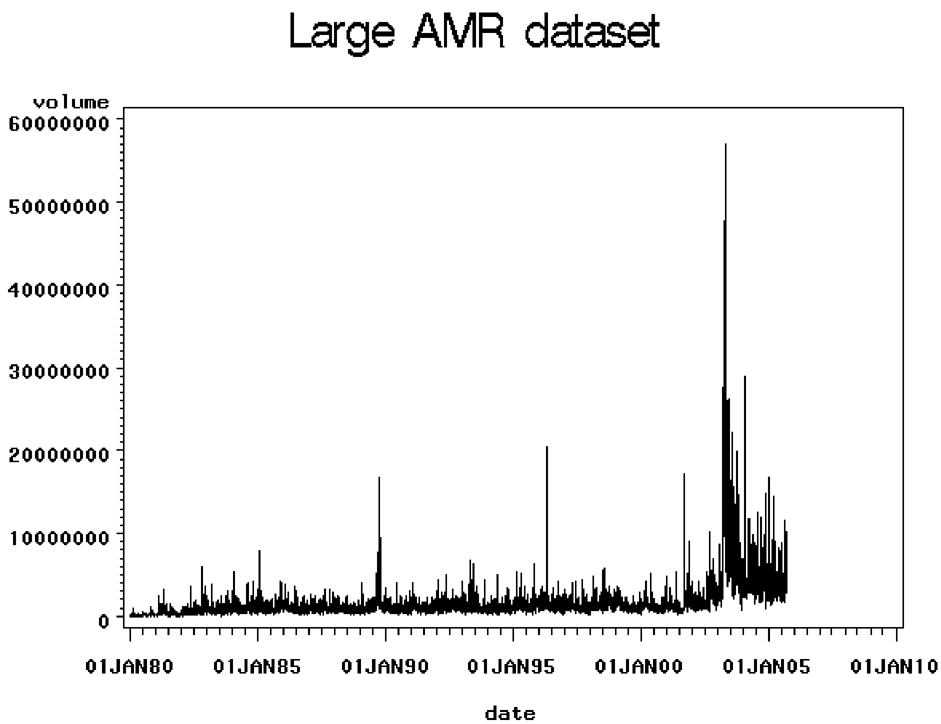
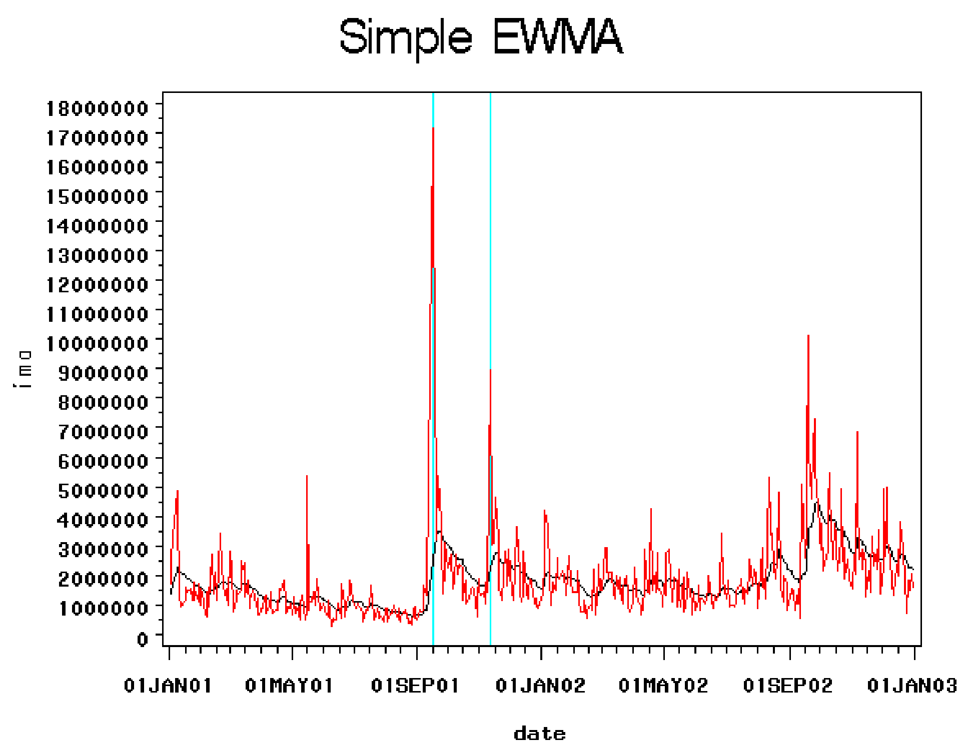
American Airlines stock volume – 25 years:



Near 9/11/2001



Vertical lines at 9/11/2001 and 12/11/2001 (after crash off of NY)
Black "predictions" from exponentially weighted moving average with $\hat{Y}_t = .9\hat{Y}_{t-1} + .1Y_{t-1}$. Time series model may help.
9/11 and next crash intervention model (SAS)

```
axis1 label = (angle = 90);

*************************************
*  Input and sort the data          *
*************************************;
Data AMR; title "Large AMR dataset";
infile "F:\SAMSI\Americanbig.csv" dlm="," dsd firstobs=2 missover;
length datedum $ 9.;
input datedum $  open high low close volume;
date = input(datedum, date9.);  drop datedum;
format date date7.;
proc sort data=AMR; by date;
proc gplot; plot volume*date; symbol1 v=none i=join;
run;

********************************
* Add intervention variables   *
********************************;
Data American; set AMR;
WTC = (date="17sep2001"d);
CRASH = (date="12nov2001"d);
label CRASH = "Crash of AA Flt. 587 east of New York";
surprise = volume - ima;
if _n_ = 1 then IMA = volume;
else IMA = .9*IMA+.1*volume;
format date date7.; retain IMA;

************************
* Graph the data       *
************************;
proc gplot; Title "Simple EWMA";
plot (ima volume)*date/overlay href="17sep2001"d "12nov2001"d
chref=cyan vaxis=axis1;
where '01jan01'd < date < '01jan03'd;
symbol1 v=none i=join;
proc print; var date volume;
where ('01sep01'd < date < '01jan03'd)and(volume>5000000);
run;

******************************
*  Fit intervention model    *
******************************;
proc arima data=AMERICAN;
```

```
i var=volume crosscor=(WTC CRASH) noprint;
e input = ( (1)/(1,2) WTC (1)/(1,2) CRASH) plot p=2 q=1;
f lead=0 out=out1 id=date;
where '01jan01'd < date < '01jan03'd;
proc print data=out1 (obs=10);

****************************
*  Plot results            *
****************************;

proc gplot data=out1; title "ARIMA transfer function";
plot (forecast volume)*date/overlay href="17sep2001"d "12nov2001"d
chref=cyan vaxis=axis1;
where '01jan01'd < date < '01jan03'd;
proc gplot data=out1; title "ARIMA transfer function";
plot (forecast volume)*date/overlay vaxis=axis1;
plot residual*date/overlay vref=0 vaxis=axis1;
where '01jul01'd < date < '11sep01'd;
proc gplot data=American; title "EWMA 'surprises'";
plot surprise*date/overlay vref=0 vaxis=axis1;
where '01jul01'd < date < '11sep01'd;
run;
*********************************************************************
```

The ARIMA Procedure

Conditional Least Squares Estimation

Parameter	Estimate	Standard Error	t Value	Approx Pr>|t|	Lag	Variable
MU	1895175.1	241956.3	7.83	<.0001	0	volume
MA1,1	0.80798	0.06487	12.45	<.0001	1	volume
AR1,1	1.30707	0.08535	15.31	<.0001	1	volume
AR1,2	-0.33545	0.07374	-4.55	<.0001	2	volume
NUM1	15624717	831551.1	18.79	<.0001	0	WTC
NUM1,1	-9564494.0	3086912.7	-3.10	0.0021	1	WTC
DEN1,1	-0.21308	0.18425	-1.16	0.2481	1	WTC
DEN1,2	0.38677	0.07282	5.31	<.0001	2	WTC
NUM2	7534484.3	842654.2	8.94	<.0001	0	CRASH
NUM1,1	4260018.6	2401054.1	1.77	0.0767	1	CRASH
DEN1,1	0.79740	0.31164	2.56	0.0108	1	CRASH
DEN1,2	0.04974	0.17505	0.28	0.7764	2	CRASH

Interpretation:

X_t = WTC indicator 0 0 0 1 0 0 0 …

$$\frac{15624717 + 9594494\,B}{(1 + .213B - .387\,B^2)} X_t$$

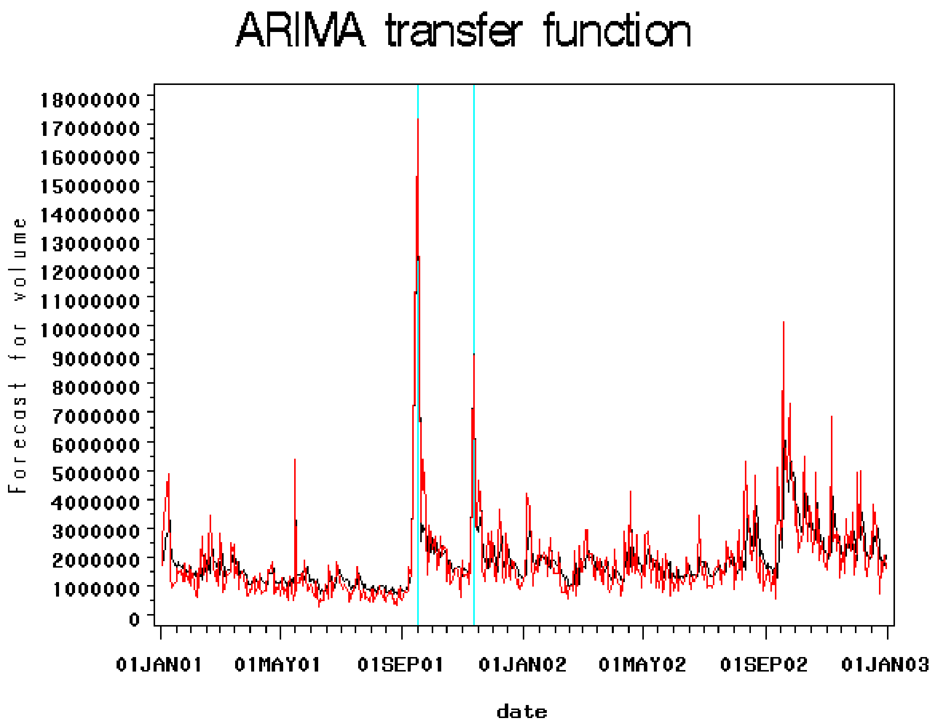
Similarly for X_t = second crash indicator
Error term is ARMA(2,1)

Residual Checks

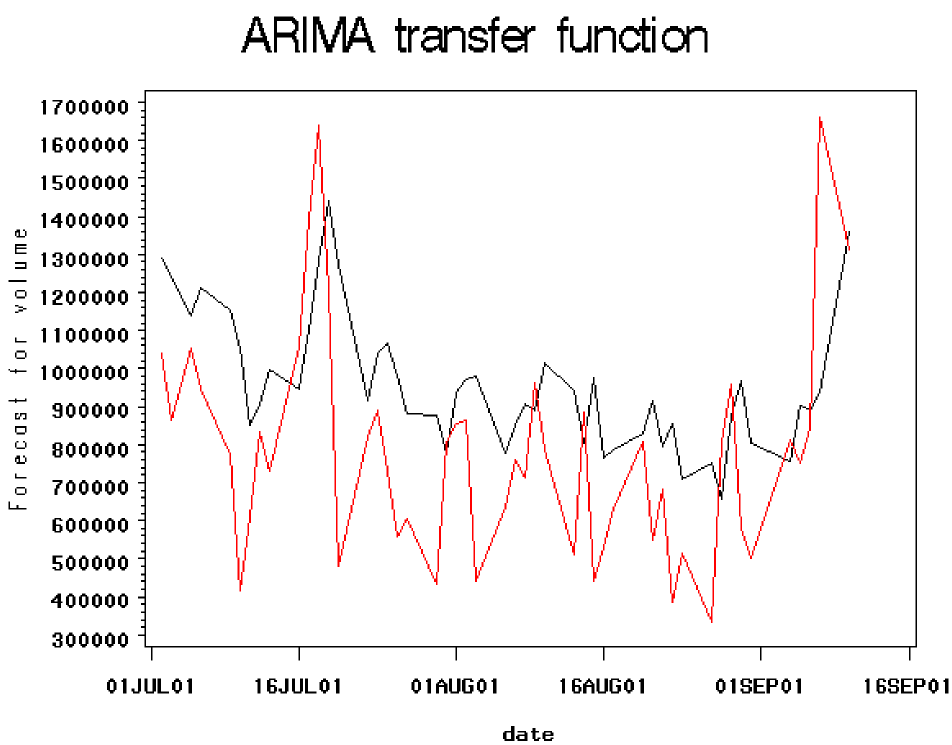
Autocorrelation Check of Residuals

To Lag	Chi-Square	DF	Pr > ChiSq	---------Autocorrelations-------------					
6	11.07	3	0.0114	-0.002	-0.008	0.016	0.060	0.059	-0.121
12	13.69	9	0.1336	0.032	-0.019	-0.042	-0.030	-0.034	-0.002
18	20.49	15	0.1541	-0.082	-0.017	0.005	0.013	-0.074	0.023
24	37.27	21	0.0157	0.116	0.088	-0.087	-0.036	0.045	0.011
30	43.28	27	0.0245	-0.046	-0.016	0.059	-0.041	0.061	0.008
36	51.68	33	0.0203	0.069	0.013	-0.042	0.085	0.032	0.029
42	55.44	39	0.0425	-0.045	0.020	0.066	-0.002	-0.011	-0.002
48	56.92	45	0.1096	0.020	-0.011	-0.009	0.002	-0.005	0.046

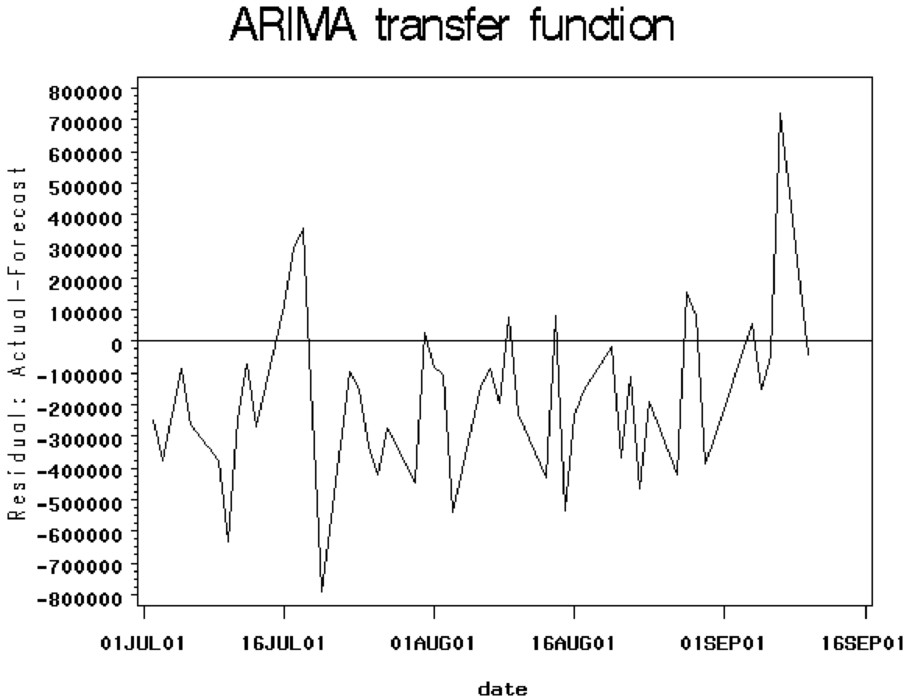
Forecasts from this model shown below:



Data before 9/11with transfer function forecast:



Residuals before 9/11/01:



Example 2: "Nenana Ice Classic"

Touted as evidence of global warming
In 1917, engineers at Tanana river near Nenana Alaska erected tripod on ice, connect to clock, bet on time tripod would move downstream to stop clock -> beginning of spring. Betting caught on and continues each year – pot is now $285,000. Signal is (possibly) ramp intervention.

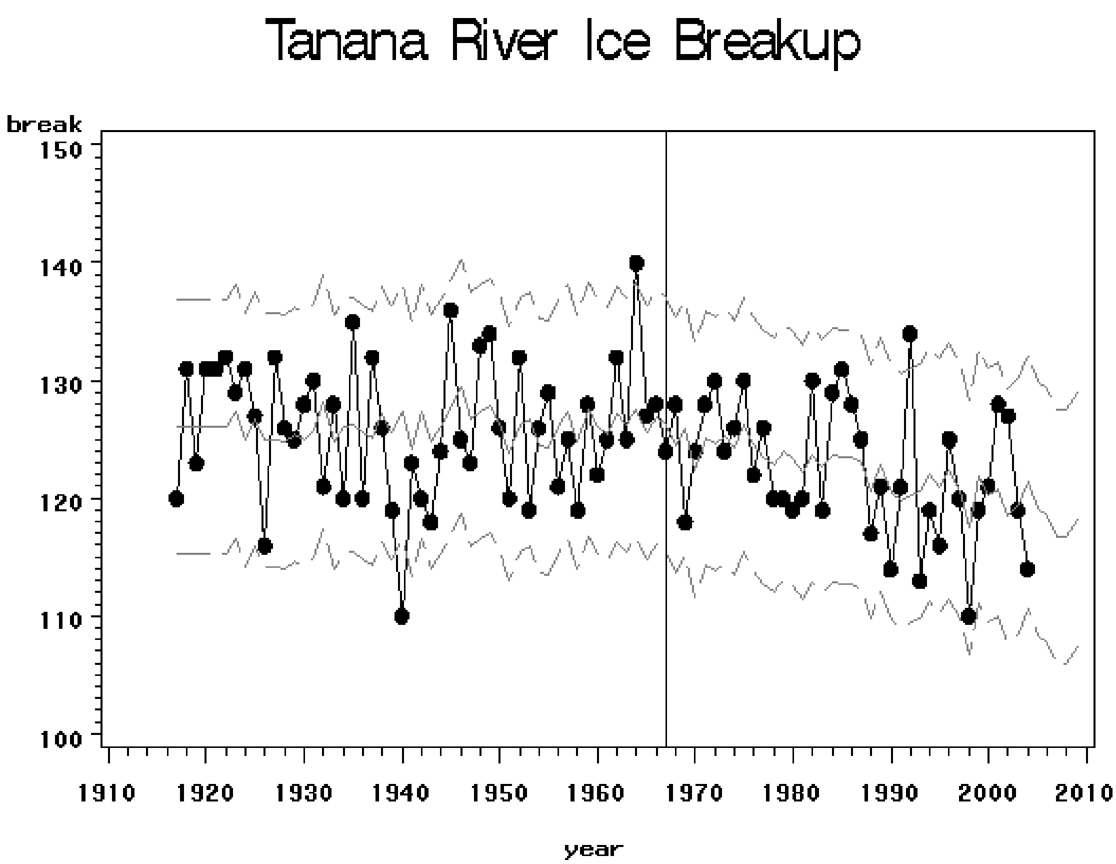
```
options ls=76;   ** Demos  Nenana.sas  **;
* Ice breakup time in Tanana River near Nenana,
Alaska - for years residents have bet on the
breakup time, which is considered the unofficial
start of spring.
A wooden tripod is used to measure the breakup.
More information is available at

http://fairbanks-alaska.com/nenana.htm
 ;
Data Ice; input year 1-4 mon $ 8-10 day 12-13;
month = 5; if mon="Apr" then month=4;
break = MDY(month,day,1960);
*23456789 123456789 123456789;
cards;
1917   Apr 30  11:30 a.m.
1918   May 11   9:33 a.m.
1919   May  3   2:33 p.m.
1920   May 11  10:45 a.m.
1921   May 11   6:42 a.m.
1922   May 12   1:20 p.m.
1923   May  9   2:00 a.m.
1924   May 11   3:10 p.m.
1925   May  7   6:32 p.m.
1926   Apr 26   4:03 p.m.
1927   May 12   5:42 a.m.
1928   May  6   4:25 p.m.
1929   May  5   3:41 p.m.
1930   May  8   7:03 p.m.
1931   May 10   9:23 a.m.
1932   May  1  10:15 a.m.
1933   May  8   7:30 p.m.
1934   Apr 30   2:07 p.m.
1935   May 15   1:32 p.m.
1936   Apr 30  12:58 p.m.
1937   May 12   8:04 p.m.
1938   May  6   8:14 p.m.
1939   Apr 29   1:26 p.m.
1940   Apr 20   3:27 p.m.
1941   May  3   1:50 a.m.
1942   Apr 30   1:28 p.m.
1943   Apr 28   7:22 p.m.
1944   May  4   2:08 p.m.
1945   May 16   9:41 a.m.
```

1946	May 5	4:40	p.m.
1947	May 3	5:53	p.m.
1948	May 13	11:13	a.m.
1949	May 14	12:39	p.m.
1950	May 6	4:14	p.m.
1951	Apr 30	5:54	p.m.
1952	May 12	5:04	p.m.
1953	Apr 29	3:54	p.m.
1954	May 6	6:01	p.m.
1955	May 9	2:13	p.m.
1956	May 1	11:24	p.m.
1957	May 5	9:30	a.m.
1958	Apr 29	2:56	p.m.
1959	May 8	11:26	a.m.
1960	May 2	7:12	p.m.
1961	May 5	11:31	p.m.
1962	May 12	11:23	p.m.
1963	May 5	6:25	p.m.
1964	May 20	11:41	a.m.
1965	May 7	7:01	p.m.
1966	May 8	12:11	p.m.
1967	May 4	11:55	a.m.
1968	May 8	9:26	a.m.
1969	Apr 28	12:28	p.m.
1970	May 4	10:37	a.m.
1971	May 8	9:31	p.m.
1972	May 10	11:56	a.m.
1973	May 4	11:59	a.m.
1974	May 6	3:44	p.m.
1975	May 10	1:49	p.m.
1976	May 2	10:51	a.m.
1977	May 6	12:46	p.m.
1978	Apr 30	3:18	p.m.
1979	Apr 30	6:16	p.m.
1980	Apr 29	1:16	p.m.
1981	Apr 30	6:44	p.m.
1982	May 10	5:36	p.m.
1983	Apr 29	6:37	p.m.
1984	May 9	3:33	p.m.
1985	May 11	2:36	p.m.
1986	May 8	10:50	p.m.
1987	May 5	3:11	p.m.
1988	Apr 27	9:15	a.m.
1989	May 1	8:14	p.m.
1990	Apr 24	5:19	p.m.
1991	May 1	12:04	a.m.
1992	May 14	6:28	a.m.
1993	Apr 23	1:01	p.m.
1994	Apr 29	11:01	p.m.
1995	Apr 26	1:22	p.m.
1996	May 5	12:32	p.m.
1997	Apr 30	10:28	a.m.
1998	Apr 20	4:54	p.m.
1999	Apr 29	9:47	p.m.
2000	May 1	10:47	a.m.
2001	May 8	1:00	p.m.
2002	May 7	9:27	p.m.

```
2003   Apr 29   6:22 p.m.
2004   Apr 24   2:16 p.m.
   ;
%let yr0=1967;
data dates; do year=1917 to 2020;
ramp=(year-&yr0)*(year>&yr0); output; end;
data all; merge Ice dates; by year;
proc arima; i var=break crosscor=(ramp) noprint;
e input=(ramp) p=(6);
f lead=5 id=year out=out1;
proc gplot;
plot (break u95 l95 forecast)*year/overlay href=&yr0;
title "Tanana River Ice Breakup";
symbol1 v=dot i=join c=black;
symbol2 v=none i=join l=2 c=gray r=2;
symbol3 v=none i=join c=gray;
run;

** Optional: Using NLIN to estimate ramp start point **;
proc nlin data=all;
parms C=1960 a=126 b=-.2 ;
  X = (year-C)*(year>c);
model break = a + b*X;
run;
```



The ARIMA Procedure

Conditional Least Squares Estimation

Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|	Lag	Variable
MU	126.01962	0.59155	213.03	<.0001	0	break
AR1,1	-0.21784	0.10929	-1.99	0.0494	6	break
NUM1	-0.18686	0.04326	-4.32	<.0001	0	ramp

Autocorrelation Check of Residuals

To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	4.81	5	0.4399	-0.040	0.043	-0.064	0.054	-0.197	-0.034
12	14.37	11	0.2134	0.056	-0.089	-0.090	0.215	-0.023	-0.167
18	18.06	17	0.3850	-0.044	0.079	0.033	-0.060	0.129	-0.063
24	21.22	23	0.5679	-0.054	0.031	0.016	-0.123	-0.036	-0.075

Model for variable break

Estimated Intercept 126.0196

Autoregressive Factors

Factor 1: 1 + 0.21784 B**(6)

Input Number 1

Input Variable	ramp
Overall Regression Factor	-0.18686

Tanana River Ice Breakup

The NLIN Procedure

Dependent Variable break

Method: Gauss-Newton

Iterative Phase

Iter	C	a	b	Sum of Squares
0	1960.0	126.0	-0.2000	2850.8
1	1975.1	125.6	-0.2248	2714.6
2	1965.7	126.0	-0.1527	2710.9
3	1967.8	126.0	-0.1860	2702.2
4	1967.6	126.0	-0.1873	2702.1
5	1967.6	126.0	-0.1873	2702.1

NOTE: Convergence criterion met.

Source	DF	Sum of Squares	Mean Square	F Value	Approx Pr > F
Model	2	403.5	201.7	6.35	0.0027
Error	85	2702.1	31.7894		
Corrected Total	87	3105.6			

Parameter	Estimate	Approx Std Error	Approximate 95% Confidence Limits	
C	1967.6	10.7354	1946.2	1988.9
a	126.0	0.7895	124.4	127.6
b	-0.1873	0.0868	-0.3599	-0.0147

Approximate Correlation Matrix

	C	a	b
C	1.0000000	-0.3926600	-0.7957997
a	-0.3926600	1.0000000	0.0000000
b	-0.7957997	0.0000000	1.0000000