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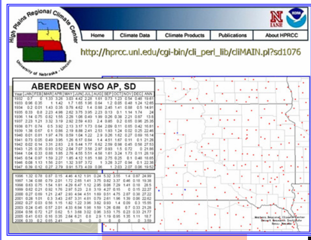
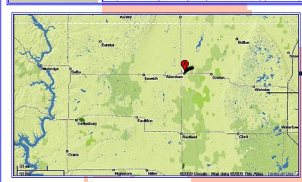
Precipitation in Aberdeen, SD: Data Analysis Approach

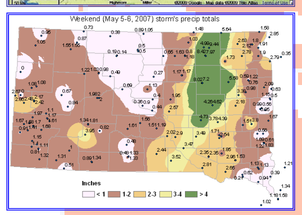
The research of an unusual climate event: precipitation in Aberdeen May 5 & 6, 2007

Shmagin Boris A., Carol A. Johnston, and Dennis Todey

Department of Agriculture & Biosystem Engineering & Department of Biology & Microbiology, South Dakota State University, Brookings, SD 57007







No	period [year]	amplitude	phase
1	3	1.525	2.552
2	7	1.451	4.302
3	14	1.084	4.219
4	18	1.066	-1.355
5	26	1.451	2.920

No	period [month]	amplitude	phase
1	4	0.154	2.893
2	6	0.258	-0.353
3	10	0.070	-0.366
4	12	1.315	3.348
5	18	0.123	1.493
6	21	0.119	1.023
7	25	0.117	2.033
8	27	0.158	2.698
9	29	0.129	2.673
10	31	0.135	-0.558
11	36	0.103	1.853
12	44	0.135	-1.132
13	47	0.049	-1.306
14	51	0.069	-0.719
15	55	0.072	-1.490
16	63	0.115	-0.770
17	71	0.095	-0.464
18	83	0.108	4.309
19	96	0.061	4.653
20	110	0.033	2.246
21	138	0.055	0.096
22	168	0.083	4.024
23	218	0.083	-1.536
24	316	0.117	2.648

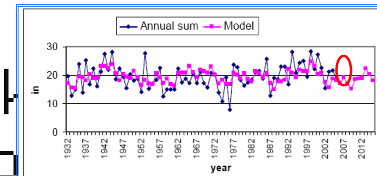
Model of simplified Fourier analysis:

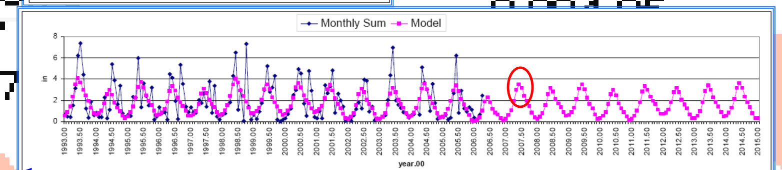
$Y(t) = a + b*t + Ai* \cos (2t/Ti – \Phi i)$

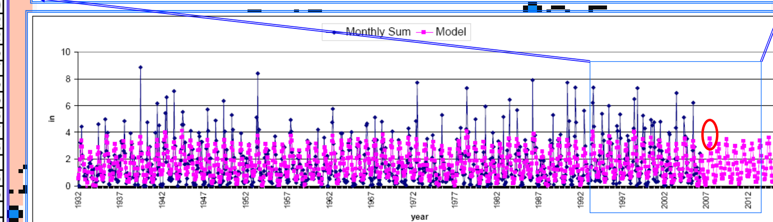
Where a+b*t is a linear part of equation; **Ai, Ti, Φi** are amplitude, period and phase of i-cosinusoid.

The equation quotients are computed separately for each selected period and for all periods together under the condition of minimization of the random part

Year.00	Monthly Sum of Precipitations	Model
2005.25	0.35	1.92
2005.33	2.64	2.91
2005.42	6.21	3.33
2005.50	0.8	2.86
2005.58	2.9	2.08
2005.67	1.19	1.56
2005.75	0.95	1.13
2005.83	1.35	0.55
2005.92	1.11	0.10
2006.00	0.33	0.02
2006.08	0.2	0.12
2006.17	0.65	0.35
2006.25	2.41	0.97
2006.33		1.85
2006.42		2.25
2006.50		1.83
2006.58		1.17
2006.67		0.83
2006.75		0.61
2006.83		0.26
2006.92		0.05
2007.00		0.21
2007.08		0.56
2007.17		1.04
2007.25		1.89
2007.33		2.97
2007.42		3.49
2007.50		3.12
2007.58		2.40
2007.67		1.90
2007.75		1.45
2007.83		0.82
2007.92		0.32
2008.00		0.23
2008.08		0.39
2008.17		0.73
2008.25		1.51
2008.33		2.57
2008.42		3.11
2008.50		2.76
2008.58		2.10
2008.67		1.68
2008.75		1.33
2008.83		0.84
2008.92		0.50
2009.00		0.56
2009.08		0.85

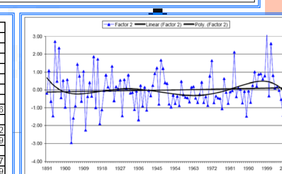


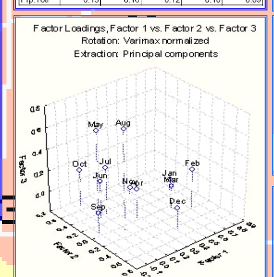


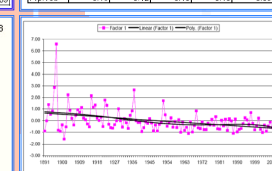


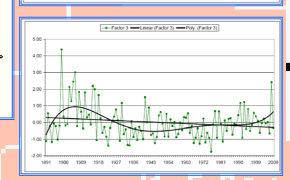
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
May	**0.72**				-0.25
Aug	0.69				
AnnHY	0.68	0.45	0.37	0.31	0.29
Jan		**0.78**	0.30		
Feb		**0.72**			
Mar		0.59			
Oct			0.69		
Nov		0.48	0.52		
Jun			0.25	0.65	
Apr				0.65	0.26
Sep					**0.82**
Jul	0.31		0.35	-0.56	
Dec		0.33	-0.56		0.32
Expl.Var	1.72	2.13	1.55	1.31	1.16
Prp.Totl	0.13	0.16	0.12	0.10	0.09

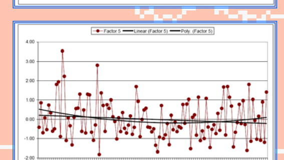
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Jan	0.78	0.30			
Feb	0.73				
Mar	0.59				
Oct		0.70			
Nov	0.48	0.54			
Aug			0.74		
May			0.71		
Apr	0.25			0.64	0.26
Jun		0.26		0.64	
Sep					0.82
Dec	0.35	-0.55			0.29
Jul		0.35	0.25	-0.58	
Expl.Var	1.94	1.42	1.24	1.21	1.07
Prp.Totl	0.16	0.12	0.10	0.10	0.09

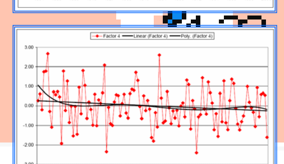












The daily, monthly and annual sum of precipitation was analyzed for station Aberdeen-Airport, South Dakota (NOAA COOP #390020) with traditional normative statistical descriptions of precipitation variability and with methods of data analysis (MDA). MDA was applied to analyze empirical data for seasonality and regularity of high values of daily precipitation. The goal for research was formulated as finding a way to forecast extremes, such as the flooding of Aberdeen in May 2007 after a 30-hour, 8.42 inch rain event.

Daily data were available for 415,556 of the 422,294 days of station operation (1890-2008; data file SD390020 from NOAA National Climatic Data Center). For 9629 days the precipitation was >= 0.01 in., for 516 >= 1.0 in., for 86 >= 2.0 in., for 24 >= 3.0 in., and for 4 >= 4.0 in. The daily values cannot be considered as having any use for the forecast. The observations of 1423 monthly sums of precipitation have the following characteristics: mean = 1.802 in.; geometric mean = 0.856 in.; median = 1.26 in.; minimum = 0.0; maximum = 12.39 in. Other characteristics may be presented like: values <0.1 in. constitute 5%; <1.0 in. -- 42.66%; <3.0 in. -- 80.74%; <5.2 in. -- 95.29%; <7.71 in. -- 99.02%.

Simplified Fourier analysis was performed for monthly data, and 31 cyclic components were determined and used in a model to represent the data with periods from 4 to 379 months. The biggest amplitude from those components belongs to period of 12 months (1.396), and the next largest amplitude (0.261) had a period length of 6 months. The lowest amplitude (0.033) has a period of 75 months; the longest period 379 months has an amplitude of approximately twice that height (0.066). Fourteen periods have amplitudes higher that 0.1.

The same analysis was performed on data obtained from the High Plains Regional Climate Center that was collected between January 1932 and April 2006. The model has mean equal 1.623 in. and the same two periods: 12 and 6 months, - with the biggest amplitudes: 1.315 and 0.258, and the model showed the increase in precipitation during May 2007 (3.494 in) that bigger that in April (2.965 in), June (3.115 in) 2007, and May (2.246 in) 2006.

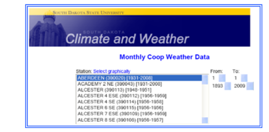
Mean annual precipitation for the time interval 1891- 2007 was 21.627 in. Simplified Fourier analysis presented a model of annual variability with eight cyclic components. The biggest amplitude (2.26) has the longest period of 46 years; the smallest (0.336) has a period of 31 years. Five components (46, 3, 10, 24, and 8 years) have amplitudes larger that 1.0 The same analysis for annual sum for time interval 1932-2006 presents mean = 19.514, and a model with five components of 3, 7, 14, 18, and 26 years with sequential altitudes 1.525, 1.451, 1.084, 1.066, and 1.451. The model shows that 2007 annual precipitation is moderately greater than the long-term mean value.

During 118 hydrological years, the mean of annual sum for hydrologic year is 21.617 in., the minimum is equal 9.07 and maximum is equal 41.44. The highest mean of 3.704 in. for monthly sum during this time interval has June, the second of 2.948 in. has May; but May has the highest maximum equal 12.39 and June only has 10.91.

The factor analysis on the matrix of monthly sum of precipitations {P118*12,13} shows that the annual sum mostly associated with May and August; the seasonal variability may be described by five factors (cumulative variance reflected by the model is equal 57.4%). The seasonal regime may be well represented by the factor scores; four factors charts (for factors 1, 3, 4, and 5) show different degrees of decrease in sum of precipitations for analyzed interval. In contrast, for factor 2 slightly increased.

The assumption of possible forecast for precipitation and connected flooding was considered based on the obtained results of daily, monthly and annual sums of precipitation. The highest daily sum of precipitation may be expected in month with biggest monthly sums in May and June.

The time series of annual sum and monthly sums of precipitations have cycles with periods of 24, 31 and 46 years, and 286 and 379 months; traditional tools of characterization variability have to be applied to the longest as it is possible time series.



Year.00	Monthly Sum of Precipitations	Model
2006.58	2.470	1.875
2006.67	2.670	1.458
2006.75	0.1300	1.095
2006.83	0.1200	0.705
2006.92	0.880	0.533
2007.00	0.0900	0.687
2007.08	1.160	1.039
2007.17	1.880	1.653
2007.25	3.420	2.674
2007.33	12.230	3.722
2007.42	2.430	4.080
2007.50	0.790	3.621
2007.58	2.190	2.916
2007.67	1.640	2.352
2007.75	1.480	1.793
2007.83	0.02000	1.172
2007.92	0.900	0.755
2008.00	0.0700	0.668
2008.08	0.2400	0.801
2008.17	1.760	1.233
2008.25	0.810	2.123
2008.33	1.320	3.098
2008.42	3.210	3.444
2008.50	6.260	3.033
2008.58	1.240	2.426
2008.67	3.610	2.003
2008.83	1.802	-0.1902
2008.92		1.175
2009.00		0.942
2009.08		1.027
2009.17		1.309
2009.25		1.861
2009.33		2.838
2009.42		**3.864**
2009.50		**4.229**
2009.58		**3.806**
2009.67		3.164
2009.75		2.686
2009.83		2.227
2009.92		1.712
2010.00		1.395
2010.08		1.393
2010.17		1.583
2010.25		2.040
2010.33		2.917
2010.42		3.839
2010.50		4.094
2010.58		3.557
2010.67		2.797

No	period [year]	amplitude	phase
1	3	1.692	0.614
2	8	1.059	-0.689
3	10	1.399	3.295
4	14	0.821	3.903
5	17	0.769	1.798
6	24	1.326	1.575
7	31	0.348	3.665
8	46	2.260	2.104

No	period [month]	amplitude	phase
1	4	0.11608	-0.657
2	6	0.26166	3.683
3	12	1.39597	2.263
4	18	0.11837	0.787
5	21	0.14747	0.826
6	27	0.13355	0.329
7	29	0.12877	-1.414
8	32	0.10346	-0.896
9	36	0.11455	1.399
10	38	0.13457	-0.182
11	43	0.10273	4.277
12	45	0.08845	-1.085
13	47	0.10034	3.528
14	49	0.08006	2.861
15	52	0.06607	2.736
16	54	0.06138	2.398
17	56	0.09179	3.187
18	62	0.10266	0.432
19	69	0.09308	2.501
20	75	0.03289	1.524
21	83	0.09453	4.527
22	96	0.1005	-0.304
23	103	0.04252	-0.812
24	113	0.12823	4.268
25	123	0.11112	3.148
26	138	0.07752	2.319
27	154	0.08843	0.782
28	170	0.05376	3.231
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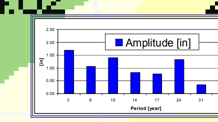
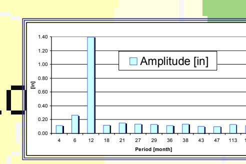
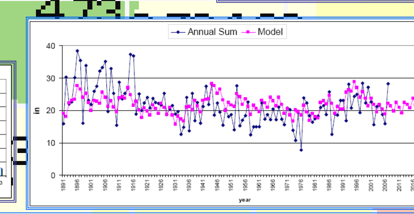
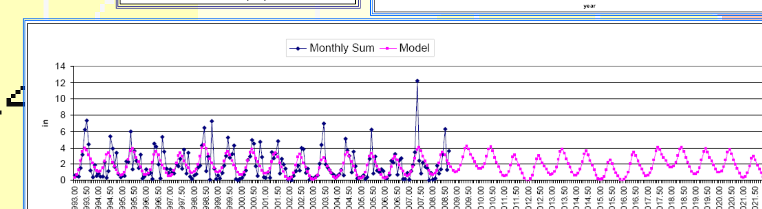
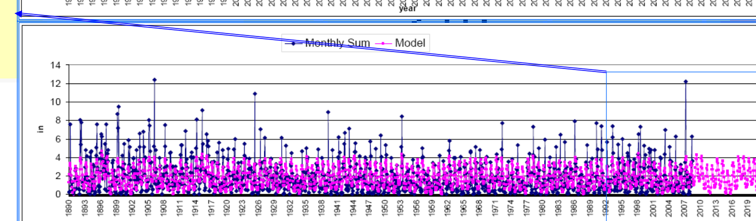
30	286	0.10013	1.901
31	379	0.0656	3.405









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CLIMATE REPORT
NATIONAL WEATHER SERVICE ABERDEEN SD
841 AM CDT SUN JUN 15 2008
..................................

THE ABERDEEN CLIMATE SUMMARY FOR THE MONTH OF MAY 2008
CLIMATE NORMAL PERIOD 1971 TO 2000
CLIMATE RECORD PERIOD 1896 TO 2008

WEATHER          OBSERVED            NORMAL  DEPART   LAST YEAR`S
                  VALUE    DATE(S)   VALUE   FROM     VALUE  DATE(S)
                                             NORMAL

PRECIPITATION (INCHES)
RECORD
 MAXIMUM         12.23    2007
 MINIMUM          0.28    1948
TOTALS            1.32                2.69   -1.37    12.23
DAYS >= .01        10                 9.9     0.1       11
DAYS >= .10         4                 5.6    -1.6        6
DAYS >= .50         1                 1.8    -0.8        3
DAYS >= 1.00        0                 0.4    -0.4        3
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Rain in the U.S. Midwest

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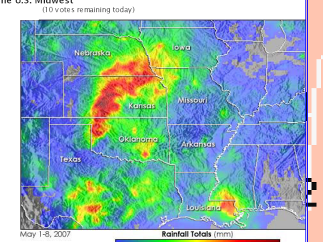

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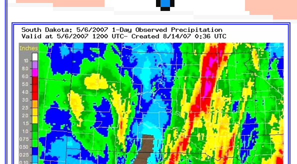
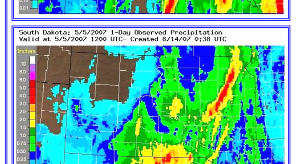
The powerful storms that moved across the U.S. Midwest during the first week of May 2007 brought wind, hail, tornadoes, and drenching rain. This image shows rainfall totals over parts of Oklahoma, Kansas, and Nebraska between May 1 and May 8, based in part on measurements made by the Tropical Rainfall Measuring Mission (TRMM) satellite.

More than 400 millimeters (15.7 inches) of rain fell over some regions, corresponding with locations where the National Weather Service reported severe weather. A wide swath of red and orange (between 240 and 400 millimeters of rain) arcs in a clockwise direction from western Oklahoma, through central Kansas, and into southeastern Nebraska. The reddish-orange bull's-eye over southeastern Louisiana is evidence of the torrential rains that pounded visitors to the annual New Orleans Jazz Festival. South-central Texas' Edward Plateau was soaked with more than 240 millimeters of rain during the period, as well.

From May 4 to May 8, the National Weather Service received approximately 683 reports of severe weather, 140 of which were reports of tornadoes, including the massive F5 tornado that devastated the city of Greensburg, Kansas. Beyond the damaging winds and tornadoes, the torrential rain triggered extensive flooding throughout the Central Plains. On the evening of May 7, flood warnings were in effect from South Dakota to southern Texas, and by May 8, the Hydrologic Information Center reported moderate to major flooding at 53 stream gauge sites in South Dakota, Iowa, Kansas, Nebraska, Missouri, and Arkansas. The floods could be as severe as the 1993 flood, one of the costliest floods in U.S. history, reported the Associated Press.

NASA image by Hal Pierce.





Inches: < 1 | 1-2 | 2-3 | 3-4 | > 4

This rainfall event set the state record 24 hr precipitation total of 8.75" at Groton.

Eos, Vol. 90, No. 12, 24 March 2009

EOS
EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 90 NUMBER 12
24 MARCH 2009
PAGES 101–108

The "Maya Express": Floods in the U.S. Midwest

PAGES 101–102

The 2008 floods in the U.S. Midwest culminated in severe river flooding, with many rivers in the region cresting at record levels during May and particularly June. Twenty-four people were killed and more than 140 were injured as a result of the floods. Nine states were affected: Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, South Dakota, and Wisconsin. In Iowa, 83 of the state's 99 counties were declared disaster areas. Cedar Rapids, Iowa, was among the cities hardest hit by flooding. At one point, water covered 1300 city blocks across 24 square kilometers, inundating 3900 homes and most of the city's infrastructure and municipal facilities. The flood, which also damaged the Midwest's corn and soybean crops, was presaged by unusually heavy snowpack the preceding winter and by anomalously heavy rainfall during the spring.

It is natural to compare the events of June 2008 with the memorable Midwest floods of 1993. The U.S. Geological Survey characterized both of these incidents as "500-year floods." Using near-real time observational data sets, the characteristics of the 2008 flood have been investigated from the perspective of the atmospheric branch of the water cycle, and the flood has been compared with that of 1993 and more generally with the history of heavy precipitation and climate in the region over the past 30 years.

The floods over the central United States during June and July 1993 have been thoroughly studied. Observational studies have characterized the patterns and timing of the heavy rains that led to the floods, as well as the large-scale circulation of the atmosphere at that time. Many numerical studies using weather and climate models have attributed the flood to patterns of sea surface temperature in the tropics, quasi-stationary large-scale circulation anomalies in the atmosphere, or soil moisture conditions across sections of North America.

Back-trajectory calculations that attribute the moisture that falls as rain to specific locations where evaporation supplied that moisture have shown that a tropical source of moisture fed the 1993 floods [*Dirmeyer and Brubaker*, 1999]. Specifically, advected moisture (from an upstream area, or "fetch") was identified as coming from the western Gulf of Mexico and the western Caribbean Sea, well outside the usual sources of moisture for rainfall over the region. Did the floods of 2008 share these characteristics? Are there attributes that are common to the most severe Midwest floods?

Floods in 1993 Compared to 2008

Figures 1a and 1b show precipitation anomalies for June and July 1993 and for May and June 2008, respectively, using data from the Global Precipitation Climatology Project of the World Climate Research Programme. Both flood events were characterized by wet conditions in the months prior to

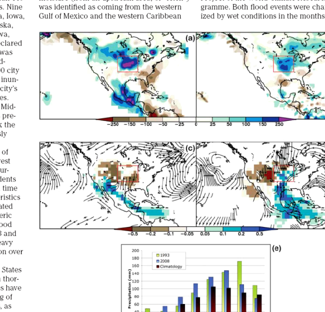


Fig. 1. Rainfall anomalies (in millimeters) for (a) June and July 1993 and (b) May and June 2008. Wind anomalies averaged over the lowest 30 hectopascals (shown only where anomalies exceed 1 meter per second) and anomalies of evaporative source supplying moisture to rainfall over the area in the red box (expressed as a percentage of total source) for (c) 1993 and (d) 2008. (e) Time series of monthly precipitation over the area in the red box for 1993 and 2008, compared with climatology (average precipitation) based on data from 1979 to 2007.

By P. A. Dirmeyer and J. L. Kinter III