G-CSC Epidemics group
An introduction to disease modelling via SEIRD

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Overview

Situation

1. Diseases are not nice
2. Infectious diseases are doubly not nice
3. Infectious diseases in todays interconnected world are horrible

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Question: Are we able to broadly understand their behavior?

Situation

- Infectious disease models can give quantitative answers
- Although not perfect, results can guide policy
- Won't yield insights into disease itself but its effect on society

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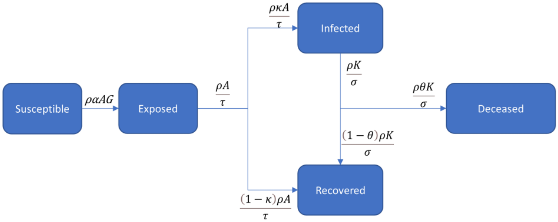
- The user can define scenarios...and fit the models to real life data

The EpidemicsRunner is quick response guidance tool, that allows a non-expert user to quickly simulate various epidemics scenarios based on real data.

SEIRD Model

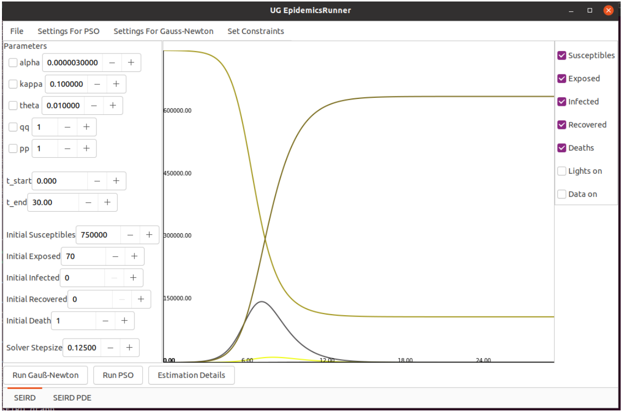
- The (S)usceptible (E)xposed (I)nfected (R)ecovered (D)eceased model is a well known framework to model the spread of infectious diseases
- It is the simplest model found in EpidemicsRunner
- Is a robust basis for other more specialized models



SEIRD Model (ODE)

$$
\begin{aligned}
\frac{dS}{dt} &= -\alpha SE \\
\frac{dE}{dt} &= \alpha SE - \frac{1}{qq}E \\
\frac{dI}{dt} &= \frac{\kappa}{qq}E - \frac{1}{pp}I \\
\frac{dR}{dt} &= \frac{(1-\kappa)}{qq}E + \frac{(1-\theta)}{pp}I \\
\frac{dD}{dt} &= \frac{\theta}{pp}I
\end{aligned}
$$

ODE Widget - Overview



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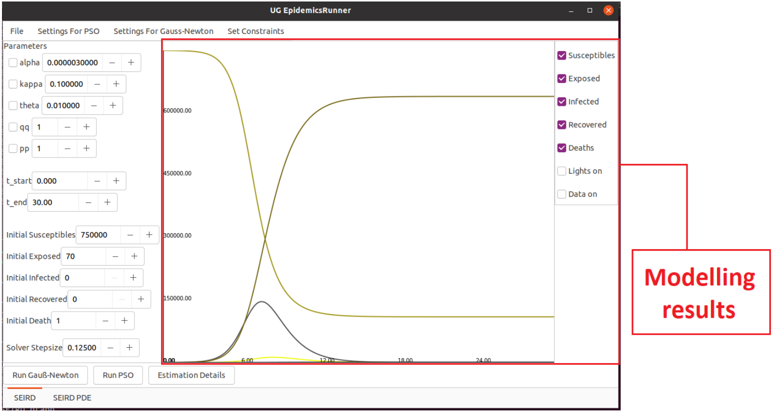

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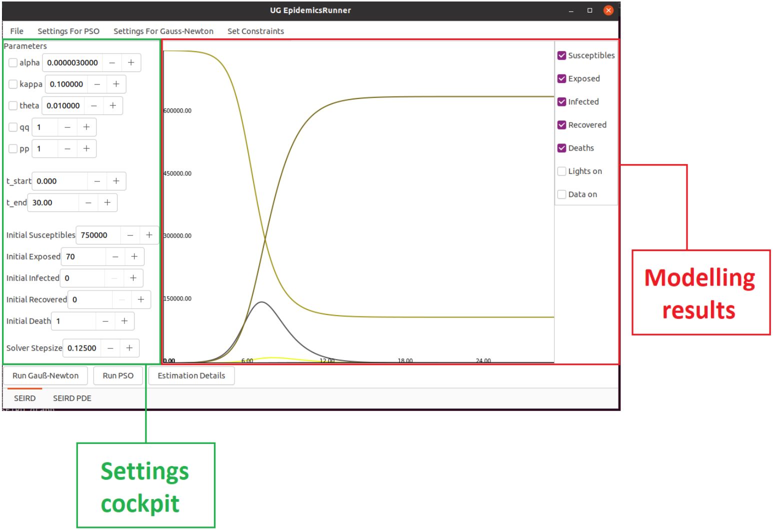

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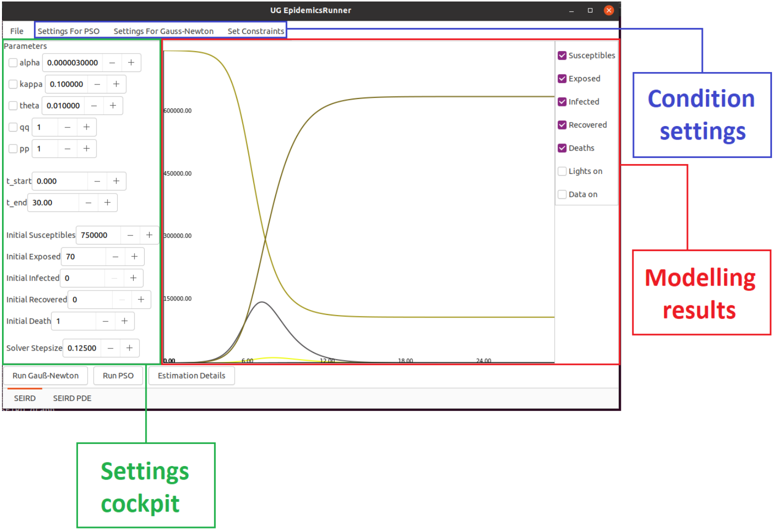

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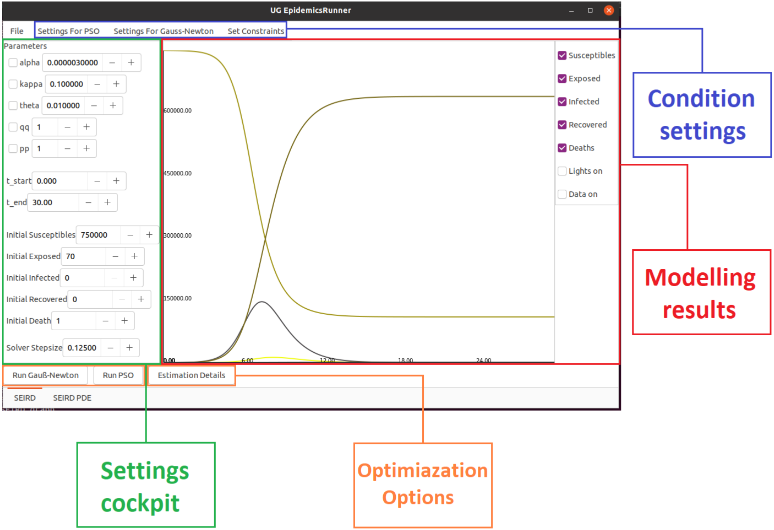

Live "modelling" session 1

Let us model α for a scenario:

1. Rapid spread:

Infected	820000
Exposed	2018
timeframe	37 days

2. Infection Wave (optional):

Infected	820000
Exposed	8147
timeframe	81 days

Partial differential Equations (PDE)

Limits of the **ODE** model:

- Only dependent on time
  $\rightarrow$ no spatial or structural "awareness" of the model
- Different regions need to either be modelled individually or clustered together

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Advantages of the **PDE** model:

- Other parameters can be factored into the modelling process (space, demographic, etc.)
- Multiple regions can be modelled at the same time with different parameters

Partial differential Equations (PDE)

$$
\begin{aligned}
\frac{dS}{dt} + \nabla[-\mathbf{D}\nabla G] &= -\alpha SE \\
\frac{dE}{dt} + \nabla[-\mathbf{D}\nabla A] &= (\alpha SE - \frac{1}{qq}E) \\
\frac{dI}{dt} &= (\frac{\kappa}{qq}E - \frac{1}{pp}I) \\
\frac{dR}{dt} + \nabla[-\mathbf{D}\nabla R] &= (\frac{(1-\kappa)}{qq}E + \frac{(1-\theta)}{pp}I) \\
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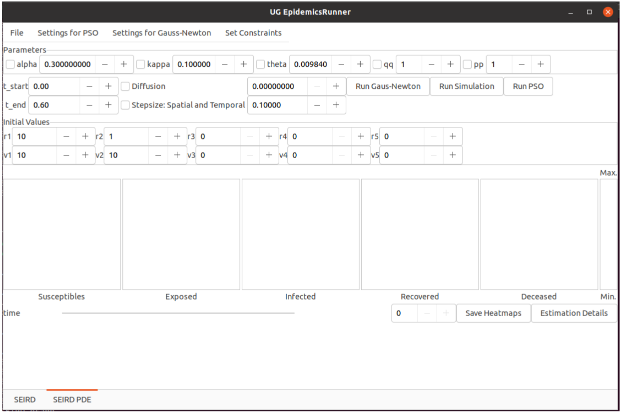
The PDE widget - Overview



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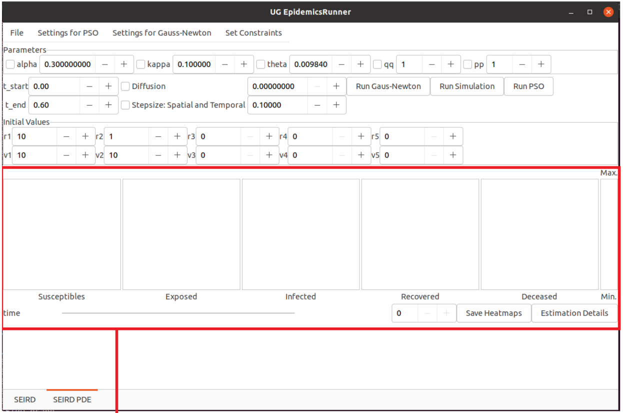
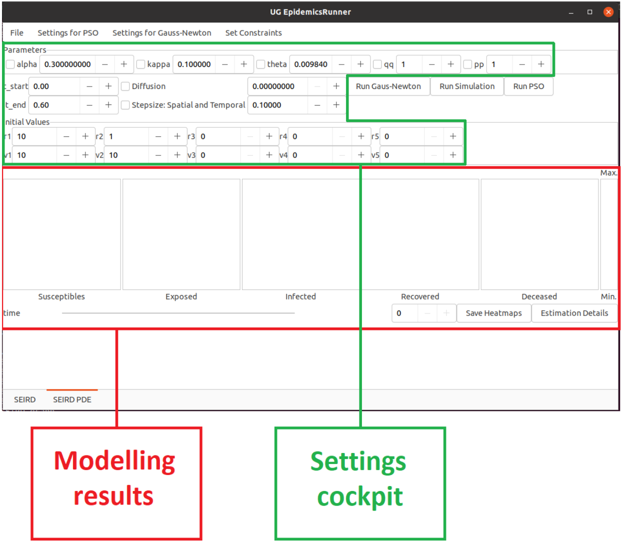


Modelling results

The PDE widget - Overview



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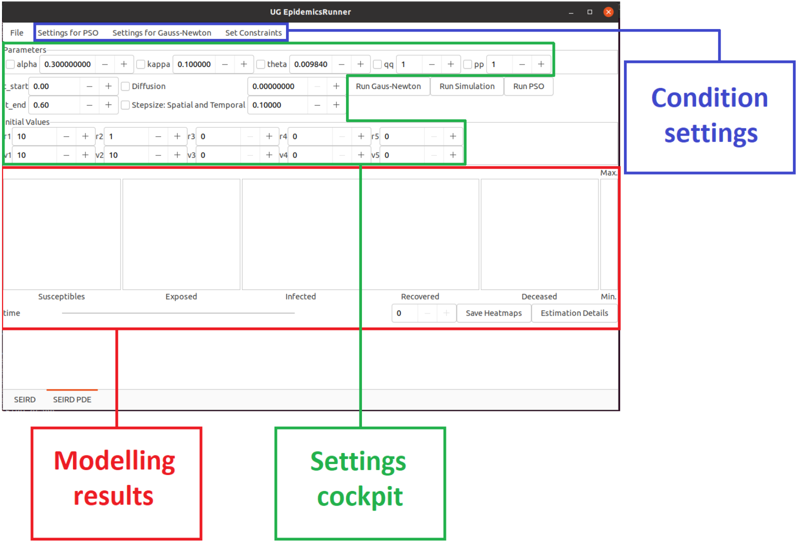

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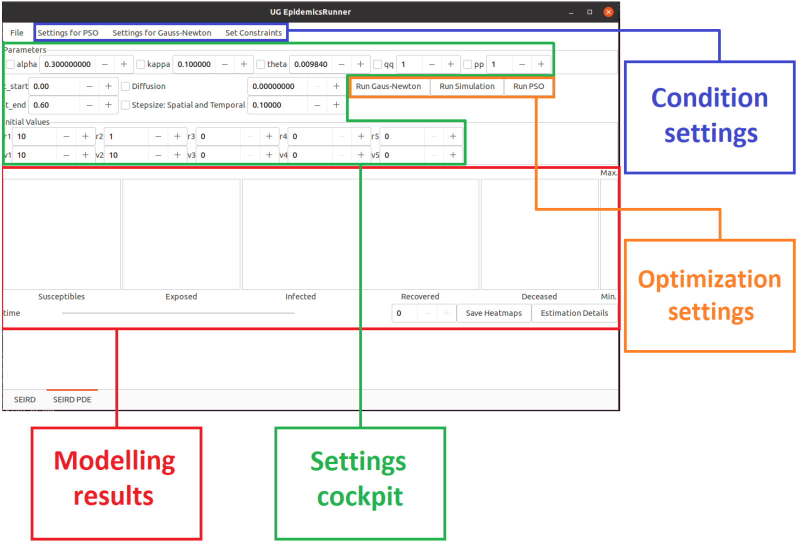


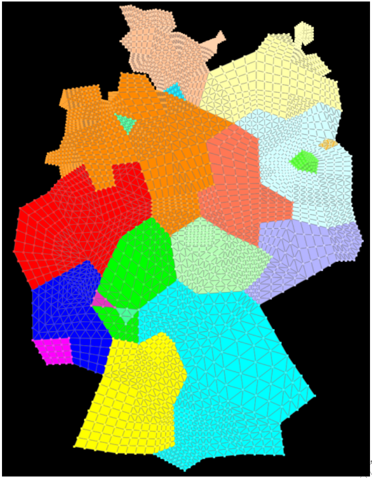
Live "modelling" session 2

- Let us start to simulate a small scenario
- And meanwhile look at the result of a longer simulation, with a finer grid

Modelling Covid in Germany

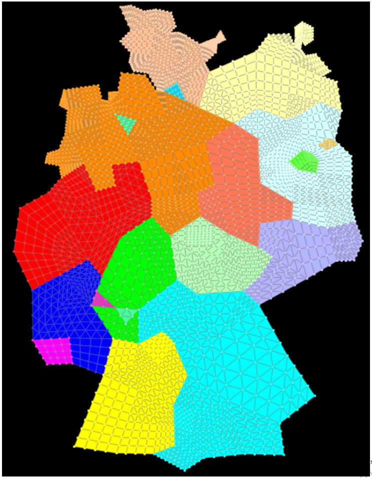
Modelling Covid in Germany

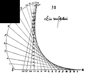
- We started out with a grid of Germany.



Modelling Covid in Germany

- We started out with a grid of Germany.
- But of course, once you have a gird...





Modelling Covid in Germany

...you can play with the model

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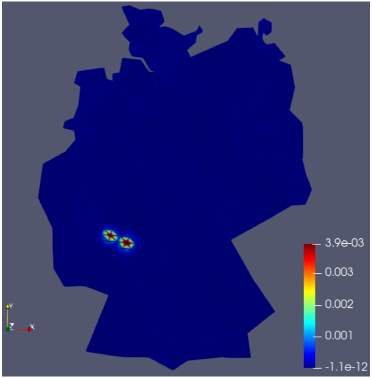
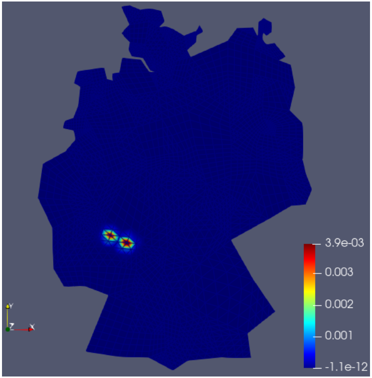


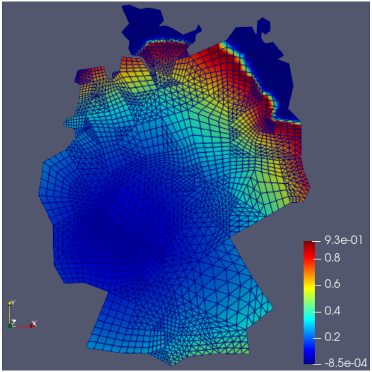
reasonable parameters

Modelling Covid in Germany

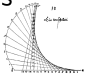
...you can play with the model



reasonable parameters

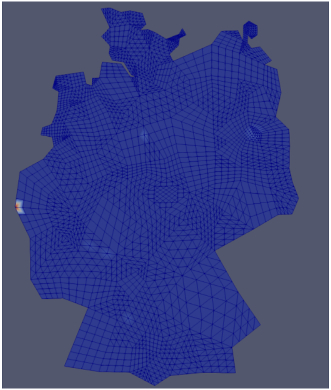


not so reasonable parameters



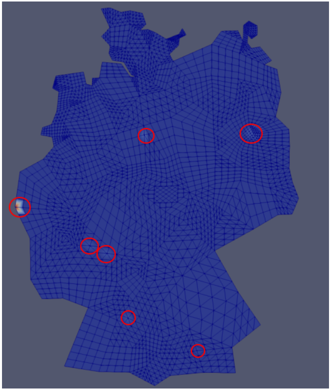
Modelling Covid in Germany

- Of course we also did some serious modelling

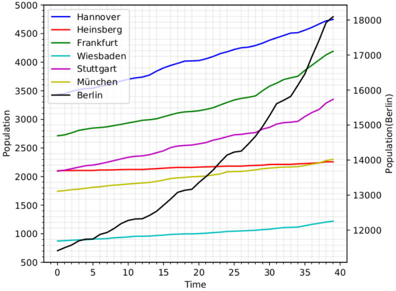


Modelling Covid in Germany

- Of course we also did some serious modelling
- PDE model for seven cities in Germany
  - Hannover
  - Heinsberg
  - Frankfurt
  - Wiesbaden
  - Stuttgart
  - München
  - Berlin

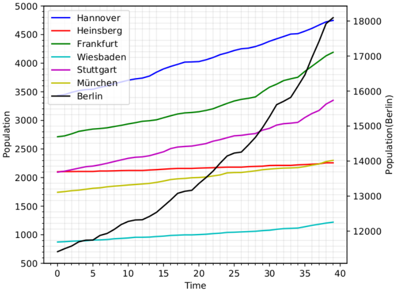


Modelling Covid in Germany

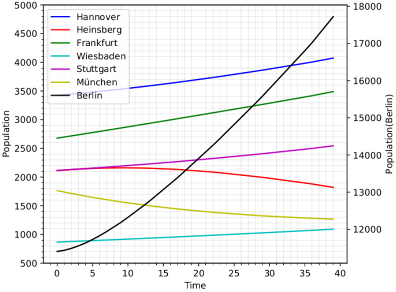


Real world infection cases

Modelling Covid in Germany



Real world infection cases



Modelled infection cases

Big and small ideas for applications

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Future topics:

- Modelling of smaller areas with finer grid [in progress]
- Use the model in differenct scenarios (countries, diseases, ...)
- Compare SEIRD with statistical models

Big and small ideas for applications

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- Modelling of smaller areas with finer grid [in progress]
- Use the model in differenct scenarios (countries, diseases, ...)
- Compare SEIRD with statistical models

Current applications:

- Public health management (easy modelling of scenarios)
- Use SEIRD to prepare for future epidemics/pandemics (Supplies, Beds, Employees)
- Study and understand the mechanics of disease spreading

Questions, Answers and Discussions

Thank you for your attention and for hosting this event!