H23F-0938 A framework to simulate impacts of climate change on malaria transmission in West Africa

Teresa K Yamana and Elfatih A B Eltahir

Civil & Environmental Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA

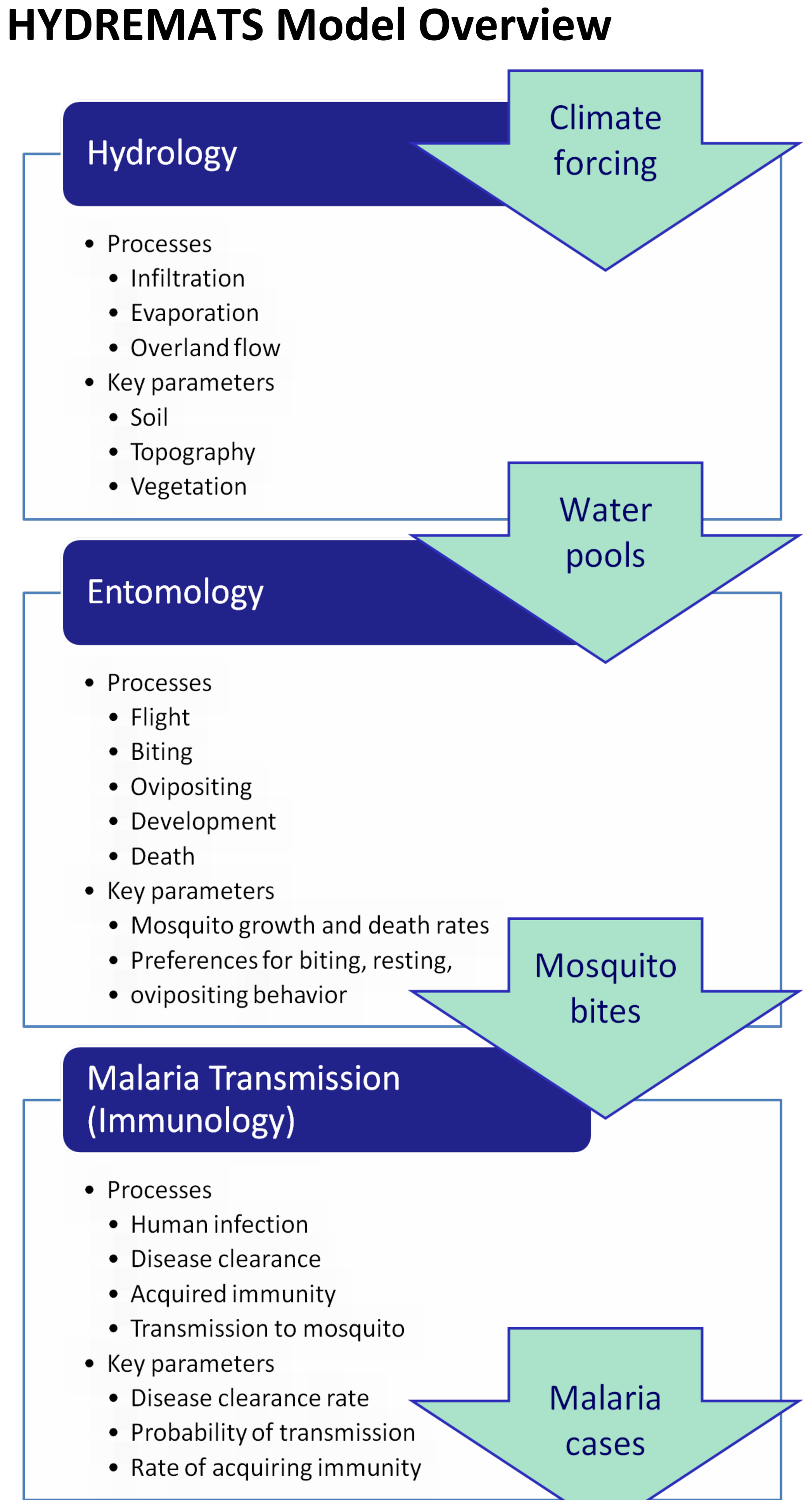
Introduction

Increases in temperature and changes in precipitation due to climate change are expected to alter the spatial distribution of malaria transmission. This is especially true in West Africa, where malaria prevalence follows the current north-south gradients in temperature and precipitation.

We use the Hydrology, Entomology and Malaria Transmission Simulator (HYDREMATS), a mechanistic model of malaria transmission, to establish relationships between environment, entomology and malaria.

We then develop a framework to translate predictions of climate change into predicted changes of mosquito populations and malaria prevalence.

HYDREMATS Model Overview



Simulations

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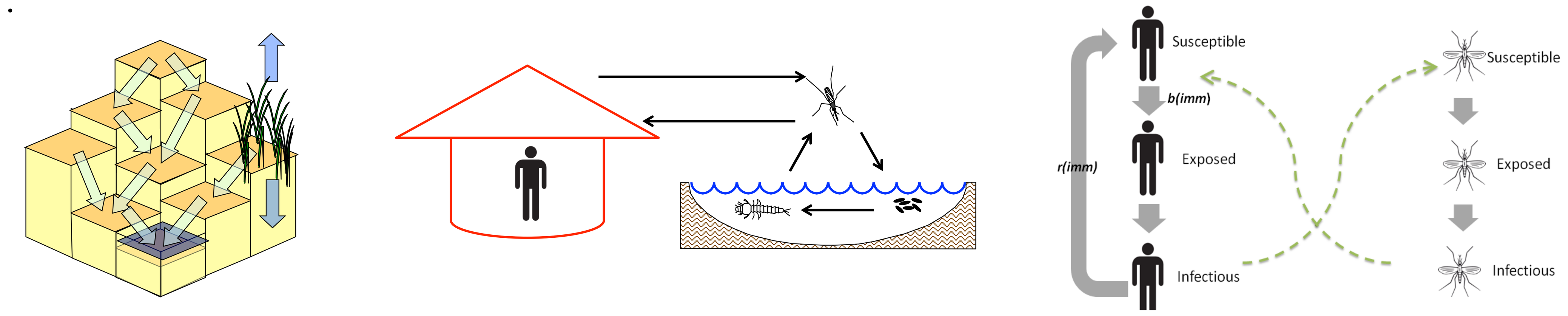
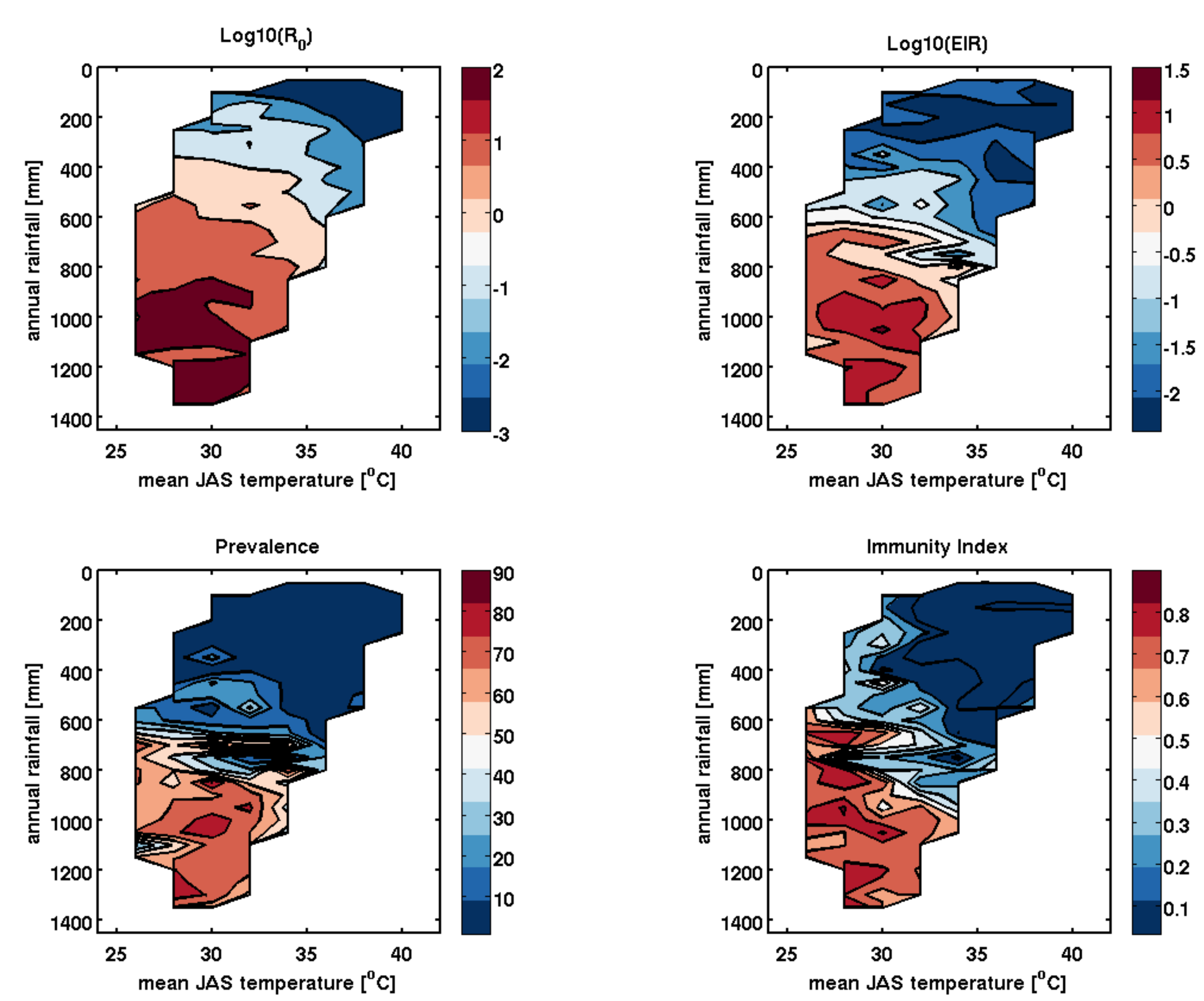


Hydrology Entomology Malaria Transmission

The Hydrology component of HYDREMATS uses environmental inputs to explicitly simulate overland flow and location, depth, temperature and persistence of water pools required by *Anopheles* mosquitoes for breeding. The Entomology component simulates the life cycle of individual mosquito agents. In the Malaria Transmission component, the parasite is spread among human agents through mosquito bites. (Bomblies et al. 2008, Yamana et al. 2013)

Using combinations of environmental inputs from satellites and reanalysis products, we simulated malaria transmission for 1600 years. The results of these simulations allow us to establish relationships between climate and various aspects of malaria epidemiology, some of which are difficult to measure in the field.

Results: Linking environment to malaria in current and future climate



The figures to the left were created by interpolating the results of each simulated year. The x-axis is temperature averaged July-September, and the y-axis is the total annual rainfall for that year.

The upper-left figure shows R_0 as a function of rainfall and temperature. Malaria transmission can only occur when R_0 is greater than 1, corresponding to the red shaded area. As expected, R_0 is higher in cool, wet climates than it is in hot dry climates.

The relationships between climate and EIR, immunity and prevalence are less straightforward, as these values depend not only on the climate and entomology conditions for the given year, but also reflect conditions in past years due to the feedbacks between infectious bites, acquired immunity and prevalence.

The framework developed here can be used to demonstrate the effects of climate change. Any location can be shown on the above surfaces as a cloud of points representing current rainfall and temperature conditions, and their corresponding values of R_0, EIR, prevalence and immunity.

The extent of interannual variability is represented by the spread between points. As temperatures increase and rainfall patterns change, the cloud of points shifts. Changes in temperature and rainfall taken from global climate models can be applied to these figures to show the effect of climate change on malaria transmission.

Definitions

R_0 : Basic reproduction number
The number of secondary infectious that would result from a single infected person. This is a measure of environmental suitability for malaria transmission and depends primarily on temperature and mosquito population size

EIR: Entomological inoculation rate
The number of infectious bites per person per year. Depends on both the entomology and the parasite rate.

Prevalence: The fraction of people infected by malaria

Immunity index: A measure of the level of acquired immunity in the population ranging from 0 (no immunity) to 1 (maximum immunity).

References

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Further information

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Website: http://eltahir.mit.edu
Email: tkcy@mit.edu