SATELLITE-BASED REAL TIME & EARLY WARNING SYSTEM for MONITORING VECTOR BORNE DISEASES

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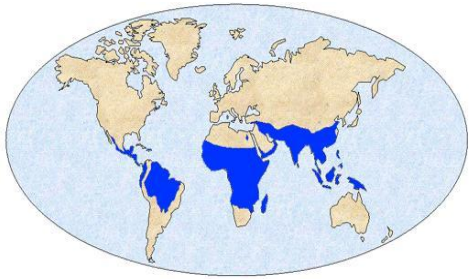
Global Burden of Infectious Diseases Caused by Arthropod Vector

Global Burden of Infectious Diseases Caused by Anthropod Vector

Diseases	Disease Burden (% from total)	Mortality (% from total)
Malaria	**78**	**89**
African trypanosomiasis	**3**	**3**
Lymphatic filariasis	**10**	**0**
Dengue fever	**1**	**2**
Leishmamiasis	**5**	**5**
Chaga disease	**1**	**1**
Onchocerciasis	**2**	**0**

Based on Disability Adjusted Life Years (DAILY) – the number of healthy years of life lost due to premature death and disability (World Health Organization 2002, The World Health Report, Geneva).

Malaria Facts: **WORLD**


Malaria Geographic Distribution

- **109 world countries are affected by malaria**
- **3.2 billion people (48% of the world's population) are at risk**
- **350–500 million clinical malaria cases occur annually**
- **1.5-3 million people die from malaria annually (account 4-5% of global fatalities)**
- **Children & Pregnant women vulnerable**

  One million children dies annually

- **Areas: Africa, Asia, Latin America, the Middle East & part of Europe**

IMPORTANT GOALS

- Early detection of environmental conditions conducive for mosquito development & spread of malaria
- Monitoring Malaria Start/End, Area, Intensity & Impacts

MALARIA & NVIRONMENT

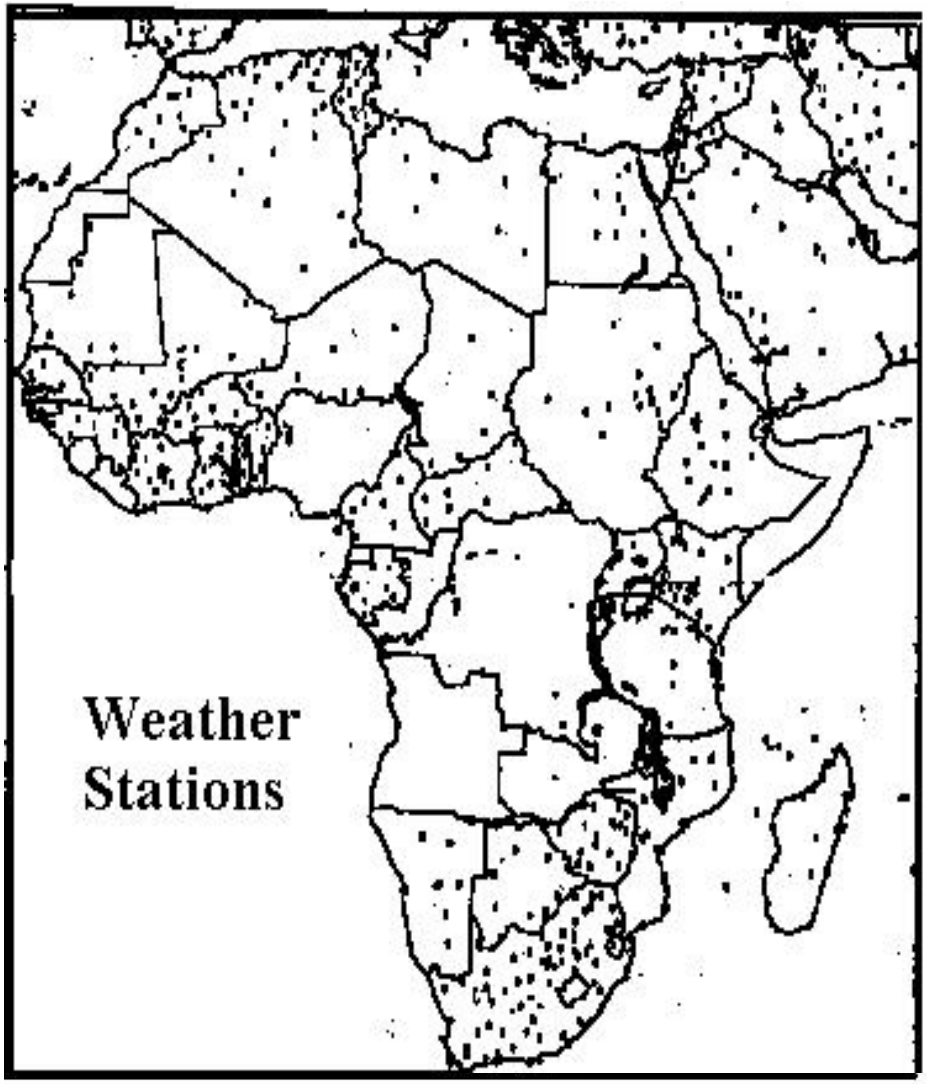
- **CLIMATE & LANDSCAPE determine**
  distribution of mosquito-borne diseases
- **WEATHER affects**
  timing, duration, and intensity of outbreaks
- **WARM & WET surface stimulates**
  mosquito's activities to carrying the disease to people

AFRICA: GTS (WMO-based) weather station network

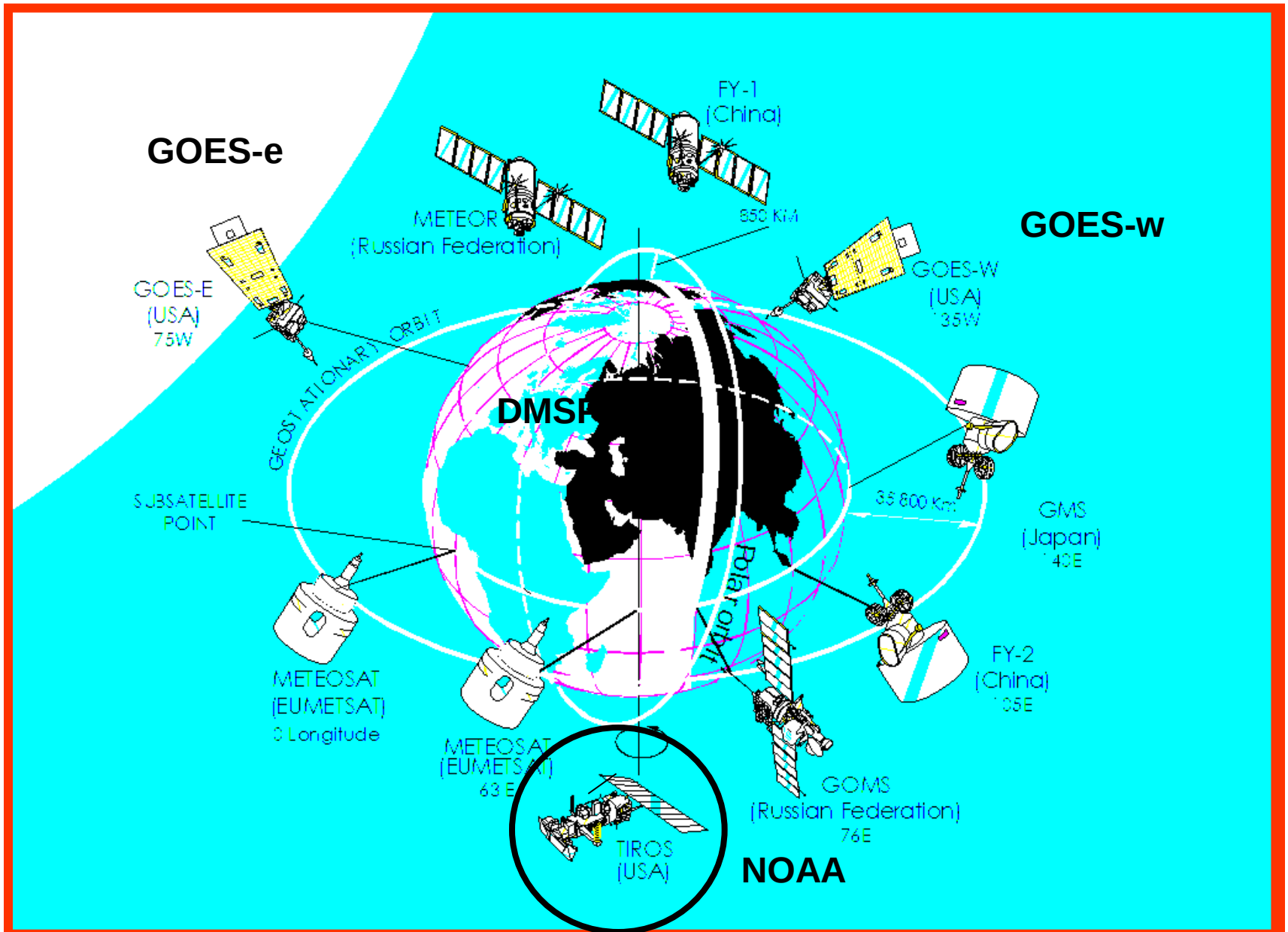
On the average

One weather station
Covers
23,000 sq. km

NOAA satellites
cover
16 sq. km



The Space Based Global Observing System, 2000
A Combination of Geostationary and Polar Orbiting Satellites



Can satellite data identify WARM & WET surfaces?

WARM & WET surface stimulates
mosquito's activities to carrying the disease to people

Vegetation Health Indices (VH)

- **VH are proxy providing cumulative estimation of vegetation condition (health) from AVHRR surface reflectance in VIS, NIR & IR wavelengths**

- **VH characterize land surface Temperature (IR) and Moisture from vegetation greenness & vigor (VIS & NIR)**

- **VH is represented by**

Vegetation Condition Index (VCI) - MOISTURE VCI=(ND-NDmin) /(NDmax-NDmin)
Temperature Condition Index (TCI) - TEMPERATURE TCI=(Btmax-BT) /(Btmax-Btmin)
Vegetation Health Index (VHI) - HEALTH VHI=a*VCI+(1-a)*TCI

AVHRR-derived Vegetation Health

A combination of Temperature and Moisture Characteristics

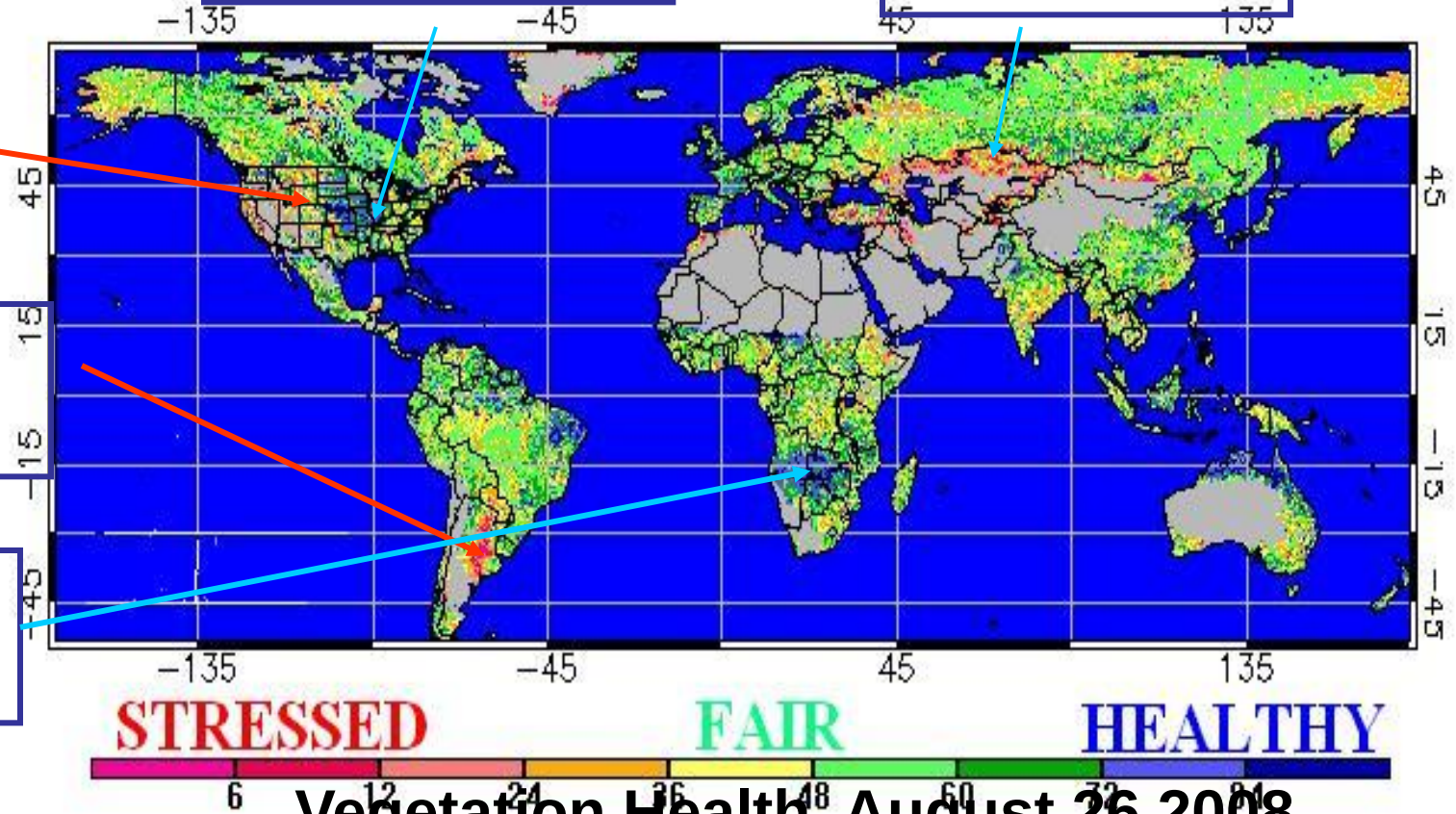
Central USA
Healthy vegetation
Impact: ***Good crops***

Kazakhstan
Vegetation stress
Impact: ***Bad crops***

Western USA
Vegetation stress
Impact: ***Fire***

Argentina
Vegetation Stress
Impact: ***Drought***

Southern Africa
Healthy Vegetation
Impact: ***Malaria***



Vegetation Health, August 26 2008

Significance: Vegetation Health estimates vegetation condition – a proxy for drought, crop & pasture production, fire, malaria; http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH

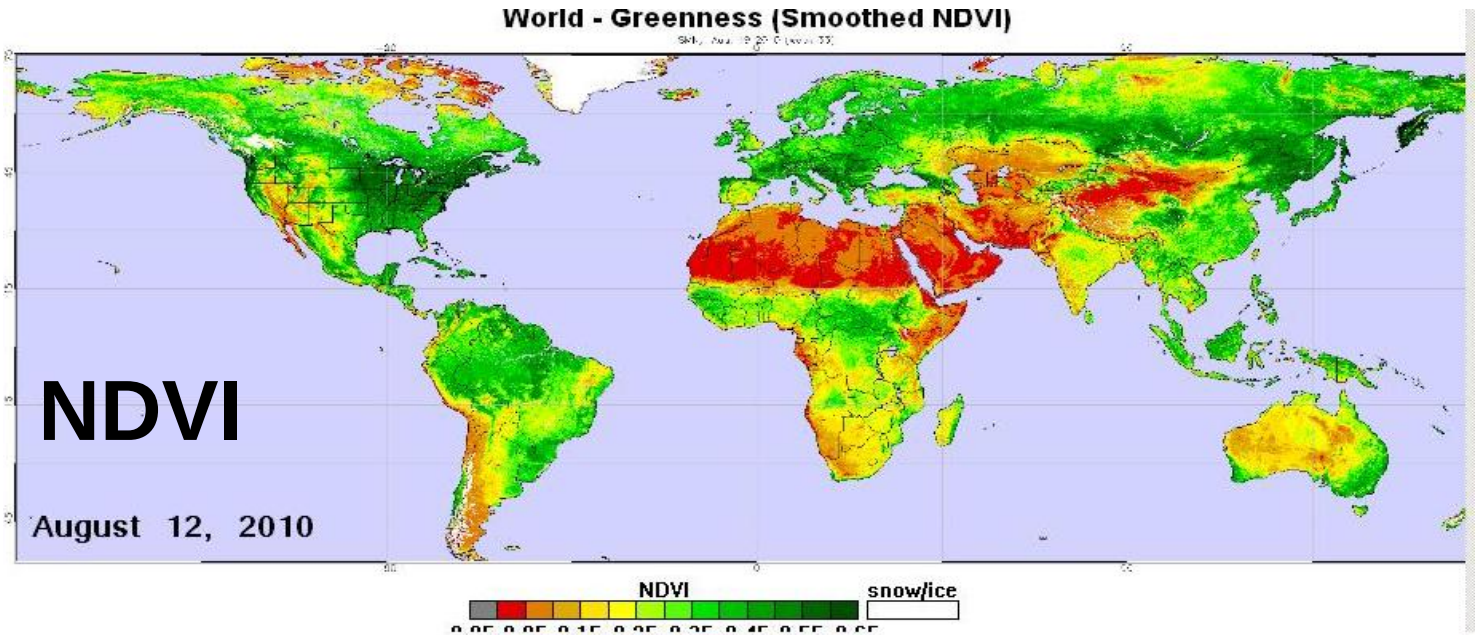
Project Lead: Felix Kogan

Sponsor: NOAA/NESDIS

NDVI & Vegetation Health (VH)

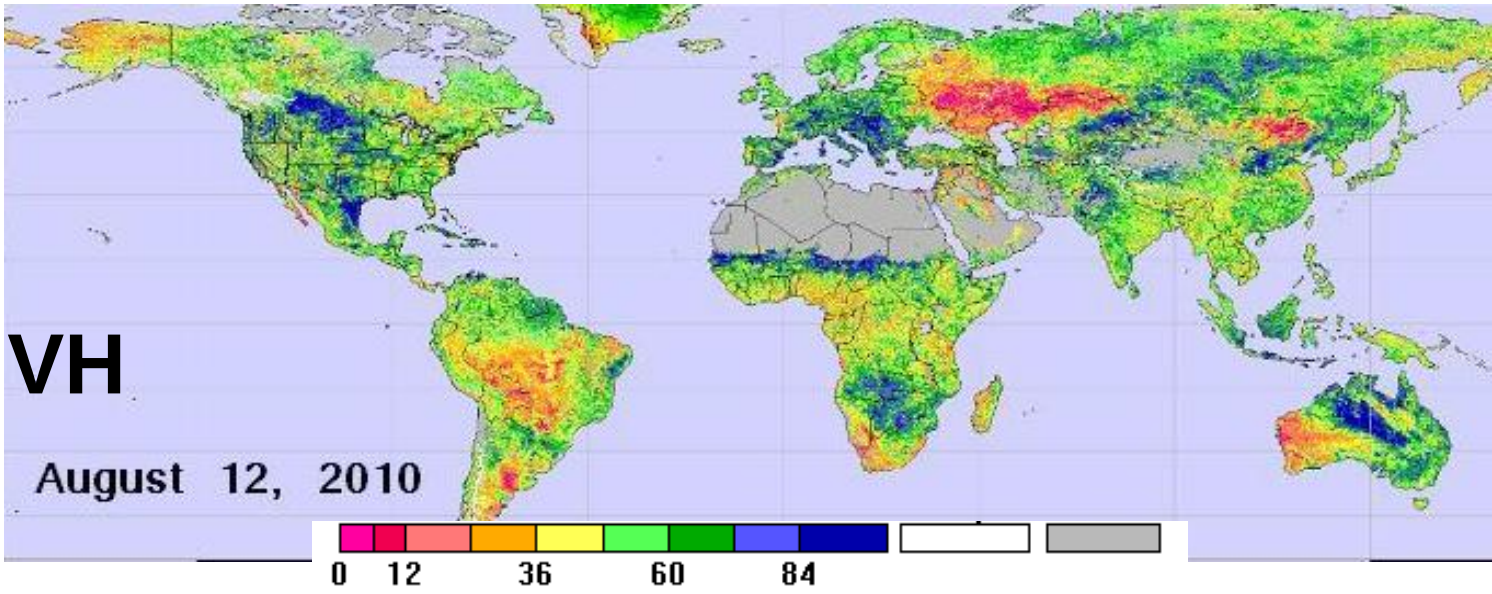
NDVI represents

-Ecosystems
-Weather



VH represents

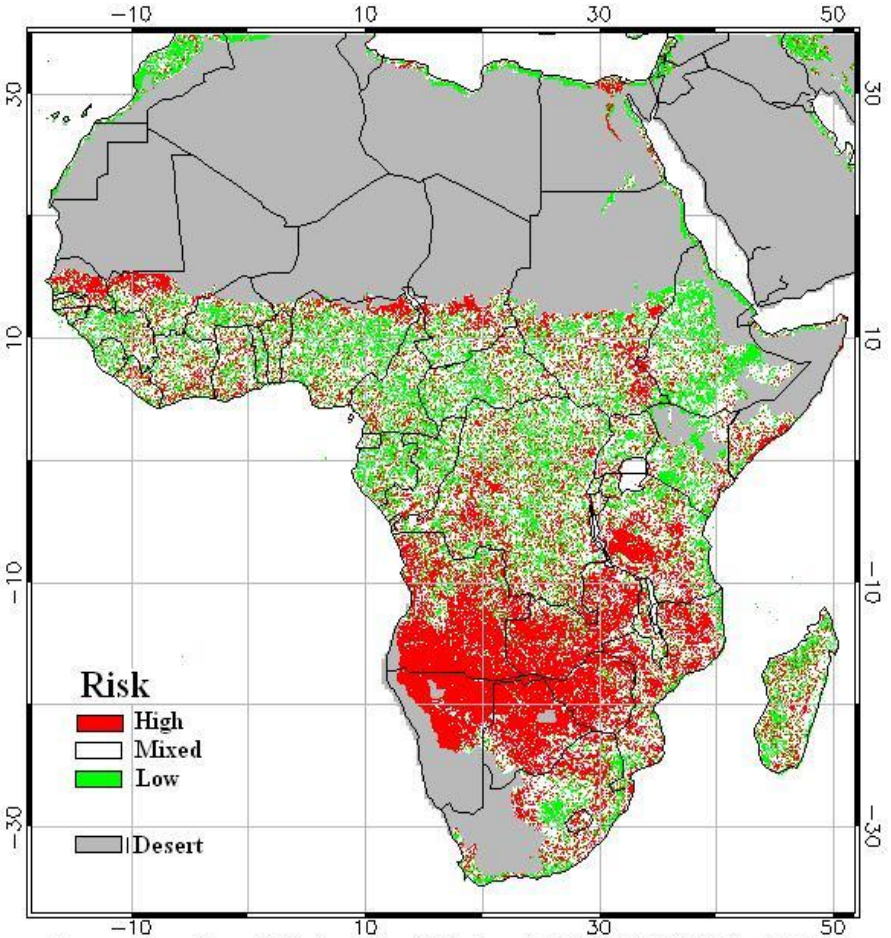
-Weather



Malaria RISK AREA

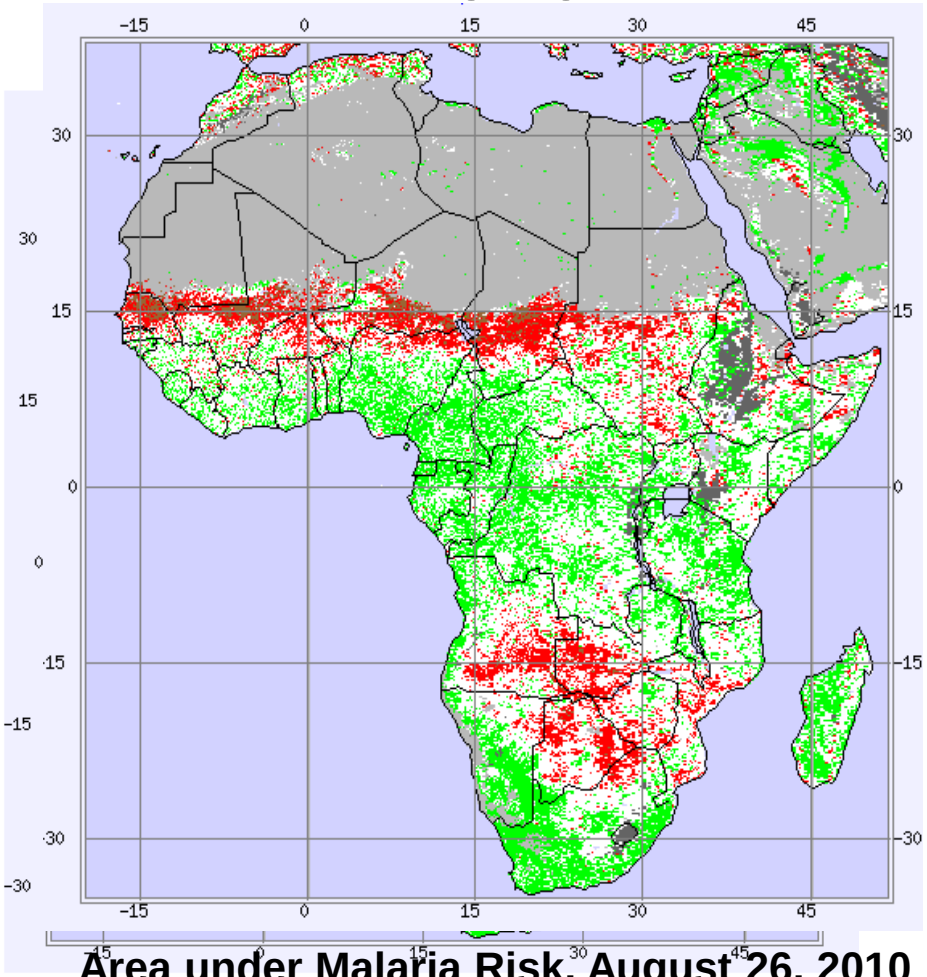
AUGUST 26

2008



Area under Malaria Risk, AUGUST 26, 2008

2010

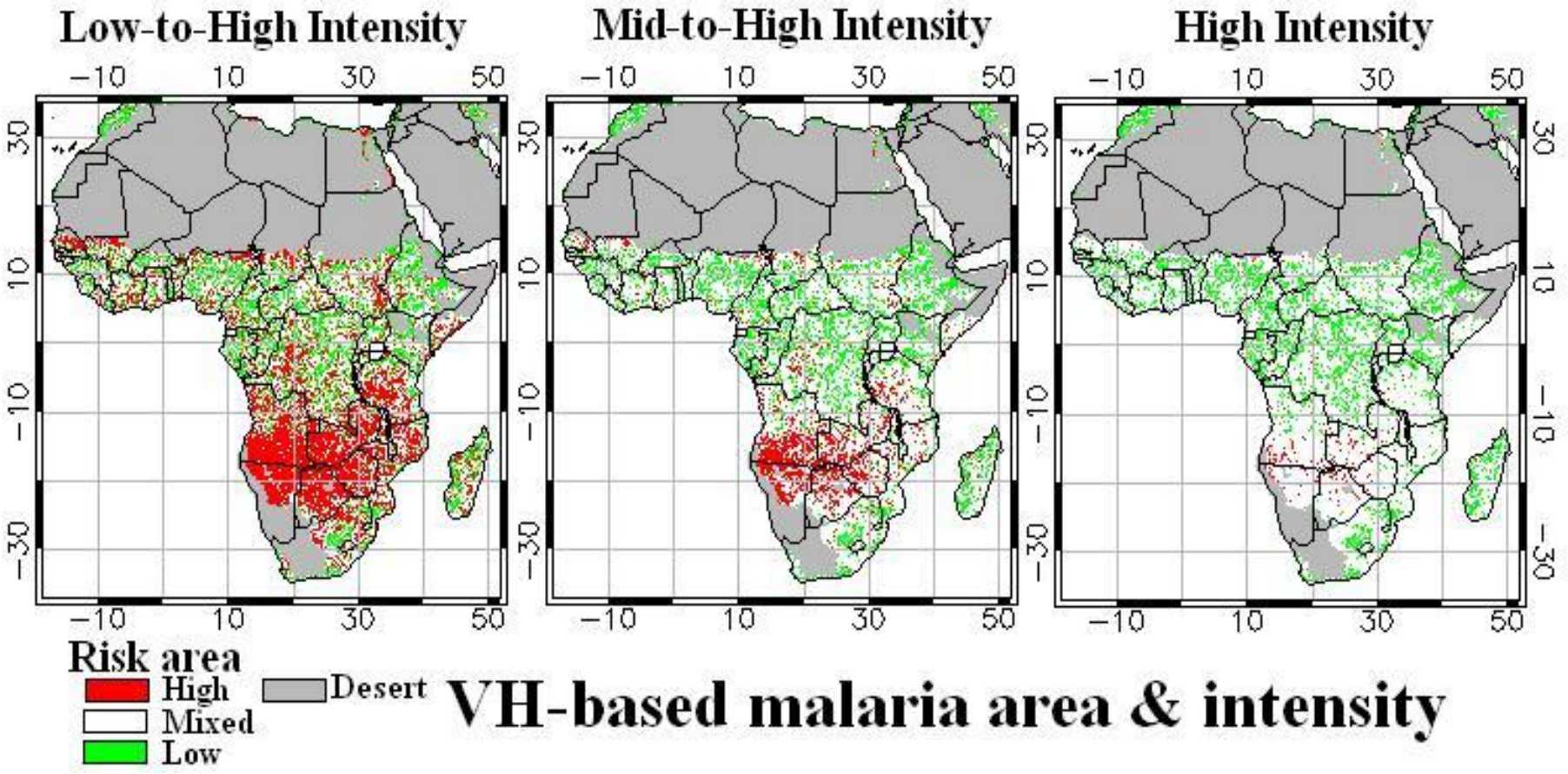


Area under Malaria Risk, August 26, 2010

Malaria risk maps identify priority areas to fight epidemics based on AVHRR-estimated weather condition

Malaria Risk AREA & INTENSITY

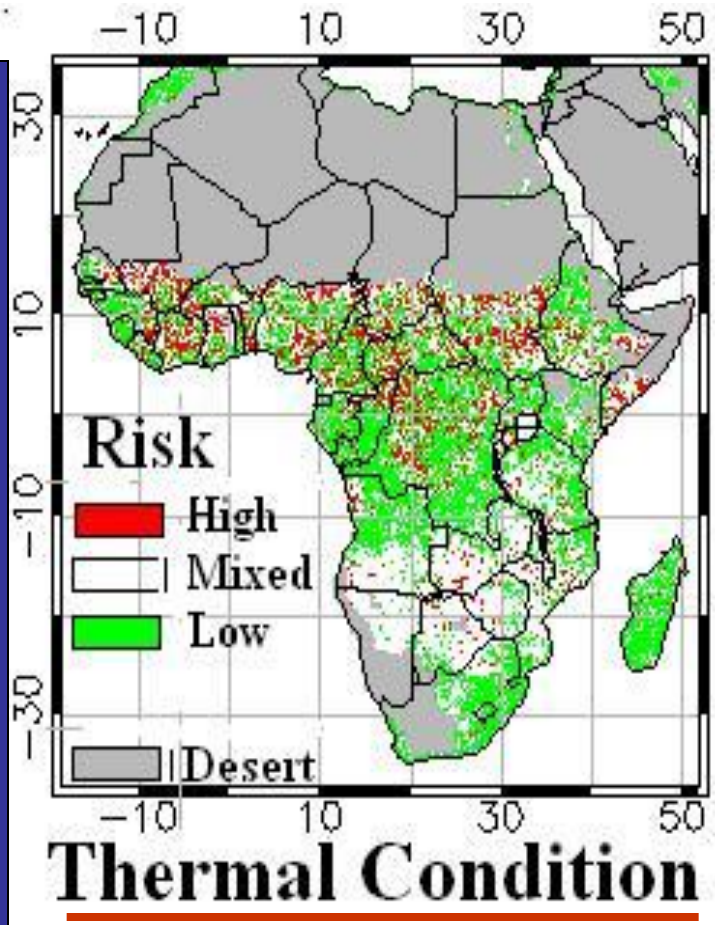
AUGUST 26, 2008



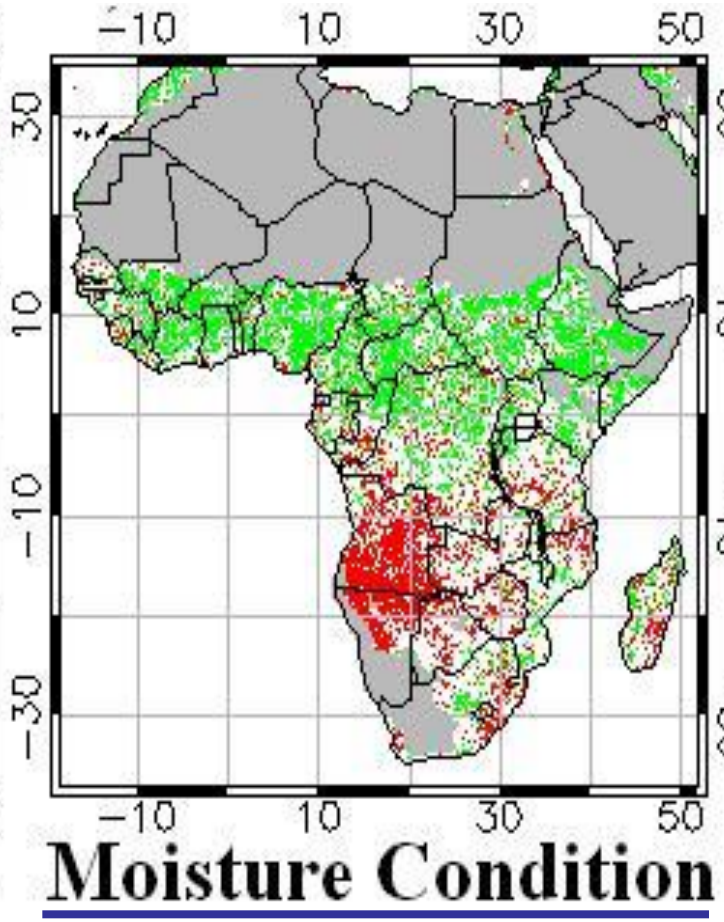
Malaria risk map identify priority areas & additional resource needed to fight epidemics effectively

WEATHER CONDITIONS Triggering INTENSIVE Malaria AUGUST 26, 2008

Malaria risk map identify priority areas and additional resource needed to fight epidemics effectively



Thermal Condition

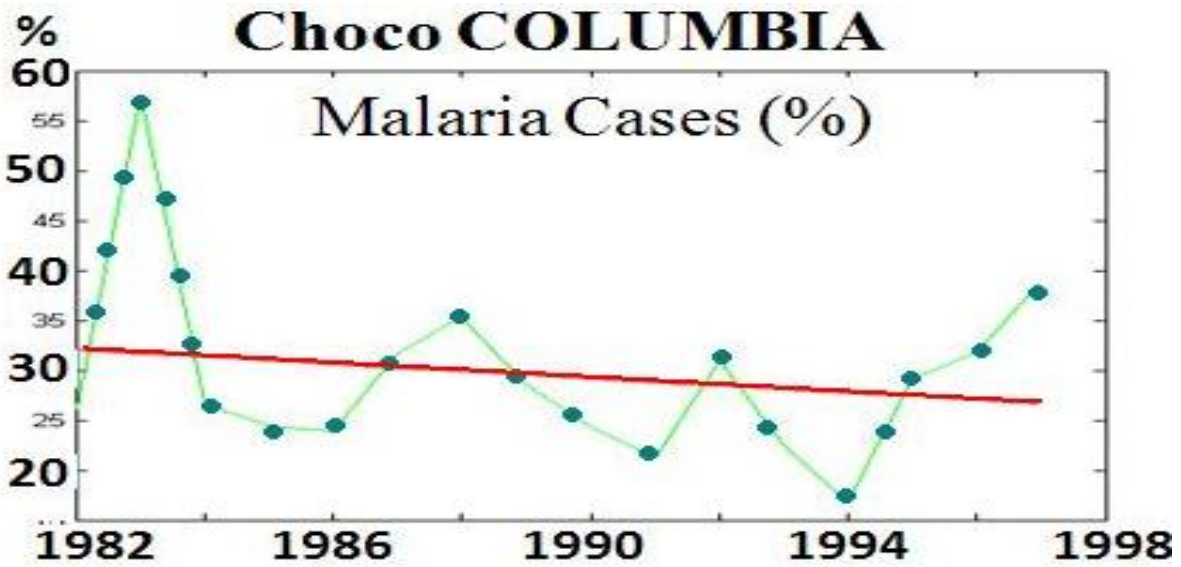


Moisture Condition

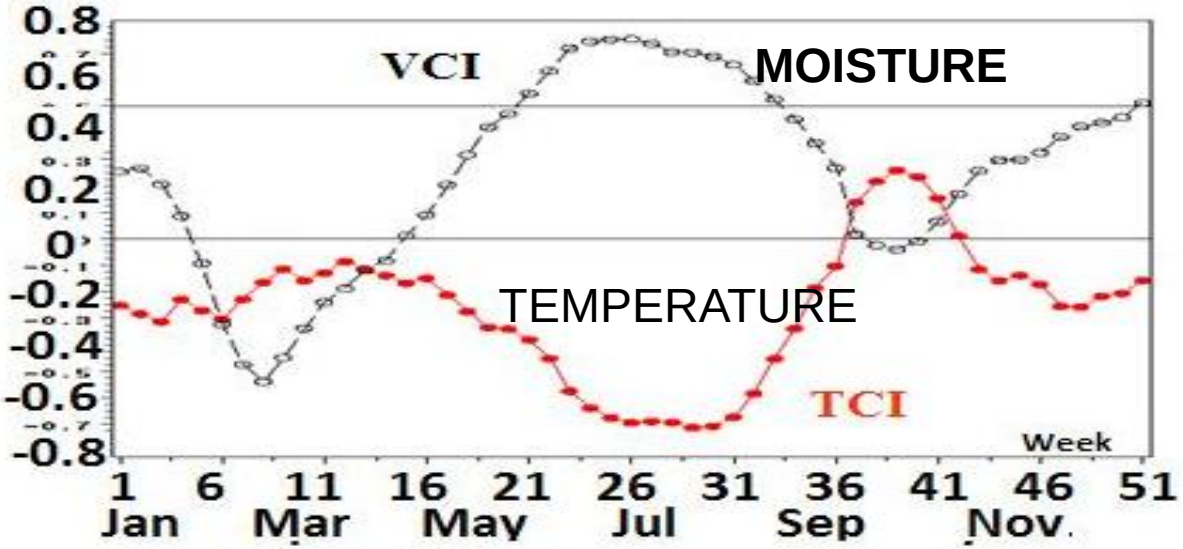
INTENSIVE MALARIA

S. AMERICA: Modeling malaria incidents vs VCI & TCI

Malaria cases (MC) - % from total number of tested people per year
MC deviation from trend (DY) per year



Correlation of annual DY with VCI and TCI

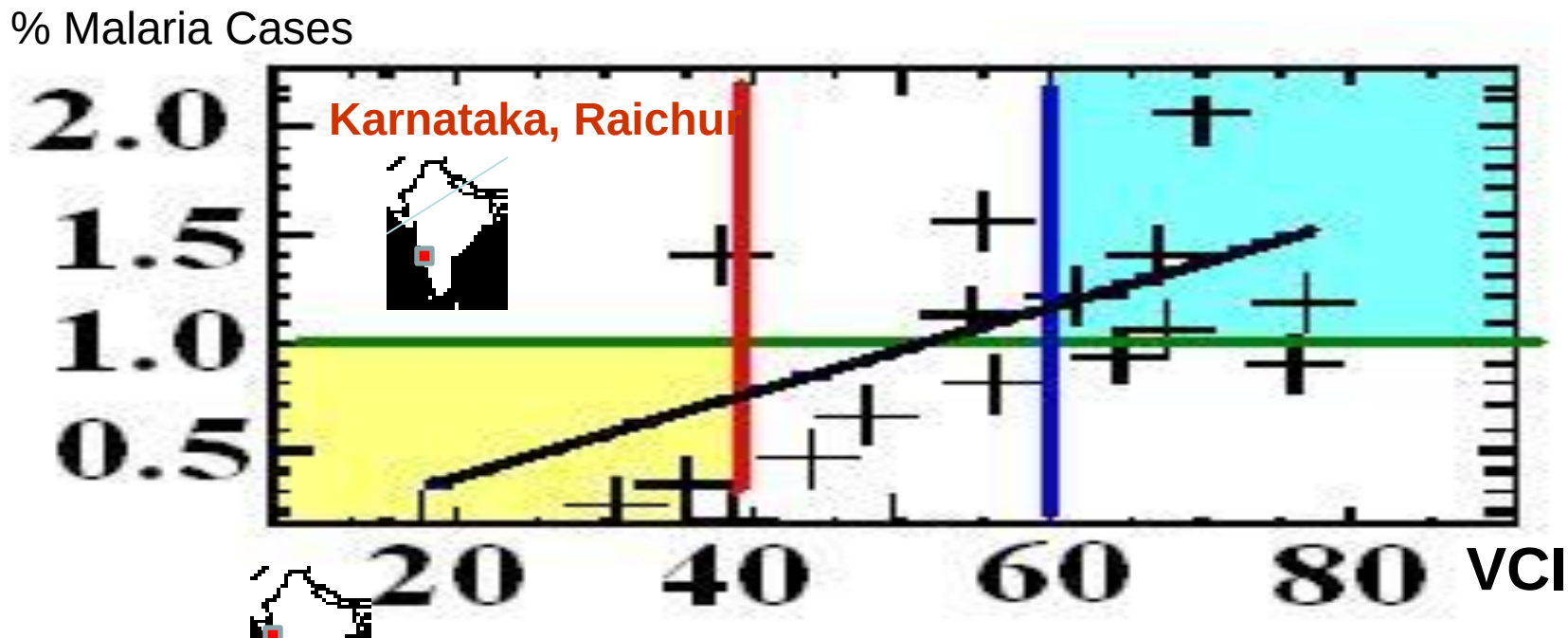


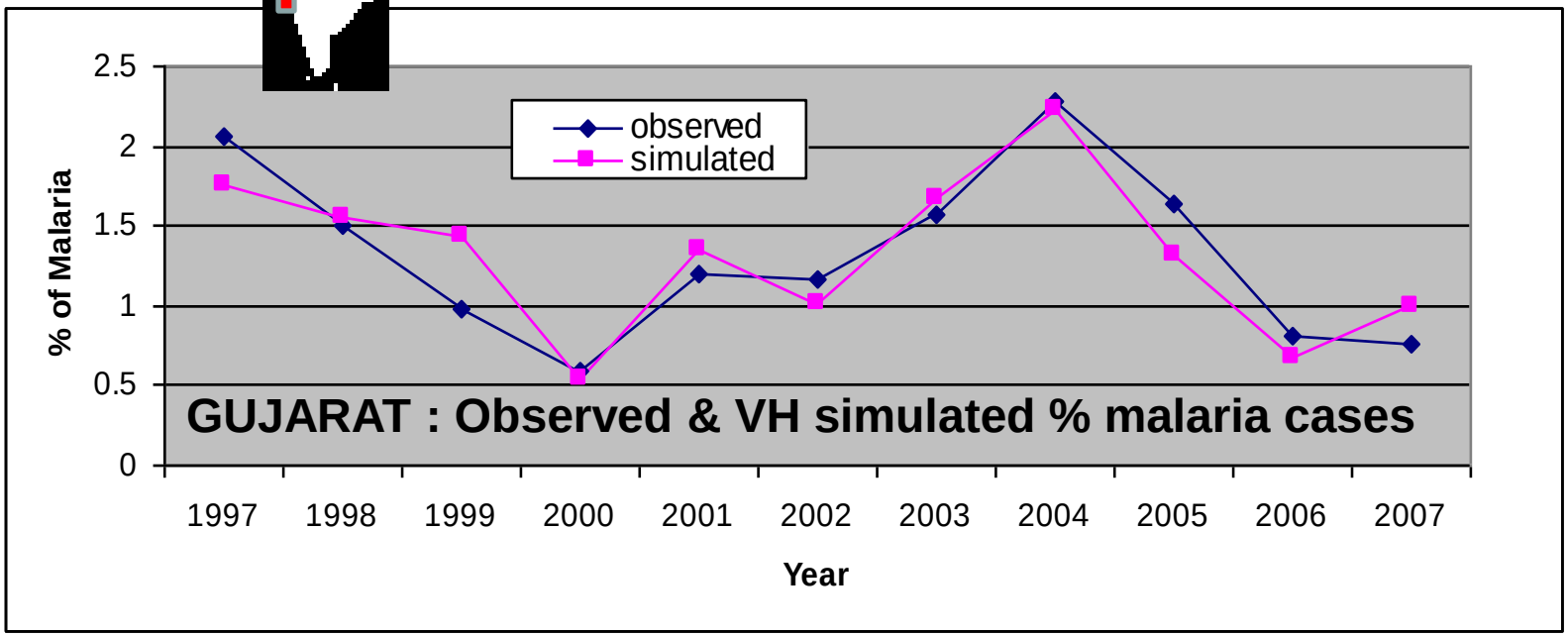
Correlation of % malaria cases (deviation from trend) with weekly VCI and TCI

More cases – Hot & Moist

Less Cases – Cool & Dry

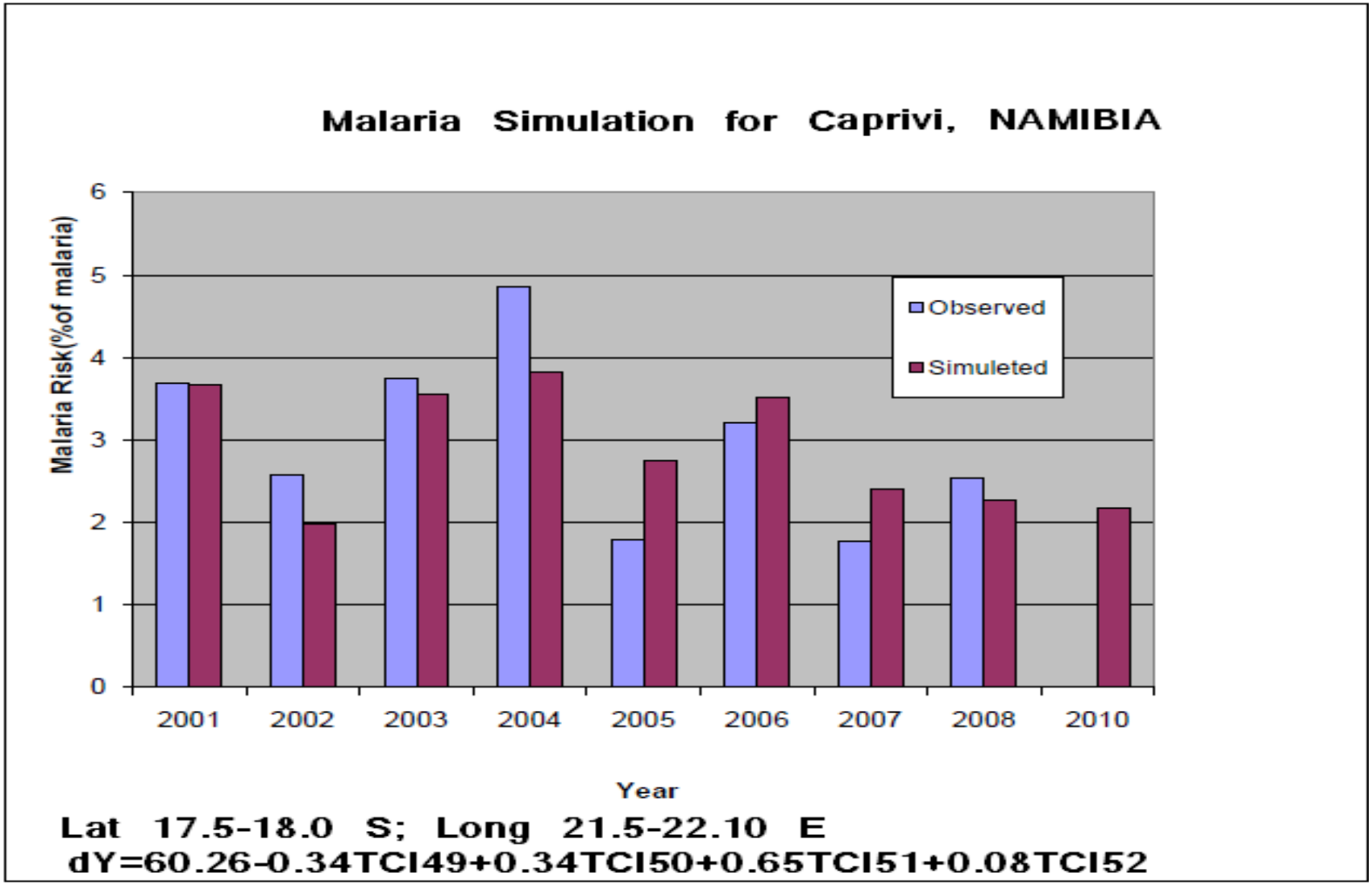
ASIA: Malaria Cases (%) vs. VH, INDIA





AFRICA: Malaria observed and simulated (%) from VH (TCI) data in Caprivi NAMIBIA

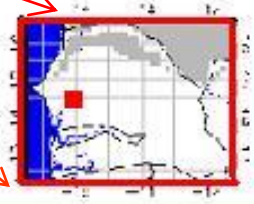
CAPRIVI



AFRICA: VH & Malaria in DRY CLIMATE

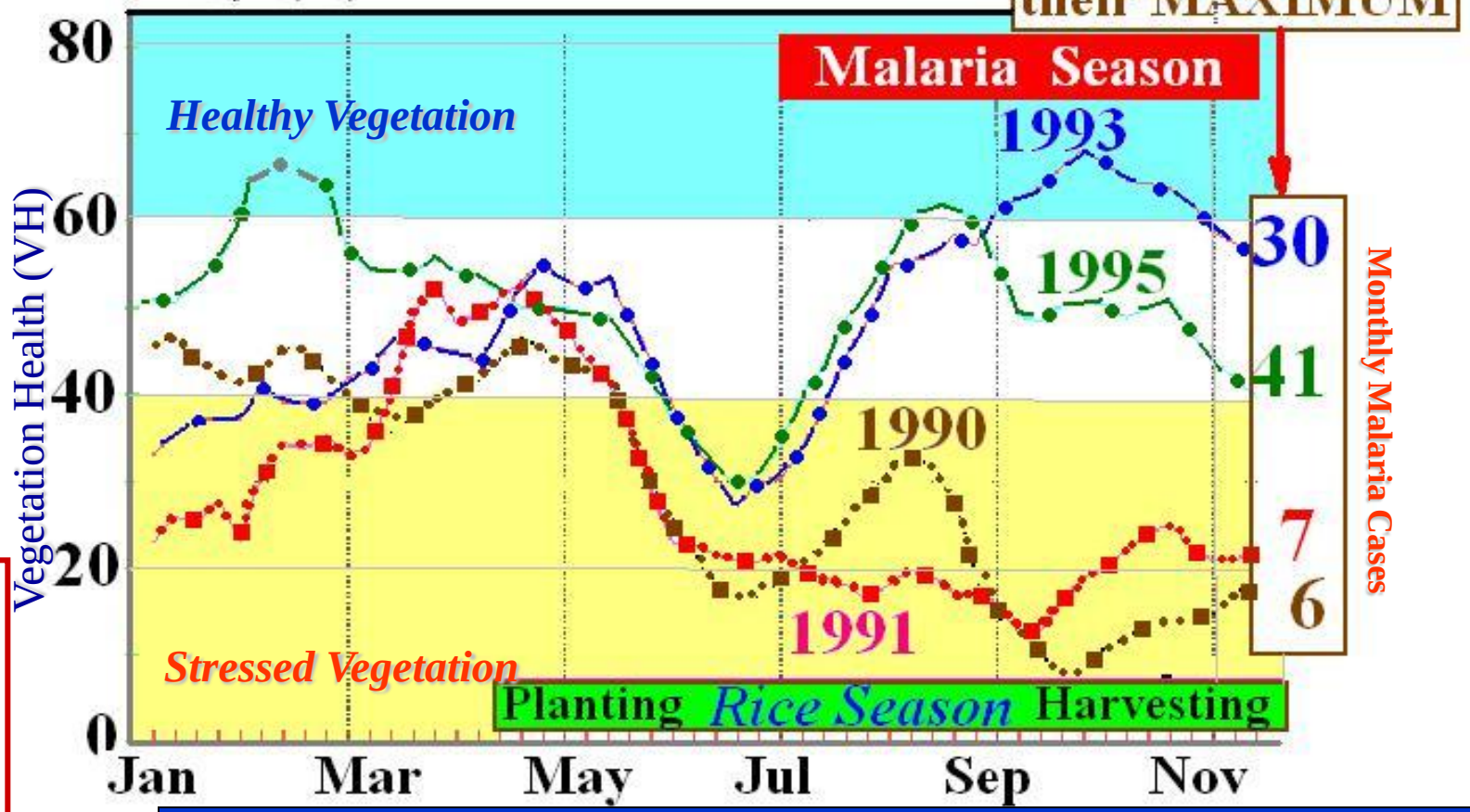
SENEGAL

1990, 1991, 1993, 1995



Healthy Vegetation
(1993, 1995)
4-5 times more malaria cases then stressed vegetation

NO Malaria if dry condition in semi-arid climate



Climate controls selection of VH strategy

AFRICA: VH-Malaria Risk Area, 2002-2003
Endemic Area – TANZANIA, RWANDA

TANZANIA

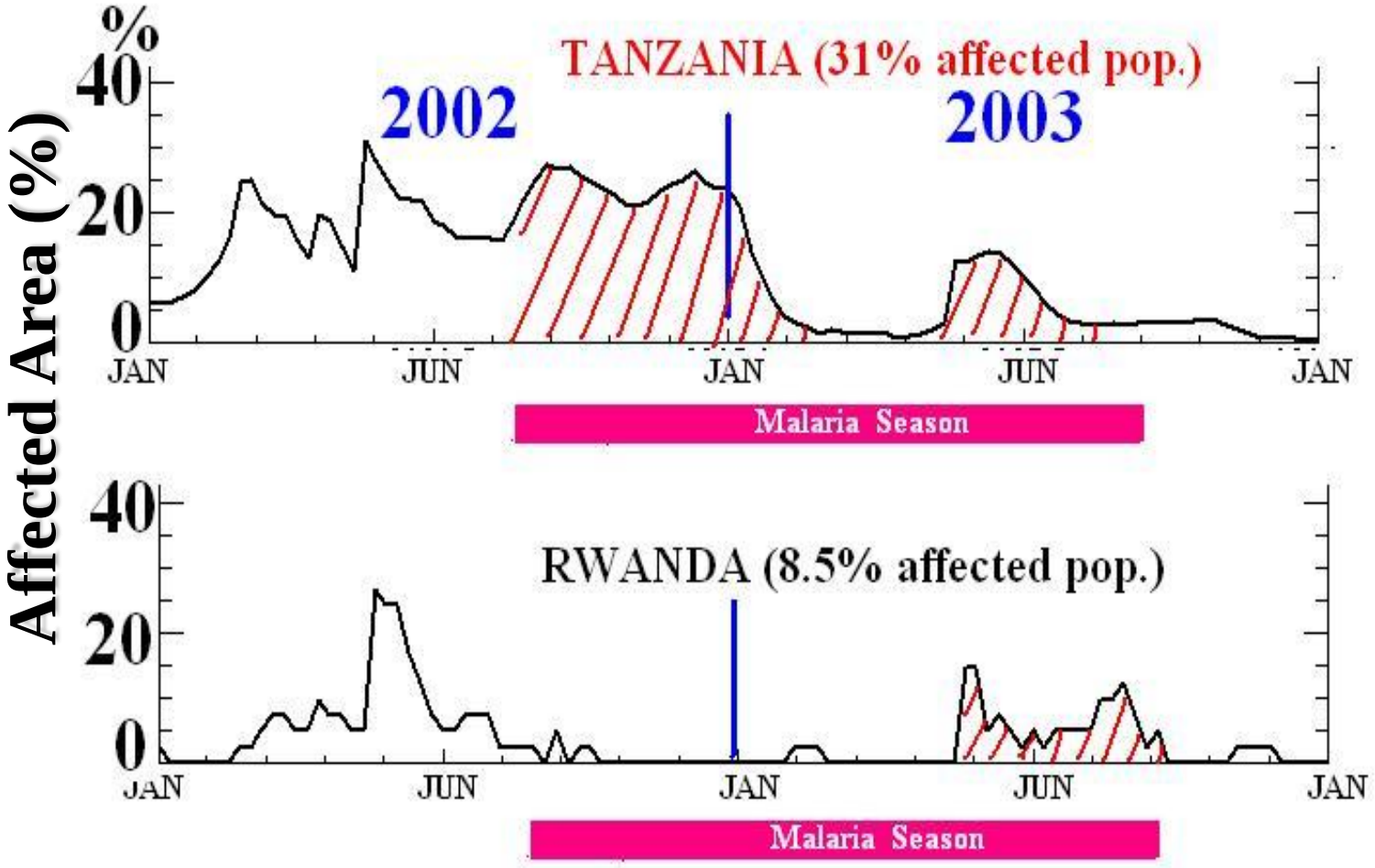
-25-30% malaria risk area, Sep-Jan

- April-June provided 3-4 months advance malaria indication

RWANDA

-<5% malaria risk area, Sep-May

- Pre-season malaria risk area was low indicating no malaria risk



*** VH provides malaria risk area for an entire country**

*** Pre-season VH forecasts malaria epidemics**

NOAA Capabilities (Examples)

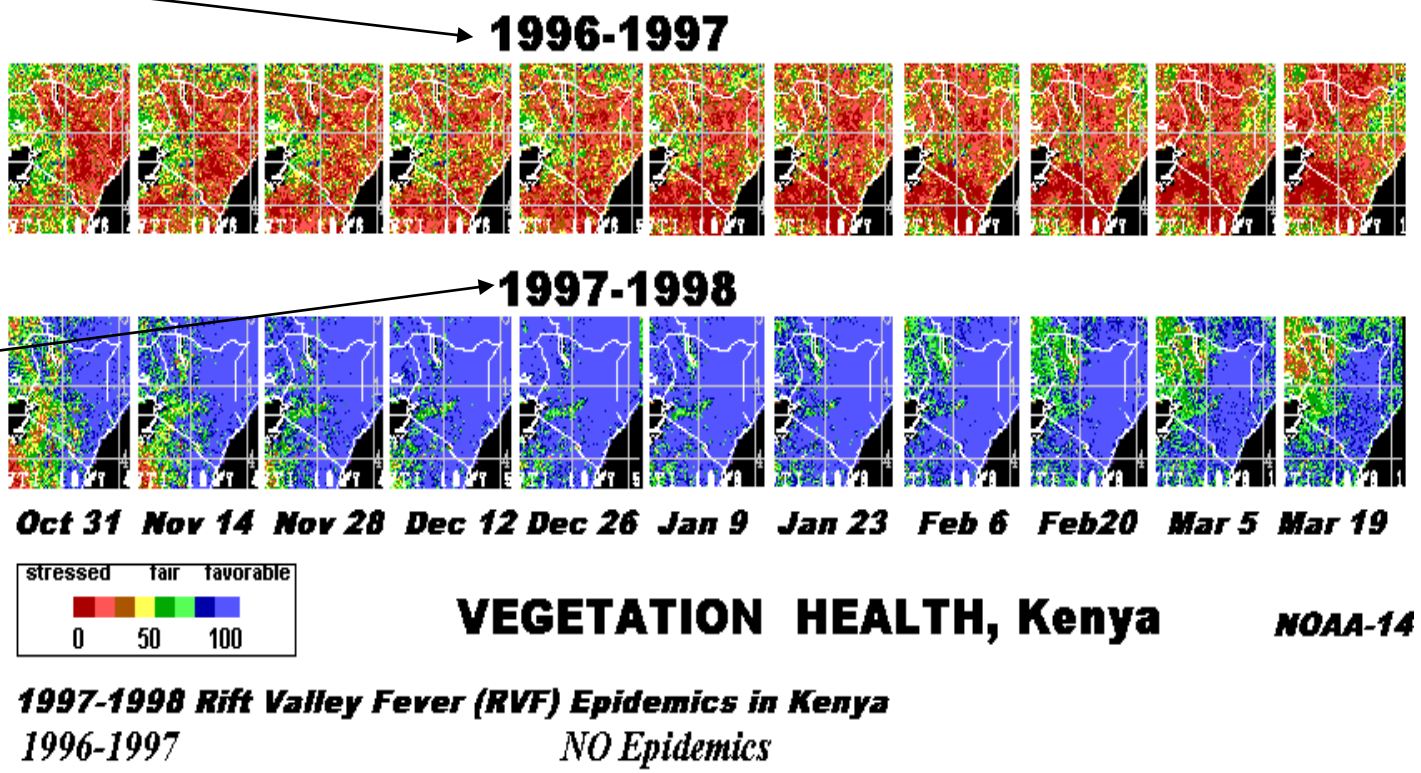
KENYA: RVF (Rift Valley Fever) & Vegetation Health (VH)

1996-97

VH<20 - Severe DROUGHT – NO RVF epidemics

1997-98

VH>80 - FAVORABLE condition – Intensive RVF epidemics

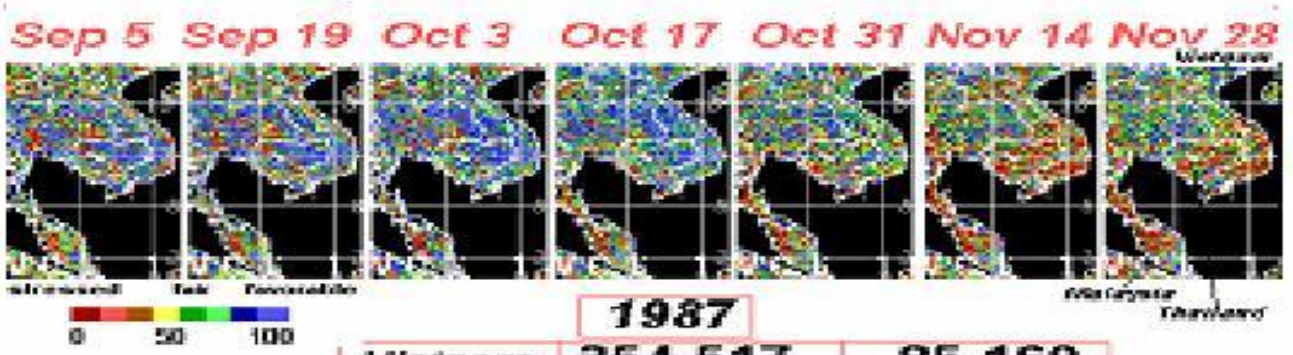


NOAA has capability to identify & monitor other mosquito-born diseases

1987 & 1988 **Dengue Fever** & VH

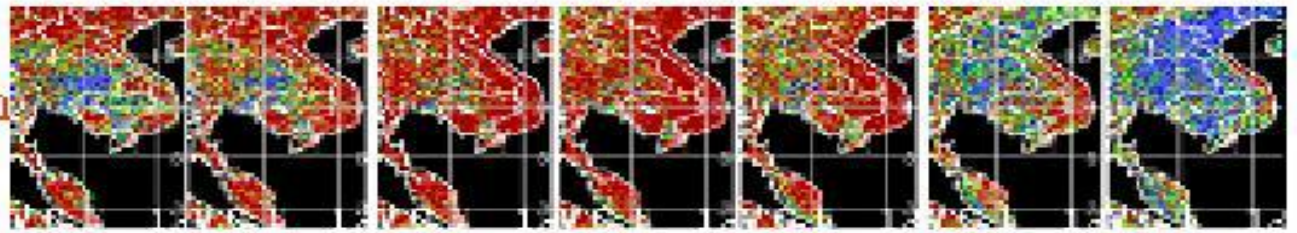
Vietnam, Thailand, Malaysia

Vegetation Health and Dengue Fever Disease



NUMBER of CASES

	1987	1988
Vietnam	354,517	85,160
Thailand	174,265	26,926
Malaysia	304	233



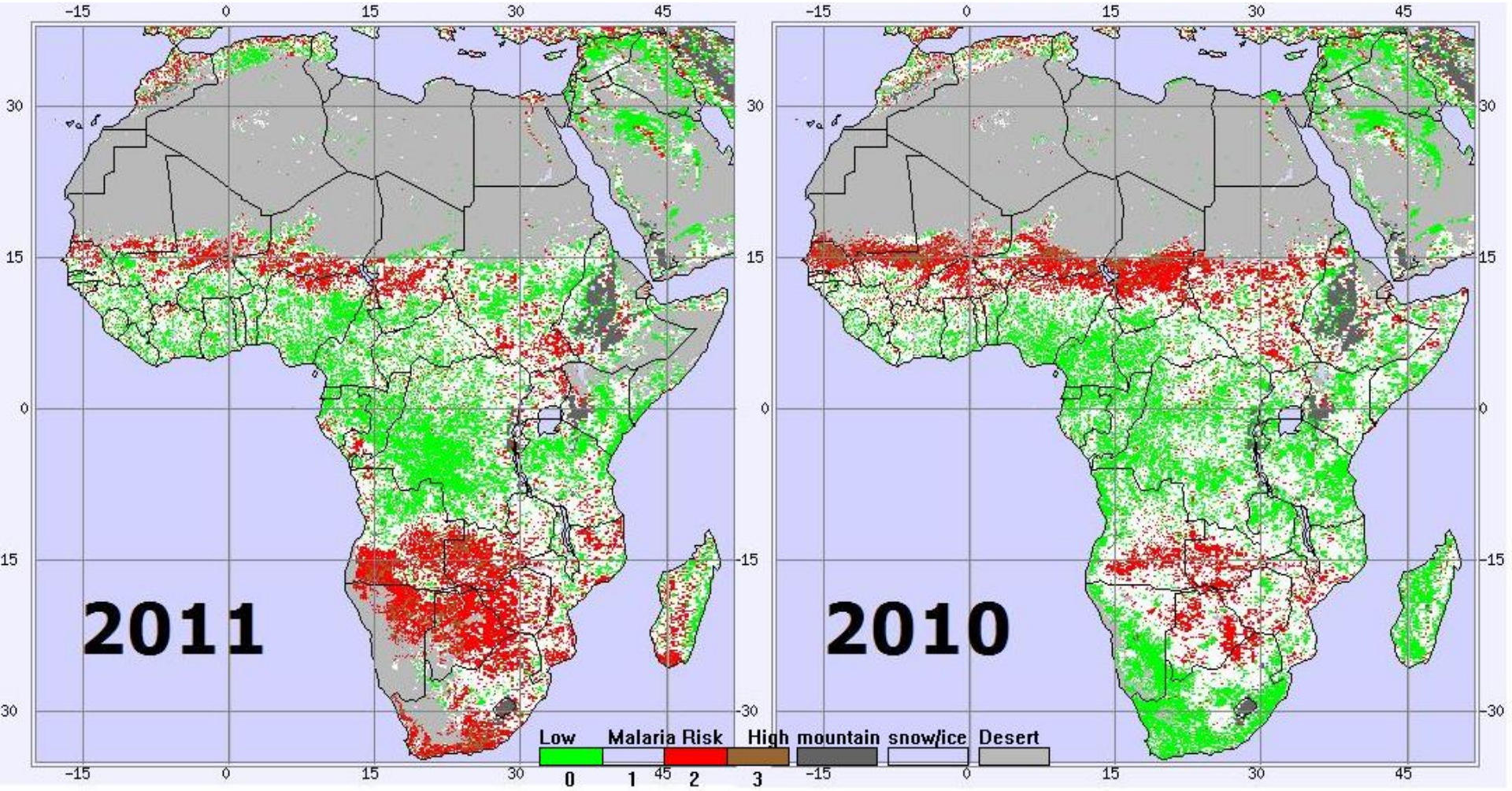
Vegetation Health & Dengue Hemorrhadic Fever Cases

Source NOAA-9 & WHO

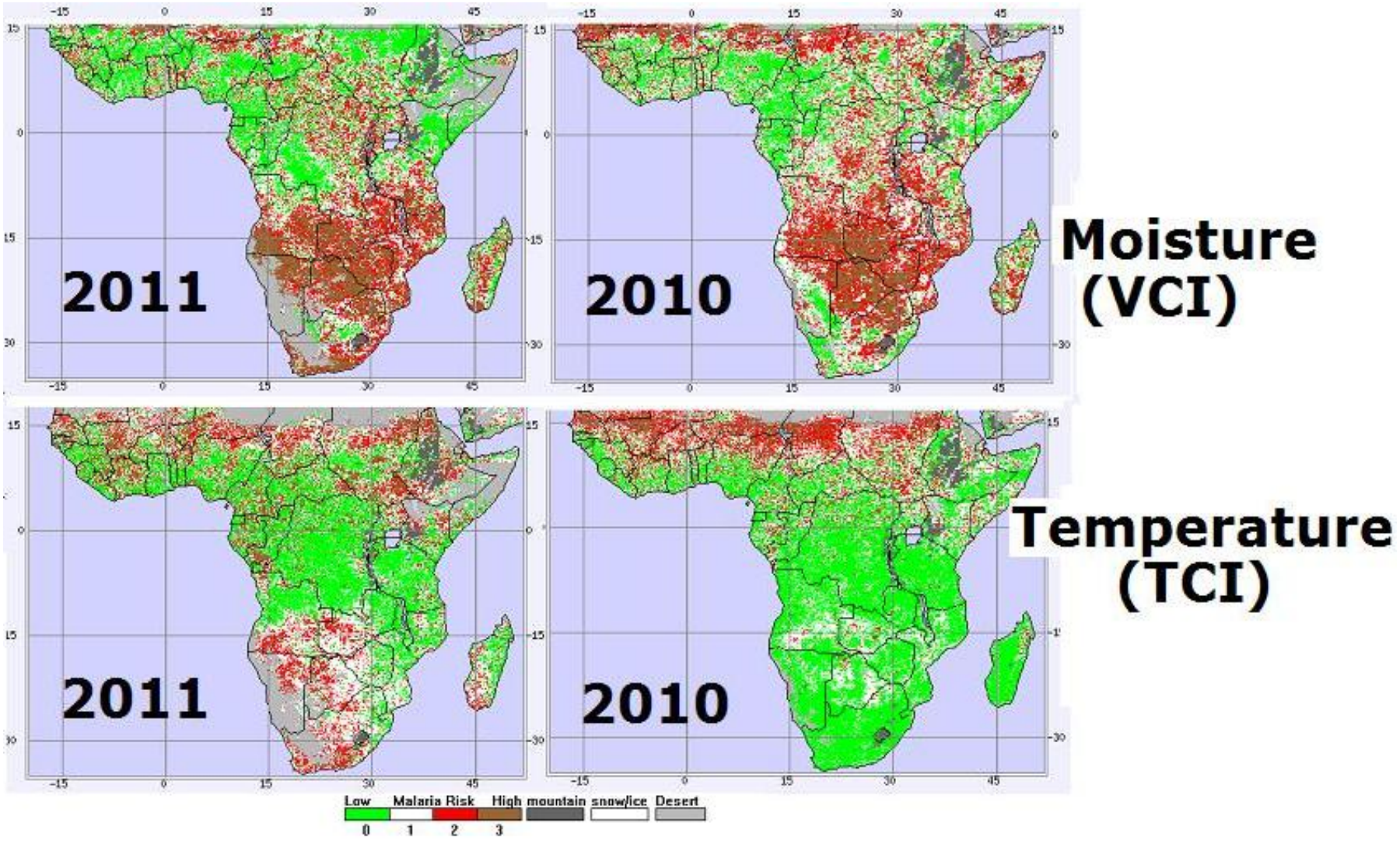
Vegetation Health Web

http://www.orbit.nesdis.noaa.gov/smcd/emb/vci

VH-based Malaria Risk
September 10



VH-based Moisture & Thermal Conditions



PUBLICATIONS

2011

F. Kogan, Alfred Powell and Oleg Fedorov (Editors), 2011: *Use of Satellite and In-Situ Datato Improve Sustainability.* Springer, 314 pp.

A. Rahman, L. Roytman, M. Goldberg, **and F. Kogan,** : Comparative Analysis on Applicability of Satellite and Meteorological Data for Prediction of Malaria in Endemic Area in Bangladesh. *Am. J. Trop. Med. Hyg.,* 82(6), pp. 1004–1009.

2010

Rahman, A. **F. Kogan,** L. Roytman, M. Goldberg and W. Guo, 2010**.** Modeling and prediction of malaria vector distribution in Bangladesh from remote sensing data. *Int. J. Rem. Sens.*. **Vol 30.**

F. Kogan, W. Guo, and A.Jelenak 2010**:** Global Vegetation Health: Long-Term Data Records. *Use of Satellite and In-Situ Data to Improve Sustainability.* pp. 247-256.

2002

R. Singh and **F. Kogan,** 2002: Monitoring vegetation condition from NOAA operational polar-orbiting satellites over India region. *Journal of the Indian Society of Remote Sensing* **30**, 3, 117-119.

F. Kogan, 2002: World Droughts in the New Millennium from AVHRR-based Vegetation Health Indices. *Eos, Trans. of Amer. Geophys. Union*, **83**, No 48, 26 November, 557-564.

CONCLUSIONS

Vegetation Health (VH) provide

- **Malaria risk predictions, diagnostics & assessments**
- **Malaria start and end**
- **Zones of enhanced mosquitoes activities and a risk of malaria transmission**
- **Malaria intensity**
- **Up to four months warning**
- **Validation of malaria treatments**
- **Other mosquitoes-born diseases (dengue, RVF etc.)**

BACK UP

AVHRR Data for Land Use

Sensor: ***Advanced Very High Resolution Radiometer (AVHRR)***

Satellites: ***NOAA-7, 9, 11, 14, 16, 18, 19***

Data Resolution: ***Spatial - 4 km (GAC), 8 & 16 km;***
Temporal - 7-day composite

Period: **31 years (1981-2011)**

Coverage: **World** ***(75 N to 55 S)***

Channels: **VIS (ch1), NIR (ch2), Thermal (ch4, *ch5)***