

Soilscales of the coastal plains in the Caspian region: primary spatial differentiation and evolution

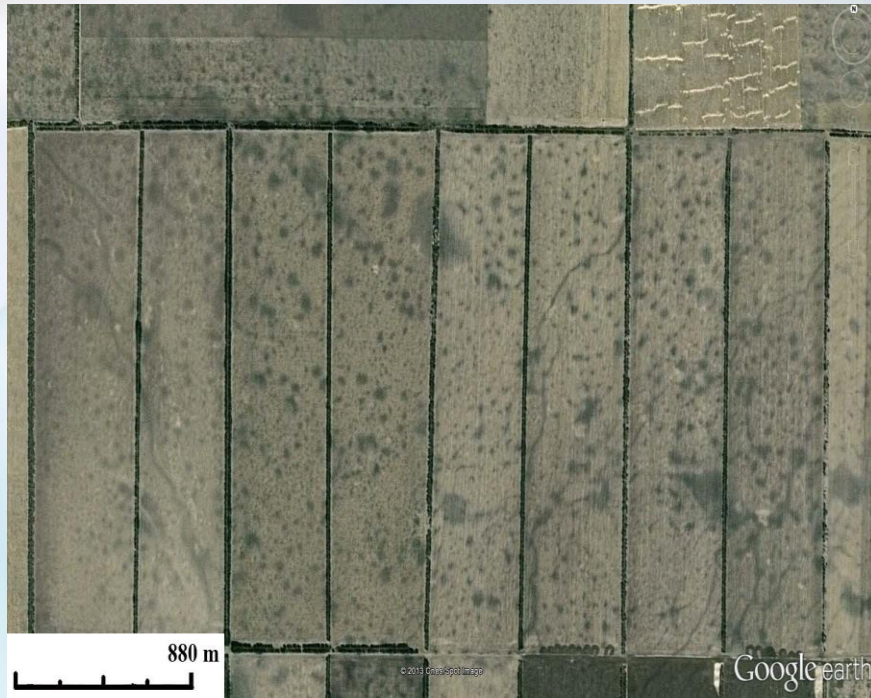
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Soil pattern in the Caspian lowland



Arable lands with crops

**Virgin lands with
natural vegetation**



Formulation of the problem

- Soil and vegetation patchy pattern is a typical feature of the Caspian Lowland (Dokuchaev 1883; Kostychev 1885; Zemyatchenskii 1894; Bogdan 1910; Bessonov & Neustruev 1904)
- Main hypotheses : phytogenic, zoogenic, topogenic and paleocryogenic. Conditions – semihydromorphic (ground water level 3-6(9) m) (Abaturov & Zubkova 1972; Demkin & Ivanov 1985; Gennadiev 1990; Ivanova 1930; Nikolaev et al., 1995)
- New facts on dynamism of microtopography and the occurrence of well-pronounced spatial soil differentiation even under smoothed microtopography (Khitrov 2005; Konyushkova & Abaturov 2016; author data) are demanding for the revision of the modern concepts of soil cover formation and evolution in the Caspian region
- Many facts implies that primary spatial differentiation of soil salinity occurs at the earliest stages of soil formation (at the stage of solonchak), often under flat microtopography (Mozharova 1984, 1985; Puzanova 1992)
- At present, there is no enough data about the primary spatial differentiation of soil cover at the young coastal plains which are conjugated with the study of vegetation and microtopography with the relation to salinity

The goal of the study

- Analysis and identification of main factors leading to primary spatial differentiation of soil cover at the loamy and clayey deposits of the young coastal plains of the Caspian region under different lithology and climate

Study area



Dagestan (Russia)

Caspii-2

age 150-300 yr. (cal BP)

-25.8 m below sea level

Golestan (Iran)

Iran-1

age ~ 60-70 yr.

-25.2 m below sea level

Iran-3

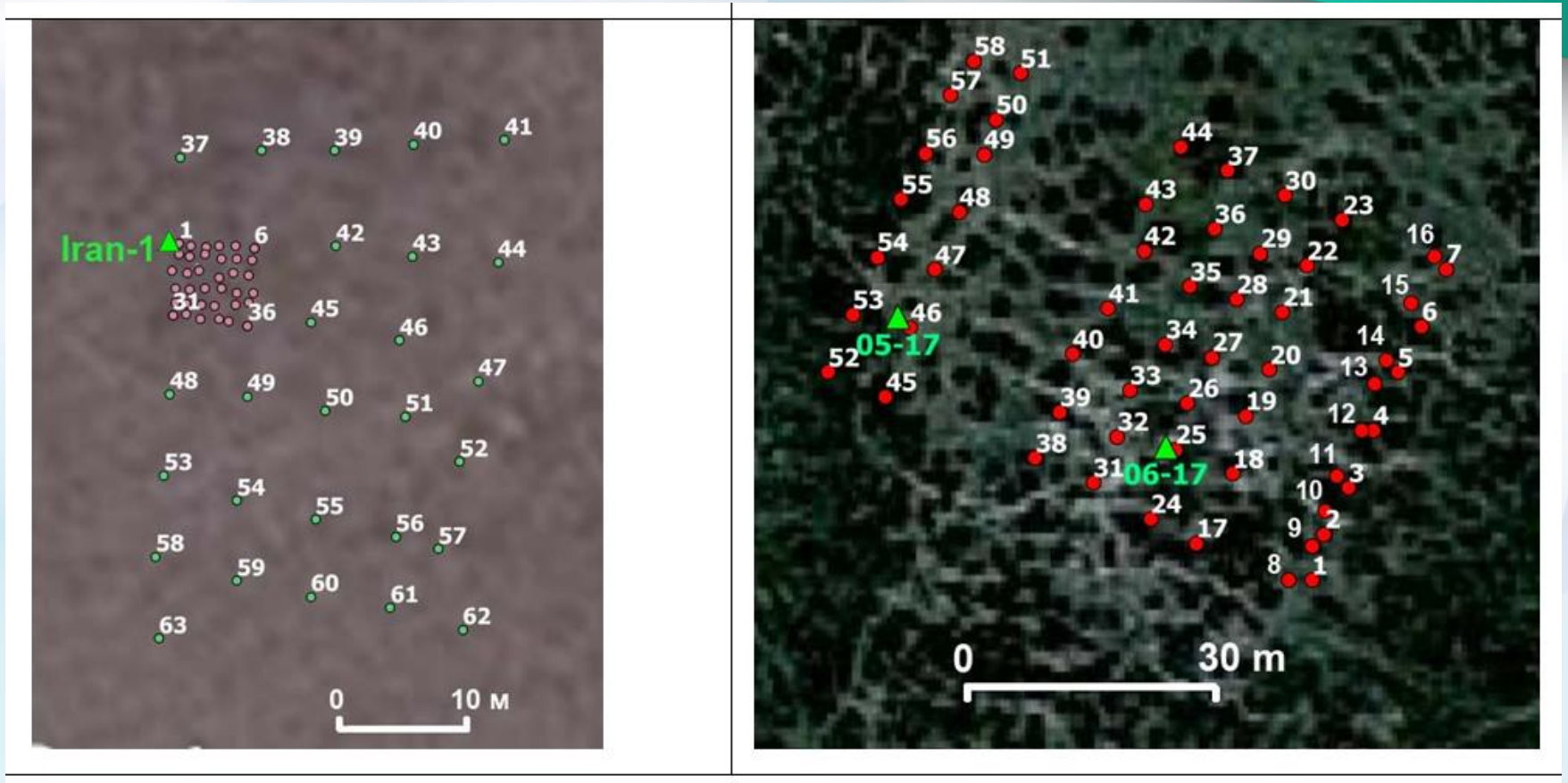
age ~ 4 yr.

-27.4 m below sea level

Methods of study

- Detailed soil sampling with 1-5 meter interval between sampling points
- Soil pits morphology (macro- and micro-)
- Portable devices (ORP, pH and EC measurements)
- DGPS (differential GPS for microtopography measurements)
- Chemical analysis
- Microbiological studies
- Space-borne imagery
- Digital soil mapping
- Geobotanical studies
- Radiocarbon dating

Ground truth data

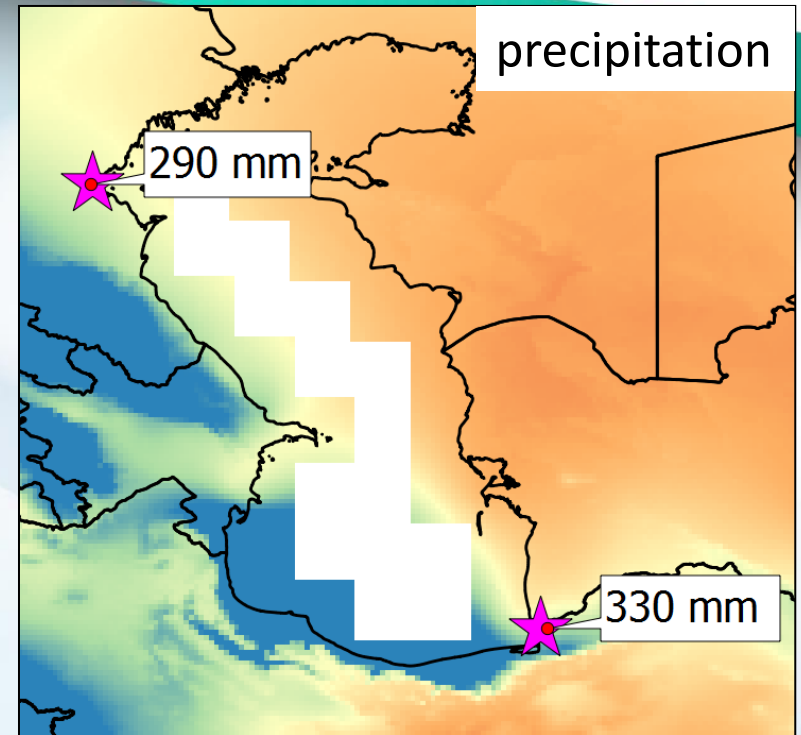
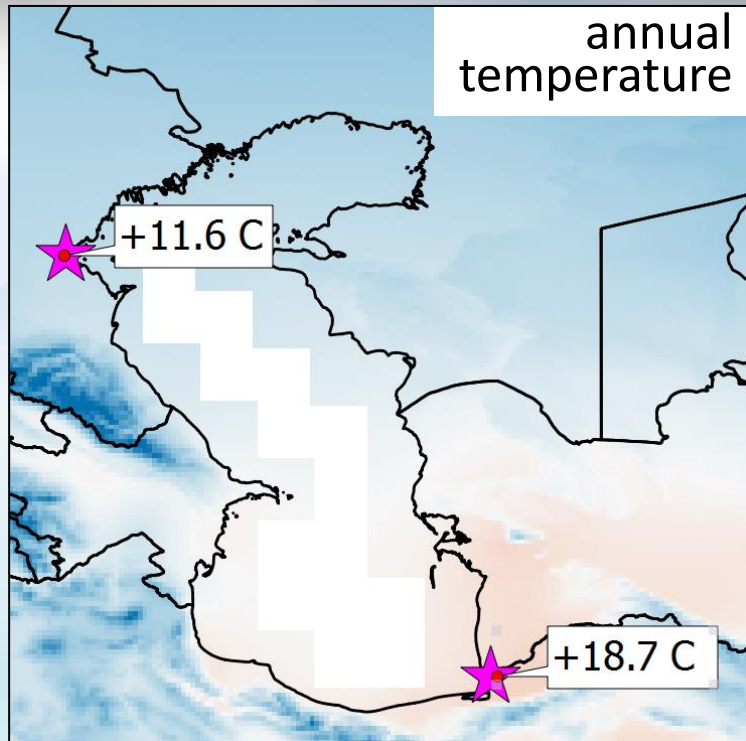


Iran-1 (63 boreholes + 1 pit)

Caspian-1 (58 boreholes + 2 pits)

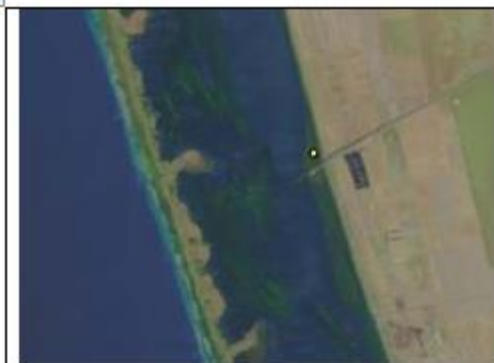
Boreholes are shown with circles, the boreholes are shown with triangles

Climatic features



Meteostation	T° january	T° july	T° annual	Precipitation (meteostation)	Precipitation (CGIAR worldclim)	Precipitation warm (Apr-Sept)	Precipitation cold (Oct-March)	Aridity coefficient
Iran (Bender Torkeman)	+8.4	+29.1	+18.7	465	330	157	308	0.29
Russia (Lagan)	-3.3	+25.9	+11.6	303	290	167	136	0.30

Recently dried up Gomishan lagoon



7 July 2013



5 April 2014



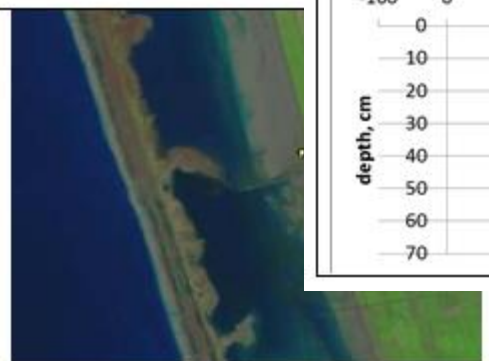
7 March 2015



10 April 2015



13 April 2017

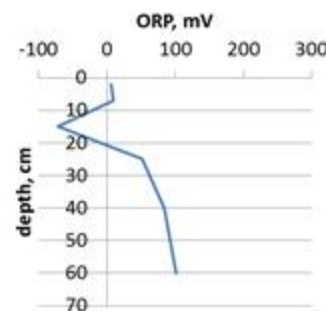
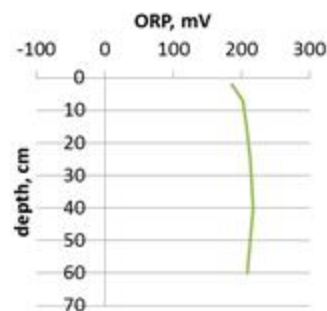


15 March 2018

Green *Salicornia* at the elevated bumps with cracks



Sparse *Salicornia*

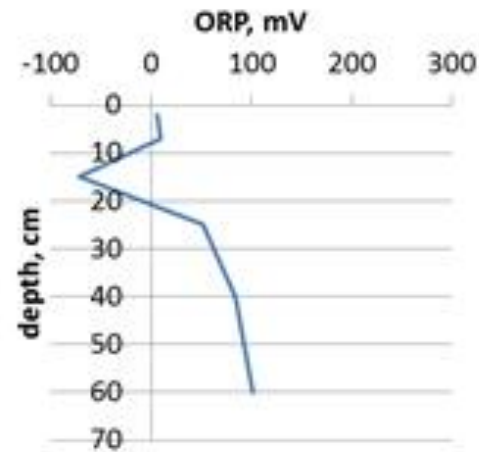
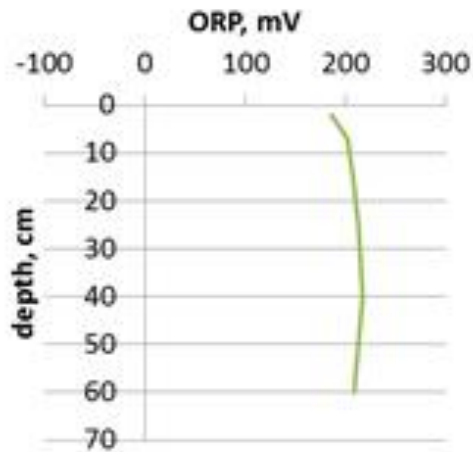


Colonization of the young dry land with *Salicornia*

Green *Salicornia* at the elevated bumps with cracks



Sparse *Salicornia*

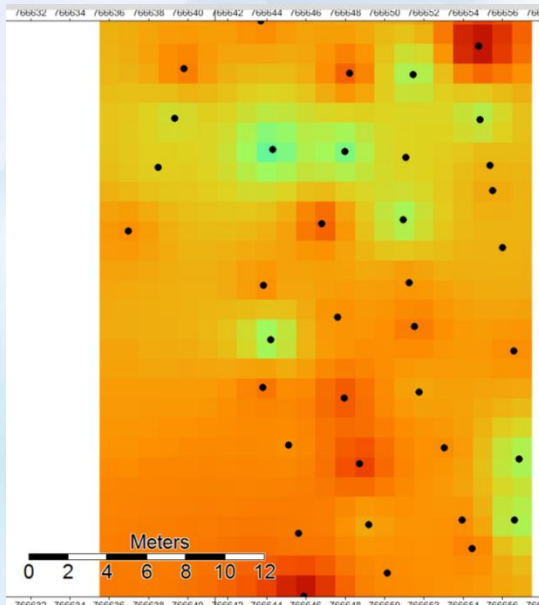


Colonization along the cracks

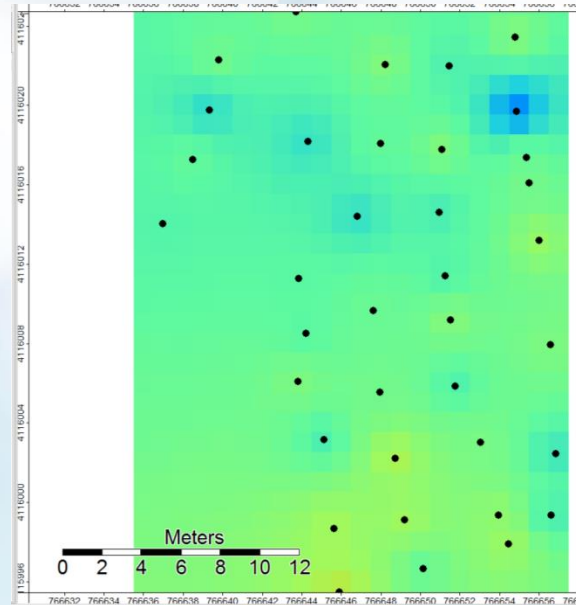


Salinity pattern (4 years of soil formation)

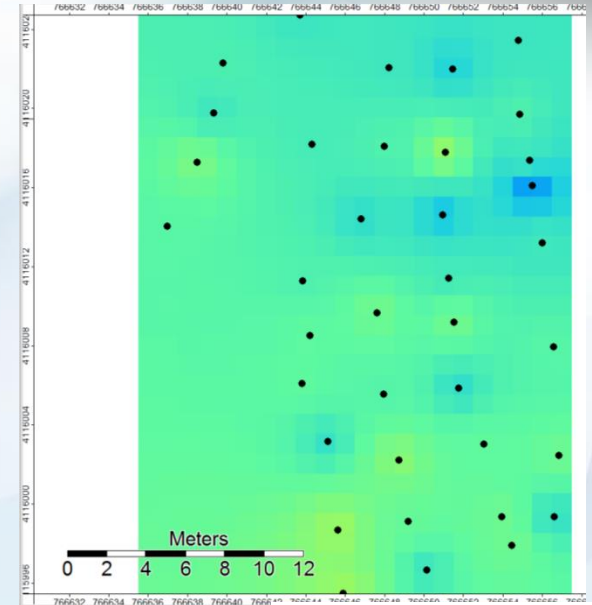
0-5 cm



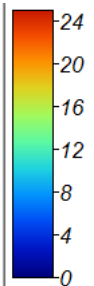
5-10 cm



10-20 cm



EC 1:2.5 (dS/m)



Iran-3

Vegetation at older plots

Iran-1

(Halocnemum community)



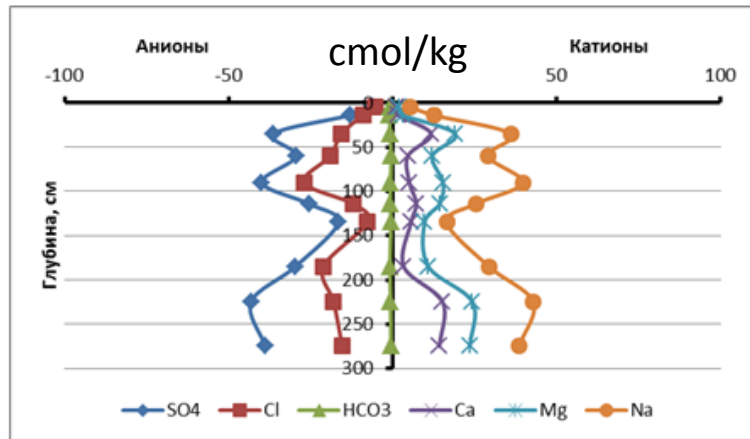
Caspian-2

(Tamarix community)

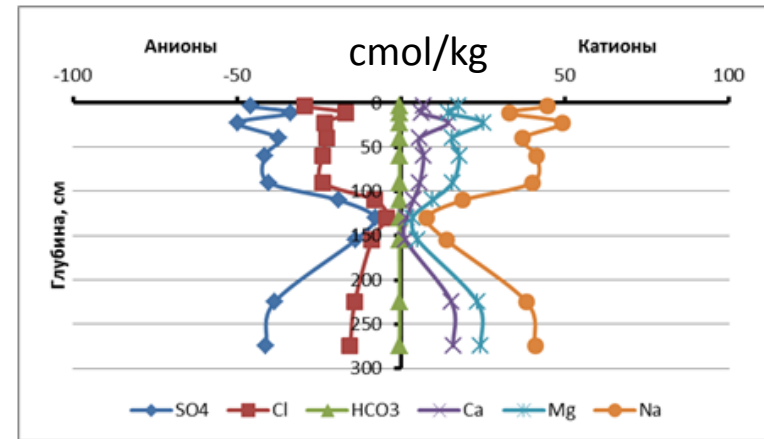


Soils

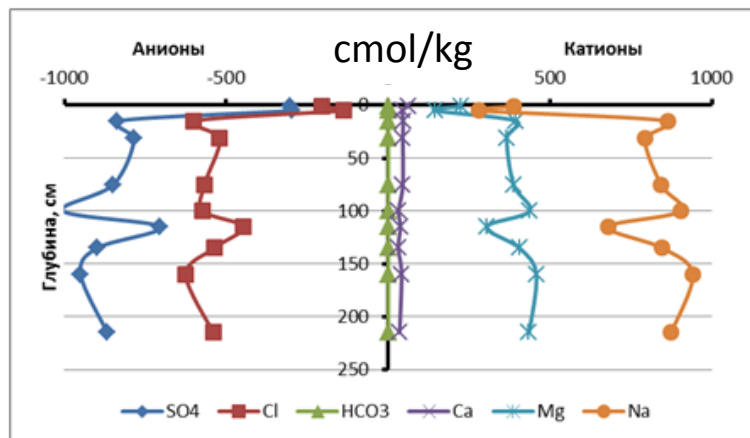
Pit 05-17



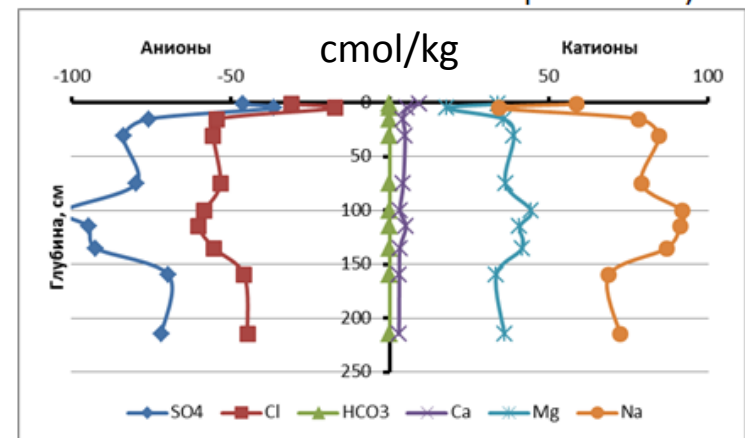
Pit 06-17



Pit Iran-1
(soil paste extract)

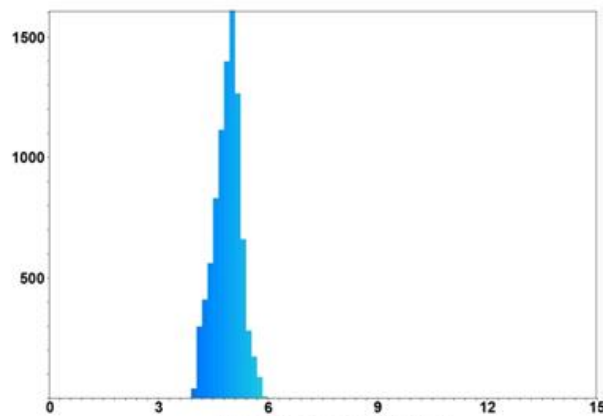
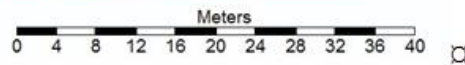
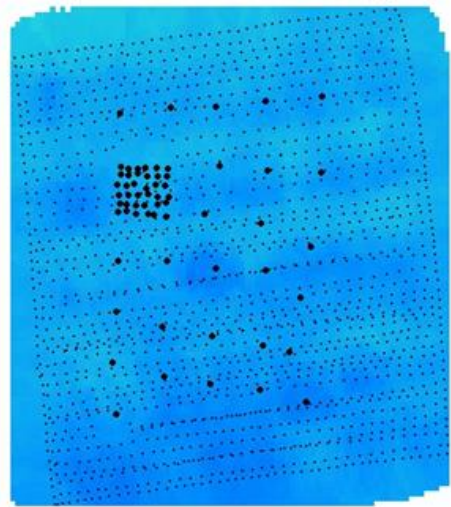


Pit Iran-1
(after recalculation into 1:5 water extract which is
in accord with the Russian procedure)



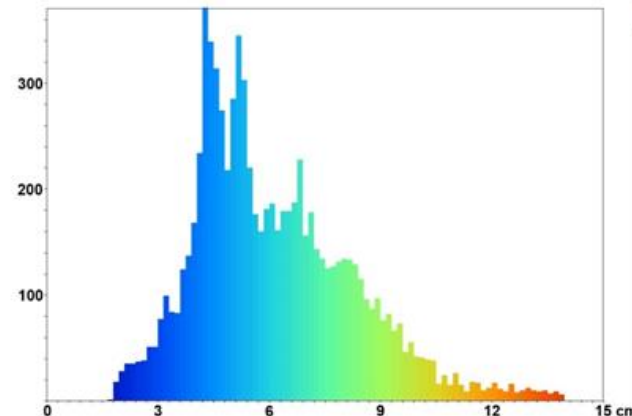
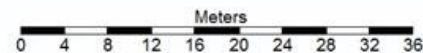
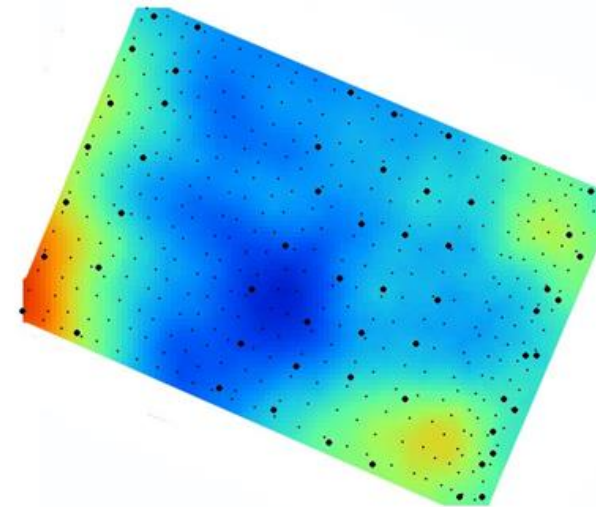
Microtopography

Iran-1 (25x20 m)



Relative altitude, cm

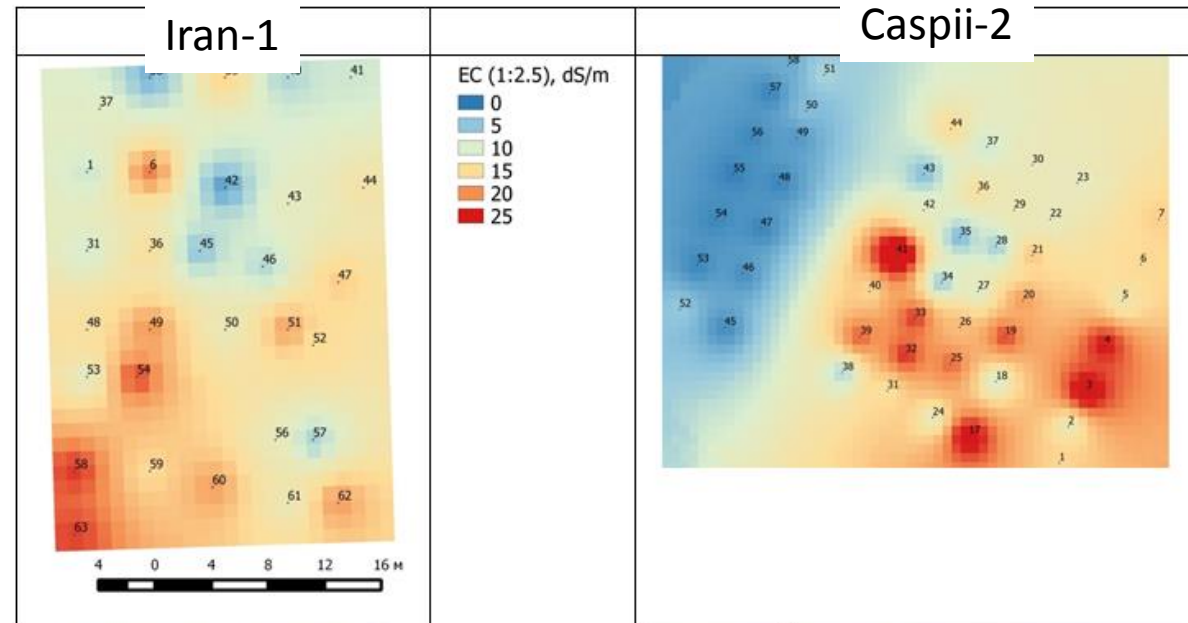
Caspian-2 (45x30 m)



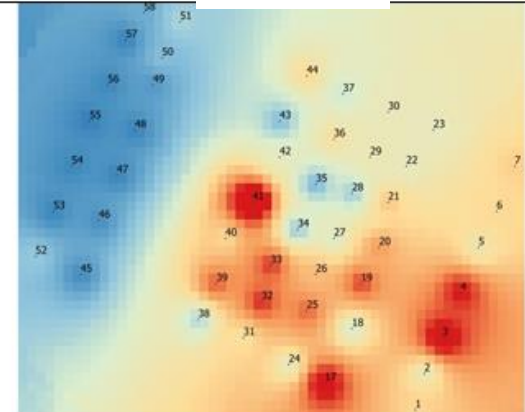
Relative altitude, cm

Salinity pattern (>60-70 years of soil formation)

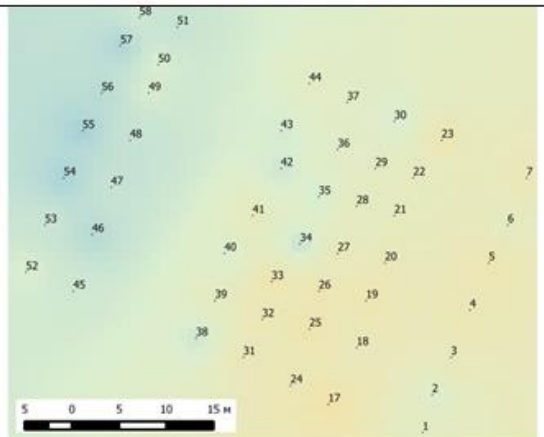
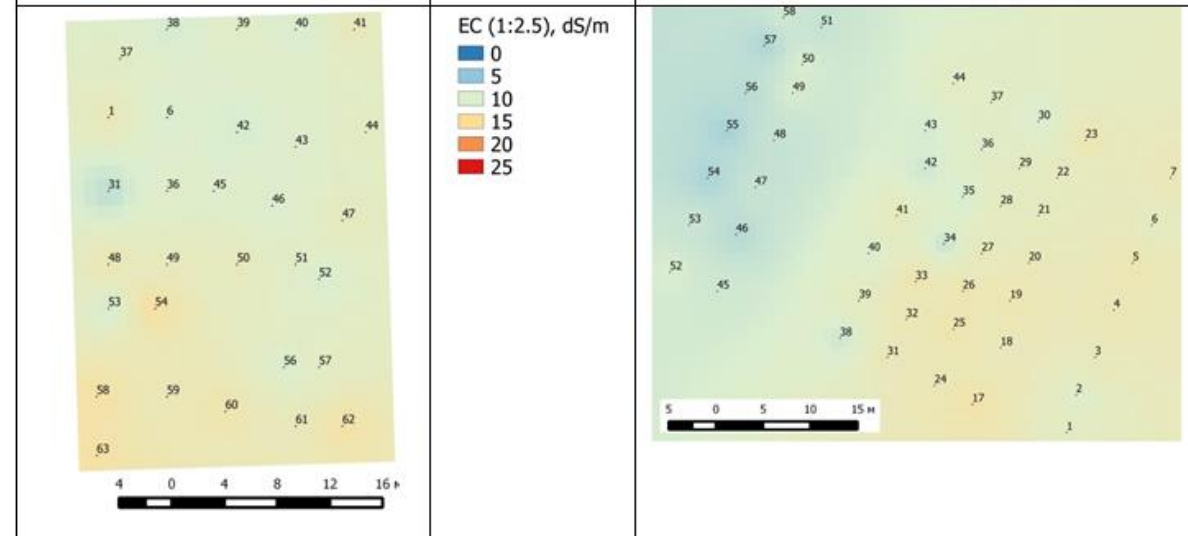
0-5 cm



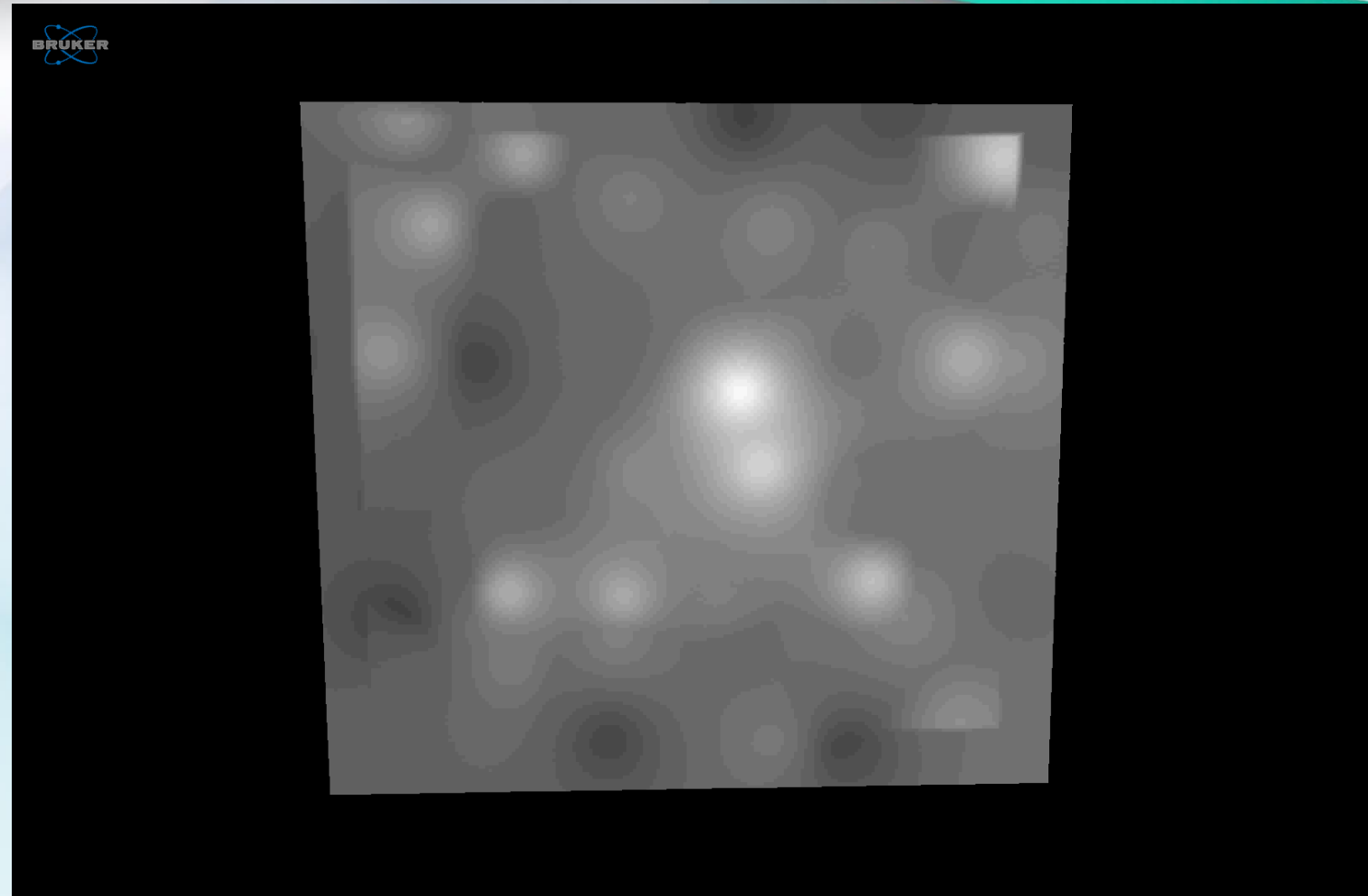
Caspian-2



0-100 cm



3-D salinity map

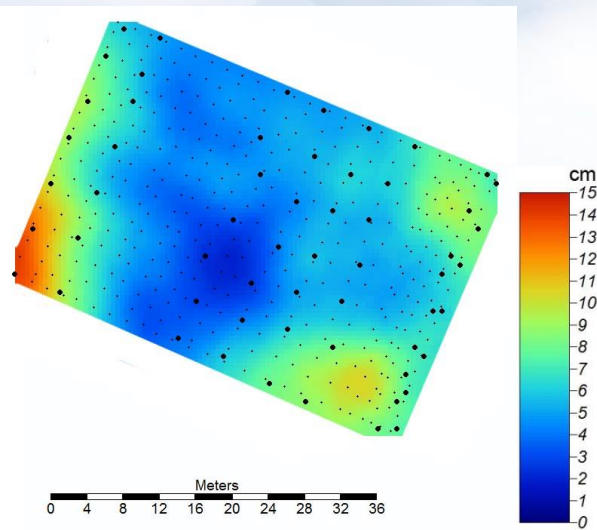


The comparison of the salinity of the studied sites

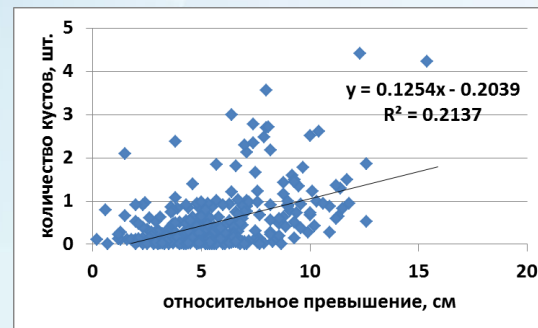
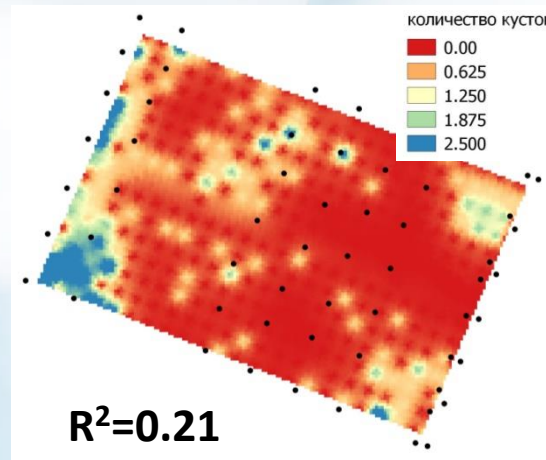
	0-5 cm	5-10 cm	10-20 cm	20-30 cm	30-50 cm	50-70 cm	70-100 cm	0-100 cm
Russia (Caspian-2)								
No of samples	49	49	49	49	49	49	49	49
Mean	11.7	10.6	8.9	10.3	10.5	10.2	11.1	10.5
Minimum	0.5	0.7	2.7	4.8	5.8	5.4	8.3	6.6
Maximum	35.2	15.2	13.2	14.2	14.2	13.4	13.0	13.4
Range	34.7	14.5	10.5	9.4	8.4	8.0	4.7	6.8
SD	8.6	4.1	2.4	2.3	2.0	1.6	1.3	1.8
Iran (Iran-1)								
No of samples	63	63	63	63	63	63	63	63
Mean	12.0	8.4	9.4	10.7	10.1	10.8	11.8	10.8
Minimum	2.4	2.8	4.7	6.2	4.7	7.1	5.6	7.2
Maximum	25.3	14.8	17.2	15.3	13.9	15.1	17.1	14.2
Range	22.9	12.0	12.4	9.1	9.2	8.0	11.4	7.0
SD	6.0	3.0	2.8	2.2	2.1	1.9	2.0	1.5
t-test (p)								
Mean	0.80	0.00	0.32	0.30	0.25	0.07	0.04	
Variance	0.01	0.02	0.28	0.83	0.88	0.14	0.00	

The relationship between microtopography and tamarix location (Caspian-2)

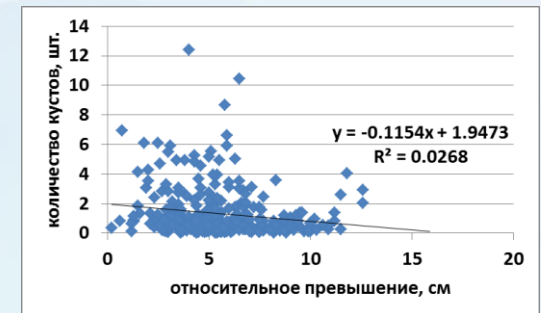
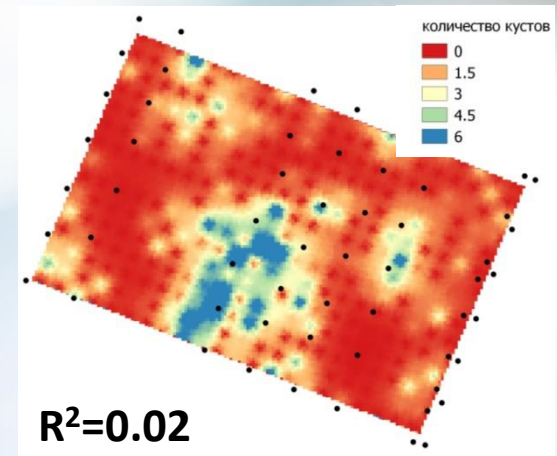
Microtopography



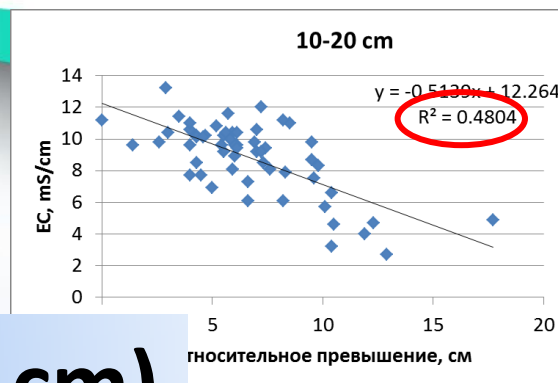
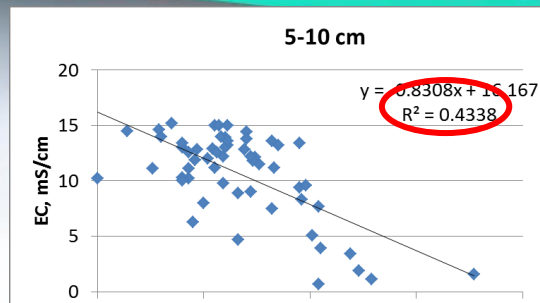
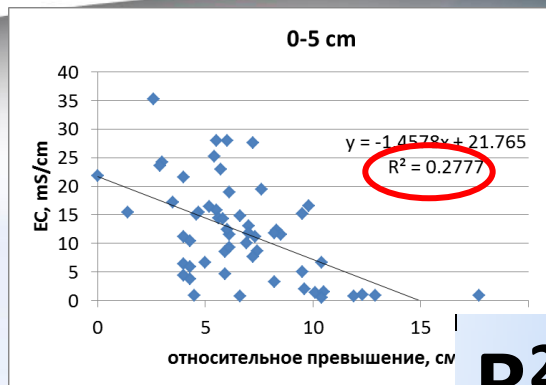
Big shrubs of tamarix



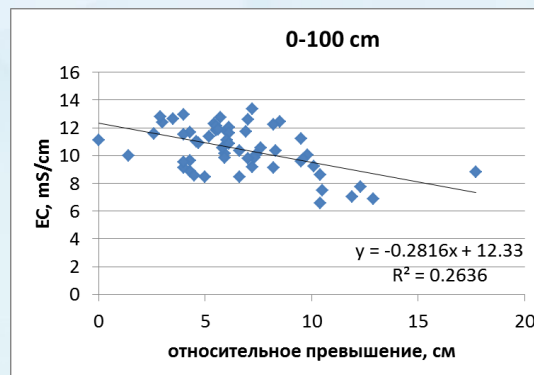
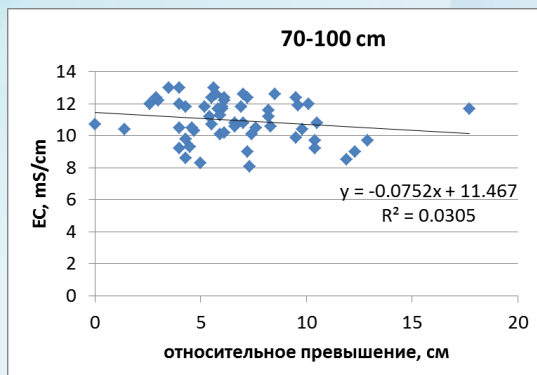
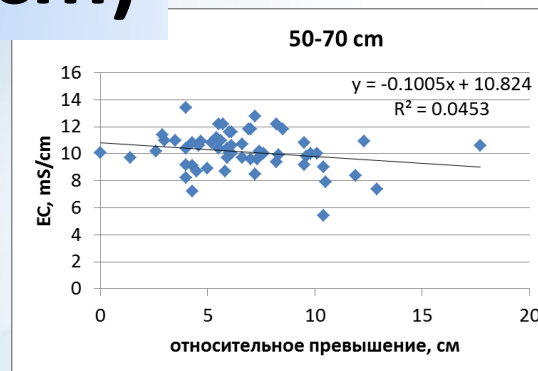
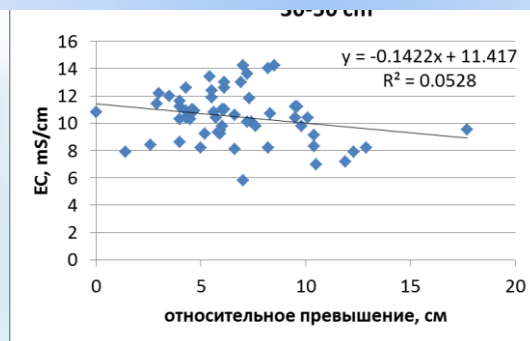
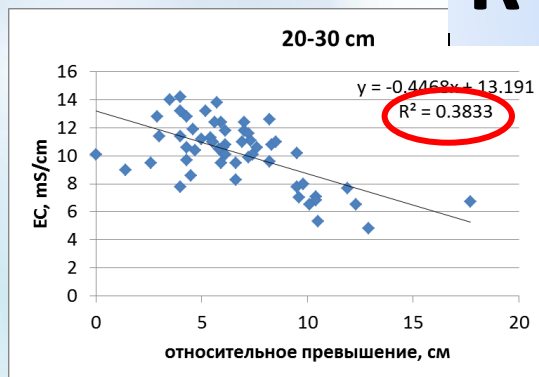
Small shrubs of tamarix



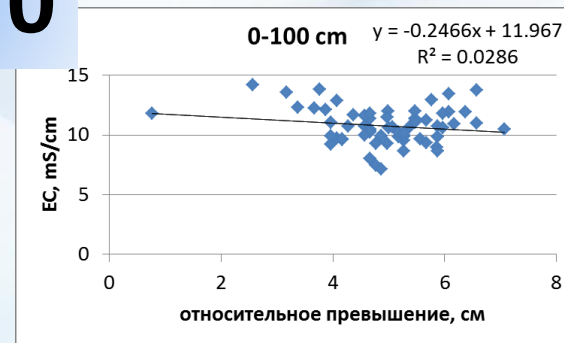
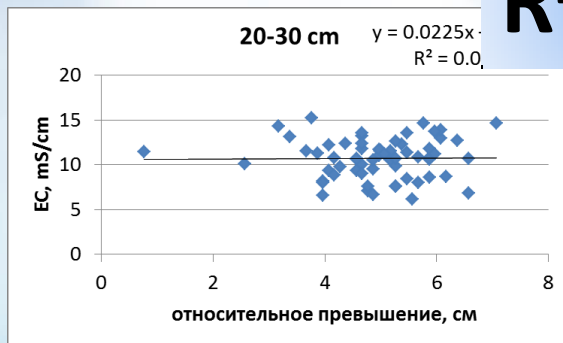
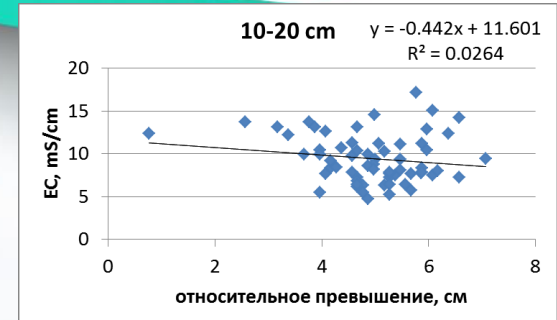
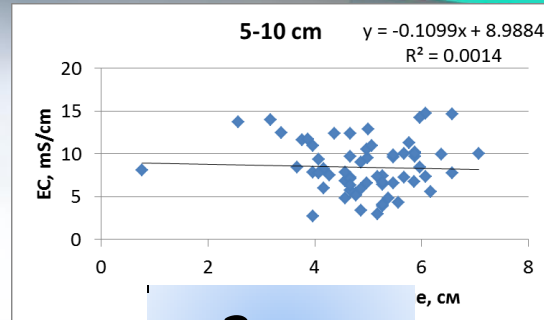
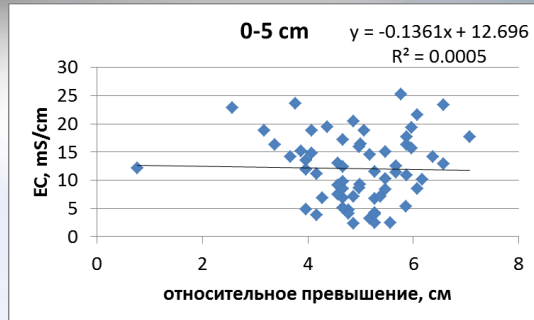
The relationship between salinity and microtopography (Caspian-2)



$R^2 \sim 0.3-0.5$ (0-30 cm)



The relationship between salinity and microtopography (Iran-1)



$R^2 \sim 0$

Main conclusions

- The differentiation of soils by their salinity takes place during first decades and centuries of subaerial soil formation and antedates the differentiation of other components of environment (vegetation, microtopography, developed soils)
- At the earliest stages of subaerial development of the coastal plains, the differentiation of soil cover by its salinity occurs in the upper 50-70 cm with a maximal pronunciation at the upper 5 cm. The spatial variation of soil salinity is very similar at the studied sites despite the differences in vegetation, climate and microtopography between them.
- As a hypothesis, we suggest that the primary trigger of differentiation at the fine-textured deposits is the formation of contraction cracks which serve as tunnels to leaching of salts. The subsequent evolution of the landscape “fastens” and strengthens the spatial heterogeneity formed in the previous stages.

Thank you for your attention!

