

# Prediction of a Rift Valley Fever Outbreak using Earth Observations

East Africa: December 2006 to May 2007

Symposium on Earth Observations:  
*A Future Informed By Sound Science*  
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Center for Strategic and International Studies

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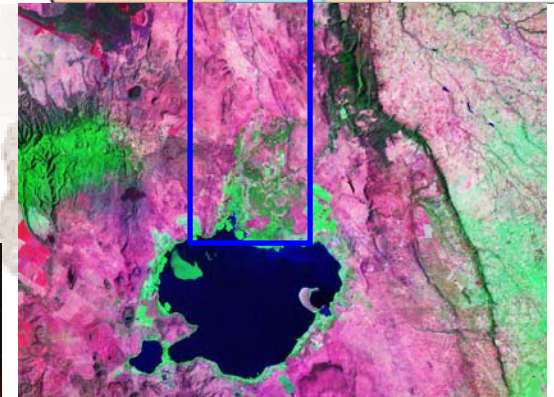
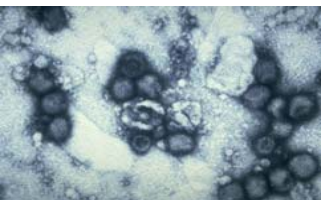
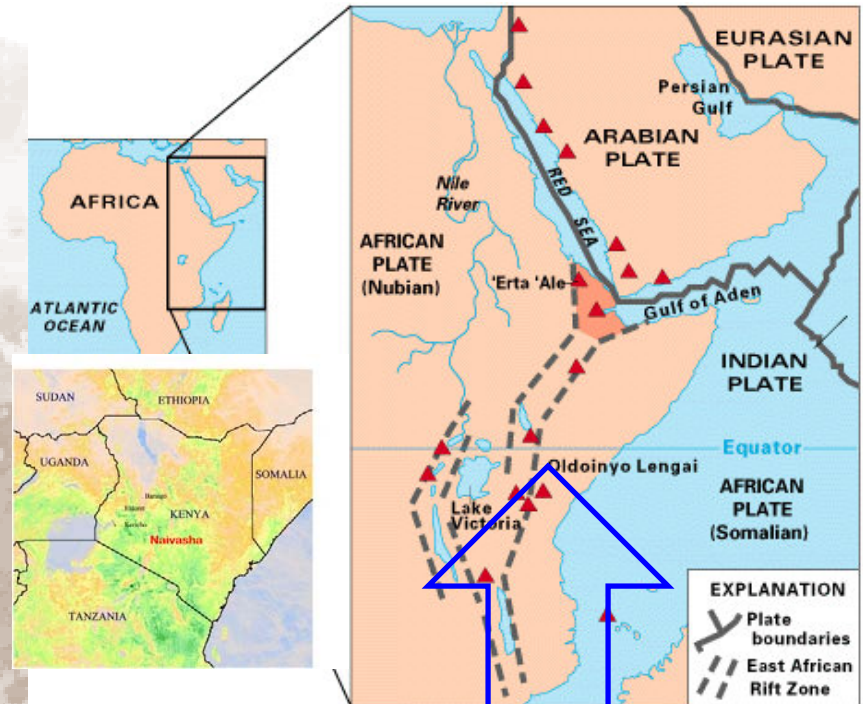
# Alerts and outbreaks, 2005-2008

Country or region	Outcome in risk area
Madagascar (2008)	RVF (520 cases, 20 deaths)
South Africa (2008)	RVF (18 cases)
Sudan (2007)	RVF (698 cases, 222 deaths)
East Africa (2006)	RVF (922 cases, 218 deaths)
Arabian Peninsula (2005)	No RVF
Sudan (2005)	No RVF (Yellow fever)



# Rift Valley Fever

- Viral zoonosis of livestock, humans.
- Africa and Arabian peninsula.
- Animals infected by mosquitoes.
- Humans infected by animal exposure/mosquitoes.
- Disease in humans:
  - Flu-like +/- hemorrhage, encephalitis
  - Mortality: Humans 1-20%, Animals 80 – 100%
- 1997-8 East Africa: ~100,000 infections.
- Key public health actions:
  - Veterinary: vaccination, stop movement
  - Vector: Control of immature and adult mosquito
  - Human: reduce animal product exposure, mosquito protective measures
- Treatment – experimental drug ribavirin is being studied for its effectiveness against Rift Valley fever.
- No licensed vaccine or virus-killing medicine is available for human use

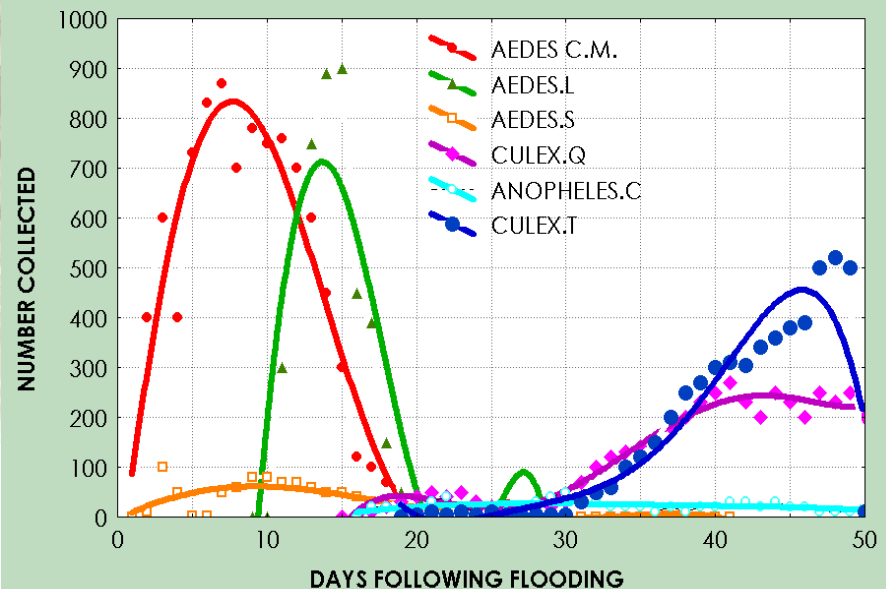


# Vector Dynamics and Ecology



- Emergence and population expansion of a number of disease vectors (mosquitoes, mice, locusts) often tends to follow the trajectory of the green flush of vegetation in semi-arid lands
- Dry – Wet cycles appear to maintain the virus cycle through time

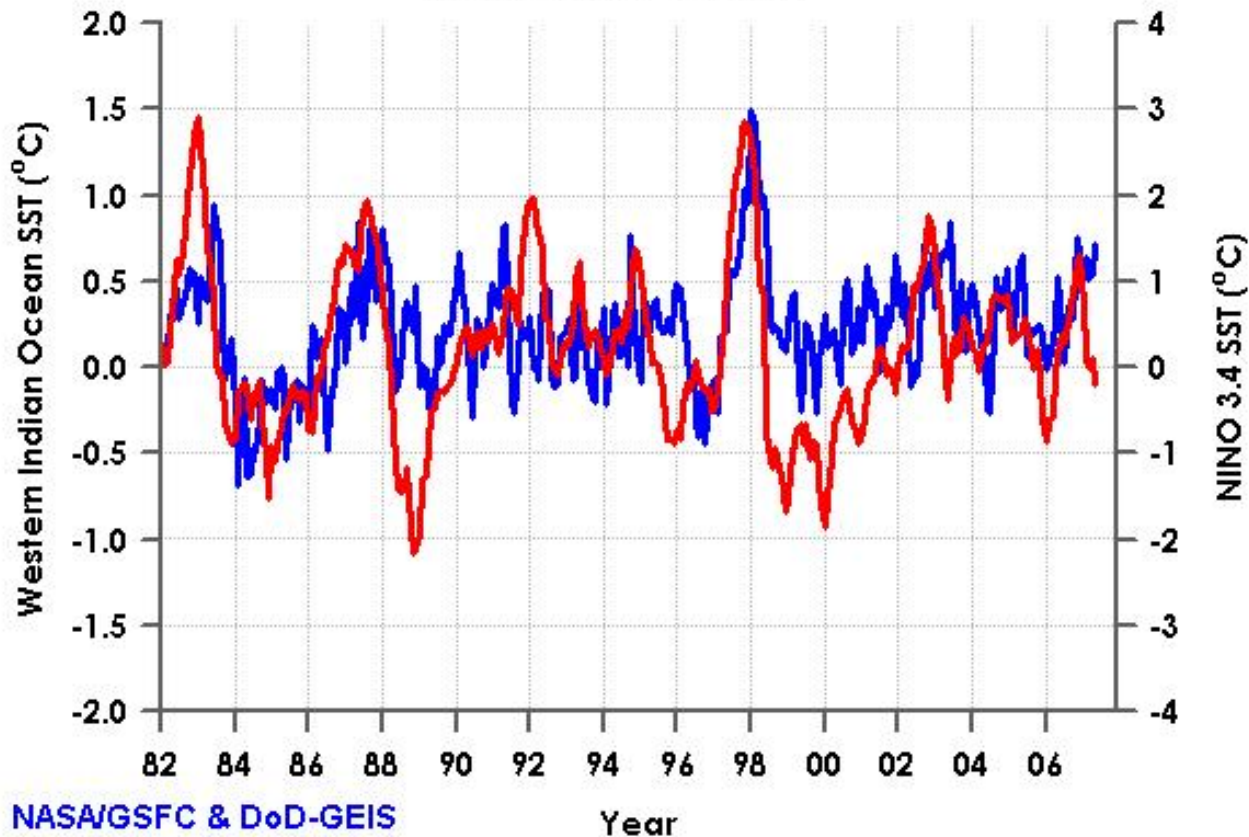
Evolution of Mosquito Populations after a Flood Event



# Operational Application

## 1. Leading Climatic Indicators: NINO3.4 SST, SOI

Western Indian Ocean and NINO 3.4 SST anomalies  
January 1982 - May 2007

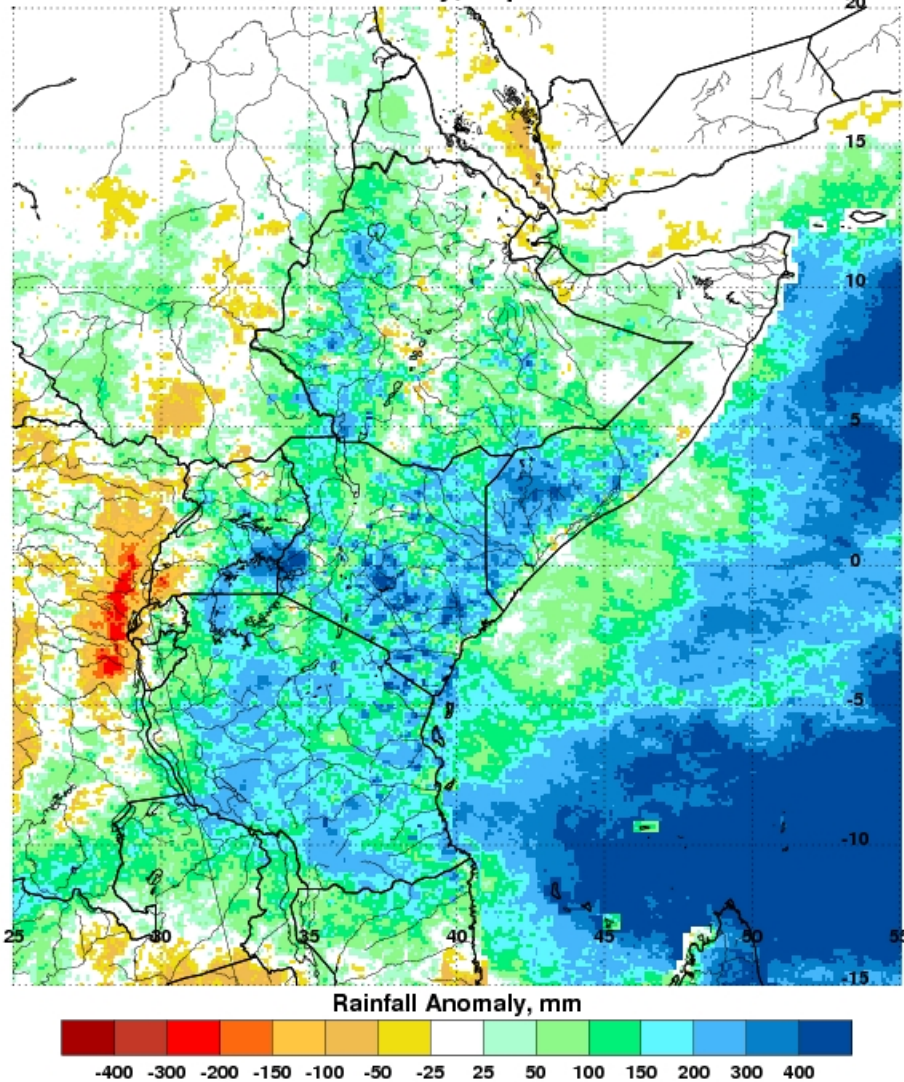


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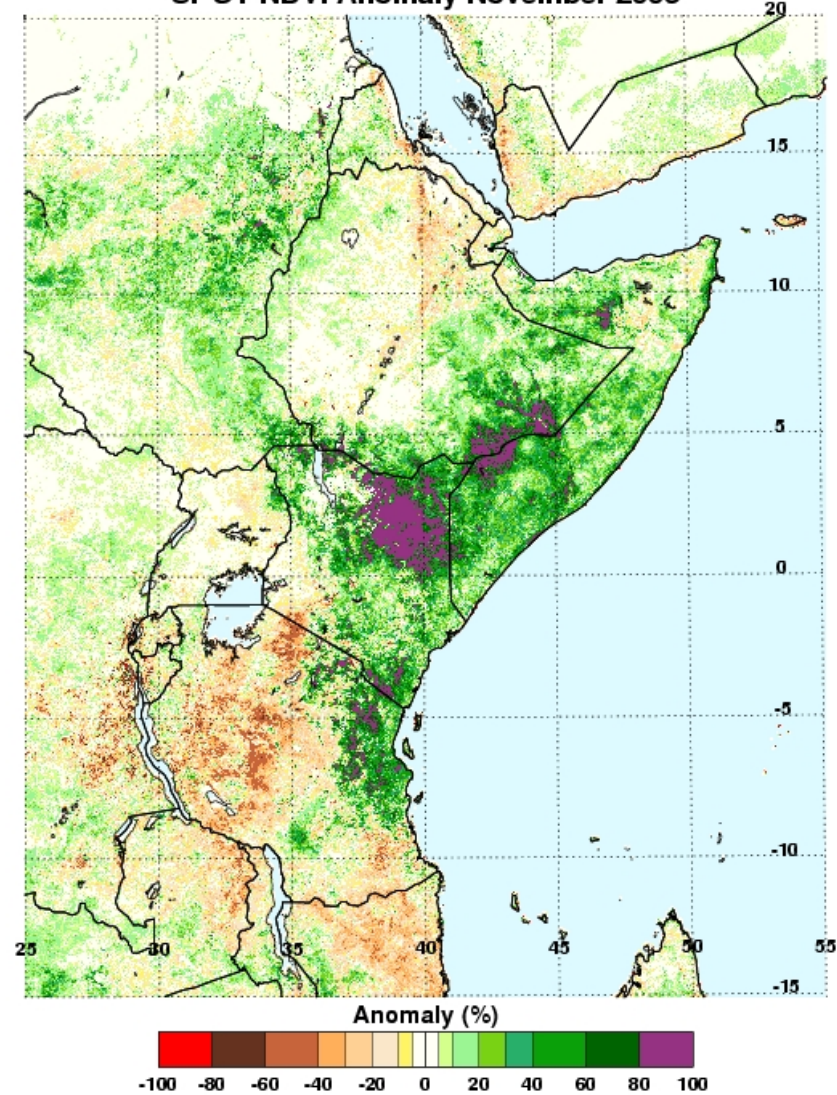


# Seasonal Summary: Rainfall SOND 2006

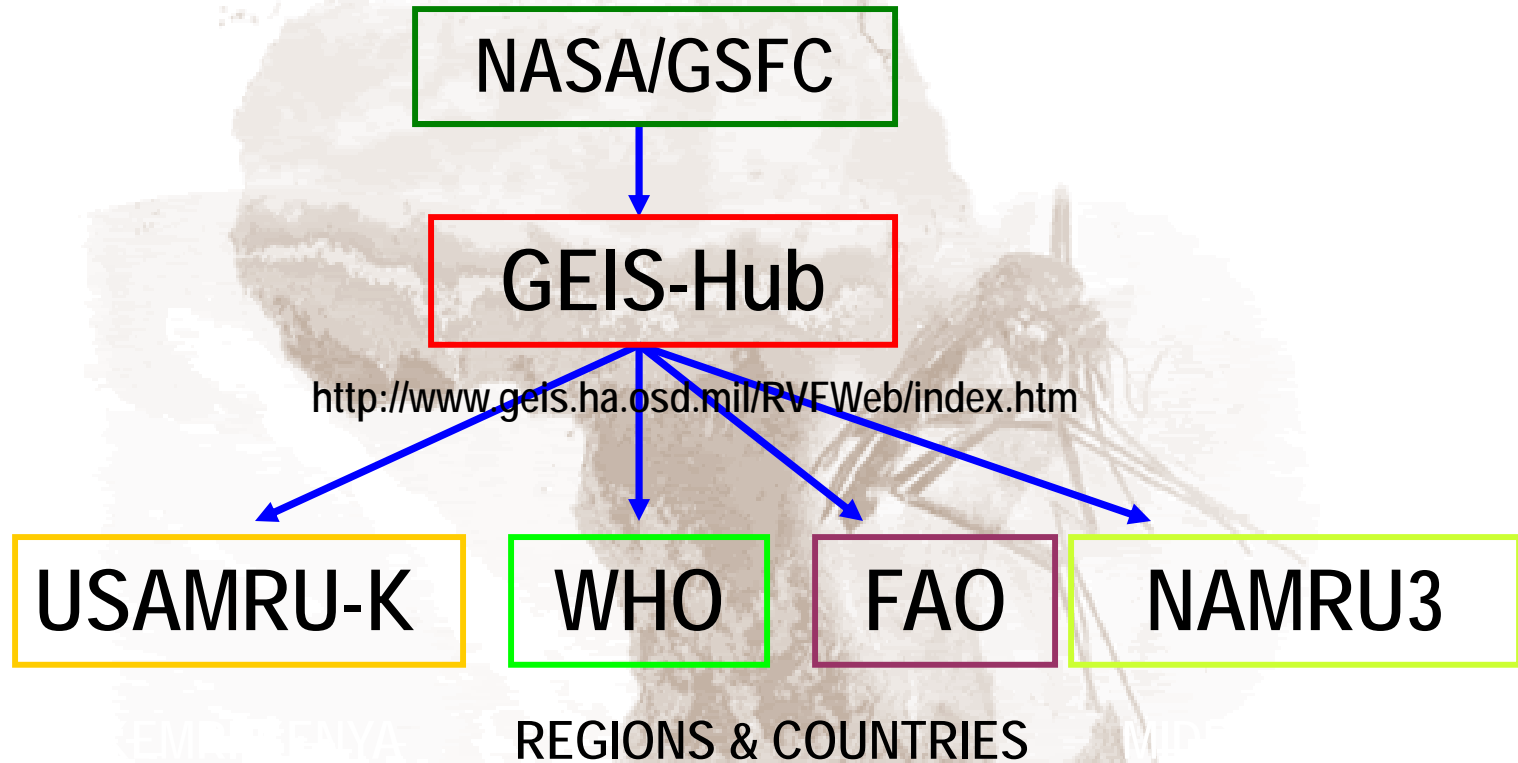
Cumulative Rainfall Anomaly, September - December 2006



SPOT NDVI Anomaly November 2006



# Information Dissemination



Early warnings – incremental monthly public domain, Alerts – customized e.g. EMPRES

# FAO Alerts: Emergency Prevention System (EMPRES) for Transboundary Animal and Plant Pests and Diseases



## EMPRES WATCH

### Possible RVF activity in the Horn of Africa

#### 1. Introduction

Rift Valley fever (RVF) is an arthropod-borne viral disease of ruminants, camels and humans. It is a significant zoonosis which may present itself from an uncomplicated influenza-like illness to a haemorrhagic disease with severe liver involvement and ocular or neurological lesions. In animals, RVF may be unapparent in non-pregnant adults, but outbreaks are characterised by the onset of abortions and high neonatal mortality. Transmission to humans may occur through close contact with infected material (slaughtering or manipulation of runts), but the virus (Phlebovirus) is transmitted in animals by various arthropods including 5 mosquito genus (*Aedes*, *Culex*, *Mansonia*, *Anopheles*, *Coquillettidia* and *Eretmapodites*) with more than 30 species of mosquitoes recorded as infected and some of them been proved to have a role as vectors. Most of these species get the infection by biting infected vertebrates, yet some of these (specifically *Aedes* species) transmit the virus to their eggs. These infected pools of eggs can survive through desiccation during months or years and restart the transmission after flooding, and then other species (*Culex* spp.) may be involved as secondary vectors.

#### 2. Disease ecology and climatic drivers in the horn of Africa

This vertical infection explains how the disease can persist between outbreaks.

RVF virus (RVFV) is recorded to occur from South Africa to Saudi Arabia including Madagascar, in varied bioclimatic ecotypes, ranging from wet and tropical countries such as the Gambia, irrigated regions such as the Senegal River Valley or the Nile Delta, to hot and arid areas such as Yemen or Chad. The occurrence of RVF can be endemic or epidemic, depending on the climatic and vegetation characteristics of different geographic regions. In the high rainfall forest zones in coastal and central African areas it is reported to occur in endemic cycles which are poorly understood. Currently available evidence suggests that this may happen annually after heavy rainfall, but at least every 2-3 years otherwise. In contrast, in the epidemic areas in East Africa, RVF epidemics appear at 5 to 15 year cycles. These areas are generally relatively high rainfall plateau grasslands, which may be natural or cleared from forests. In the much drier bushed Savannah grasslands and semi-arid zones, which are characteristic for the Horn of Africa, epidemic RVF has manifested itself only a few times in the past 40 years, in 1961-62, 1982-83, 1989 and in 1997-1998.

In addition the possibility exists that RVFV may spread outside traditionally endemic areas, or even out of the continent of Africa, mostly due to the large range of vectors capable of transmitting the virus and requires a level of viraemia in ruminants and humans that is sufficiently high to infect mosquitoes. Such a situation occurred following the unusual floods of 1997-1998 in the Horn of Africa countries, and subsequently the disease spread to the Arabian Peninsula in 2000.

The ecology of RVF has been intensively explored in East Africa. Historical information has shown that pronounced periods of RVF virus activity in Africa have occurred during periods of heavy, widespread and persistent

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<http://www.fao.org/ag/againfo/programmes/en/empres/home.asp>

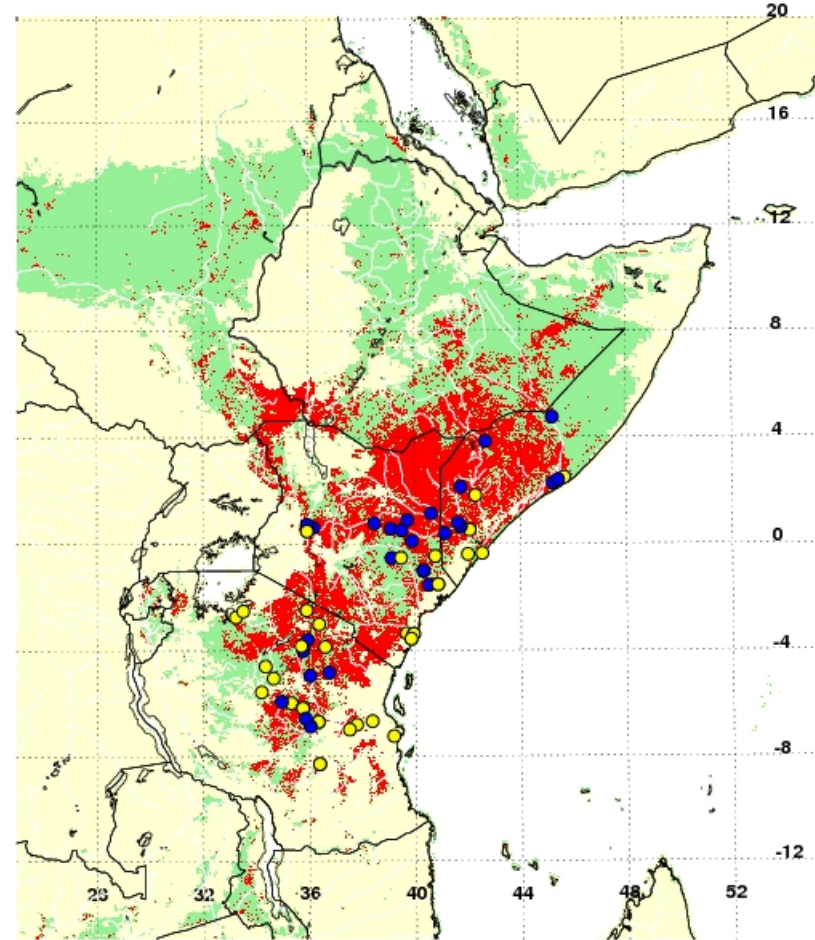
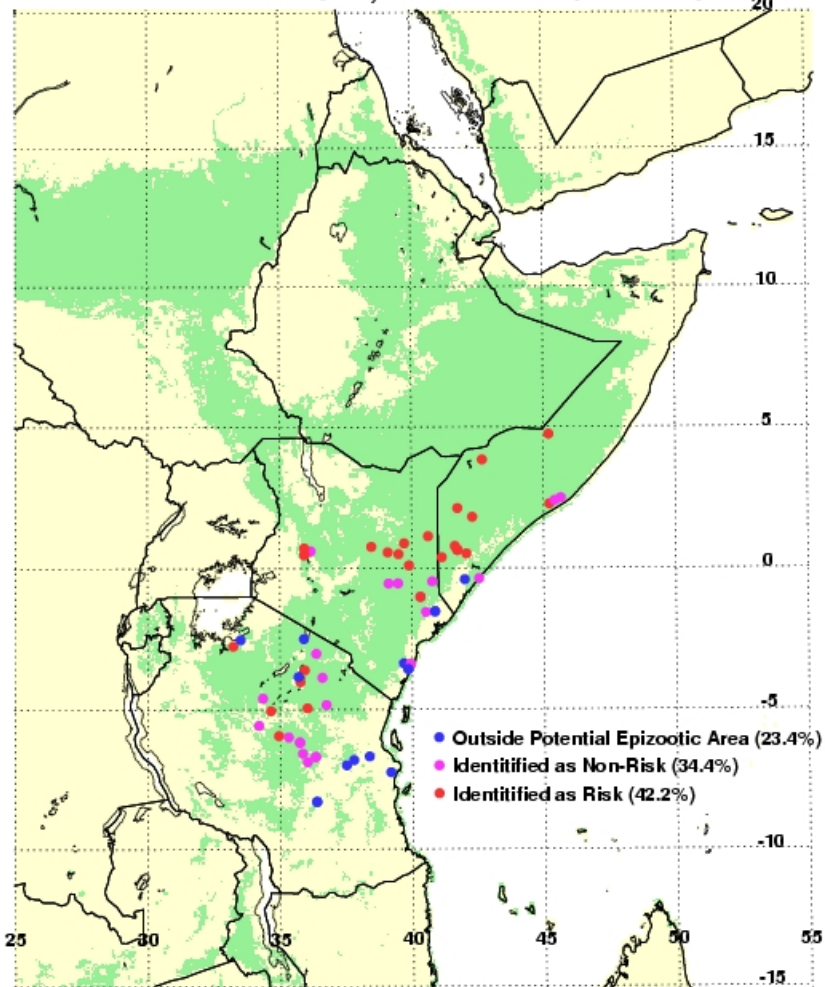


# Field Outbreak Data: WHO, CDC Combined

## RVF Risk Potential and Outbreak Sites

Sep 2006 - May 2007

### RVF Risk Prediction, 2006-2007 Outbreak Sites



■ RVF risk areas

● Identified as Non-Risk

■ RVF potential epizootic areas

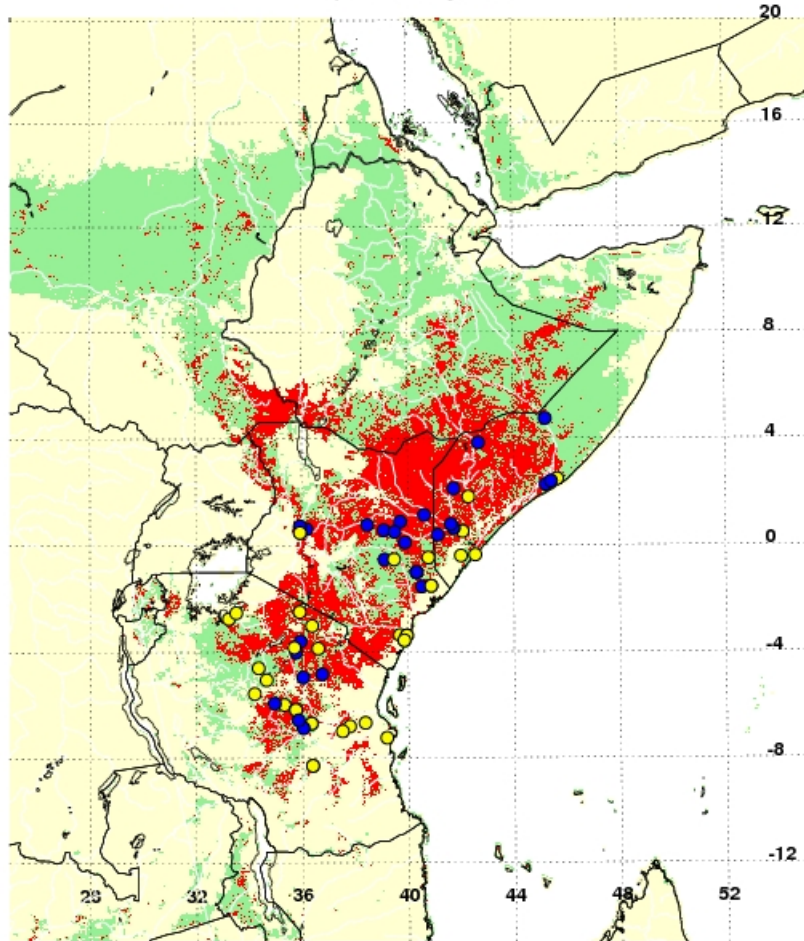
● Identified as Risk



# RVF Potential and Cases : Sept 2006 - May 2007

RVF Risk Potential and Outbreak Sites

Sep 2006 - May 2007



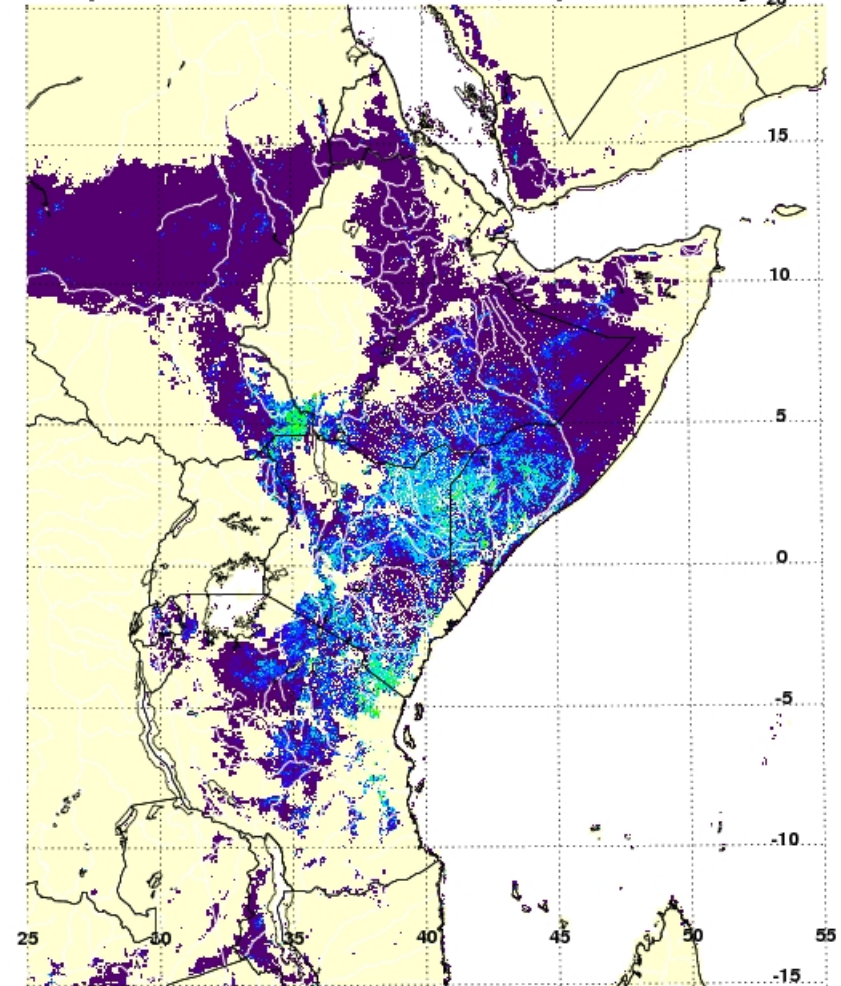
RVF risk areas

Identified as Non-Risk

RVF potential epizootic areas

Identified as Risk

Composite RVF Risk Potential, Sep 2006 - May 2007



Number of Risk Months



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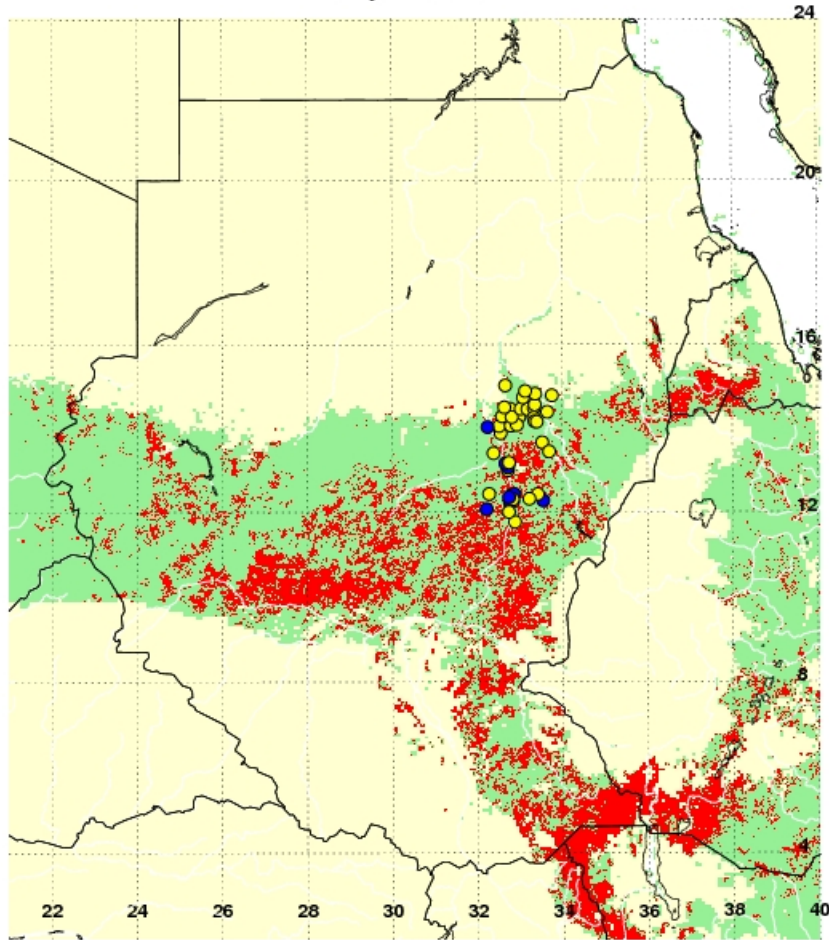


United States Department Of Agriculture  
Agricultural Research Service

# RVF Potential and Cases : May - November 2007

RVF Risk Potential and Outbreak Sites

May - Nov 2007



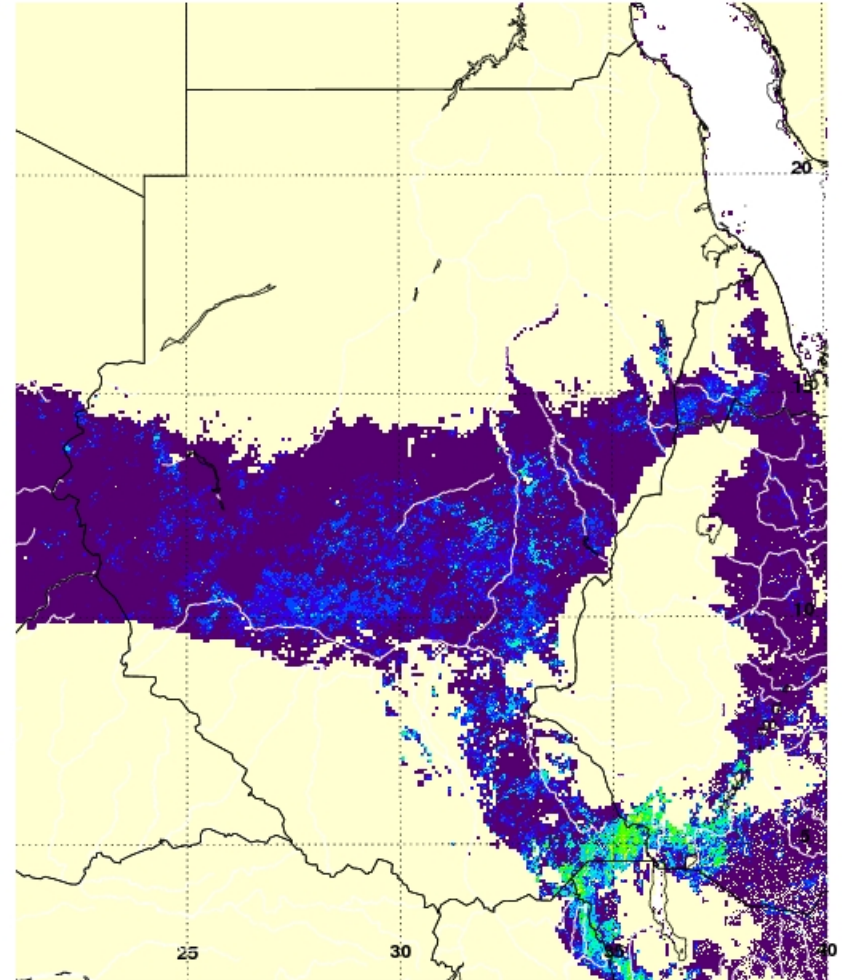
RVF risk areas

Identified as Non-Risk

RVF potential epizootic areas

Identified as Risk

Composite RVF Risk Potential, May - Nov 2007



Number of Risk Months



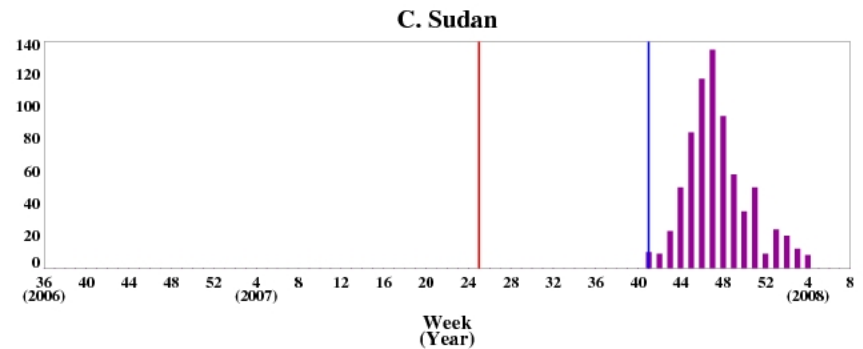
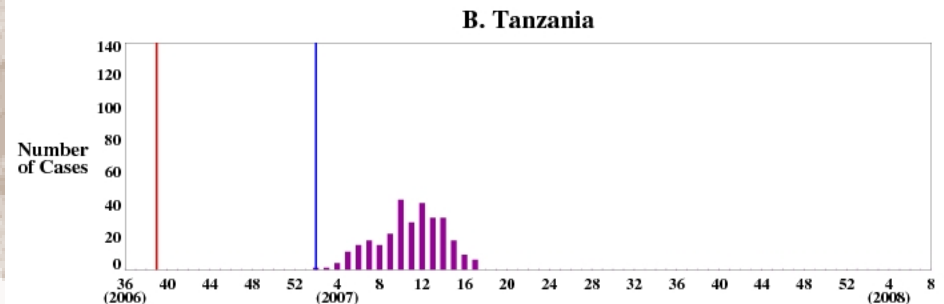
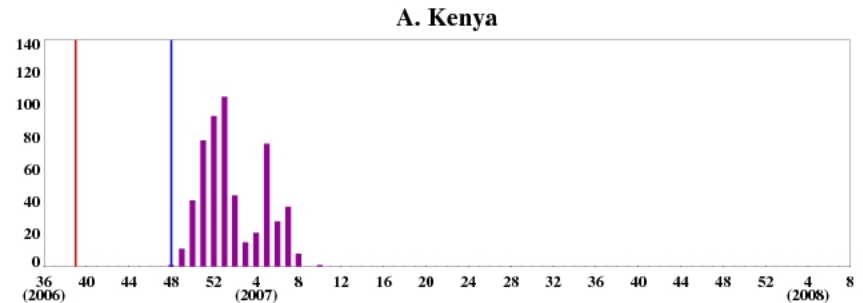
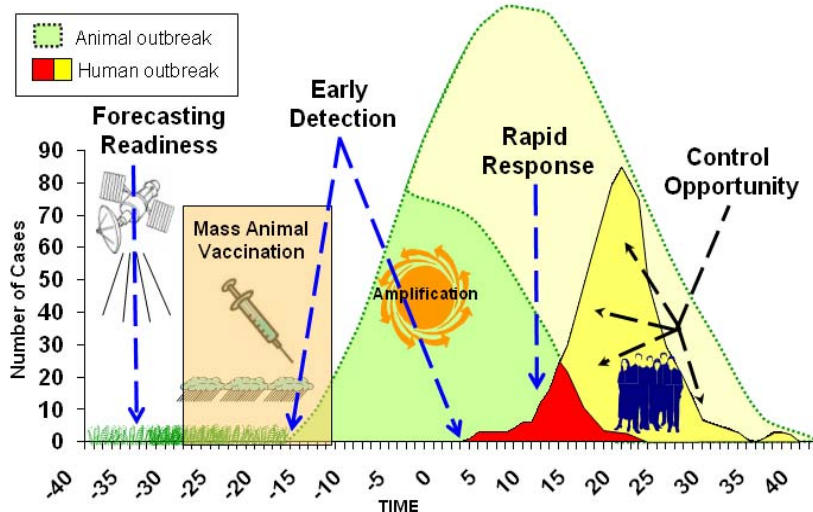
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Agricultural Research Service

# Prediction vs. Outbreak Timing – Epi-Curves: 2006 - 2008



— Week of First Warning

— Week of First Case

Anyamba et al (In Review AJTMH)

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- NOAA Climate Prediction Center, Camp Springs, Maryland.
- USDA Foreign Agricultural Service (FAS), Washington D.C.

## Field Data Support

- Jason Richardson, David Schnabel & USMARU/GEIS-K Entomological Team
- Rosemary Sang & KEMRI Field Team
- Robert Breiman, Allan Hightower CDC Team – Kenya
- Pierre Formenty, WHO; Stephan De La Rocque, FAO

## Collaborators

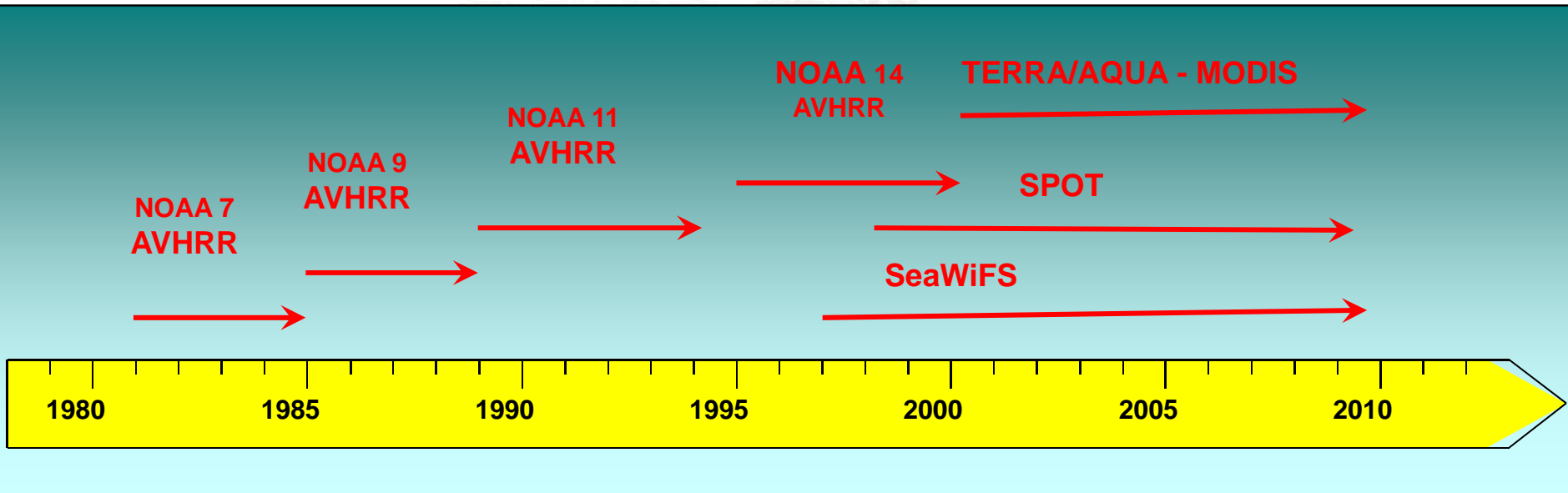
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- Food and Agricultural Organization (FAO), Rome.



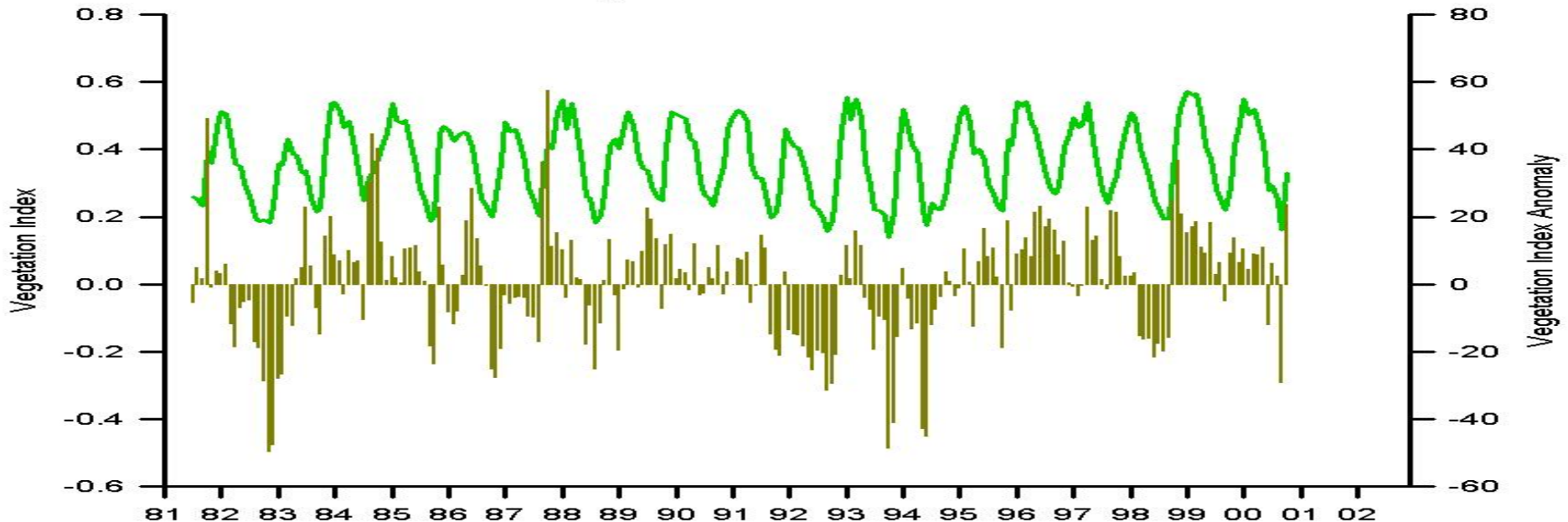
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# Time Series Measurements

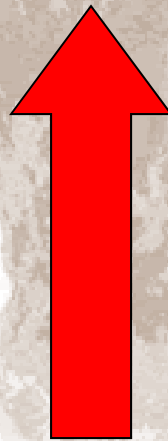
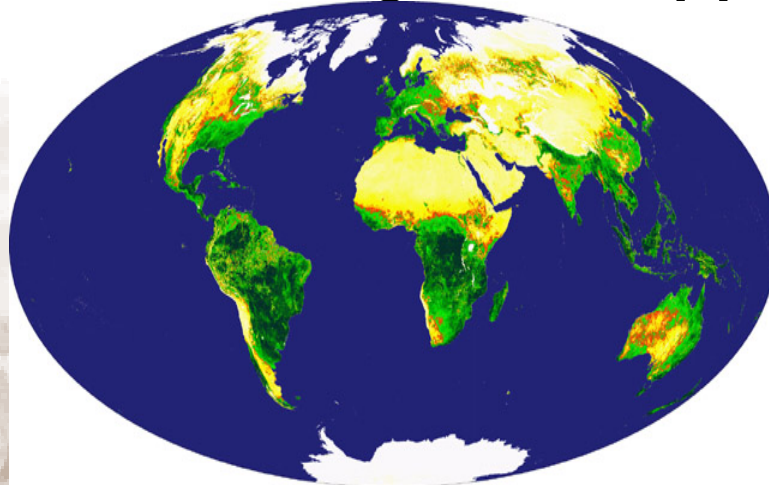


Vegetation Index Time Series

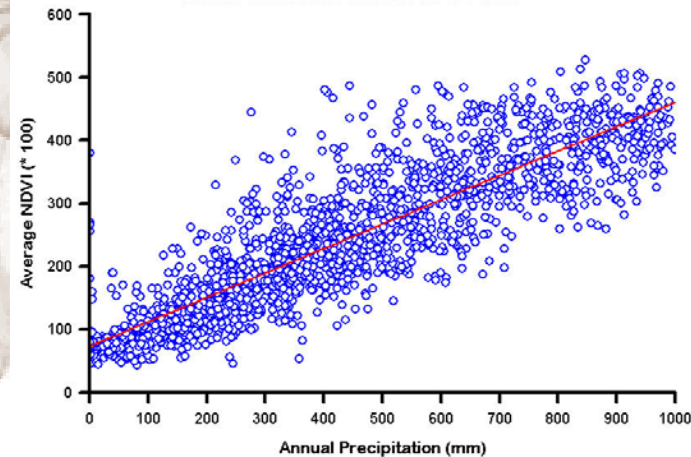


# Satellite Monitoring and Mapping

- Systematic Sampling - 27 year land surface data record
- 8km spatial resolution
- 10, 15-day, monthly temporal resolution
- Long-term Time Series Data sets – enables Retrospective analysis climate variability: drought & flood patterns, applications e.g.. disease outbreak patterns and provides basis for risk mapping
- Recent: SPOT Vegetation – global 1km:1998--, MODIS – 250m – 1km: 2000 --, Selective acquisitions from: LANDSAT, SPOT HRV: 10 – 30m



Rainfall vs NDVI  
Sahel-Sudanien Africa: 1982-1997



NDVI : measure of biosphere dynamics == can be used as the cumulative response indicator of climatic variables: precip, temp and their variability over time especially in arid and semi-arid areas == memory of climate (Nicholson, Tucker,various)