

# Calibration of a regional agent-based travel demand model to simulate the spread of COVID-19

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## Background

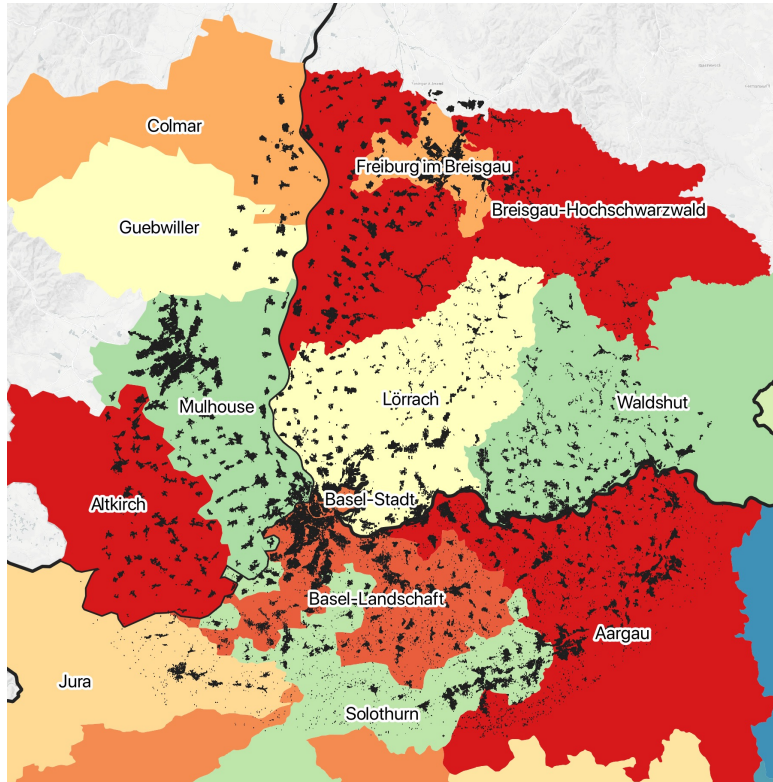
External traffic

Spatial restrictions

Calibration

Next steps

- Increased interest since outbreak of COVID-19 pandemic
- Long history of classical compartmental models
  - Disease spreading as a series of stocks (compartments) and flows
  - Most common version has four compartments: susceptible, exposed, infected, recovered (SEIR)
- Limiting core assumption: Spatially homogeneous population
  - Especially serious limitation when it comes to clustered outbreaks
- Use of an agent-based travel demand model in combination with an epidemiologic extension overcomes this issue
  - Pandemic can be simulated by tracking the interactions of agents and subsequently identifying infections by following their contact network



- MATSim Basel is a trinational agent-based travel demand model in the Greater Basel area
  - Covers the Cantons Basel-Land, Basel Stadt completely and Aargau, Bern, Jura and Solothurn partially
  - Covers part of Baden-Württemberg in Germany and the department Haut-Rhin in France
  - Accounts for cross-border traffic between the three countries
  - Includes external traffic from outside the model area and vice-versa based on traffic counts
- Combination with an epidemiological model to simulate the spread of the pandemic

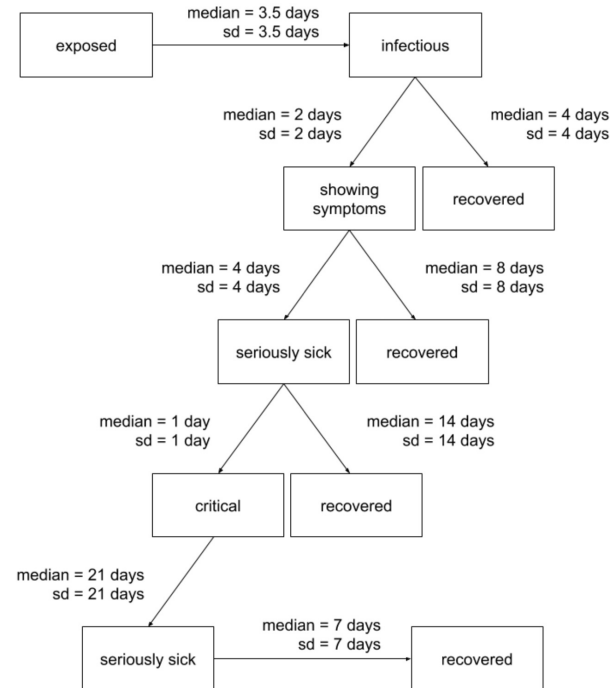
Contact model

- Persons have contact, if they are in the same facility or vehicle at the same time
- Facilities are split into rooms / smaller households to match distributions

Infection model

- Infection probability is dependent on multiple parameters:
  - Theta (calibration parameter)
  - Contact intensity
  - Contact duration
  - Shedding and intake
  - Outdoor factor
  - Susceptibility and infectivity

Progression model\*



\*distributions taken from literature

#### Goals:

- Transport models commonly include external traffic entering and traversing the model area:
  - To be able to predict disease spreading because of disease import, it is necessary that external traffic is disaggregated and interacts with internal traffic
- The trinational nature of the Basel region necessitates :
  - To account for differences in policy measures between countries,
  - And the resulting disease spreading in the different countries
- Present preliminary calibration results

Background

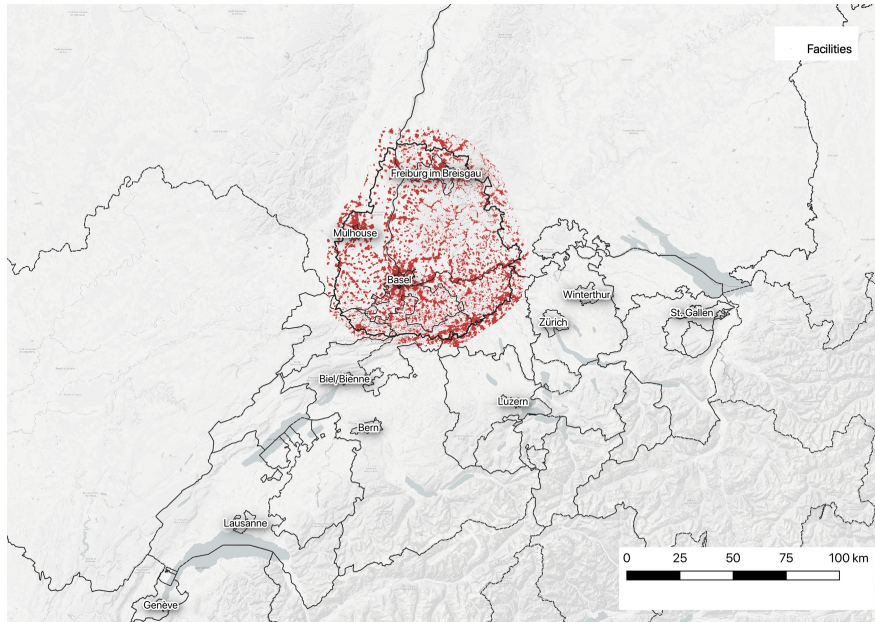
**External traffic**

Spatial restrictions

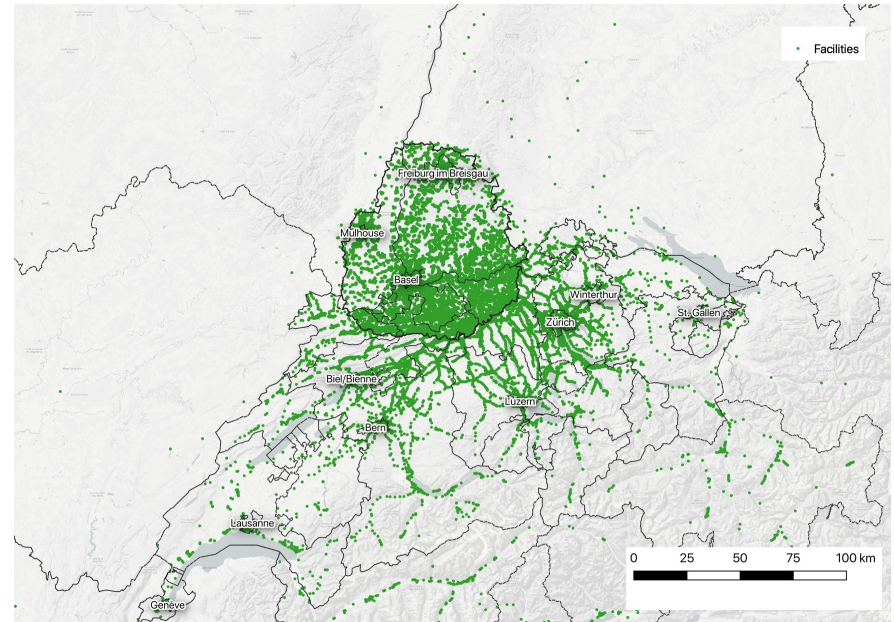
Calibration

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Internal traffic



External traffic



- Merging of facilities of internal and external facilities in MATSIM Basel
- Generation of one-way trips across model border on the basis of traffic counts
- Subdividing into categories by start-time and distance between locations
- Sampling trip with given start time, distance category, travel mode and trip purpose from same subset in the Microcensus (MZMV)
- Replacing current one-way activity plans with return trips to the same facility (i.e., home (outside model area) – destination – home

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```

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      </activity>
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      </leg>
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      </activity>
  </plan>
</person>

```

Background

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## Restrictions in Switzerland

Switzerland had many spatially varying policy measures across cantons

Measures in adjacent countries were mostly much stricter than in Switzerland

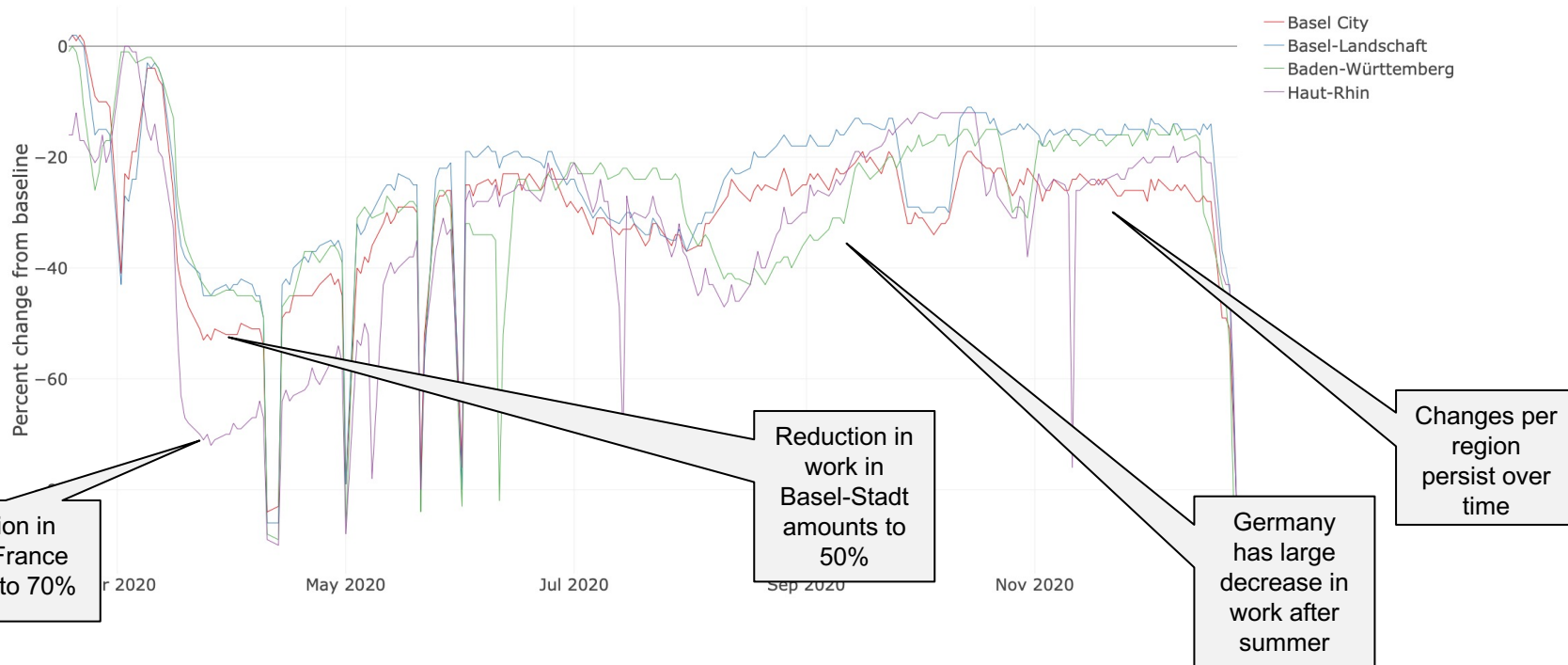
- Residents in different parts of the model area were affected differently by the pandemic
- Different restrictions led to interactions between adjacent cantons / countries

## Restrictions In EpiSim (initially)

- Restrictions in EpiSim result in a reduction or increase of activities as a result of policies.
- These are specified by a start date, number of activities remaining and the concerned activity.
- The reduction can be derived from telco data, Google Mobility reports or other sources.
- In the beginning, these activities were generic and the reduction / increase were assumed to be homogenous across regions and countries.

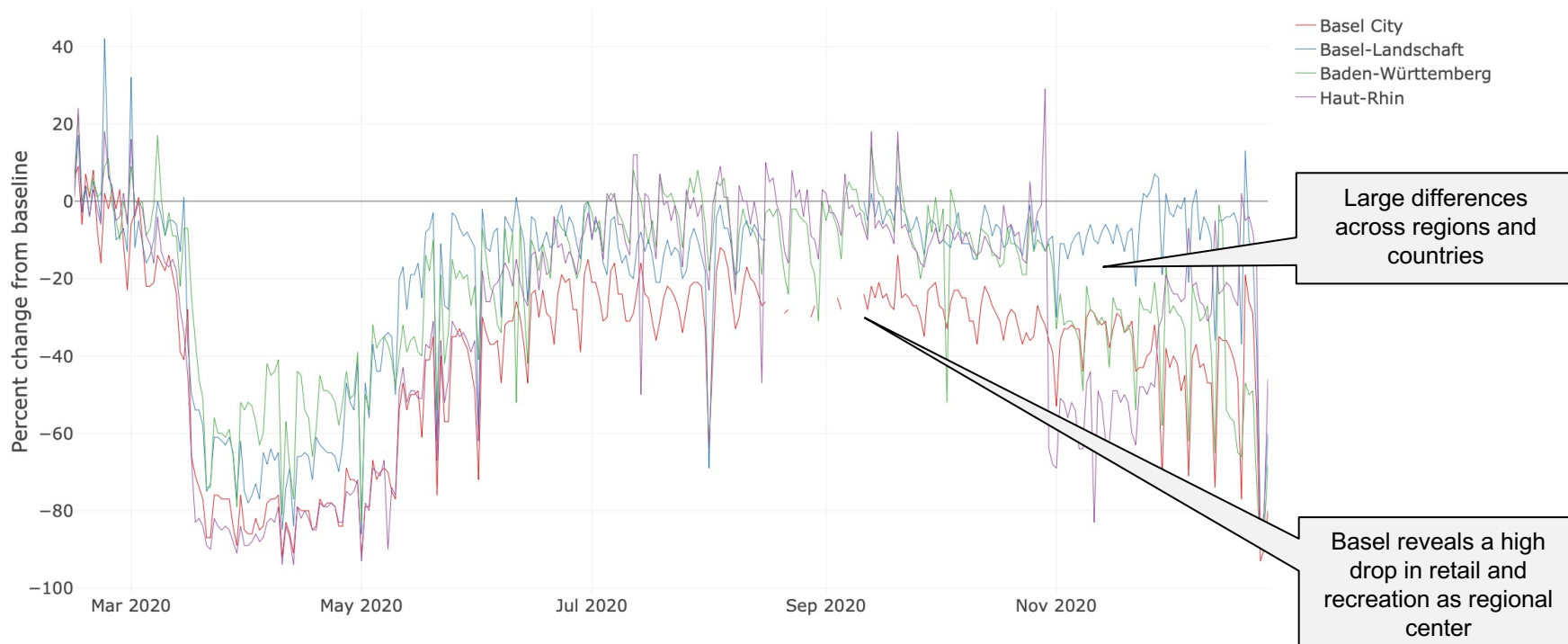
```
restrictions.restrict(LocalDate.parse("2020-03-16"), fraction: 0.1, ...activities: "education_secondary", "education_hi  
.restrict(LocalDate.parse("2020-03-18"), fraction: 0.72, ...activities: "work")  
.restrict(LocalDate.parse("2020-03-18"), fraction: 0.59, ...activities: "shop", "leisure", "other")  
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.restrict(LocalDate.parse("2020-03-25"), fraction: 0.28, ...activities: "shop", "leisure", "other")
```

Percent change from baseline - Workplaces



Source: Google Mobility Reports – selected areas & only weekdays

Percent change from baseline - Retail and Recreation



Source: Google Mobility Reports – selected areas & only weekdays

### Solution:

Add geographic boundary to the MATSIM facilities and the restrictions

- E.g., region, district (or other spatial level)

### Procedure:

Applicability of a restriction on a given event is assessed by checking the region of the facility

- Requires additional attribute for facilities

Restrictions are specified per region, i.e., per desired spatial subdivision

- Requires separate restriction files for each spatial level in the model

### Advantages

- Activities are not changed
- The required structural changes in EpiSim are already implemented
- Approach allows to implement a multitude of spatially varying policies and restrictions:
  - Masks
  - Tracing
  - Reduction of activities
  - Reduction of disease import
  - Closing of large events (sports, etc.)
  - Relocation of activities (inside → outside)

→ Policies and restrictions can be specific to certain activity purposes and spatial levels

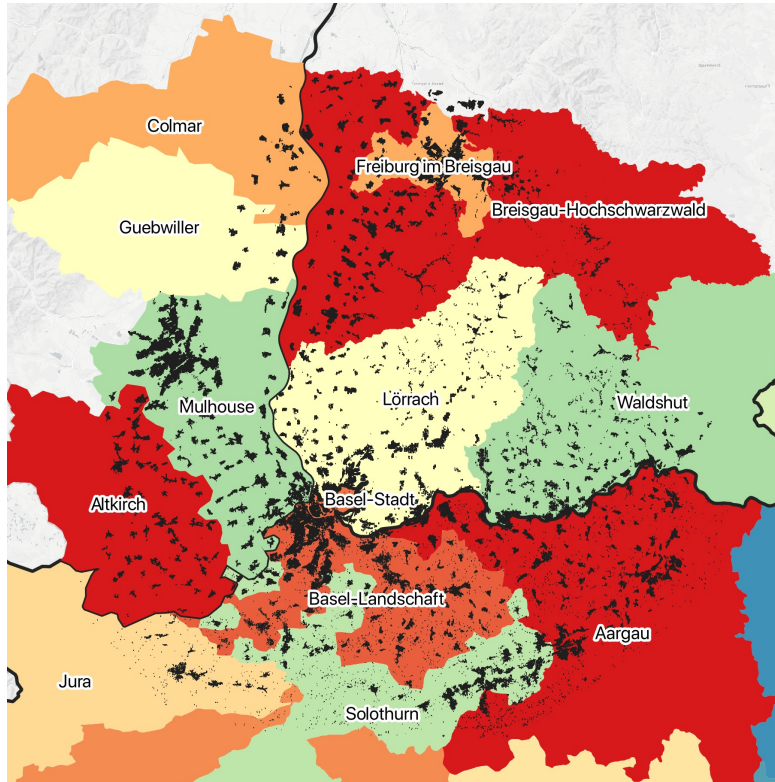
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Model area with individual agents represented as **dots**

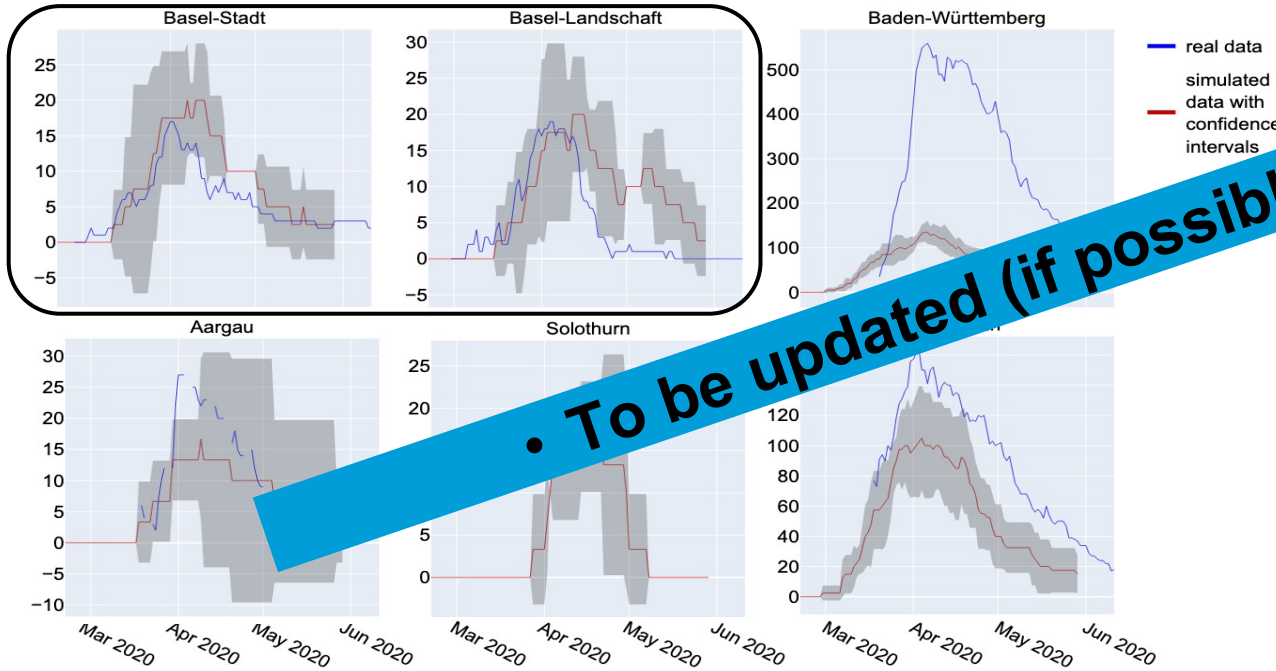
### Recursively updating to match infections

1. **Theta:** To match initial increase in first 3-4 weeks of pandemic without measures in place
2. **Initial infections:** To match initial number of infections in first 3 months of pandemic
3. **Imported cases:** Calibration after first lockdown
4. Contact intensity
5. Hospital factor
6. **Restrictions:** Percentage of people still going to work

### With:

- CH: Cantonal level
  - Cantons that are fully covered in model area (BS, BL)
  - Cantons that are partially covered with scaling (JU, SO, AR)
- DE: Landkreis level
  - Landkreise that are fully covered (Lörrach)
  - Downscaling of other Landkreise to included municipalities
- FR: Departmental level
  - Downscaling data from Haut-Rhin to included municipalities

Cantons Critical (ICU)



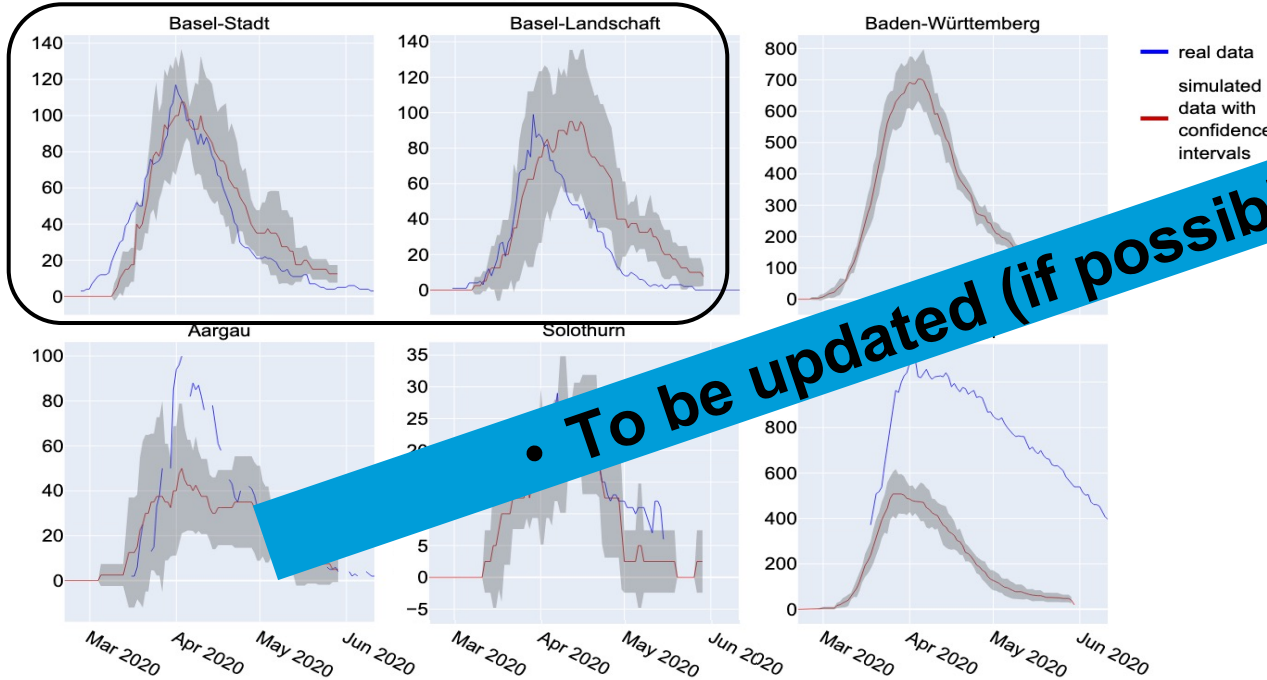
Cantons require lower number of initial infections compared to Switzerland model

Two reasons:

- Incomplete coverage of some of the cantons
- Influence of Haut-Rhin and Baden-Württemberg

No complete sample of MATSim Basel in Baden-Württemberg, Haut-Rhin, Aargau and Solothurn

Cantons Seriously Sick (Hospitalized)



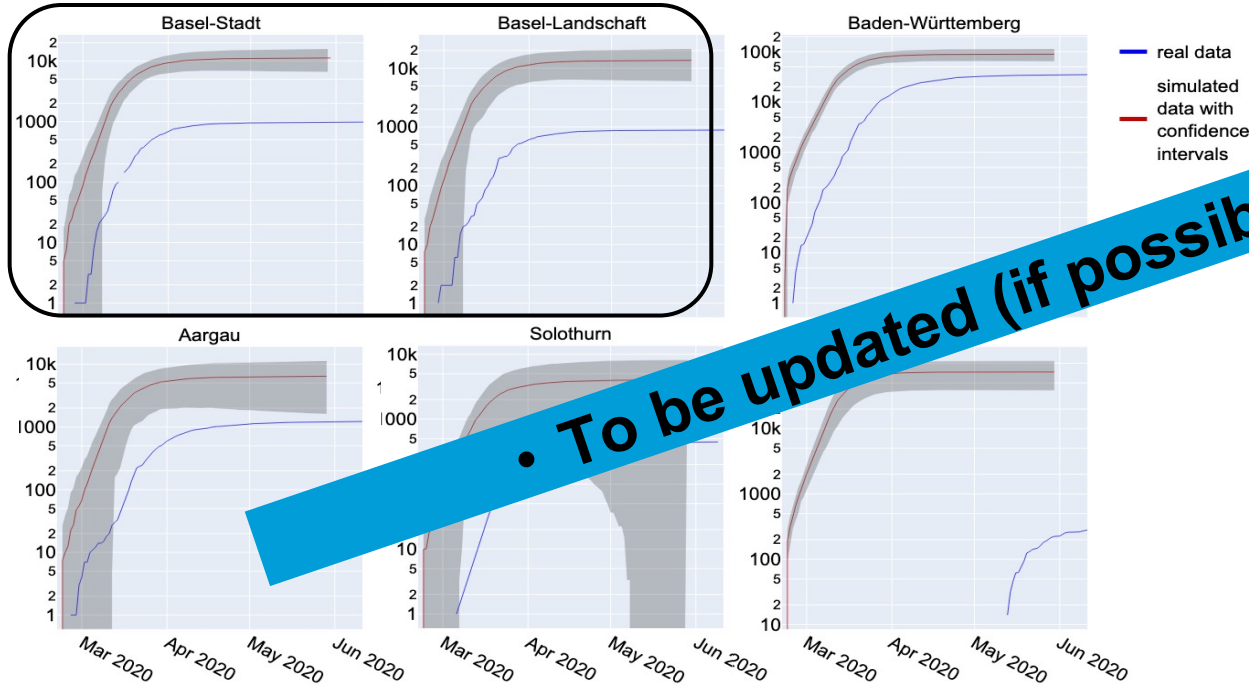
- Good fit for Swiss cantons, especially Basel-Stadt and Basel-Landschaft (also Solothurn)

Real figures for Haut-Rhin and Baden-Württemberg have to be scaled down according to coverage or a different spatial resolution has to be used

No complete sample of MATSim Basel in Baden-Württemberg, Haut-Rhin, Aargau and Solothurn

No hospital figures for Baden-Württemberg

Cantons Cumulative Contagious



Higher numbers than reported

- Higher numbers than reported
- Unknown cases at the beginning → reported cases are lower than real cases
- At the same time cases for "incomplete" cantons have to be lower due to limited coverage
- Interaction of case numbers between cantons

No complete sample of MATSim Basel in Baden-Württemberg, Haut-Rhin, Aargau and Solothurn

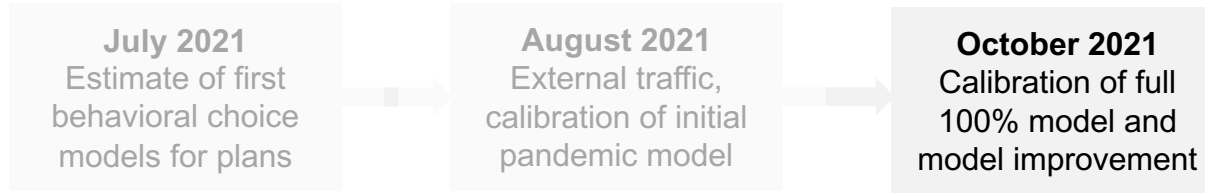
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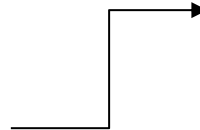
**Next steps**



Refinement of spatial restrictions and definition of additional policy measures



Final calibration of model on different spatial levels



**Potential improvements:**

Considering the region of residence with hospital / ICU assignment instead of only including the closest hospital

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