Framework to integrate Space-based and in-situ sENSing for dynamic vUlnerability and recovery Monitoring

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List of Acronyms

GFZ	German Research Centre for Geosciences, DE
EUCENTRE	European Centre for Training and Research in Earthquake Engineering, IT
DLR	German Aerospatial Agency, DE
NGI	Norwegian Geotechnical Institute, NO
UCAM	University of Cambridge, UK
CAIAG	Central Asian Institute for Applied Geosciences, KG
IGEES	Institute for Geology and Earthquake Engineering, TJ
ICAT	ImageCat Ltd., UK
EC	European Commission
WP	Workpackage
DoW	Description of Work
ESA	European Space Agency
GIS	Geographic Information System
SQL	Structured Query Language
GEM	Global Earthquake Model
ID	Identifier
OID	Object Identifier
VHR	Very High Resolution
HR	High Resolution
MR	Medium Resolution
OGC	Open Geospatial Consortium
WMS	Web Map Service

WFS	Web Feature Service
WCS	Web Coverage Service
GML	Geographic Markup Language
ISO	International Organization for Standardization
SDI	Spatial Data Infrastructure

Executive Summary

Focus Maps have been designed to provide to end-users with simple tools to understand where to focus the effort of collecting data in the field. A focus map is a representation of the spatial “relevancy” with respect to the set of available information, and constraints. (See SENSUM Deliverable 3.3).

Combining the spatial hazard and the spatial exposure, for instance, a SENSUM user could obtain a focus map defining the spatial density of probability of sampling a location given the level of hazard and the extent of the exposure, therefore increasing the efficiency of the data collection and integration task.

The Focus Maps have been implemented in a software package which can easily be accessed by Quantum GIS (QGIS), a popular and FOSS (Free, Open Source Software) GIS environment.

In the following, the QGIS software package and its components are described and and several application examples are provided. The underlying R package is described in a separate (annexed) document.

1. Introduction

The **Qgis-R tools** are a collection of Quantum GIS (QGIS) scripts and models developed within the FP-7 SENSUM Project to implement algorithms for generating Focus Maps, a key step in the development of efficient data collection schemes. The tools are subdivided in scripts and models, each type referring to a specific scripting type (See QGIS Sextante documentation for further details). Each script is an ascii file containing an header and a body. The header contains a set of special instructions to automatically generate the graphical user interface of the script itself. The body of the script in this case is composed by R code. The scripts can acts as simple wrappers for the R packages and function, or can implement themselves original algorithms.
The models refer to a graphical processing environment recently introduced in QGIS. This framework allows for combining different algorithms, possibly developed themselves in different environments (R, GRASS, SAGA, OTB, etc) in a single processing pipeline which is defined by visual blocks (either inputs, or algorithms). Contrary to the scripts, the models are saved in a non-friendly ascii format and cannot be directly edited.
The Focus Map utilities are based on the SENSUM R package 'focusmapr'. The Documentation of this package is provided as a separate document.
In the following a brief description of the tools and models is provided.

2. Installation

The scripts and models can be downloaded from https://www.github.com/SENSUM-Project/Qgis-R where the latest development version is residing.
Linux: copy all the files from the folder “rscripts” to the folder “~/.qgis2/processing/rscripts”. Copy all the files from the folder “models” to the folder “~/.qgis2/processing/models”. The files with extension “.help” contain a short documentation about the individual scripts/models.
Windows: same procedure, with the related paths (always in the user´s Documents folder).
The processing scripts are available in QGIS under the Processing->Toolbox menu item, which provides a simple graphical interface. When starting QGIS, all available scripts and models are automatically loaded.
In order to run the scripts, a clean R installation (<= 3.0) has to be present in the system.

3. Scripts

GenerateDensity

The script generates a two-dimensional density from a set of points (vector layer), using a kernel density approach.

Inputs

vec_layer		Input vector layer contatining a set of points
sigma		Parameter of the kernel used to compute the density
resolution_x		X resolution of output raster
resolution_y		Y resolution of output raster

Outputs

dens	raster	Output raster density

GenerateFocusMap

The scripts takes in input a list of raster layers, and combines them to generate a Focus Map. Up to four input rasters can be used. Two different pooling can be chosen, either “linear” or “loglinear”. The normalization is based on a rejection bound approach for outliers rejection (a rejection bound [0,1] is equivalent to standard normalization). In case the input layers have different resolution and origin, they can be resampled (according to the first element of the list).

Inputs

input_rasters	Multiple rasters	List of input raster layers, with same projection.
high_rejection_bound	number	Higher rejection bound (hrb). 0<=lrb<hrb<=1
low_rejection_bound	number	Lower rejection bound (lrb). 0<=lrb<hrb<=1
pooling_str	string	“linear” (additive) or “loglinear” (multiplicative)
resample_rasters	boolean	If “True” input rasters are resampled according to the first layer´s resolution
equal_weighting	boolean	If “True” weights are set equal to 1/n_input_layers
weight_1	number	Weight of first raster layer
weight_2	number	Weight of first raster layer
weight_3	number	Weight of first raster layer
weight_4	number	Weight of first raster layer

Outputs

focus_map	Raster	Output raster layer. The extent is the intersection of the input layers´ extents

GenerateFocusMap_2inputs

Same functionalities as GenerateFocusMap script, but with two fixed input raster layers to allow for graphical modeling.

Inputs

input_raster1	*raster*	First input raster layer
input_raster2	*raster*	First input raster layer
high_rejection_bound	number	Higher rejection bound (hrb). 0<=lrb<hrb<=1
low_rejection_bound	number	Lower rejection bound (lrb). 0<=lrb<hrb<=1
pooling_str	string	“linear” (additive) or “loglinear” (multiplicative)
resample_rasters	boolean	If “True” input rasters are resampled according to the first layer´s resolution
equal_weighting	boolean	If “True” weights are set equal to 1/n_input_layers
weight_1	number	Weight of first raster layer
weight_2	number	Weight of first raster layer

Outputs

focus_map	raster	Output raster layer. The extent is the intersection of the input layers´ extents

RasterFlip_y

Performs a flipping of the input raster around 'y' axis.

Inputs

raster_layer	raster	Input raster layer

Outputs

output_layer	raster	Output raster layer

Models

Demo_cologne_1

The script generates a set of sampling points based on a focus map. The focus map is generated from two layers, the extent of a flood scenario and the density of buildings (see Fig. 1). This model has been designed to implement a demo for the city of cologne. The input files to run the demo are available for download in the github repository of the software package.

The generated points are automatically written in a table postgreSQL/postgis database.

Note:

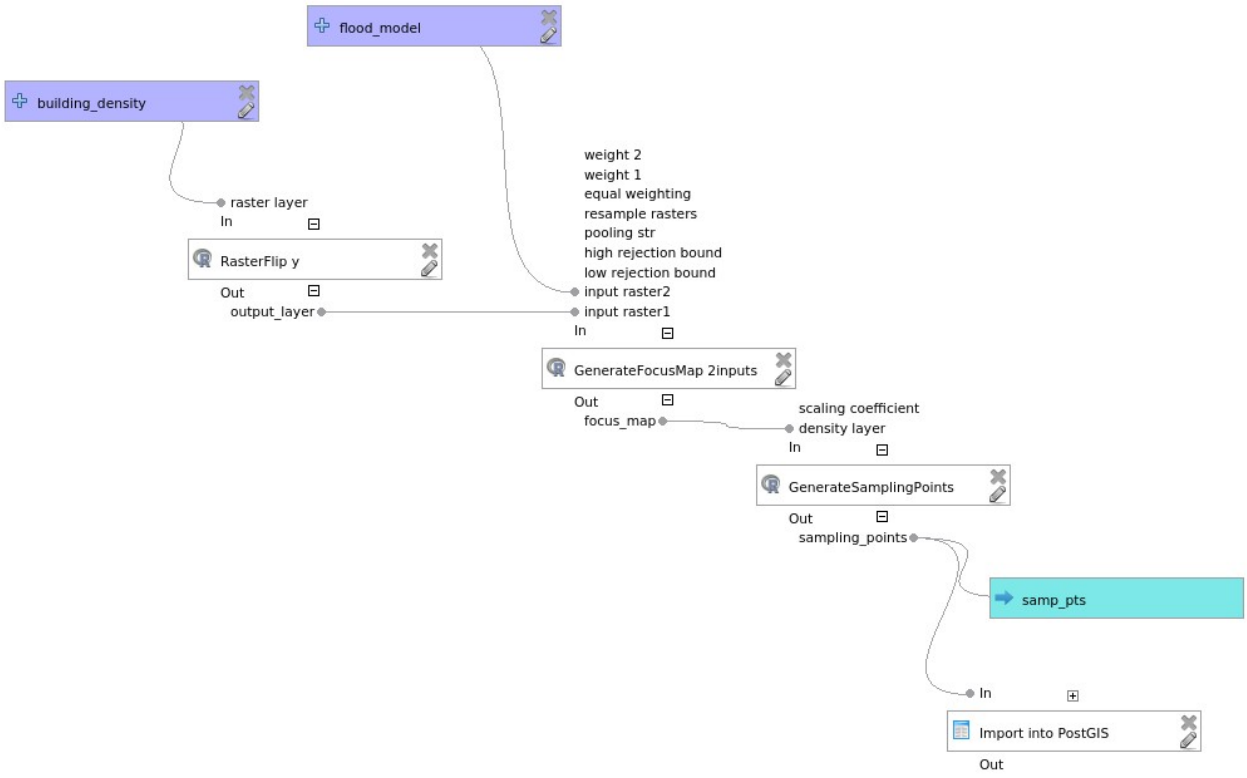

Figure 1: Structure of the QGIS model demo_cologne_1. In purple the input rasters, in cyan the output vector. The white blocks represent processing stages

Inputs

building_density	raster	Density of buildings, generated using the QGIS heatmap plugin. The density raster

		has been generated with the QGIS heatmap utility, and must be flipped in order to be further processed.
flood_model	raster	Flooding scenario

Outputs

samp_pts	vector	Set of sampling points generated according to the focus map

Example

In the following an example of usage of the above described software packages is shown.
NOTE: The data necessary to run the example can be downloaded from the public repository https://github.com/SENSUM-project/Qgis-R.

Generating a focus map

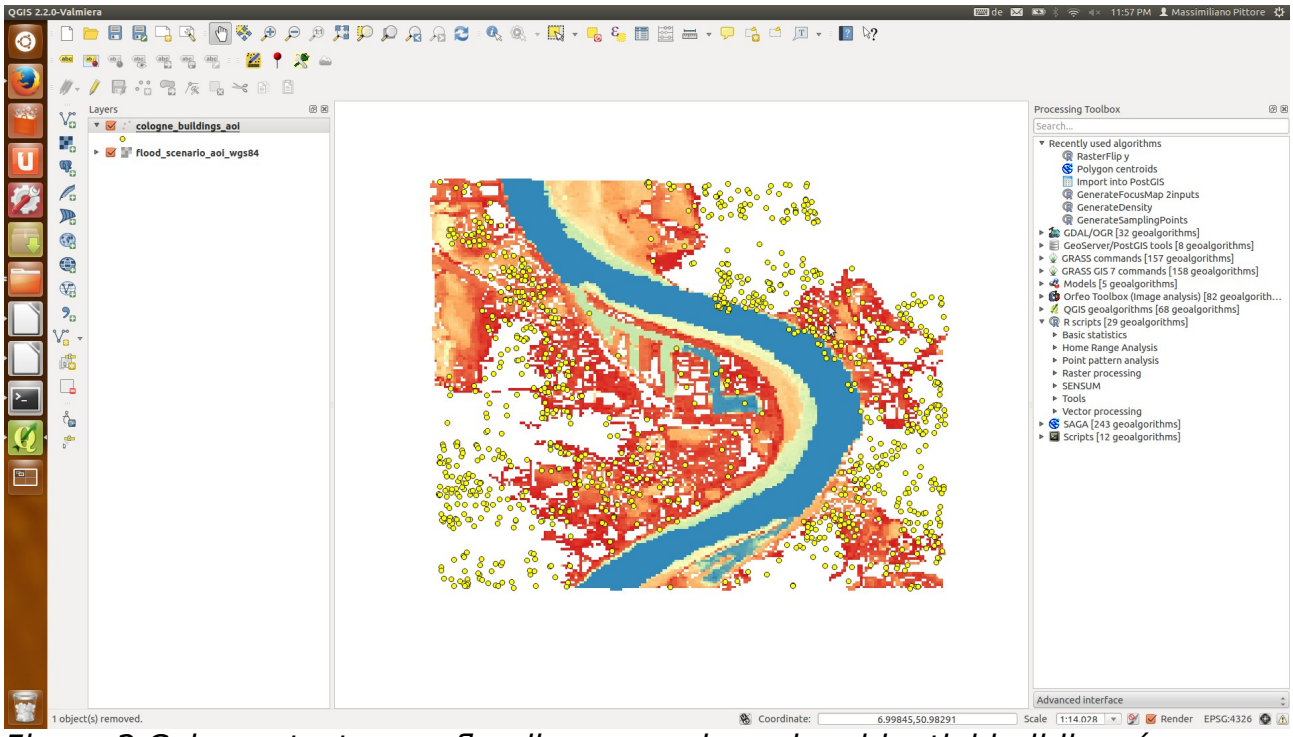

Figure 2 Cologne test case: flooding scenario and residential buildings´ distribution

In Fig. 2 the input data are shown. In this example, the Cologne (Germany) test case is considered. The available data is composed by a flooding scenario and the spatial distribution of residential buildings in the area possibly exposed to flooding.
Our goal is to generate a focus map which combines the hazard (flooding) layer with the exposure (buildings) layer.
As first operation, a raster describing the density of building is generated by using the *GenerateDensity* script. As input layer we choose the vector (shapefile) containing the buildings´ centroids in the area (see Fig. 14). The kernel sigma is chosen (0.03 degrees, since the layer´s projection is WGS84) such to find a tradeoff between the granularity and the informativeness of the resulting density.

Several values of the parameters can be used, and the most significant result can be later picked up.
In Fig. 4 the resulting density is shown, with superimposed the building centroids.

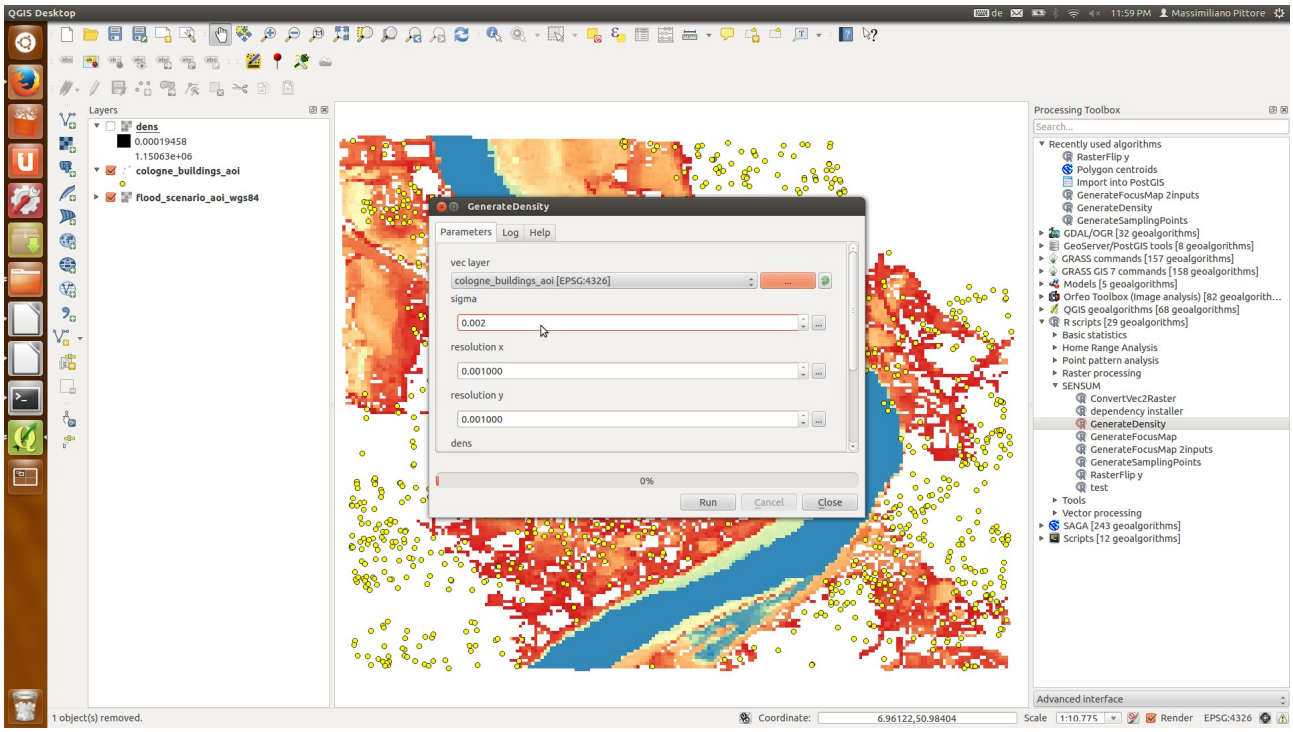

Figure 3 Generation of an heatmap density map of the residential buildings.

It is now possible to generate a focus map by combining the building density layer and the hazard layer. The script *GenerateFocusMap* is therefore selected

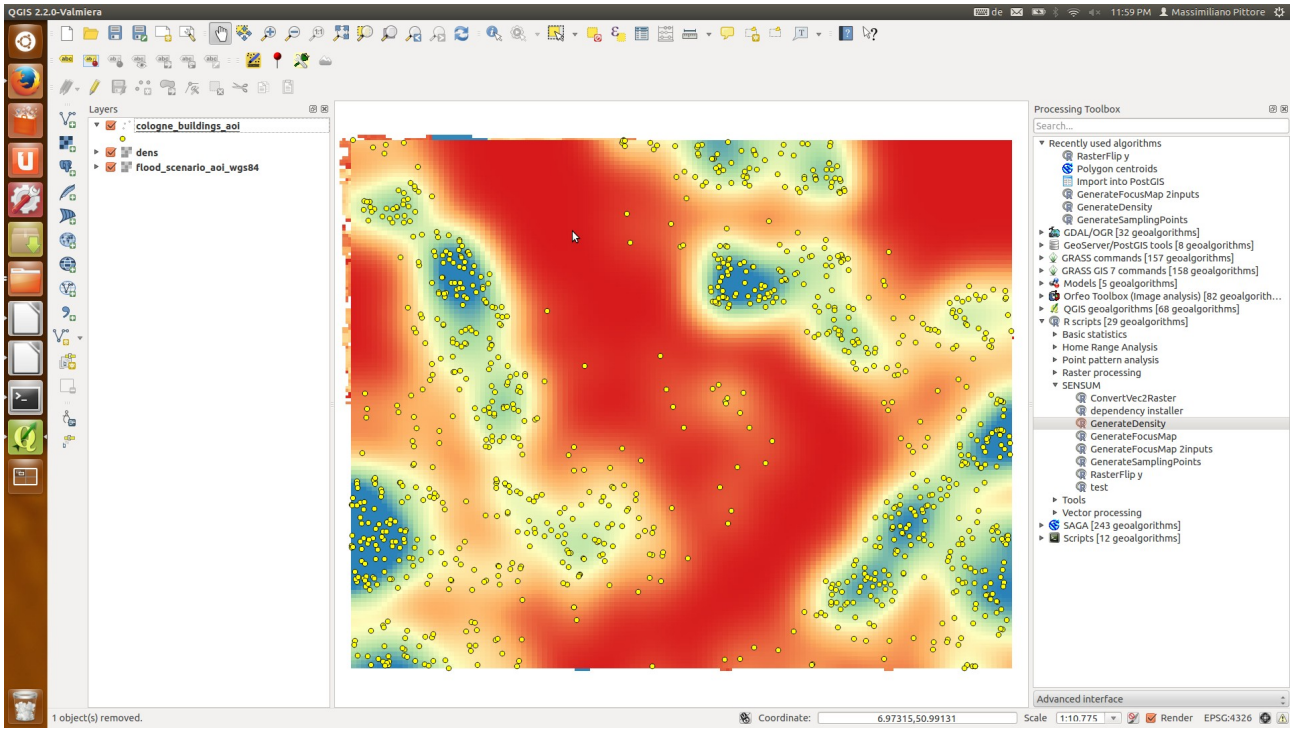

Figure 4 Resulting kernel density of the buildings´ distribution

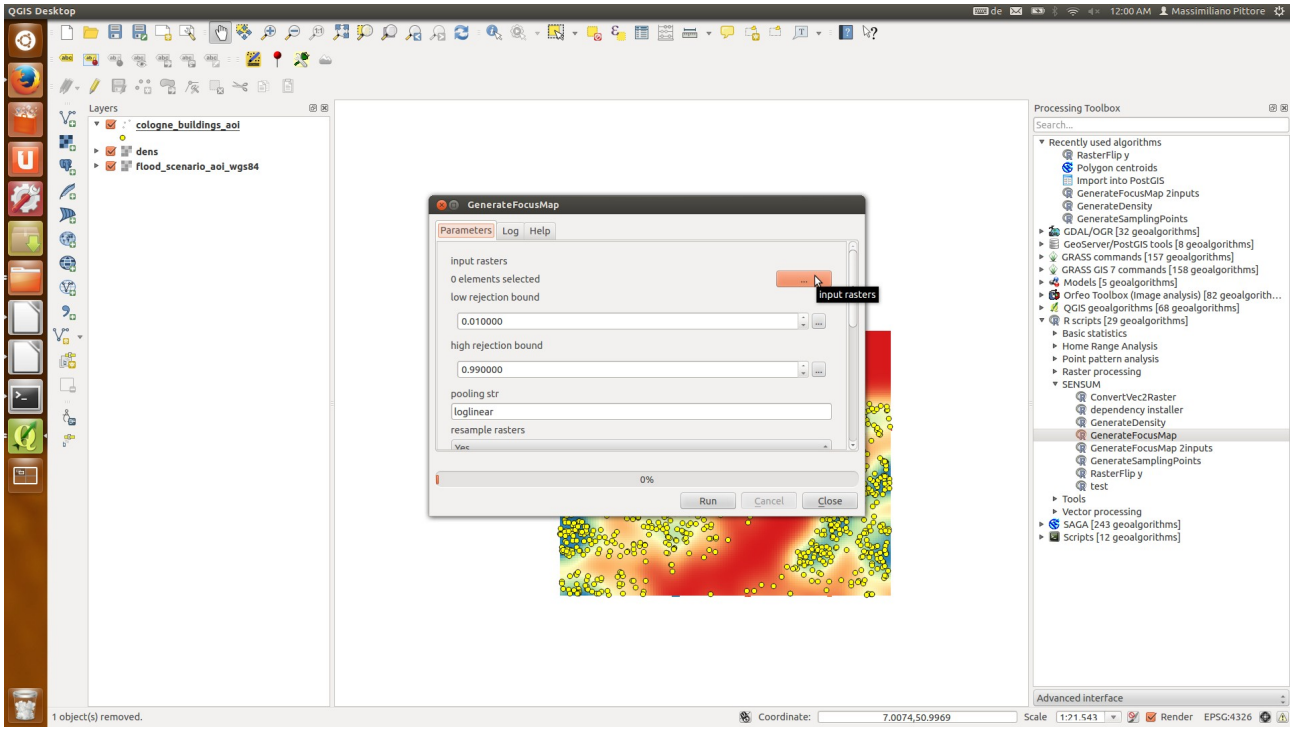

Figure 5 Interface of the GenerateFocusMap *script, part of the SENSUM scripts in the left processing menu*

from the SENSUM processing tools (on the right of the QGIS environment, in

Fig. 5.
The input rasters are selected by clicking on the input button. The layers are selected from the working environment (see Fig. 6).
In this example we leave unchanged all of the options of the script. Since by default the equal weighting scheme is active, the script assigns a 0.5 weight to each of the raster layers.
The chosen pooling operator is loglinear, as default.
Once the parameters are correctly set, by clicking on '*run*' the script is processed.
The resulting focus map is shown in Fig. 7 As we can observe, the areas which are both exposed to flooding, and shows higher building density are highlighted by the focus map.

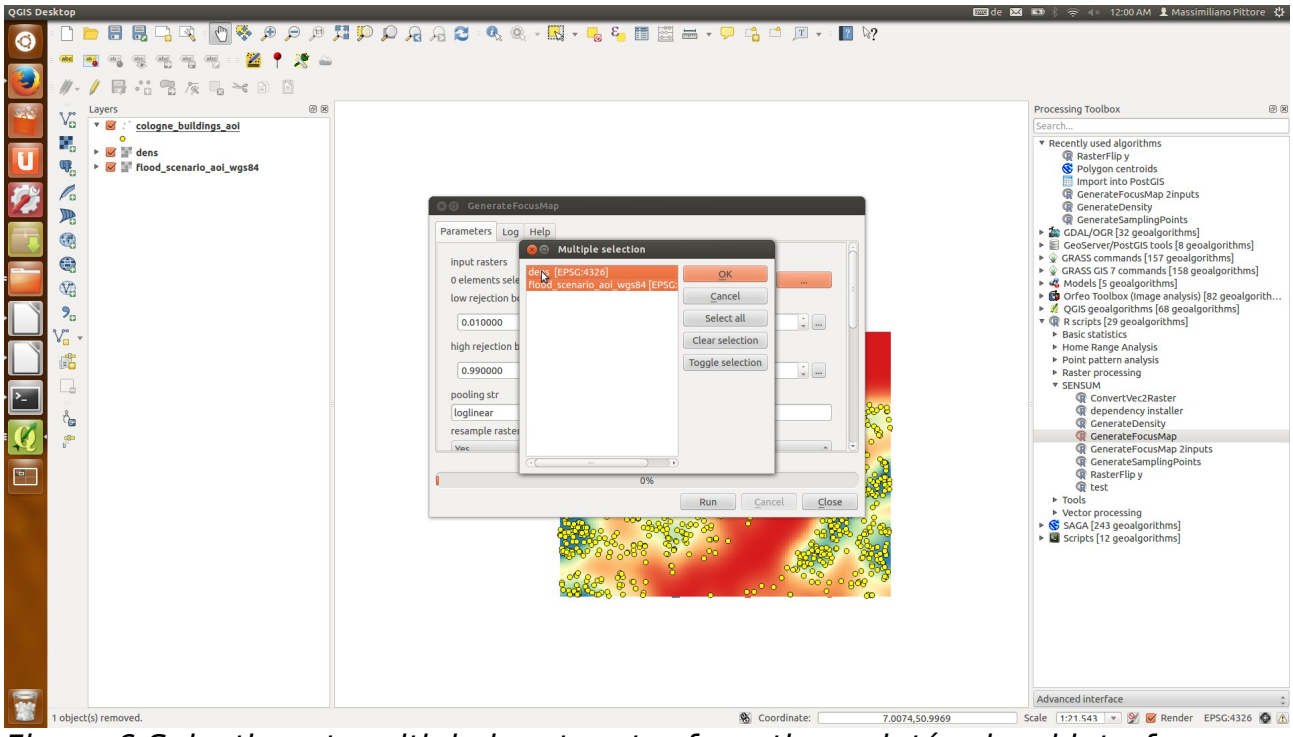

Figure 6 Selection ot multiple input raster from the script´s visual interface

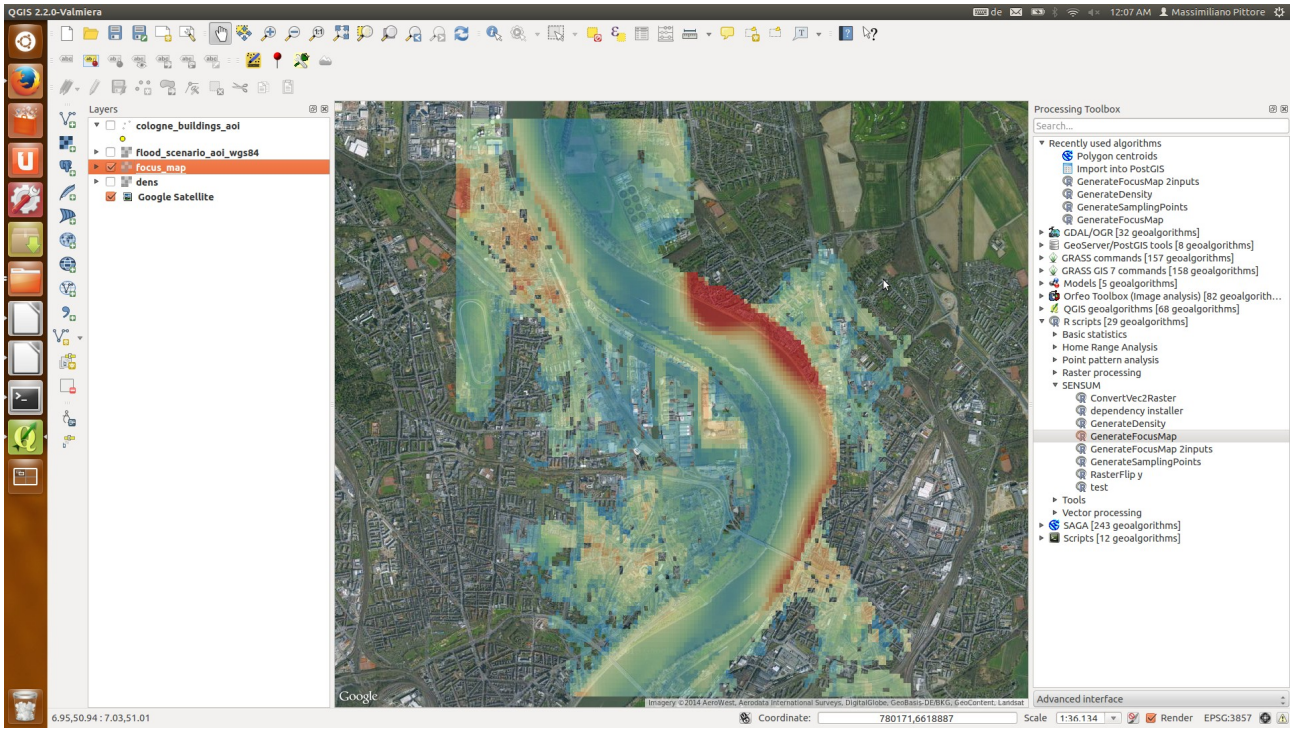

Figure 7 Resulting focus map. In background, the city of Cologne is visualized through the openlayers plugin.

Creating a Model

In order to further streamline this procedure, is moreover possible to generate a QGIS script model, to be loaded as graphical pipeline for further processing tasks.