The mechanism of groundwater fluctuations induced by sea tide in unconfined aquifers

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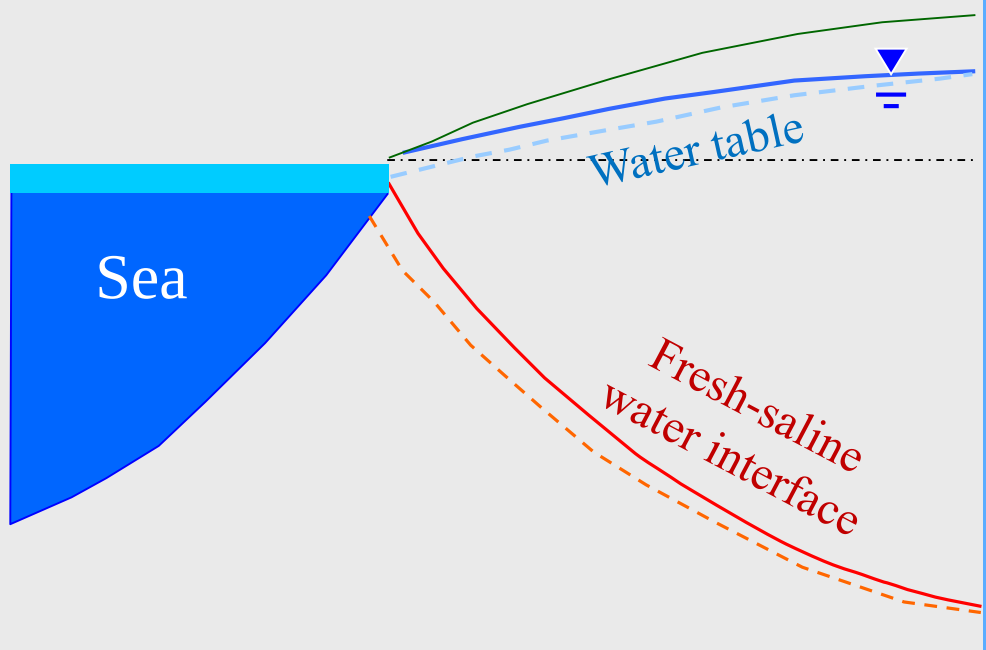
Short Introduction

Sea tides cause:

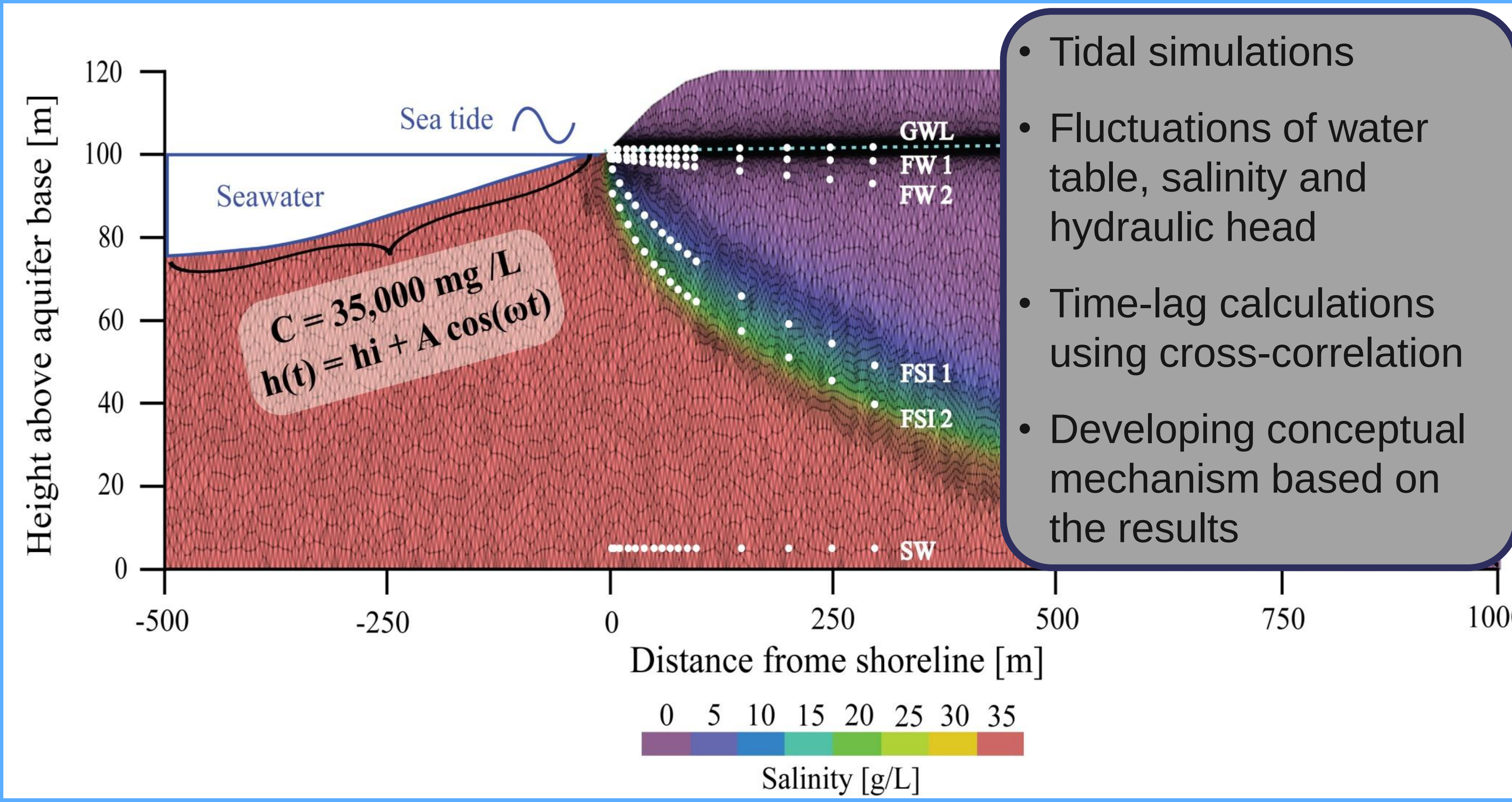
- Water table fluctuations
- Fresh-saline water interface fluctuations



- **Does the water table and the fresh-saline water interface (FSI) fluctuate simultaneously?**
- **What is the mechanism and dynamics of the coastal groundwater system?**

Methods 1. Numerical model

Theory - based on 2D numerical model (Feflow)

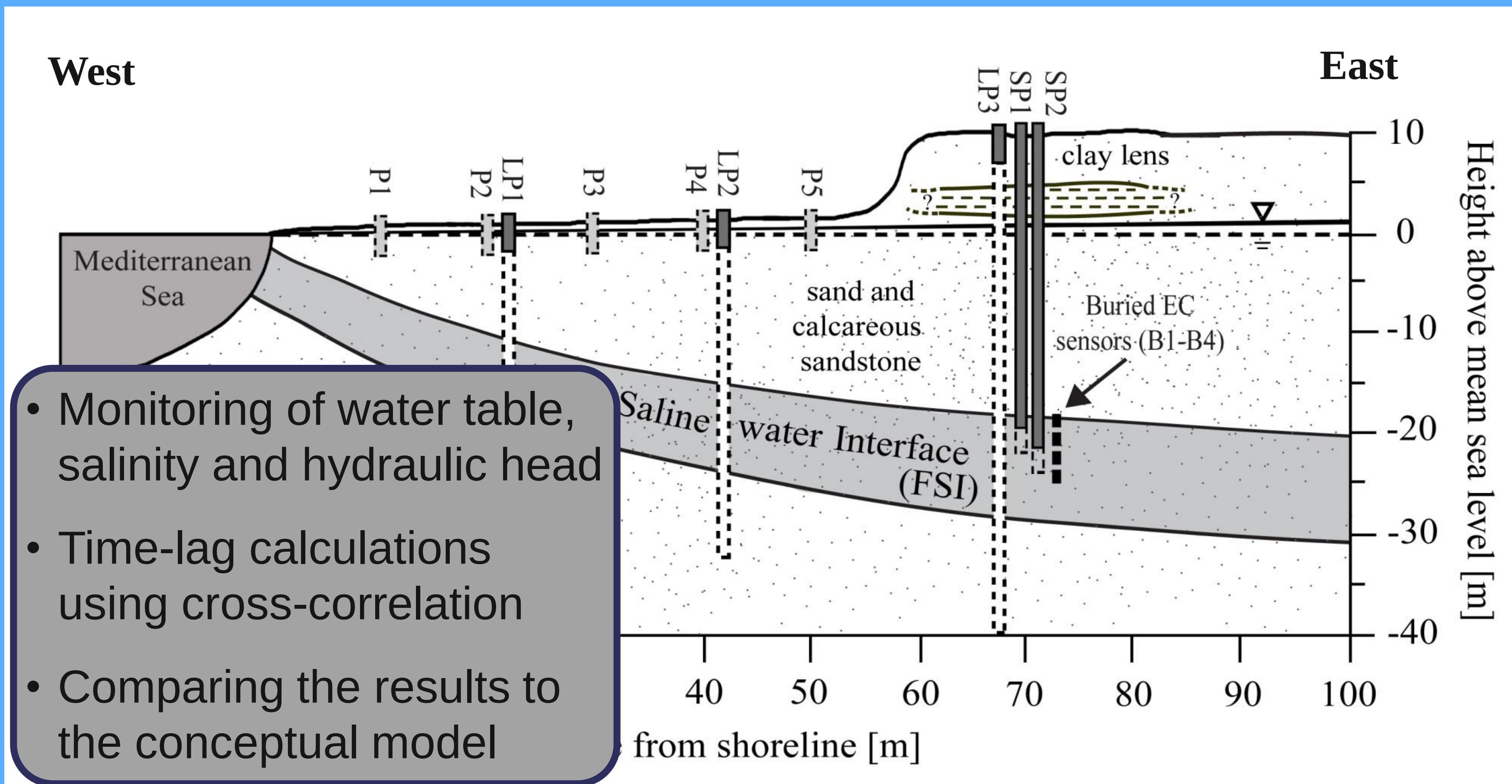


- Tidal simulations
- Fluctuations of water table, salinity and hydraulic head
- Time-lag calculations using cross-correlation
- Developing conceptual mechanism based on the results

Levanon et al., 2016. ADWR

Methods 2. Field observation

Coastal aquifer of Israel



- Monitoring of water table, salinity and hydraulic head
- Time-lag calculations using cross-correlation
- Comparing the results to the conceptual model

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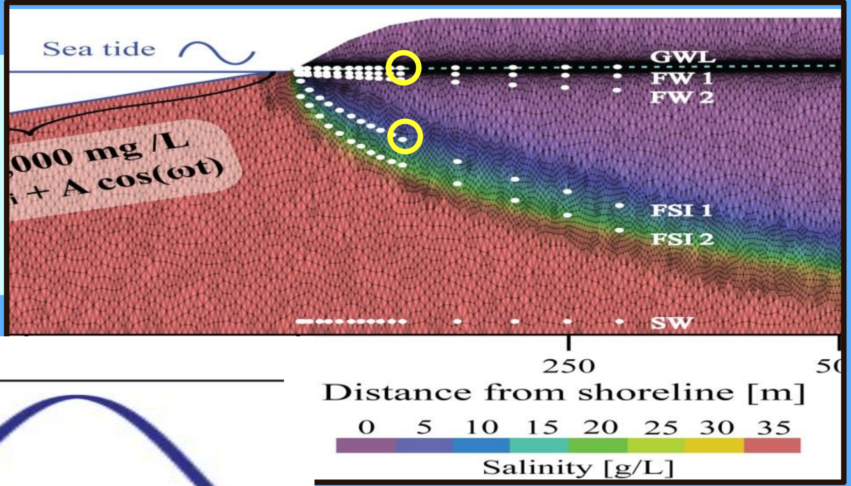
Results

Numerical model

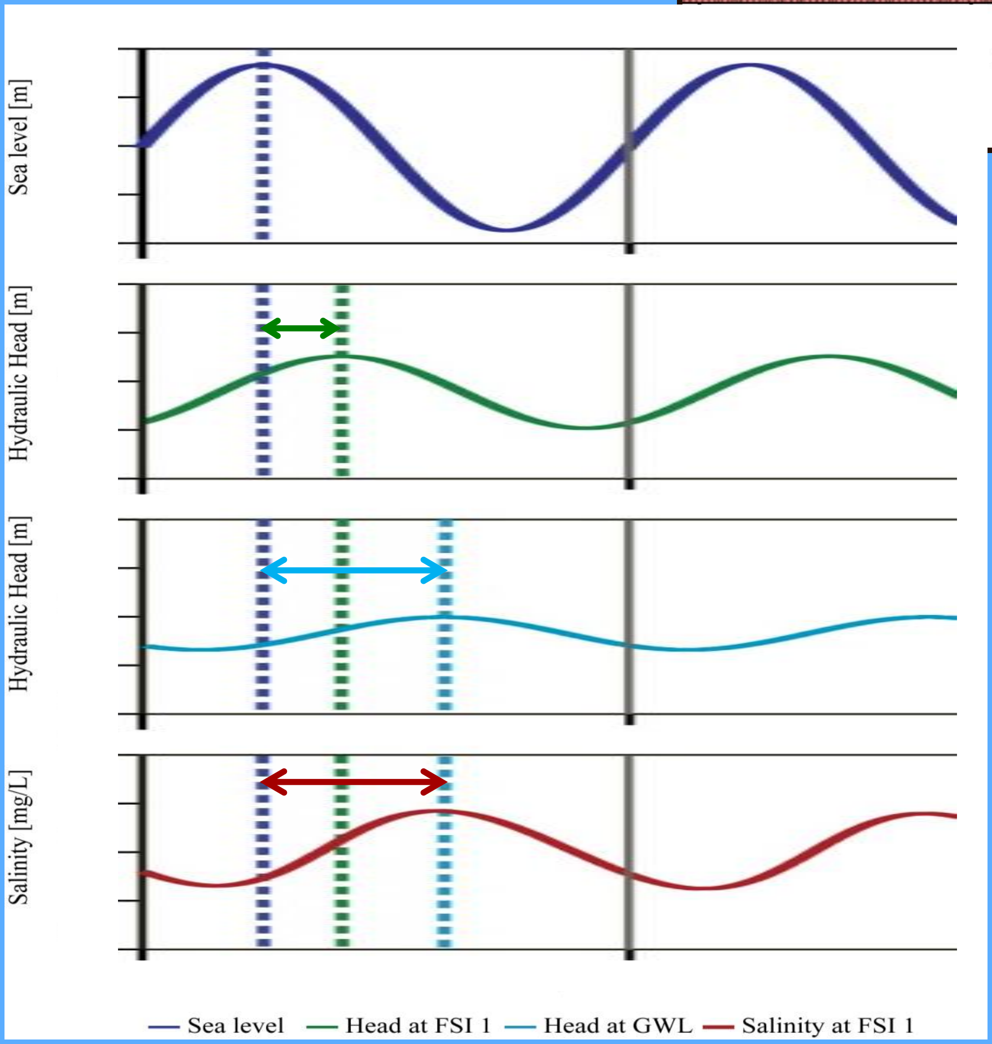


Sea level

Head in the FSI (100 m)

Water table (100 m)

Salinity in the FSI (100 m)



- Different time-lags for water table and hydraulic head in the FSI
- Different time-lags for hydraulic head and salinity in the FSI

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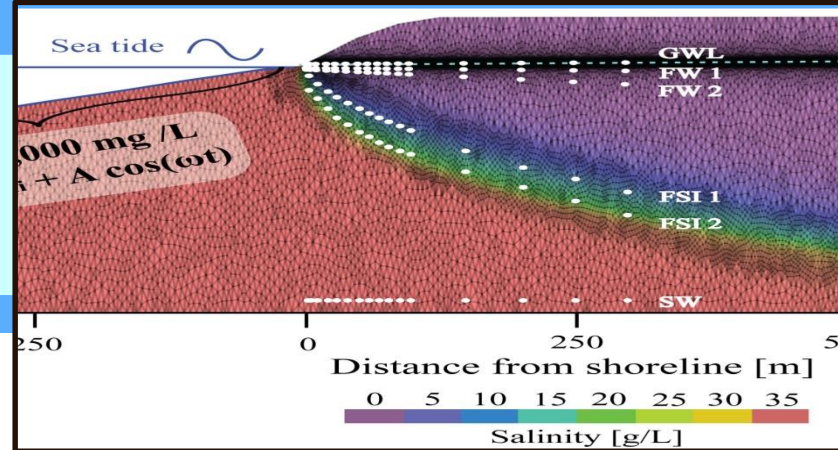
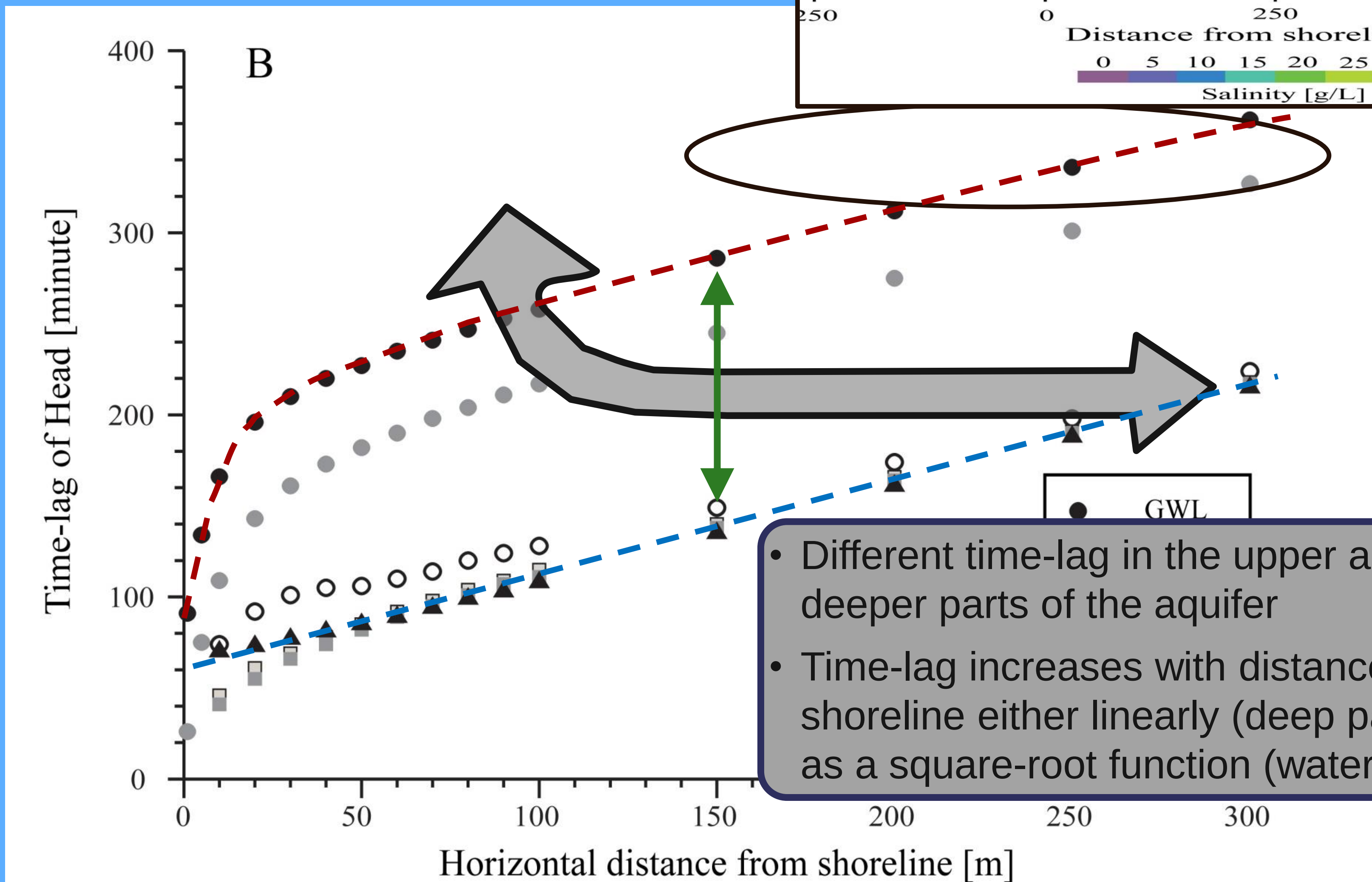
Results

Numerical model





- Different time-lag in the upper and deeper parts of the aquifer
- Time-lag increases with distance from shoreline either linearly (deep parts) or as a square-root function (water table)

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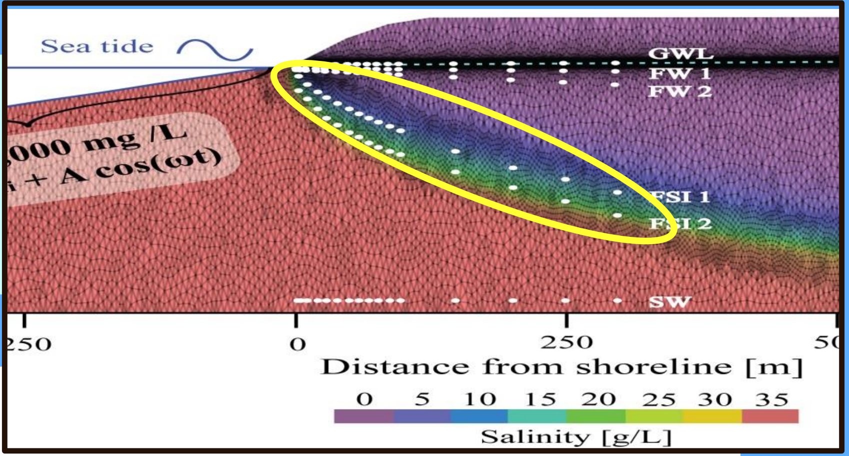
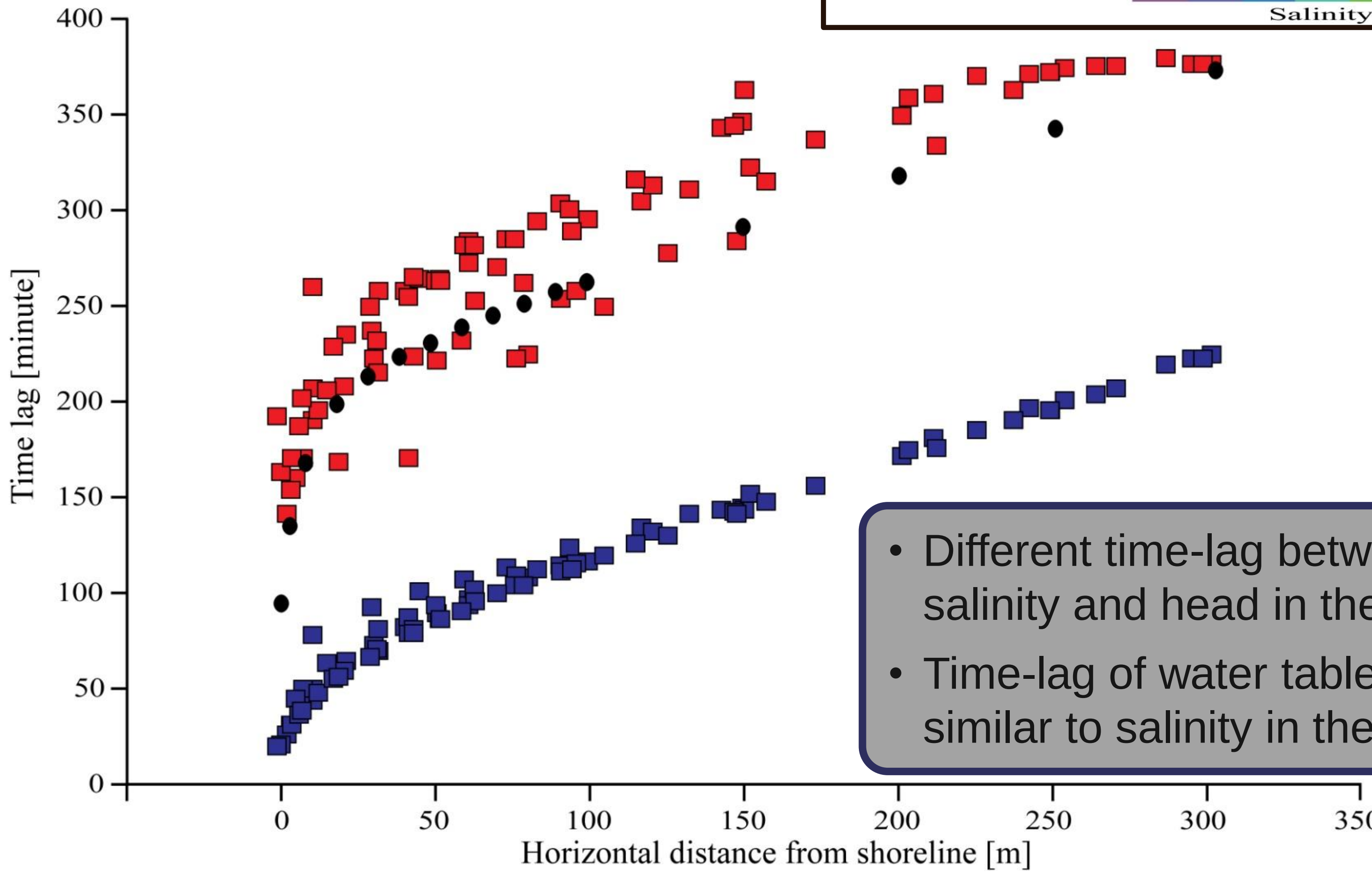
Results

Numerical model





- Different time-lag between salinity and head in the FSI.
- Time-lag of water table is similar to salinity in the FSI.

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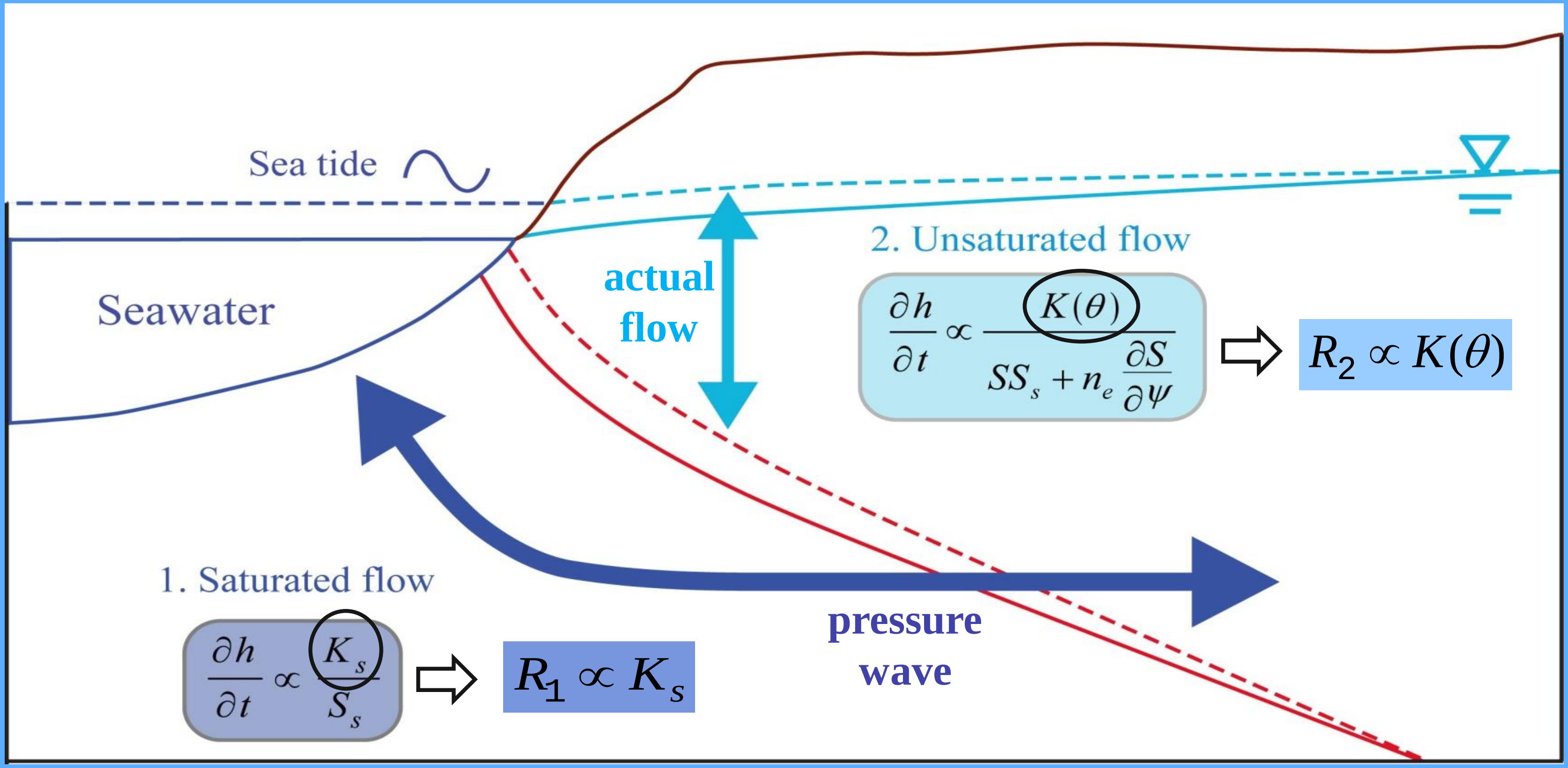
Theoretical mechanism



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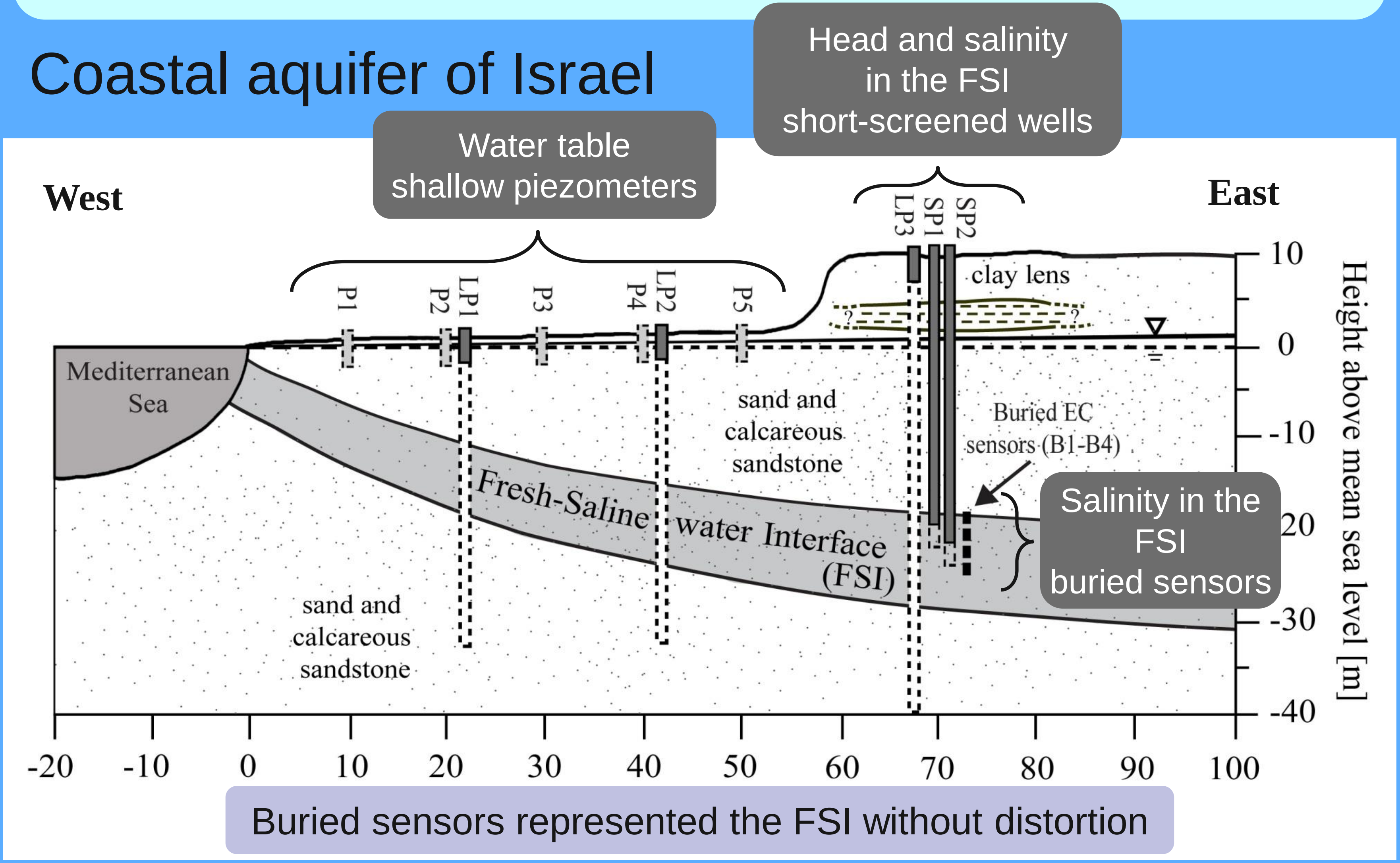
The first process is faster since it controlled by $\boldsymbol{K_s}$,
while the second one is slower since it controlled by $\boldsymbol{K(\theta)}$

Conclusions so far

- Tidal influence composed of two processes, occurring simultaneously:
  1. Pressure wave propagation in the deeper part of the aquifer, controlled by the saturated parameters.
  2. Fluctuations of the fresh water body, controlled by the unsaturated flow in the capillary zone.
- The time-lag of the salinity in the FSI and of the water table is similar, both larger than time-lag of hydraulic head in the FSI.
- The actual flow and solute transport are controlled by the unsaturated flow in the capillary zone.

Field: monitoring set-up

Coastal aquifer of Israel



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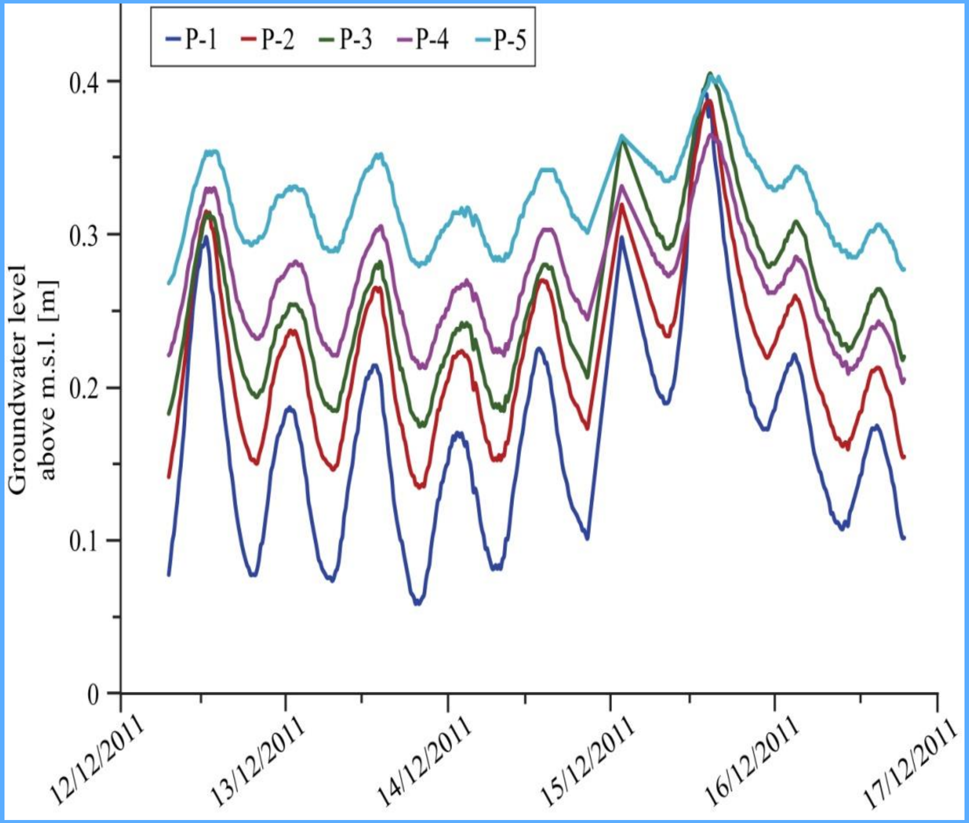
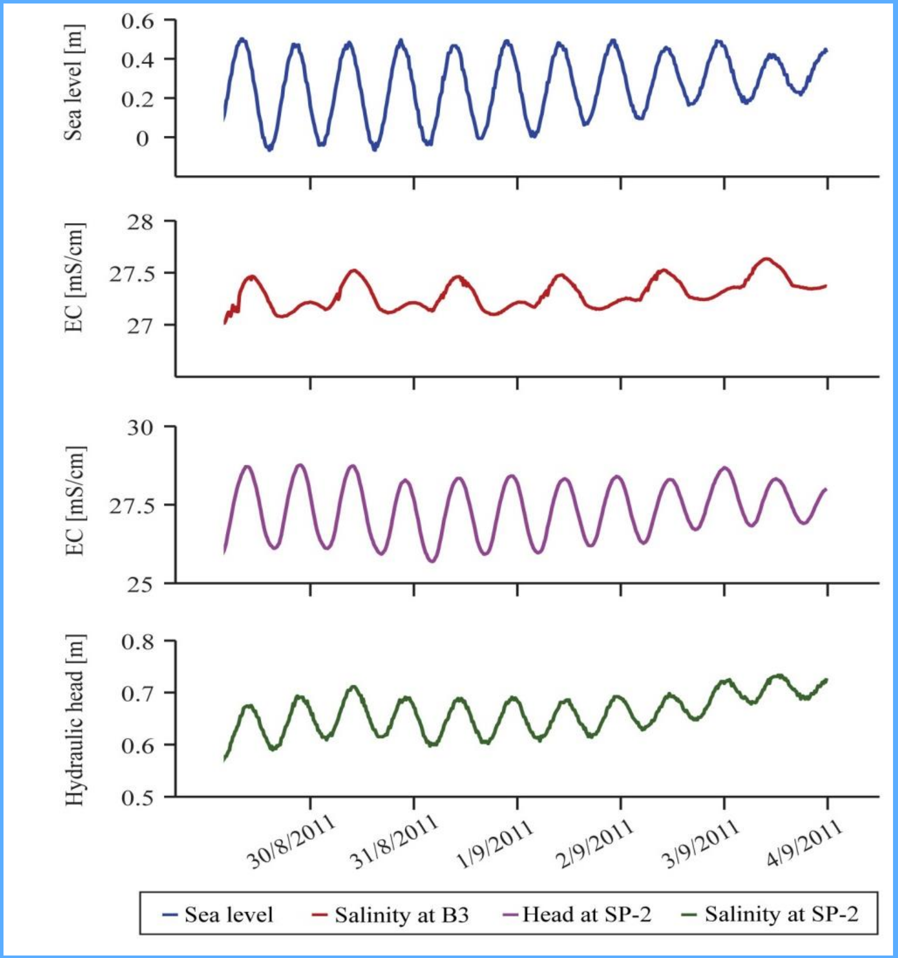
Results Field: raw data

Head and salinity in the FSI

Water table fluctuations





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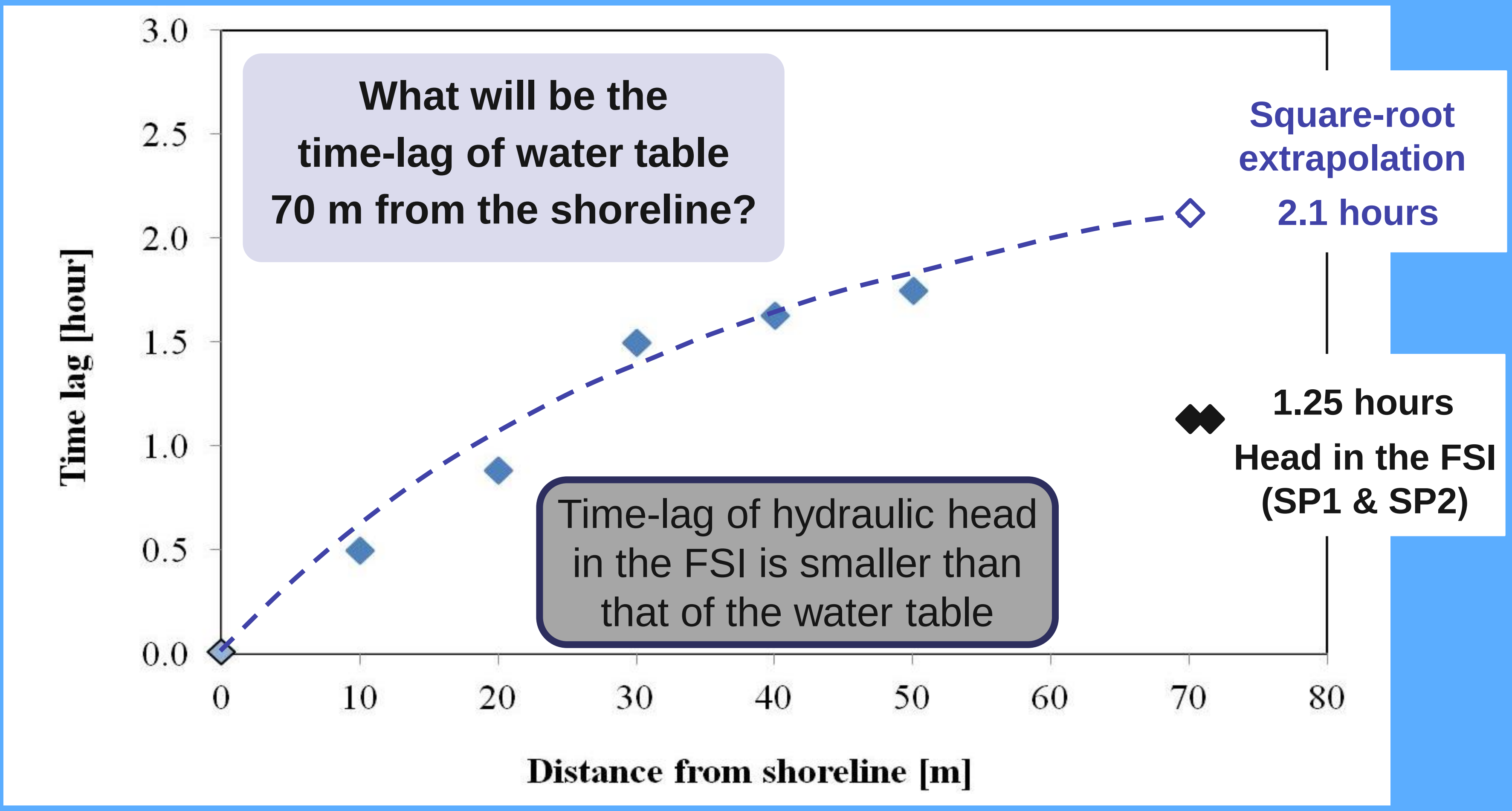
Results Field: time-lag

Time-lag of water table



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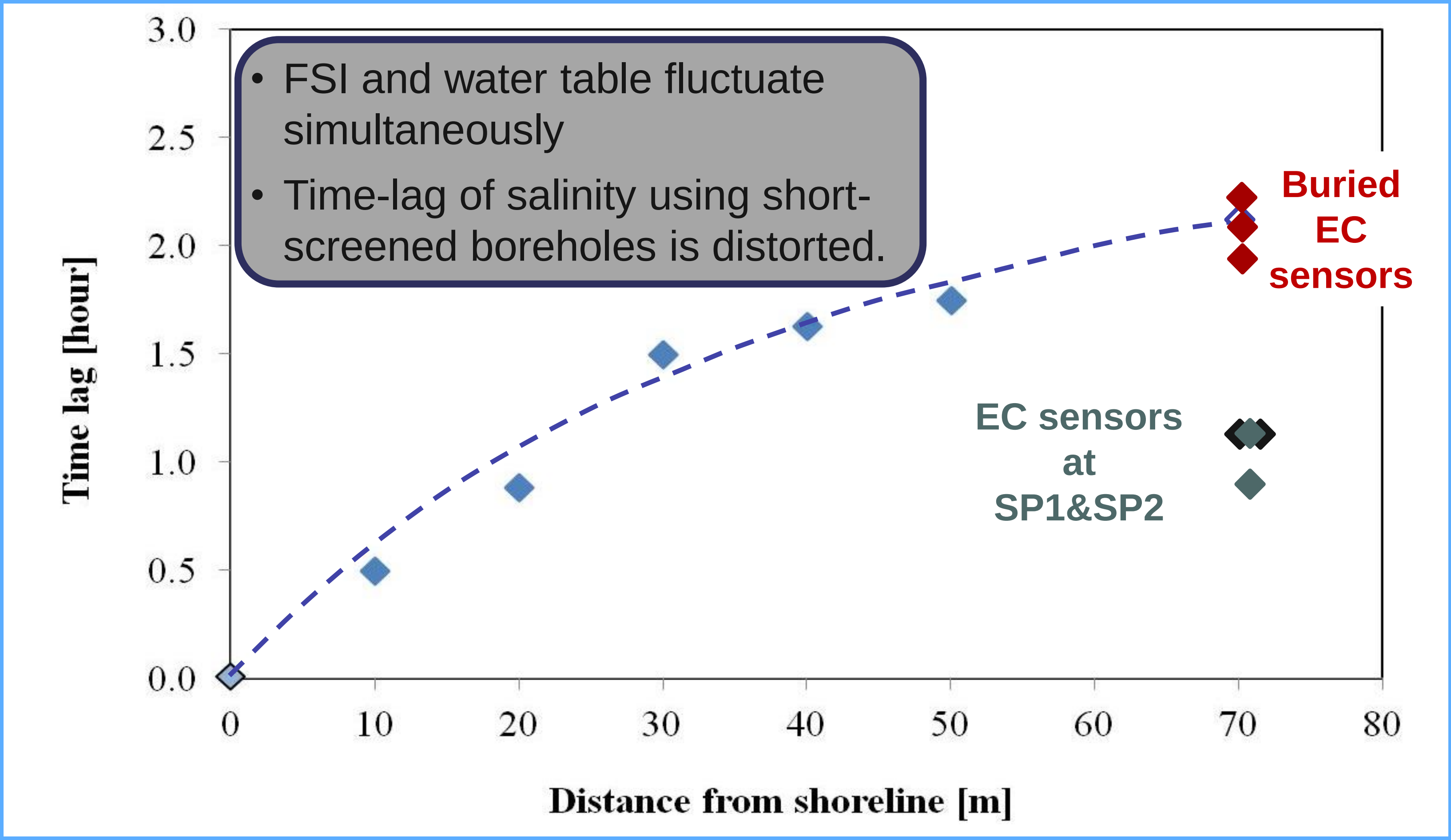
Results Field: time-lag

Time-lag of salinity in the FSI



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Conclusions

- In general - field results are in good correlation with the numerical model.
- Numerical and field results indicate mechanism which includes two processes:

  1. Pressure wave propagation, controlled by saturated parameters.
  2. Actual water fluctuations, controlled by unsaturated parameters.

- Hydraulic head fluctuations in the deeper part of the aquifer is faster than the actual flow, since it controlled by the pressure wave (first process).
- Water table and the salinity in the FSI fluctuate simultaneously, since both controlled by the unsaturated flow (second process).
- In the short-screened boreholes only the first process influence, since there is no capillary zone in the borehole.


Thanks!