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INTRODUCTION

The Mancha Oriental System (MOS) (7,260 km^2), is one of the largest aquifer within Spain. MOS is located in the SE of Spain is completely confined within the physical Jucar river basin (Fig. 1). Since the 80's, the exploitation of groundwater resource has become a key driver for the socio-economic development of region. Irrigation agriculture area currently exceeds (1,000 km^2), and groundwater abstraction runs at rate of more than 400 Mm^3/yr (Estrela, 2004), from which 98% is used for irrigation. This figure contrasts with the available groundwater resources estimated in the Jucar Hydrological Plan, which is 320 Mm^3. The quantitative analysis made by Jucar river basin Authority for the MOS clearly indicates that environmental objectives are not currently satisfied and that there is a risk of not reaching good status by 2015 as specified in the Water Framework Directive WFD. The implementation of the WFD requires the application of numerical modelling that can answer questions concerning the complex interactions of surface and ground waters.

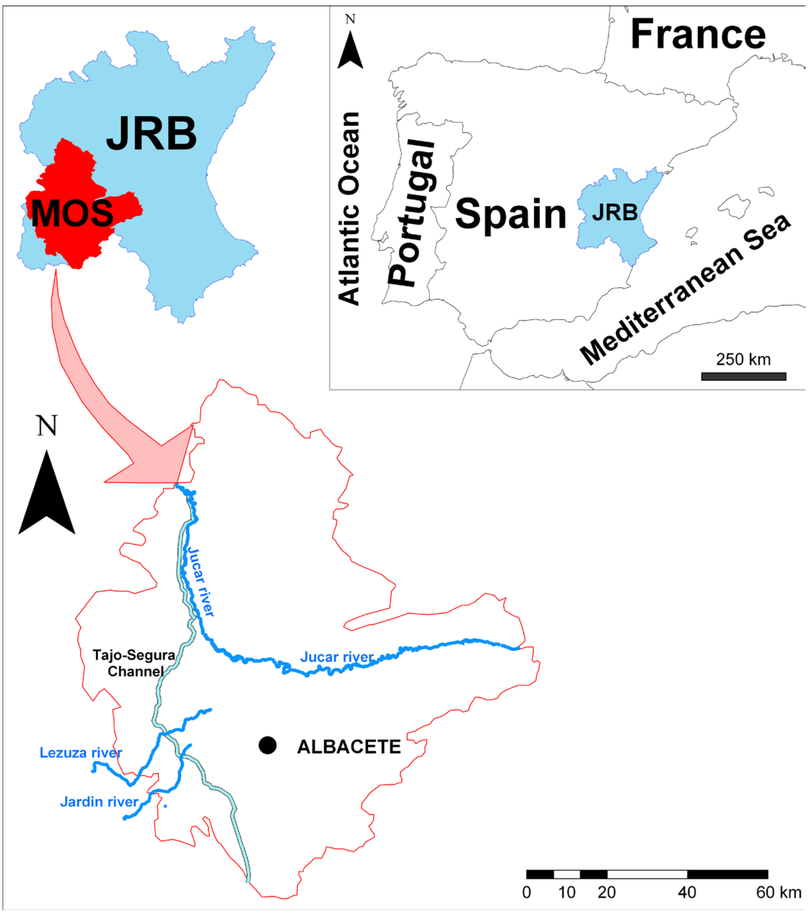

Figure 1. Location of Mancha Oriental System (MOS). Jucar River Basin (JRB).

Aquifer-river interactions can be drawn from different methodologies, however the assessment, quantification and spatial prediction of river-aquifer interactions is usually provided with numerical models that can represent the overall complexity of regional hydrogeological systems (Sophocleous 2002). In this work presents the development of a three-dimensional large-scale numerical groundwater flow model by MODFLOW.

MODEL DEVELOPMENT

The area of study was divided horizontally in three dimensions into square cells of 1 km, lined up in a northerly direction with 126 columns and 131 rows for a total of 16,506 cells per layer. The 3D geometry of the lithostratigraphic layers has also been incorporated, generating a model of six layers with three aquifer units and three semipermeable units. The temporal discretization was defined for a period of 23 years (1982 to 2005), with stress periods taken on a monthly scale. The boundary conditions were defined by making model limits coincide with the physical limits of the system. The Jucar River was represented as a boundary condition with specific potential in terms of limits within the area of study. To hydraulically characterize the hydrogeologic units in the MOS we reviewed data in (Sanz et al. 2009). Recharge values from rainwater infiltration in the MOS which were obtained from JRB water authorities (CHJ). To determine groundwater abstraction for irrigation, we used a multitemporal and multispectral analysis of Landndsat 5-TM and Landsat 7-ETM+ satellite images. Estimating groundwater pumping for urban and industrial uses has been performed by relating the volume of water used in supplying areas in the MOS with population data (see for further details Sanz et al., in press).

Calibration was performed in two phases: steady and transient state. In the steady state, the permeability and storage coefficient were modified to minimize differences between groundwater levels observed and simulated. This calibration yielded initial conditions for simulations in the transient state. Calibration was considered finished and satisfactory when the simulated and observed tendencies of groundwater evolution distributed spatially throughout the aquifer coincided, and when the differential discharges simulated in various reaches of the Jucar River were similar to the discharge values recorded (Fig. 2).

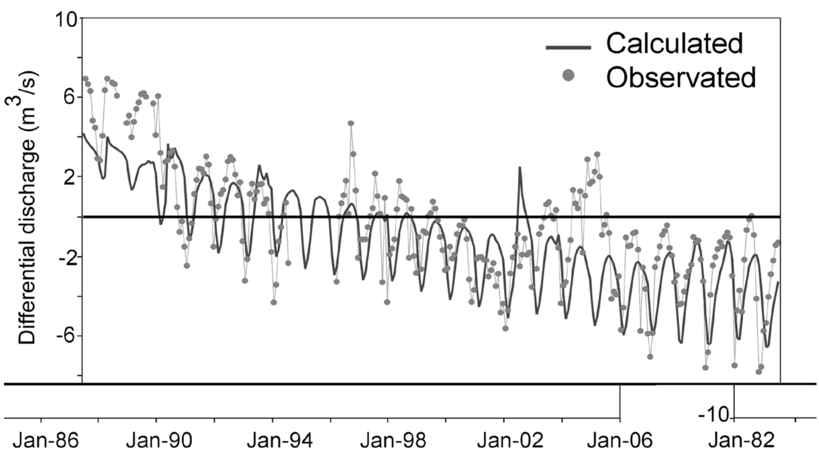

Figure 2. Monthly differential discharge values obtained from gauging stations in middle reach of the Jucar river.

MODEL RESULTS

MOS groundwater flow model was calibrated successfully and it has allowed details on the hydrogeological system and establish both in space and in time the qualitative and quantitative relationship between the river and the aquifer system, with respect to the pumping of groundwater (see Sanz et al., in press). Model results show that although groundwater extractions increase progressively from the '80s, the loss of groundwater storage tends to decrease. This behaviour is related to the system's response to effects from pumping-induced river-aquifer relations. The river-aquifer disconnection point may be affected and drain less aquifer discharge than before pumping initiated. When a river passes from a losing river to gaining there is a disconnection and the disconnection point begins to move downstream (Fig. 3). MOS model groundwater has become a useful tool that allows assessment, quantification and spatial prediction of river-aquifer interactions under influence of groundwater abstractions in MOS.

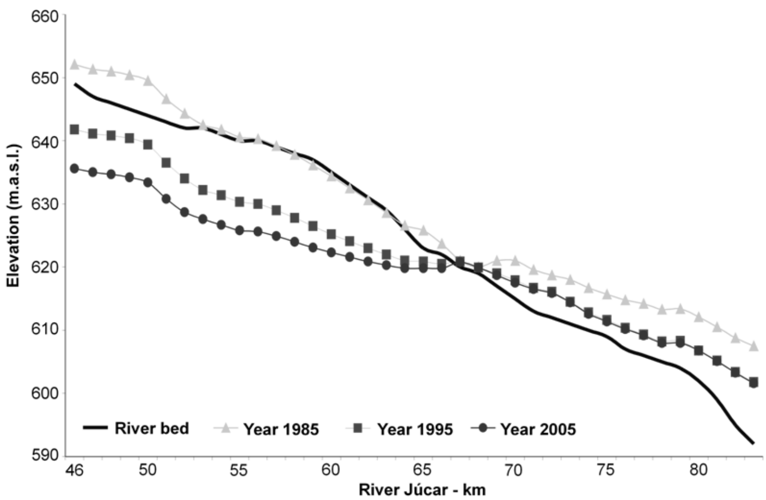

Figure 3. Simulated groundwater table below the river bed 1985, 1995, and 2005 from middle stretch of the Jucar river.

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