Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Visualising KNMI seismologic data using ArcGIS 10.0

T.A. Vogel

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Part of the research assignment of
T.A. Vogel
Student International Land and Water Management at the Wageningen University

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Other components of output:
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Colophon

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Author T.A. Vogel
T: 06 15425674
E: teun.vogel@wur.nl
Contact person Raymond Sluiter
T: 030 2206 446
E: raymond.sluiter@knmi.nl

Koninklijk Nederlands Meteorologisch Instituut (KNMI)
Wilhelminalaan 10 | 3732 GK De Bilt
Postbus 201 | 3730 AE | De Bilt

Outline

Summary

This report has been written as part of the internship at the KNMI from November 2013 till January 2014. During the internship, two maps of the Seismology department were revised from scratch to the current state of art. The report explains all the results of the internship in a clear way to make revising of the maps in the future easier. Besides this, the report contains Quick Reference Guides, which can help to convert the *templates* into a map in a short time.

Introduction

Supervisor: Gert-Jan van den Hazel / Raymond Sluiter
Subject: visualizing the seismological data state of art with ArcGIS

In the last twenty years, the GIS data for the seismology department of KNMI has grown enormously. All data and shape files have been stored in the database but because of its large size, it has become more and more inefficient and unclear. Because the ArcGIS templates were gradually changed over the time, the taken analyses are not clear and logical. A lot of tables and formulas are given twice or in a lot of different ways. Meanwhile, the program ArcGIS itself has been changed over the years, which caused changes of analyses and buttons.

Because of a redistribution of tasks inside the department, this is a good time to revise the GIS database and renew the maps from scratch, as efficient as possible. This renewing has now resulted in clear maps with as less shape files and layers as possible.

In this report, first the internship content will be explained,
followed by the clarification of the changed maps as part of the two internship tasks. In this section, it is written down what analyses have been done, how the resulting templates can be kept up to date in the future and how these templates can be converted into a map or poster.

The two tasks were as follows:
1. Renewing the overview map ArcGIS templates and use them to create a new poster: 'seismicity map of the Netherlands' (called: the overview map)
2. Setting up a new analysis map used to show the last analysed quake (called: the analysis map)
Thereafter, it is explained how the data is structured now in the geo database and how this data needs to be used.

In the appendices all figures of the used complicated analyses and the quick reference guide are given. The quick reference guide can be used to convert the templates into a map or a poster in a short period of time.
Looking into the future, the program ArcGIS will change several times and the KNMI maps will be used for other goals. When revising is needed again, this report could be helpful to do this in a short time.

The overall output of the internship is:
- Renewed maps (built up from scratch), coupled with a clear Geodatabase
- A presentation at the VU and KNMI
- An article in the GIS Magazine
- This report which can be read as a manual

Part one: Revise the overview map

Purpose of the map

The overview map is a seismicity map of the Netherlands that visualises the spatial distribution of all the earthquakes in history throughout the country. To give extra information about these earthquakes and partly explain why they occur, several other attributes are shown, e.g. the fault-lines to explain the tectonic earthquakes and the location of gas fields to clarify their relationship with the induced quakes.
This map is mainly used to be converted into a large poster, which can be found on the wall in the analysis room at the seismology department at KNMI. Visitors, new employees and interested people can watch this poster to see the overview of quakes in the Netherlands and surroundings. A person who sees the map should immediately understand what all the colours, shapes and sizes mean, which is difficult to accomplish, since a lot of attributes must be shown.
Besides this, the map can be used as a map on the internet so it can be viewed by many other people.

The map has a quite high resolution to make the poster visually at its optimum, and consists of the following components, layered most efficiently upwards from below: (see appendix 1)

-Elevation map
-Borders
-Faults
-Gas fields
-Events
-Stations

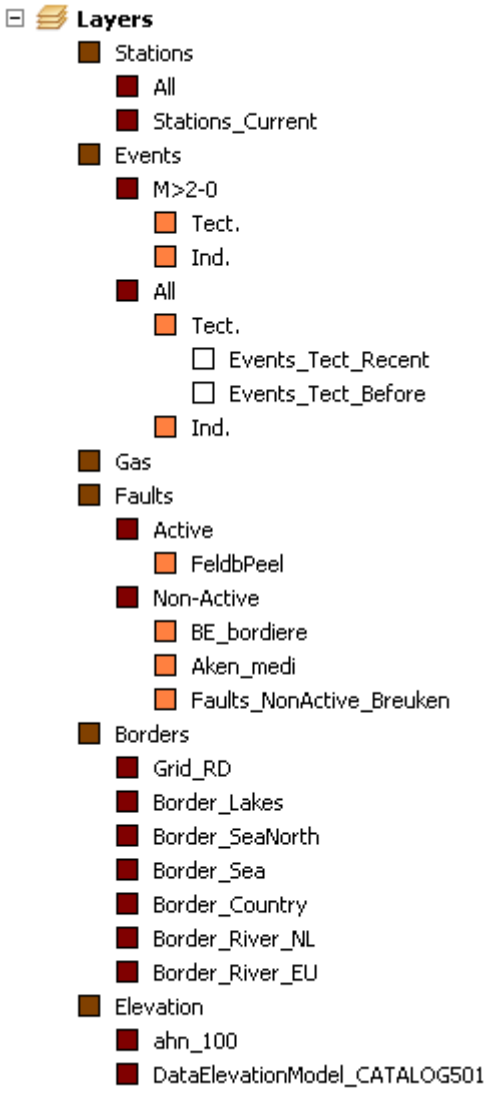
These are extensively described in the following parts.

Design with ArcGIS

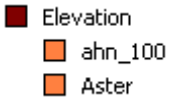
To make the map as clear as it should be, the database had to be revised too. It was decided to design a complete new map from scratch by setting up a map template, which should result in an efficient structural map. The goal for this part of the internship: making a map which is at least as good as the old map, but trying to make it even better.
The map was set up layer by layer, each time keeping in mind that it should be efficient to store in the database and easy to possibly repeat the analyses in the future. Some layers were set up almost in the same way as it was done in the old map. Other layers changed in colour or size and others were deleted or replaced by more recent datasets.

It was decided to draw the map using the projection of the coordinate system RD new, because this system gives the country the shape as it should have, in the eyes of every Dutch person. Actually, this map shows the correct distance between places (so-called equidistant), which results in a less realistic shape. However, each citizen of the Netherlands is used to this shape and when the map would be converted into another coordinate system (e.g. WGS) it will become less clear. Showing Europe in its entirety in the RD, will give it a 'unreal' shape, but as long as not the whole of Europe is shown on the map, the borders will retain their 'real' shape (Kadaster, 2013).
In this chapter, the analyses and used tools in ArcGIS are given layer by layer. An explanation on each layer is given with the assumptions and considerations which have

been taken. To make modifying the maps in future easier, the source of each layer is mentioned, and where the data is stored in the new geodatabase.
In the figures in appendices 1 and 2, each layer is given to clarify how the template is being designed. The Template in which the map is designed can be found in: Map geodatabase: 1.Overzichtskaart.gdb



Layer: Elevation



Database: 1.Geodatabase_KNMI_Kaart\Elevation
Source: -Aster (NASA)
-RWS AHN (Actueel Hoogtebestand Nederland) (AHN, 2013)

Type: Raster Grid, continuous, signed integer.
Resolution: 15x15 m cell size and 100x100m cell size
Units: meters
Definition: Background base map of the map, giving the elevation in meters.
Purpose: Clarify the possible relationship between elevation and tectonic earthquakes and between elevation and faults.
Can give information on presence of induced quakes in lower areas.
Exaggerate the elevation in the Netherlands, by using a manual 'logarithmic' colour scale (see: colours)

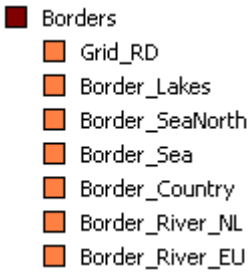
Considerations / Detailed information:

This dataset has been set up using different sources. The ASTER file from NASA has been downloaded from the internet. (Aster, 2009). Because of the high resolution of 0.5x0.5 meter, which is too high than needed for this purpose, some analyses and tools were used to convert the data into one raster map. This can be found below.
However, this data was not reliable at locations where the elevation was lower than sea level ('*polders*'). It was decided to use the AHN of Rijkswaterstaat where the Aster dataset was not reliable. The following tools were used:

Aster:
Converted into a mosaic file (see Appendix 5)
Tab 'Symbology': Stretched symbology
AHN:
Converted into a mosaic file (see Appendix 5 for an example).
Tab 'Symbology': Classified symbology in which all values >150 meters are excluded. In this way, only the lower parts of the Netherlands are given. The parts above sea level are visualised by Aster. Same raster grouping values as 'Aster' imported.

Colours: The colours vary in a scale between Green, Yellow, Brown, Grey and White. Important for this layer was the visualisation of the elevation in both the high and low areas of The Netherlands. This was done by making the colour scale logarithmical. In other words: Changing from the colours green to yellow on the map, is a difference between -4 meters and 10 meters while changing from the colours brown to grey means a difference between 150 and 200 meters. In this way, the small elevations in 'de Utrechtse Heuvelrug' are as notable as those in 'de Ardennen'. At least it attracts more attention, because this is not the usual way of visualising the elevation. (See Appendix 5)

Layer: Borders



Database: 1.Geodatabase_KNMI_Kaart\Borders

Definition: All layers which are not important for the real purpose of the map, but which do have to be shown to make the map clear.

Purpose: Create clearance about the map, e.g. to see where the border of the country is, and to have an idea of where the rivers are situated.

Country border

Source: Bens01\datasets\KNMI\Europe\Countries
Type: Vector
Info: Only visible at the border between two countries. Shape file is made hollow, so only borders are visible. Data frame clipped by rectangle (Arctoolbox > Spatial Analyst Tools > Extraction > Extract by rectangle)

River (NL and EU)

Source: Bens01\datasets\KNMI\Netherlands
Type: Vector
Info: Same colour as sea. Outline width: 0,5

RD Grid

Source: Gisdata\Seismo
Type: Vector
Info: Grid of X and Y tiles

Seas

Source: Bens01\datasets\KNMI\Netherlands
Type: Vector

Lakes

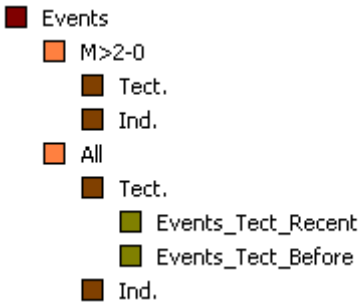
Source: Bens01\datasets\V&W\WIS
Type: Vector feature class

Considerations/Detailed information:

On top of this layer: sea, to make borders between country and sea invisible for a better look of the map. The polylines are made visible on borders between country and country.

Colours: Seas/Rivers: RGB: 158.187.215.
RD_grid: Light grey

Layer: Events



Database: 1.Geodatabase_KNMI_Kaart\Events
Source: Direct plotted events from *Nederquake*
Type: Vector points

Definition: Both induced and tectonic earthquakes from the table *Nederquake* plotted into the RD Grid (X&Y)
Purpose: To give a clear overview of all the earthquakes in history in the Netherlands and surroundings. One can choose between the induced and tectonic quakes and there is also the possibility to show the 'heavy' quakes of Magnitude >2,0 only.

Considerations/Detailed information:
The earthquakes have been divided in different layers:

All earthquakes

- **Induced earthquakes**
  These earthquakes can be found in the table by 'TYPE: GH' and are induced by extraction of gas and therefore mainly occur in Groningen.

- **Tectonic earthquakes**
  Can be found by 'TYPE: TH' and are a result of tectonic movements in the southern part of the Netherlands. These are divided into two groups:
  -Recent earthquakes (occurred after 2000)
  -Older earthquakes (occurred before the 21st century)
  The symbols used to represent the earthquakes are split in five classes, sorted by Magnitude. The classes are:
  M<1 Small earthquakes, hard to analyse by computer
  M1-2 Medium earthquakes, hard to feel by human
  M2-3 Larger earthquakes, felt by human, small damages possible
  M3-4 Large earthquakes, larger damages
  M>4 By Dutch standards really large, happens rarely.
  So the larger the Magnitude, the larger the symbol in the map. The large Magnitudes get exaggerated large symbols, because they do not occur often.

Earthquakes with M>2,0

Earthquakes with a magnitude smaller than 2,0 can hardly be felt by human. (FALW VU, 2013) Only less than 25% of the induced earthquakes are larger than this 2,0. All other quakes can cause damage but are not large. To make the map not looking too catastrophic, it was chosen to make it possible to only show the heavier earthquakes. This is done by using the query:

"MAGNITUDE" >= 2.0 AND ("TYPE" = 'GH')

The same is done to the tectonic earthquakes:

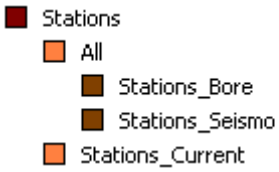
"MAGNITUDE" >= 2.0 AND ("TYPE" = 'TH')

It was decided to order the symbols in size, so that the large symbols would not overlap the small.

Colours: red/light red and green

See appendix 3 for the result of this layer.

Layer: Stations



Database: 1.Geodatabase_KNMI_Kaart\Stations
Definition: Reproduction of both '*dieptemeters*' and '*oppervlaktemeters*' of the table *StatNed* on RD projection.
Purpose: To see the spatial distribution of measurement stations. These stations can found throughout the whole country varying from accelerometers, boreholes and meters at the surface. In this way it can be seen which meter can be found where. For example, a lot of borehole meters can be found in Groningen because at that place a lot of shallow, small quakes occur, which have to be registered.

Source: Table *Statned* in Access file Nederquake
Type: Vector points, classified by 'S-Type'

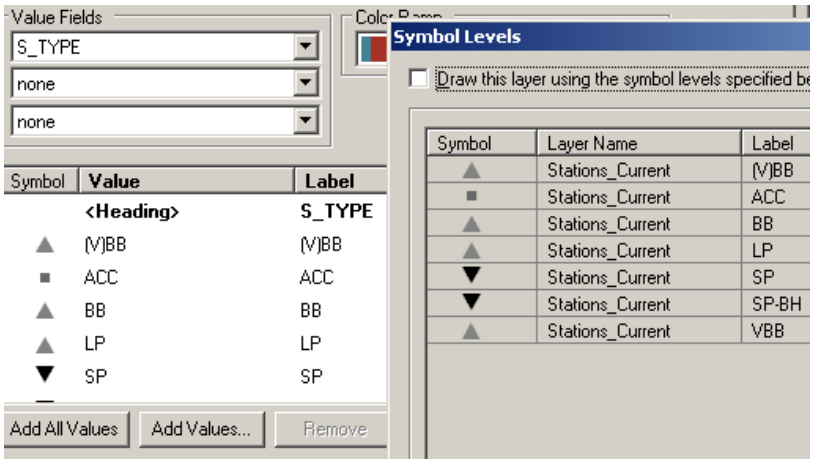
Considerations/Detailed information:

Two layers have been made, namely one for the current stations, which are still being used (+/- 80), and one for the total amount of stations which have ever existed (+/- 180). Besides this, different stations have been distinguished.

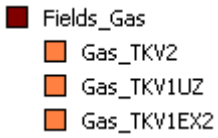
- **Total stations:**
  Because there are different seismometers used to analyse movements of the earth, these have to be plotted differently in the map. This difference is given in the table *Nederquake* at the column: S_Type. Symbols categorized by value field: 'S_TYPE'. Some stations did get a different name in the table, but are the same type of meter, so has to be given the same symbol in the map (e.g.: (V)BB and BB). See figure below for given symbols.
- **Current stations:**

By using the query:
[IN_OPERATION] = 'Y'
Symbols are given in the same way as in layer 'Current stations'

Colours: Grey to Black
Fixed/ Changeable: Fixed



Layer: Gas fields



Database: 1.Geodatabase_KNMI_Kaart\Gasnew
Definition: All known gas fields that can be used to extract gas by the Netherlands.
Purpose: To make clear that most induced earthquakes occur nearby the gas fields. There is a certain relationship between this gas extraction and the quakes that occur. This is easy to see in this map.

Source: NLOG Gas Fields
Type: Vector, Polygon features

Considerations/Detailed information:

The gas fields added in the following way:

1. Download from NLOG (NLOG, 2013)
2. Open the file in Google Earth
3. Right click the file on the left side of the screen > Save place as.. > KMZ
4. In ArcGIS, go to ArcToolbox > Conversion tools > From KML > From KML to Layer.
5. Change browse bar in 'Input KML File' into KMZ files, choose saved KMZ file and convert.

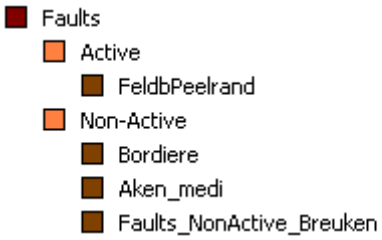
The transparency of the fields was set at 30%

Colours: RGB: 255.255.115
It was decided to put this layer onto the map, but as a part of trying to make it not too prominent, transparency was set at 70% and it was given the colour yellow.

Fixed/ Changeable: Fixed

See appendix 3 for the result of this layer.

Layer: Faults



Database: 1. Geodatabase_KNMI_Kaart\Breuken
Definition: All important faults of the Netherlands that have something to do with the occurring earthquakes.
Purpose: Show the relationship between faults ('*horsten*' and '*slenken*') and earthquakes in the southern parts of the Netherlands.

Source: Gisdata\Seismo
Type: Vector polylines

Considerations/Detailed information:

It was presumed that almost all faults are non-active at the moment. However, the Feldbiss and Peelrandbreuk, which are well-known faults for Dutch citizens, are given as active. These faults still make the earth move sometimes.

Colours: Polylines in grey and dark grey to point out the difference between the active and non-active faults.

See appendix 3 for the result of this layer.

Relate layers with table *Nederquake*

When the map was set up using ArcGIS, it was needed to be related with table *Nederquake* to make it usable for the Seismologic department of the KNMI. For example, when a new earthquake occurs it should be plotted into the table directly, and be visible in the map.
By making a connection between the map and the Microsoft Access file *Nederquake*, the map will stay up to date. This is done to the layers Events and Stations, in the following way:

1. In the ArcCatalog, expand 'Database Connections' and double-click 'Add OLE DB Connection.
2. Double-click 'Microsoft JET 4.0 OLE DB Provider'
3. In tab 'verbinding'/'connection' select the Microsoft Access file *Nederquake*
4. Click 'Test connection' and click OK. The map is now connected to the table.
5. Expand the new OLE DB Connection and drag the tables into the template
6. Right click the table and choose: Display X and Y. NB: Do not convert this layer into a shapefile: in that case, the connection will be lost immediately.
7. A new layer has been formed now, while connected with the original *Nederquake* table.

As a result of this relation, each time when opening the *template*, the connection is refreshed automatically and every change in the Access file will be modified in the *template.*
The formed connection was called: OLE DB Connection_Overview.odc.

Convert into a map with a legend

The conversion described below can be viewed in a short version in the quick reference guide in appendix 12.

Because the program ArcGIS is limited in making the legend clear and is not really about visualising the final maps into detail including the legends, it was decided to only make a small legend in ArcGIS. In the next chapter it will be explained how the *template* still can be converted in a high definition poster.

A legend was created using the 'insert legend' tool in ArcGIS. Exactly the same layers as in the old map were inserted in this legend, to make it look the same.

Two templates were created:
1. Output\Mapgeodatabase, in which the actual map is stored. In this template, one can choose what to see on the poster, for example data frame location and scale.
1. Output\Legenda, in which the Legenda is being designed.

When a map has to be printed or uploaded on the internet as a high resolution image, the right way to do this is:

1. Open Template *Mapgeodatabase*
2. Change view to: 'Layout-view'
3. Decide what scale you want to have and what should be visible on the map.
4. Insert>Picture: *Volledig.jpg*
   When your reference scale is not 1:1.000.000, choose Picture: *Volledig-Scalebar*
5. Double-click on the picture and choose 'size and positioning'
6. Change size width to: 20,89 cm. (Height will change automatically)

7. Drag the picture in the right position and right-click>order>Send to back
8. Insert a new scale bar, when reference scale is not 1:1.000.000
9. Export the new map (DPI: 400-500)

Eventually, the legend itself can be changed in the Template: *Legend*

See also Appendix 7

Keeping the map up to date in the future

In the future, the map will have to be revised again. This short chapter has been made to make this procedure easier and faster. Some considerations:

- Some shape files (e.g. elevation and borders) will not have to be changed in the future. However, some files need to be revised each few years, for example to make a new poster. These shape files are listed below and it is explained how they should be changed to keep them up to date.

Earthquakes

As explained before, each time a new earthquakes occurs, this is automatically plotted in the table and the template. However, when a new poster will be made in a few years, one should think about this:

- Maybe the earthquakes later than 2000 are not 'recent' enough, so a new classification is needed. One could decide to make all earthquakes light red, except the ones later than 2005.
- Maybe in a few years there will be too much earthquakes to keep the map clear. Then, it could be decided to only plot the last X earthquakes, or make a selection of earthquakes which had a Magnitude larger than 2.5.

Stations

This shape file could have to be changed in the future. In this case, one should think about this:

- Do all stations still exist? Do they all have to be plotted?
- Next year about 60 new stations might be installed in the northern parts of the Netherlands. This will make the map less clear than before. Maybe it will be an appropriate solution to make the symbols a bit smaller.

- Each time making a new poster:
  The map which can be created using the steps described on the previous page, is good enough to be published on the internet. However, when the map has to be converted into a poster, a better legend is needed.

Doing this, the procedure is thus:

1. Exporting the new map with the legend into PDF (Or: the exported map and the exported legend)
2. Send this PDF to the studio, where the new poster can be made. In this way, exactly the same poster can be created. Also, the complicated elevation scale bar can be converted by a designer using for example Adobe CS.

Example: Appendix 9

Part two: Modifying the analysis map

Purpose of the map

The goal of this map is to show where the last earthquake took place. This should be done in a simple way, and that is why visualization is not of real interest in this case. When a new quake is analysed by one of the KNMI analysts, it is plotted into this map directly. After that, the head of the department has to accept the analysis as right. At that moment, he must be able to see where the quake occurred and how large it was, in a short period of time. At this point, the map is not clear visualized by a legend, but because of the knowledge of its user, it is still clear enough. The 'analysis map' is a map which is not used to explain the occurrence of earthquakes, or to show all of them as it is done on the large map or poster in the previous chapters.

Design a new map from template

Compared to the overview map, this map is less complicated. The elevation is not given, because this could make the map unclear and does not meet its purpose. The analysis map is designed in a different template. This is because almost all layers are different than the Earthquake map. The layers are given below and explained when needed. Some general comments on the choices which have been made:

- The gas fields are chosen to be layered under the country and sea map. This is to make it more clear that these are gas fields, and no clouds. In the original map the fields are shown with a high transparency, which immediately gives the impression to be a higher layer, up in the air. Now, the fields are shown below the sea and country level and by making the transparency of that layers higher, it looks like the gas fields are below ground level, which comes closer to reality.
- Not all rivers are given, to keep the map as clear as possible. Visualising the rivers is not useful when one needs to know how and where the quake took place.
- The names of the towns can be given. This layer can be checked or not and by zooming respectively in and out, more or less names will be given.

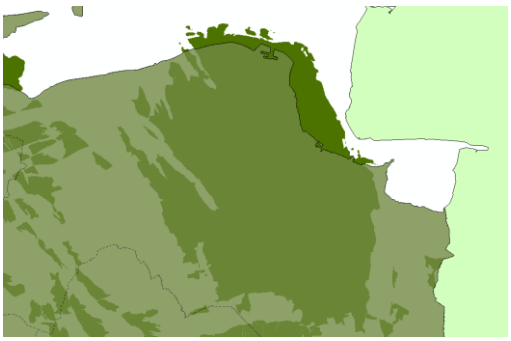
For more detail explanation, see below. The different layers are given in figure 1.

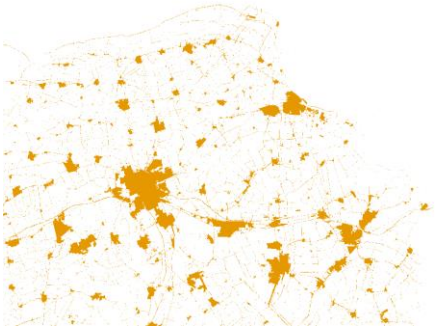
Figure 1: Overview of the layers in the analysis map template.

Layer: Borders

Database: Seisan\Output2\Data\Borders
Definition: All vector layers which increase clarity concerning the borders on the map, e.g. country borders or cities.
Purpose: As background of the map
Source: Most: KNMI\The Netherlands, and: NLOG_Fields
Type: Vector points or lines

Considerations/Detailed information:
The NLOG fields are added in the way as described in appendix 6. As mentioned before, the gas fields are placed as bottom layer. By making the other layers transparent, the fields seem to be below ground level.
Colours: The Netherlands are chosen to be coloured as dark green, as it was done in the original map. The other countries are light green coloured, because these layers are of no importance for the map. It was chosen to give all gas fields the same colour. However in the attribute table, seven different fields are given and can be checked when needed.





Layer: Built areas

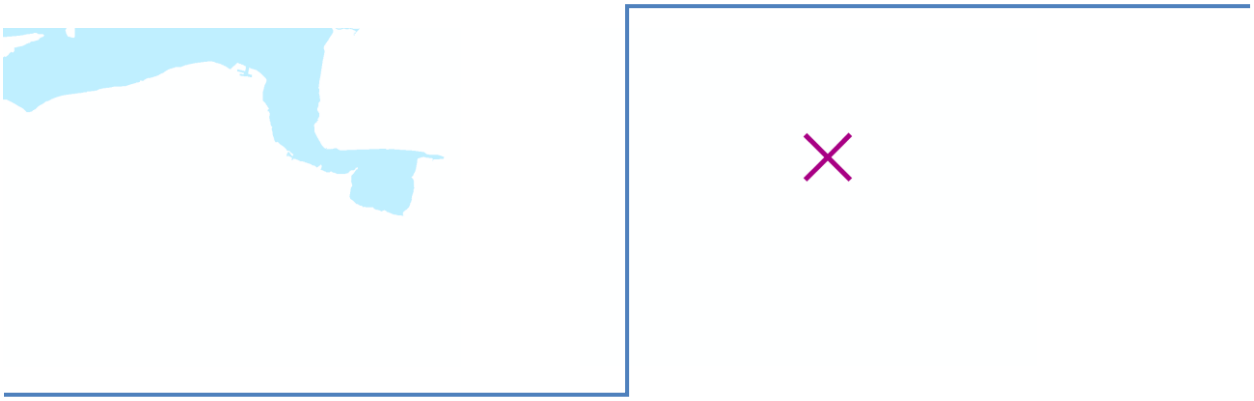
Database: Seisan\Output 2\HGN and \Plaatsnamen
Definition: All cities and towns in the Netherlands
Purpose: To make it possible to see where the earthquake took place. Sometimes it is good to know which towns or cities are close by the hypocentre. On the original map, only large towns were given. Now it is decided to show all built objects, including the small villages. This might be important, when an earthquake took place below one of these villages.
Source: Small villages: HGG (*Historisch Grondgebruik*)
Towns: CBS *Bevolkingskernen* (CBS, 2013)
Type: Vector (CBS) and Raster (HGG), Cell size 25x25m

Considerations/Detailed information:
Layers are clipped on the Netherlands. There has been added one option to select: turn on the labels of the names of the cities and towns. See explanation in chapter: 'convert into a map'
Colours: All areas are given the colours orange (RGB: 230, 152, 0). In Top250, all other values are set as 'no colour'.

Layer: Water

Database: Seisan\Output2\Data\EU_Sea or \NL_River
Definition: Water polygons which are needed to show the sea and (some) rivers.
Purpose: To see if there is a river close by the earth quake location.
Source: Datasets\KNMI\the Netherlands\
Type: Vector

Considerations/Detailed information:
Not all rivers are shown, to keep the map 'clean' and easy to read. Transparency of sea is set at 30% to make gas fields visible.
Colours: Both rivers and sea are shown as light blue (RGB: 163, 232, 255)



Layer: Cross

Database: Seisan\Output 2\Data\Events (Related to table *Nederquake*)
Definition: A large cross on the location of the last earthquake
Purpose: To see where the most recent earthquake took place. Because the density of quakes is high at some locations, this cross is needed to be able to see where exactly the hypocentre is.
Source: *Nederquake*
Type: Vector point

Considerations/Detailed information:
This layer originally contained all earthquakes, but using the query definition tab (Related: LQ) only the last quake is shown. Because this layer is also related to the table *Nederquake*, this cross will change of location each time that a new quake occurred.
Colours: Purple (RGB: 168, 0, 132), size 80,00

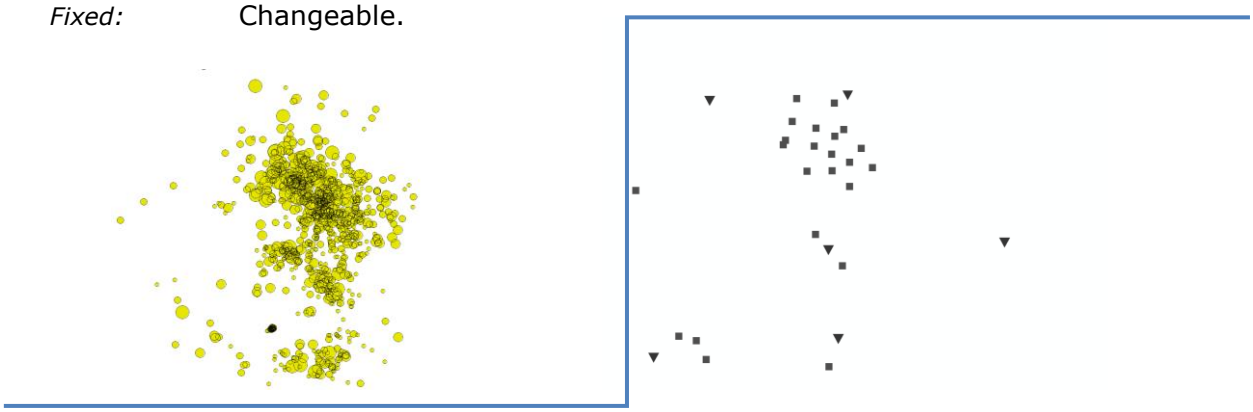
Layer: Events

Database: Output 2\Data\Events (Related to table *Nederquake*)
Definition: All analysed earthquakes in history, which are described in table *Nederquake*, divided in induced and tectonic quakes.
Purpose: To show the location of all earthquakes in history, analysed by KNMI.
Source: *Nederquake*
Type: Vector points, displayed on map by X and Y points (RD projection)

Considerations/Detailed information:

- Because of the high amount of quakes which are on the map, a lot of them are not really visible. To reduce this problem in the large map, the small quakes were layered above the larger quakes. However, in this map this is not a good solution, because a lot of quakes will still be not visible. It was decided to plot the quakes in two layers. A layer with transparent rings are layered on top of a layer with symbols that are filled. In this way, all events can be seen on the map.
- Like in the other map, induced and tectonic events are distinguished.
- To make the map not chaotic, it was decided to give the small events (<2,0M) a very small symbol. From 2,0 up to the largest event the symbols have a larger size.

Colours: Tectonic quakes are coloured red and induced quakes are green.
Fixed: Changeable.



Layer: StatNed

Database: 2.Output\Data\Stations
Definition: Used stations to record earthquakes in the Netherlands.
Purpose: To make clear where the stations are situated and which types are being used.
Source: *Nederquake* StatNed
Type: Vector points, projected into RD_X and RD_Y, connected to table

Considerations / Detailed information:

Distinguishing the stations which are still being used and the ones that used to be active is done by using the Definition Query tab in the layer properties. In the field: GESLOTEN, the still existing stations have been given the number '0'.

The query for active stations: 'GESLOTEN'=>'0'
The query for non-active stations: 'GESLOTEN'='0'

Stations which are not being used for analyses are given 40% transparency
For distinguishing the different seismometers, see layer Stations in Overview Map.

Colours: Colours have been chosen to be black, grey and light grey
Fixed: Fixed, but data is constantly updated by table StatNed.

A new option: Showing 'LQ Stations'
When a new quake is plotted in the analysis map, this is visualized by putting a cross at that location. It is explained that this makes the analysis easier. In this new map, an option has been designed to also display the stations which analysed the last quake (LQ). In some other analysis programs this is done too, because this is an adequate tool to see by which stations the quake was felt. A new layer was created to make this possible:

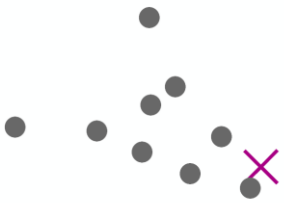
Layer: LQ Stations

Database: Related to query 'LQ_Stations'
Definition: All stations which were used to analyse the LQ
Purpose: To make clear at which locations the quake could be felt, and to see which seismometers were used to analyse the quake.
Source: Table *Nederquake, Readings* and *Statned*.
Type: Vector points

Considerations/Detailed information:

A new query was made in Microsoft Access table *Nederquake*, using the tables *Nederquake, Readings* and *StatNed.* These tables were related by ID and Station Name (appendix 8). In this way, each reading is given, including the name and location of the station which registered the quake. On the Related tab of this query, the criteria used was: ="LQ". When this query is dragged into the template in ArcGIS, all stations which were used to analyse the LQ are given. The symbology of these stations is the same as in the layer "StatNed". Besides this, a small cross is placed at the location of LQ. This is done to mark the epicentre of the quake, because this is sometimes unclear when the LQ found place in for example Groningen, where a lot of other quakes are layered. See appendix 8 for explaining figures.

Colours: The same as in layer "StatNed"; grey, circles
Fixed/Changeable: Constantly changing.



Relate with table *Nederquake*

By making a connection between the map and the Microsoft Access file *Nederquake*, the map will stay up to date. This is done to the layers: Events, Stations and the cross in the following way:

1. In the ArcCatalog, expand 'Database Connections' and double-click 'Add OLE DB Connection.
2. Double-click 'Microsoft JET 4.0 OLE DB Provider'
3. In tab 'verbinding'/'connection' select the Microsoft Access file *Nederquake*
4. Click 'Test connection' and click OK. The map is now connected to the table.
5. Expand the new OLE DB Connection and drag the tables into the template
6. Right click the table and choose: Display X and Y. NB: Do not convert this layer into a shapefile. In that case the connection with the Access file will be lost immediately.
7. A new layer has been formed now, while connected with the original *Nederquake* table.

For this map, the Connection was called: OLE DB Connection_Analysis.odc
As a result of this relation, each time when opening the *template*, the connection is refreshed automatically and every change in the Access file will be modified in the *template.*

Convert into a map

The map can be easily converted into a map which can be exported or printed. In the lay-out view, the scale reference bar is automatically inserted, and put into the left upper corner. In the right upper corner, a text is inserted. In this text, the Quake Number (QNR) can be written. Besides this, the logo of KNMI is visible on the upper-midst of the page. In this way, the map looks exactly the same as the old one. A legend is not needed for this map because the user knows what is visualised on the map, as explained before.

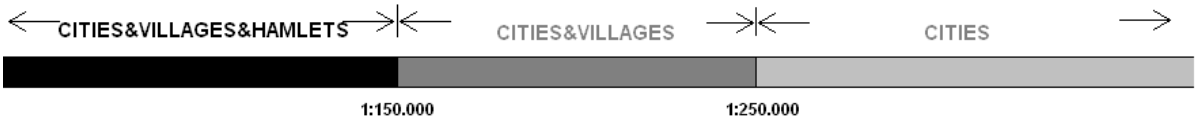
In this map, it is possible to change the reference scale. This has to be done in the layout view and not in the data view to keep the exported map scaled as inserted.
Because it will be necessary sometimes to zoom in on the map, this is possible now. Certainly in the Groningen province this needs to be done, because there are too many quakes to make a clear visualization on the map.

In this map the names of the towns and villages can be given. This can be done by clicking on Borders > Bebouwing > Namen tonen. This layer consists of three datasets of cities and towns. By zooming in or out, more or less names will be given. In this way, also the names of very small hamlets can be seen, when the map is zoomed in, which is sometimes necessary to know in which area the quake took place. How this was done can be found below:

Three datasets:

- *Naam_Stad*; only large cities, as shown in the normal exported map with scale 1:400.000
- *Naam_Dorp*; also smaller villages like *Winschoten*
- *Naam_Kernen*; each city, town, village and hamlet

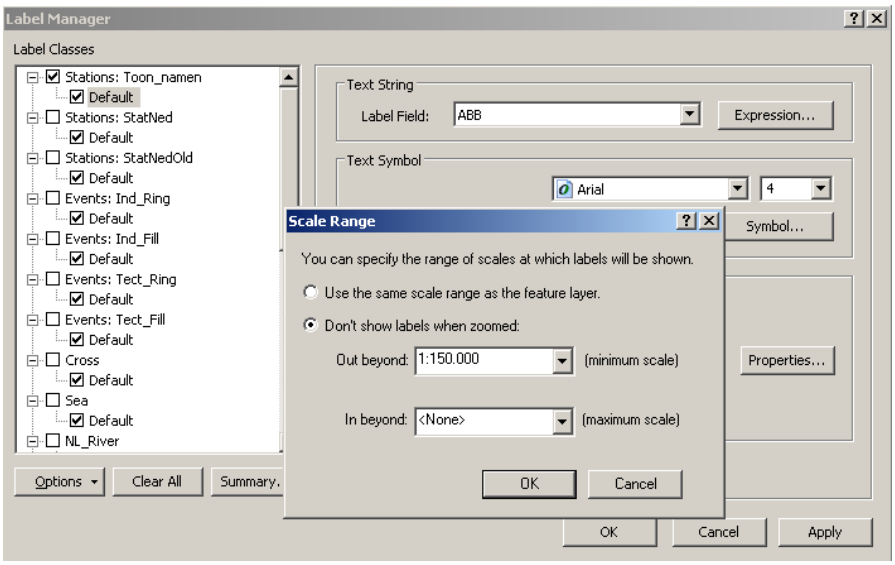
Each dataset is set to 100% transparency to make the vector points invisible. By clicking the window 'Customize'>Toolbars>Labelling, it is possible to make the labels visible or invisible at a certain scale range. This has been done in this way:



Now, the different labels will be visible by zooming in or out.

Stations name

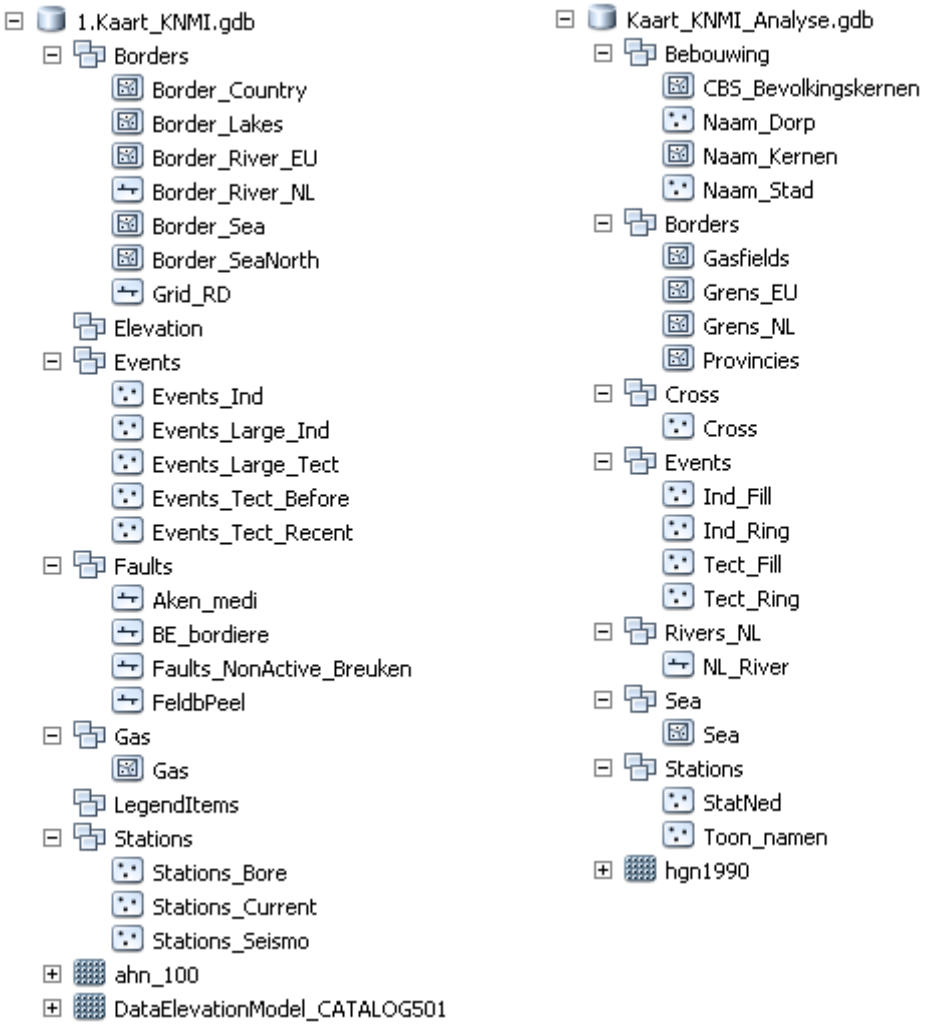
Also, the names of the stations can be given. This can be done by clicking on the dataset 'stations'>Namen tonen. This was done by making the stations transparent and turning on the labels. The labels are automatically turned on when the scale is smaller than 1:150.000, which was done by using the labelling toolbar:



To show the results of using these tools, some maps were added in appendix 10. First, a map with scale 1:400.000 is given, which is the normal scale of the analysis map. Secondly, two extra maps are given, visualizing the changes when the map is zoomed in, which could be used when a quake occurred in the neighbourhood of the city Groningen.

Setting up a File Geodatabase

All data of the created layers in this internship were stored in folders . However, to make it easier to transport all data from computer to computer, all files were stored in a File Geodatabase. In that way, all data can be found in one map, and this is much more clearer in ArcCatalog:



A file geodatabase can be created by right clicking 'New> File Geodatabase' in the ArcCatalog. To make the geodatabase clear, it is advised to create different feature datasets. In this feature dataset a vector dataset can be imported by right clicking 'Import > Feature class (simple).
In case of inserting a raster dataset: New > Raster dataset.
Some layers are not stored in the geodatabase, because they are directly connected to the table *Nederquake*.

Conclusions

The maps and templates have been revised in ArcGIS 10.0, as was the goal for this internship. Some conclusions can be drawn to make clear what has been done to accomplish this:

- Converting the template 'Overview map' into a poster has been done as good as possible. Because this internship was not really about maximizing visualisation it was concluded to make it as good as possible in ArcGIS, but outsourcing the final layout to the a design studio, which will be able to convert it into an appropriate poster.

- All data which needs to be up to date in the future, is related to Microsoft Access' tables and queries. In this way, the templates are being changed automatically when a new quake is plotted or when a new station has been added to the table *Statned.* For showing the stations which were used to analyse the last quake (LQ) a new query was formed.

- Some new options were created:

Overview Map:
  Fixed legend map; easy converting into a poster
  Easy changing between tectonic recent and old quakes
  Possibility to choose between all stations and current stations
  Well-structured layers in ArcGIS

Analysis Map:
  More cities shown
  Show labelling of cities and villages
  Last quake stations

- A few layers have been changed in colours to make them more clear

- (e.g. the colour of the rivers)

- A few layers have been added or grouped to make them well-structured and efficient

- A few layers have been deleted because they were not needed

- All data has been stored in the File Geodatabase, as described on page 29. This makes the database structured in one place and easy to see or change

- The planning as a whole went well. The original planning made in the first week of the internship, has not been changed very much. The time that was planned as a has been used to finalize the templates and this report.

Finally, the internship has resulted in a well-structured and efficient way of storing data for the templates for ArcGIS. The difference on structure between before and after the internship can be seen in Appendix 11.

Hereafter, all appendices with both explanations on the analyses and the real manual as quick reference guide can be found in the appendices.

References

Used websites

AHN (2013), *Algemeen Hoogtebestand Nederland*. Requested from Rijkswaterstaat. Version: 100x100m, May 2013. Elevation model of the Netherlands used for the *layer* Elevation.

ArcGIS Forum, a website where a lot of tools are being discussed and explained by ArcGIS users.

ArcGIS Online (2013), ESRI. online web service where all tools available in the program ArcGIS are explained.

Aster (2009), Version two of GDEM GIS dataset (Data Elevation Model) from Aster by Japanese Ministry of Economy, Trade and Industry (METI) and United States National Aeronautics and Space Administration (NASA).
http://asterweb.jpl.nasa.gov/gdem.asp

CBS (2013), Dataset of the *Centraal Bureau Statistieken* in The Netherlands. Free to download from website of CBS.

FALW Vrije Universiteit (2013), Website of Faculteit der Aard- en Levenswetenschappen. Information on magnitudes of earthquakes and scale of Richter and Mercalli.

Kadaster (2013), information on the Rijksdriehoeksstelsel.
http://www.kadaster.nl/web/Themas/Registraties/Rijksdriehoeksmeting/Rijksdriehoeksstelsel.htm

Nationaal Georegister (2013),
http://www.nationaalgeoregister.com

Youtube (2013), website which can be used to watch videos on how analyses and tools in ArcGIS work. This website is used extensively to make the templates as they are now.
http://www.youtube.com

Used programs

ArcGIS Desktop 10.0

ArcGIS Desktop Help 10.0
Provides answers to various questions on the program ArcGIS Desktop.
http://resources.arcgis.com/en/help/main/10.1/index.html#//

ArcCatalog 10.0
Provides a Catalog window that is used to organize and manage various types of geographic information for ArcGIS Desktop, for example the Geo database and templates.

ArcSearch 10.0

ArcToolbox 10.0
Provides a toolbox which contains all tools and analyses that can be used in the program ArcGIS Desktop. This Toolbox has been used much to make the templates for this internship.

Outlook

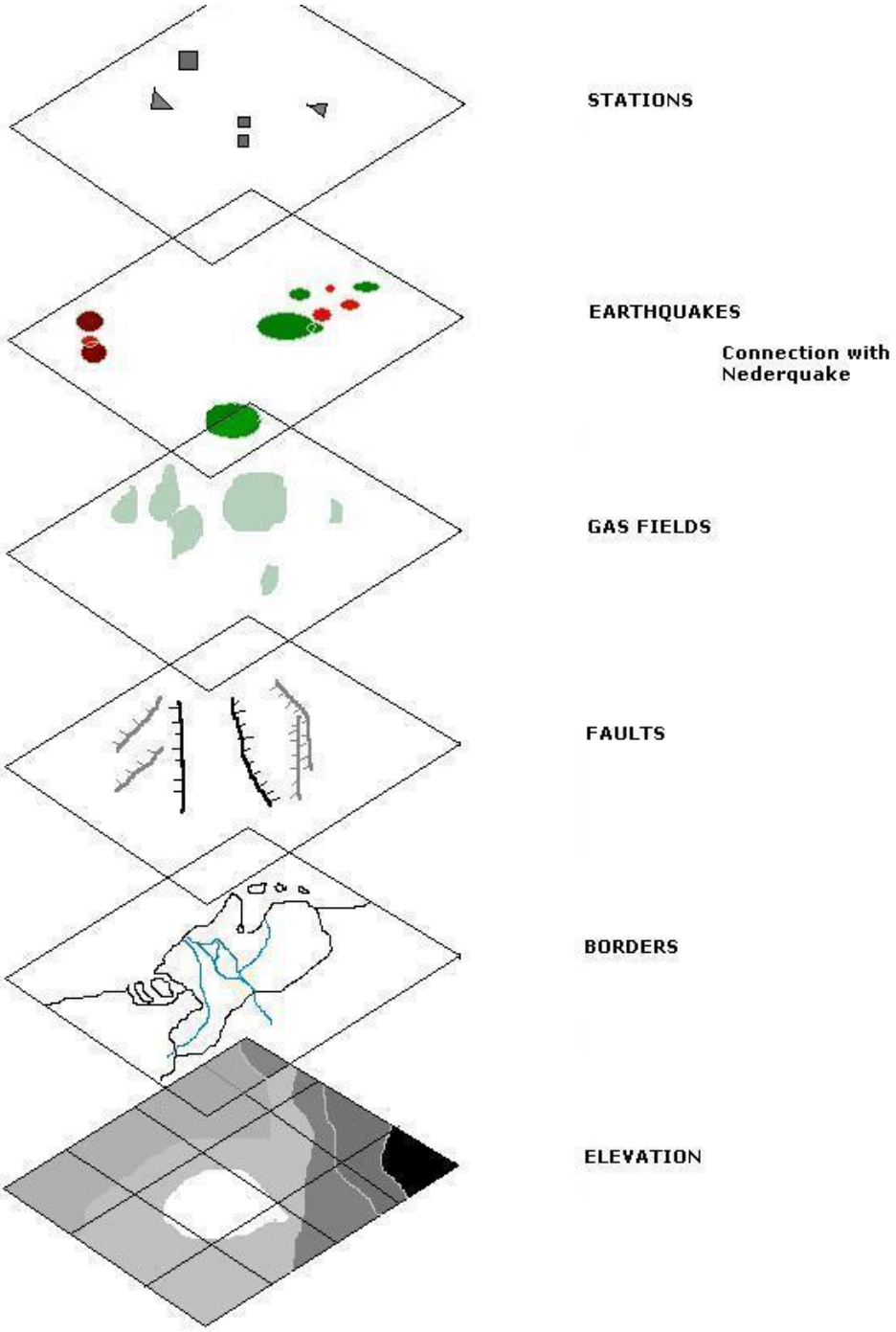
During the internship, I have been really into the details of the database and some things seemed to be very inefficient and not logical to me. Because it was not part of my assignment or there was no time I was not able to tackle those problems. I listed these things below as an advice, so it still could be used in the future:

- The whole of the Access file *Nederquake* should to be rebuild. Nederquake has been set up during a period of 30 years, and now some tables are not relevant or double. Making the Access table clear, 75 percent of the amount of tables could be thrown away. Actually, revising all of the tables will take quite a lot of time.
- In table 'Nederquake', one quake (QNR=10) is given the type: gH instead of GH. This small difference has to be changed.
- For the elevation on the Overview map, the AHN of 25 meter could be used instead of the 100x100 meter pixels which is used now. The computer used during this internship did not have enough space to run the 25 meter layer in the program ArcGIS very well.
- A possible addition to the analysis map could be all datasets containing the faults in the Netherlands and surroundings. It could be useful to be able to see where the faults are situated when analysis is done.

Appendices

Appendix 1

Overview of layer structure in template Overview Map

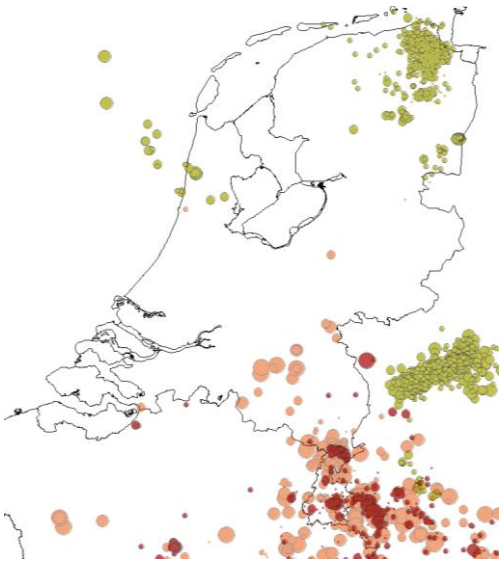


Appendix 2

Overview of layers content in ArcGIS

Appendix 3

Overview of results of different layers, as layered in ArcGIS *template* Overview map.



Appendix 4

How to..

Convert different raster files into one mosaic.

1. Download NASA Aster files, store them and extract.
   (Stored: 1.Geodatabase_KNMI_Kaart\Elevation\Aster)

2. Resample all files (10-4 into 5,0E-4)
   (Toolbox/Data Management Tools/Raster/Raster Processing/Resample)
   (Stored: KNMI/Kaart/Basismap/Resampled)

3. Creating a new Catalog in ArcMap
   (Right-click → New → File Geodatabase and New → Catalog Raster)

   Raster Catalog Name: DataElevationModel_CATALOG50
   Coordinate System: RD_New
   Raster Management type: Unmanaged
   'OK'

4. Load files into Catalog
   (Right-Click → Load → From Database)

5. N.B.: Load full map (/resamples) (one mouse click on map 'resamples' and 'add')

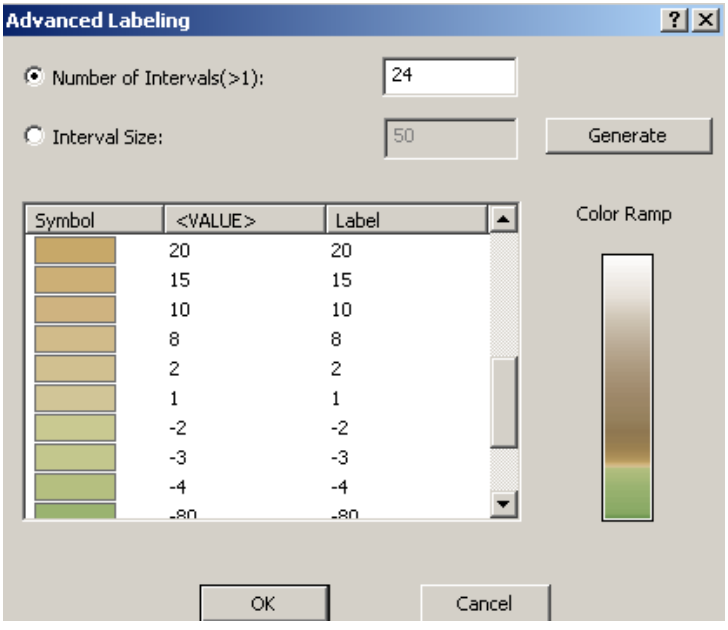
6. Drag Catalog into 'Template'; all maps are visible now

7. Convert into Raster dataset
   (Toolbox/Data Management Tools/Raster/Raster Dataset/Raster Catalog to Raster Dataset)

Appendix 5

Scaling the elevation.

Exaggeration of elevation differences in lower areas, as can be seen: 24 intervals, of which 10 between a elevation range of -4 to 20 meters, so 42% of intervals for 3% of elevation heights. Properties > Symbolisation > Advanced Labelling.



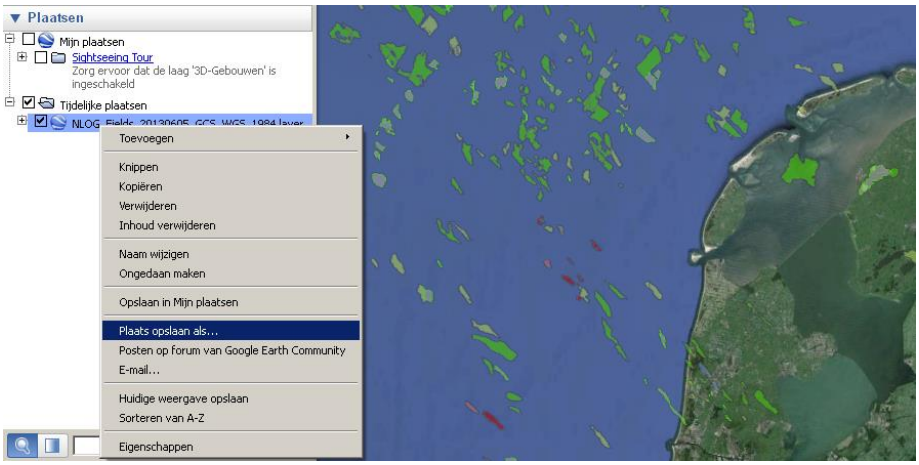
Appendix 6

How to…

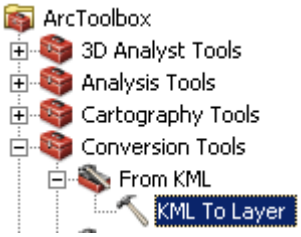
Add a KML file in ArcGIS

The gas fields added in the following way:

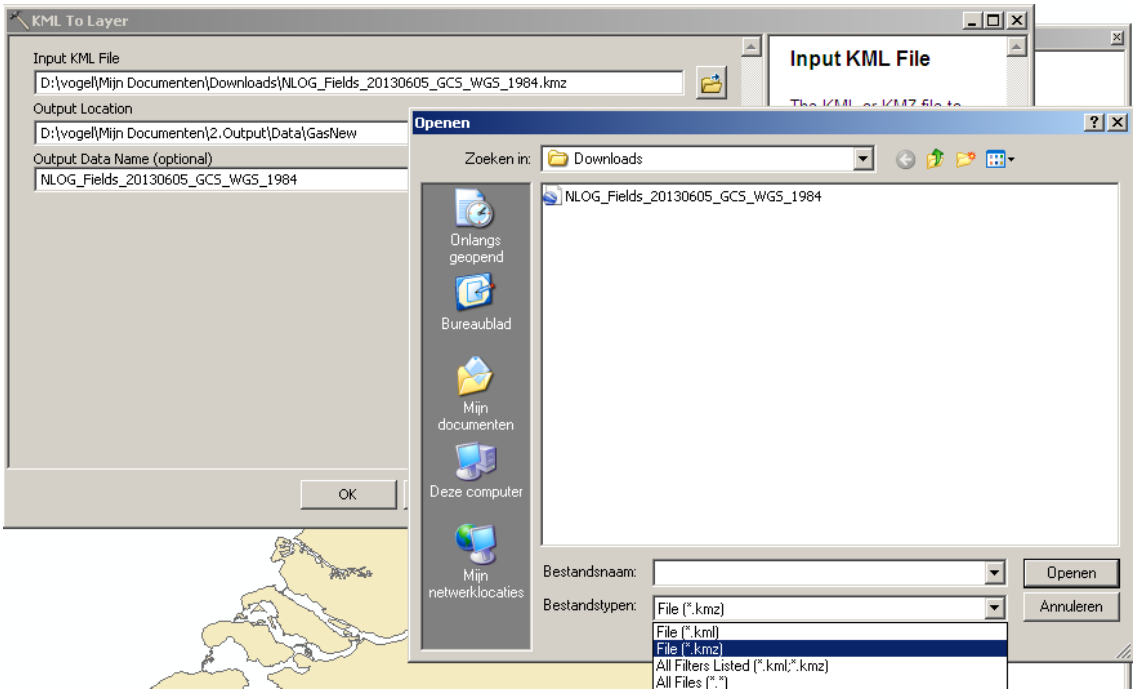
1. Download from NLOG (NLOG, 2013)
2. Open the file in Google Earth by double clicking on it
3. Right click the file on the left side of the screen > Save place as.. > KMZ



4. In ArcGIS, go to ArcToolbox > Conversion tools > From KML > From KML to Layer.



5. Change browse bar in 'Input KML File' into KMZ files, choose saved KMZ file and convert.



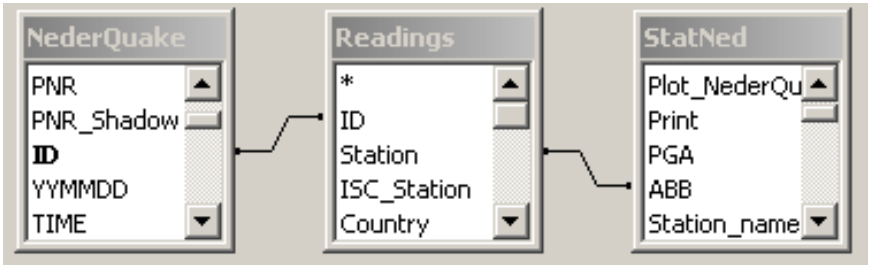
Appendix 7

How to..

Make query: LQ_Stations.

Explanation on query LQ_Stations, as part of the new optional layer in Analysis Map

1. Make a new query in Access
2. Select the three tables: *Nederquake, Readings* and *StatNed.*
3. Drag the tables into the query and combine them as in the figure below:



4. Make a query with six columns, gathering its information from the three tables, as done below:

Veld:	ID	X_RD	Y_RD	Related	X_RD	Y_RD
Tabel:	NederQuake	StatNed	StatNed	NederQuake	NederQuake	NederQuake
Sorteervolgorde:						
Weergeven:	☑	☑	☑	☑	☑	☑
Criteria:				"LQ"		
Of:						

5. By saving the design view and changing to query view, the next query will become visible:

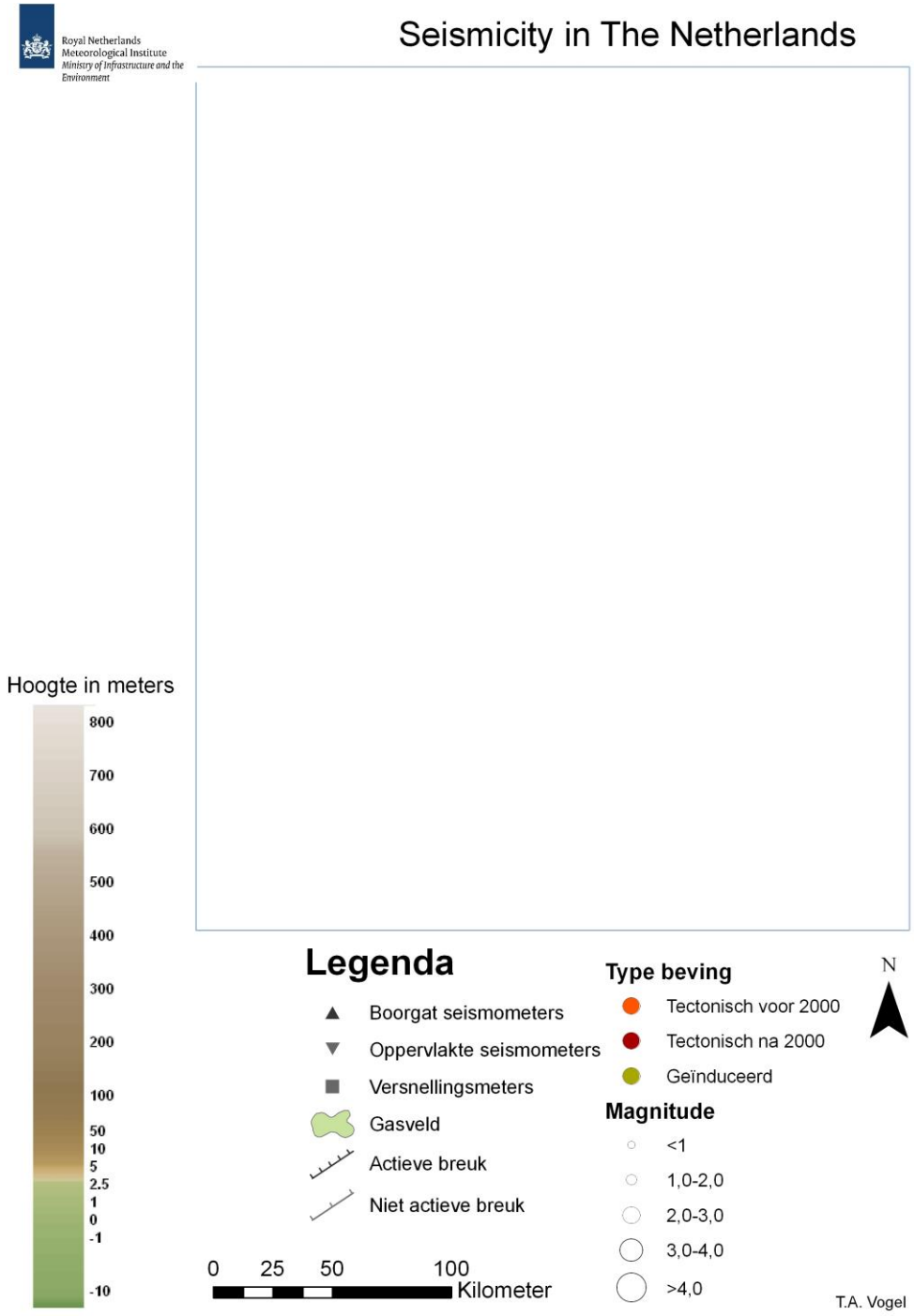
LQ_Stations : Selectiequery

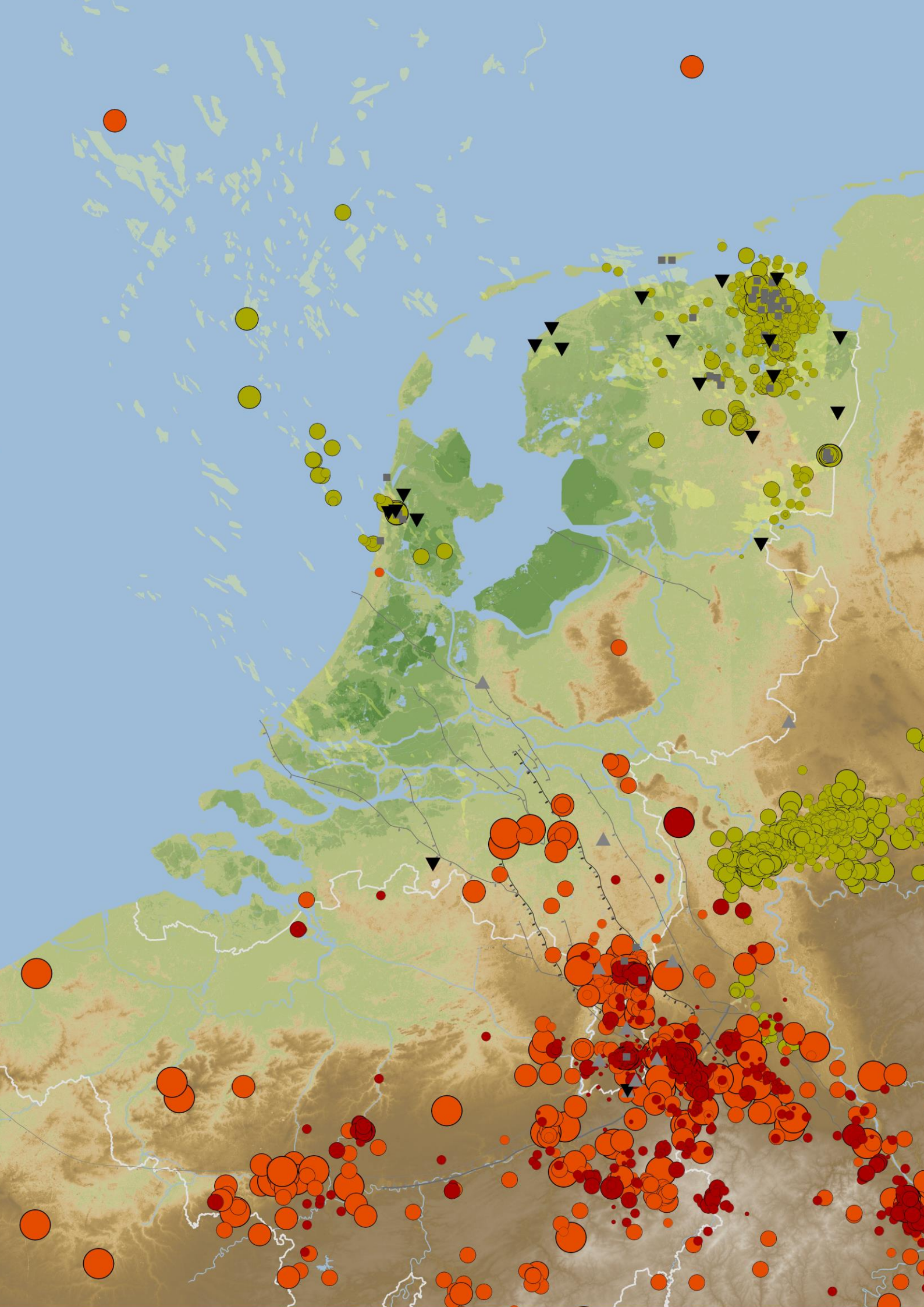
ID	StatNed.X_R	StatNed.Y_RD	Relate	NederQuake	NederQuake
20131126235453.090	251512	593017	LQ	252.087,70	594.216,32
20131126235453.090	245564	595016	LQ	252.087,70	594.216,32
20131126235453.090	238567	596391	LQ	252.087,70	594.216,32
20131126235453.090	245968	602407	LQ	252.087,70	594.216,32
20131126235453.090	249934	595842	LQ	252.087,70	594.216,32
20131126235453.090	248208	593805	LQ	252.087,70	594.216,32
20131126235453.090	243078	596157	LQ	252.087,70	594.216,32
20131126235453.090	247375	598600	LQ	252.087,70	594.216,32
20131126235453.090	246048	597585	LQ	252.087,70	594.216,32
20131126235453.090	227786	602784	LQ	252.087,70	594.216,32

6. Now each reading is given with the X and Y coordinates of the station and the X and Y coordinate of the reading. Because of the criteria 'LQ', the query only shows the readings of LQ. By connecting this query to ArcGIS, all stations will become visible which analysed the last quake.

Appendix 8

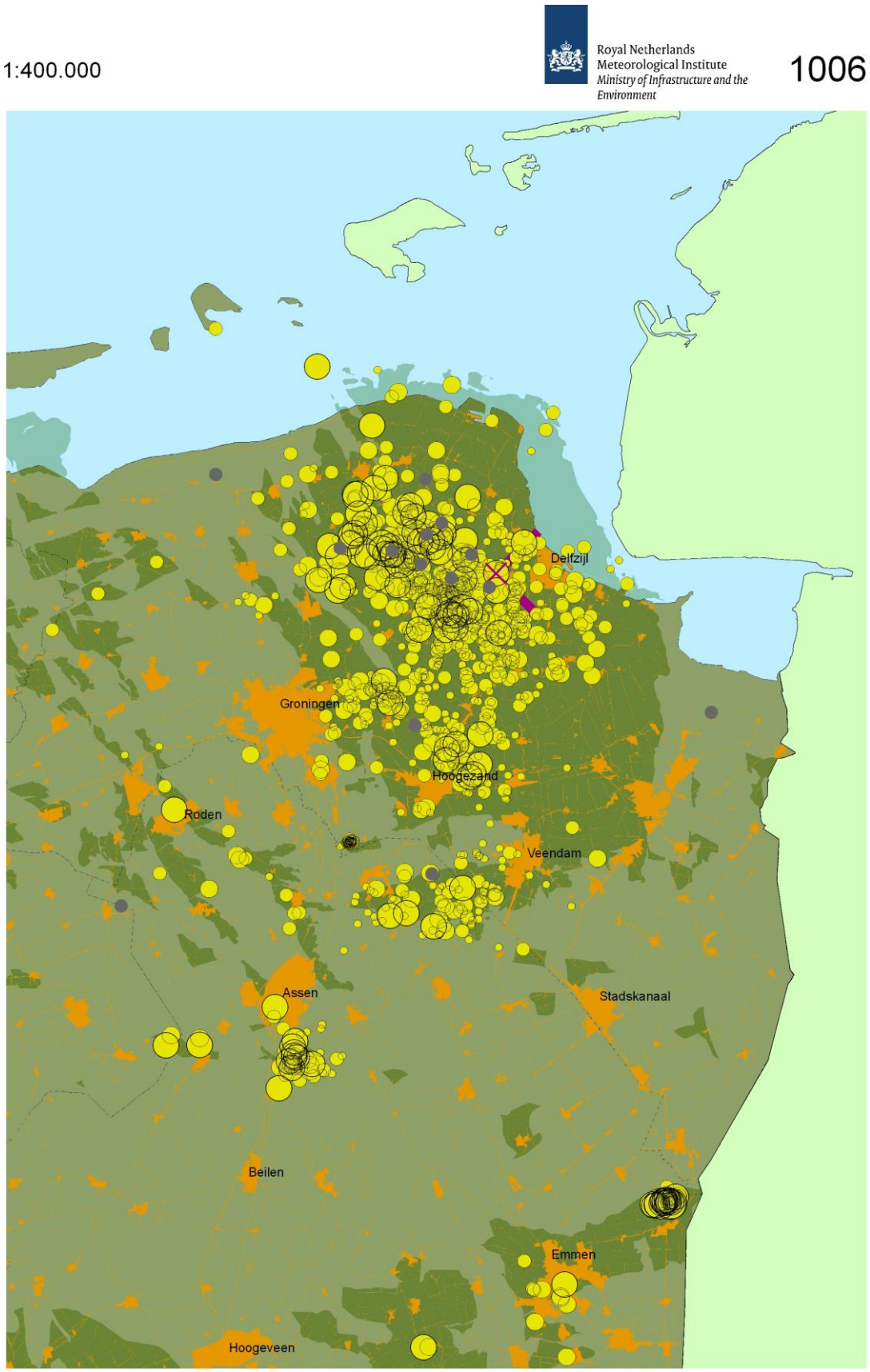
Overview of the final legend and overview map (next page)





Appendix 9

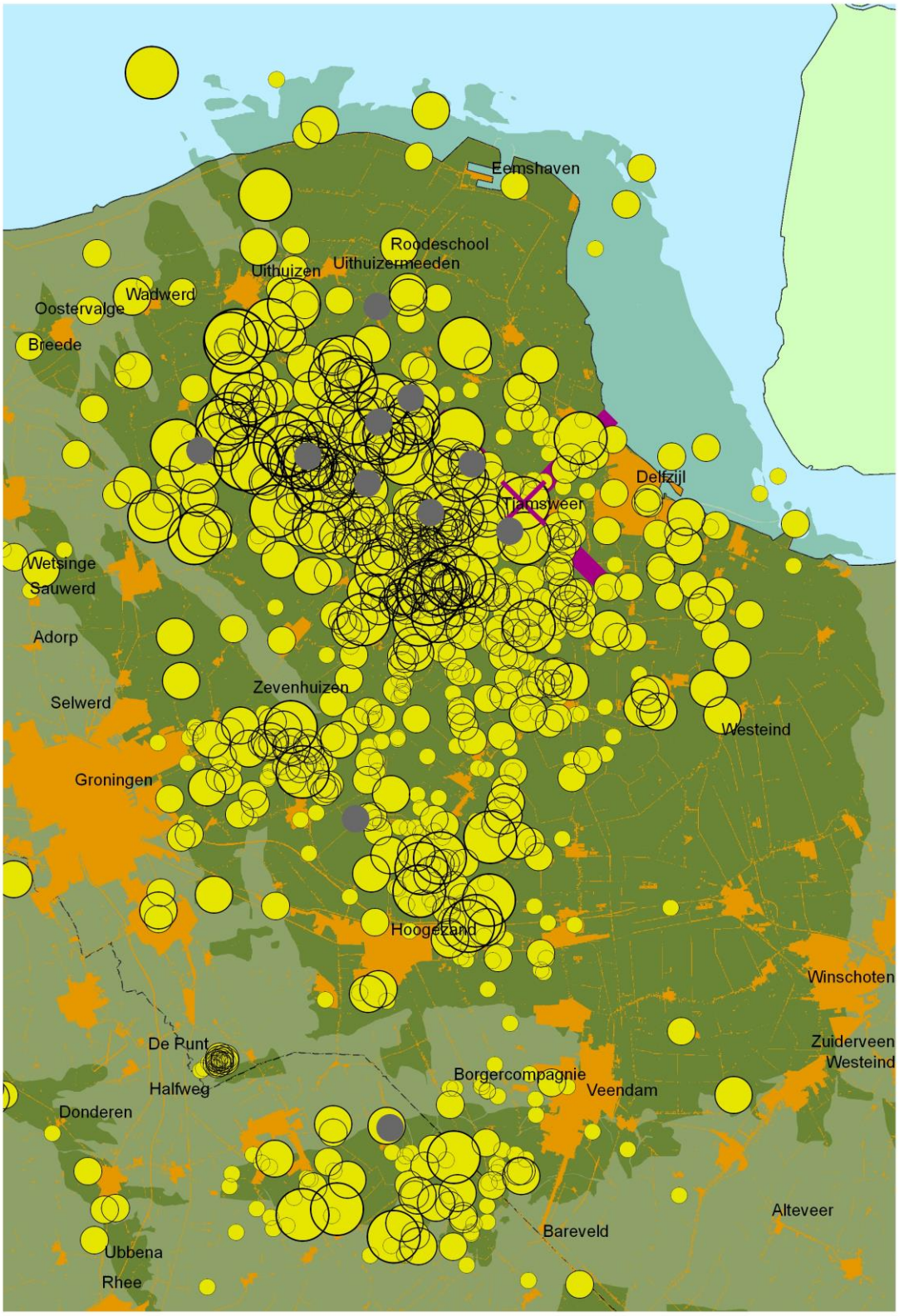
Overview of the final analysis maps. 1:400.000, 1:200.000 and 1:100.000.



1:200.000

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

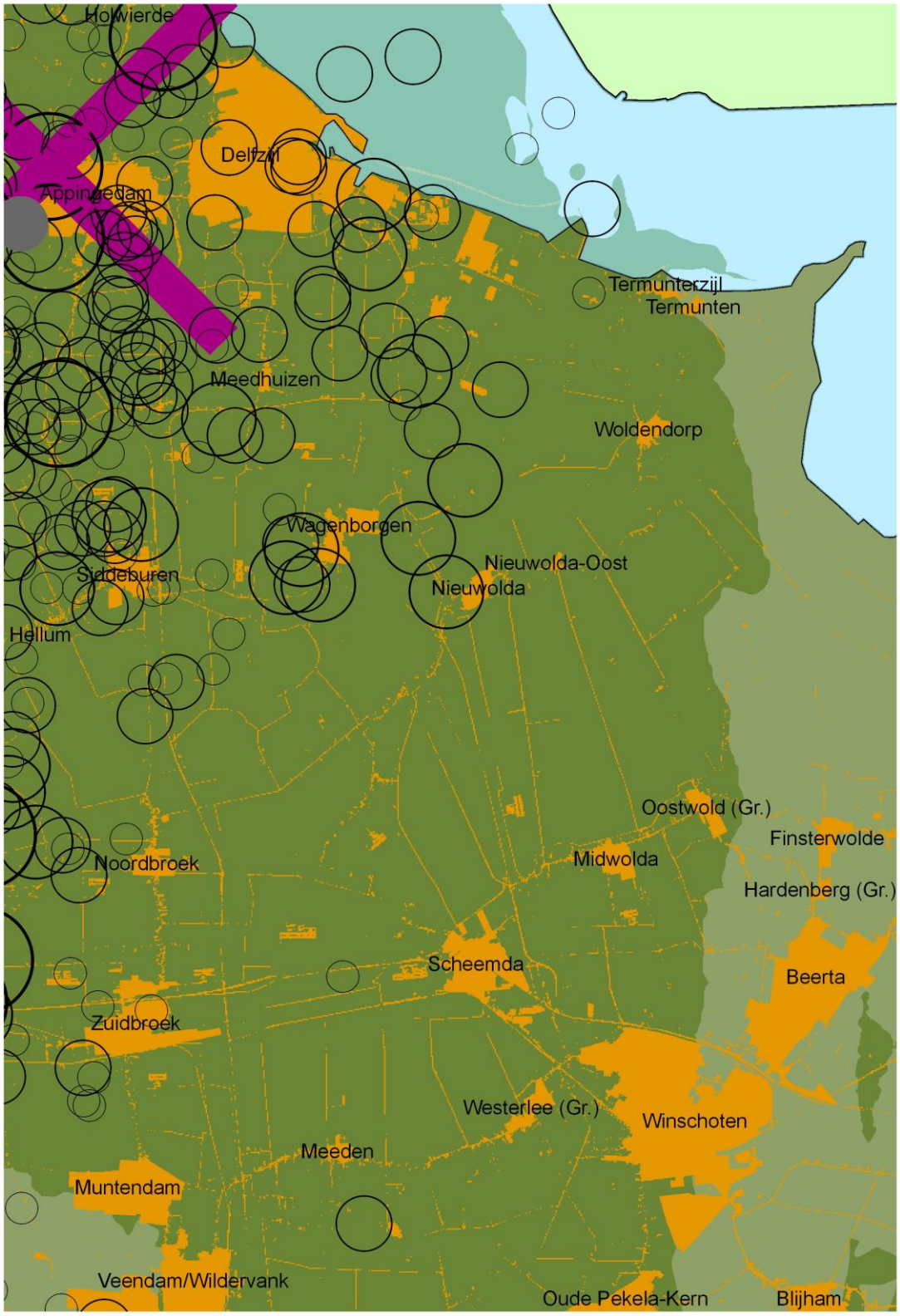
1006



1:100.000

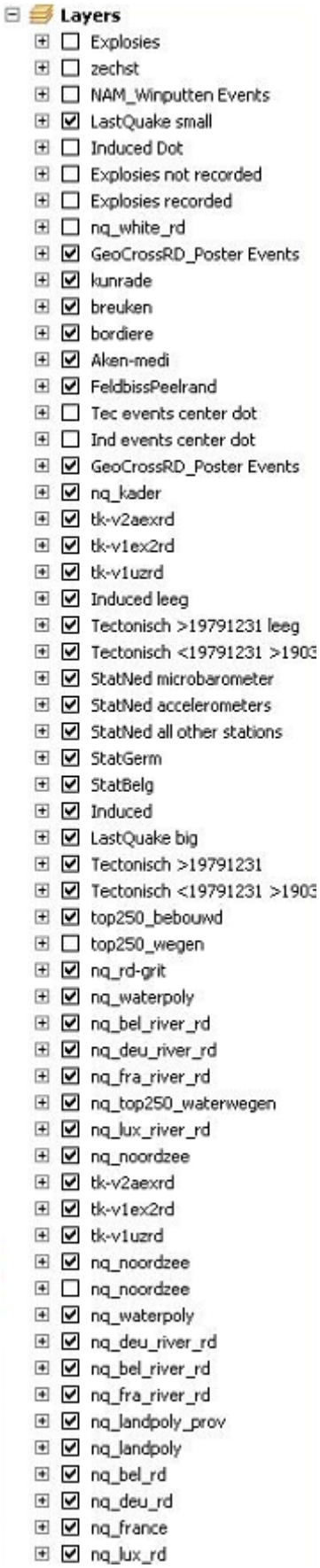
Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

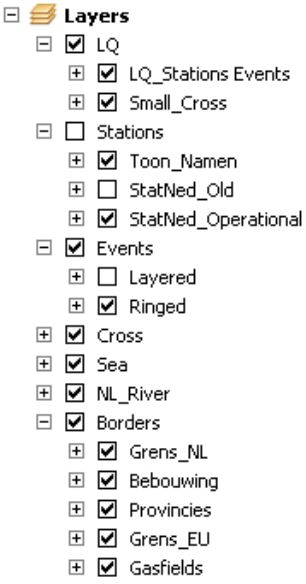
1006



Appendix 10

The structure in ArcGIS template 'Analysis Map' before and after the internship:





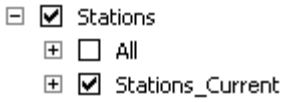
Appendix 11

Quick Reference Guide 1

Converting the Overview Map into a map or poster

1. Open ArcGIS Template Mapgeodatabase
2. Change view to 'layout-view' 
3. Decide what scale and data frame view has to be visible on the map, with: 
4. Insert>Picture: Volledig.jpg
   Note: When your reference scale is not 1:1.000.000, choose Picture: Volledig-Scalebar.
5. Double-click on the picture and choose 'size and positioning'. Use: 
6. Change size width to: 20,89 cm. (Height changes automatically)
7. Drag the picture in the right position and right-click > 'order' > 'Send to back'
8. Insert a new scale bar, when reference scale is not 1:1.000.000
9. Take considerations and look at options as written below:

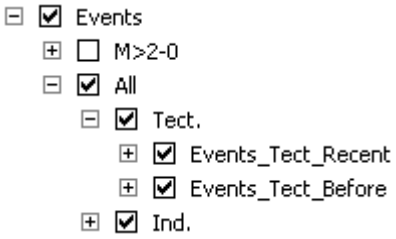
Considerations



- Which stations have to be shown on the map?
  Choose between 'all stations' or 'current stations'
- Show RD Grid (Double click 'Layers' > 'Grids' > check 'Measured Grid' > 'Apply')

Possible other options

- When legend needs to be changed, this can be done in template 'Legend'.
- Change the limit value between 'recent' and 'old' quakes. This is now set at 2000, but might be changed in the future, to make visualisation better.
  This can be done by:
  Double click on layer 'Events_Tect_Recent'
  > Tab: 'Definition Query'
  > Change '20000000' in e.g. '20050000'
  -Do the same for layer 'Events_Tect_Before'



10. Export the new map and send to KNMI Studio to make a new poster
    File > Export map

Appendix 12

Quick Reference Guide 2

Converting the Analysis Map template into a map

1. Open ArcGIS template AnalyseKaart
2. Change view to 'layout-view' 
3. Switch to the right view by dragging the map with: 

   Note that the Last Quake Cross should be visible on the map
4. Eventually, change the map's scale reference bar 

5. Change title of QNR at the right upper corner by double-clicking on it. Use: 
6. See considerations and other options below to finalize the visualization

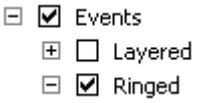
Considerations

- Which scale reference will be the best for this map?
  Think of: - Amount of quakes visible; not too crowded?
  - City names visible; names of hamlets also expected to be visible?
  E.g. when a new quake occurs in the neighbourhood of Groningen, scale 1:200.000 would be the best option. However, when five quakes occur at the same place in one week, it would be useful to zoom in to make the small villages visible.

- Show all stations or only the stations that were used to analyse LQ?

Possible other options:

- Show RD Grid (Double click 'Layers' > 'Grids' > check 'Measured Grid' > 'Apply')
- Map with quakes becoming too crowded? Choose 'Layered' instead of 'Ringed'
- Show only the quakes of 2013

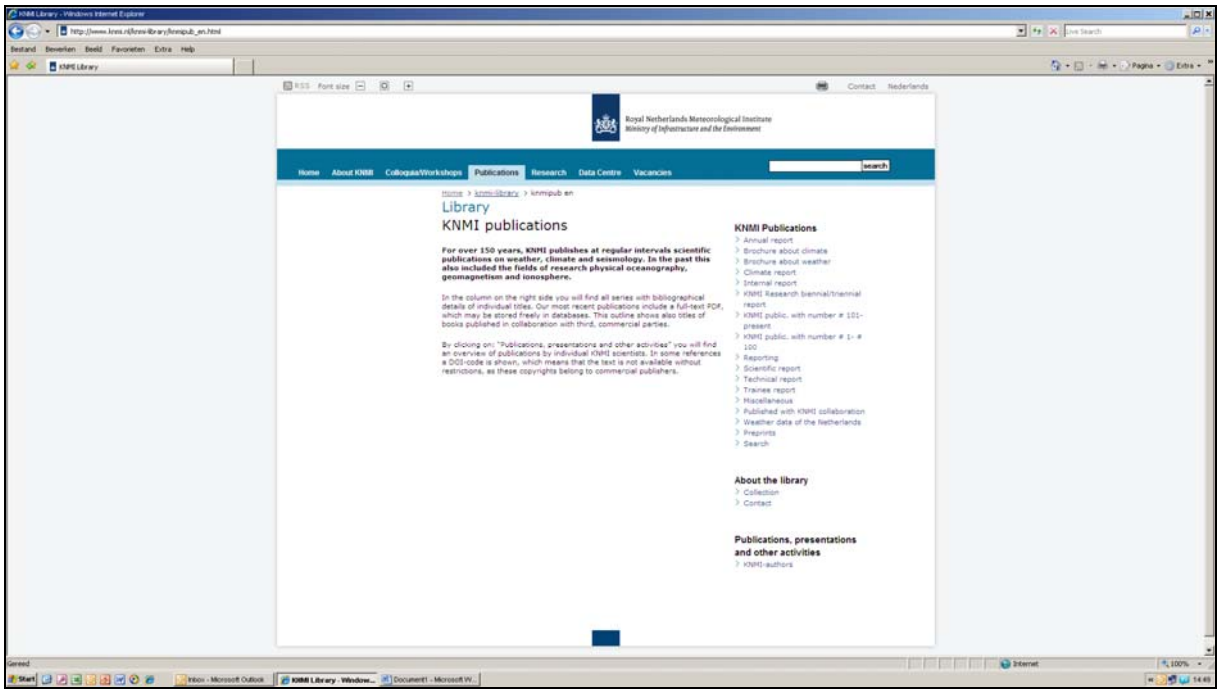


- Eventually, label the names of the LQ stations. This is automatically done when scale reference is 1:150.000 or smaller, but might be useful to do it also at another scale.

7. Export map or print map (File > Print or File > Export map)

A complete list of all KNMI-publications (1854 – present) can be found on our website

www.knmi.nl/knmi-library/knmipub_en.html



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