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Tests of the Missionland dataset

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English summary

The objective of the NATO Science and Technology Organization Task Group MSG-071 "Missionland" is to construct a dataset from which simulation environment databases can be created. FFI is planning to use the dataset. As a first test a small subset of the dataset has been used to create a simple visual database using Terra Vista. In order to create a low resolution Joint Theater Level Simulation terrain, a resampling of the Missionland dataset have been performed. The resampled low resolution Missionland elevation data have been integrated into a real world dataset, since a larger area than the area covered by the Missionland dataset was needed to create the Joint Theater Level Simulation terrain.

Sammendrag

NATO STO MSG-071 “Missionland” har som mål å lage et komplett sett med kildedata som kan benyttes til å lage syntetisk miljø for bruk til simulering for trening og øving. Fra disse kildedata vil det kunne lages databaser både for visualisering og for simulering. Denne rapporten beskriver eksempel på bruk av første versjon av dette datasettet for å lage en visuell database for et område som har data med høy oppløsning, og et eksempel på en terrengdatabase med relativ lav oppløsning for bruk i “Joint Theater Level Simulation”.

Contents

1 Introduction

The objective of the NATO Science and Technology Organization Task Group MSG-071 "Missionland" [1] is to construct a dataset from which simulation environment databases can be created. The scope of the group was to provide a static environmental representation of a substantial geographical area for use within NATO and NATO Partnership for Peace countries. A dataset with different geologies, climate and feature types enables for use within a wide range of simulation systems.

FFI is planning to use the Missionland dataset. As a first test a small subset of the dataset has been used to create a simple visual database using Terra Vista [2]. The tests have been done with different versions of the dataset, due to ongoing work in MSG-071. A Joint Theater Level Simulation (JTLS) [3] terrain have also been created from a resampled Missionland dataset. In JTLS the terrain is represented as a grid of hexagons. To cover Missionland and neighbouring ocean areas, the hexagon size was set to 4 km.

2 Visual database created from high resolution Missionland data

The temperate island highlighted in Figure 2.1 shows the part of the Missionland dataset used to create a visual database in Terra Vista. This island represents one of the more detailed areas of the Missionland dataset. The first downloaded dataset had no imagery, but that has been added to the latest version (dataset-v1).

The cells were delivered with the following data:

A Elevation data
  - Georeferenced Tagged Image File Format (GeoTIFF) with 0.0002778 arc degrees resolution[1] (~ 30 m)

B Feature data
  - ESRI[2] Shapefiles [4] with point, line or area feature data

No imagery data were available for the cells, but a library with 3D models, basic textures, airport templates and a feature library database was provided. The feature library database is a Microsoft Access database with data tables containing description of the feature library. This database holds the Missionland specific feature attribute mapping to common schemas as SEDRIS Environmental Data Coding Specification (EDCS) [5], Feature and Attribute Coding Catalogue (FACC) [6] and Defence Geospatial Information Workgroup (DGIWG) [7] Feature Data Dictionary (DFDD) [8].

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[1] Elevation data resolution at equator is $0.002778(2\pi R)/360 = 30.9245$ m, using earth radius $R = 6378137$ m (WGS84).

[2] Environmental System Research Institute (ESRI®). http://www.esri.com

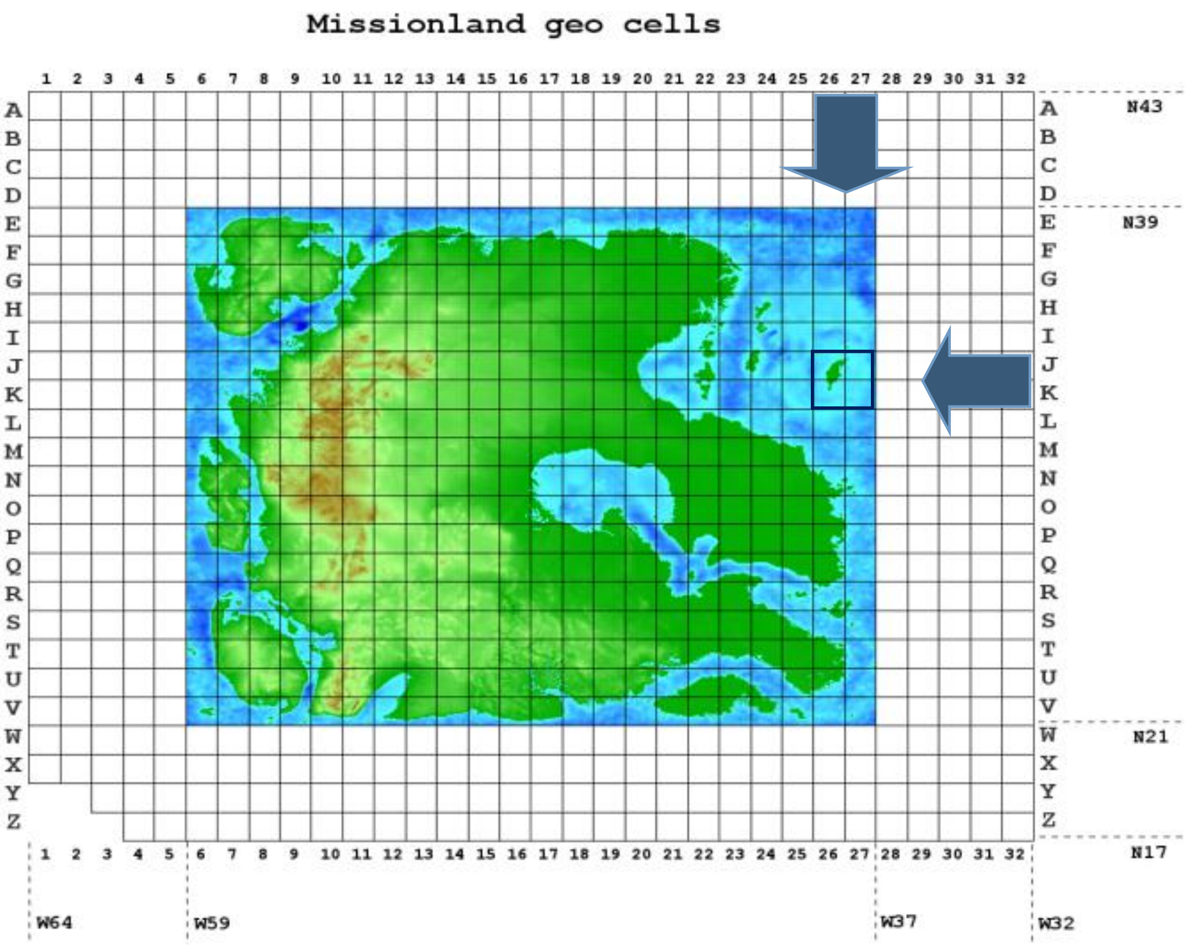


Figure 2.1 The highlighted area is the part of the Missionland dataset tested in Terra Vista.

2.1 Elevation data

The elevation data from the cells was imported into Global Mapper ™ [9], and as an example the GeoTiff metadata for cell J27 is shown in Appendix A. The *MIN ELEVATION* value in cell J27 was reported as -32766.713 m, but it should have been set to -733.157 m. This may have impact on the colouring of different elevations, when displayed in a tool such as Global Mapper. In a later version of data for cells J27 and K27, incorrect or missing elevation data at the rightmost edge of the cells were found as shown in Figure 2.2. The incorrect elevation data gives a large negative number for the *MIN ELEVATION* value in the metadata.

2.2 Feature data

In order to use the default feature data code selector in Terra Vista the data should have been assigned FACC values. A Python[3] script has been created to add FACC to the existing shape vector data, based on the ML_FID to FACC mapping found in the Missionland feature library database. The ML_FID is an attribute that identifies the features in the shapefiles.

[3] www.python.org

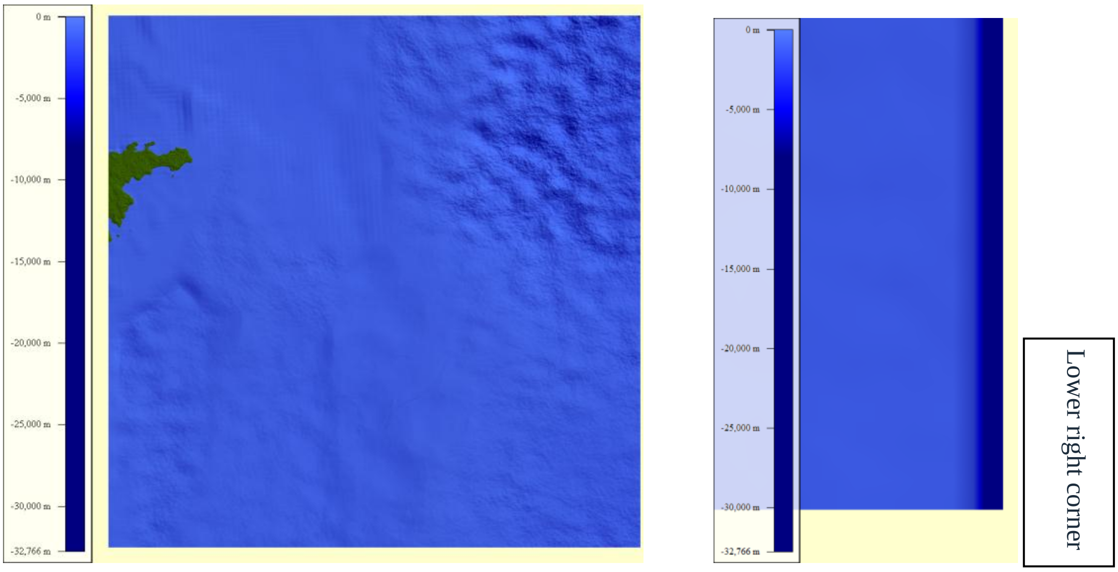


Figure 2.2 Global Mapper used for visualization of elevation data for cell J27.

The feature data table from the Microsoft Access database was exported to a Microsoft Excel 97 worksheet. The first entries in this worksheet are listed in Appendix B.1. We used the xlrd [4] Python library to read the Excel worksheet. Based on the data from the worksheet, a mapping from the ML_FID to FACC was found. The osg (osgeo)[5] Python library was used to add the matching FACC value to all elements in the shapefiles. A road that is identified by the attribute *ML_FID = 20*, is extended with the new FACC attribute *code = AP030*. The Python script used to add this attributes to all features in the shapefiles is given in Appendix B.

2.3 Building a database in Terra Vista

Elevation data and the modified vector data were imported into Terra Vista and a simple visual database (using default Terra Vista textures) was created. In the Terra Vista build log, a few of the area features were reported as non-closed areas, but that is not unusual.

The resulting OpenFlight[10] database was imported into MÄK VR-Vantage [11] 3D visualization software and different parts of the database was examined. Viewed from a high altitude the database looks reasonable good as shown in Figure 2.3. Zooming into details, some parts of the database look as shown in Figure 2.4. The default textures in Terra Vista give sharp edges and large contrasts between different areas of the database.

We discovered that lakes and ponds were not created correctly. Since all water surfaces in the source data are represented as ocean polygons, all water surfaces will be set to sea level (zero altitude) in the database as shown in Figure 2.5. To get the correct representation of lakes and ponds in Terra Vista, the lake and pond polygons were manually extracted from the water vector

[4] http://pypi.python.org/pypi/xlrd
[5] http://wiki.osgeo.org/wiki/OSGeo_Python_Library

files and given the new attribute *code = BH080*. The correct representation of a pond in the visual database is shown in Figure 2.6.

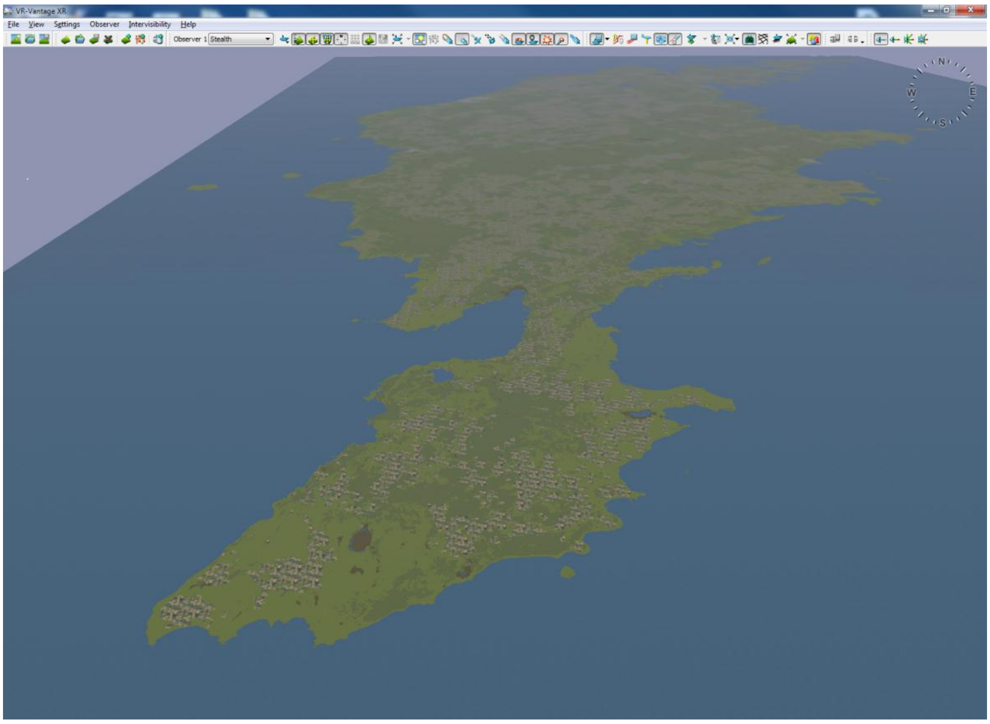


Figure 2.3 Temperate island visual database overview created with default settings in Terra Vista.

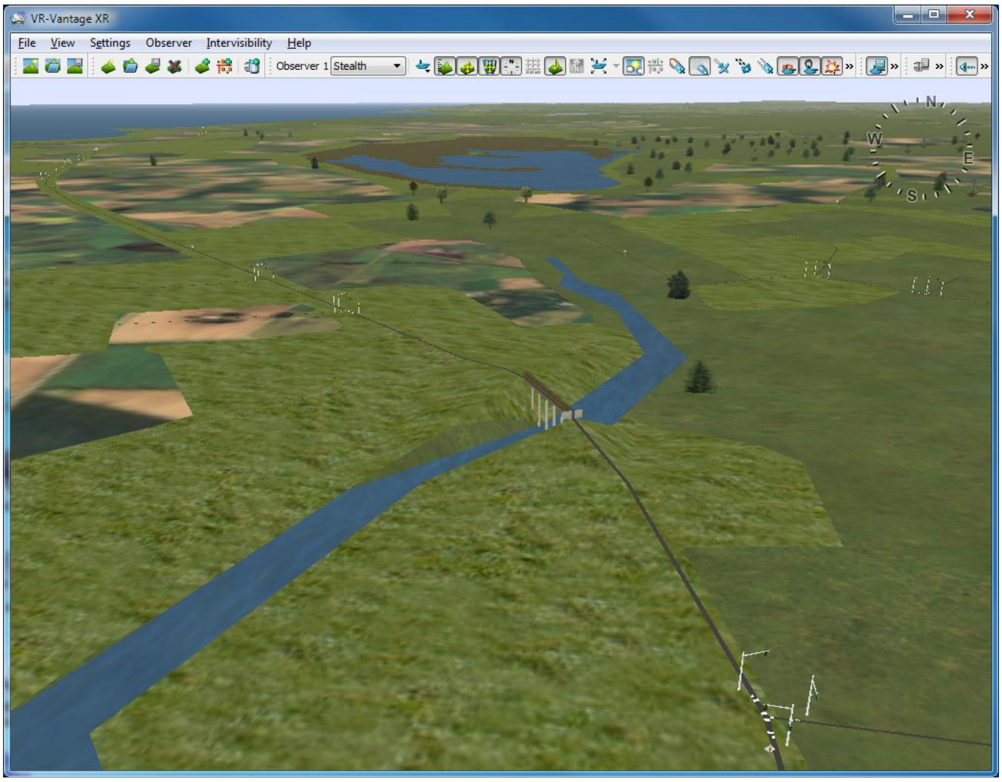


Figure 2.4 Temperate island detailed view.

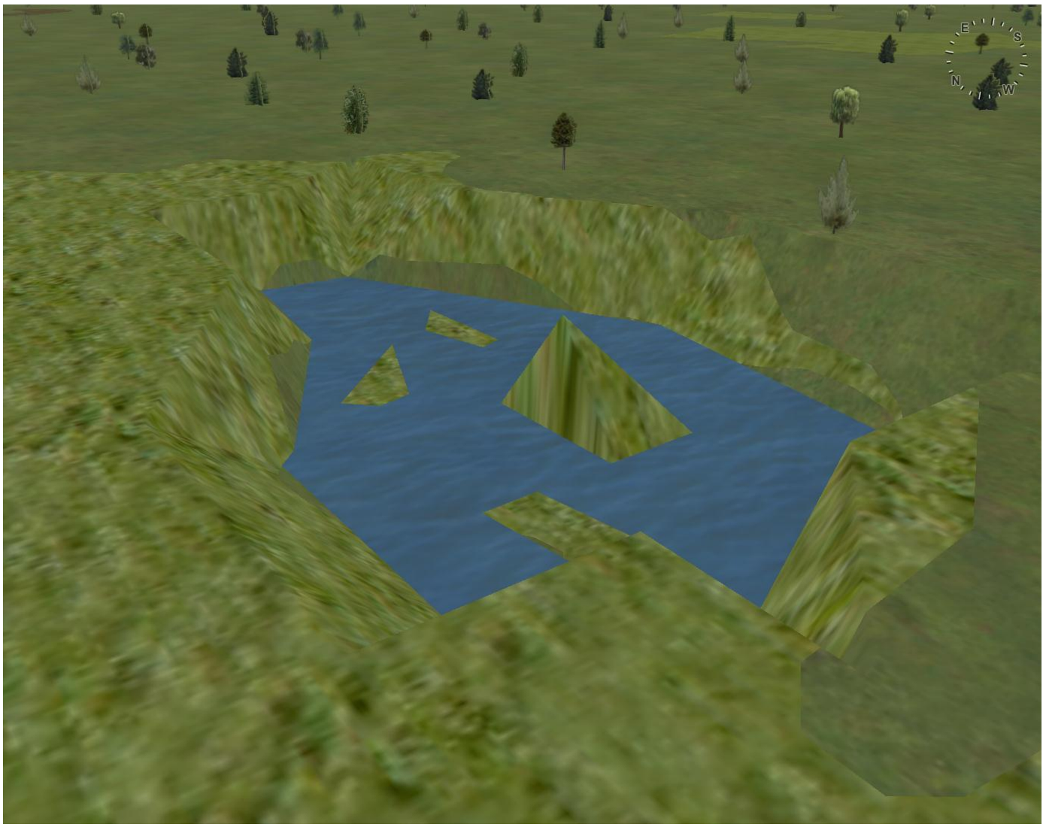


Figure 2.5   Pond represented as ocean surface in Terra Vista.

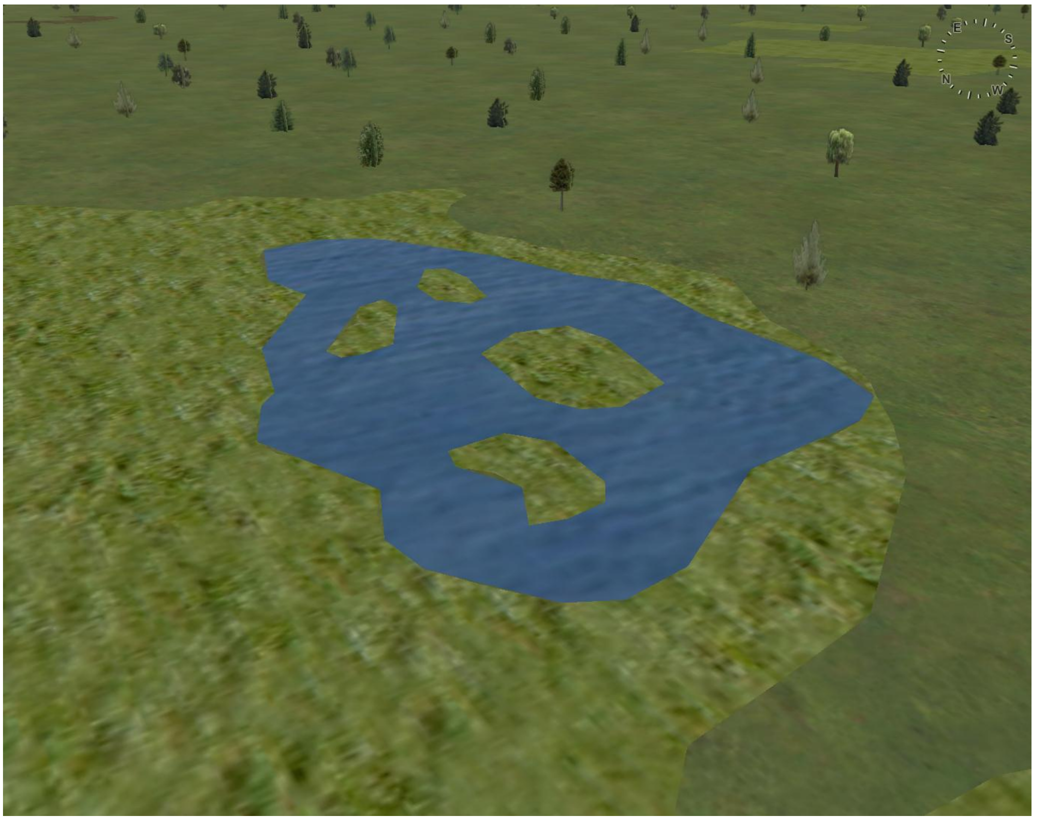


Figure 2.6   Correct representation of a pond in Terra Vista.

2.4 Use of imagery data in Terra Vista

In the latest version of the dataset, synthetic created imagery data was included as shown in Figure 2.7. The imagery data has the primary road network included, but no rivers or lakes.

Figure 2.7 Imagery data covering the temperate island in MissionLand.

In Figure 2.8 we can see that there is a mismatch between the imagery and the culture data. The figure shows the following combination of source data:

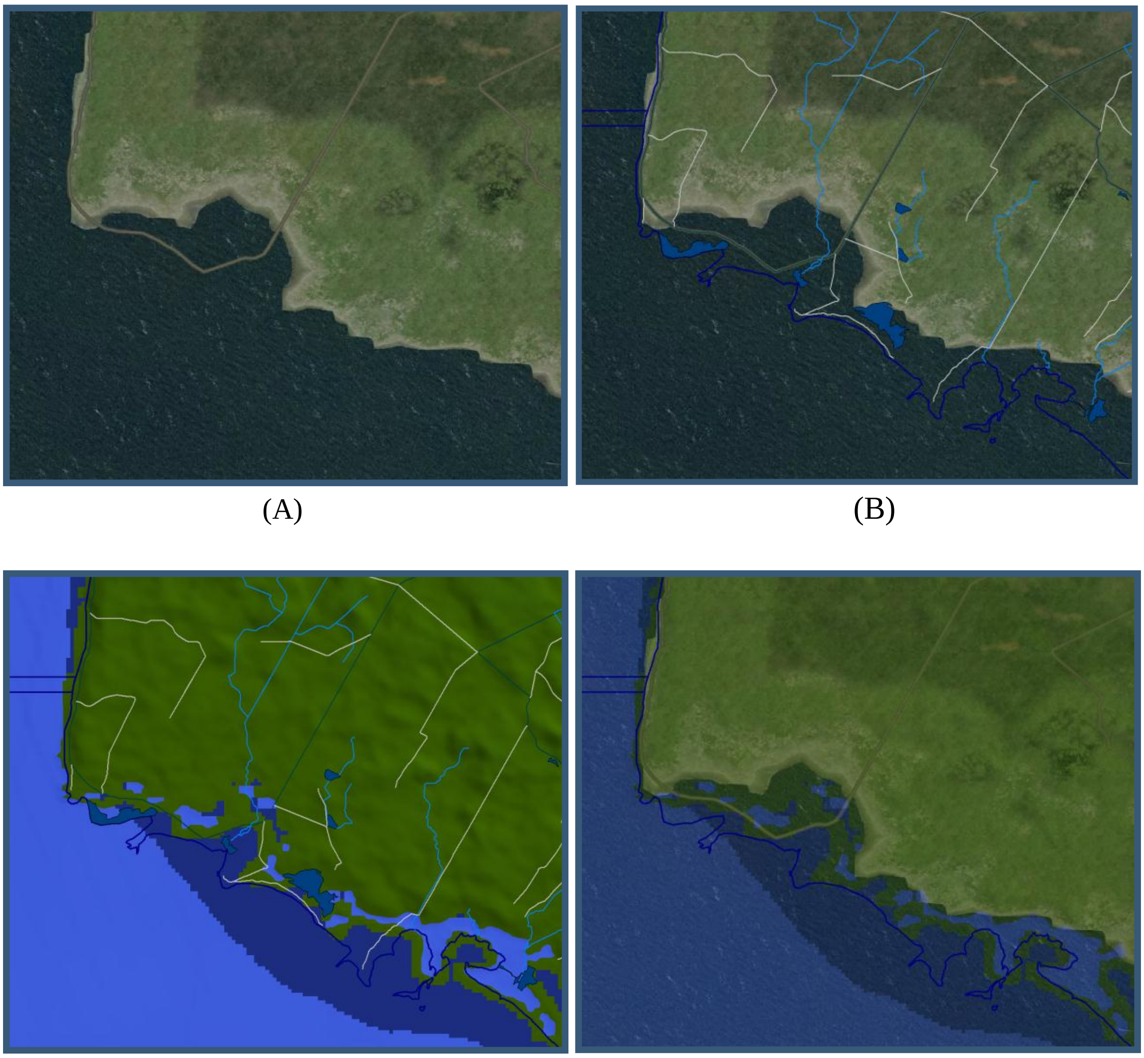
(A) Imagery only

(B) Imagery and vector data

- Primary road
- Dirt road
- Rivers
- Lake/pond
- Ocean

(C) Elevation (dark blue areas has zero elevation) and vector data

(D) Imagery, elevation (40% transparency) and ocean (shoreline) vector data



(A) (B) (C) (D)

Figure 2.8 A more detailed view of the temperate island.

The primary road data is placed correct, but some of the land areas are not defined correct in the synthetic images. At some locations the correlation is good, but for some areas correlation could have been better.

In spite of this flaw, the imagery data was imported into Terra Vista, and some of the textures used in Terra Vista were modified. Selected areas with geotypical textures were blended with the geospecific texture from the imagery data. This method will reduce the stand out effect from different terrain areas you can experience, by using geotypical textures only. The result from a rebuild of the visual database is shown in Figure 2.9.

Some of the differences in the source data can be seen as darker areas along some parts of the coastline of the island. The vector data defines these areas as land, but the texture from the imagery indicates that it is ocean. Figure 2.10 shows more details of different areas of the island. The part of the island shown in Figure 2.8 is the area marked with (3) in Figure 2.10. We can also see that the northern part of the island (4) has a better match between the different source data types.

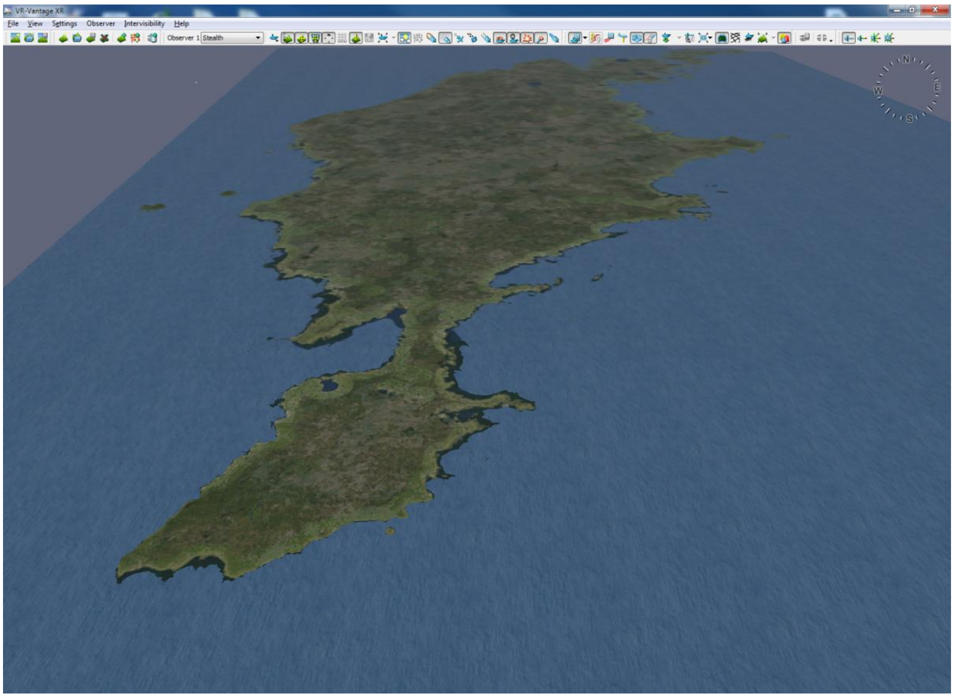
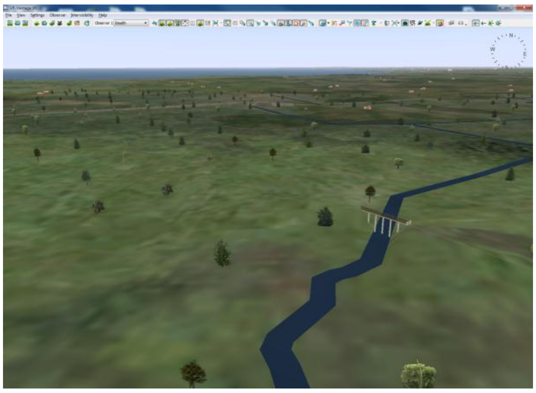
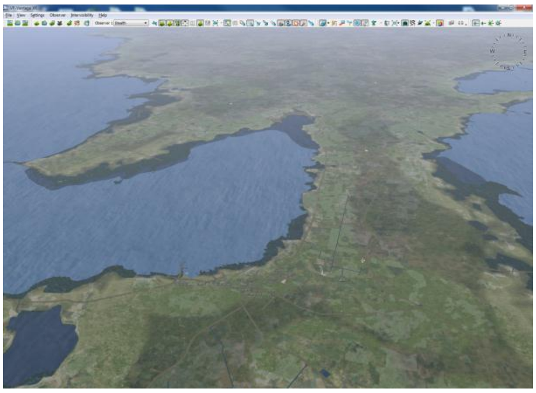


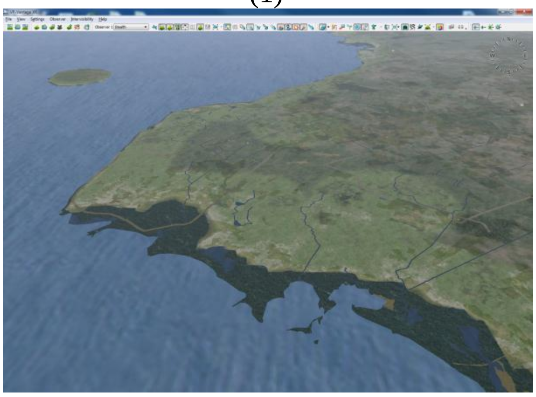
Figure 2.9 Temperate island visual database created in Terra Vista using texture blending.



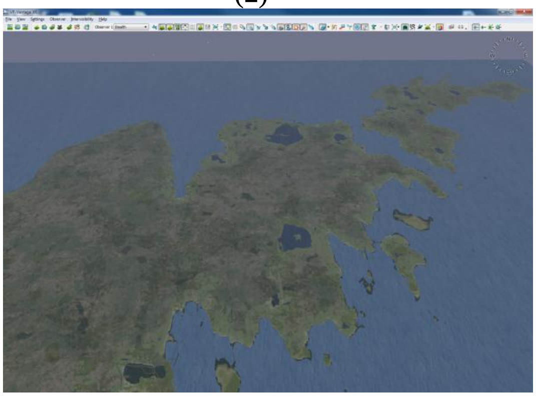
(1)



(2)



(3)



(4)

Figure 2.10 Different parts of the temperate island created in Terra Vista using texture blending.

3 Joint Theater Level Simulation terrain

A Joint Theater Level Simulation (JTLS) terrain has been created from the Missionland dataset. In JTLS the terrain is represented as a grid of hexagons. To cover Missionland and neighbouring ocean area, the hexagon size was set to 4 km. With a grid size of 932x775, the size of the terrain in JTLS is approximately 3200 x 3100 km [6] (width x height).

The tool used to populate the hexagons with elevation and sea depth data, uses low resolution elevation data as input. A Python script was used to create a Global Mapper script for resampling the whole Missionland elevation dataset to Digital Terrain Elevation Data (DTED) level 0 resolution (0.00833 arc degrees resolution). After running this Global Mapper script, the resampled GeoTIFF elevation files were imported back into Global Mapper and exported as DTED level 0 elevation data. The Python and Global Mapper scripts are listed in Appendix C.

A Java based tool for populating a JTLS terrain file with DTED level 0 elevation and depth data has been made at FFI.

3.1 Resampling and integrating Missionland elevation data with real world data.

From the National Oceanographic and Atmospheric Administration (NOAA) web pages [12] a global elevation and bathymetry dataset can be downloaded. A world wide 1 arc minute resolution data set (named ETOPO1) [13] has been resampled and converted to DTED level 0 resolution (0.5 arc minutes). Figure 3.1 shows a colour shaded relief image of the ETOPO1 dataset downloaded from the NOAA web pages.

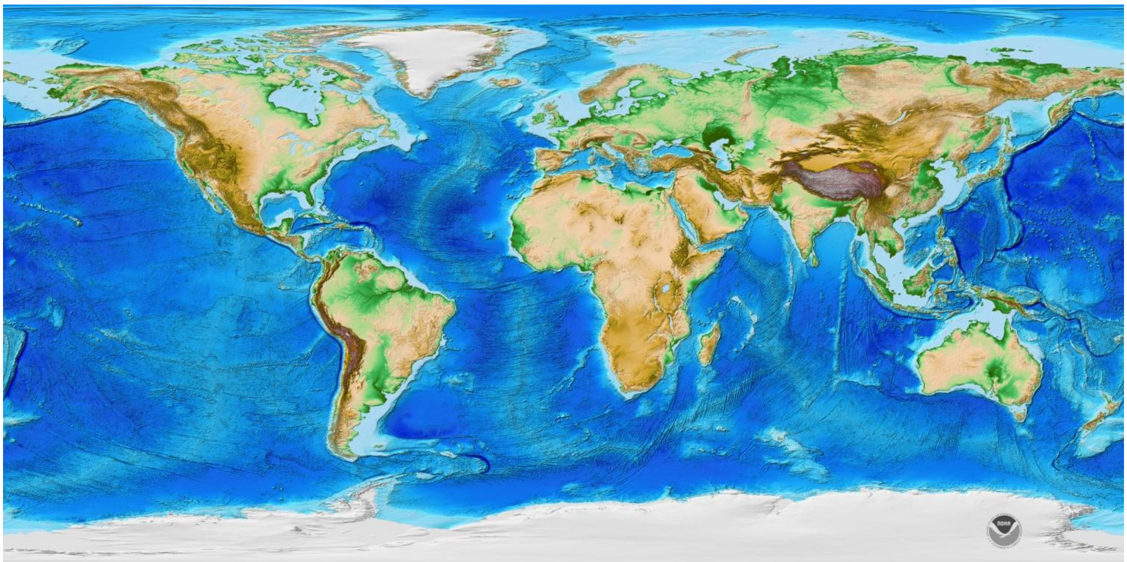


Figure 3.1 Downloaded colour shaded-relief image visualizing the ETOPO1 dataset.

[6] $xsize \approx 932 \cdot 4 \cdot \frac{\sqrt{3}}{2} = 3228\ \text{km}$, $ysize = 775 \cdot 4 = 3100\ \text{km}$

In order to integrate the newly created low resolution Missionland dataset into the ETOPO1 data, the dataset had to be edited. First an extended seabed was added around the Missionland continent, since the outer ocean ring was not present in the downloaded Missionland dataset. ITED [14] was used to do a quick and simple blending of the extended Missionland data into a slightly larger area cut out from the ETOPO1 data. The large depth difference between the real world seabed and the Missionland seabed was a challenge. Figure 3.2 shows the result of this process. The new dataset was then integrated into the global ETOP1 dataset as shown in Figure 3.3.

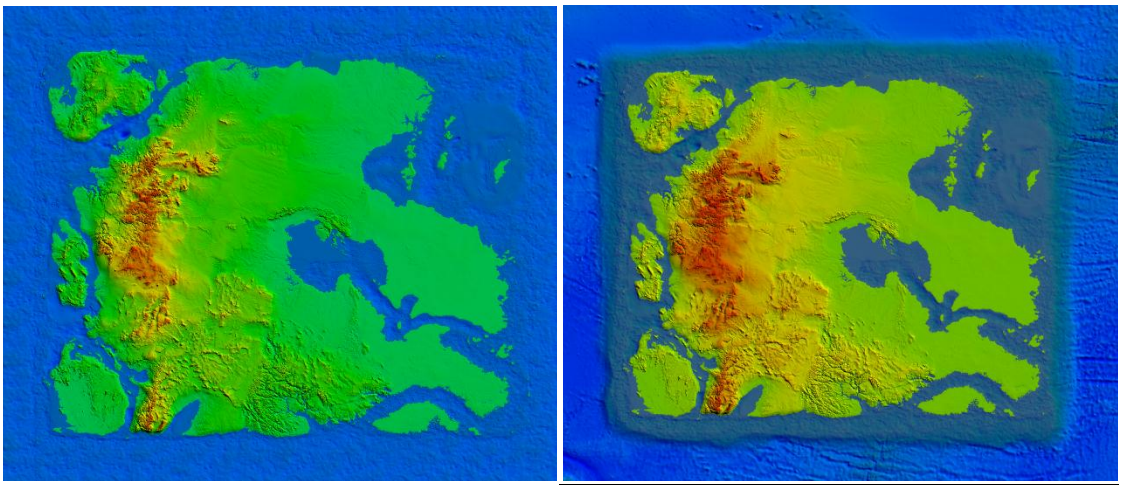


Figure 3.2 Missionland with extended seabed (left) and Missionland integrated with an area cut out from the ETOPO1 dataset (right).

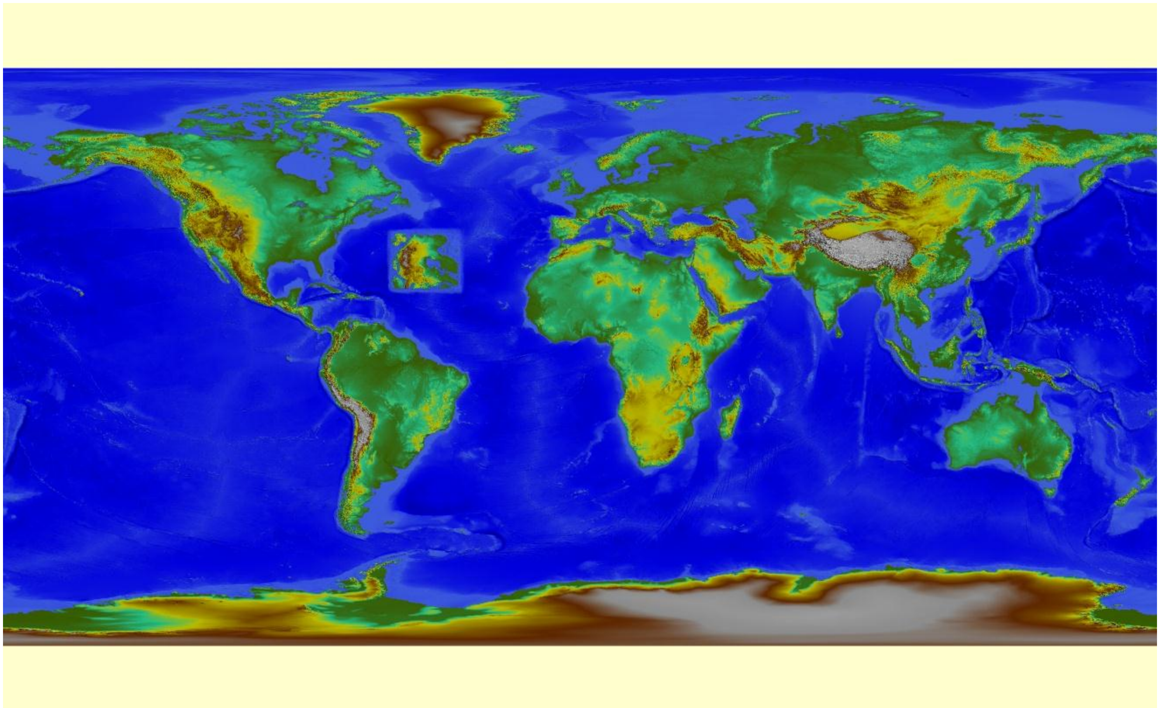


Figure 3.3 Missionland integrated into the ETOPO1 dataset.

3.2 Populating a JTLS terrain with elevation data

A JTLS terrain is defined by two text files. The terrain definition file defines the Lambert conformal map projection parameters and the size of the area covered. The terrain file holds the data for each hexagon and the six hexagon borders. A Java based application has been developed at FFI to set the terrain type based on the elevation or depth read from a DTED level 0 dataset. The land terrain type is set to a type depending on the terrain height found in the center position of the hexagon. Low terrain is set to an open terrain type; medium terrain is set to forest, and high terrain as mountain as shown in Figure 3.4. An outline of the JTLS terrain area is shown in Figure 3.5.

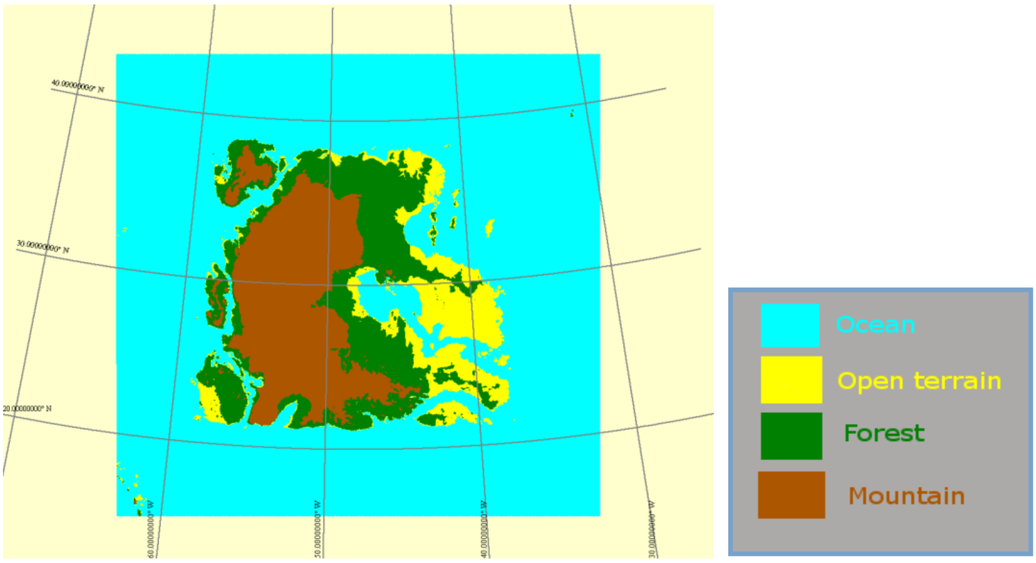


Figure 3.4 JTLS terrain type and depth/elevation is set based on resampled DTED level 0.

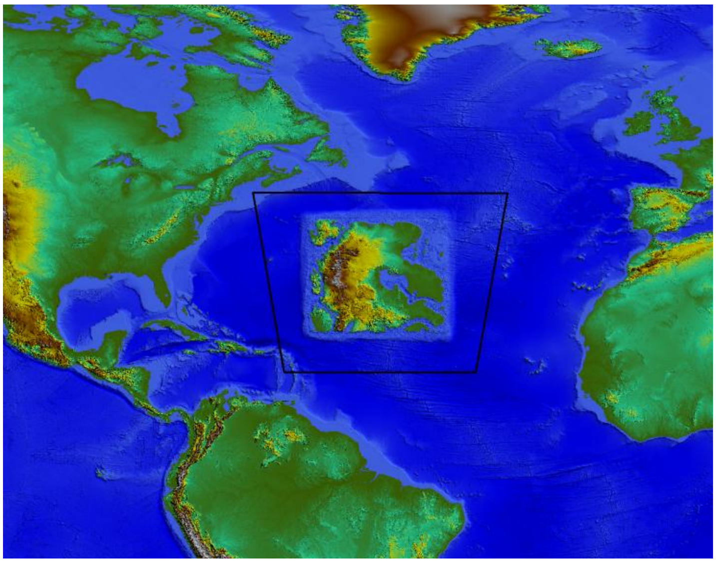


Figure 3.5 The area covered in the JTLS terrain is outlined.

3.3 Use of Missionland vector data

The use of the original Missionland vector data in JTLS was found to be difficult, since the data is organized as separate vector data for each of the geocells. A Python script was created to copy one specified feature type (e.g. road) from the shapefiles in all cells, into one single shape file covering the whole Missionland continent. As an example, the road data was simplified and incorporated into the JTLS terrain as shown in Figure 3.6.

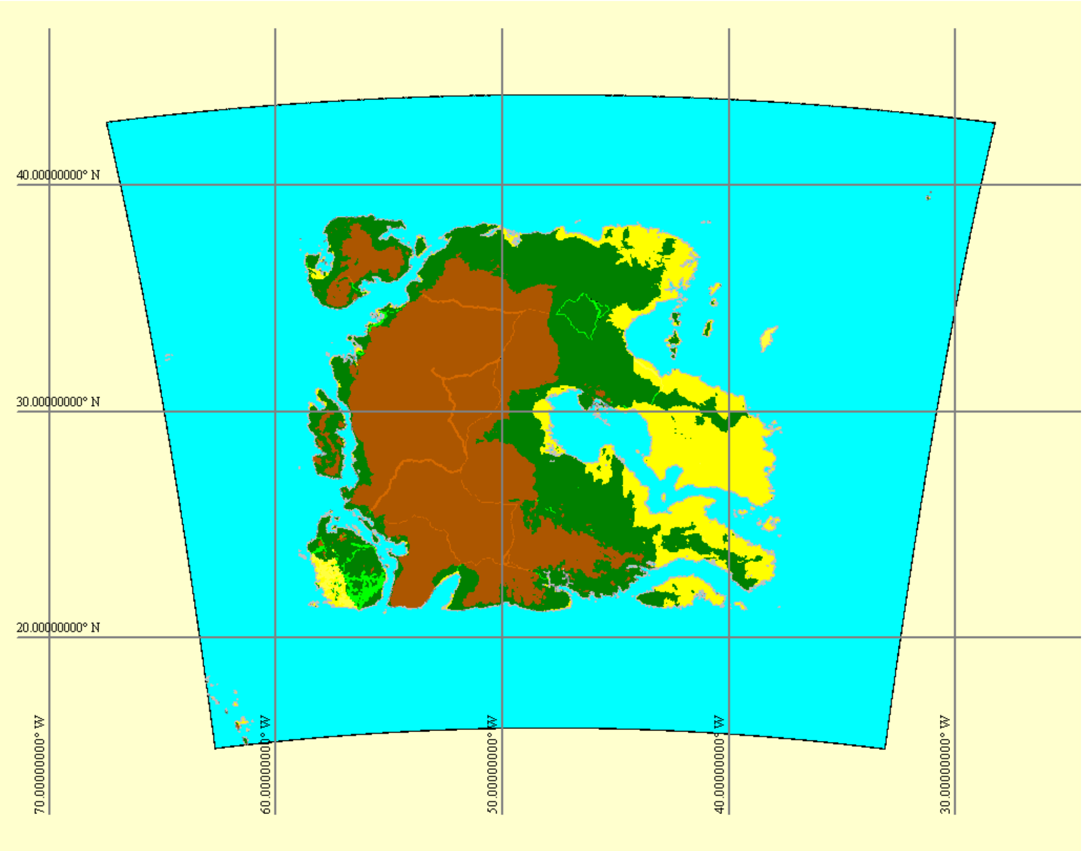


Figure 3.6 JTLS terrain with road network.

For some of the other feature types the extraction and simplifying of the data, turned out to be a difficult task. The different land use and vegetation types consist of a very large number of small areas as shown in Figure 3.7. That makes it much more difficult to create the coarse data needed to set the corresponding terrain type in the JTLS terrain hexagons as shown in Figure 3.8.

The river vectors are also difficult to simplify since they are composed of a large number of small segments. A total of 15,751,839 river segments were found in the shape data. In Figure 3.9 one river segment is selected, and the feature information about this segment tell us that this feature is only 61.521 m long and only has two vertices. It would have been better to have larger segments with several vertices. The areas which are based on real world data have such river segments. In a JTLS terrain the rivers have to be defined to run along one of the borders of the hexagons.

The simplifying of terrain surface type and river feature data for further development of the JTLS terrain, was found too difficult to automate, and we decided not to bring this work to an end.

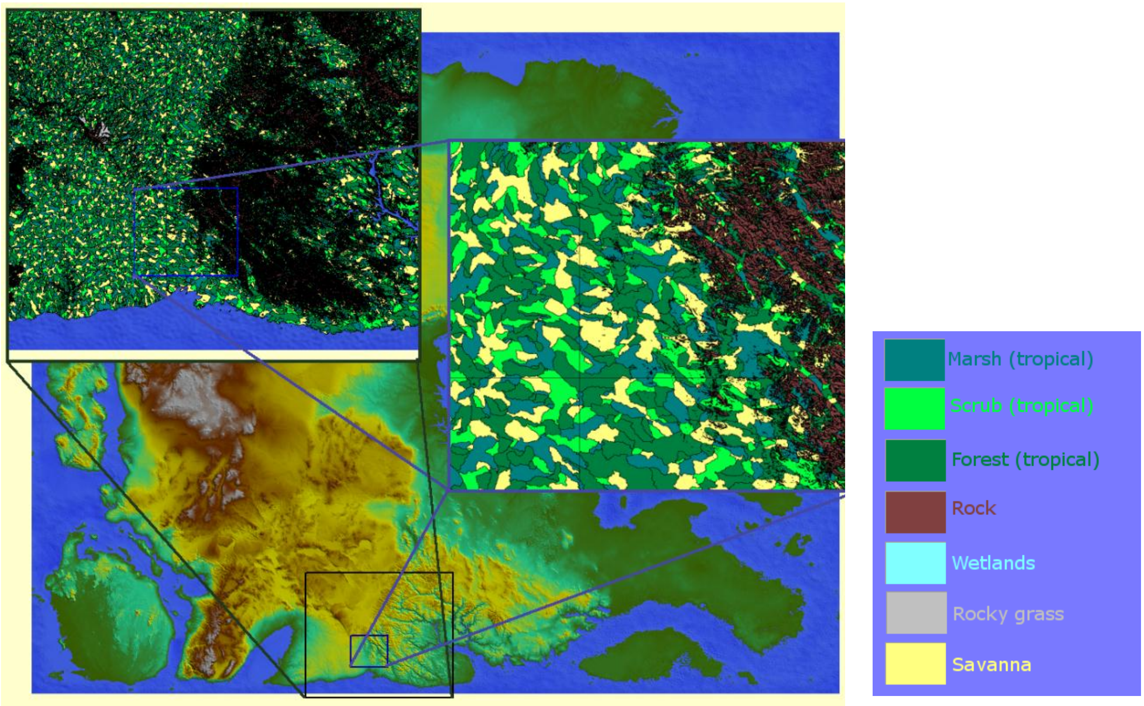


Figure 3.7 Example from the tropical part of Missionland. Different types of vegetation or ground surfaces are colorized.

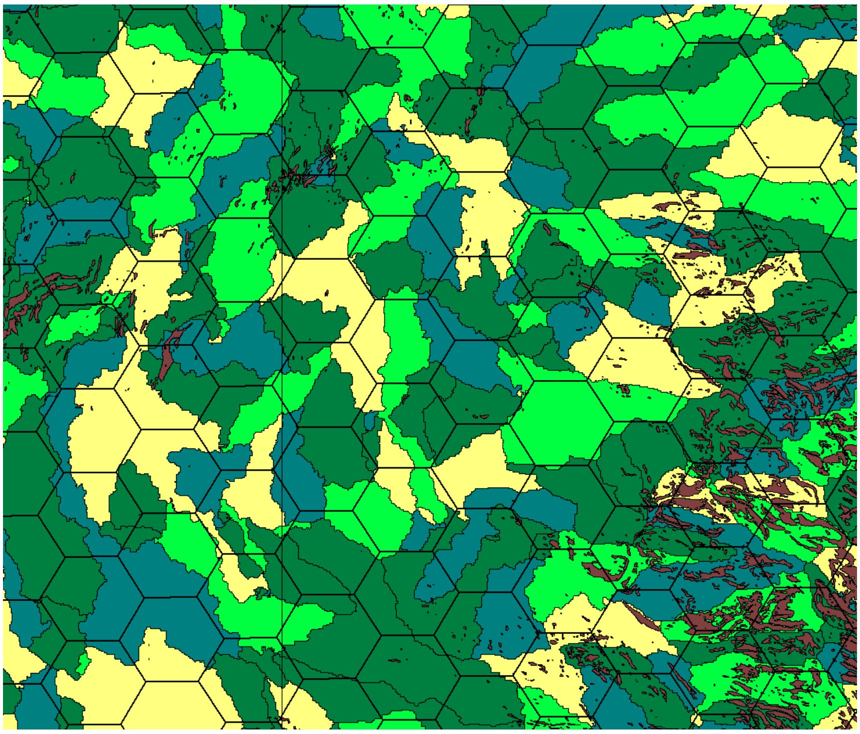


Figure 3.8 JTLS hexagons and Missionland area surface types.

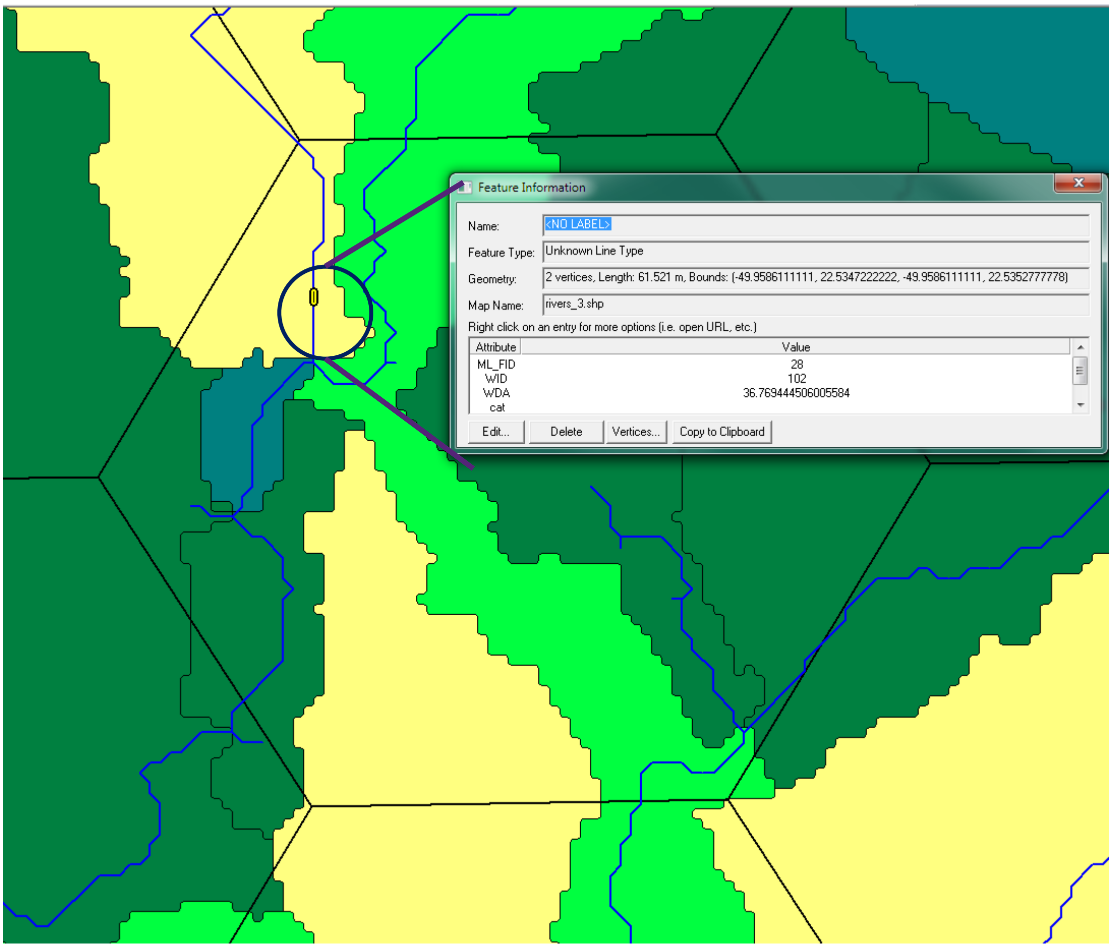


Figure 3.9 River segment information.

4 Conclusion

The first impression from our tests of the Missionland dataset is that this is a good start on the road to create a complete dataset that can be used as source data to create non geospecific simulation environment databases. The use of the data for a specific purpose will identify any improvements that have to be done to make the dataset even more complete. This report describes two different uses of the dataset. The first example shows the use of high resolution data to create a visual database, and the second example an attempt to create a low resolution JTLS terrain database. To complete the creation of the JTLS terrain, further work has to be done.

Some shortcomings have been discovered during these tests:

- The outer ring that integrates Missionland into real world data is missing.
- Correlation between imagery, elevation and vector data.
- Ocean and lakes should have different ML_FID values.
- Different types of land use should consist of larger coherent areas.
- Longer river segments should have been created.

References

[1] NATO STO, "STO Task Group MSG-071- Missionland Final Report (Draft)", NATO STO, 2012.

[2] Presagis, "Terra Vista", (2010). [Online]. Available: http://www.presagis.com/products_services/products/modeling-simulation/content_creation/terra_vista

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[12] NOAA, "National Oceanographic and Atmospheric Administration website", (2013). [Online]. Available: http://www.ngdc.noaa.gov/mgg/global/global.html

[13] C. Amante and B. W. Eakins, "ETOPO1 1 Arc-minute global relief model : Procedures, data sources and analysis", NOAA, Mar. 2009.

[14] M. F. Aasen and L. H. Breivik, "Interactive Terrain Editor (ITED)", Forsvarets forskningsinstitutt, FFI-rapport 2011/01216, June 2011.

[15] MSG-071, "MSG-071- Missionland Contribution Guide (Draft)", NATO STO, Version 0.5, Aug. 2012.

Abbreviations and acronyms

NATO	North Atlantic Treaty Organization
STO	Science and Technology Organization
MSG	Modelling and Simulation Group
ESRI	Environmental System Research Institute
FFI	Forsvarets forskningsinstitutt (Norwegian Defence Research Establishment)
JTLS	Joint Theater Level Simulation
GeoTIFF	Georeferenced Tagged Image File Format
FACC	Feature and Attribute Coding Catalogue
EDCD	Environmental Data Coding Specification
DTED	Digital Terrain Elevation Data
DGIWG	Defence Geospatial Information Working Group
DFDD	DGIWG Feature Data Dictionary
NOAA	National Oceanographic and Atmospheric Administration
ITED	Interactive Terrain Editor

Appendix A GeoTIFF elevation metadata example

Table A.1 below shows the GeoTIFF elevation metadata reported by Global Mapper for cell J27.

FILENAME	MissionLand\geocells\J27_W38_N33\Elevation\J27_W38_N33.tif
DESCRIPTION	J27_W38_N33.tif
UPPER LEFT X	-38.0000000000
UPPER LEFT Y	34.0000000000
LOWER RIGHT X	-37.0000000000
LOWER RIGHT Y	33.0000000000
WEST LONGITUDE	38.00000000° W
NORTH LATITUDE	34.00000000° N
EAST LONGITUDE	37.00000000° W
SOUTH LATITUDE	33.00000000° N
PROJ_DESC	Geographic (Latitude/Longitude) / WGS84 / arc degrees
PROJ_DATUM	WGS84
PROJ_UNITS	arc degrees
EPSG_CODE	4326
COVERED AREA	10322 sq km
NUM COLUMNS	3601
NUM ROWS	3601
NUM_BANDS	1
PIXEL WIDTH	0.0002778 arc degrees
PIXEL HEIGHT	0.0002778 arc degrees
MIN ELEVATION	-32766.713 meters
MAX ELEVATION	29.715 meters
ELEVATION UNITS	meters
BIT_DEPTH	32
PHOTOMETRIC	Greyscale (Min is Black)
BIT_DEPTH	32
SAMPLE_FORMAT	Floating Point
ROWS_PER_STRIP	1
COMPRESSION	None
PIXEL_SCALE	(0.000277777777778, 0.000277777777778, 1)
TIEPOINTS	(0.00, 0.00, 0.00) --> (-38.0001388889, 34.0001388889, 0.0000000000)
MODEL_TYPE	Geographic lat-long system
RASTER_TYPE	Pixel is Area
VERT_DATUM	None Specified

Table A.1 GeoTIFF elevation metadata from Global Mappet

Appendix B Adding FACC data to shapefiles

The Python script in Appendix B.2 reads Missionland feature mapping information from a Microsoft Excel 97 worksheet and adds FACC data to all features in all shapefiles found in a directory and all its subdirectories (Appendix B.3). Table B.1 shows an extract of the first entries in the Excel worksheet. The columns with EDCD and DFDD mapping are removed from the data shown in Table B.1. The ML_FID attribute value is identical to the value from the ID column in this worksheet. This script is inspired by the "Update vector attributes" script found in the MSG-071 Missionland Contribution Guide [15].

B.1 Extract of first 29 entries in the feature mapping worksheet

ID	Name	Description	FeatureType	FACCMapping
5	temperate_fields	Polygons with field texture for temperate zone	AREA	EA010
6	rocky_grass	Polygon with rocky grass texture	AREA	EB010
7	rock	Polygon with rock texture	AREA	DB160
8	runway_asphalt	Polygon of runway with asphalt texture	AREA	GB055
9	Mixed forest	Polygon with mixed forest canopy texture	AREA	EC015
10	ocean	Polygon with ocean texture	AREA	BA040
11	silo	model of sile	POINT	AM020
12	cemetery	model of cemetery	POINT	AL030
13	church	model of church	POINT	AL015
14	farm house	3D model of farm house	POINT	AL015
15	Building footprint	Draw building footprint on map	AREA	AL015
16	Recreational buildings	Polygon with recreational buildings texture	AREA	AI020
17	Orchard	Polygon with orchard texture	AREA	EA040
18	Built-up area	Polygon with built-up area texture	AREA	AL020
19	Wetlands	Polygon with wetlands texture	AREA	BH095
20	Road	Extruded line with road texture	LINE	AP030
21	Cycle path	Extrude line with cycle path texture	LINE	AP050
22	Jetty	Extrude line with jetty texture	LINE	BB140
23	Depth line	Depth line on map only	LINE	BE015
24	Animal welfare area	Line on map for animal welfare area	LINE	AL005
25	Ferry route	Ferry route on map	LINE	AQ070
26	Height line	Height line on map	POINT	CA010
27	Railroad	Extruded line with railroad texture	LINE	AN010
28	River	Extrude line with river texture	LINE	BH140
29	Underground river	Underground river, on map only	LINE	BH115

Table B.1 Feature mapping table

B.2 Python Script used to add FACC attributes to Missionland feature data

```
'''
Created on 8. nov. 2012

Reads MS-Excel file with Missionland feature data mapping and adds
the matching FACC attribute to all features for all the Shapefiles
in a directory and all its sub directories.

The MS-Excel file with features created by exporting the feature form
from the MS-Access file: ML_feature_library_database.mdb

@author: Arild Skjeltorp, FFI
'''
from xlrd import open_workbook
from osgeo import ogr
import sys
import dirEntries


def find_index(lst, name):
    for i in xrange(len(lst)):
        if name == lst[i]:
            return i
    return -1

def find_FACC_code(xl_sheet,ML_FID):
    atr_names = []
    row = 0
    for col in range(xl_sheet.ncols):
        atr_names.append(xl_sheet.cell(row,col).value)
    fidx = find_index(atr_names,"FACCMapping")
    nx = find_index(atr_names,"Name")
    if fidx != -1 and nx != -1:
        idx = find_index(atr_names,"ID")
        if idx != -1:
            for row in range(xl_sheet.nrows):
                if xl_sheet.cell(row,idx).value == ML_FID:
                    return [ML_FID, xl_sheet.cell(row,fidx).value, xl_sheet.cell(row,nx).value]
    return [ML_FID,"None","Unknown"]
```

```
def HasField(layer, field):
    layer_defn = layer.GetLayerDefn()
    field_names = [layer_defn.GetFieldDefn(i).GetName() for i in range(layer_defn.GetFieldCount())]
    return field in field_names

def EnsureFieldExists(layer, field, fieldType):
    layer_defn = layer.GetLayerDefn()
    field_names = [layer_defn.GetFieldDefn(i).GetName() for i in range(layer_defn.GetFieldCount())]
    if not(field in field_names):
        new_field = ogr.FieldDefn(field, fieldType)
        layer.CreateField(new_field)

if (len(sys.argv) < 3):
    print "Please provide MS Excel 97 file and Shape file directory as arguments"
else:
    try:
        wb = open_workbook(sys.argv[1])
        print "Opened excel file: " + sys.argv[1]
        # get ML shape attributes form excel sheet. Assume only one Sheet
        s = wb.sheet_by_index(0)
        print "Sheet name : " + s.name
        filelist = dirEntries.dirEntries(sys.argv[2], True, "shp")
        for shapefile in filelist:
            try:
                hShp = ogr.Open(shapefile, 1)
                print "Processing shape file: " + shapefile
                layer = hShp.GetLayer()
                EnsureFieldExists(layer, 'code', ogr.OFTString)
                if HasField(layer,'ML_FID'):
                    feat = layer.GetNextFeature()
                    numfeatures = layer.GetFeatureCount()
                    print "Number of features in layer= " + str(numfeatures)
                    nfeat = 0
                    nerr = 0
                    while feat is not None:
                        mlfid = feat.GetFieldAsInteger('ML_FID')
                        facc_code = find_FACC_code(s,mlfid);
                        if (facc_code[1] != 'None'):
                            try:
                                feat.SetField('code',str(facc_code[1]))
                                layer.SetFeature(feat)
```

```
                nfeat +=1
              except:
                nerr +=1
            feat = layer.GetNextFeature()
          layer.SyncToDisk()
          hShp = None
          print "Changed attribute for " + str(nfeat) + " features"
          if (nerr > 0): print "number of errors = " + str (nerr)
      except:
        print "Unable to open shape file: " + shapefile
  except:
    print "Unable to open excel file: " + sys.argv[1]
  print "Ready"
```

B.3 Python script: dirEntries.py

```
import os

def dirEntries(dir_name, subdir, *args):
  '''Return a list of file names found in directory 'dir_name'
  If 'subdir' is True, recursively access subdirectories under 'dir_name'.
  Additional arguments, if any, are file extensions to match filenames. Matched
    file names are added to the list.
  If there are no additional arguments, all files found in the directory are
    added to the list.
  Example usage: fileList = dirEntries(r'H:\TEMP', False, 'txt', 'py')
    Only files with 'txt' and 'py' extensions will be added to the list.
  Example usage: fileList = dirEntries(r'H:\TEMP', True)
    All files and all the files in subdirectories under H:\TEMP will be added
    to the list.
  '''
  fileList = []
  for file in os.listdir(dir_name):
    dirfile = os.path.join(dir_name, file)
    if os.path.isfile(dirfile):
      if not args:
        fileList.append(dirfile)
      else:
        if os.path.splitext(dirfile)[1][1:] in args:
          fileList.append(dirfile)
```

```
        # recursively access file names in subdirectories
        elif os.path.isdir(dirfile) and subdir:
            print "Accessing directory:", dirfile
            fileList.extend(dirEntries(dirfile, subdir, *args))
    return fileList
```

Appendix C GeoTIFF resampling scripts

The Python script in Appendix C.1 creates a Global Mapper script that imports a GeoTIFF file and saves a resampled file to a new directory. This action is done for every GeoTIFF file found in the given directory and all its subdirectories. The first lines of the created Global Mapper script are shown in Appendix C.2.

C.1 Python script creating a Global Mapper script

```
# Arild Skjeltorp
import sys
import os
import dirEntries

sys.stdout.write("Generates a Global Mapper script that resamples all tiff-files to 1000m resolution (DTED
level 0)\n")
#check command line arguments
path = "G:\\MissionLand\\current\\geocells"
if  len(sys.argv) > 1:
   path = sys.argv[1]
ofile = "ML_resample.gms"

#create a list of .tif files in 'path' and all its subdirectories
fileList = dirEntries.dirEntries(path, True, "tif")

outfile = open(ofile,'w')
outfile.write("GLOBAL_MAPPER_SCRIPT VERSION=1.00\nUNLOAD_ALL\n")
outfile.write("// Resample to 1000m resolution \n")

for fname in fileList:
   out_fname = os.path.basename(fname)
   print out_fname

   outfile.write("IMPORT FILENAME=\"%s\"\n" % (fname))
   outfile.write("EXPORT_ELEVATION FILENAME=\"resampled\\%s\" TYPE=GEOTIFF
SPATIAL_RES=0.00833,0.00833 \n" % (out_fname))
   outfile.write("UNLOAD_ALL\n")

outfile.close()
```

C.2 Global Mapper script created from Python

```
GLOBAL_MAPPER_SCRIPT VERSION=1.00
UNLOAD_ALL
// Resample to 1000m resolution
IMPORT FILENAME="G:\MissionLand\current\geocells\E10_W55_N38\Elevation\E10_W55_N38.tif"
EXPORT_ELEVATION FILENAME="resampled\E10_W55_N38.tif" TYPE=GEOTIFF
SPATIAL_RES=0.00833,0.00833
UNLOAD_ALL
IMPORT FILENAME="G:\MissionLand\current\geocells\E11_W54_N38\Elevation\E11_W54_N38.tif"
EXPORT_ELEVATION FILENAME="resampled\E11_W54_N38.tif" TYPE=GEOTIFF
SPATIAL_RES=0.00833,0.00833
UNLOAD_ALL
.
.
.
```