ENVIRONMENTAL AND ECOLOGICAL CONDITIONS LEADING TO EPIZOOTIC AND EPIDEMIC ACTIVITY

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An Integrated Approach to Controlling RVF in Africa & the Middle East
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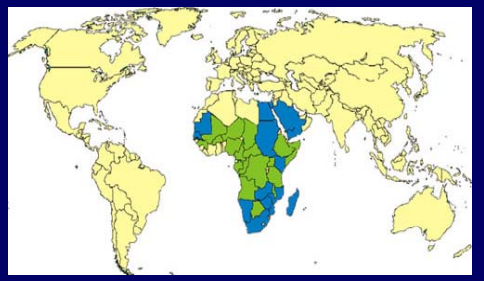
INTRODUCTION

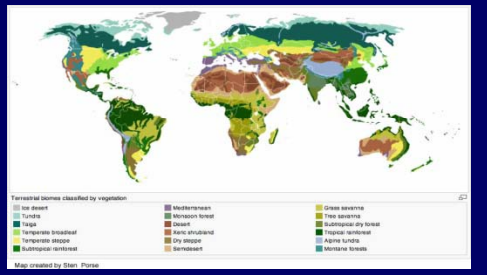
- RVF IS BECOMING AN ISSUE OF GLOBAL CONCERN DUE TO ITS RECENT SPREAD OUTSIDE AFRICA AND ITS HIGH ECOLOGICAL PLASTICITY & ADAPTATION.



- THE WIDE GEOGRAPHIC DISTRIBUTION OF RVF WHICH COVERS DIFFERENT BIOMES / ECO-REGIONS PUTS IT UNDER THE INFLUENCE OF A VARIETY OF ECOLOGICAL & ENVIRONMENTAL CONDITIONS.

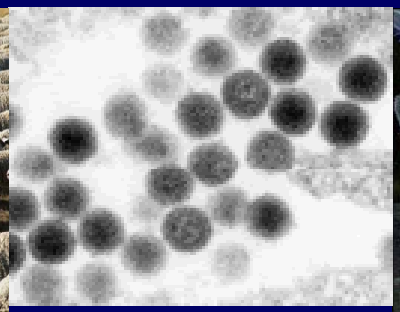
- THESE CONDITIONS INTERACT TO SHAPE RVF ENDEMIC & EPIZOOTIC / EPIDEMIC DYNAMICS THAT VARY FROM ONE ECO-REGION TO ANOTHER.

- ONE OF THE MAIN CONCERNS OF THE NATIONAL & INTERNATIONAL SCIENTIFIC COMMUNITIES IS HOW THE ENVIRONMENTAL & OR ECOLOGICAL CONDITIONS MAY LEAD TO EPIZOOTIC / EPIDEMIC RVF ACTIVITY.



AIM

- **VIEW THE ENVIRONMENTAL CONDITIONS / FACTORS WITHIN THEIR BROADER / HOLISTIC CONTEXT**
- **REVIEW OUR CURRENT UNDERSTANDING OF ENVIRONMENT – RVF LINKAGES**
- **IDENTIFY THE GAPS & NEEDS IN THIS AREA**


THE ENVIRONMENTAL SYSTEMS APPROACH TO RVF

- **MANY ENVIRONMENTAL & ECOLOGICAL CONDITIONS/FACTORS HAVE BEEN IDENTIFIED OR HYPOTHESIZED TO AFFECT RVF ACTIVITIES.**

- **THEY USUALLY STEM FROM NATURAL, HUMANE & MAN-MADE INTERACTIONS.**

- **SUCH COMPLEX & MULTI-FACET INTERACTIONS SHOULD BE STUDIED & ANALYZED WITHIN AN INTEGRATED - HOLISTIC APPROACH**

- **THE SUGGESTED APPROACH IS:**

“THE ENVIRONMENTAL SYSTEMS MODEL”

"THE ENVIRONMENTAL SYSTEMS MODEL"

- **OUR ENVIRONMENT FALLS UNDER THE INFLUENCE OF A COMPLEX WEB OF RELATIONS AMONGST THREE LEADING SYSTEMS:**

1. **THE BIOSPHERE**
2. **THE SOCIOSPHERE**
3. **THE TECHNOSPHERE**

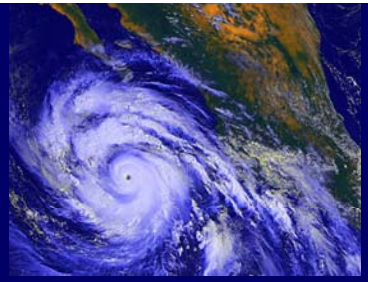
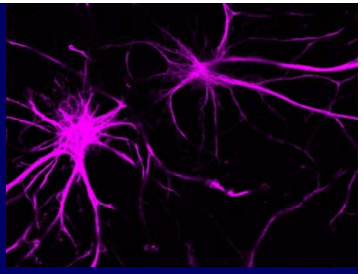
- **ALL PHENOMENA & EVENTS WE EXPERIENCE IN THIS WORLD ARE THE OUTCOMES OF HOW THESE 3 SYSTEMS INTERACT**
- **RVF IS NO EXCEPTION**
- **THE SYSTEMS, HOW THEY INTERACT & HOW THEIR INTERACTIONS MAY AFFECT RVF ACTIVITY**

THE BIOSPHERE

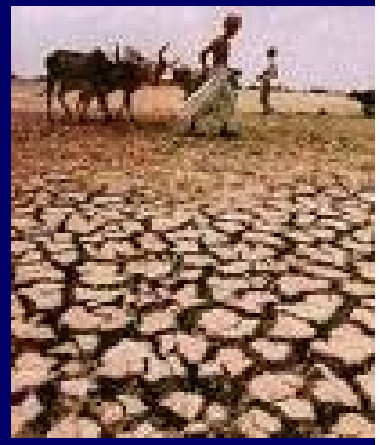
- THE ENVELOPE OF THE PLANET EARTH
- WHERE LIFE EXISTS OR MAY EXIST
- THE NATURAL SYSTEM WITH ITS ABIOTIC AND BIOTIC COMPONENTS
- NATURAL PHENOMENA
- MAN'S ACTIONS INTRODUCE

A LTERATIONS AND CHANGE

  - CLIMATE
  - OCEANS
  - LANDS
  - BIODIVERSITY



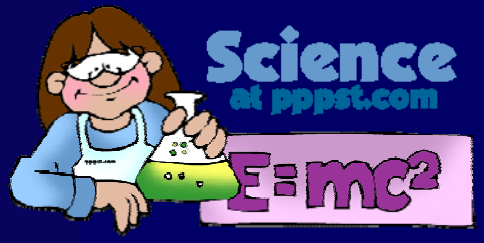



THE SOCIOSPHERE

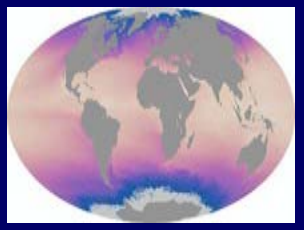
- THE SPHERE OF MAN'S NEEDS & ASPIRATIONS
- MAN-ADAPTED SYSTEMS OF ORGANIZING RELATIONSHIPS OF HUMAN SOCIETIES & BETWEEN THESE & OTHER SPHERES
- EVOLVED THROUGH AGES OF HUMAN HISTORY
- SHAPED BY PRESENT- DAY INFLUENCES THROUGH POLITICS, LEGISLATION, INSTITUTIONS, ETC
  - SOCIO-CULTURAL,
  - SOCIO-POLITICAL, &
  - SOCIO-ECONOMIC PROFILES

THE TECHNOSPHERE

- A TOTALLY MAN-MADE SYSTEM OF STRUCTURES & TECHNOLOGIES
- PLANNED, DESIGNED & OPERATED WITHIN THE SPACE OF THE BIOSPHERE
- TO RESPOND TO MAN'S NEEDS & ASPIRATIONS OF THE SOCIOSPHERE
- PARTIALLY CONTROLLED BY MAN DUE TO INHERENT LINKS TO PROCESSES OF THE BIOSPHERE (e.g. EARTHQUAKES)



- SETTLEMENTS
- INDUSTRIES
- TRANSPORTATION/COMMUNICATION
- WATER RESOURCES MANAGEMENT SYSTEMS
- SCIENCE & TECHNOLOGY



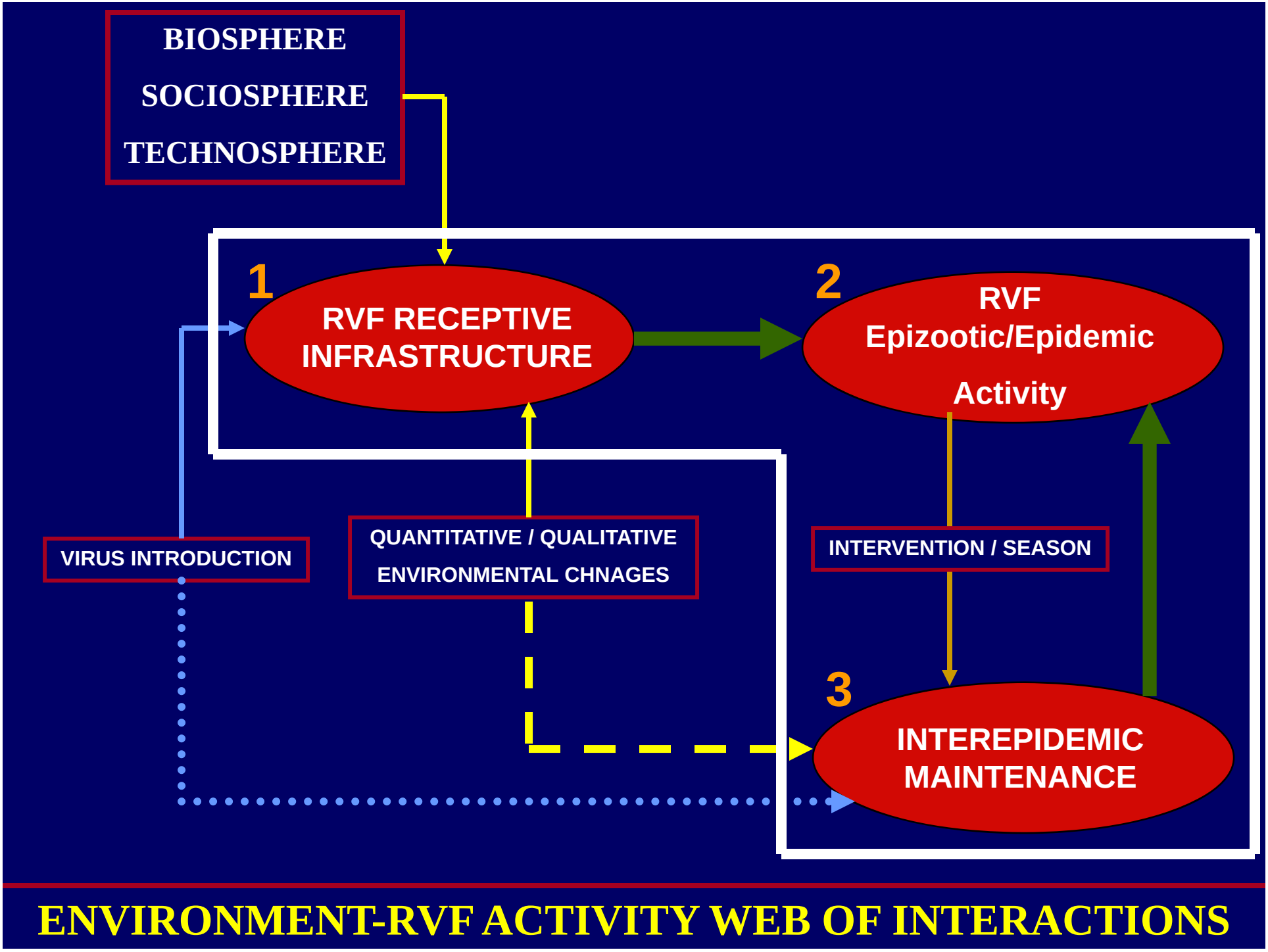
BIO-SPHERE

TECHNO-SPHERE

ENVIRONMENTAL PHENOMENA & EVENTS

SOCIO-SPHERE

INTERACTIONS OF ENVIRONMENTAL SYSTEMS



ENVIRONMENT-RVF ACTIVITY WEB OF INTERACTIONS

RVF RECEPTIVE INFRASTRUCTURE

BIOSPHERE INPUTS

ABIOTIC

- **FAVORABLE CLIMATE (temp., humidity, precipitation – regional/local)**
- **GEOLOGY/LAND FORMS (coastal plains, wadis/valleys, mountains, etc)**
- **TOPOGRAPHY (small scale variation, depressions: e.g. dambos)**
- **SURFACE & UNDERGROUND HYDROLOGY (availability of surface water, high water table, etc)**
- **SOIL (water bearing capacity, infiltration, etc)**

RVF RECEPTIVE INFRASTRUCTURE

BIOSPHERE INPUTS (cont.)

BIOTIC

- VEGETATION (type, distribution, etc)
- ECOSYSTEMS / HABITATS (support for vectors, hosts & reservoirs)
- VECTORS (diversity, bionomics, vector competence [horizontal/vertical], etc)
- ANIMALS (diversity, distribution, immune status, etc)
- HUMAN POPULATIONS (density/crowding, distribution, age, etc)

RVF RECEPTIVE INFRASTRUCTURE

SOCIOSPHERE INPUTS

- **POVERTY**
- **CULTURE & BELIEVES (e.g. low risk perception, adaptation to hazardous situations, high value of animals, etc)**
- **EDUCATION/AWARENESS LEVEL (e.g. illiteracy, lack of awareness)**
- **RELIGION (slaughtering practices, seasonal animal importation)**
- **RURAL BEHAVIOR PATTERNS (e.g. mixing people & animals in settlements, sleeping outside houses in summer, etc)**
- **LOW HOUSING STANDARDS (e.g. accessible to vectors and rodents)**

RVF RECEPTIVE INFRASTRUCTURE

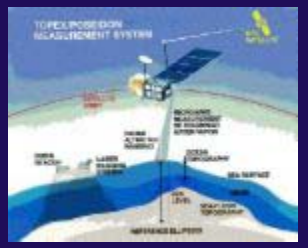
SOCIOSPHERE INPUTS (cont.)

- LACK OF PROPER SERVICES / PHYSICAL INFRASTRUCTURE (e.g. provision of potable water without a parallel drainage system)
- NOMADISM (e.g. high mobility of pastoral nomadic herds)
- INTENSIVE ANIMAL TRADE (legal & illegal through vast, un-controlled borders)
- INADEQUATE VETERINARY & HUMAN HEALTH INFRASTRUCTURE
- LACK OF AWARENESS OF DECISION-MAKERS (e.g. reluctance to allocate resources for surveillance & preparedness)
- POLITICAL /MILITARY CONFLICTS

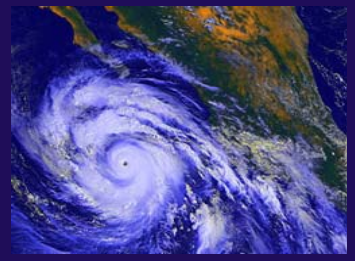
RVF RECEPTIVE INFRASTRUCTURE

TECHNOSPHERE INPUTS

- **LAND USE CHANGE (e.g. deforestation, urbanization, water impoundment, etc)**
- **INTENSE IRRIGATION / DRAINAGE NETWORKS & AGRICULTURAL PRACTICES**
- **WATERSHED MANAGEMENT PRACTICES (e.g. water harvesting in KSA)**
- **WATER RESOURCES MANAGEMENT (e.g. Aswan, Senegal & Yemen dams)**
- **POORLY PLANNED HUMAN SETTLEMENTS (e.g. close proximity to vector habitats; lack of proper drainage; etc)**
- **POOR PASTURE MANAGEMENT PRACTICES**
- **RAPID TRANSPORTATION SYSTEMS**
- **LARGE ECONOMIC DEVELOPMENT PROJECTS**
- **INADEQUATE TECHNOLOGICAL CAPABILITIES /LOW PROFESSIONAL PRACTICE**



ENVIRONMENTAL CONDITIONS LEADING TO EPIZOOTIC & EPIDEMIC RVF ACTIVITY



ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

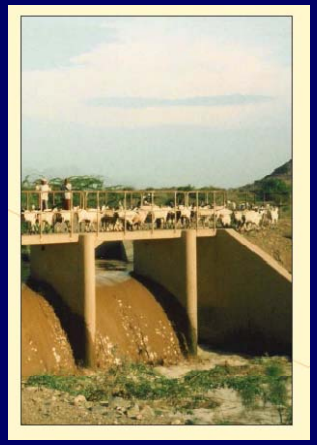
DRIVER	SOURCE	COMPONENTS	PROCESSES
LAND USE CHANGE	SOCIO TECHNO BIO	DEFORESTATION LAND RECLAMATION AGRICULTURE EXTENSION URBANIZATION	HABITAT FRAGMENTATION, DISTURBANCE IN WILDLIFE HABITATS CREATION OF NEW HABITATS, INCREASE WATER AVAILABILITY, INTRODUCTION OF ANIMALS & HUMANS TO NEW AREAS, INTERACTION WITH WILDLIFE SHIFTS IN VECTOR SPECIES COMPOSITIONS, SHIFTS IN HOST POPULATION COMPOSITION, ALTERATION IN VECTOR- HOST DYNAMICS VET / HEALTH INFRASTRUCTURE & HUMAN BEHAVIOR

ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

DRIVER	SOURCE	COMPONENTS	PROCESSES
ANIMAL MOVEMENT	SOCIO BIO	TRADE ILLEGAL TRADE MOBILITY OF PASTORAL NOMADIC HERDS	INTRODUCTION OF INFECTED ANIMALS TO NEW AREAS INTRODUCTION OF INFECTED ANIMALS TO PREVIOUSLY AFFECTED AREAS INTODUCTION OF NAÏVE ANIMALS TO ENDEMIC FOCI ALTERATION IN HOST POPULATION COMPOSITION & ABUNDANCE ALTERATION IN VECTOR FEEDING BEHAVIOR ALTERATION IN HOST – VECTOR DYNAMICS VIRUS AMPLIFICATION VET / HEALTH INFRASTRUCTURE & HUMAN BEHAVIOR

ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

DRIVER	SOURCE	COMPONENTS	PROCESSES
WATER MANAGEMENT PROJECTS	SOCIO TECHNO BIO	DAMS BARRAGES WATER HARVESTING / WATERSHED MNGT LARGE IRRIGATION PROJECTS	WATER STORAGE, WATER SPILL OVER INCREASE IN SURFACE WATER HIGH WATER TABLE INCREASE WATER AVAILABILITY, INCREADE VEGETATION COVER EXPAND VECTOR HABITATS, MODIFICATION OF MICROCLIMATE EXPAND VECTOR GEOGRAPHIC RANGE ALTER VECTOR SPECIES COMPOSITIONS, INCREASE VECTOR ABUNDANCE ATTRACT NEW HUMAN & ANIMAL POPULATIONS ENHANCE RODENT / RESERVOIR HABITAT ALTERATION IN VECTOR- HOST DYNAMICS VET / HEALTH INFRASTRUCTURE & HUMAN BEHAVIOR

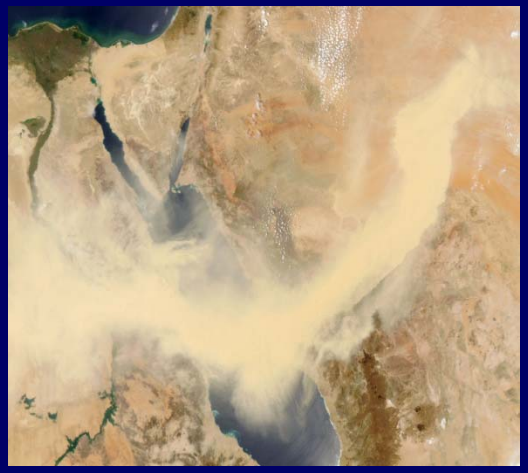


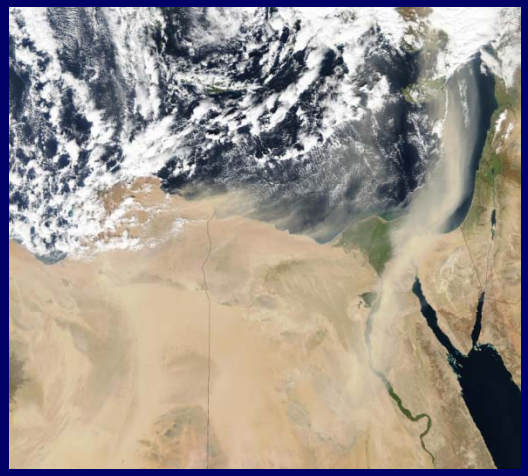
ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

CLIMATIC EVENTS 1

DRIVER	SOURCE	COMPONENTS	PROCESSES
STORMS	BIO	WIND SAND STORMS	INFECTED VECTORS ARE BLOWN INTO NEW AREAS VIRUS IS BLOWN INTO NEW AREAS ?? INFECTED VECTOR – HOST CONTACT

THEORIES WITH NO SCIENTIFIC EVIDENCE





ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

CLIMATIC EVENTS 2

DRIVER	SOURCE	COMPONENTS
RAINFALL	BIO	SEASONAL LOCAL RAINFALL

PROCESSES

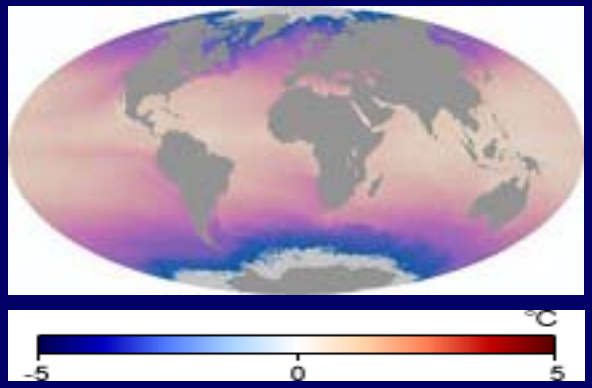
- ALTERNATION BETWEEN DROUGHT & RAINY SEASONS
- FLUSHING OF VECTOR BREEDING SITES (INTENSITY /DURATION)
- WATER COLLECTION / STORAGE
- WATER FILLING OF DEPRESSIONS
- WATER POOLS IN WADIS
- VEGETATION GROWTH
- FLOODING OF AEDES VECTOR HABITATS
- RE-DISTRIBUTION OF AEDES INFECTED EGGS
- CREATION OF NEW VECTOR HABITATS (LAG TIME)
- INCREASE IN VECTOR ABUNDANCE
- INCREASE IN ANIMAL GRAZING & MOVEMENT BETWEEN AREAS
- DISTURB RESERVOIR / RODENT HABITATS
- INCREASE VECTOR – HOST CONTACT
- CHANGES IN HOST – VIRUS – VECTOR DYNAMICS
- VET / HEALTH INFRASTRUCTURE & HUMAN BEHAVIOR

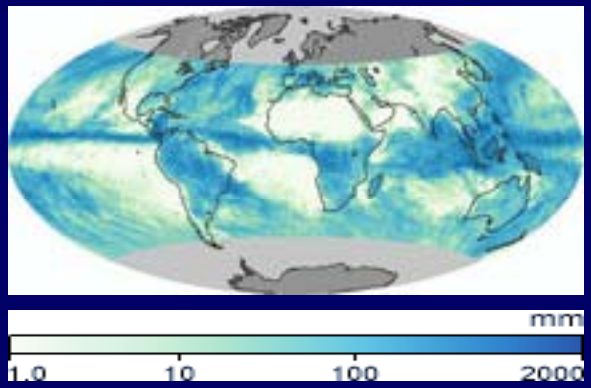
ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

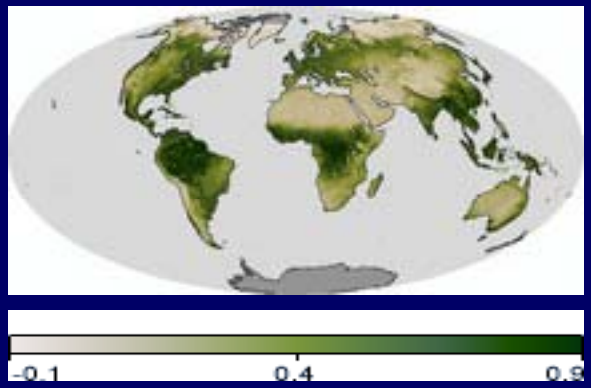
CLIMATIC EVENTS 3

El Niño-Southern Oscillation (ENSO)

- ENSO COMPRISES CHANGES IN SST IN THE PACIFIC OCEAN & IN ATMOSPHERIC PRESSURE ACROSS THE PACIFIC BASIN
- IT OCCURES IRREGULARLY EVERY 2 – 7 YEARS
- IT IS ASSOCIATED WITH EXTREME WEATHER CONDITIONS







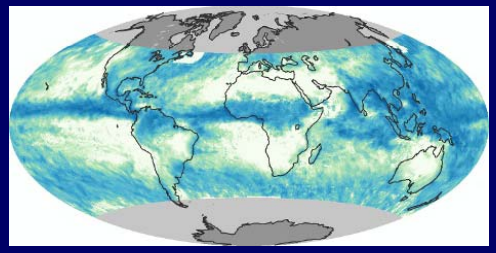
SST **RAINFALL** **NDVI**

ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

CLIMATIC EVENTS 3

DRIVER	SOURCE	COMPONENTS
ENSO	BIO	ABOVE - NORMAL RAINFALL

PROCESSES



- ALTERNATION BETWEEN DROUGHT & HEAVY RAIN CONDITIONS
- HIGH WATER - BEARING CAPACITY SOILS
- LAND FLOODING & FLUSHING OF VECTOR BREEDING SITES
- WATER FILLING OF DEPRESSIONS
- FLOODING OF AEDES VECTOR HABITATS
- RE-DISTRIBUTION OF AEDES INFECTED EGGS
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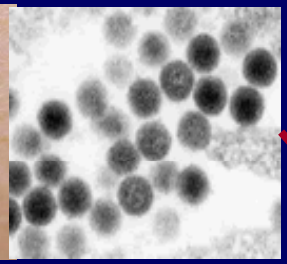
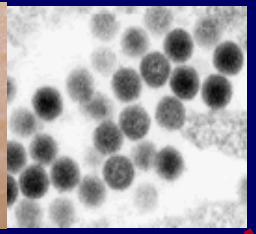



ENDEMIC CYCLE

ABOVE NORMAL RAINFALL

NORMAL RAINY SEASONS


EPIDEMIC CYCLE

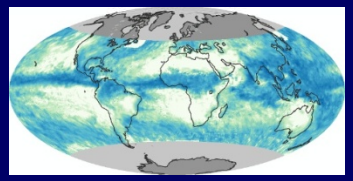



RVF ECOLOGY IN KENYA

ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

CLIMATIC EVENTS 4

DRIVER	SOURCE	COMPONENTS
ENSO TELECONNECTION	BIO	ABOVE – NORMAL RAINFALL OVER THE RIVER NILE BASIN



PROCESSES

- INCREASE IN EGYPT'S WATER BUDGET
- INCREASE IN WATER STORAGE IN ASWAN DAM
- BREACH MAXIMUM WATER HOLDING CAPACITY
- INCREASE IN WATER FLOW TO NILE BASIN DOWN STREAM
- INCREASE IN WATER AVAILABILITY
- HIGH WATER TABLE
- ALTERATION IN RODENT HABITATS
- EXPAND VECTOR HABITATS
- INCREASE VECTOR ABUNDANCE
- INCREASE AGRICULTURAL YIELD
- CHANGES IN HOST – VIRUS - VECTOR DYNAMICS
- VIRUS AMPLIFICATION
- VET / HEALTH INFRASTRUCTURE & HUMAN BEHAVIOR

Conceptual Model of RVF Epidemics in Egypt

HYDROLOGIC FACTORS

A — I. RAINFALL IN AFRICA
triggered by climatic factors
{El-Niño in Pacific & Indian oceans}
- Equatorial Plateau (14%) Mongalla St.
- Ethiopian Plateau (86%) Gambeila St.

B — II. Q & WL
Upstream HAD
- S. Sudan (Malakal St.) – White Nile
- N. Sudan (Dongola St.) – Main Nile

C — III. Q & WL
at Aswan
- Natural Inflow at Aswan - Main Nile
- Water arriving Aswan - Main Nile
- Lake Nasser St. - Main Nile

D — IV. Q & WL
Downstream HAD
- Gaafra St. - Main Nile
- Damietta St. - Nile Delta
- Rosetta St. – Nile Delta

SOCIO-ECONOMIC FACTORS

VI. Greater Bairam
Feast dates / slaughter of imported animals

ENTOMOLOGIC FACTORS

V. Mosquito densities
Increased areas of mosquito vector breeding habitats

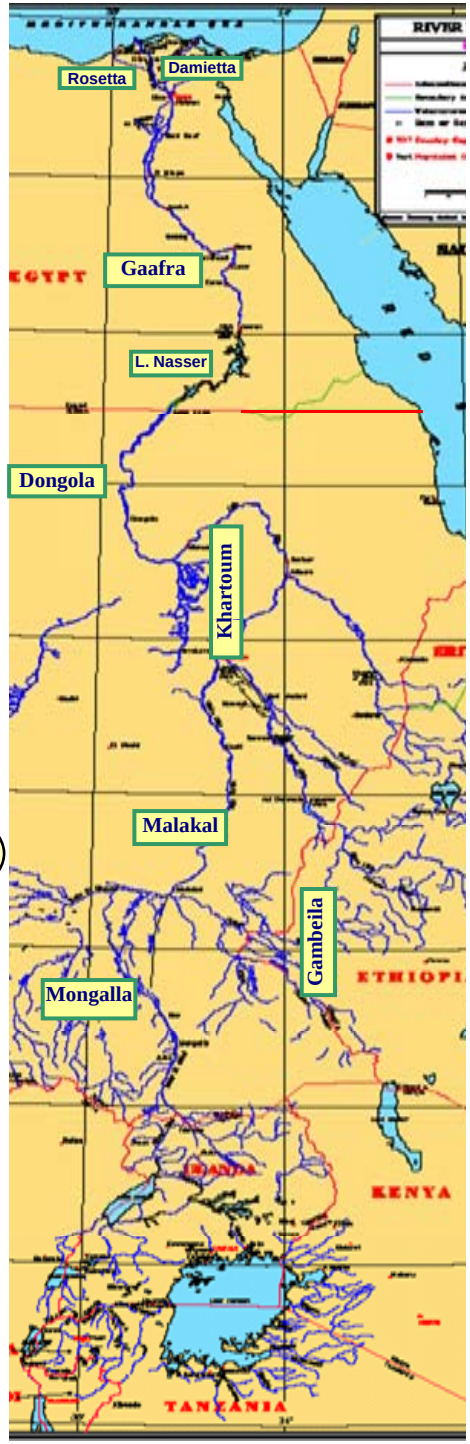
ENVIRONMENTAL CONDITIONS

VII. Env. conditions
Favorable temperature & humidity

IF
same temporal and spatial window frame
THEN

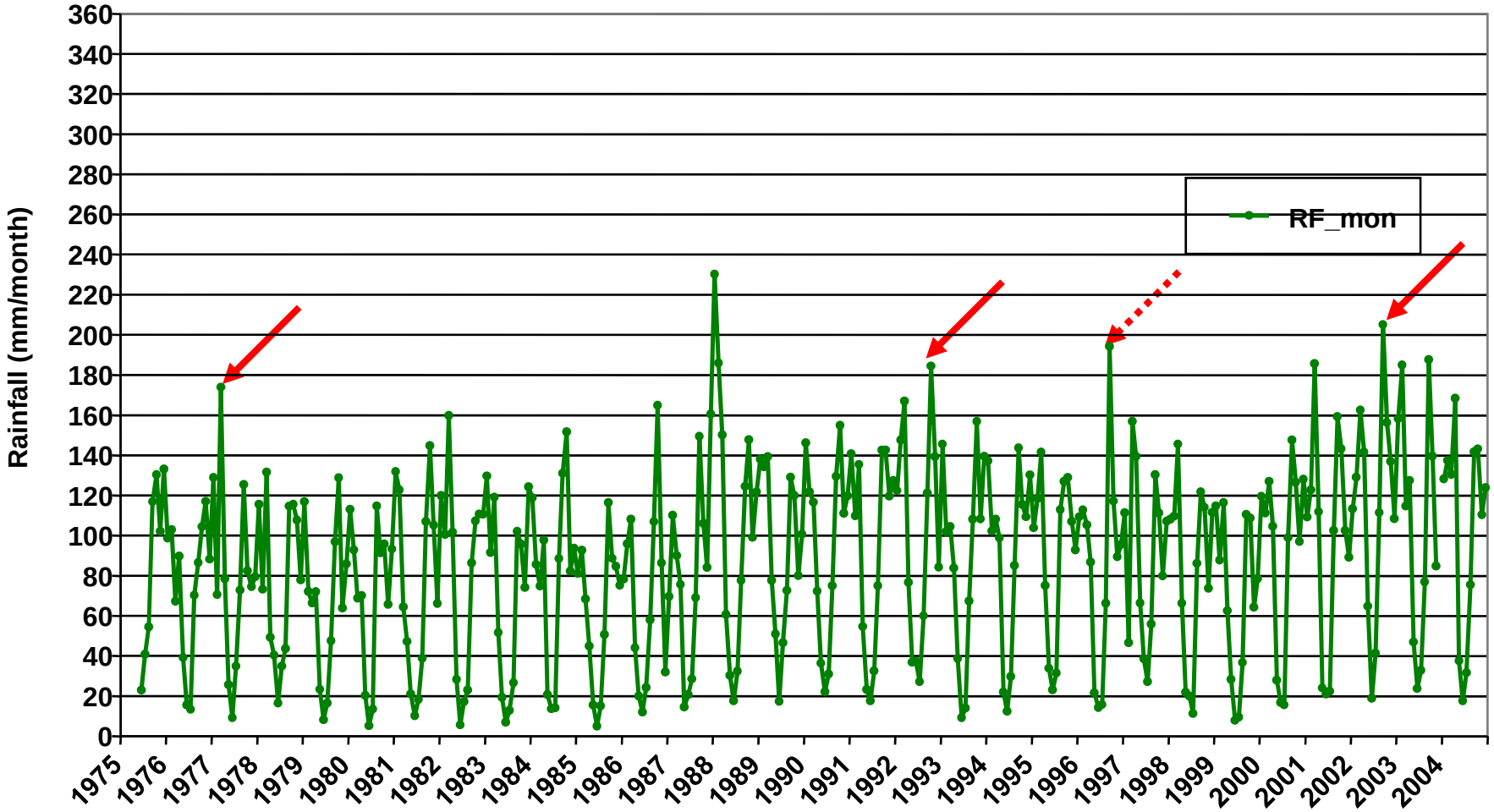
R V F
o u t b r e a k

EPIDEMIOLOGIC FACTORS

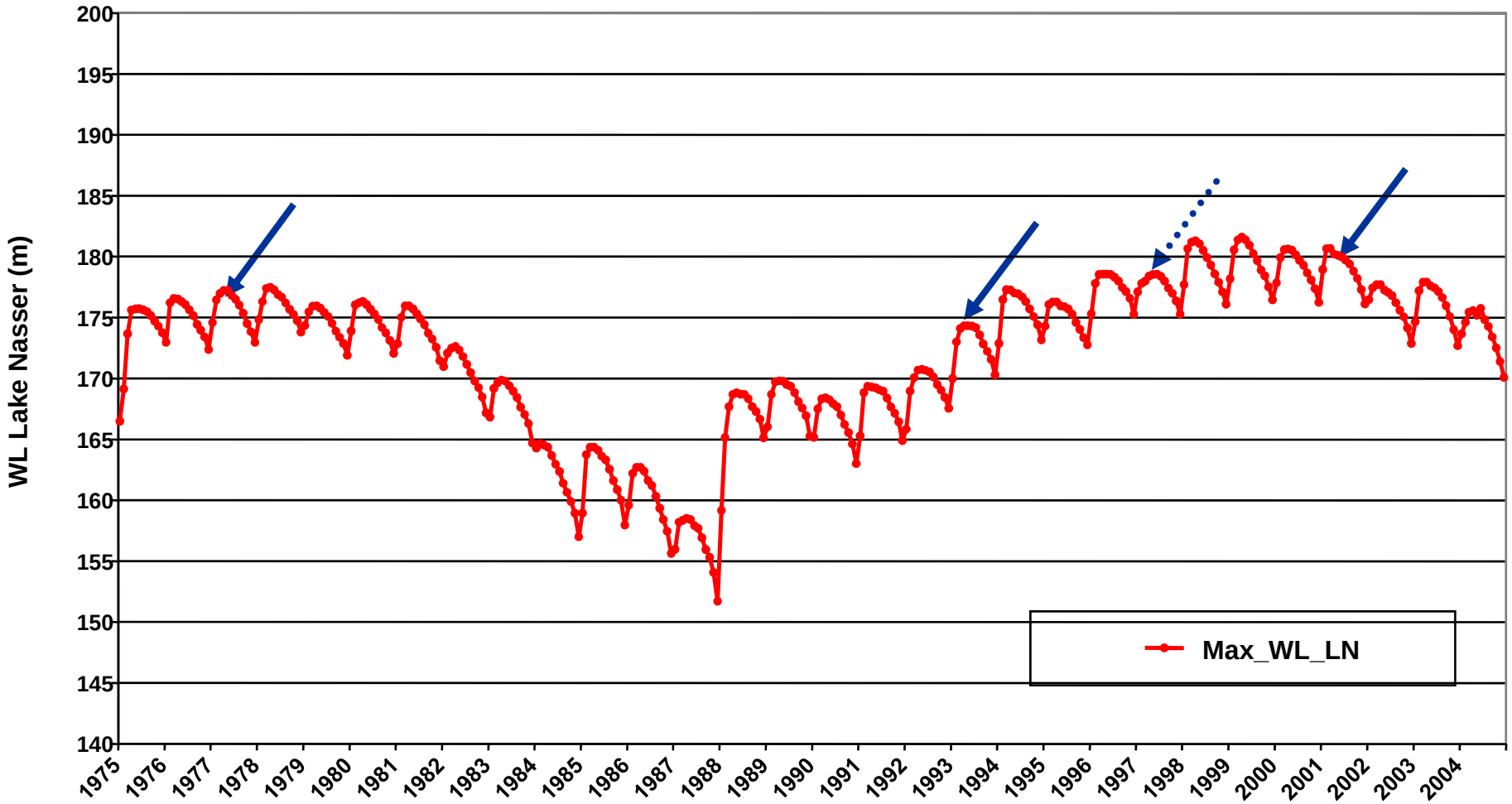


RAINFALL AT MONGALA STATION

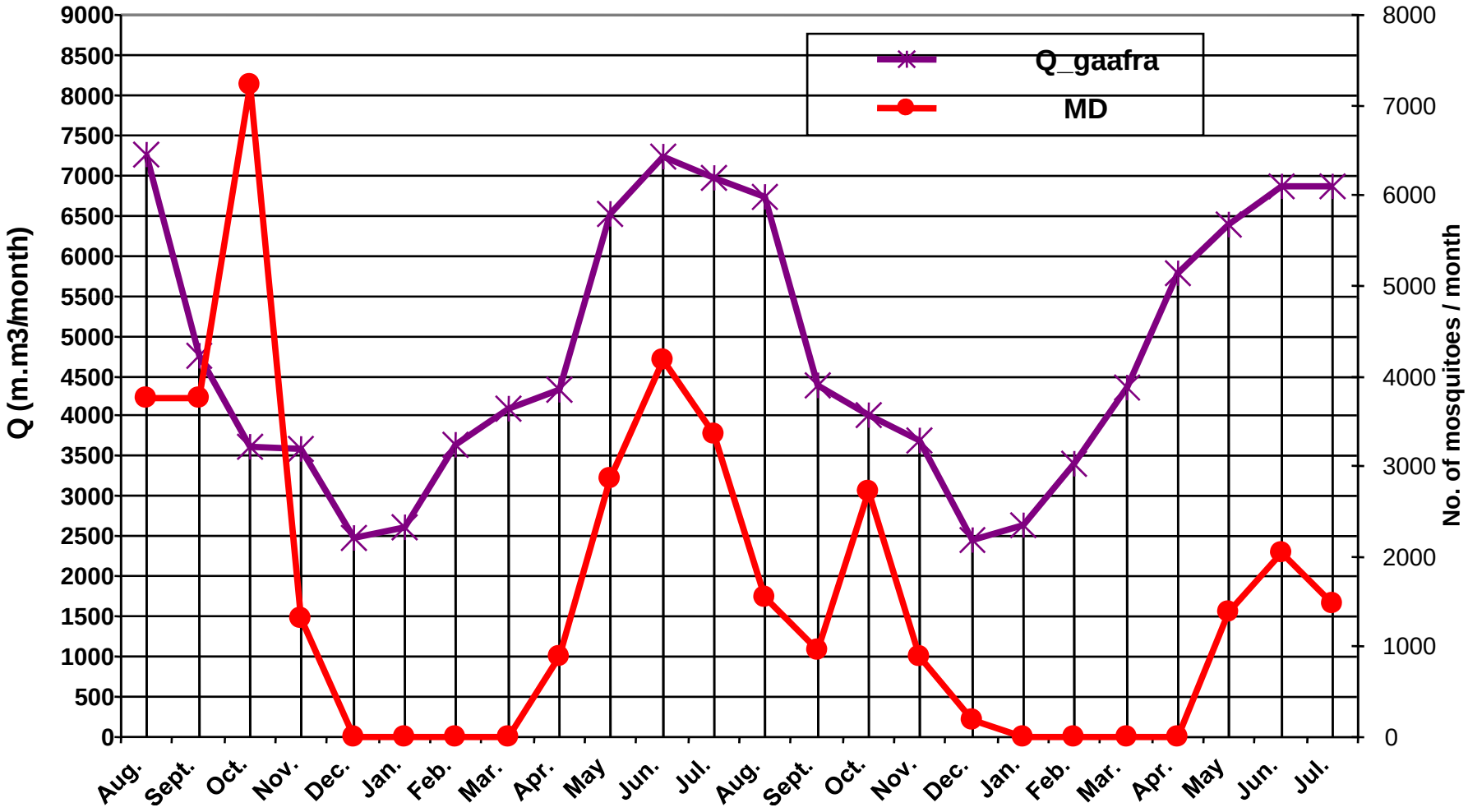
(EQUATORIAL PLATEAU)1975-2005



MAXIMUM MONTHLY WATER LEVELS AT LAKE NASSER 1975-2005



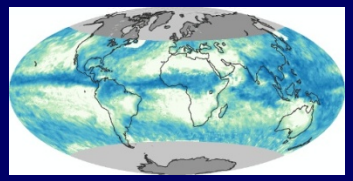
CX. PIPIENS DENSITIES IN RELATION TO WATER DISCHARGES AT GAAFRA STATION



ENVIRONMENTAL DRIVERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

CLIMATIC EVENTS 4

DRIVER	SOURCE	COMPONENTS
ENSO TELECONNECTION	BIO	ABOVE – NORMAL RAINFALL OVER THE RIVER NILE BASIN



PROCESSES

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- VET / HEALTH INFRASTRUCTURE & HUMAN BEHAVIOR

GLOBAL ENVIRONMENTAL CHANGE

DRIVER

GLOBAL WARMING

SOURCE

TECNO

BIO

COMPONENTS

HIGHER TEMP
SEA LEVEL RISE

EXTREME CLIMATE EVENTS

PROCESSES

SHIFT IN VECTOR DISTRIBUTION

SHIFT IN VEGETATION BELTS

SHORTER EIP

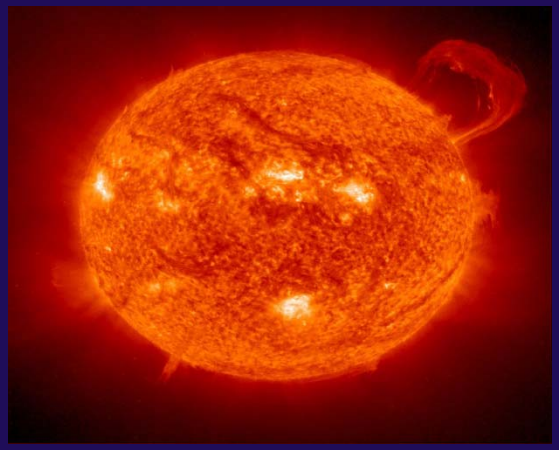
LONGER VECTOR LIFE

IMPACT ON HUMAN / ANIMAL HEALTH & IMMUNITY STATUS

INCREASED RAINFALL

PRESSURE ON WATER RESOURCES

SOCIAL / BEHAVIORAL CHANGES



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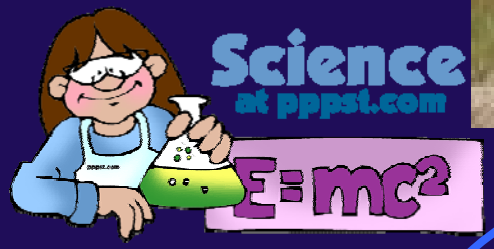
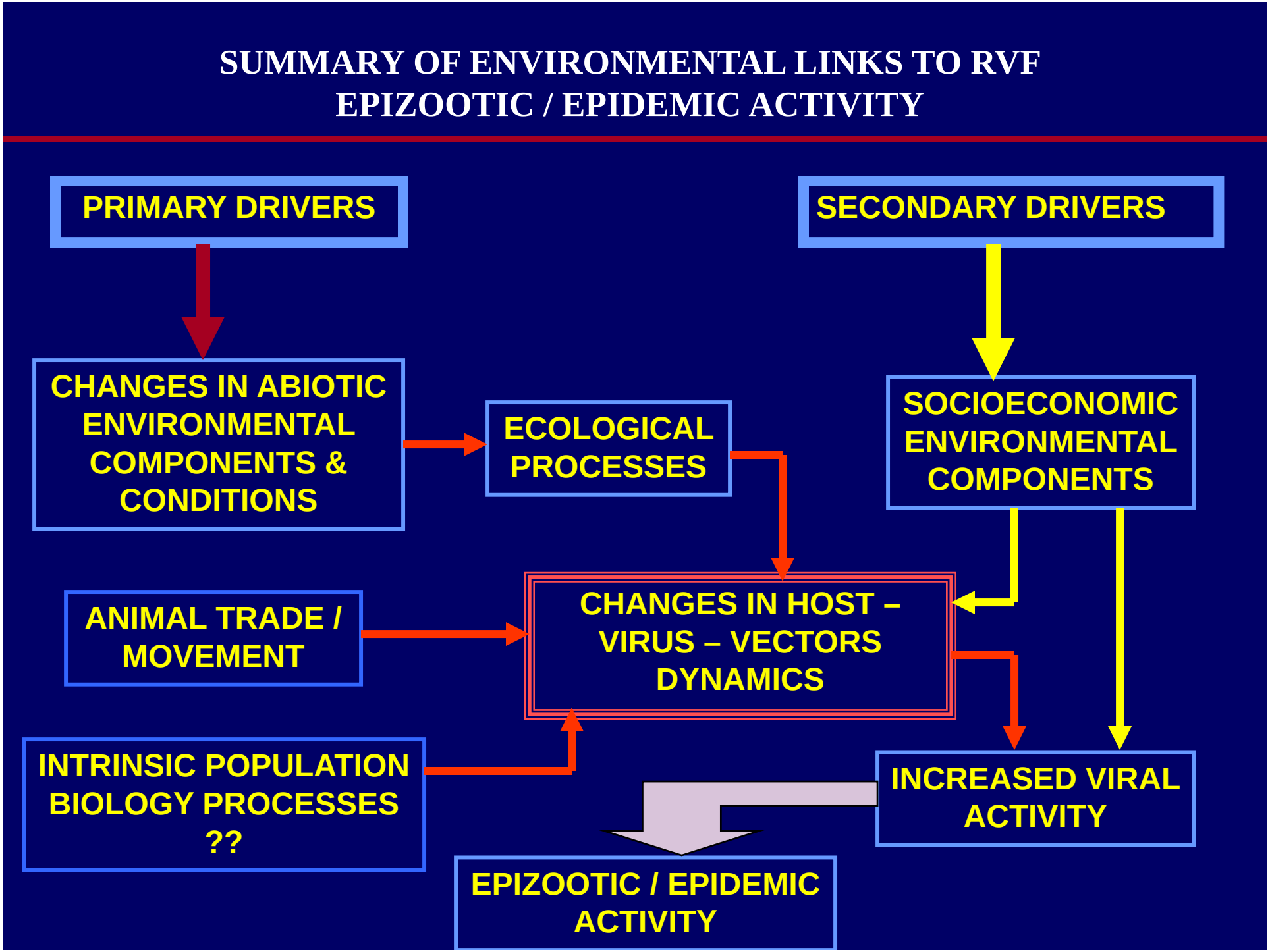


SOCIOECONOMIC INPUTS & OR MODIFIERS OF EPIZOOTIC / EPIDEMIC ACTIVITY

SUMMARY OF ENVIRONMENTAL LINKS TO RVF EPIZOOTIC / EPIDEMIC ACTIVITY



ENVIRONMENTAL CONDITIONS INFLUENCE RVF THROUGH INDIRECT EFFECTS ON THE ECOLOGY OF VECTORS, HOSTS, VIRUS AND THEIR INTRICATE POPULATION DYNAMICS

VECTOR VARIABLES

- CLIMATE, MICRO-CLIMATE
- HABITATS
- SPECIES COMPOSITION
- GEOGRAPHIC DISTRIBUTION
- SEASONAL ABUNDANCE OF DIFFERENT VECTORS
- HOST FEEDING PATTERNS (TIME & SPACE)
- HOST SEEKING BEHAVIOR
- VECTOR COMPETENCE (+ VERTICAL TRANSMISSION POTENTIAL)

VIRUS VARIABLES

- GENETICS
- VIRULENCE
- PATHOGENICITY

HOST VARIABLES

- NON-HUMAN VERTEBRATE POPULATION SIZE
- ANIMAL POPULATION COMPOSITION (LOCAL, IMPORTED, NOMADIC)
- ANIMAL SPECIES COMPOSITION, RELATIVE ABUNDANCE
- NUTRITIONAL STATUS
- HERD IMMUNITY
- RESERVOIR HOSTS
- HUMAN POPULATION SIZE
- NATURE OF INTERACTION BETWEEN ANIMAL & HUMAN HOSTS

CONCLUSIONS

- RVF EPIZOOTIC / EPIDEMIC ACTIVITY IS INFLUENCED BY ENVIRONMENTAL FACTORS & CONDITIONS GENERATED THROUGH COMPLEX INTERACTIONS BETWEEN BIO-PHYSICAL, SOCIETAL & TECHNOLOGICAL SPHERES

- RVF EPIDEMIC ACTIVITY MAY PRECIPITATE DUE TO DIFFERENT MECHANISMS IN DIFFERENT ECO-REGIONS; EVEN IF DERIVED BY THE SAME INPUT

- CURRENT KNOWLEDGE SUGGESTS THAT CHANGES IN THE ABIOTIC ENVIRONMENTAL COMPONENTS / CONDITIONS AS WELL AS ANIMAL MOVEMENT ARE THE MOST IMPORTANT PRIMARY DRIVERS OF RVF EVENTS

CONCLUSIONS (cont.)

- QUANTITATIVE SCIENTIFIC EVIDENCE LINKING ENVIRONMENTAL DRIVERS TO CHANGES IN HOST – VIRUS – VECTOR DYNAMICS LEADING TO OUTBREAKS IS STILL POOR

- THE ROLE OF SOCIOECONOMIC & TECHNOLOGICAL FACTORS IN EPIDEMIC GENESIS IS NOT SUFFICIENTLY ADDRESSED

- OUR UNDERSTANDING OF HOW RVF EVENTS ARE PRECIPITATED IS STILL FAR FROM COMPLETE

NEEDS

- HOLISTIC & QUANTITATIVE STUDIES ASSESSING THE LINKAGES BETWEEN ENVIRONMENTAL VARIABILITY (IN THE 3 SYSTEMS) & EPIDEMIC CYCLES
- EVIDENCE – BASED INVESTIGATIONS SHOWING THAT OUTBREAK EVENTS HAVE A PLAUSIBLE BIOLOGICAL LINK WITH PHYSICAL ENVIRONMENTAL CHANGES IN DIFFERENT ECO-REGIONS
- UNDERSTAND THE MECHANISMS & DYNAMICS OF INTER – EPIDEMIC MAINTENANCE IN DIFFERENT ECO - REGIONS
- RAISE AWARENESS TOWARDS PREPAREDNESS & PREVENTION
- BRIDGE THE GAP BETWEEN SCIENTIFIC / TECHNOLOGICAL DEVELOPMENTS & OPERATIONAL PRACTICES
- STRENGTHEN GLOBAL SCIENTIFIC COOPERATION & NETWORKING