INTERNATIONAL CONFERENCE

GROUNDWATER, KEY TO THE SUSTAINABLE DEVELOPMENT GOALS

PARIS - May 18 -20, 2022

Assessment of the combined impact of climate change and pumping on groundwater resources (Kou Basin, Burkina Faso)

Presented by Justine TIROGO

Dr Anne JOST, Sorbonne Université

Dr Angelbert BIAOU, 2iE

Pr Youssouf KOUSSOUBE, UJKZ

Pr Pierre RIBSTEIN, Sorbonne Université

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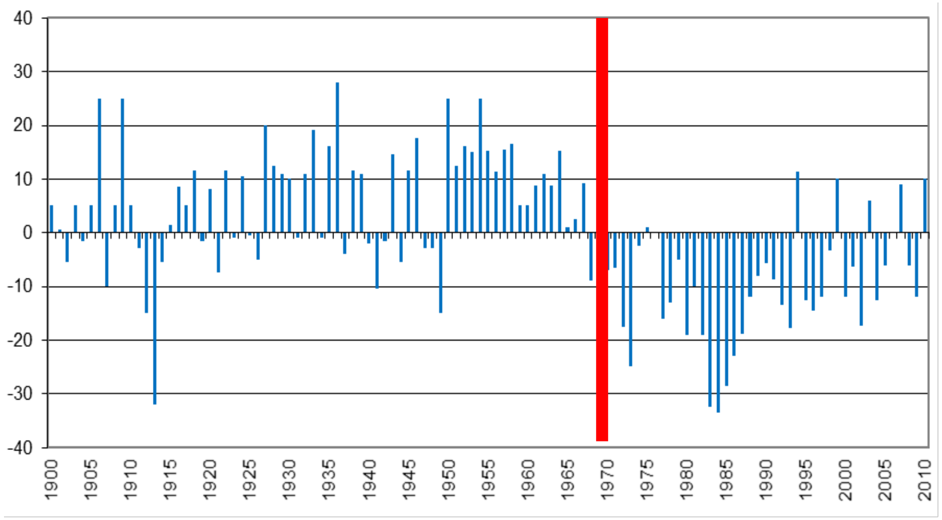
PRESENTATION PLAN

INTRODUCTION

High interannual and decadal rainfall variability in West Africa

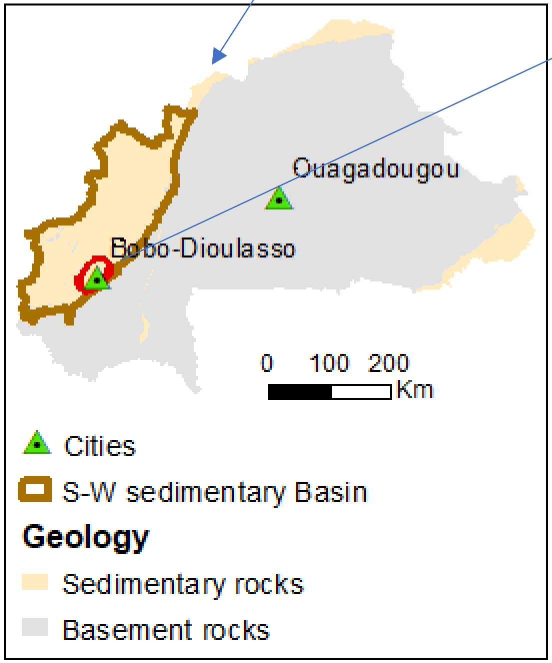


A long period of drought since the 1970s

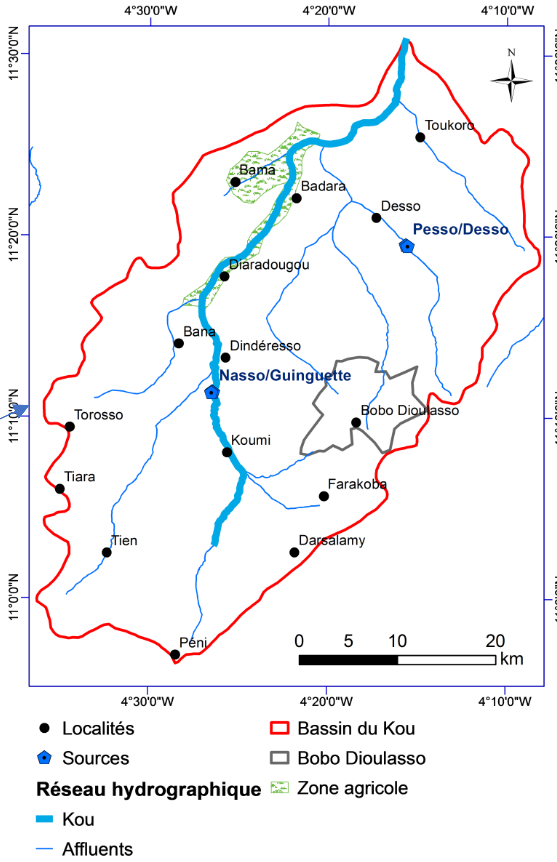
Rainfall index from 1900 to 2010 in the Niger River basin

- Impact of drought on runoff is well documented (e.g. Descroix et al., 2009; Mahé et al., 2009).
- Impact of climate variability on groundwater is less well known
- However, groundwater resource is increasingly used

INTRODUCTION

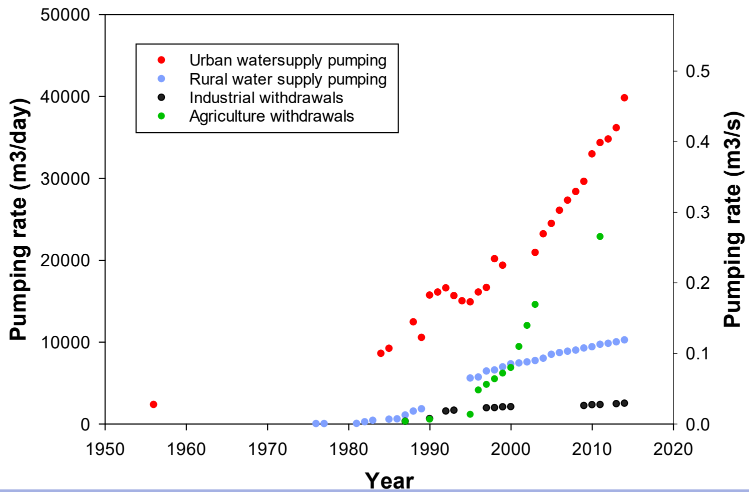


Study area : Kou basin (1,816 km²)



- Southeastern edge of the **Taoudeni sedimentary basin**
- Located in the **Sudanian** area
- Important **Nasso-Guinguette springs** with exceptional discharge in west Africa (more than 1.8 m³/s in 2011)
- Groundwater resources are a major socioeconomic asset

INTRODUCTION



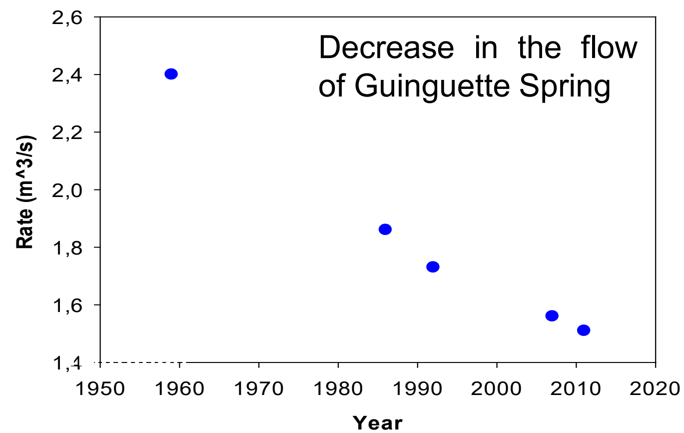
Groundwater is used for several purposes (drinking water supply, agriculture, industry)

Water needs are growing :

Withdrawals have increased from **2,300 m³/day** in 1960 to more than **75,000 m³/day** in 2014 - **more than 30 times in half a century**

Observations that raise questions

- Decrease in the flow of springs
- Disappearance of springs
- Decrease in the groundwater level

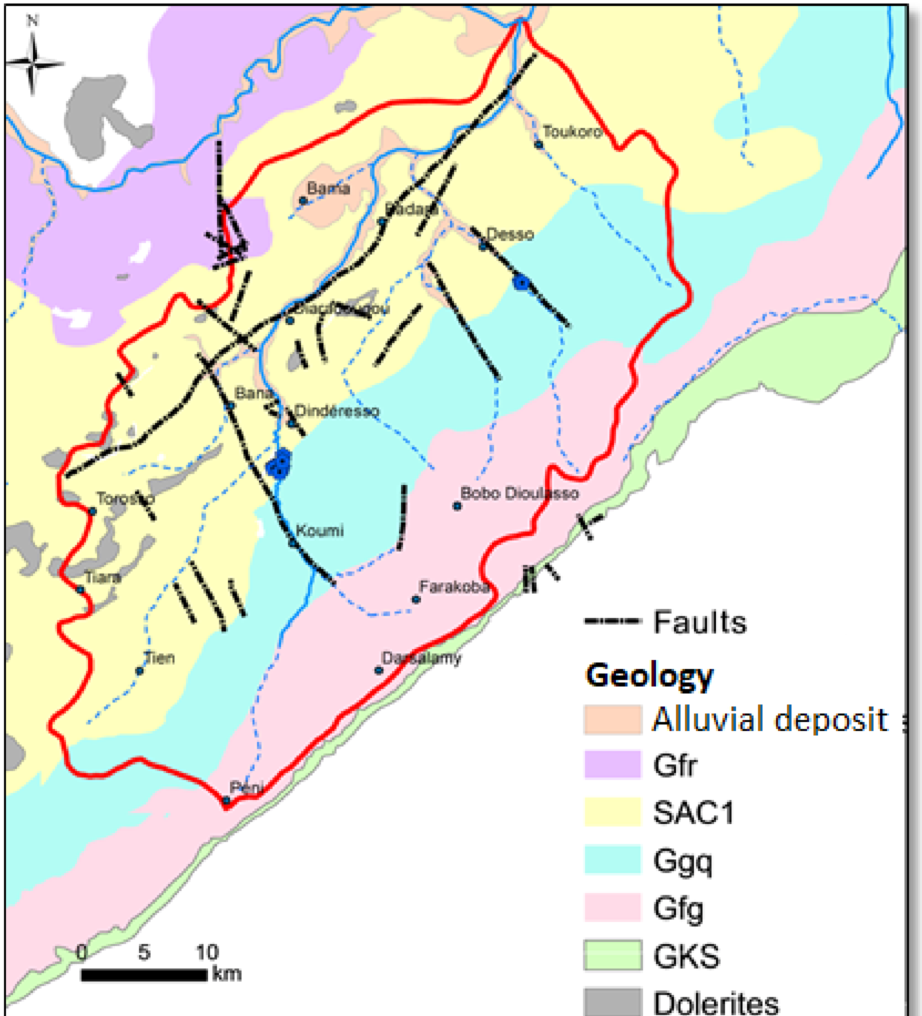


What is the share of climate and withdrawals in the depletion of the resource?

Ans.: Hydrogeological 3D model calibrated in steady state and transient regime

MATERIAL AND METHODS

Geology and Hydrogeology

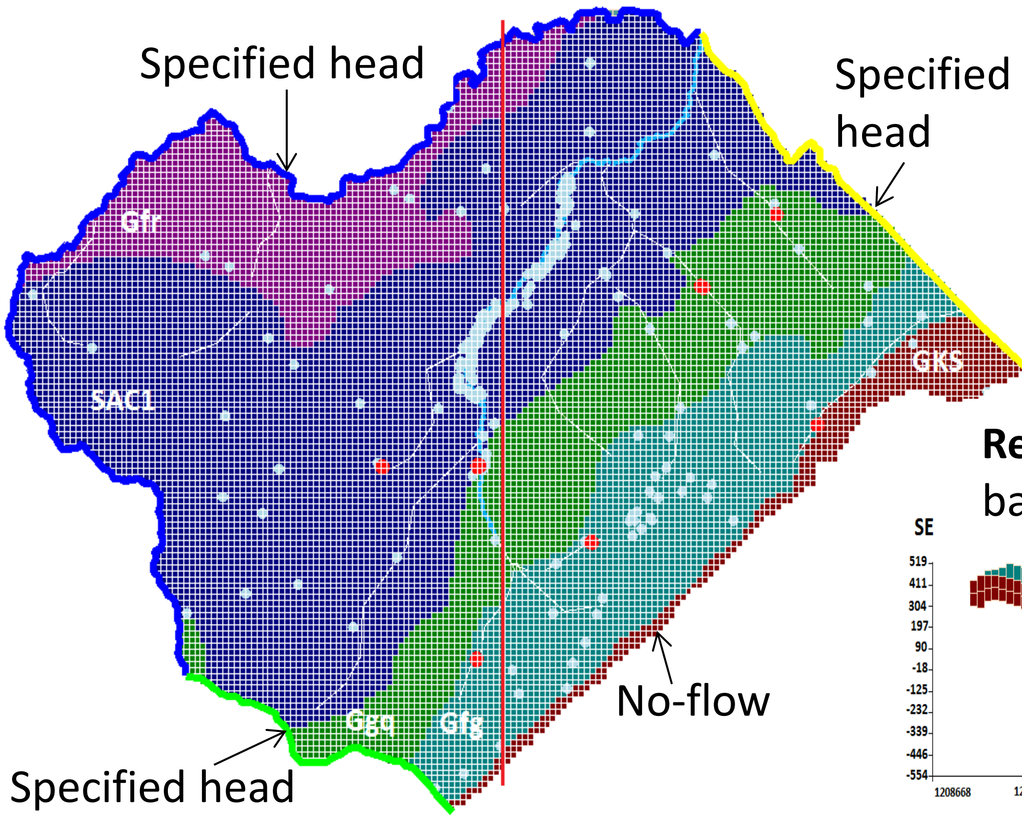


- **Five sandstone-dominated formations** with a monoclinal structure and a **slight dip of 2°** to the NW.
- **Total thickness** that could reach **2,000 m** deep in its western part
- Several **major faults** create important hydraulic connections between the different aquifers

MATERIAL AND METHODS

Hydrogeological 3D model calibrated in steady state and in transient regime

Conceptual and numerical model



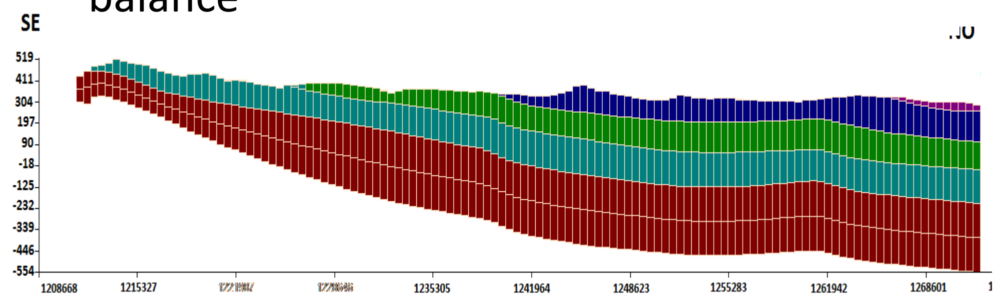
Numerical code : Modflow-2005

Interface Visual Modflow Flex

A conceptual model based on the state of the art

Hydrogeological boundaries

Recharge derived from the Thornthwaite balance



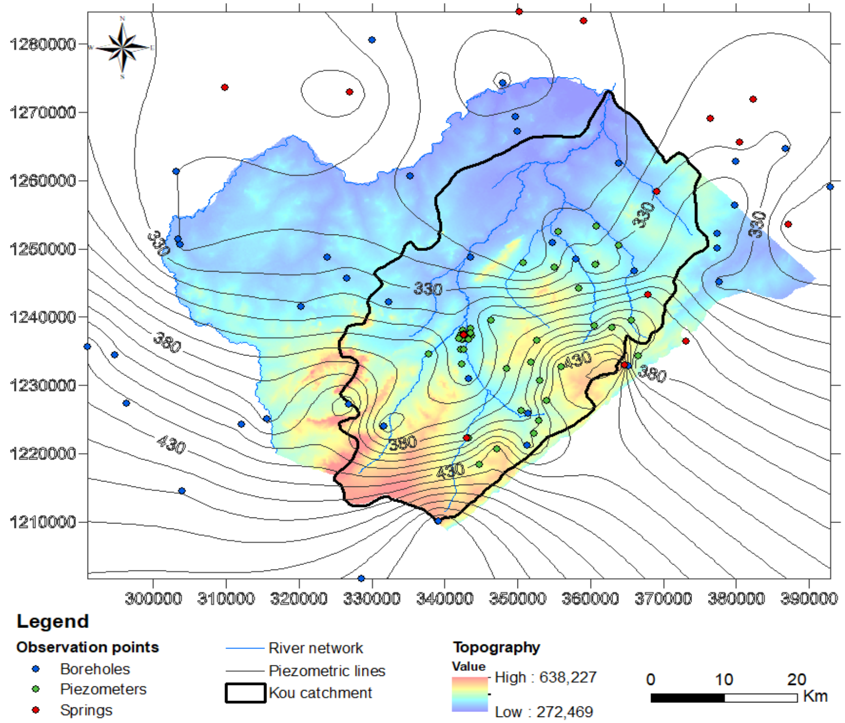
- Regular 500 m × 500 m grid cells
- Vertical discretization in 6 layers

MATERIAL AND METHODS

Calibration/ simulation	Period	Objective
Steady state calibration	1995 to 1999 (low-flow period)	Understand aquifers hydrodynamic and simulate the response of the water table
Steady state validation	2014 (low-flow period)	
Transient state at a monthly time step	1995–2014	
Transient state simulated at an annual time step	1961–2014	Analyze the effect of climate variability on the water table and in particular the impact of the great drought of the 1970s

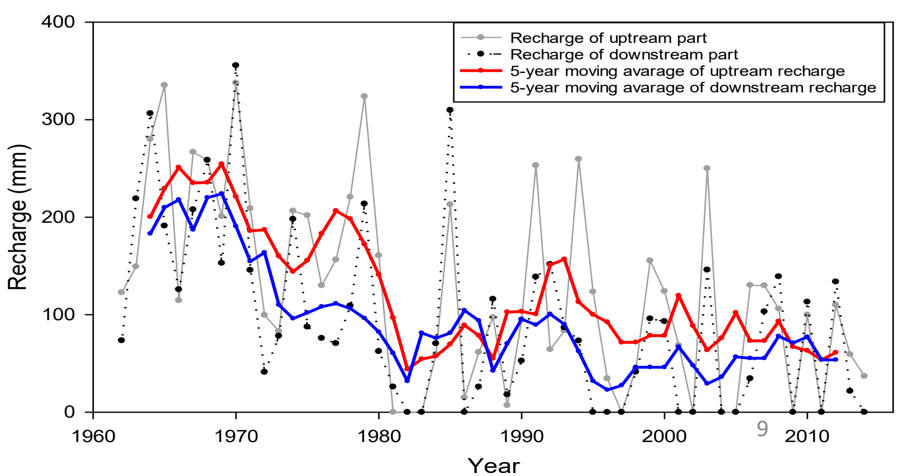
MATERIAL AND METHODS

Groundwater-level data and recharge



Observations

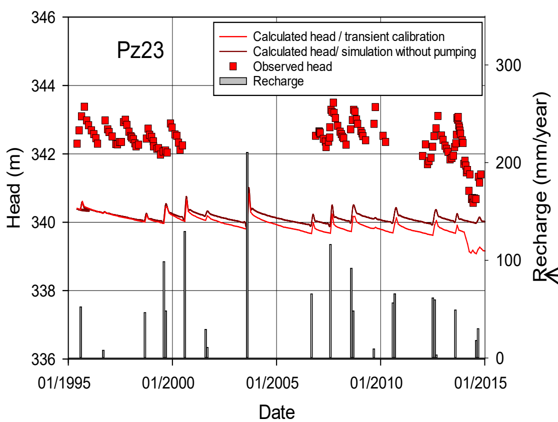
- 68 groundwater-level (piezometers and boreholes) : 1995-2014
- Flow of the Kou River : 1960-2014
- Discharge of 9 springs

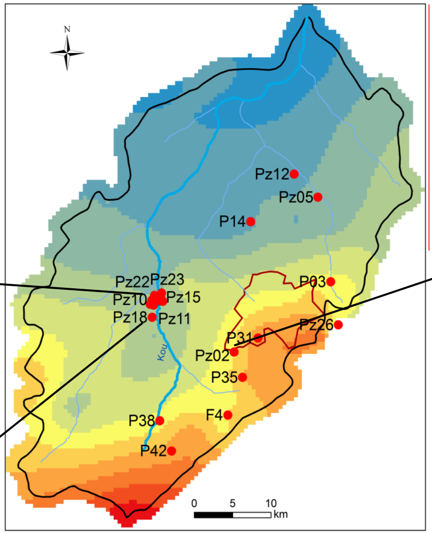


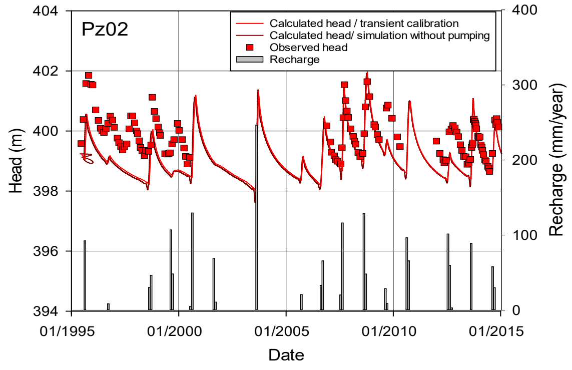
Monthly recharge during the period 1961–2014 by using Thornthwaite balance

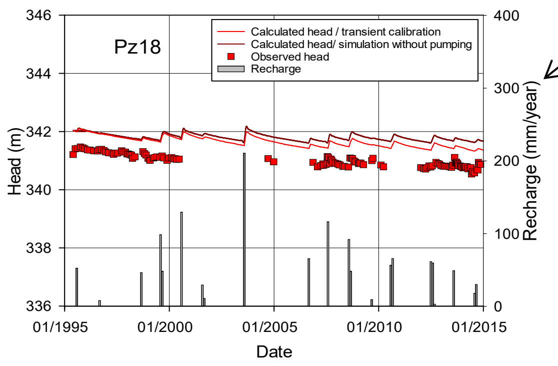
RESULTS

Transient calibration results and simulation without pumping

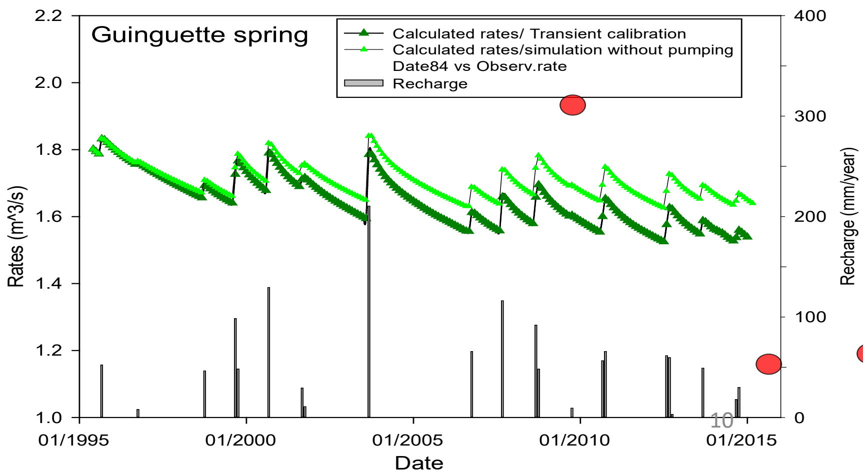








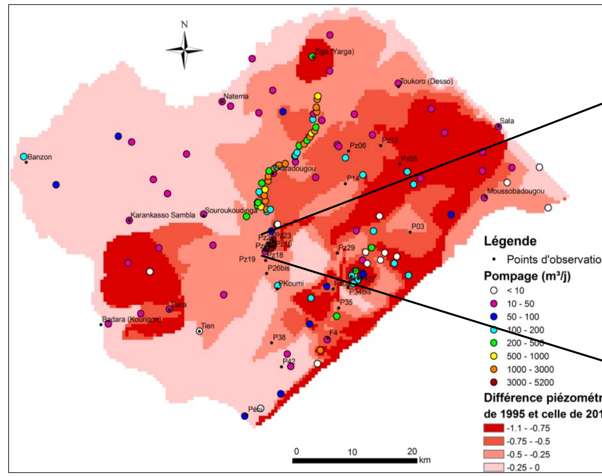
The Guinguette spring simulated and observed flow

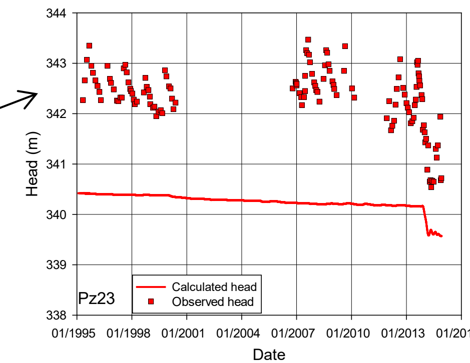


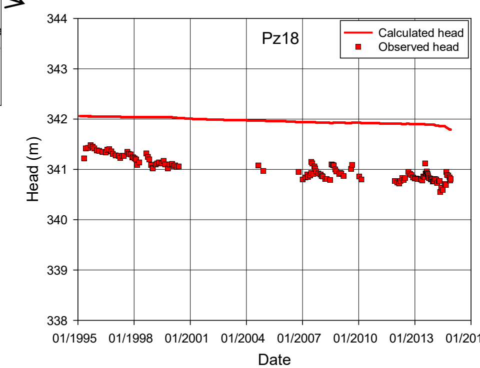
RESULTS

Response of the water table to pumping

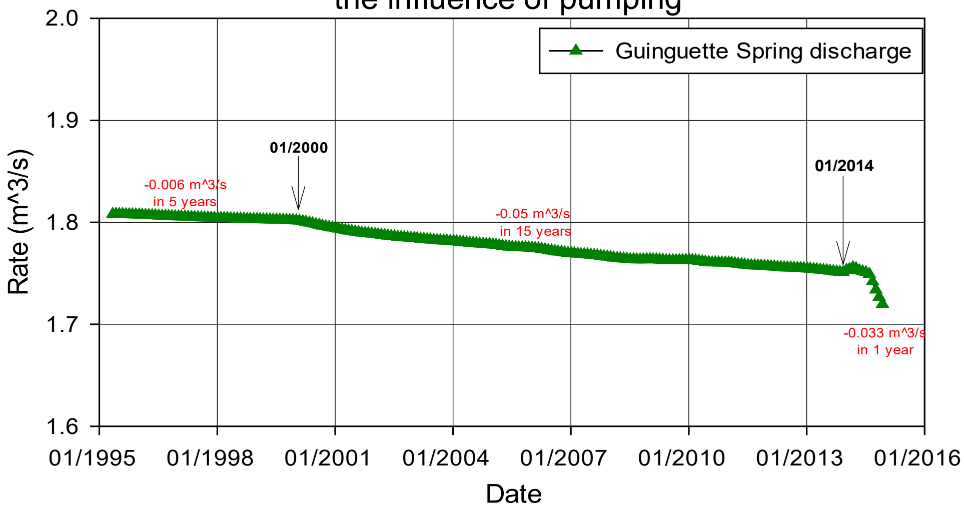
- Drop in the water table from 0.25 to 1 m
- Decrease correlated with the start of large pumping operations
- 30% of the simulated drop at the Guinguette between 1995 and 2014





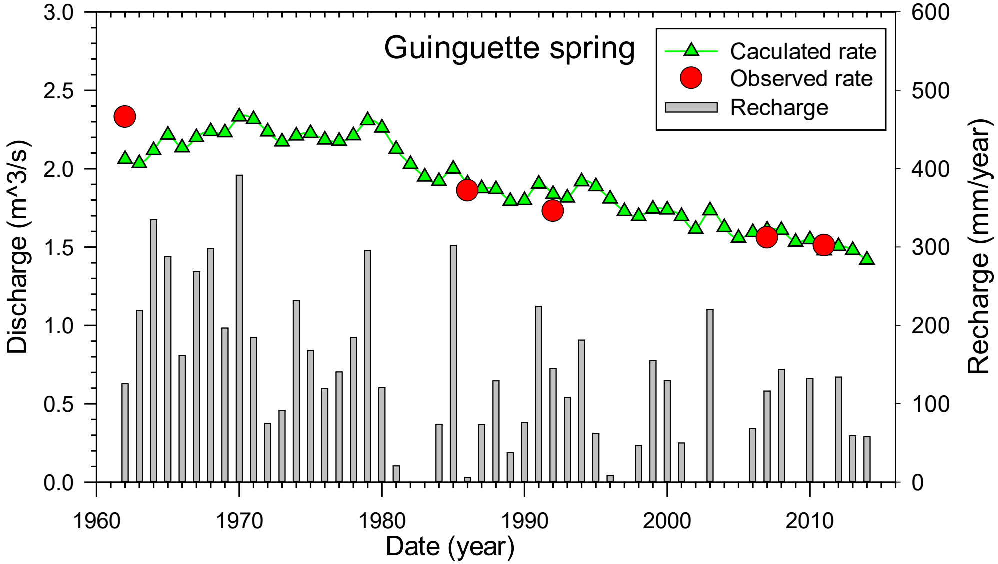


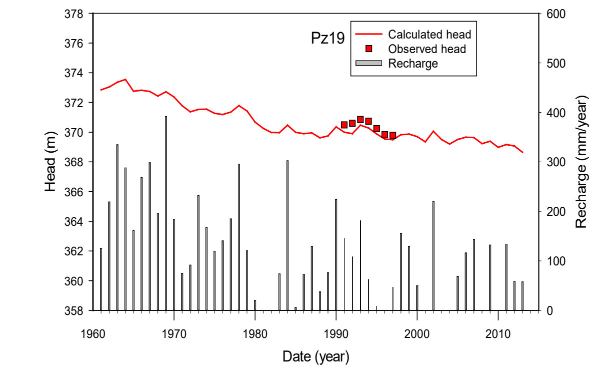
Variation in the discharge of the Guinguette spring under the influence of pumping

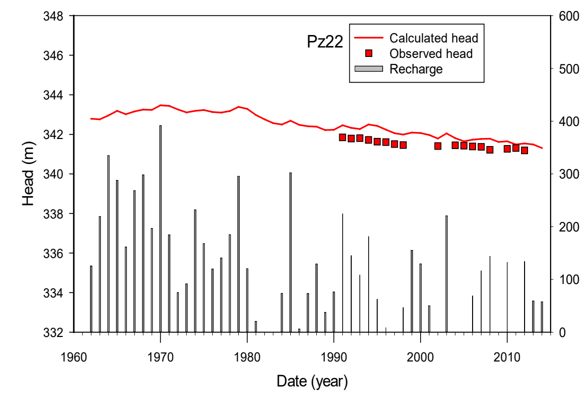


RESULTS

Impact of climate on the water table from 1961 to 2014







- Sensitivity to interannual variations in recharge, which has been on a long-term downward trend since 1979
- The largest decreases occur during periods of zero or very little recharge (below 100 mm/year) over several consecutive years

CONCLUSION AND PERPECTIVES

- The drop in the water table is the result of the combined effect of pumping and the decrease in recharge
- The increase in the occurrence of deficit years since the 1970s leads to a decrease in the water table level
- The increase in pumping over the last 20 years has had significant impacts on the water table
- The population and therefore the need for water will continue to increase and climatic conditions are not expected to improve in West African region
- It will then be necessary to turn to a more efficient use of the resource (Sustainable Development Goals - SDG 6.4 and to integrated management (SDG 6.5).

- Diversify the areas of withdrawals and seek the most productive areas
- Use this model as a management tool to analyze the impact of future pumping positions and thus help select optimal position
- Use the model to monitor the evolution of the water table to prevent a drop to a critical level by defining alert thresholds in the model
- Use to evaluate the impact of future climate change

THANK YOU
FOR YOUR ATTENTION