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Scenario-based approach for assessing the impact of water management measures on hydrological drought dynamics

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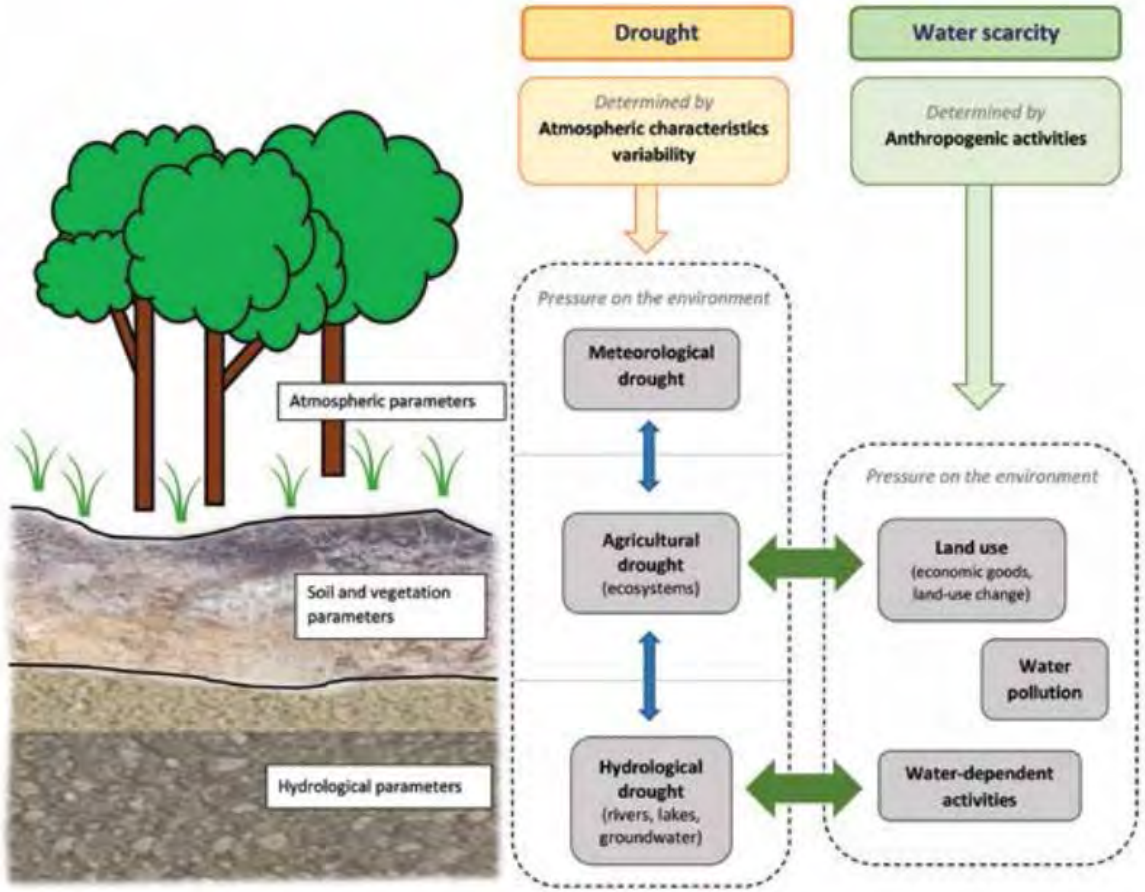
https://humdrought.igf.edu.pl/

Background



- Drought as natural phenomena - climate variability
- Human-induced and human-modified drought (Van Loon et al., 2016)
- Increased human impacts – human-water interactions

Source: Gregorič et al. (2019)

Background

- Hydrological drought becoming more challenges
- Various water management strategies to use surface water and groundwater as measures for mitigating drought
  - ✓ Increasing water retentions
  - ✓ Water transfers
  - ✓ Increase water use
- If not properly implemented, these strategies might lead to environmental problems.

Vistula river in Warsaw, July 21, 2022

Source: https://notesfrompoland.com/2022/07/26/water-level-of-rivers-in-poland-drastically-low/

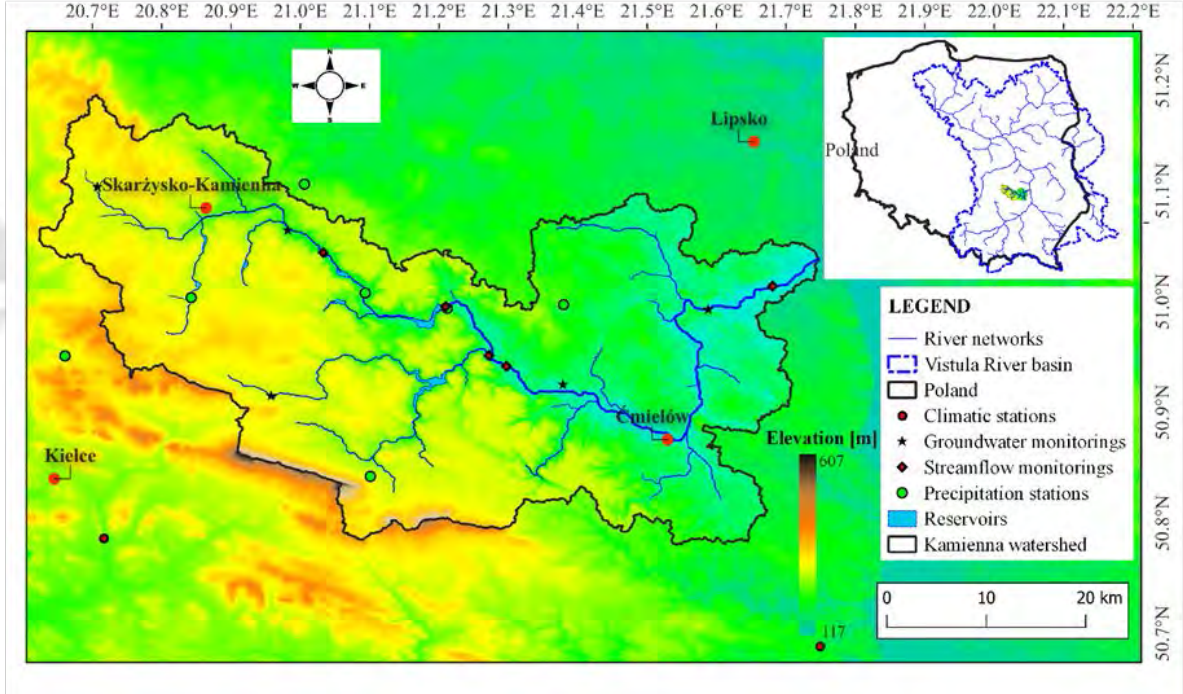
Objectives

The aim of this study is@

- to assess the impact of water abstraction from reservoirs on drought dynamics
- to assess the advantages of using coupled surface and groundwater models (SWAT-MODFLOW) over a semi-distributed SWAT model.

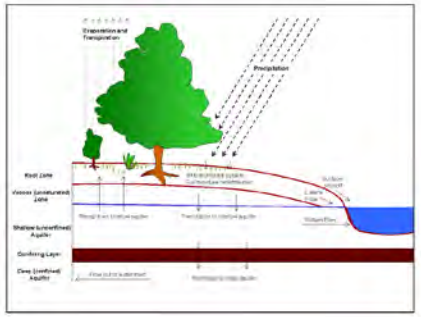
https://haskoningdhv.pl/en/projects/wiory-flood-protection-reservoir-on-the-swislina-river/

Study area

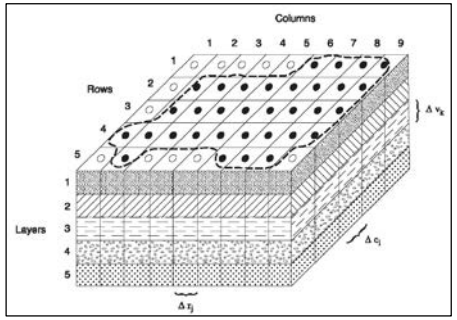


- Kamienna river: the left tributary of the Vistula River
- Known for its exposure to drought and flood hazards
- Significant changes in runoff processes
- Water transfers to the watershed
- Intensive man-made water retentions
- Abstractions of groundwater resources

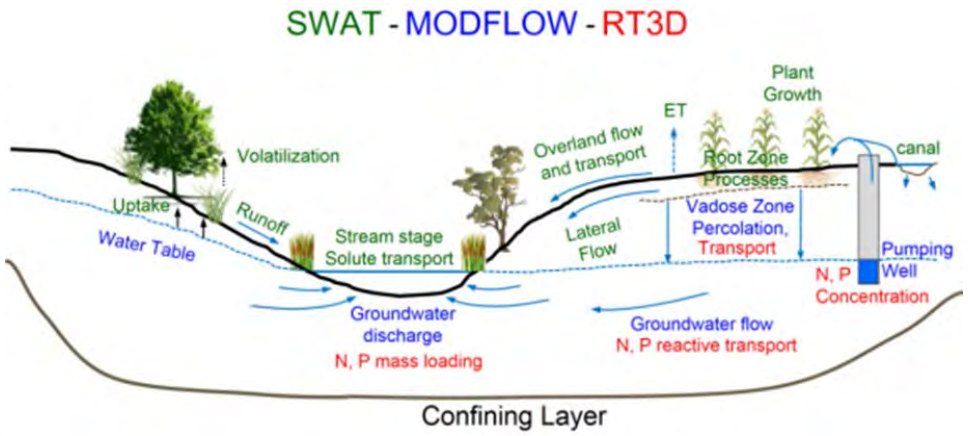
Methods



Sources: Neitsch et al. (2011)



Sources: Harbaugh (2005)



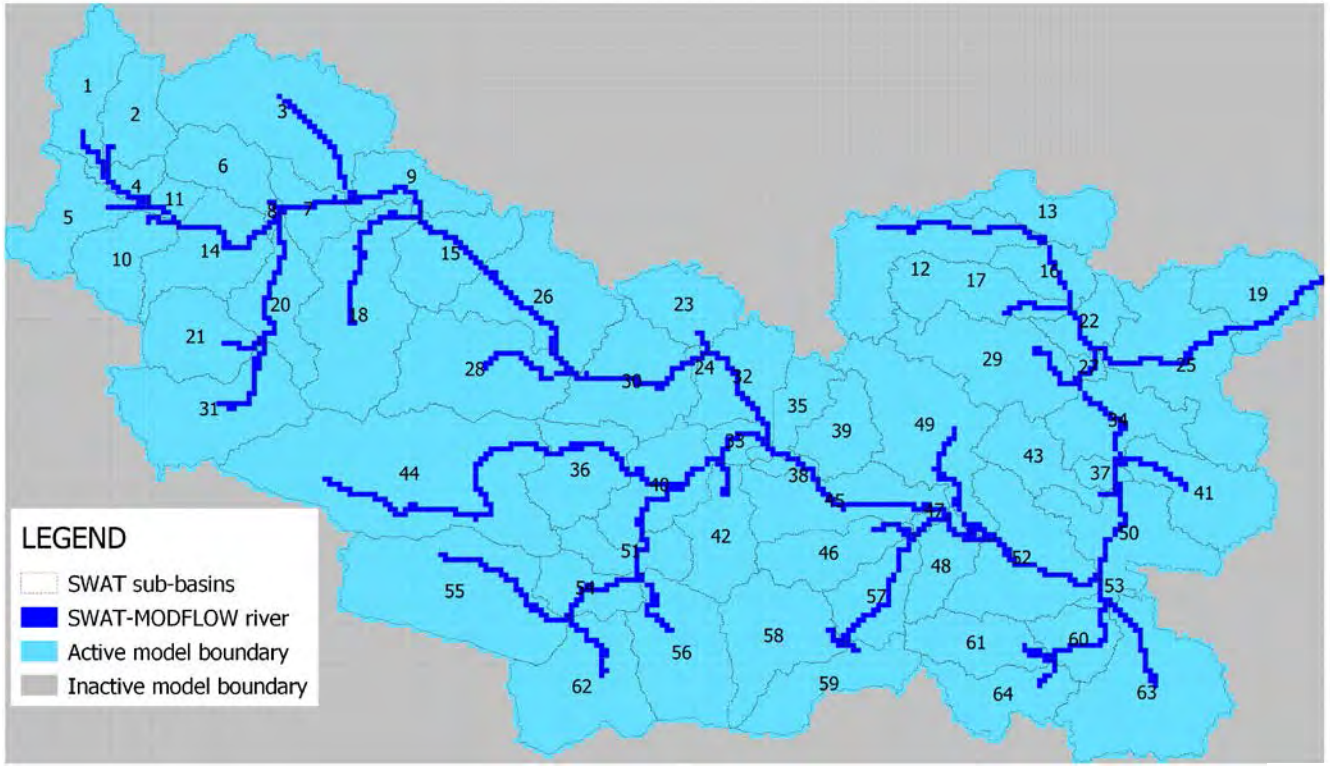
Sources: Park et al. (2017)

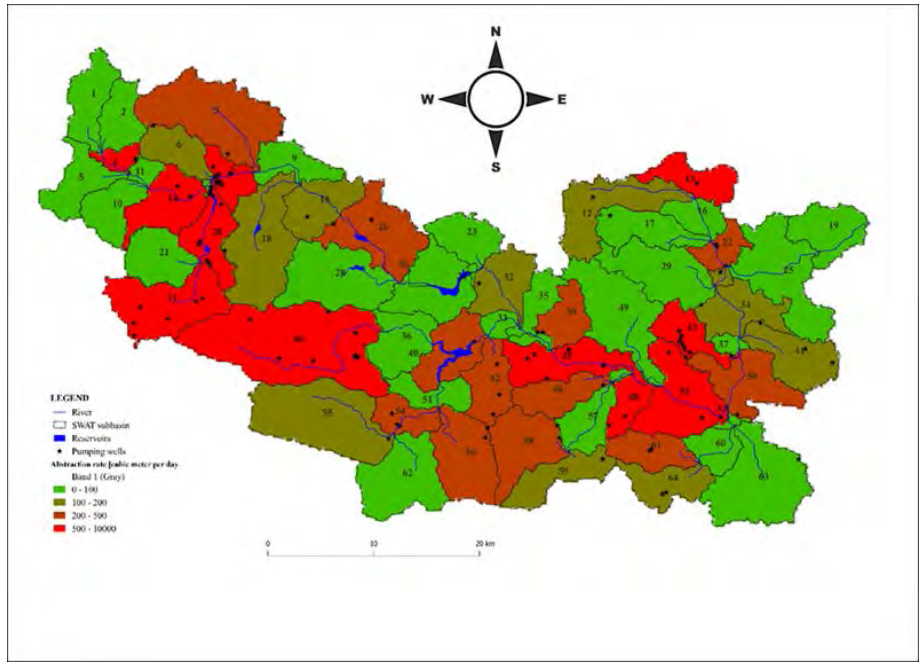
SWAT	MODFLOW
▪ Semi-distibuted	▪ Fully distributed
▪ Simply GW flow by lumped linear reservoir approach	▪ Simplify land Surface processes

SWAT-MODFLOW

- Simulate complex hydrological processes by improving the limitations of both models

Methods

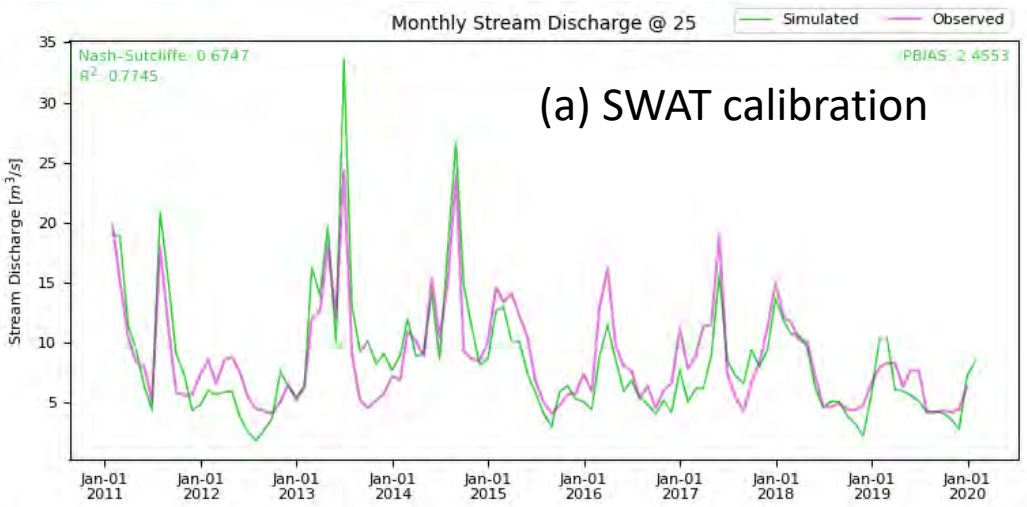


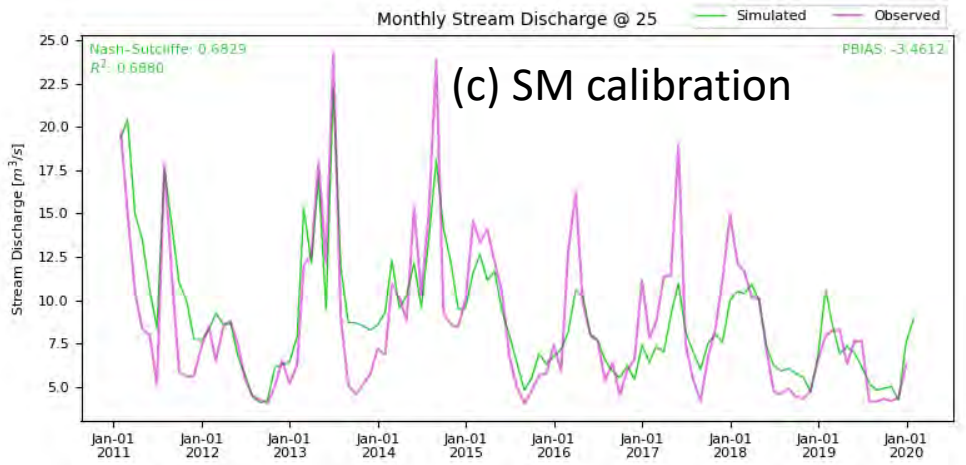


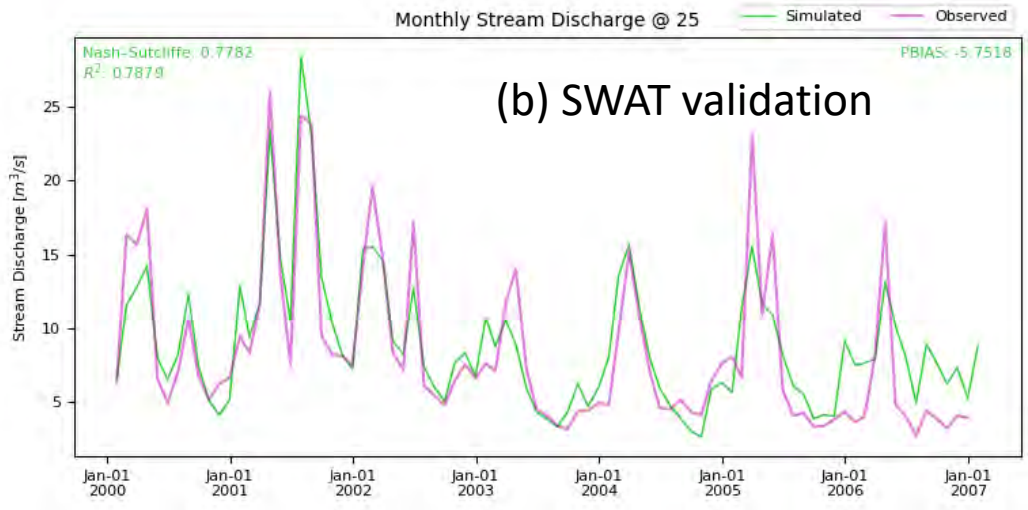
- SWAT model: 64 sub-basins and 1425 HRUs
- MODFLOW: 39562 grids of 300m resolution
- SWAT-MODFLOW model: 118530 disaggregated HRUs

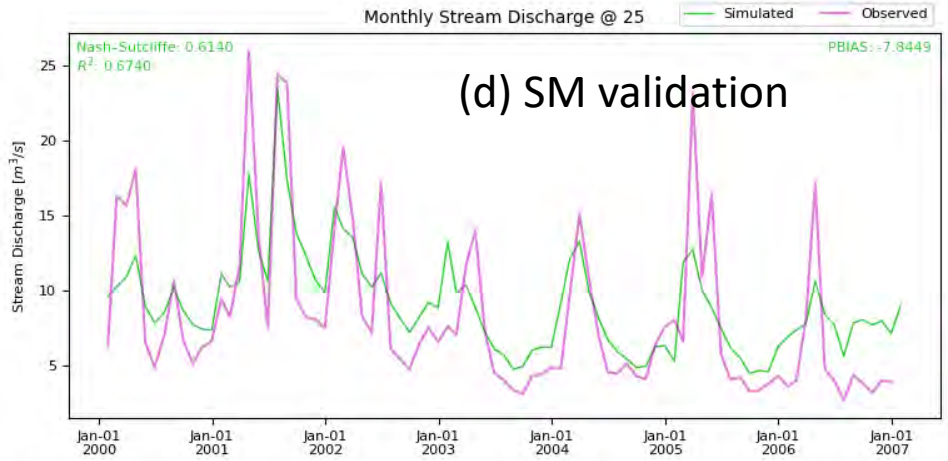
- S0 - reference scenarios indicating the current water use.
- S1- indicates water extraction is twice current water use

Results


Monthly Stream Discharge @ 25
Simulated
Observed
Nash-Sutcliffe: 0.6747
R^2: 0.7745
PBIAS: 2.4553
(a) SWAT calibration
Stream Discharge [m^3/s]
Jan-01 2011
Jan-01 2012
Jan-01 2013
Jan-01 2014
Jan-01 2015
Jan-01 2016
Jan-01 2017
Jan-01 2018
Jan-01 2019
Jan-01 2020

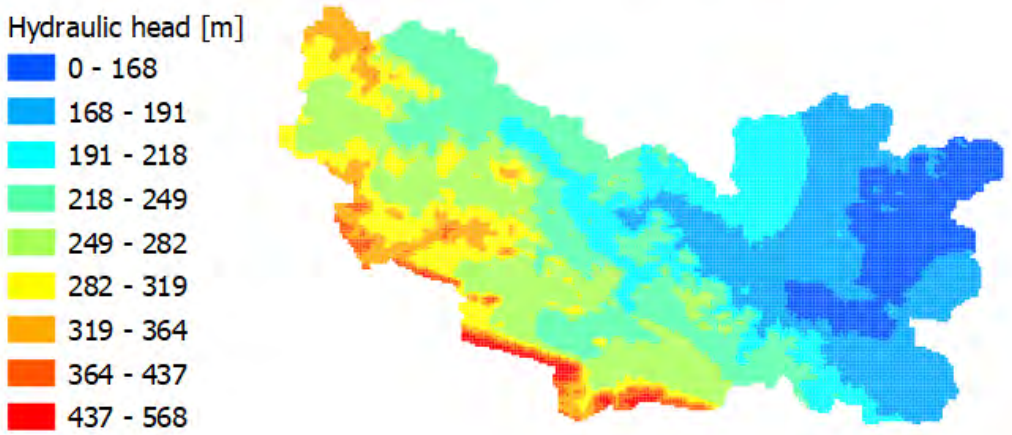

Monthly Stream Discharge @ 25
Simulated
Observed
Nash-Sutcliffe: 0.6829
R^2: 0.6880
PBIAS: -3.4612
(c) SM calibration
Stream Discharge [m^3/s]
Jan-01 2011
Jan-01 2012
Jan-01 2013
Jan-01 2014
Jan-01 2015
Jan-01 2016
Jan-01 2017
Jan-01 2018
Jan-01 2019
Jan-01 2020


Monthly Stream Discharge @ 25
Simulated
Observed
Nash-Sutcliffe: 0.7782
R^2: 0.7879
PBIAS: -5.7518
(b) SWAT validation
Stream Discharge [m^3/s]
Jan-01 2000
Jan-01 2001
Jan-01 2002
Jan-01 2003
Jan-01 2004
Jan-01 2005
Jan-01 2006
Jan-01 2007

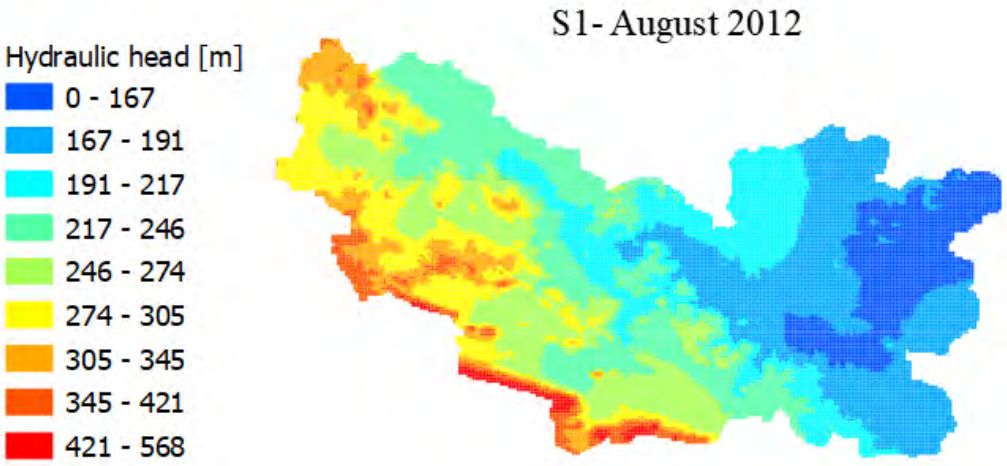

Monthly Stream Discharge @ 25
Simulated
Observed
Nash-Sutcliffe: 0.6140
R^2: 0.6740
PBIAS: -7.8449
(d) SM validation
Stream Discharge [m^3/s]
Jan-01 2000
Jan-01 2001
Jan-01 2002
Jan-01 2003
Jan-01 2004
Jan-01 2005
Jan-01 2006
Jan-01 2007

Results

S0- August 2012



S1- August 2012



- Seepage from the river to groundwater decreases under S1
- Discharge from groundwater shows an increases under S1.
- Difference in hydraulic head

Conclusions

- The graphical comparison shows that the model SWAT performs better than the coupled SWAT-MODFLOW in capturing high flows.
- The two models differ in their performance during validation, but both models yield acceptable model performance.
- The increased water abstraction scenario shows the changes in groundwater levels and the interaction between groundwater and surface water during drought.

Conclusions