Groundwater Management Optimization

by ALL_WATER_gw

New problem formulation & additional functionalities.

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Outline

- Problematic,
- General conceptual model and objective,
- Problem formulation and resolution methodology,
- ALL_WATER_gw presentation,
- Case study application.
Problematic

Water demand: 1500 m³/d
Salinity: < 1 g/L
Min. cost

How much water has to be taken from each well?
General Conceptual Model

Demand site nodes

Transmission links

Groundwater nodes

Wells

Max Abstraction(well) & Max Drawdown(well)

D(d)

D(1)

S(se)

S(1)

D(d, t) & Qty(d)

F_{\text{max}} D(se,d) & Cost(se,d)

Qty (se) & Vol(se)

WEAP

MODFLOW
Objective

The main objective of this work was to develop a multi-objective optimization tool for groundwater management.
Problem formulation (1/4)

OBJECTIVES

Objective 1:
Satisfy the water demands of the sites “d” at every time step “t”.

Objective 2:
Minimize the maximal drawdown.
Objective 3:
Minimize the unit cost of water.
Problem formulation (3/4)

CONSTRAINTS

1. Water supply from each groundwater node to any demand site must be lower than the maximal transmission link capacity.

2. Water abstraction from each well must be lower than the maximal acceptable value.

3. Water drawdown in each well cell must be lower than the maximal acceptable value.

4. Water quality supplied to each of the demand sites must be lower than the maximal acceptable value.
Resolution methodology

1. Multi-objective Genetic Algorithm

2. PARETO optimality Concept

\[
\text{Fitness 1} = \frac{p_1 \times f_{DS} \times (1 + \text{MaxEQty}) + p_2 \times f_{DD} \times (1 + \text{MaxEQag})}{p_1 + p_2}
\]

\[
\text{Fitness 2} = f_c
\]
Historic MODFLOW model

MODFLOW simulation to compute the cell heads

Future MODFLOW model

Abstractions optimization
ALL_WATER_gw in the Framework
WEAP – MODFLOW DSS

WEAP Model

WEAP-MODFLOW DSS

MODFLOW Model

MODFLOW
Historic and Future Models

ALL_WATER_gw

User:
Priorities - Constraints
Options - Parameters

Optimal Abstractions

Outputs for analyses
ALL_WATER_gw User interface

Welcome for using the free ...

ALL_WATER_gw

Version: 1.2.1
for Windows XP, Vista and Seven
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To be used:
- With WEAP version 3.004 or later
- As Stand alone application

This tool is supported by the BGR - ACSAD cooperation project
Read in the WEAP Area

Read in the Linkage and the MODFLOW model

Summary of the inputs
Objectives and constraints

GA parameters

Objectives weights

Progression
Statistics of the optimal solutions

Choose a well

Evaluate and save optimal solutions

Proposed optimal solutions
Case study application

- 9 groundwater nodes,
- 16 demand sites,
- 24 Transmission links,
- Period: 1983 – 2015,
- Monthly time step,
- Optimization 2013-2015,
WEAP-MODFLOW model for Zeuss Koutine
Water Demand (not including loss, reuse and DSM)
Scenario: Reference, All months (12)

Figure. Monthly water demand for domestic and touristic demand sites nodes.
Simulation results

MODFLOW Cell Head
Layer: 1, Row: 24, Column: 25

Reference
changement climatique

January 1982 to December 2015
Optimization results

Figure. Overview of the “ DEMAND_FRACT.csv” file produced by ALL_WATER_gw.
**Figure.** Optimized and Reference “Average Cost of Water” (KWh per m3).
Figure. Optimized and Reference cells heads of two piezometers.
Summary & Conclusions

- **ALL_WATER_gw** can be used in the framework of WEAP-MODFLOW or as stand alone tool.
- It considers the main objectives and constraints for groundwater management,
- For real groundwater, it was able to identify optimal management solutions,
- **ALL_WATER_gw** is a free tool.
شكرا
Merci
Thank You
Danke schön