4. Assessment of future changes in air humidity (based on research results [5])

4.1. Observed humidity trends

Humidity deficit is a difference between saturation vapor pressure and actual vapor pressure under given temperature. 6 stations were selected to describe man's impact on humidity regime. These stations characterize the following areas: Nukus station - irrigated Amudarya downstream; Tamdy station - central Kyzylkum; Tashkent station - submountain zone where urbanization influence is stronger; Dzhizak station - Golodnaya steppe, with irrigated area extended intensively over last decades; and, Chimbay and Muynak stations - Priaralie (besides, Muynak is the former near-shore station).

Autumn changes in average humidity deficit (data of these stations) are shown in Fig. 23.

Though Nukus station is located not far from irrigated schemes, its humidity deficit trends are similar to those observed at Tamdy station. Long-term trends are not observed for winter and spring, while there is a tendency to deficit increase in summer and autumn. Humidity deficit tends to increase almost in all seasons at Tashkent station, and Dzhizak station records anthropogenic decrease of humidity deficit. Humidity deficit trends are practically unequivocal in Priaralie - as the sea depletes, humidity deficit grows in all seasons and amplitude of fluctuations increases. It is even visible that homogeneity of observational series breaches. This is connected with the regression of the Aral Sea.

Thus, humidity deficit is very climate-sensible indicator of drought. If local man's impact is absent, this indicator fixes tendencies to increased aridity in autumn-summer period.

Evaporativity. Evaporativity behavior in particular seasons was estimated by N.N.Ivanov's formula with L.A. Molchanov's adjustments for conditions of Uzbekistan [4, 6]

$$E_m = 0{,}00144 \, (25 + T)^2 \cdot (100 - a), \tag{1}$$

where T is average monthly temperature, a is average monthly relative humidity. Calculation of actual evaporation is specific and very complex problem /5/. However, value calculated by formula (1) is an objective test for assessing potential evaporation trends in given meteorological conditions.
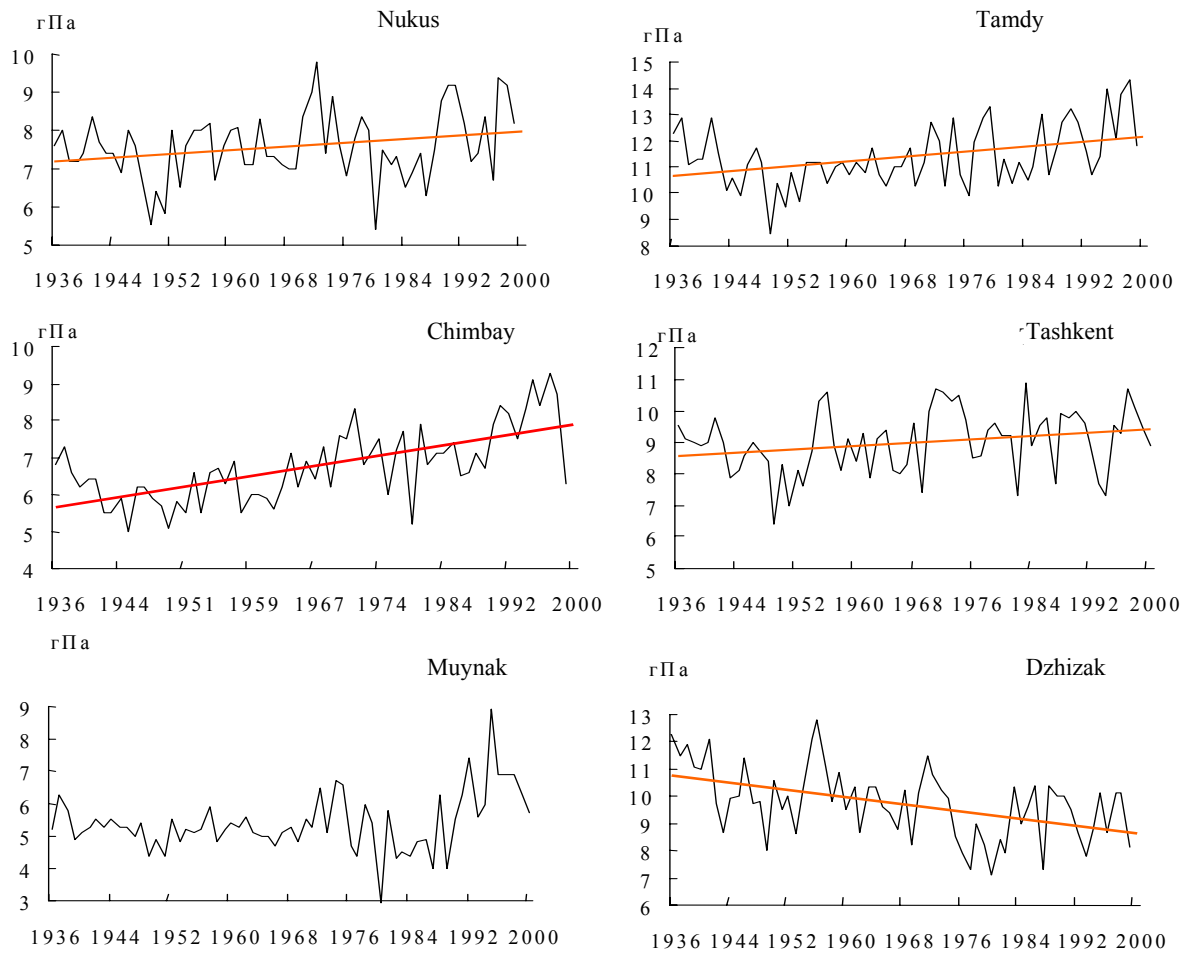
Fig. 23 | Changes of average autumn humidity deficit by weather stations located in Uzbekistan
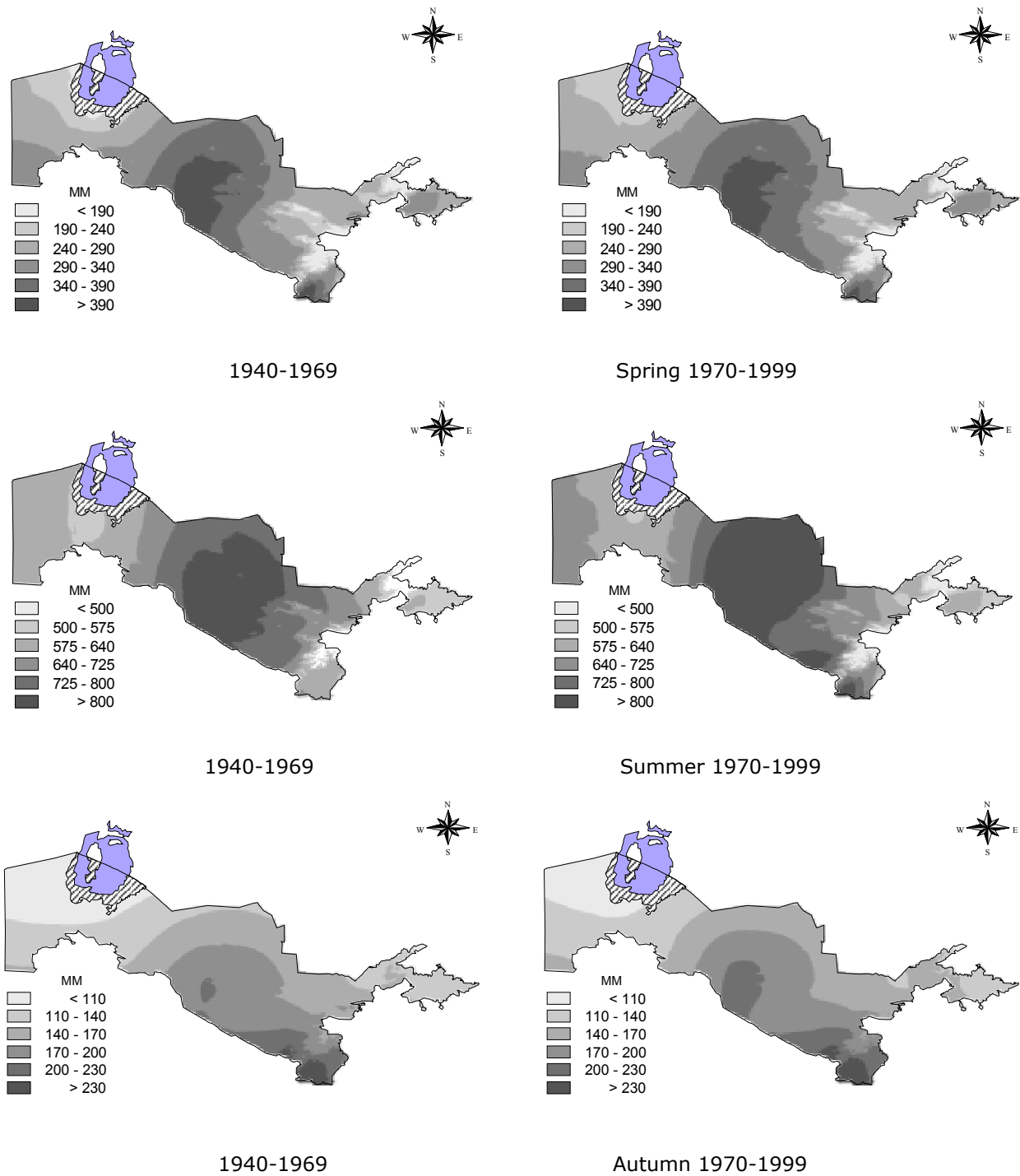
MM
< 190
190 - 240
240 - 290
290 - 340
340 - 390
> 390

1940-1969

MM
< 190
190 - 240
240 - 290
290 - 340
340 - 390
> 390

Spring 1970-1999

MM
< 500
500 - 575
575 - 640
640 - 725
725 - 800
> 800

1940-1969

MM
< 500
500 - 575
575 - 640
640 - 725
725 - 800
> 800

Summer 1970-1999

MM
< 110
110 - 140
140 - 170
170 - 200
200 - 230
> 230

1940-1969

MM
< 110
110 - 140
140 - 170
170 - 200
200 - 230
> 230

Autumn 1970-1999

Fig. 24 | Evaporation values computed for various 30-years period

The minor difference between evaporation values computed for various 30-years periods is observed in spring. In summer an increased evaporativity is observed during 1970-1999. Besides Priaralie, evaporativity increases over the whole plane area in the republic, including Ferghana Valley and Valleys of Surkhandarya and Kashkadarya. Only in Golodnaya Steppe evaporativity decreases under influence of human-induced changes (Fig. 24). Area, which is characterized by maximum seasonal evaporativity during current 30-years period, has covered essential plane zone of Uzbekistan. Trends observed in summer are particularly important since they make major contribution to annual total. Autumn is also characterized by the increase of in posse evaporation.

4.2. Experiment on humidity estimation under climatic scenario (SANIGMI's study)

On a basis of "ideal forecast" conception an attempt was made to develop scenario of absolute specific humidity changes based on relationships with average monthly air temperatures.

Computation of prospective changes in air humidity under scenario conditions was based on regression equations formulated on a basis of actual data. Table 23 gives cumulative correlation coefficients for particular stations in Uzbekistan. Given correlation coefficients indicate to the close relationships during winter and spring months. This allows us to obtain reliable estimations of air humidity changes on a basis of average monthly temperatures.

Table 23 | Cumulative correlation coefficients (R_{svod}) used under inclusion of three predictors in the equation of regression to compute water vapor pressure (absolute specific humidity)

Station	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Zhaslyk	0.89	0.86	0.76	0.37	0.42	0.37	0.39	0.46	0.36	0.68	0.73	0.85
Chimbay	0.88	0.88	0.80	0.58	0.43	0.43	0.24	0.38	0.63	0.71	0.67	0.92
Akbaytal	0.81	0.85	0.66	0.32	0.31	0.52	0.55	0.44	0.45	0.53	0.69	0.86
Tamdy	0.79	0.87	0.59	0.46	0.47	0.39	0.30	0.49	0.36	0.53	0.72	0.79
Samarkand	0.73	0.89	0.57	0.63	0.68	0.12	0.26	0.79	0.15	0.5	0.42	0.72
Karakul'	0.84	0.89	0.69	0.41	0.48	0.34	0.48	0.49	0.36	0.56	0.71	0.8
Dzhizak	0.84	0.91	0.71	0.51	0.57	0.53	0.58	0.55	0.44	0.47	0.41	0.78
Tashkent	0.79	0.84	0.67	0.67	0.63	0.30	0.39	0.62	0.42	0.54	0.65	0.83
Pskem	0.33	0.73	0.66	0.68	0.45	0.32	0.46	0.33	0.38	0.58	0.66	0.73
Ferghana	0.72	0.86	0.57	0.65	0.77	0.46	0.29	0.67	0.55	0.62	0.62	0.79

It should be noted that, in spite of temperature, air humidity for continental regions depends mainly on general atmospheric circulation pattern. In summer and autumn, when there is no outside humidity inflow, which is characteristic of Uzbekistan, relationship between temperature and absolute specific humidity becomes weaker but considerable inverse relationship arises between temperature and relative humidity (Table 24) [8].

Table 24 | Coefficients of correlation between average monthly temperatures and relative humidity by weather stations

Station	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Chimbay	0,04	-0,1	-0,57	-0,63	-0,70	-0,79	-0,82	-0,8	-0,72	-0,58	-0,34	-0,06
Tamdy	-0,28	-0,25	-0,50	-0,54	-0,57	-0,57	-0,62	-0,55	-0,55	-0,61	-0,4	-0,28
Tashkent	-0,59	-0,57	-0,67	-0,73	-0,80	-0,83	-0,83	-0,78	-0,85	-0,78	-0,64	-0,57
Ferghana	-0,33	-0,38	-0,71	-0,72	-0,79	-0,79	-0,8	-0,8	-0,83	-0,76	-0,57	-0,39
Samarkand	-0,57	-0,49	-0,71	-0,73	-0,76	-0,80	-0,84	-0,77	-0,81	-0,81	-0,67	-0,62
Termez	-0,64	-0,65	-0,73	-0,82	-0,81	-0,81	-0,82	-0,79	-0,84	-0,82	-0,64	-0,64

Obtained results indicate to a need for further developmental works on estimation of humidity parameters under climate change. Additional complexity during estimation of humidity changes in Uzbekistan is caused by various local man's impacts (depletion of the Aral sea, presence of irrigation systems and irrigated schemes, appearance of artificial lakes). It is necessary to continue with study and estimation of humidity changes subject to local man's impact that breaches homogeneity of humidity observational series.

Developed regression equation methods allow us to provide preliminary estimation of humidity changes under climatic scenario. For practical purposes as a scenario of relative humidity for short-term the values averaged over last decade may be used, as an analogue of future climate warming (Table 25). Sequence of stations corresponds to the list given in section 2.4, Table 12.

Table 25 | Average values of relative humidity (%) over 1991-2000 by 50 stations in Uzbekistan

Station	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1	87	85	78	57	53	44	42	40	48	59	79	88
2	78	74	67	51	47	40	36	37	41	51	69	77
3	71	67	59	47	45	42	41	44	48	53	63	71
4	80	76	72	59	56	47	43	46	54	59	70	78
5	79	72	61	49	49	46	48	48	51	54	69	79
6	84	81	75	64	61	54	53	50	58	62	75	83
7	80	73	64	52	49	45	47	50	53	58	72	80
8	84	78	66	54	51	45	46	49	52	57	73	83
9	79	72	58	42	39	30	29	30	33	44	66	79
10	72	68	56	43	37	29	24	24	28	36	59	71
11	55	52	45	39	35	31	29	31	35	38	45	54
12	80	75	63	50	40	31	27	27	31	46	68	79
13	71	64	53	47	39	33	32	33	37	43	64	68
14	76	75	72	62	57	45	41	41	47	58	68	73
15	83	81	77	67	59	47	42	42	50	60	76	84
16	80	76	69	57	51	40	36	39	48	57	68	75
17	78	75	69	59	53	40	35	37	46	60	72	76
18	81	74	65	53	45	37	37	39	43	53	67	79
19	78	72	62	50	44	36	35	36	42	52	67	77
20	82	76	63	47	38	27	25	23	28	41	67	79
21	78	75	70	61	53	39	36	37	43	52	67	78
22	79	78	77	69	57	45	41	42	47	60	73	80
23	67	67	66	57	50	35	29	28	32	42	54	60
24	72	70	68	62	56	41	37	39	47	56	65	71
25	79	75	75	68	62	53	52	56	60	65	73	76
26	69	65	64	53	42	32	34	36	40	47	57	63
27	63	63	63	58	55	49	45	45	52	56	58	60
28	67	64	64	58	53	45	45	48	50	56	63	65
29	76	70	70	58	46	36	34	37	44	54	67	75
30	63	67	71	66	60	46	41	39	45	55	60	60
31	72	71	68	61	56	46	44	45	50	60	69	71
32	79	78	72	63	56	44	43	46	50	60	73	79
33	83	81	75	67	63	49	41	41	46	59	75	81
34	79	79	76	65	60	43	34	34	40	53	70	78
35	72	73	76	72	69	60	51	47	53	60	66	69
36	73	68	63	59	58	48	44	44	49	59	69	72
37	81	76	68	60	56	45	44	45	48	57	71	80
38	87	84	76	69	65	56	58	63	65	69	79	86
39	85	80	71	63	59	49	47	50	54	63	76	85
40	80	76	73	65	60	50	51	57	61	69	77	80
41	88	83	76	70	65	58	59	62	64	72	82	88
42	69	68	67	60	62	54	47	39	41	53	65	70
43	57	61	68	62	61	49	43	39	42	50	56	56
44	72	72	75	72	65	61	57	49	49	59	69	71
45	83	76	64	54	48	42	39	39	44	58	72	83
46	80	75	67	60	56	49	47	49	53	64	74	82
47	85	79	70	62	58	51	54	59	61	68	79	86
48	87	81	72	64	58	51	52	56	62	69	80	88
49	79	72	67	61	54	47	48	53	56	62	74	83
50	82	76	68	61	59	52	56	58	63	68	75	84