Food and Agriculture Organization of the United Nations

Managing salt-affected soils for sustainable future

Optimising leaching practice in saline and sodic soils using modelling approach

2nd Meeting of the International Network of Salt-Affected Soils (INSAS)

M. REZAEI; H. REZAEI; R. MIRKHANI; N. DAVATGAR;

Soil and Water Research Institute (SWRI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran;

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International Network of Salt-Affected Soils

Meisam.rezaei1@gmail.com

SWRI Soil & Water Research Institute 1952

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Introduction

- To promote crop productivity the accumulated excessive soluble salts in the rootzone of arid and semi-arid irrigated soils, needs to leach.

- But how much water and when?

- Traditional leaching requirement (LR) calculation and application seems not to be the appropriate and effective practice in such regions (Corwin et al., 2012).

The problem statement...

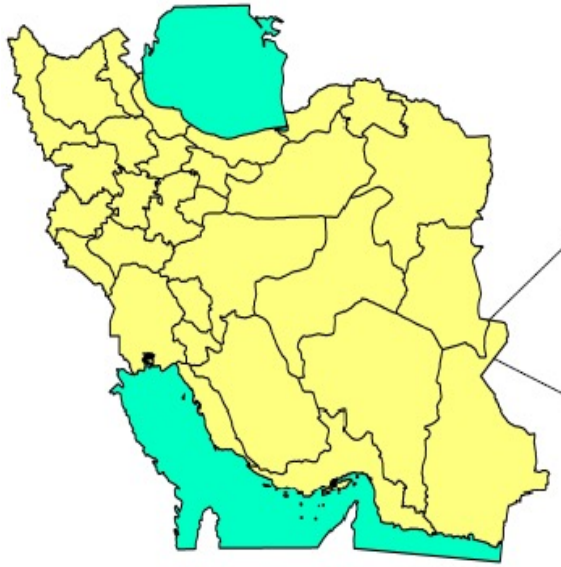
Evaluating the leaching practice and optimising LR in saline and sodic soils using modelling approach

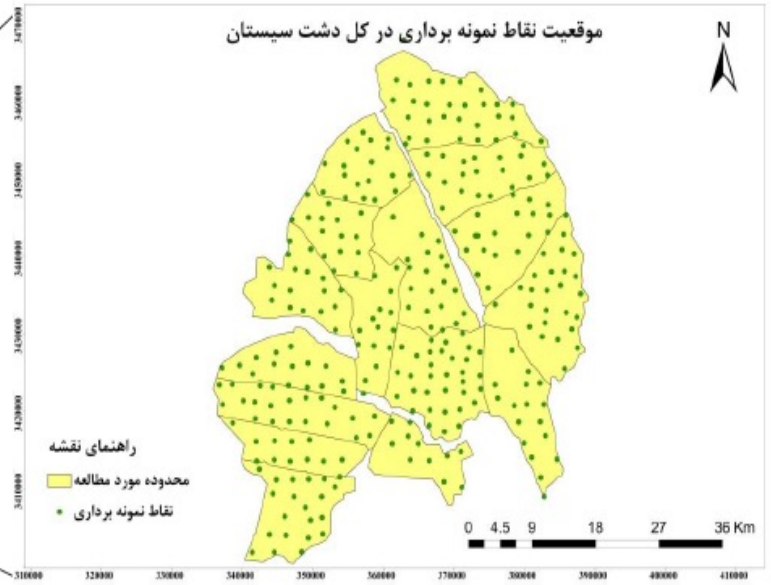
Objective

Optimizing leaching requirement and salute transport by taking into account the transient conditions in the southeast of Iran with sever salinity and sodicity conditions using Hydrus-1D

A case study: Sistan plain

- 46000 ha
- Extreme Dry climate
  - Rainfall (55 mm/year)
  - Temperature (mean max 34.5, mean min 8.5° C)
- Limitations:
  - water scarcity and salinity
- Source of salinity:
  - Dissolution of solutes
  - Wind erosion
  - Evaporation (~4800 mm/year)
  - Water quality
  - Flood
  - **Agricultural practices/water management**

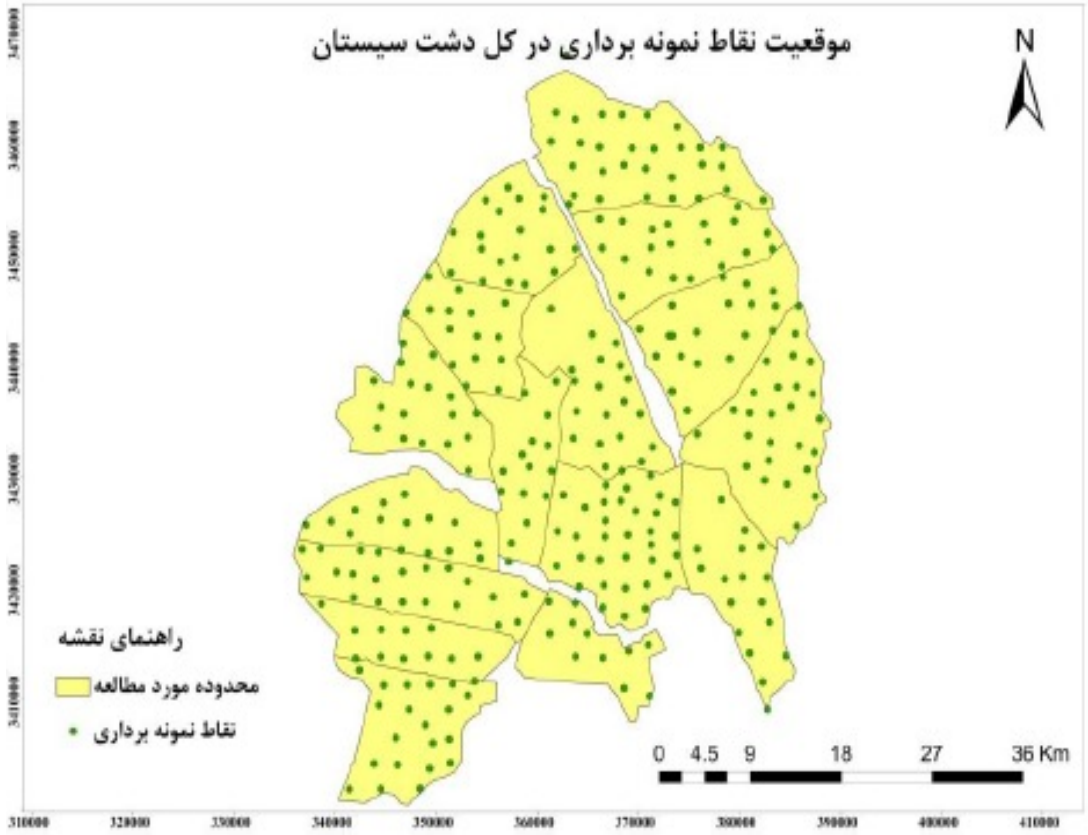




Methods

- 312 soil profiles
- Physiochemical properties
  - Texture
  - Bulk density, SP
  - Surface layer K_{sat} and FC, PWP
  - ECe
  - SAR
  - pH
  - Soluble Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, HCO_3^{-}, Cl^{-}, SO_4^{2-}

- 8 profiles /sites were selected for leaching studies



Methods

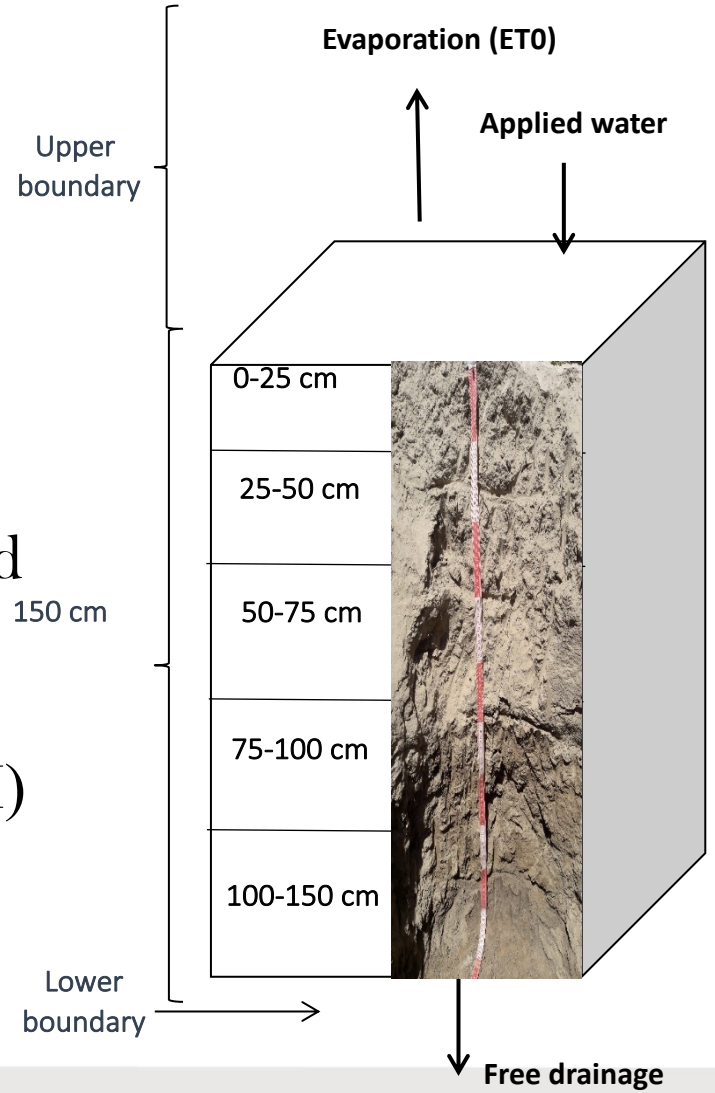
- August to September 2019
- Intermittent/consequent flooding method
- GRP cylinders
- Applied water: 100 cm (4 intervals)
- Chemical composition of applied water
- Soil samples: 0-25, 25-50, 50-75, 75-100 and 100-150 cm

Methods: Model conceptualization

Hydrus 1D (hydrological model):

(Simunek et al 2013)

- Hydraulic model: MVG without air entry value and hysteresis
- Root water uptake model: Feddes model with solute stress
- Upper boundary condition: atmospheric (precipitation, LAI and ETp,)
- Bottom boundary condition: free drainage
- Solute transport module: Major Ion Chemistry (UNSATCHEM)



Methods:

Local SA using python programing

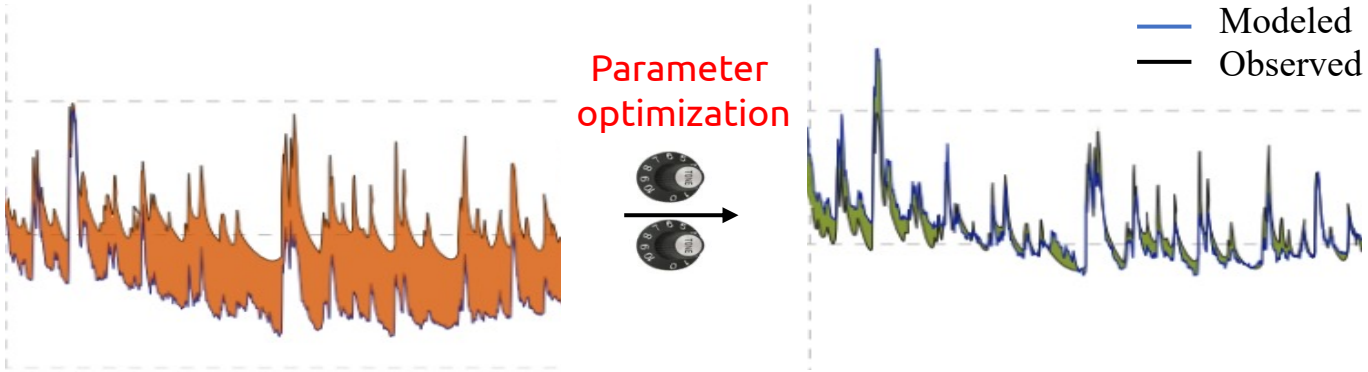
- Hydraulic parameter (*RETC* and *Rosetta*): θ_s, θ_r, α, n , K_{sat}
- Hydrodynamic/Longitudinal dispersivity: D

$$\Delta x_j = p_f . x_j$$

$$\text{CAS} = \frac{\partial y(t)}{\partial x} = \lim_{\Delta x_{j\to 0}} \frac{y(t, x_j + \Delta x_j) - y(t, x_j - \Delta x_j)}{2\Delta x_j}$$

$$\text{CTRS} = \frac{\partial y(t)}{\partial x} . \frac{x_j}{y}$$

Inverse solution



Initial hydraulic parameter set
Initial transport parameter

Optimized transport and hydraulic parameter set

$$C_e = 1 - \frac{\sum_{i=1}^{n}(O_i - S_i)^2}{\sum_{i=1}^{n}(O_i - \bar{O})^2}$$

$$r^2 = \left(\frac{\sum_{i=1}^{n}(O_i - \bar{O})(S_i - \bar{S})}{\sqrt{\sum_{i=1}^{n}(S_i - \bar{S})^2 \sum_{i=1}^{n}(O_i - \bar{O})^2}}\right)^2$$

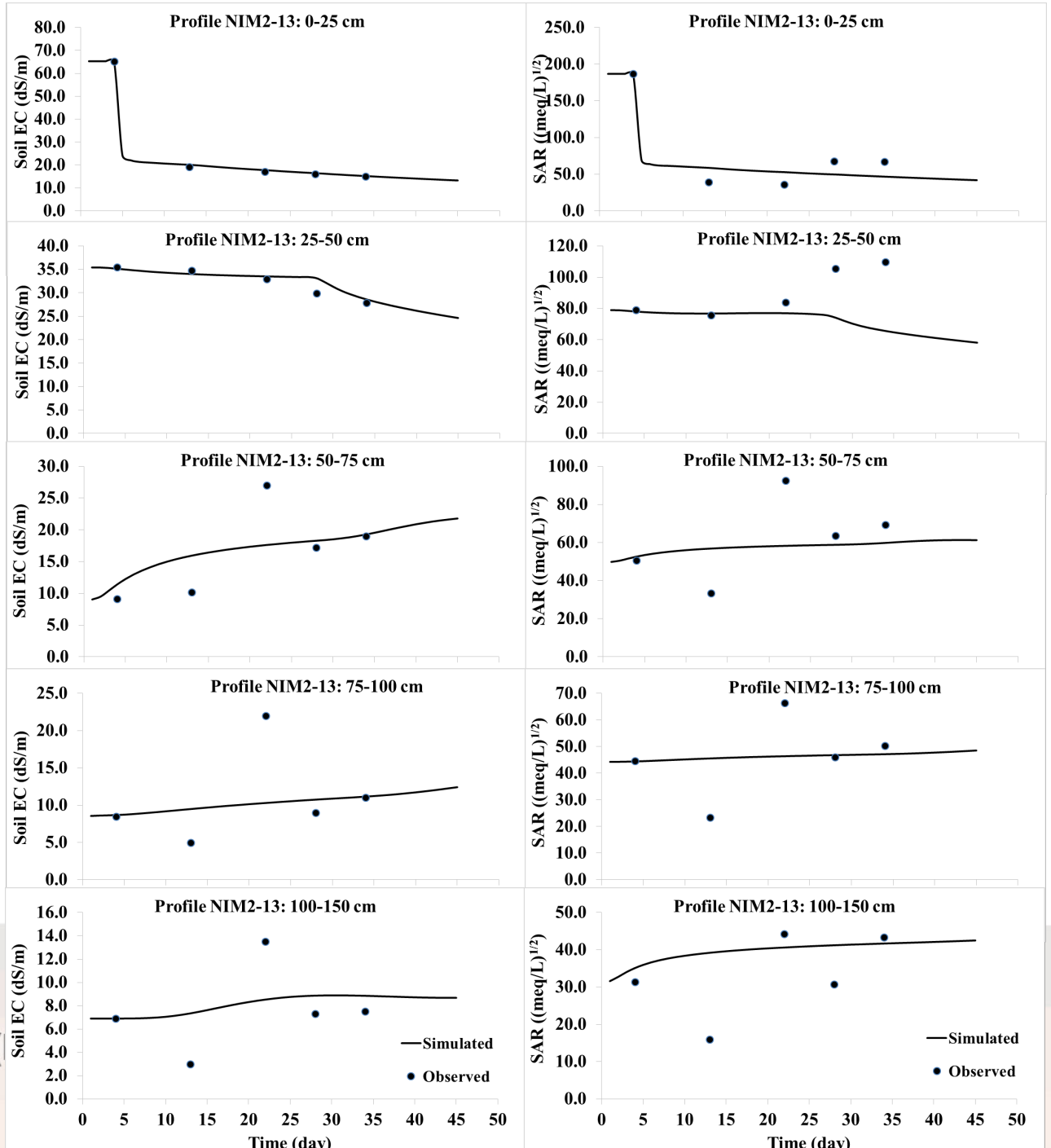
$$RMSE = \sqrt{\frac{\sum_{i}^{n}(O_i - S_i)^2}{n}}$$

Results:

calibration (ECe) and validation (SAR)
Profile NIM2-13

K_{sat} and D were optimized

Validation			Calibration			NIM2-13
Ce	R^2	RMSE	Ce	R^2	RMSE	Depth (cm)
0.91	0.99	16.3	0.99	0.99	0.60	0-25
-2.01	0.7	24.5	0.76	0.78	1.5	25-50
0.05	0.23	19.2	0.39	0.46	5.05	50-75
0.05	0.14	13.4	0.05	0.10	5.6	75-100
-0.27	0.12	11.6	0.15	0.22	3.1	100-150



Much more water is needed (>200 cm)

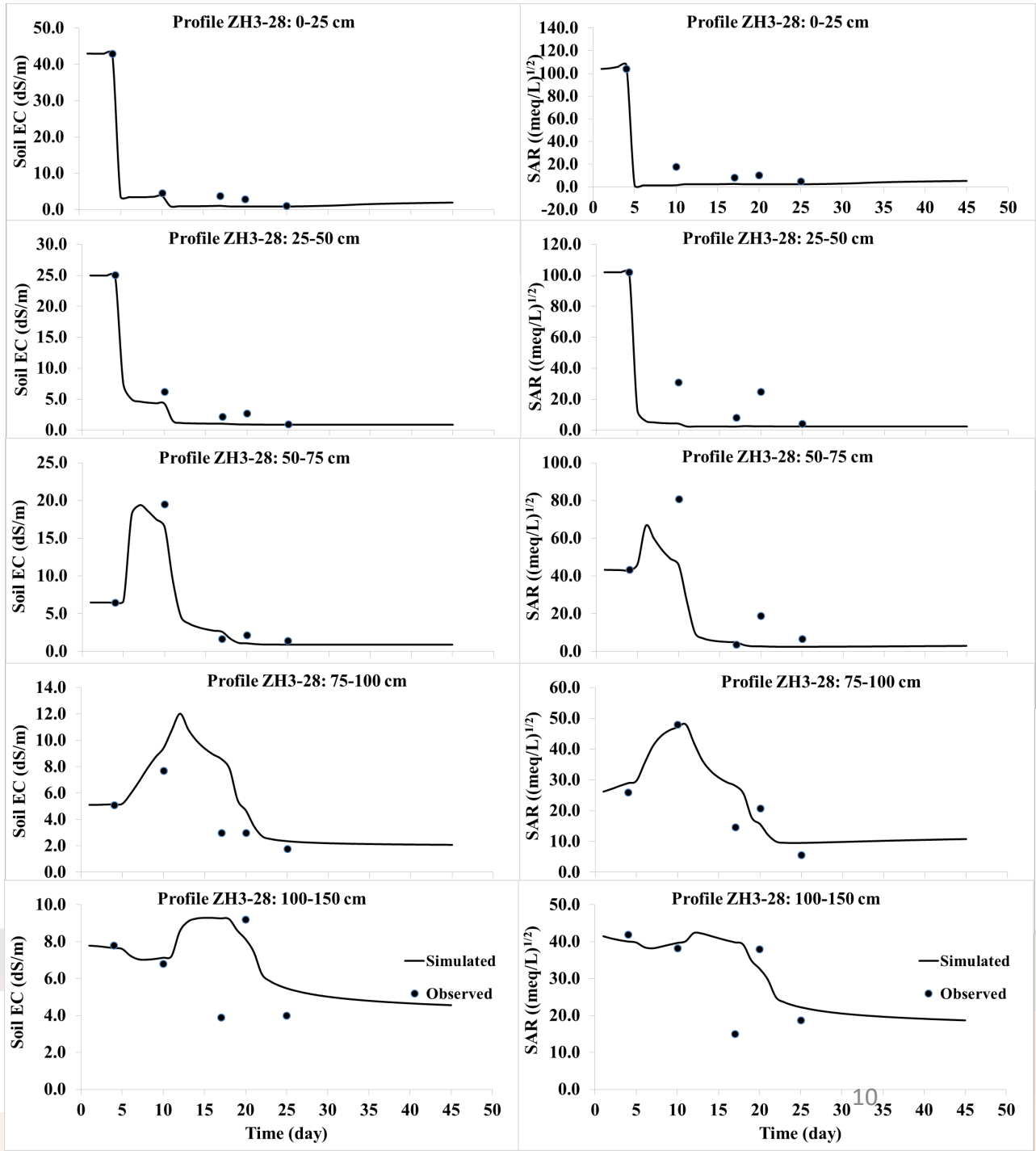
Results

Profile Zh3-28

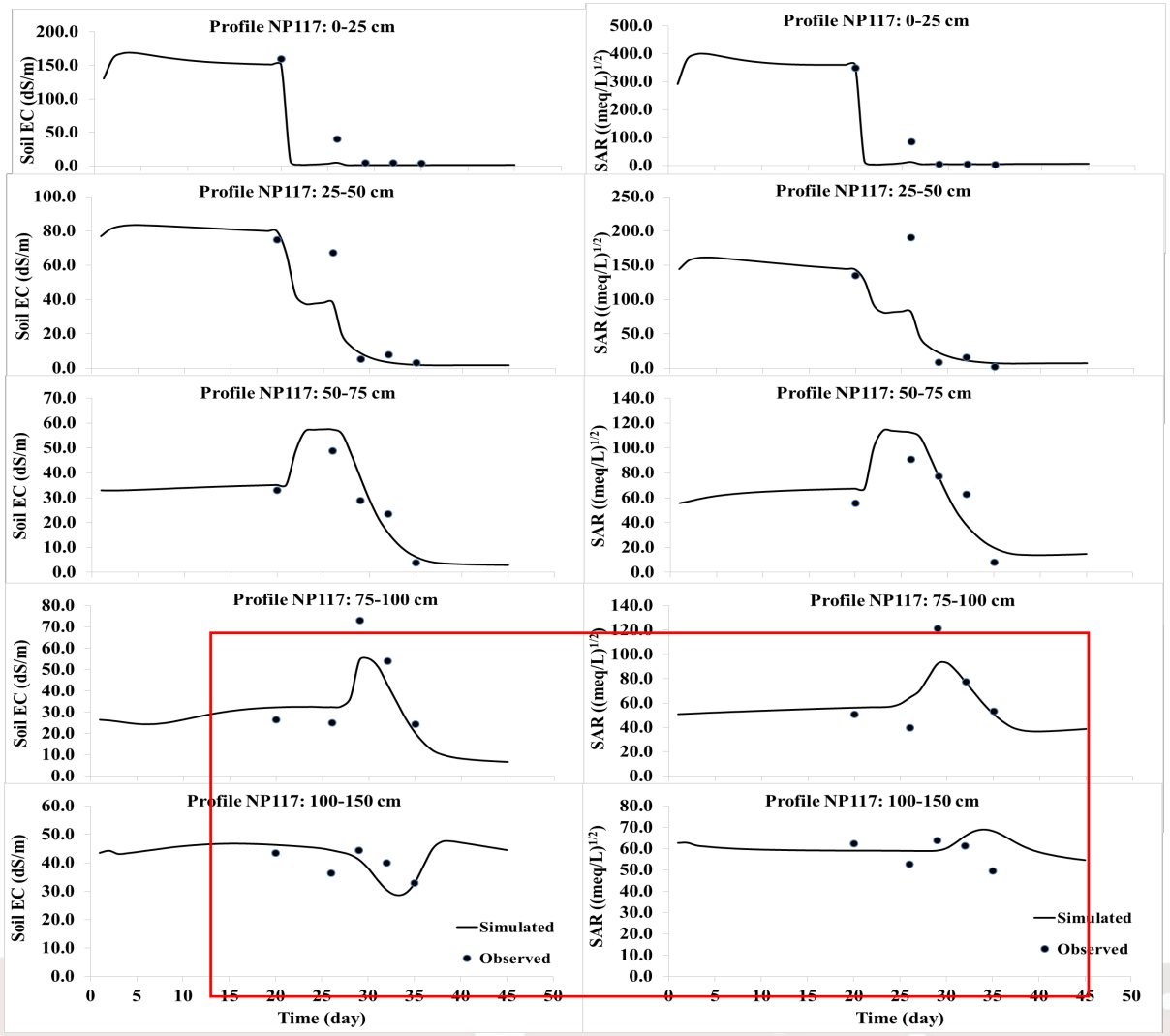
validation			calibration			Zh3-28
Ce	R^2	RMSE	Ce	R^2	RMSE	Depth (cm)
0.96	0.98	8.05	0.99	0.99	1.3	0-25
0.90	0.92	12.2	0.98	0.99	1.1	25-50
0.75	0.82	15.8	0.95	0.98	1.4	50-75
0.81	0.81	7.7	-0.02	0.50	1.8	75-100
0.19	0.16	14.8	-0.38	0.04	3.4	100-150

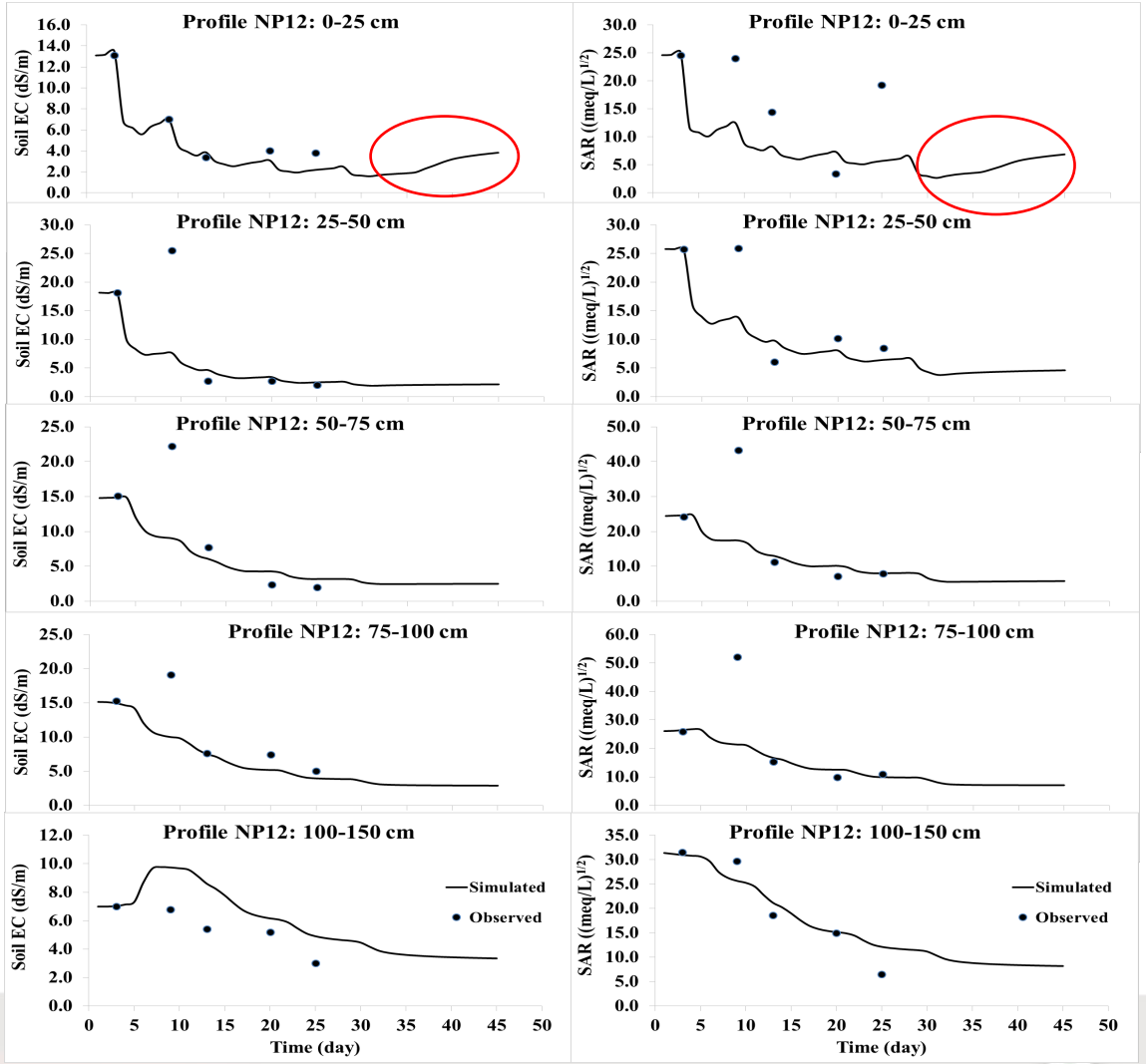
K_{sat}, n and D were optimized

Less water is needed (20<leaching>25 cm)



Results





Less water is needed (leaching<15 cm)

Less water is needed (leaching<30 + 5 cm)

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Results

limitations

Take home message:

Applied approach *is promising method* ***to suggest the required leaching water*** *for specific locations and time*

- *In saline-sodic soils* ***SAR*** *of root zone may* ***increase*** *due to leaching practice, therefore more attention in water management is needed.*

- *Sharp change in* ***hydraulic properties*** *specially* ***infiltration rate is limiting factor*** *in leaching and* ***water*** *management in* ***Layered saline*** *soils (preferential flow).*

- *leaching practice should be applied before cultivation, during growing season and might done after harvesting with proper amount of water as suggested by model.*

Salinity ***management with participatory approaches*** *is* ***crucial*** *in Iran and need further* ***attention*** *and* ***financial supports***

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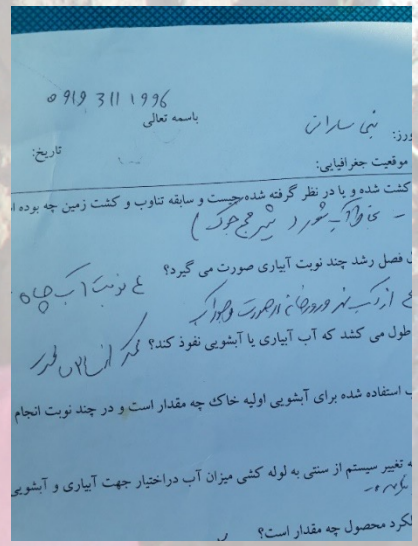

موسسه تحقیقات خاک و آب

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Thanks for you attention

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