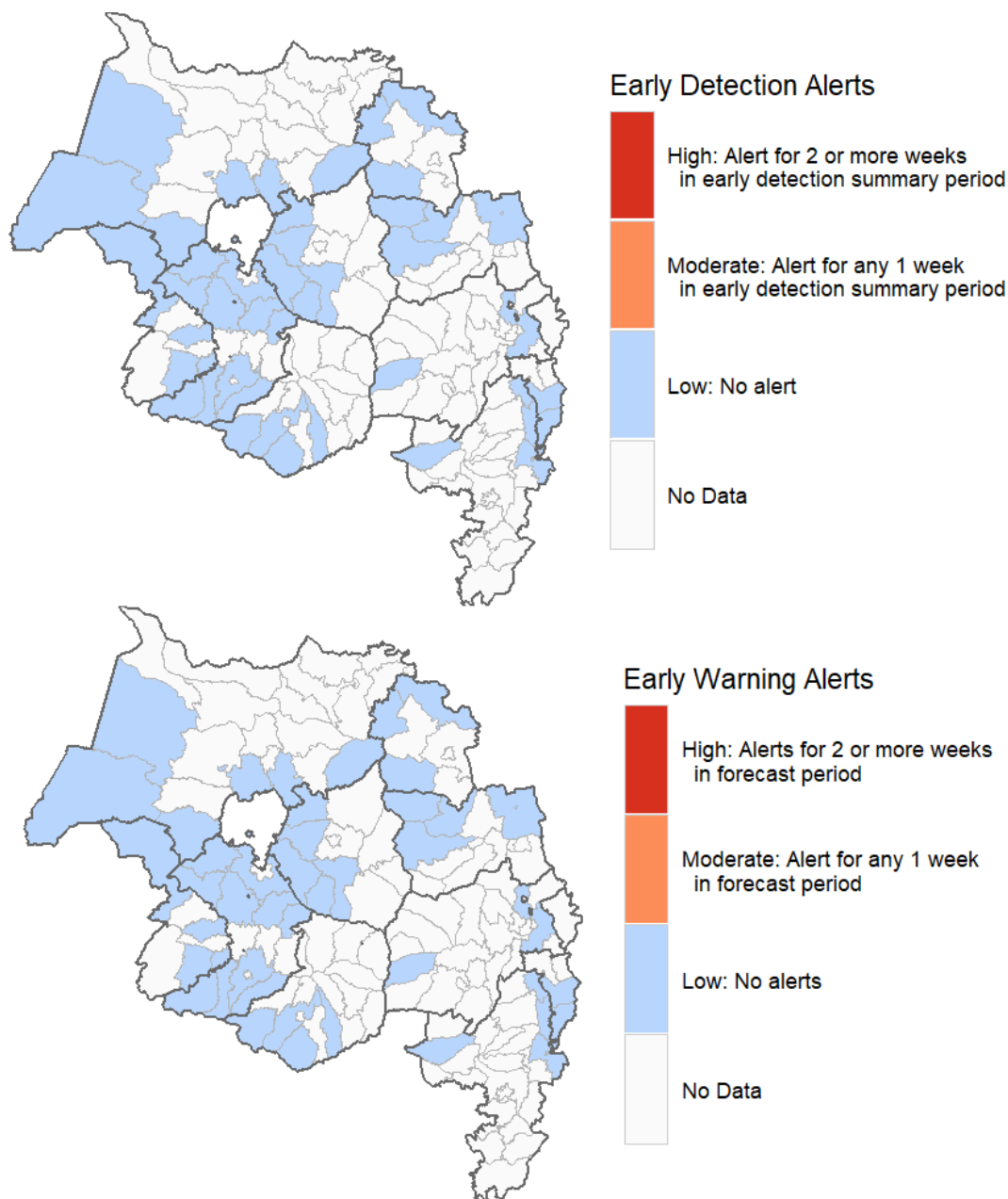# Demonstration Malaria Early Detection and Early Warning Report for Selected Woredas in the Amhara Region of Ethiopia
Week 52: December 24, 2018 - December 30, 2018

Simulated Data

March 26, 2019

1 Alert Summaries

1.1 Alert Map: *P. falciparum* and mixed malaria

Early Detection Period: Last 4 weeks of known epidemiological data.
Date range: Dec 09, 2018 through Dec 30, 2018.
Early Warning Period: Forecasting period of 8 weeks.
Date range: Jan 06, 2019 through Feb 24, 2019.

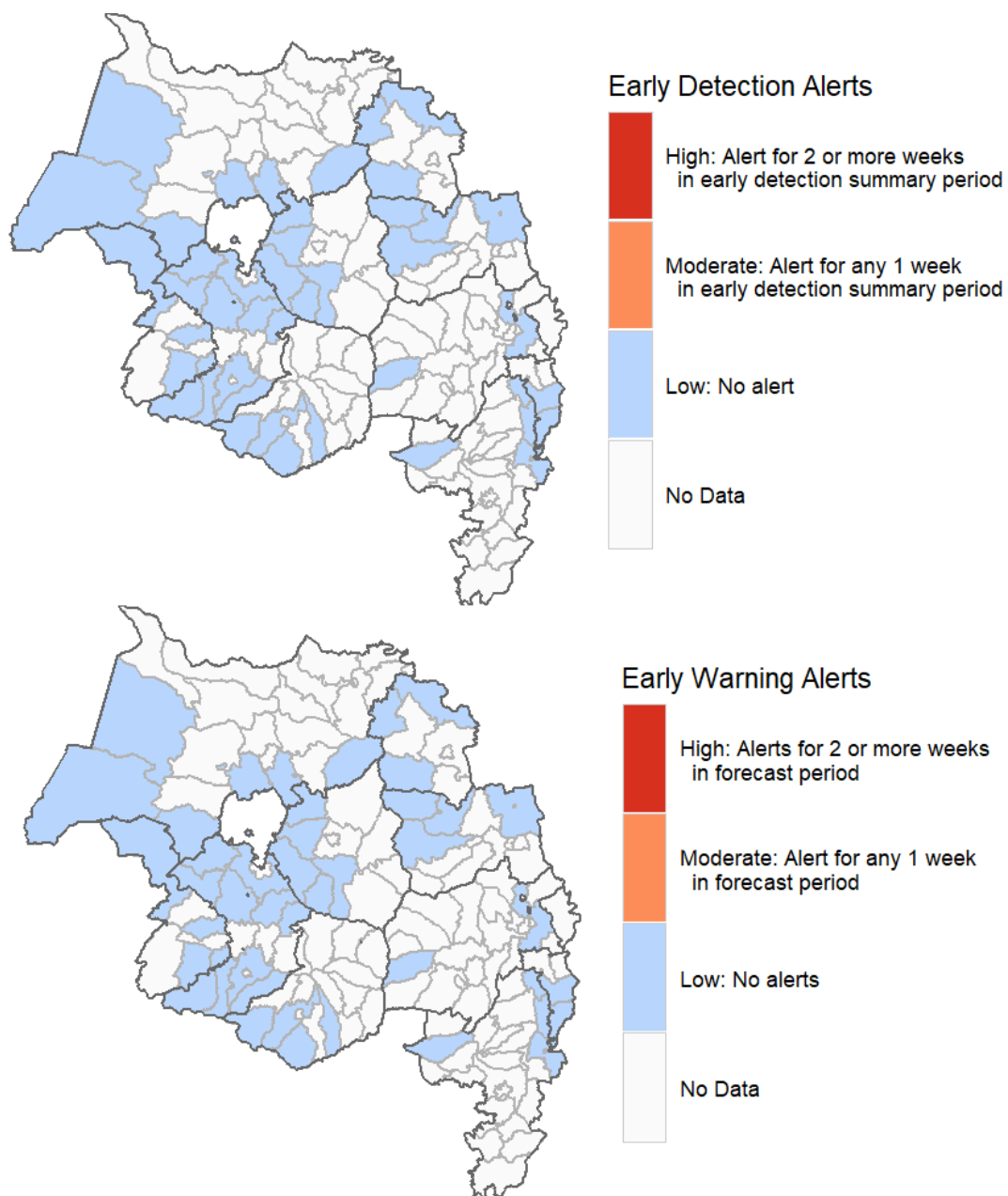## 1.2   Alert Listing: *P. falciparum* and mixed malaria

Zone	Woreda	Early Detection Alert	Early Warning Alert	Both

Early Detection Alerts are alerts generated during the early detection period, and are based on the reported incidence in these weeks. "High" level indicates two or more weeks in this period had incidences greater than the alert threshold, "Medium" means one week, and "Low" means no weeks had alerts.

Early Warning Alerts are alerts generated during the forecast (early warning period), and are based on the relationship between historical incidence values and environmental conditions. Alerts occur when this relationship shows a forecasted value greater than the alert threshold. "High" indicates two or more weeks, "Medium" one week, and "Low" having zero weeks with alert status during the early warning period.

Looking at the results in combination, Early Detection Alerts inform on recent potentially abnormally high incidence values, while Early Warning Alerts indicate that the environmental conditions and seasonality are favorable (or unfavorable) for abnormally high incidence values. The column "Both" indicates if alarm levels for a woreda are at Medium or High for both Early Detection and Early Warning.

1.3 Alert Map: *P. vivax*

Early Detection Period: Last 4 weeks of known epidemiological data.
Date range: Dec 09, 2018 through Dec 30, 2018.

Early Warning Period: Forecasting period of 8 weeks.
Date range: Jan 06, 2019 through Feb 24, 2019.

1.4 Alert Listing: *P. vivax*

Zone	Woreda	Early Detection Alert	Early Warning Alert	Both

Early Detection Alerts are alerts generated during the early detection period, and are based on the reported incidence in these weeks. "High" level indicates two or more weeks in this period had incidences greater than the alert threshold, "Medium" means one week, and "Low" means no weeks had alerts.

Early Warning Alerts are alerts generated during the forecast (early warning period), and are based on the relationship between historical incidence values and environmental conditions. Alerts occur when this relationship shows a forecasted value greater than the alert threshold. "High" indicates two or more weeks, "Medium" one week, and "Low" having zero weeks with alert status during the early warning period.

Looking at the results in combination, Early Detection Alerts inform on recent potentially abnormally high incidence values, while Early Warning Alerts indicate that the environmental conditions and seasonality are favorable (or unfavorable) for abnormally high incidence values. The column "Both" indicates if alarm levels for a woreda are at Medium or High for both Early Detection and Early Warning.

1.5 Reference Map
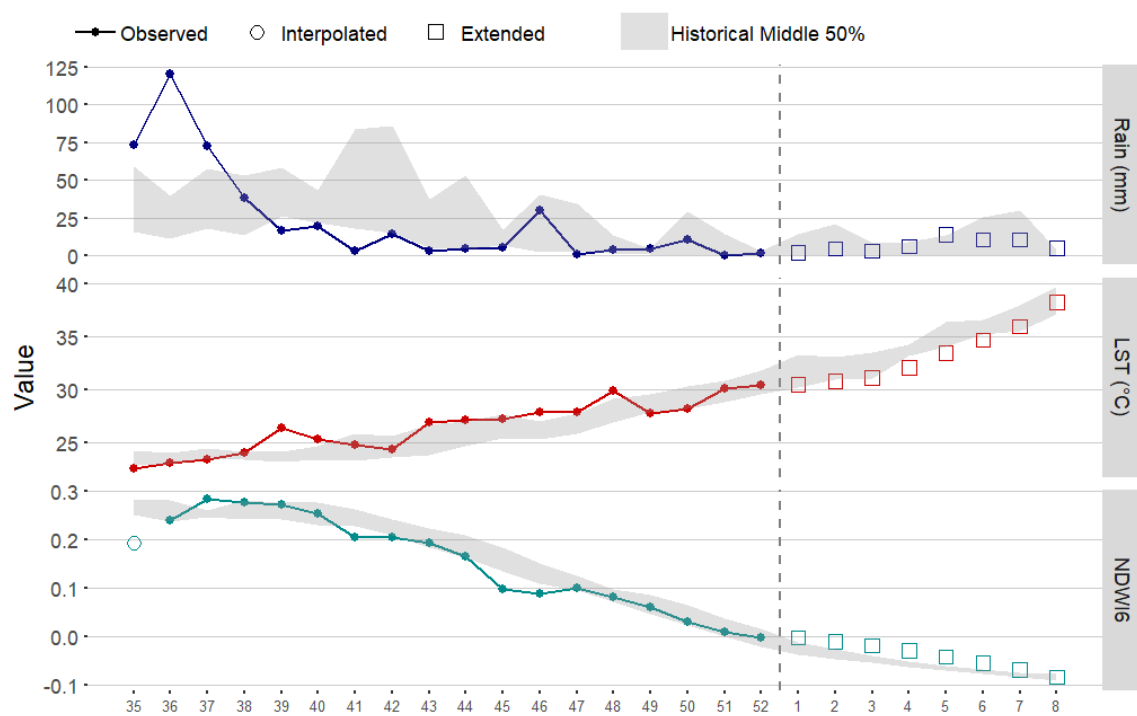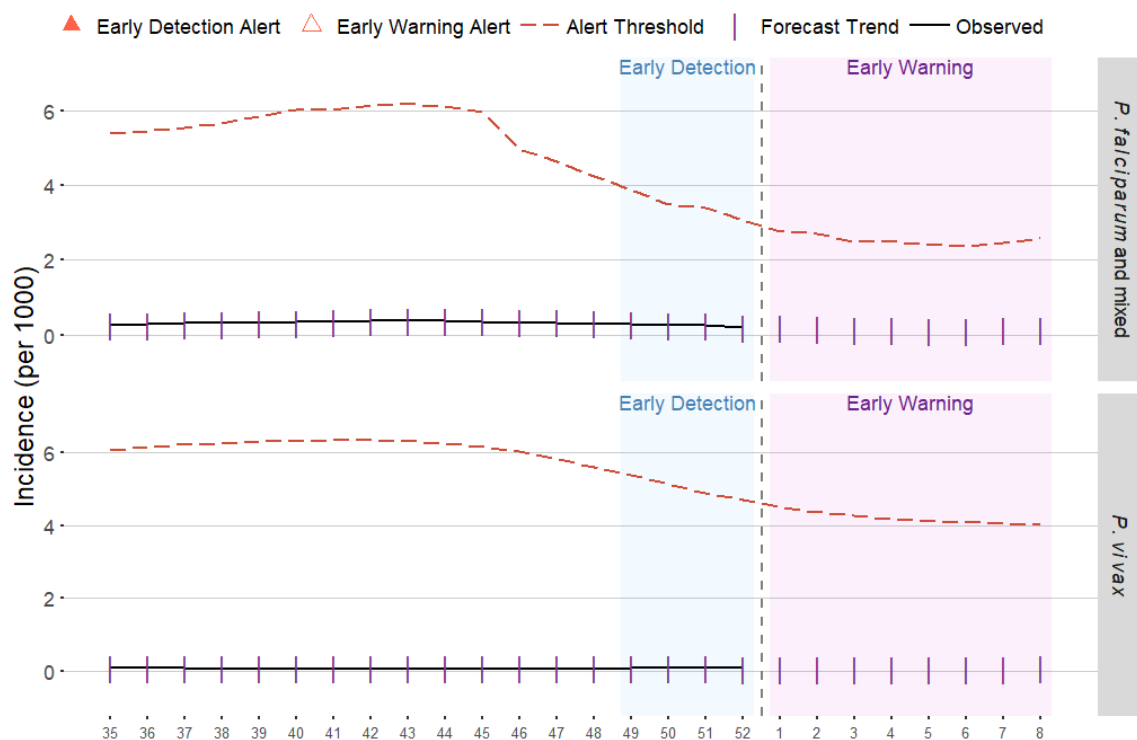
Woredas in the EPIDEMIA project
Amhara Region, Ethiopia

2 Woreda Reports

2.1 Awi: Ankesha

See last report section 4 for a description of details and individual woreda reports.
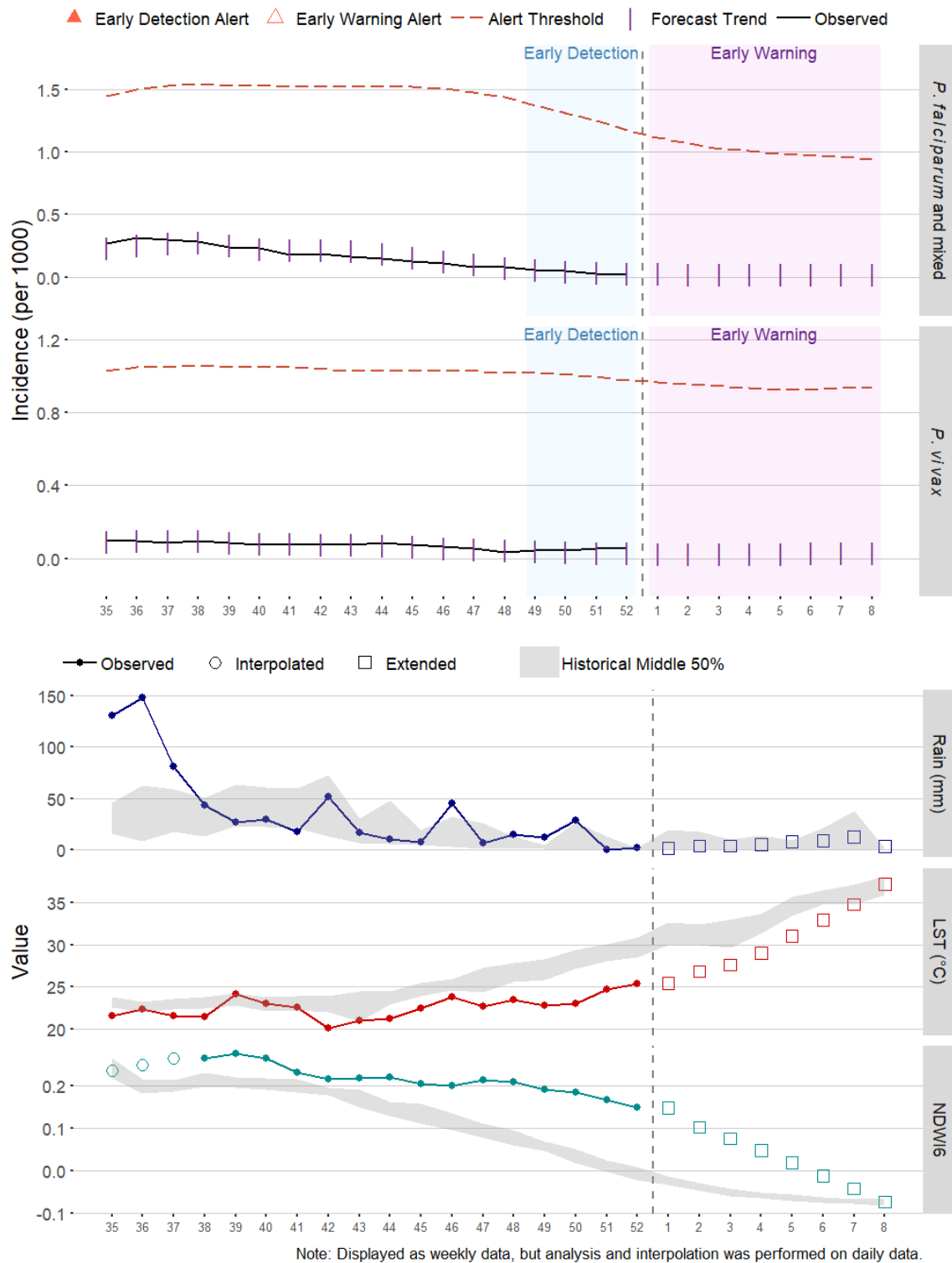
2.2   Awi: Fagita Lekoma

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.
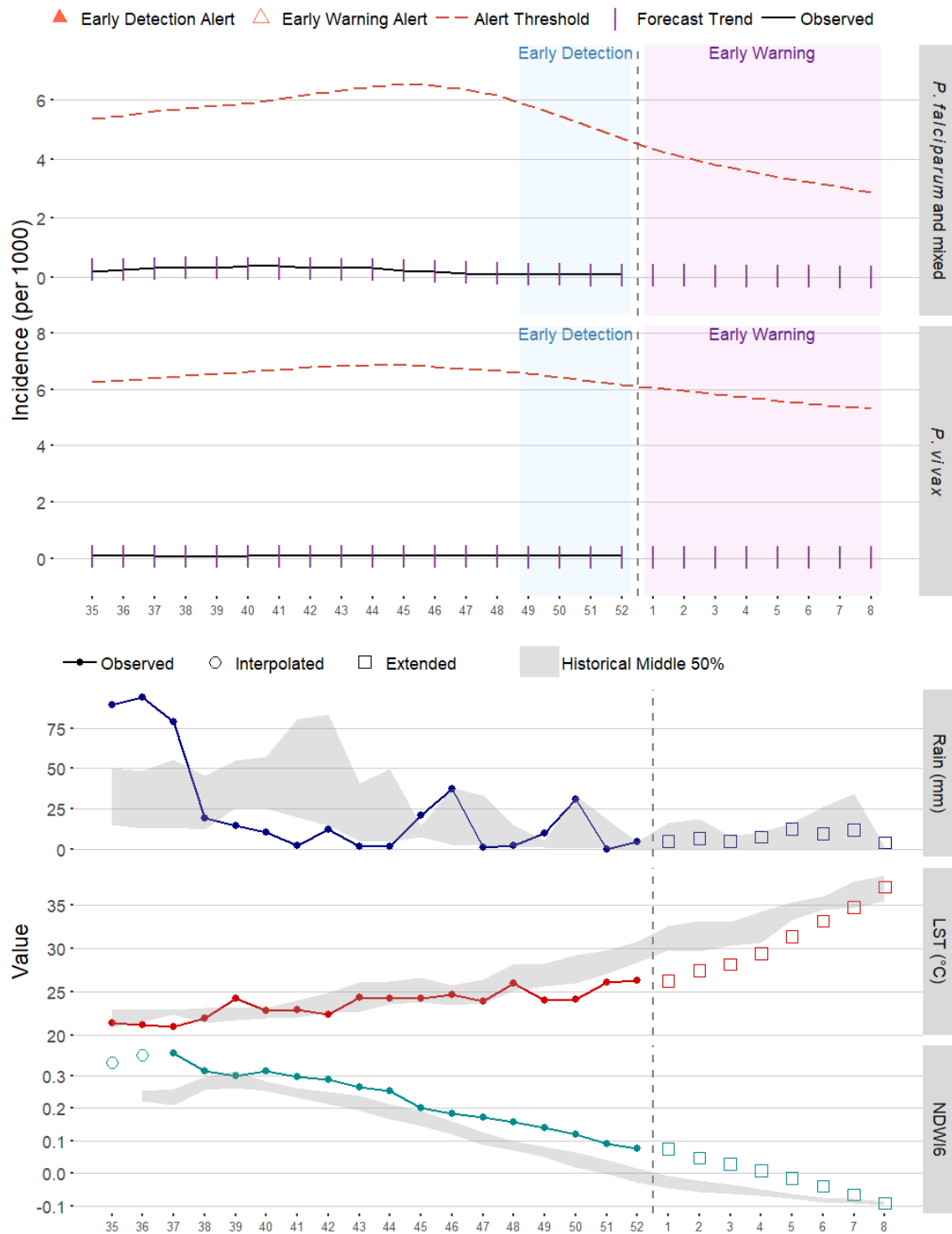
Report compiled on 26 March 2019

2.3 Awi: Guagusa Shekudad

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.4   Awi: Jawi

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
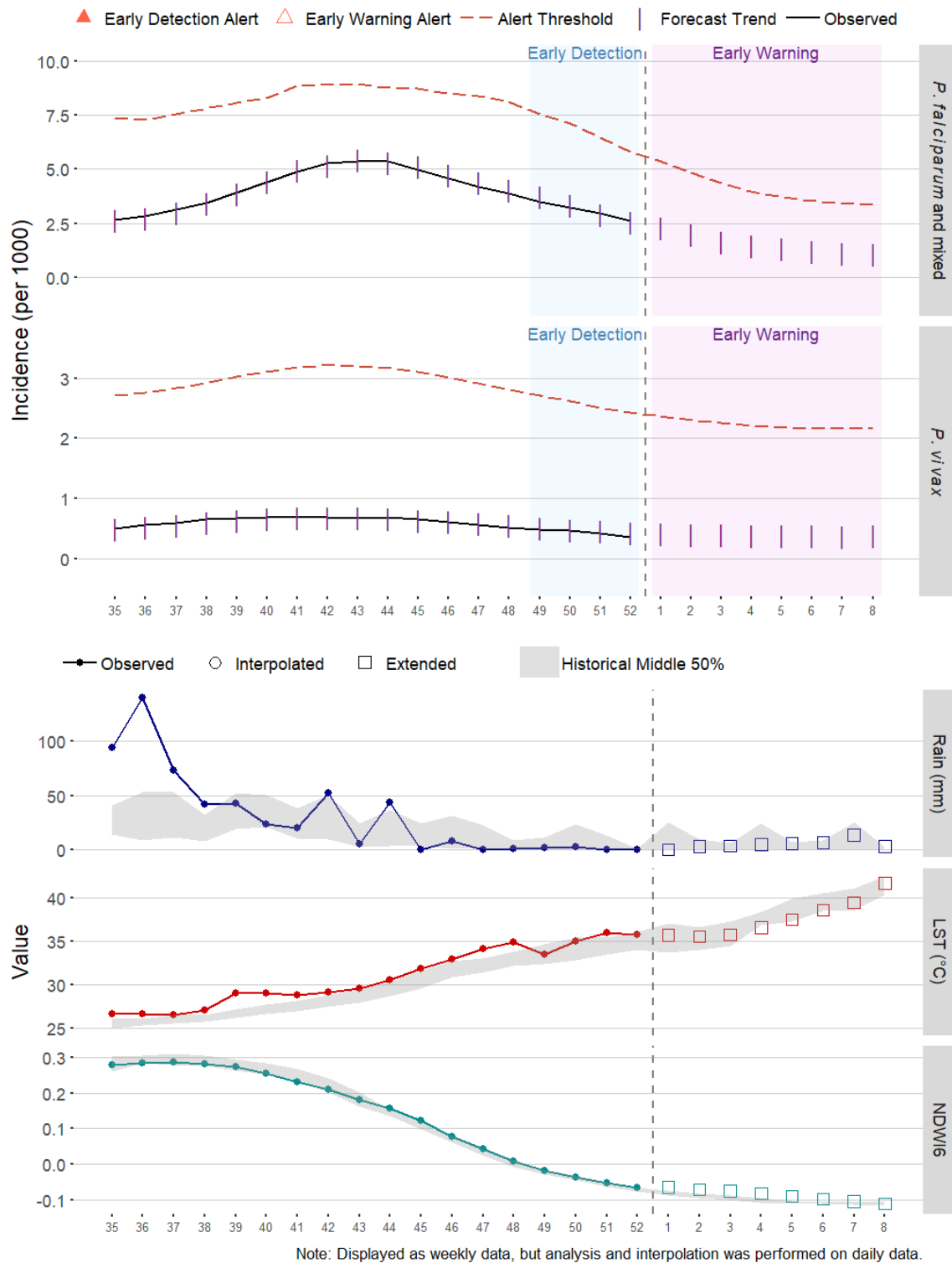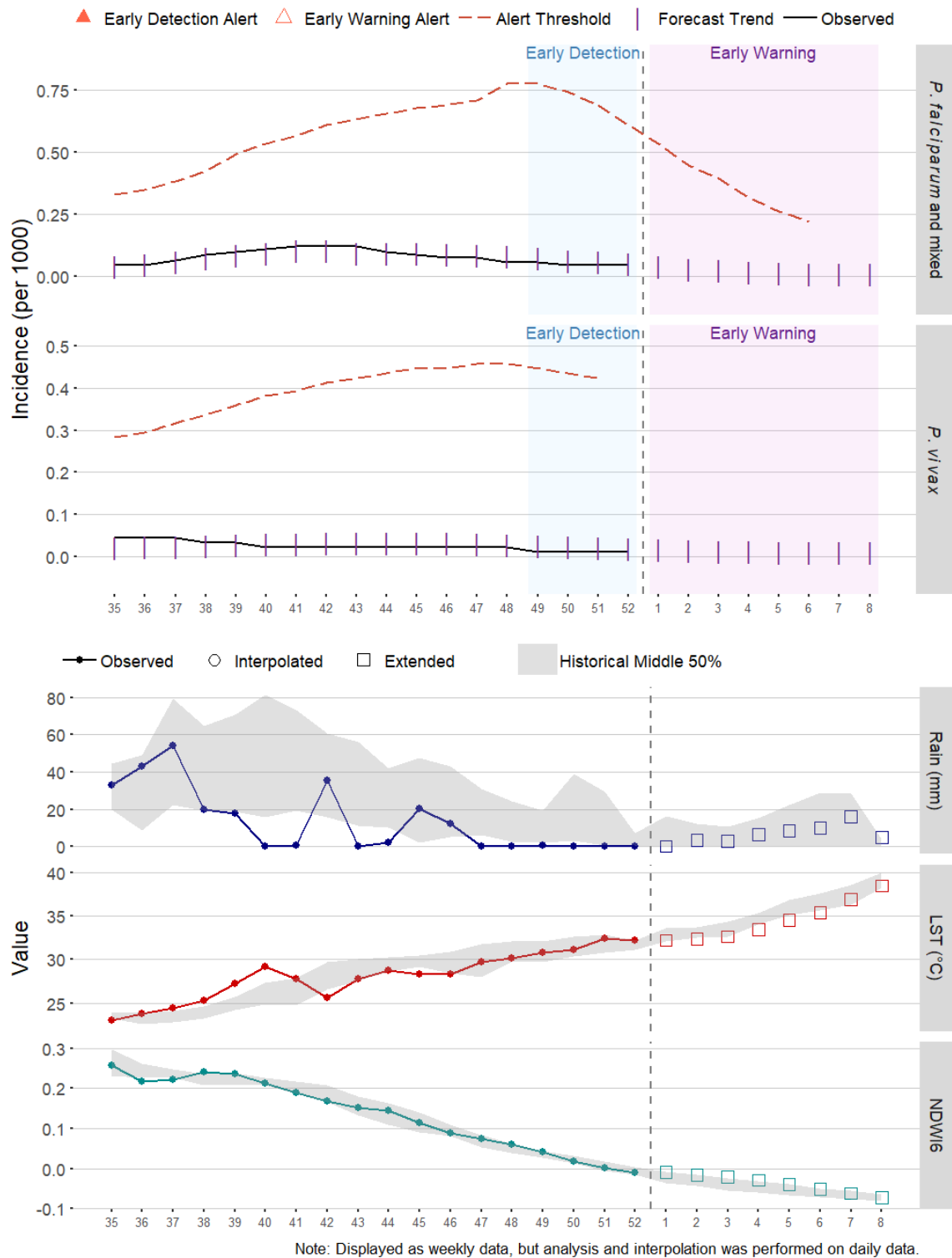
See last report section 4 for a description of details and individual woreda reports.

2.5   East Gojjam: Awabel

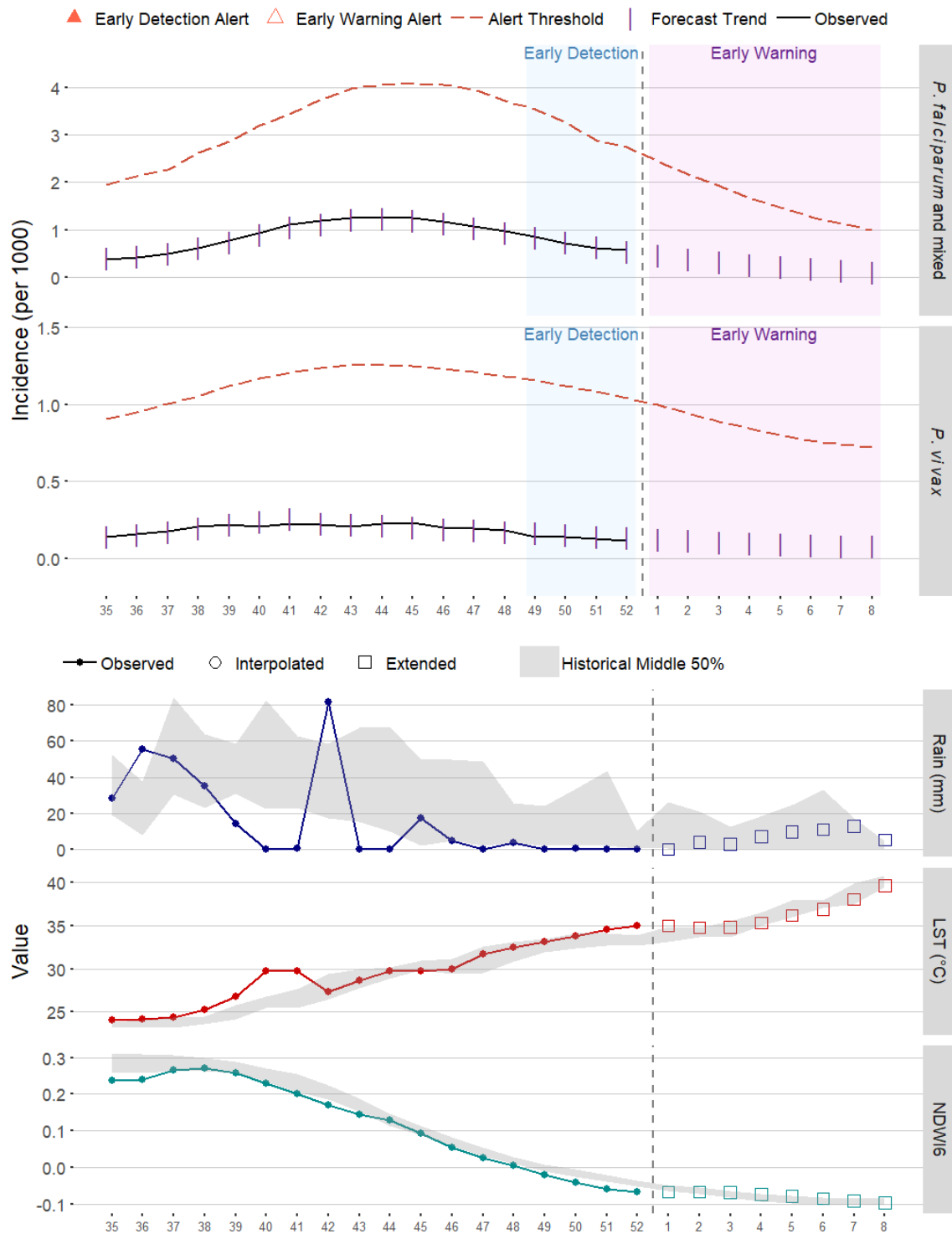Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.6   East Gojjam: Baso Liben

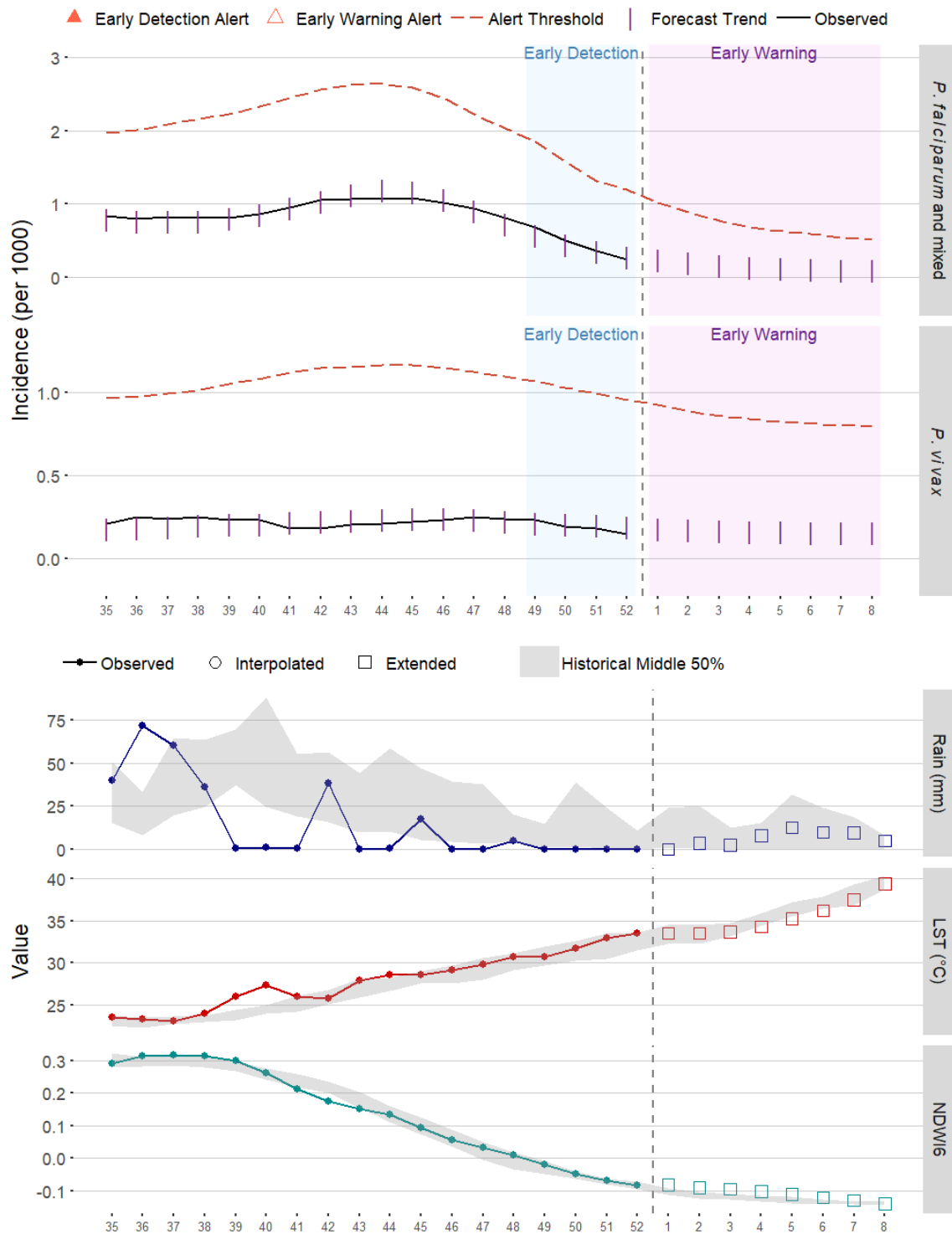Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.7   East Gojjam: Debre Elias

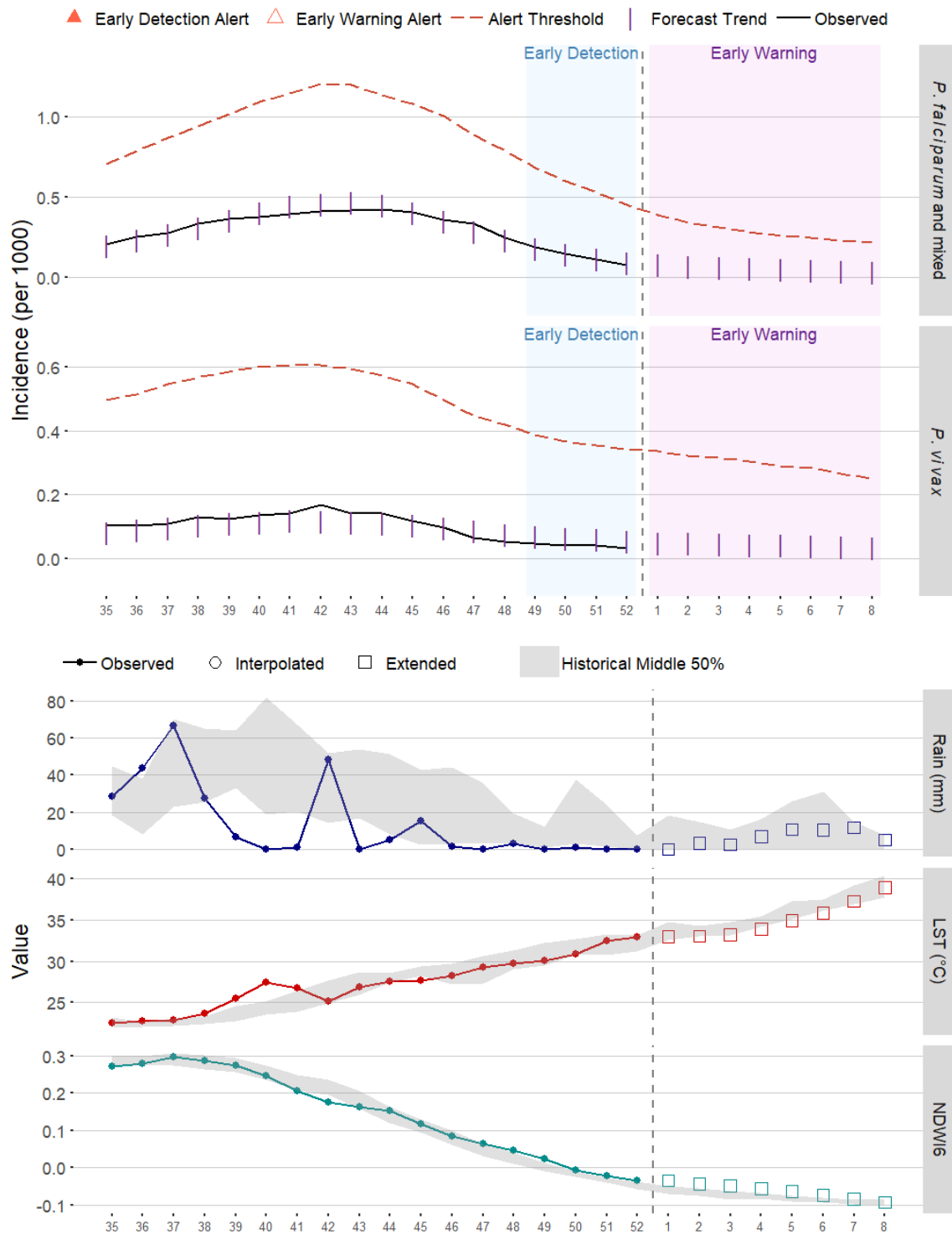Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.8   East Gojjam: Gozamin

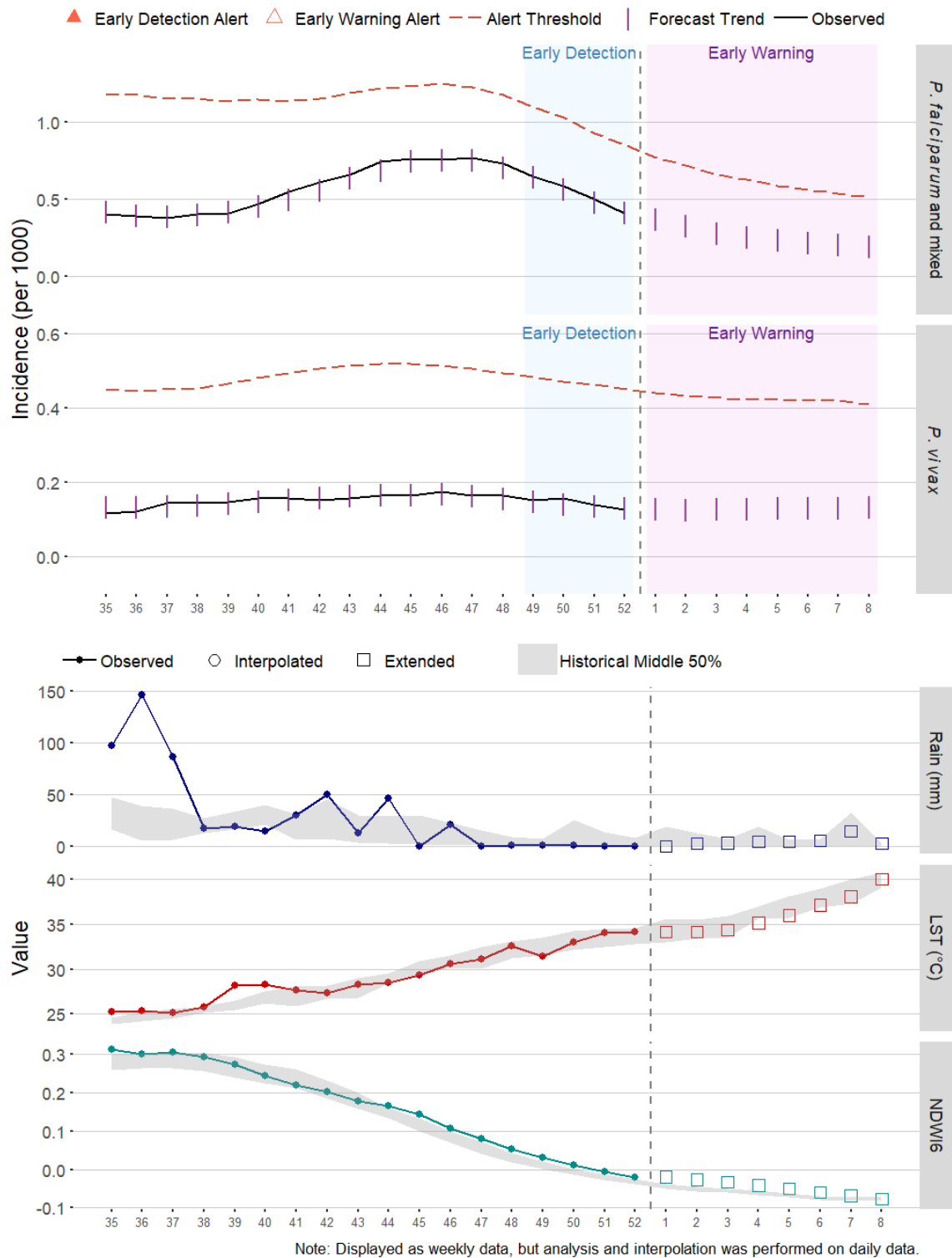Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.9   North Gondar: Alefa

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
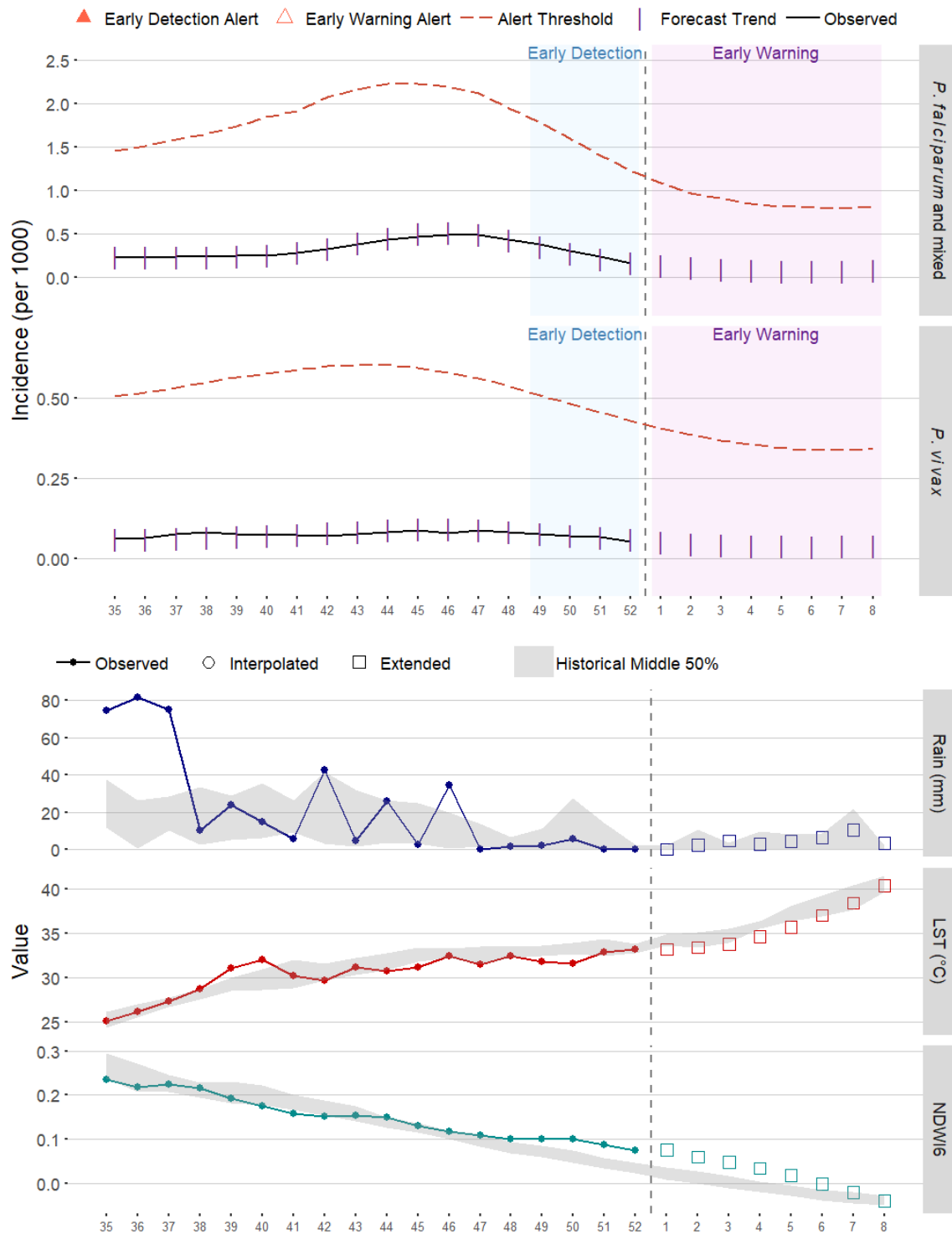
See last report section 4 for a description of details and individual woreda reports.

2.10 North Gondar: Denbia

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
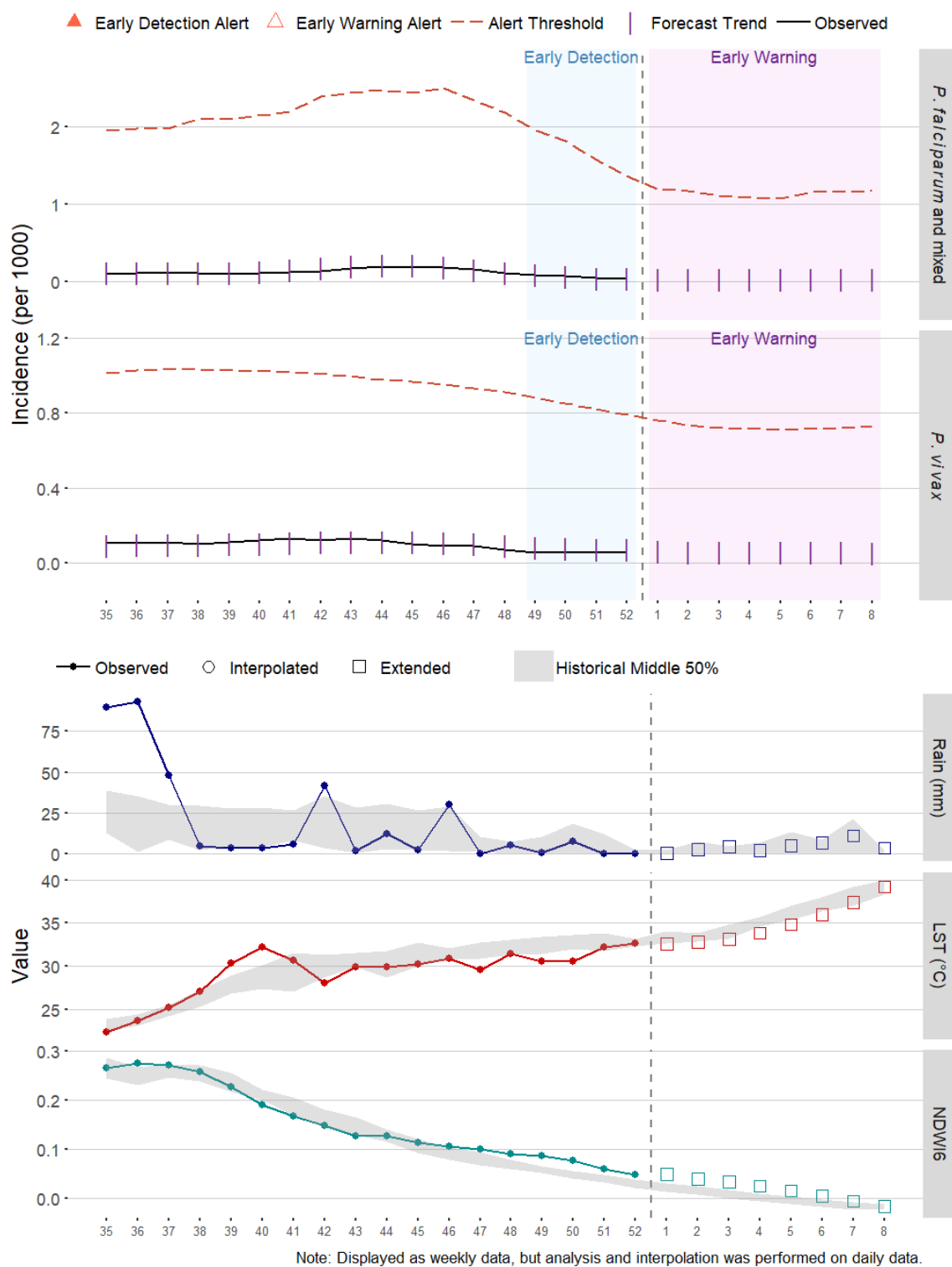
See last report section 4 for a description of details and individual woreda reports.

2.11 North Gondar: Gondar Zuria

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
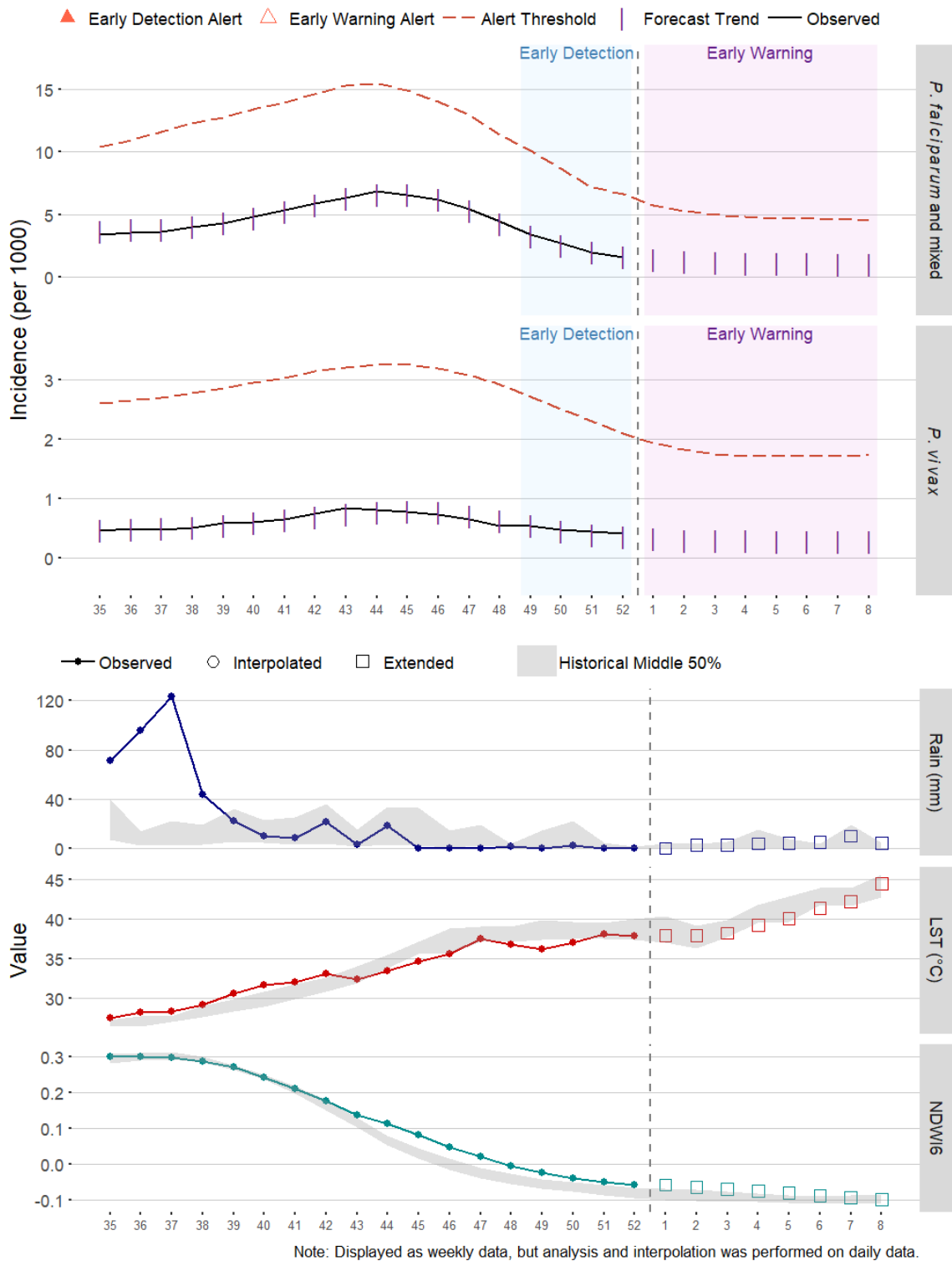
See last report section 4 for a description of details and individual woreda reports.

2.12   North Gondar: Metema

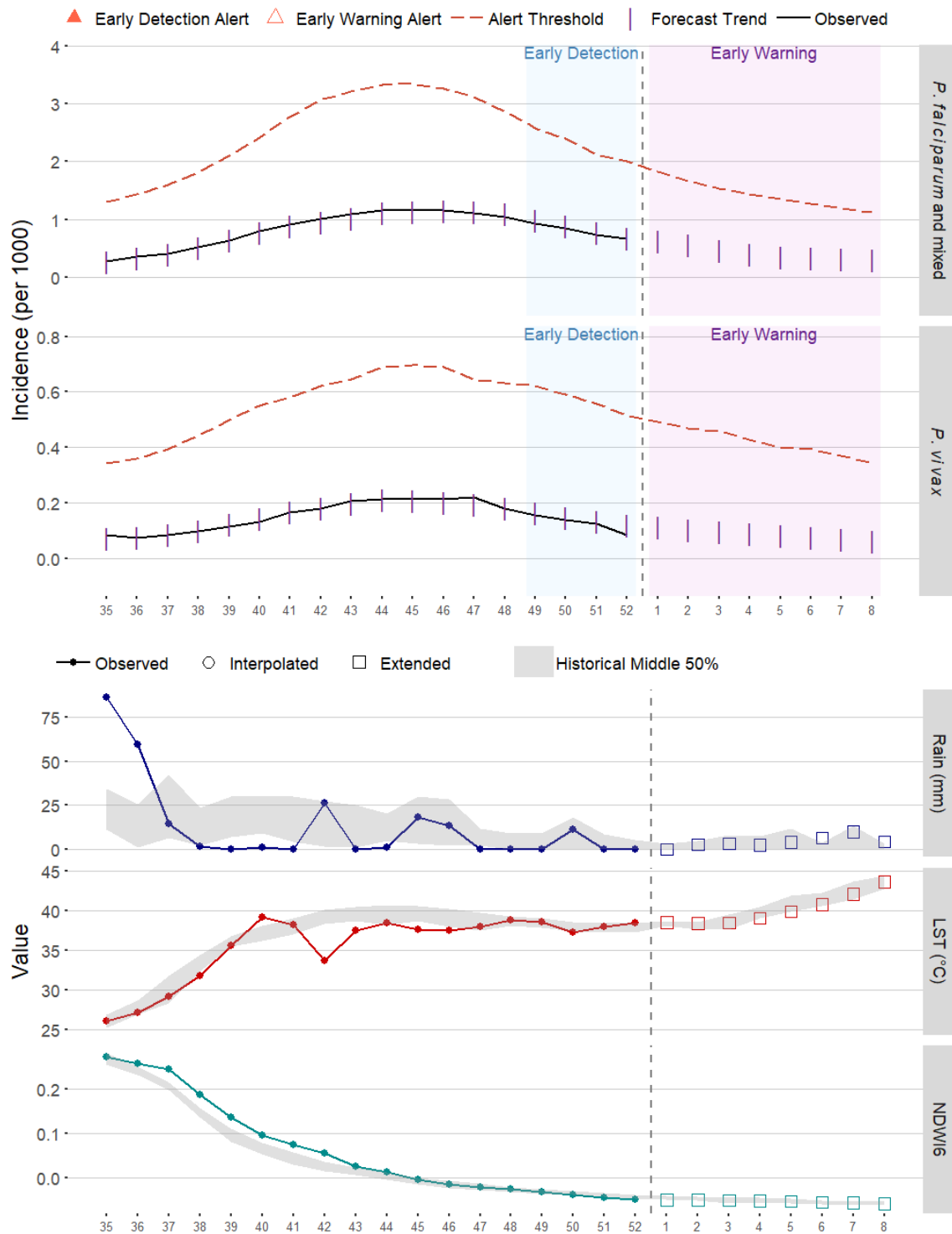Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.13   North Gondar: Misrak Belesa

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
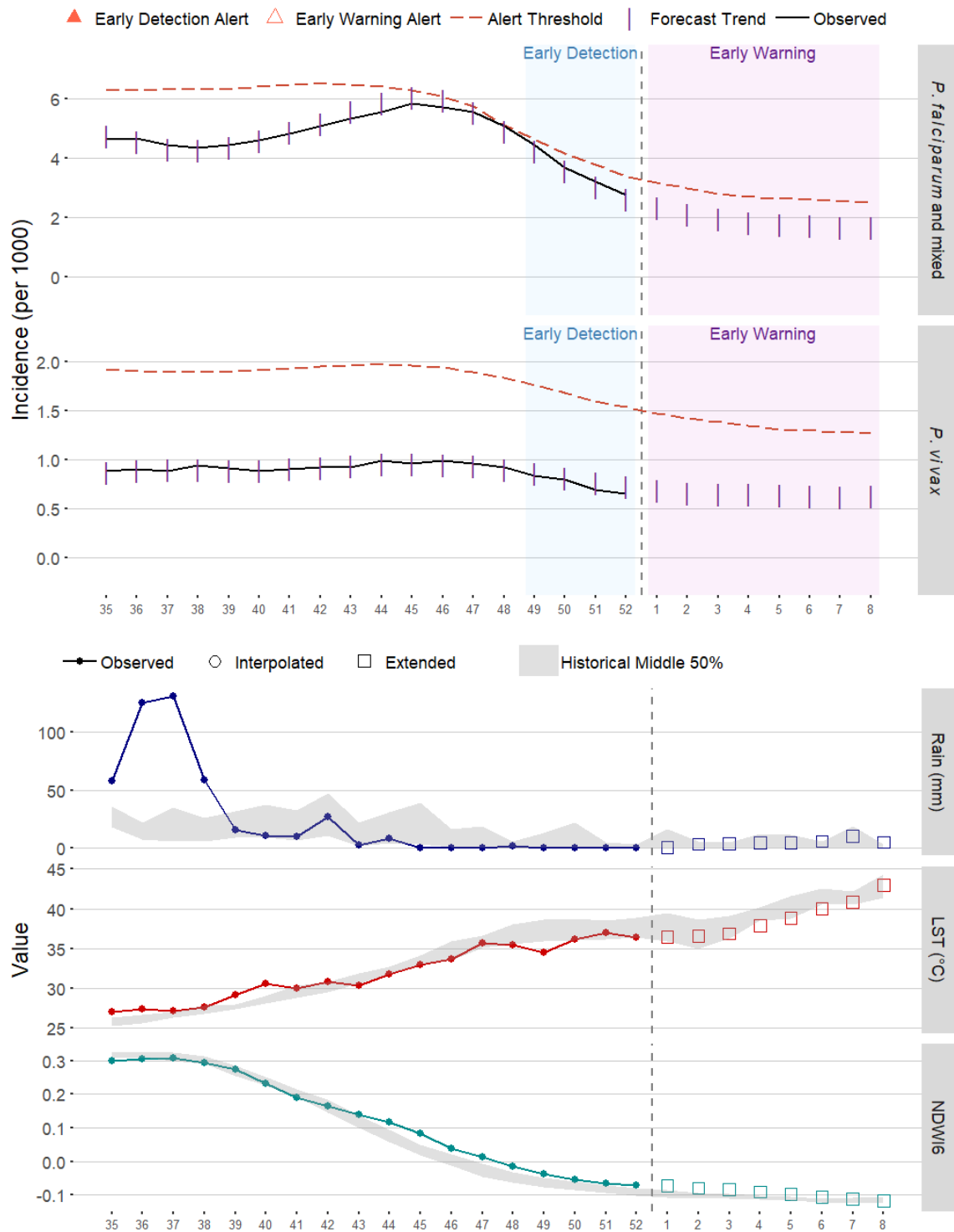
See last report section 4 for a description of details and individual woreda reports.

2.14   North Gondar: Quara

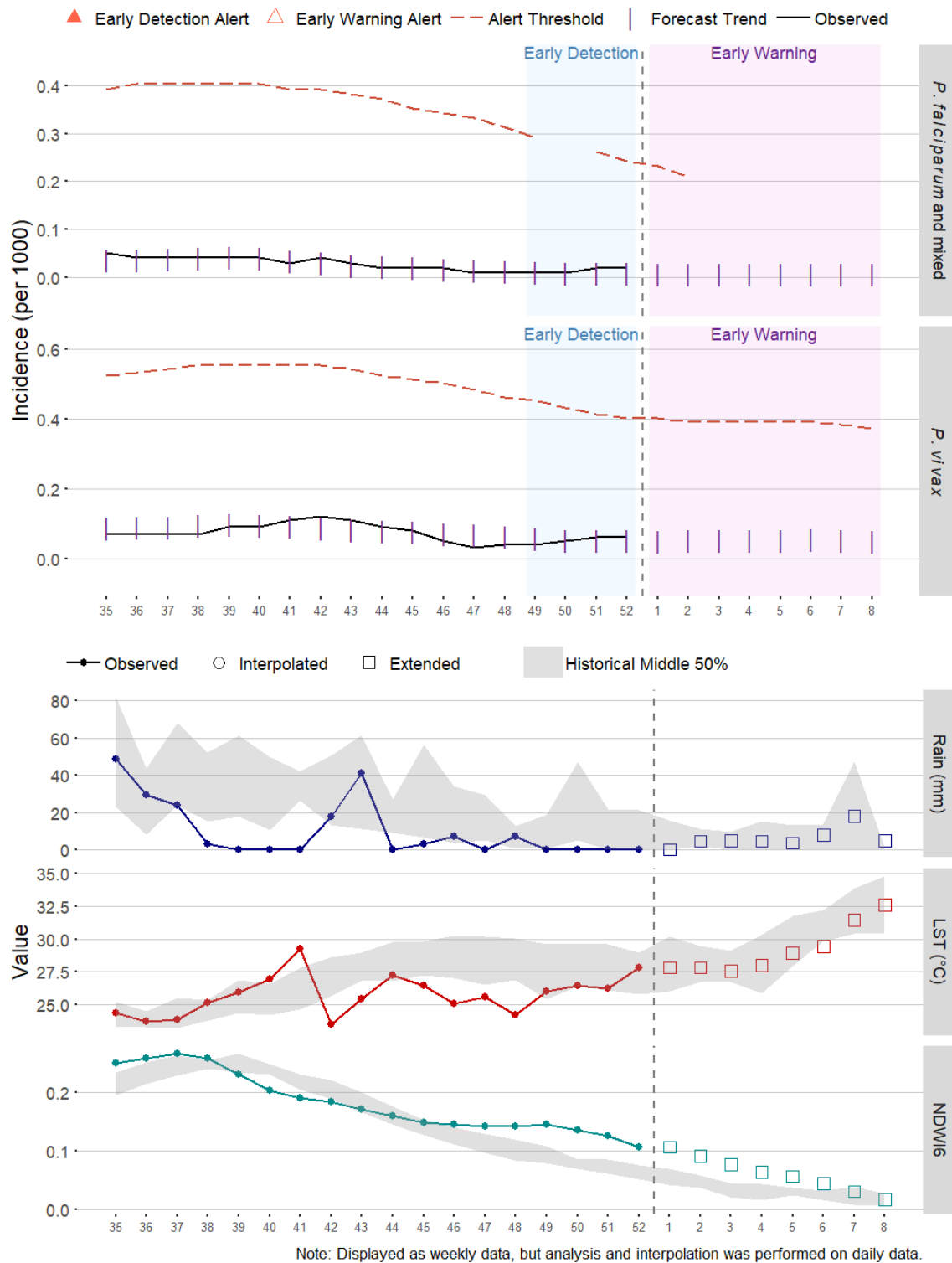Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.15   North Shewa: Antsokiya Gemza

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
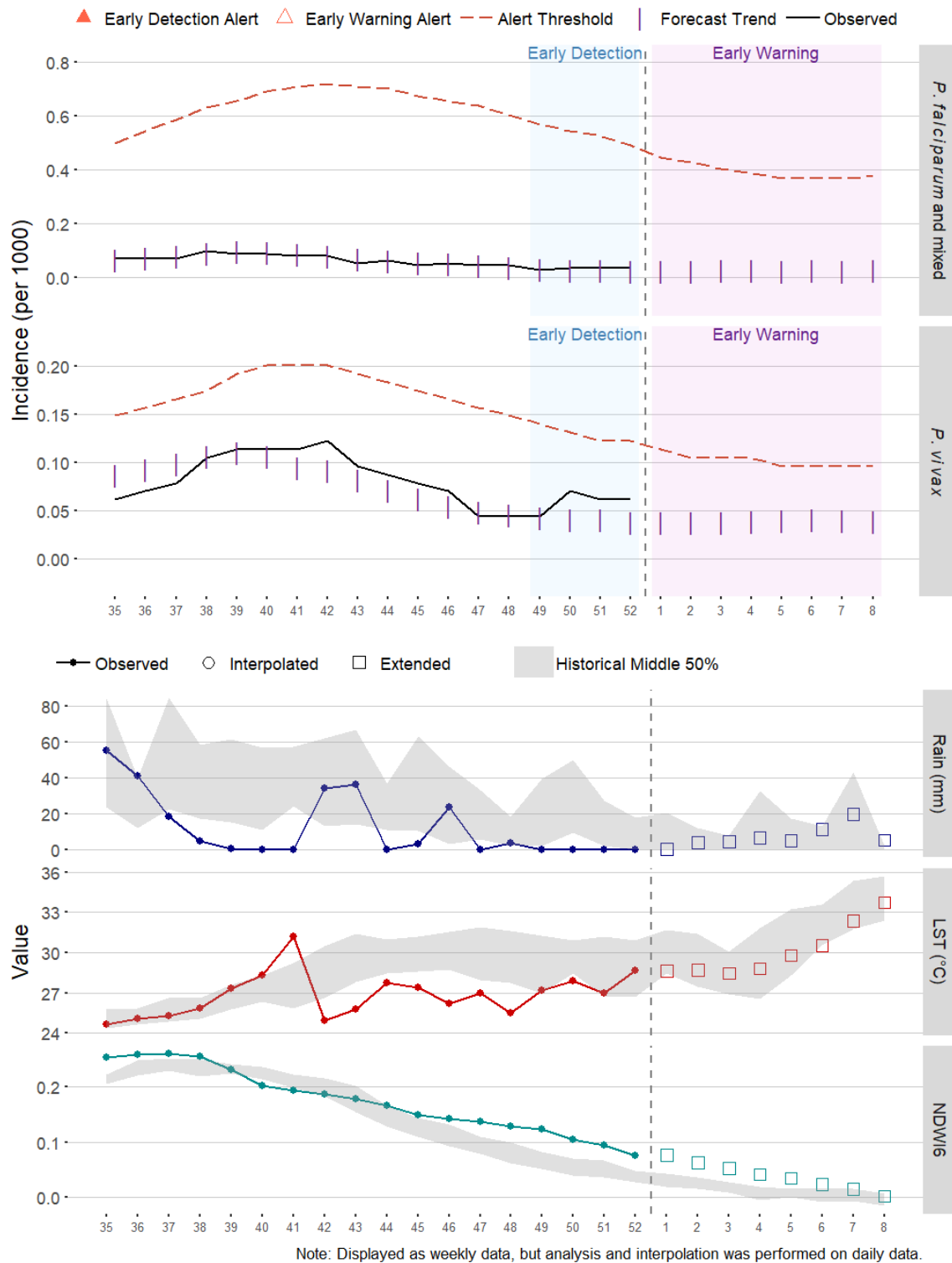
See last report section 4 for a description of details and individual woreda reports.

2.16   North Shewa: Efratana Gidim

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.17   North Shewa: Kewet
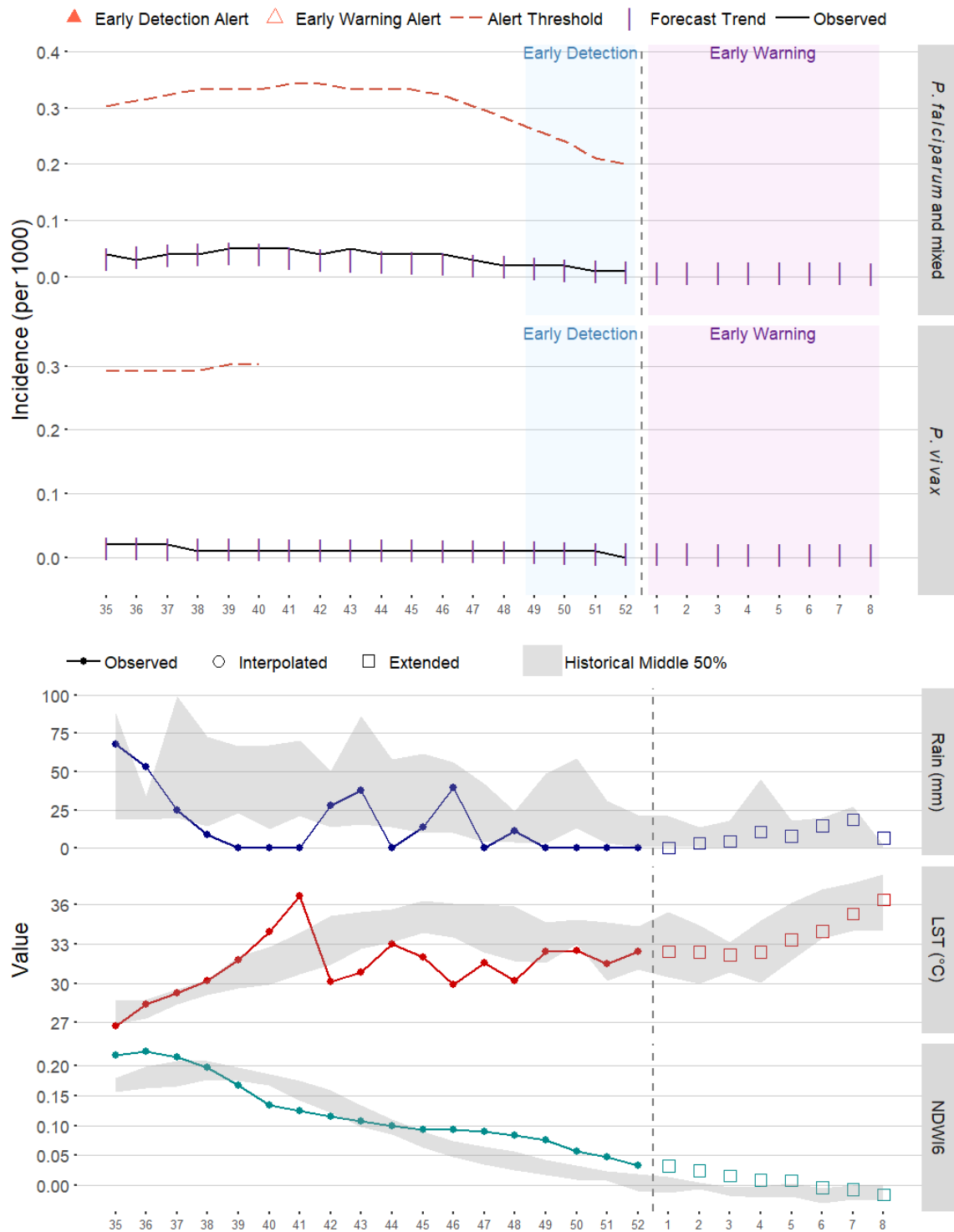
Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.18   North Shewa: Merehabete
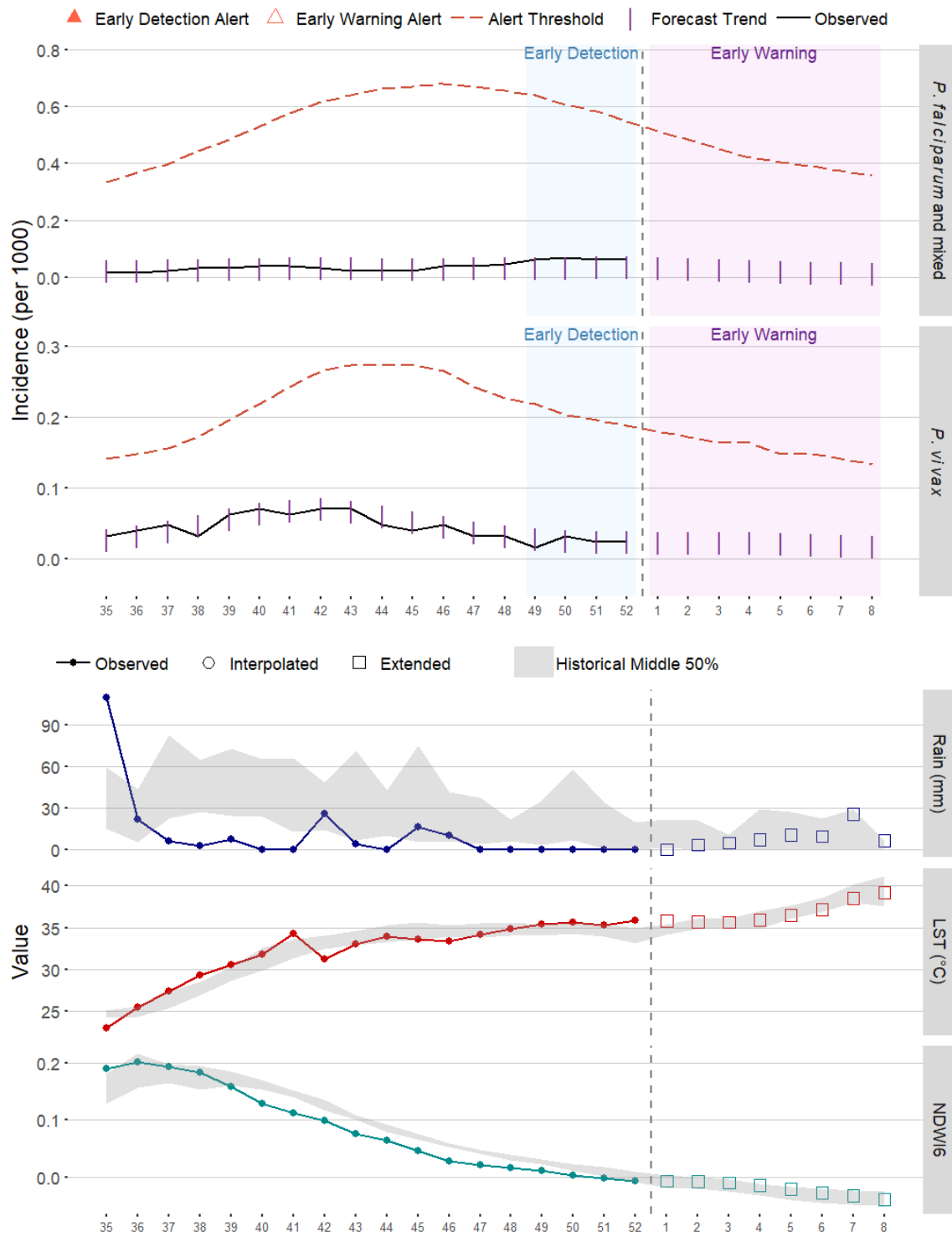

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.19   North Shewa: Shewa Robit

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.20   North Wollo: Bugna

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

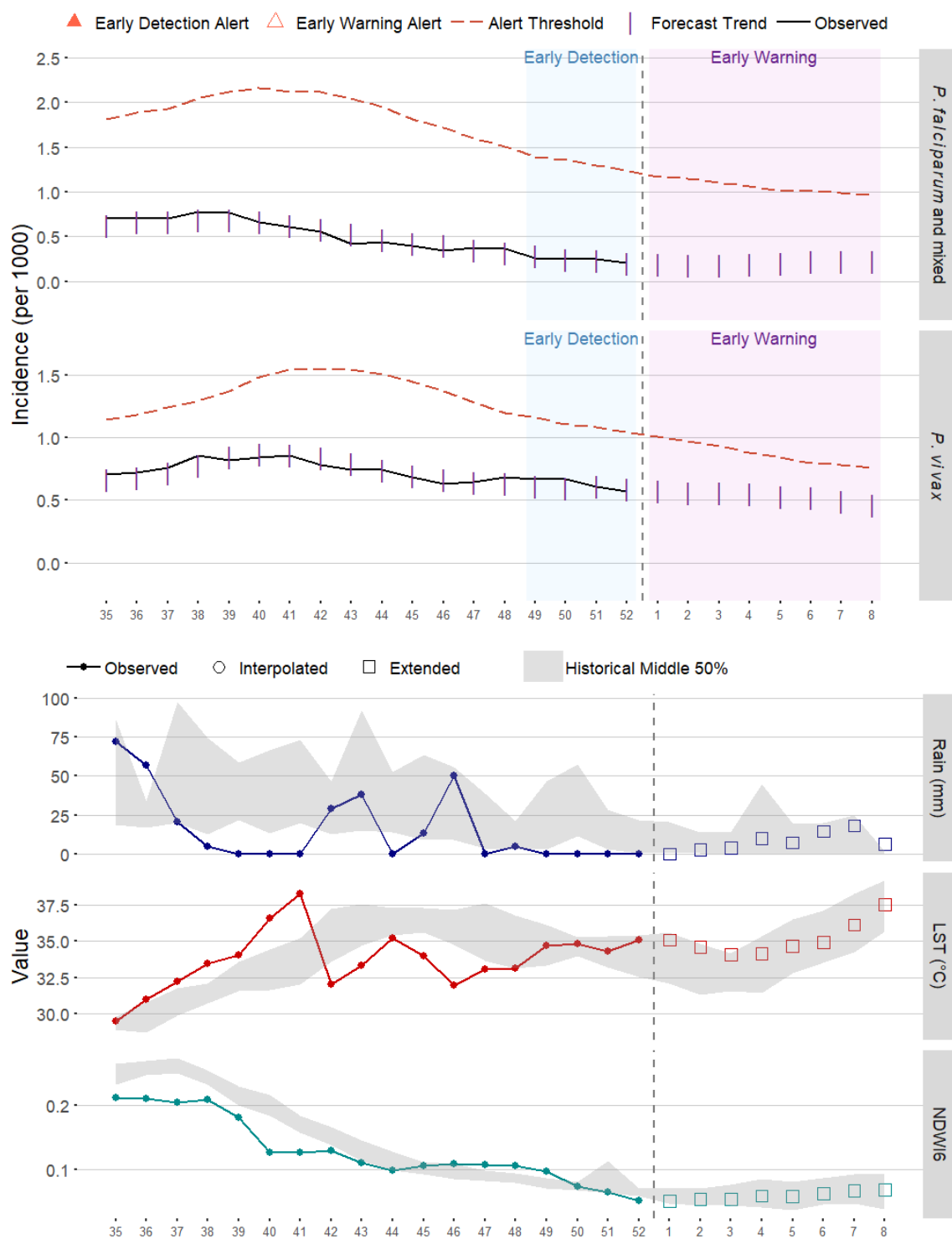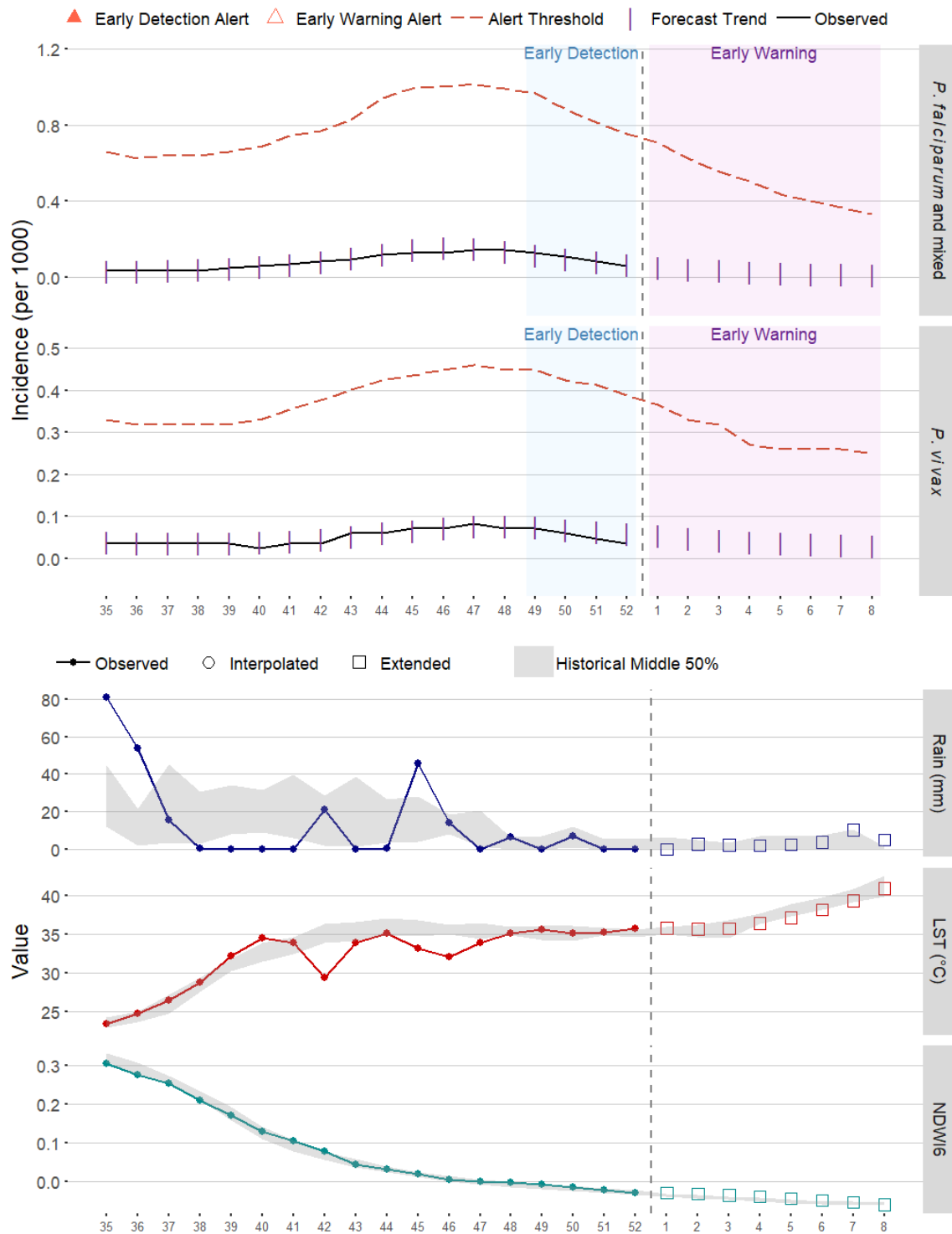See last report section 4 for a description of details and individual woreda reports.

2.21   North Wollo: Kobo Town

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
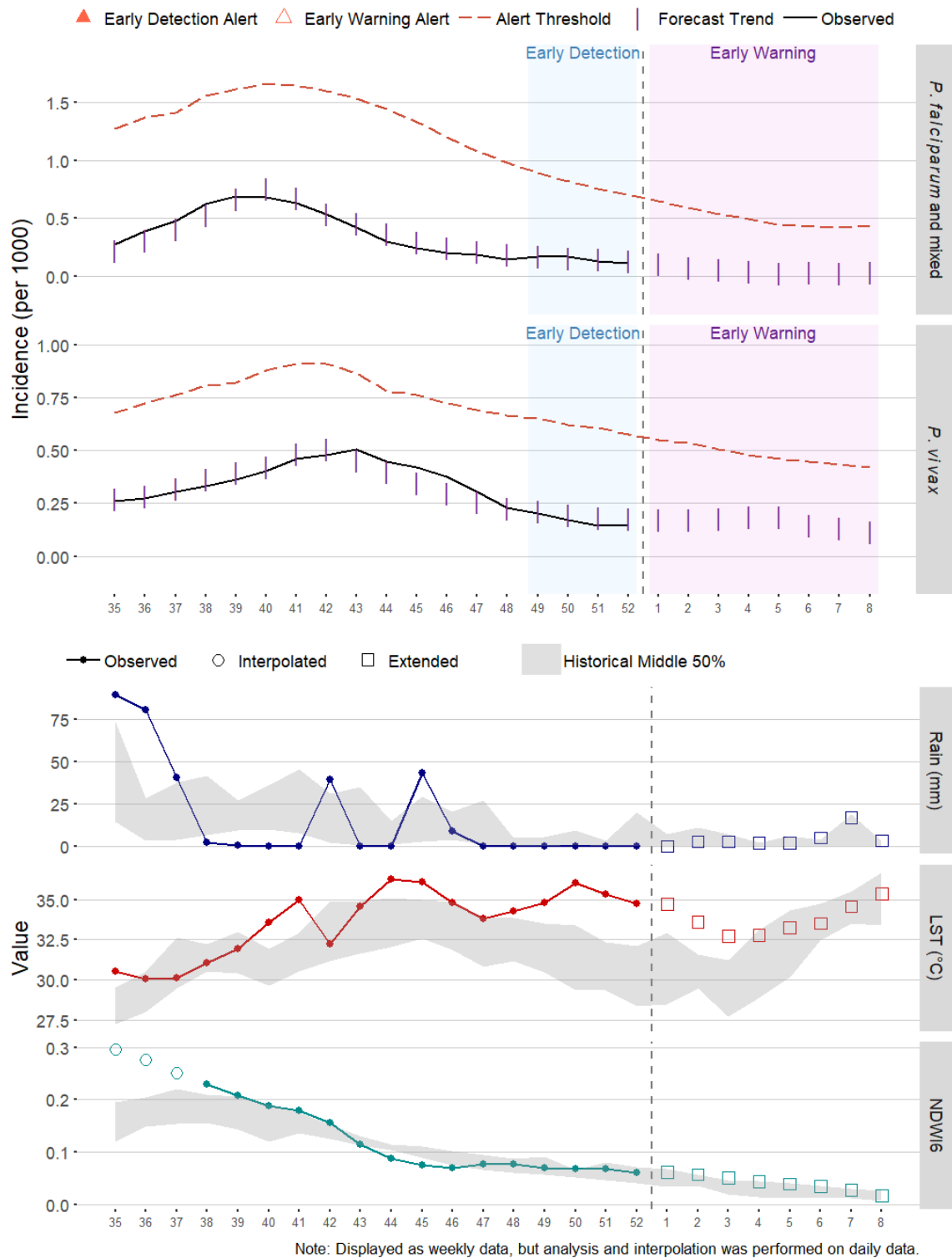
See last report section 4 for a description of details and individual woreda reports.

2.22   North Wollo: Lasta

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
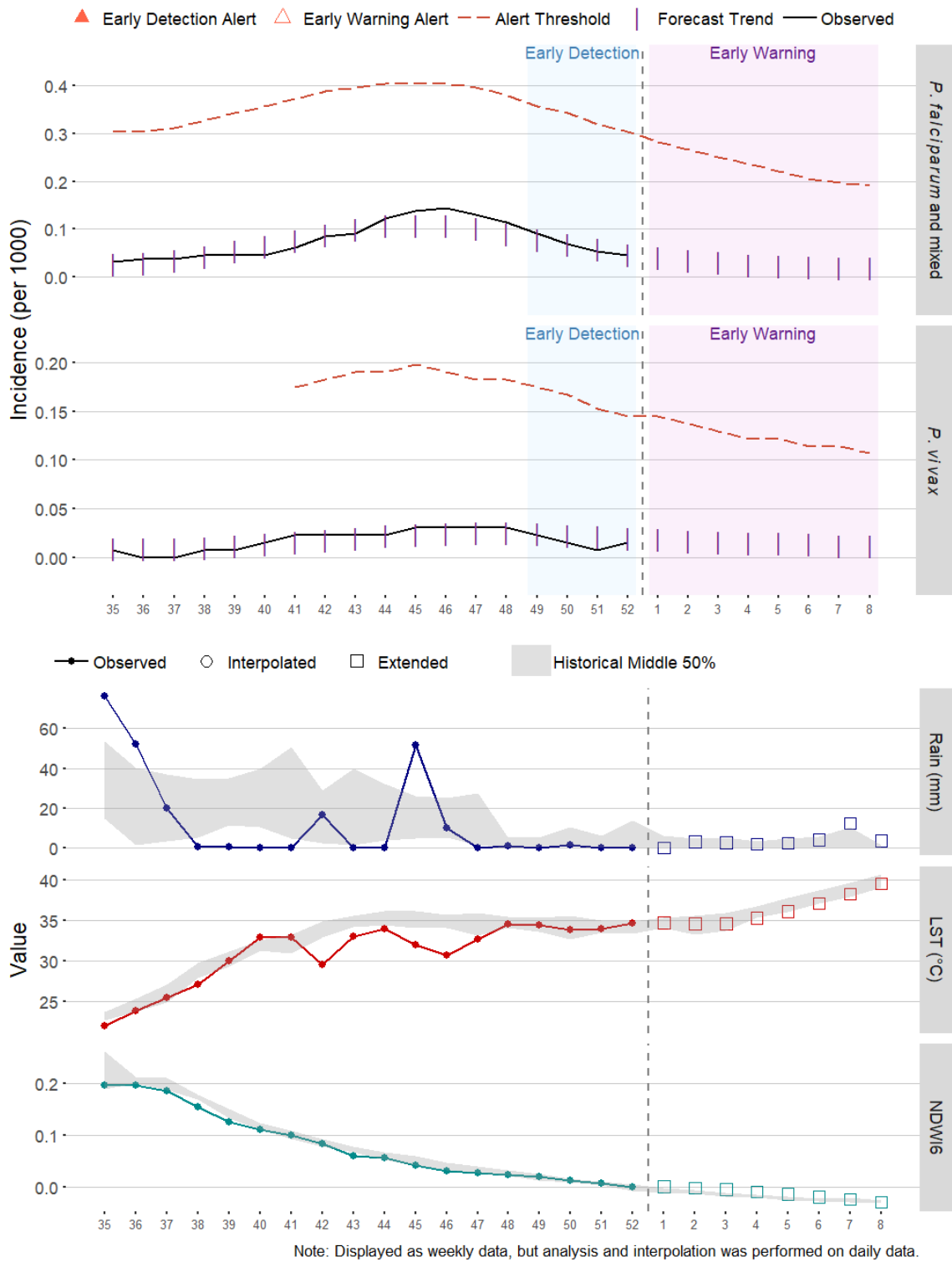
See last report section 4 for a description of details and individual woreda reports.

2.23   North Wollo: Mekit

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
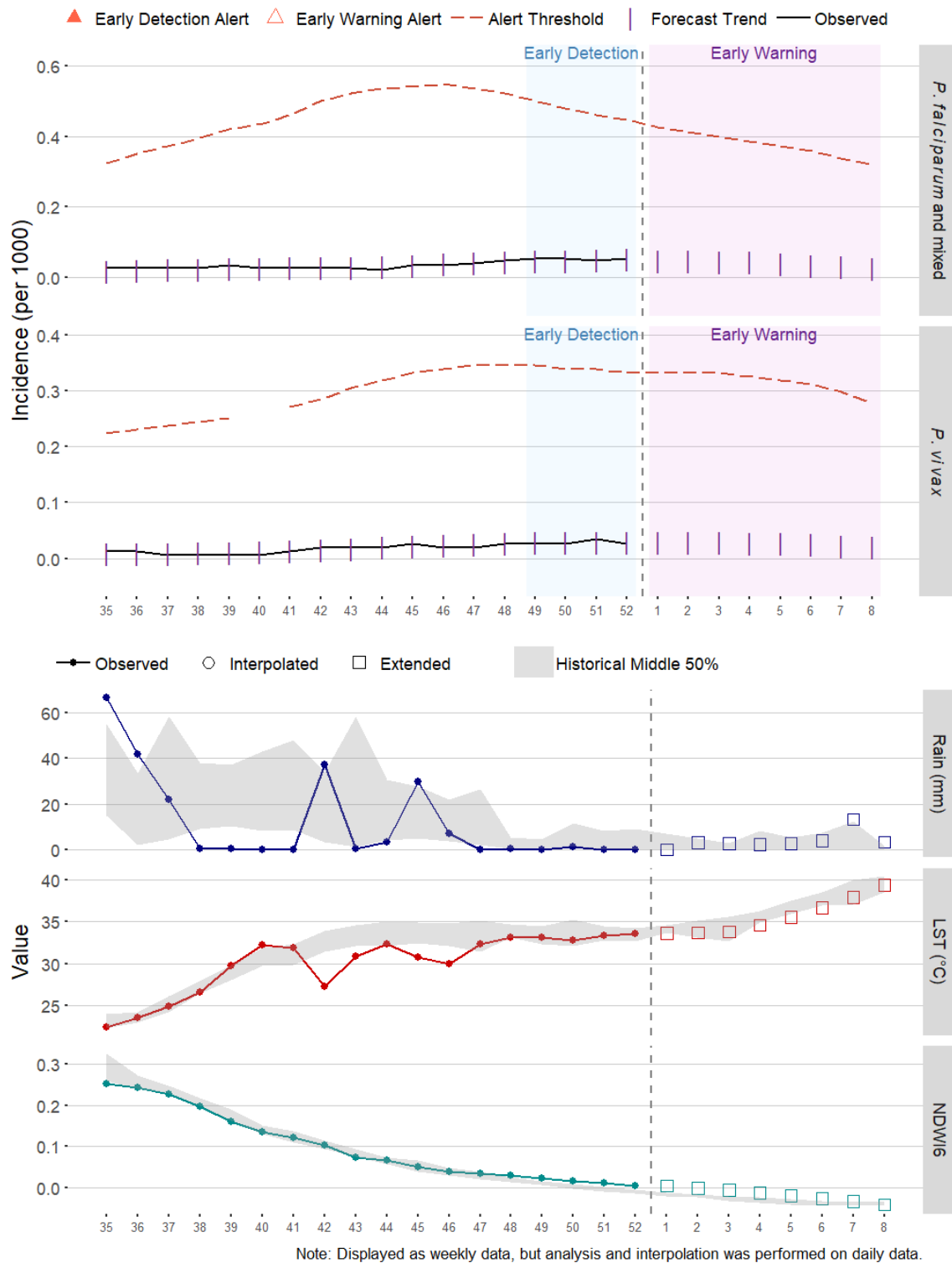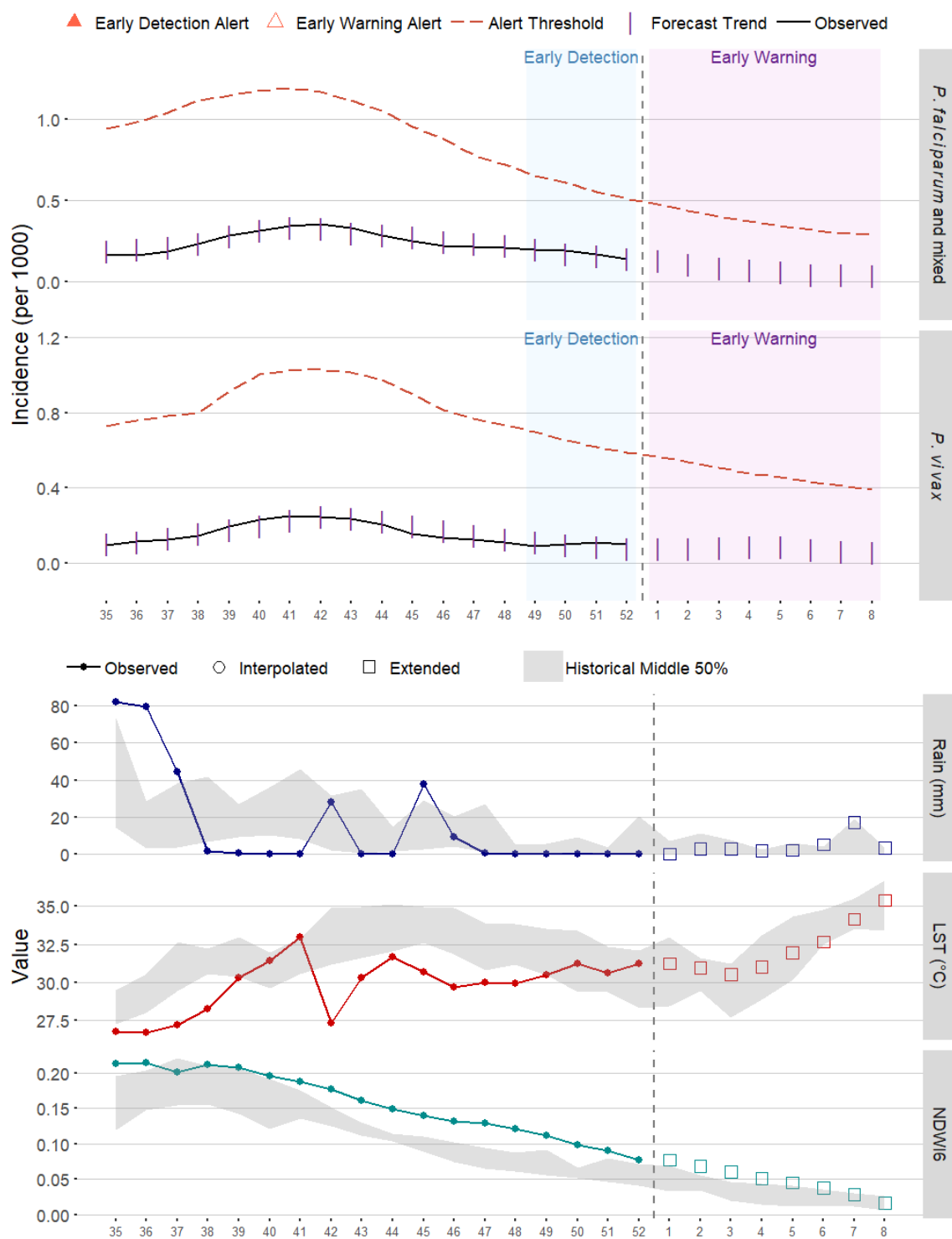
See last report section 4 for a description of details and individual woreda reports.

2.24   North Wollo: Raya Kobo

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
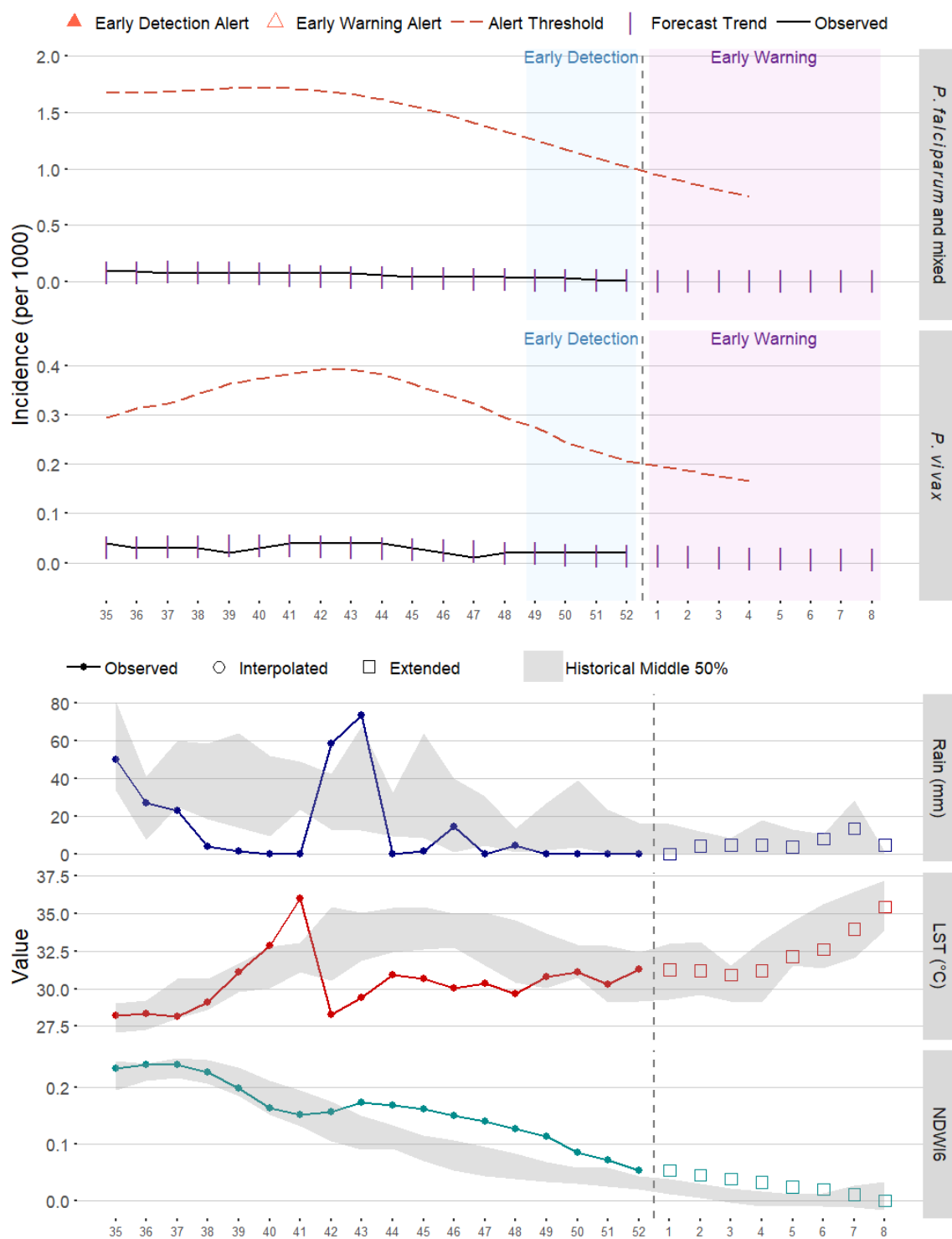
See last report section 4 for a description of details and individual woreda reports.

2.25   Oromia: Artuma Fursi

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
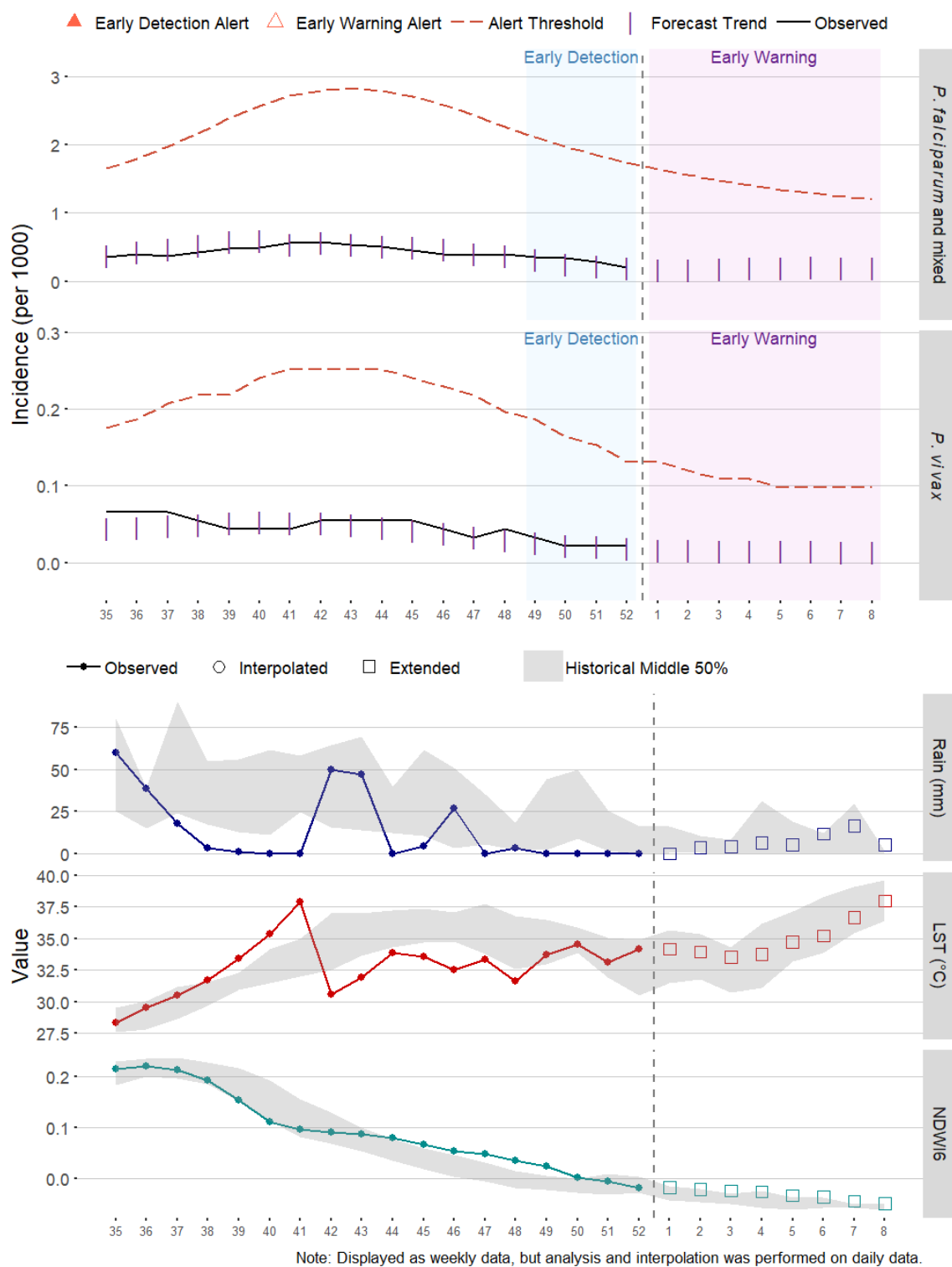
See last report section 4 for a description of details and individual woreda reports.

2.26   Oromia: Jilie Timuga

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.27   South Gondar: Andabiet

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
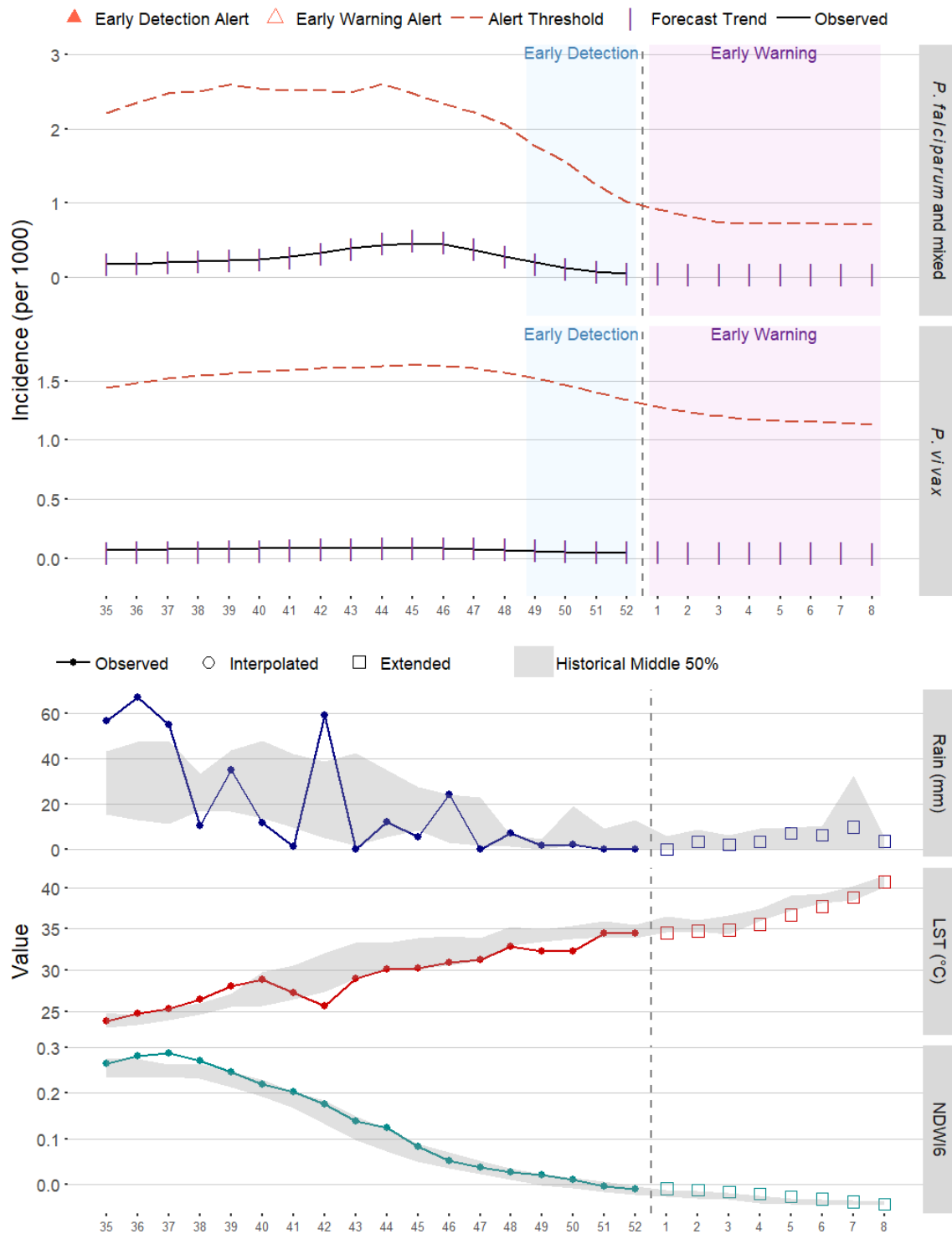
See last report section 4 for a description of details and individual woreda reports.

2.28   South Gondar: Dera

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
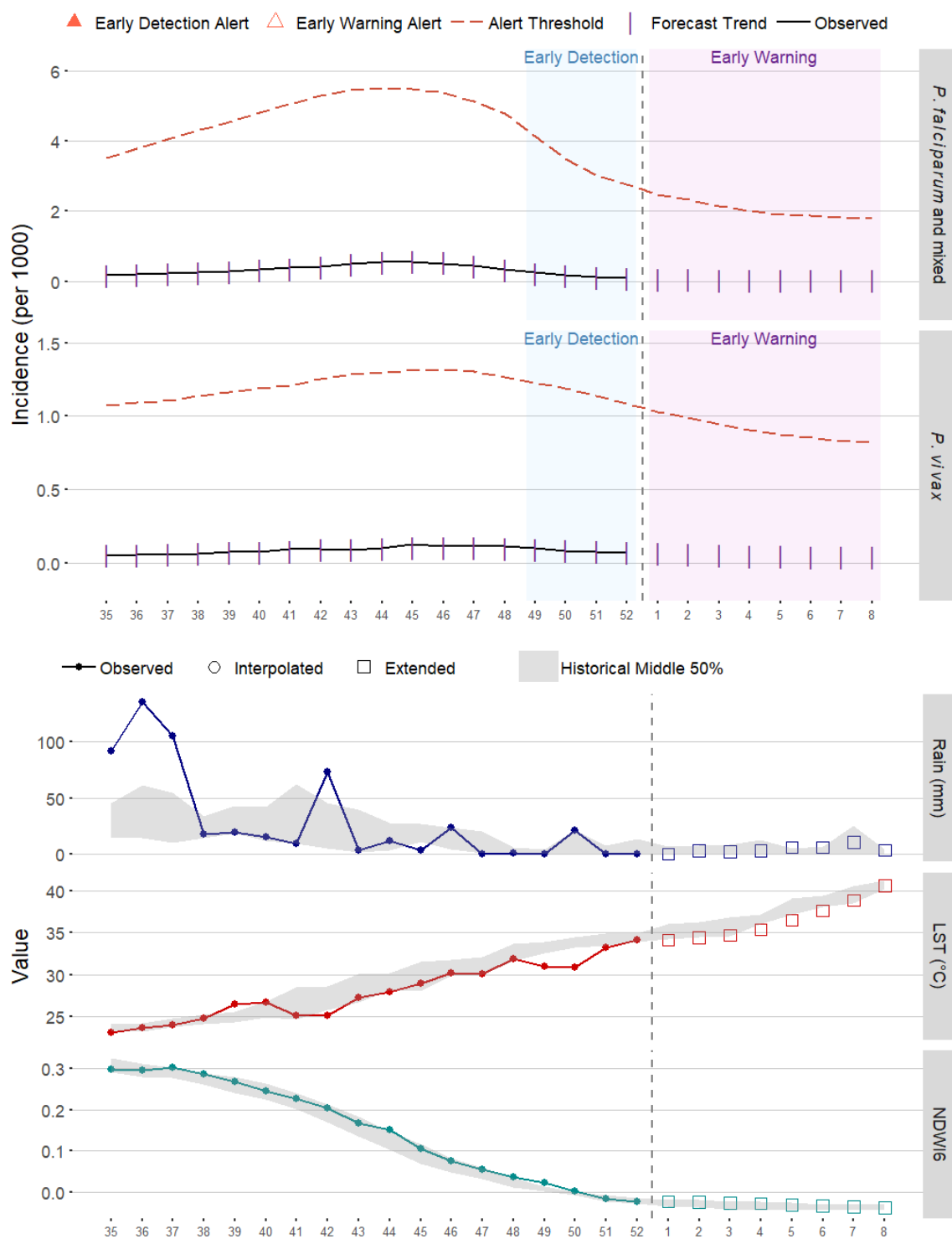
See last report section 4 for a description of details and individual woreda reports.

2.29   South Gondar: Estea

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
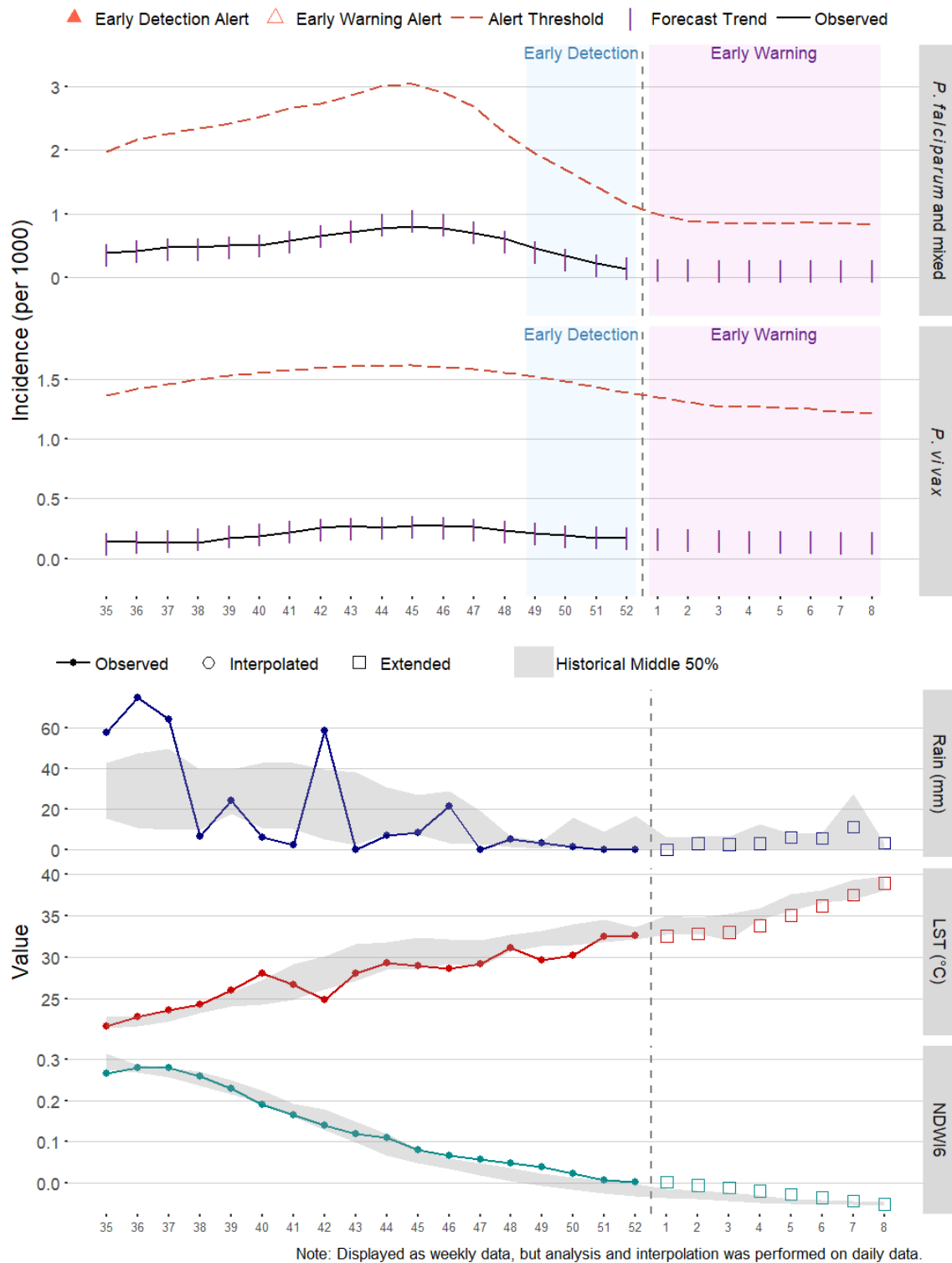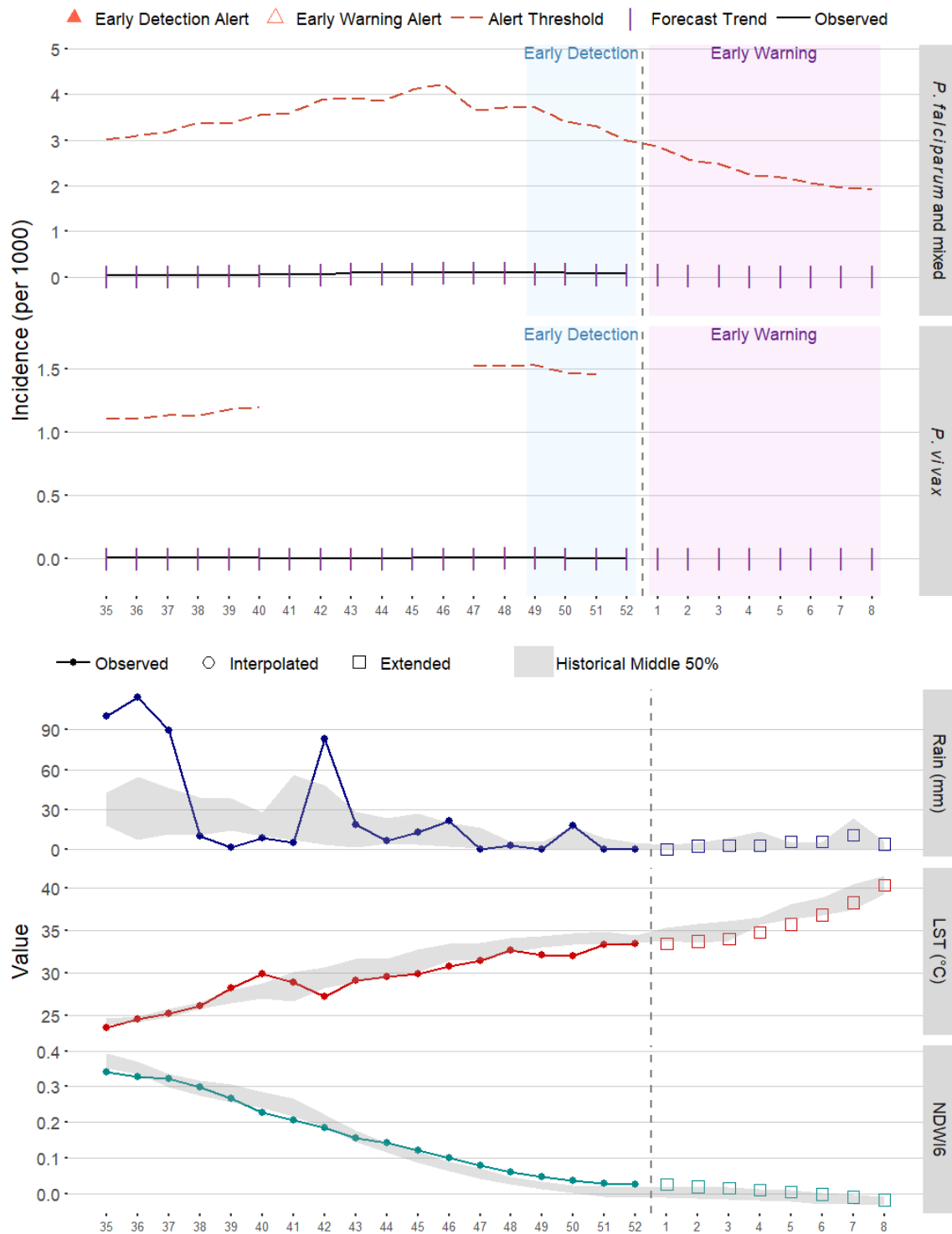
See last report section 4 for a description of details and individual woreda reports.

2.30 South Gondar: Fogera

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
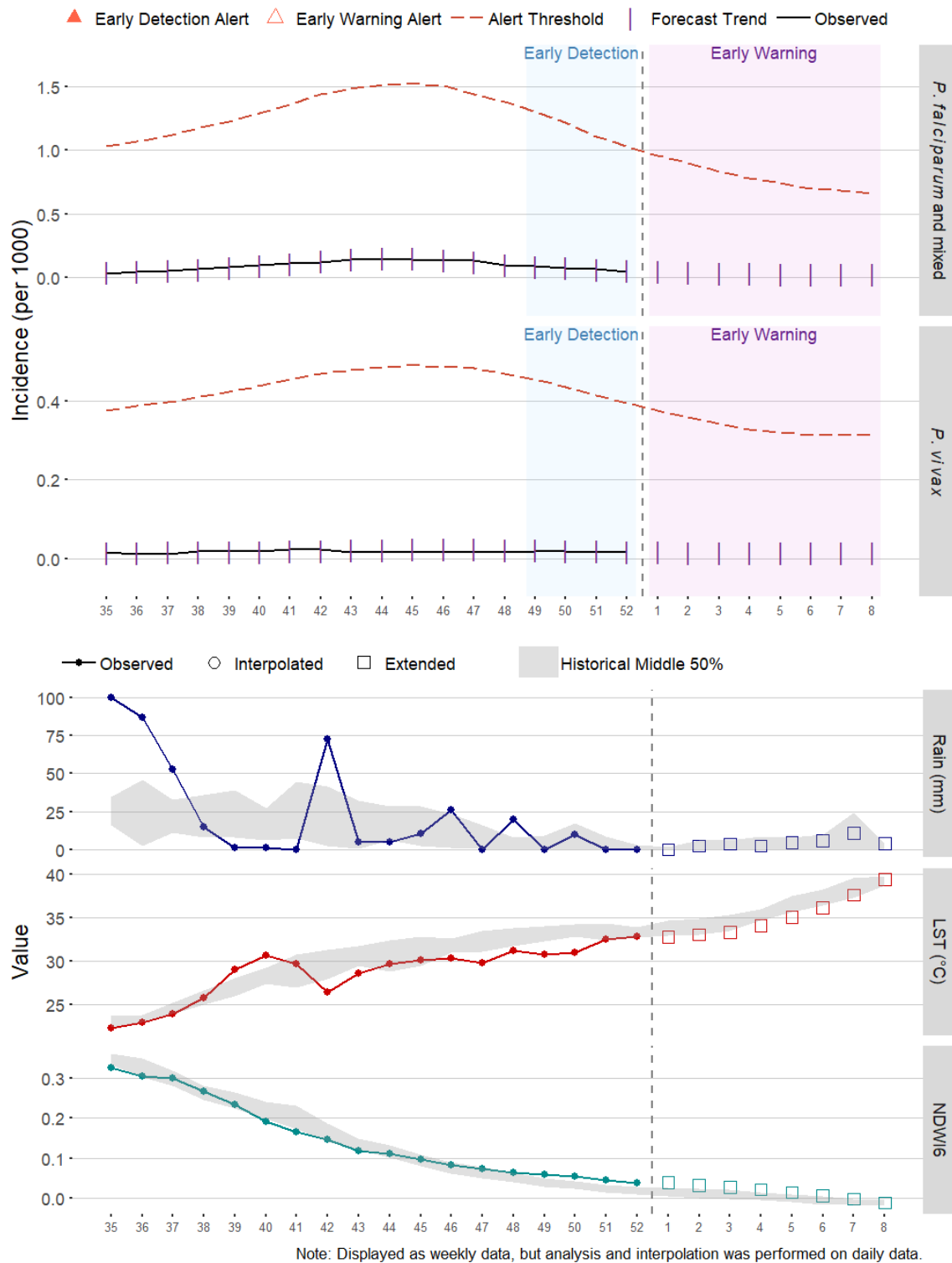
See last report section 4 for a description of details and individual woreda reports.

2.31 South Gondar: Libokemkem

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
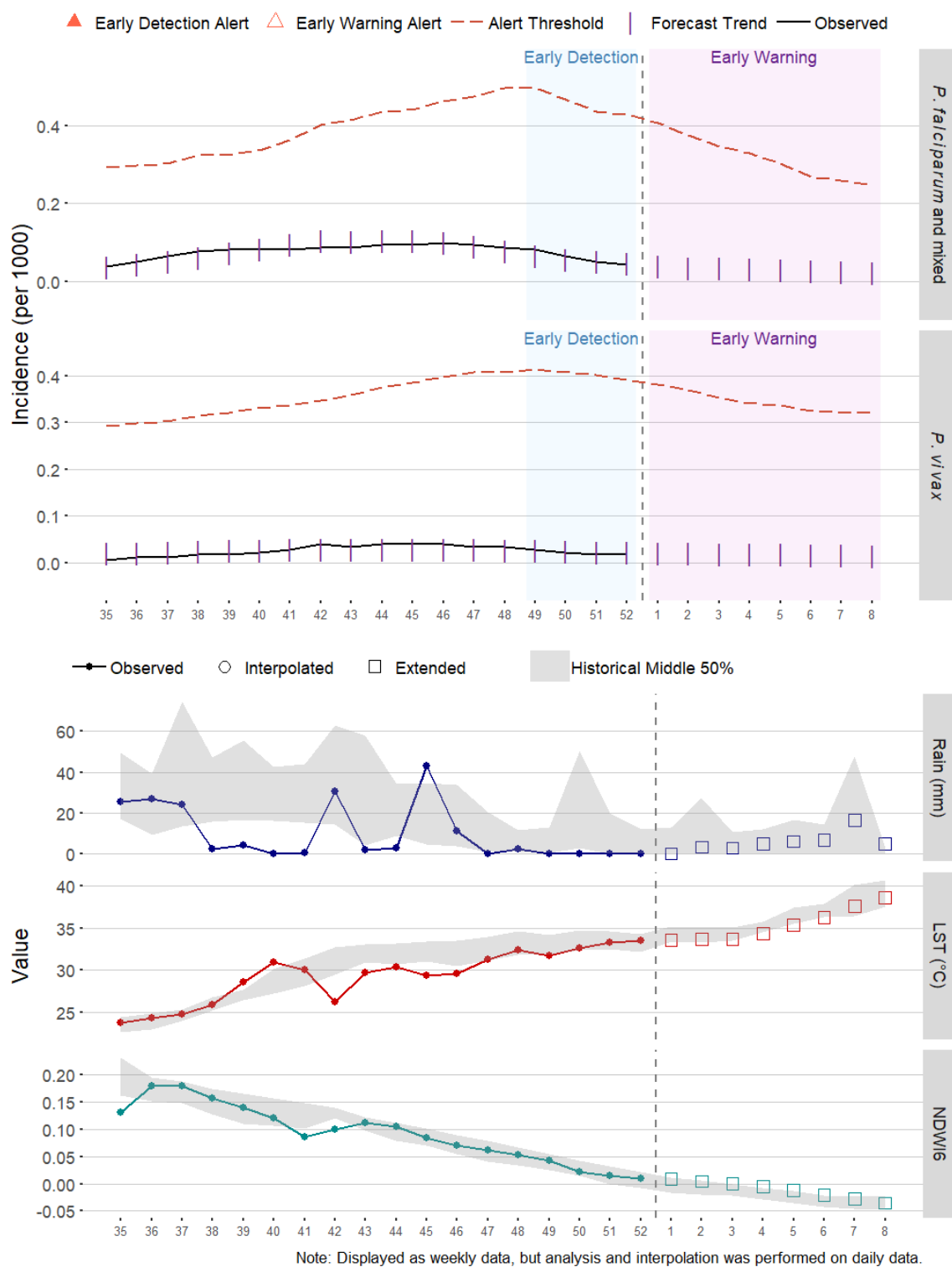
See last report section 4 for a description of details and individual woreda reports.

2.32   South Wollo: Borena

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.33   South Wollo: Kalu

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
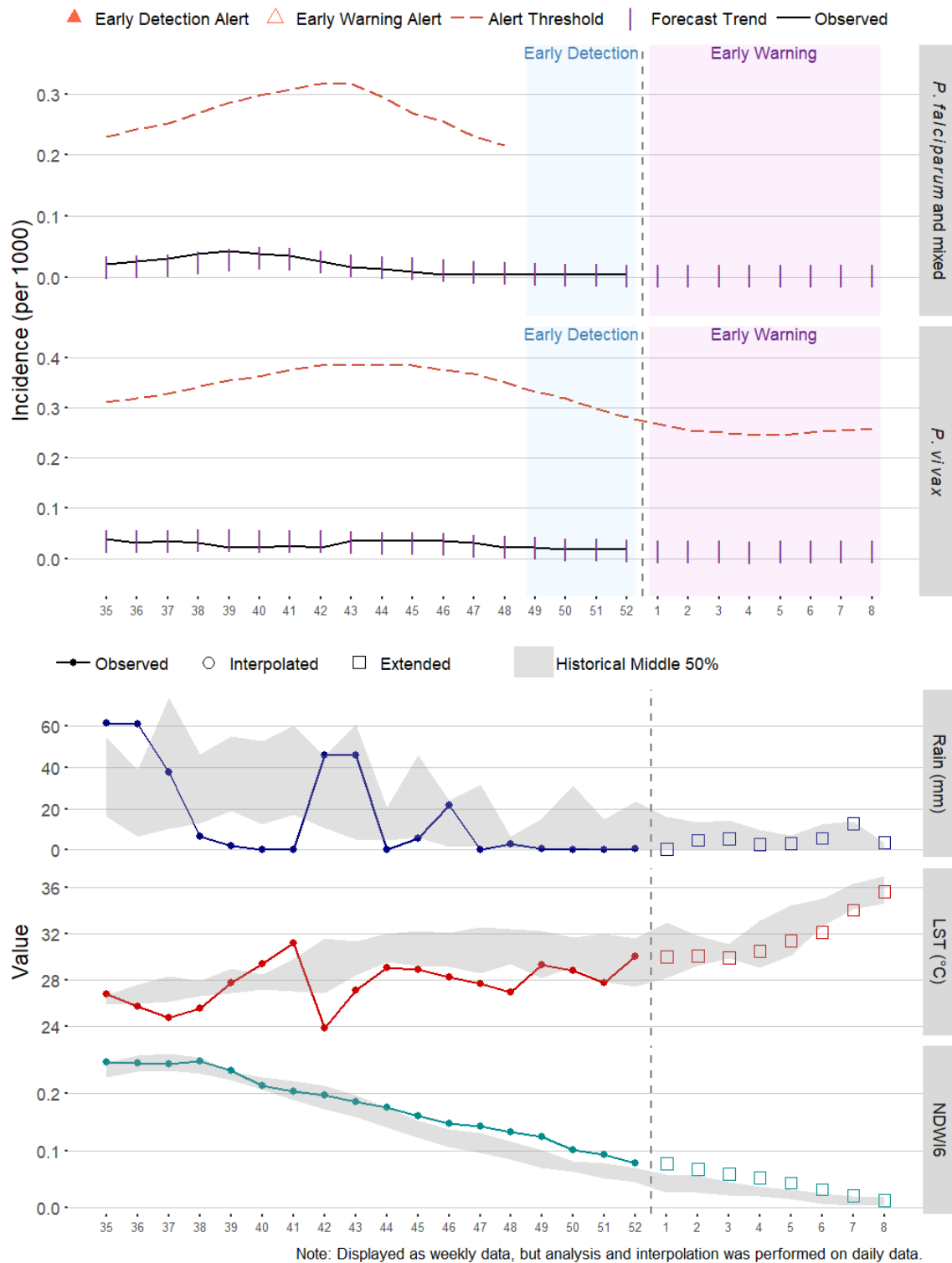
See last report section 4 for a description of details and individual woreda reports.

2.34   South Wollo: Tehulederie

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
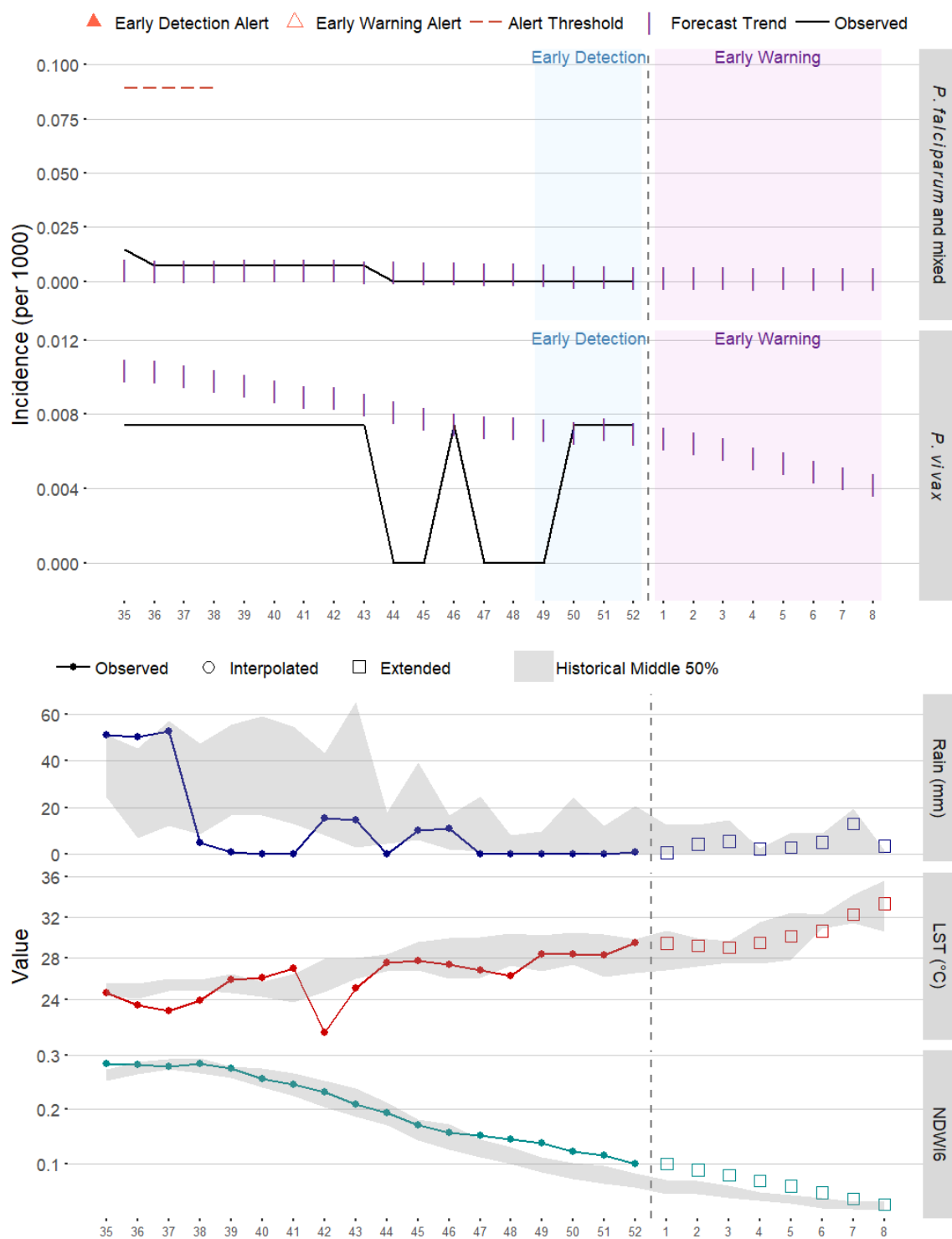
See last report section 4 for a description of details and individual woreda reports.

2.35 Waghimira: Abargelie

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
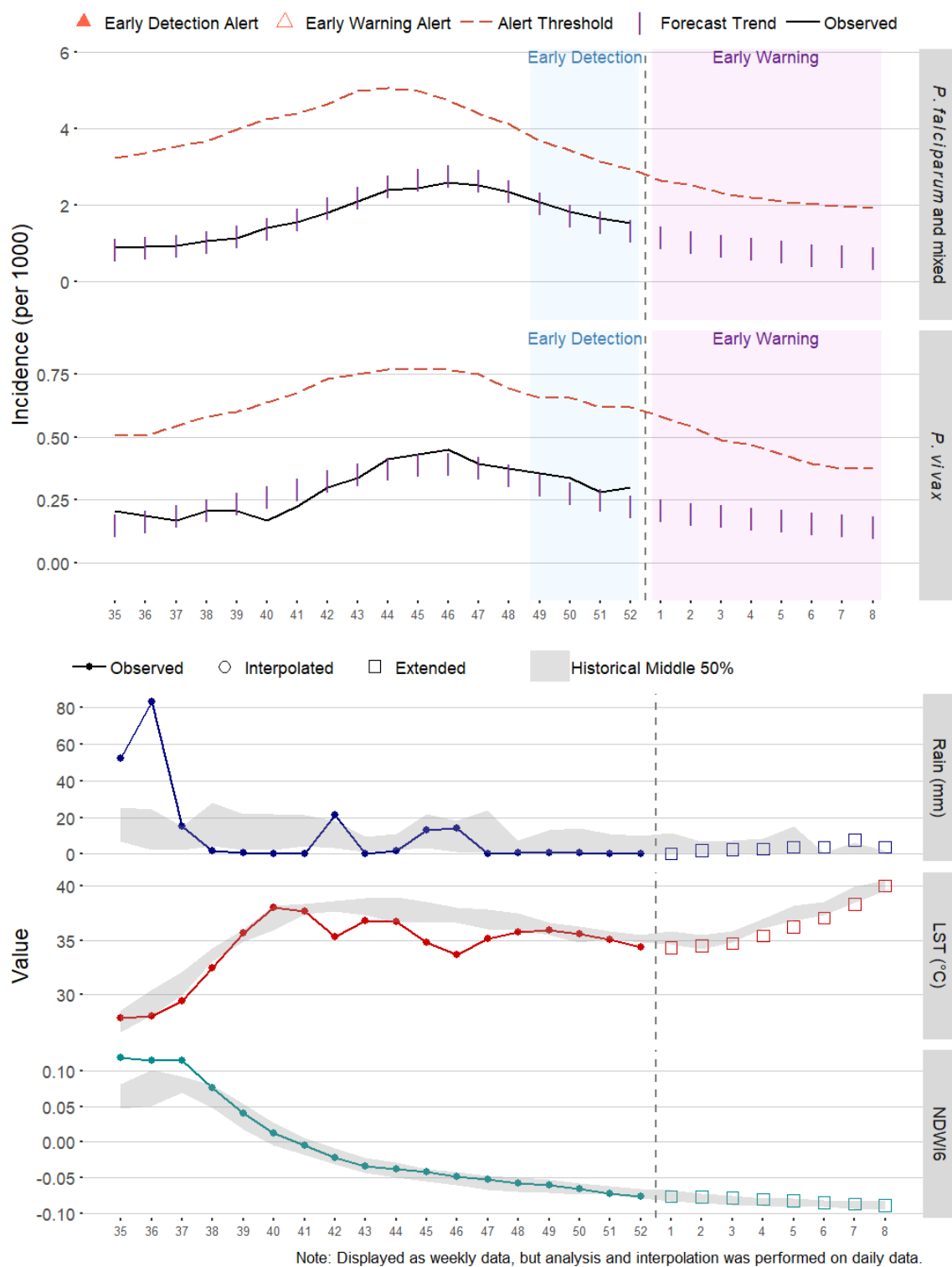
See last report section 4 for a description of details and individual woreda reports.

2.36 Waghimira: Dehena

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
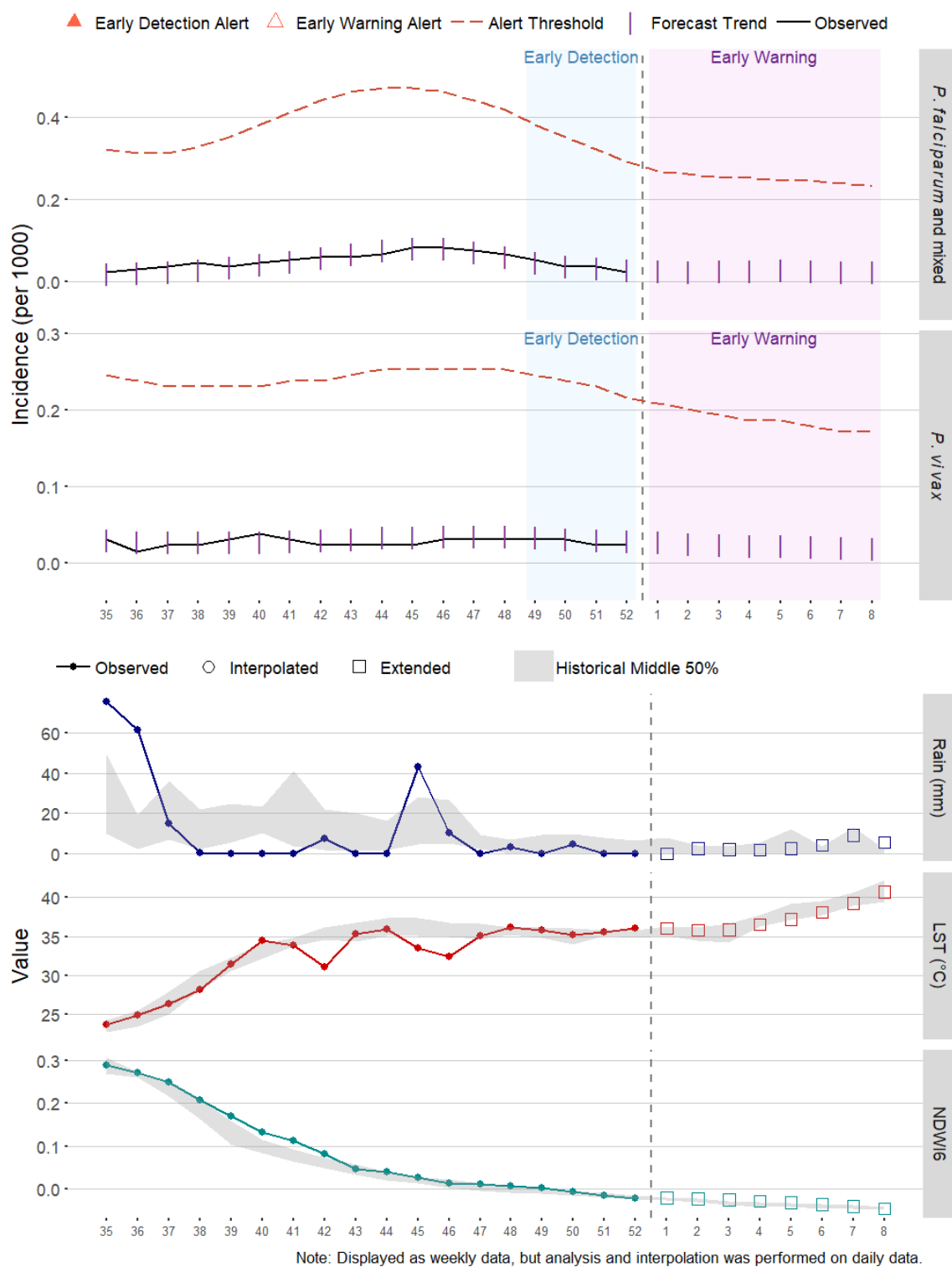
See last report section 4 for a description of details and individual woreda reports.

2.37   Waghimira: Sehela

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
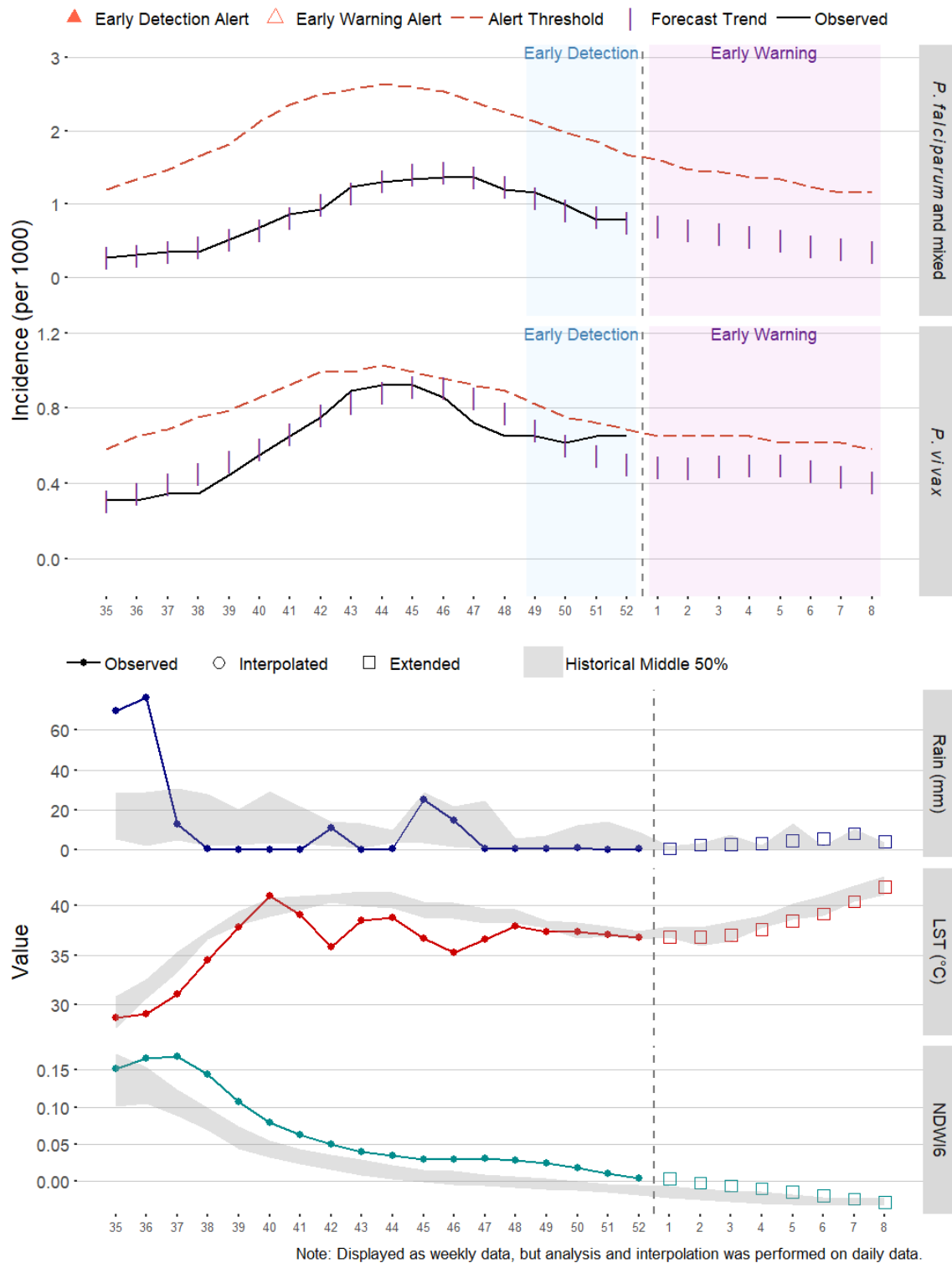
See last report section 4 for a description of details and individual woreda reports.

2.38   West Gojjam: Bahir Dar Zuria

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.39   West Gojjam: Burie Zuria

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.

See last report section 4 for a description of details and individual woreda reports.

2.40   West Gojjam: Dembecha

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
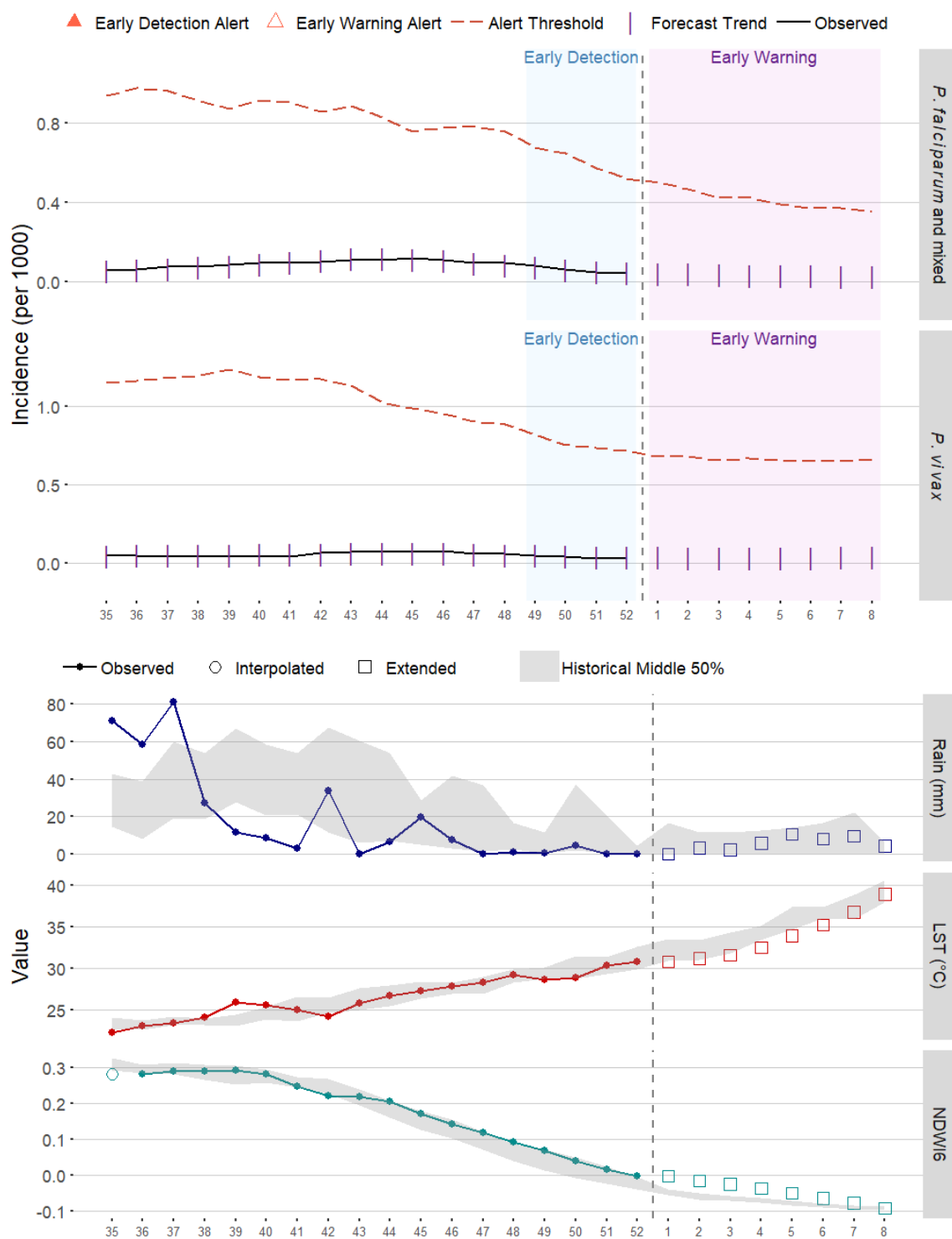
See last report section 4 for a description of details and individual woreda reports.

2.41   West Gojjam: Gonji Kolela

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
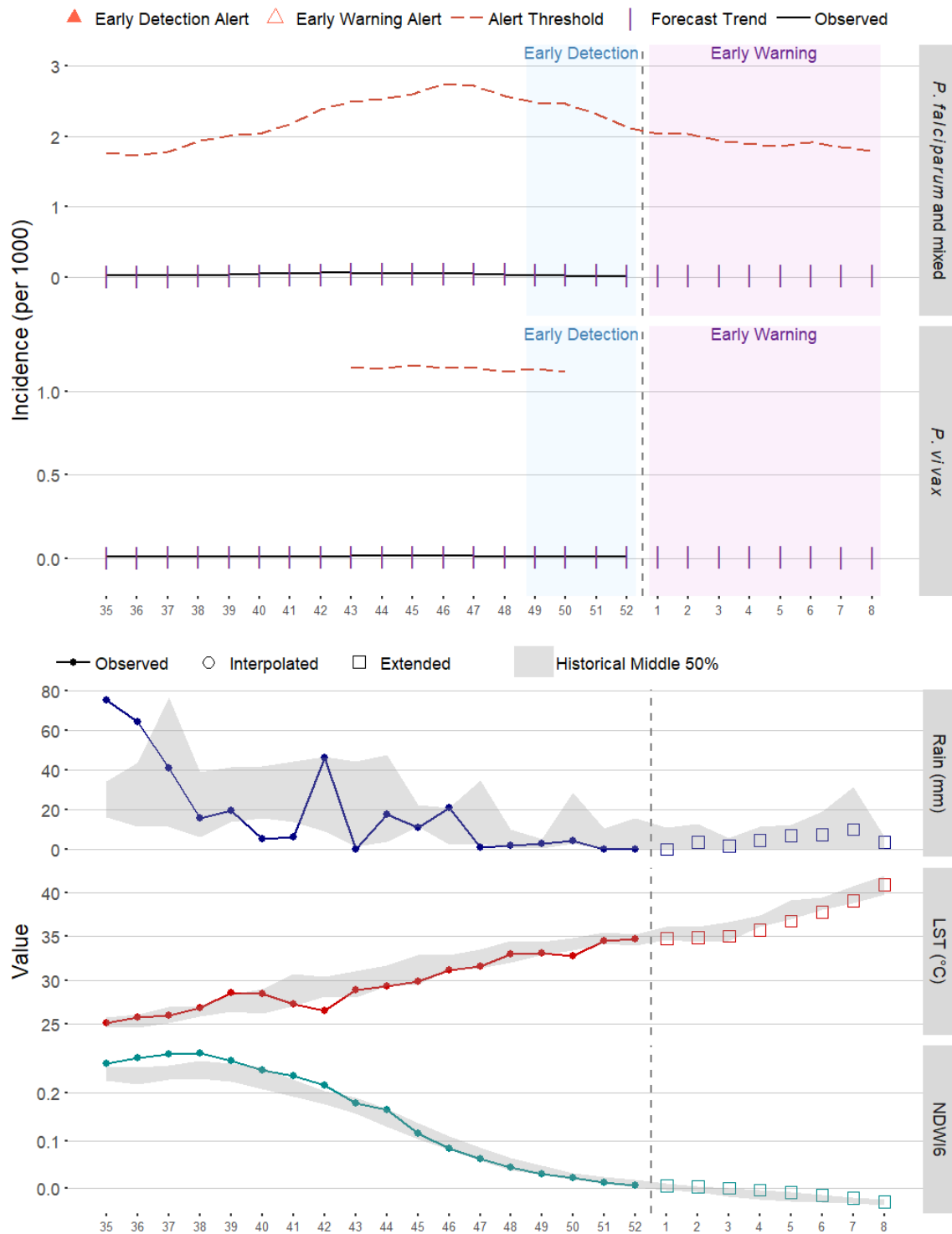
See last report section 4 for a description of details and individual woreda reports.

2.42   West Gojjam: Jabi Tehnan
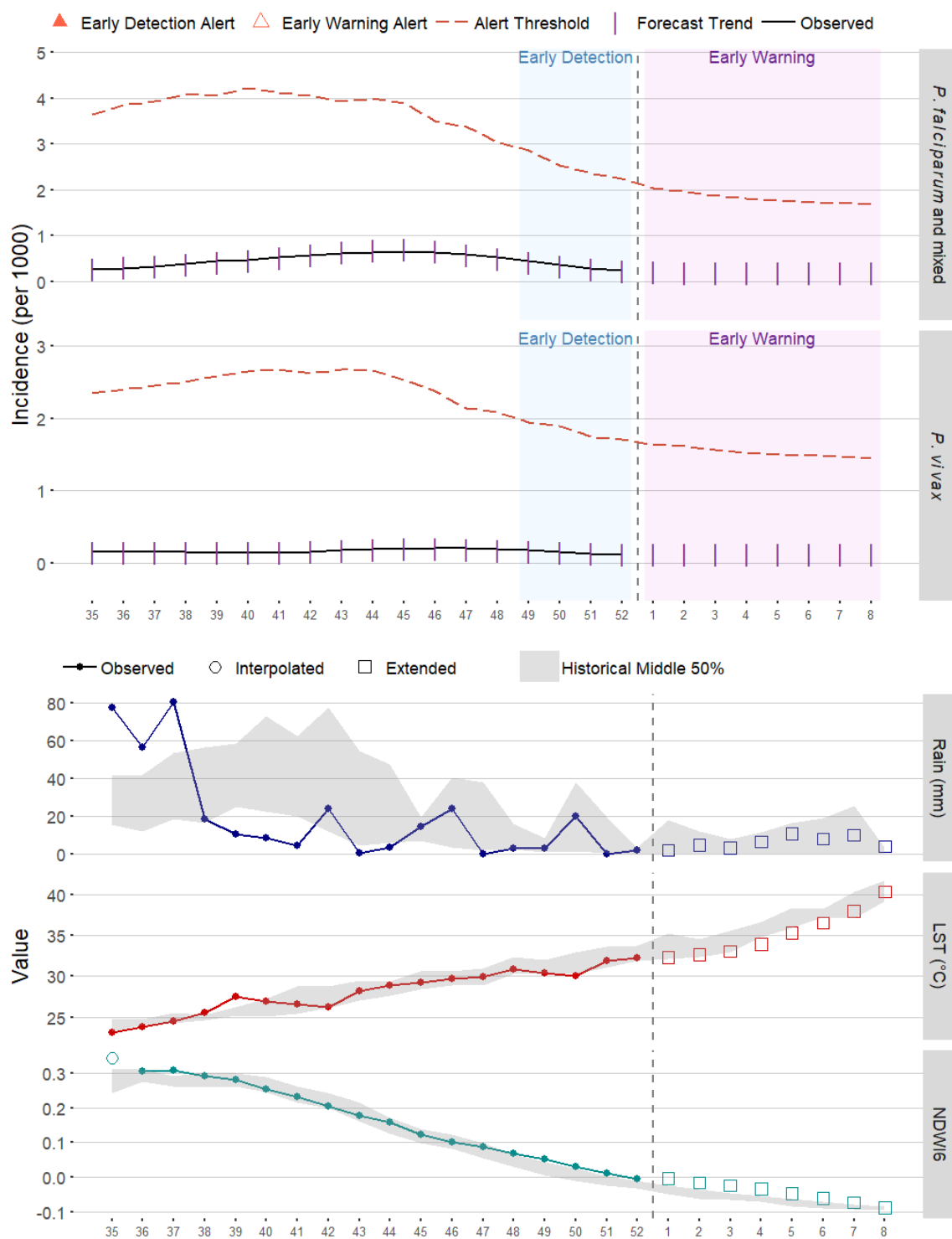
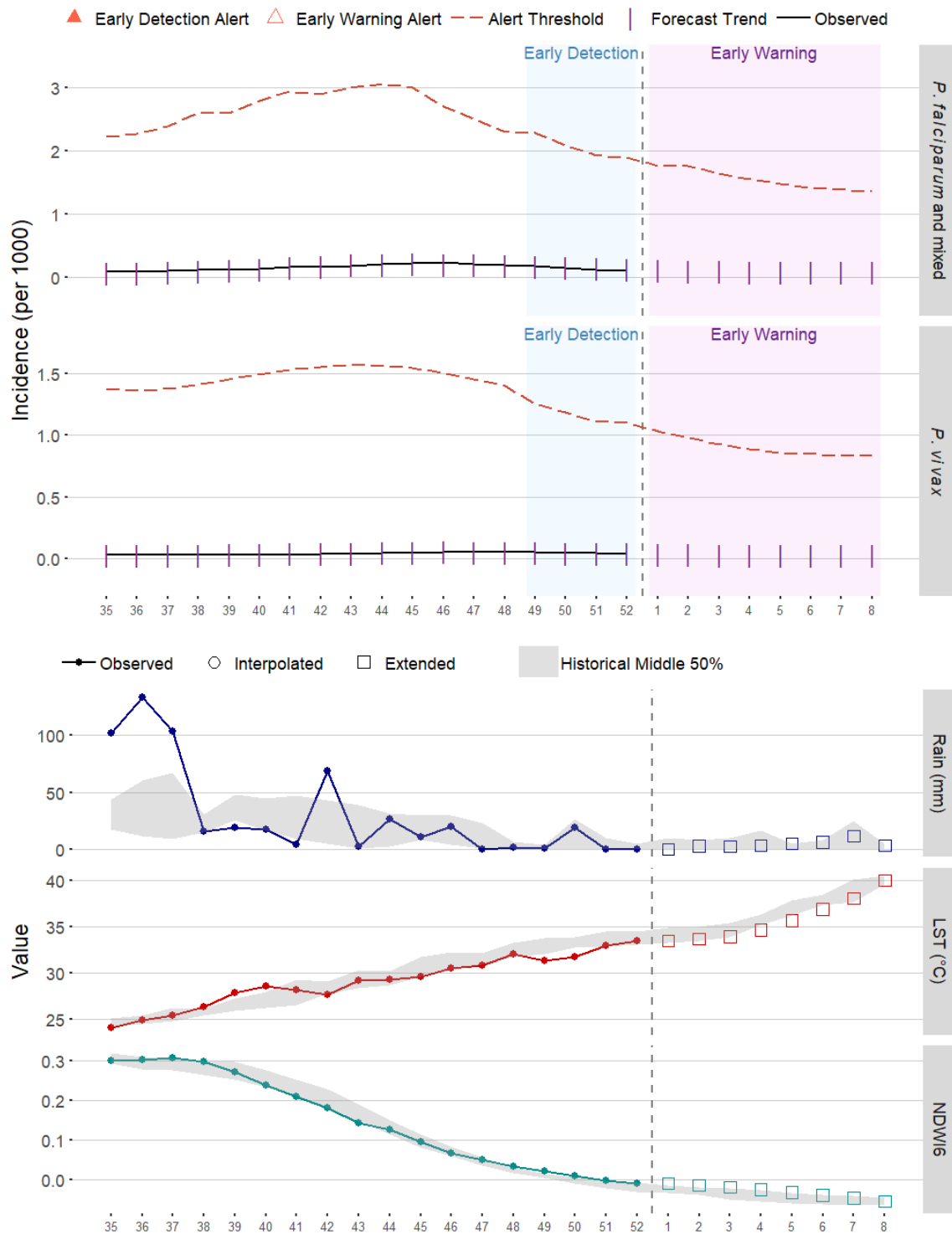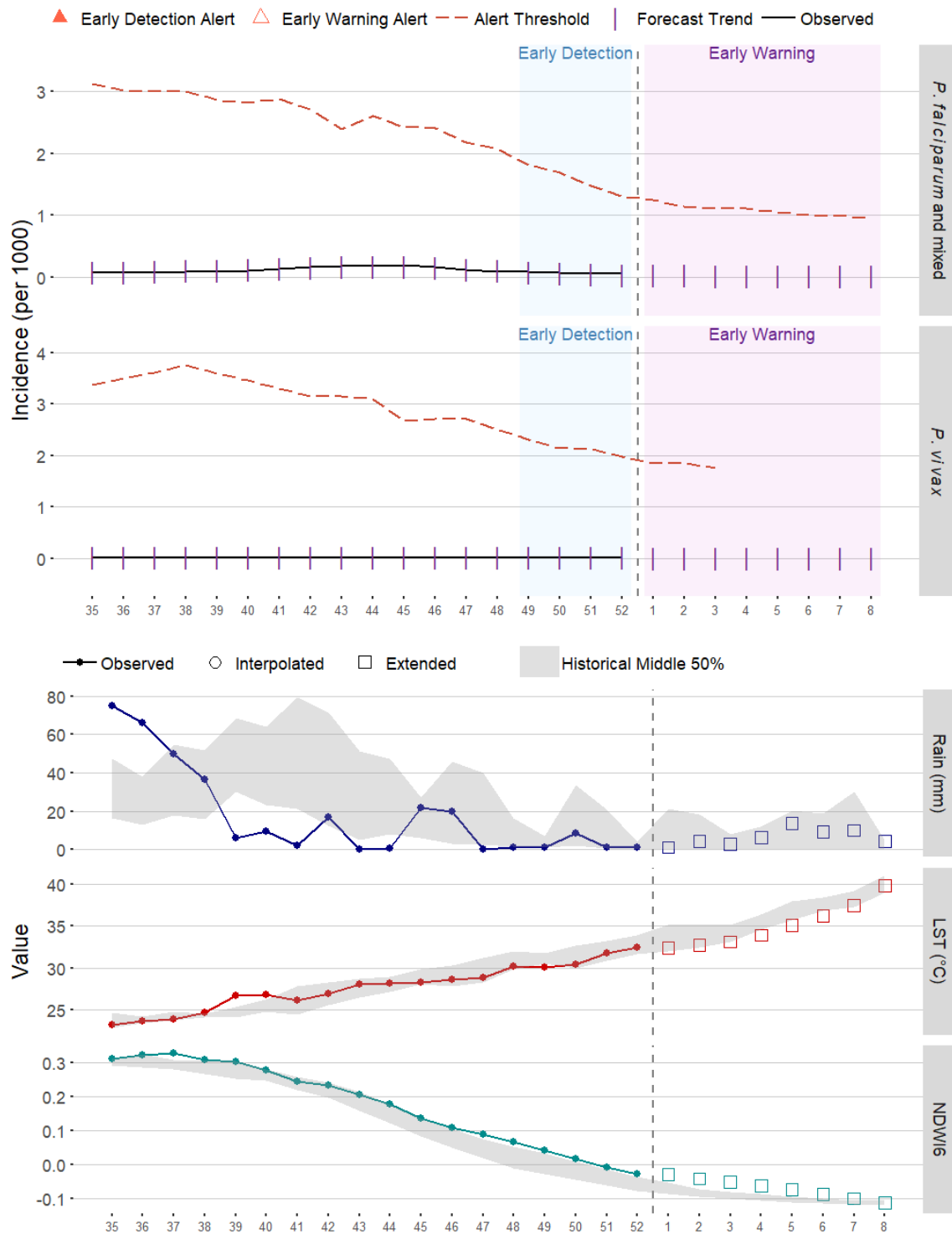See last report section 4 for a description of details and individual woreda reports.

2.43 West Gojjam: Mecha

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
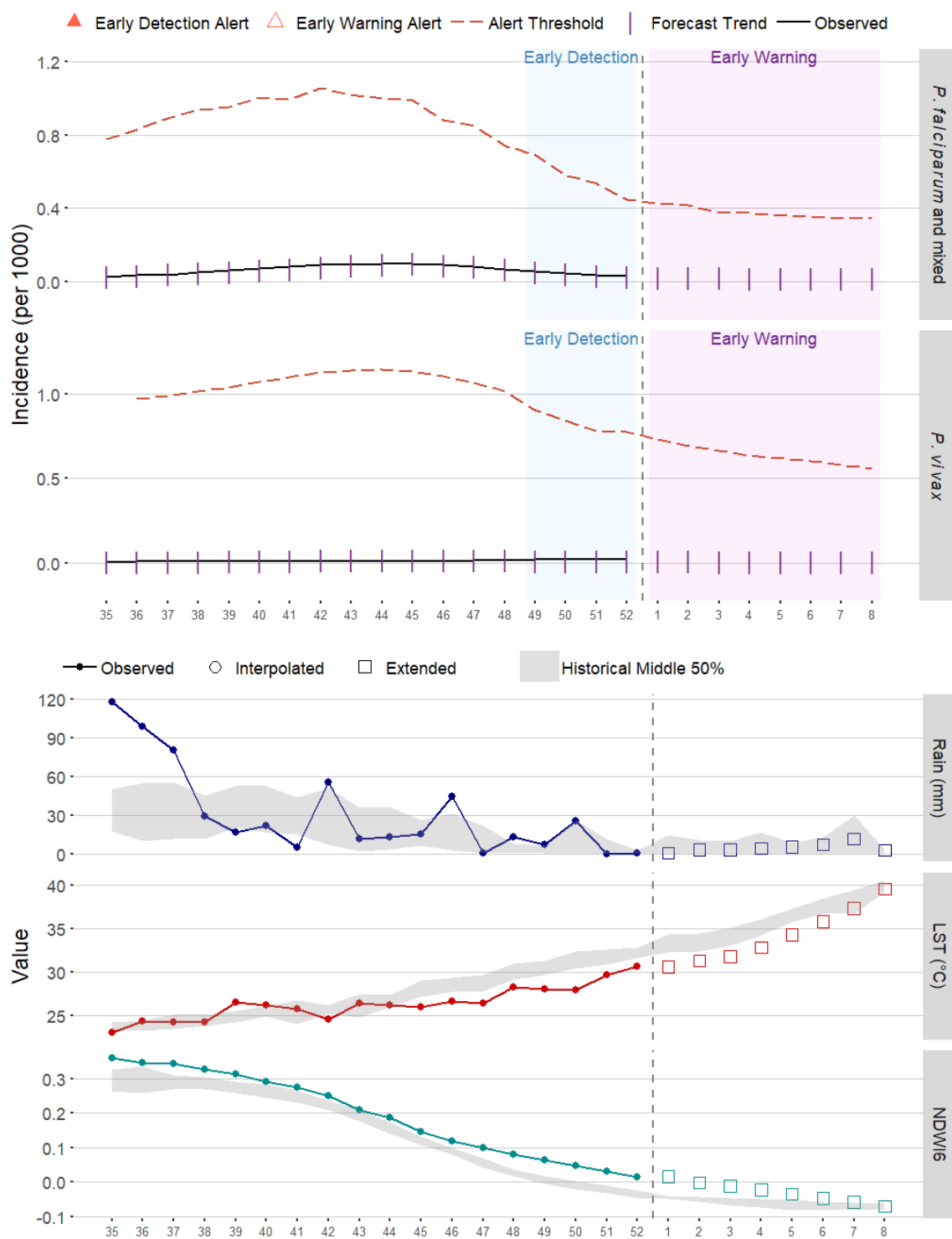
See last report section 4 for a description of details and individual woreda reports.

2.44 West Gojjam: North Achefer

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
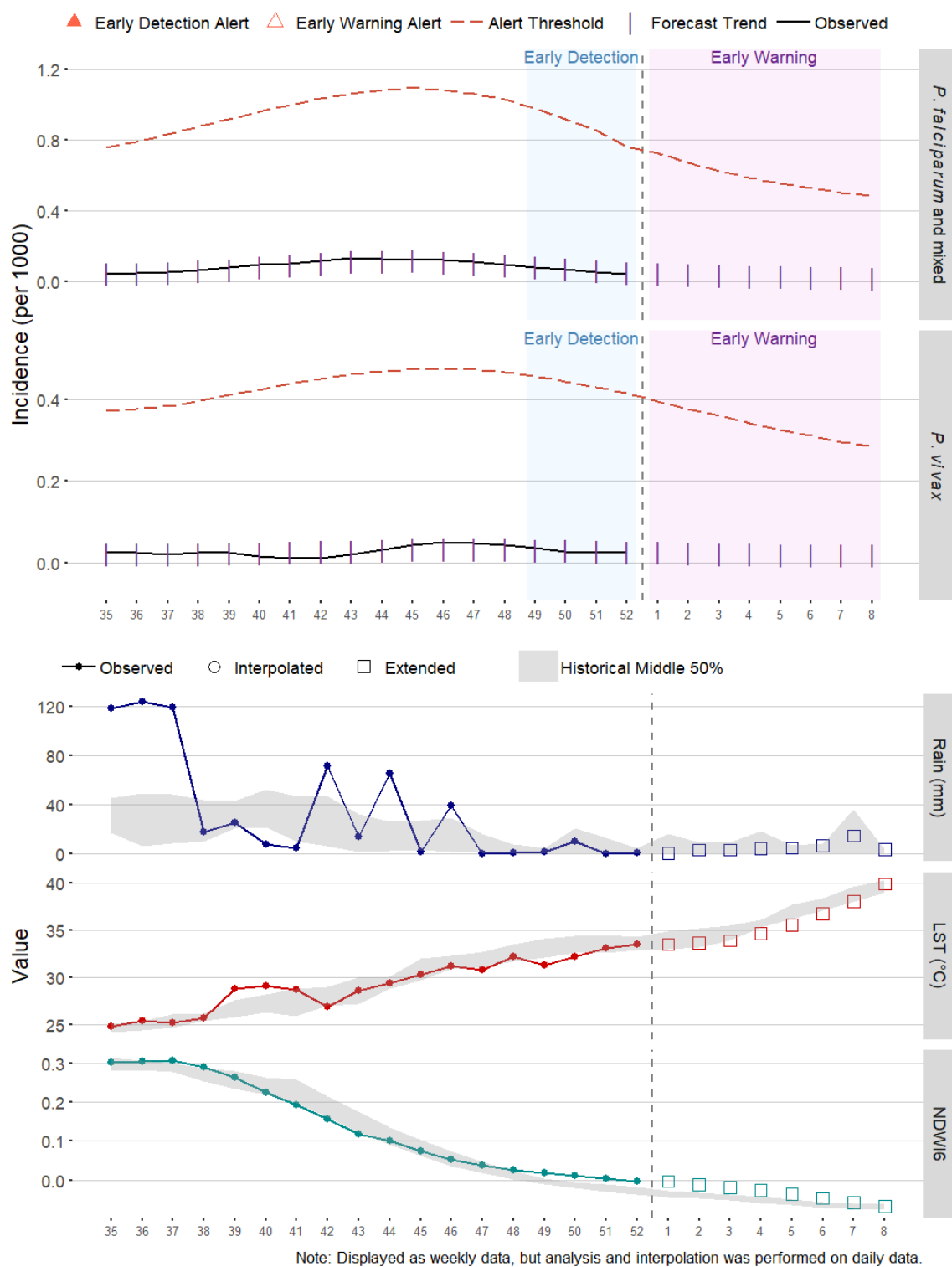
See last report section 4 for a description of details and individual woreda reports.

2.45   West Gojjam: South Achefer

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
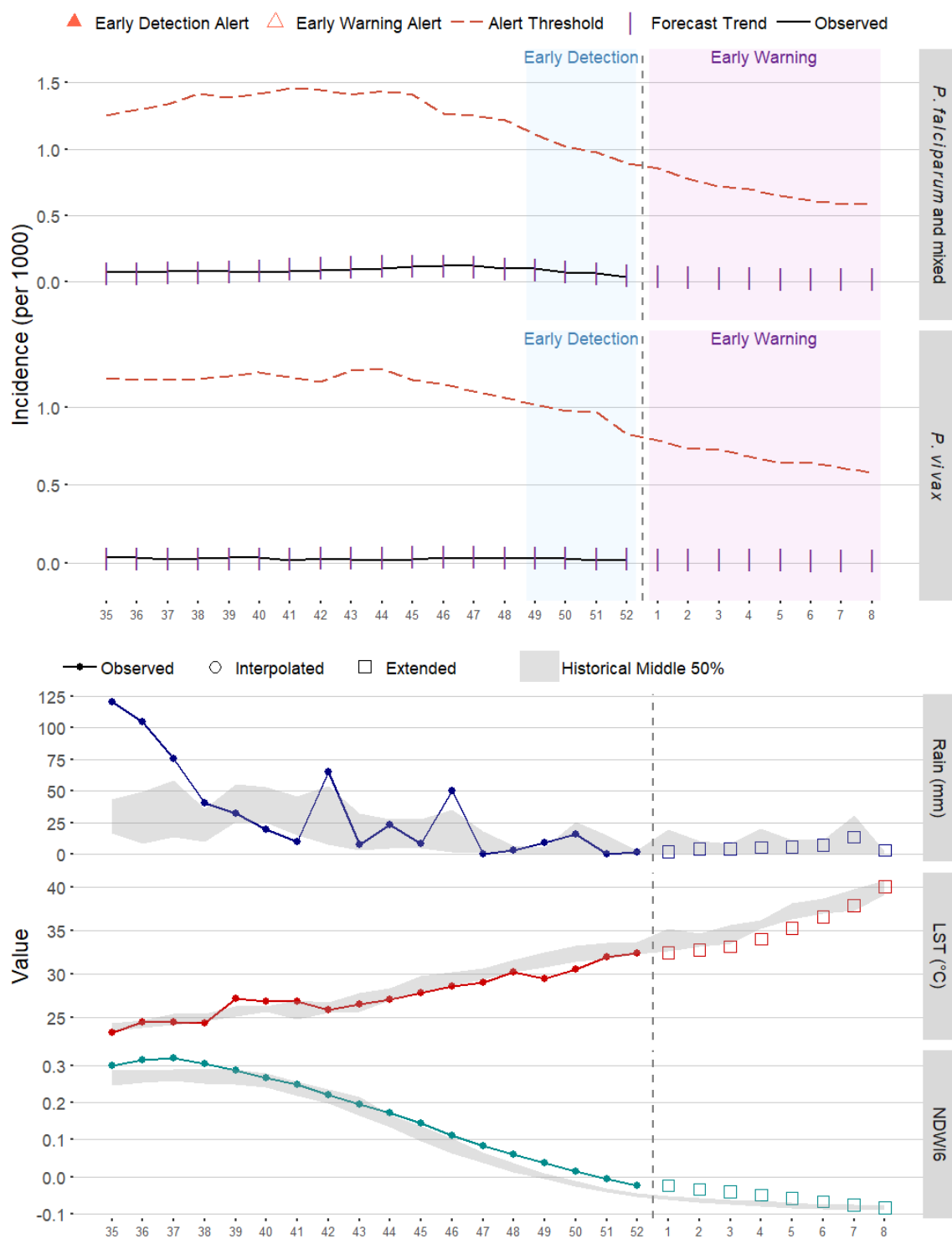
See last report section 4 for a description of details and individual woreda reports.

2.46   West Gojjam: Womberma

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
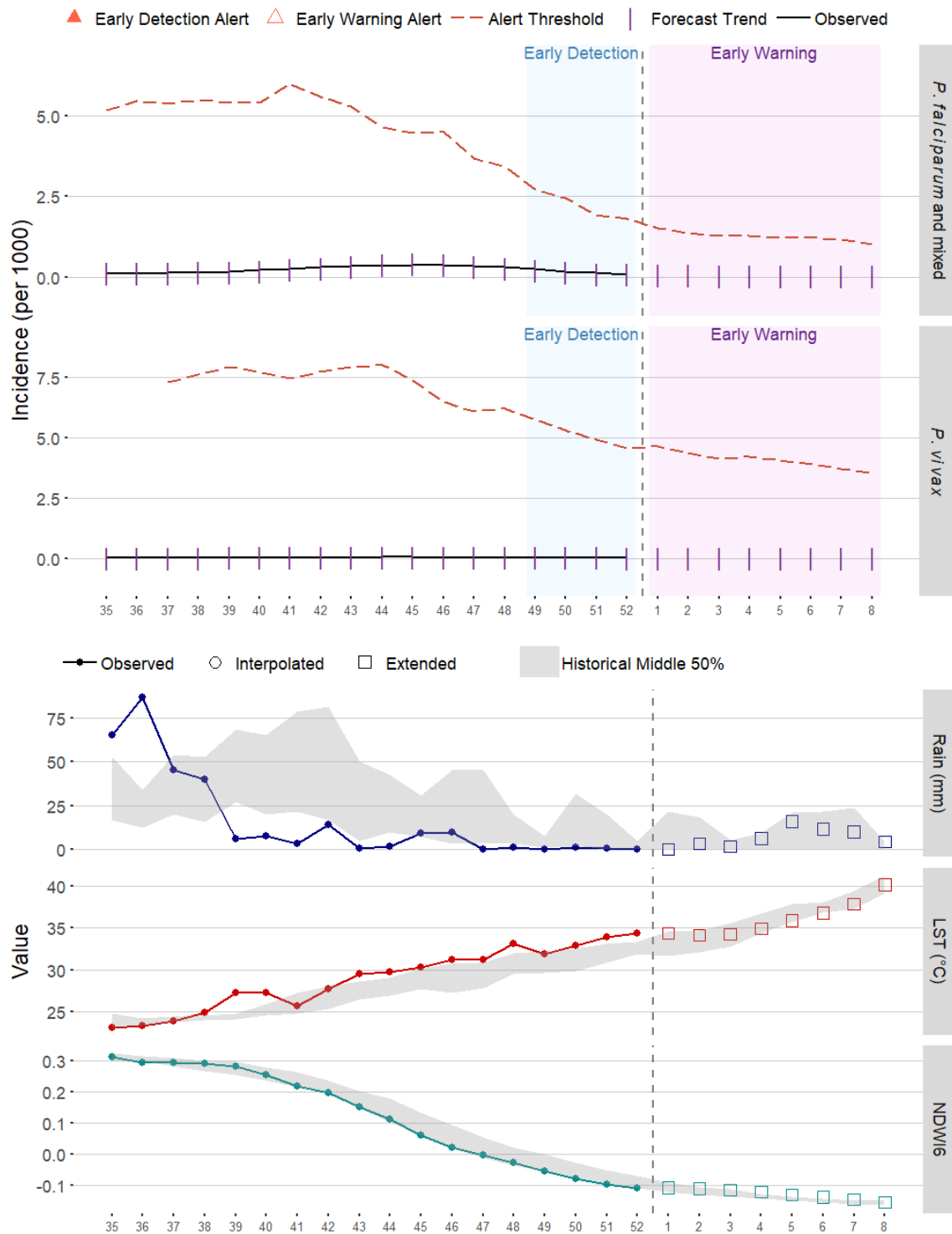
See last report section 4 for a description of details and individual woreda reports.

2.47   West Gojjam: Yilmana Densa

Note: Displayed as weekly data, but analysis and interpolation was performed on daily data.
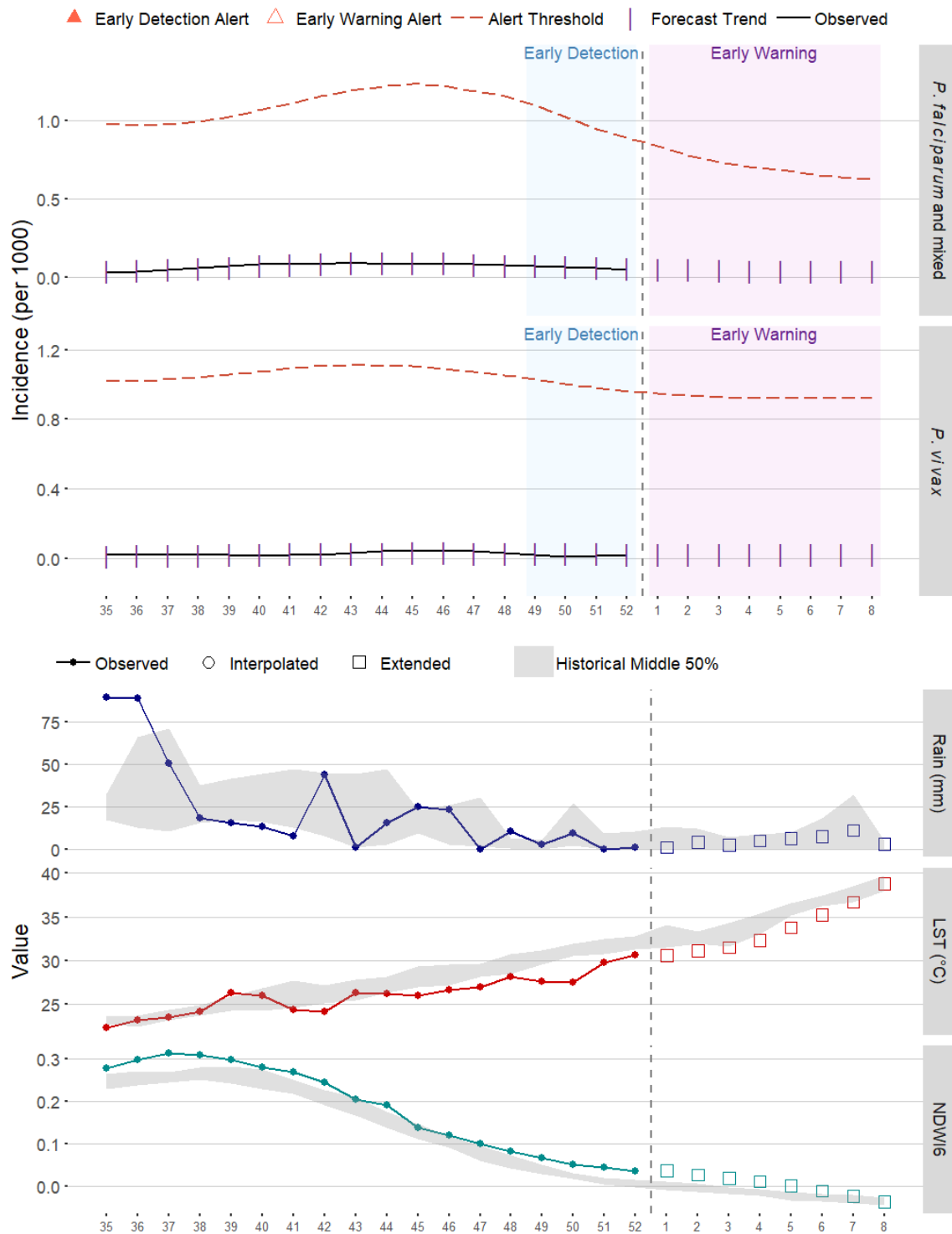
See last report section 4 for a description of details and individual woreda reports.

3 Maps

3.1 Overall Incidence

Total Malaria Incidence
Mean of the Early Detection Period
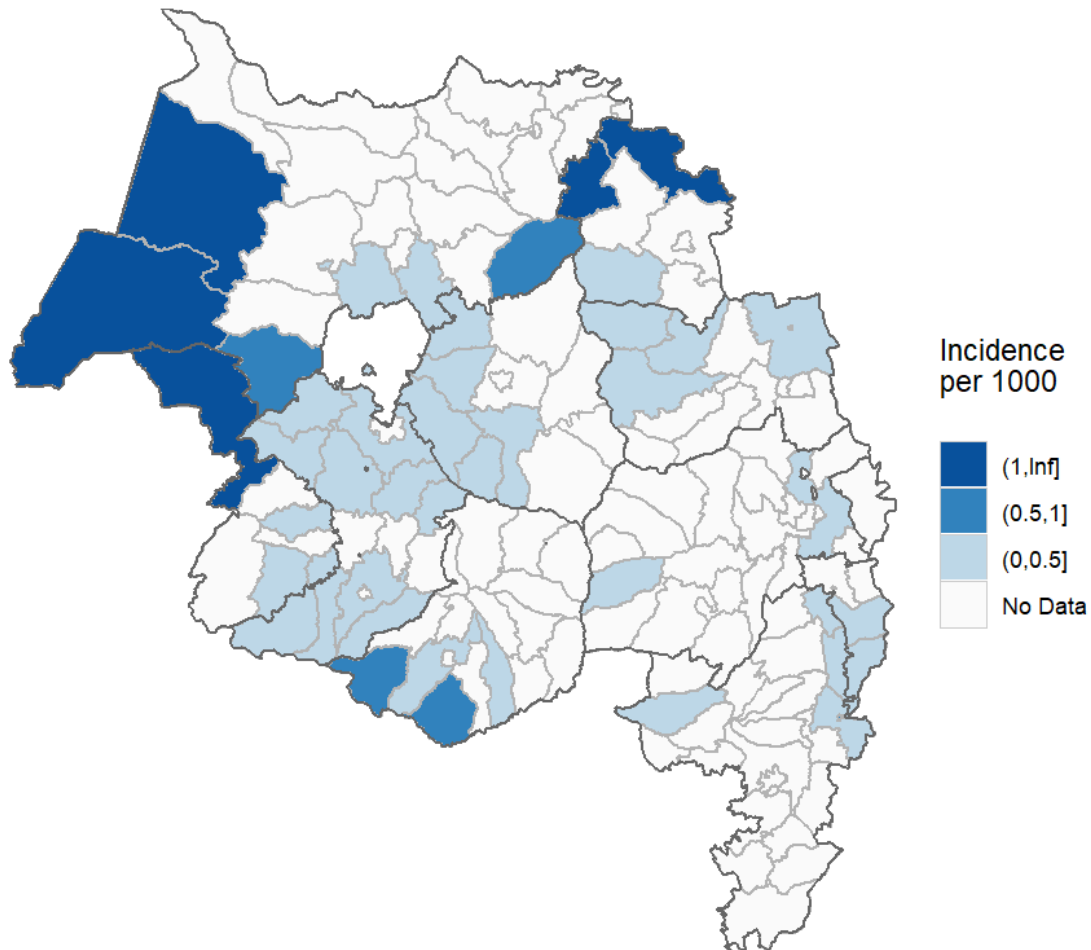
Total malaria consists of P. falciparum, P. vivax, and mixed infections.
Summarized from Dec 09, 2018 through Dec 30, 2018

3.2   Incidence by Species

Malaria Incidence by Species
Mean of the Early Detection Period

P. falciparum and mixed infections

Incidence per 1000

- (0.5,Inf]
- (0.25,0.5]
- (0,0.25]
- No Data
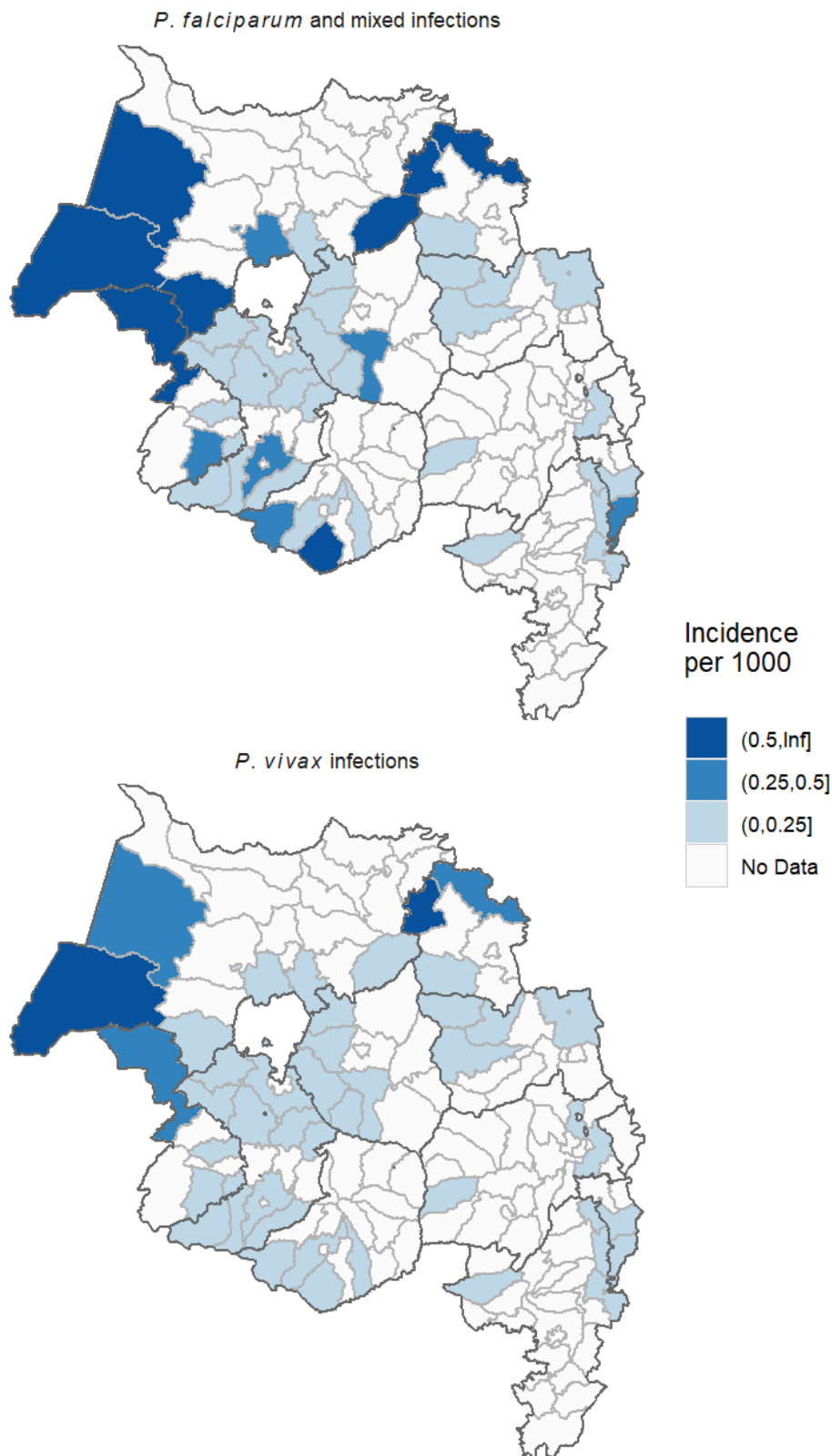
P. vivax infections

P. falciparum malaria includes mixed infections; P. vivax does not.
Summarized from Dec 09, 2018 through Dec 30, 2018

3.3 Environmental Data

Rainfall Anomalies
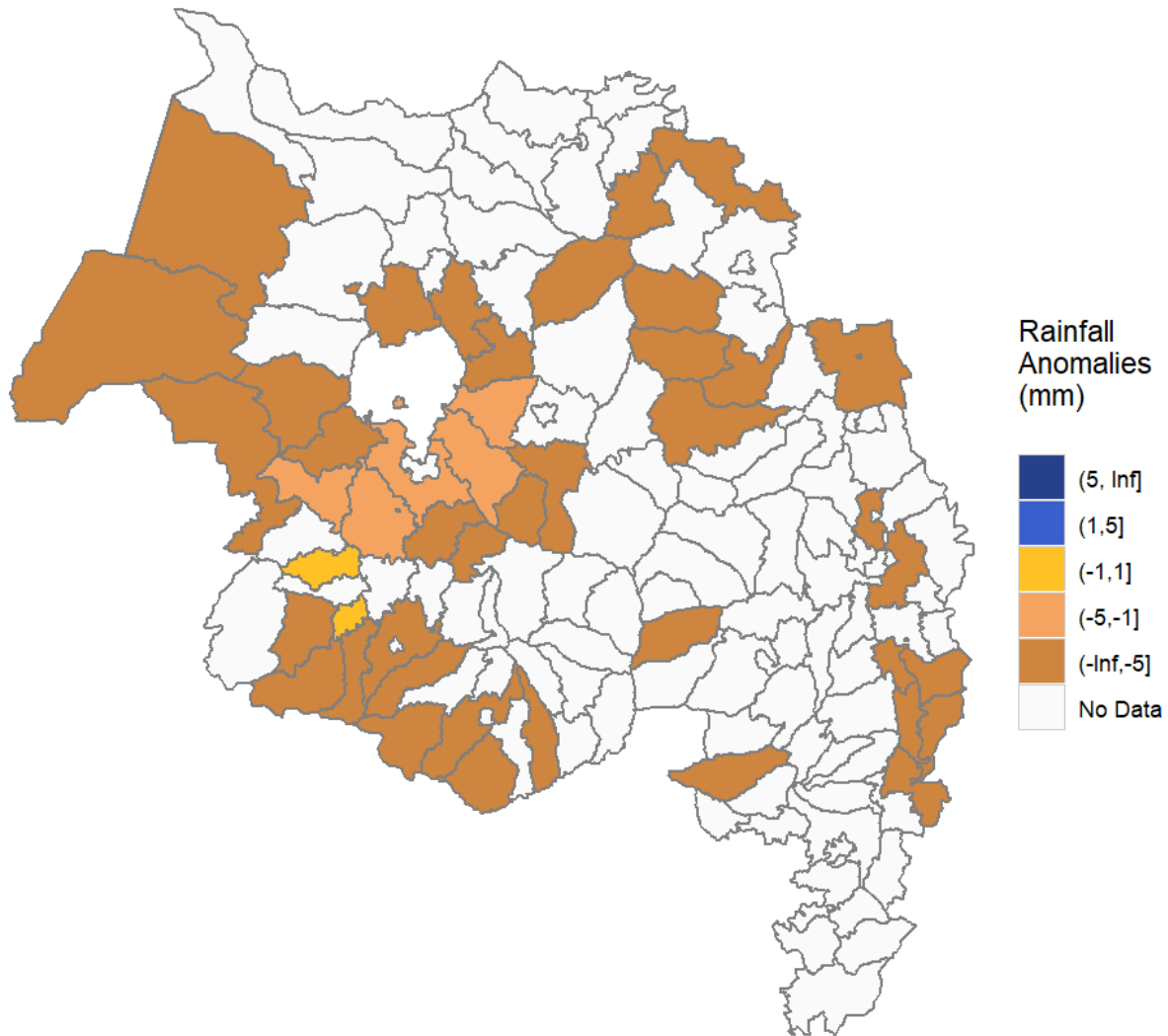
Anomaly values are calculated as the mean of the observed values
during the Early Detection Period minus 15-year means.

Daytime Land Surface Temperature (LST) Anomalies

Anomaly values are calculated as the mean of the observed values
during the Early Detection Period minus 15-year means.

Normalized Difference Water Index Anomalies
NDWI is an index for vegetation water content

NDWI6
Anomaly

- (0.008, Inf]
- (0.002,0.008]
- (-0.002,0.002]
- (-0.008,-0.002]
- (-Inf,-0.008]
- No Data

Anomaly values are calculated as the mean of the observed values
during the Early Detection Period minus 15-year means.

4 Background

4.1 Overview

The goal of the EPIDEMIA project is to integrate information from malaria surveillance with remotely-sensed environmental data to support the monitoring and forecasting of malaria risk in the Amhara region of Ethiopia.
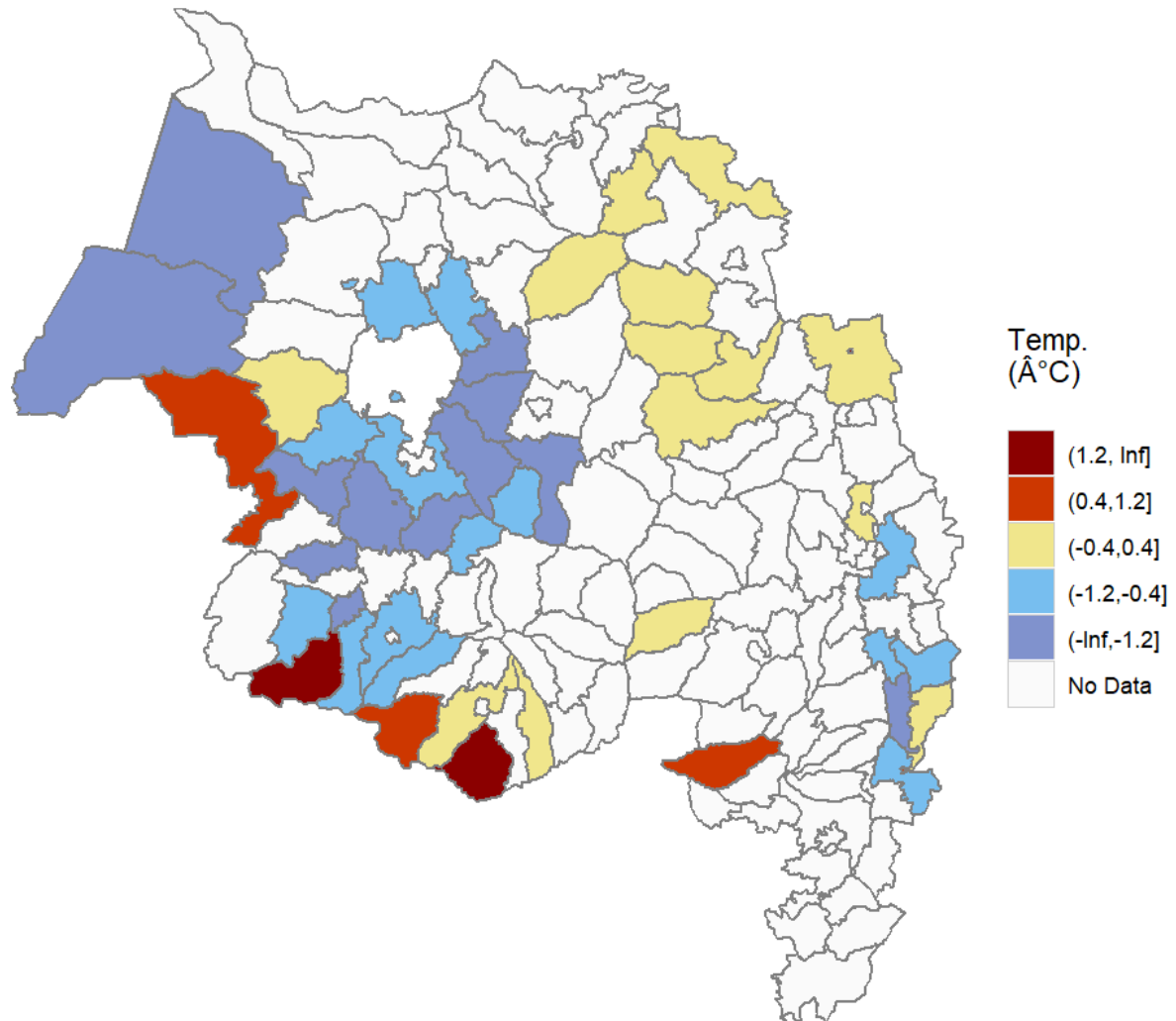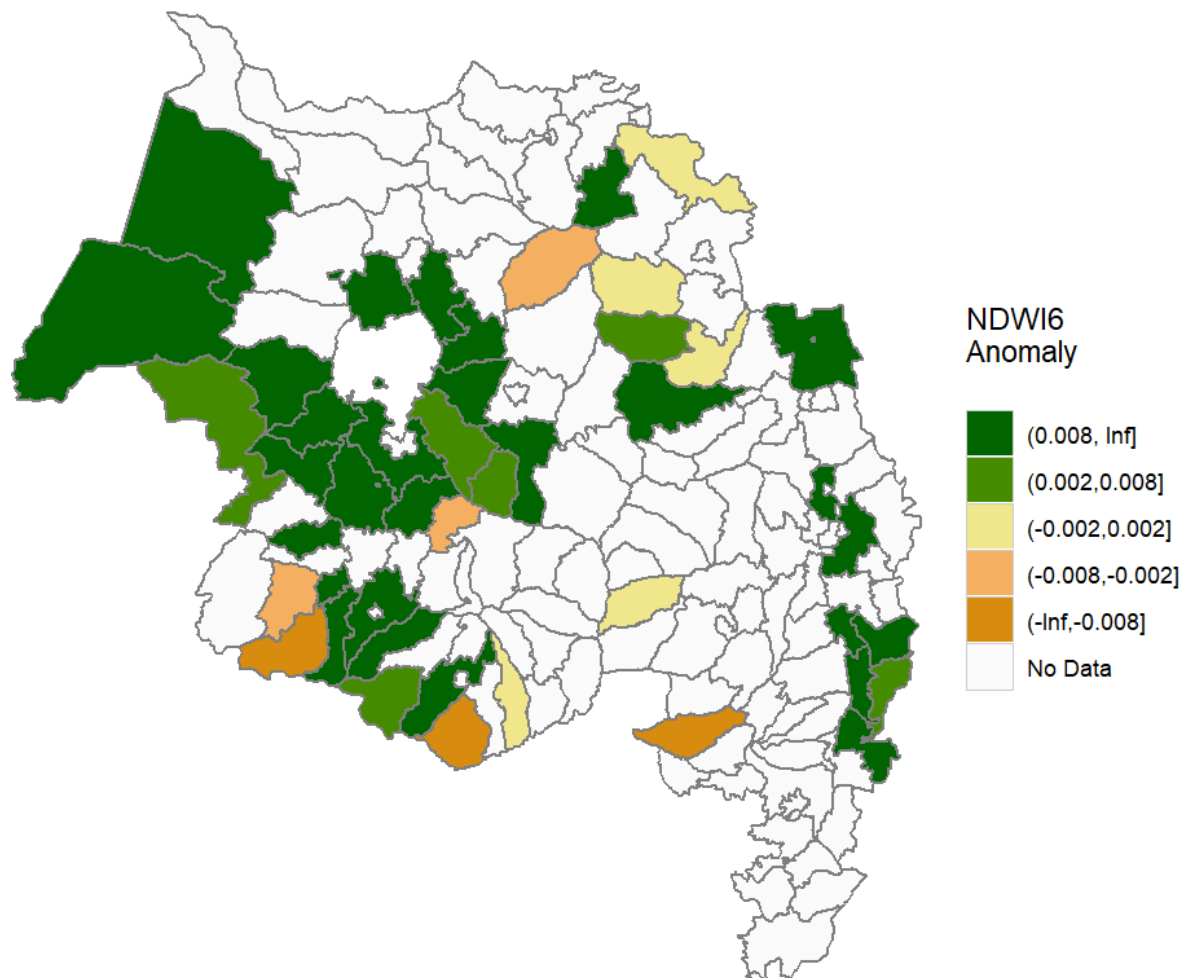
This report presents environmental and epidemiological surveillance and forecasting results for 47 woredas in the Amhara region for the past 18 weeks through 8 weeks forecasted into the future.

Alerts are generated by an anomaly detection algorithm run over the number of cases (observed or estimated, adjusted for population) during the entire time length of the report. We have chosen a variation of the Farrington Improved algorithm, as tests showed that this algorithm performed best for our data. The Farrington method, in various forms, is actively used at some European health centres for surveillance. The Farrington method accounts for seasonality, long-term trends, and past events when calculating the alert thresholds. Alerts are triggered when incidence passes this threshold. Historical alerts for an individual woreda can be viewed in the timeseries control charts appearing on the woreda report page.

Early Detection Alerts are alerts that are triggered during the early detection period, which defined as the 4 most recent weeks of known epidemiology data. The number of alerts are summarized in section 1, Alert Summaries: showing maps and lists of woredas that have early detection alerts for both *P. falciparum* and mixed malaria, and *P. vivax*. "High" level indicates two or more weeks in this period had incidences greater than the alert threshold, "Medium" means that one week was in alert status, and "Low" means no weeks had alerts. This period is highlighted on the individual woreda report control charts in section 2, Woreda Reports.

Forecast Models were developed through the use of a genetic algorithm to determine the optimal combination of environmental variables, as well as the clustering of woredas. Woredas were clustered, or grouped, by the pattern of how the malaria incidence behaves, or responds, to the environmental variables - woredas where these responses were similar were placed in the same cluster. This gives us greater ability and power for the forecast model. The model is based on a general additive model (GAM) regression of multiple factors, including the woreda cluster, lagged anomalies of the environmental drivers, long terms trends, and seasonality.

For the *P. falciparum* and mixed malaria model, the environmental variables are rainfall, daytime Land Surface Temperature (LST), and Normalized Difference Water Index (NDWI6; a satellite-derived index for vegetation water content). For the *P. vivax* model, the environmental variables are rainfall, the mean of daytime and nighttime LST, and NDWI6.

Early Warning Alerts are alerts generated by the Farrington detection algorithm run over the future (early warning period) forecast estimates. These early warning alerts indicate that the environmental conditions are favorable (or unfavorable) for abnormally high incidence values, based on past trends. In section 1, Alert Summaries, which includes both *P. falciparum* and mixed malaria, and *P. vivax*, "High" indicates two or more weeks, "Medium" one week, and "Low" having zero weeks with alert status during the early warning period. Timeseries graphs showing which week is triggering an alert can be found on the individual woreda report charts in section 2, Woreda Reports.

4.2 Woreda Report Description

The individual woreda report displays control charts related to incidence and alerts (top half) and timeseries graphs of the environmental variables (bottom half).

There are two control charts, one for *P. falciparum* and mixed malaria, and one for *P. vivax*. Each chart displays the observed incidence of malaria for the previous 18 weeks of known epidemiological data. Using the models defined in the previous section 4.1, forecasts for both historical values (18 weeks) and future estimates (8 weeks), are shown. Alert thresholds, calculated from the anomaly detection algorithm, are calculated and plotted for the entire report length. If too many of the historical case counts for that time of year have been zero, alert thresholds may not be shown. Early detection alerts (as filled triangles at the base of the graph at that week) are shown both for historical weeks, and in the shaded early detection period (defined as the 4 most recent weeks of known epidemiology data). Early warning alerts (unfilled triangles in the differently shaded early warning period) are shown based on the forecasts. See previous section 4.1 for further details on alerts. The vertical line demarks the time point between known data and forecast estimates.

The environmental timeseries graphs show the variables associated with *P. falciparum* and mixed malaria: rainfall, daytime Land Surface Temperature (LST), and Normalized Difference Water Index (NDWI6). Observed values (derived from satellite data) are marked as filled circles, and any values that needed to be interpolated (because of missing data due to clouds, etc.) are in unfilled circles. For the future values, shown in unfilled squares, the data has been extended based on the mean of the previous week and on the historical mean for that week of the year. The gray shaded area are the historical environmental covariate values: shown from the 25th to 75th percentile, called the 'Middle 50%'. All analysis and interpolation of environmental data has been done on a per day basis, and were summarized to a weekly level (sum of rainfal, mean of temperature, etc.) for display. The vertical line demarks the time point between known epidemiological data and forecast estimates, same as in the control charts above. Depending on when the report is run, known environmental data may be used in the forecast portion.