Real time groundwater accounting by proxy models and farm-wells data

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Introduction

Demanding more fresh water

Water scarcity

Uncertainty on water supply

Augmented surface flows out of basins

Increased reliance on groundwater

Population growth + Agriculture expansion + Effects of Climate Change
Our Stage

A watershed, where water serves multipurpose systems:

- Irrigation
- Domestic
- Municipal
- Industrial
- Hydropower
- Recreational
- Ecosystems
- others
Groundwater reliance: Groundwater is hidden from human view, the state of the resource, i.e. abundance or depletion, is hardly clear enough for people to understand the effects of their actions, until it is too late.

...is complex
Groundwater management

• Not very effective
• Effects of groundwater development are not sufficiently obvious
• Managed independently of surface water
• Lack of transparency regarding groundwater development and undesirable effects
• Negative effects: overdraft, subsidence, water supply problems
• Need of feedback to water users and managers about groundwater dynamics
• Water accounting is complex
Groundwater accounting is difficult, done by complex models, and costly in terms of data, money and time.

(Source: Dogrul, 2015)
Case in Yolo County, California
Case in Yolo County, California

Davis and Woodland area, contained in the integrated hydrologic model Yolo County IWFM.
Farm-wells in the study area. The observed change in head for the shallow and intermediate aquifers, is the average of 23 shallow and 29 intermediate wells, the simulated heads are the average of 628 model nodes.
Steep learning curve to use, costly in terms of data, money, and time.

To correlate historical simulated outputs of change in head vs net recharge, pumping, and change in storage:

Simple equations that use change in head data for groundwater accounting:

Transfer Functions
Groundwater Change in Storage Proxy

Proxy for monthly change in storage intermediate aquifer: \( dS \text{ Proxy Int} \)
Groundwater Change in Storage Proxy Application

Observed change in head in the Intermediate aquifer is the input for the proxy.

Monthly change in storage estimation in the intermediate aquifer

- dS Proxy Int estimate
- dS Proxy Int 95% low
- dS Proxy Int 95% up
- dS model
Groundwater Proxy Functions

Possible by aquifer layers (shallow, intermediate, deep aquifer), to obtain:

Net Recharge Proxy
Pumping Proxy
Change in Storage Proxy
Groundwater Budget by Hydrologic Proxies

Aquifer proxy estimates for water years 1970 to 2015

<table>
<thead>
<tr>
<th>Hydrologic component (million m³/mo)</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recharge</td>
<td>3.31</td>
<td>15.24</td>
<td>27.19</td>
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<tr>
<td>Pumping Shallow</td>
<td>0.19</td>
<td>0.62</td>
<td>1.04</td>
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<tr>
<td>Pumping Intermediate</td>
<td>5.51</td>
<td>13.44</td>
<td>22.51</td>
</tr>
<tr>
<td>Aquifer Change in Storage</td>
<td>-31.60</td>
<td>-0.02</td>
<td>40.08</td>
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</tbody>
</table>
Key messages

• Groundwater is becoming the main source of water to supply demand given population growth, agriculture expansion, and climate change effects.

• Groundwater management is not very effective, carrying overdraft, subsidence, water supply problems, and lack of accounting.

• Hydrologic proxy functions can be developed to estimate key groundwater budget components based on observed groundwater data already available, providing critical information for water decision makers and users.

• Results from this work offer general ways to quickly make transparent water users actions on the groundwater system.
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Thank you!

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THANK YOU!

Please direct all questions and concerns to:

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