Quantifying Weather and Climate Impacts on Health in Developing Countries (QWeCI)

Science Talk

Rainfall and RVF emergence in Senegal: beyond twenty years of investigations, lessons learned and perspectives

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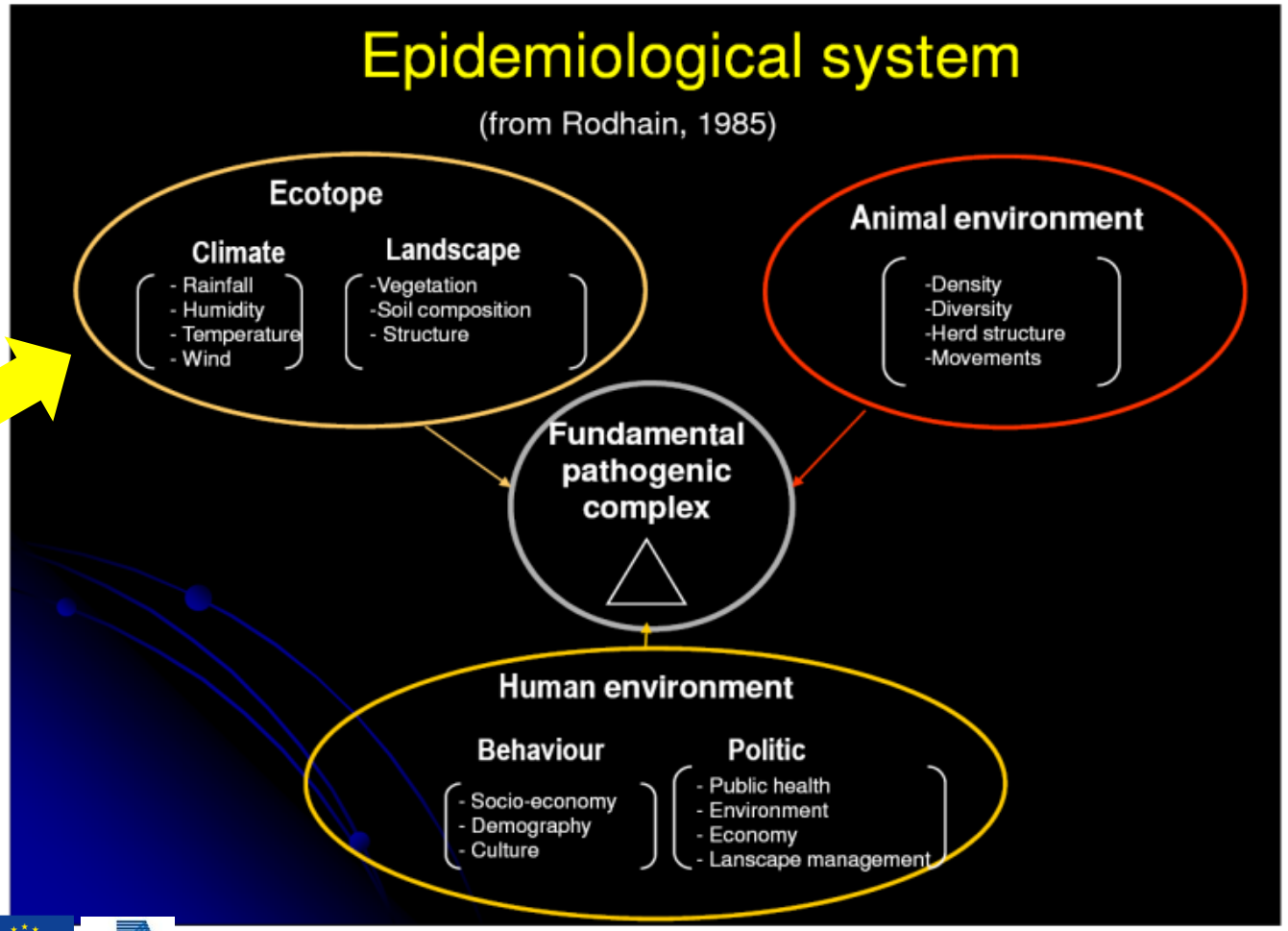
Outline of my talk

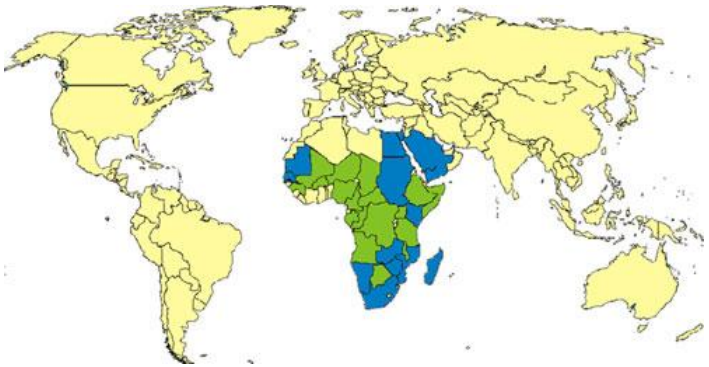
- Introduction
- Ideas during the 1980s and 1990s
- The ideas and majors achievements during the 2000s
  - *Times for multidisciplinary projects…*
- Conclusion and Perspectives: Lessons learned

- **Climate variability is a key component determining incidence number of diseases (vector-born especially) with significant human and animal health impacts.**



Rift Valley Fever

Zoonosis transmitted by *Aedes* and *Culex* mosquitoes to animals (sheep, goats, camels).
Human affected by contact with viraemic blood / organs
RVF virus (*Phlebovirus*, family *Bunyaviridae*).



Distribution of Rift Valley Fever.
Blue: endemic areas
Green: epidemic areas

Senegal & Mauritania RVF hot spots in West Africa.

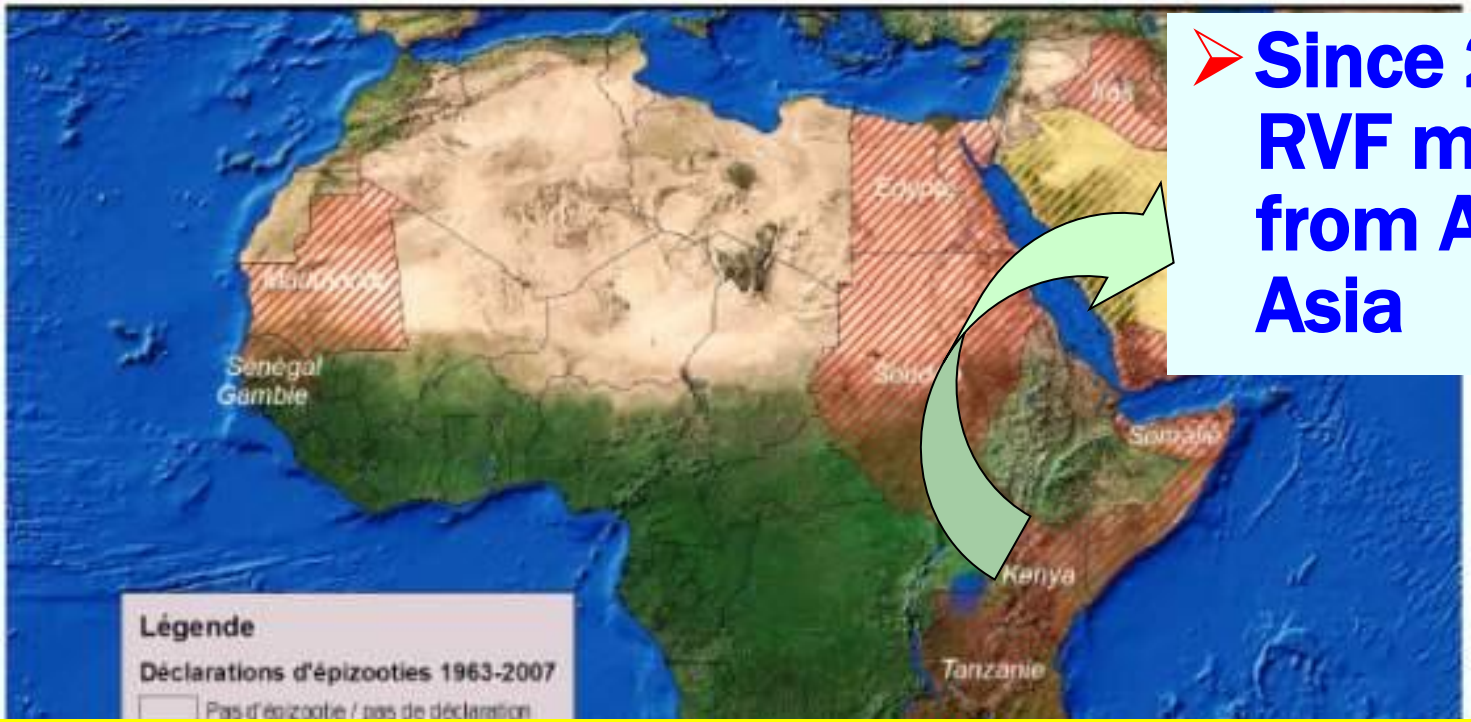
source: CDC, USA

Symptoms:

Rift Valley Fever (RVF): *Historical overview (major dates)…*

1912-13 | **1931** | **1948**

1st R outb lake (Prel Boul

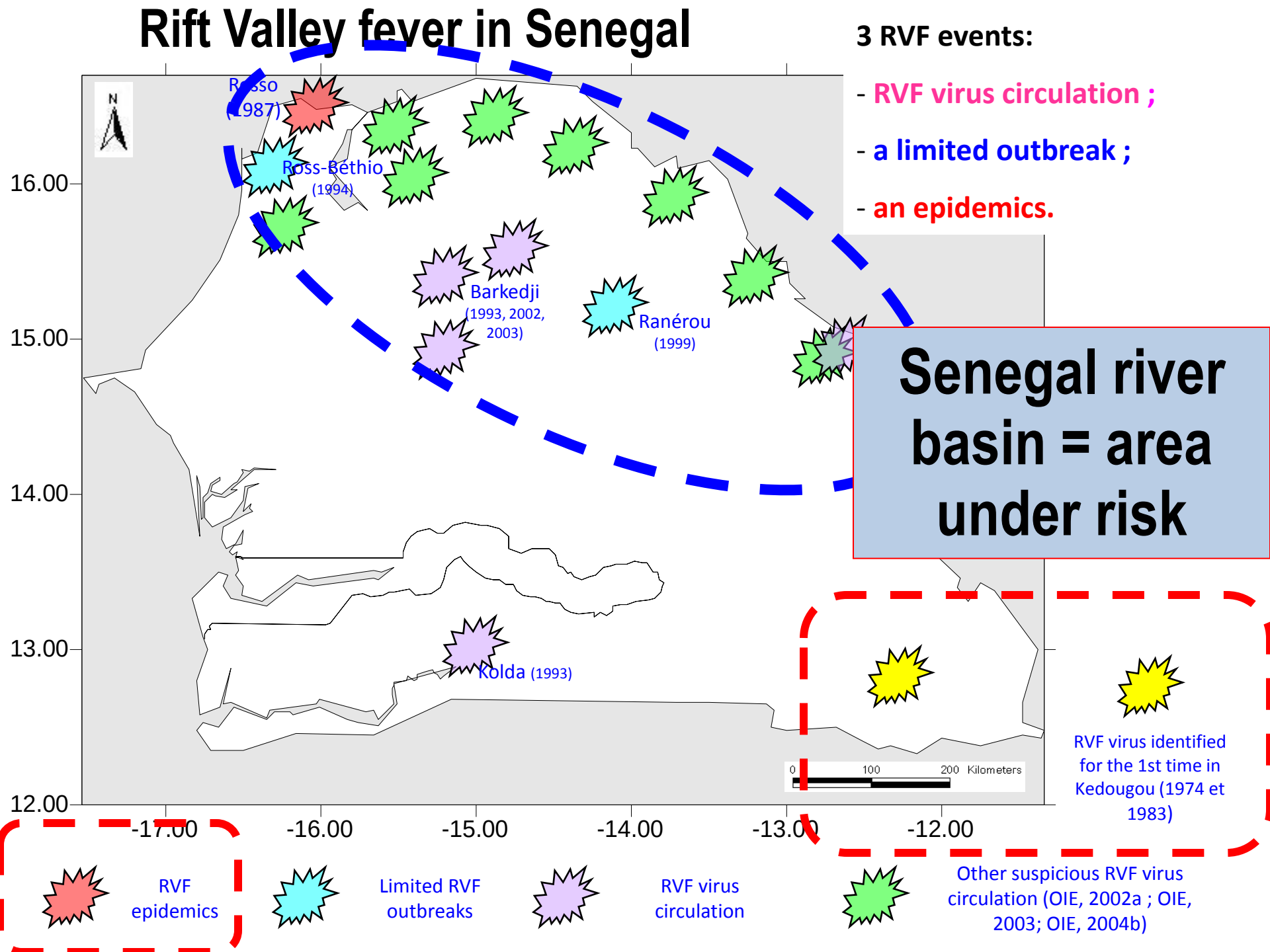


➢ **Since 2000, RVF moved from Africa to Asia**

✓**RVF is a one of the 40 emergent and re-emergent diseases that can affect human being…**

✓**RVF virus = potential agent for bioterrorism!**

Rift Valley fever in Senegal



3 RVF events:

- RVF virus circulation ;
- a limited outbreak ;
- an epidemics.

Senegal river basin = area under risk

Some statements during 1980s and 1990s

- After the RVF epidemics of Rosso in 1987, the temptation was great **to transpose the epidemiological pattern developed in Kenya to West Africa** (Diallo, 1995)

- Some scientists tried to explain the **1987 RVF epidemics** by "**more heavy**" rainfall than before (Jouan et al, 1990)

- **Rainfall is still the big issue but relevant conclusions need to be improved!**

- **One major statement is: no climate scientist was involved in**

One good news: RVF vectors has been identified in the Ferlo area (Fontenille et al, 1999)!

Climate and Satellite Indicators to Forecast Rift Valley Fever Epidemics in Kenya

Kenneth J. Linthicum,[1]* Assaf Anyamba,[2]* Compton J. Tucker,[2]
Patrick W. Kelley,[1] Monica F. Myers,[2] Clarence J. Peters[3]

All known Rift Valley fever virus outbreaks in East Africa from 1950 to May 1998, and probably earlier, followed periods of abnormally high rainfall. Analysis of this record and Pacific and Indian Ocean sea surface temperature anomalies, coupled with satellite normalized difference vegetation index data, shows that prediction of Rift Valley fever outbreaks may be made up to 5 months in advance of outbreaks in East Africa. Concurrent near–real-time monitoring with satellite normalized difference vegetation data may identify actual affected areas.

Rift Valley fever (RVF), a viral disease first described in Kenya in 1931 (*1*), affects domestic animals and humans throughout sub-Saharan Africa and results in widespread livestock losses and frequent human mortality. Its occurrence is known to follow periods of widespread and heavy rainfall associated with the development of a strong intertropical convergence zone, the region in the equatorial tropics where air currents from the north and south converge and produce precipitation (*2*). Such heavy rainfall floods mosquito breeding habitats in East Africa, known as "dambos," which contain transovarially infected *Aedes* mosquito eggs and subsequently serve as good habitats for other *Culex* species mosquito vectors (*3*). The most recent RVF epizootic/epidemic was in East Africa in late 1997 and early 1998.

Vegetation responds to increased rainfall and can be easily measured by satellite. Normalized difference vegetation index (NDVI) data from the advanced very high resolution radiometer (AVHRR) on National Oceanic and Atmospheric Administration (NOAA) satellites have been used to detect conditions suitable for the earliest stages in an RVF epizootic (*4*). Refinement in determining the spatial distribution of RVF viral activity, through identification of ideal mosquito habitat, has been possible with higher resolution Landsat, Systeme pour l'Observation de la Terre (SPOT), and airborne synthetic aperture radar data (*5*); however, predictive indicators are needed to forecast RVF outbreaks. Here we show that several climate indices can be used to predict outbreaks up to 5 months in advance.

The El Niño–Southern Oscillation (ENSO) phenomenon is a principal cause of global interannual climate variability (*6*, *7*). Warm ENSO events are known to increase precipi-

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Some tipping events…

The recent work carried out by Linthicum et *al* (1999) in eastern Africa played a start up role in sensitizing the Local Scientific Community in Senegal to new approach of modeling climate sensitive diseases.

2000: a

(Surveillance

been set

cy)

New concept / New approach (Marechal et al, 2008)

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 a concept based on a deterministic approach of the climate-environment-health relationships and on an original and really adapted space offer.

This will cont

Environment

2000: Majors findings...

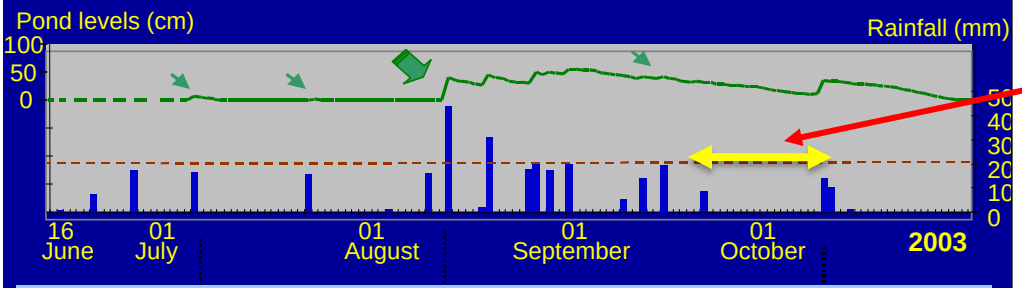
- **For the 1st time in Senegal RVF history the relationship between rainfall, pond variations and RVF vectors dynamics has been set up**

Some relevant references:

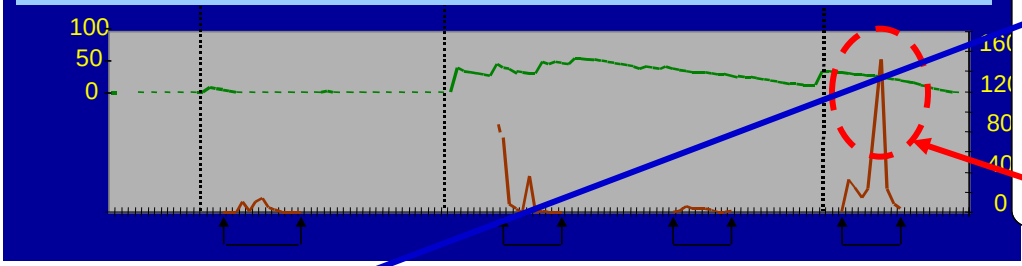
Ndione et al (2003)
Ndione et al (2005)
Mondet et al (2005)
Ba et al (2005)
Ndione et al (2008)
Lacaux et al (2007)
Vignolles et al (2009)

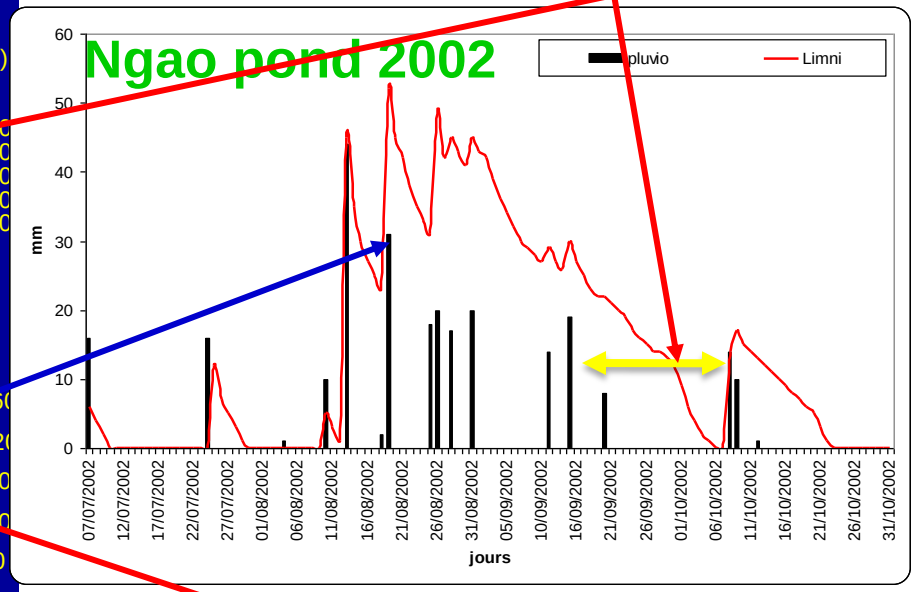
Dry spells are important too…

Rainfall, ponds levels and Aedes mosquitoes in Furdu

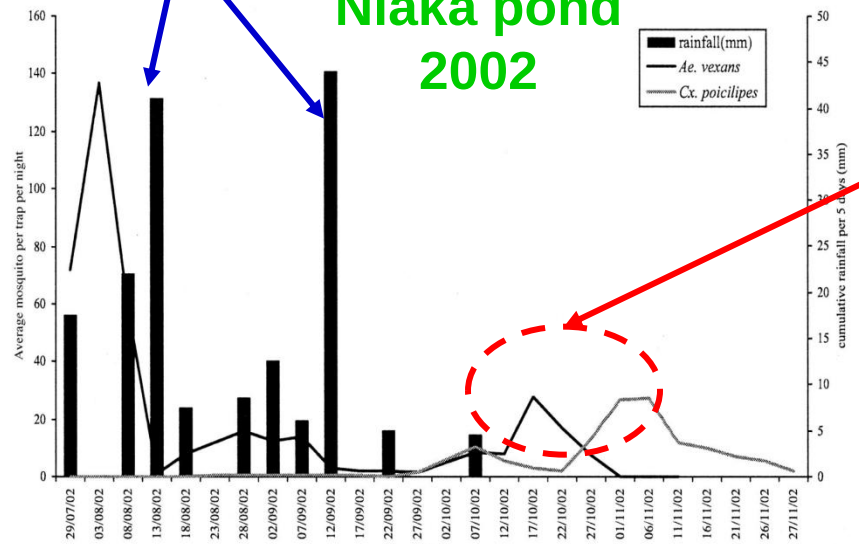


Ponds levels (cm) & Aedes females in Furdu (Mondet et al, 2005)



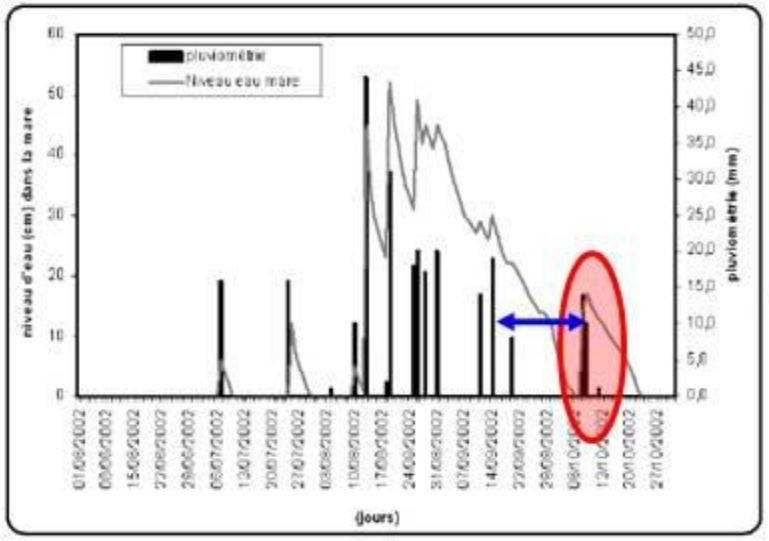


Rainfall distribution and frequency is a key factor controlling mosquitoes dynamics



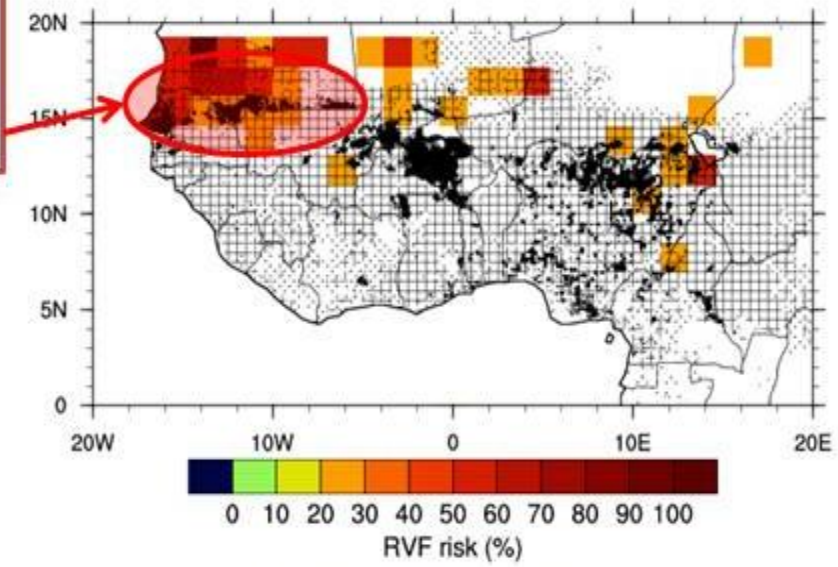
Field studies are a key component for understanding RVF emergence mechanism'

RVF in Senegal: climate emergence assumption (Ndione et al, 2008)



Ndione et al, 2008

RVF risk Hotspots: Senegal Mauritania



Caminade et al, 2011

Dry spell followed by a rainfall peak during the late rainy season (Sep-Oct) over Northern Senegal (*Ndione et al, 2008*)

→ Rehydrating ponds

→ mosquitoes hatching + hosts

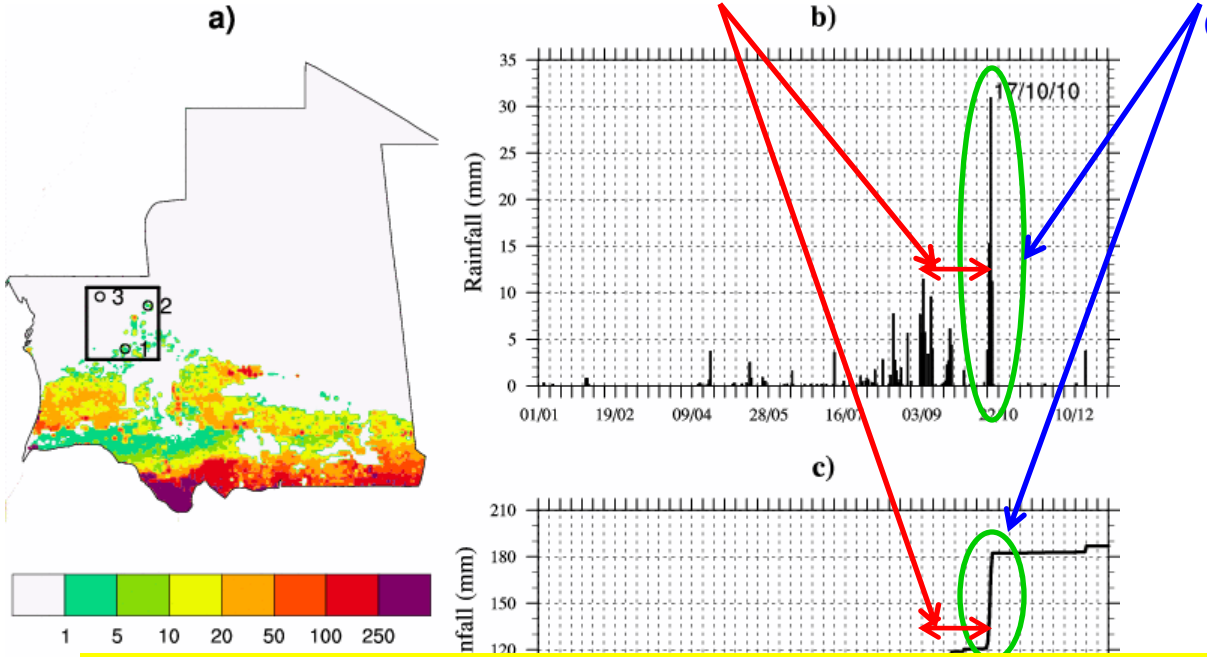
→ high RVF risk

Rift Valley Fever risk (%) based on rainfall from ERAINTERIM reanalysis (1990-2007). The number of RVF risk events is defined by a dry spell (10 consecutive days with total rainfall below 1mm) followed by a convective event (high precipitation defined by one or two days following the dry spell above the 90th percentile) occuring during the late rainy season (SON). The total number of RVF risk events is then rescaled to range between 0 and 100% to define the risk. The dotted, crossed and filled black areas depict animal host densities (cattle + buffalo + sheep + goats) above 1, 10 and 100 per km2 (FAO, 2005).

Mauritania 2010 RVF outbreak: climate issue

dry spell
(17 days!)

Large rainfall event (60mm!)



Such rains had not been observed for decades; the local residents refer to 1956 (locally known as the "year of the fever") to describe similar events (El Mamy et al, 2011).

a) Location of the outbreaks and animal density (shading)

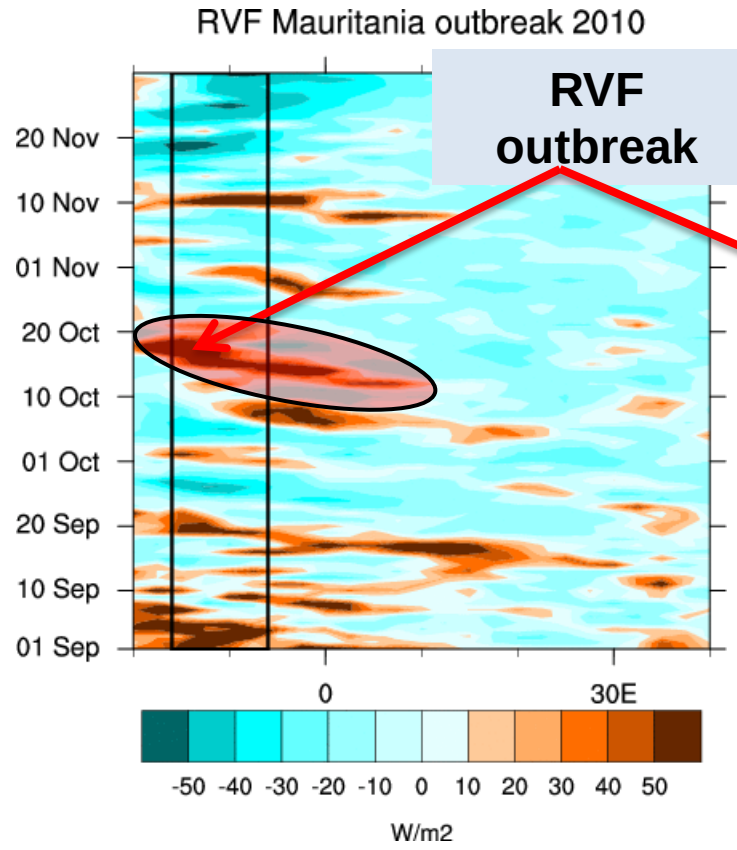
b) Rainfall index (mm) averaged over 19°N-21°N, 14.75°W-12.75°W (area where the outbreak occurred in Mauritania) for 2010 based on the TRMM dataset.

c) Cumulative rainfall

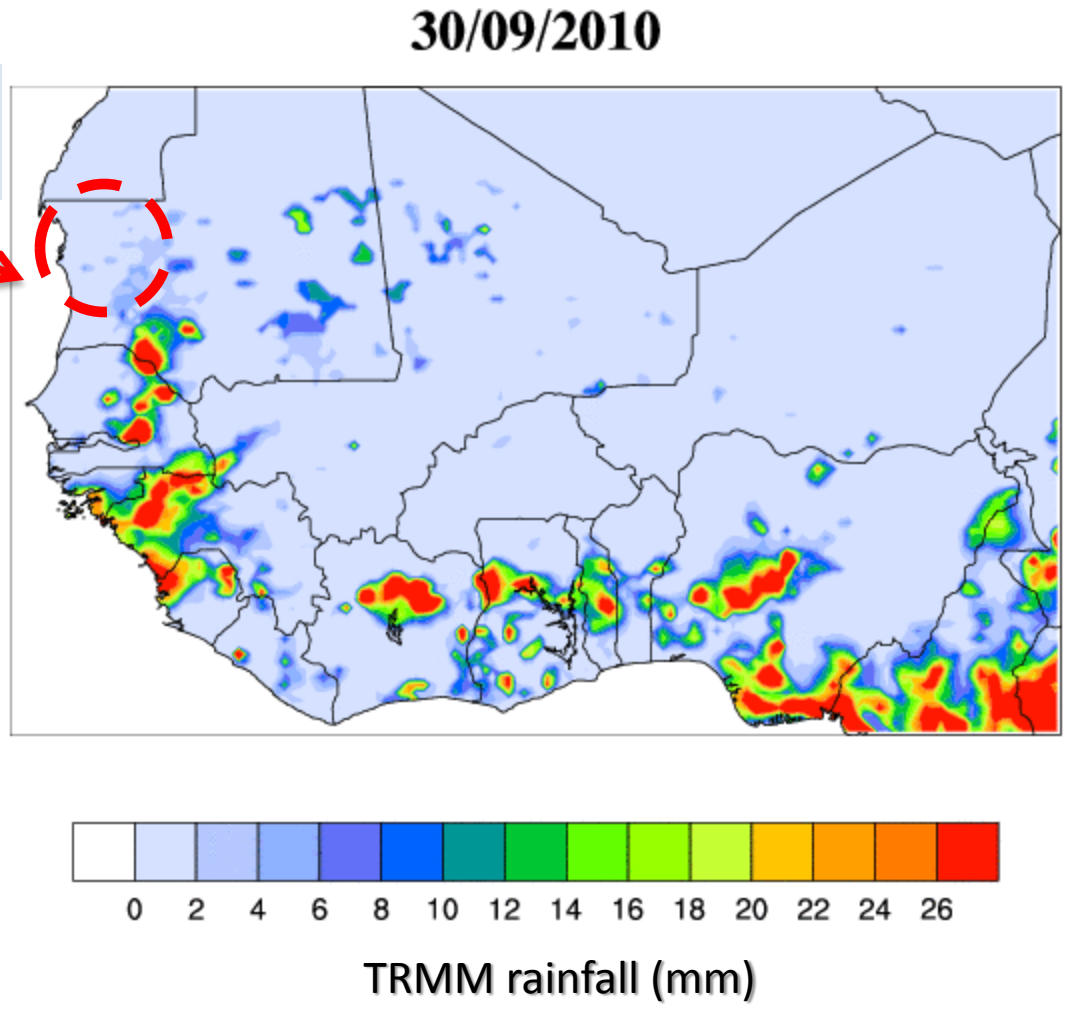
A dry spell started on the 29th of September, and it was followed

One good news: we have same rainfall behaviour than RVF emergence in the Ferlo area (Senegal)!

Mauritania outbreak Nov 2010 (2/2)

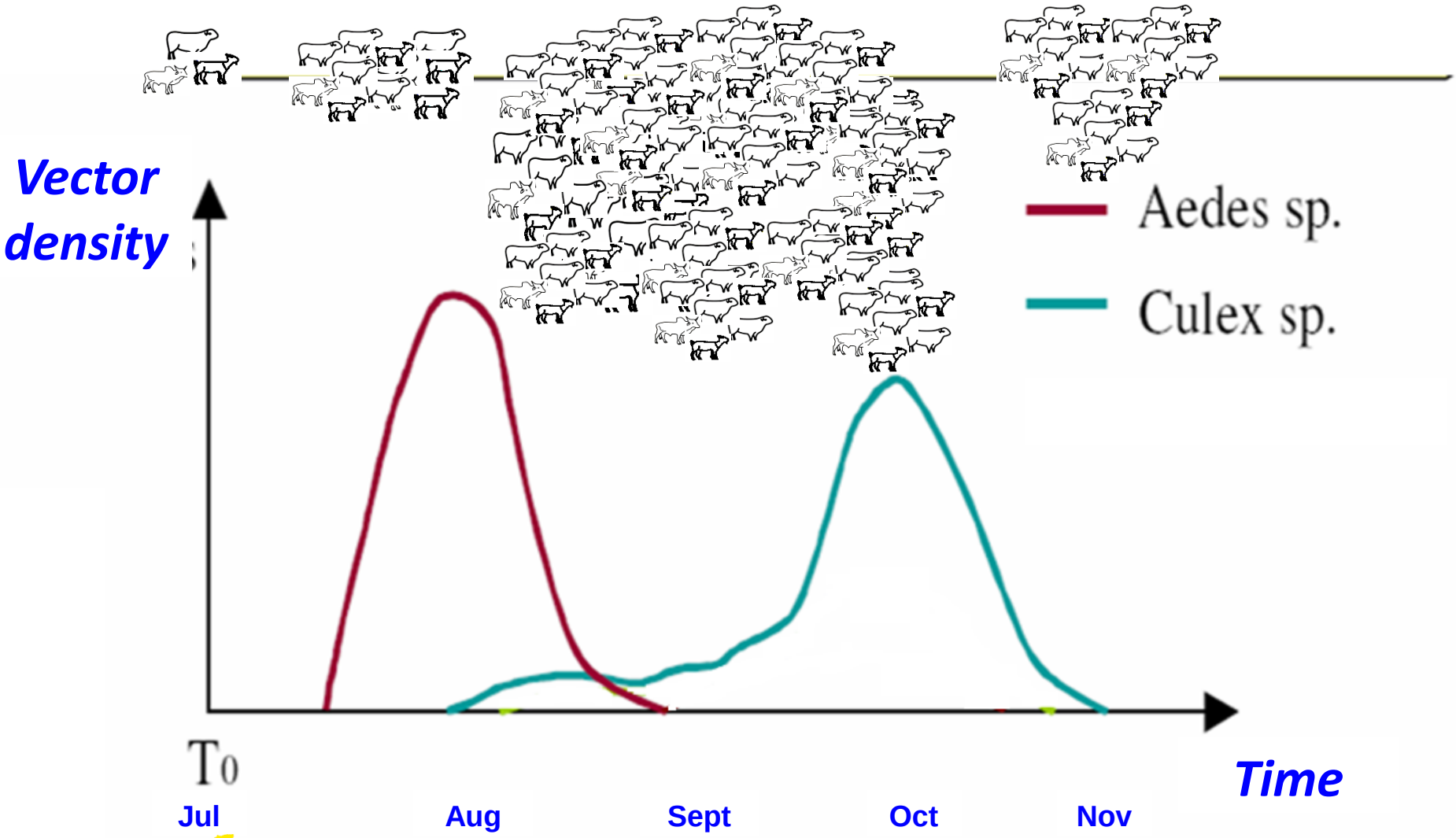


Hovmoeller OLR anomaly (NCEP). 16°N-20°N average
Convective event in brown

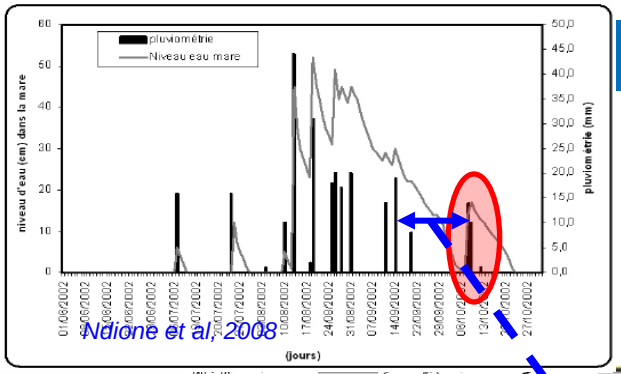


TRMM rainfall (mm)

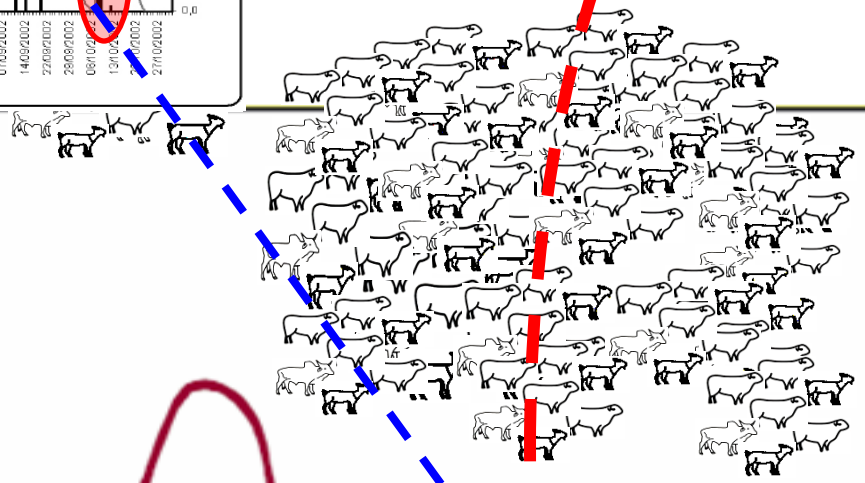
No RVF Outbreak (*normal year*)!

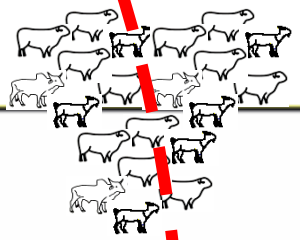


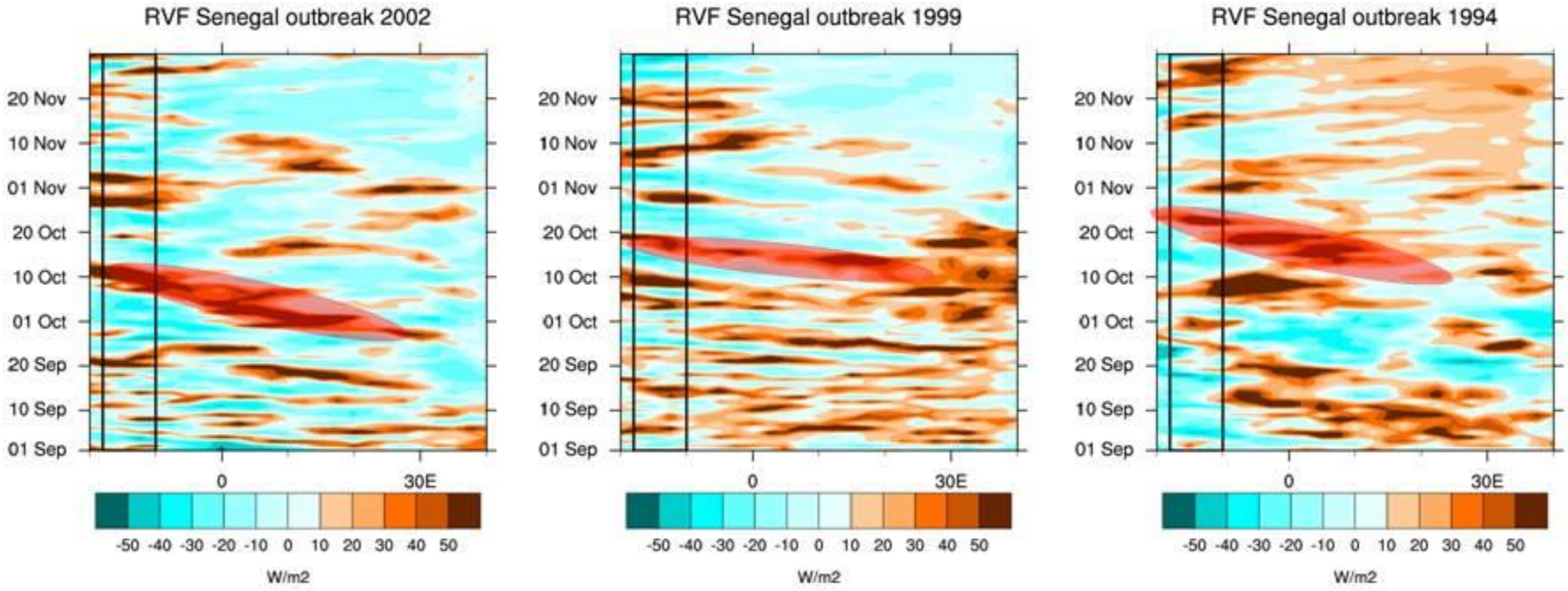
RVF Outbreak



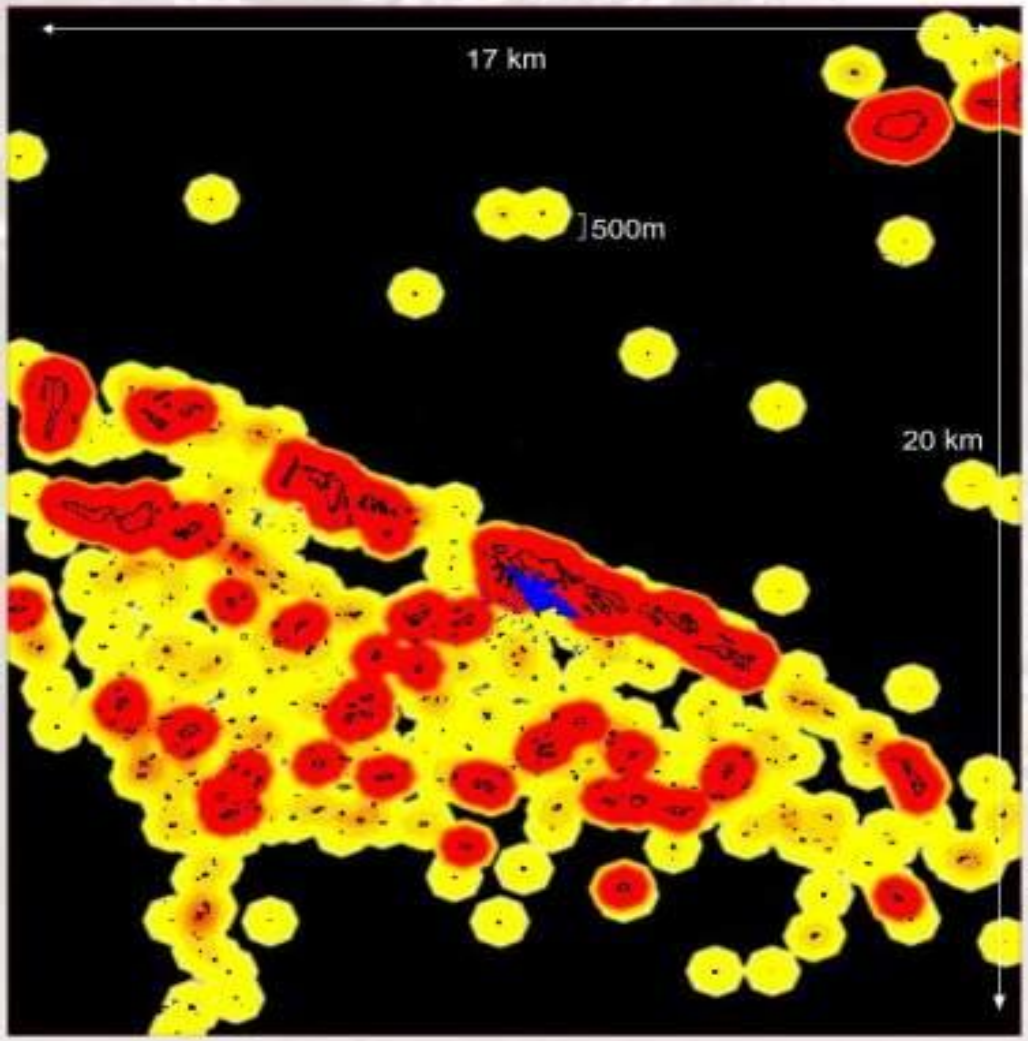
Ndione et al, 2008






RVF Senegal outbreak 2002
RVF Senegal outbreak 1999
RVF Senegal outbreak 1994
20 Nov
10 Nov
01 Nov
20 Oct
10 Oct
01 Oct
20 Sep
10 Sep
01 Sep
0
30E
-50 -40 -30 -20 -10 0 10 20 30 40 50
W/m2

Dynamical ZPOM and associated risks



July 1st, 2003

July 28th, 2003

August 26th, 2003

September 6th, 2003

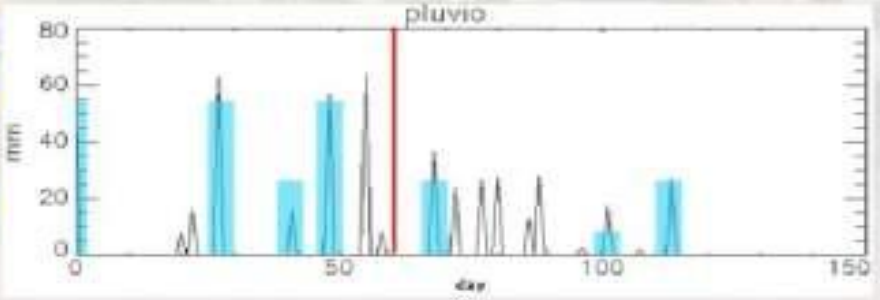
October 9th, 2003

Scale ● ON ● OFF

Ponds ● ON ● OFF

Cattle Parks ● ON ● OFF

Productive rainfall events ● ON ● OFF



Simulation available online:

http://www.geospatialhealth.unina.it/fulltext.php?ida=75

The QWeCI study site: Barkedji Health and Environment Observatory

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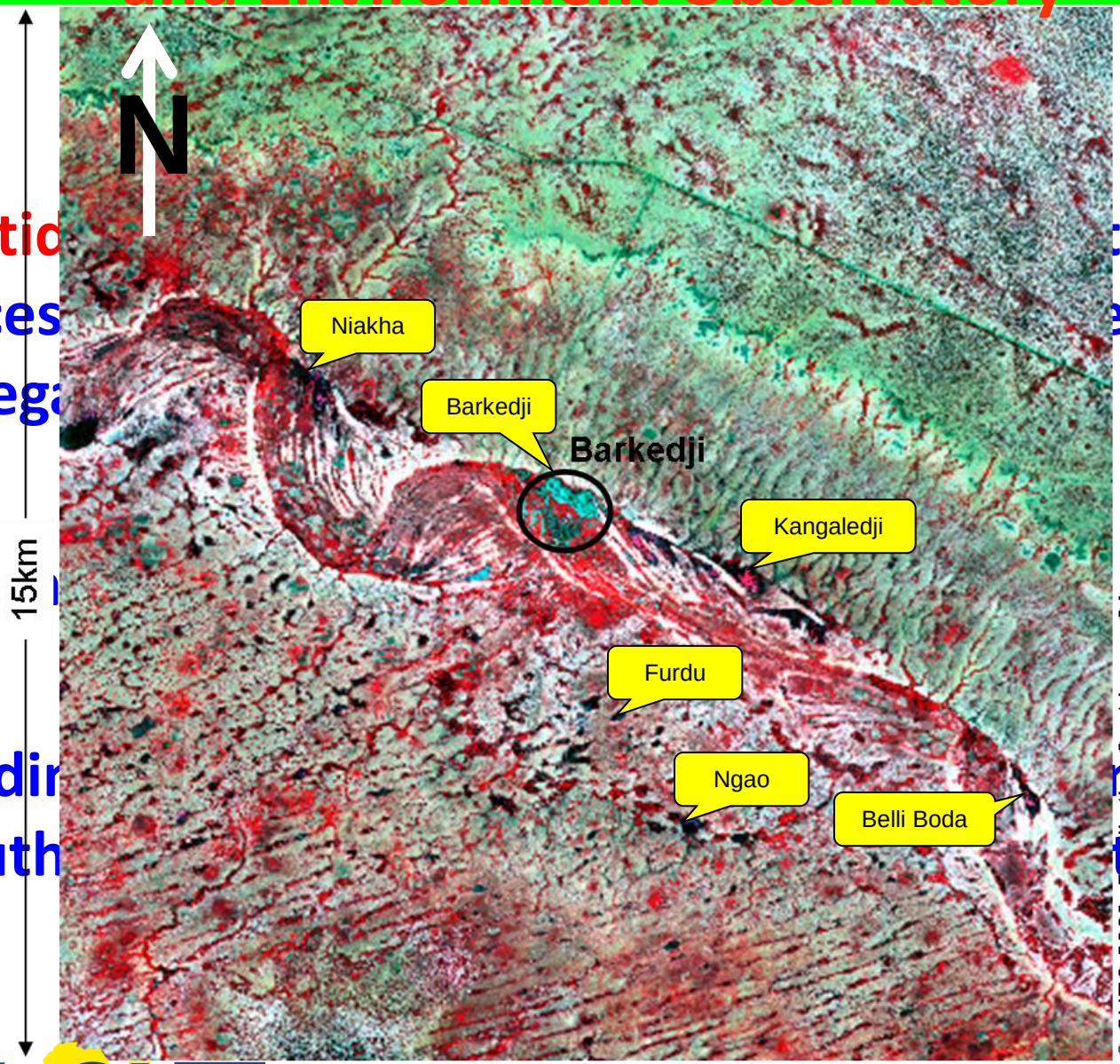
- Mov…
- Buildir… …nership (South… …y building



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