Spatial and Temporal Trends in the Hydrologic Cycle, Chesapeake Bay Watershed, 1927-2012

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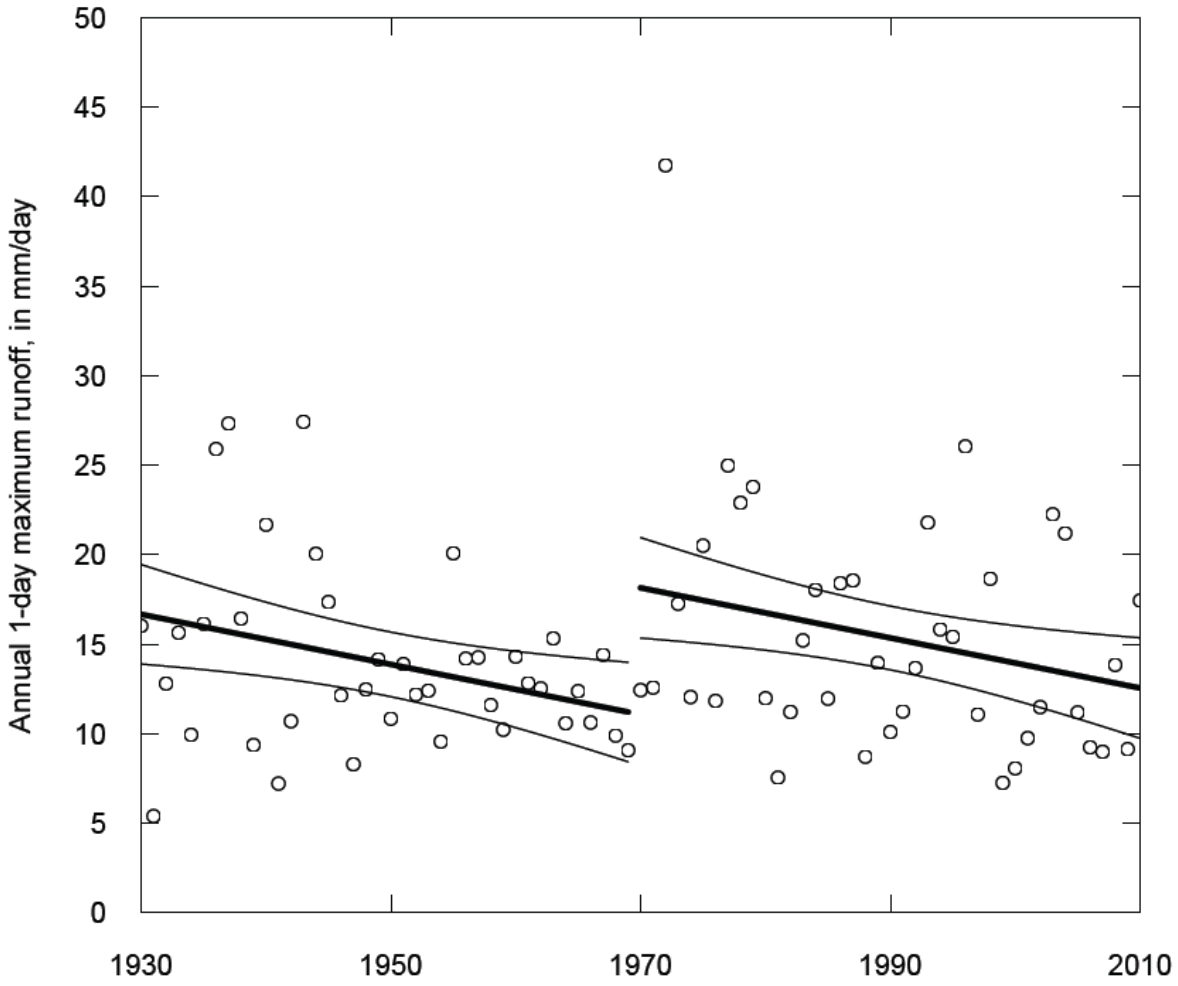
Previous Research

Rice and Hirsch (2012): spatial difference in discharge trends between north and south in the Chesapeake Bay watershed. Dividing line was approximately the Mason-Dixon Line

Mean 1-Day Maximum Runoff
1930-2010

North

South



Rice and Hirsch, 2012

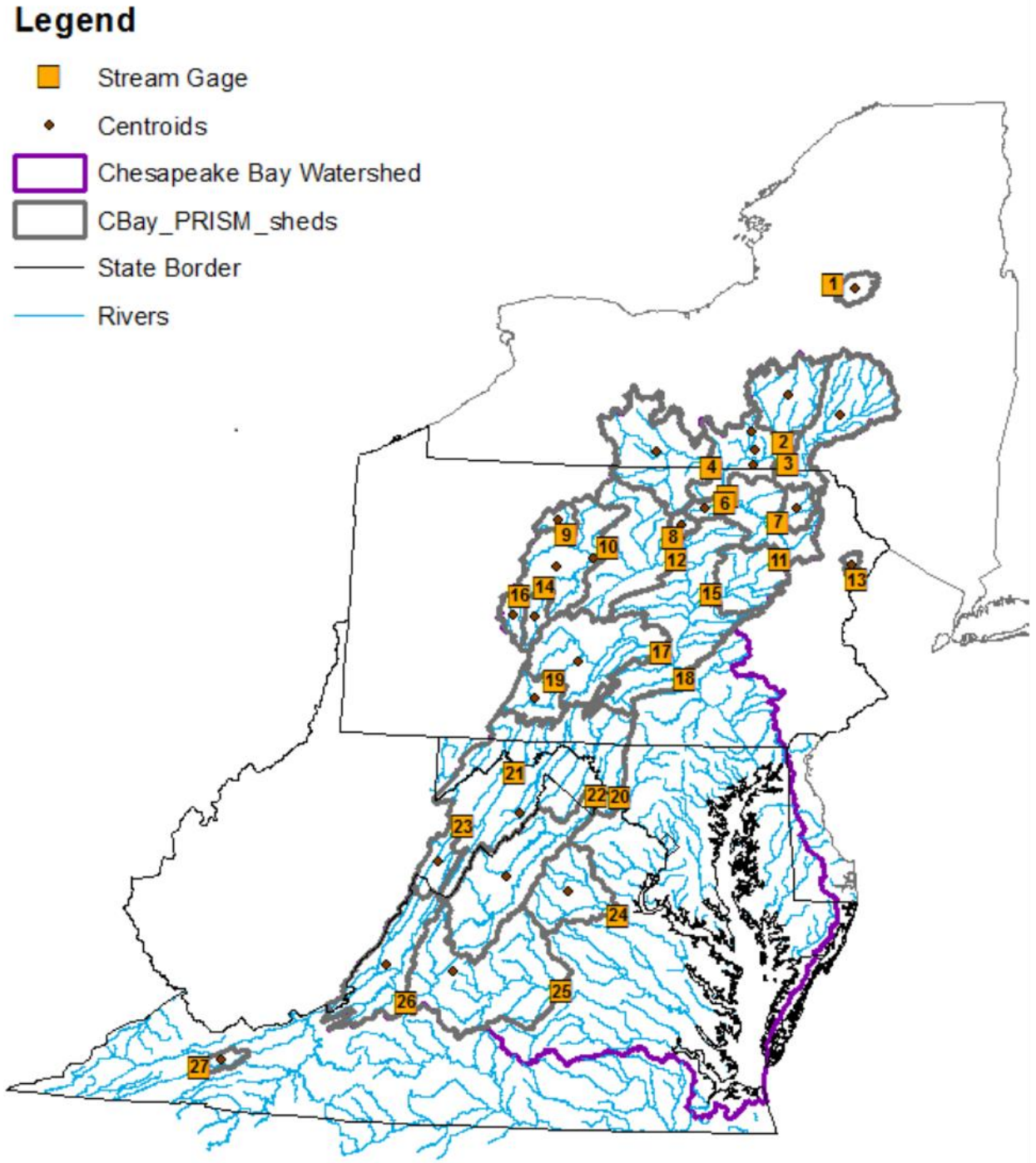
Objectives

Examine the hydrologic cycle for two 43-year intervals:

1927-1969 vs. 1970-2012

for 27 CB watersheds

- Precipitation
- Discharge



Site ID	Area, km2	Area, mi2
0425250	787	304
0151250	3,841	1,483
0150300	5,781	2,232
0153100	6,491	2,506
0153150	20,194	7,797
0153200	557	215
0153400	992	383
0155000	448	173
0154300	704	272
0154550	7,705	2,975
0153650	25,796	9,960
0155150	14,716	5,682
0143950	303	117
0154150	961	371
0154050	29,060	11,220
0154100	816	315
0156700	8,687	3,354
0157050	62,419	24,100
0156200	1,958	756
0163850	24,996	9,651
0160850	3,784	1,461
0163650	7,876	3,041
0160650	1,686	651
0166800	4,131	1,595
0203500	16,193	6,252
0201950	5,369	2,073
0348800	572	221

Precipitation Analysis

All calculations used

PRISM annual data specific to each watershed

Slope of linear regression of year vs. annual precipitation in each watershed for 4 intervals

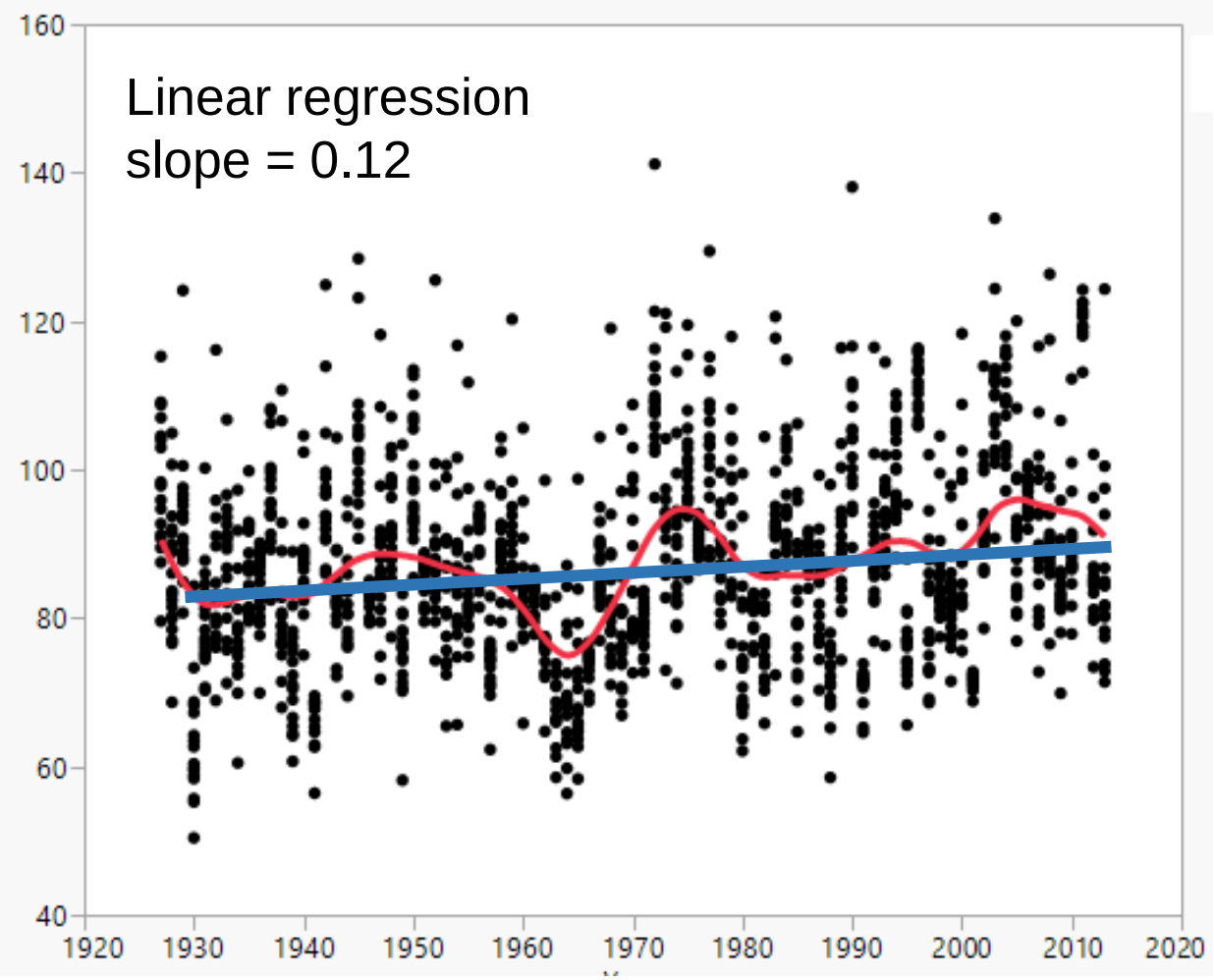
	1927-2012	1927-1969	1970-2012	1985-2012
North	0.12	-0.15	0.11	0.45
South	0.09	-0.18	-0.01	0.16

North

South

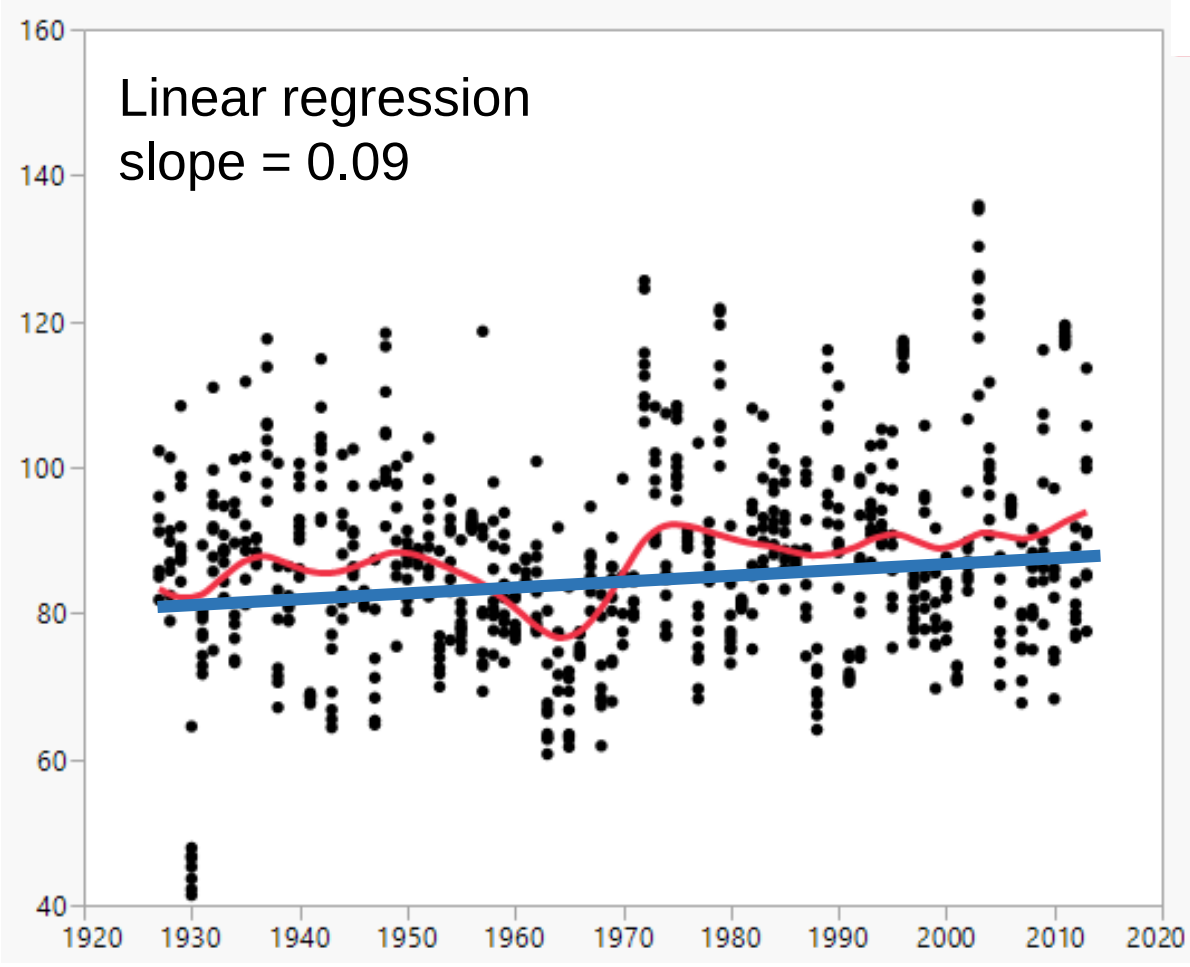
	1927-2012	1927-1969	1970-2012	1985-2012
04252500	0.1324	-0.1058	0.0403	0.3733
01512500	0.1471	-0.0827	0.2440	0.6391
01503000	0.1442	-0.1650	0.2743	0.7168
01531000	0.1385	-0.0850	0.1793	0.5043
01531500	0.1287	-0.1059	0.1979	0.5506
01532000	0.1329	-0.1518	0.1781	0.5996
01534000	0.1078	-0.1959	0.1526	0.4826
			0.0984	0.5080
			0.0197	0.2373
			-0.0106	0.2502
			0.1883	0.5395
			0.0082	0.3230
			0.1415	0.5475
			-0.0072	0.2931
			0.1615	0.4990
			-0.0368	0.2088
			0.0340	0.4357
01570500	0.1047	-0.1693	0.0769	0.4290
01562000	0.1186	-0.1693	0.0195	0.4129
01638500	0.0990	-0.1579	-0.0025	0.2292
01608500	0.0938	-0.1704	0.0143	0.1734
01636500	0.0976	-0.1586	-0.0060	0.0765
01606500	0.0870	-0.2075	0.0170	0.1798
01668000	0.1079	-0.1796	-0.0448	-0.0412
02035000	0.0802	-0.2058	-0.0319	-0.0163
02019500	0.0725	-0.1827	0.0166	0.1381
03488000	0.0522	-0.2281	-0.0385	0.2472

Annual Precipitation Data



NORTH

SOUTH



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Precipitation Key Points:

1. Overall increasing trend for 1927-2012

2. 1960s drought very evident in the record and likely caused the 1927-1969 linear regression slopes to be negative;

3. Average linear regression slopes for 1927-2012 are lower than for 1985-2012 for both north and south
   - North: average slope is 4 times higher for 1985-2012 relative to 1927-2012;
   - South: average slope is 2 times higher for 1985-2012 relative to 1970-2012.

Discharge Analysis

Slope of linear regression of year vs. annual Q in each watershed for 4 intervals

North

	1927-2012	1927-1969	1970-2012	1985-2012
North	11	-19	0.13	60
South	4.1	-13	-17	-7.8

South

	1927-2012	1927-1969	1970-2012	1985-2012
04252500	2.815	-0.7595	0.5410	3.619
01512500	3.667	-9.873	7.263	30.07
01503000	5.666	-13.80	7.513	46.85
01531000	5.412	-10.47	1.695	29.89
01531500	22.93	-24.03	16.49	119.9
01532000	0.5809	-0.9320	0.0392	3.810
01534000	1.356	-1.713	2.213	8.715
01550000	0.6902	-0.4326	-0.5137	2.741
01543000	0.3827	-2.691	-0.6869	1.566
		657	-7.984	-20.95	7.756
		56	-36.96	25.59	181.0
		620	-27.84	-37.92	19.70
		148	-1.3460	0.4859	3.825
		908	-1.931	-2.491	0.6903
		20	-55.96	33.40	200.1
		346	-1.715	-3.220	-0.4997
		56	-27.52	-12.37	30.44
		27	-118.9	-14.66	388.7
01562000	1.957	-5.976	-4.459	5.167
01638500	17.54	-43.82	-49.82	11.82
01608500	3.676	-2.741	-5.400	-4.110
01636500	6.775	-12.46	-11.73	-5.926
01606500	2.374	-0.2071	-1.975	-1.740
01668000	1.985	-9.861	-10.04	1.286
02035000	1.418	-35.94	-55.29	-56.78
02019500	0.7817	-9.646	-13.79	-19.89
03488000	0.1802	-0.0929	-2.135	-0.1088

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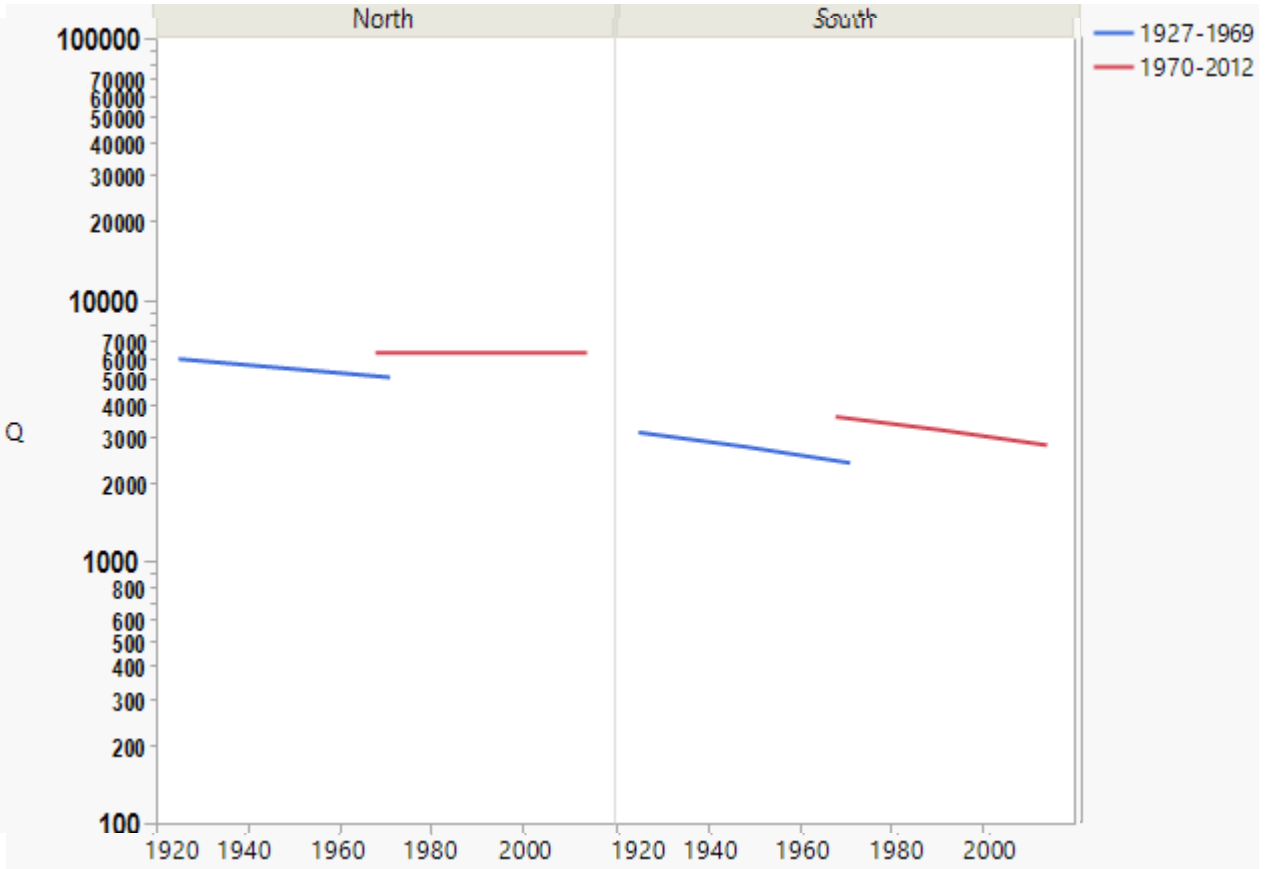
Precipitation

Discharge



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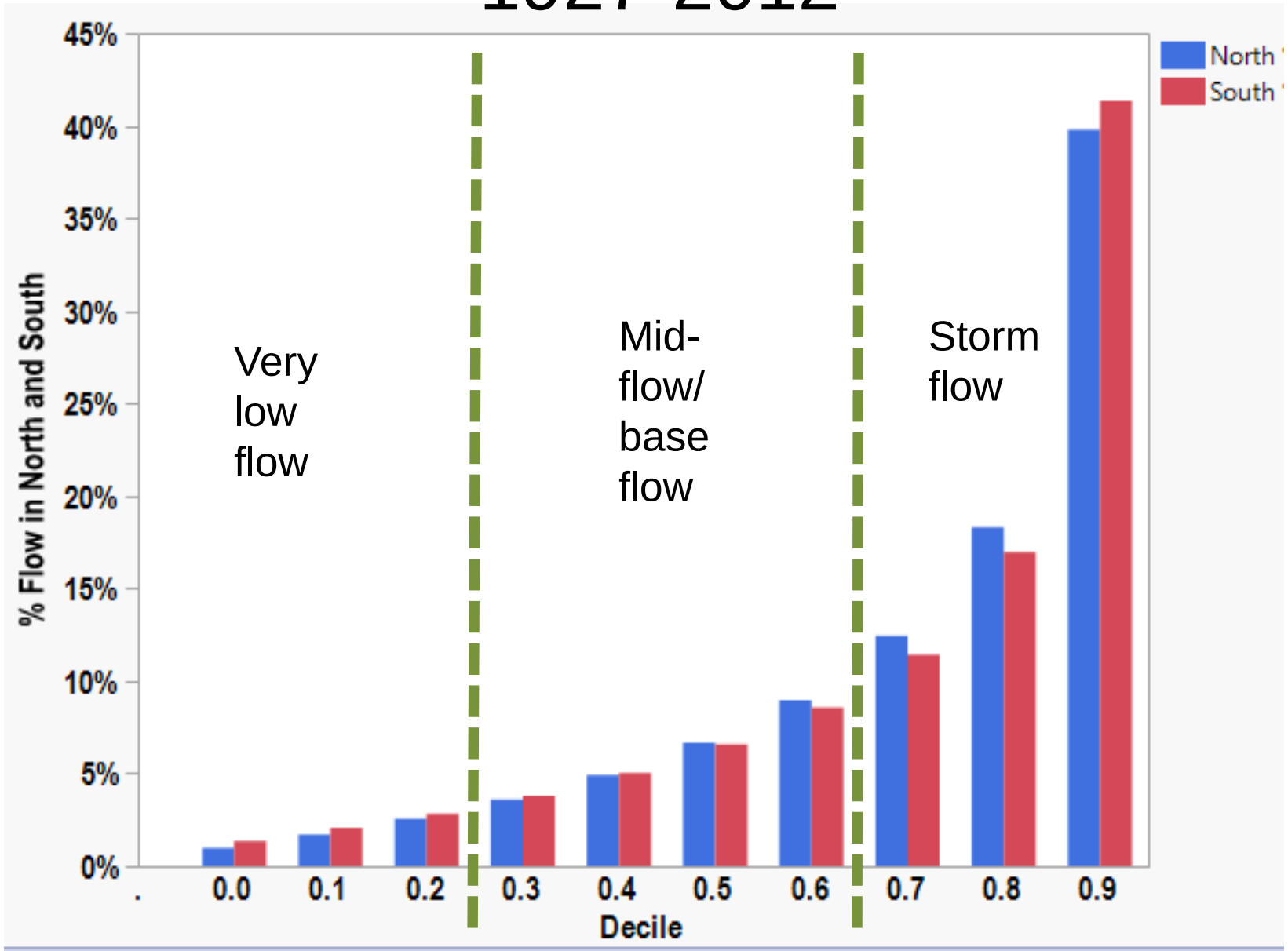
Analysis for 1927-2012

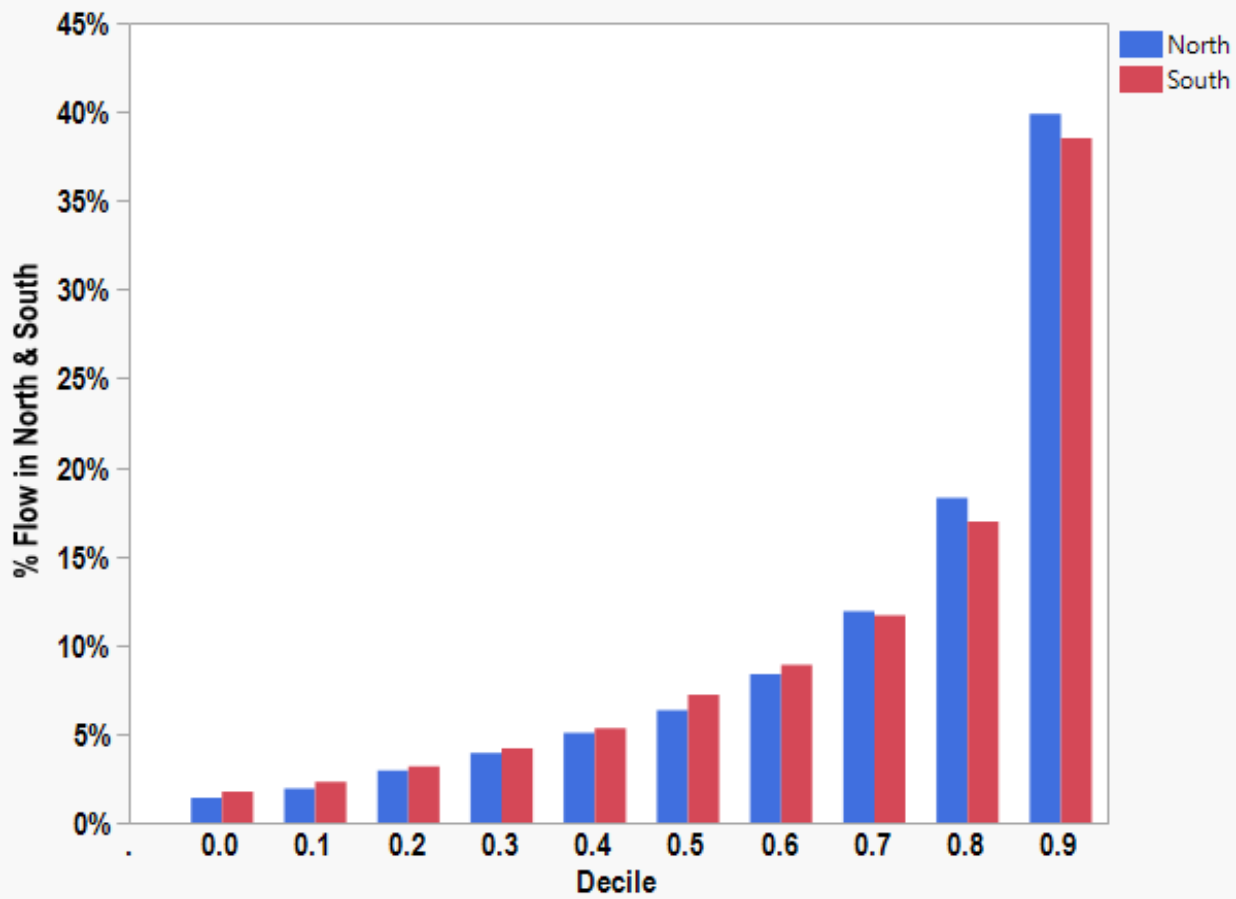
- Daily mean Q for 27 sites for 86 years
- Analyzed distribution by site; saved probability scores, calculated deciles
- Location = North or South
- Interval = 1927-1969 or 1970-2012
- Grouped by Location, Interval, and Decile
- Summed Q in each group
- Calculated % of flow in each group

Percent of Discharge in Each Decile 1927-2012

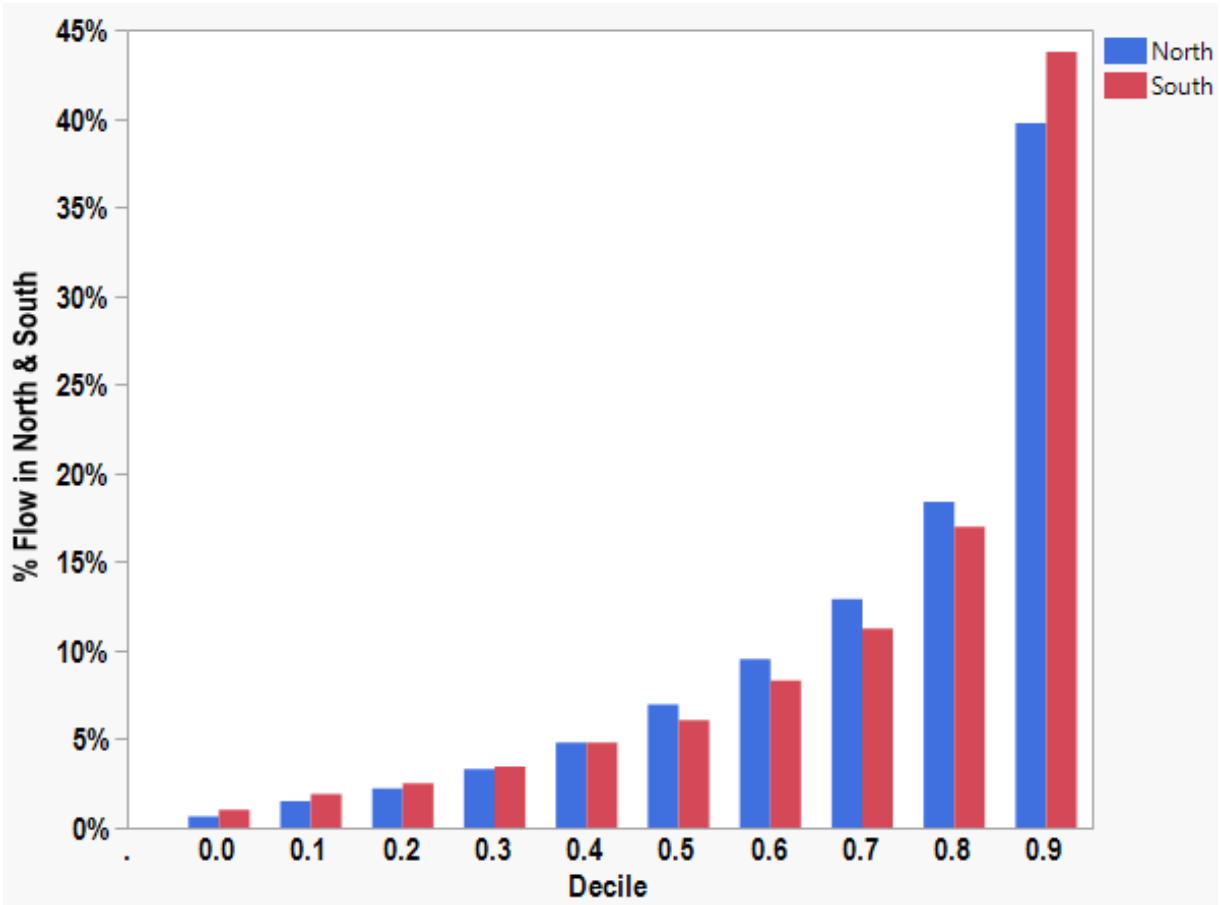


Percent of Discharge in Each Decile

1927-1969



1970-2012



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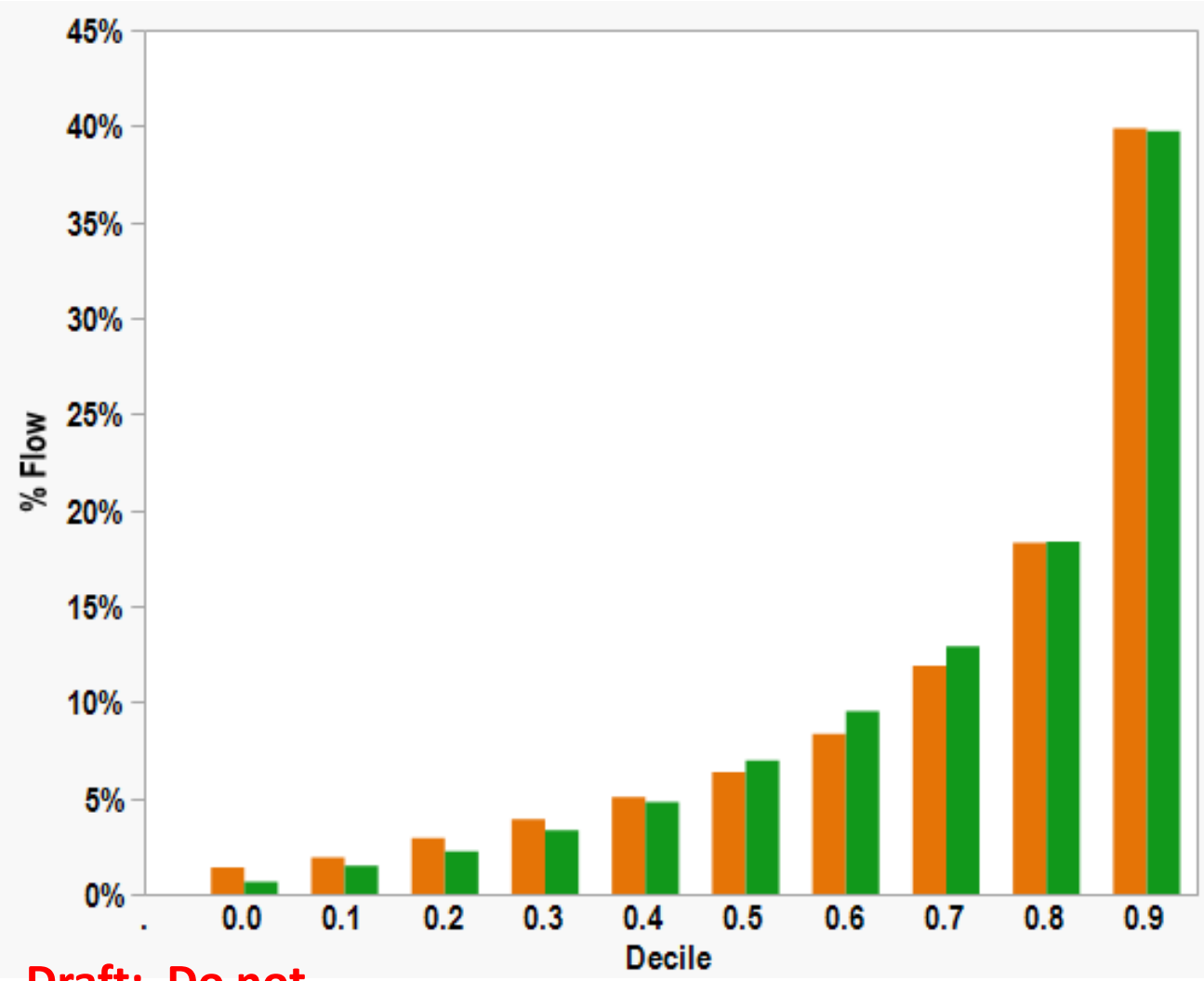

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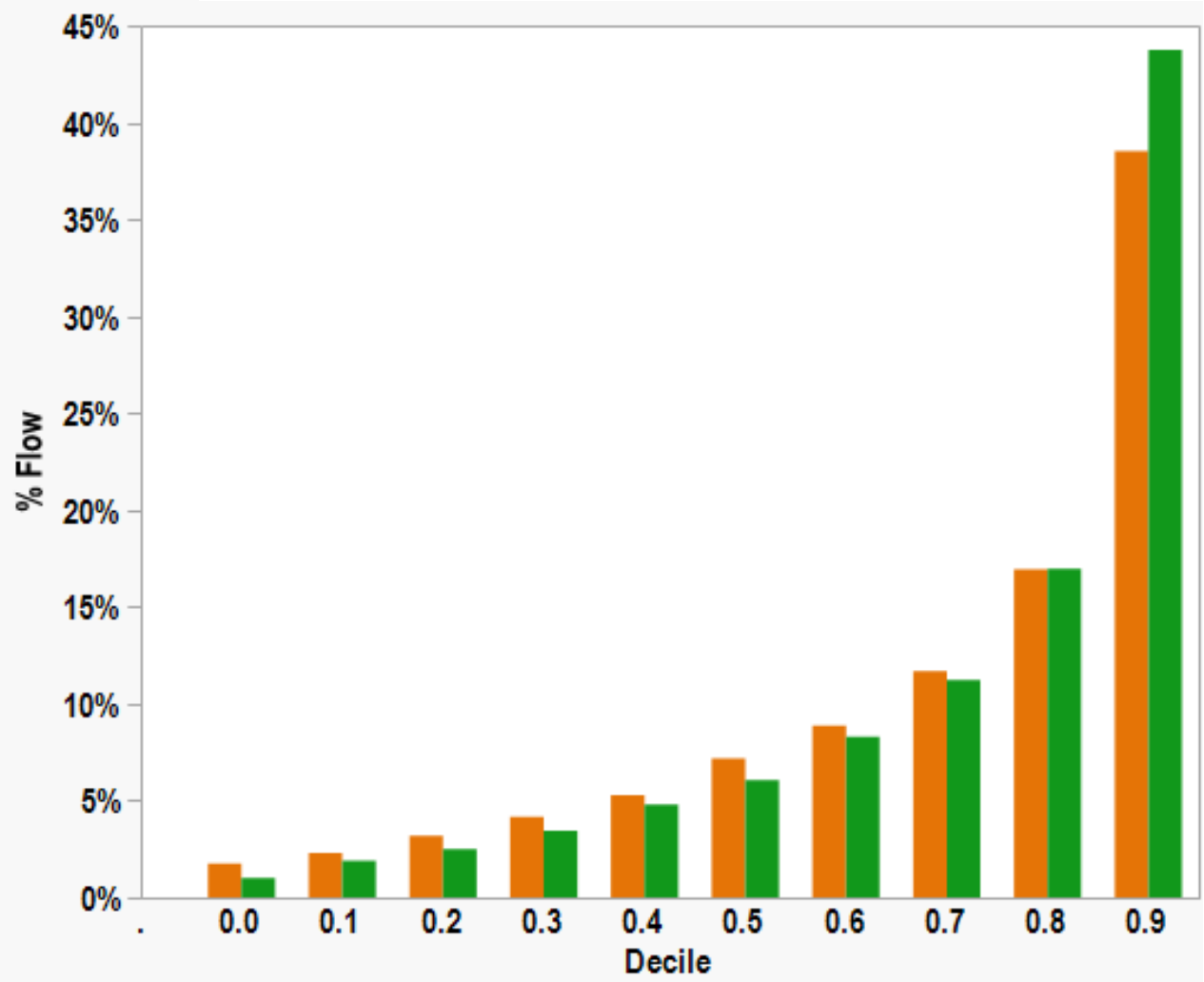
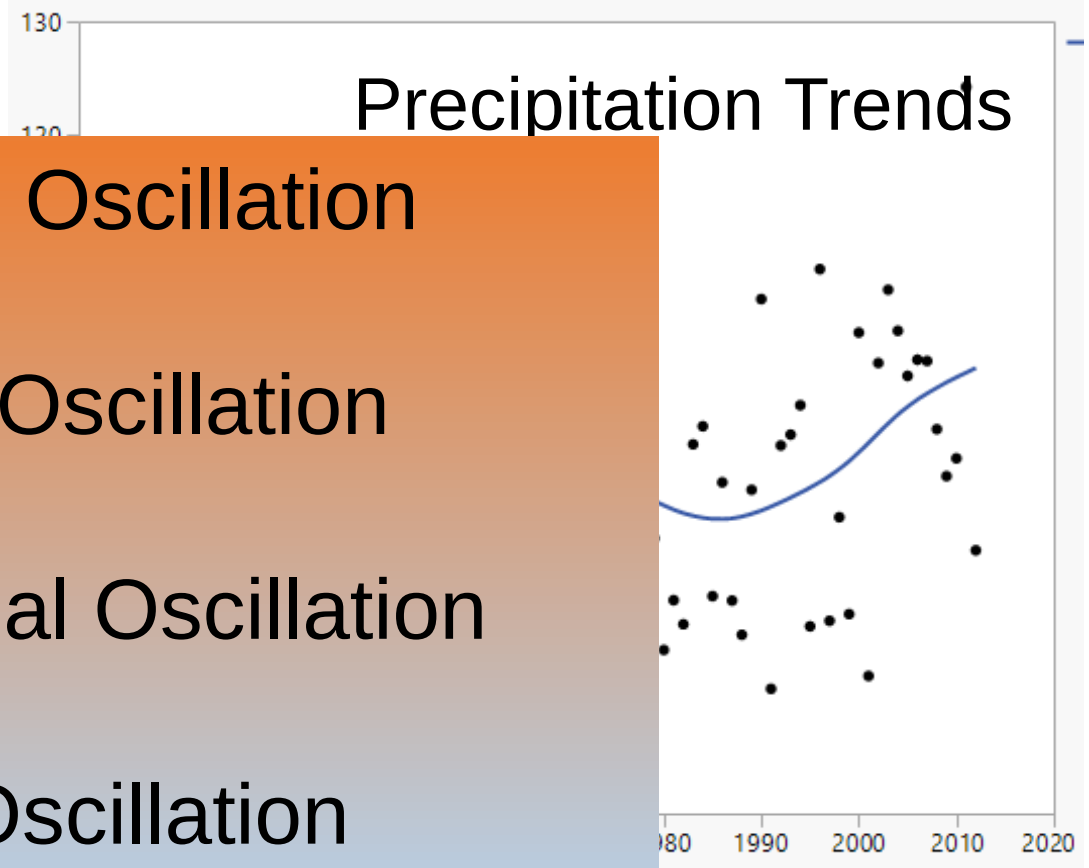


Discharge Key Points

- Stormflow (greater than 70th percentile, especially highest decile) has increased more in the **south** than the **north** in the latter interval

- Mid-flows (30-70th deciles) have increased more in the **north** than the **south** in the latter interval

- Lowest flows (0-30th deciles) have stayed much the same



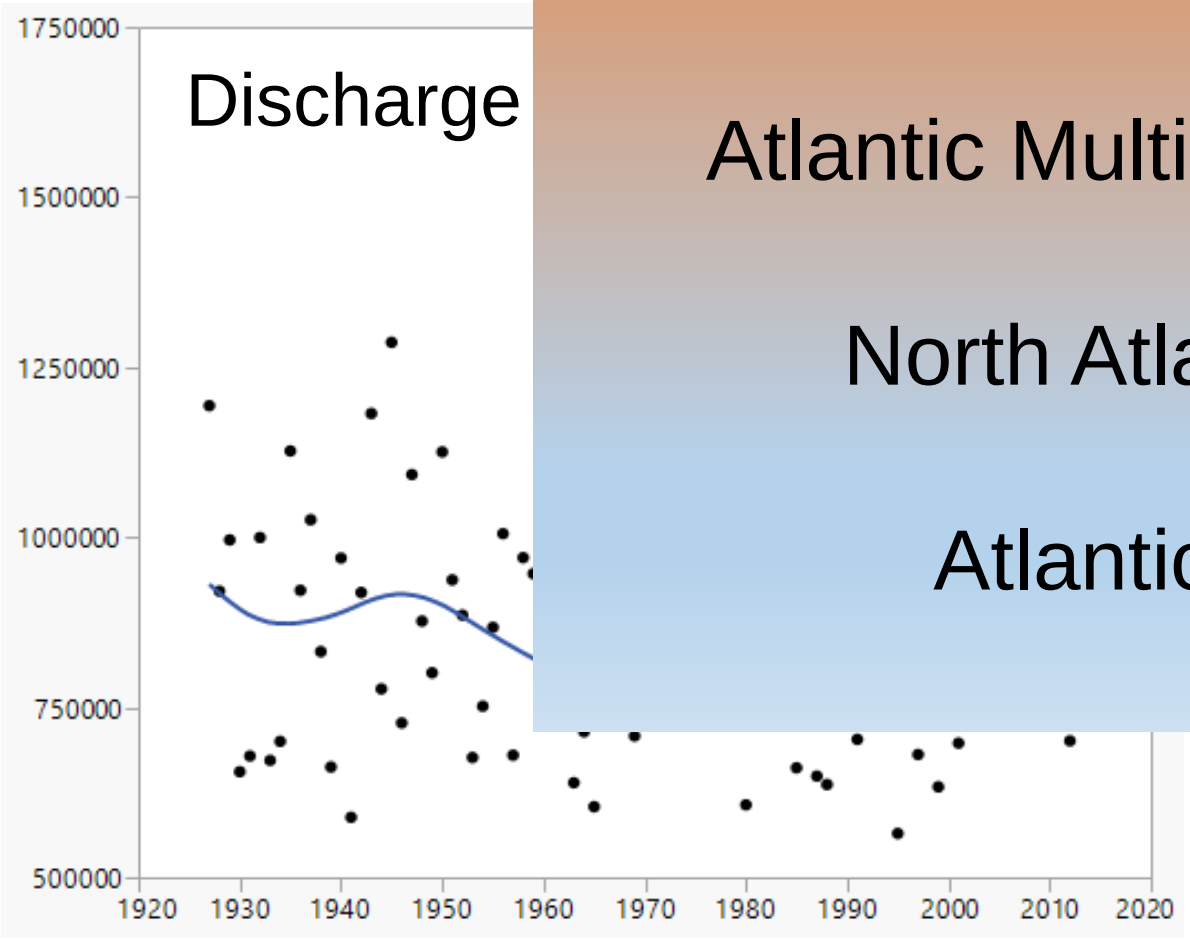
El Niño Southern Oscillation

Pacific Decadal Oscillation

Atlantic Multidecadal Oscillation

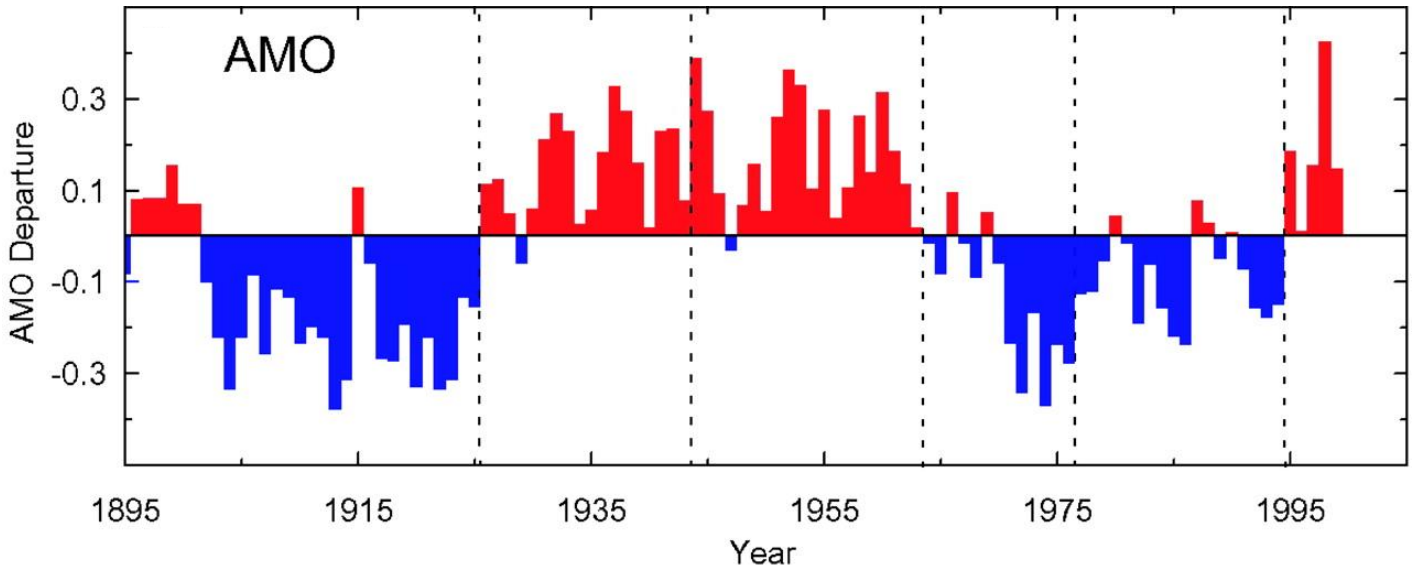
North Atlantic Oscillation

Atlantic Tripole, etc.



AMO timing:

- 1927-1964 (warm)
- 1965-1996 (cool)
- 1997-current (warm)



Gregory J. McCabe et al. PNAS 2004;101:4136-4141

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Questions & Discussion