GeoTOP and NetCDF

Version 29 March 2023, related to the publication of GeoTOP v1.5.

TNO – Geological Survey of the Netherlands disseminates the GeoTOP model in several ways. One way is a so-called NetCDF-file which can be downloaded from TNO's OPeNDAP-server. NetCDF (Network Common Data Form) is a data format that supports array-oriented multi-dimensional data such as the 3D voxels of GeoTOP. This document describes how to use the OPeNDAP-server to select an area of interest and download that part of the model as a NetCDF-file. It also describes how to open the file as a *voxel layer* in Esri's ArcGIS Pro (version 2.6.0 and higher).

Note: due to developments of the OPeNDAP server, the download procedure might be subject to future changes. If you come across any difficulties when downloading a NetCDF-file from the server, please contact us via https://www.dinoloket.nl/en/contact.

Download GeoTOP (complete model)

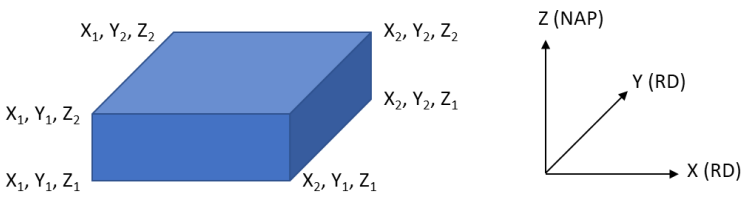
1. Unfortunately, the OPeNDAP server does not allow a download of the complete GeoTOP model in a single NetCDF-file. However, the server does allow to download large cut-outs of the model, for instance a combination of the three southern provinces (Zeeland, Noord-Brabant and Limburg). When downloading such a large area, it is important to limit the file size by selecting a single attribute, for instance the *most likely lithological class*.

2. In case you do want to use the NetCDF-file of the full GeoTOP model, please contact us via https://www.dinoloket.nl/en/contact. We will then send you the file.

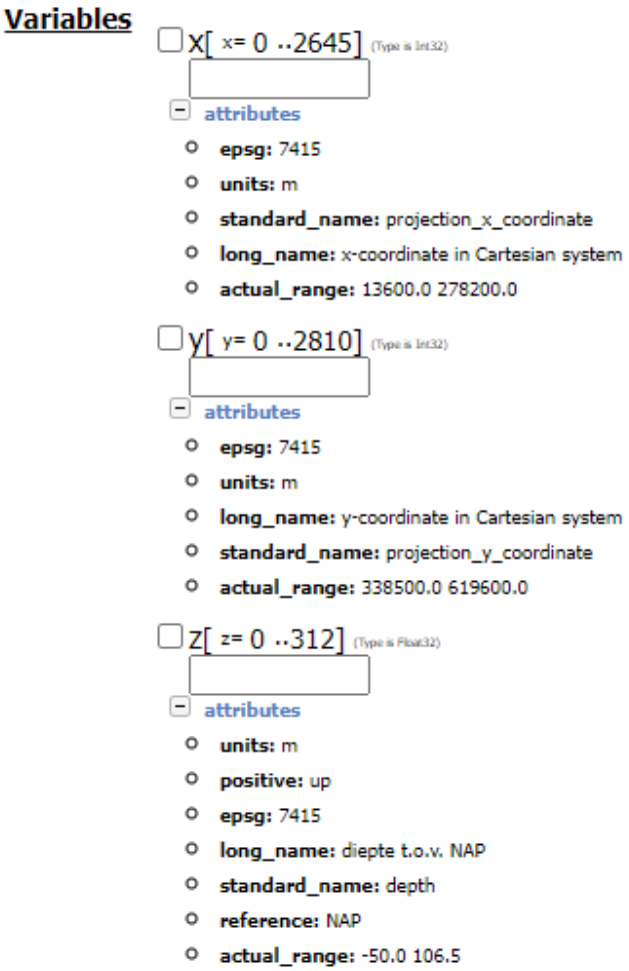
Download GeoTOP model (area of interest)

1. Use your browser to go to https://www.dinodata.nl/opendap/GeoTOP/geotop.nc.html

2. To download an area of interest of the GeoTOP model, you must enter the range of X, Y and Z *indices* (sequence numbers) of the voxels within your area of interest on the web page. GeoTOP itself uses the Rijksdriehoekstelsel (RD, Dutch national grid) in the X and Y directions and NAP (Dutch ordnance datum, 0 m NAP is approximately mean sea level) in the Z direction. NetCDF, however, uses the *indices* in the regular 3D grid of the voxel model. The following instruction describes how to convert the RD and NAP coordinates of your area of interest in the corresponding *indices* of the NetCDF-file.



3. First, determine the *actual range* of the X, Y and Z coordinates in the NetCDF-file. The *actual range* defines the origin and range of the file in RD and NAP coordinates. You can find the *actual range* by clicking on the plus sign ('+') next to the variables X, Y and Z.



Note the starting values of the *actual* range which define the origin. In GeoTOP version v1.5 these values are 13600 m for X, 338500 m for Y and -50 m for Z. It is possible that the *actual range* values change when a new version of GeoTOP is published.

4. Next, determine the RD and NAP coordinates of your area of interest. For X and Y, select multiples of 100 m. For Z, use multiples of 0.5 m (each voxel measures 100 x 100 x 0.5 m):
   - X: (X_1 westernmost coordinate, X_2 easternmost coordinate).
     - Example: X_1 = 92000 m and X_2 = 94000 m.
   - Y: (Y_1 southernmost coordinate, Y_2 northernmost coordinate).
     - Example: Y_1 = 435000 m and Y_2 = 437000 m.
   - Z: (Y_1 lowest NAP-height, Z_2 highest NAP-height).
     - Example: Z_1 = -50 m NAP and Z_2 = +10 m NAP.

5. Determine de *indices* for the **X-direction**:
   - Decrease both X_1 and X_2 by the starting value of the *actual range*.

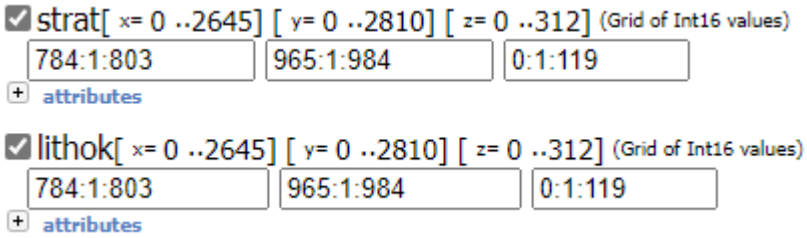
- Example: X_1 = 92000 – 13600 = 78400 m and X_2 = 94000 – 13600 = 80400 m.
- Divide both X_1 and X_2 by 100. Subsequently, decrease X_2 by 1.
  - Example: for X_1 = 78400 and X_2 = 80400 the *indices* are 784 and 803 respectively.

6. Determine the *indices* for the **Y-direction**:
   - Decrease both Y_1 and Y_2 by the starting value of the *actual range*.
     - Example: Y_1 = 435000 – 338500 = 96500 m and Y_2 = 437000 – 338500 = 98500 m.
   - Divide both Y_1 and Y_2 by 100. Subsequently, decrease Y_2 by 1.
     - Example: for Y_1 = 96500 and Y_2 = 98500 the *indices* are 965 and 984 respectively.

7. Determine the *indices* for the **Z-direction**:
   - Multiply both Z_1 and Z_2 by 2 and increase the outcomes by 100 and 99 respectively.
     - Example: for Z_1 = -50 en Z_2 = +10 the *indices* are 0 and 119 respectively.
   - In most cases you will probably want to select the full depth range of the GeoTOP model. In that case, the corresponding *indices* are 0 and 312 respectively.

8. Determine which GeoTOP-attributes *(variables)* you wish to download. Check these attributes on the web page. It is not necessary to check the variables X, Y and Z. If, for example, you want to download the geological unit (‘strat’) and the lithological class (‘lithok’), you only need to check these two attributes.

9. Next, enter the *indices* determined in step 3 through 7 in the boxes of each checked attribute, using the following format:
   - $index_1$: 1 : $index_2$
     - Example:



10. Finally, click “Get as NetCDF 4” at the top of the web page to download the NetCDF-file.

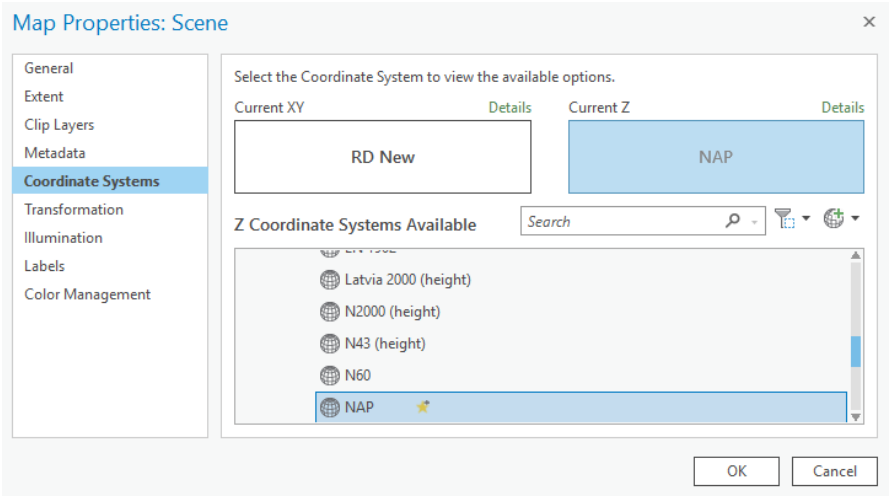
11. After the download is complete you may want to rename the file to a name of your choosing. For use in ArcGIS Pro, it is useful to take this opportunity to change the extension from '.nc4' to '.nc'.

How to load a NetCDF-file in ArcGIS Pro

To load a NetCDF file in ArcGIS Pro, please prepare the following:

1. Start ArcGIS Pro and open a new *Local Scene*.
2. In the Scene Map Properties window, select *Coordinate Systems*.
3. For the XY coordinates, select *Projected Coordinate System / National Grids / Europe / RD New*.
   (RD New is the Dutch national grid.)
4. For the Z coordinate, select *Vertical Coordinate System / Gravity-related / Europe / NAP*.
   (NAP is the Dutch Ordnance Datum, 0 m NAP is approximately mean sea level.)

The *Map Properties* window should now look like this:

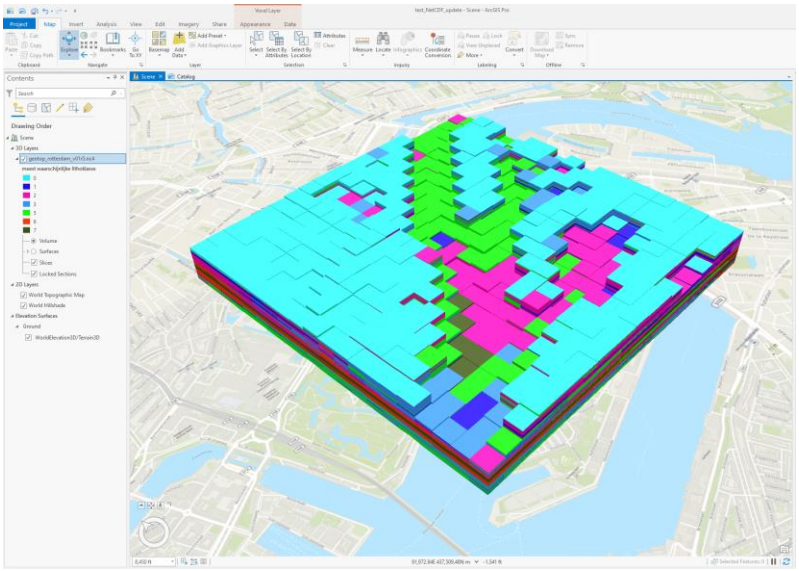


5. Optionally, select the *General* tab and change the *Display Units* as well as the *Elevation Units* to metres. The coordinates will then be displayed in metres rather than in decimal degrees.
6. Click OK to save the selections made and close the window.

You are now ready to load the NetCDF-file:

1. In the Map ribbon/menu bar, select *Add Data / Multidimensional Voxel Layer.*
2. Use the button *Import Data Source* to navigate to the NetCDF-file.
3. The Add Voxel Layer window now shows the attributes you selected on the OPeNDAP-server web page, for example:
   a. *Strat* = stratigraphical unit the voxel belongs to
   b. *Lithok* = most likely lithological class that is representative for the voxel
4. Click OK to close the window and start importing the voxel data set. After some processing time, ArcGIS Pro shows a map view of the top of the model (if necessary, use the *Zoom To Layer* function).

Using the navigation functionality of ArcGIS Pro, you can tilt the model and get an impression of its 3D nature. Please refer to the information provided by Esri for details on how to navigate, create slices and cross-sections, make selections, increase or decrease the vertical exaggeration etc.

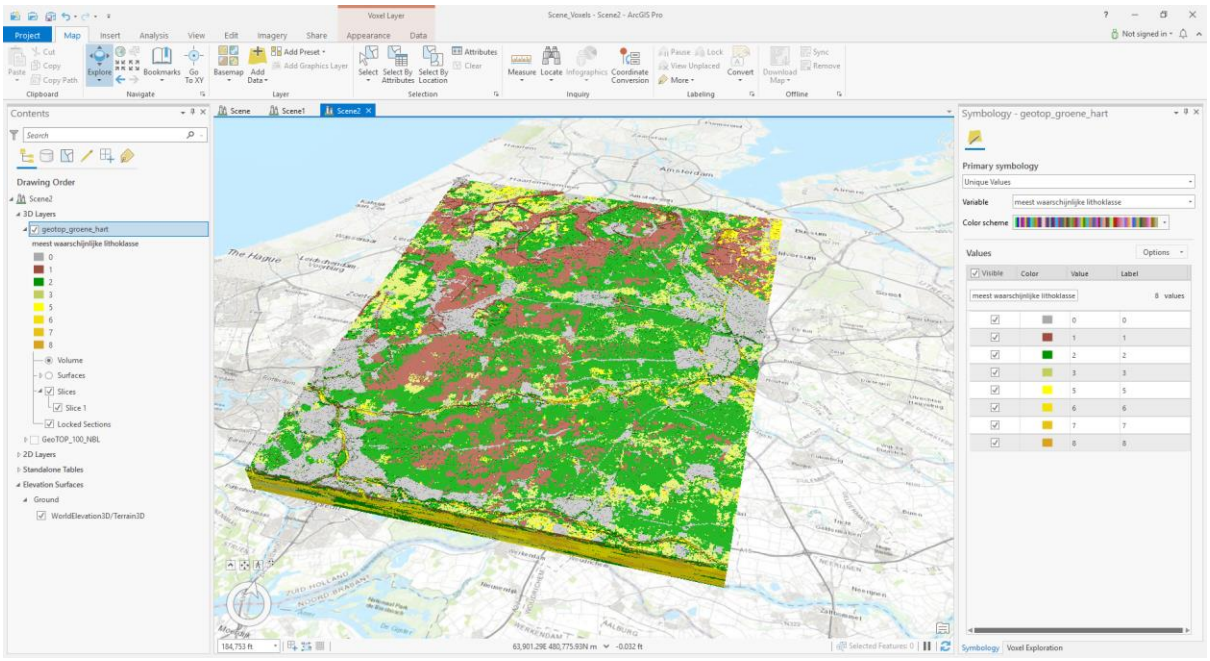


GeoTOP Colour scale

TNO recommends to use GeoTOP's standard colour scale. Table 1 shows these preferred colours for the attribute *most likely lithological class*.

LITHO_CLASS_CD	DESCRIPTION	VOXEL_NR	SEQ_NR	RED	GREEN	BLUE	HEX
a	Antropogenous material	0	0	200	200	200	#C8C8C8
v	Organic material (peat)	1	1	157	78	64	#9D4E40
k	Clay	2	2	0	146	0	#009200
kz	Clayey sand, sandy clay and loam	3	3	194	207	92	#C2CF5C
zf	Fine sand	5	5	255	255	0	#FFFF00
zm	Medium sand	6	6	243	225	6	#F3E106
zg	Coarse sand	7	7	231	195	22	#E7C316
g	Gravel	8	8	216	163	32	#D8A320
she	Shells	9	9	95	95	255	#5F5FFF

Table 1: Code, description, voxel number as used in the NetCDF-file, sequence number for the legend, RGB-colour codes and HEX colour codes of the lithological classes in GeoTOP.



Part of the GeoTOP voxel model using TNO's colour scale.

The colour scale of the geological units (lithostratigraphical units) is included in the official download of the GeoTOP model on DINOloket and BROloket.

GeoTOP attributes

The downloaded NetCDF-file can contain the attributes listed in Table 2.

Attribuut	Omschrijving
X	X-coordinate of the voxel midpoint in RD (m)
Y	Y-coordinate of the voxel midpoint in RD (m)
Z	Z- coordinate of the voxel midpoint in NAP (m)
Strat	Geological (lithostratigraphical) unit (layer) the voxel belongs to
Lithok	Most likely lithological class which is representative of the voxel
Kans_1	Probability (0..100%) the voxel contains the lithological class 'organic material (peat)'
Kans_2	Probability (0..100%) the voxel contains the lithological class 'clay'
Kans_3	Probability (0..100%) the voxel contains the lithological class 'clayey sand, sandy clay and loam'
Kans_4	Not in use
Kans_5	Probability (0..100%) the voxel contains the lithological class 'fine sand'
Kans_6	Probability (0..100%) the voxel contains the lithological class 'medium sand'
Kans_7	Probability (0..100%) the voxel contains the lithological class 'coarse sand'
Kans_8	Probability (0..100%) the voxel contains the lithological class 'gravel'
Kans_9	Probability (0..100%) the voxel contains the lithological class 'shells'
Onz_lk	The extent to which the model is able to provide an unambiguous estimate of the lithological class which is representative of the voxel (0..100%)
Onz_ls	The extent to which the model is able to provide an unambiguous estimate of the geological unit the voxel belongs to (0..100%)

Table 2: Attributes in the GeoTOP NetCDF-file.

Useful links

GeoTOP and TNO

Contact TNO – Geological Survey of the Netherlands (DINOloket):

https://www.dinoloket.nl/en/contact

GeoTOP webportaal:

https://www.dinoloket.nl/en/subsurface-models

GeoTOP informatie:

https://www.dinoloket.nl/en/detailing-the-upper-layers-with-geotop

https://www.dinoloket.nl/en/want-to-know-more

ArcGIS Pro

GeoTOP in ArcGIS Pro:

https://www.arcgis.com/home/item.html?id=1e227c9dee7f4382994ba644337fbd8e

What is a *Voxel Layer*?:

https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/what-is-a-voxel-layer-.htm

Exploring Voxel Layers (*Slice and Section Tools*):

https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/explore-voxel-layer.htm

Changing the appearance of a Voxel Layer:

https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/change-the-appearance-of-a-voxel-layer.htm

NetCDF and OPeNDAP

NetCDF:

https://en.wikipedia.org/wiki/NetCDF

OPeNDAP:

https://en.wikipedia.org/wiki/OPeNDAP

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