Nowcasting COVID-19 hospitalization incidences in Germany

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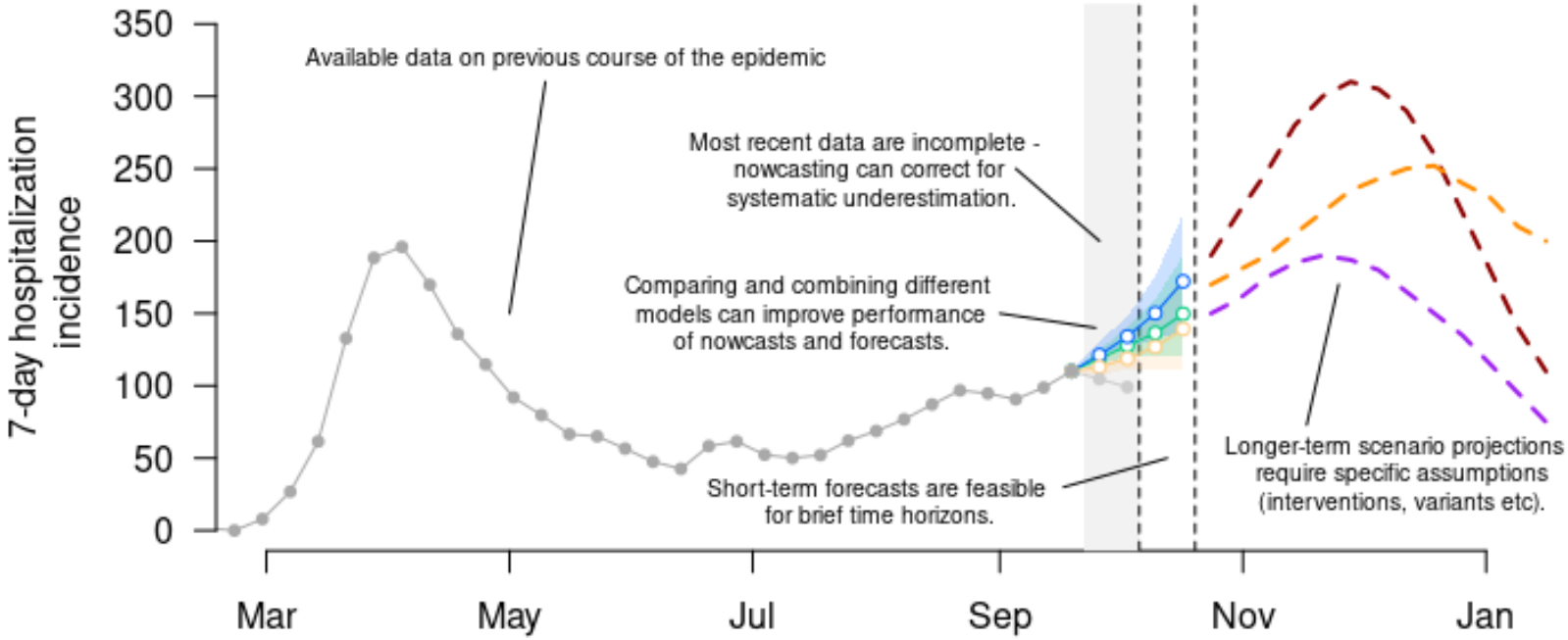
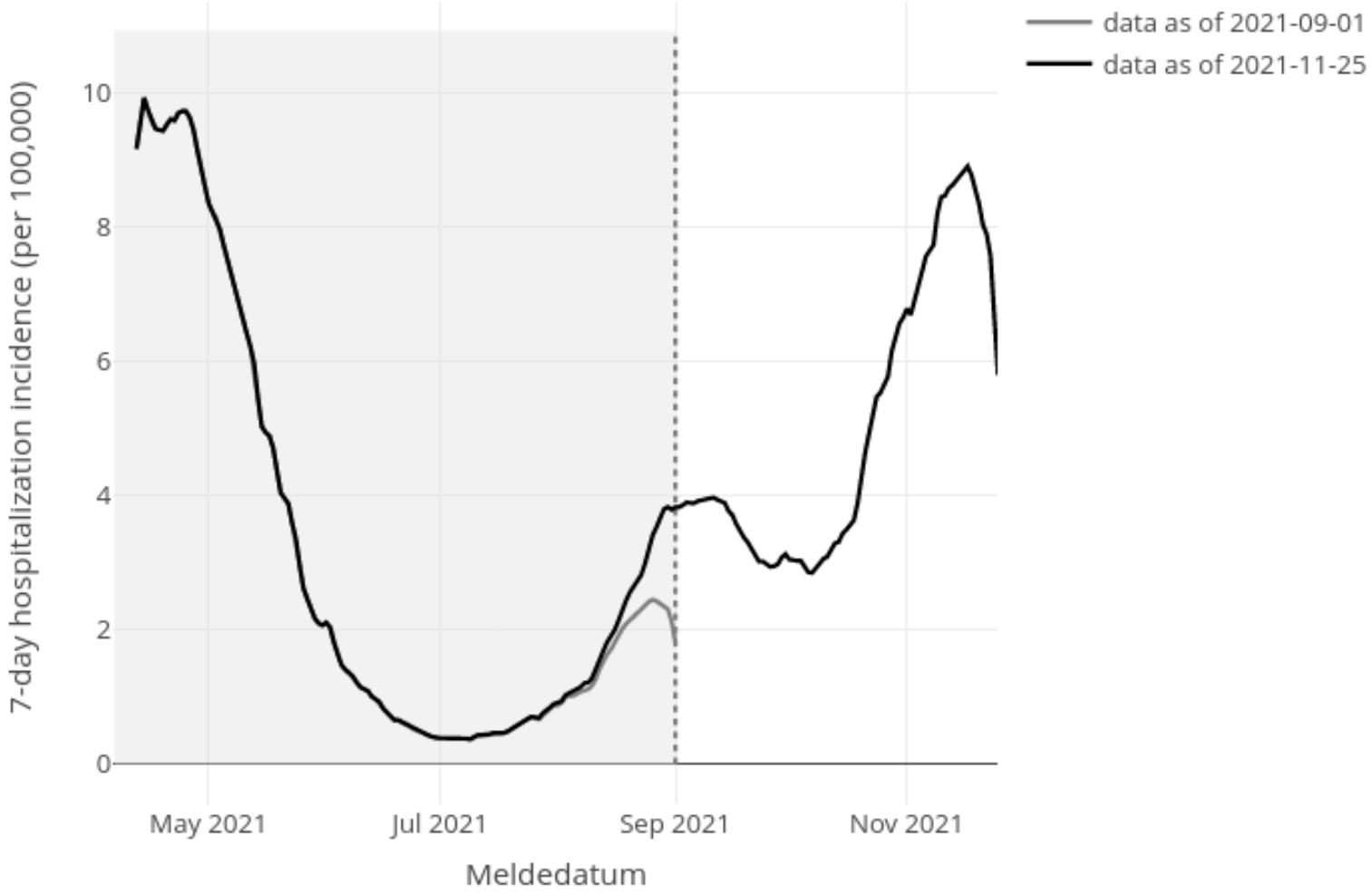
December 8, 2021

Nowcasting, Forecasting and scenario projections



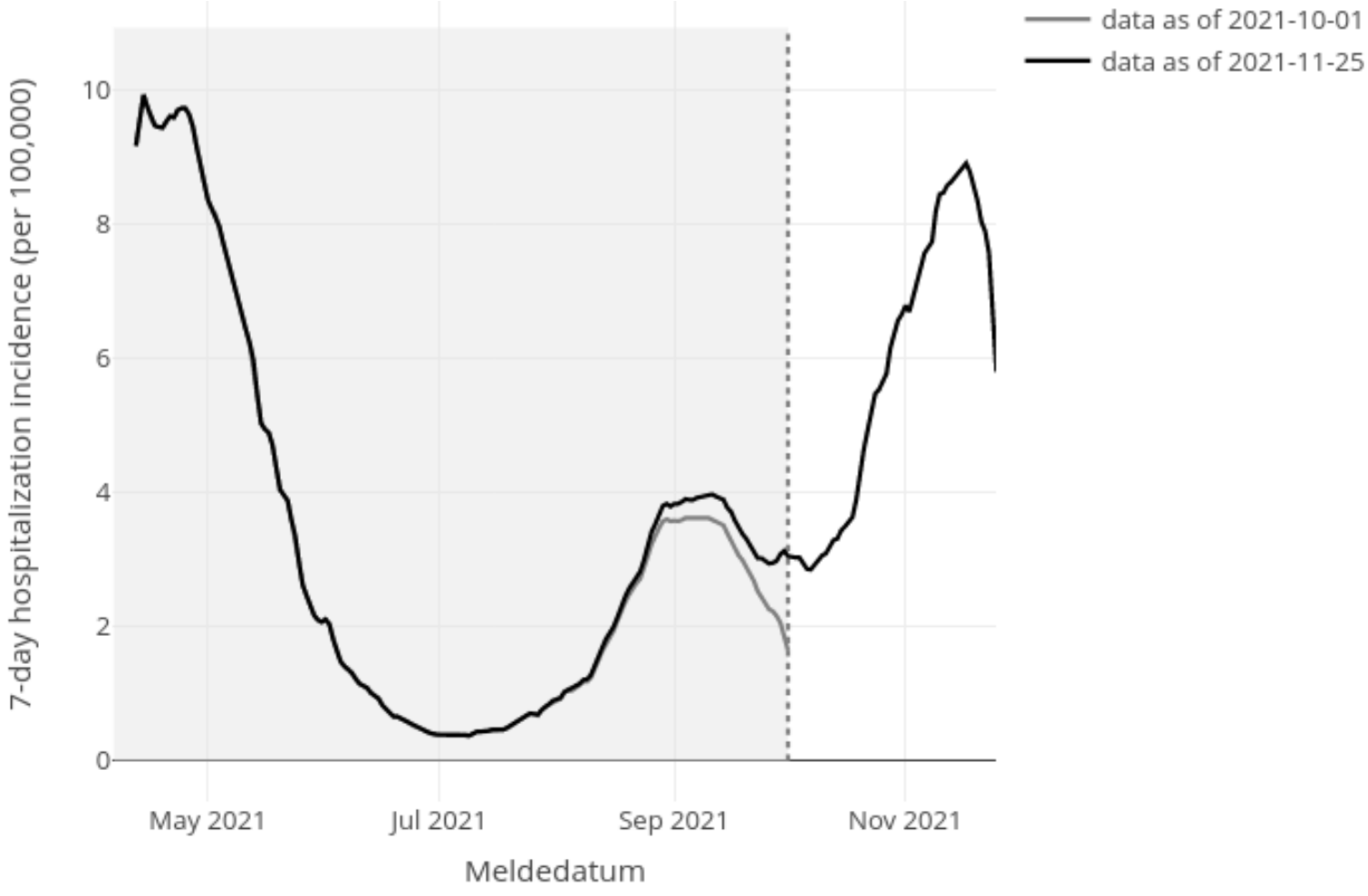
Seven-day hospitalization incidences in Germany

Data from 1 September



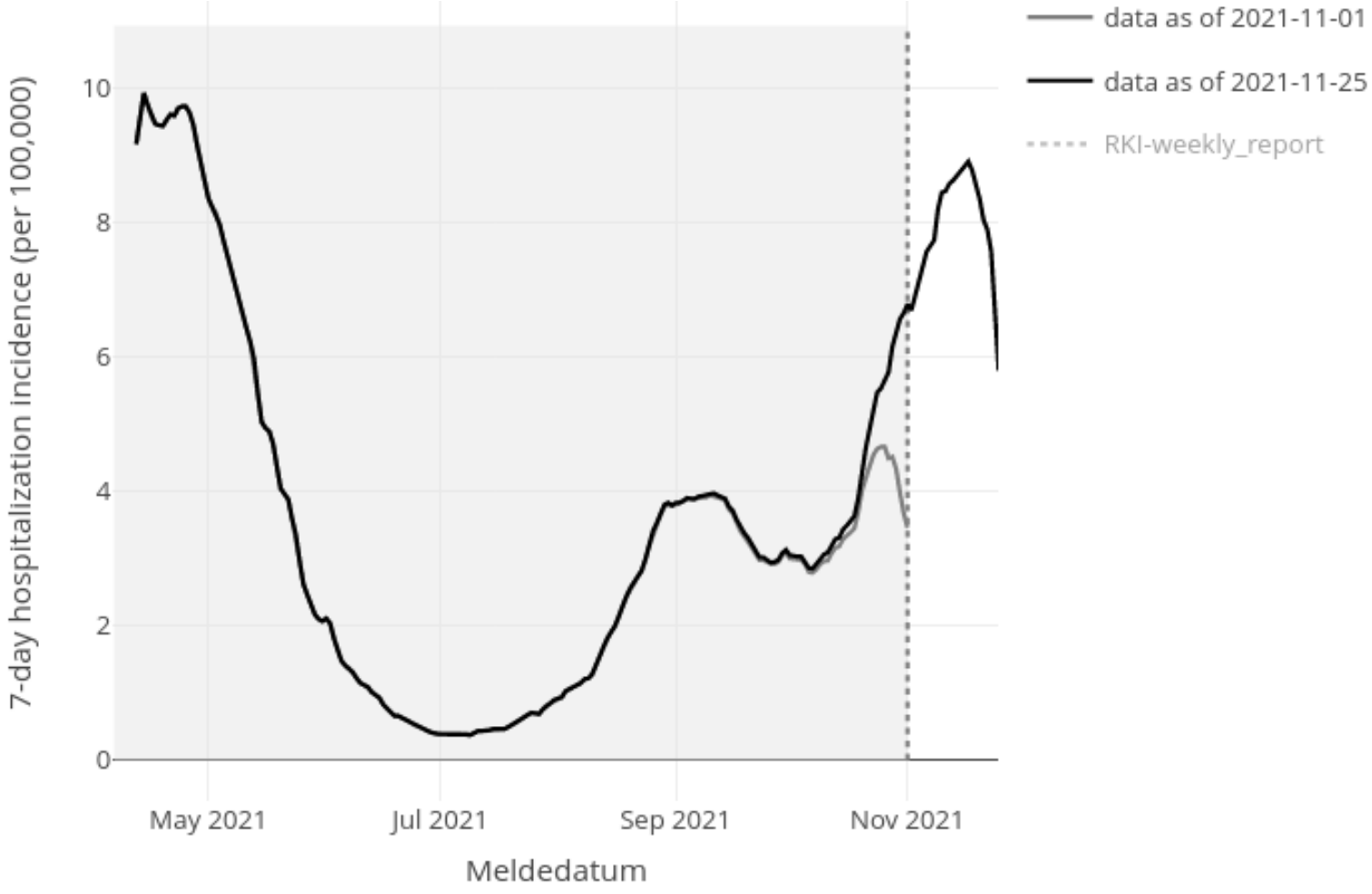
Seven-day hospitalization incidences in Germany

Data from 1 October



Seven-day hospitalization incidences in Germany

Data from 1 November



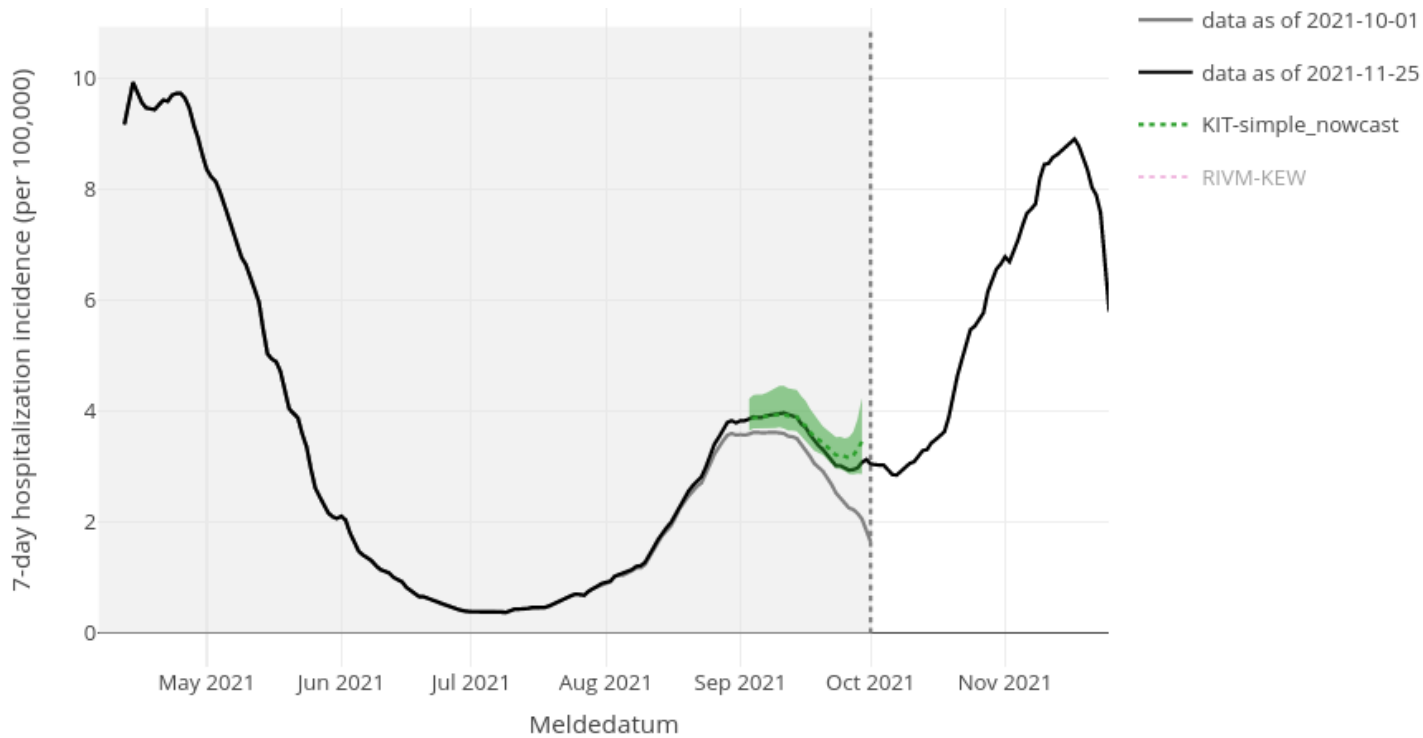
Definition of the 7-day hopsitalization incidence

(This definition is specific to Germany)

- **Legal definition:** The number of persons, who over a seven-day period
  - have been registered electronically as a COVID-19 case by a local health authority (*Meldedatum*)
  - and have been hospitalized (not necessarily during the seven-day period)
- This is *not* the number of new hospitalizations over the last seven days
- **Most recent values are biased downwards due to two types of delays:**
  - delay between *Meldedatum* ($\approx$ positive test) and hospitalization
  - delay between hospitalization and appearance in RKI data

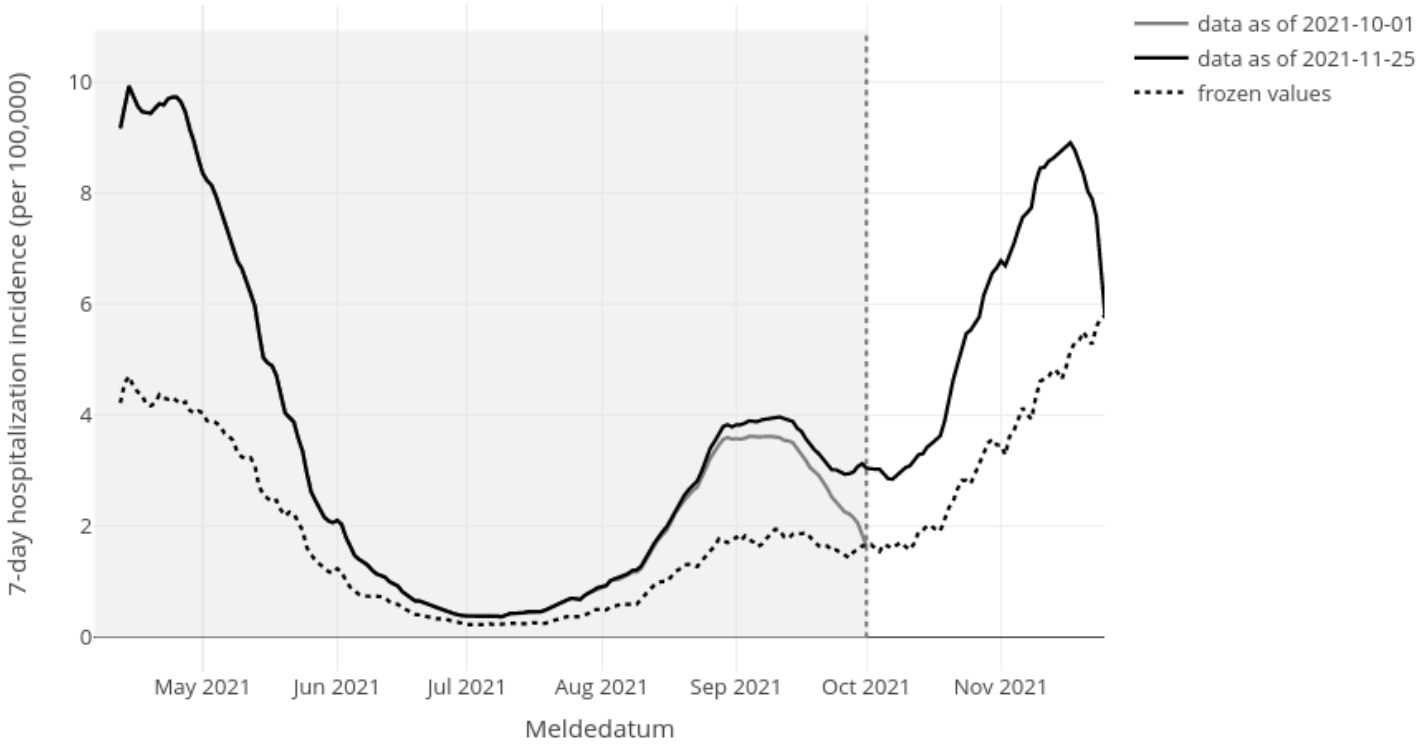
General nowcasting setting

- Many epidemiological indicators are subject to delays (unless aggregated by time of reporting)
- **Nowcasting** aims at estimating the total number of events based on preliminary data



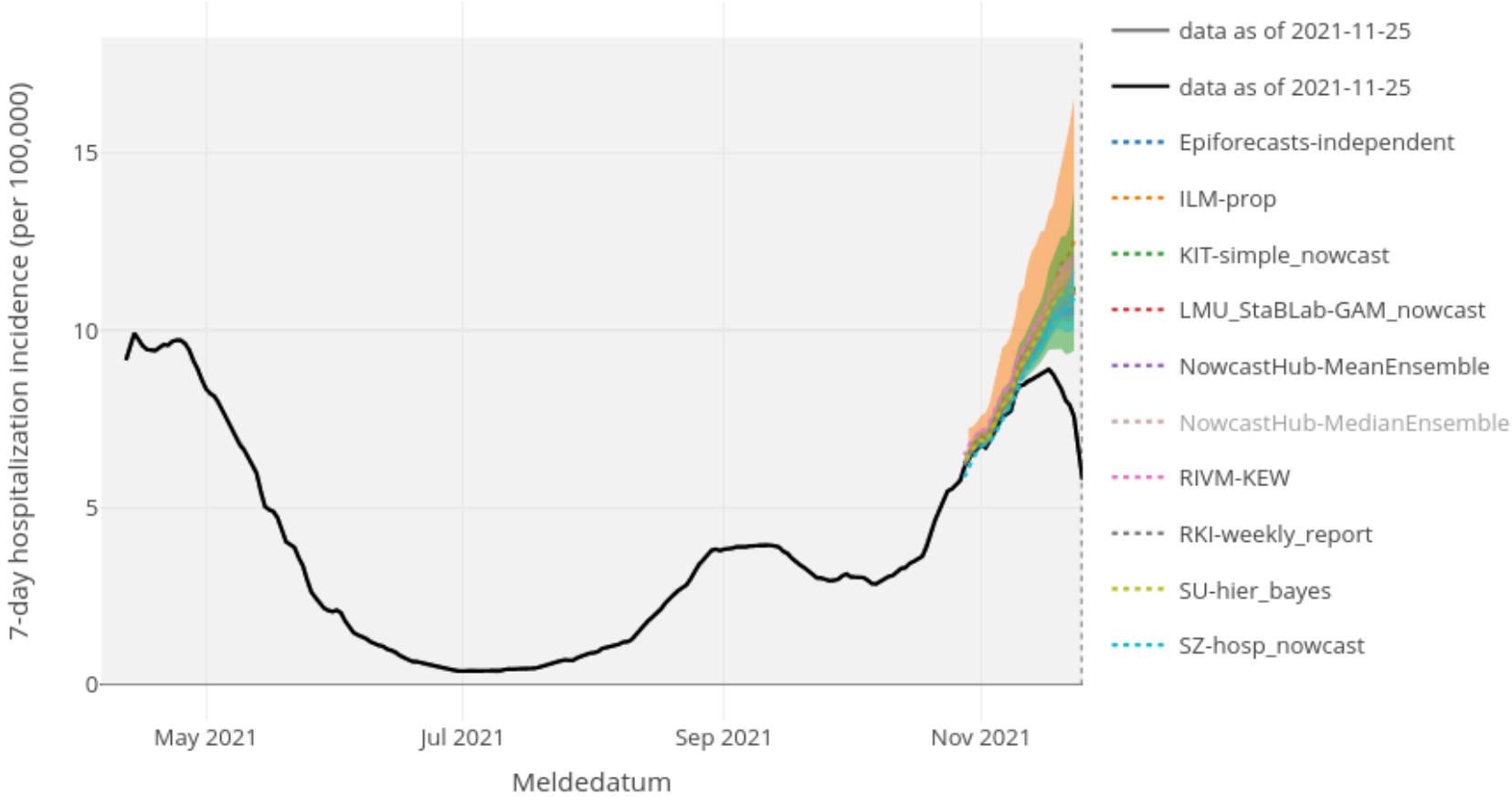
Alternative solution: re-define indicator

- E.g., all threshold systems in Germany refer to "frozen values": for each date use value as of that date
- All values "similarly incomplete" $\rightarrow$ trends interpretable
- Upside: no statistical processing
- Downside: reporting speed varies across federal states



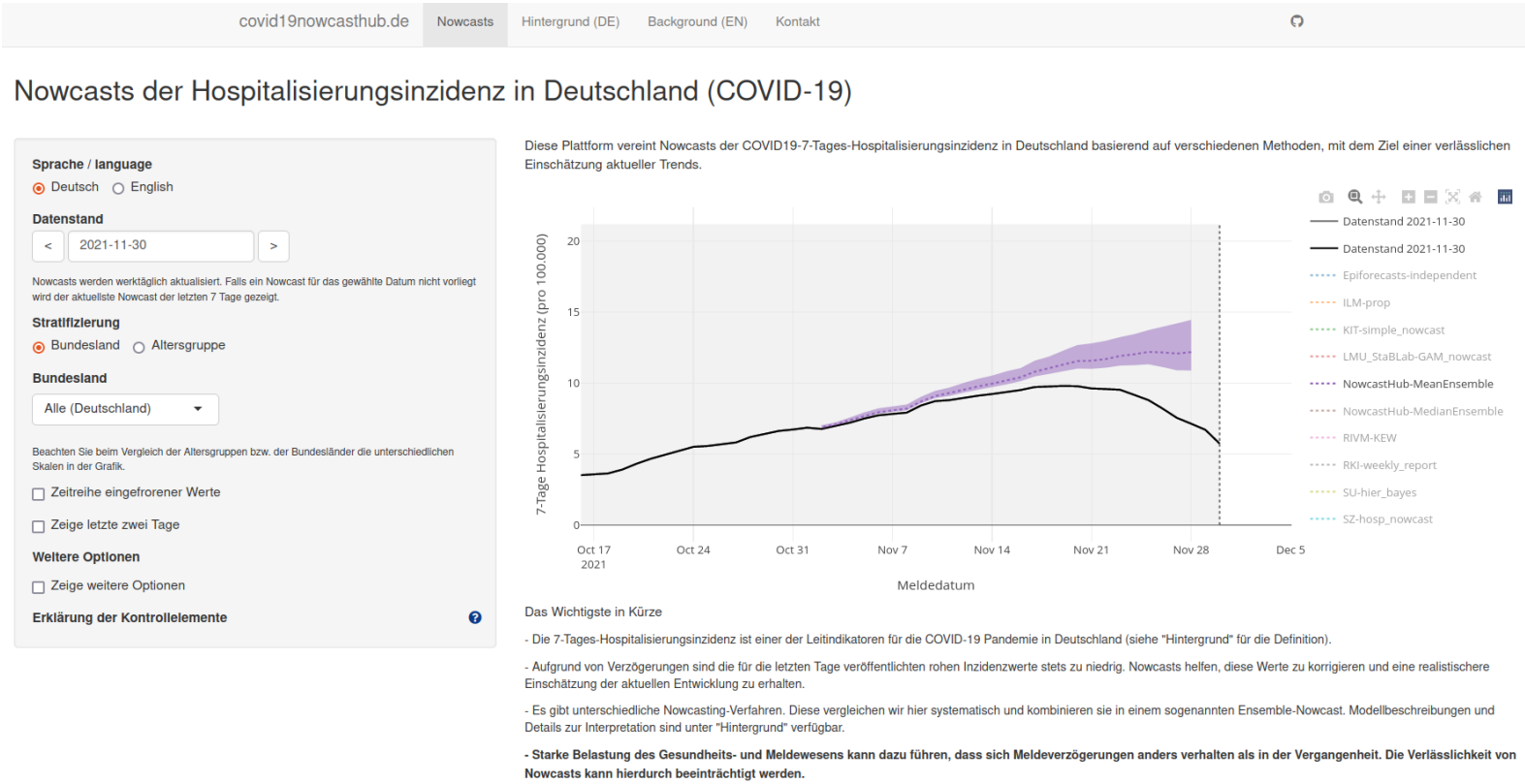
Multi-model approach

- Showing several models gives a better idea of the uncertainty
- Combining models can (hopefully) improve nowcasts
- Allows us to identify particularly reliable models



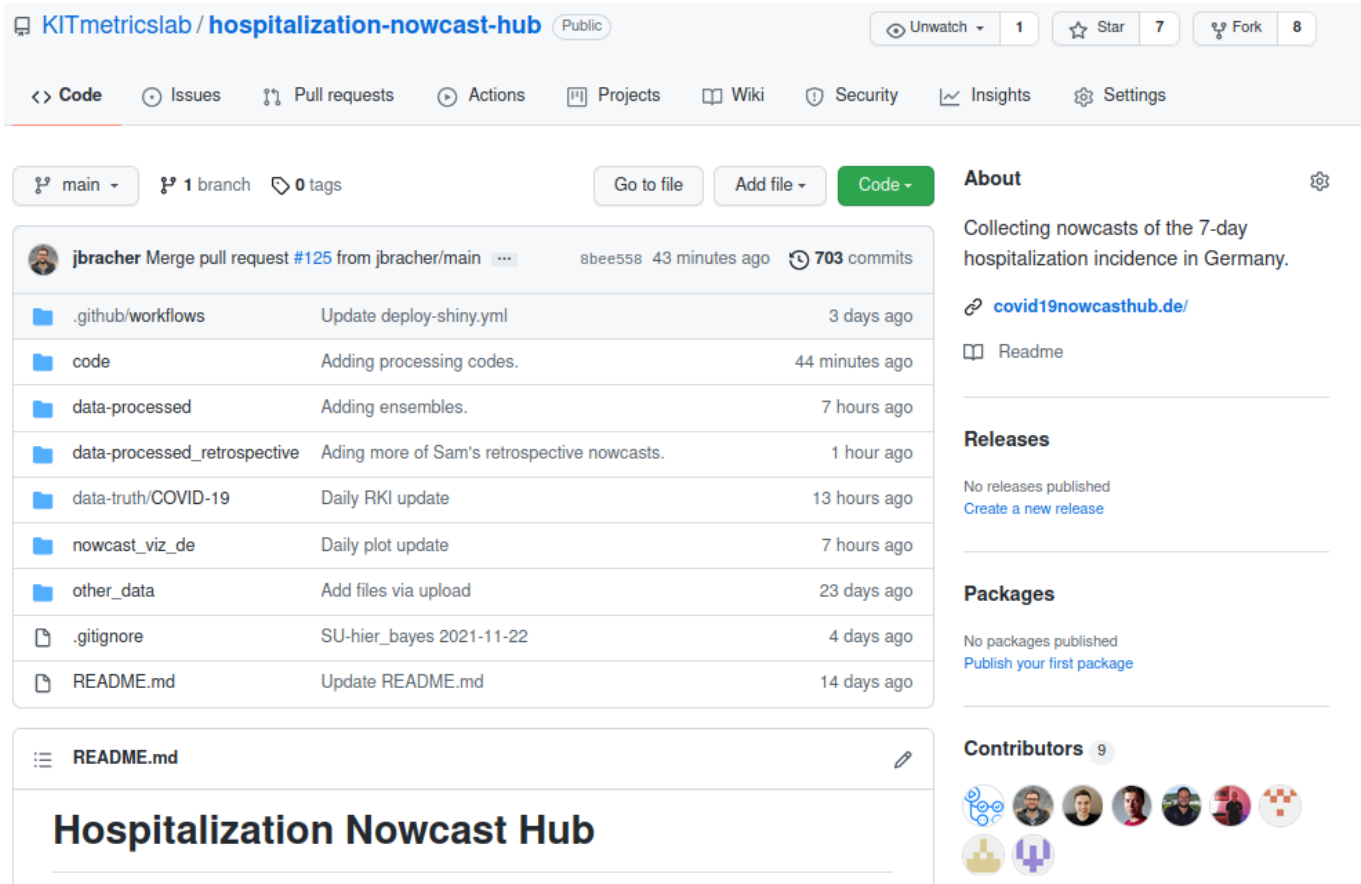
Interactive online platform

- Since mid-November available at `https://covid19nowcasthub.de/`
- Contains nowcasts for current day and 28 days back
- stratified by federal state and age group



Public GitHub repository

- `https://github.com/KITmetricslab/hospitalization-nowcast-hub`
- Pretty much the same as the Forecast Hubs



Included models

We collect outputs from models run by the following teams:

- University of Stockholm, SE
- TU Ilmenau, DE
- Süddeutsche Zeitung, DE
- RIVM, Bilthoven, NL
- Robert Koch Institute, DE
- LSHTM, UK
- LMU Munich, DE
- KIT Karlsruhe, DE

Corrected estimates by RKI

- Since 1 Dec RKI has published daily nowcasts and incl state-level nowcasts

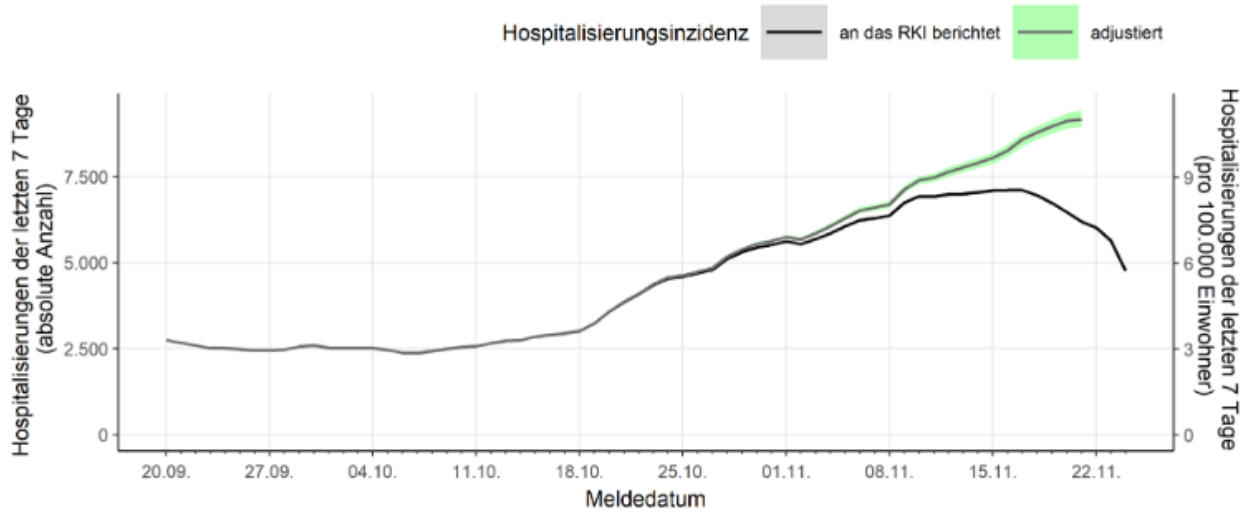


Abbildung 10: Berichtete 7-Tage-Hospitalisierungsinzidenz (schwarze Linie) und Schätzung der adjustierten Hospitalisierungsinzidenz unter Berücksichtigung von verzögert berichteten Hospitalisierungen (dunkelgraue Linie mit grün ausgewiesenem Schätzbereich). Die Skalen geben die jeweilige absolute Anzahl (y-Achse, links) und den Anteil pro 100.000 Einwohner (y-Achse, rechts) an.

- Thanks a lot to folks at RKI for guidance and publicly providing suitable data.

The reporting triangle

Example with maximum reporting delay of 5 days:

day	$d=0$	$d=1$	$d=2$	$d=3$	$d=4$	$d=5$	total
1	$x_{1,0}$	$x_{1,1}$	$x_{1,2}$	$x_{1,3}$	$x_{1,4}$	$x_{1,5}$	x_1
2	$x_{2,0}$	$x_{2,1}$	$x_{2,2}$	$x_{2,3}$	$x_{2,4}$	$x_{2,5}$	x_2
$\vdots$							
t^*-5	$x_{t^*-5,0}$	$x_{t^*-5,1}$	$x_{t^*-5,2}$	$x_{t^*-5,3}$	$x_{t^*-5,4}$	$x_{t^*-5,5}$	x_{t^*-5}
t^*-4	$x_{t^*-4,0}$	$x_{t^*-4,1}$	$x_{t^*-4,2}$	$x_{t^*-4,3}$	$x_{t^*-4,4}$	$x_{t^*-4,4}$	x_{t^*-4}
t^*-3	$x_{t^*-3,0}$	$x_{t^*-3,1}$	$x_{t^*-3,2}$	$x_{t^*-3,3}$	$x_{t^*-3,4}$	$x_{t^*-3,5}$	x_{t^*-3}
t^*-2	$x_{t^*-2,0}$	$x_{t^*-2,1}$	$x_{t^*-2,2}$	$x_{t^*-2,3}$	$x_{t^*-2,4}$	$x_{t^*-2,5}$	x_{t^*-2}
t^*-1	$x_{t^*-1,0}$	$x_{t^*-1,1}$	$x_{t^*-1,2}$	$x_{t^*-1,3}$	$x_{t^*-1,4}$	$x_{t^*-1,5}$	x_{t^*-1}
t^*	$x_{t^*,0}$	$x_{t^*,1}$	$x_{t^*,2}$	$x_{t^*,3}$	$x_{t^*,4}$	$x_{t^*,5}$	x_{t^*}

On day t^*, the black cells are known, the blue cells need to be estimated.

Approaches taken by different teams

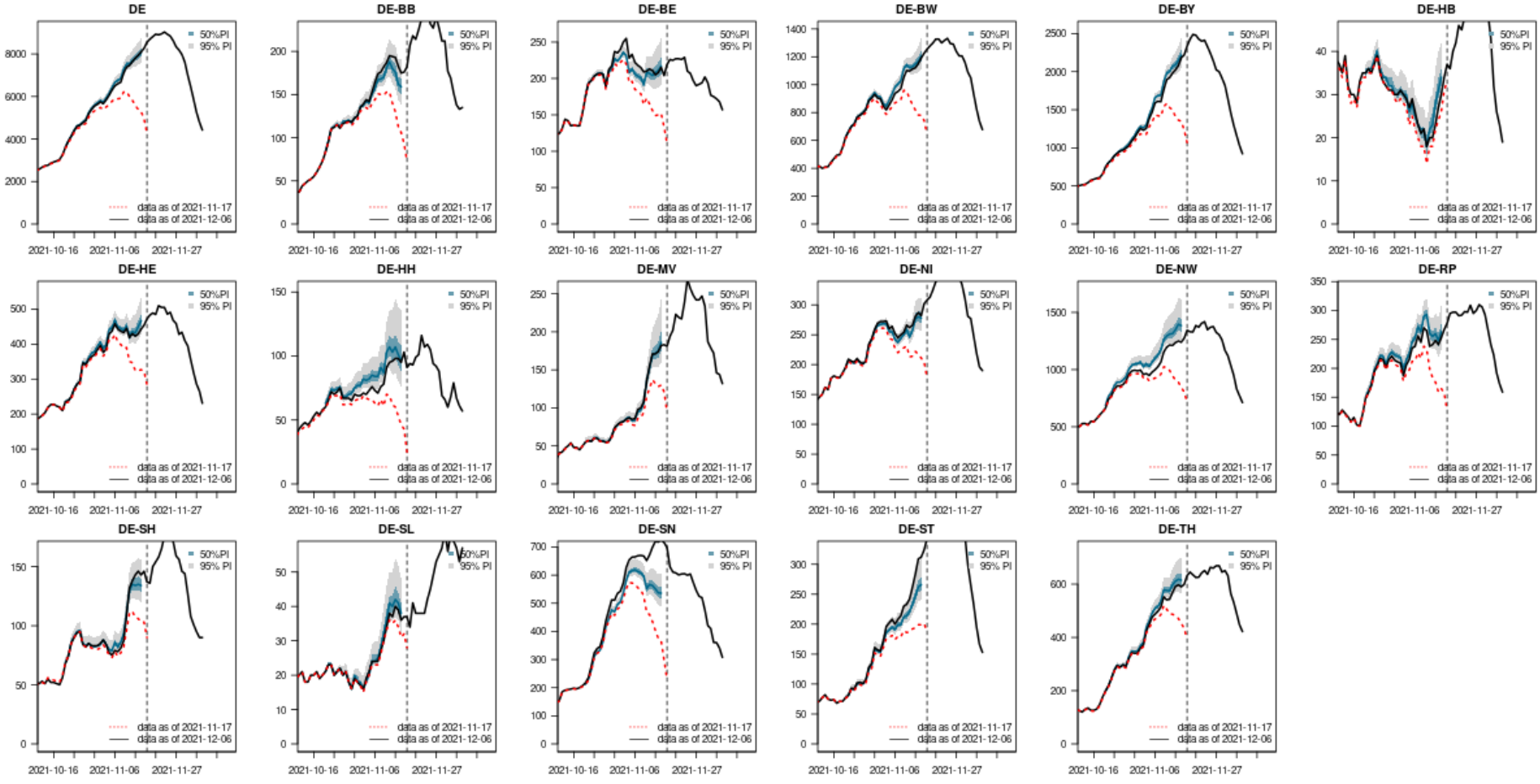
Three main sources of information on unknown values:

- partial observations for same day
- (partial) observations from surrounding days
- number of cases in preceding days/weeks

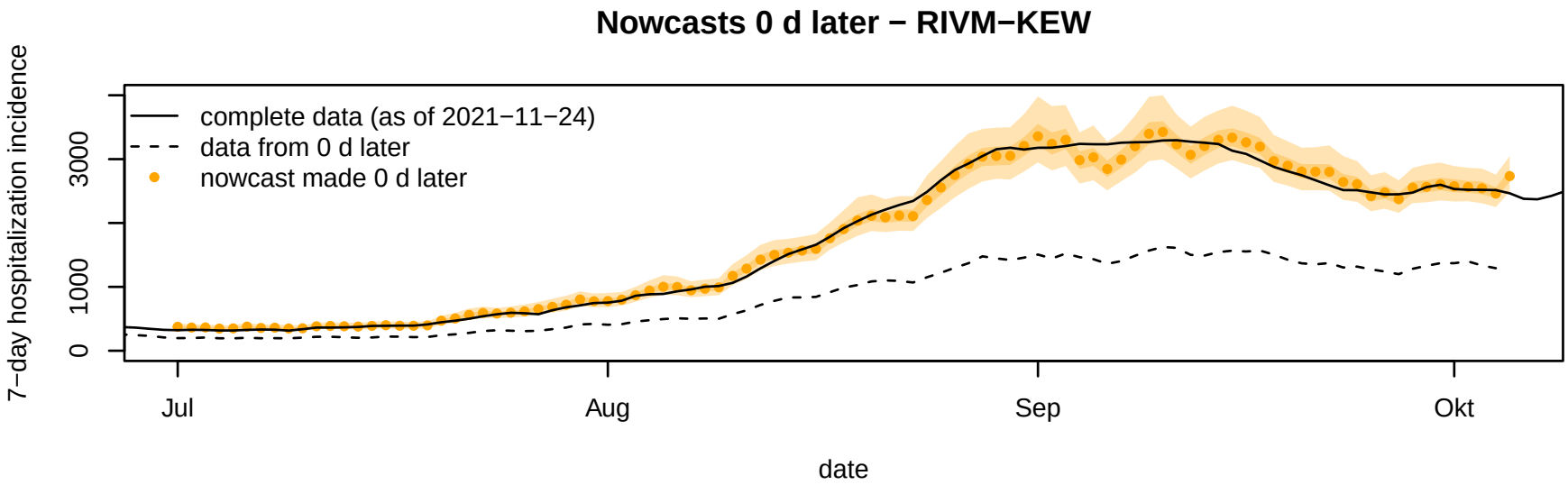
Strategies to extrapolate the reporting triange:

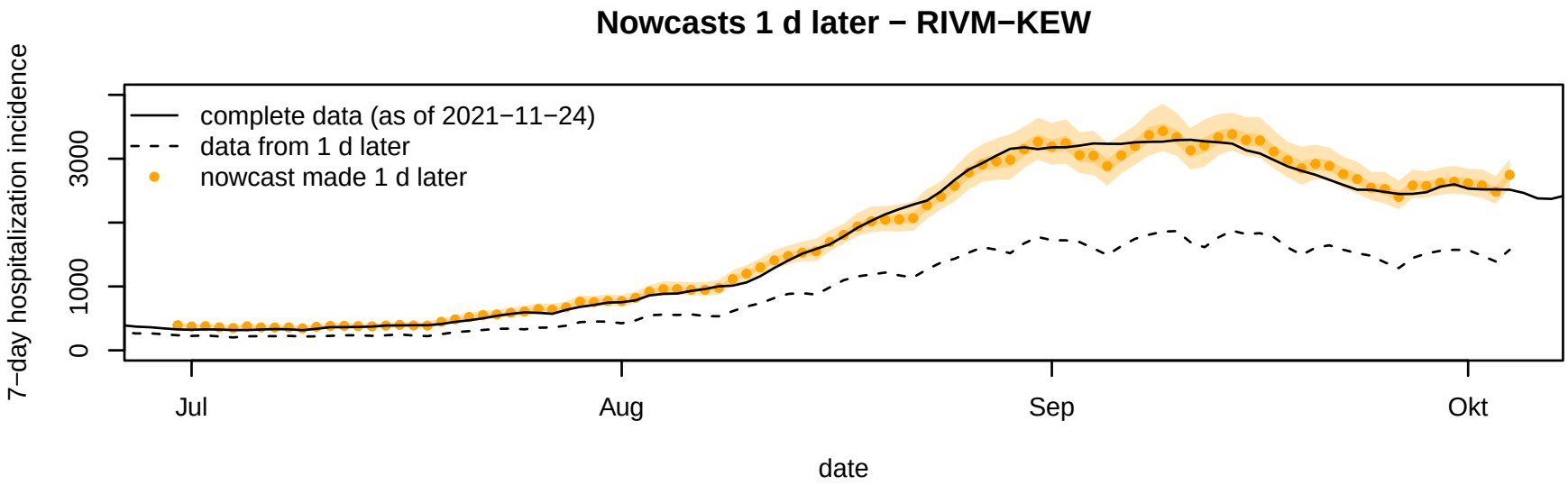
- Multiplication factors (KIT; the *reference model*, RKI, SZ) ●
- Regression with splines for time trends (RIVM, LMU) ● ●
- Random walk / autoregressive approaches with parametric reporting delays (LSHTM, SU) ● ●
- Regression on case incidences (TU Ilmenau) ●

First ensemble nowcast (17 Nov)



Visually assessing retrospective nowcasts





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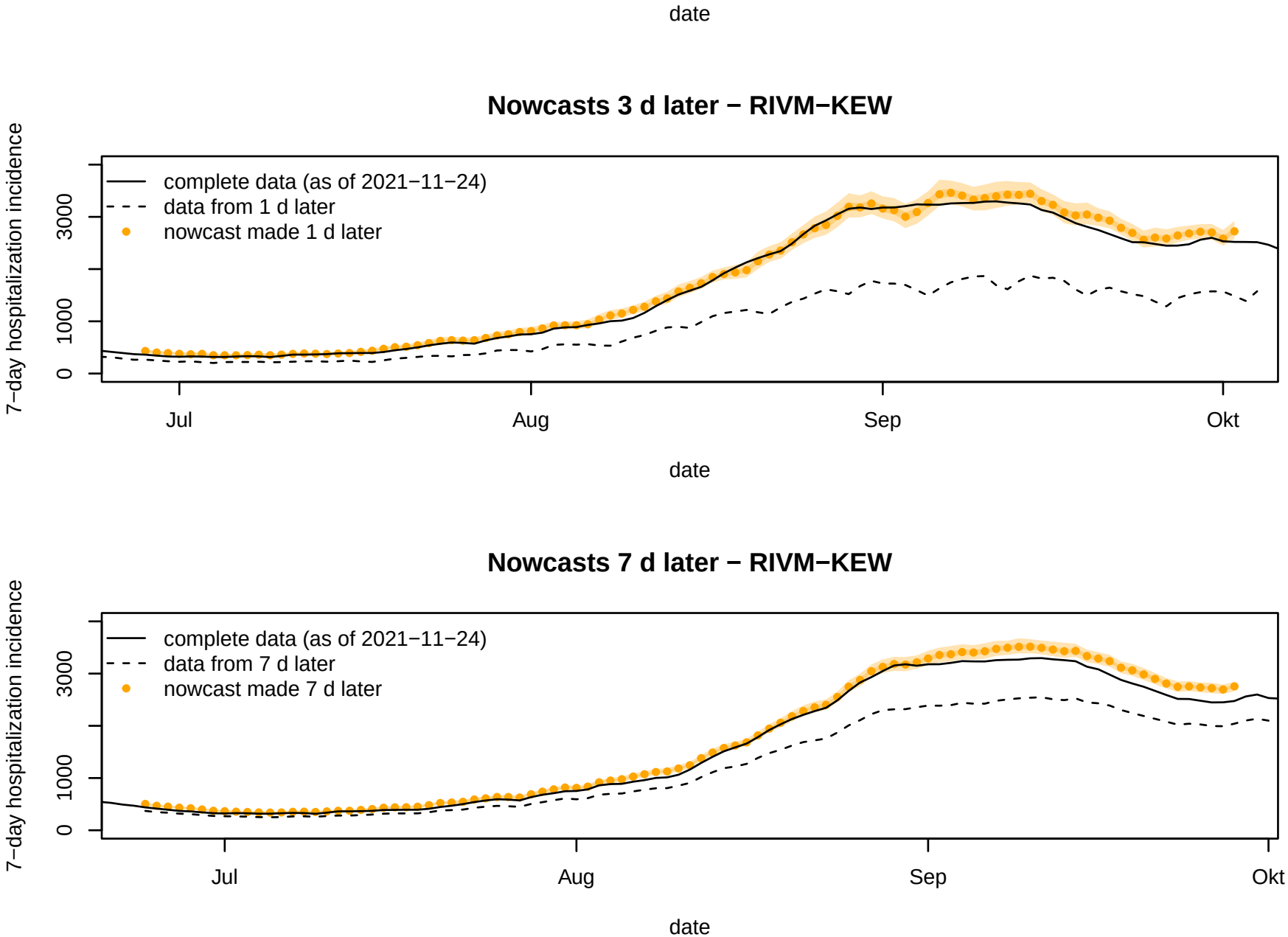

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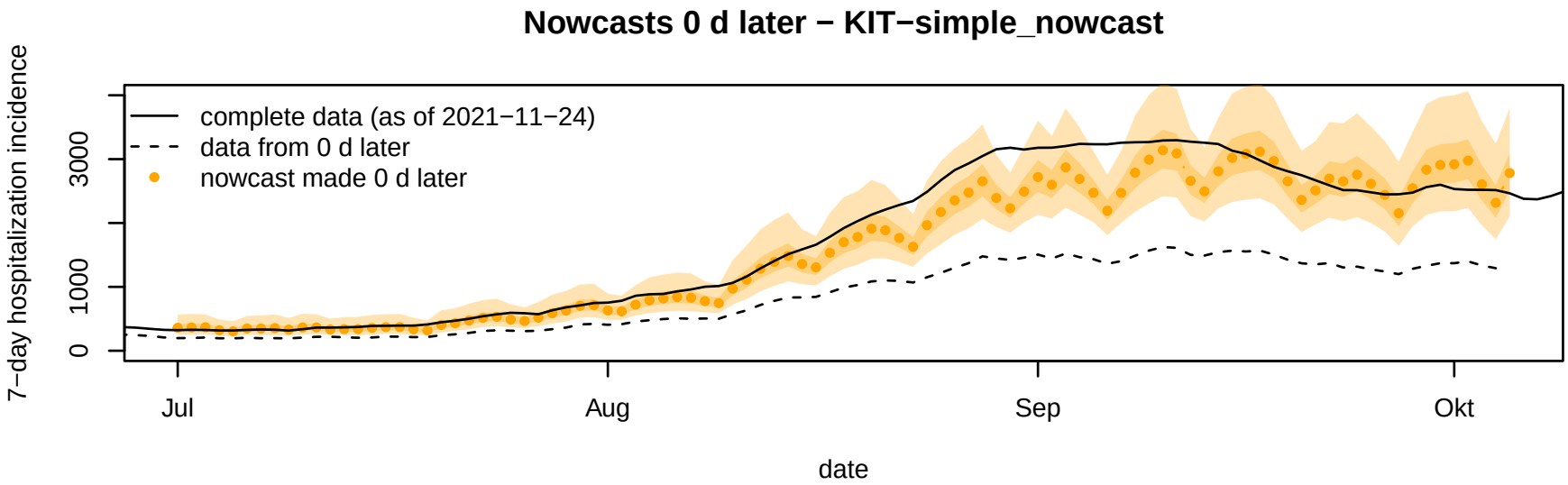

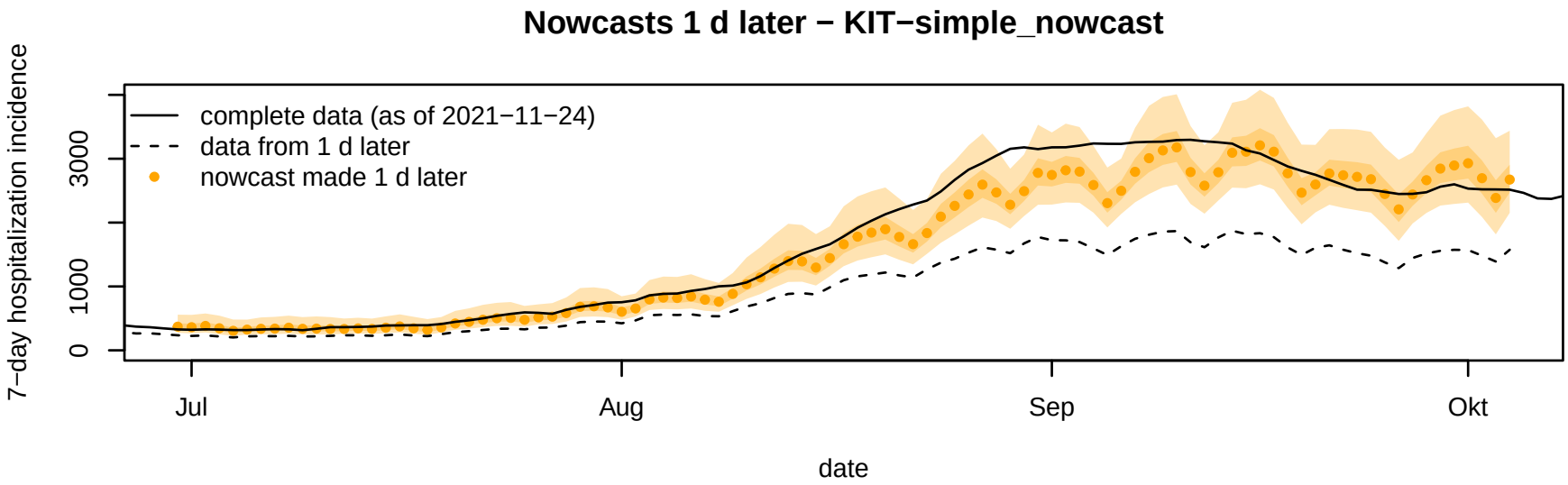

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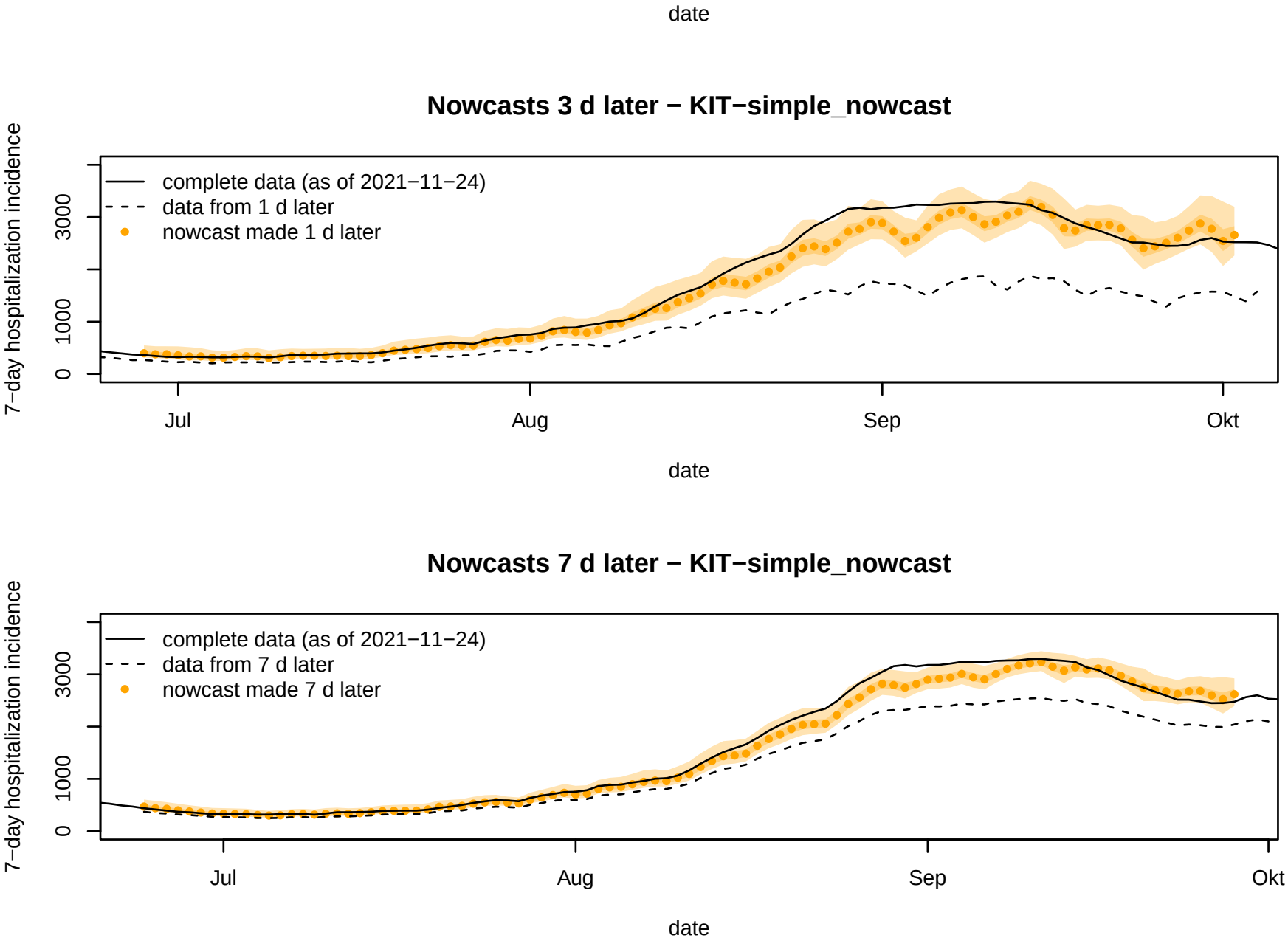
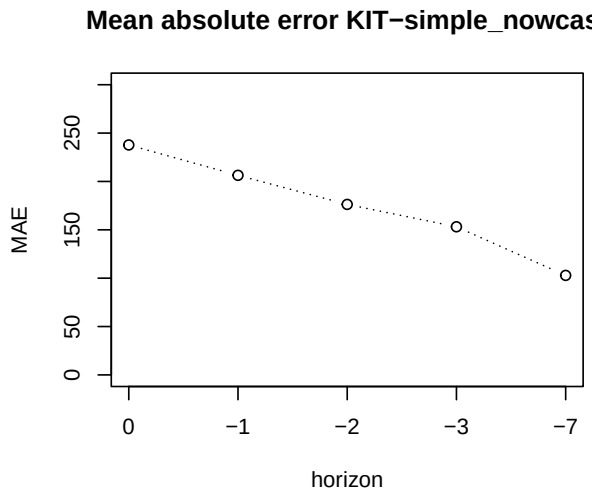
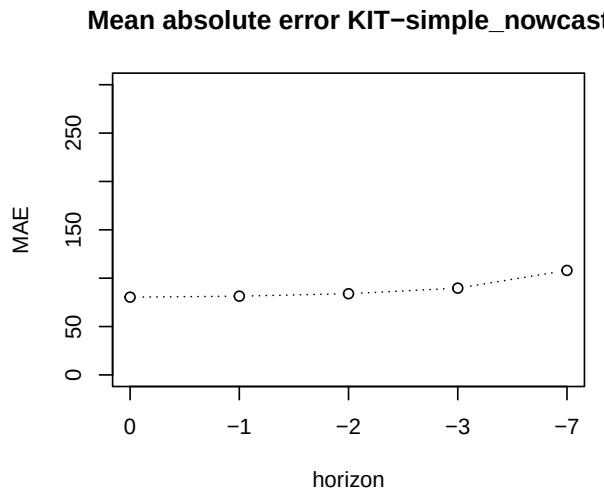
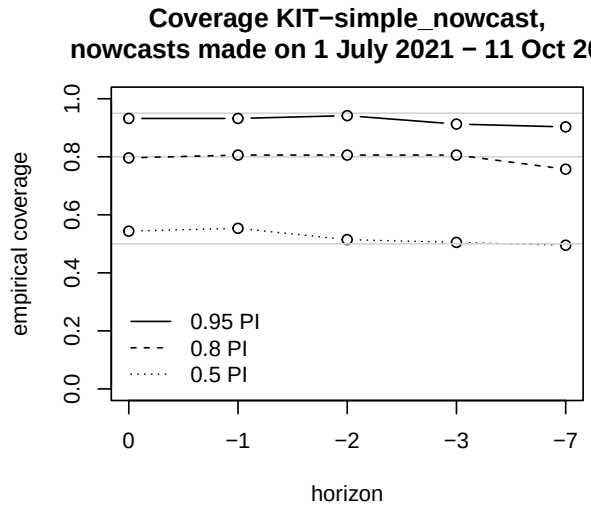
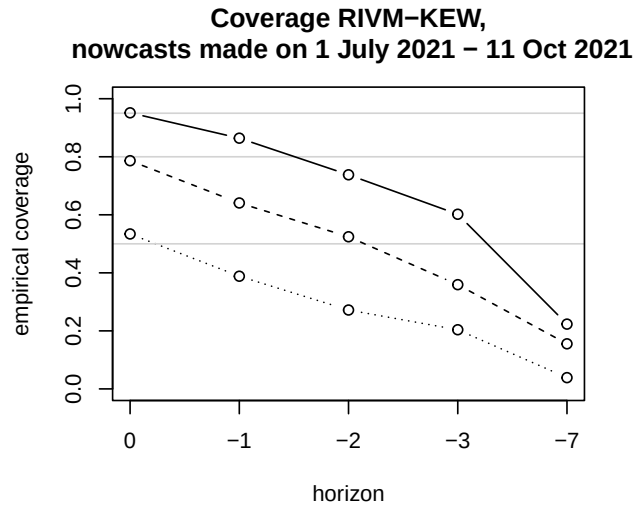


MAE and calibration of retrospective nowcasts







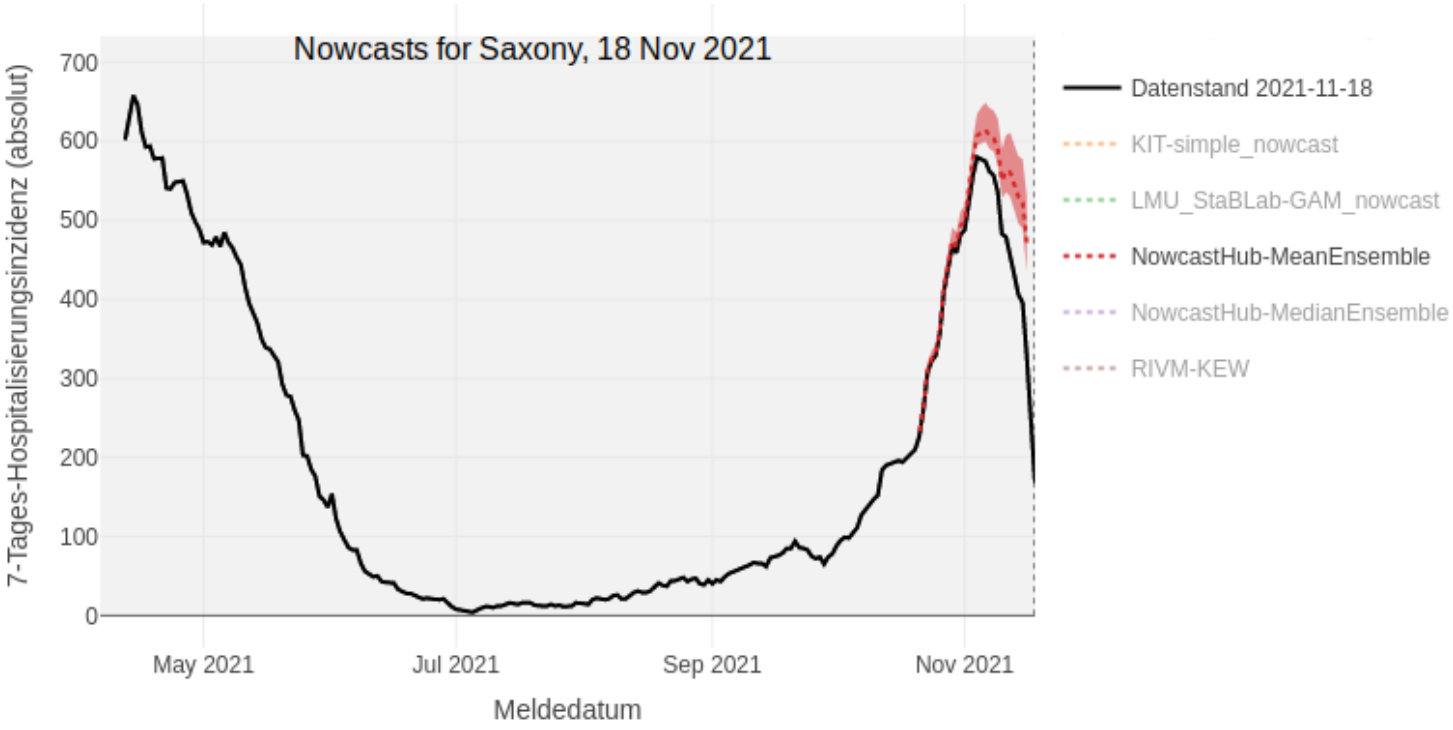


→ different models have different strengths – hopefully the ensemble can strike a good balance

When can things go wrong?

(In principle always.)

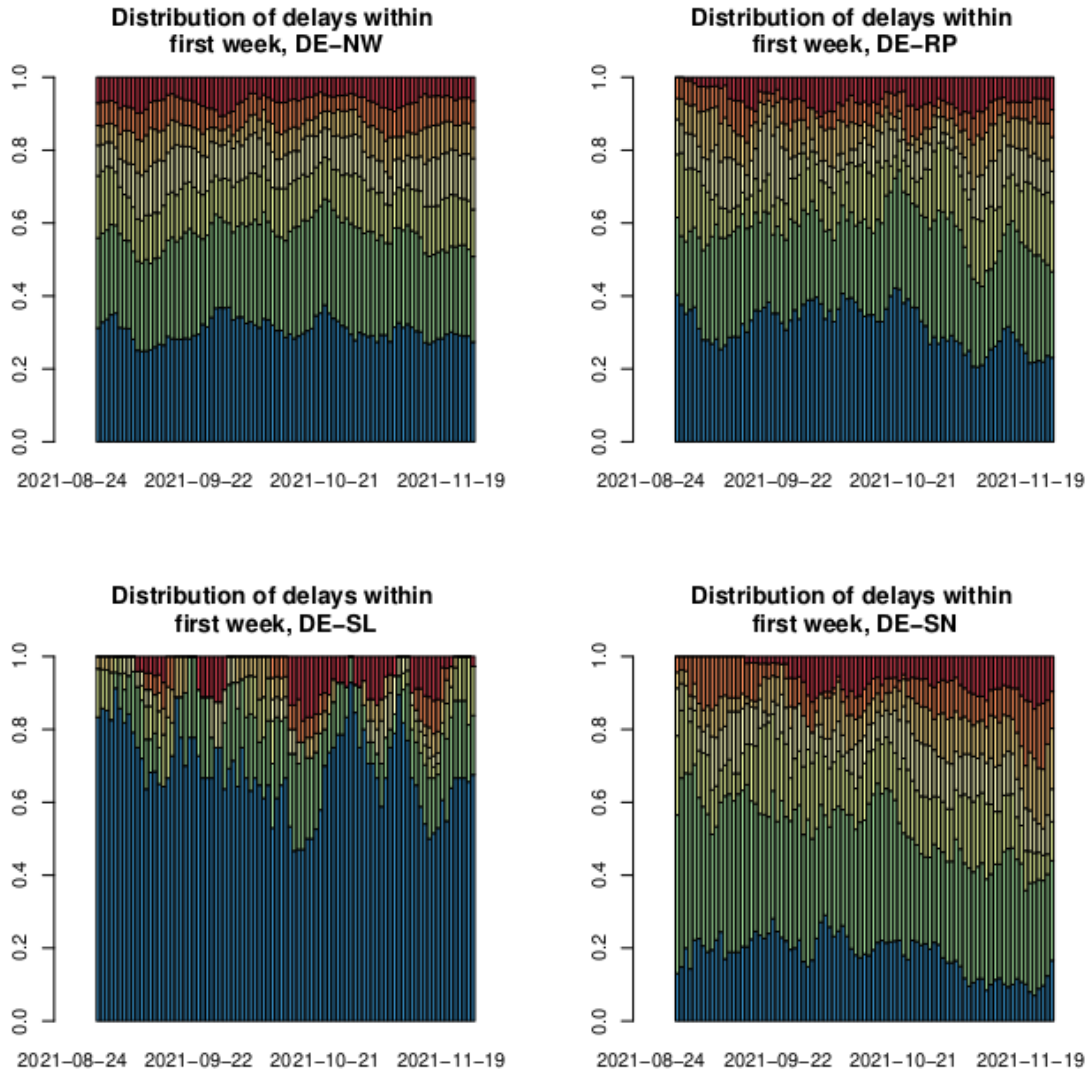
- Main assumption of most methods: delay distributions remain temporally stable.
- This may not be the case when the health system is under stress.
- Nowcasts will tend to under-estimate the true numbers when delays get longer.



- Difficulty: this is not a rapid feedback environment

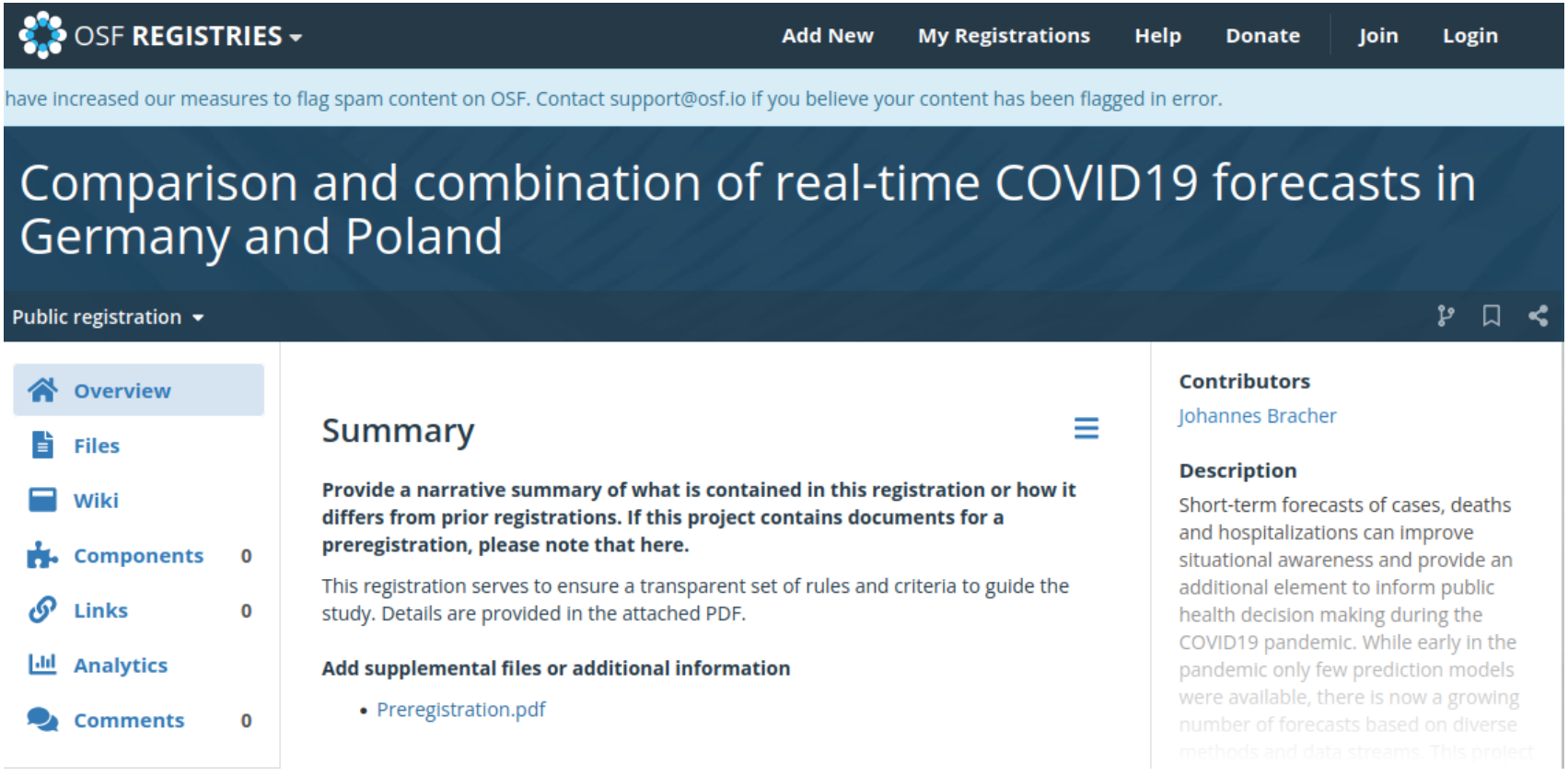
Changing delay distributions

Delay distributions (conditional on delay ≤ 7 days), smoothed over 7-day window:



Pre-registered and prospective evaluation study

Study protocol: `https://osf.io/mru75/`



Previous pre-registered studies on short-term forecasts

Article | Open Access | Published: 27 August 2021

A pre-registered short-term forecasting study of COVID-19 in Germany and Poland during the second wave

J. Bracher, D. Wolffram, J. Deuschel, K. Görgen, J. L. Ketterer, A. Ullrich, S. Abbott, M. V. Barbarossa, D. Bertsimas, S. Bhatia, M. Bodych, N. I. Bosse, J. P. Burgard, L. Castro, G. Fairchild, J. Fuhrmann, S. Funk, K. Gogolewski, Q. Gu, S. Heyder, T. Hotz, Y. Kheifetz, H. Kirsten, T. Krueger, E. Krymova, M. L. Li, J. H. Meinke, I. J. Michaud, K. Niedzielewski, T. Ożański, F. Rakowski, M. Scholz, S. Soni, A. Srivastava, J. Zieliński, D. Zou, T. Gneiting, M. Schienle & List of Contributors by Team -Show fewer authors

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National and subnational short-term forecasting of COVID-19 in Germany and Poland, early 2021

J. Bracher, D. Wolffram, J. Deuschel, K. Görgen, J.L. Ketterer, A. Ullrich, S. Abbott, M.V. Barbarossa, D. Bertsimas, S. Bhatia, M. Bodych, N.I. Bosse, J.P. Burgard, J. Fiedler, J. Fuhrmann, S. Funk, A. Gambin, K. Gogolewski, S. Heyder, T. Hotz, Y. Kheifetz, H. Kirsten, T. Krueger, E. Krymova, N. Leithäuser, M.L. Li, J.H. Meinke, B. Miasojedow, J. Mohring, P. Nouvellet, J.M. Nowosielski, T. Ozanski, M. Radwan, F. Rakowski, M. Scholz, S. Soni, A. Srivastava, T. Gneiting, M. Schienle

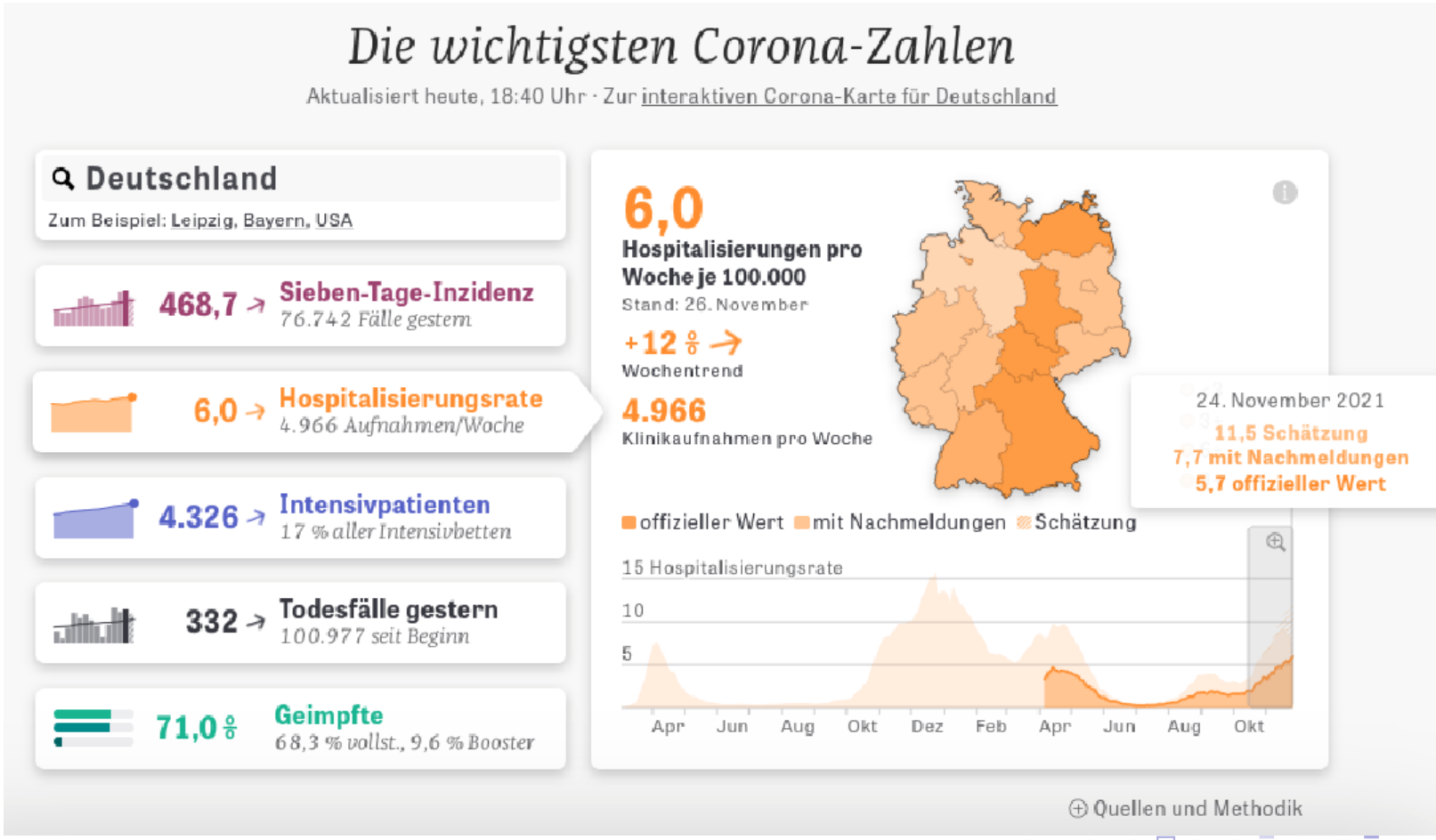
doi: https://doi.org/10.1101/2021.11.05.21265810

Real-time evaluation by Sam Abbott

https://epiforecasts.io/eval-germany-sp-nowcasting/real-time-method-comparison/

Dissemination

- Everything is publicly available under open licenses
- Referenced in RKI weekly report
- Shown with regular updates e.g. at Zeit Online, Neue Zürcher Zeitung, NDR



End

- It is hard to tell how good current nowcasts are.
- But they are certainly better than just showing the raw time series.

- Looking at just one indicator is not a good idea.
- There may be more useful ways of defining hospitalization indicators (though hampered by practical constraints).

- If you have a similar setting in your country - don't hesitate to reach out.
  - our setup is open-source and under MIT license
  - most teams' analysis codes are public, too

Thanks

Many thanks to (in reverse alphabetical order): D. Wolffram, J. van de Kassteele, M. Weigert, A. Ullrich, D. Syliqi, M. Schienle, H. Kuechenhoff, T. Hotz, S. Heyder, D. Hailer, F. Guenther, T. Gneiting, S. Funk, M. an der Heiden, S. Abbott