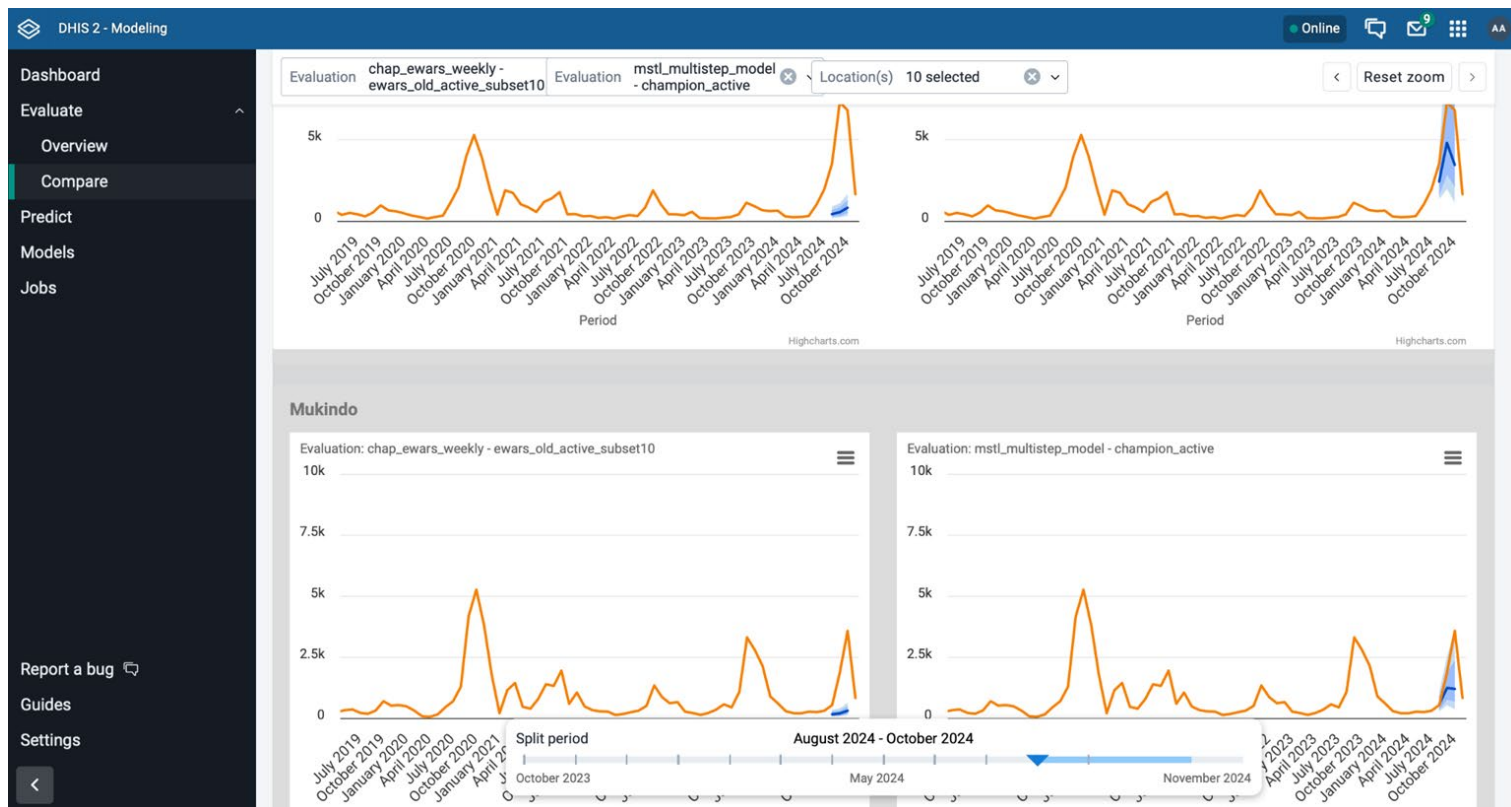


Malaria Modeling In Chap

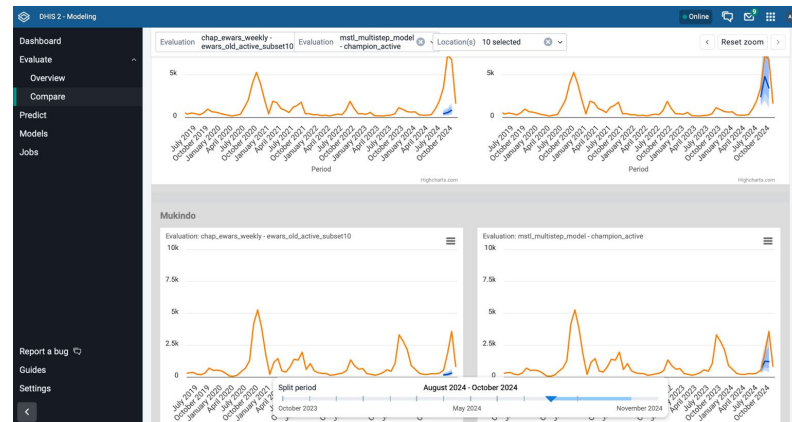
Interventions, Risk Maps, and the importance of asking the
right questions

Malaria Modeling in CHAP, Past and Present

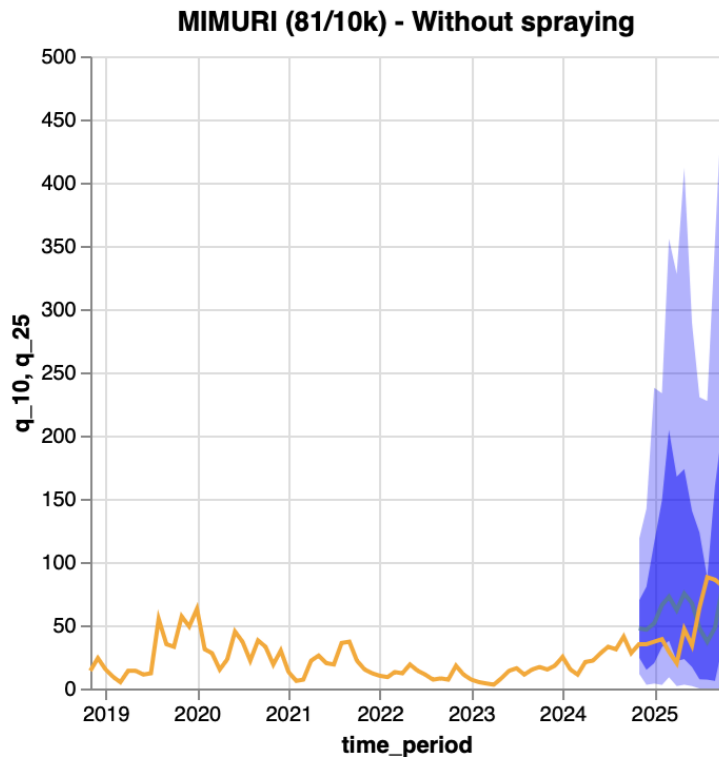
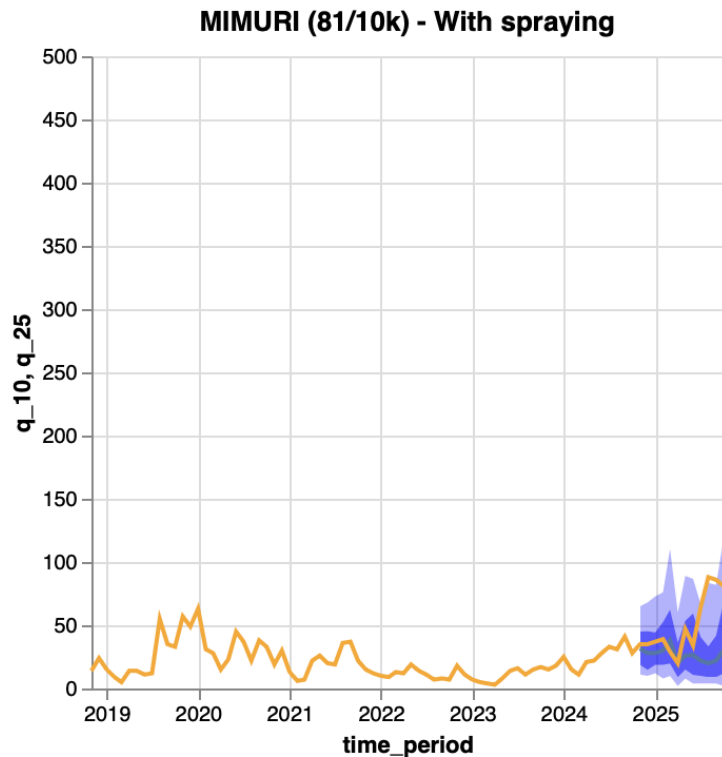


Malaria Modeling in CHAP, Past and Present

- Much of the improvements have been driven by: Which model/data gives us lowest log-CRPS?
- Guiding principle: A model that is good at predicting disease curves will be good at answering related questions.
- This will only take us so far
- What are the actual questions we want to answer?
- This has implications for the whole pipeline

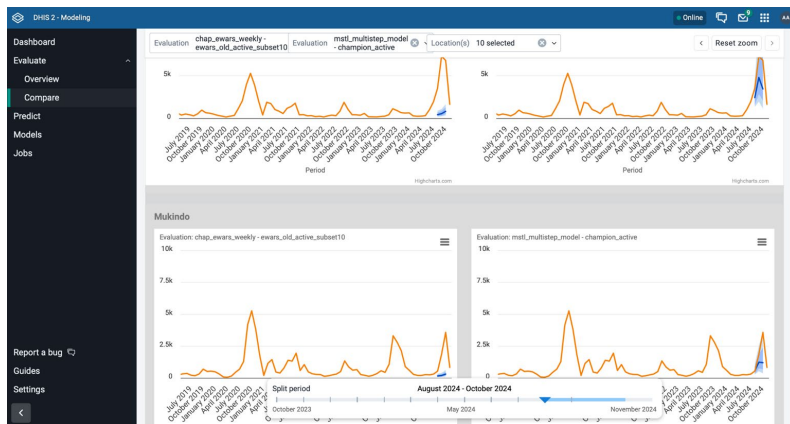


Question: What is the effect of interventions?

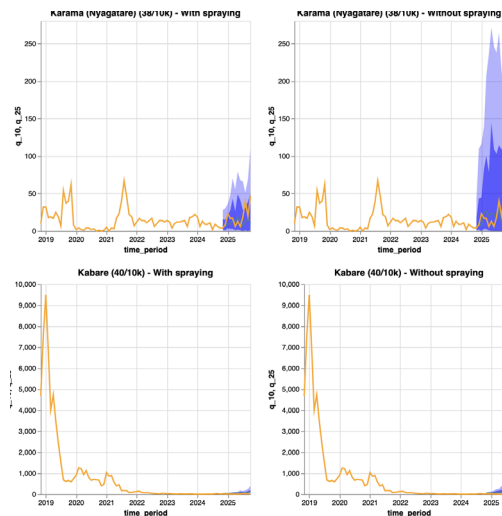


Question: What is the effect of interventions?

Why we would trust a model:
log-CRPS



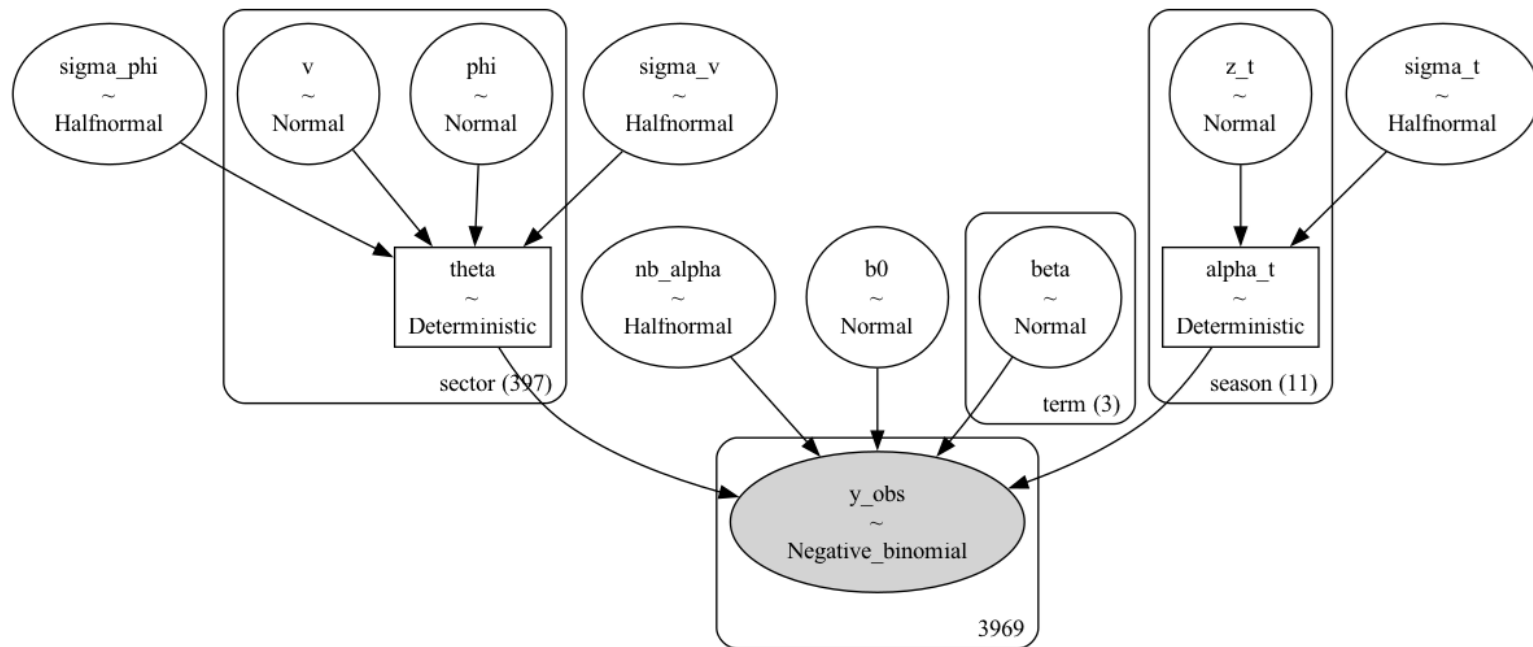
What we use it for: Counterfactuals



Can we trust the counterfactual analysis?
How should we evaluate the model in order to trust the counterfactual?

Question: What is the effect of interventions? (Classic)

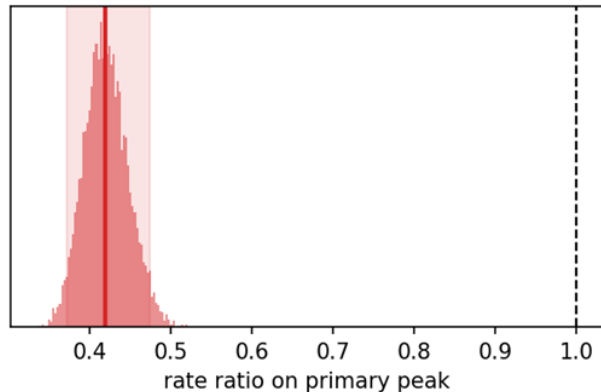
IRS spray-timing model — M1 (timing only, no interaction), NB-ICAR, primary malaria peak
phi = intrinsic CAR (ICAR) spatial prior over sectors (shown as a placeholder node)



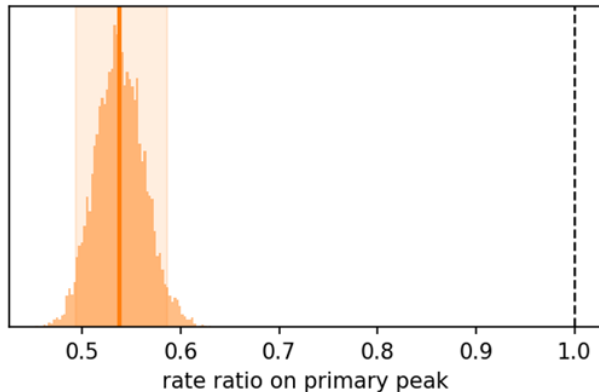
Question: What is the effect of interventions? (Classic)

Timing main-effect posteriors (M1, no interaction) — IRS protection by spray window (<1 → protective; dashed = no effect)

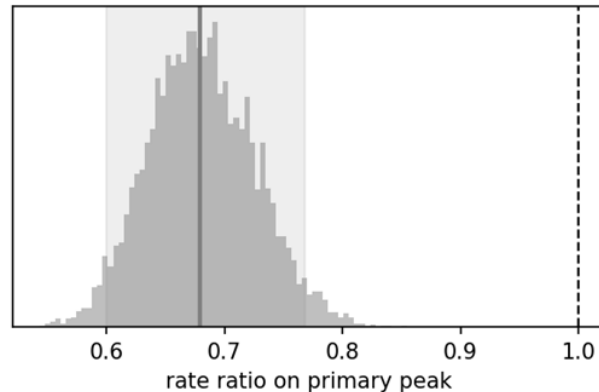
early_this — fresh (0-2 mo)
RR = 0.42 [0.37, 0.47]



late_last — recent carry-over (5-9 mo)
RR = 0.54 [0.49, 0.59]

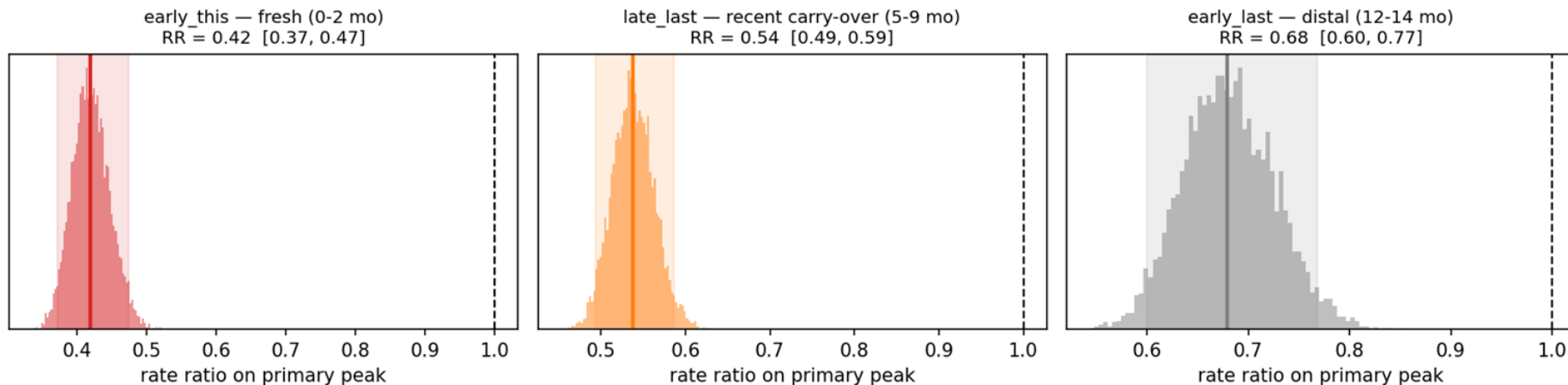


early_last — distal (12-14 mo)
RR = 0.68 [0.60, 0.77]



Question: What is the effect of interventions? (Classic)

Timing main-effect posteriors (M1, no interaction) — IRS protection by spray window (<1 → protective; dashed = no effect)

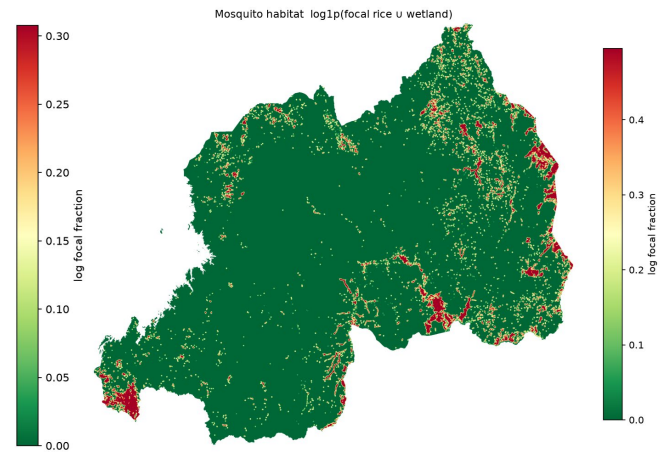
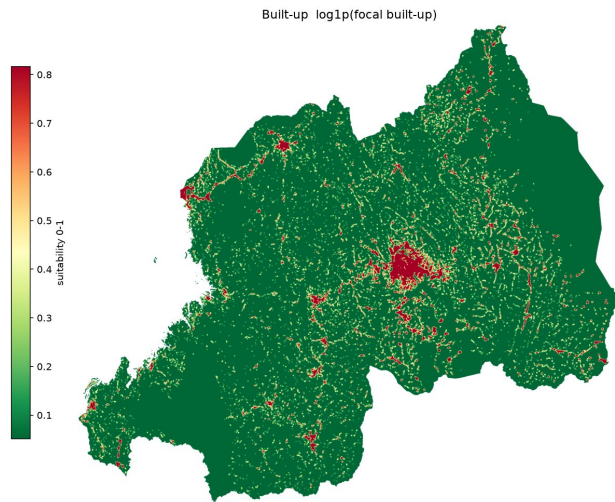
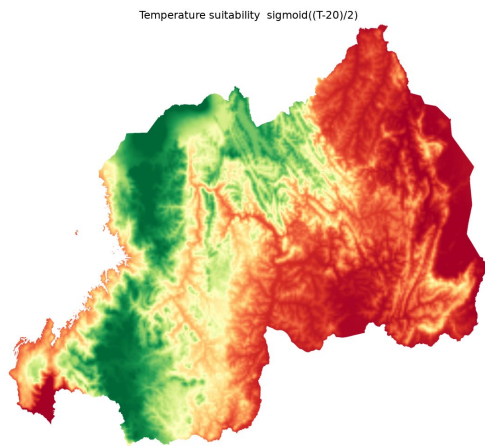


How would we validate if this model is good?

Question: How should interventions be prioritized?

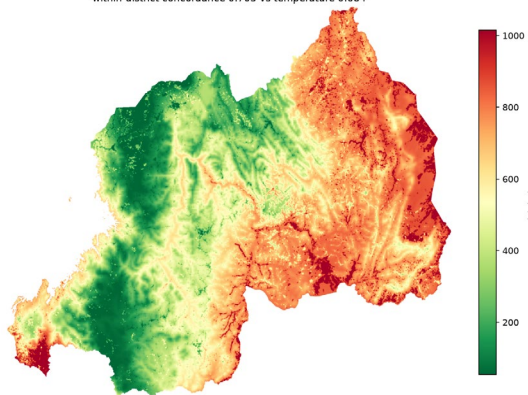
- Can we create risk map models that help increase the resolution of malaria incidence?
- Could such a map help with allocation of interventions

Risk Maps

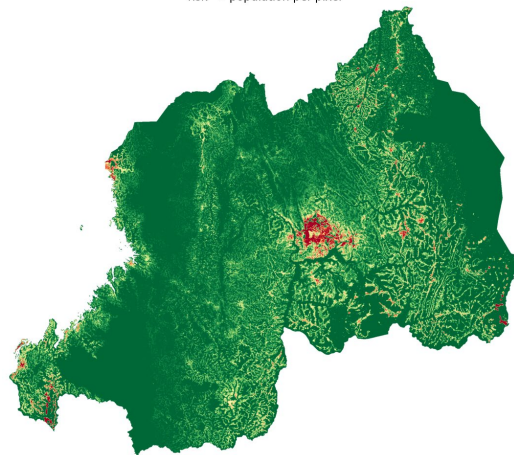


Risk Maps

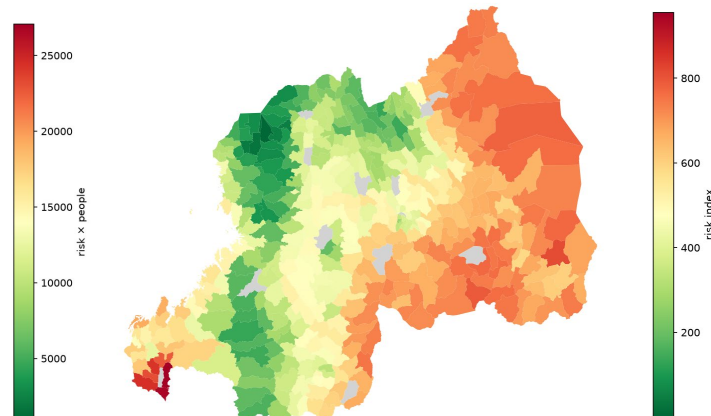
Locally tailored malaria risk (sigmoid temp $T_0=20$, $k=2$)
within-district concordance 0.705 vs temperature 0.684



Population-weighted risk (expected-burden surface)
 $\text{risk}^2 \times \text{population per pixel}$



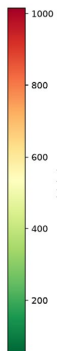
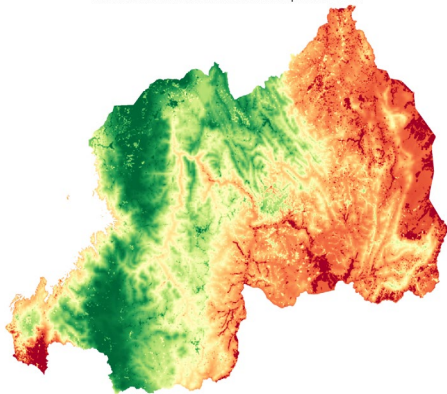
Per-sector malaria risk (population-weighted)



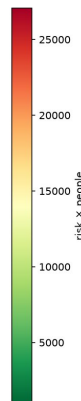
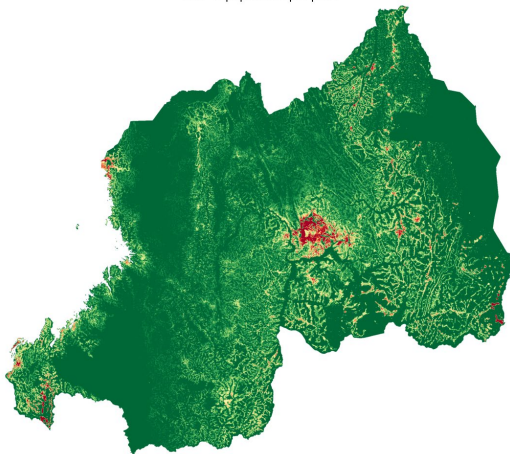
Risk Maps

How good is this map at ranking sectors by incidence within a district?

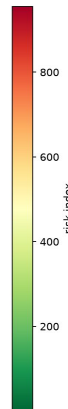
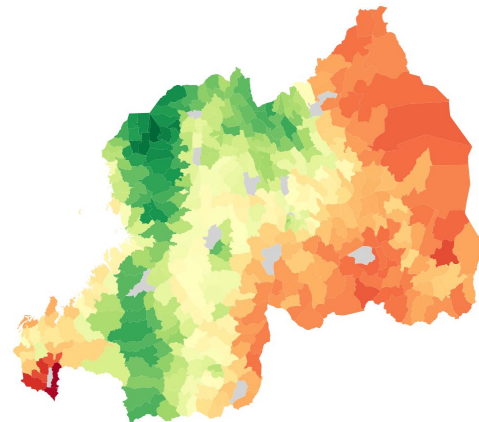
Locally tailored malaria risk (sigmoid temp $T_0=20$, $k=2$)
within-district concordance 0.705 vs temperature 0.684



Population-weighted risk (expected-burden surface)
 $\text{risk}^* \times \text{population per pixel}$



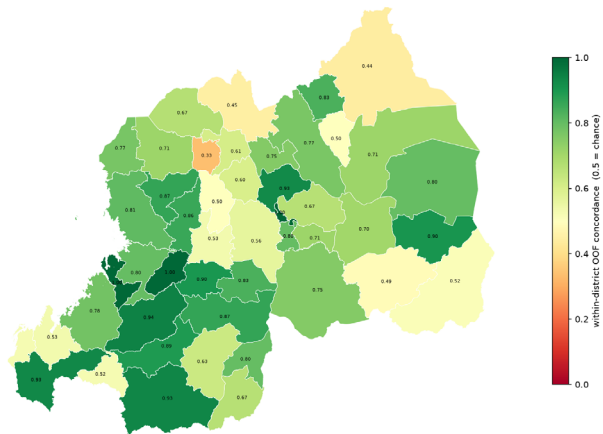
Per-sector malaria risk (population-weighted)



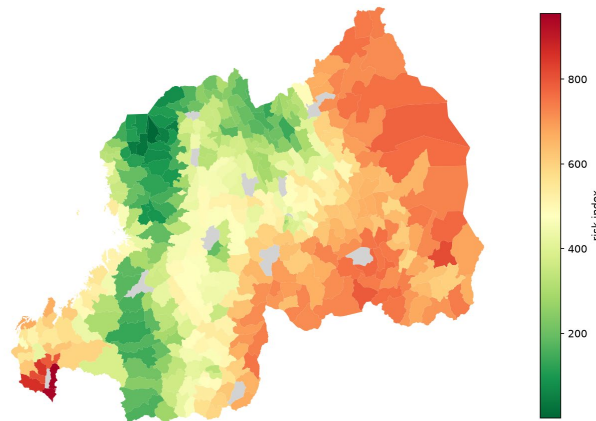
Risk Maps

How good is this map at ranking sectors by incidence within a district?

Risk-map out-of-fold concordance by district — 46 districts (mean 0.73)
leave-one-district-out · green = local incidence ordering recovered, red = worse than chance



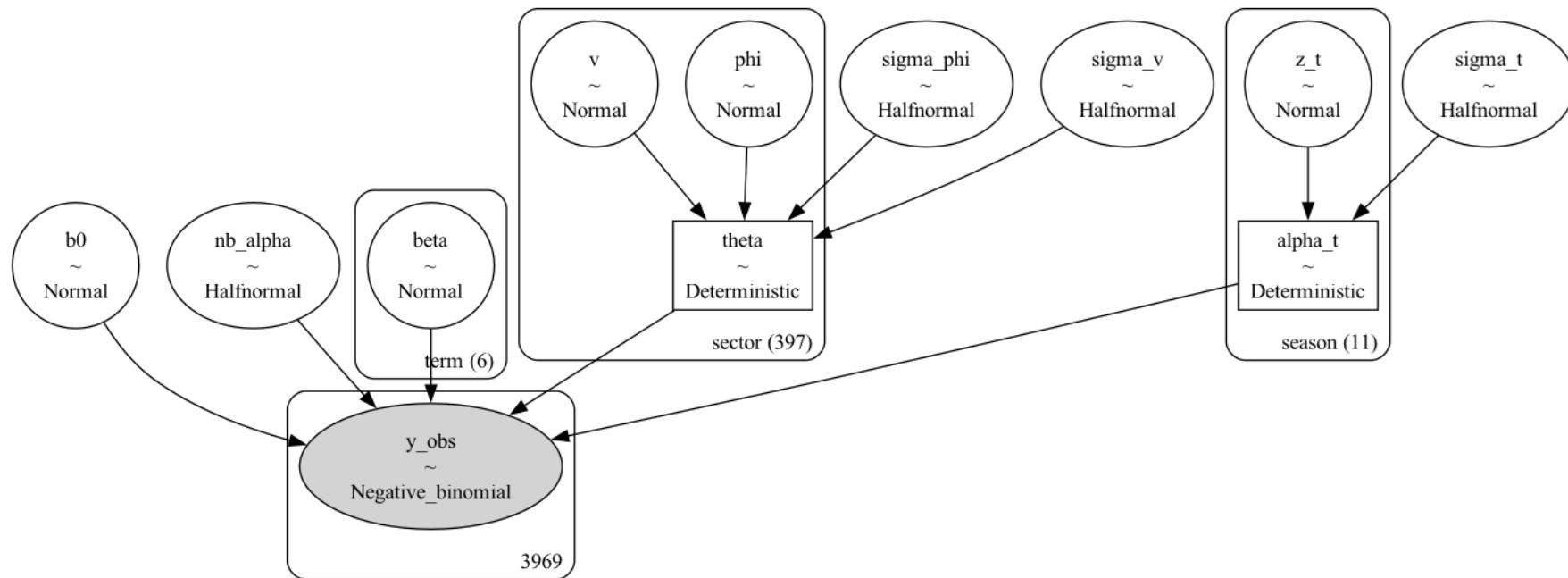
Per-sector malaria risk (population-weighted)



But how good is it at ranking cells within a sector? Or anything within a cell?

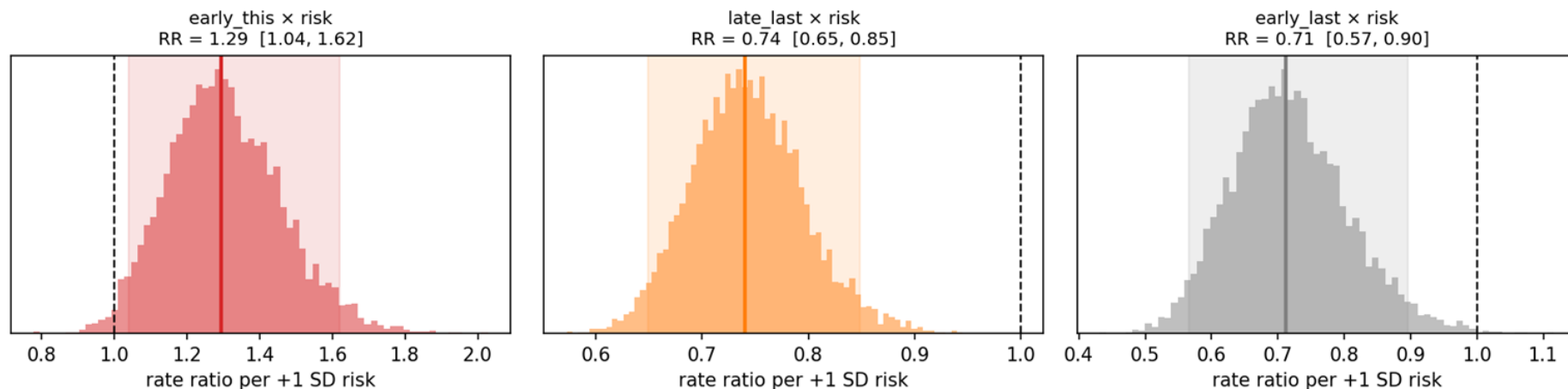
Question: Where do interventions have a large effect?

IRS spray-timing $\times$ risk-map interaction (M2) — NB-ICAR, primary malaria peak
phi = intrinsic CAR (ICAR) spatial prior over sectors (shown as a placeholder node)



Question: Where do interventions have a large effect?

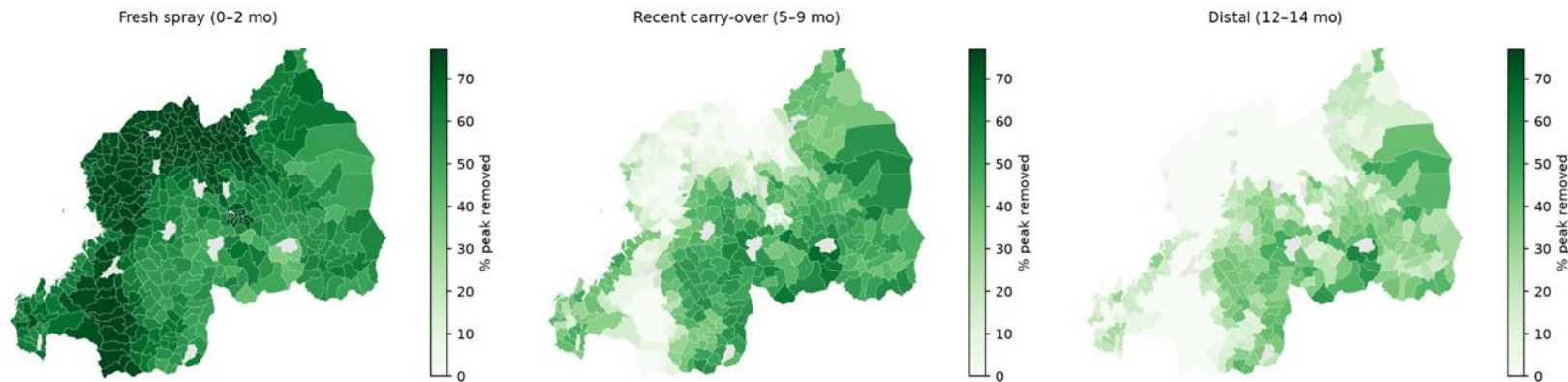
Interaction posteriors — IRS protection vs environmental risk (<1 → deepens with risk, >1 → weakens; dashed = no interaction)



Spraying seem to have a larger effect where risk is high

Question: Where do interventions have a large effect?

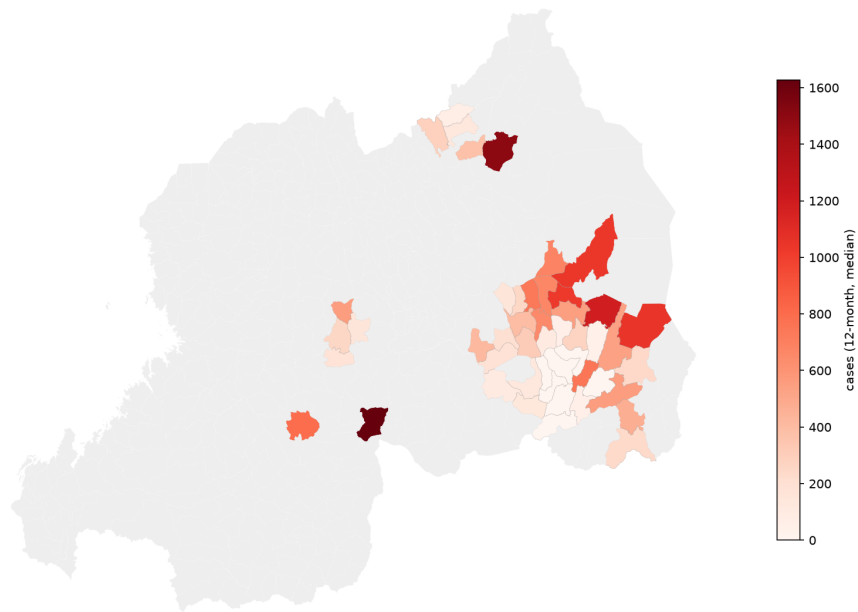
Modelled IRS protection per sector, by spray window (shared scale): carry-over & distal deepen in the high-risk east; the fresh window (non-robust, map-dependent) is protective throughout



Protection is the model's implied rate-ratio reduction evaluated at each sector's own environmental risk (a deterministic transform of the left map via the carry-over $\times$ risk coefficient), not an independent spatial estimate.

Question: Where do interventions have a large effect?

Predicted increase in 12-month malaria cases if 2024 spraying were removed
48 selected sectors · total 20,950 cases · model: monthly AR (auto_regressive_monthly)

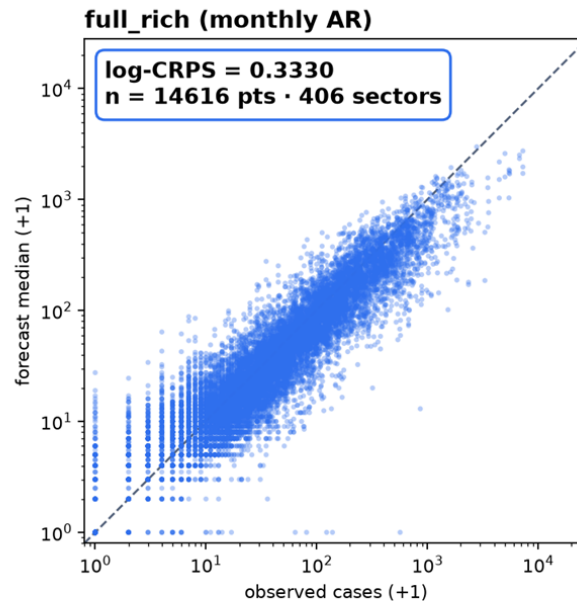
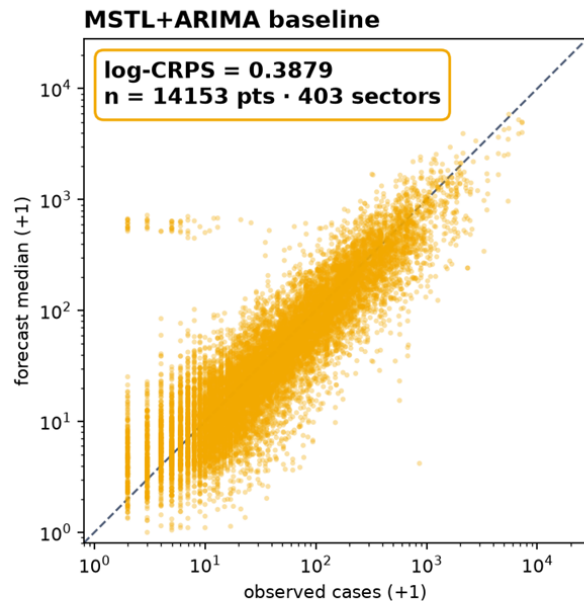


Malaria Modeling in Chap: Future

- Work with concrete policy relevant questions
- Make models relevant for policy relevant questions
- Make evaluation algorithm adapted to the question
- Make custom metrics that capture the performance on the questions
- Make custom visualizations to build trust in the models performance

Question specific visualization/metric

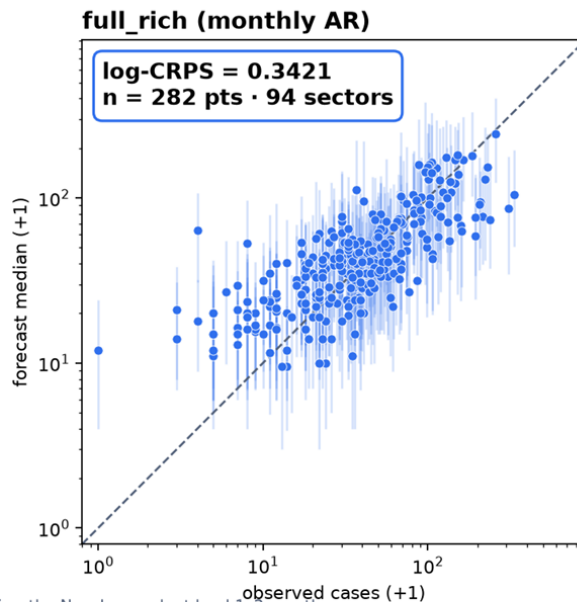
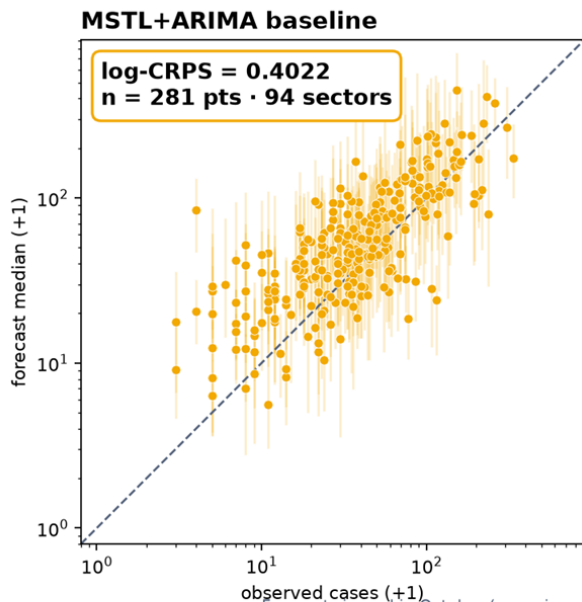
Model skill — full evaluation
Rwanda active-spray — observed vs forecast, all sectors & horizons



Full evaluation — every sector, every forecast period (2023-10 ... 2024-11) and horizon (1-3 months).
Dashed = perfect forecast · log-CRPS lower = better.

Question specific visualization/metric

Model skill in the spray-decision zone
Rwanda — forecasting the Nov-Jan peak from the October IRS window



Forecasts issued in October (pre-primary IRS window), predicting the Nov-Jan peak at lead 1–3 months.
Sectors = ever-sprayed AND trailing-year incidence in the middle 50% (Q25–Q75) of eligible sectors — the gray zone where the spray call is uncertain (band /1000: 2023→24 peak 7.3–39.5 · 2024→25 peak 6.0–60.8). Dashed = perfect forecast · faint bars = 80% interval · log-CRPS lower = better.