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A GIS Representation of the Temporal-Spatial Characteristics of the Land Cover - For a Wind Energy Application

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Objectives

Sustainable energy sources have become more popular in the past years and continue to do so. Wind energy is among the sustainable energy sources. Wind energy is generated by wind turbines.

The core objective of this master's thesis is to develop an automated process. The general functions of the automated process, application or tool, are required to contribute to the estimation of the wind speed at the wind turbine positions.

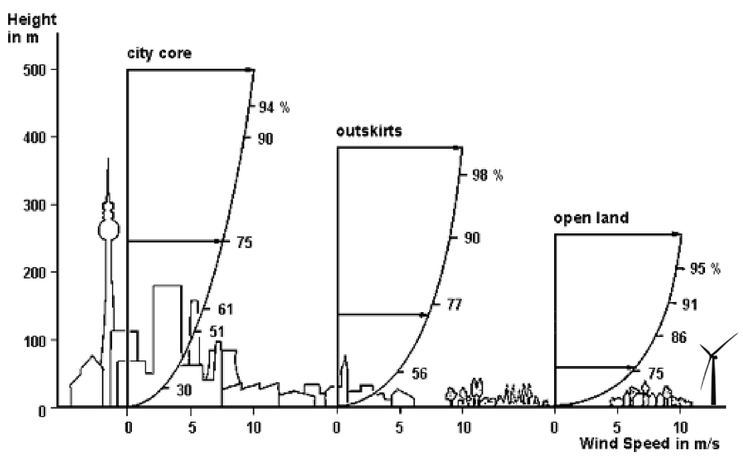
The properties of the surrounding terrain have a significant impact on the wind speed and thus the power generation of a wind turbine.

The master's thesis follows a GIS (geographical information system) based approach. Hence, the aim is to extract spatial data and derive the parameters needed. These parameters are then used to estimate the energy production of wind turbines. In addition to the parameters, the automated process is supposed to draw charts onto the map – for each wind turbine. It is an objective of the automated tool to analyze the data by month. This is because the conditions change throughout the year. The automated tool is to represent boundary conditions around single wind turbines – or wind turbine positions, for the wind characteristics over time and direction.

Parameters

The wind speed directly affects the power generation of the wind turbine. The wind speed is measured by measurement stations. There is a general increase in wind speed with altitude (above ground). There are local wind profiles. These are graphs which show how exactly the specific regions' wind speed increases as the altitude increases. There are two properties of the surrounding terrain of each wind turbine which influence the wind speed: the surface roughness and the terrain ruggedness.

The surface roughness is described by the parameter surface roughness length z_0. The surface roughness length is primarily influenced by the land cover class of the corresponding surface. The surface roughness affects the local wind profiles. This is shown in the following figure:

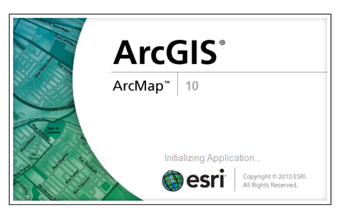


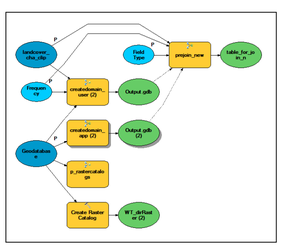
The wind profiles - the increase in wind speed with height above ground – varies significantly over the three different surfaces: city core, outskirts and open land.

The terrain ruggedness does not describe the surface of the terrain, but the shape i.e. the ruggedness of the terrain. It is known that the flow of the wind breaks at slopes of 30% or higher. The corresponding parameter is the terrain ruggedness index RIX. The RIX is used to estimate the prediction error of the calculated wind speed.

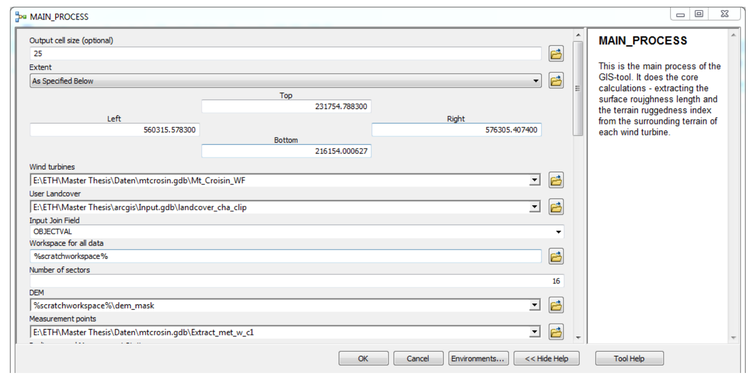
Results

The result of this master's thesis includes a GIS tool which was developed using the *modelbuilder* of *ArcGIS 10* from *ESRI*.

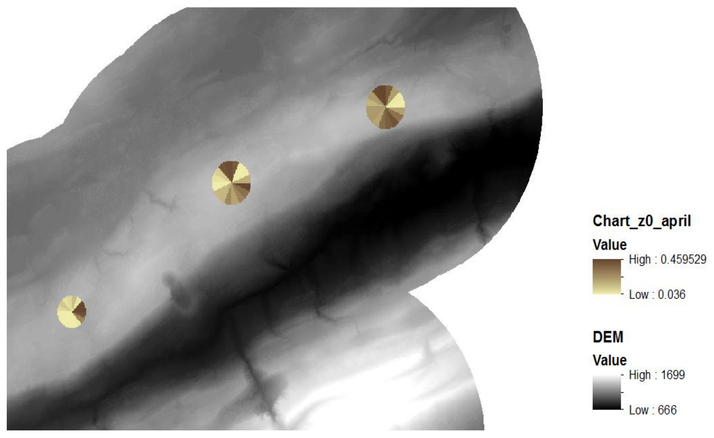




The tool is flexible and user-friendly. The tool consists of three phases. Each phase has an executable model. The three phases are executed sequentially using three corresponding graphical user interfaces (GUI). In the following figure one of these graphical user interfaces is shown.



The tool derives the parameters from the surrounding terrain for each wind turbine. All derived information is appended to the wind turbine shapefile including the nearest measurement station for each wind turbine and its attributes. Additionally, raster charts are created and drawn on a map. These charts represent the surface roughness length values per sector. For each wind turbine there are twelve charts – one per month (see figure below).



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