Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

18 July 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 short term forecasts of the trajectory of the pandemic, identifying states and union territories that are at 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.

The reproduction number (Rt) for India nudged up over the past week and now stands at 0.98, close to the threshold of one. The trend value of the daily growth rate of cases has risen to -0.5 %. Newly reported COVID-19 cases are likely to decline marginally in the days ahead. By 1 August 2021, reported cases per day is likely to be about 35,200.

Daily reported cases are likely to increase in six states that have reproduction numbers currently exceeding one: Arunachal Pradesh, Kerala, Manipur, Mizoram, Nagaland, and Telangana (see page 4). The positive growth rates of cases appear to be accelerating in Kerala, Manipur, Mizoram, Nagaland, and Telangana (see pages 38-40). Notably, Arunachal Pradesh, Kerala, Manipur and Mizoram lead other Indian states in case rates normalised for population (page 6).

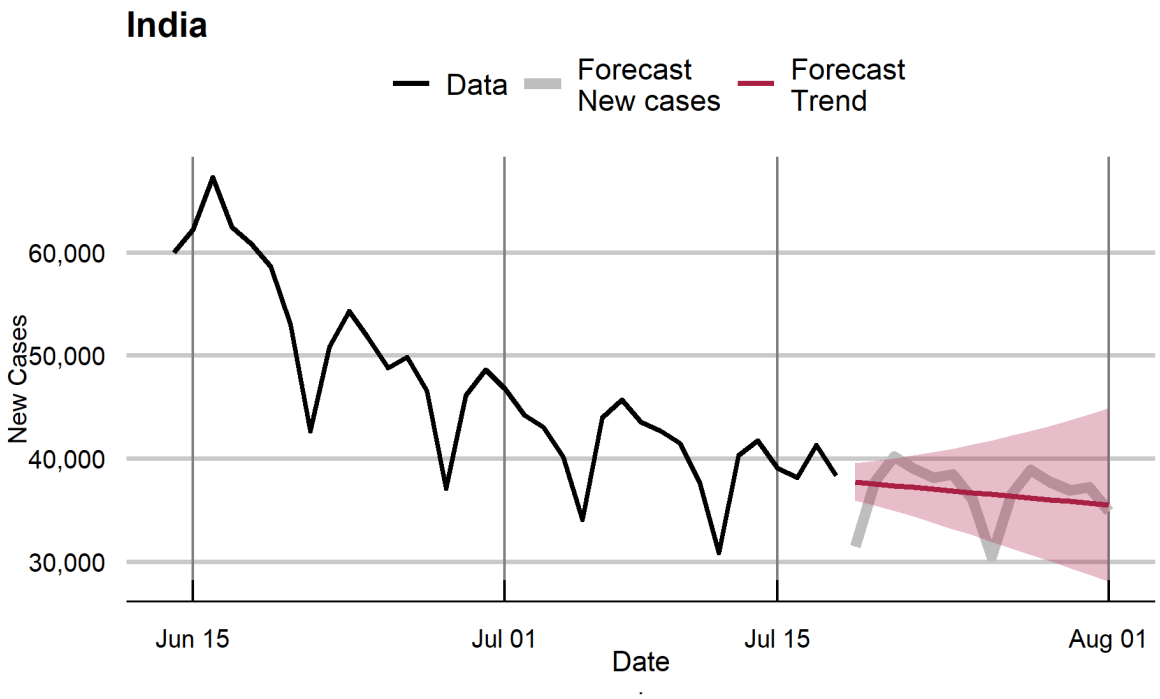
It is important to restrain social and spatial spill-overs from areas of high infection incidence. It is worth noting that flare-ups that emerged in recent weeks in some states - Maharashtra, Chhattisgarh, Himachal Pradesh – appear to have abated.

Mean absolute percentage error of the forecasts of daily cases in India given in the July 10 tracker, for the period July 11-17, was 4.4%. The accuracy of forecasts rely on the quality of the reported data. Changes in government pandemic policies and in transmission relevant social behaviour may cause realised numbers to depart from forecasts.

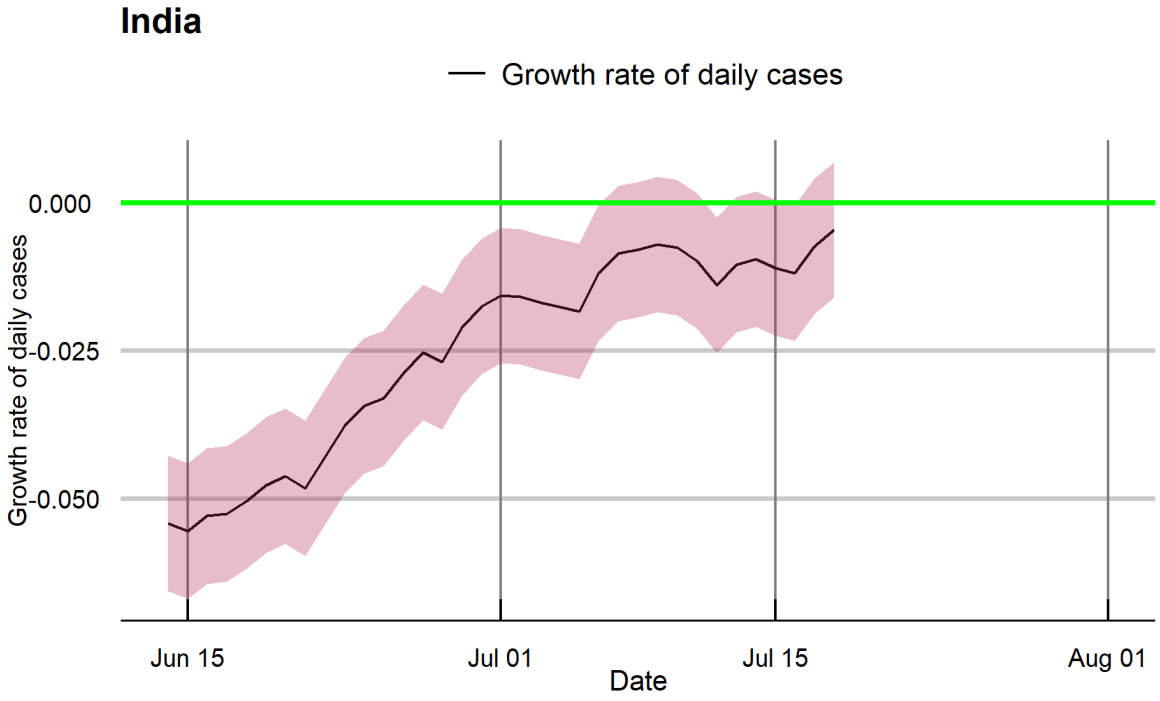
[1] CJBS COVID-19 Tracker for India can be accessed at: www.jbs.cam.ac.uk/covid-india
The companion spreadsheet contains all the estimates and forecasts.

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

Daily Covid-19 cases in India: Forecast

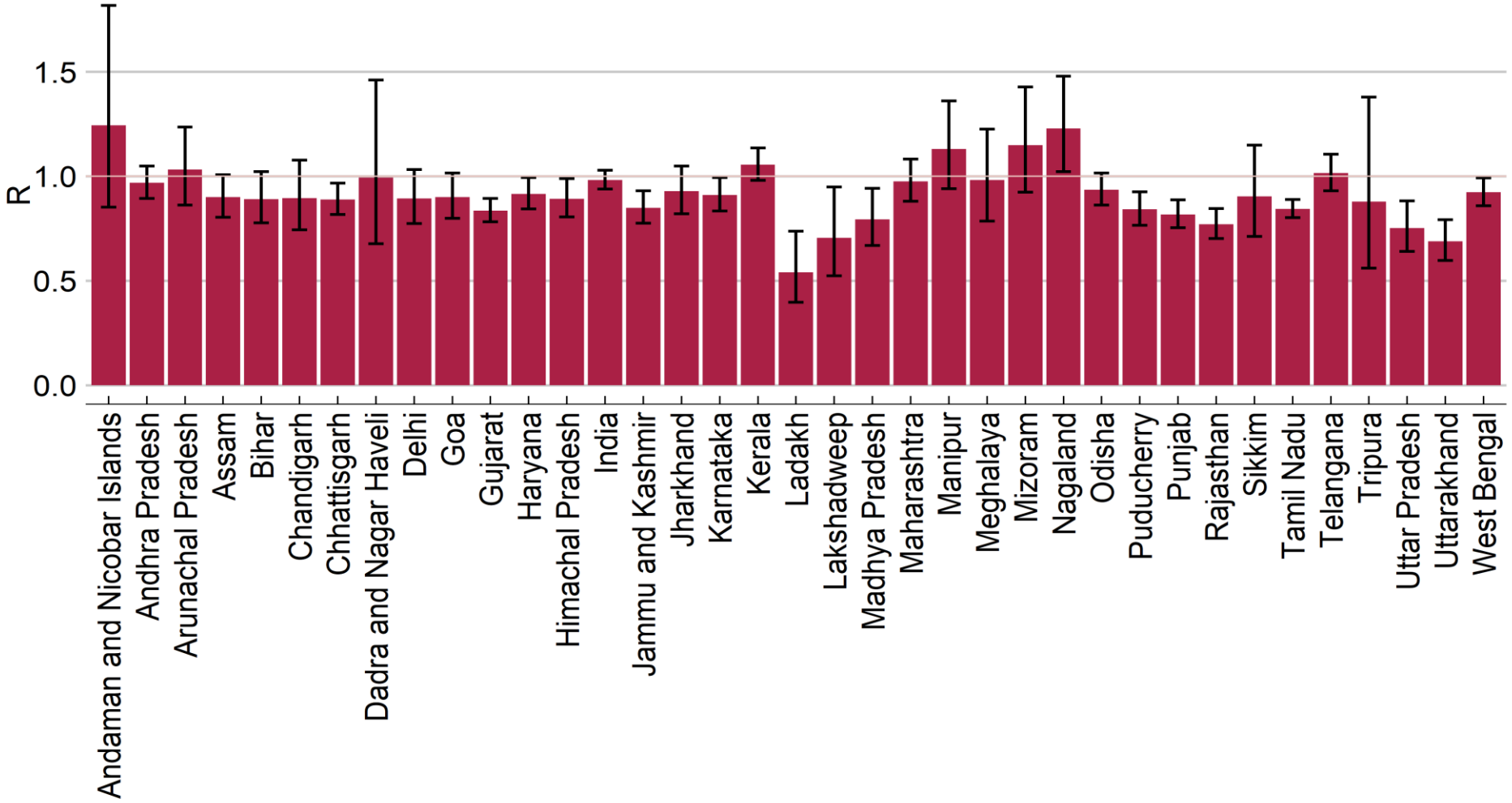


Forecasts of daily new cases for the period 19 July 2021 to 1 August 2021, based on data till 18 July 2021. New COVID-19 cases is likely to number about 35,200 per day by 1 August 2021.

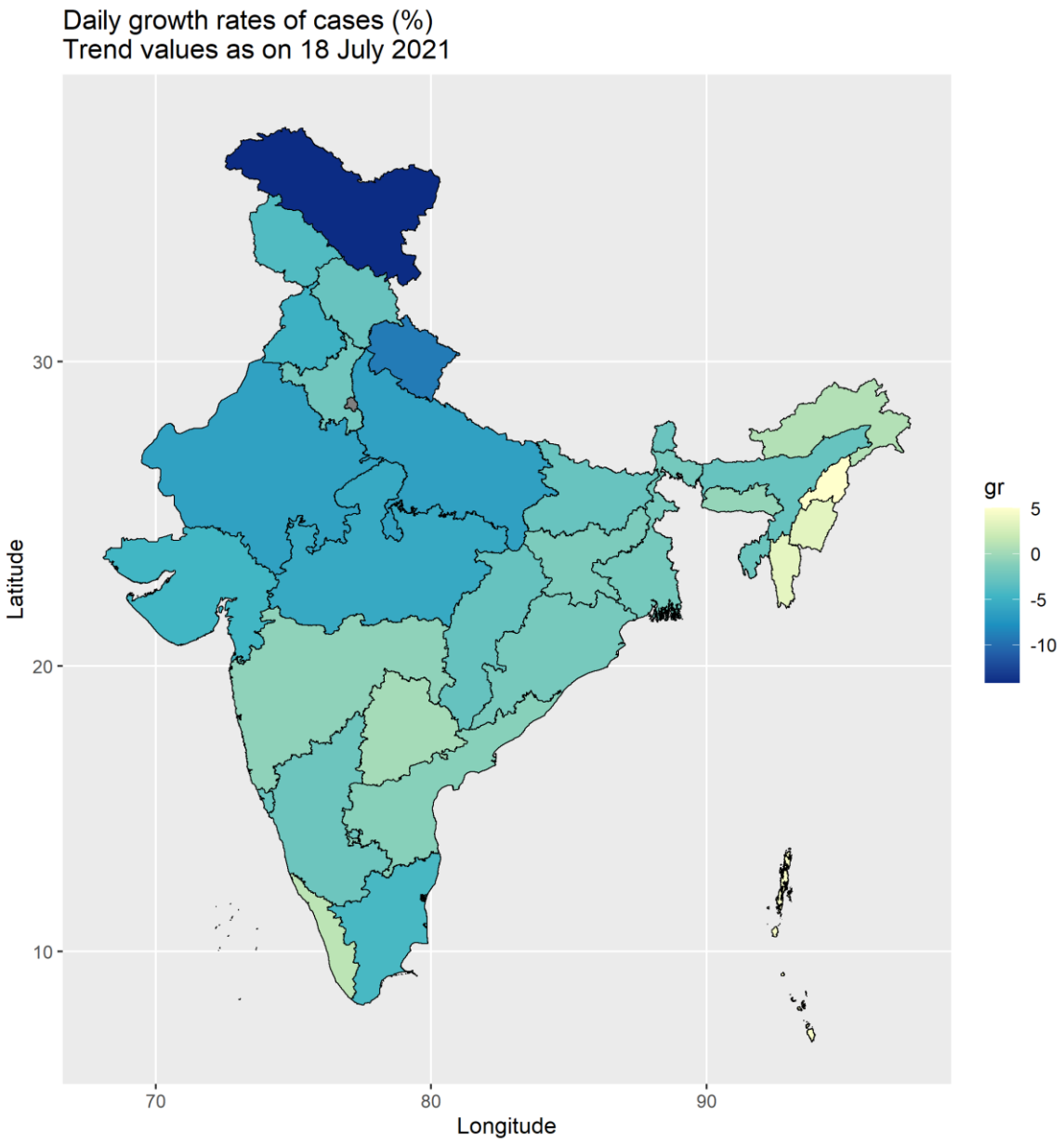


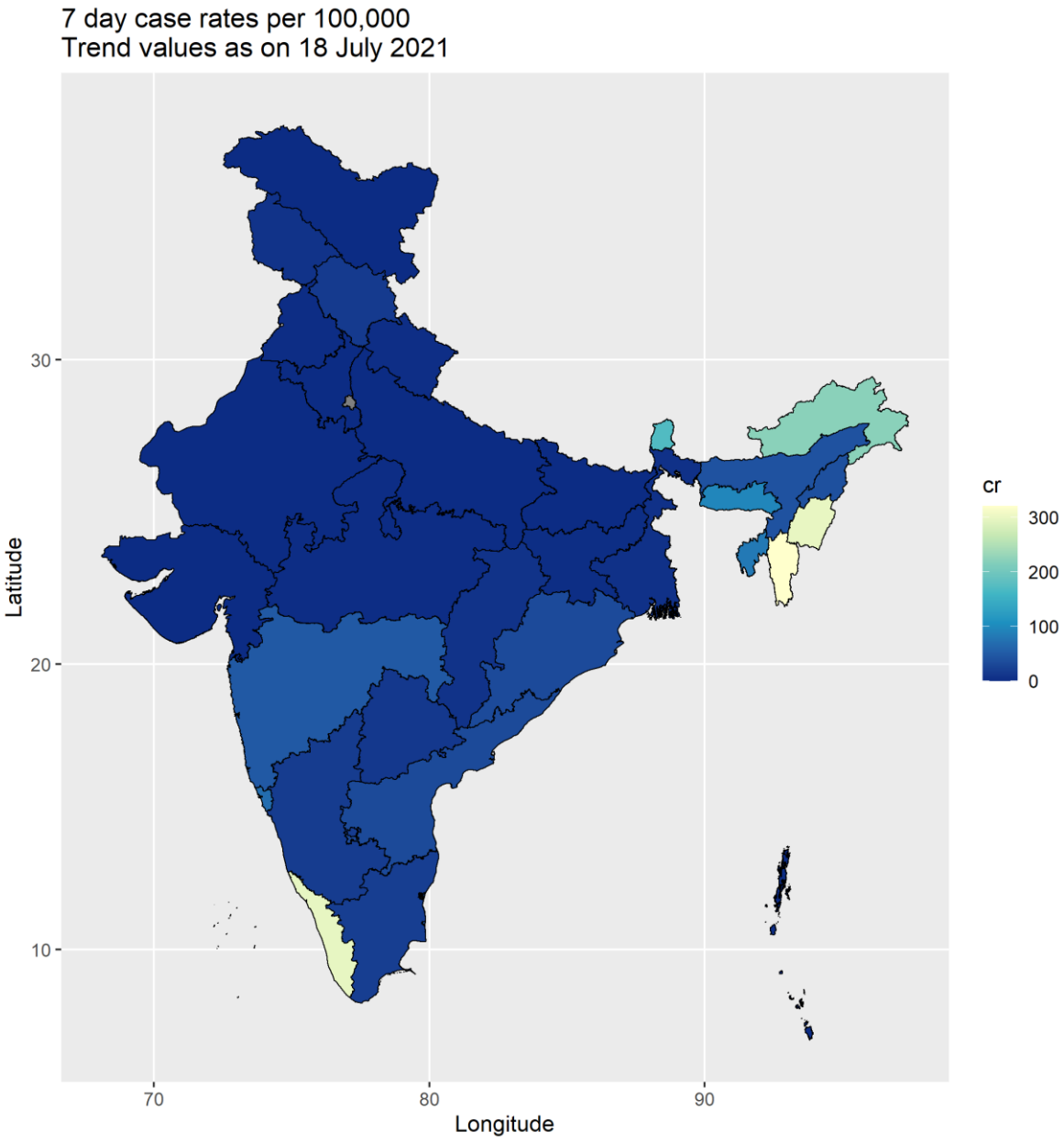
The filtered trend in the growth rate of daily new cases: -0.5% as on 18 July 2021.

R_t: 18 July 2021

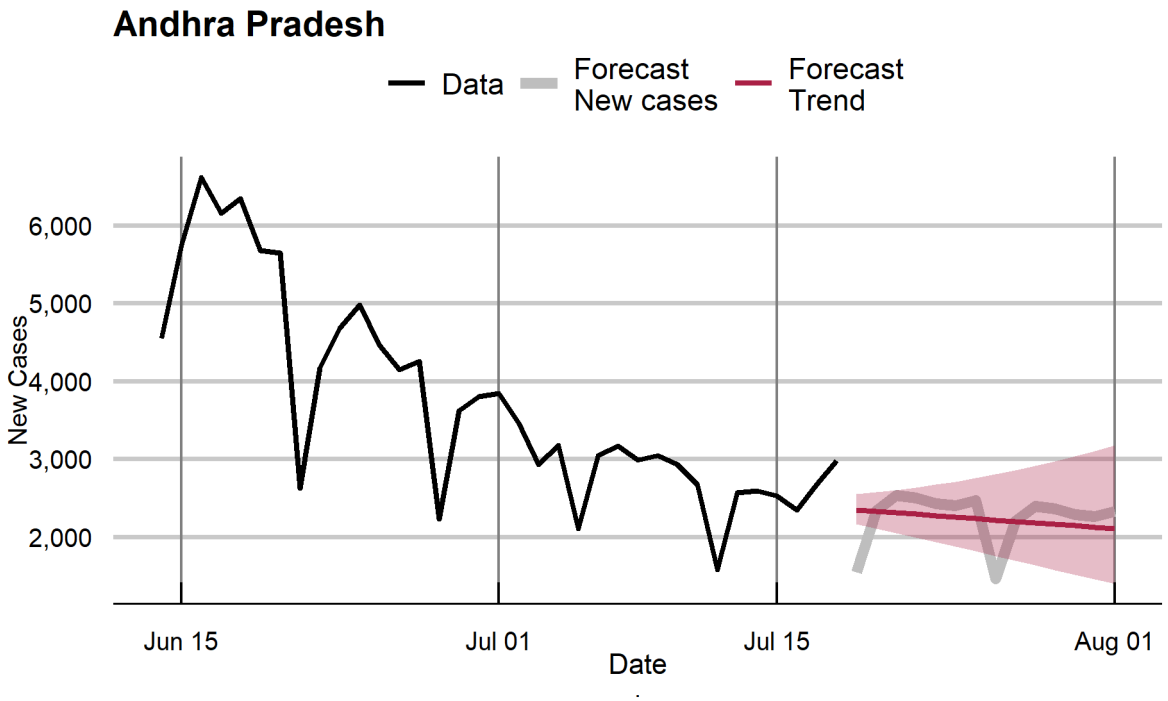


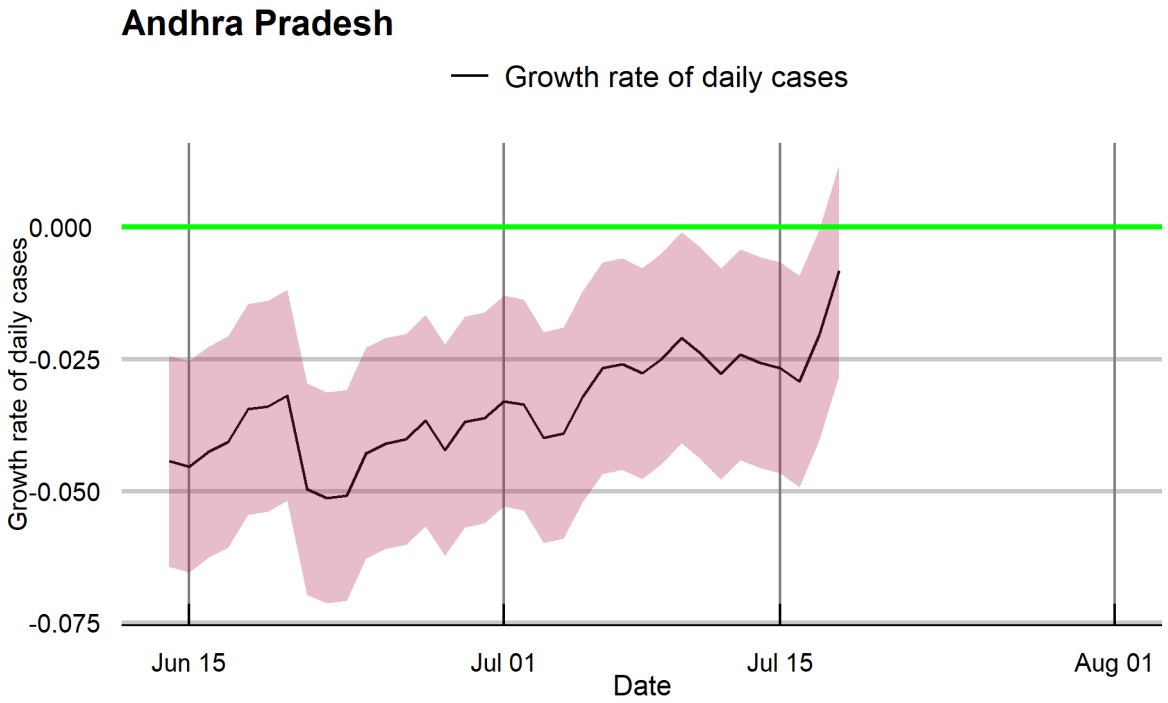
Bar chart shows point estimates of R and the ± 1 standard deviation confidence intervals

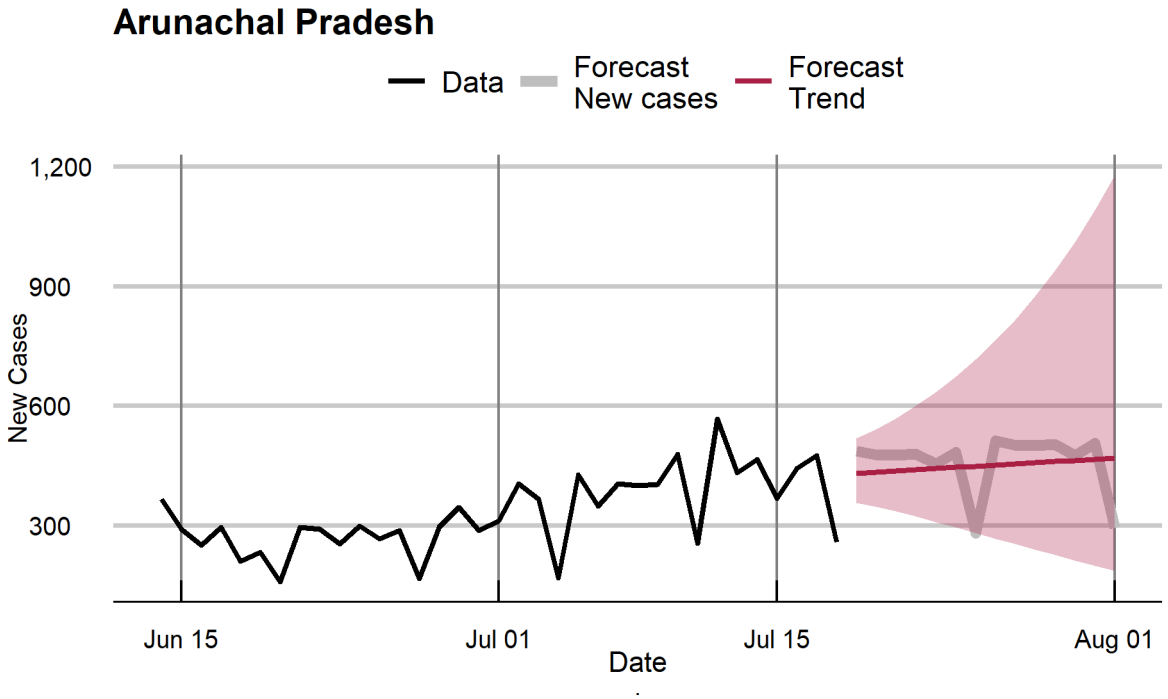

Daily growth rates of cases (%)
Trend values as on 18 July 2021
Latitude
30
20
10
70
80
90
Longitude
gr
5
0
-5
-10

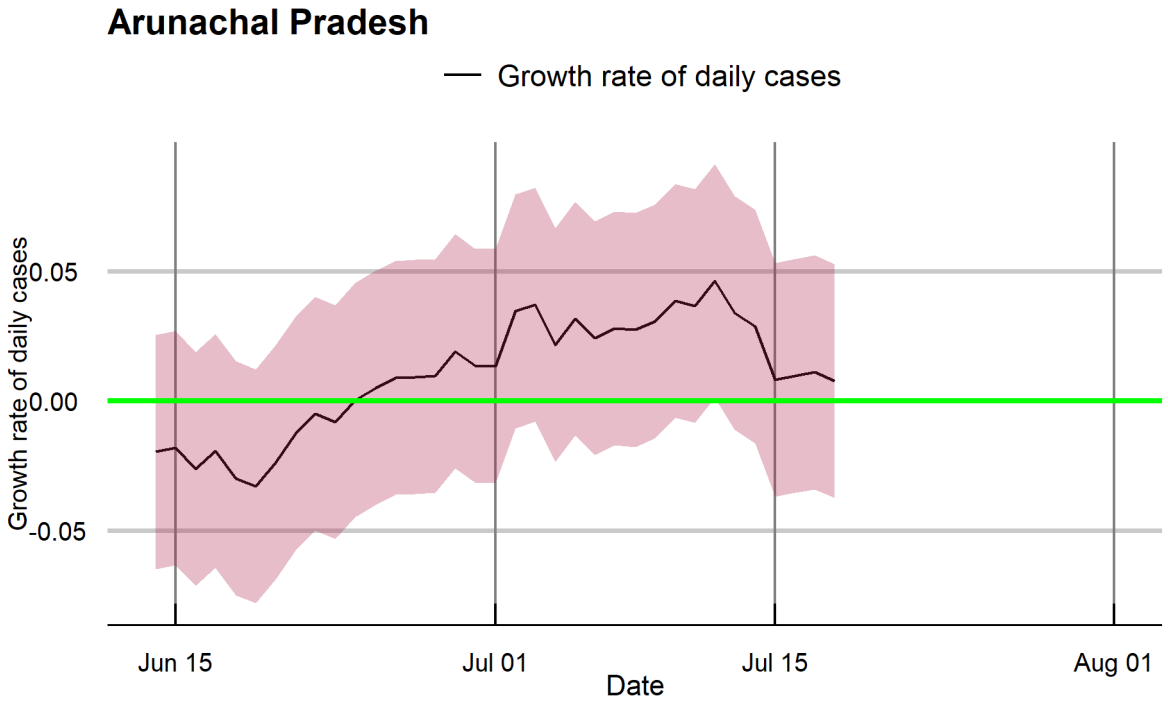

7 day case rates per 100,000
Trend values as on 18 July 2021
Latitude
30
20
10
70
80
90
Longitude
cr
300
200
100
0

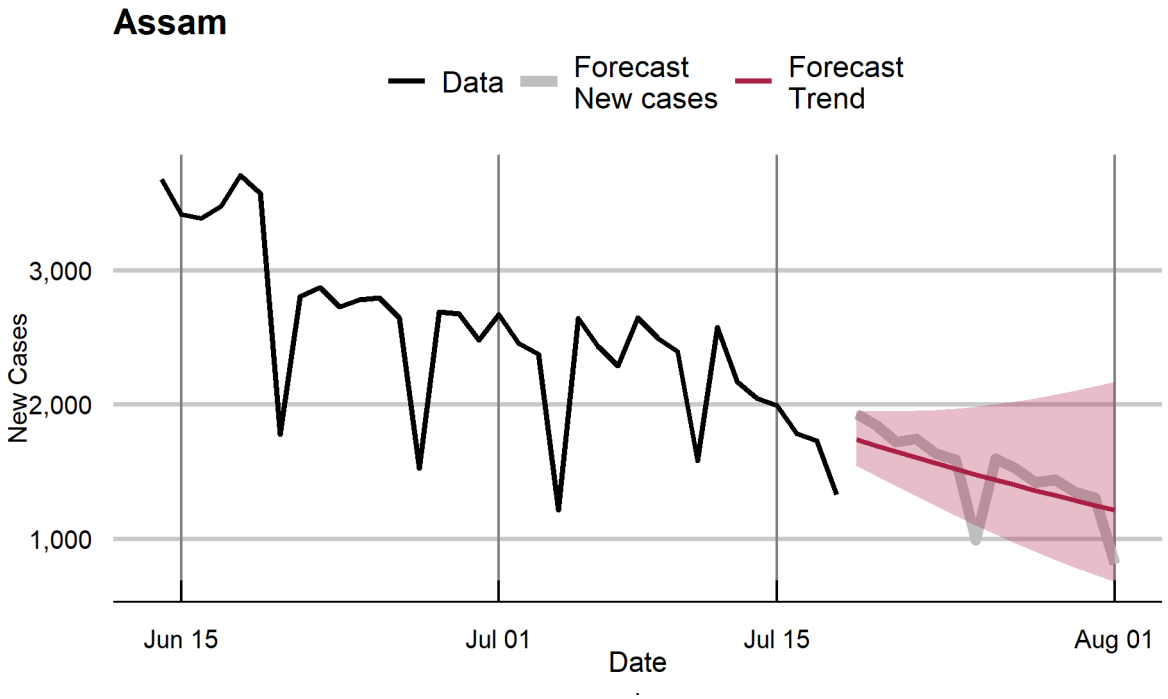
Case forecasts and growth rates: States and Union territories

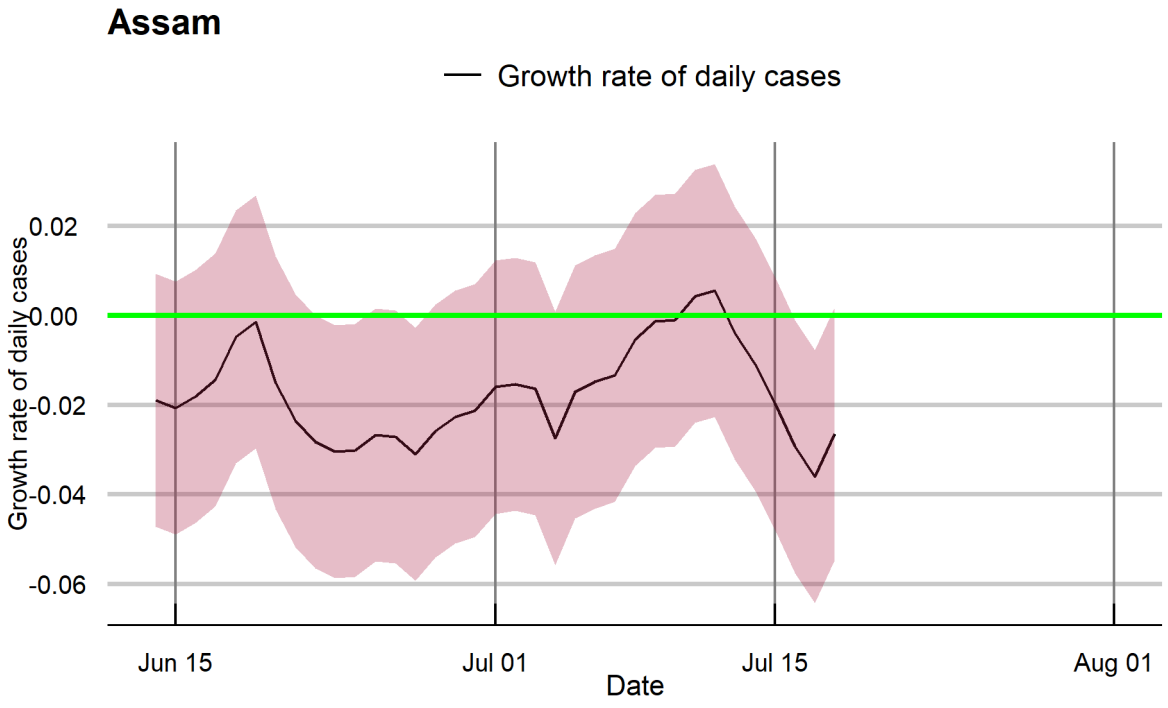


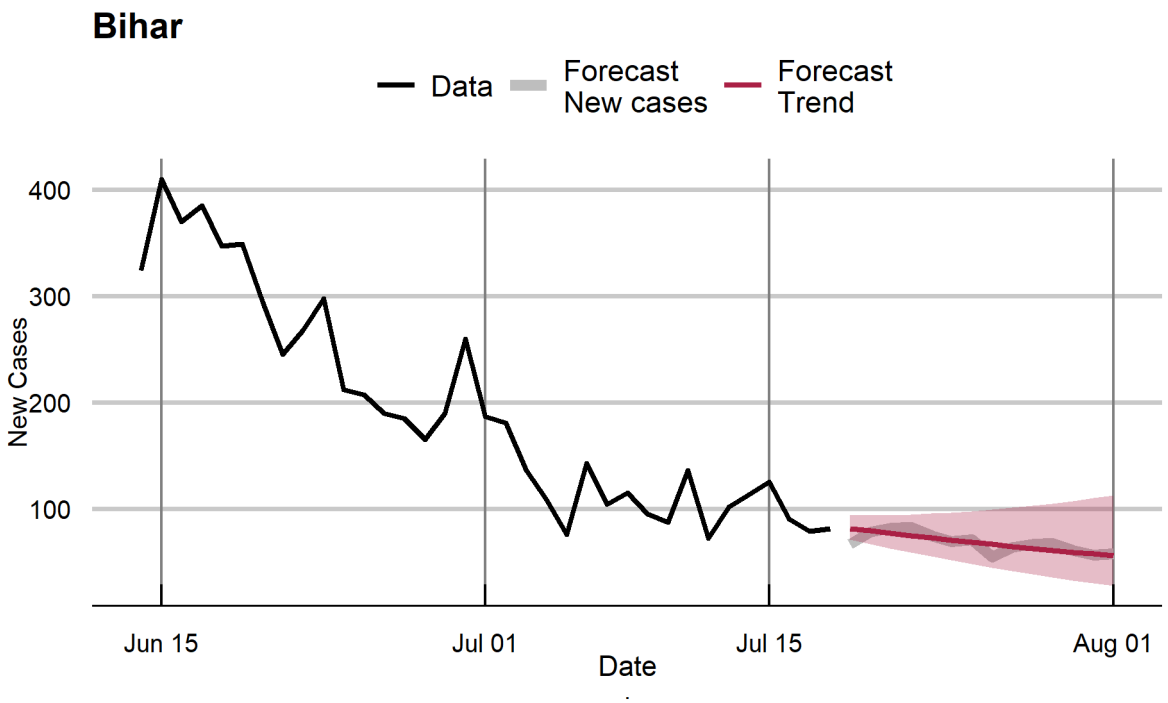


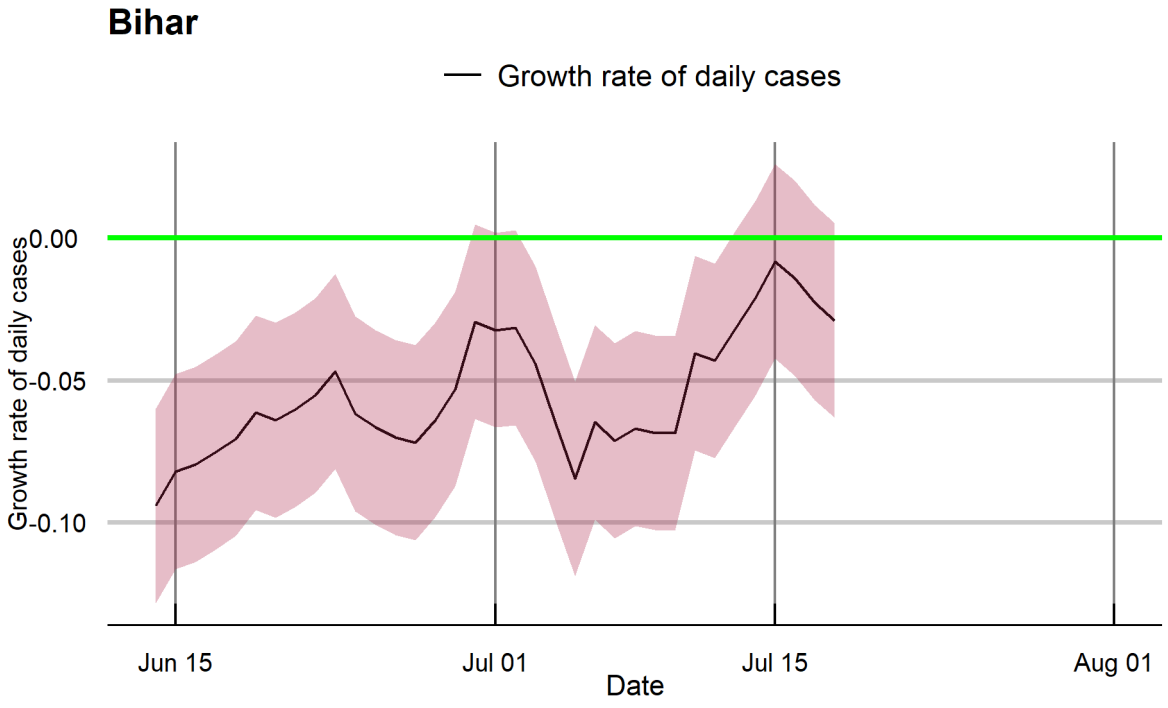

Arunachal Pradesh
Data
Forecast
New cases
Forecast
Trend
1,200
900
600
300
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

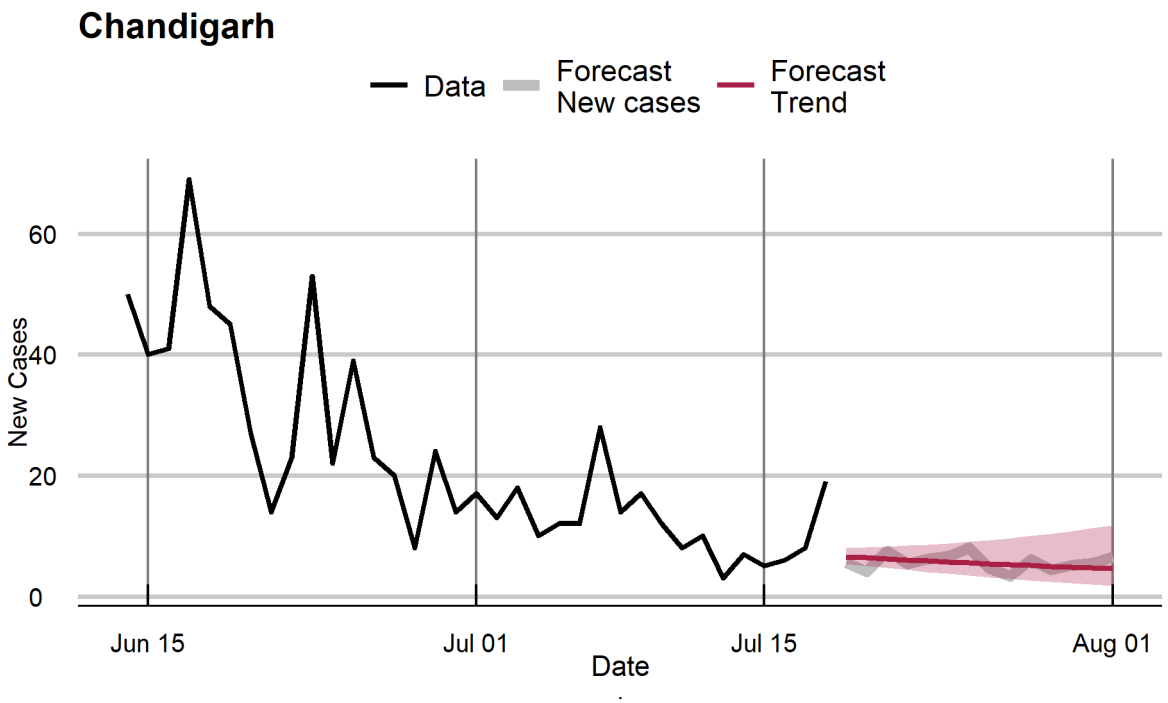

Arunachal Pradesh
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

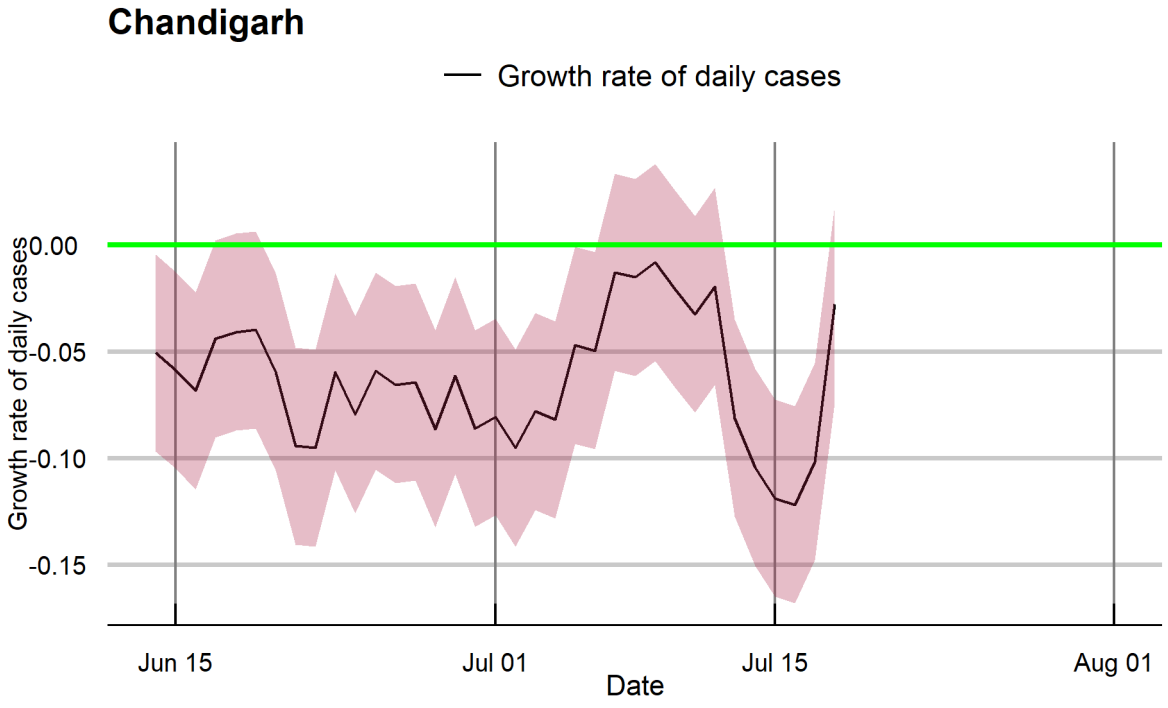

Assam
Data
Forecast
New cases
Forecast
Trend
3,000
2,000
1,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

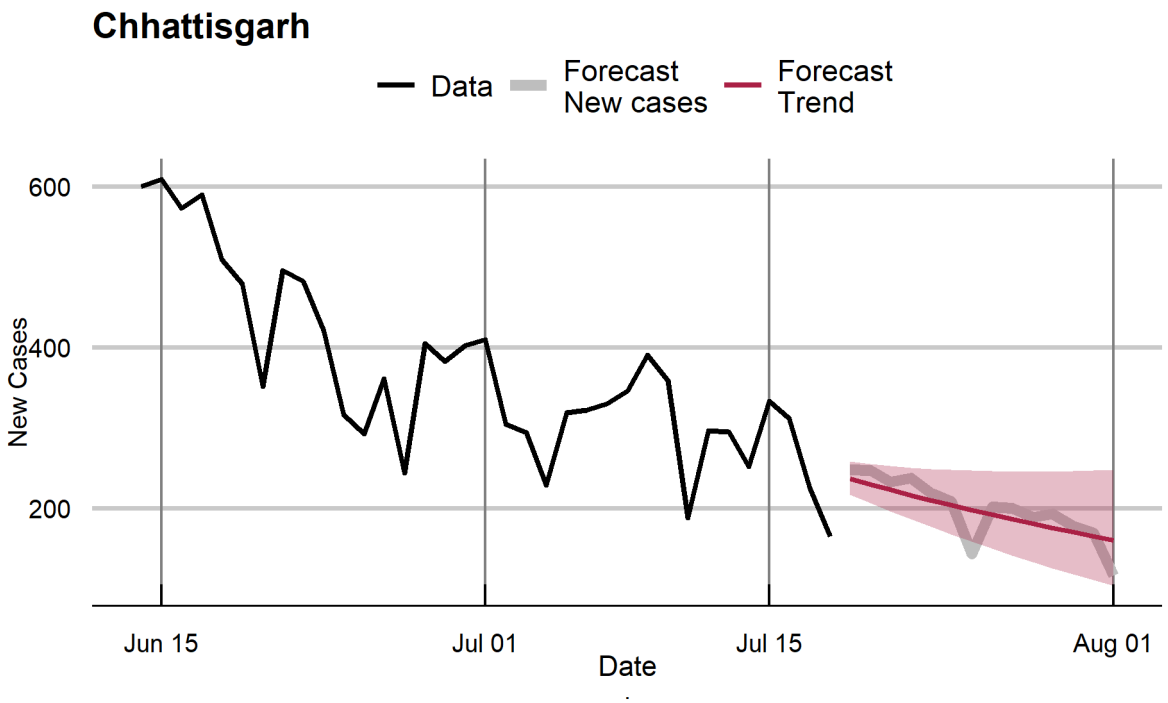

Assam
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

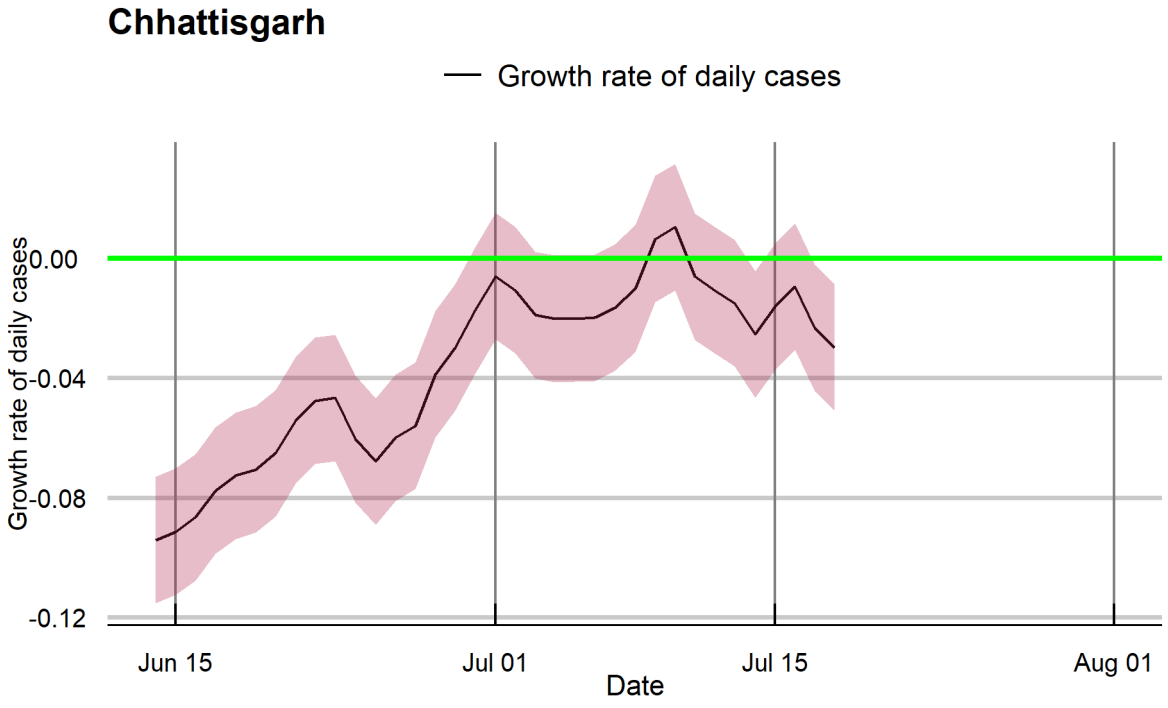

Bihar
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

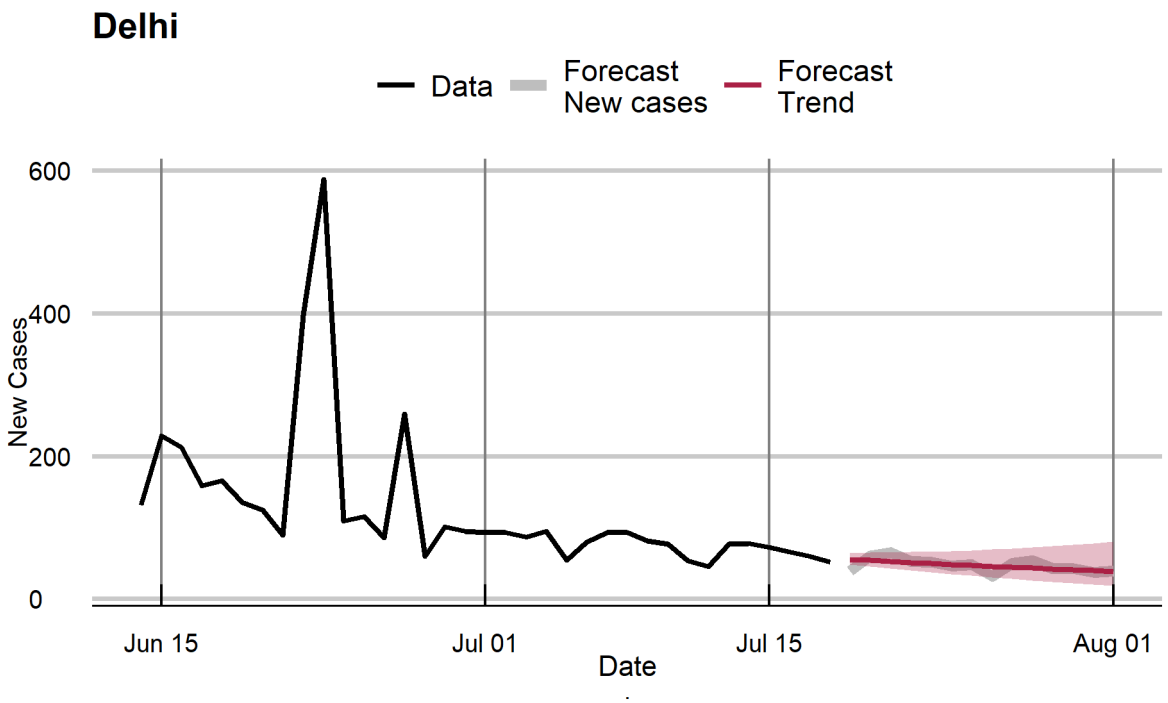

Bihar
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

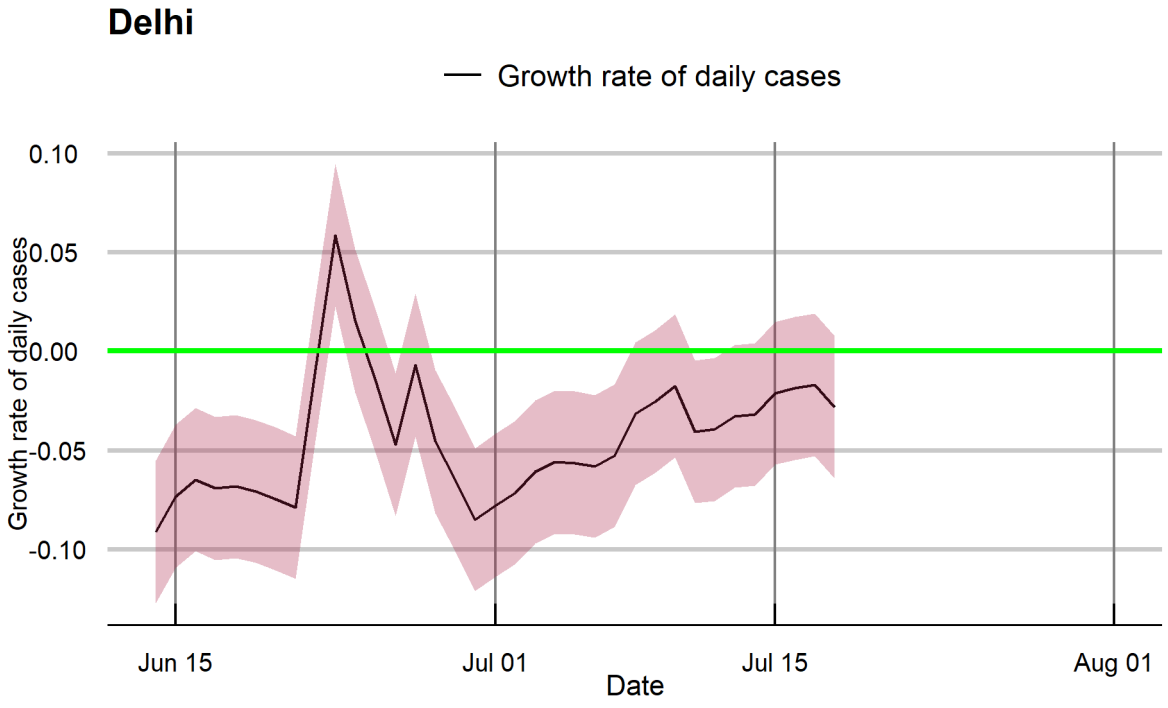

Chandigarh
Data
Forecast
New cases
Forecast
Trend
60
40
20
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

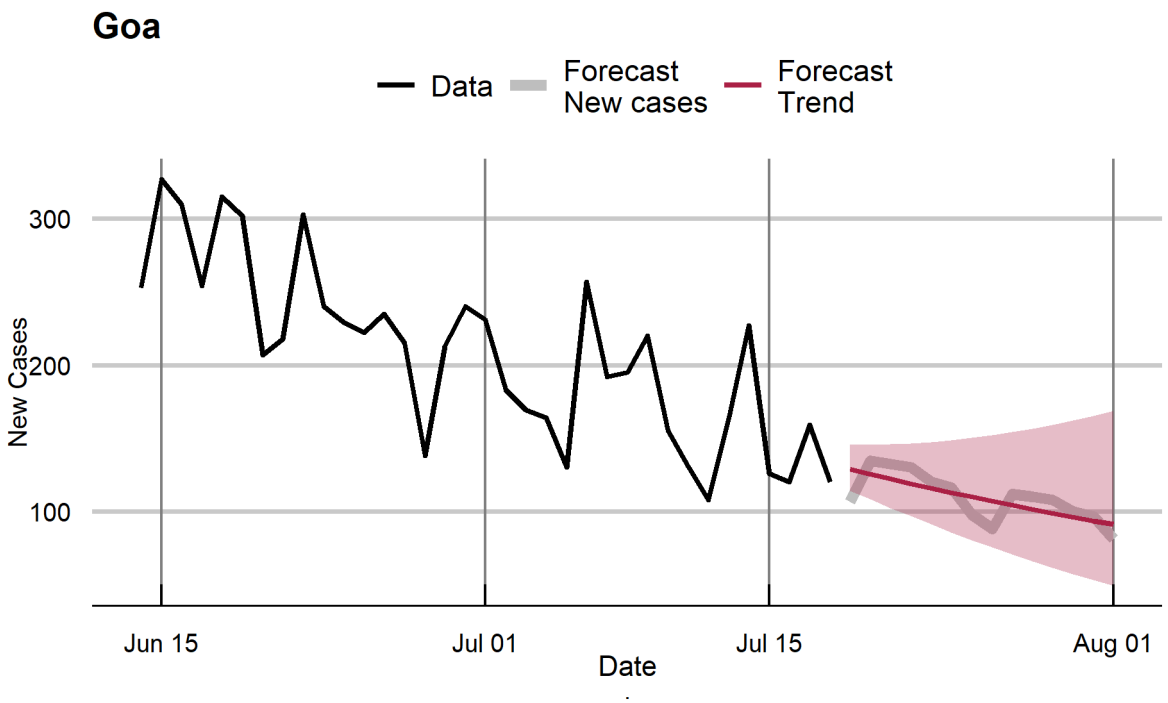

Chandigarh
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

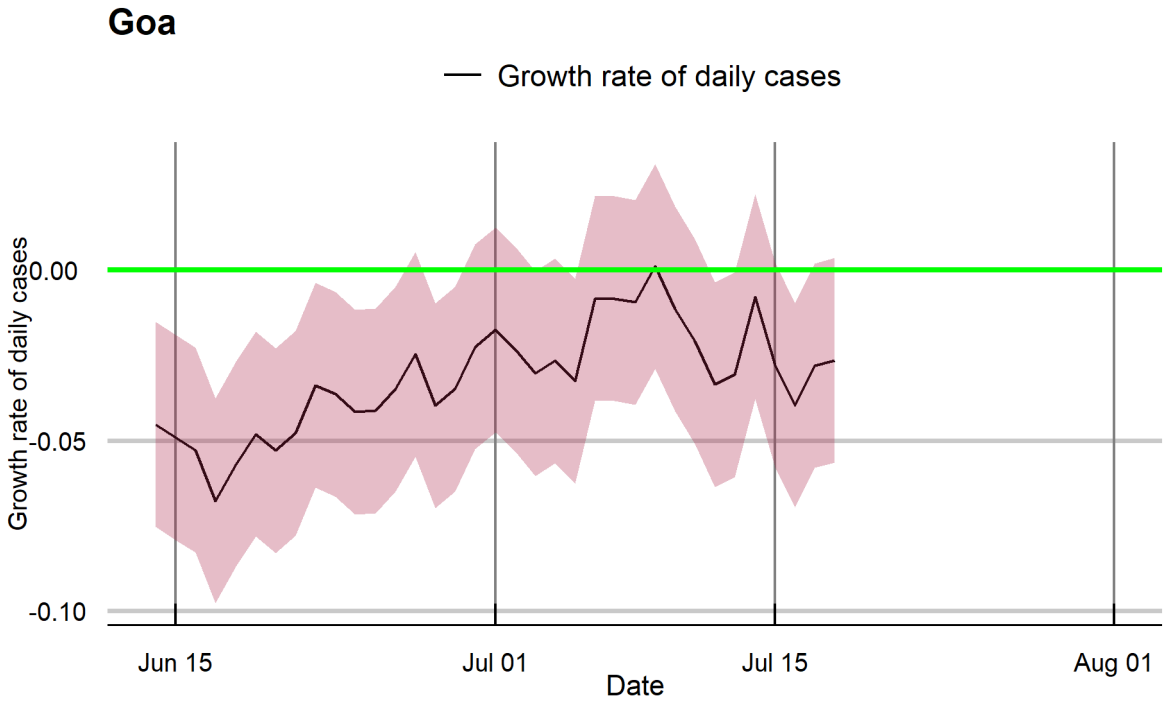

Chhattisgarh
Data
Forecast
New cases
Forecast
Trend
600
400
200
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

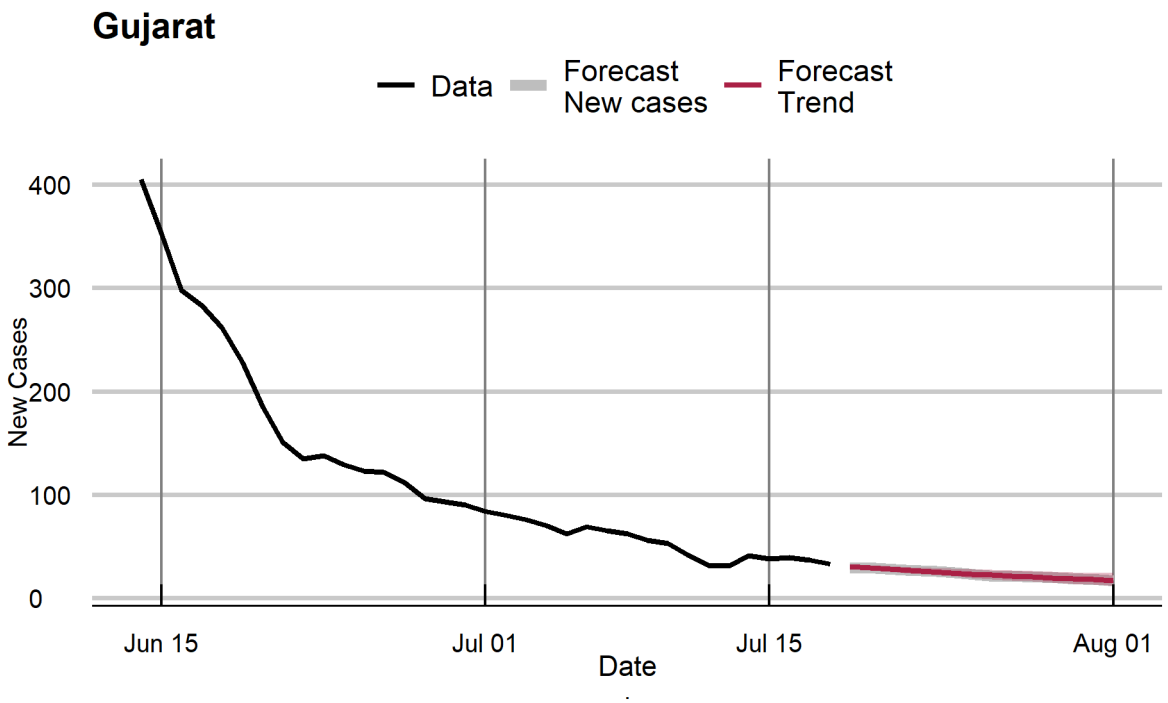

Chhattisgarh
Growth rate of daily cases
0.00
-0.04
-0.08
-0.12
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

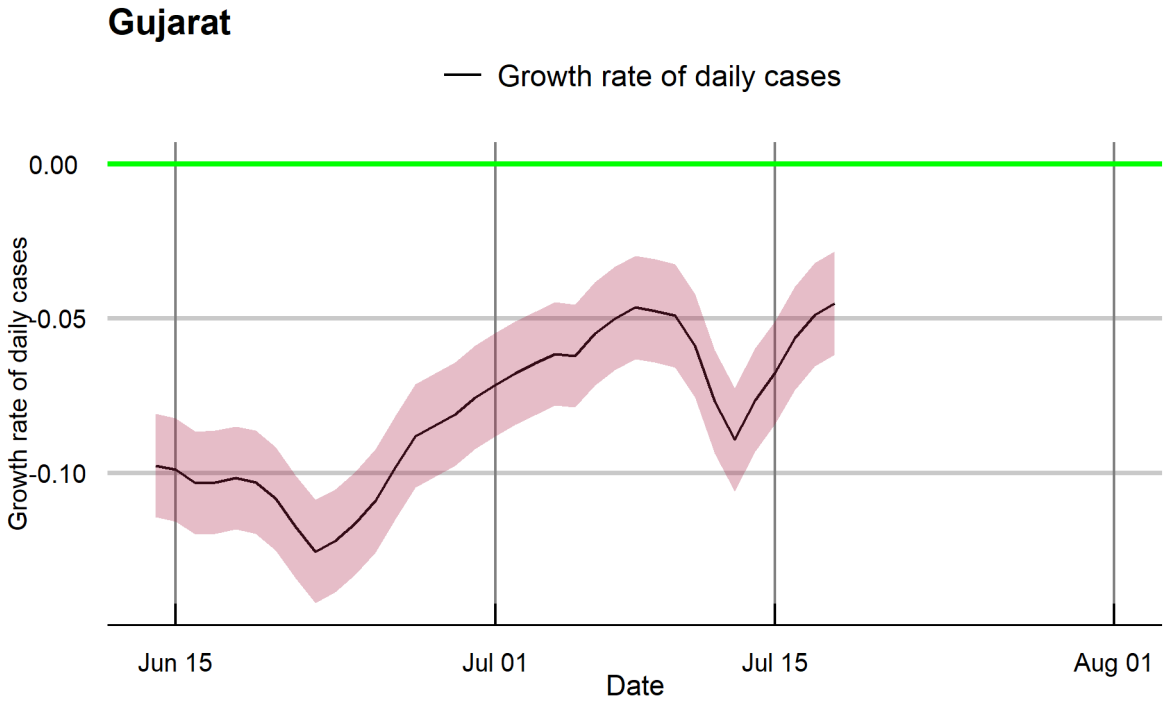

Delhi
Data
Forecast
New cases
Forecast
Trend
600
400
200
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

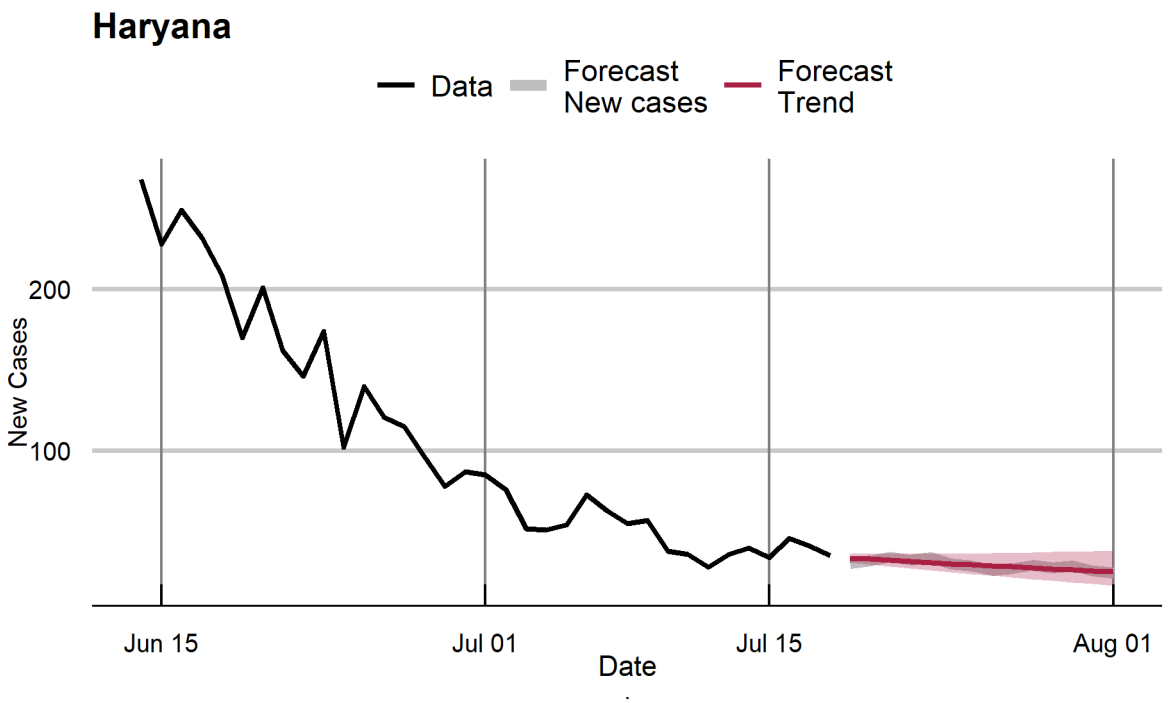

Delhi
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

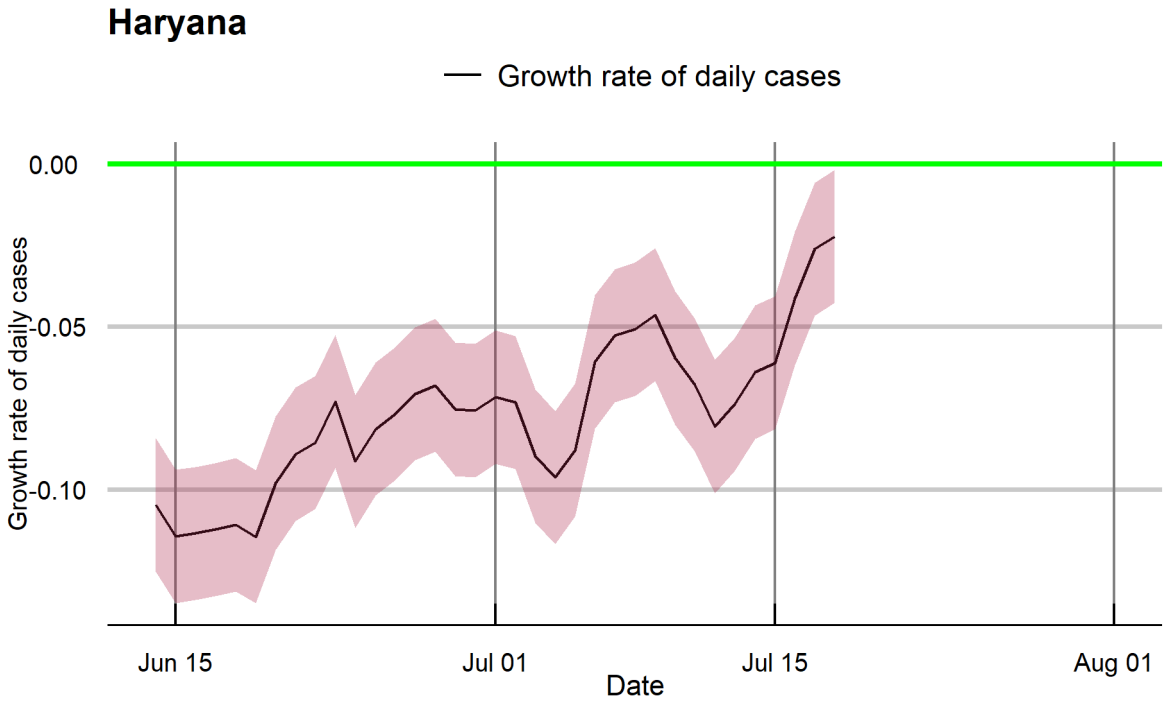

Goa
Data
Forecast
New cases
Forecast
Trend
300
200
100
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

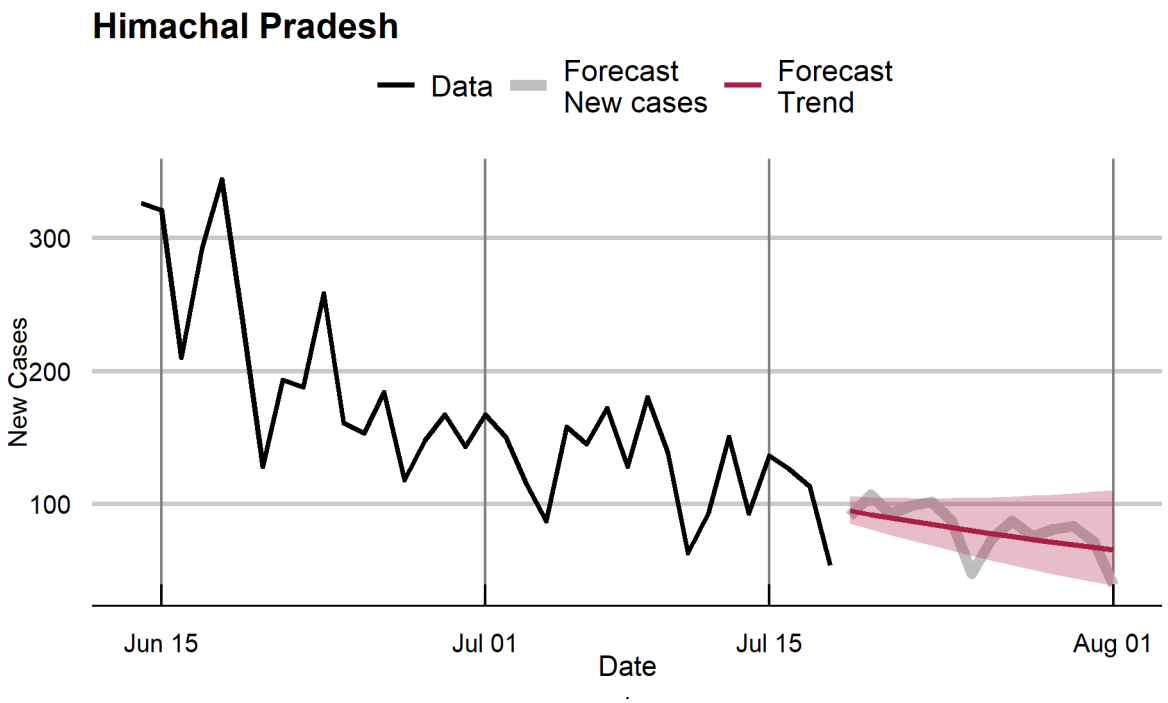

Goa
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

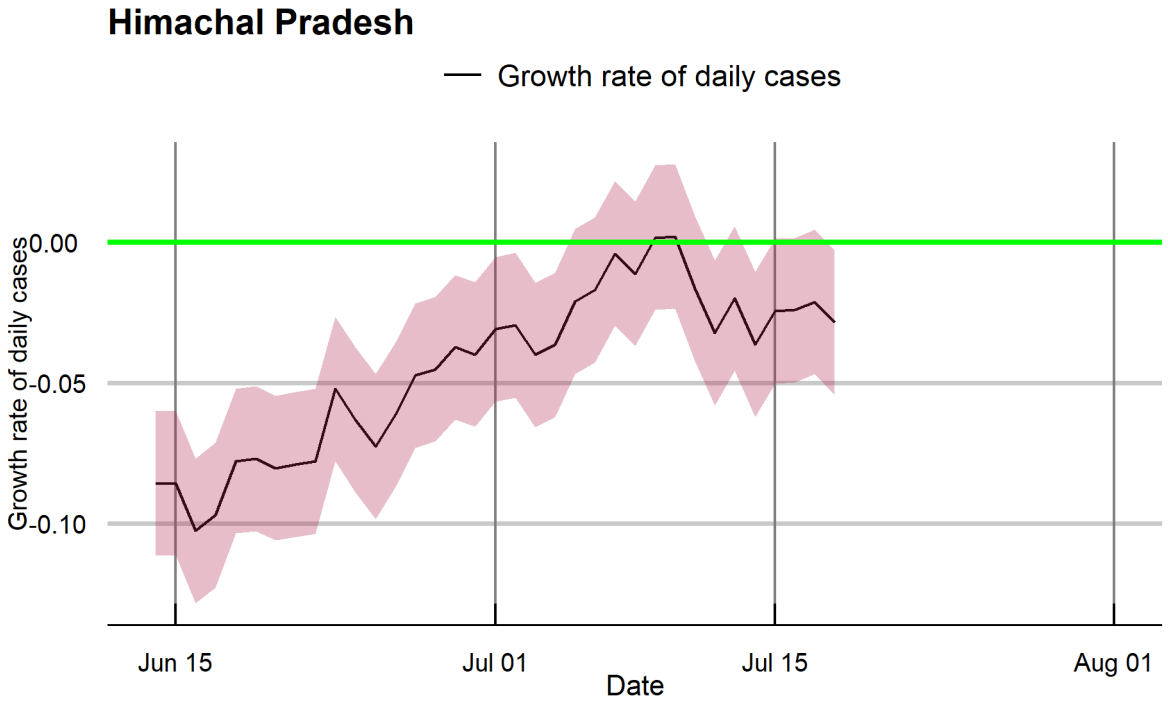

Gujarat
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

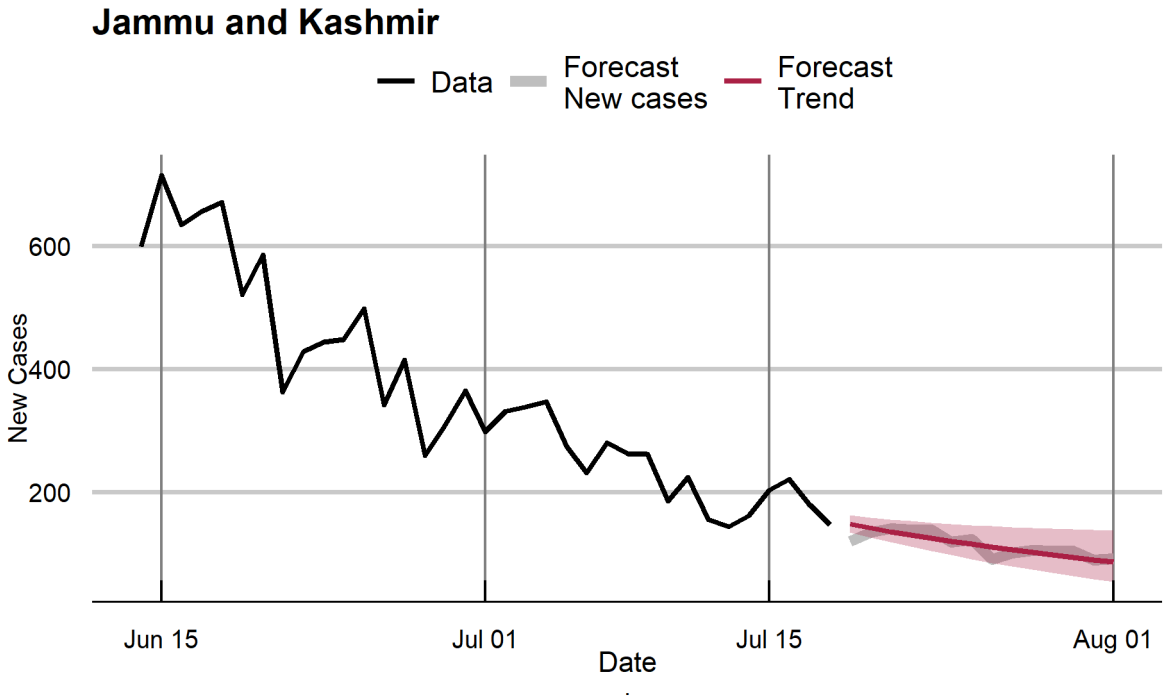

Gujarat
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

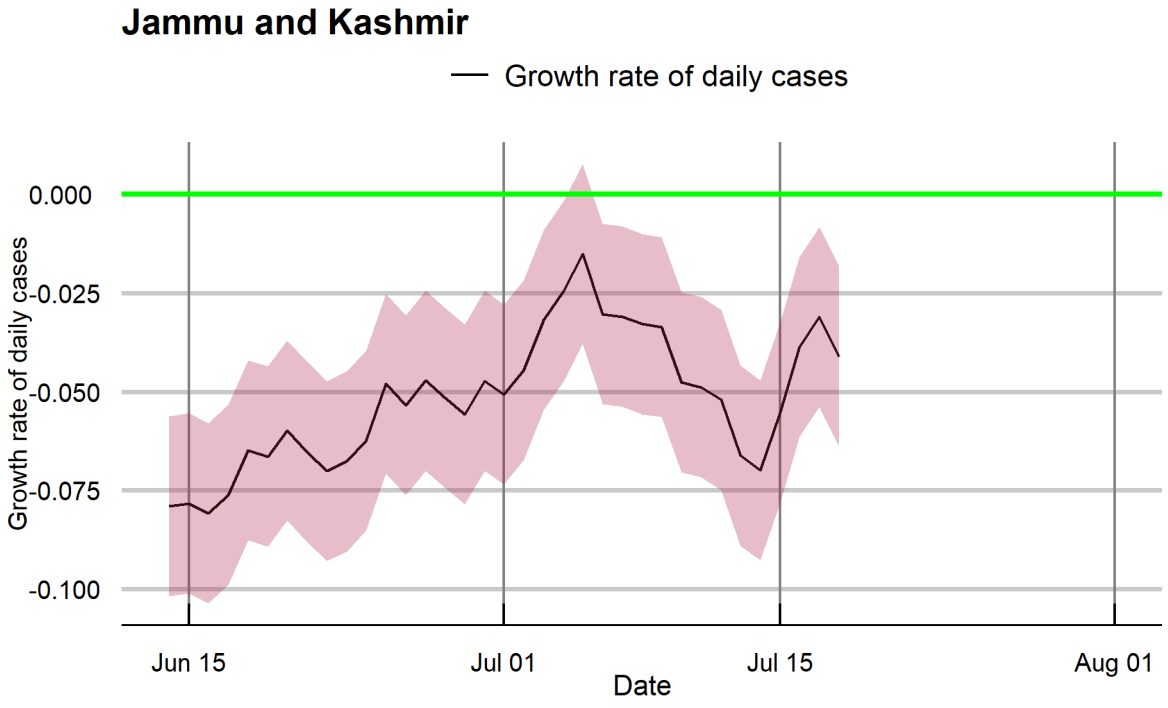

Haryana
Data
Forecast
New cases
Forecast
Trend
200
100
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

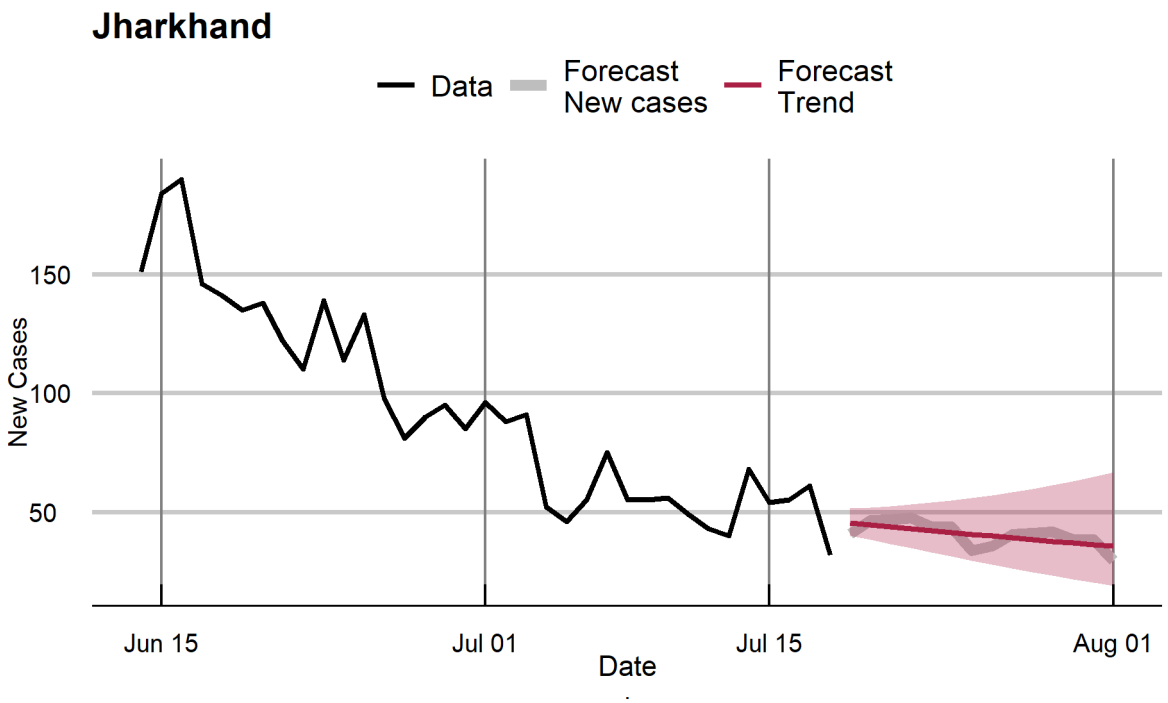

Haryana
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

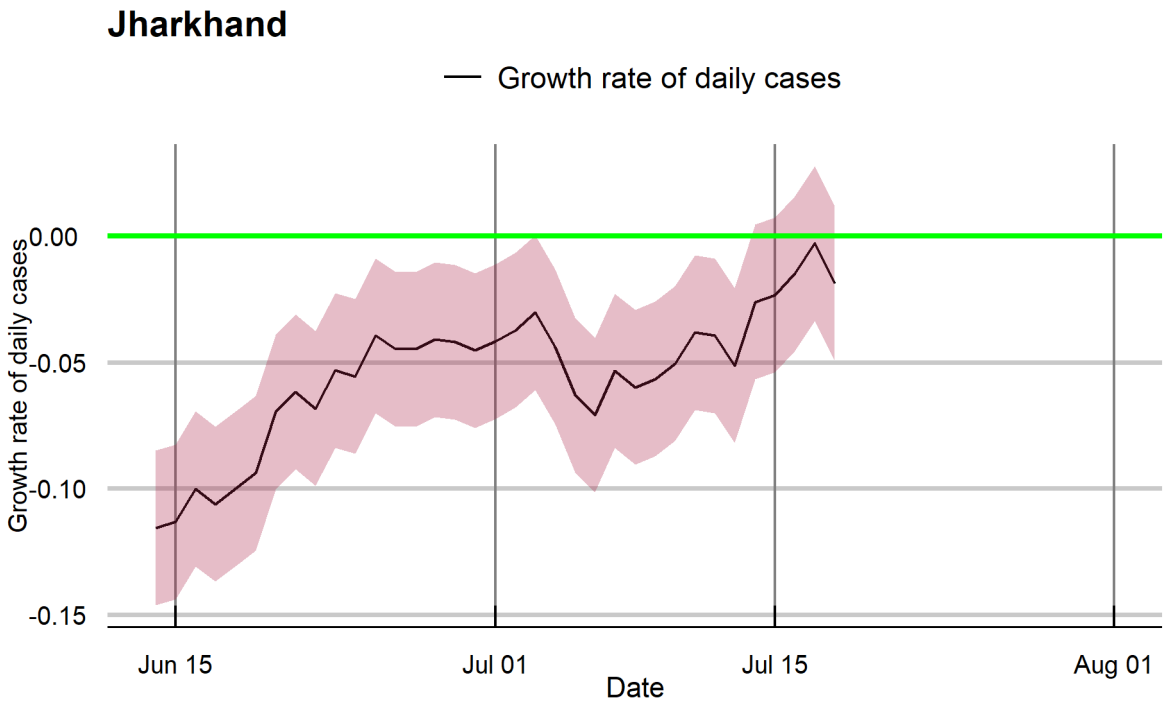

Himachal Pradesh
Data
Forecast
New cases
Forecast
Trend
300
200
100
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

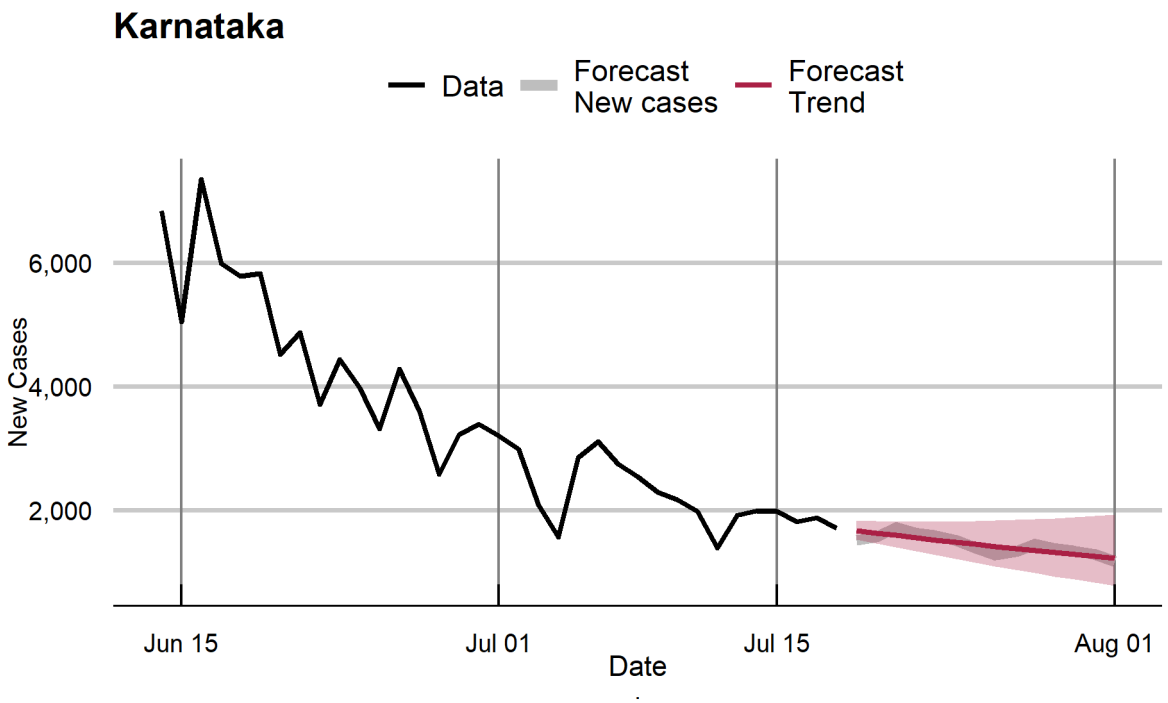

Himachal Pradesh
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

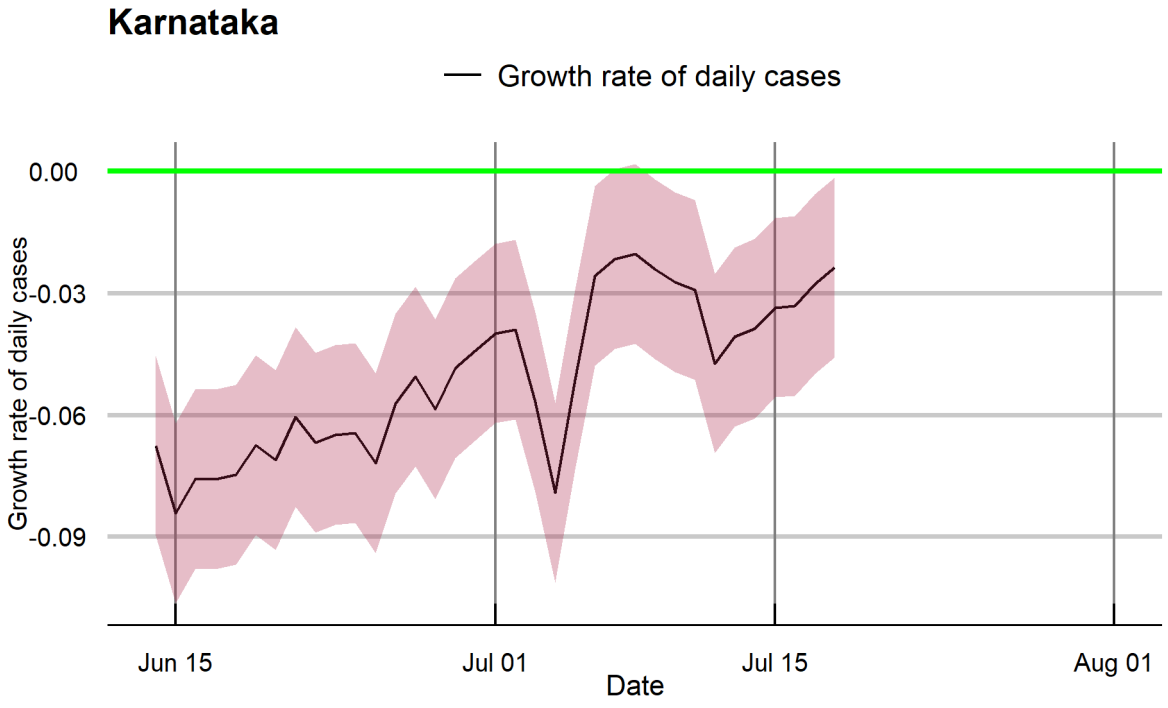

Jammu and Kashmir
Data
Forecast
New cases
Forecast
Trend
600
400
200
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

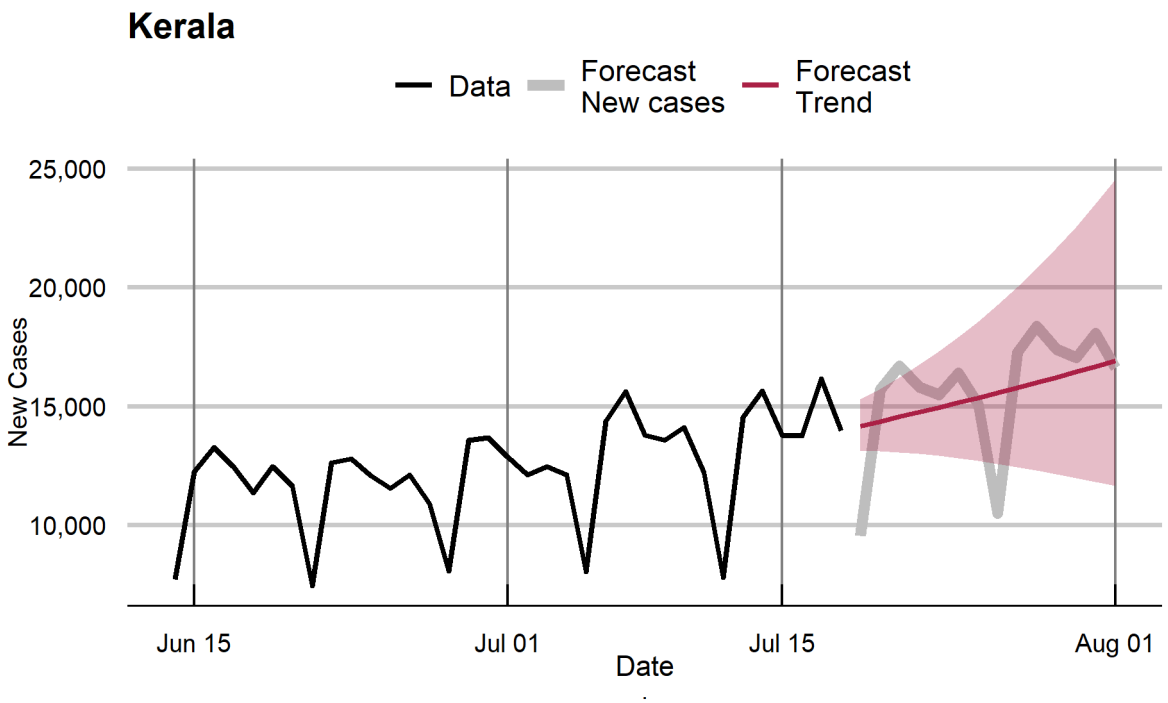

Jammu and Kashmir
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
-0.100
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

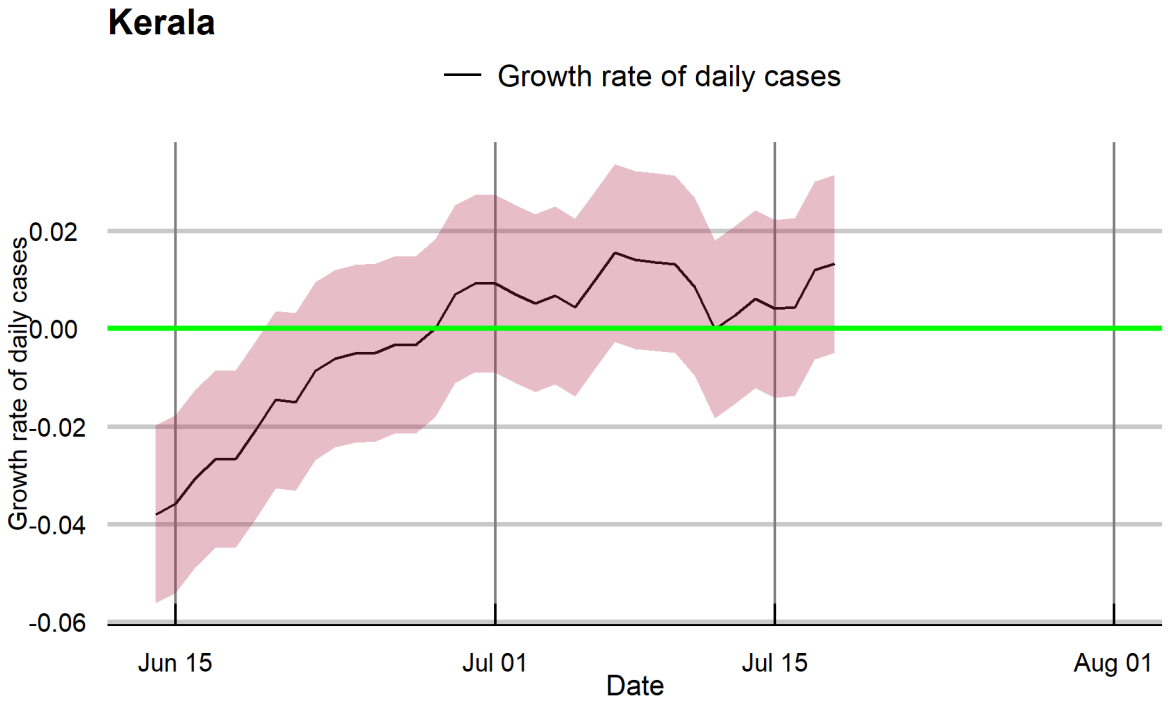

Jharkhand
Data
Forecast
New cases
Forecast
Trend
150
100
50
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

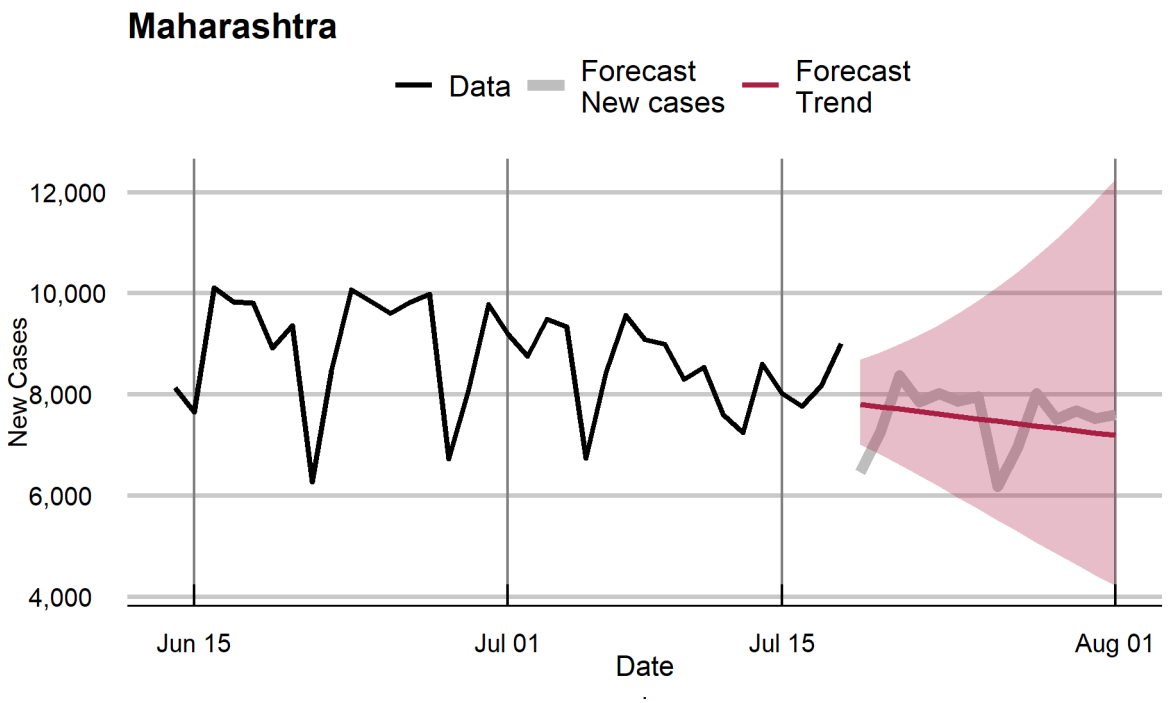

Jharkhand
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

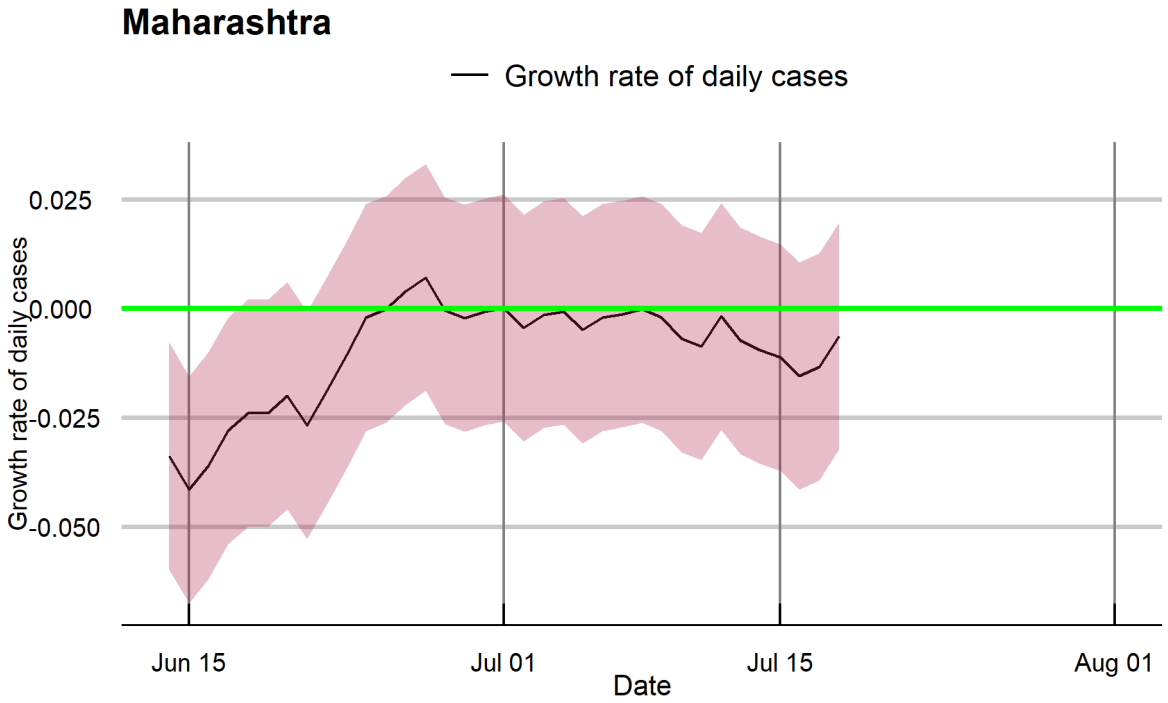

Karnataka
Data
Forecast
New cases
Forecast
Trend
6,000
4,000
2,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

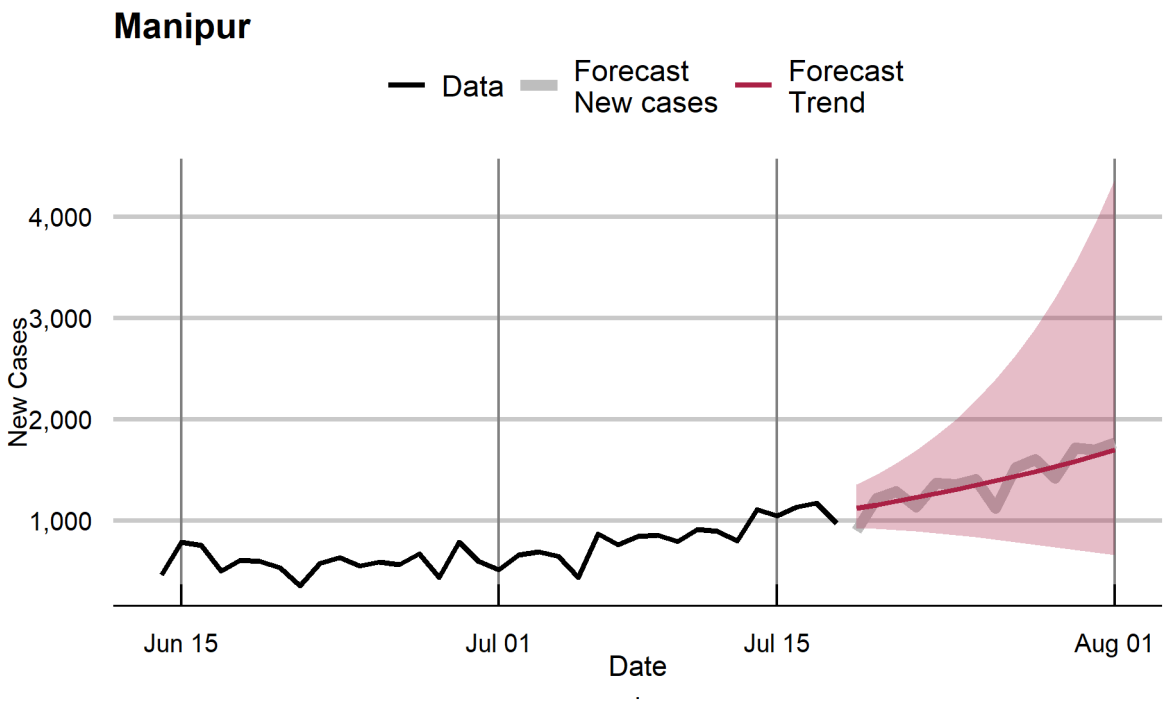

Karnataka
Growth rate of daily cases
0.00
-0.03
-0.06
-0.09
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

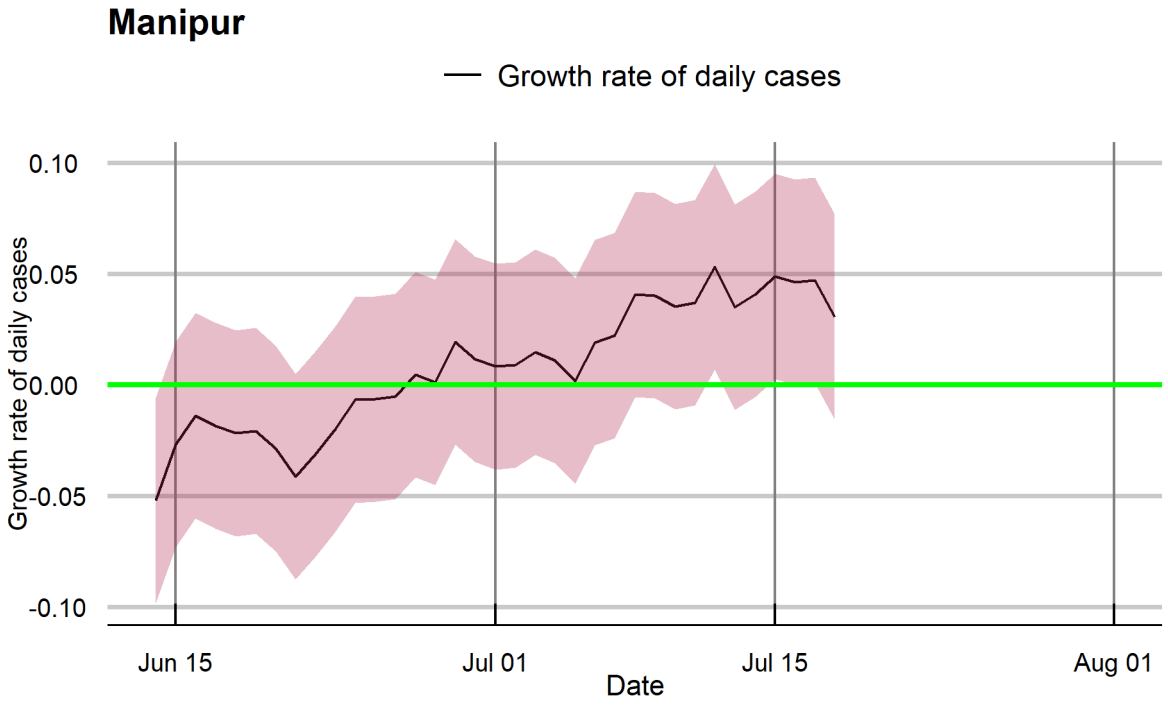

Kerala
Data
Forecast
New cases
Forecast
Trend
25,000
20,000
15,000
10,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

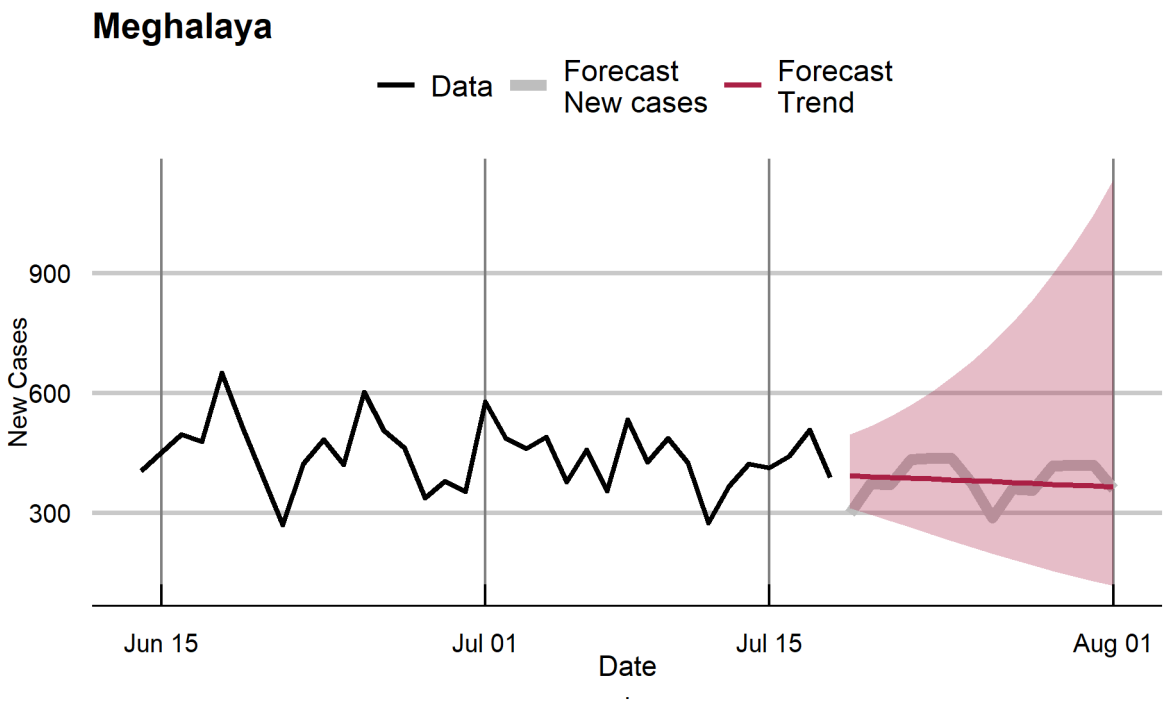

Kerala
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

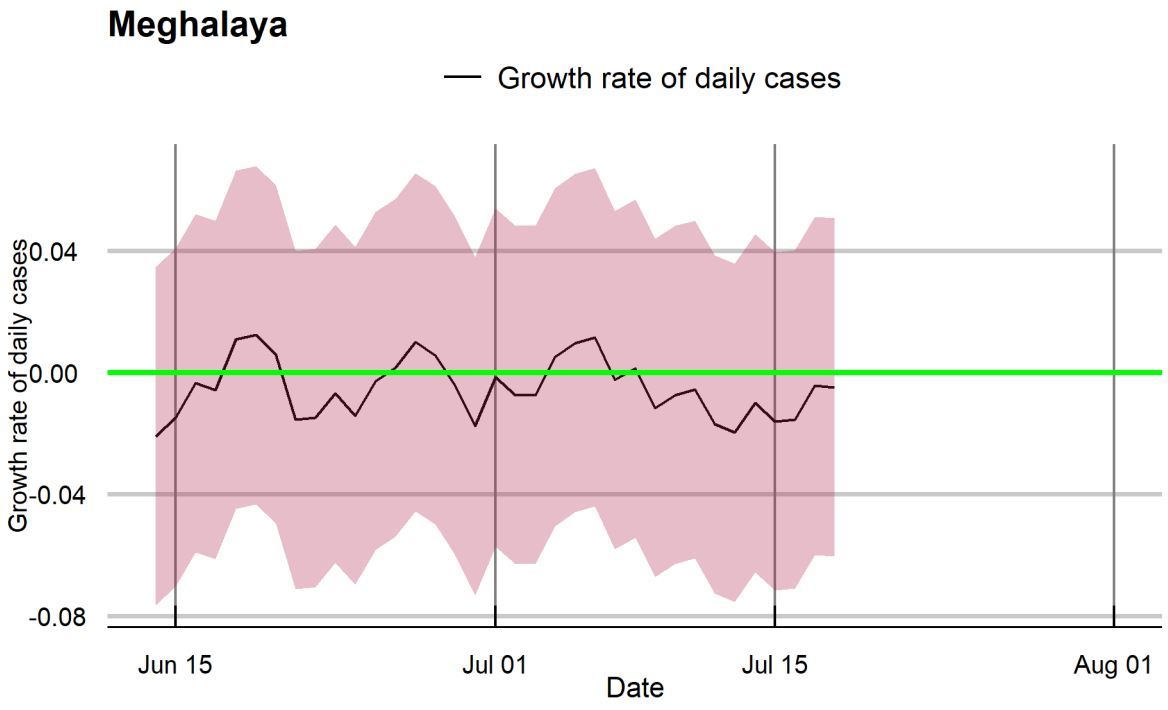

Maharashtra
Data
Forecast
New cases
Forecast
Trend
12,000
10,000
8,000
6,000
4,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

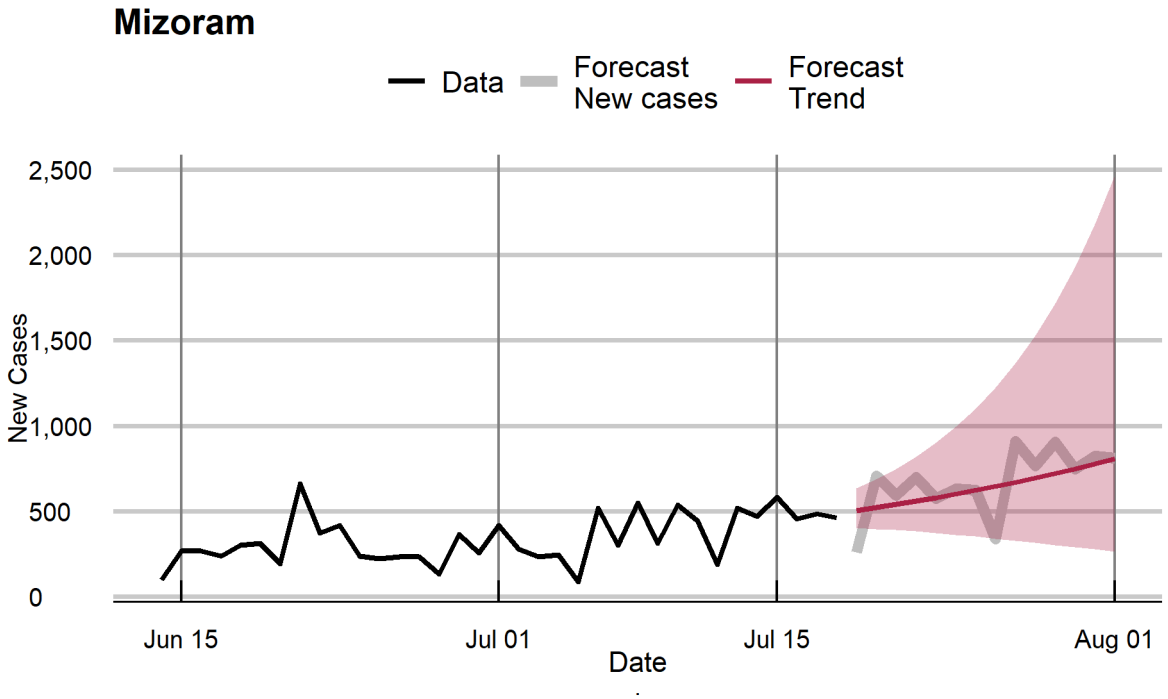

Maharashtra
Growth rate of daily cases
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

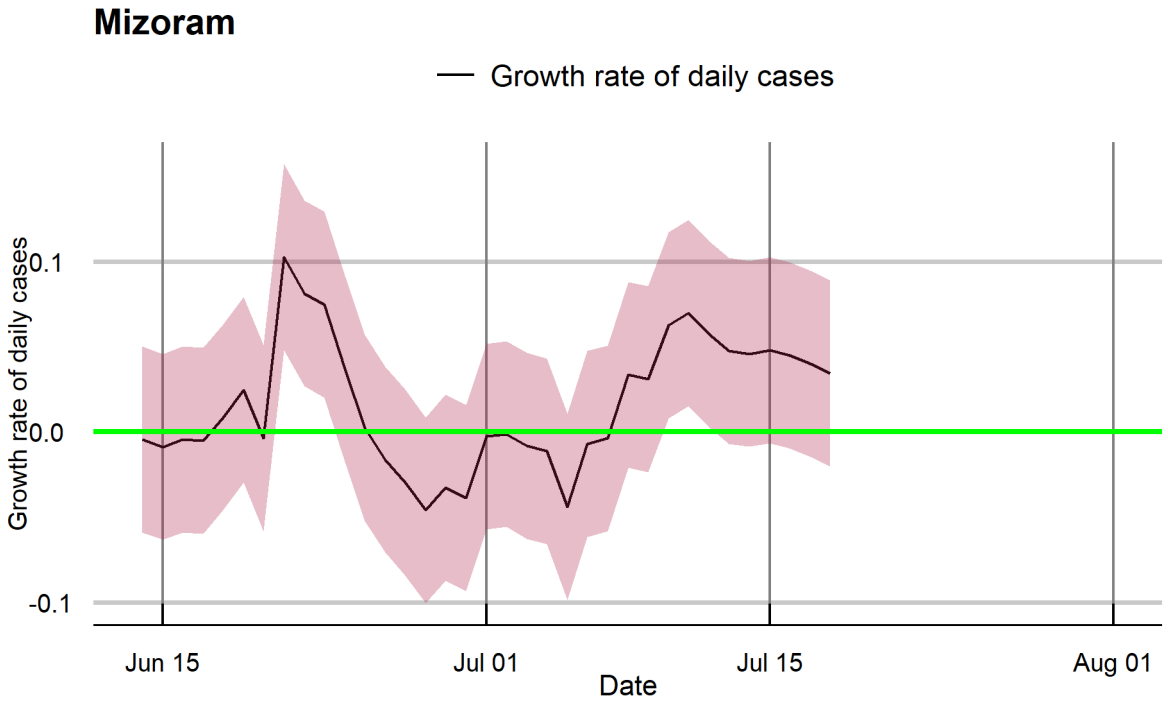

Manipur
Data
Forecast
New cases
Forecast
Trend
4,000
3,000
2,000
1,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

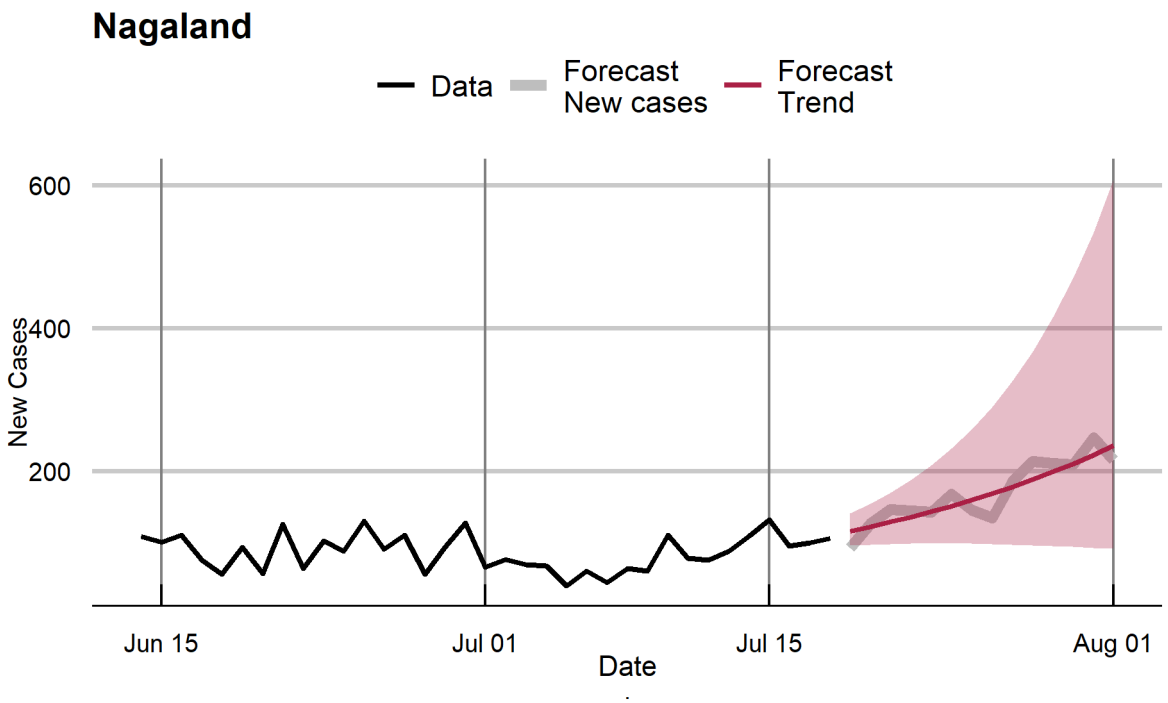

Manipur
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

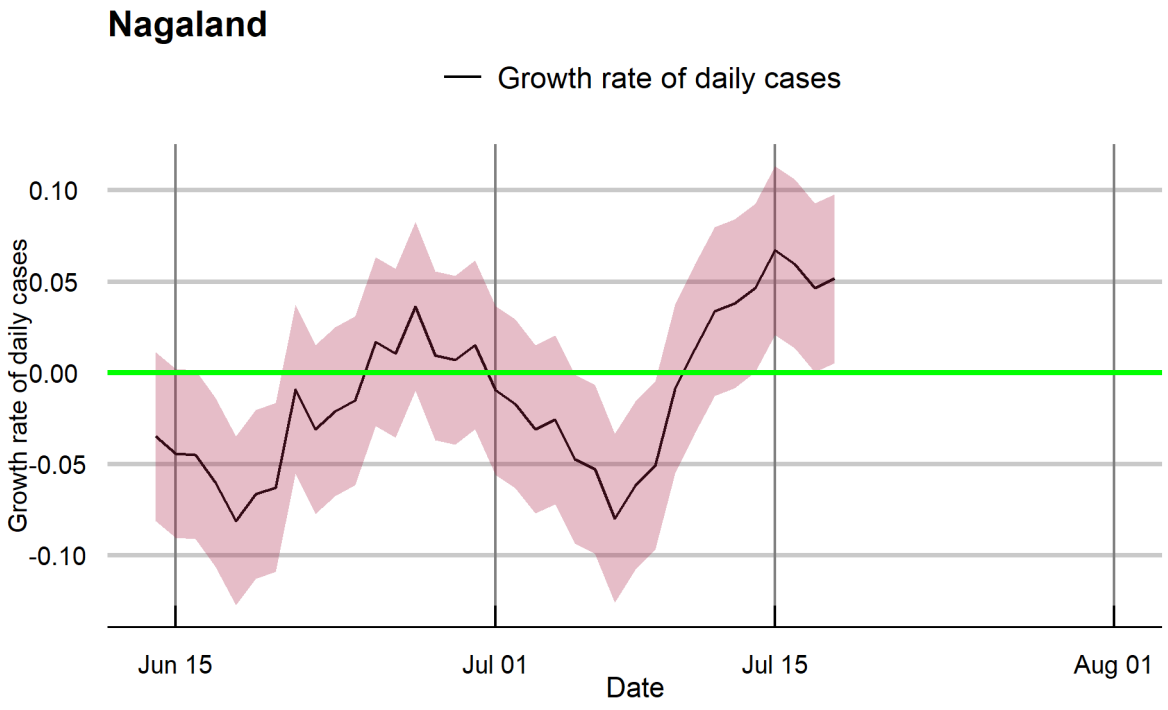

Meghalaya
Data
Forecast
New cases
Forecast
Trend
900
600
300
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

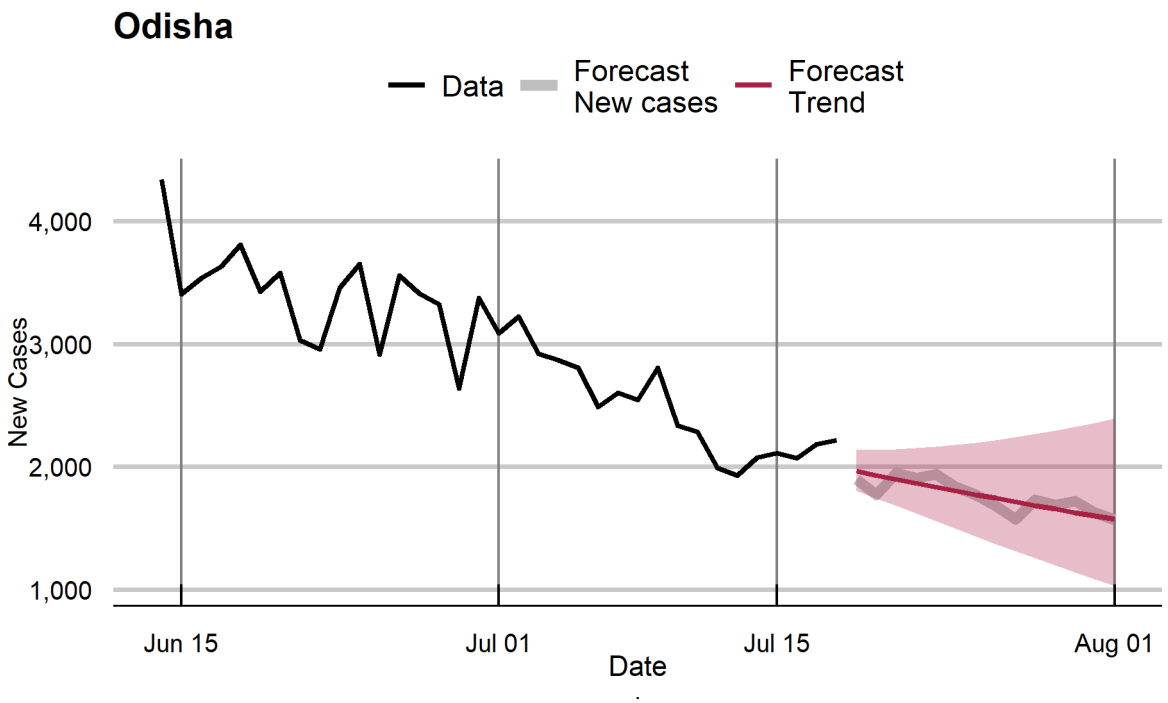

Meghalaya
Growth rate of daily cases
0.04
0.00
-0.04
-0.08
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

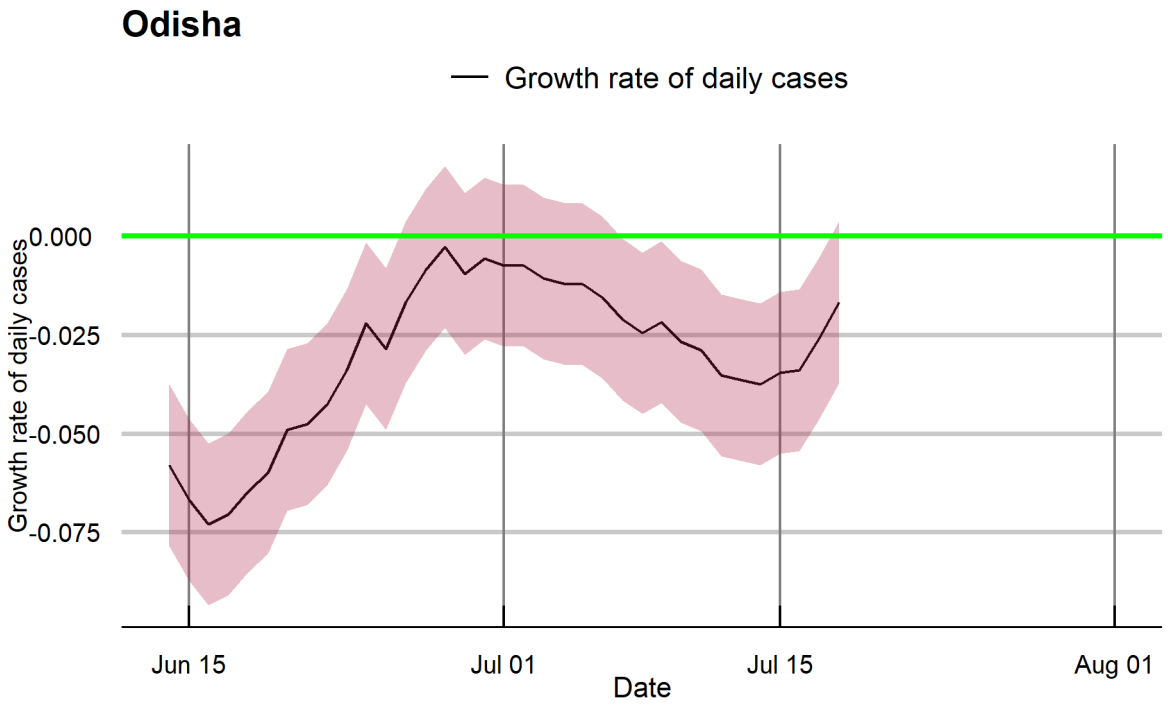

Mizoram
Data
Forecast
New cases
Forecast
Trend
2,500
2,000
1,500
1,000
500
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

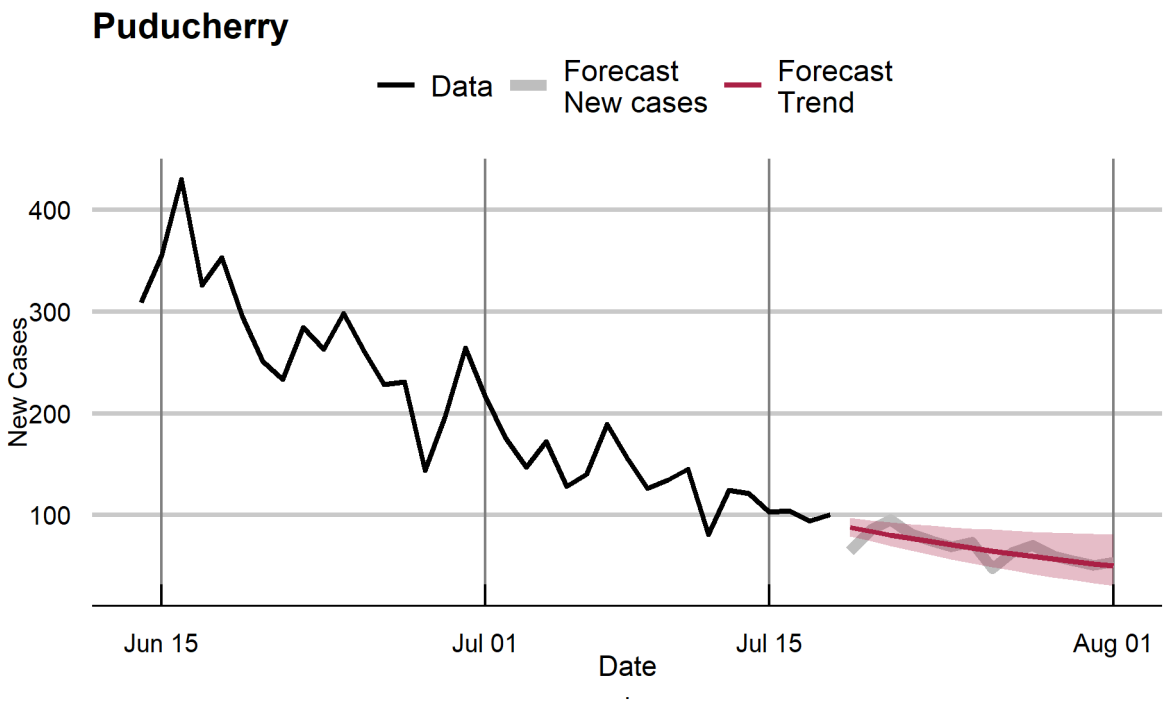

Mizoram
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

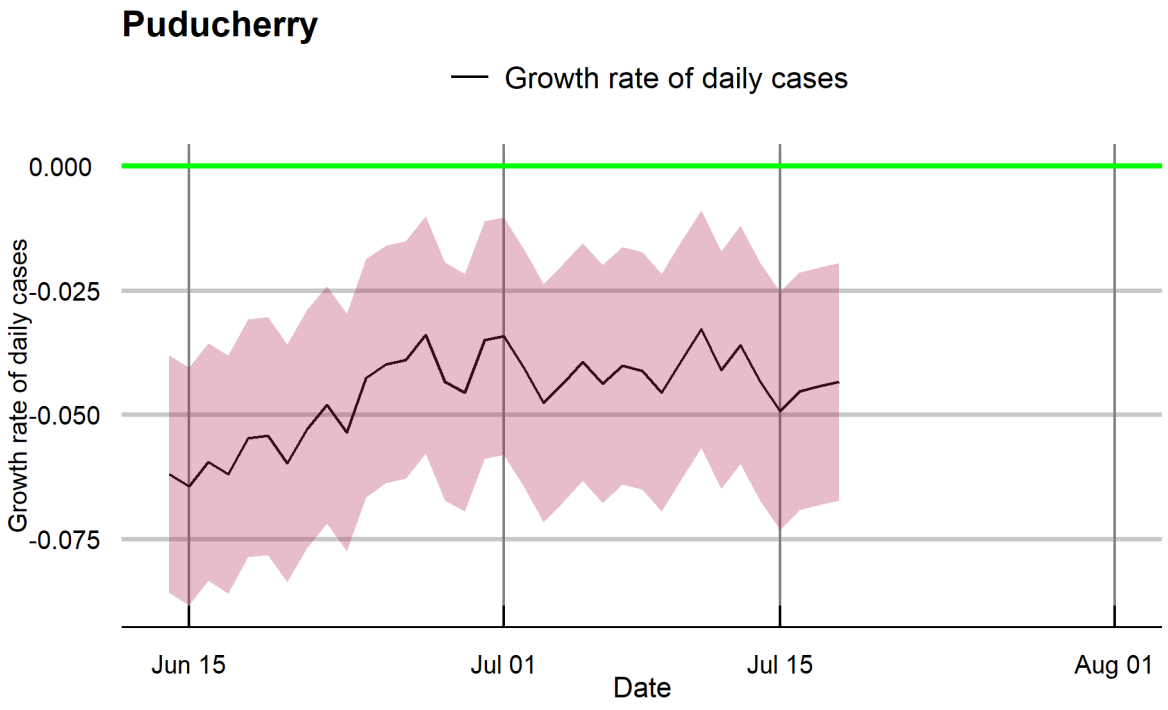

Nagaland
Data
Forecast
New cases
Forecast
Trend
600
400
200
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

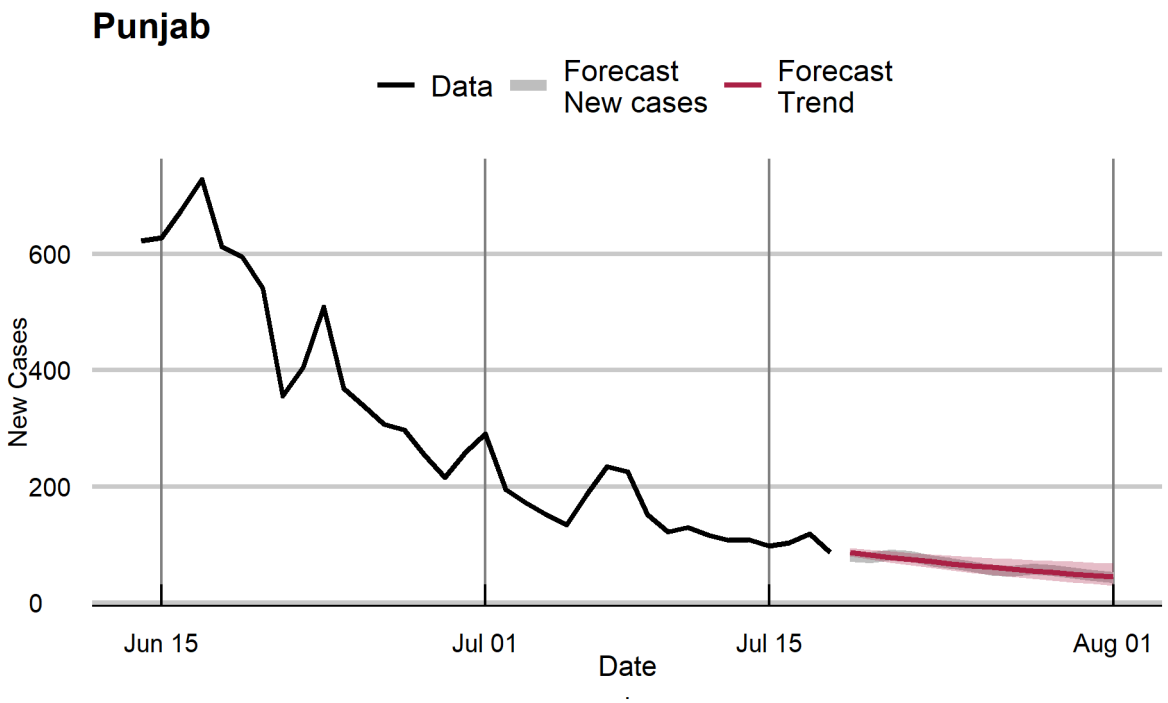

Nagaland
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

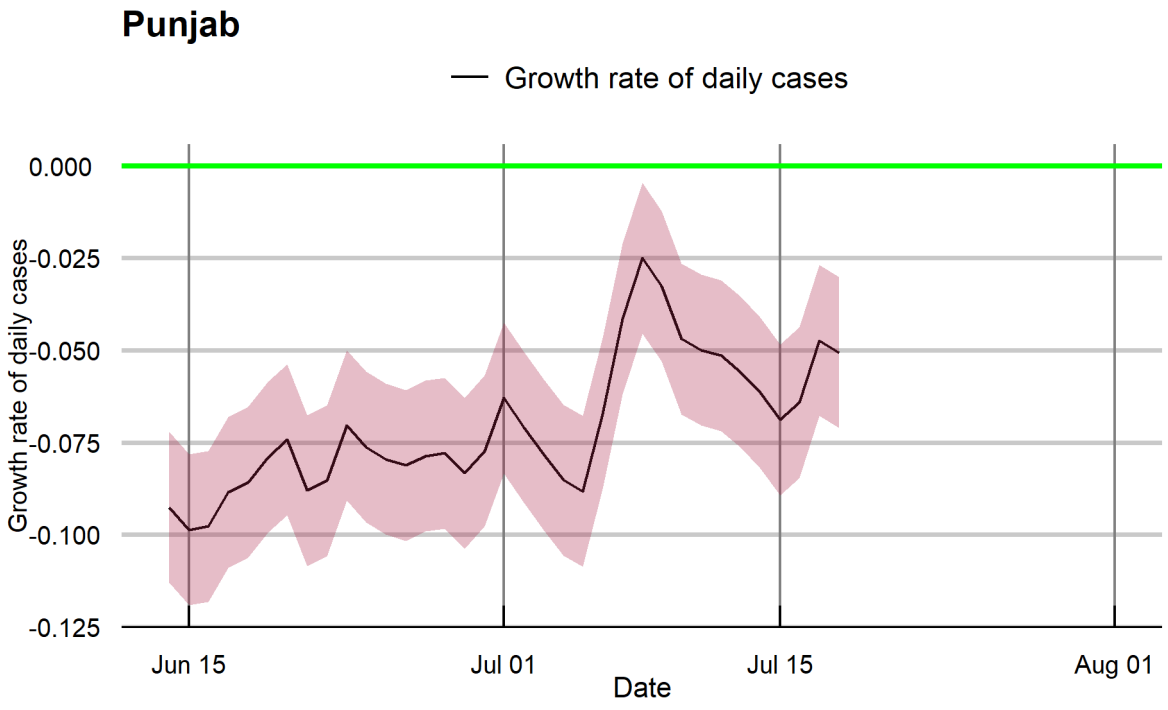

Odisha
Data
Forecast
New cases
Forecast
Trend
4,000
3,000
2,000
1,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

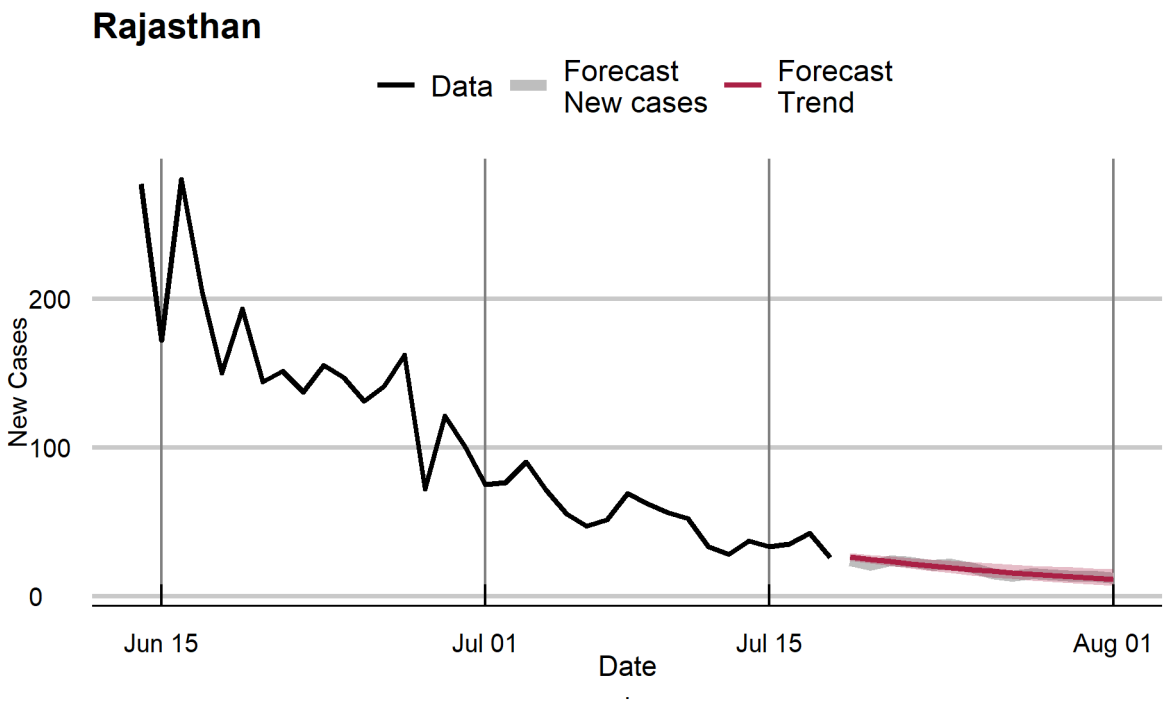

Odisha
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

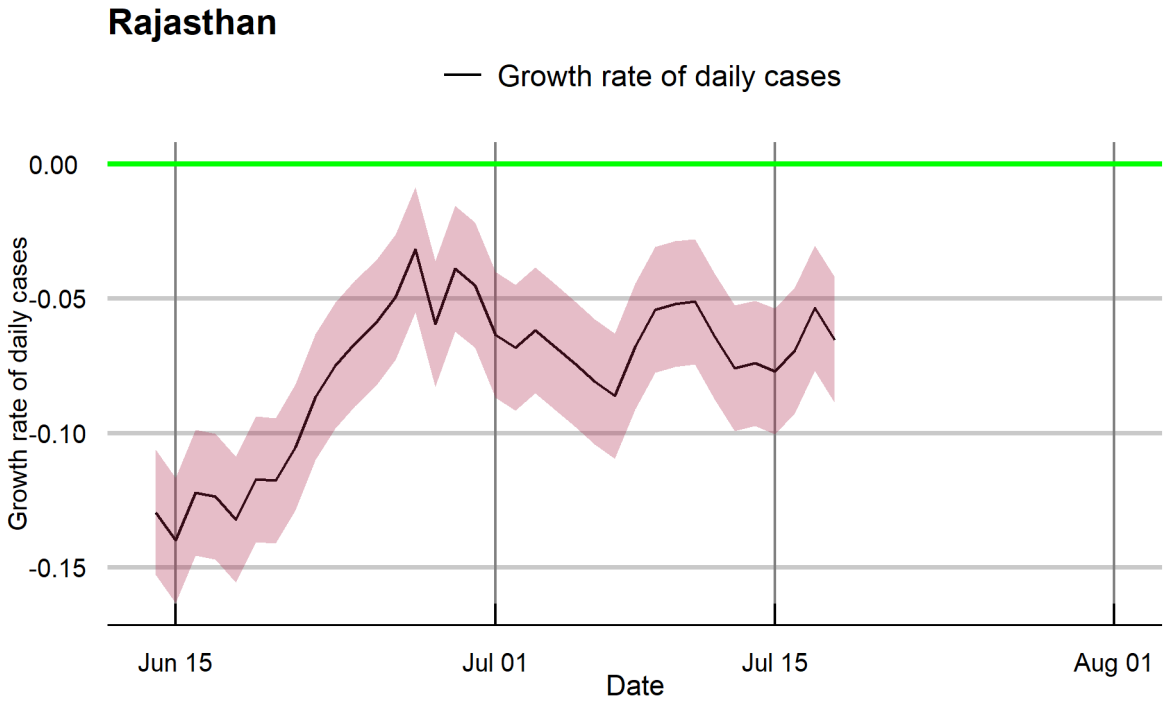

Puducherry
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

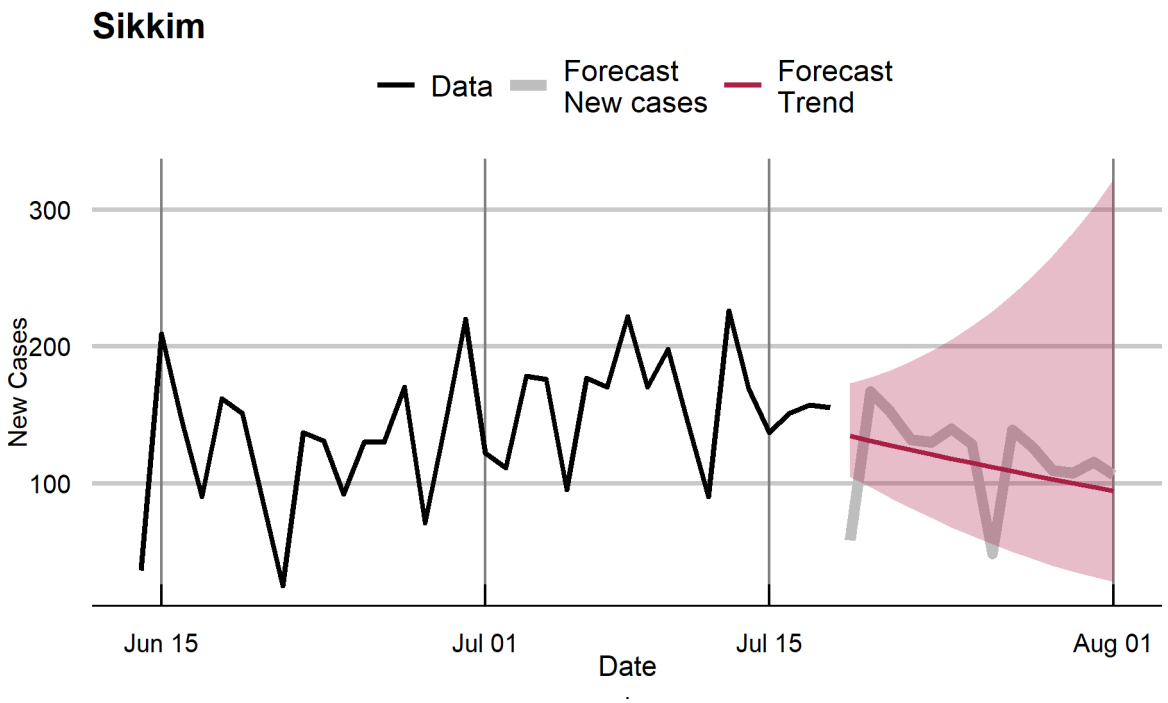

Puducherry
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

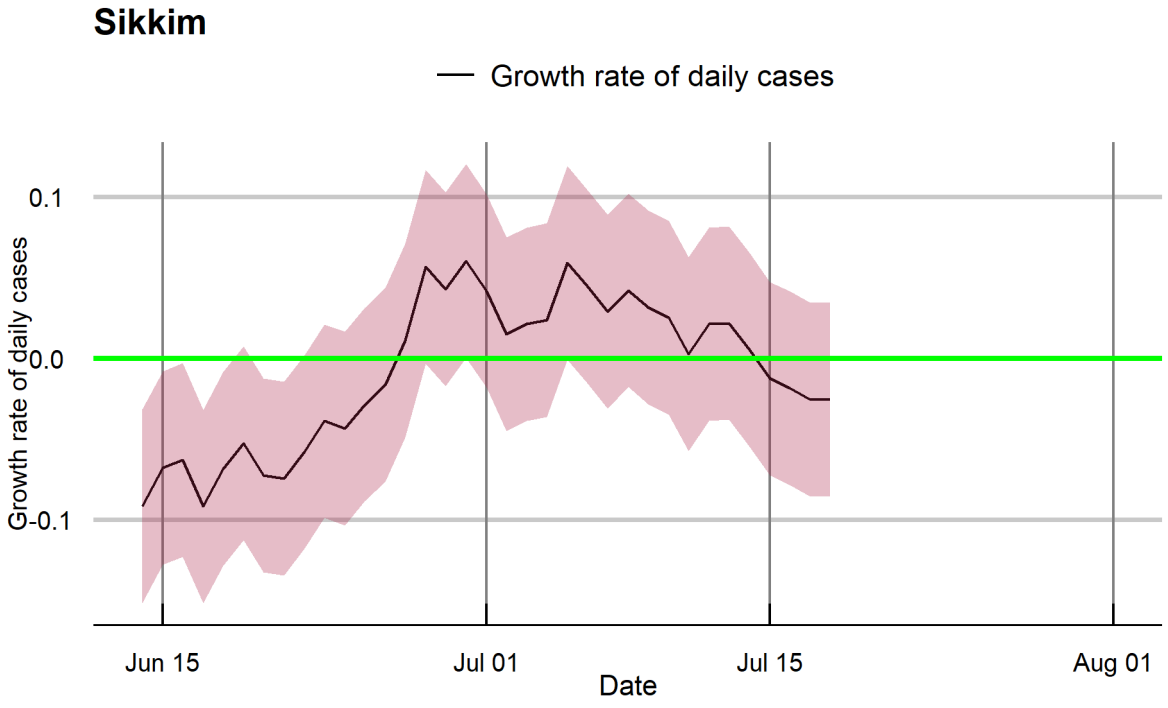

Punjab
Data
Forecast
New cases
Forecast
Trend
600
400
200
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date


Punjab
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
-0.100
-0.125
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

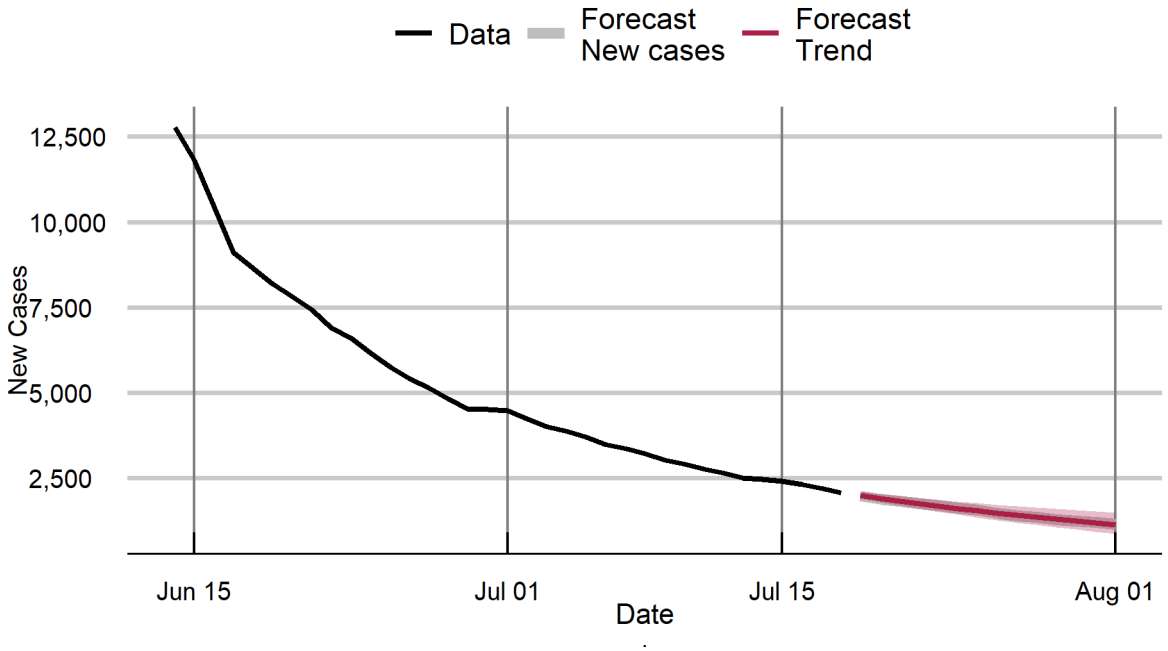

Rajasthan
Data
Forecast
New cases
Forecast
Trend
New Cases
200
100
0
Jun 15
Jul 01
Jul 15
Aug 01
Date


Rajasthan
Growth rate of daily cases
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Jun 15
Jul 01
Jul 15
Aug 01
Date

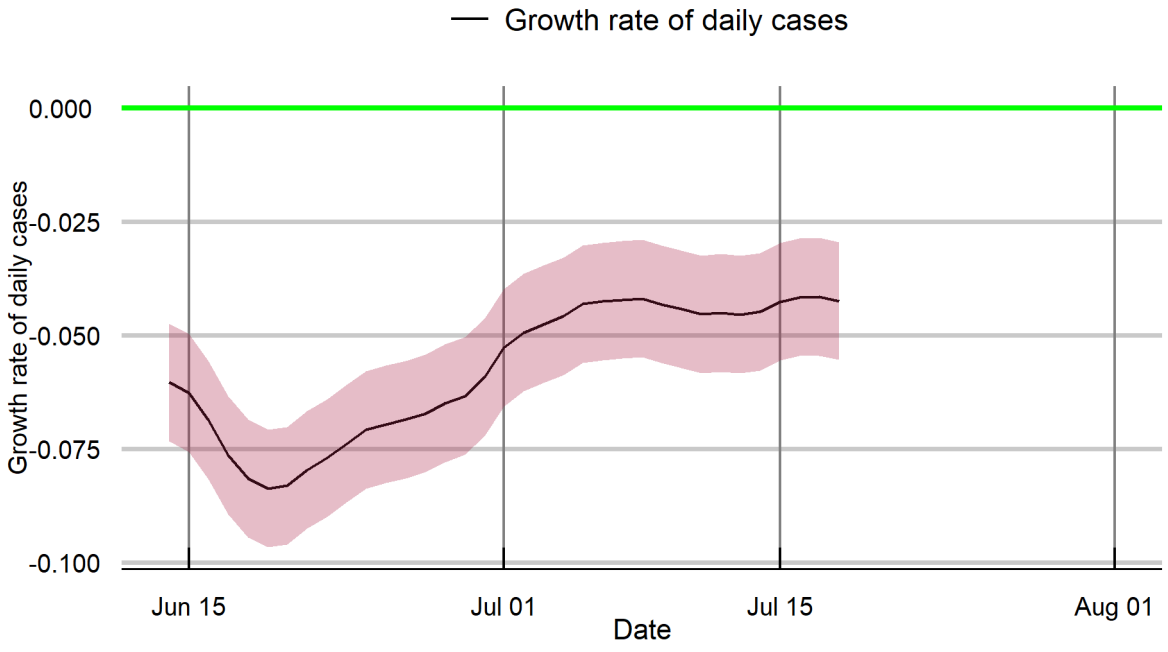

Sikkim
Data
Forecast
New cases
Forecast
Trend
300
200
100
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

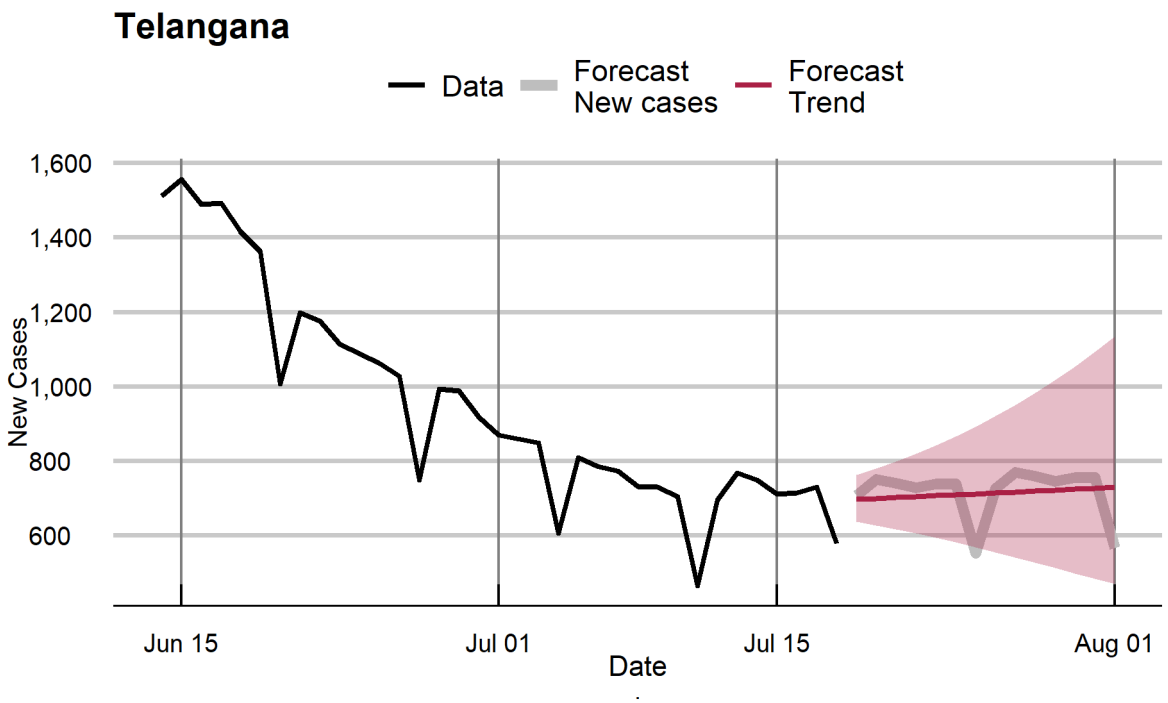

Sikkim
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

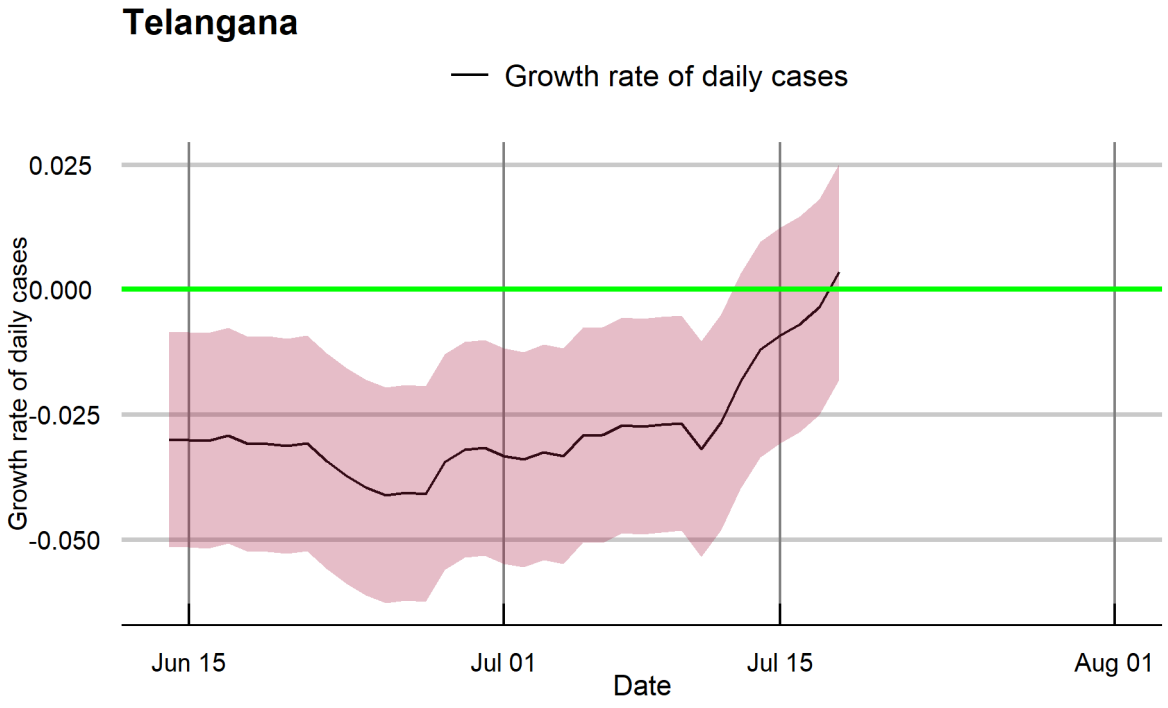
Tamil Nadu

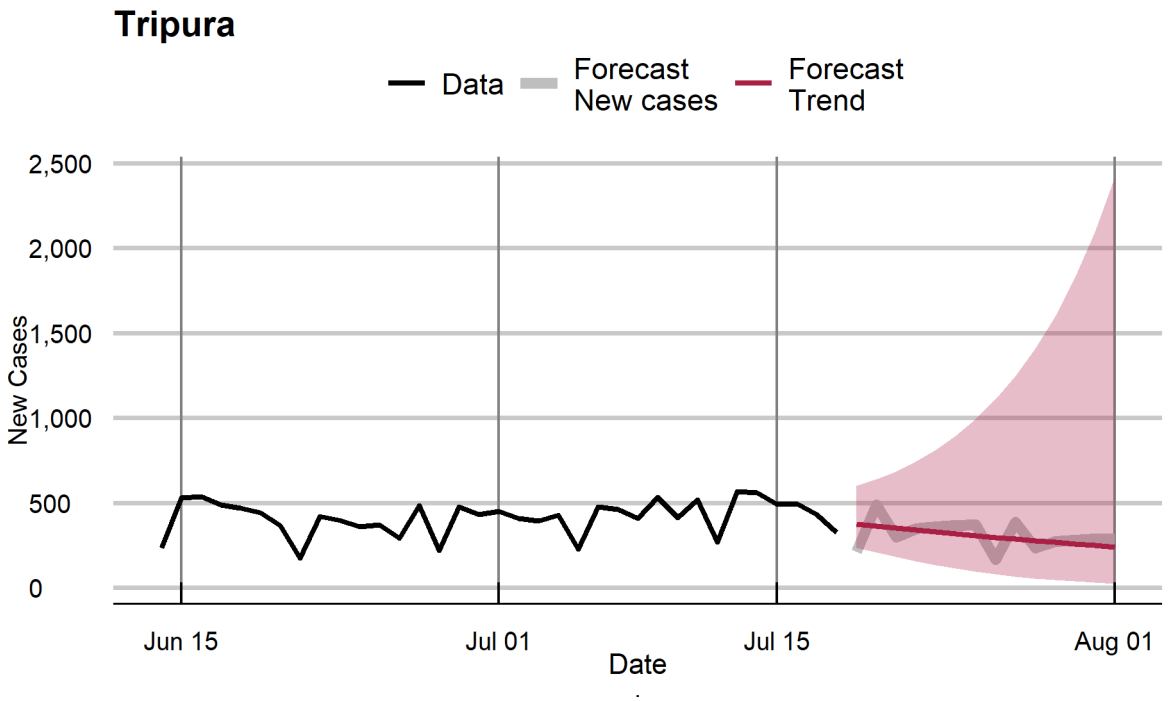


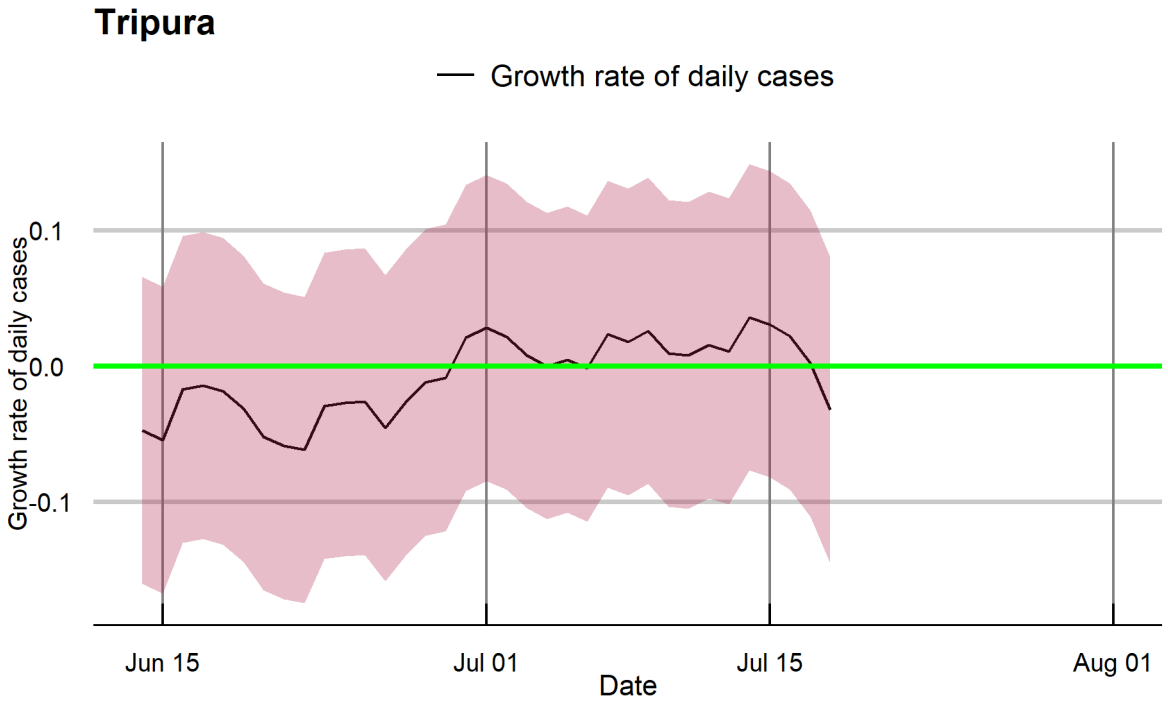
Tamil Nadu

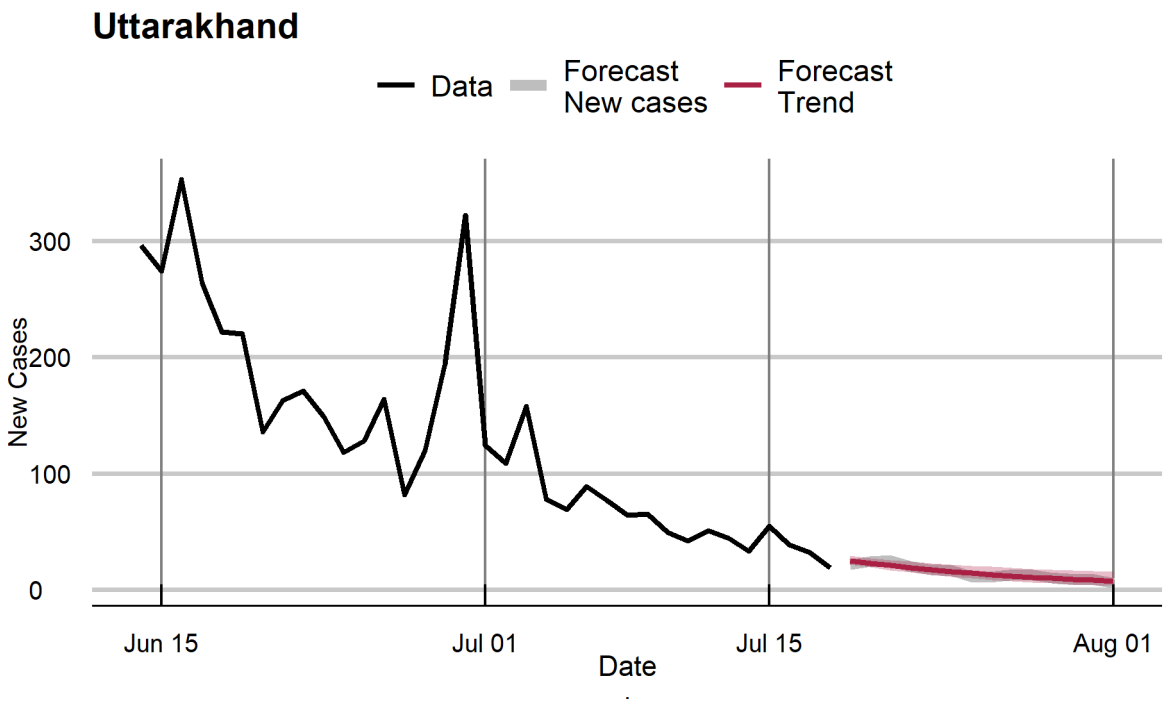


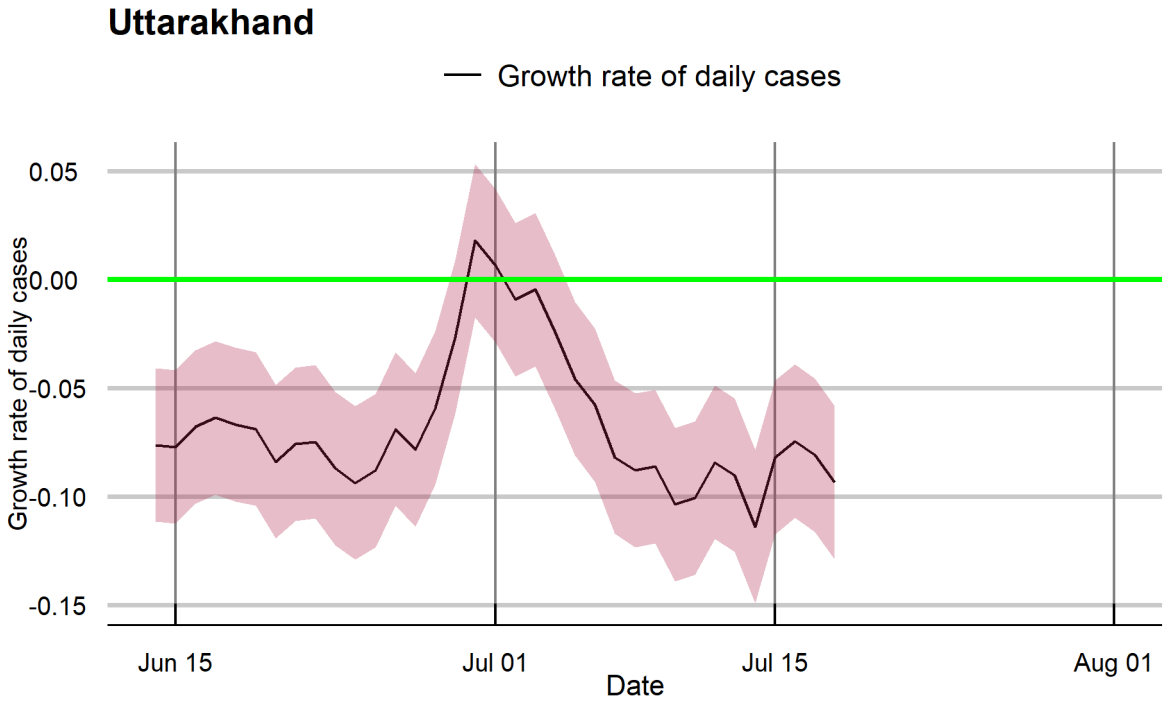

Telangana
Data
Forecast
New cases
Forecast
Trend
1,600
1,400
1,200
1,000
800
600
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

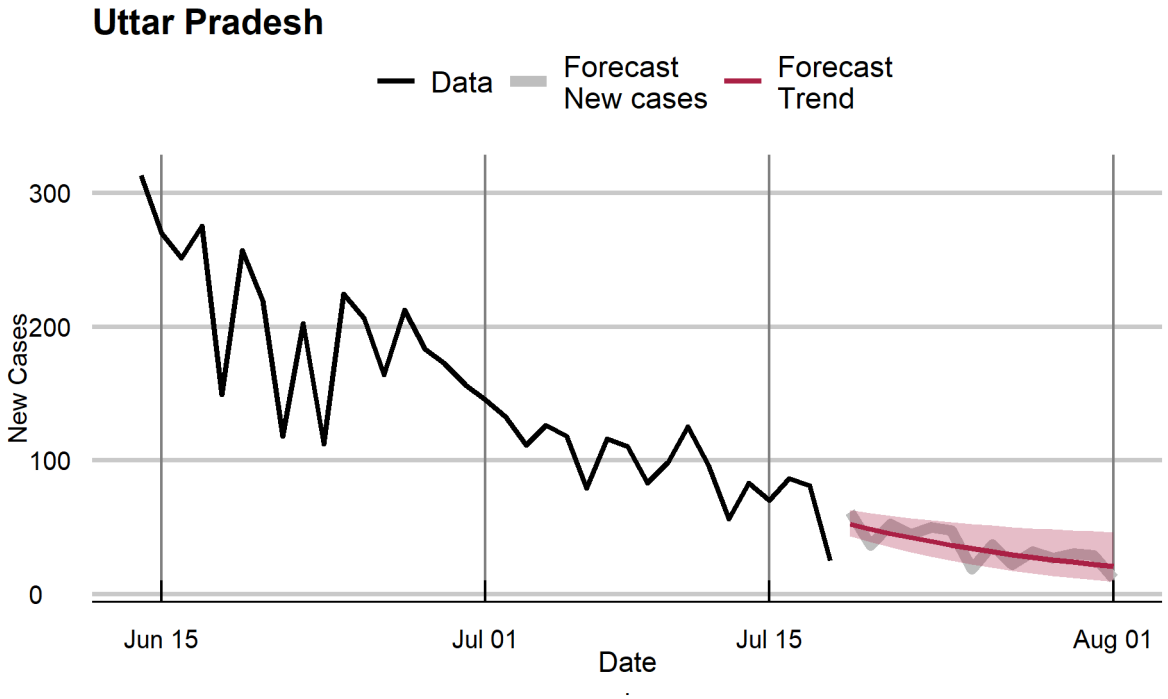

Telangana
Growth rate of daily cases
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

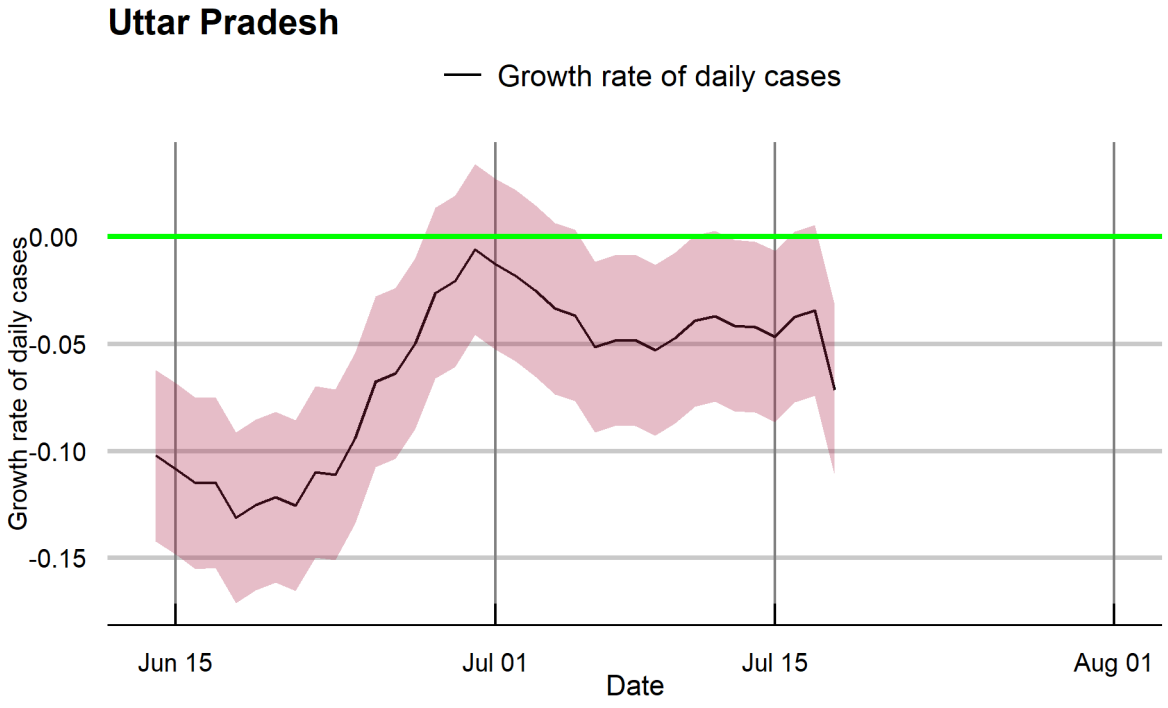

Tripura
Data
Forecast
New cases
Forecast
Trend
2,500
2,000
1,500
1,000
500
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

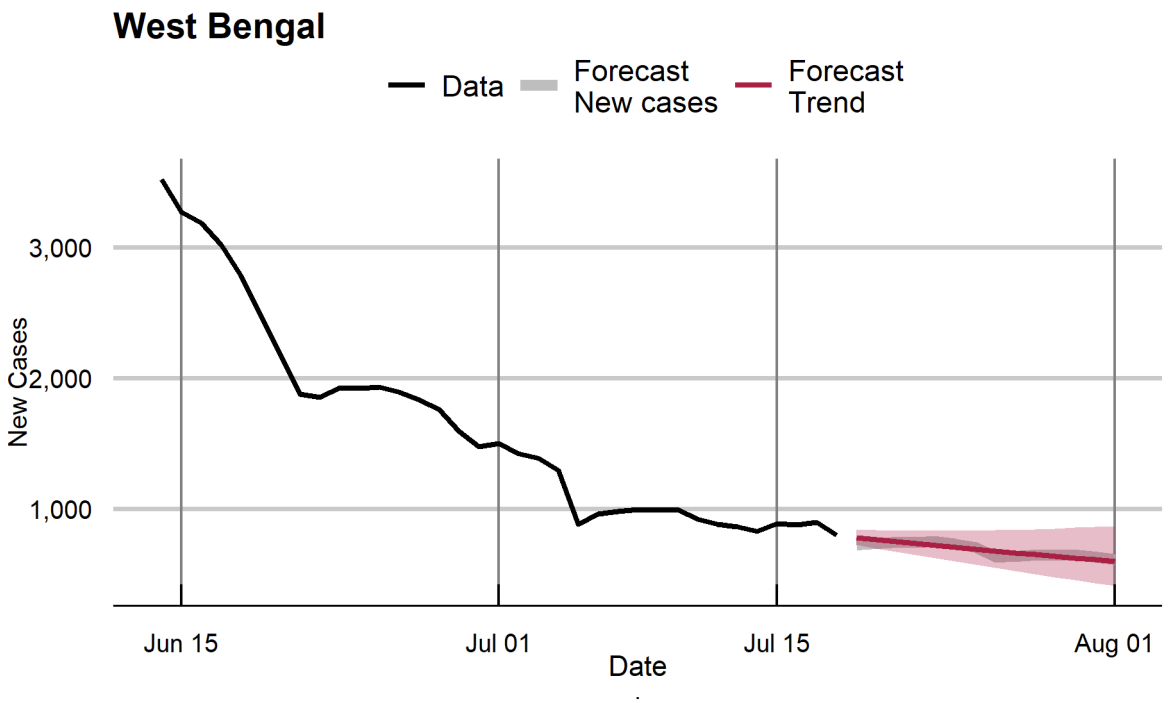

Tripura
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

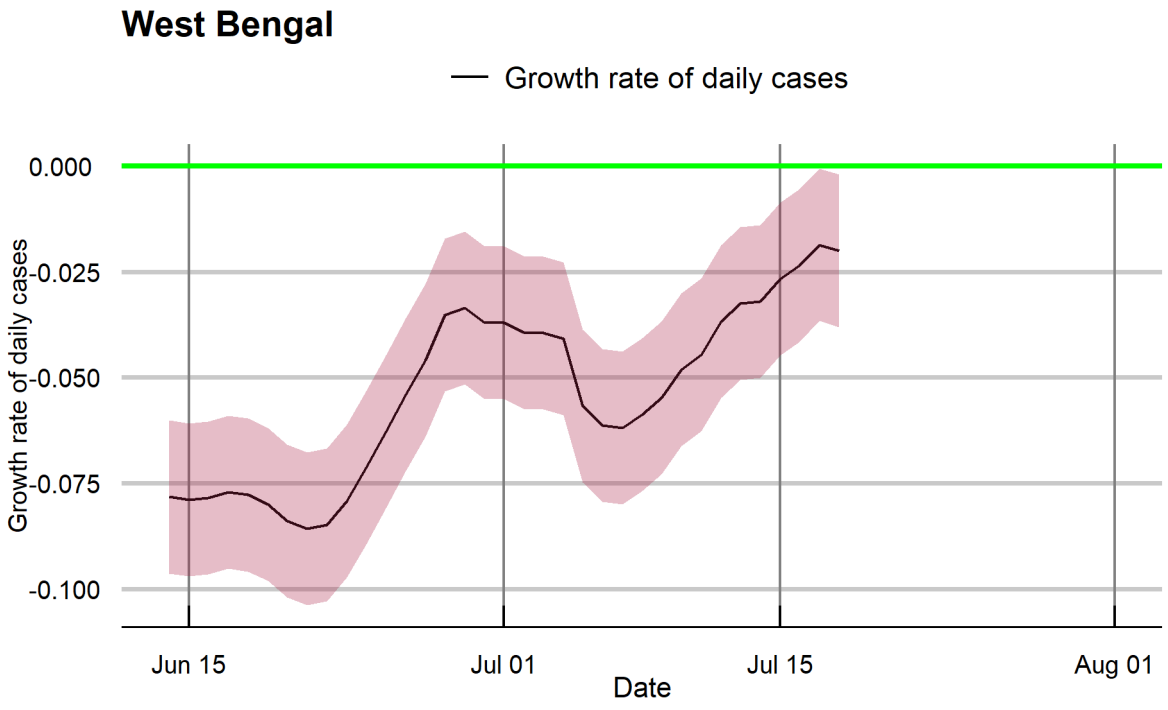

Uttarakhand
Data
Forecast
New cases
Forecast
Trend
300
200
100
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date


Uttarakhand
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date


Uttar Pradesh
Data
Forecast
New cases
Forecast
Trend
300
200
100
0
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

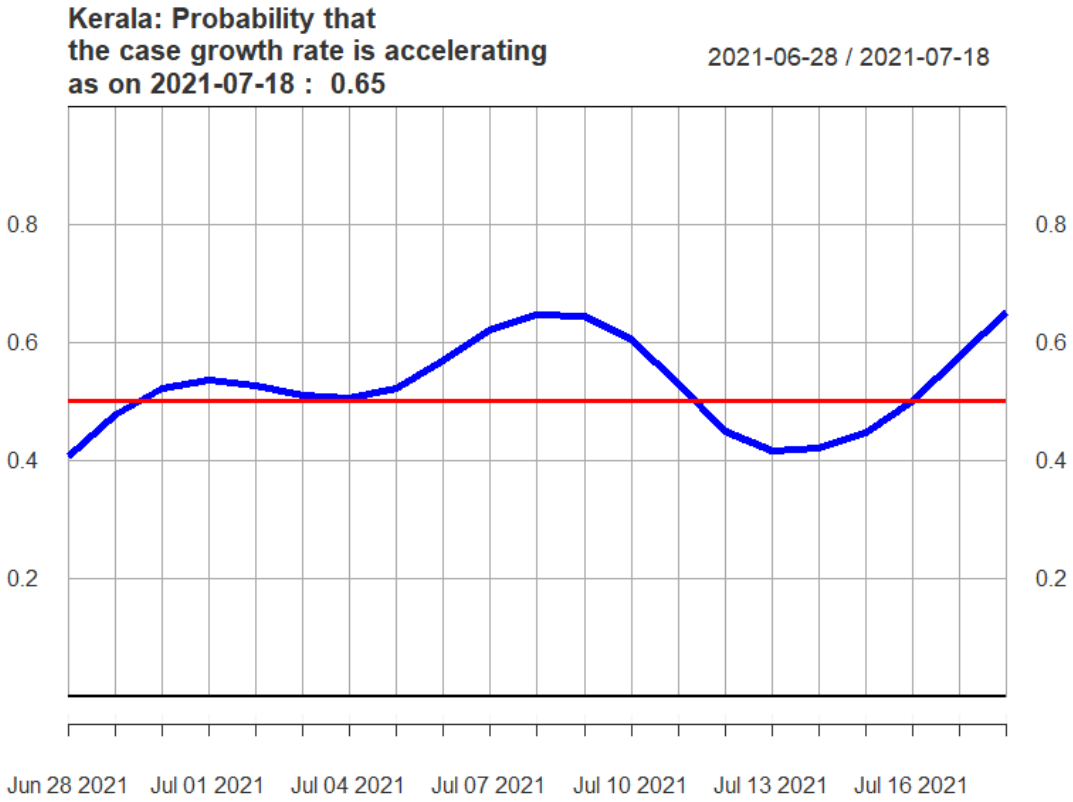

Uttar Pradesh
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

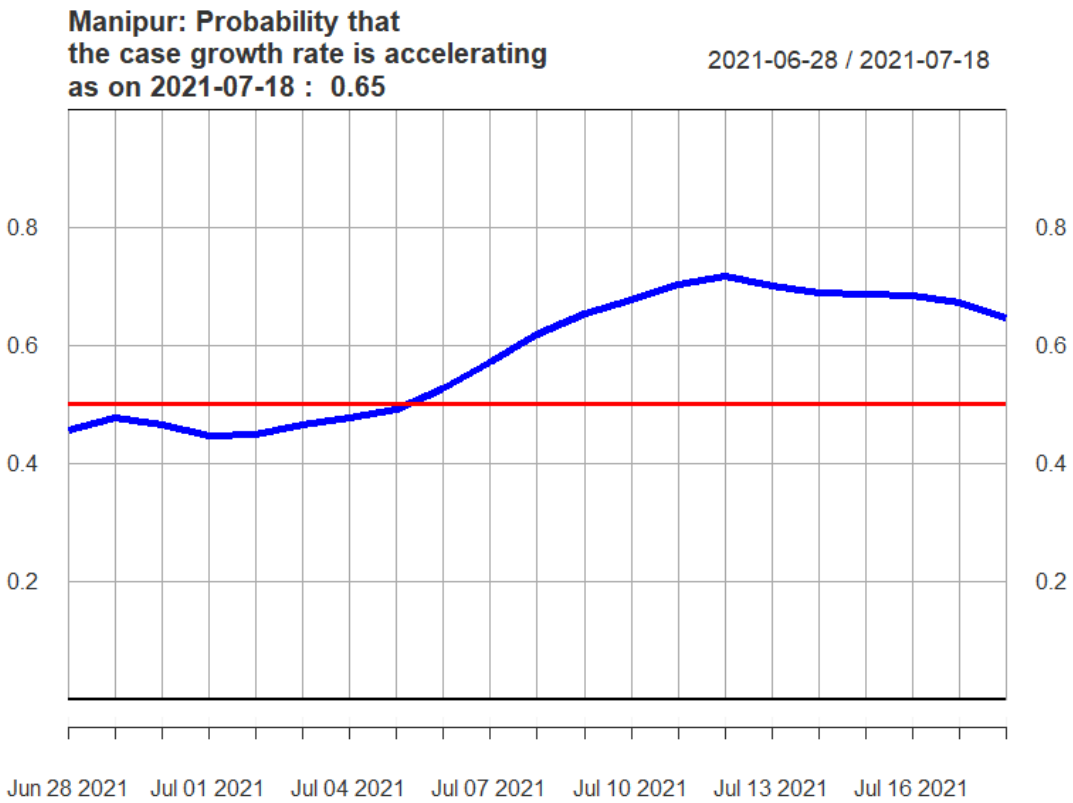

West Bengal
Data
Forecast
New cases
Forecast
Trend
3,000
2,000
1,000
New Cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

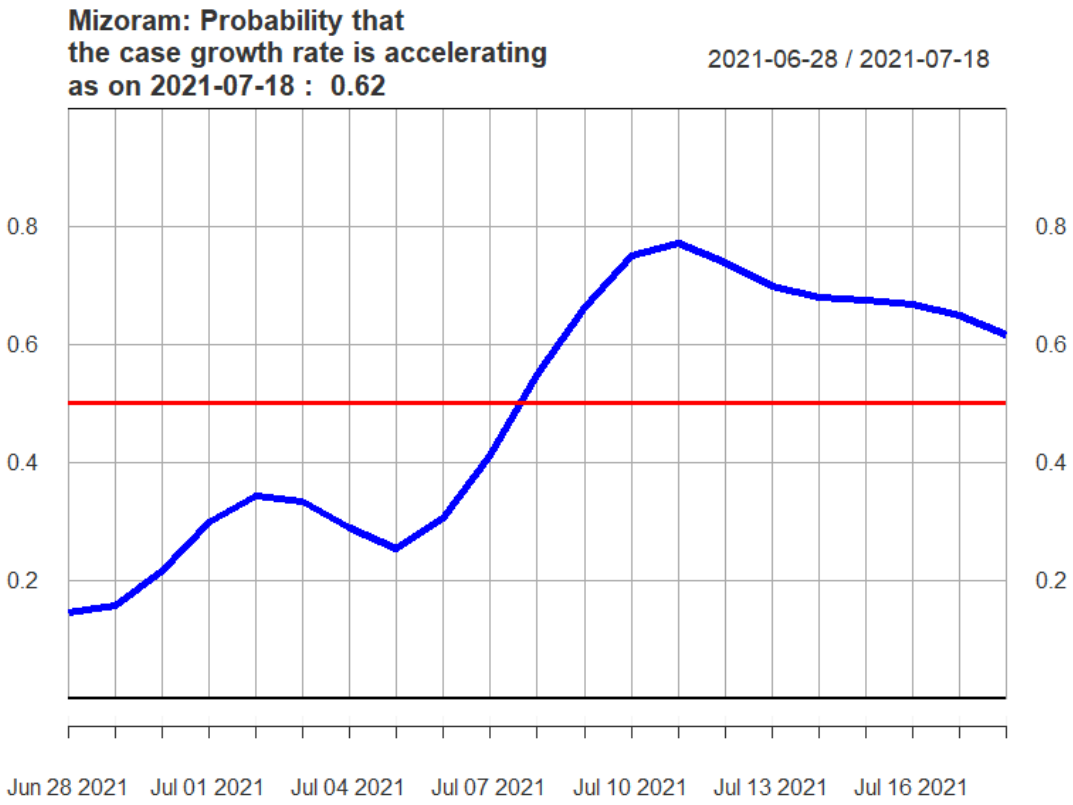

West Bengal
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
-0.100
Growth rate of daily cases
Jun 15
Jul 01
Jul 15
Aug 01
Date

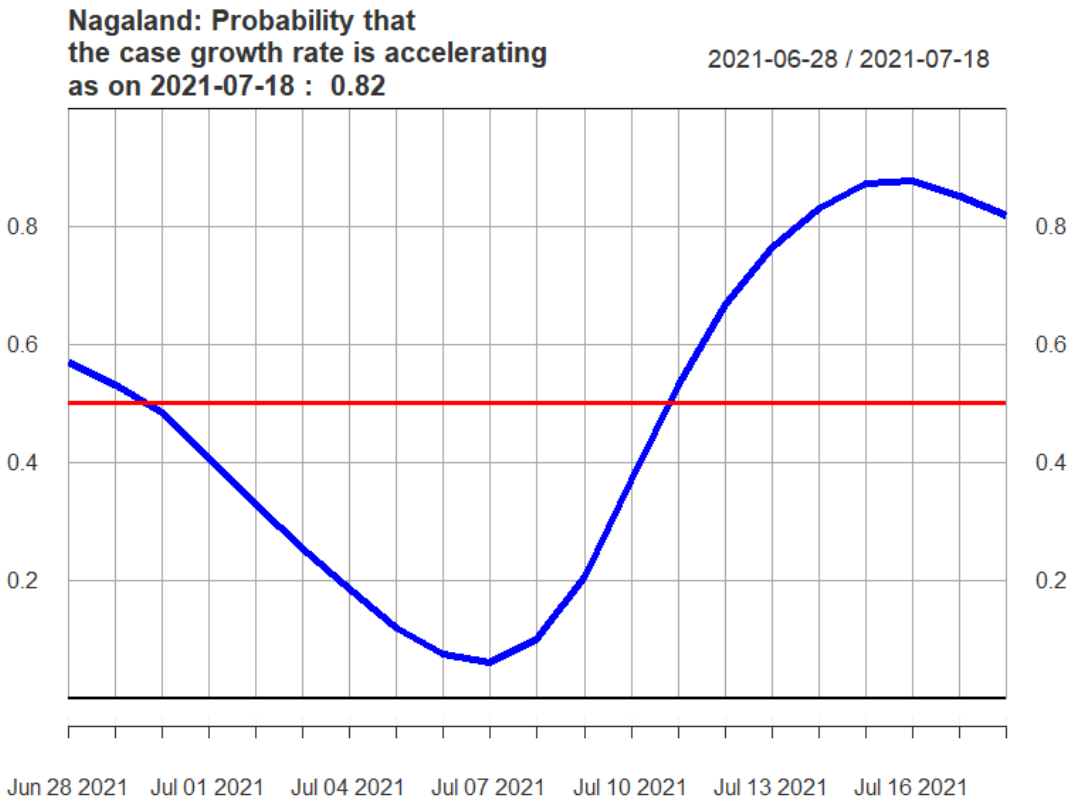
The nature of growth in new cases:

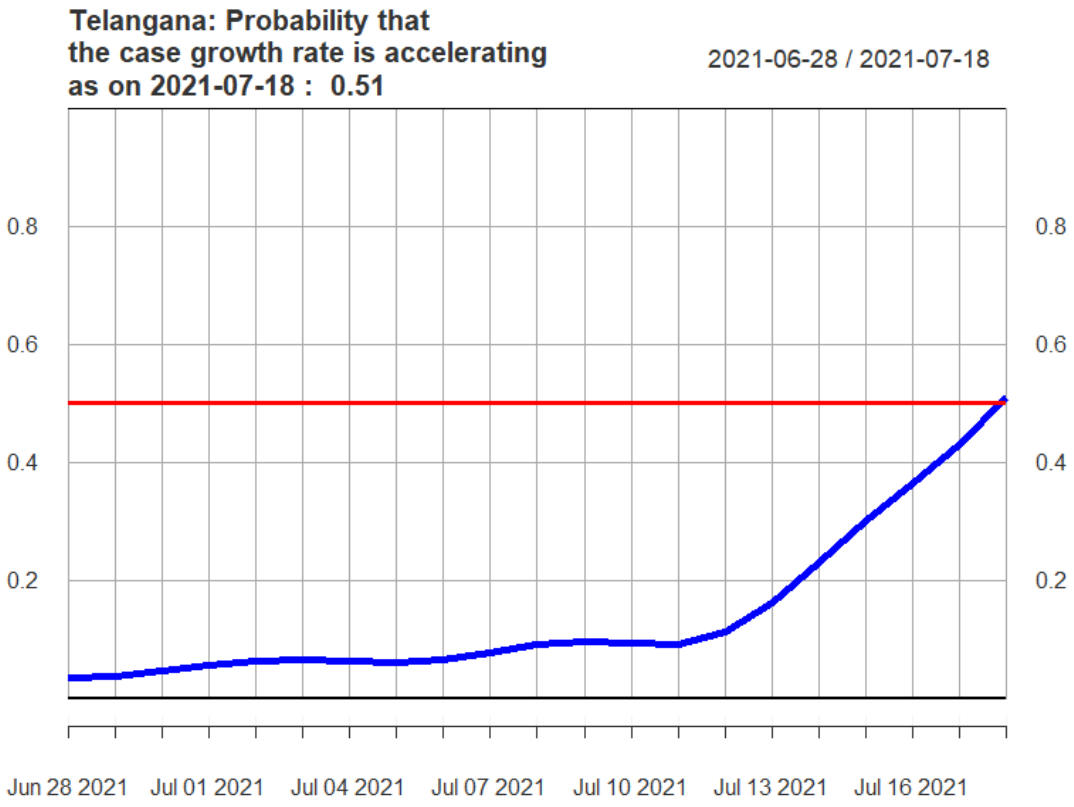
States with positive daily growth rates which are likely to be accelerating

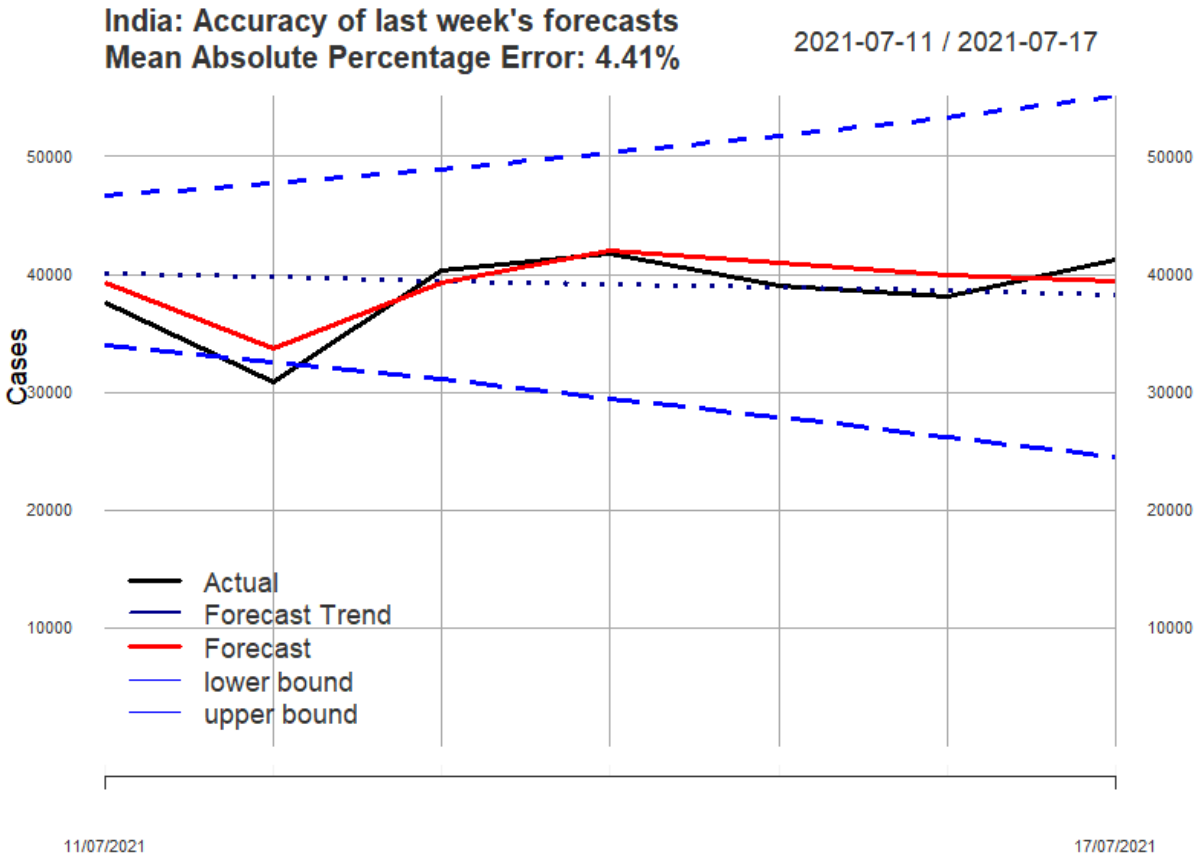





Mizoram: Probability that
the case growth rate is accelerating
as on 2021-07-18 : 0.62
2021-06-28 / 2021-07-18
0.8
0.6
0.4
0.2
Jun 28 2021
Jul 01 2021
Jul 04 2021
Jul 07 2021
Jul 10 2021
Jul 13 2021
Jul 16 2021


Nagaland: Probability that
the case growth rate is accelerating
as on 2021-07-18 : 0.82
2021-06-28 / 2021-07-18
0.8
0.6
0.4
0.2
Jun 28 2021
Jul 01 2021
Jul 04 2021
Jul 07 2021
Jul 10 2021
Jul 13 2021
Jul 16 2021


Telangana: Probability that
the case growth rate is accelerating
as on 2021-07-18 : 0.51
2021-06-28 / 2021-07-18
0.8
0.6
0.4
0.2
Jun 28 2021
Jul 01 2021
Jul 04 2021
Jul 07 2021
Jul 10 2021
Jul 13 2021
Jul 16 2021


India: Accuracy of last week's forecasts
Mean Absolute Percentage Error: 4.41%
2021-07-11 / 2021-07-17
Cases
50000
40000
30000
20000
10000
Actual
Forecast Trend
Forecast
lower bound
upper bound
11/07/2021
17/07/2021

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: is assessed using mean absolute percentage error of the forecasts of cases over the past week. Forecast accuracy will in general be lower for the smaller states / union territories. It is important to pay attention to the confidence intervals around the forecasts. The coverage of the confidence intervals 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*-estimates are based on the nowcast of the growth rate; the 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%.

Probability The probability that the growth of new cases is increasing at an increasing rate is extracted from the statistical model. The pandemic phase is of extreme concern when this probability exceeds 0.5.

Note: The accuracy of forecasts rely on the quality of the published data. Further, changes in government pandemic policies and in transmission relevant social behaviour may lead realised numbers to deviate from forecasts.

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

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