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Extended Abstracts

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title: **Estimating agricultural extractions, use of a model for the validation of the hypotesis: Case of the Camp de Tarragona (Catalonia, Spain)**

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INTRODUCTION

The Catalan Agency of Water (the Agency) has full competences concerning the control, management and planning of water resources in approximately the Eastern half of the Catalan territory, in NE Spain. The Agency has commissioned a model of the aquifers defined in the Camp de Tarragona region, at the southern part of Catalonia, mainly for management purposes (Fig. 1).

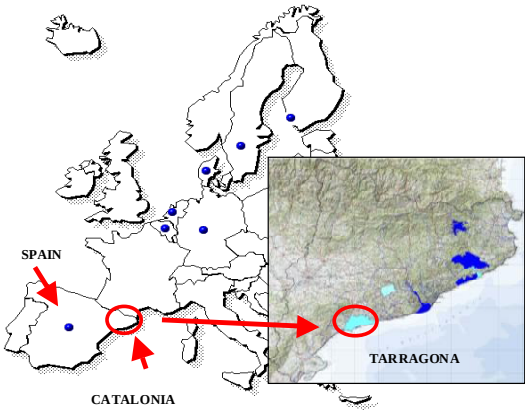

Figure 1. Situation of the Camp de Tarragona aquifers.

The model has been calibrated in flow and transport. It was initially developed with Visual Modflow (VMod) and afterwards with Feeflow due to numerical issues.

The study area is characterized by a very complex geology, which has been simplified in the model. This considers four different layers representing a porous, isotropic and homogeny medium, with a total of 86.921 are active cells, for a transient period comprised between 2000 and 2007, monthly distributed.

Boundary conditions are of three types: no flux, prescribed flux and prescribed head for the contact aquifer-sea (Fig. 2). 132 injection wells were implemented to simulate the prescribed flux. The industry and supply extractions are accounted for by means of 166 real wells with monthly series. Virtual wells were defined to represent the agricultural withdrawal; they were assigned in proportion to the irrigated surface.

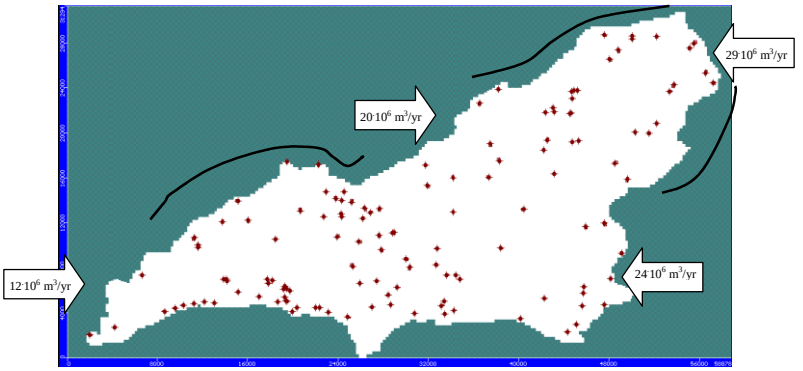

Figure 2. Contour conditions: no flux, in black line, and imposed flux, with arrows (summing up 85·106 m^3/yr). The dots indicate supply and industrial wells.

GROUNDWATER PUMPING FOR IRRIGATION

One of the key issues when building-up a management-oriented groundwater numerical model is how to quantify agricultural extractions, at least in regions where it is the most important activity in the zone, as it occurs in Tarragona (Figure 2: soil uses). This determination is not simple because of the lack of enough gauging devices and a reliable wells' inventory, which demands estimating surfaces and taking into account social, economical and technical aspects.

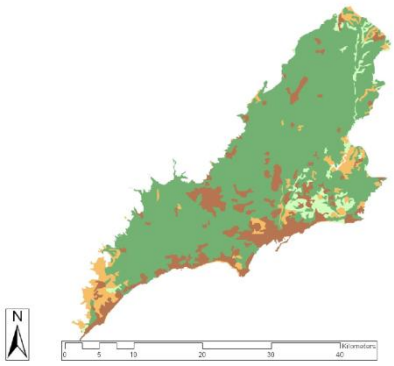

Figure 3. Soil distribution use; in green: agricultural area. (The Agency, 2009).

Pumping for crop irrigation is very important in the *Camp de Tarragona*, and may represent about 80% of total groundwater extraction on a yearly basis. This occurs because the industrial and urban supply are served preferably by surface water coming from the Ebro river transfer in a high percentile (Table 1). There is also another fraction from local surface water reservoirs, but this is a smaller amount as compared with the mains sources of water.

Table 1. Water consumption within the Camp de Tarragona region.

Origin	Irrigation ($\times 10^6$ m^3/yr)	Urban + industry ($\times 10^6$ m^3/yr)
Ebro river transfer	12	60
Groundwater	68	12
Total	80	72

Assessing groundwater withdrawal is therefore essential, and requires defining not only the total yearly amount but also its monthly distribution. Mediterranean climate is so variable that strong differences may arise between consecutive years.

The irrigations needs were estimated with the code GARCO (Agency, 2007), which considers different variables and makes use of real meteorological data, the type of crop and conventional parameters. The figure obtained per hectare and for each kind of crop was implemented in a GIS map. Figure 4 and Table 3 show the results obtained for the irrigation needs of apple trees.

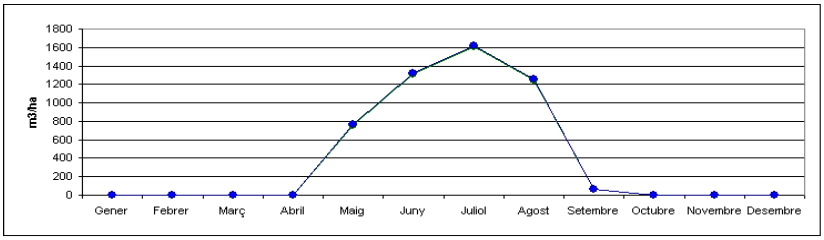

Figure 4. Mensual distribution of the extraction for the apple crop.

Table 3. Irrigation needs for apple-tree crops as obtained with GARCO in the Camp de Tarragona. Irrigation efficiency is assumed at 90%, whilst the effective precipitation is set at 70% of registered rain. The guarantee criterion is that, during 70% of the total period (on a monthly basis), the whole surface can be irrigated.

Meteorological station - MAS BOVE-CONSTANTI	Effective precipitation - 70 %
Guarantee Criteria - 70 %	Apple
Inici: 1-1-93 / Final: 31-12-07	Irrigation efficiency- 90 %

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Averg	70 %
Jan	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0
Feb	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	1	1
Mar	0	1	0	0	0	0	0	12	0	0	0	0	0	0	0	1	1
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	657	844	961	661	920	675	427	725	881	511	514	670	641	1087	1236	761	769
Jun	1453	1529	1223	1354	781	1423	1203	750	1531	1309	1221	1469	1348	1501	1570	1311	1326
Jul	1388	1863	1672	1599	1509	1850	1405	1693	854	1750	1702	1553	1532	1857	1828	1603	1621
Aug	1055	1482	1154	1037	1236	1066	1348	1447	1641	869	1367	1309	885	1438	1310	1243	1257
Sep	56	0	66	72	124	108	1	0	0	55	135	0	0	0	338	64	64
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Des	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4609	5719	5076	4723	4571	5122	4384	4643	4906	4494	4939	5002	4408	5882	6282	4984	5039

However, implementing the irrigation allocations obtained with GARCO for all the agricultural needs (Table 3) in the numerical model (Agency, 2010) did not yield the expected results, because it demanded lower pumping values to reproduce the measured piezometric heads. It became clear that agricultural pumping should be lower than the theoretical needs, which posed the question whether (1) the calculation method was incorrect or (2) it would be necessary to take into account additional assumptions.

As for the first topic, i.e. determining the reliability of the theoretic calculations on irrigation consumption, a comparison with a well-known real case was done: estimating the water needs of a golf playground according to GARCO's results and to pumping data registered in wells for a certain period. Both figures matched very well, thus validating the computations.

This is why the analysis focused on identifying additional factors to amend de estimations. In order to understand the observed disagreements, it was decided to organize a meeting with specialists in local agriculture. The technical staff belonging to the Agricultural Department (DAR) and the Institute of Techno-Alimentary Research (IRTA) was most helpful to clarify the points that affect on the calculation carried out initially.

The point is that farmers in Tarragona irrigate principally with groundwater, coming from deep aquifers (100 to 150 meters deep wells), which implies a cost in their activity, so they take care not to irrigate if it is not indispensable. Farmers do prefer to reduce the crop yield instead of increasing the final cost. The irrigation habits in the area consist of applying low irrigation techniques, such as water stress (which may imply not to irrigate during summer, in July and August) and of course not irrigating all the soil area that is included in the GIS maps.

Therefore, a percentile reduction had to be applied to agricultural extractions, mostly during the summer period, when the water stress approach is adopted. The final allocation of water per hectare was in the end set at 2.000 m^3/yr. This amount matches with the IRTA and DAR estimations. The values before and after considering this are presented in Table 3.

Table 3. Consumption of agriculture, calculated initially and after modifications (finally implemented).

Year	Waste of GW for agriculture ($10^6 m^3$/year)	
	Before modification	After modification (economic and social aspects)
2000	75	63
2001	69	67
2002	64	52
2003	74	62
2004	73	61
2005	70	58
2006	95	83
2007	107	95
Average	78	68

The balance results with this extraction series is shown in the Table 4. With this adjustments the model outcome matches well with the piezometric heads, so it seems that this is a satisfactory solution.

Table 4. Balance on case basis. All numbers in 10^6 m^3/yr.

	Sea inputs	Sea outputs	Lateral inputs	Extraction	Recharge	Variation
2001	0	–24	85	–85	32	8
2002	0	–26	85	–91	23	–9
2003	0	–26	85	–75	3	–13
2004	0	–29	85	–86	45	15
2005	0	–30	85	–85	50	20
2006	0	–31	85	–79	80	55
2007	0	–33	85	–105	31	–22
2008	0	–33	85	–116	29	–35

This solution is not needed everywhere, at least not within the territory of the Catalan inner basin (Eastern half of Catalonia). It depends on the local particularities, i.e. on the economic and social (also historic) aspects related to water management by the final users as concerns groundwater pumping, before implementing the right values in a model.

In parallel, the Agency is making a Water Management Plan of all Catalonia, which requires estimating the consumption of water for each activity. Issues about the reliable extractions arose in a similar way for future scenarios at a regional scale. The same concept has been applied in the Management Plan.

CONCLUSIONS

In short, quantifying groundwater pumping for irrigation purposes is essential to improve water management but it requires both a technical and a socio-economic approach, and dealing with local stakeholders, in order to obtain the expected results. This is a specially critical issue when numerical modelling is involved.

REFERENCES

Catalan Agency of Water, 2007: *GARCO 1.0 Manual d'Usuari* (GARCO 1.0 Users Manual).

Catalan Agency of Water, 2009: *Desenvolupament d'un model numèric per a la simulació de flux subterrani i transport de clorurs al camp de Tarragona (Development of a numerical model for simulate the subterranean flux and clorurs transport in camp of Tarragona).* In Catalan.

Catalan Agency of Water, 2010: *Elaboration of a groundwater flow and transport model to quantify balances and estimate the agricultural extractions in the camp of Tarragona (NE Spain).* CMRW2010 XVIII International Conference on Water Resources.

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