PRESENT AND PROJECTED IMPACT OF CLIMATE CHANGE ON WATER RESOURCES IN UKRAINE: ASSESSMENT AND ADAPTATION MEASURES

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OBJECTIVES OF PRESENTATION

- present general information about climate research activity in Ukraine
- present some results of studies of climate change impact on surface runoff of rivers located in different natural zones of Ukraine and its possible consequences on some sectors of Ukrainian economy

Main river basins and neighboring countries of Ukraine

NATURAL CHARACTERISTICS OF UKRAINE

- **AREA – 603.7 thousand sg. km**

- **CLIMATE TYPES – GENERALY, MODERATE-CONTINENTAL TYPE, IN SOUTHERN COST OF CRIMEA – SUBTROPICAL TYPE**

- **AVERAGE ANNUAL PRECIPITATION DISTRIBUTION – FROM 300 mm IN SOUTH - EAST TO 1500 mm**

  IN CARPATIANS MOUNTAINS

- **NATURAL ZONES: FOREST (20% OF TERRITORY), MIXED-FOREST (35%), STEPPE (40%), MOUNTAINS (5%)**

- **TOTAL AVERAGE ANNUAL RUNOFF – 209.23 cub. Km (49.0 cub. Km FORMED IN UKRAINE)**

- **POTENTIAL WATER RESOURCES IN A YEAR PER AN INHABITANT – 1.6 CUB. KM**

WEATHER, CLIMATE AND SURFACE WATERS RELATED ACTIVITIES IN UKRAINE

- **STATE HYDROMETEOROLOGICAL SERVICE IS THE PRINCIPAL GOVERNMENTAL BODY RESPONSIBLE FOR:**

  a) METEOROLOGICAL, CLIMATE AND HYDROLOGICAL OBSERVATION; b) HYDROMETEOROLOGICAL FORECASTING; c) PROVIDING DIFFERENT USERS WITH CLIMATE AND CLIMATE – RELATED SERVICES

- **IT OPERATES 187 WETHER STATIONS (30 OF THEM ARE INCLUDED IN THE BASIC CLIMATOLOGICAL NETWORK OF THE WORLD METEOROLOGICAL ORGANIZATION) AND ABOUT 400 HYDROLOGICAL STATIONS**

- **RESEARCHES IN THIS AREA ARE CARRIED OUT BY A NUMBER SCIENTIFIC AND EDUCATIONAL INSTITUTIONS SUBORDINATED TO THE STATE HYDROMETEOROLOGICAL SERVICE, NATIONAL ACADEMY OF SCINCES, MINISTRY OF EDUCATION**

LEGAL AND INSTITUTIONAL BASIS OF CLIMATE CHANGE RESEARCHES IN UKRAINE

- **Ukraine signed the UN Framework Convention on Climate Change in June 1992; Ukrainian Parliament ratified it in October 1996**

- **Observation data of the State Hydrometeorological Service is the principal source of information about present climate and its possible change**

- **To strength climate research activity the National Climate Program was adopted by Ukrainian Governmental in 1997. The program has been implemented during 1998-2004**

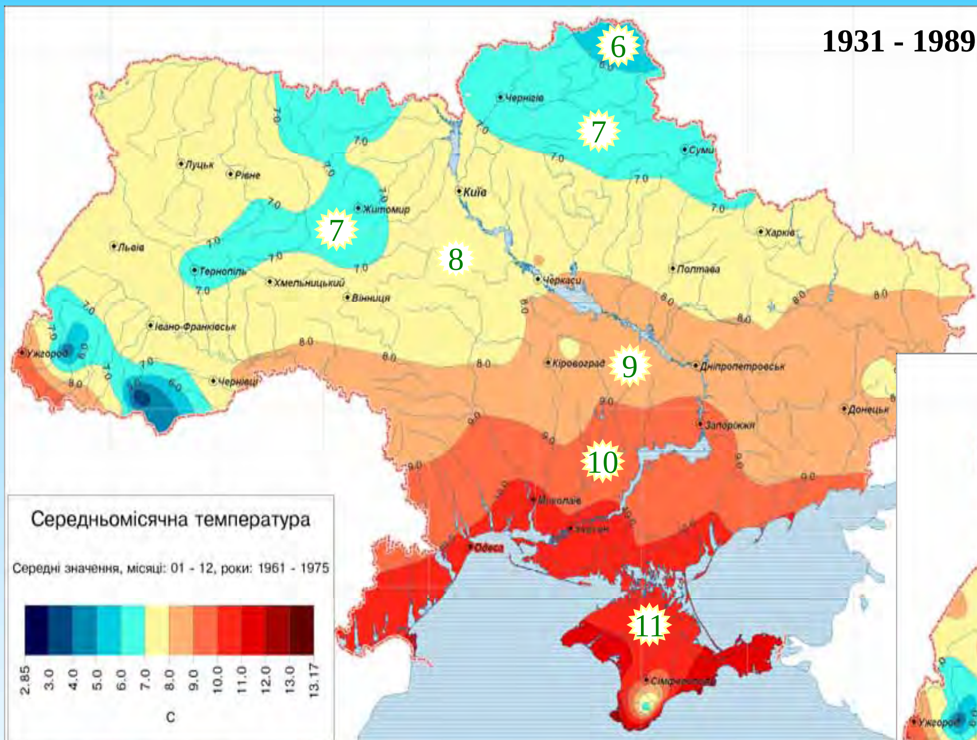
METHODOLOGY AND DATA USED IN RESEARCHES

IN ORDER TO ASSESS THE PRESENT IMPACT OF CLIMATE CHANGE:

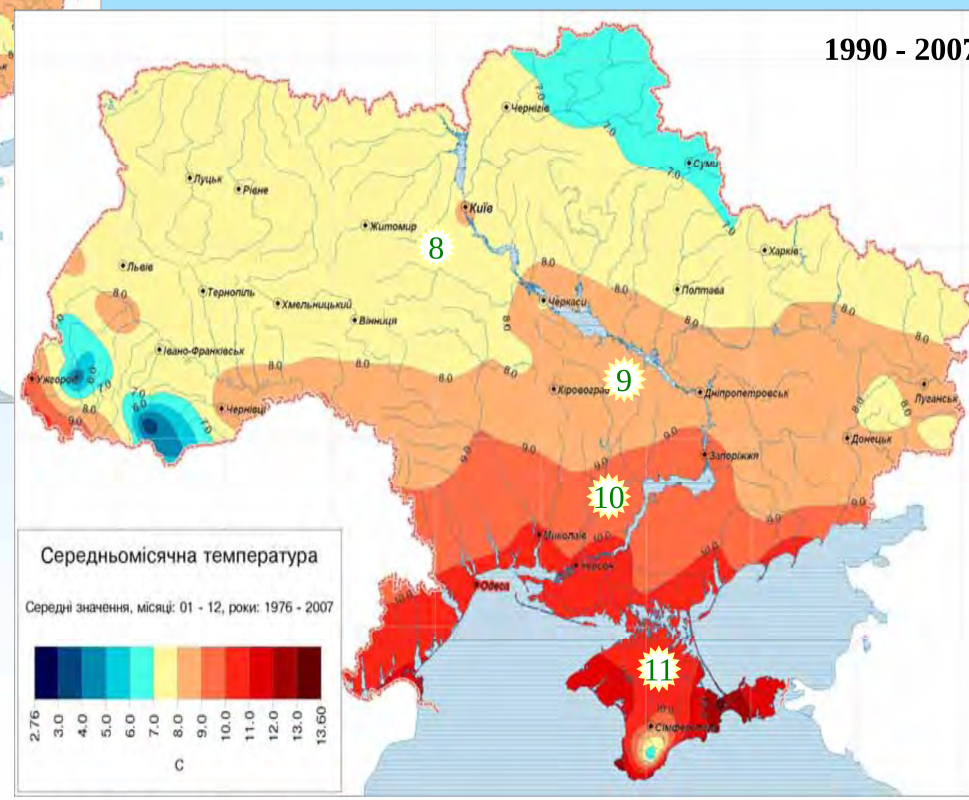
- **COMPLEX STATISTICAL ANALYSIS OF LONG-TERM SERIES OF AIR TEMPERATURE AND PRECIPITATION OBSERVATIONS (FOR 80 AND MORE YEARS) AS WELL AS RIVER FLOW DATA (FOR 50 AND MORE YEARS)**

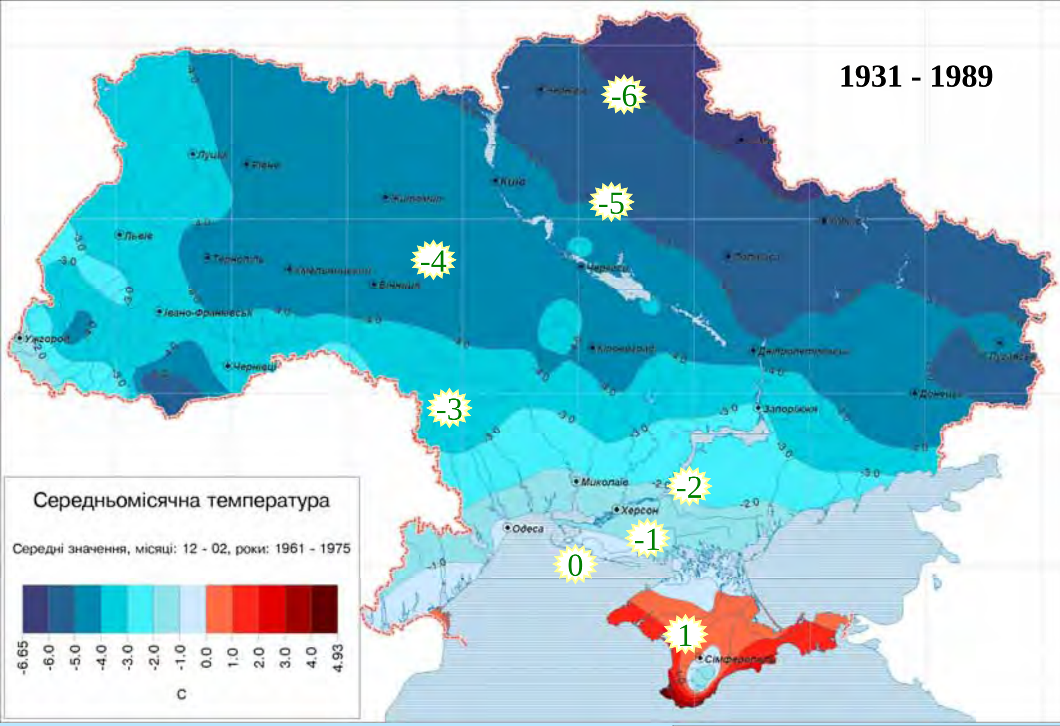
- ***IN ORDER TO PROJECT THE EXPECTED IMPACT OF CLIMATE CHANGE:***
- **GLOBAL ATMOSPHERIC AND OCEAN CIRCULATION MODELS FOR THREE (A2, A1B, B1) IPCC (SRES) SCENARIOS OF WORLD'S ECONOMICAL AND SOCIAL DEVELOPMENT:**
- **HYDROLOGICAL MODELS ELABORATED BY UKRAINIAN SCIENTISTS**

2. Peculiarities of major climatic parameters changes in Ukraine in XX century and estimation of their probable development tendencies (regional climate changes) (by V. Osadchyi, V. Babiche

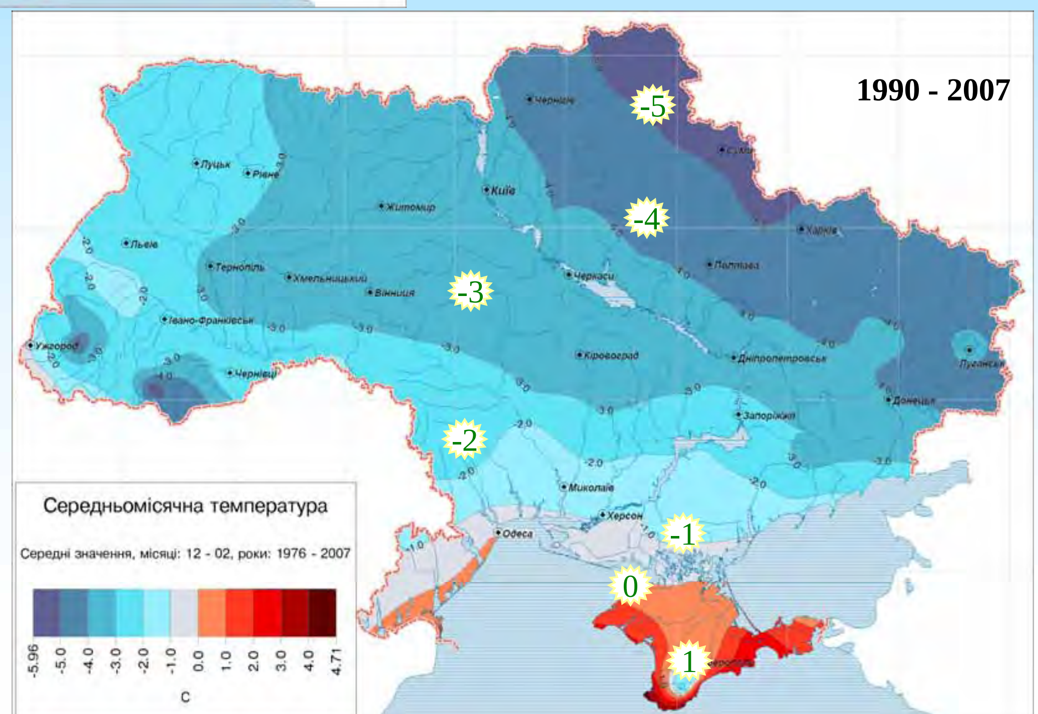


Mean annual air temperature in Ukraine





Mean air temperature in Ukraine (winter)



CHANGE IN THE ANNUAL PRECIPITATION SUM

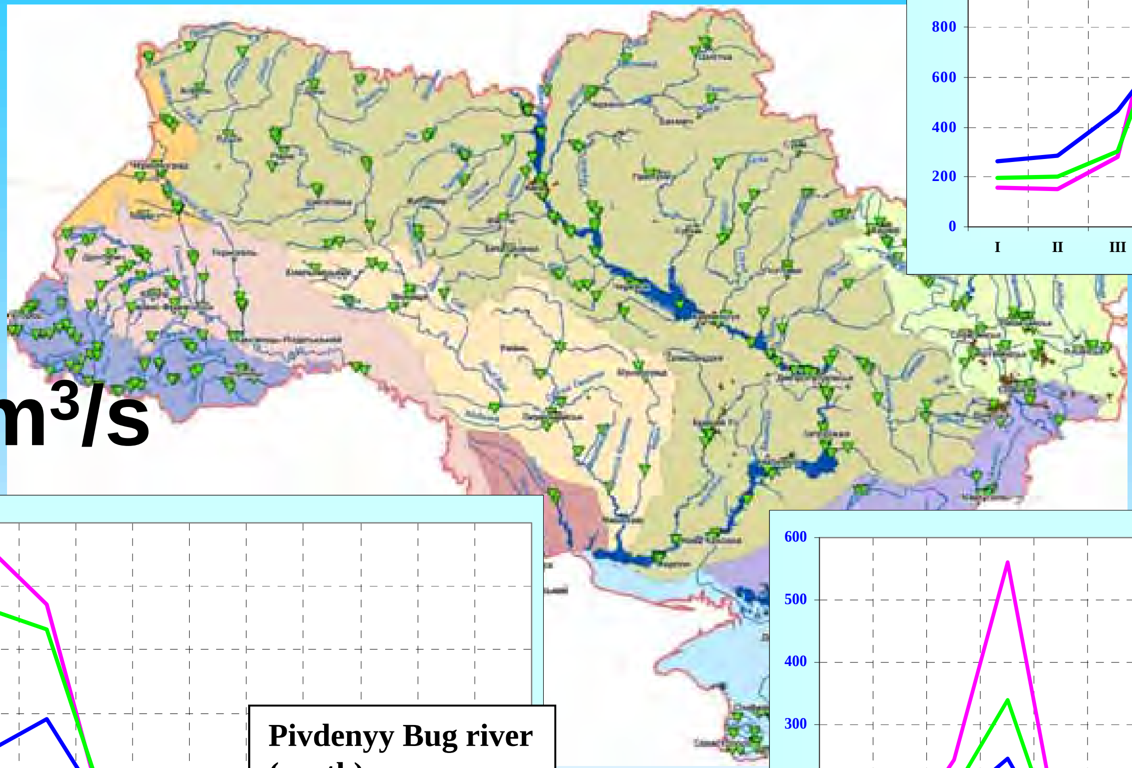
(by V. Osadchyi, V. Babichenko)

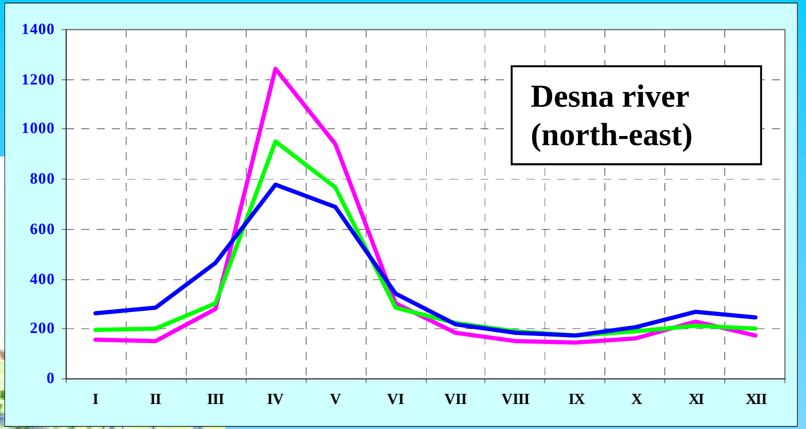
REGRESSION‘S EQUATIONS OF TRENDS OF MEAN ANNUAL DISCHARGES (by A. Shereshevskyi, V. Manukalo)

River – Station	Observ. period	Regression
Dnipro – Kyiv	**1928-2007**	**Y = 0.041X + 163**
Desna – Chernigiv	**1895-2007**	**Y= 0.02X + 328**
Siverskyi Donets	**1923-2007**	**Y = -0.04X + 48.3**
Pivdennyi Bug	**1914-2007**	**Y = 0.10X + 85.5**
Prut –Chernivtsy	**1895-2007**	**Y = -0.43X + 100**
Psel – Zapsilia	**1950 - 2007**	**Y = -0.37X + 43.3**
Uzh - Uzhgorod	**1947 - 2007**	**Y = -0.04X + 30.2**
Dnister – Zalischyk	**1895 - 2007**	**Y = -0.17X + 236**
Latorisa -Mukachev	**1847 - 2007**	**Y = -0.12X + 22.7**

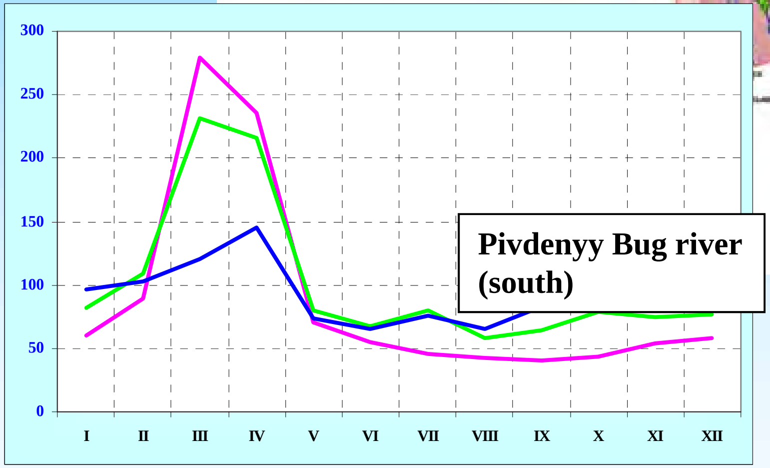
REGRESSION'S EQUATION OF TRENDS OF MEAN SEASON'S DISCHARGES (by A. Shereshevskyi, V. Manukalo)

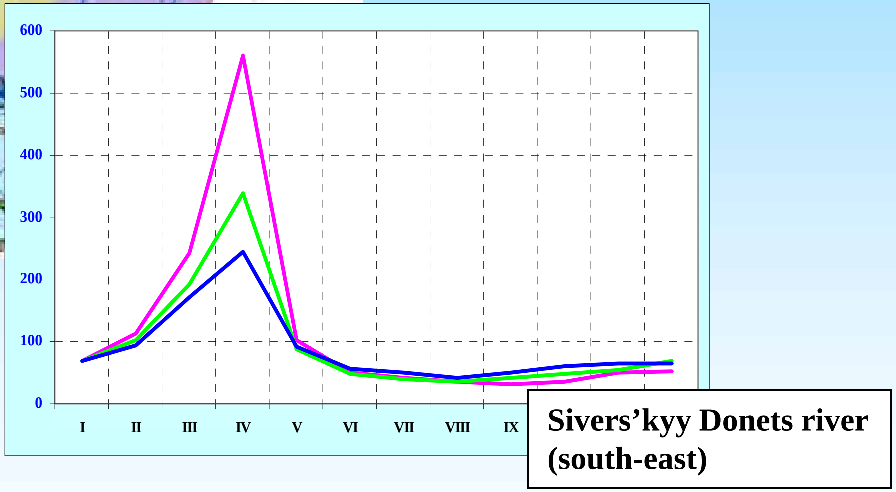
RIVER-STATION	DECEM.-FEBR.	MARCH-JUNE	JULY-NOVEMB.
Dnipro – Kyiv	Y=7.28X + 460	Y=-7.33X+ 2131	Y=2.13X+ 556
Desna–Chernigiv	Y=1.91X + 142	Y=-1.36X+ 626	Y=1.86X+ 134
Siverskyi Donets	Y=2.71X + 324	Y=-3.82X+ 112	Y=0.91X+ 97.5
Pivdennyi Bug	Y=2.86X + 87.5	Y=-3.72X+98.5	Y=1.13X+ 77.7
Prut –Chernivtsy	Y=3.67X + 111	Y=-5.25X+140	Y=1.33X+ 106
Psel – Zapsilia	Y=2.49X + 55.7	Y=-2.85X+78.5	Y=1.33X+ 106
Uzh - Uzhgorod	Y=3.77X + 28.2	Y=-3.45X+50.0	Y=-0.42X+ 33.5
Dnister–Zalischk	Y=3.00X + 182	Y=-2.68X+176	Y=-0.39X+ 167
Latorisa-Mukach	Y=3.55X + 37.9	Y=-2.93X+61.2	Y=-0.69X+ 67.0



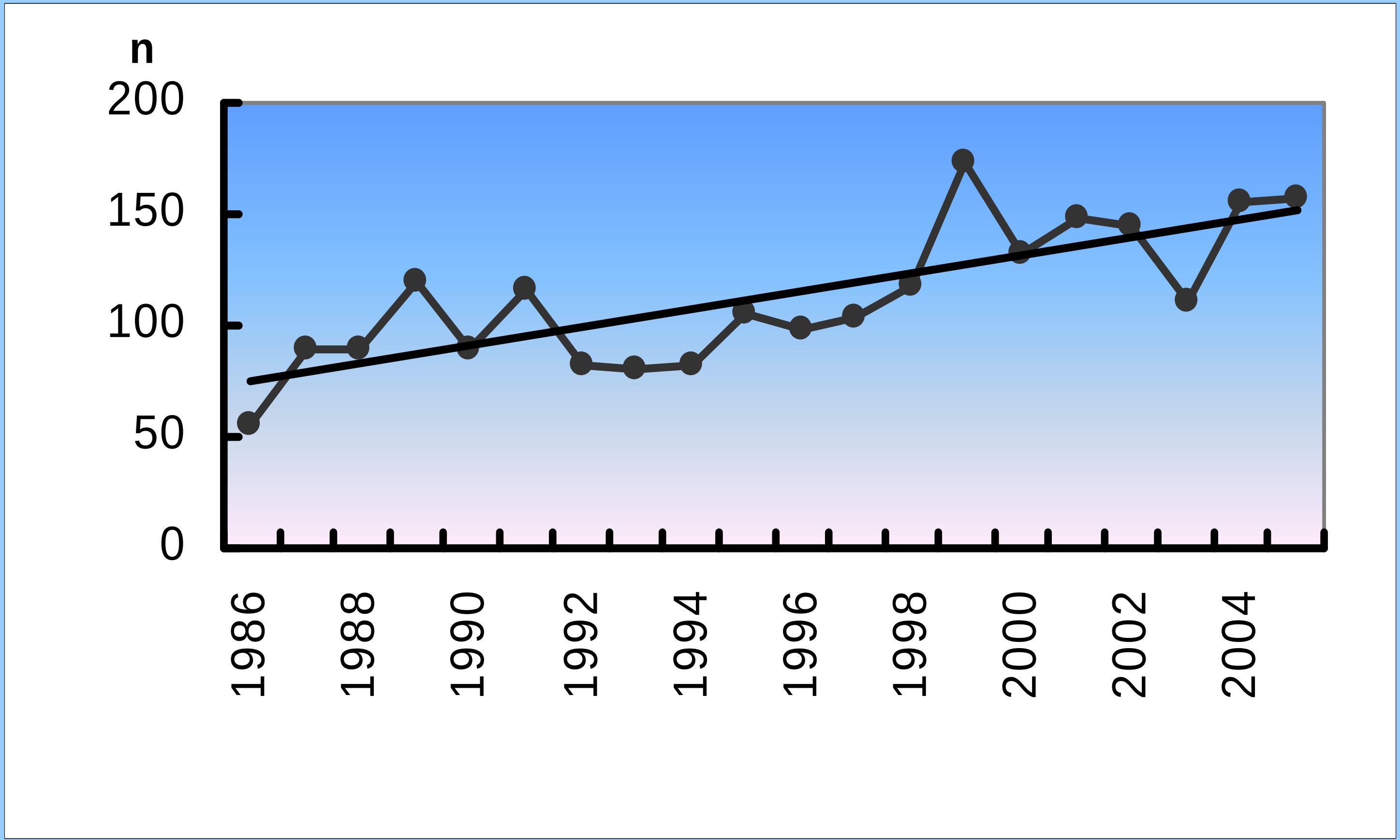


Q, m^3/s





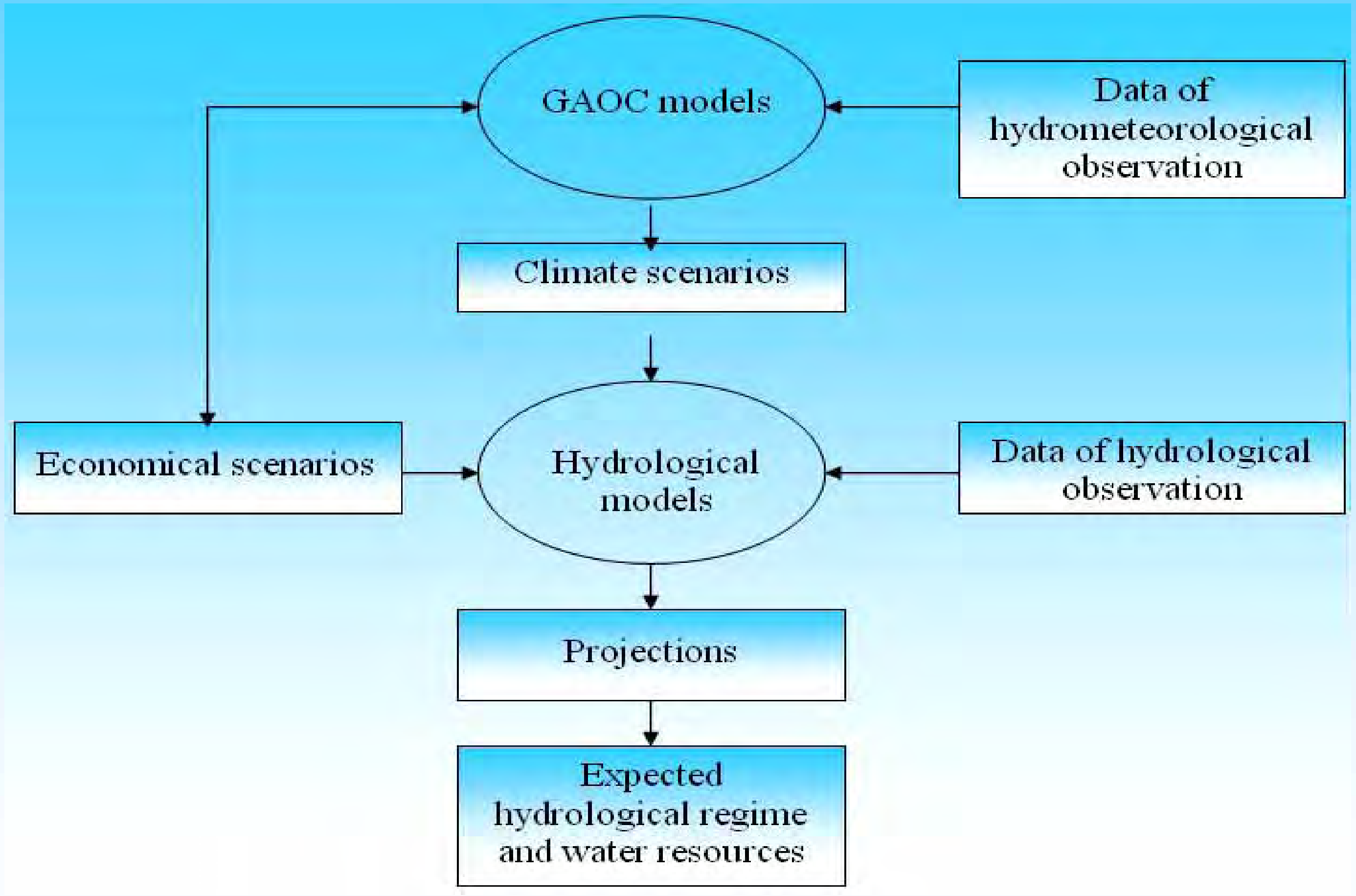
1931-1960 1961-1989 1991-2007



Annual fluctuations of extreme hydrometeorological events at the territory of Ukraine. Number of cases (n) and linear trend (by V. Osadchyi, V. Babichenko)

Consequences of extreme hydrometeorological events

General process of evaluation of expected climate change impact on hydrological regime and water resources



№	Model	Year	Country	Developer	Horizontal steps and vertical levels number	Calculations upon scenarios (B1-A1B-A2)	Grid dimension (Ukraine)
1	BCCR-BCM2.0	2005	Norway	Bjerknes Centre for Climate Research	T63 (1.9°x1.9°) L31	1-1-1	7 x 3
2	NCAR-CCSM3	2005	USA	National Center for Atmospheric Research	T85 (1.4°x1.4°) L26	9-7-4	13 x 5
3	CGCM3.1 (T47)	2005	Canada	Canadian Centre for Climate Modeling and Analysis	T47 (~2.8°x2.8°) L31	5-5-5	5 x 2
4	CGCM3.1 (T63)	2005	Canada	Canadian Centre for Climate Modeling and Analysis	T63 (~1.9°x1.9°) L31	1-1-0	7 x 3
5	ECHAM5 / MPI-OM	2005	Germany	Max Planck Institute for Meteorology	T63 (1.9°x1.9°) L31	5-4-3	10 x 4
6	GFDL-CM2.1	2005	USA	U.S. Department of Commerce / National Oceanic and Atmospheric Administration (NOAA) / Geophysical Fluid Dynamics Laboratory (GFDL)	2.0° x 2.5° L24	1-1-1	7 x 4
7	MIROC3.2 (hires)	2004	Japan	Center for Climate System Research (University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC)	T106 (~1.1°x1.1°) L56	1-1-0	16 x 7
8	MIROC3.2 (medres)	2004	Japan	JAMSTEC	T42 (~2.8°x2.8°) L20	3-3-3	7 x 3
9	MRI-CGCM2.3.2	2003	Japan	Meteorological Research Institute	T42 (~2.8°x2.8°) L30	5-5-5	7 x 3
10	UKMO-HadGEM1	2004	UK	Hadley Centre for Climate Prediction and Research / Met Office	~1.3°x1.9° L38	1-1-1	10 x 6

MODELLING OF CLIMATE CHANGE IN UKRAINE

Coefficients of linear trend of projected minimum, mean and maximum annual air temperatures, and precipitation in XXI century (by S. Krakovska)

Scenarios and seasons		Temperatures, ˚ C			Precipitation, mm
		Minimum	Mean	Maximum	
A2	Winter	0.068	0.052	0.039	0.195
	Spring	0.041	0.038	0.035	0.107
	Summer	0.039	0.042	0.046	-0.305
	Autumn	0.044	0.043	0.040	-0.190
B1	Winter	0.035	0.029	0.019	0.061
	Spring	0.024	0.022	0.020	0.103
	Summer	0.021	0.021	0.023	-0.080
	Autumn	0.022	0.021	0.019	-0.017

Methodological approaches used for estimation of expected change in hydrological regime

- daily flow data from rivers located in different natural zones with basin areas up to 15,000 – 20,000 sg. km and with minimum human impact on runoff were used
- several water balance models with ten days period time steps were used to simulate the impact of climate change on river flow
- combination of water balance models and fluvial hydraulic methods to estimate an impact of projected climate change on flow of the Dnipro river (main Ukrainian river)

PRIOR EVALUATION OF EXPECTED CHANGES IN HYDROLOGICAL REGIME BY 2030
(by V. Manukalo and all)

- **NORTHERN PART OF TERRITORY (FOREST ZONE):**

  A) 15-25% RISE OF MEAN ANNUAL RUNOFF; B) RISE OF WINTER RUNOFF AND FALL OF SPRING RUNOFF

- **SOUTH AND SOUTH-EASTERN PART (FOREST-STEPPE AND STEPPE ZONES):**

  A)30-50% DECREASING MEAN ANNUAL RUNOFF;

  B) ABOUT 50% OF ANNUAL FLOW WILL PASS IN WINTER MOUNTHS; C) INCREASING DROUGHTS RISK

- **CARPATHIANS MOUNTAIN RIVERS:**

  INCREASING FREQUENCY OF EXTREM FLOODS

ASSESSMENT OF THE DNIPRO RIVER RUNOFF CHANGE AT THE KAHOVKA Hydropower Plant by 2050, CUB. M/S

(by A. Shereshevskyi, V. Manukalo)

IPCC Scenarios	Probability %	Mean annual flow	Winter (December -March)	Spring (April – June)	Summer-Autumn (Jul.–Nov.)
Natural river runoff	5 50 95	2470 1620 1070	1970 1060 650	5380 3050 1680	1780 1000 590
B1 SRES scenario	5 50 95	3120 1700 730	5880 2580 870	3000 1380 680	2140 900 300
A2 SRES scenario	5 50 95	710 230 150	1030 380 160	750 300 100	580 300 160

THE MOST LIKELY EFFECTED SECTORS OF ECONOMY BY IMPACT OF CLIMATE CHANGE ON SURFACE WATERS

- **AGRICULTURE IN THE SOUTHERN PART OF THE COUNTRY DUE TO INCREASING THREAT OF DROUTS**

- **HUMAN SETTLEMENTS AND INDUSTRY WATER SUPPLY IN SOUTHERN AND SOUTH-EASTERN PART OF THE COUNTRY DUE TO DECREASING AVAILABLE WATER RESOURCES, ESPECIALLY, IN SUMMER PERIOD**

- **ENCREASING ECONOMIC LOSSES AND LOSSES OF PROPERTY IN MOUNTAIN REGIONS DUE TO A RISE OF THREAT OF FLOODS**

- **GETTING WORSE OF WATER QUALITY IN WATER BODIES IN SOUTHERN AND SOUTH-EASTERN PART OF THE COUNTRY DUE TO DECREASING ENVIRONMENTAL FLOW**

SOME POSSIBLE NEGATIVE CONSEQUENCES OF CLIMATE CHANGE IMPACT ON WATER RESOURCES IN THE DNIPRO RIVER BASIN FOR A2 SRES SCENARIO

- **HYDROENEGETICS**

  EXPECT A DECLINE IN PRODUCTION OF ELECTRIC POWER ON SIX HYDROELECTRIC POWER PLANTS ON DNIPRO RIVER. TRERE WILL BE

  A NEED TO BUILD ADDITIONAL THERMAL POWER PLANTS. TOTAL ECONOMIC LOSSES WILL MAKE FROM 250 TO 350 MLN USD

- **WATER TRANSPORT**

  THERE WILL BE A NEED TO REALIZE THE WORKS ON DEEPENING THE NAVIGABLE RIVER-BED. THE COST OF THESE WORKS WILL MAKE FROM 120 TO 160 MLN USD

- **IRRIGATION**

  A DEFICIT OF WATER, WHICH IS NECESSARY FOR IRRIGATION, WILL INCREASE. THERE WILL BE A NEED TO REDUCE THE AREA OF IRRIGABLE LANDS, RESULTING IN A DECLINE IN COLLECTION OF GRAIN-CROPS, WHICH ARE AMONG THE MAIN EXPORT ITEMS OF UKRAINE. ANNUAL LOSSES CAN MAKE FROM 150 TO 350 MLN USD

DIRECTIONS OF FURTHER ACTIVITIES

- DEVELOPMENT OF COMPLEX WATER BALANCE MONITORING INCLUDING DATA ABOUT: RIVER FLOW; EVAPORATION FROM SOIL, LAND AND WATER SURFACE; SOIL WATER SUPPLY; WATER EQUIVALENT OF SNOW PACK
- ASSESSMENT OF EXPECTED CHANGES IN HYDROLOGICAL REGIME AND WATER RESOURCES USING NEW ACHIEVEMENTS IN THE AREA OF CLIMATE CHANGE AND HYDROLOGICAL MODELLING
- PREPARATION OF RECOMMENDATIONS ADDRESSED ON ELABORATION OF ADAPTATION MEASURES
- IN ORDER TO STRENGTH ACTIVITIES IN THE ASSESSMENT OF THE FUTURE CLIMATE CHANGE IMPACT ON SOCIAL AND ECONOMIC DEVELOPMENT AS WELL AS ENVIRONMENT OF UKRAINE THE PREPARATION OF THE SECOND PHASE OF THE NATIONAL CLIMATE PROGRAM IS COMPLETED BY THE STATE HYDROMETEOROLOGICAL SERVICE IN COOPERATION WITH OTHER CLIMATE- AND WATER-RELATED SECTORS OF ECONOMY


Thank you very much
for your kind patience
and attention !