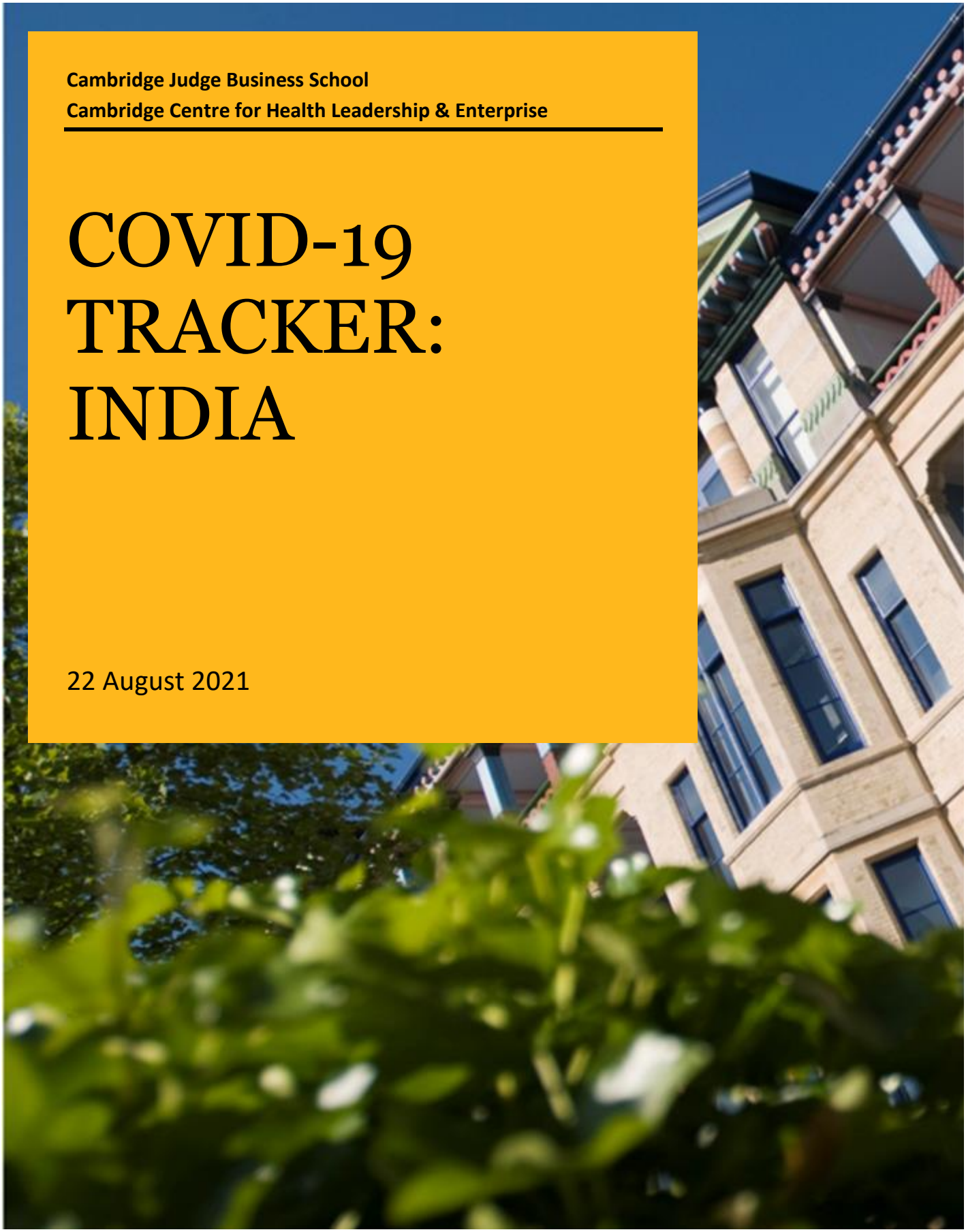
Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

22 August 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 effective reproduction number (R_t) for India as a whole has dropped further over the past week, to 0.90. The trend value of the growth rate of new cases is lower at -2.5% as of now. The trend value of reported cases is likely fall below 21,000 per day by 5th September.

At present the epidemic is settling concurrently with very few exceptions across states: reported cases are expected to stay relatively steady in Haryana, Jammu and Kashmir and Mizoram, but accelerate in Goa (page 40).

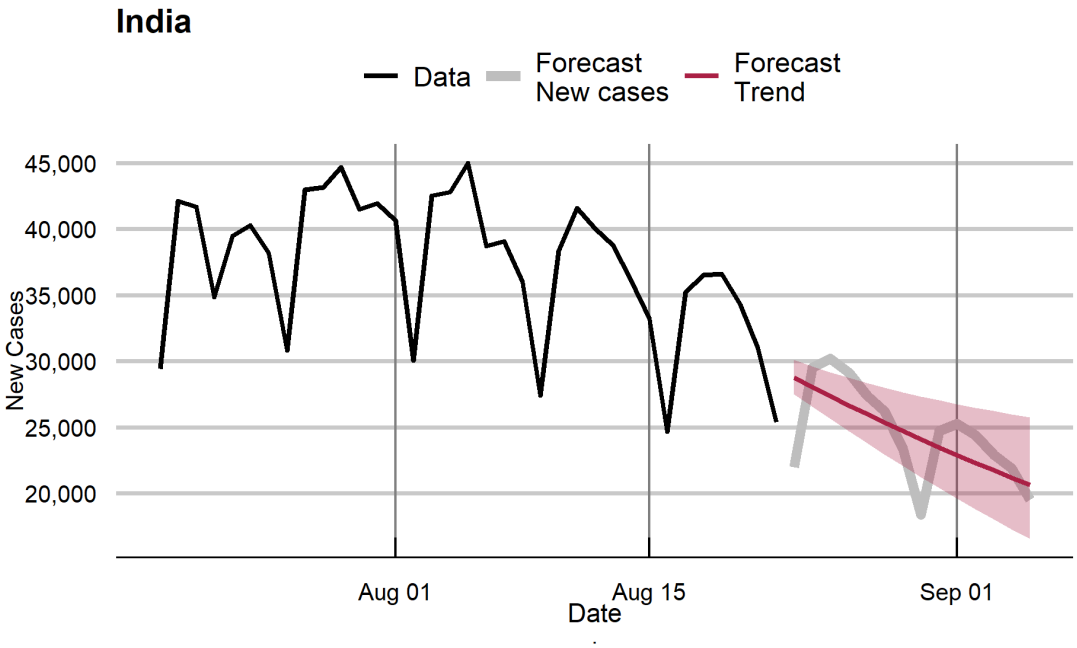
The current settling of the epidemic in India can be attributed for the most part to a substantial proportion of the population acquiring partial immunity, due to prior infection from the Delta or earlier variants, combined with vaccinal immunity of the small vaccinated proportion, as well as local restrictions. It is important to note that immunity of either type is known to be imperfect and transient with respect to the Delta variant. The waning of the immune response is liable to prepare the ground for successive outbreaks in the foreseeable future as the susceptible population grows and then declines recurrently. This is broadly consistent with the oscillating patterns in the growth rates of reported cases in most states. Boosting the vaccination rate, combined with prompt containment when necessary can reduce the risk of acute surges, while global efforts to develop more effective vaccines continue.

Mean absolute percentage error of the forecasts of daily cases in India given in the August 15 tracker, for the period August 16 to 22, was 6.96%. Changes in government pandemic policies and in transmission relevant social behaviour may cause realised numbers to depart from forecasts.

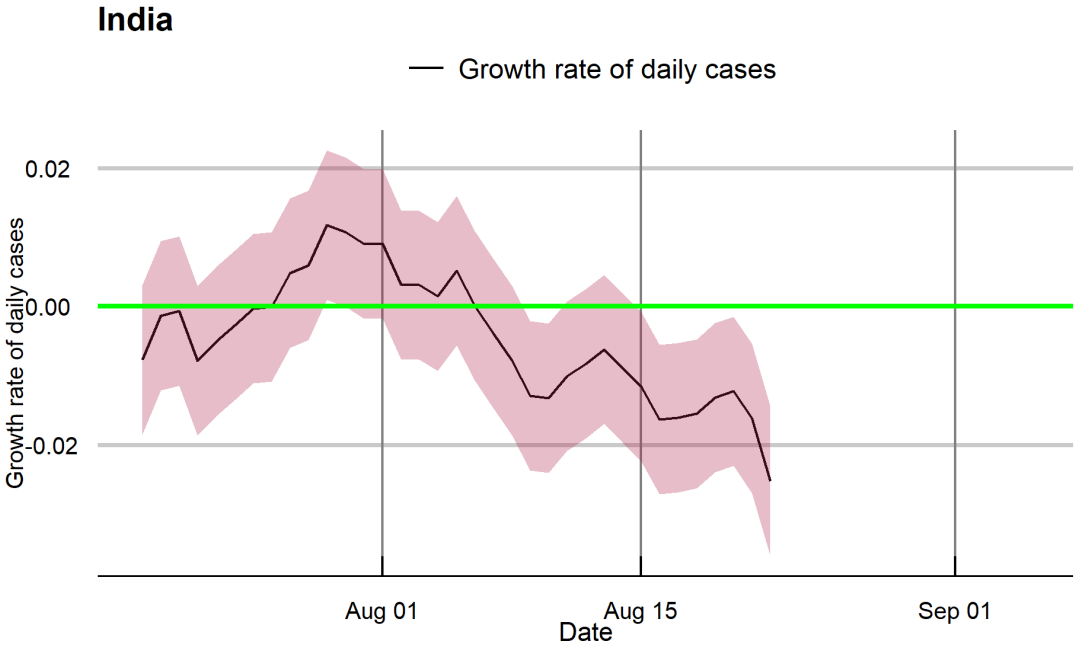
[1] CJBS COVID-19 Tracker for India can be accessed at: www.jbs.cam.ac.uk/covid-india
The companion spreadsheet contains all the estimates and forecasts.

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

Daily Covid-19 cases in India: Forecast

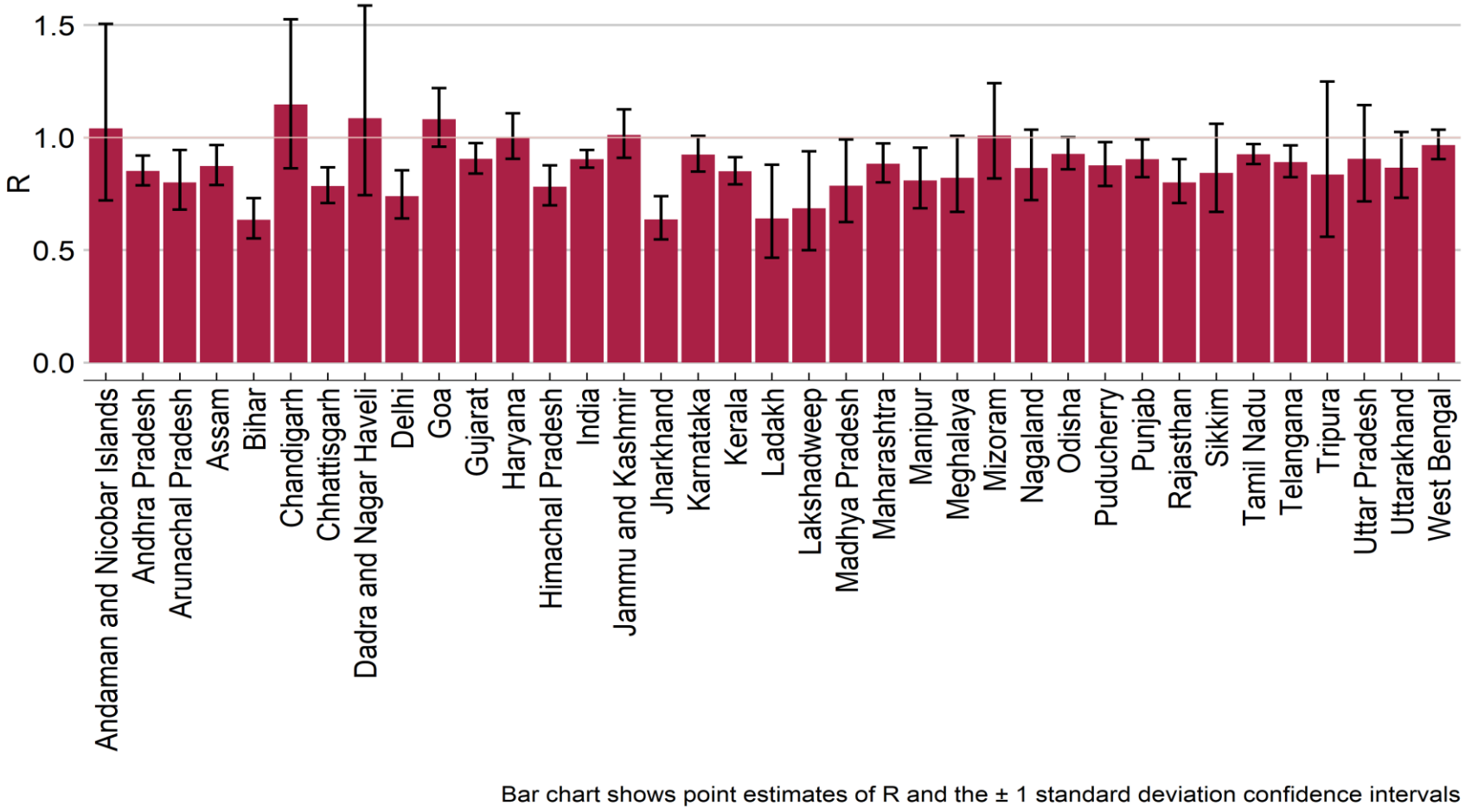


Forecasts of daily new cases for the period 23rd August to 5th September 2021, based on data till 22nd August 2021. The trend value of new COVID-19 cases is likely to be just under 21,000 per day by 5th September 2021.



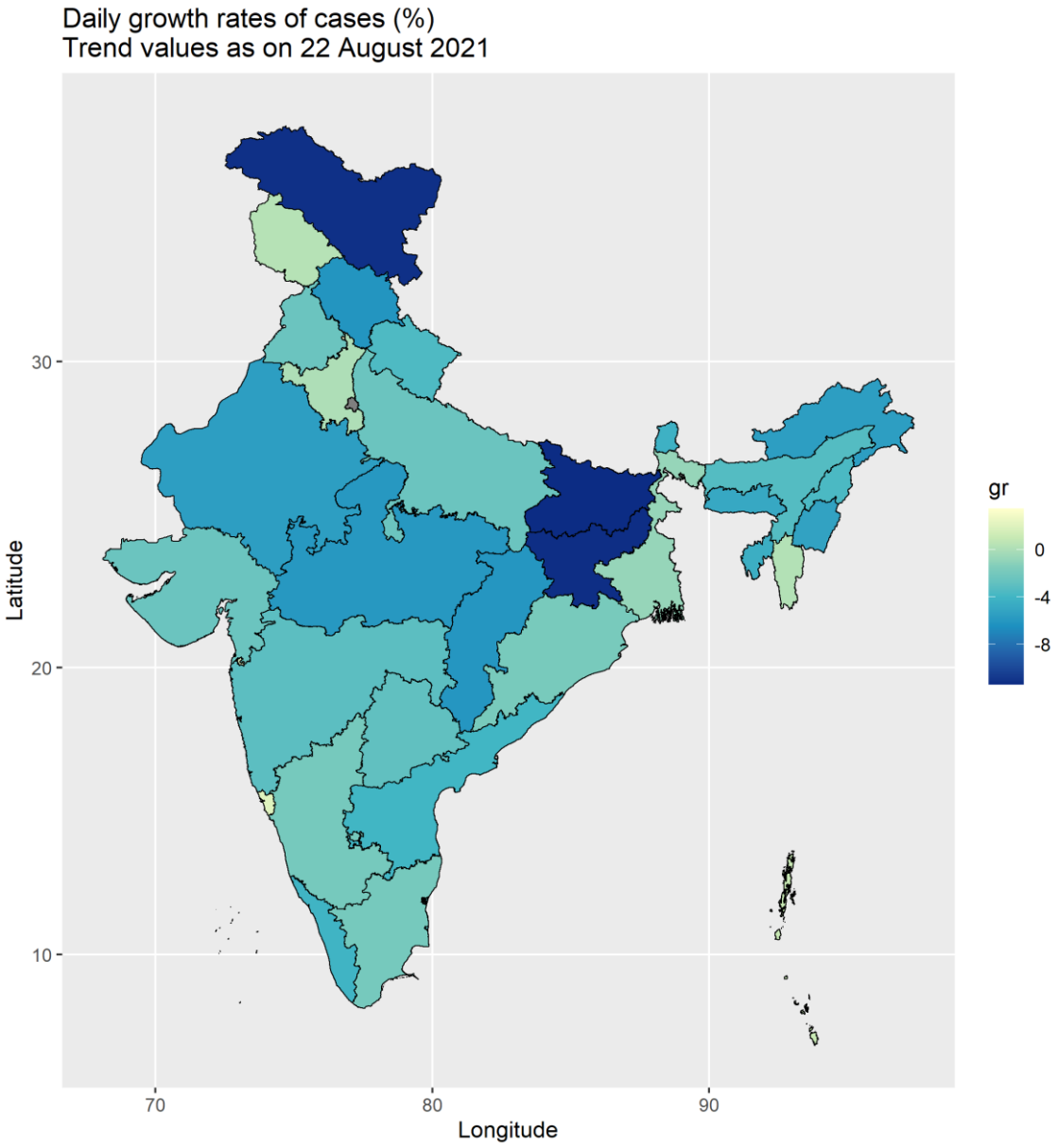
The filtered trend in the growth rate of daily new cases was -2.5% as on 22nd August 2021.

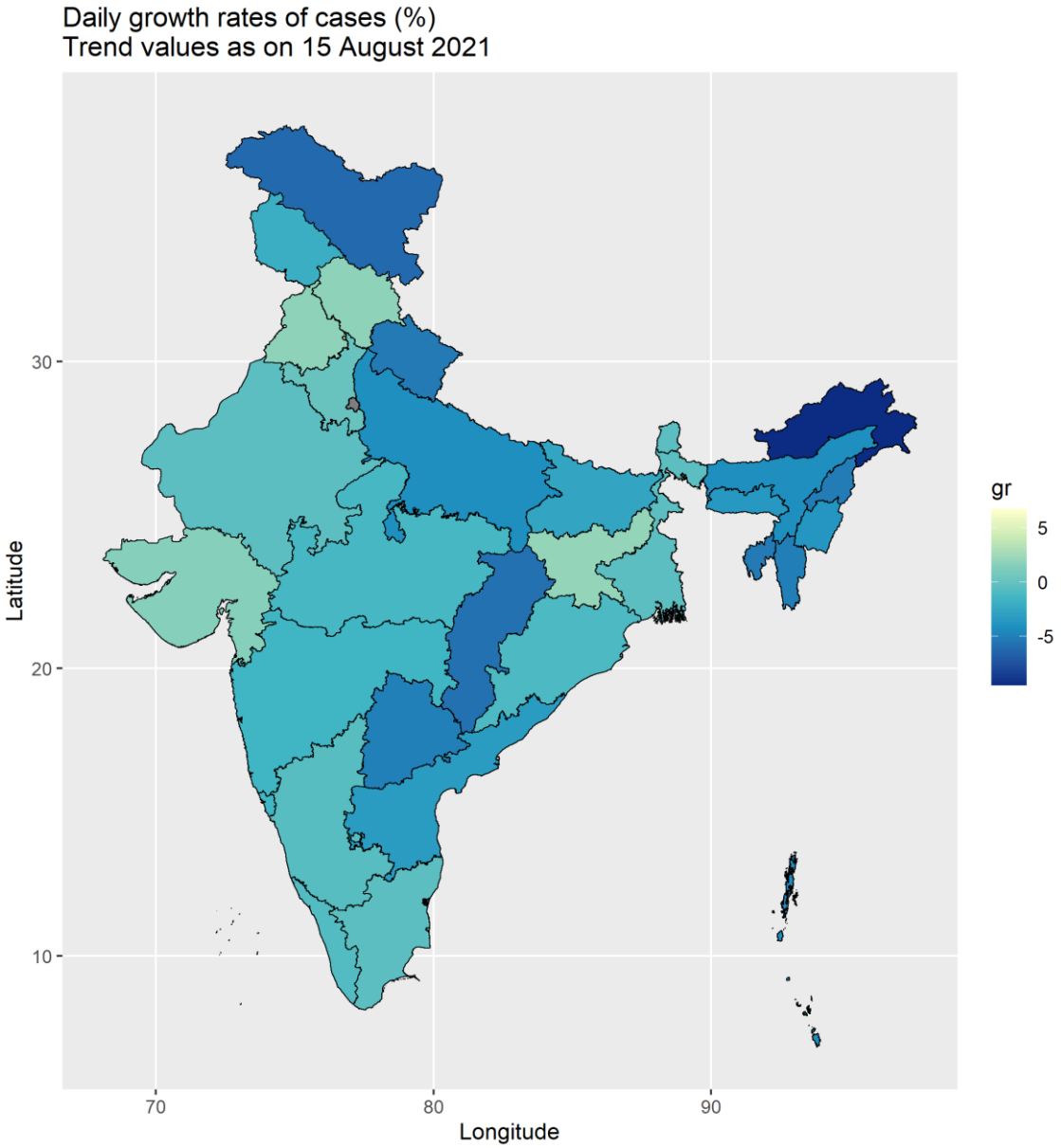
R_t: 22 August 2021

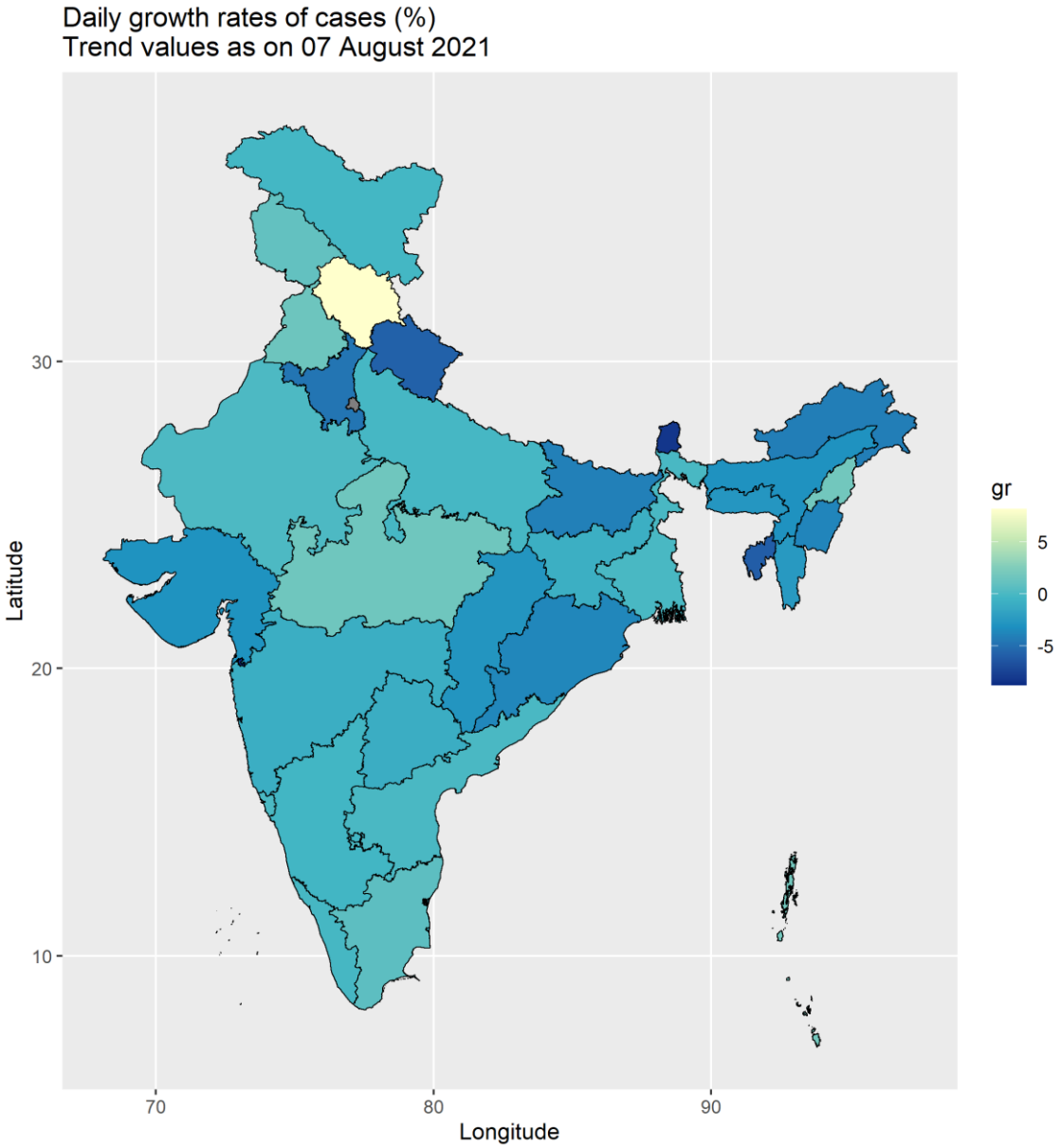


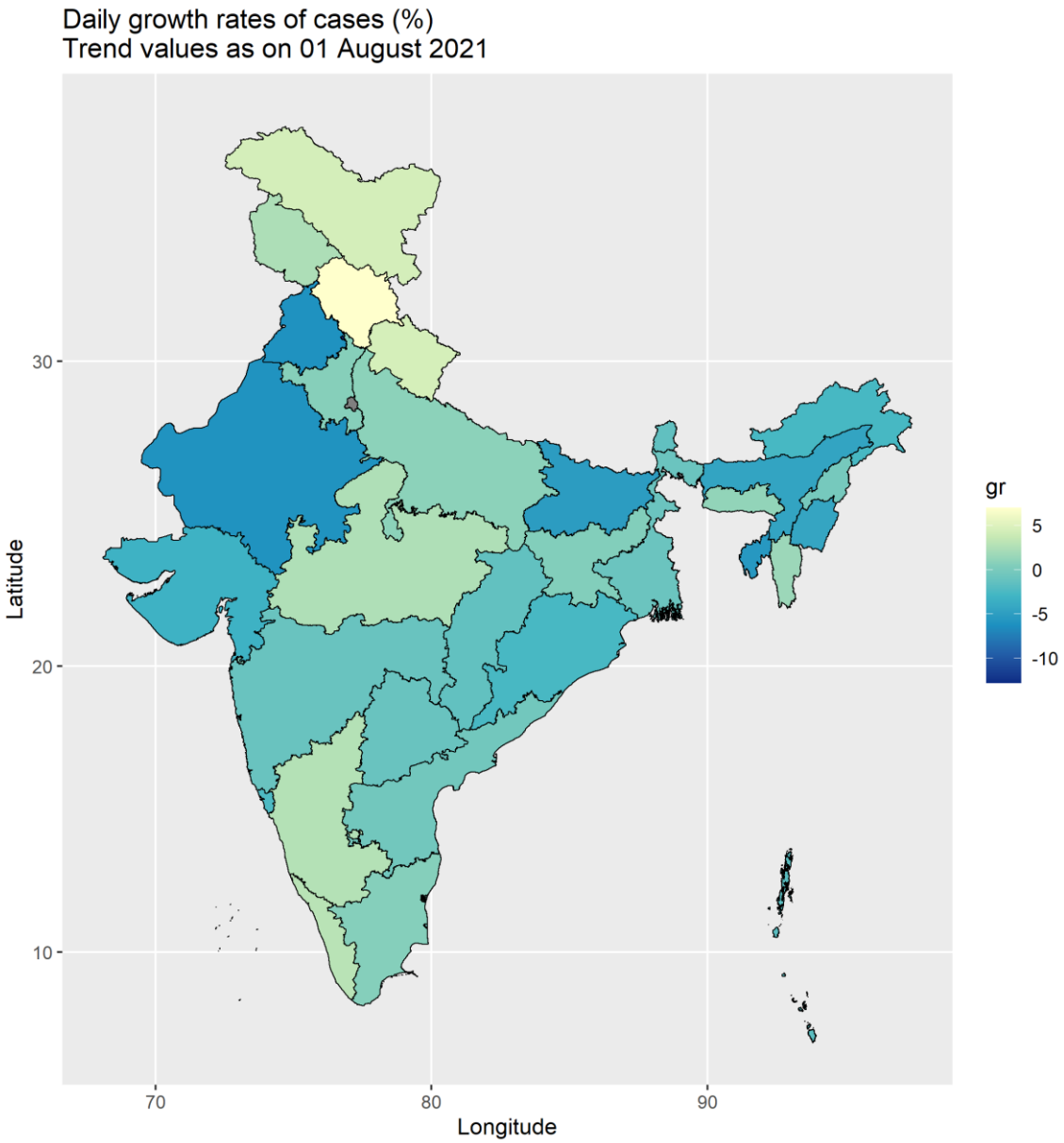
Bar chart shows point estimates of R and the ± 1 standard deviation confidence intervals

Note: Data anomaly for Chandigarh, and small daily numbers (less than 30) currently for Andaman and Nicobar Islands, Bihar, Chhattisgarh, Dadra and Nagar Haveli, Delhi, Gujarat, Haryana, Jharkhand, Ladakh, Lakshadweep, Madhya Pradesh, Rajasthan, Uttar Pradesh and Uttarakhand make the forecasts and estimates less precise.

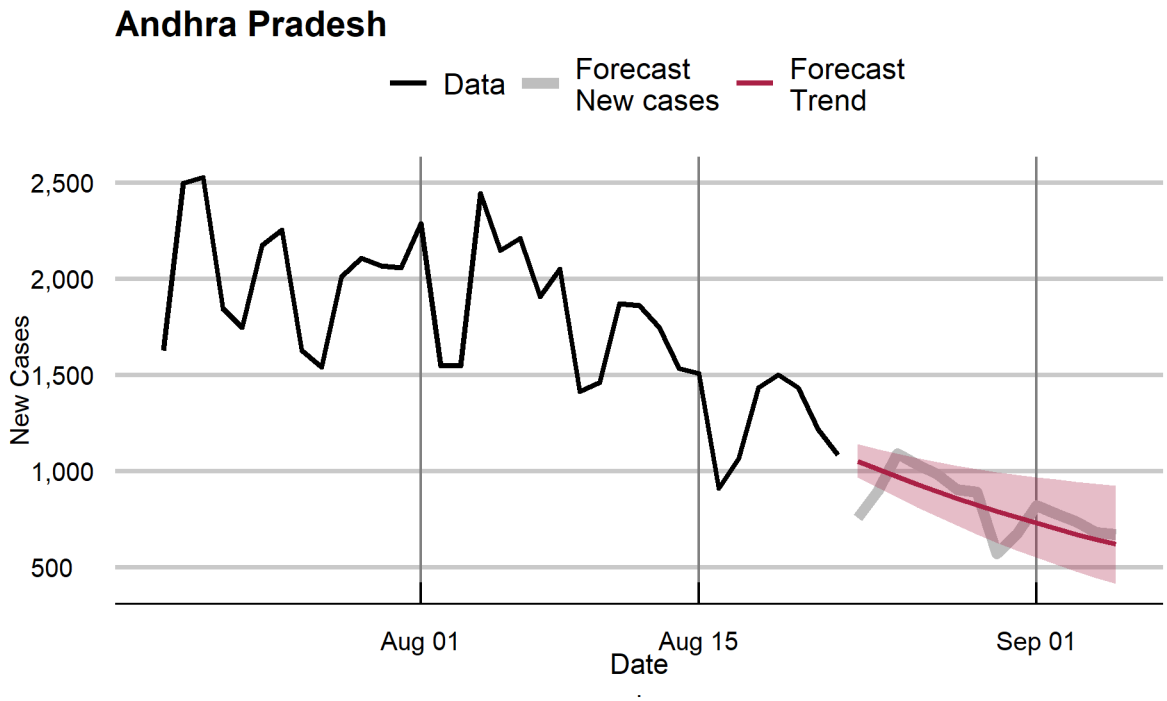

Daily growth rates of cases (%)
Trend values as on 22 August 2021
Latitude
30
20
10
70
80
90
Longitude
gr
0
-4
-8

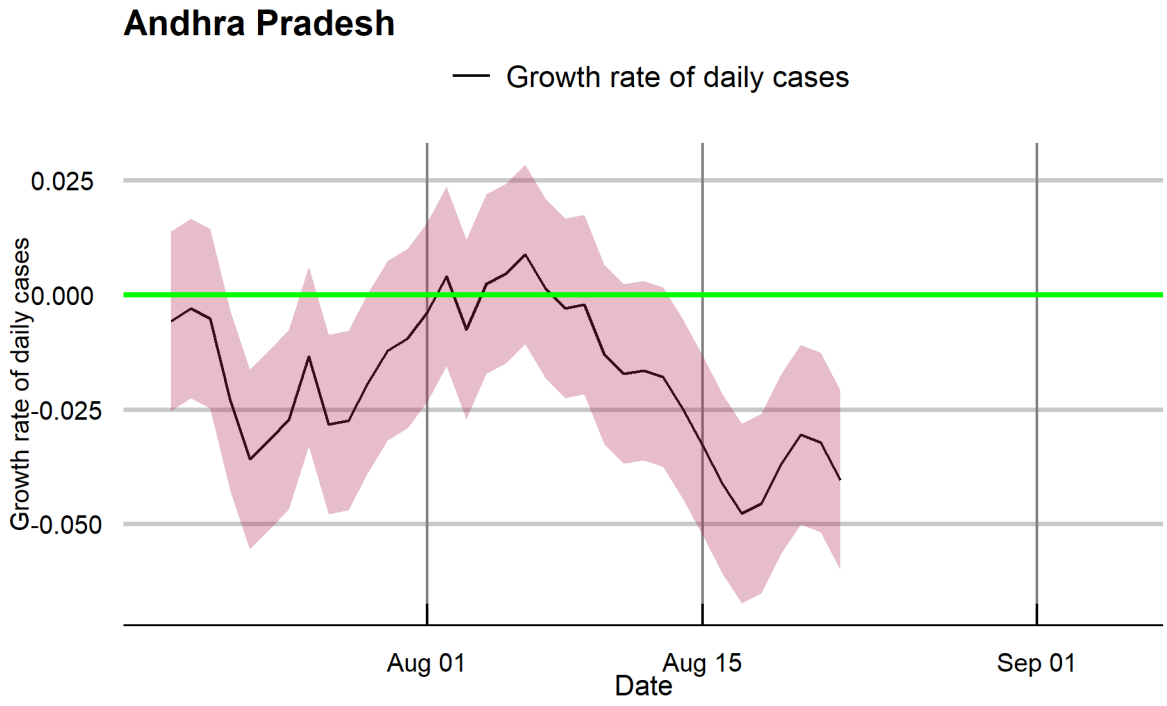

Daily growth rates of cases (%)
Trend values as on 15 August 2021
Latitude
30
20
10
70
80
90
Longitude
gr
5
0
-5

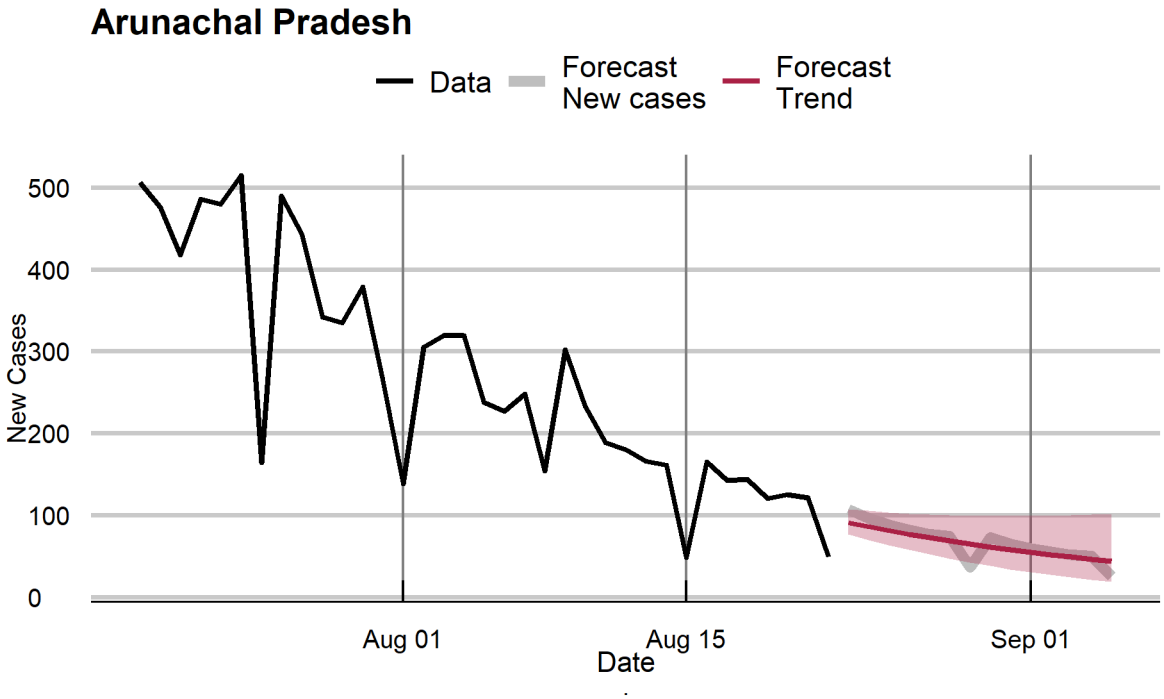

Daily growth rates of cases (%)
Trend values as on 07 August 2021
Latitude
30
20
10
70
80
90
Longitude
gr
5
0
-5

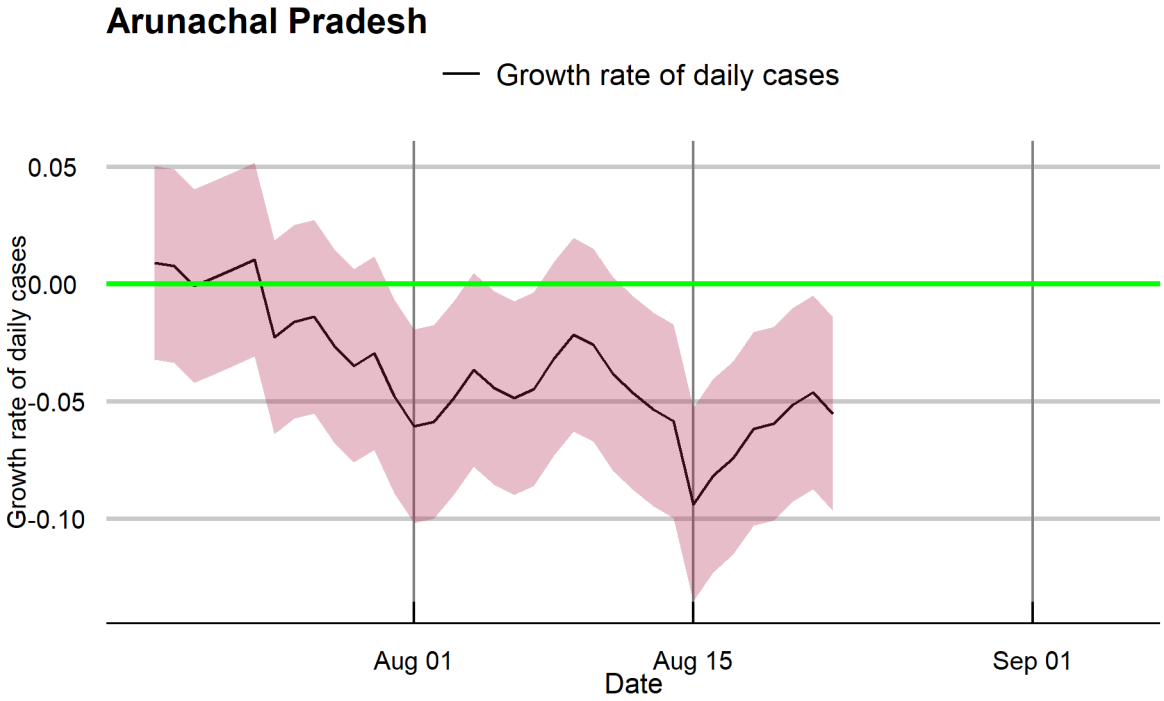

Daily growth rates of cases (%)
Trend values as on 01 August 2021
Latitude
30
20
10
70
80
90
Longitude
gr
5
0
-5
-10

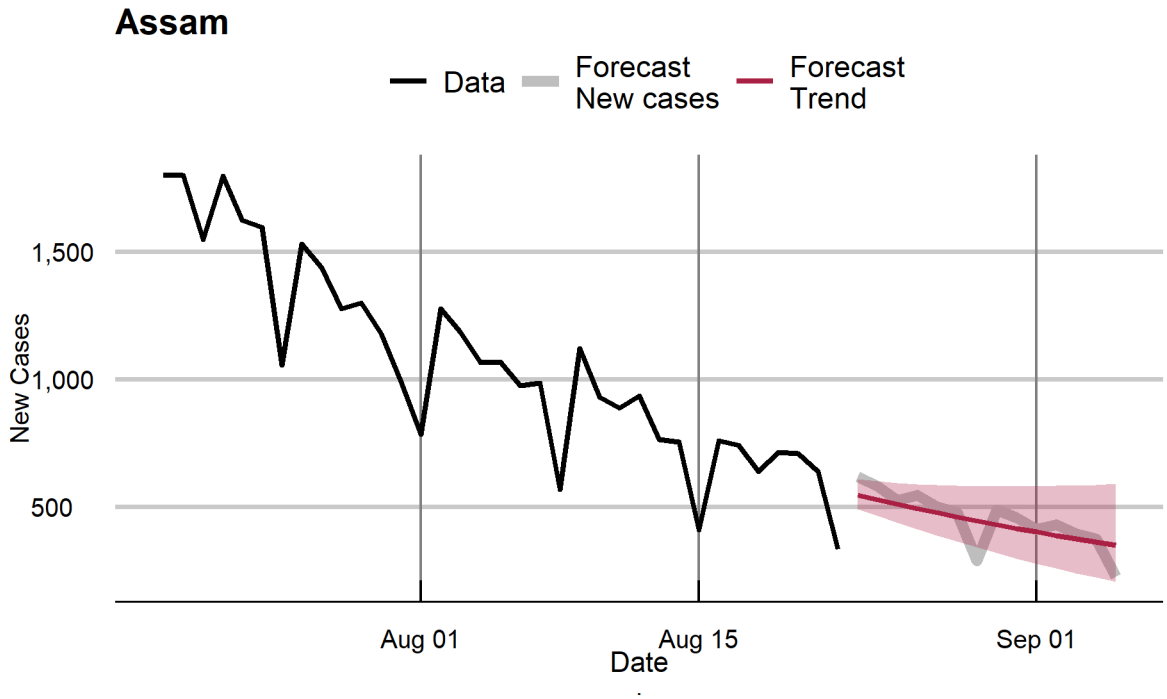
Case forecasts and growth rates: States and Union territories

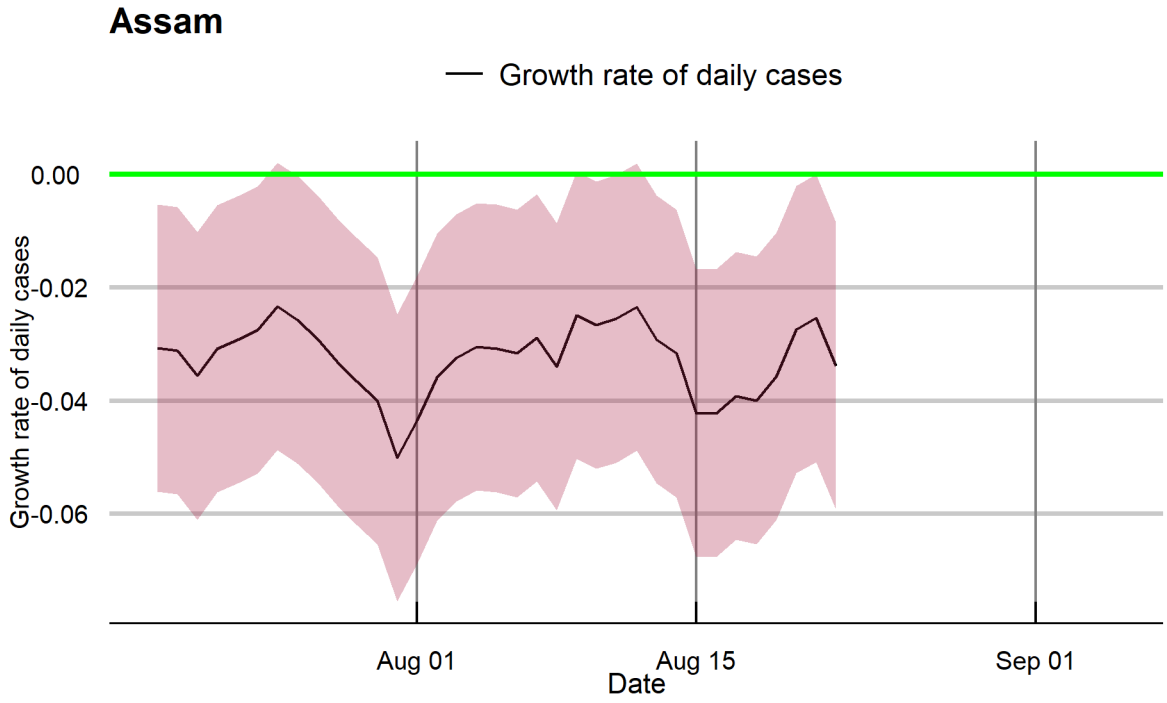


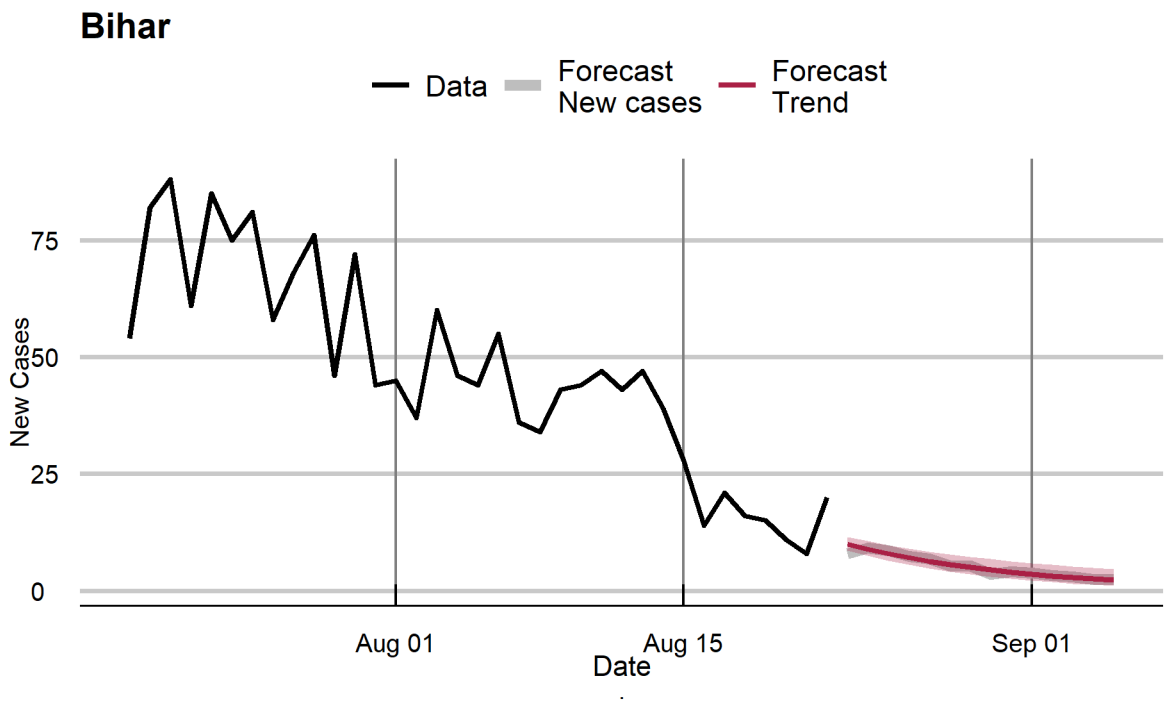


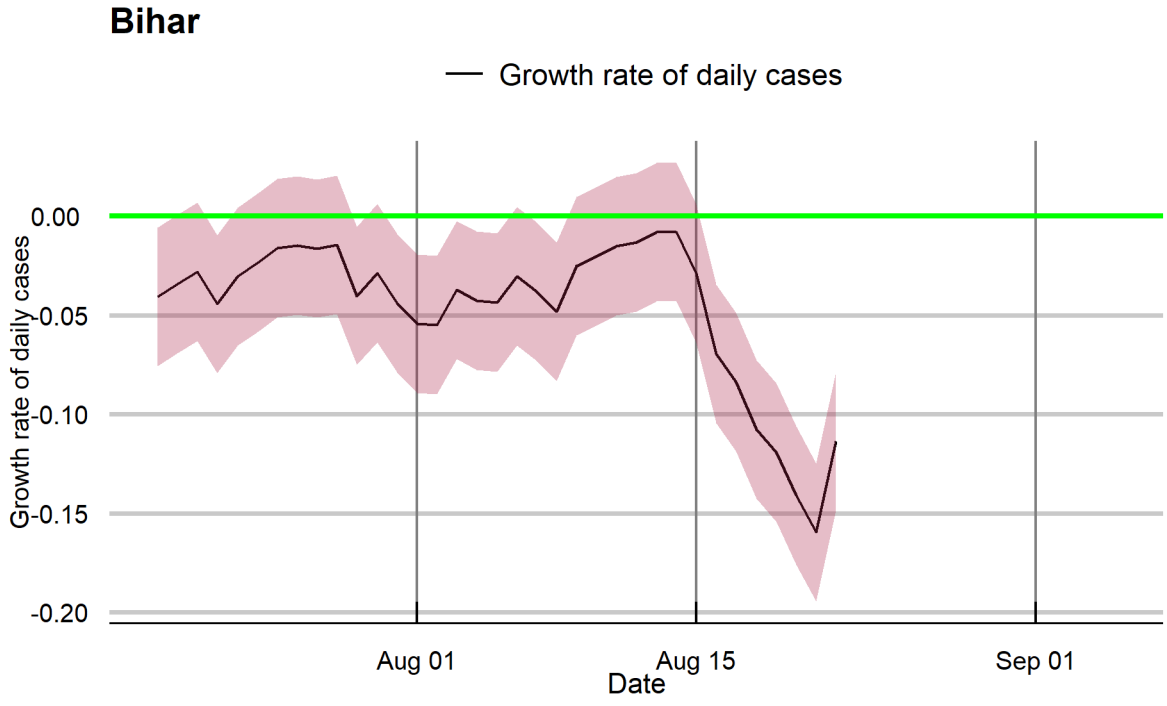

Arunachal Pradesh
Data
Forecast
New cases
Forecast
Trend
500
400
300
200
100
0
New Cases
Aug 01
Aug 15
Sep 01
Date

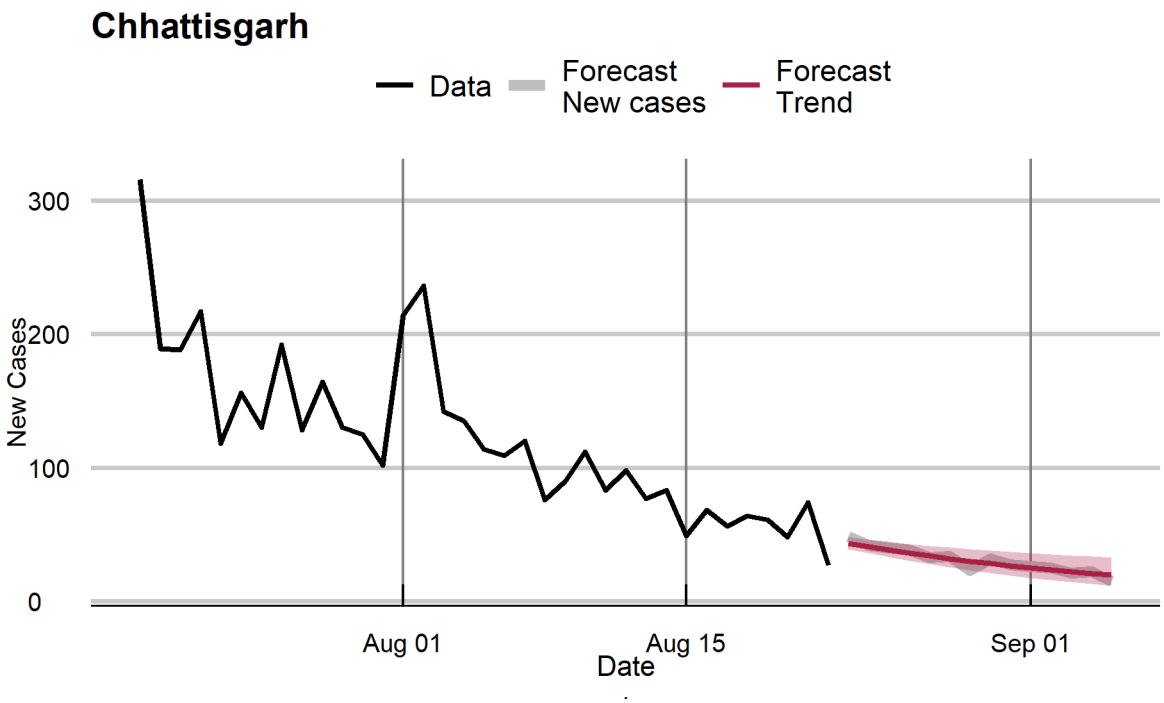

Arunachal Pradesh
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

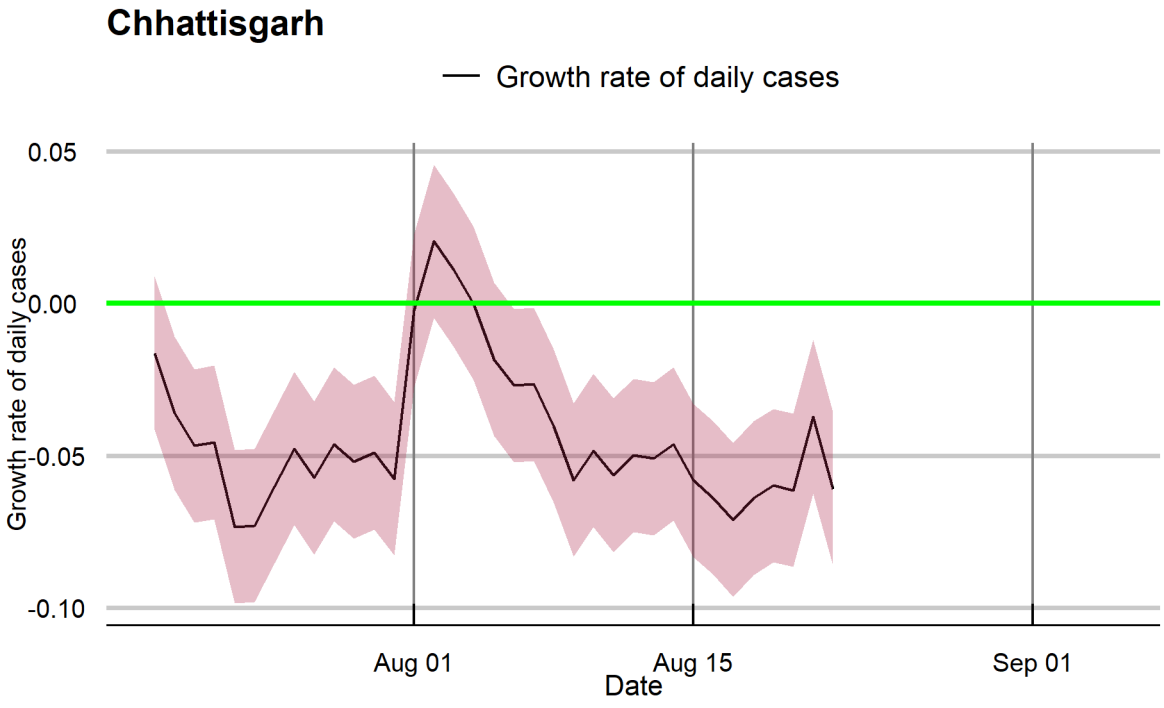

Assam
Data
Forecast
New cases
Forecast
Trend
1,500
1,000
500
New Cases
Aug 01
Aug 15
Sep 01
Date

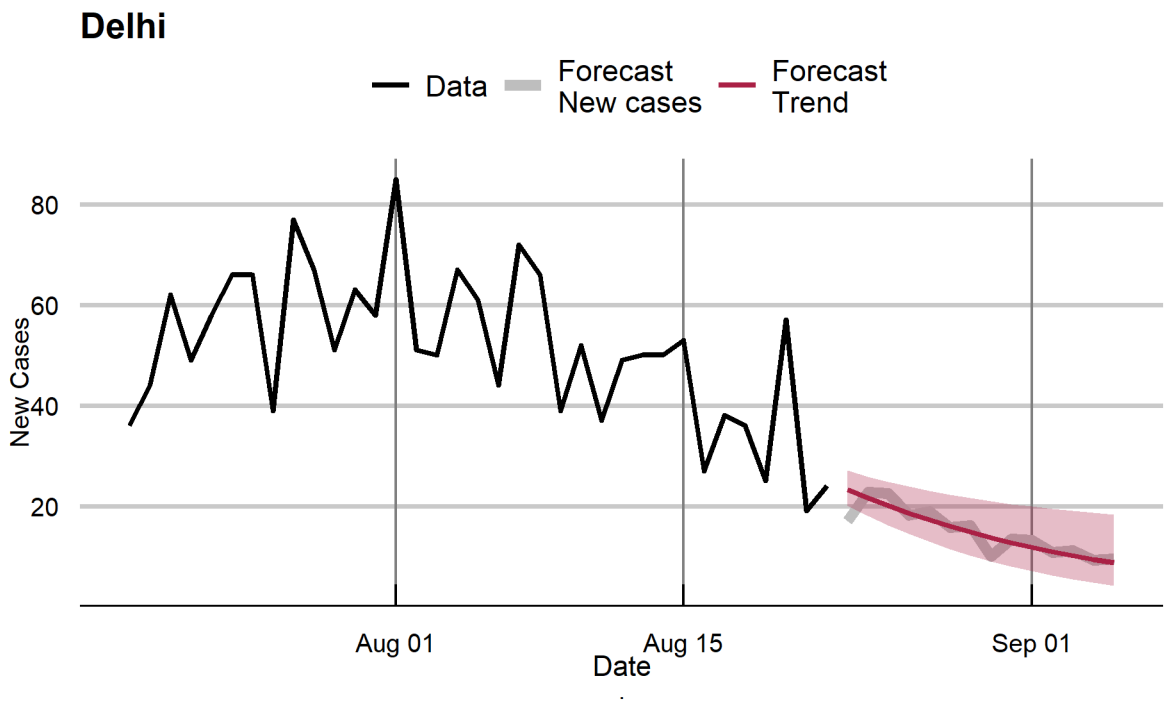

Assam
Growth rate of daily cases
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

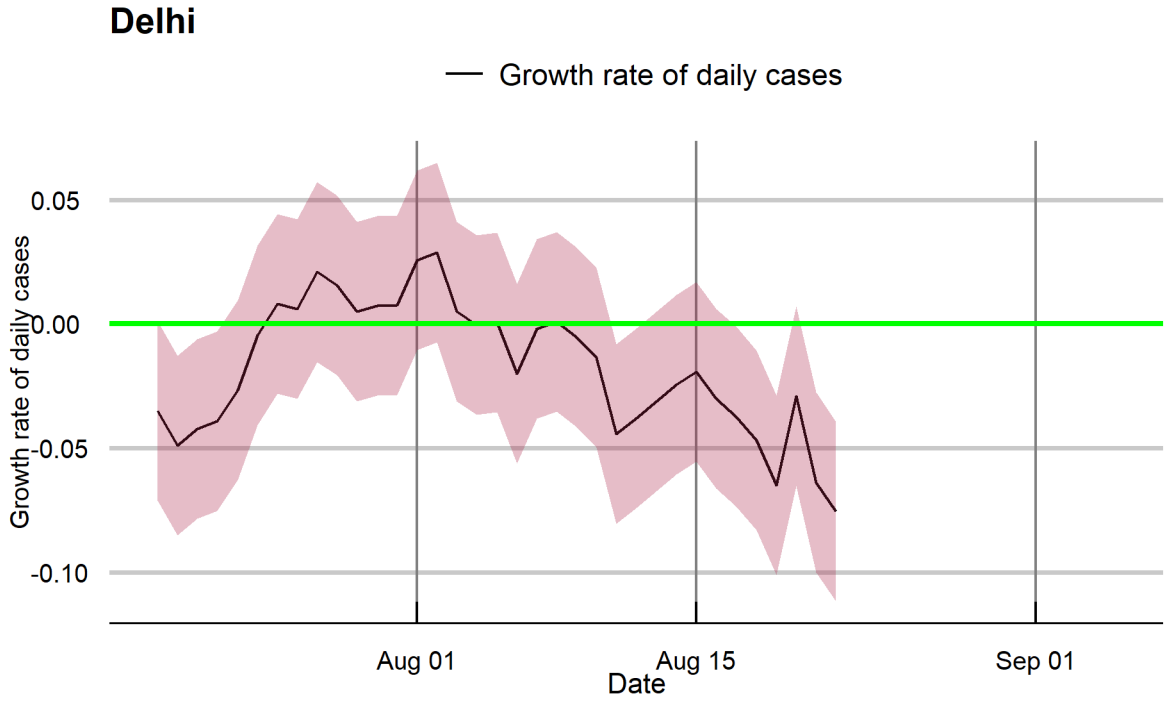

Bihar
Data
Forecast
New cases
Forecast
Trend
New Cases
75
50
25
0
Aug 01
Aug 15
Sep 01
Date

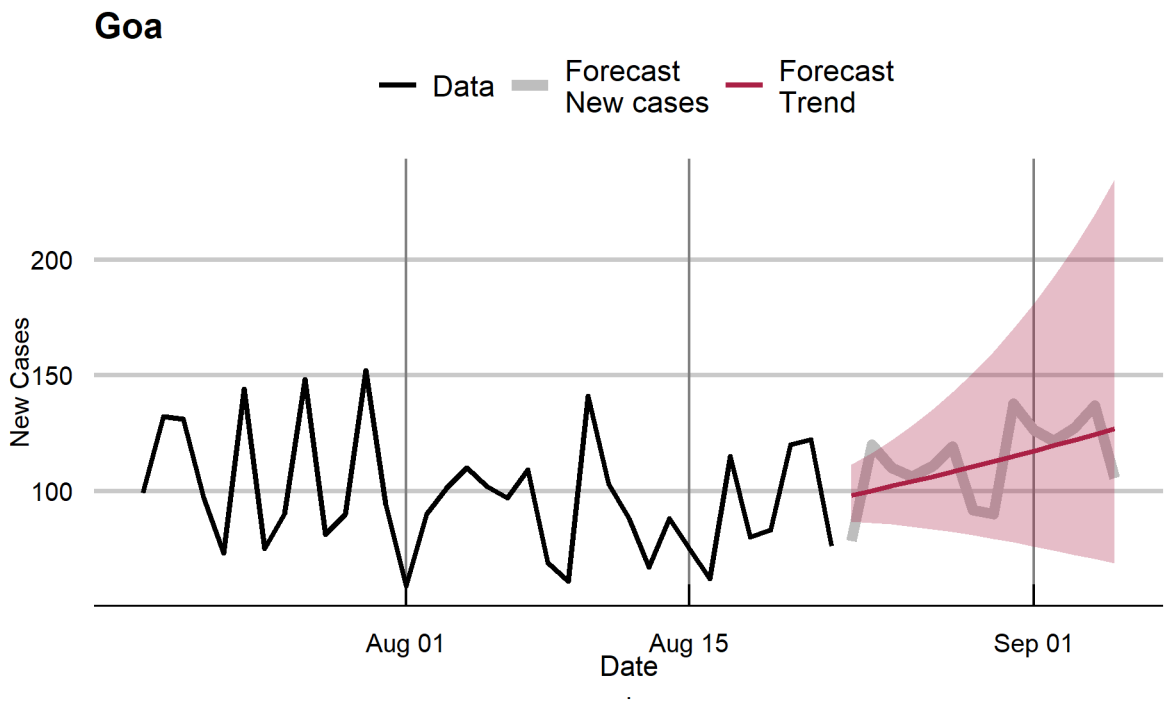

Bihar
Growth rate of daily cases
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
-0.20
Aug 01
Aug 15
Sep 01
Date

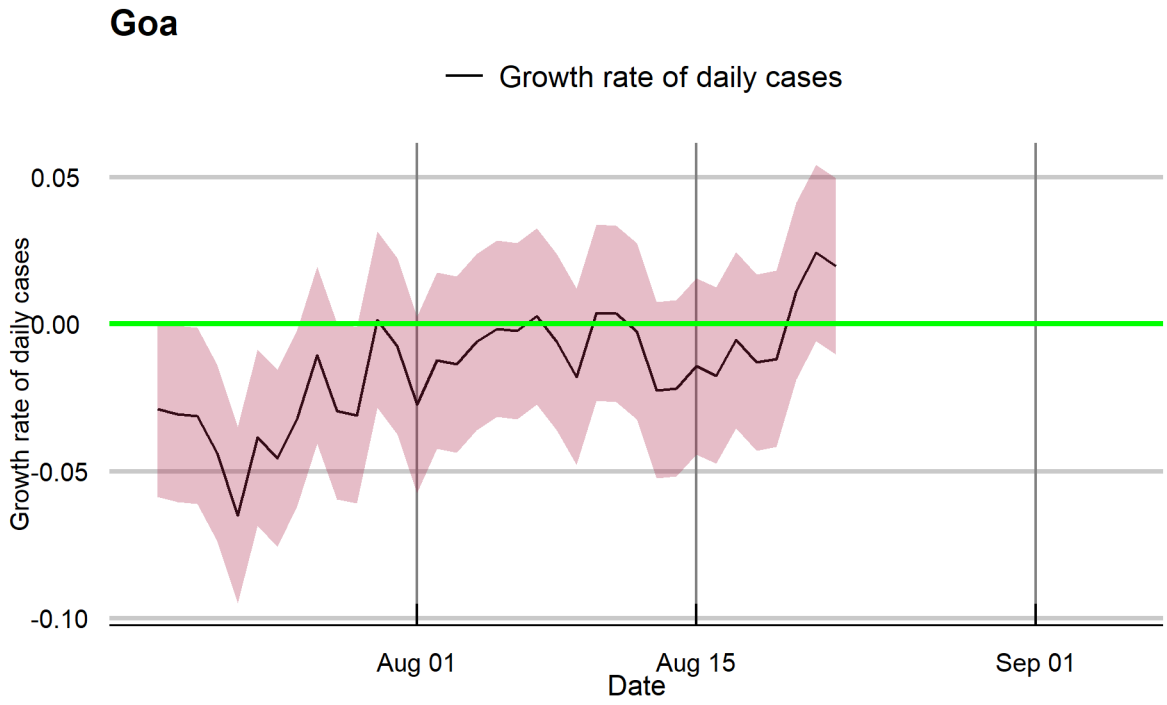

Chhattisgarh
Data
Forecast
New cases
Forecast
Trend
300
200
100
0
New Cases
Aug 01
Aug 15
Sep 01
Date

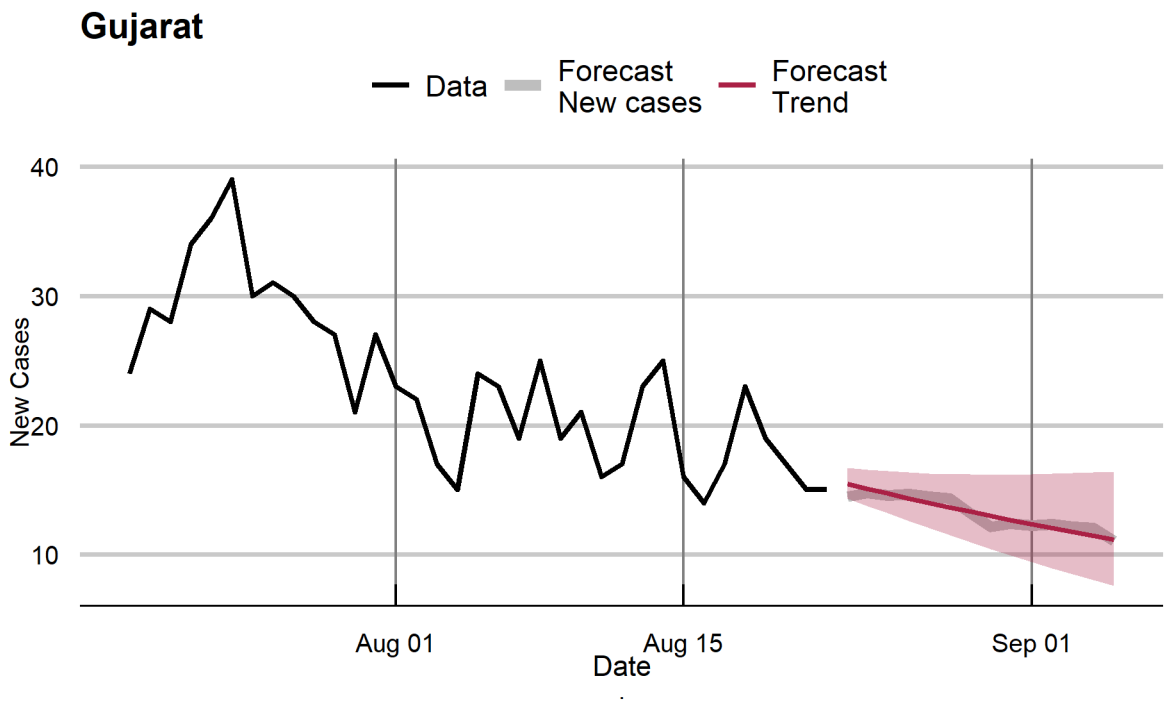

Chhattisgarh
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

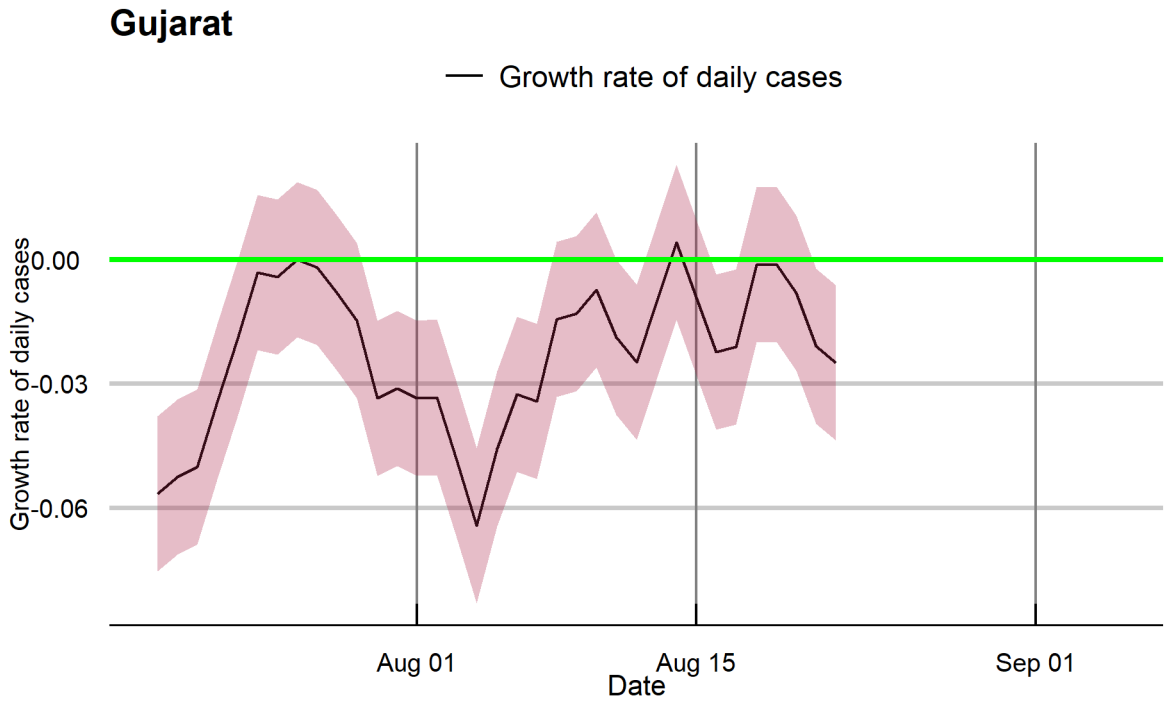

Delhi
Data
Forecast
New cases
Forecast
Trend
80
60
40
20
New Cases
Aug 01
Aug 15
Sep 01
Date

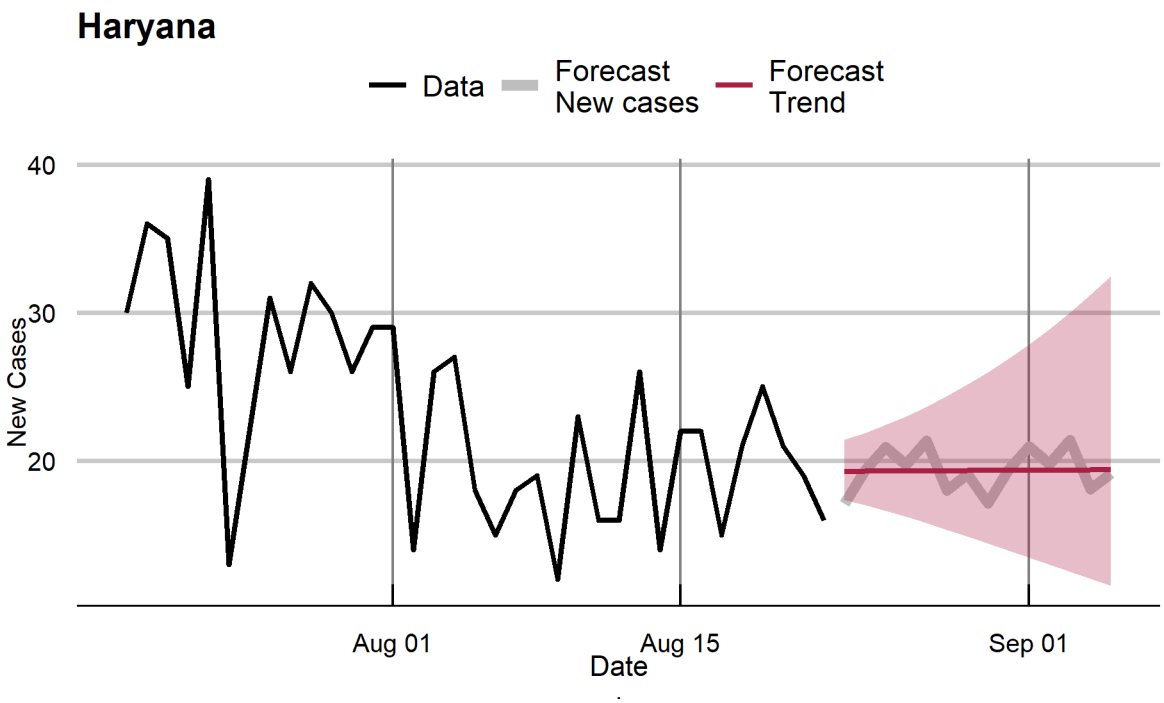

Delhi
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

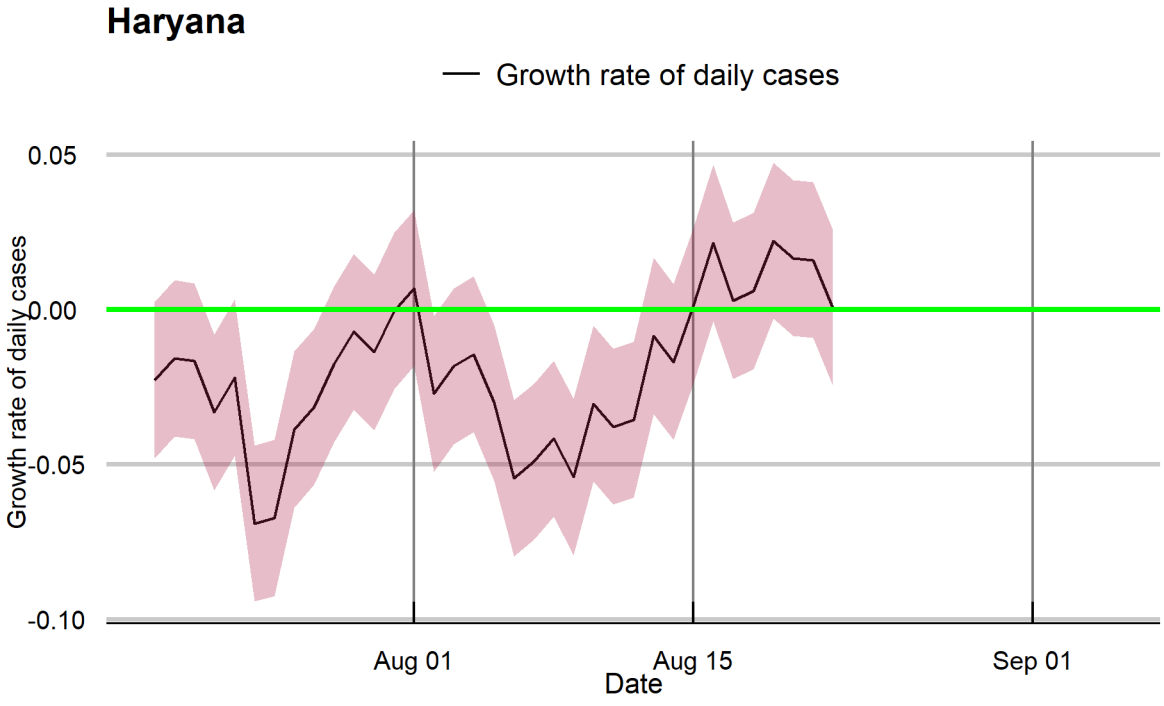

Goa
Data
Forecast
New cases
Forecast
Trend
200
150
100
New Cases
Aug 01
Aug 15
Sep 01
Date

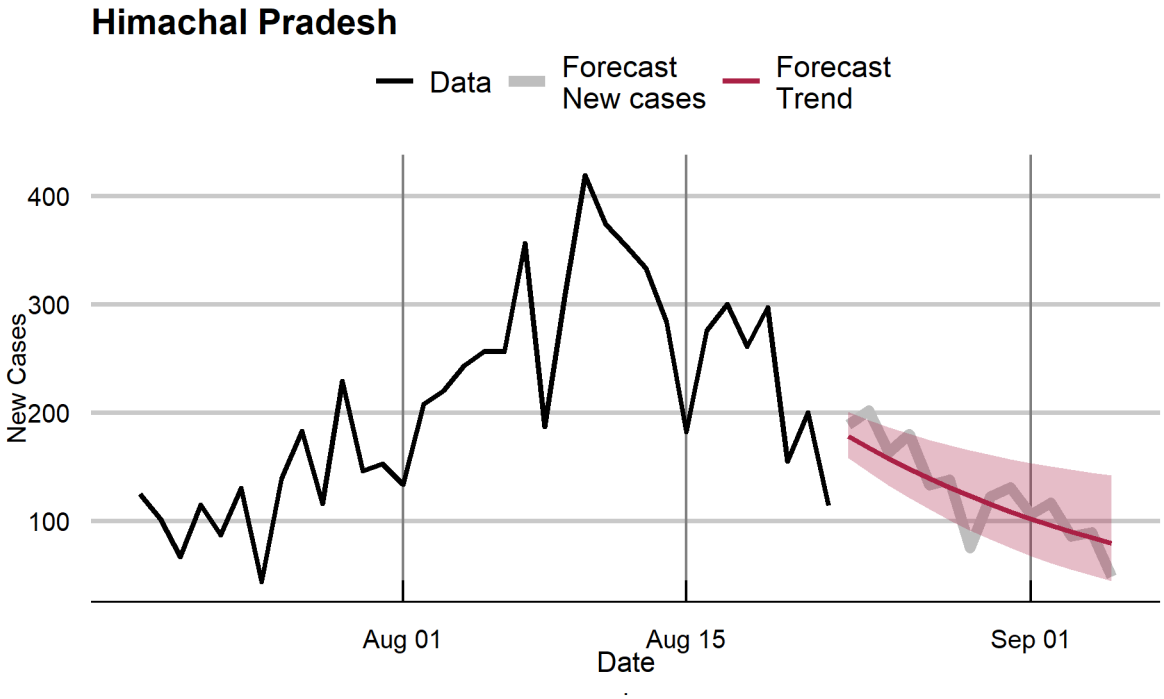

Goa
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

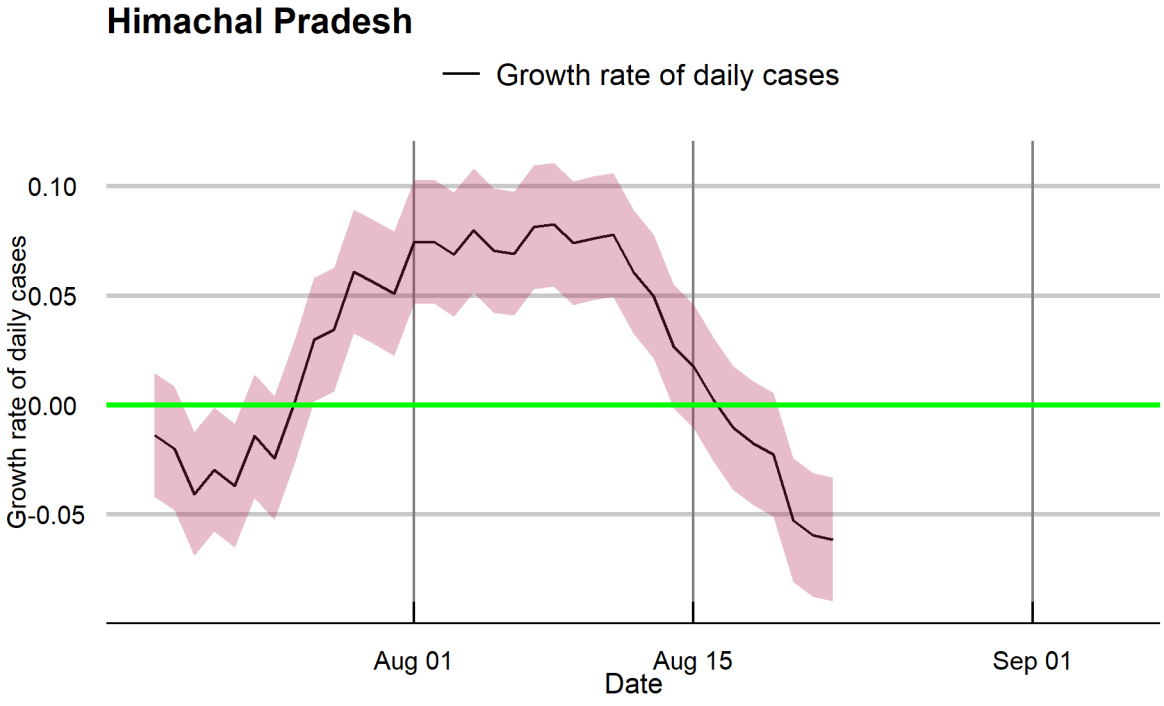

Gujarat
Data
Forecast
New cases
Forecast
Trend
40
30
20
10
New Cases
Aug 01
Aug 15
Sep 01
Date

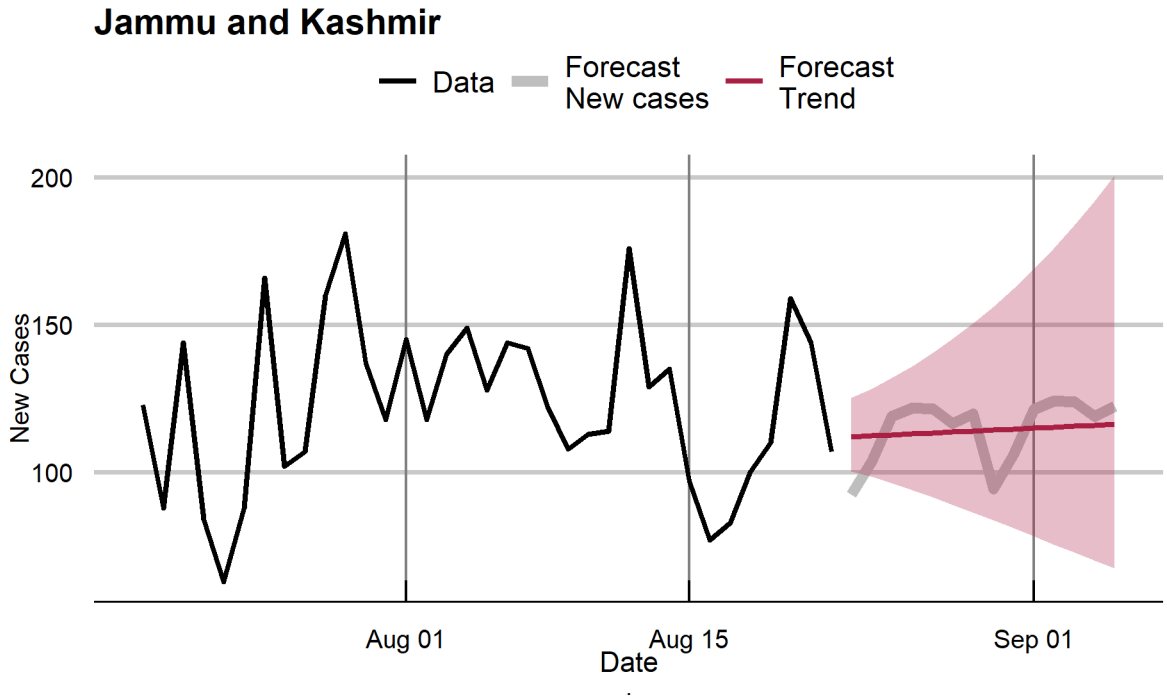

Gujarat
Growth rate of daily cases
0.00
-0.03
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

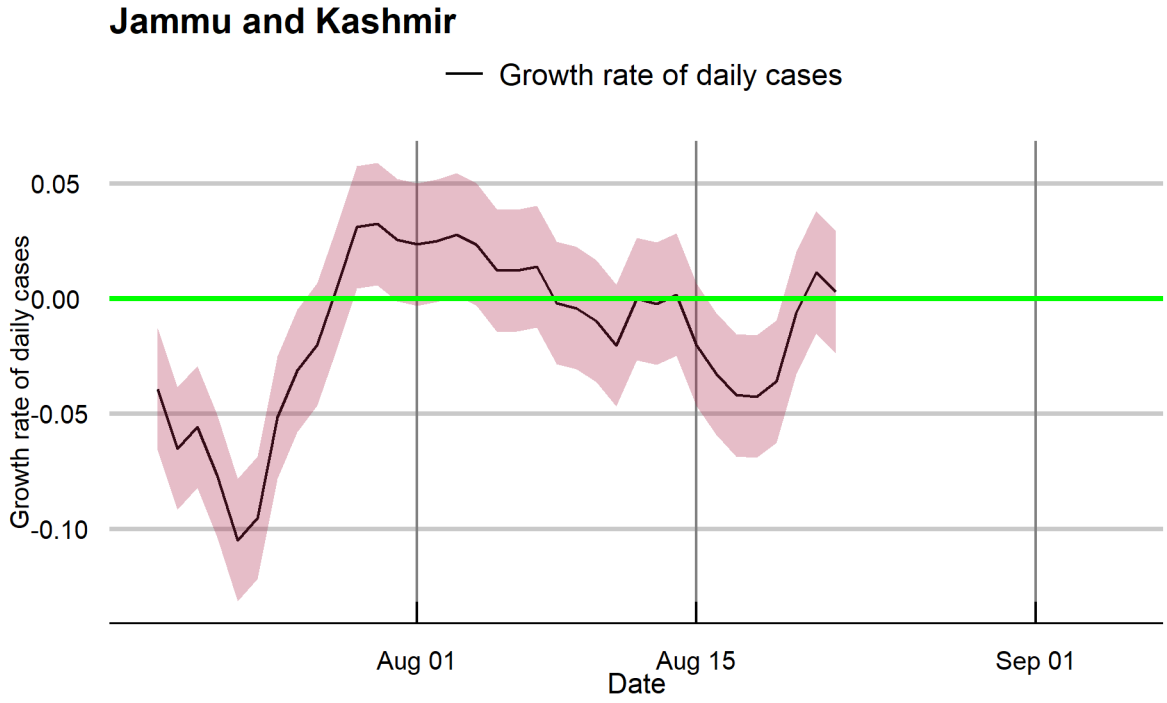

Haryana
Data
Forecast
New cases
Forecast
Trend
40
30
20
New Cases
Aug 01
Aug 15
Sep 01
Date

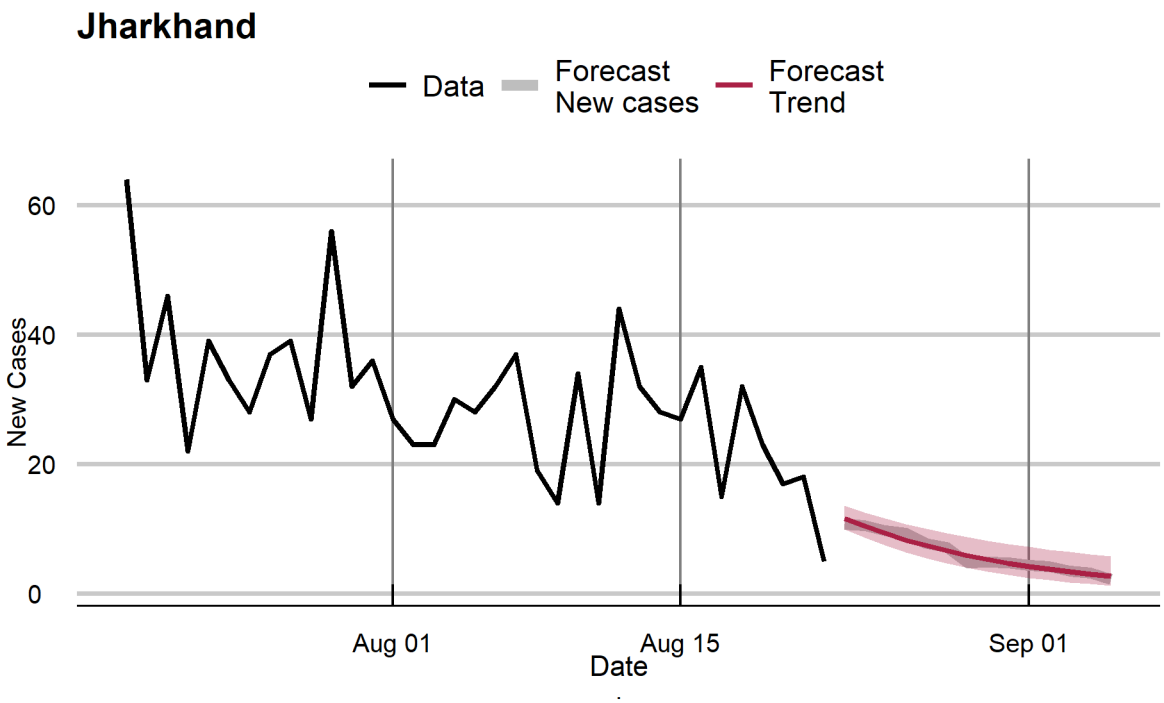

Haryana
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

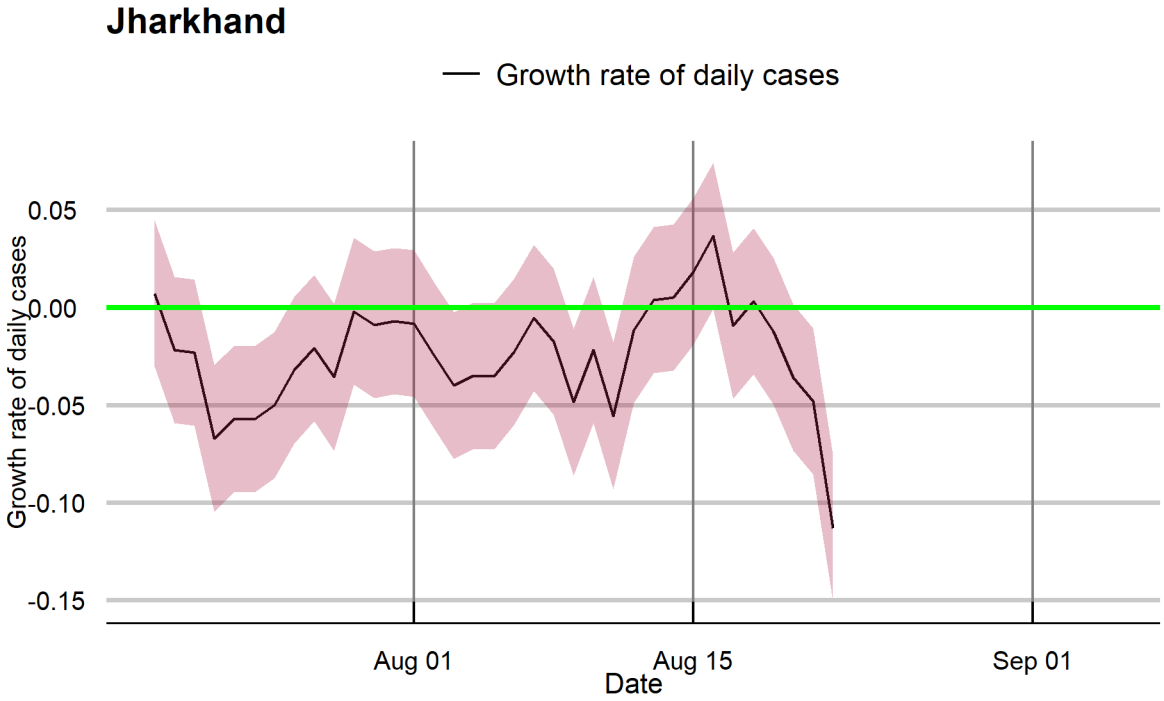

Himachal Pradesh
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
New Cases
Aug 01
Aug 15
Sep 01
Date

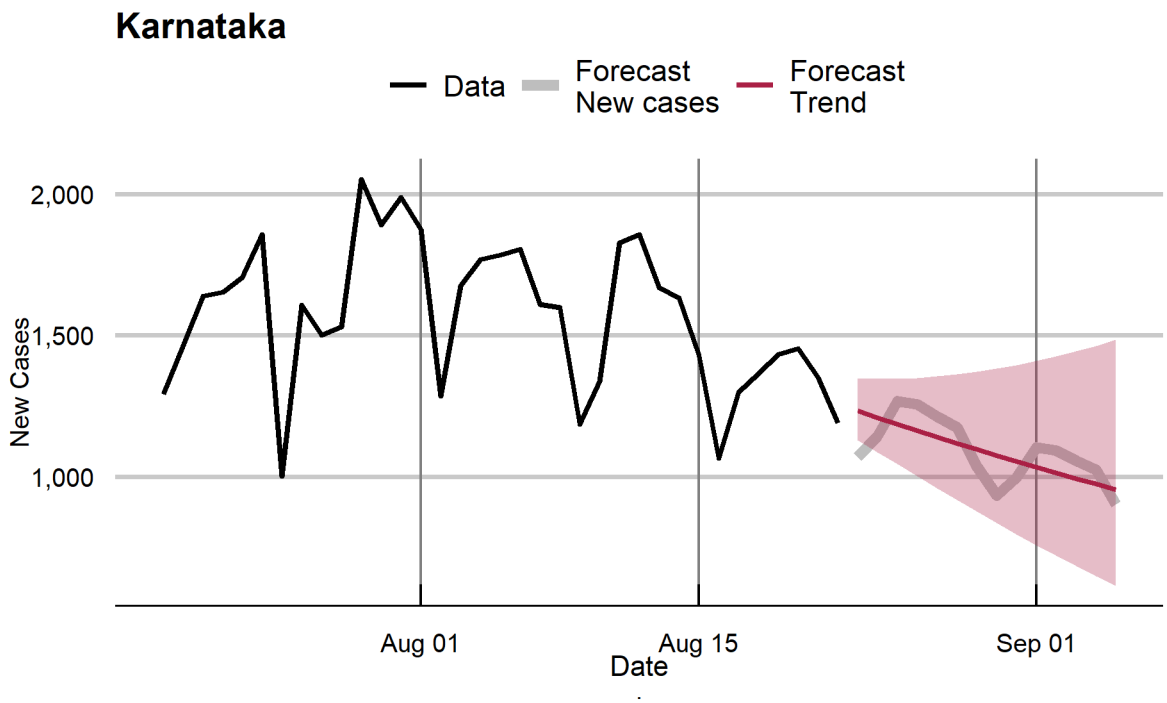

Himachal Pradesh
Growth rate of daily cases
0.10
0.05
0.00
-0.05
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

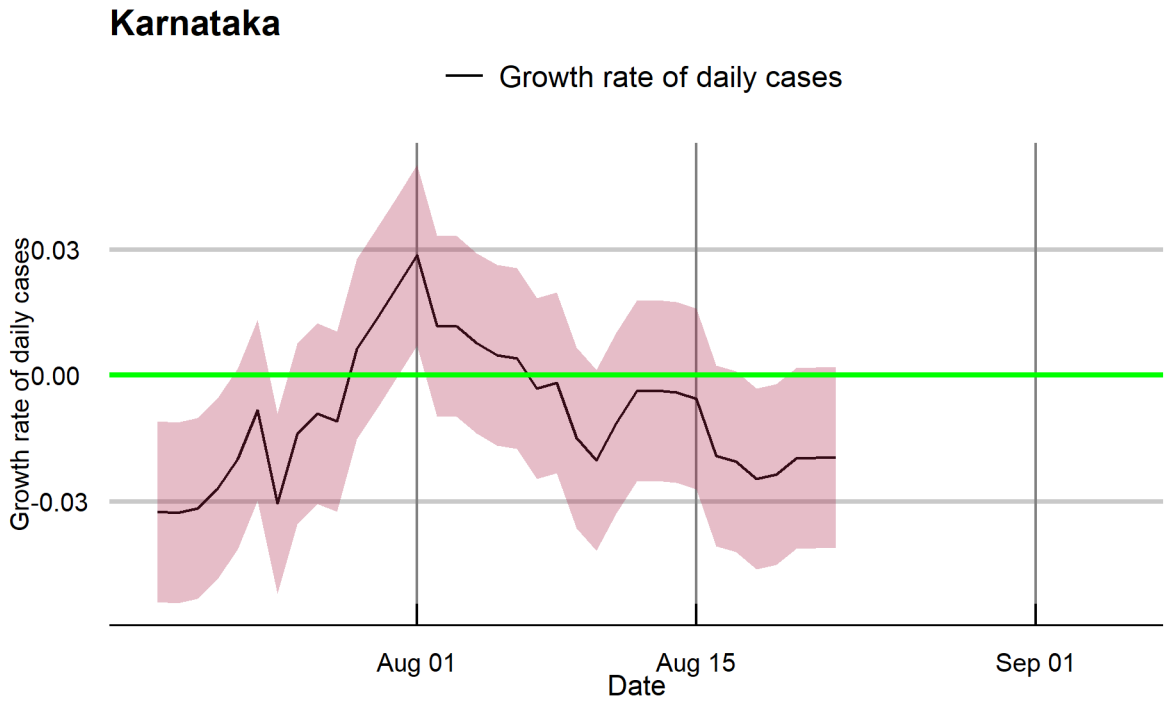

Jammu and Kashmir
Data
Forecast
New cases
Forecast
Trend
200
150
100
New Cases
Aug 01
Aug 15
Sep 01
Date

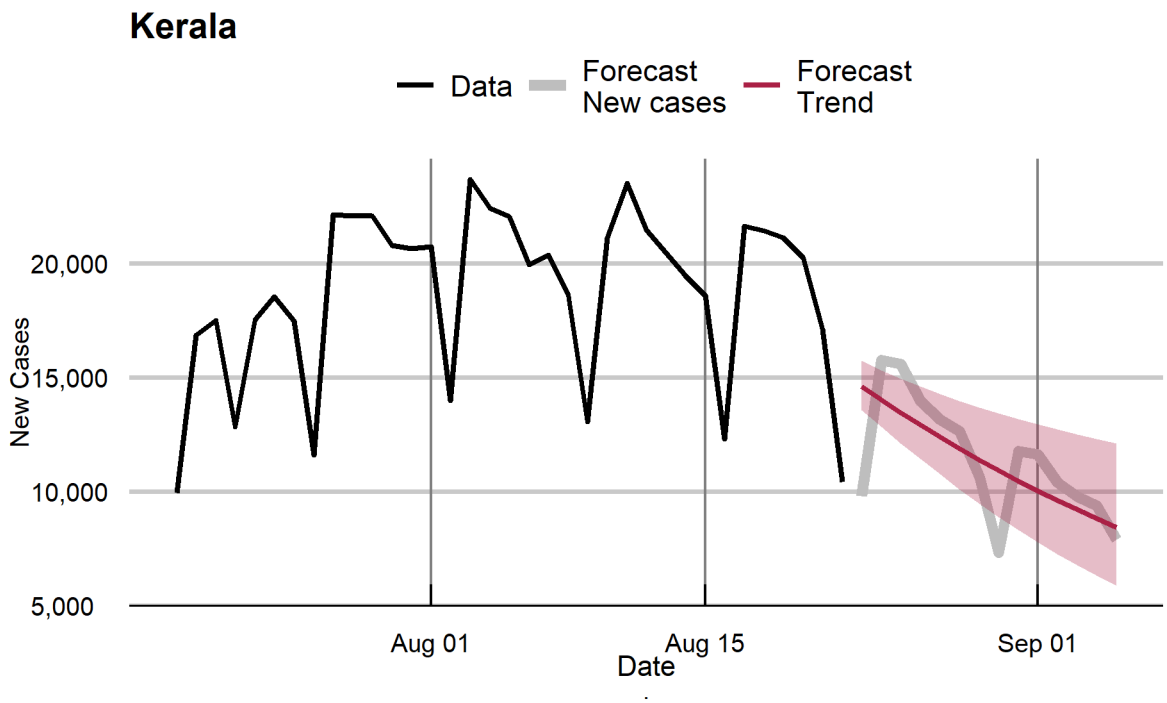

Jammu and Kashmir
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

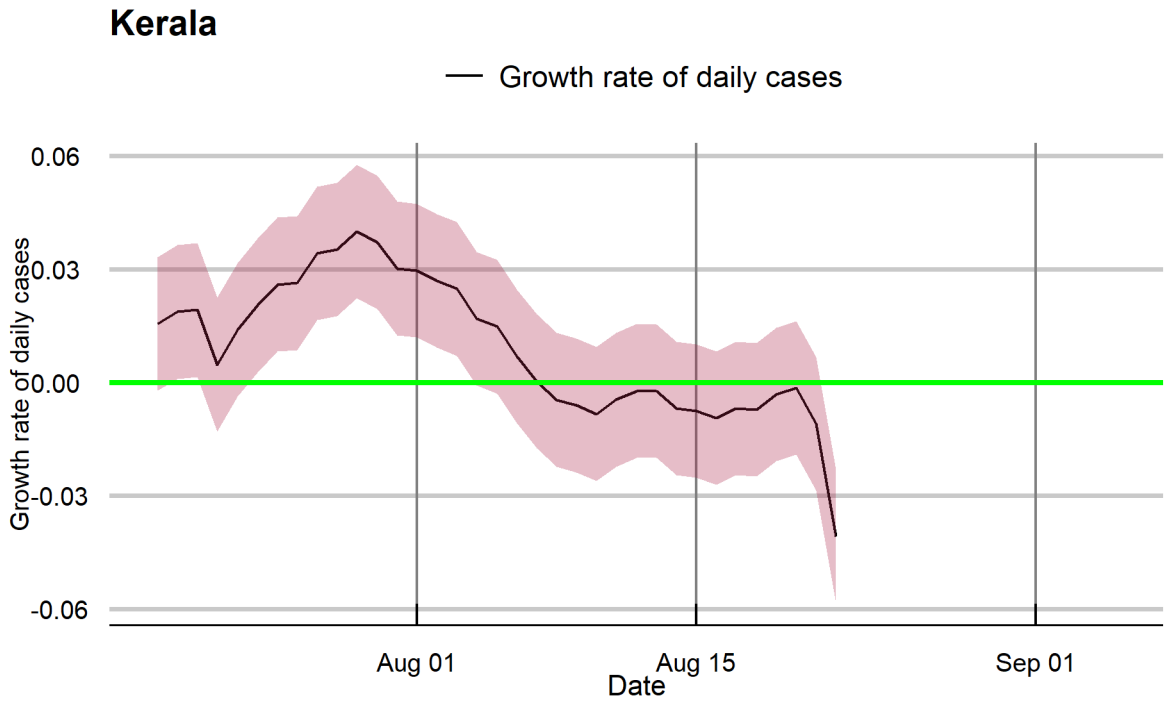

Jharkhand
Data
Forecast
New cases
Forecast
Trend
60
40
20
0
New Cases
Aug 01
Aug 15
Sep 01
Date

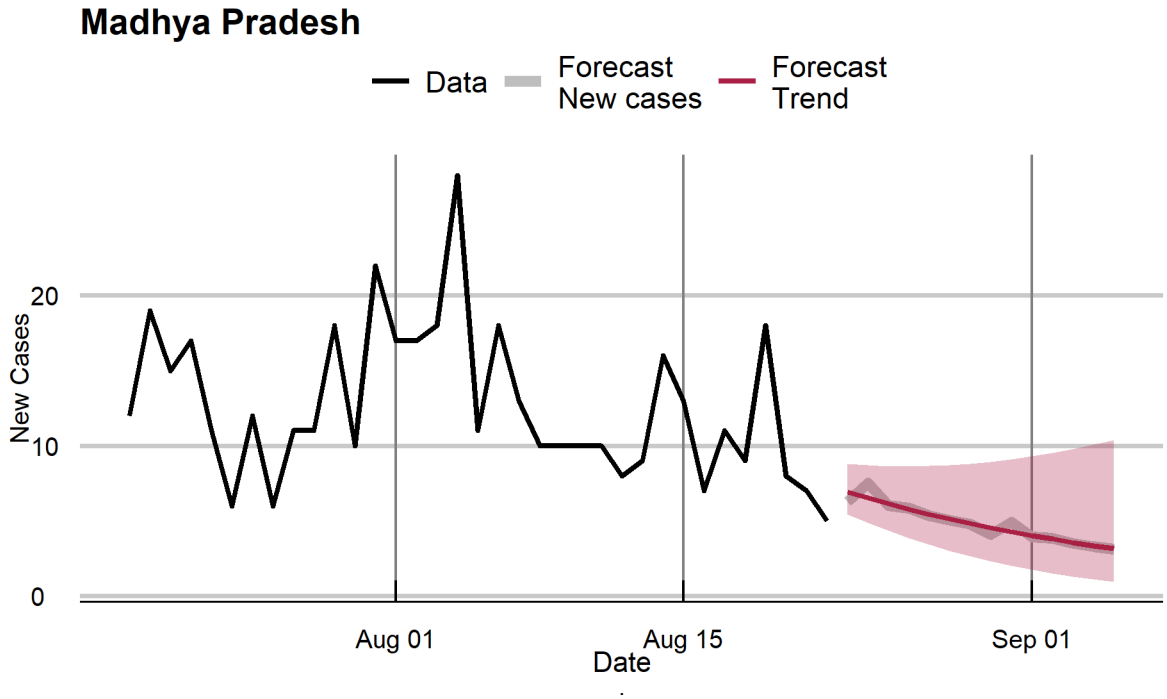

Jharkhand
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

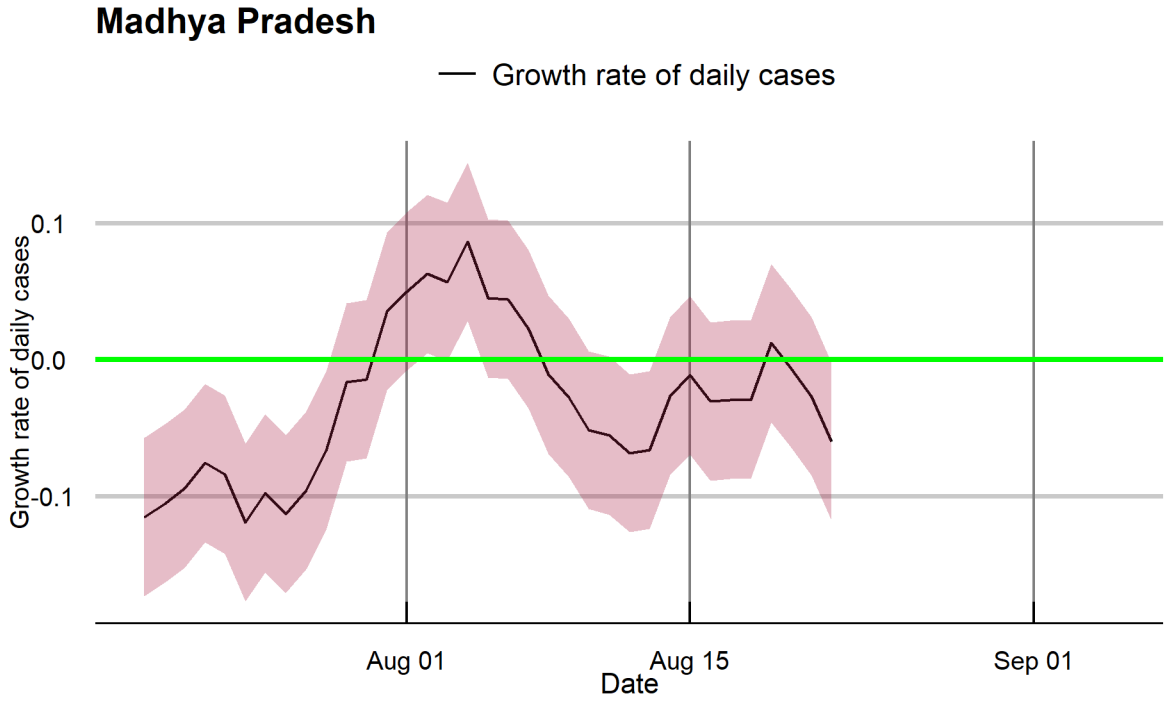

Karnataka
Data
Forecast
New cases
Forecast
Trend
2,000
1,500
1,000
New Cases
Aug 01
Aug 15
Sep 01
Date

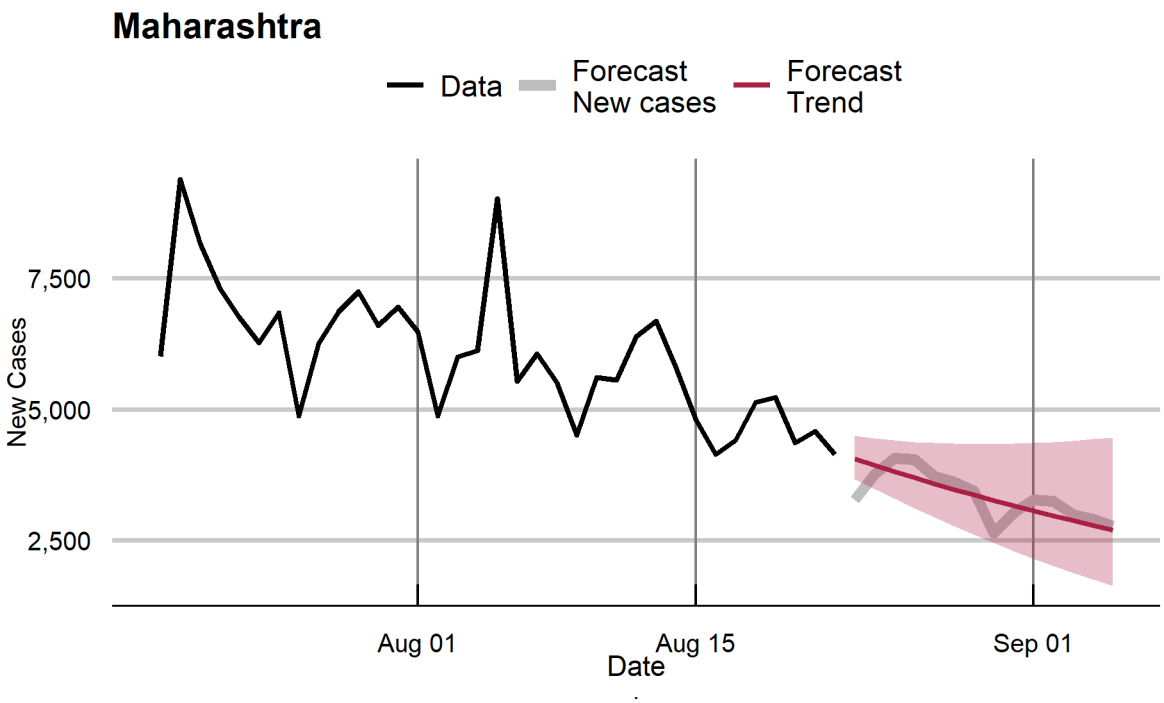

Karnataka
Growth rate of daily cases
0.03
0.00
-0.03
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

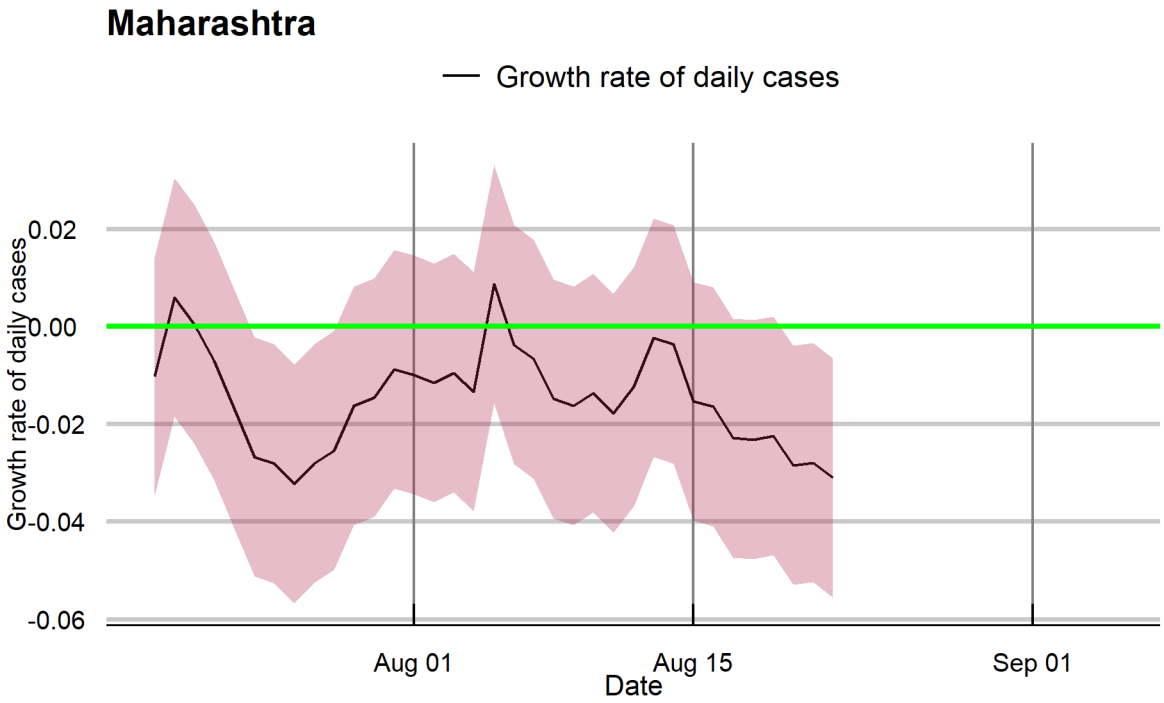

Kerala
Data
Forecast
New cases
Forecast
Trend
20,000
15,000
10,000
5,000
New Cases
Aug 01
Aug 15
Sep 01
Date

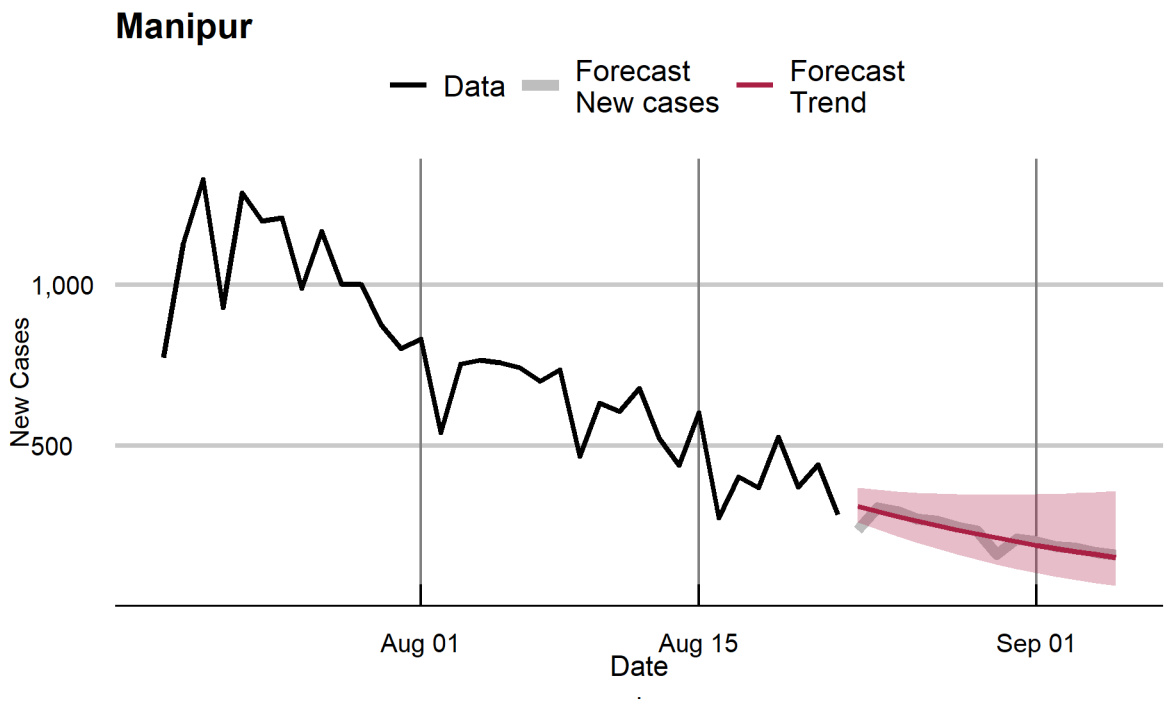

Kerala
Growth rate of daily cases
0.06
0.03
0.00
-0.03
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

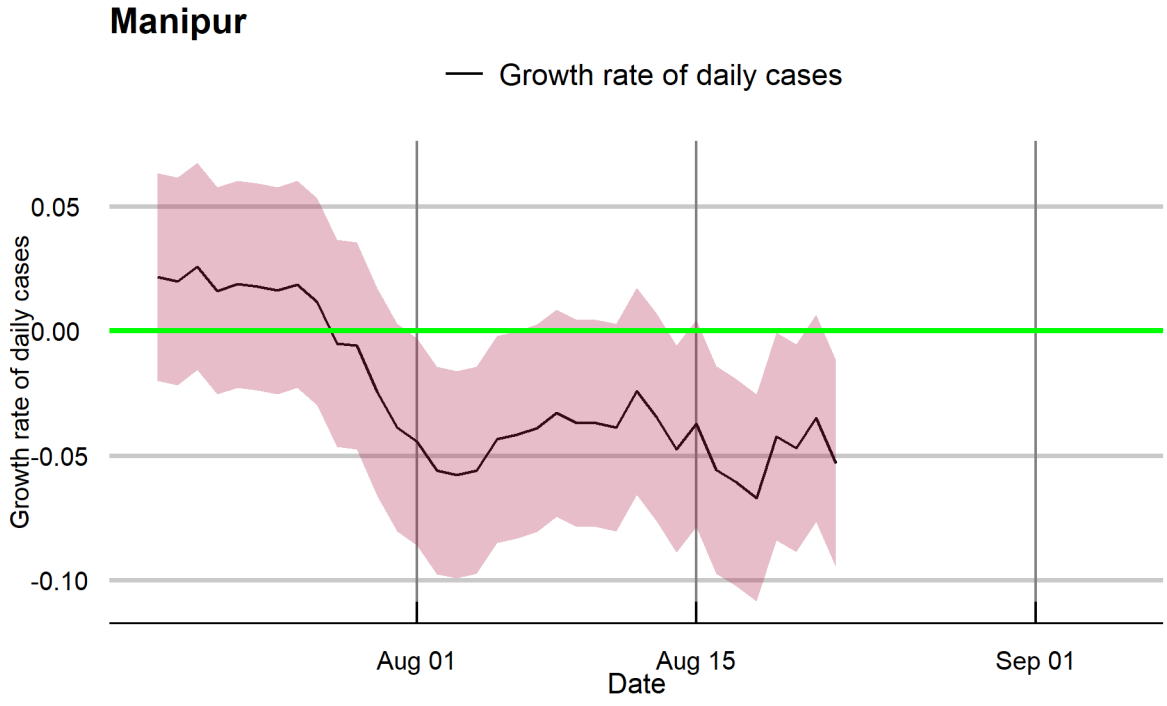

Madhya Pradesh
Data
Forecast
New cases
Forecast
Trend
New Cases
20
10
0
Aug 01
Aug 15
Sep 01
Date

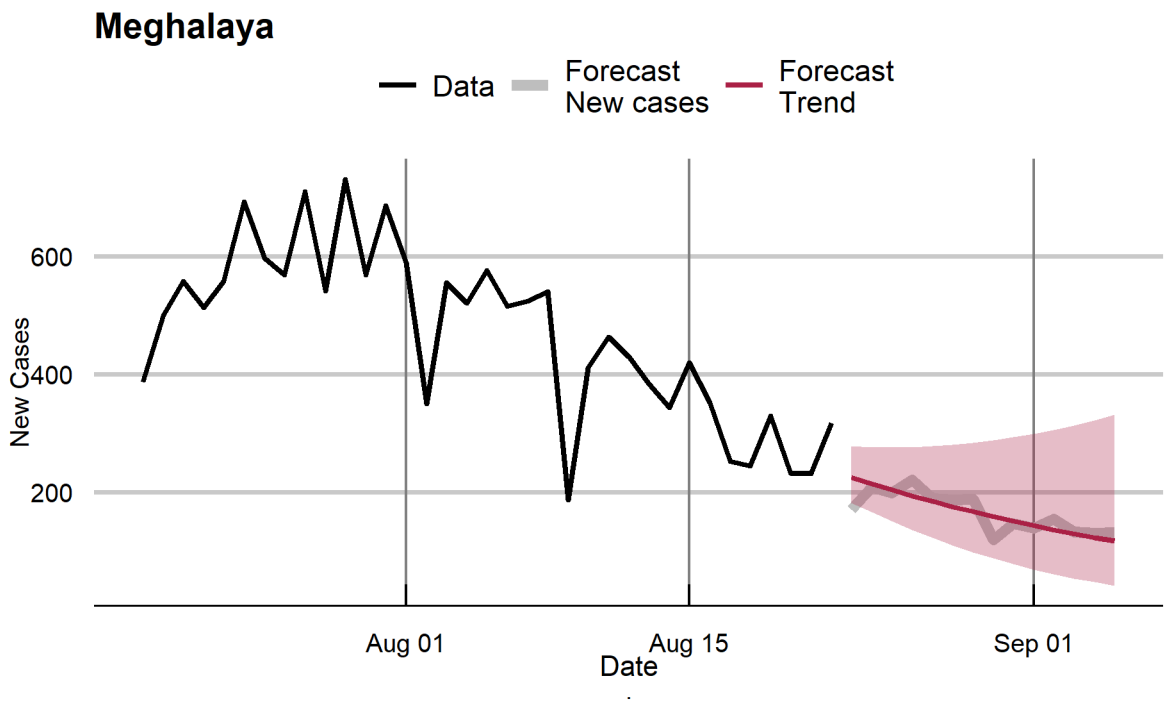

Madhya Pradesh
Growth rate of daily cases
Growth rate of daily cases
0.1
0.0
-0.1
Aug 01
Aug 15
Sep 01
Date

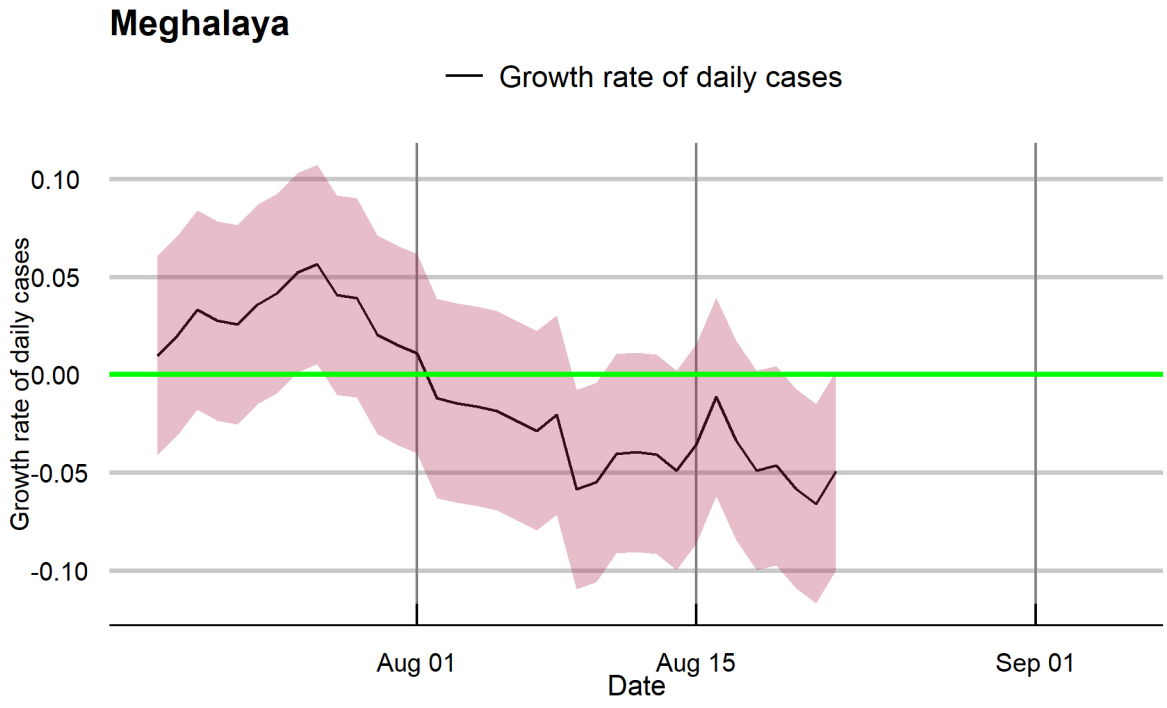

Maharashtra
Data
Forecast
New cases
Forecast
Trend
7,500
5,000
2,500
New Cases
Aug 01
Aug 15
Sep 01
Date

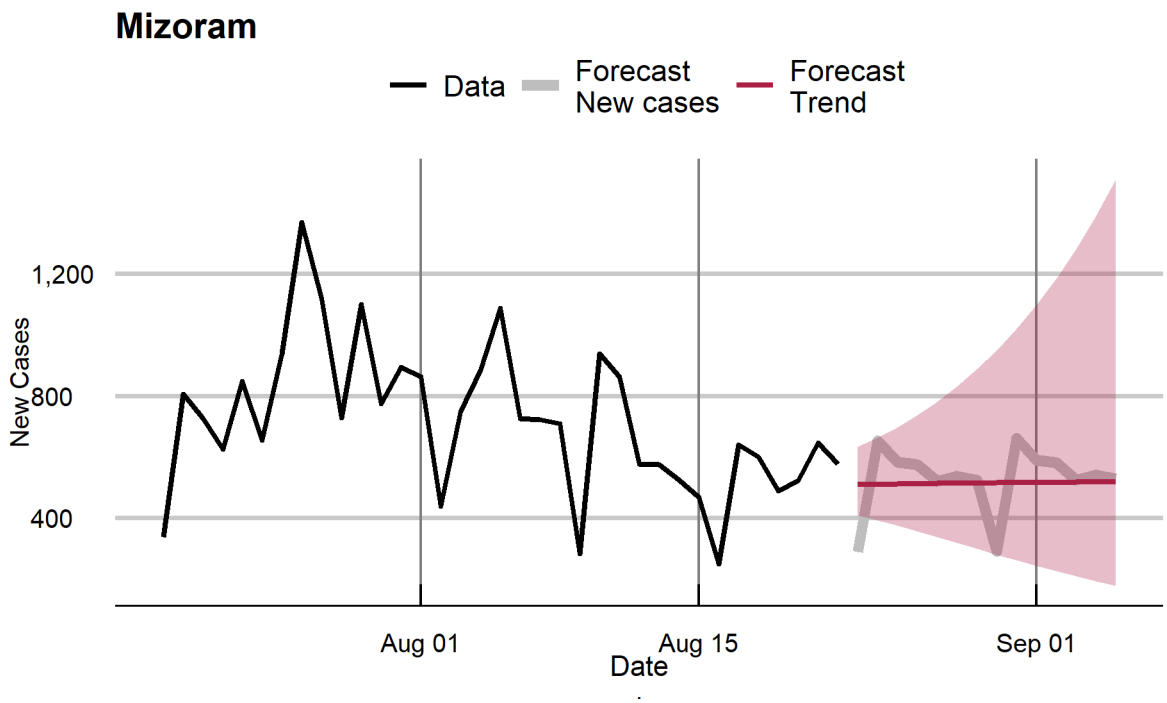

Maharashtra
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

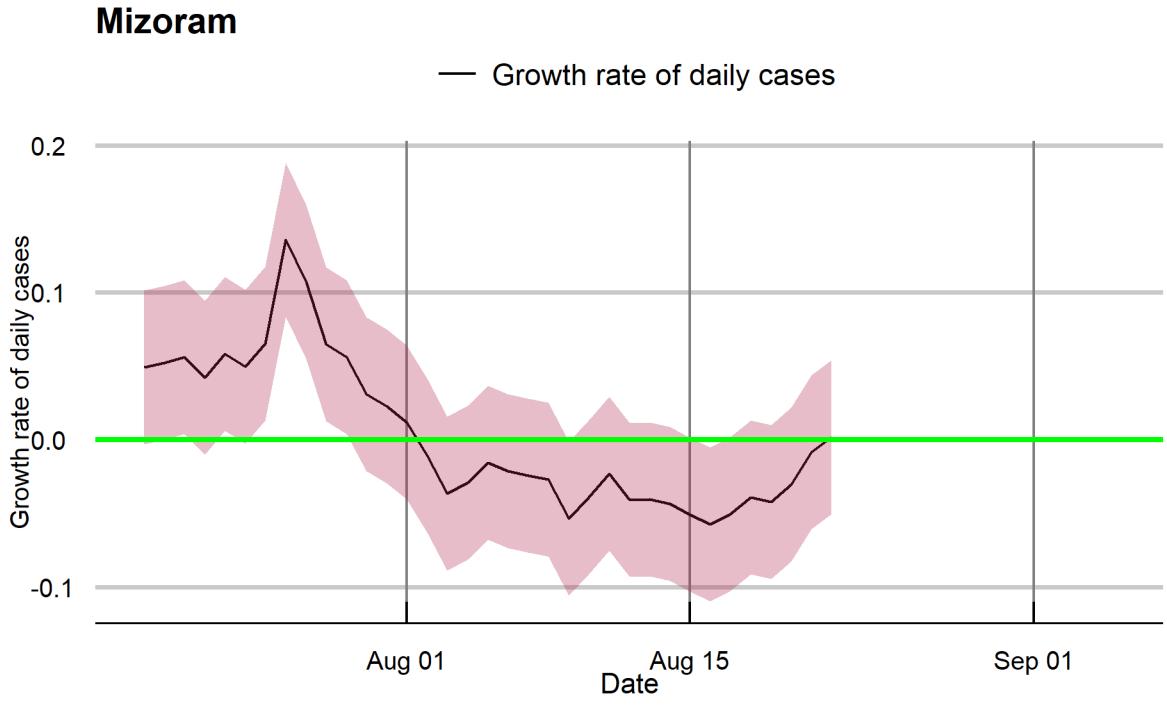

Manipur
Data
Forecast
New cases
Forecast
Trend
1,000
500
New Cases
Aug 01
Aug 15
Sep 01
Date

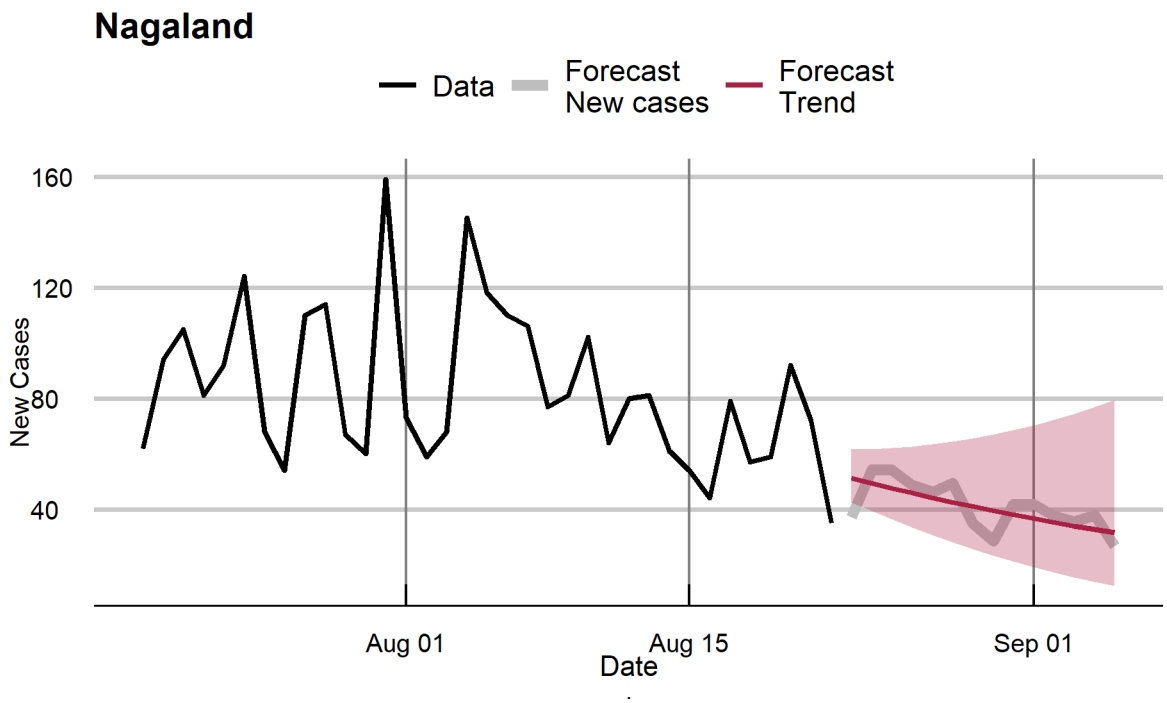

Manipur
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

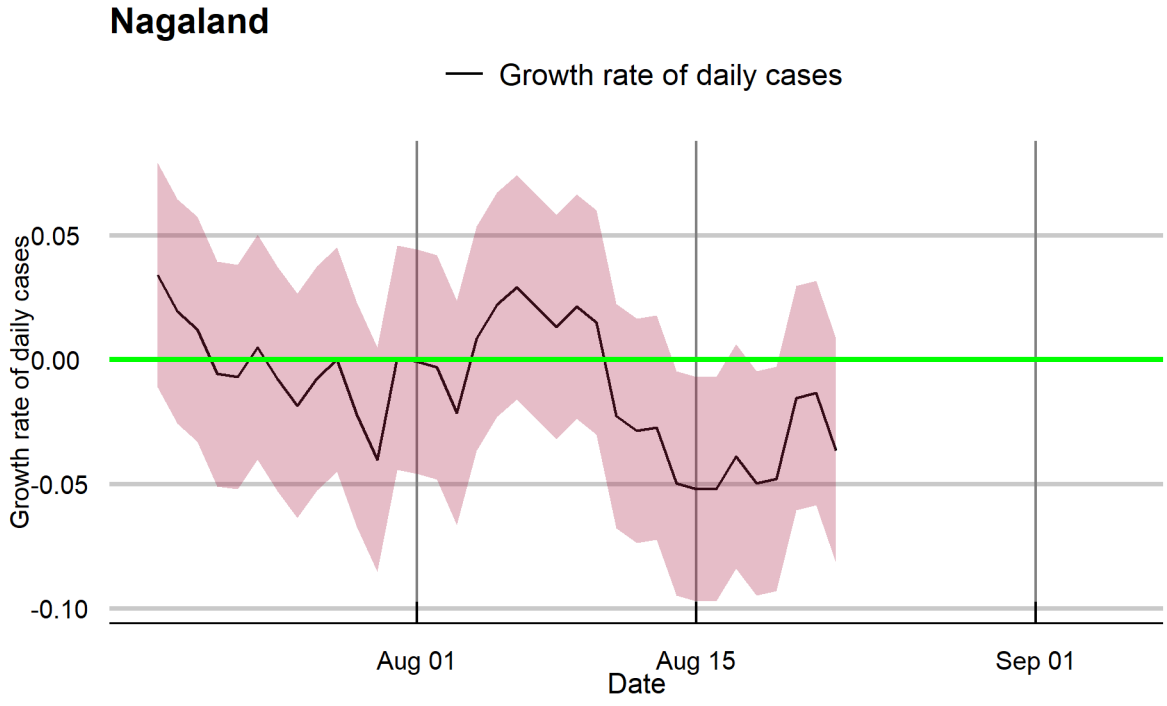

Meghalaya
Data
Forecast
New cases
Forecast
Trend
600
400
200
New Cases
Aug 01
Aug 15
Sep 01
Date

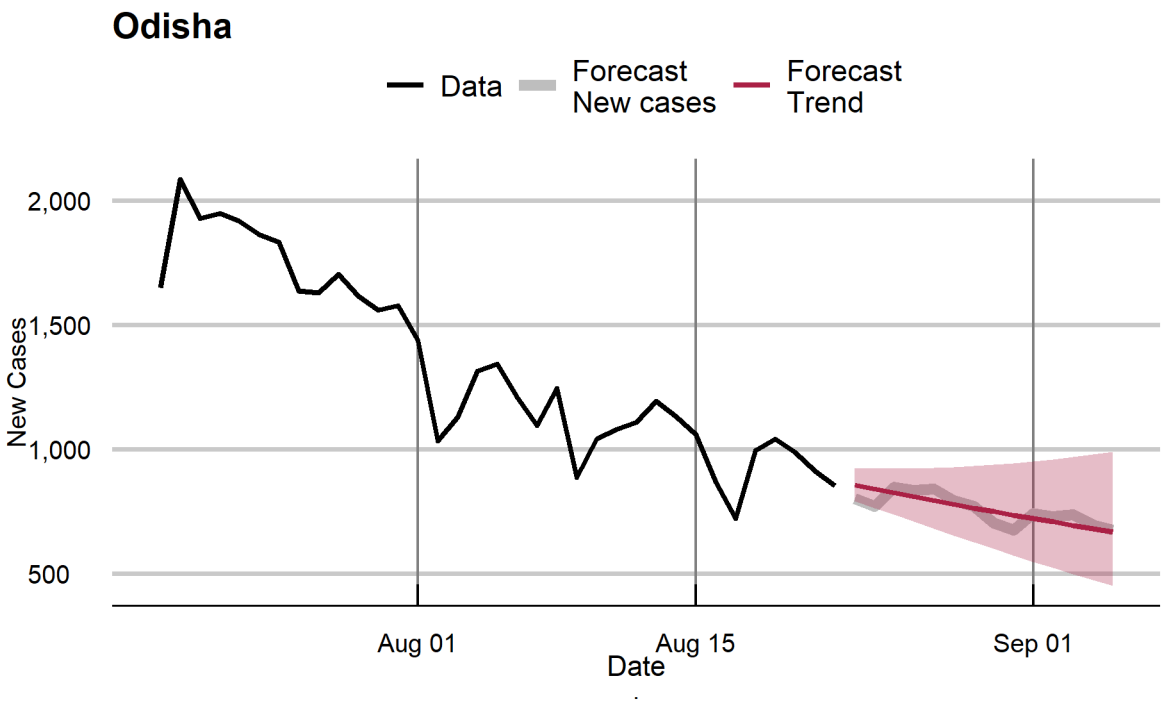

Meghalaya
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

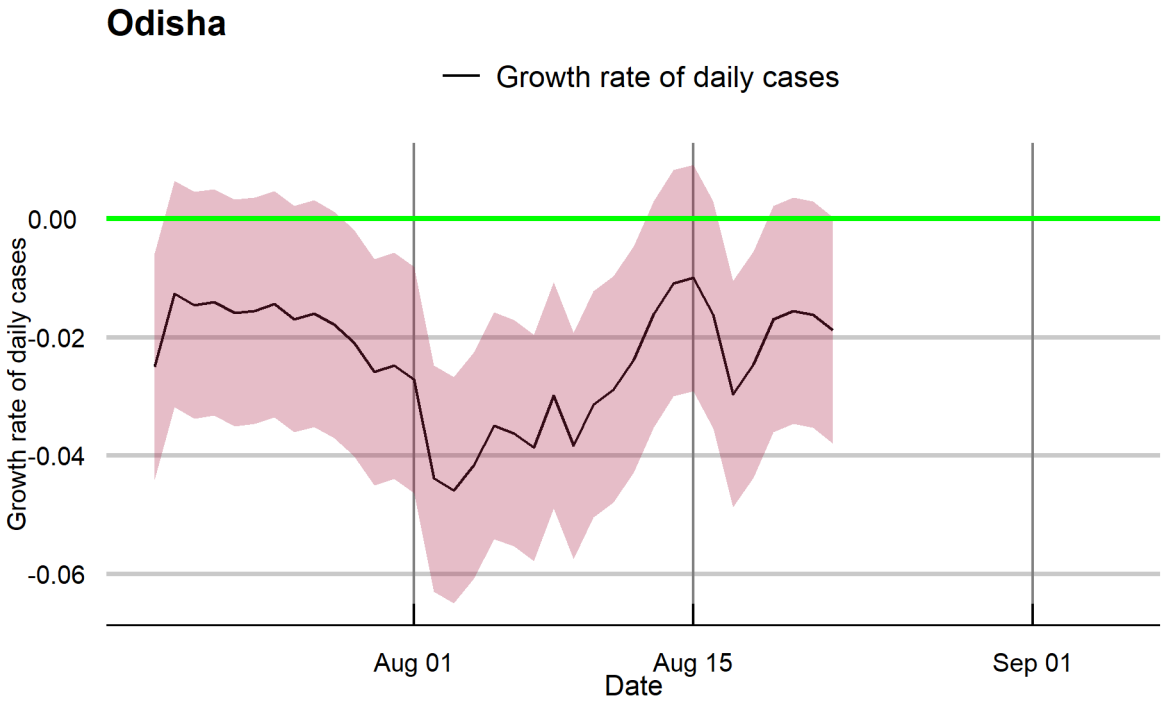

Mizoram
Data
Forecast
New cases
Forecast
Trend
1,200
800
400
New Cases
Aug 01
Aug 15
Sep 01
Date

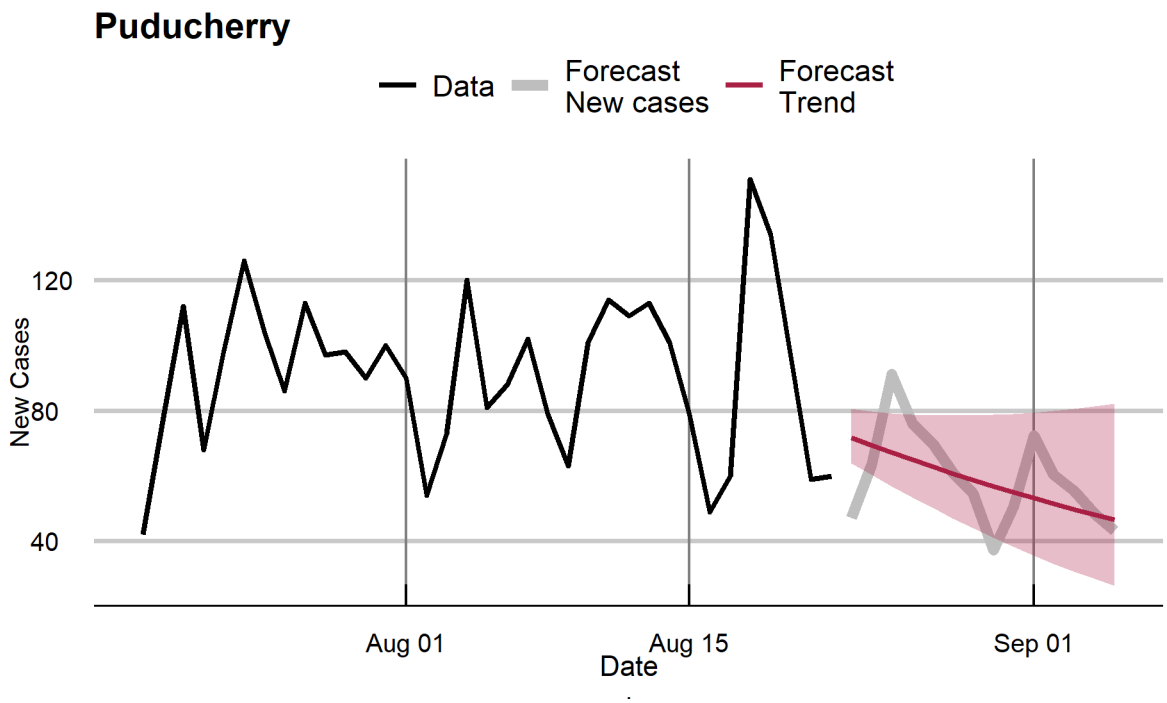

Mizoram
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

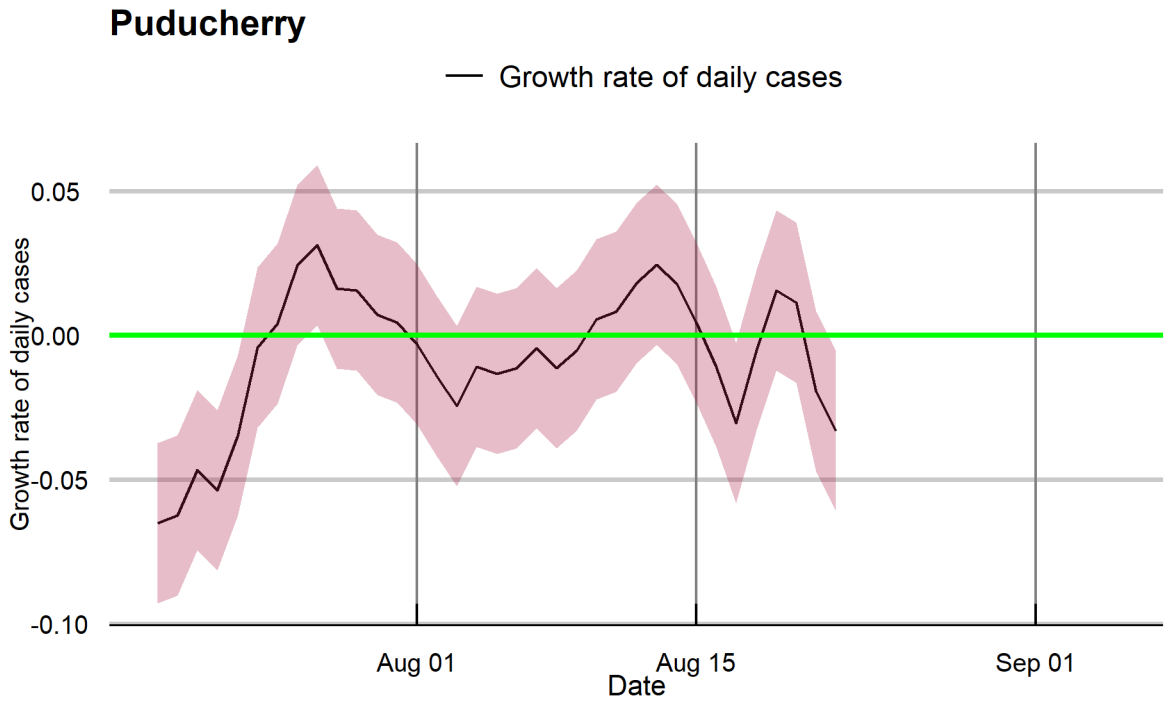

Nagaland
Data
Forecast
New cases
Forecast
Trend
160
120
80
40
New Cases
Aug 01
Aug 15
Sep 01
Date

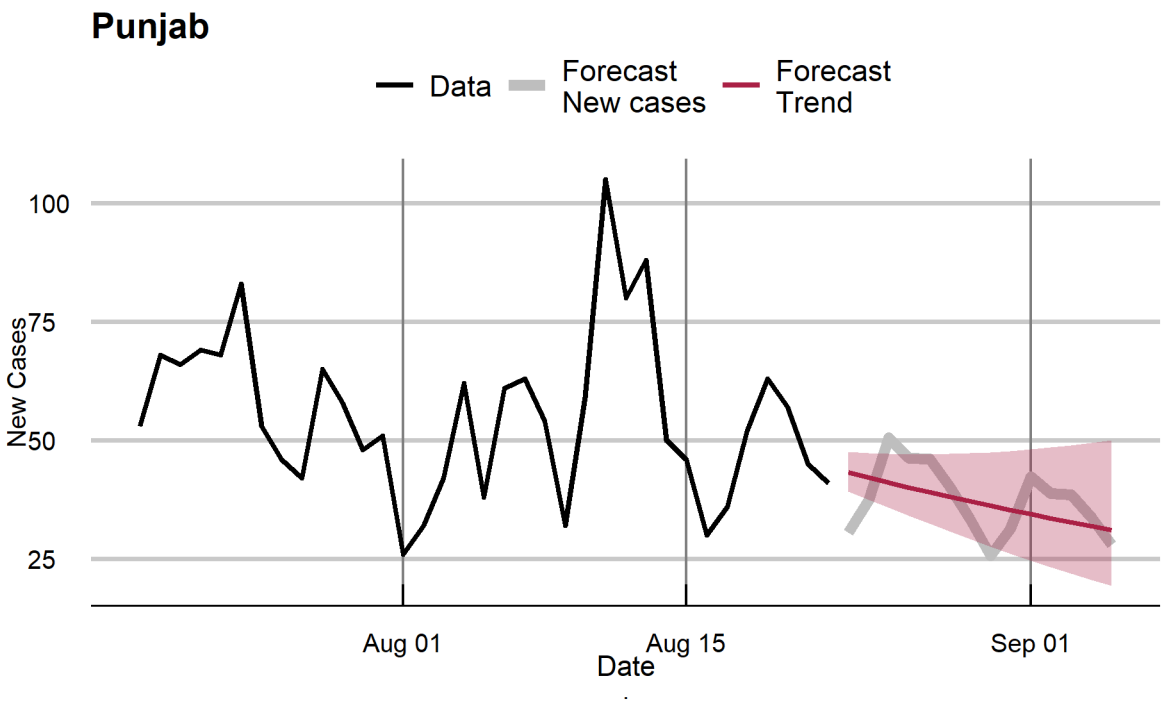

Nagaland
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

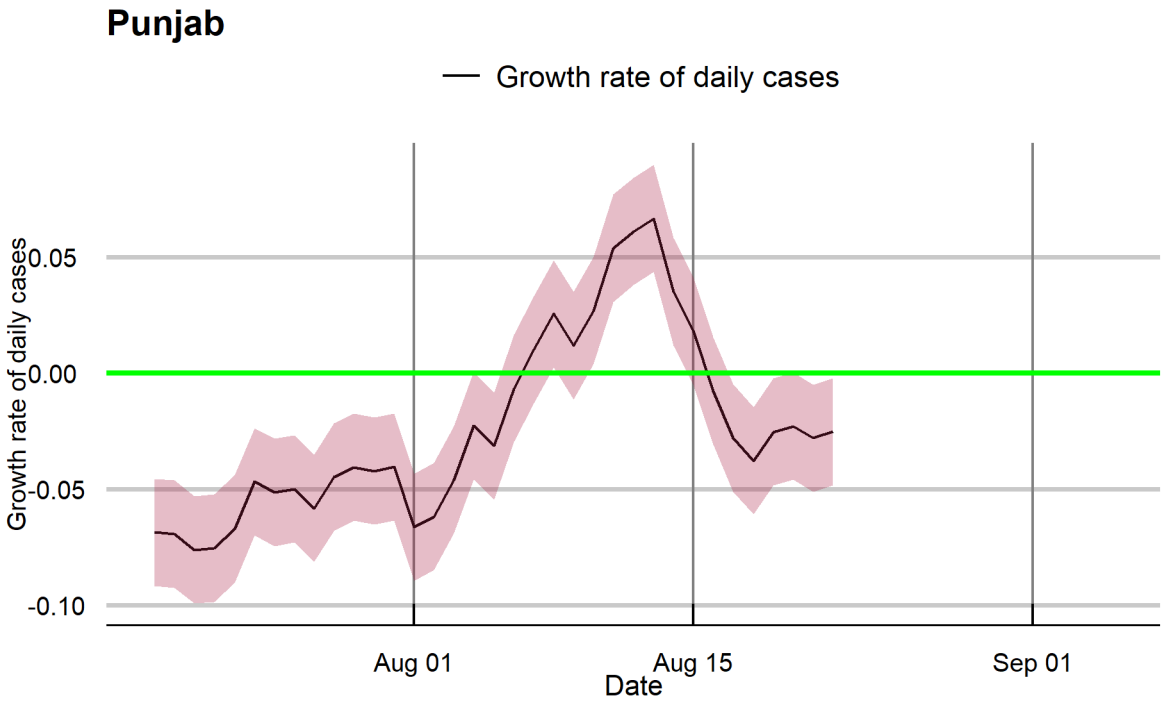

Odisha
Data
Forecast
New cases
Forecast
Trend
2,000
1,500
1,000
500
New Cases
Aug 01
Aug 15
Sep 01
Date

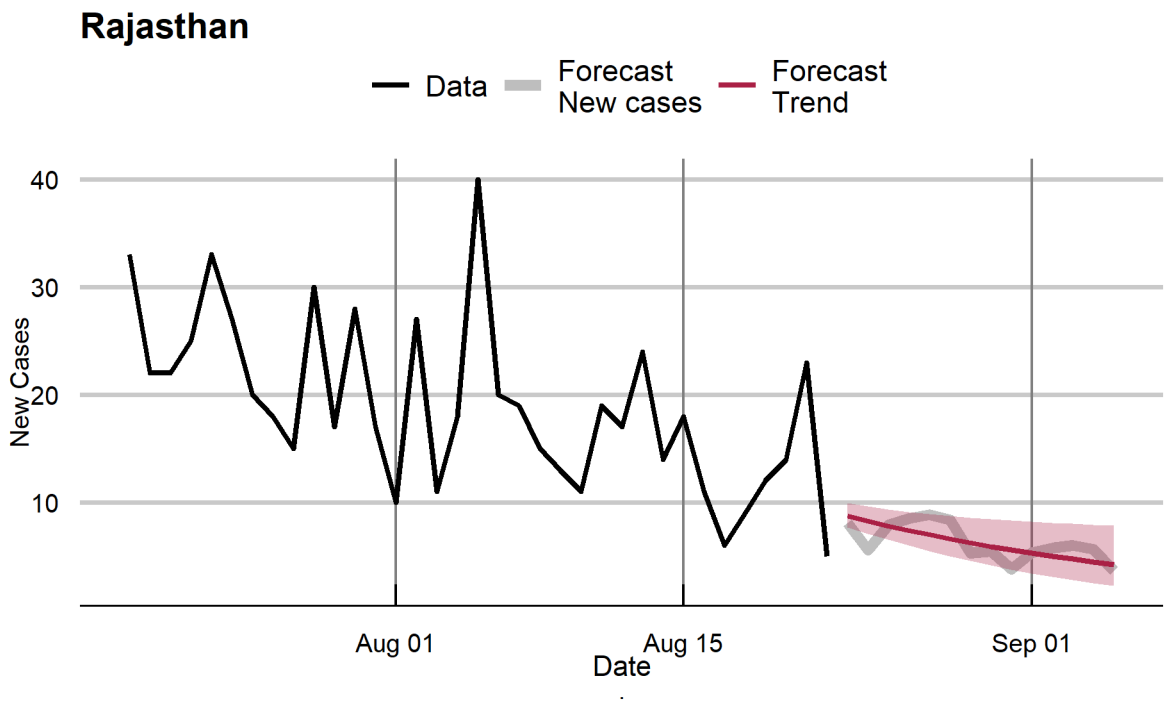

Odisha
Growth rate of daily cases
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

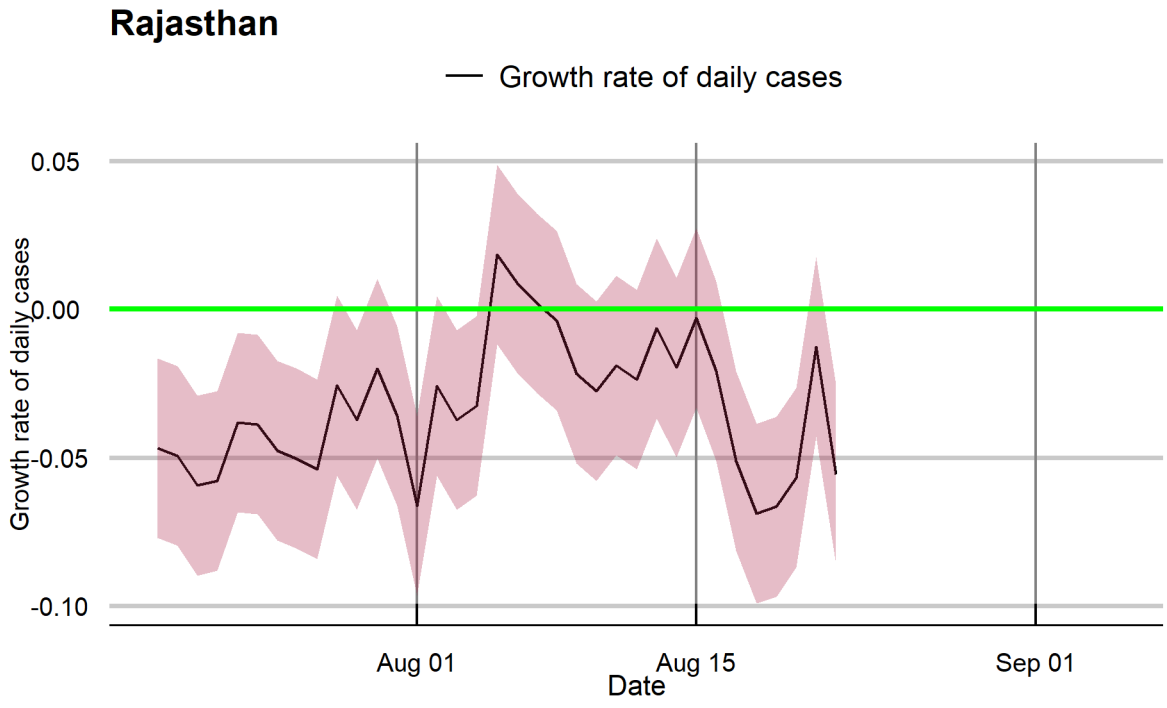

Puducherry
Data
Forecast
New cases
Forecast
Trend
120
80
40
New Cases
Aug 01
Aug 15
Sep 01
Date

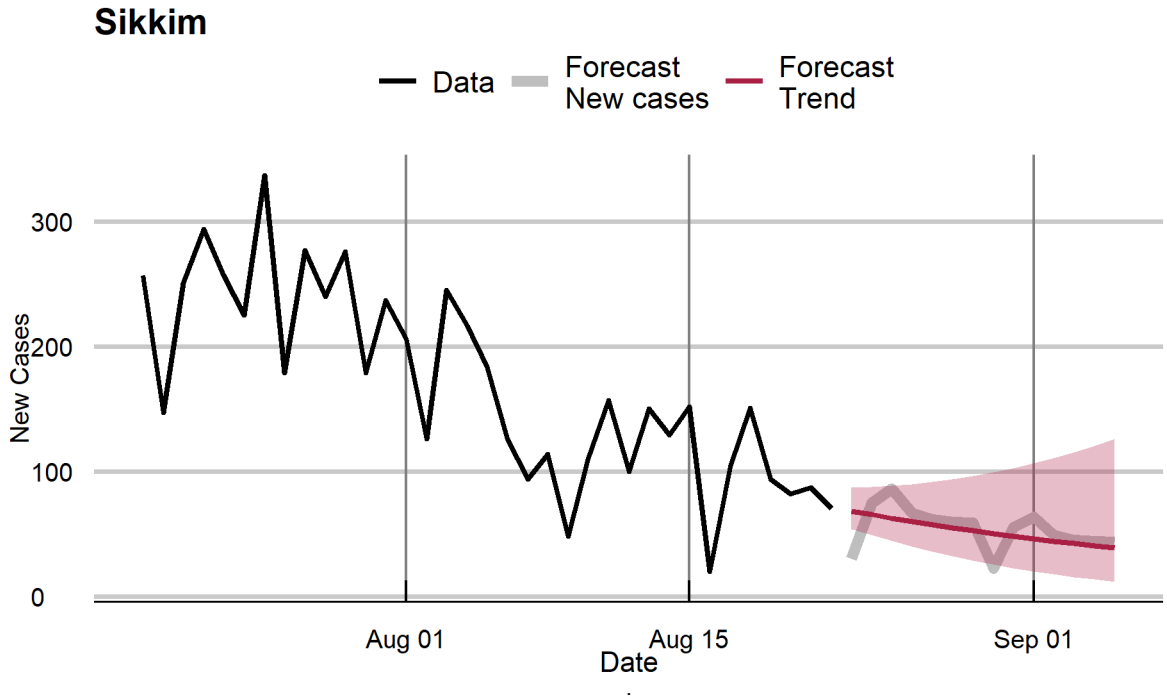

Puducherry
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

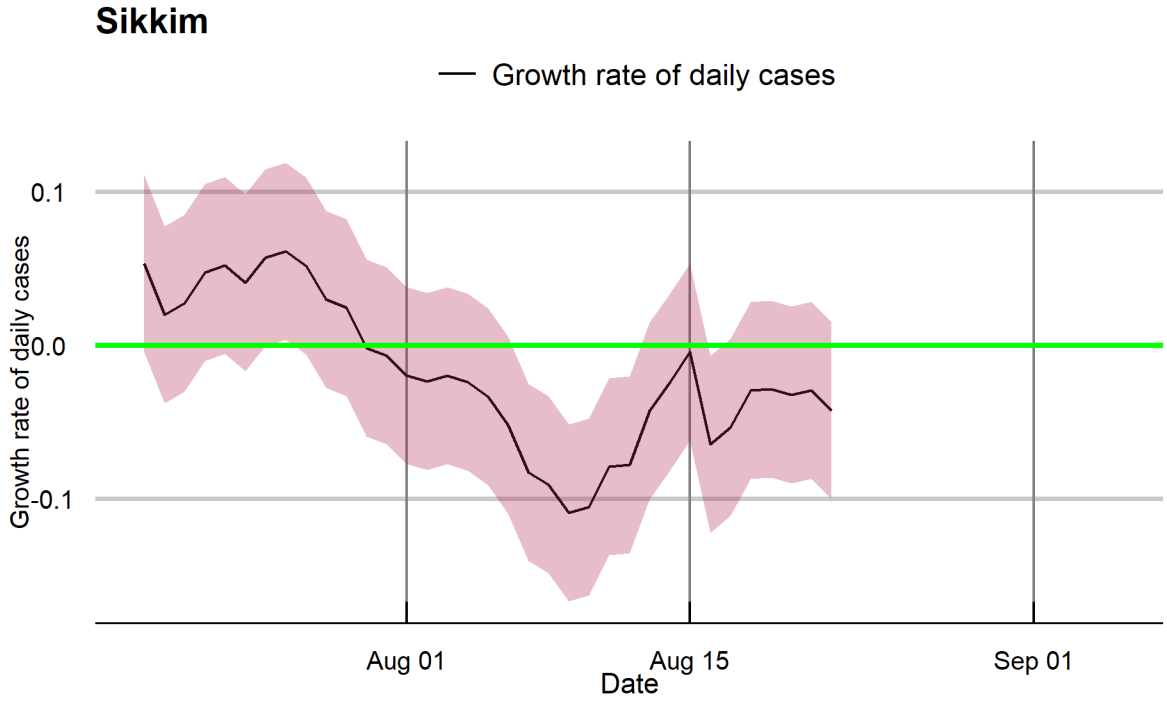

Punjab
Data
Forecast
New cases
Forecast
Trend
100
75
50
25
New Cases
Aug 01
Aug 15
Sep 01
Date

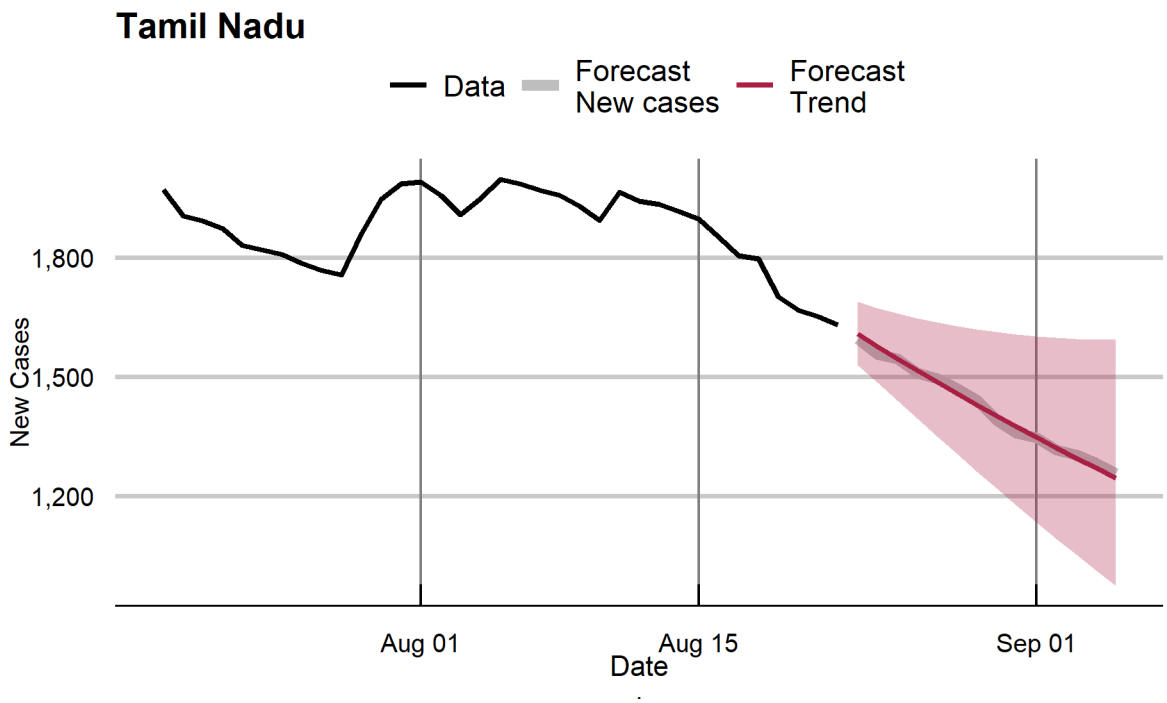

Punjab
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

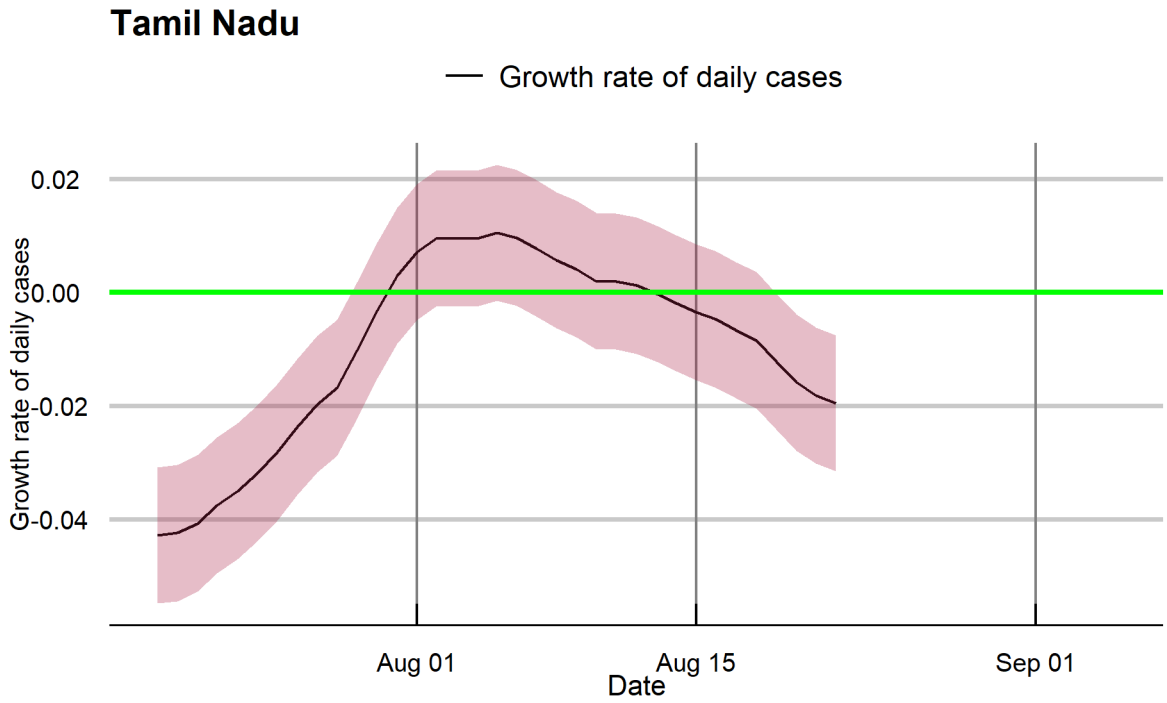

Rajasthan
Data
Forecast
New cases
Forecast
Trend
40
30
20
10
New Cases
Aug 01
Aug 15
Sep 01
Date

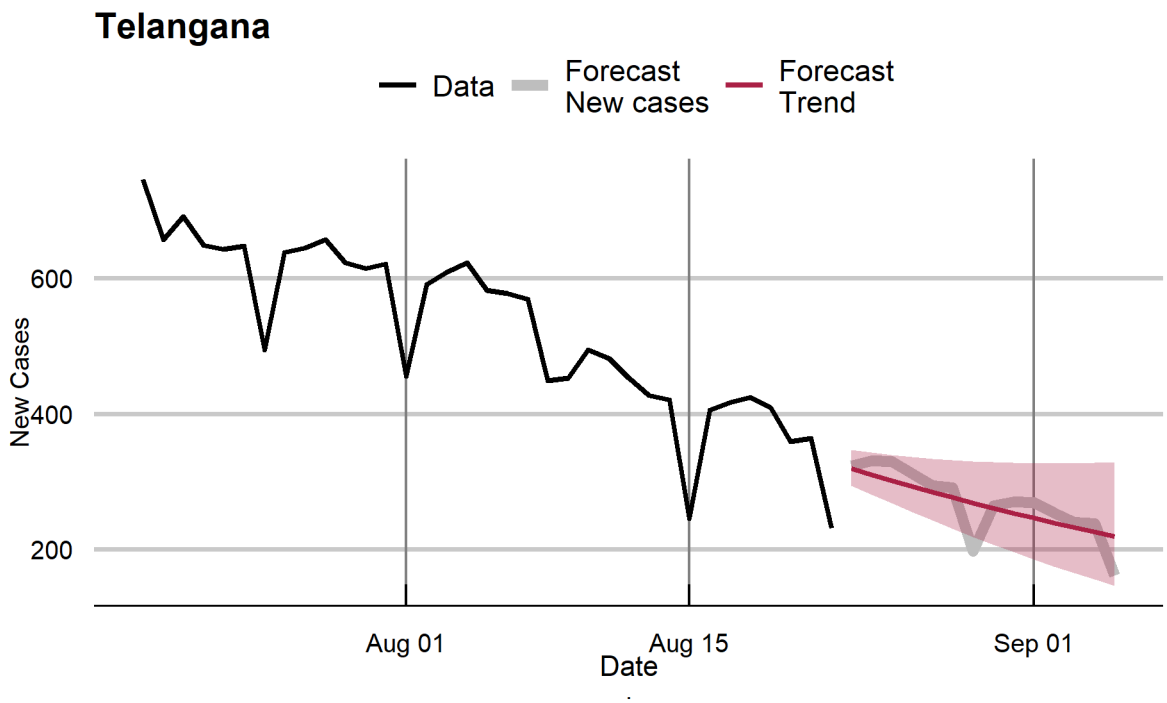

Rajasthan
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

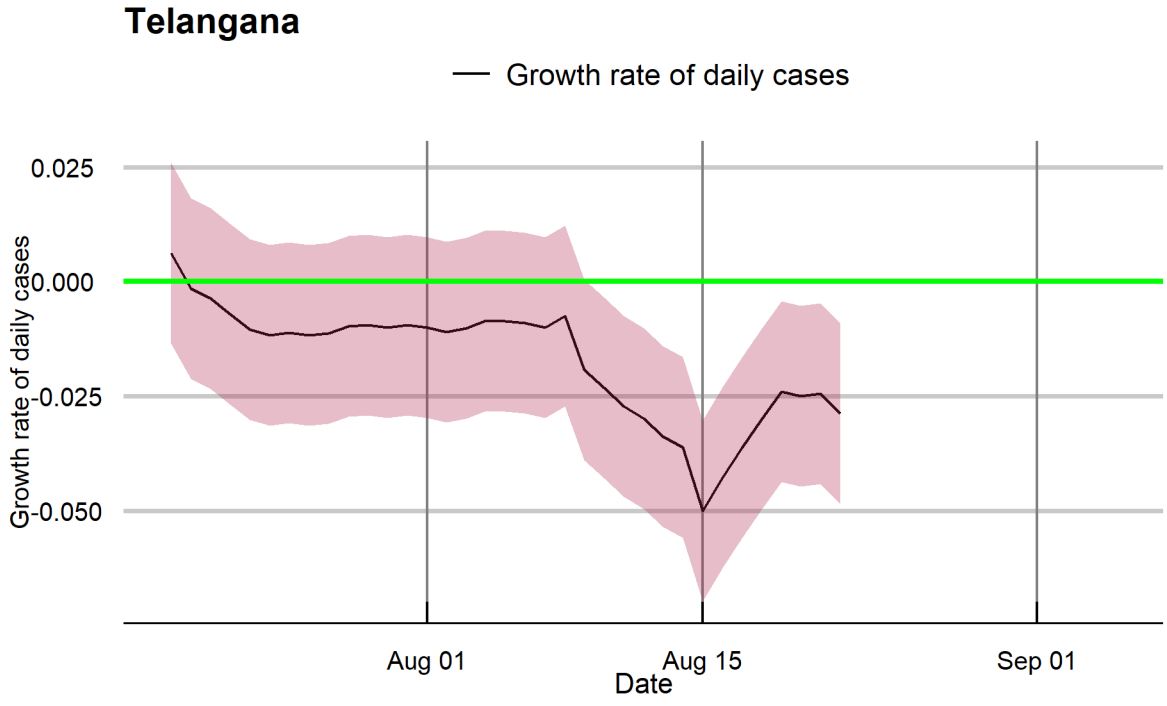

Sikkim
Data
Forecast
New cases
Forecast
Trend
300
200
100
0
New Cases
Aug 01
Aug 15
Sep 01
Date

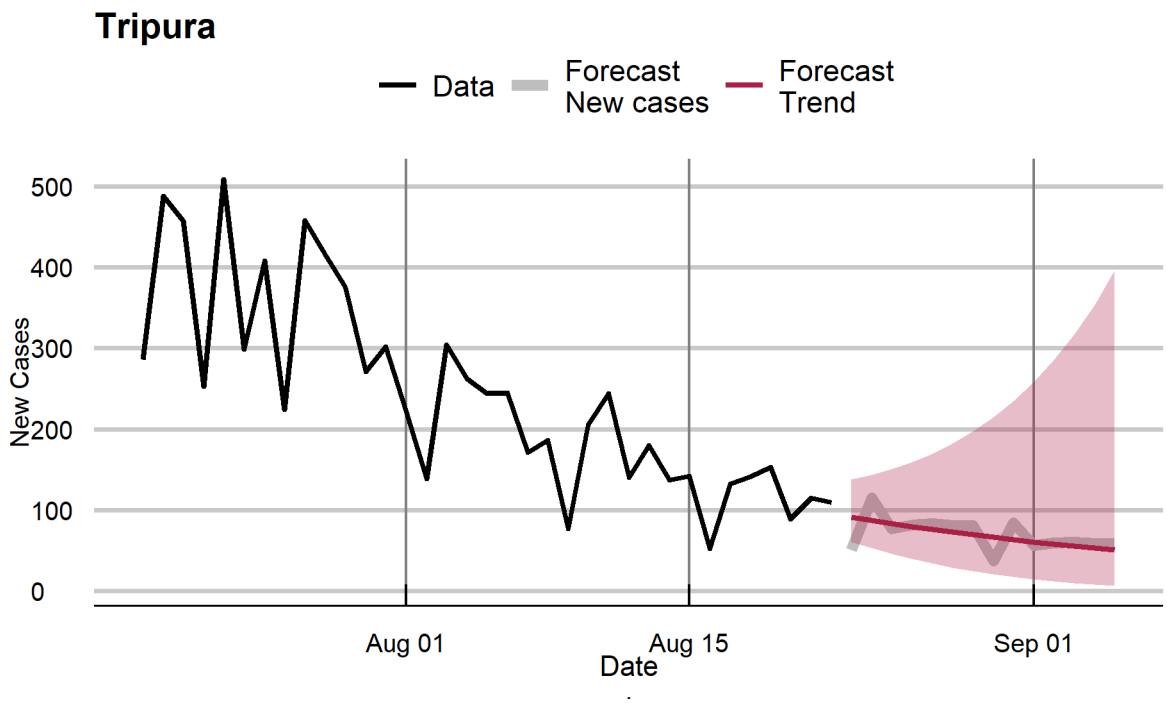

Sikkim
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

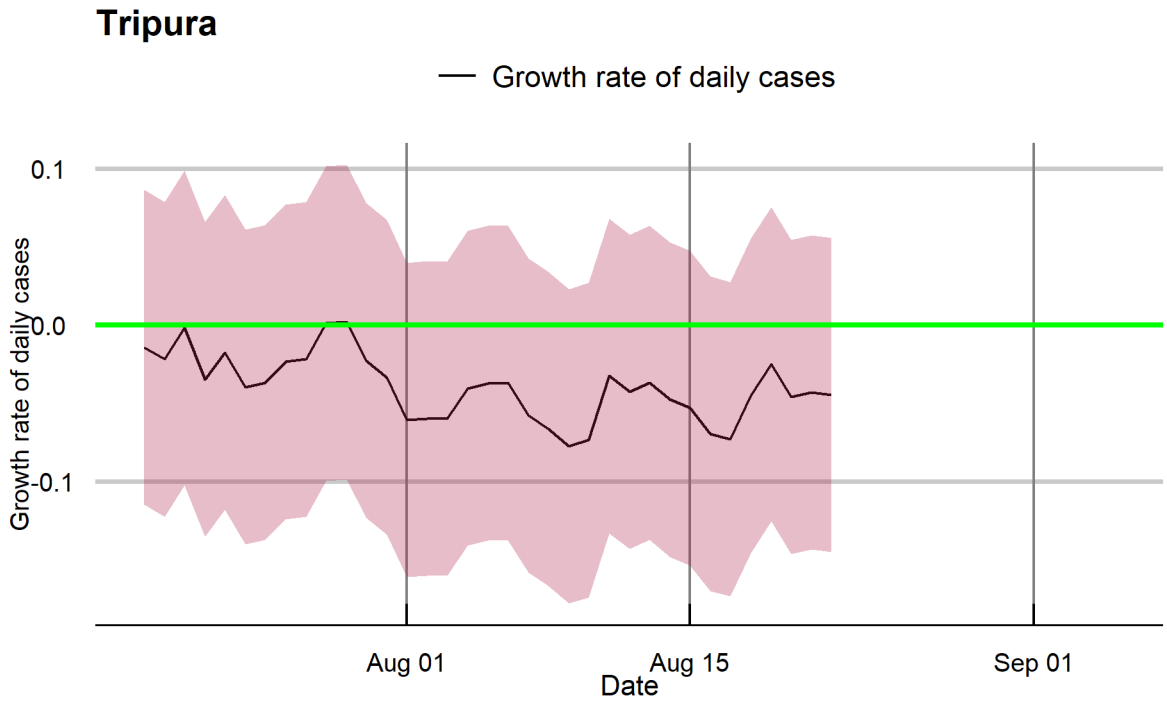

Tamil Nadu
Data
Forecast
New cases
Forecast
Trend
1,800
1,500
1,200
New Cases
Aug 01
Aug 15
Sep 01
Date

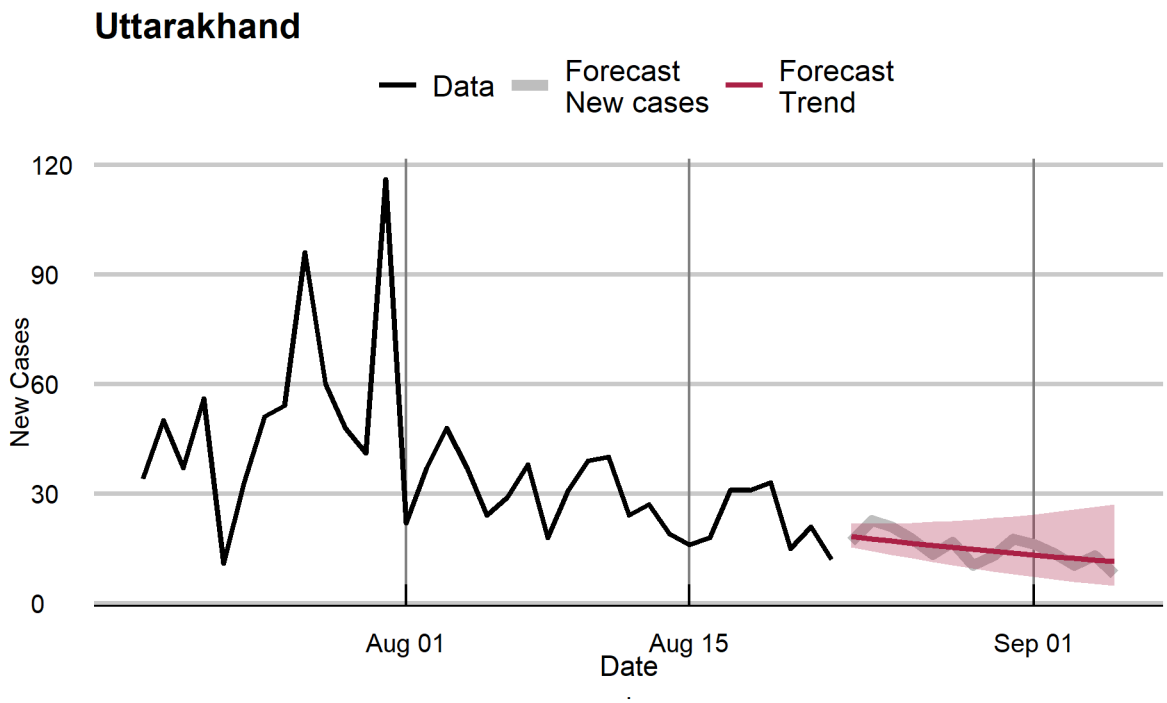

Tamil Nadu
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

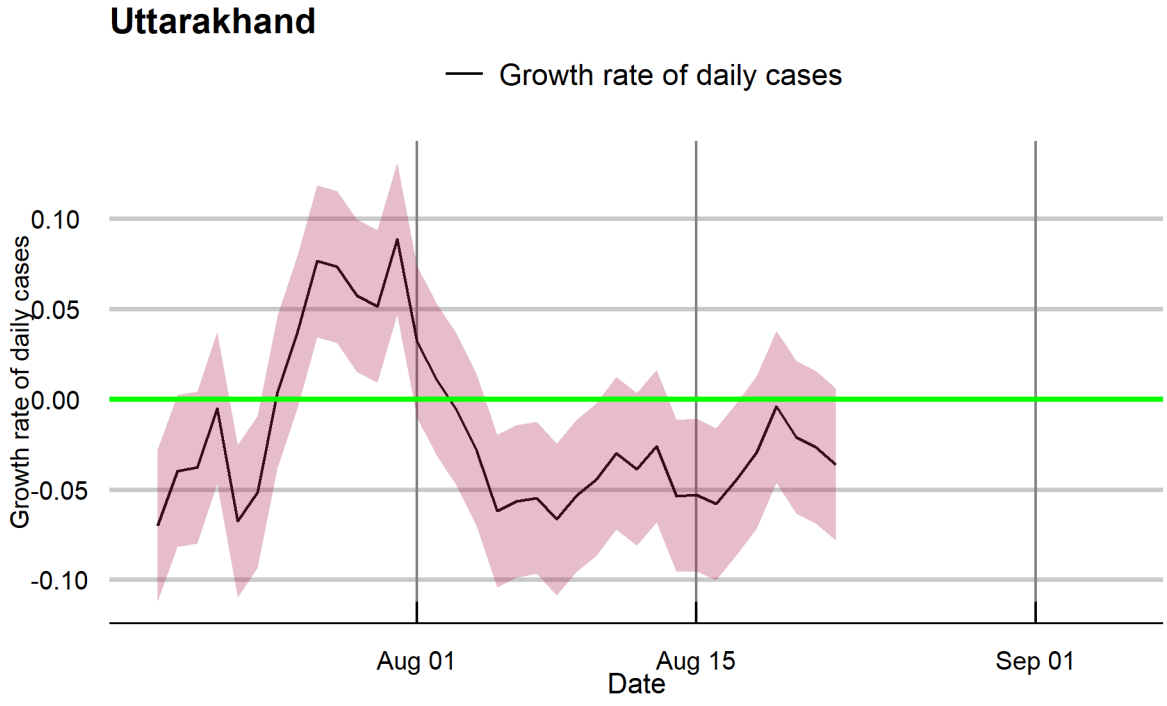

Telangana
Data
Forecast
New cases
Forecast
Trend
600
400
200
New Cases
Aug 01
Aug 15
Sep 01
Date

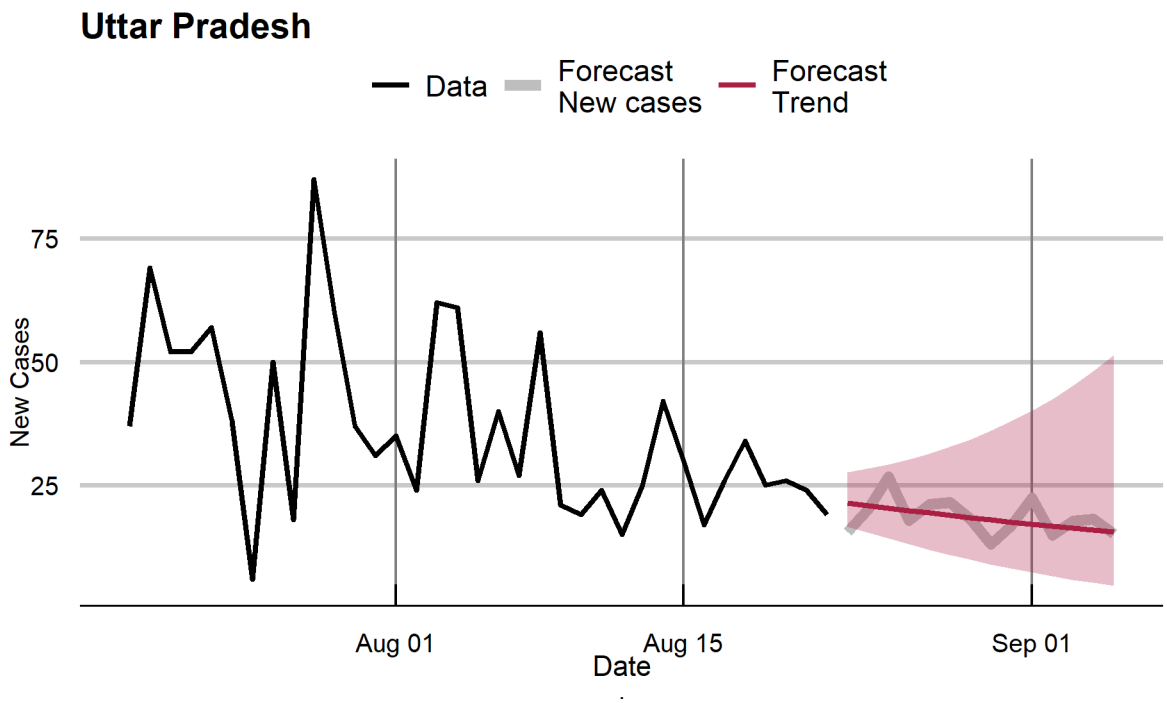

Telangana
Growth rate of daily cases
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

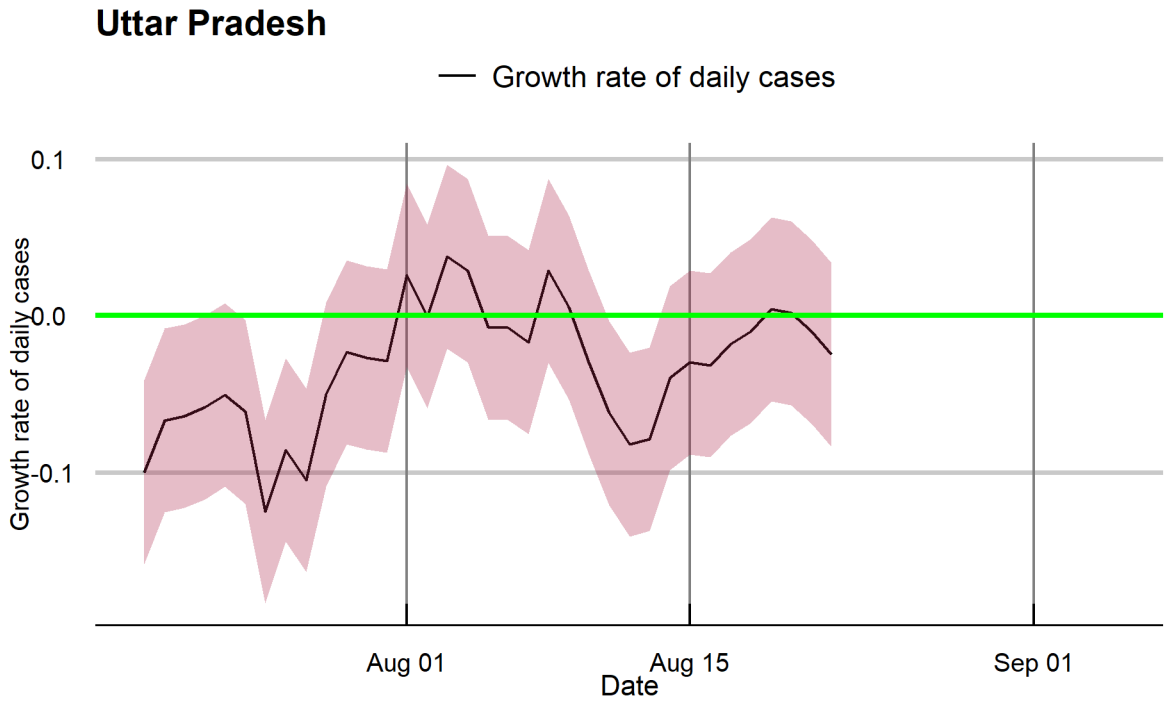

Tripura
Data
Forecast
New cases
Forecast
Trend
500
400
300
200
100
0
New Cases
Aug 01
Aug 15
Sep 01
Date

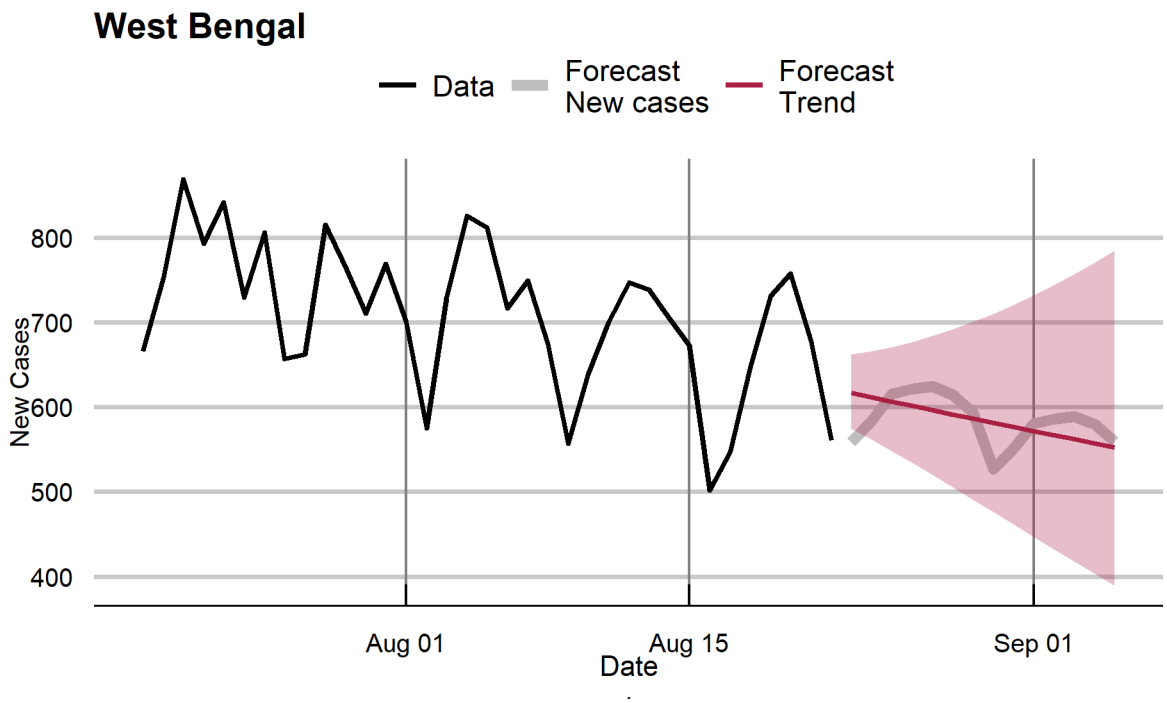

Tripura
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

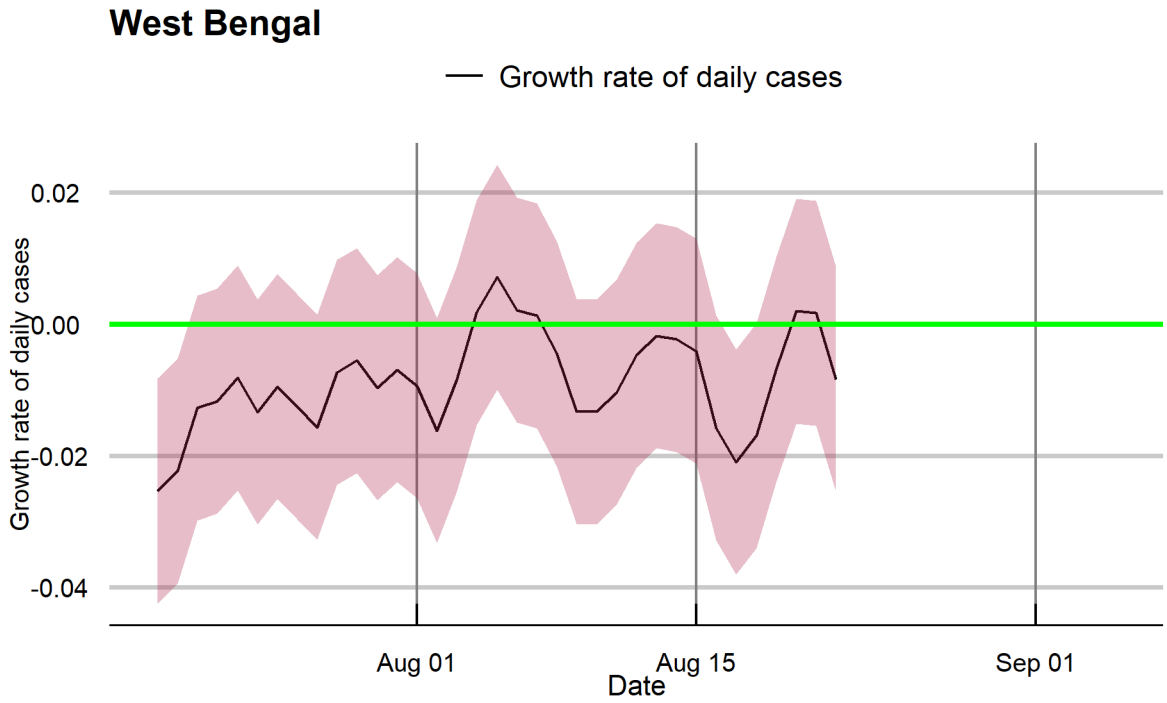

Uttarakhand
Data
Forecast
New cases
Forecast
Trend
120
90
60
30
0
New Cases
Aug 01
Aug 15
Sep 01
Date


Uttarakhand
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date


Uttar Pradesh
Data
Forecast
New cases
Forecast
Trend
75
50
25
New Cases
Aug 01
Aug 15
Sep 01
Date

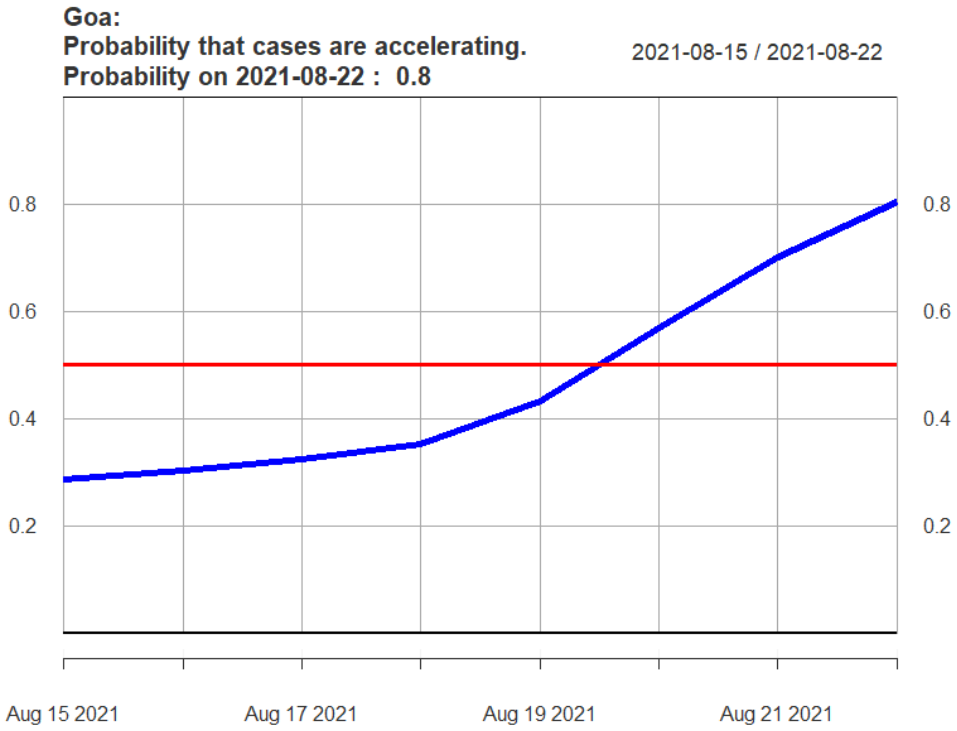

Uttar Pradesh
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

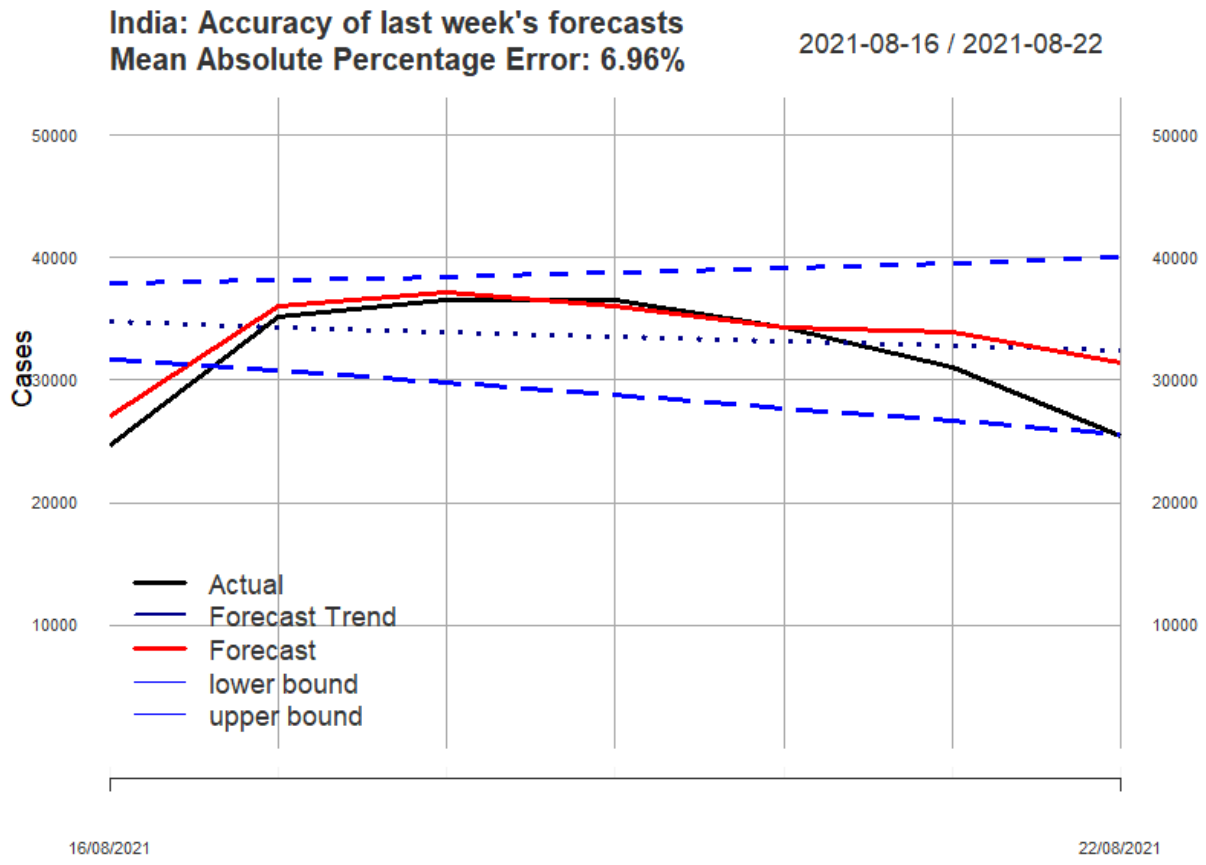

West Bengal
Data
Forecast
New cases
Forecast
Trend
800
700
600
500
400
New Cases
Aug 01
Aug 15
Sep 01
Date


West Bengal
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Date

The nature of growth in new cases:

States/UTs with high odds that case numbers are currently accelerating




India: Accuracy of last week's forecasts
Mean Absolute Percentage Error: 6.96%
2021-08-16 / 2021-08-22
Cases
50000
40000
30000
20000
10000
Actual
Forecast Trend
Forecast
lower bound
upper bound
16/08/2021
22/08/2021

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.

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