On-demand Model Validation in Infectious Disease Early Warning Systems
# Malaria Forecasts in Ethiopia Using R Package epidemiar

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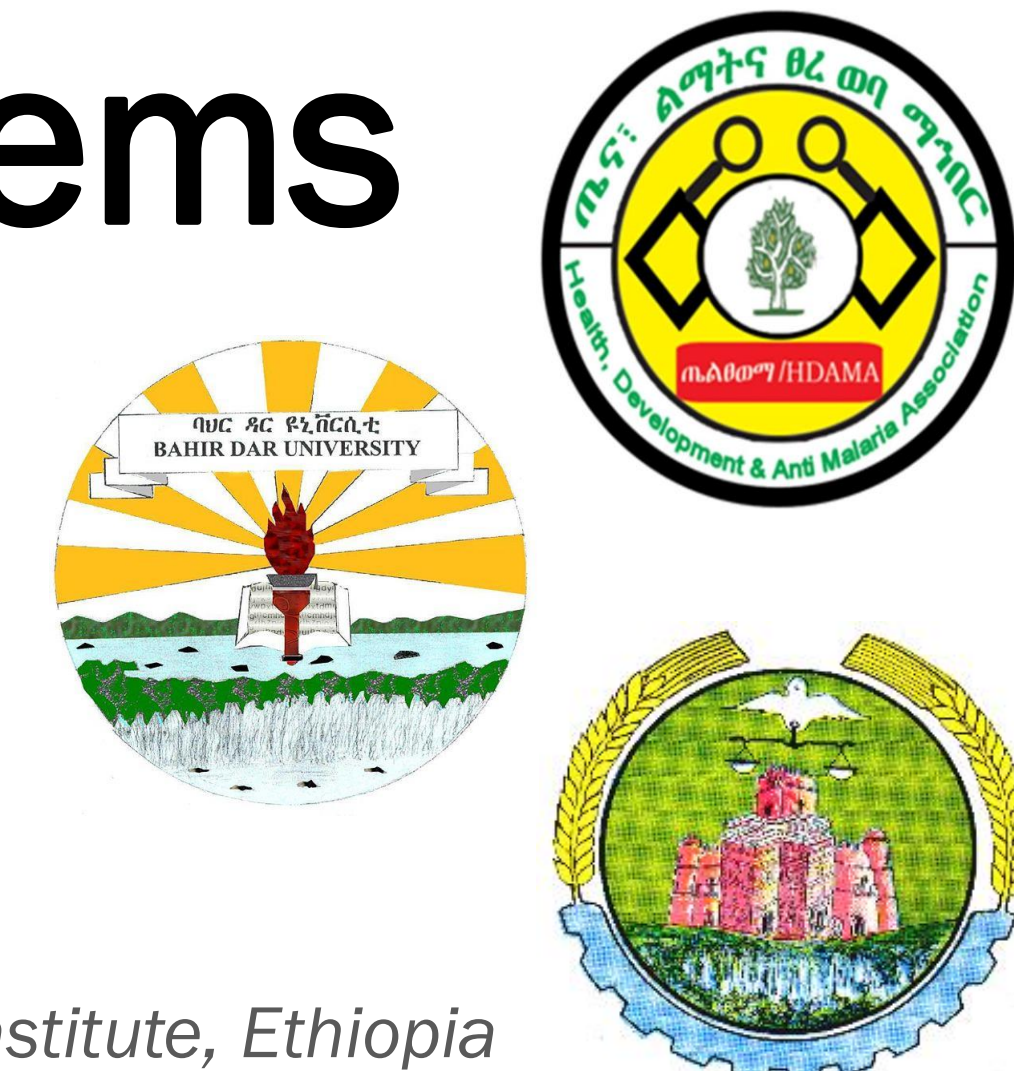
EPIDEMIA research project

Epidemic Prognosis Incorporating Disease and Environmental Monitoring for Integrated Assessment
- Create early warning malaria forecast reports integrating epidemiological & environmental data

R package **epidemiar**

- Modeling, forecasting & validation functions
- Flexible – supports various environmentally-mediated diseases, locations, environmental variables
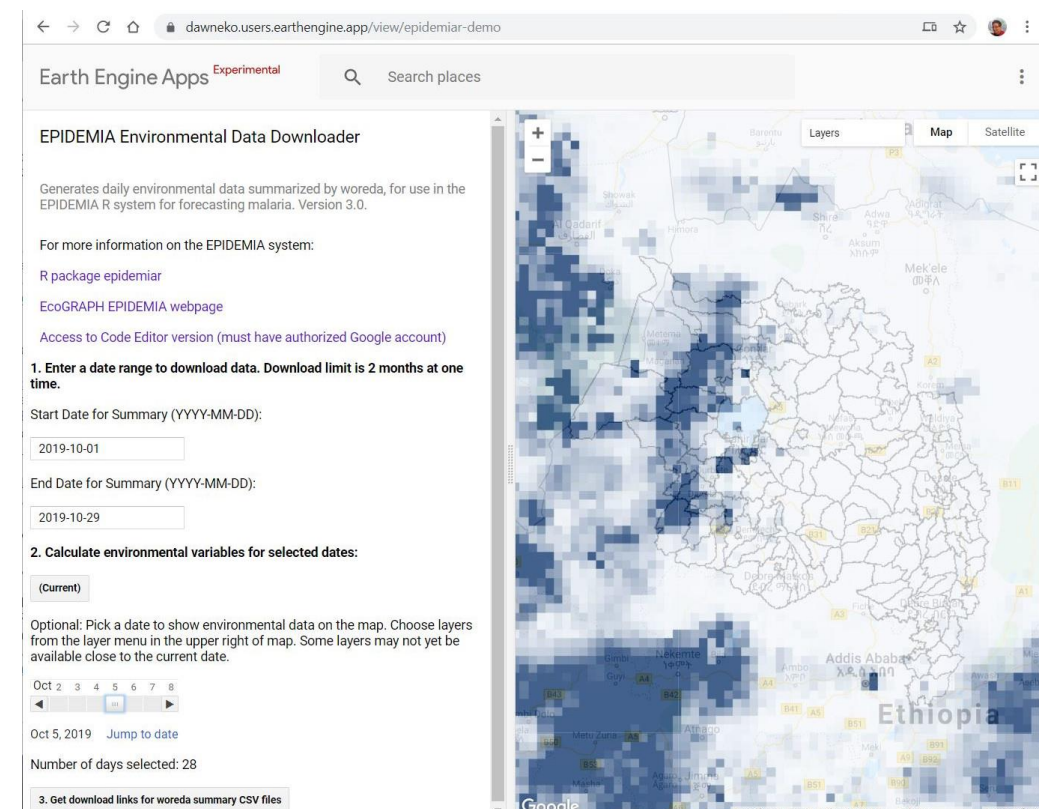- Event detection: Farrington improved algorithm
- https://github.com/EcoGRAPH/epidemiar

Custom R project

- Region & disease-specific settings for local data input, modeling, event detection, and report formatting
- https://github.com/EcoGRAPH/epidemiar-demo

Google Earth Engine App

- Environmental data summaries
- Fast, on-demand
- Small download

Malaria in Amhara region of Ethiopia
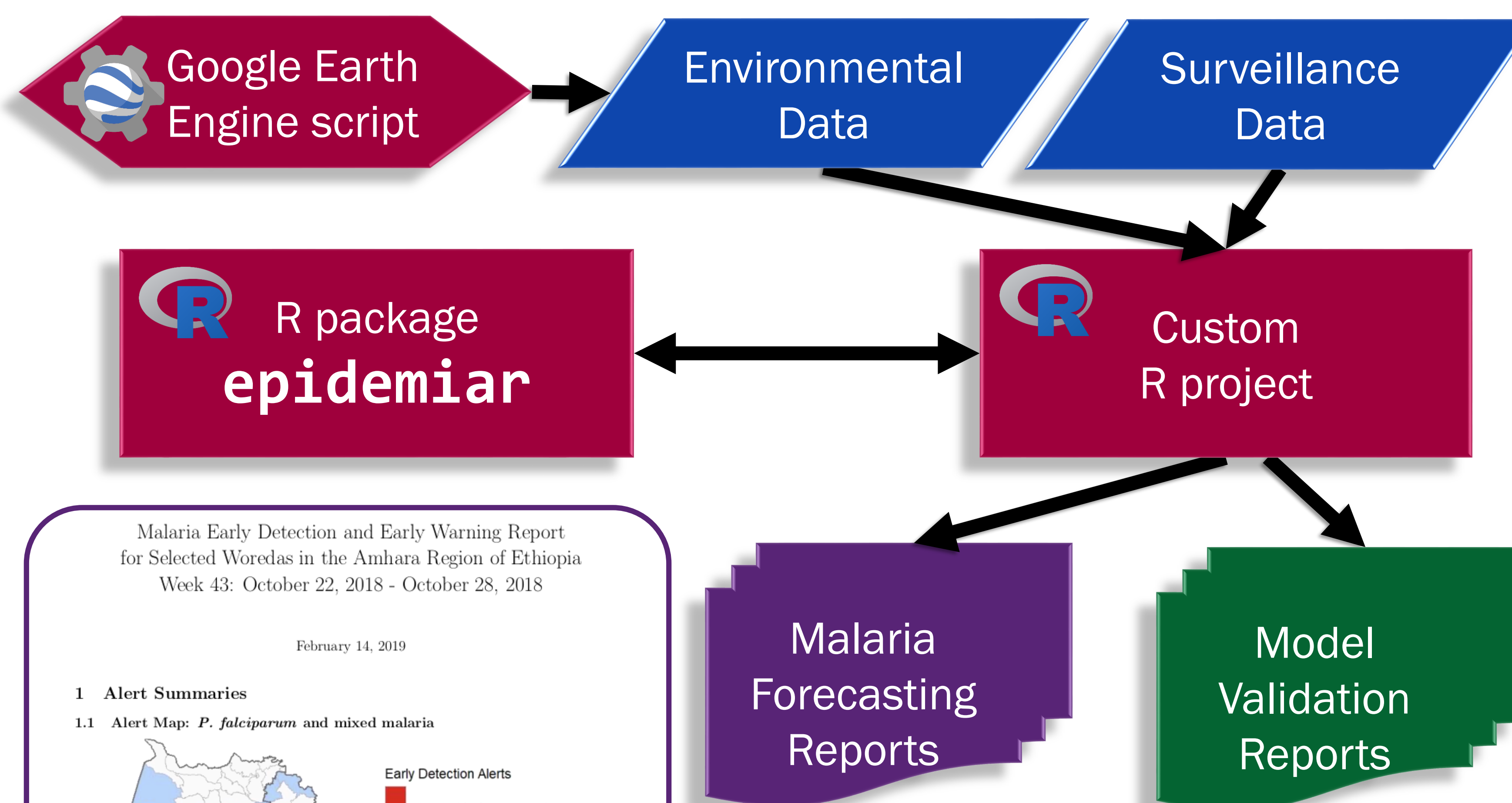
P. falciparum and mixed species
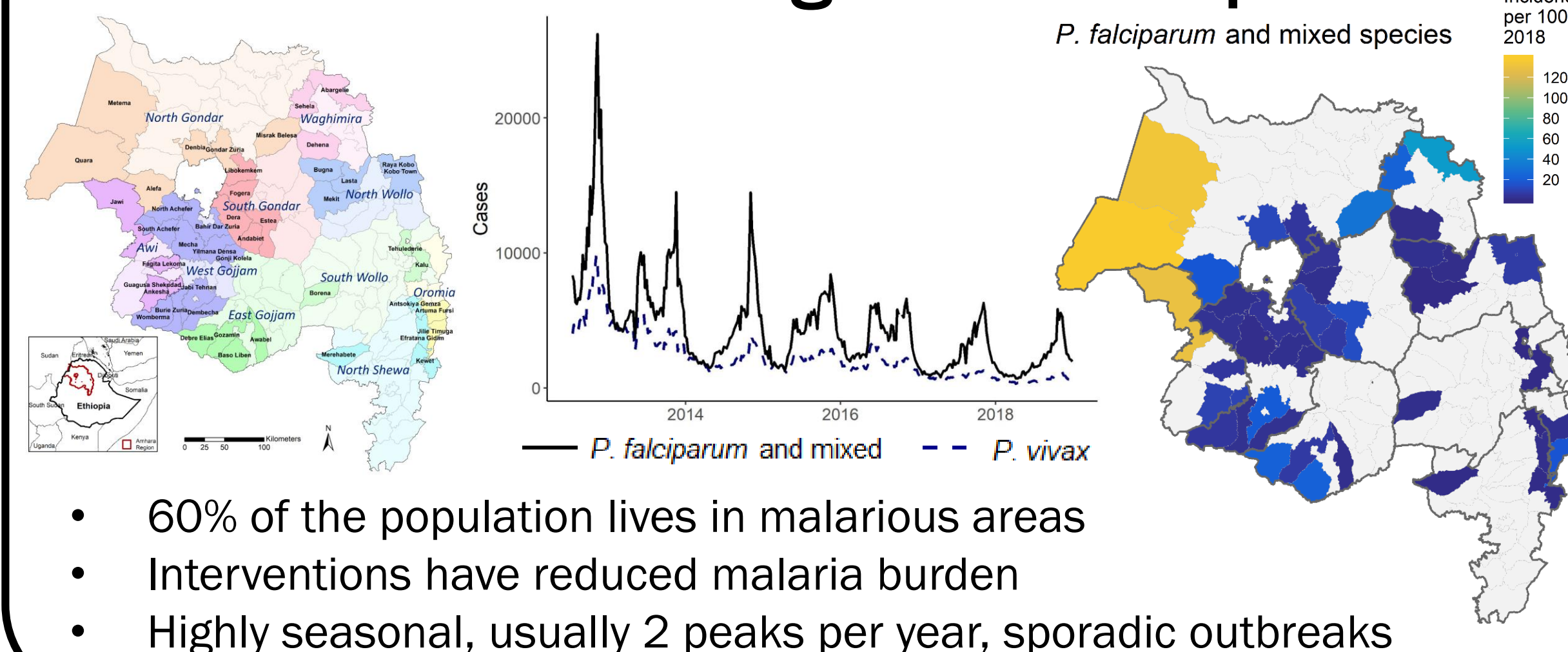
- 60% of the population lives in malarious areas
- Interventions have reduced malaria burden
- Highly seasonal, usually 2 peaks per year, sporadic outbreaks

Malaria Forecast Reports

- Developed with researcher and public health feedback
- Currently forecasts 8 weeks into the future
- Early detection and early warning alerts
- Can be run from a desktop/laptop
- Map summaries and per district reports
- Includes environmental factors for context

EPIDEMIA Forecasting System

Google Earth Engine script → Environmental Data / Surveillance Data

R package **epidemiar** ↔ Custom R project

Malaria Forecasting Reports / Model Validation Reports

Malaria Early Detection and Early Warning Report for Selected Woredas in the Amhara Region of Ethiopia
Week 43: October 22, 2018 - October 28, 2018

February 14, 2019

1 Alert Summaries

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

Early Detection Alerts
- High: Alert for 2 or more weeks in early detection summary period
- Moderate: Alert for any 1 week in early detection summary period
- Low: No alert
- No Data

Early Warning Alerts
- High: Alerts for 2 or more weeks in forecast period
- Moderate: Alert for any 1 week in forecast period
- Low: No alerts
- No Data

Early Detection Period: Last 4 weeks of known epidemiological data. Date range: Oct 07, 2018 through Oct 28, 2018.
Early Warning Period: Forecasting period of 8 weeks. Date range: Nov 04, 2018 through Dec 23, 2018.

2.14 North Gondar: Quara

Early Detection Alert / Early Warning Alert / Alert Threshold / Forecast Trend / Observed

Observed / Interpolated / Extended / Historical Middle 50%

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

Model Assessment & Validation

- Built into forecasting model system
- On demand, user-specified time range
- User-specified future forecast period

Skill Scores

- Accuracy statistics
  - Mean Absolute Error (MAE),
  - Root Mean Squared Error (RMSE)
  - R^2 (variance explained),
- Compare against naïve models
  - Average week of the year: based on historical epidemiological data
  - Persistence: last known value carried forward *n* weeks
- Skill score shows relative improvement of forecast model over naïve model, calculated per accuracy statistic

Validation statistics for 2018 *P. falciparum* & mixed species

Week Ahead	MAE	RMSE	R^2
1	19.5	54.0	0.76
2	21.1	59.7	0.71
4	23.5	68.0	0.62
6	25.3	76.9	0.51
8	26.0	73.6	0.55
10	27.5	92.6	0.29
12	26.8	95.5	0.25

Model overall view: Skill scores for 2018 *P. falciparum* and mixed species forecasts
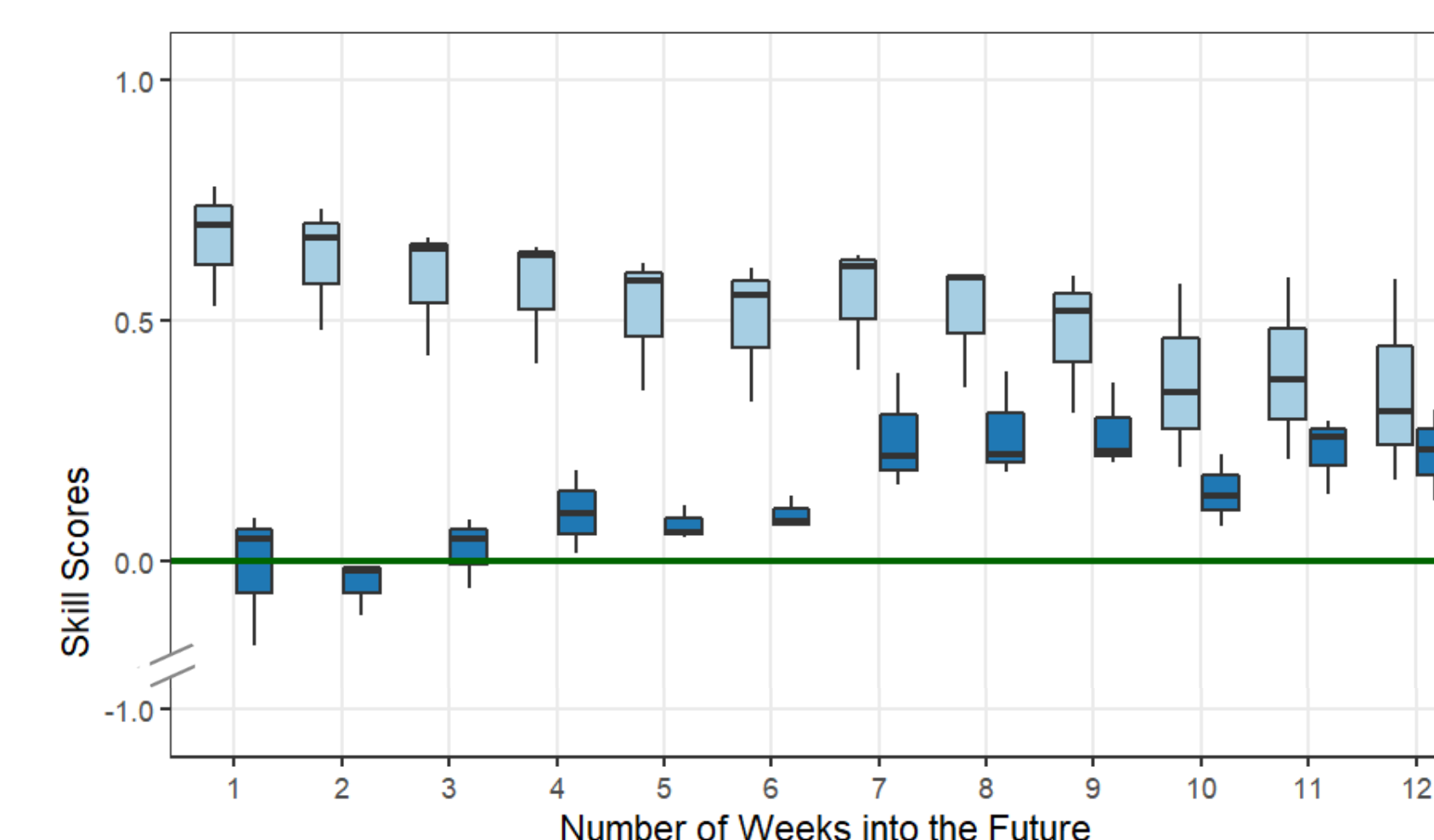
Average Week of Year / Persistence

Geographic View of Validation

- Geographic insights at district level
- Maps help visualize geographic patterns
- Low skill could indicate presence of malaria drivers other than environmental variables
- Increases the transparency of the modeling and forecasts
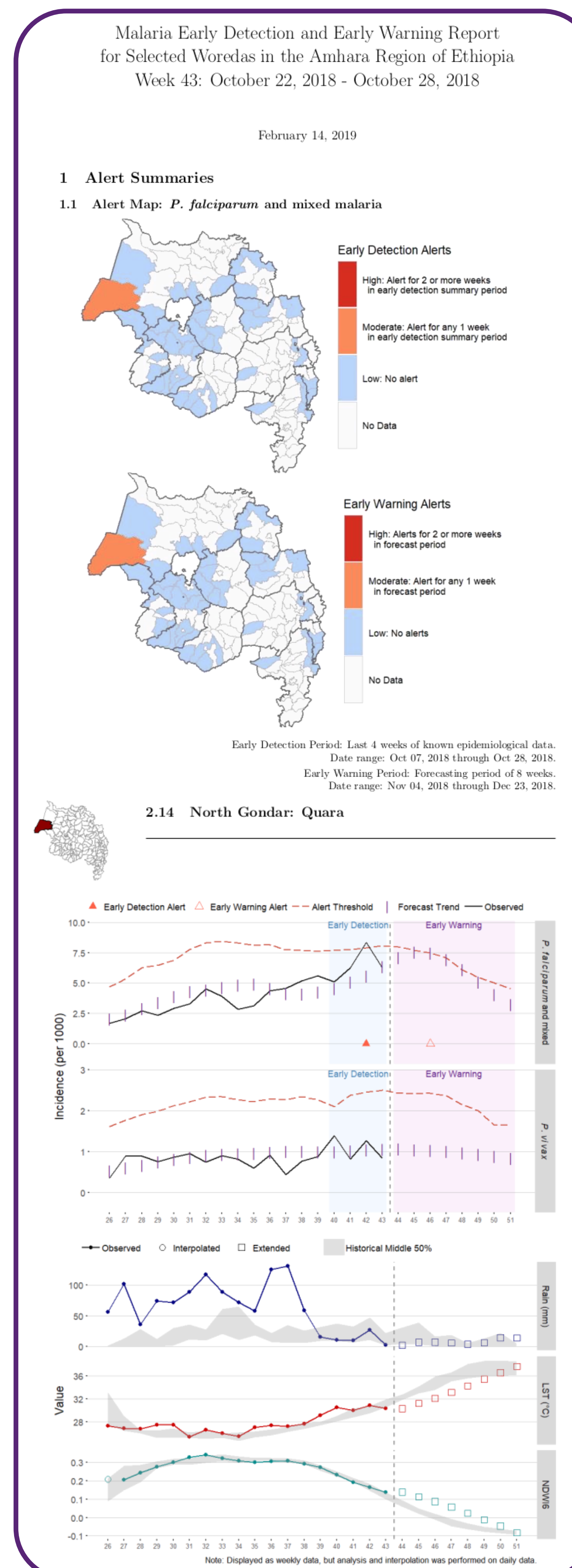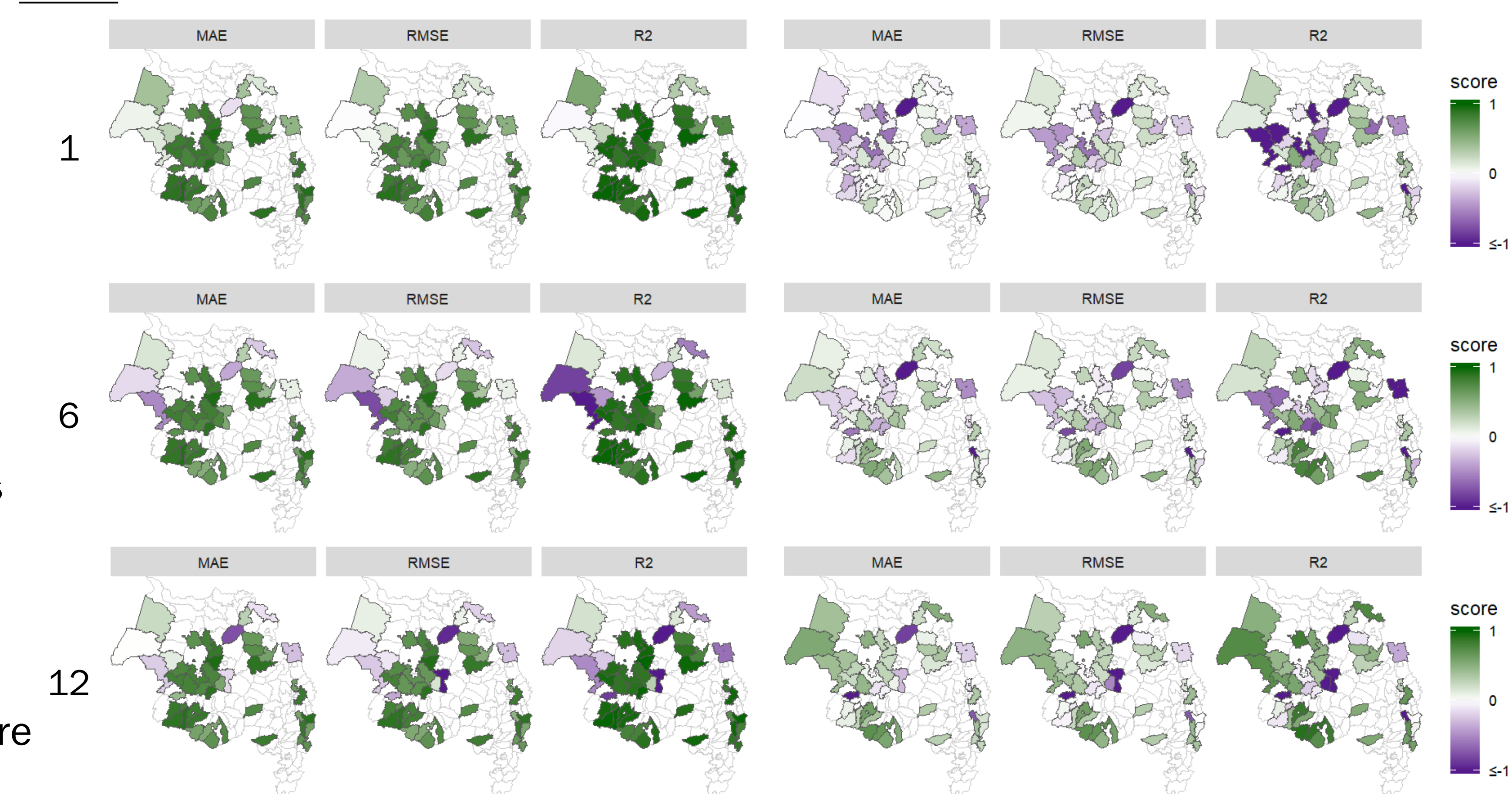- Identifies locations where model works well and where it does not

Week Ahead: 1, 6, 12

Compared to Average Week — MAE / RMSE / R2
Compared to Persistence — MAE / RMSE / R2

Skill scores for 2018 *P. falciparum* & mixed species forecasts

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