Groundwater-levels and seawater intrusion: a conceptual analysis of Paramali Aquifer, Cyprus

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Aims & Objectives

AIMS:

- Create a conceptual understanding of the aquifer
- Assess groundwater-levels interactions with changes in precipitation and abstraction.
- Explore the relationship between groundwater-levels and salinity, focusing on droughts and adaptive strategies (groundwater management).

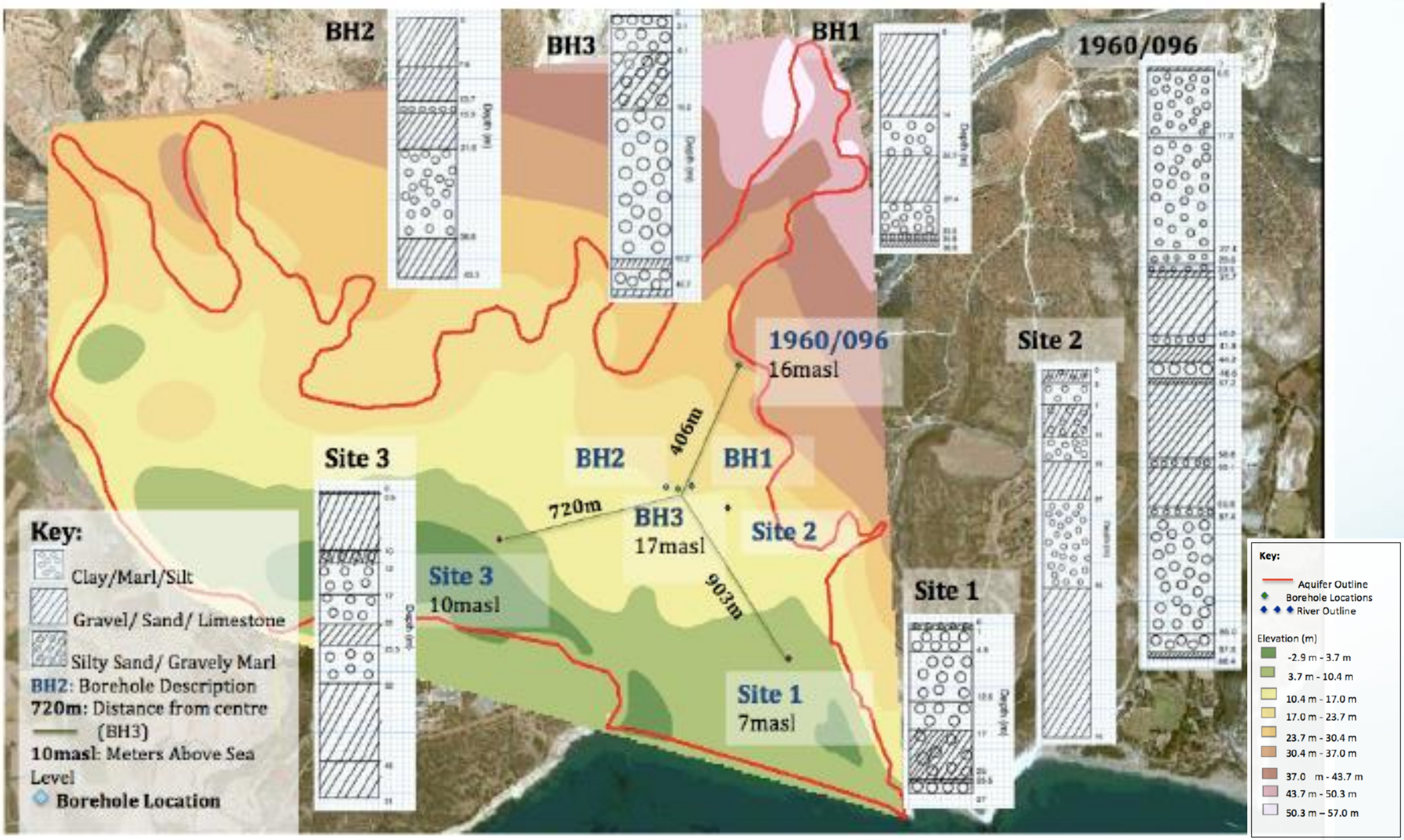
OBJECTIVES

- Examine whether groundwater recharge is biased to heavy rain
- Examine the relationship of both groundwater withdrawals and rainfall
- Assess temporal and spatial changes in salinity using chloride concentrations.

Study Area- Paramali Village

- 220 inhabitants (2011 census)
- Main Agriculture: vineyards, citrus and olive trees
- Average Rainfall: 464mm/year
- 3.8km2 Aerial Extent
- >80 boreholes (2 by WDD, 3 by MOD, rest are private boreholes)
- Use: Monitoring and Abstraction
  - Consumption for Western Sovereign Base Area- Episkopi and Akrotiri
  - Agricultural purposes

Study Area- Paramali Aquifer



Methodology

- Long term trends of Graphical Representations
- Analysis of changes between hydrological years
- Pearson Moment Correlation Coefficient (PMCC).

Figure 3.1: Water Sample Collection for WSBA boreholes (BH1-BH3)

Model

1. Assess the interaction between groundwater recharge and discharge

$$h_{t+1} = h_0 + \frac{R_t - D_t}{Sy}$$

Where: (equation 1)

- h_{t+1} : Change in groundwater levels
- h_0 : Initial groundwater levels
- R_t : Recharge time series
- D_t : Discharge time series
- Sy : Specific yield

Model

2. Cooper- Jacob Relationship- to calculate induced discharge (degree abstraction influences groundwater levels)

$$s = \frac{2.303Q}{4\pi T}\log\left(\frac{2.25Tt}{r^2 S}\right)$$

Where:

- Q : pumping rate (m^3/month)
- r : radial distance from pumping well to observation well (m)
- s : drawdown (m)
- S : storativity (dimensionless)
- t : elapsed time since start of pumping (month)
- T : transmissivity (m^2/month)

$$D_{ta} = \frac{Q_t}{A} \qquad \text{(equation 5)}$$

Where:

- D_{ta} : Induced discharge time series
- Q_t : Abstraction time series
- A : Area of influence

Model

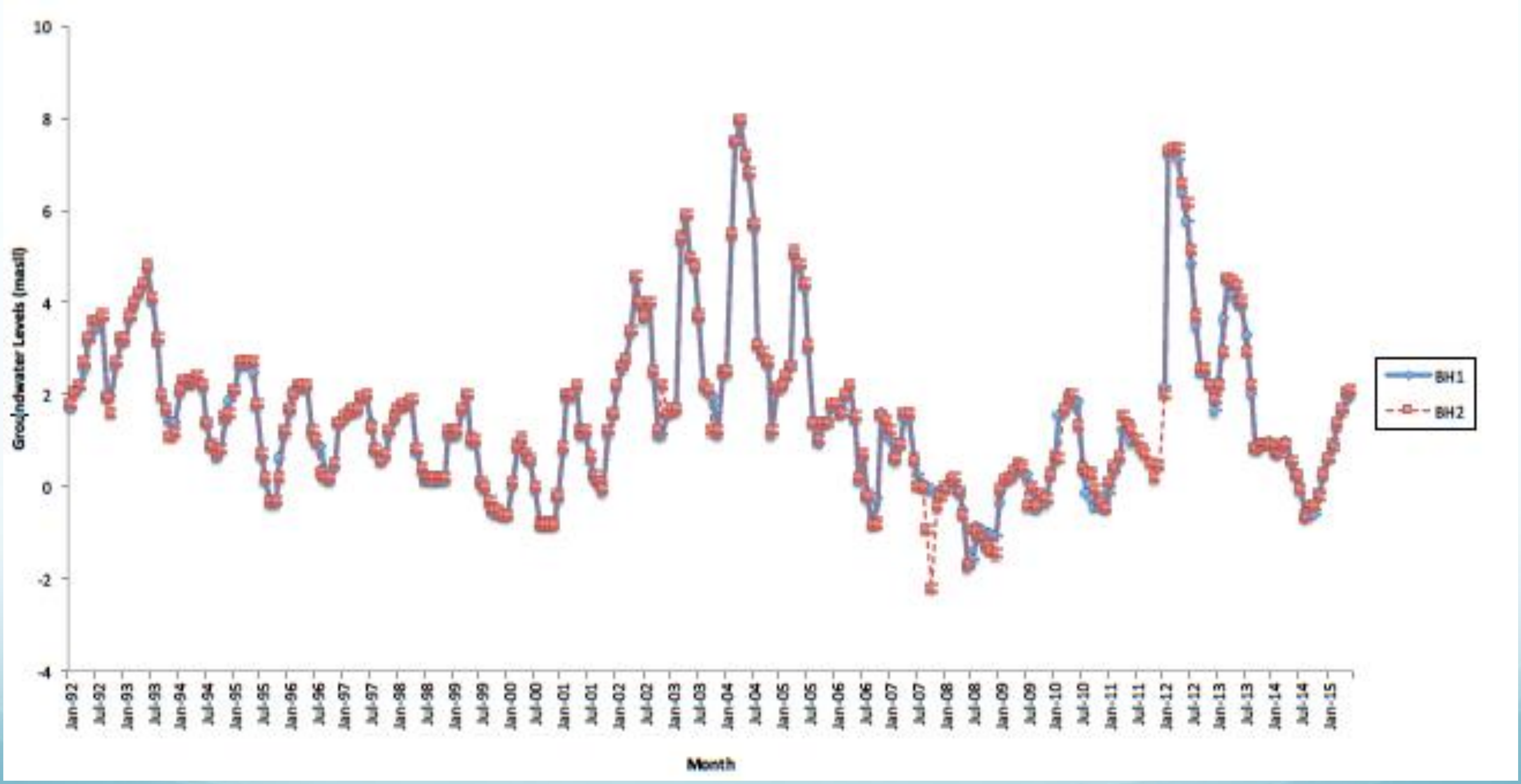
3. Calibrate the Model- Nash Sutcliffe model efficiency

$$E = 1 - \frac{\sum_{t=1}^{T}(Q_o^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_o^t - \overline{Q_o})^2} \qquad \text{(equation 6)}$$

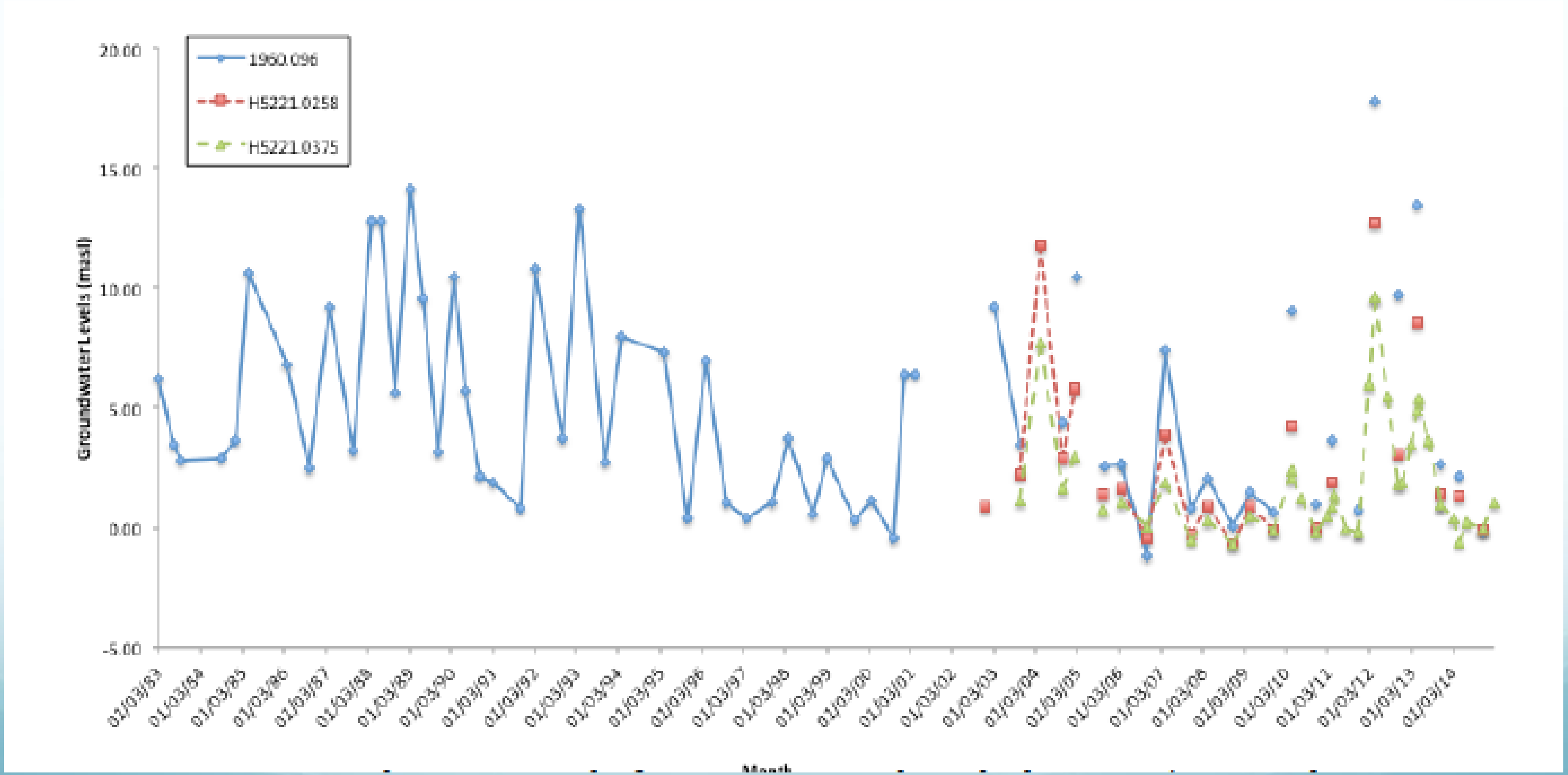
Where:

- E : Nash-Sutcliffe model efficiency coefficient
- Q_o^t : Observed data
- Q_m^t : Simulated Data
- $\overline{Q_o}$: Average of Observed Data

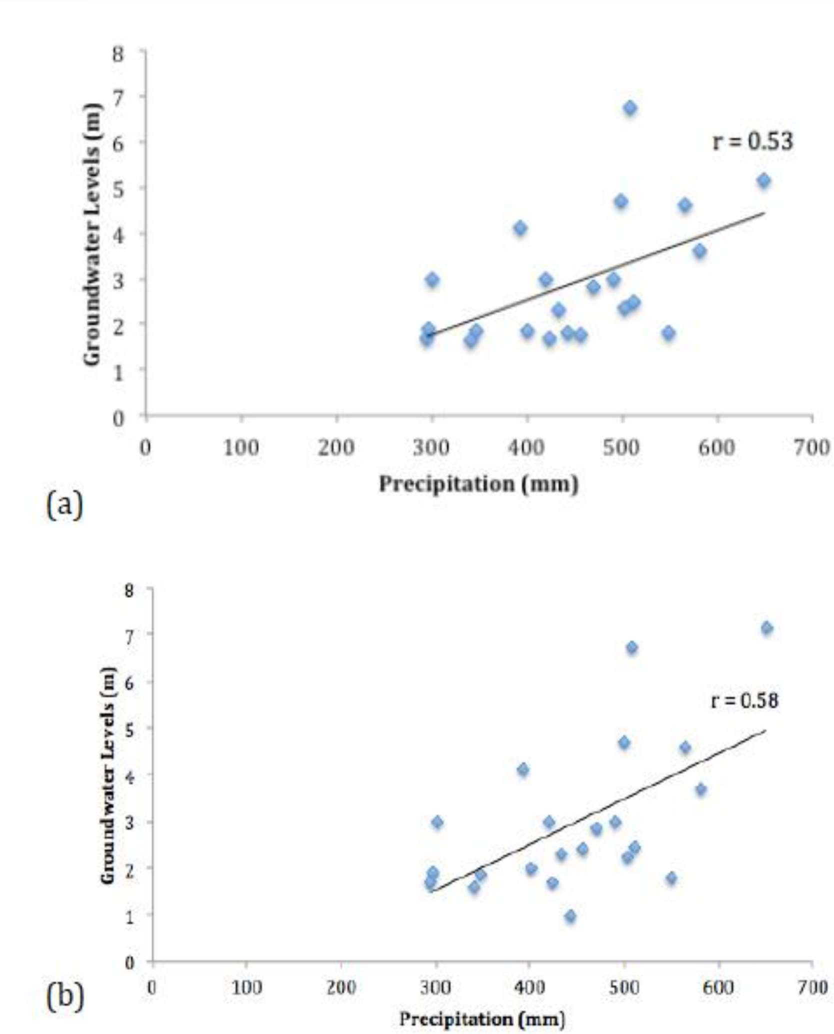
Results: Paramali Aquifer over time

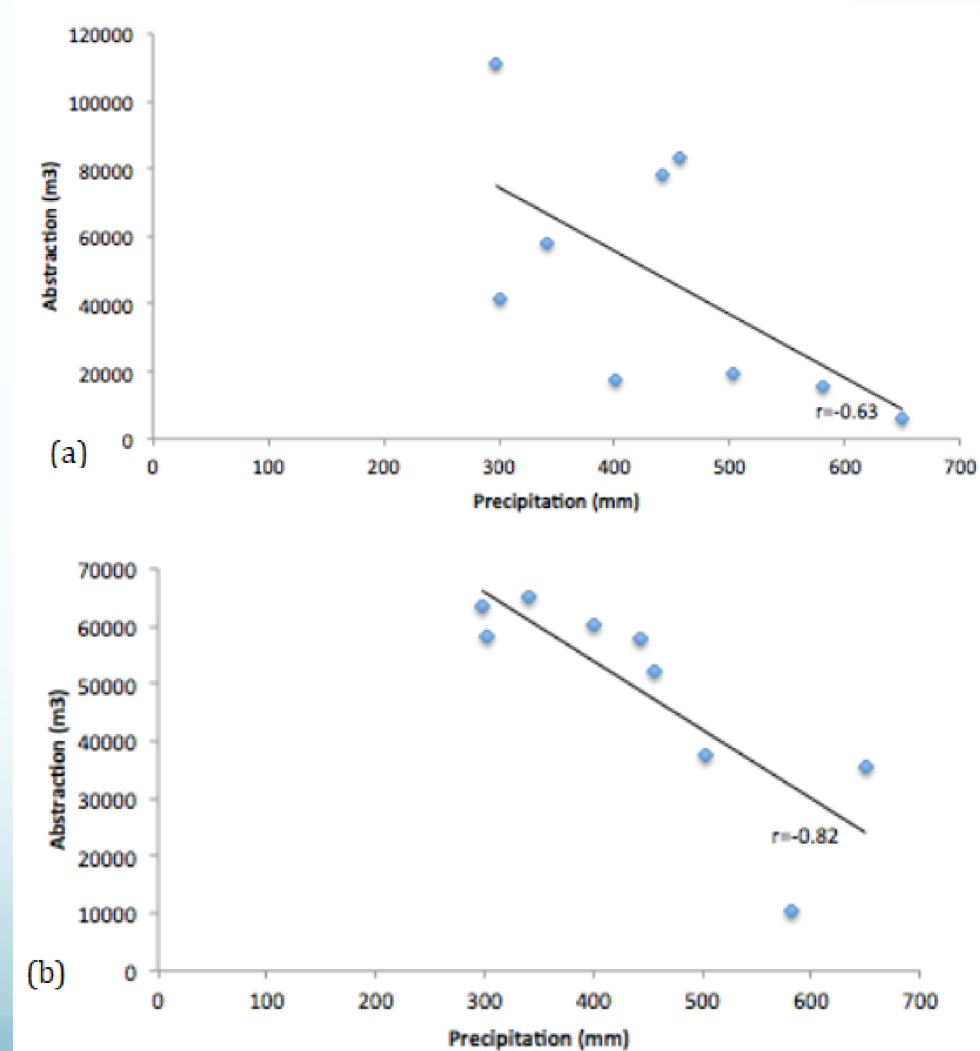


Results: Paramali Aquifer over time

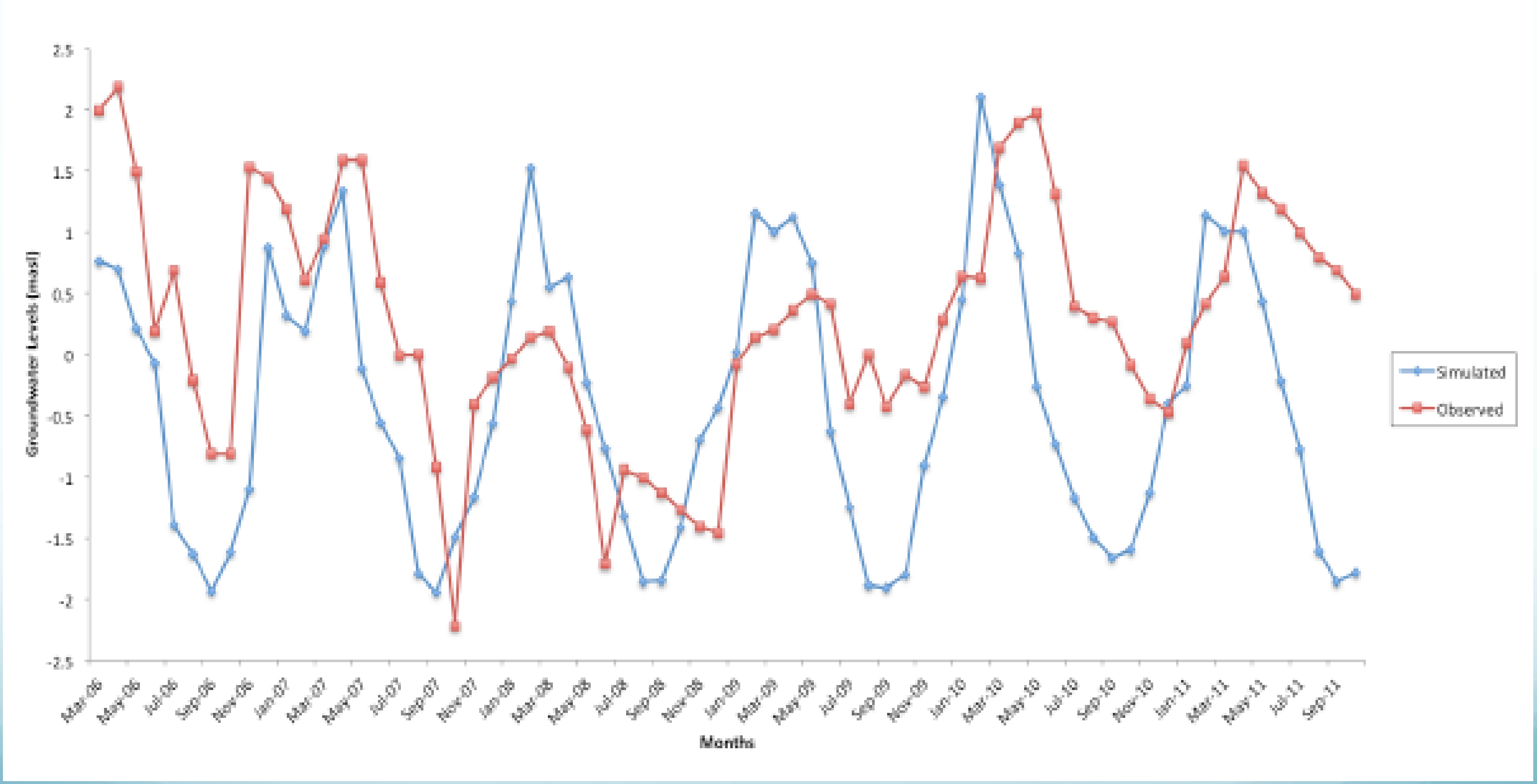


Relationship of Groundwater levels with Precipitation and Abstraction

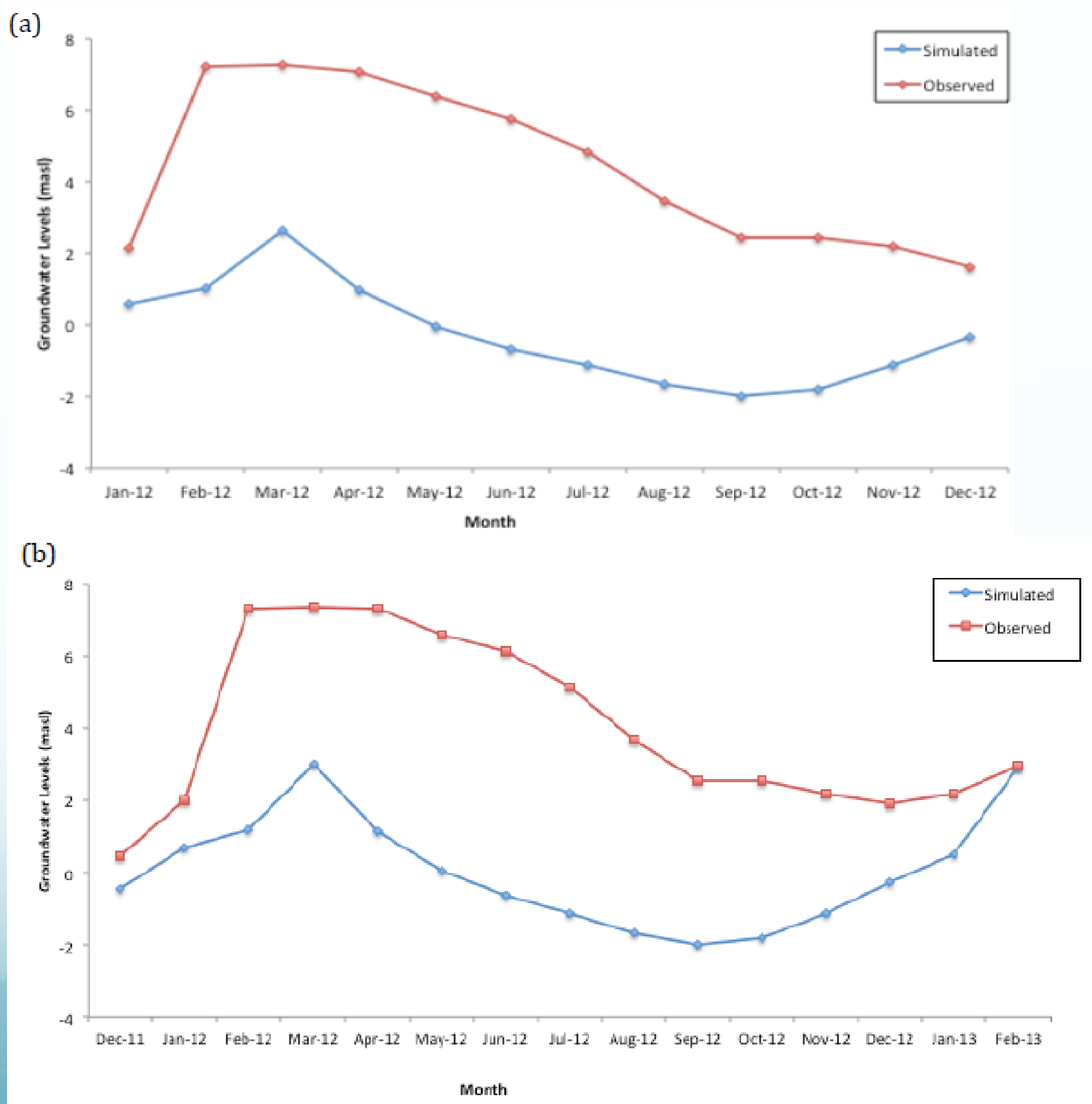




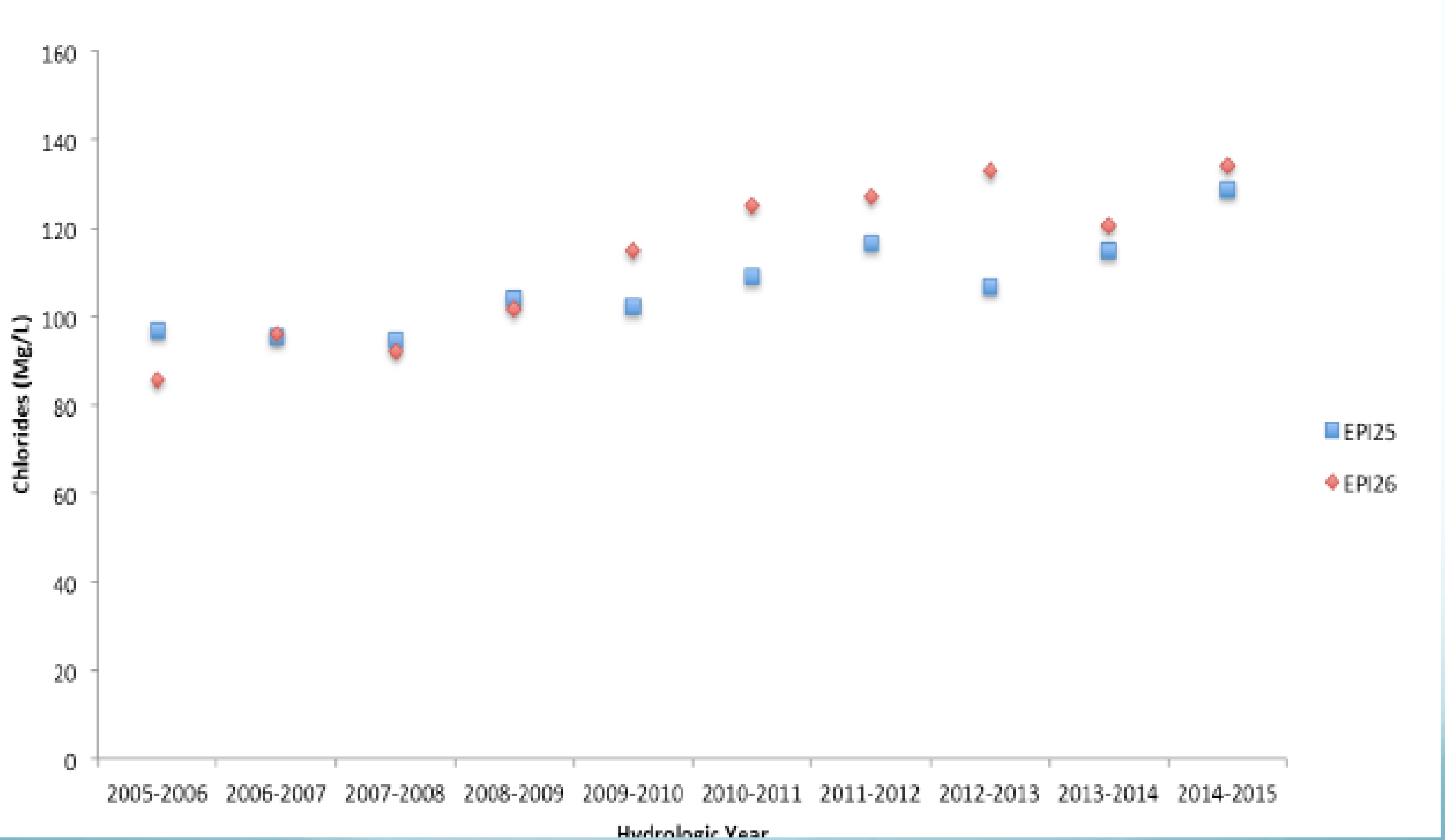
Model Results



Managed Aquifer Recharge



Salinity



160
140
120
100
80
60
40
20
0
Chlorides (Mg/L)
2005-2006
2006-2007
2007-2008
2008-2009
2009-2010
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
EPI25
EPI26

Salinity

EPI21

EPI20

Concluding Remarks

- Seasonal rainfall is the driving force
- Heavy rainfall contributes disproportionately to groundwater recharge
- 2 month time lag (unsaturated zone of 0.25m/day)
- Model creates a baseline of future reactions to future intense rainfall
- Link between groundwater levels and salinity→ remain unclear.
- MAR may be the way forward
- Paramali Aquifer benefits from heavy rainfall and MAR

Further Research

- MAR may alleviate groundwater stresses
- MAR may mitigate drought effects
- Able to predict future climate change impacts
- Recognise the evaluations deduced in this study and extend how groundwater-levels may be influenced by climate change considering the CMIP3 data.

Thank you for you time!

Questions?