INSIDE FS GLOBAL 2008

Technical background and detailed product information

Version 1.00

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1. INTRODUCTION

This document provides some information on how the FS Global dataset was compiled and how it works in FSX. Understanding how the scenery works helps to get most of it, because the behaviour of scenery objects can be adjusted according to user preferences.

The concept of FS Global is to make the best geographic data available for Flight Simulation and to provide a near-global coverage. Huge areas of fantastic landscape remain unexploited or far less detailed than it could be even with the newest edition of the Microsoft Flight Simulator – the FSX. FS Global allows to explore millions of square kilometers of landscape in South America, Africa and Asia, or to see the Alps in Europe in far greater detail than with the default scenery. It is a base scenery that exclusively contains elevation data, and will combine seamlessly with highly detailed local airport scenery.

FS Global 2008 is based on SRTM data in the first place. Microsoft used SRTM data for parts of the FSX default scenery as well, so why do we need FS Global? Maybe this gives a first impression: The highly compressed FS Global terrain files have a total size of 12.3 GB, while the terrain files of FSX (Professional Edition) add up to 1.26 GB, barely more than a tenth of the size. Apart from the far greater coverage FS Global aims for a better quality. While we find every error of the SRTM dataset in the FSX default scenery, enormous efforts have been made to correct these errors in FS Global. Looking at many billion elevation points for this global scenery, such work will never be complete, but there is a great improvement over earlier editions of FS Global. Additionally, the resolution has been increased and reaches 19 m now in some areas.

2. SRTM

In February 2000 NASA in cooperation with ESA and NASDA conducted a Space Shuttle flight (STS-99) to acquire the most complete high-resolution topographic database of Earth. The orbiter Endeavour was equipped with a special interferometric radar system, consisting of two antennas: one was located in the payload bay, the other one extended on a mast 60m into space. During the 11-day mission the complete landmass between 60° north latitude and 54° south latitude was mapped in up to four swaths.

SRTM delivered an elevation model covering almost 120 million square kilometers of terrain in a lateral resolution of 1 arc second (approx. 30m). However, for political reasons, the full resolution dataset was only released for the U.S. territory. Global coverage is available in 3 arc second resolution. The dataset as it has been released to public consists of 35,9 billion elevation points or 67 GB (uncompressed). Further information can be obtained from the SRTM websites:

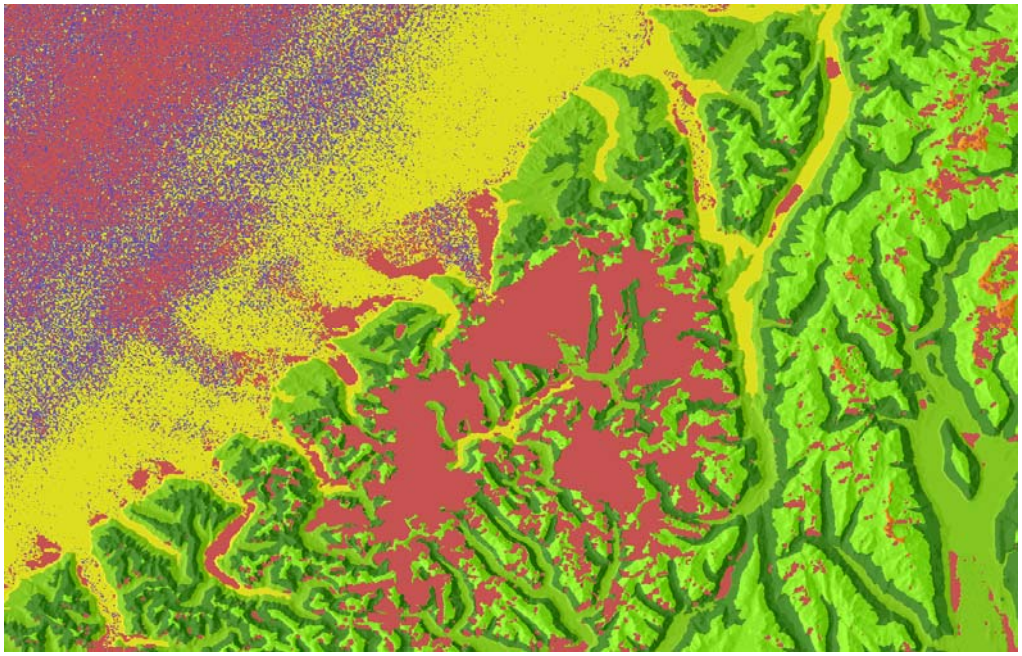
http://www2.jpl.nasa.gov/srtm/ and http://www.dlr.de/srtm/

Due to the principle of measurement SRTM data contain errors and voids, areas were no valid data are available. The reason is poor reflection of the radar signal on certain surfaces like sand or snow. Also shadowing effects play an important role: the radar often looked in a certain angle at the surface, so that the terrain behind steep slopes remained invisible for any measurement. The goal was to obtain the surface elevation of the Earth, not the elevation of tree-top or roof-top level. However, due to similar shadowing effects, in some very dense built-up areas measurements were distorted towards a higher elevation.

Although these errors affect less than 0,2% of the total landmass surveyed, they do affect the most prominent landmarks, especially mountain summits. This makes SRTM unsuitable for use in Flight Simulation without further processing.

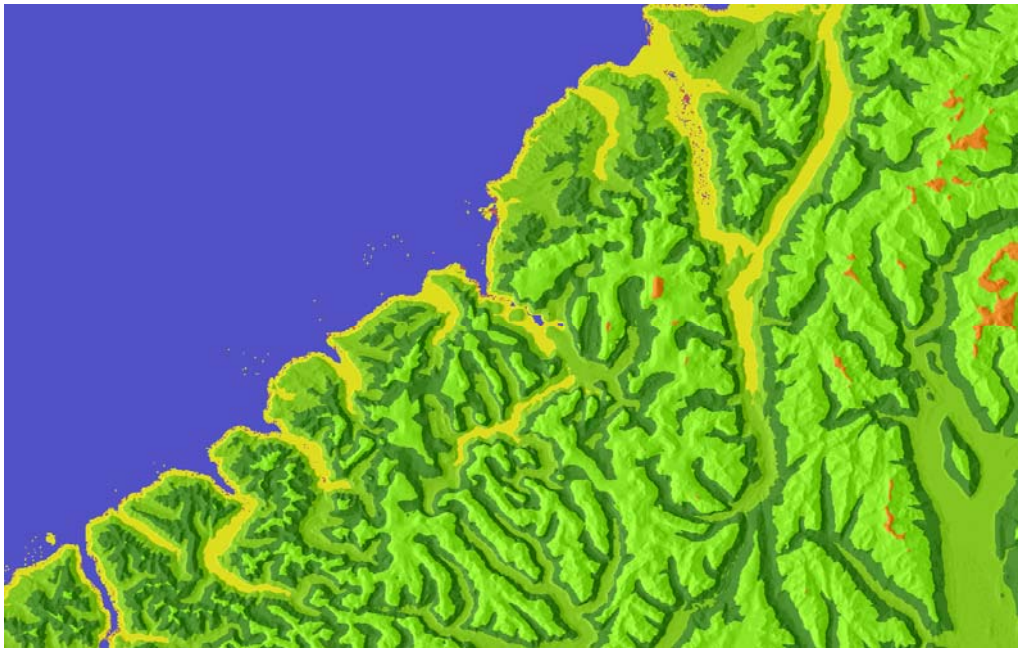
3. IMPROVING SRTM

Here is an image that shows elevation data for a part of New Zealand – voids are indicated by the red colour:



To cover small areas of data voids a simple spline interpolation can give good results. We have specialized in adapting more sophisticated algorithms for this problem using statistic and empiric approaches. By analyzing the slopes around a data void and the surrounding terrain characteristics, the algorithm can provide a good guess on how the missing data should look like. For example, the interpolation at the slopes of the table mountains in south-eastern Venezuela uses totally different parameters than in the rolling hills of the Black Forest in Germany. While reprocessing the data, we have further improved and corrected this approach by manual adjustments.

Here you can see the image of the above section after such initial reprocessing has been done:



This approach works well for certain, small areas or specific problems like shadowing of mountain slopes. But the void areas in the image above are too big already. Interpolation can not recover features that are definitely lost, like characteristic mountain summits or ridges where not even the ridge crest is available in the dataset.

So there is need for other sources. Unfortunately there is no digital dataset of global coverage available that can be compared to SRTM. In the FSX default scenery, terrain elevation in South America, Africa and most of Asia is based on the older GTOPO30 mesh. At many locations in high mountains the GTOPO30 elevation is wrong by more than 1.000 m due to combined vertical and lateral error. Using this source to amend SRTM data in void areas would rather worsen the result than improve it. For many countries local elevation meshes are available, that are even better than SRTM. They are used for military and industry applications like telecommunication, and they cost much more than a product like FSGlobal would generate as total sales volume. Moreover, the owner of the data usually doesn't allow any release to the public.

The only country with excellent data coverage available for free is the United States, thanks to the Freedom of Information Act. For the rest of the world, we have collected all mesh data that we were allowed to use. For very prominent Summits we've acquired local maps and generated a digital elevation mesh manually. This is the "hard way", the most time-consuming approach, but it was necessary to provide a significant improvement over the elevation data of the previous version, FSGlobal 2005.

There is one man who has specialized in this kind of work and who allowed us to build on his work for further improvement of FS Global: Jonathan de Ferranti. Most of our new, high-quality rendition of the Alps is based on his data, as well as Scandinavia beyond 60° N. He also provided several summits in the Andes and in the Himalaya. You may find more interesting information on his website:

http://www.viewfinderpanoramas.org/

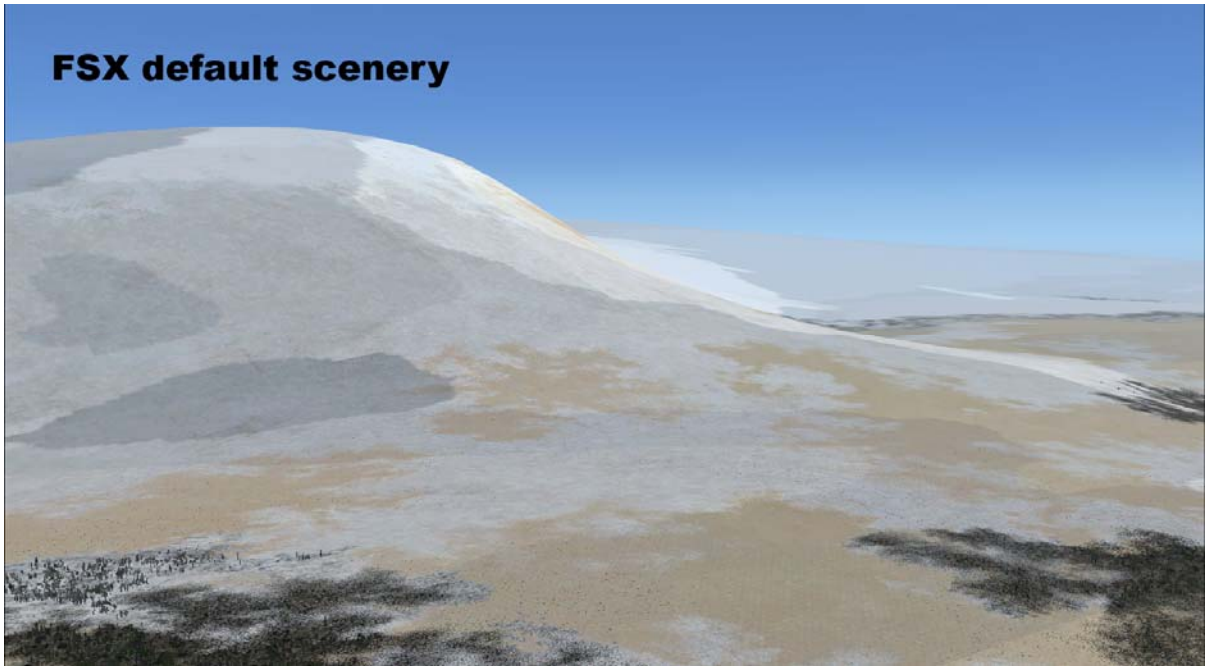
4. DATA COVERAGE IN FSX DEFAULT SCENERY

The FSX default scenery covers U.S. territory and a few very small areas in 38 m resolution (LOD10) and several developed regions in 76 m (LOD9) resolution, based on barely corrected SRTM data. A coverage map of the default scenery elevation mesh can be found in the appendix. In fact, the FSX elevation data for North America is quite good already. For that reason, FS Global 2008 provides no improvements north of the Mexican border or in Hawaii. For possible future extensions and compatibility there still is a mesh for North America included on the DVDs, but it is not active with the current installation of FS Global 2008. Here is a list of the LOD10 meshes of the FSX Professional Edition – the file naming convention is explained in a separate section below:

Region	Scenery area filename (xxyy)
USA & Carribean	0101, 0102, 0201, 0202, 0301, 0302
Alaska	0000, 0001, 0100, 0101
Hawaii	0003
Samoa	0004
Puerto Rico	0303
Pazifik	1002, 1003, 1103
Rio de Janeiro	0405
Cliffs of Dover	0601
Athen	0602

Things don't look so good in Europe, although FSX offers high resolution data there as well. The probably most prominent mountain of Switzerland, 4478 m high Matterhorn, does practically not exist in FSX, only the lower third of the Hörnli ridge is visible. Even SRTM errors that are easier to catch, like spikes and holes, have been transferred to the FSX default scenery. Here is a hole in the Moselle River in Germany near Koblenz, where the highway A61 crosses the valley – "Highway to Hell":

The terrain quality outside the detailed scenery areas in Europe, North America and parts of Asia is very poor. The direct comparison with FS Global shows a dramatic difference. The following two screenshots have been taken in exactly the same position in Patagonia, the coordinates are S49° 19,68' W072° 57,80', Altitude 7105 ft, magnetic heading 296, it is a view to the Mount Fitzroy massif.



5. DATA COVERAGE IN FS GLOBAL 2008

Here are the facts:

- Global coverage generally according to SRTM availability between 54° southern latitude and 60° northern latitude in approx. 76 m resolution (LOD9). Corrected SRTM data using local meshes, manual data acquisition and contributions from Jonathan de Ferranti.
- Coverage of the European Alps in a resolution of 19 m (LOD11), surrounding areas in 38 m resolution (LOD10).
- Coverage in Scandinavia extends to the North Cape, beyond 71° N.
- Using the new “quad mesh” technology introduced with FSX, intermediate meshes for far-distance views are included with each BGL starting with LOD4. For that reason, FS Global 2008 is not compatible with FS2004 / FS9.
- No data for Antarctica and the arctic regions except Scandinavia. We had these data in earlier versions of FS Global, but after Microsoft brought some improvements there (Iceland, east coast of Greenland), we currently have do data for significant improvements in these areas.
- The North America mesh of FS Global 2008 is currently not active. The reason is that the default scenery offers a 38 m resolution (LOD10) in mostly good quality. A higher resolution would be possible (down to 10 m), but as FS Global is a base scenery covering huge areas, that would be a waste of resources rather than a valuable improvement. We leave this to specialized local sceneries covering smaller areas.

It is important to understand how elevation data of different sceneries interact. Generally, a scenery layer that stands higher in the scenery library and has a lower number under “Priority” supersedes any scenery that stands below. That is why it is important to install FS Global correctly. In some earlier versions of Microsoft Flight Simulator there have been special rules for elevation data, this is not the case for FSX.

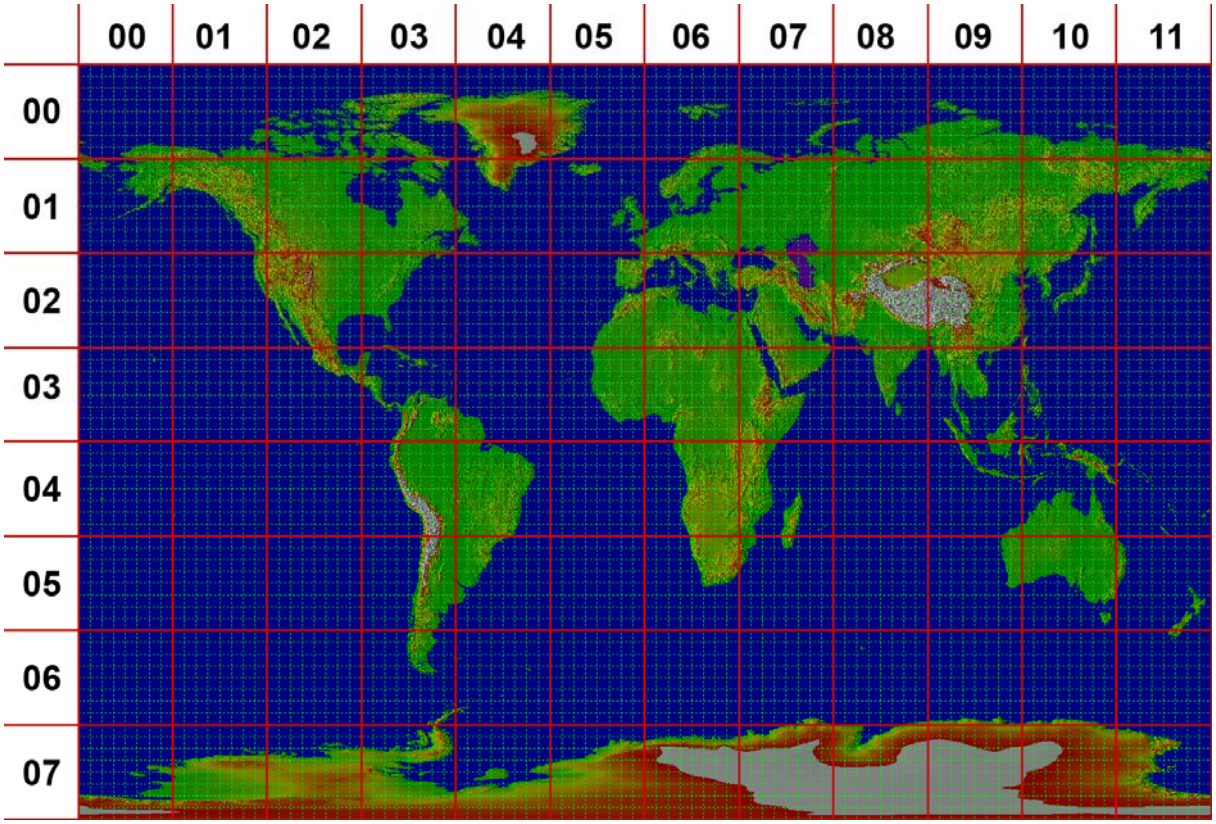
There is one exception: Independent from their order in the scenery library, higher *resolution* elevation data always supersede lower resolution data.

Example: In the previous section we’ve seen that the file DEM0601.BGL of the default scenery contains a small LOD10 mesh for the Dover Cliffs. FS Global installs in a higher level than the base scenery and generally overwrites the base scenery, as both sceneries offer an LOD9 resolution in Europe. Except in the area of Dover, where the LOD10 mesh of the default scenery has higher priority. So what you see in Flight Simulator is the best combination of both: the LOD10 Mesh of the default scenery at the Cliffs, and the FS Global mesh everywhere else.

This concept usually makes sense, as it protects the higher quality data. However, if you want to deactivate the default scenery completely, it is the best to rename the file {FSX main directory}\Scenery\0601\scenery\dem0601.bgl with a different file ending. Doing so will prevent FSX from loading these data, and it even reduces the loading time slightly. The Cliffs of Dover will still be present, although not quite as steep due to the lower resolution of the mesh.

6. FILENAMES IN FSX AND FS GLOBAL

The FSX base scenery is strictly organized in a tiling system. The earth is divided into 12 columns of 30° of longitude and 8 rows of 22,5° of latitude each:



Directory names and filenames are derived from this system by naming the column first and the row next. The base scenery for Germany, for example, is completely contained in the Folder “0601 Base”. And there we find a file named “DEM0601.BGL” that contains the elevation data (DEM for Digital Elevation Model). So the complete elevation data of FSX are distributed over 96 files named DEMxxyy.BGL.

There also is a second file naming system: you see the finer green grid in the image above. Each “red” cell is segmented into 8 x 8 “green” cells. Again, they are numbered from left-top to right-bottom, running from “0000” to “9563”. This file naming system is used by other scenery data (e.g. APXxxyy0.BGL) as well as FS Global. Except that FS Global uses three digits for each number, resulting in filenames like DG0xx0yy.BGL. The additional “0” doesn’t really make sense here, but was introduced by the original Microsoft SDK tools we used for compilation.

Of course it would have been easier for us, and for the user as well, to use another file naming system than the one explained above. But certain concepts, especially the inclusion of lower resolution intermediate meshes made it necessary to adhere to the FSX conventions and internal boundaries. And it’s not too difficult to calculate the coverage area when you see the filename, here are the formulas:

Longitude coverage:	-180 + 3.75 * x	to	-180 + 3.75 * (x+1)
Latitude coverage:	90 – 2.8125 * (y+1)	to	90 – 2.8125 * y

X and Y the indices as described above, referring to the filename scheme DG0xx0yy.BGL. And vice versa – to calculate the file that covers a certain point that is defined by (Latitude, Longitude):

XX: truncate ((Longitude + 180°) / 3.75)
YY: truncate ((90 – Latitude) / 2.8125)

Example:

The Matterhorn summit is at E007° 39.5' (= 7.65833°), N45° 58.6' (= 45.97667°). Inserting these values to our formula leads to:

XX = truncate ((7.65833+180) / 3.75) = truncate (50.04) = 50
YY = truncate ((90-45.97667) / 2.8125) = truncate (15.65) = 15

So the Matterhorn summit is contained in the FS Global file DG050015.BGL.

Just take care that western longitudes and southern latitudes are represented by negative values for longitude respective latitude. The FS Global files are distributed in directories covering one continent or area each. Here are the directory names:

Local Meshes	Meshes for local adaptation of SRTM and airport terrain
AFR	Africa
ASI	Asia
CSA	Central and South America
EUR	Europe
OCE	Oceania

Please refer to the appendix to see where the boundaries for these areas are.

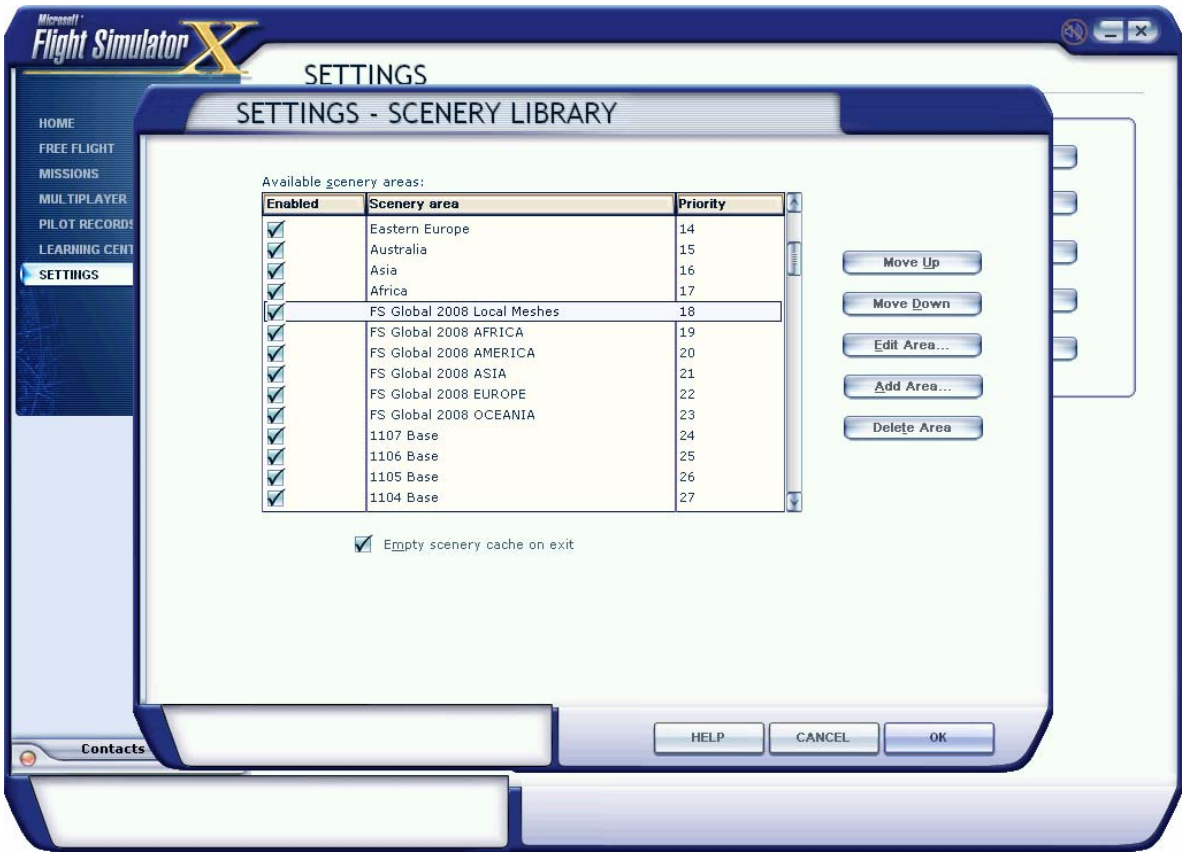
7. MANUAL INSTALLATION

This section explains how to install FSGlobal manually, and by that way explains what the installation program exactly does with FSX. Installation is quite easy and takes three steps:

1) **Copy** the terrain data from the DVDs to a hard disk directory. You have a free choice where to put the files, you can even distribute FS Global over several drives, just avoid the default scenery directories of FSX. And you should leave the directory structure intact: the BGL files have to reside in a subdirectory named “scenery”.
2) **Modify your Terrain.cfg** file. This step is optional and is explained further down in this document.
3) **Register FS Global** in the scenery library. The recommended way to do this is through the corresponding FSX menu, but you may also just edit the Scenery.cfg file.

At the last point you should know about one thing that is new to FSX. There are two versions of the Scenery.cfg file. You should NOT touch the Scenery.cfg in the FSX default directory! The one you need to edit can be found under C:\Documents and Settings\All Users\Application data\Microsoft\FSX.

FS Global should be installed right above the base scenery. So with a maiden FSX installation the scenery library would look like this after correct registration of FS Global:

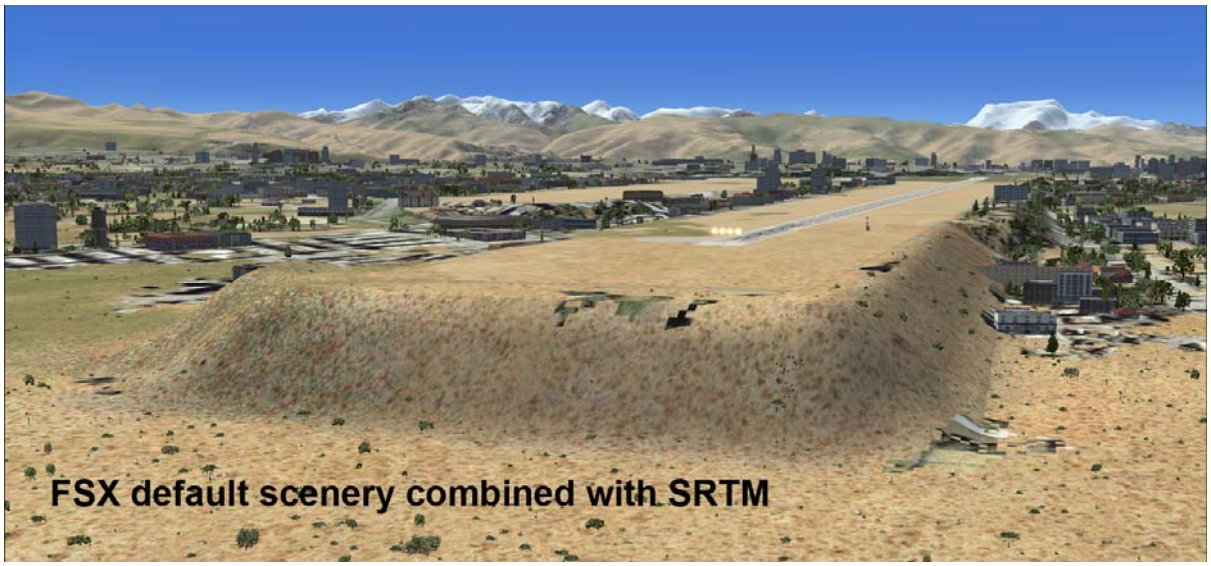


8. FS GLOBAL AND AIRPORTS: INTRODUCING LOCAL MESHES

FS Global changes the elevation of the Flight Simulator terrain, and nothing else. For that reason there are very few compatibility problems with other add-ons or the default scenery. There are however problems, when scenery objects introduce their own elevation data and that value differs too much from SRTM data. In flat and clear areas where airports usually can be found, the reliability of SRTM data is very high and their vertical accuracy is mostly within 2 m. In all cases where we have analyzed conflicts, the SRTM data were correct.

One typical reason for a conflict lies in a very old concept that is used in scenery design for Flight Simulator. FSX airports usually have to be totally flat at one unique elevation. The surrounding terrain is forced to that elevation and flattened. Now Microsoft, as well as developers of add-on scenery, uses the official aerodrome elevation to build the airport upon. Unfortunately that aerodrome elevation *always* represents the highest of all runway thresholds; it is an extreme value, *not* an average value or the elevation of the airport reference point.

And real world airports are everything but flat, even rather large and popular airports have a significant slope. In Madrid, for example, threshold elevations differ by 123 feet, in Cairo it's a difference of 192 feet – almost the height of a regular CAT I minimum. What happens when the misplaced airport enforces such a wrong elevation can be seen here:



This is the western end of the airport of La Paz, Bolivia. The runway 10 threshold has a real world elevation of 13.112 ft, Microsoft places it at 13.313 ft – that is an error of 201 ft. The higher elevation is true for the other end, runway 28, and the real world airport has a significant slope. The slope can be seen in the SRTM data, which are very precise and deliver the correct picture. So the runway *should* be at the level of the surrounding terrain. The problem is not so obvious with the elevation mesh of the default scenery, because due to its coarse resolution, it adapts smoother to the airport elevation.

So the problem is that the airport enforces a wrong elevation. We cannot solve the problem, as it is impossible for a project like FS Global to redesign so many airports, but we can improve the looks. We just added a little file to FS Global named SLLP.BGL (SLLP is the ICAO code for La Paz) which adapts the terrain to the wrong airport elevation in a smooth way. It is not correct, but it looks better:

This file is installed in the scenery area “local meshes”, which is registered in the scenery library with a higher priority than FS Global and therefore supersedes the default FS Global terrain. Placing this local mesh in a separate file allows us to provide the correct elevation data with the default FS Global mesh. So if ever add-on scenery with a correctly sloped runway becomes available, it will fit perfectly into FS Global after just removing the local mesh file.

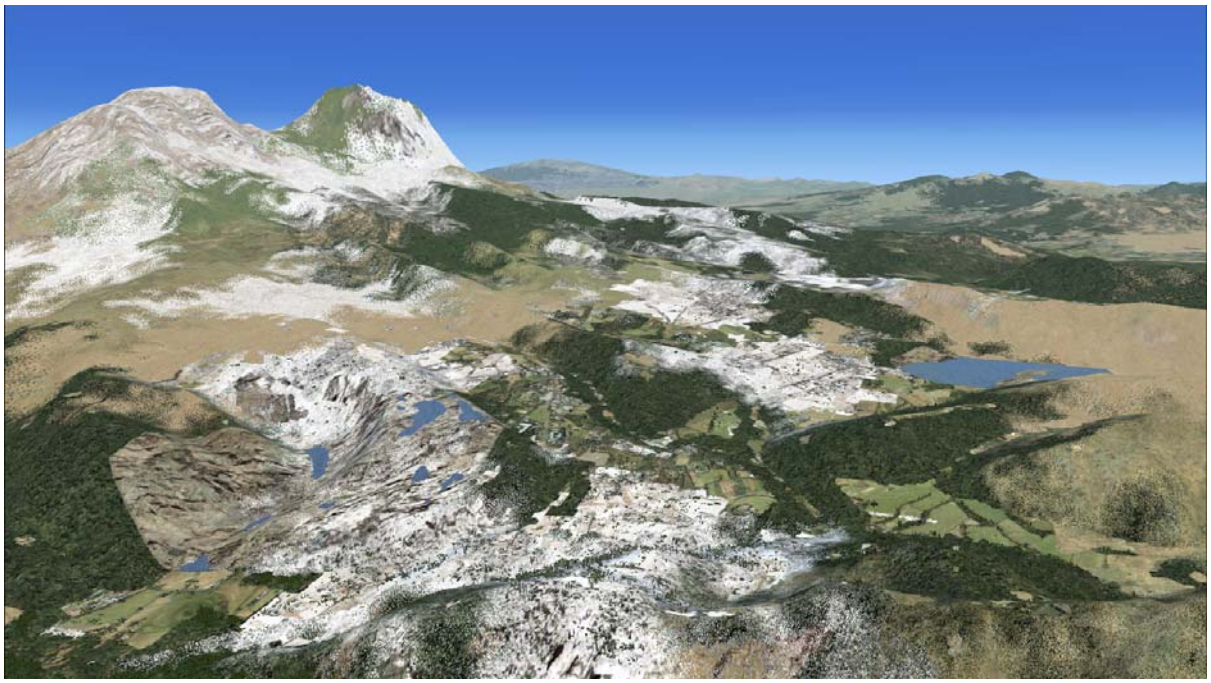
FS Global is developed by people who have a regular job and just spend their spare time with Flight Simulation. It exceeds our capacity to provide such a local mesh for every airport or add-on scenery in the world. So if you are a developer and intend to place an airport at a locally wrong elevation, we ask you to provide such a local mesh.

Finally, here is another famous airport, as seen when combining with high-resolution terrain data. It is the island of Madeira in the Atlantic Ocean. Microsoft has placed the aerodrome at an elevation of 711 ft, while the real world elevation is 147 ft for runway 05, and 192 ft for runway 23. That is an elevation error of more than 500 ft. Not the only one, but probably the most prominent one. We are asking you to understand that it makes no sense to adopt any precise elevation mesh to such nonsense data.

9. FS GLOBAL AND VECTOR DATA

It's not only the airports that enforce their own elevation. Every water body, road or railroad in FSX is carrying its own elevation data, which was simply derived from the default scenery elevation mesh and therefore is consistent with the default scenery. This kind of scenery data is called vector data, because it is defined by discrete coordinates (vectors) and not by a grid as a bitmap or mesh.

Here are two images from the north slopes of the huge Cayambe volcano in northern Ecuador. The first image shows the potential conflict, the second how it is solved with FS Global.

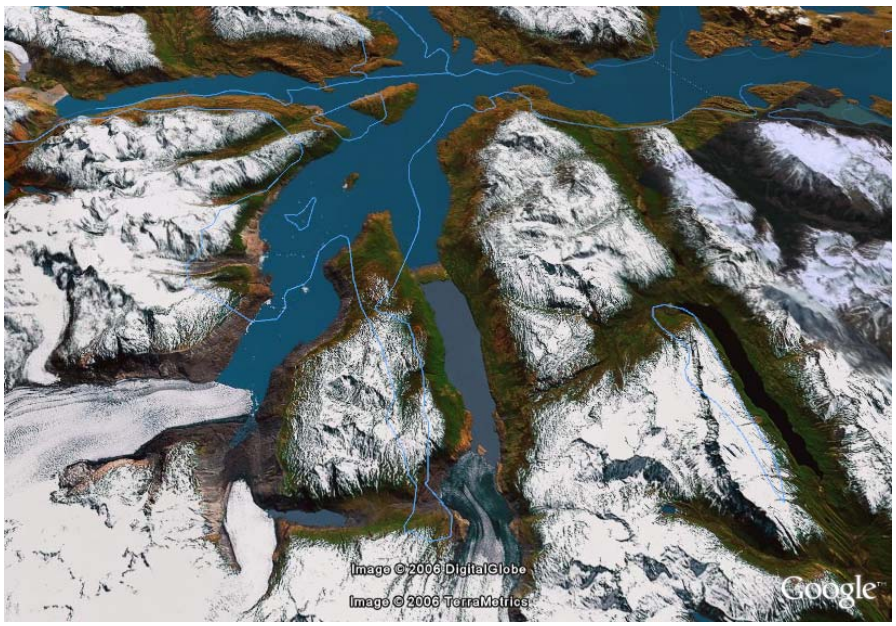


The large pools in the first image are defined in the FSX default scenery. Based on very bad GTOPO30 data they have been placed at an elevation that is more than 1000 m to high. To understand the conflict, we can use Google Earth as a tool, because it is capable to display precisely georeferenced satellite images overlayed with the same

vector data that are used in FSX default scenery. Here it is obvious that the left lake doesn't exist in the satellite imagery at all, and the right one is misplaced:

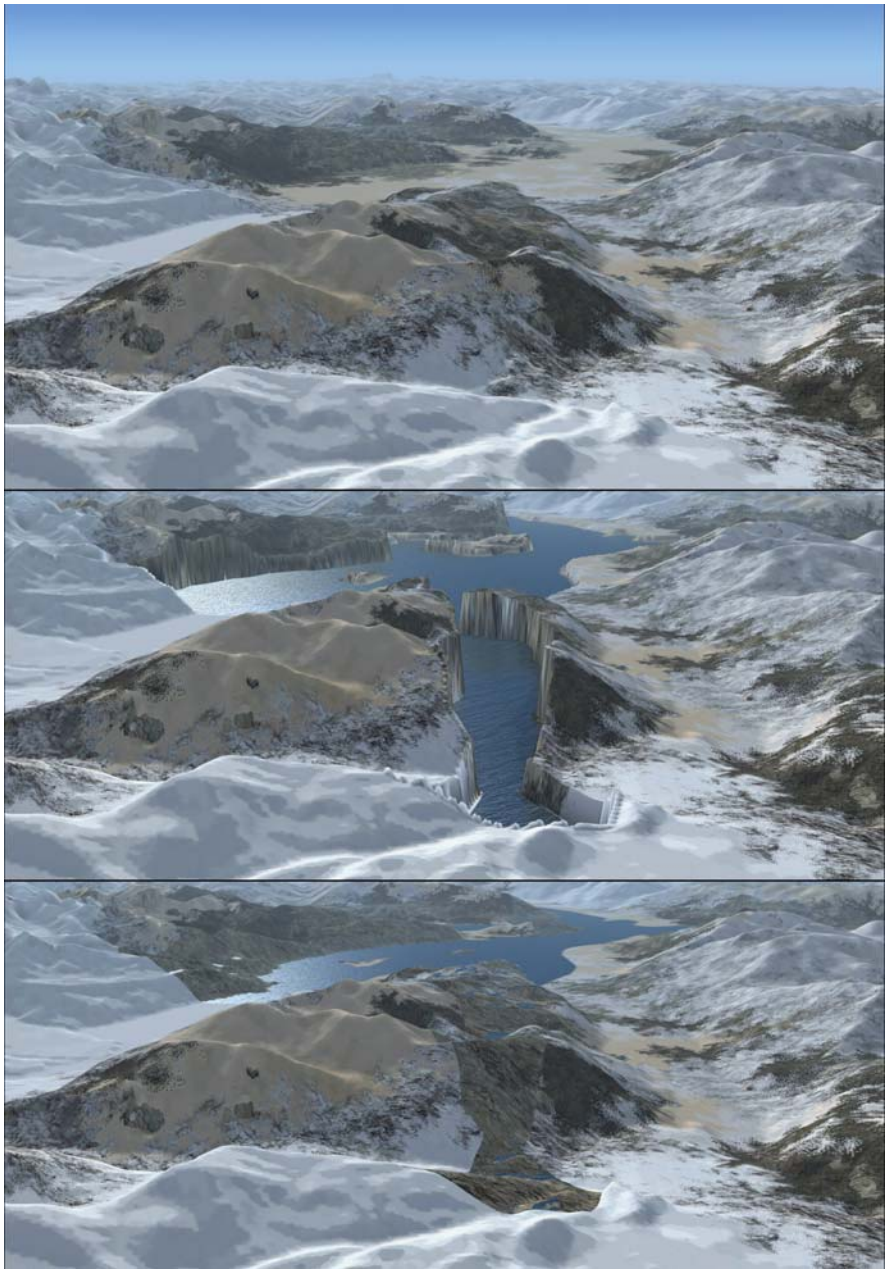
In Google Earth the lakes don't have any elevation information, they are just drawn onto the surface provided by the elevation mesh. FSX can be configured to do it the same way, as the second image above shows. There is a function in the graphic engine, that automatically replaces the water texture with a rock texture whenever the slope exceeds a certain steepness. This makes sense when combined with a good elevation mesh, as only those places where the presence of water is likely are displaced as water.

Here is another example that shows the conflict between an inaccurate shoreline and precise terrain/satellite data. First the Google Earth image, it's Lago Chico in southern Chile:



The southern arm of the lake is misplaced to the southwest by more than two miles. The same can be observed with Flight Simulator. Of the following three images, the

first one shows the naked elevation data of FS Global with the vector scenery deactivated. The second one shows the combination with default vector scenery without further adjustments and the third image shows FS Global with the terrain flattening function deactivated for certain scenery objects.

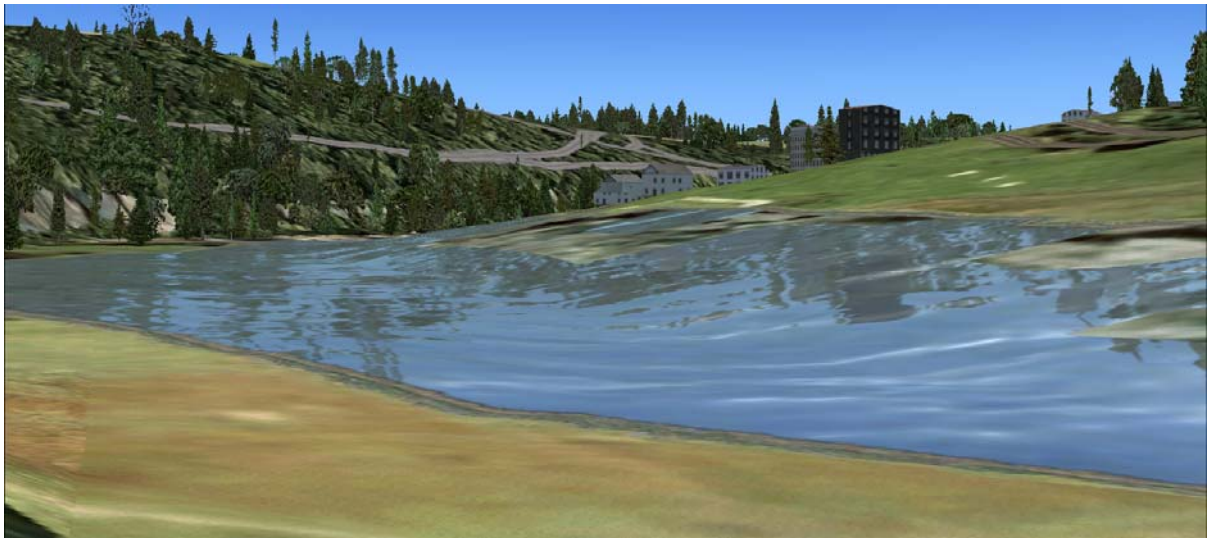


Due to the lack of better data sources we have to live with the default vector scenery for now. After a lot of testing we think that the solution demonstrated above is currently the best way to combine FS Global with the default vector scenery.

We provided a tool named FSG_No_Flatten.exe that configures your FSX easily as shown above, or to return it to its original state. Details about how it is working come with the next section.

10. TERRAIN.CFG

The FS Global 2008 installation routine recommends to deactivate the flatten function of several scenery objects. It is the default setting to do this, but it is optional and it may have disadvantages, like water texture on uneven surfaces:



After a lot of testing, we found that the negative side effect of not having even water bodies is usually barely noticeable from any reasonably flying altitude. Also, the default scenery contains a lot of water bodies that are not flat due to erroneous elevation information in them. Overall, there are much more advantages than disadvantages. However, if you find that the default settings suit your preferred places in the Flight Simulator world better, you can easily return to the defaults or change the settings manually.

The configuration tool FSG_No_Flatten.exe edits the file TERRAIN.CFG that can be found in the FSX default directory. This file must be dealt carefully with and it is to be expected that many scenery add-ons will make changes to that file without appropriate notification to the user.

The TERRAIN.CFG defines the settings for several hundred generic scenery objects like water bodies, roads or airport polygons. Each section begins with an entry [Texture.NNN], where NNN is a number. FSG_No_Flatten.exe looks up a couple of sections and exclusively changes the “FlattenMode” setting to “none” – or back to the default value.

Here are the settings in the TERRAIN.CFG that are changed by default:

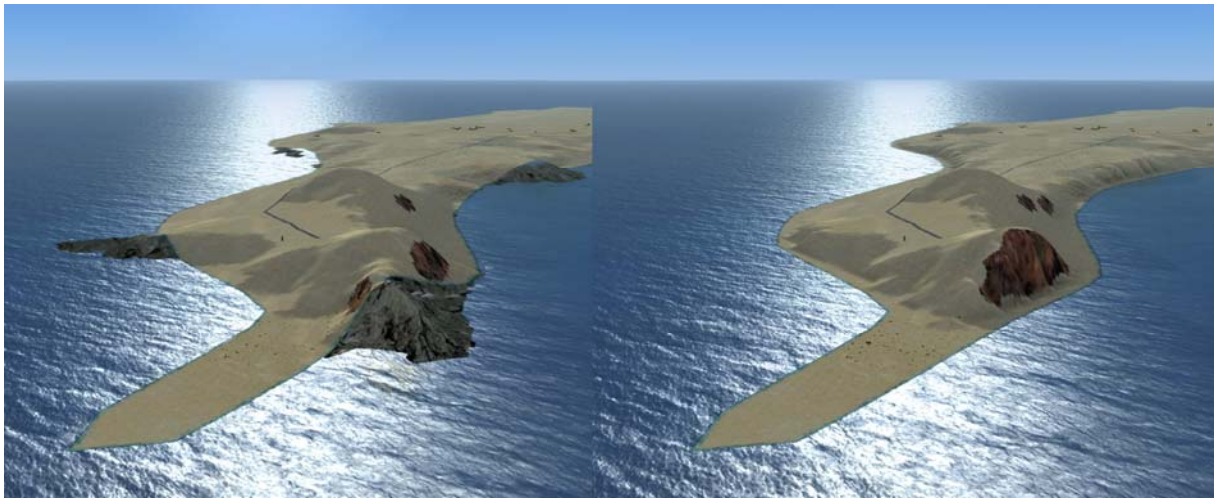
Texture-number [Texture.###]	**Object type**	**Default FlattenMode (old)**	**FlattenMode for FSGlobal (new)**
0, 1	Water bodies	FlattenMode=offset	FlattenMode=none
116 – 163 (48 x)	Roads	FlattenMode=flat	FlattenMode=none
195	Bay, Harbor	FlattenMode=slope	FlattenMode=none
196, 197, 198	Water bodies	FlattenMode=slope	FlattenMode=none
200	Railroads	FlattenMode=flat	FlattenMode=none

Unfortunately, it is not sufficient only to change the flatten mode for water bodies. When you go back to the section “DATA COVERAGE IN FSX DEFAULT SCENERY” in this document, you will find a picture with a “hole” in the Moselle River. The wrong

elevation of the hole is coded in the elevation mesh (that is fixed by installing FS Global), but also in the river polygon, the highway, three roads and the railroad. So the flatten function for all these object types has to be deactivated to fix the hole.

We did not dare to change the flatten mode setting for “default ocean” ([TEXTURE.194] and [TEXTURE.199]) objects, because we expected possible interference with other scenery. You might want to try changing this manually. Here is an example that shows Cape of Good Hope near Cape Town, South Africa. The default scenery coastline is very inaccurate at this prominent location. The left image shows the FS Global elevation data combined with the default coastline and the flatten mode for all water bodies switched off. You can imagine real shape of the Cape and see that the long arm of the coastline doesn’t belong there.

The right image shows what you currently get with FS Global and the default setting. The (truly) southernmost point of the Cape is clipped of by the inaccurate shoreline, and the terrain flattened to sea level.



Of course, the best solution will always be to acquire more accurate coastlines. We are working on future solutions, but cannot offer a solution on a global scale as quickly as a small local scenery can. Quite shortly after release of FSX we already found detailed coastline add-ons on the internet. In such areas with good vector data coverage the flattening problem becomes partly obsolete.

Also on the internet we found a modified version of the TERRAIN.CFG file by Richard Ludowise and Luis Féliz-Tirado (fsx_modified_terrain_cfg.zip on www.avsim.com). This file turns off the function that displays rock instead of water on greater slopes. However, that problem becomes obsolete when you turn off the flatten mode as described above, and have an underlying mesh that provides a rather even surface. FS Global offers a great improvement in that field, the demonstrated problem with the River Thames in London is not existent anymore with FS Global!

So we do not recommend using that file, but if are annoyed by too much rock instead of water in the area where you prefer to fly, you may do so. Just remember: By simply **overwriting the TERRAIN.CFG** with another version you **will delete all settings** that FS Global and other add-ons might have applied to that file. To recover the settings for FS Global, you just need to execute the configuration tool “FSG_No_Flatten.exe” once again. Same applies if another add-on has overwritten the TERRAIN.CFG after installation of FS Global.

11. ACKNOWLEDGEMENT

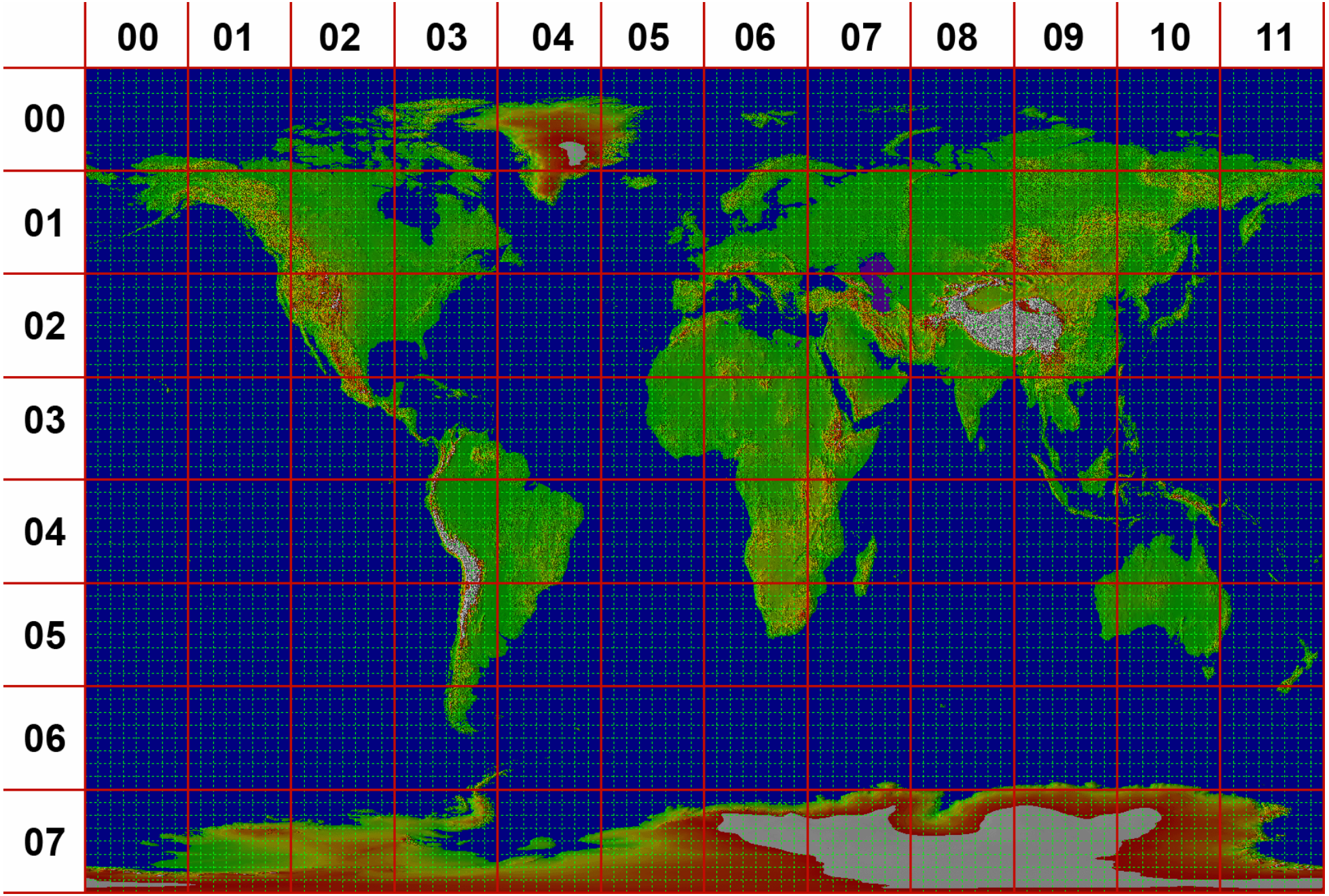
Special thanks to

- **Jonathan de Ferranti**
- **NASA and USGS for SRTM**

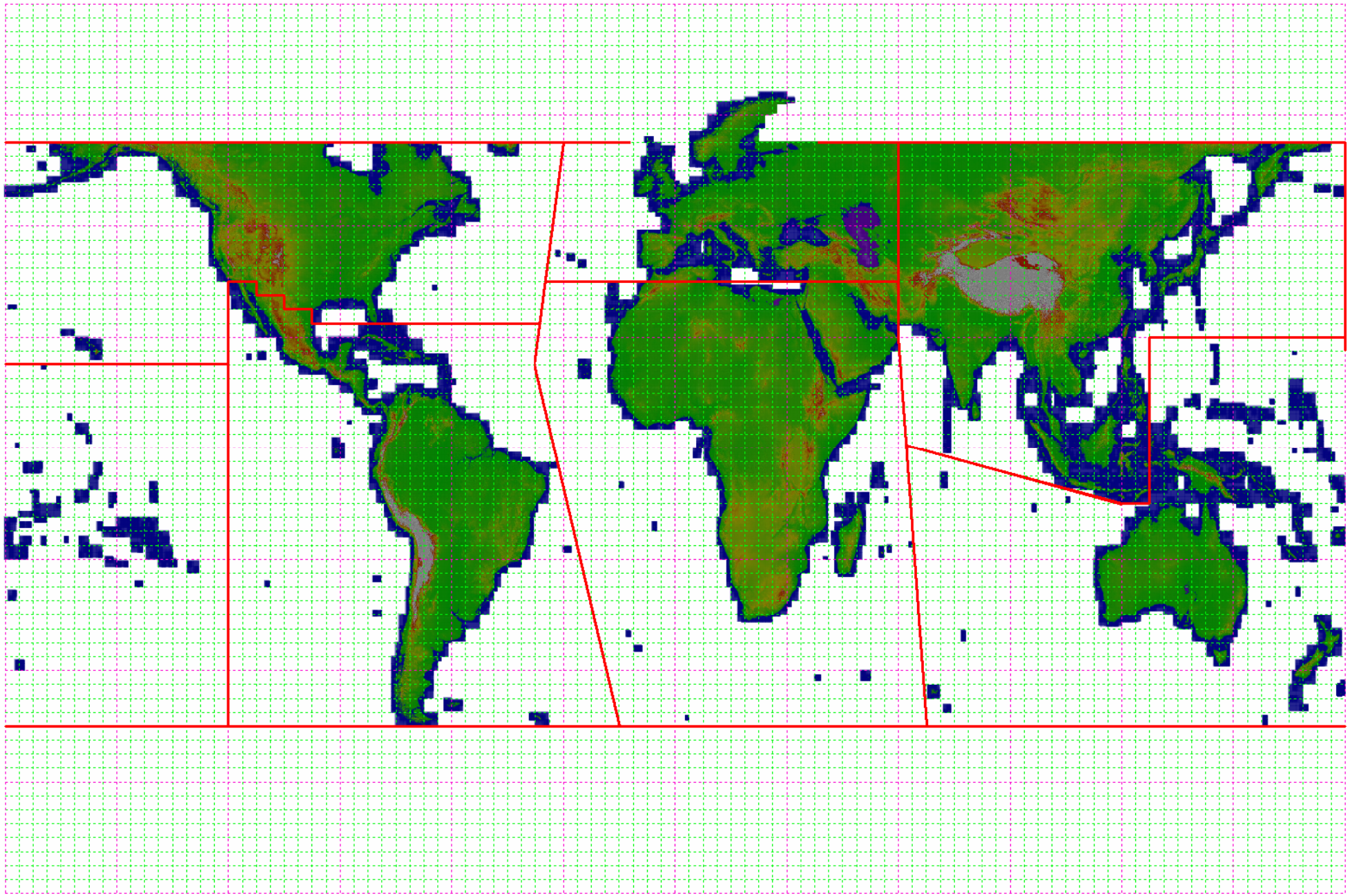
12. APPENDIX

The following pages display the coverage of FSX and FSGlobal data.

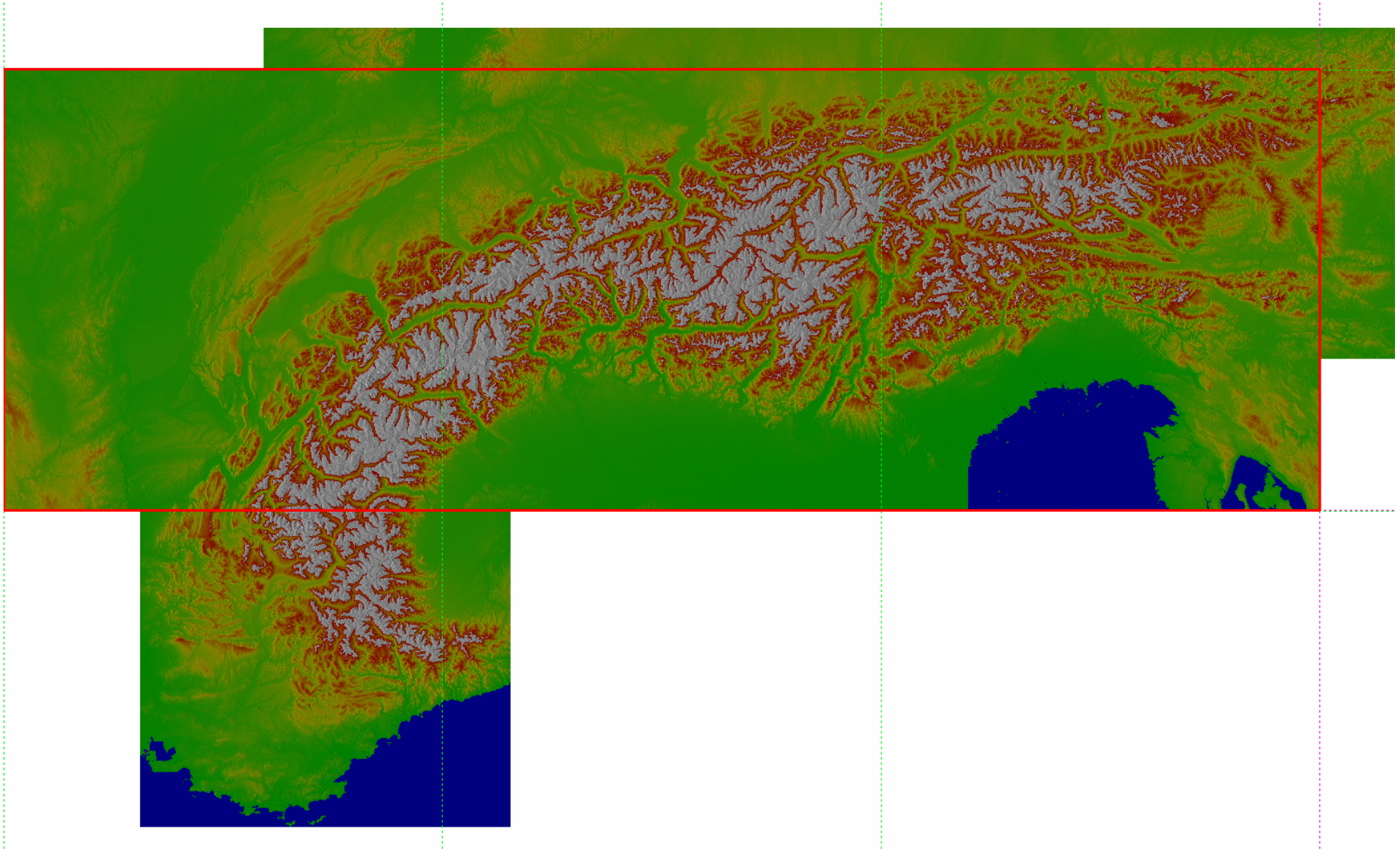
Base Scenery Areas in FSX



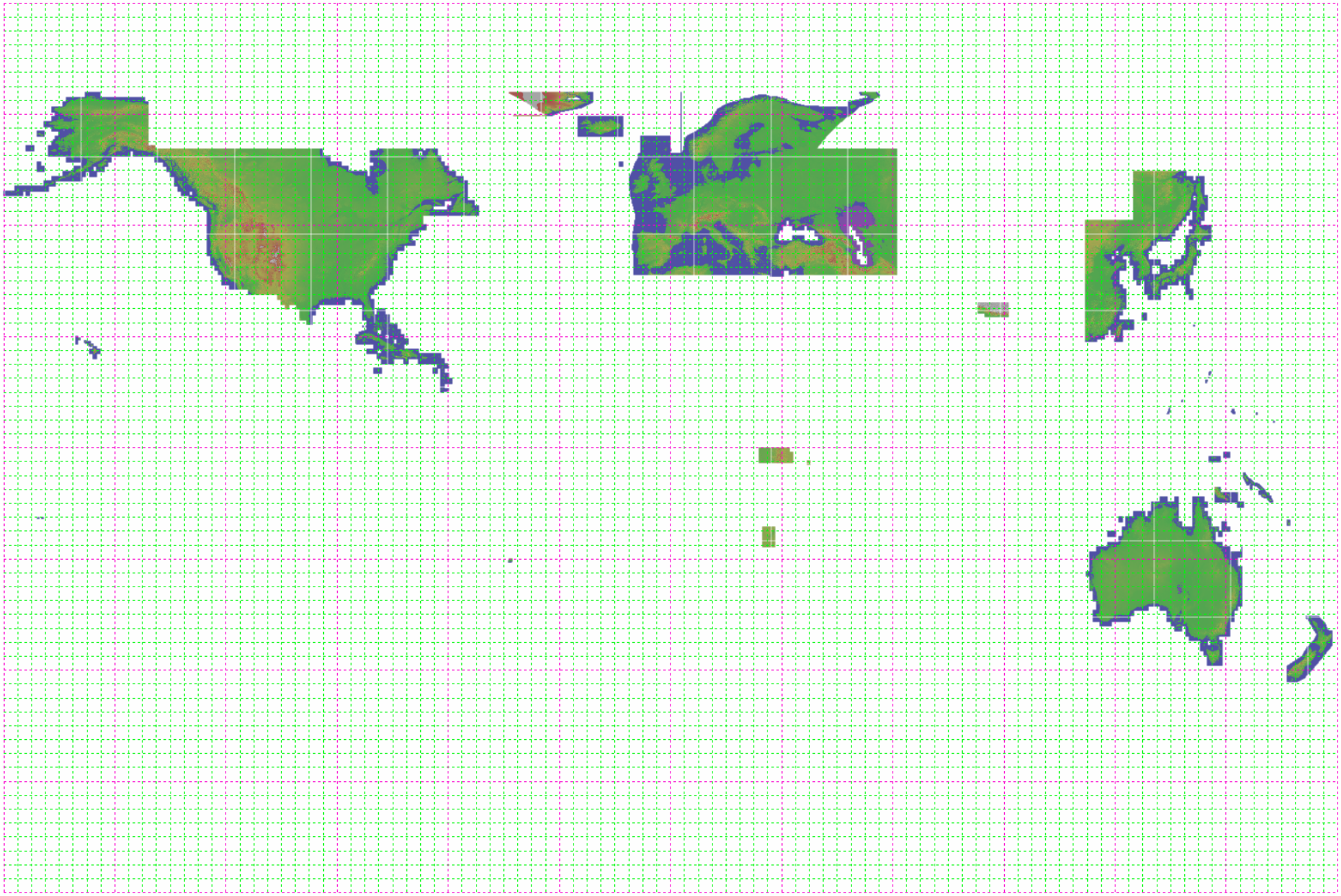
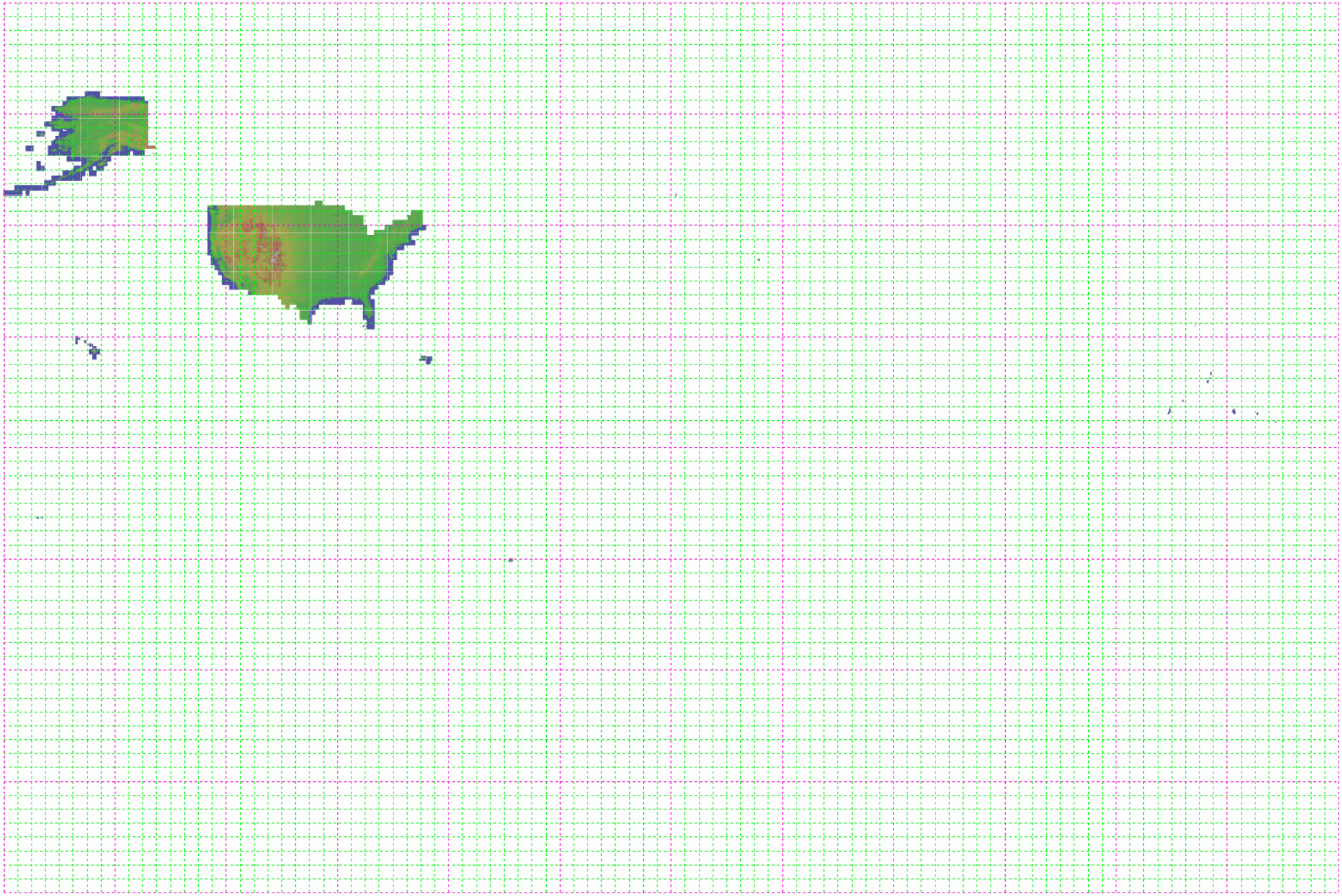
FS Global Coverage (LOD 9, 10, 11) and Areas



FS GLOBAL ALPS: LOD 10 (all visible) AND LOD 11 (red rectangle)



FSX Professional Edition: default scenery coverage in LOD 9



FSX Professional Edition: default scenery coverage in LOD 10