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Modelling fast spreading patterns of airborne infectious diseases using complex networks

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The pandemics of SARS (2002/2003) and H1N1 (2009) have impressively shown the potential of epidemic outbreaks of infectious diseases in a world that is strongly connected. Global air travelling established an easy and fast opportunity for pathogens to migrate globally in only a few days. This made epidemiological prediction harder. By understanding this complex development and its link to climate change we can suggest actions to control a part of global human health affairs.

In this study we combine the following data components to simulate the outbreak of an airborne infectious disease that is directly transmitted from human to human:

- Global Air Traffic Network (from openflights.org) with information on airports, airport location, direct flight connection, airplane type
- Global population dataset (from SEDAC, NASA)
- Susceptible-Infected-Recovered (SIR) compartmental model to simulate disease spreading in the vicinity of airports. A modified Susceptible-Exposed-Infected-Recovered (SEIR) model to analyze the impact of the incubation period.
- WATCH-Forcing-Data-ERA-Interim (WFDEI) climate data: temperature, specific humidity, surface air pressure, and water vapor pressure

These elements are implemented into a complex network. Nodes inside the network represent airports. Each single node is equipped with its own SIR/SEIR compartmental model with node specific attributes. Edges between those nodes represent direct flight connections that allow infected individuals to move between linked nodes. Therefore the interaction of the set of unique SIR models creates the model dynamics we will analyze.

To better figure out the influence on climate change on disease spreading patterns, we focus on Influenza-like-Illnesses (ILI). The transmission rate of ILI has a dependency on climate parameters like humidity and temperature. Even small changes of environmental variables can trigger significant differences in the global outbreak behavior. Apart from the direct effect of climate change on the transmission of airborne diseases, there are indirect ramifications that alter spreading patterns. An example is seasonal human mobility behavior which will change with varied climate conditions. The direct and indirect effects of climate change on disease spreading patterns will be discussed in this study.