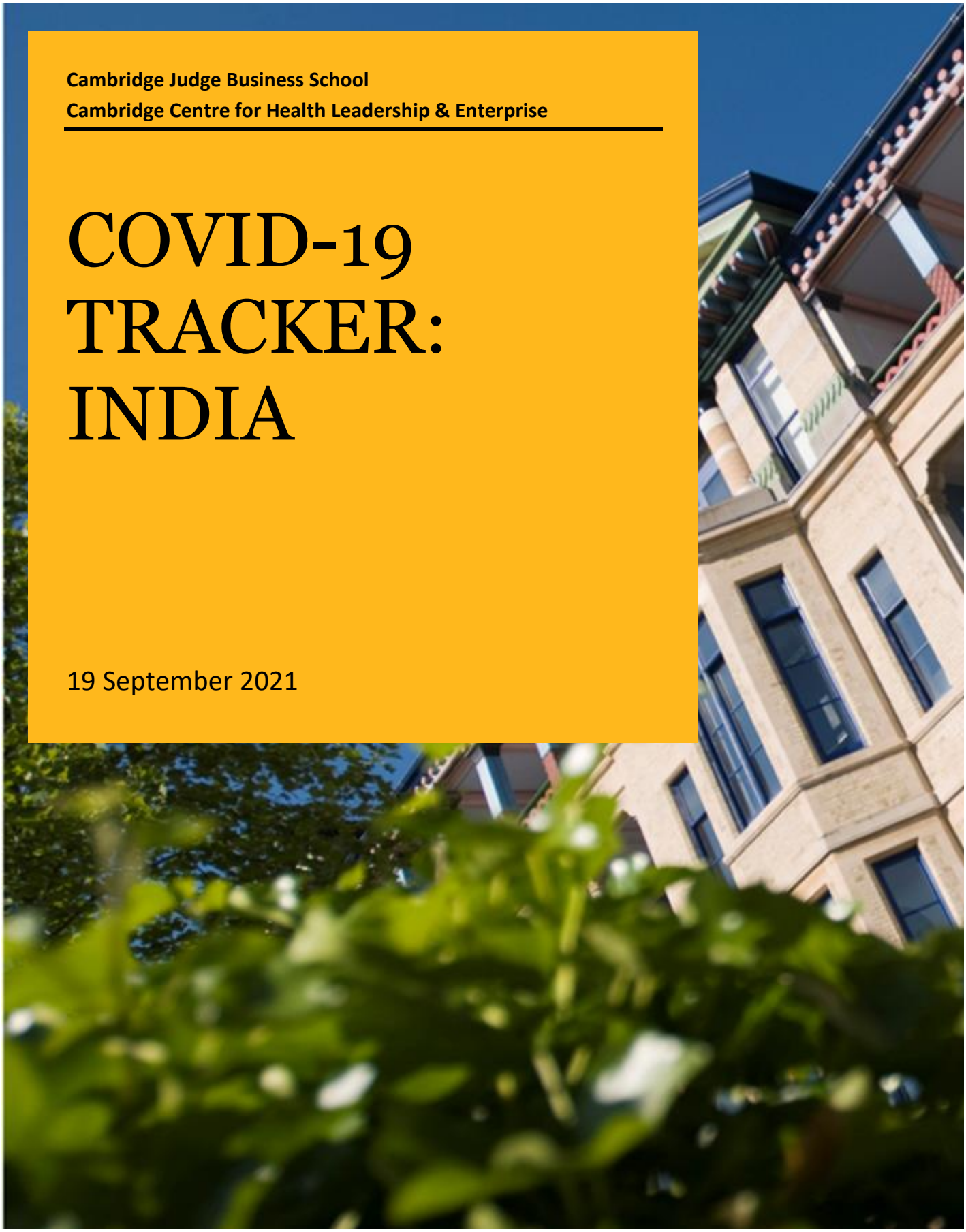
Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

19 September 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] was 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 has risen to 0.98 as of 19 September (up from 0.88 a week ago). The filtered daily growth rate has increased to -0.6% (up from -3.3% a week ago). The trend value of reported cases in India is expected to be around 27,250 per day in two weeks, by 3 October.

A rapid ascent of the growth rate of cases in Maharashtra (to 9.1% as of 19 September) is largely responsible for the national upturn. Maharashtra now accounts for 11% of the cases in country and has an R value of 1.44. Festival gatherings in September and associated increased testing appear to have contributed. On a positive note, the growth rate in the state peaked on September 16, and appears to be heading down (page 23). This mirrors the experience of Kerala, where a post-Onam surge in August began to dissipate swiftly. Note however that while daily cases continue to decline in Kerala, the growth rate of cases bottomed out on 16 September and has starting rising, though it remains negative as of now (page 21).

Nine other states show tendencies of increase in infection, of which Mizoram and Tamil Nadu have sizeable incidences and are of concern.

[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.

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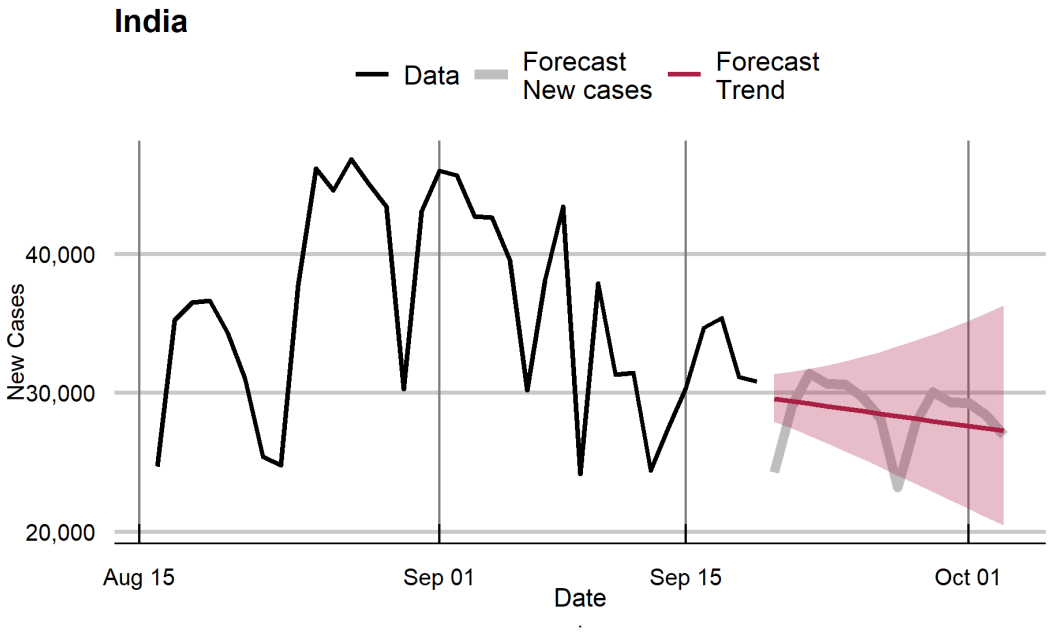
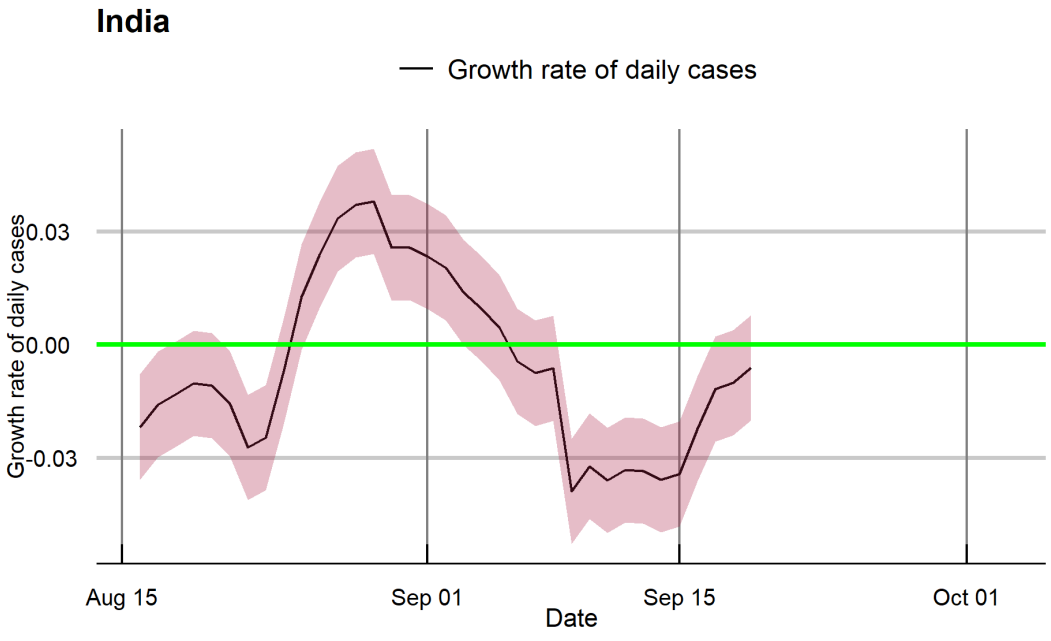
Daily Covid-19 cases in India: Forecast

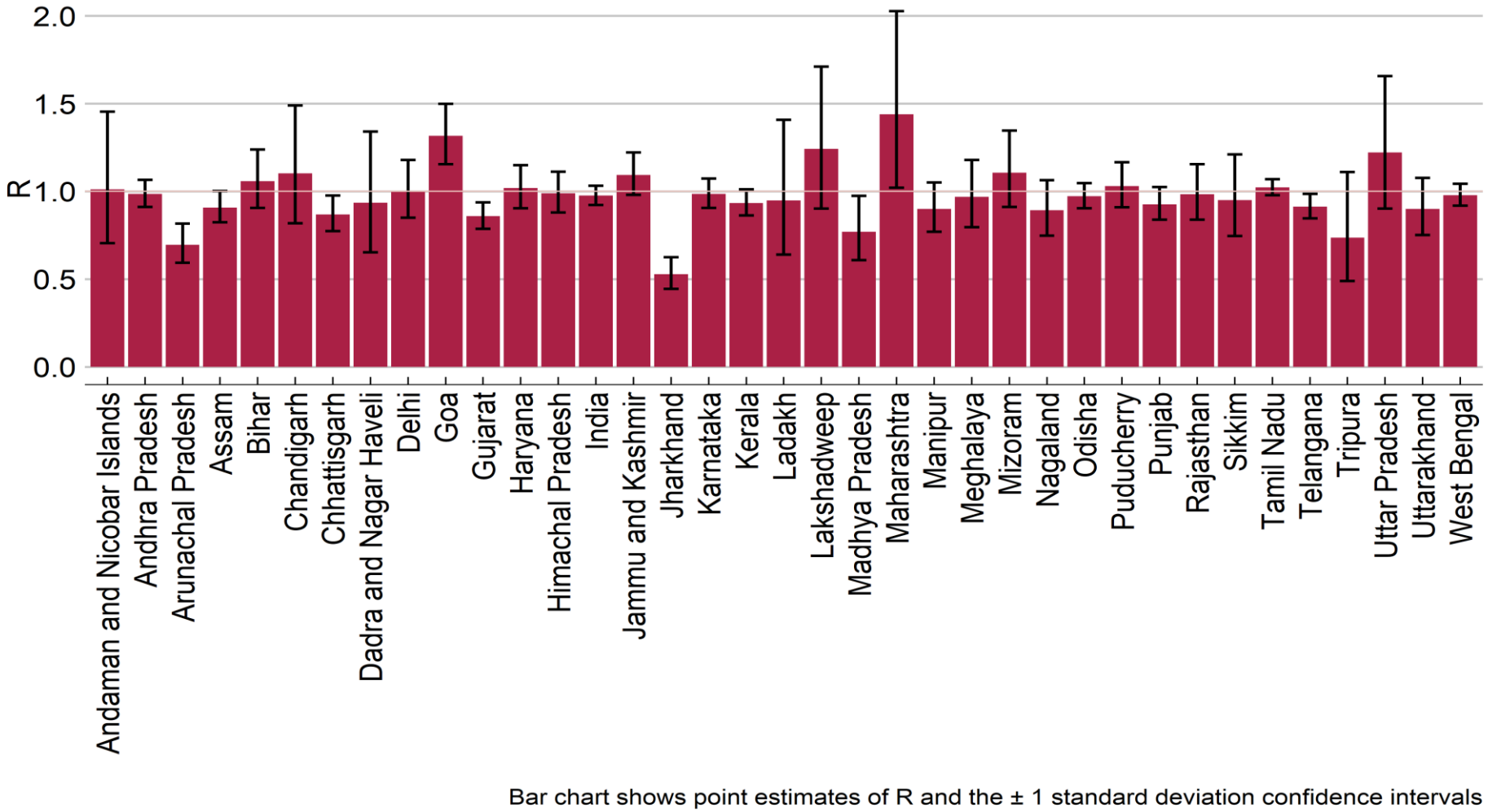
Forecasts of daily new cases for the period 20 September to 3 October 2021, based on data till 19 September 2021. The trend value of new COVID-19 cases is likely be around 27,250 per day by 3 October. The recent rising tendency of the growth rate suggests that this forecast may turn out to be optimistic.



The filtered growth rate of daily new cases was -0.006 (-0.6 %) as on 19 September 2021. The rising tendency in recent days might lead the growth rate to turn positive in the coming days.

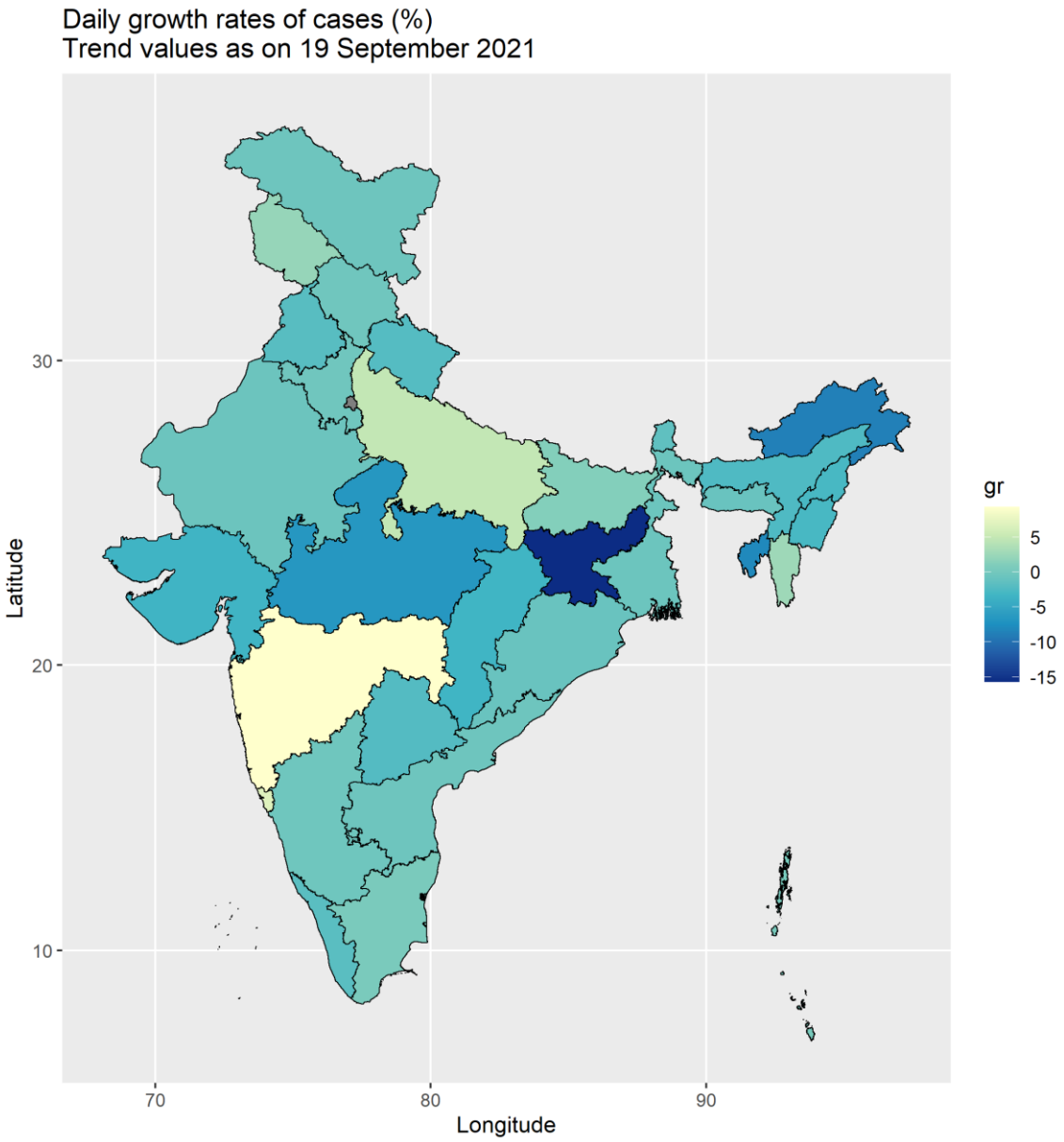


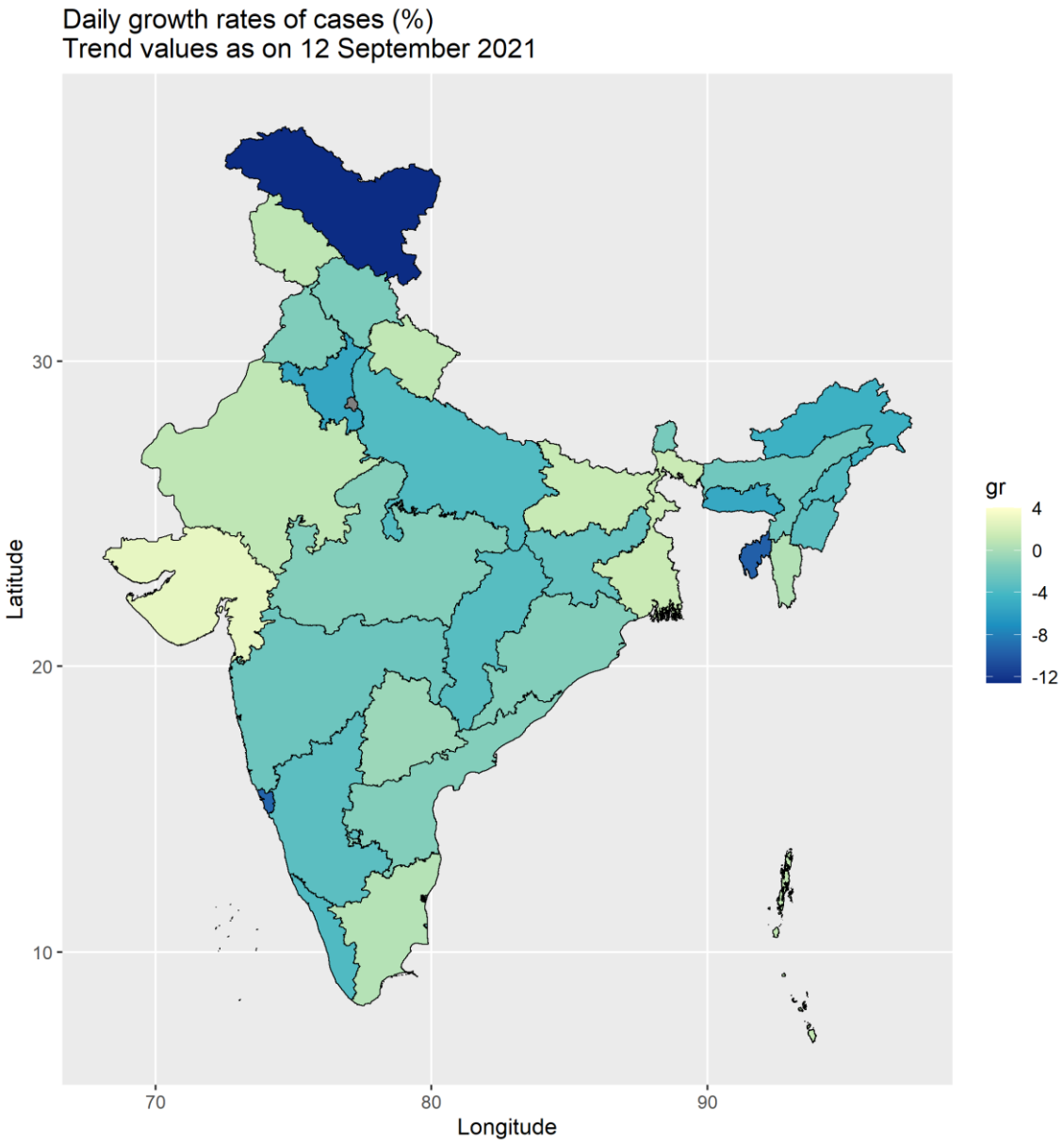
R_t: 19 September 2021



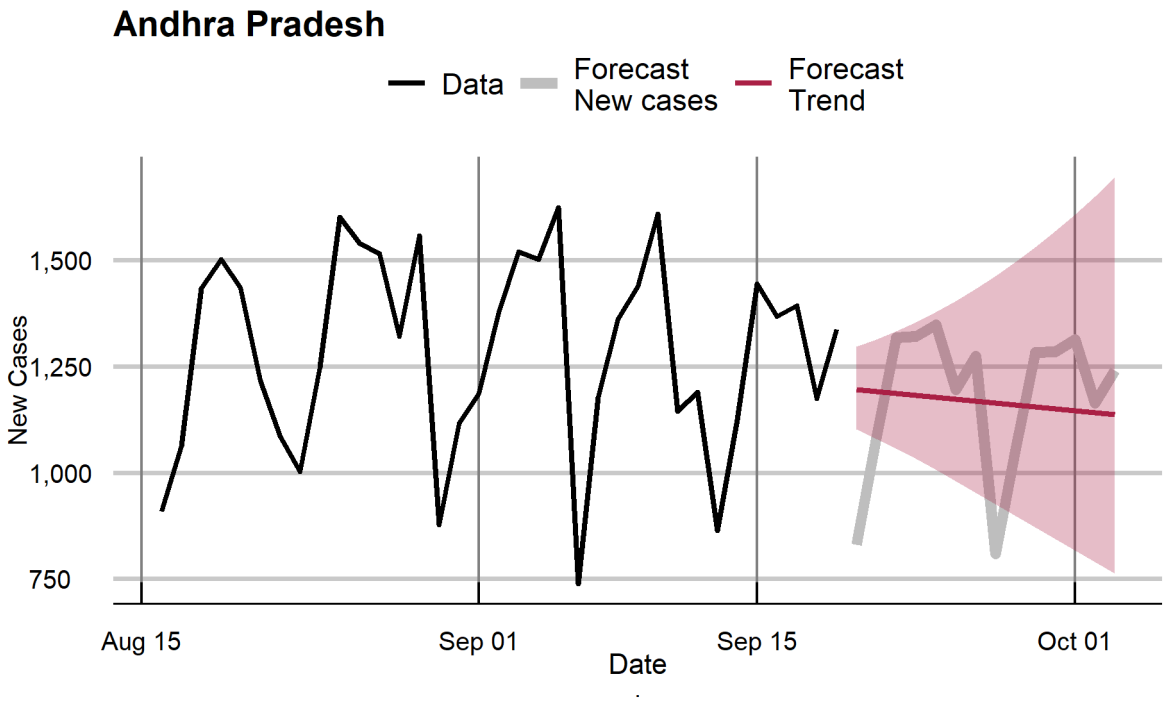
Bar chart shows point estimates of R and the ± 1 standard deviation confidence intervals

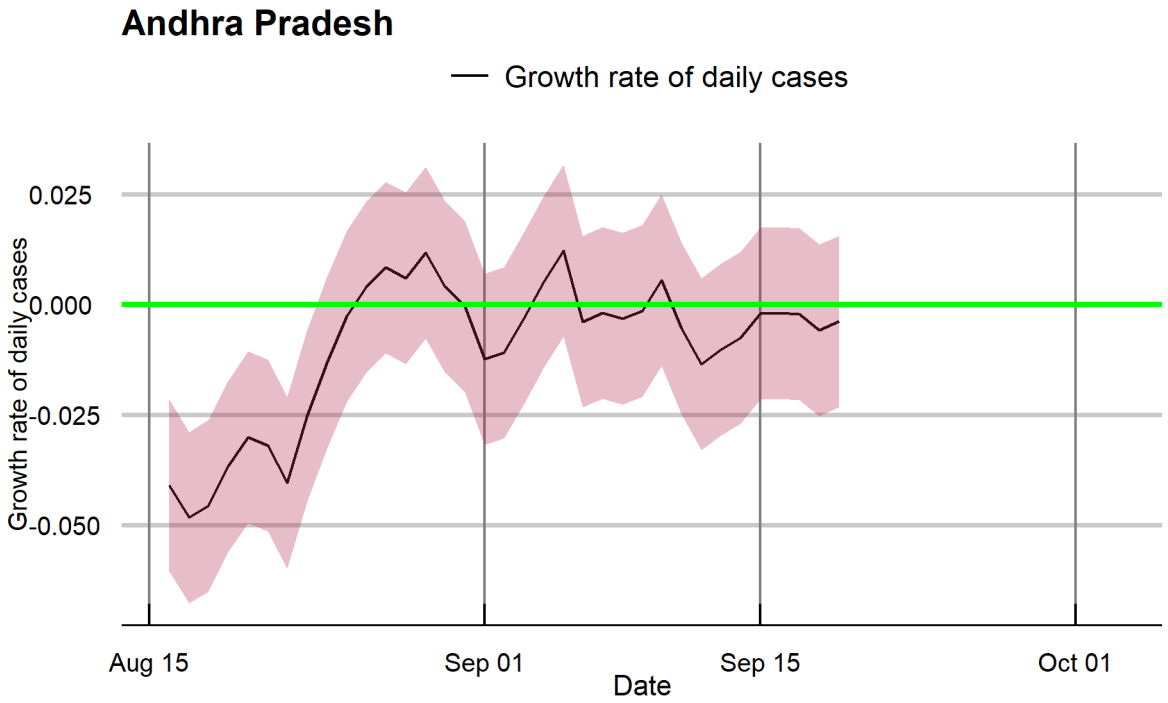
Note: Small daily numbers (less than 25) currently seen in Arunachal Pradesh, Bihar, Chandigarh, Chhattisgarh, Gujarat, Haryana, Jharkhand, Madhya Pradesh, Nagaland, Rajasthan and Uttarakhand, make their estimates and forecasts less precise.

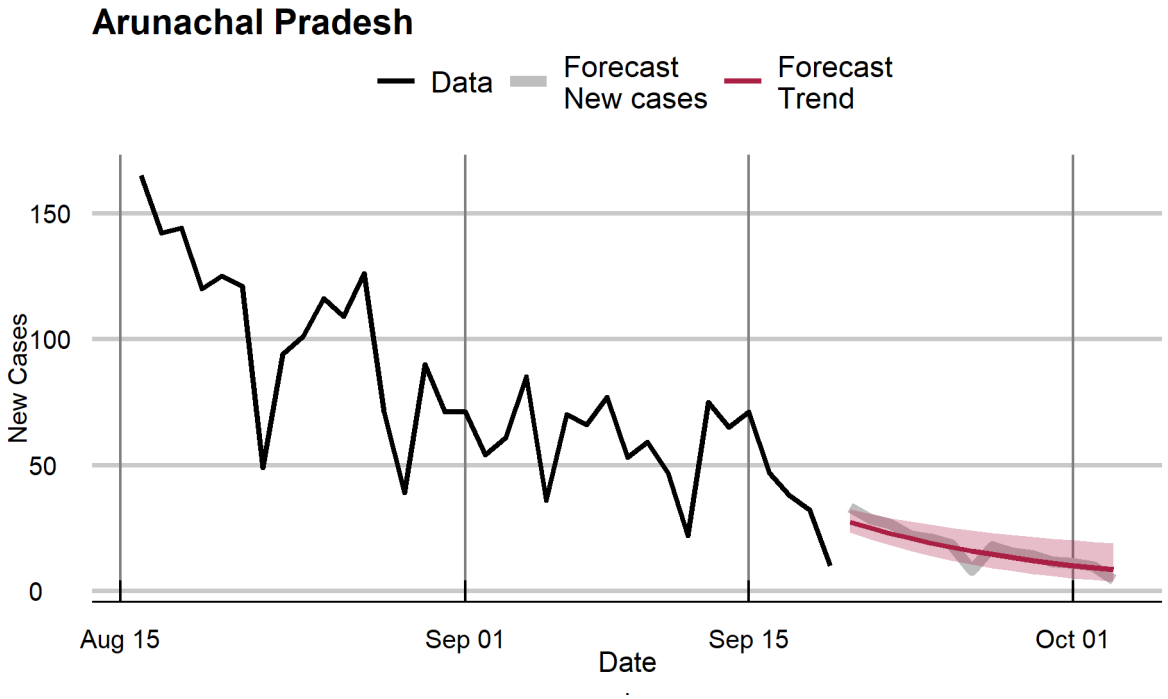

Daily growth rates of cases (%)
Trend values as on 19 September 2021
Latitude
30
20
10
70
80
90
Longitude
gr
5
0
-5
-10
-15

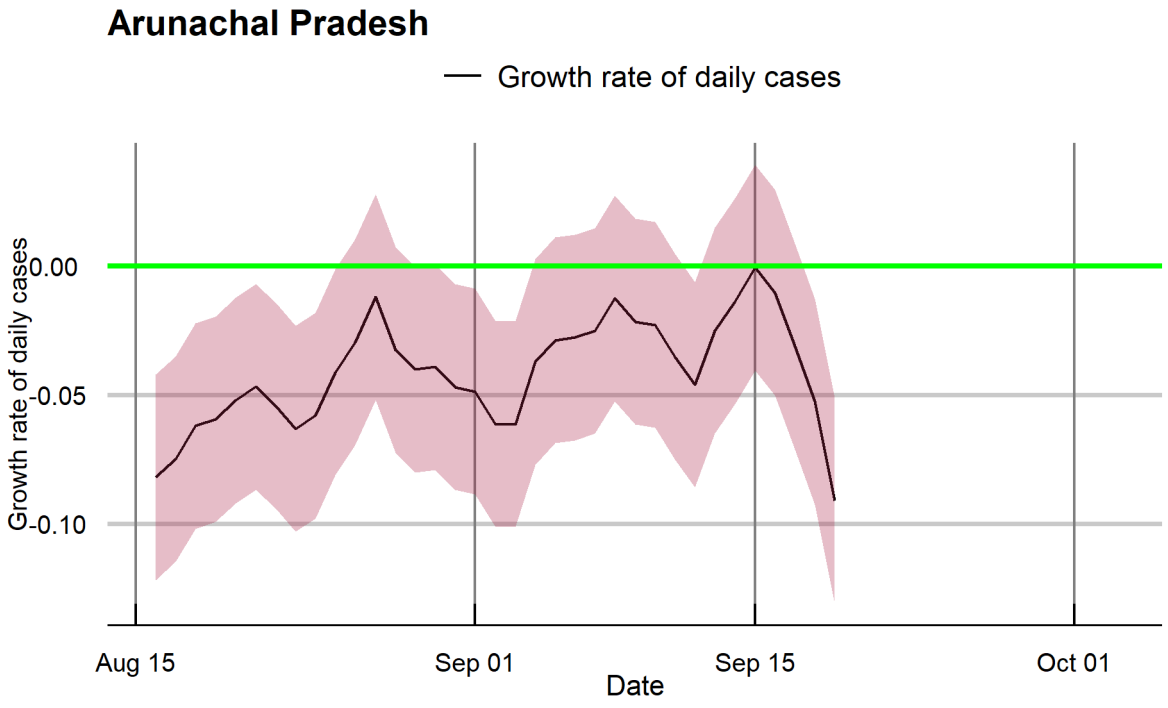

Daily growth rates of cases (%)
Trend values as on 12 September 2021
Latitude
30
20
10
70
80
90
Longitude
gr
4
0
-4
-8
-12

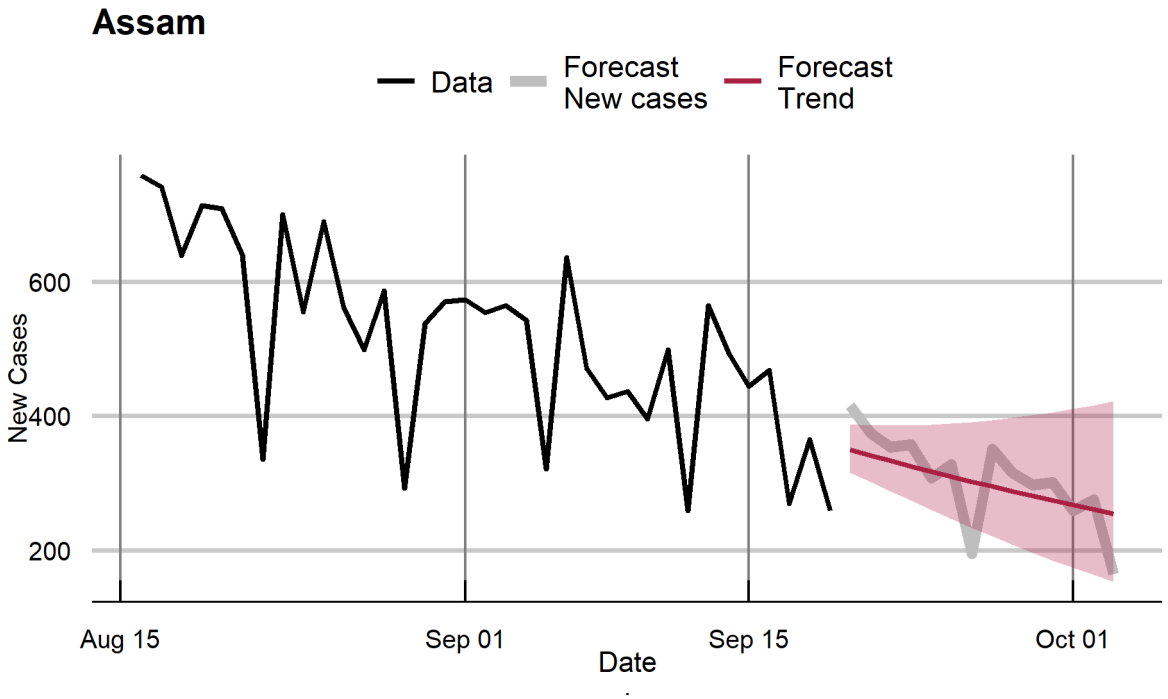
Case forecasts and growth rates: States and Union territories

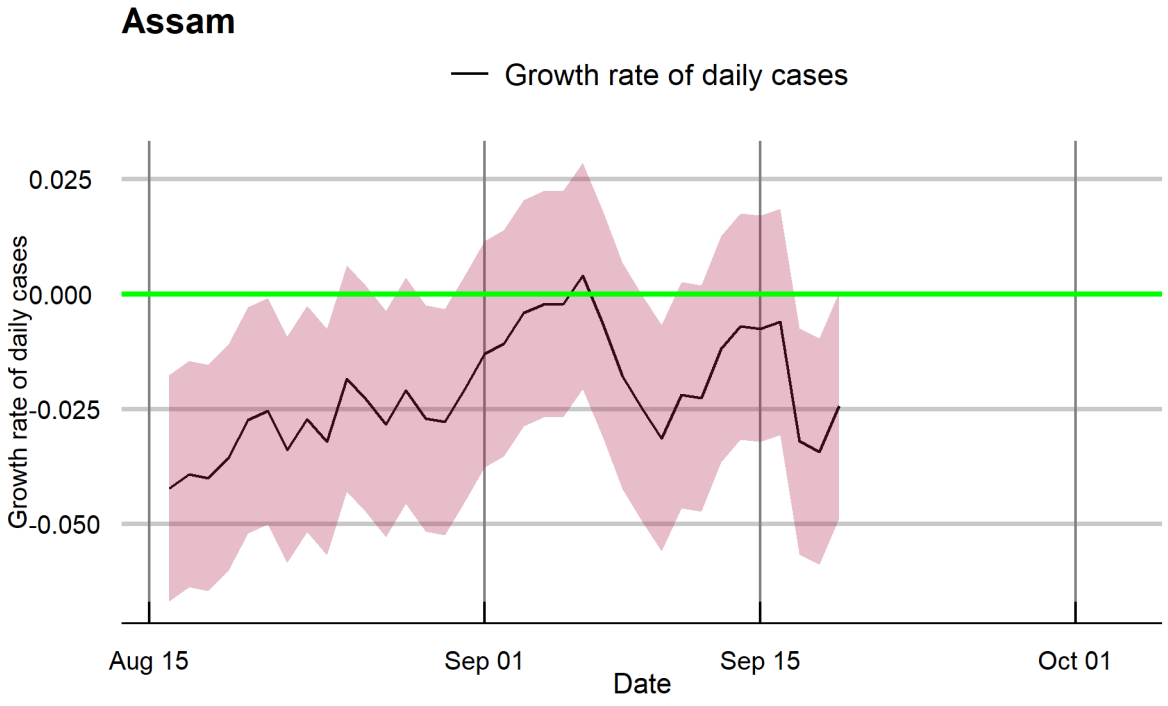


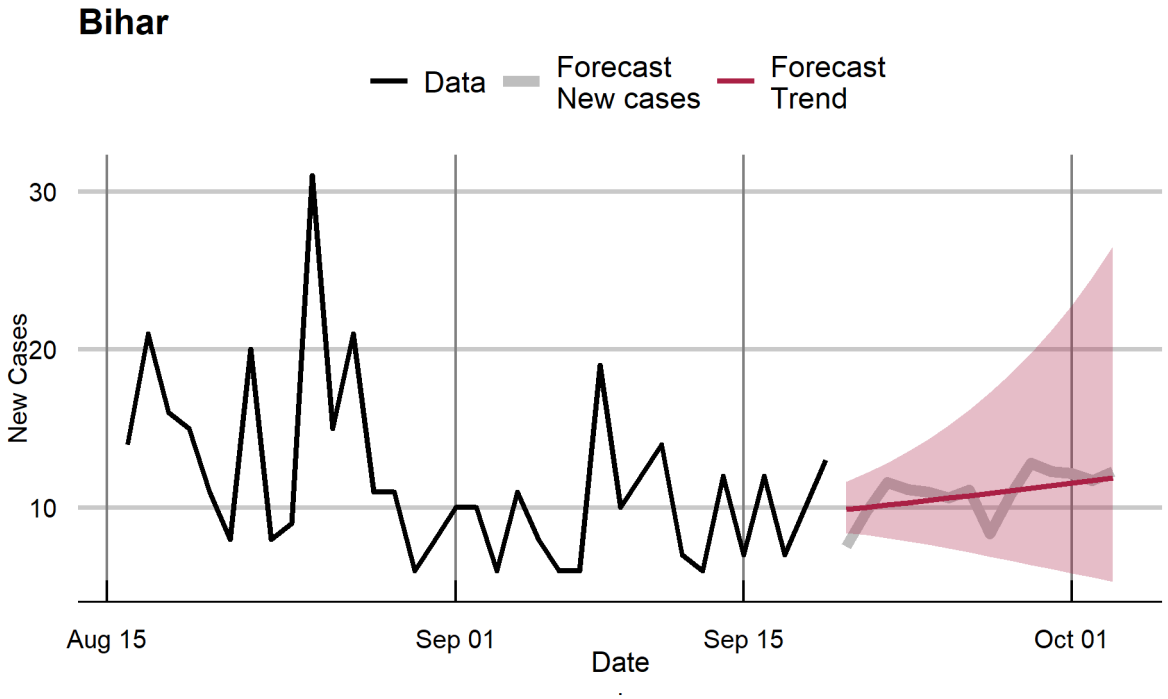


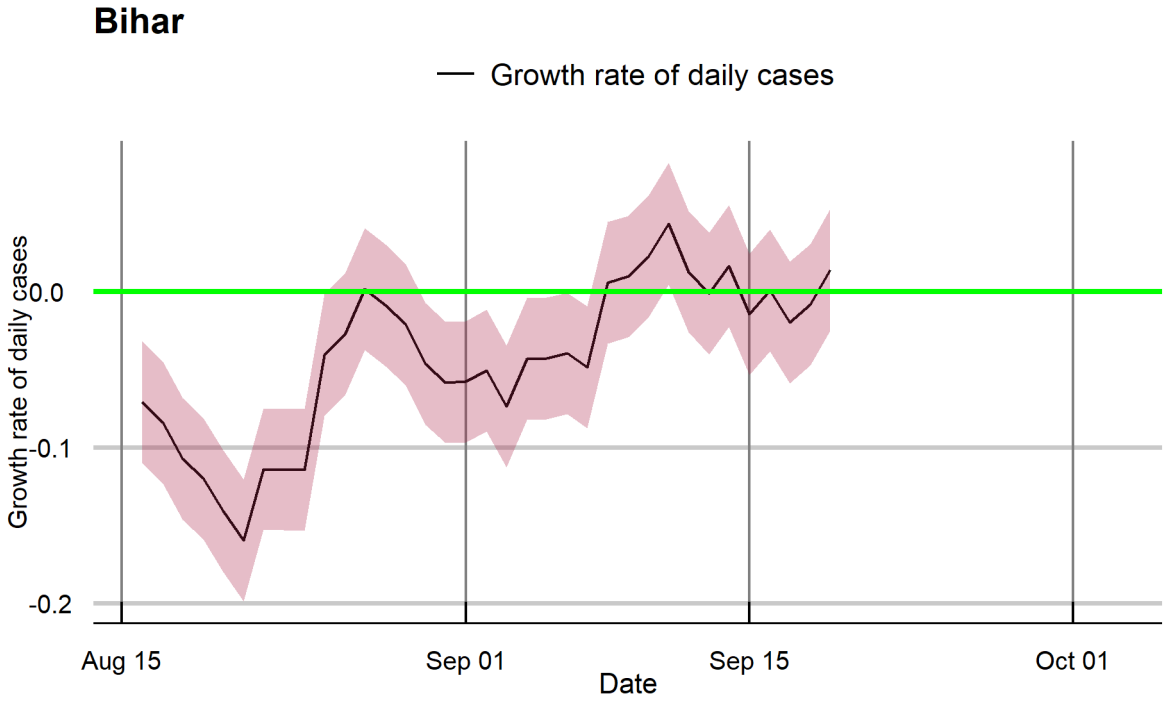

Arunachal Pradesh
Data
Forecast
New cases
Forecast
Trend
150
100
50
0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

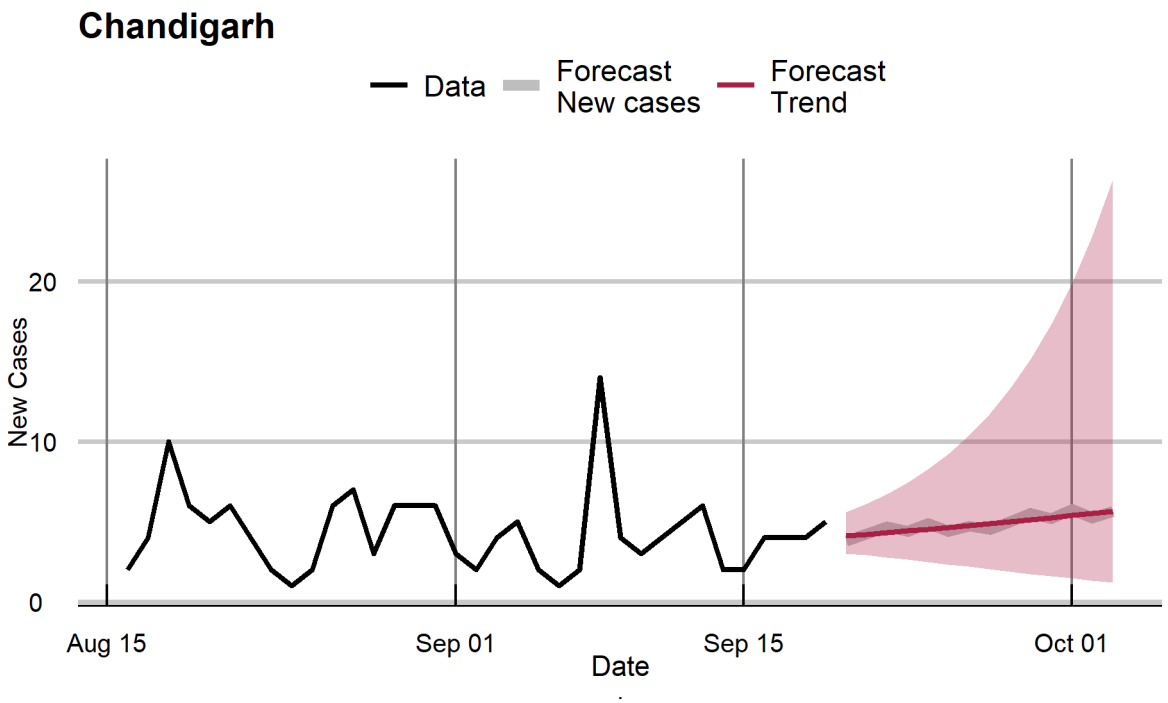

Arunachal Pradesh
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

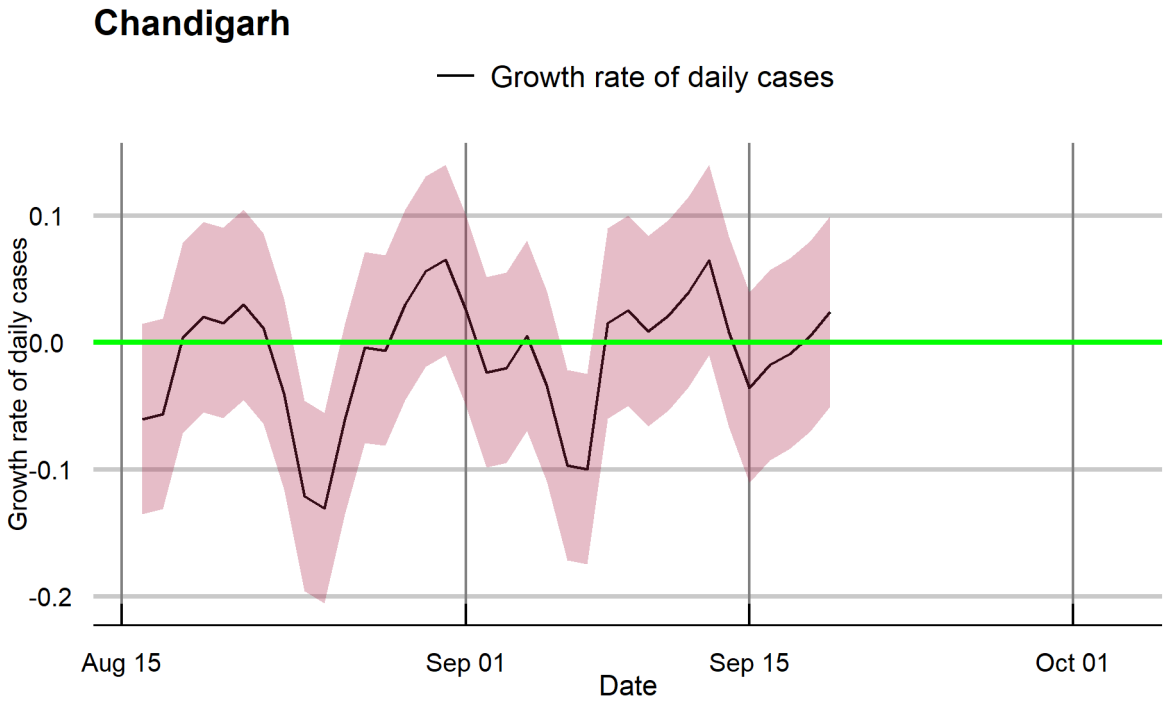

Assam
Data
Forecast
New cases
Forecast
Trend
600
400
200
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

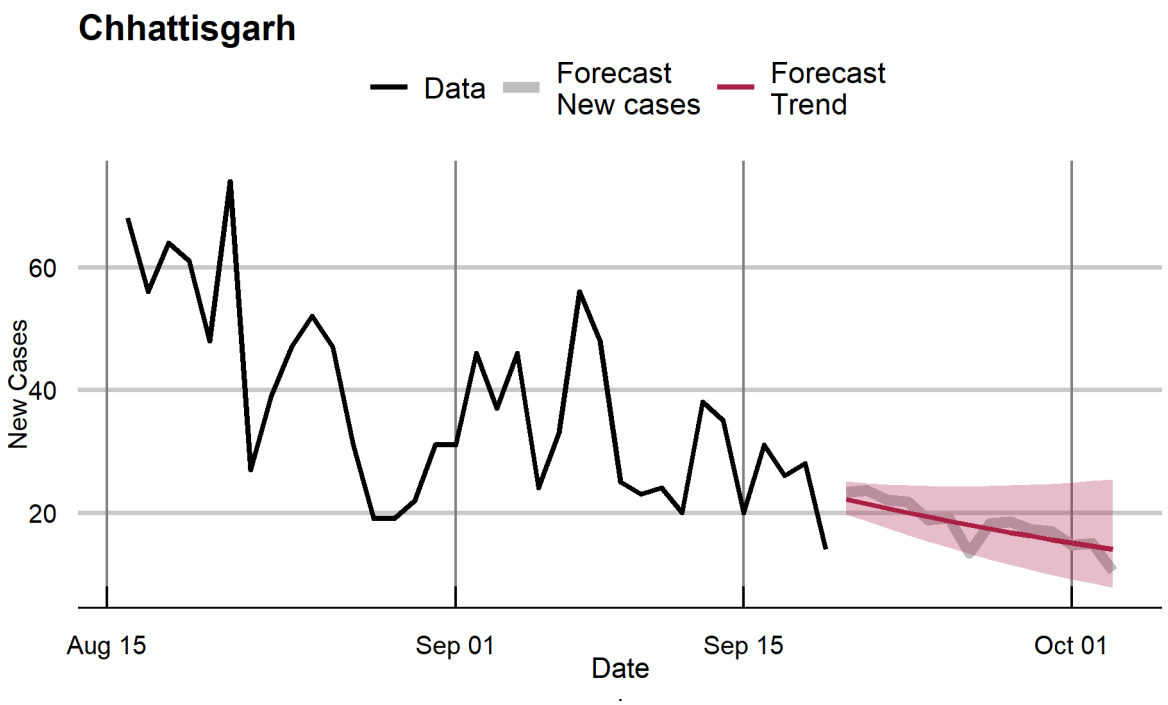

Assam
Growth rate of daily cases
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

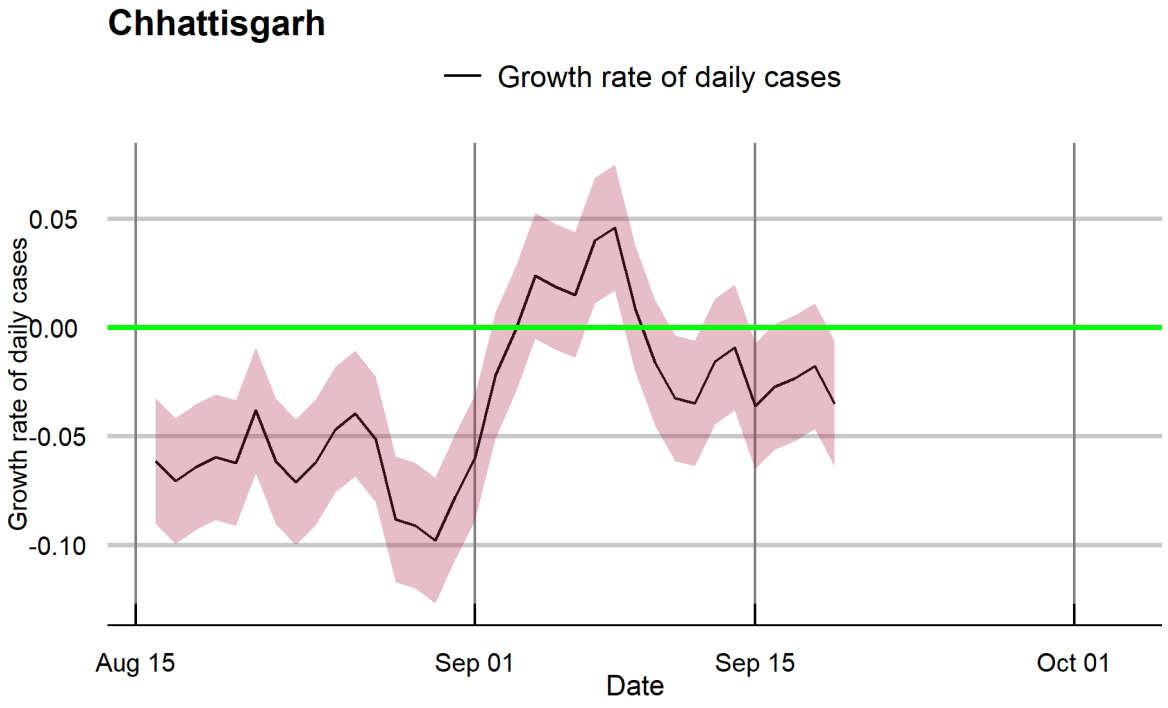

Bihar
Data
Forecast
New cases
Forecast
Trend
30
20
10
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

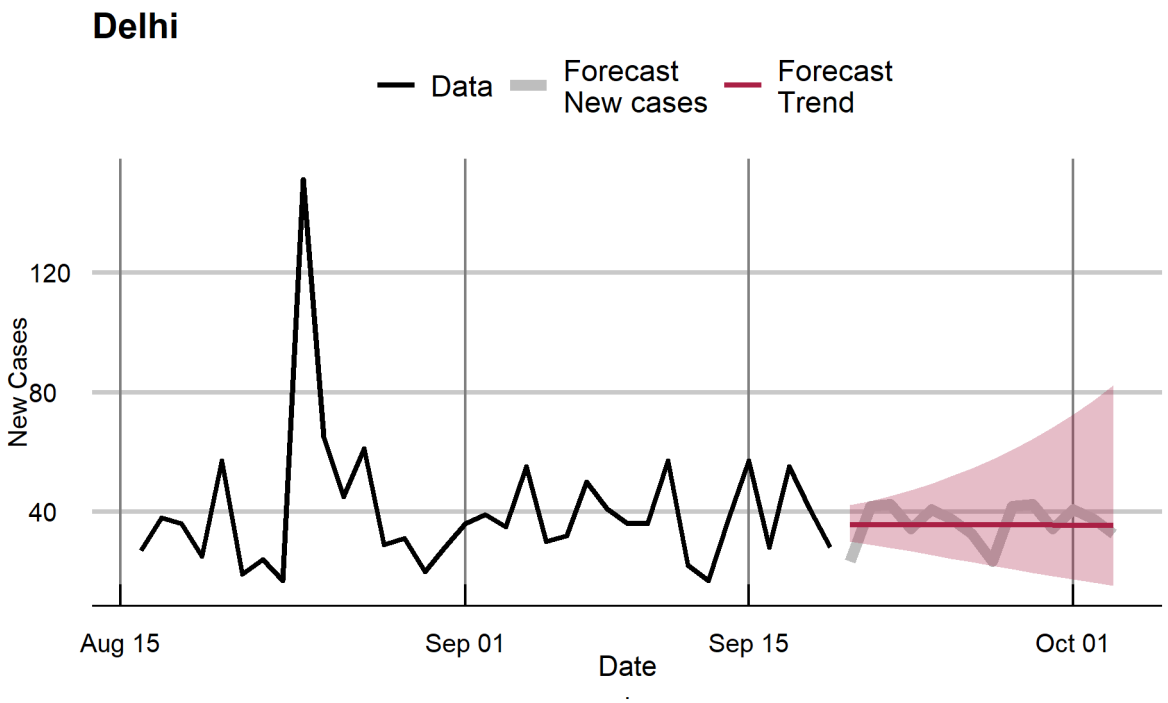

Bihar
Growth rate of daily cases
0.0
-0.1
-0.2
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

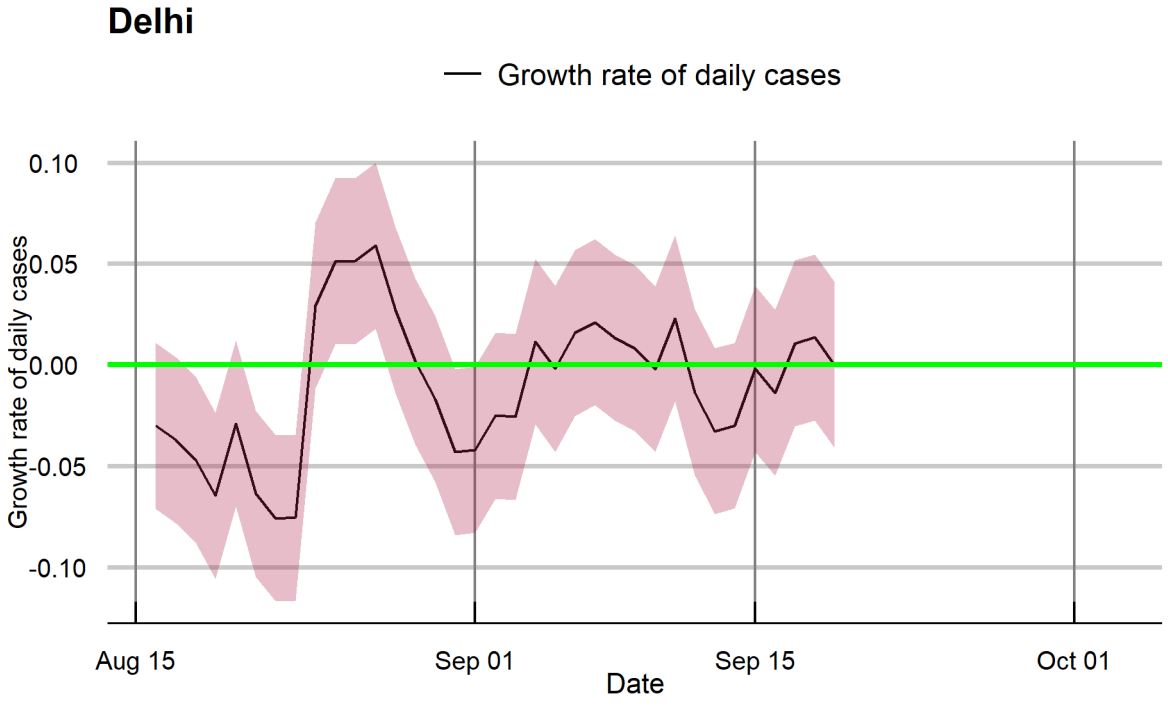

Chandigarh
Data
Forecast
New cases
Forecast
Trend
20
10
0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

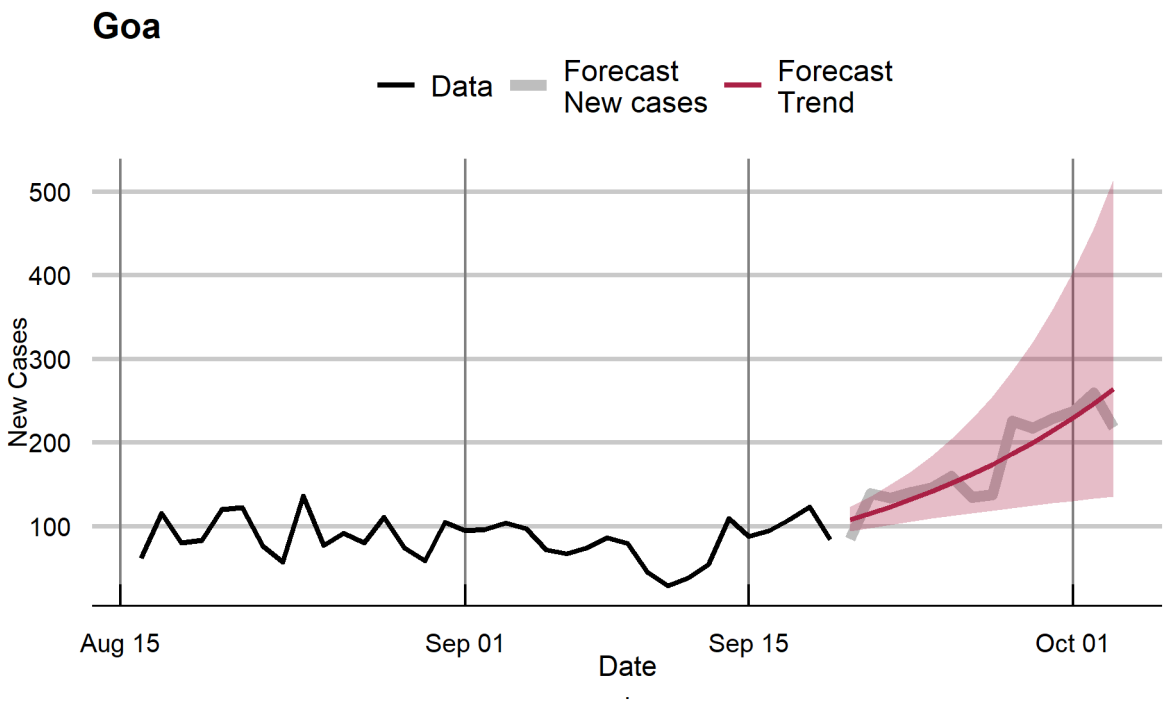

Chandigarh
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

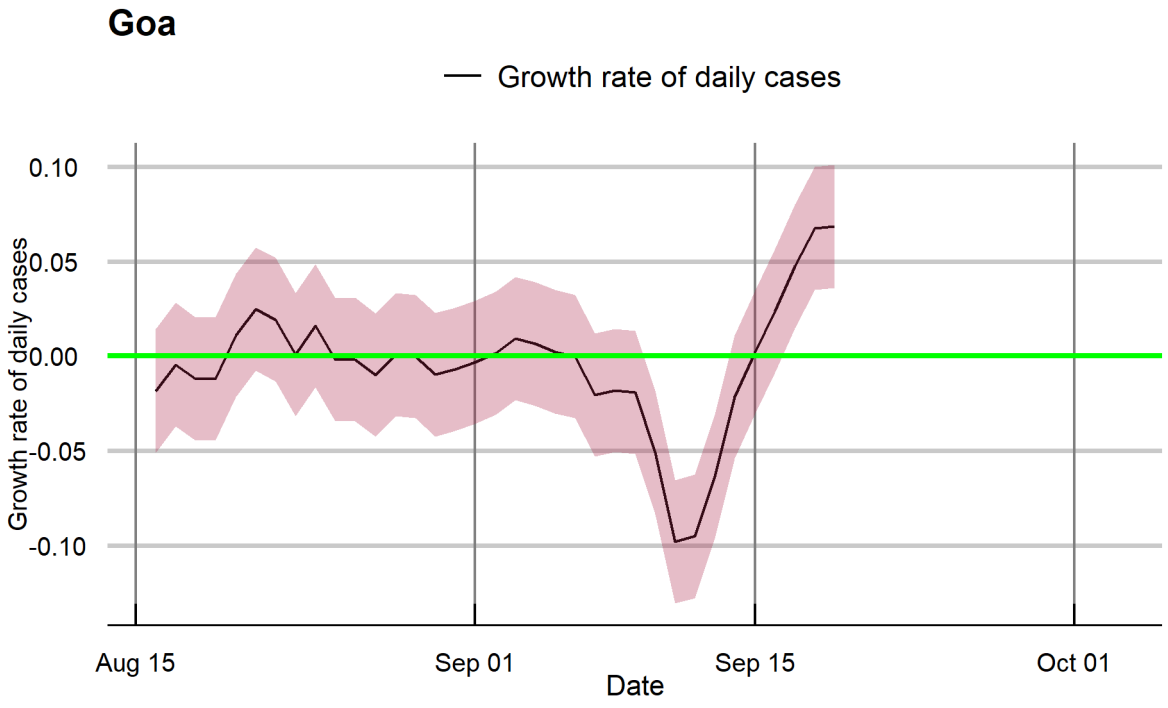

Chhattisgarh
Data
Forecast
New cases
Forecast
Trend
New Cases
60
40
20
Aug 15
Sep 01
Sep 15
Oct 01
Date

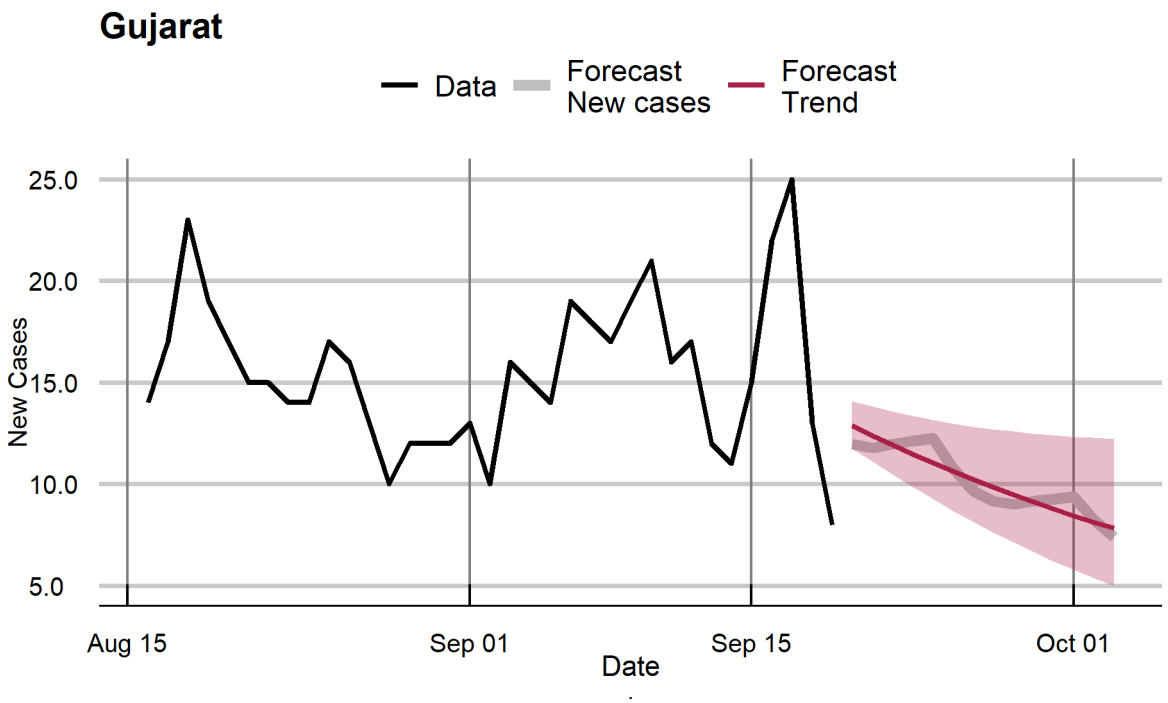

Chhattisgarh
Growth rate of daily cases
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Aug 15
Sep 01
Sep 15
Oct 01
Date

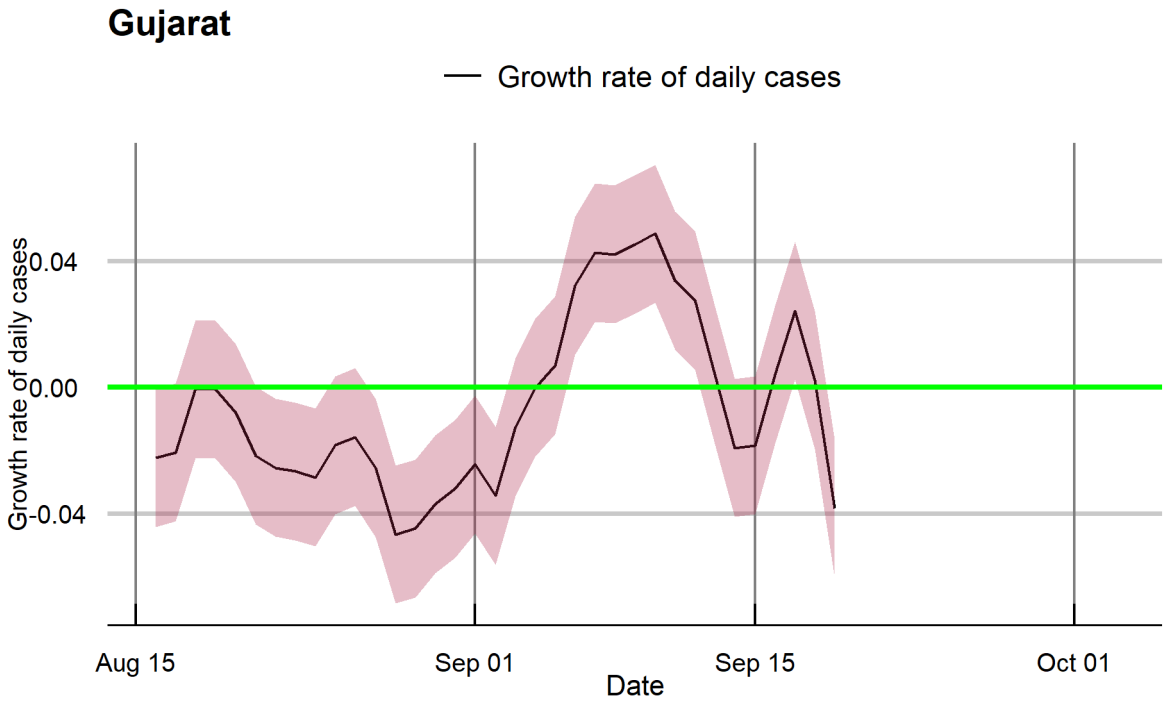

Delhi
Data
Forecast
New cases
Forecast
Trend
120
80
40
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

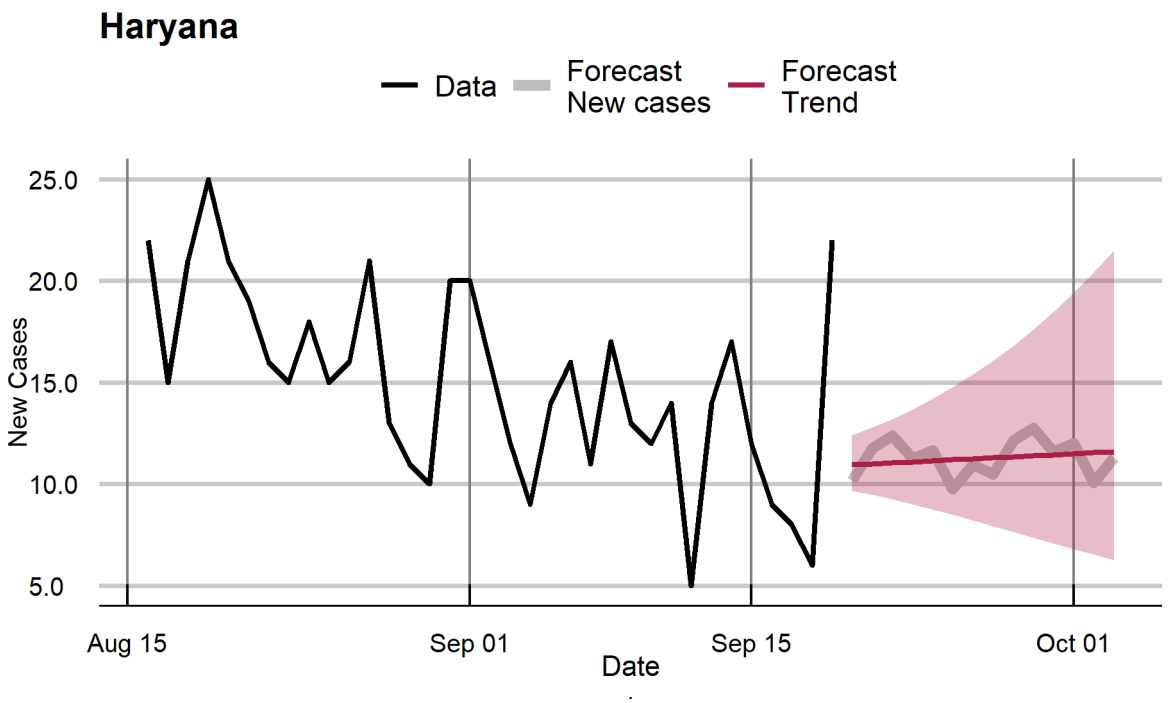

Delhi
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

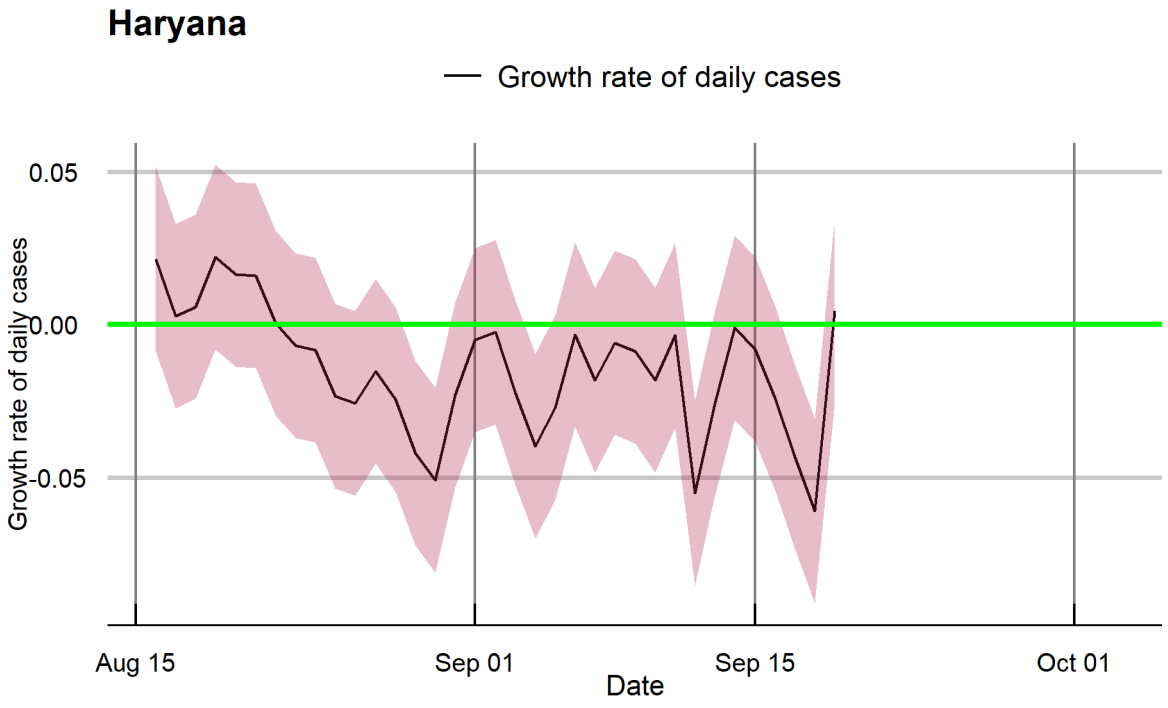

Goa
Data
Forecast
New cases
Forecast
Trend
500
400
300
200
100
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

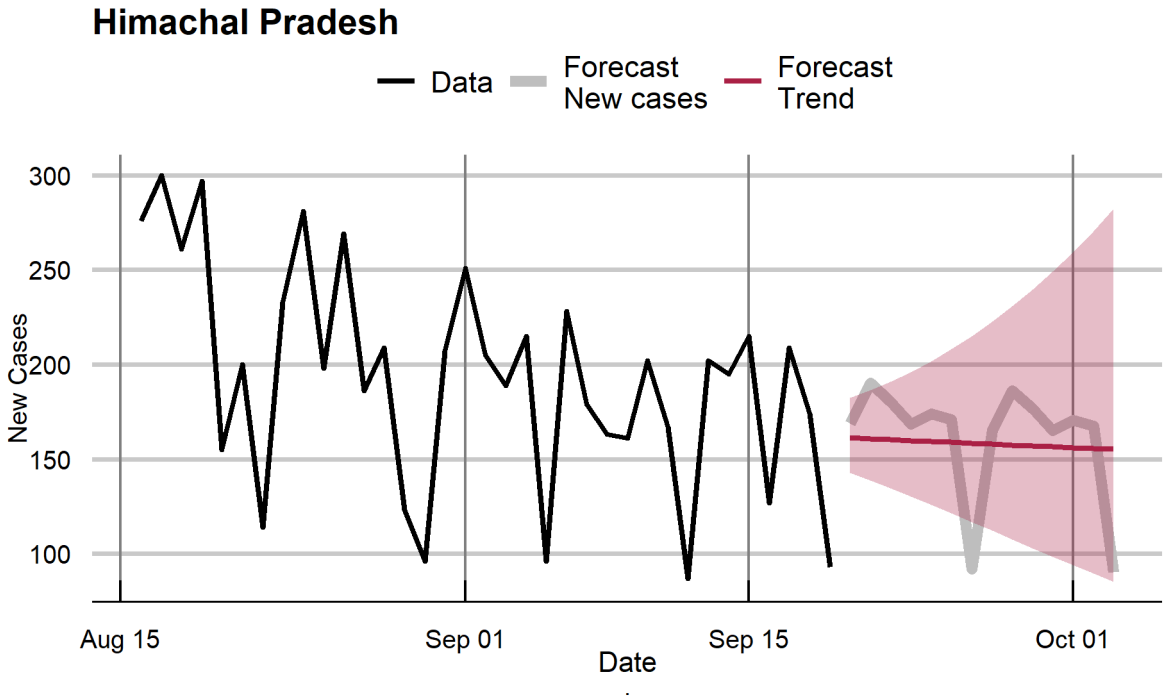

Goa
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

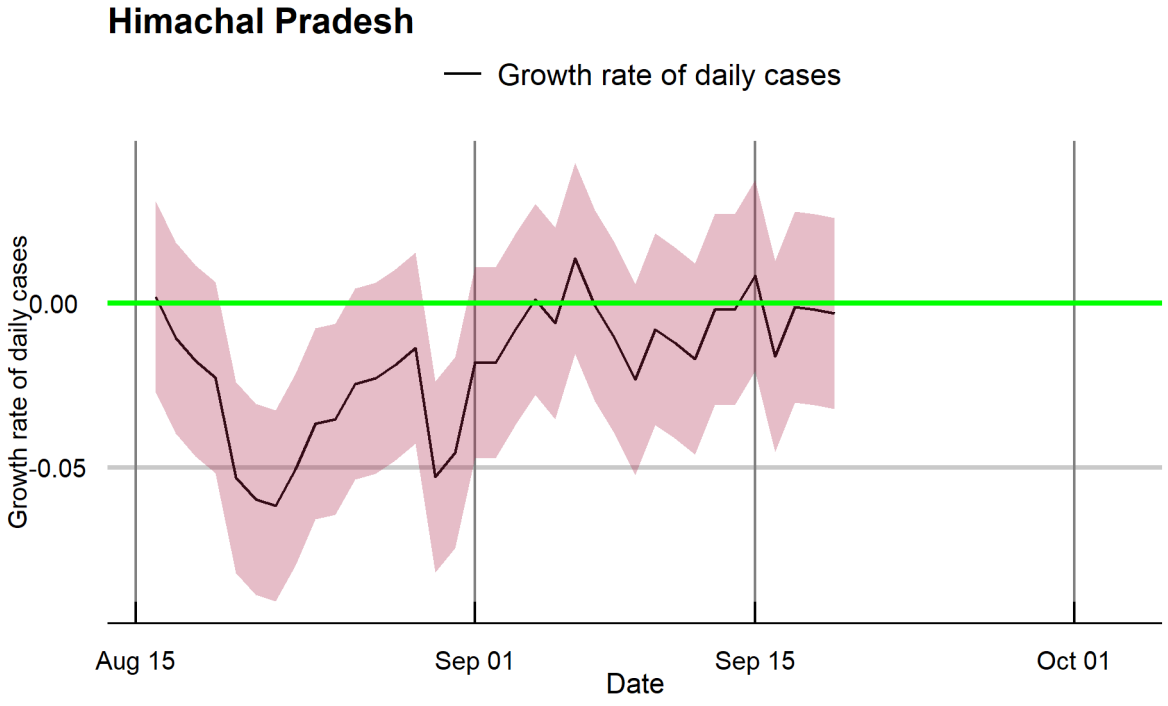

Gujarat
Data
Forecast
New cases
Forecast
Trend
25.0
20.0
15.0
10.0
5.0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

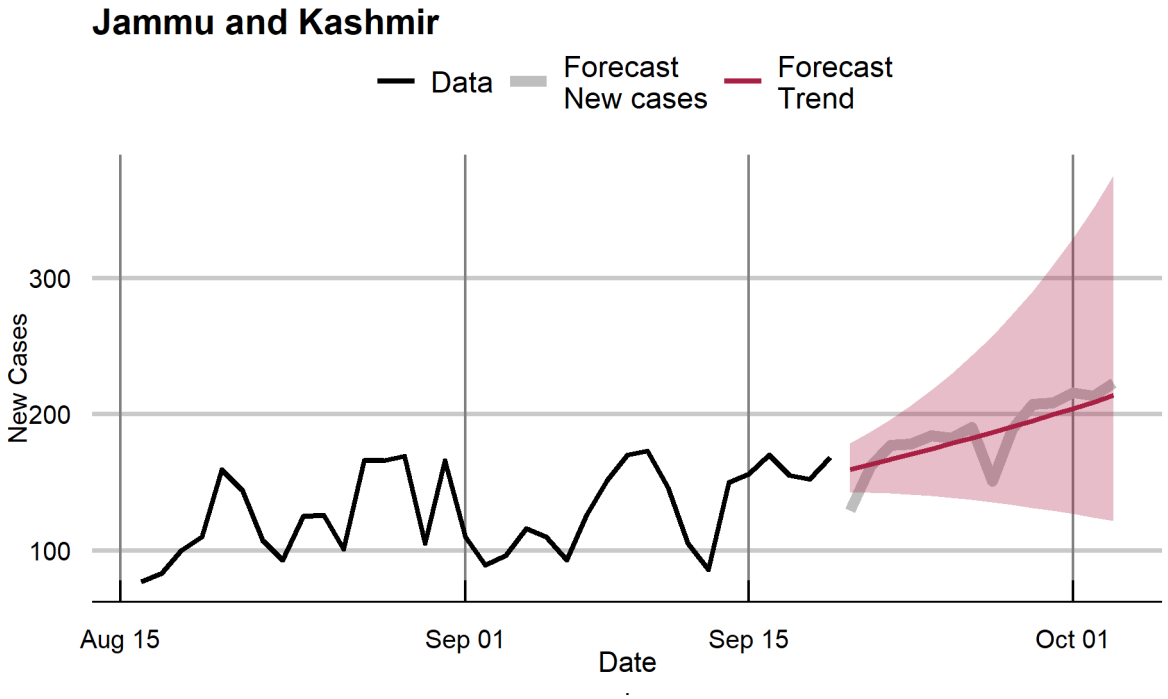

Gujarat
Growth rate of daily cases
0.04
0.00
-0.04
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

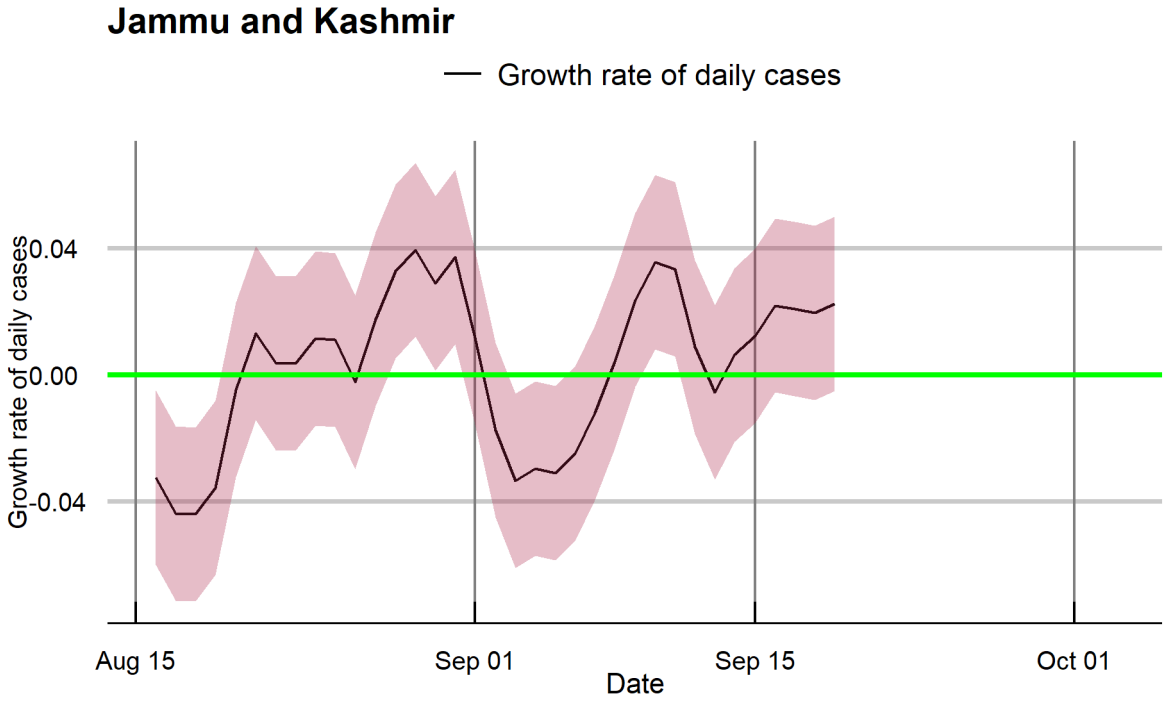

Haryana
Data
Forecast
New cases
Forecast
Trend
25.0
20.0
15.0
10.0
5.0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

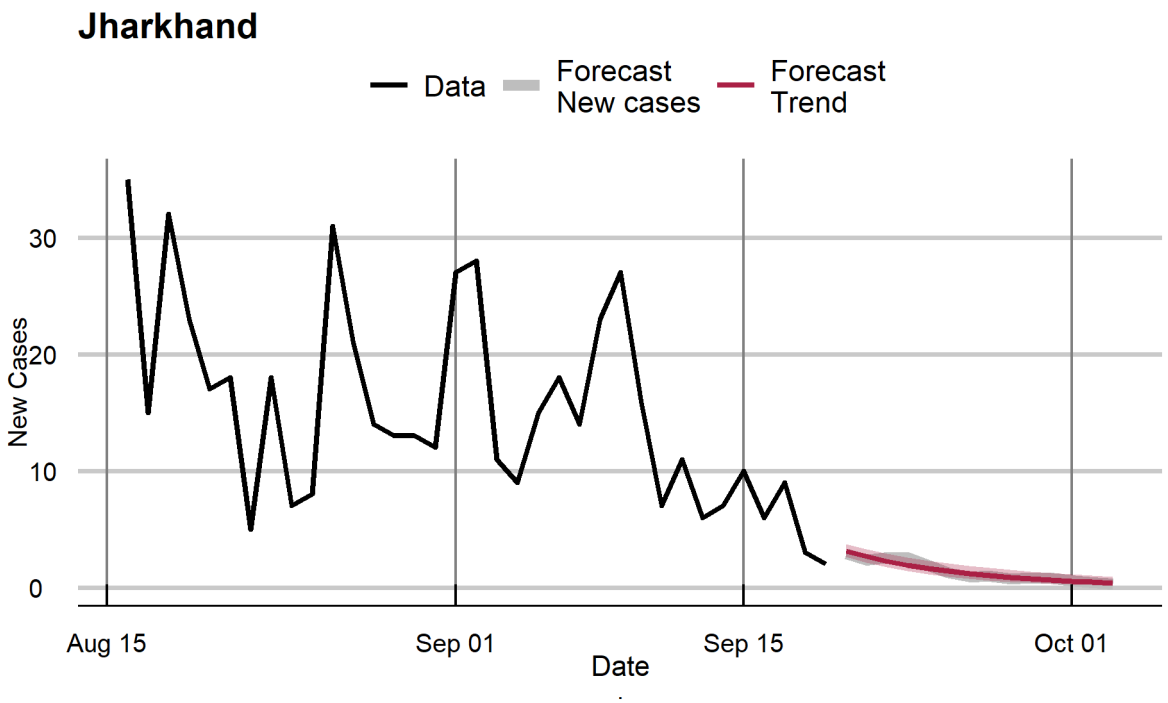

Haryana
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

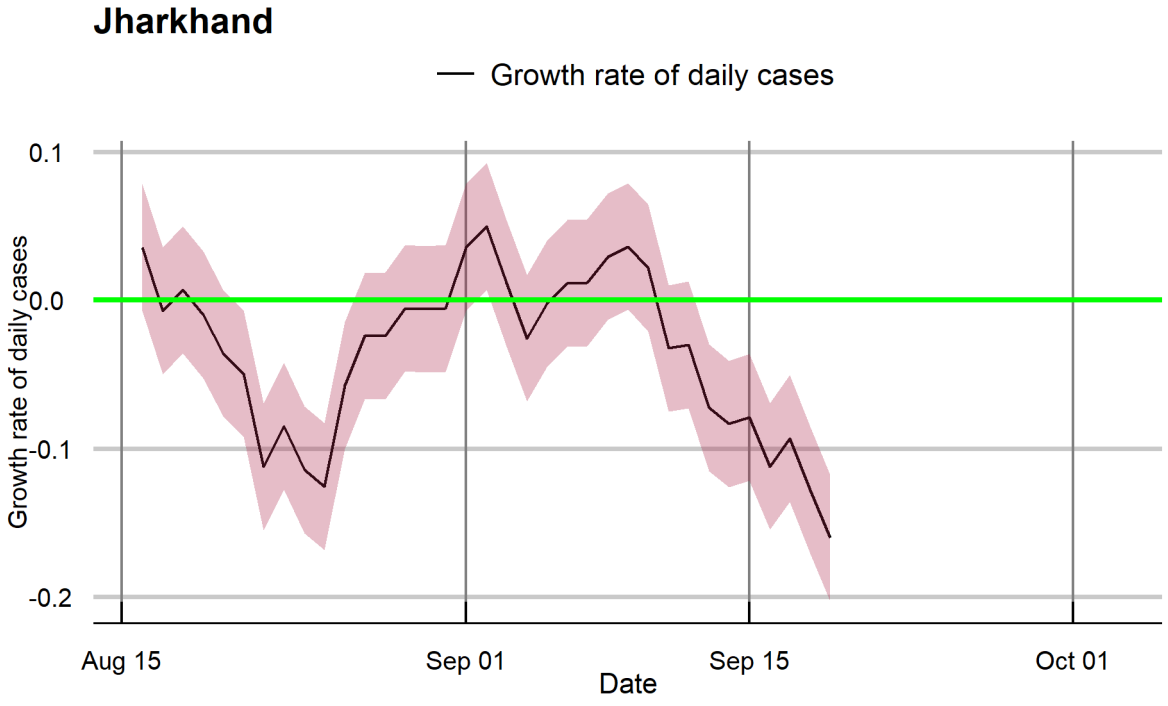

Himachal Pradesh
Data
Forecast
New cases
Forecast
Trend
300
250
200
150
100
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

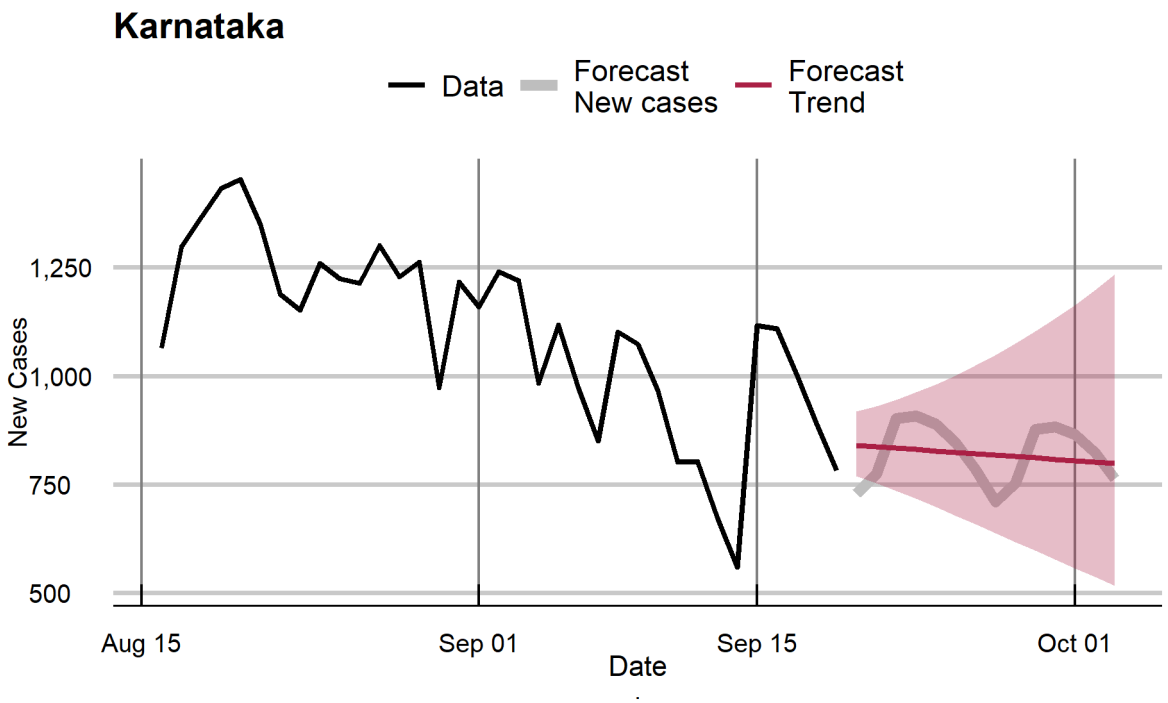

Himachal Pradesh
Growth rate of daily cases
0.00
-0.05
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

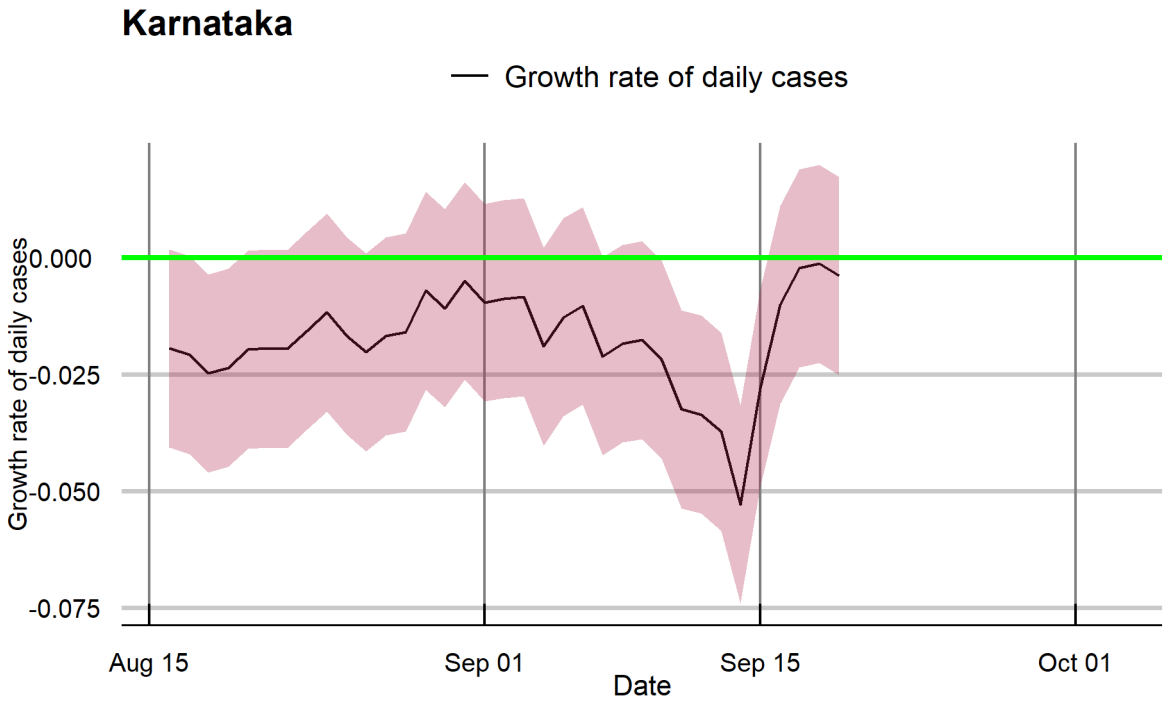

Jammu and Kashmir
Data
Forecast
New cases
Forecast
Trend
300
200
100
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

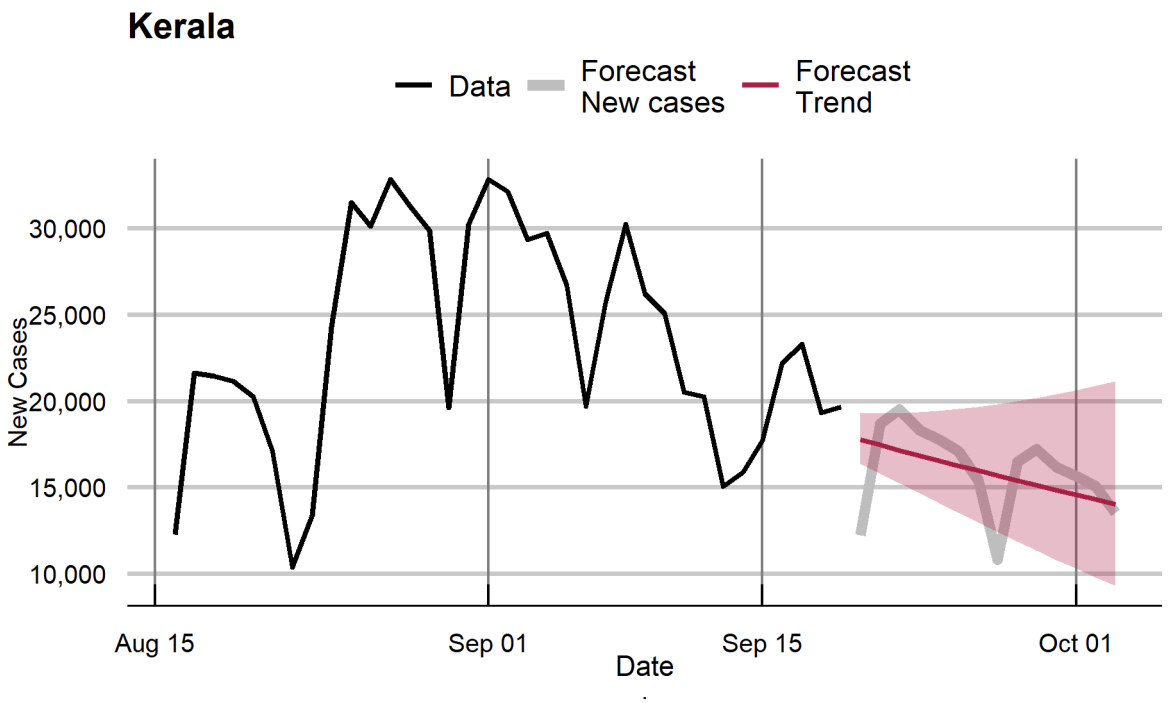

Jammu and Kashmir
Growth rate of daily cases
0.04
0.00
-0.04
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

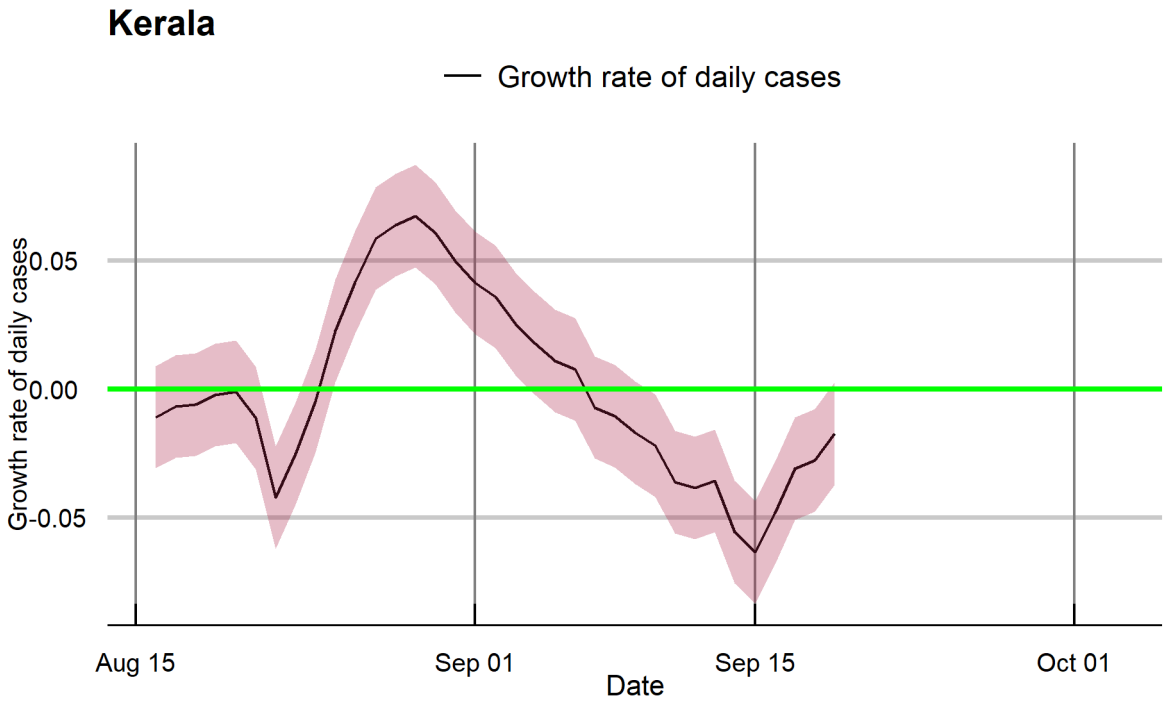

Jharkhand
Data
Forecast
New cases
Forecast
Trend
New Cases
30
20
10
0
Aug 15
Sep 01
Sep 15
Oct 01
Date

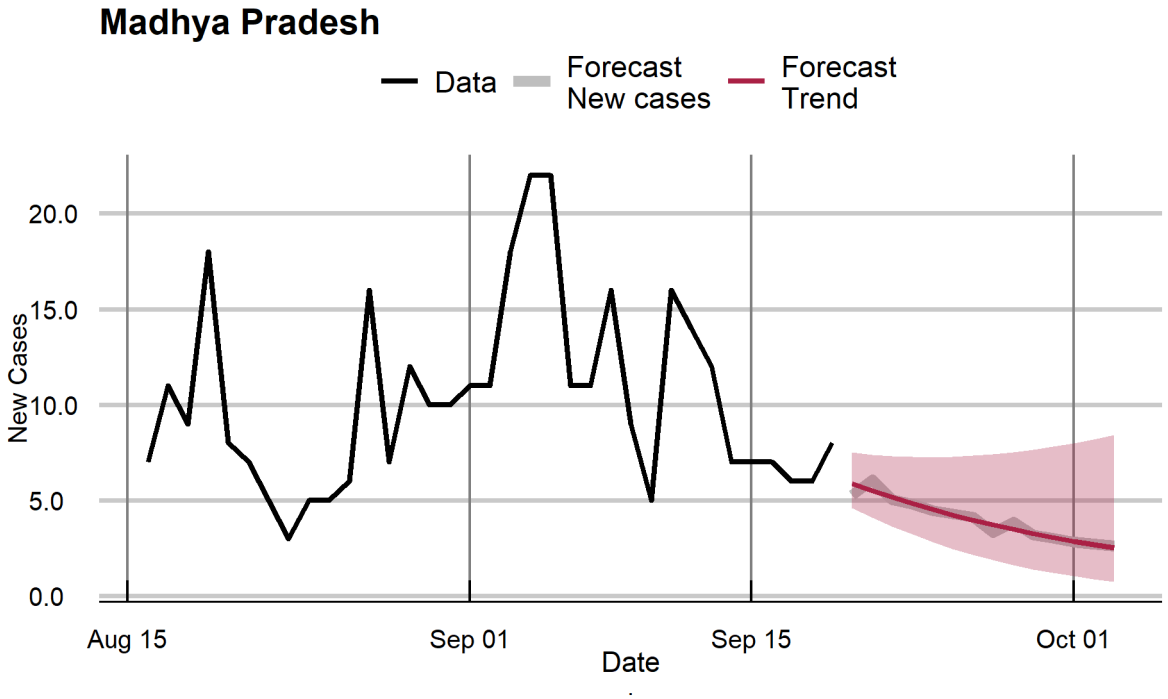

Jharkhand
Growth rate of daily cases
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
Aug 15
Sep 01
Sep 15
Oct 01
Date

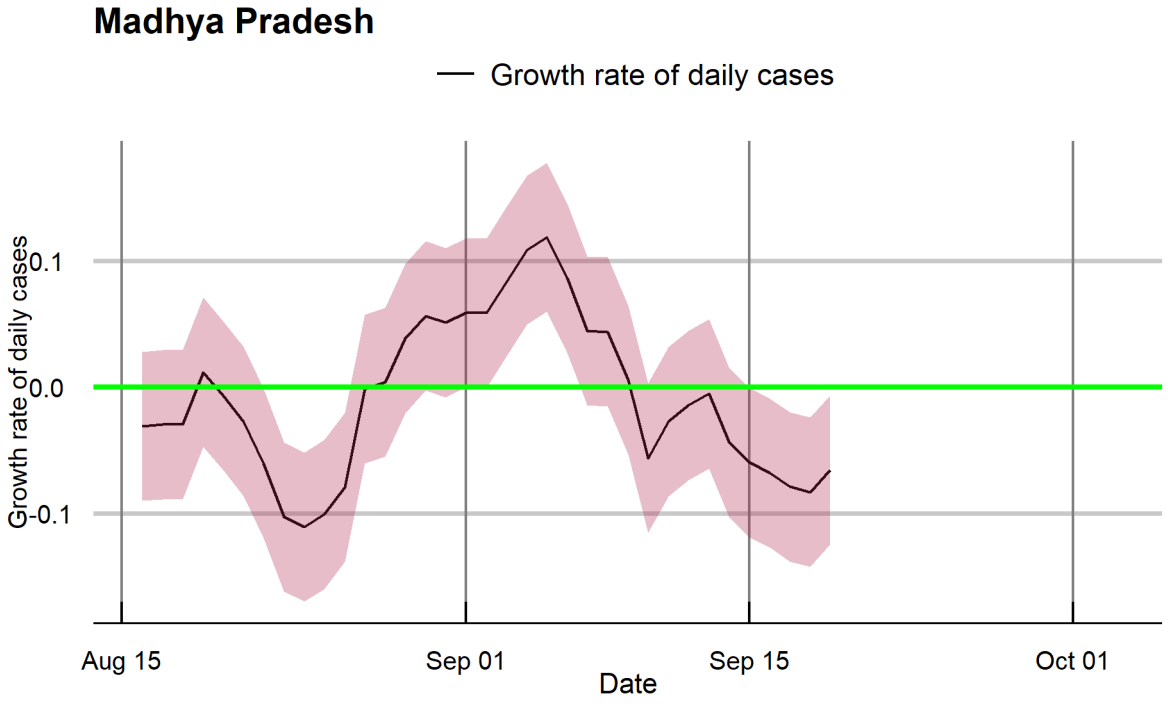

Karnataka
Data
Forecast
New cases
Forecast
Trend
1,250
1,000
750
500
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

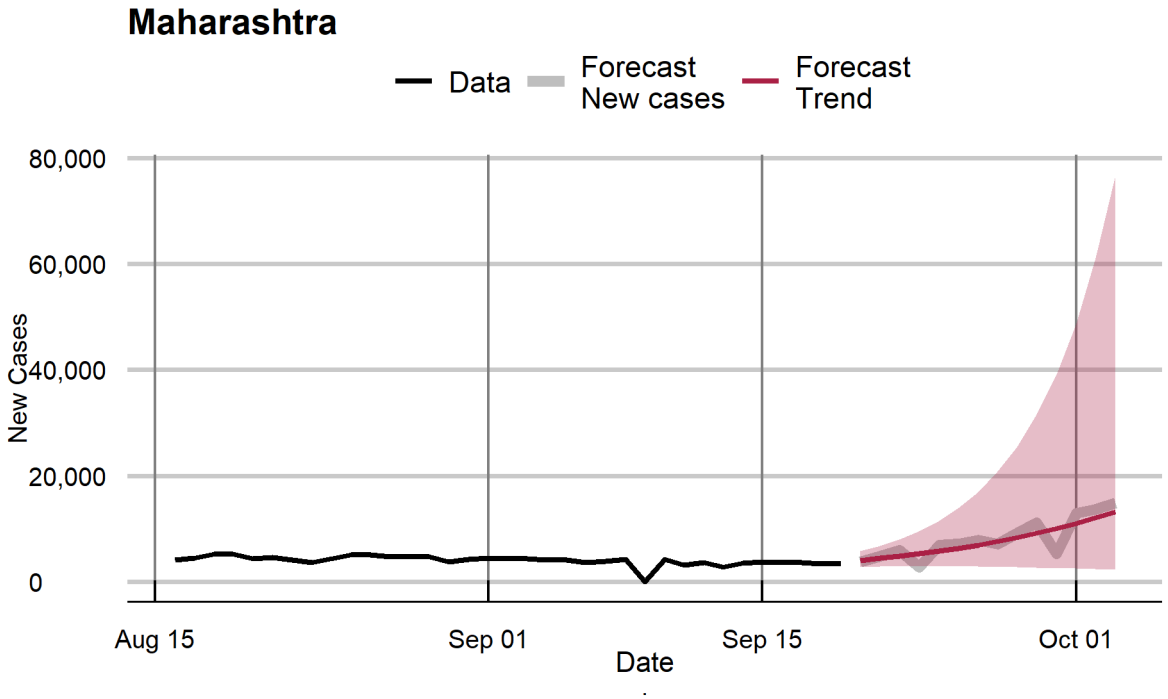

Karnataka
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

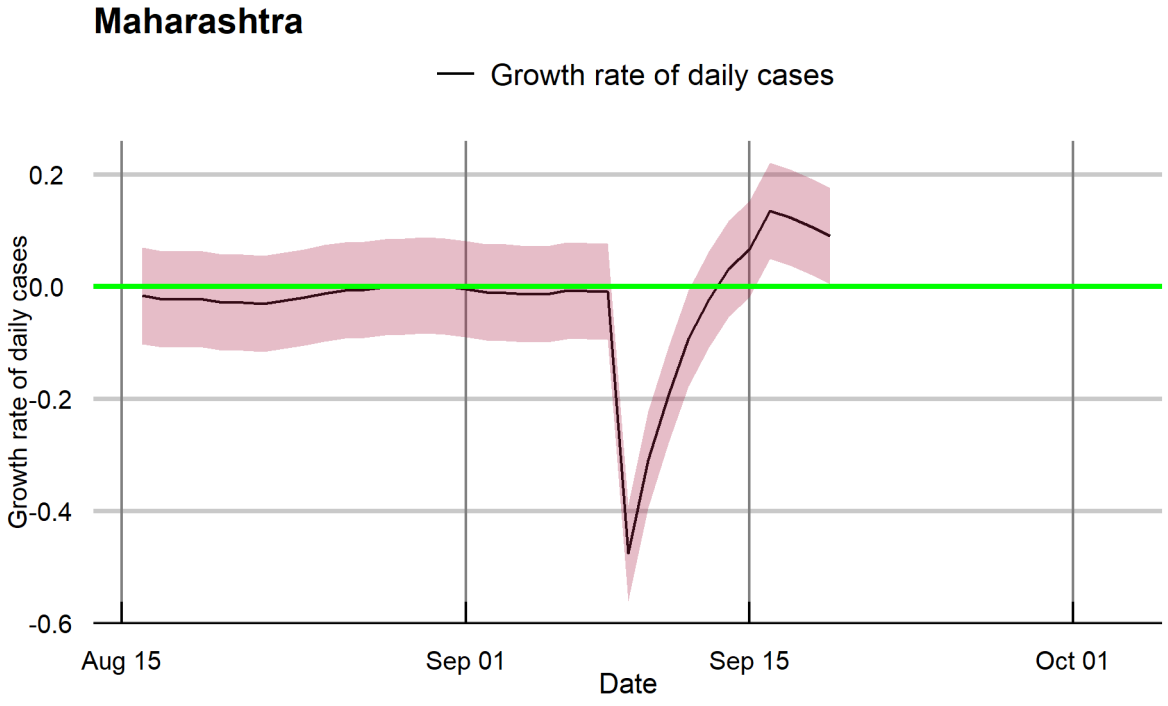

Kerala
Data
Forecast
New cases
Forecast
Trend
30,000
25,000
20,000
15,000
10,000
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

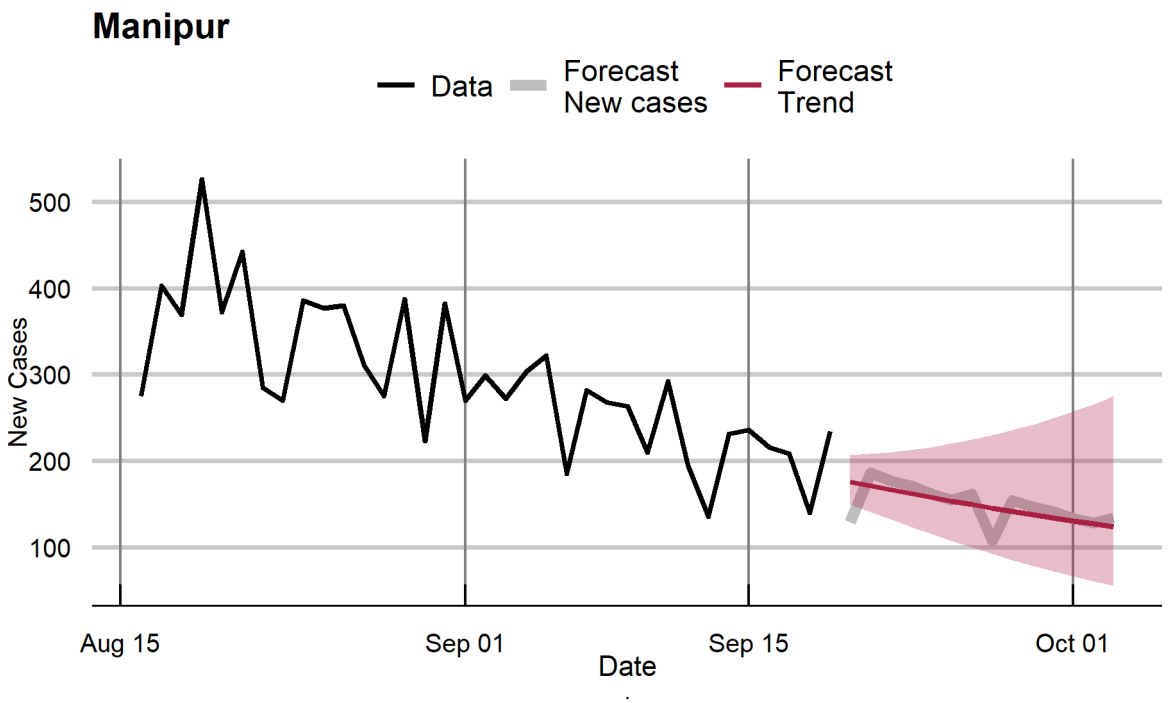

Kerala
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

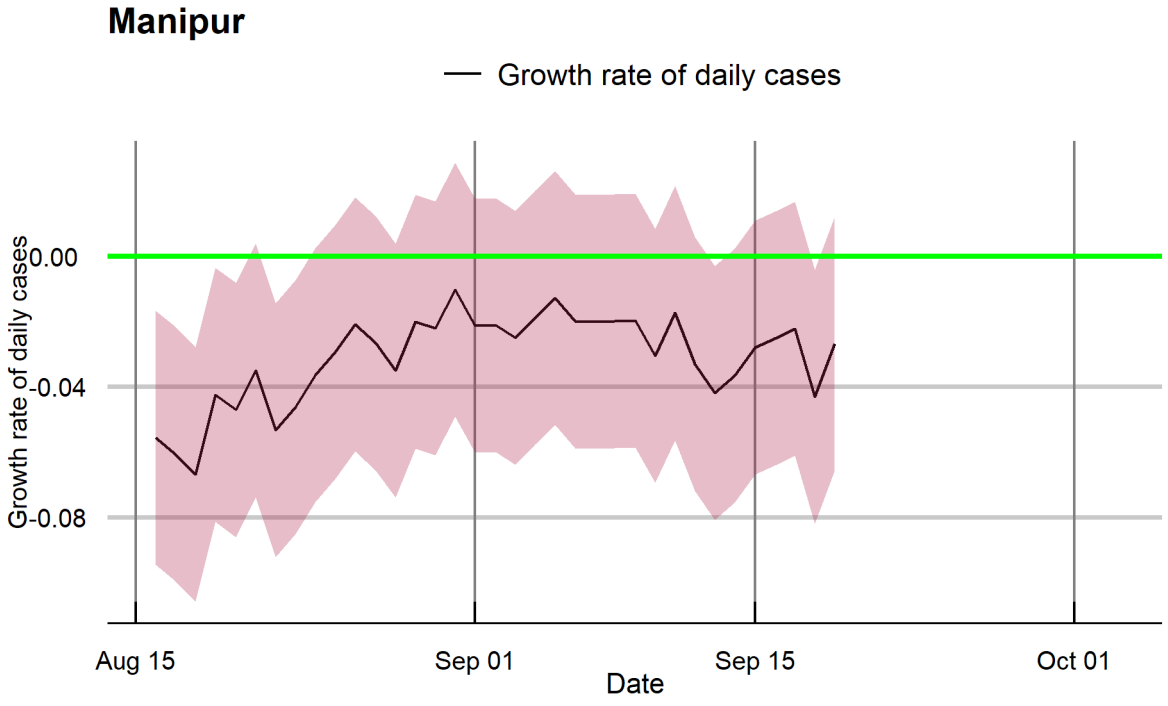

Madhya Pradesh
Data
Forecast
New cases
Forecast
Trend
20.0
15.0
10.0
5.0
0.0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

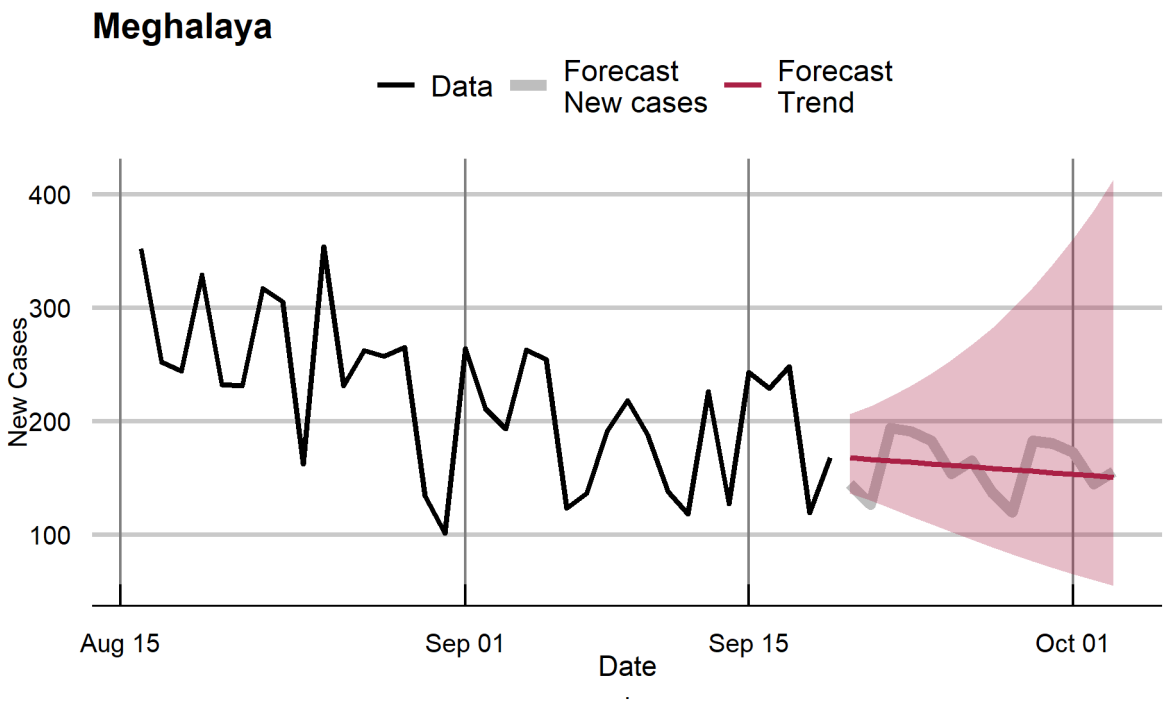

Madhya Pradesh
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

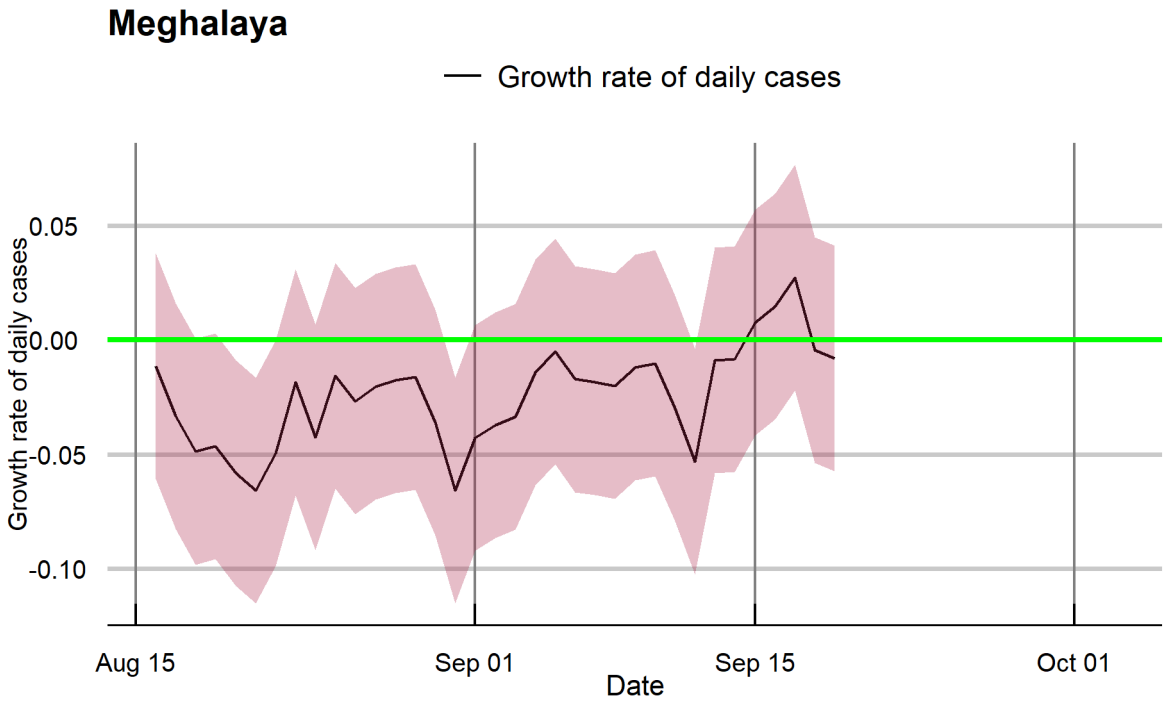

Maharashtra
Data
Forecast
New cases
Forecast
Trend
80,000
60,000
40,000
20,000
0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

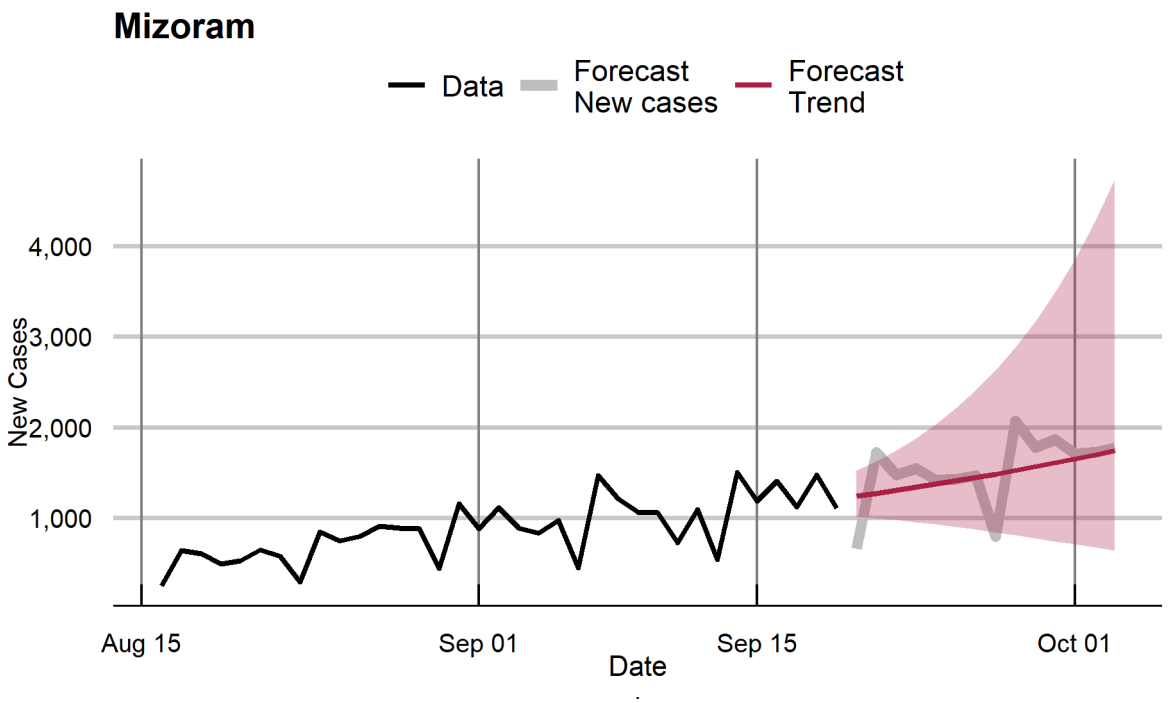

Maharashtra
Growth rate of daily cases
0.2
0.0
-0.2
-0.4
-0.6
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

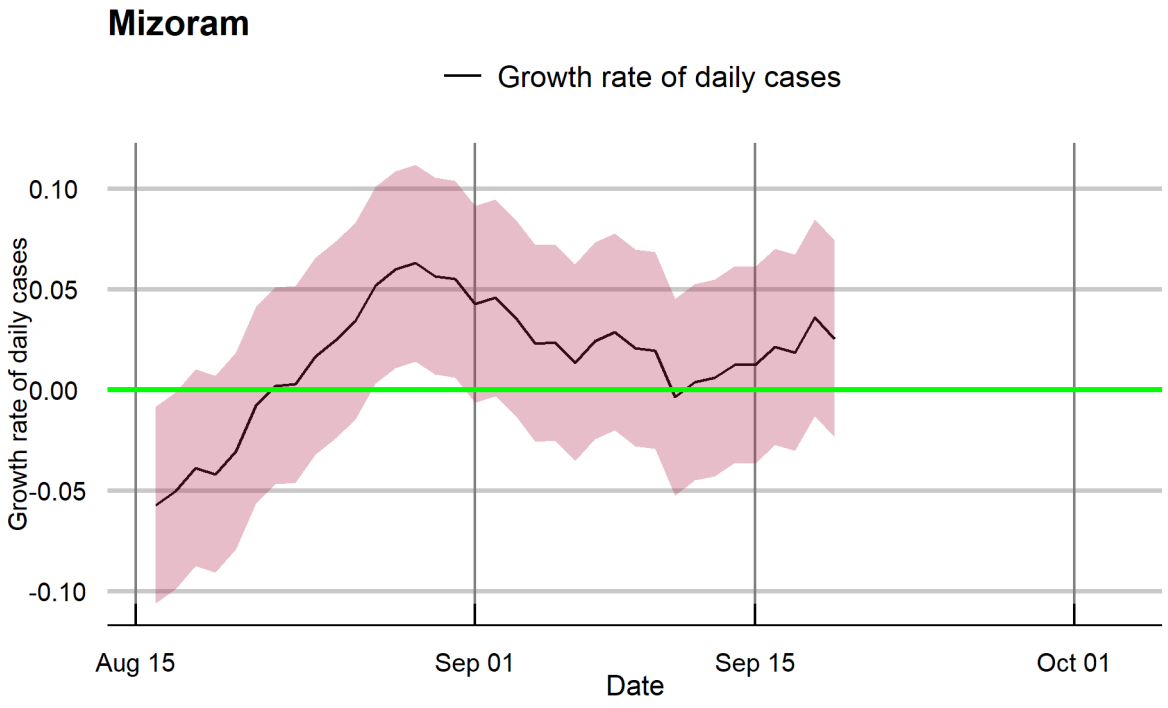

Manipur
Data
Forecast
New cases
Forecast
Trend
500
400
300
200
100
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

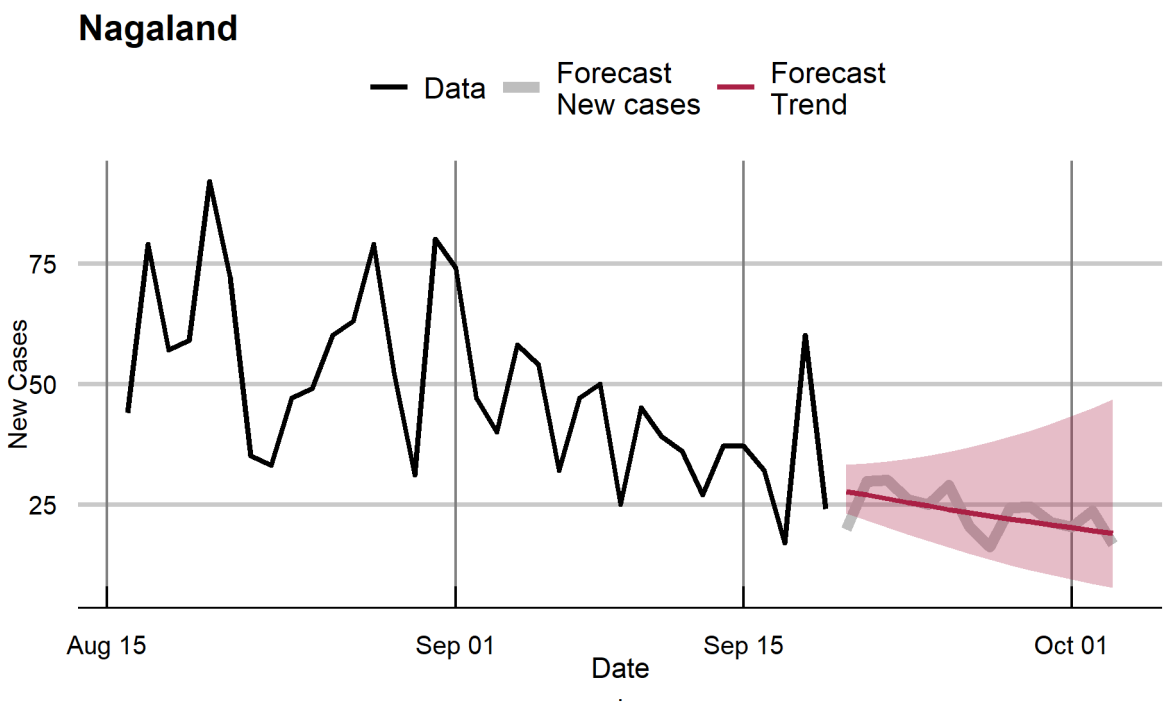

Manipur
Growth rate of daily cases
0.00
-0.04
-0.08
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

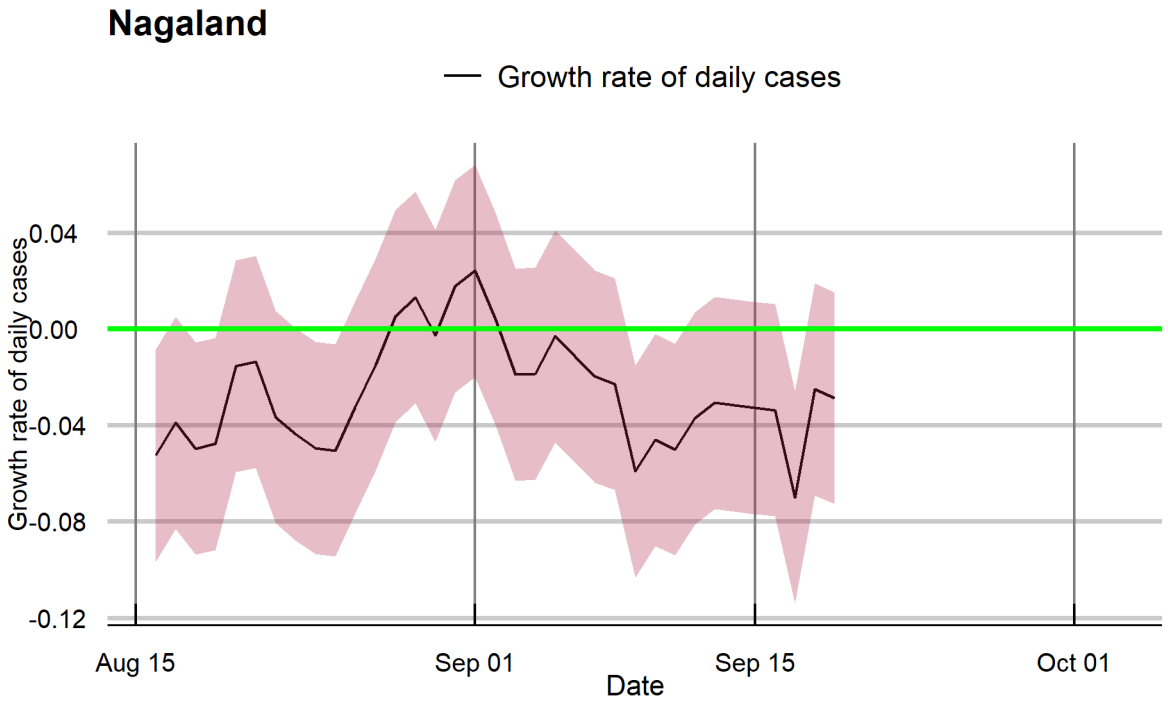

Meghalaya
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

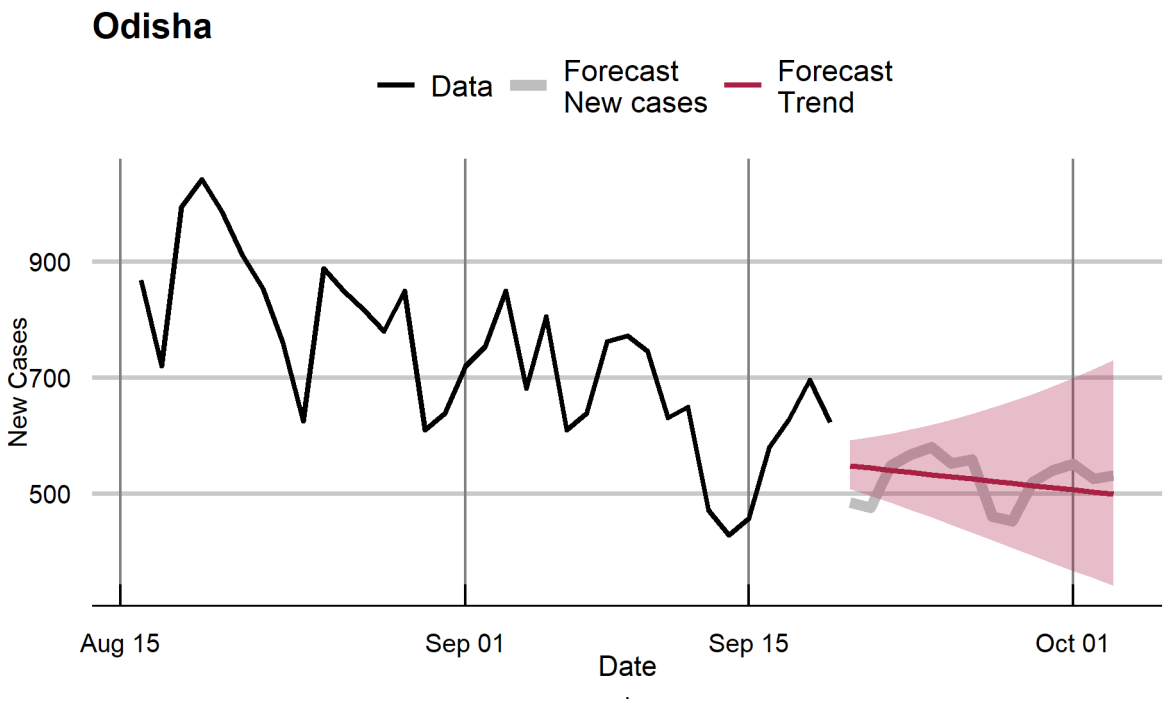

Meghalaya
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

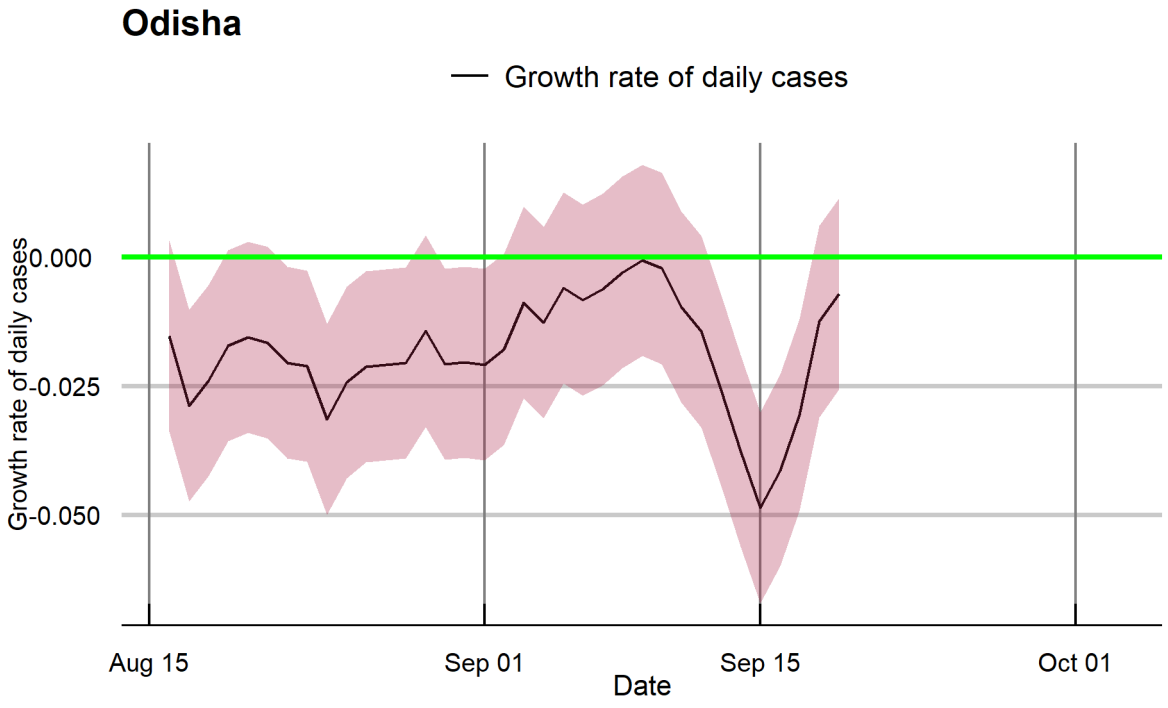

Mizoram
Data
Forecast
New cases
Forecast
Trend
4,000
3,000
2,000
1,000
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

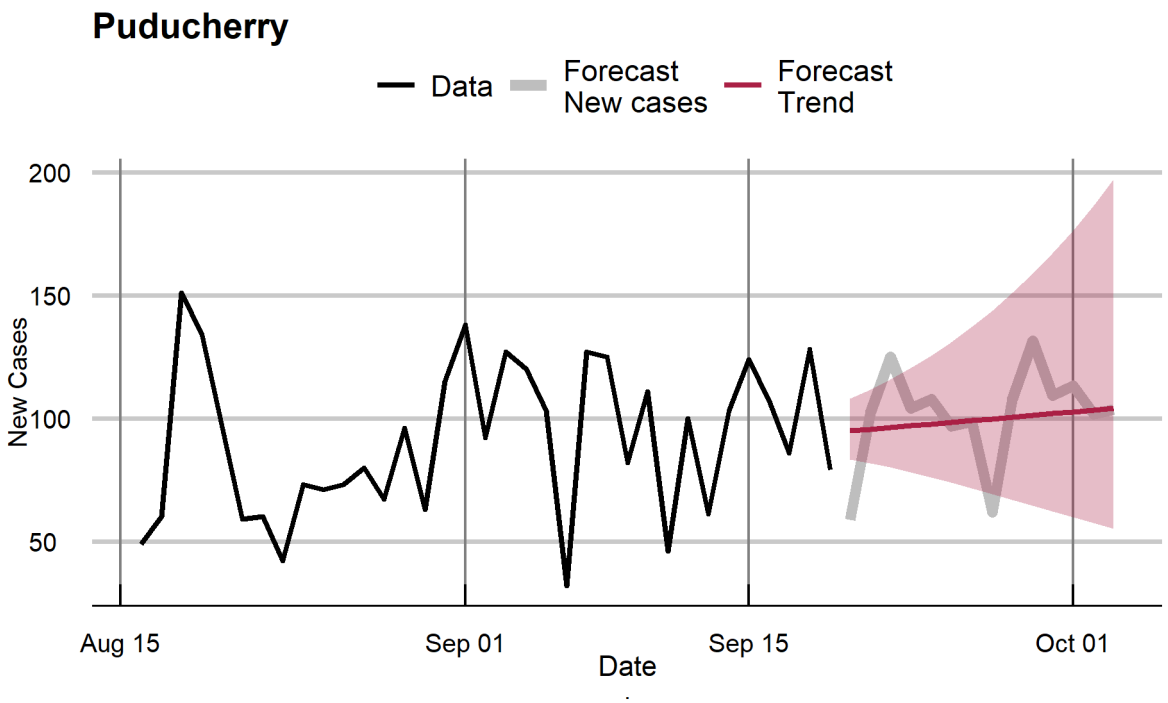

Mizoram
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

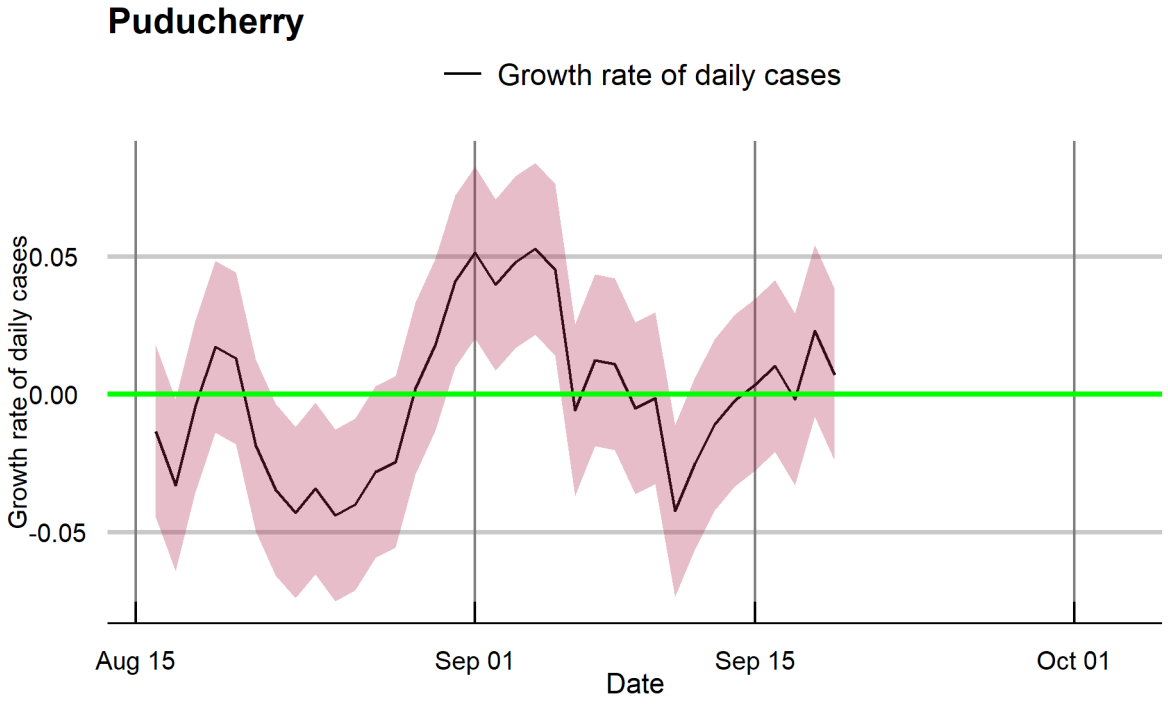

Nagaland
Data
Forecast
New cases
Forecast
Trend
75
50
25
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

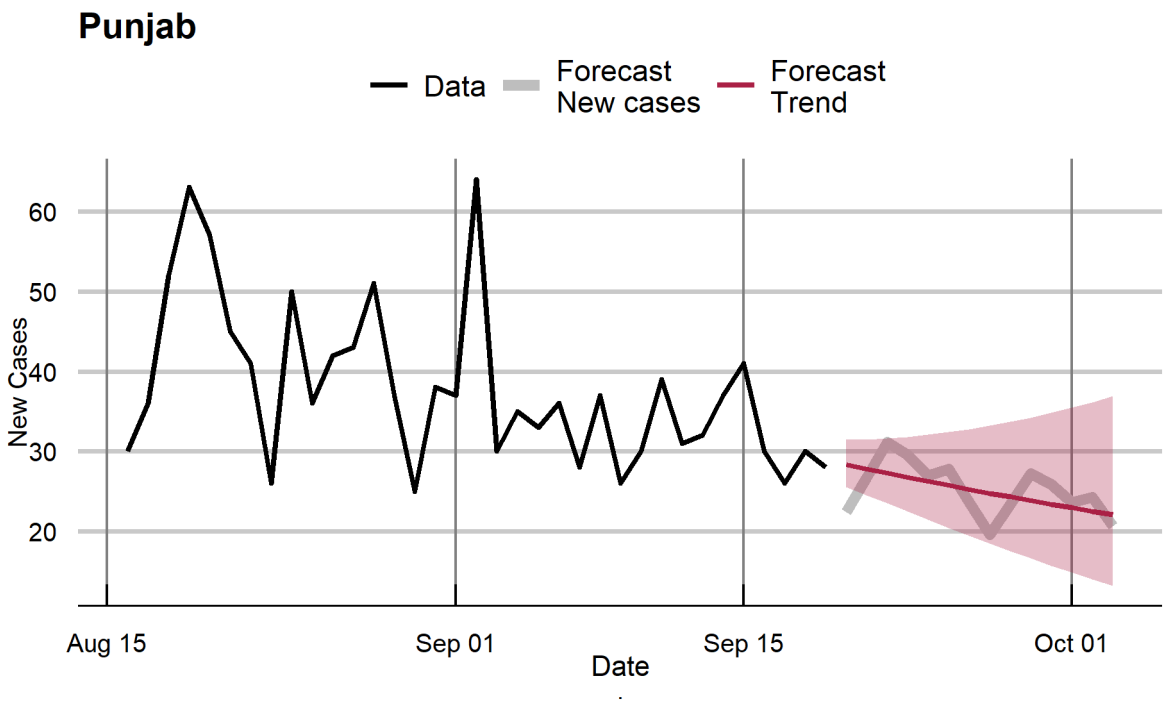

Nagaland
Growth rate of daily cases
0.04
0.00
-0.04
-0.08
-0.12
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

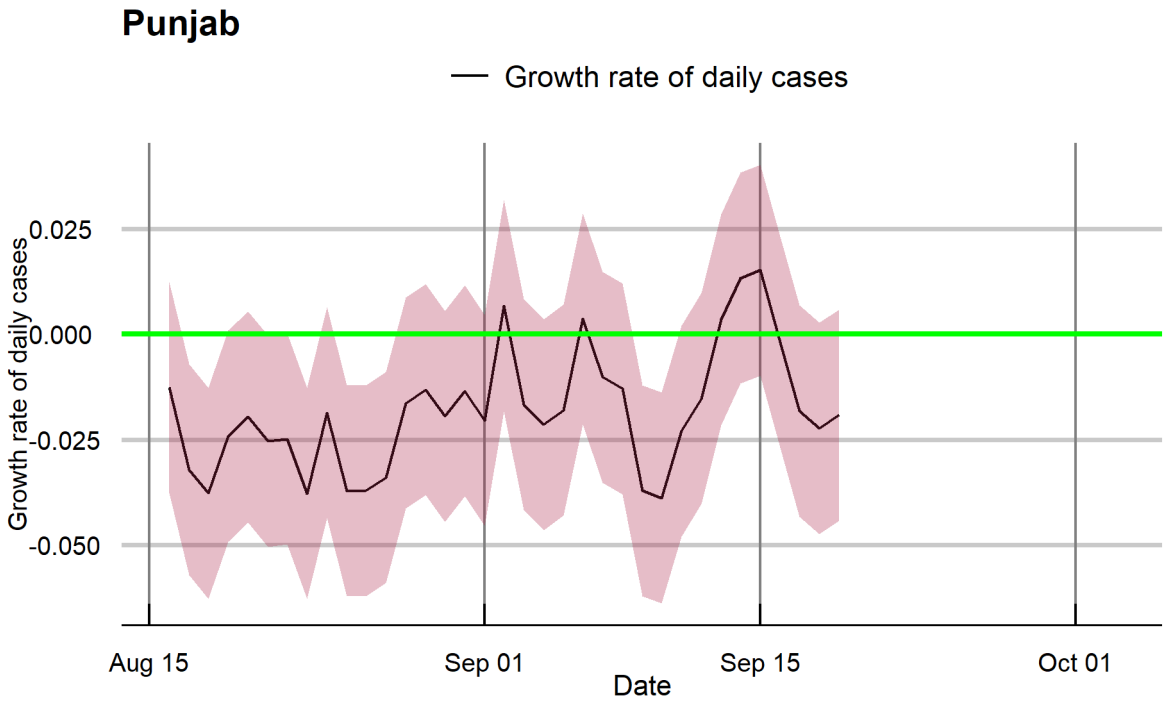

Odisha
Data
Forecast
New cases
Forecast
Trend
900
700
500
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

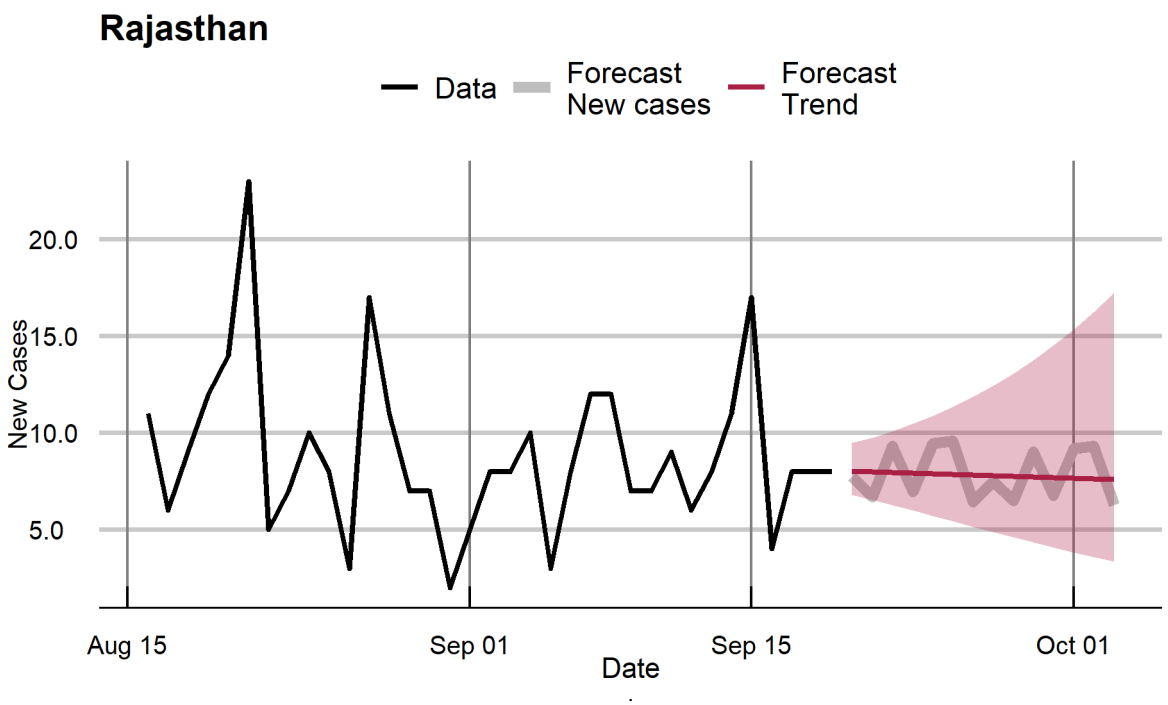

Odisha
Growth rate of daily cases
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

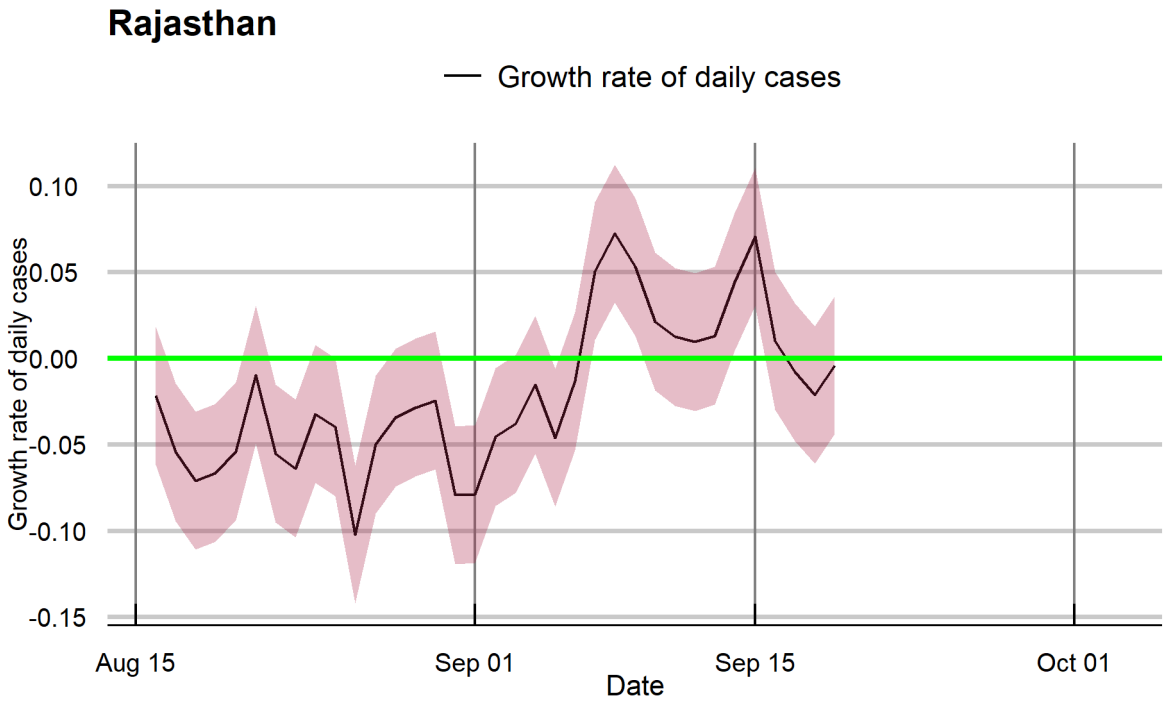

Puducherry
Data
Forecast
New cases
Forecast
Trend
200
150
100
50
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

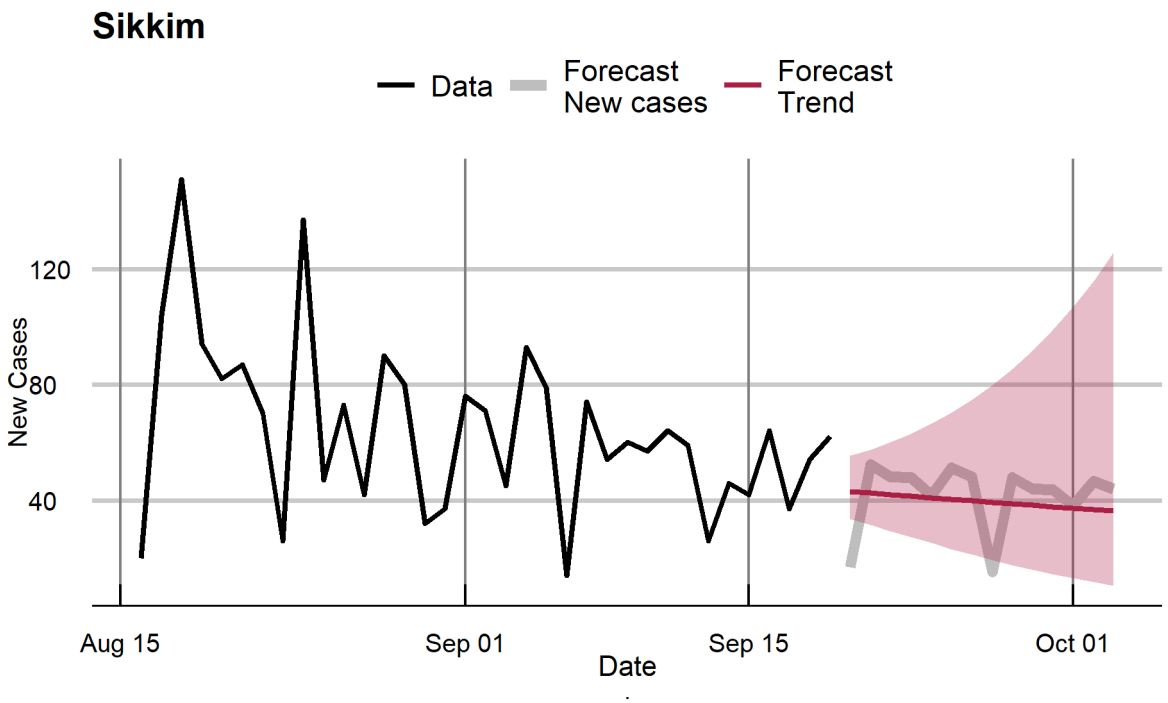

Puducherry
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

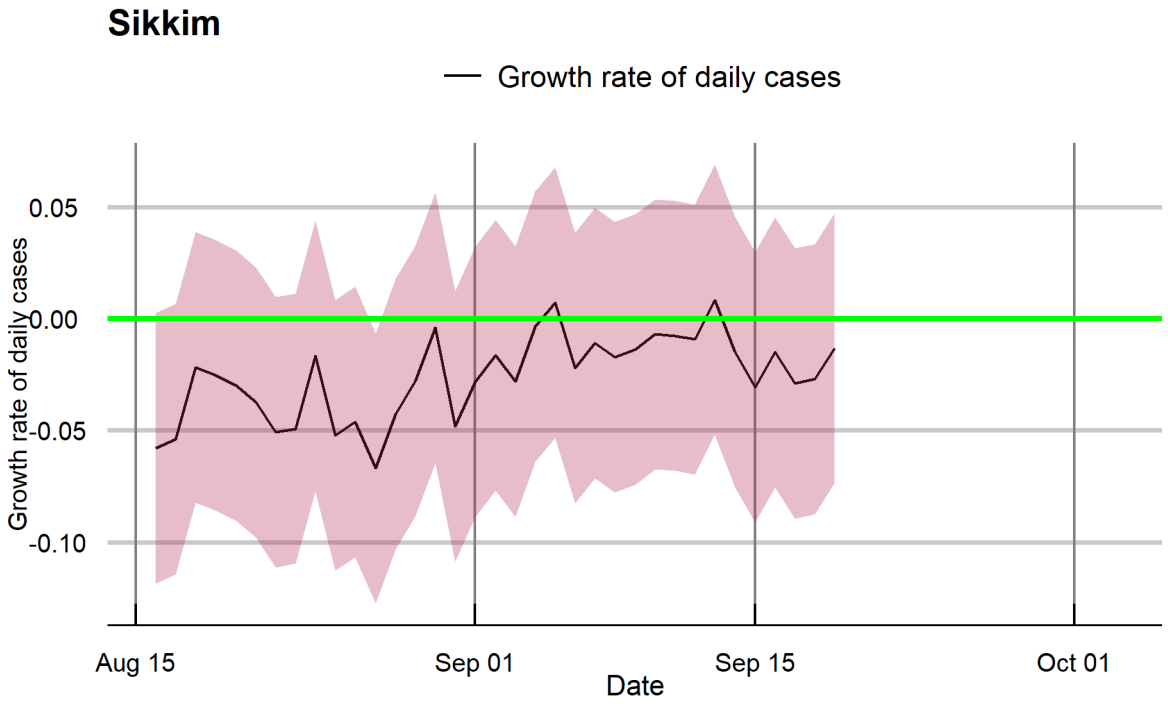

Punjab
Data
Forecast
New cases
Forecast
Trend
60
50
40
30
20
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date


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

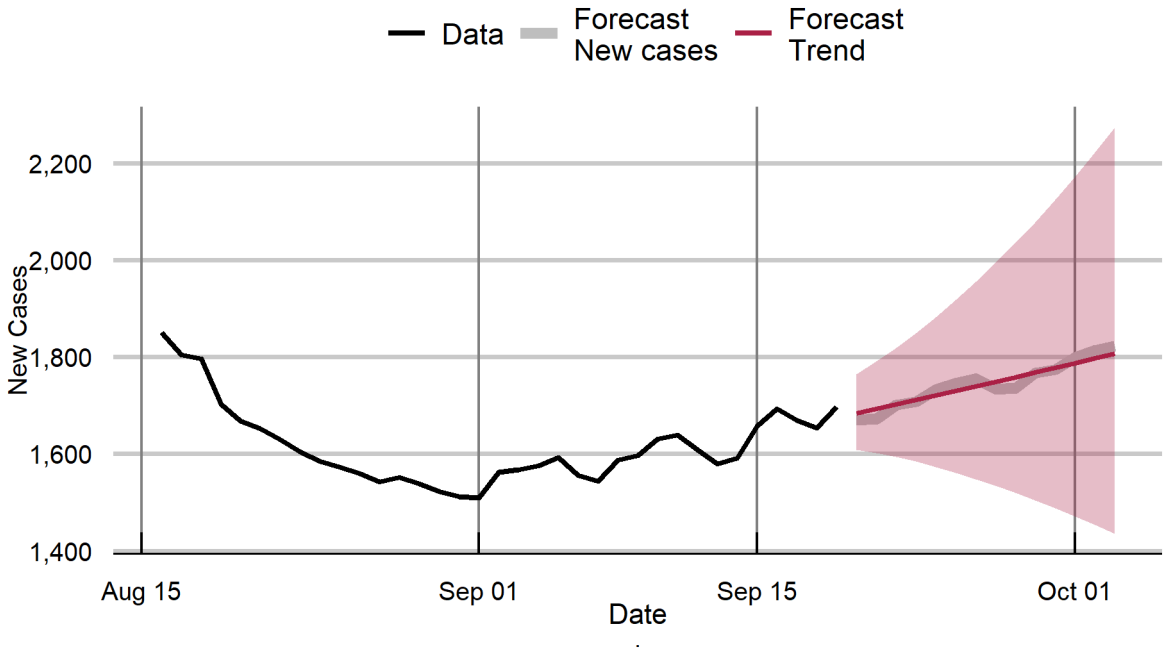

Rajasthan
Data
Forecast
New cases
Forecast
Trend
20.0
15.0
10.0
5.0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date


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

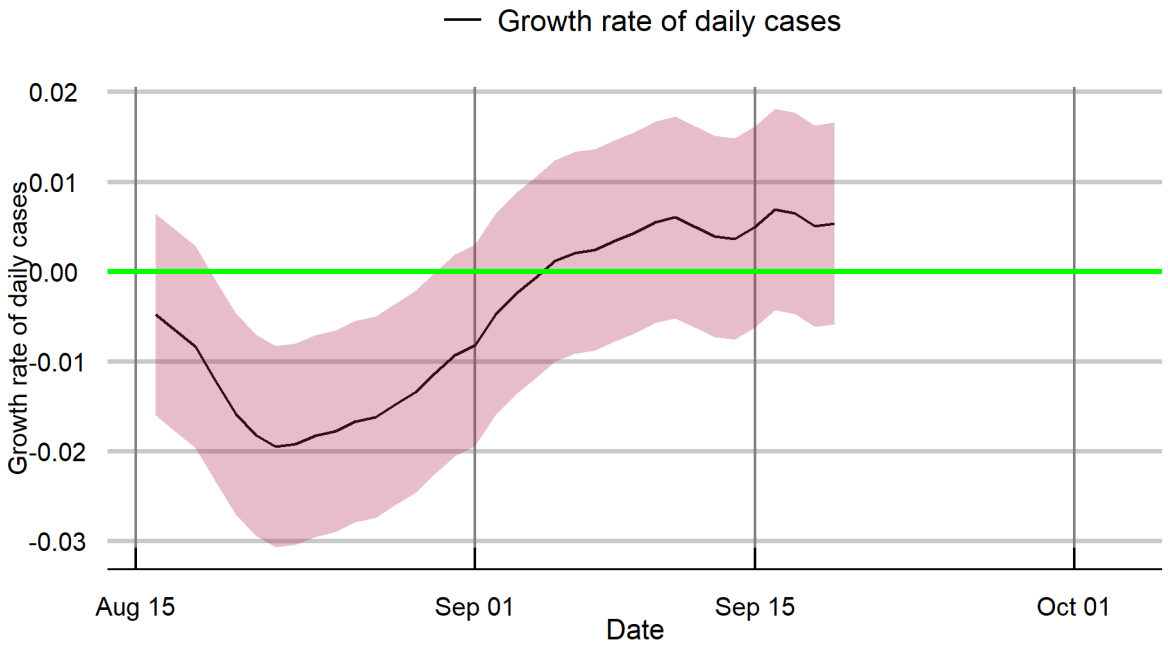

Sikkim
Data
Forecast
New cases
Forecast
Trend
120
80
40
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

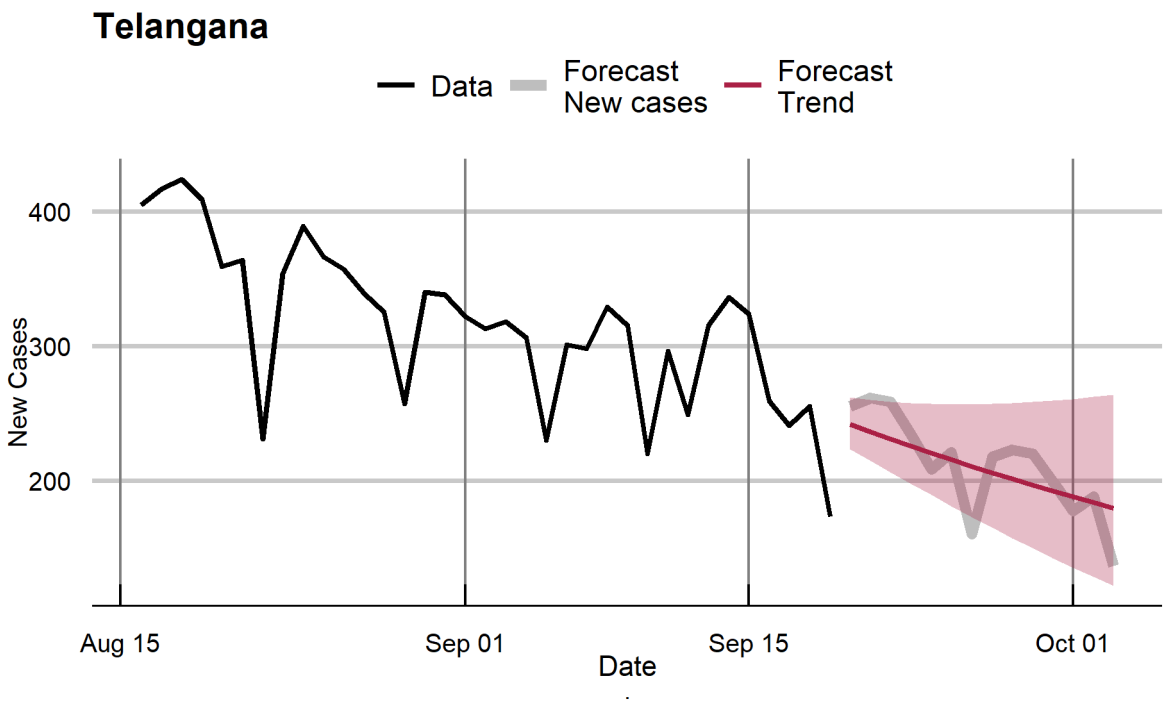

Sikkim
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

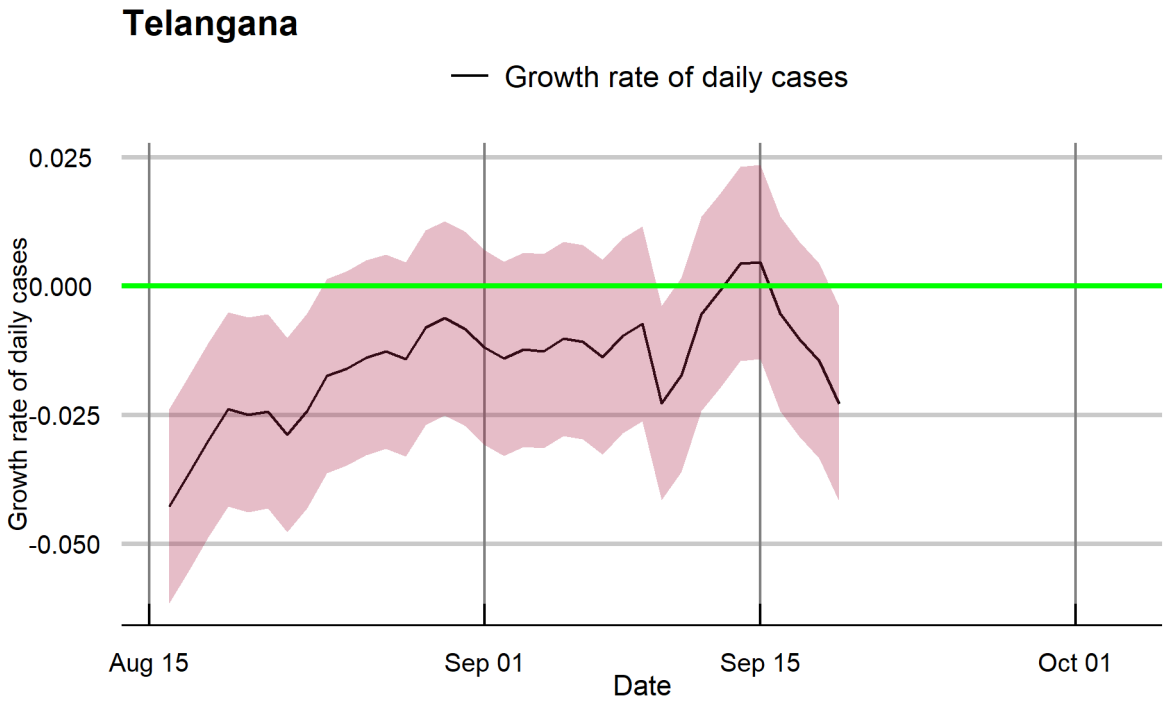
Tamil Nadu

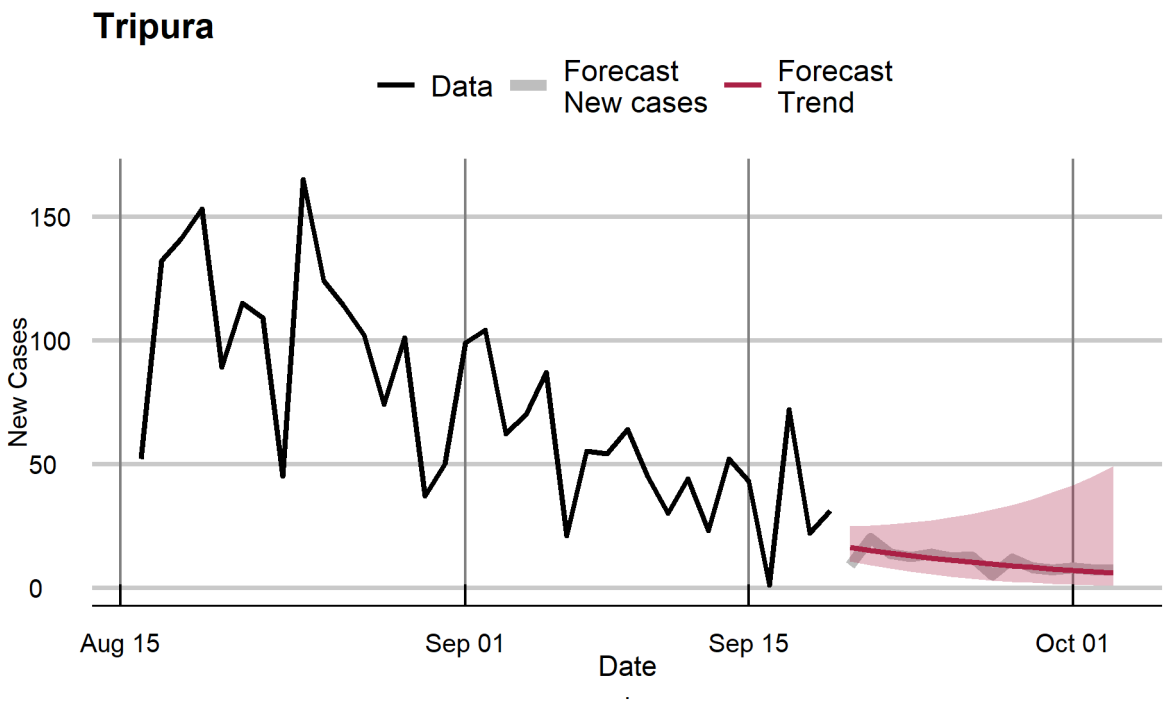


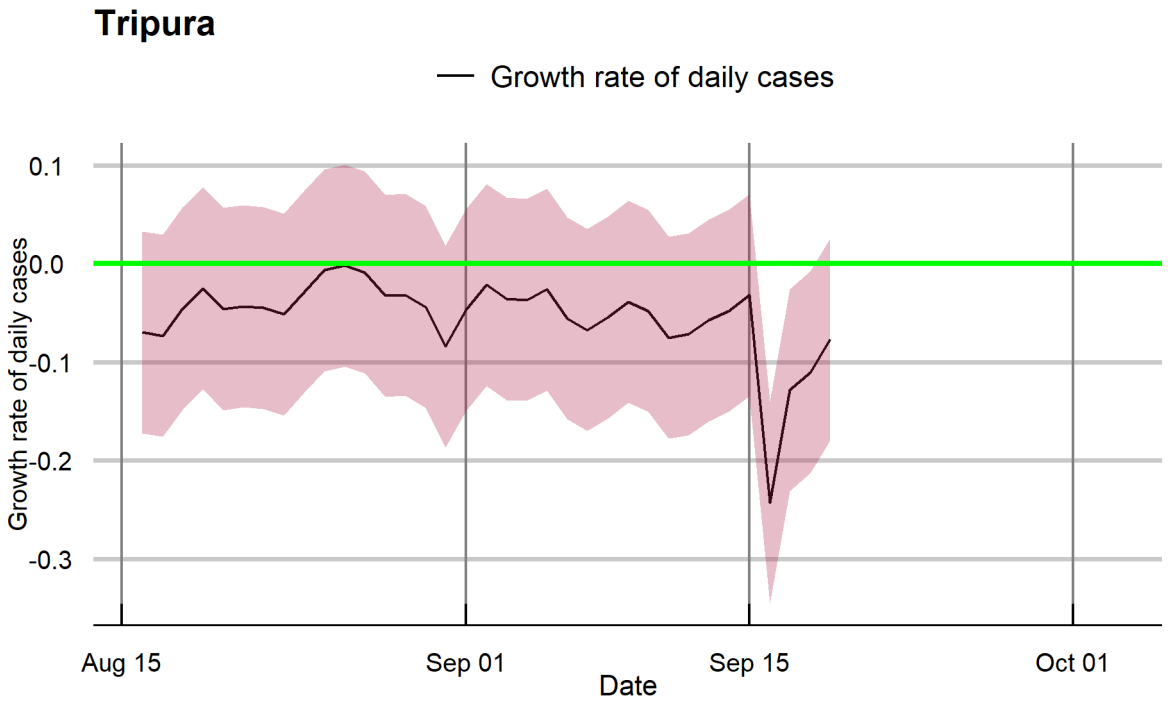
Tamil Nadu

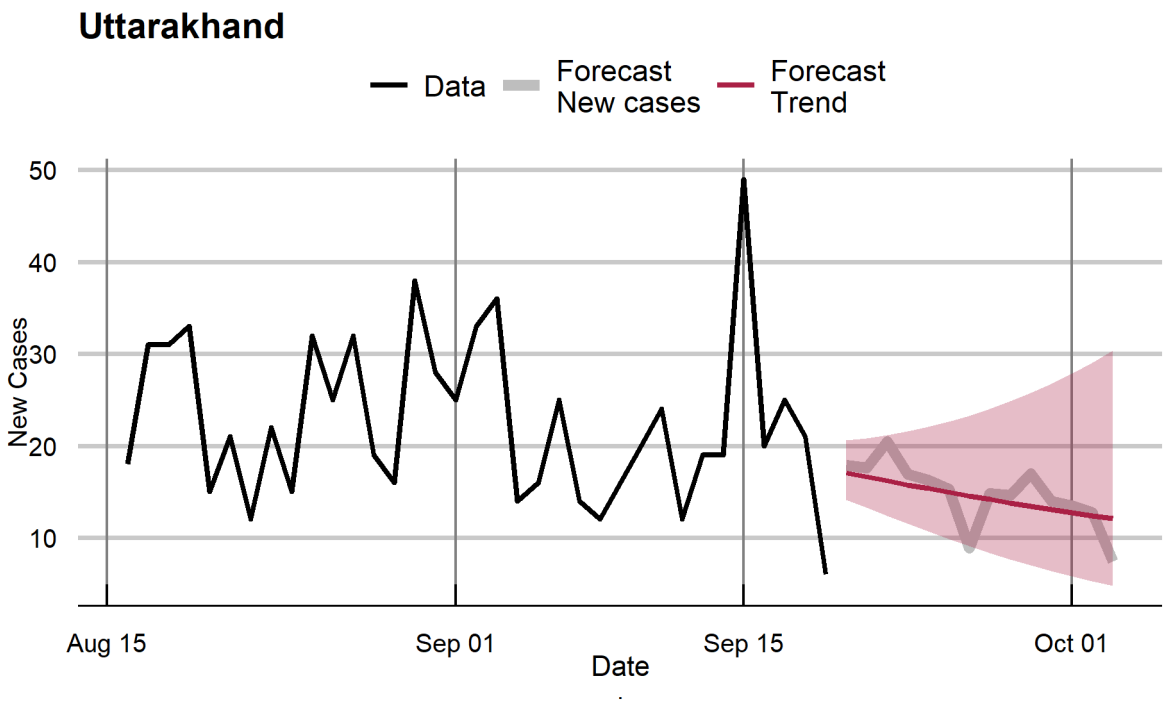


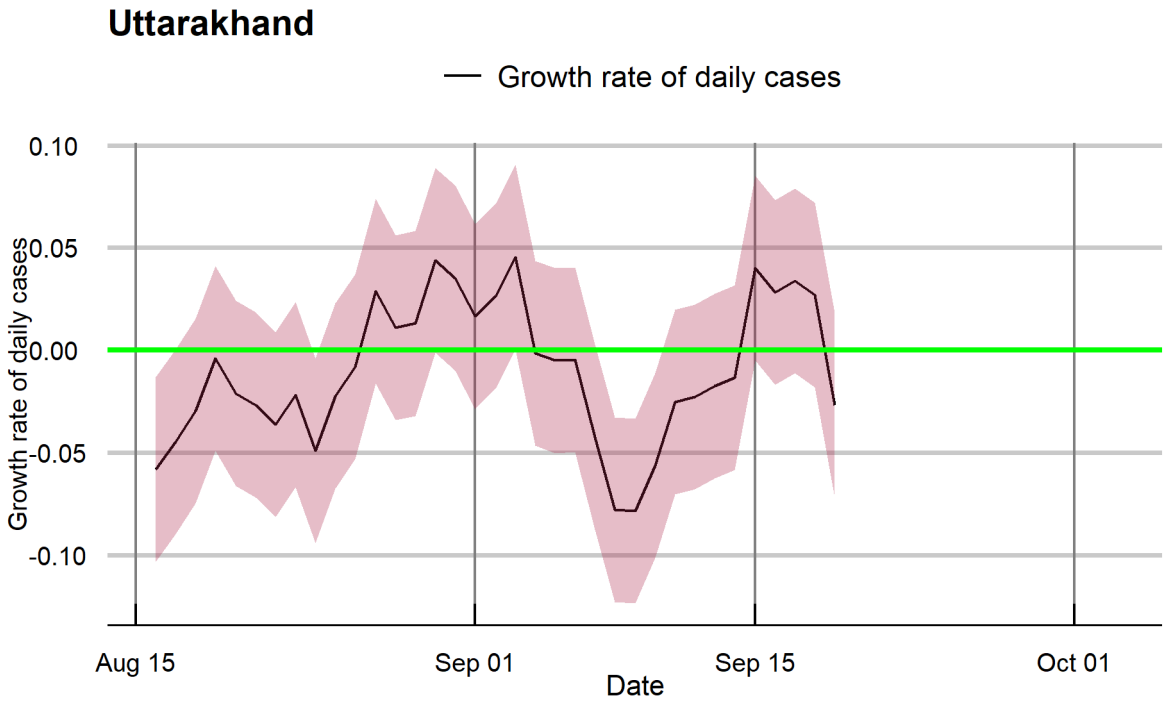

Telangana
Data
Forecast
New cases
Forecast
Trend
400
300
200
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

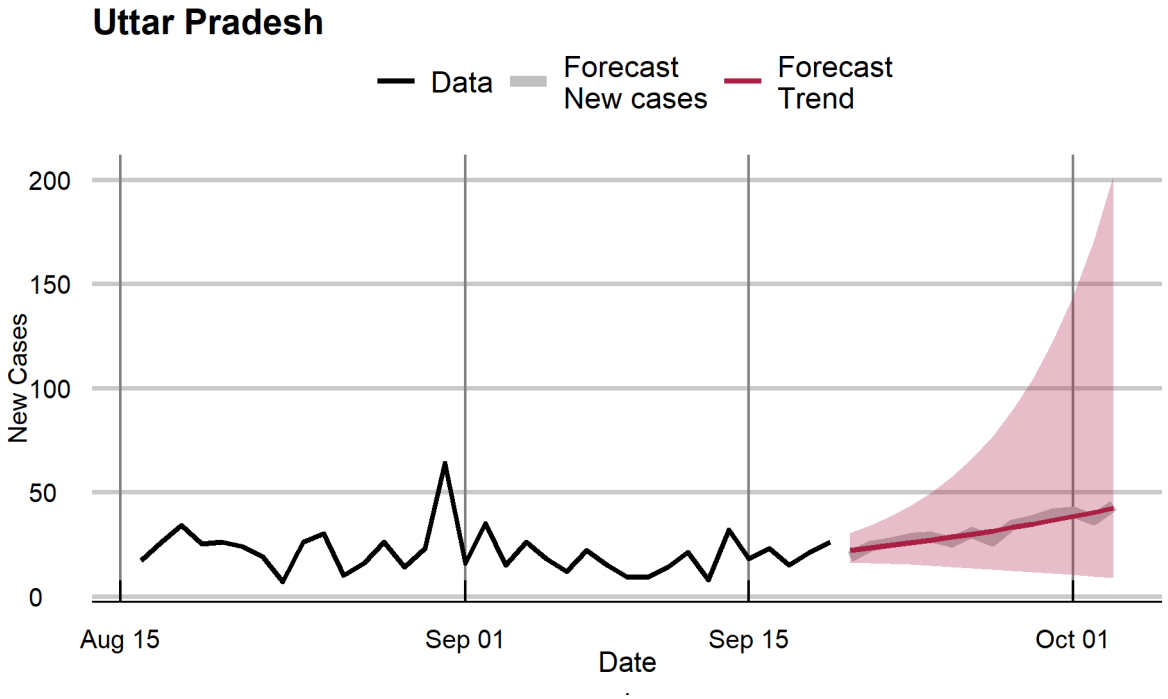

Telangana
Growth rate of daily cases
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

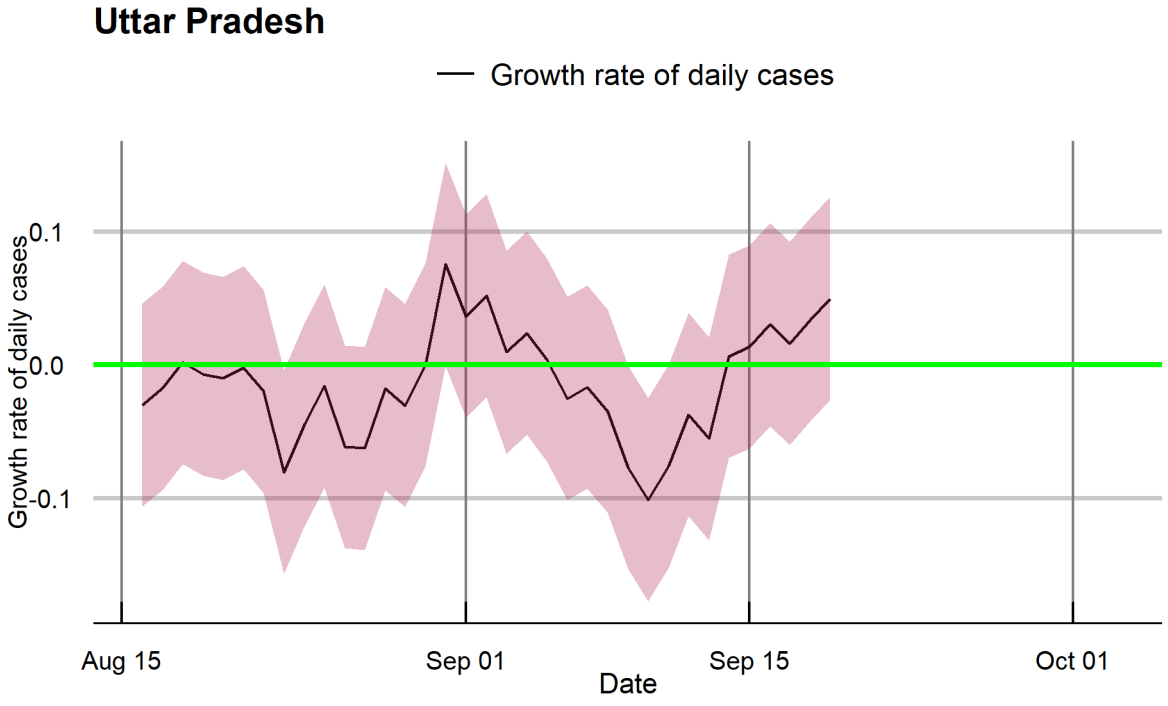

Tripura
Data
Forecast
New cases
Forecast
Trend
150
100
50
0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

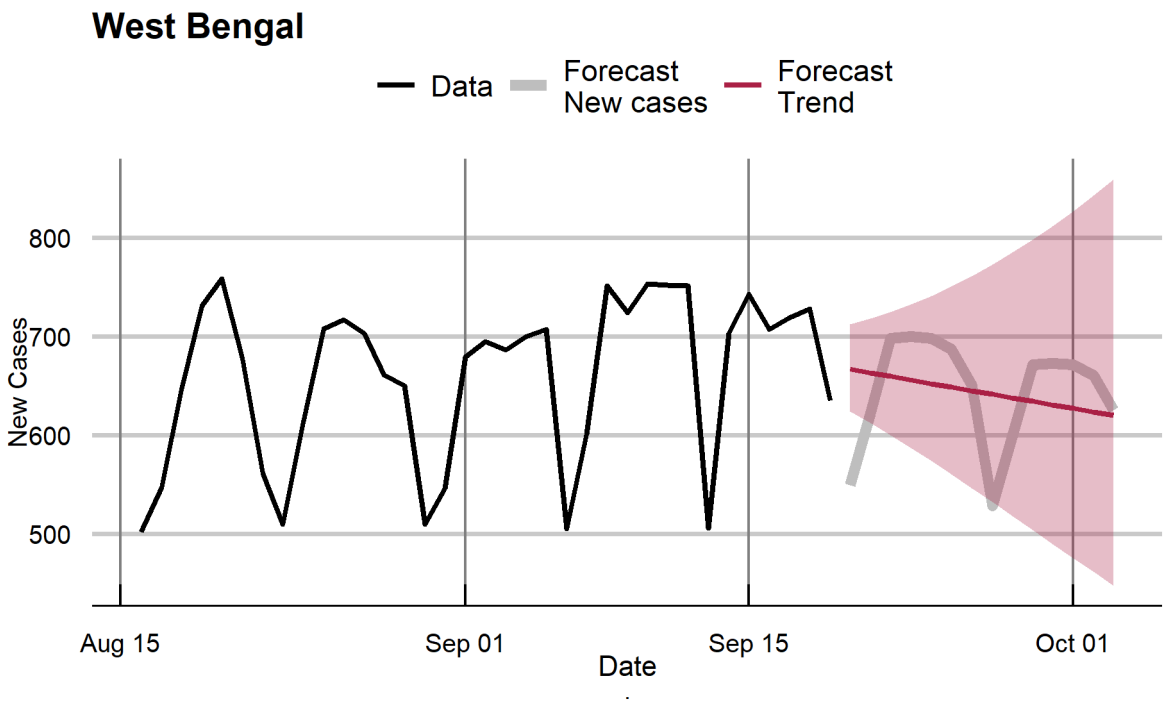

Tripura
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
-0.3
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

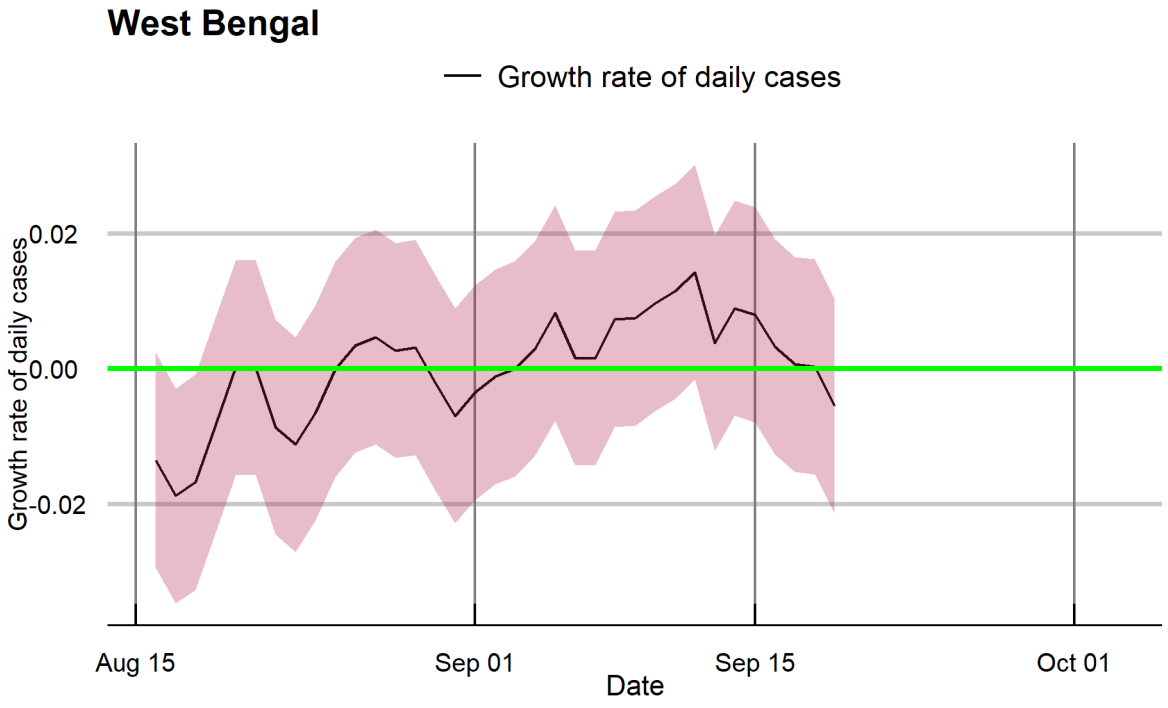

Uttarakhand
Data
Forecast
New cases
Forecast
Trend
50
40
30
20
10
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date


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


Uttar Pradesh
Data
Forecast
New cases
Forecast
Trend
200
150
100
50
0
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

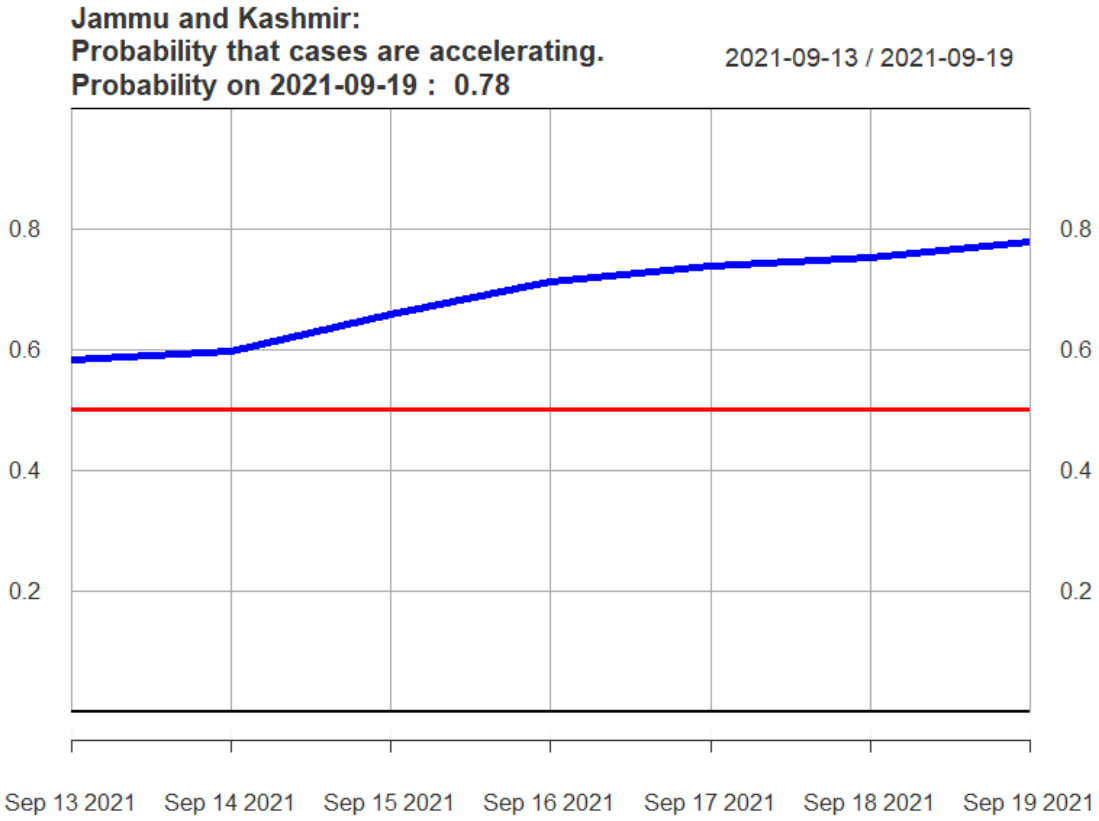

Uttar Pradesh
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

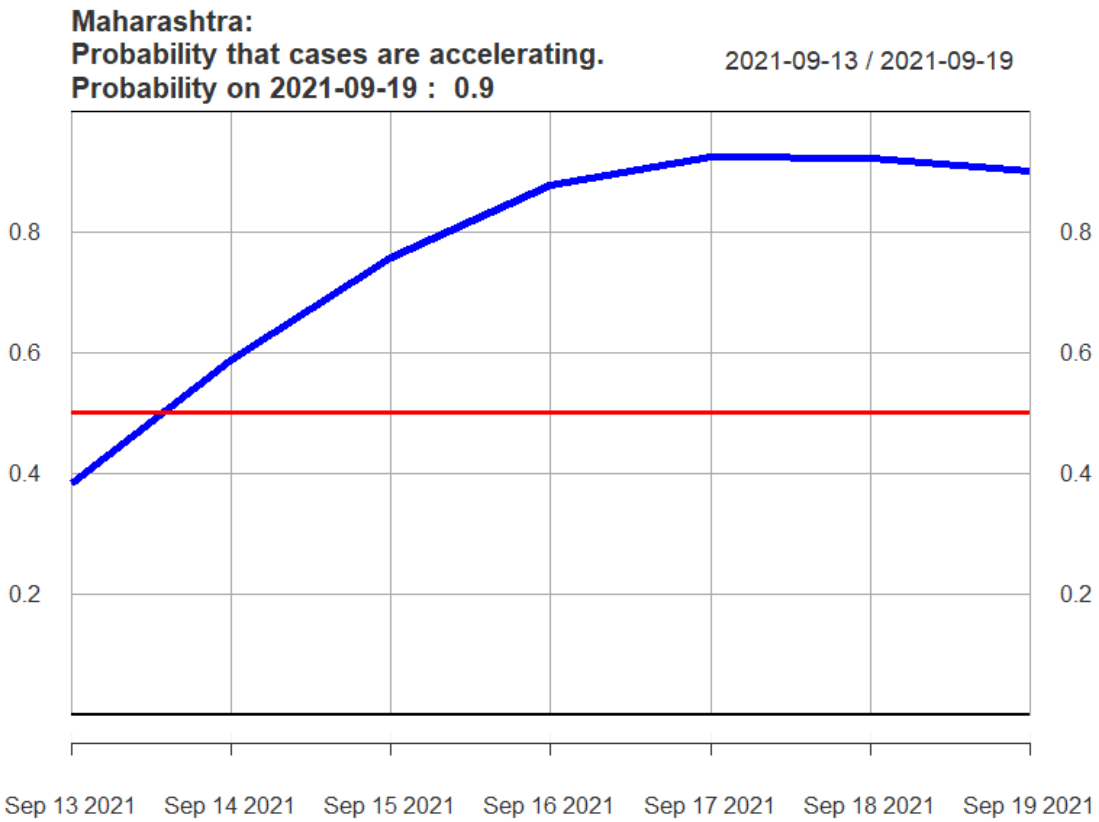

West Bengal
Data
Forecast
New cases
Forecast
Trend
800
700
600
500
New Cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

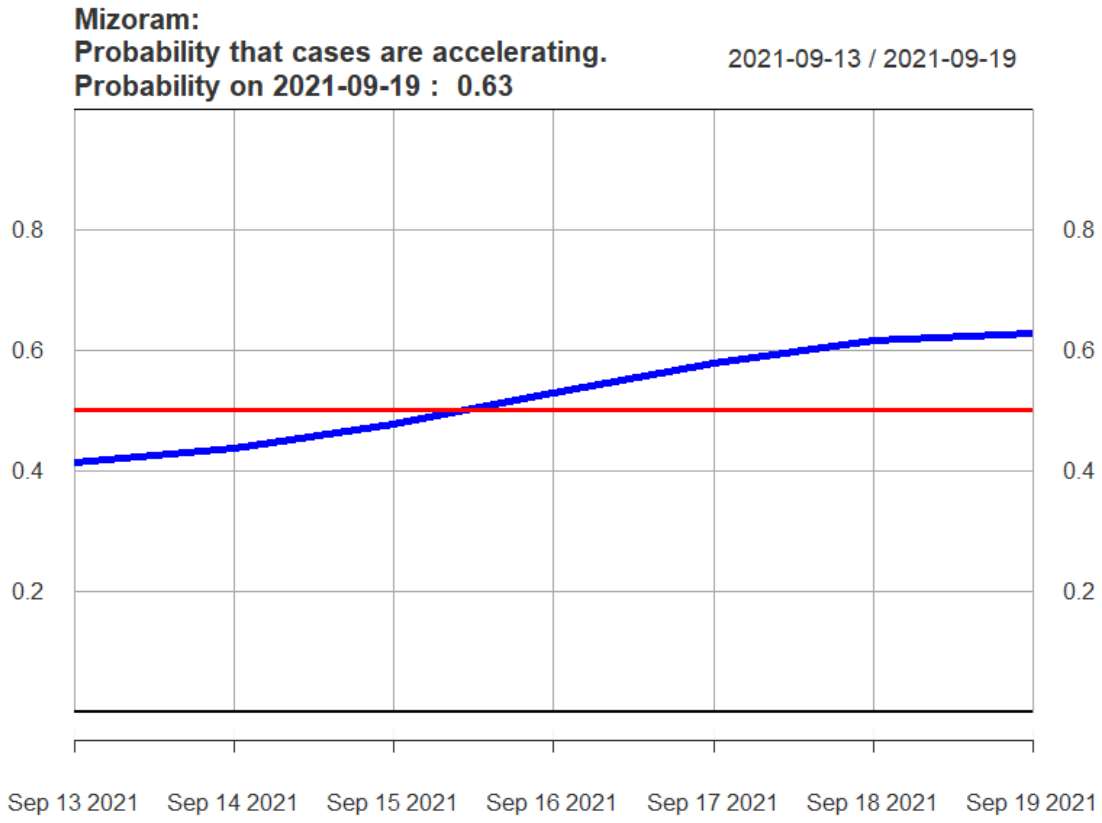

West Bengal
Growth rate of daily cases
0.02
0.00
-0.02
Growth rate of daily cases
Aug 15
Sep 01
Sep 15
Oct 01
Date

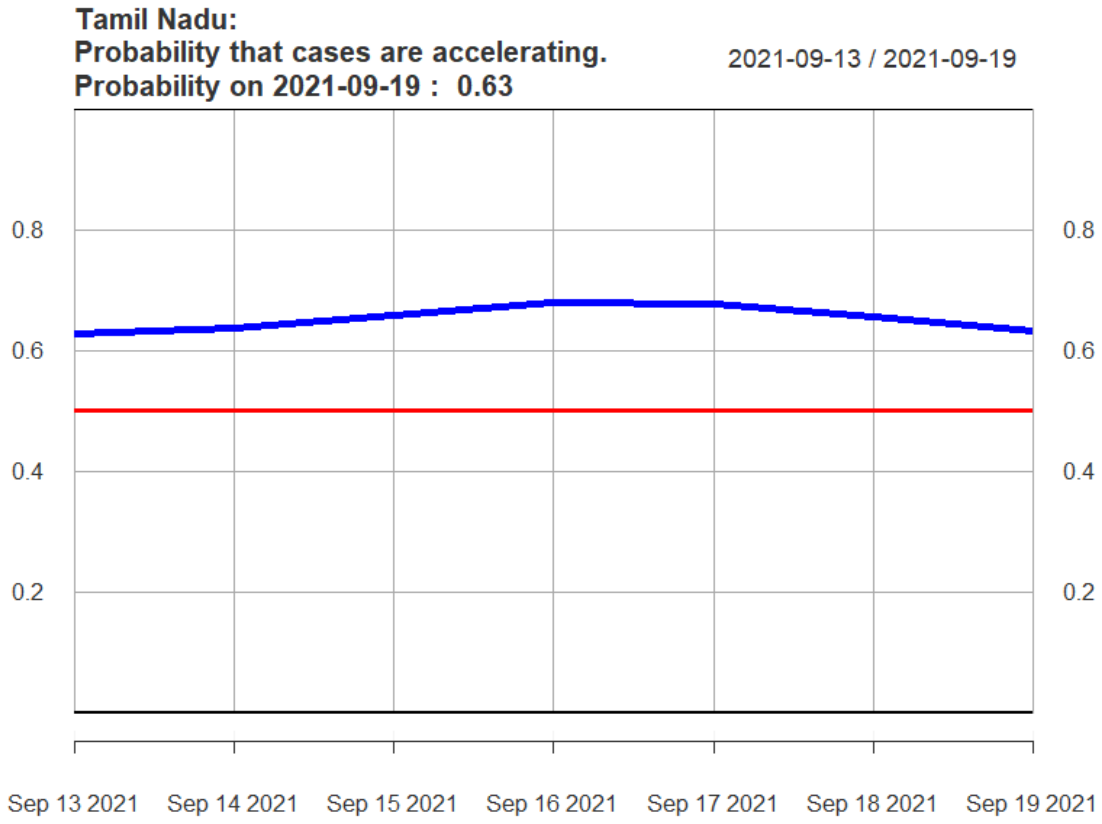
Probability that daily cases are accelerating

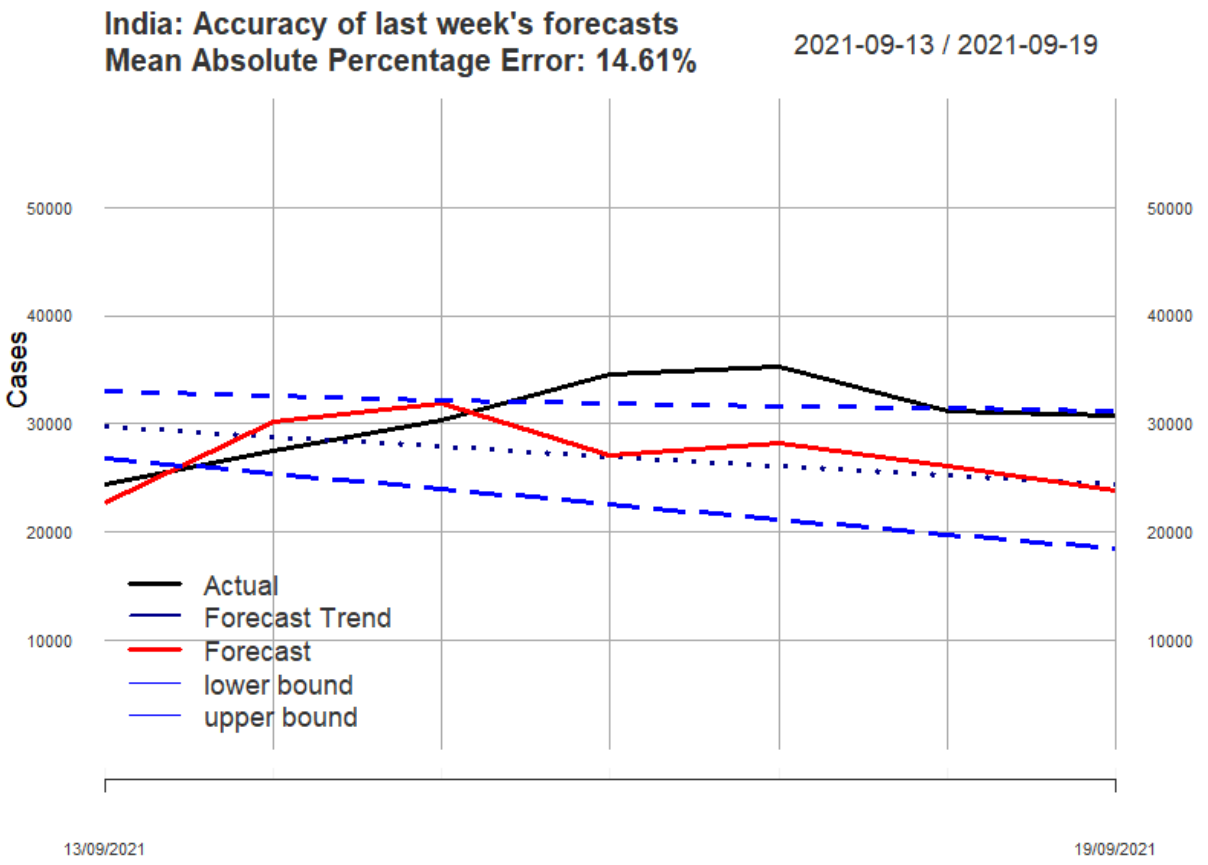
State with cases exceeding 100 and probability of acceleration greater than 0.5






Mizoram:
Probability that cases are accelerating.
Probability on 2021-09-19 : 0.63
2021-09-13 / 2021-09-19
0.8
0.6
0.4
0.2
Sep 13 2021
Sep 14 2021
Sep 15 2021
Sep 16 2021
Sep 17 2021
Sep 18 2021
Sep 19 2021


Tamil Nadu:
Probability that cases are accelerating.
Probability on 2021-09-19 : 0.63
2021-09-13 / 2021-09-19
0.8
0.6
0.4
0.2
Sep 13 2021
Sep 14 2021
Sep 15 2021
Sep 16 2021
Sep 17 2021
Sep 18 2021
Sep 19 2021



Note: Actual cases in the period 16-19 September fell above predictions for that period based on data till 12 September. This suggests that the transmission rate has risen relative to the past. This is largely attributable to the sharp rise in cases in Maharashtra.

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*. 256, 110-126. doi:10.1017/nie.2021.12.

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 (2021). A farewell to R: Time series models for tracking and forecasting epidemics. *Journal of the Royal Society Interface* (forthcoming). 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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