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Multi-source data integration for parallel COVID-19 incidence forecast

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CABAHLA meeting 15/6/2022

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BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

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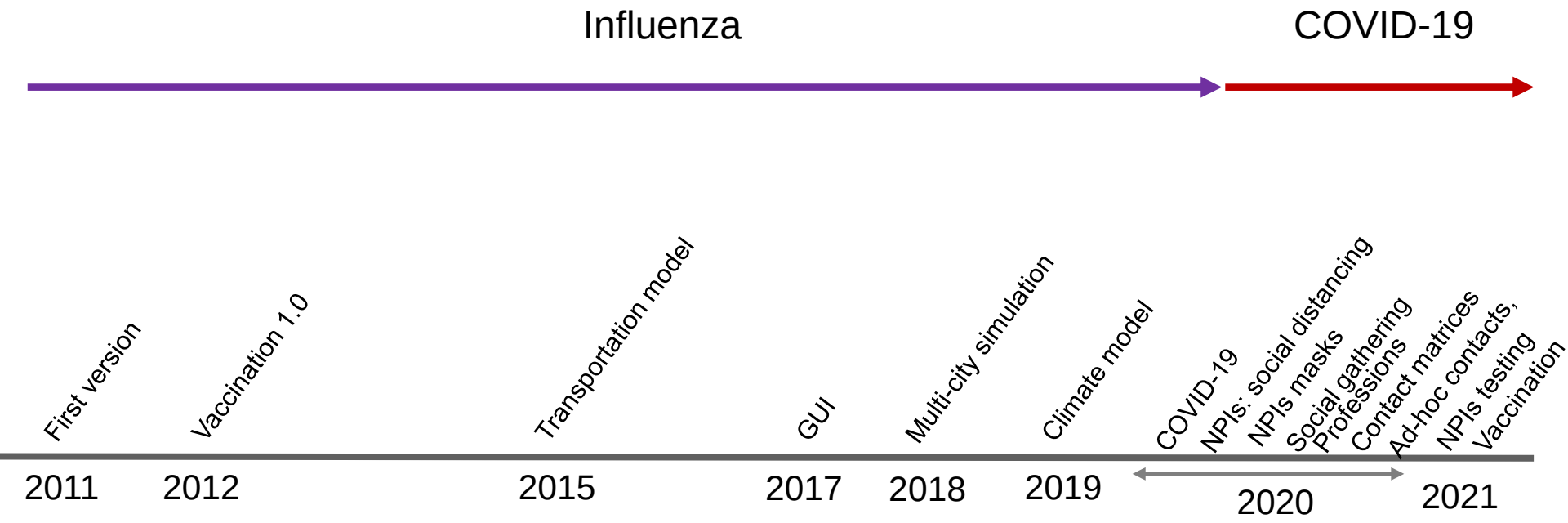
RES RED ESPAÑOLA DE SUPERCOMPUTACIÓN

Overview

- Epigraph provides COVID-19 forecast for Spain (including all provinces)
  - Ongoing: Germany and Finland
- Forecasted information:
  - Long-term and short-term incidence and hospitalization cases
  - Evaluation of different vaccination strategies
  - Evaluation of waning immunity scenarios
  - New COVID-19 variants
- Partners (that receive the forecasted information):
  - Panel responsible of the design and implementation of the COVID-19 vaccination program for Spain (David E. Singh is member of the panel)
  - European COVID-19 Forecast Hub
  - Centro Nacional de Epidemiología
  - Spanish Ministry of Health (Vaccination Area)
  - European Centre for Disease Prevention and Control (ECDC)
  - Comunidad de Madrid
- Decision-making support
  - European Commission, Ministry of Health

Overview

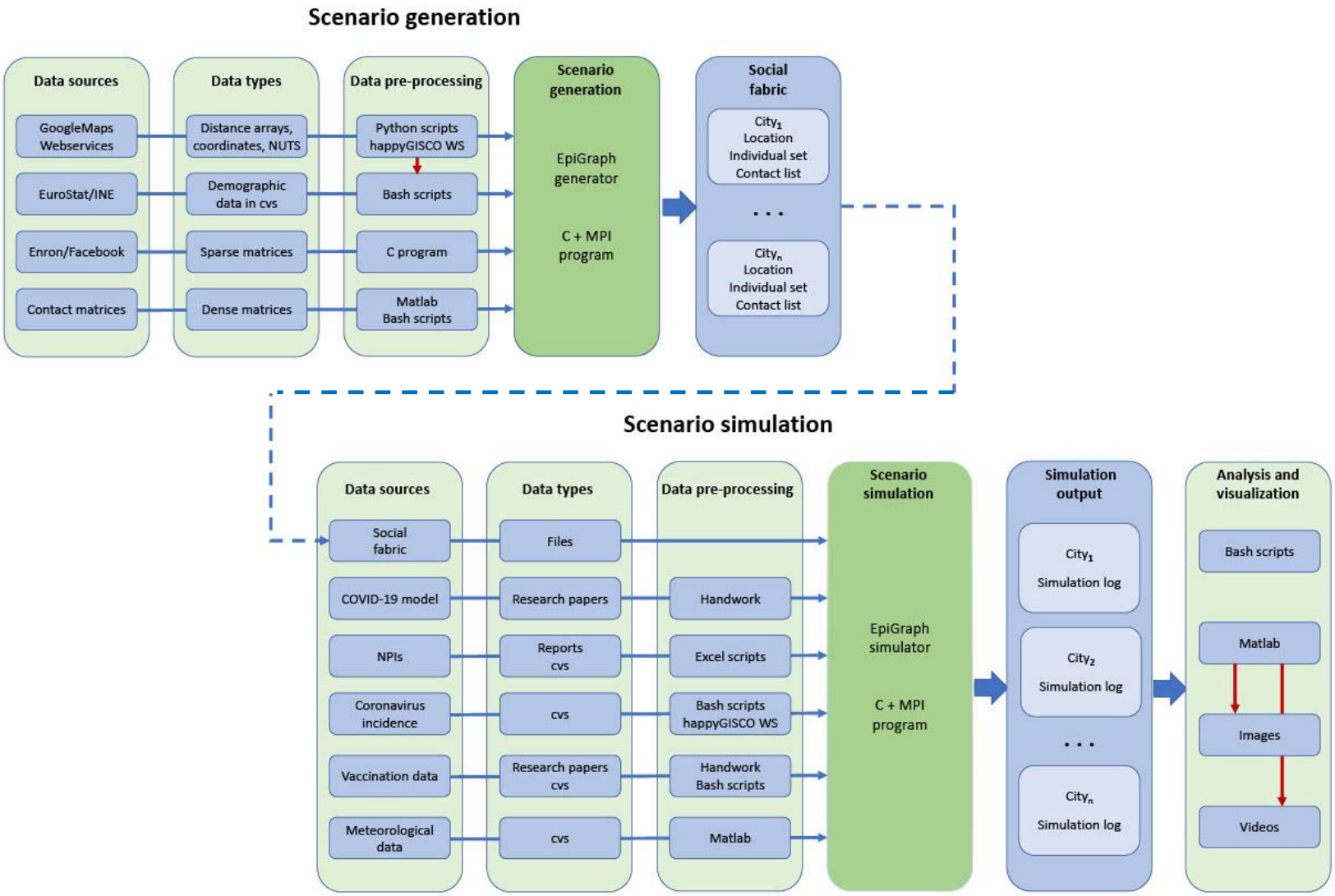
- EpiGraph
  - Parallel program
  - Developed in C language with MPI
  - 20,000 code lines



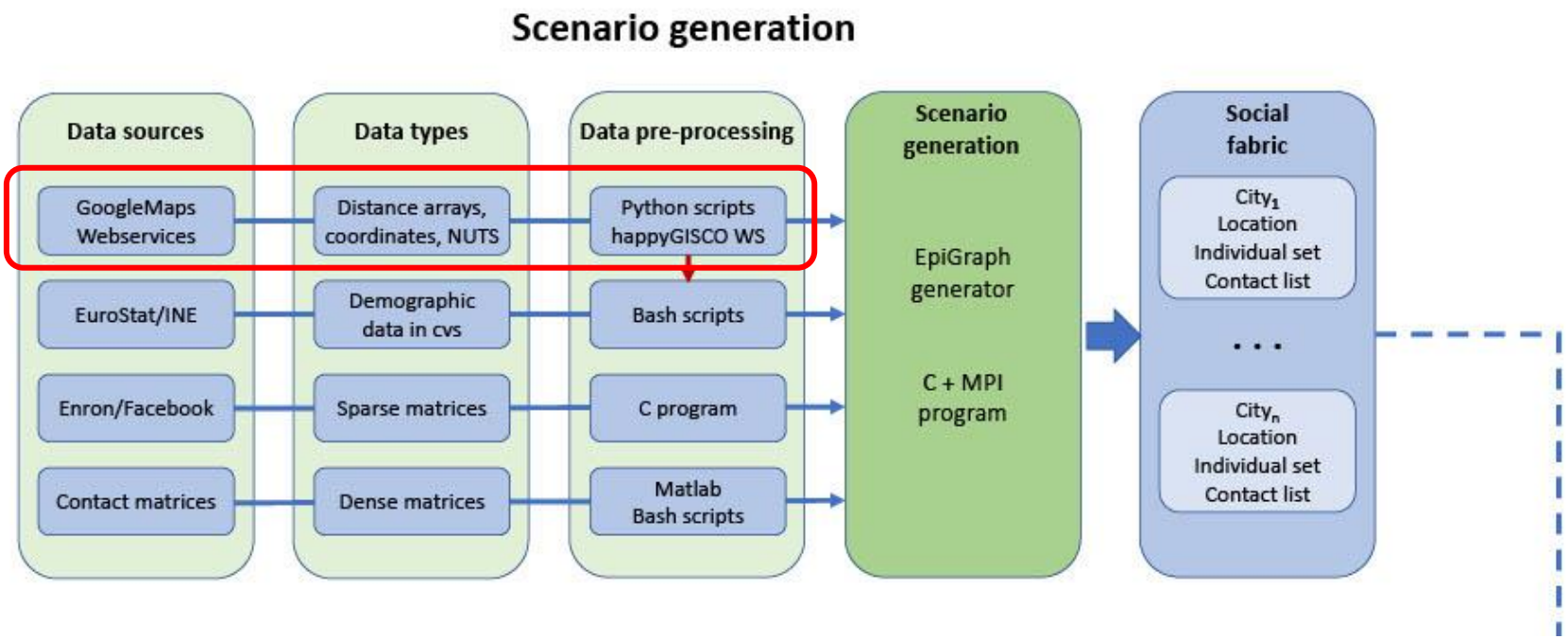
Overview

- EpiGraph
  - Parallel program
  - Developed in C language with MPI
  - 20,000 code lines
- Integrates models
  - The pathogen (influenza, COVID-19, including variants)
  - Social interactions
  - Vaccine effectiveness
  - Transportation model
  - Climate conditions
- Implements politics
  - Non pharmaceutical interventions
  - Vaccination

Data management

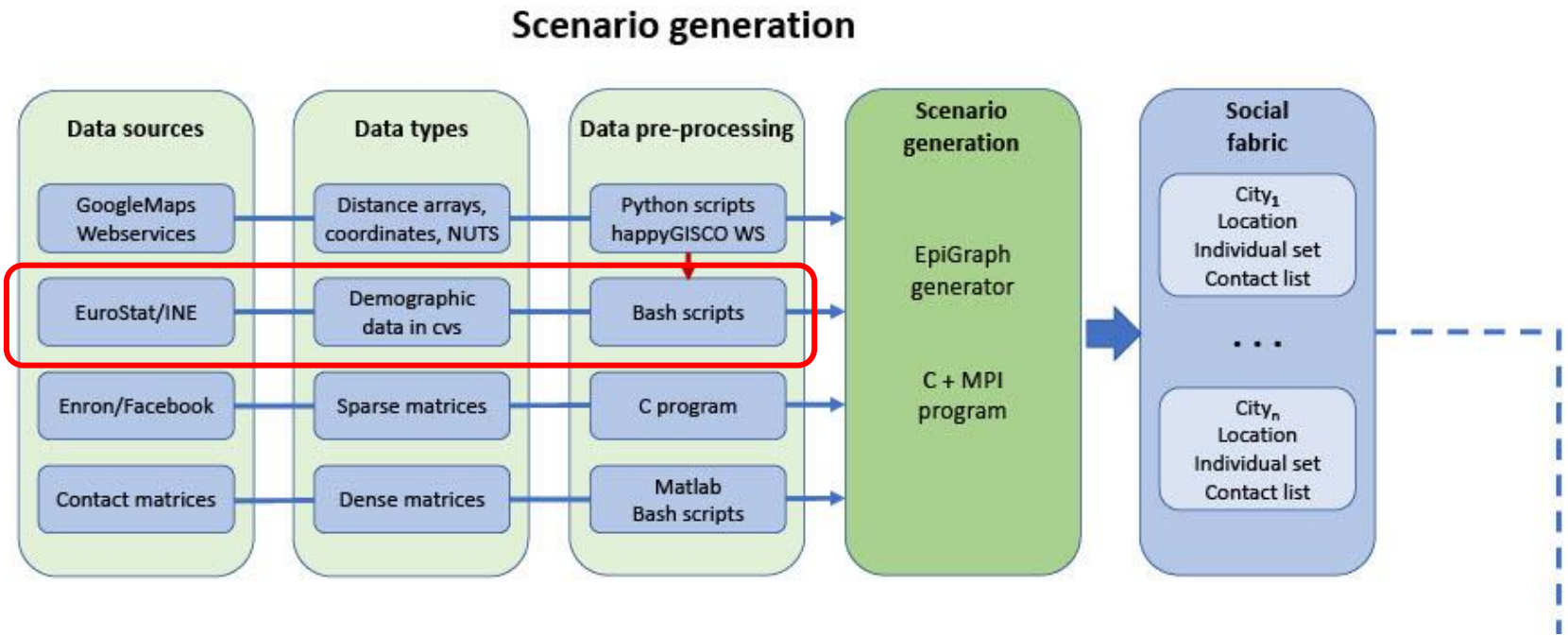


Data management



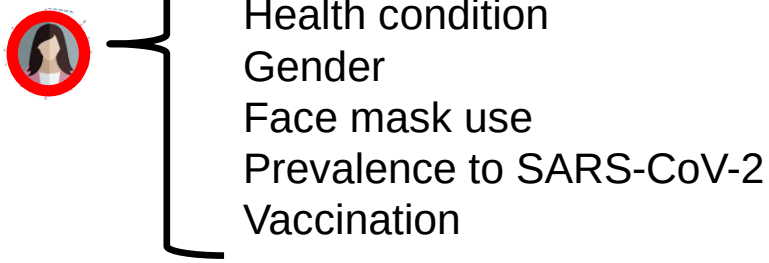
- Social model built from different data sources
- City geolocation used by the transportation model and for accessing the demographic data.

Data



- EuroStat and Spanish Statistic Institute for modelling the population
  - Population Pyramid
  - Family size distribution
  - Job sectors

Social model



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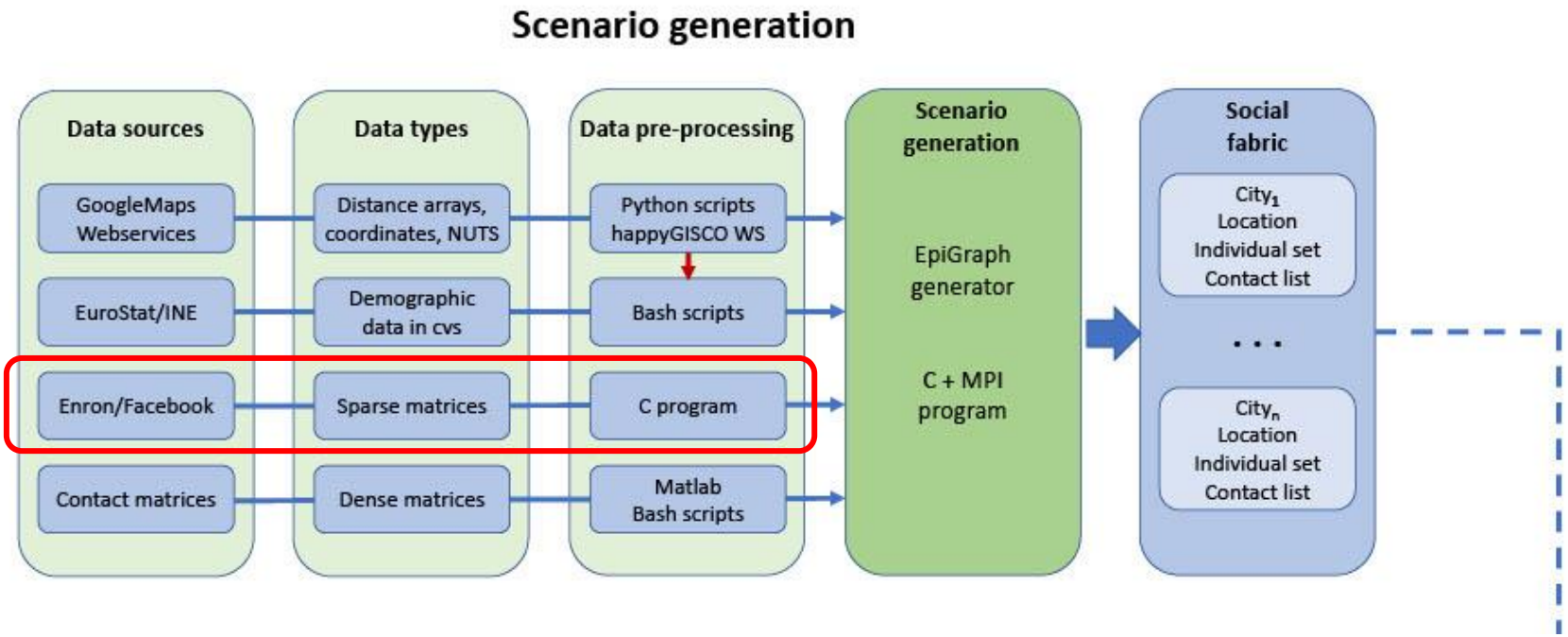
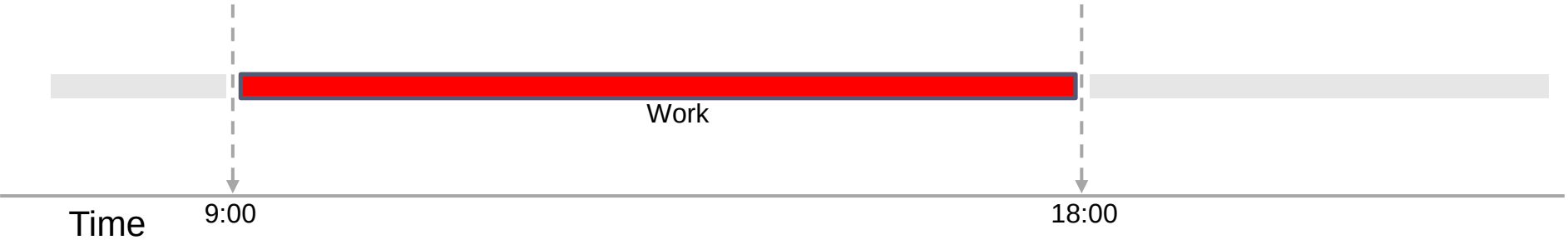


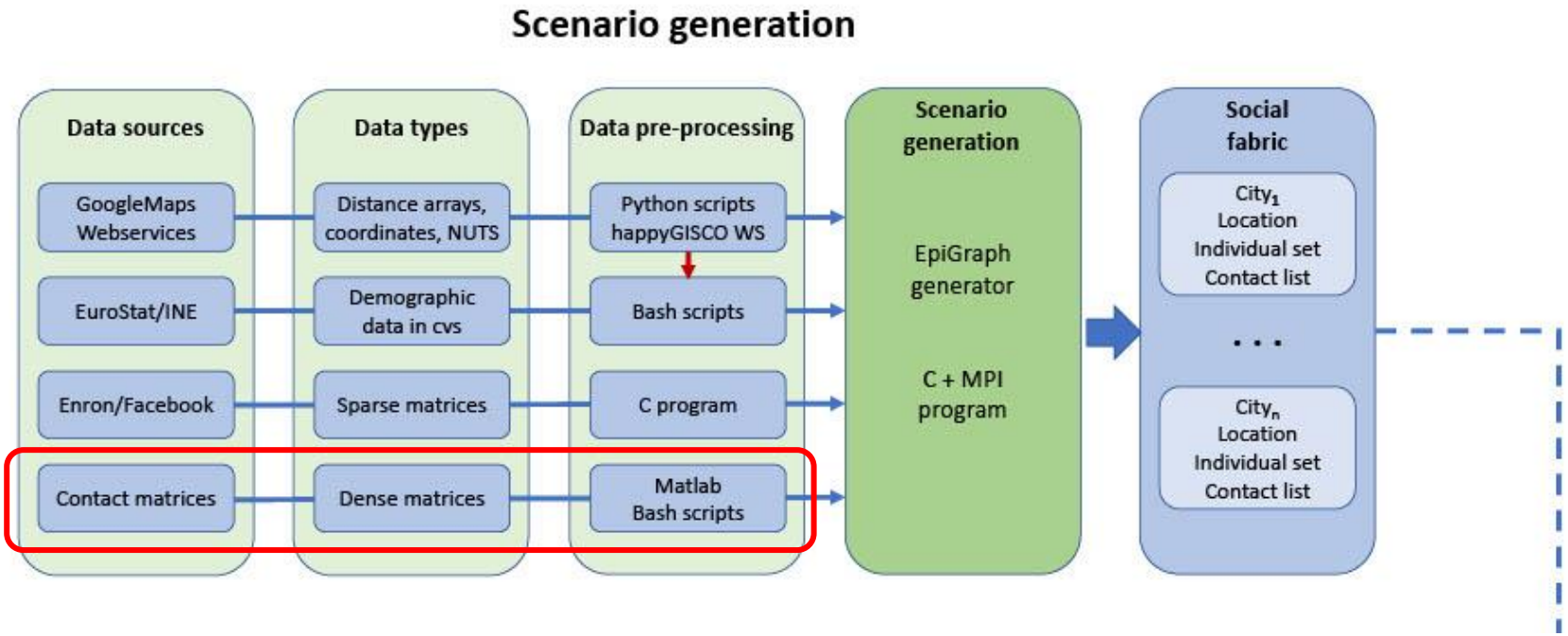
- Social networks are used to model the social contact patterns of each collective
  - Enron email corpus for work contacts
  - Facebook for student, elderly people and unemployed contacts

Social model



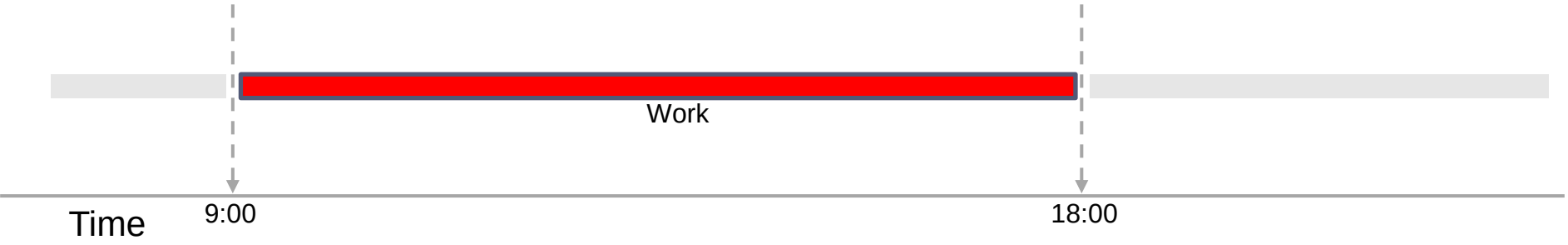
Work group

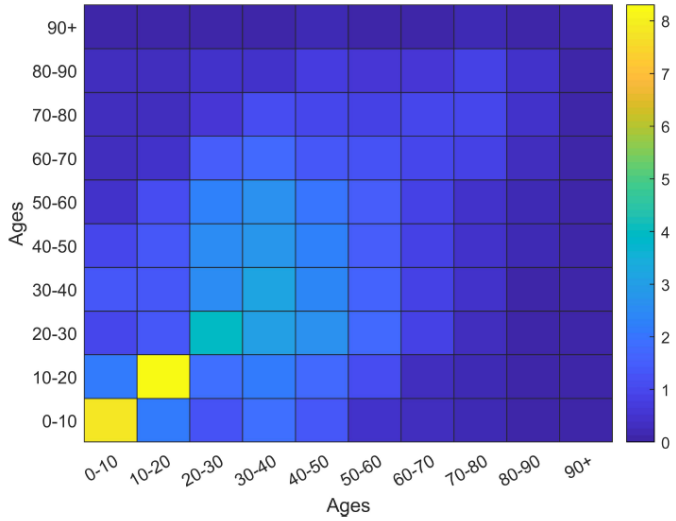
Data



- Contact matrices represents average number of daily interactions between individuals
  - Based on age intervals
  - Separated by groups: students, workers, etc.
- Different contact matrices for each country

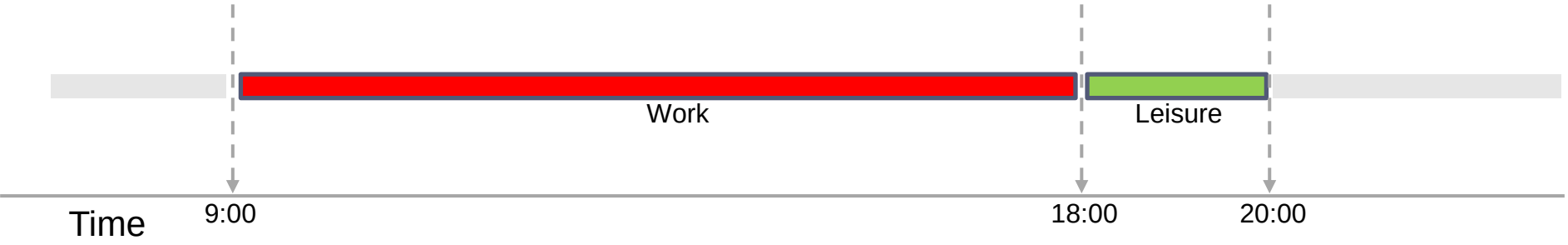
Social model

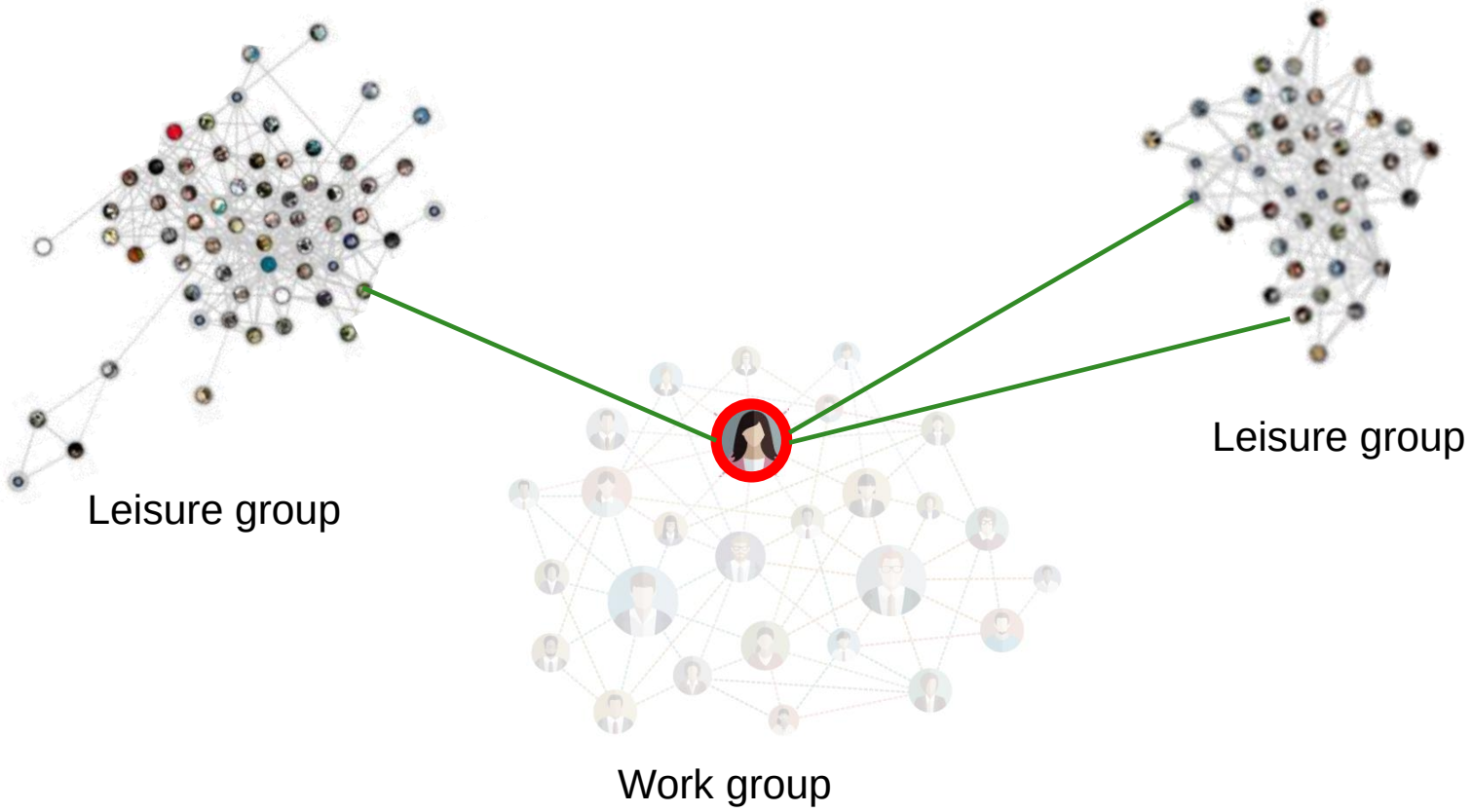




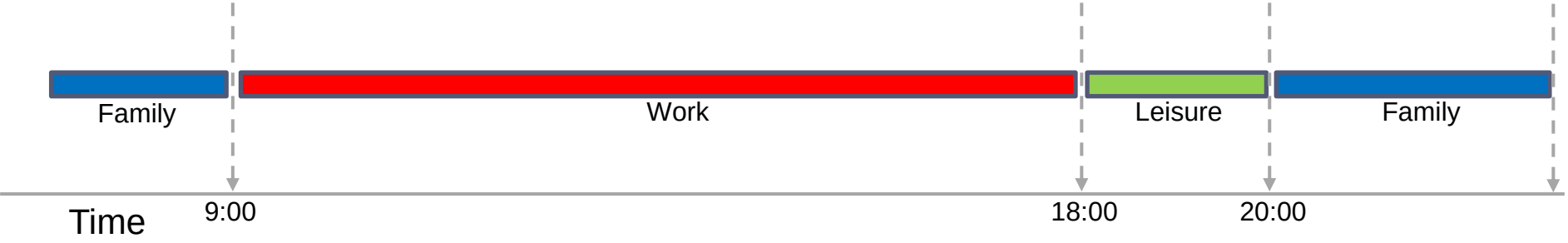
Work group

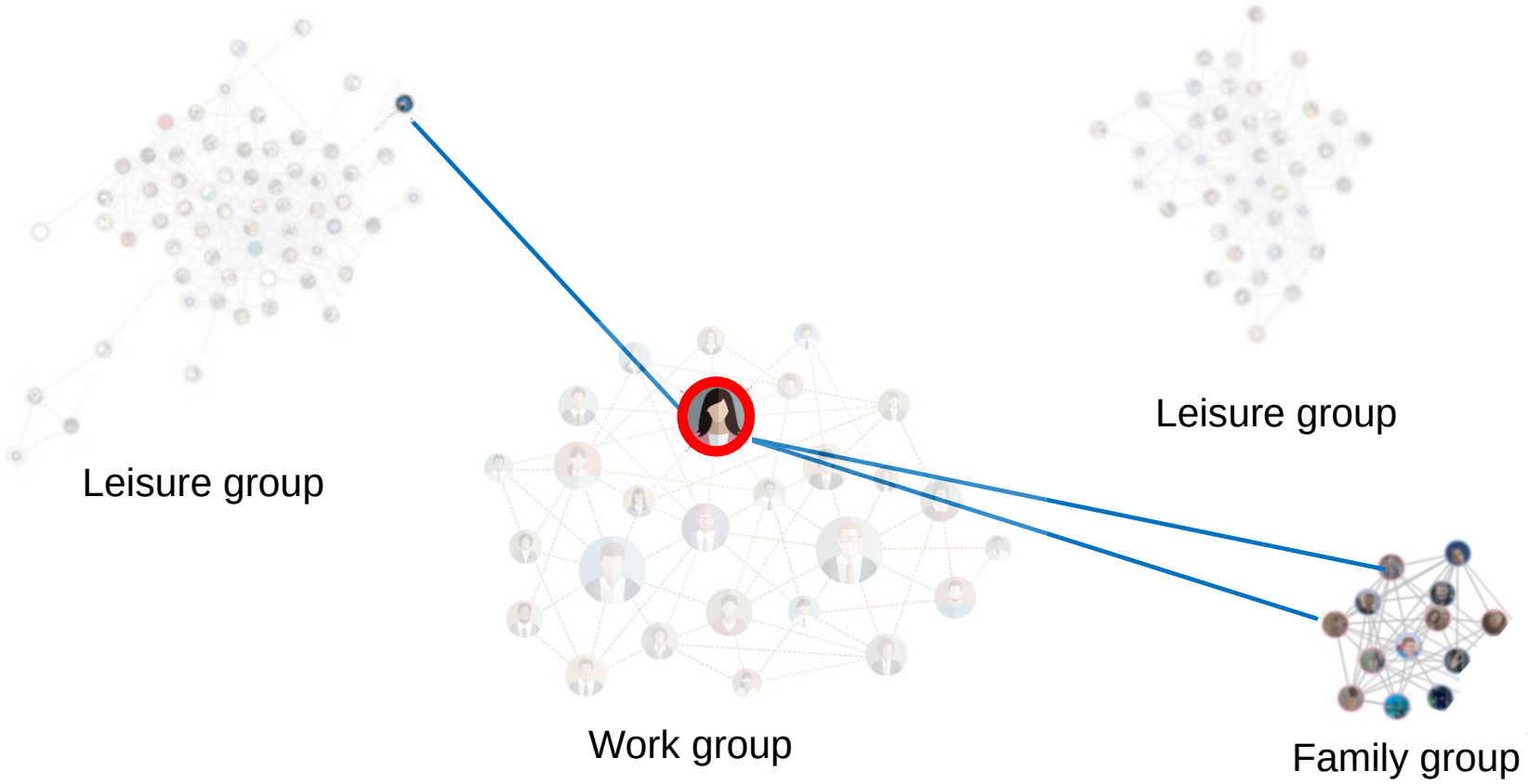
Social model





Social model





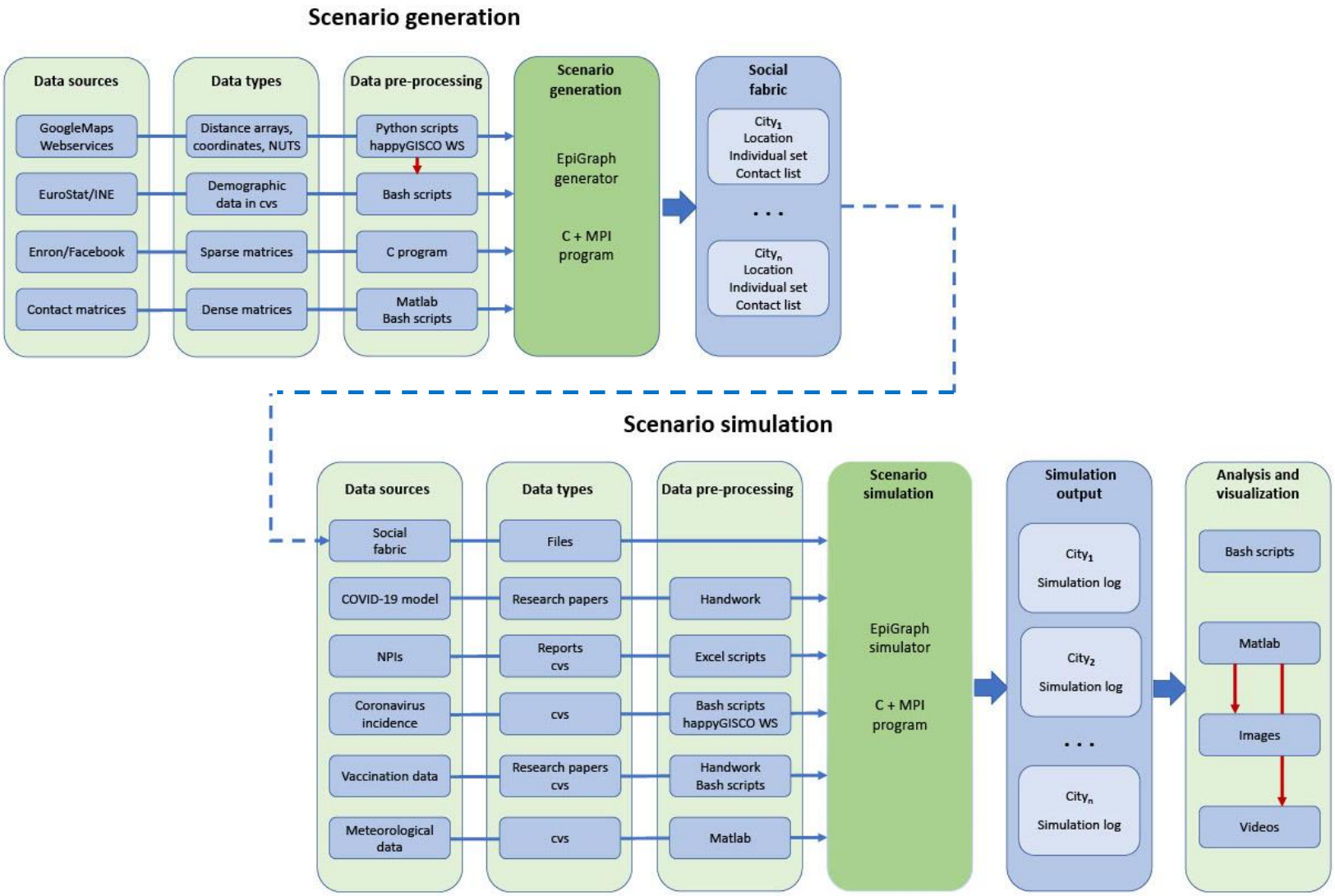
Social model

- We model different collectives:

- Static contacts for some collectives
  - Teachers with students
  - Socio-sanitary workers with elderly people in nursing homes

- Dynamic contacts for some collectives
  - Health professionals
  - Security forces
  - Catering workers

Data management



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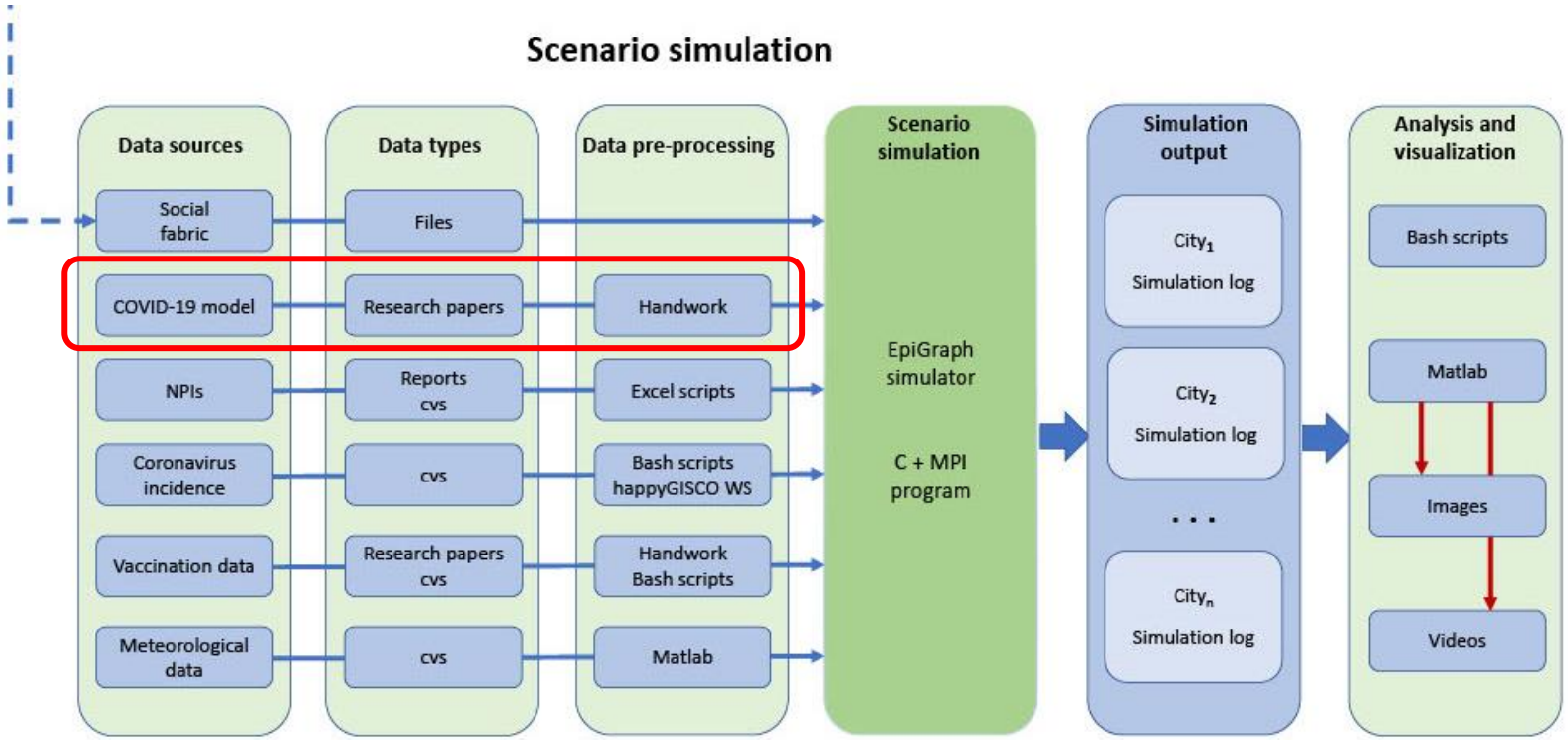
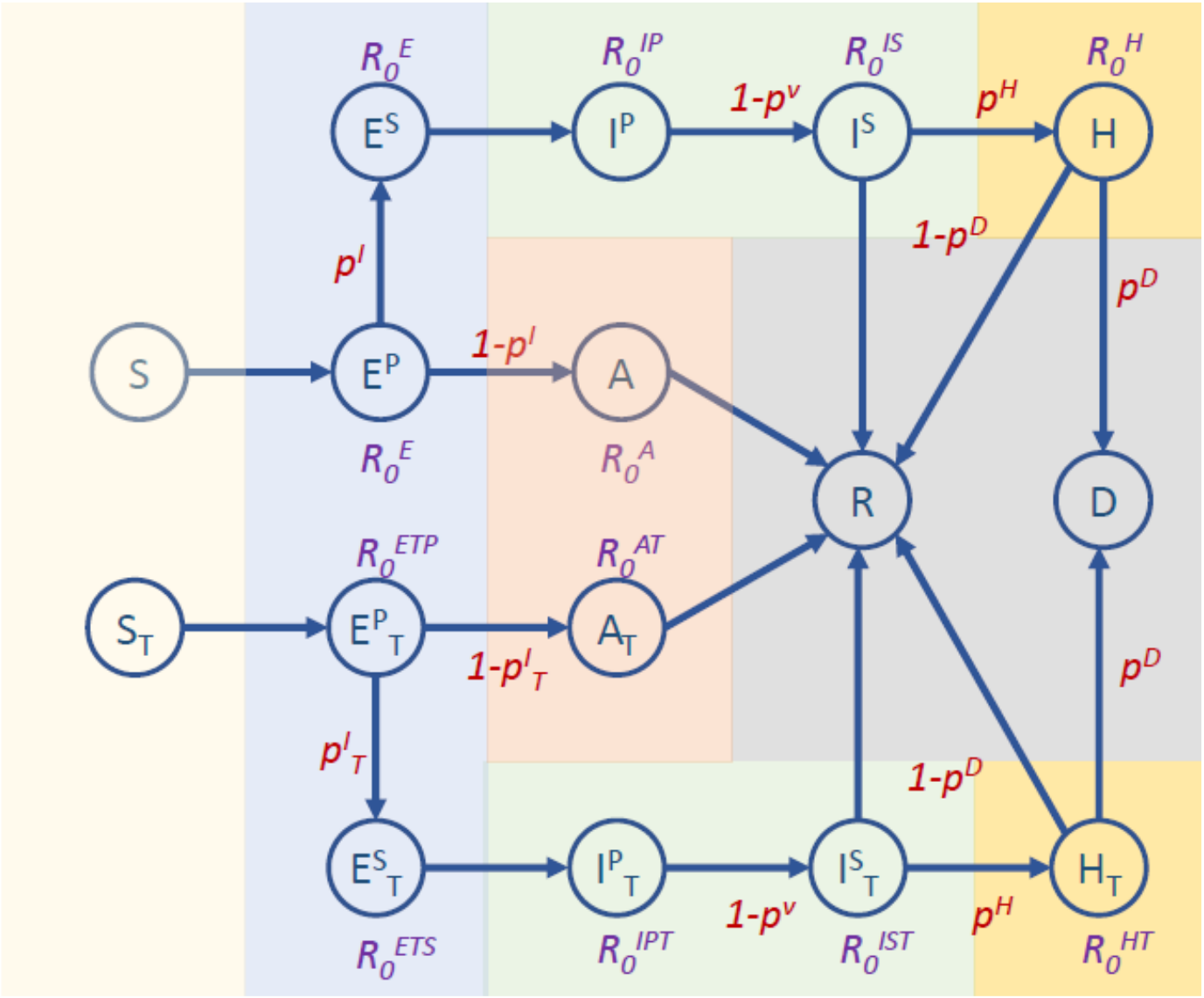


- Epidemiologic model characterizes the COVID-19 propagation.
- Calibrated based on research papers.

Epidemiologic model



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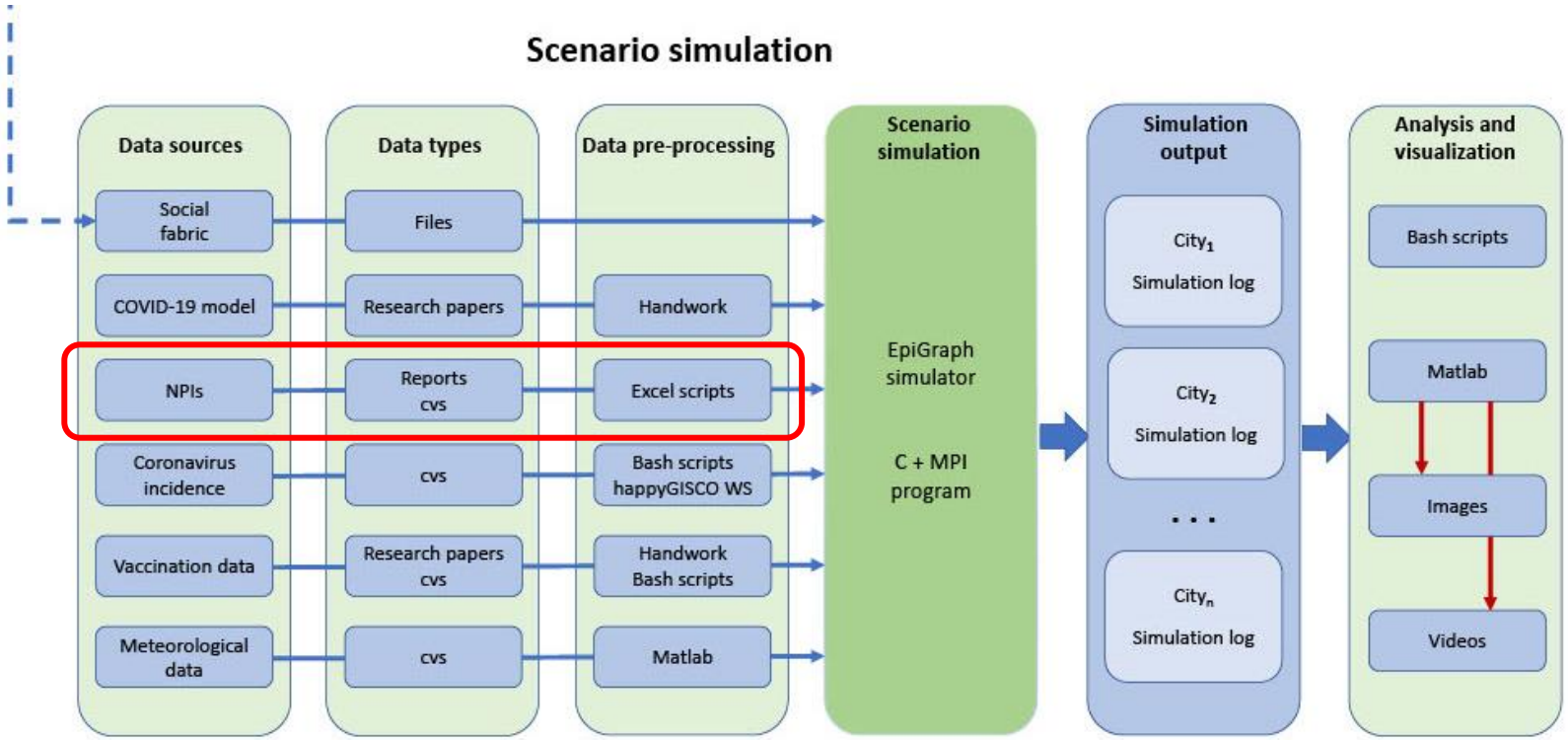
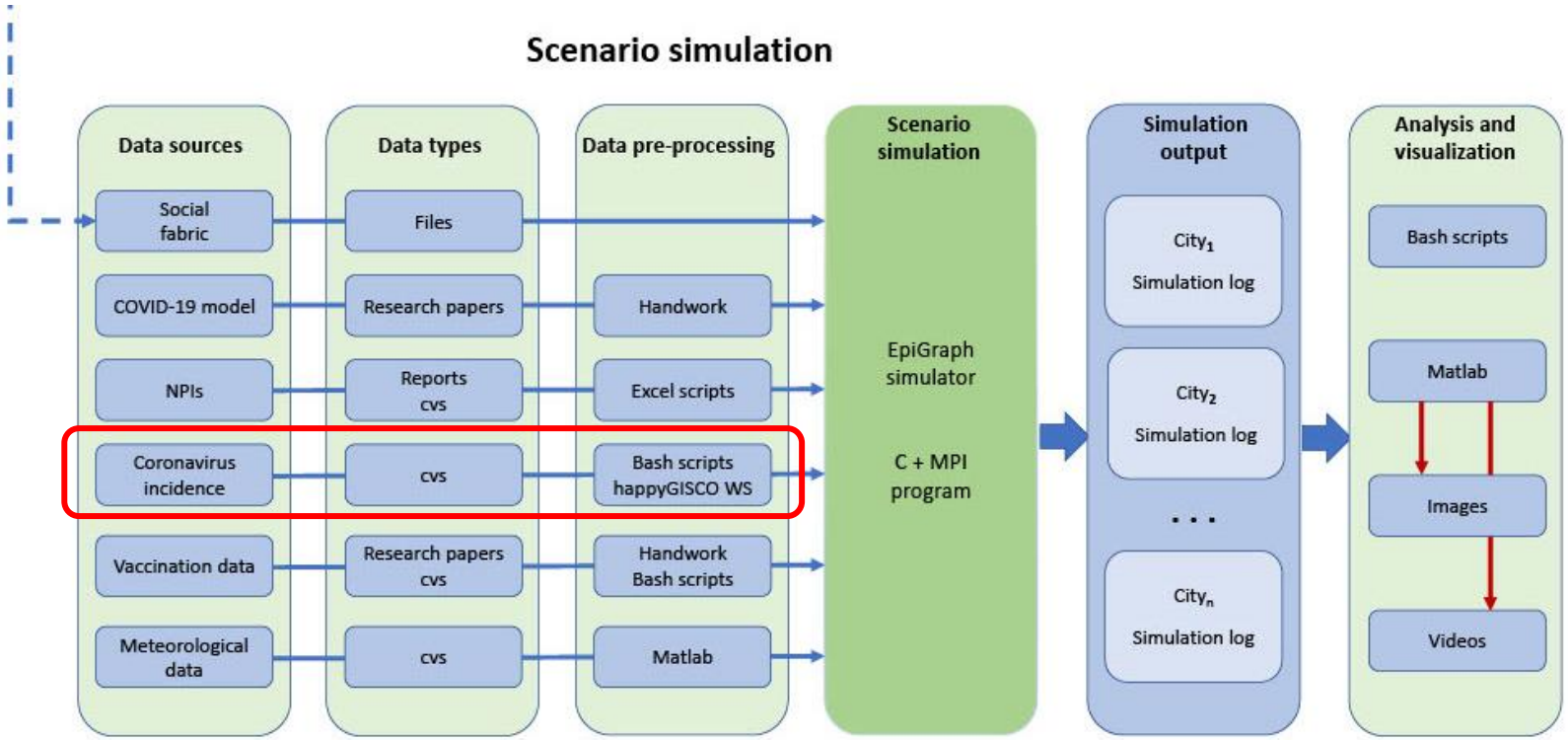


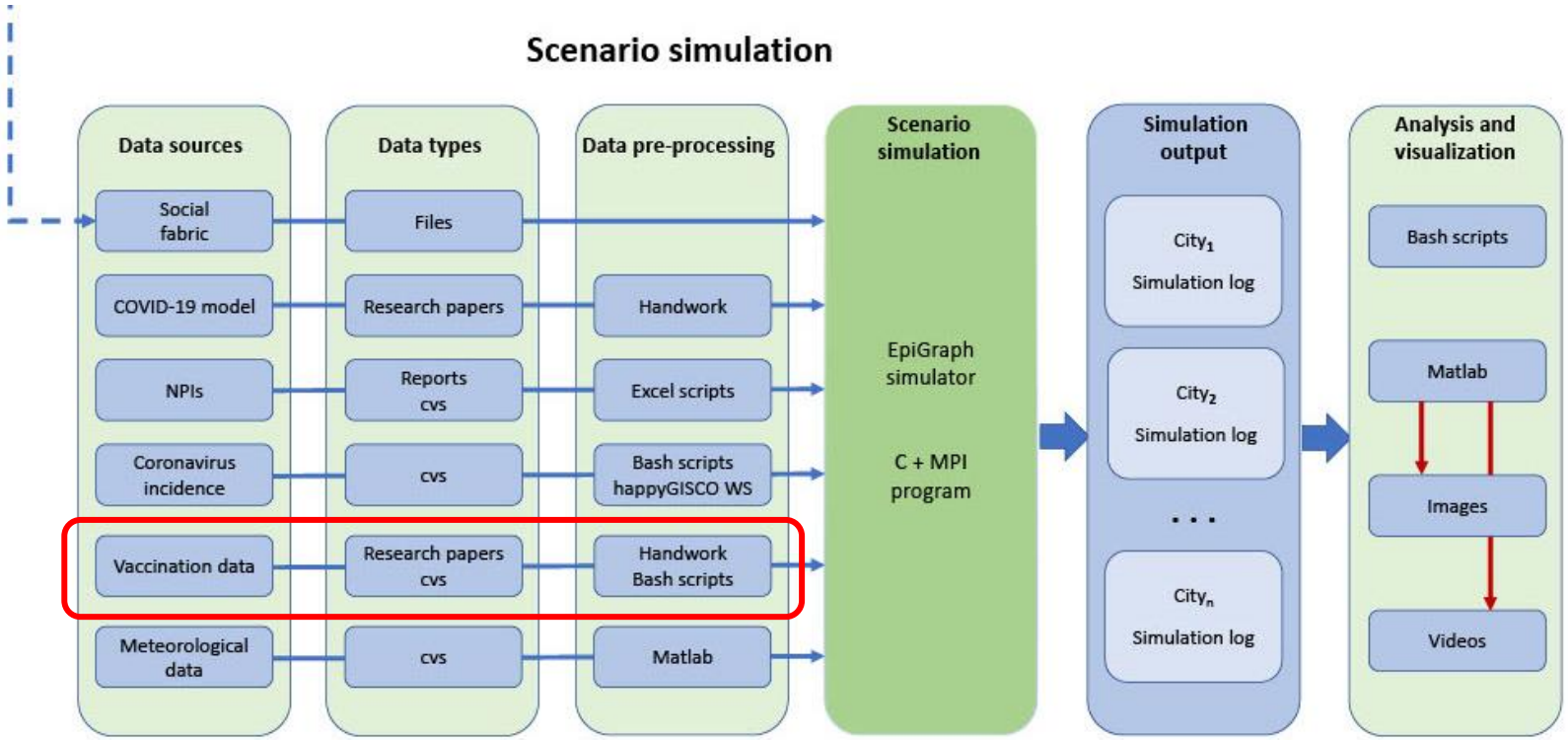
- Non-pharmaceutical intervention was collected from reports from Spanish Health Ministry and European Centre for Disease Prevention and Control

Data



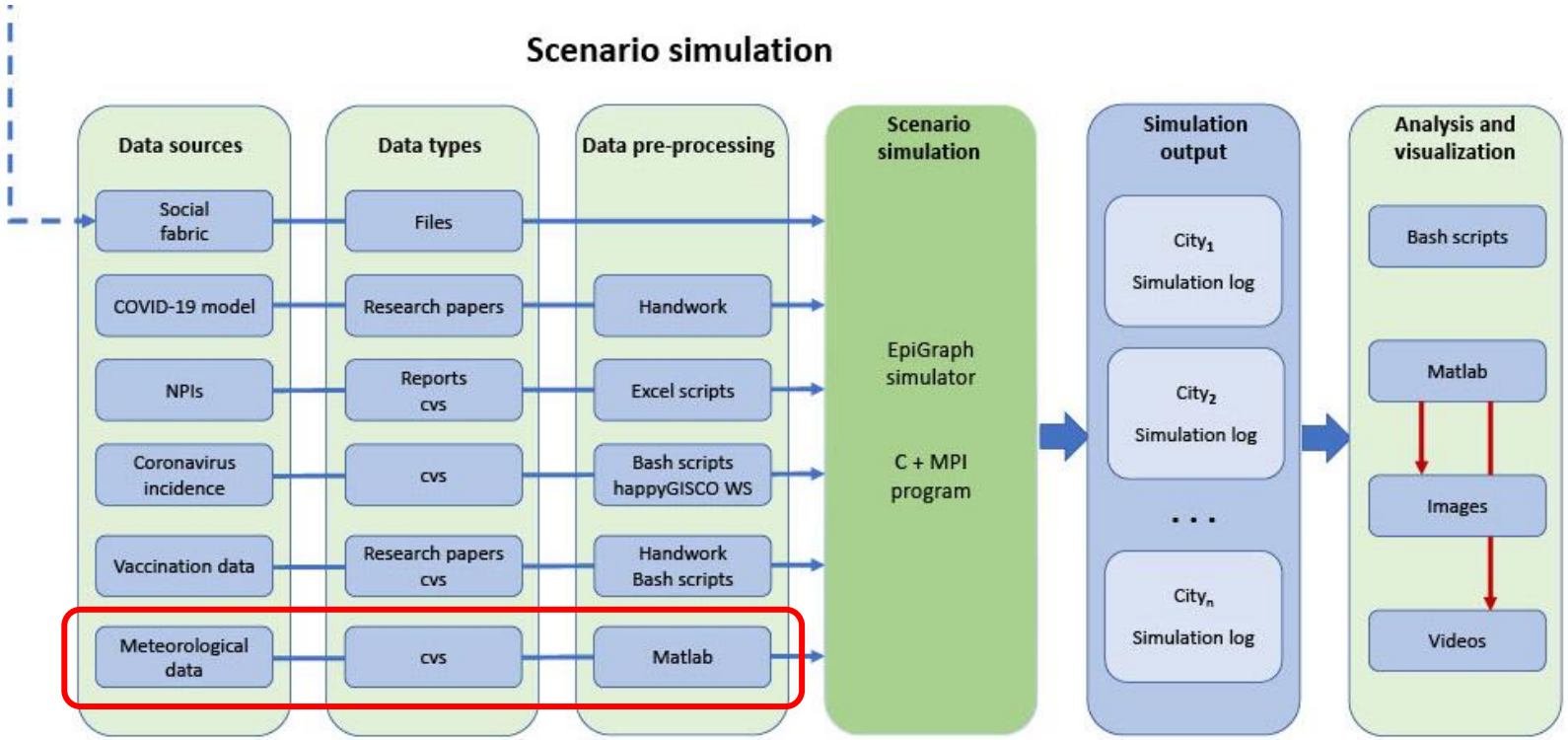
- Coronavirus incidence is used to set the initial percentage of the infected population of each city.

Data



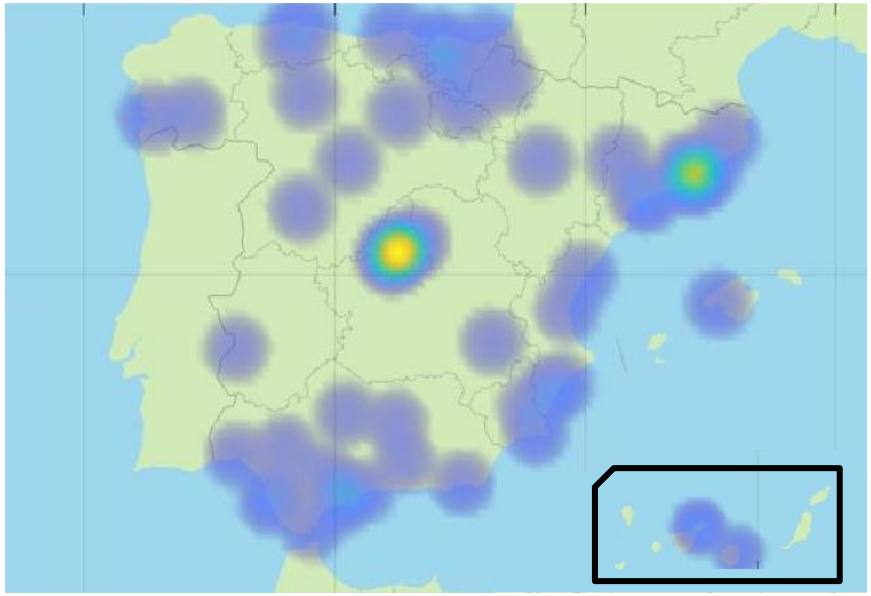
- Vaccination data includes:
  - The vaccine effectiveness model
  - The vaccination strategy

Data

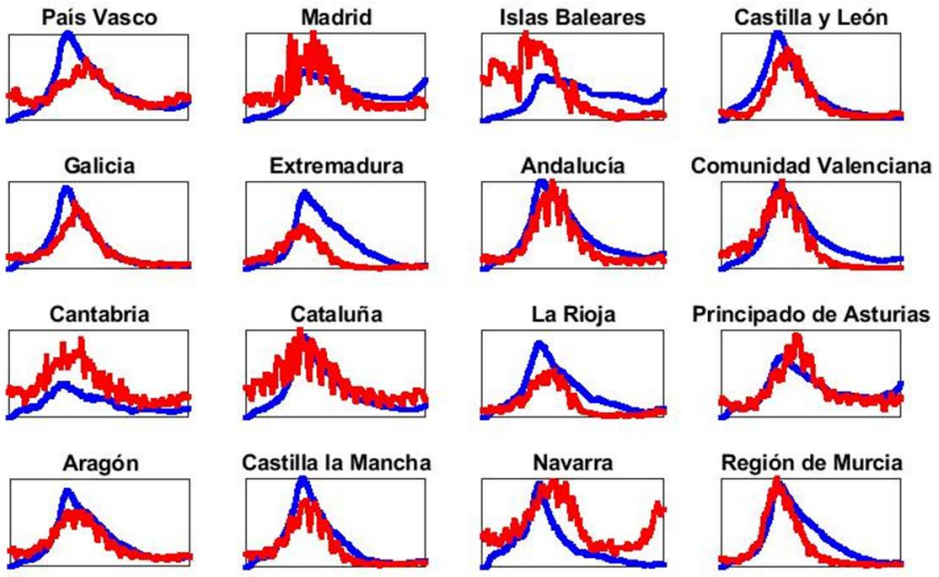


- Meteorological data consisting samples taken by meteorological stations in Spain
  - Pressure, humidity and temperature.
  - 10-minute samples

Results



64 most populated Spain cities



Simulation (blue line) fit to real cases (red line) by province

- Median of cities of the same province
- Aggregated province data

Current research directions

- Vaccination strategies
  - New COVID-19 variants
- Mask use relaxation
- Evaluating the impact of social gathering events.
- European Covid-19 Forecast Hub
  - https://covid19forecasthub.eu/