Precipitation trends for Western Turkey in associated with North Atlantic Oscillation (NAO) Index

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Abstract In this study, intermediate duration rainfall (IDR) extremes (t = 1, 6, 12 and 24 hours) at 7 stations are considered to search for possible trends taking into account North Atlantic Oscillation (NAO) Index using Mann-Kendall Test statistics. The results show that most of the stations have generally positive trends at different rainfall durations for the record periods. In addition to, some rainfall durations have statistically much more significant trends according to NAO index.
Keywords precipitation; trend; Mann-Kendall; North Atlantic Oscillation (NAO); Western Turkey

INTRODUCTION

Precipitation is perhaps the most important component of the complex hydrologic cycle because of its impact on our daily life. Therefore, precipitation is often taken as a starting point towards the understanding of changes of the governing processes of climate. Point precipitation data is extensively recorded over the land surface and constitutes an important element for monitoring the hydrological cycle. The study of precipitation variability is very relevant, mainly because of its impact on society, economic activities (e.g. agriculture), land use and water resources. Actually, temperature has the main effect on climatic change, so both precipitation and temperature trend research may be considered together, especially at the interpretation stages.

The atmospheric circulation is the principal control that determines the climate variability. Atmospheric circulation and teleconnection patterns can be characterized by using circulation indices, such as the indices developed for El Nino-Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), the Arctic Oscillation (AO) or the North Sea- Caspian Pattern (NCP).

The NAO has been considered as one of the most important connection patterns: it significantly affects Atlantic weather patterns and produces regional climatic anomalies associated with itself, particularly in Europe and the Mediterranean Basin. The NAO indices (NAOIs) were mostly characterized by a persistent positive anomaly episode dominating over the years of the 1980s and 1990s. So the scientific studies have been performed since early 1990s. Hurrell and van Loon (1997) explained that precipitation anomalies (including dry wintertime conditions over southern Europe and the Mediterranean regions, and the wetter than normal conditions over northern Europe and Scandinavia since 1980) were linked to the behaviour of the NAO.

A number of studies were also performed on climatic variability and anomalies over the Mediterranean basin and surrounding countries and regions for the influence of the NAO (e.g. Rodo *et al.*, 1997; Wibig, 1999; Delitala *et al.*, 2000). Results of studies on the relationships between precipitation in Turkey and the NAO (Erlat, 2002) have pointed out that annual and, in particular, long winter precipitation amounts for the period 1930 to 2000 tended to decrease during the positive NAO phase and to increase during the negative NAO phase. According to Erlat (2002), the period approximately from 1940 to 1970 generally consisted of marked wet conditions in

Turkey, whereas the period of 1971-94 was generally dominated by dry conditions. The maximum annual and winter precipitation amounts occurred in the year 1963, corresponding to a marked negative NAOI. Apparent decreased precipitation in the years 1973 and 1989 corresponded with markedly positive NAOI winters.

DATA AND METHODOLOGY

The annual intermediate duration rainfall (IDR) extreme data set (t = 1, 6, 12 and 24 hours) were collected by the Turkish State Meteorological Service (TSMS). The locations, elevations, record periods of the stations and population of the city are shown in Table 1 and spatial distributions are in Fig. 1.

Table 1 Station locations, population and IDR data variation.

Station	Longitude (^{0}E)	Latitude (^{0}N)	Elevation (m)	Population	Record Duration
Adana	35.20	37.00	20	2125140	1944 - 2004 (58)
Antakya	36.12	36.10	100	1300726	1958 - 2004 (46)
Antalya	30.42	36.53	50	1719751	1950 - 2004 (55)
Bursa	29.04	40.11	100	2192166	1951 - 2004 (54)
Çanakkale	26.25	40.09	3	464975	1958 - 2004 (39)
Denizli	29.05	37.47	428	850029	1959 - 2004 (38)
İzmir	27.10	38.26	25	3370866	1938 - 2004 (56)

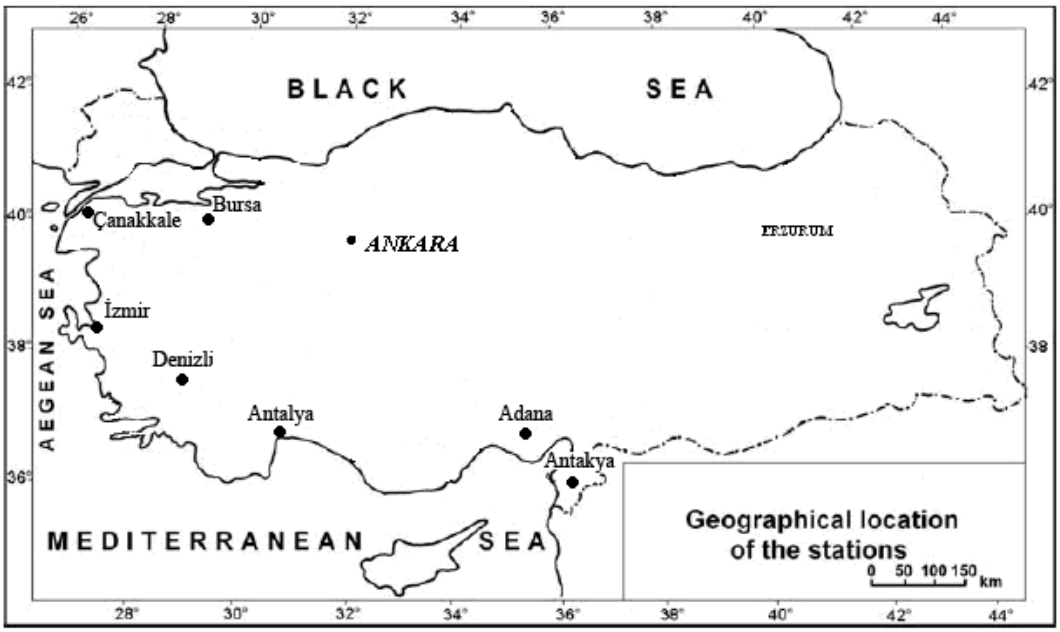

Fig. 1 Spatial distribution of analyzed stations.

Mann – Kendall test

A non-parametric trend test, Mann - Kendall, is applied to IDR series of 7 stations. If a Mann – Kendall statistic of a time series is higher than 1.96, there is a 95% significant increase in that particular time series. If the result is just the reverse, i.e. lower than – 1.96, there is a 95% significantly decreasing trend in the series. In the

same way, a time series is higher than 1.645, there is a 90% significant increase and lower than – 1.645, there is a 90% significantly decreasing trend in the series.

RESULTS

Annual extreme trends in IDR for the period indicated using the Mann–Kendall statistic, are summarized in Table 2.

Table 2 Mann – Kendall results of IDR.

Station	1 hour	6 hours	12 hours	24 hours
Adana	0.1342	1.4221	1.2879	0.3824
Antakya	- 0.8427	0.3409	0.8427	0.4829
Antalya	3.0708**	1.8076*	2.0109**	1.6770*
Bursa	1.5816	1.7607*	2.1859**	0.7386
Çanakkale	0.2298	- 1.6694*	- 1.4516	- 1.8871*
Denizli	- 0.5029	0.5783	0.7166	- 0.1509
İzmir	3.4560**	4.6787**	4.0144**	2.3747**

* Significant at 10 per cent level
** Significant at 5 per cent level

Antalya has 90% significant increase in all durations. Bursa has positive trends in 6 hours and 12 hours. Çanakkale has negative trends in 6 hours and 24 hours. Significantly positive trends are determined at 95% confidence level in İzmir. Adana, Antakya and Denizli has no trends in annual intermediate durations. Trends in İzmir and Antalya are shown in Fig. 2, 3, 4, 5, 6 and 7.

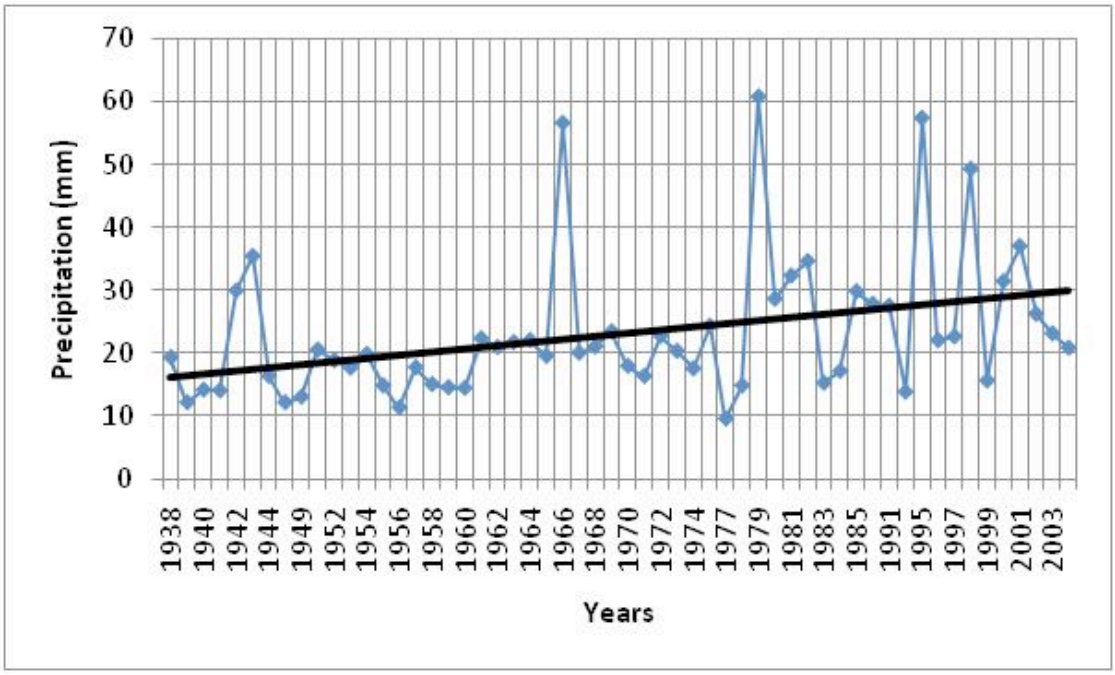

Fig. 2 1 hour duration precipitation at İzmir station

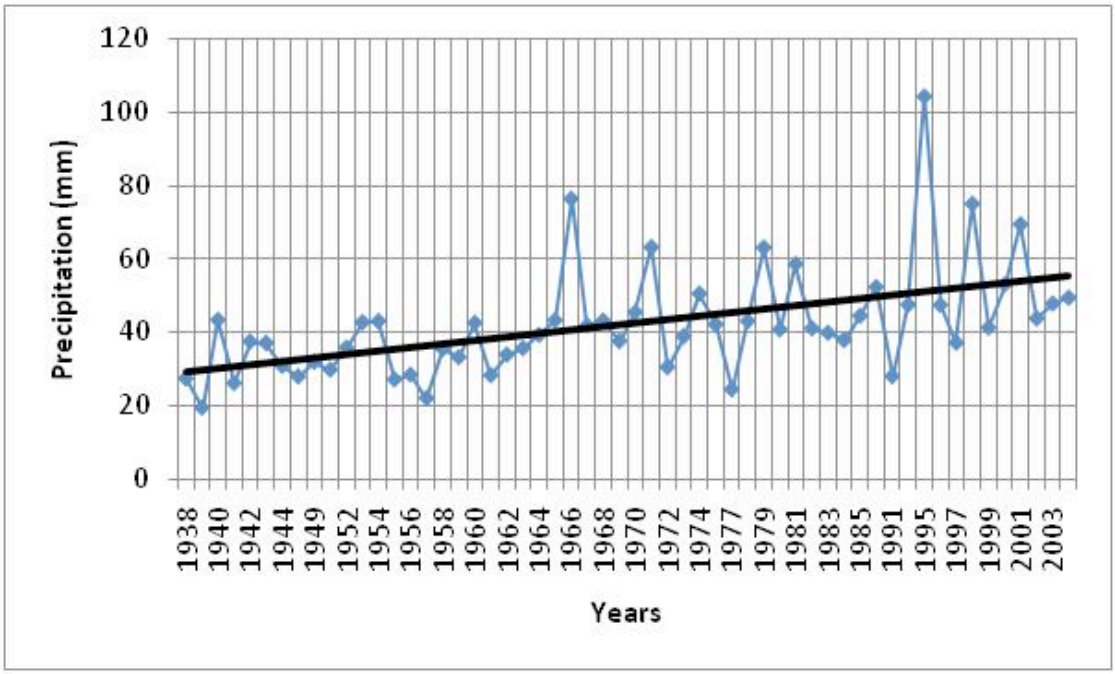

Fig. 3 6 hours duration precipitation at İzmir station

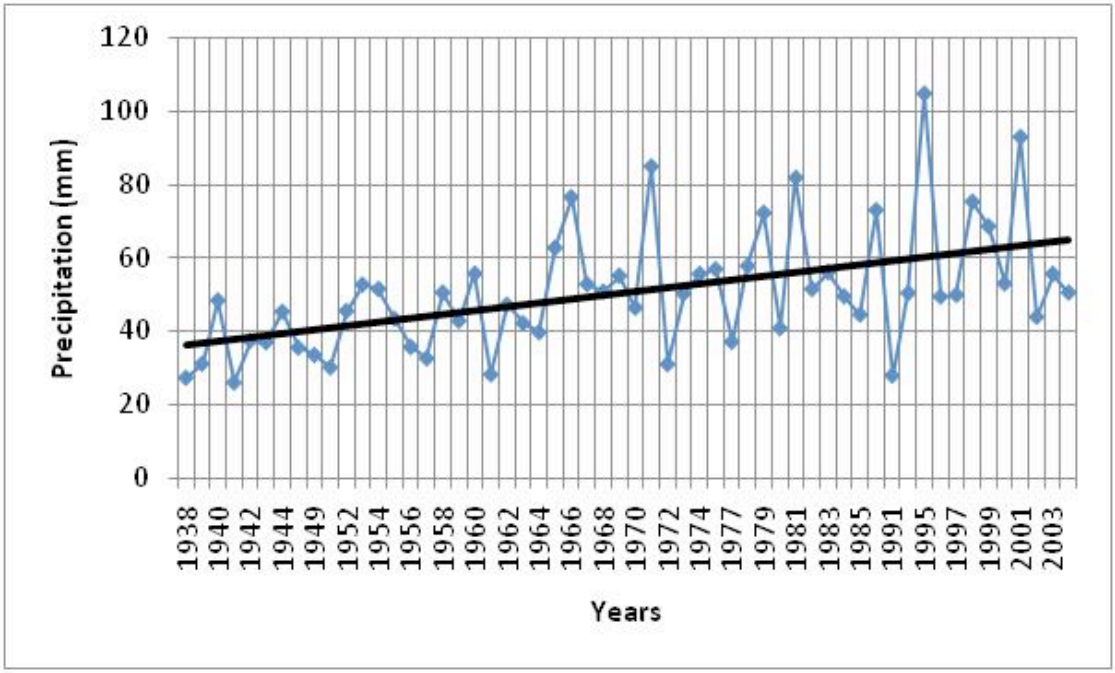

Fig. 4 12 hours duration precipitation at İzmir station

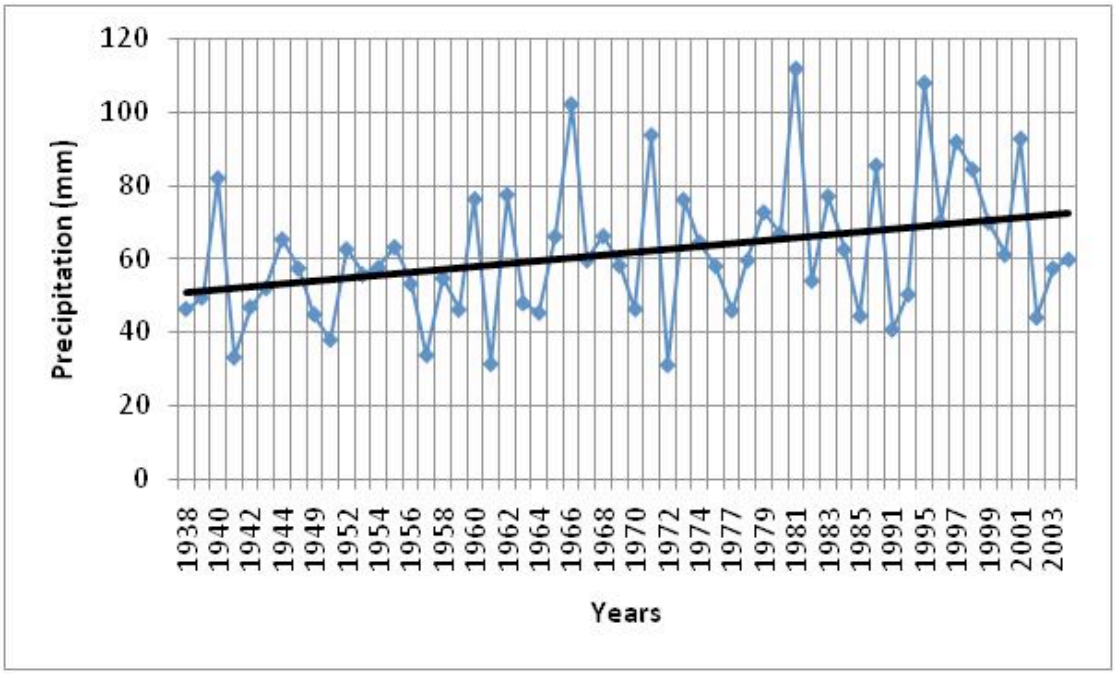

Fig. 5 24 hours duration precipitation at İzmir station

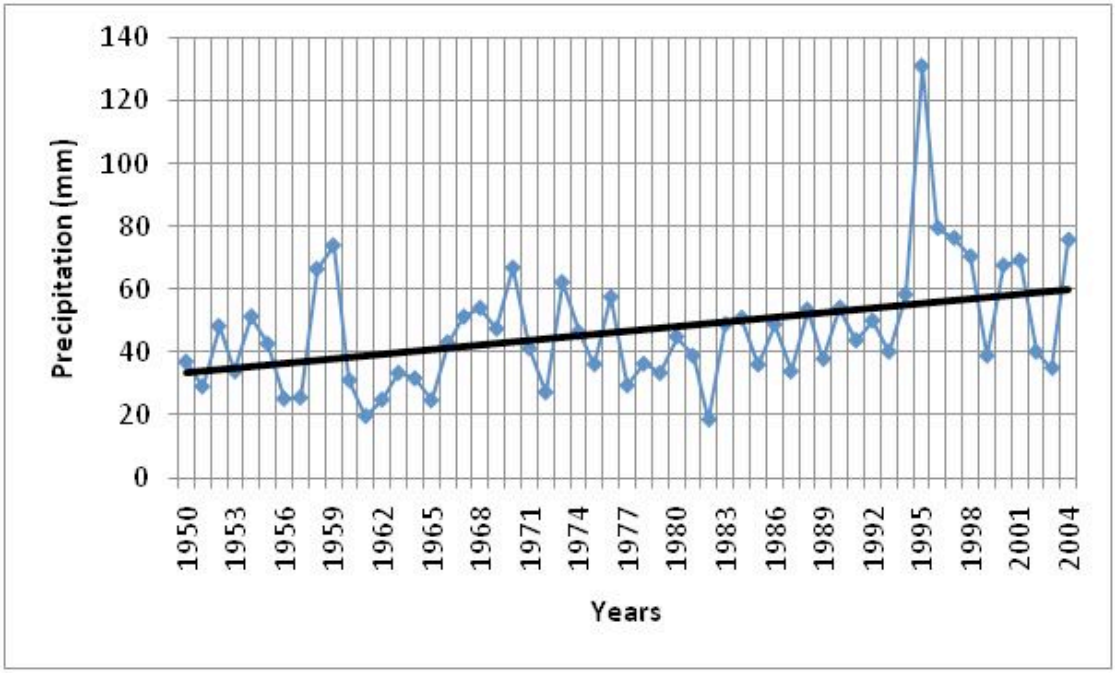

Fig. 6 1 hour duration precipitation at Antalya station

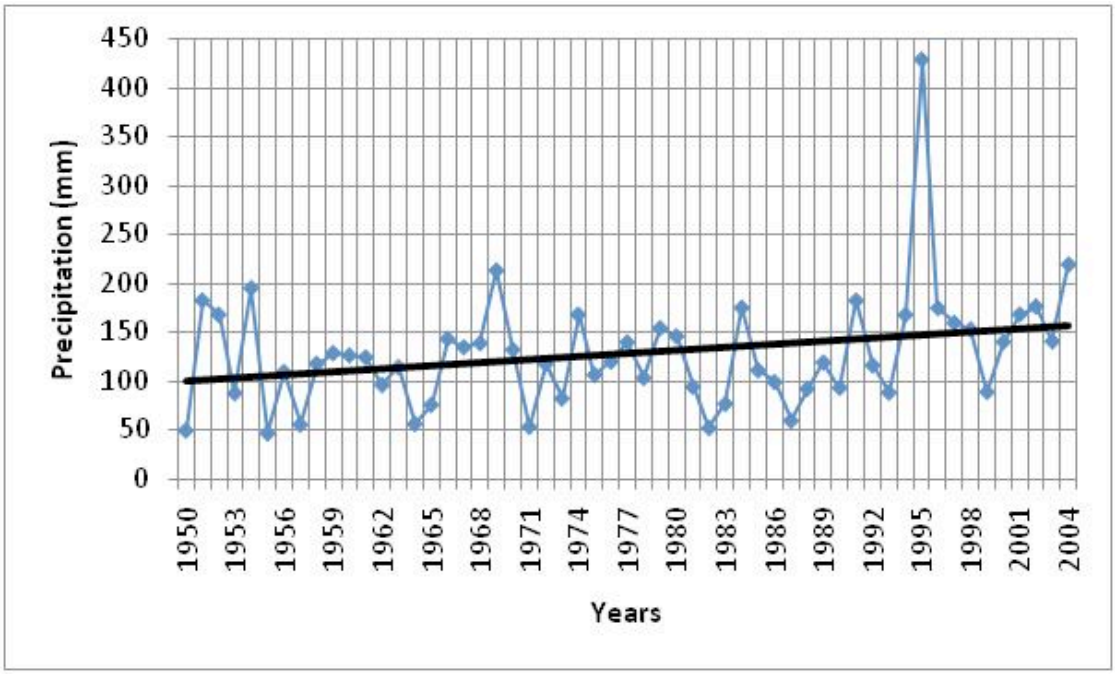

Fig. 7 12 hours duration precipitation at Antalya station

There were precipitation anomalies in 1973 and 1974 over Turkey for the influence of the NAO. So the annual IDR data set divided two groups, before 1973 and after 1974, for all stations. The same Mann – Kendall test procedure is applied and the results of the test are shown in Table 3.

Table 3 Mann – Kendall results of IDR (before 1973 and 1974 - 2004).

	Adana	Antakya	Antalya	Bursa	Çanakkale	Denizli	İzmir
1 hour (-1973)	- 0.6671	- 1.7815*	0.8185	2.0072	- 0.3050	0.7785	2.2541**
1 hour (1974-2004)	- 2.6174**	0.1870	2.6684**	0.7478	1.1021	0.0834	0.4713
6 hours (-1973)	- 0.6046	- 0.2969	0.2232	2.7467**	- 1.1592	0.0000	2.8054**
6 hours (1974-2004)	- 1.0878	0.6289	1.9716*	1.0368	0.0441	1.0840	1.1658
12 hours (-1973)	- 0.8756	0.1979	0.1736	2.4298**	- 1.1592	- 0.3114	2.8379**
12 hours (1974-2004)	- 0.8158	0.9518	1.6656*	0.3059	- 0.2645	1.1466	0.2480
24 hours (-1973)	- 0.0834	- 0.9897	0.3721	0.3962	- 1.6472*	- 0.6228	1.2649
24 hours (1974-2004)	- 0.8498	0.7648	2.0056**	- 0.1360	- 0.6172	0.0834	0.1736

* Significant at 10 per cent level
** Significant at 5 per cent level

Antalya has also 90% significant increase between 1974 – 2004 for 1 to 24 hours. Adana has decrease in 1 hour duration after 1974, Antakya has also a decrease in 1 hour but before 1973. Bursa has increase in 6 and 12 hours before 1973. Çanakkale has negative trend in 24 hours duration before 1973. Significantly positive trends are determined at 95% confidence level in İzmir for 1, 6 and 12 hours until 1973. Denizli has no trends as in general IDR.

CONCLUSIONS

According to this study, some stations in western Turkey has been affected by NAO. Especially, İzmir and Antalya stations has positive trend for 1, 6, 12 and 24 hours. İzmir has also positive trend before 1973, in contrast, Antalya has positive after 1973.

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