Food and Agriculture Organization of the United Nations

موسسه تحقیقات خاک و آب

1st Meeting of the

International Network of Salt-Affected Soils

(INSAS)

Modelling solute transport in salt-affected soils: case studies from Iran

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15 April 2021

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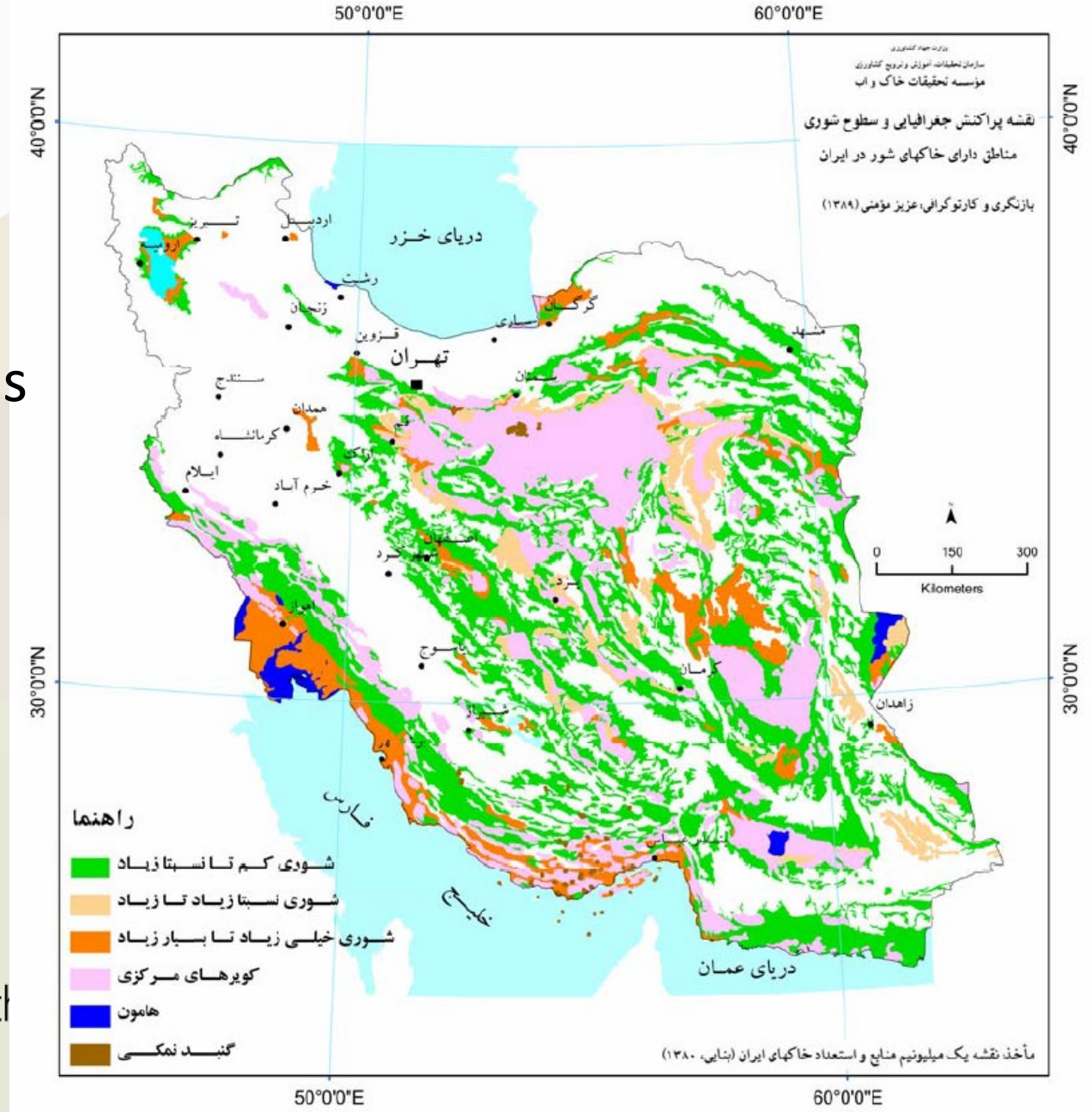
An overview of soil salinity status of Iran

- 6.8 Mha of agricultural land are saline
- 4.3 Mha salinity and/or sodicity problems



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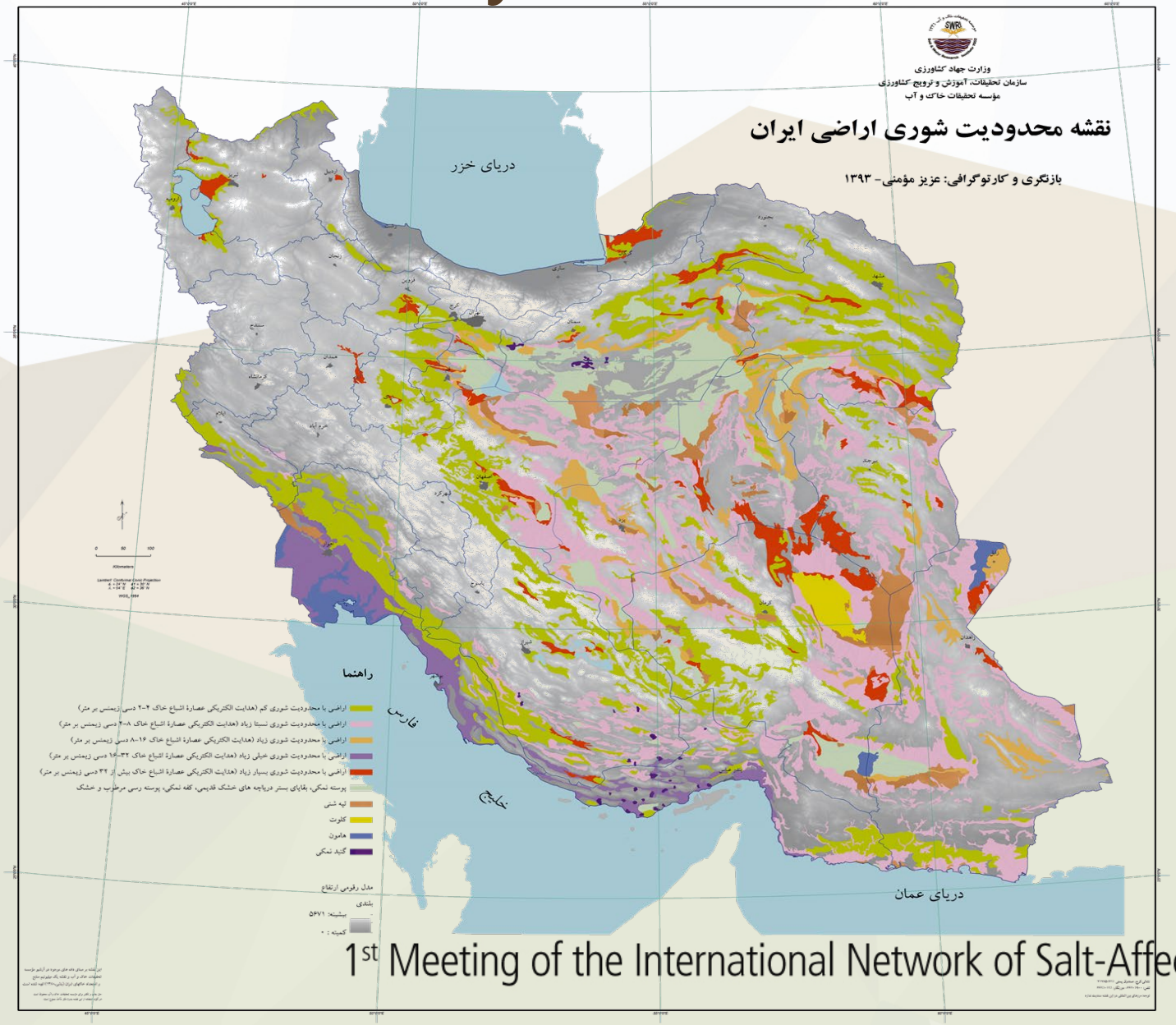
Moameni (2011)

An overview of soil salinity status of Iran



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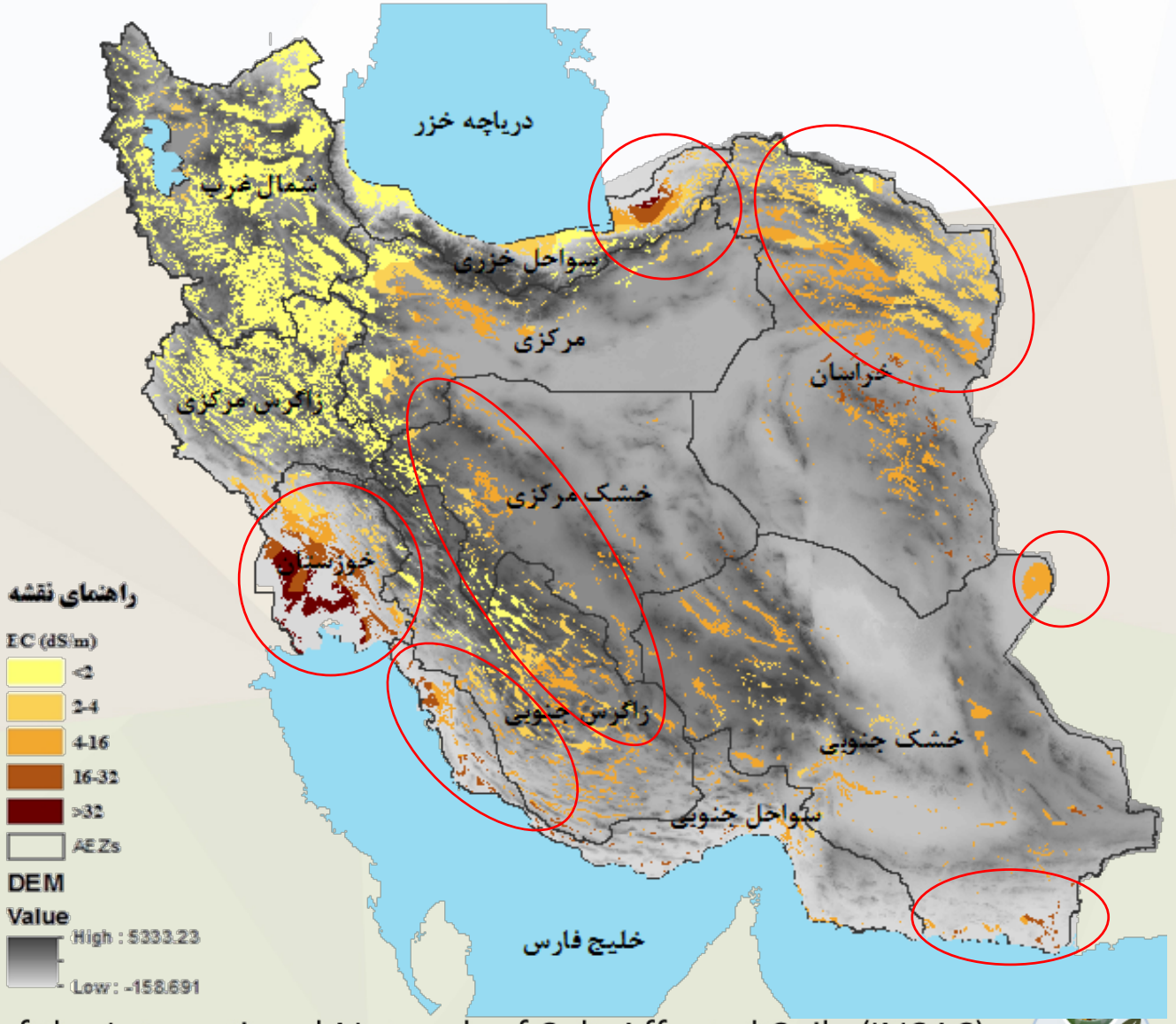
Moameni, (2014)

An overview of soil salinity status of Iran

- According to most recent dataset (but limited!) and Agro-Ecological Zone



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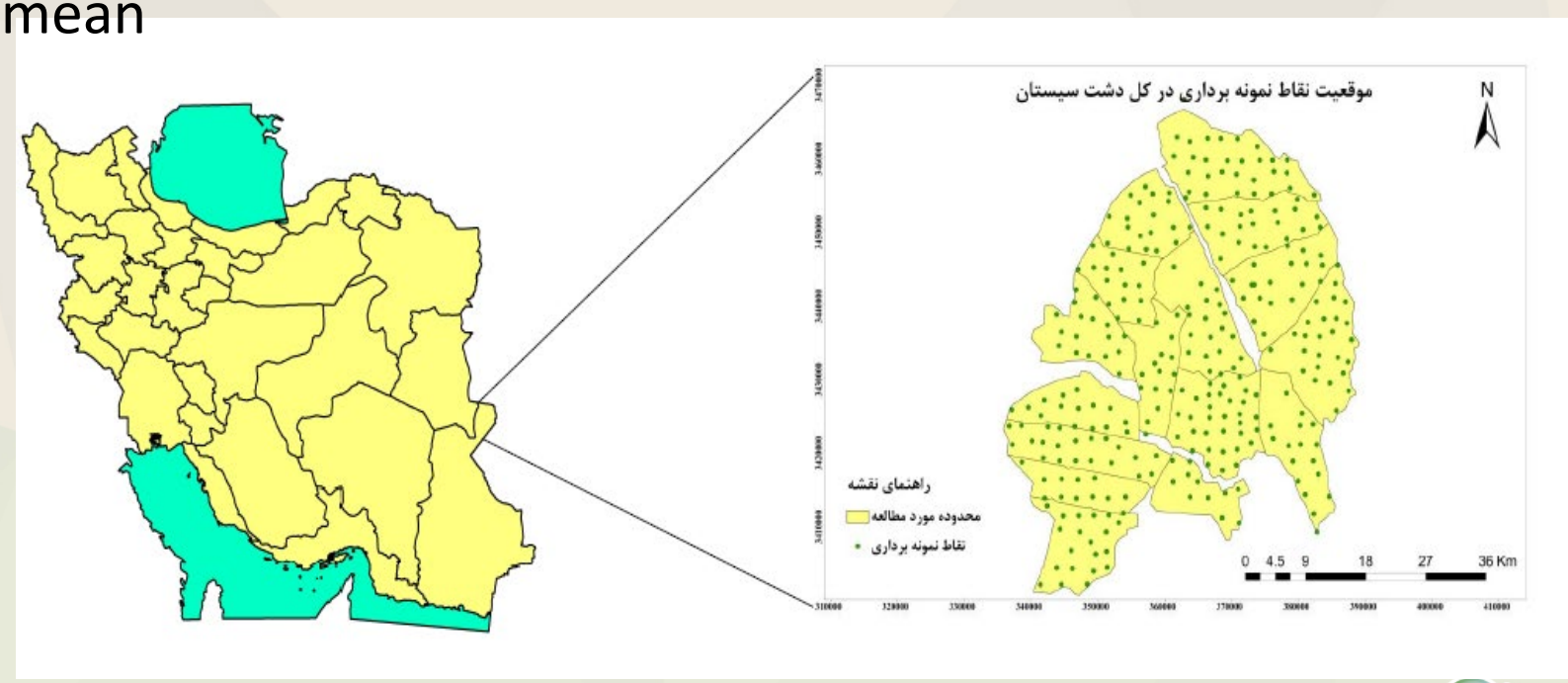
Saadat et al, (2020)

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**



The problem statement…

Assessing irrigation systems and leaching/reclamation for different field conditions using novel methods and strategy

Objectives

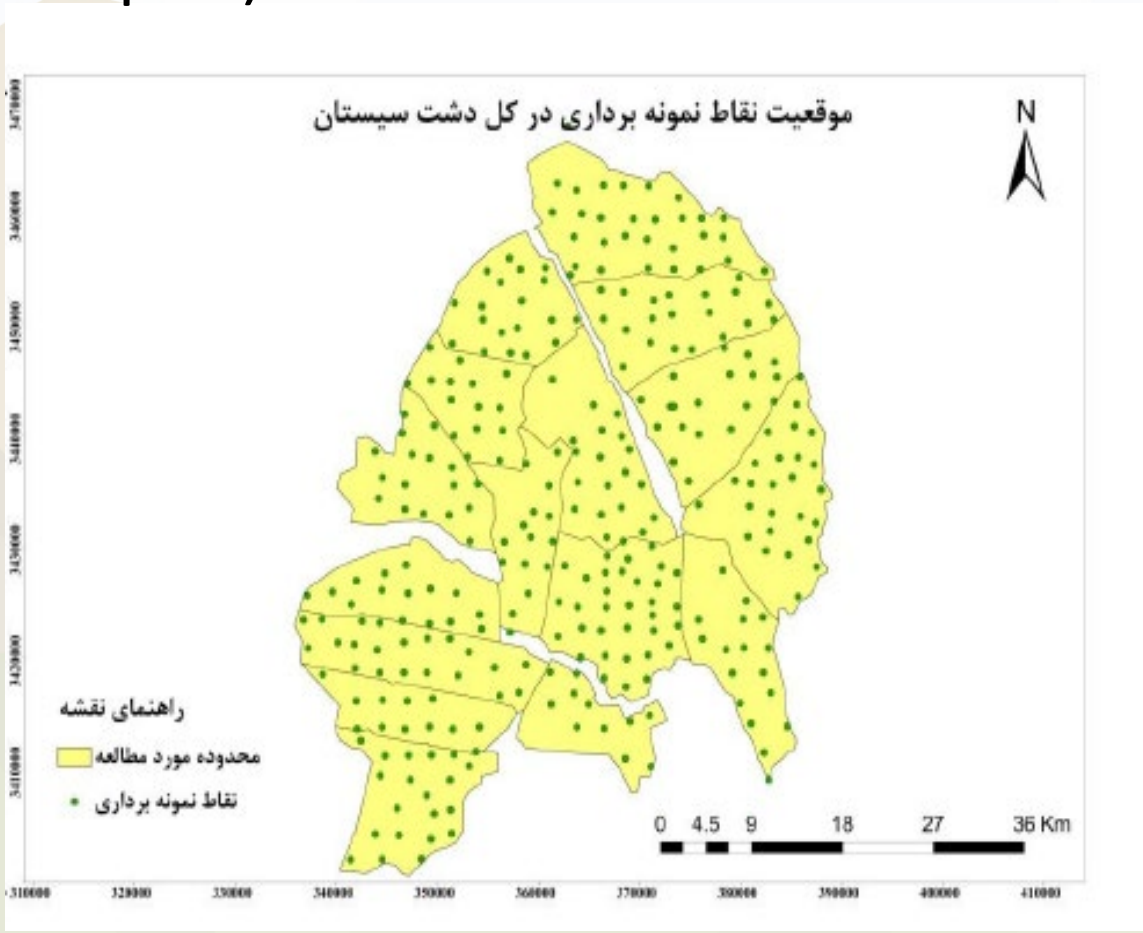
- *Developing a modeling approach for assessing irrigation systems (furrow or drip irrigation) on soil salinity/sodicity status for long period of time (Hydrus-1/2/3D)*
- *Evaluating leaching requirement and salute transport*

A case study: Sistan plain

- 312 soil profiles (about 4 layers => 1248 soil samples)

  181 soil profiles + 2080 soil samples (0-30 cm)

- 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-}

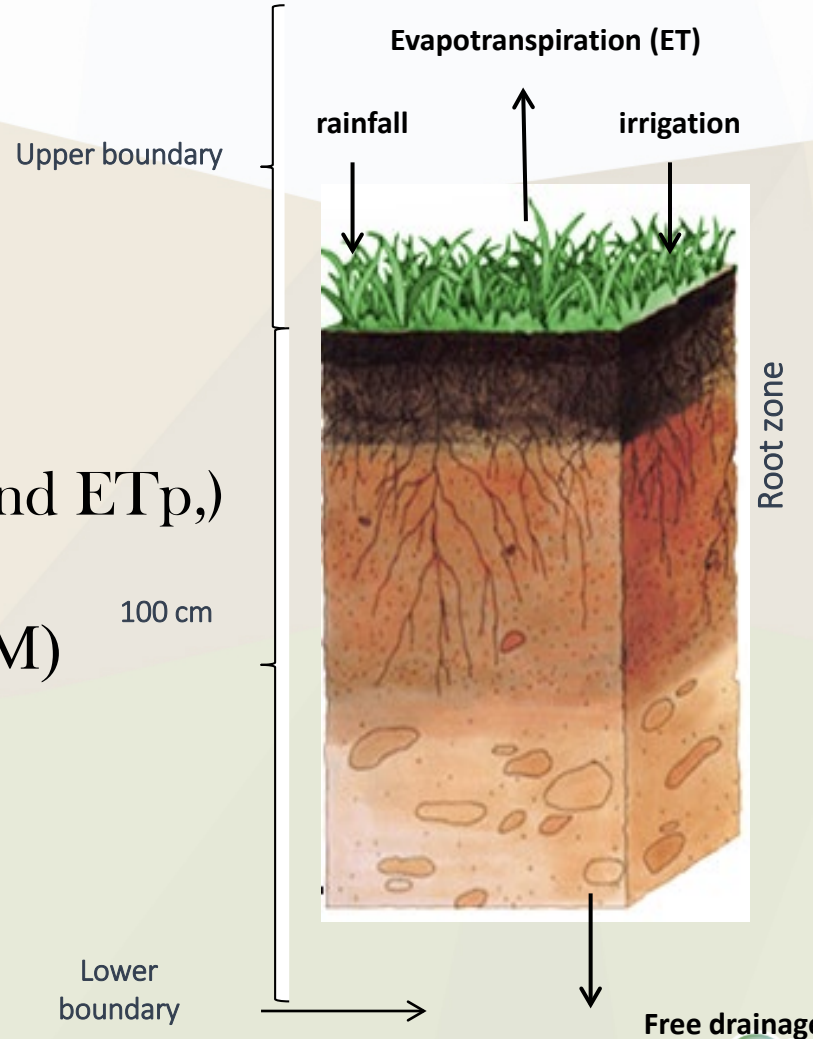


1-D Modeling at monitoring locations: Model conceptualization

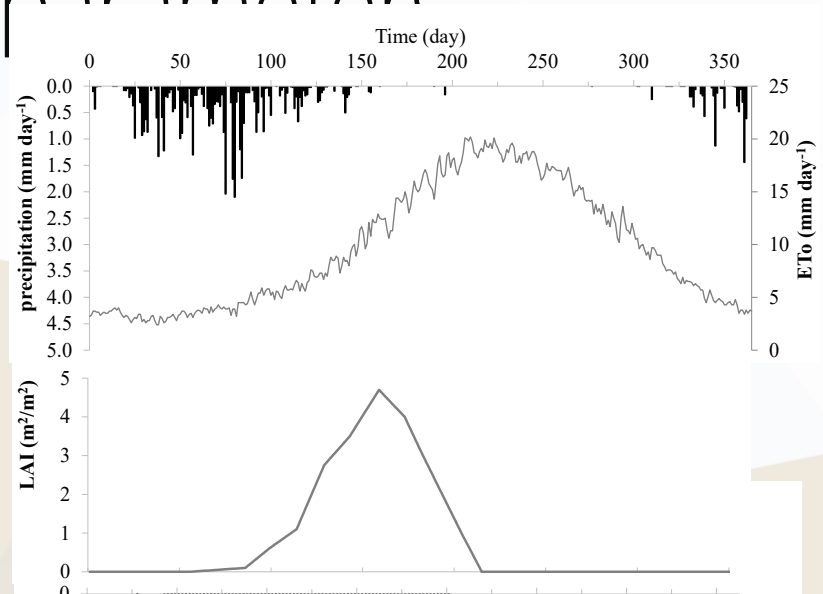
Hydrus 1D (hydrological model):

(Simunek et al 2013)

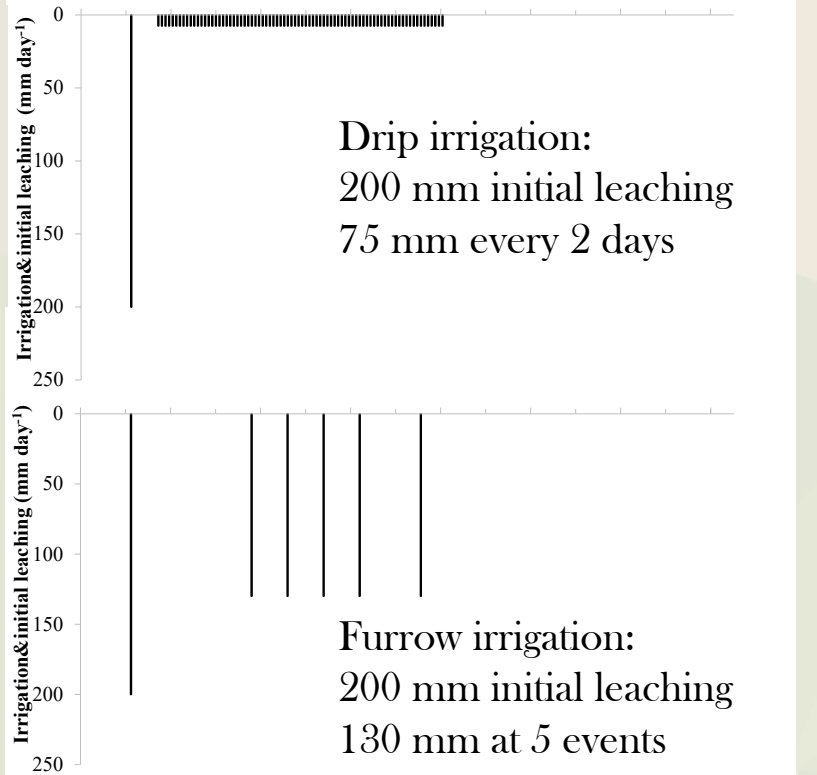
- Hydraulic model: MVG without air entry value and hysteresis
- Root water uptake model: Feddes model with solute stress
- Upper boundary condition: atmospheric (precipitation, LAI and ETp,)
- Bottom boundary condition: free drainage
- Solute transport module: Major Ion Chemistry (UNSATCHEM)



HP Modeling at monitoring locations: Spatial input parameters



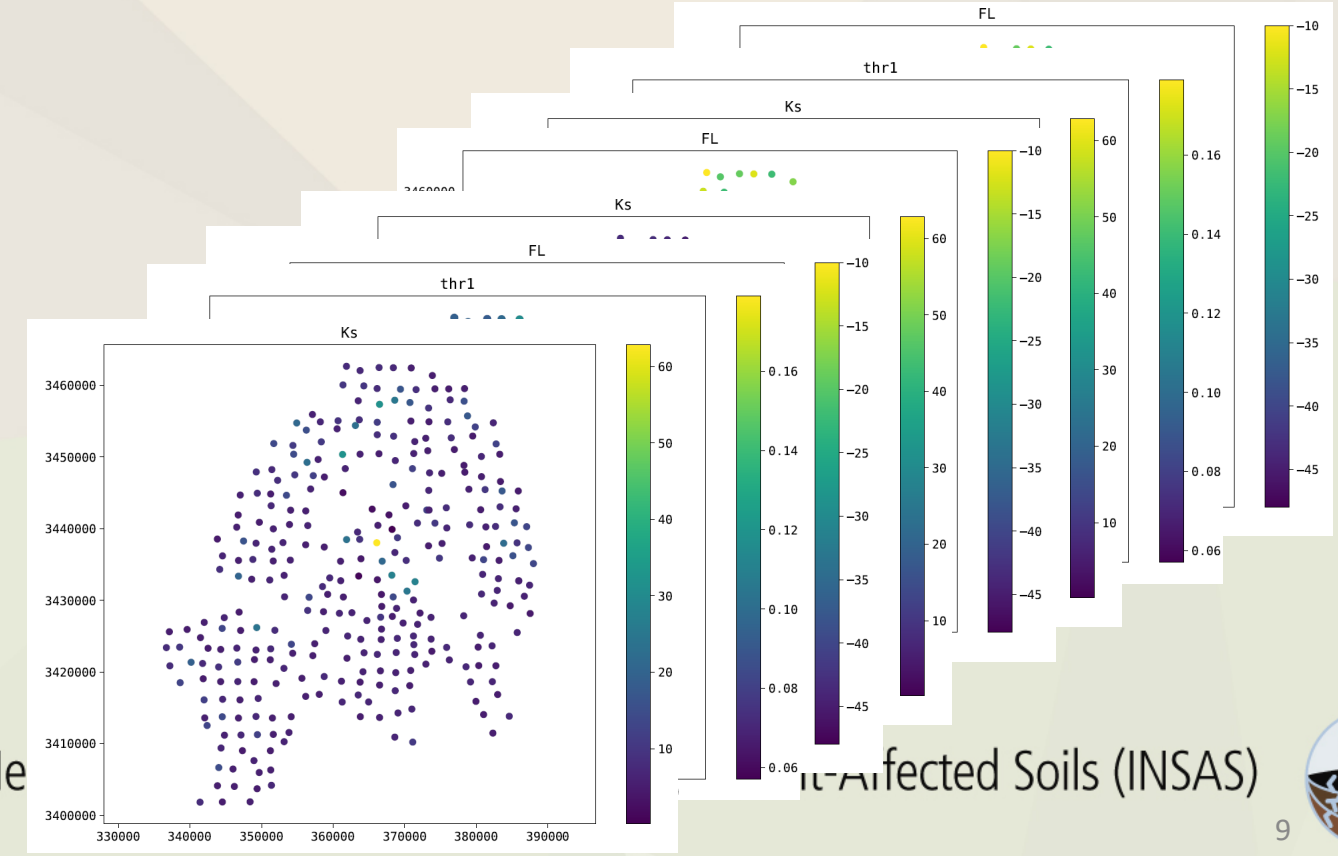
Drip irrigation:
200 mm initial leaching
75 mm every 2 days



Furrow irrigation:
200 mm initial leaching
130 mm at 5 events

- Soil profile layers and chemical composition: according to each profile characterization
- Input MVG hydraulic parameters: using *Rosetta-v3beta* in python

Zhang and Schaap (2017)



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1-D Modeling at monitoring locations: Model implementation

The plain is represented as a collection of 1D columns
Each column parameterized using (*MVG*, depth, solution composition of each layer)
longitudinal dispersivity (D_L): 10 (0.1 of soil depth), transverse dispersivity (D_T): 1 (0.1 of D_L)(Ramos et al., 2012)

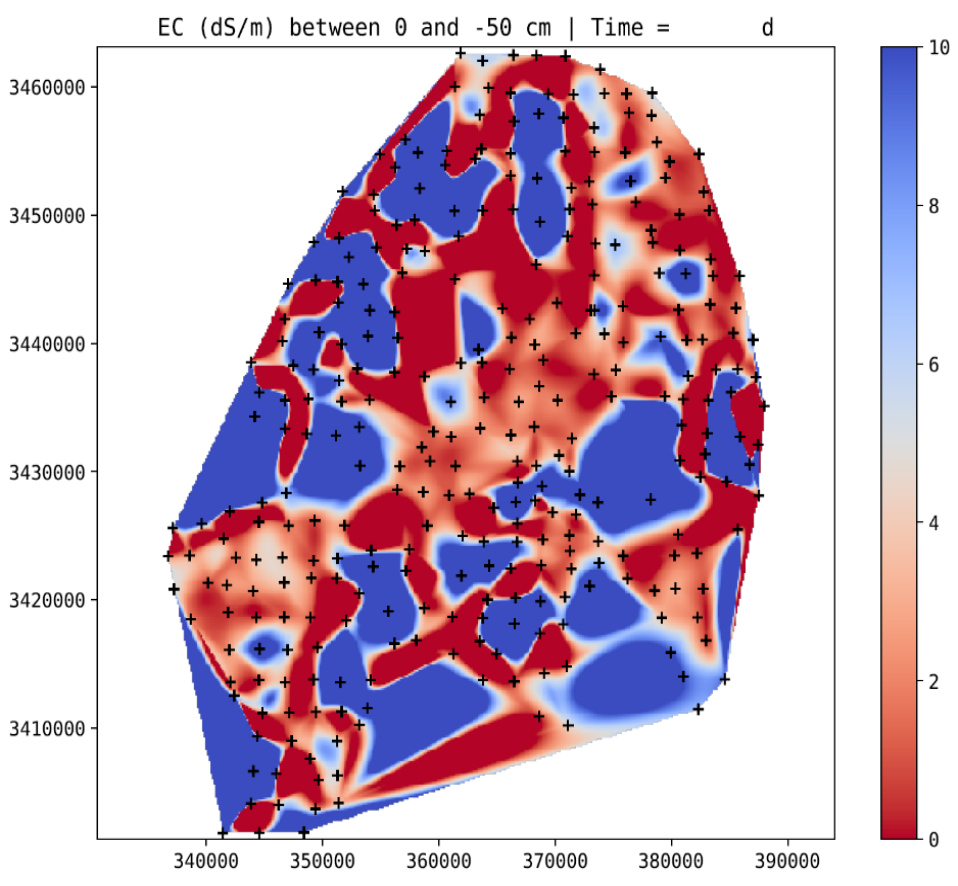
Step 1. Initialization
Initialize and adjust conceptual model
Programmed scripts/routines in Python
Prepare input text file i.e., solution composition, LD and *MVG parameters*

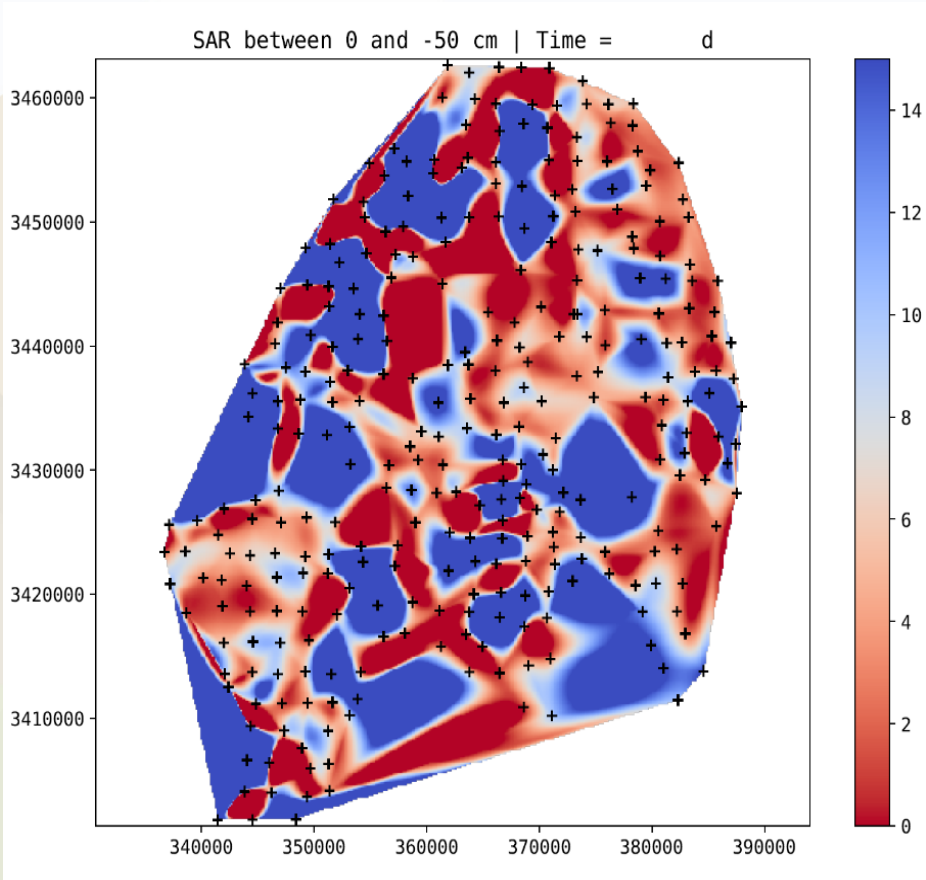
Step 2. Checkup programing
Read and check all files and model routines
Pre-test of scripts by running the program
Replacement and set of input data for each run of location

Step 3. Pre-processing
Run the model for each column/soil profile
Save the initial results

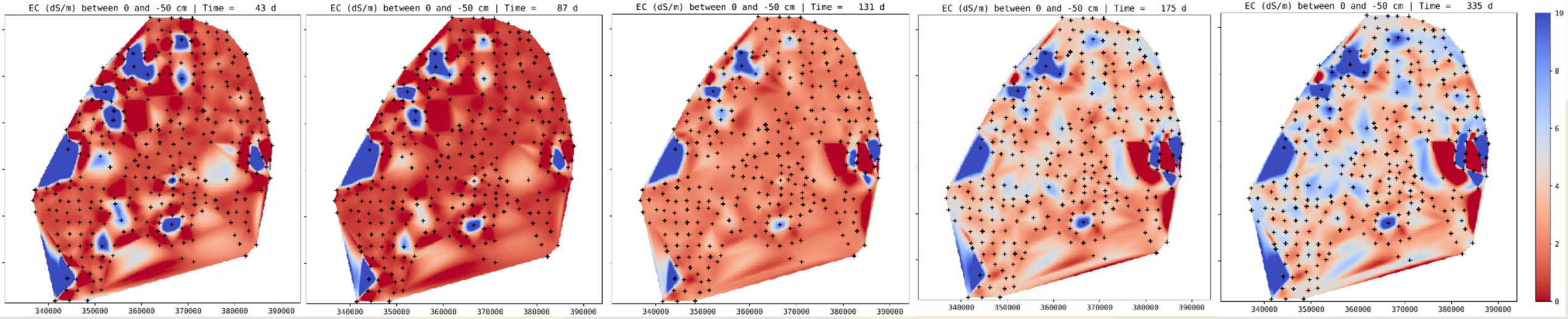
Step 4. Post-processing
Reload and read the output files
Analyzing the results
Compute plain scale ECe, SAR, soil water status and yield
Visualize the results and interpret

Modeling results: day 0, initial condition

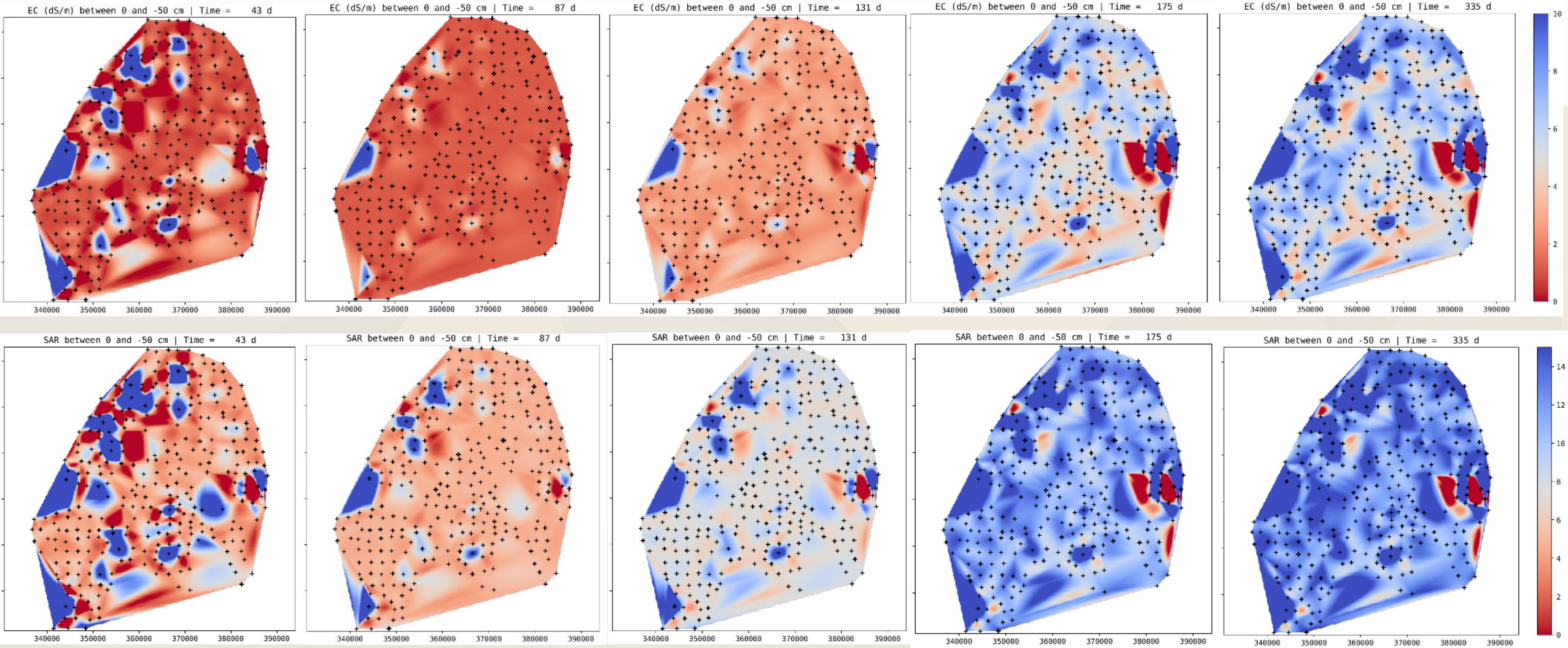




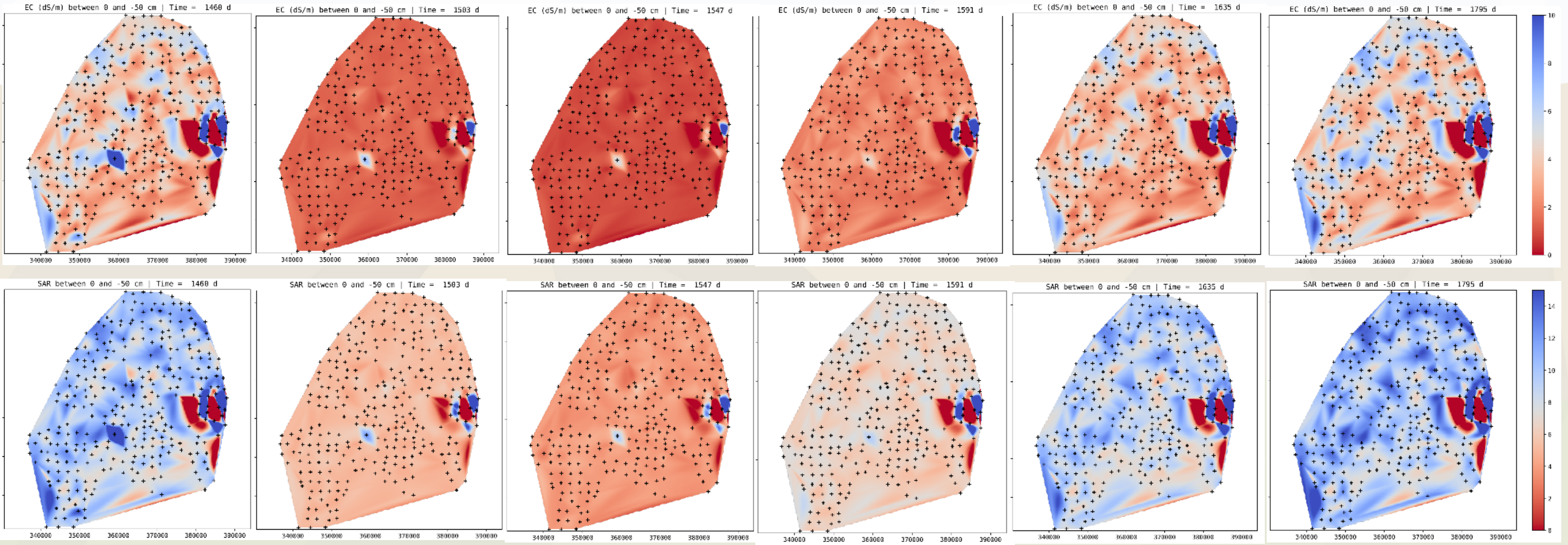
Modeling results: first year, furrow irrigation



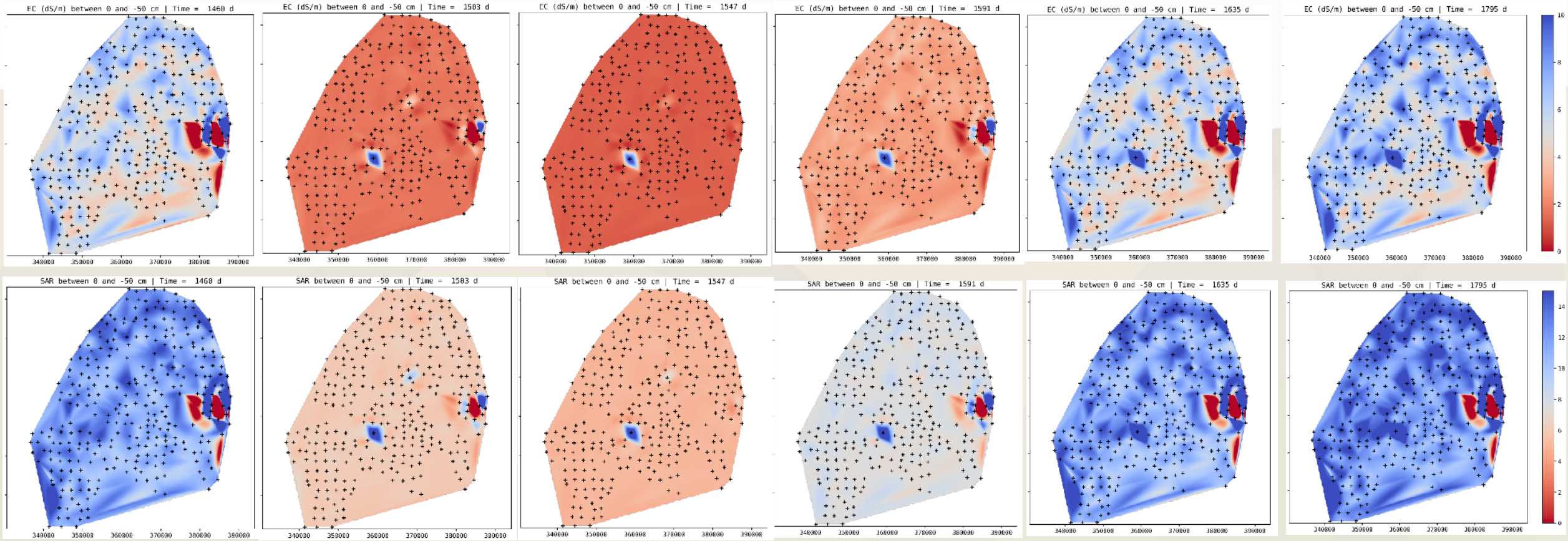
Modeling results: first year, drip irrigation



Modeling results: fifth year, furrow irrigation



Modeling results: fifth year, drip irrigation



Take home message:

Spatial and temporal variability of soil hydraulic properties and uncalibrated model increase uncertainty of results.

According to assumptions drip irrigation resulted in higher EC and SAR compared to furrow irrigation.

System sustainability will be achieved if applying the irrigation strategies considered in this study.

Due to the fields heterogeneity, the uniform distribution of water irrigation and leaching may not be an efficient approach

Leaching and remediation expriments:

- 12 profiles were selected
- 0-100 cm water (0, 25, 50, 100 cm)

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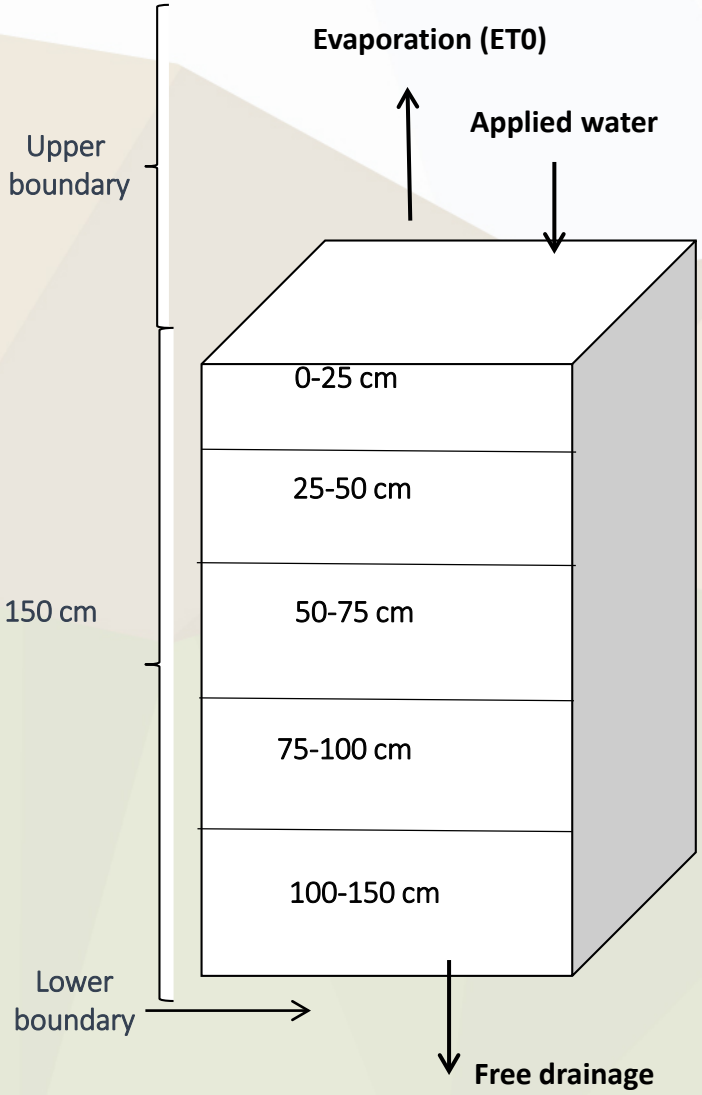
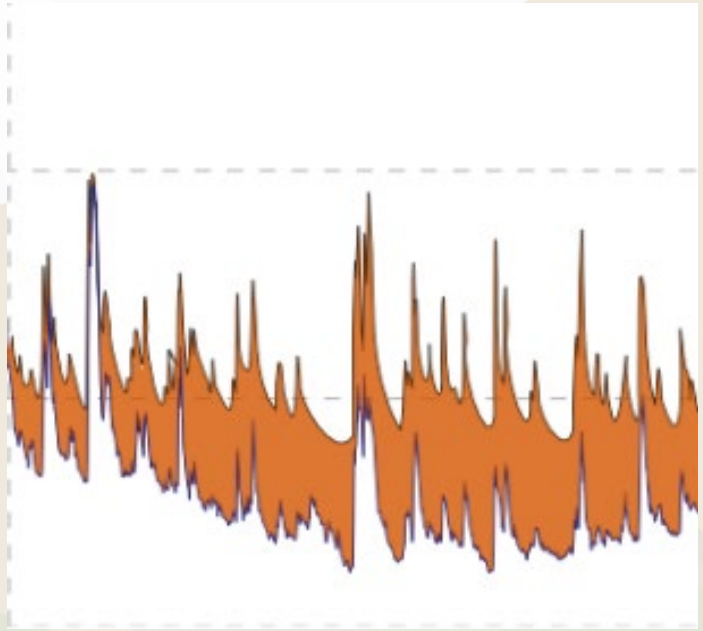
Leaching expriments: Model conceptualization-calibration

Hydrus 1D (hydrological model):

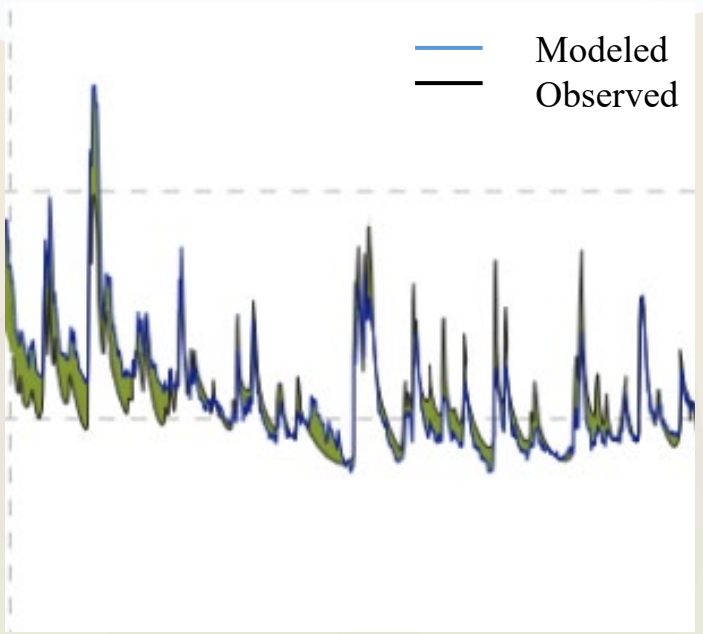
(Simunek et al 2013)



Inverse modeling after sensitivity analysis



Parameter optimization



Initial hydraulic parameter set
Initial transport parameter

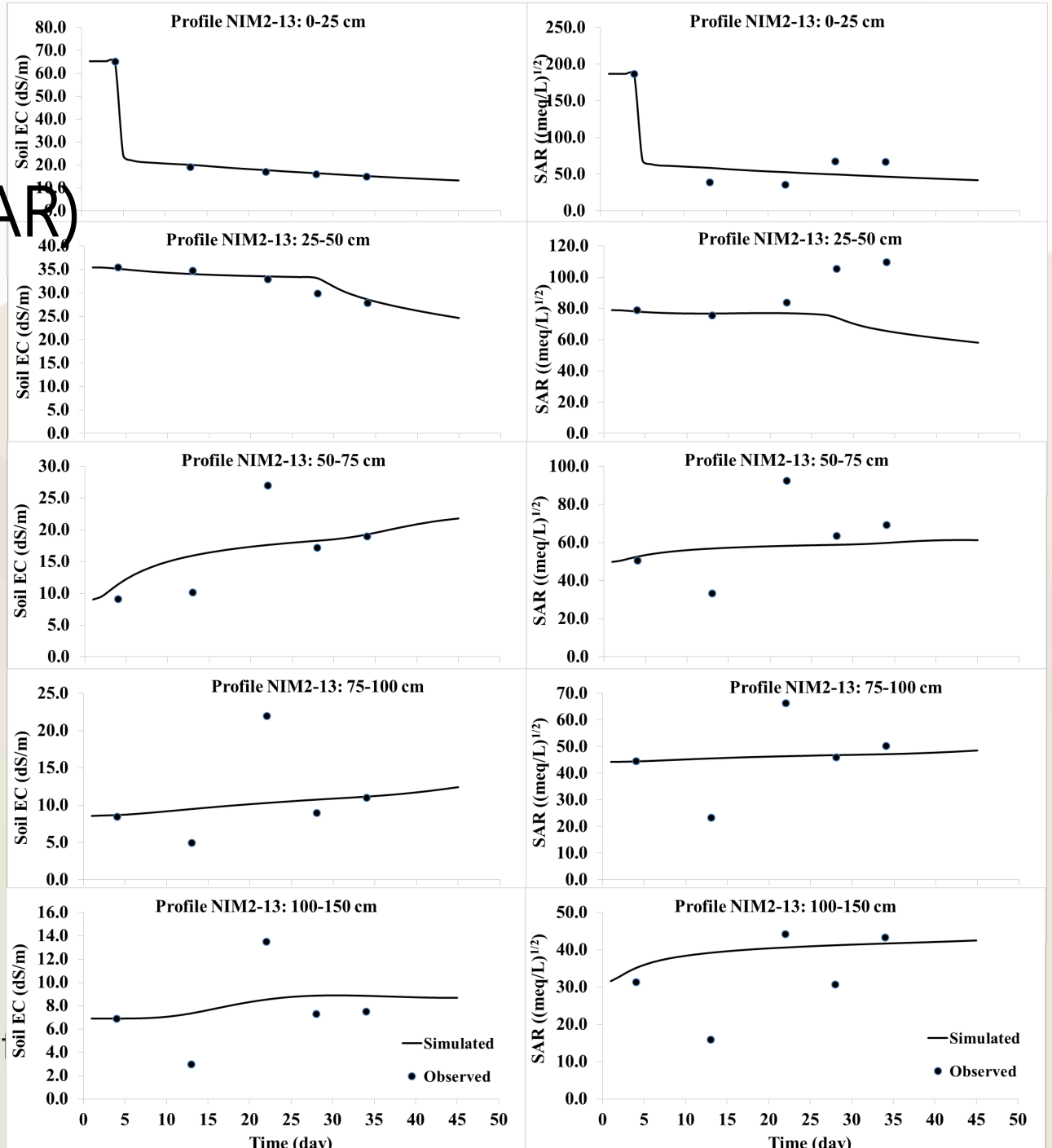
Optimized transport and hydraulic parameter set

Leaching expriments: 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



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Much more water is needed (>200 cm)

Leaching expriments: results

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

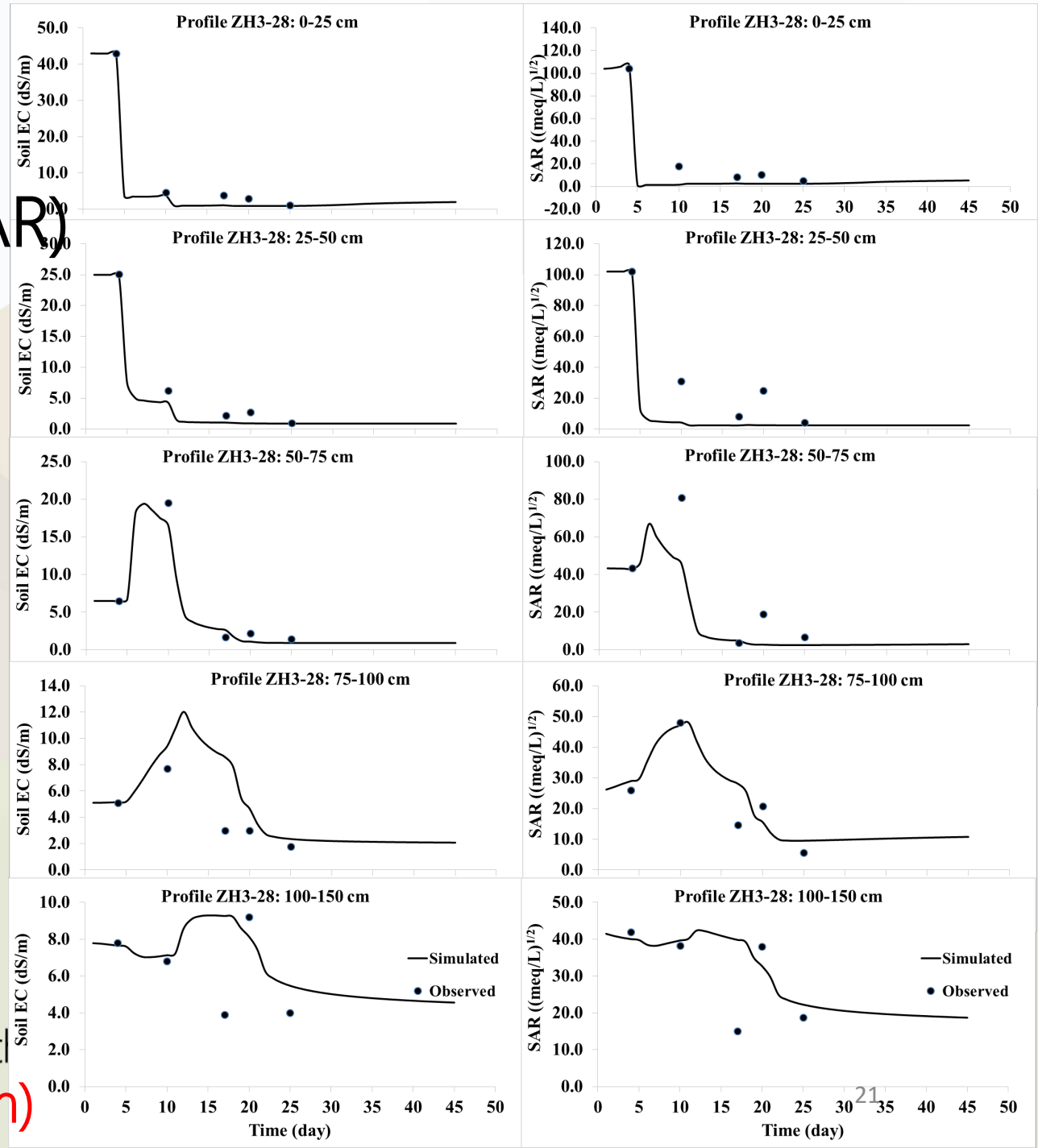
Leaching expriments: results

calibration (ECe) and validation (SAR) 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 (100>leaching>20 cm)



Take home message:

Applied approach *is promising method* ***to suggest the required leaching water*** *for specific locations* ***=>*** *its* ***map*** *will be generated over the plain.*

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

Deep tillage + remediation practices *+…are* ***needed*** *for water management.*

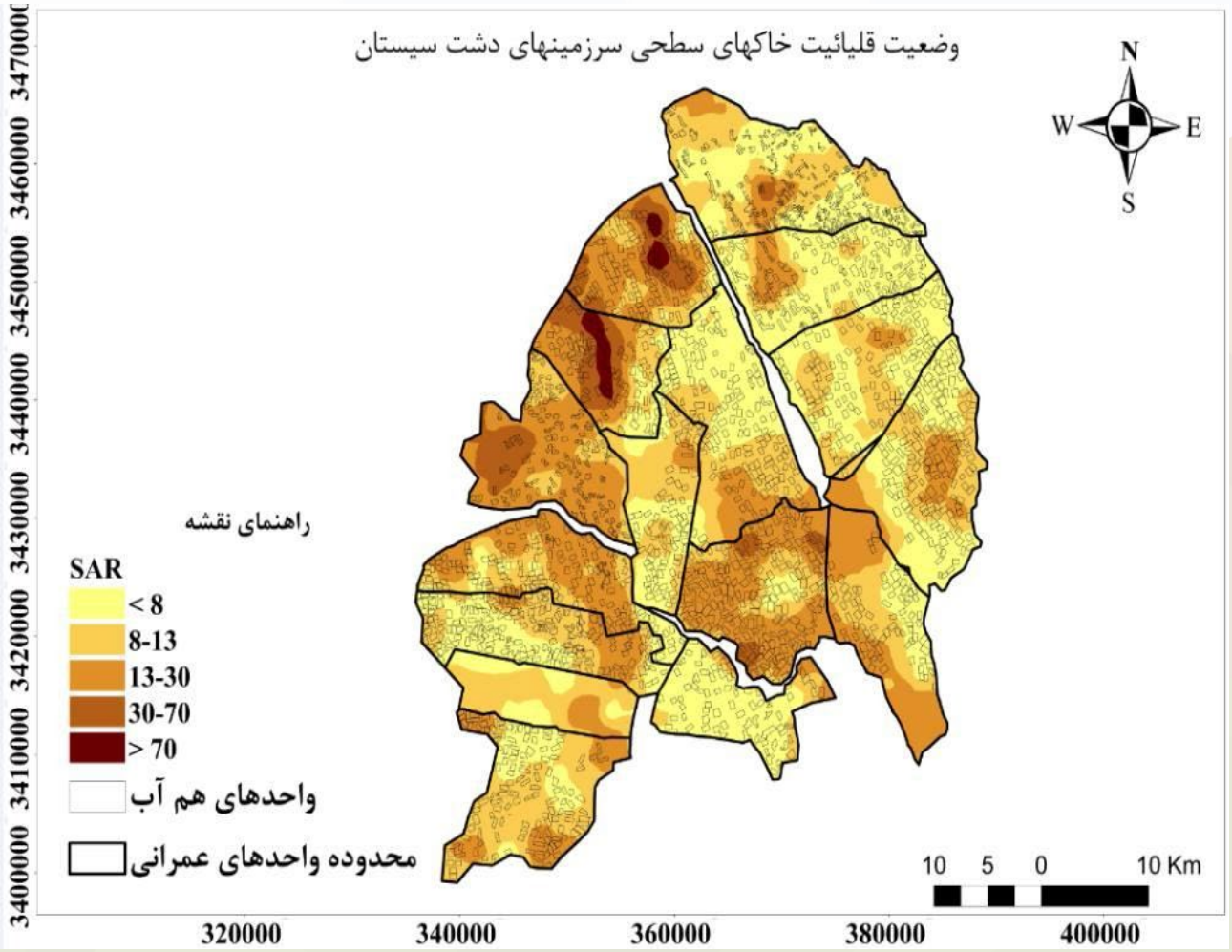
Salinity ***monitoring*** *is* ***crucial*** *in Iran and need further* ***attention*** *and* ***financial supports***

the

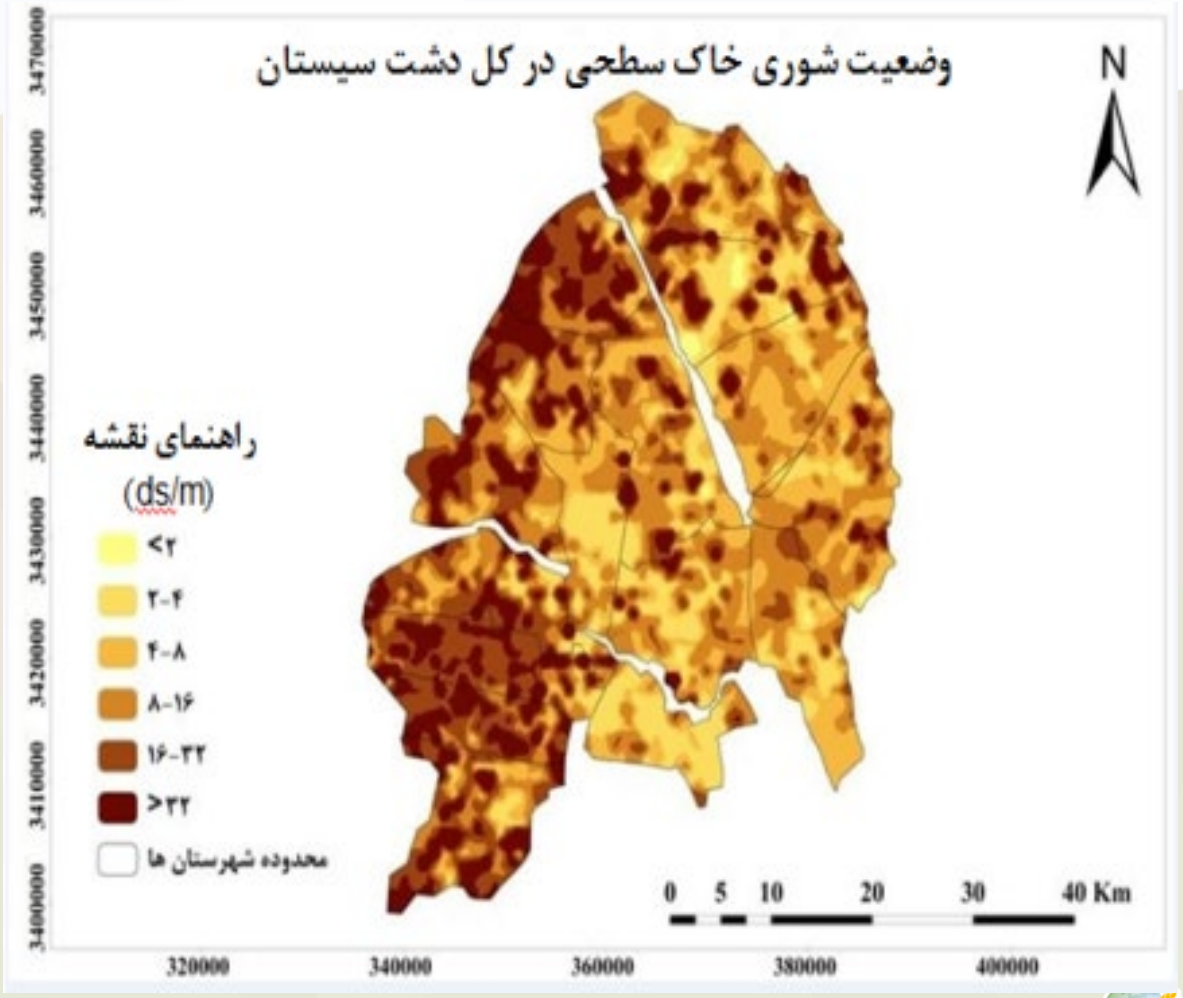
Thanks for you attention

Initial condition maps: using GIS tool

SAR



salinity



Modeling results: Hydrus 1-D

not-saline

n	α	θ_s	θ_r	K_s	SAR	sand	silt	clay	pH	EC	depth	
	cm^{-1}	cm^3/cm^3		cm/d		%				ds/m	cm	
1.313	0.0069	0.418	0.117	10.891	1.7	40	40	20	8.3	0.5	0-13	Zab 1-14
1.414	0.0062	0.382	0.084	9.871	1.3	20	49	31	8.2	0.5	13-28	
1.234	0.0097	0.460	0.141	6.129	1.2	64	25	11	8.5	0.4	28-64	
1.331	0.0081	0.443	0.129	6.1	7.6	60	32	8	8.0	6.3	64-90	

saline

n	α	θ_s	θ_r	K_s	SAR	sand	silt	clay	pH	EC	depth	
	cm^{-1}	cm^3/cm^3		cm/d		%				ds/m	cm	
1.450	0.0040	0.404	0.092	8.291	513.1	23	69	8	8.2	163	0-16	Nim 2-13
1.490	0.0087	0.361	0.059	27.79	118.0	7	48	45	8.3	65	16-32	
1.473	0.0126	0.366	0.061	33.296	34.2	8	35	57	8.5	10	32-70	
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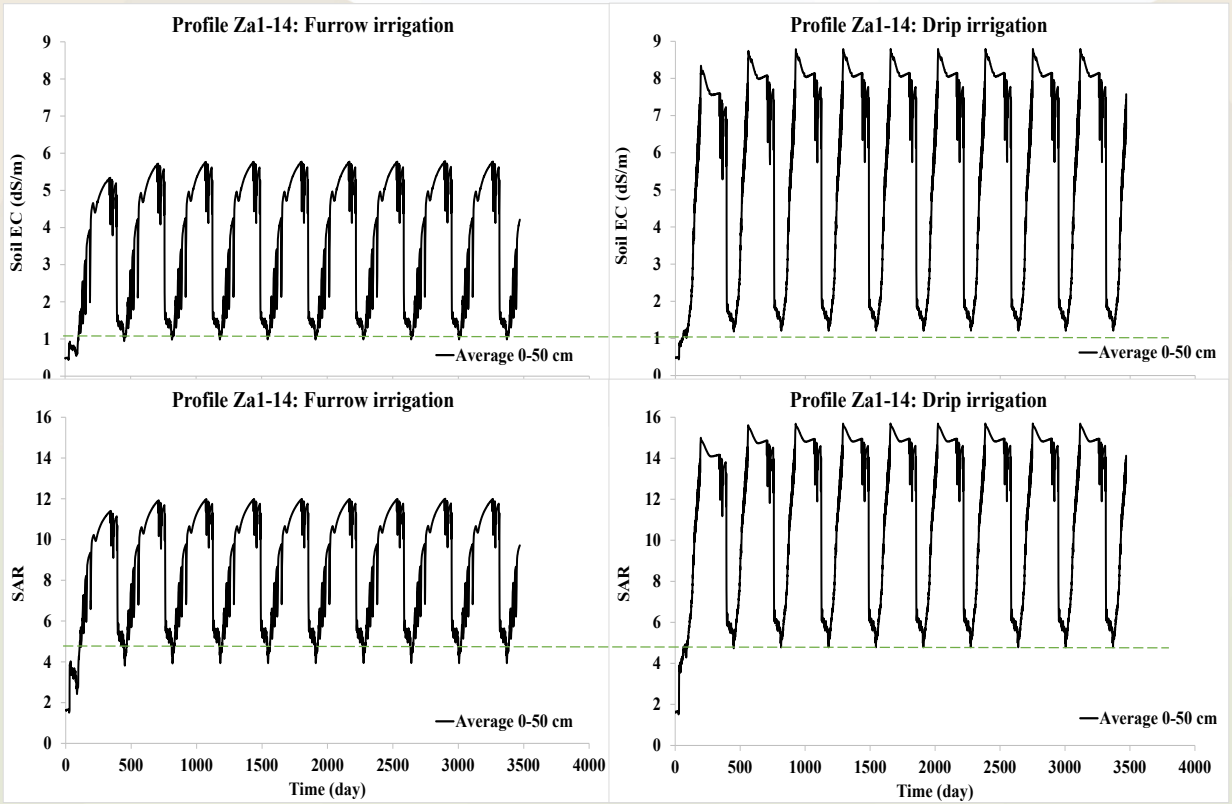
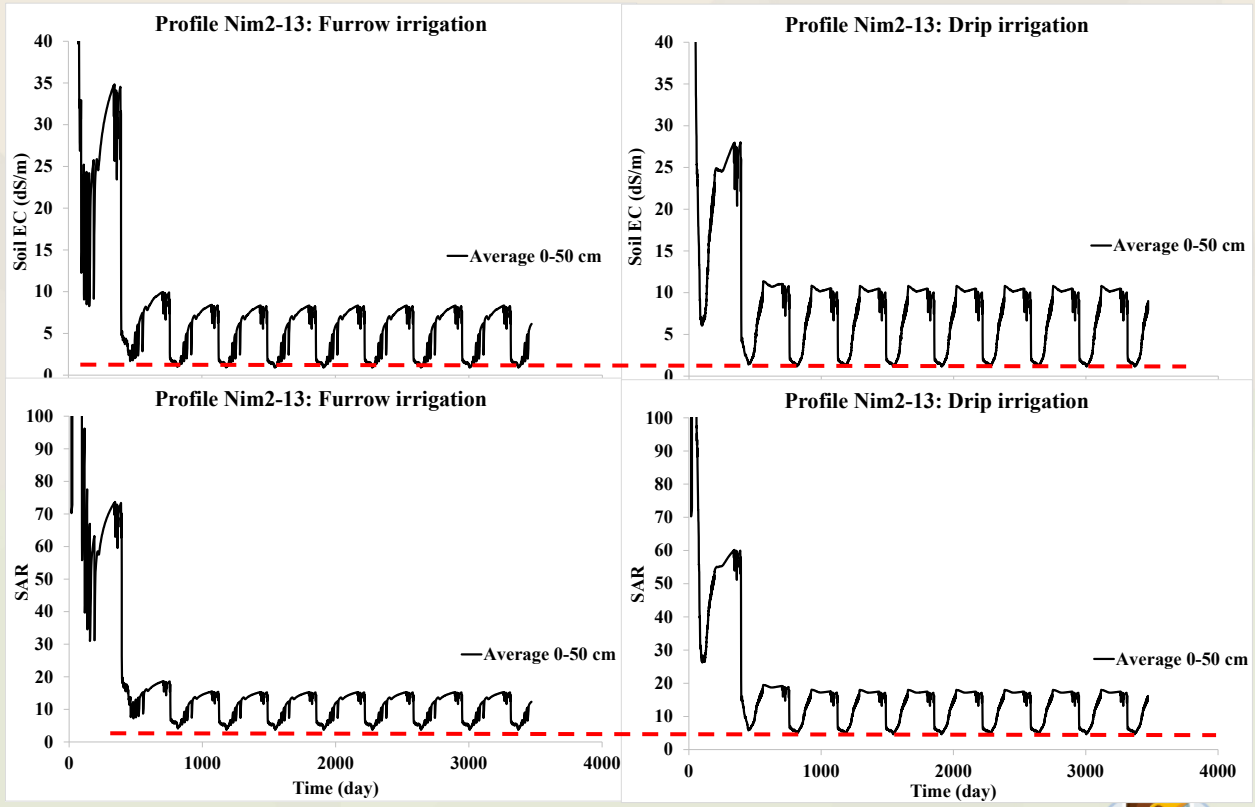
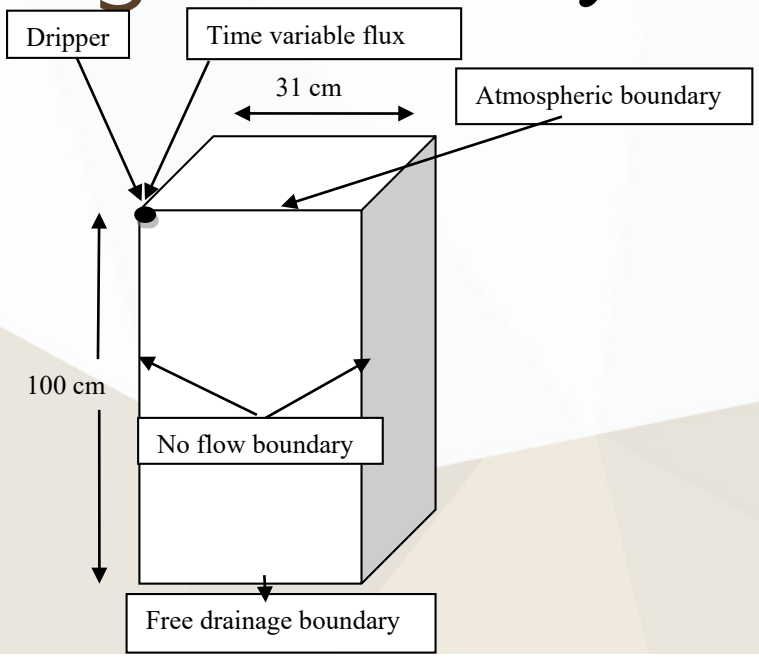




Modeling results: Hydrus 2/3D (Simunek et al 2013)



n	α	θ_s	θ_r	K_s	SAR	sand	silt	clay	pH	EC	depth	
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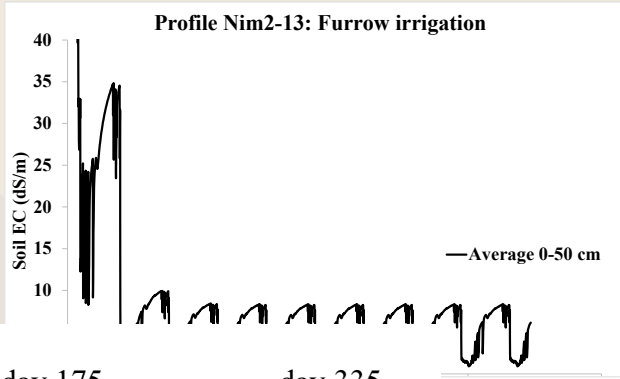

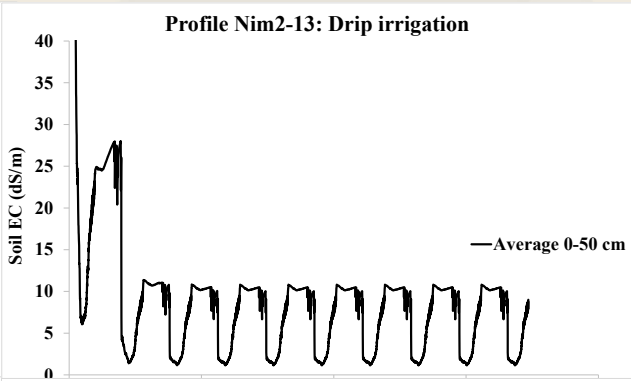

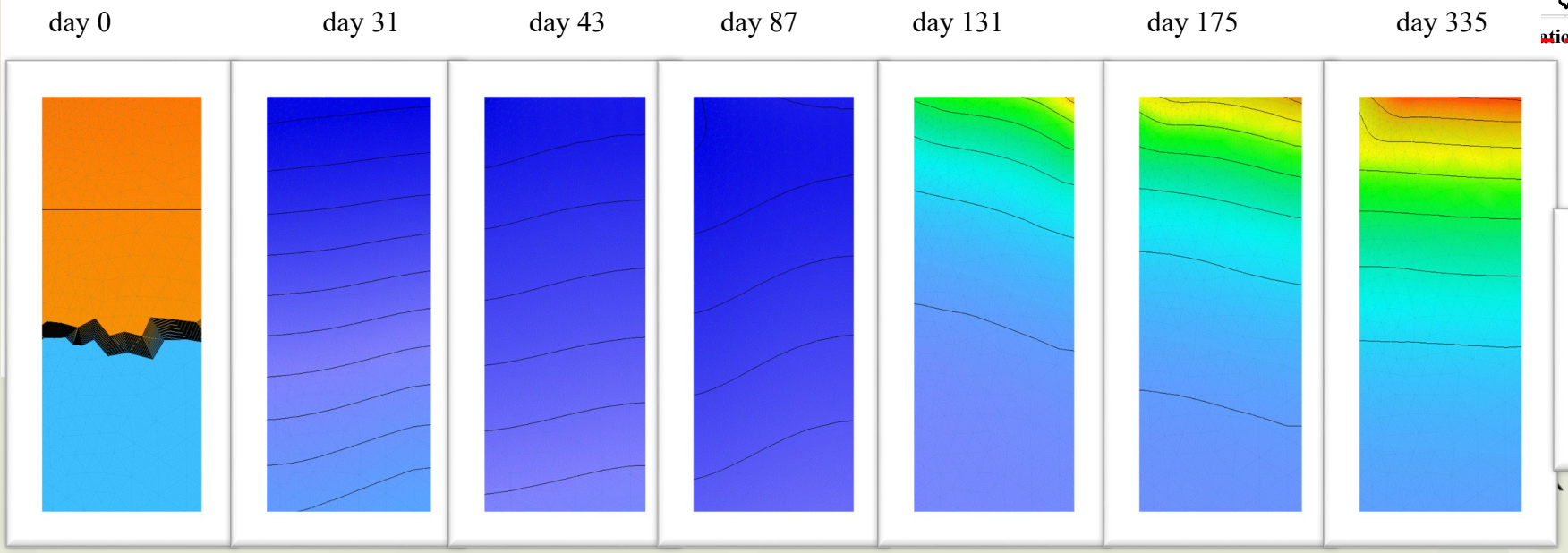

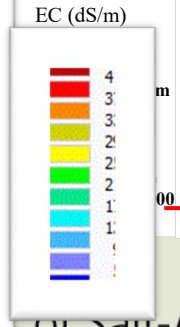

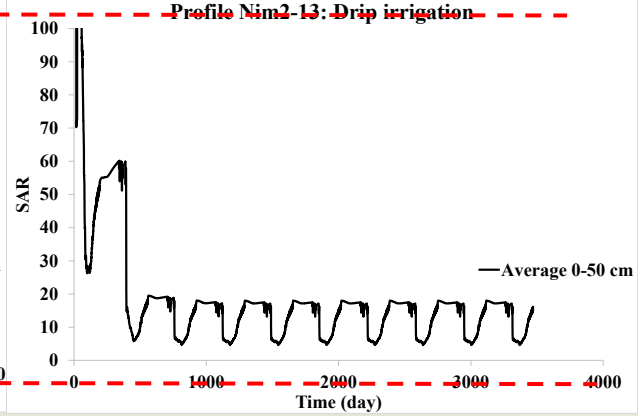

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