TELE-EPIDEMIOLOGY

URBAN MALARIA MAPPING

Vanessa Machault

Advances in Geospatial Technologies for Health

12-13/09/2011

To develop a robust pre-operational methodology to draw <u>dynamic high resolution</u> malaria <u>entomological</u> risk maps in urban settings at two levels:

- risk maps of the *Anopheles* breeding sites with larval productivity

- risk maps of the *Anopheles* adult densities

Based on:

Ground : large data collection
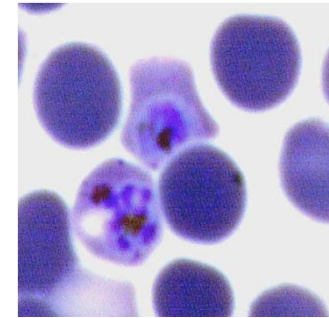
Remote sensing : appropriate data and images

Malaria transmission cycle

Vector female mosquito
Anopheles sp

Parasite
Plasmodium sp

Climate
Environment
Human

- Speed of development

- Spatial and temporal distribution
- Speed of larval development
- Adult survival

Human host

- Distribution and Vulnerability

Urban malaria – Dakar, Senegal

- **60% of the world population will live in cities (2030)**
- **Epidemics of malaria (low parasite transmission, delayed acquired immunity)**
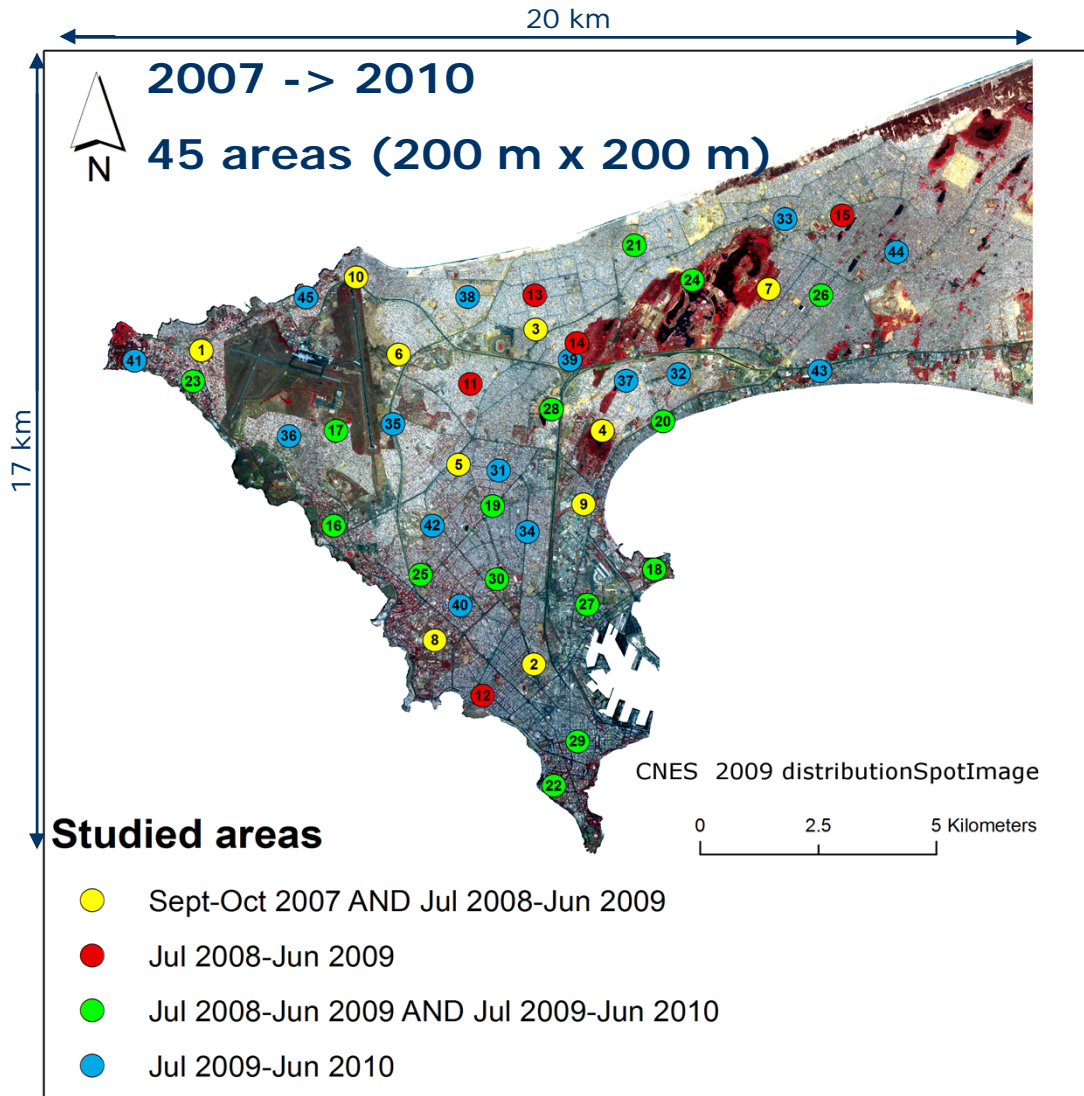
    -> emerging disease

2.5 millions inhabitants in 2007

Sahelian climate

Rainfall: 150-550 mm
(July - October)

Ground entomological data collection

20 km

2007 -> 2010

45 areas (200 m x 200 m)

17 km

CNES 2009 distributionSpotImage

0   2.5   5 Kilometers

Studied areas

- 🟡 Sept-Oct 2007 AND Jul 2008-Jun 2009
- 🔴 Jul 2008-Jun 2009
- 🟢 Jul 2008-Jun 2009 AND Jul 2009-Jun 2010
- 🔵 Jul 2009-Jun 2010

Adult mosquitoes collection / 15 days

- *Human landing catch*
- *2 exterior + 1 interior*

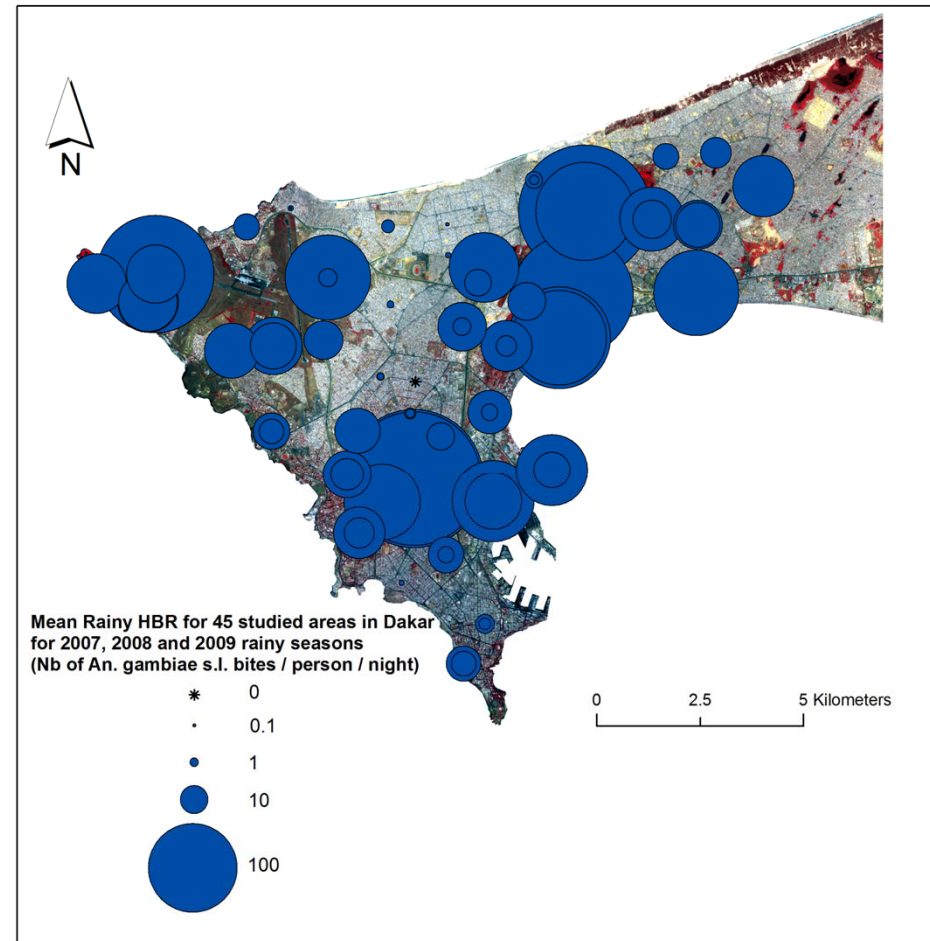
Water bodies + larvae collection / 10 days

- *Exhaustive*
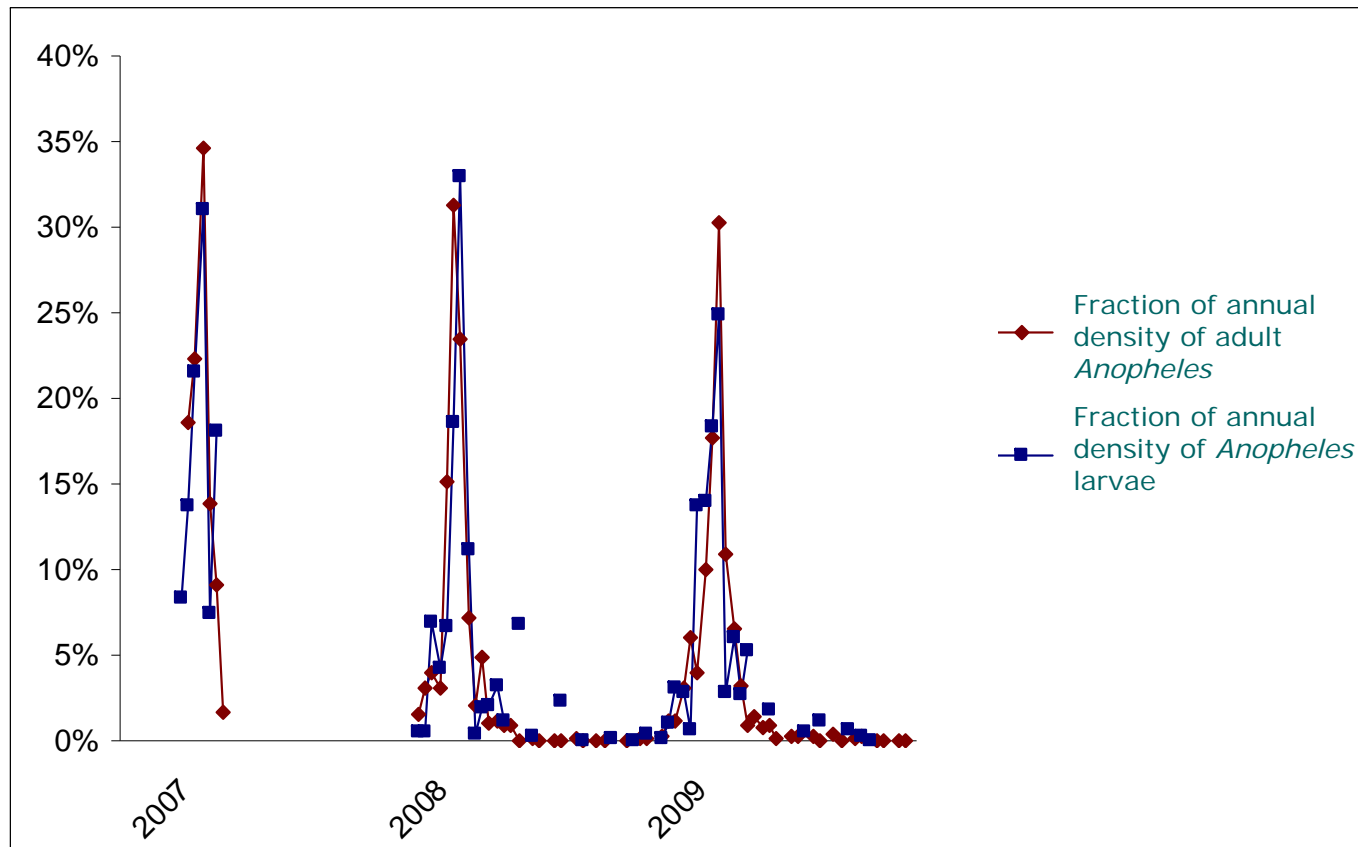
~3000 observations

Spatial heterogeneity in Dakar

Heterogeneity of the breeding sites

(environment, size, persistence, productivity...)

Mean Rainy HBR for 45 studied areas in Dakar for 2007, 2008 and 2009 rainy seasons (Nb of An. gambiae s.l. bites / person / night)

*	0
.	0.1
●	1
●	10
●	100

From 0 to 250 *Anopheles* bites/person/night

Need for spatial risk mapping

Intra-annual heterogeneity

Peak of *Anopheles* in the rainy season

Need for temporal risk mapping

Dynamic pre-operational mapping methodology

Predict the entomological variables observed on the ground

Using statistical analysis

Preliminary step

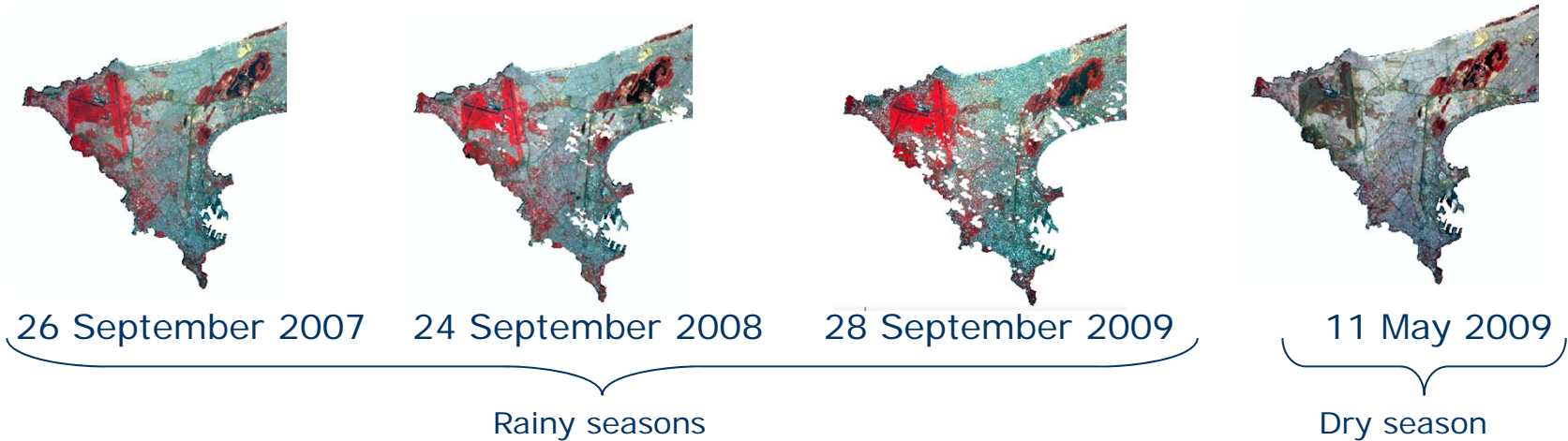**Water bodies detection**

Step 1

Anopheles **larval densities mapping**

Step 2

Adult *Anopheles* densities mapping

Remotely sensed earth observation data

SPOT-5 images (2,5 m + 10 m)

26 September 2007   24 September 2008   28 September 2009   11 May 2009

Rainy seasons   Dry season

* Vegetation, soil, humidity indicators

* Land use and land cover

Digital Elevation Model (SRTM - 90m)

* Altitude

Meteorological data

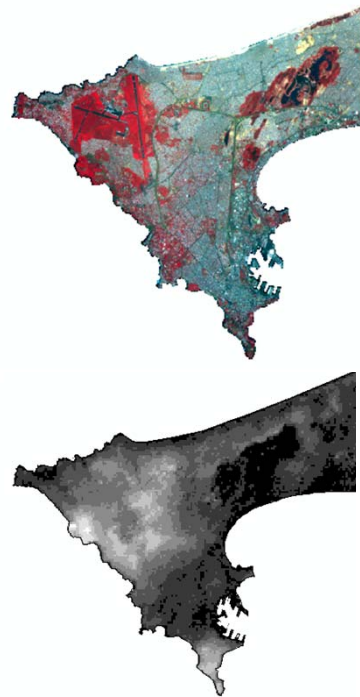**MODIS images (1km – 8 days)**
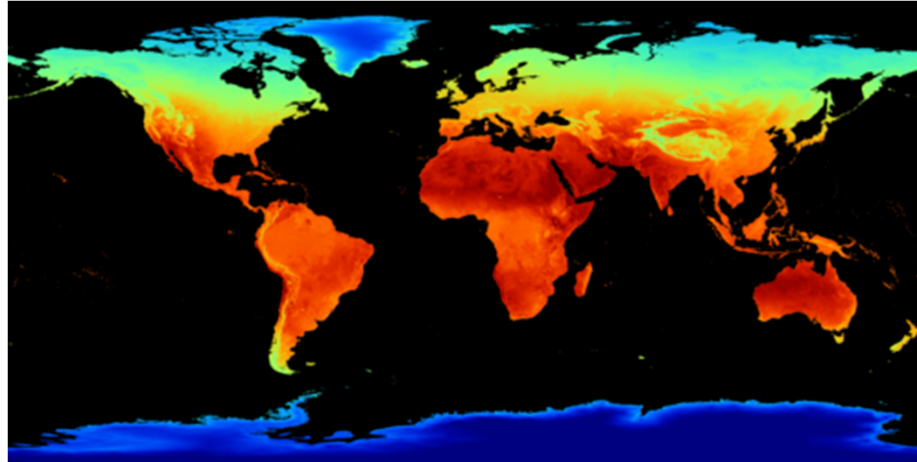
* Land Surface Temperature (LST)

* Daily ground rainfall measurement

Preliminary step: water detection

Predict the water observed on the ground
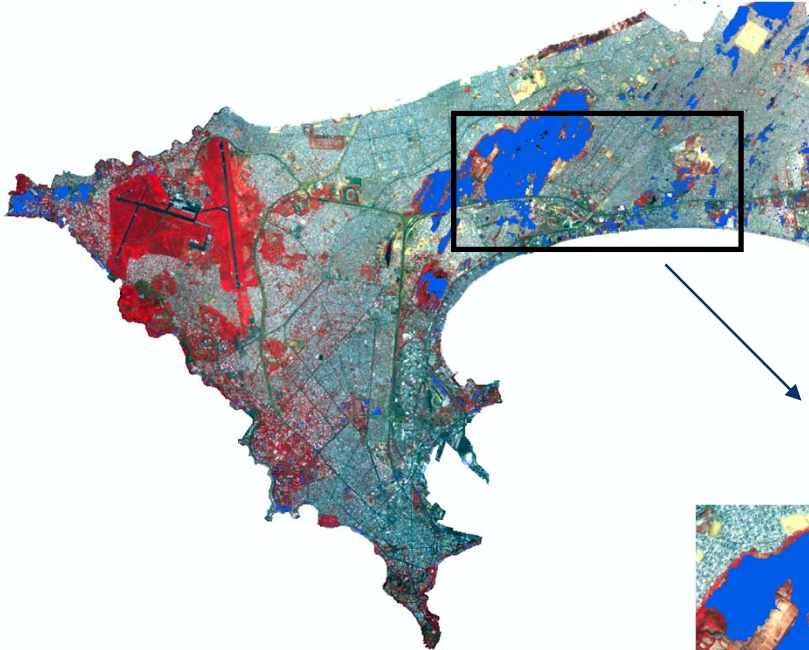
Logistic regression

200m

Geographic Information System

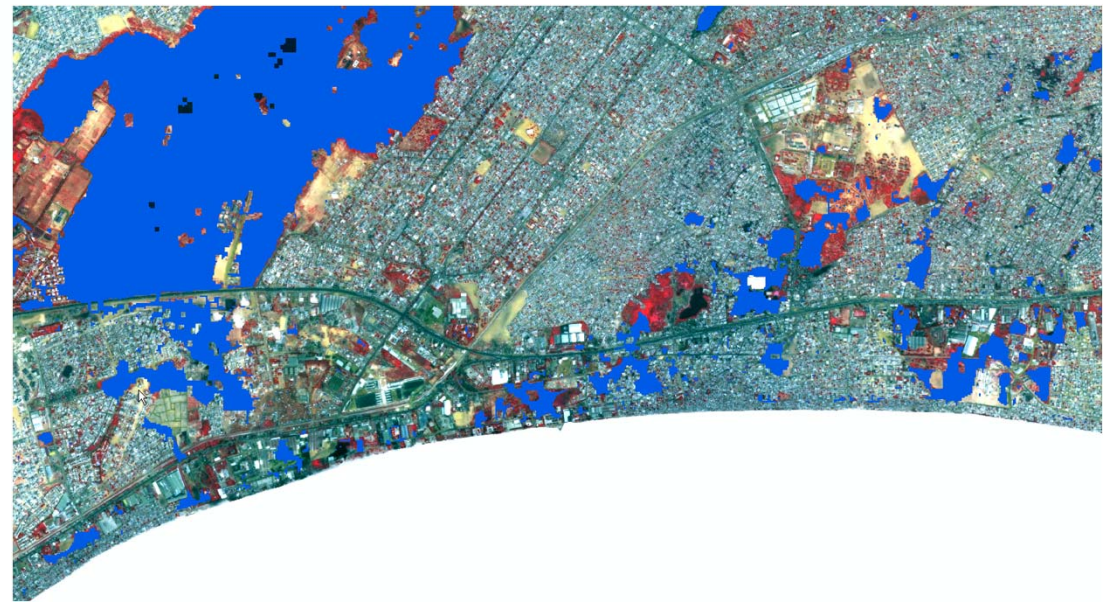**Probability of presence of water in 10m pixels is related to:**

- **Humidity (SPOT-5 Modified NDWI of the rainy season)**

- **Persistent vegetation (SPOT-5 NDVI of the dry season)**

- **Absence of buildings (SPOT-5 classification)**

- **Low altitude = water table (SRTM)**

Inversion and extrapolation of the model to Dakar

Yearly map

Spatial resolution 10m

Step 1: prediction of the presence of larvae

Predict the presence of larvae observed on the ground

Logistic regression

200m

Geographic Information System
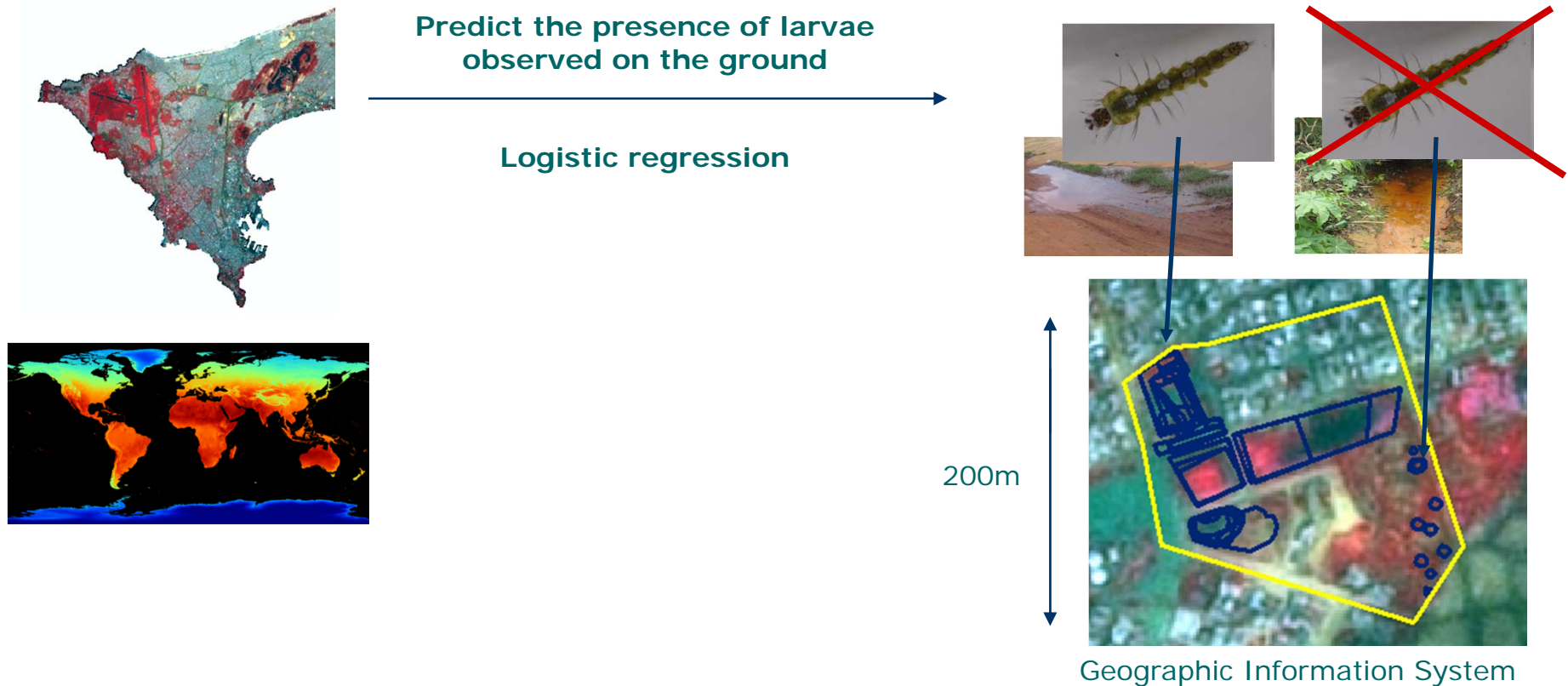
Probability of presence of larvae in water bodies is related to:

- **Temporary collection, muddy bottom (SPOT-5 NDWI MCFeeters and Soil Brightness of the dry season)**

- **Outside of market garden (SPOT-5 NDWI MCFeeters of the dry season)**

- **Night LST (MODIS)**

- **Total rainfall in the preceding 30 days (ground)**

Step 1: map of presence of *Anopheles* larvae

Inversion and extrapolation of the model to Dakar
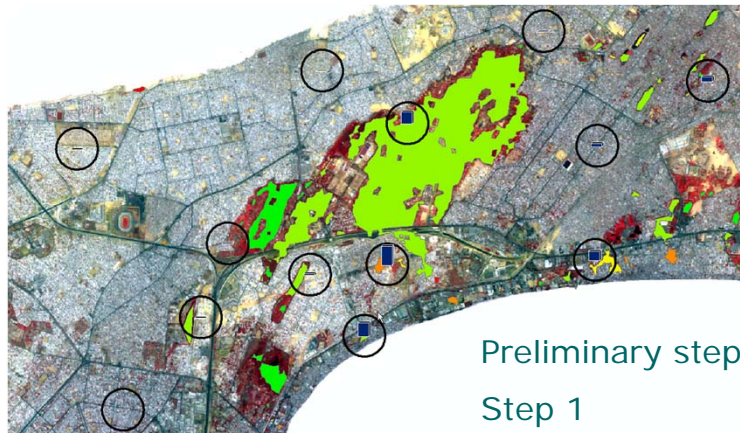using the preliminary step
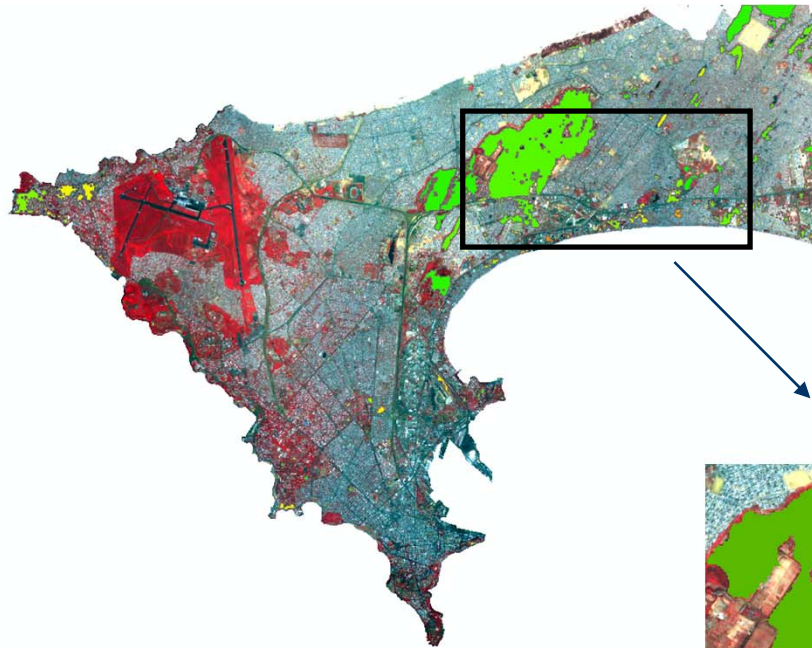
Daily map

Spatial resolution 10m

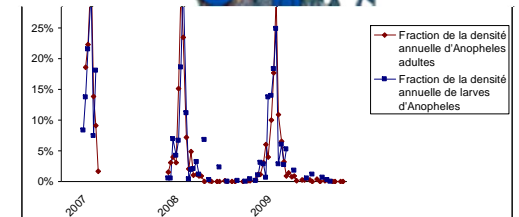**Annual probability of presence of Anopheles larvae (2009)**

🟩	Low	0%
🟩		
🟨	Medium	50%
🟧		
🟥	High	100%

Step 2: prediction of *Anopheles* adult densities

Predict the number of adults recorded on the ground

Negative binomial regression
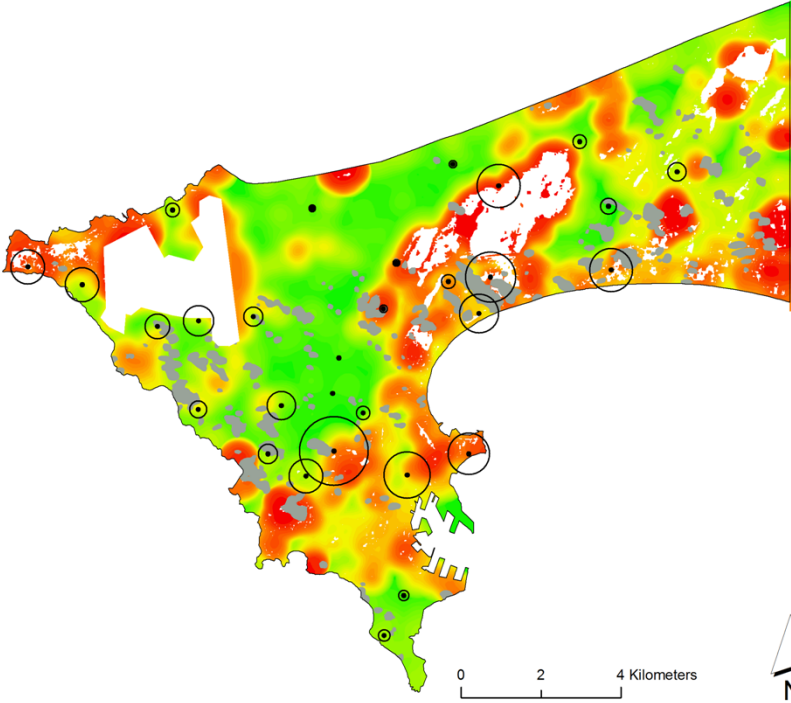
Preliminary step

Step 1

Number of *Anopheles* bites is related to:

- **Predicted surface of water (preliminary step) in the surroundings, weighted by rainfall**

- **Larval productivity (step 1) in the surroundings, summed for the preceding 30 days**

- **Mosquito survival rate 82% (literature)**
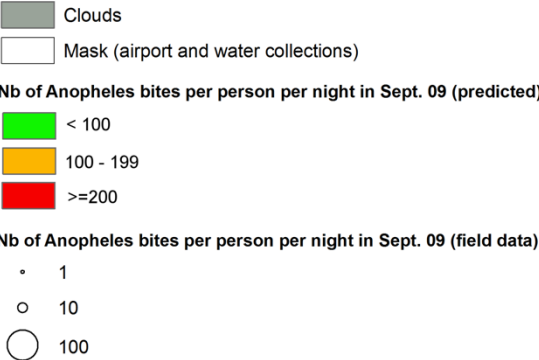
- **Urbanization = dilution of bites (SPOT-5 classification)**

Inversion and extrapolation of the model to Dakar

20 September 2009

Daily map

Spatial resolution 10m

0   2   4 Kilometers

N

Clouds

Mask (airport and water collections)

Nb of Anopheles bites per person per night in Sept. 09 (predicted)

< 100

100 - 199

>=200

Nb of Anopheles bites per person per night in Sept. 09 (field data)

·   1

○   10

◯   100

Remotely-sensed environmental + meteorological data = robust pre-operational methodology to draw different levels of malaria entomological dynamic maps

The models predict the entomological features for any year
-> can predict future risk (EWS)

Guiding, planning and focusing malaria control (national hygiene services)

Peters and Pasvol: Atlas of Tropical Medicine and Parasitology 6th edition © 2006 Elsevier Ltd

Validation and adaptation of the methodology in Bamako (Mali) et N'Djamena (Chad)
IRBA, MRTC (Bamako), CNES, OMP

Industrialization of the mapping methodology -> operational tools
CNES, SIRS, SERTIT, IRBA, OMP

Adaptation of the methodology in rural settings (Burkina Faso)
Univ. Heidelberg, CRSN, CNES, OMP

Research of added value of Very High Resolution imagery
CNES, SERTIT, SIRS, OMP

www.redgems.org

vanessamachault@yahoo.com.br

jean-pierre.lacaux@aero.obs-mip.fr