DSP/ARP/Service Applications & Valorisation

A Conceptual Approach of Tele-epidemiology Applied to the Rift Valley Fever in Senegal

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1 - Improving access to healthcare

Treating patients at remote and mobile sites

2 - Environment / Climate / Health

Monitor, predict and prevent epidemics

Tele-epidemiology *consists in monitoring and studying the propagation of human and animal diseases (water, air and vector borne diseases) which are closely linked to climate and environmental changes, based on space technology. The French Space Agency (CNES) has thus developed, with its partners, a concept based on a deterministic approach of the climate-environment-health relationships and on an original and really adapted space offer.*

The tele-epidemiology conceptual approach

Multidisciplinary approach based upon the study of the key mechanisms favoring emergence and propagation of infectious diseases linking disciplines like environmental sciences, epidemiology, climatology, entomology, hydrology, microbiology…

The analysis of those processes is a key step in the development of new and original risk mapping using space technology

1- Experimental design mainly field studies

- *Observing strategy: monitoring and assembling multidisciplinary in-situ datasets*
- *Diagnostic: extract and identify the main physical and biological mechanisms at stake*

2- Obtaining well adapted products from Space

- *Remote-sensing monitoring of environment, linking epidemics with confounding factors*
- *Remote-sensing from space: use of products, fully adapted to the various spatio-temporal scales of variability*

3- and dedicating modeling

- *Modeling towards an operational Early Warning System (EWS);*
- *Validating/testing EWS*

- **Concept currently applied to different infectious diseases :**
  - **Malaria in urban areas: Puerto Iguazu (Argentina), Dakar (Senegal), Bamako (Mali), Ndjamena (Tchad)**
  - **Malaria in rural areas in Burkina Faso**
  - **Bilharzia in China**
  - **Vibrio in the Mediterranean basin**
  - **Dengue in Argentina and in Martinique Island**

- **Elaboration of an operational system ⇨ RVF in Senegal**

Tele-epidemiological conceptual approach applied to Rift Valley Fever (RVF) Monitoring in Senegal

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Toujours un temps d'avance

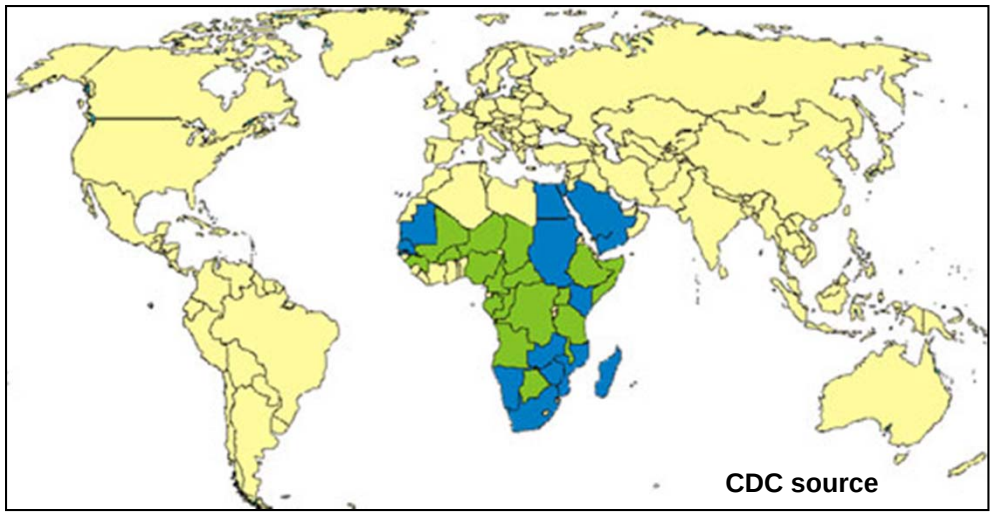
DIREL/DSV

Reflets

Rationale: The Rift Valley Fever (RVF)

- The Rift Valley Fever (RVF) is an arthropod-borne viral disease,
- Found essentially in Africa
- Primarily spread amongst domestic animals by the bites of infected mosquitoes, especially *Aedes vexans* and *Culex poicilipes* ⇨ The abundance of such RVF vectors is directly linked to **ponds' dynamics** and their vegetation cover and turbidity degree. The ponds' dynamics is associated with the **spatio-temporal variability of rainfall events**.
- RVF virus could also infect humans
- RVF is causing epizootics of spontaneous abortion and high mortality rate for domestic animals

⇨RVF can cause very serious economic losses in livestock.



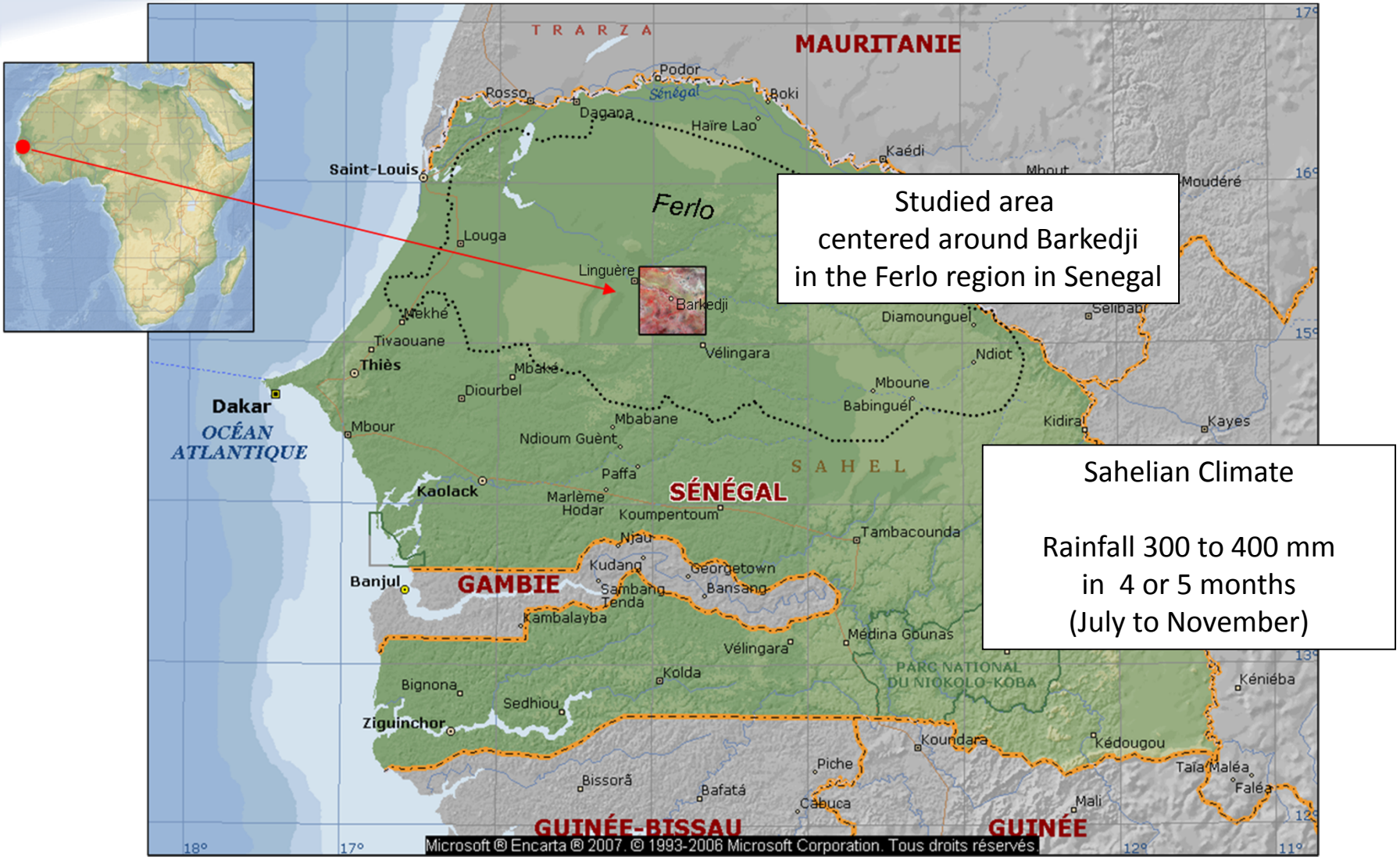
Countries with endemic disease and substantial outbreaks of RVF

Gambia, Senegal, Mauritania, Namibia, South Africa, Mozambique, Zimbabwe, Zambia, Kenya, Sudan, Egypt, Madagascar, *Saudi Arabia, Yemen*

Countries known to have some cases, periodic isolation of virus, or serologic evidence of RVF :

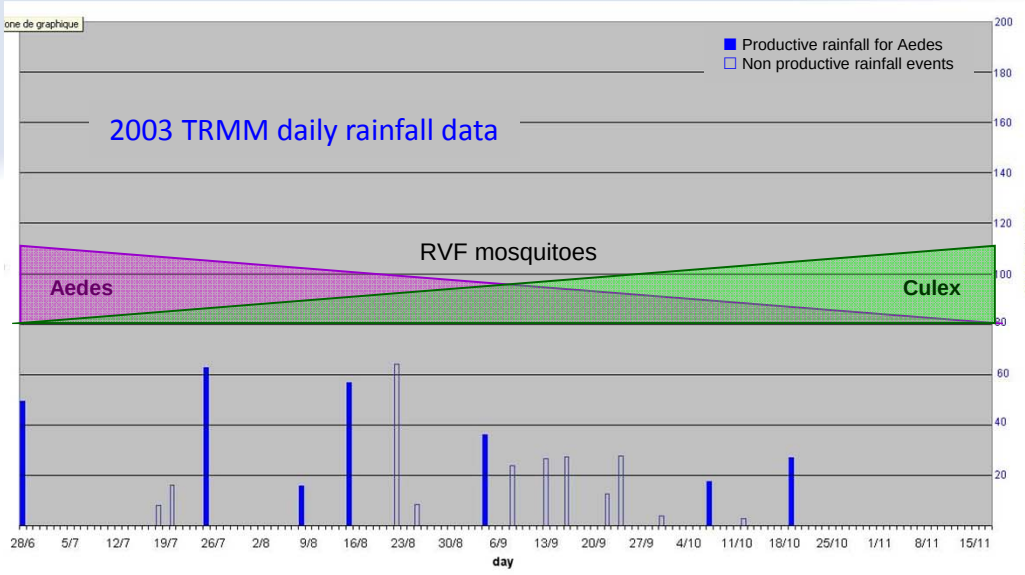
Botswana, Angola, Democratic Republic of the Congo, Gabon, Congo, Cameroon, Nigeria, Central African Republic, Chad, Niger, Burkina Faso, Mali, Guinea, Tanzania, Malawi, Uganda, Ethiopia, Somalia

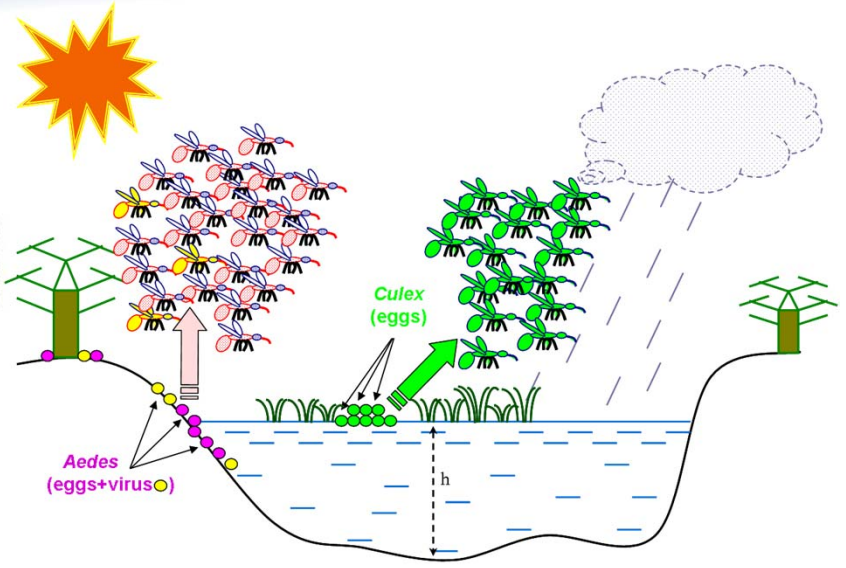
The studied area

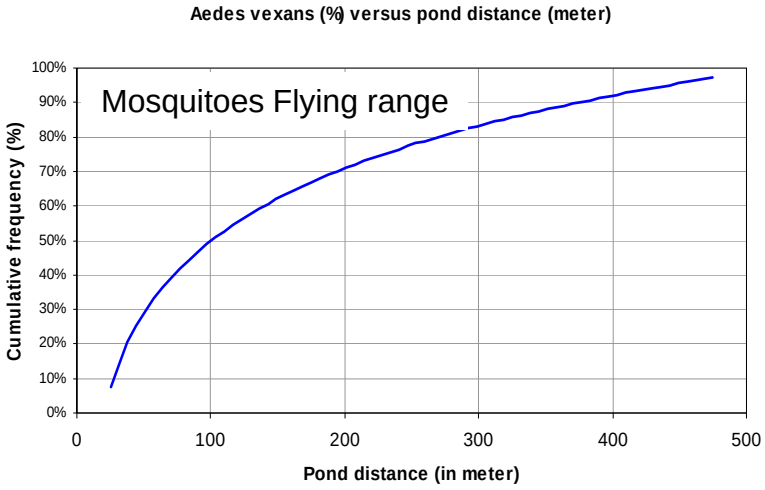


Understanding mechanisms at stake

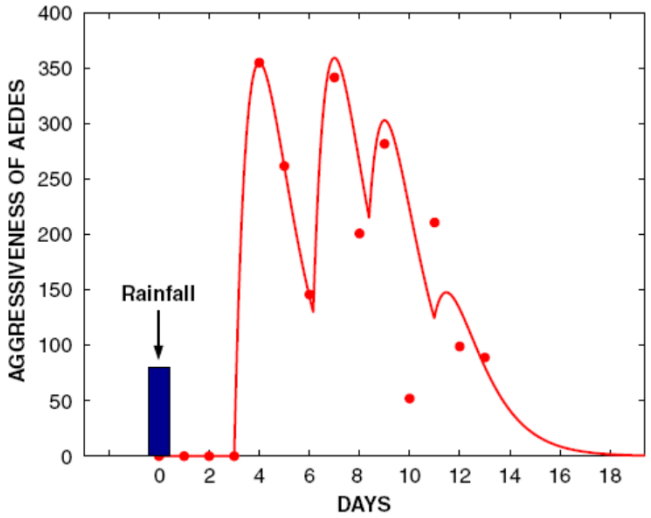
From rainfall event to vectors' aggressiveness







Adapted from Bâ et al 2005



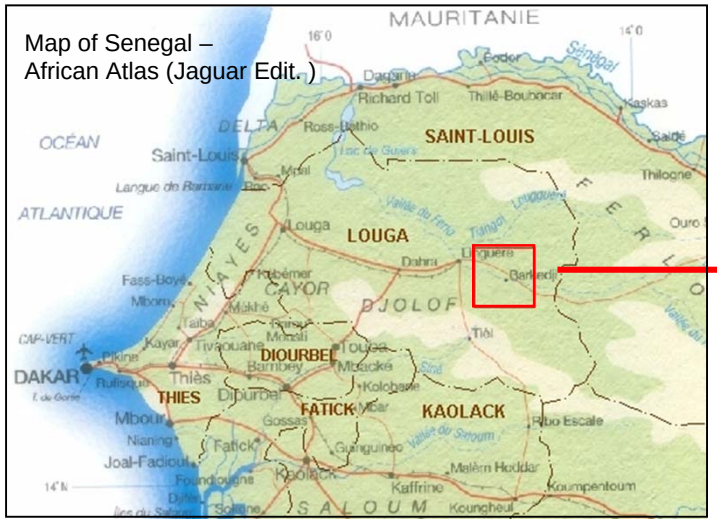
Ndiaye et al., 2006

A Remote-sensing tool applied to Rift Valley Fever (RVF) Monitoring

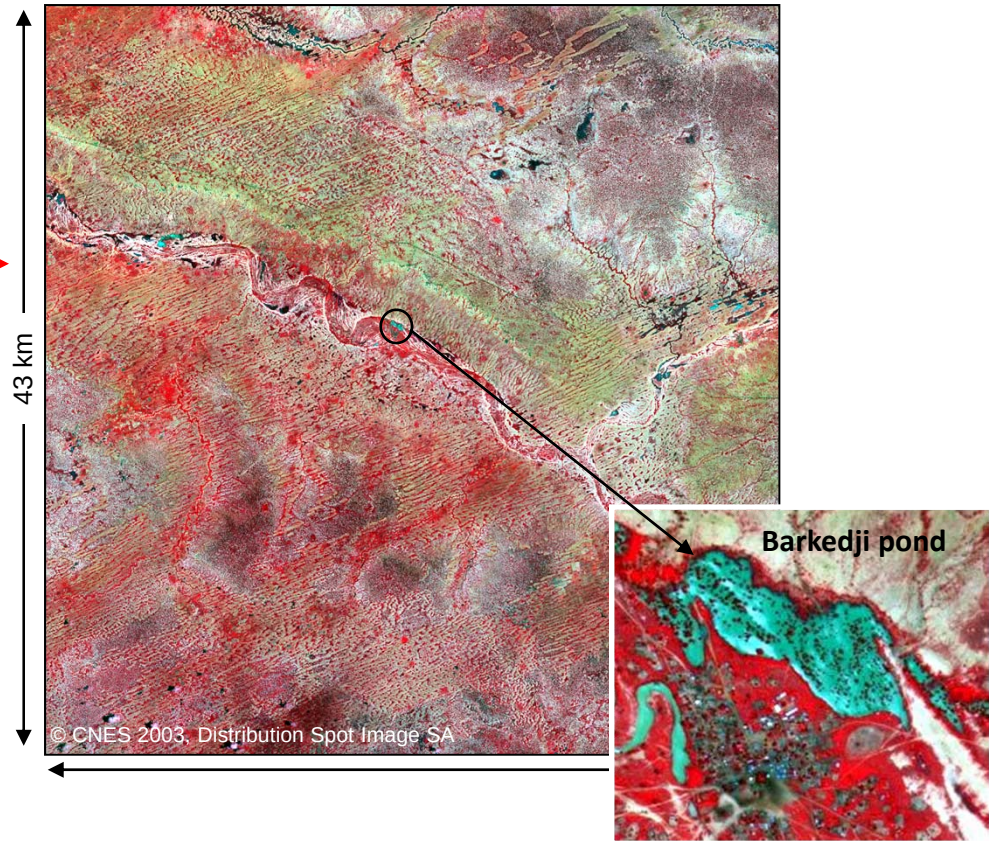
Analyses and processing of high-spatial resolution satellite images (SPOT 5, 10m)

Computation of ponds' area, their vegetation cover and turbidity

Evaluation of Zones Potentially Occupied by Mosquitoes (ZPOM)



Multi-spectral SPOT 5 Image (high-spatial resolution -10m)



On the 26/08/2003
Studied area: 198 337 ha
Number of ponds: 1354
Ponds' area: 1703 ha
Ponds' percentage: 0,9%

Detection of ponds and their characteristics

Developing brand-new indices by combining various wavelengths

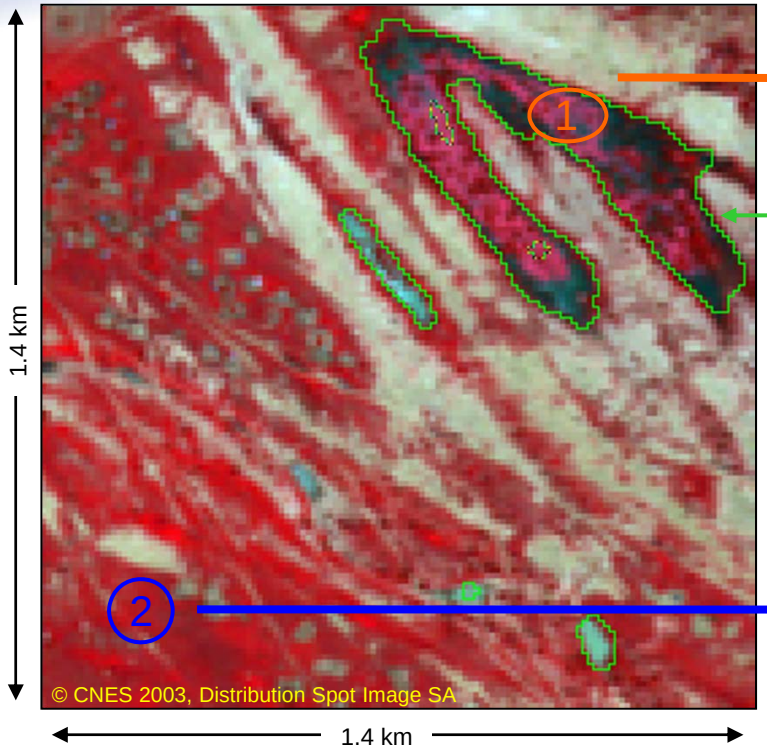
Ponds detection → **NDPI f(MIR, Green)**

Ponds characteristics

- **% Vegetation** → **NDVI f(NIR, Red)**
- **% Turbidity** → **NDTI f(Red, Green)**

A Remote-sensing tool applied to Rift Valley Fever (RVF) Monitoring

Spot 5, multi-spectral high-spatial resolution (10-m)
August 26th, 2003 (during the rainy season)



False color composite

Pond south-west Barkedji
15 ha (peak of rainy season)
55% covers by vegetation
45% free water

1- pond vegetation

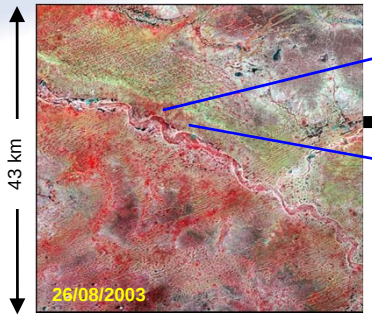
2-sahelian savanna

The new Normalized Difference Pond Index or:
NDPI = (MIR-Green)/ (MIR+Green)

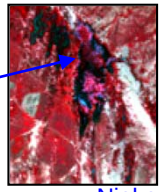
A Remote-sensing tool applied to Rift Valley Fever (RVF) Monitoring

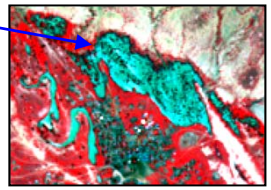
Identify environmental factors of Aedes & Culex presence by remote sensing to obtain risk map

SPOT5 multispectral Image
high spatial resolution -10m
(Program ISIS/CNES)



1354 ponds

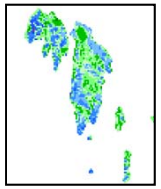

Niaka

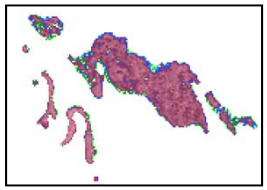

Barkedji

Ponds detection NDPI

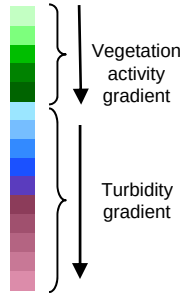
Ponds' area

Characterization NDVI & NDTI





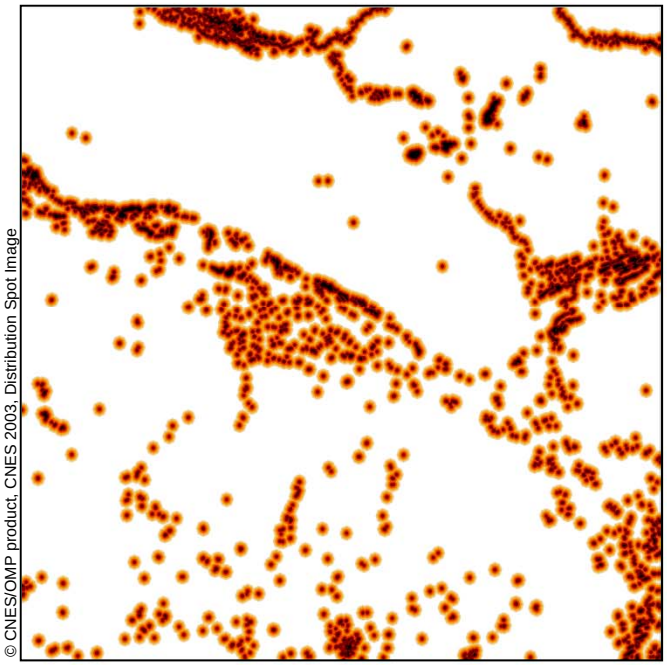
Ponds' characterization



Vegetation Cover

Turbidity

Zones Potentially Occupied by Mosquitoes (ZPOM)



© CNES/OMP product, CNES 2003, Distribution Spot Image

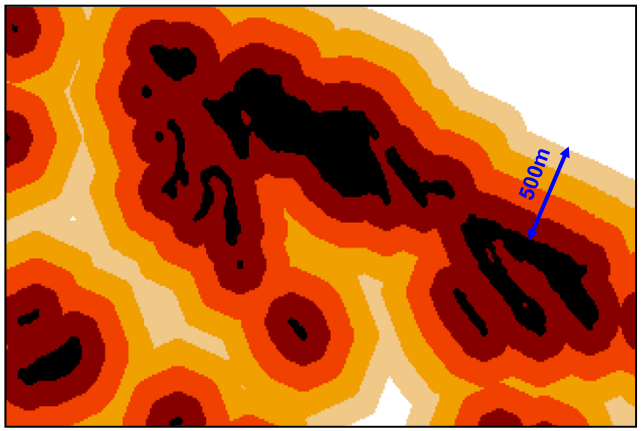
26/08/2003

Ponds ~ 1%

ZPOM = 25%

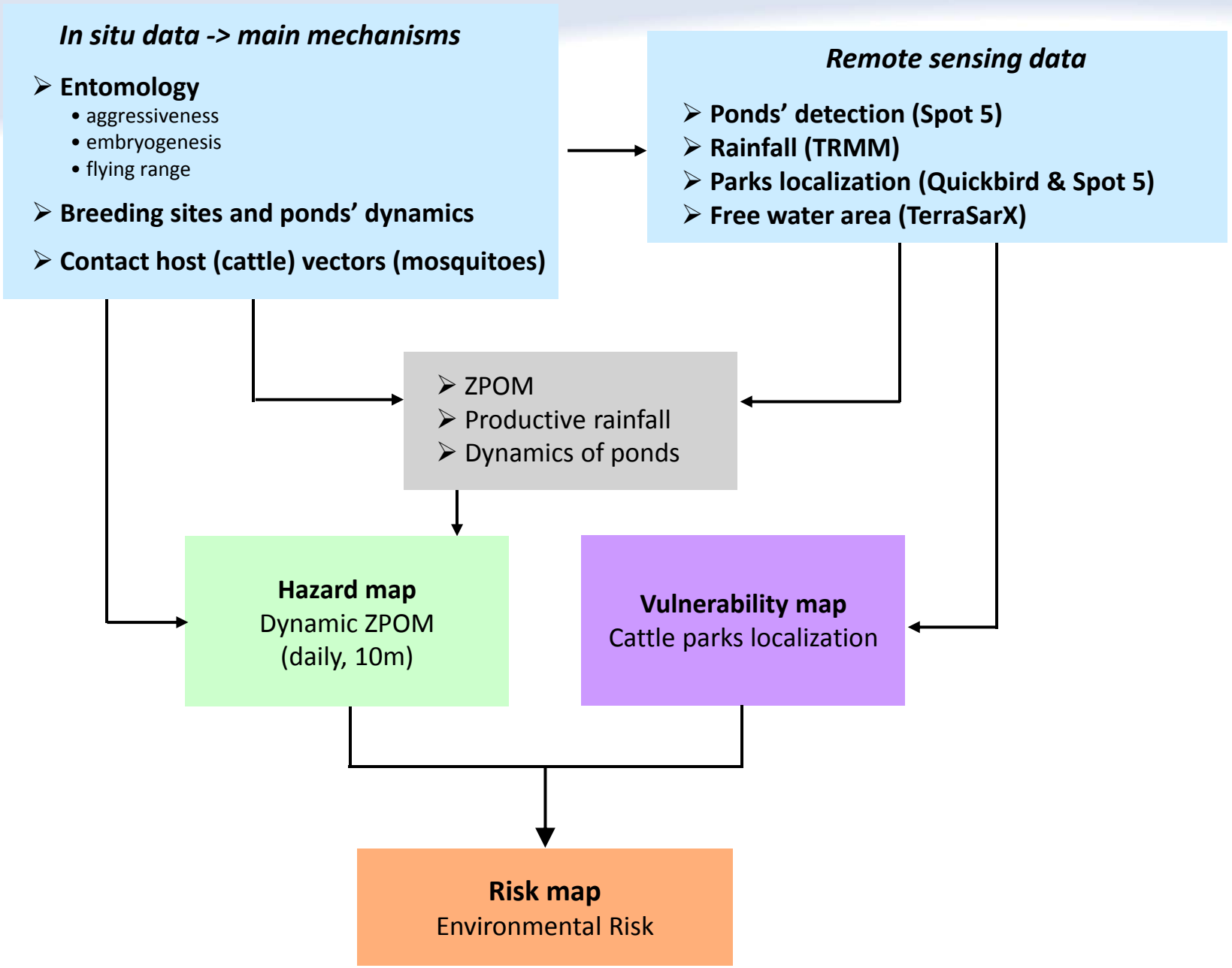
Mosquitoes flying range
~500m (Bâ et al., 2005)

Mapping the ZPOM

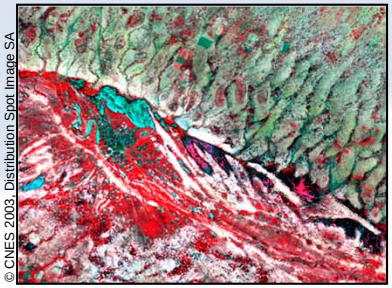


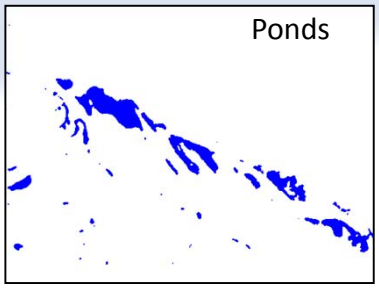
Analyses and processing of high-spatial resolution images (SPOT 5, 10m) allows to detect ponds' area like their vegetation cover and turbidity and finally evaluate Zone Potentially Occupied by Mosquitoes (ZPOM)

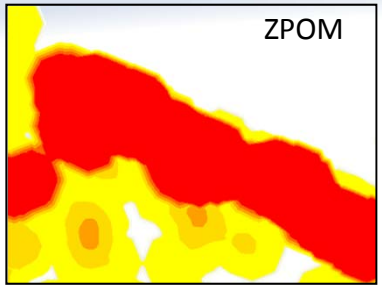
The integrated conceptual approach for RVF

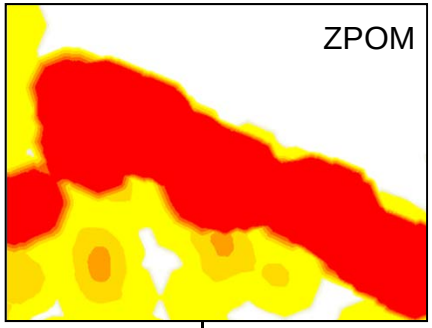


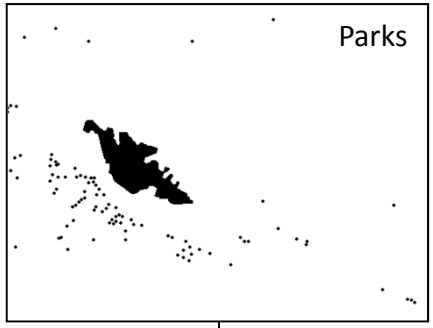
From remote sensing to risk







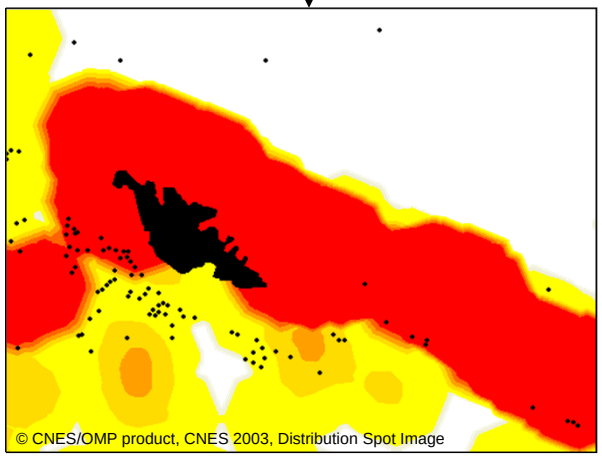




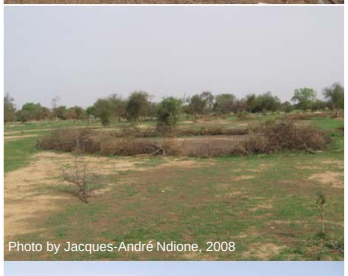
Hazard

Vulnerability

Risk



Some parks …

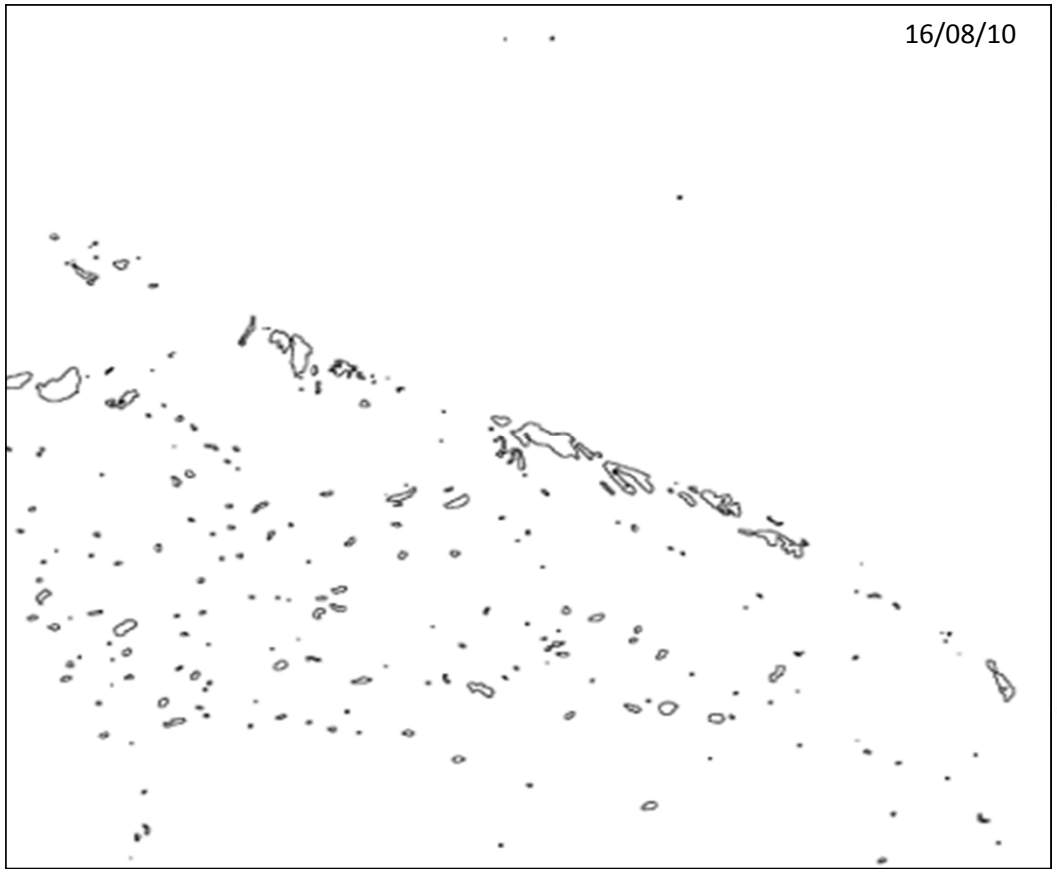


31st July 2010: productive rainfall
61,3mm

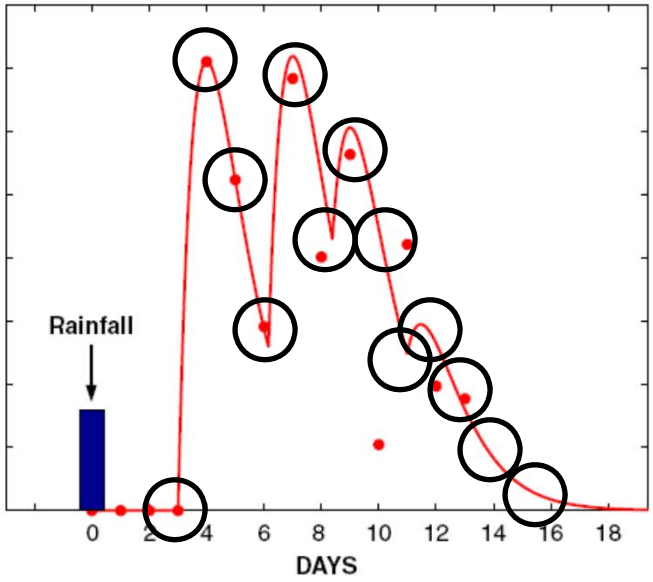
Agressiveness of *Aedes*
from 31st July to 15 August 2010

Hazard : Potential Presence of Aedes

Aucun	Faible	Moyen	Fort	Très fort



Aggressiveness' of *Aedes vexans*



Studied area (15km*15km) centered on Barkedji

Conclusion

- Development of an integrated methodological approach to obtain environmental risk mapping based on space technology
- Concept currently applied to different infectious diseases at different places
- Towards the elaboration of operational Early Warning Systems
- This conceptual approach is meant to be applied to other diseases in other places with different environments

Contacts & informations

Telehealth CNES : www.cnes.fr/telesante & http://RedGems.org

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