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Sustainable management of politically and economically highly relevant water resources in hydraulically, climatically and ecologically highly dynamic carbonate groundwater aquifers of the Mediterranean, Subproject 6

MedWaterDSS Handbook

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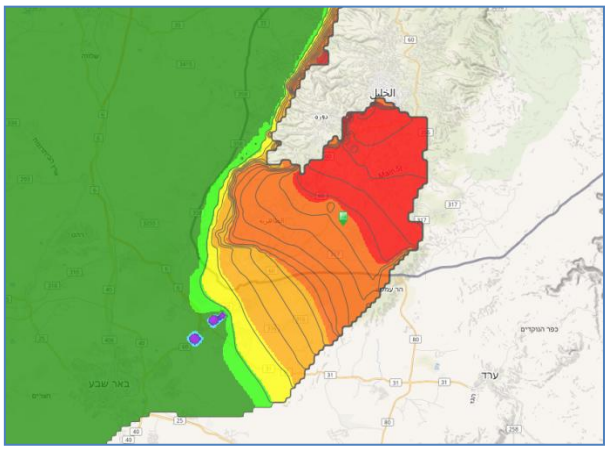

The project on which this paper is based was funded by the German Federal Ministry of Education and Research under the funding code 02WGR1428F. The responsibility for the content of this documentation lies with the authors.

MedWaterDSS – Handbook

Data structure and contents

The WebGIS application MedWaterDSS was designed and developed as an expert system. The user here is the end customer, e.g. an engineering office or a water management administration with the corresponding expertise.

The user can view and export spatial (maps, tool "Base data") and explanatory factual data in tabular and diagrammatic form ("Statistics" tool) for his project area for a selected spatial level (raster-, polygon-based). Live processing is also possible via the implemented Theis function for mapping well drawdowns ("Groundwater modelling" tool).

In the application, the data are structured hierarchically. The top level is a model run of MODFLOW. A model run consists of the model procedure (MODFLOW) and the selected time period (single year or period) with its respective parameters. A reference model and a comparison model can be selected to generate delta maps. Numerous parameters exist for each model run (e.g. specific storage, transmissivity, conductivity, etc.). Climate parameters (precipitation, temperature, cloud coverage, relative humidity, etc.) are shown for the selected period (year). In addition, there is topographical information (base layers), administrative information (administrative layers) and information for the characterisation of natural areas and land use (environmental parameters).

The data in the map image ("Base data" tool) and at the level of statistical evaluations ("Statistics" tool) can be filtered both land-use-specific and area-specific.

A basic prerequisite for the interactive use of the "Groundwater modelling" tool by the users is the creation of a user-specific project administration. In this project administration, calculation projects can be created, configured or deleted. This makes it possible for the user to access and modify modelling results even after the application has been terminated. The system login when calling up the application ensures that each user can only view and edit his own project, but not those of other users (with a separate login). It is also necessary to set up a data download in order to be able to use the user-specific results externally. The download is grid-based via an export module and also enables the export of MODFLOW model states for a defined target time without performing an analytical calculation via the Theis function.

Numerous external data are integrated and processed in the DSS, which originate from different sources and were transferred by different partners. A summary of the data sets, including a brief thematic description and their origin, is given in Table 1 below.

Table 1. External data included, brief description and references

Name / data set	**Description / data source**	**Provided by**
Geodata on topographic themes	Road network, water network, place names, etc. / https://www.openstreetmap.org	Freely available under the Open Database License
Administrative units	Country boundary, Israel, Palestine, Districts / https://www.openstreetmap.org	Freely available under the Open Database License
Catchment geometries	Yarkon Taninim, Recharge areas, Basins, Subbasins / Hydrological Service Israel (HIS), GADM data v3.6-	Partner University Würzburg
Report cells	Test areas / MODFLOW	Partner TU Berlin
Wells	Well locations / -	Partner TU Berlin
Redline	- / HIS	Partner TU Berlin
Land use type	Land cover data 2015 / European Space Agency (ESA, resolution 300 m)	Partner University Würzburg
Elevation	Digital terrain model (DEM) / SRTM 30 (resolution 30 m, LP DAAC, USGS/EROS, Sioux Falls, SD, http://Ipdaac.usgs.gov)	Partner University Würzburg
HWSD soil	Harmonized World Soil Database / https://data.isric.org	Freely available
Leaf area index	Leaf area index / Euro-Mediterranean Center on Climate Change (CMCC), resolution app. 8 km, daily	Partner TU Berlin
Precipitation	Rainfall / Euro-Mediterranean Center on Climate Change (CMCC), resolution app. 8 km, daily	Partner TU Berlin
Convective precipitation	Convective precipitation / CMCC, resolution app. 8 km, daily	Partner TU Berlin
Evaporation	Evaporation / CMCC, resolution app. 8 km, daily	Partner TU Berlin

Mean temperature	Mean temperature / CMCC, resolution app. 8 km, daily	Partner TU Berlin
Max. temperature	Maximum temperature / CMCC, resolution app. 8 km, daily	Partner TU Berlin
Min. temperature	Minimum temperature / CMCC, resolution app. 8 km, daily	Partner TU Berlin
Cloud coverage	Wolkenbedeckung / CMCC, resolution app. 8 km, daily	Partner TU Berlin
Relative humidity	Relative Feuchte / CMCC, resolution app. 8 km, daily	Partner TU Berlin
Groundwater level upper / lower aquifer	GW-level upper / lower aquifer / Output file MODFLOW	Partner TU Berlin
Recharge upper / lower aquifer	Groundwater recharge upper / lower aquifer / Output file MODFLOW	Partner TU Berlin
Confined / unconfined upper / lower aquifer	Demarcation of confined / unconfined upper / lower aquifer / -	Partner TU Berlin
Transmissivity upper / lower aquifer	Transmissivity upper / lower aquifer / Output file MODFLOW	Partner TU Berlin
Saturated thickness upper / lower aquifer	Saturated thickness upper / lower aquifer / Output file MODFLOW	Partner TU Berlin
Conductvity coeffi-cient upper / lower aquifer	Conductvity coefficient upper / lower aquifer / Output file MODFLOW	Partner TU Berlin
Well name, well type, filter location, pump-ing rate	Well name, well type, filter location, pumping rate / -	Partner TU Berlin

Layout and funktions

The MedWaterDSS web application can be accessed via the internet address "grow-medwater.de/dss" or via the MedWater project homepage "grow-medwater.de" and clicking on the "DSS Demo" button.

The start page of the application then opens (Figure 1). Here the user can choose the free login or a password-protected access, which is currently reserved for the workgroup (Login workgroup). The free login offers full functionality in the tools "Base data" and "Statistics", but only a demo function for the tool "Groundwater modelling". Here, only existing demo projects that have already been calculated can be called up. Calculations via the Theis function and the download function are deactivated. The password-protected access, on the other hand, offers the full functionality of the application. It is currently reserved for members of the working group. Interested parties who would like to test or use the system may receive their own login access with user name and password.

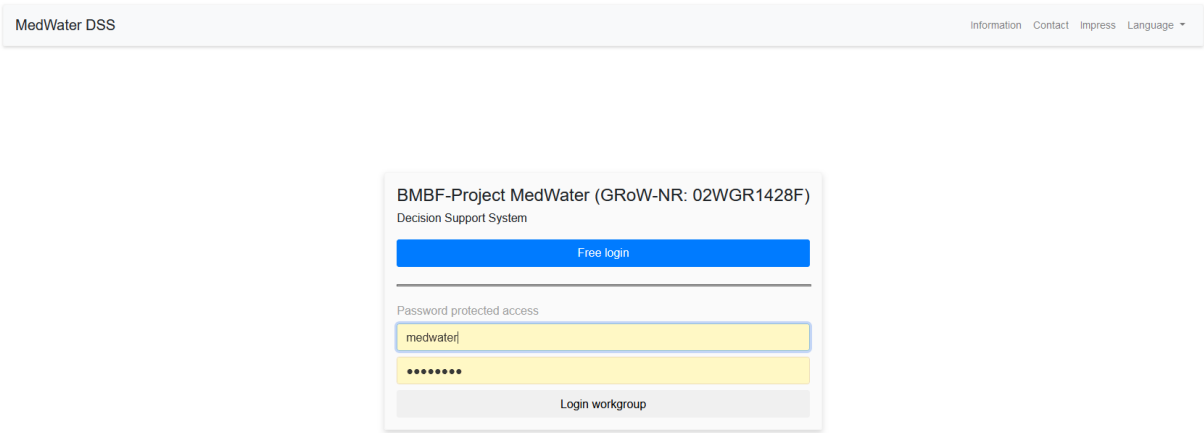

Figure 1. Home page of the MedWaterDSS web application

After activating the login, the tool "Base data" (Figure 2) opens by default.

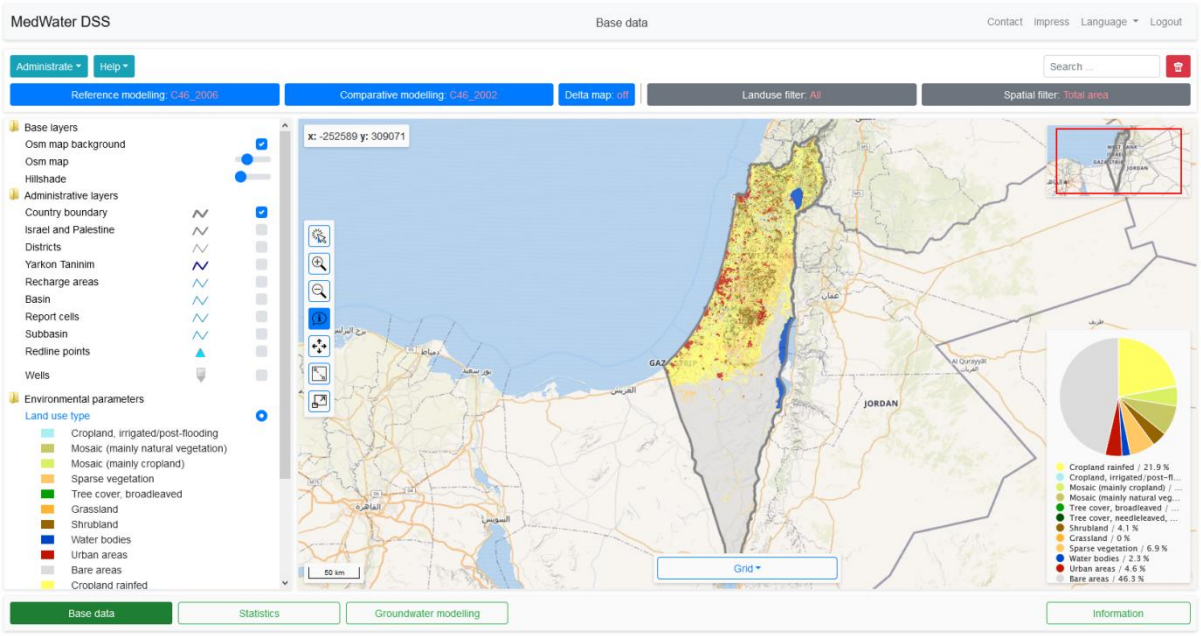

Figure 2. Tool „Base data“

The session can be ended via the "Aministrate" select menu (top left). Alternatively, this is also possible via the "Logout" button on the right-hand side (top). Basically, each session should be ended via one of the two available options. It is also possible to export the data shown in the map image in Shape (polygon geometries) or HDF5 (raster) format here ("Export data" button of the"Administrate" menu). In addition, a readme file is output.

To the right of the "Administrate" menu is the "Help" select menu. Here, contact information or user documentation (MedWaterDSS Handbook) in pdf format can be called up.

Using the Select menu bar above the map, a reference modeling of MODFLOW, related to a year to be defined, can be selected in the left button. To the right, a comparative modeling can be selected. By clicking the "Delta map" button, a difference map for the parameter selected in the layer tree is created from both model runs (Delta map on). The corresponding parameter data set of the "Comparative modelling" is subtracted from the selected parameter data set of the "Reference modelling". Only identical parameters can be set in difference to each other. No difference map can be created in the system from different parameters (e.g. "Precipitation" with "Evaporation"). The selection of "Comparative modelling" only has an effect if the selection "Delta map" is set to "on".

The "Landuse filter" can be used to select the raster-related data in the map image for specific land uses to be selected (Figure 3).

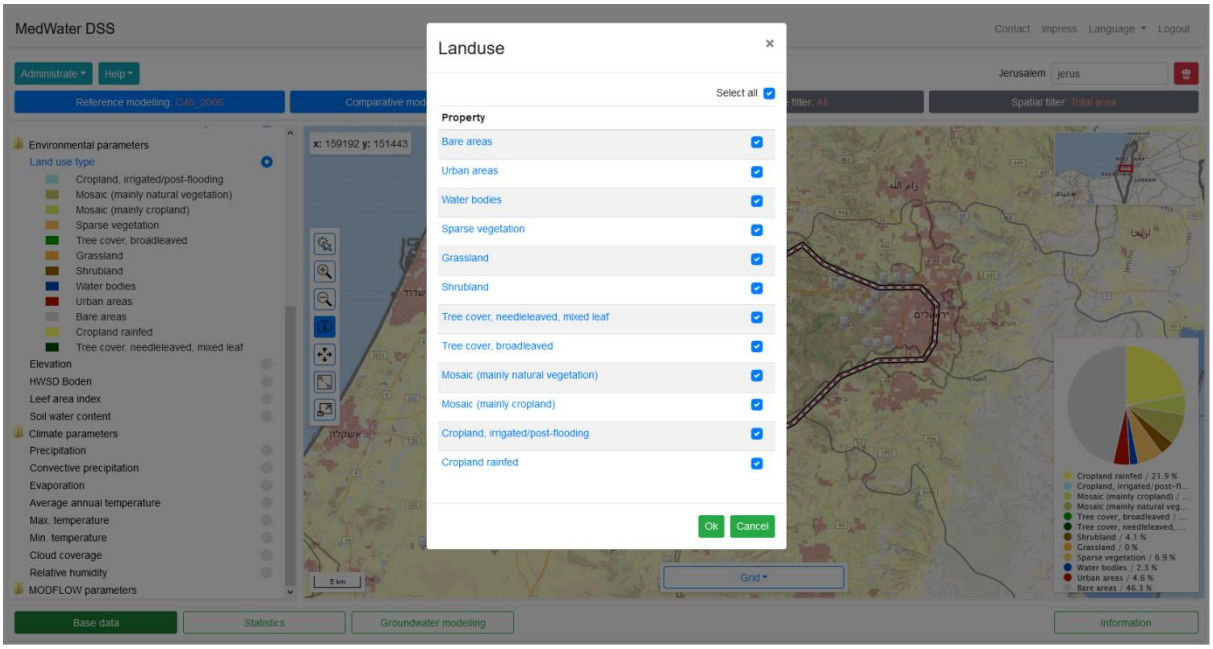

Figure 3. Tool „Base data“ – Use of „Land use filter“

Another selection option is possible via "Spatial filter". Here, a spatial level can first be selected (e.g. the category "Recharge areas") and then, after clicking the "Next" button, one or more corresponding spatial elements (e.g. "Yatta") of the selected category (Figure 4).

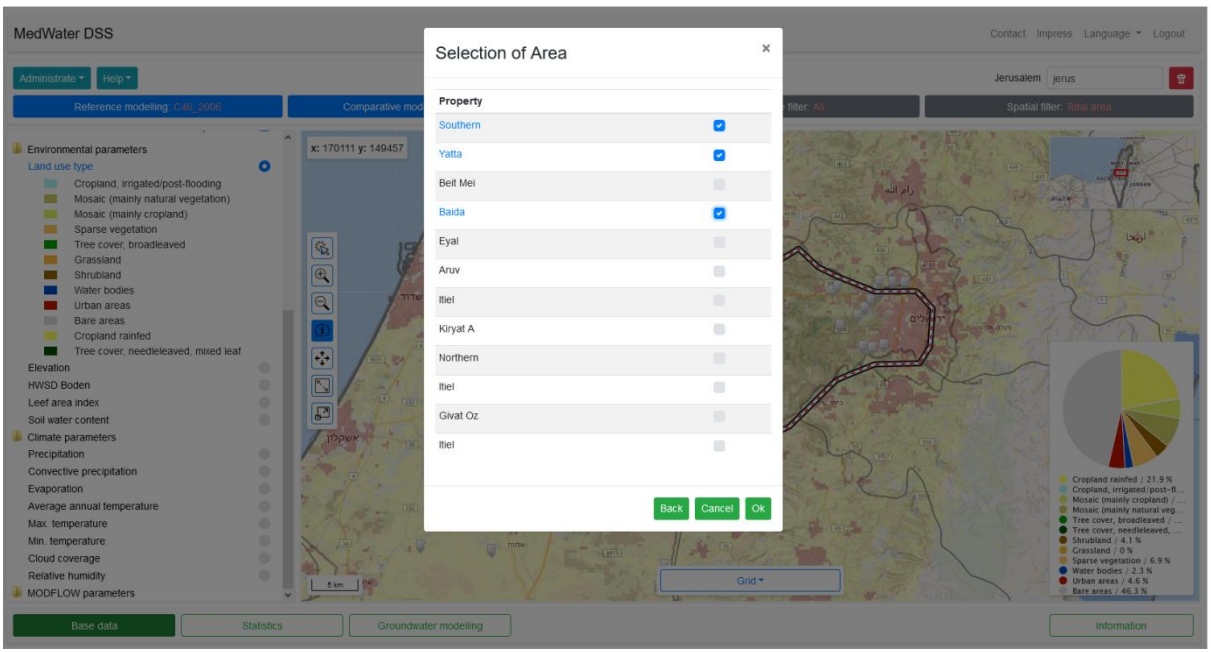

Figure 4. Tool „Base data“ – Use of „Spatial filter“

On the left side of the application is the layer tree. This groups the layers into folders (-) and subfolders (+).

- Base Layers
  + Osm map background
  + Osm map
  + Hillshade
- Administrative layers
  + Country boundary
  + Israel and Palestine
  + Districts
  + Yarkon Taninim
  + Recharge areas
  + Basin
  + Report cells
  + Subbasin
  + Redline points
  + Wells
- Environmental parameters
  + Land use type
  + Elevation
  + HWSD Soil map
  + Leaf area index
- Climate parameters
  + Precipitation
  + Evaporation
  + Average annual temperature
  + Max. temperature
  + Min. temperature
  + Cloud coverage
  + Relative humidity
- MODFLOW parameters
  + Groundwater level upper / lower aquifer
  + Specific storage / yield upper / lower aquifer
  + Recharge upper / lower aquifer

+ confined / unconfined upper / lower aquifer
+ Transmissivity upper / lower aquifer
+ Saturated thickness upper / lower aquifer
+ Conductivity upper / lower aquifer

Multiple selection is possible for the "Base layer" and "Administrative layers" folders. Only one theme can be selected from the remaining three folders, which is then executed in the map content. The two subcategories "Osm map" and "Hillshade" can be dimmed via a slider.

Figure 5 gives an overview of the various features in the "Base data" tool.

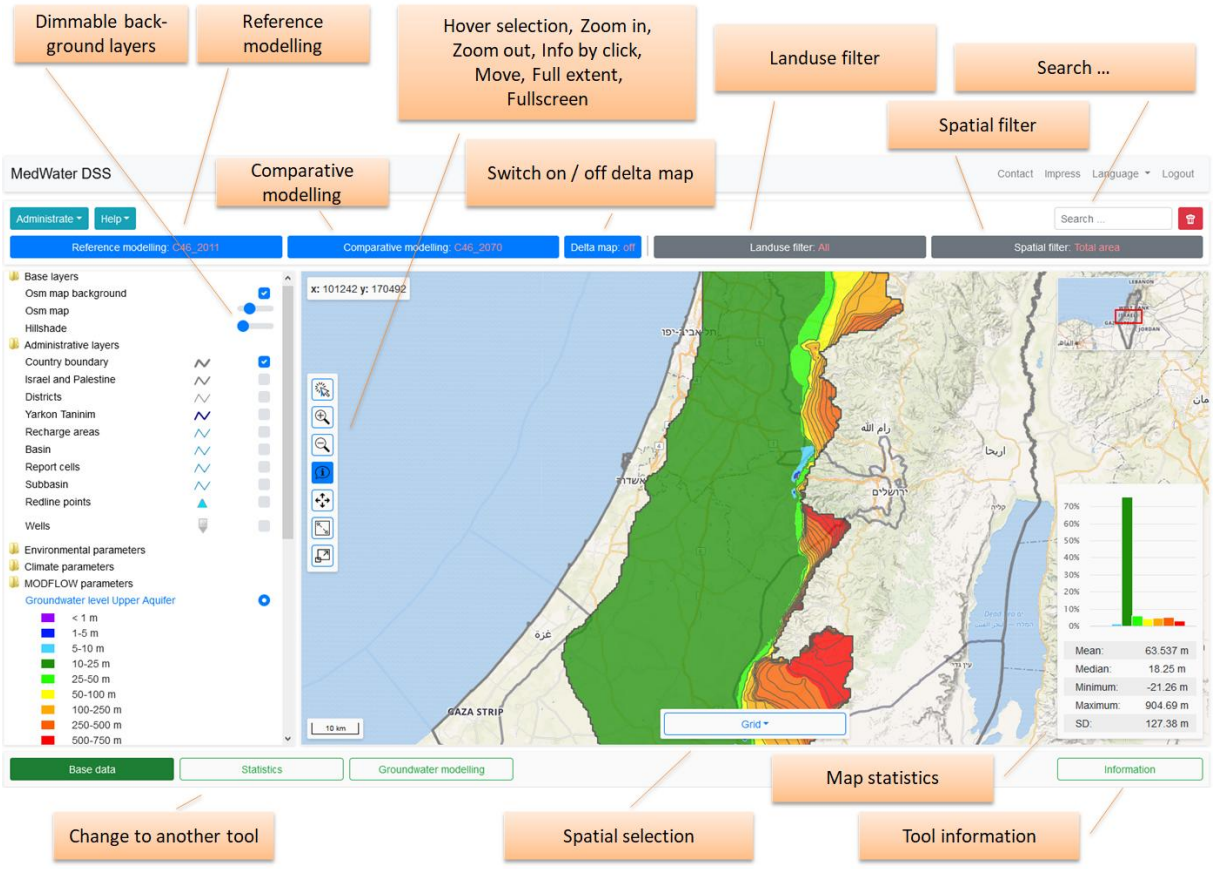

Figure 5. Tool „Base data“ – Important features

Using the i-button, a tabular summary of the MODFLOW parameters can be obtained for each underlying raster cell by mouse click (Figure 6). Using the hover function, the parameter value of the underlying cell can be displayed for the raster layer and the polygon layers, but not the accompanying parameters.

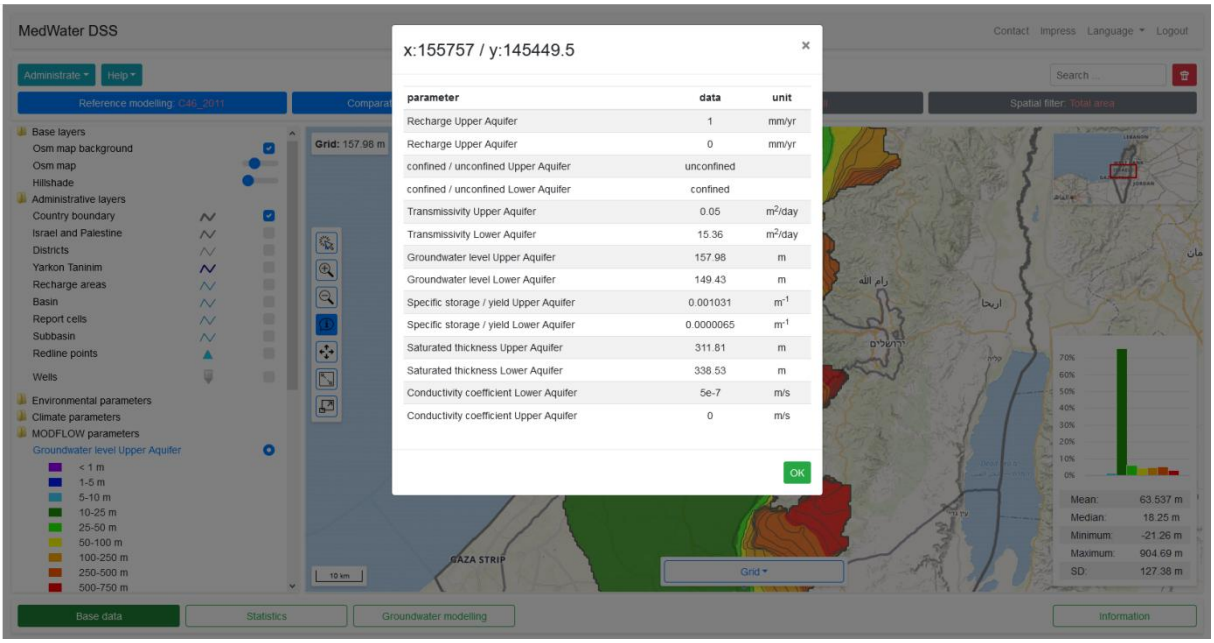

Figure 6. Tool „Base data“ – i-button

In the lower right corner of the application there is a list of area-unweighted statistical values (mean, median, ...) for the displayed map image. Above this is a diagram showing the distribution of the occurrence of the legend classes. It should be noted that no spatial distribution is shown here, but rather a grouping of the individual values present in the layer (no area weighting).

The map shows natural parameters from the category "Environmental parameters" such as soil type, slope, etc.. Furthermore, selected climate parameters ("Climate parameters") and the MODFLOW parameters) can be called up. Objects of spatial units can be found via a spatial search. A mouse click on the map provides information on the selected parameter and the accompanying parameters of the same section.

On the left edge of the map there is a toolbar with "hover selection", "zoom in", "zoom out" of the map, "I-button", "move", "full extension" and "full screen".

The user receives brief information on the "Base data" tool by clicking on the "Information" button at the bottom right of the screen.

Switching to the "Statistics" tool is done by clicking on the corresponding "Statistics" button at the bottom left of the screen. Figure 7 shows the basic structure of the interface that opens after a mouse click.

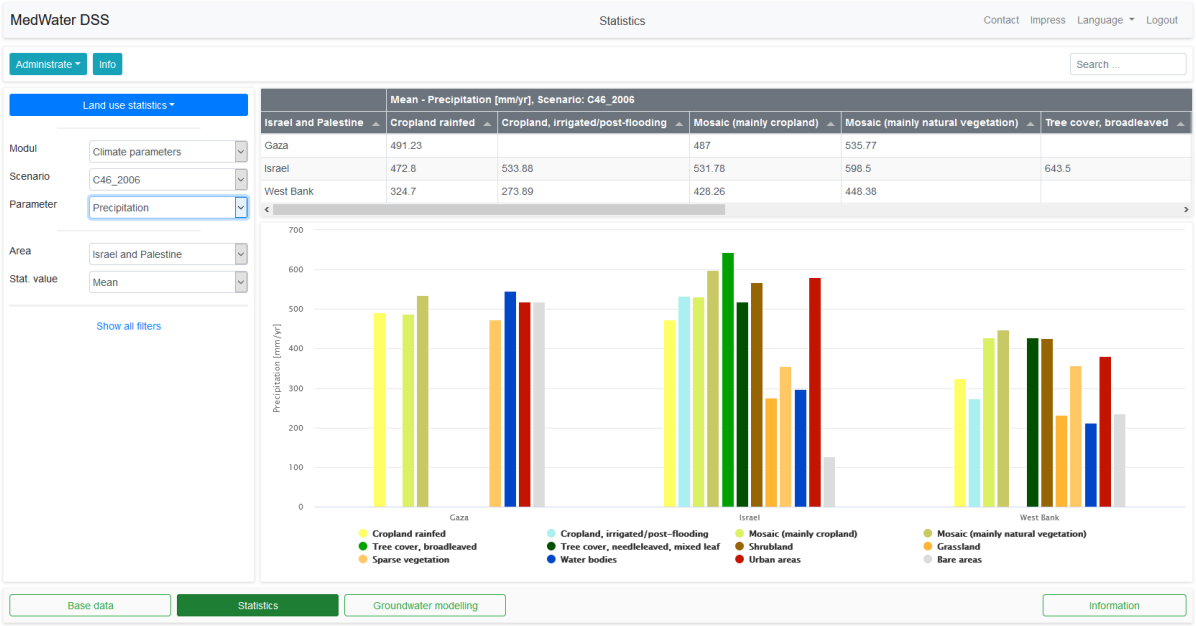

Figure 7. Tool „Statistics" – overview

The results from the tabular overview can be downloaded as a CSV or XLSX file via the "Administrate" select menu (top left).

To the right of the "Administrate" menu is the "Help" select menu. Here you can choose between contact information or user documentation in PDF format.

At the top right there is a free-text search in which the spatial units contained in the table query can be selected further. The table then only shows the selected units.

The select menu bar located under "Administrate" contains the selection fields

- „Land use statistics" (Evaluation by land use type for the regions of a spatial unit for one parameter),
- „Parameter statistics" (Parallel evaluation for the regions of a spatial unit for several parameters),
- „Scenario statistics" (Parallel evaluation for the regions of a spatial unit for several scenarios and one parameters),
- „Area statistics"(Evaluation of the percentage distribution and the area shares of the land use types for the regions of a spatial unit),
- „Redline statistics"(Comparison of groundwater levels with defined red lines).

In the selection field "Module" you can choose between

- „Climate parameters“,
- „Environmental parameters“ and
- „MODFLOW parameters“.

In the "Scenario" selection field, you can specify which model run (year) is to be considered.

In the selection field "Parameter", the available parameters (see tool "Base data") are available for selection depending on the selected module.

In the "Area" selection field, one of the available spatial units can be selected.

In the selection field "Stat. Value" you can determine which statistical value (Mean, Median, Maximum, Minimum, Standard deviation (SD), Total (Sum)) is to be queried.

In addition, the selection can be further limited by restricting the land use (filter "Land use") or the spatial unit and the region (filter "Region").

The results of the selection are shown in the central table field and at the same time in the diagram field below and can be exported as a table (see above).

Brief information on the "Statistcs" tool is available via the "Information" button at the bottom right.

Switching to the "Groundwater modelling" tool is done by clicking on the corresponding "Groundwater modelling" button at the bottom left of the screen. Figure 8 shows the structure of the user administration that opens after the mouse click.

The user can create a new project by clicking the blue button "Add new project". First, a dialogue window opens in which a name and a description for the new project are to be entered (Figure 9).

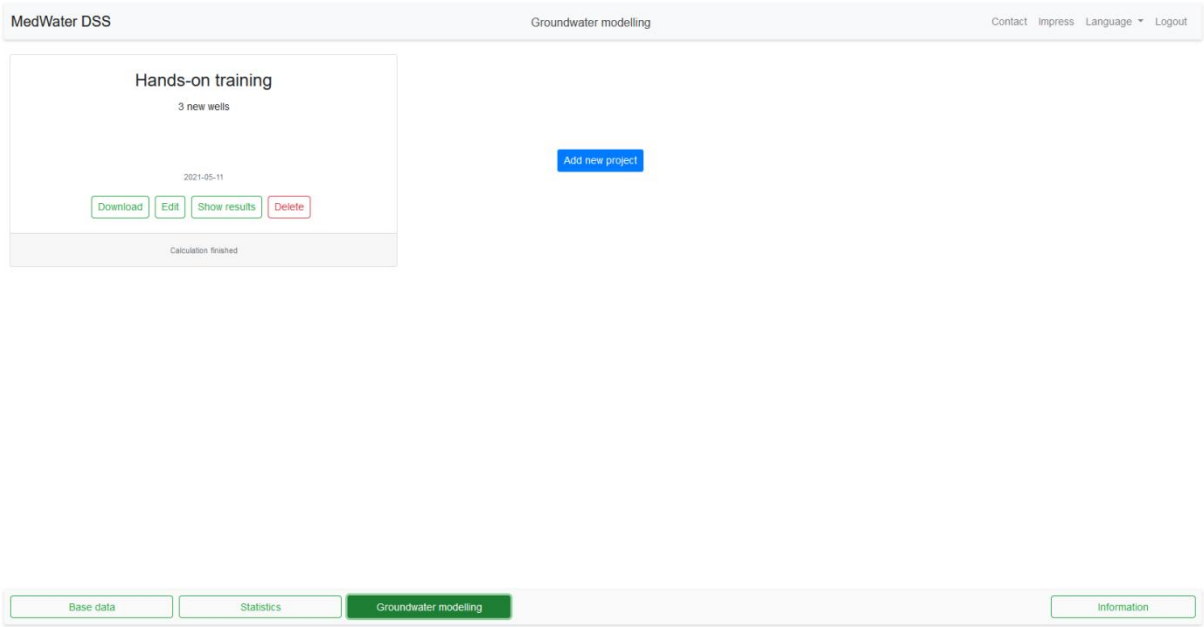

Figure 8. Tool „Groundwater modeling" – user administration

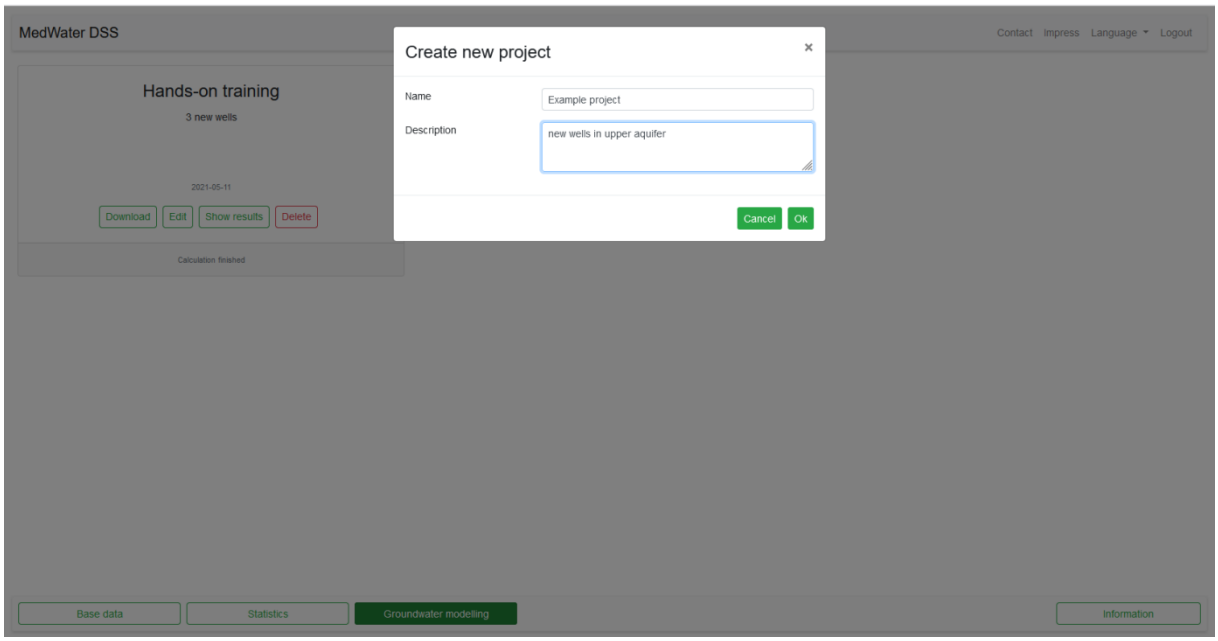

Abbildung 9. Creating a new project in the user administration

Figure 10 shows the user administration interface after creating the new project "Example project".

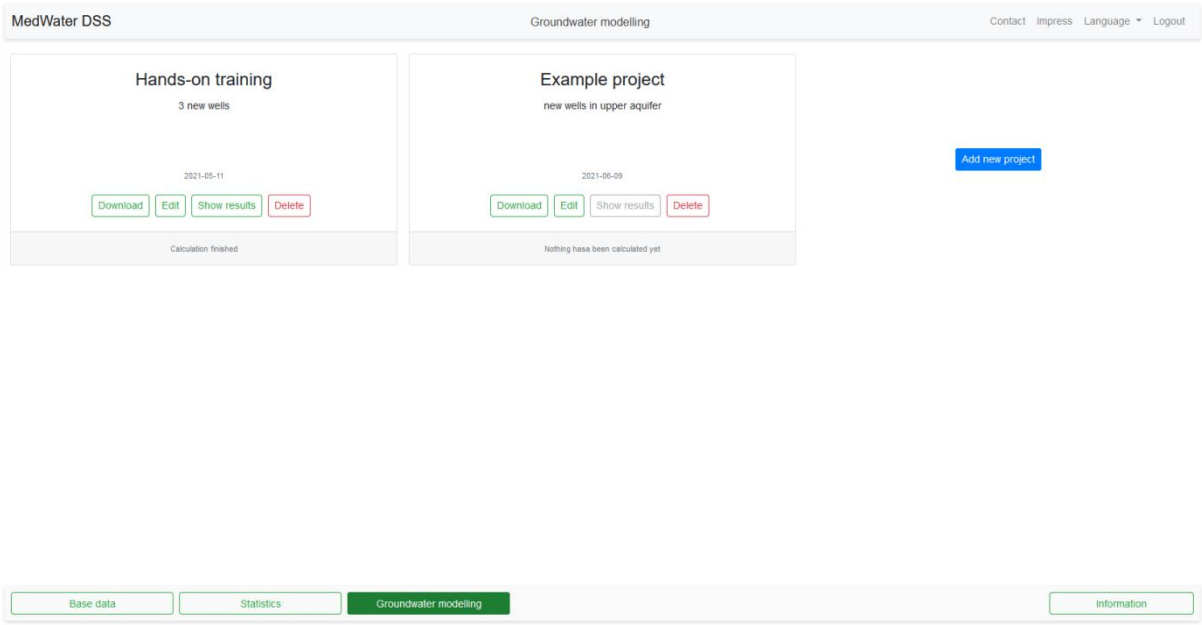

Figure 10. Updated user administration after creation of the new project „Example project“

The user can now switch to the editing mode via the "Edit" button. In the right part of the new page (Figure 11), the project name appears at the top and the selected or preset base model of MODFLOW below it. To the right, you can set the "Start time" and the "Result time" for the live processing to be carried out. The result output in the subsequent steps always refers to the "Result time". Below this is a list of the wells already present and included in the MODFLOW modelling with their names and the "Filter location" (upper or lower aquifer). The zoom button locates the well in the map window on the right. The "Edit/Show" button can be used to call up the pumping rates set for an existing well.

In the right-hand window of the project page (Figure 11), a map of the transmissivity of the upper aquifer appears by default when called up, or after clicking on the lower aquifer. In addition, the existing wells and any newly created wells are shown.

New wells are set via the "Add new well" button to the left of the map window by subsequently clicking on a desired well location in the map window (Figure 12). The pumping rates can be set manually for each year of the project period by dragging with the mouse or alternatively by switching to the table view (mouse click on "Table") in the table that opens.

After pressing "Ok", the project window opens again with the newly created well in the well list and highlighted in green in the map view. The well can be deleted manually or deactivated for subsequent calculations.

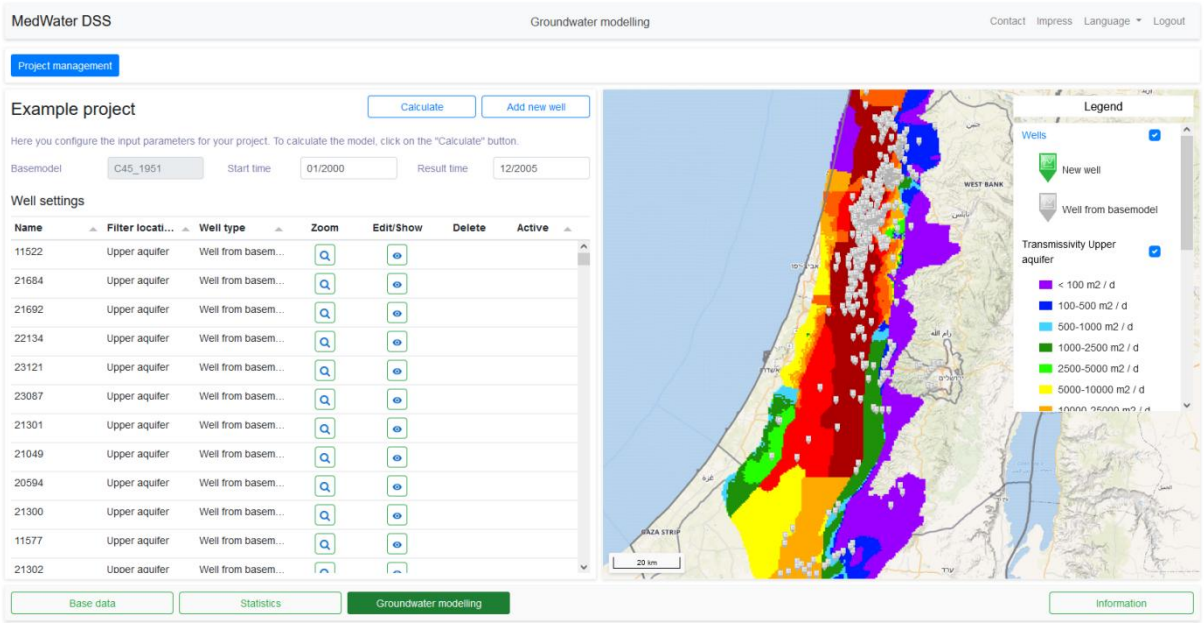

Figure 11. Project page for editing and resetting wells

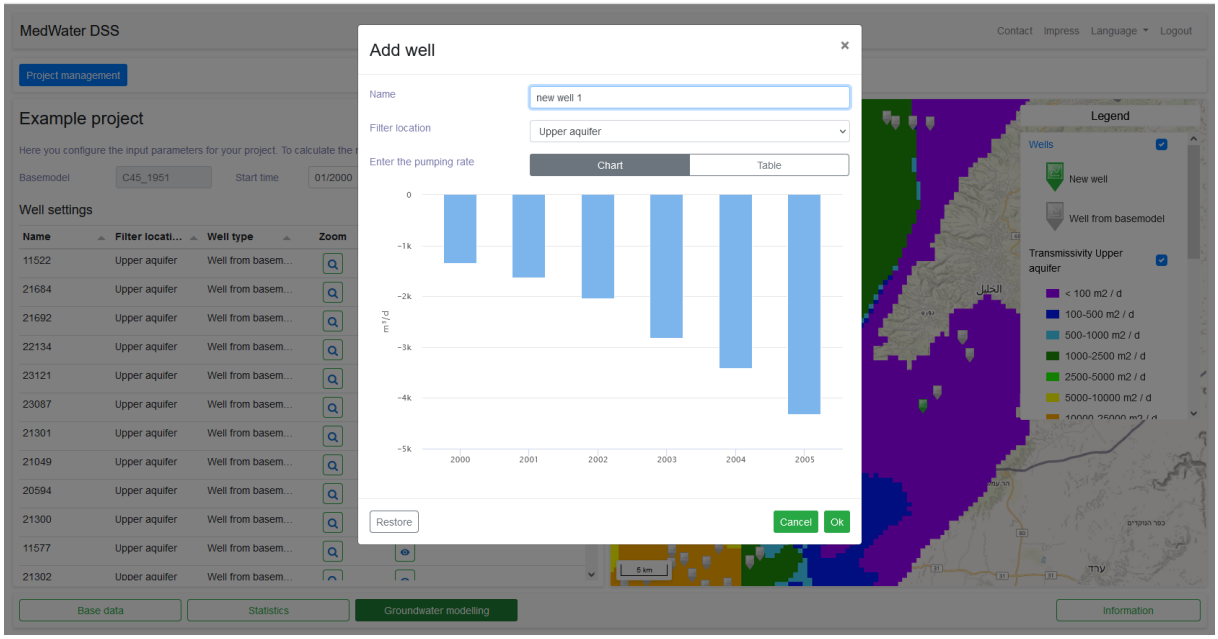

Figure 12. Dialogue box for creating a new well and setting the pumping rates in the project period

The recalculation of the groundwater surface of the MODFLOW model run by the Theis function in the context of live processing is triggered via the "Calculate" button. First, the user is transferred back to the project administration, where the calculation is processed in the selected project and its status is documented (Figure 13).

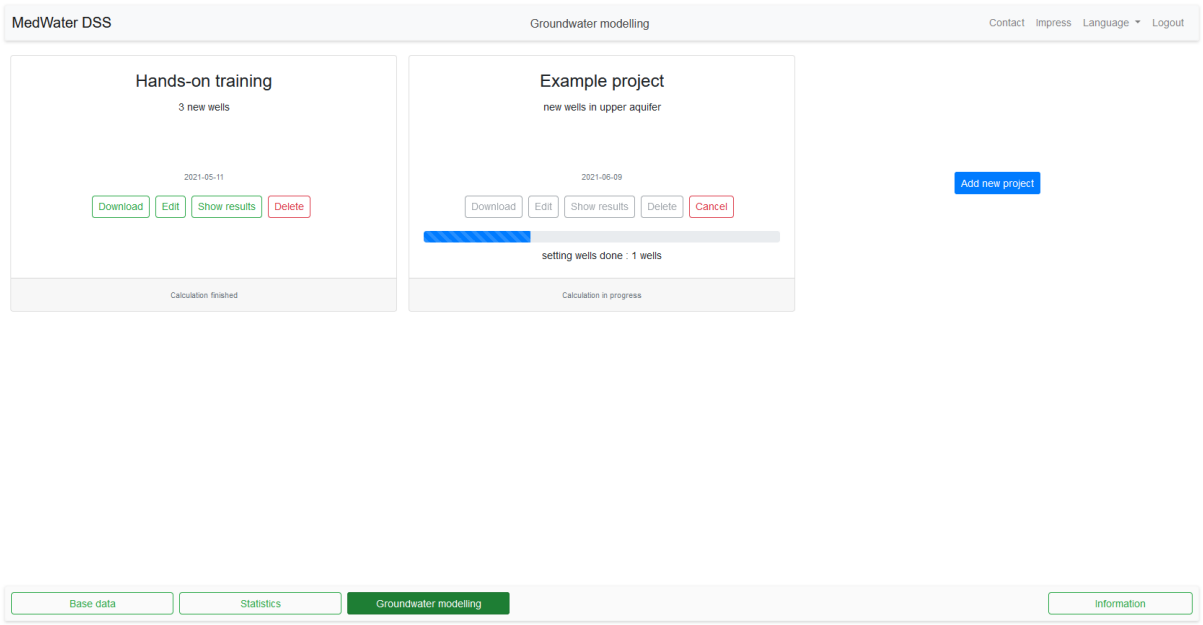

Figure 13. Carrying out live processing on the project management page

After finalising the calculation, the results can be called up via the "Show results" button. The project page opens with the results (Figure 14 to 16) for the "Upper aquifer" or the "Lower aquifer", depending on where a new well is filtered. As already described in the "Base data" module, the "Base layers", "Administrative layers" and "Environmental parameters" are shown, if available for the project period. In addition, the MODFLOW parameters at result time (without live processing) are shown.

+ Groundwater level Upper / Lower Aquifer
+ Specific storage / yield Upper / Lower Aquifer
+ Transmissivity Upper / Lower Aquifer
+ Saturated thickness Upper / Lower Aquifer
+ Conductivity coefficient Upper / Lower Aquifer

and the “Model data at result time” (after live processing has been set up)

+ THEIS Groundwater level Upper / Lower Aquifer (based on MODFLOW results)
+ THEIS Drawdown Upper / Lower Aquifer (without integration of MODFLOW results).

Figure 14. Project page with result display of the MODFLOW model runs at "result time" without applied live processing

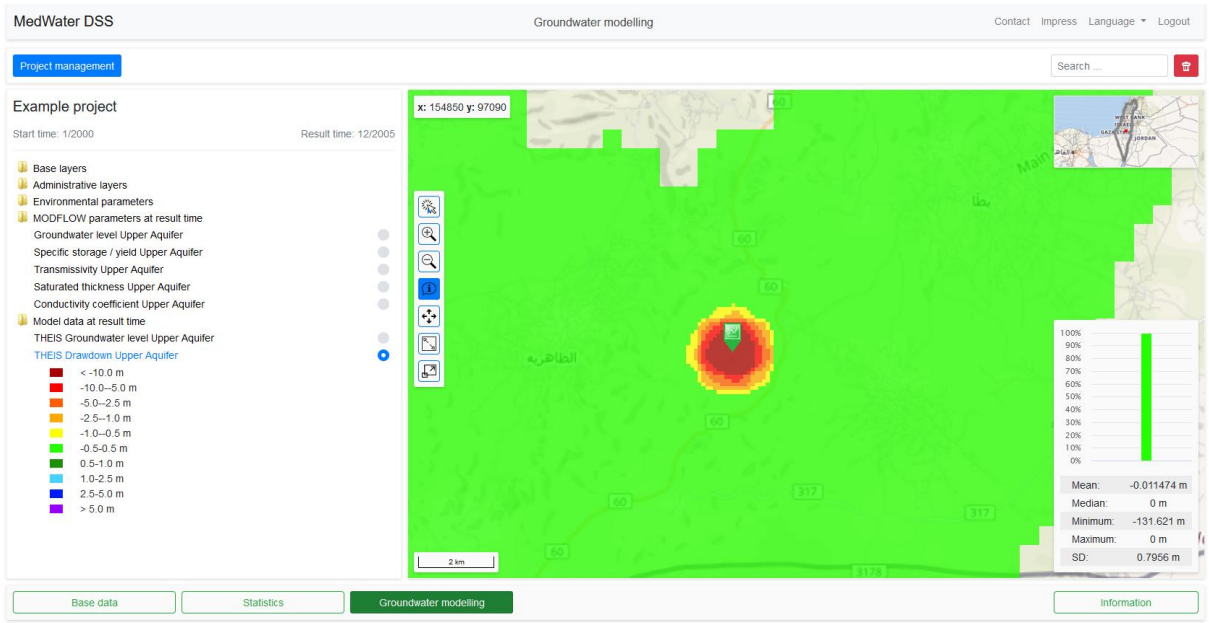

Figure 15. Project page with result presentation of the well lowering as part of the Theis function for the newly constructed well

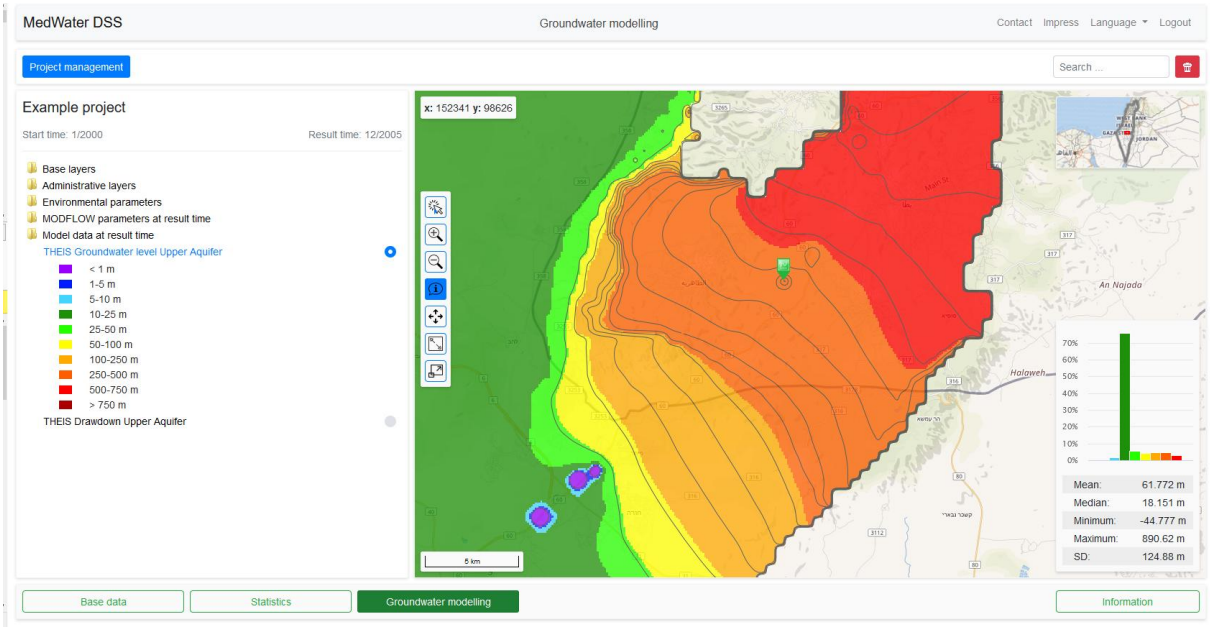

Figure 16. Project page with result display of the MODFLOW model runs at "result time" with live processing set up via the Theis function in the area of the newly created well

For each grid cell, the results can be retrieved as a table by mouse click (Figure 17).

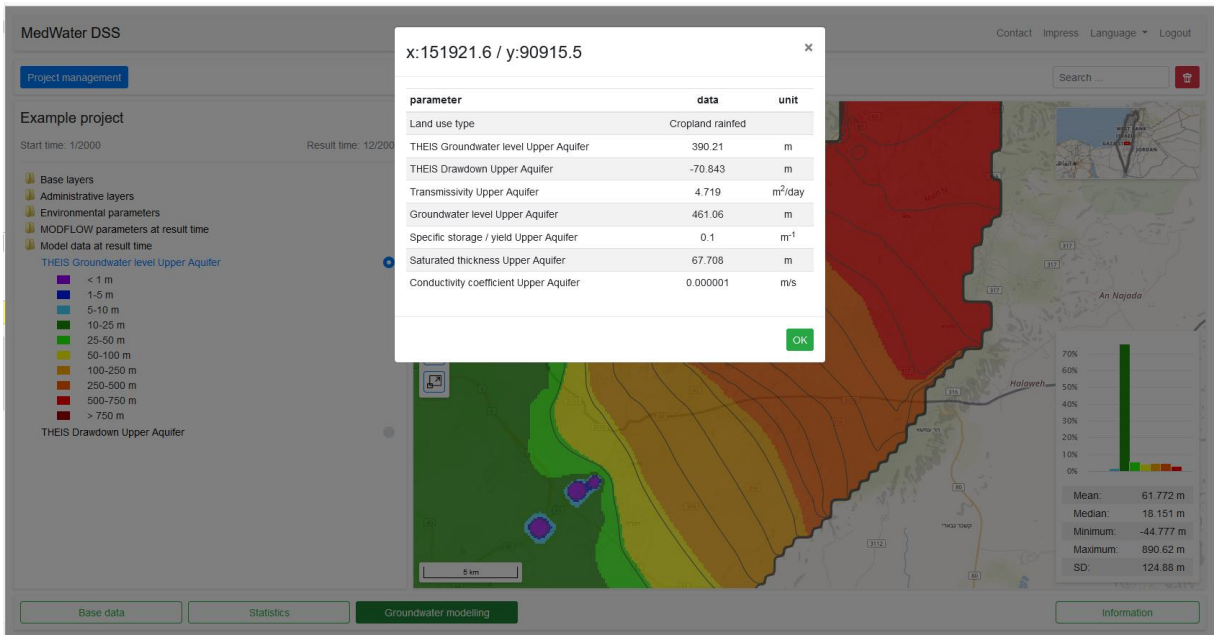

Figure 17. Retrieval of grid-related information on the model results

A download of the raster-based results of the groundwater surface calculated from the MODFLOW model runs and the applied live processing is possible via the switch back to project management by

activating the download button in the project. The user then receives a ZIP-FILE of the HDF5 raster data, which can be read and processed in other environments and management systems, including a readme file.

Information on the "Groundwater modelling" module can also be accessed via the "Information" button on the bottom right of the page.

The application should always be closed via the logout menu (top right).