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Research Article

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Modern Water Balance of the Caspian Sea: Potential Disaster Scenarios

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ABSTRACT

The study deals with the Caspian Sea modern water balance. Sea level at main hydrological gauges, total river runoff to the Caspian Sea, total precipitation and evaporation data from the ERA-5 reanalysis and outflow to the Kara-Bogaz-Gol Bay are considered. Based on statistical assessments and a special forecast model, two probabilistic forecasts of the Caspian Sea water level change up to 2070 were given. The first forecast relates to the current hydrometeorological condition of the sea, the second accounts undergoing climate changes. Both scenarios show a rapid drop of the Caspian Sea water level down to -30 m and -32 m respectively from current -28 m driven by climate change models.

Keywords: Caspian Sea Water Level Drop, Water Balance, Scenarios of Water Level

Methods

Data sets of several hydrological characteristics of the Caspian Sea water balance were used from 1950 to 2022, including total river runoff from the main rivers flowing into the Caspian Sea (Volga, Ural, Sefidrud, etc), total precipitation and evaporation obtained from ERA5-Land reanalysis, as well as total outflow to the Kara-Bogaz-Gol Bay. These data sets were used to calculate statistical parameters, including the annual mean, Cs (skewness coefficient), Cv (coefficient of variation), Cs/Cv attitude, σ (standard deviation) and (r1) lag-1 autocorrelation coefficient in order to use them for modelling and forecasting the Caspian Sea water level up to 2070 using a special model "AQUA" that was developed at the Russian Academy of Sciences.

Results

The modelling results show that with the rise of average annual temperature caused by global warming, evaporation from the sea surface also increases (and precipitation on the contrary decreases), which with a 99% exceedance probability will cause the sea level to drop to critical mark of -33 meters by 2070. Under stationary climate (excluding the effects of global warming) the sea level is also expected to decrease and to fluctuate around -29-30 m on average by 2070 (figure 1).

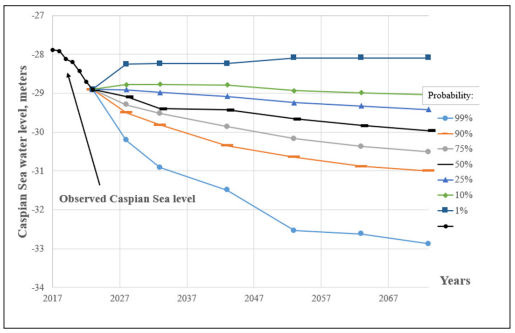

Figure 1: probability forecast of the Caspian Sea water level

Conclusion

The components of the current water balance of the Caspian Sea have been analyzed, and a probabilistic forecast (scenario) of the sea water level has been given. The results show that under stationary climate Caspian Sea water level would remain

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approximately the same as it is observed nowadays (-28-29 meters above sea level). However, if evaporation increases due to climatic changes such as global warming, the sea level could dramatically decline to -33 meters (figure 1). Such scenario may have disastrous effect not only on human livelihoods, but also may lead to a complete loss of port functionality and substantial restructuring of the sea's ecosystem.

Table 1: Extreme probabilistic forecast of the Caspian Sea level

Exceedance Probability %	Forecast Timeliness in years					
	5	10	20	30	40	50
1	-28.3	-28.2	-28.2	-28.1	-28.1	-28.1
10	-28.8	-28.8	-28.8	-29	-29	-29
25	-28.9	-29	-29.2	-29.2	-29.3	-29.4
Mean	-29.1	-29.4	-29.4	-29.7	-29.8	-30
75	-29.3	-29.5	-29.9	-30.2	-30.4	-30.5
90	-29.5	-29.8	-30.4	-30.6	-30.9	-31
99	-30.2	-30.9	-31.5	-32.5	-32.6	-33

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