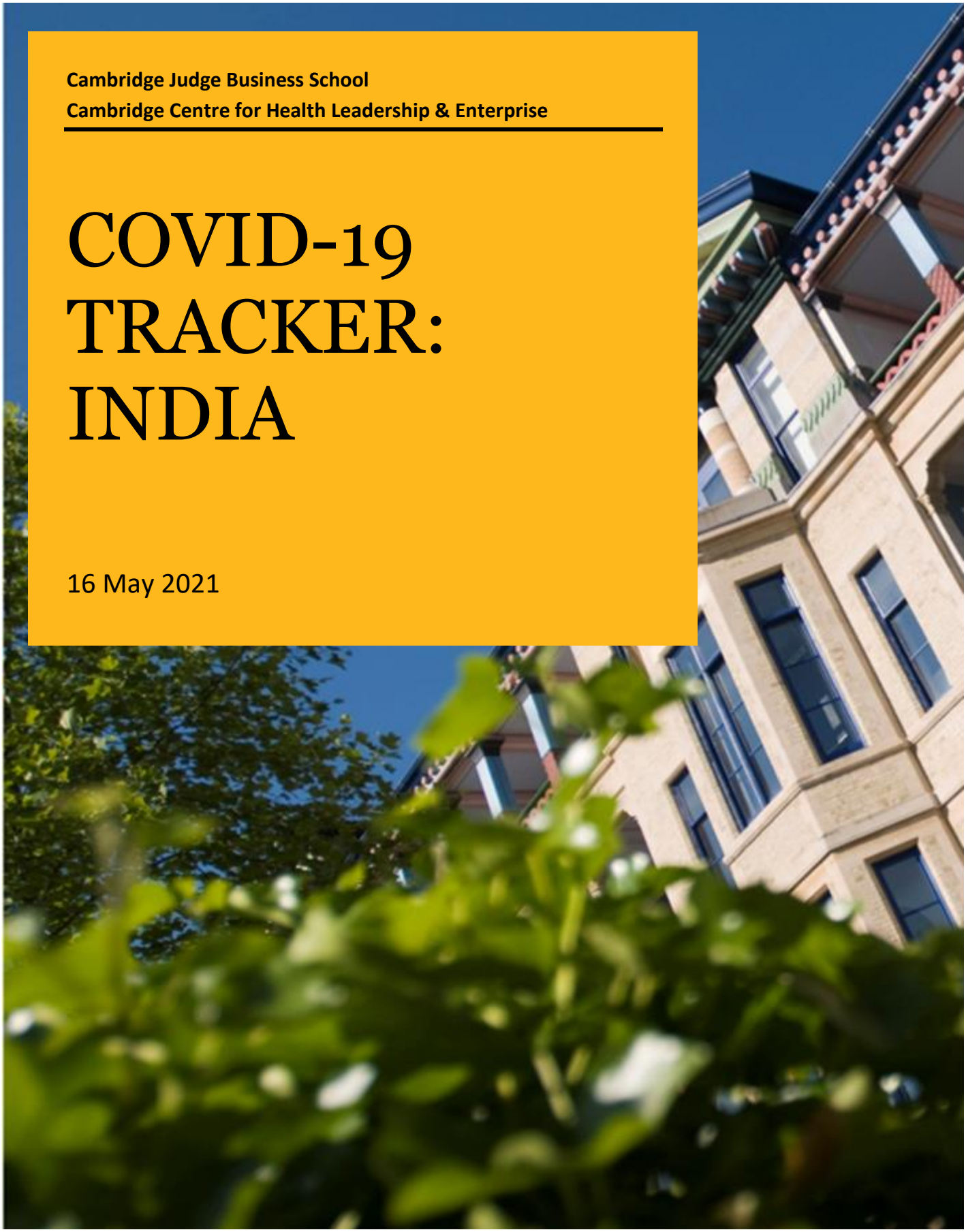
Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

16 May 2021



Centre for Health Leadership & Enterprise
UNIVERSITY OF CAMBRIDGE Judge Business School
HSTP Health Systems Transformation Platform
National Institute of Economic and Social Research

This tracker[1] has been developed by researchers at Cambridge Judge Business School and National Institute of Economic and Social Research, working with Health Systems Transformation Platform in India, as part of a pandemic monitoring series devoted to India and its states and union territories. It provides near term forecasts of the trajectory of the pandemic, identifying states and union territories that are at high risk of increases in infection incidence.

The forecasts are based on a structural time series model that uses historical data in estimation but adapts to the trend emerging in the most recent period. The model is described in: Harvey and Kattuman (2021) "Time series models based on growth curves with applications to forecasting coronavirus". *Harvard Data Science Review*, Special issue 1 - COVID -19.

Newly reported COVID-19 cases in India will likely decline to just under 150,000 per day by the end of May 2021. With few exceptions, Indian states and union territories are now past the peak and entrained on downward trajectories.

Trend values of daily cases are forecast to increase significantly in Tripura, Meghalaya, Manipur and Tamil Nadu over the next two weeks. The filtered daily growth rates at the end of the observation period on 16 May imply doubling times of 12 days for Tripura, 13 days for Meghalaya, 19 days for Manipur and 30 days for Tamil Nadu.

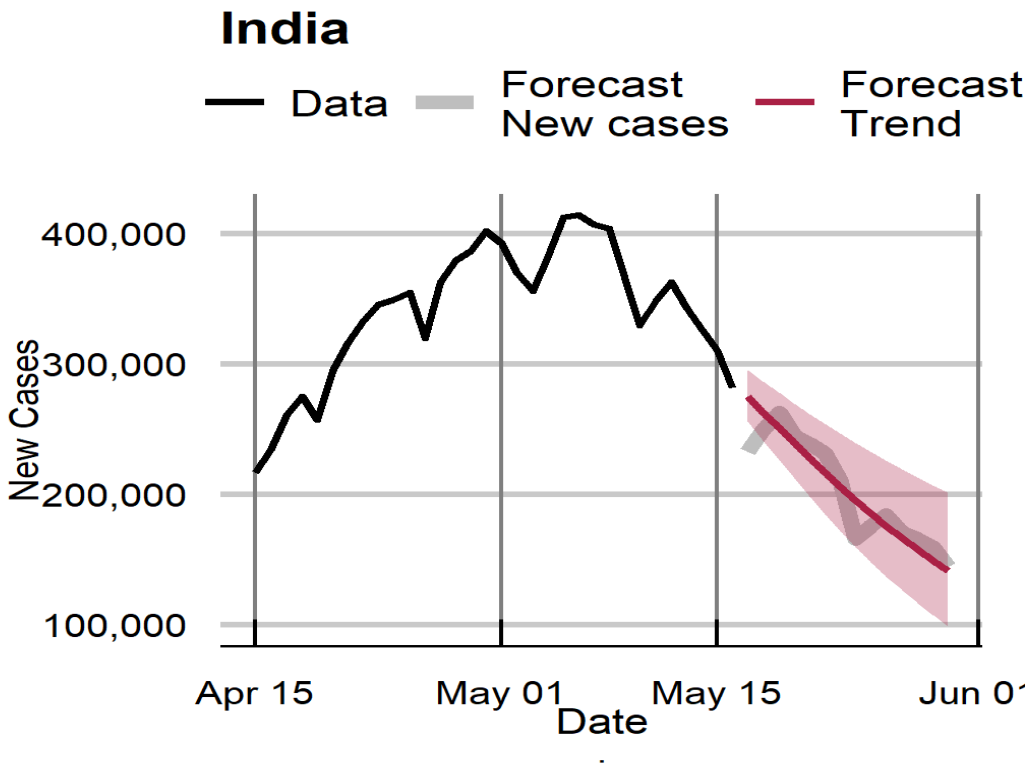
Following the peak in reported cases, daily deaths attributed to COVID-19 in India appears to have peaked now. The trend value of daily deaths will likely decline steadily to under 3,500 per day by the end of May 2021.

Mean absolute percentage error of the forecasts in the 9 May tracker of daily cases in India for the week beginning 10 May 2021 is 7.2%.

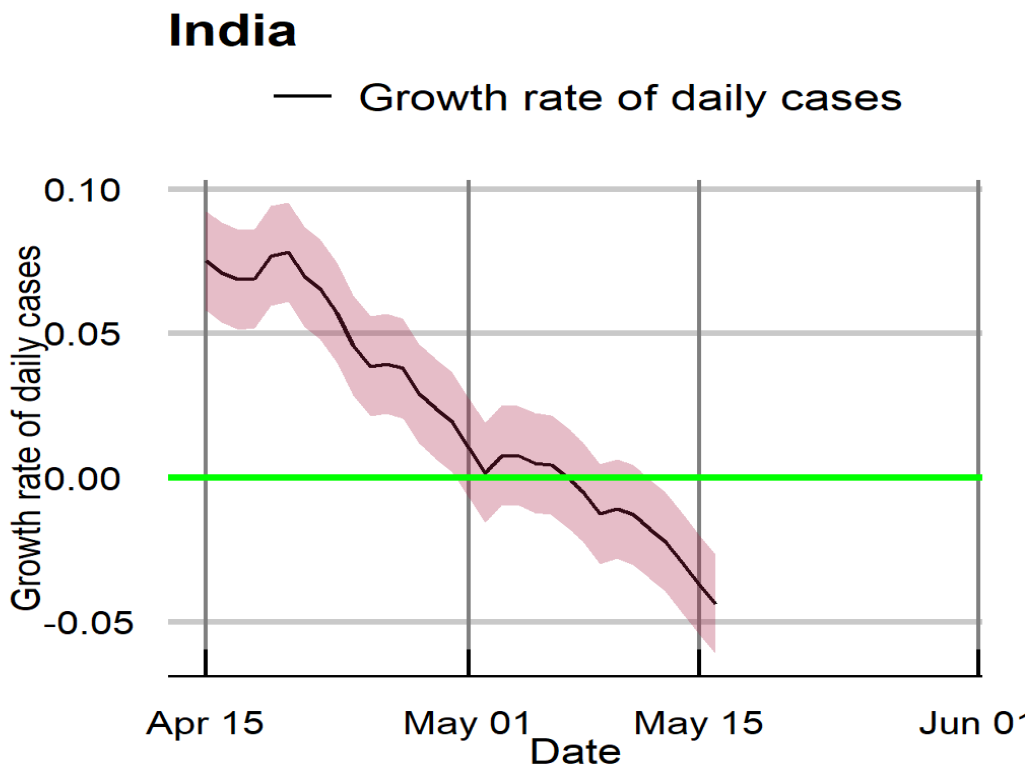
The accuracy of forecasts rely on the quality of the reported data. Near term changes in government pandemic policies, as well as transmission relevant social behaviour will cause realised numbers to depart from forecasts. Volatility in data, observed in particular for Goa, Himachal Pradesh, Jammu and Kashmir, Mizoram, Nagaland and Sikkim, make forecasts less accurate.

[1] CJBS COVID-19 Tracker for India can be accessed at: www.jbs.cam.ac.uk/covid-india
The companion spreadsheet contains all the estimates and forecasts.

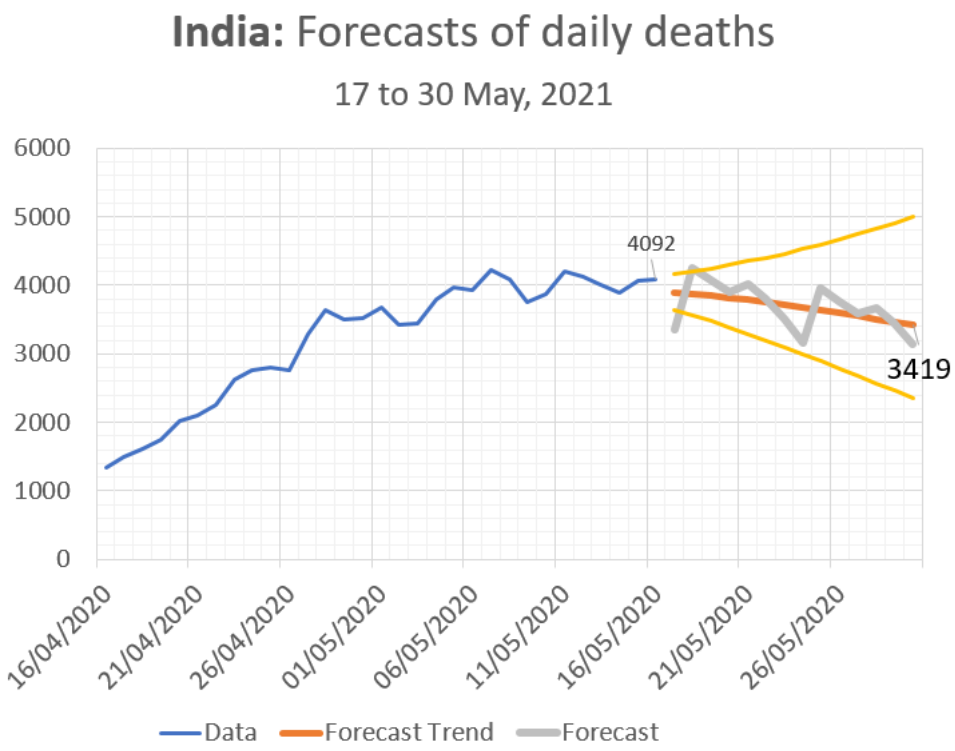
Contact: Paul Kattuman <p.kattuman@jbs.cam.ac.uk>



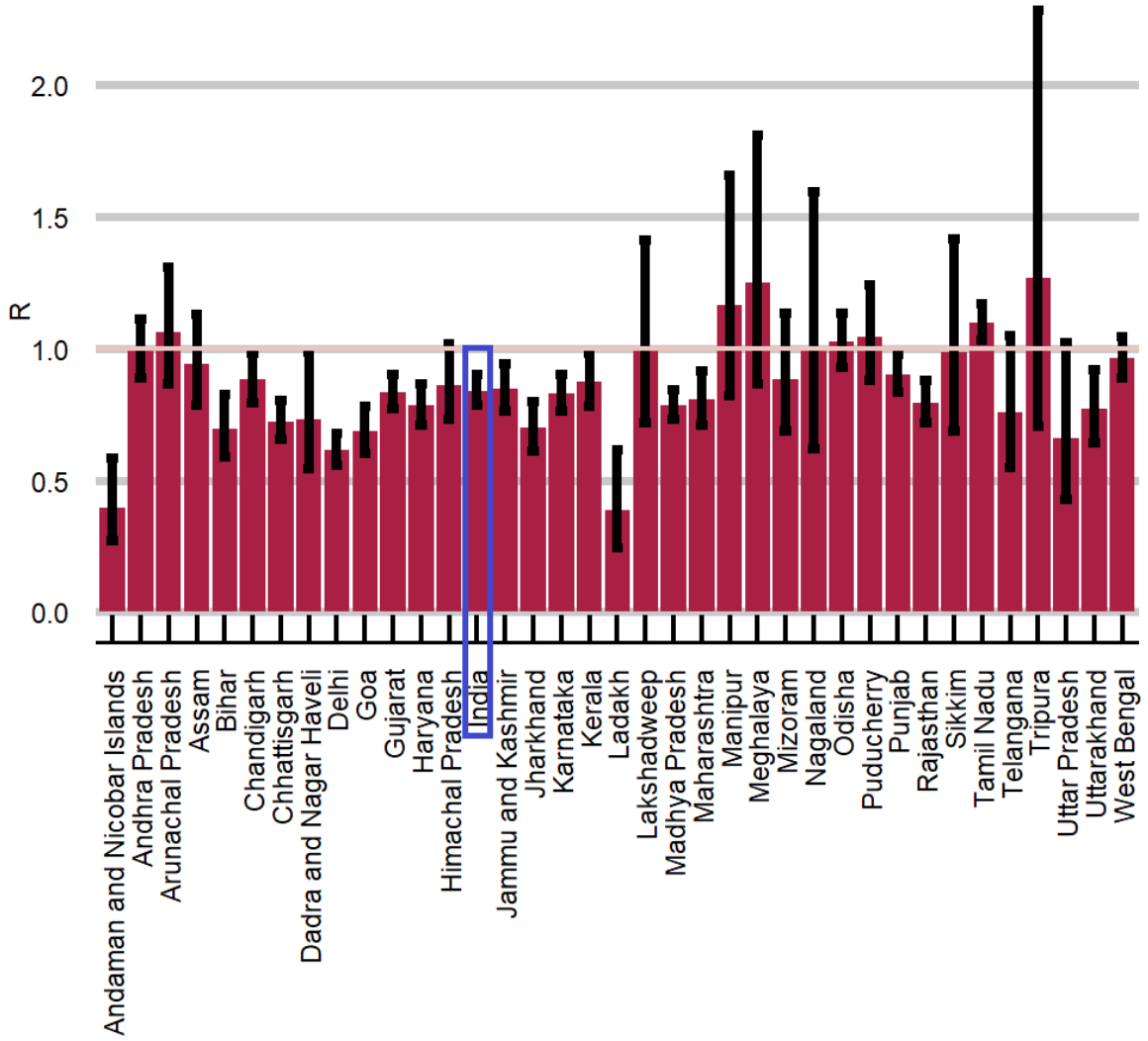
Forecasts of daily new cases for the period May 17 to 30, 2021, based on data till 16 May 2021.

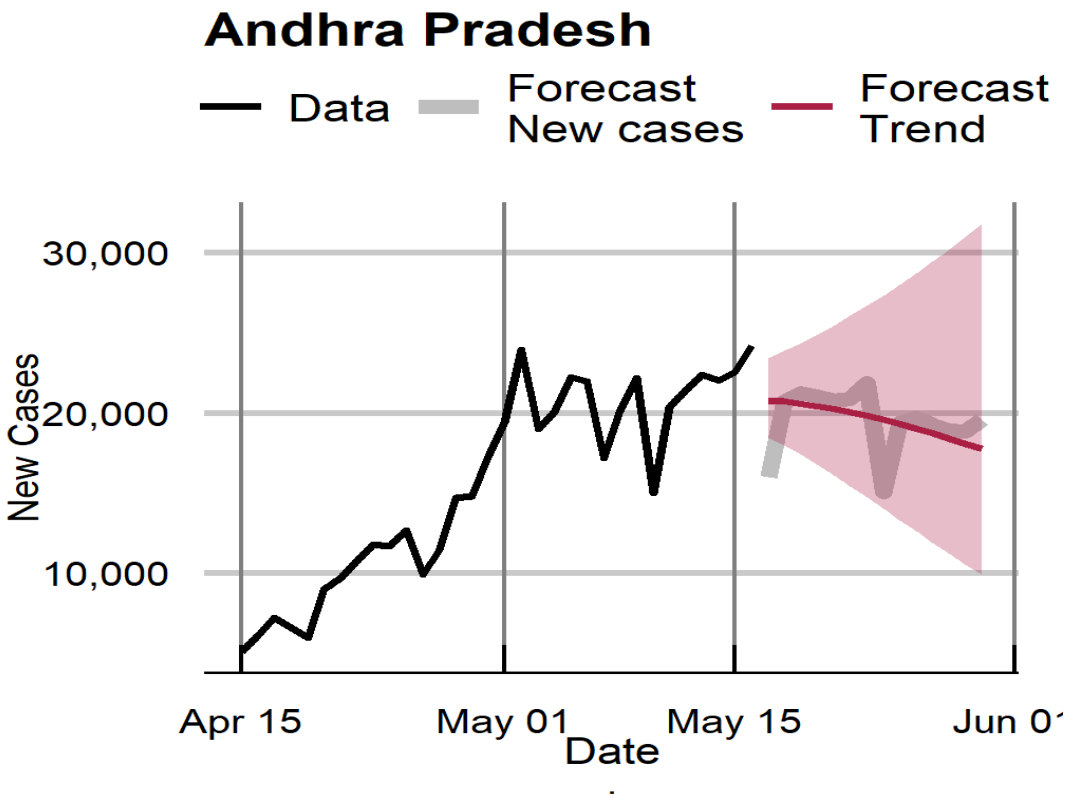


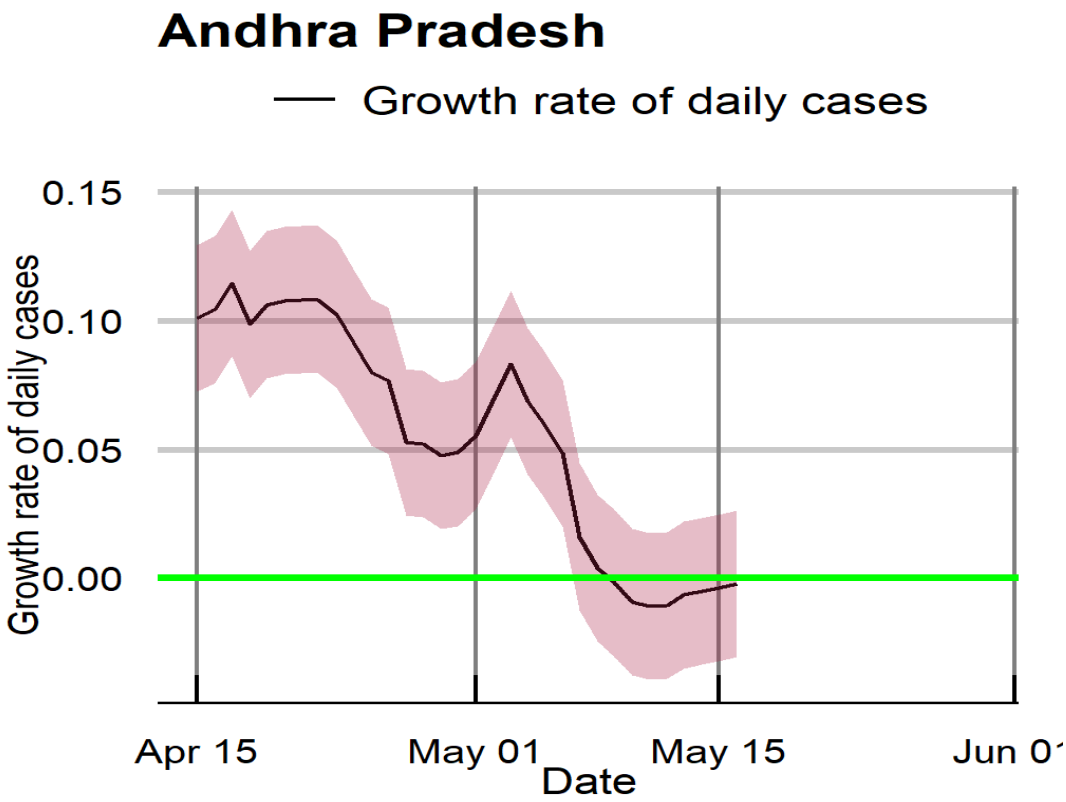
The filtered trend in the growth rate of daily new cases. Final date: 16 May 2021.

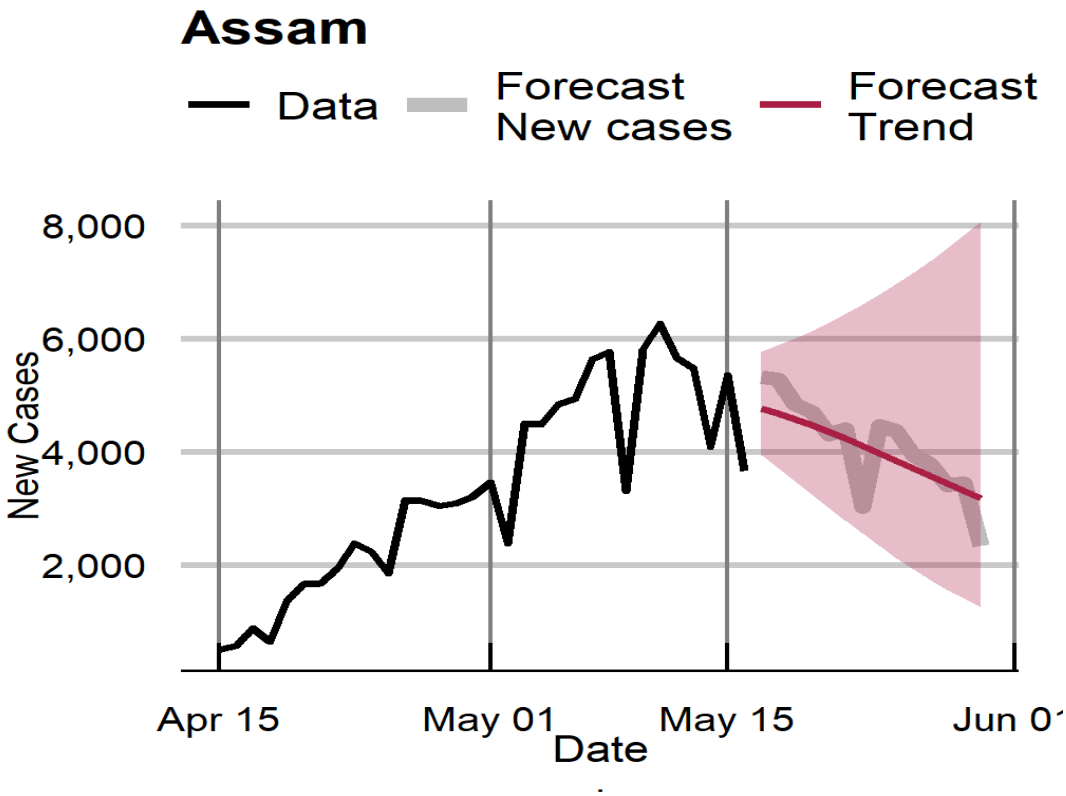

India: Forecasts of daily deaths
17 to 30 May, 2021
6000
5000
4000
3000
2000
1000
0
4092
3419
16/04/2020
21/04/2020
26/04/2020
01/05/2020
06/05/2020
11/05/2020
16/05/2020
21/05/2020
26/05/2020
Data
Forecast Trend
Forecast

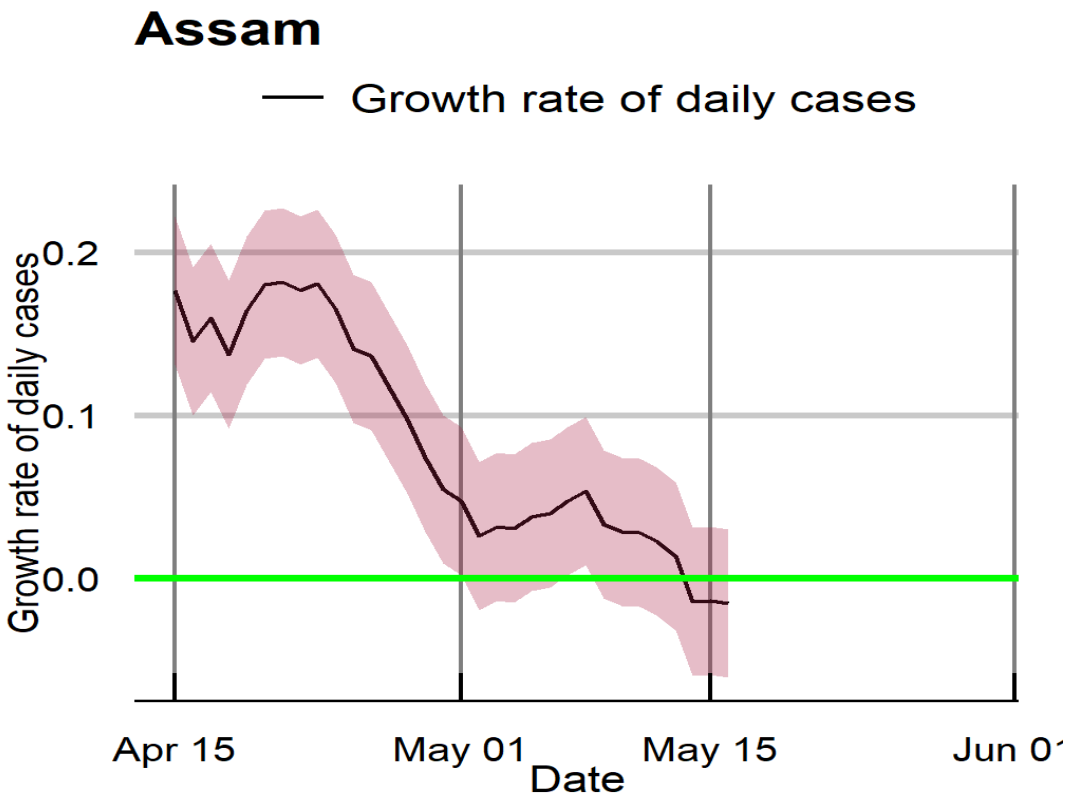
R_t : as on 16 May 2021

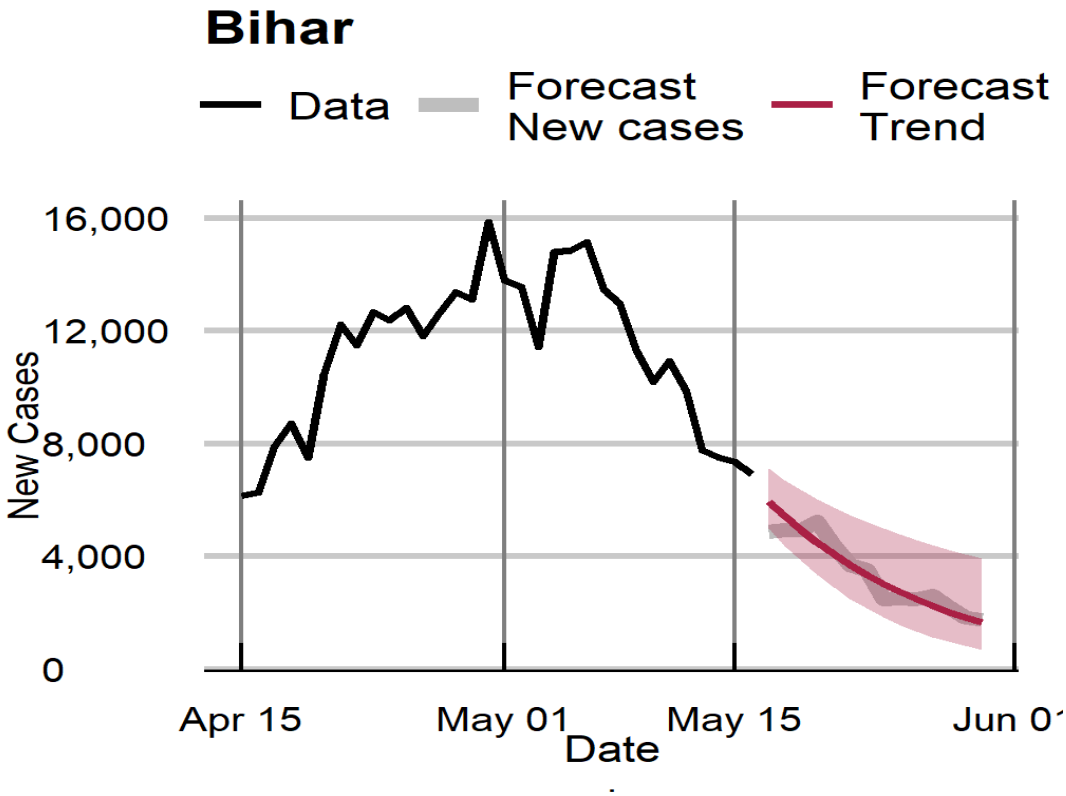


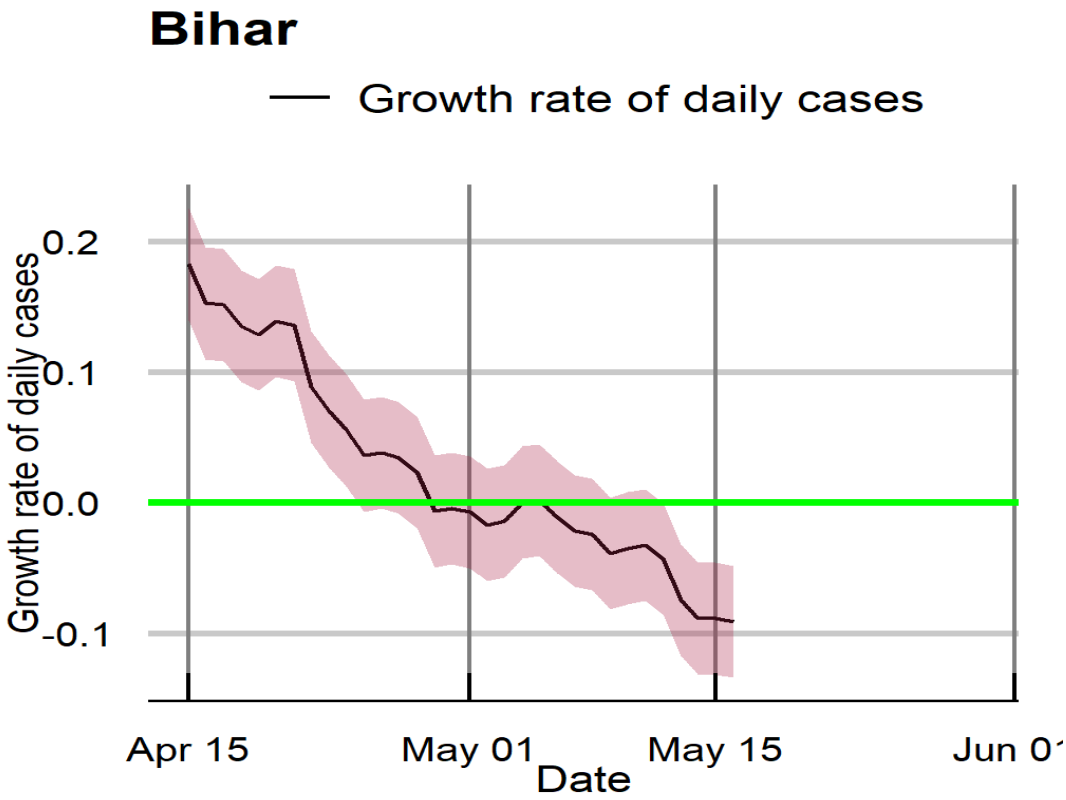

Andhra Pradesh
Data
Forecast
New cases
Forecast
Trend
30,000
20,000
10,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

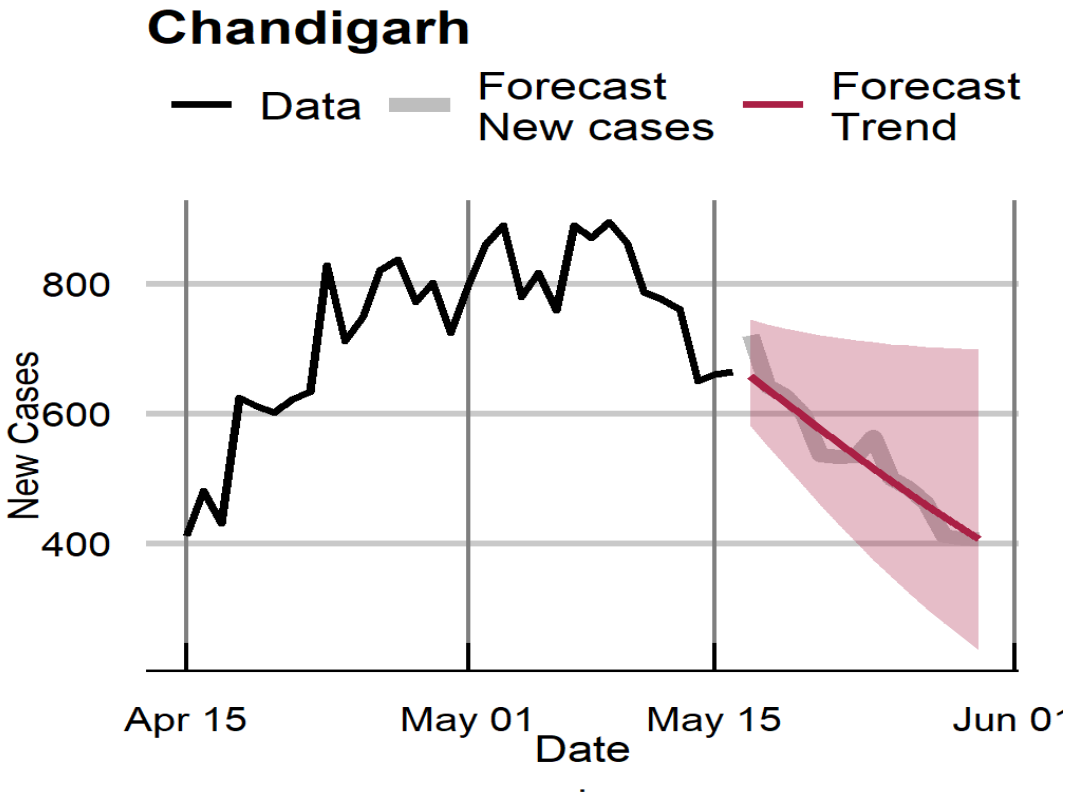

Andhra Pradesh
Growth rate of daily cases
0.15
0.10
0.05
0.00
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

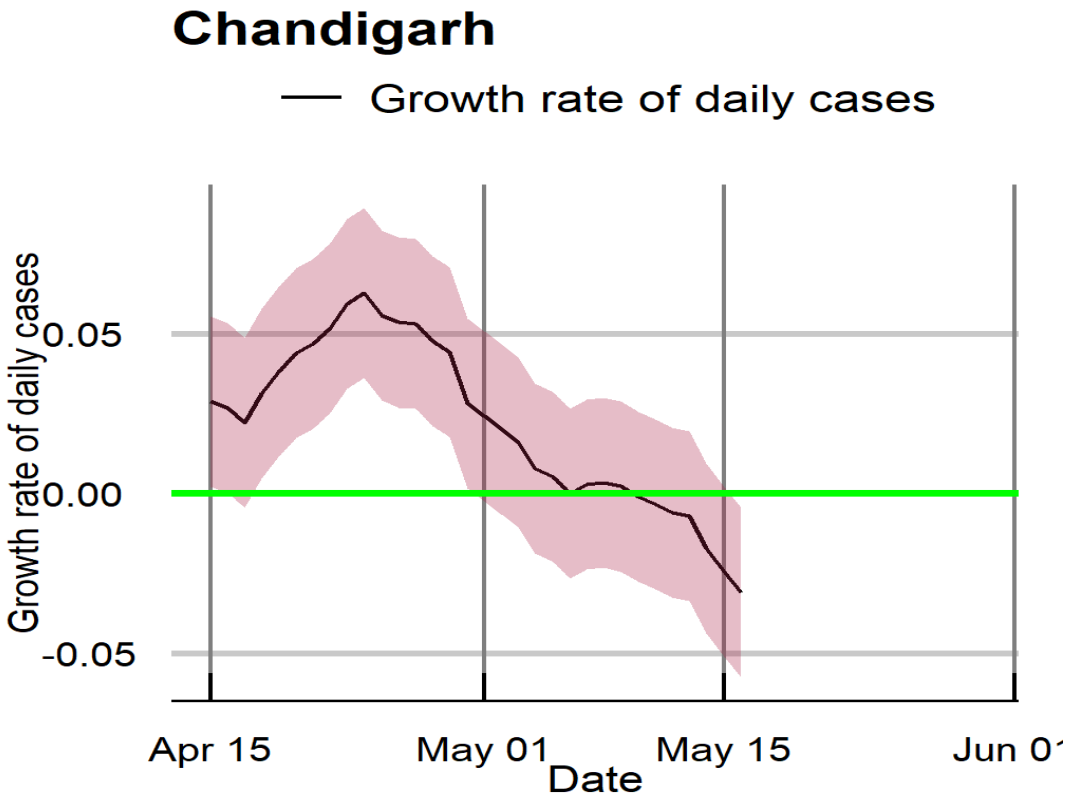

Assam
Data
Forecast
New cases
Forecast
Trend
8,000
6,000
4,000
2,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

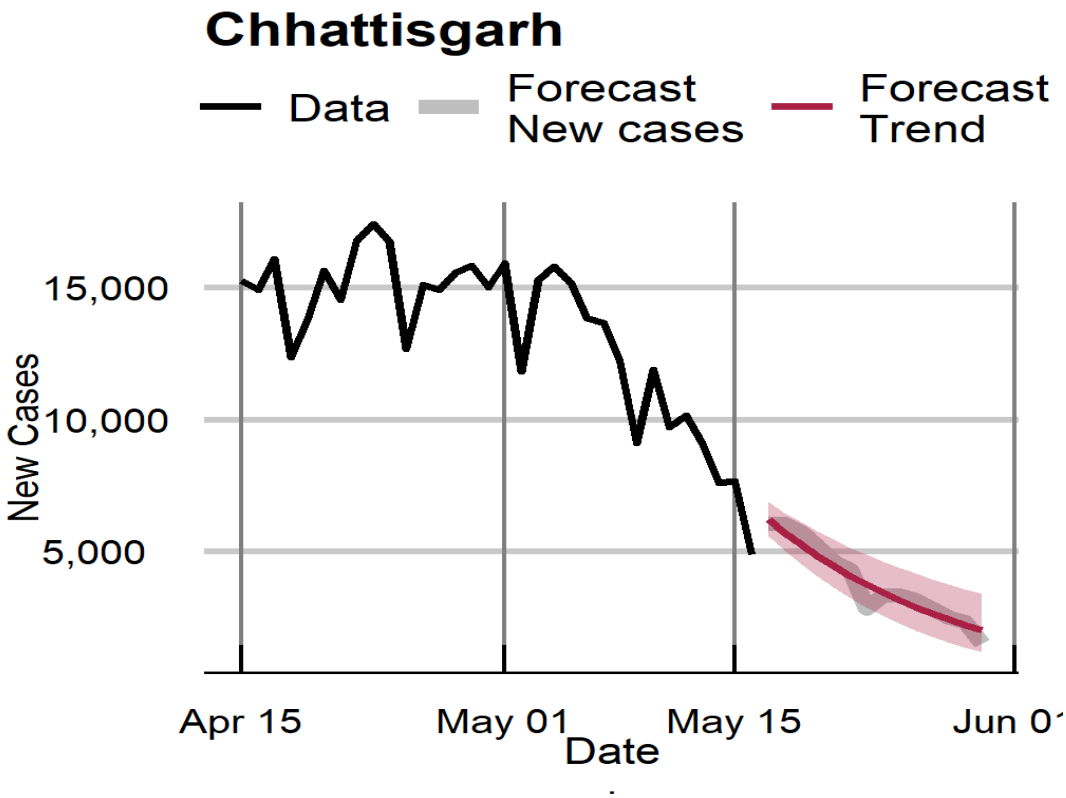

Assam
Growth rate of daily cases
0.2
0.1
0.0
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

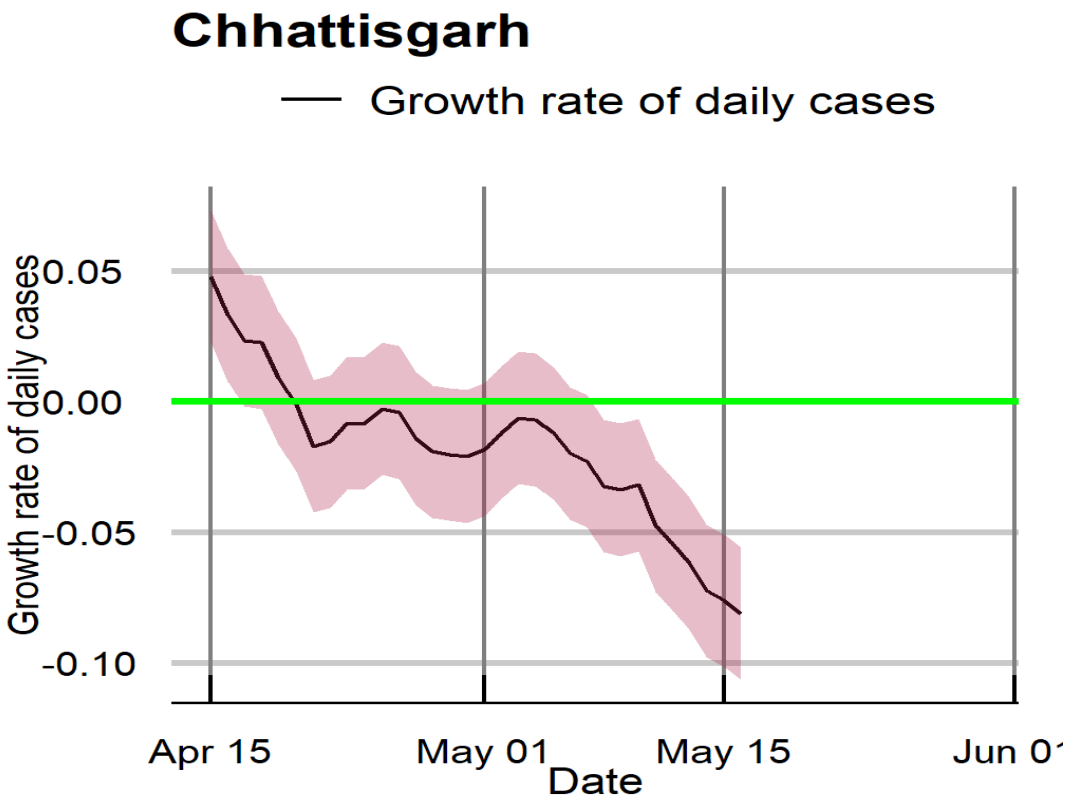

Bihar
Data
Forecast
New cases
Forecast
Trend
16,000
12,000
8,000
4,000
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

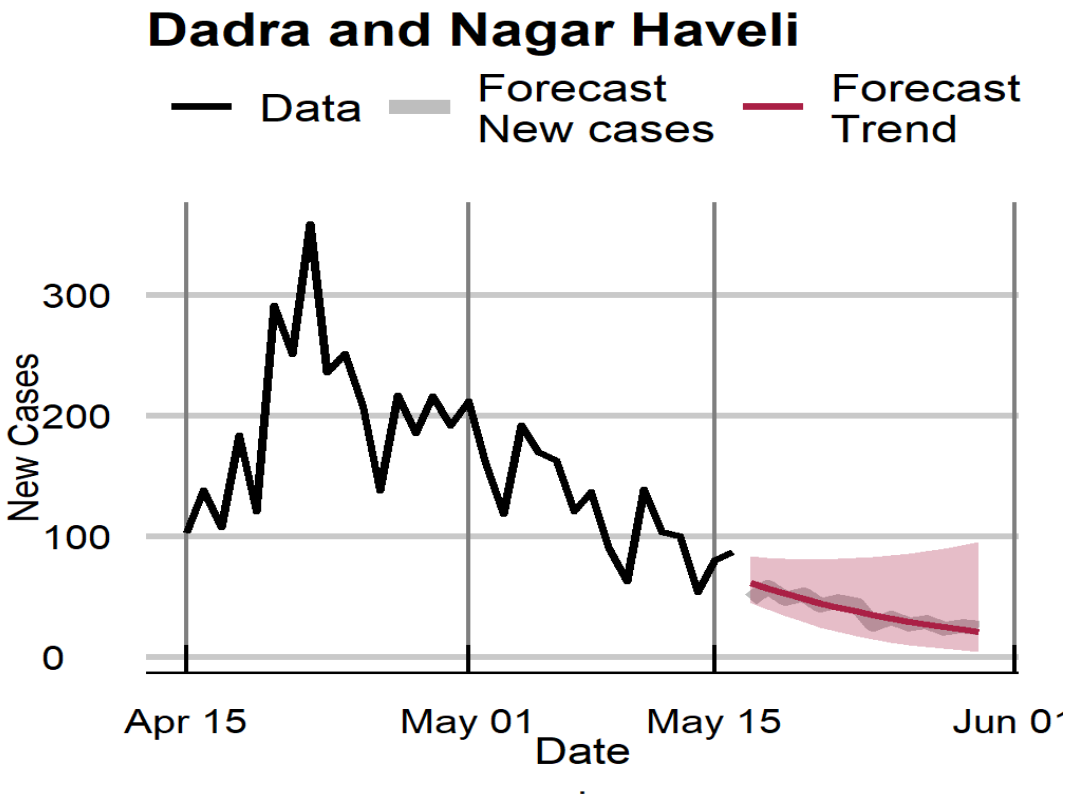

Bihar
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

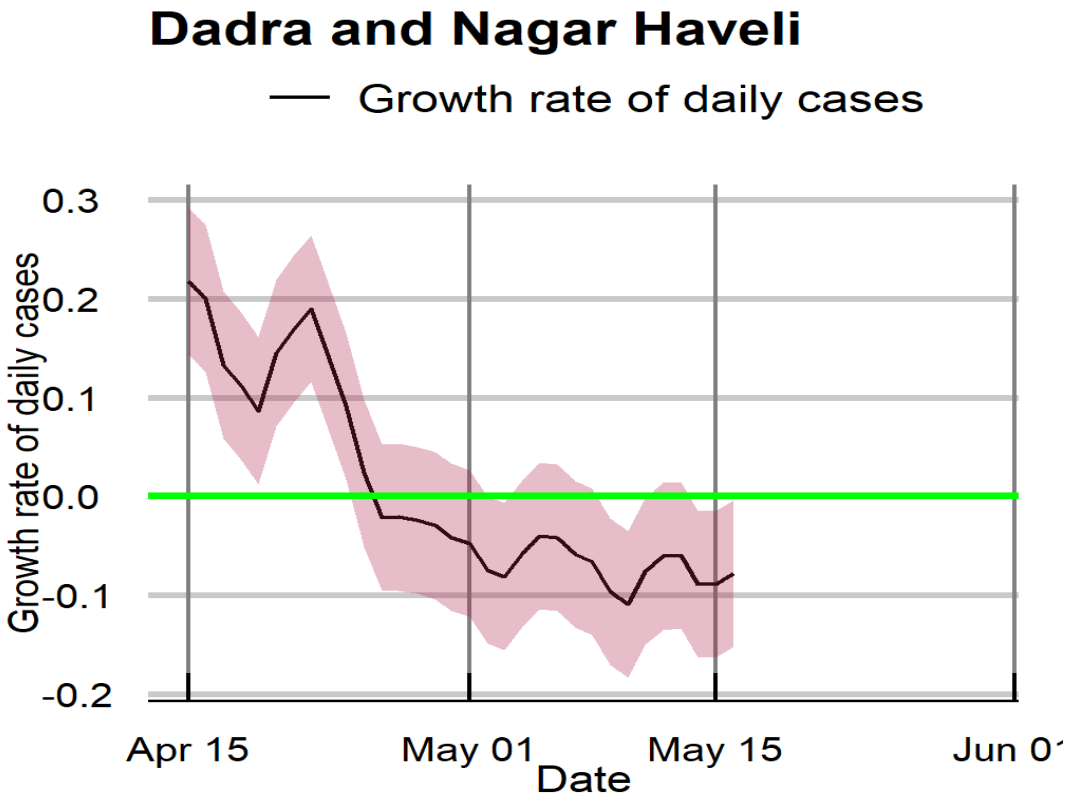

Chandigarh
Data
Forecast
New cases
Forecast
Trend
800
600
400
New Cases
Apr 15
May 01
May 15
Jun 0
Date

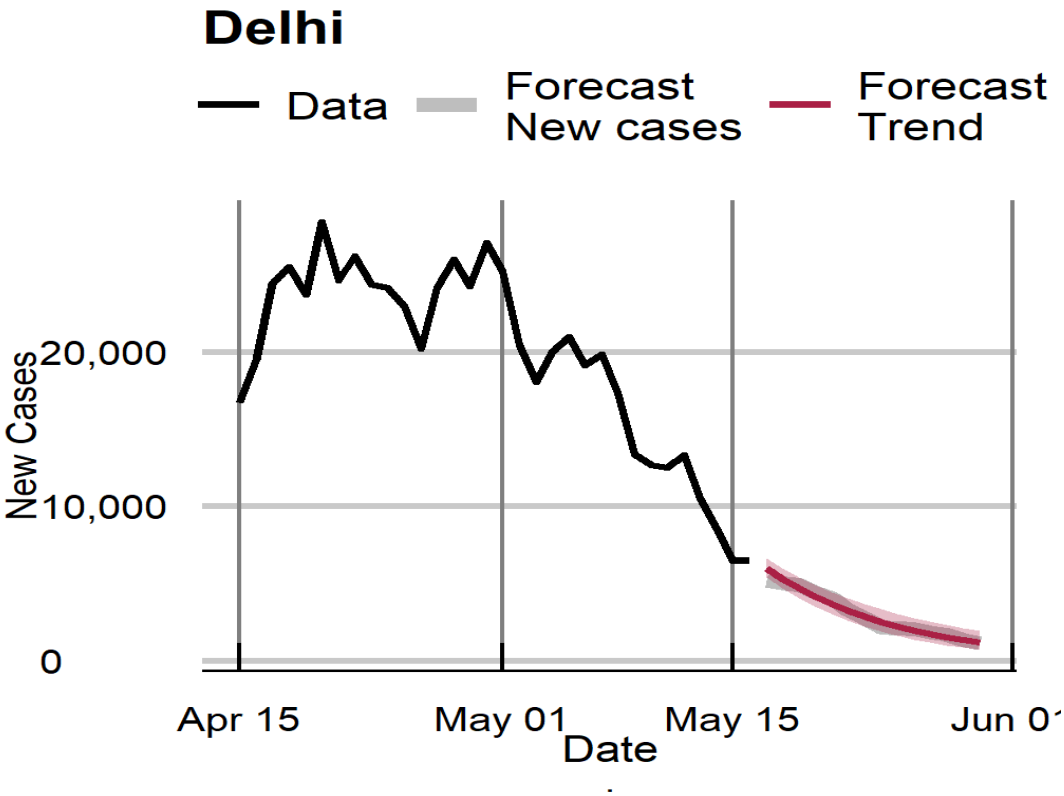

Chandigarh
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

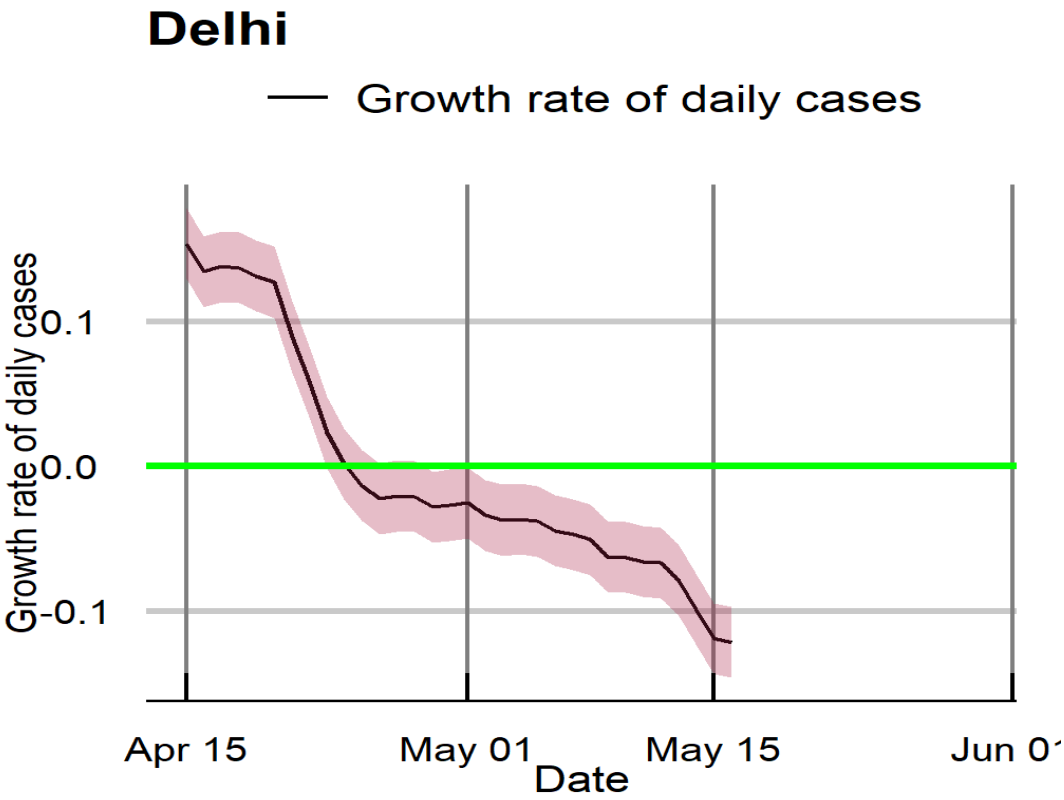

Chhattisgarh
Data
Forecast
New cases
Forecast
Trend
15,000
10,000
5,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

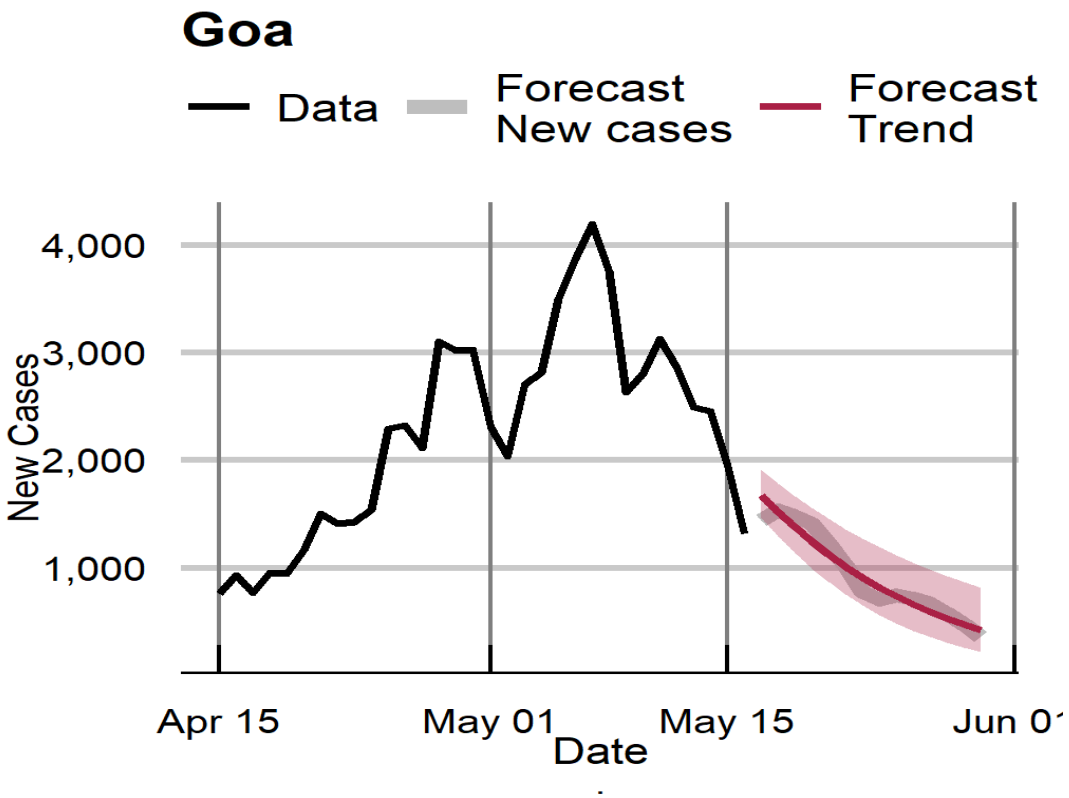

Chhattisgarh
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

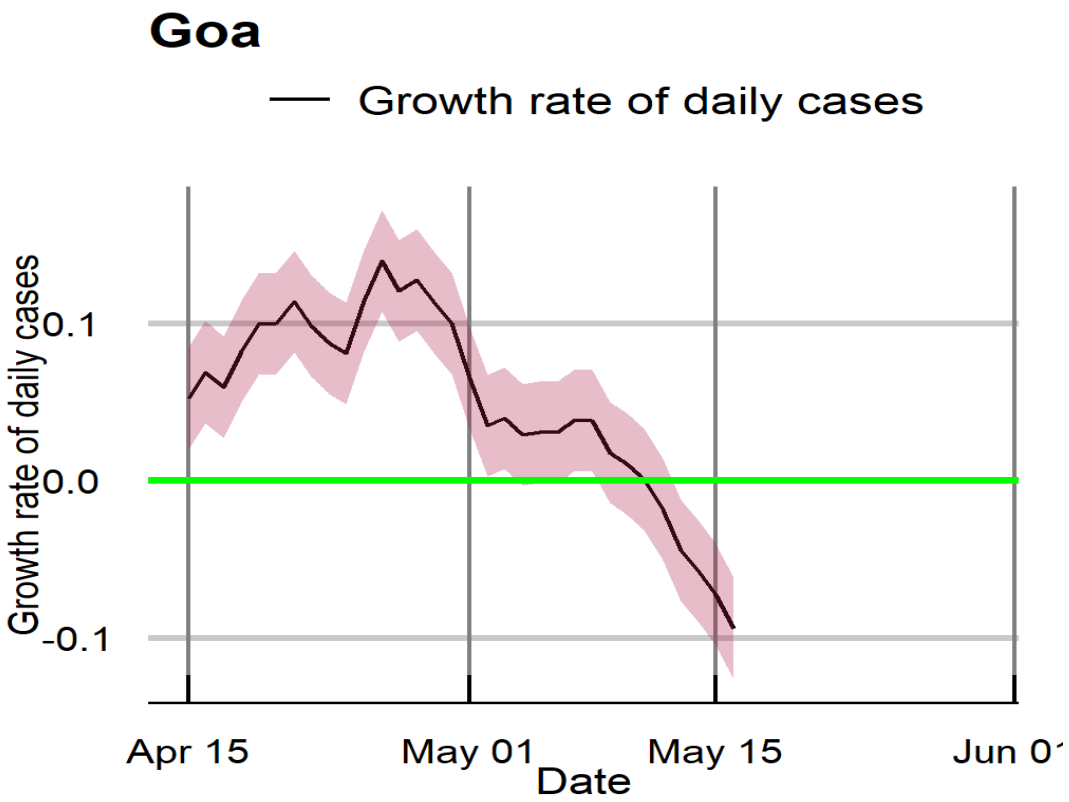

Dadra and Nagar Haveli
Data
Forecast
New cases
Forecast
Trend
300
200
100
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

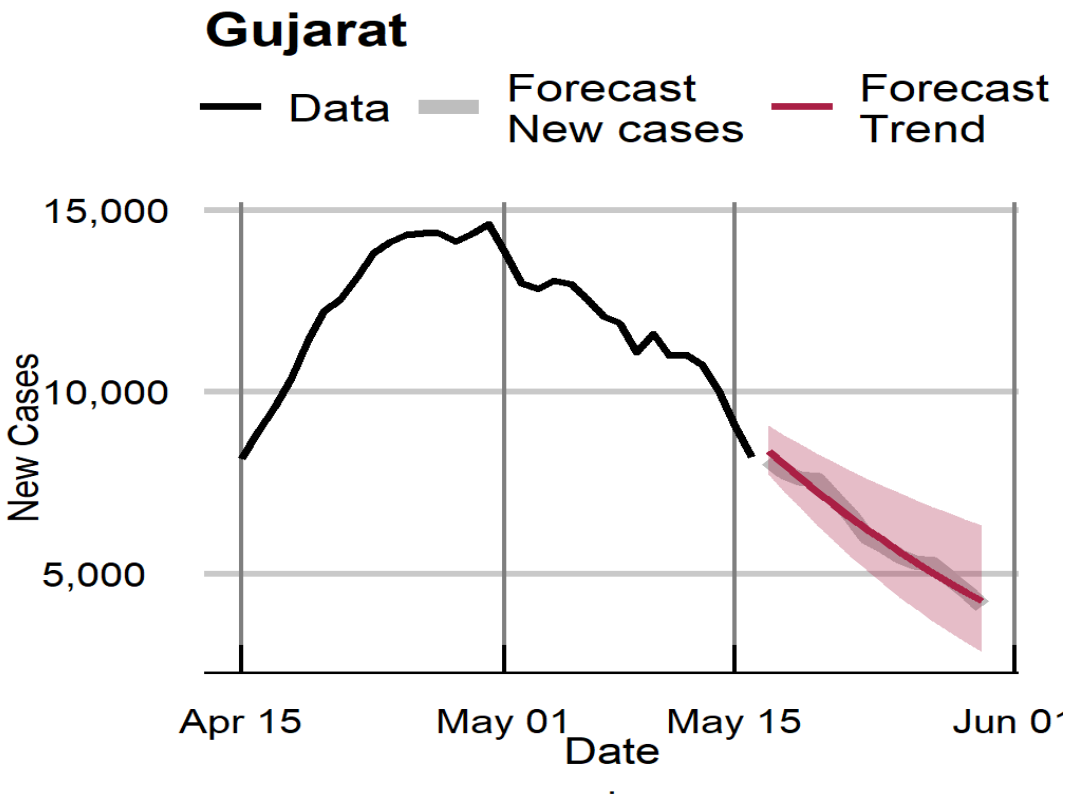

Dadra and Nagar Haveli
Growth rate of daily cases
0.3
0.2
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

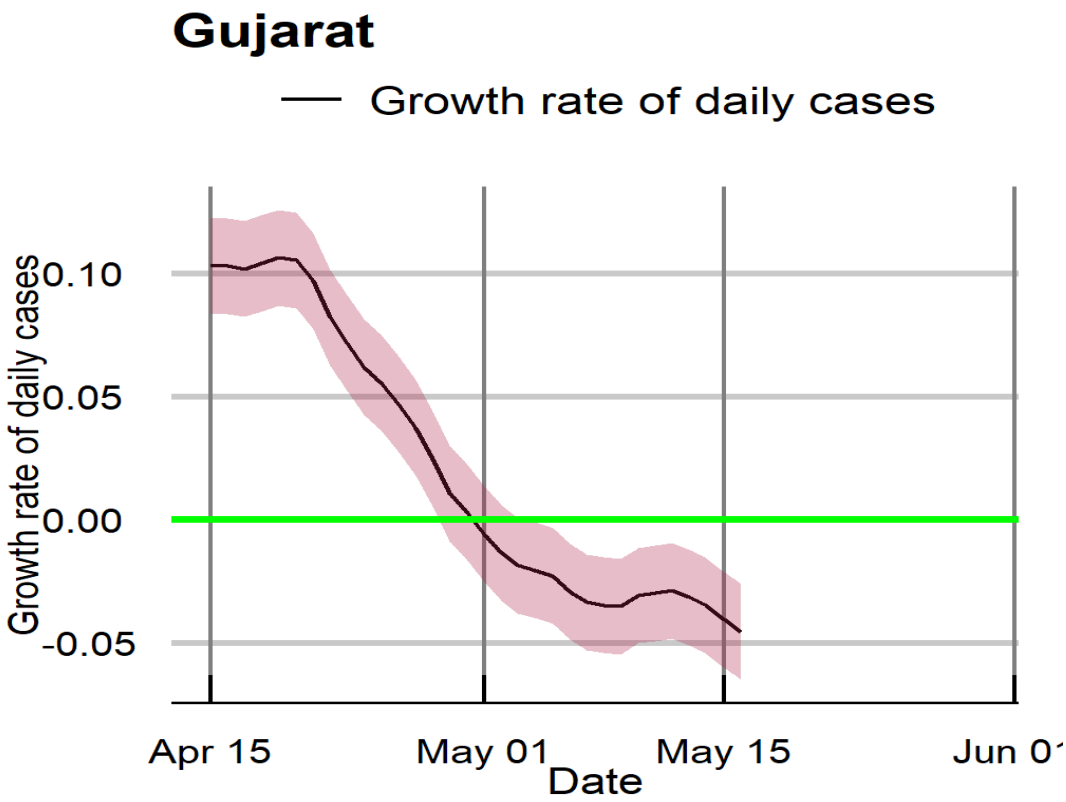

Delhi
Data
Forecast New cases
Forecast Trend
New Cases
20,000
10,000
0
Apr 15
May 01
May 15
Jun 0
Date

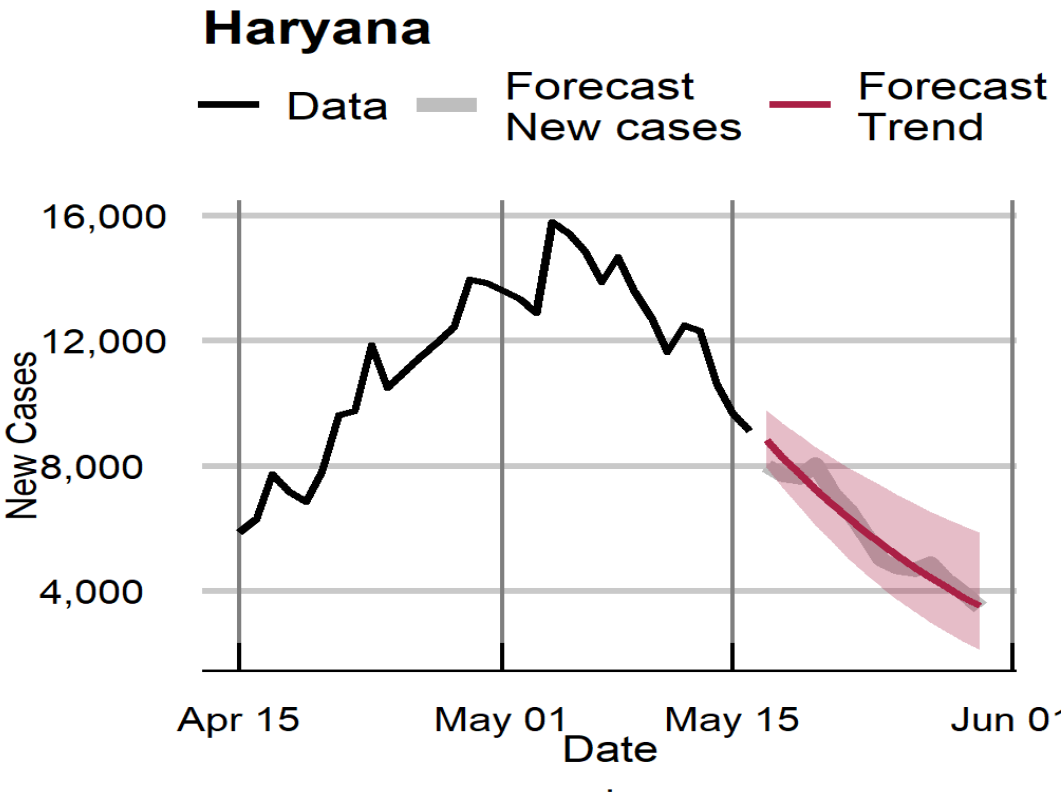

Delhi
Growth rate of daily cases
Growth rate of daily cases
0.1
0.0
-0.1
Apr 15
May 01
May 15
Jun 0
Date

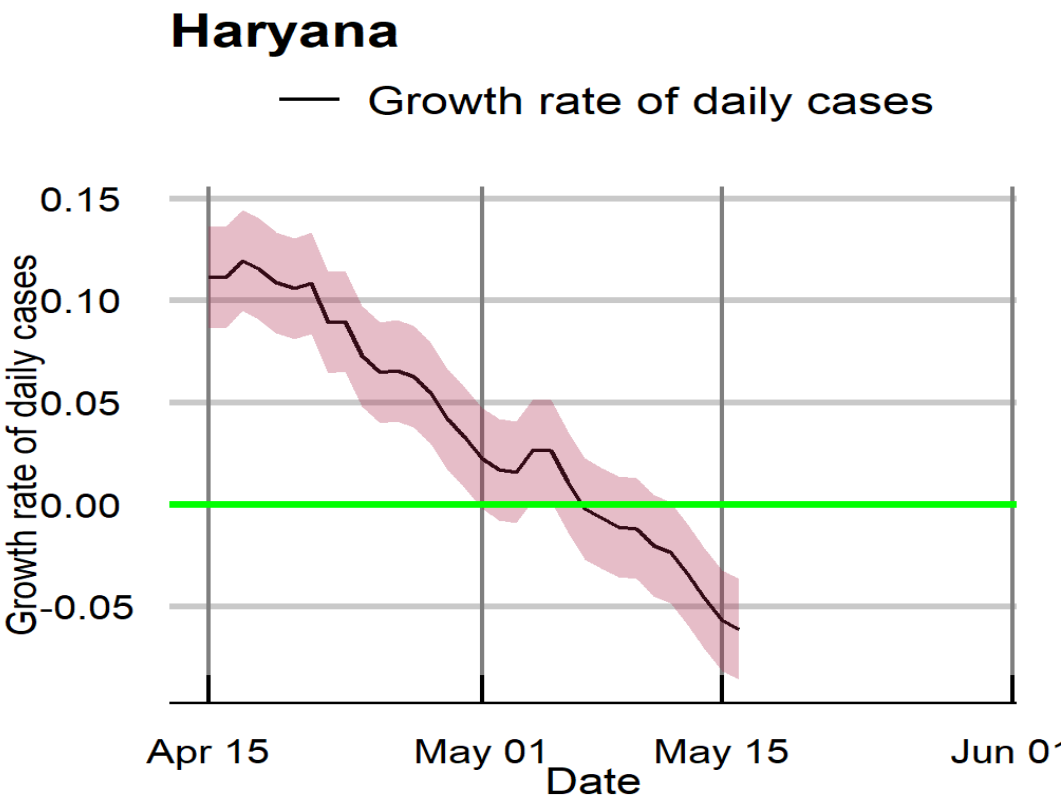

Goa
Data
Forecast New cases
Forecast Trend
4,000
3,000
2,000
1,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

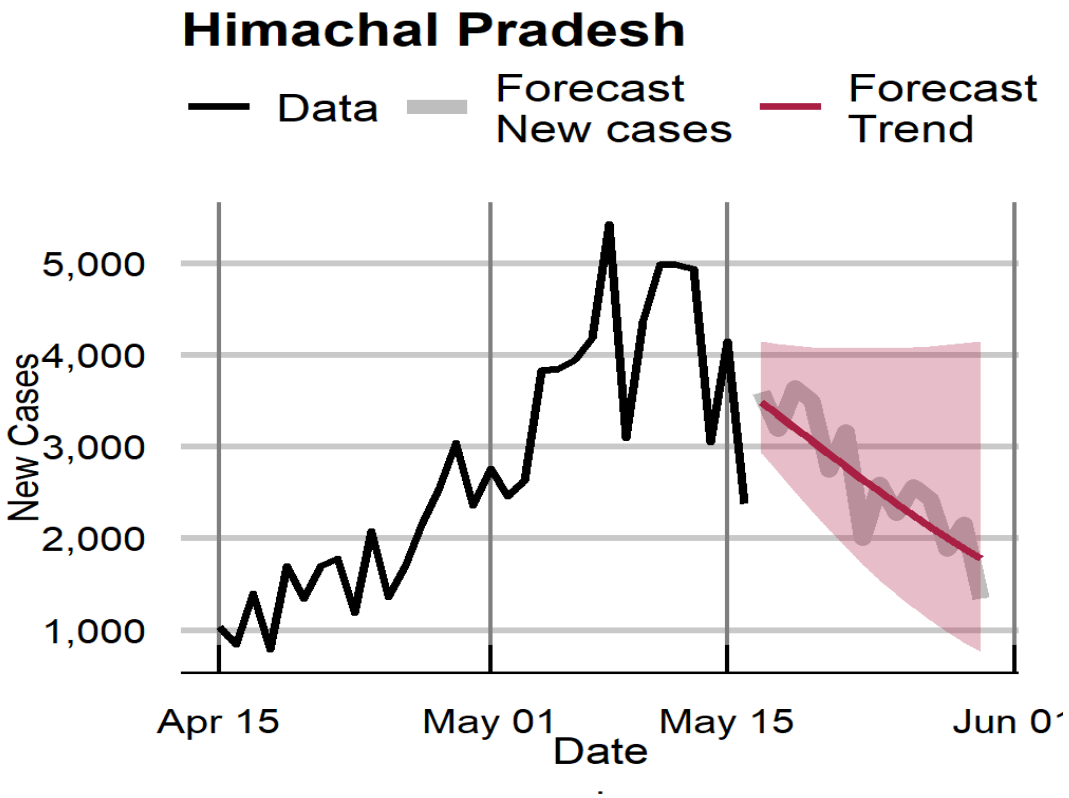

Goa
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

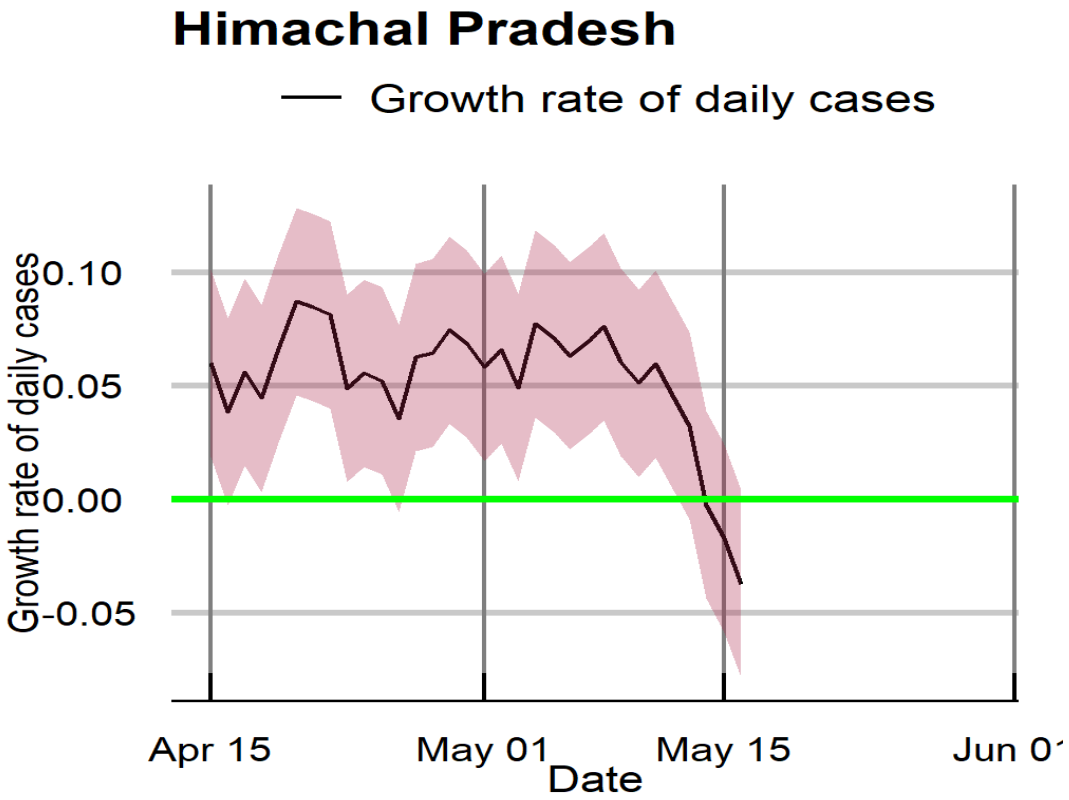

Gujarat
Data
Forecast New cases
Forecast Trend
15,000
10,000
5,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date


Gujarat
Growth rate of daily cases
0.10
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date


Haryana
Data
Forecast New cases
Forecast Trend
16,000
12,000
8,000
4,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date


Haryana
Growth rate of daily cases
0.15
0.10
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date


Himachal Pradesh
Data
Forecast
New cases
Forecast
Trend
New Cases
5,000
4,000
3,000
2,000
1,000
Apr 15
May 01
May 15
Jun 0
Date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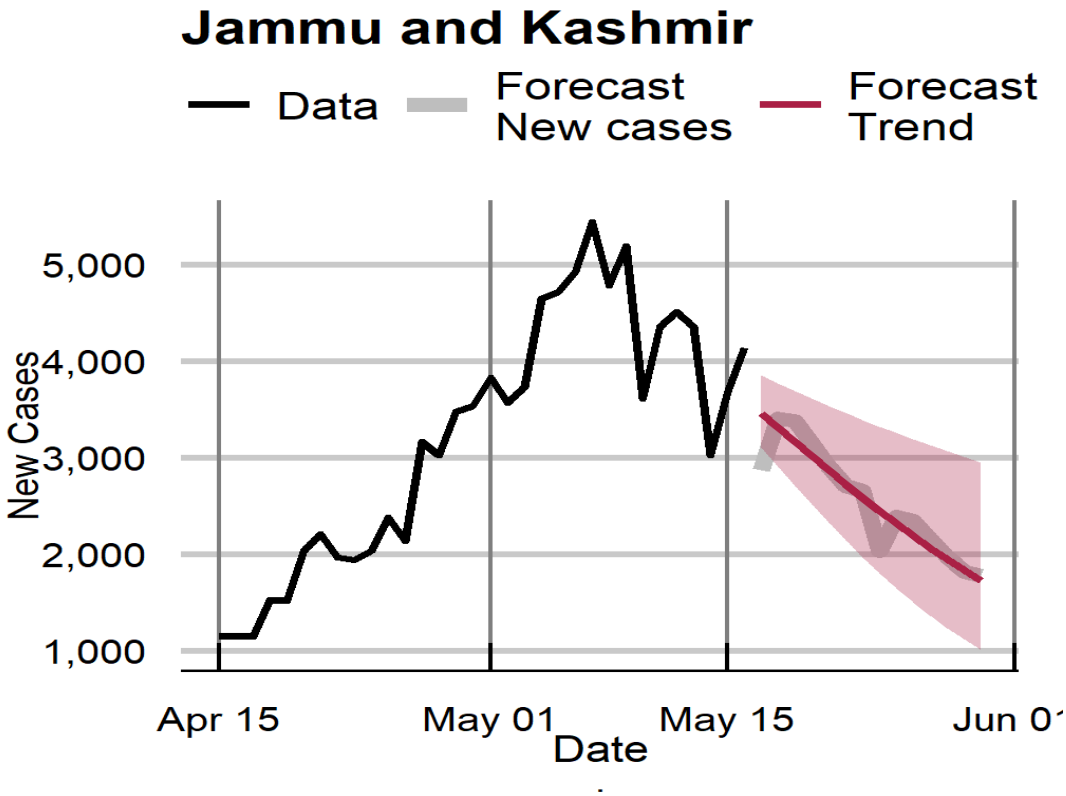
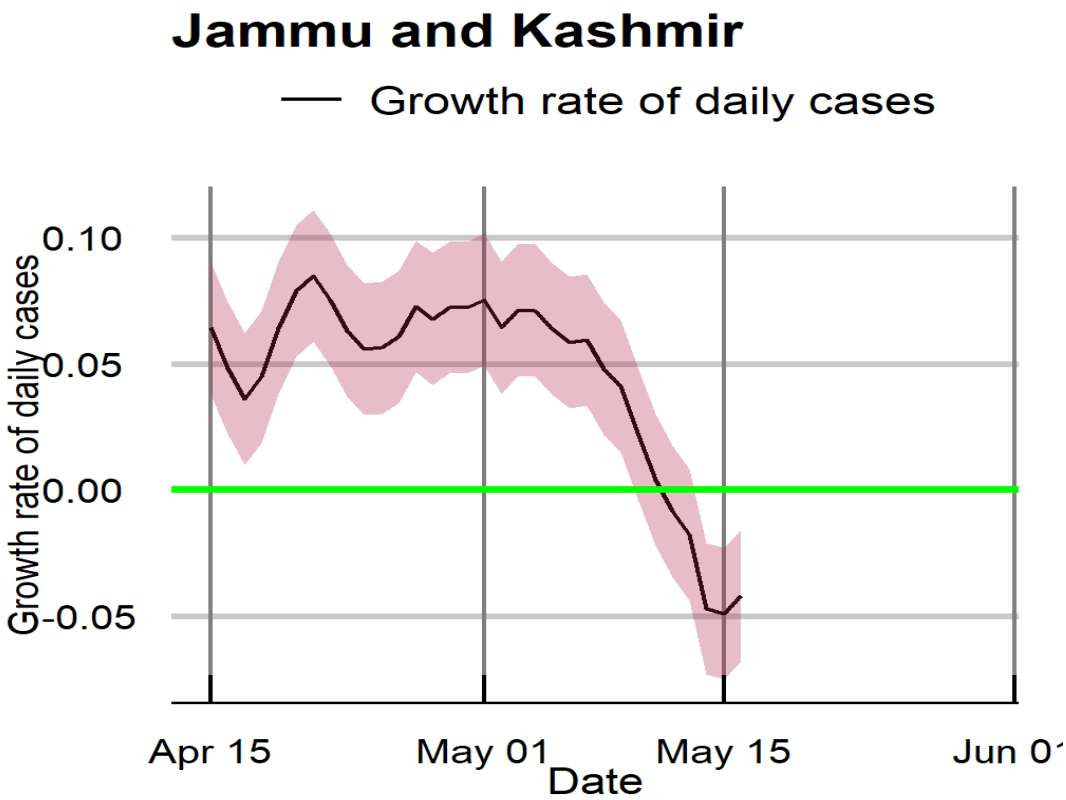
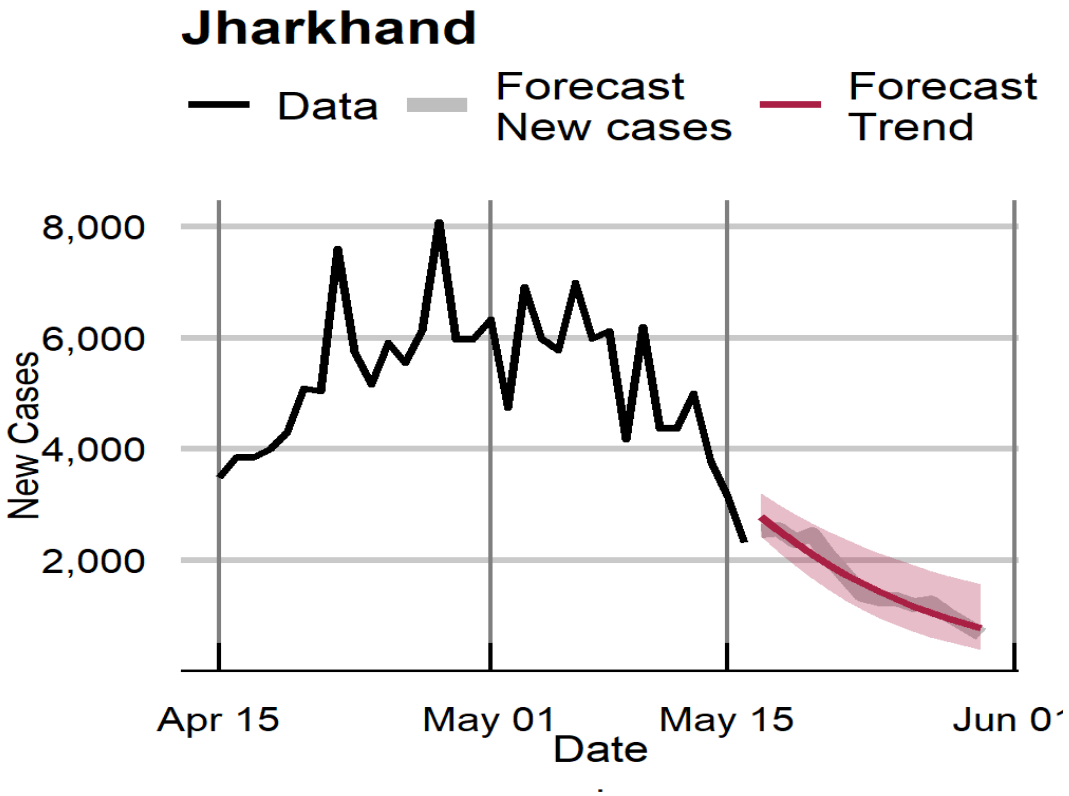
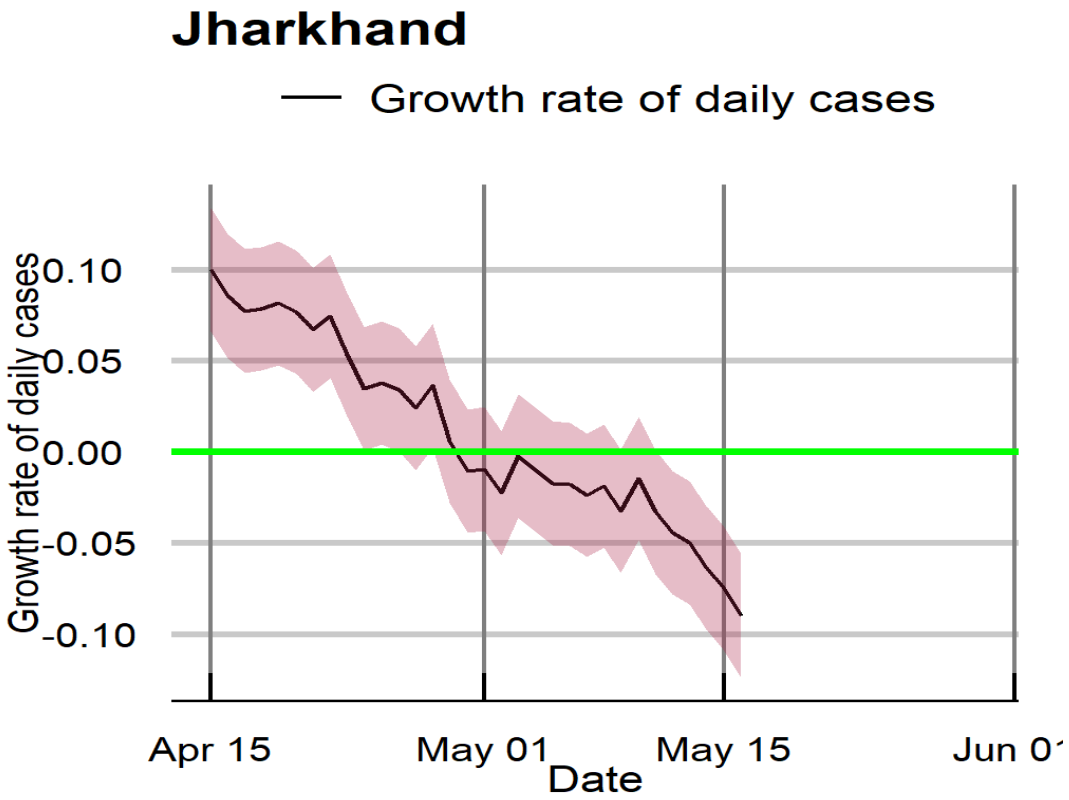
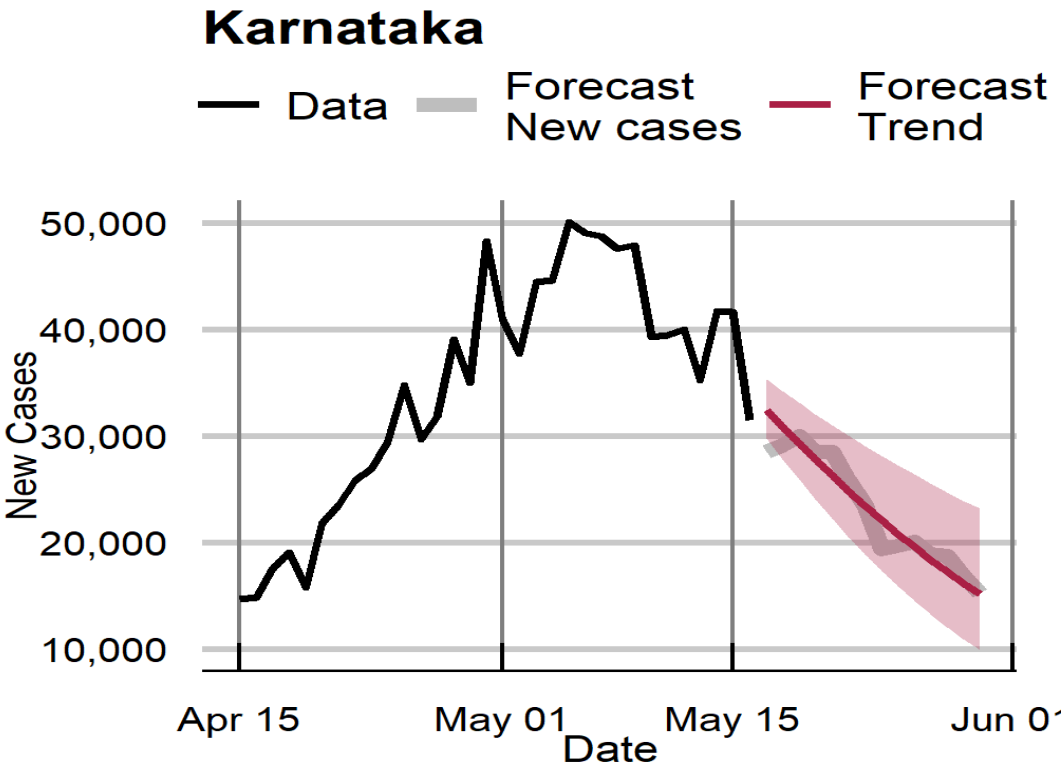
Growth rate of daily cases
Growth rate of daily cases
0.10
0.05
0.00
-0.05
Apr 15
May 01
May 15
Jun 0
Date

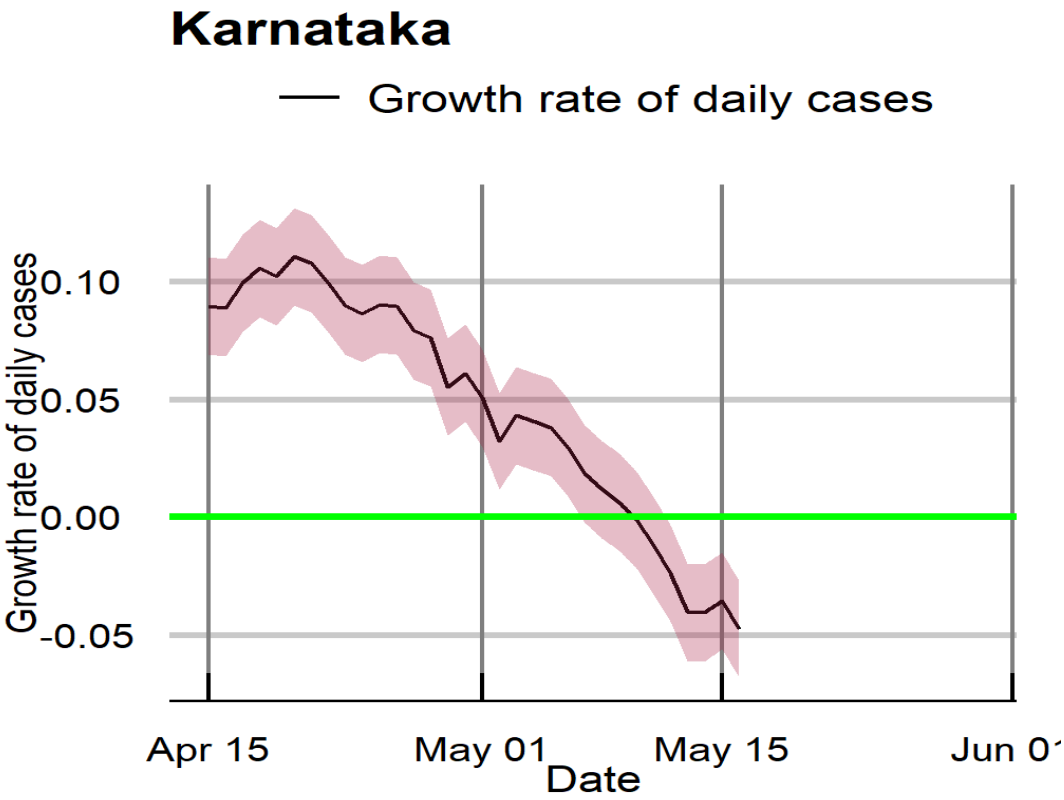

Jammu and Kashmir
Data
Forecast
New cases
Forecast
Trend
New Cases
5,000
4,000
3,000
2,000
1,000
Apr 15
May 01
May 15
Jun 0
Date

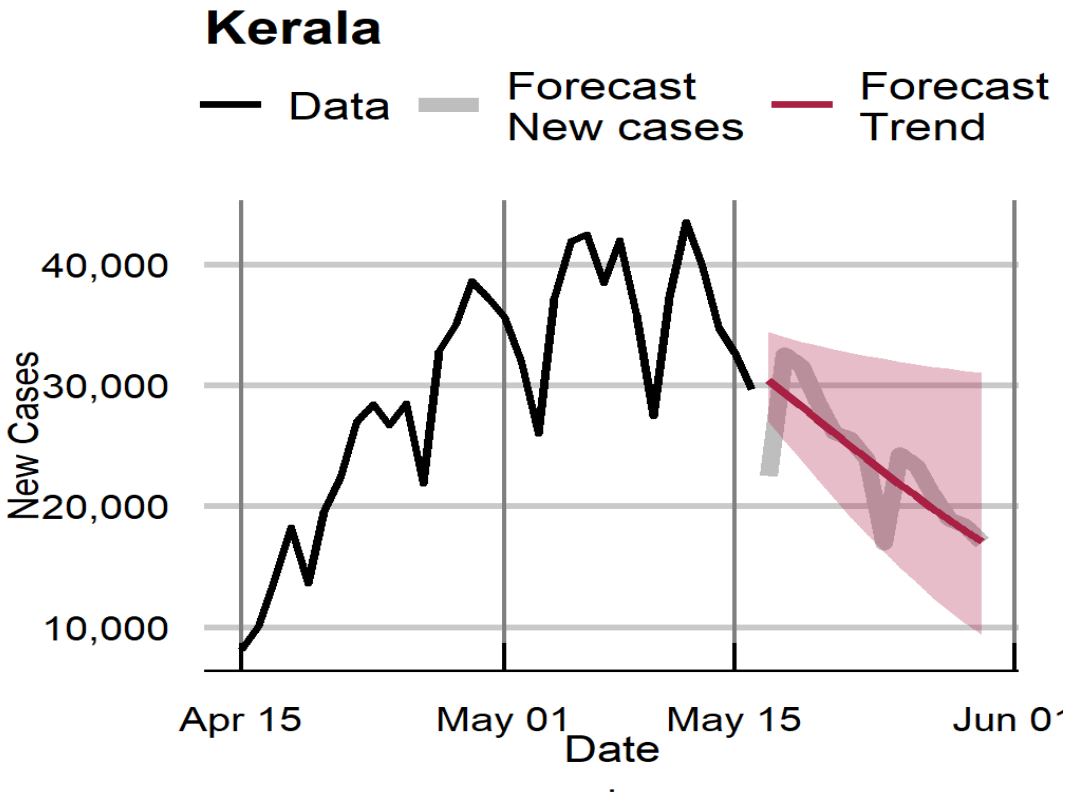

Jammu and Kashmir
Growth rate of daily cases
Growth rate of daily cases
0.10
0.05
0.00
-0.05
Apr 15
May 01
May 15
Jun 0
Date

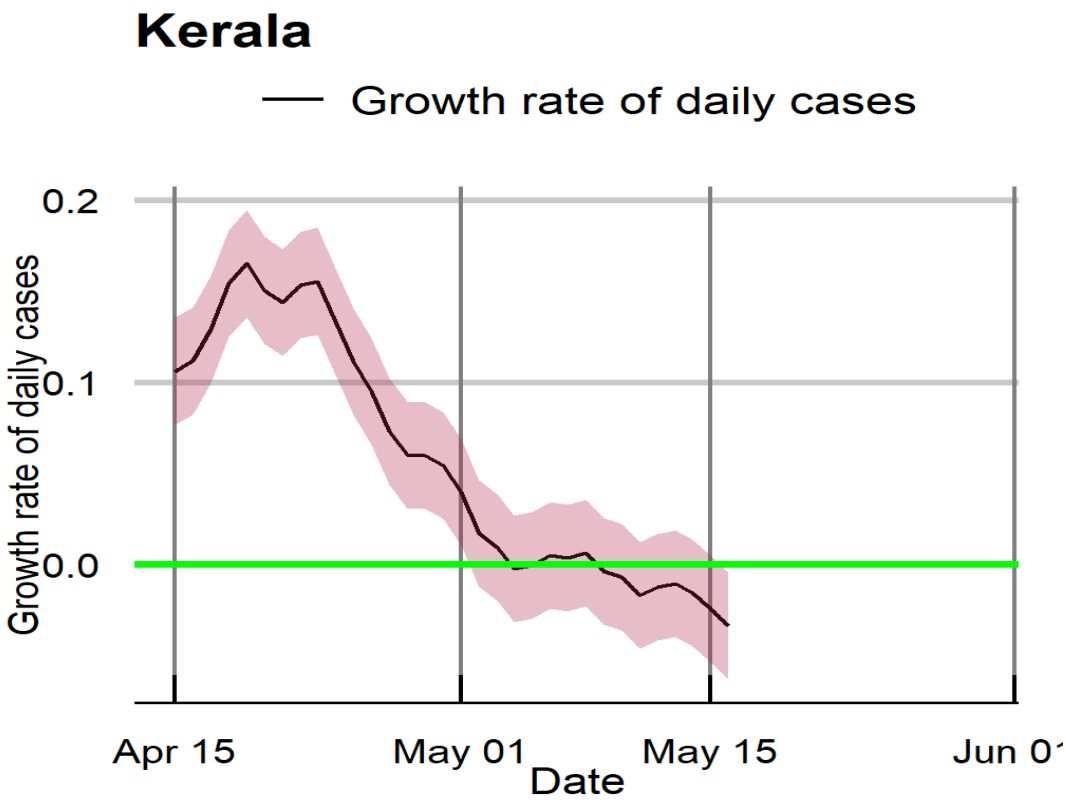

Jharkhand
Data
Forecast New cases
Forecast Trend
8,000
6,000
4,000
2,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

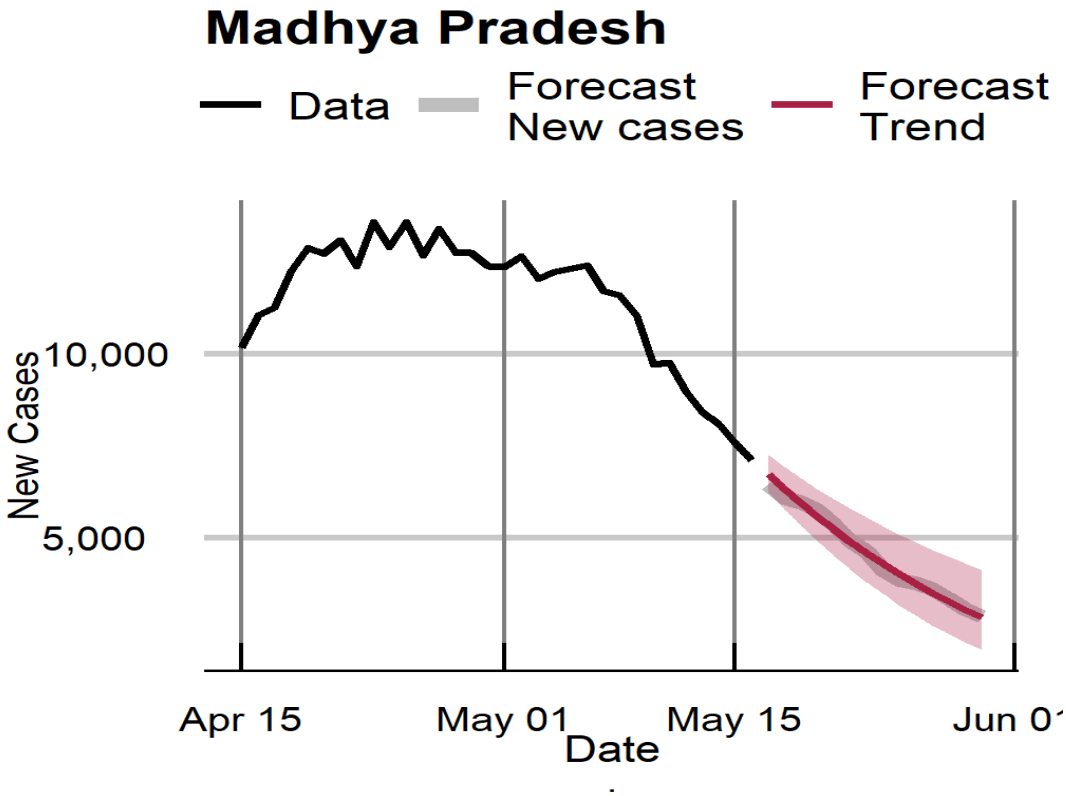

Jharkhand
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

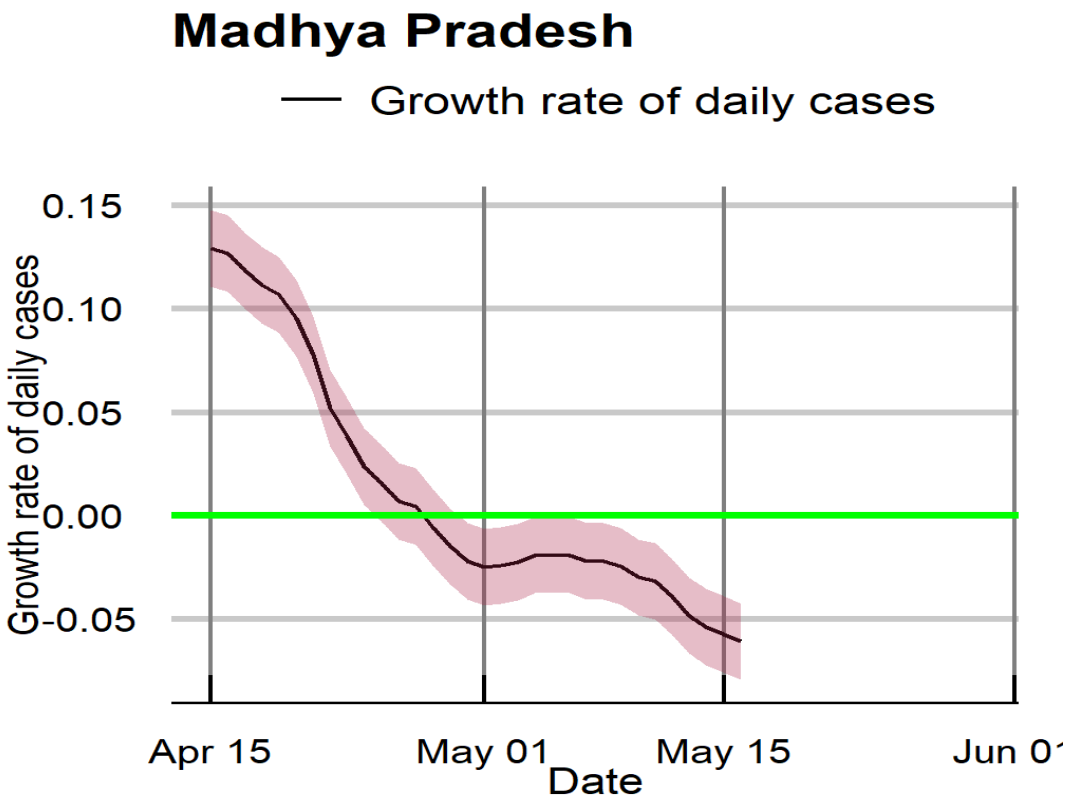

Karnataka
Data
Forecast New cases
Forecast Trend
50,000
40,000
30,000
20,000
10,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

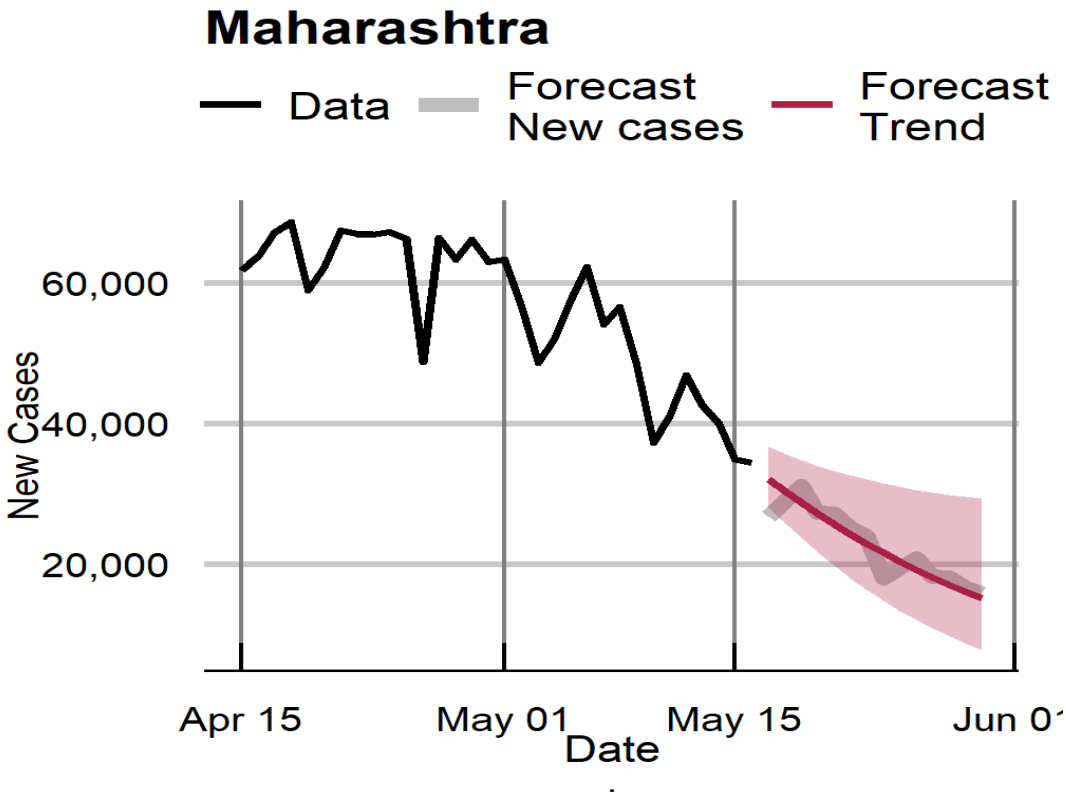

Karnataka
Growth rate of daily cases
0.10
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

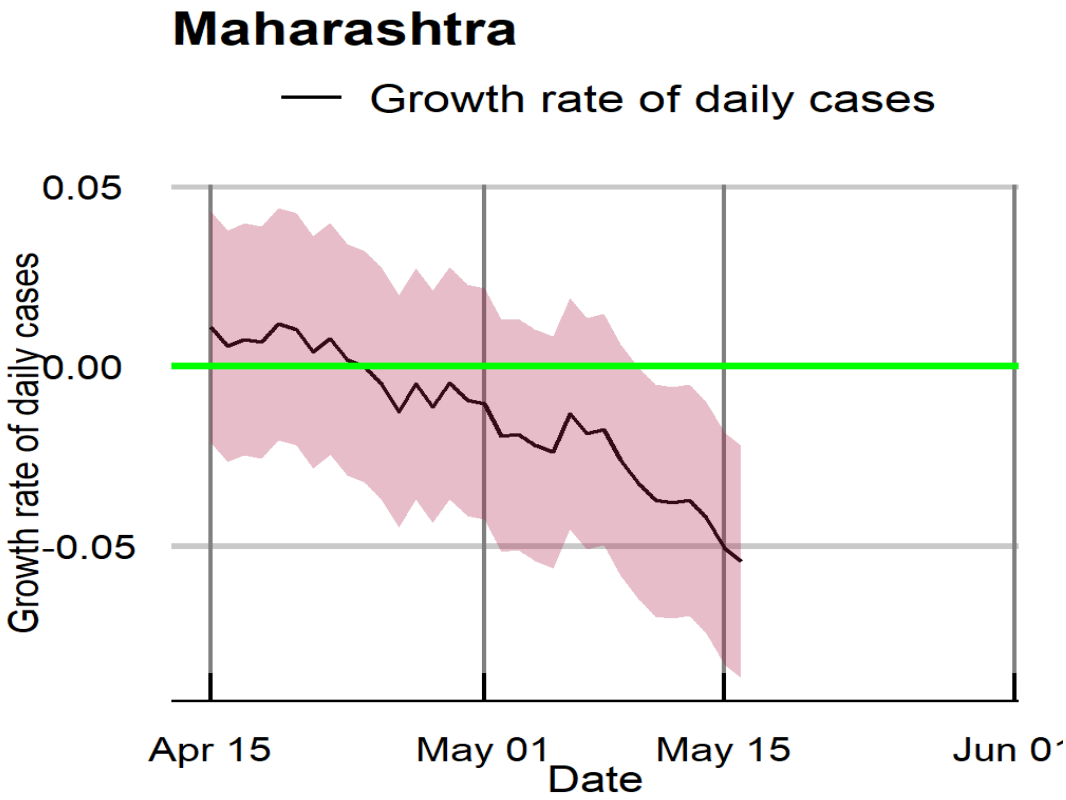

Kerala
Data
Forecast
New cases
Forecast
Trend
40,000
30,000
20,000
10,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

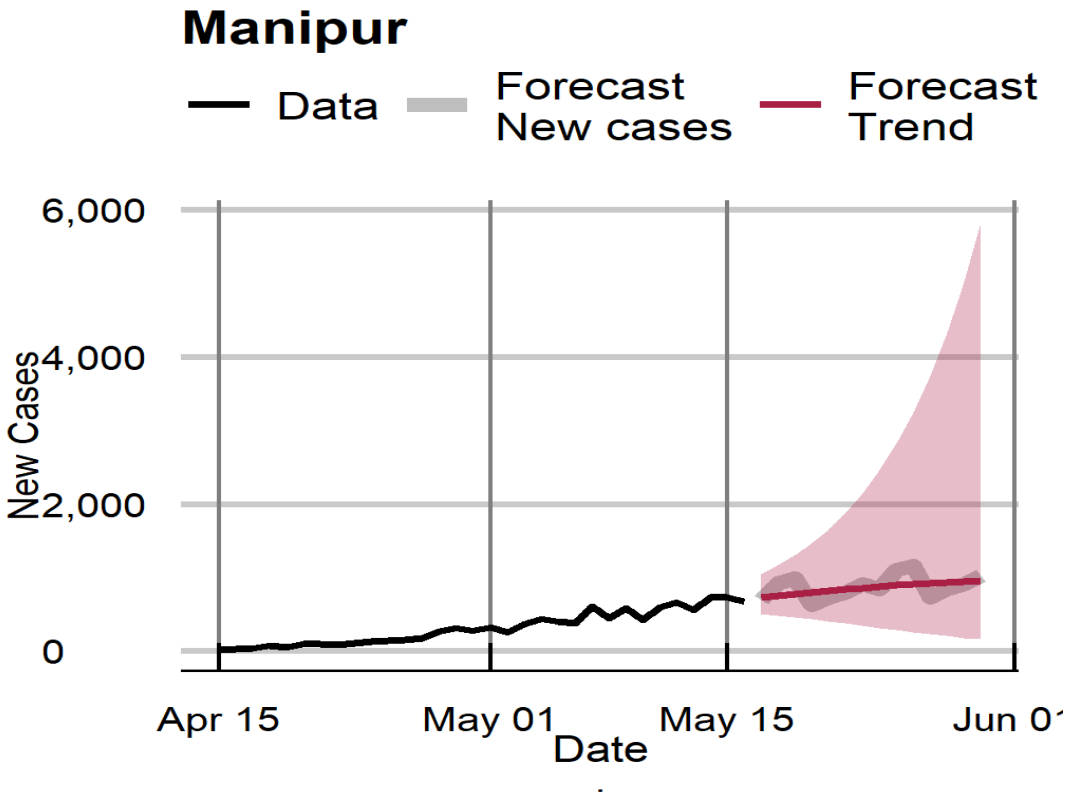

Kerala
Growth rate of daily cases
0.2
0.1
0.0
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

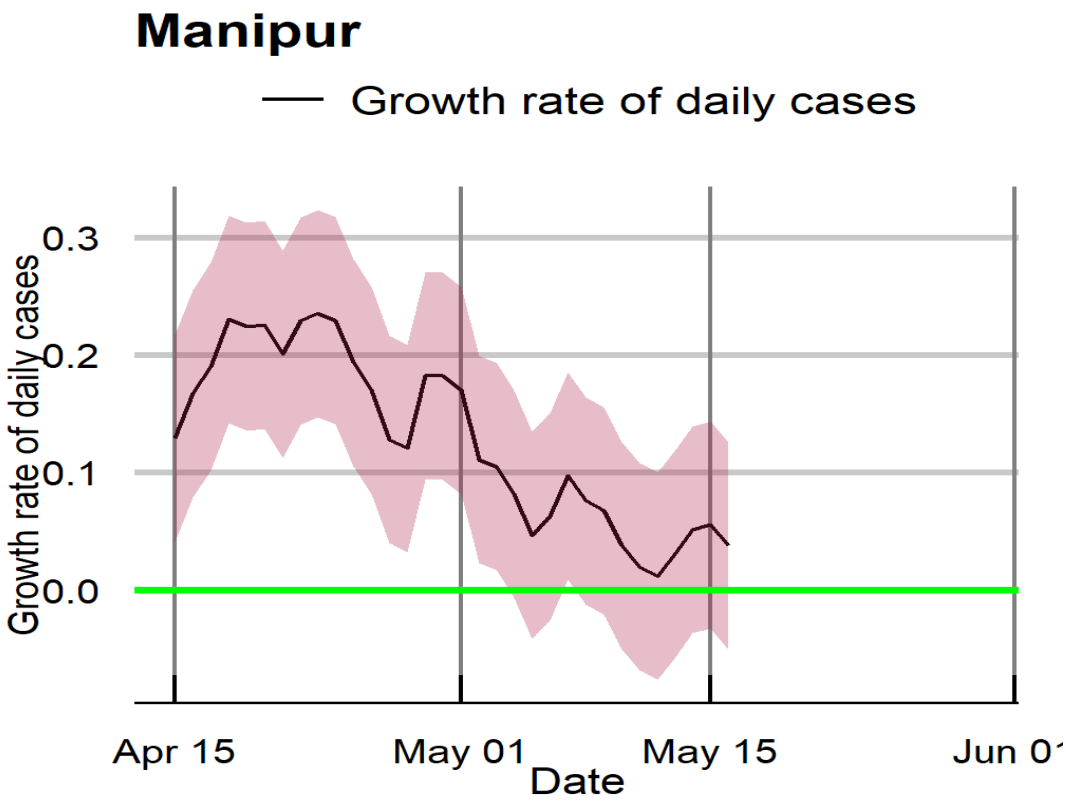

Madhya Pradesh
Data
Forecast
New cases
Forecast
Trend
New Cases
10,000
5,000
Apr 15
May 01
May 15
Jun 0
Date

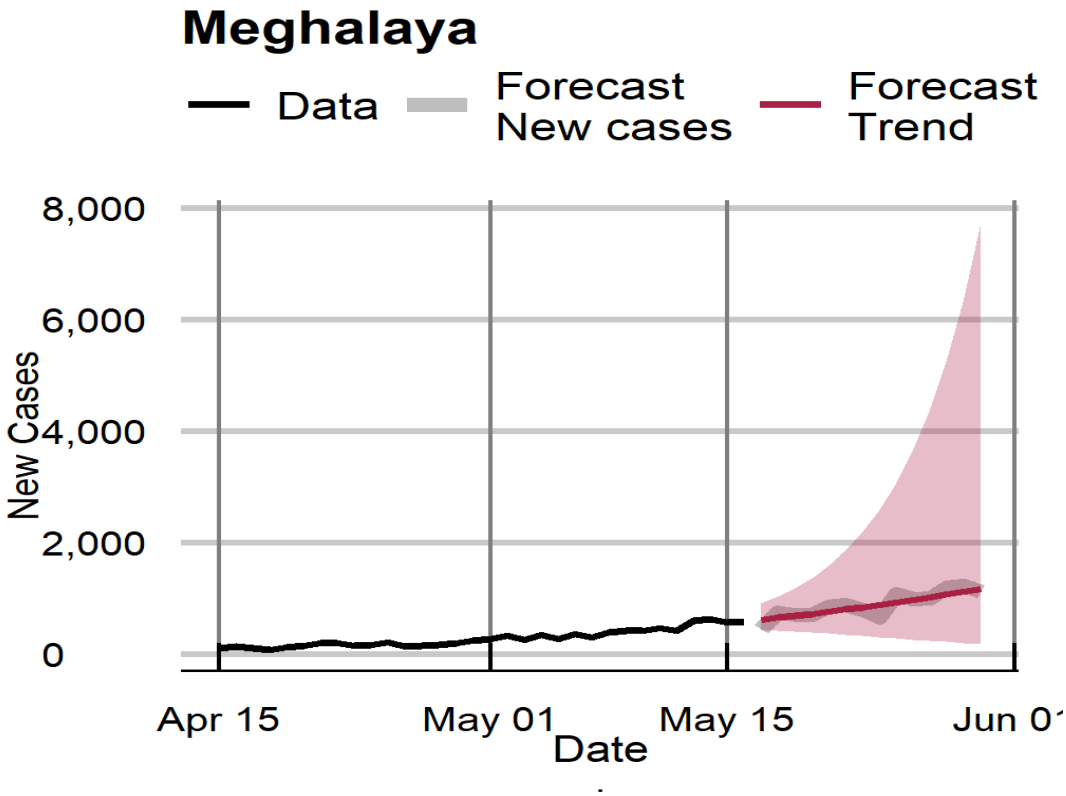

Madhya Pradesh
Growth rate of daily cases
Growth rate of daily cases
0.15
0.10
0.05
0.00
-0.05
Apr 15
May 01
May 15
Jun 0
Date

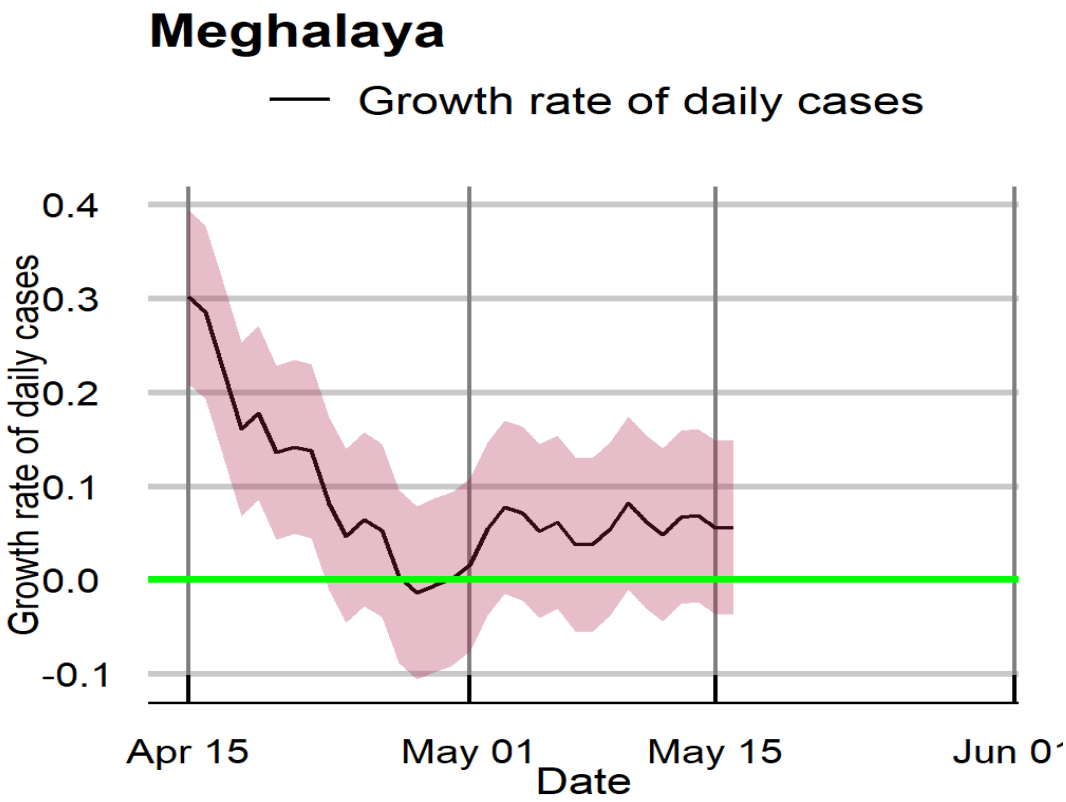

Maharashtra
Data
Forecast New cases
Forecast Trend
60,000
40,000
20,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

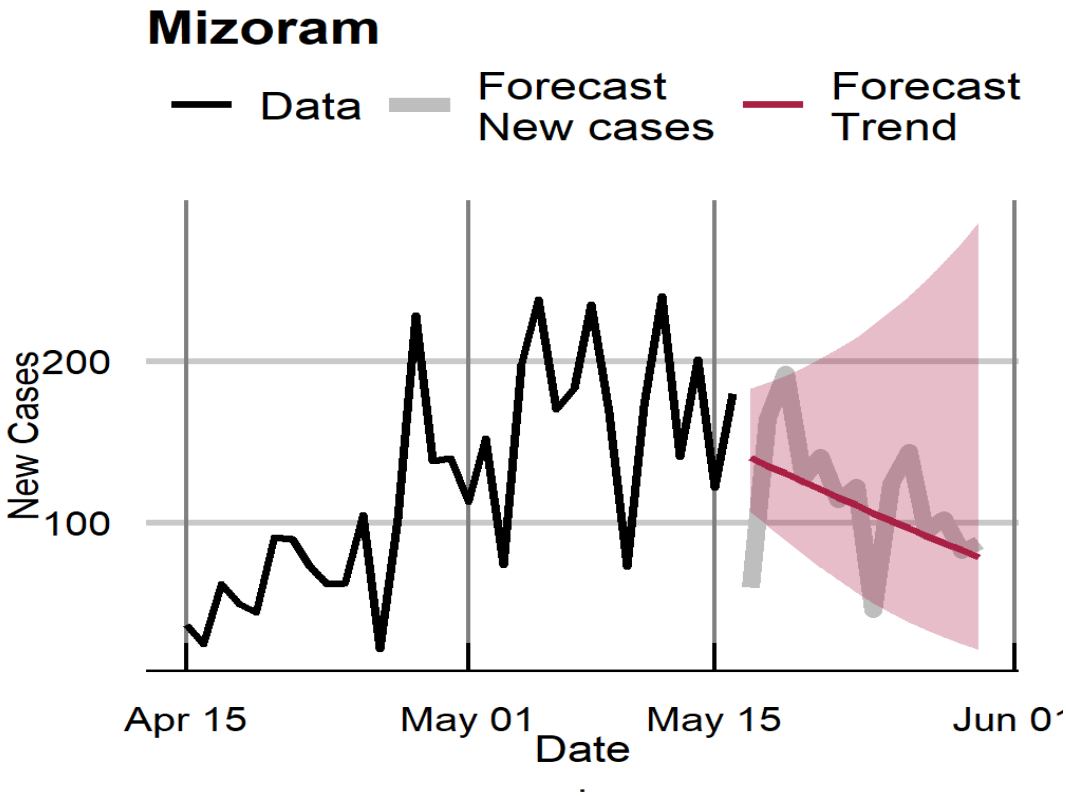

Maharashtra
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

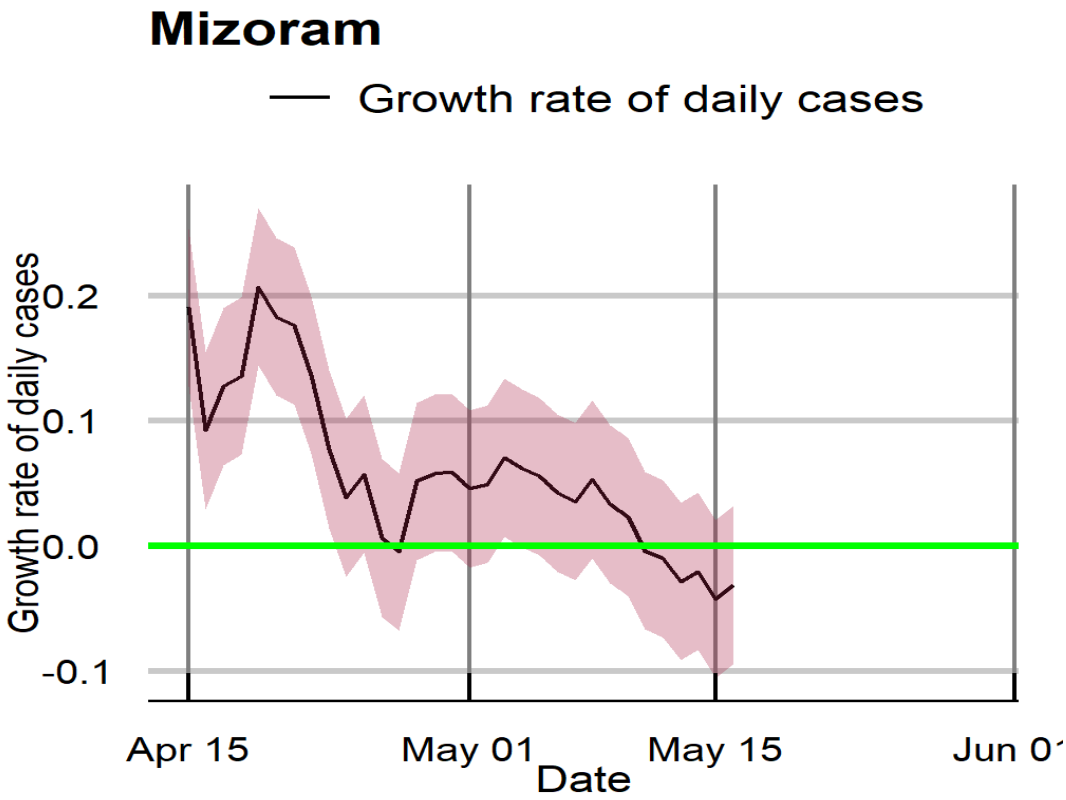

Manipur
Data
Forecast New cases
Forecast Trend
6,000
4,000
2,000
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

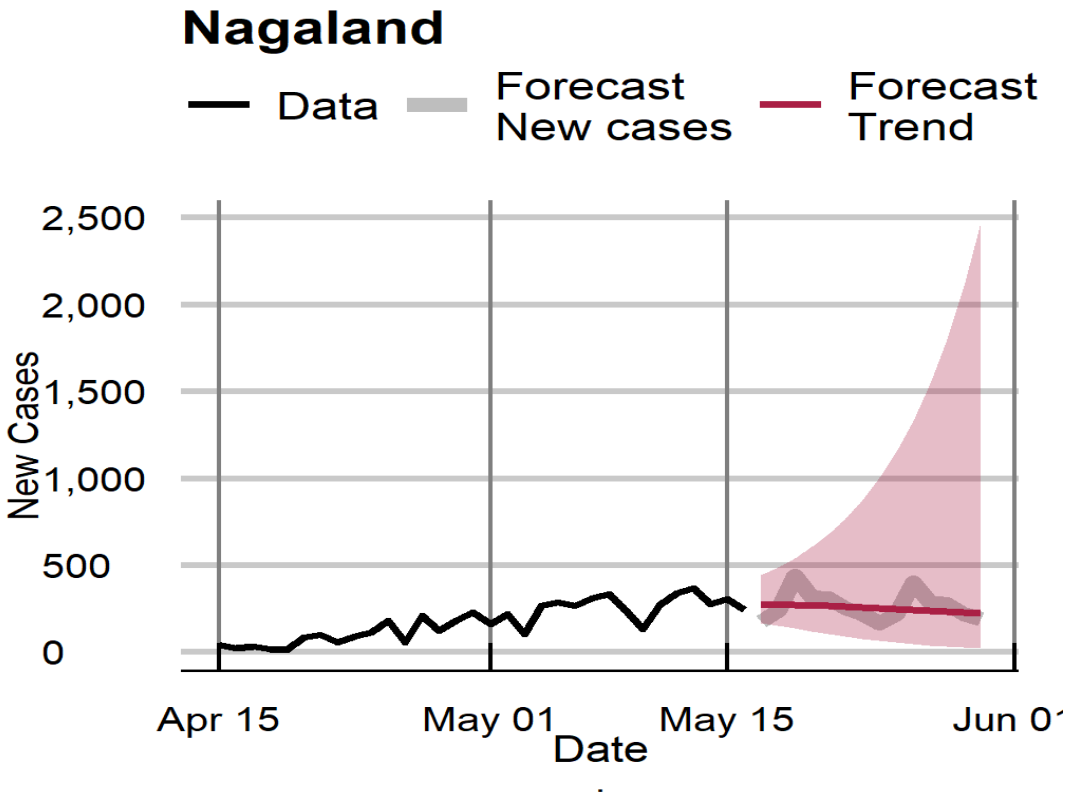

Manipur
Growth rate of daily cases
0.3
0.2
0.1
0.0
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

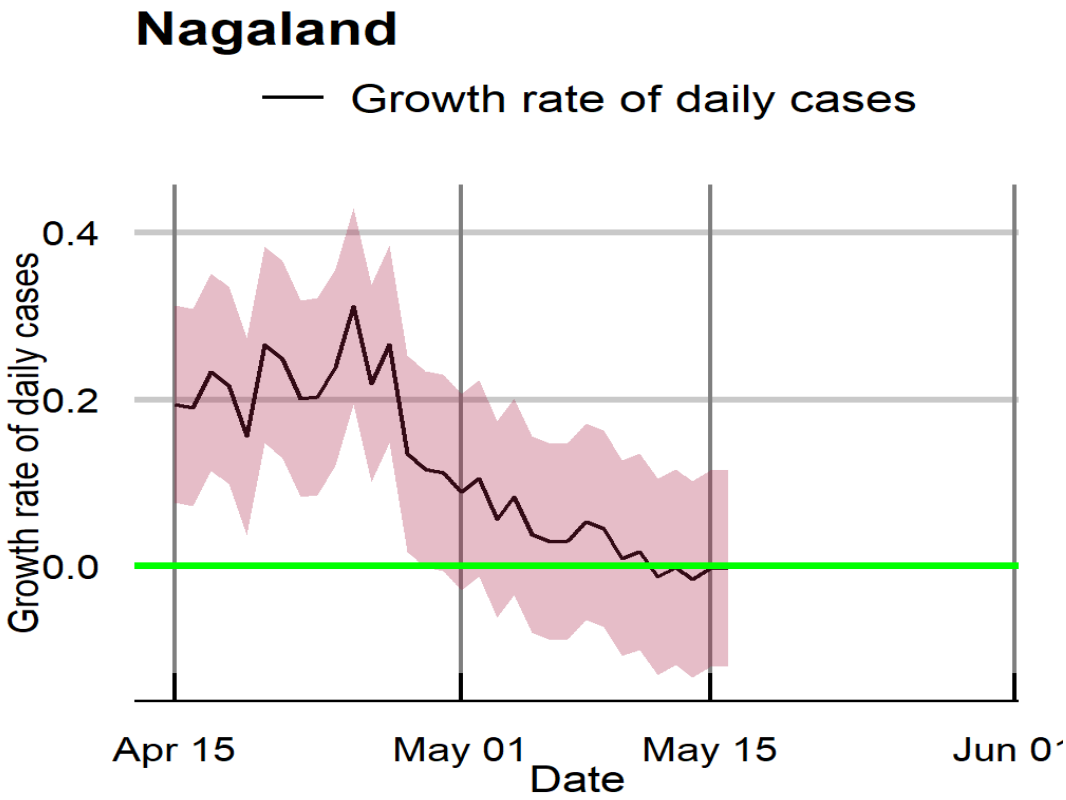

Meghalaya
Data
Forecast New cases
Forecast Trend
8,000
6,000
4,000
2,000
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

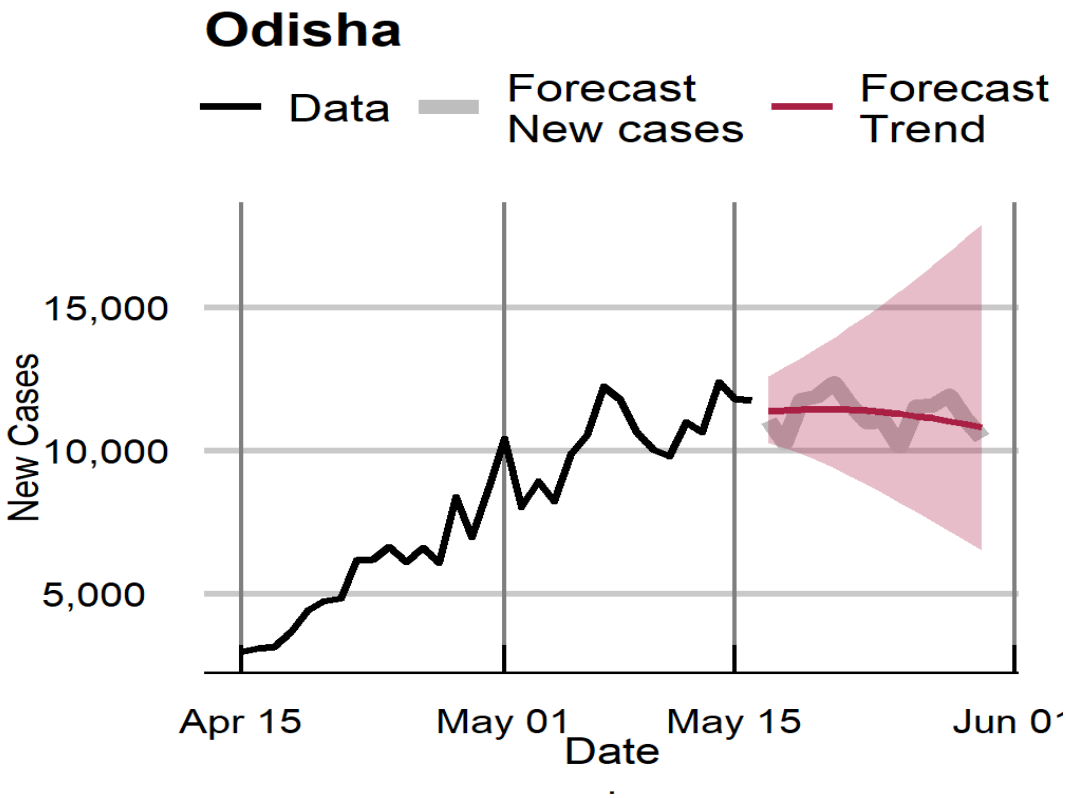

Meghalaya
Growth rate of daily cases
0.4
0.3
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

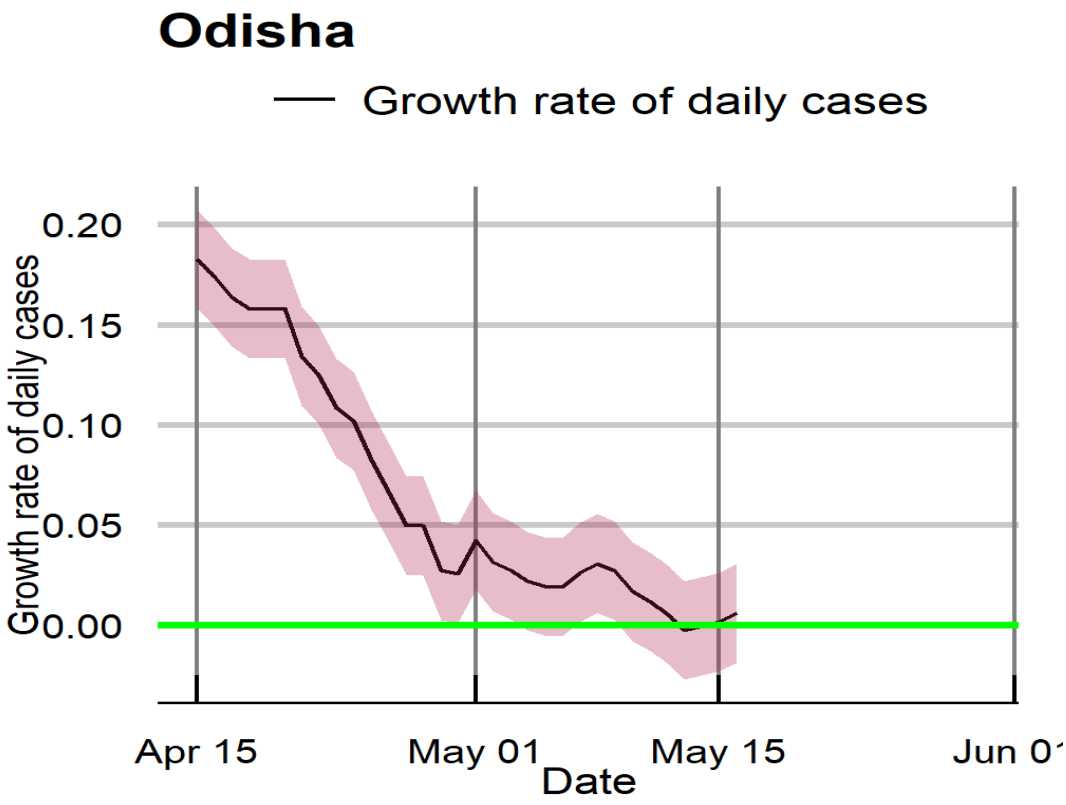

Mizoram
Data
Forecast
New cases
Forecast
Trend
New Cases
200
100
Apr 15
May 01
May 15
Jun 0
Date

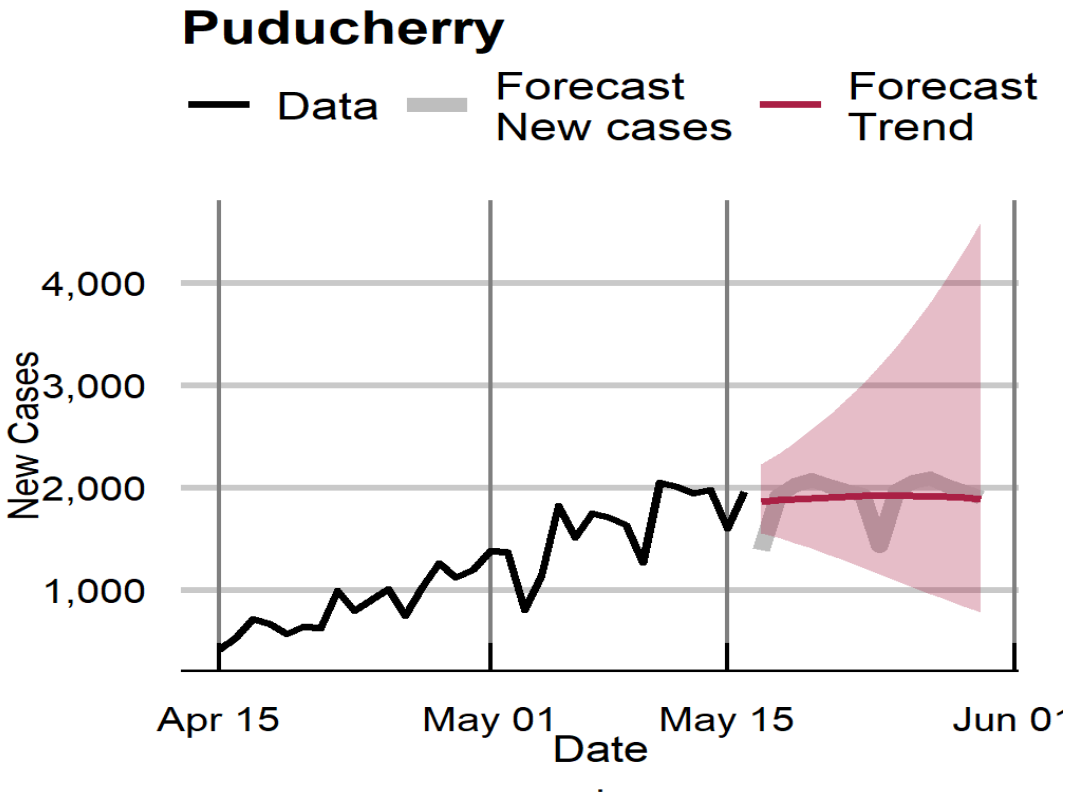

Mizoram
Growth rate of daily cases
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Apr 15
May 01
May 15
Jun 0
Date

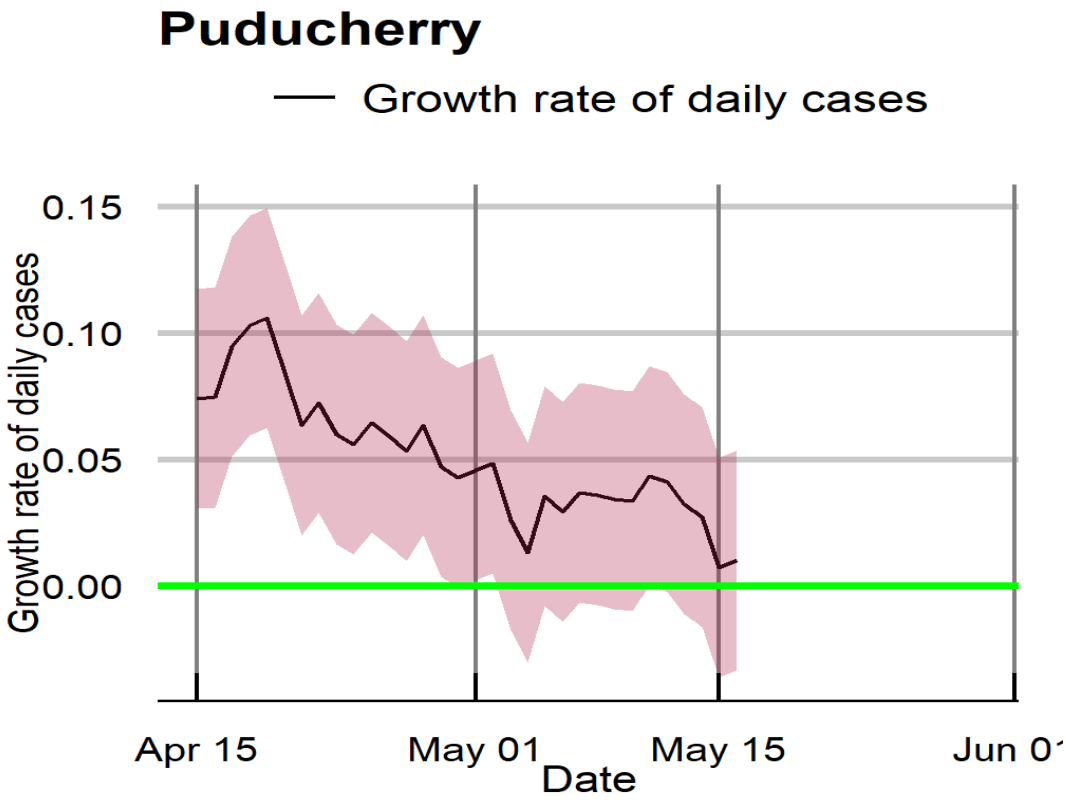

Nagaland
Data
Forecast
New cases
Forecast
Trend
2,500
2,000
1,500
1,000
500
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

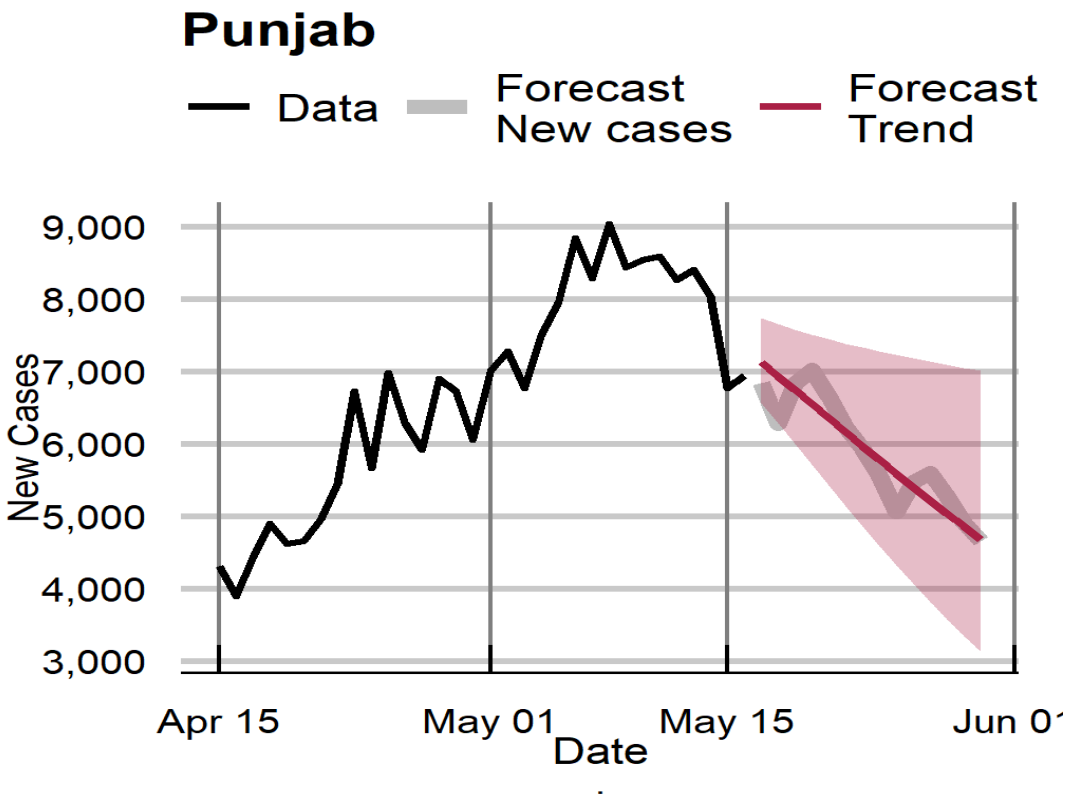

Nagaland
Growth rate of daily cases
0.4
0.2
0.0
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

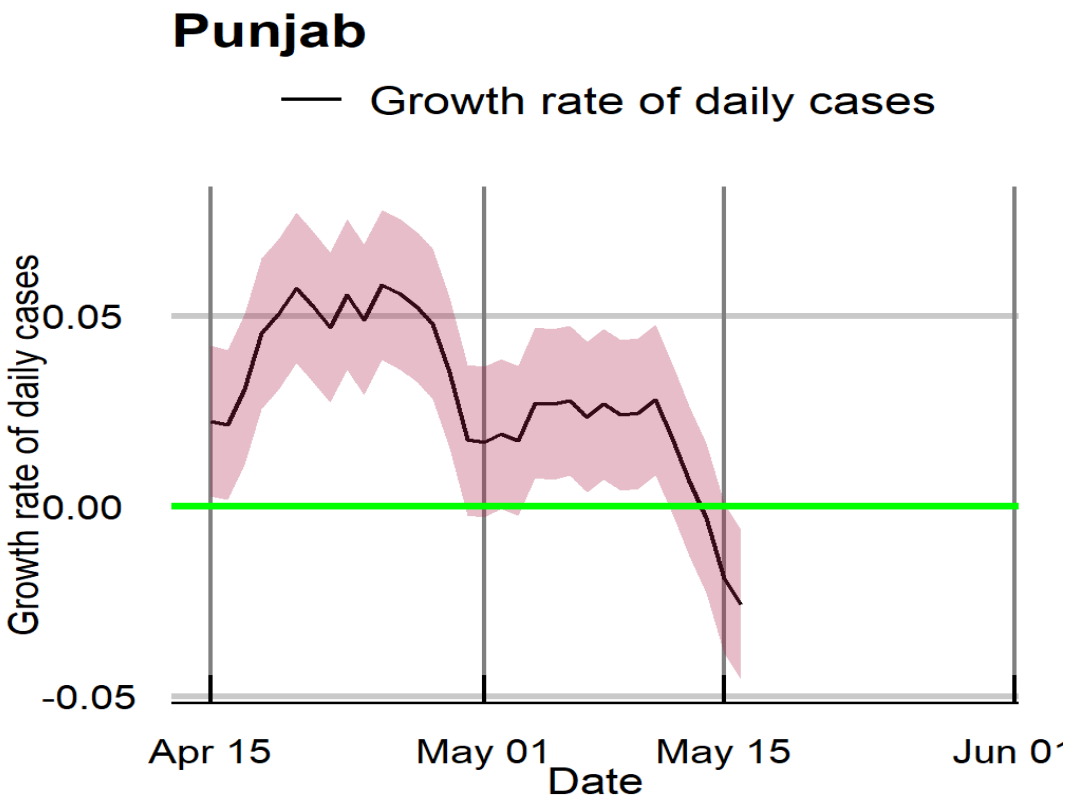

Odisha
Data
Forecast
New cases
Forecast
Trend
15,000
10,000
5,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

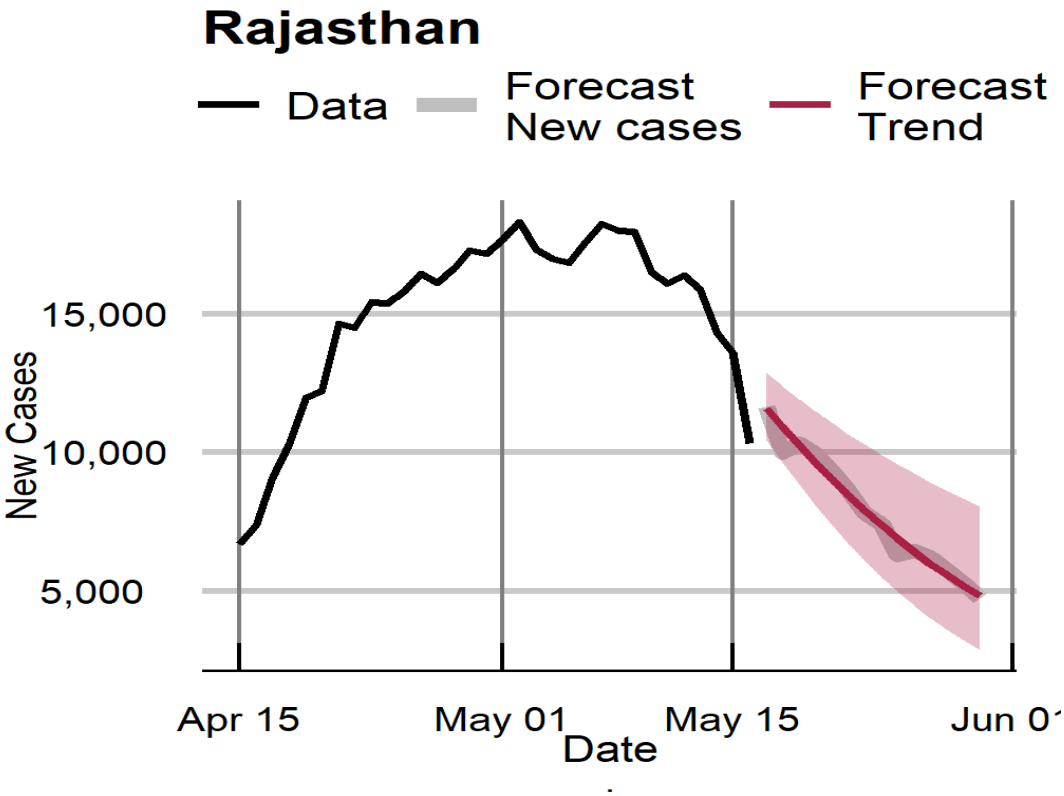

Odisha
Growth rate of daily cases
0.20
0.15
0.10
0.05
0.00
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

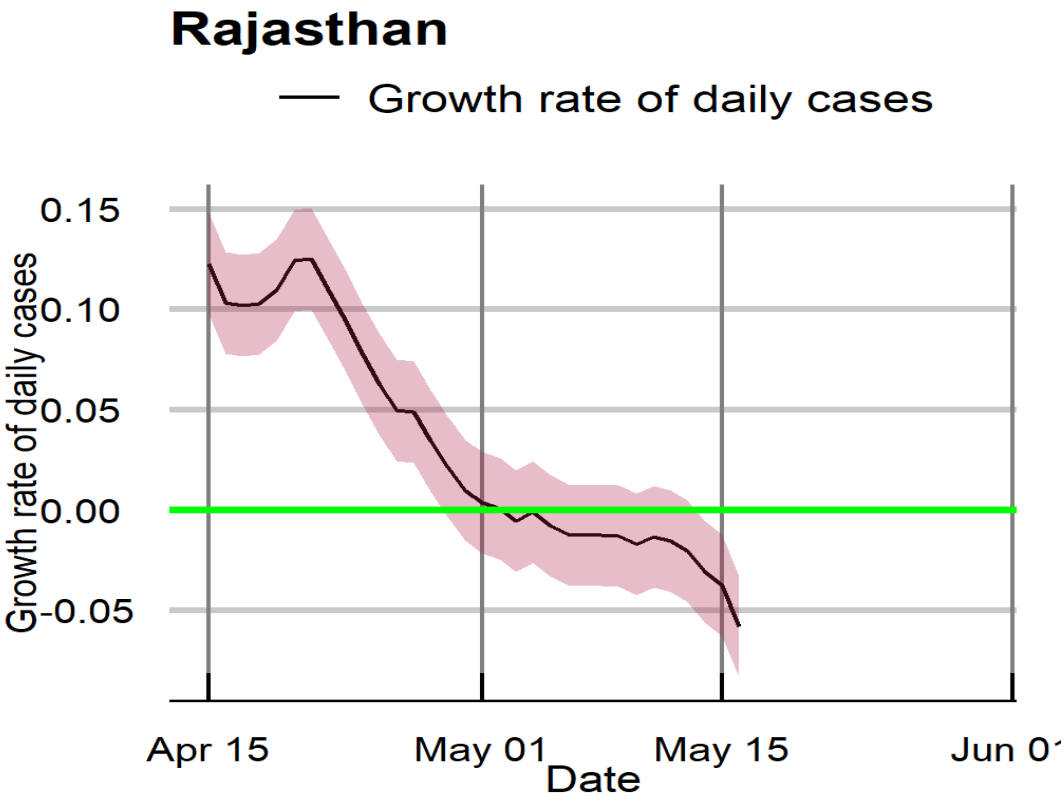

Puducherry
Data
Forecast
New cases
Forecast
Trend
4,000
3,000
2,000
1,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

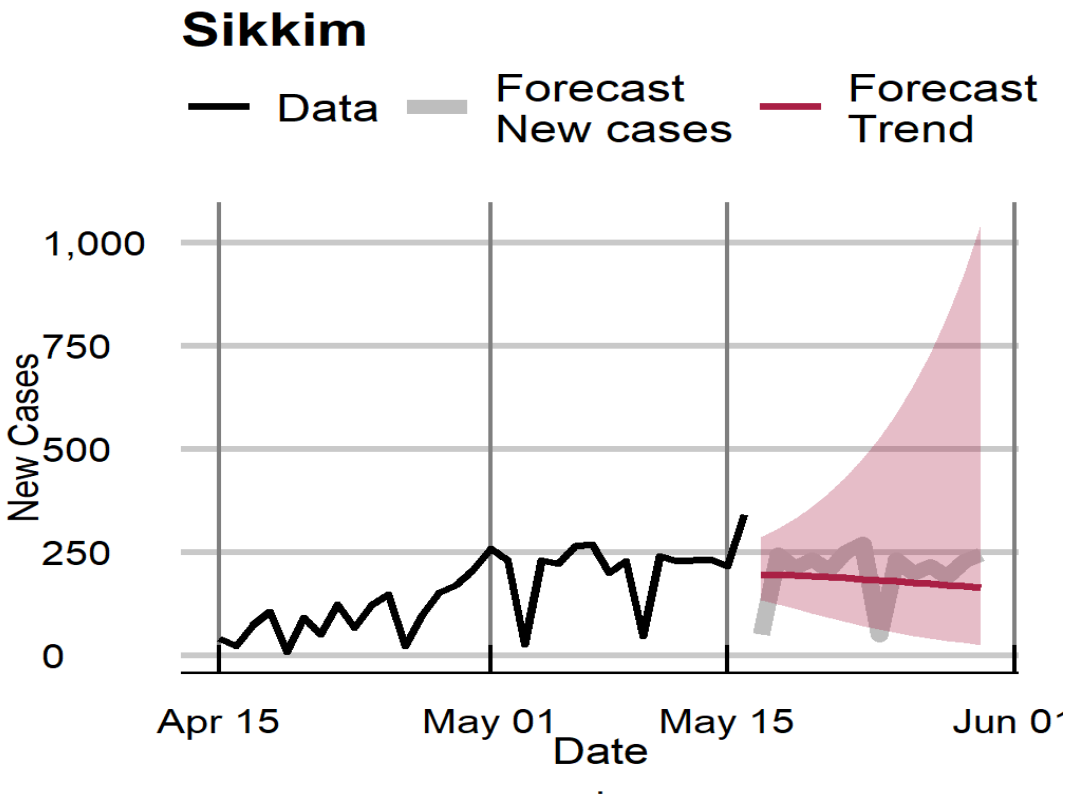

Puducherry
Growth rate of daily cases
0.15
0.10
0.05
0.00
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

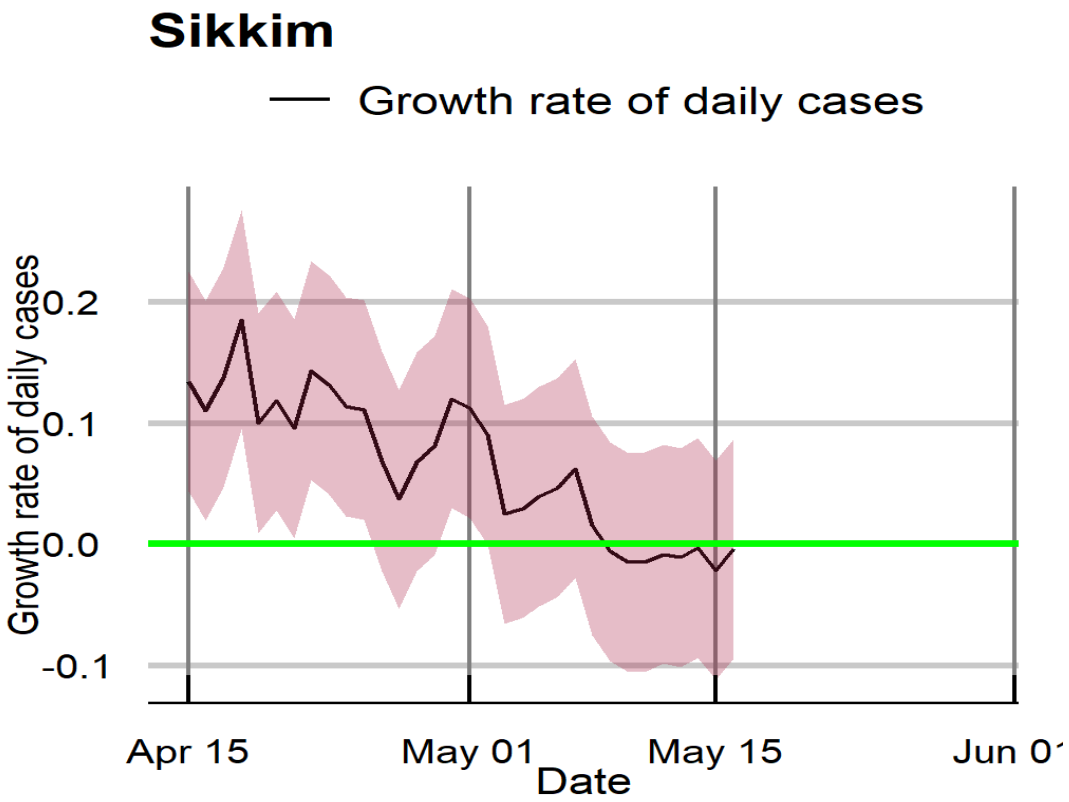

Punjab
Data
Forecast New cases
Forecast Trend
9,000
8,000
7,000
6,000
5,000
4,000
3,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

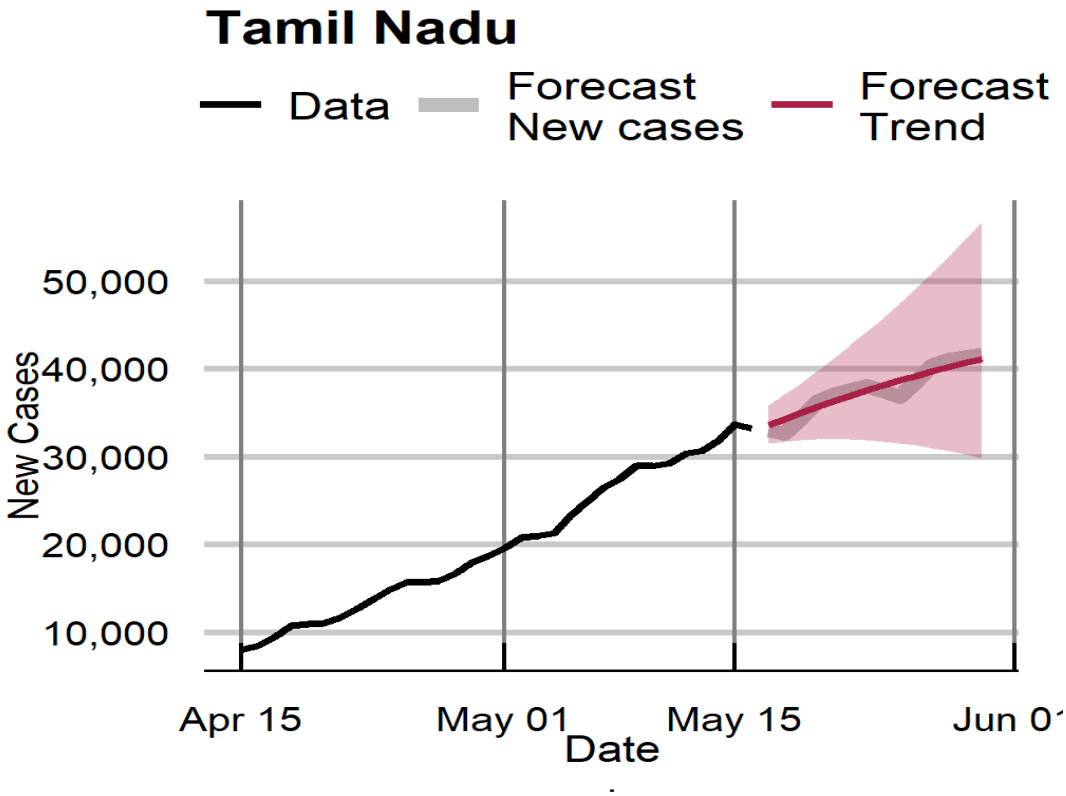

Punjab
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

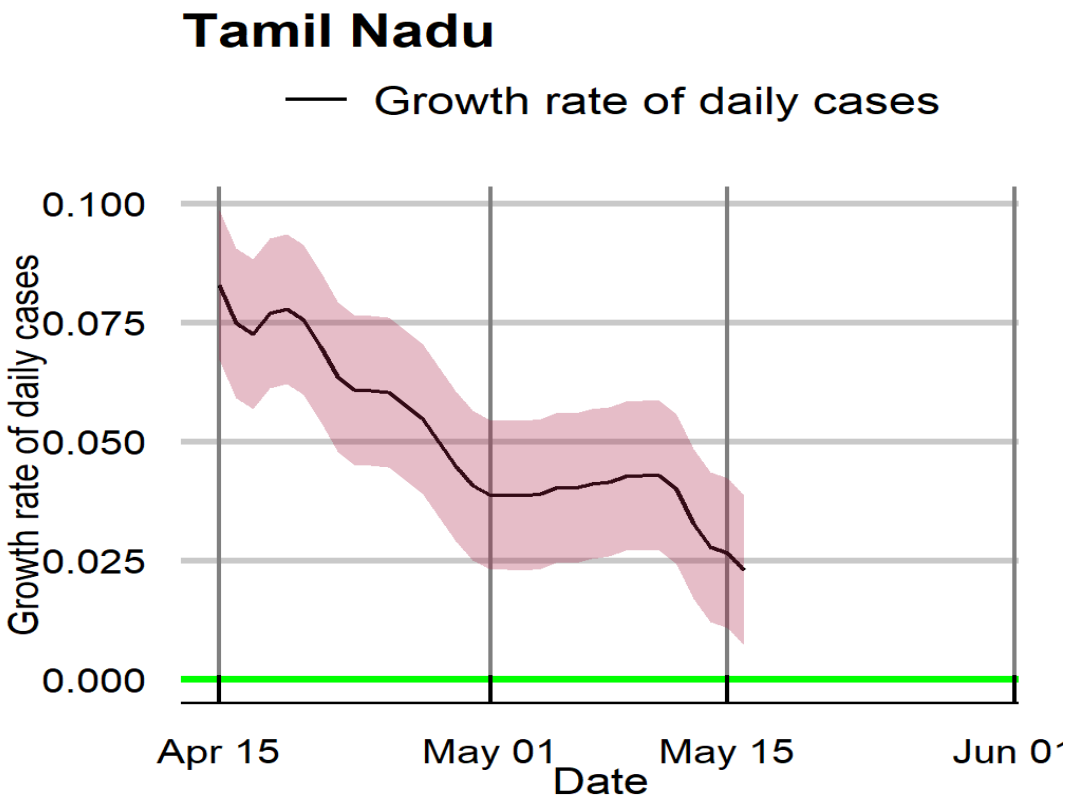

Rajasthan
Data
Forecast New cases
Forecast Trend
15,000
10,000
5,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

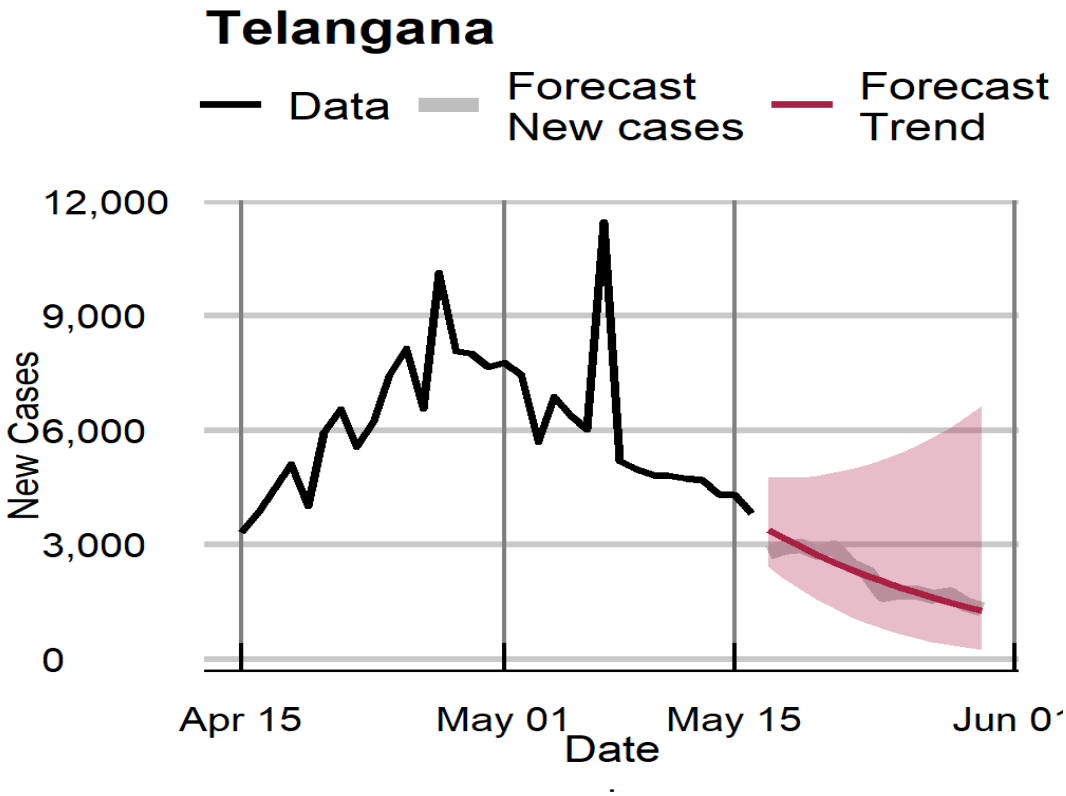

Rajasthan
Growth rate of daily cases
0.15
0.10
0.05
0.00
-0.05
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

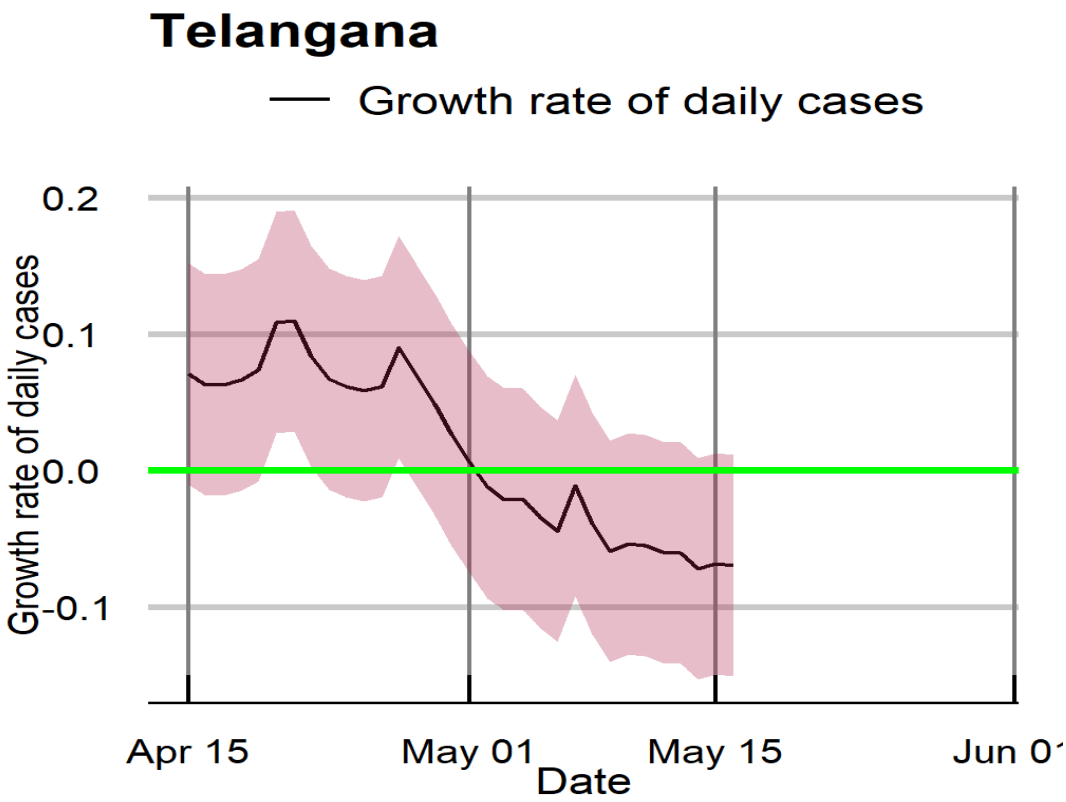

Sikkim
Data
Forecast
New cases
Forecast
Trend
1,000
750
500
250
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

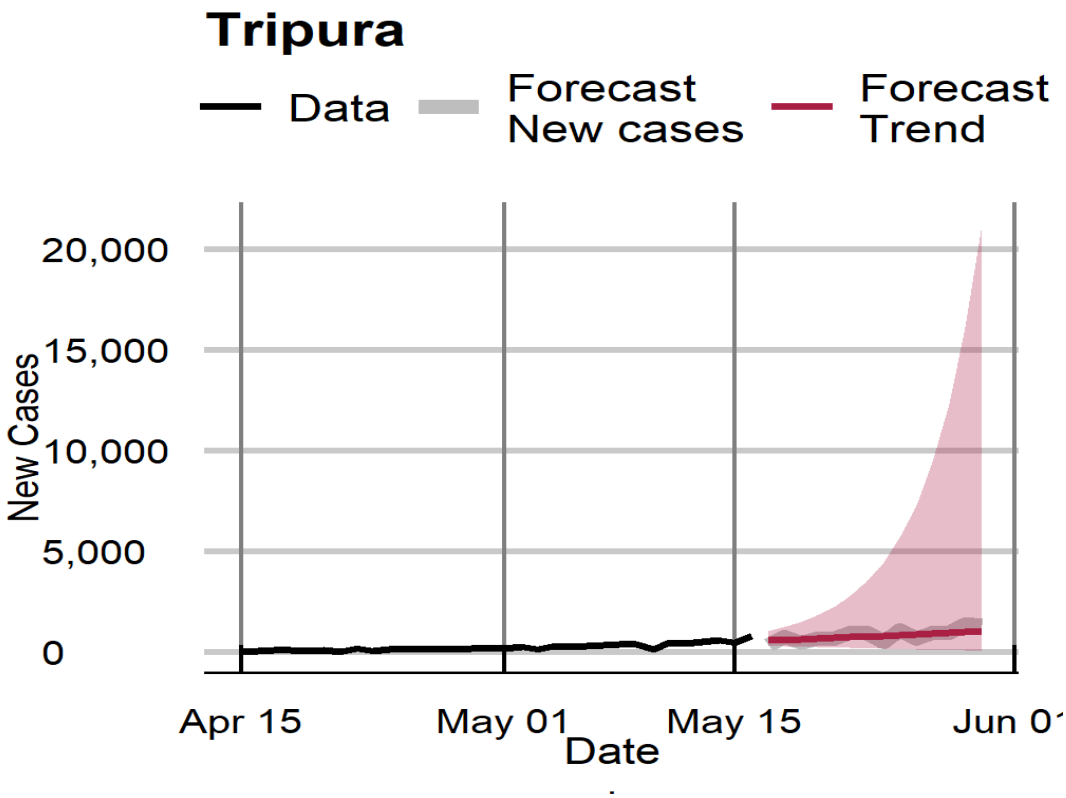

Sikkim
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

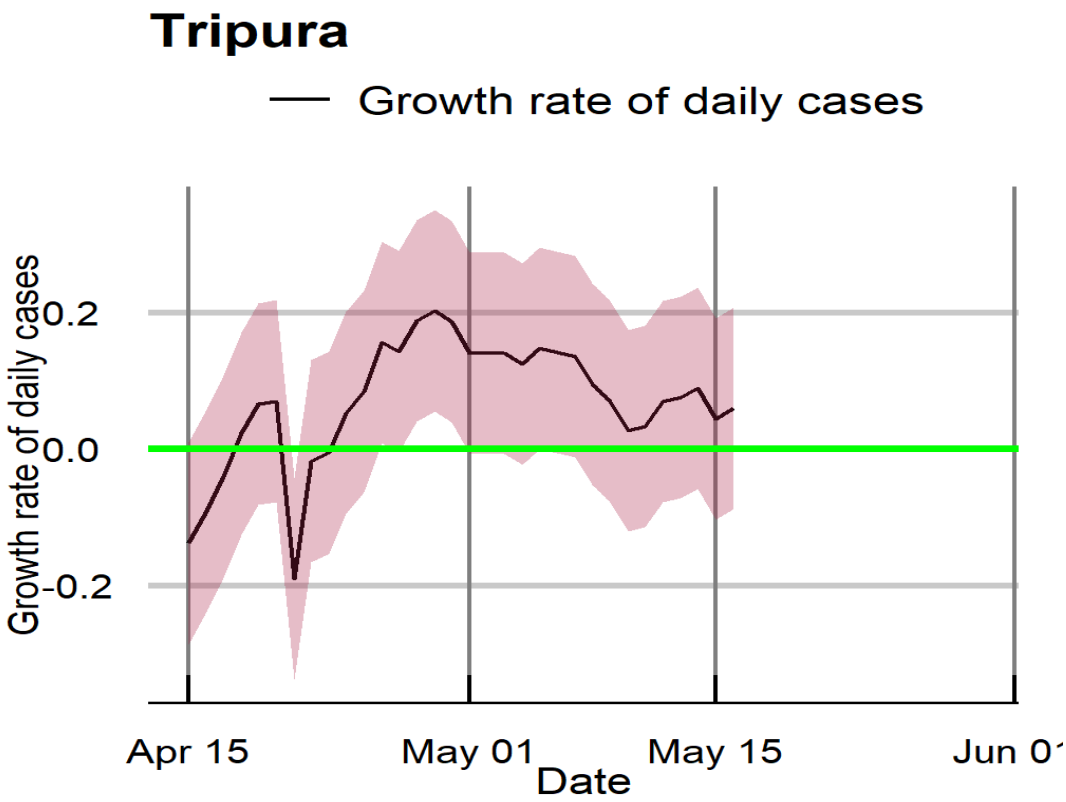

Tamil Nadu
Data
Forecast
New cases
Forecast
Trend
50,000
40,000
30,000
20,000
10,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date

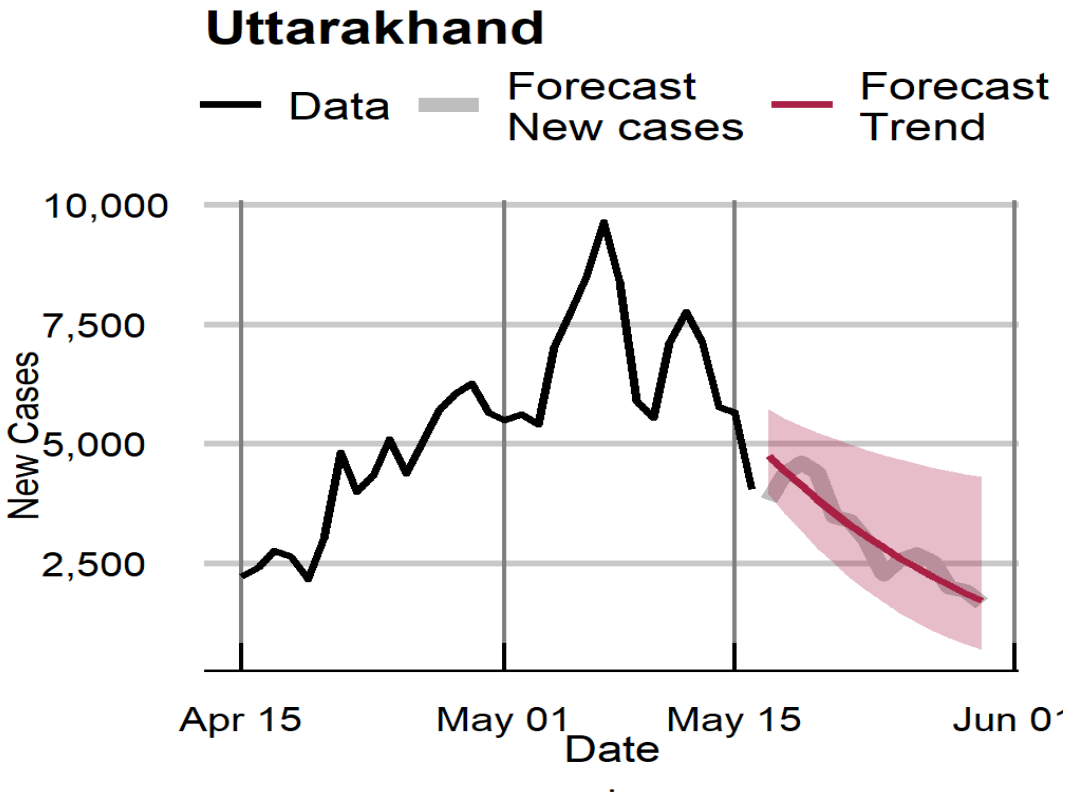

Tamil Nadu
Growth rate of daily cases
0.100
0.075
0.050
0.025
0.000
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

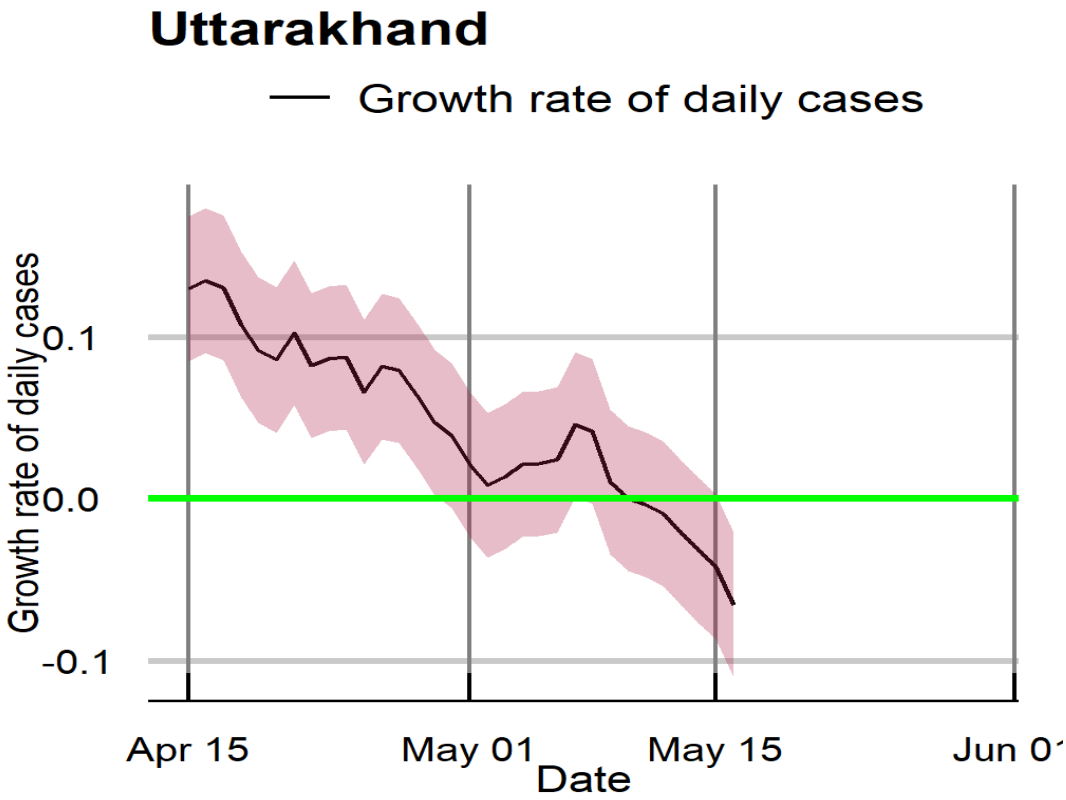

Telangana
Data
Forecast New cases
Forecast Trend
12,000
9,000
6,000
3,000
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

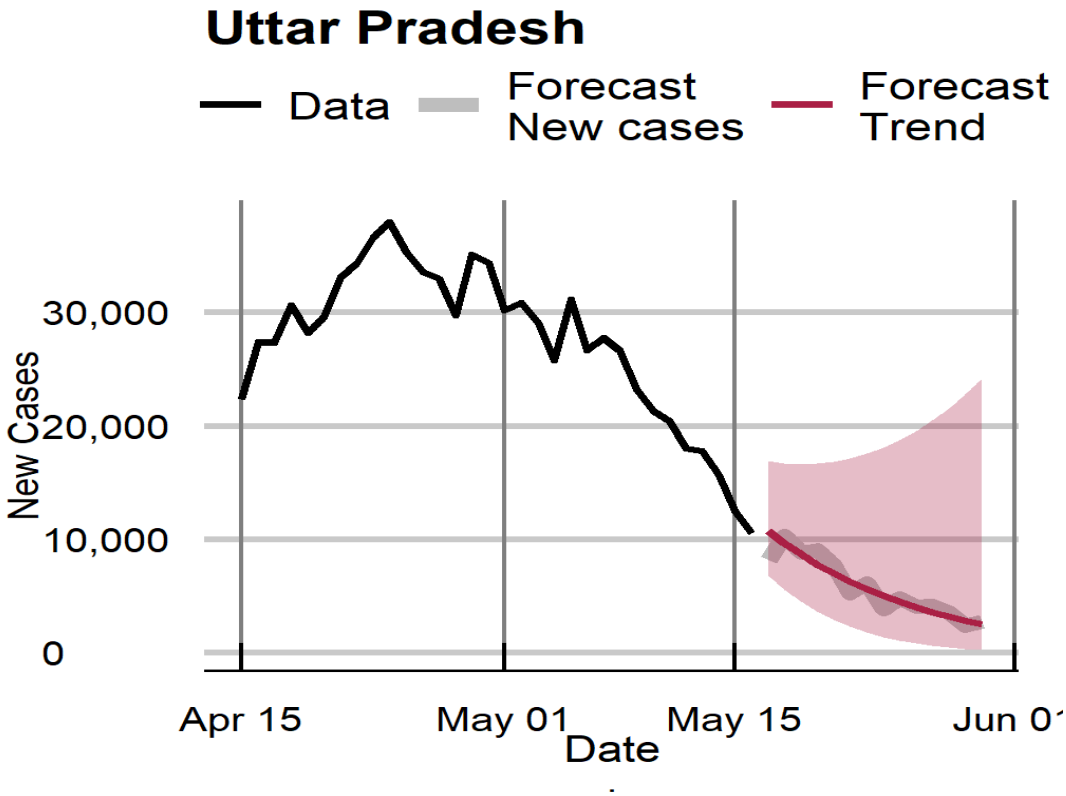

Telangana
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

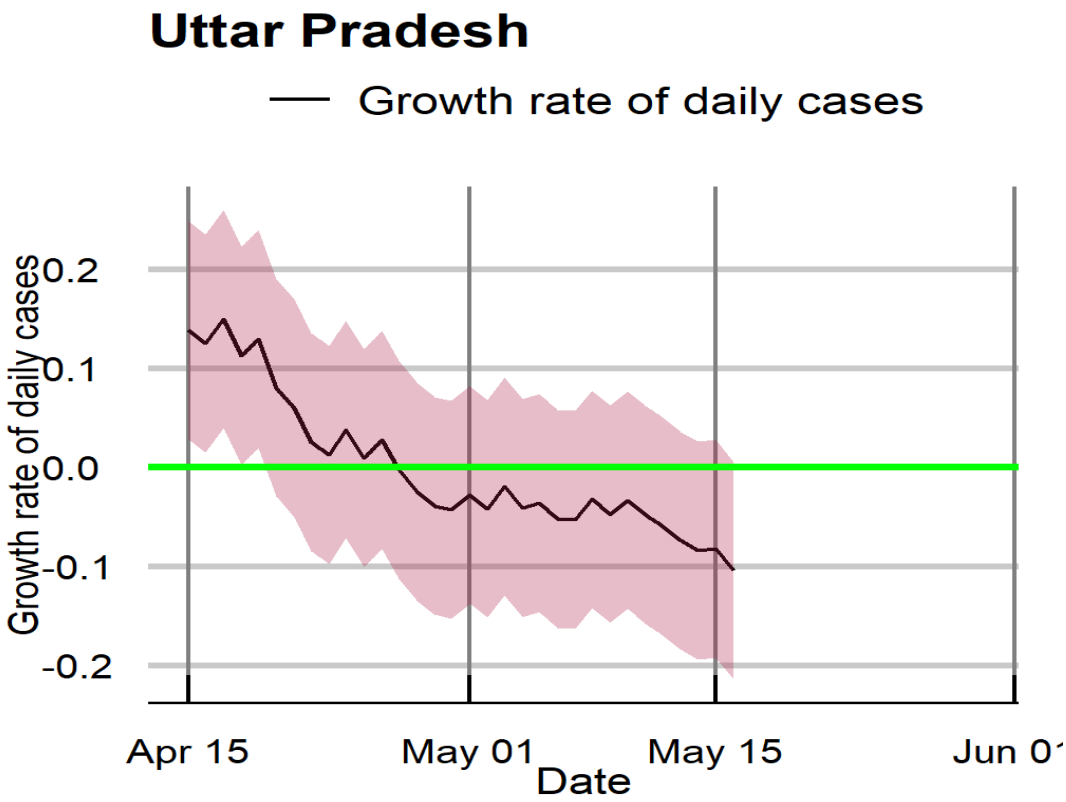

Tripura
Data
Forecast New cases
Forecast Trend
20,000
15,000
10,000
5,000
0
New Cases
Apr 15
May 01
May 15
Jun 0
Date

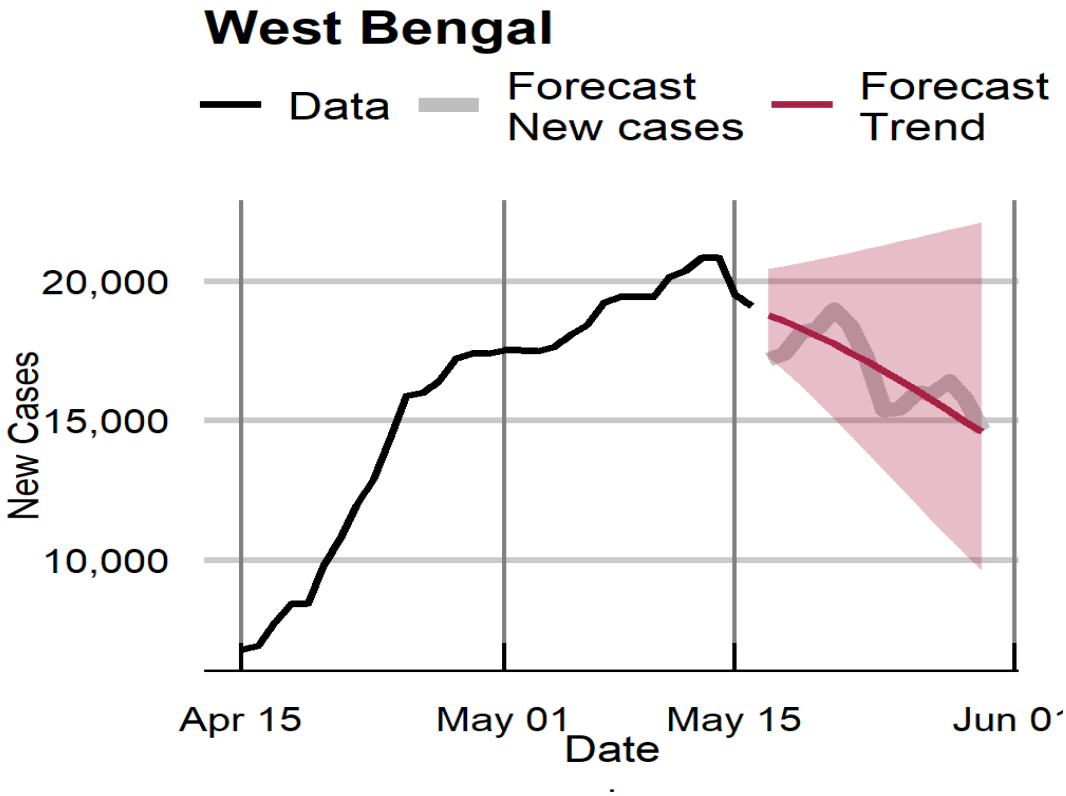

Tripura
Growth rate of daily cases
0.2
0.0
-0.2
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

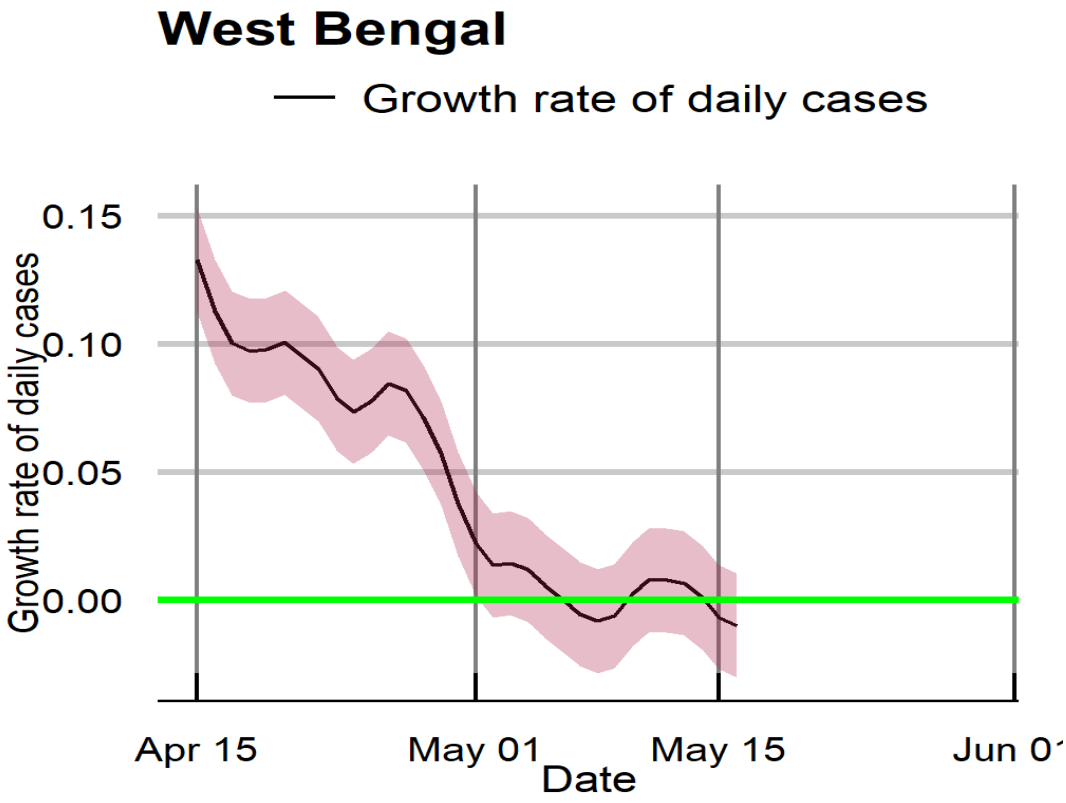

Uttarakhand
Data
Forecast New cases
Forecast Trend
10,000
7,500
5,000
2,500
New Cases
Apr 15
May 01
May 15
Jun 0
Date


Uttarakhand
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date


Uttar Pradesh
Data
Forecast
New cases
Forecast
Trend
New Cases
30,000
20,000
10,000
0
Apr 15
May 01
May 15
Jun 0
Date


Uttar Pradesh
Growth rate of daily cases
Growth rate of daily cases
0.2
0.1
0.0
-0.1
-0.2
Apr 15
May 01
May 15
Jun 0
Date


West Bengal
Data
Forecast New cases
Forecast Trend
20,000
15,000
10,000
New Cases
Apr 15
May 01
May 15
Jun 0
Date


West Bengal
Growth rate of daily cases
0.15
0.10
0.05
0.00
Growth rate of daily cases
Apr 15
May 01
May 15
Jun 0
Date

Notes

Data: COVID-19 confirmed cases and deaths data are sourced from COVID19-India API: https://api.covid19india.org/

New cases: forecasts. Forecasts above are based on a structural time series model that uses all the data in estimation but adapts to the trend emerging in the most recent period. The method is described in: Harvey, A. and P. Kattuman (2020). Time series models based on growth curves with applications to forecasting coronavirus. *Harvard Data Science Review*, Special issue 1 - COVID -19. https://hdsr.mitpress.mit.edu/pub/ozgjx0yn/release/2 , and Harvey, A., P. Kattuman, and C. Thamotheram (2021). Tracking the mutant: forecasting and nowcasting COVID-19 in the UK in 2021. *National Institute Economic Review*. Forthcoming.

Forecast accuracy: When estimated with data up to May 2, the mean absolute percentage error of the forecasts for the 7 day period, May 3-9, is 6.1%. Forecast accuracy will in general be lower for the smaller states / union territories. It is important to pay attention to the confidence interval around the forecasts. The coverage of the confidence interval presented is 68%, implying there is 16% probability of the upper bound being exceeded.

New cases: growth rate. The filtered trends presented for daily growth rates of cases are estimated using the Kalman filter, applied to the observed series. The method filters out day of the week effects and random noise to reveal the underlying signal. Unlike methods such as the moving average, this method adapts the trend to changes in real time and characterises underlying patterns of surges or attenuations that are hidden in the volatile series. The method is described in the papers listed above.

***R*:** The *R*-estimation approach is described in Harvey, A. and P. Kattuman (2020b). A farewell to R: Time series models for tracking and forecasting epidemics. *Center for Economic Policy Research* (CEPR) working paper, 51. https://cepr.org/content/covid-economics. The confidence interval is based on one standard deviation, with coverage of 68%.

The quality of forecasts rely on the quality of the published data. Further, near term changes in government pandemic policies, as well as transmission relevant social behaviour will realised numbers to depart from forecasts.

Andrew Harvey[*], Paul Kattuman[*], Rajeev Sadanandan[#], Stefan Scholtes[*], Craig Thamotheram[+]

[*]University of Cambridge
[#]Health Systems Transformation Platform
[+] National Institute of Economic and Social Research

Cambridge Centre for Health Leadership & Enterprise
Cambridge Judge Business School
University of Cambridge
Trumpington Street
Cambridge
CB2 1AG
United Kingdom

T +44(0)1223 339700
health@jbs.cam.ac.uk
www.jbs.cam.ac.uk/health