

# Forecasting Model Similarity (for inc hosp)

Johannes Bracher, Evan Ray, Nick Reich, Nutch Wattanachit, Li Shandross

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## COVID-19 Forecasting Model Similarity Analysis for 1-4 Week Ahead Incident Hospitalization

In this analysis, we extend the work of Bracher, et. al that evaluates the similarity between Covid-19 models using Cramer's distance. This work was applied to forecasts for incident deaths (inc deaths) and incident cases (inc cases) and here we apply it to incident hospitalizations (inc hosp).

We must first make some adjustments to the inc hosp forecast data, which have a temporal resolution of "day" instead of "week," unlike inc case and inc death. This presents a challenge because the horizons will be different for the same target end date if the forecast dates between two models differ by only a single day. (This is not an issue when the temporal resolution is in terms of weeks, which are defined by epidemiological week, not the number of days between forecast date and target end date.) Thus, we create a new variable called horizon week to solve this issue. This variable counts horizons between 1 and 7 to have a horizon week of 1, horizons between 8 and 14 to have a horizon week of 2, etc. Hence, the analyses used on inc death and inc cases should be able to be applied easily to the inc hosp data.

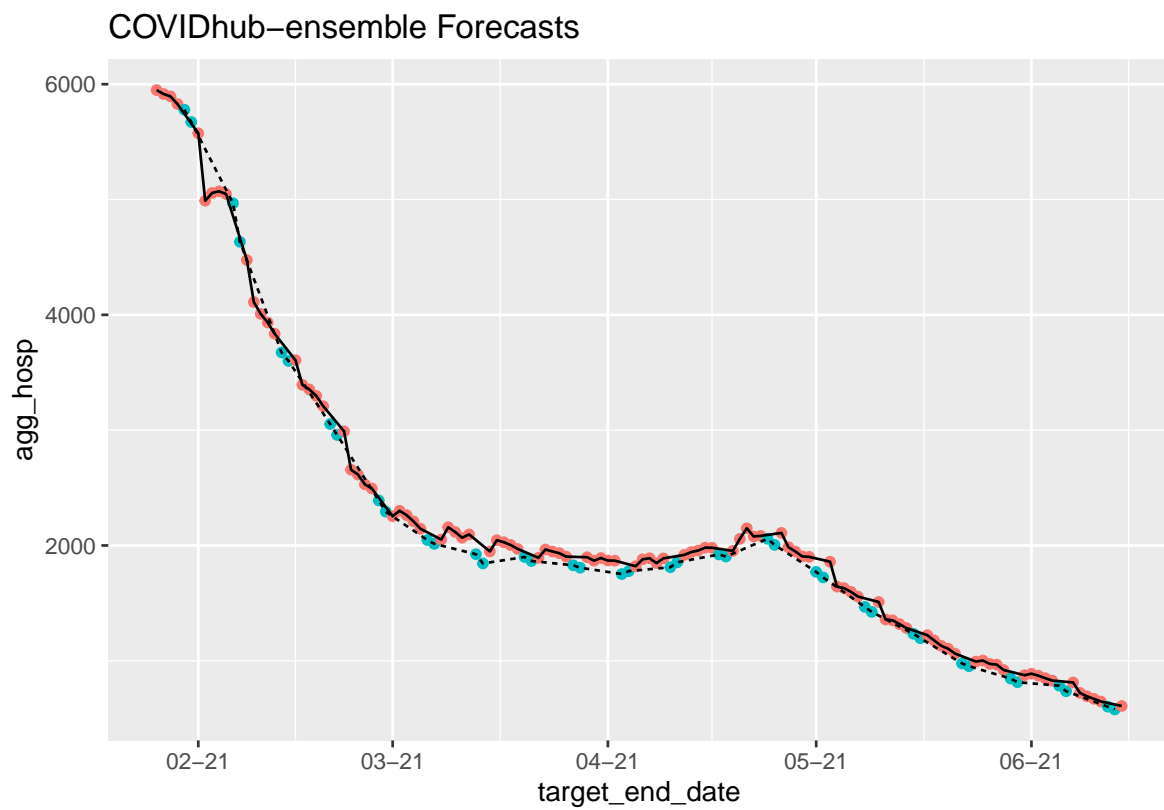
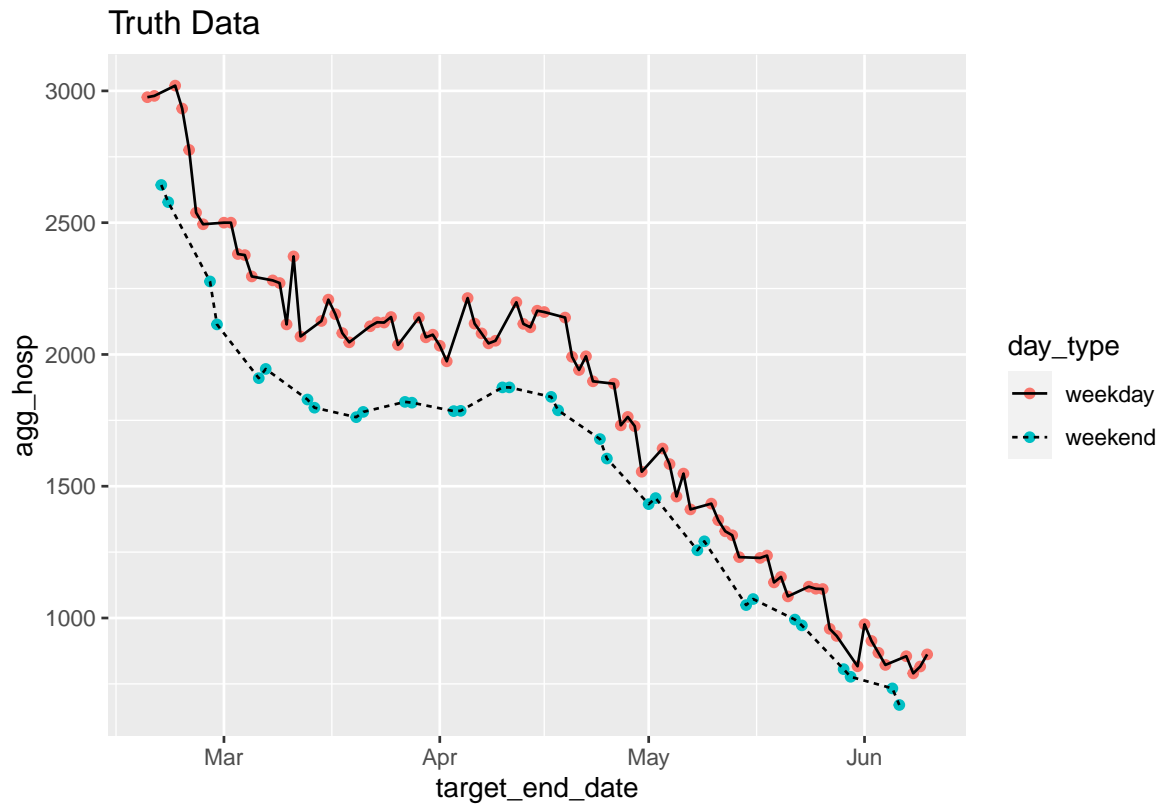
This initial analysis only examines target end dates for a single day of the week, Thursday, to account for models that include day of the week effects. However, this will be expanded later to more days, perhaps even exploring if performing the analysis on different days of the week leads to different results in terms of model similarity.

The pairwise approximated Cramer's distances are calculated for the models that have complete submissions for all targets, all probability levels, and no missing forecasts between January 28th, 2020 and June 10th 2021. We aggregate results for the five locations that have the highest number of number of COVID-19 hospitalizations during this period as well as the five locations with the lowest number for the same date range.

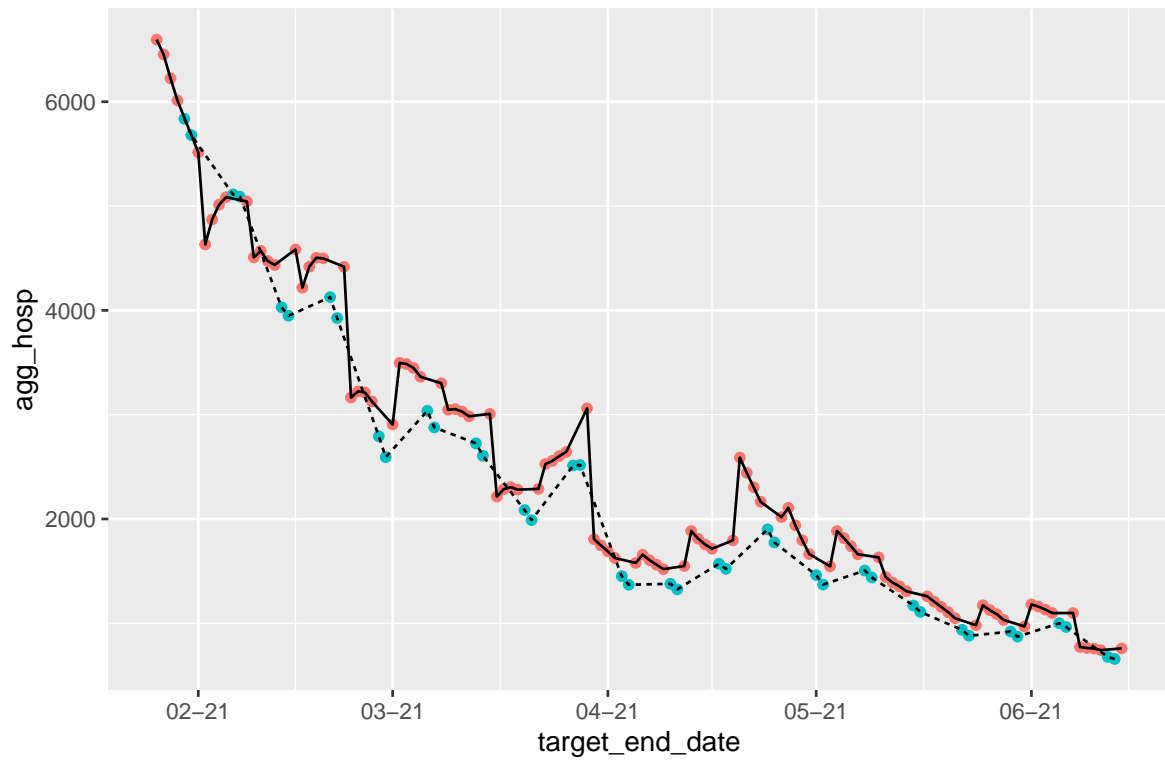
There are nine models that fulfilled the criteria for both the five locations with highest cumulative deaths and the five locations with lowest cumulative deaths.

### Day of the Week Effects

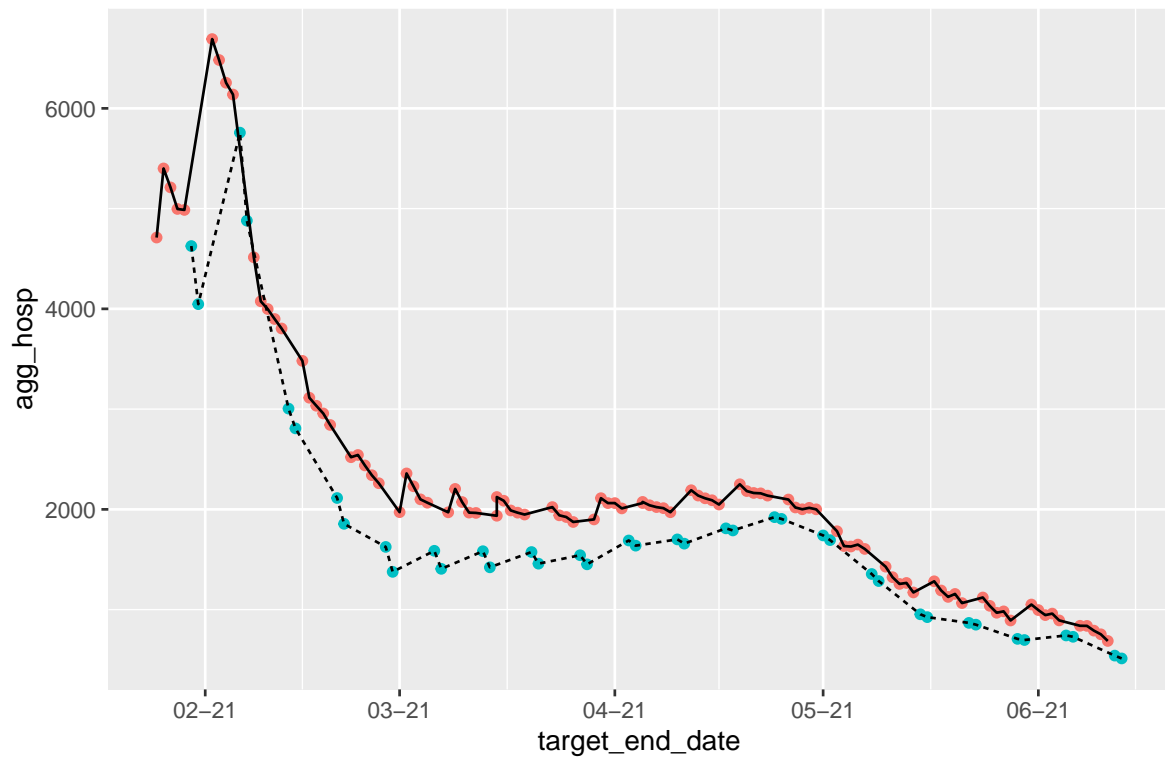
We can plot point forecasts to see if any of the models incorporate day of the week effects (i.e. do forecasts certain days of the week specifically show lower/higher hospitalizations compared to other days).



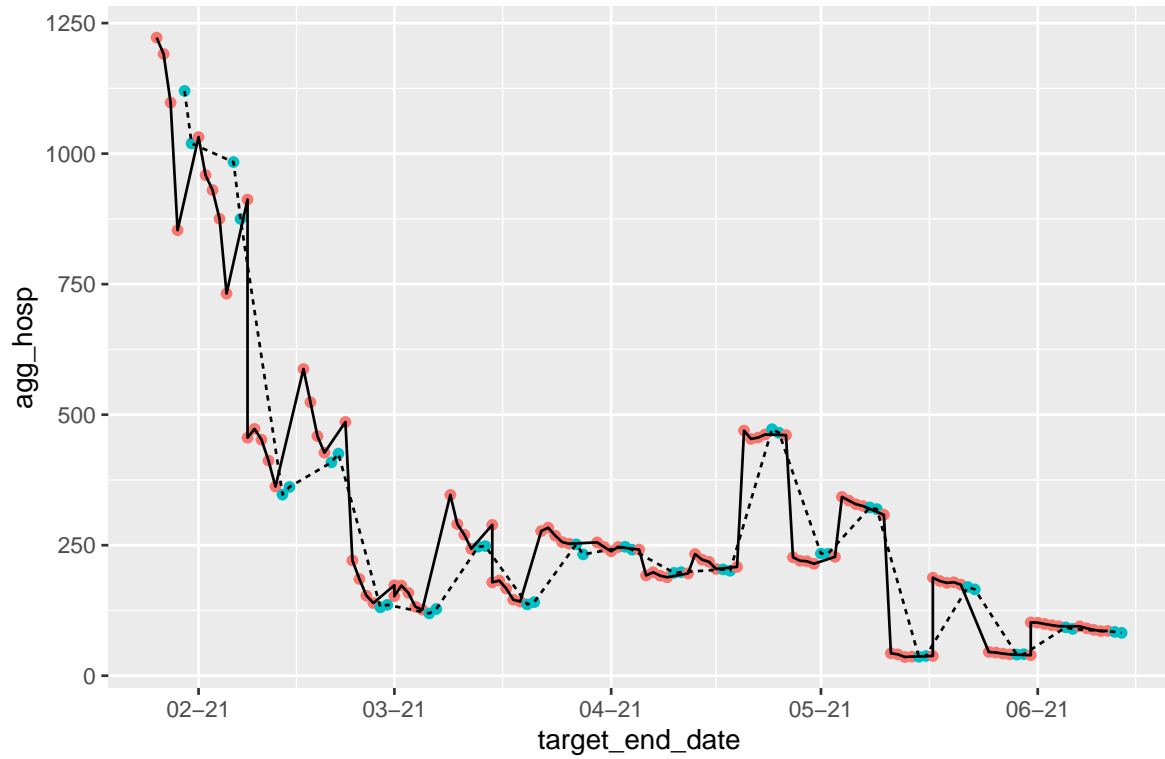
JHUAPL-Bucky Forecasts



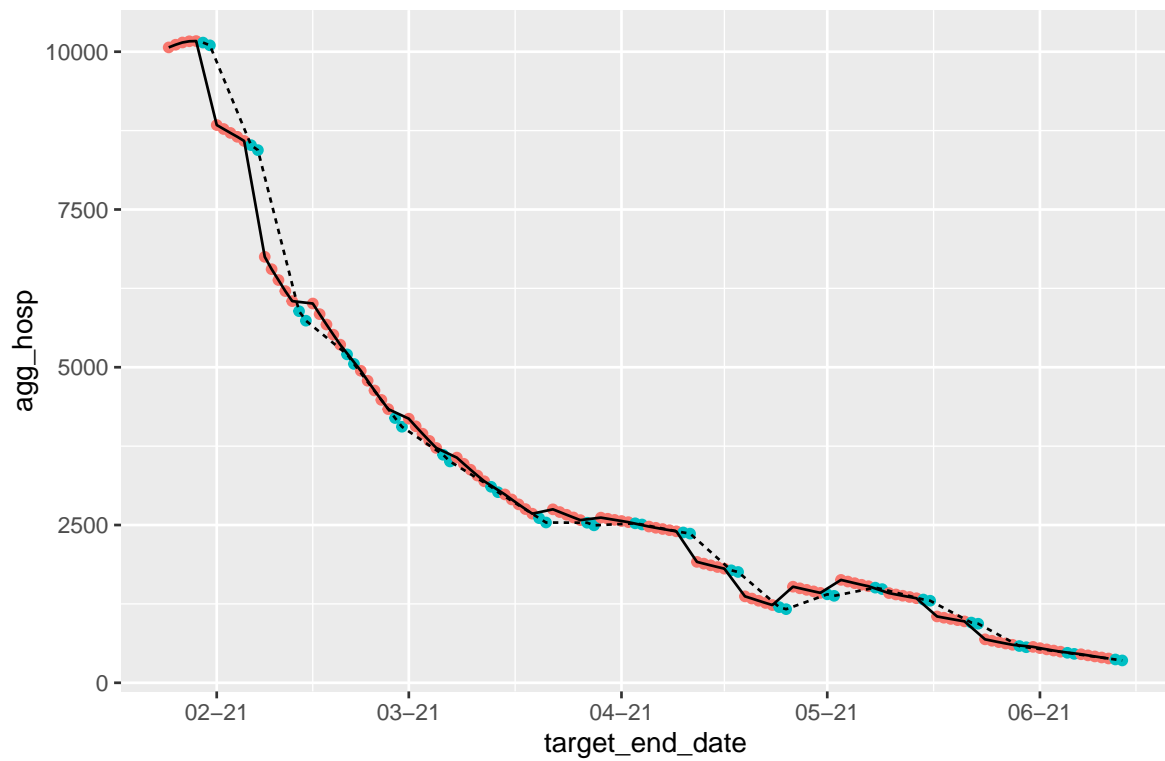
JHUAPL-Gecko Forecasts



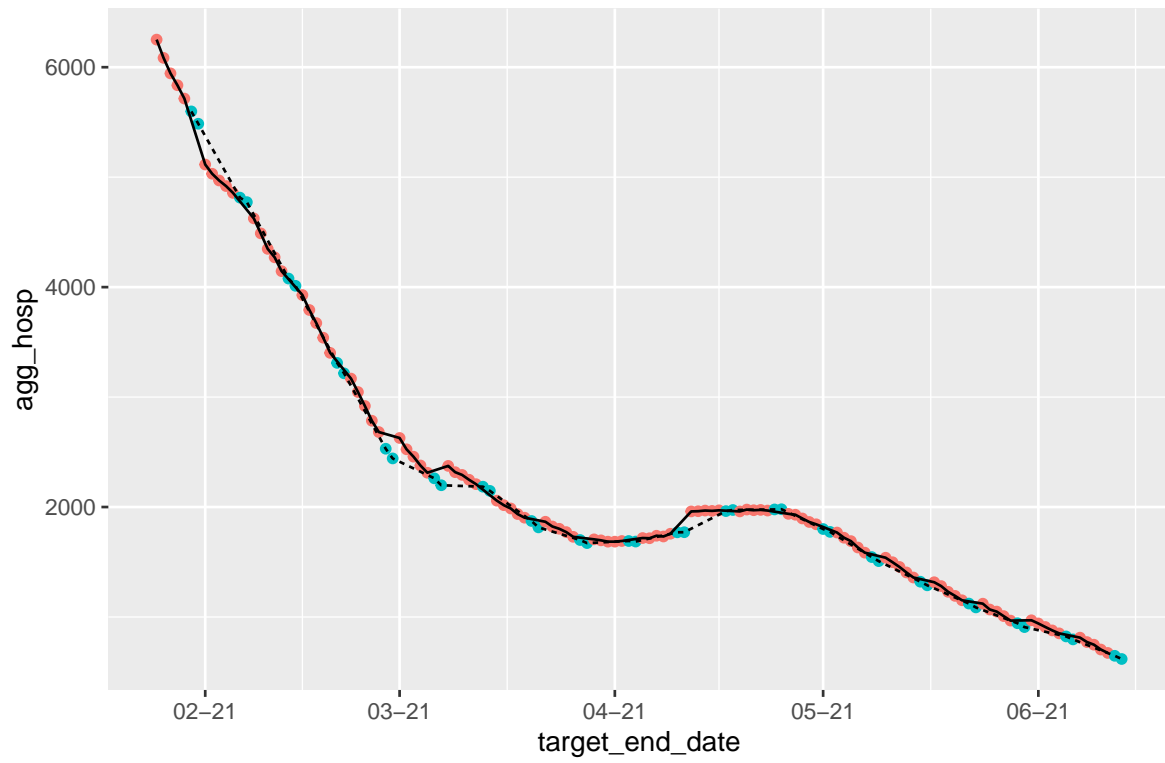
Google\_Harvard-CPF Forecasts



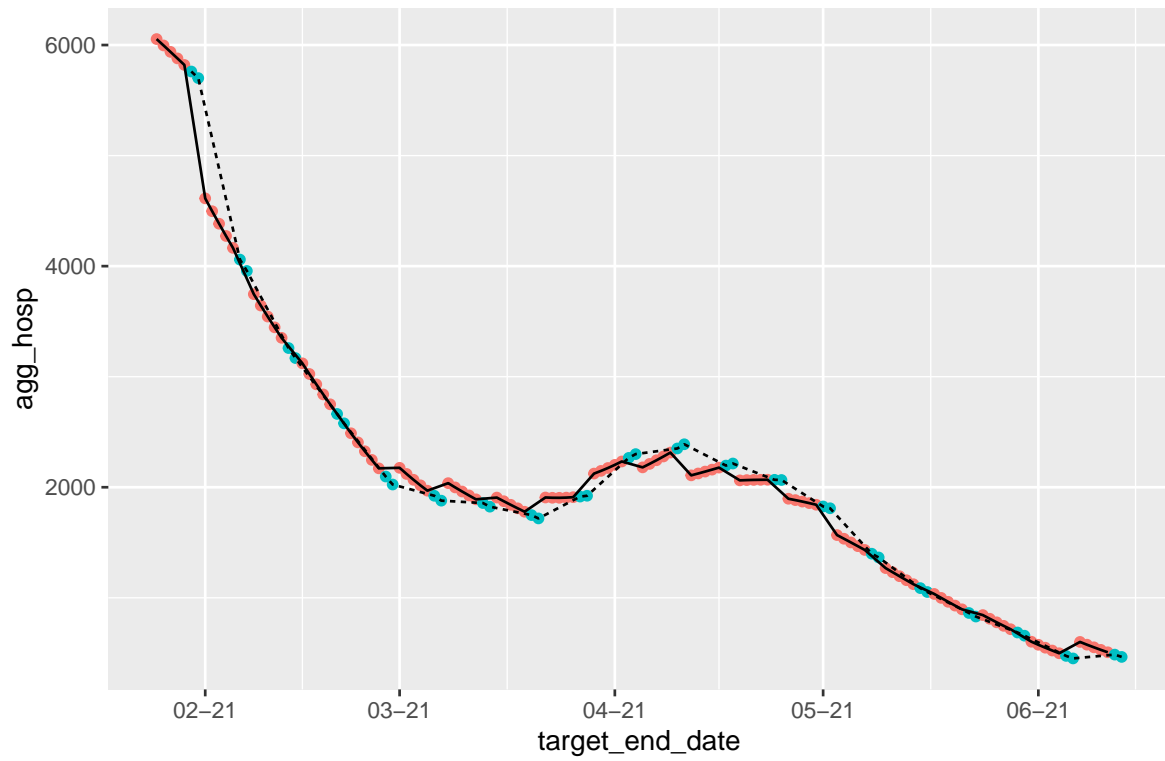
Covid19Sim-Simulator Forecasts

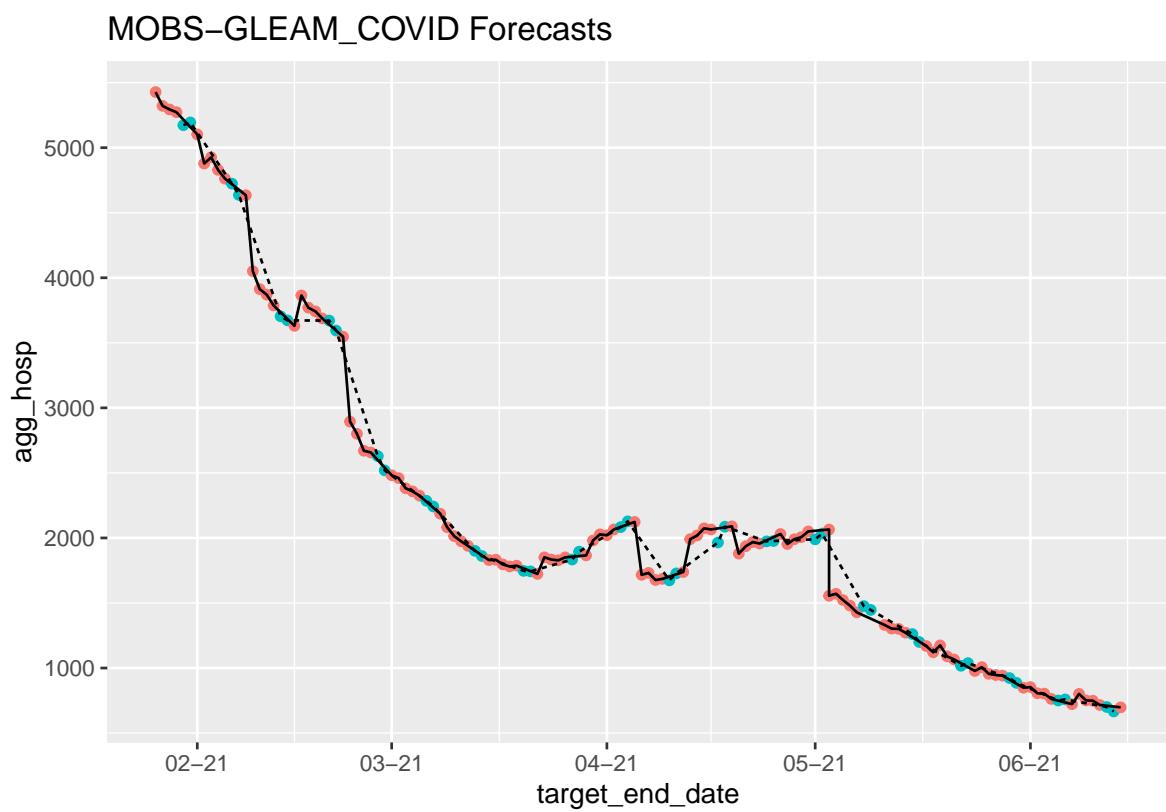
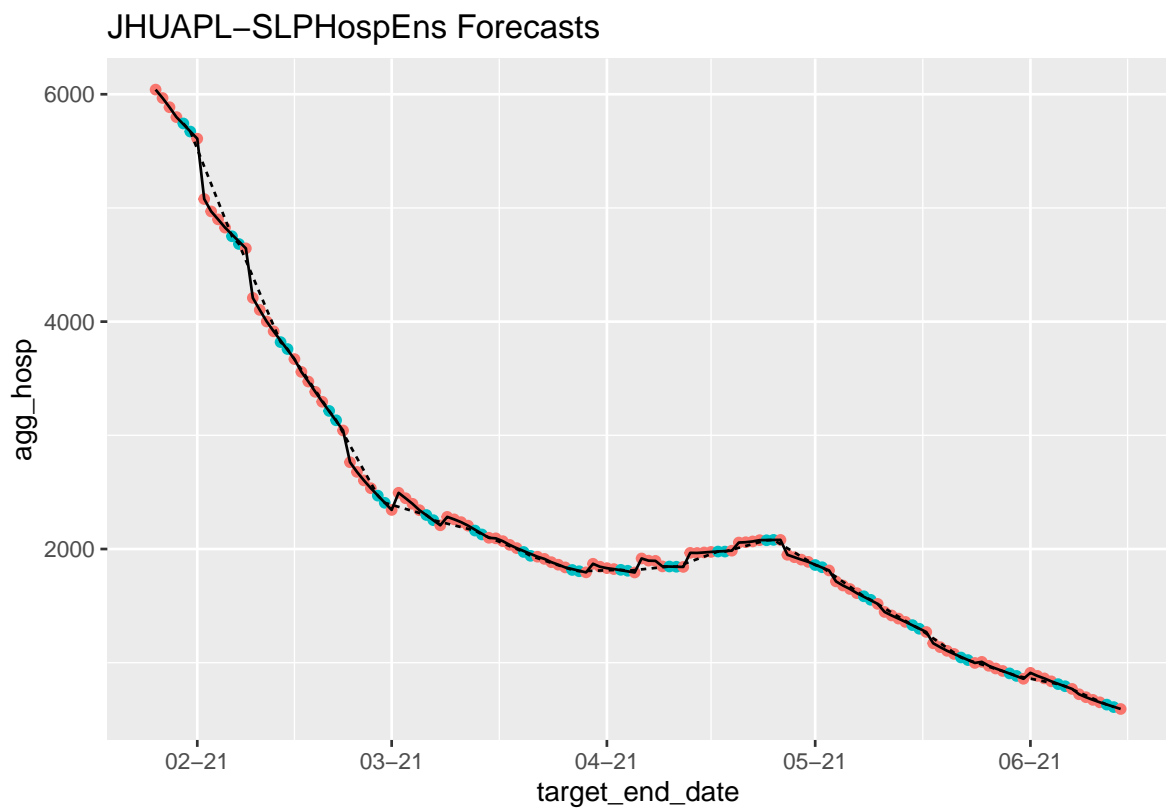


CU-select Forecasts



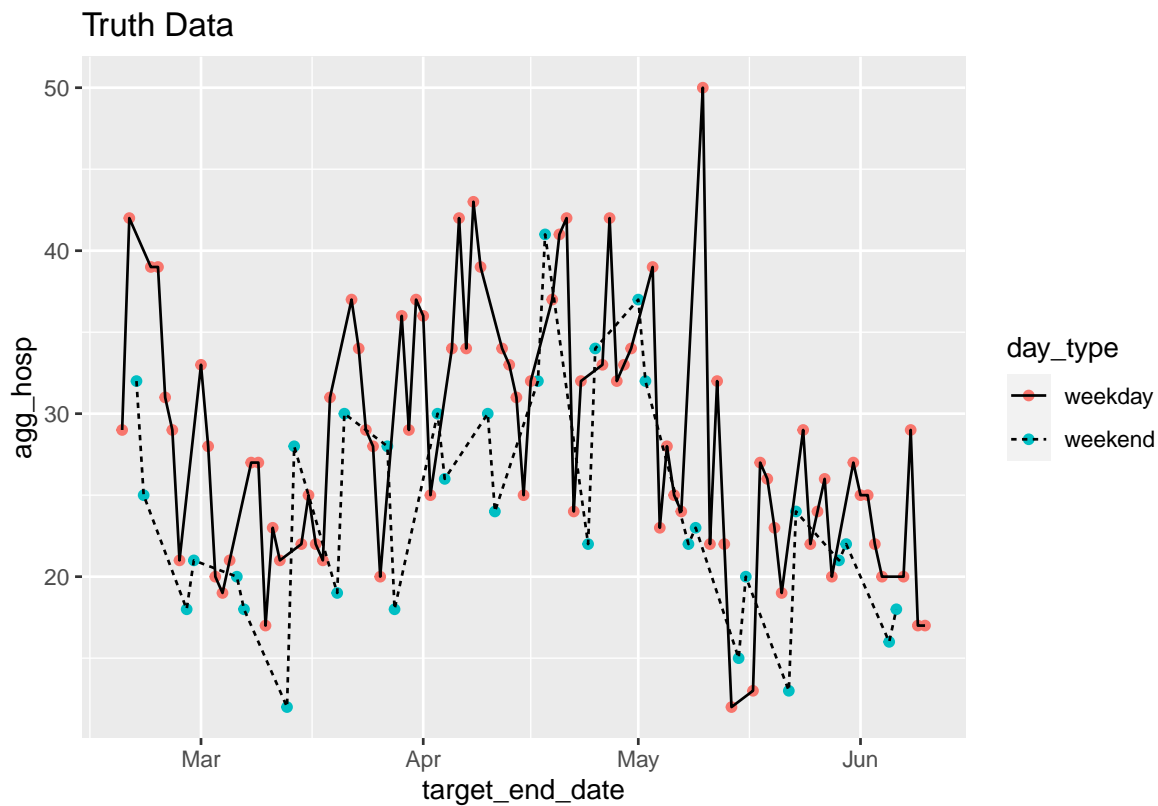
Karlen-pypm Forecasts



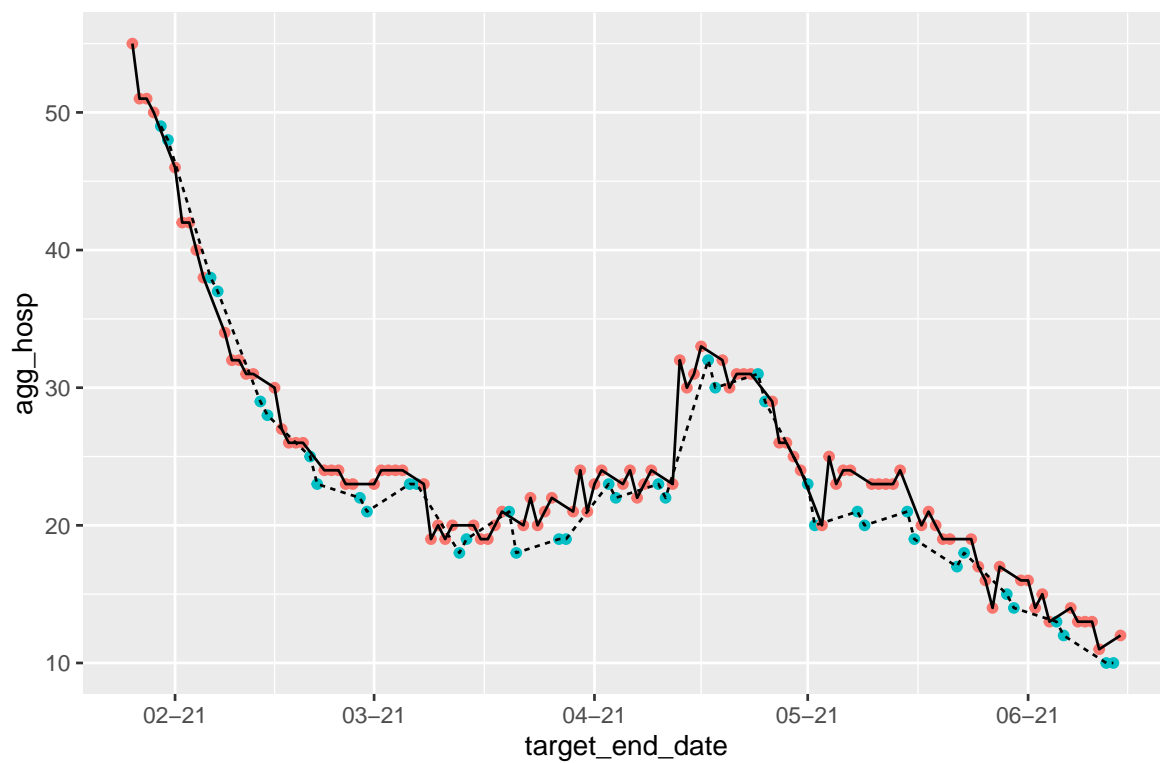


Truth data has always shown day of the week effects (weekends always have lower inc hosp) but the models

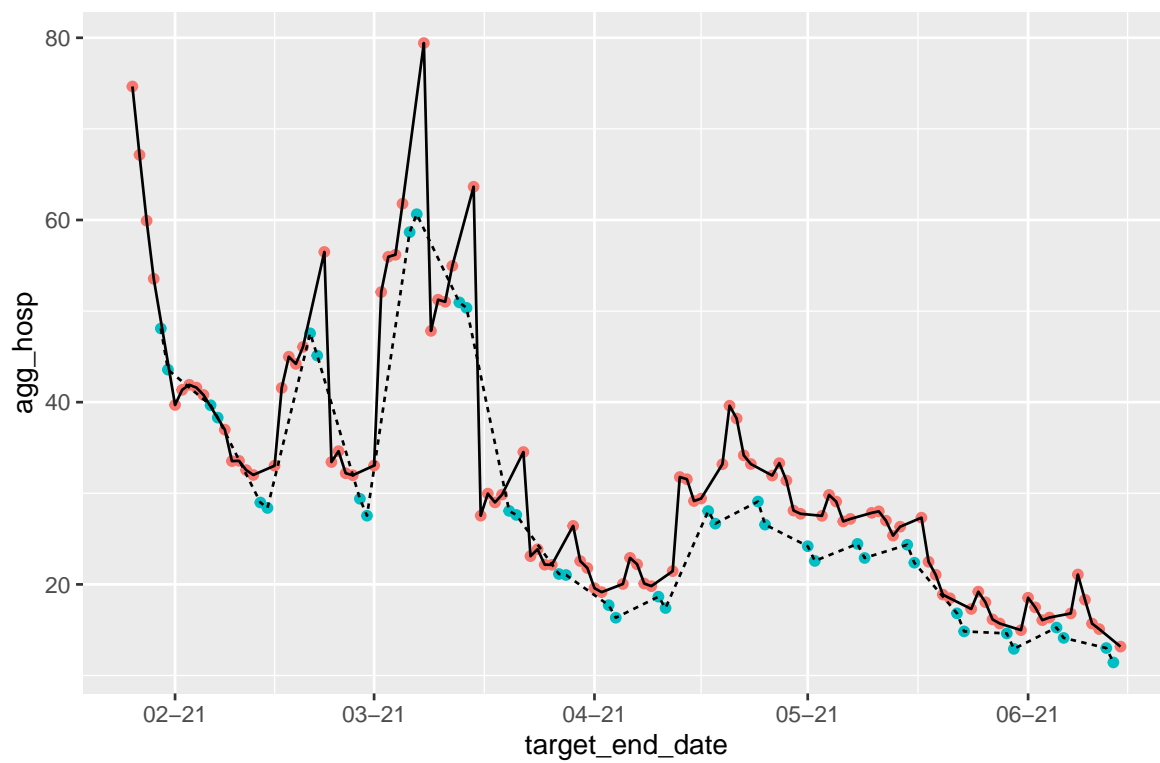
seemed to predict lower inc hosp on Tuesdays for the end of December/beginning of January, then most seem to switch to lower weekend end inc hosp sometime during 2021.



COVIDhub-ensemble Forecasts

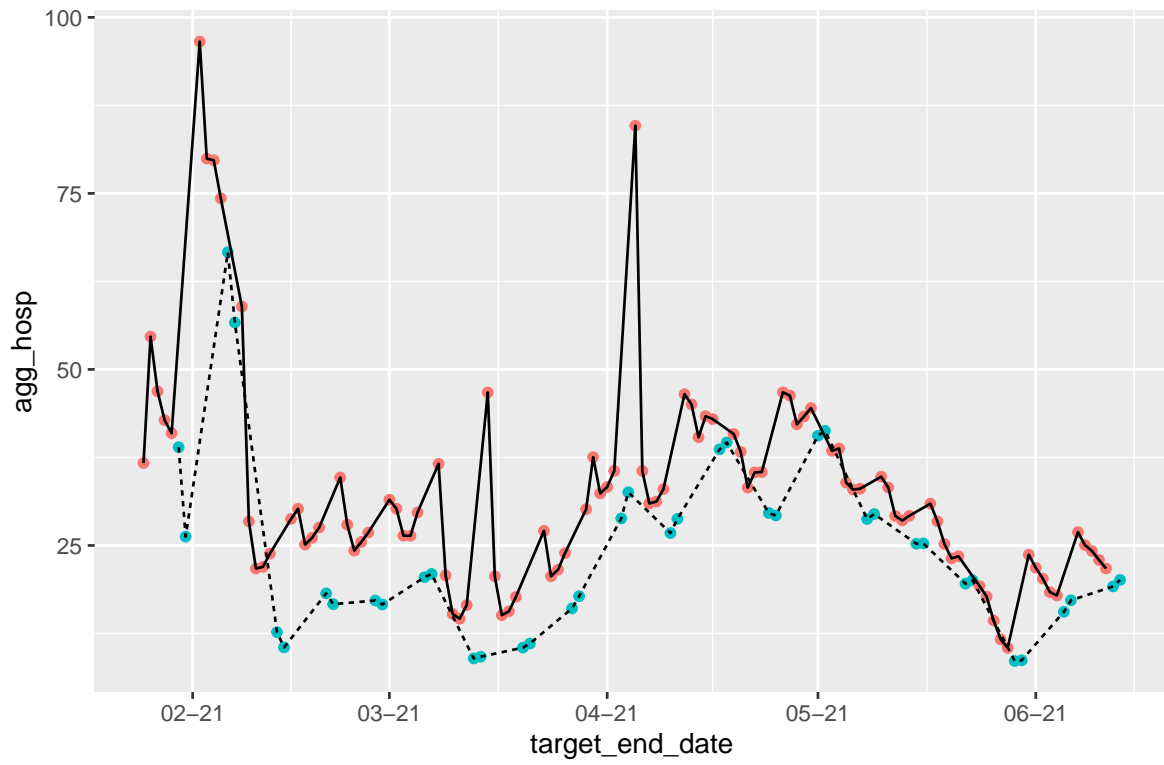


JHUAPL-Bucky Forecasts

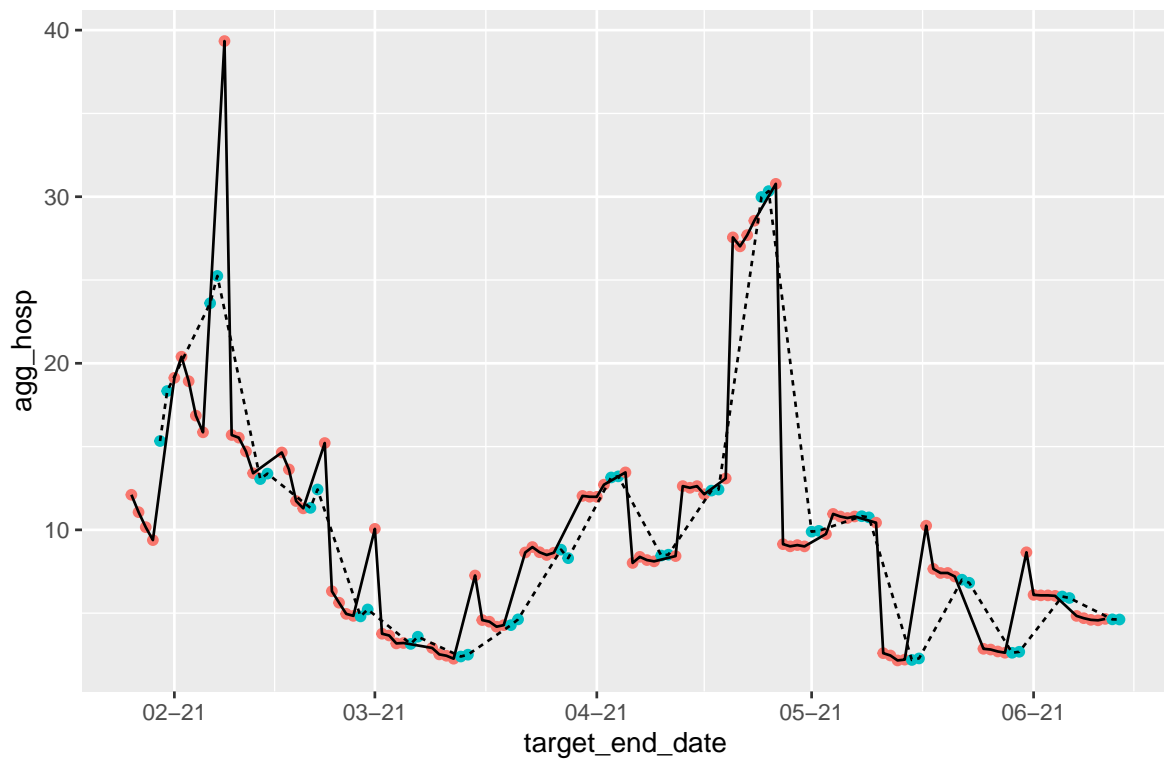




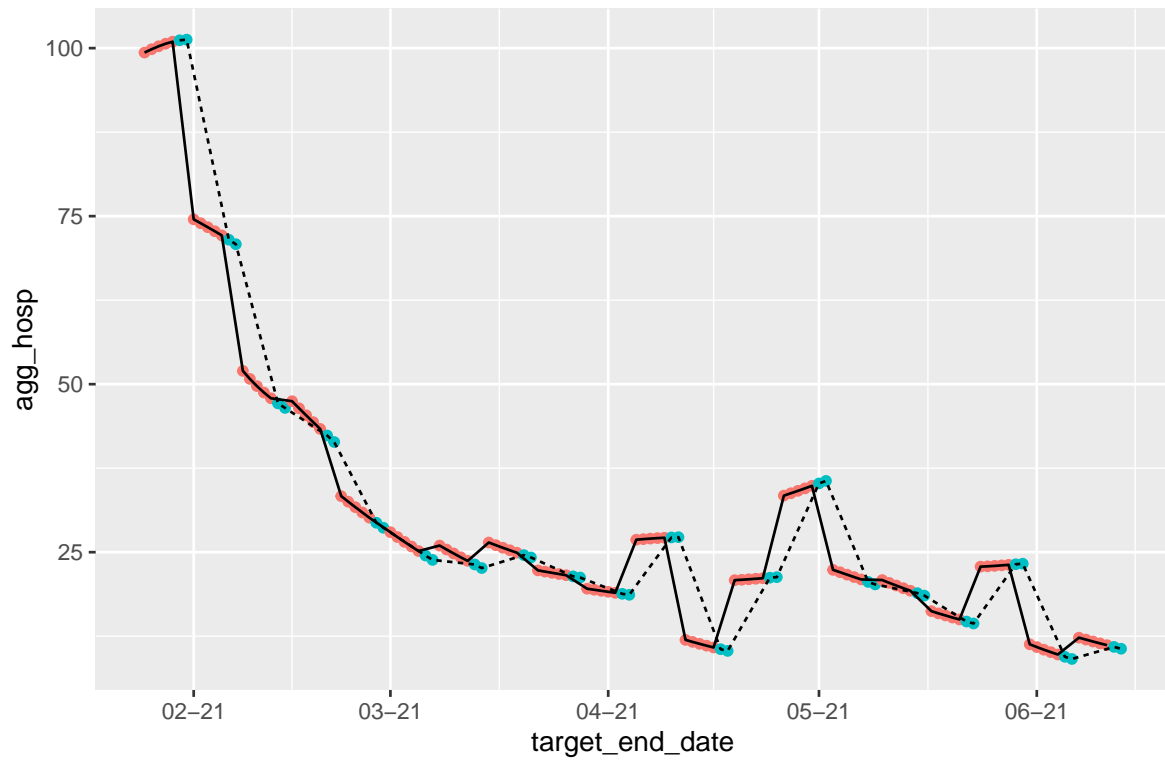
JHUAPL-Gecko Forecasts



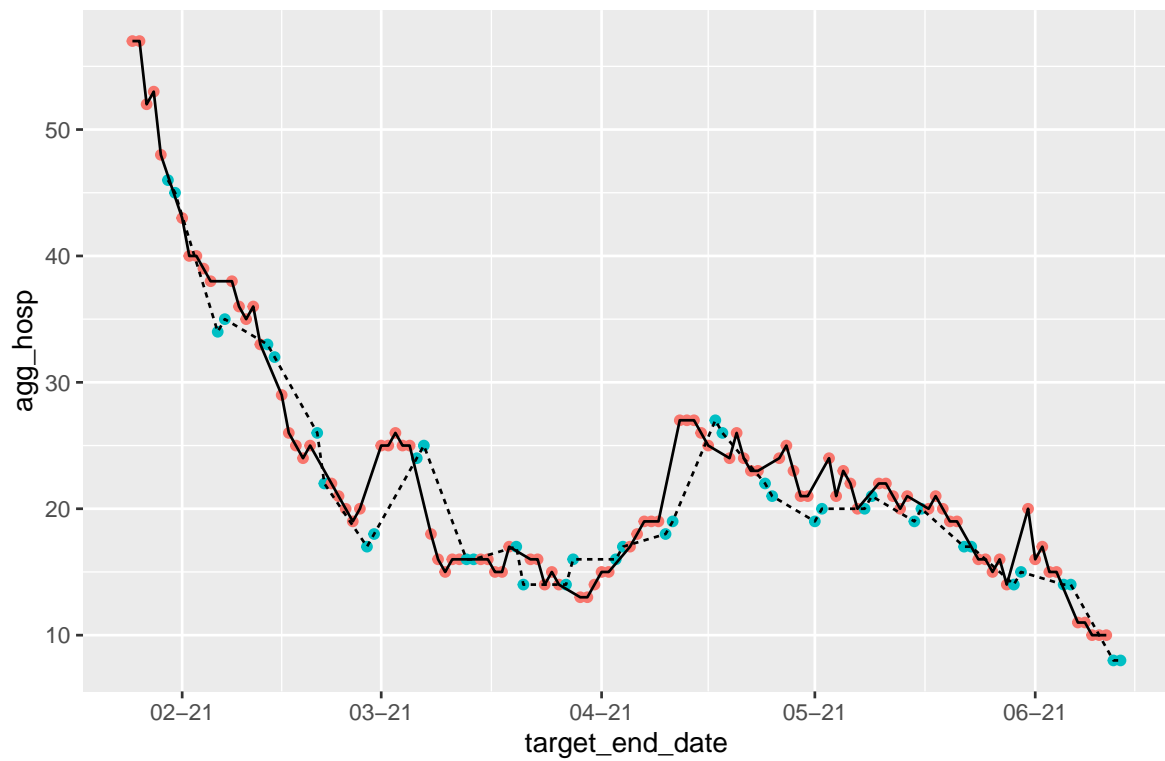
Google\_Harvard-CPF Forecasts



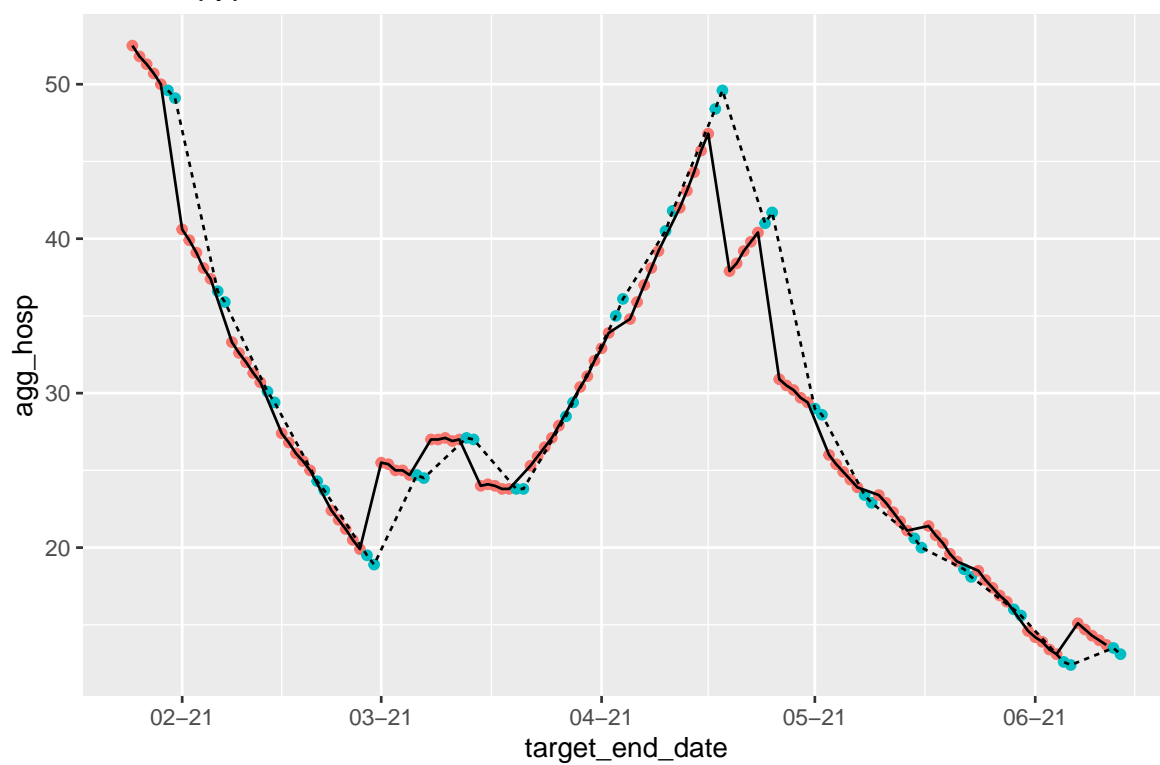
Covid19Sim-Simulator Forecasts



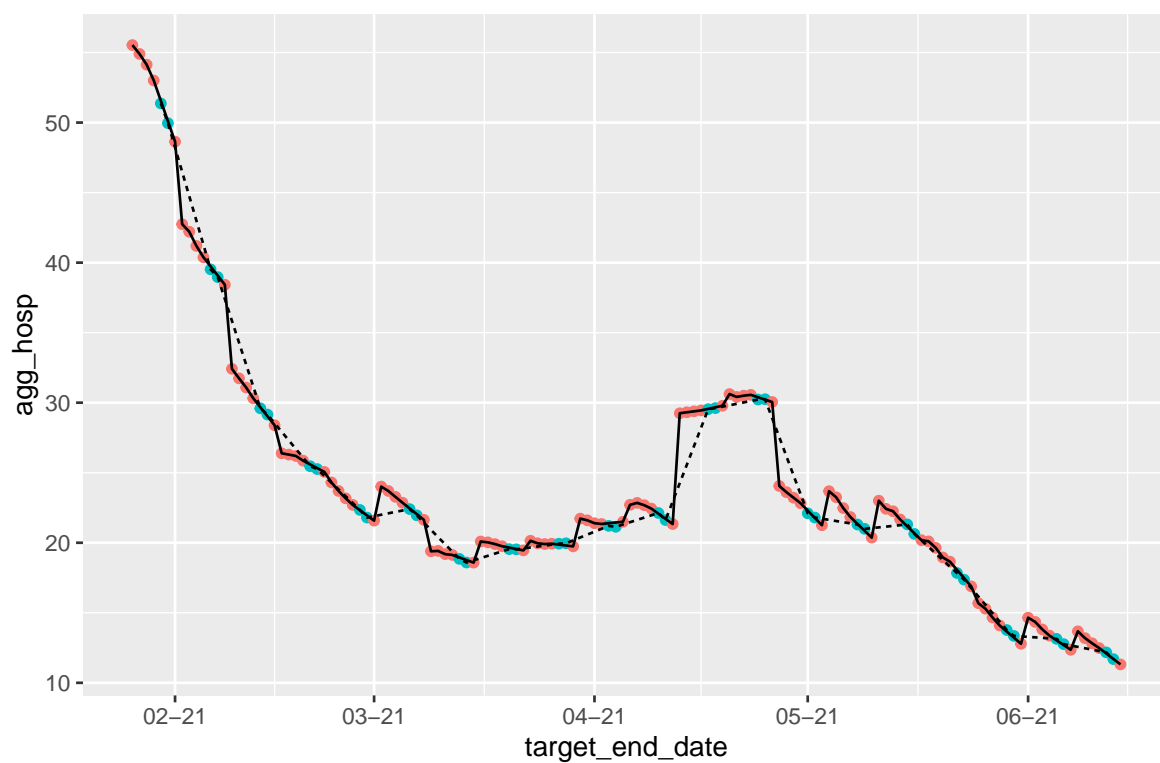
CU-select Forecasts



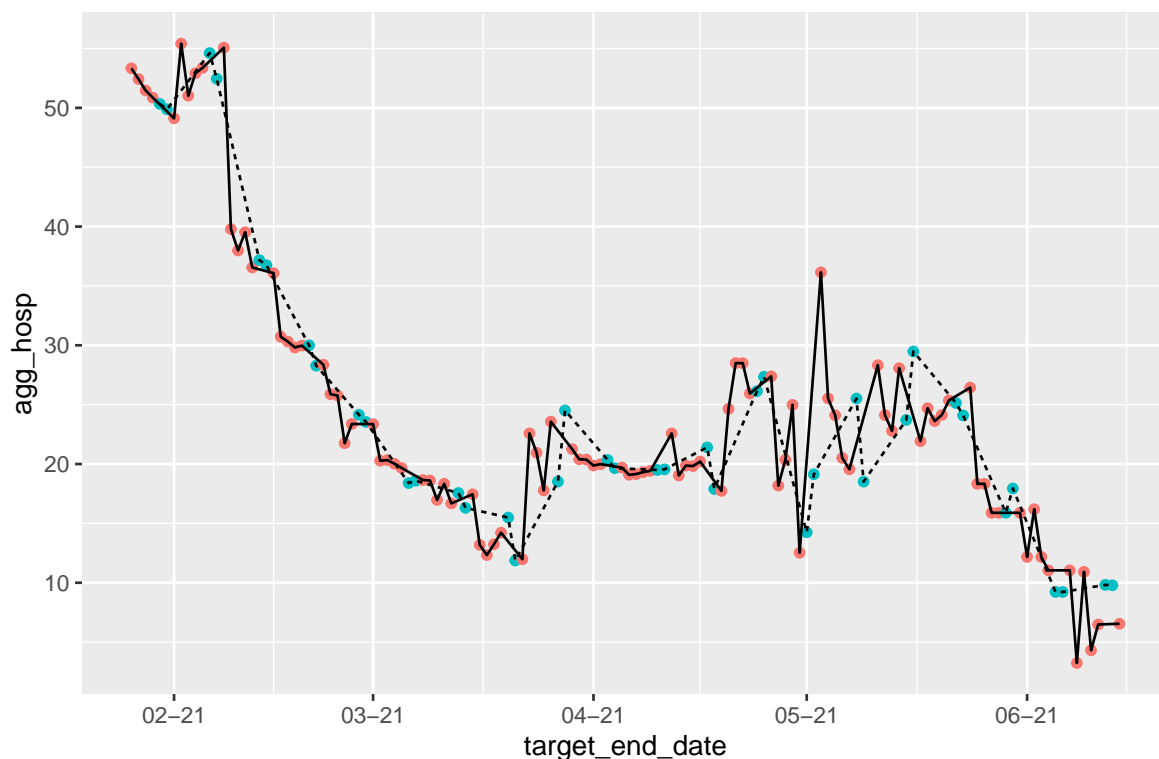
Karlen-pypm Forecasts



JHUAPL-SLPHospEns Forecasts



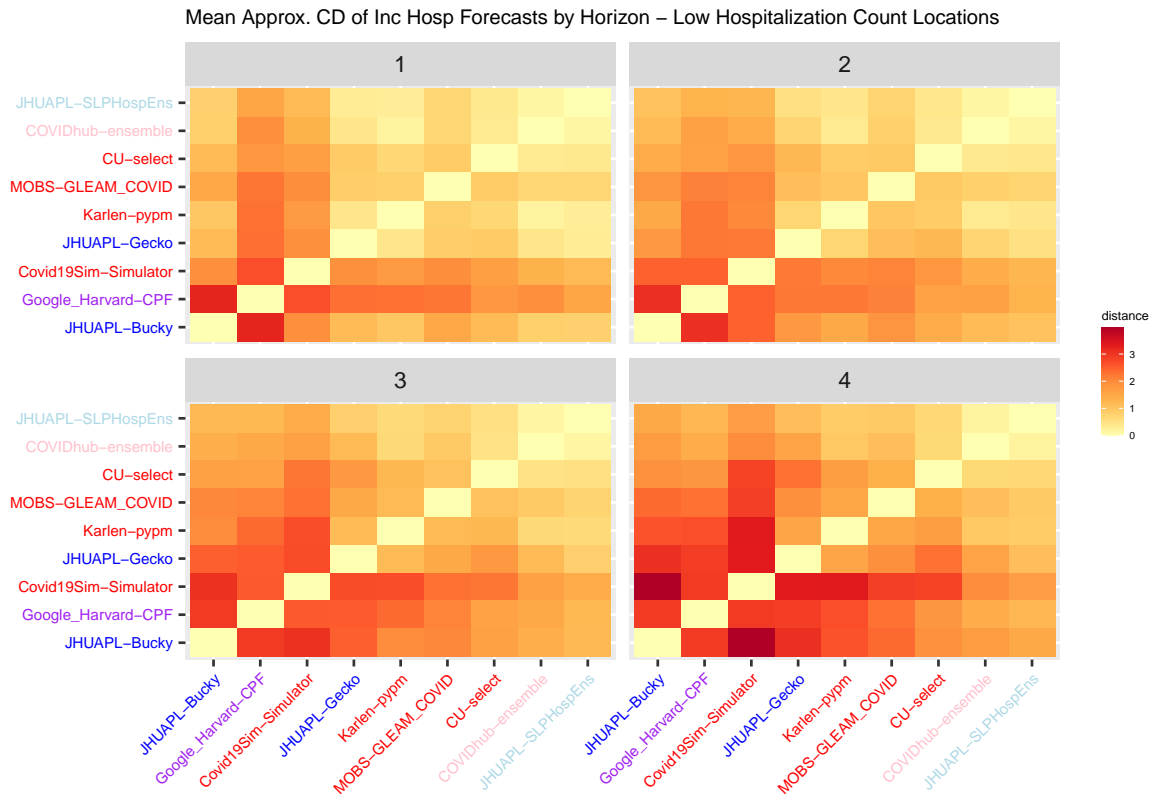
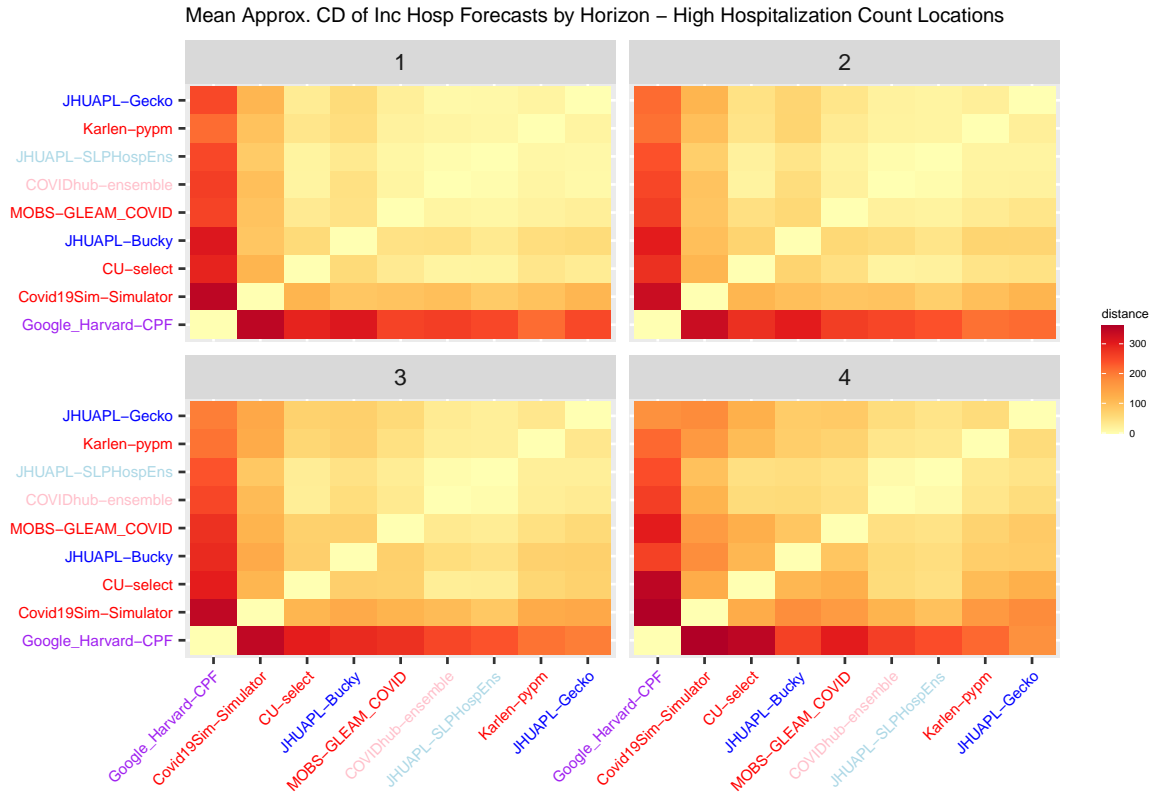
## MOBS-GLEAM\_COVID Forecasts



The low hosp location truth data doesn't present such a clear pattern as to day of the week effects that suggest that weekends or weekdays generally have less inc hosp values. However, most of the models seem to switch to incorporating a day of the week effect at about the same time as that for the high count values.

Model	Day of Week Effect
Covid19Sim-Simulator	FALSE
COVIDhub-ensemble	ENS incl
CU-select	FALSE
Google_Harvard-CPF	UNCLEAR
JHUAPL-Bucky	TRUE
JHUAPL-Gecko	TRUE
JHUAPL-SLPHospEns	ENS excl
Karlen-pypm	FALSE
MOBS-GLEAM_COVID	FALSE

We can visualize the mean approximated pairwise distances across all time points in a heat map shown below. The distance from the model to itself is zero. The  $x$ -axis is arranged based in an ascending order of the model's approximate pairwise distance from the COVIDhub-ensemble. So, the first model is the model that is most dissimilar (on average) to the ensemble in this time frame.

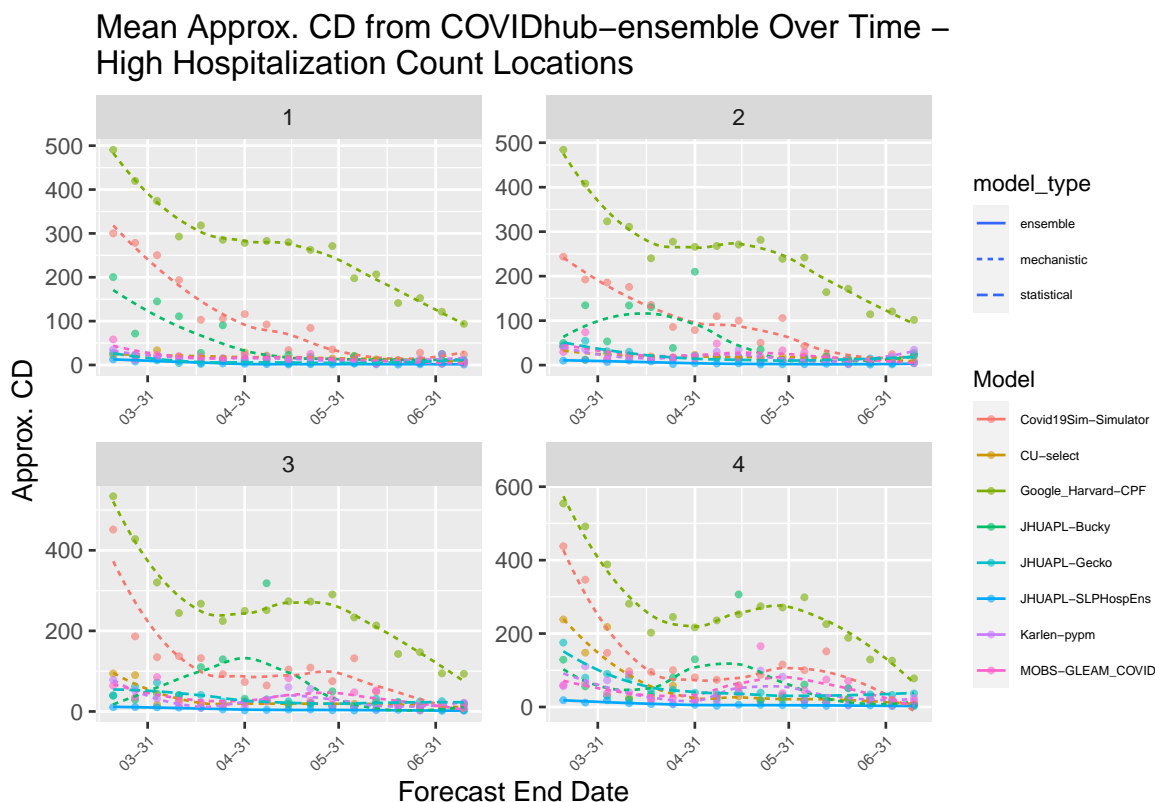


Google\_Harvard-CPF is generally the least similar to the other models for both the high count and low

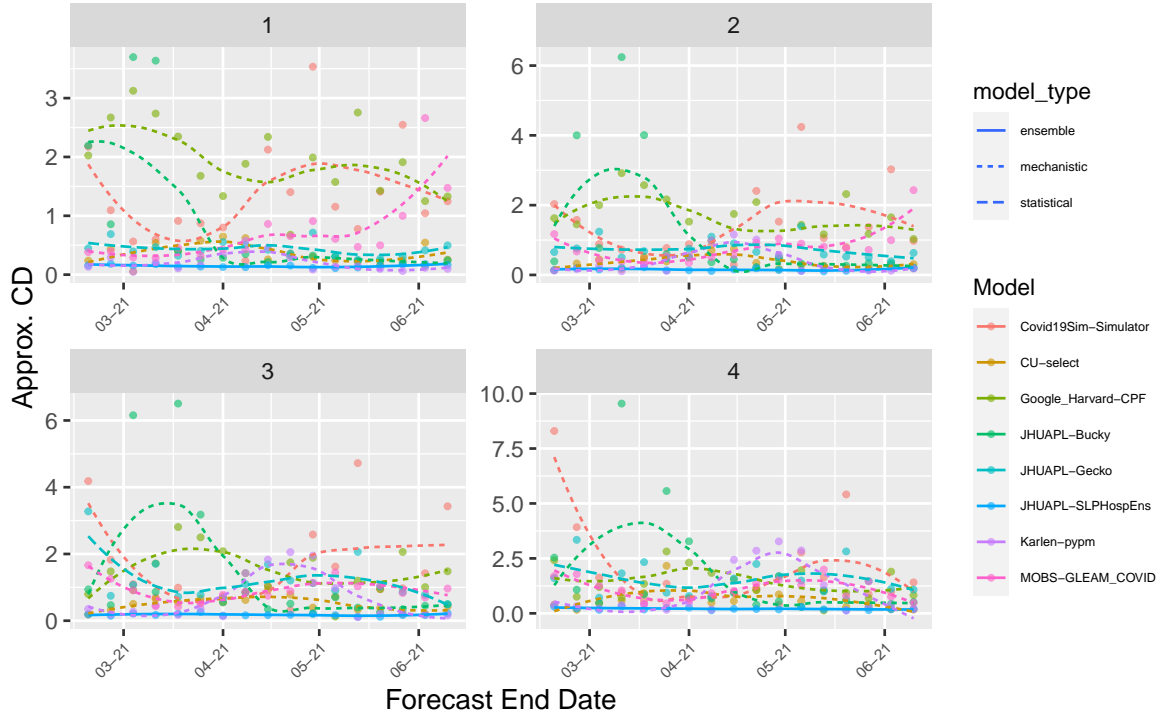
count locations. This is true across all horizons for the high count locations, but only true for one and two week horizons of the low count locations. Covid19Sim-Simulator and JHUAPL-Bucky show similar Cramer's Distances at three and four week horizons at the low count locations. Covid19Sim-Simulator is the second least similar model for the high count locations, but its Cramer's Distance is much smaller than that of Google\_Harvard-CPF. Of note is similar differences between models at all horizons for high count locations, unlike the results shown for inc cases and inc deaths which show substantial differences between models as horizon length increases.

For low count locations, models with day of the week effect tend to have higher Cramer's Distances, but there doesn't seem to be much of a pattern for high count locations.

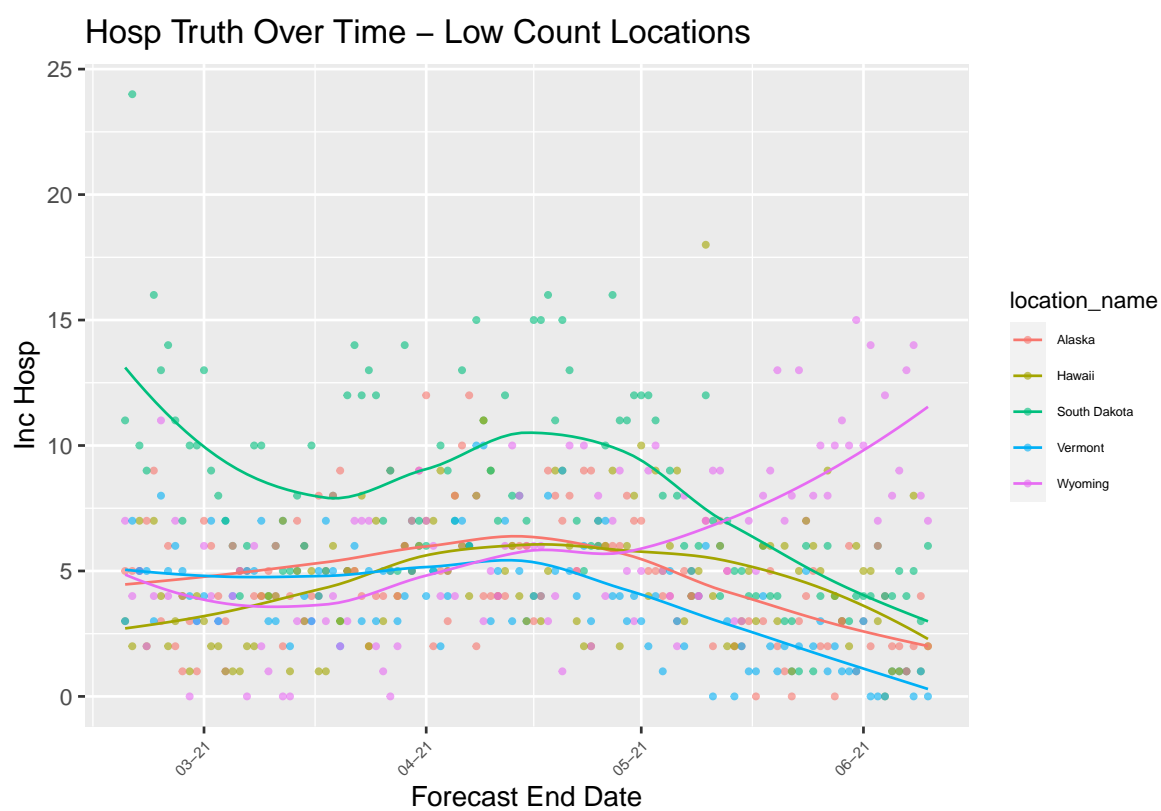
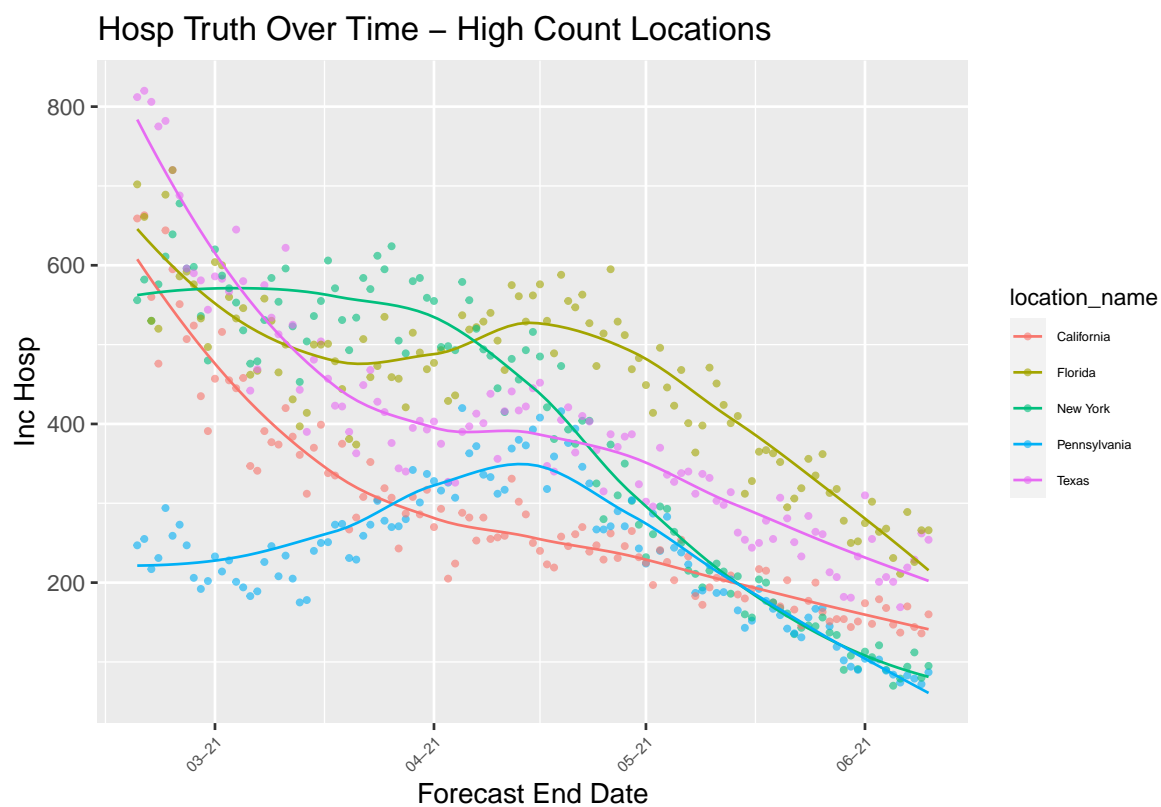
We can also look at the approximated pairwise distances to see how the models become more similar or dissimilar over time.



## Mean Approx. CD from COVIDhub-ensemble Over Time – Low Hospitalization Count Locations



The scatterplots show that the Google\_Harvard-CPF, Covid19Sim-Simulator, and JHUAPL-Bucky models tend to differ from the Covidhub-ensemble model compared to the other models. This seems to align with the results shown in the heat maps above that show that Google\_Harvard-CPF, Covid19Sim-Simulator, and JHUAPL-Bucky tend to have the highest mean Cramer's Distance from the other models. In high count locations, Google\_Harvard-CPF is very different from the ensemble model from February until April. However, in low count locations, JHUAPL-Bucky shows a peak in around March, although this peak is not largely different, as the scale is pretty small.

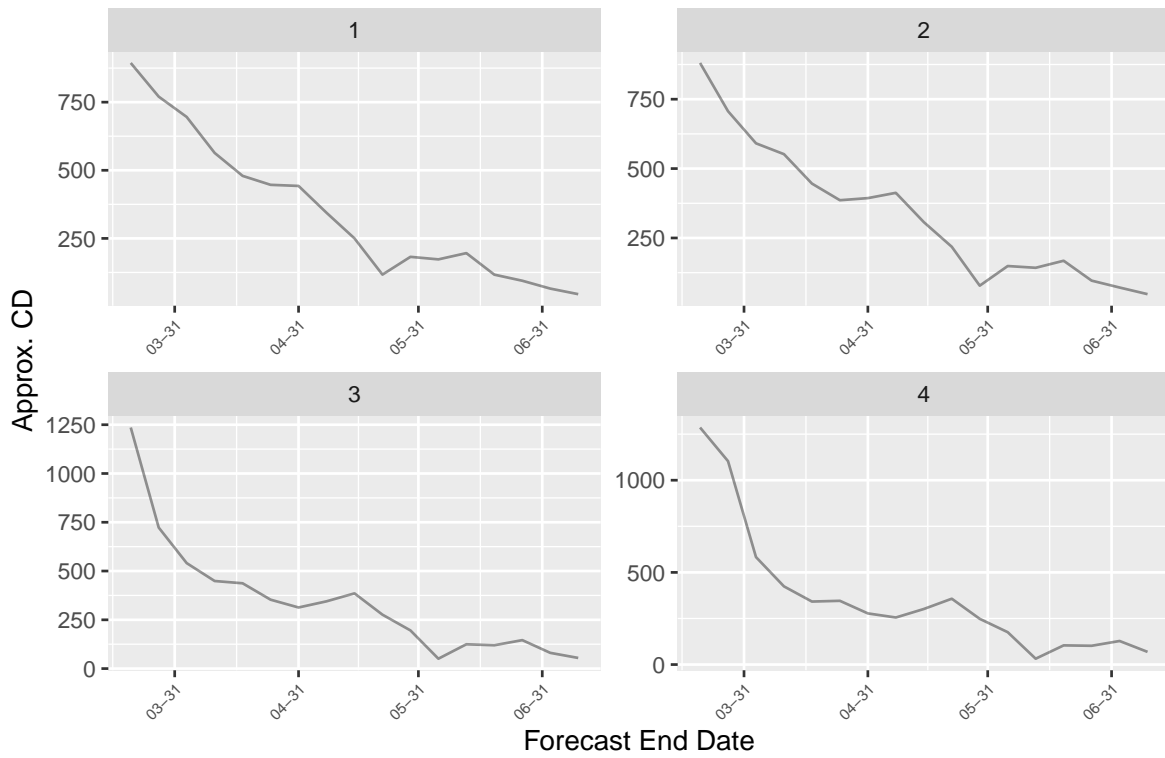


It seems that Google\_Harvard-CPF and Covid19Sim-Simulator's differences from the ensemble model follow

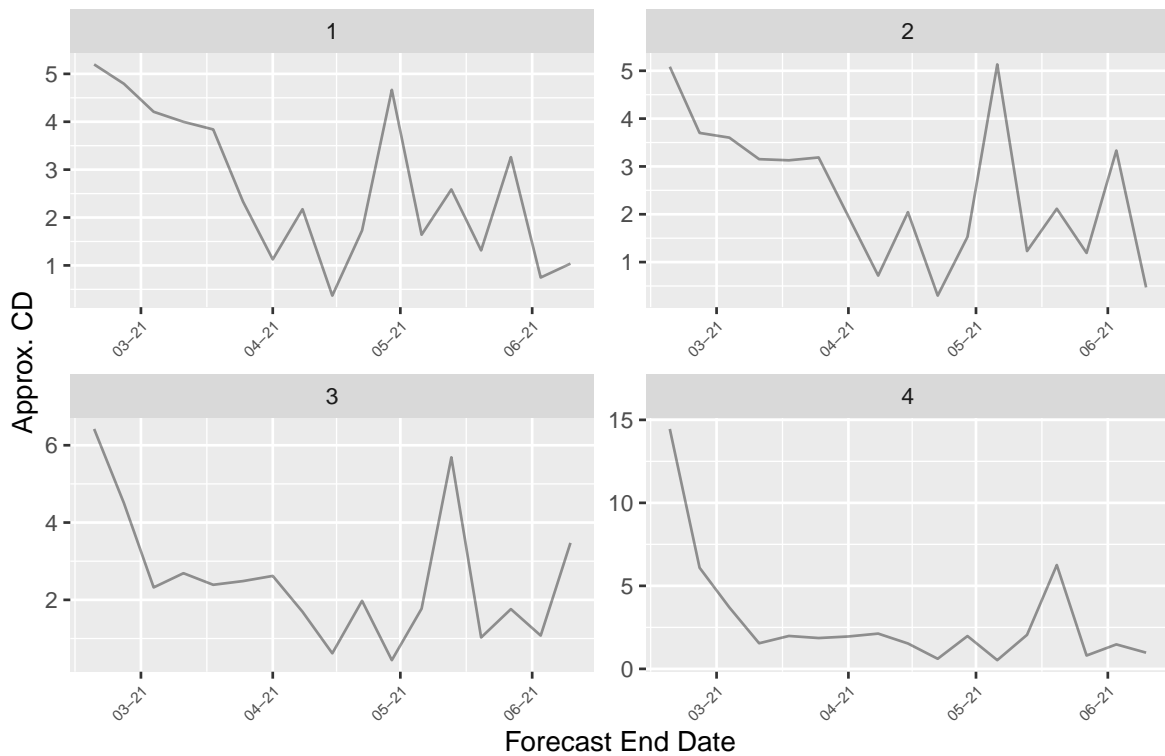


the trends shown by the truth data.

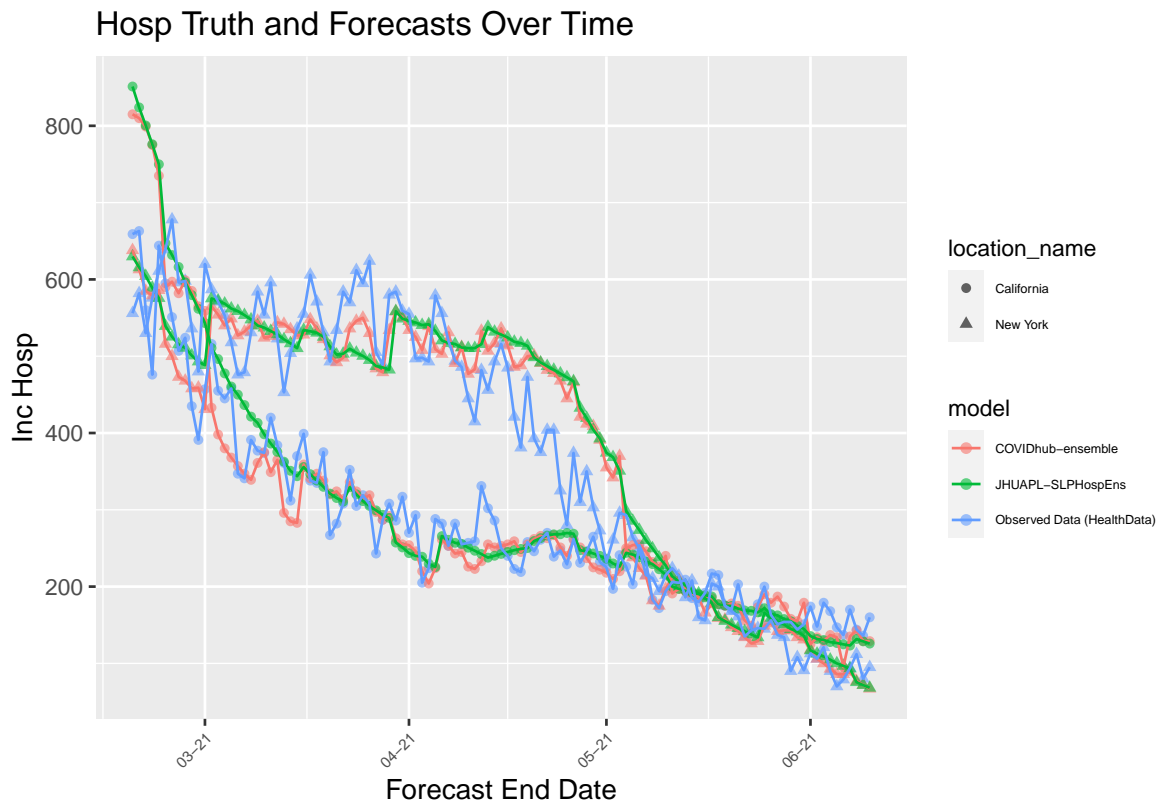
Approx CD over Time – Covid19Sim–Simulator and Google\_Harvard–CPF



Approx CD over Time – Covid19Sim–Simulator and Google\_Harvard–CPF



These plots indicate that the difference between the models at the high count locations seems to shrink over time. Since the low count locations approx CD is so low, it is difficult to draw conclusions from the plots.



We can also cluster the distances using hierarchical clustering.

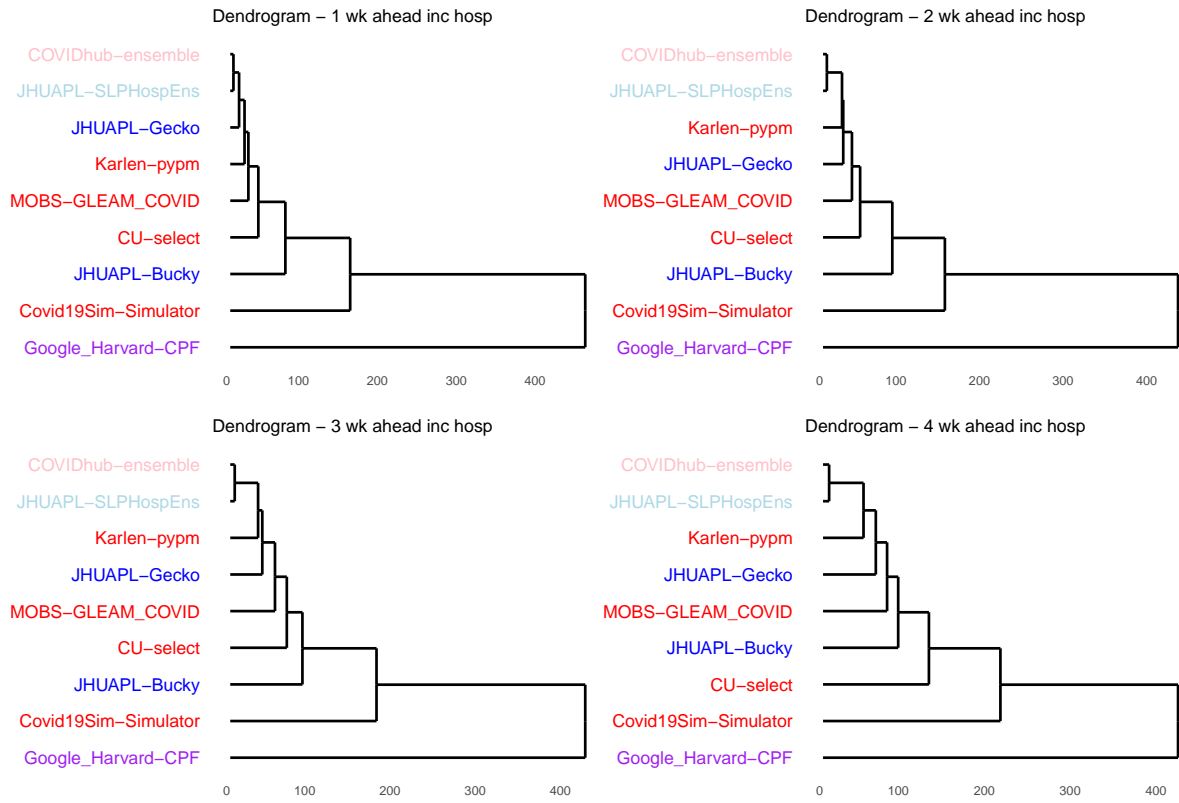


Figure 1: High Hospitalization Count Locations

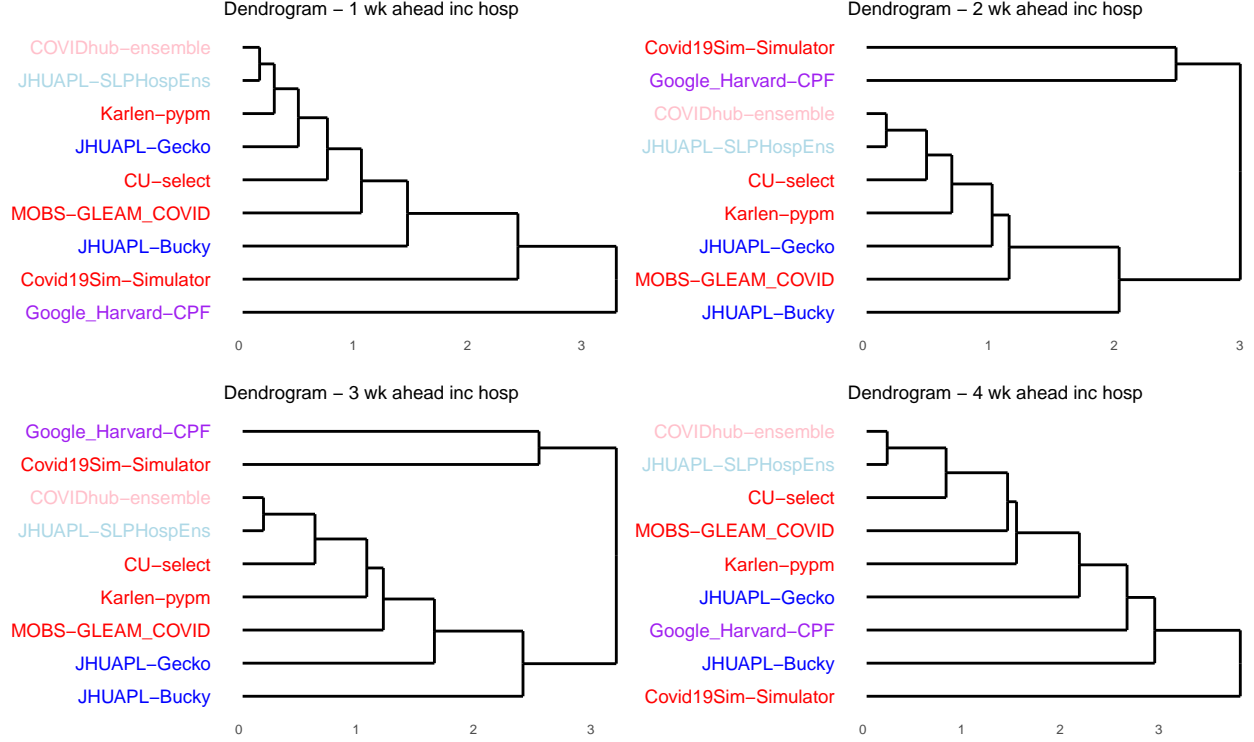


Figure 2: Low Hospitalization Count Locations

For both high count and low count locations, all of the dendrograms show that Google\_Harvard-CPF is generally the most dissimilar to the other models, and substantially so for the high count locations, followed by Covid19Sim-Simulator. However, the scale for differences in Cramer Distance for the low count locations is very small, which may be a result of low hospitalizations, which may explain why Google\_Harvard-CPF and Covid19Sim-Simulator show similar Cramer's Distances for low count locations. We can also see that the ensembles are the most similar among models.

Overall, it seems that Google\_Harvard-CPF is consistently the most dissimilar from the other models by a substantial amount, followed by Covid19Sim-Simulator, across almost all horizons for both high-count and low count regions. It does not seem that models with day of the week effects are more dissimilar from the COVIDhub-ensemble model than models without day of the week effects.