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The ZoonosisMAGS project : towards a generic platform for population-based geo-simulation of zoonose spread

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In the ZoonosisMAGS Project we develop a generic software platform to model and simulate the propagation of zoonoses over large territories, taking into account the geographic characteristics of the landscape (mainly land-cover) in relation to the suitability of different areas to the survival, dispersal and establishment of populations of the different species involved in a particular zoonose, as well as their influence on the evolution and interactions of these populations. A virtual geographic environment (VGE) is generated from geo-referenced vector data (such as Geobase) and preprocessed in order to minimize the number of cells (polygons) and to enhance them landscape with information such as survival suitability and topological information (such as 'orientation' and 'mean distance' of neighbors) that will be used to deal with species mobility in the simulator. Species' evolution and interactions are modeled thanks to an extension of epidemiological compartment models in the form of state-transition diagrams integrating not only traditional compartment transitions (species stage evolution, species' interactions, maturation and mortality), climatic (influence of temperature) and environmental (influence of area suitability) parameters, but also mobility of species (carrier and carried species) to reflect dispersal phenomena. Moreover, the ZoonosisMAGS System provides an interface to enable public health officers to monitor the spread of the zoonose in the VGE and to explore the possible impacts of different intervention scenarios (i.e. larvicide application) in the context of various atmospheric conditions (i.e. temperature change, heavy rain falls).

In this chapter we present a new formalism that extends traditional compartment models with spatial characteristics in relation to contact and mobility behaviours of interacting species. We present the main components of the ZoonosisMAGS platform : informed virtual geographic environment, management of the extended compartment model, overview of the system architecture and the simulation engine. Illustrations of the formalism and simulation tools are provided for the case of Lyme disease.

We also present ZoonosisMatSim, our Matlab rapid prototyping tool for zoonose simulation that uses our extended compartment formalism to simulate the evolution and interactions of species populations in a limited geographic area. This tool offers a user-friendly interface allowing a

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user to specify the parameters of the extended compartment models, to select climatic scenarios (i.e. daily temperatures), to create scenarios in relation to insect and animal behaviour (i.e. import of ticks by migrating birds), and to human intervention (i.e. larviciding). Hence, this Matlab prototyping tool allows for the assessment, calibration and comparison of compartment models for zoonoses and is complementary to the full-scale geosimulator ZoonosisMAGS. For instance, we used ZoonosisMatSim to generate input and simulation output data sets for sample areas in order to test the simulation results of the full-scale simulation carried out using the ZoonosisMAGS Platform over extended territories.