Simulation of Malaria Transmission among Households in a Thai Village using Remotely Sensed Parameters

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Malaria Modeling and Surveillance is a project in the NASA Applied Sciences Public Health Application Program. NASA satellite data, climate model output, ground measurements, and commercial satellites data are used for predicting malaria transmission risk. Thailand and Indonesia are our main application areas.

Our three objectives, the benefits, and the main techniques used are shown.

Remote sensing data, climate model output, and ground measurement data are used in this project, along with those from TRMM, MODIS, MODIS, AVHRR, GMAO, GCM, SRES, GPPC, and NASA.

Our risk prediction model uses meteorological parameters derived from satellite and ground-based measurements. Surface temperature is from MODIS (Moderate Resolution Imaging Spectroradiometer), vegetation index is from AVHRR (Advanced Very High Resolution Radiometer) and MODIS, and precipitation is from TRMM (Tropical Rainfall Measuring Mission). Distributions of these parameters for 4 Thailand seasons are shown.

Detection of ditches using 1 meter ground data (albeit roads of 4 km, allowed):

Ditches are important larval habitats of Anopheles sinensis. Our textural-contextual classification techniques can accurately identify these potential larval habitats. This particular test site is in South Korea.

An example for Objective 1:
Irrigation and drainage ditches are important larval habitats of Anopheles sinensis. Our textural-contextual classification techniques can accurately identify these potential larval habitats. This particular test site is in South Korea.

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An example for Objective 2:
Neural network methods are used for forecasting or prediction. Hindcast is used to measure the performance. In this example, the left figure shows the actual average monthly incidence in 2001. And the right figure shows the hindcast one. The two are in good agreement.

This poster mainly concerns Objective 3.

An example for modeling is given here – a hamlet with 23 houses and 2 cattle sheds, which are surrounded by 24 groups of larval breeding sites. Each household has 4 residents; and each resident has no or her own activity and immunity. This hypothetical hamlet in approximately 1/3 of a real test site. Although we can model the entire village, we still use this hamlet for quick hypothesis testing.

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SIMULATION OF MALARIA TRANSMISSION AMONG HOUSEHOLDS IN A THAILAND VILLAGE USING REMOTELY SENSED PARAMETERS

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We have used discrete-event simulation to model the malaria transmission in a Thailand village with approximately 700 residents. Specifically, we model the detailed interactions among the vector life cycle, sporogonic cycle and human infection cycle under the explicit influences of selected extrinsic and intrinsic factors. Some of the meteorological and environmental parameters used in the simulation are derived from Tropical Rainfall Measuring Mission and the Ikonos satellite data. Parameters used in the simulations reflect the realistic condition of the village, including the locations and sizes of the households, ages and estimated immunity of the residents, presence of farm animals, and locations of larval habitats. Larval habitats include the actual locations where larvae were collected and the probable locations based on satellite data. The output of the simulation includes the individual infection status and the quantities normally observed in field studies, such as mosquito biting rates, sporozoite infection rates, gametocyte prevalence and incidence. Simulated transmission under homogeneous environmental condition was compared with that predicted by a SEIR model. Sensitivity of the output with respect to some extrinsic and intrinsic factors was investigated. Results were compared with mosquito vector and human malaria data acquired over 4.5 years (June 1999 – January 2004) in Kong Mong Tha, a remote village in Kanchanaburi Province, western Thailand. The simulation method is useful for testing transmission hypotheses, estimating the efficacy of insecticide applications, assessing the impacts of nonimmune immigrants, and predicting the effects of socioeconomic, environmental and climatic changes.