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GROUNWATER MANAGEMENT AND CLIMATE CHANGE

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Abstract

The aim of this research project was to clarify to what extent a sustainable groundwater management is affected by climate change and in how far adaptation strategies have to be developed for the compensation of climate effects. This problem has been processed exemplarily for the area of the 'Hessisches Ried' and the 'Odenwald'. Using regionalised time series data from the IPCC scenario simulation A1B, the changes in the groundwater regime until the year 2100 have been determined. A range of essential topics such as changes in water demand, future serviceable groundwater resources, potential extend of groundwater related conflicts of interest and alternatives to a controlled ground water management for the compensation of climate effects have been examined. As the demand for drinking water basically depends on the demographic development, the demand for make-up water in agriculture will increase considerably due to climate change while the water yield will stay comparatively stable for the northern Oberrheingraben. With dryer summers and more precipitation in the wintertime, the dynamics of groundwater levels will increase as well as the requirements for groundwater management.

1. INTRODUCTION

Climate Change is taking place and it is scientifically beyond dispute that anthropogenic greenhouse-gas emissions are to be held accountable. The future rise in temperature is to be anticipated differently, varying with and depending on the underlying future-scenario considered. It is clear however that an adaptation is required to the inevitable outcome that climate change implicates. To what extend this applies to groundwater-management was subject to a research project within the area of south Hesse. The project was financed by the funding program "klimazwei - research for climate protection and protection from climate impacts" of the German Federal Ministry for Education and Research (BMBF).

2. INVESTIGATION AREA AND DATA SET

The area of investigation lies south of the City of Frankfurt Main and adjoins to the river Rhein in the west. The research project involves the porous aquifer of the Hessisches Ried and the joint aquifer of the Odenwald. All statements in the following discussion are limited to the area of the Hessisches Ried.

The data set used in this investigation was derived from the global climate model ECHAM 5 in conjunction with the scenario simulations by the IPCC. For the scenario simulation A1B regional models based on statistical methods like the WETTREG-2006- (CEC Potsdam) and STAR 2- (PIK) data sets have been drawn upon as well as the dynamic climate model CLM. For the CLM data set the precipitation has been subjected to a bias-correction. The time series used for this investigation covers the years 1961 to 2100.

fig.1: Area of investigation

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3. SOIL MOISTURE SIMULATION AND GROUNDWATER MODELING

In soil moisture simulations on a daily basis the groundwater recharge has been identified as an essential parameter in climate change with a significant impact on groundwater management. For this purpose the soil characteristics have been accounted for in a 250 m square grid with 19 soil profile classes which on their part consist of a total of 31 different soil types. Land use has been derived from the analysis of satellite images and specified differently for 3 characteristic periods (1960-1975, 1976-1990 and 1991-2100). Due to an improved data basis for the last period, 19 categories of land use could be identified compared to 10 categories for the previous periods.

The groundwater modelling has been conducted with a true 3-dimensional finite element model. Fig.2 displays the element mesh of 12 vertical layers, each consisting of about 33.000 nodes and 42.000 elements, their parameterisation reflecting the current knowledge of the geological situation.

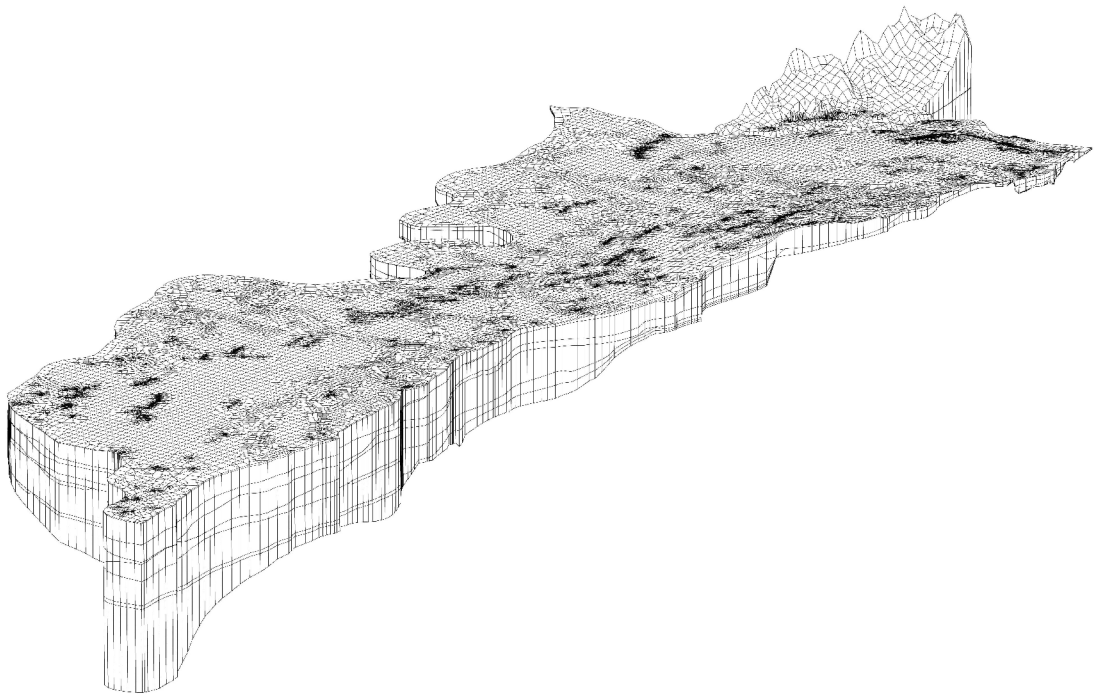

fig.2: Configuration of the employed groundwater model

4. RESULTS

The evaluation of consequences induced by climate change on the groundwater management in the Hessisches Ried showed that

- the regional climate modelling still features considerable deficits with regard to water economy.

Regarding the climatic water balance the WETTREG-data shows a range of variation too low compared to the observation data (1960-2005), whereas the STAR2-datas climate signal appears to be too remotely pronounced and the CLM-data features too low potential evapotranspiration and too high precipitation rates even after the bias-correction.

These differences emerge, though all models are comparable in regards to temperature rise and they all show the same tendency for lower summer rainfall levels and a higher precipitation during the winter. Changes in groundwater levels owing to climate change in the area of investigation are therefore afflicted with a great uncertainty.

The demand for agricultural irrigation on the other hand is to rise significantly. Fig.3 shows the development of the demand for agricultural irrigation, that has been calculated directly and culture-specifically at run time during the soil moisture simulation. The required amount for irrigation will almost double due to dry and hot summers. The study of climate impacts on the investigation area has been carried out with complex methods under the current state of knowledge. It became evident that this approach is capable of quantifying comparatively small changes in both the water balance and the groundwater situation. Even more is this approach

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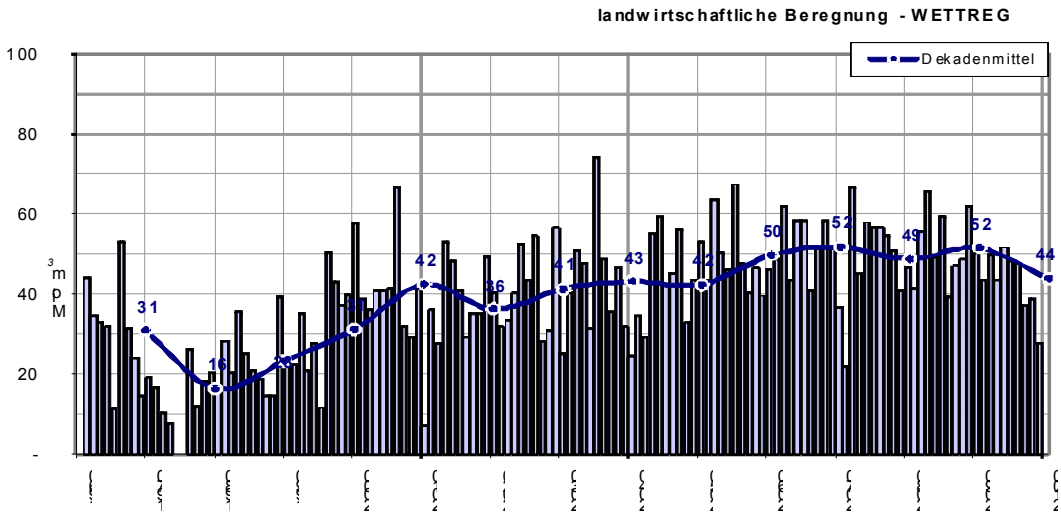

fig.3: Annual agricultural irrigation rates for the investigation area in m.m³ (WETTREG)

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