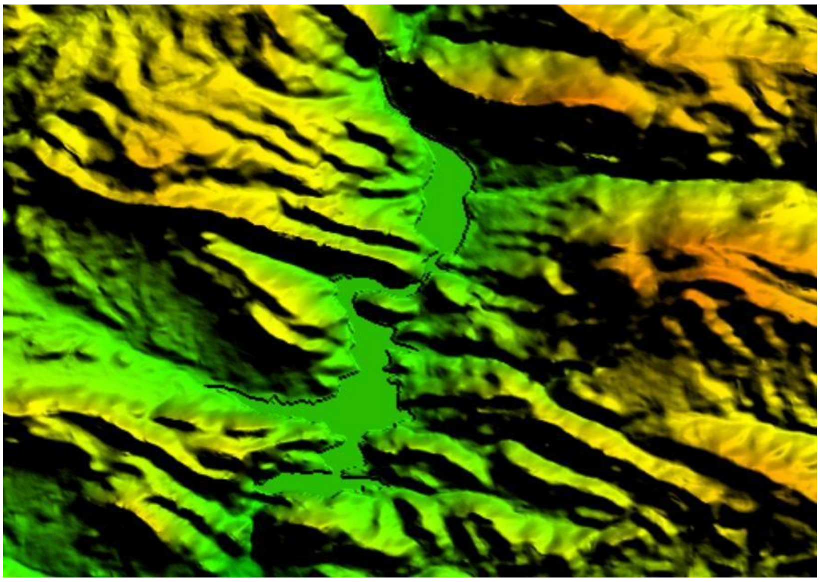


Figure 2-41. DEM after water burn-in (sample 2).

2.16 MANUAL EDITING

Manual editing in the IES environment is the final step in the process. The data is ingested into IES and made available to the editor. In 3D the editor will review the data to ensure water elevations are correct, rivers are monotonic, there are no blunders and the tile edges match. Any errors found by the editor will be fixed using tools available to them in IES. The progress of the tile will be tracked in the Data Management System Explorer (DMSe).

QUALITY CONTROL CHECK

Each tile will go through a QC and an Independent Quality Control (IQC). The QC and IQC Technicians will review the data in 3D to ensure the tile was edited to the proper specification. Any rework found by the QC or IQC technician will be done in IES.

Each tile will also go through Automatic Check in the IES Job Controller. Job Control will check that lakes are flat, rivers are monotonic, oceans are set to 0, water is 10 cm below the land shoreline and the tiles edges match. Any automatic errors will be reviewed by the technician and fixed if needed in IES.

Notes:

1. One DEM post equals 2 arc seconds (~30m).
2. DEM data is a combination of Aster and SRTM data.
3. The water mask has already been produced and lakes/ocean are automatically flattened.
4. Please contact Assistant Production Manager (APM)/Production Manager if you come across issues or problems.
5. Set monotonicity tool parameter step height to " = 0.5 (default = 0.1).

Basic Editing Instructions:

1. Check all water bodies.
2. Do not modify classification (except locks/embankments/edges that may cut-off water bodies).
3. Check and fix all blunders.
4. Please refer to classification mask not the imagery.
5. If there is an island within a water body and it has same elevation as water body, raise the island to 1 m above the water body elevation.

General Work Instructions:

1. Open your tile in IES, reviewing the DSMe to determine which tile to edit.
2. Check for "Unknown" (0) class.
    a. Change Unknown" (0) Classification to Bald (34) Classification. The Unknown class causes improper water network placement after the "Water Network" tool is run. The Shoreline tool cannot be run on Unknown Classification.
3. Review all blunders, if you find any review the area in Google Earth. Fix any valid blunder.

4. Check the River Classification, but do not flatten the elevations. Run Water Network tool.
    a. Review Water Control Points (WCPS). Change any improper WCPs before running Monotonicity tool ("step height" = 0.5). Recheck river elevations after monotonicity is run.
    b. River elevations cannot be negative unless flowing into a negative lake. Lakes can be lower than zero if the surrounding terrain is negative.
    c. If the river steps are too rapidly and the you cannot step it to 50 cm, capture and report it to the APM.
5. Most of the time the water bodies at the edge of the tile do not go to the edge of the tile. Fix any water bodies to insure edges match.
6. Make sure lakes/rivers are set to one decimal place (e.g. 123.4 not 123.42). If you review the water body in the color water flow display you will not be able to tell if a lake is set to different elevations if the elevation is not set to one decimal place.
7. Review shaded relief for water bodies that are digging or floating. Fix if needed.
8. Some rivers have been classified as lakes. Please set to river and step it properly.
9. Beware of locks/embankments in water bodies. If you come across one review area in Google Earth. If you find any that are not set to land, please fix by:
    a. Classify lock/embankment as "Bald". If embankment is too low use Unprojected Hill Top (6002) vector to raise the elevation.
10. Check entire DEM edge to make sure the tile edge matches with the adjacent tile edges.
11. Use Pull Tool to pull all water bodies to the DTM so, to avoid rejection in Job Control.
12. Run Fix Shoreline, WBV, and G1 tools. Then check the error points and fix any valid error.
13. Import final DSM/DTM the adjacent tile which already edited (higher state/master tile)
    a. Open all surrounding tiles to review the edge.
14. Complete tile and run through job control.
15. Fix any valid errors from job control.
16. The tile is now ready for QC and IQC.

3. EU-HYDRO

3.1 PRODUCTION ENVIRONMENT FOR POLYGON FEATURES AND OVERVIEW OF WORKFLOW

The production environment implemented for the production of the EU-HYDRO database presents the following features:

- **True 64-bit environment** (HW / OS / SW) – Ubuntu Linux 10.04 LTS
- **Parallel computing** workflow – Linux / GRASS / GDAL scripts (no commercial SW involved, complete utilization of HW resources
- **Runs on a Linux server** – No graphical interface required
- **High level of automation** – “robotic behaviour” of scripts with complete elimination of human interference
- **High level of flexibility** – easy to modify the scripts and adapt them to a certain working environment, as well as include algorithms for other land cover classes.
- **High level of performance** – All images of IMAGE2006 processed in approximately 100 hours on 4C Linux WS with 8 Gb RAM and 5 Tb storage.
- **Multi-user RDBMS** (PosqtgreSQL/PostGIS) is used as database container for the production team and SDI interfaces.
- **FOSS GIS software** (Quantum GIS, GRASS GIS) used by the production team.

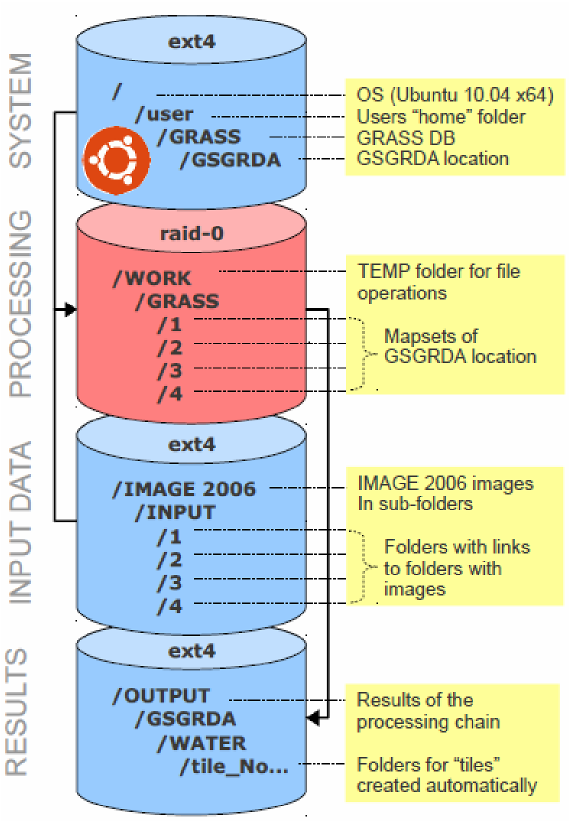


Figure 3-1. Overview of processing environment for polygon features.

The following figures describe the workflow and the different stages of the EU-DEM production:

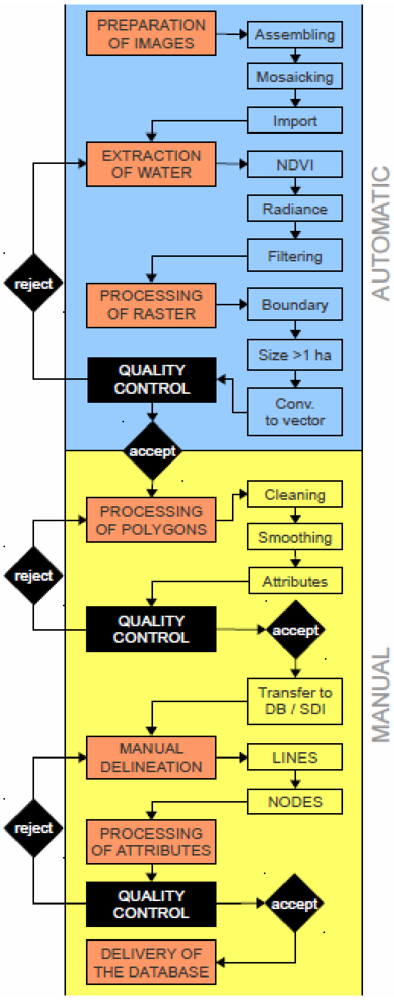


Figure 3-2. Overview of EU-HYDRO production workflow (water polygons, lines and nodes)

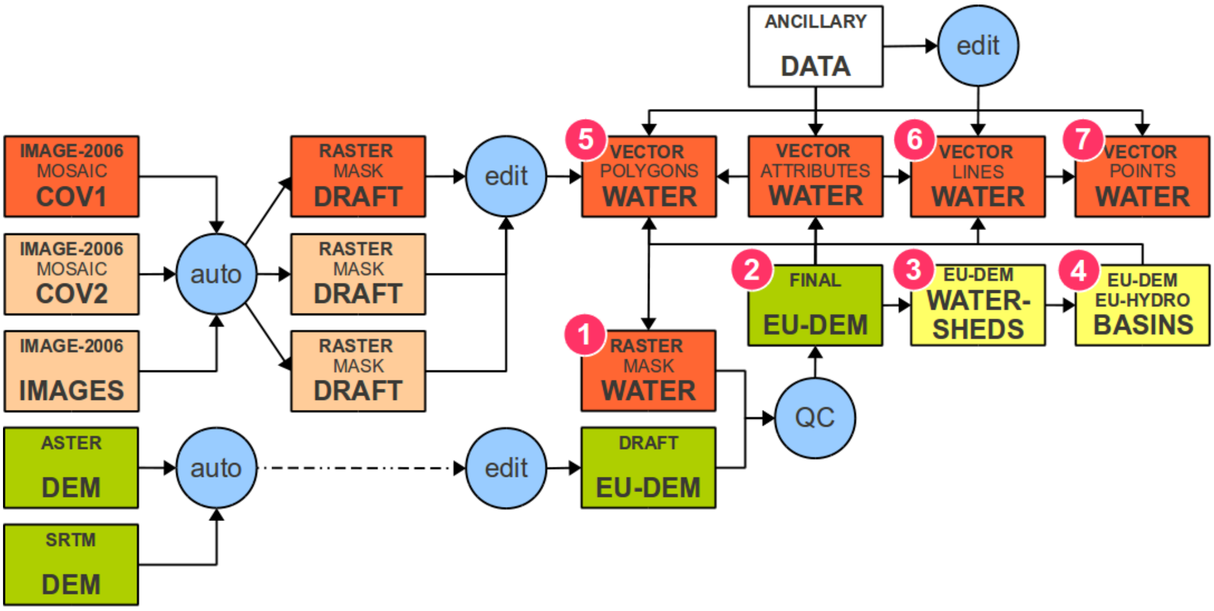
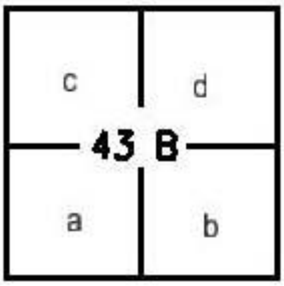


Figure 3-3. General work sequence for the production of EU-HYDRO

3.2 PROCESSING OF SPACE IMAGERY

Space imagery is the main data source for the creation of geometric features, for both lines and polygons. This section provides a comprehensive list of the sequence of operation steps carried out in this part of the work flow.

1. **ARC:** Creation of composites **COV1** (spring images) and **COV2** (autumn images) from imagery from IMAGE2006.
2. **ARC:** Transformation of composites COV1 and COV2 to production coordinate system **ETRS89_LAEA** and **GeoTIFF** format.
3. **ARC:** Subdivision of composites COV1 and COV2 into quarters, conversion into **TIFF** format and compressing into **GZ** archives (sample for naming of archive ***02DB_2006_COV1_MAX1234.tif.gz***). Compressed archives are placed on server, main directory **Gsrv-orto/ARC-laikinas/IMG2006_MOS_ABCD**:
   a. Colour images – subdirectory IMG
   b. Panchromatic images - subdirectory PCS
   c. Subdirectories IMG and PCS have identic inside structure: subdirectories **COV1** and **COV2**, which are subdivided into subdirectories named by **quarters** (sample 02D), where are placed GZ archives of compresszed images.



Subdivision of composites into quarters

Figure 3-4. Subdivision of composites into quarters.

3.3 PROCESSING OF POLYGONS FEATURES OF HYDROGRAPHY

4. **ARC**: **Automated processing** of composites COV1 and COV2 to produce all polygon features of hydrography. Vector data are placed in **SHP** format onto server, main directory **Gsrv-orto/ARC-laikinas/WATER_TILES:**
    a. Subdirectories **COV1** and **COV2**, which are subdivided into subdirectories named by **quarters** (sample 02D), where vector data are placed. Raster data, used for vector extraction, is placed here too. Sample for naming of directory: ***10DD_2006_COV1_MAX1234_water_mask.****
5. **ARC**: **Self-control** for creation of polygon features of hydrography:
    a. Are all data created?
    b. Are data named properly and placed into proper directories?
    c. If YES – informing **FS** about data as ready for further processing
6. **PD: Control** for creation of polygon features of hydrography:
    a. Are all data created?
    b. Are data named properly and placed into proper directories?
    c. If YES – informing **GIS** about data ready for smoothing of plygon borders
7. **GIS**: Smoothing of vector data of polygon features of hydrography. Processed data are placed in **SHP** format onto server, main directory **Gsrv-D/FS-F/EURO_HIDRO**:
    a. Subdirectories **COV1** and **COV2**, which are subdivided into subdirectories named by **quarters** (sample 02D), where vector data are placed. Sample for naming of directory: ***21DA_REZ.****
8. **GIS**: **Self-control** for smoothing of polygon features of hydrography:
    a. Are all data created?
    b. Are data named properly and placed into proper directories?

9. **GIS**: Search and deleting of polygon features of hydrography, smaller than minimal size. After deleting – informing **FS** about data as ready for further processing.
10. **PD: control** for smoothing of polygon features of hydrography:
    a. Are all data created?
    b. Are data named properly and placed into proper directories?
    c. If YES – data are distributed in **FS** for analysis and editing.
11. **PD:** Operators copy onto local computers data from directories **Gsrv-orto/ARC-laikinas/IMG2006_MOS_ABCD and Gsrv-D/FS-F/EURO_HIDRO**
12. **PD:** Operators visually estimate quality of compostes COV1 and COV2 for clouds and make decission which composite will be used as main. Analysis and editing of data:
    a. Elimination of clouds, flood waters and other non-hydrographics objects.
    b. Polygon features of hydroghaphy are classified into layers (using ***HIDRO_SHAPEFILE*** template):
        i. WATER_BODIES
        ii. RESERVOIRS
        iii. RIVERS_NETWORK_P
        iv. CANALS
        v. SEAS
        vi. DITCHES
    c. Editing of small hydrographic features placed on one linear hydrographic feature:
        i. If after merging these small objects, common object will be less than 3km in length – small polygon features are deleted; in longer than 3km – small polygon features are merged into one polygon feature.
        ii. If a small polygon feature is close neighbour to a big one – they are merged.
    d. Attribute table for polygon features of hydrography is filled as much as possible during classification and editing
    e. **ECRINS** water body data are transferred into EU-HYDRO database when attributes need to be identical (e.g. Lake_ID), otherwise equivalent fields are filled according to ECRINS' coding rules.
    f. **ERM water bodies integration**: Link tables (inland_water_t, river_network_p_t) are created linking feature Ids from both layers by spatial assignation. Quality check is performed to assure this automatic operation has been completed and the table created.
    g. Edited data are placed in **SHP** format into directory **Gsrv-D/FS-F/EURO_HIDRO,** subdirectory **PO_SMOOTH_TIKRINIMUI**, where data is separated according to cell and quarter numbers.

13. **PD: Preliminary control of topology + attributes and editing** of data by control specialists, informing of **GIS** for complex automated data control (according to what is specified in document GSGRDA-PLN-8100-02-IE).
14. **GIS**: Additional field **STATUS** (int, initial value 0) is added to database tables. **Complex automated data control** for topology and attributes, search for duplicate elements. Status of control indicated in field STATUS :
    a. 0 – data correct
    b. 1 – attribute error
    c. 2 – topology error
    d. 3 – attribute and topology error
    e. 4 – duplicated polygon elements
15. **GIS**: Data with errors are saved in **SHP** format in directory **Gsrv-D/FS-F/EURO_HIDRO/PO_SMOOTH_TIKRINIMUI**, subdirectories for cells and quarters.
16. **GIS**: **Self-control** of complex automated control of **topology and attributes** of polygon features of hydrography:
    a. Are all data checked?
    b. Are data named properly and placed into proper directories?
    c. If YES – **FS** is informed about data as ready for further processing.
17. **PD:** Operators provide editing of erroneous data and return data back to GIS for automated complex control (p. 14-16)
18. **PD:** After all topology and attribute errors are eliminated (field STATUS=0 for all objects), data is placed into directory **Gsrv-D/FS-F/EURO_HIDRO**, subdirectory **PO_SMOOTH_PATAISYTI**, subdirectories for cells and quarters. FS control specialists are informed about finalization of data capture and editing.
19. **PD:** Control specialists provide ***20% control of polygon features of hydrography***, results are fixed in control sheet and errors are ridentified in field STATUS:
    a. 0 – data correct
    b. 1 – attribute error
    c. 2 – topology error
    d. 3 – attribute and topology error
20. **PD:** If unacceptible errors are detected – data is returned back to production team for analysis and editing, repeating procedures p.14-19. Final data is placed into server directory **Gsrv-D/FS-F/EURO_HIDRO** subdirectory **EURO_PLOTAI_BAIGTI**, subdirectories for cells and quarters with **self-control**:
    a. Are all data finished?
    b. Are data named properly and placed into proper directories?
    c. If YES – **GIS** is informed to add polygon vector data to **PostGIS** database

21. **GIS**: Polygon vector data is added to **PostGIS** database with **self-control:** is data added properly?

3.4 CREATION OF RASTER MASKS

22. **ARC**: Processing vector data of polygon features of hydrography from directory **Gsrv-D/FS-F/EURO_HIDRO/EURO_PLOTAI_BAIGTI** :
    a. Data is copied into local computer and merged into continuous territories
    b. Additional technical field **CODE** (int) is added to database and automatically filled using value of DFDD field:
        i. 0 – land;
        ii. 1 – lakes;
        iii. 2 – water reservoirs;
        iv. 3 – rivers (polygons);
        v. 4 – canals (polygons);
        vi. 5 – sea/ocean
23. **ARC**: *Ad-hoc* GRASS GIS automated data processing script is used to generate 1x1 degree 8-bit 25m resolution raster images from merged vector data of polygon features of hydrography. Images are transformed into geographic co-ordinate system (**WGS84**) **with** shift of raster corners to centers of pixels. Raster images after self-control (is data correct and full) is sent (by e-mail or via FTP) to Project partners (Intermap and Indra) to be used for callibration of EU-DEM.
24. **ARC**: *Ad-hoc* GRASS GIS automated data processing script is used to generate 250x250km 8-bit 25m resolution raster images from merged vector data of polygon features of hydrography. Images are transformed into geographic co-ordinate system (**ETRS_LAEA**) **without** shift of raster corners from centers of pixels. Raster images after self-control (is data correct and full) is sent (by e-mail or via FTP) to Project partners (Intermap and Indra).

3.5 PROCESSING OF LINE AND POINT FEATURES

25. **PD**: **Interpretation/delineation** and self-control by operators of line features of hydrography using composites and reference material into PostGIS database.

    Line density: In order to provide an appropriate and heterogeneous line density for the work scale, ECRINS has been identified as the most homogeneous data source, as it is a drainage network directly extracted from a DEM. Thus, delineation work will use ECRINS as reference for the **identification** (not delineation) of what actual water courses must be included in the data base. On top of that, ERM lines and topomaps will also be used as visual reference for the location of other water courses that may be missing in ECRINS, but visible on the imagery. High resolution imagery, such as that provided by GoogleEarth will also be used as auxilliary information in a dualwindow environment. NextMap (high resolution) elevation information will also be used as reference data used as hillshade images.

Delineation will take IMAGE2006 as spatial reference. Those water courses that may not be clearly visible in IMAGE2006, but are present in ECRINS will be confirmed using some of the above mentioned data, but delineated over the imagery using a best-guess approach interpreting the auxiliary data.

26. **PD**: Attribute filling. Some attributes will be filled as production/digitising operations are taking place (e.g. ECRINS names). Most of them will be filled automatically once the geometric features dataset is complete.
27. **GIS**: Checking and cleaning of database from duplicates, merging of short polylines, division of long polylines into segments <5km, etc, according to quality control specifications described in document GSGRDA-PLN-8100-02-IE.
28. **ERM line features integration**: Link tables (river_network_l_t, Dams_t) are created linking feature Ids from both layers by spatial assignation. Quality check is performed to assure this automatic operation has been completed and the table created.
29. **PD**: Adding of nodes, partial attributing (as *catchments are not produced until the DEM is finished*) of line and point features of hydrography, self-control by operators.
30. **GIS**: Control of database – topology and pre-defined attributes. Reporting to **PD** for data improvements. Repeating points 26-27 until data satisfies QC standards.

3.6 PROCESSING OF CATCHMENTS, FINALISATION OF POLYGON, LINE AND POINT FEATURES

31. **ARC**: Creation and self-control of polygons of catchments, after EU-DEM is finished.
32. **PD**: Attributing of polygons of catchments, final attributing of line and point features (*based on catchments*)
33. **GIS**: Control of database – topology and pre-defined attributes. Reporting to **FS** for data improvements. Repeating p.32-33 until data is clean.
34. **PD**: Control specialists provide ***20% control of polygon features of hydrography***, results are fixed in control sheet and errors are identified in field STATUS:
    a. 0 – data correct
    b. 1 – attribute error
    c. 2 – topology error
    d. 3 – attribute and topology error
35. **PD**: If unacceptible errors are detected – data is returned back to production team for analysis and editing, repeating procedures p.27-33.

3.7 GENERAL REMARKS ON QC

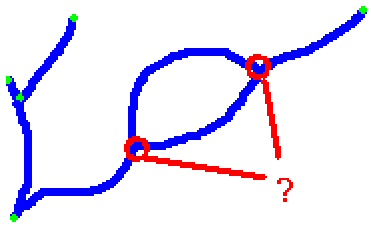
Although document GSGRDA-PLN-8100-02-IE describes QC procedures in detail, here is provided a summary of the most important quality issues to be checked, as part of the production process.

3.7.1 Polylines

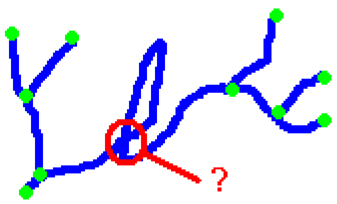
3.7.1.1 Topology

The following topological features will be checked:

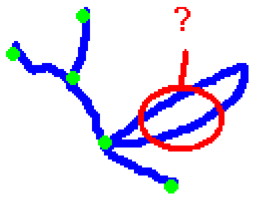
- Null length polylines: Null length polylines have no length but still remain in the dataset (typical error in ArcGIS geodatabase)
- Multipart polylines: Those composed of more than one polyline and are invalid network elements.



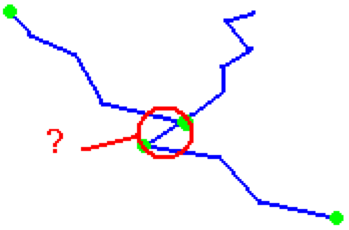
- Self-intersecting polylines: When a polyline crosses itself.



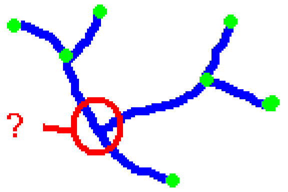
- Closed polylines: Polylines that start and end at the same point.



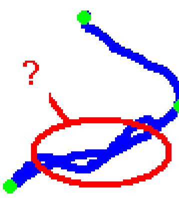
- Small lines composed of 2 vertices smaller than a given distance: Small polylines composed of only two vertices may be errors.



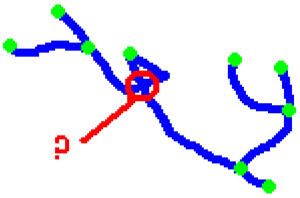
- Disconnected polylines: Those polylines that intersect another one but not a node, thus disrupting the connectivity of the network.



- Doubled-digitised polylines: Typical digitising error or external data integration.

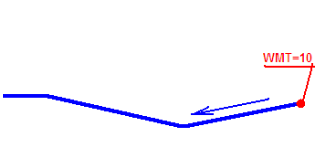
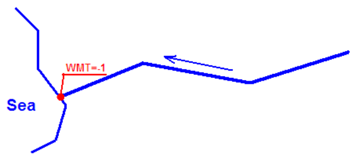
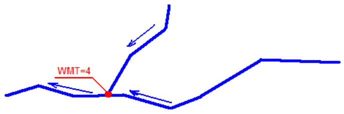
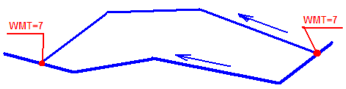
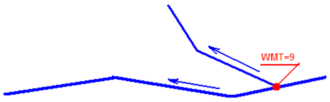
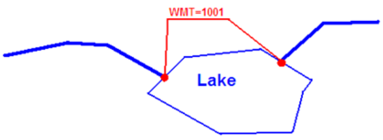
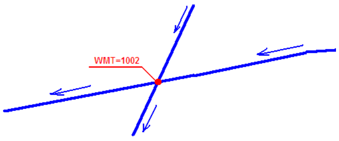
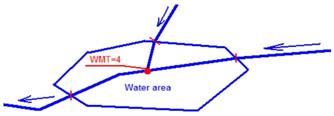
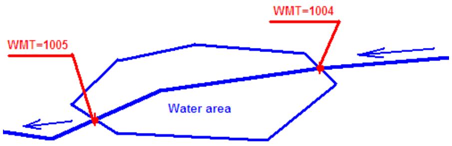


- Intersecting polylines: Polylines should only intersect at nodes.



3.7.2 Nodes

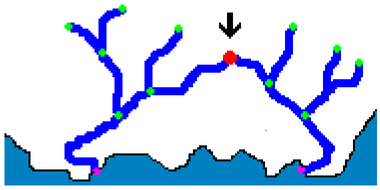
Visual control for appropriate nodes

<table>
<tr>
<td>Headwaters WMT=10
</td>
<td>Mouth WMT=1
</td>
<td>Confluence WMT=4
</td>
</tr>
<tr>
<td>Anabranch WMT=7
</td>
<td>Distributary WMT=9
</td>
<td>River Segment WMT=1000
</td>
</tr>
<tr>
<td>Endoreic system WMT=1001
</td>
<td>Hydrographic features on different levels WMT=1002
</td>
<td>Linear network must intersect on center-lines of watercourses
</td>
</tr>
<tr>
<td>If watercourse crosses water area feature – segmentation on cross-point of polygon and line by nodes
</td>
<td></td>
<td></td>
</tr>
</table>

3.7.2.1 Topology

The following topological features will be checked:

- Sources within network: Nodes within the network that are acting as sources for more than one catchment.



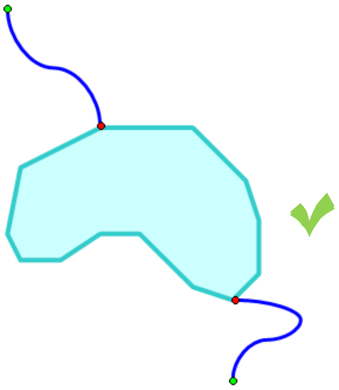
- Lines will not have pseudo nodes.

3.7.3 Integration of polygons, polylines and nodes

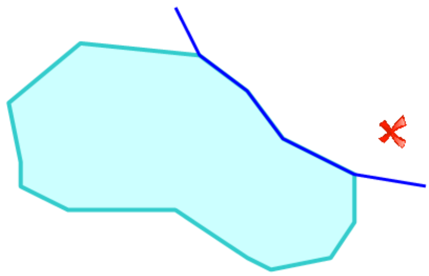
3.7.3.1 Topology

The following topological features will be checked:

- End or start line nodes will snap the boundary of water bodies when streams end or start at water bodies.



- Lines will not be tangent to water bodies.



- Lines will not cross water bodies unless they are the centre line of them.
- Nodes will always snap lines and water body boundaries if they are inlets or outlets.

3.7.4 Attributes

Attributes will be checked for:

- Completeness: All those mandatory fields must be filled.
- Value correctness: Those fields with fixed ranges of values or discrete concrete values will be checked for correctness. However, to avoid this type of error, the database is designed to work with value domains for such fields, so that values not considered to be correct can not be entered.
- Coding specification correctness: Those fields which values are coded in a particular way (e.g. most IDs in ECRINS) will be checked for correctness.
- Attribute integration: Those attributes that must be integrated directly from ECRINS (e.g. River_ID) will be checked by spatially linking those attributed features from ECRINS with the corresponding ones from EU-HYDRO. In this way, table records will be easily compared and inconsistencies, omissions and commissions found, and therefore corrected.

4. PRODUCTION STATUS

4.1 EU-DEM

At the date, they have been delivered 717 tiles of EUDEM covering the area shown in the following figure.

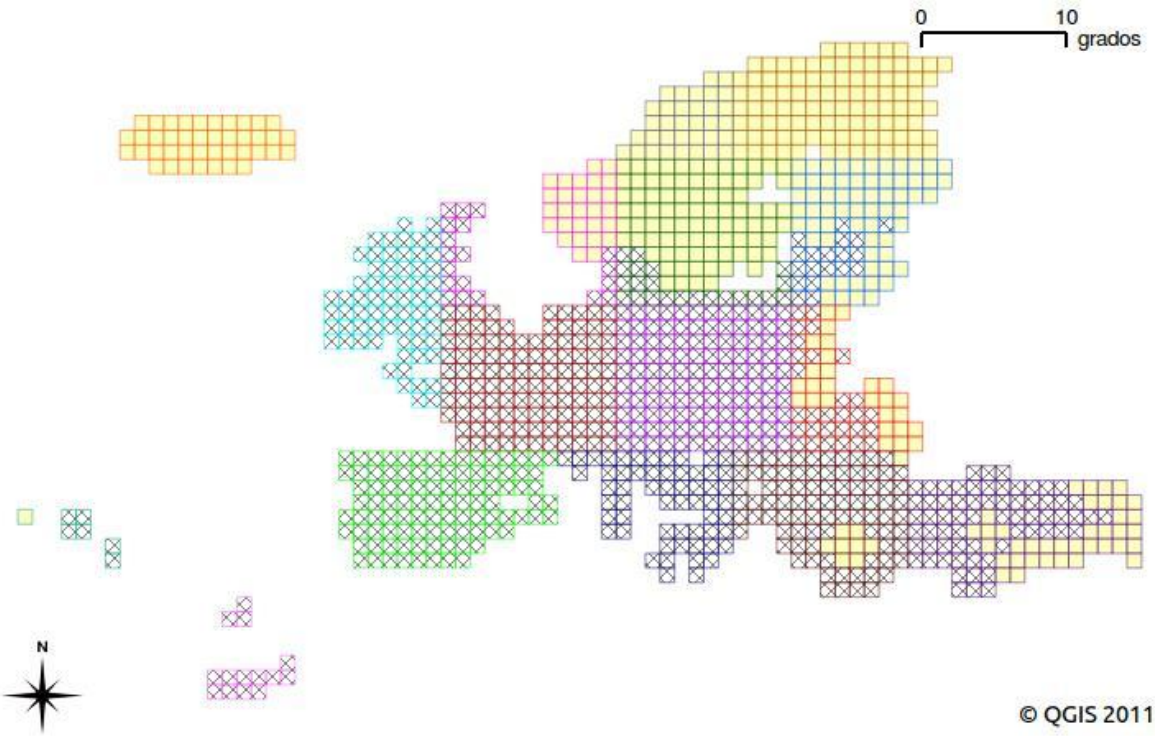


Figure 5: EUDEM Production Status

Dashed squares means already delivered while plain colour means in process.

It has been delivered as well the RMS_EUDEM layer for 436 tiles.

4.2 EU-HYDRO

For EUHYDRO it has been made a different distribution of tiles that is reflected in the following graphic:

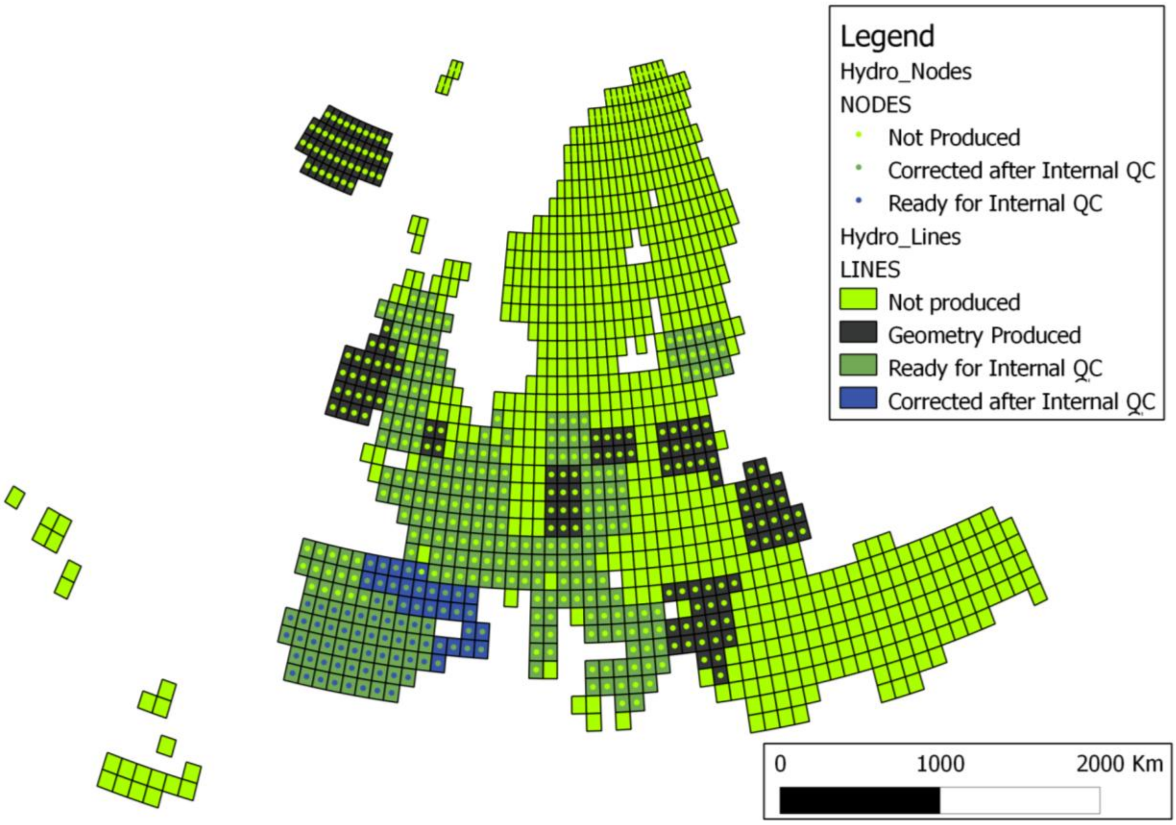


Figure 6: EUHYDRO Production Status

As it may be seen geometry production is around 45%, final attribute contents will be defined in short time.