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Matematycznego i Komputerowego
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How it is done – large scale geographical microsimulation model for pandemics

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Formal cooperation

- Membership in the advisory group for Ministry of Health Adam Niedzielski (weekly meetings)
- Trusted advisor of the Chancellery of Prime Minister (Centre for Strategic Analysis)
- ICM Forecasts are plugged in the GisCOVID-19 system led by Government **Centre** for Security
- Collaboration with Warsaw authorities.

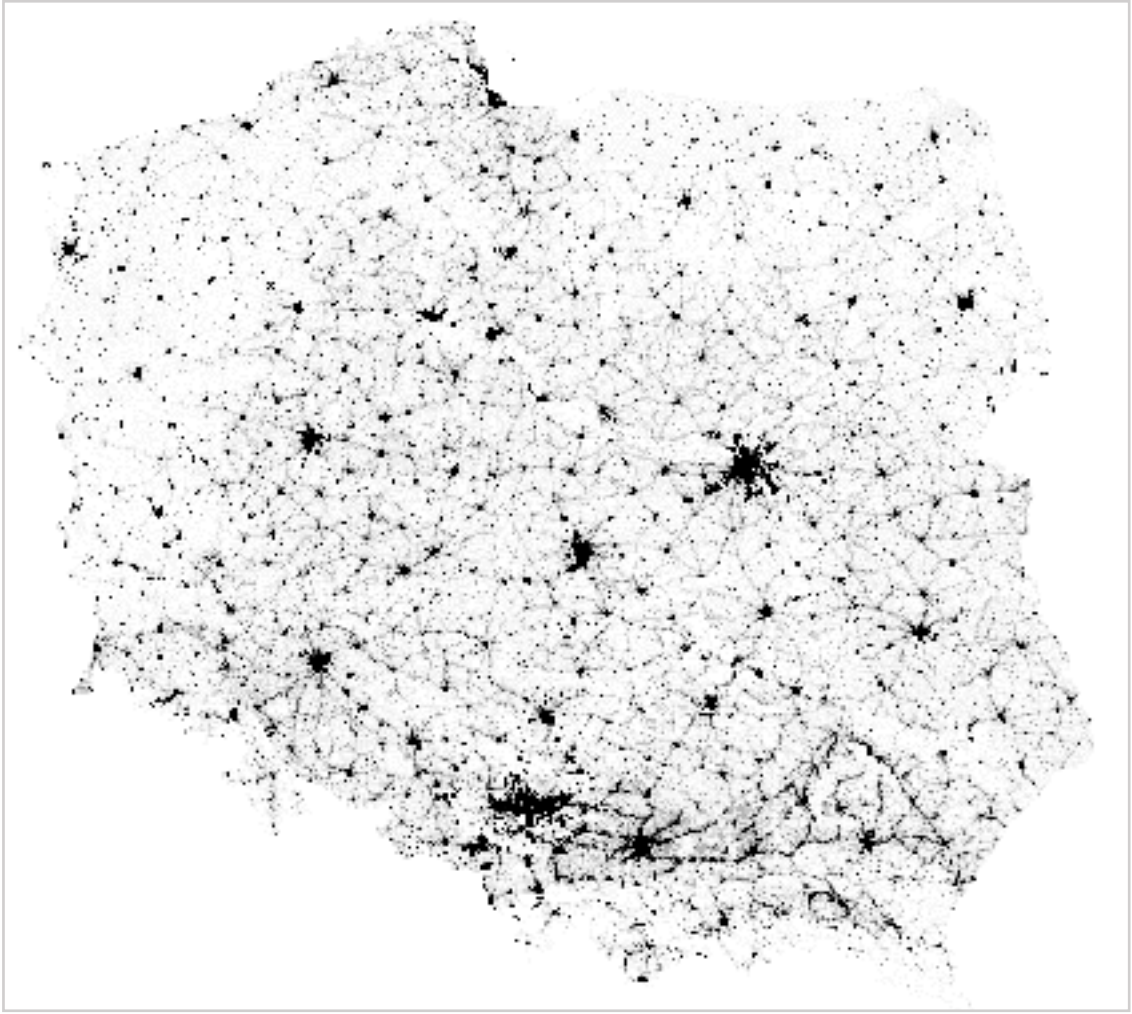
ICM UW epidemiological model

- Agent-based model (microsimulation model),
- Idea of the model: detailed representation of the demographic and sociological structure of Poland combined with the probabilities of virus transmission.

- Geo-localisation of each agent (a person)
  An agent is assigned (permanently or temporally) to a context,
- Contexts: representations of possible contact spots: kindergartens, households, schools, workplaces, etc…
- Transportation module
  trains, cars, daily commutation.

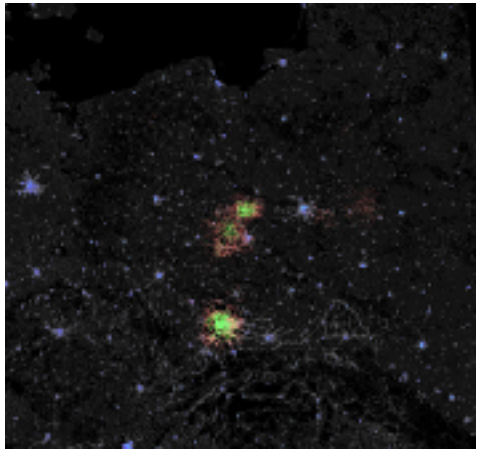
Our model is geo-referential:

Based on the population density map:



Reminder: ICM epidemic model is geo-referential

4 IV



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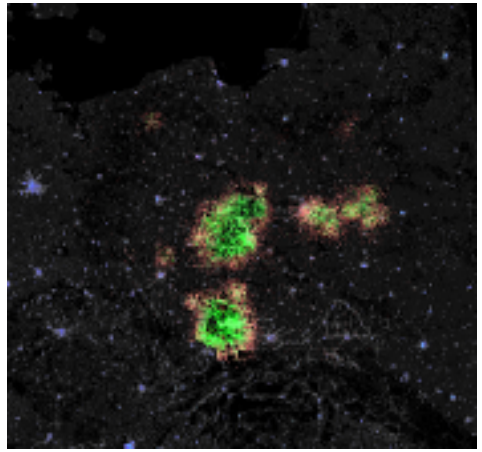

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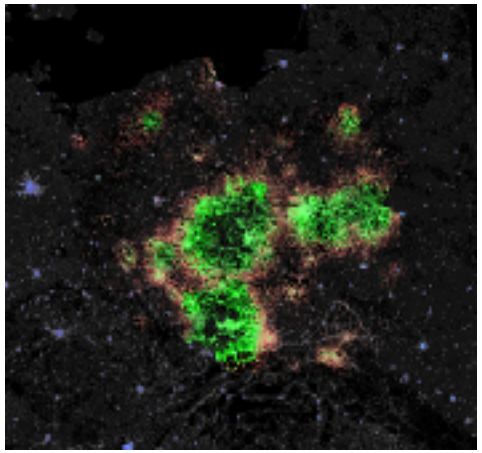

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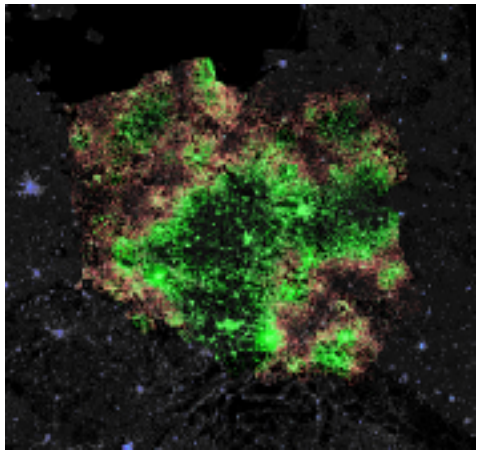

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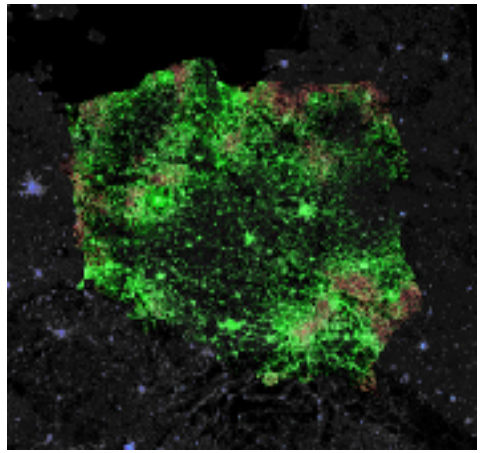
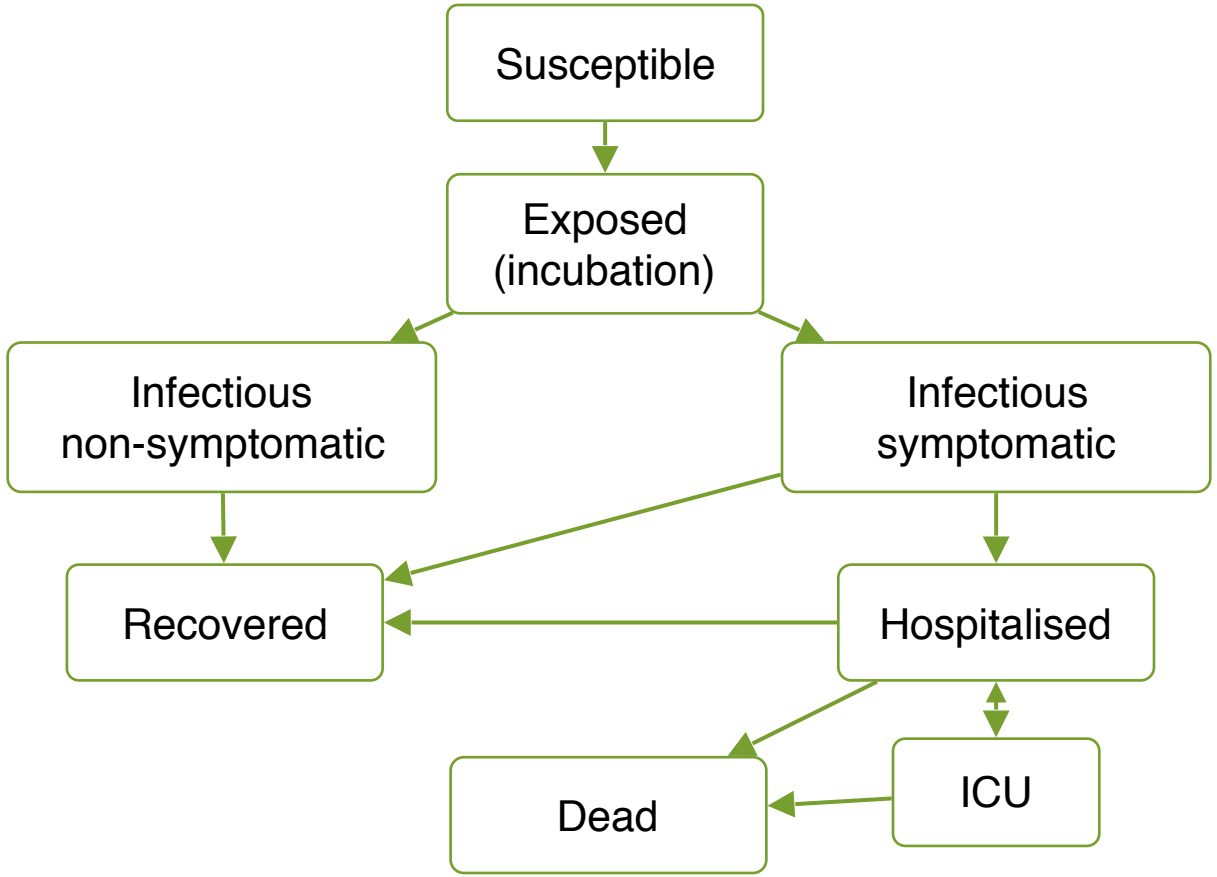


10 VII

Shockwave

Agent Based Model is also an (extended) SEIR model

Possible states of an agent



- The times of being in a given state can be approximated by means or given as distributions (e.g. gamma distr.)
- The probabilities of the transmission among states are given in a form of transmission matrix

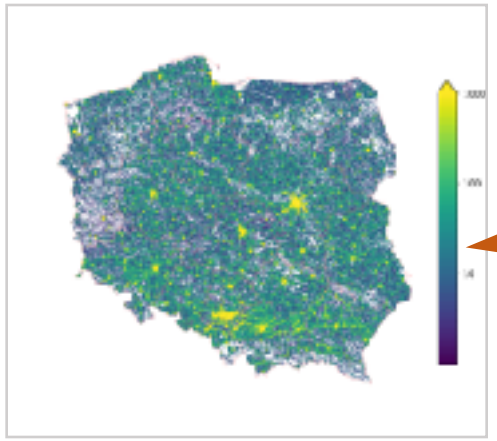
Infection probability:

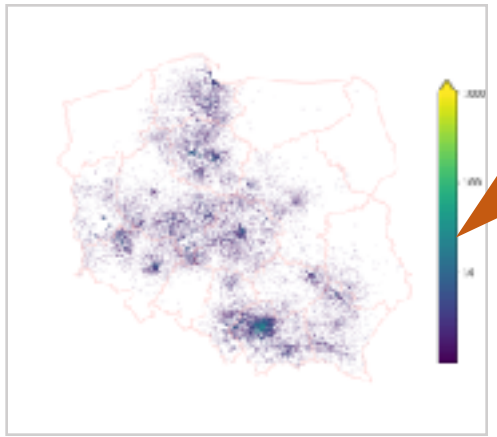
- Depends on the number of infected people met in a given context and the specific weight of the context.

$$p^j = 1 - \exp\left(-\alpha\beta_{hh} I^j_{hh} - \alpha \sum_i^{contexts} \beta_i \frac{f I^j_i}{1-(1-f) I^j_i}\right)$$

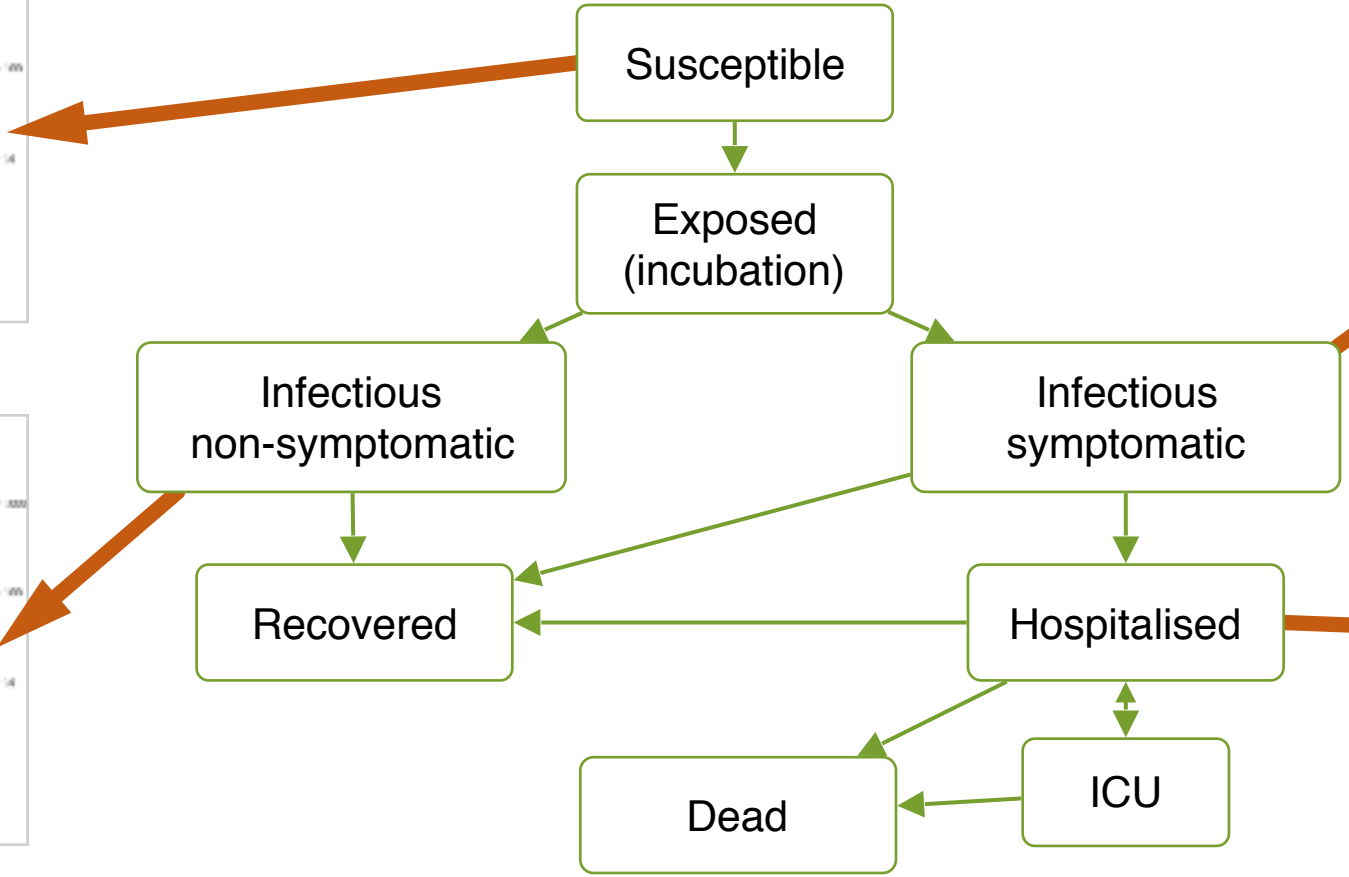
f – fraction of people not staying at home when infected
α– the relative infectivity of the virus
β– context's weights
I – current infectivity of the context (as the whole).

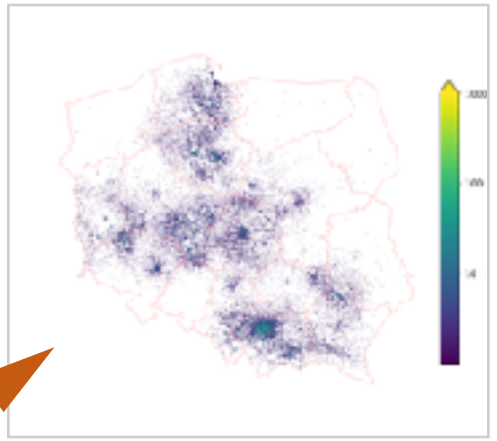
Agent states can be visualised on the map

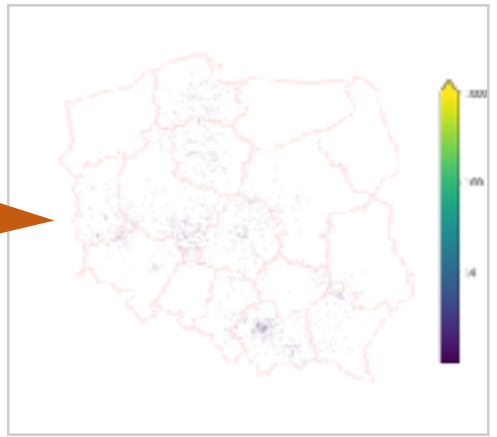




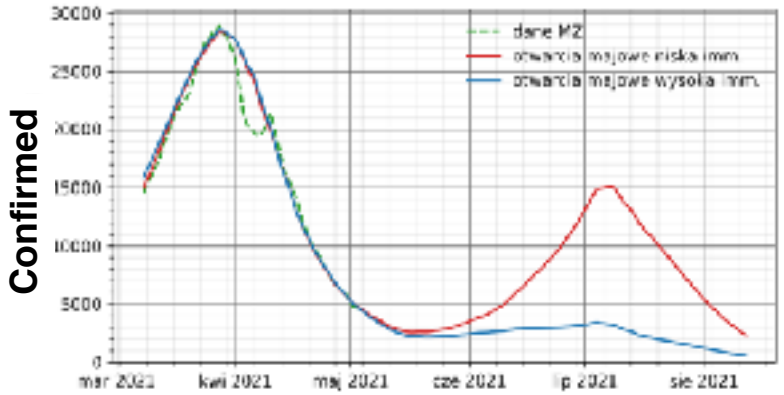
Possible states of an agent

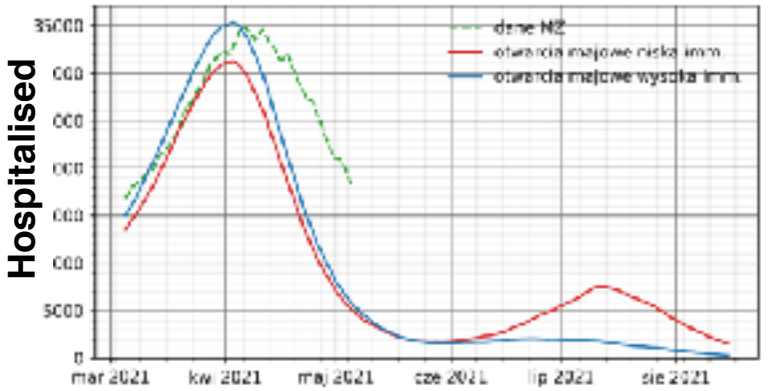


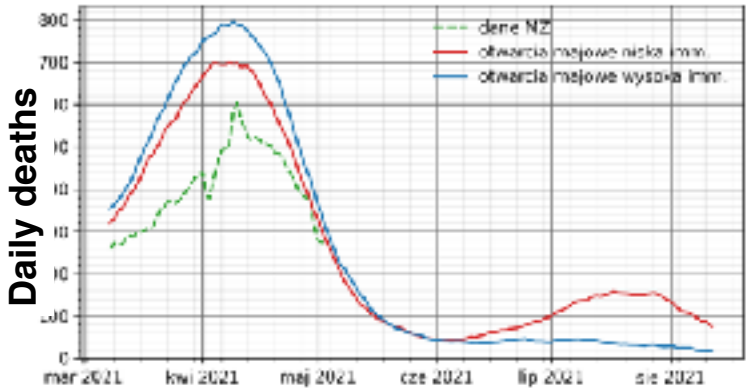


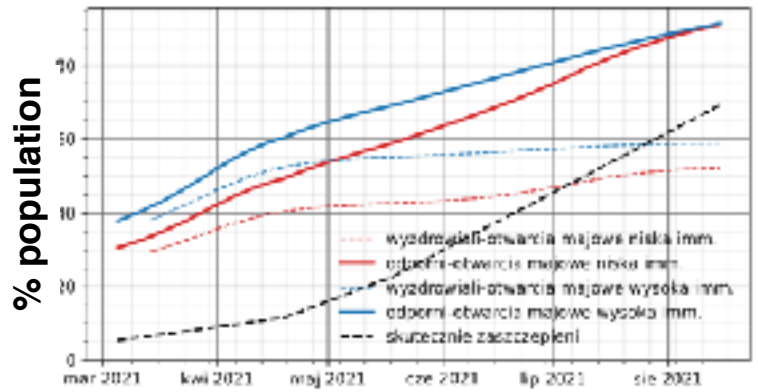


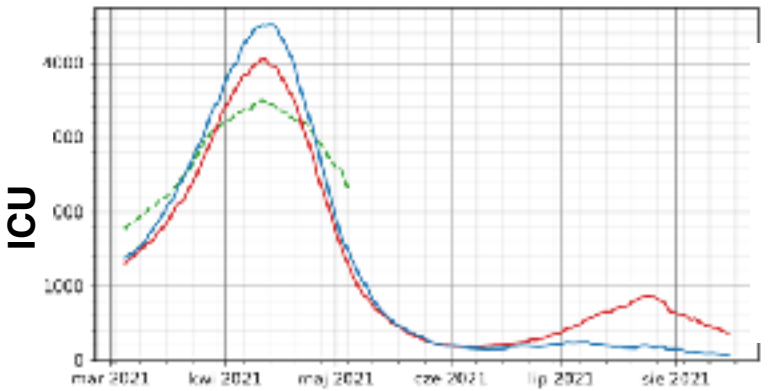
Current forecast (with variants)

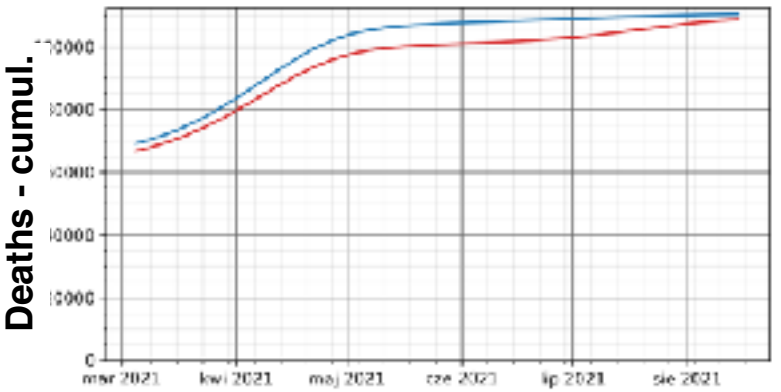




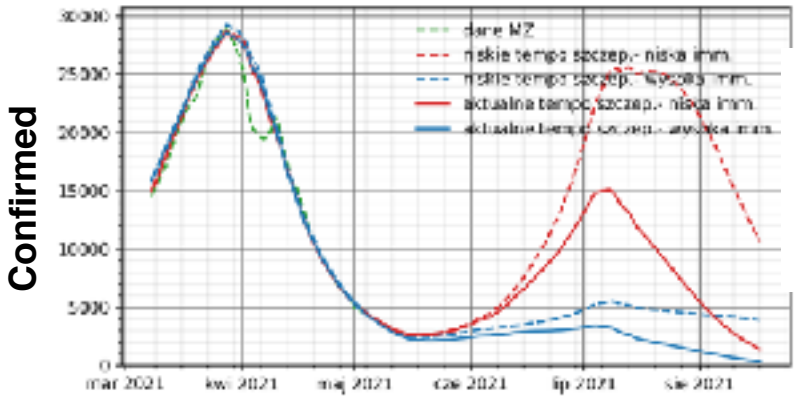


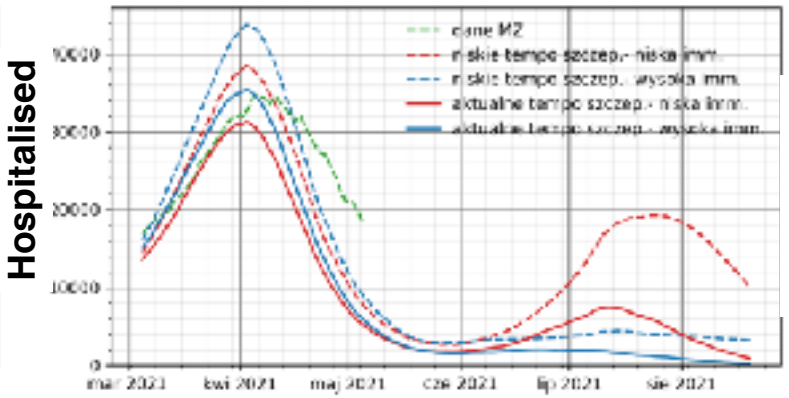


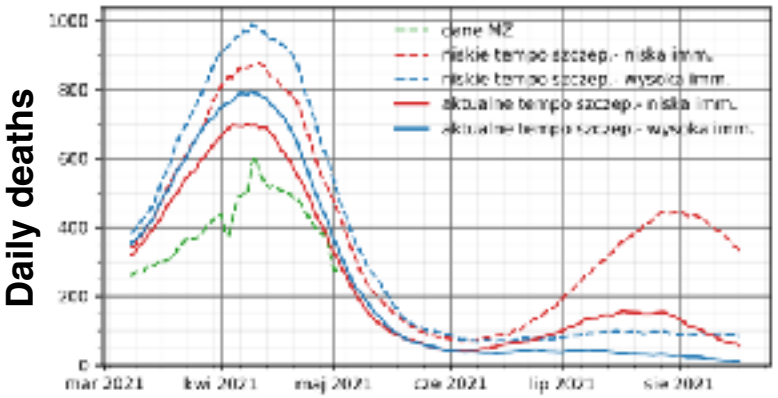


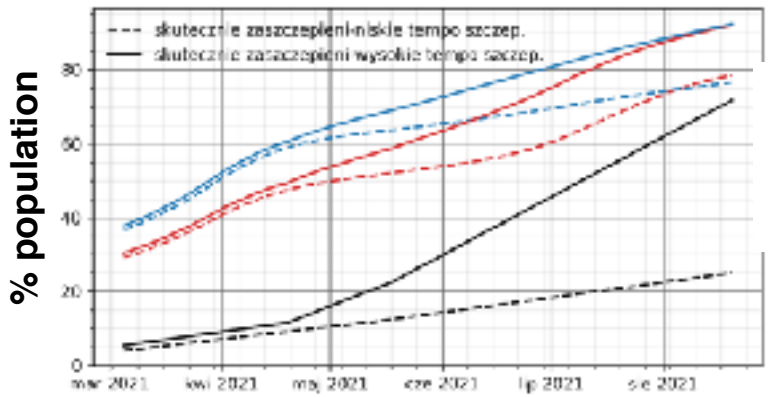


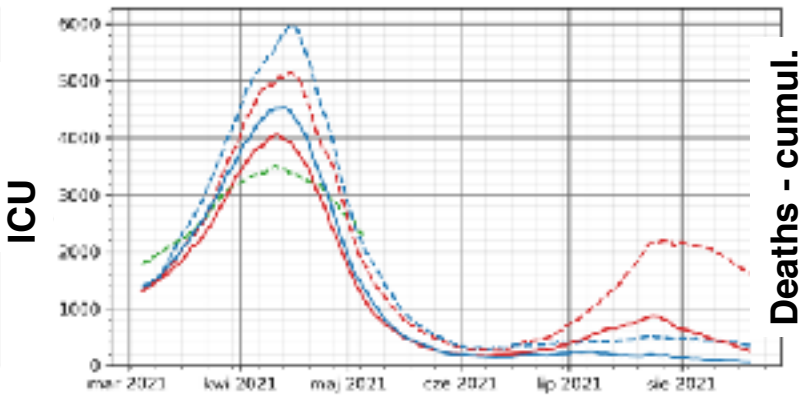
Hypothetical scenarios - What if?
What if vaccinations would be slower?

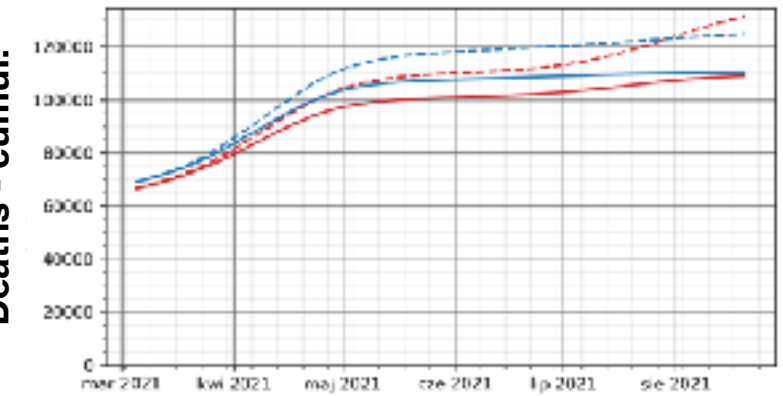




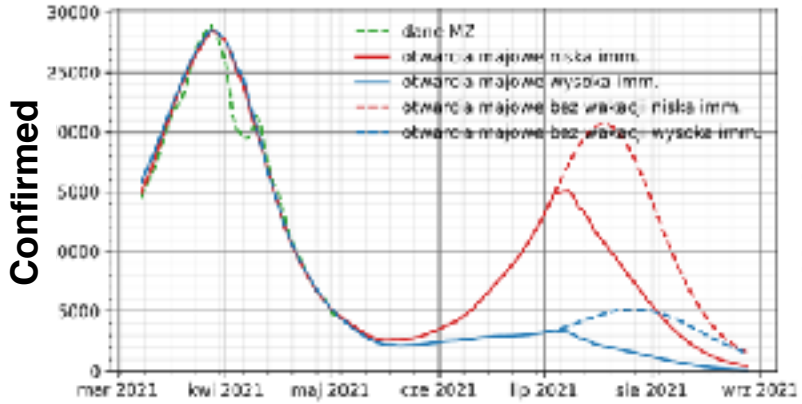


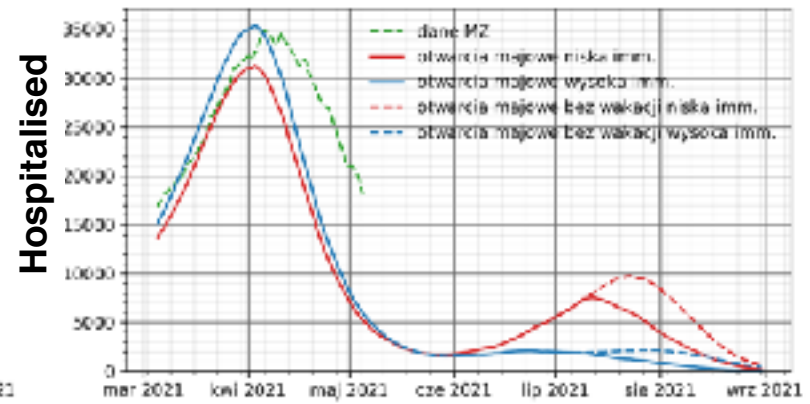


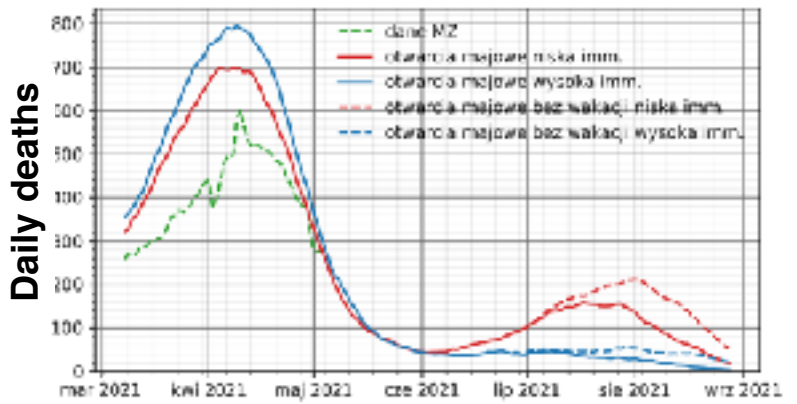


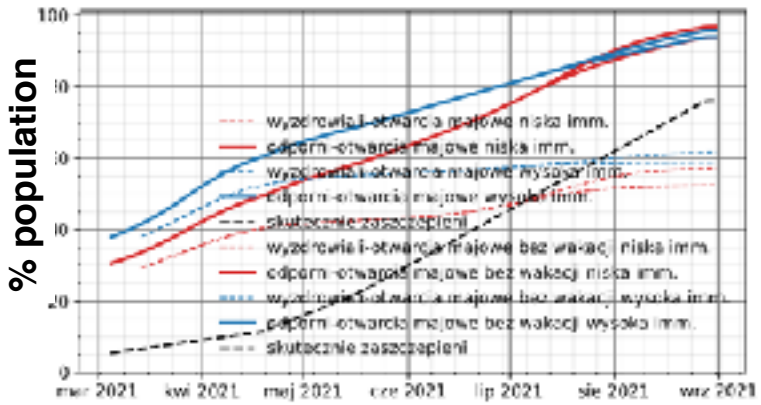


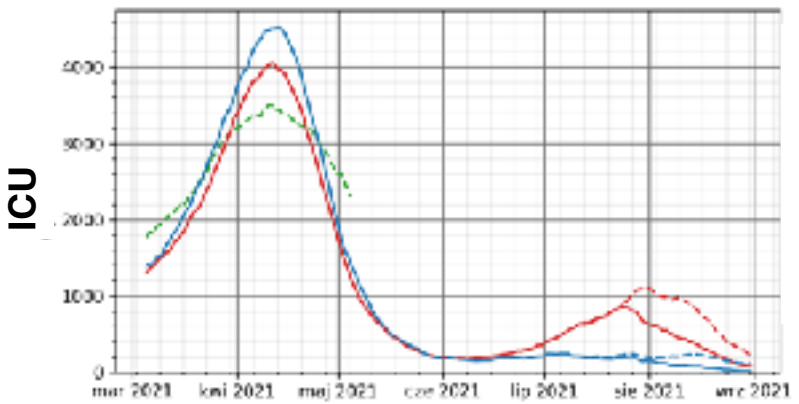
Hypothetical scenarios - What if?
What if schools would not be closed on 30 Jun

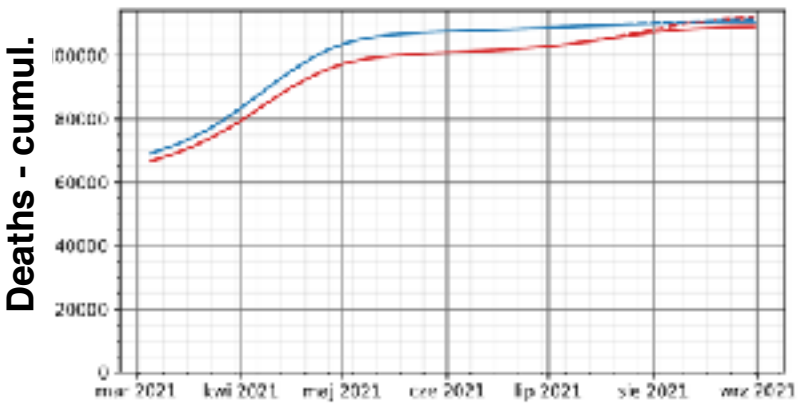












The greatest challange: the data

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(quasi) Stationary data

Virtual society reconstruction
(stationary contact structure)

- Households localisation and size distribution
- Schools, workplaces, etc…
- Public places (restaurants, sport, shopping)

Universal data

Medical:

- Course of the disease (e.g length of the incubation period)
- Hospitalisation rate
- Fatality rate

Virological:

- Transmissibility in various contacts
- Morbidity of virus variants
- Re-infection probability
- …

Country specific data

Epidemiological:

- Statistics: confirmed, quarantined, death, etc…
- Administrative interventions

People's behavioural changes

- Visits in households
- Mobility
- Sanitary habits

Calibration procedure

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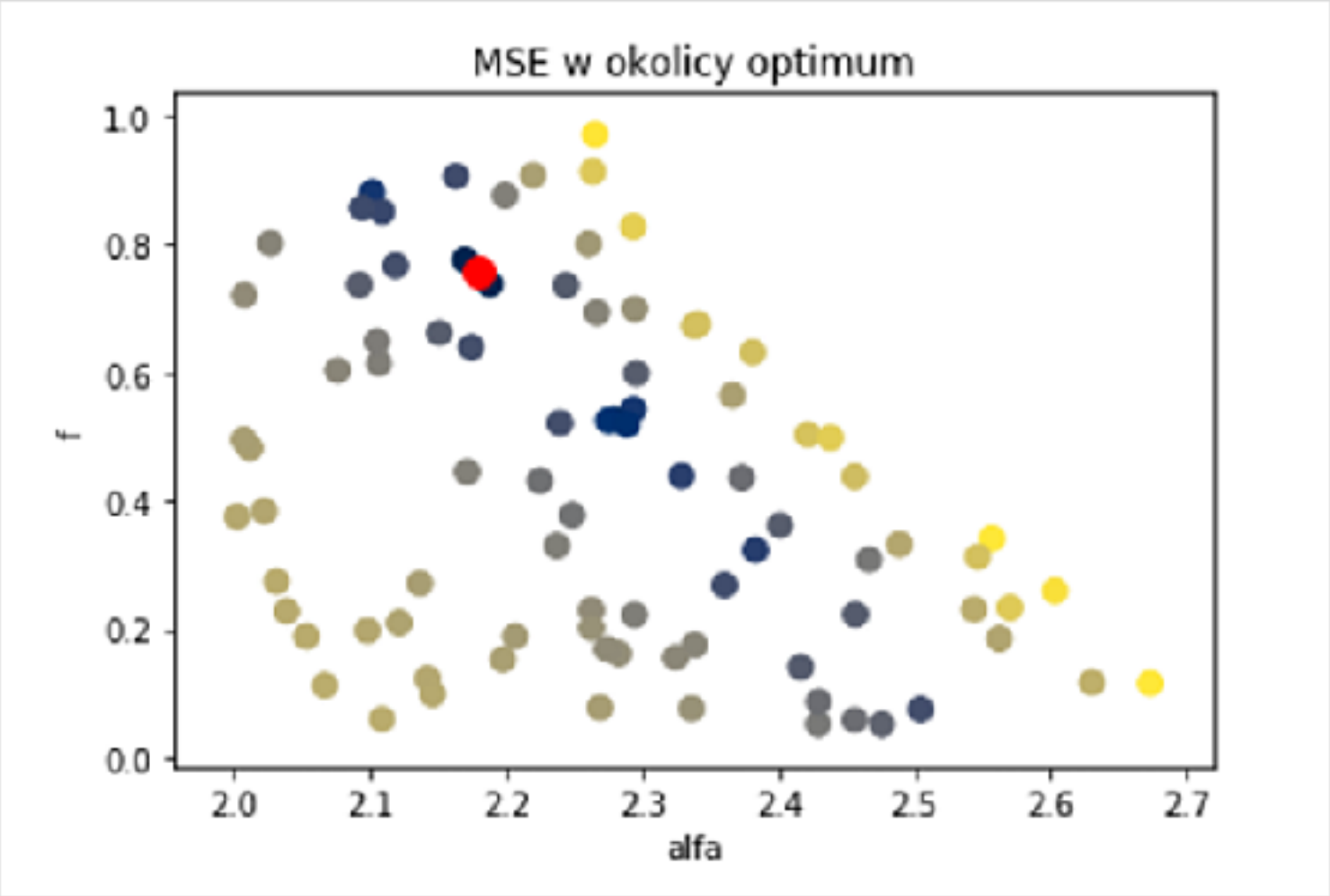
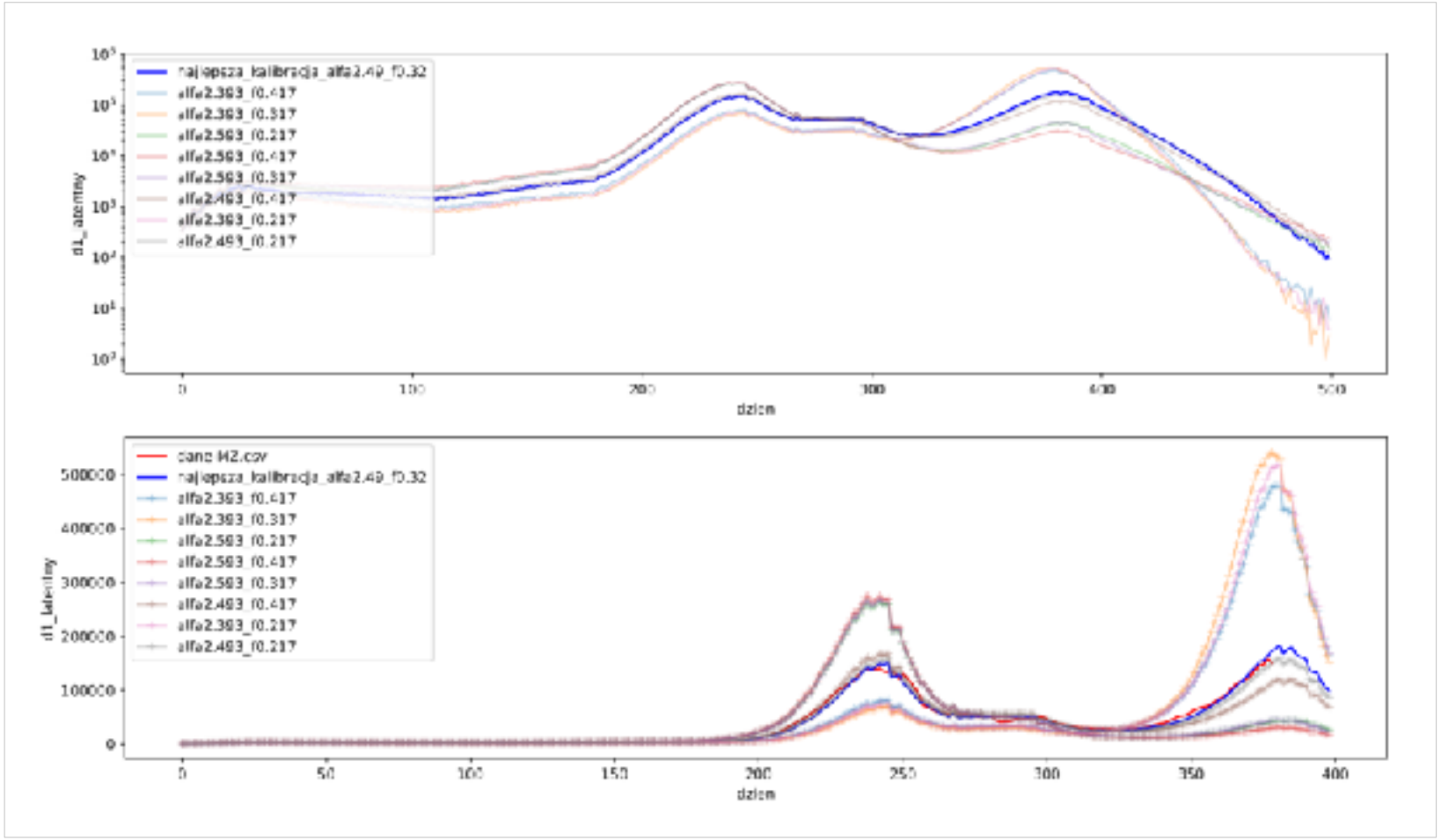
- Seeding of ‘patients zero’ (based on first reported cases on powiat level),
- State transition matrix estimation (Manual, Data driven, expert knowledge),
- Calibration of infectiousness (α) and ratio of symptomatic leaving home (f) (Bayesian Optimization),
- Calibration of the contexts weights (educated guess, expert knowledge).

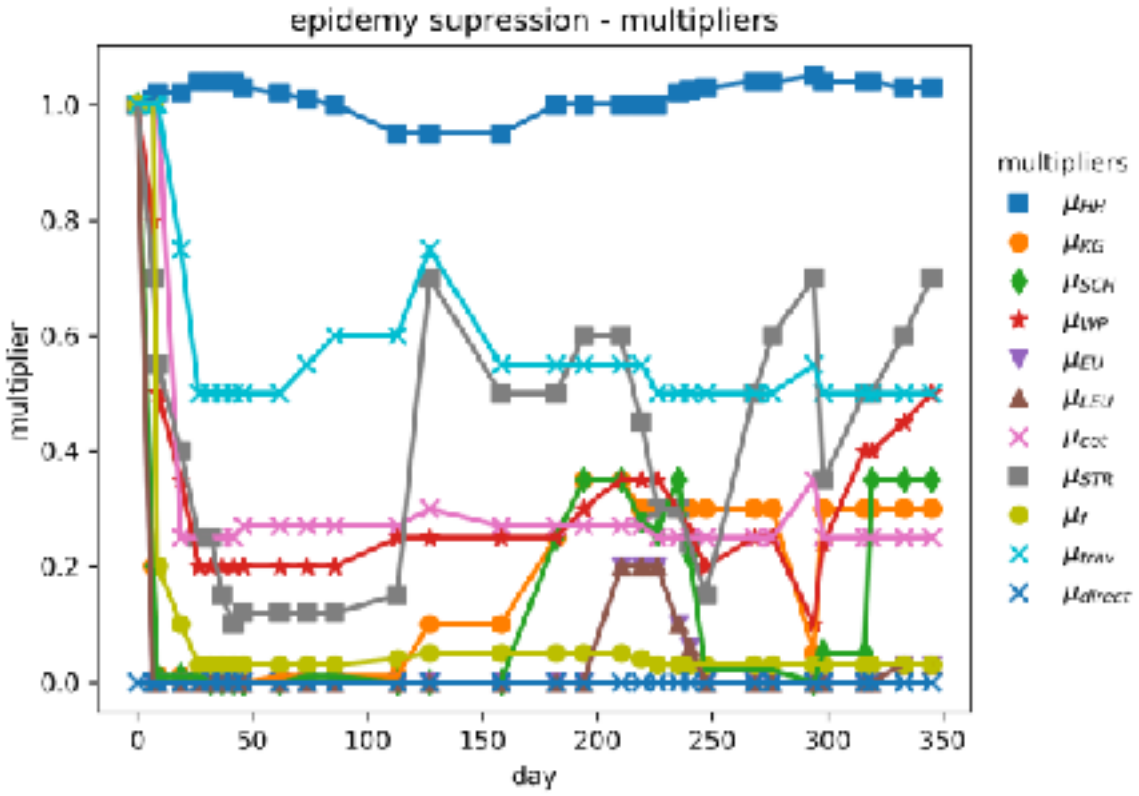
Calibration of α (infectiousness) and f (willingness to leave home)

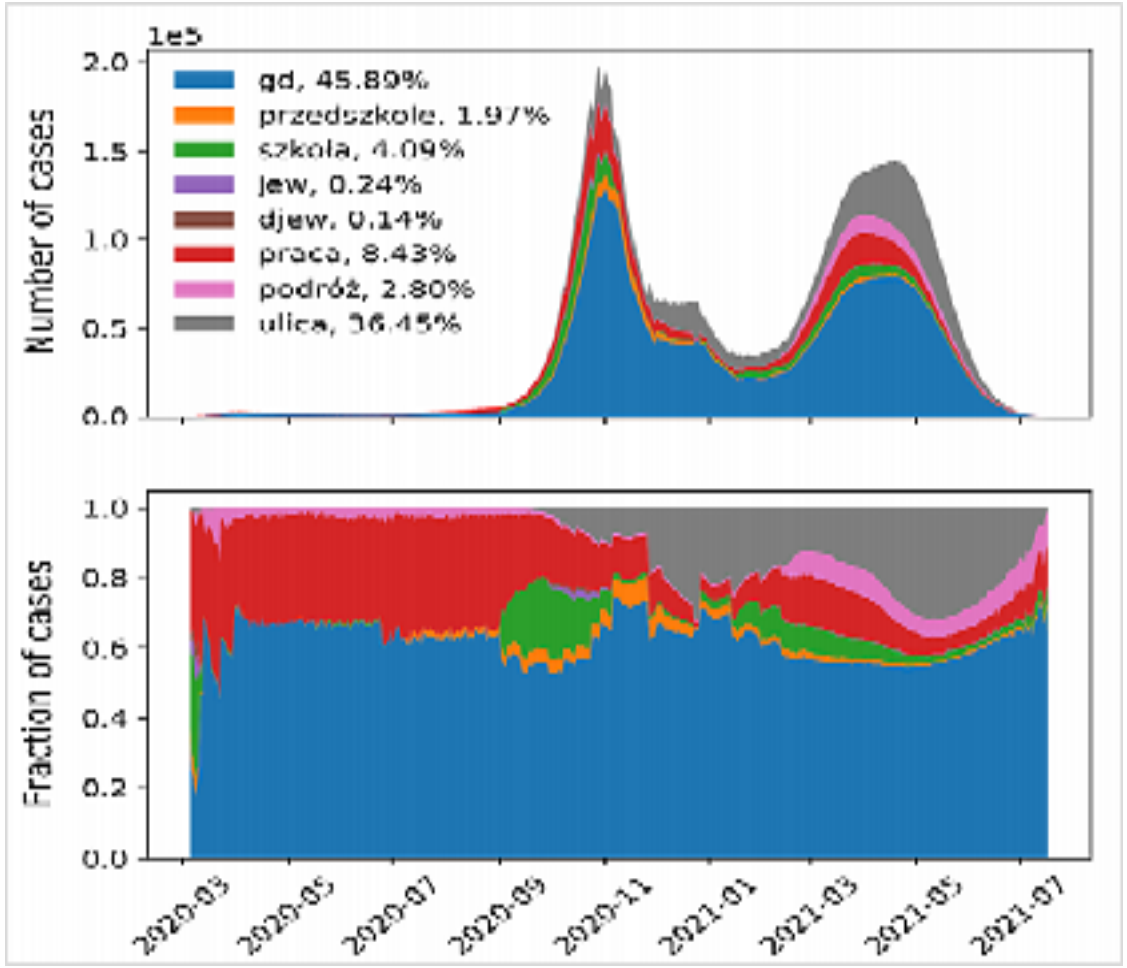


Calibration of α (infectiousness) and f (willingness to leave home)

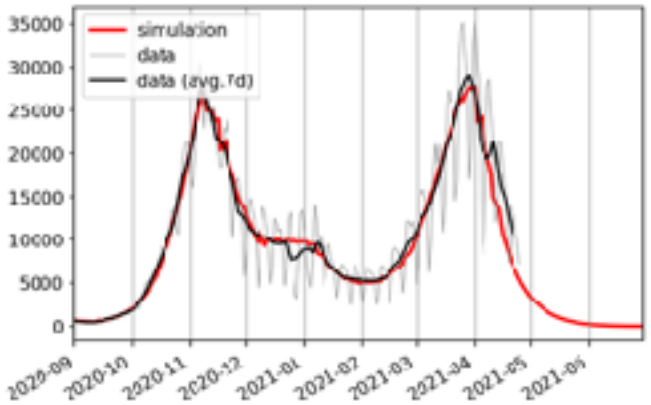


Calibration of contexts weights



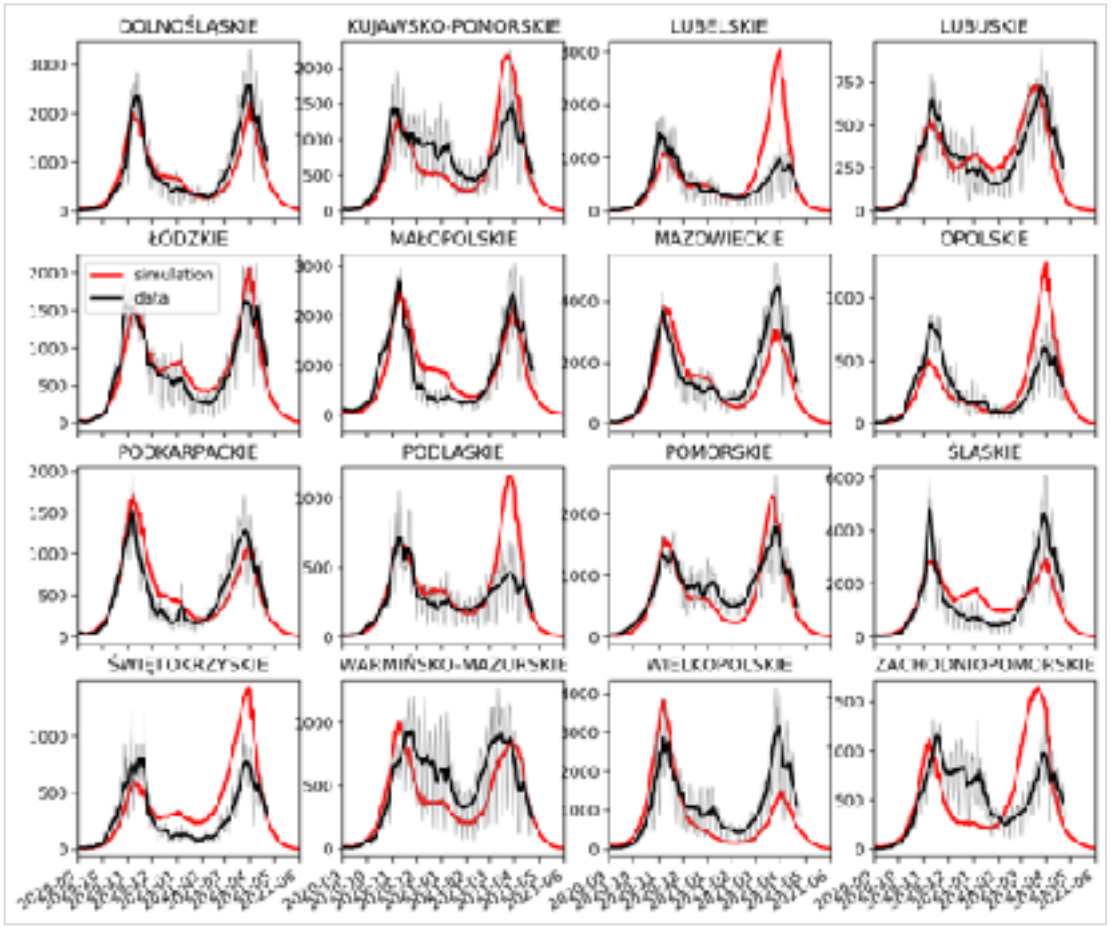


Voivodeships



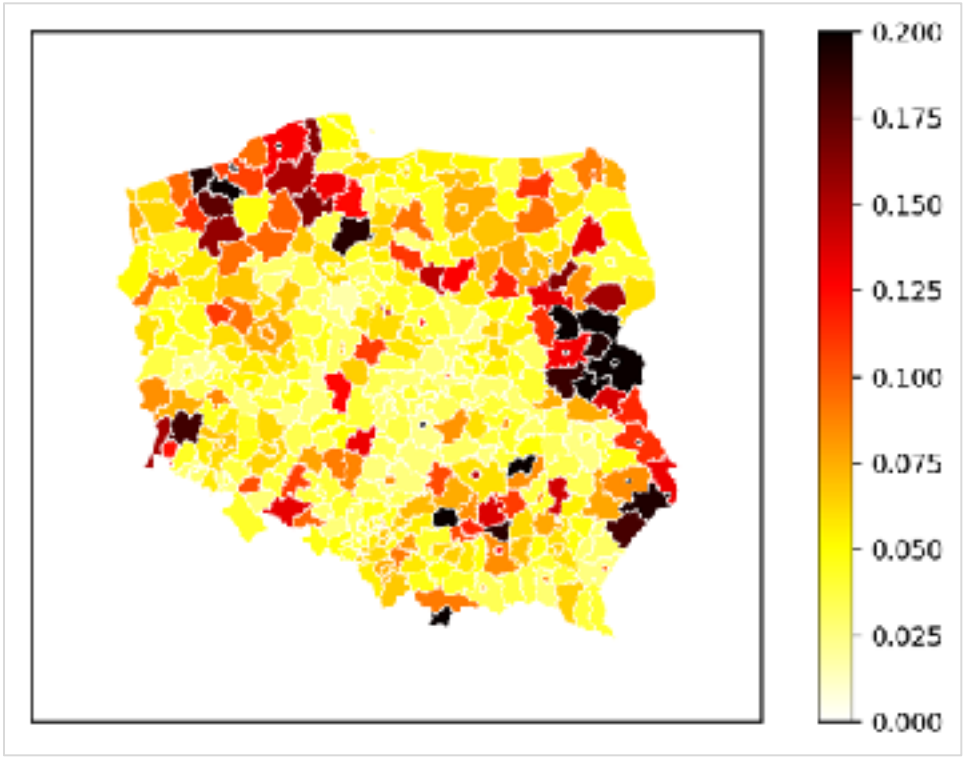
- No regional fitting, just plot of aggregated numbers
- Relatively good agreement at voivodeship level

Registered new cases

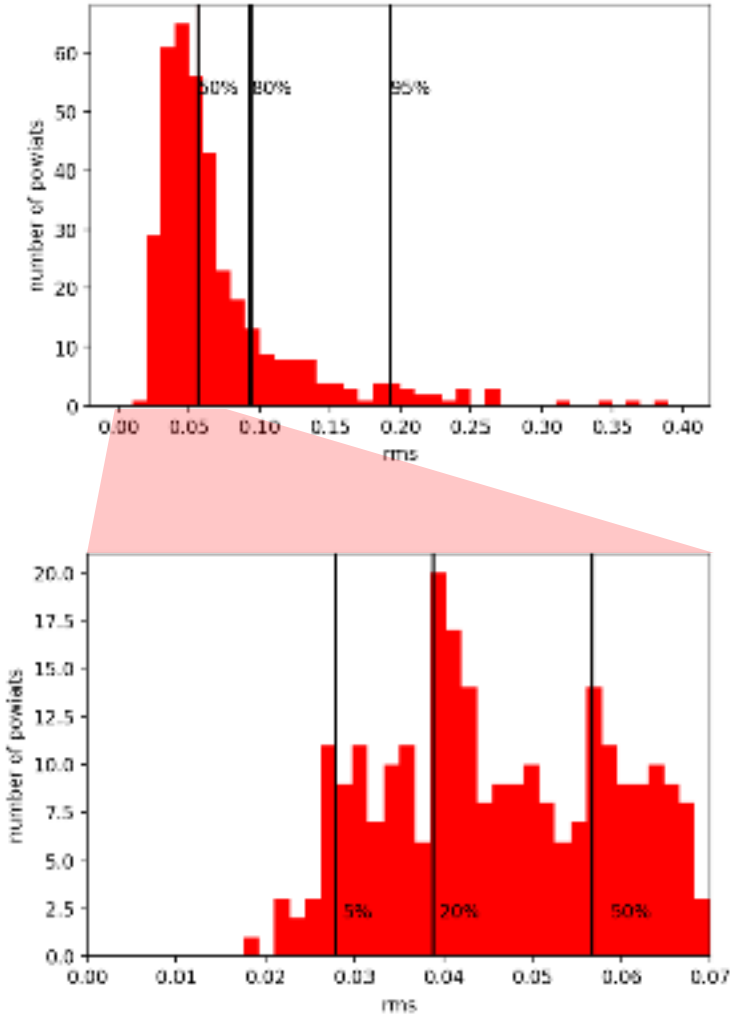


Counties

- rms as an averaged relative deviation between simulation and data,
- Z is „dark figure” – ratio of all cases to registered cases (Z≈5),
- some counties agree very well, some do not.

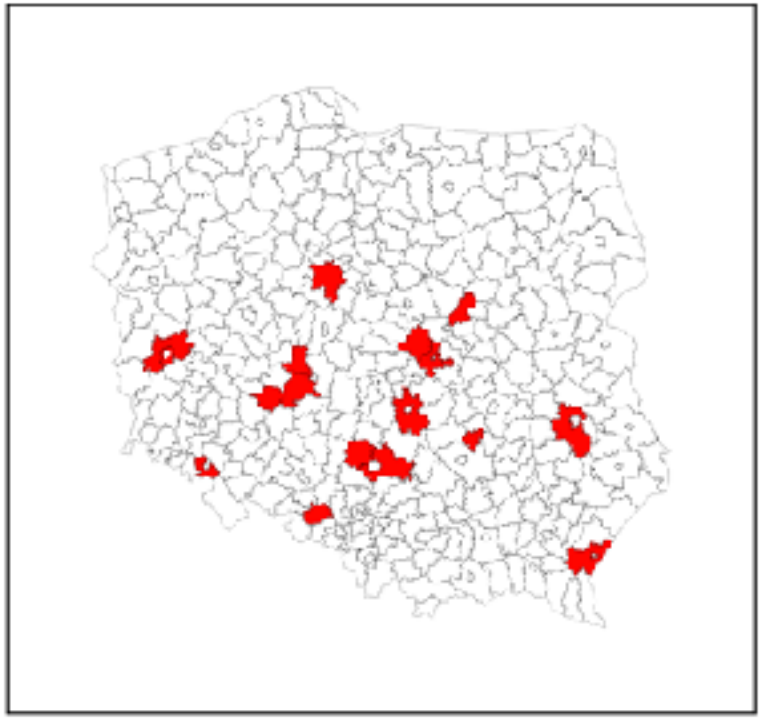


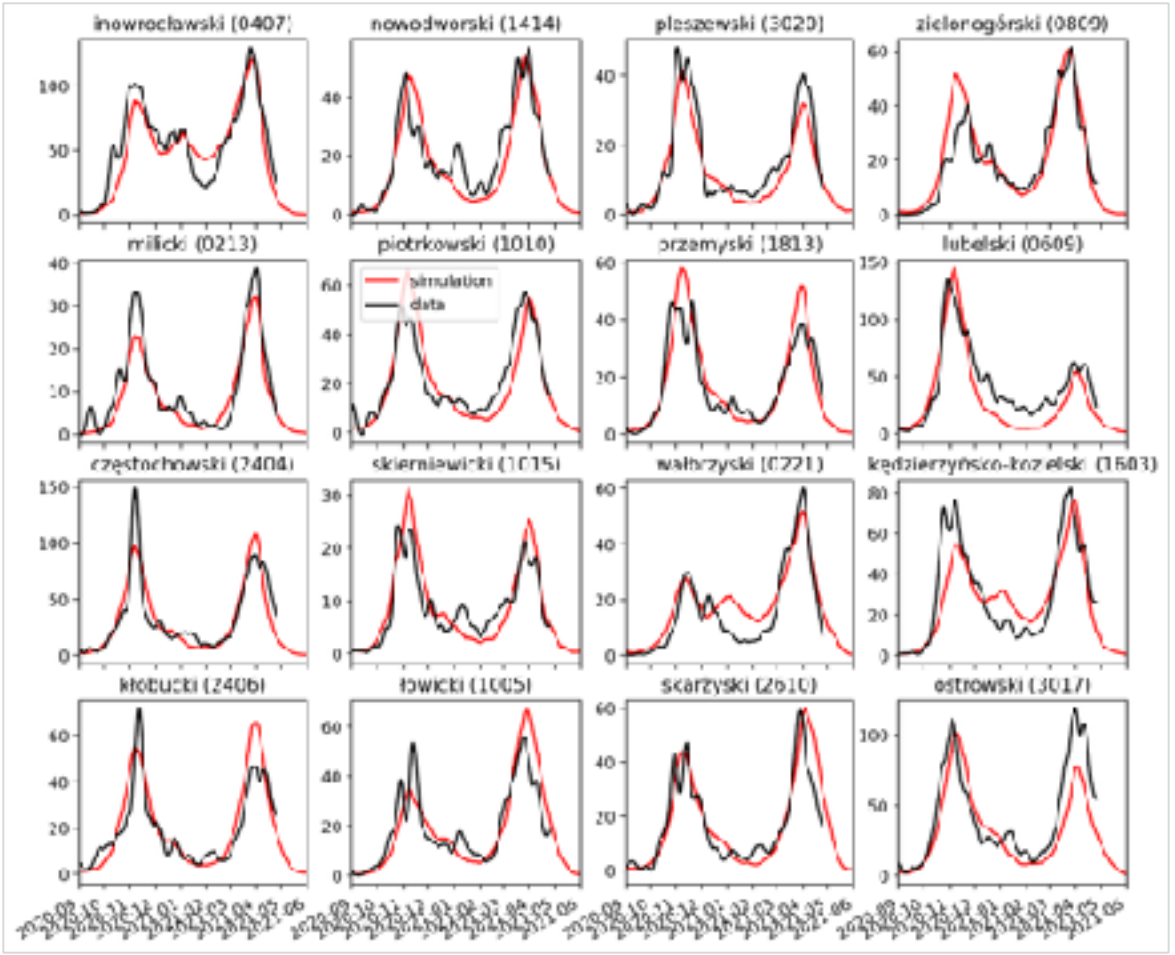
$$rms = \frac{\sqrt{\sum_{time}(sim/Z - data)^2}}{\sum_{time} data}$$



Counties

Registered new cases, best rms





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Thank you for your attention

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