Early Warning: Remote Sensing of Climatic, Ecological Indicators and RVF Risk Mapping

Re-emergence of Rift valley fever in Southern Africa : how to better predict and respond ?

OIE Southern Africa Regional Seminar

Bloemfontein (South Africa), February 16 – 18th, 2009

Assaf Anyamba
NASA/Goddard Space Flight Center
Biospheric Sciences Branch, Code 614.4,
Greenbelt, MD 20771

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WHERE IS THE BEEF?

Kenya meat exports to Europe banned

Story by JEFF OTIENO Nation Newspaper

Publication Date: 4/22/2008

Kenya has lost its beef export quota to Europe over its failure to control animal diseases.

The 4,000 metric tonnes meat export per year quota has now been taken over by Botswana.

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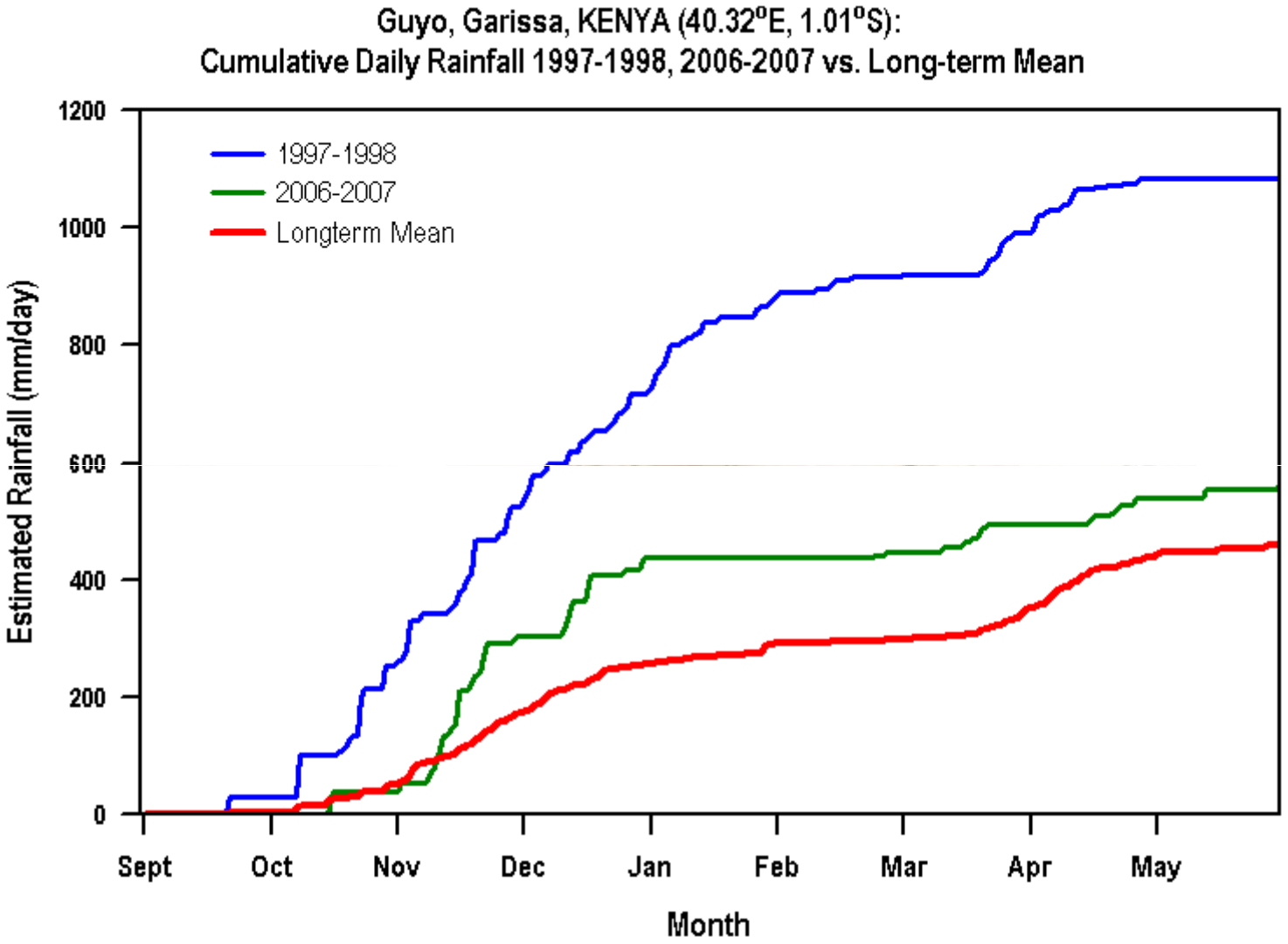
RVF OUTBREAK CONTEXT



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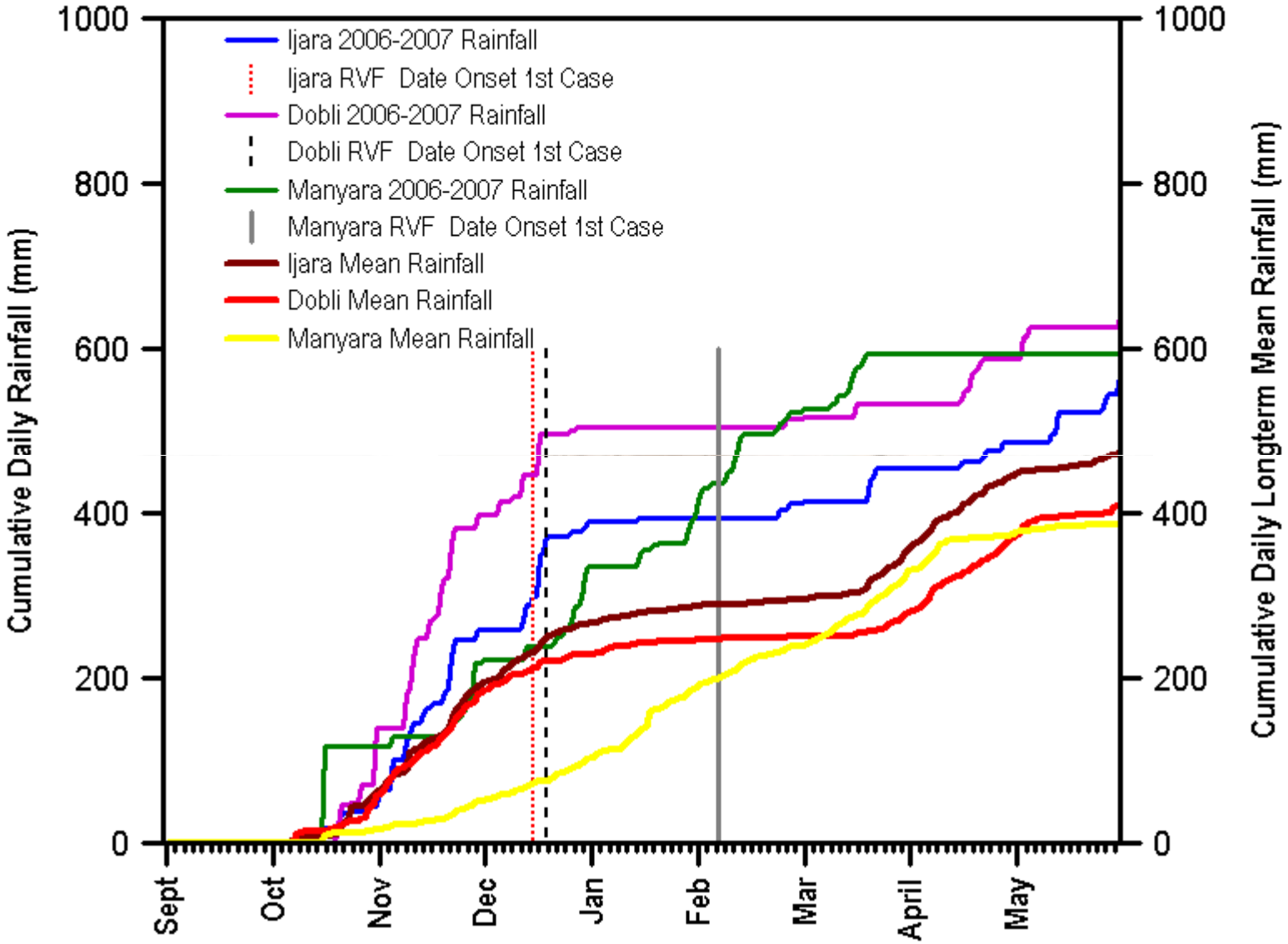
Horn of Africa: Rainfall vs. Outbreak Timing



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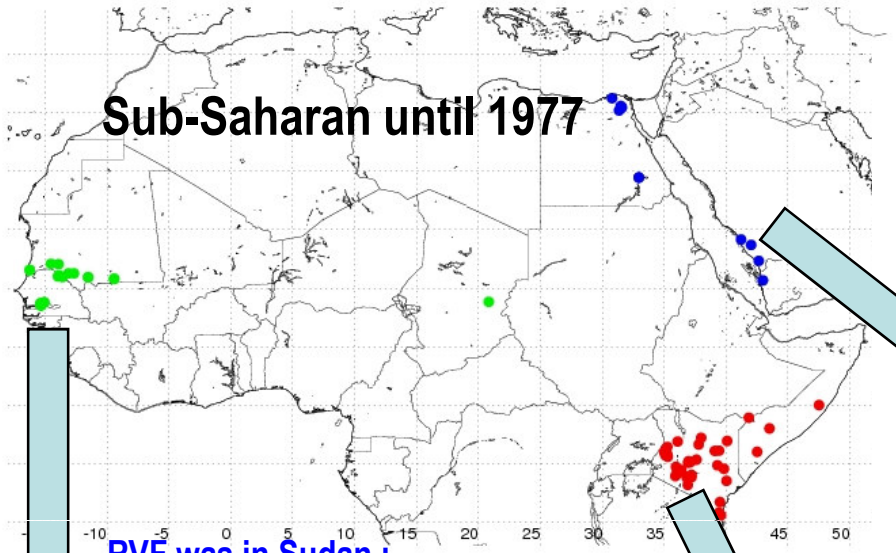
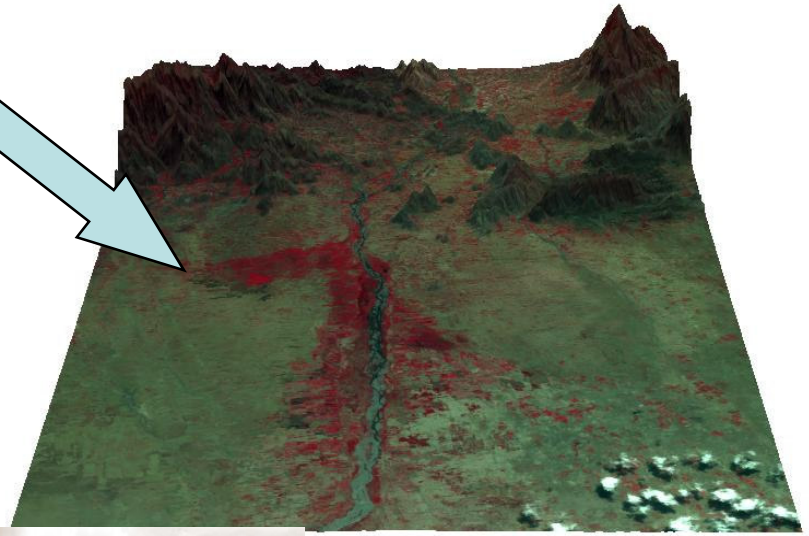
Clusters of Recent RVF Outbreaks



Sub-Saharan until 1977

RVF was in Sudan :
1973 Extensive outbreak
1976 Limited outbreak
1981 Serologic evidence

Coastal Flood Plain 2000



Riverine Flood Plain 87

Savanna Grassland 1997-98, 2006-07

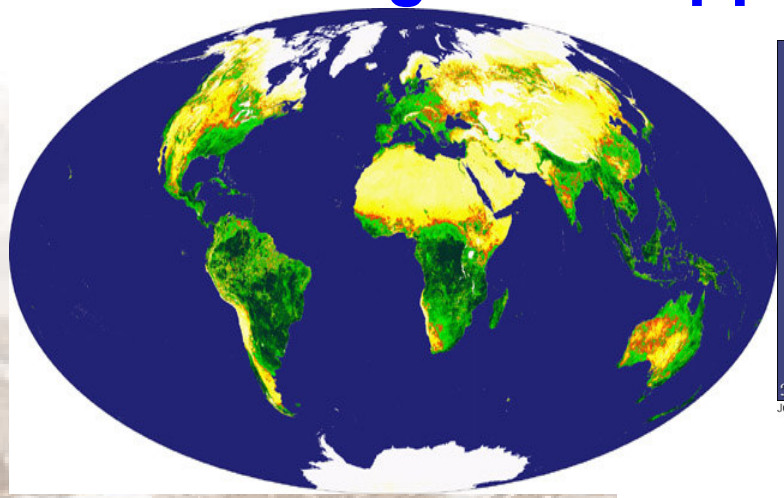
Dambos

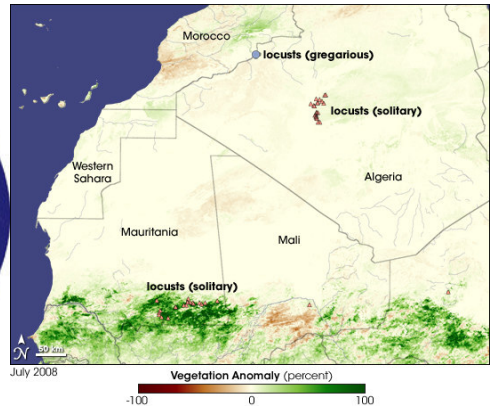
WET

DRY

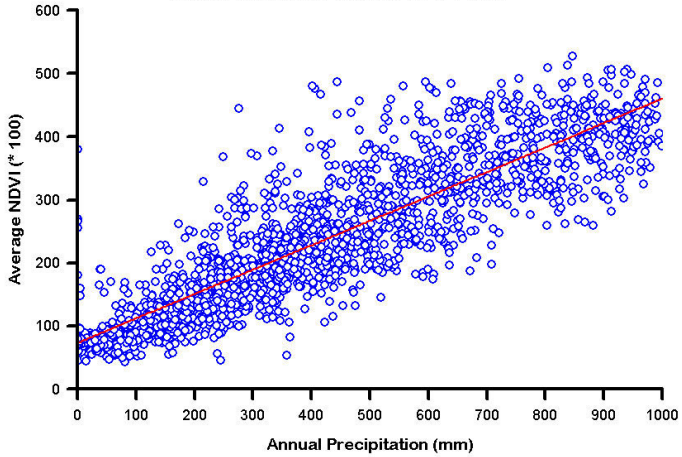
Satellite Monitoring and Mapping

- systematic sampling (27 yr data record from NOAA-AVHRR Instrument – Long- term Data Records)
- 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-Sudanian Africa: 1982-1997



Normalized Difference Vegetation Index: Most Commonly used measure of biosphere dynamics == can be used as the cumulative response indicator of climatic parameters: precip, temp and their variability over time especially in arid and semi-arid areas == memory of climate

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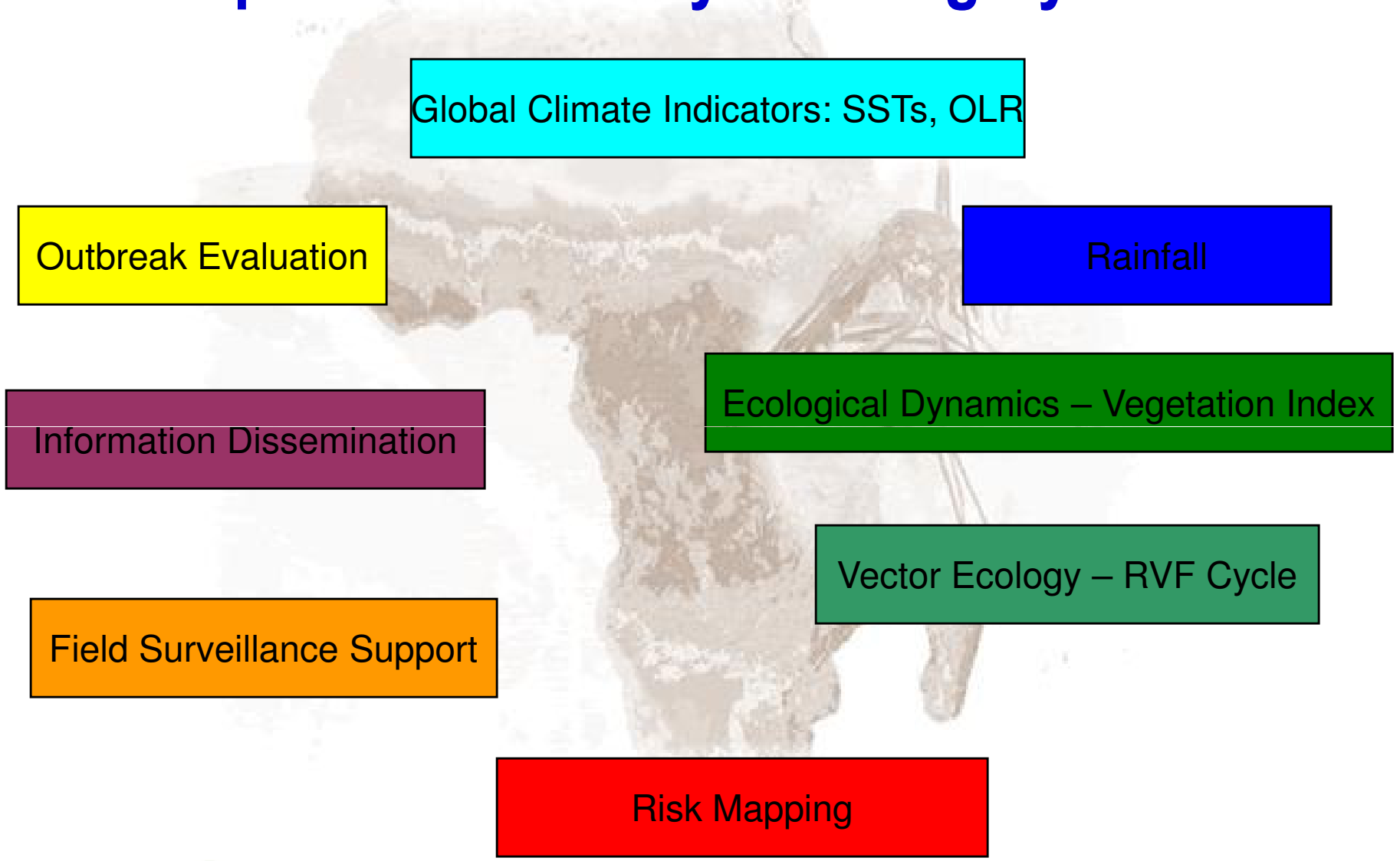
Components of Early Warning System



Department of Defense Global Emerging Infections System

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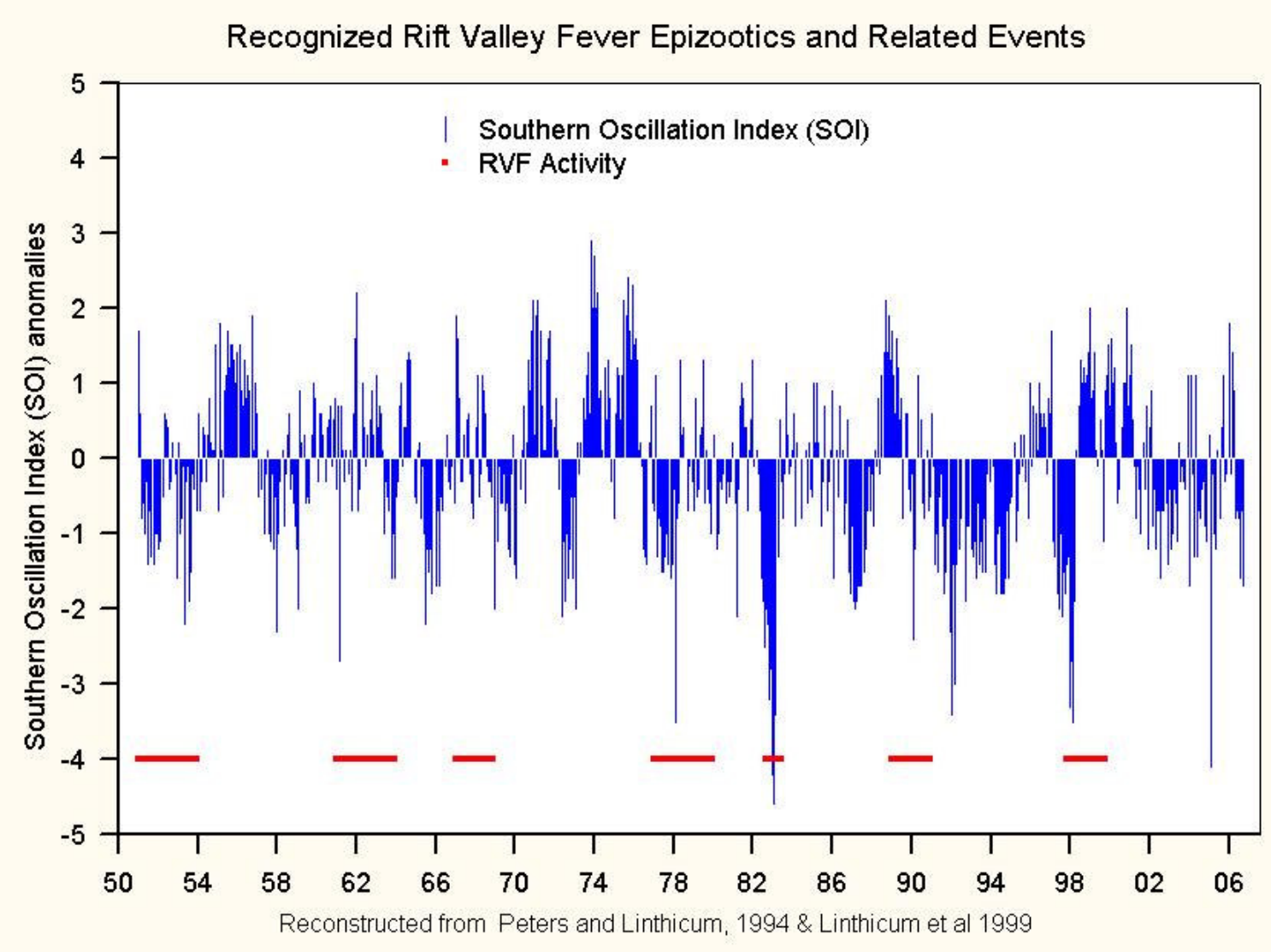
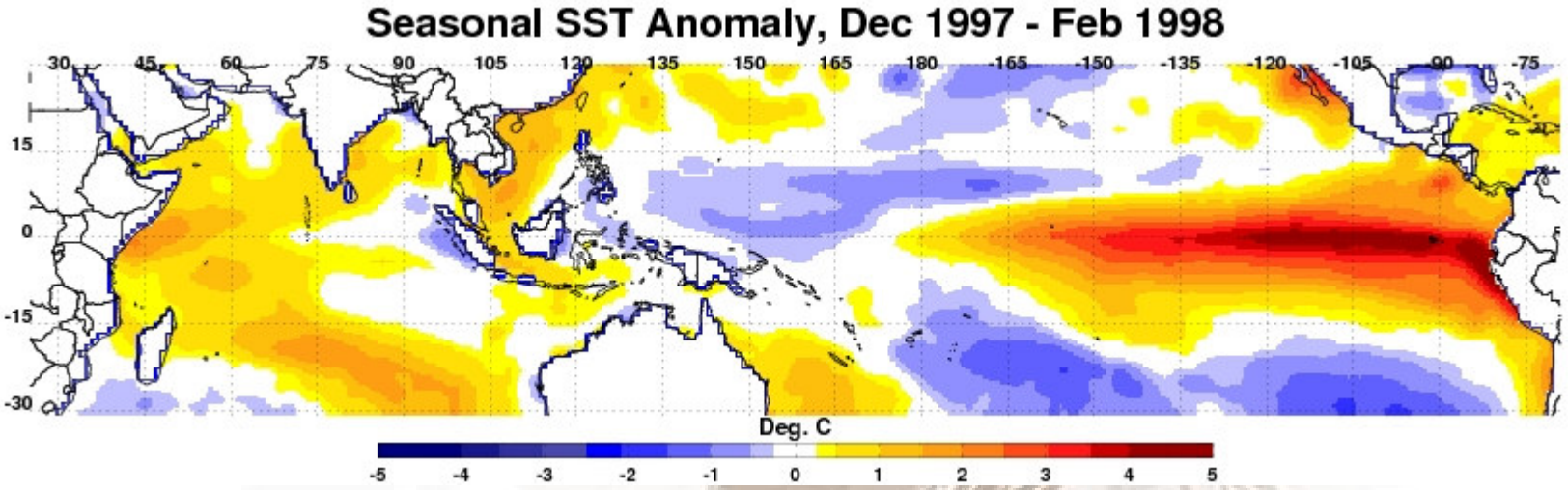
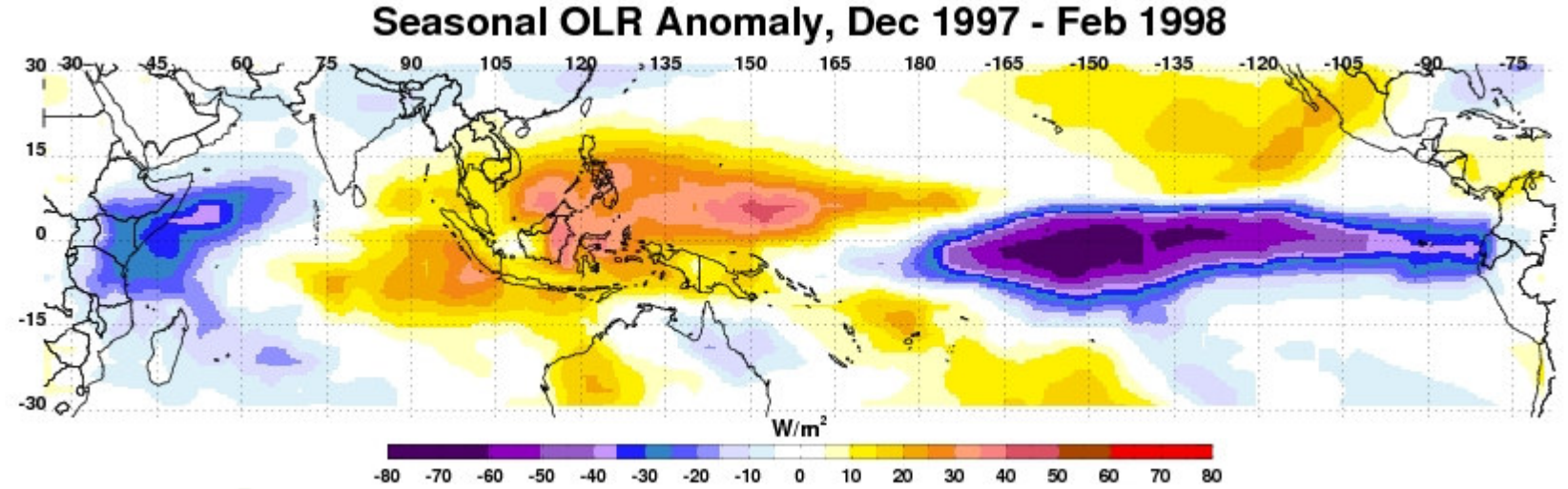
1a. Southern Oscillation Index



1b. Sea Surface Temperatures



1c. Outgoing Longwave Radiation



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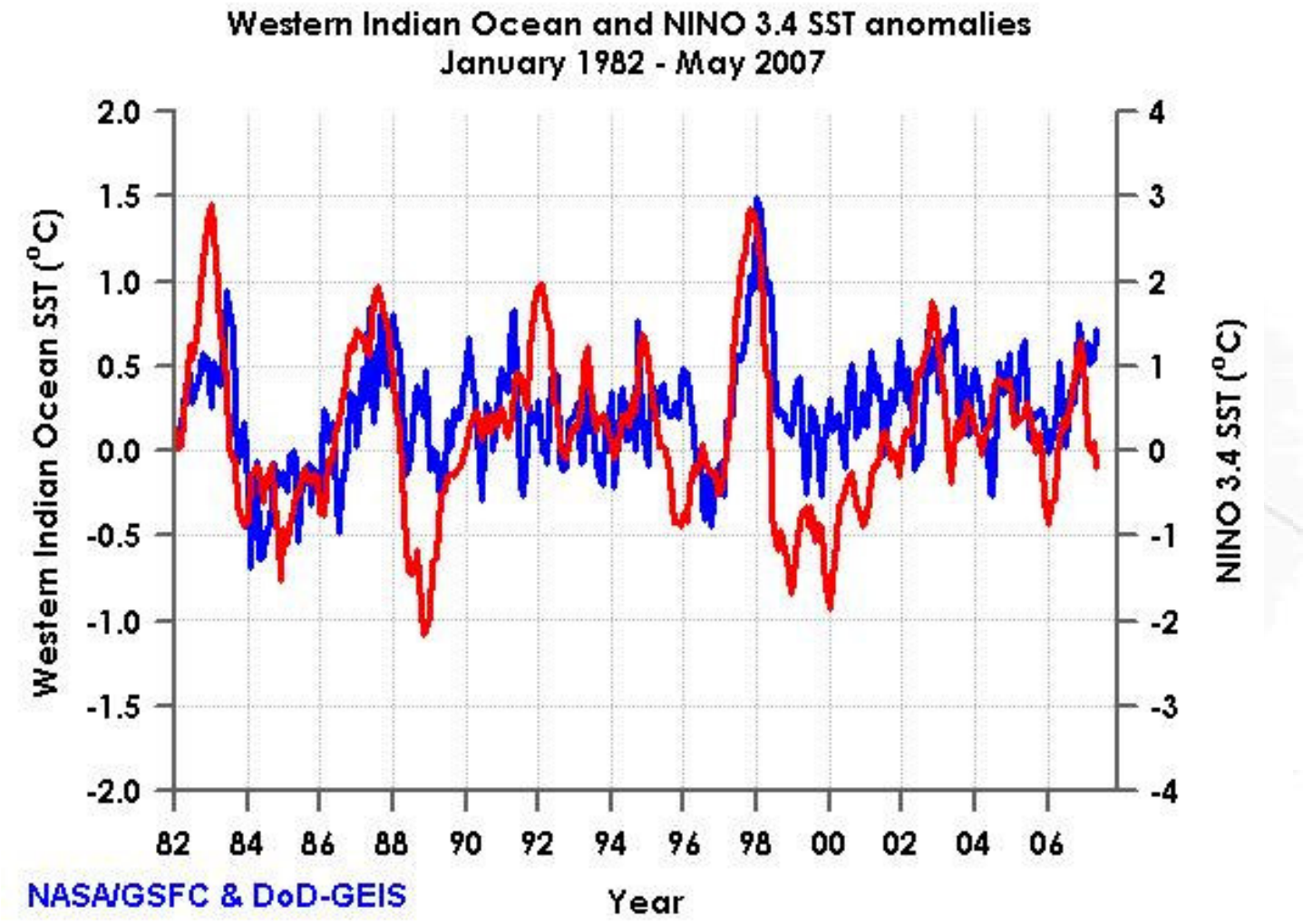
1d. SST Indicators: NINO3.4 SST, WIO



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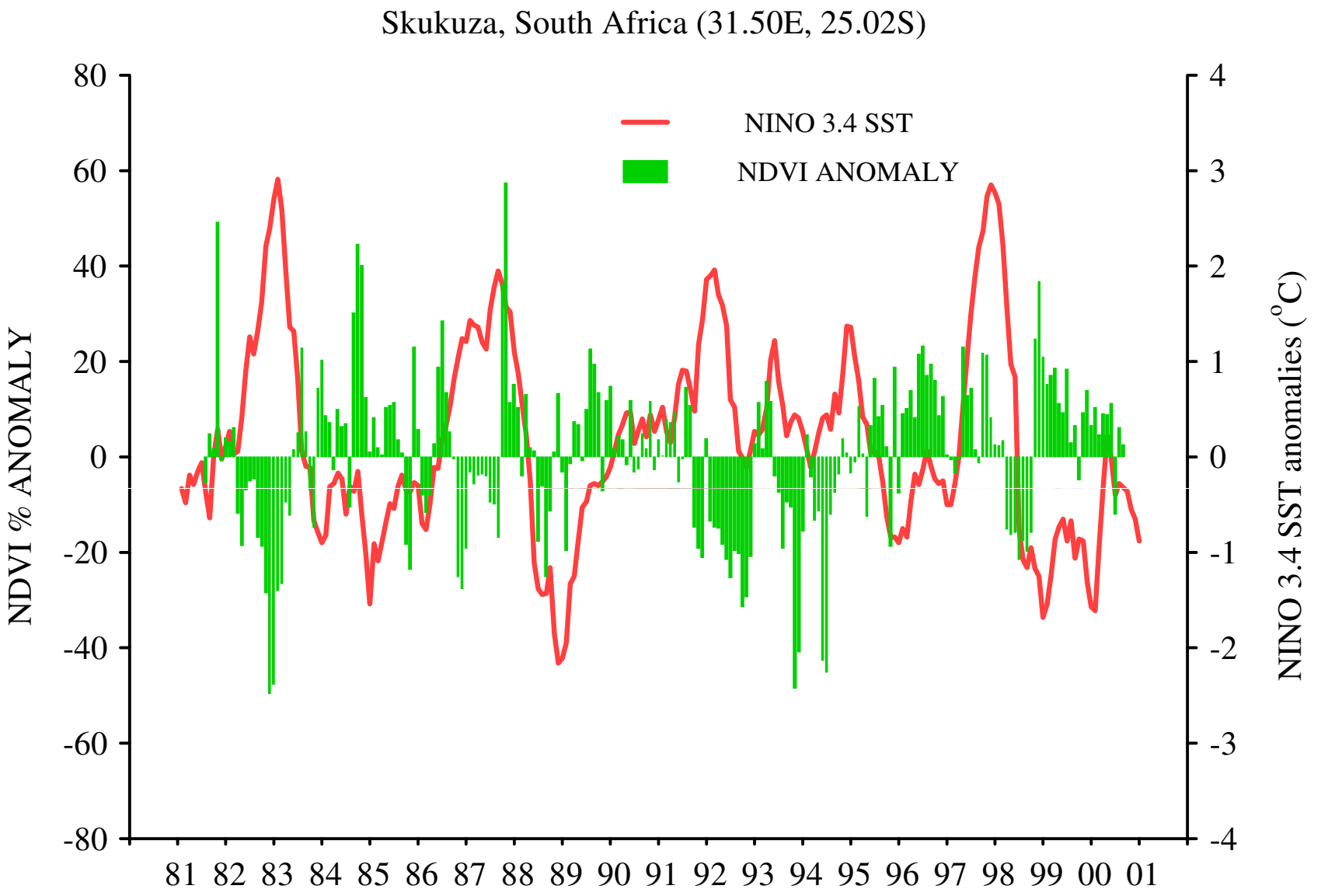

Department of Defense Global Emerging Infections System

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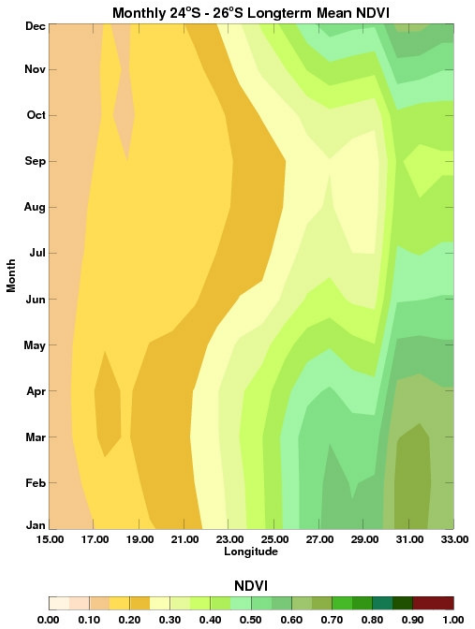
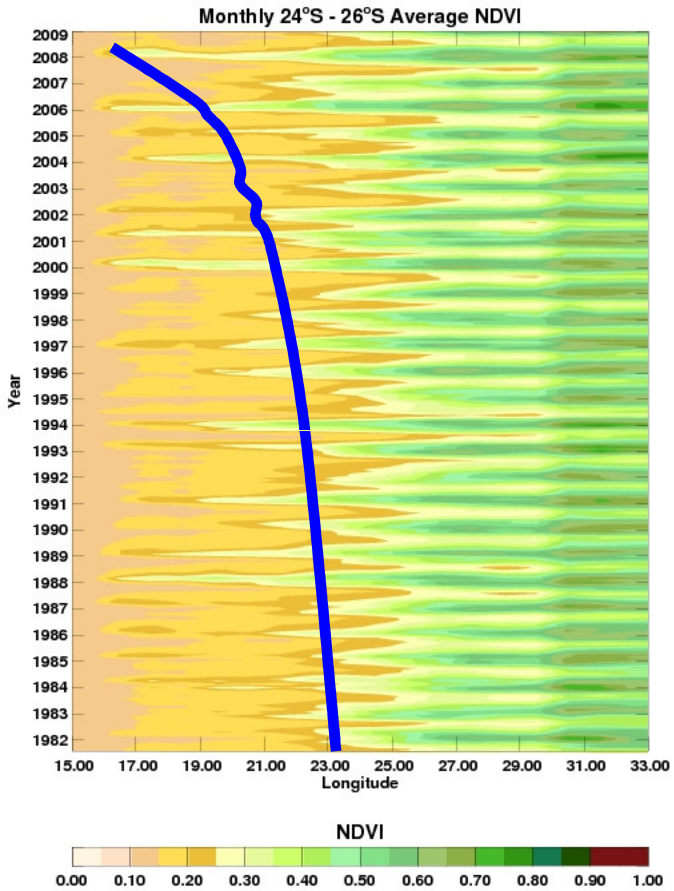
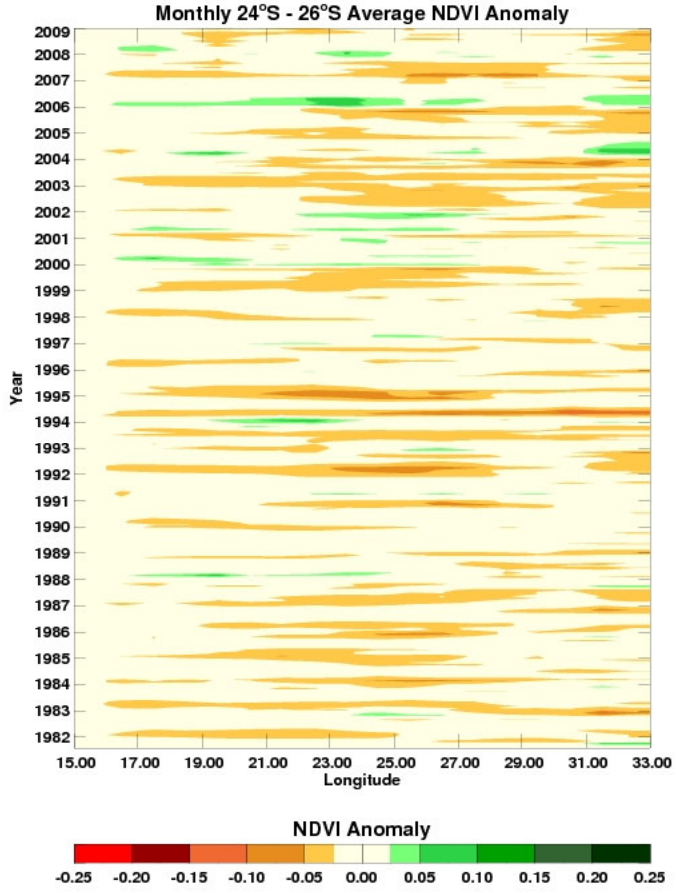
Historical Ecological Patterns







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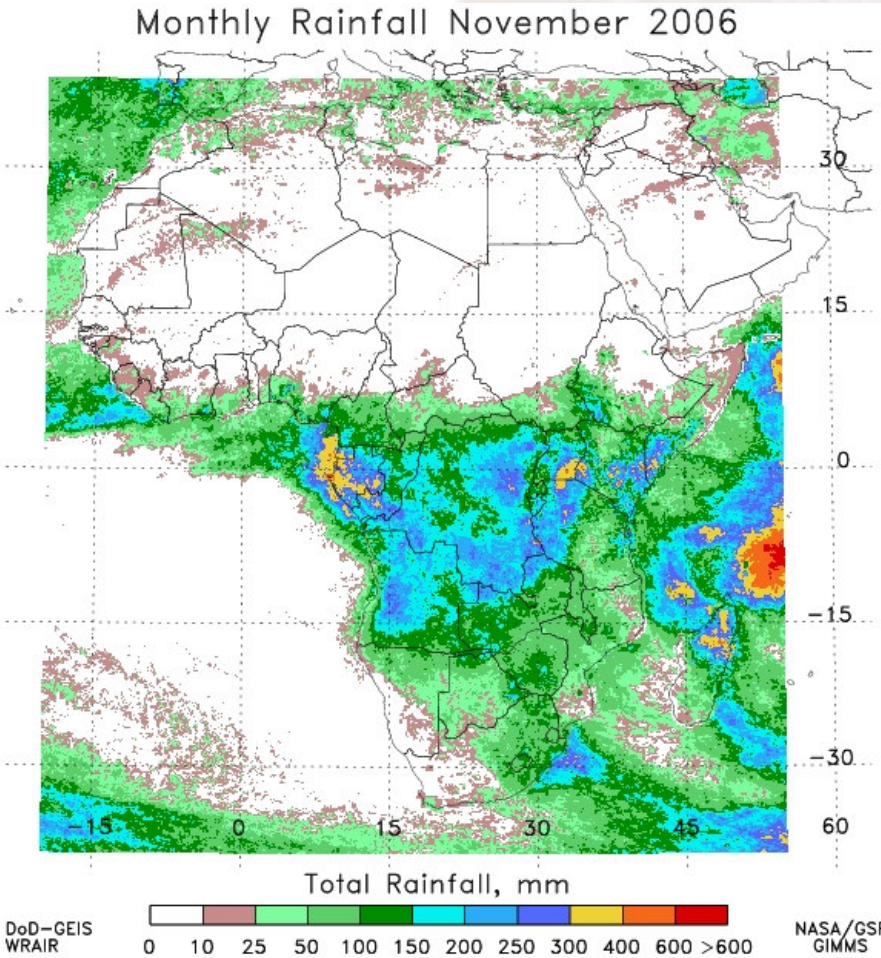
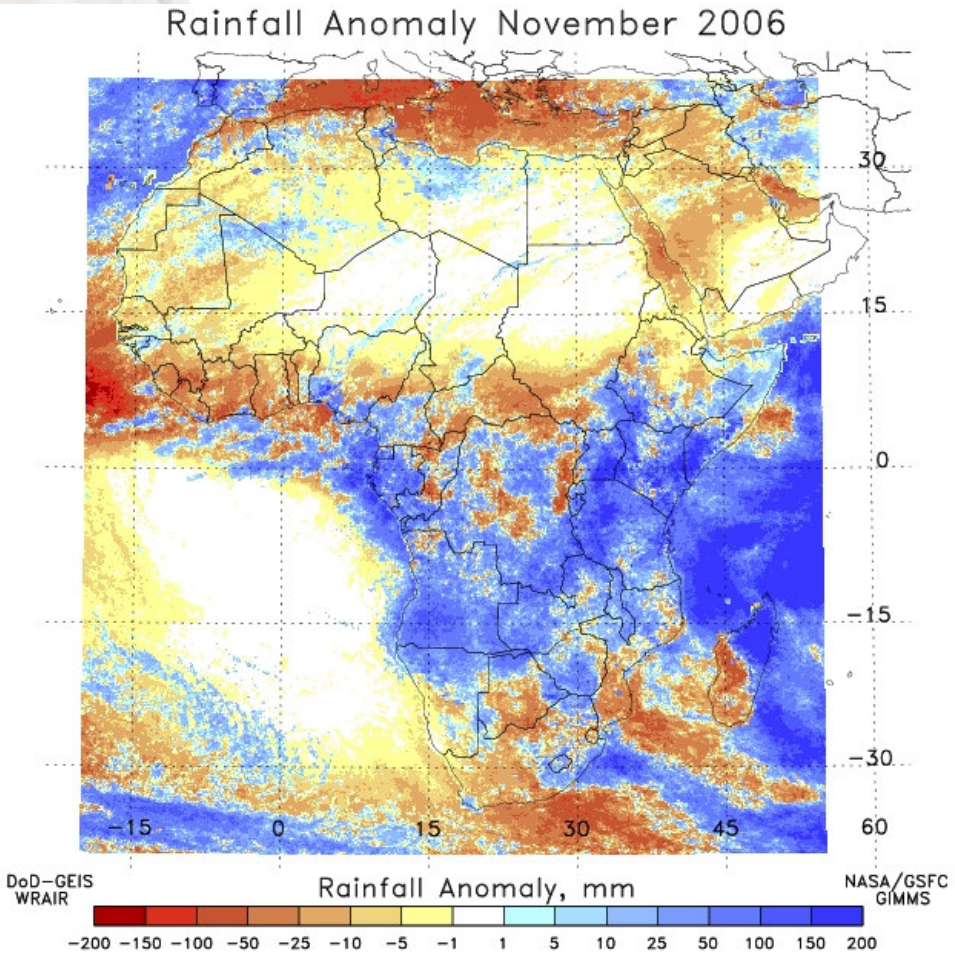
2a. Rainfall – Total + Anomalies





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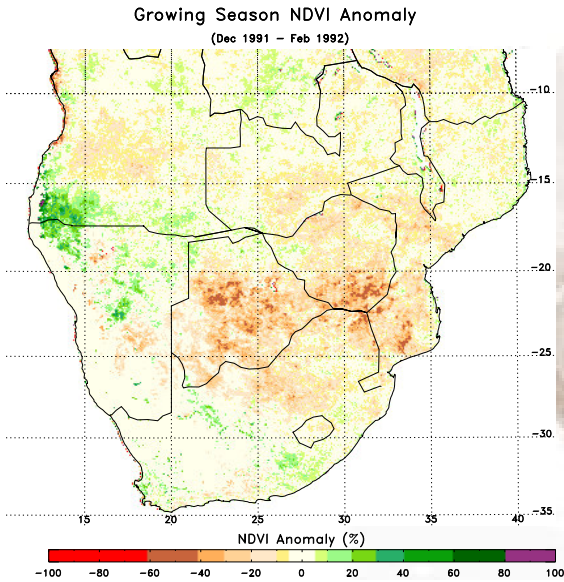
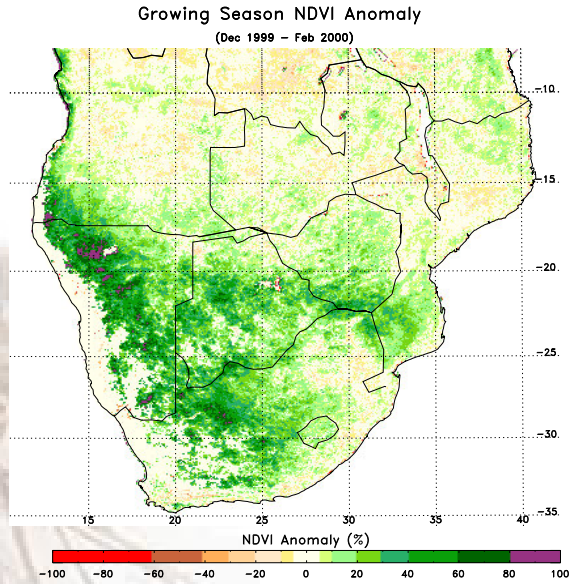
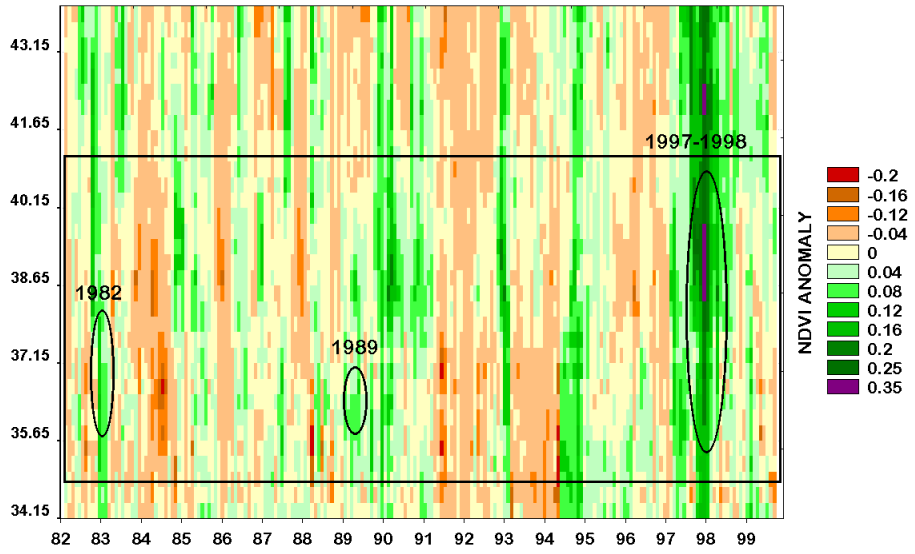
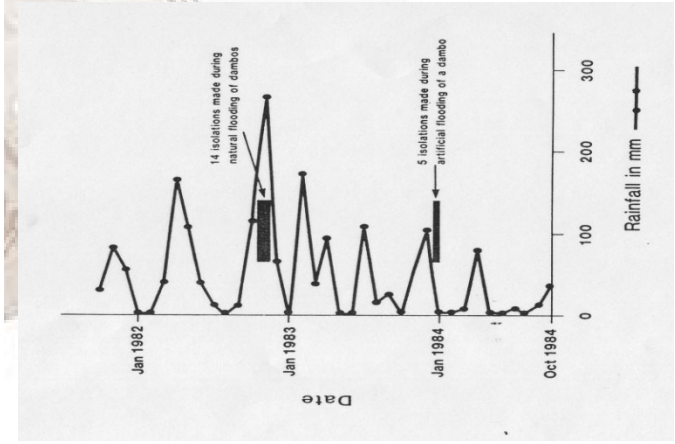
3c. Moisture/Ecological Fluxes = Vector Abundance









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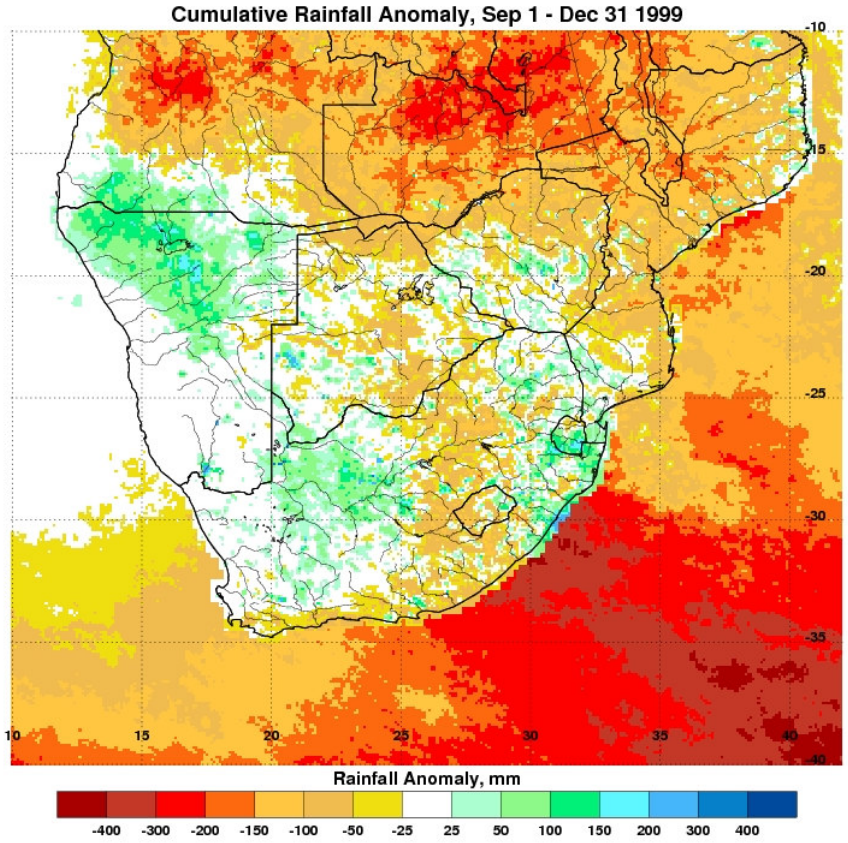
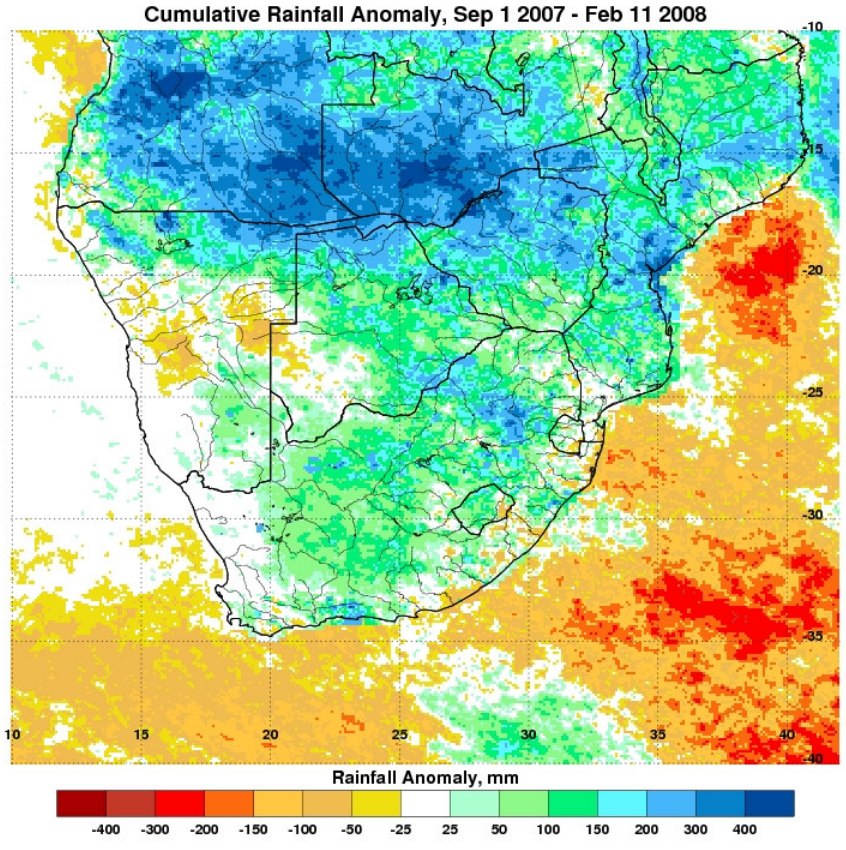
2b. Rainfall -- Cumulative





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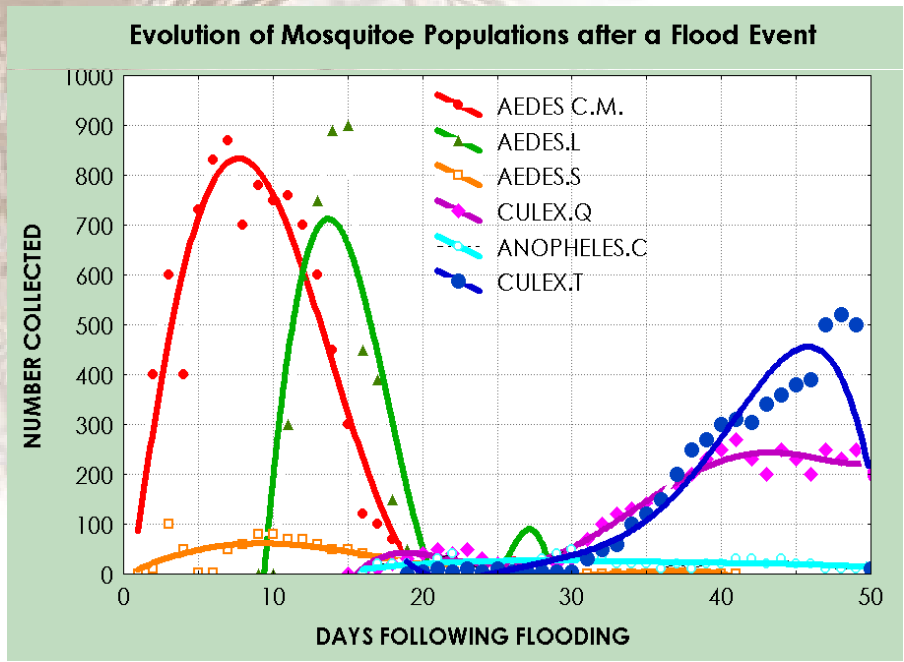
3a. Vector Dynamics and Ecology

- 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



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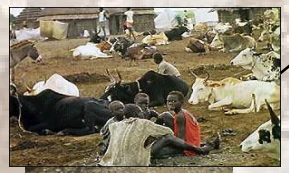
3b. RVF Life Cycle

Climatic factors (heavy and widespread rainfall)

Aedes mcintoshi infected with RVF virus transovarially

Dry Season

Deposit RVF Infected Eggs



RVF Virus introduced into domestic animals and humans, and extensive amplification and secondary transmission

Floodwater *Aedes & Culex* mosquitoes + direct transmission (aerosol, contact)

Rain

Endemic Cycle

Virus persists during dry season/inter-epizootic period through vertical transmission in *Aedes* mosquito eggs

Epidemic Cycle

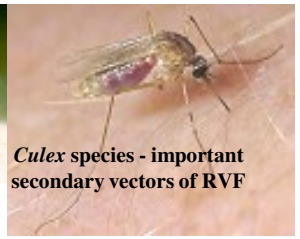
Flooding results in mass hatching of infected *Aedes* eggs and subsequent *Culex* mosquitoes leading to RVF outbreak

RVF virus can be introduced into domestic animals but minimal amplification and secondary transmission

Rainy Season

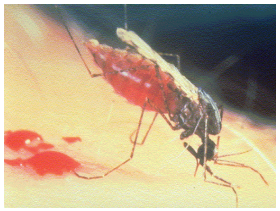
Rain

Only *Aedes* species produced during limited flooding



Culex species - important secondary vectors of RVF

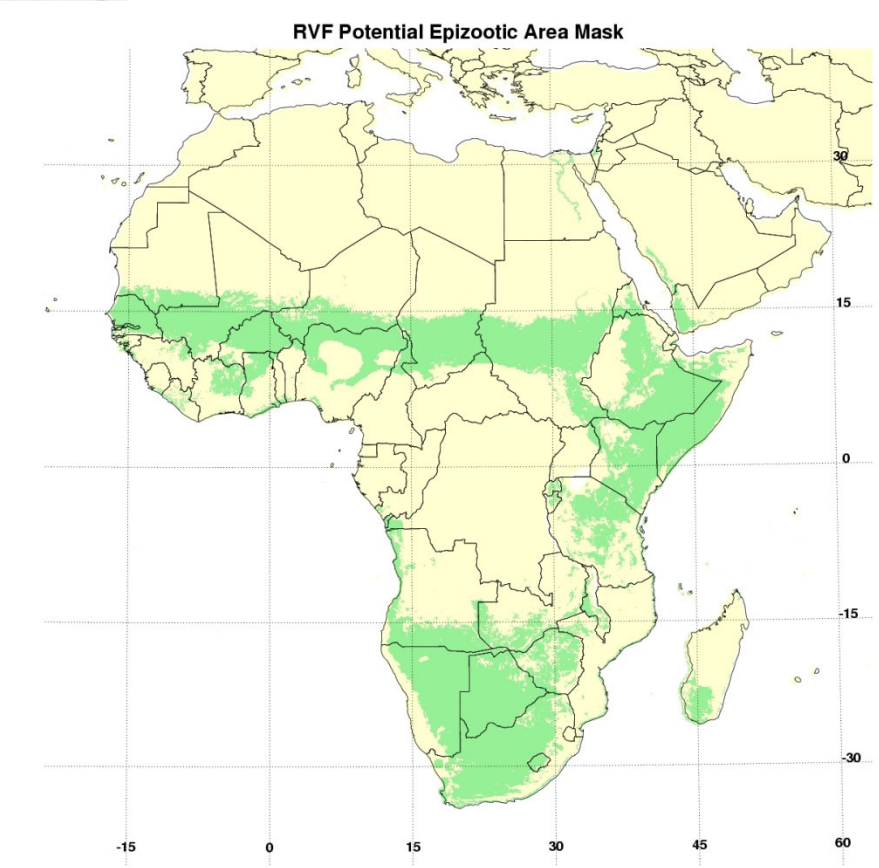
Aedes species followed by *Culex* produced in large numberss



Anopheles mosquitoes not involved RVF transmission

5a. RVF Risk Mapping: Setup

- **RVF – epizootics occur under favorable and persistent eco-climatic conditions**
- **Can be mapped – either as rainfall or vegetation – through NDVI integrates all the required conditions**
- **Algorithm:**
  - Mapping of **potential epizootic areas** – based on literature survey and climate variable thresholding= potential epizootic area mask (PEAM) – (C. J. Peters & K.J. Linthicum in Handbook of Zoonoses)
  - A given pixel is included within the potential epizootic area if and only if it satisfies one of the following rules for Africa and SW Arabia: (1)[(longitude between 25 and 33 E) OR (latitude < than 25 N and longitude > 33 E) OR (latitude < 20 N and longitude < 25 E) AND (mean monthly NDVI between 0.15 and 0.5 NDVI units) AND (mean annual total precipitation between 100 and 850 mm)]; OR (2)[(latitude between 24 and 36 N) AND (longitude between 30 and 35 E) AND (mean monthly NDVI between 0.15 and 0.5 NDVI units)].
  - NDVI anomaly calculation -- + anomalies > 0.025 threshold (desert calibration) over 3 month period
  - Persistently + anomalies must have three month mean > 0.1
  - All “pixels” that meet this criteria and are within the PEAM are mapped to have conditions necessary for the occurrence of RVF activity



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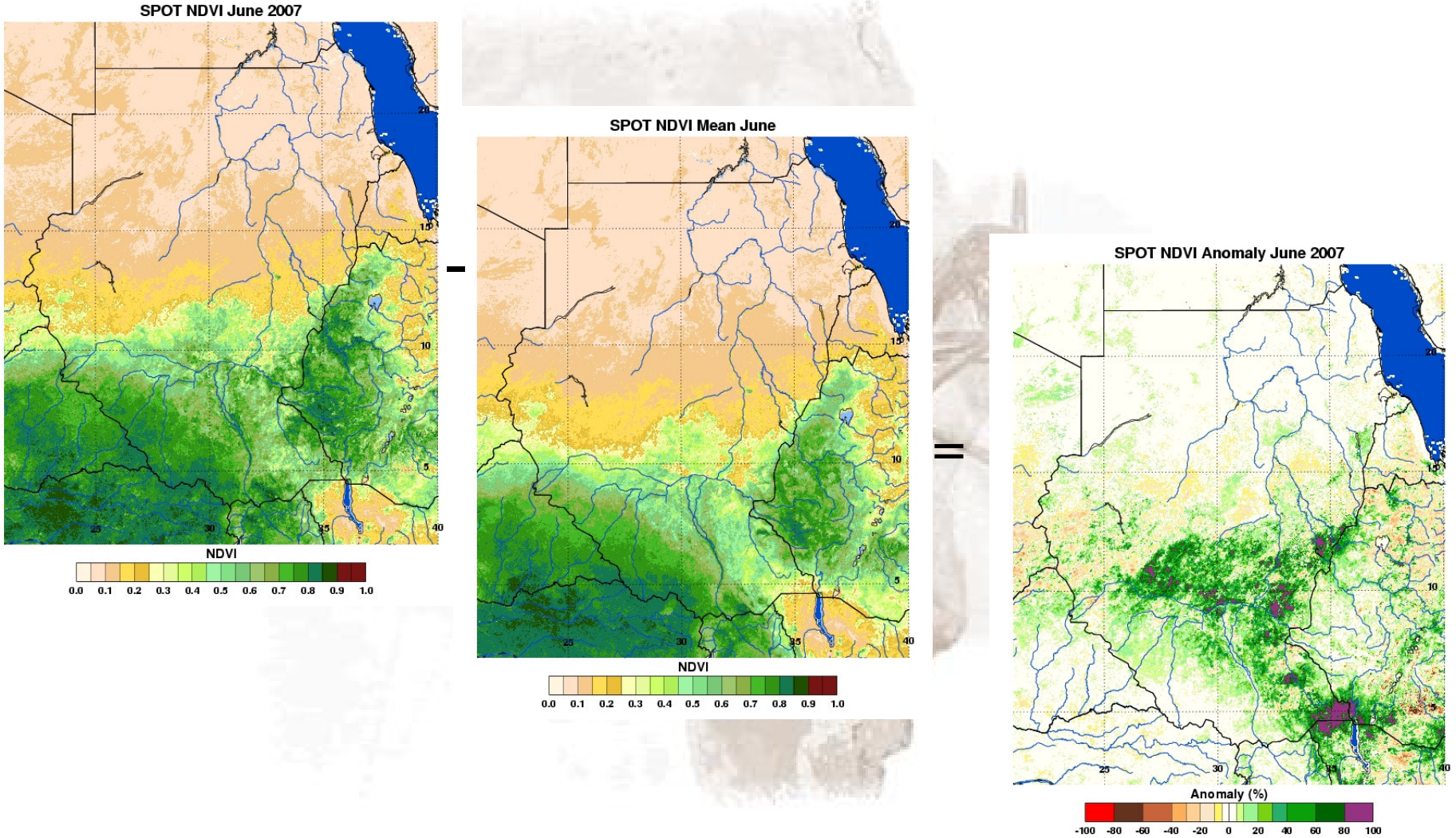
4a. Ecological Indicators: NDVI + anomalies



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