Uncertainty estimates: Pregolya river runoff response to climate

ECOSUPPORT Project: Advanced tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making

Atlantic Branch of P.P.Shirshov's Institute of Oceanology of Russian Academy of Sciences

Dmitry A. Domnin, *e-mai: dimanisha@rambler.ru*; Boris V. Chubarenko, *e-mai: chuboris@mail.ru*

Global climate change

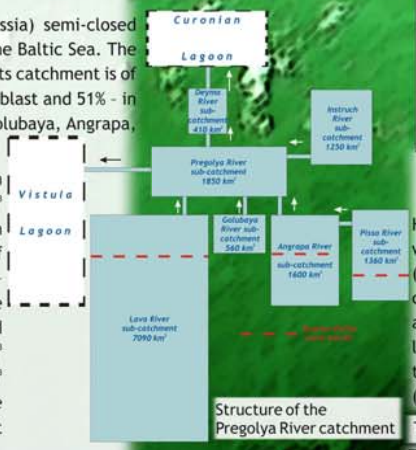
The need for impact assessments of climate change for their practical use in medium- and long-term planning of socio-economic development emphasized in the Climate Doctrine of the Russian Federation (2009).

Accoding to different scenarios of climate change the lower range of temperuture increase may amount to 1.5-2 °C, and the upper range will become 4-5 °C up to end of the XXI century. Quantity of precipitation will increase in northern and middle latitudes, which is associated with good regime, and central continental areas will become drier. In addition, the interannual variability of rainfall can increase dramatically.

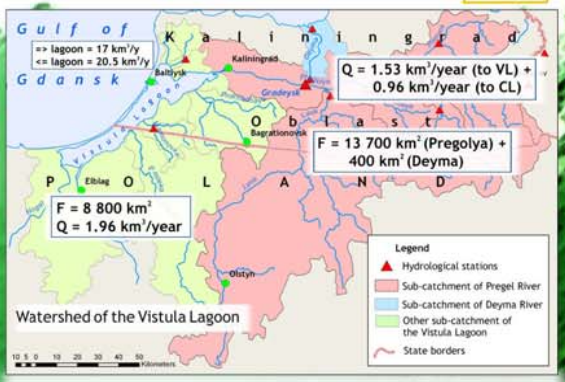
Watershed area

Vistula Lagoon is a cross-border (between Poland and Russia) semi-closed lagoon with the only inlet (Baltiysk Strait) that connects it with the Baltic Sea. The Pregolia River is the main river (44% of total runoff to the lagoon), its catchment is of 13.7 ths. km². 49% of the watershed is located in the Kaliningrad Oblast and 51% - in the Poland. Main tributaries of the Pregolya River are Instruch, Golubaya, Angrapa, Pissa rivers.

1.53 km³ of fresh water per year falls into the Vistula Lagoon from Pregelya River catchment; all other rivers contribute 1.96 km³ water per year (56%) to the lagoon. The Pregolya River mainstream divides into two streams in Gvardeysk town. Pregolya River itself carries away 60% of water to the Vistula Lagoon, and its branch - Deyma River takes about 40% (0.96 km³) of water volume to the Curonian Lagoon. Water exchange between the Vistula Lagoon and the Baltic Sea via the Baltiysk Strait is rather active. In total, 17 km³ of water per year inflow into the lagoon from the sea, and 20.5 km³ of water per year comes from the Vistula Lagoon back to the sea. The difference (3.5 km³ of water per year) is the freshwater budget component of the Vistula Lagoon water balance.

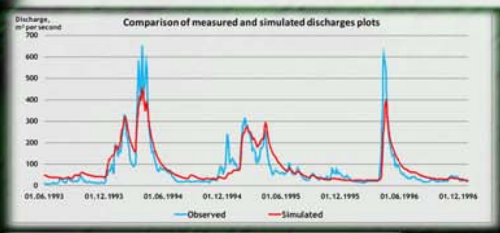


Structure of the Pregolya River catchment



Watershed of the Vistula Lagoon

The hydrological data measured in Gvardeysk were used for calibration (hydrological yearbooks, 1993-1996). Measuring point is locates at 56 km above the mouth of the Pregolya River, before separation into two streams. The data of observation at meteostation Chernyakhovsk were used for time series of precipitation and temperature. The model flow in the cross-section of trailing sub-basin are compared with measured data (Table 2).



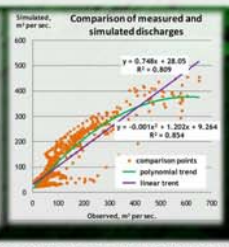


Table 2. Discharge (calibrated) versus measurements, Pregolia River, Gvardeysk, 1993-1996

Time series	Mean (m³/sec)	Mean (km³/year)	Maximum (m³/sec)	Minimum (m³/sec)
Observed data	81	2.6	280	19
Simulated data	89	2.8	243	29

The average measured water consumption is 81 m³/sec and simulated dischage is 89 m³/sec. The correlation coefficient between the measured and modeling data sets is 0.9. The value of reliability in the polynomial approximation (2 degree) is 0.85, in liner approximation is 0.81.

Modelling tool

Analysis of runoff from the Pregolia River catchment conducted by HYPE model (HYdrological Predictions for the Environment). This model was developed by Swedish Meteorological and Hydrological Institute (SMHI). The model calculates the time evolution of the value of runoff in closing cross-sections of catchment, taking into account evaporation and infiltration into the soil. Incoming data is digital elevation model, land use structure, soil types, time series of precipitation and temperature. Calibration is required for time series of discharge values (Table 1) at the hydrological stations inside the catchment.

Table 1.Sources of input modeling data

Parameter	Unit	Source
Catchment area	km²	SRTM data (Shuttle Radar Topography Mission), GIS calculation
Soil types	% of area	Soil maps of Kaliningrad Oblast and Poland, GIS calculation
Land use structure	% of area	Land use maps of Kaliningrad Oblast and Corine Land Cover for Poland, GIS calculation
Altitude	m	SRTM data (Shuttle Radar Topography Mission), GIS calculation
Slope catchment	degrees	SRTM data (Shuttle Radar Topography Mission), GIS calculation
Precipitations	mm per day	Observed (1993-1996)
Temperature	°C per day	and climate model (1981-2098) data
Discharge	m³/s	Data from hydrological yearbooks (1981-1996)

Climate changes scenarios

The assessment of river runoff response to possible climate change in the XXI Century was conducted using predictive meteorological data (1971-2098), which were prepared by Swedish Meteorological and Hydrological Institute (SMHI) basing on different models (Meier et al., 2011). Four scenarios were used for hydrological HYPE modelling for the period of 1981-2098 :

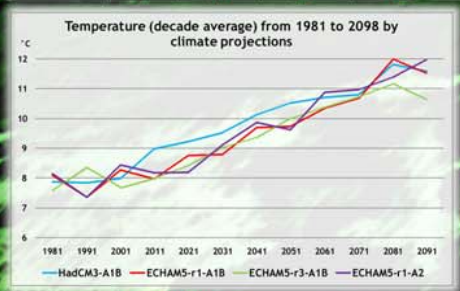
RCAO+ HadCM3 under scenario A1B

RCAO+ ECHAM5-r1 under scenario A1B

RCAO+ ECHAM5-r3 under scenario A1B

RCAO+ ECHAM5-r1 under scenario A2

to estimate uncertainties of the climate response assessment.



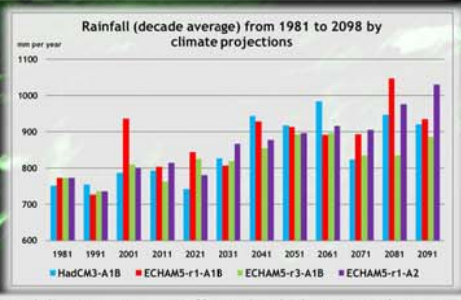


Table 3. Climate decade average characteristics for beginning and end of 1981-2098 period by different climate models

Model-scenario	Temperature, C			Precipitations, mm		
	1981-1990	2090-2098	increase	1981-1990	2090-2098	increase
HadCM3-A1B	7.9	11.6	3.7	750	920	170 (+23%)
ECHAM5-r1-A1B	8.1	11.5	3.4	770	930	160 (+21%)
ECHAM5-r3-A1B	7.6	10.4	2.8	770	890	120 (+16%)
ECHAM5-r1-A2	8.2	12.0	3.8	770	1030	260 (+34%)

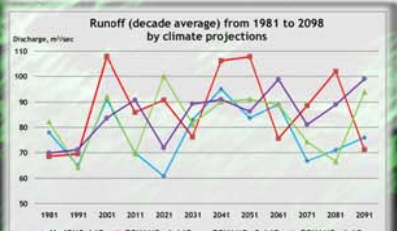
According to used climate models projections for the South East Baltic in the period 1981-2098, it is expected that an increase of temperature will be up to 2.8-3.8 °C, and the precipitations will increase by 16-34%. The biggest rise of temperature and precipitations is attributed to the climate scenario A2.

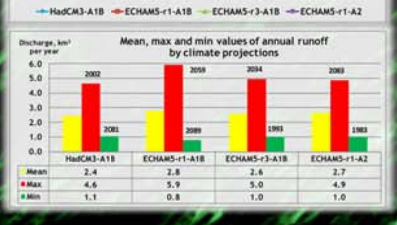
Response of discharge

River runoff from the Pregolya River catchment was calculated for different climate projections based on global scenarios of increase of local air temperature (A1B: 2.8-3.7 °C, A2: 3.8°C) and precipitation (A1B: 16-23%, A2: 34%).

Annual variability in average runoff is rather high, it varies between 40-160 m3/sec. The uncertainty in estimation of cumulative discharge is about 2-7%. In all four scenarios of atmospheric forcing model results show the tiny general increase of the runoff from the Pregolia River catchment. Maximum rate of increase is for scenario A2. Average decade discharge has a very small oscillations, it varies from 2.4 km3/year (HadCM3-A1B) to 2.8 km3/year (ECHAM5-r1-A1B) for the period 1981-2098.

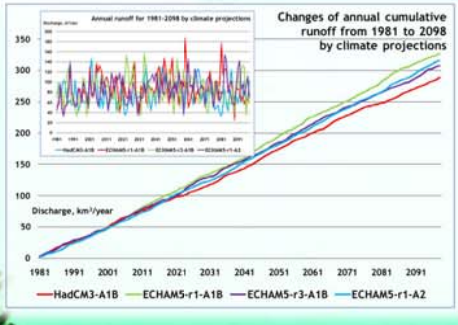
Even if air temperature and precipitations significantly increase, we may say that the increase in river discharge from the Pregolia River catchment is practically absent. That unexpected response of surface water runoff may be a result of an increase of evaporation from the catchment area.





Trends of temperature, rainfall and discharge by climate projections

Model-scenario	Temperature	Rainfall	Discharge
HadCM3-A1B	↗	↗	→
ECHAM5-r1-A1B	↗	↗	→
ECHAM5-r3-A1B	↗	↗	→
ECHAM5-r1-A2	↗	↗	↗



Acknowledge

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