

Analysis of the IHME COVID 19 Forecasting Model – April 28th Update

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Introduction

- The COVID 19 virus is having a major effect on the economy
- During the last month, more than 26 million U.S. workers filed for unemployment due to the shut down a significant share of the economy
- It has become clear that the Institute for Health Metrics and Evaluation (IHME) at the University of Washington is playing a large role in the formation of policy
 - The data used in this analysis is sourced from <http://www.healthdata.org/covid>
- It is important to document and understand the ex-post performance of the prediction model and the periodic revisions that are made in the predictive model
- This is an update of the April 21st discussion that consists of three more released models



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States Covered along with the U.S.

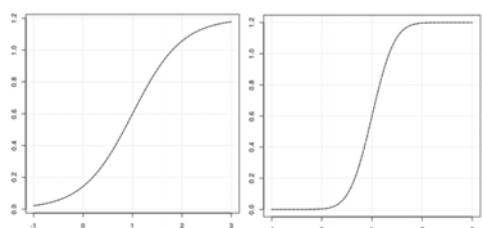
State	State	State	State
Kansas	Texas	Colorado	Arizona
New York	Georgia	Missouri	Massachusetts
California	Michigan	Nebraska	Minnesota
Florida	South Carolina	Oklahoma	Washington
Illinois	Tennessee		



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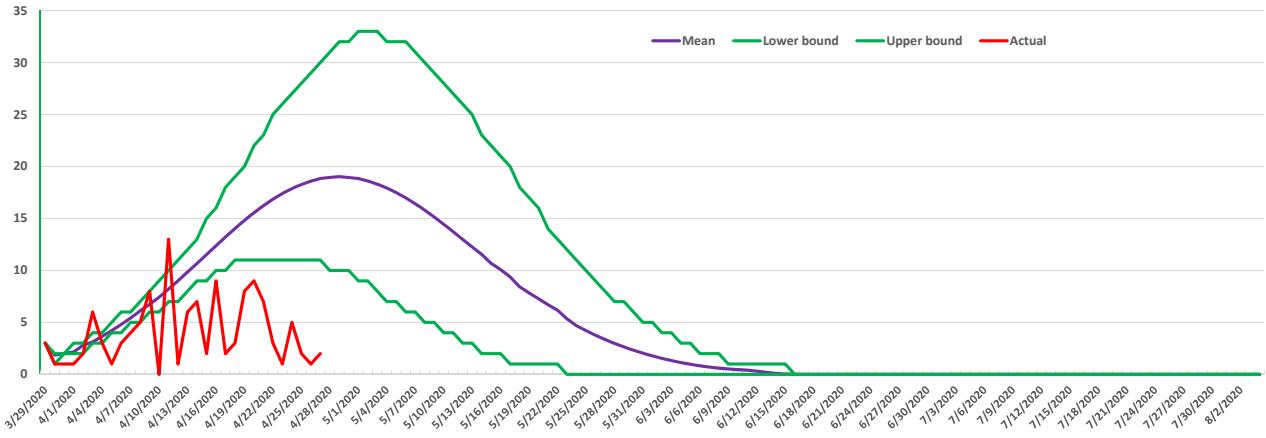
Original IHME Modeling Approach

- A statistical forecasting model using a parameterized spline
 - Using CurveFit via Python
 - Fit in log space
 - Assumed a sigmoid shape (logistic function)
 - A bounded nonlinear optimization problem
 - Used the L-BFGS-B algorithm that requires derivatives
 - Used local and national government and WHO websites
 - John Hopkins Covonavirus data
 - Article has not completed peer-review as of April 28th.
- <https://www.worldometers.info/coronavirus/country/us/> and <https://covidtracking.com/>



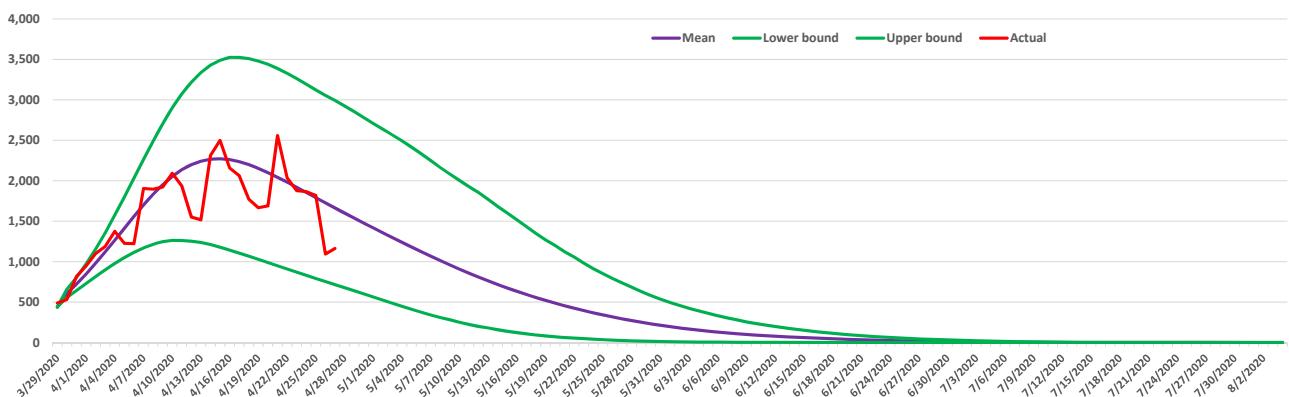
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Kansas COVID 19 Daily Death Projections March 26



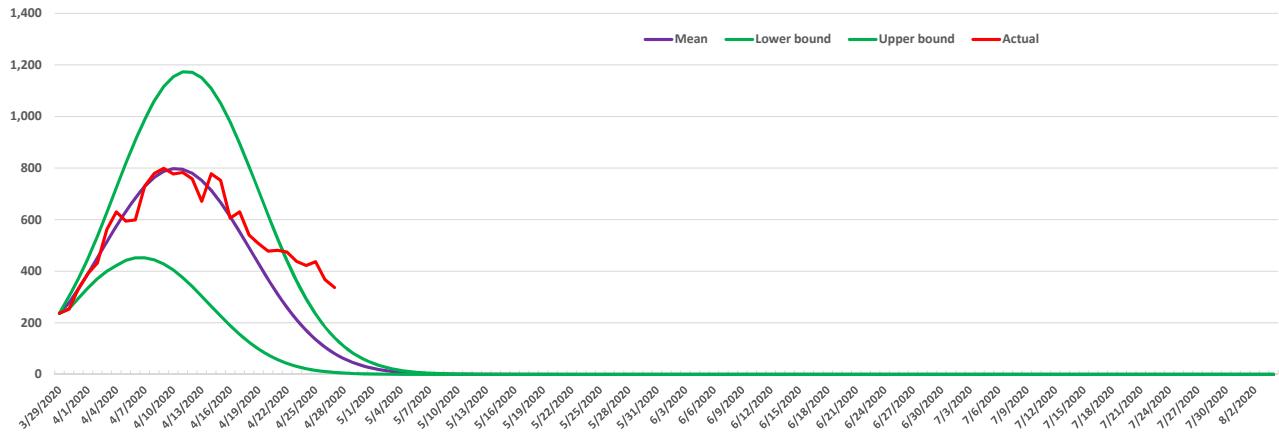
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U.S. COVID 19 Daily Death Projections March 26



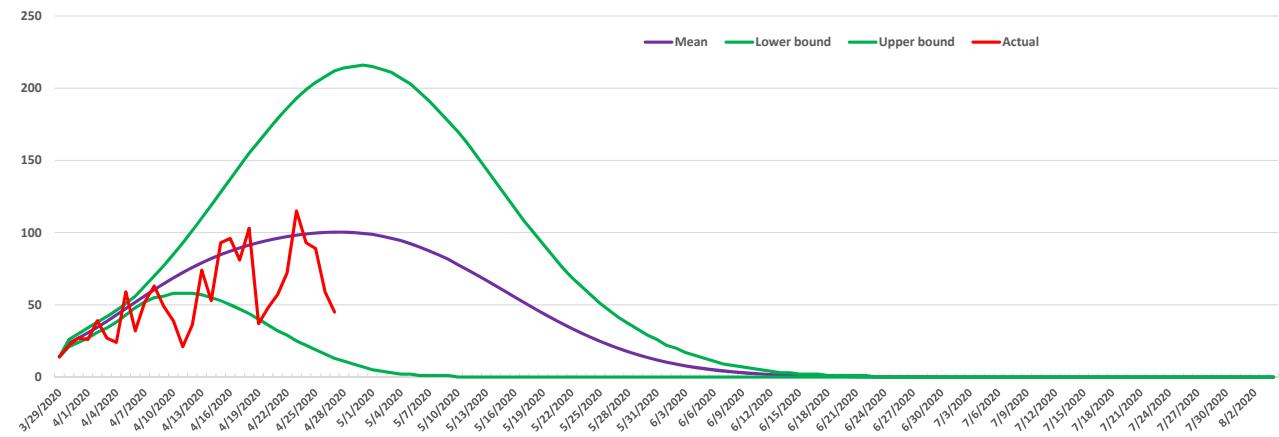
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New York COVID 19 Daily Death Projections March 26



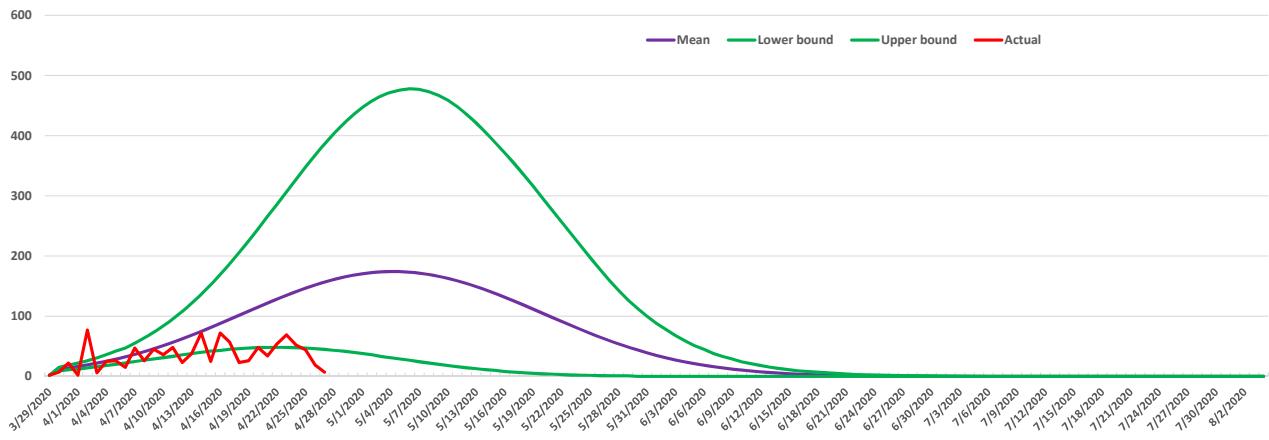
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California COVID 19 Daily Death Projections March 26



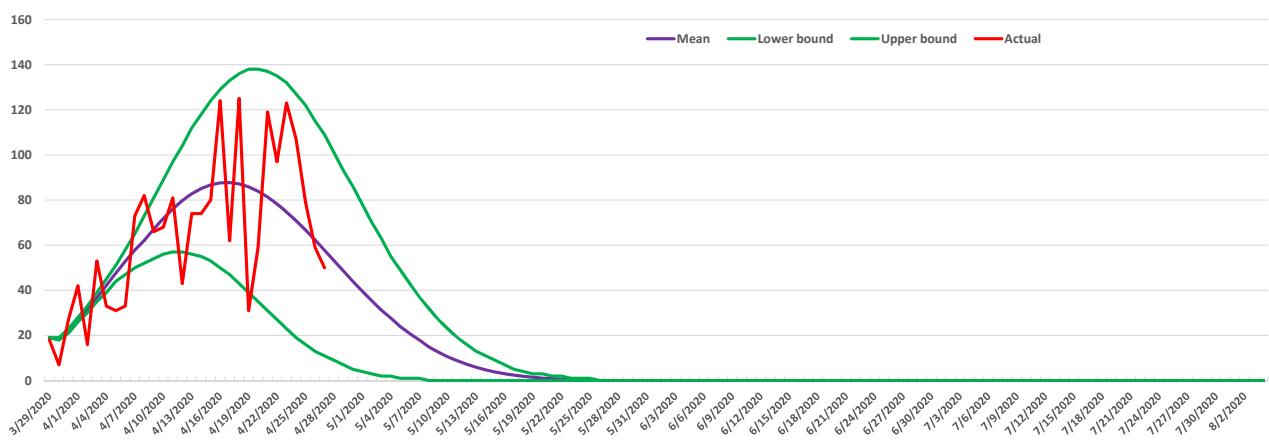
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Florida COVID 19 Daily Death Projections March 26



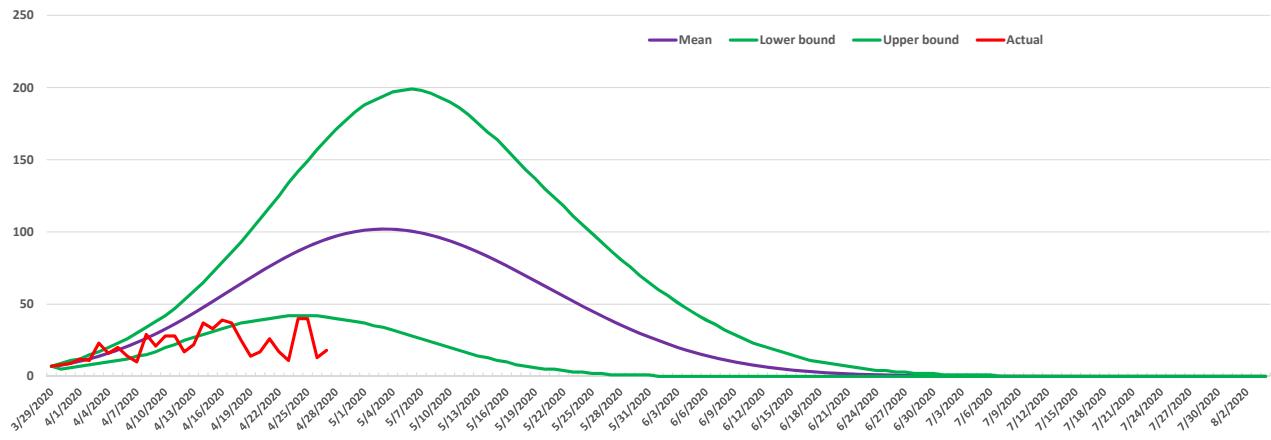
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Illinois COVID 19 Daily Death Projections March 26



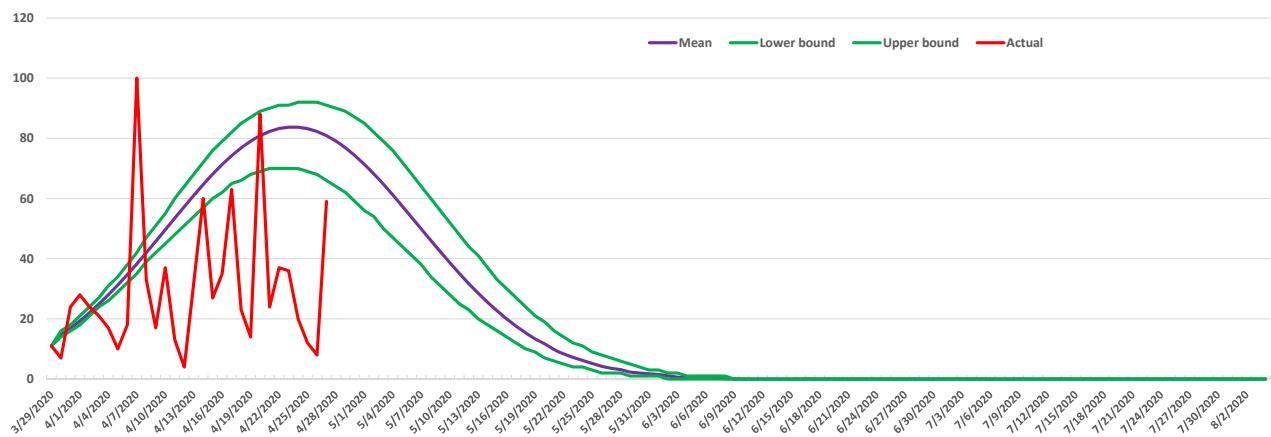
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Texas COVID 19 Daily Death Projections March 26



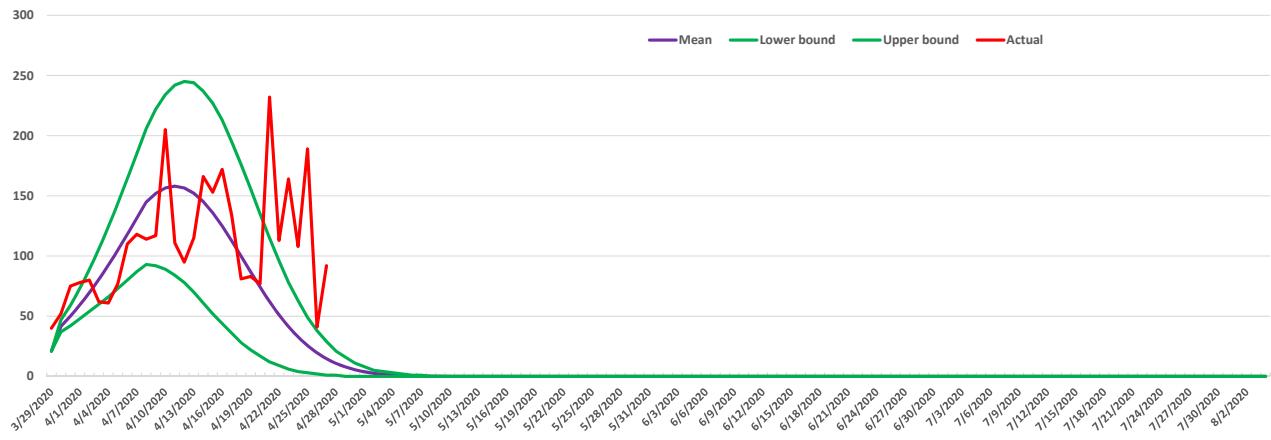
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Georgia COVID 19 Daily Death Projections March 26



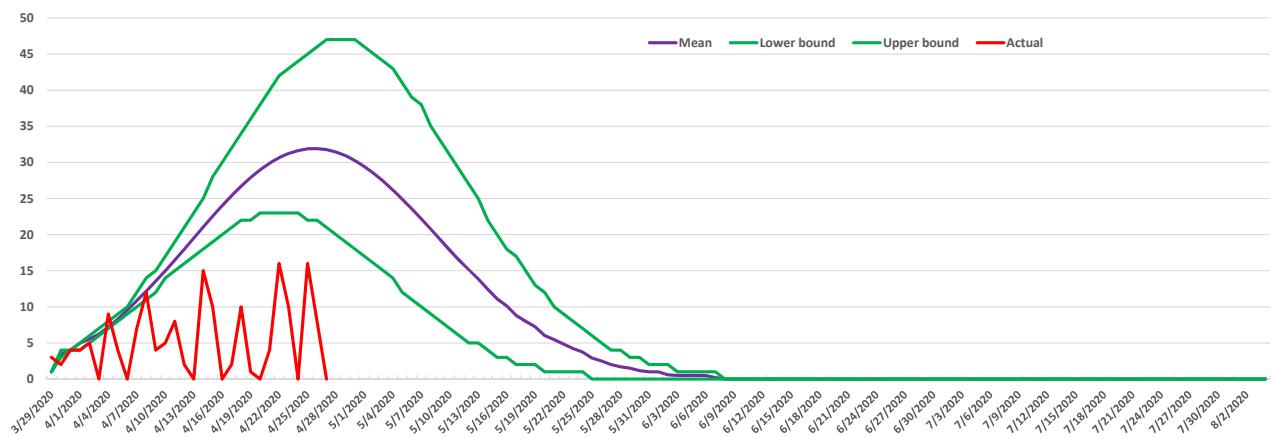
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Michigan COVID 19 Daily Death Projections March 26



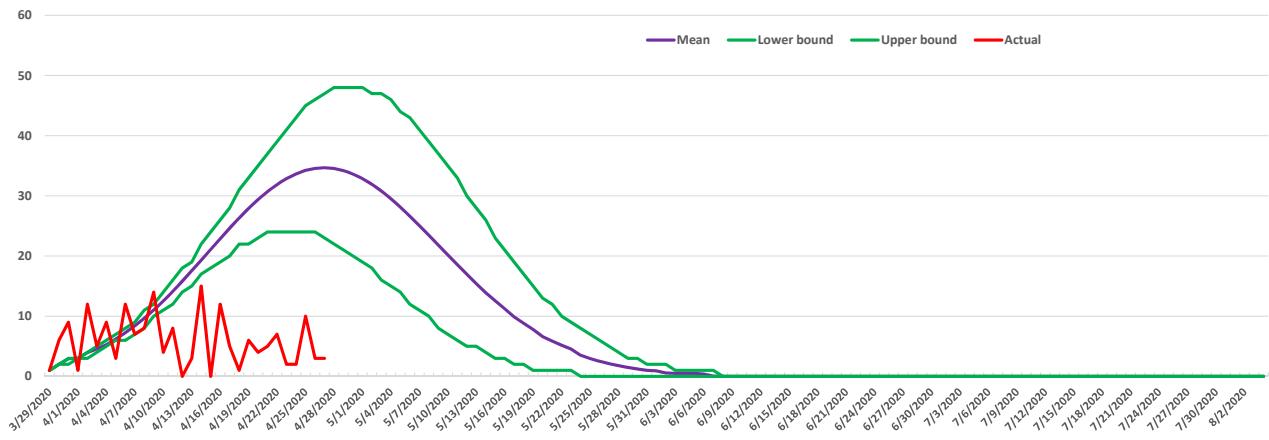
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South Carolina COVID 19 Daily Death Projections March 26



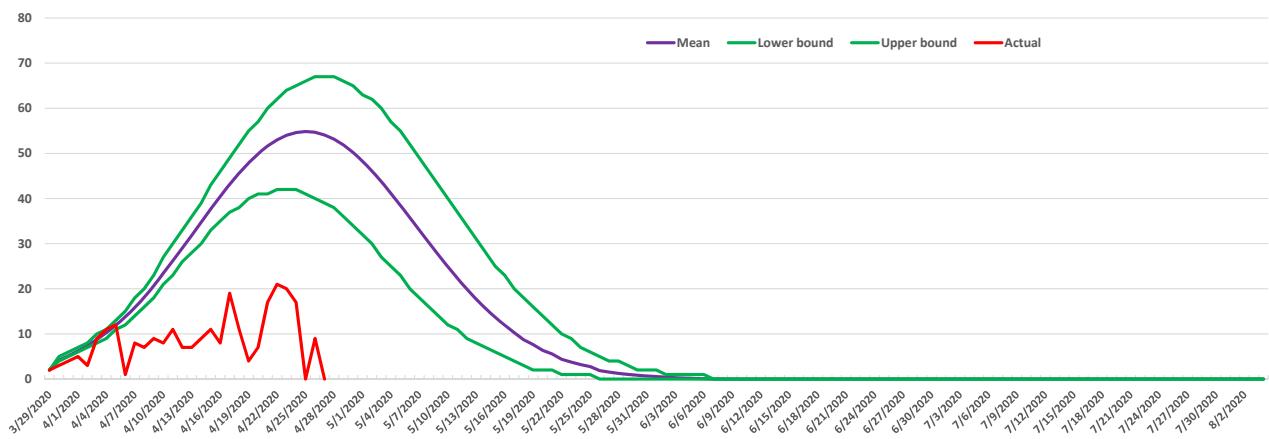
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Tennessee COVID 19 Daily Death Projections March 26



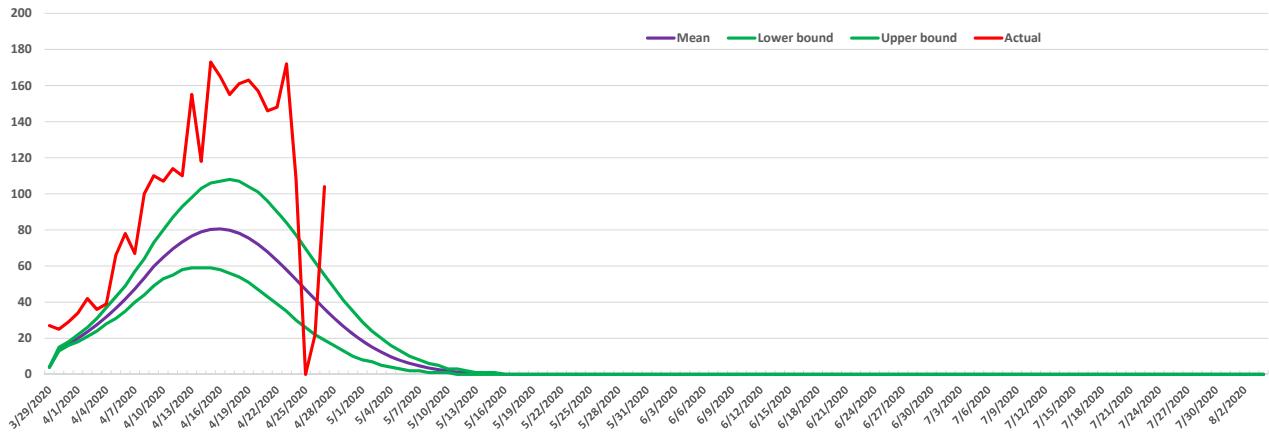
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Arizona COVID 19 Daily Death Projections March 26



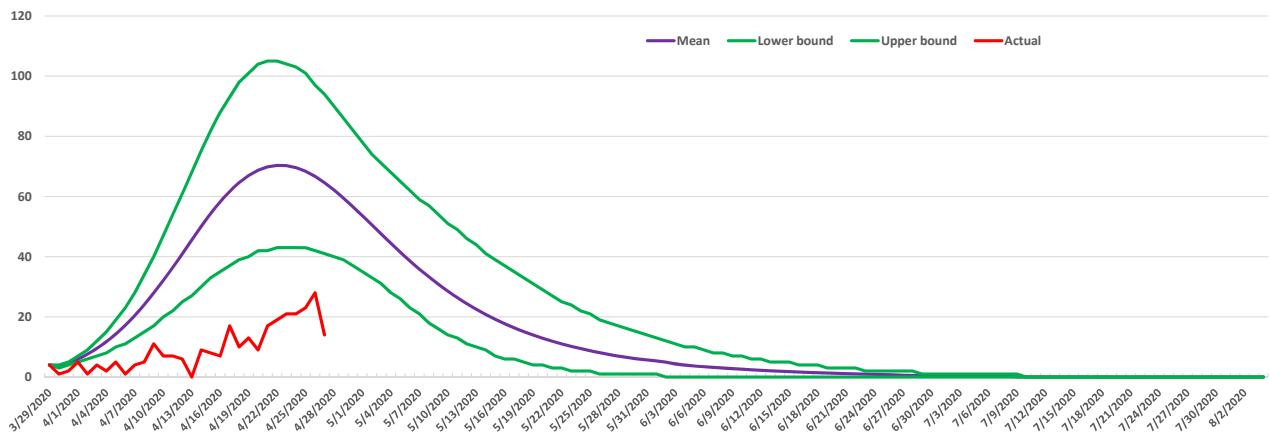
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Massachusetts COVID 19 Daily Death Projections March 26



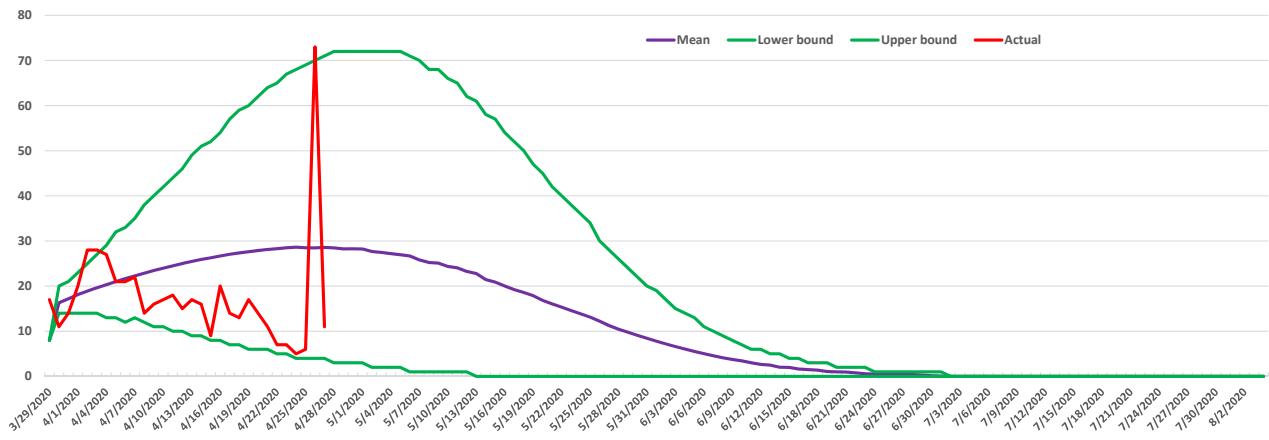
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Minnesota COVID 19 Daily Death Projections March 26



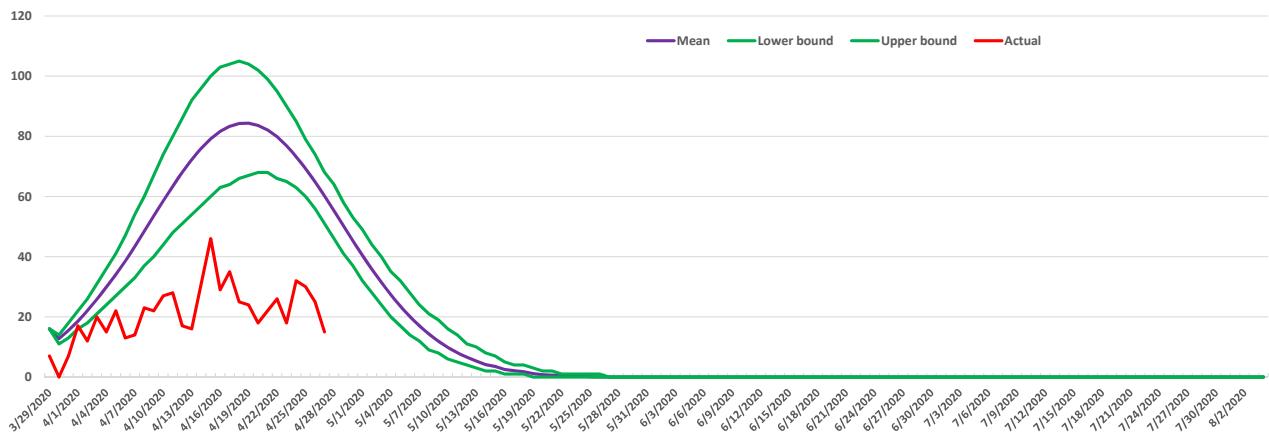
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Washington COVID 19 Daily Death Projections March 26



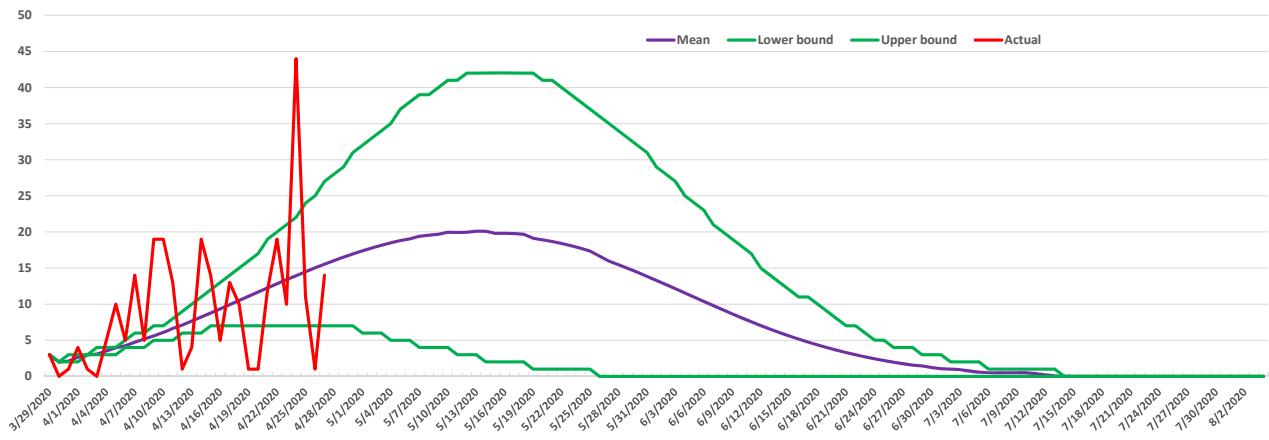
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Colorado COVID 19 Daily Death Projections March 26



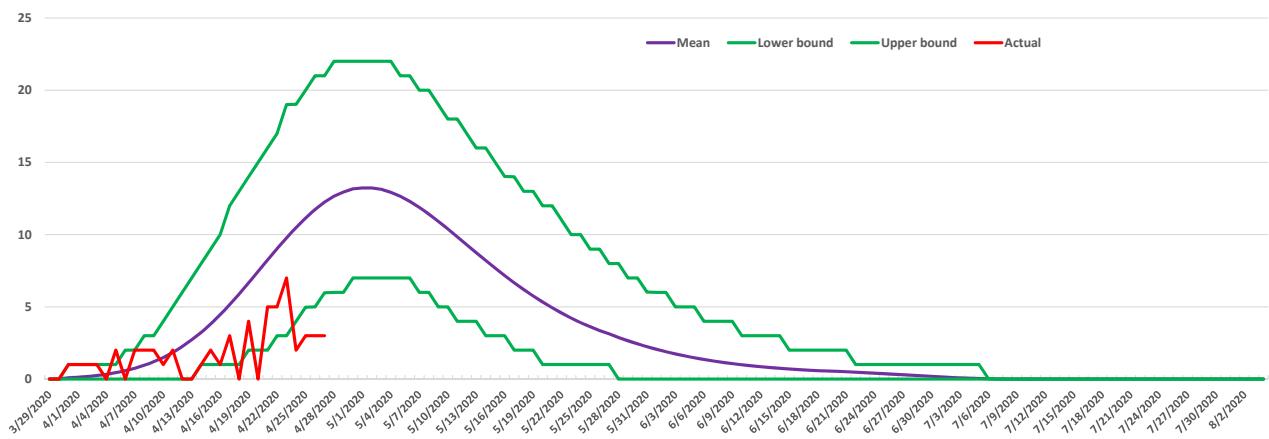
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Missouri COVID 19 Daily Death Projections March 26



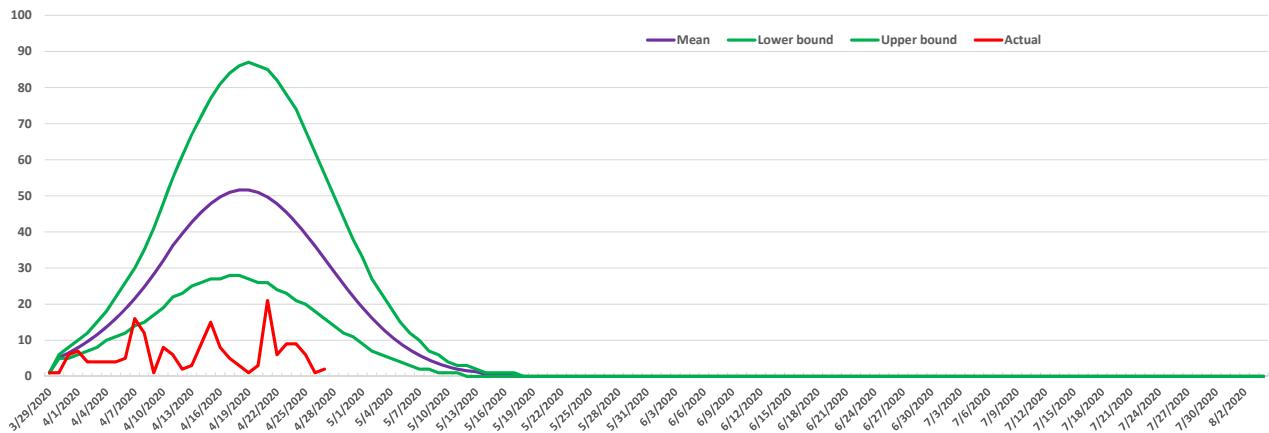
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Nebraska COVID 19 Daily Death Projections March 26



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Oklahoma COVID 19 Daily Death Projections March 26



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Forecasting performance of the March 26th model daily death projection

State	RMSE	MAE	MAPE	Bias
California	26.47	20.14	48%	15.71
Florida	60.40	44.31	225%	39.03
Illinois	23.91	19.35	39%	-1.61
Kansas	8.59	6.45	323%	6.12
New York	128.01	89.25	19%	-69.92
Texas	36.66	26.20	143%	25.26
United States	307.90	223.51	15%	108.20

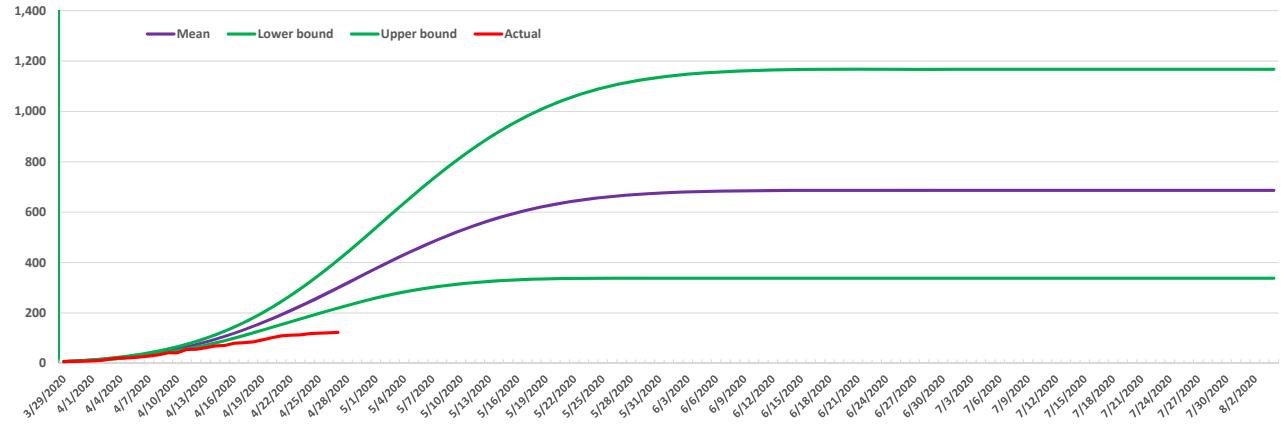
RMSE is root mean squared error – square each error, sum the errors, take the average, and calculate the square root
 MAE is the mean absolute error – the average absolute value of the error

MAPE is the mean absolute percentage error – take the absolute value of the error, divide by the actual, and average
 Bias is the average of the sum of the errors. A positive number indicates an over-prediction



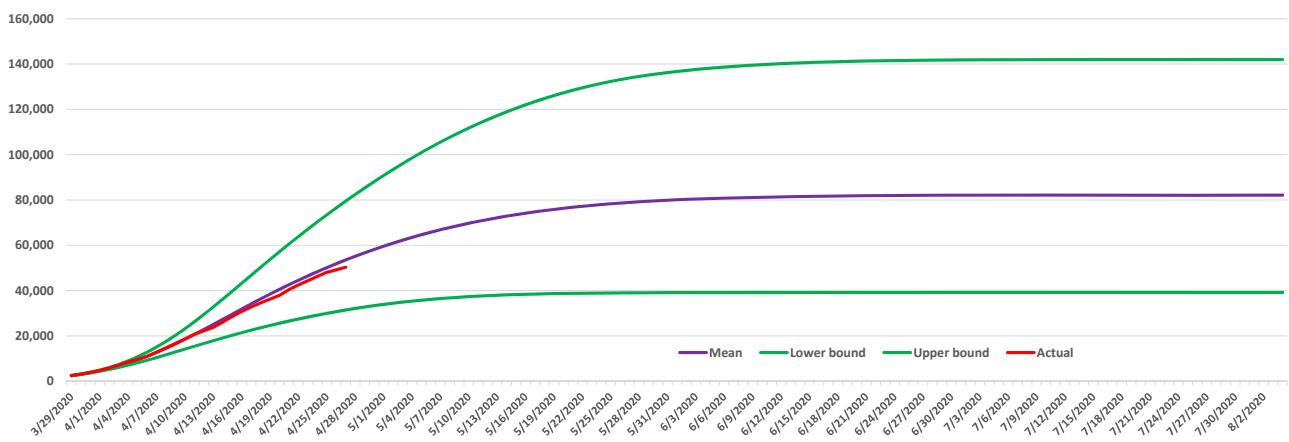
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Kansas COVID 19 Cumulative Death Projections



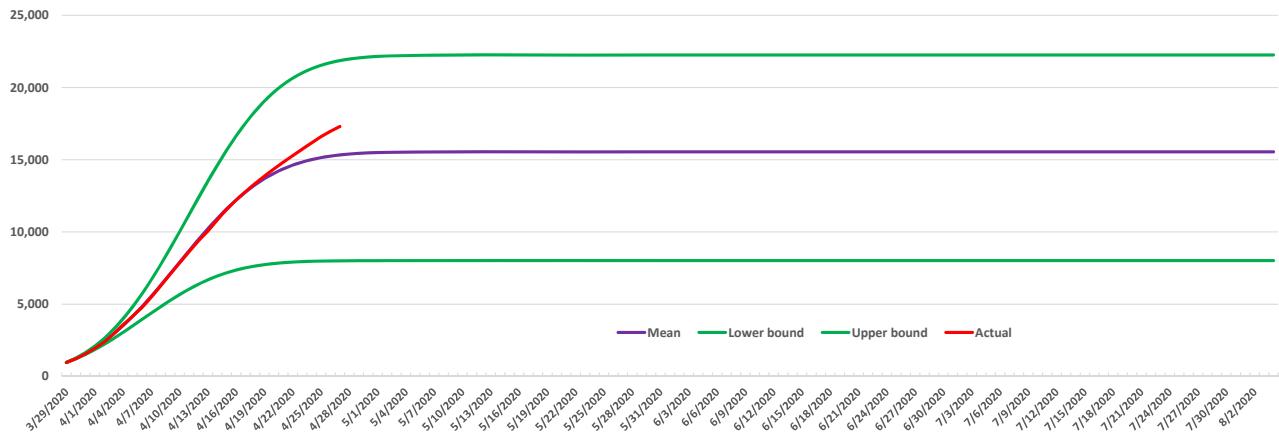
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U.S. COVID 19 Cumulative Death Projections



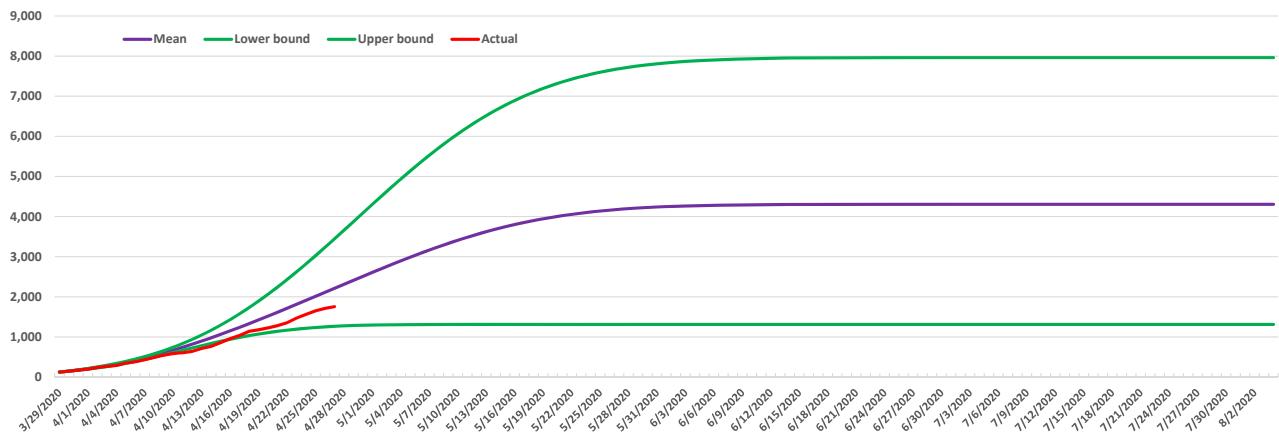
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New York COVID 19 Cumulative Death Projections



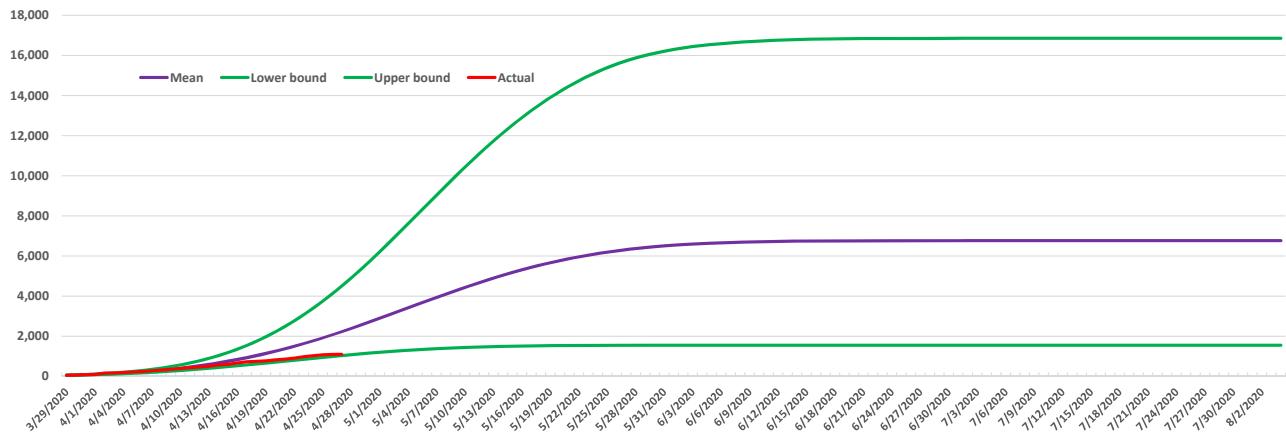
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California COVID 19 Cumulative Death Projections March 26



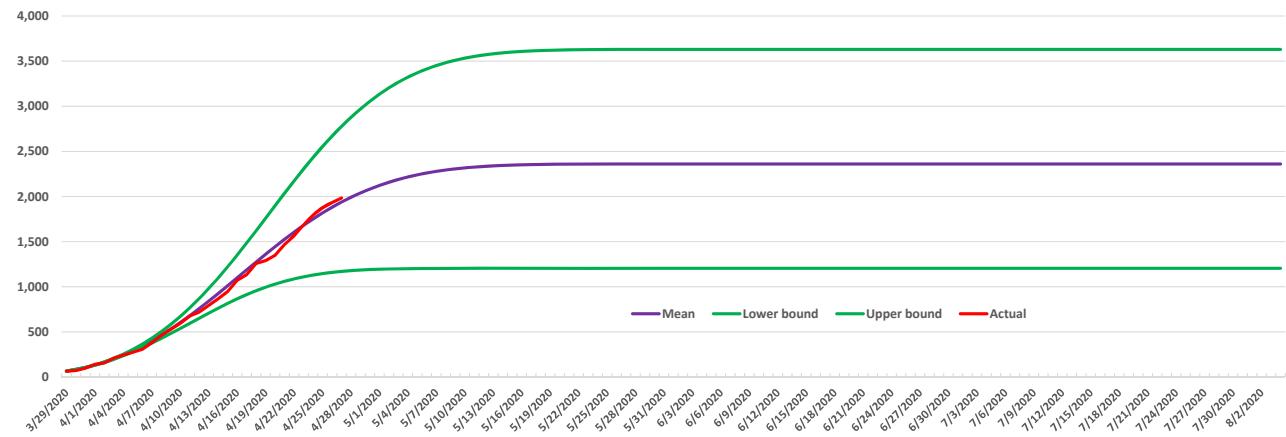
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Florida COVID 19 Cumulative Death Projections March 26



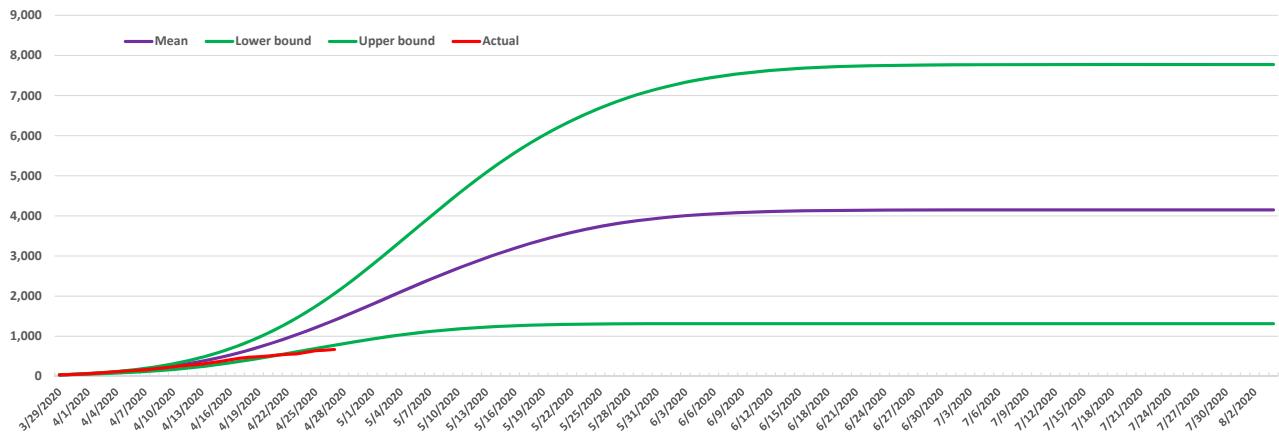
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Illinois COVID 19 Cumulative Death Projections March 26



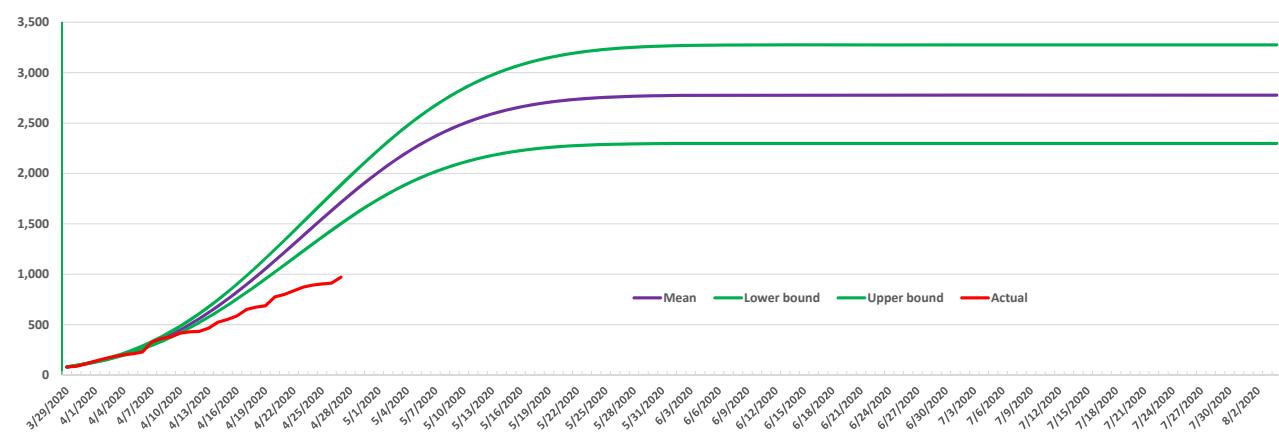
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Texas COVID 19 Daily Death Projections March 26



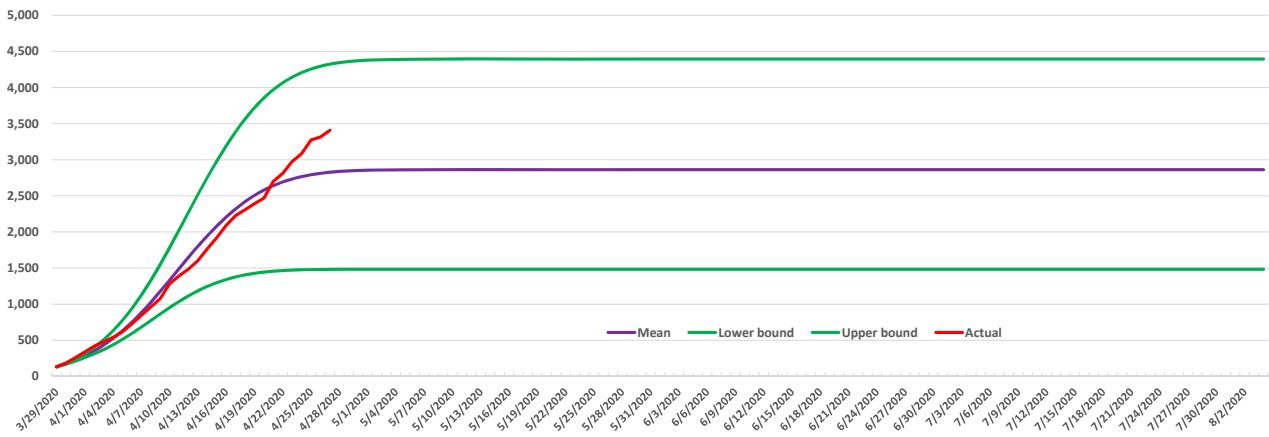
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Georgia COVID 19 Cumulative Death Projections



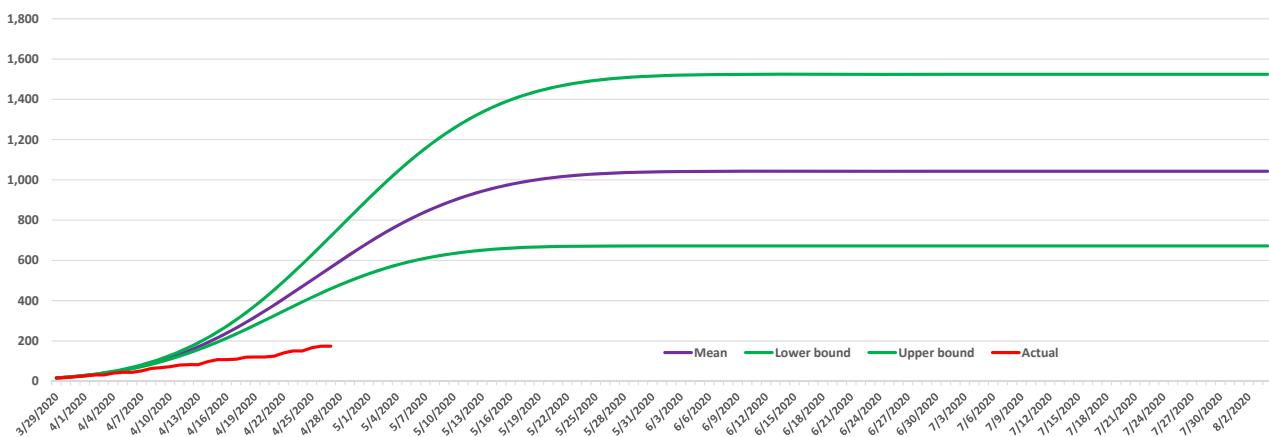
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Michigan COVID 19 Cumulative Death Projections



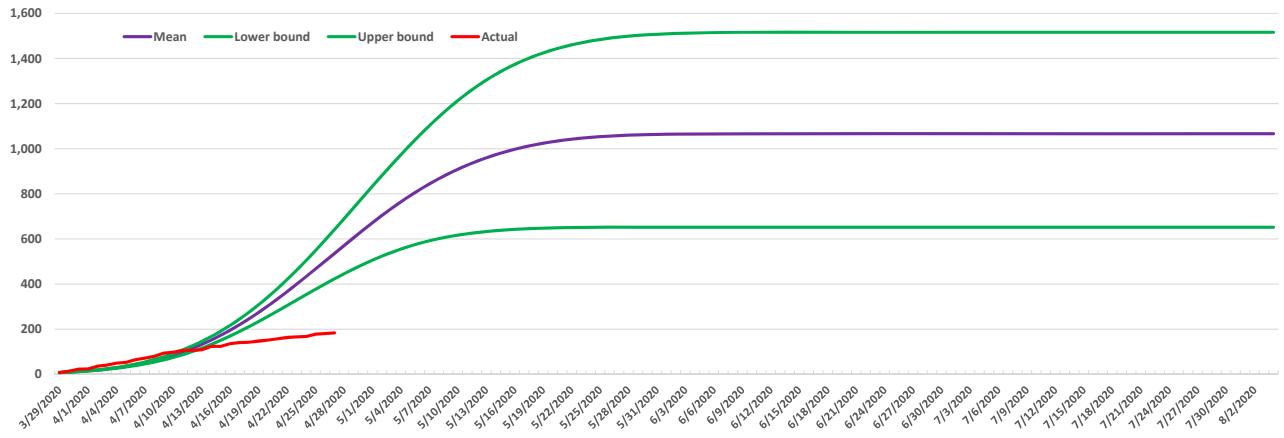
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South Carolina COVID 19 Cumulative Death Projections



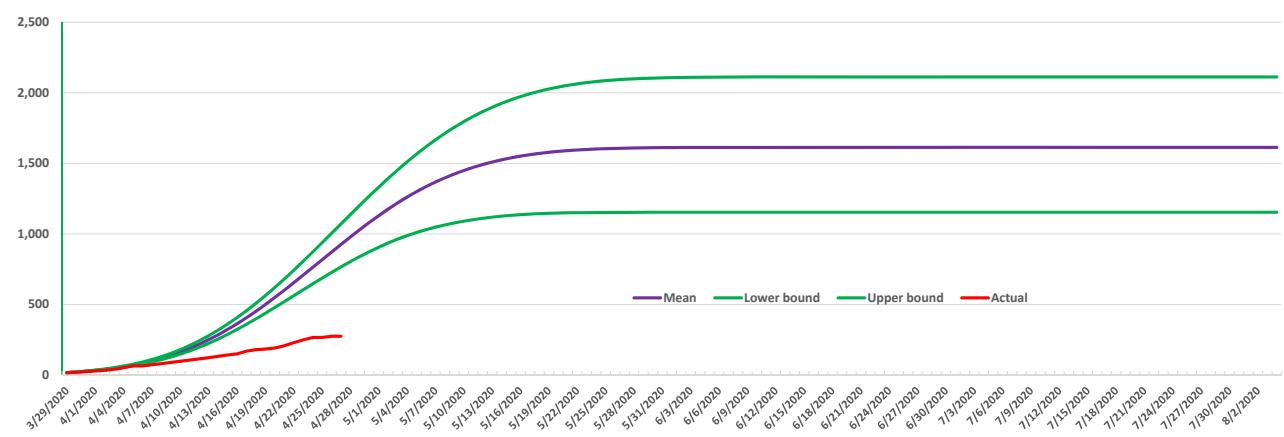
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Tennessee COVID 19 Cumulative Death Projections March 26



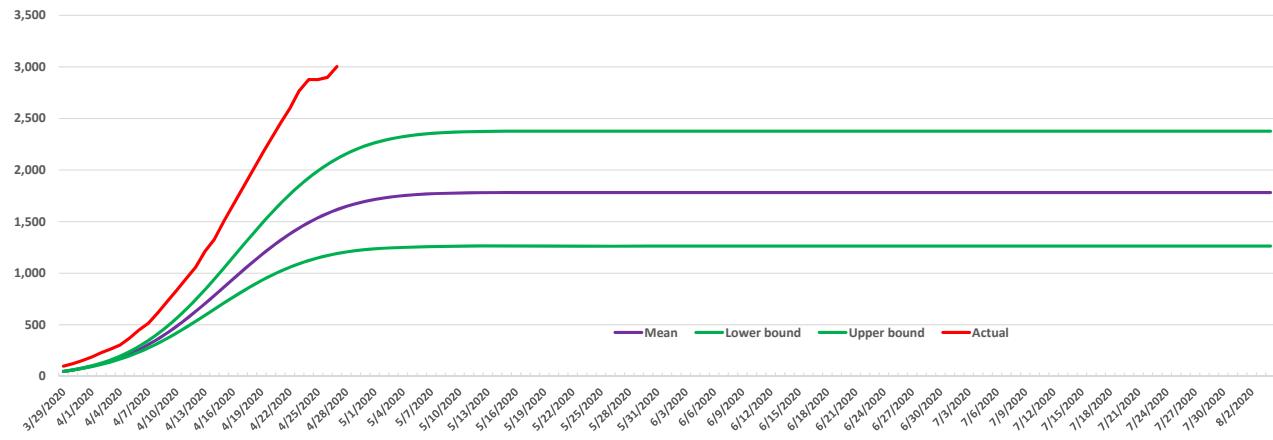
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Arizona COVID 19 Cumulative Death Projections



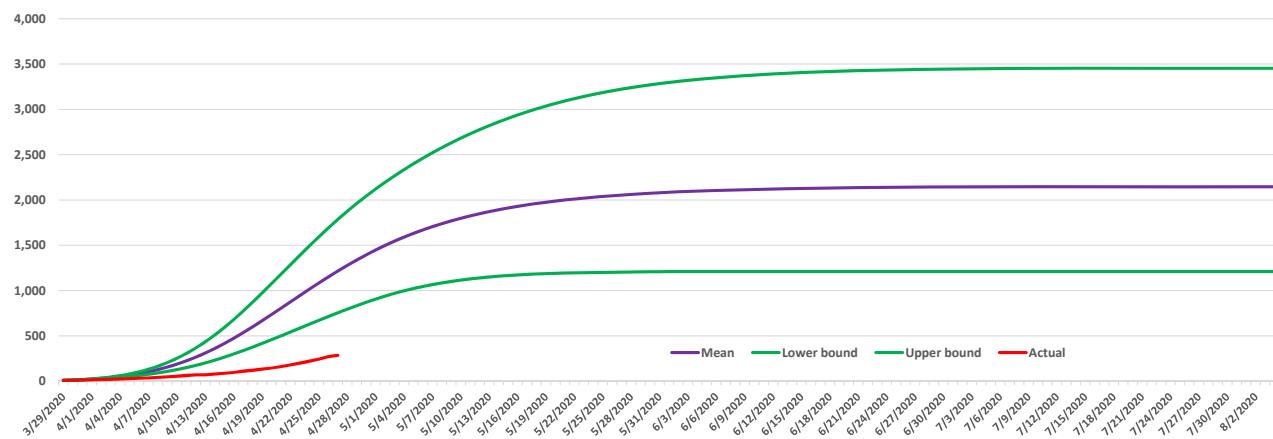
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Massachusetts COVID 19 Cumulative Death Projections



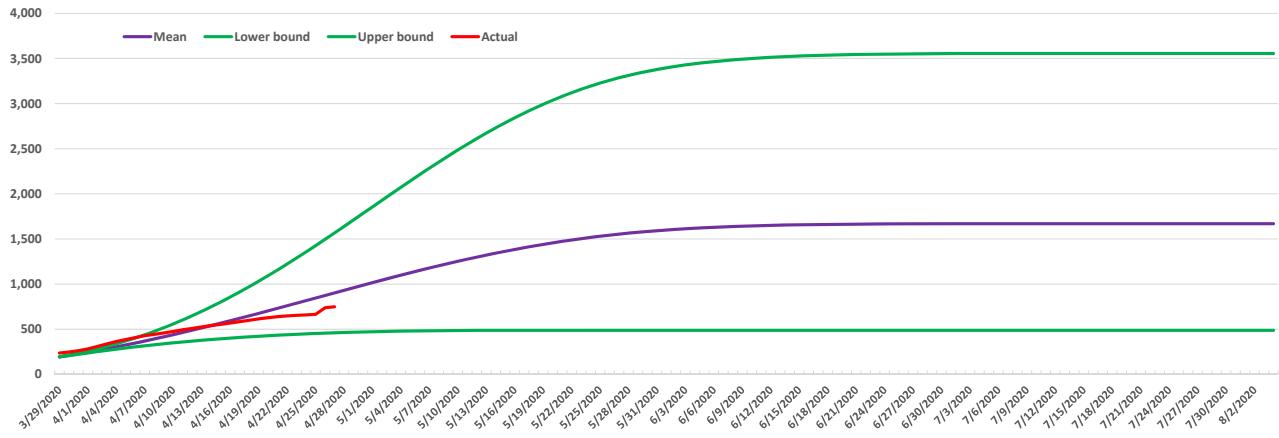
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Minnesota COVID 19 Cumulative Death Projections



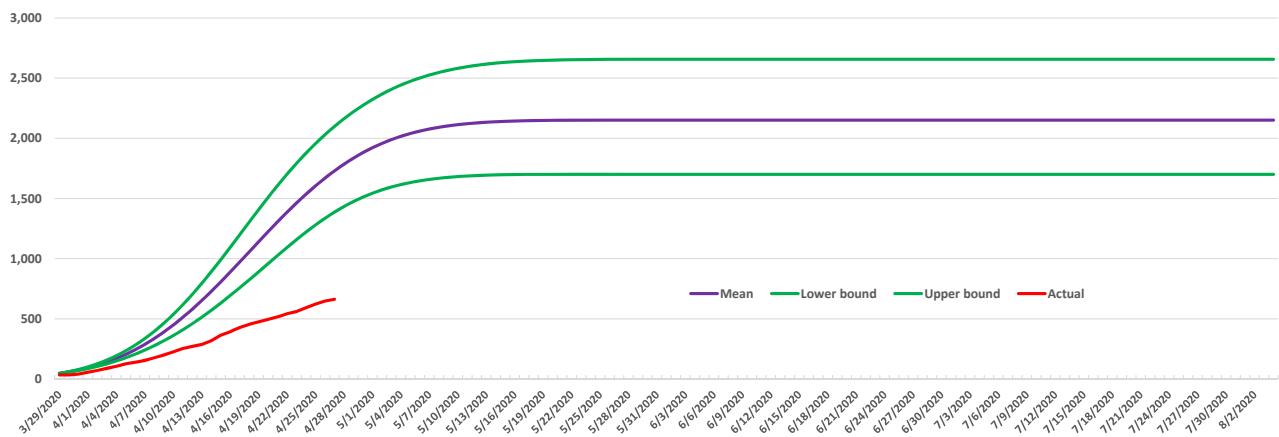
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Washington COVID 19 Cumulative Death Projections March 26



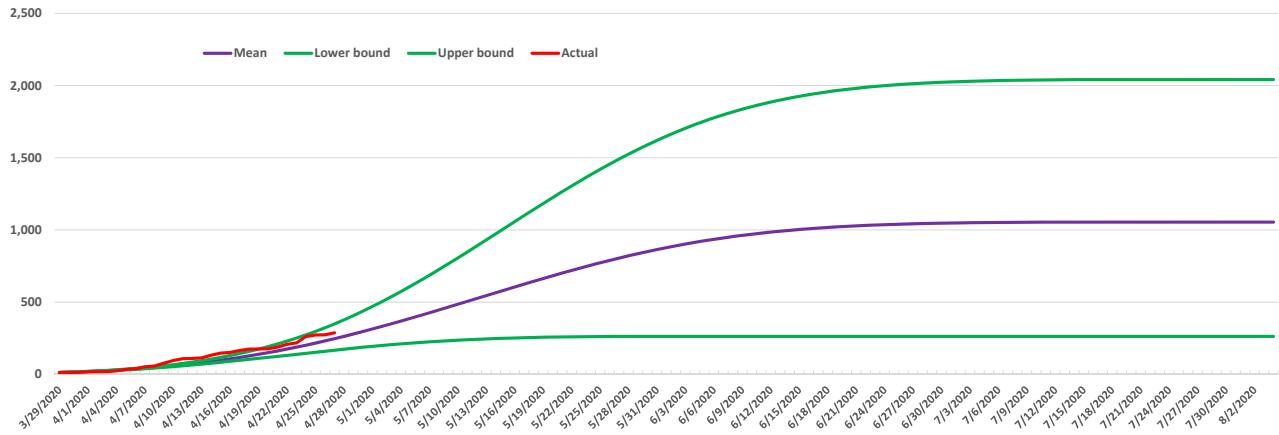
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Colorado COVID 19 Cumulative Death Projections March 26



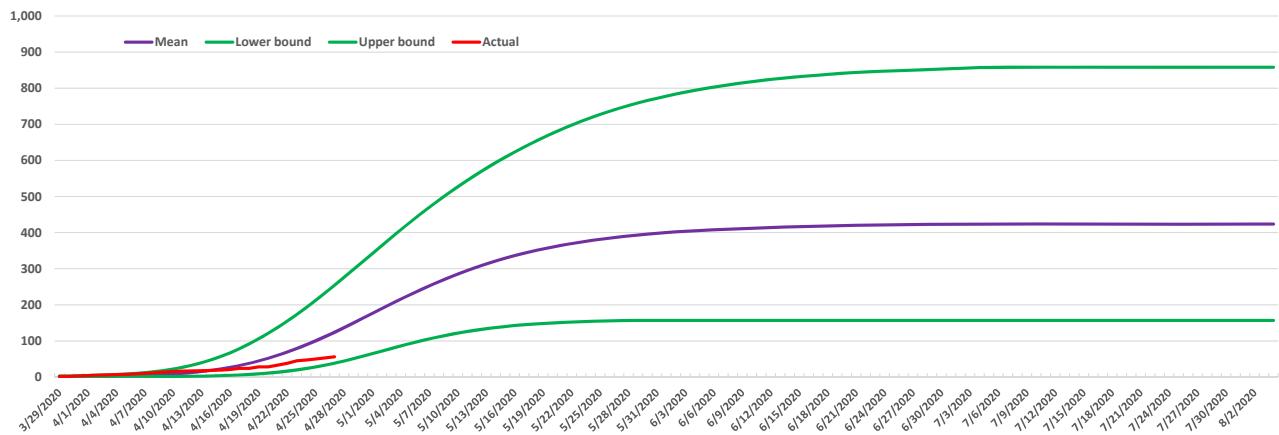
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Missouri COVID 19 Cumulative Death Projections March 26



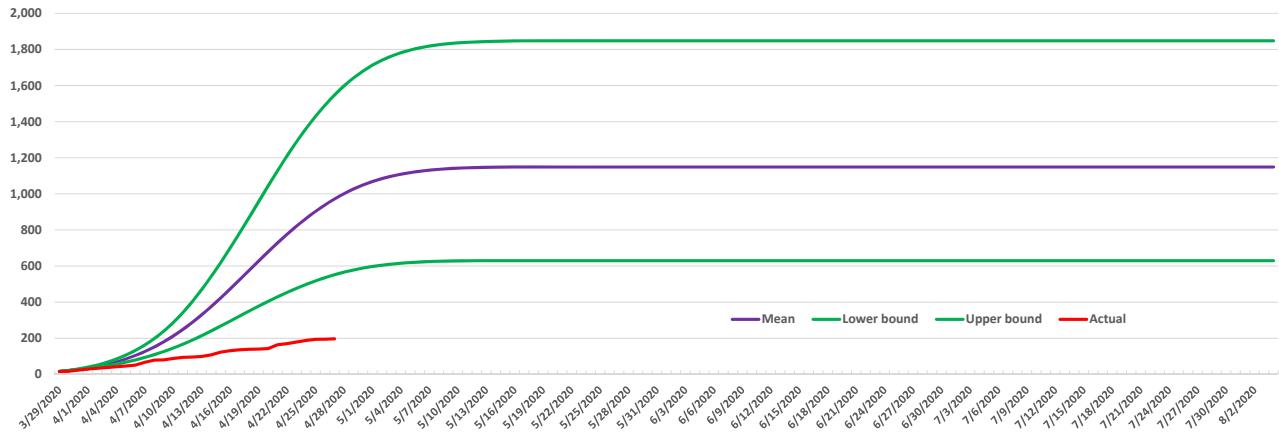
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Nebraska COVID 19 Daily Death Projections March 26



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Oklahoma COVID 19 Daily Death Projections March 26



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Forecasting performance of the March 26th model cumulative death projection

State	RMSE	MAE	MAPE	Bias
California	222.11	172.35	17%	172.35
Florida	418.73	259.50	32%	27.08
Illinois	40.50	31.59	4%	16.02
Kansas	70.69	47.36	53%	47.36
New York	641.12	340.65	3%	-281.65
Texas	281.65	175.53	34%	172.91
United States	1,462.44	1,090.29	4%	907.44

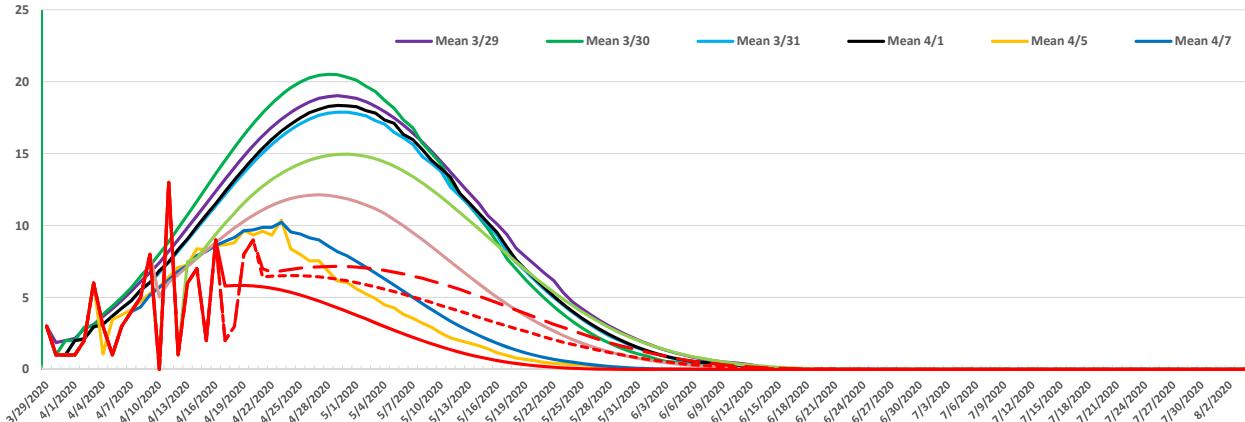
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Kansas COVID 19 Daily Death Projections Revised Forecasts



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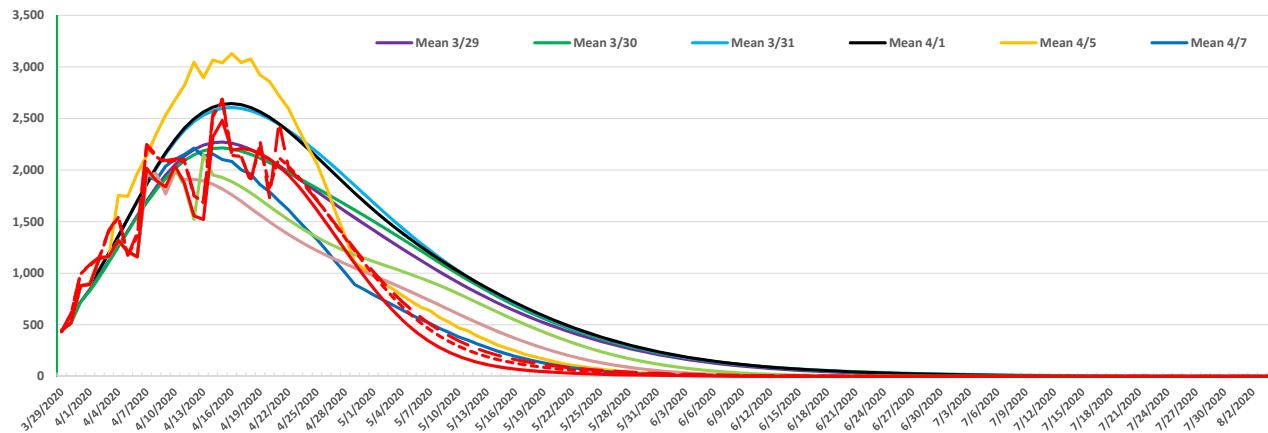
Forecasting performance of the COVID 19 Kansas daily death projections

	RMSE	MAE	MAPE	Bias	Bias/MAE
1 – day	1.53	1.31	53.1%	0.08	6%
2 – day	2.15	1.78	78.8%	0.48	27%
3 – day	3.33	2.53	129.4%	0.63	25%
4 – day	1.36	1.07	47.0%	0.58	54%
5 – day	3.55	2.90	181.1%	2.11	73%
6 – day	4.08	2.97	120.1%	2.29	77%
7 – day	2.52	1.88	66.0%	1.27	67%
8 – day	3.47	2.86	81.0%	2.37	83%
9 – day	3.90	2.80	155.5%	1.58	56%
10 – day	2.75	2.19	43.2%	1.82	83%



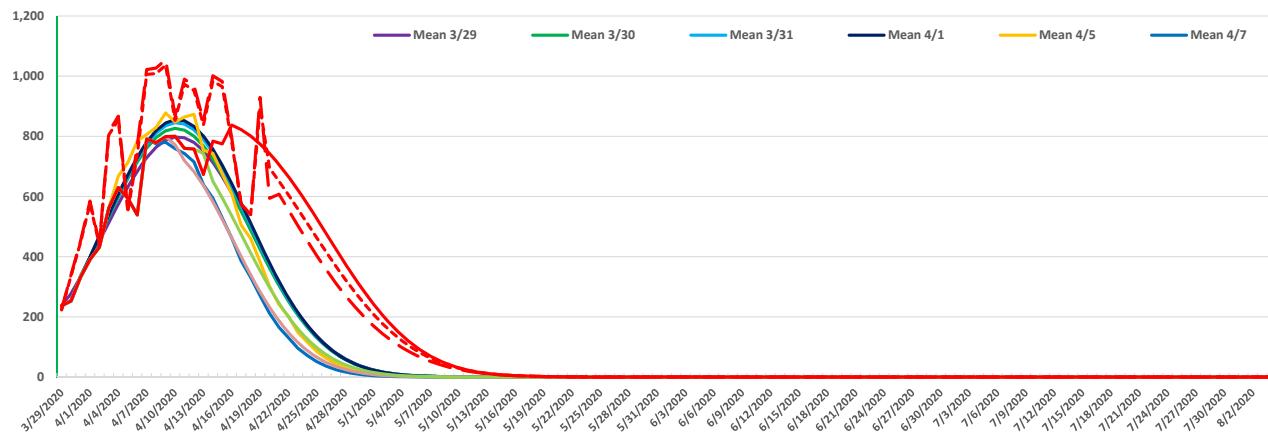
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U.S. COVID 19 Daily Death Projections Revised Forecasts



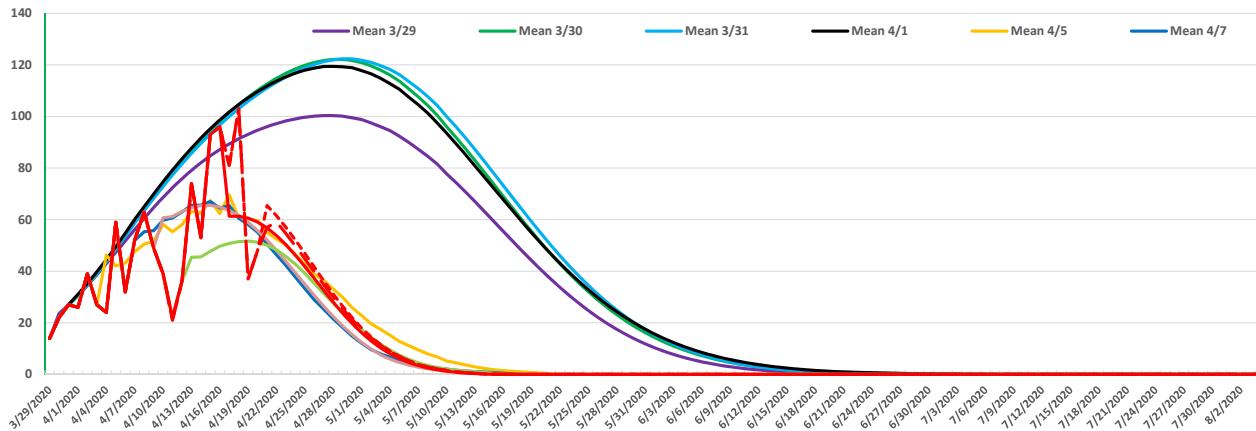
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New York COVID 19 Daily Death Projections Revised Forecasts



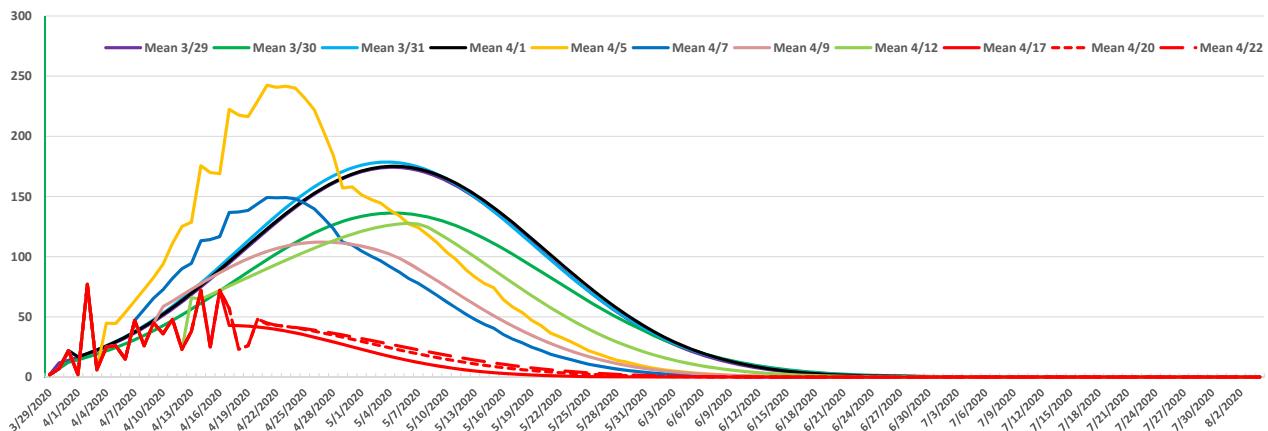
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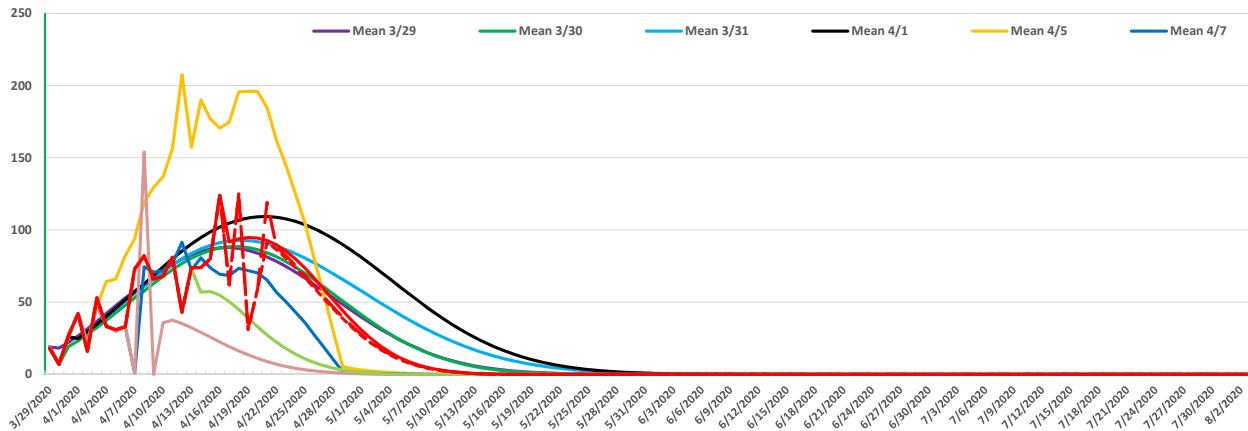
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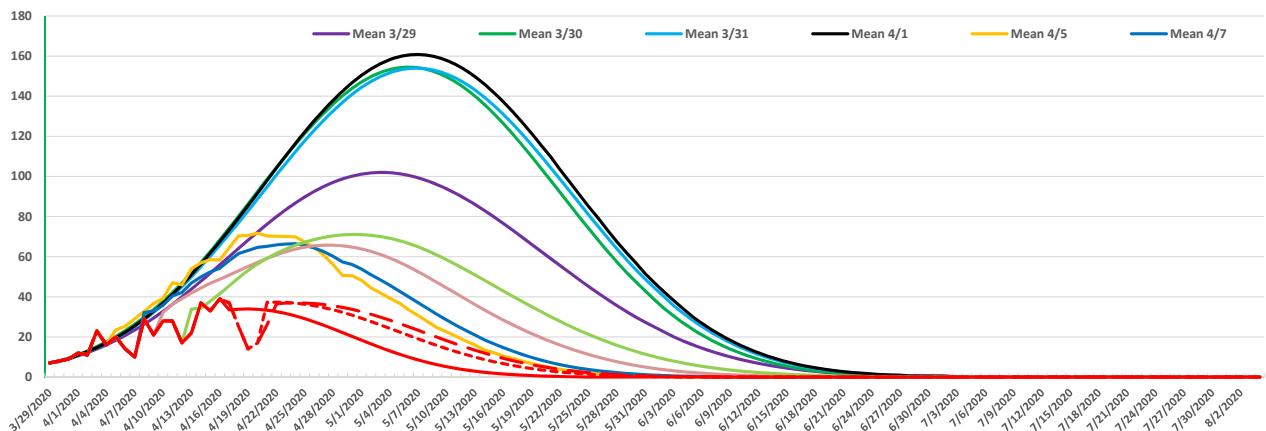
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Illinois COVID 19 Daily Death Projections Revised Forecasts



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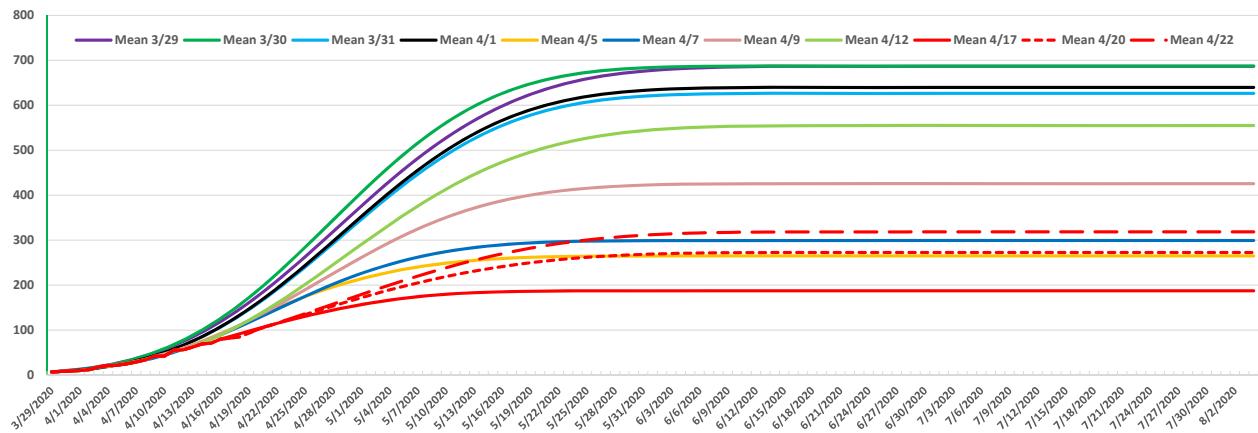
Projected Date of Maximum Daily Death from the IHME COVID 19 Model

Model Date	CA	FL	IL	KS	NY	TX	U.S.
March 29	April 28	May 4	April 17	April 29	April 10	May 3	April 15
March 30	April 29	May 4	April 18	April 28	April 10	May 6	April 15
March 31	April 29	May 4	April 18	April 30	April 10	May 7	April 16
April 1	April 28	May 4	April 21	April 29	April 10	May 7	April 16
April 5	April 17	April 21	April 12	April 23	April 9	April 20	April 16
April 7	April 15	April 23	April 12	April 27	April 9	April 24	April 12
April 9	April 15	April 27	April 11	April 29	April 9	April 28	April 10
April 12	April 19	May 6	April 13	April 30	April 10	April 30	April 13
April 17	April 16	April 2	April 19	April 19	April 16	April 19	April 15
April 22	April 18	April 2	April 18	April 29	April 8	April 24	April 15
April 27	April 22	April 23	April 18	May 4	April 9	April 22	April 15



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Kansas COVID 19 Cumulative Death Projections Revised Forecasts



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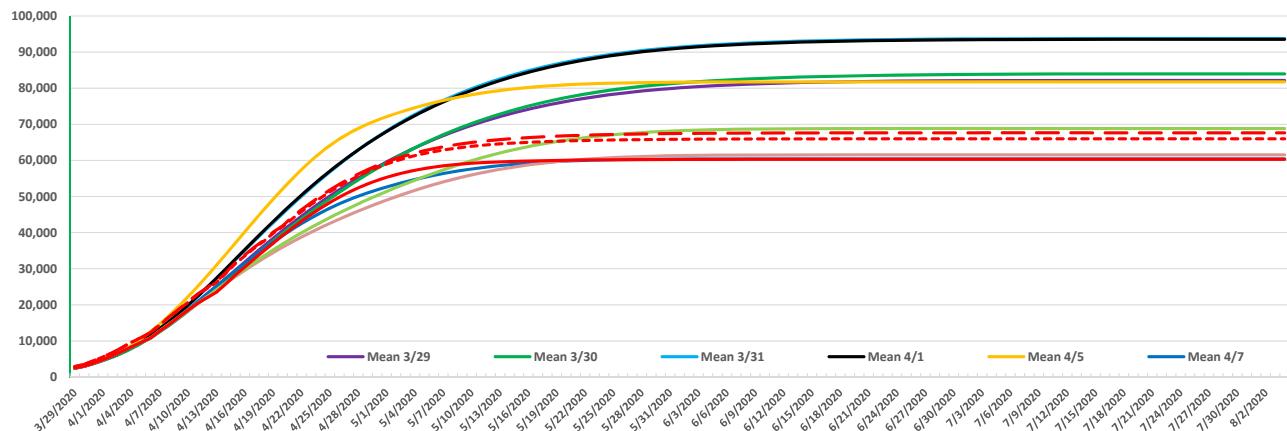
Forecasting performance of the COVID 19 Kansas cumulative death projections

	RMSE	MAE	MAPE	Bias	Bias/MAE
1 – day	1.68	1.54	8.0%	0.10	7%
2 – day	2.79	2.41	10.0%	0.16	6%
3 – day	4.37	3.53	10.1%	0.81	23%
4 – day	4.22	3.40	9.3%	1.63	48%
5 – day	6.05	3.94	8.6%	3.94	100%
6 – day	9.92	6.62	13.0%	6.23	94%
7 – day	11.99	8.45	16.1%	7.50	89%
8 – day	14.50	10.46	17.4%	9.87	94%
9 – day	11.03	8.01	14.2%	8.01	100%
10 – day	13.27	9.83	15.1%	9.83	100%



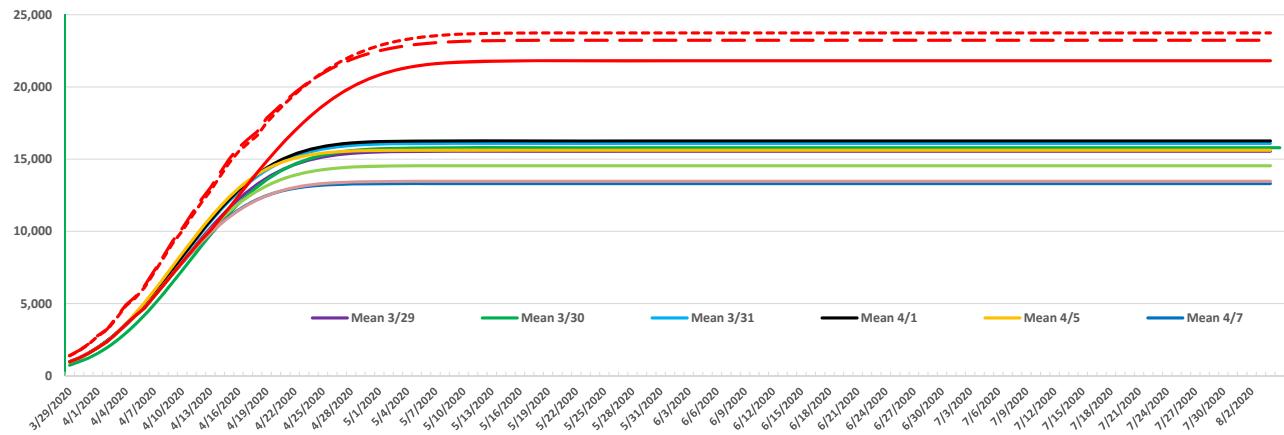
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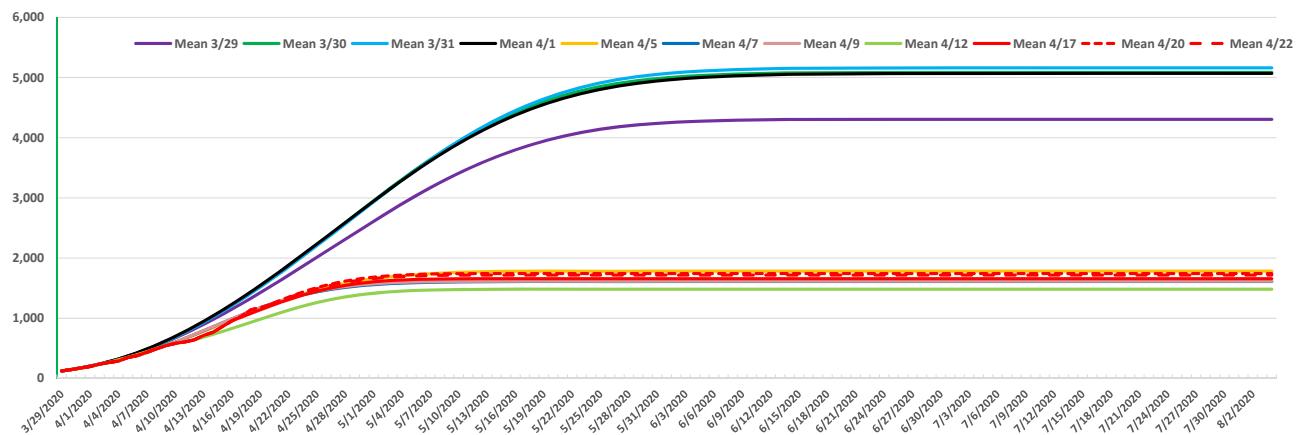
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New York COVID 19 Cumulative Death Projections Revised Forecasts



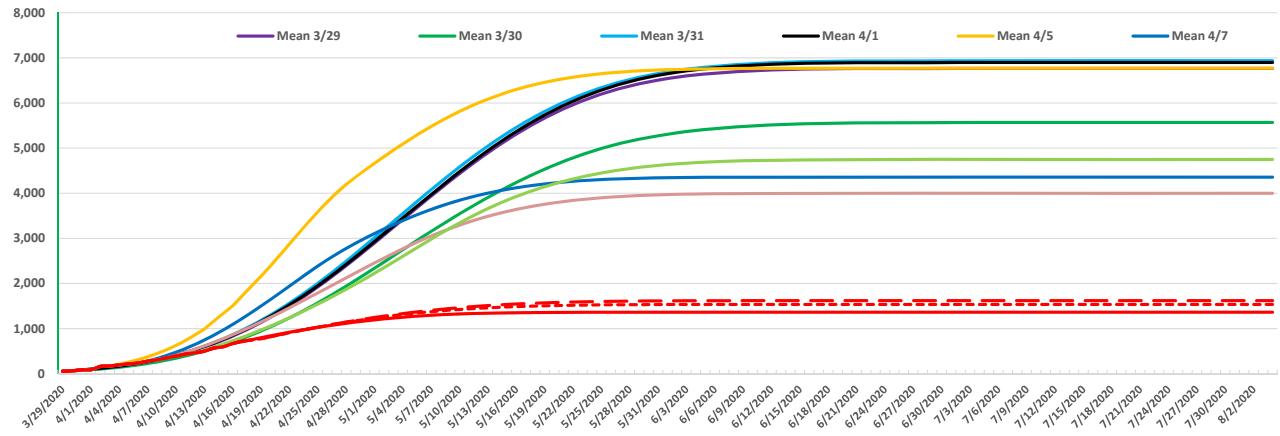
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California COVID 19 Cumulative Death Projections Revised Forecasts



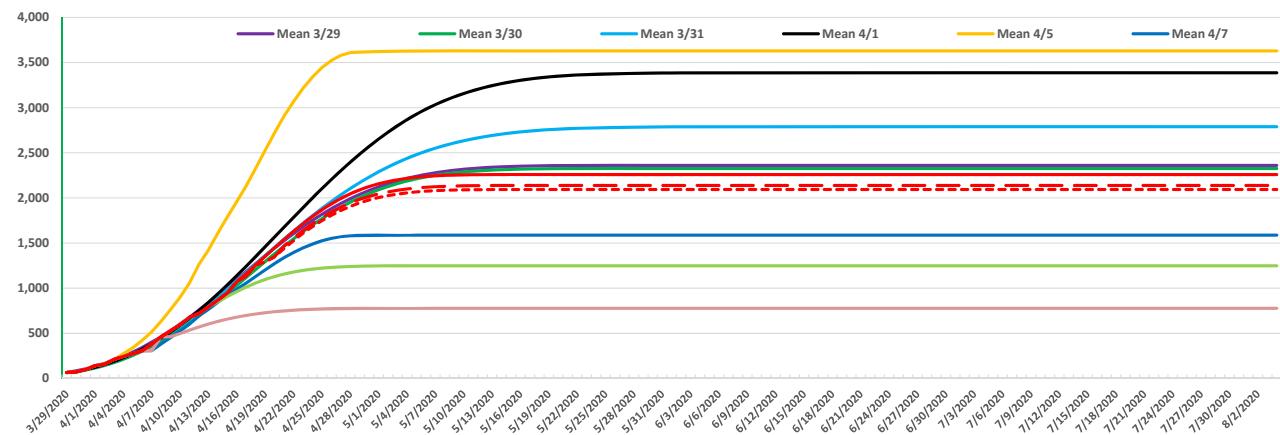
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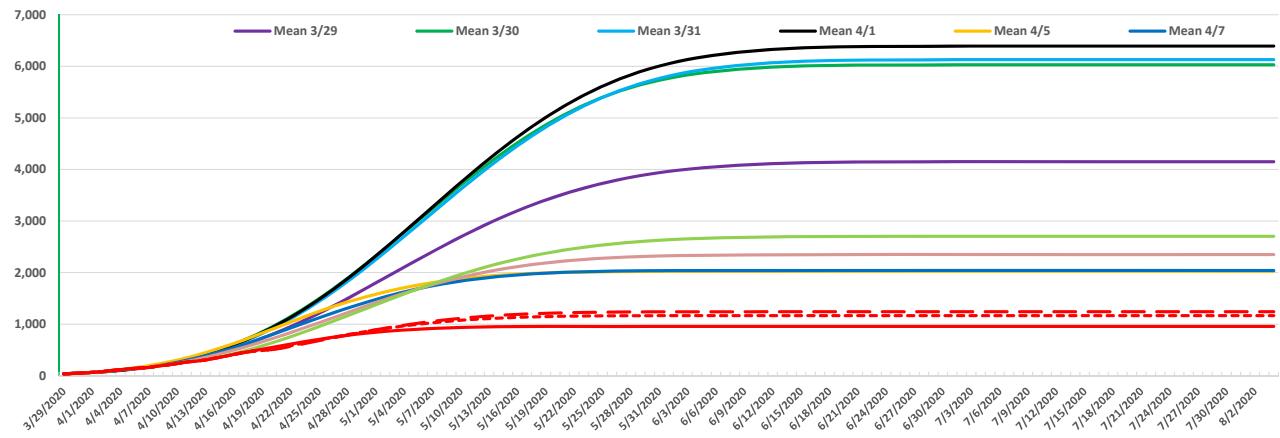
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Illinois COVID 19 Cumulative Death Projections Revised Forecasts



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Texas COVID 19 Cumulative Death Projections Revised Forecasts



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Projected August 4th Cumulative Death from the IHME COVID 19 Model

Model Date	CA	FL	IL	KS	NY	TX	U.S.
March 29	4,306	6,766	2,360	687	15,546	4,150	82,141
March 30	5,086	5,568	2,326	687	15,788	6,029	83,967
March 31	5,161	6,937	2,789	627	16,090	6,128	93,765
April 1	5,068	6,897	3,386	640	16,261	6,392	93,531
April 5	1,783	6,770	3,629	265	15,618	2,025	81,766
April 7	1,611	4,357	1,588	299	13,307	2,042	60,415
April 9	1,616	3,999	777	426	13,643	2,350	61,545
April 12	1,483	4,748	1,248	555	14,542	2,704	68,841
April 17	1,658	1,363	2,259	187	21,812	957	60,308
April 20	1,743	1,537	2,093	273	23,741	1,166	65,976
April 22	1,719	1,620	2,138	318	23,232	1,241	67,641
April 26	2,017	1,914	2,316	366	23,930	1,656	74,703



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Projected August 4th Cumulative Death from the IHME COVID 19 Model

Model Date	CO	MO	NE	OK	GA	MI	SC	TN
March 29	2,151	1,055	424	1,149	2,777	2,862	1,043	1,067
March 30	1,883	1,219	442	1,100	2,648	3,007	1,034	4,985
March 31	2,135	1,283	448	1,312	2,916	3,235	1,060	3,259
April 1	2,154	1,290	447	1,419	3,232	3,169	1,095	3,422
April 5	302	352	459	813	3,413	2,963	442	587
April 7	457	548	289	697	2,630	2,103	470	617
April 9	540	1,161	273	965	3,564	1,977	572	612
April 12	456	1,713	281	929	3,718	2,373	680	481
April 17	715	362	127	359	1,369	3,304	217	231
April 20	649	385	245	306	1,981	3,361	261	235
April 22	719	438	347	335	2,254	3,379	283	233
April 26	1049	537	463	282	2,480	3,785	353	257



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Projected August 4th Cumulative Death from the IHME COVID 19 Model

Model Date	AZ	MA	MN	WA
March 29	1,613	1,782	2,146	1,670
March 30	1,575	1,507	1,038	1,621
March 31	1,380	2,357	1,061	1,233
April 1	1,387	2,381	932	978
April 5	570	8,254	625	632
April 7	775	5,625	456	700
April 9	974	6,739	442	842
April 12	1,005	8,219	656	855
April 17	267	3,236	195	694
April 20	480	3,898	301	779
April 22	583	4,242	360	812
April 26	793	5,498	688	841



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Percentage Change from the Original Model to the April 26 Release

	Percent Change		Percent Change
California	-53.2%	Oklahoma	-75.5%
Florida	-71.7%	Georgia	-10.7%
Illinois	-1.9%	Michigan	32.3%
Kansas	-46.7%	South Carolina	-66.2%
New York	53.9%	Tennessee	-75.9%
Texas	-60.1%	Arizona	-50.8%
Colorado	-51.2%	Massachusetts	208.5%
Missouri	-49.1%	Minnesota	-67.9%
Nebraska	9.2%	Washington	-49.6%
United States	-9.1%		



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Concluding Thoughts

- The IMHE model has been used to drive policy decisions that have resulted in large negative economic effects for the U.S. in general and the agricultural economy specifically
- The change in data definition of death has had an effect on the U.S. and New York projections along with other states
 - This makes modeling extremely difficult
- Fairly large revisions to the cumulative death totals and the peak of daily deaths both upwards and downwards
 - Are the revisions due to society flattening the curve or due to inaccurate models?



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