Concept of a web-based Decision Support System and live-processing tool

Key findings

- The Decision Support System enables stakeholders to make efficient use of limited groundwater resources in the Western Mountain Aquifer.
- The tool illustrates climate and land use changes in the form of interactive maps.
- The results from a numerical MODFLOW model are analyzed and visualized in a graphical user interface (GUI) and post-processed in a live routine for dynamic queries and responses.
- Data storage and processing is mainly based on raster formats (netCDF, hdf5, vrt) to ensure high-performance computing.

Motivation

For the implementation of a sustainable water resources management, web-based information systems are used as an interface between science and practice. Groundwater resources in Mediterranean carbonate aquifers are limited and might decrease in the future due to the effects of climate change. Tools and user interfaces are necessary that enable both professionals and technical authorities, as well as direct users of water resources, to make the most efficient use of these limited groundwater resources. Therefore, there is a high demand for user-friendly, applied, and interactive Decision Support Systems (DSS) that illustrate process dependencies and predicted system states, and allow the user to generate dynamic queries and corresponding system responses. To fulfill these requirements for the Western Mountain Aquifer in Israel and the West Bank, a web-based DSS is needed that combines results from numerical modeling with a live-processing tool. It is based on an analytical approach that can be effectively used by stakeholders to test-run their own individual scenarios and develop proposals for solutions.

Methodology

The DSS was developed and continuously adjusted based on close cooperation with the Hydrological Service of Israel (HSI). It consists of three interlinked components: an import routine to convert numerical modeling results into the DSS data environment, a control environment to change the configuration of a selected model and perform live-processing, and a graphical user interface (GUI) to visualize the results (Figure 1). Thematically, the DSS is divided into the modules „Base data“, “Statistics”, and „Groundwater modelling“. The „Base data“ module helps with a deeper understanding of regional runoff and groundwater recharge. The underlying numerical

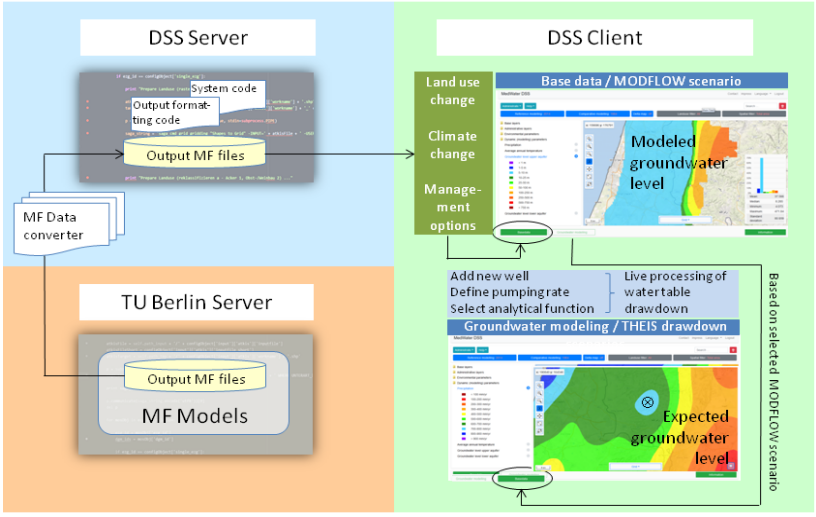

Figure 1: Conceptual design and workflow of the web-based Decision Support System

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MedWater

MODFLOW model developed at the TU Berlin considers aspects of land use, climate, and management change from 1951 to 2070. All data were transferred into the DSS and can be visualized (GUI) and evaluated ("Statistics" module). In the "Groundwater" module, the user can apply existing models and actively adapt selected elements (set new wells, change pumping rates) to generate dynamic queries and corresponding system responses. For this purpose, a user administration was established.

Results

The entire process chain „Configuration - Control - Visualization" is mapped based on groundwater recharge. The user can apply an existing model and actively adapt (configure) selected elements (e.g., setting new wells with infiltration or abstraction rates). After appropriate configuration and subsequent post-processing, the recalculation of depression funnels and groundwater hydrographs is done by applying the analytical THEIS well function (Figure 2). Thus, regional, grid-related statements about changing groundwater levels can be made in a temporally and spatially differentiated manner within the framework of a live-processing routine. Technical adaptations by the HSI as well as data exchange are no longer necessary. A delay in obtaining the results caused by long computing times is also eliminated. This increases the suitability of the system for groundwater management in the sense of decision support. Access to the DSS and its graphical user interface is designed in a way that even stakeholders who were not actively involved in the MedWater project can use it effectively and perform their own scenarios analyses. For data processing, fast formats (hdf5, NetCDF) and effective raster data processing is used. The web-based DSS has a responsive design, so that it can also be used on mobile devices.

Application

The innovative and exploitative potential of the developed DSS can be seen in the coupling of numerical modeling with user-friendly, analytical live-processing tools. However, it must be pointed out that the results do not have the depth of a complete numerical model. The DSS can be used directly by the Israeli partners or easily be transferred to an Israeli web server and then used in conjunction with the HSI's own models. The HSI has already expressed interest in the possibility of integrating saltwater intrusion into the MODFLOW model and thus the DSS. Adjustments and extensions of the system as well as transfer to other regions are easily possible if required data are available.

Open-source tools & data

Open-source tools (e.g., Mapserver, Mapproxy, GDAL, Python, NumPy) are used to minimize investments and maintenance costs for stakeholders working with the DSS. A web server with configured geosoftware and backup system is used as a technological basis. The development of the graphical user interface (GUI) is browser-based. For this, the frameworks of Bootstrap, jQuery, and OpenLayers are used. Data storage and processing is mainly based on raster formats (netCDF, hdf5, virtual raster technology) to ensure high-performance computing.

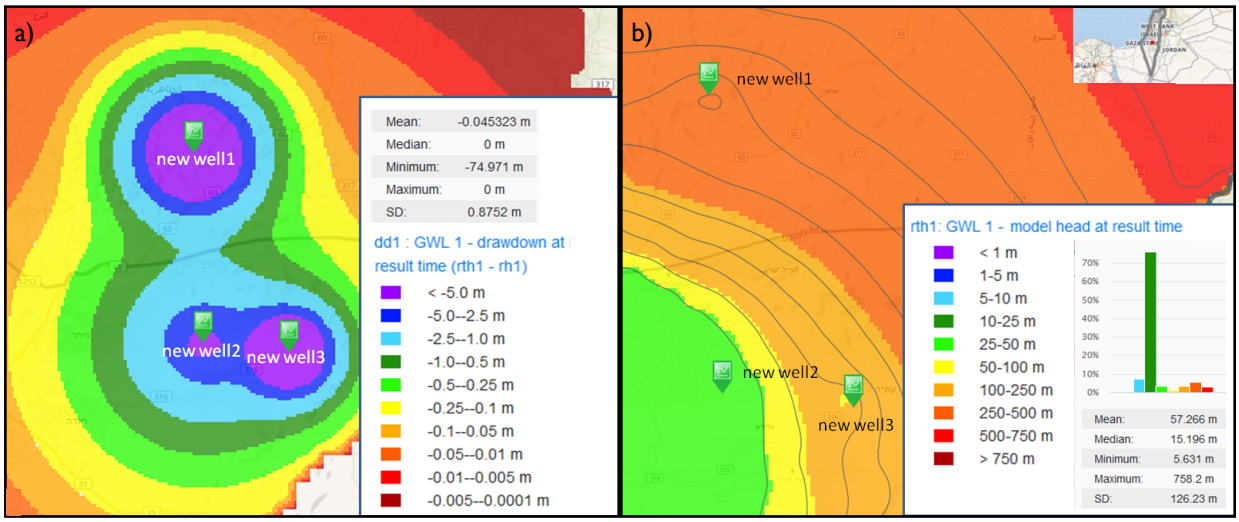

Figure 2: a) Recalculated drawdown by the THEIS well function and b) groundwater level simulated by the MODFLOW model combined with the analytical calculation.

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