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Long-term groundwater recharge: sensitivity to climate and land use changes

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A project to build a surface disposal facility in Dessel (North-East of Belgium) for low-level nuclear waste is being developed by the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (Ondraf/Niras). Typically, the performance of the facility has to be assessed for several thousands of years. In this respect, groundwater recharge rate is an important variable to estimate because it eventually influences the fate of radionuclides that may reach groundwater.

The objective of this study is to assess the relative importance of climate and land use changes on the regional groundwater recharge in the Dessel area for the next several thousands of years.

Regional groundwater recharge is calculated by coupling the model Hydrus-1D (Simunek et al., 2005) with a GIS. Simulations use time series of precipitation and evapotranspiration data on soil profiles and vegetation data representative for the dominant land uses of the study area (coniferous (12%) and deciduous (11%) forests, cropland (21%) and grassland (11%)).

The sensitivity of groundwater recharge to long-term climate change is assessed through the use of climatic analogues stations. Using criteria of altitude and distance to moisture source similar to the study area, potential analogue stations were collected for a number of climate states (current maritime temperate, subtropical, cold without or with permafrost). Among these potential stations, representative analogues were chosen for each climate based on expected short-term climate change and geological information about past climate in the study area.

The sensitivity to land use change is assessed by varying the surface occupied by the different land uses and/or by changing the parameterisation of the vegetation cover (LAI, interception capacity, etc.).
On the time scale considered, it is important to take into account the correlation between climate and land use. It is expected that climate change will have a significant impact on land use. Some combinations of land use and climate are unrealistic or negligible (e.g. crop land in a tundra climate) and some vegetation parameters of a given land use may depend on climate variables. Therefore, effective approaches to estimate regional groundwater recharge on the long-term need to consider both climate and land use changes.

Preliminary results show that for the subtropical climate (which should apply for the study area by 2100 AD), groundwater recharge calculated with Gijon (Sapin) analogue station without changing land use would decrease compared to its current value.

For the colder climate states, groundwater recharge is expected to significantly decrease. Thaw/freezing processes and permafrost development were not simulated but would probably mean even less infiltration. Groundwater recharge is higher under deciduous and coniferous forests than under a grass (pasture) cover for two of the three climate states considered.

Different scenarios of land use change in the long term can be explored. For example, an abandonment of human settlements in the study area (i.e. land use conversion of 100% to coniferous or deciduous forest), would significantly groundwater recharge in all climate states considered.

An important limitation to the results of this study at this stage is that the correlation between soil type and land use was not accounted for. Also, the feedback between climate and vegetation parameters (e.g. LAI) was

not accounted for.

References.

Simunek, J., M. Sejna, and M.Th. van Genuchten (2005), HYDRUS-1D, version 4.14, code for simulating the one-dimensional movement of water, heat, and multiple solutes in variably saturated porous media.