Homogeneity and Trend Analysis in Precipitation and Streamflow Data of the Eastern Black Sea Region, Turkey

Presentation on behalf of
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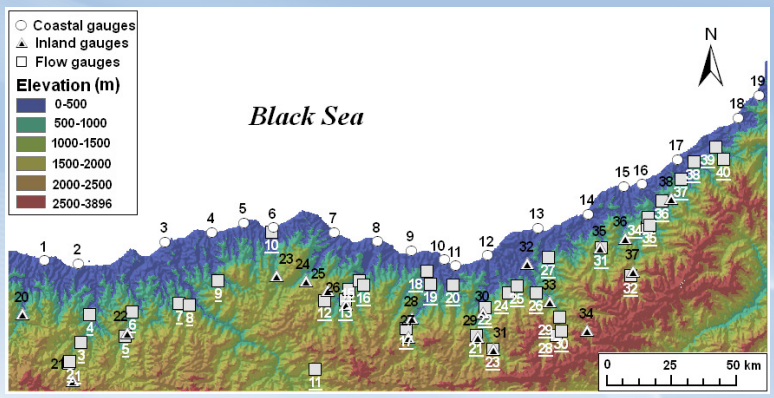
Study Area



- High mountain ranges run parallel to the sea coast as the north boundary of the study area, and rise to more than 3000 m above mean sea level
- Mild and humid climate dominates. Yearly average temperature is about 14-15 °C in the coastline.
- The prevailing wind direction of the coastal part of Eastern Black Sea Region occurs between west and north part of the wind rose.
- The average precipitation of the coastal area of this region is more than 1000 mm.

Precipitation Data

- Mean annual precipitation observations from 38 rain gauges are used in this study.
- Elevations of the rain gauges range from 6 to 1700 m.

Coastal					Inland				
No	Gauge No.	Operated by	Gauge name	Elev. (m)	No	Gauge No.	Operated by	Gauge name	Elev. (m)
1	1453	DMİ	Bulancak	10	20	22-018	DSİ	Sofulu	600
2	17034	DMİ	Giresun	38	21	22-001	DSİ	Tamdere	1700
3	1460	DMİ	Tirebolu	70	22	22-020	DSİ	Sinir	750
4	1299	DMİ	Gorele	20	23	1623	DMİ	Tonya	900
5	1300	DMİ	Eynesil	10	24	1624	DMİ	Duzkoy	850
6	1302	DMİ	Vakfikebir	25	25	22-017	DSİ	Guzelyayla	1250
7	17626	DMİ	Akcaabat	6	26	1626	DMİ	Macka	300
8	17037	DMİ	Trabzon	30	27	22-011	DSİ	Kayaici	1050
9	1471	DMİ	Arsin	10	28	1787	DMİ	Dagbasi	1450
10	1472	DMİ	Arakli	10	29	22-016	DSİ	Koknar	1218
11	1473	DMİ	Surmene	12	30	1801	DMİ	Caykara	264
12	1475	DMİ	Of	9	31	1962	DMİ	Uzungol	1110
13	17040	DMİ	Rize	9	32	1476	DMİ	Kalkandere	400
14	1312	DMİ	Cayeli	10	33	1803	DMİ	İkizdere	800
15	17628	DMİ	Pazar	79	34	22-003	DSİ	Sivrikaya	1650
16	1156	DMİ	Ardesen	10	35	1480	DMİ	Kaptanpasa	525
17	1015	DMİ	Findikli	100	36	22-009	DSİ	Hemsin	500
18	17042	DMİ	Hopa	33	37	22-013	DSİ	Meydan	1100
19	818	DMİ	Kemalpasa	75	38	22-019	DSİ	Tunca	500

DMI (State Meteorological Service), DSI (State Hydraulics Works) with Turkish acronym

- This study used a common period of 46 years between 1960 and 2005.
- To complete the gap in any gauge record, regression equations were developed using continuous data from the neighboring gauges.

Flow Data

- Mean annual flow observations from 40 flow gauges are used in this study.
- Elevations of the flow gauges range from 17 to 1450 m.
- The flow record length ranges from 10 to 49 years between 1944 and 2006 with some gaps in the data
- To complete the gap in any gauge record, regression equations were developed using continuous data from the neighboring gauges.
- The observed flow is not influenced by any upstream dam or water structure.

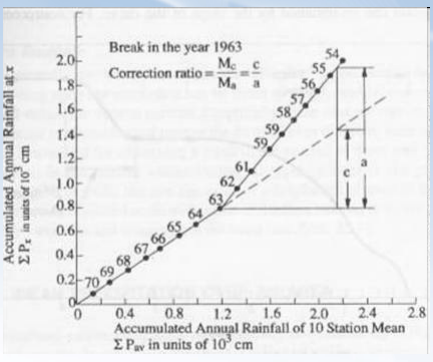
Gauge No	Gauge name	Area (km^2)	Elevation (m)	Stream	Operated by	No
2202	Agnas	635.7	78	Kara	EIE	19
2206	Kanlipelit	708	257	Değirmendere	EIE	14
2213	Dereli	713.0	248	Aksu	EIE	4
2215	Derekoy	445.2	942	Camlidere	EIE	29
2218	Simsirli	834.9	308	Iyidere	EIE	26
2228	Bahadirli	191.4	17	Fol	EIE	10
2232	Topluca	762.3	233	Firtina	EIE	34
2233	Toskoy	223.1	1296	Toskoy	EIE	28
2236	Ikisu	317.2	1037	Aksu	EIE	1
22006	Koprubasi	156	60	Abuçağlayan	DSI	38
22007	Serah	154.7	1170	Haldizen	DSI	23
22013	Suttasi	124.9	188	Kavraz	DSI	8
22034	Findikli	258.6	258.6	Yanbolu	DSI	18
22044	Aytas	421.2	510	Kara	DSI	17
22049	Baskoy	186.2	75	Kapistre	DSI	39
22052	Ulucami	576.8	260	Solaklı	DSI	22
22053	Ortakoy	173.6	150	Surmene	DSI	20
22057	Alcakkopru	243	700	Ogene	DSI	21
22058	CucenKopru	162.7	240	Gorele	DSI	9
22059	Ciftdere	121.5	250	Galyan	DSI	16
22061	Ortakoy	261	380	Altın	DSI	13
22062	Konaklar	496.7	300	Hemsin	DSI	33
22063	Mikronkopru	239.2	370	Halo	DSI	35
22066	Cevizlik	115.9	400	Maki	DSI	25
22068	Yenikoy	171.6	470	Baltaci	DSI	24
22071	Ikisu	292.7	990	Aksu	DSI	2
22072	Arili	92.15	150	Arili	DSI	37
22073	Tuglacik	397.9	400	Yagli	DSI	6
22074	Cat	277.6	1250	Hemsin	DSI	32
22076	Kemerkopru	302.2	230	Durak	DSI	36
22078	Toskoy	284.3	1210	Toskoy	DSI	30
22080	Sinirkoy	296.9	650	Yagli	DSI	5
22082	Komurculer	83.3	250	Salarha	DSI	27
22084	Ikisu	149.6	1450	Korum - Yagli	DSI	11
22085	Kaptanpasa	231.2	480	Senoz	DSI	31
22086	Ogutlu	728.4	160	Degirmendere	DSI	15
22087	Hasanseyh	256.8	370	Gelevera	DSI	7
22088	Ormanustu	150	770	Macka	DSI	12
22089	Kucukkoy	66.37	310	Balli	DSI	40
22090	Alancik	470.2	700	Aksu	DSI	3

EIE (Electrical Power Resources Survey and Development Administration), DSI (State Hydraulics Works) with Turkish acronym

Methods

Double Mass Curve

A double-mass curve analysis is a graphical method used to identify or adjust inconsistencies in a given record by comparing its time trend with a relatively stable record of another station or an average of several nearby surrounding stations.



Methods

Mann-Kendall Trend Test

- It is free from an assumption of underlying probability distribution;
- It is robust to the effects of outliers and gross data errors;
- It allows the existence of missing data (as only ranks are used);
- It also gives the point in time of the beginning of a developed trend (when its sequential version is used).

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}(x_j - x_k)$$

$$\mathrm{sgn}(x_j - x_k) = \begin{cases} +1 & if \quad (x_j - x_k) > 0 \\ 0 & if \quad (x_j - x_k) = 0 \\ -1 & if \quad (x_j - x_k) < 0 \end{cases}$$

$$Var(S) = \left[n(n-1)(2n+5) - \sum_t (t-1)(2t+5) \right] / 18$$

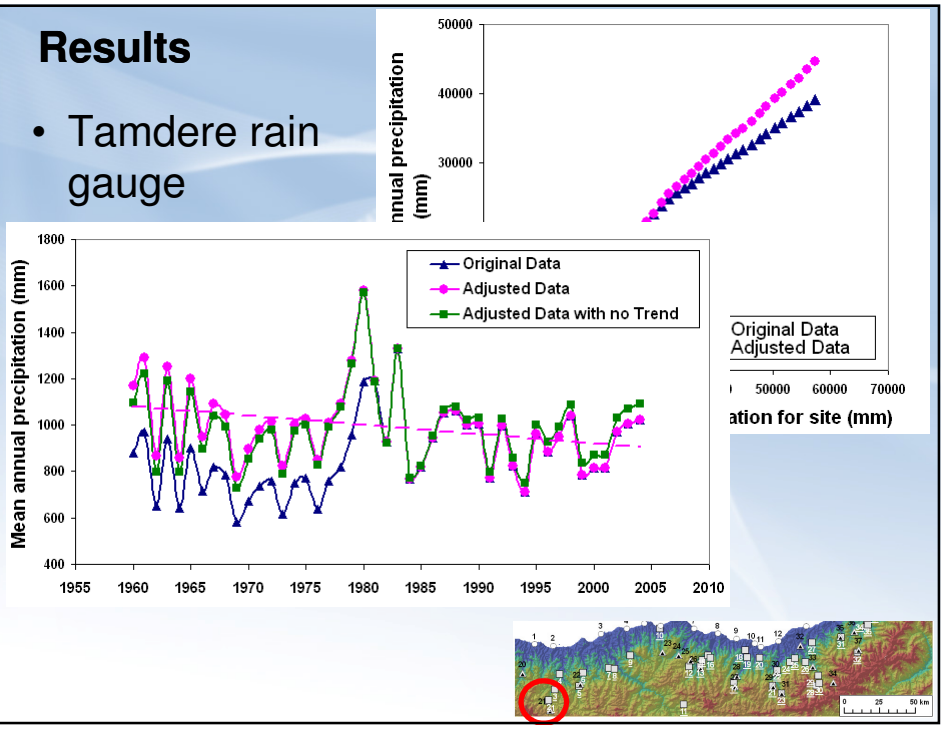
$$z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & if \quad S < 0 \end{cases}$$

Thus, in a two-sided test for trend, the Ho should be accepted if $|z| \le z\alpha/2$ at the α level of significance. A positive value of S indicates an 'upward trend' and a negative value indicates a 'downward trend'.

For the Mann-Kendall test; the significance level (α) is generally set to be 0.05

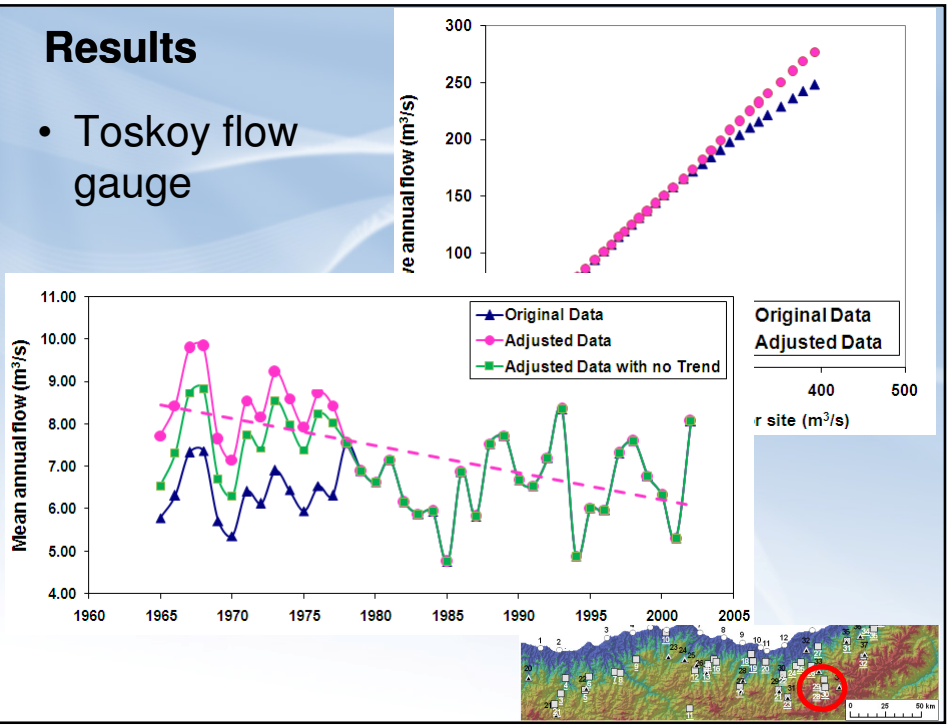
Results

- Tamdere rain gauge

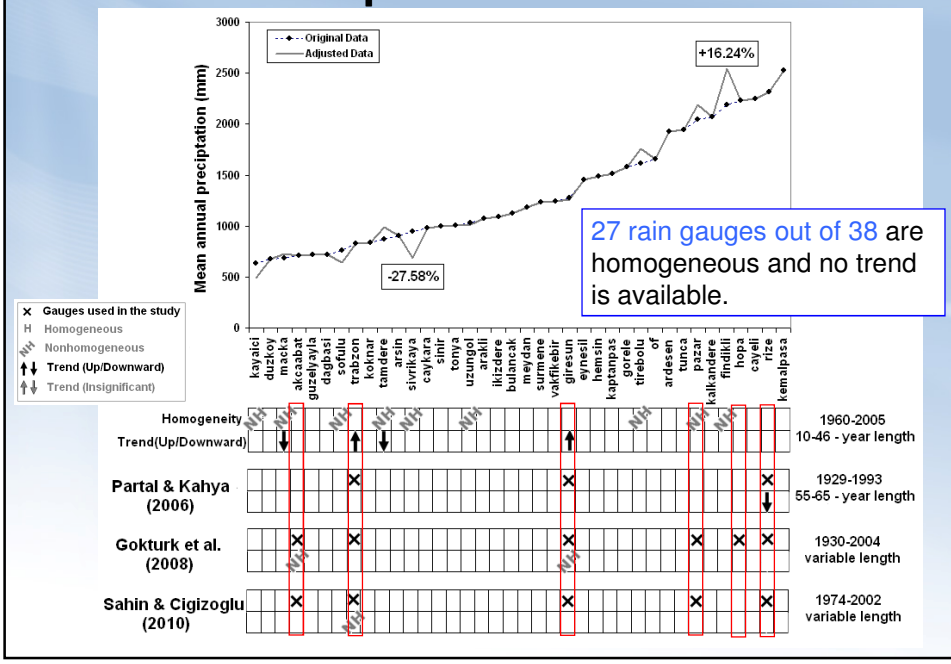


Results

- Toskoy flow gauge

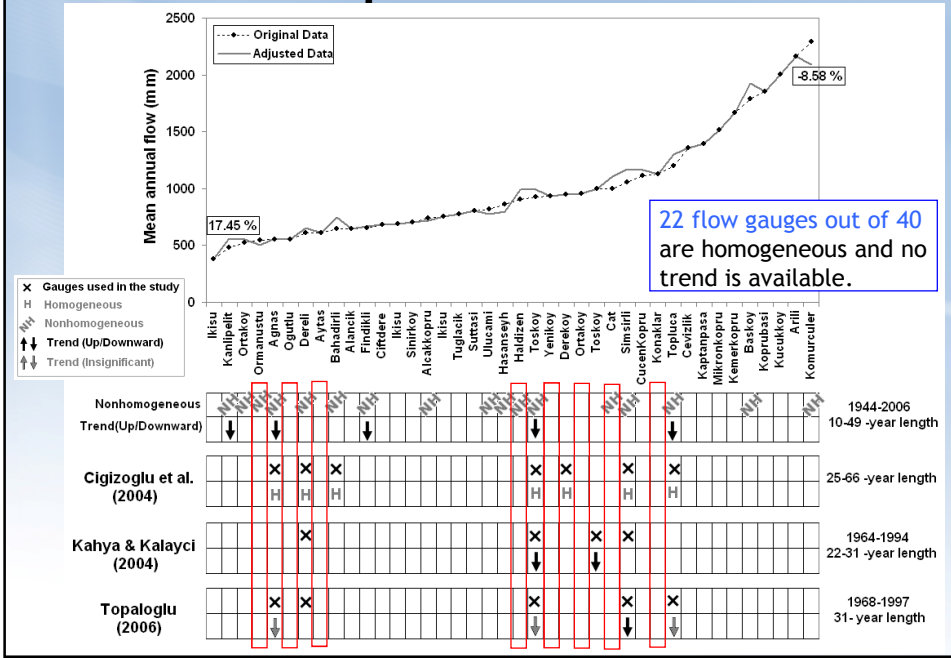


Results & Comparison



27 rain gauges out of 38 are homogeneous and no trend is available.

Results & Comparison

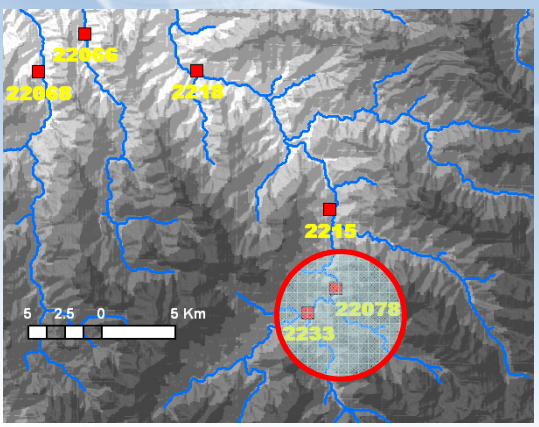


Conclusions

- It was found that 27 gauges out of 38 are homogeneous and no trend is available. For the remaining 11 gauges, the non-homogeneity and/or the available trends were found insignificant such that the adjusted precipitation values were found not greater than 28% of the precipitation observed.
- It was found that 22 gauges out of 40 were homogeneous and no trend was available. For the remaining 18 gauges, the non-homogeneity and/or the available trends were found insignificant. The most significant difference between the observed and the adjusted flow was found 17.45% in Kanlipelit (2206).

Conclusions

- One can realize that there are two gauges named Toskoy (2233 and 22078) on the same stream. A trend was found in 2333 whereas no trend was available in 22078. Trend was found when data in 2233 was homogenized.
- In addition, data length is 38 years from 1965 to 2002 for 2233 and 10 years from 1986 to 2001 for the gauge 22078. This shows the effect of data length on trend analysis and also depicts how controversial results can be obtained for the same region.



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Effect of coastline configuration on precipitation distribution in coastal zones

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Thank you very much…

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