Snow Cover in South Dakota: statistical analysis of spatiotemporal diversity

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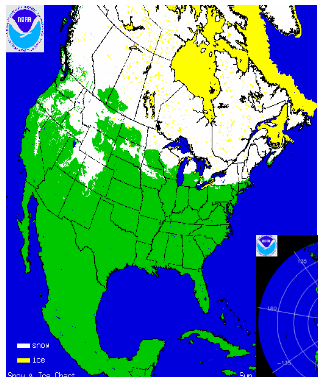
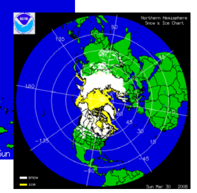
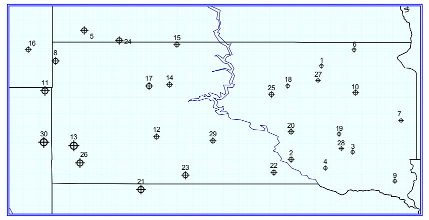






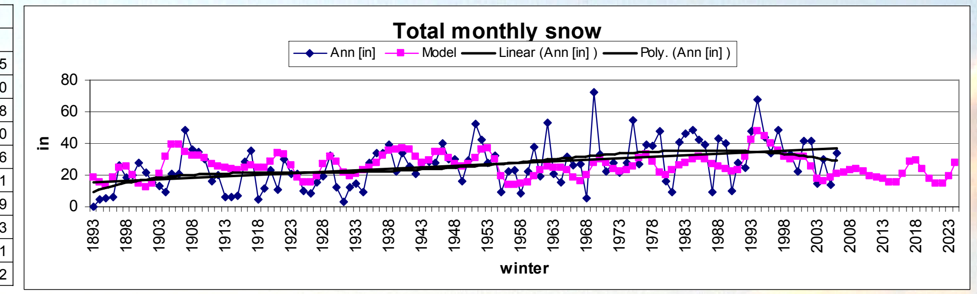
Stations with monthly total snow. Size of circle present an altitude

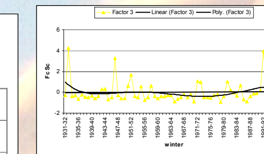
Model of simplified Fourier analysis:

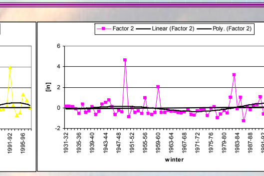
$$Y(t) = a + b*t + A_i* \cos(2t/T_i - \Phi_i)$$

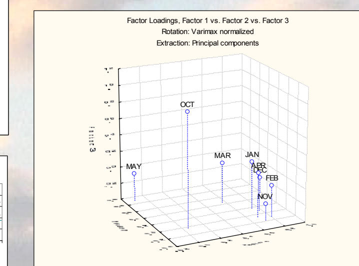
Where a+b*t is a linear part of equation; A_i, T_i, Φ_i are amplitude, period & phase of i-cosinusoid. The equation quotients are computed separately for each selected period & for all periods together under the condition of minimization of the random part

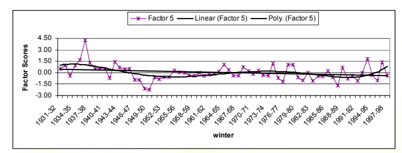
Table for model		
No	Years	Amplitude
1	4	1.35
2	6	2.80
3	8	4.38
4	11	3.70
5	15	2.56
6	18	1.61
7	22	1.79
8	29	3.83
9	40	3.51
10	56	3.22

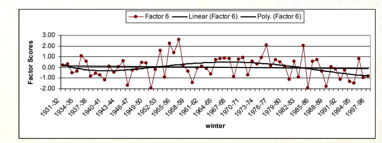


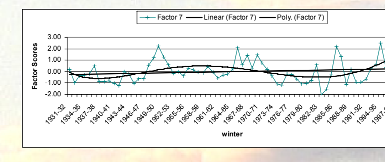




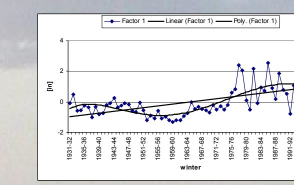


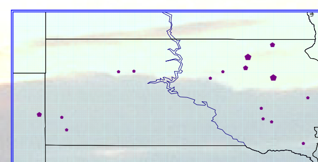




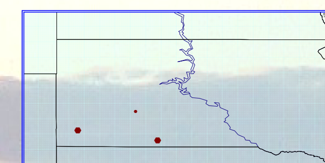


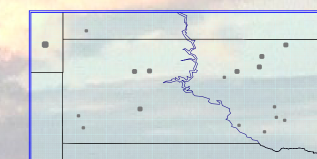
Factor Loadings from model of 12 months for Bowman Court House, ND & Factor Scores for seasons of time interval 1931-1998

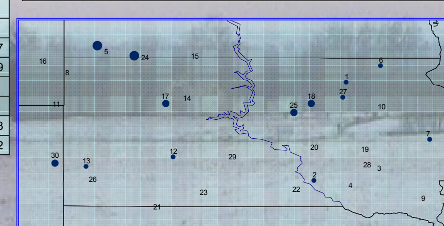


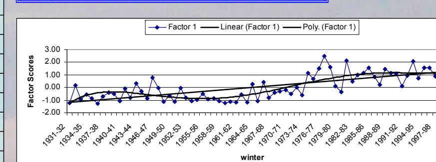


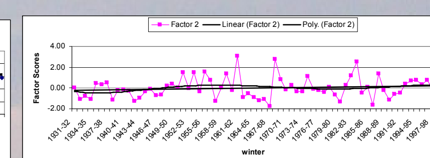
Loadings on SD map for every Factor from model of 25 stations & Factor Scores for time interval 1931-1998

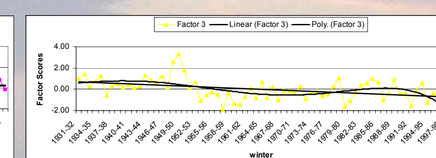


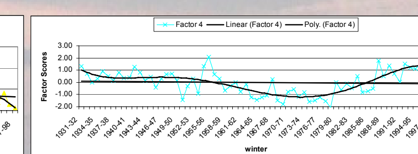


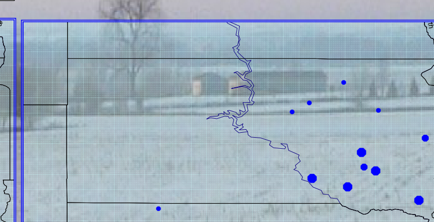


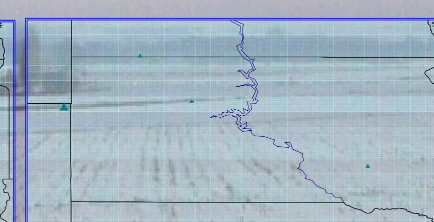


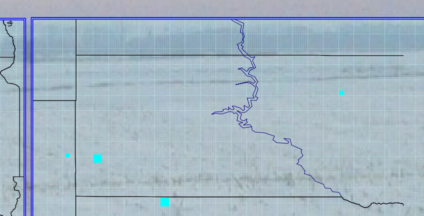












Factor Loadings for 25 stations & time interval 1931-1998

Station	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
ABERDEEN WSO AP, SD	0.26	0.33			***0.64***		0.43
ACADEMY 2 NE, SD	0.42	**0.72**					
ALEXANDRIA, SD		**0.86**					
ARMOUR, SD		**0.86**					
BOWMAN CH, ND	**0.89**						
BRITTON, SD	0.45				0.40		***0.52***
BROOKINGS 2 NE, SD	0.40	***0.68***				-0.29	
CENTERVILLE 6 SE, SD		**0.79**			0.30		
CLARK, SD		0.44			**0.75**		
COLONY, WY			**0.89**				
COTTONWOOD 3 E, SD	0.48						***0.52***
CUSTER, SD	0.30		-0.25	**0.74**			
DUPREE 5 NNE, SD			***0.50***				***0.63***
EUREKA, SD							**0.83**
FAITH, SD	***0.65***						0.46
FAULKTON 1 NW, SD	***0.53***	0.34				-0.26	0.46
FORESTBURG 3 NE, SD		**0.81**					
GORDON 6 N, NE		0.31		**0.77**			
HARRISON, NE	-0.30					**0.71**	
HETTINGER EFA, ND	**0.84**		0.29				
HIGHMORE 1 W, SD	***0.62***	0.39					
HOT SPRINGS, SD					0.28	**0.79**	0.27
MELLETTE, SD	0.34			0.30	***0.51***		0.49
MITCHELL, SD		**0.70**	0.34		0.25		
NEWCASTLE, WY	***0.54***			0.39	***0.53***		
Expl.Var	4.19	5.12	1.63	1.67	2.39	1.60	2.93
Prp.Totl	0.17	0.20	0.07	0.07	0.10	0.06	0.12

Abstract: Snow distribution and accumulation influence many human activities and the dynamic sustainability of ecological systems. Snow cover distribution analysis is a second research step towards creating a Atlas of Climate and Water Resources for SD (temperature analysis was presented last year). We analyzed the regional diversity of monthly total snowfall based on long-term data obtained from the High Plains Regional Climate Center for South Dakota. Multidimensional statistical methods were used, & the results presented for the State of South Dakota.

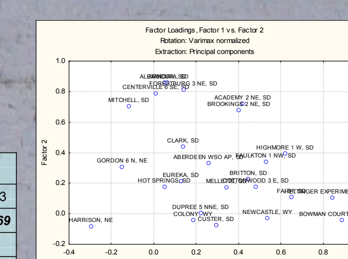
The sets of initial matrixes were compiled with snow observations for the state. The first type of initial matrix of time series $\{X_{t*n}\}$, where t = number of years (67) & n = number of meteorological stations (25), contains 25 stations with mutual observational interval (1931-1998) of 67 winters. The second type of initial matrix $\{X_{t*m}\}$, where t = number of years (67) & m = number of months in a year, included seven initial matrixes.

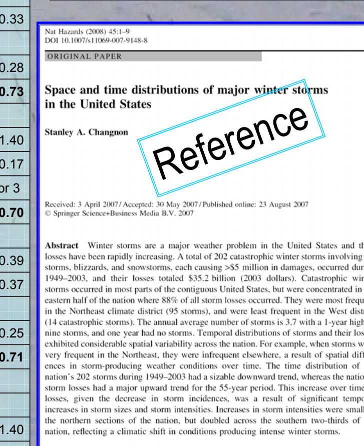
Statistical analysis allowed us to differentiate weather stations by temporal trends & spatial distribution for the time intervals 1931-1998. The average annual sum of total monthly snowfall (October-May) ranged from 25.5 to 53.5 inches for 25 stations trough this time interval. The most variable stations (Bowman Court House, Alexandria, Colony, Gordon, Clark, Hot Springs & Eureka) were determined; their seasonality was described (the most variable months & correlation among months during period of snowfall) & their seasonal regime determined.

	Factor I - Bowman Court House, ND			Factor II - Alexandria, SD				Factor III - Colony, WY			
Variable	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3		Factor 1	Factor 2	Factor 3	Factor 4
OCT			**0.97**	0.26	0.37			0.48			
NOV	**0.72**					***0.60***			***0.67***	0.40	
DEC	**0.78**			**-0.78**						**0.89**	
JAN	**0.74**				***0.68***				**0.78**		
FEB	**0.80**			**-0.85**					0.38		***0.69***
MAR	***0.57***	0.45				***-0.67***		**0.74**		-0.29	
APR	**0.70**				**0.77**				-0.25		**0.77**
MAY		**0.89**			-0.40	0.57		***0.66***		0.26	
Expl.Var	3.14	1.09	1.05	1.42	1.38	1.24		1.42	1.27	1.16	1.14
Prp.Totl	0.39	0.14	0.13	0.18	0.17	0.16		0.18	0.16	0.14	0.14
Variable	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4
OCT			**0.97**				***0.65***	***0.51***			
NOV	**0.72**					**0.72**			***0.69***	0.40	
DEC	**0.78**			**0.76**		0.26				**0.89**	
JAN	**0.74**				**0.76**				**0.78**		
FEB	**0.80**			**0.83**				-0.28	0.34		***0.67***
MAR	**0.59**	0.44			-0.27	-0.37	**0.71**	**0.76**		-0.29	
APR	**0.70**				**0.76**						**0.79**
MAY		**0.90**			-0.29	***0.59***		***0.60***			
Annual	**0.97**			**0.87**	0.36		0.32	*0.59*	**0.55**	0.31	0.48
Expl.Var	4.10	1.10	1.07	2.10	1.51	1.17	1.16	**1.76**	1.56	1.25	1.37
Prp.Totl	0.46	0.12	0.12	0.23	0.17	0.13	0.13	0.20	0.17	0.14	0.15

	Factor IV - Gordon 6N, NE			Factor V - Clark, SD				Factor VI - Hot Springs, SD				Factor VII - Eureka, SD		
Variable	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3		Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3
OCT			**-0.88**			**0.85**		**0.74**						***0.69***
NOV	***0.61***	-0.26	-0.46	***0.67***					**0.81**				**0.83**	
DEC	***0.66***			**0.73**					***0.60***	-0.29			***0.54***	-0.42
JAN	***0.64***			***0.60***						**-0.80**		**0.76**	0.27	0.33
FEB	***0.65***			0.42	-0.39	-0.49		**0.75**			0.25		***0.69***	
MAR	0.31	***0.60***			0.39						**0.94**	0.43		-0.28
APR	***0.57***				***0.55***	-0.35		-0.31	0.48	0.40		0.28		**-0.73**
MAY		**0.83**			***0.80***			-0.39		***0.51***		**0.83**		
Expl.Var	2.10	1.20	1.07	1.63	1.35	1.14		1.44	1.28	1.15	1.07	1.60	1.63	1.40
Prp.Totl	0.26	0.15	0.13	0.20	0.17	0.14		0.18	0.16	0.14	0.13	0.20	0.20	0.17
Variable	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3
OCT			**0.89**			**0.85**			-0.75					**0.70**
NOV	***0.61***	-0.30	0.42	**0.74**				**0.70**				**0.82**		
DEC	***0.65***			**0.72**				**0.62**			0.31	***0.55***		-0.39
JAN	***0.63***			0.41	-0.38		0.48				**0.85**	0.26	**0.73**	0.37
FEB	***0.65***			***0.52***	-0.34	-0.48			**-0.78**			***0.66***		
MAR	0.36	***0.59***					**0.89**			**0.88**			0.46	-0.25
APR	***0.58***				***0.63***	-0.32		***0.58***	0.29		-0.34	0.29	0.31	**-0.71**
MAY		**0.82**			**0.80**				0.37	0.36	-0.44		**0.83**	
Annual	**0.93**	0.30		**0.83**			***0.52***	**0.77**	-0.30	***0.50***		**0.82**	***0.55***	
Expl.Var	2.97	1.27	1.12	2.22	1.37	1.13	1.32	1.85	1.54	1.32	1.19	2.33	1.89	1.40
Prp.Totl	0.33	0.14	0.12	0.25	0.15	0.13	0.15	0.21	0.17	0.15	0.13	0.26	0.21	0.16

Scatter plot for Factor Loadings of 25 stations & time interval 1931-1998

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ORIGINAL PAPER

Space and time distributions of major winter storms in the United States

Stanley A. Changnon

Reference

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Abstract Winter storms are a major weather problem in the United States and their losses have been rapidly increasing. A total of 202 catastrophic winter storms involving ice storms, blizzards, and snowstorms, each causing >$5 million in damages, occurred during 1949–2003, and their losses totaled $35.2 billion (2003 dollars). Catastrophic winter storms occurred in most parts of the contiguous United States, but were concentrated in the eastern half of the nation where 88% of all storm losses occurred. They were most frequent in the Northeast climate district (95 storms), and were least frequent in the West district (14 catastrophic storms). The annual average number of storms is 3.7 with a 1-year high of nine storms, and one year had no storms. Temporal distributions of storms and their losses exhibited considerable spatial variability across the nation. For example, when storms were very frequent in the Northeast, they were infrequent elsewhere, a result of spatial differences in storm-producing weather conditions over time. The time distribution of the nation's 202 storms during 1949–2003 had a sizable downward trend, whereas the nation's storm losses had a major upward trend for the 55-year period. This increase over time in losses, given the decrease in storm incidences, was a result of significant temporal increases in storm sizes and storm intensities. Increases in storm intensities were small in the northern sections of the nation, but doubled across the southern two-thirds of the nation, reflecting a climatic shift in conditions producing intense winter storms.

Keywords Storms · Winter · Climate change