Supplementary Material for

Spatially shifting temporal points: estimating pooled within-time series variograms for scarce hydrological data

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Introduction

The supplementary material contains one table, one figure, an R-script and sample data.

The table (Table S1) presents the change in the number of available data points and data density, smallest and largets spatial-lags and summary statistics, i.e. minimum, mean, maximum and coefficient of variation of annual total precipitation in hydrological wet days (PRCPTOT) in Bangladesh within the 1948-2007 series. A sample of four representative years, i.e. 1948, 1966, 1983 and 2007, is presented in Figure 3 in the manuscript.

The figure (Figure S1) illustrates the change in spatial location, distribution and density of the available data points for PRCPTOT in Bangladesh within the 1948-2007 series. A sample of four representative years, i.e. 1948, 1966, 1983 and 2007, is also integrated in Figure 3 in the manuscript.

The R-script contains the reference manual and codes for estimating pooled within-time series (PTS) variograms by applying newly developed spatially shifting temporal points (SSTP), available averaging empirical variograms (AEV) and a modification of AEV, i.e. weighted averaging empirical variograms (WAEV) methods. The script uses the provided sample data as input and provides the estimation of PTS variograms by above methods as output. The script was tested using the latest R version 3.2.0 -- "Full of Ingredients" that was released on 16.04.2015. Installation of three packages are required: "spacetime", "intamap" and "gstat", where installation of "intamap" requires pre-installation of the dependency packages: "mvtnorm", "evd" and "sp". The dependencies may also be automatically installed by R while installing the packages. The installation guideline is provided in the script. Further details and documentations on R and the packages are available from: http://www.r-project.org/. To get

familiar with R, usage examples are available from:

http://tryr.codeschool.com/levels/1/challenges/1.

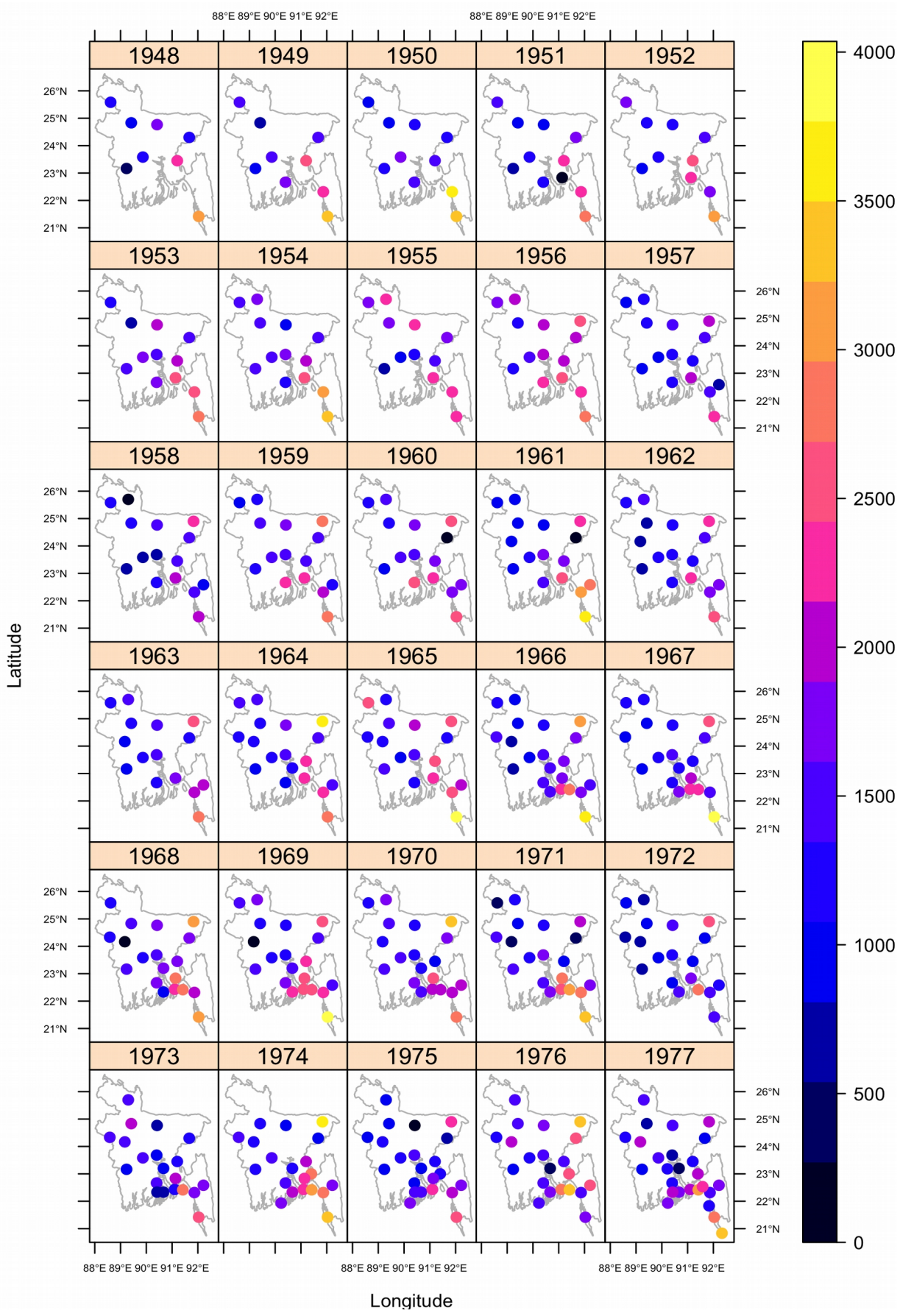
The sample data contains computed PRCPTOT values at the available data points in Bangladesh for 1993-2007 series. This is a 'STFDF data' and provided in '.Rdata' format. Details on the data format, instructions on how to read and analyze the data are provided in the R-script and package vignettes.

Contribution is welcome for further development of SSTP method. The R-script and sample data are available via a public GitHub repository: https://github.com/AvitBhowmik/SSTP, where end-users can suggest changes and development, and also report bugs.

Table S1: Number of available data points, data point density, smallest- and largets-spatial-lags, and minimum (min.), mean, maximum (max.) and coefficient of variation (CV) of annual total precipitation in hydrological wet days (PRCPTOT) in Bangladesh for each time step (year) within 1948-2007 series.

Year	Available number of data points	Data point density (point/10,000 km^2)	Spatial lag (km)		PRCPTOT (mm)			
			Smallest	Largest	Min.	Mean	Max.	CV
1948	8	0.5	95.38	489.85	494	1532	3028	53.59
1949	9	0.6	95.22	489.85	574	1772	3369	47.40
1950	10	0.7	96.76	489.85	981	1708	3521	54.98
1951	11	0.7	68.57	489.85	225	1447	2916	53.77
1952	10	0.7	68.57	489.85	972	1778	3131	37.96
1953	12	0.8	62.08	489.85	671	1818	2813	32.95
1954	13	0.9	64.69	549.70	1006	1876	3378	36.73
1955	12	0.8	64.69	549.70	779	1744	2374	31.25
1956	14	0.9	65.64	549.70	1214	2016	2913	24.55
1957	15	1.0	61.83	549.70	651	1334	2324	33.51
1958	15	1.0	61.83	549.70	188	1263	2185	46.63
1959	15	1.0	61.83	549.70	859	1754	2888	34.38
1960	14	0.9	61.83	549.70	999	1763	2622	30.80
1961	15	1.0	61.83	549.70	878	1765	3617	51.61
1962	16	1.1	61.83	549.70	723	1447	2510	36.97
1963	15	1.0	60.14	549.70	967	1571	2839	36.03
1964	18	1.2	62.00	549.70	938	1690	3530	40.71
1965	17	1.2	61.86	549.70	1050	1860	4036	42.58
1966	21	1.4	32.57	549.70	767	1648	3694	46.48
1967	19	1.3	32.57	549.70	850	1601	3836	46.16
1968	18	1.2	32.57	484.33	1001	1892	3132	35.15
1969	19	1.3	32.57	549.70	1080	1930	3872	36.84
1970	20	1.4	32.57	549.70	952	1761	3315	34.87
1971	20	1.4	32.57	549.70	389	1662	3489	53.31
1972	19	1.3	59.25	549.70	740	1259	2856	45.51
1973	20	1.4	29.16	549.70	545	1435	2785	40.07
1974	20	1.4	32.80	478.82	849	1932	3710	43.27
1975	22	1.5	29.39	549.70	17	1353	2519	43.83
1976	21	1.4	32.57	549.70	329	1840	3371	42.07
1977	26	1.8	26.61	543.36	430	1654	3271	44.14
1978	23	1.6	28.22	543.36	84	1697	2853	39.48
1979	25	1.7	28.22	543.36	424	1615	3126	46.25
1980	25	1.7	29.04	543.36	327	1327	2758	44.84

1981	25	1.7	26.77	543.36	104	1629	3649	44.75
1982	27	1.8	28.22	543.36	732	1981	3976	47.10
1983	27	1.8	28.22	543.36	640	1822	3326	42.48
1984	27	1.8	28.22	543.36	1237	2182	4010	32.81
1985	28	1.9	28.22	539.70	701	1667	3230	39.59
1986	28	1.9	28.22	539.70	1081	1787	3133	26.13
1987	29	2.0	28.22	539.70	1124	2204	4076	36.16
1988	29	2.0	28.22	539.70	951	1959	3626	37.98
1989	30	2.0	28.22	549.70	675	1508	3958	47.28
1990	30	2.0	28.22	549.70	747	1656	3093	39.07
1991	32	2.2	28.52	538.09	1077	1960	4499	37.55
1992	32	2.2	28.52	538.09	638	1395	2849	39.57
1993	32	2.2	28.52	538.09	29	1873	3722	36.73
1994	32	2.2	28.52	538.09	696	1366	4261	53.88
1995	31	2.1	27.51	538.09	1033	1800	3528	32.17
1996	31	2.1	27.51	538.09	779	1613	3185	38.31
1997	31	2.1	27.51	538.09	962	1840	3346	32.61
1998	31	2.1	27.51	538.09	727	1948	3752	42.04
1999	32	2.2	28.52	538.09	961	2015	3661	34.14
2000	32	2.2	28.52	538.09	868	1637	3919	49.42
2001	32	2.2	28.52	538.09	818	1765	4516	51.05
2002	32	2.2	28.52	538.09	1016	1940	3186	29.74
2003	31	2.1	29.51	538.09	719	1621	4024	48.12
2004	32	2.2	28.52	538.09	1386	2117	3889	28.25
2005	32	2.2	28.52	538.09	708	1702	3605	37.84
2006	32	2.2	28.52	538.09	688	1604	3697	40.27
2007	32	2.2	28.52	538.09	1290	1993	3271	28.55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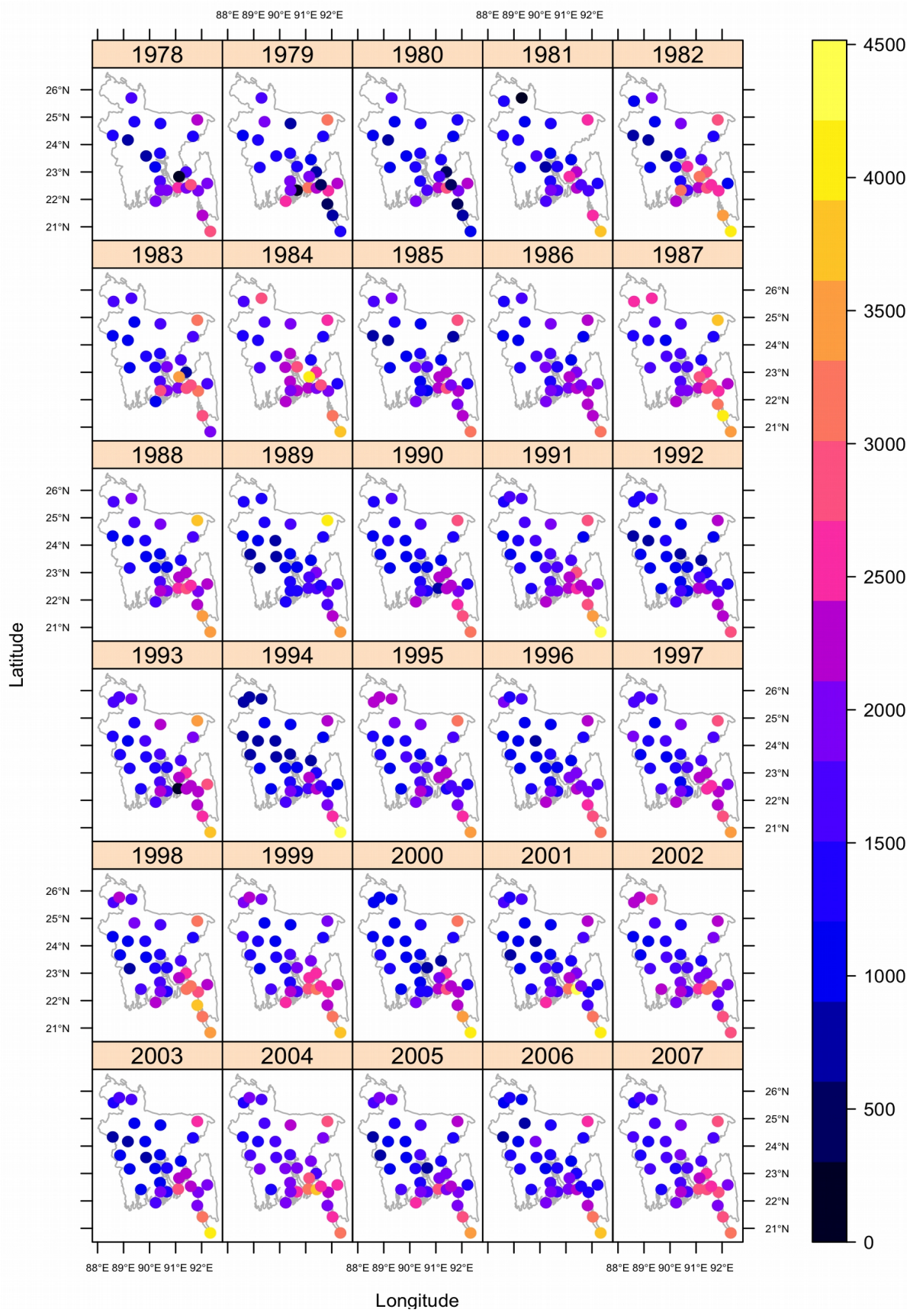

Figure S1. Spatial location, distribution and density of available data points (rain-gauge) for each year and annual total precipitation in hydrological wet days (PRCPTOT) (in mm).