



The Caspian Sea level problem under changing climate

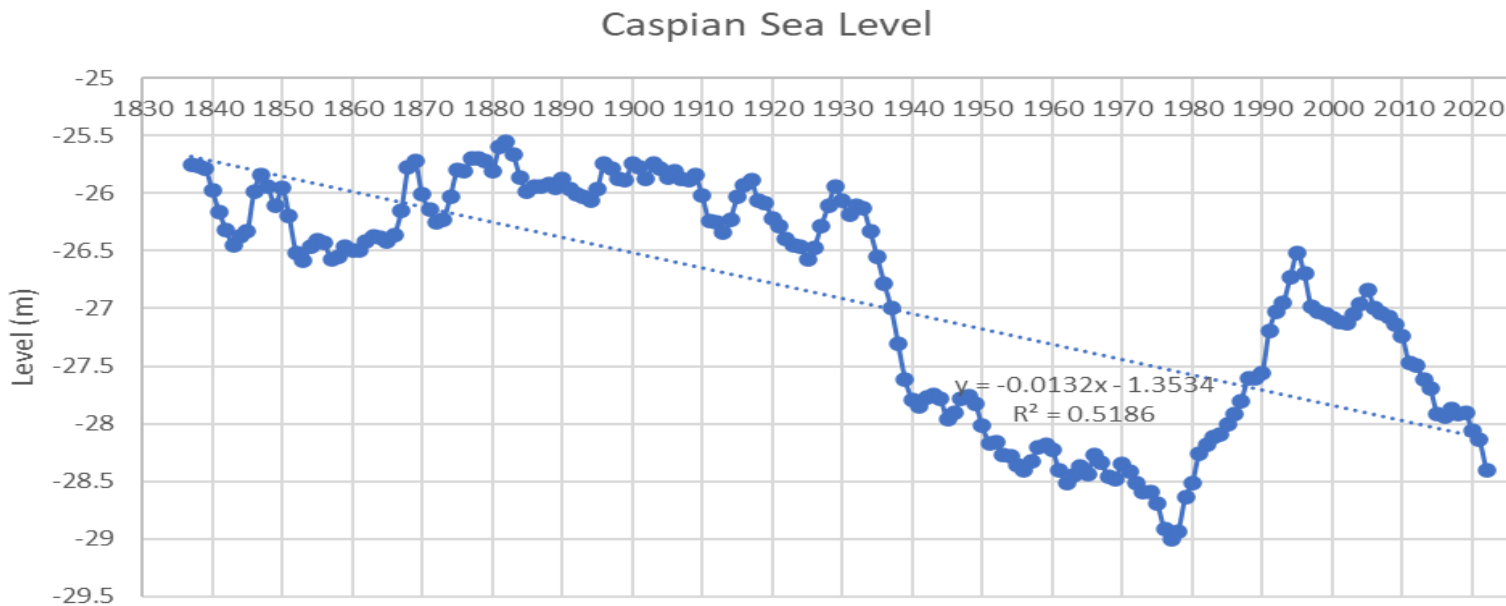
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SIGNIFICANT FLUCTUATIONS OF THE SEA

Environmental refuges
Underground water level rise
Desertification

the amplitude of fluctuations 3.8m



Caspian Sea

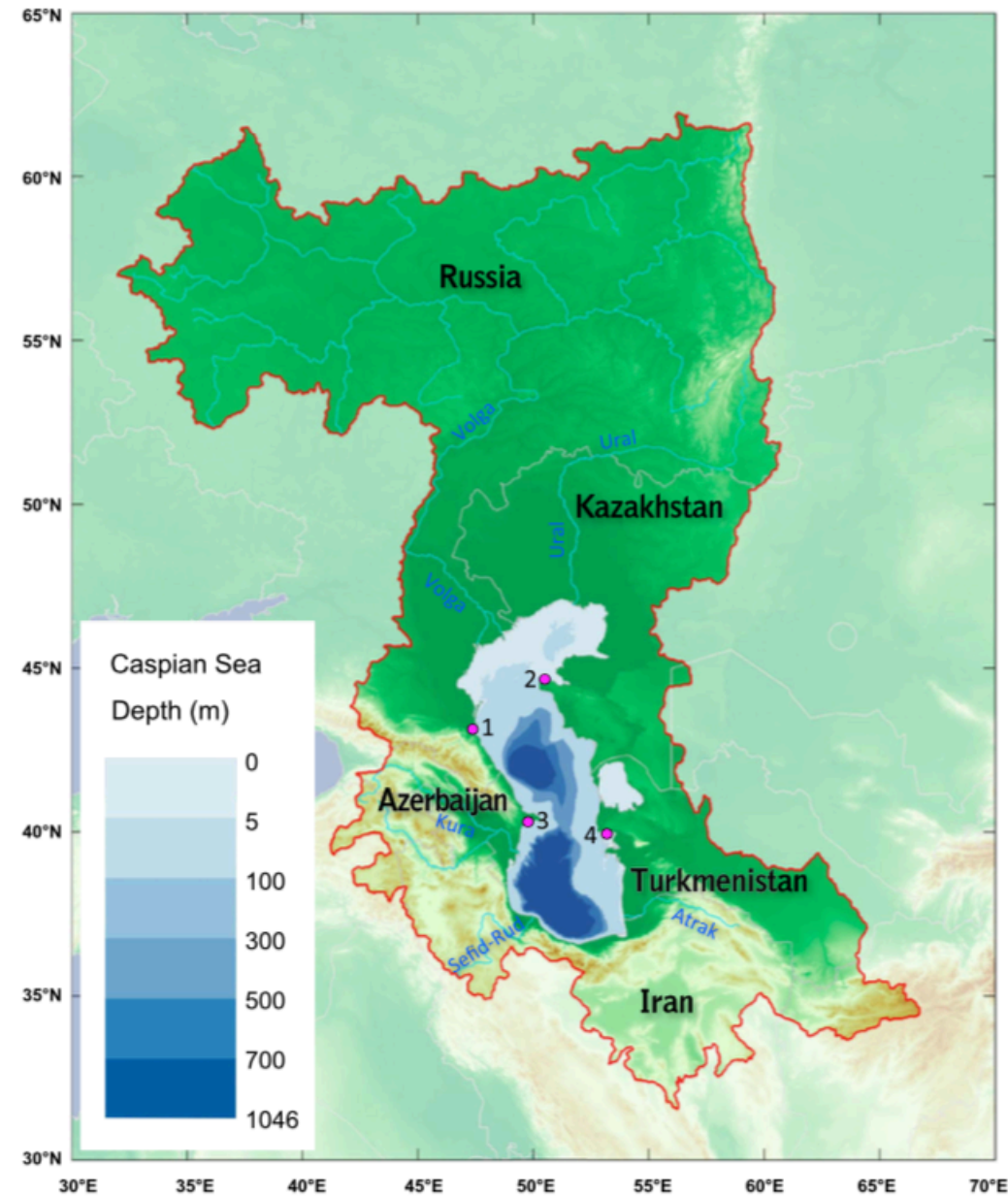
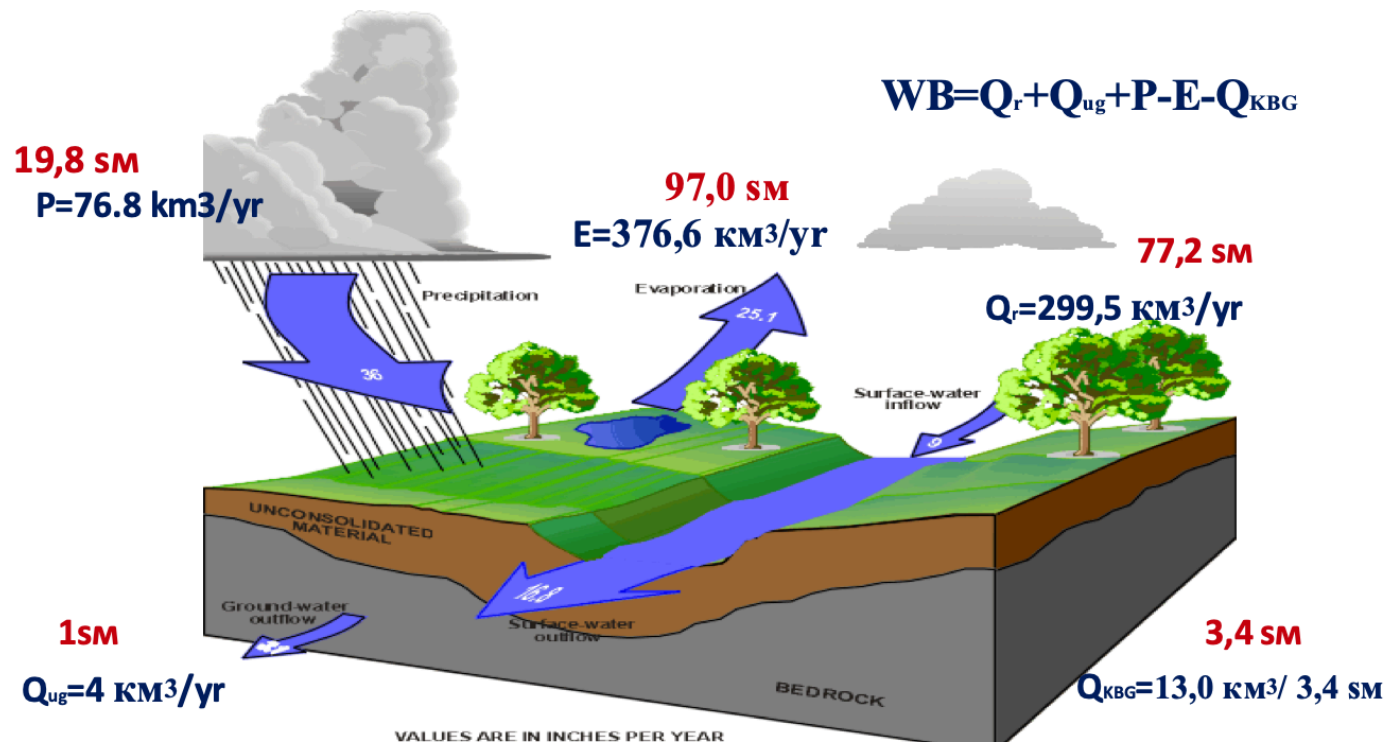
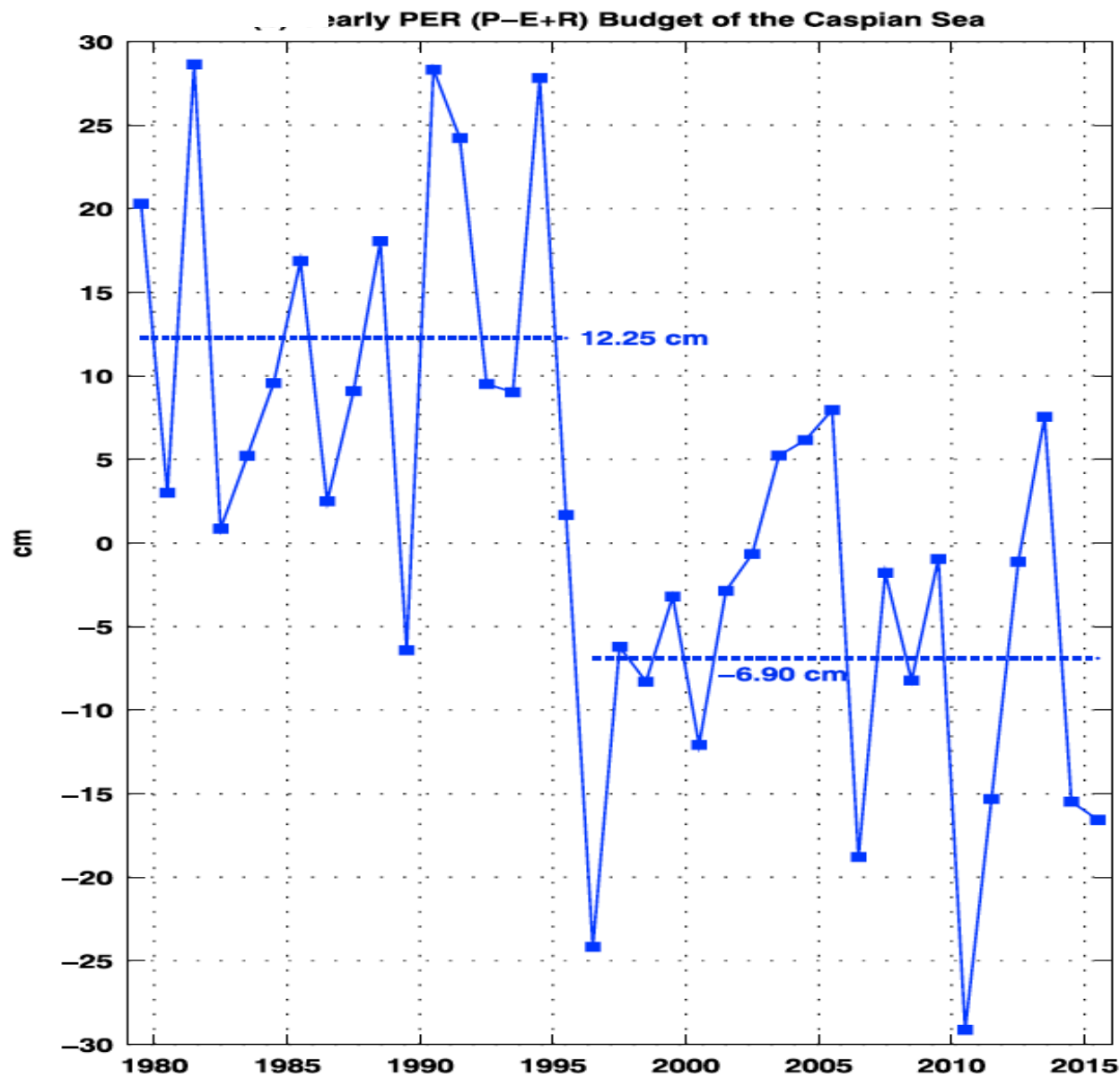
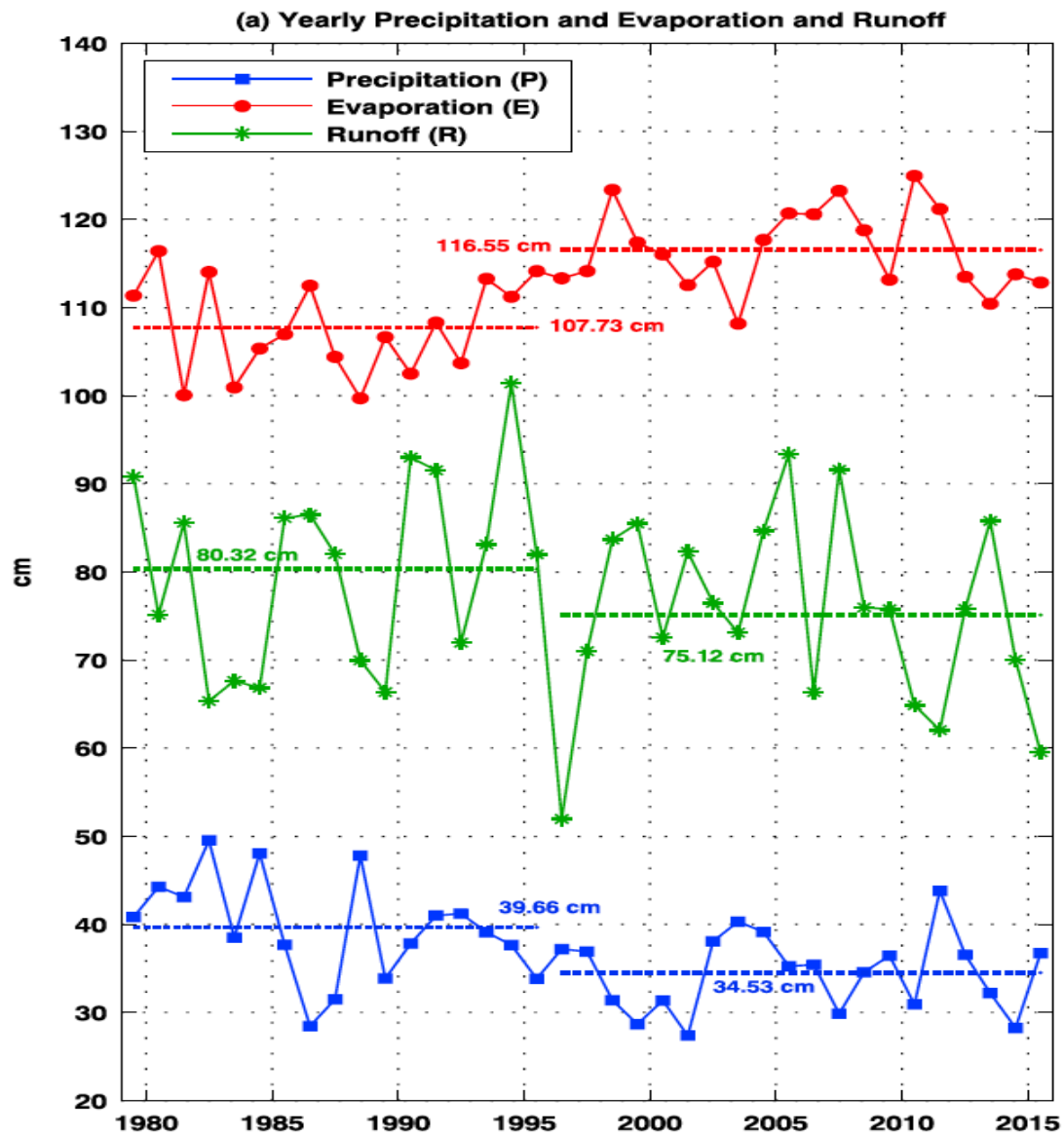


Figure 1. Map of the Caspian Sea and Caspian drainage (enclosed by the red contour line). The Caspian Sea is surrounded by five countries: Russia, Kazakhstan, Turkmenistan, Iran, and Azerbaijan. Four tide gauge stations (1 = Makhachkala, 2 = Fort Shevchenko, 3 = Baku, and 4 = Turkmenbashi), from which the historical Caspian Sea level observation time series is derived, are marked by magenta dots.

CSL changes can be estimated by the following water mass balance equation:

$$\frac{dH}{dt} = P - E + R$$



Caspian Sea Level Rates

1979.01–1995.12 (cm/yr)

1996.01–2015.12 (cm/yr)

2005.01–2015.12 (cm/yr)

Observations

Precipitation (P)

12.74

-6.72

-9.13

Evaporation (E)

39.66

34.53

34.55

$P-E$

107.73

-68.07

-82.02

-83.01

Volga Runoff (R)

-68.07

74.02

65.23

62.21

Total Runoff (R^*)

74.02

80.32

75.12

74.65

$P-E + R^*$ (YB)

12.25

-6.90

-8.36

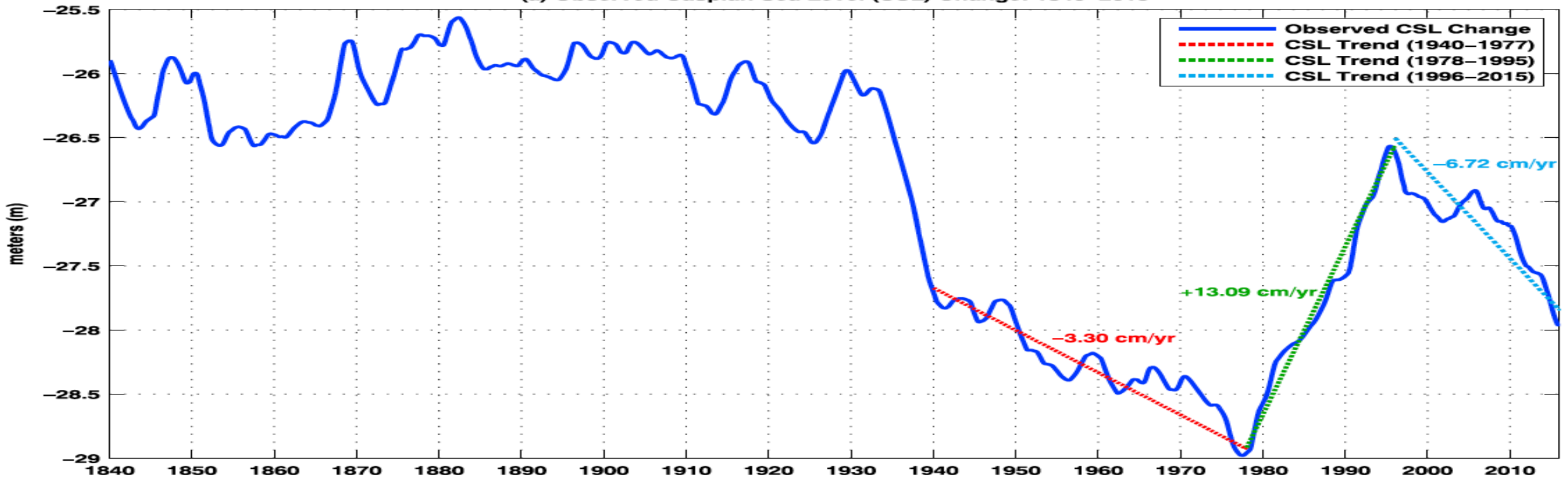
$P-E + R^*$ (FI)

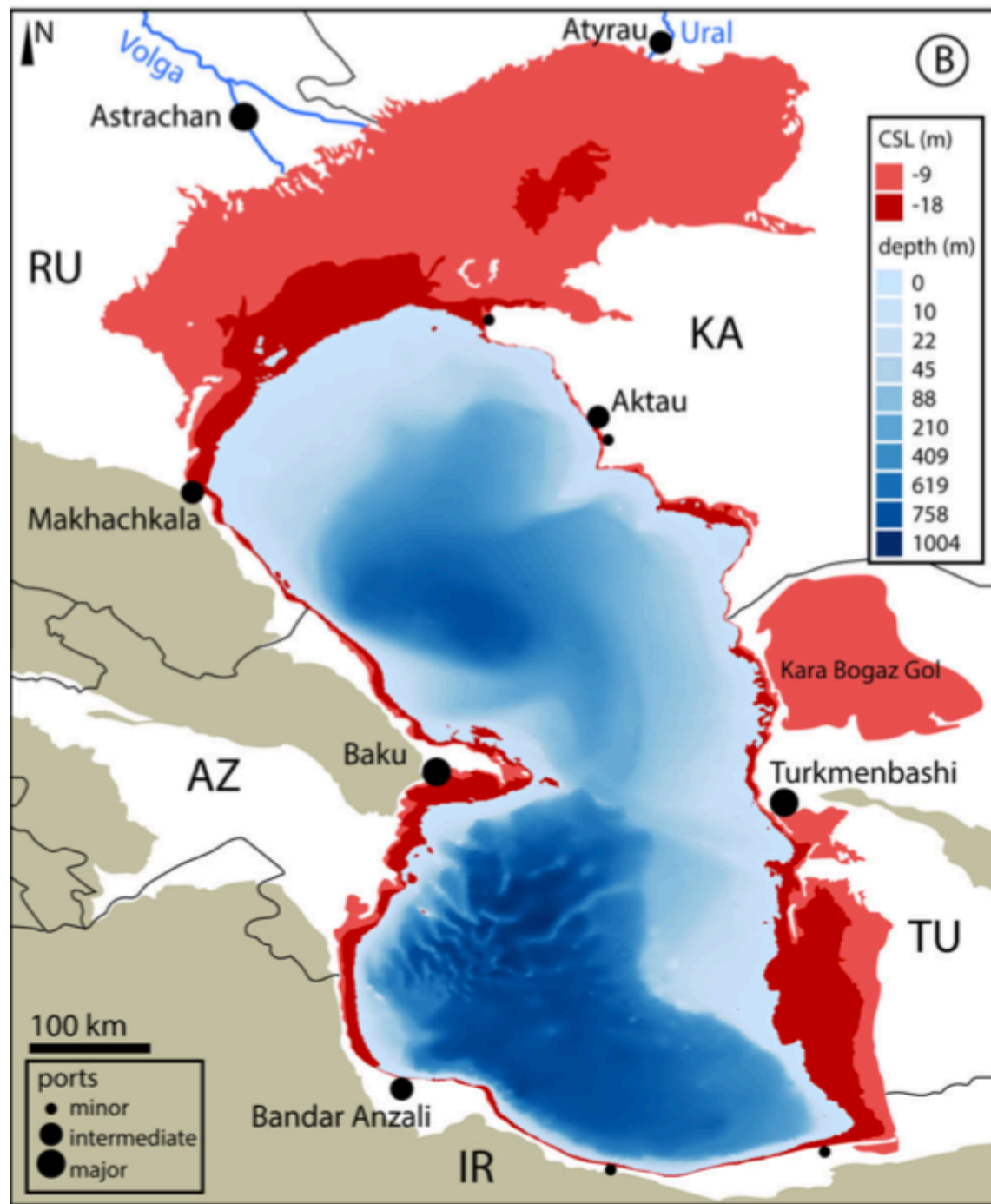
12.38

-6.79

-8.48

(a) Observed Caspian Sea Level (CSL) Change: 1840–2015





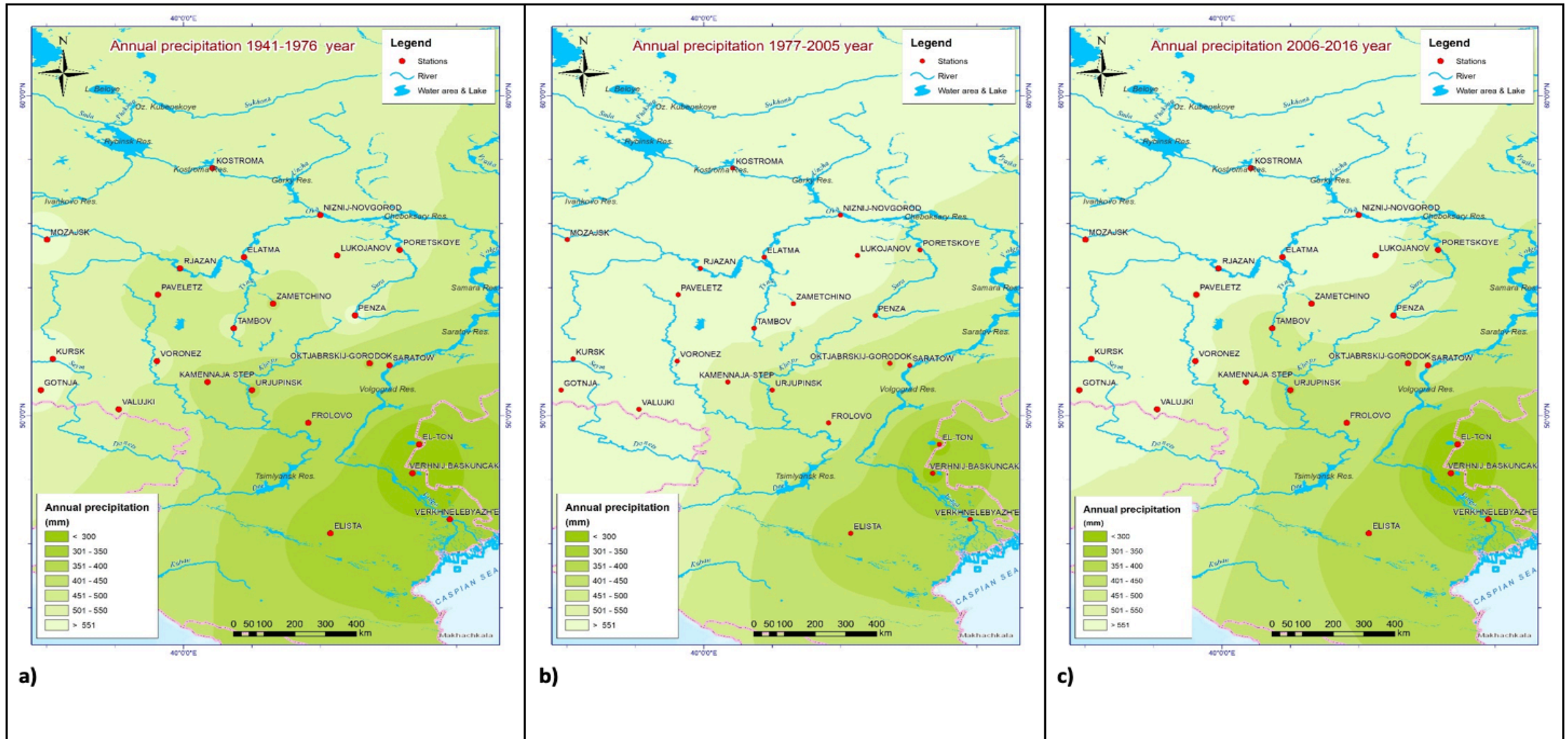
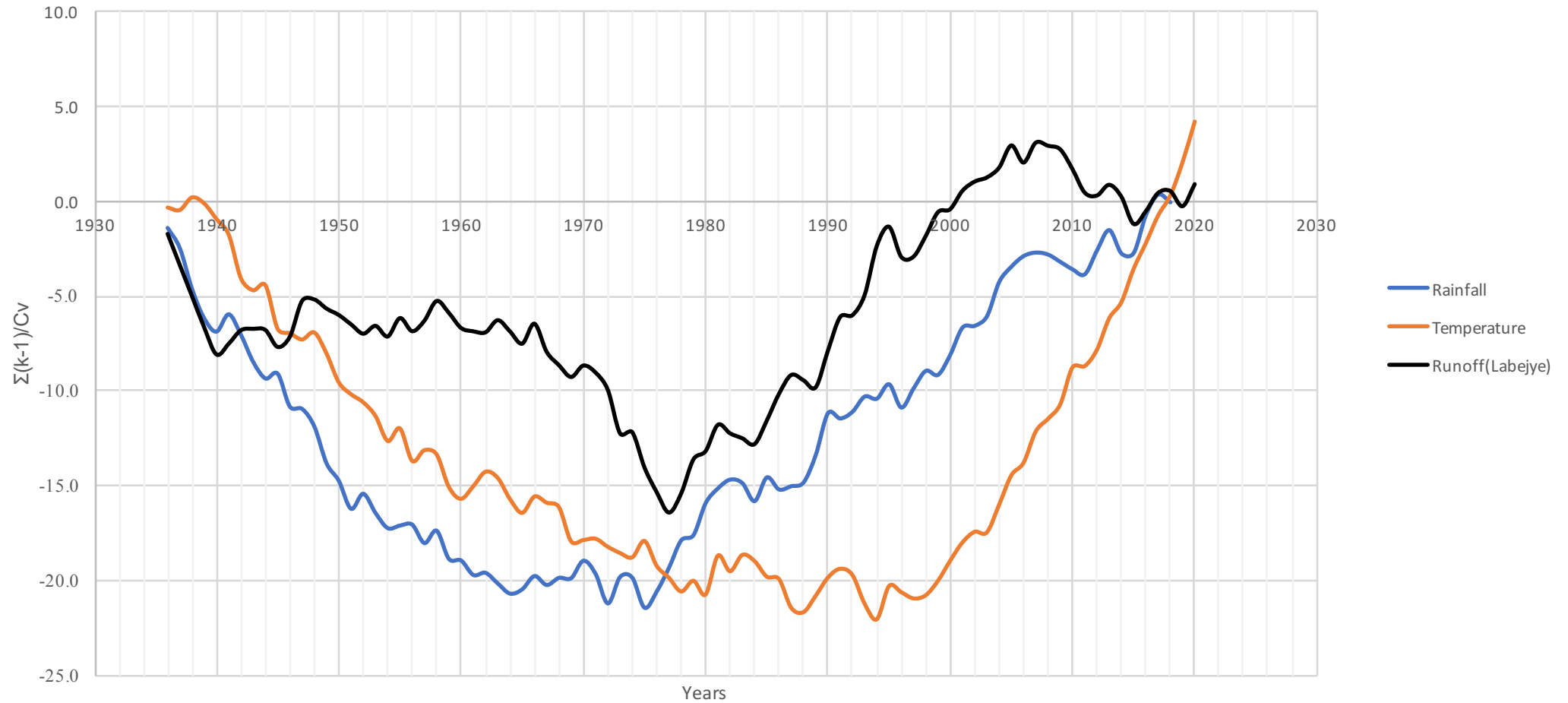
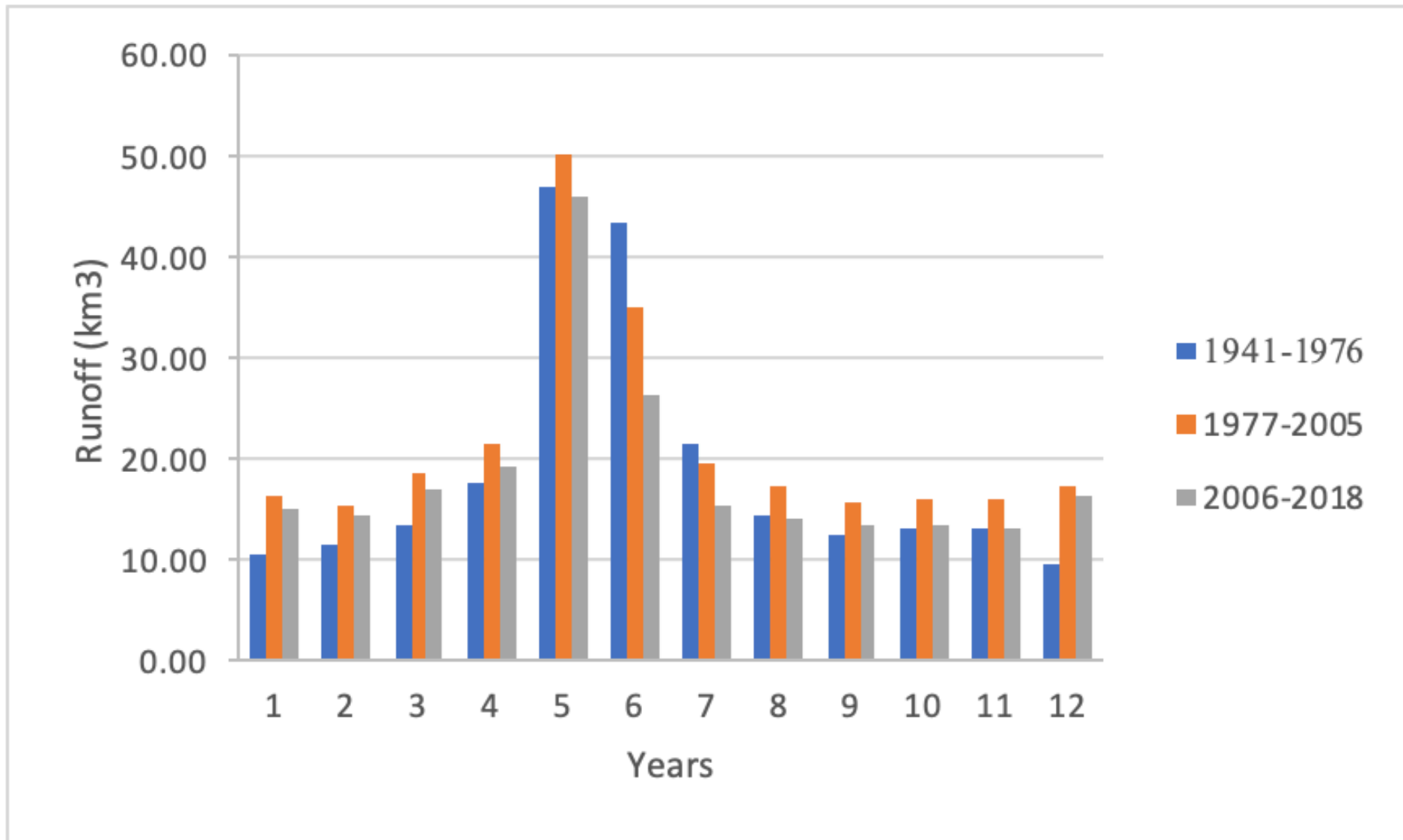


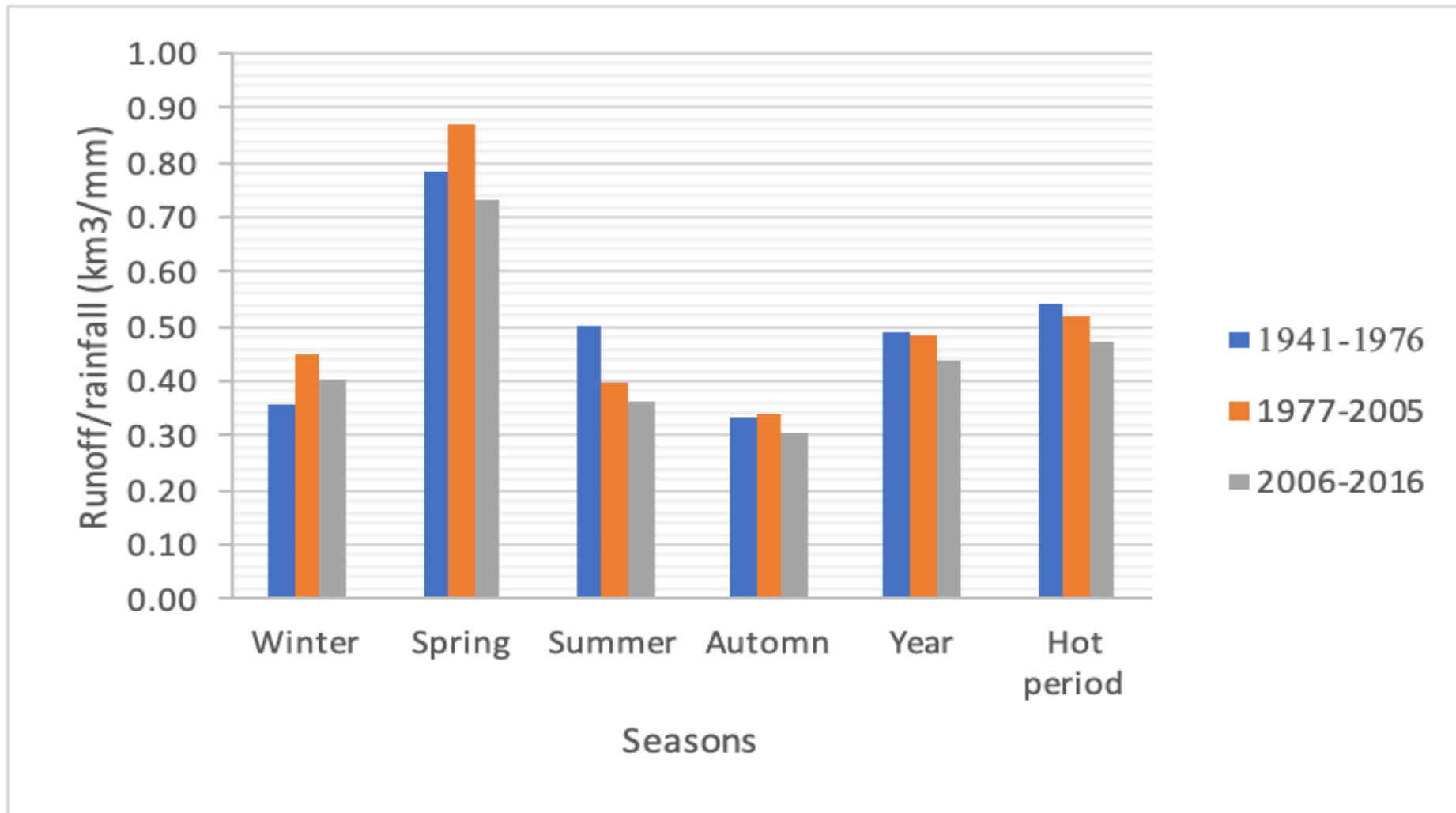
Figure 6. Distribution of average annual precipitation in the basin of the river. Volga in different periods of time: a) 1941-1976; b) 1977-2005; c) 2006-2018



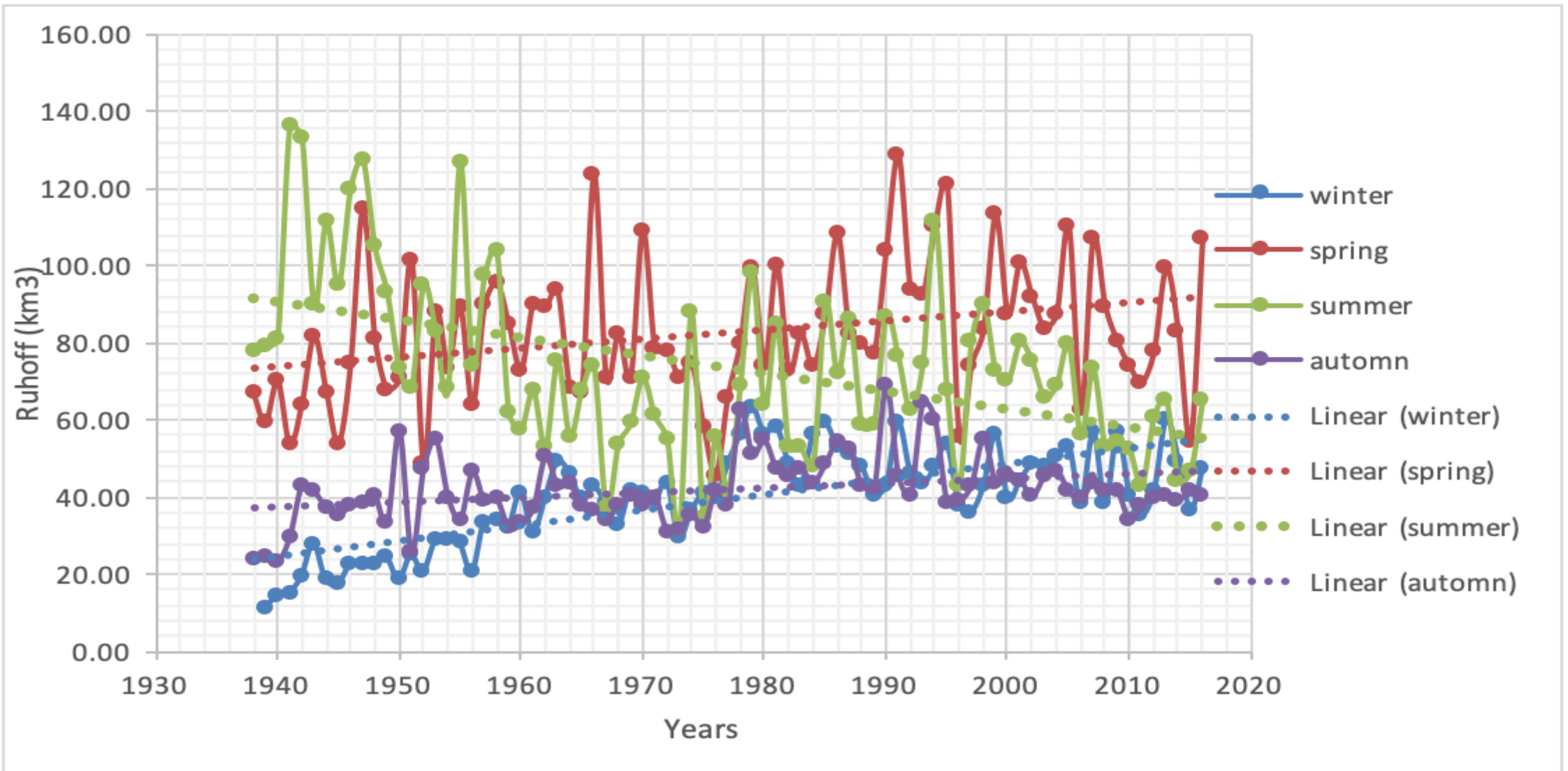
Difference-integral curves of the annual flow of the Volga River (Verkhneye Lebyazhie), the annual amount of precipitation in the river basin and the average annual air temperature in the river delta



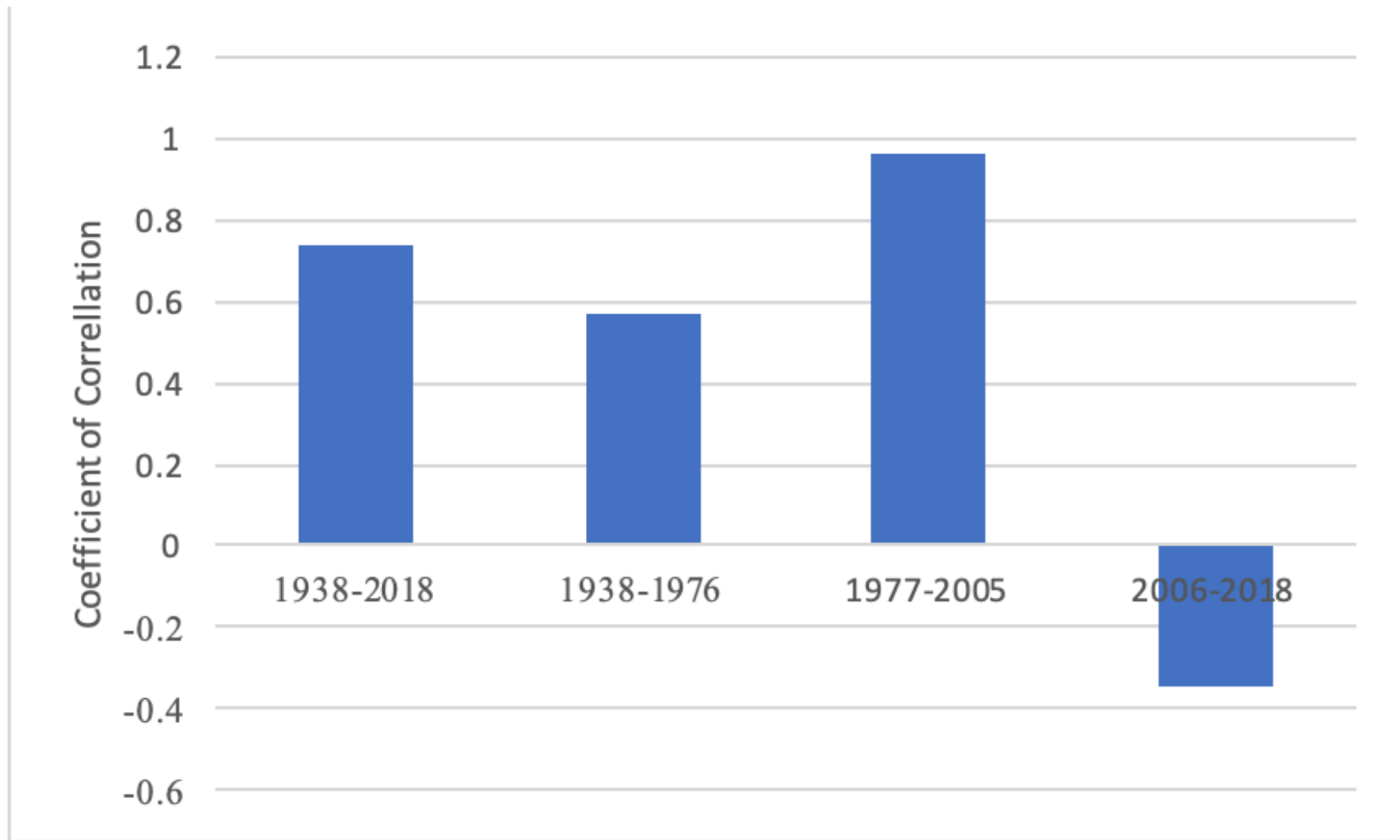
Distribution of the Volga River flow by months in the Upper Lebyazhye hydrological point



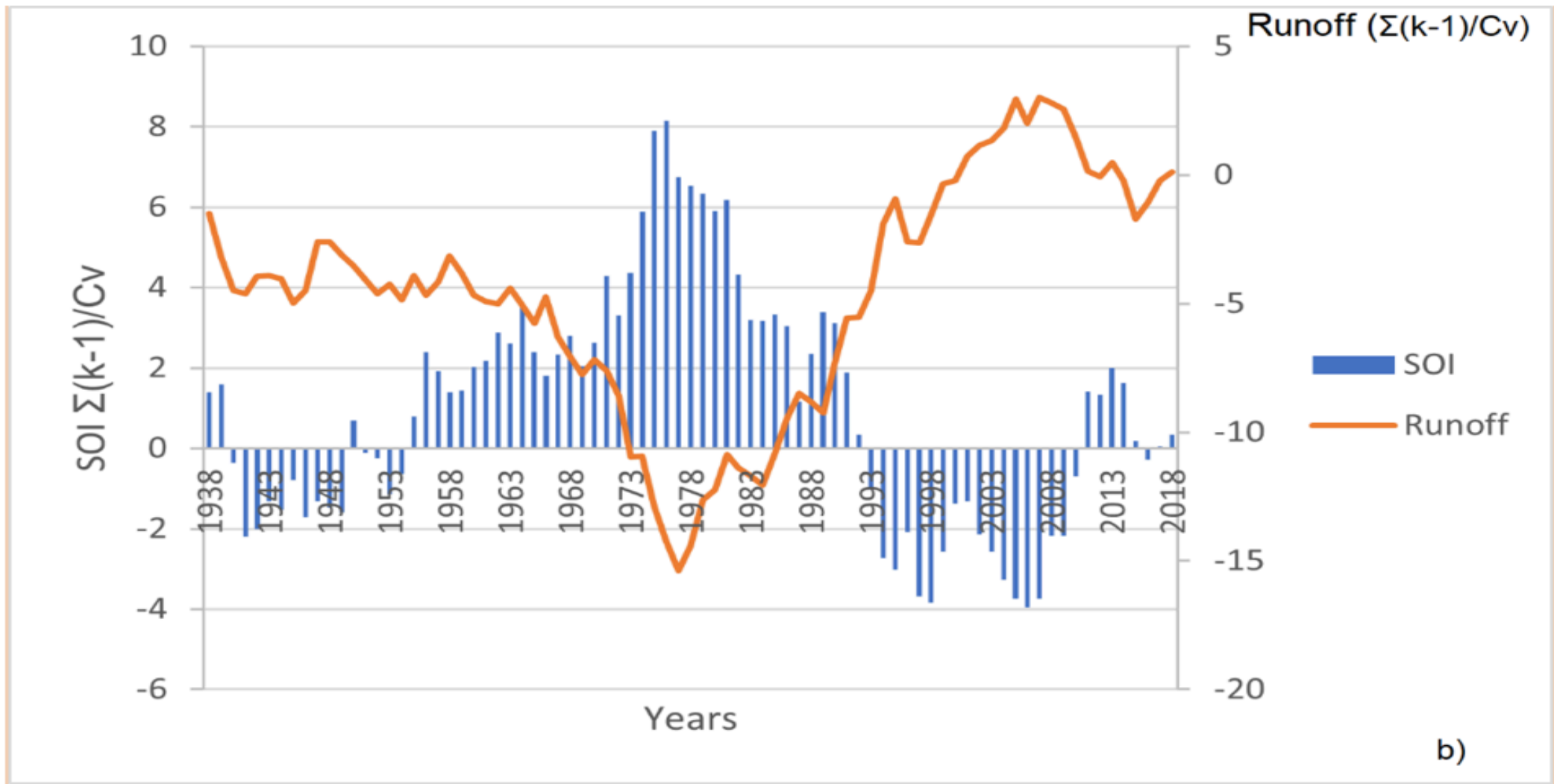
Seasonal distribution of the flow/precipitation ratio (km³/mm) in the Upper Lebegye hydrological station (Volga River) in different periods



Temporal course of seasonal flows of the Volga River at Verkhneye Lebyazhie



The correlation coefficient between precipitation in the Volga River basin and runoff at the hydrological point Verkhneye Lebyazhie



Curves of time variations of SOI and annual runoff in the Volga River (a) and their difference integrals for the period 1938-2018

Correlation coefficients between the level of the Caspian Sea and various climate indices for the period 1900-2018

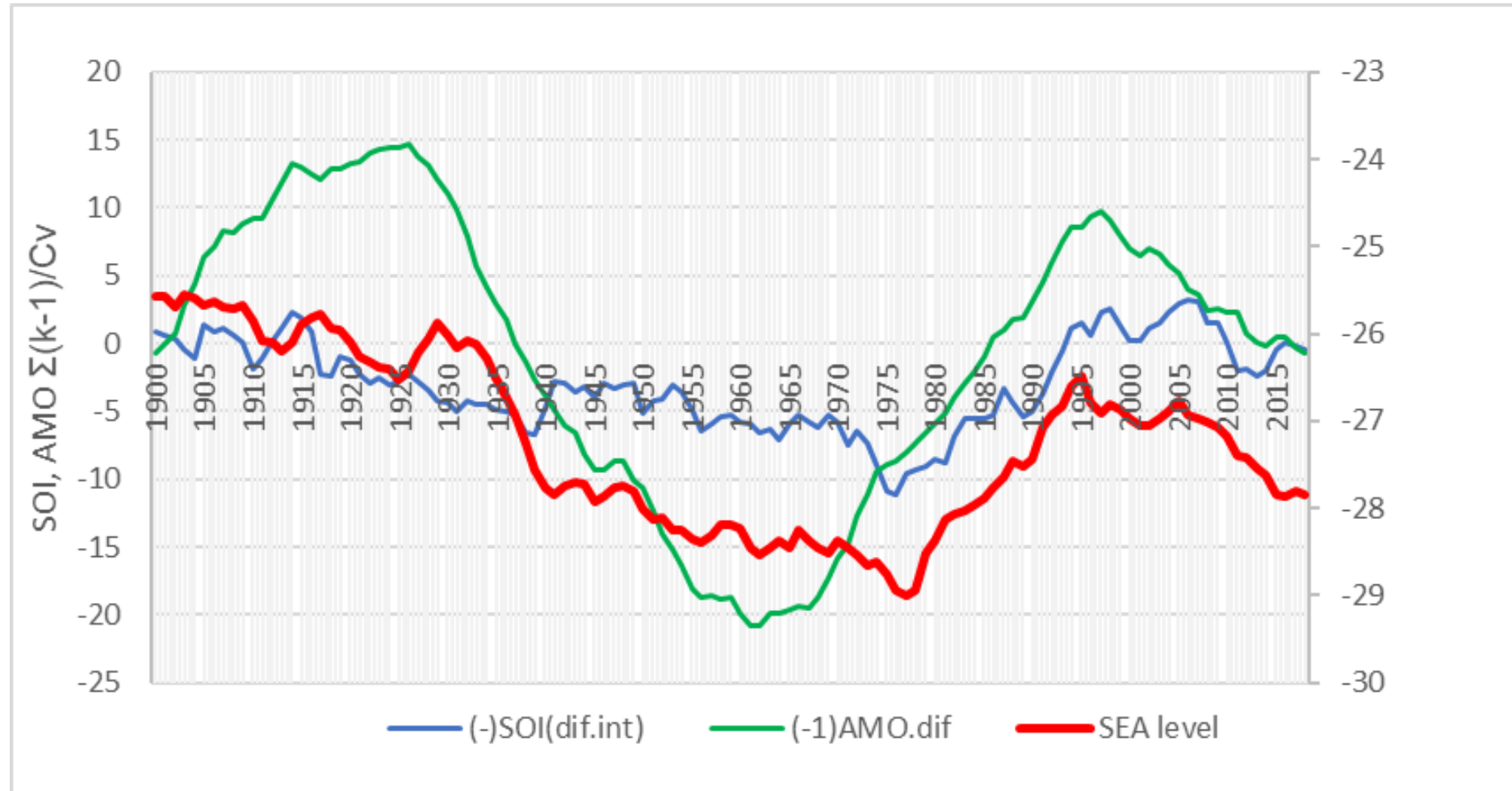
The difference integrals are represented as:

$$\Sigma(k_i-1)/C_v$$

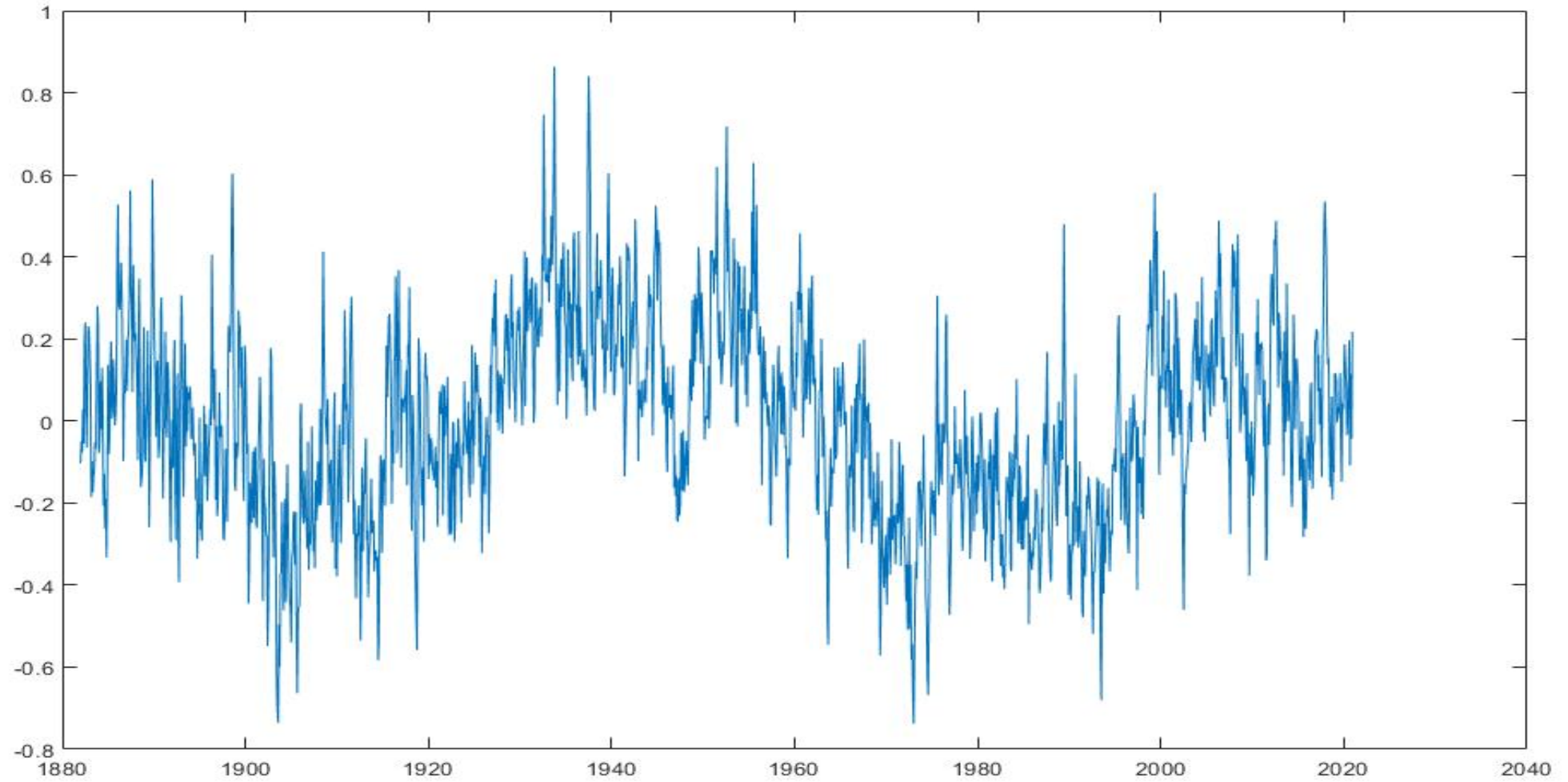
where K_i - is the ratio of the current value of the series to its mean,
 C_v is the coefficient of variation (Panin, 2014).

Periods	Climate indexes					
	SOI	int.SOI	AMO	int.AMO	NAO	int.NAO
1900-2018	0.035	-0.676	0.001	-0.840	0.044	-0.161
1900-1930	0.140	-0.513	-0.317	0.801	-0.182	-0.849
1931-1976	-0.100	-0.425	0.630	-0.871	0.009	0.014
1977-1995	-0.149	-0.950	-0.186	-0.983	0.170	0.785
1996-2018	0.083	-0.716	0.124	-0.855	-0.516	0.726

SOI – AMO – CSL Forecast for the CSL 2045



AMO



Thank You