Climate change and Mosquito-borne diseases in Americas: Toward dynamical modelling and prediction at local scale using Earth observation

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ABSTRACT

According to WHO (2015), vector-borne diseases, including mosquito-borne diseases (MBDs like West Nile virus (WNV), Malaria, Dengue Fever or Zika), account for 17% of infectious diseases and are responsible for more than a million cases each year. A well-known is malaria, transmitted by *Anopheles* vectors, which 41% of the world population (about 2.3 billion people) is exposed to.

Many studies focus on the possible reasons of rapid expansion of MBDs: climate change, demographic growth, global mobility of goods and people, rapid and chaotic urban spreading, landscape fragmentation and changes in land cover and/or use, ecological changes, together with the challenges faced by health systems and vector control.

The distribution of MBD is determined by a complex dynamics involving actors of the epidemiological cycle and their relationship with environmental, social and economic factors as well as control actions.

The goal of the present work is to improve our capacity to characterize and predict risk area for MBD transmission using multi-sensor, multi-resolution remote-sensing data, from a public health perspective.

More precisely, this study aims at:

- Characterizing and predict adult mosquito density variation by using microclimatic variation in time and space
- characterizing mosquito habitat and human population exposition to mosquito using land cover
- presenting the synergistic potential of combining the two above mentioned strategies for a better assessment of MBD exposure risk

From a methodological point of view:

- Strategy 1: AVHRR and MODIS images acquired in southern Quebec, Canada, between 2010 and 2015 were used to estimate daily microclimate indicators including the percent vegetation cover (PVC), an indicator of vegetation quantity, surface temperature (ST), the Modified temperature/vegetation index (MTVX), an indicator of the near-surface air temperature, and the Temperature/vegetation dryness Index (TVDI), an indicator of surface moisture. The relationship between these indicators and field data related to population density of several MBDs’ vectors was evaluated using correlation analyzes.

- Strategy 2: Several layers of information was merged to characterize vector habitats, human activities and their interactions in French Guyana and Brazil: land cover maps were obtained from the fusion of high and very-high resolution optical and SAR images. They gave access to crucial information such as the location and characteristics of wetlands (more or less vegetated) and forested areas, known as the breeding and resting sites of the vectors, respectively. These maps were then combined with epidemiological and entomological data to establish a framework of human-vector interactions.

- An in-depth assessment of the possibilities to merge strategies 1 and 2 was conducted, including the demonstration of the feasibility and the synergistic effect of this merge.
Each strategy resulted in the production of:

- daily microclimatic indicators useful for dynamical modelling of MBDs' vectors at local scale,
- land cover maps, seasonal landscape-based index of human-vector interactions and hazards maps (exposition of the population to the vectors).
- A methodological framework that optimizes the merge of the results generated in step 1 and 2, from a public health perspective.

This study is a preliminary step towards the construction of a common project aiming at developing the collaboration and sharing the methodologies/competencies between IRD and PHAC. In the frame of this collaboration, future developments could involve the integration of an index of population sensitivity to MBDs in order to mitigate more accurately current and future health issues associated with MBDs.