Food and Agriculture Organization of the United Nations

Risk Modelling and Forecasting Tools for Enhanced Early Warning: "The Example of Rift Valley Fever"

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1. Background

FAO Animal Health Service (AGAH) mandate:

- Prevent, contain and control the world's most serious livestock diseases at their source, while also surveying for newly emerging pathogens in a changing environment

Core activities (EMPRES/GLEWS):

- *Early warning* and *early detection* to enhance early action and response

Protecting livestock against diseases and preventing their spread is one of the keys to fighting hunger, malnutrition and poverty

1. Background – what is needed

- Early Warning Systems (EWS) to provide information on occurring animal health hazards that might evolve into disasters unless early response is undertaken.

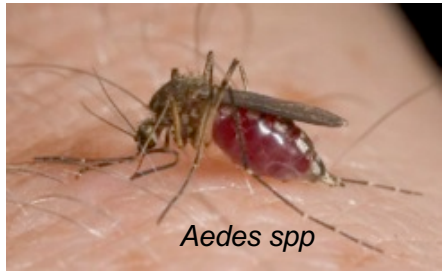
- EWS should be based on indicators that can be easily monitored to detect risk conditions

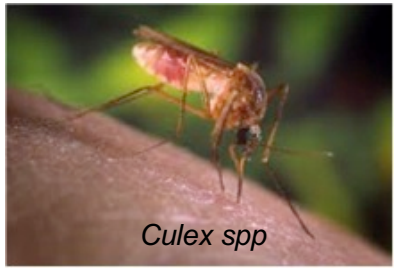
- Indicators should be specific (tend not to occur when outbreaks aren't seen)

- Cost effective

1. Rift Valley fever (RVF)

- Major zoonotic viral vector-borne disease
- Cattle, sheep, goats, camels, wildlife and humans
- Transmitted by mosquitoes species (e.g., *Aedes*, *Culex*), but also through the contact with infected animals
- Transovarial transmission in *Aedes*
- Spill-over from wild animals
- Driven by climate variability

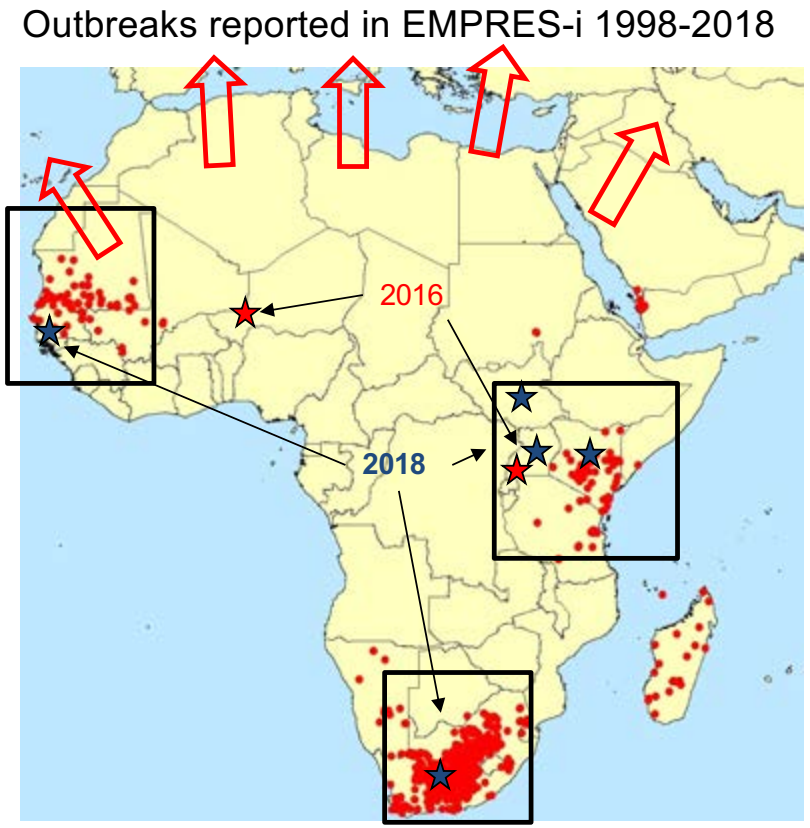

Aedes spp


Culex spp

1. RVF distribution and main hotspots

- 2012 and 2015 - 2018: abnormal weather conditions across western and eastern Africa leading to increased risk and RVF outbreaks

- Growing concern of geographical spread (Middle East and European Union countries)



1. RVF climatic risk factors

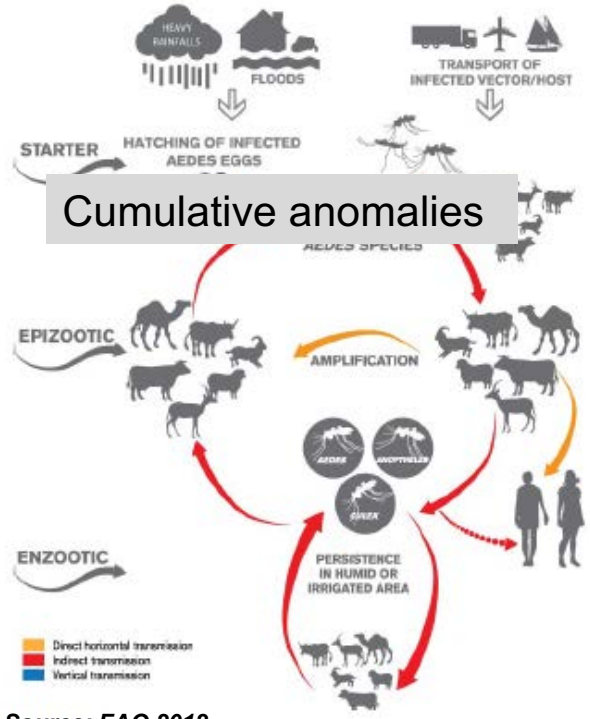
<u>Influence viral activity & vector abundance:</u>

- Heavy rains, floods, dry spells
  (+) Hatching mosquito eggs
- High temperature
  (+) feeding frequency
  (+) egg production
  (-) duration of development cycle

→ Allows forecasting outbreaks

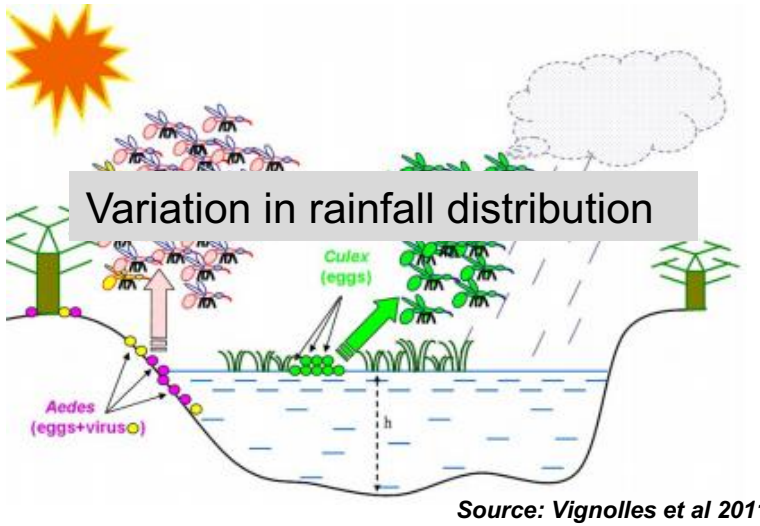
1. RVF vector ecology, epidemiology

East Africa - **Flooding areas** (e.g., dambos, Kenya)



Source: FAO 2012

West Africa - **Temporary ponds** and **dry spells** (e.g., Senegal)



Source: Vignolles et al 2011

We captured this regional variation in rainfall patterns to predict vector(s) dynamics and RVF at-risk areas **in East and West Africa**

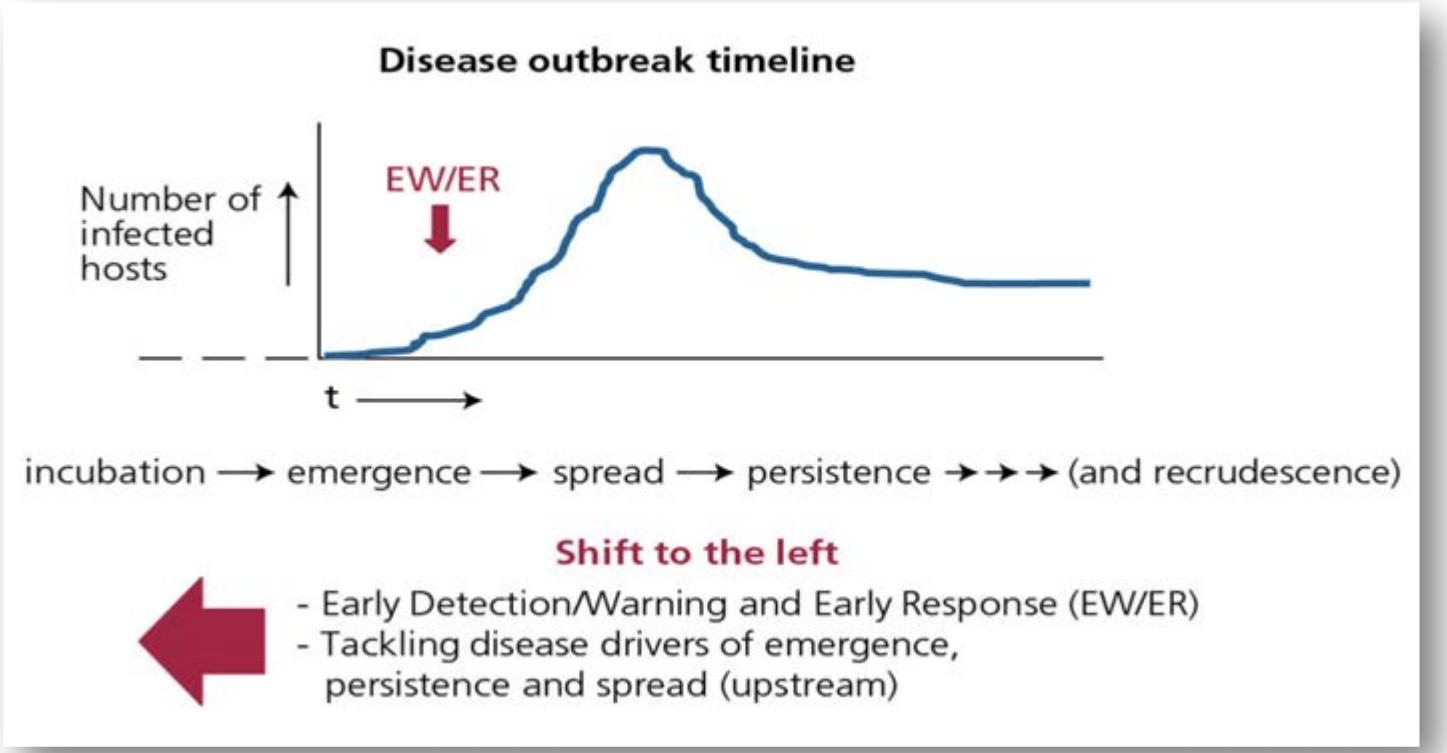
2. Environmental Monitoring using Remote Sensing

- Earth observation
- Massive data collected
- Long time-series
- Near real-time environmental data (climate, vegetation, T, soil, etc.)
- Data increasingly available free of charge
- Cost-effective
- Real-time Early Warning Systems
- Real-time risk modelling & forecasting
- Ground truth

2. Environmental Monitoring in Animal Health

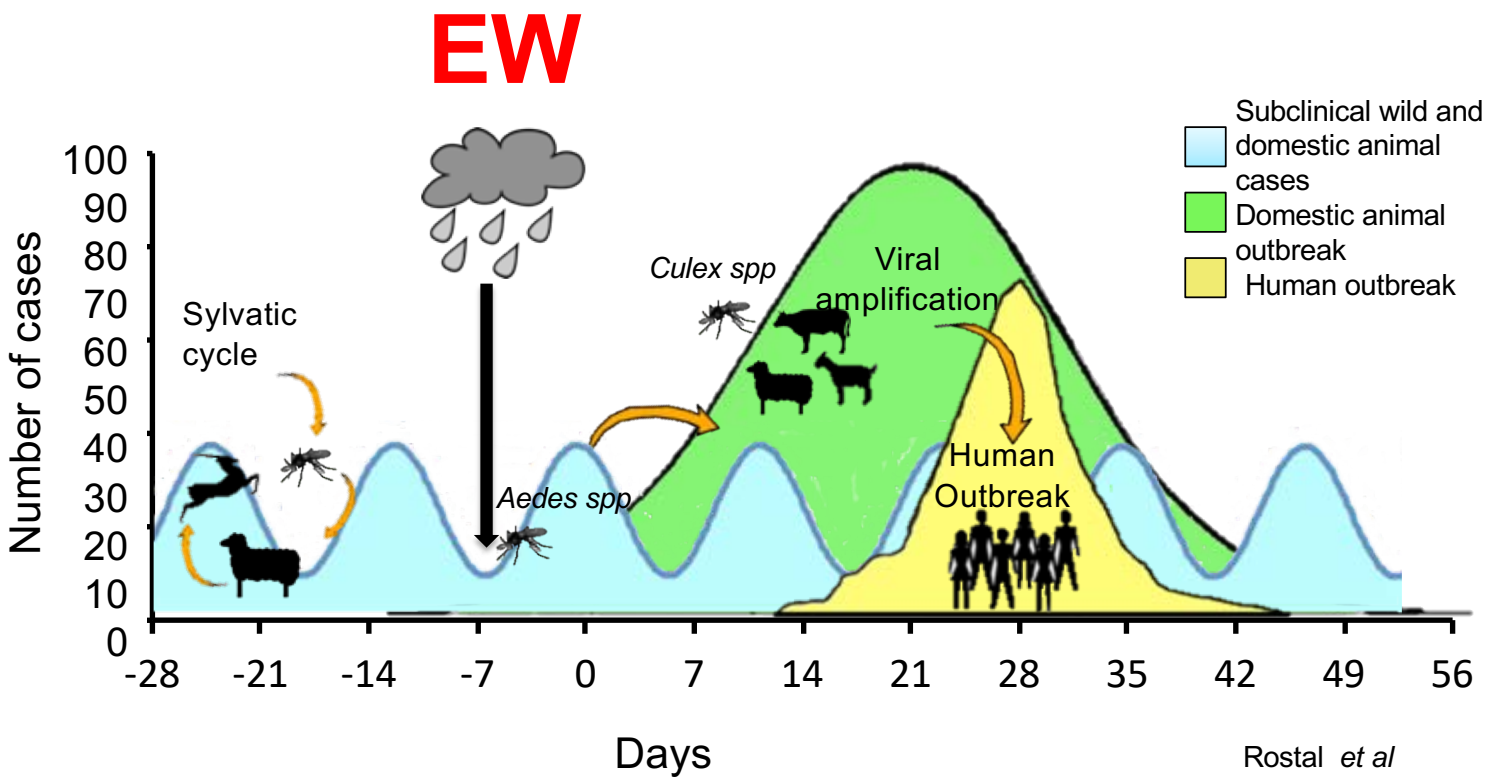
Why is the EM applied in animal health?

"EM of disease drivers helps to stay at the left side of the epi curve"



Source: *Changing Disease Landscape (World of Livestock 2013; FAO)*

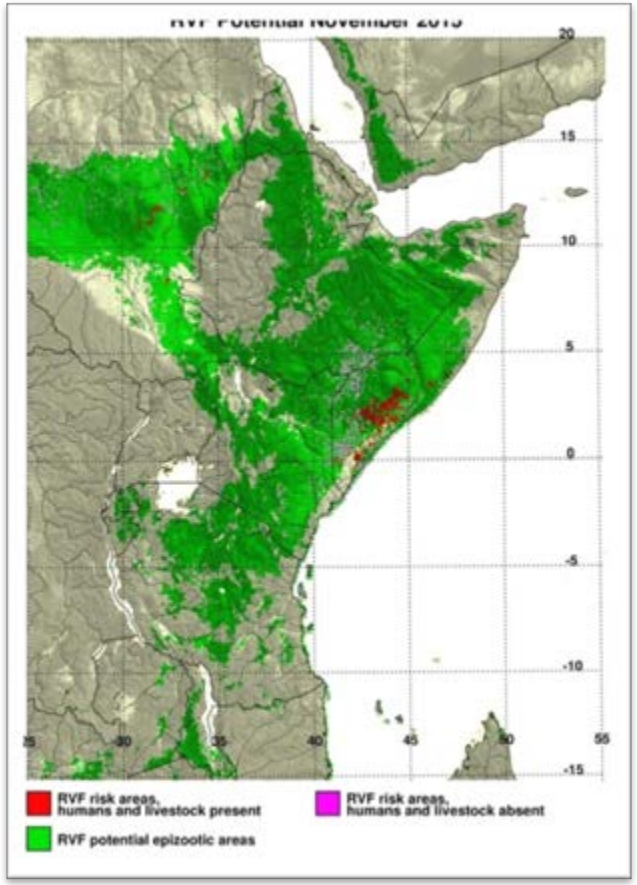
2. Environmental Monitoring for RVF



3. FAO RVF Early Warning (EW) System

Developed by NASA, FAO, WHO and OIE is based on:

- Climatic (rainfall, ENSO, SST) & vegetation (NDVI) anomalies (Anyamba et *al*. 2009)
- Retrospective analysis for model calibration/validation:
  - Field observations and outbreaks evaluations
  - Different RVF modeling approaches
- EW messages



3. FAO RVF Early Warning System

3 main components:

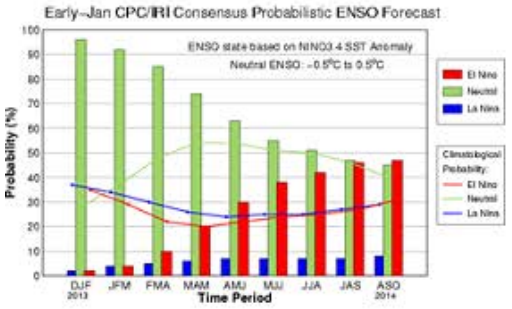
- Climate-based model (Anva
- ENSO (El Nino Southe urrent state and forecast
- Current a nal rainfall maps

Risk map & Risk Assessment every month

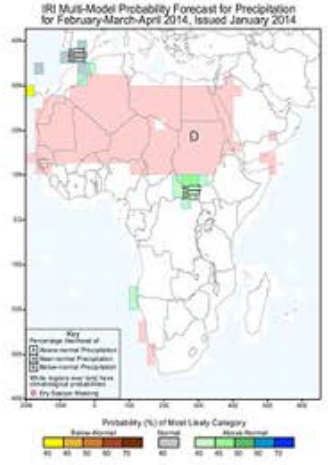
3. Example: RVF assessment for Jan – Feb 2014

- ENSO: low probability of warm-event
- Rainfall forecast: low probability of heavy rainfall
- NDVI anomalies in Jan-Feb 2014: limited areas

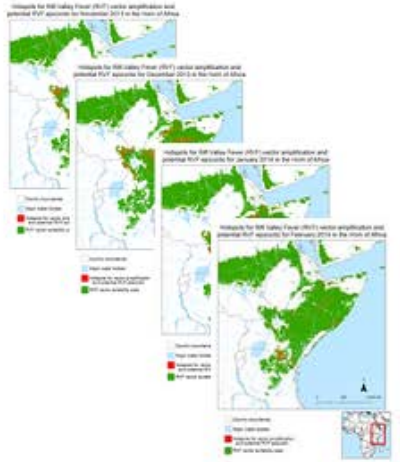
ENSO



Rainfall forecast



RVF risk maps



LOW RISK

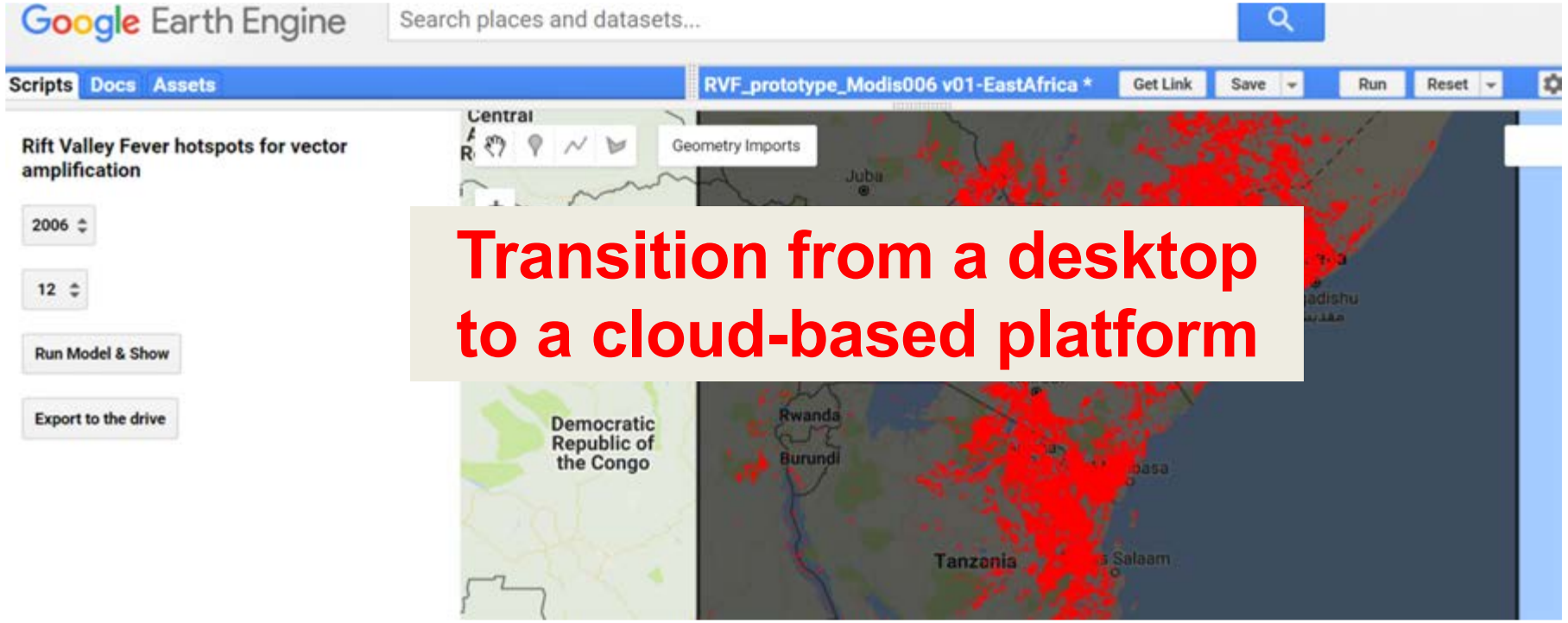
3. RVF alerts - early warning messages

- Numerous alerts to the countries at risk (joint RA with NASA, WHO, OIE field)
- In the past 3 years:
  - East Africa (**2015**, **2016**, **2017, 2018**)
  - West Africa (**2016** and **2017**)
  - Southern Africa (**2018**)
- RVF forecasts in quarterly FAO bulletins (**FCC and EWEA**)

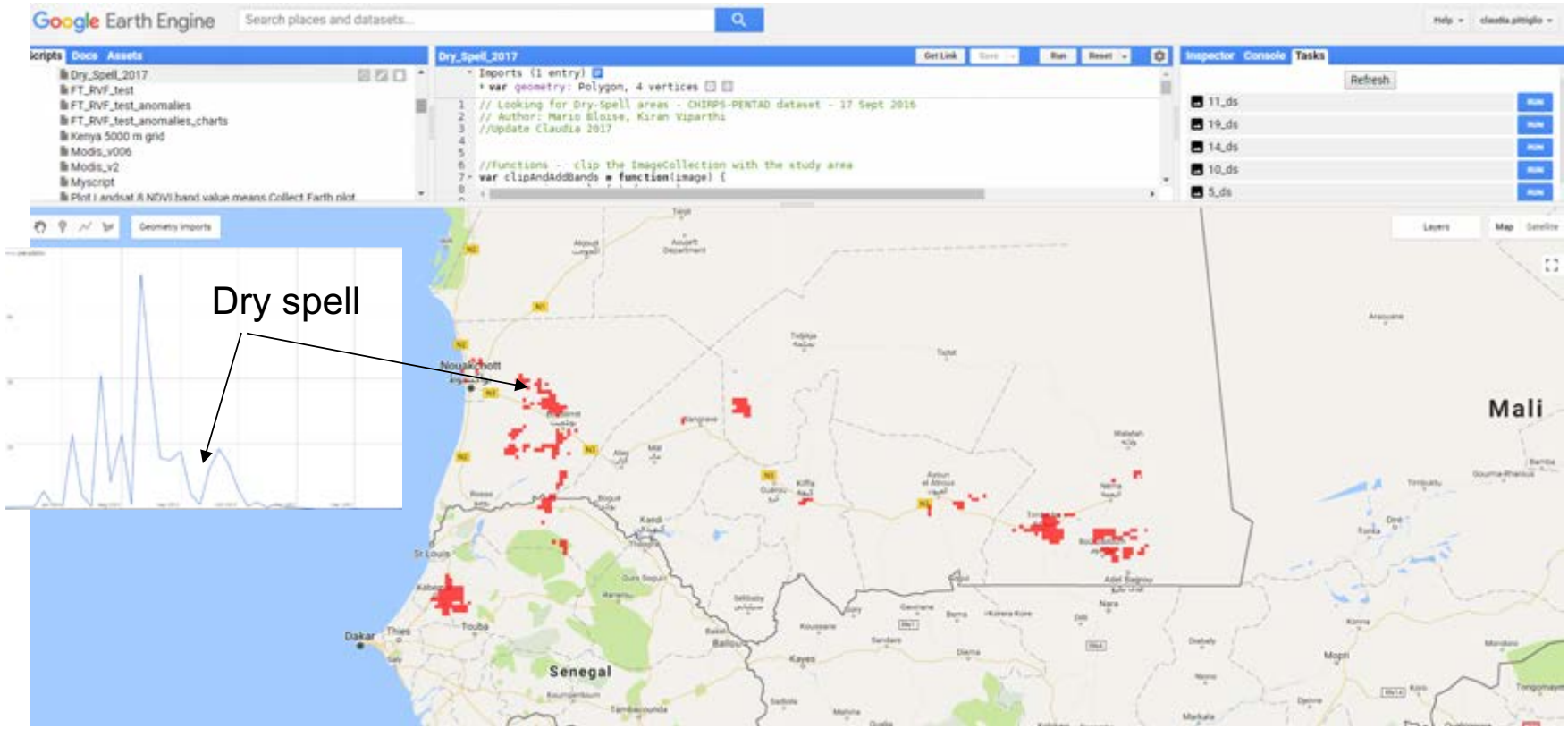
3. RVF Early Warning Tool (FAO prototype)

Claudia Pittiglio - Focal Point

Near-real time monitoring and risk mapping of RVF vector amplification with GEE



3. Google Earth Engine and dry spells



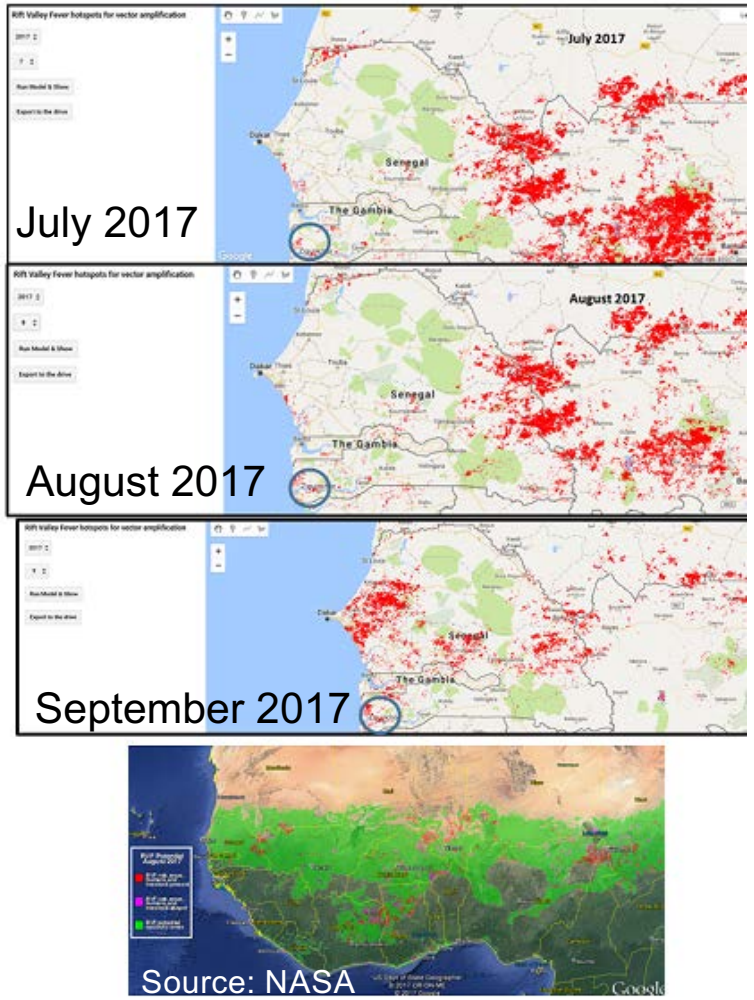
4. West Africa alert

July-Sept 2017

- Joint FAO-NASA RA

Jan 2018:
RVF human case in the Gambia

Source: FAO prototype



4. East Africa joint RA and first alert

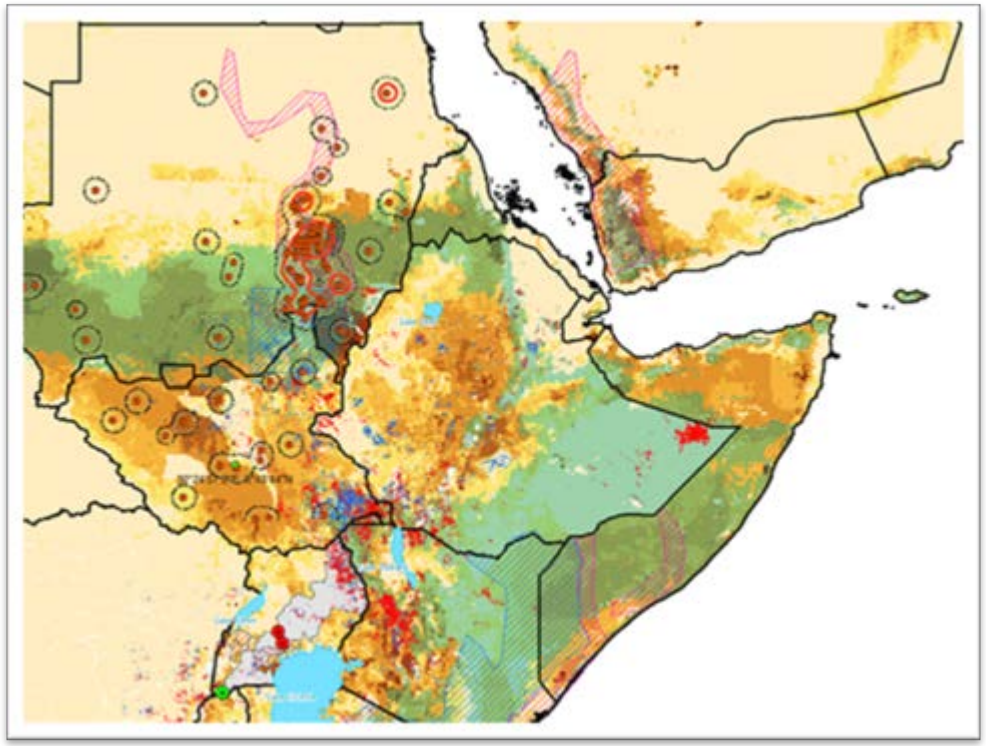
Nov 2017- Jan 2018

Uganda

- Joint FAO-WHO RA in early Dec 2017

South Sudan

- Joint FAO-WHO-OIE RA in Jan 2018



4. Southern Africa alert

Jan-Feb 2018

- Joint FAO-NASA RA in early Feb 2018

May 2018:
RVF reported in South Africa

Food and Agriculture Organization of the United Nations

Animal Production and Health Division

Southern African countries at risk of Rift Valley fever (RVF)

According to a climate monitoring system available at the National Aeronautics and Space Administration (NASA) and FAO, southern Africa has experienced heavy rains during the last weeks that may result in suitable environmental conditions for the emergence of the Rift Valley fever (RVF).

Based on the risk maps prepared by FAO in consultation with NASA for the period October-December 2017, **major potential hotspots of RVF vector amplification are located in north-western Namibia, south-eastern Botswana, south-western and northern Zimbabwe and wide areas in Mozambique.** The enclosed risk maps are generated from remotely-sensed data on precipitation and vegetation anomalies relevant for the RVF vector amplification.

Considering that precipitation forecasts for February and March 2018 predict above-normal rainfall in the region, **FAO advises that the veterinary services and livestock farmers' communities remain vigilant on the potential occurrence of RVF outbreaks in human and/or animal populations.**

Map 1: (a) Predicted RVF risk areas are shown in red and highlighted by grey circles. Past RVF occurrences (black dots) between 1968-2014 overlaid on (b) the vector suitability areas (green); (c) the human population counts and (d) the livestock numbers (in tropical livestock units). (e) Predicted precipitation anomalies for February 2018. Above-normal rainfall is shown from green to blue, while below-normal rainfall is shown from yellow to red.

In order to prevent and mitigate any occurrence of RVF in the region,

FAO ADVISES COUNTRIES AT RISK TO

- Increase syndromic surveillance of unusual abortion storms at any stage of pregnancy among small ruminants, camels and cattle;
- Increase awareness of RVF clinical signs among farmers and workers in abattoirs and animal markets through newspapers, radio, mobile phones or other means of communication.

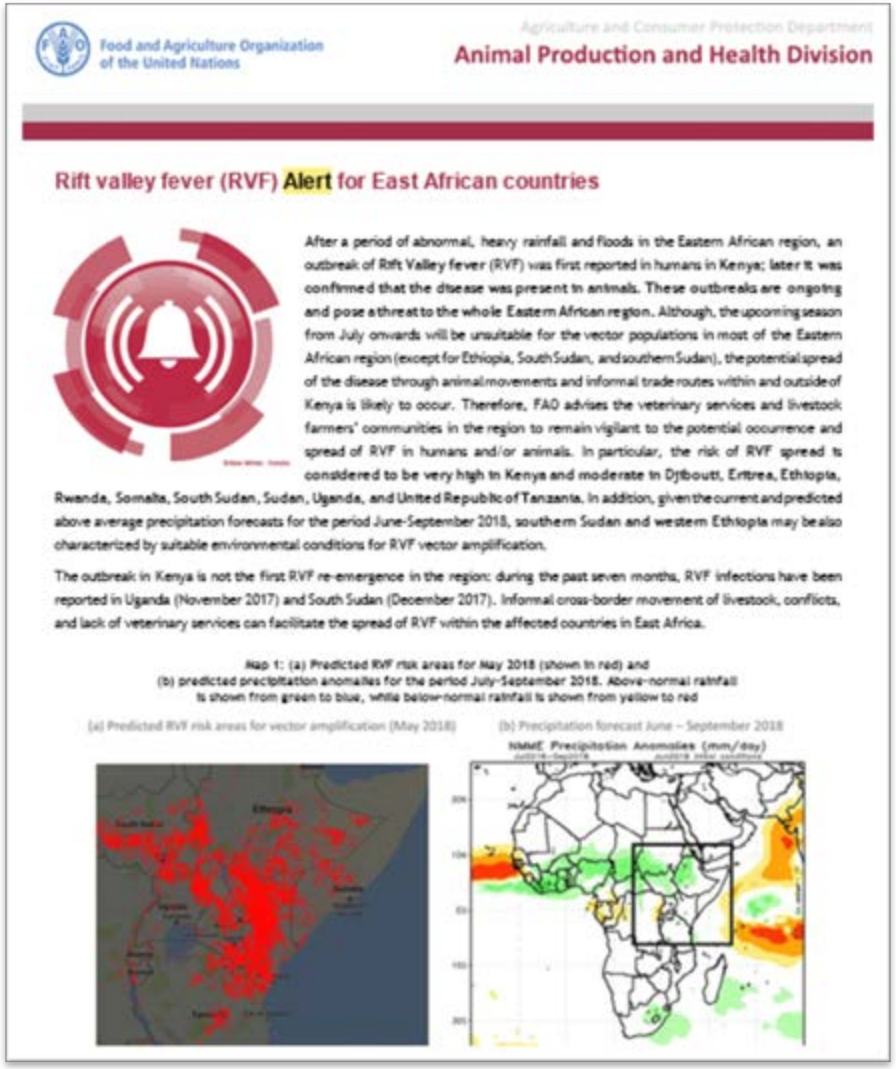
4. East Africa second alert

Issued on April 2018

FAO Risk Assessment (April 2018)

- **High** risk of RVF vector amplification in Kenya
- **Moderate** for the rest of EA

June 2018:
RVF reported in Kenya



Food and Agriculture Organization of the United Nations

Agriculture and Consumer Protection Department

Animal Production and Health Division

Rift valley fever (RVF) Alert for East African countries

After a period of abnormal, heavy rainfall and floods in the Eastern African region, an outbreak of Rift Valley fever (RVF) was first reported in humans in Kenya; later it was confirmed that the disease was present in animals. These outbreaks are ongoing and pose a threat to the whole Eastern African region. Although, the upcoming season from July onwards will be unsuitable for the vector populations in most of the Eastern African region (except for Ethiopia, South Sudan, and southern Sudan), the potential spread of the disease through animal movements and informal trade routes within and outside of Kenya is likely to occur. Therefore, FAO advises the veterinary services and livestock farmers' communities in the region to remain vigilant to the potential occurrence and spread of RVF in humans and/or animals. In particular, the risk of RVF spread is considered to be very high in Kenya and moderate in Djibouti, Eritrea, Ethiopia, Rwanda, Somalia, South Sudan, Sudan, Uganda, and United Republic of Tanzania. In addition, given the current and predicted above average precipitation forecasts for the period June-September 2018, southern Sudan and western Ethiopia may be also characterized by suitable environmental conditions for RVF vector amplification.

The outbreak in Kenya is not the first RVF re-emergence in the region: during the past seven months, RVF infections have been reported in Uganda (November 2017) and South Sudan (December 2017). Informal cross-border movement of livestock, conflicts, and lack of veterinary services can facilitate the spread of RVF within the affected countries in East Africa.

Map 1: (a) Predicted RVF risk areas for May 2018 (shown in red) and (b) predicted precipitation anomalies for the period July-September 2018. Above-normal rainfall is shown from green to blue, while below-normal rainfall is shown from yellow to red

(a) Predicted RVF risk areas for vector amplification (May 2018)

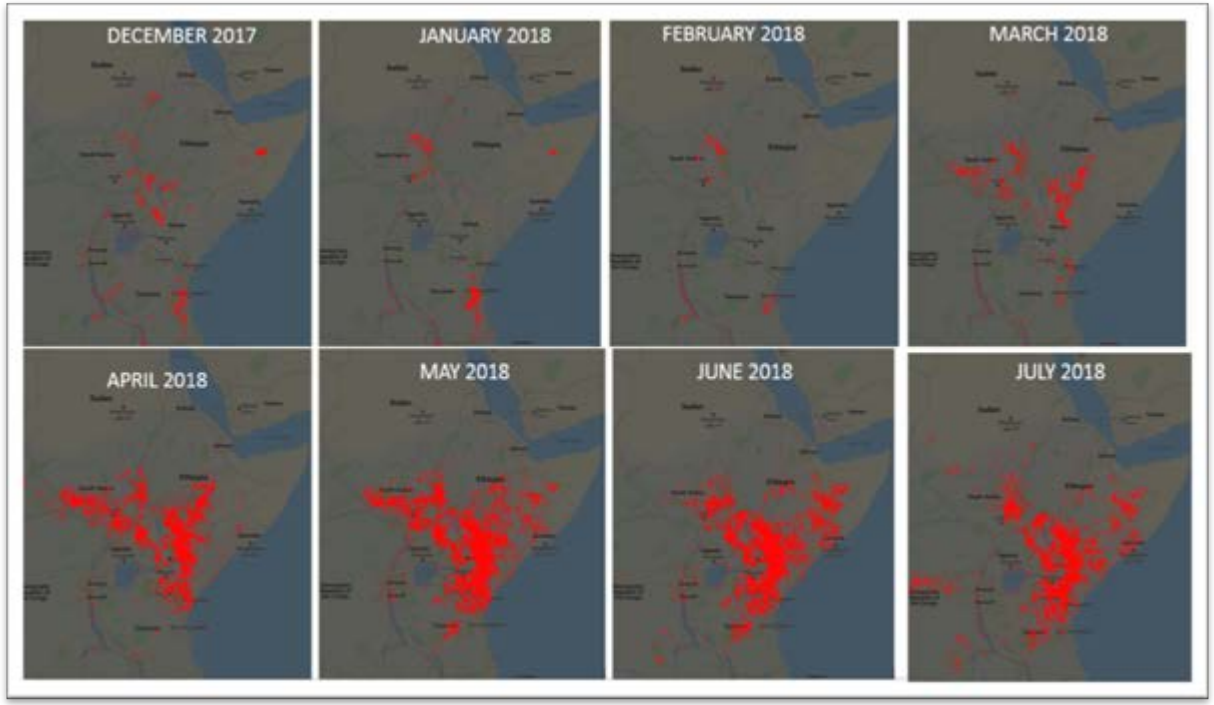
(b) Precipitation forecast June – September 2018

NMME Precipitation Anomalies (mm/day)

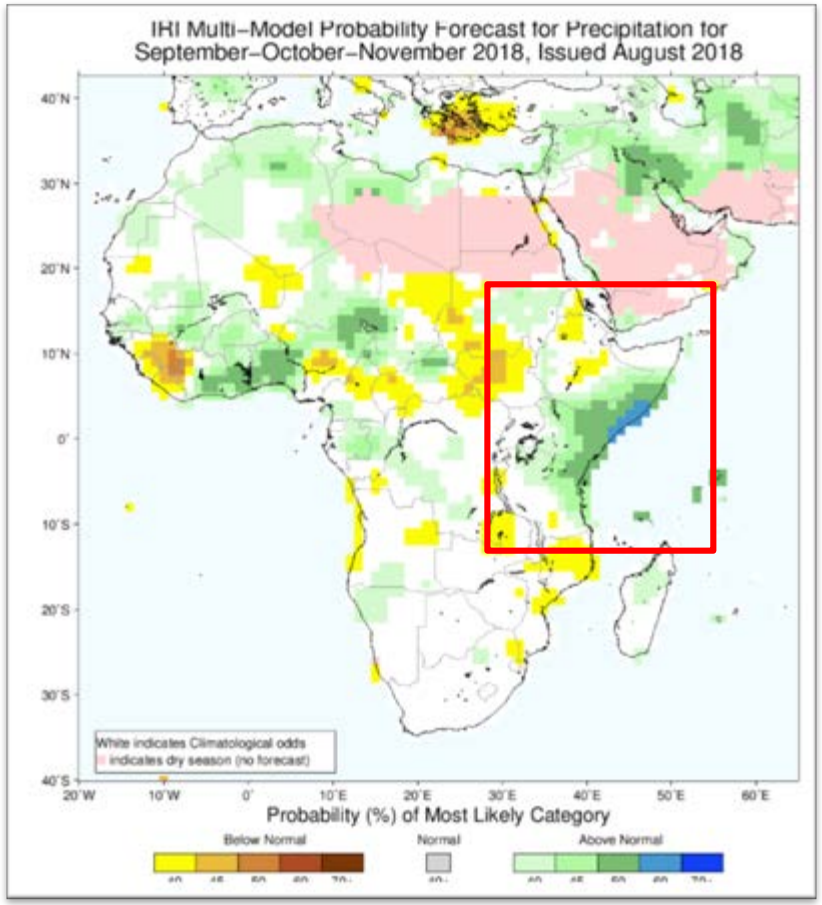
4. RVF forecast Sept-Nov 2018

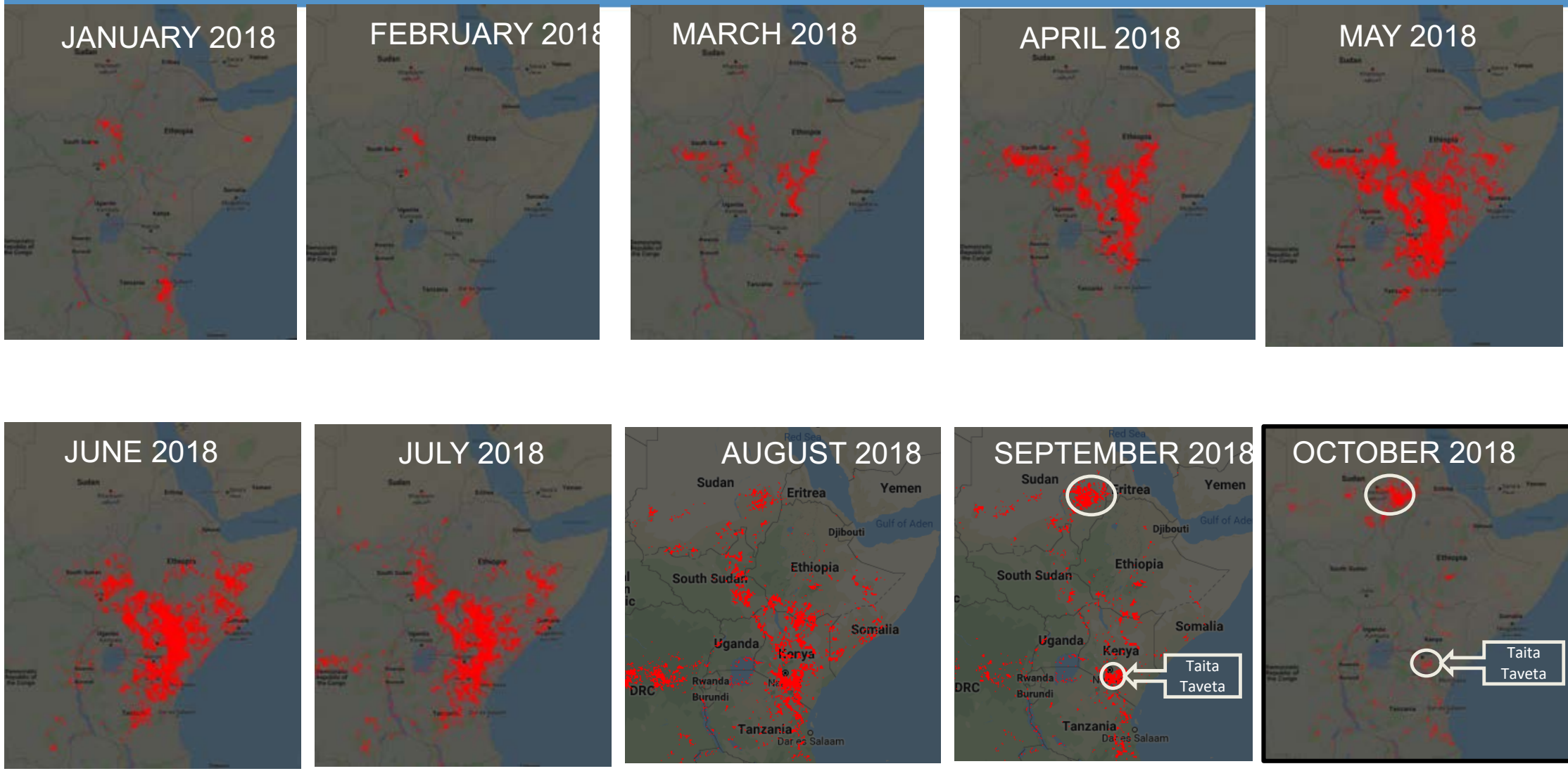
High risk of RVF spread in the region

RVF risk maps from Dec 2017 to July 2018

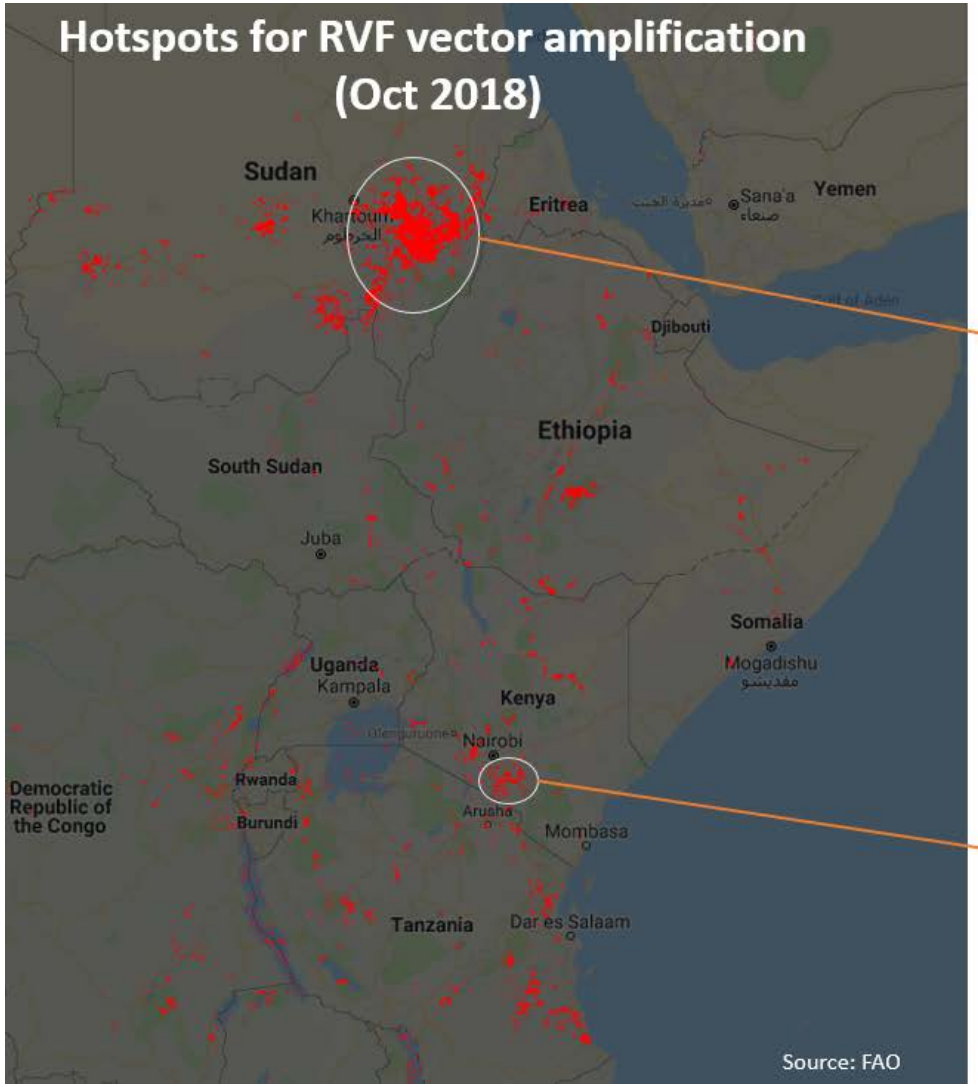


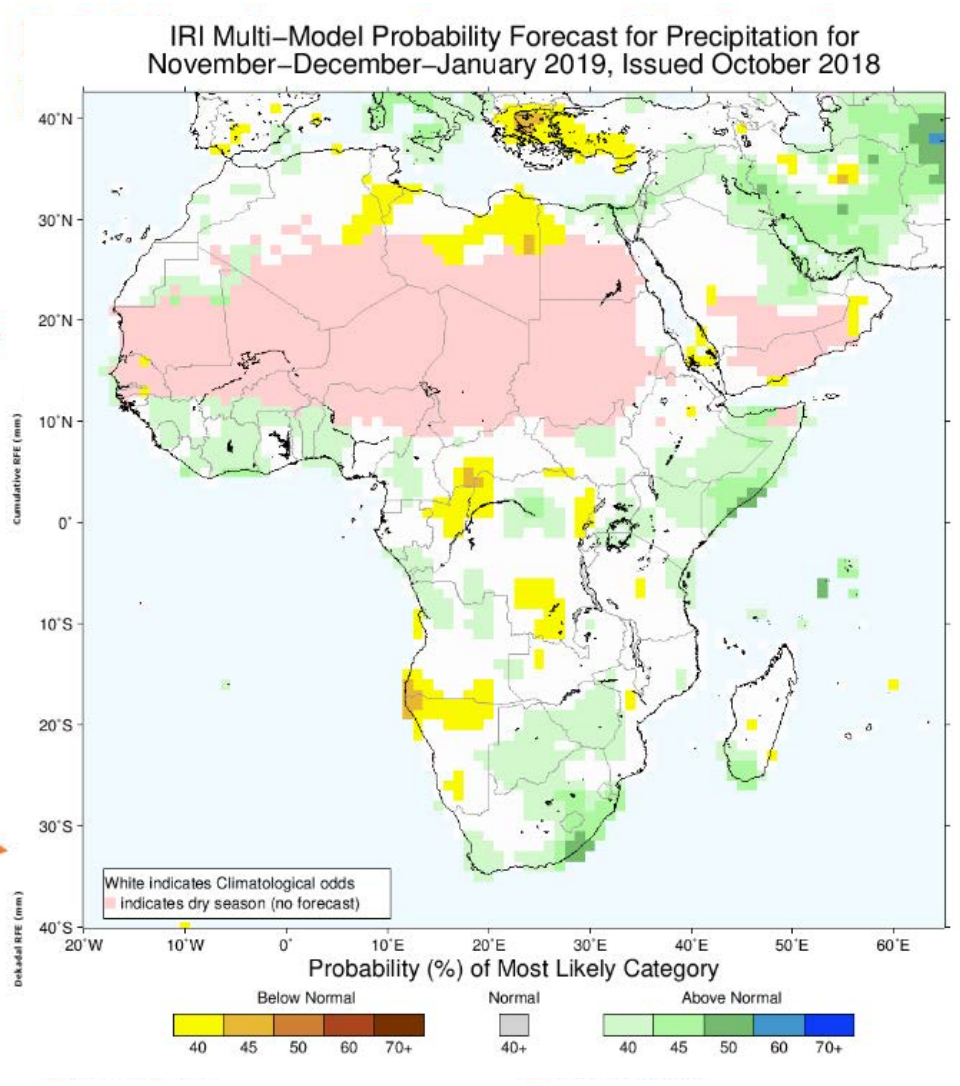
IRI Precipitation forecast (SON 2018)





Source: FAO RVF prototype


Hotspots for RVF vector amplification
(Oct 2018)
Sudan
Khartoum
Eritrea
Sana'a
Yemen
Djibouti
Ethiopia
South Sudan
Juba
Somalia
Mogadishu
Uganda
Kampala
Kenya
Nairobi
Rwanda
Democratic
Republic of
the Congo
Burundi
Arusha
Mombasa
Tanzania
Dar es Salaam
Source: FAO


IRI Multi-Model Probability Forecast for Precipitation for
November-December-January 2019, Issued October 2018
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
60°E
White indicates Climatological odds
indicates dry season (no forecast)
Probability (%) of Most Likely Category
Below Normal
Normal
Above Normal
40
45
50
60
70+
40+

4. Strengths and Challenges of the RVF EWS

STRENGHTS	CHALLENGES
Near real-time environmental monitoring system	Real-time validation of RVF at risk areas (mosquito surveillance, sentinel herds; expert knowledge, etc.)
Cost-effective	Calibration for countries with no RVF outbreak data
Availability of RVF risk maps on monthly basis	Establish a network of experts to discuss the RVF risk maps and update the RVF situation
Accurate predictions for endemic countries with RVF historical data	Data sharing to assess the occurrence and spread based on effective exposure (n animals, vaccinations, animal movement, trade)
	Quantitative RA: Integration of other risk factors to assess and quantify animals and humans at risk

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Thank you for your attention

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