Regional climate changes in Ukraine in the 21st century based on the projections of AOGCMs and RCMs

Svitlana Krakovska (1), Liudmyla Palamarchuk (2), Iryna Shedemenko (3), Galyna Djukel (1) and Natalia Gnatiuk (1,2)

(1) Ukrainian Hydrometeorological Institute, Kiev, Ukraine
(2) Kiev National Shevchenko University, Cathedra of Meteorology and Climatology, Ukraine
(3) Institute for Safety Problems of NPP NASU, Kiev, Ukraine

Objective:

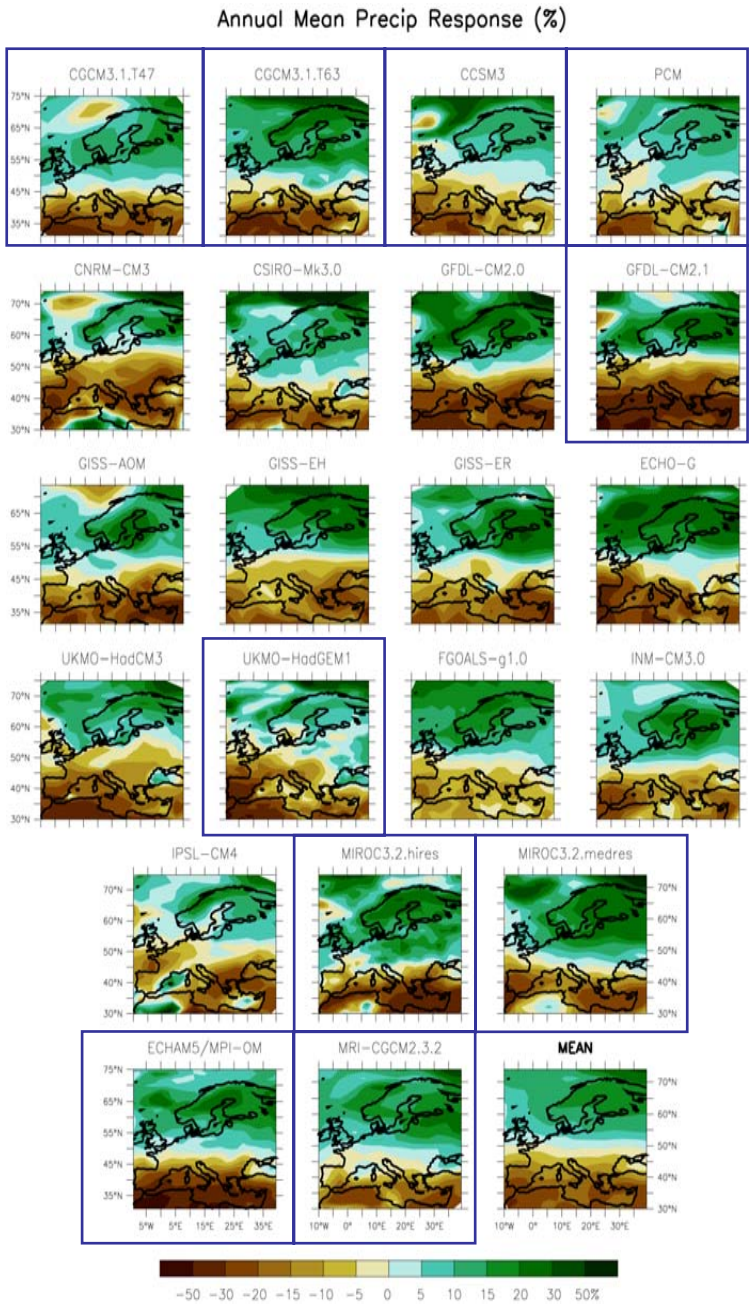
- To obtain quantitative characteristics of projected climate changes in Ukraine for three SRES scenarios (B1, A1B, A2) in the 21st century.

Methodology:

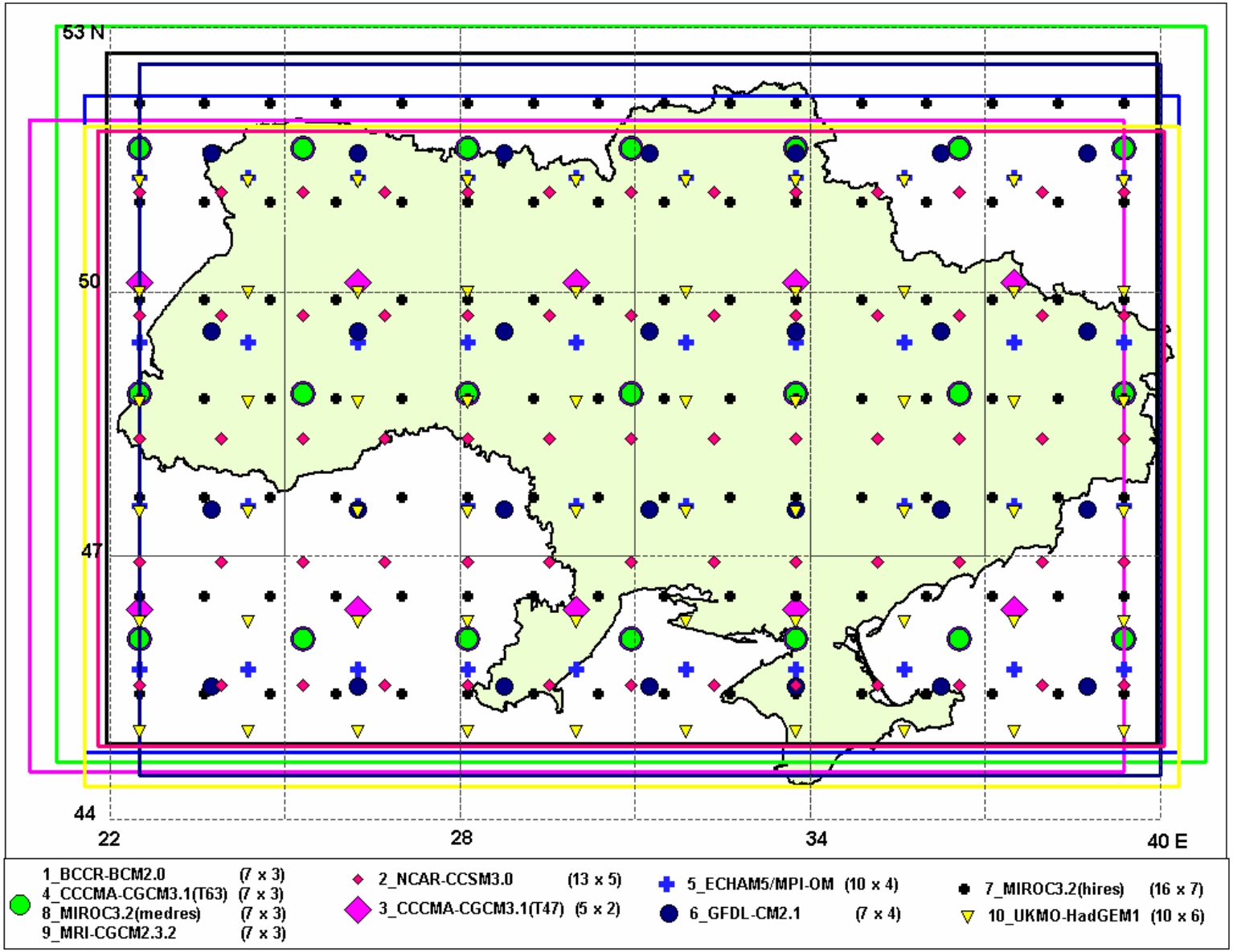
- A set of 10 AOGCMs with the highest complexity and resolution presented in the IPCC AR-4 (2007) was chosen.
- If a model had more than one run, an ensemble mean was obtained for such models.
- Yearly mean surface temperatures and precipitation sums were averaged over the territory of Ukraine for every model. Then ensemble mean of all models was obtained and time series were plotted and analyzed.
- 10-year periods of the 21st century were compared with the first decade to obtain quantitative characteristics of projected climate changes in Ukraine

Model ID, Vintage	Sponsor, country	Atmosph. Top,resol.	Number of expe-rim. B1-A1B-A2
1: BCCR-BCM2.0, 2005	Bjerknes Centre for Climate Research, Norway	top = 25 hPa T63 (1.9°x1.9°) L16	1-1-1
2: NCAR-CCSM3, 2005	National Center for Atmospheric Research, USA	top = 2.2 hPa T85 (1.4°x1.4°) L26	9-7-4
3:CGCM3.1 (T47), 2005	Canadian Centre for Climate Modelling and Analysis, Canada	top = 1 hPa T47 (2.8°x2.8°) L31	5-5-5
4:CGCM3.1 (T63), 2005	Canadian Centre for Climate Modelling and Analysis, Canada	top = 1 hPa T63 (1.9°x1.9°) L31	1-1-0
5: ECHAM5 / MPI-OM, 2005	Max Planck Institute for Meteorology, Germany	top = 10 hPa T63 (1.9°x1.9°) L31	5-4-3

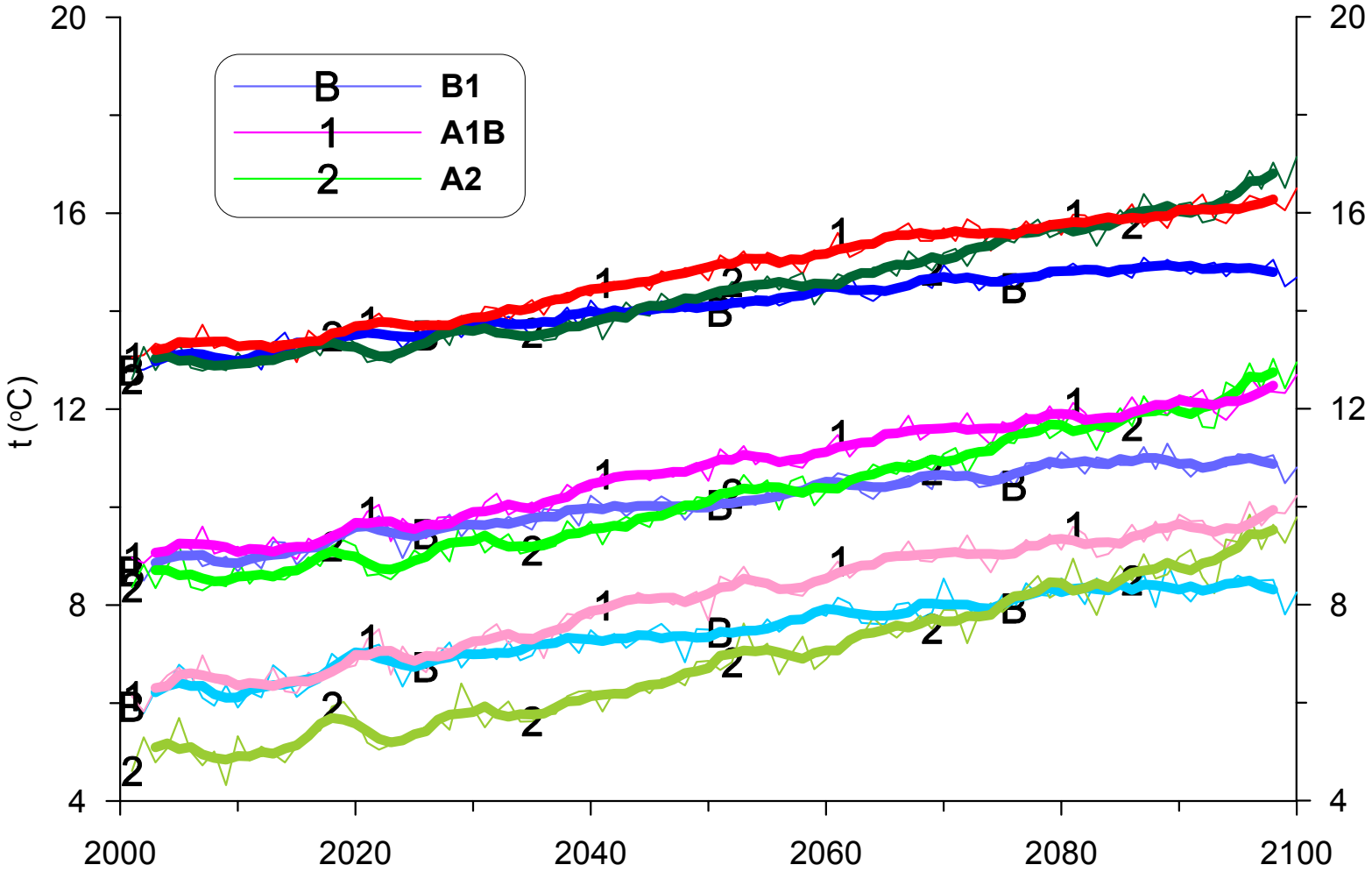
Model ID, Vintage	Sponsor, country	Atmosph. Top,resol.	Number of expe-rim. B1-A1B-A2
6: GFDL-CM2.1, 2005	U.S. Department of Commerce / NOAA / GFDL, USA	top = 3 hPa 2.0° x 2.5° L24	1-1-1
7: MIROC 3.2 (hires), 2004	Center for Climate System Research, National Institute for Environmental Studies, JAMSTEC, Japan	top = 40 km T106 (1.1°x1.1°) L56	1-1-0
8: MIROC 3.2(medres), 2004	JAMSTEC, Japan	top = 30 km T42 (2.8°x2.8°) L20	3-3-3
9: MRI-CGCM2.3.2, 2003	Meteorological Research Institute, Japan	top = 0.4 hPa T42 (2.8°x2.8°) L30	5-5-5
10: UKMO-HadGEM1, 2004	Hadley Centre for Climate Prediction and Research / Met Office, UK	top = 39.2 km (1.3°x1.9°) L38	1-1-1



Coordinates of AOGCMs over Ukraine

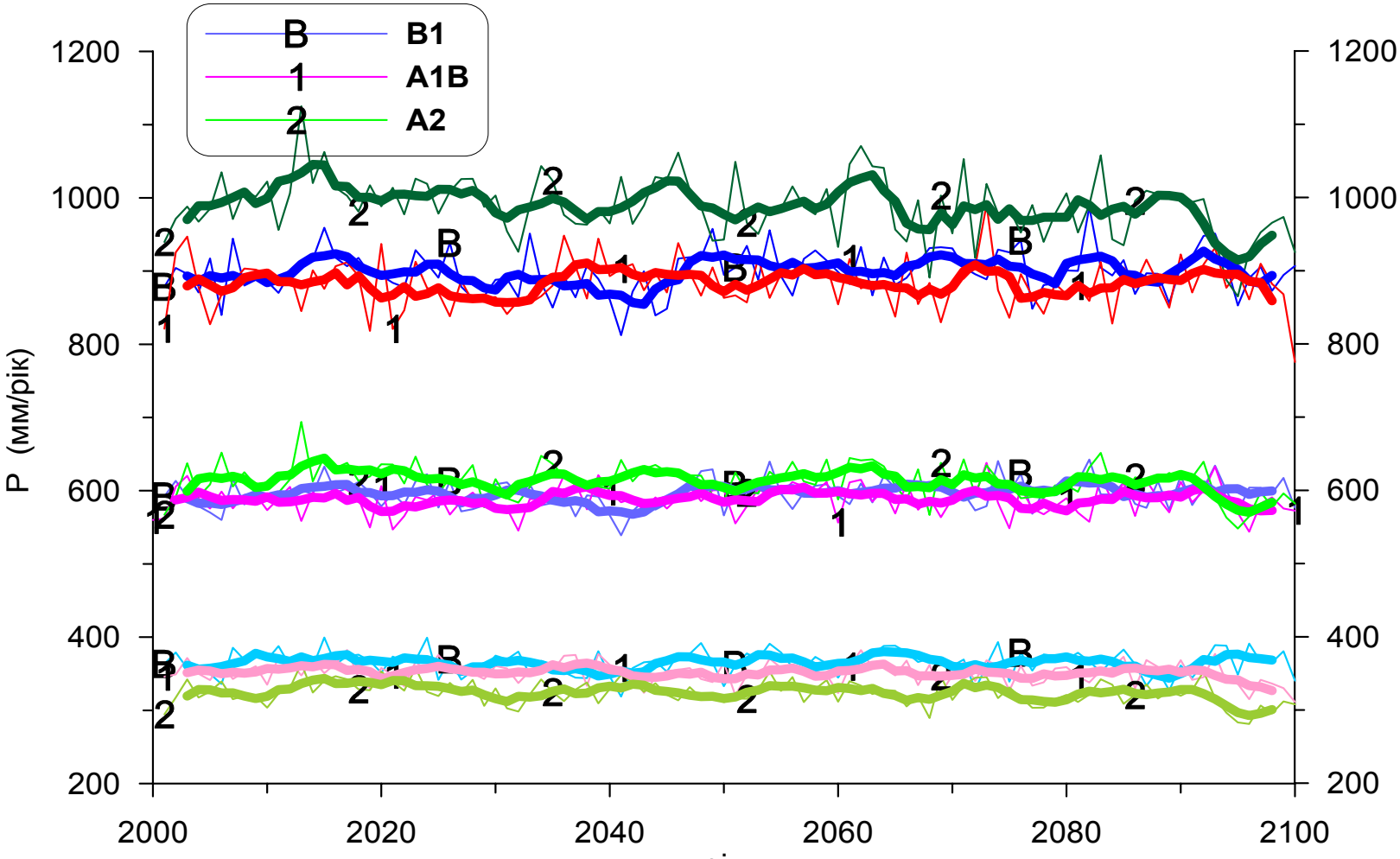


Projected changes of min, mean and max temperatures averaged over Ukraine in the 21st century (10 AOGCM's ensemble mean)



Bold lines – 5-year running averagespik

Projected changes of min, mean and max yearly precipitation averaged over Ukraine in the 21st century (10 AOGCM's ensemble mean)



Bold lines – 5-year running averages

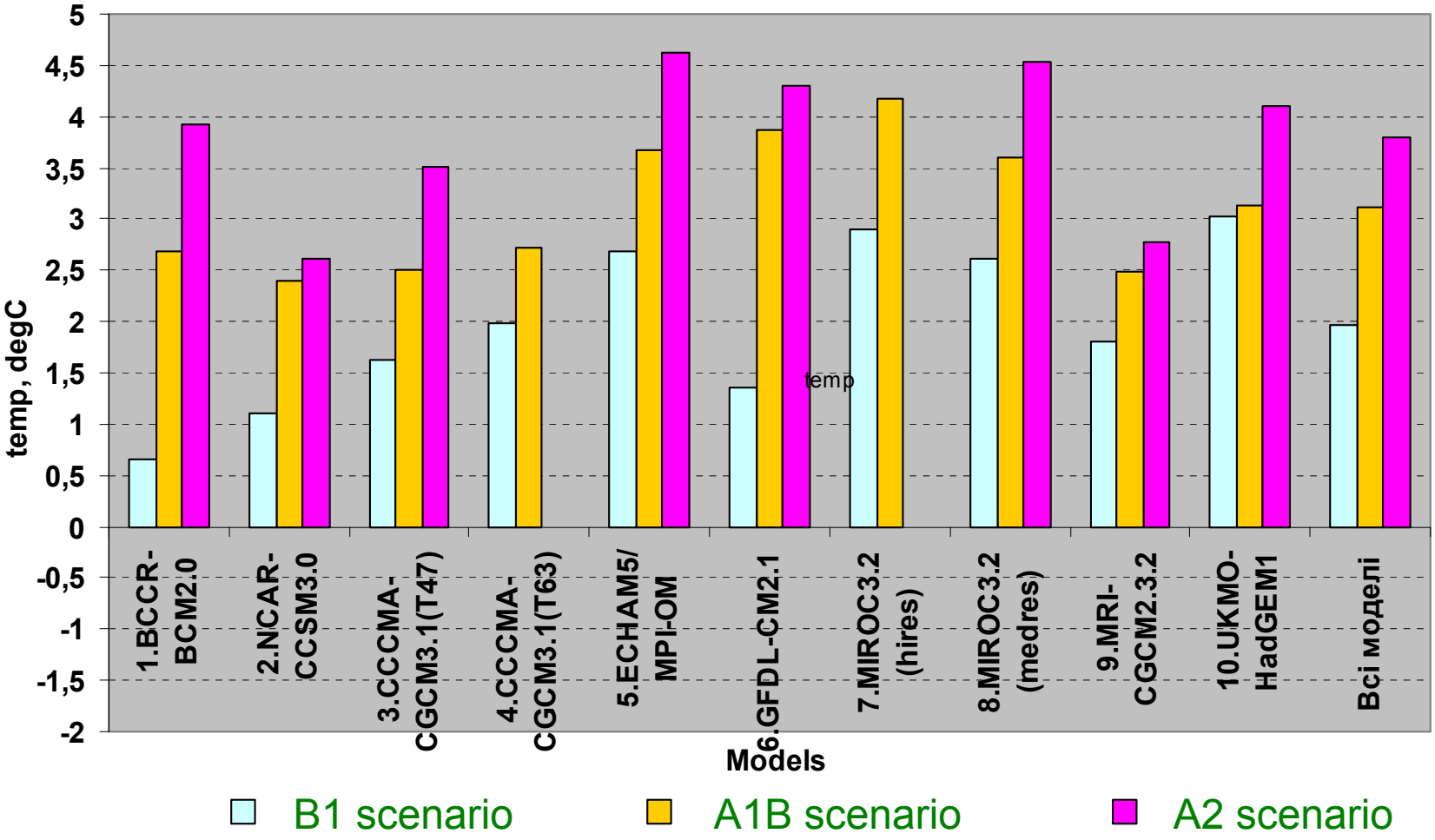
10-year mean temperature differences (degC) comparable to the 2001-2010 period

	10-year periods in the 21st century								
	2	3	4	5	6	7	8	9	10
B1 scenario									
Mean	0,3	0,7	0,9	1,1	1,4	1,7	1,8	2,1	2,0
σ	0,3	0,4	0,5	0,6	0,7	0,7	0,5	0,7	0,8
Min	-0,2	-0,1	0,2	0,2	0,2	0,6	1,2	1,1	0,7
Max	0,7	1,4	1,8	2,1	2,4	2,9	2,5	3,5	3,0
A1B scenario									
Mean	0,1	0,5	1,0	1,5	1,9	2,3	2,6	2,8	3,1
σ	0,4	0,4	0,3	0,3	0,3	0,3	0,5	0,6	0,7
Min	-0,8	-0,2	0,4	1,0	1,5	1,8	1,6	2,2	2,4
Max	0,4	1,2	1,5	2,0	2,6	2,8	3,3	3,9	4,2
A2 scenario									
Mean	0,2	0,4	0,7	1,2	1,7	2,2	2,7	3,2	3,8
σ	0,2	0,2	0,3	0,3	0,3	0,5	0,5	0,7	0,8
Min	0,0	0,0	0,3	0,8	1,2	1,5	2,0	2,1	2,6
Max	0,5	0,7	1,1	1,6	2,2	3,0	3,3	4,3	4,6

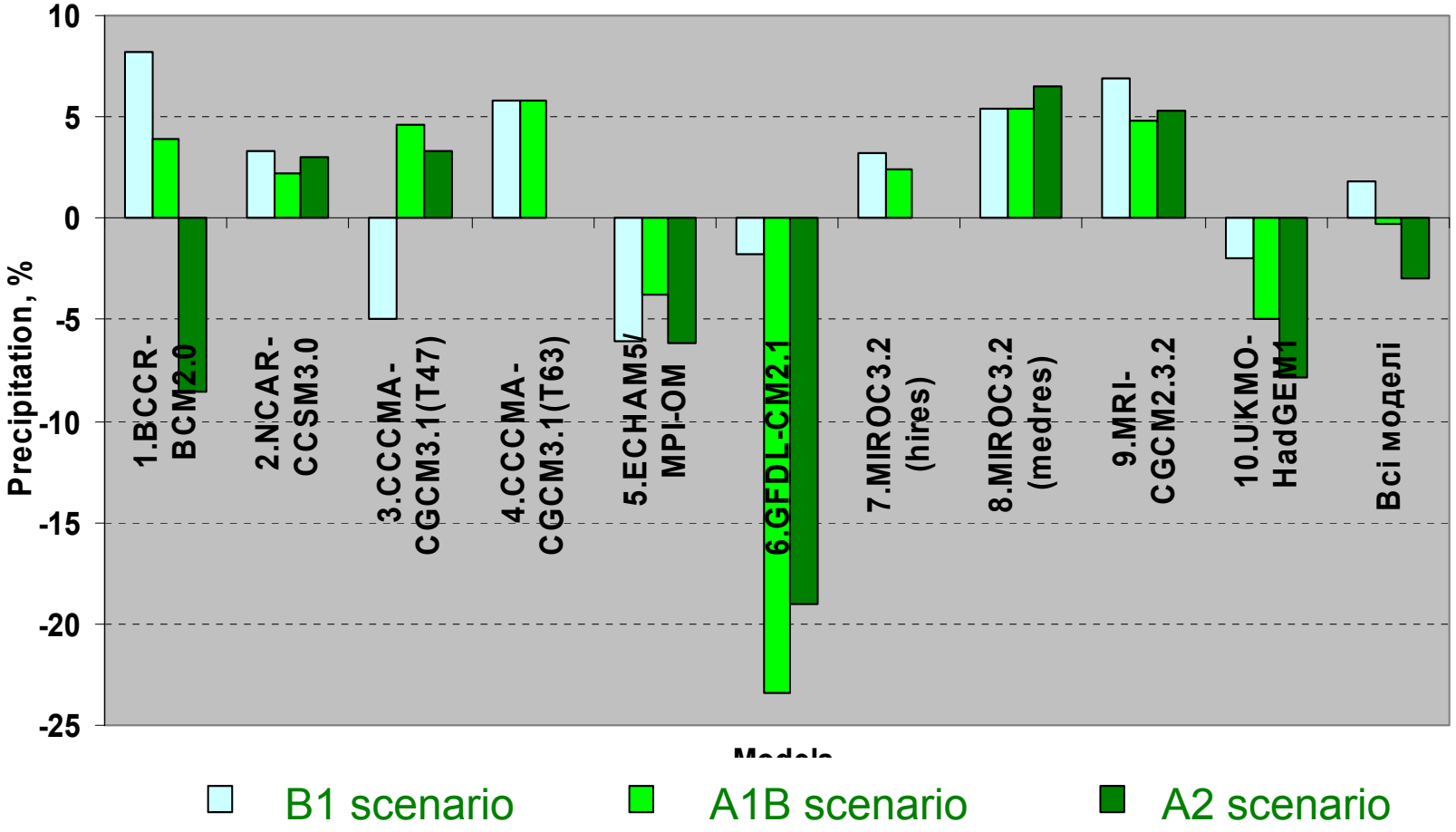
10-year mean precipitation differences (%) comparable to the 2001-2010 period

	10-year periods in the 21st century								
	2	3	4	5	6	7	8	9	10
B1 scenario									
Mean	2,0	0,8	0,0	-0,3	2,2	2,3	1,8	2,3	1,8
σ	4,2	5,4	4,4	5,0	4,6	5,3	5,4	4,2	5,1
Min	-2,8	-9,5	-9,2	-12,3	-3,4	-6,4	-9,2	-2,4	-6,0
Max	9,9	7,2	5,2	5,7	9,7	8,4	10,7	9,5	8,2
A1B scenario									
Mean	0,1	-1,4	0,5	0,3	0,5	0,5	0,1	0,3	-0,3
σ	3,3	4,1	3,9	5,3	3,5	5,4	7,6	6,9	8,9
Min	-5,7	-9,5	-5,5	-9,6	-5,1	-9,1	-15.5	-12,5	-23,4
Max	5,3	2,8	4,9	8,1	4,4,	9,8	9,9	10,6	5,8
A2 scenario									
Mean	3,7	1,2	0,5	1,6	1,1	1,8	0,2	1,3	-2,9
σ	3,4	3,2	2,2	2,9	5,0	2,7	6,1	10,4	8,9
Min	-2,6	-2,8	-2,8	-1,3	-6,4	-3,2	-12,6	-16,3	-19,0
Max	9,3	7,4	3,5	7,5	7,1	5,0	7,9	11,6	6,5

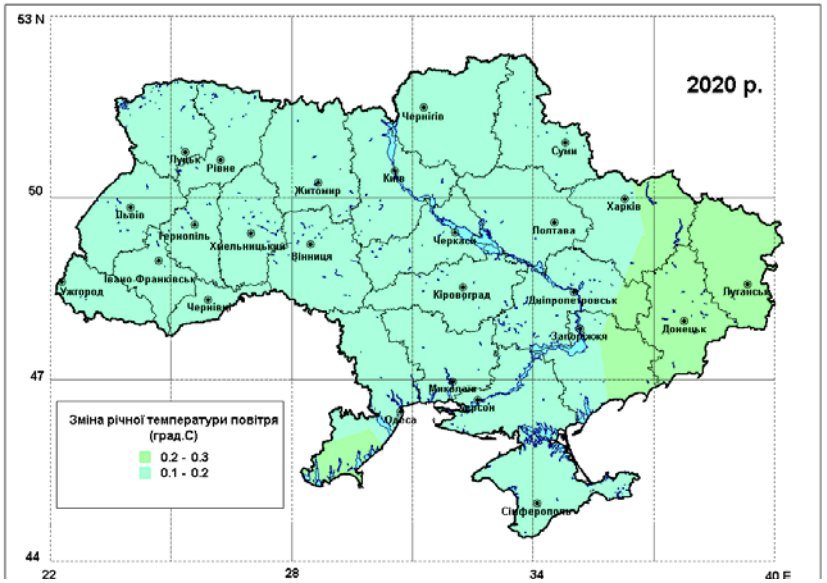
Projected last 10-year temperature differences at the end of the 21st century in Ukraine

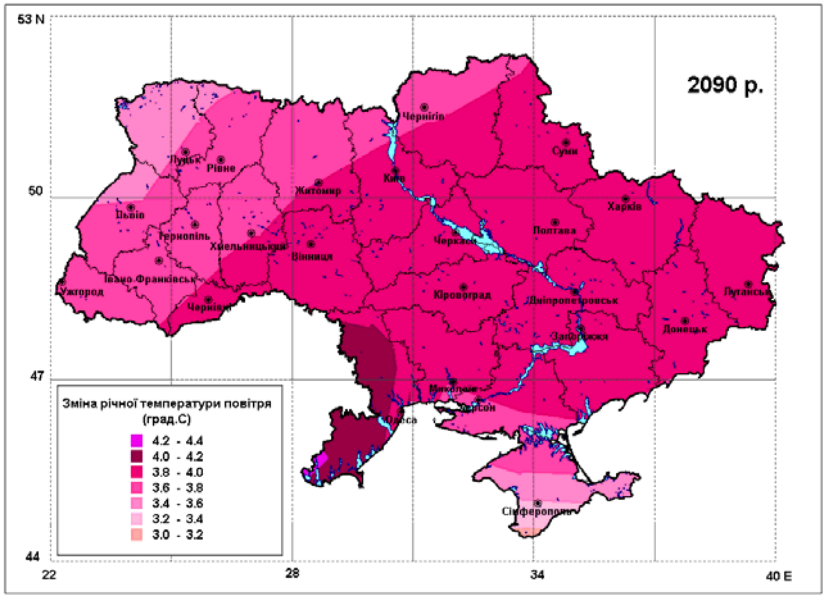


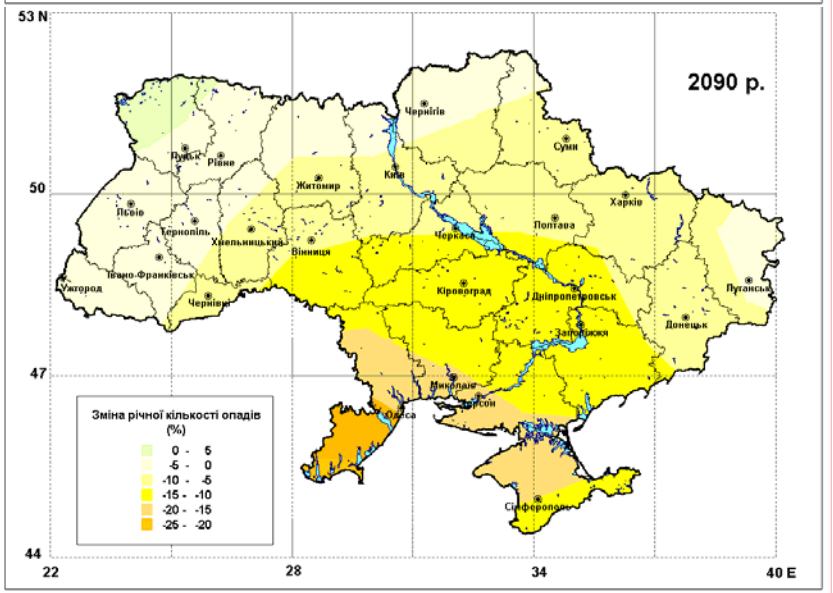
Projected last 10-year precipitation differences at the end of the 21st century in Ukraine



Decadal temperature (^{0}C) and precipitation (%) differences in Ukraine comparable with 2001-10. ECHAM5/MPI-OM A1B







Linear trend coefficients for seasons in Ukraine to the end of the 21st century

Scenarios and seasons		temp, °/year			precip, mm/year		
		min	mean	max	min	mean	max
B1	DJF	0.035	0.029	**0.019**	0.047	0.061	0.072
	MAM	0.024	0.022	0.020	0.054	0.103	0.163
	JJA	0.021	0.021	0.023	-0.056	-0.080	-0.135
	SON	0.022	0.021	0.019	0.023	0.017	-0.015
A1B	DJF	0.053	0.041	0.031	0.017	0.123	0.208
	MAM	0.041	0.037	0.034	0.008	0.103	0.162
	JJA	0.035	0.037	0.040	-0.085	-0.185	-0.335
	SON	0.040	0.037	0.035	-0.114	0.002	-0.010
A2	DJF	**0.068**	0.052	0.039	0.065	0.189	**0.243**
	MAM	0.041	0.038	0.035	0.087	0.107	0.113
	JJA	0.039	0.042	0.046	-0.174	-0.305	**-0.552**
	SON	0.044	0.043	0.040	-0.130	-0.190	-0.265

S2P1

Ensemble of AOGCMs in the study of seasonal climate changes in Ukraine for the 21st century

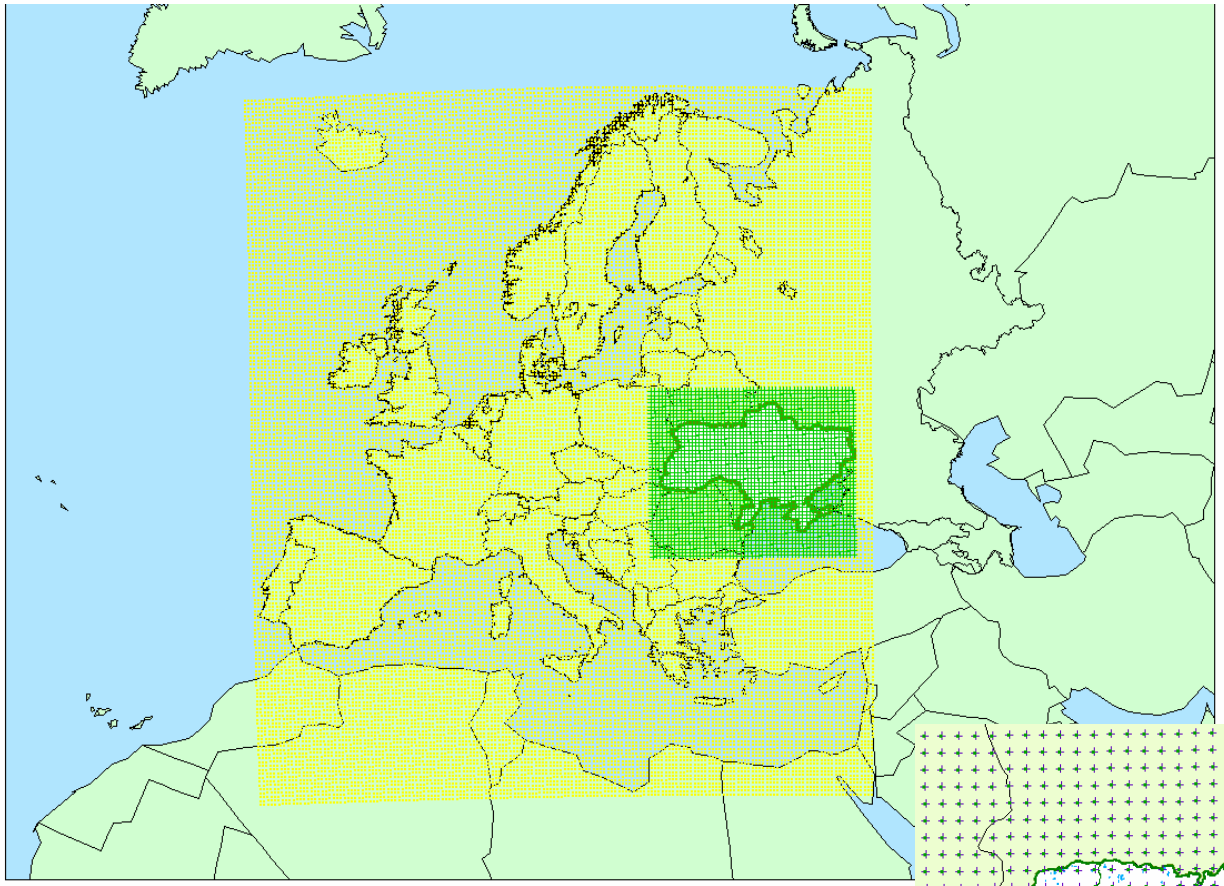
Gnatiuk N.V.[1,2], S.V. Krakovska[1], L.V. Palamarchuk[2], I.P. Shedemenko[3], G.O. Djukel[1]

[1] Ukrainian Hydrometeorological Institute, Kiev
[2] Kiev National Shevchenko University, Cathedra of Meteorology and Climatology
[3] Institute for Safety Problems of NPP NASU, Kiev

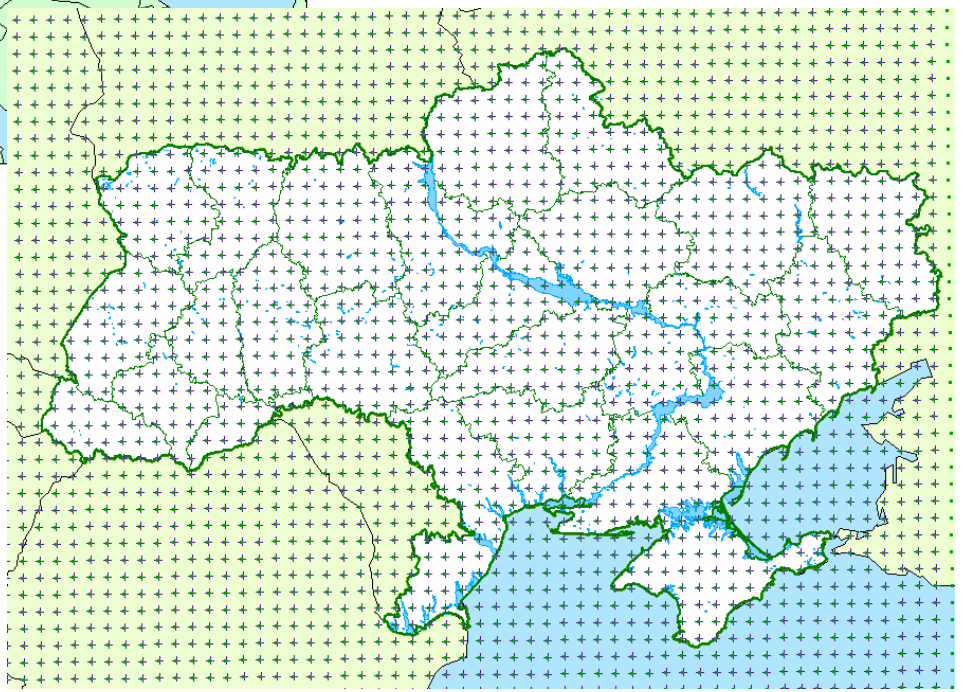
CONCLUSIONS

- **For the first time quantitative characteristics of probable climate changes in Ukraine during the 21st century for B1, A1B and A2 scenarios have been obtained from an analysis of 84 runs of 10 AOGCMs from the AR4 IPCC-2007.**
- **Projected by AOGCMs surface temperature differences over the territory of Ukraine to the end of the 21st century will be in limits: B1 – from 0.7 to 3.0 oC; A1B – from 2.4 to 4.2 oC; and A2 – from 2.6 to 4.6 oC.**
- **There is not such agreement for precipitation variations during the 21st century between AOGCMs, and precipitation changes vary from -23.4% to +11.6%.**
- **The model ECHAM5/MPI-OM has been determined as the most successful AOGCM and its results can be recommended as initial and boundary conditions for simulation of climate of Ukraine with regional climate models.**

UKRAINE in REMO

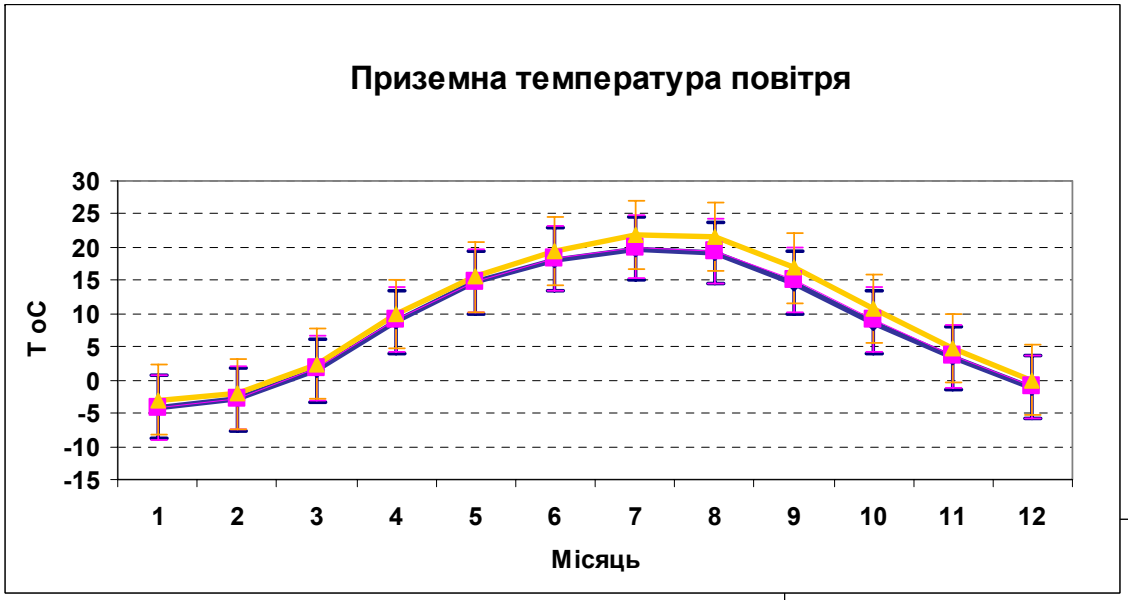


Grid REMO 170 x 190



Grid Ukraine 56 x 46

Year-round distribution of surface temperature and precipitation in Ukraine averaged over 1961-90



METEO

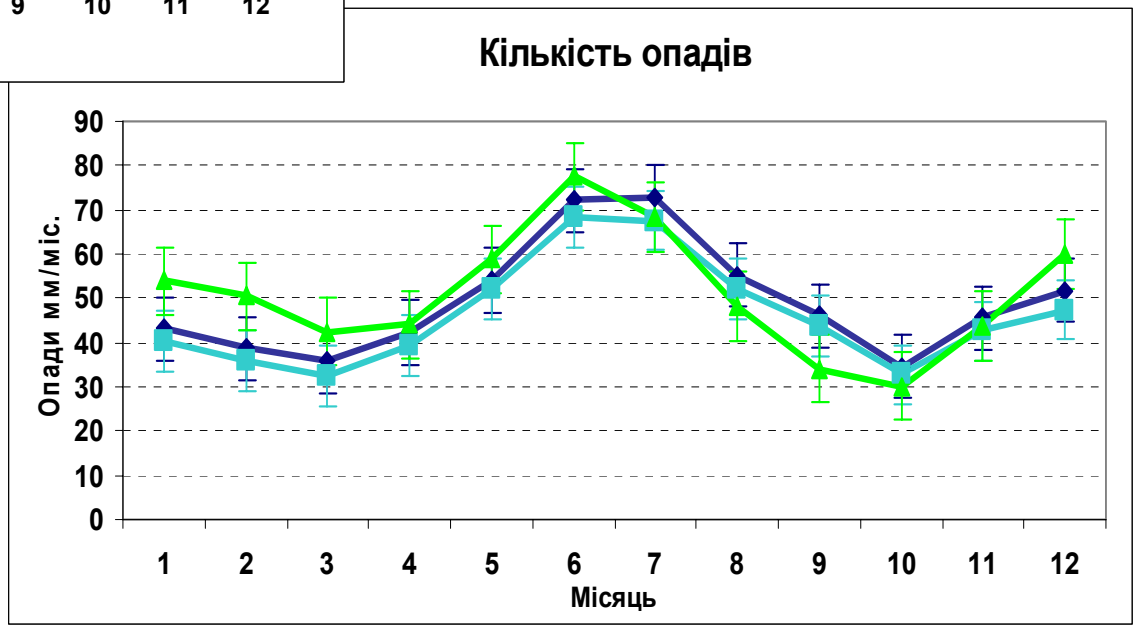
CRU

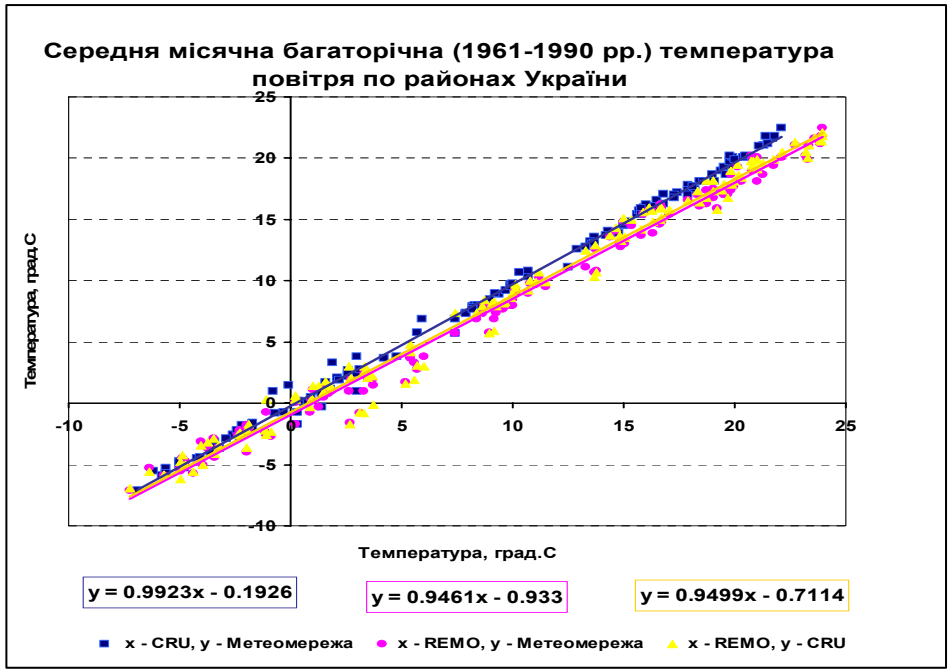
REMO

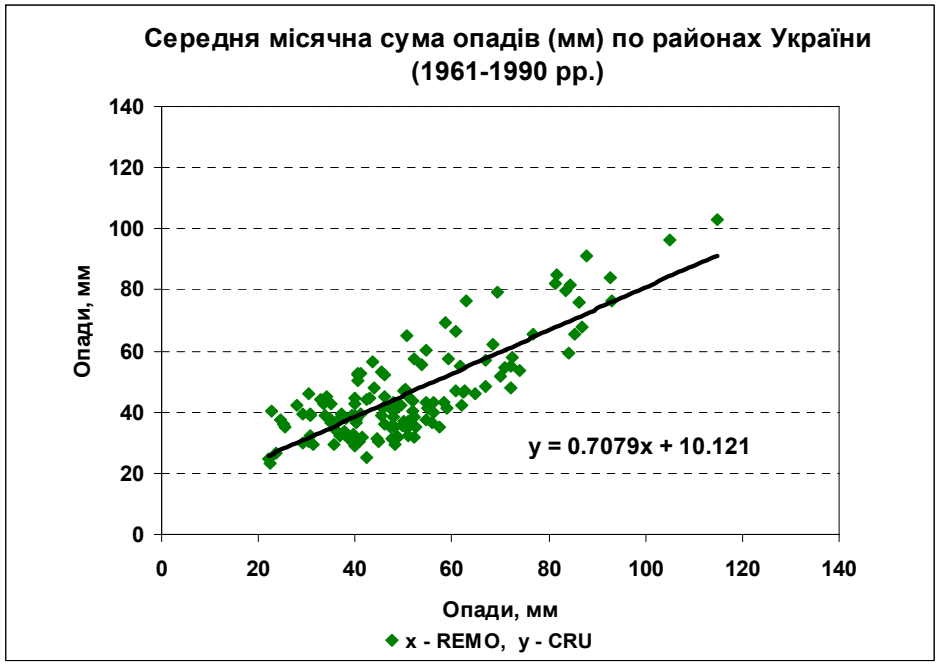
CRU

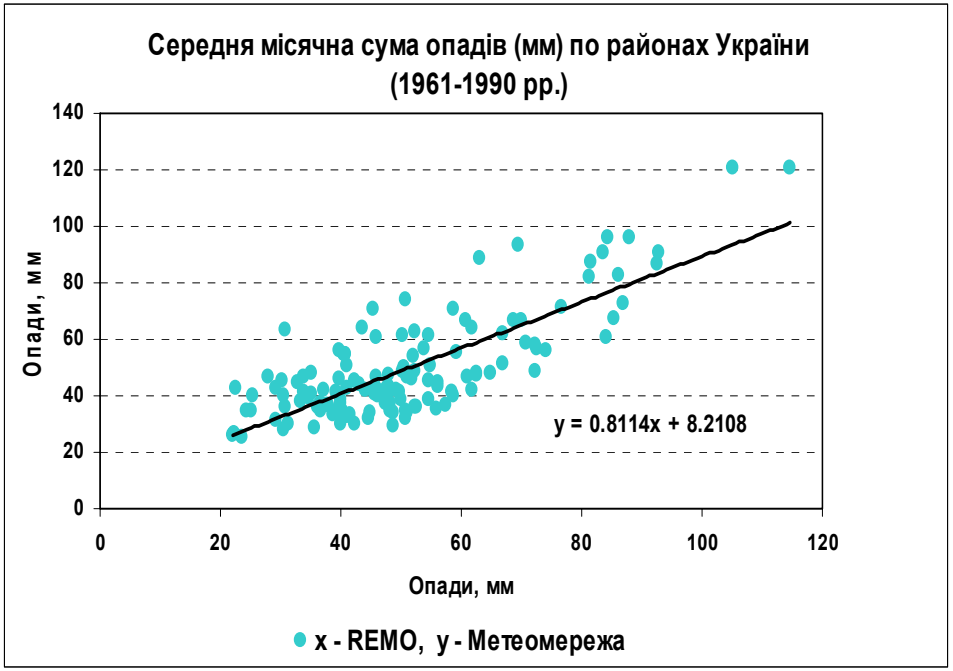
REMO

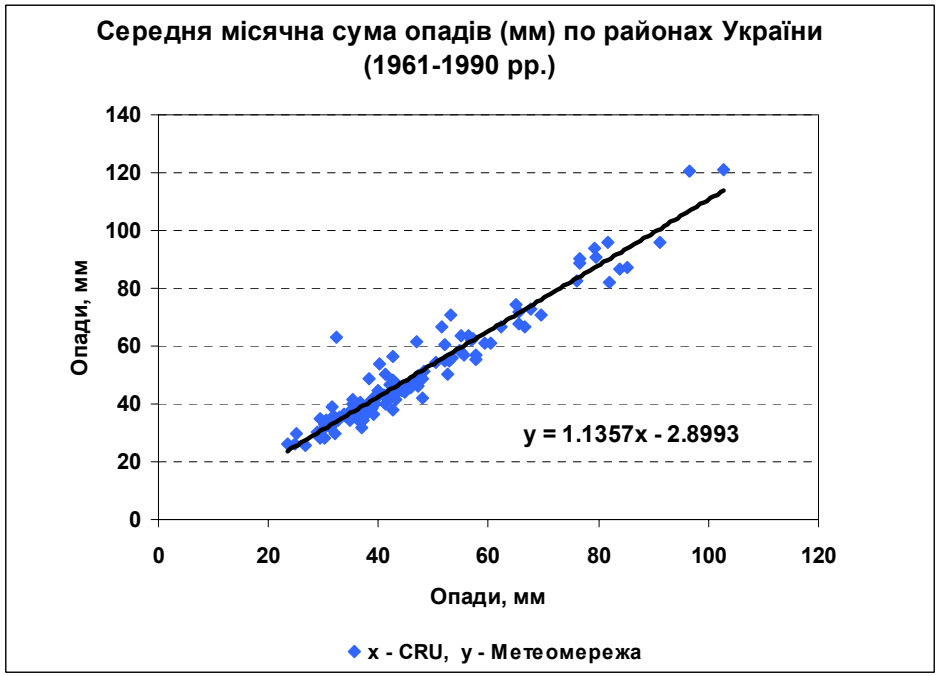
METEO



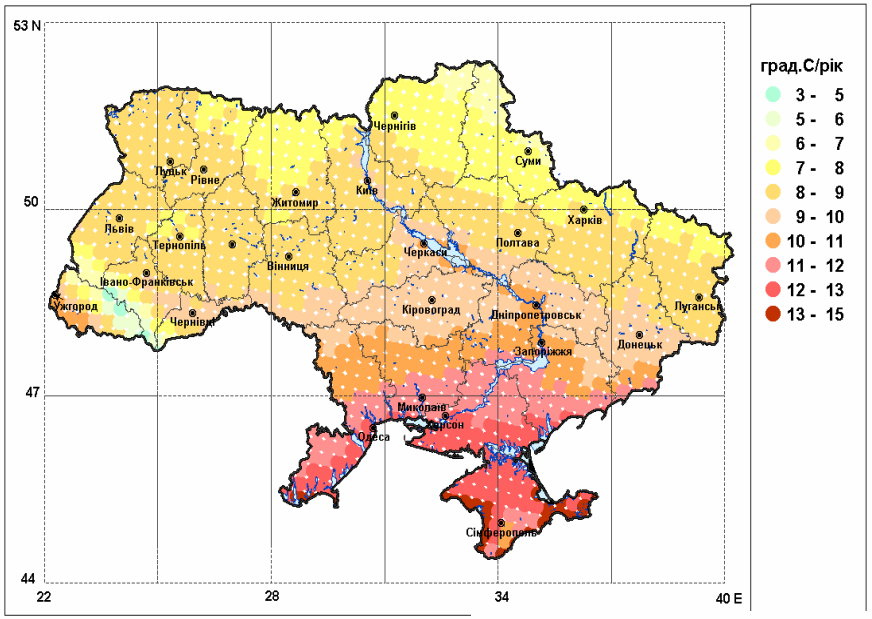

Середня місячна багаторічна (1961-1990 рр.) температура повітря по районах України
Температура, град.С
Температура, град.С
y = 0.9923x - 0.1926
y = 0.9461x - 0.933
y = 0.9499x - 0.7114
x - CRU, y - Метеомережа
x - REMO, y - Метеомережа
x - REMO, y - CRU


Середня місячна сума опадів (мм) по районах України (1961-1990 рр.)
Опади, мм
Опади, мм
y = 0.7079x + 10.121
x - REMO, y - CRU

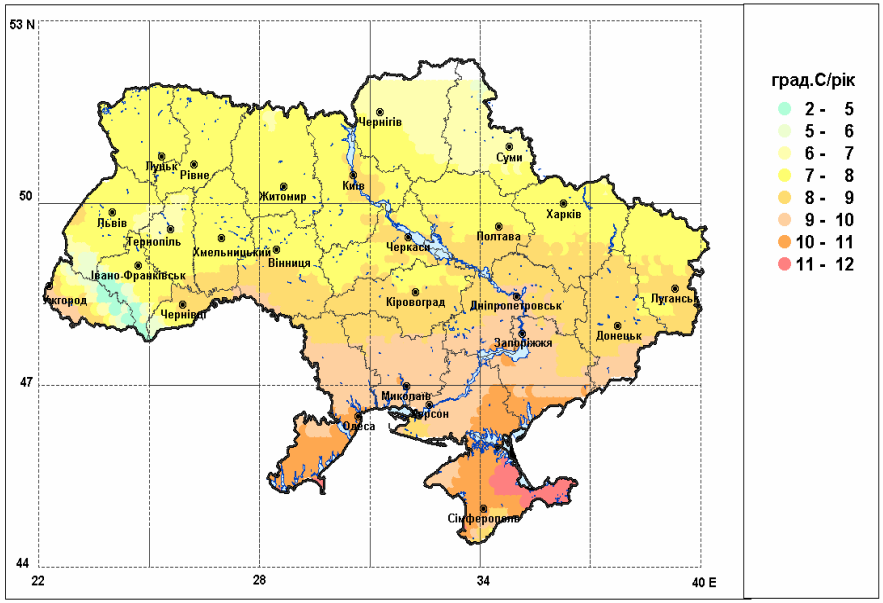

Середня місячна сума опадів (мм) по районах України (1961-1990 рр.)
Опади, мм
Опади, мм
y = 0.8114x + 8.2108
x - REMO, y - Метеомережа


Середня місячна сума опадів (мм) по районах України (1961-1990 рр.)
Опади, мм
Опади, мм
y = 1.1357x - 2.8993
x - CRU, y - Метеомережа

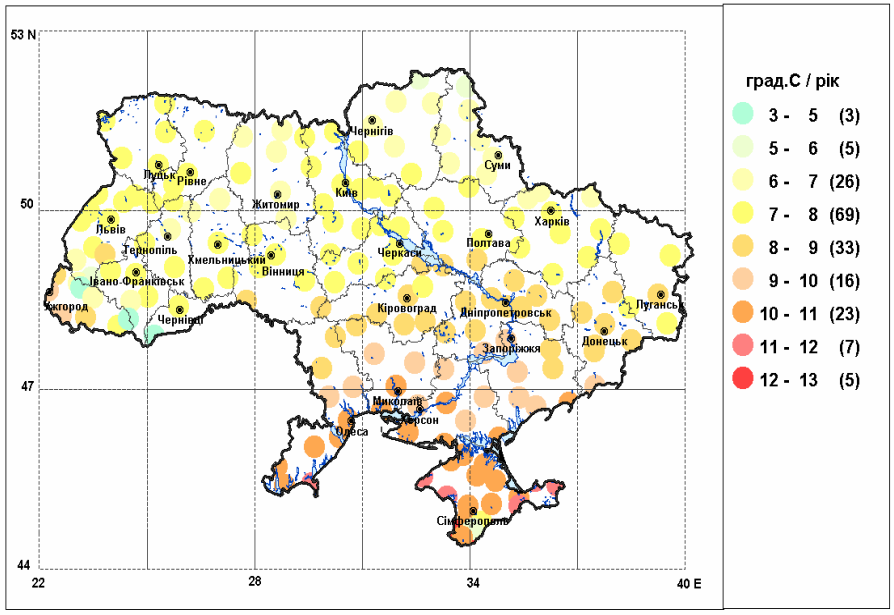
Temperature (^{0}C/year) 1961-1990



REMO



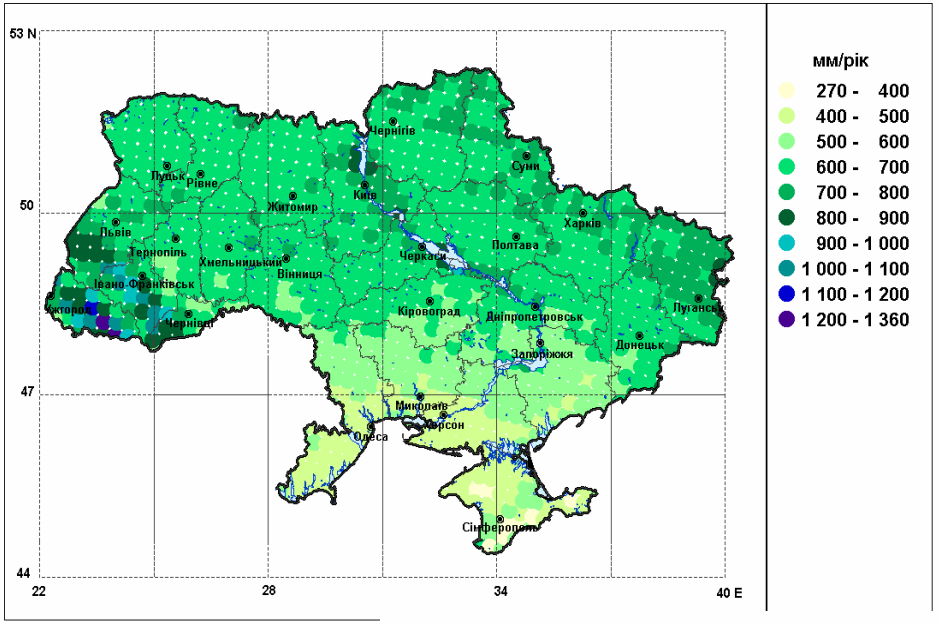
CRU



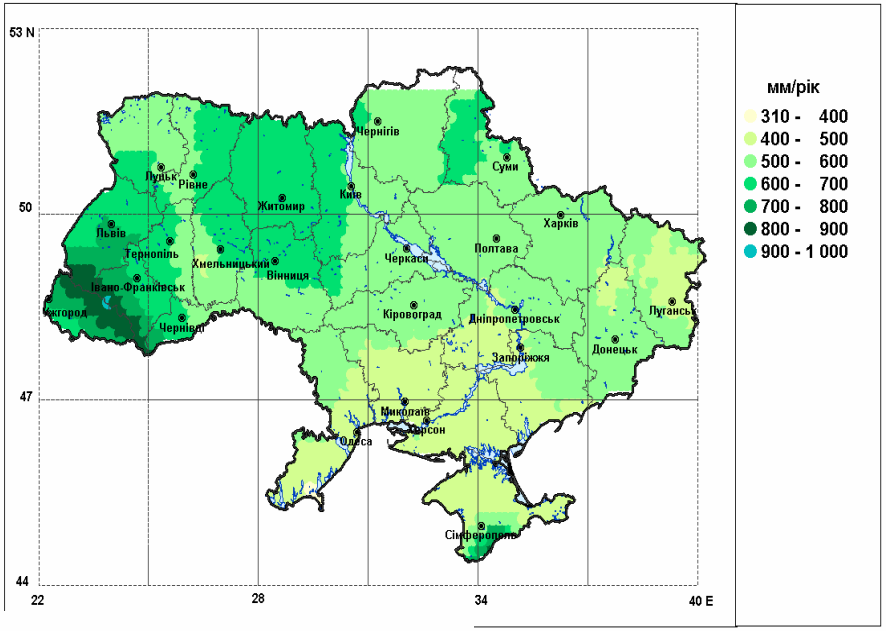
METEO

in brackets – number
of stations in gradation)

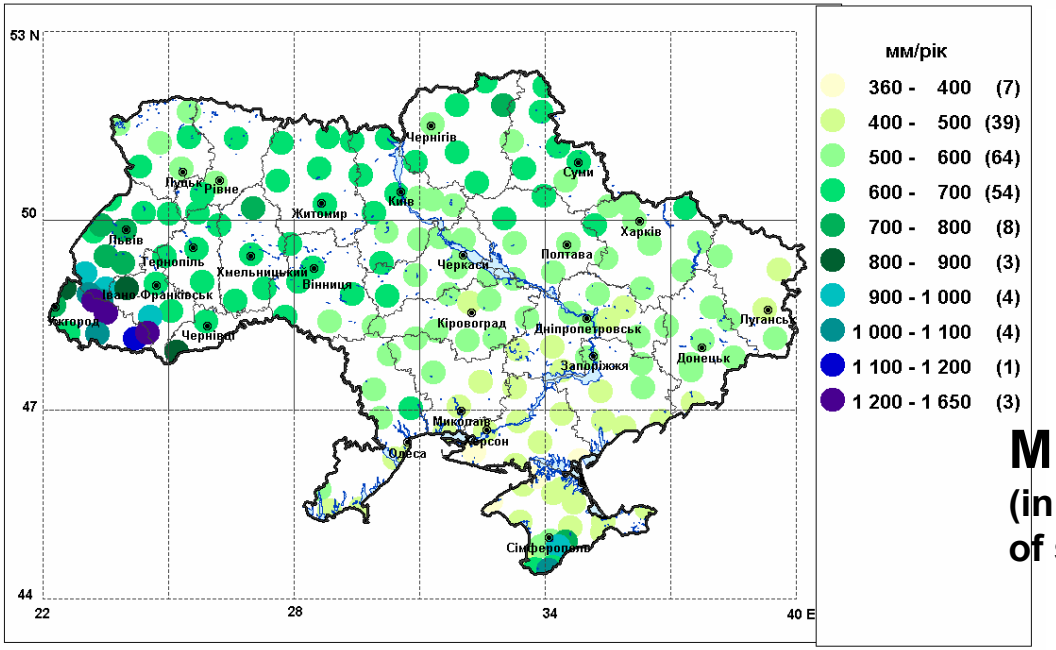
Precipitation (mm/year) 1961-1990



REMO



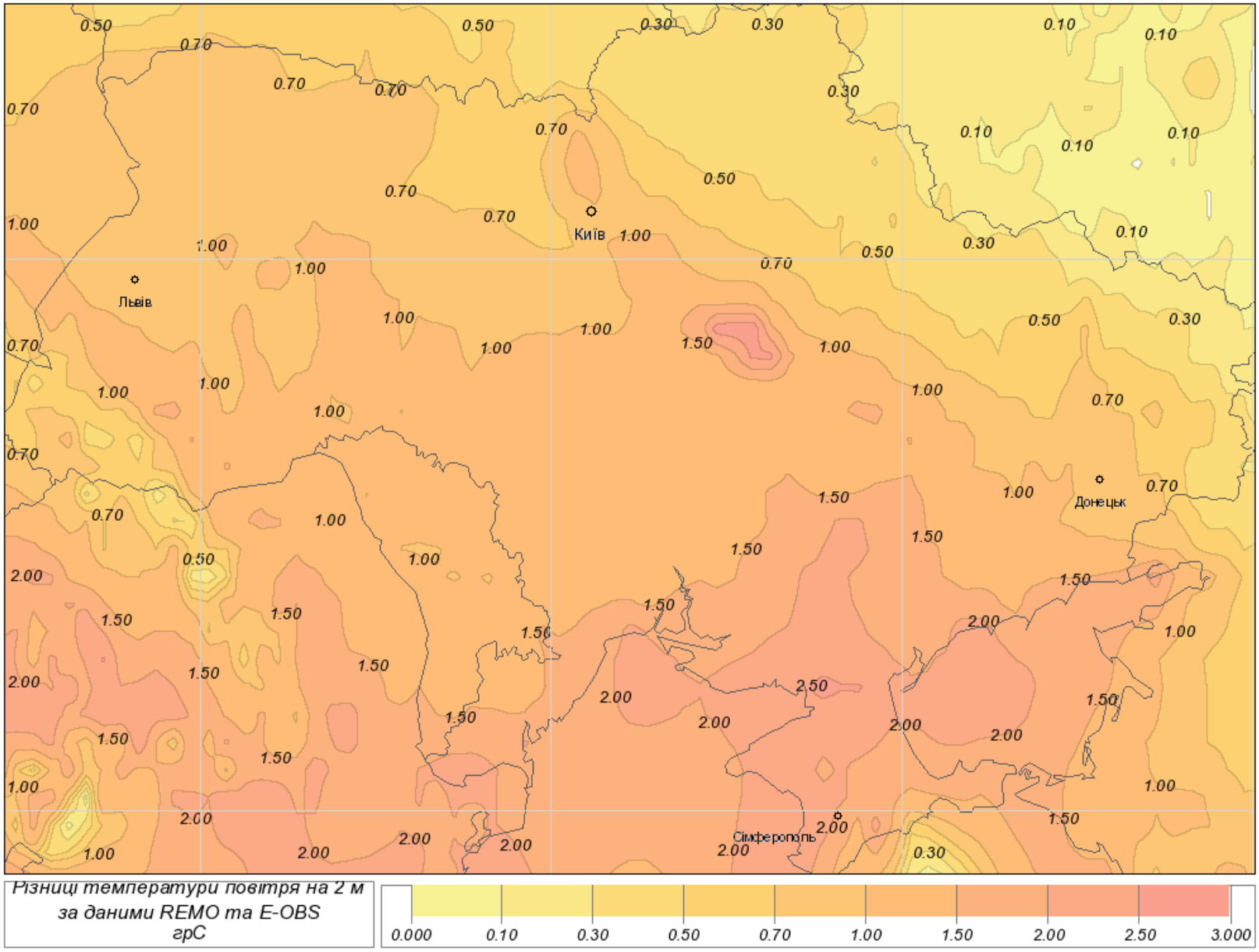
CRU



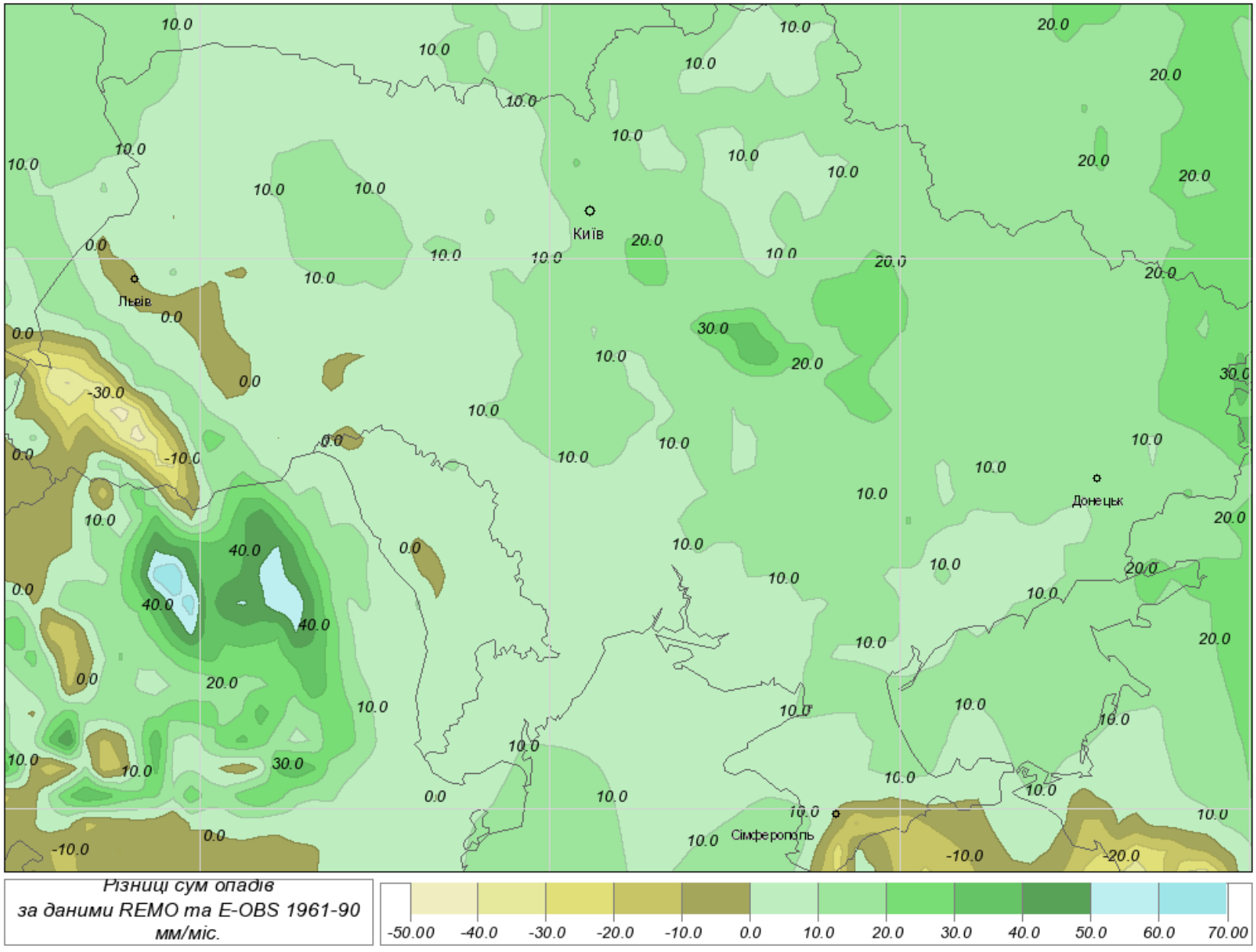
METEO

(in brackets – number of stations in gradation)

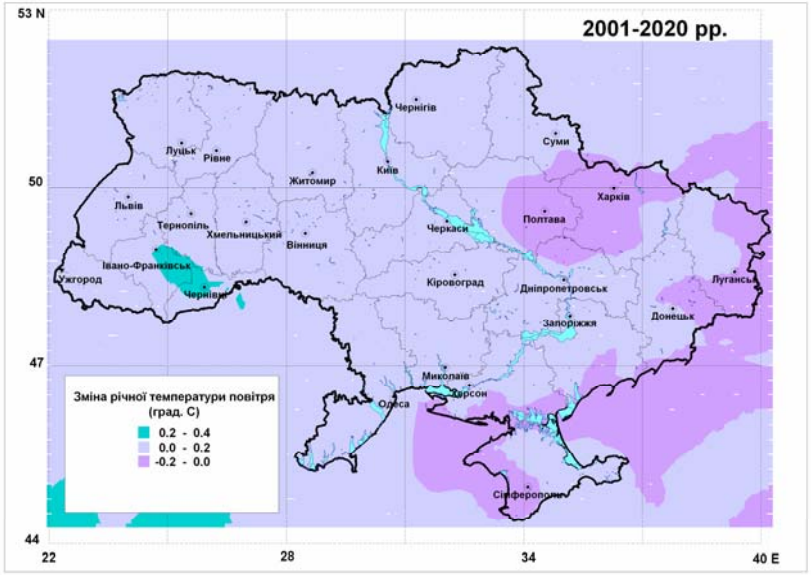
Temp diff. REMO - E-Obs (1961-90)

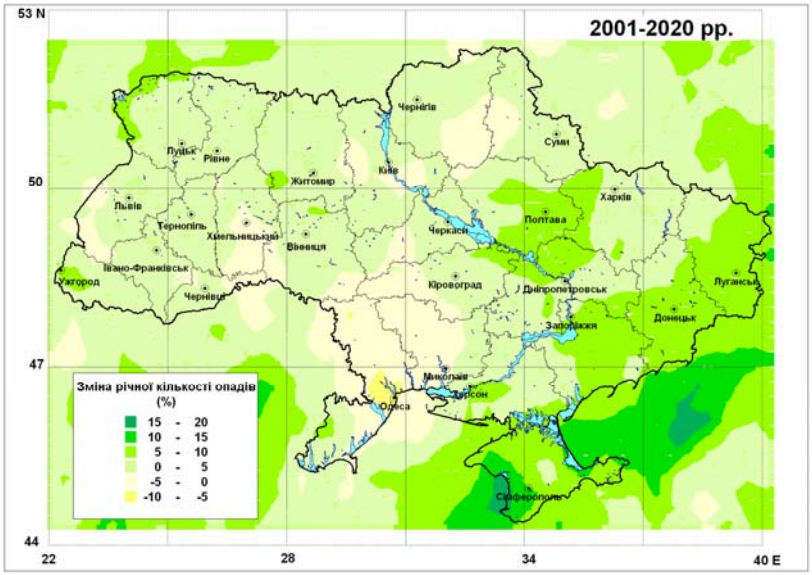


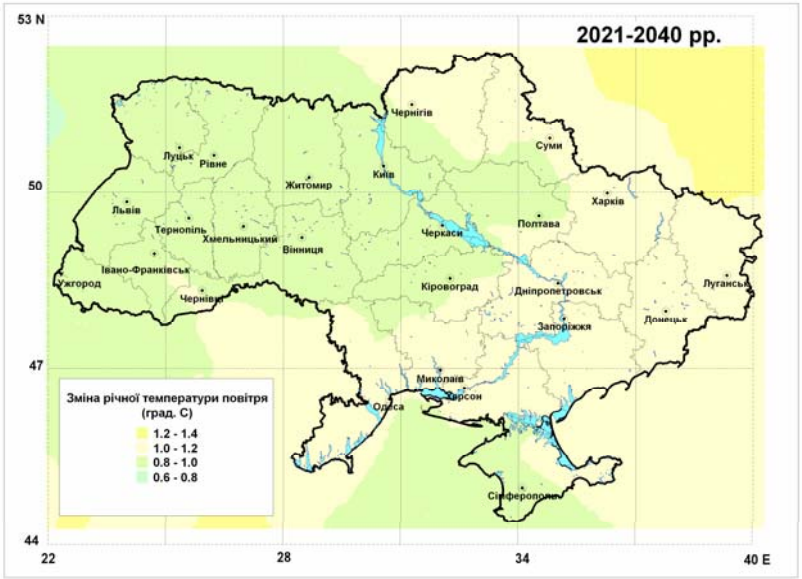
Precip diff. REMO - E-Obs (mm/month)

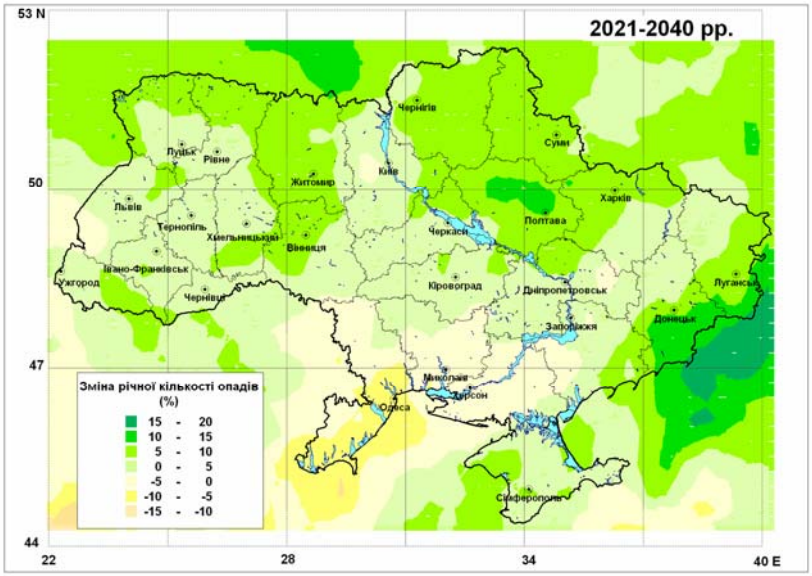


Temp (ºC) and precip (%) change over the period 1981-2000 by REMO_A1B_ECHAM5OM

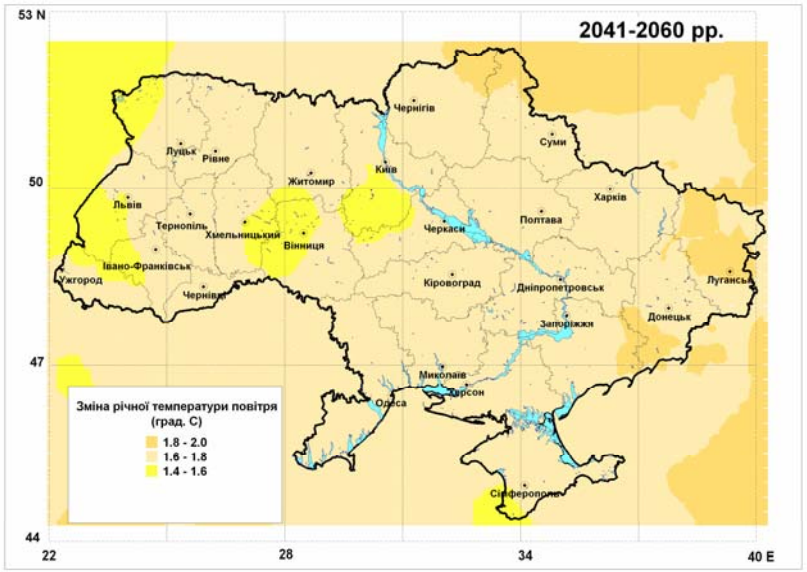


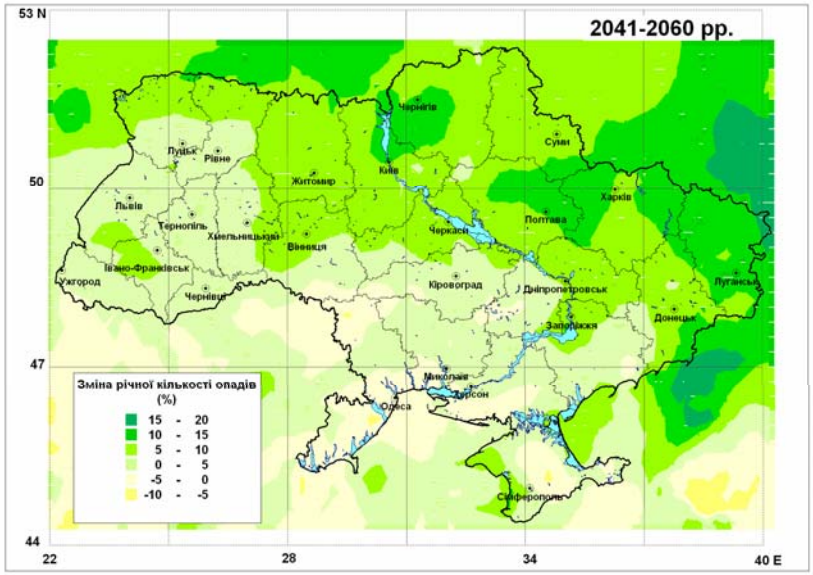


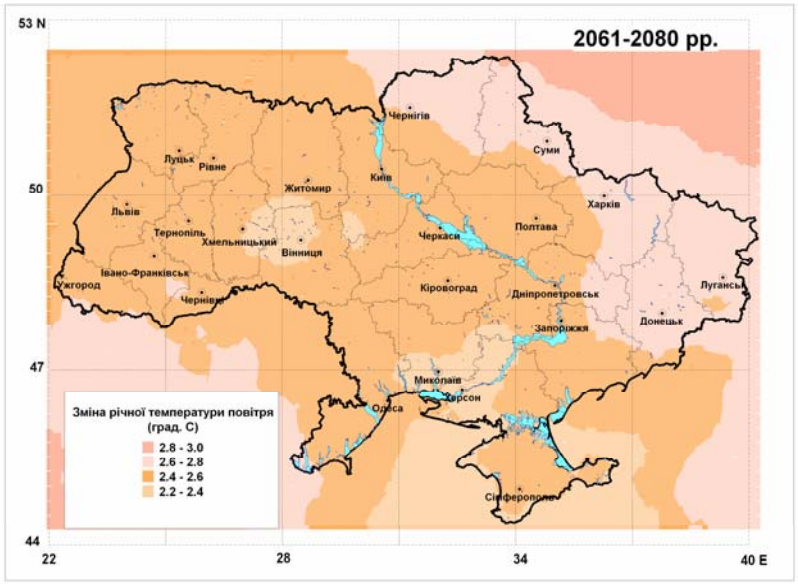


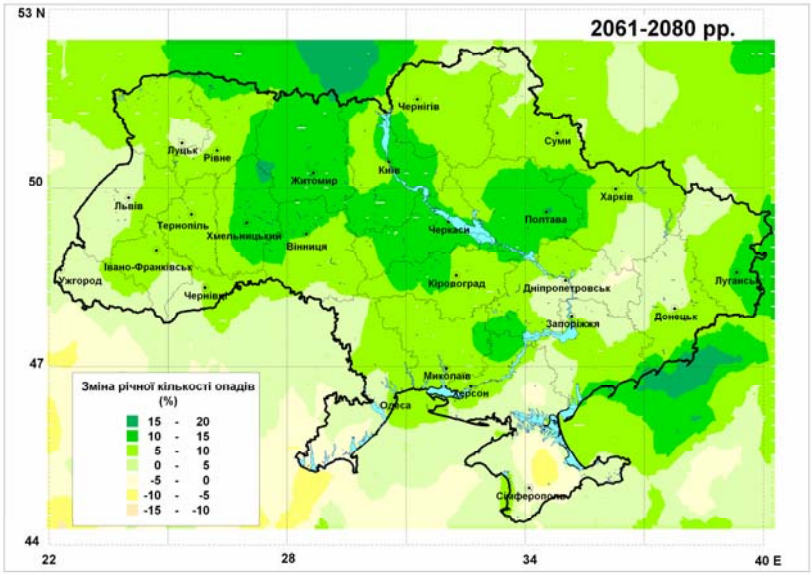


Temp (ºC) and precip (%) change over the period 1981-2000 by REMO_A1B_ECHAM5OM

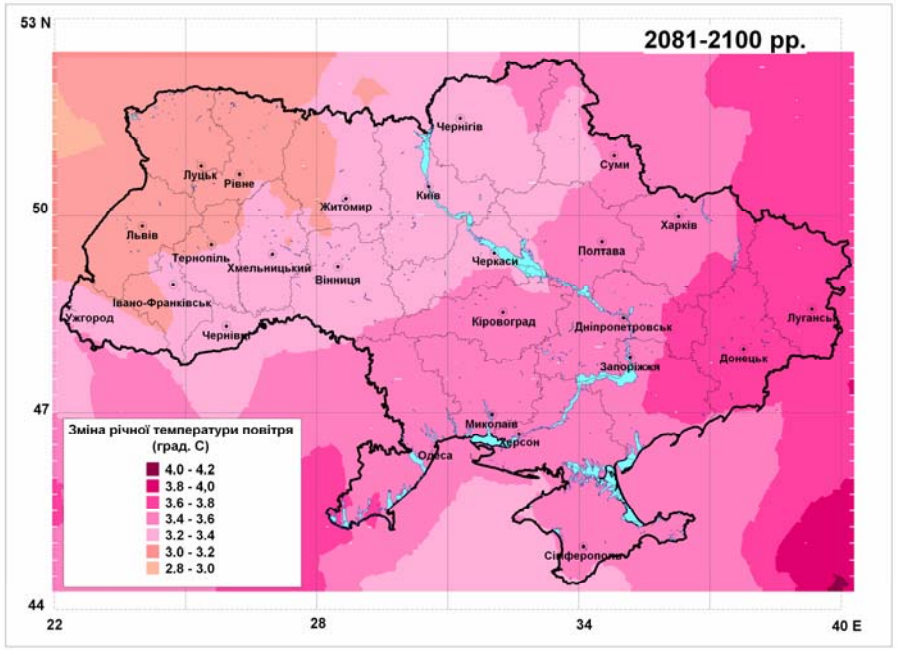


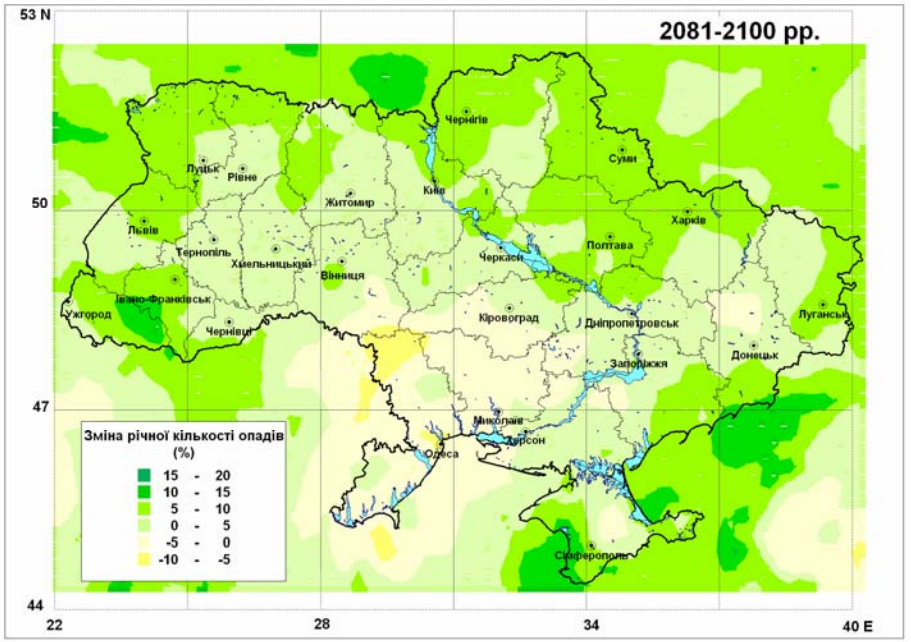






Temp (ºC) and precip (%) change over the period 1981-2000 by REMO_A1B_ECHAM5OM






ДЯКУЮ!
THANK YOU !
СПАСИБО !