Collaborative multi-model nowcasting of infectious diseases

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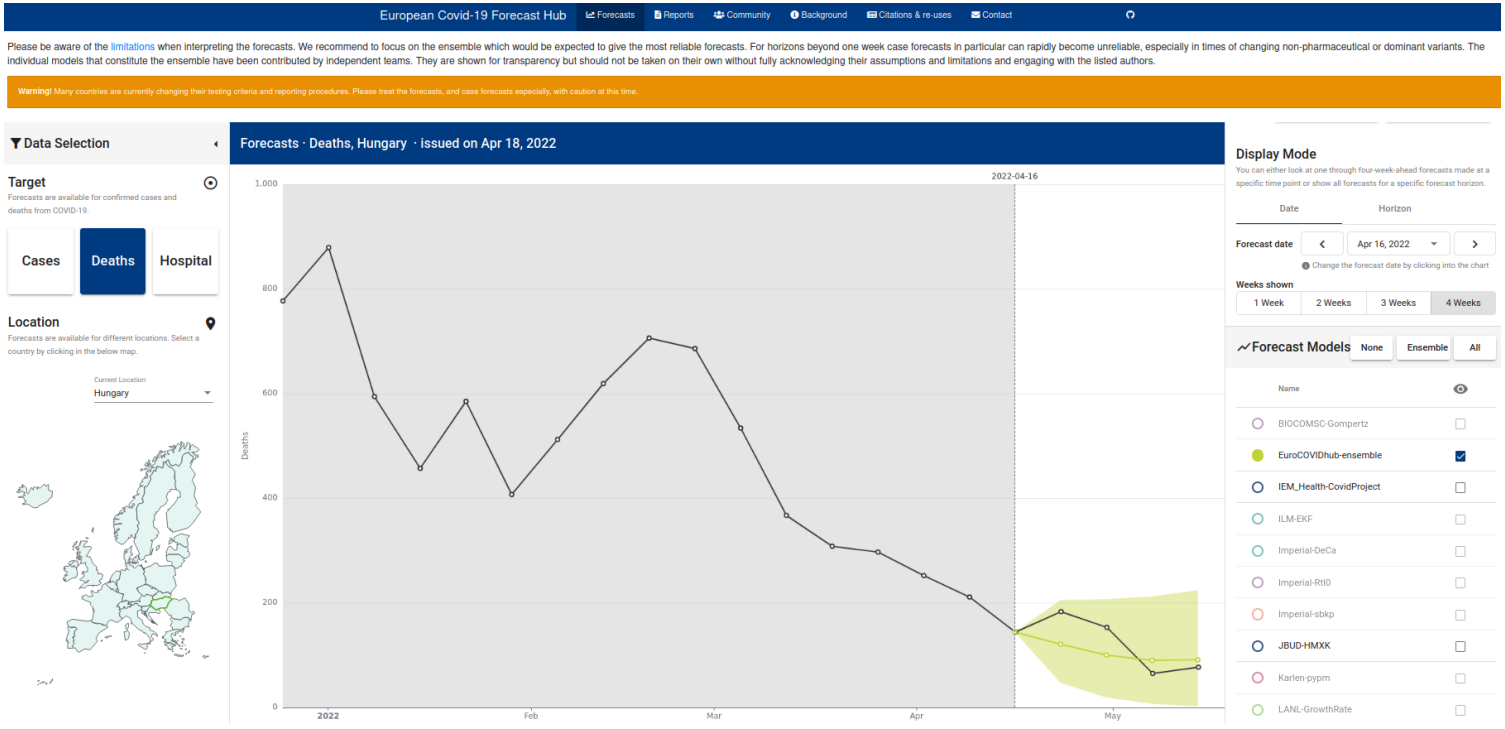
Emmy Noether-Programm

DFG Deutsche Forschungsgemeinschaft

Collaborative forecasting: The Hub principle

- **Forecast Hubs** collect forecasts by multiple teams for standardized targets.
- Example: European COVID-19 Forecast Hub (ECDC)



- Goes back to pre-COVID *CDC FluSight* challenges.

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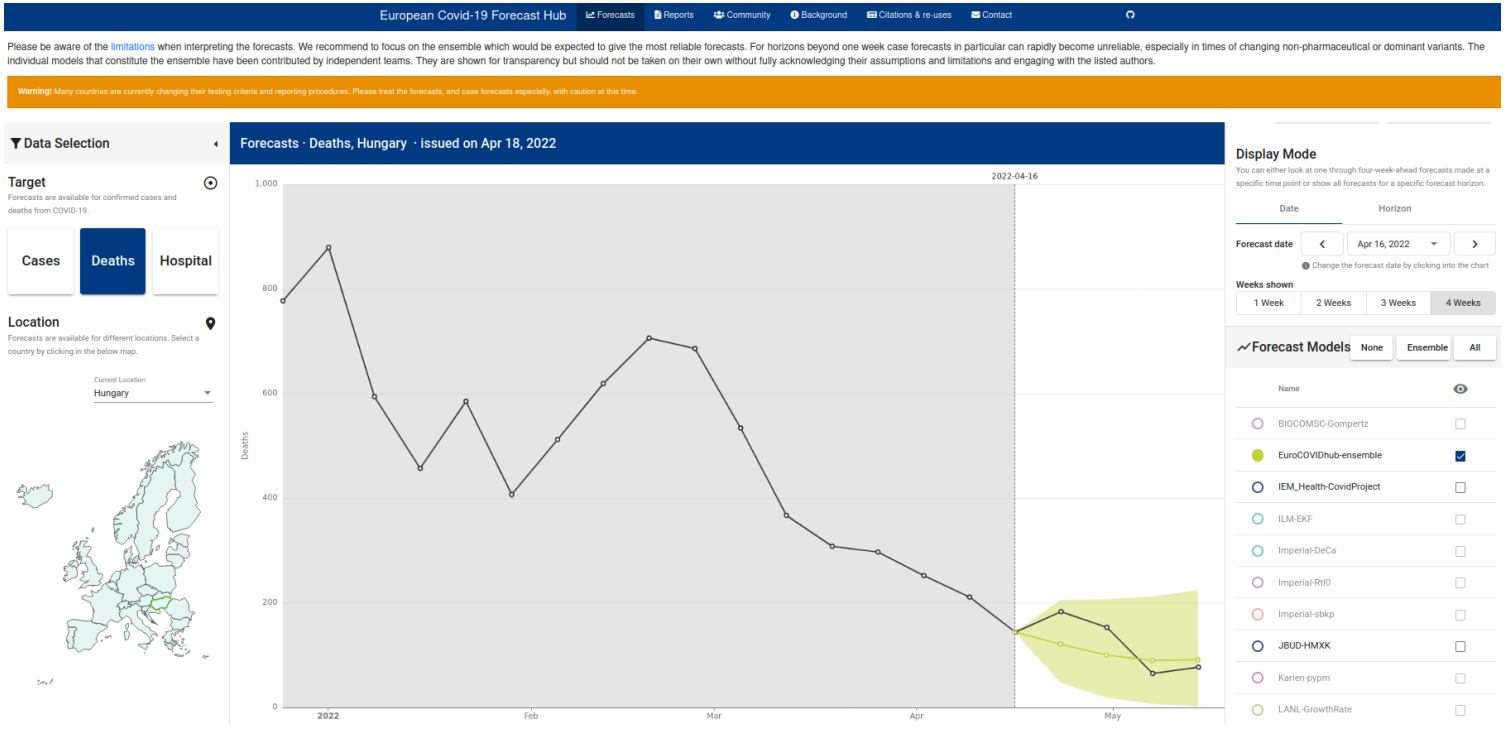

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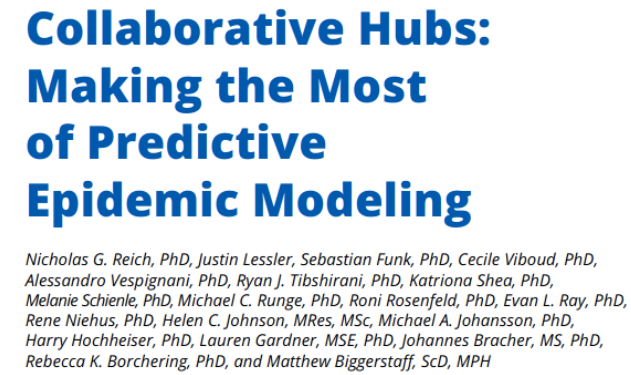
Multi-model systems and neutral comparisons

- Having multiple independently run models helps us
  - **contextualize** individual models.
  - understand model agreement and **uncertainty**.
  - transparently check **forecast quality**.
  - combine results into more robust **ensembles**.
  - **structure** modelling work and foster **exchange**.

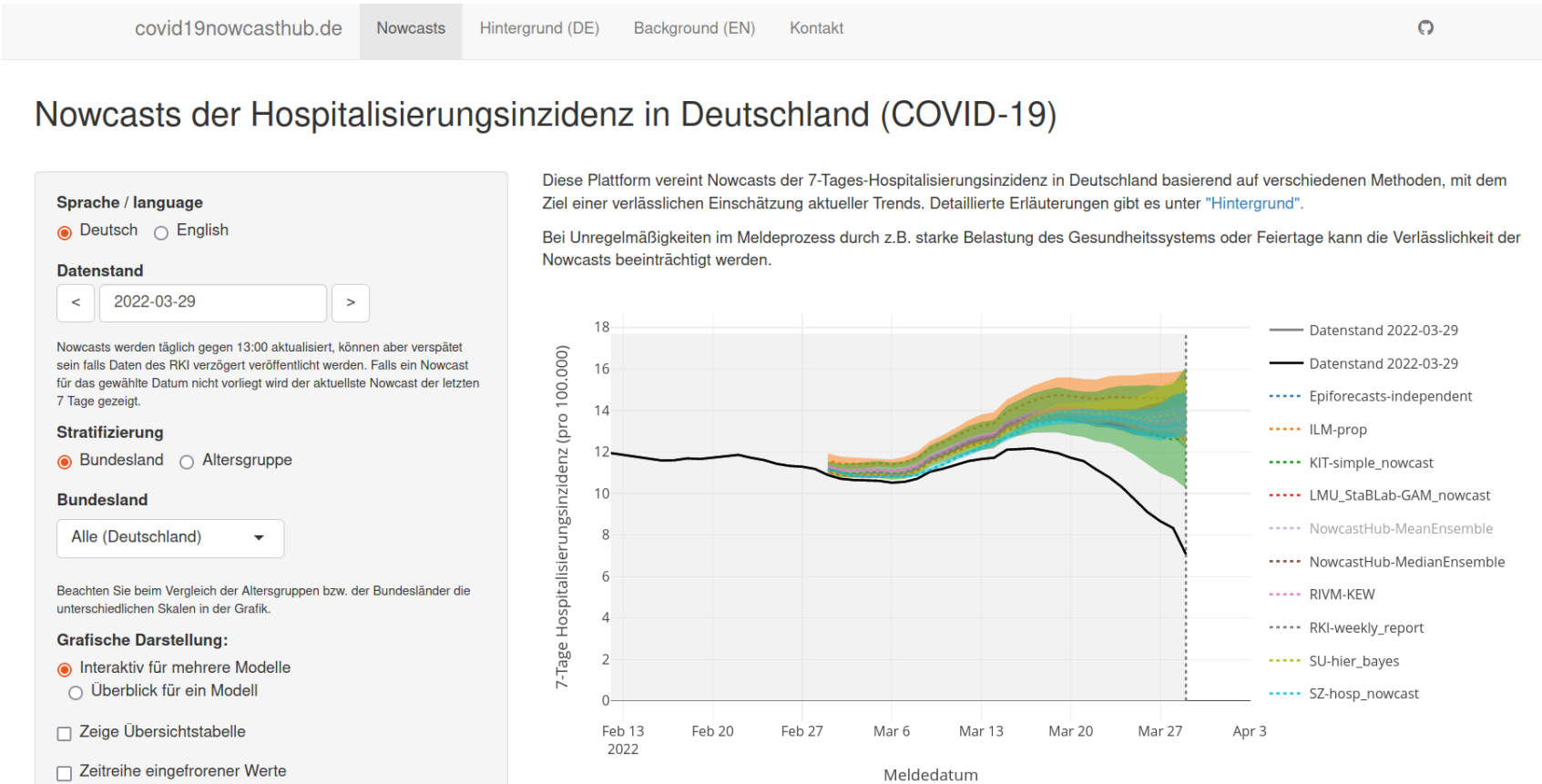

Collaborative Hubs: Making the Most of Predictive Epidemic Modeling

Nicholas G. Reich, PhD, Justin Lessler, Sebastian Funk, PhD, Cecile Viboud, PhD, Alessandro Vespignani, PhD, Ryan J. Tibshirani, PhD, Katriona Shea, PhD, Melanie Schienle, PhD, Michael C. Runge, PhD, Roni Rosenfeld, PhD, Evan L. Ray, PhD, Rene Niehus, PhD, Helen C. Johnson, MRes, MSc, Michael A. Johansson, PhD, Harry Hochheiser, PhD, Lauren Gardner, MSE, PhD, Johannes Bracher, MS, PhD, Rebecca K. Borchering, PhD, and Matthew Biggerstaff, ScD, MPH

Reich et al 2022, Am J Public Health

The German COVID-19 Hospitalization Nowcast Hub

- In Fall 2021 we launched `covid19nowcasthub.de`:
  - nowcasts for the **COVID-19 hospitalization incidence**.
  - **daily** updates from **eight nowcasting models.**



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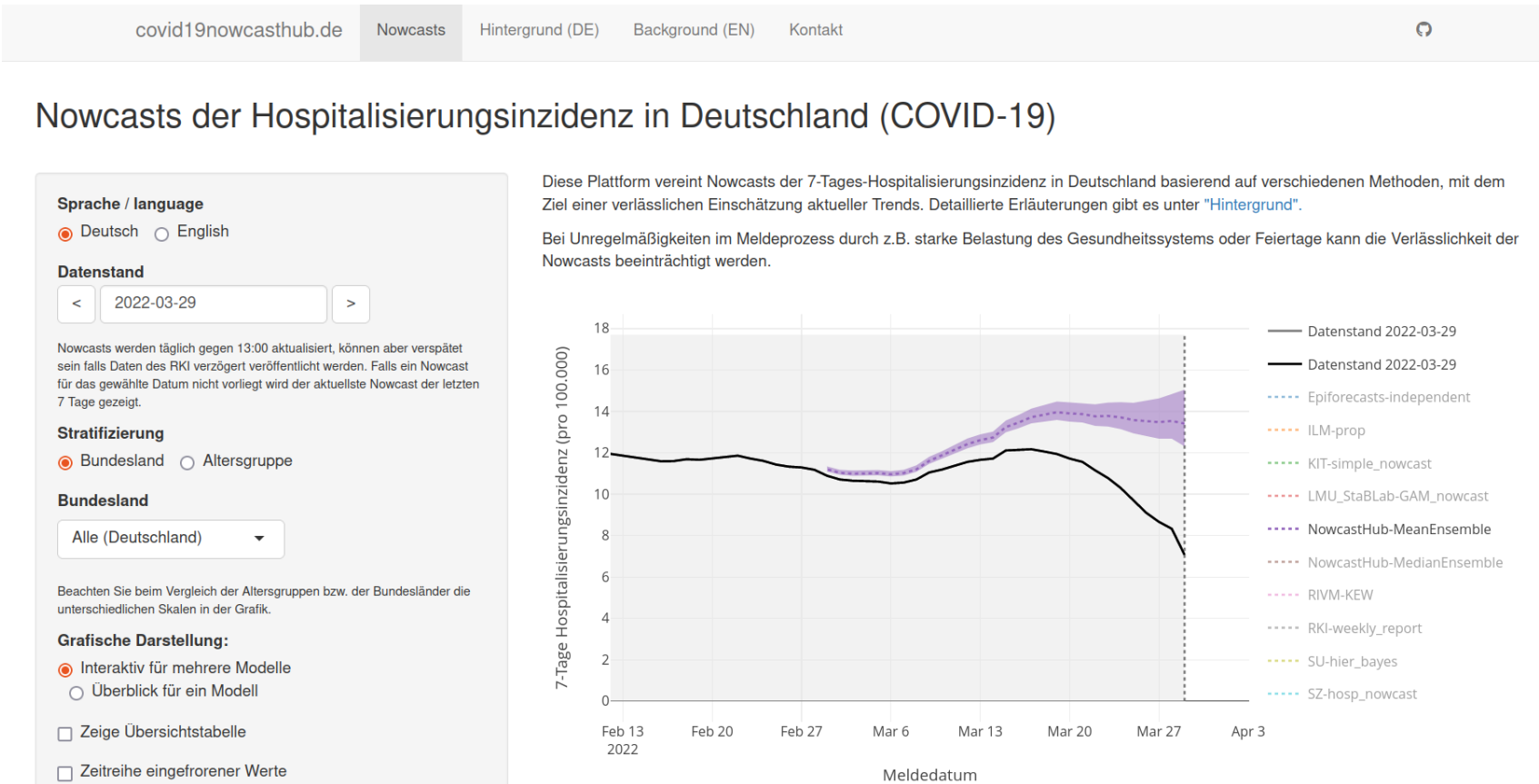

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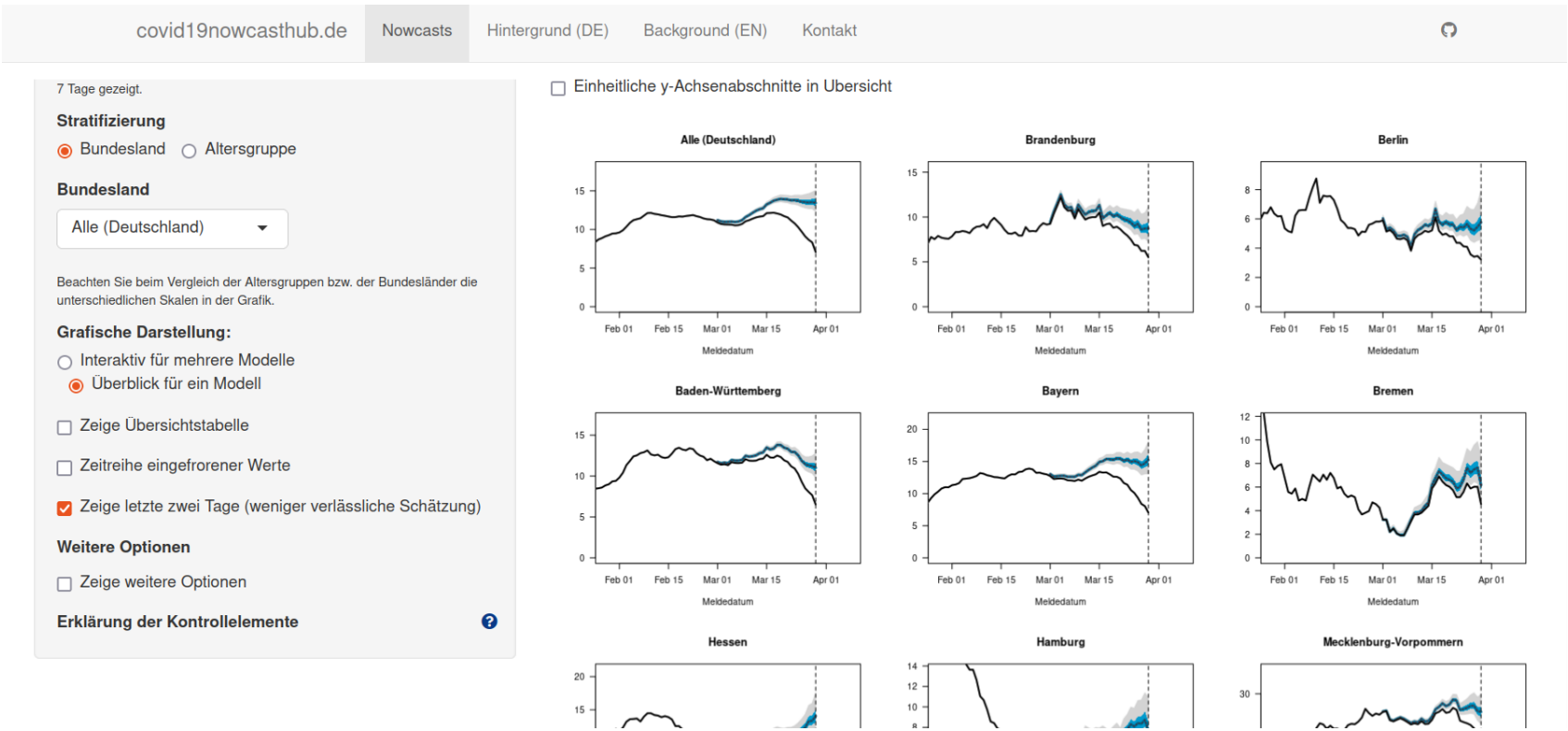
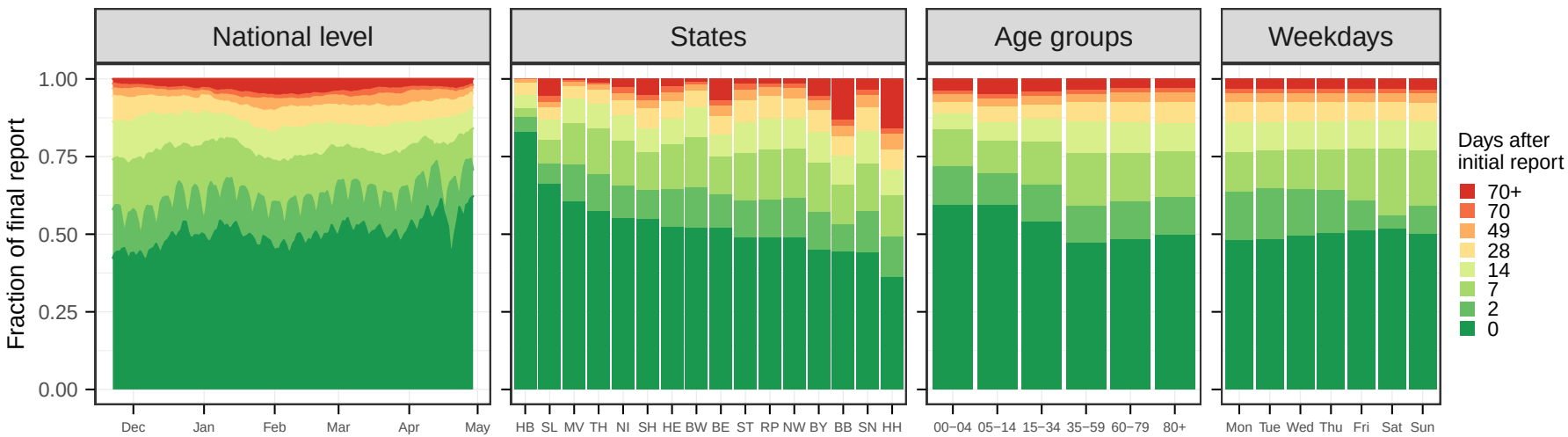


What is the 7-day hospitalization incidence?

- The number of persons (per 100.000) who
  - within a seven-day period have been tested positively for COVID-19 (*Meldedatum*).
  - and have been admitted to hospital (not necessarily during the same seven days).
- For a brief period this indicator was really important.
- **Due to delays, recent values are biased downwards.**

Initial completeness of 7-day hospitalization incidence



Approaches taken by different teams

Three main sources of information on unknown values:

- incomplete hospitalization numbers for same day
- incomplete hospitalization numbers from surrounding days
- case numbers

Strategies to extrapolate the reporting triangle:

- Multiplication factors (KIT, RKI, SZ) ●
- GAM regression (RIVM, LMU Munich) ● ●
- Bayesian hierarchical models (LSHTM, Stockholm U) ● ●
- Regression on case incidences (TU Ilmenau) ●
- Combined **ensemble** of the above.

Under the hood

- A "Forecast Hub" is essentially a GitHub repository.
- Forecasts are submitted as csv files in a standardized quantile format (via pull request).

main **hospitalization-nowcast-hub** / data-processed / KIT-simple_nowcast / **2022-03-29-KIT-simple_nowcast.csv**

dwolffram Update Baseline ✓ Latest comm

1 contributor

5337 lines (5337 sloc) | 472 KB

Search this file...

	location	age_group	forecast_date	target_end_date	target	type	quantile	value	pathogen
2	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	mean	NA	10642	COVID-19
3	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	quantile	0.025	8521	COVID-19
4	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	quantile	0.1	9131	COVID-19
5	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	quantile	0.25	9753	COVID-19
6	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	quantile	0.5	10534	COVID-19
7	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	quantile	0.75	11413	COVID-19
8	DE	00+	2022-03-29	2022-03-29	0 day ahead inc hosp	quantile	0.9	12292	COVID-19

Pre-registered evaluation study

- On 23 November 2021 we deposited a study protocol at the Open Science Foundation(`https://osf.io/mru75/`):

Comparison and combination of COVID-19 hospitalization nowcasts in Germany

Contributors: Johannes Bracher

Date created: 2021-11-23 05:38 PM | Last Updated: 2021-11-26 06:00 AM

Category: Project

Description: *Study protocol for a comparative evaluation study of different nowcasting methods applied to hospitalization incidences in Germany (Nov 2021 - Apr 2022).*

- Paper:

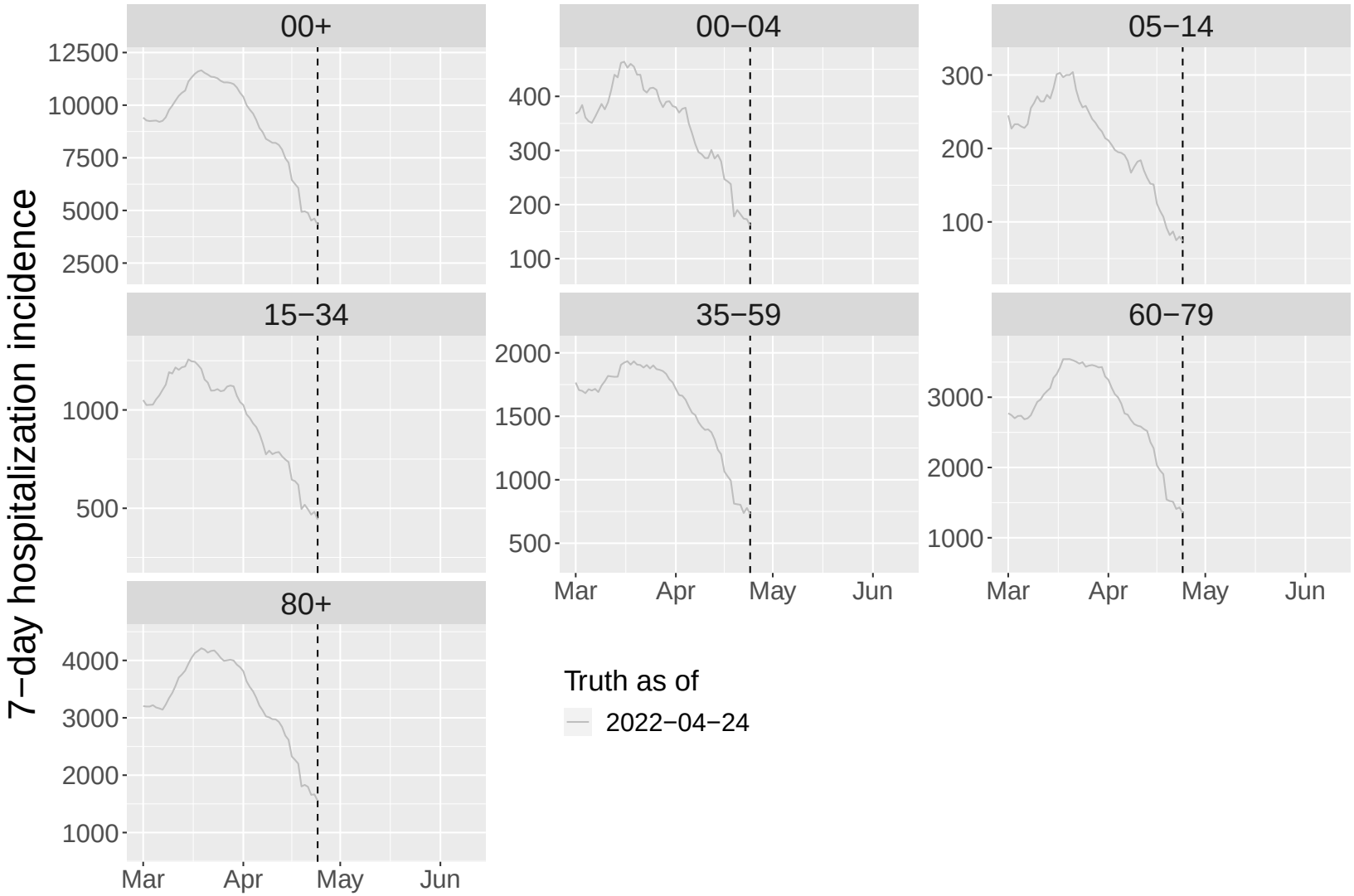
PLOS COMPUTATIONAL BIOLOGY

RESEARCH ARTICLE

Collaborative nowcasting of COVID-19 hospitalization incidences in Germany

Daniel Wolffram[1,2]*, Sam Abbott[3,4], Matthias an der Heiden[5], Sebastian Funk[3,4], Felix Günther[6], Davide Hailer[1], Stefan Heyder[7], Thomas Hotz[7], Jan van de Kassteele[8], Helmut Küchenhoff[9,10], Sören Müller-Hansen[11], Diellë Syliqi[9], Alexander Ullrich[5], Maximilian Weigert[9,10], Melanie Schienle[1,2], Johannes Bracher[1,2]

Learning 1: Nowcasts (from all models) mostly work well...



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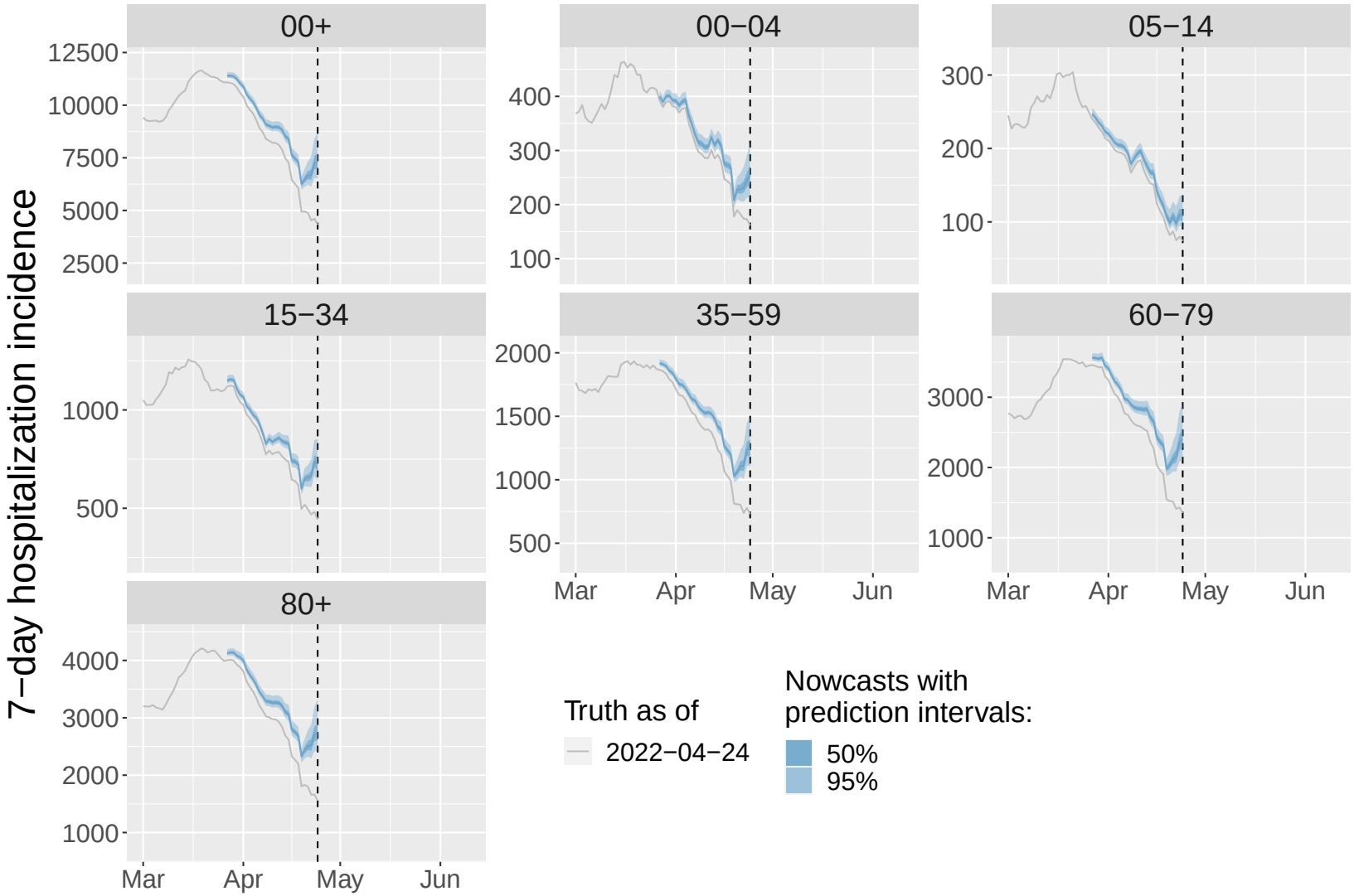

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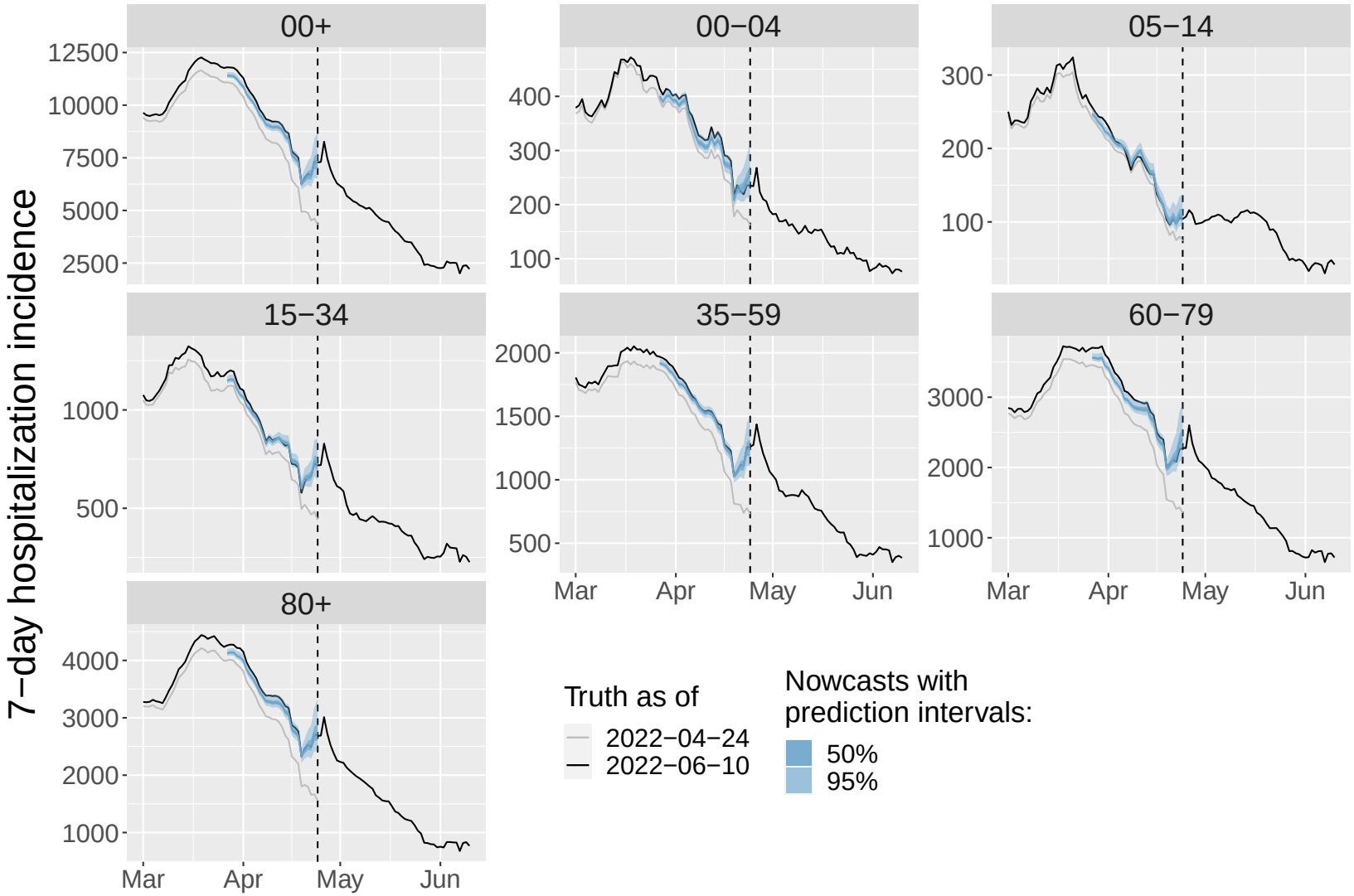
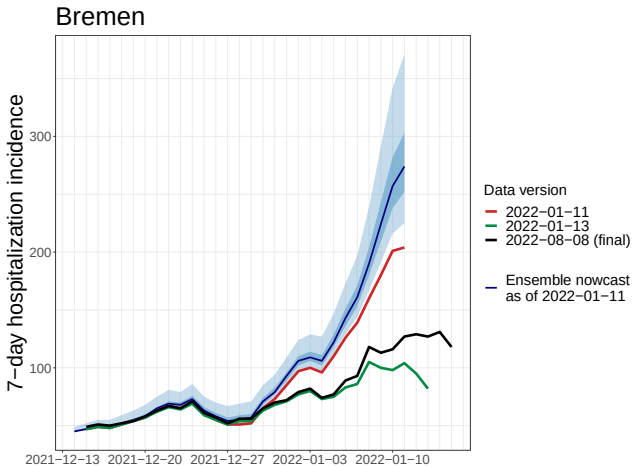
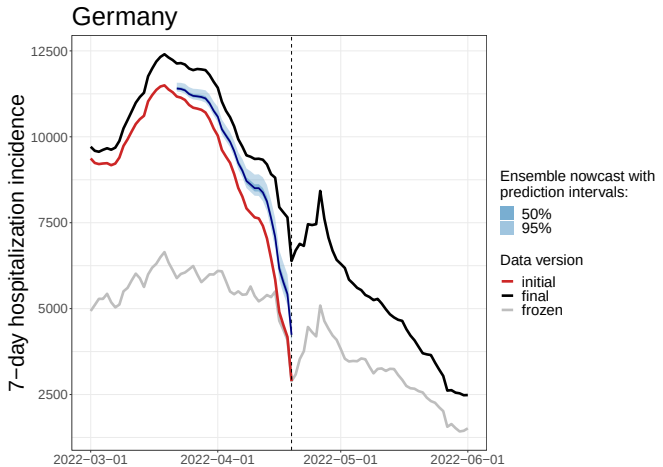
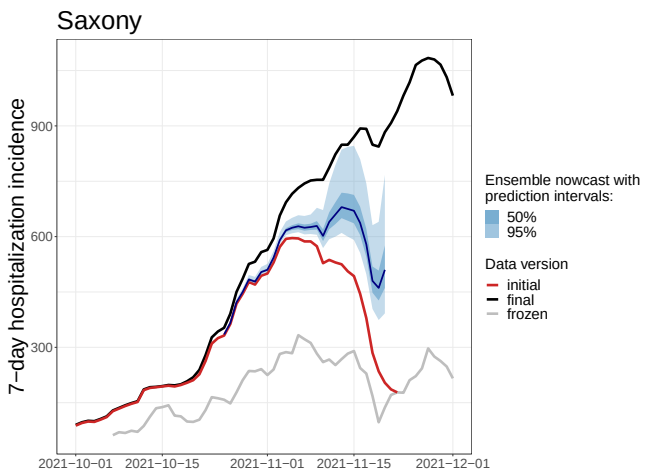


... except when they don't



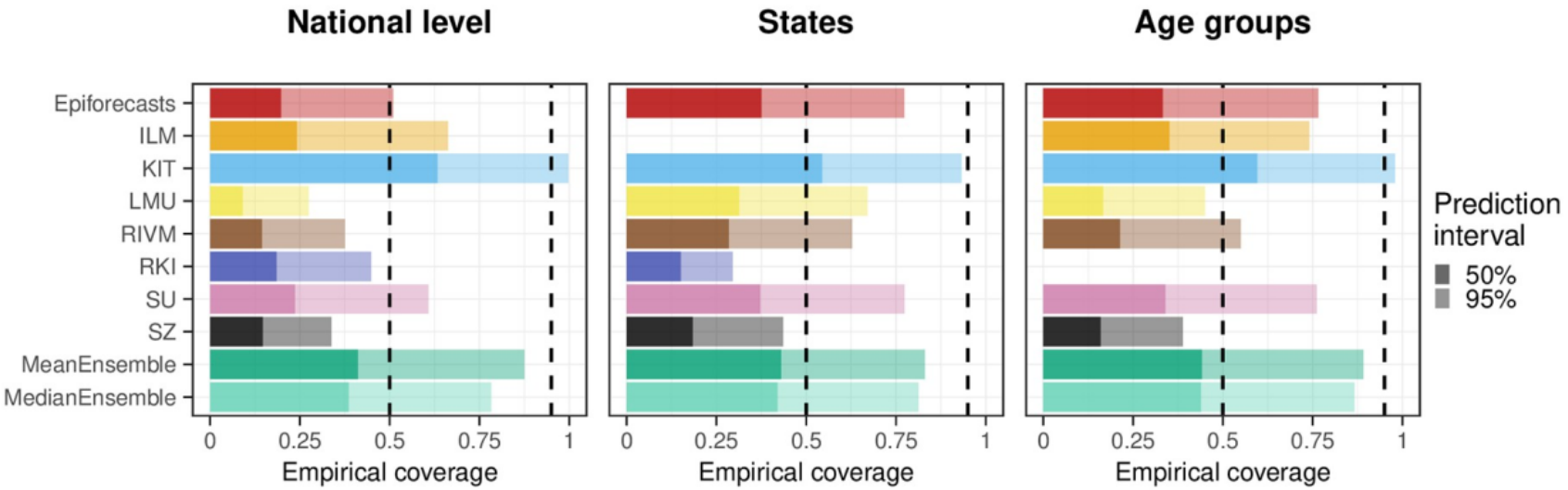




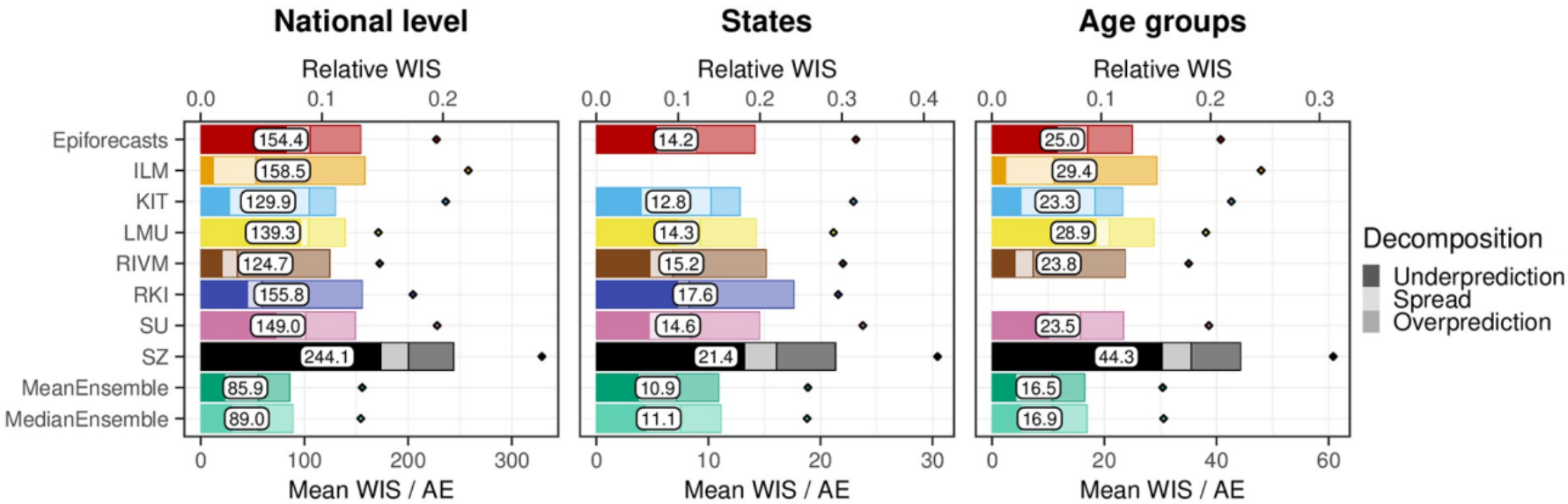
Things that throw models off

- Public holidays.
- Extreme strain on healthcare / reporting system.
- Occasional reporting hiccups.
- And sometimes there is no apparent reason.

Learning 2: Most models are overconfident

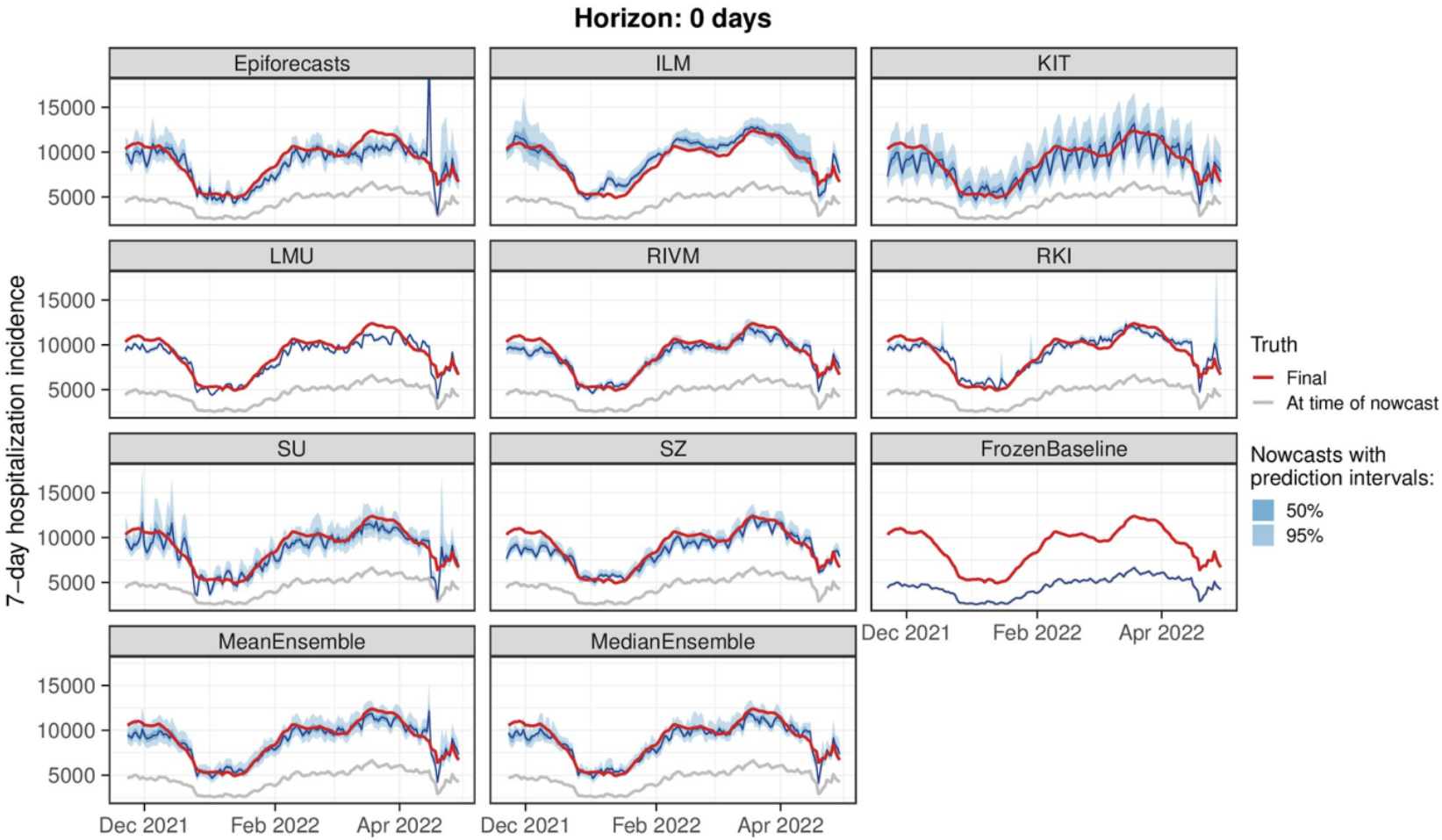


Learning 3: Ensembles work best



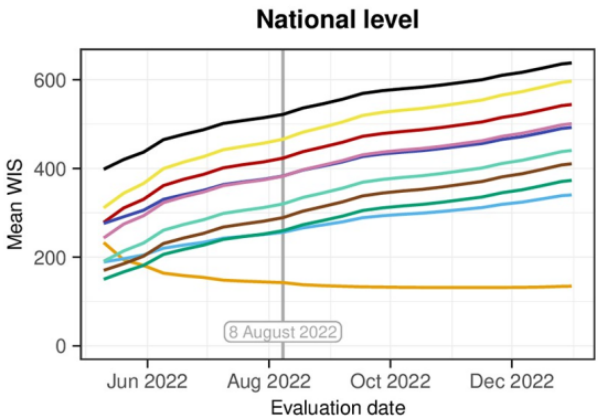
Learning 4: Weekday effects are tricky

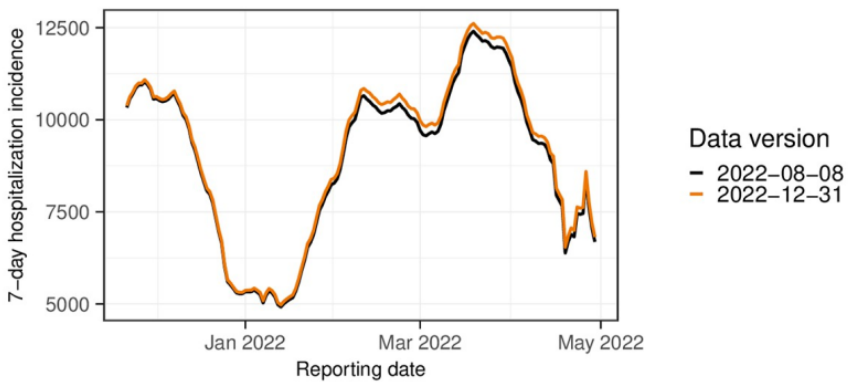
- The KIT nowcasts were biased on all days of the week apart from Wednesday.



Learning 5: We defined the target wrong

- Initially we had defined the target as "value reported 100 days after the last nowcast date (8 Aug 2022)".
- We should have used "values as after 40 days of corrections".





Follow-up work

- Using nowcasts from the Hub we studied two questions:
  - Can we apply **post-processing** to reduce over-confidence and improve individual-models nowcasts?
  - Can we improve ensemble nowcasts by **weighting members** in a data-driven manner?

Post-processing and weighted combination of infectious disease nowcasts

André Victor Ribeiro Amaral, Daniel Wolffram, Paula Moraga, Johannes Bracher

doi: https://doi.org/10.1101/2024.08.28.24312701

(accepted at PLOS Comp Bio)

Follow-up work

- Using nowcasts from the Hub we studied two questions:
  - Can we apply **post-processing** to reduce over-confidence and improve individual-models nowcasts? Yes.
  - Can we improve ensemble nowcasts by **weighting members** in a data-driven manner? No.
    But we can reduce the number of member models quite a bit.

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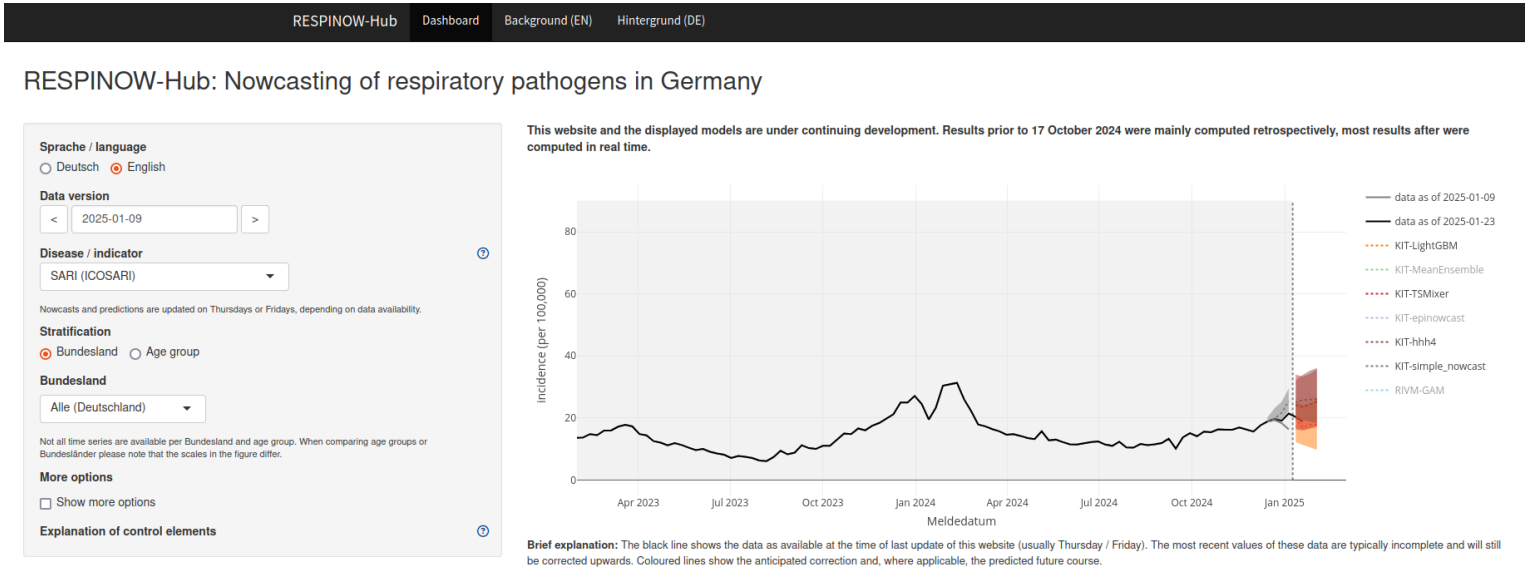
Outlook: The RespiNow Hub

- With colleagues from RKI and HZI Braunschweig we have built the *RespiNow Hub* (`respinowhub.de`).
- Goals:
  - consolidate procedures and adapt to seasonal setting.
  - small, sustainable set of models for various indicators.
  - **combine nowcasting and short-term forecasting.**



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- The presented work is based on joint work with many collaborators.
- At KIT: Daniel Wolffram, André Ribeiro Amaral, Melanie Schienle and others.



- Nowcasting teams:
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  - **Süddeutsche Zeitung** (Sören Müller-Hansen)
  - **LMU Munich** (Helmut Küchenhoff, Maximilian Weigert, Diellë Syliqi)
  - **RIVM** (Jan van de Kassteele)
  - **Stockholm University** (Felix Günther)
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