Sunspots Time Series

A Long Term Time Series Analysis

What are Sunspots?

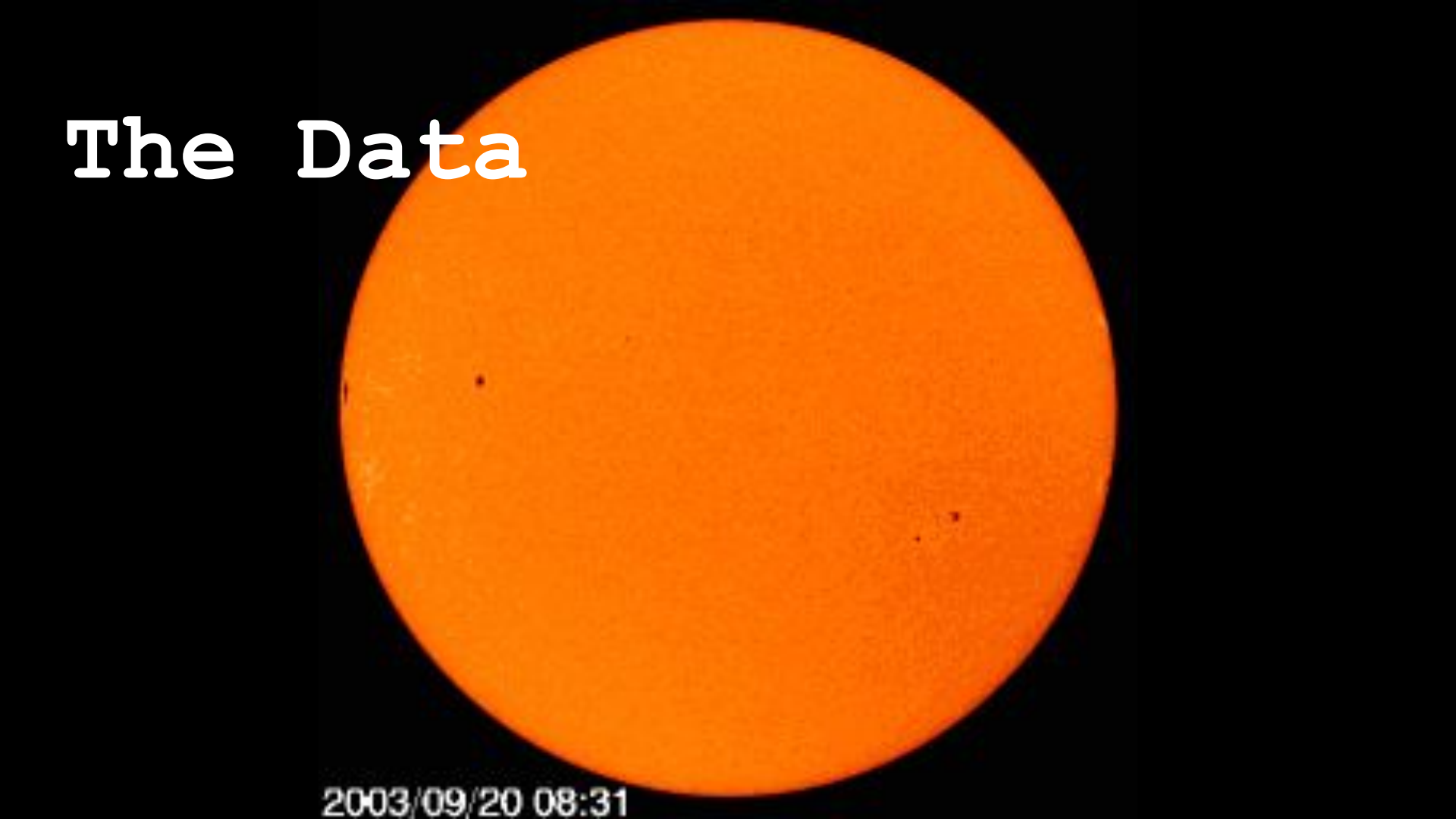
- Earth sized magnetic storms
- Correlated with the solar magnetic cycle

- Every time the Sun finishes an ~11 year cycle the magnetic poles swap places

How does it affect Earth?

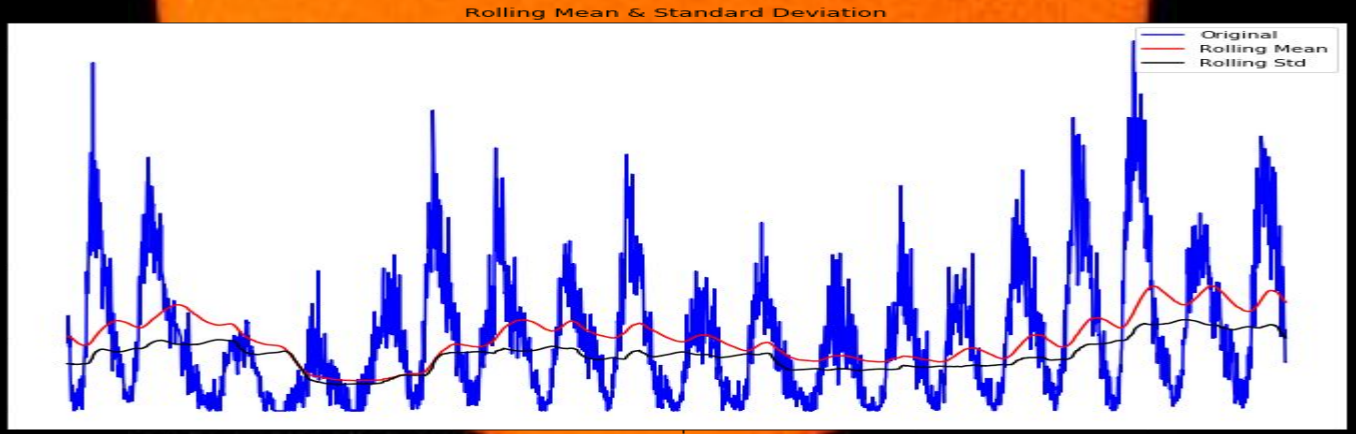
- Sunspots are correlated with Magnetic/Electrical disturbances.
- High sunspot activity is also correlated with high solar output.

The Data



The Data

- Number of sunspots per month since 1749



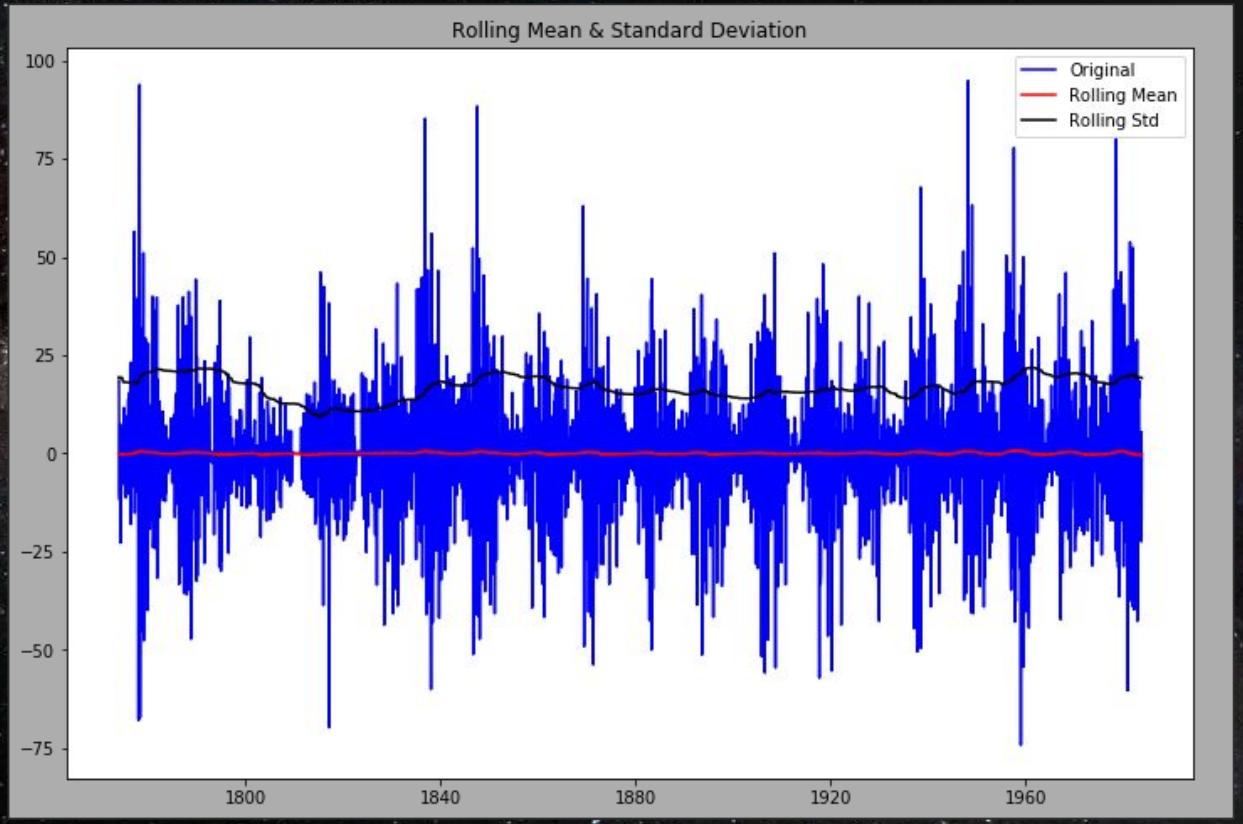
2003/09/20 08:31

First Difference

Dickey-Fuller

p-value =

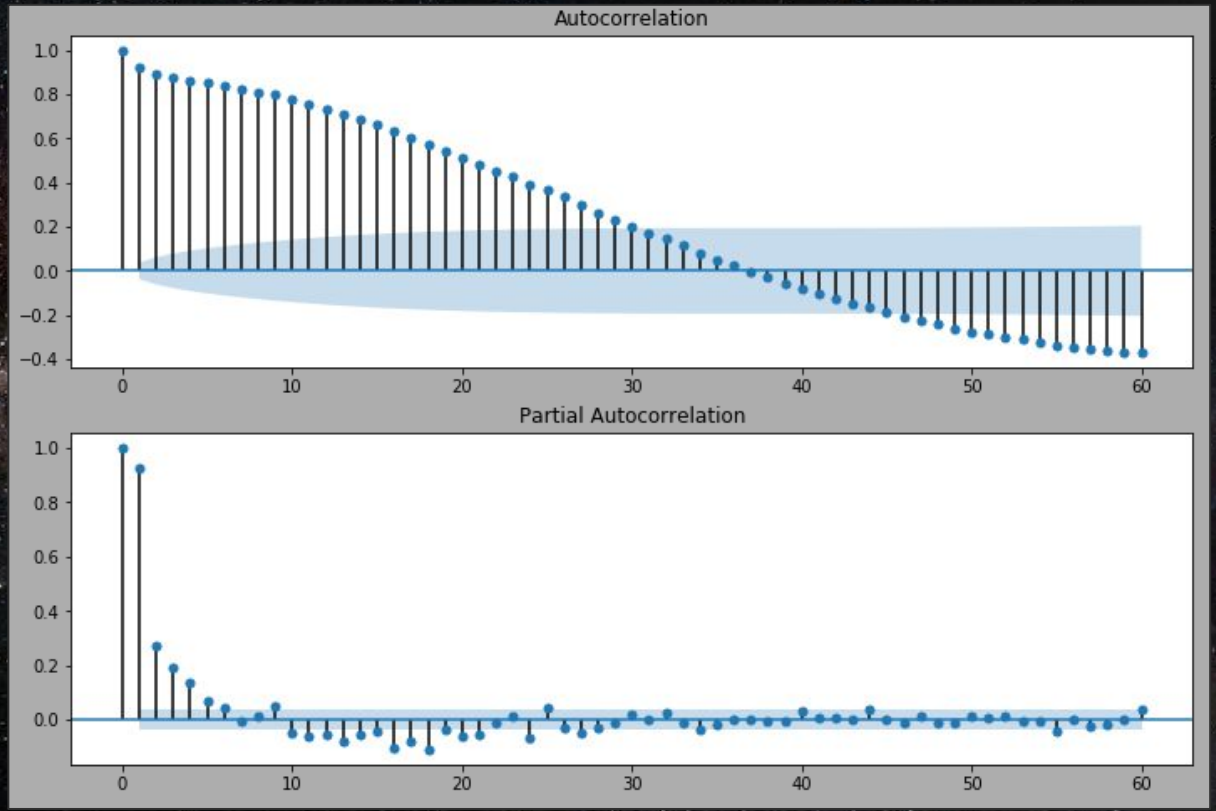
5.2 x 10e-14



ACF & PACF

Autocorrelation with original data

Partial autocorrelation with original data



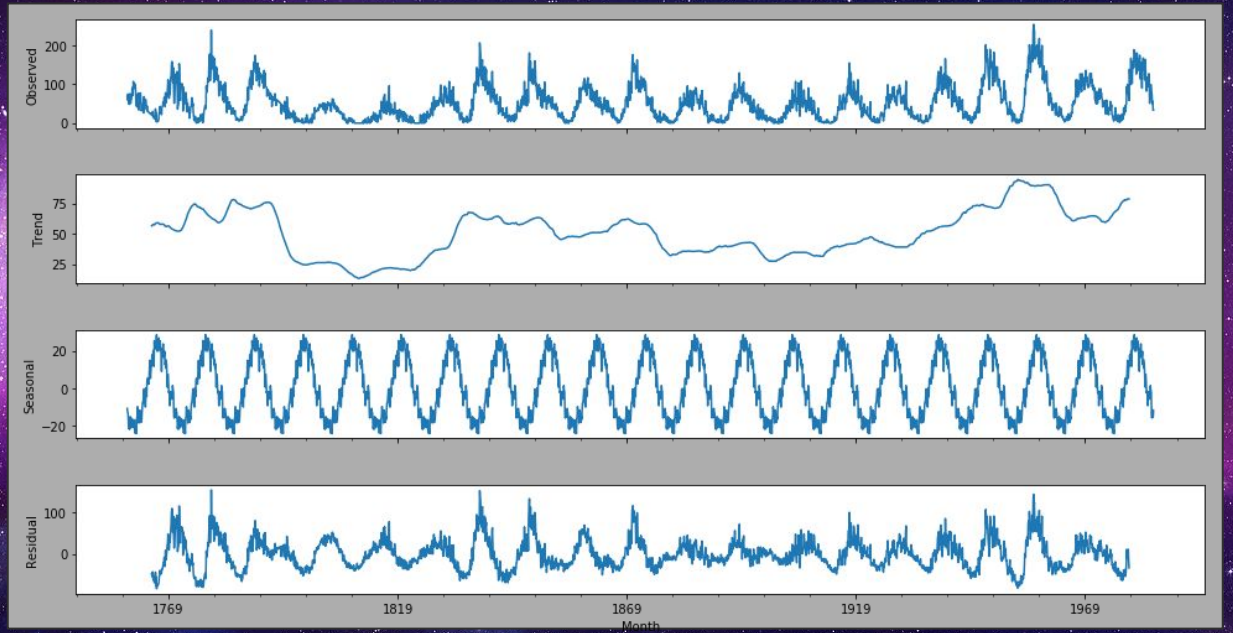
Decompose

Original Data

Trend

Seasonal

Residual



ARMA

Best parameters

p = 1
d = 0
q = 2

ARMA Model Results

Dep. Variable:	Sunspots	No. Observations:	2256
Model:	ARMA(1, 0)	Log Likelihood	-9455.359
Method:	css-mle	S.D. of innovations	15.989
Date:	Mon, 15 Jul 2019	AIC	18916.718
Time:	14:16:21	BIC	18933.882
Sample:	01-01-1749	HQIC	18922.982
	- 12-01-1936		

	coef	std err	z	P>|z|	[0.025	0.975]
const	45.0436	3.475	12.964	0.000	38.234	51.854
ar.L1.Sunspots	0.9035	0.009	99.998	0.000	0.886	0.921

Roots

	Real	Imaginary	Modulus	Frequency
AR.1	1.1068	+0.0000j	1.1068	0.0000

const	45.043609
ar.L1.Sunspots	0.903512

SARIMA

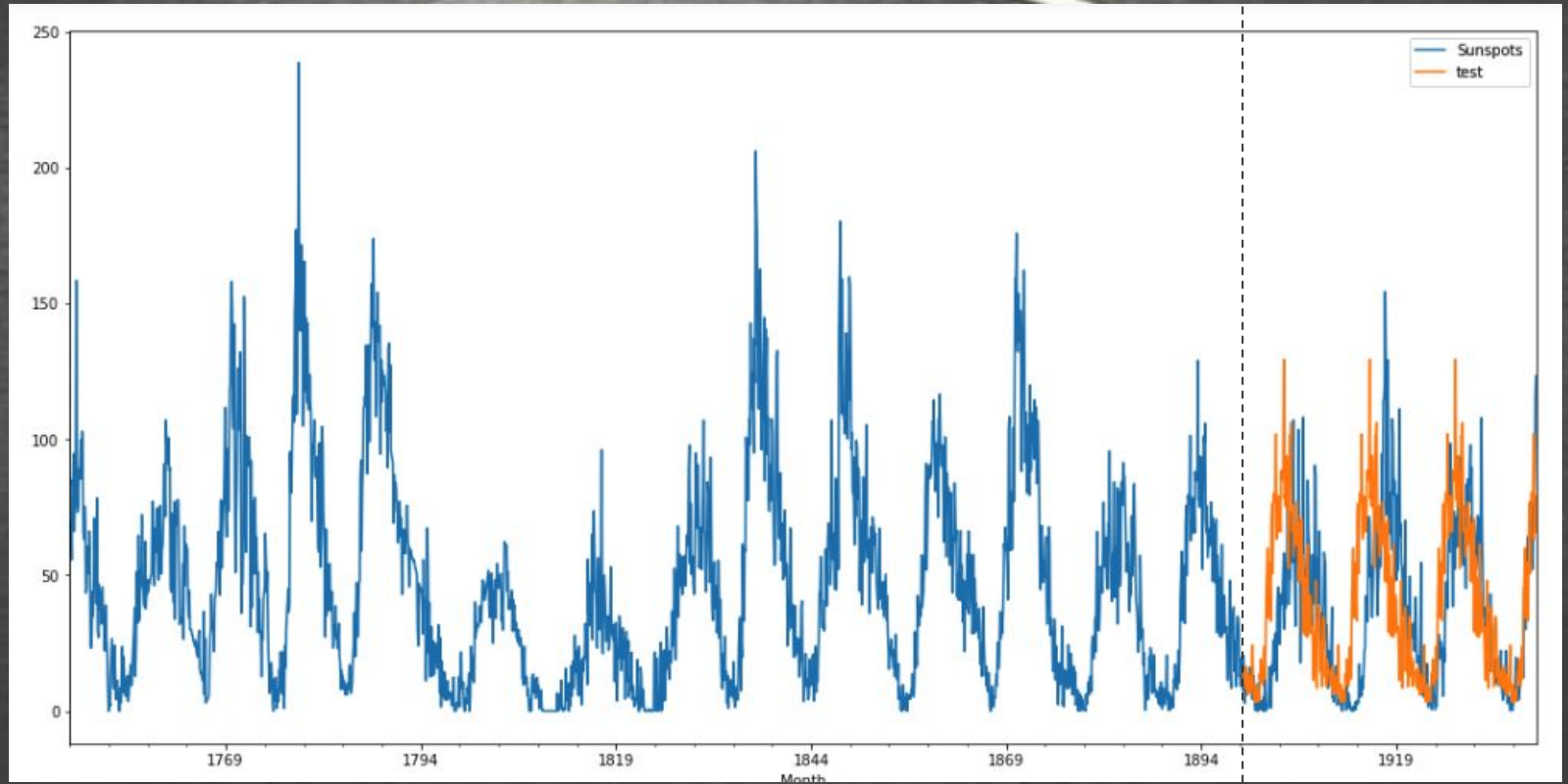
Statespace Model Results

Dep. Variable:	Sunspots	No. Observations:	2256
Model:	SARIMAX(1, 0, 1)x(0, 1, 0, 132)	Log Likelihood	-9452.861
Date:	Mon, 15 Jul 2019	AIC	18911.723
Time:	14:07:07	BIC	18928.706
Sample:	01-01-1749	HQIC	18917.940
	- 12-01-1936		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.9520	0.006	158.981	0.000	0.940	0.964
ma.L1	-0.4635	0.018	-25.419	0.000	-0.499	-0.428
sigma2	429.4240	8.731	49.186	0.000	412.312	446.536

Ljung-Box (Q):	132.73	Jarque-Bera (JB):	582.89
Prob(Q):	0.00	Prob(JB):	0.00
Heteroskedasticity (H):	0.66	Skew:	-0.07
Prob(H) (two-sided):	0.00	Kurtosis:	5.56

SARIMA Model Prediction



Sunspots Forecast until Jan 2010