INTEGRATED SURVEILLANCE AND CONTROL SYSTEM FOR MALARIA IN COLOMBIA

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SUMMER SCHOOL ON CLIMATE IMPACTS MODELLING FOR DEVELOPING COUNTRIES: WATER, AGRICULTURE AND HEALTH

EIA ESCUELA DE INGENIERIA DE ANTIOQUIA
Ser. Saber y Servir

UNIVERSIDAD NACIONAL DE COLOMBIA

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IRI

OUTLINE

ENVIRONMENTAL HEALTH AND PUBLIC HEALTH

WHY DYNAMICAL MODELS ARE USEFUL?

DYNAMICAL MODELS AND MULTI-MODEL ENSEMBLE

WHAT DO WE HAVE IN THE MULTI-MODEL ENSEMBLE?

OBJECTIVES AND CURRENT/POTENTIAL CAPABILITIES

WHAT ARE WE DOING WITH THE MATHEMATICAL MODELS?

ECO-EPIDEMIOLOGICAL SCENARIOS

HOW DO WE PROCEED AND WHAT DO WE HAVE SO FAR?

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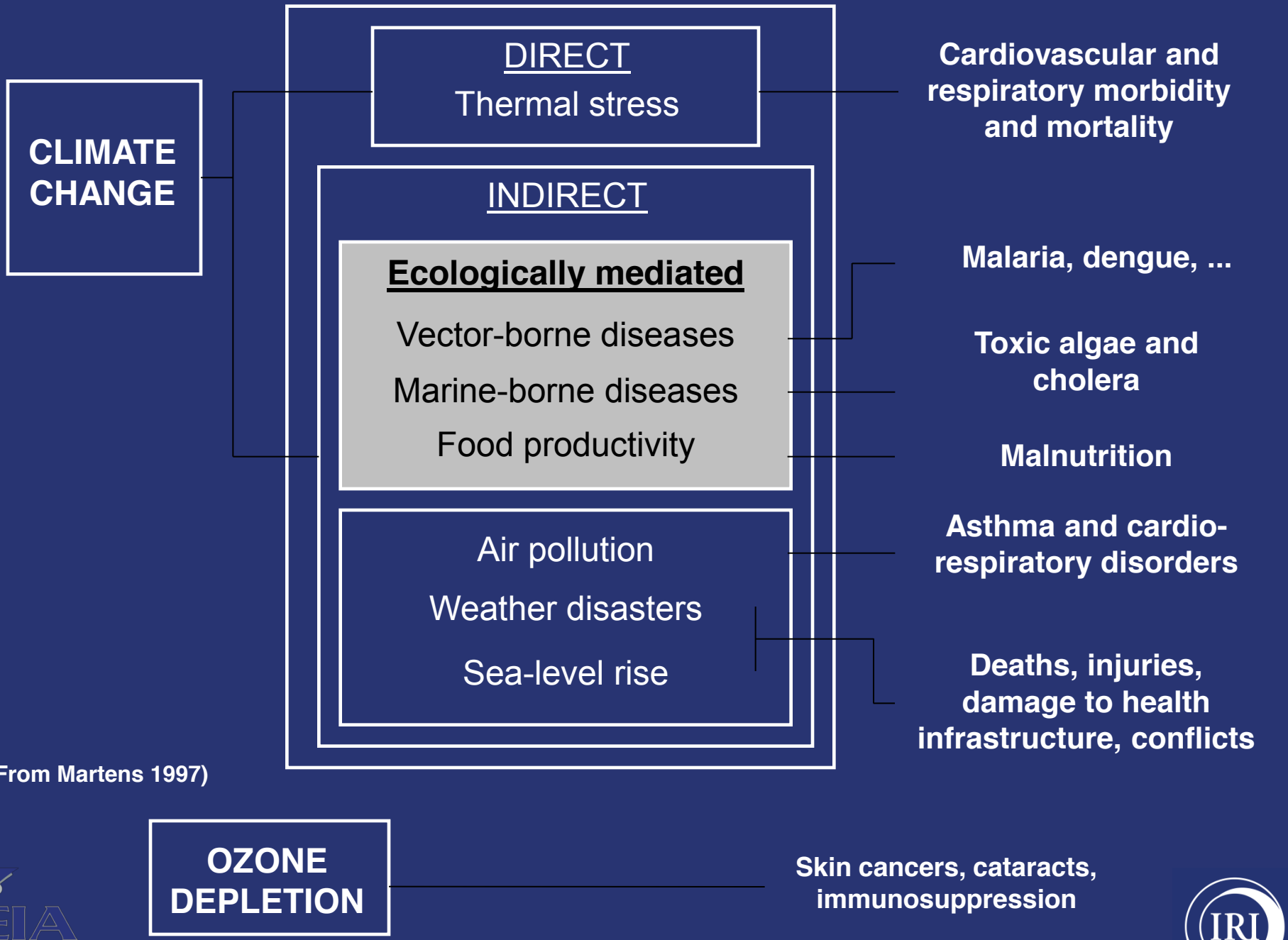
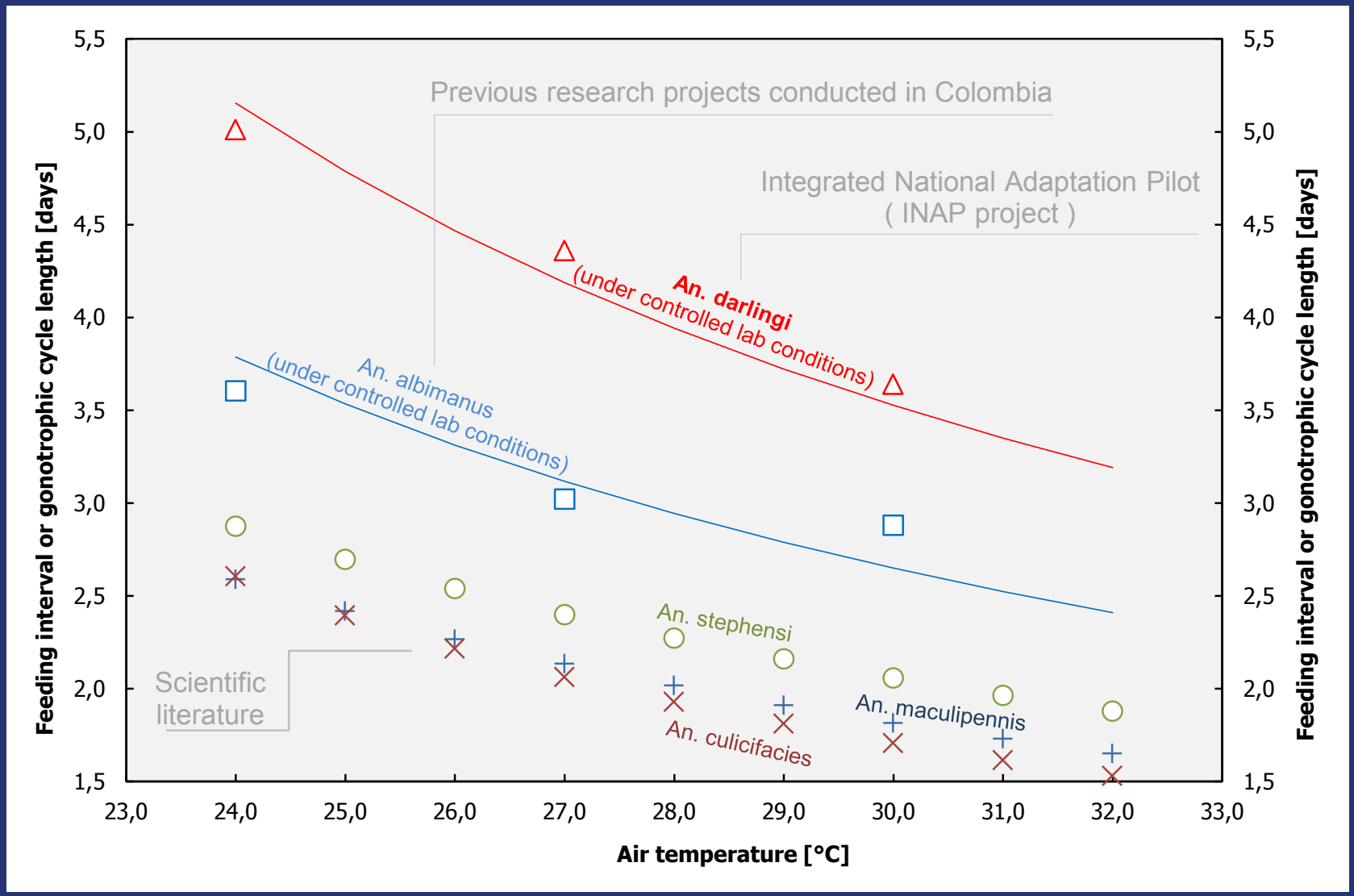


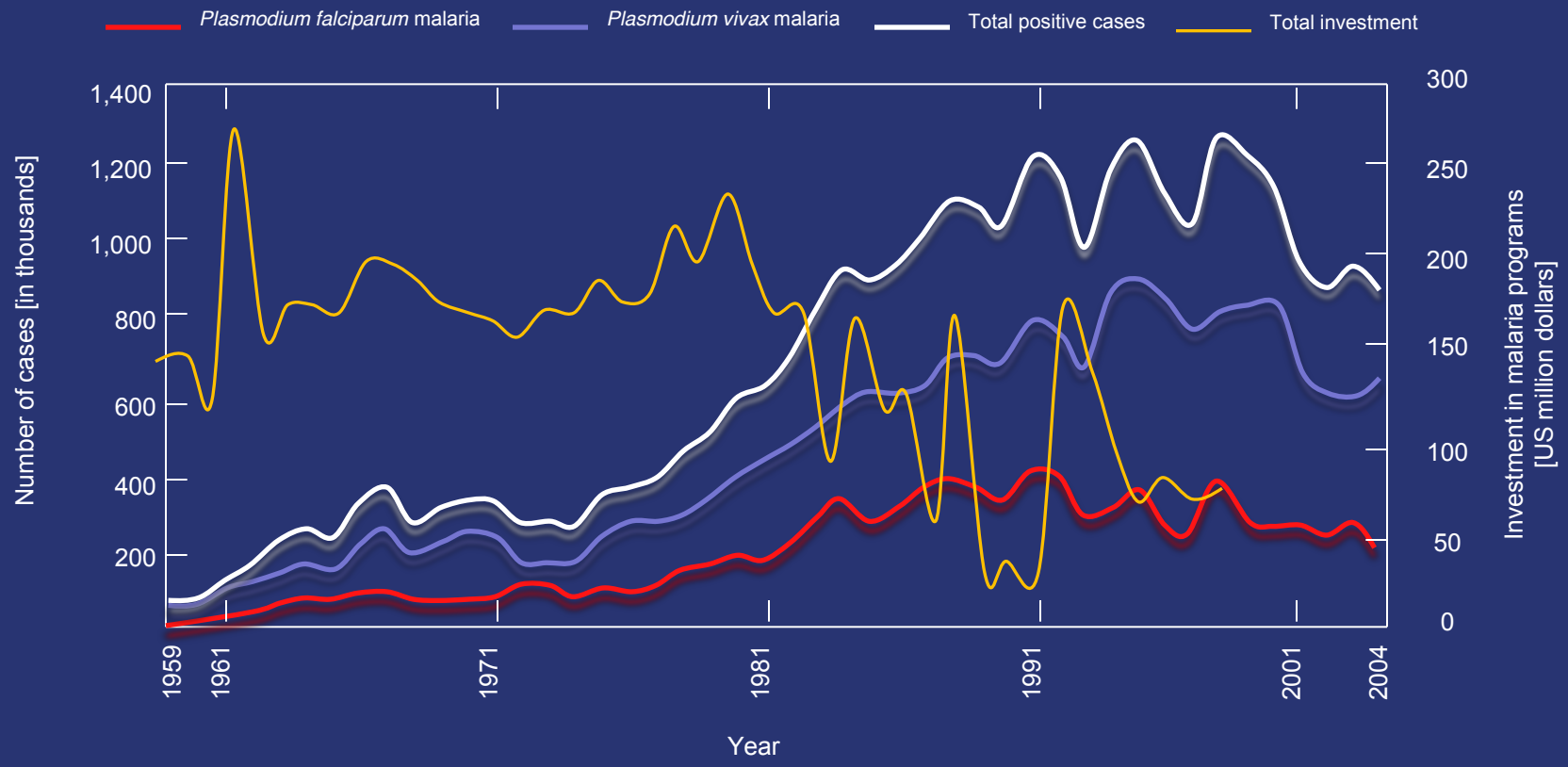
(From Martens 1997)

GONOTROPHIC CYCLE LENGTH UNDER CONTROLLED LABORATORY CONDITIONS



MALARIA IN THE AMERICAS

As of 2004, approx. 264 M individuals, out of estimated 869 M inhabitants of the Americas (i.e. **30%**), lived in areas at ecological risk of malaria transmission



Source: Regional Strategic Plan for Malaria in the Americas 2006-2010 (PAHO) and processed by Ruiz (2011) and Malaria Control in the Americas 1958 – 1999 (Mendez-Galvan, 2006)

EAST AFRICAN HIGHLANDS

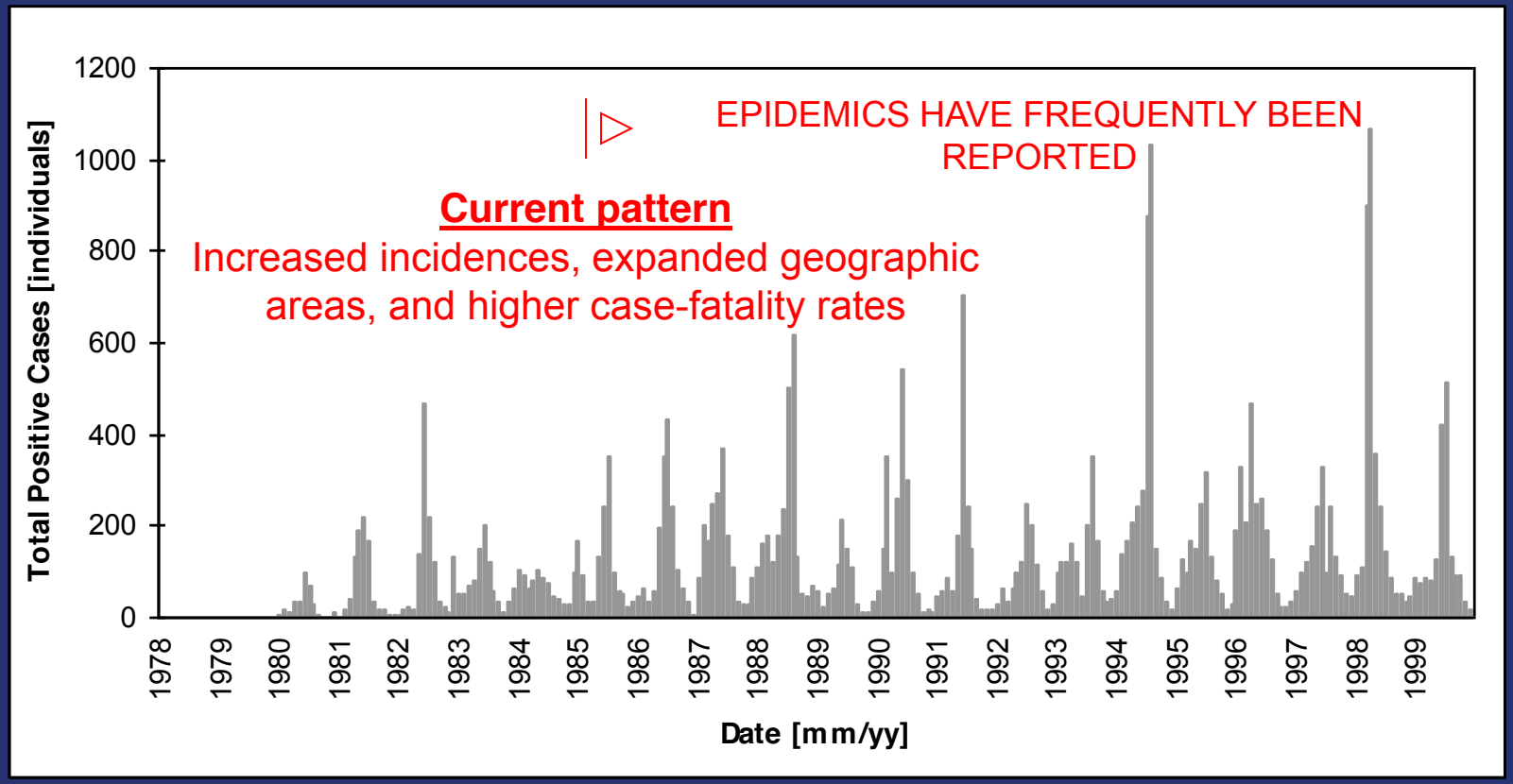
LONG FREE OF MALARIA

SPORADIC MALARIA OUTBREAKS

OUTBREAKS WERE NOT REPORTED

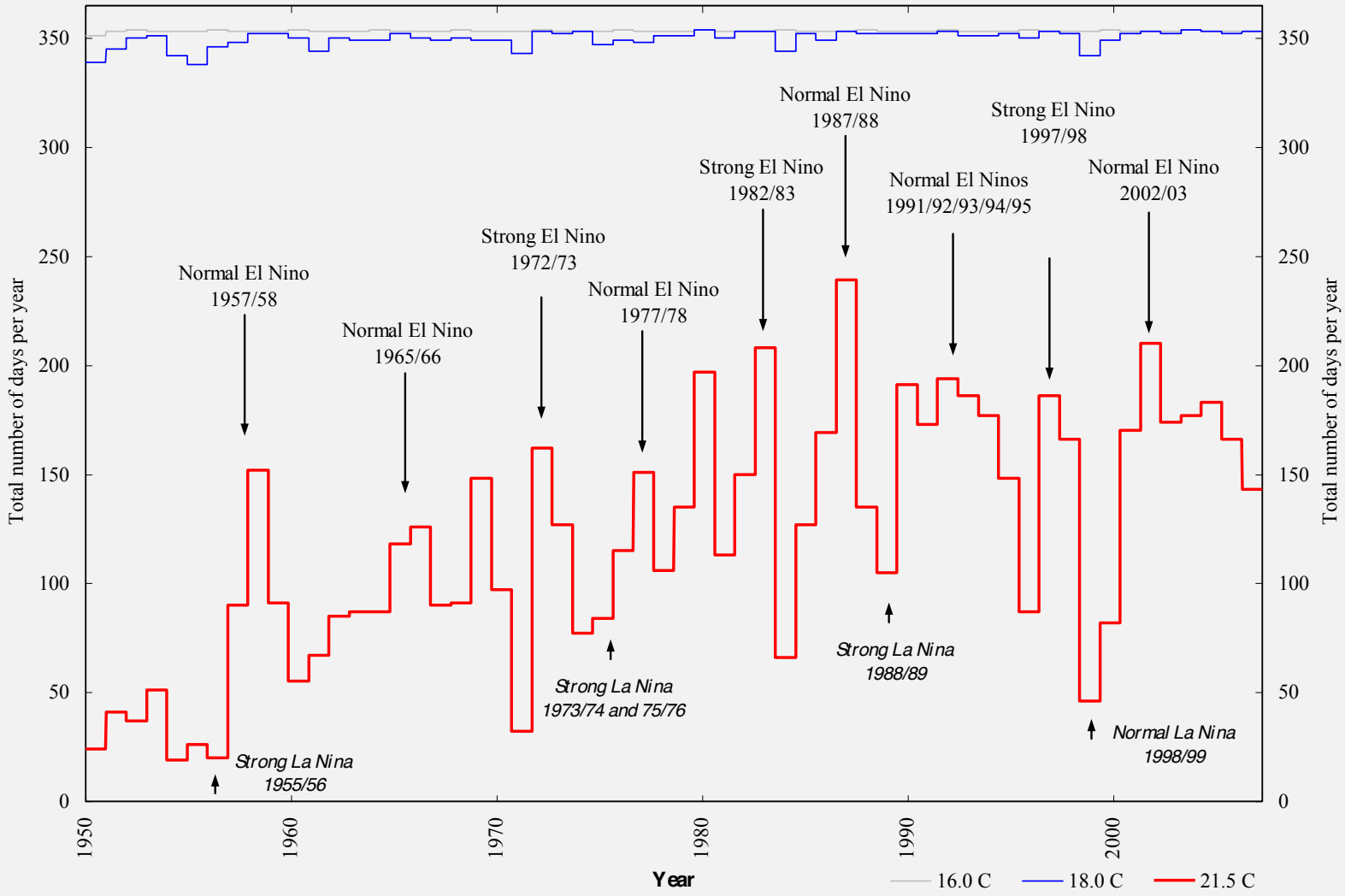
1910 1920 1950 1960 1980

MALARIA ERADICATION CAMPAIGN

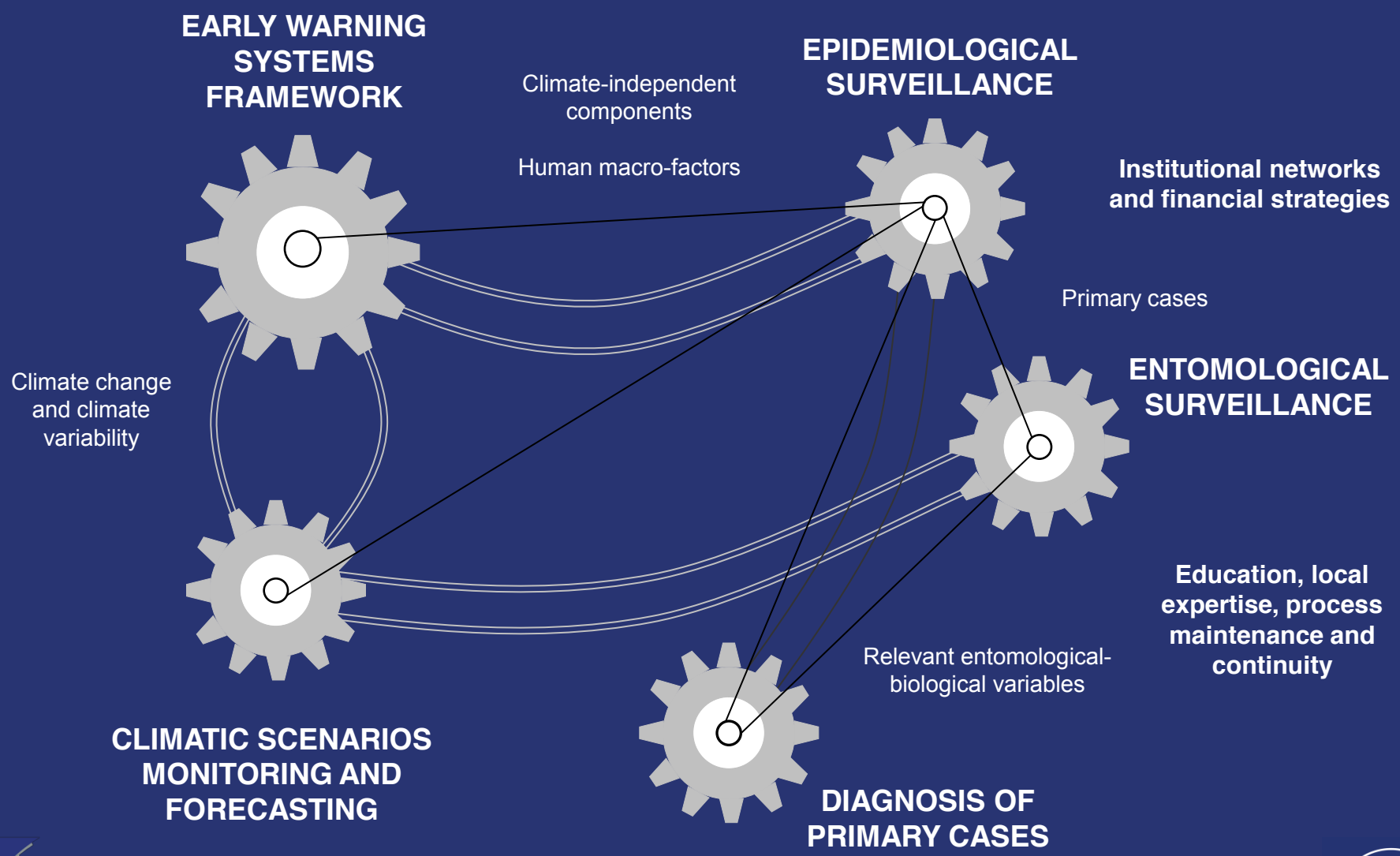


KDH village, Kisii District, Western Kenya

TOTAL NUMBER OF DAYS PER YEAR WHEN MEAN AMBIENT TEMPERATURES, OBSERVED AT 1,310 masl, WERE ABOVE 16.0°C (GREY SOLID LINE), 18.0°C (BLUE SOLID LINE), AND 21.5°C (RED SOLID LINE)



COLOMBIAN INTEGRATED SURVEILLANCE AND CONTROL SYSTEM



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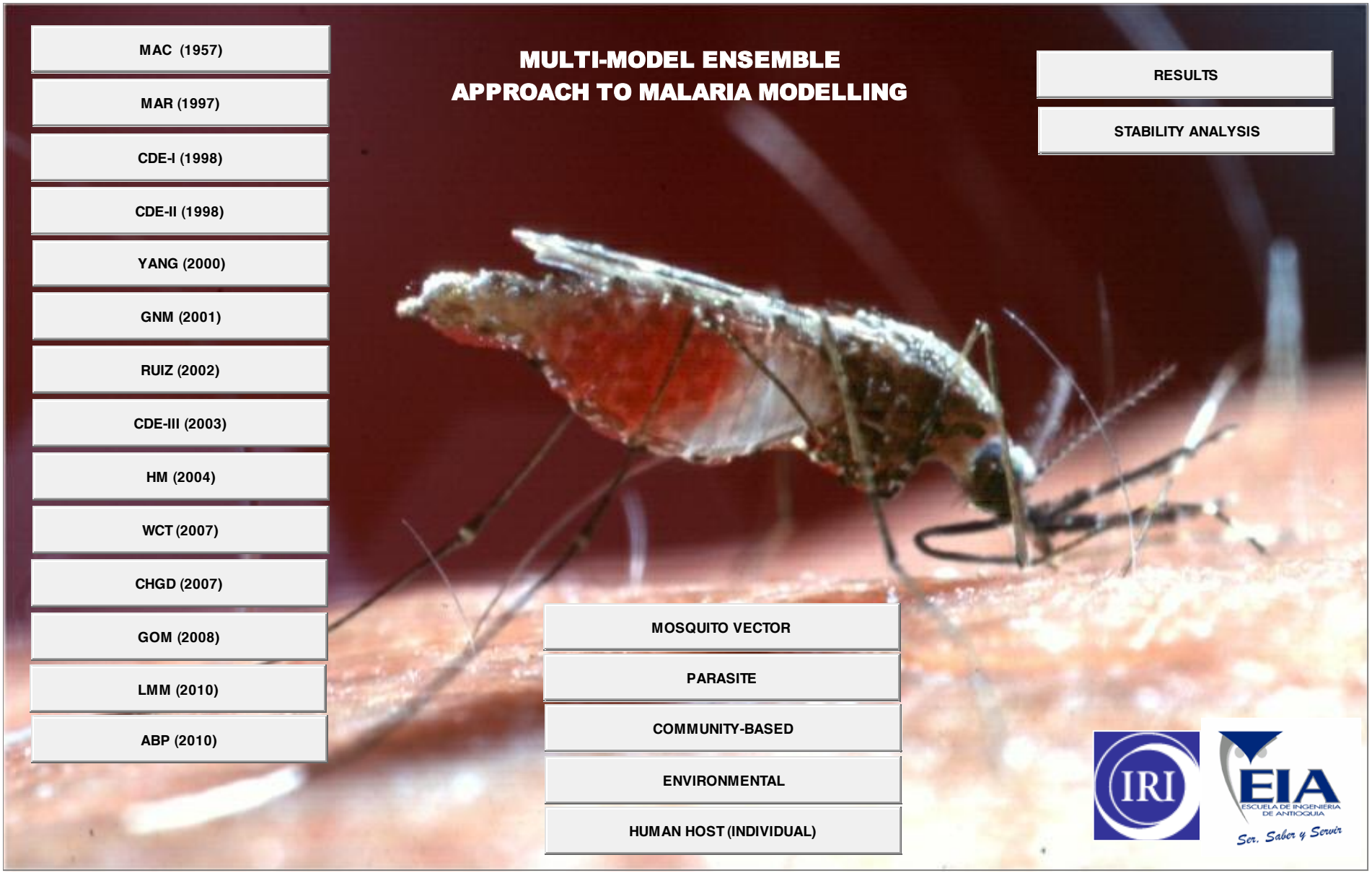
MULTI-MODEL ENSEMBLE APPROACH TO MALARIA MODELLING



- MAC (1957)
- MAR (1997)
- CDE-I (1998)
- CDE-II (1998)
- YANG (2000)
- GNM (2001)
- RUIZ (2002)
- CDE-III (2003)
- HM (2004)
- WCT (2007)
- CHGD (2007)
- GOM (2008)
- LMM (2010)
- ABP (2010)

- MOSQUITO VECTOR
- PARASITE
- COMMUNITY-BASED
- ENVIRONMENTAL
- HUMAN HOST (INDIVIDUAL)

- RESULTS
- STABILITY ANALYSIS

IRI

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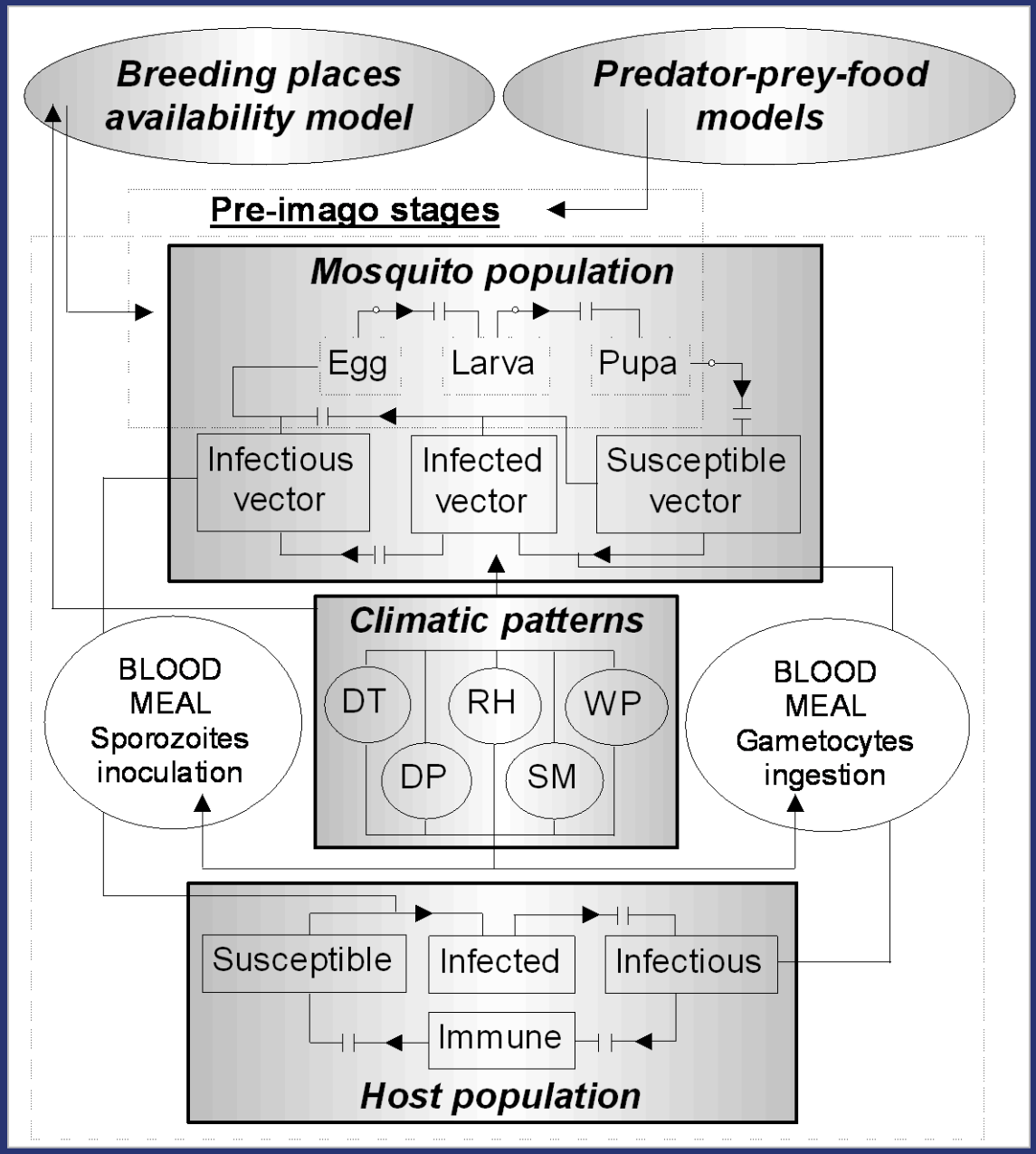


RUIZ *et al.* (2002)

ABP 2010

HUMAN HOSTS

$$\dot{S}(t) = B - \beta S(t) + \sigma R(t) - \delta_H S(t) + \rho C(t)$$

$$\dot{E}(t) = \beta S(t) - \delta_H E(t) - \gamma E(t)$$

$$\dot{I}(t) = (1-\xi)\gamma E(t) - \eta \beta I(t) + \nu C(t) - r I(t) - \Psi I(t) - \delta_H I(t)$$

$$\dot{R}(t) = r I(t) - \sigma R(t) - \delta_H R(t)$$

$$\dot{C}(t) = \xi \gamma E(t) + \eta \beta I(t) - \nu C(t) - \rho C(t) - \alpha C(t) - \delta_H C(t)$$

MOSQUITOES

$$\dot{K}(t) = k_A P - k_E K(t)$$

$$\dot{L}(t) = f[X(t) + V(t) + W(t)]\left(\frac{K(t) - L(t)}{K(t)}\right) - \delta_L L(t) - d_L L(t)$$

$$\dot{X}(t) = -c\,a\,y(t)\,X(t) - \delta_M X(t) + d_L L(t)$$

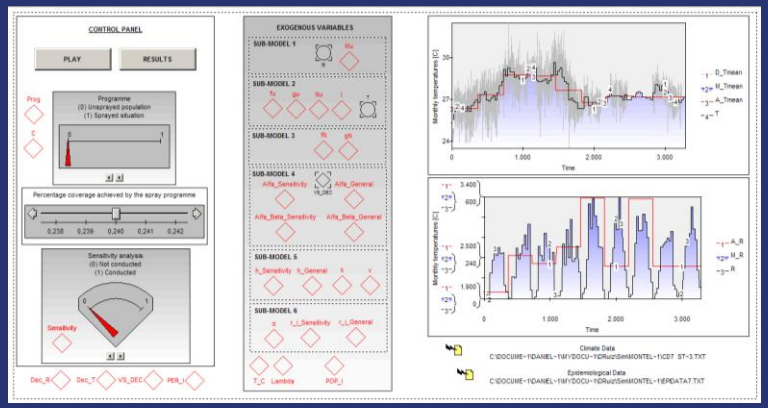
$$\dot{V}(t) = +c\,a\,y(t)\,X(t) - \gamma_P V(t) - \delta_M V(t)$$

$$\dot{W}(t) = \gamma_P V(t) - \delta_M W(t)$$

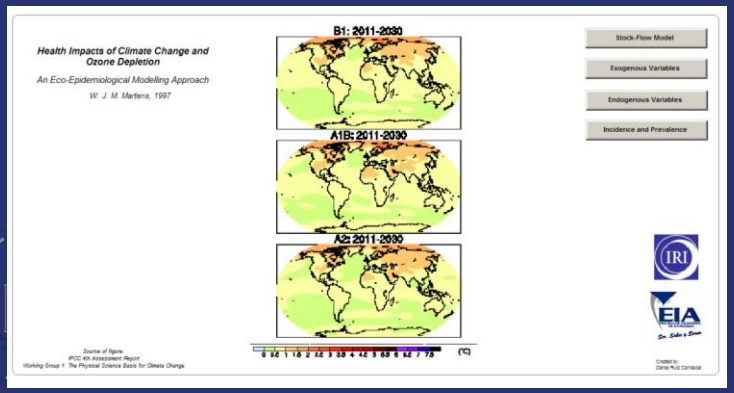
SEVEN (7) INTERACTIVE PLATFORMS

SimulMal - PowerSim

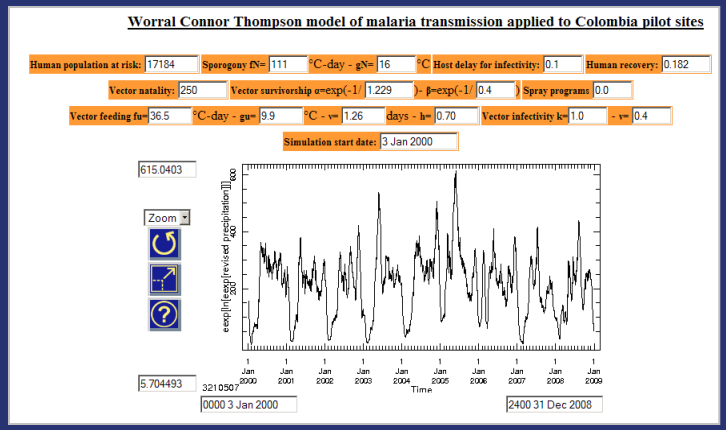
WCT – PowerSim & MS Excel versions



MAR – PowerSim

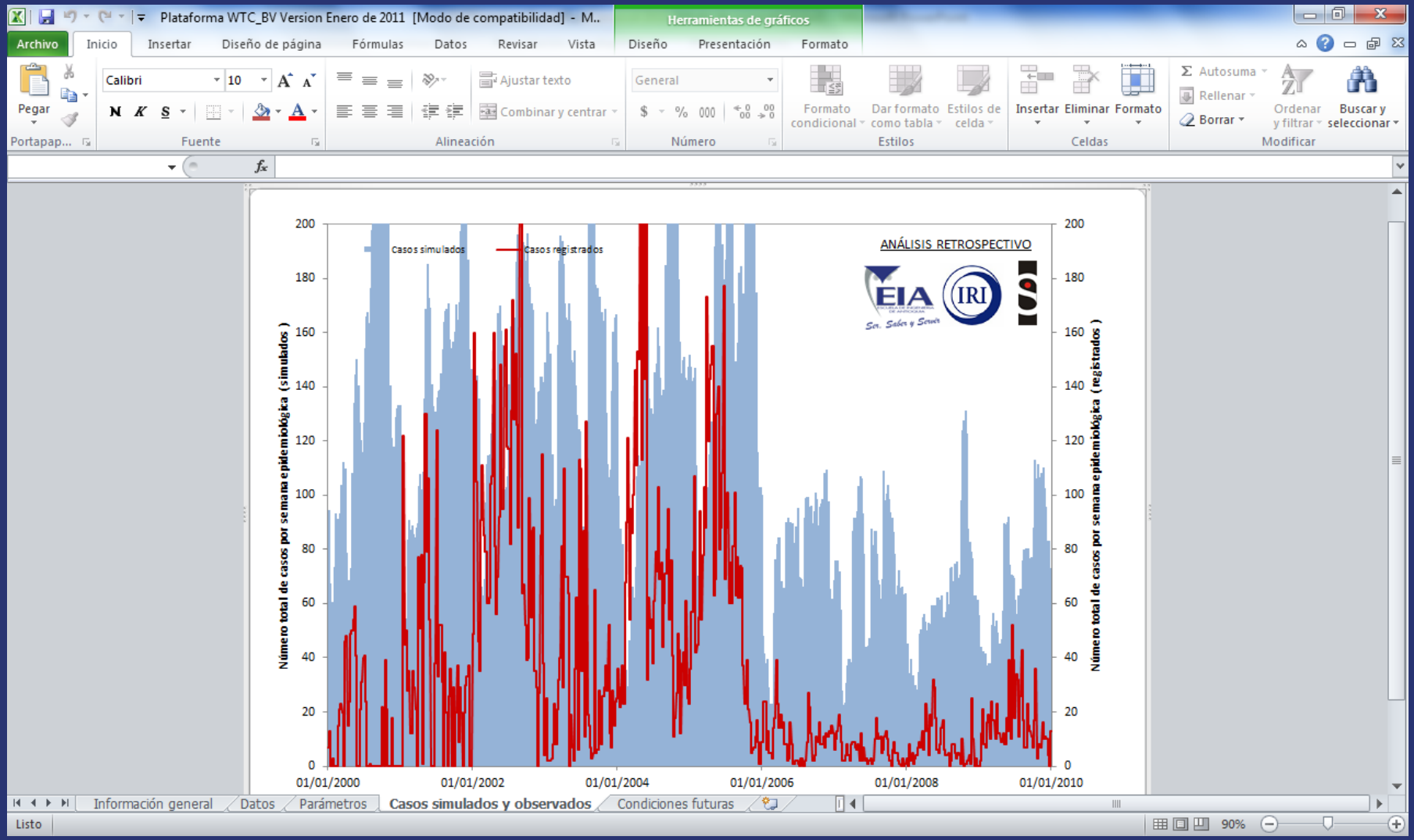


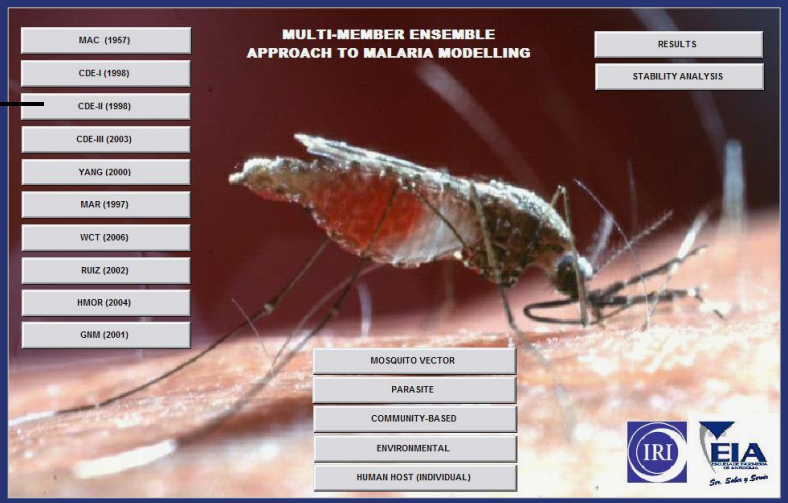
WCT – IRI online tool



MME09 Exe and Full versions

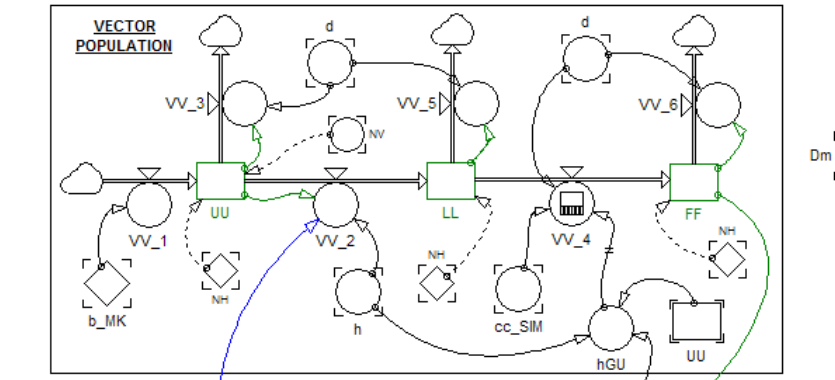
WCT – Microsoft Office Excel 2007 (for Microsoft Windows Vista Home Basic®)

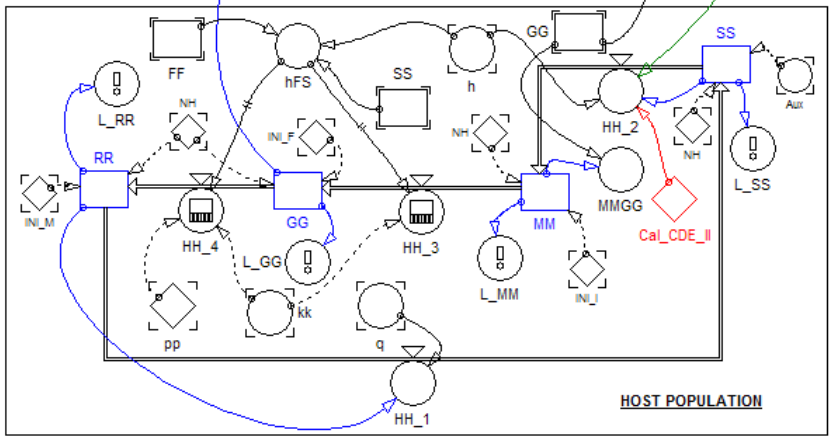


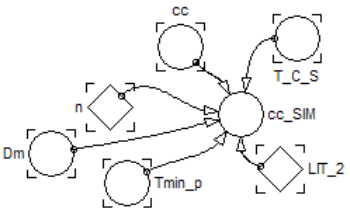


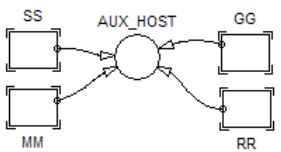
(From Ruiz 2008)

CDE-II









Level variables

UU : Proportion of susceptible vectors.
LL : Proportion of infected vectors.
FF : Proportion of infectious vectors.

SS : Proportion of susceptible humans.
MM : Proportion of infected humans.
GG : Proportion of infectious humans.
RR : Proportion of immune humans.

MME

STABILITY ANALYSIS

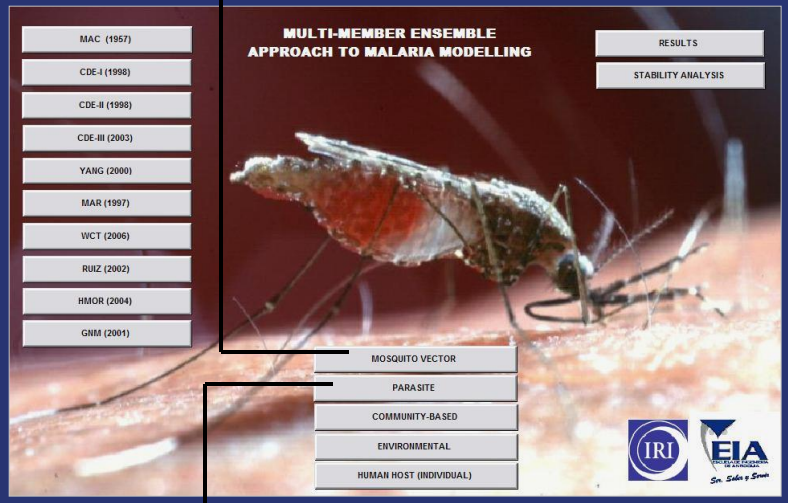
RESULTS

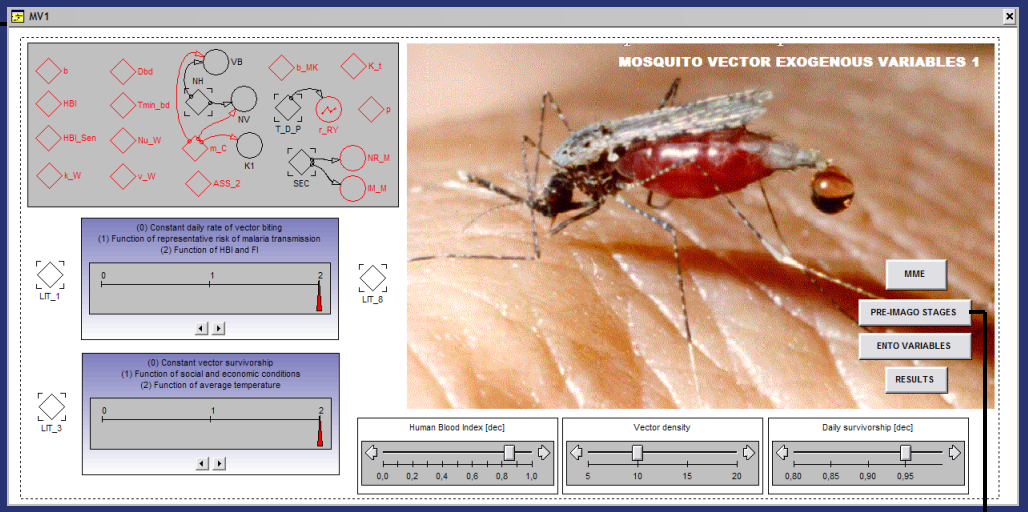
RESULTS 2

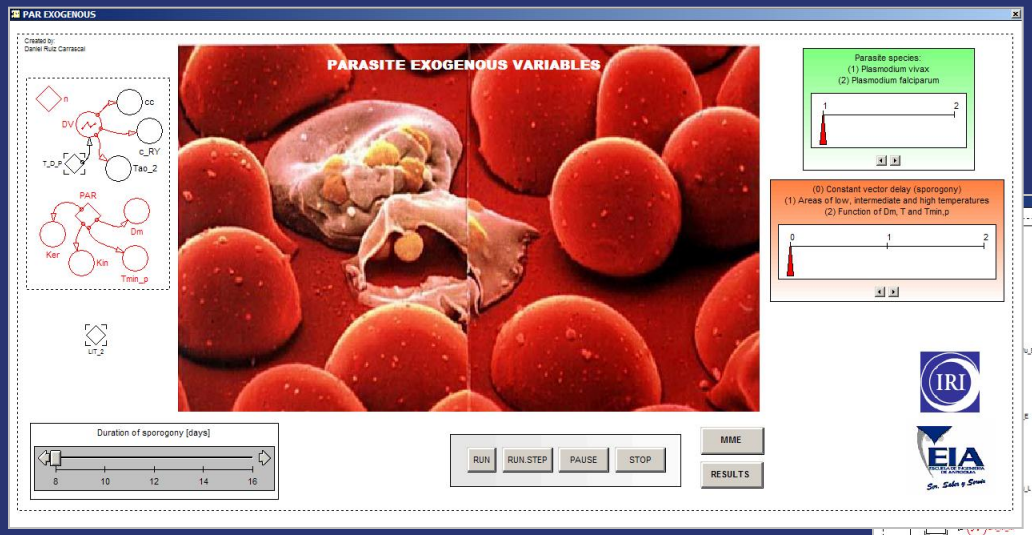
Main endogenous variables

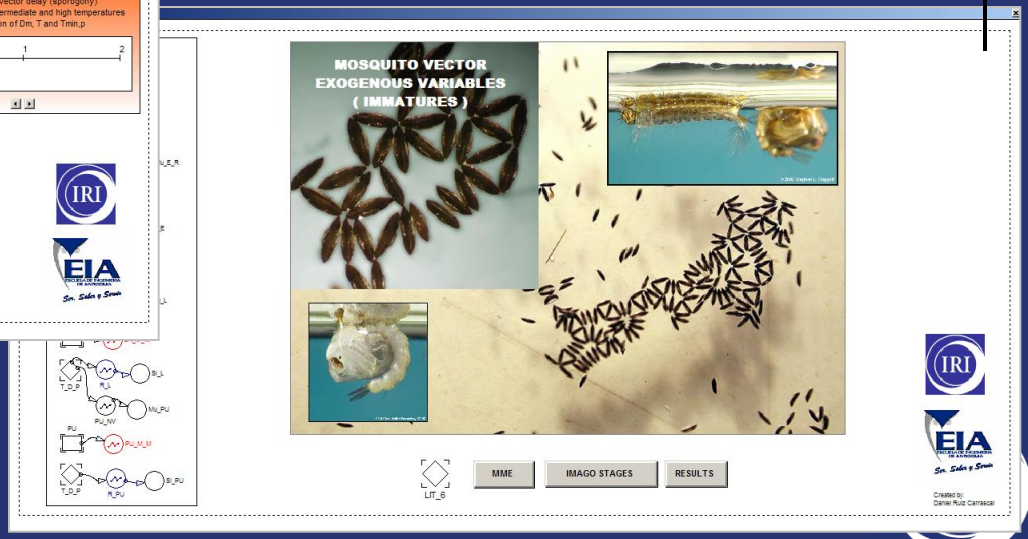
cc : Time delay between infected and infectious mosquitoes.
d : Daily rate of vector mortality.
hFS : Delayed variable between infected, infectious and immune host reservoirs.
hGU : Delayed variable between infected and infectious vector reservoirs.
kk : Time delay between infected and infectious hosts.
pp : Time delay included between infectious and immune hosts.
q : Flow rate between immune and susceptible hosts.
MMGG : Overall malaria prevalence.

Differential-delay-equation 'comparment' model discussed by McKenzie et al. (1998)









(From Ruiz 2008)

COMMUNITY-BASED VARIABLES

(×) POOR

(~) PARTIAL

(√) GOOD

LEVEL OF UNDERSTANDING

DEMOGRAPHIC CENSUS

CONDUCTED (OR ABSENT) CONTROL CAMPAIGNS

DESCRIPTION OF SURVEILLANCE ACTIVITIES

(…)

TOTAL HUMAN POPULATION AT RISK

HUMAN POPULATION GROWTH RATE

TOTAL MALARIA POSITIVE CASES

DESCRIPTION OF PARTICULARITIES

DESCRIPTION OF PREVAILING SEC

(…)

(…)

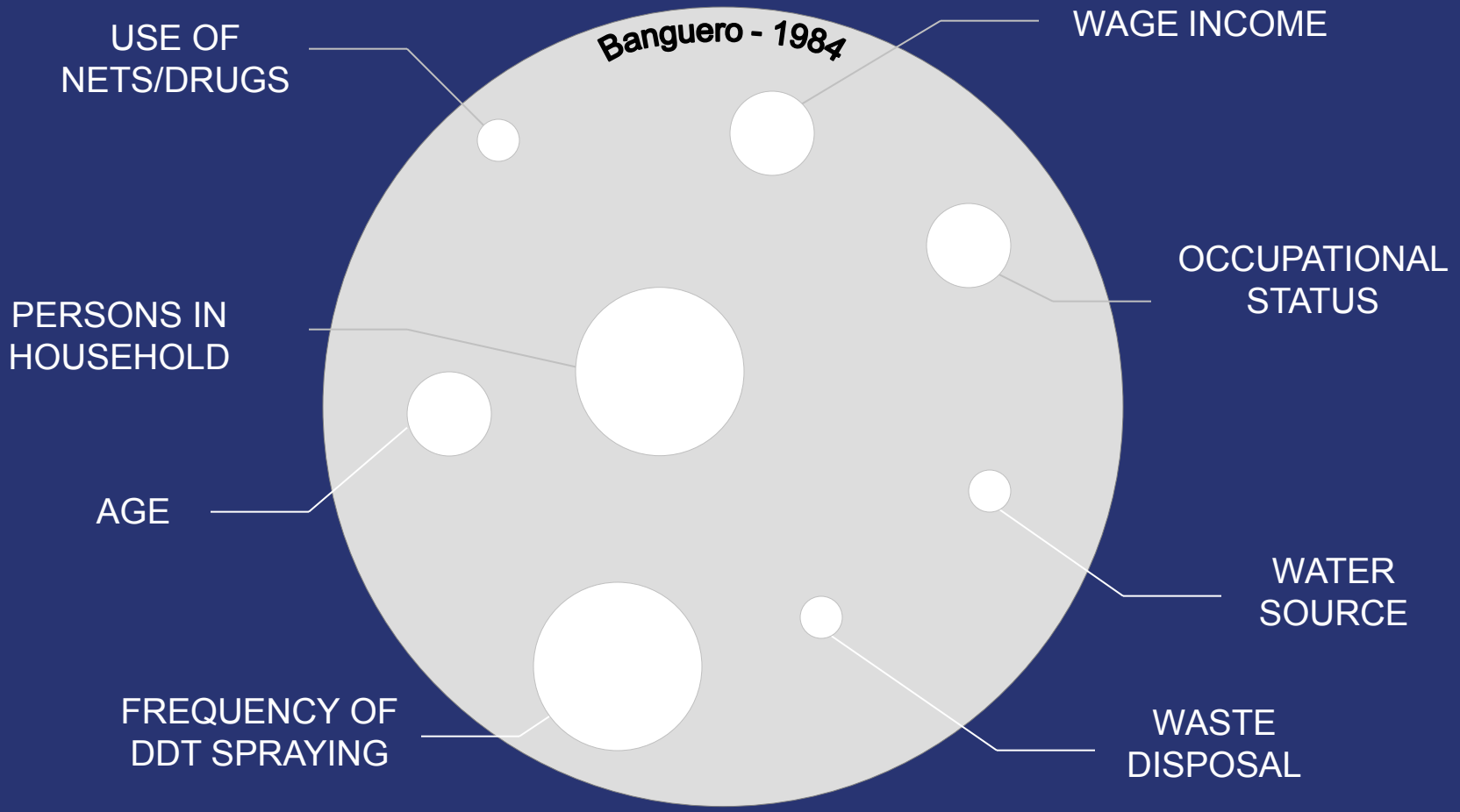
(…)

Total individuals living in rural areas

Total individuals living in urban areas

INDICATIVE REVIEW OF SOCIOECONOMIC FACTORS

Banguero (1984) Castilla & Sawyer (1993) Koram *et al*. (1995)



(source: Ruiz and Gellers, 2007)

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HOW DO WE PROCEED AND WHAT DO WE HAVE SO FAR?

CURRENT CAPABILITIES

UNDERSTAND COMPLEXITY

ESTIMATE TIMING AND SEVERITY

ANALYZE KEY-VARIABLES

POSE AND ANSWER "WHAT IF" QUESTIONS

INVESTIGATE CURRENT DECISION MAKING PROCESS AND PROVIDE QUANTITATIVE GOALS FOR EFFECTIVE INTERVENTIONS

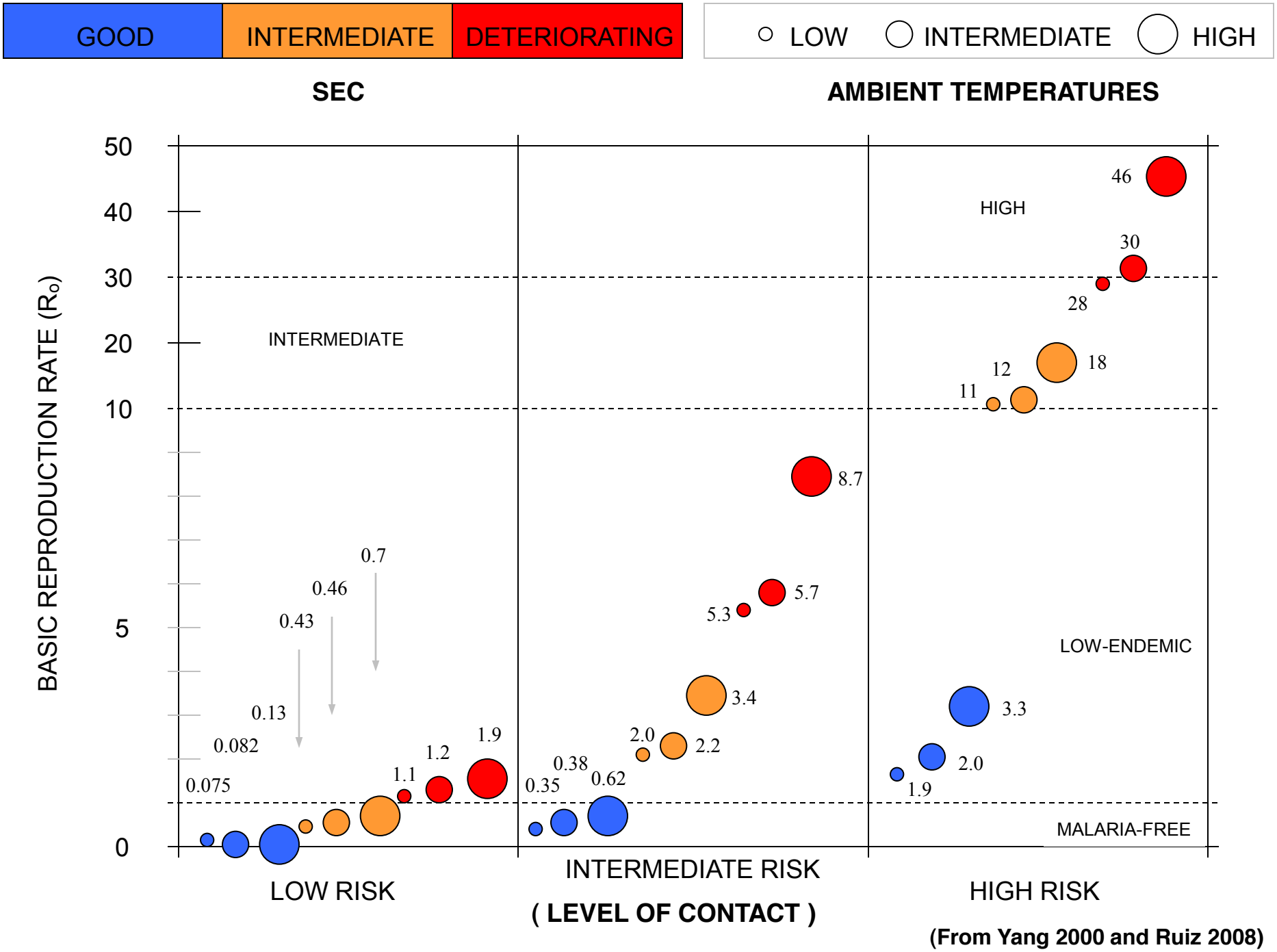
HELP DECISION MAKERS LEARN

EXPERIMENTATION-VALIDATION-ANALYSIS

FORESEEABLE FUTURE

CLIMATE FORECASTS

DECISION-MAKING PROCESSES



(From Yang 2000 and Ruiz 2008)

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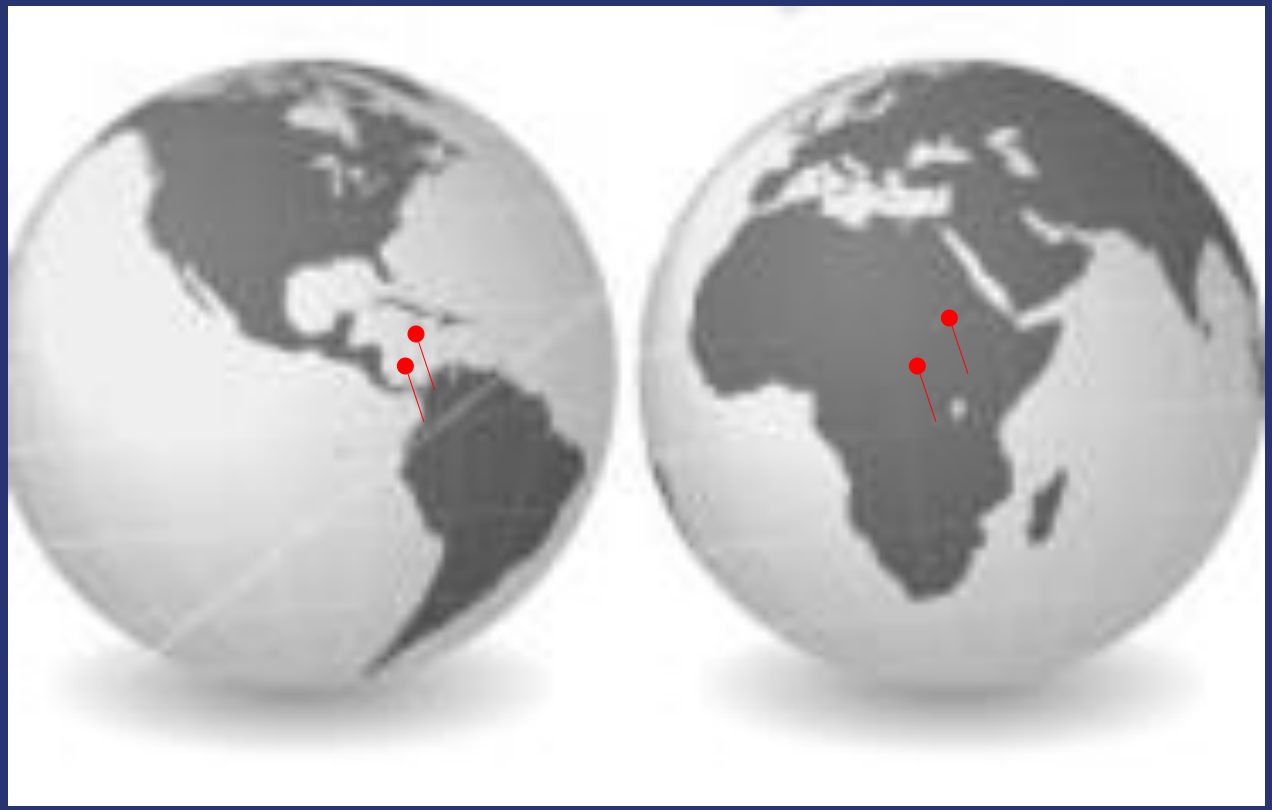
1998 1999 2000 2001 2002 2003 2004 2005 2006

NUQUÍ, COLOMBIAN PACIFIC COAST

EL BAGRE, COLOMBIAN CARIBBEAN COAST

DISTRICT OF KISII, KENYAN HIGHLANDS

DISTRICT OF CHOBE, NORTHERN BOTSWANA



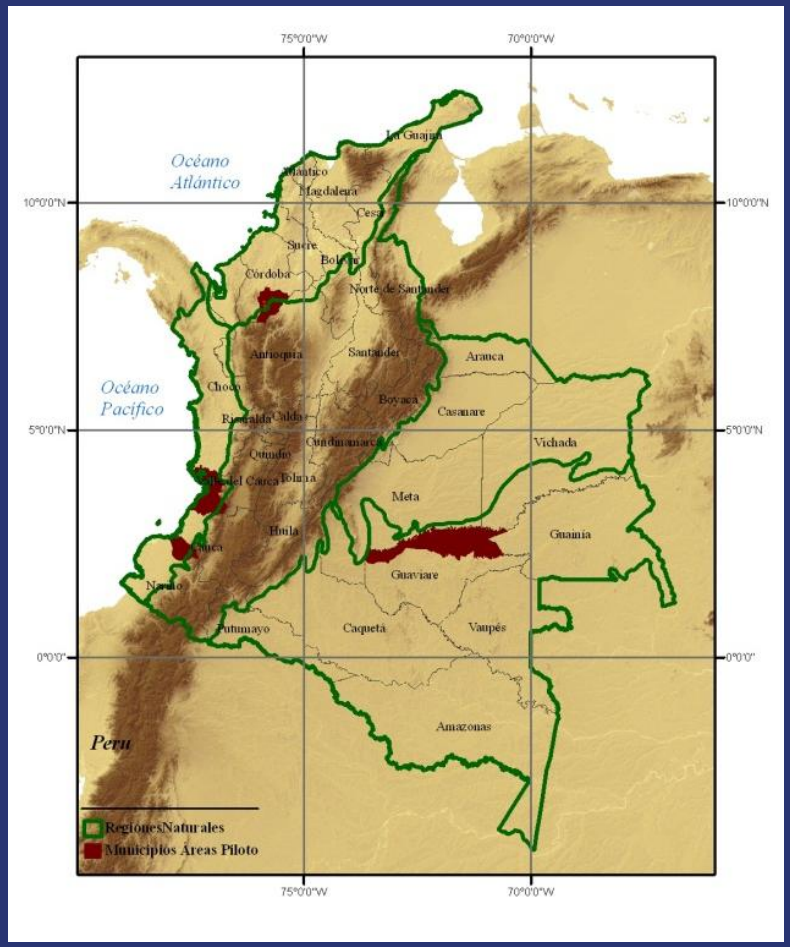
2006 2007 2008 2009 2010 2011

DISTRICT OF KERICHO, KENYAN HIGHLANDS

DISTRICT OF CHOBE, NORTHERN BOTSWANA

MUNICIPALITIES OF MONTELIBANO, PUERTO LIBERTADOR, BUENAVENTURA, AND SAN JOSE DEL GUAVIARE

CAUCASIA, NECHI, TIERRALTA, TURBO, VIGIA DEL FUERTE, AND YONDO



BASE SCENARIO

CHANGES IN INITIAL CONDITIONS

ANALYSIS OF LOCAL CONDITIONS

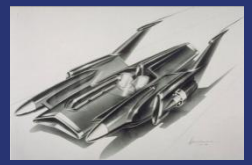
SENSITIVITY ANALYSIS

UNCERTAINTIES

PRESENT

CHANGING CLIMATE SCENARIOS

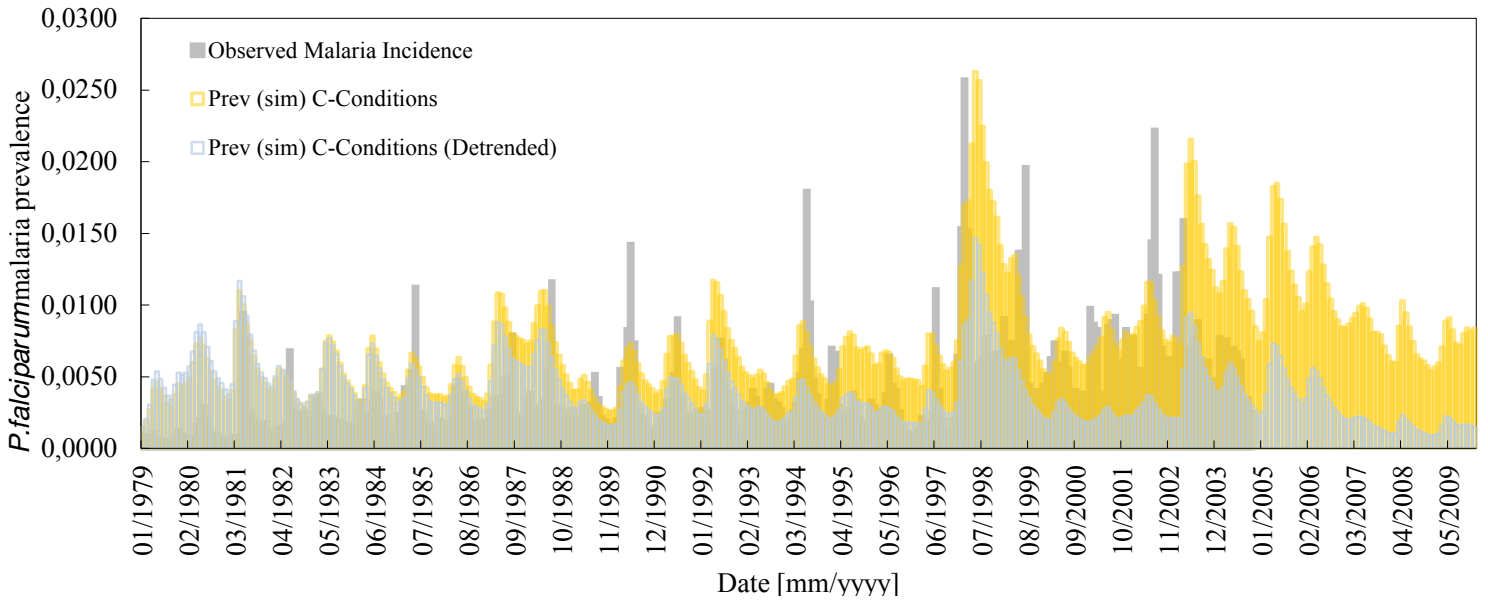
CHANGING NON-CLIMATIC FACTORS

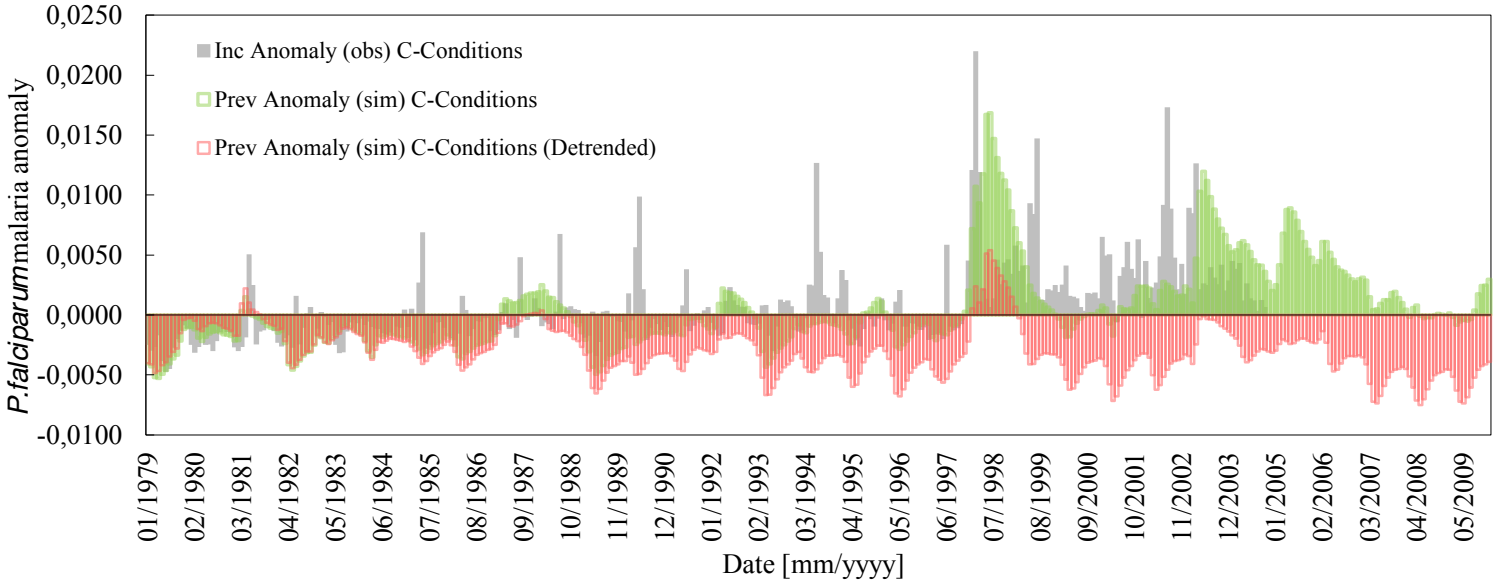


RETROSPECTIVE ANALYSES

FUTURE SCENARIOS

EAST AFRICAN HIGHLANDS, KERICHO TEA STATE, KENYA

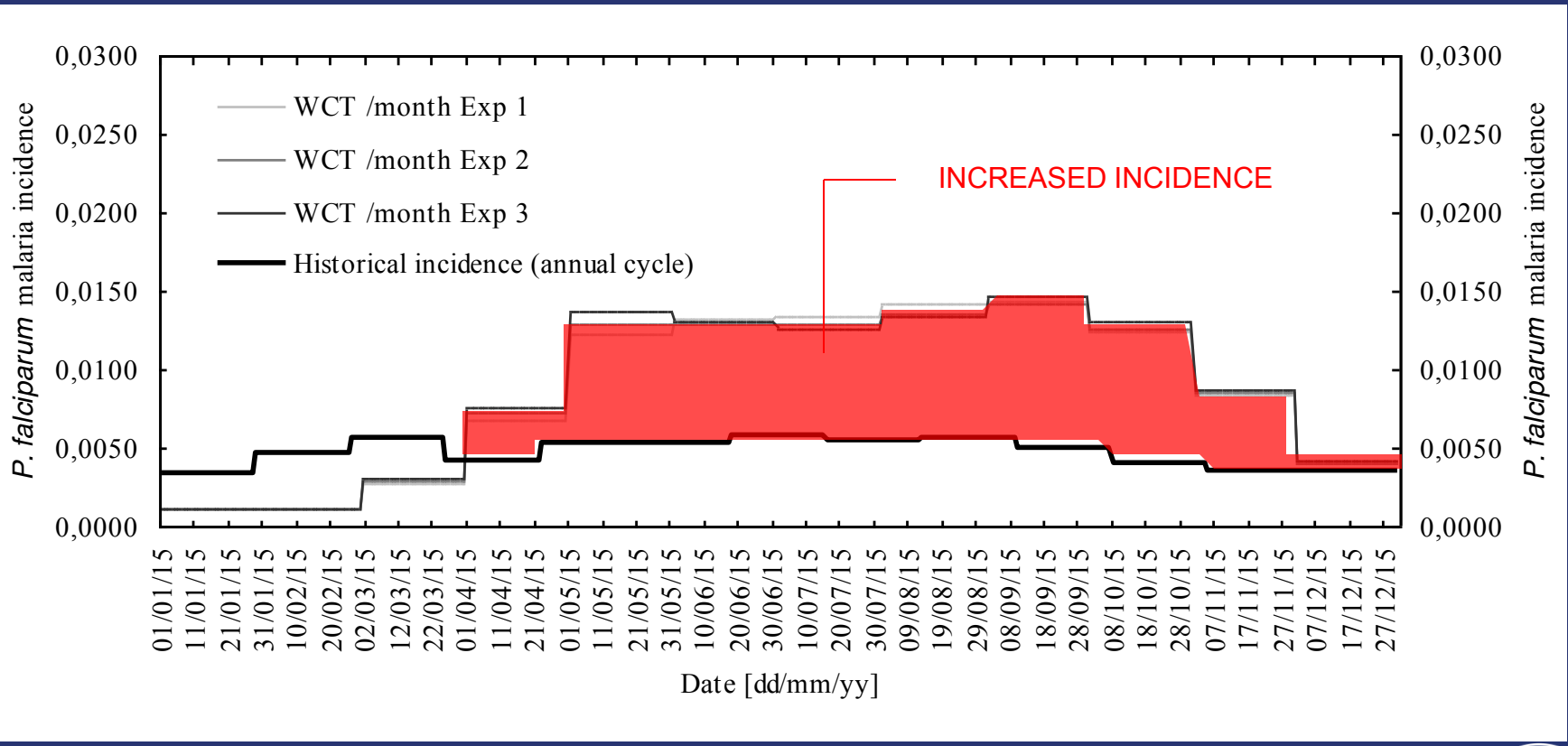




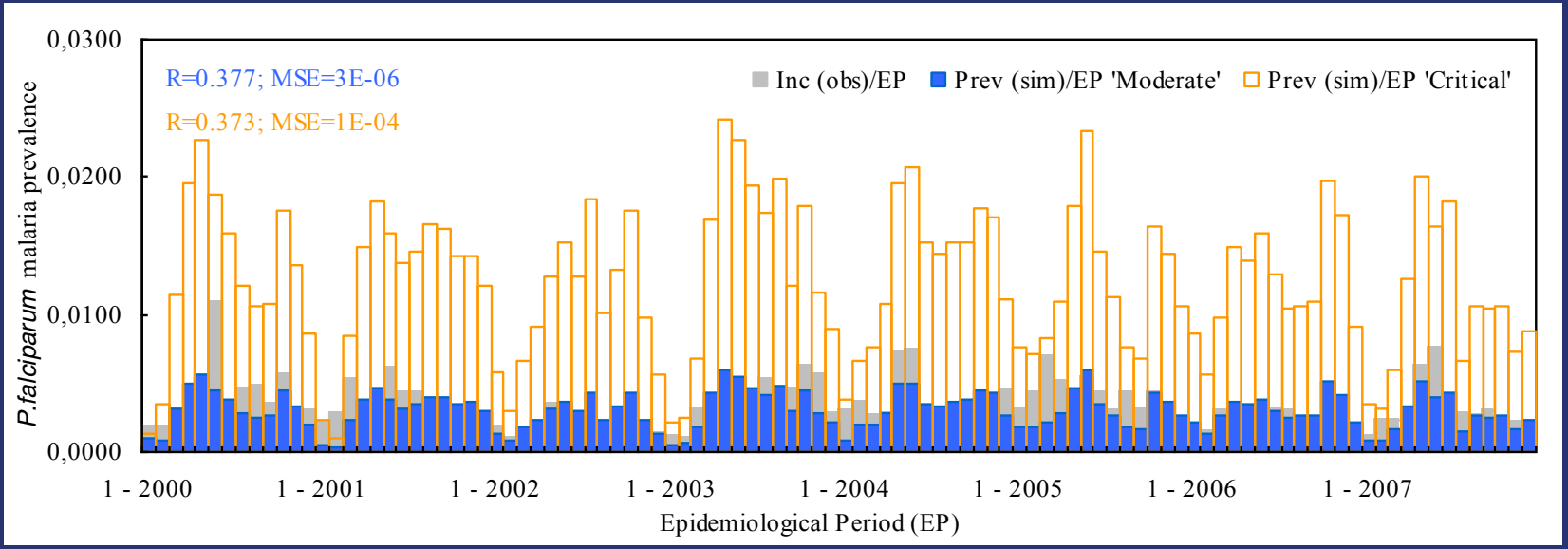
MEDIUM-TERM CLIMATE FORECAST EXPERIMENTS

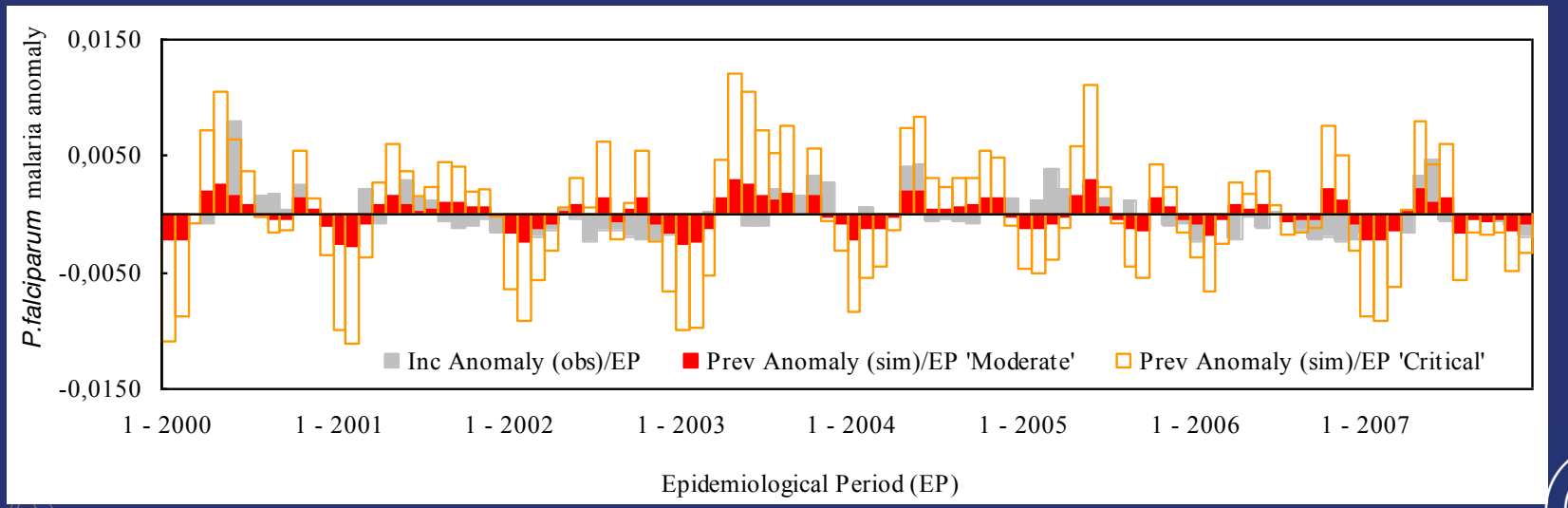
MUNICIPALITY OF MONTELÍBANO

Monthly *Plasmodium falciparum* malaria incidence suggested by the WCT model for the forecast horizon spanning from **January 01, 2015 through December 31, 2015**



SAN JOSE GUAVIARE - WCT model (MODERATE AND CRITICAL CONDITIONS)





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