Reprinted from
Indian Journal of Meteorology and Geophysics, Vol. 17, No. 4, (October, 1966)

551.508.77

On the comparison of Precipitation Gauges

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(Received 1 December 1965)

ABSTRACT. In order to assess the reliability of rainfall measurements made in India, comparisons between raingauges in routine use in the national network and raingauges adopted by WMO as International Reference Precipitation Gauges (IRPG) were organised at Poona, Bombay, New Delhi, Calcutta, Nagpur and Madras for a period of 16—28 months spread over the three years 1963-1965. The differences between the 24-hour rainfalls recorded by the IRPG and I.M.D. gauges vary between 0·3 and 2·4 per cent. The differences between these gauges at Madras, Bombay and Calcutta are statistically insignificant, while the differences between the corresponding values at the other stations as well as for all the stations combined are statistically significant. However, the differences between the 24-hour rainfalls recorded by two I.M.D. gauges vary between 0·4 and 1 per cent while the differences between two IRPG's are smaller and insignificant. All differences are insignificant above a daily fall of 25 mm. Hence one is led to conclude that the national gauges of India need a small positive correction of 1 per cent to bring them to the IRPG value. A description of the various raingauges and details of their installation are included for the benefit of those who are not familiar with these details.

1. Introduction

Even though the precipitation observations in a national network with the same type of gauge, may be satisfactory for synoptic purposes within its limits, they cease to be strictly comparable on an international scale or if different types of gauges are used. A survey (WMO 1957) made under the auspices of the World Meteorological Organisation revealed an estimated 5 to 10 per cent divergence between the annual precipitation values of neighbouring countries. For purposes of large scale international climatic studies, especially for the preparation of rainfall maps, it therefore became necessary to evolve a means of eliminating systematic differences by correlating the precipitation data of neighbouring countries and reducing them to the same standard. Following a joint meeting of the Precipitation Committee of the International Union of Geodesy and Geophysics and the Working Group of Measurement of Precipitation of the World Meteorological Organisation Commission for Instruments and Methods of Observation held at Zurich in 1955, it was agreed that an international comparison of precipitation gauges should be carried out by means of a referere gauge. It was proposed to carry out an extended series of comparisons over a period of years between precipitation gauges in use in various national networks and the reference gauge in order that reduction coefficients to bring the rainfall data to the same standard could be determined. A Snowdon precipitation gauge with Alter shield was adopted as the International Reference Precipitation Gauge (IRPG) and the principle of comparisons defined at the Second Session of CIMO (Paris 1957)—(WMO 1957). This was formally approved by WMO in 1958.

2. The International Reference Precipitation Gauge

The reference gauge adopted for use as IRPG is shown in Fig. 1. The gauge is made of copper and provided with a chamfered brass rim of 127 mm diameter. The Alter shield consists of freely hanging, spaced wedges arranged circularly around the gauge and support and is made of galvanised iron. The gauge with shield and support, is installed so that its collecting rim is one metre above the surrounding ground. The freely hanging wedges of the Alter shield give in or sway easily with the wind and hence function better than the rigid trumpet shaped shield designed by Nipher. Simple cylindrical containers with the same external dimensions as the Snowdon gauge are used as snowgauges. The gauge when used for snow measurement is installed with its rim 1·5 m above ground. The snowfall is measured by melting the collected snow and measuring its water equivalent. The rain measure is a standard tapered glass measure graduated to read millimetres of precipitation and has a capacity of 25 mm.

3. National Gauges

Three types of precipitation gauges are used in India for the routine measurement of precipitation—

(1) 127 mm raingauge with receivers of capacity either 175, 375 or 1000 mm of rainfall,
(2) 203 mm recording raingauge, and
(3) 203 mm snowgauge with Nipher shield for measurement of snow.

The three gauges are illustrated in Figs. 2 (a) and 2 (b). The height above ground of the collector rim varies from 30 cm for the 127 mm gauge to 180 cm above ground for the shielded snow gauge.

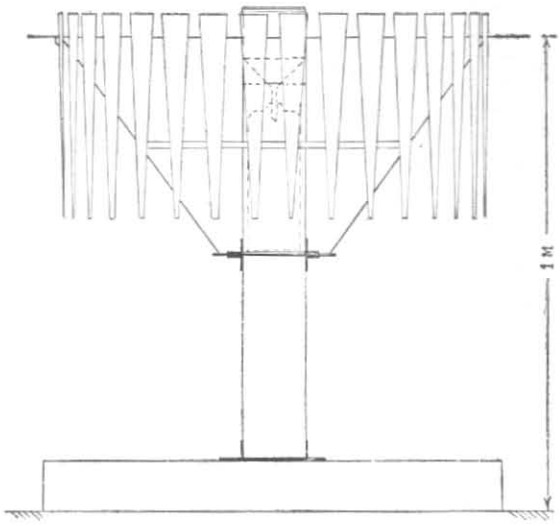

Fig. 1

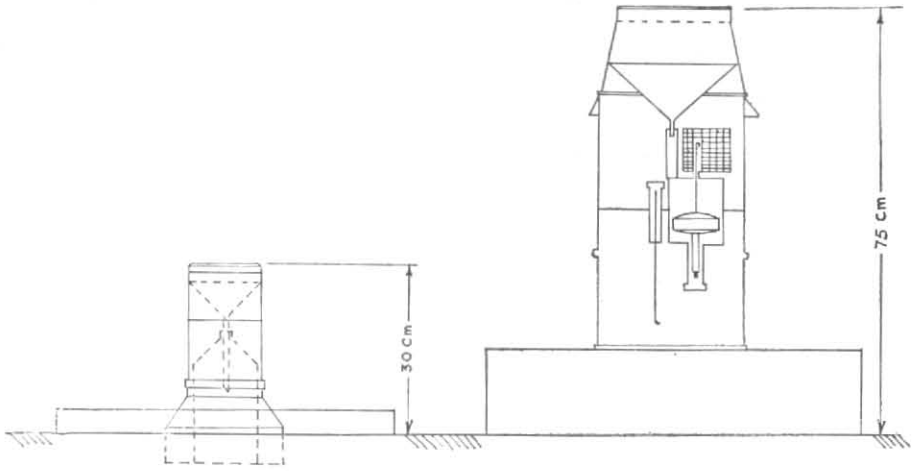

Fig. 2(a)

TABLE 1

Comparison between main IRPG's and main IMD raingauges

		Poona 27-3-1963 to 30-6-1965	Bombay 1-7-1963 to 30-6-1965	New Delhi 13-7-1963 to 30-6-1965	Calcutta 1-8-1963 to 30-6-1965	Madras 1-9-1963 to 30-6-1965	Nagpur 10-2-1964 to 30-6-1965	All stations combined 27-3-1963 to 30-6-1965
Number of observations	n	193	112	124	213	111	123	876
Total rain collected in IMD raingauge	A (mm)	1384·2	1244·6	1680·4	2649·1	537·1	1309·7	8805·7
Total rain collected in IRPG	B (mm)	1415·6	1243·5	1696·3	2656·8	549·9	1334·4	8896·5
Quotient	A/B	0·978	1·001	0·990	0·997	0·977	0·981	0·989
Difference in catch	$(A-B)$ (mm)	—31·4	+1·1	—15·9	—7·7	—12·8	—24·7	—91·4
Difference as % of A		—2·276	+0·088	—0·946	—0·291	—2·383	—1·887	—1·04
Mean difference of n observations	M (mm)	—0·1627	+0·0098	—0·1282	—0·0362	—0·1153	—0·2008	—0·1043
Standard deviation	σ	0·4769	1·2144	0·3986	0·732	0·846	0·4354	0·7149
Standard error of mean	σ'	0·0343	0·1148	0·0357	0·0501	0·0803	0·0393	0·0241
Significant factor	t	4·74	0·09	3·59	0·72	1·43	5·11	4·31

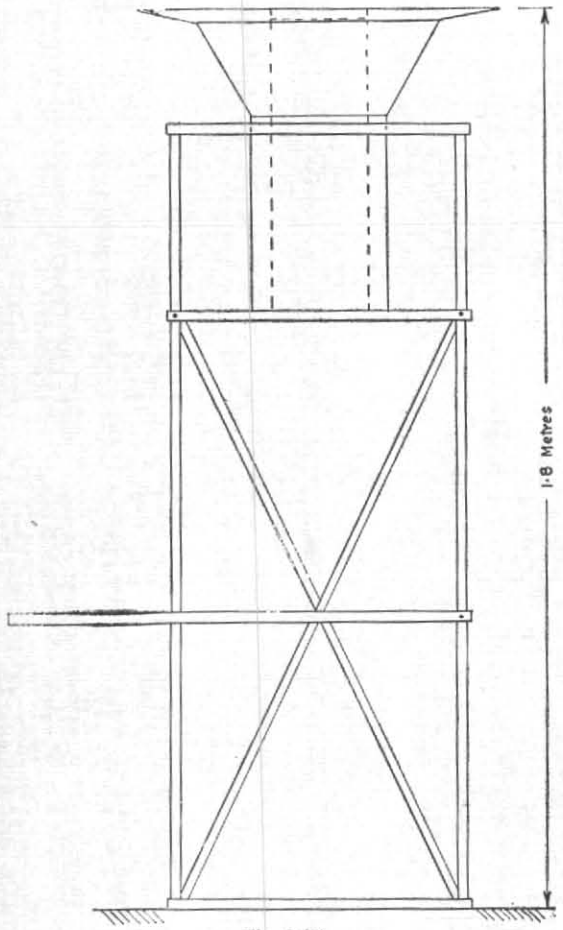

Fig. 2 (b)

The 127 mm Symon's raingauge has been in use in India since 1853 and is now installed at 4570 stations in the country. It has a shallow funnel only 40 mm below the rim, is painted black and is subject to many errors. The 203 mm recording raingauge and snowgauge are both made of galvanised iron and aluminium painted.

4. Comparative observations

The main purpose of the comparisons was the determination with reference to the IRPG, of the comparison coefficients for the different types of gauges used in the national network. Identical raingauges situated in different climatic areas, are known to have given different coefficients, even under ideal conditions of exposure (Poncelet 1959). The comparisons of national raingauges with IRPG's were, therefore, organized at six stations representative of the typical climatic regimes in the country, at Poona (18°32′ N, 73°51′E), Bombay (19°7 'N, 72°51′ E), New Delhi (28°53′ N, 77°12′ E), Nagpur (21°6′N, 79°3′ E), Calcutta (22° 39′ N, 88° 27′ E) and Madras (13°00′N, 80°11′ E).

In the present comparison two sets of raingauges were installed side by side at all stations except at Poona where sufficient space was not available.

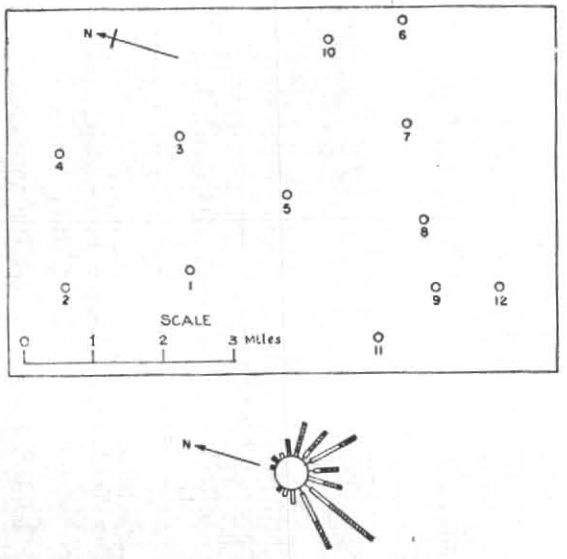

Fig. 3. Observatory enclosure at Calcutta

1. IRPG No. IMD 4/64 (Main)
2. IRPG No. IMD 7/63 (Auxiliary)
3. 127 mm raingauge 1422/61 (Main)
4. 127 mm raingauge No. 1309/60 (Auxiliary)
5. S.R. raingauge No. 354/60
6. Stevenson Screen
7. Stevenson Screen
8. 127 mm raingauge
9. S.R. raingauge
10. Evaporimeter
11. Lucimeter
12. Rain intensity recorder

This would constitute a more critical test of the behaviour of the IRPG itself. Fig. 3 is a plan of installation of the raingauges at Calcutta. The two sets of gauges are labelled main and auxiliary for convenience, although they are identical in design.

The precipitation collected in the IRPG's were measured twice a day at 0830 and 1730 IST and that collected in the 127 mm gauges at the routine hours of observations 0830, 1130, 1430, 1730 and 2330 IST. The total catch for 24 hours ending at 0830 IST was taken as one observation and entered in the tabulation forms supplied by WMO.

5. Results

(a) *IRPG — National Raingauge*

Table 1 gives the results of the comparisons between the main IRPG and the main 127 mm

TABLE 2

Comparison between main IRPG's and main IMD raingauges

		Range (mm)					
		0 to 10·0	10·1 to 25·0	25·1 to 50·0	50·1 to 75·0	75·1 to 100·0	100·1 to 125·0
Poona	n	149	29	13	2		
	M	—0·122	—0·255	—0·454	—0·050		
	σ	0·389	0·597	0·887	0·353		
	σ'	0·032	0·111	0·246	0·25		
	t	3·83	2·30	1·85	0·20		
Bombay	n	77	20	11	—	—	2
	M	—0·051	—0·080	0·009	0·95	—	2·30
	σ	1·137	1·016	1·789	0·919	—	0·565
	σ'	0·129	0·236	0·536	0·642	—	0·400
	t	0·39	0·34	0·02	1·48	—	5·75
New Delhi	n	78	24	16	3	—	3
	M	—0·141	—0·075	—0·037	—0·666	—	—0·70
	σ	0·20	0·338	0·451	1·584	—	1·229
	σ'	0·023	0·069	0·113	0·915	—	0·709
	t	6·24	2·54	0·33	0·73	—	0·99
Calcutta	n	141	36	24	9	3	3
	M	—0·199	—0·181	—0·113	0·40	0·233	
	σ	0·269	0·962	0·691	3·16	0·306	
	σ'	0·023	0·160	0·141	1·053	0·177	
	t	0·88	1·13	0·80	0·38	1·32	
Madras	n	91	16	4			
	M	—0·166	—0·287	—0·575			
	σ	0·83	0·907	0·458			
	σ'	0·087	0·227	0·229			
	t	1·91	1·27	2·51			
Nagpur	n	86	20	11	6		
	M	—0·138	—0·42	—0·364	—0·067		
	σ	0·238	0·585	0·783	0·889		
	σ'	0·026	0·131	0·236	0·363		
	t	5·31	3·23	1·54	0·18		
All stations combined	n	622	145	79	22	3	5
	M	—0·101	—0·162	—0·195	0·327	0·233	0·500
	σ	0·571	0·674	0·913	2·095	0·305	1·880
	σ'	0·023	0·056	0·103	0·446	0·176	0·840
	t	4·41	2·89	1·89	0·73	1·32	0·59

n = Number of observations M = Mean difference σ = Standard deviation σ' = Standard error of mean
t = Significant factor

TABLE 3

Comparison between main IMD raingauge and auxiliary IMD raingauge

		Bombay 1-7-1963 to 30-6-1965	New Delhi 2-11-1963 to 30-6-1965	Calcutta 1-9-1963 to 30-6-1965	Madras 1-9-1963 to 30-6-1965	Nagpur 10-2-1963 to 30-6-1965	All stations combined 1-7-1963 to 30-6-1965
Number of observations	n	207	78	184	155	118	742
Total rain collected in auxiliary raingauge	A (mm)	4346·6	902·0	2536·8	2240·5	1316·4	11342·3
Total rain collected in main raingauge	B (mm)	4328·4	895·4	2525·1	2221·4	1303·6	11273·9
Quotient	A/B	1·004	1·007	1·005	1·008	1·009	1·006
Difference in catch	$A-B$	+18·2	+6·6	+11·7	+19·1	+12·8	+68·4
Difference as % of A		+0·416	+0·732	+0·461	+0·849	+0·972	+0·603
Mean difference of n observations	M (mm)	+0·088	+0·085	+0·0636	+0·1232	+0·1085	+0·0922
Standard deviation	σ	0·38	0·253	0·179	0·265	0·313	0·292
Standard error of mean	σ'	0·026	0·029	0·013	0·021	0·029	0·011
Significant factor	t	3·39	2·96	4·81	5·79	3·76	8·38

raingauge at all the six stations for periods varying from 16 to 28 months. At all the stations, except Bombay, the total rainfall catch in the national raingauge is less than that in the IRPG. The mean difference in catch, expressed as a percentage of the total, varies from 0·3 to 2·4 per cent. At Bombay, the IRPG recorded slightly less rain than the IMD gauge, but the difference is not significant. The mean differences IRPG — National raingauge at Bombay, Calcutta and Madras are small and statistically not significant. But the mean differences at the other stations and the mean difference IRPG — National raingauge for all stations combined are statistically significant. This trend is repeated at rainfall intervals of 0—10 mm and 10·1–25 mm as seen from Table 2, where the comparative data for rainfall intervals from 0 to 125 mm in steps of 25 mm are tabulated.

(b) *Two IRPG's*

The rainfall data recorded with the main and auxiliary IRPG's show that the mean differences in rainfall catches in the two IRPG's at the same stations are small and statistically insignificant except at Calcutta. The differences range from −0·07 per cent to +0·17 per cent.

(c) *Two national raingauges*

The rainfall data recorded in the main and auxiliary national gauges at the stations are summarised in Table 3. It will be seen that two gauges at the same station record total rainfall amounts differing by 0·4–1 per cent. The mean differences in rainfall catches in the two national gauges are higher than those in the case of the IRPG's and all are statistically significant.

6. Discussion of results

From the results of comparisons between IRPG's and national raingauges at six stations in India, it is seen that a small positive correction has to be applied to the readings of the national raingauges to bring them in conformity with the IRPG's. The exact coefficient to be applied to the rainfall data can, however, be determined only after sufficiently extended series of comparisons at all stations.

An earlier comparison (Mani 1957) between the Symons and Snowdon types raingauges at a number of stations in India had shown that the shallow rim gauge collects less rain than the deep rim gauge.

Comparisons between 2 IRPG's show that the differences are small and statistically insignificant and that the IRPG, although not the best or most exact of the precipitation gauges, is quite suited for use as an international reference gauge and for obtaining reduction coefficients with the ultimate aim of eliminating systematic differences between rainfall data in different countries.

7. Acknowledgement

The author is grateful to Miss A. Mani, Director Instruments, for the encouragement and facilities provided for the study and is thankful to Shri Shahid Husain for the computations.

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