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Use of satellite-based rainfall products and spatio-temporal distribution of Rift Valley Fever vectors

by

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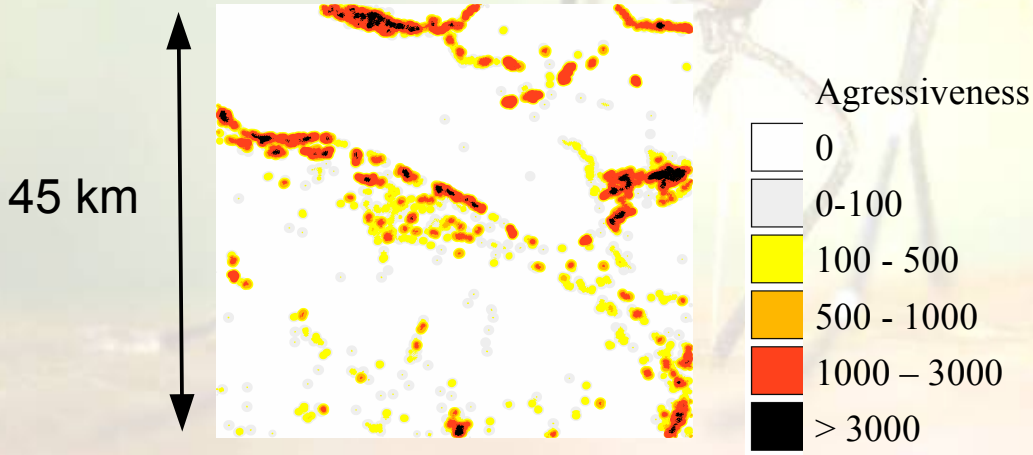
AdaptFVR: A multidisciplinary project

- GICC and CNES project
- 2008-2012
- Study area: Ferlo (Senegal)

- Objective : Provide dynamic mapping of risks associated with Rift Valley Fever vectors to stakeholders at large



► AdaptFVR project

Rift Valley Fever vector species

Tele-epidemiology

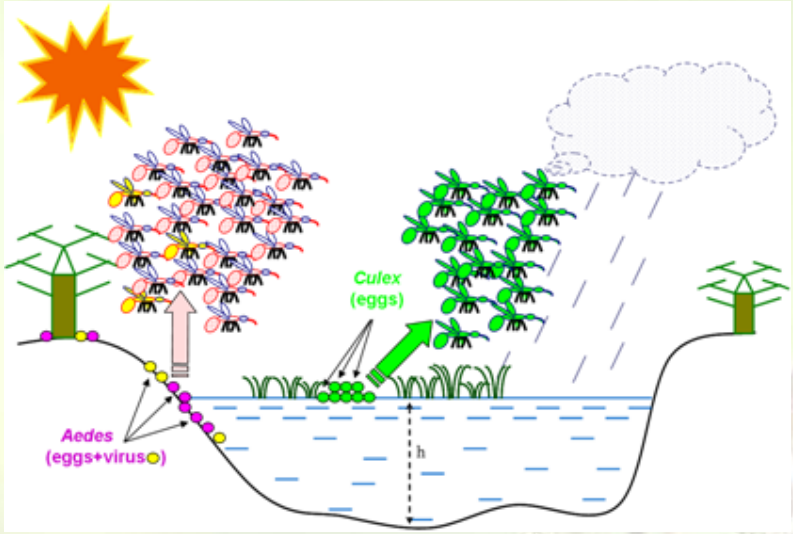
Rainfall heterogeneity in the Sahel

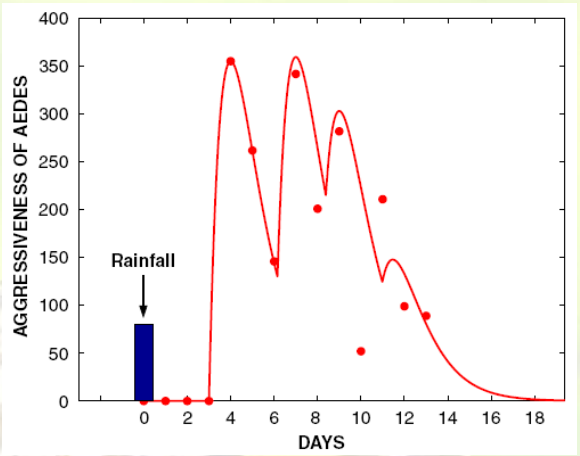
Limits from a single rain gauge

Using satellite-based products

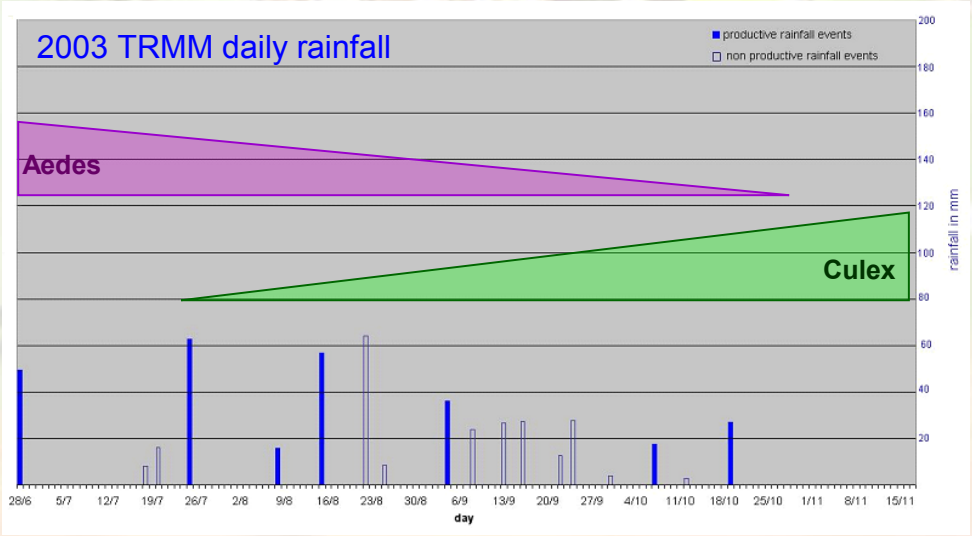
Impact of spatial heterogeneity on vectorial risks

Rift Valley Fever vector species





Ndiaye et al., 2006



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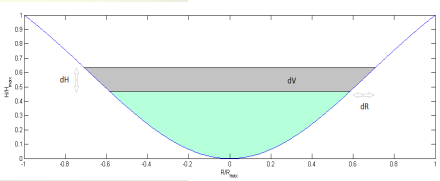
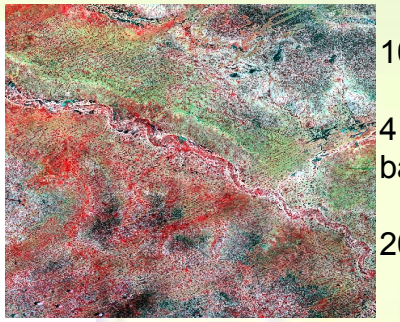
Tele-epidemiology: From rainfall to mosquitoes through ponds dynamic modeling

Rain gauge,
Satellite products



Pond modeled as a gaussian depression



10 m

4 spectral bands

2003/08/26

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Rainfall heterogeneity in the Sahel

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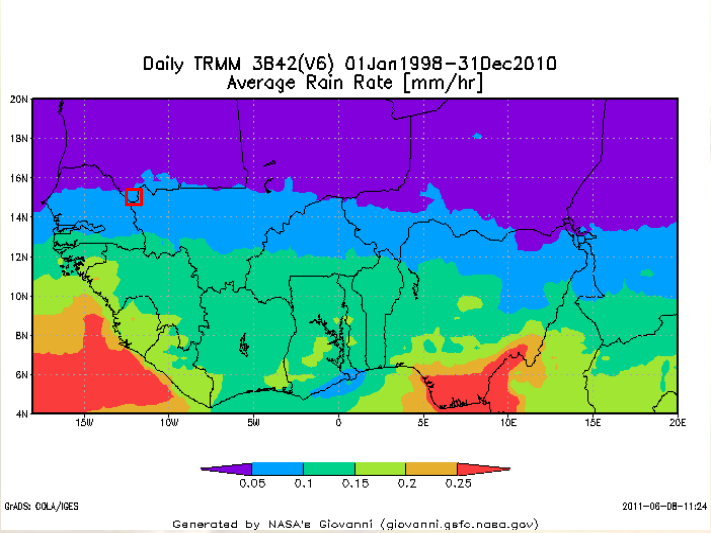
Impact of spatial heterogeneity on vectorial risks

Rainfall heterogeneity in the Sahel

- Semi-arid climate (200-to-500 mm/yr, i.e. 0.02-to-0.05 mm/h)
- Rainy season: June to October
- Deep convection dominates (squall lines and local convection)

  => Strong spatio-temporal *heterogeneity*



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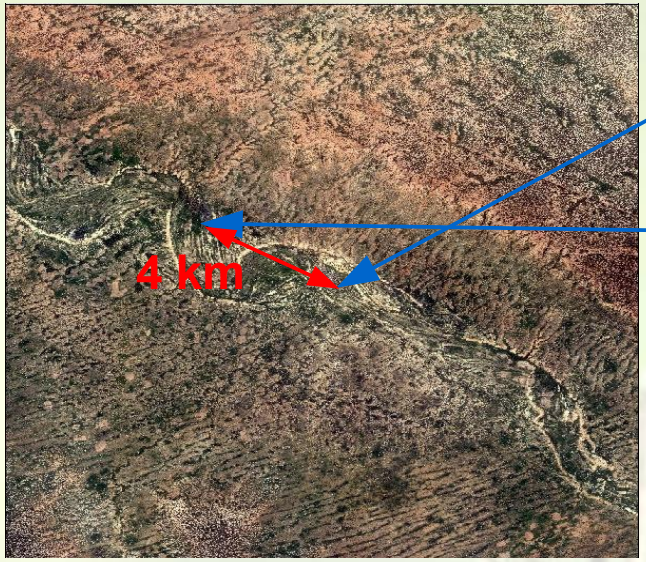
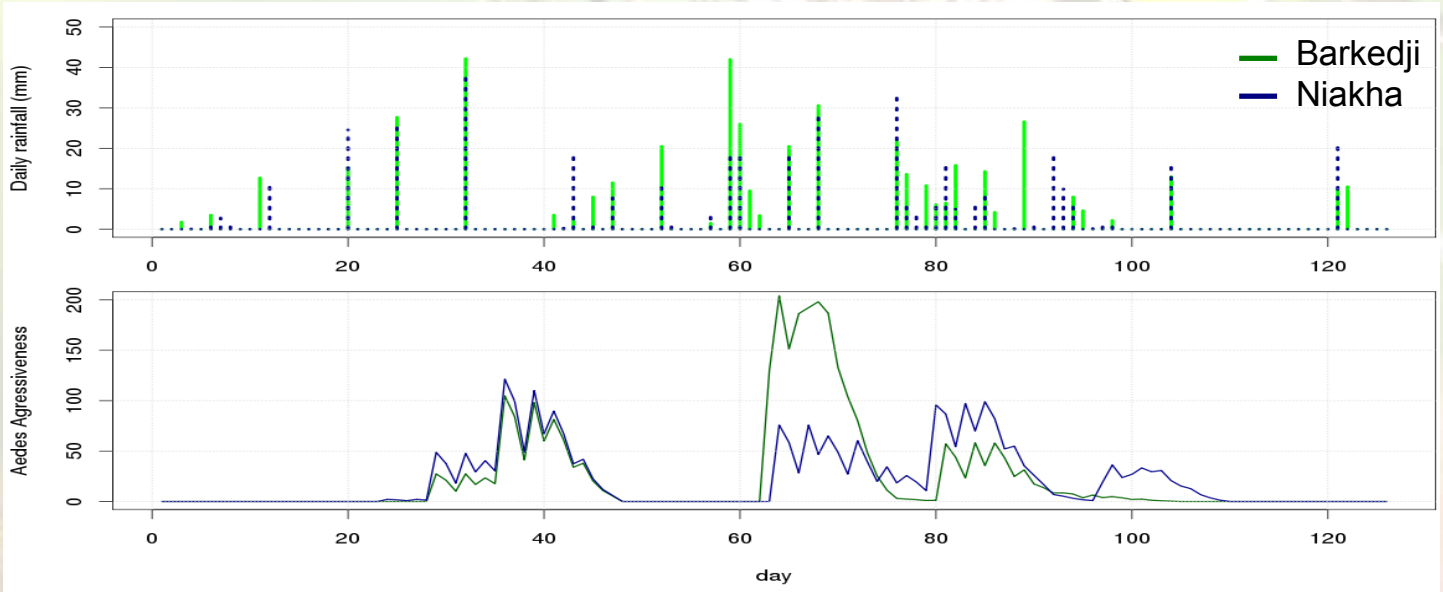
Limits from a single rain gauge (1/2)



Since 1964: a single in Barkedji

Since 2010: a second rain gauge operates in Niakha



model-calculated Aedes agressiveness, 2010

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► Limits from a single rain gauge

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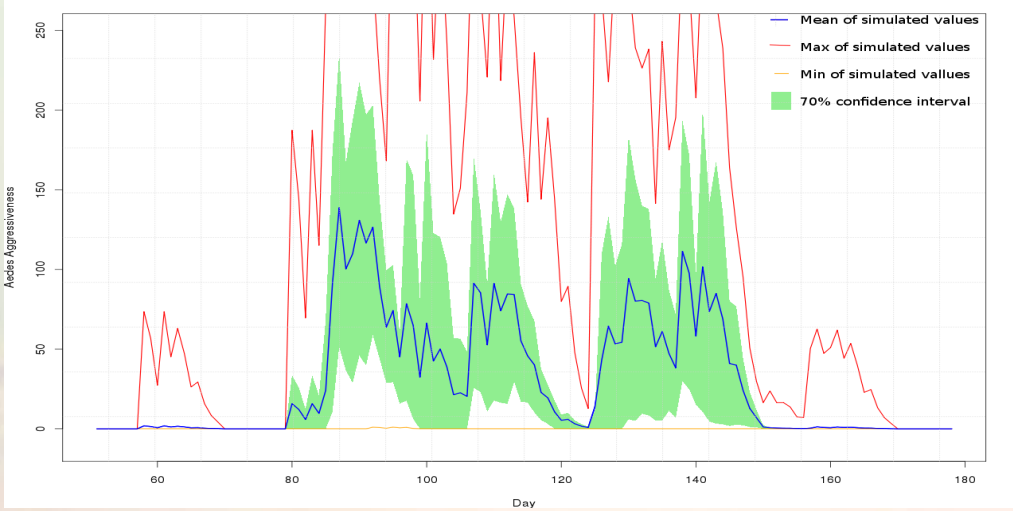
Limits from a single rain gauge (2/2)

- Radar rain fields from Benin (1 km resolution) are used as a proxy to generate a seasonal scenario.
- A single gauge sampling is simulated by taking the amount of rainfall at a random position in the field.
- 200 simulations corresponding to 200 locations of a "virtual gauge"

=> Mean of daily normalised simulations variance (and variation coefficient):

- Calculated water surface: **0.244 (49%)**
- Number of active ponds: **0.348 (59%)**
- -*Culex* agressiveness: **0.914 (96%)**
- -*Aedes* agressiveness: **3.15 (177%)**



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Using satellite-based rainfall products (1/5)

- Comparing satellite products with the AMMA-CATCH dense gauges network in Niger:

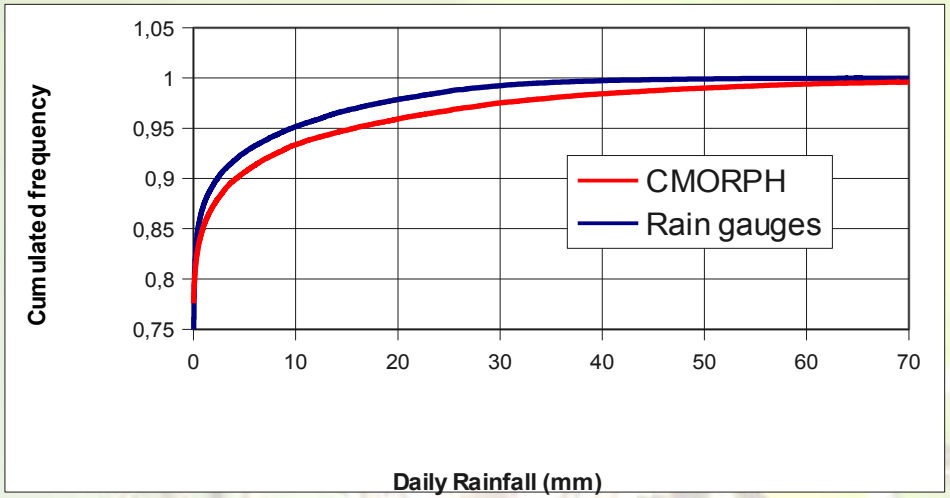
Satellite product	time-series correlation (1°x 1°, 1 day)	Bias
TMPA 3B42 RT (2006-2010)	0.752	+ 49%
PERSIANN (2003-2010)	0.713	+ 139%
CMORPH (2003-2010)	0.797	+ 78%
GSMAP NRT (2009-2010)	0.561	+ 18%
RFE 2 (2003-2010)	0.734	+ 8%
GSMAP MKV (2003-2008)	0.864	+ 57%
TMPA 3B42 V6 (2003-2010)	0.706	+ 1%

- Some products present strong biases => A correction is needed before model forcing.

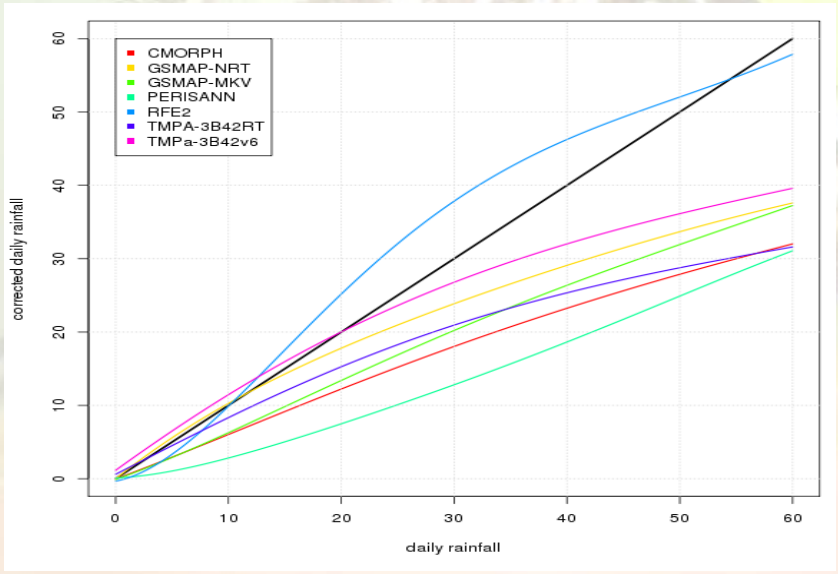
Using satellite-based rainfall products (2/5)

- Satellite rainfall products' bias correction : histogram matching

Cumulated density functions of daily rainfall rates in Niger



Correction functions obtained from Niger network data



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Using satellite-based rainfall products (3/5)

- Hydrological model outputs compared with SPOT optical images observations (2003 to 2010) :

Rainfall data input	Gauge	PERSIANN	CMorph	TMPA-3B42V6	RFE 2	GSMAP*
Correlation, water surface	0.58	0.82	0.72	0.83	0.72	0.68
MSE, water surface (ha^2)	$12x10^4$	$5.5x10^4$	$8.8x10^4$	$5.4x10^4$	$9.3x10^4$	$9.1x10^4$
Correlation, ponds number	0.55	0.85	0.82	0.86	0.75	0.85
MSE, ponds number	$14x10^4$	$2.9x10^4$	$4.3x10^4$	$3.4x10^4$	$4.6x10^4$	$2.8x10^4$

=> A better estimate of total water surface and number of active ponds:

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Using satellite-based rainfall products (4/5)

- Rainfall spatial distribution from satellite products.

  Study area is 45x45 km² (0.40°x0.40°)

  => Can satellite products provide reliable information about rainfall spatial distribution inside this area ?

Satellite product	Nominal spatial resolution	Spatial binary agreement (Niger)	Well estimated events (Niger)
TMPA 3B42 RT (2006-2010)	0.25°	0.64	65%
PERSIANN (2003-2010)	0.25°	0.66	65%
CMORPH (2003-2010)	0.25°	0.70	74%
GSMAP NRT (2009-2010)	0.25°	0.64	64%
RFE 2 (2003-2010)	0.10°	0.62	57%
GSMAP MKV (2003-2008)	0.10°	0.71	77%
TMPA 3B42 V6 (2003-2010)	0.25°	0.63	63%

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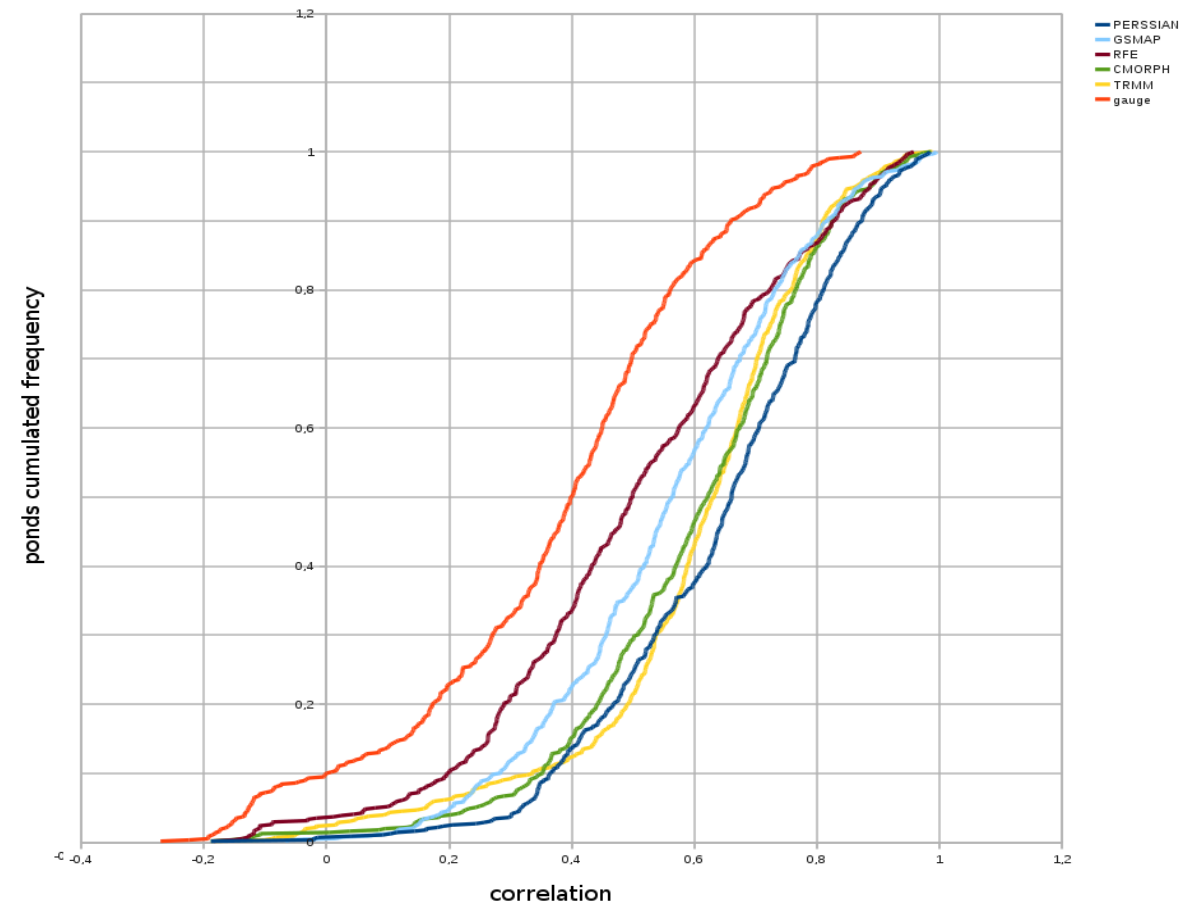
Limits from a single rain gauge

► Using satellite-based products

Impact of spatial heterogeneity on vectorial risks

Using satellite-based rainfall products (5/5)

- Satellite products improve individual pond dynamic modelling:



CDF of correlations beetween model-calculated and observed ponds surfaces

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Limits from a single rain gauge

► Using satellite-based products

Impact of spatial heterogeneity on vectorial risks

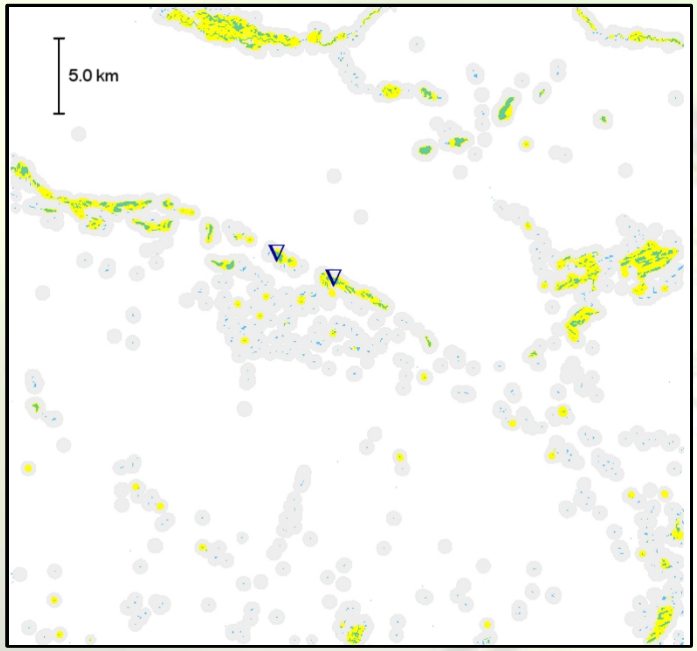
Impact of spatial heterogeneity on vectorial risks

Rain input : homogeneous rain field

- value : 29.7 mm

Aedes Agressiveness (bites/host/night)

0 | 0-100 | 100 - 500 | 500 - 1000

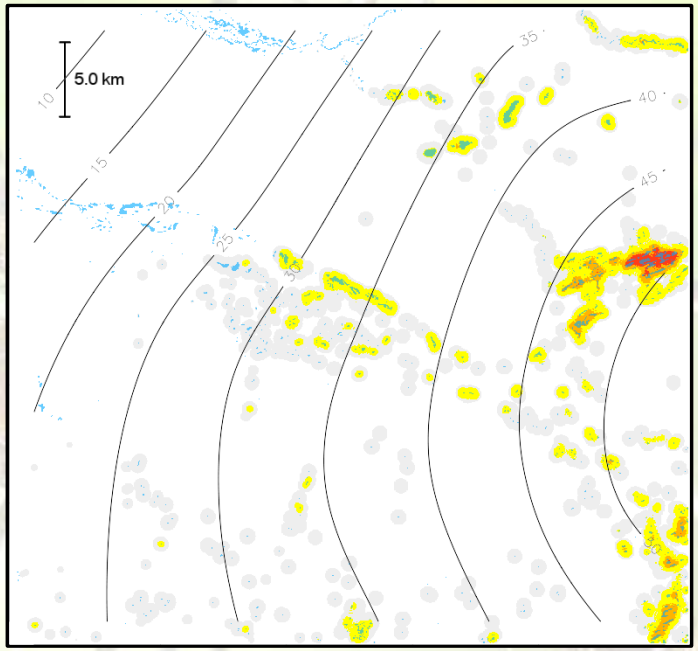


Calculated *Aedes* agressiveness

- mean value : 8.3 b h^{-1} n^{-1}
- max. value : 148 b h^{-1} n^{-1}

Rain input : heterogeneous rain field (GSMAP-MKV 2003/09/04)

- mean value : 29.7 mm
- min. value : 14.8 mm
- max. value : 52.2mm



Calculated *Aedes* agressiveness

- mean value : 17.5 b h^{-1} n^{-1}
- max. value : 701 b h^{-1} n^{-1}

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Conclusion

- Due to spatio-temporal rainfall heterogeneity of the use of a single rain gauge is unsufficient for vectorial risks estimation.
- Use of satellite rainfall data allows for a more realistic modelisation of ponds dynamics.
- From better estimates of mean rainfall within a 45x45 km scenery, the RVF vectorial risk mapping is considerably improved.

Work in progress / Future work

- Apply the technology to other infectious diseases elsewhere
- Include ecosystem variability through high-resolution new satellites products (Pleiade, SPOT 6/7, GPM …)

Publication : Guilloteau C, Gosset M, Vignolles C, Alcoba M, Tourre Y M , Lacaux J P, The impact of satellite-based rainfall products on predicting spatial patterns of Rift Valley Fever vectors, *Journal of Hydrometeorology,* in review.

An operational project

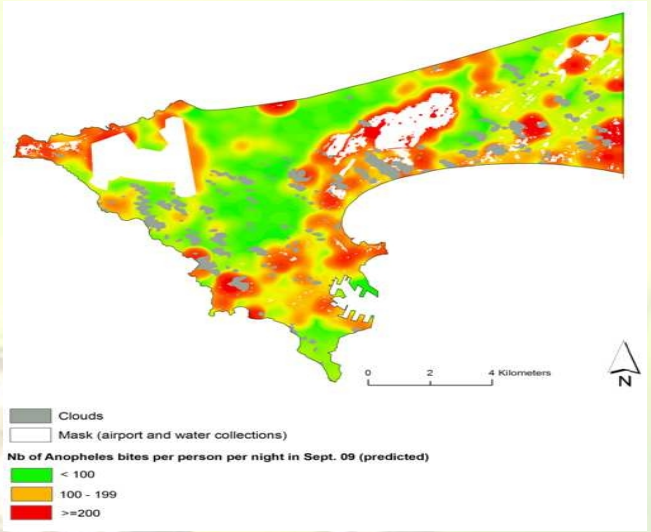
Collaboration with local authorities ...

... to take effective actions :

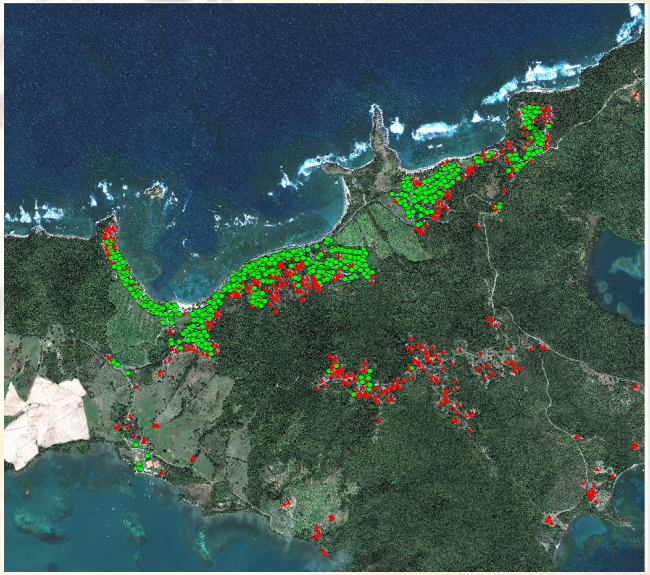
- Remove cattle from high-risk areas.
- Targeted vaccination campaigns.
- Targeted use of larvicide.

Other CNES tele-epidemiology projects

- Urban Malaria: Dakar



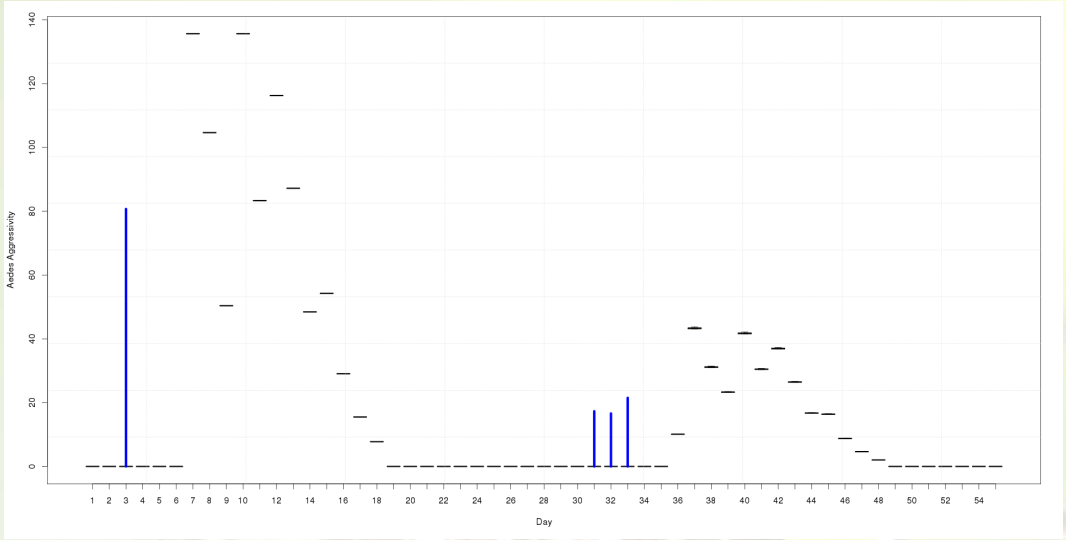
- Dengue in Martinique



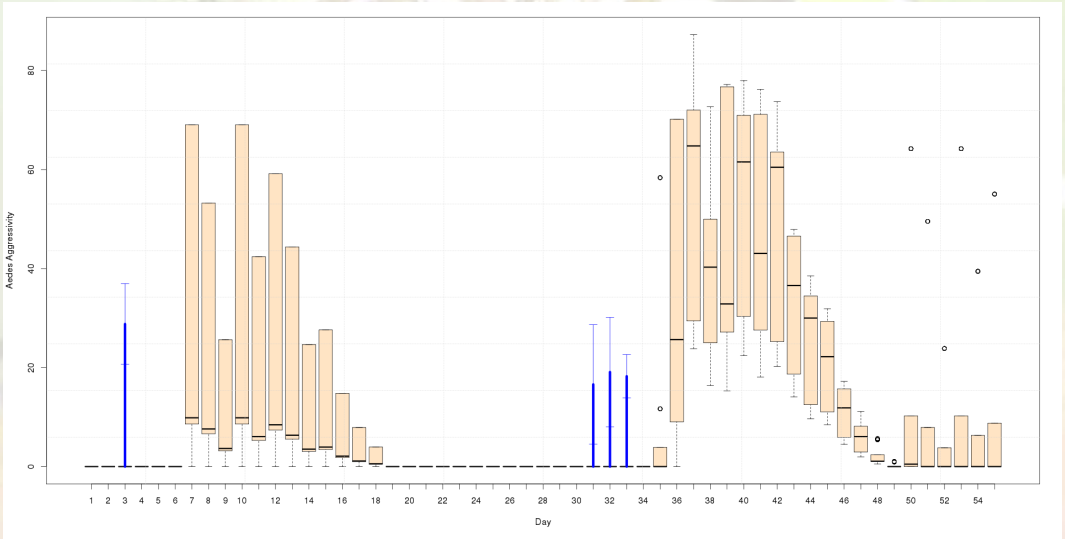
Impact of spatial heterogeneity on the vectorial risk

- Risk spatial heterogeneity from rainfall spatial heterongeneity:

Jul-Aug 2003 computed *Aedes* agressiveness associated with "medium" (≈ 0.25 ha) ponds:



Rain input : gauge



Rain input : TMPA 3B42v6

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