Applying Time Series Tools to Study Glacier Melting Rate

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Objective

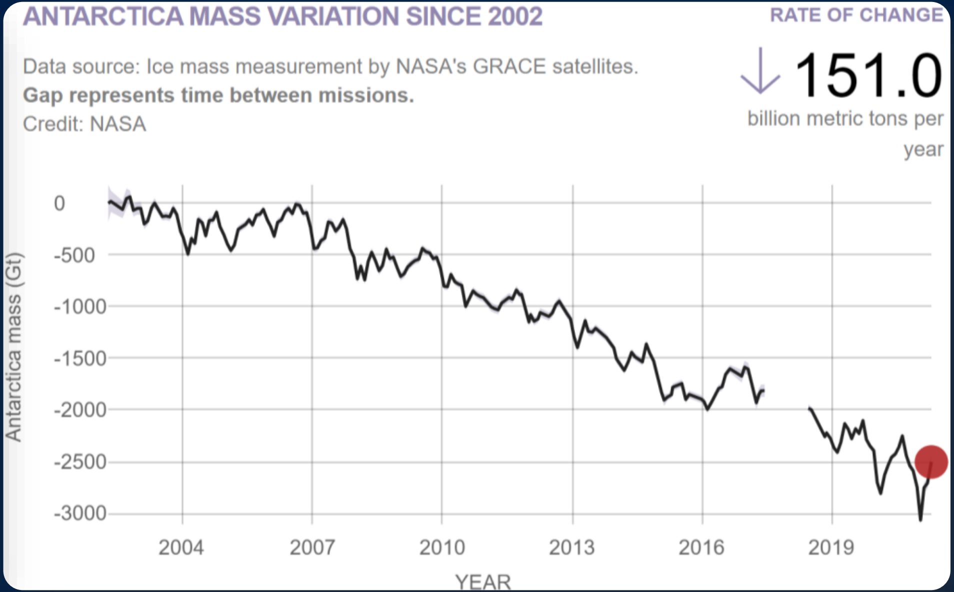
Apply Time Series platforms to study the Antarctic glacier mass data from 2002 to 2021 and to predict the melting rate for the next twenty years (2021 to 2041)

Thwaites Glacier Crisis

Scientists recently found that more warm water was flowing underneath the Antarctic glacier, the widest on the planet, than previously thought

Data

	Antarctic mass (Gigatonnes)	Year	Month	Year-Month
1	•	2002	1	01/2002
2	•	2002	2	02/2002
3	•	2002	3	03/2002
4	0	2002	4	04/2002
5	18.36	2002	5	05/2002
6	•	2002	6	06/2002
7	•	2002	7	07/2002
8	-59.82	2002	8	08/2002
9	45.54	2002	9	09/2002
10	62.69	2002	10	10/2002
11	-69.03	2002	11	11/2002
12	-49.78	2002	12	12/2002
13	-48.71	2003	1	01/2003
14	-200.03	2003	2	02/2003
15	-171.49	2003	3	03/2003
16	-43.66	2003	4	04/2003
17	0.79	2003	5	05/2003
18	•	2003	6	06/2003
19	-128.94	2003	7	07/2003
20	-122.41	2003	8	08/2003
21	-130.92	2003	9	09/2003
22	-48.06	2003	10	10/2003
23	-107.58	2003	11	11/2003
24	-273.11	2003	12	12/2003



ARIMA

Non-seasonal and seasonal

(0, 1, 0) Seasonal Model

Trend component may be masked by seasonal component

Model Summary

DF	177	Stable	Yes
Sum of Squared Innovations	190902953	Invertible	Yes
Sum of Squared Residuals	190902953		
Variance Estimate	10785.4776		
Standard Deviation	103.853154		
Akaike's 'A' Information Criterion	2159.03944		
Schwarz's Bayesian Criterion	2162.22122		
RSquare	0.98552619		
RSquare Adj	0.98552619		
MAPE	62.7004251		
MAE	74.8044093		
-2LogLikelihood	2157.03944		

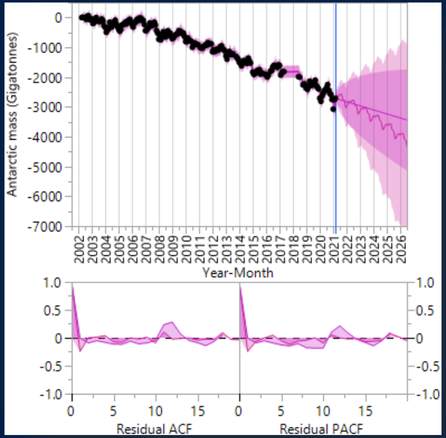
Parameter Estimates

Term	Lag	Estimate	Std Error	t Ratio	Prob>|t|	Constant Estimate	Mu
Intercept	0	-10.42635	7.758467	-1.34	0.1807	-10.426349	-10.426349

Lag	AutoCorr	Ljung-Box Q	p-Value
0	1.0000	.	.
1	-0.0039	0.0030	0.9562
2	-0.0892	1.5792	0.4540
3	-0.0512	2.1010	0.5517
4	-0.0797	3.3734	0.4974
5	-0.1122	5.9063	0.3154
6	-0.1157	8.6158	0.1964
7	-0.0565	9.2651	0.2342
8	-0.1051	11.5225	0.1738
9	-0.0897	13.1749	0.1548
10	-0.0455	13.6027	0.1919
11	0.2355	25.1284	0.0087*
12	0.2847	42.0597	<.0001*
13	0.0692	43.0658	<.0001*
14	-0.0458	43.5090	<.0001*
15	-0.0841	45.0126	<.0001*
16	-0.1400	49.1991	<.0001*
17	-0.0637	50.0707	<.0001*
18	0.0597	50.8416	<.0001*

Non-Seasonal vs Seasonal ARIMA Models

- The Seasonal ARIMA model includes the seasonal component in the forecasts and prediction interval
- The forecasting trend is much steeper after decomposing the seasonal and trend components



Model Summary

DF	142	Stable	Yes
Sum of Squared Innovations	1528569.52	Invertible	Yes
Sum of Squared Residuals	1574430.25		
Variance Estimate	10764.5741		
Standard Deviation	103.752465		
Akaike's 'A' Information Criterion	1752.44471		
Schwarz's Bayesian Criterion	1758.38434		
RSquare	0.98705993		
RSquare Adj	0.98698883		
MAPE	40.4405967		
MAE	61.9792001		
-2LogLikelihood	1748.44471		

Parameter Estimates

Term	Factor	Lag	Estimate	Std Error	t Ratio	Prob>|t|	Constant	Mu
MA2,12	2	12	0.632670	0.100669	6.28	<.0001*	Estimate	-2.3815202
Intercept	1	0	-2.381520	4.317669	-0.55	0.5821	-2.3815202	

Conclusion

- Seasonal ARIMA models could more effectively predict the glacier melting rate by decomposing the seasonal components
- Overall slope of the optimal seasonal ARIMA model was 20% greater than that of the non-seasonal ARIMA model