

## User manual

### An ArcGIS Pro Toolbox for Depth-to-Water Index Calculation

Noah Greupner | Version 1.1 | August 2024

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#### Usage

This toolbox has a GNU GPL license and is open for public use and distribution. Users are encouraged to use, share and further enhance the tool according to their needs. However, when sharing, modifying or citing the tool, please give an appropriate credit to the original creator according to the following:

*Greupner, N. (2024): DepthToWater. An ArcGIS Pro toolbox for Depth-to-Water index calculation. University of Salzburg. Available at: <https://zenodo.org/doi/10.5281/zenodo.13381566>.*

#### Background

This tool calculates the (cartographic) Depth-to-Water (DTW) index, representing the simulated vertical difference (in metres) between a landscape cell and the nearest surface water cell along the least-cost slope path. DTW is useful for soil wetness modelling and identifying areas of high or low probability of water accumulation, which can be useful for hydrologic modelling, environmental planning and landscape monitoring.

While there are openly accessible tools available for similar indices, such as the Height-Above-the-Nearest-Drainage (HAND), DTW lacks comprehensive documentation and non-proprietary tools for its calculation. Therefore, this product enables users like environmental authorities, NGOs, students or GIS analysts to calculate DTW more easily.

#### About the product

The product represents an user-friendly ArcGIS script tool which calculates the DTW index using a Digital Elevation Model (DEM) and an optional hexagonal grid layer. The implemented workflow is based on the steps described by Schönauer and Maack (2021). The encoded workflow steps implemented in this ArcGIS script tool encompass the following:

- **Pre-processing:** The input DEM is hydrologically corrected by applying an algorithm that fills sinks and depressions.
- **Stream extraction:** Flow direction and flow accumulation are calculated using the Deterministic 8 Neighbour method. Subsequently, a stream network is extracted out of the flow accumulation raster based on the Flow Initiation Area (FIA) in hectares specified by the user.
- **DTW calculation:** A slope map is derived from the initial (not hydrologically corrected) DEM and used together with the extracted stream data in a cost function for calculating the DTW index.

- **DTW aggregation (optional):** For better and faster visualization of soil wetness patterns and enhanced decision-making, the index values are averaged in hexagonal grids which can optionally be provided by the user.

Please consult the implemented code for more detailed information about the workflow.

## Prerequisites

- **ArcGIS Pro:** The tool is designed to be used within ArcGIS Pro. The *Spatial Analyst* extension is required for executing the tool. As the tool was implemented for ArcGIS Pro 3.3.0, there might be compatibility issues in other versions of the software.
- **SAGA GIS Installation:** Ensure that SAGA GIS is installed on your system as the tool relies on it for calculations of accumulated cost which are not available within the ArcGIS geoprocessing tool environment. SAGA GIS can be downloaded under <https://sourceforge.net/projects/saga-gis/>.
- **Saga\_cmd executable:** You need to know the directory path to the saga\_cmd executable ("saga\_cmd.exe") for the tool to function correctly. The executable can usually be found under *C:/Program Files/SAGA/saga\_cmd.exe*.

## Parameters

Parameter	Data Type	Type	Description
<b>Digital Elevation Model</b>	Raster Layer	Required	The Digital Elevation Model representing the terrain of the study area.
<b>Flow Initiation Area (FIA)</b>	Float	Required	The Flow Initiation Area in hectares, representing the minimum area required to initiate a stream or river. Smaller FIAs lead to more extracted streams, while a greater FIA results in fewer extracted streams and drier assumptions of the landscape. As the FIA heavily influences the resulting DTW maps, consult further information and literature before setting the FIA.
<b>Hexagons</b>	Feature Layer	Optional	Polygon feature layer containing hexagonal grid cells. If provided, the tool will aggregate the DTW values within each hexagonal cell and save the aggregated output as a separate layer.
<b>Saga_cmd Path</b>	String	Required	The file path to the SAGA GIS command-line executable ("saga_cmd.exe"). This path is necessary for executing SAGA GIS tools within the script. If SAGA GIS is installed separately (and not as part of QGIS), the executable can usually be found under <i>C:/Program Files/SAGA/saga_cmd.exe</i> .
<b>Workspace</b>	String	Required	The directory where intermediate files will be stored. This folder should have enough disk space to accommodate large raster files. By default, the tool creates a folder named <i>DepthToWater</i> under <i>C:/Temp/</i> .

<b>Output Layer</b>	Raster Dataset	Required	The file path for the DTW raster output. The name should include a <code>.tif</code> extension if saving as a TIFF file, or a file name without an extension if saving within a geodatabase.
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## Outputs

<b>DTW Raster</b>	The primary output raster showing the calculated DTW across the landscape
<b>Aggregated DTW Raster</b>	If hexagons were provided, this output represents the mean DTW value aggregated within each hexagonal cell
<b>Intermediate results</b>	The intermediate rasters (e.g. slope, flow direction, flow accumulation etc.) can be found in your workspace directory (by default <code>C:/Temp/DepthToWater</code> )

## Support

For further assistance, contact the developer or refer to ArcGIS Pro's documentation for additional help with the implemented geoprocessing tools and scripting.

## References

Schönauer, M., & Maack, J. (2021). *R-code for calculating depth-to-water (DTW) maps using GRASS GIS*. <https://doi.org/10.5281/zenodo.5638517>.