An assessment of the water consumption in Tuscany, Italy: hydrological balance simulations with the MOBIDIC model

Claudia Venturi (1), Lorenzo Campo (1), Francesca Caparrini (2), Fabio Castelli (1)

1. University of Florence, Civil and Environmental Engineering, Florence, Italy (E-mail: lcampo1@dicea.unifi.it), 2. Eumechanos, Florence, Italy (E-mail: f.caparrini@eumechanos.it)

1. Introduction

The knowledge of water withdrawals is a key element for water management and hydrologic balance. Despite the importance of this topic, this kind of information is often inadequate for the purpose of an accurate balance. The aim of this work is the formulation of water consumption scenarios, as maps of water withdrawals from surface water bodies in Tuscany, central Italy. The information collected by different local administrations were processed and used to build a tool for scenarios generation of the water withdrawals, in the framework of **PRESTIGRIS** (PREvisioni Stagionali Idrologiche per la Gestione della Risorsa Idrica e della Siccità - Hydrological seasonal forecasts for water resource and drought management), a project sponsored by Tuscany Region for the seasonal forecast of the drought and water scarcity states.

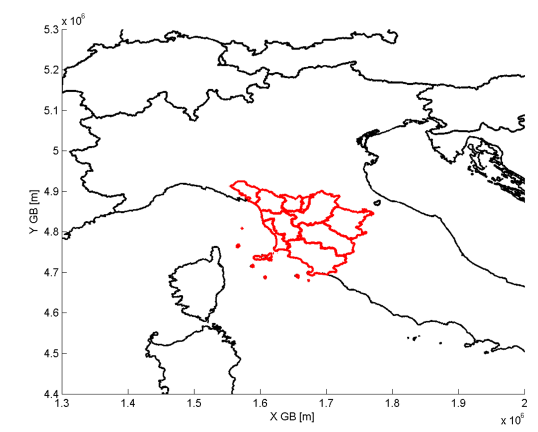

Figure 1. Tuscany, Central Italy.
Administrative divisions: Tuscany is divided into ten provinces.

2. Generation of scenarios

Local administrations databases of water concessions could be an important source of information about water consumption in Tuscany.
Unfortunately available data are often incomplete and fragmentary on large areas. For this reason, the information collected were integrated with synthetic withdrawals generated basing on the observed statistical characteristics (log-normal distribution) and on the percentages of water taken for each use. The aim was to fill gaps in the local administration registrations, obtaining an assessment of the regional water consumption and a map of water withdrawals adequate for the purpose of an accurate water balance.

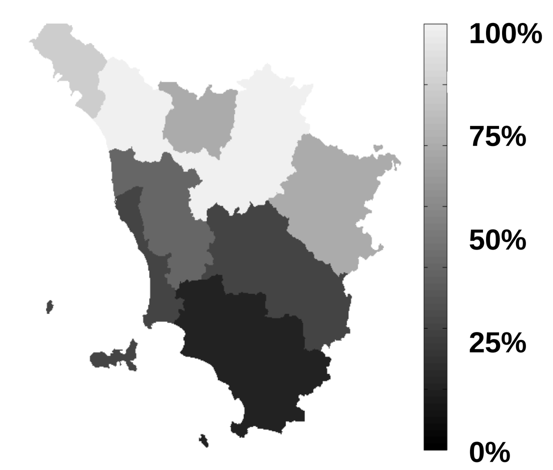

Figure 2. Evalutation of completeness for data collected by local administrations (provinces).

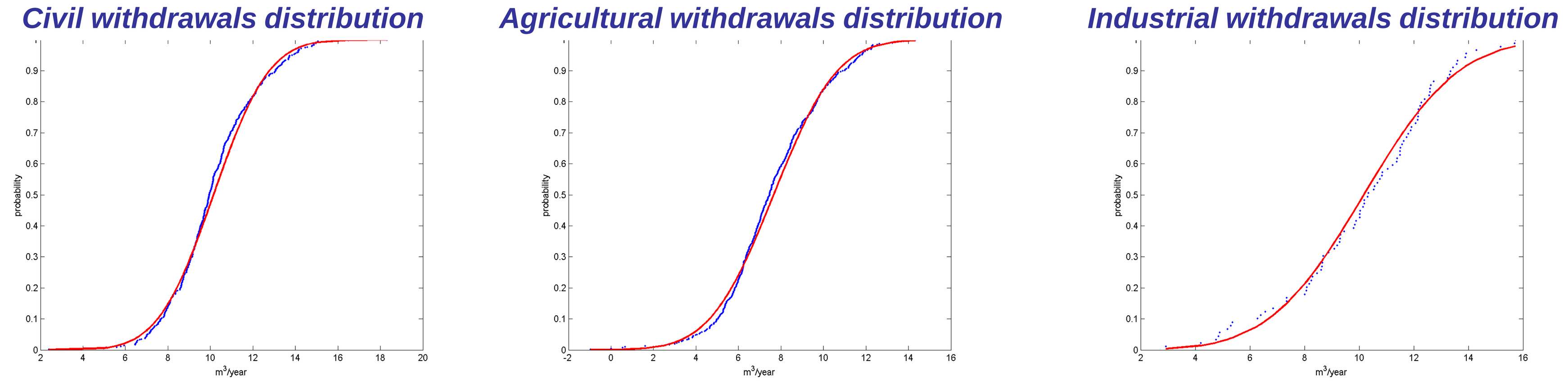

Figure 4. Annual water withdrawals: probability distribution for each use. Data collected from local administration databases on a logarithmic scale (blue) and fitted distributions (log-normal) (red).

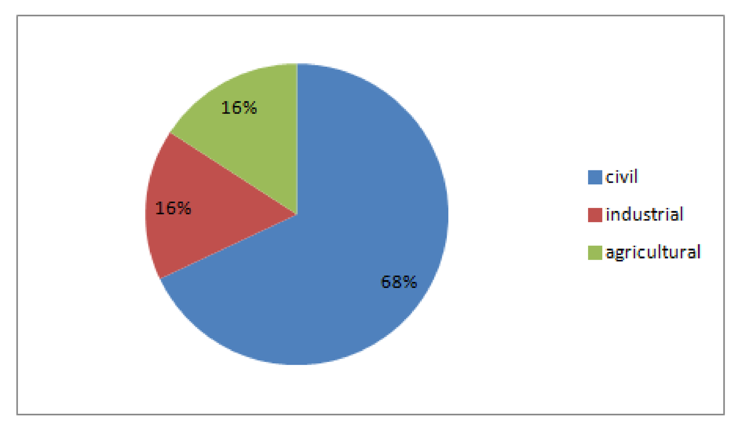

Figure 3. Main water uses in data collected by local administrations.
Percentages refer to the quantities of water taken on the average year.

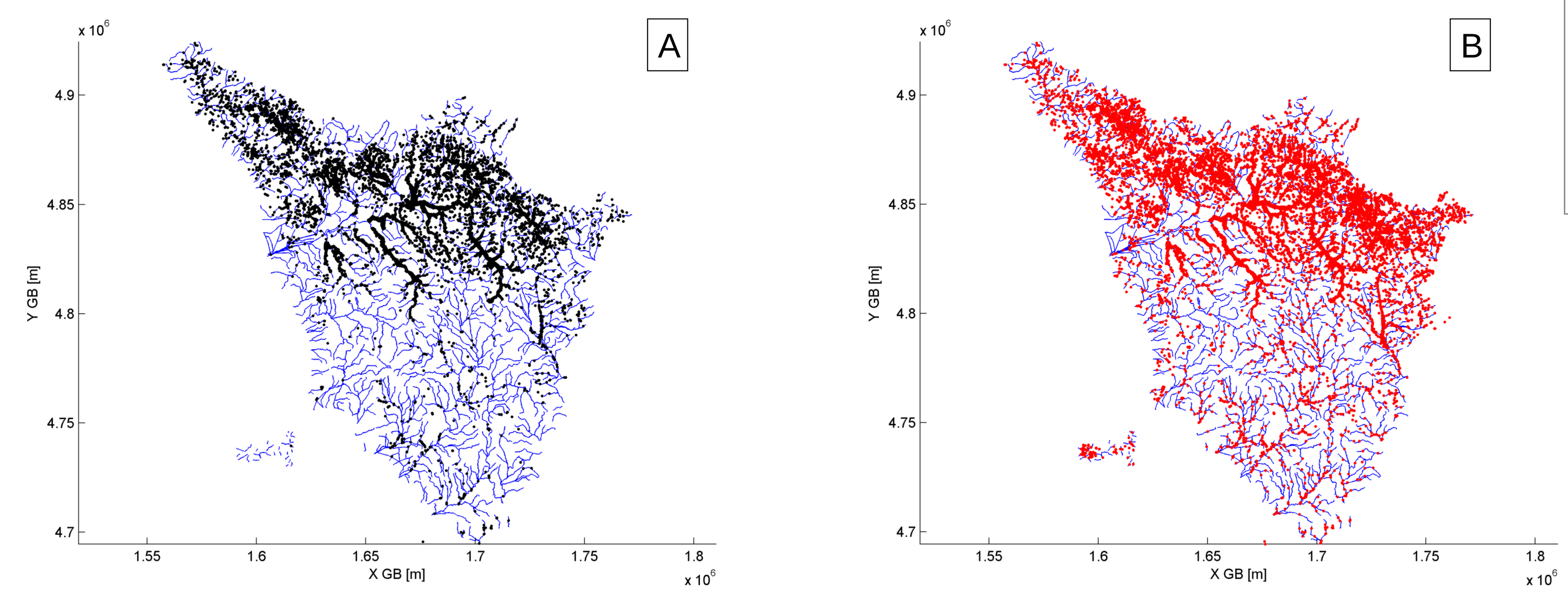

Figure 5. Maps of water withdrawals from surface water bodies in Tuscany. A) Information collected by different local administrations; B) Actual and synthetic withdrawals.

3. The MOBIDIC model

MOBIDIC (Modello di BIlancio DIstribuito e Continuo) is a distribuited hydrological model that simulates all the main processes of the hydrologic balance: network channels flow, evapotranspiration, infiltration, adsorption, percolation, hypodermic flow, base flow, hillslope flow, etc. The model is able to simulate either a single rainfall-runoff event and the hydrological balance for a period of several years.

The hydrological model MOBIDIC was used to perform simulations of the water balance at regional scale (about 23000 km²) with and without the withdrawals scenarios. The period of study was 2001-2010.

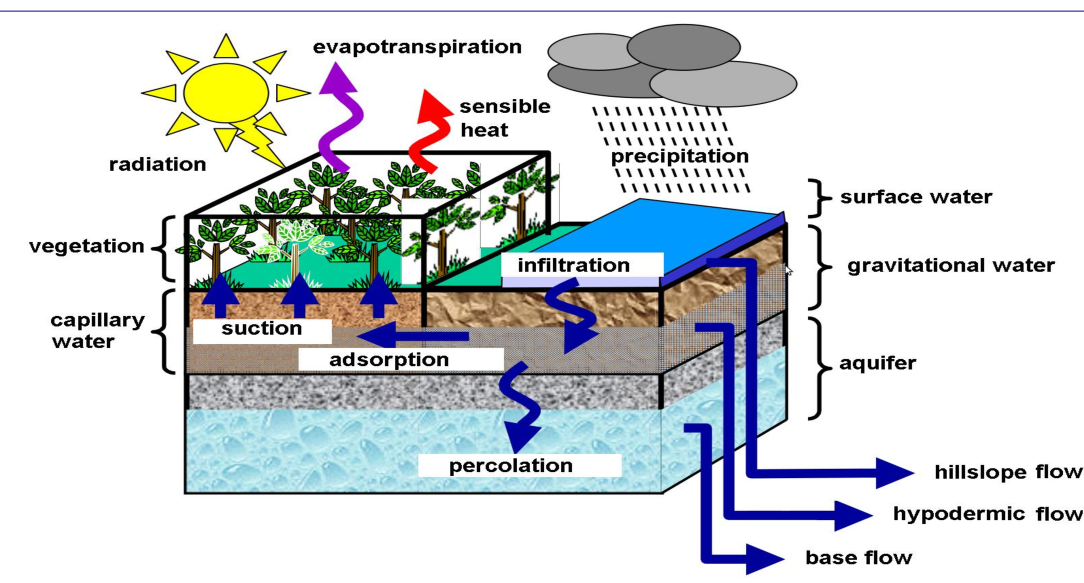

Figure 6. Schematic representation of the MOBIDIC model.

4. Results

Besides an overview of available information about water withdrawals in Tuscany, the result of this work is a quantitative scenario of anthropic pressure on the state of surface water bodies in Tuscany and in particular the outputs of the water balance at regional scale. The hydrological model MOBIDIC simulates small and large pore soil moisture, water discharge in each river branch and the quantities of water actually withdrawn. These parameters can highlight water scarcity states in a certain area at a particular moment. In the following data for Tuscany main watersheds are shown during a drought (August 2003) and a rainy period (January 2009). A comparison between simulations with and without the withdrawals is also shown.

Soil saturation

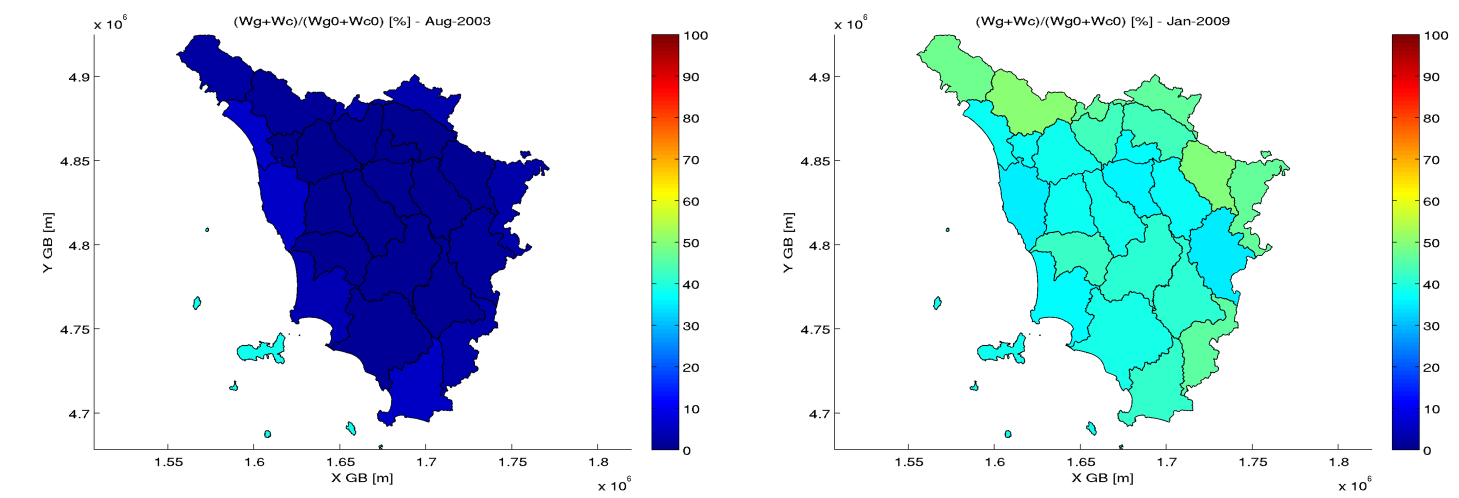

Figure 7. Small and large pore soil moisture saturation for Tuscany main watersheds (August 2003 and January 2009). $(W_g+W_c)/(W_{g0}+W_{c0})$ [%], W_g large pores soil moisture, W_{g0} maximum water holding capacity in soil large pores, W_c small pores soil moisture, W_{c0} maximum water holding capacity in soil small pores.

Rainfall and withdrawals

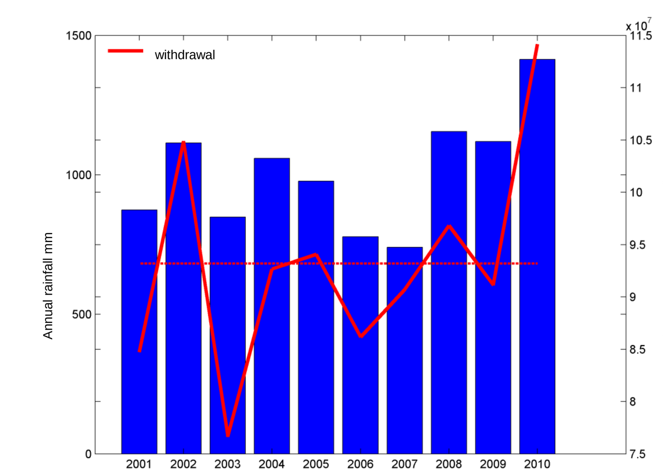

Figure 8. Annual rainfall [mm] and annual water withdrawal [m³]: 2001-2010.

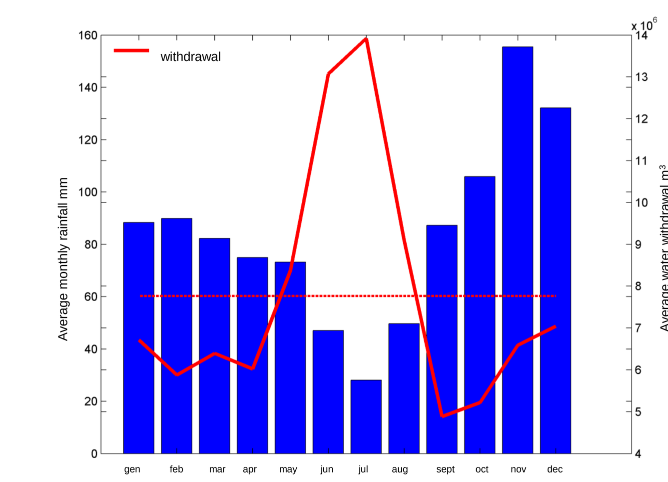

Figure 9. Average monthly rainfall [mm] and average water withdrawal [m³]: 2001-2010.

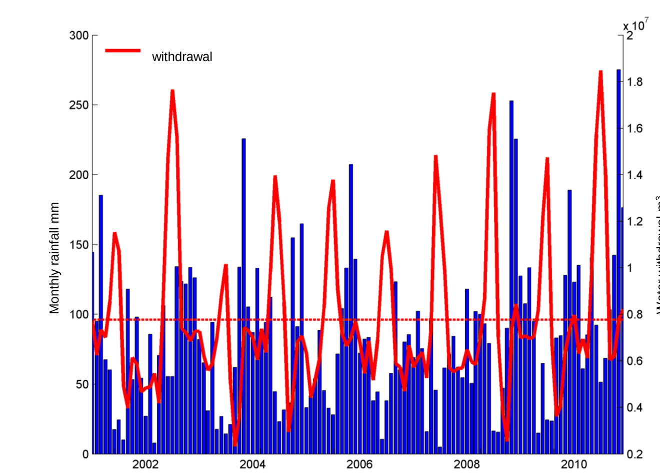

Figure 10. Monthly rainfall [mm] and water withdrawal [m³]: 2001-2010.

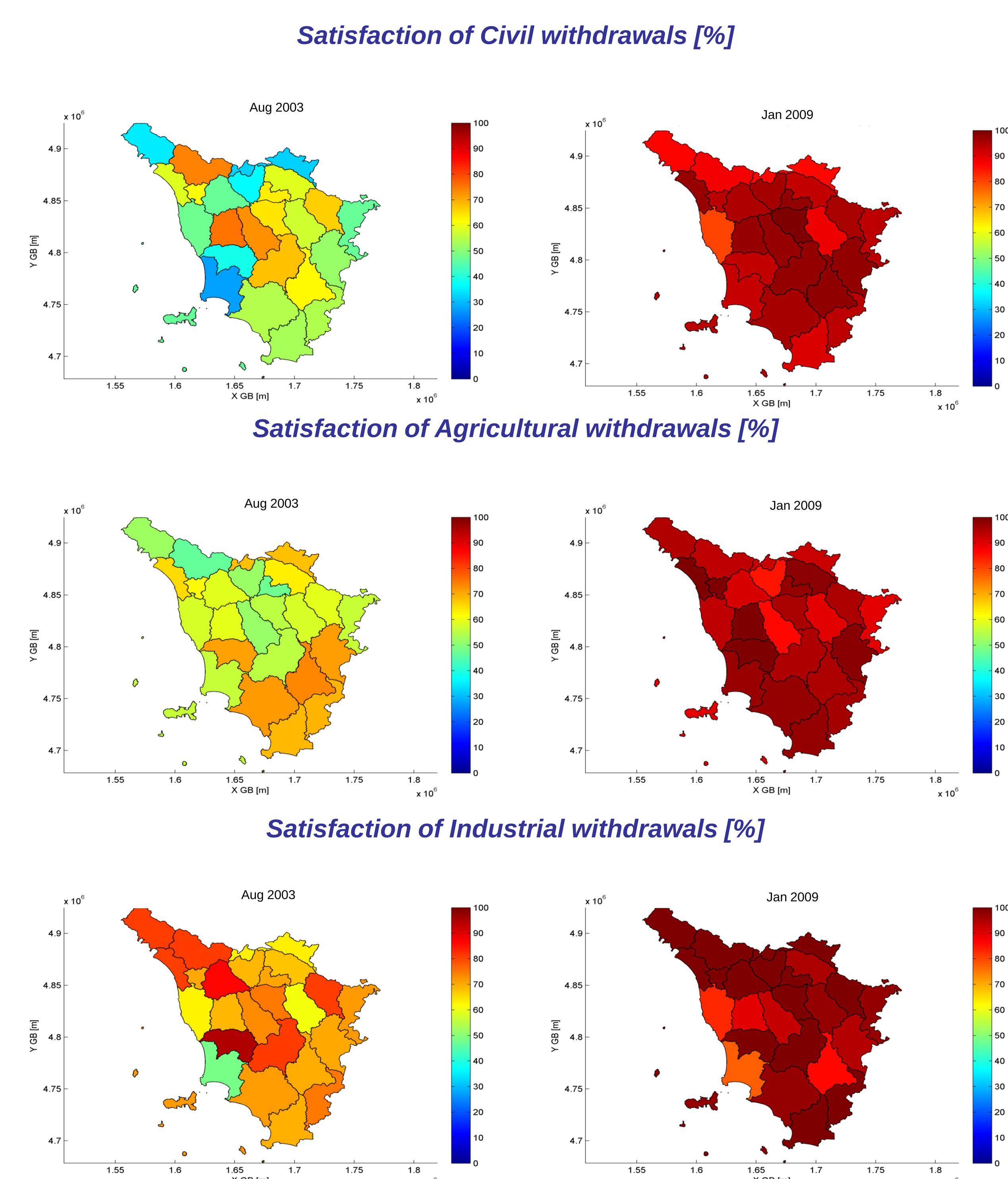

Figure 11. Satisfaction of water withdrawals [%]: data for Tuscany main watersheds. August 2003 and January 2009.

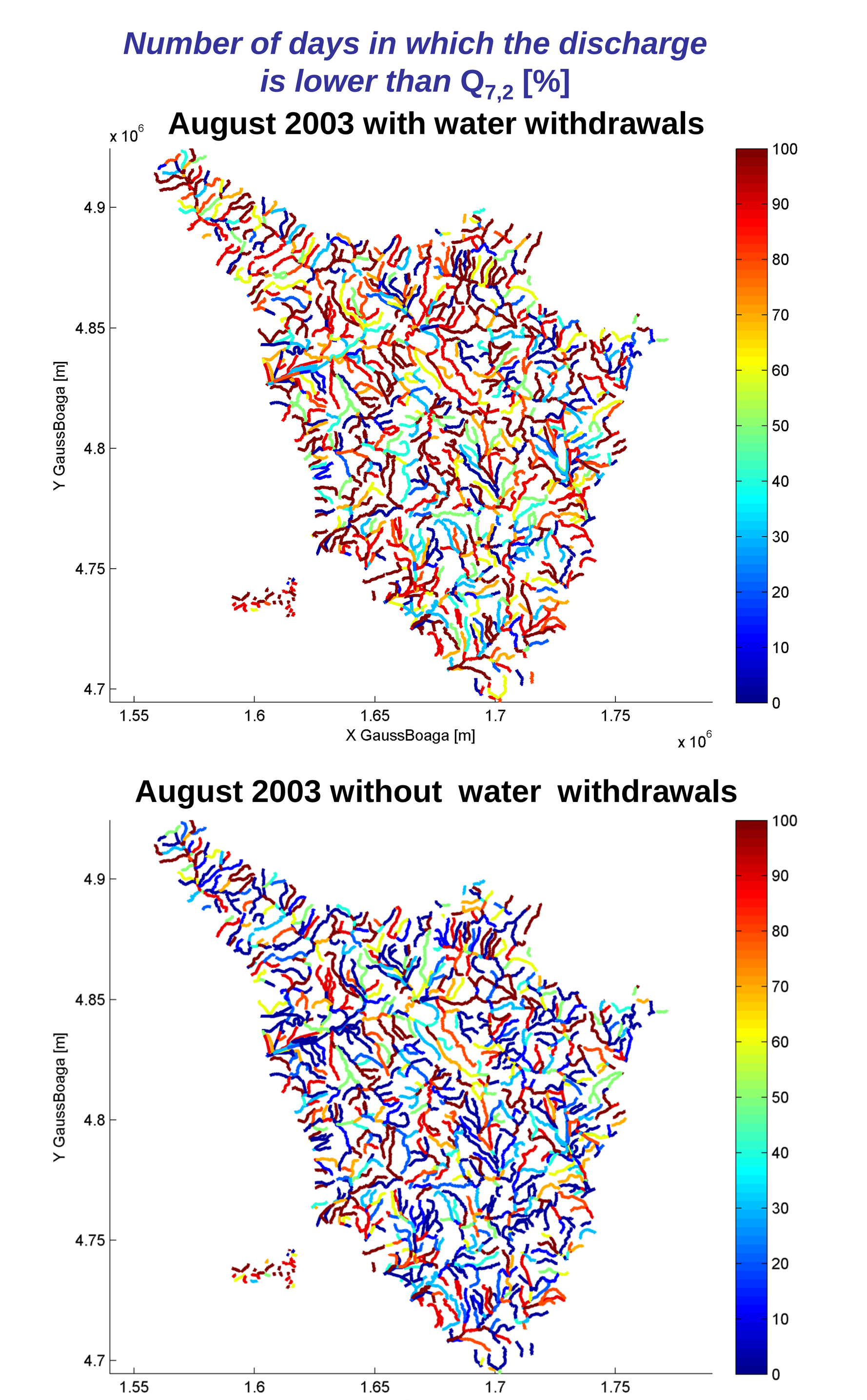

Figure 12. Days in a month [%] with discharge lower than $Q_{7,2}$, (the minimum 7-days mean discharge that has a 2-years return period). August 2003. Upper panel: with water withdrawals; lower panel: without water withdrawals.