The impact of climate change on the malaria risk in Africa

Volker Ermert

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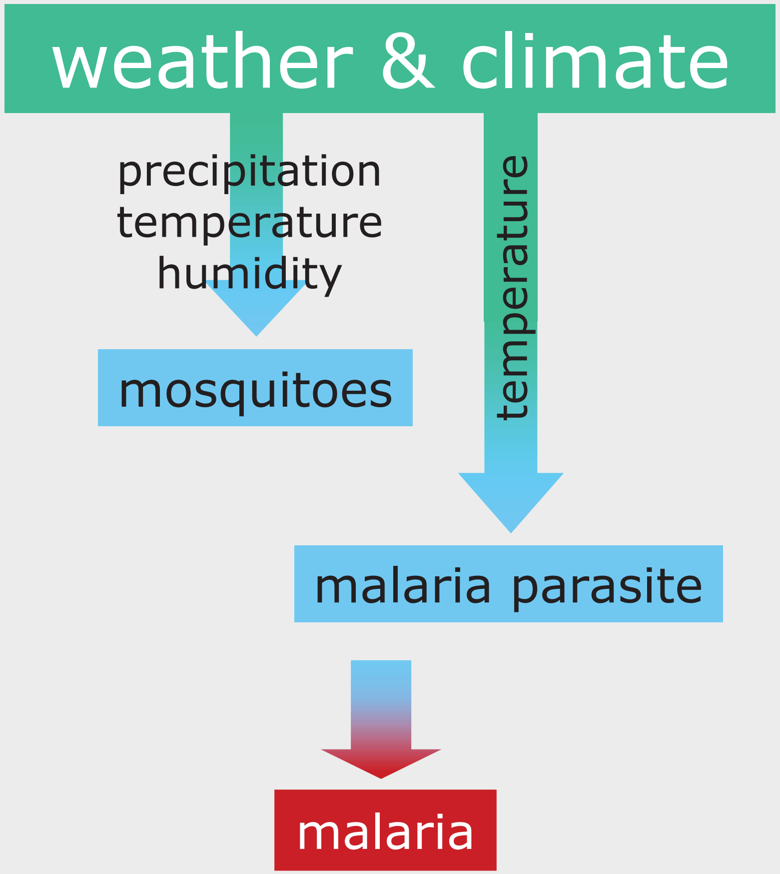
Volker Ermert, Andreas H. Fink[1], Andy P. Morse[2], Anne E. Jones[2]

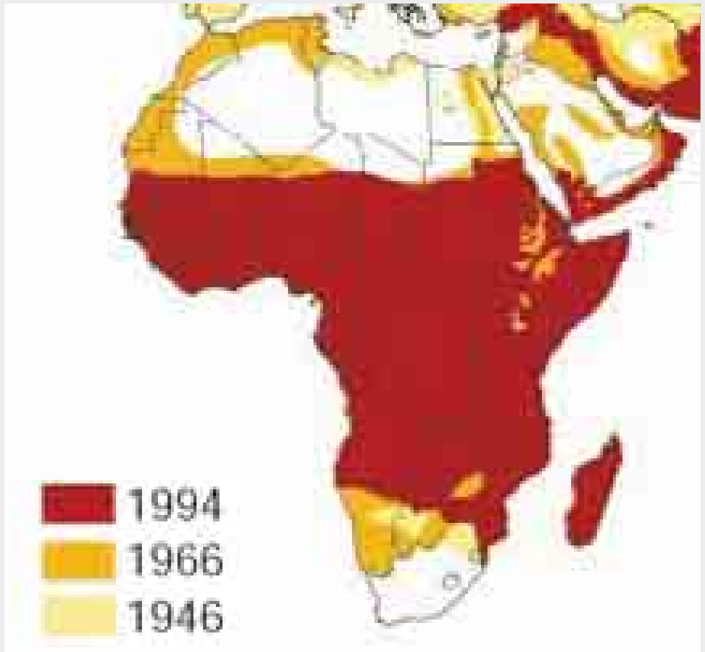
[1] Institute for Geophysics and Meteorology, University of Cologne
[2] Department of Geography, University of Liverpool

MALARIA



- > 1 million deaths each year
- 90% sub-Saharan Africa
- mostly children

Malaria risk

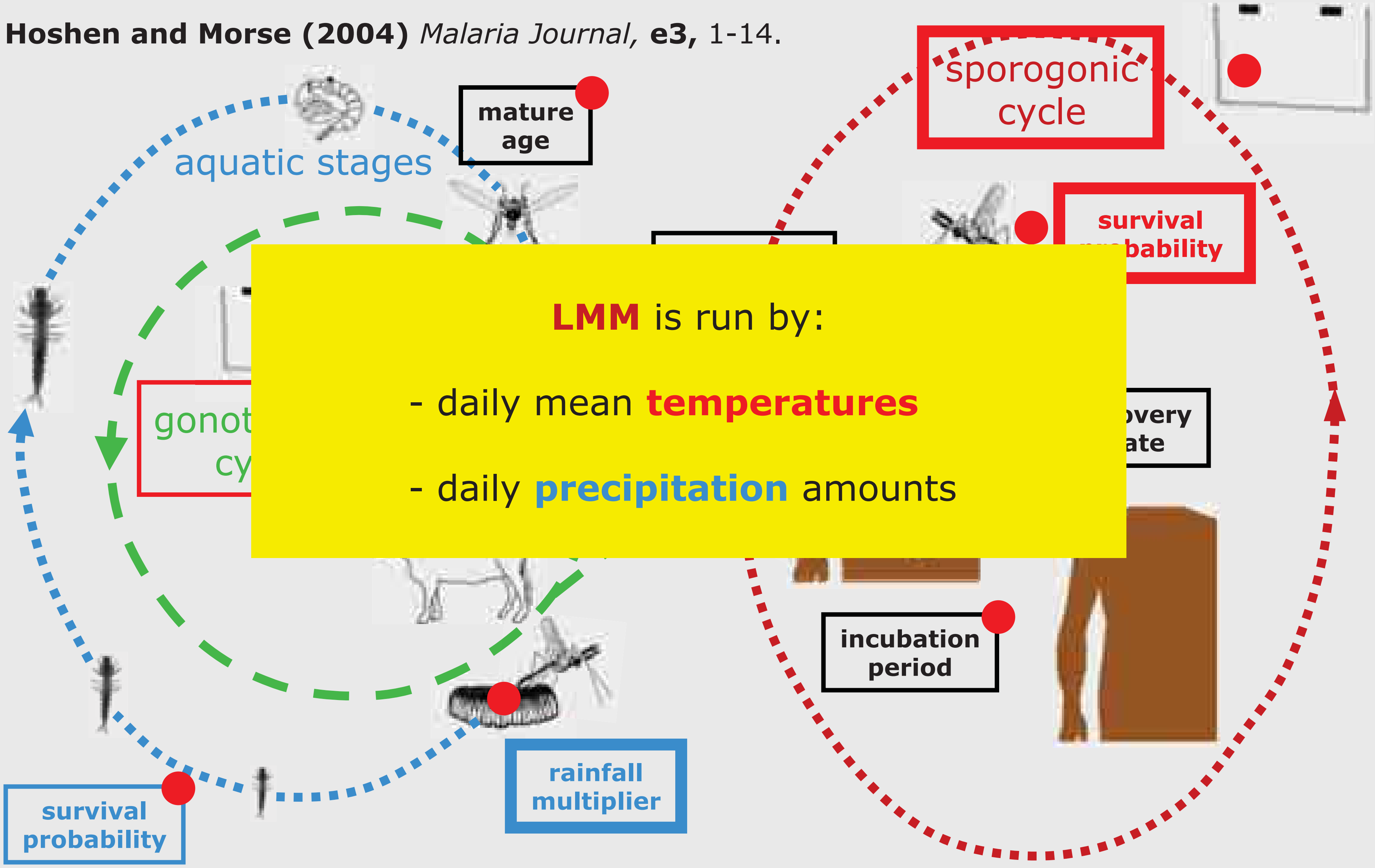


source: Sachs und Malaney (2002), *Nature*

How does the spread of malaria evolves in a warmer future climate?

„LIVERPOOL MALARIA MODEL (LMM)“

Hoshen and Morse (2004) *Malaria Journal,* **e3,** 1-14.



LMM is run by:

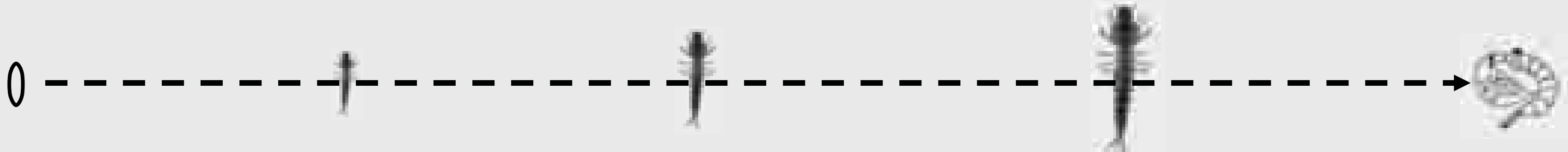
- daily mean **temperatures**
- daily **precipitation** amounts

Modification of the LIVERPOOL MALARIA MODEL (LMM)

- Literature survey ⇒ entomological & parasitological malaria data

- **egg deposition (E)**
  - number of produced eggs (**E_p**)
  - rainfall conditions ⇒ **fuzzification**

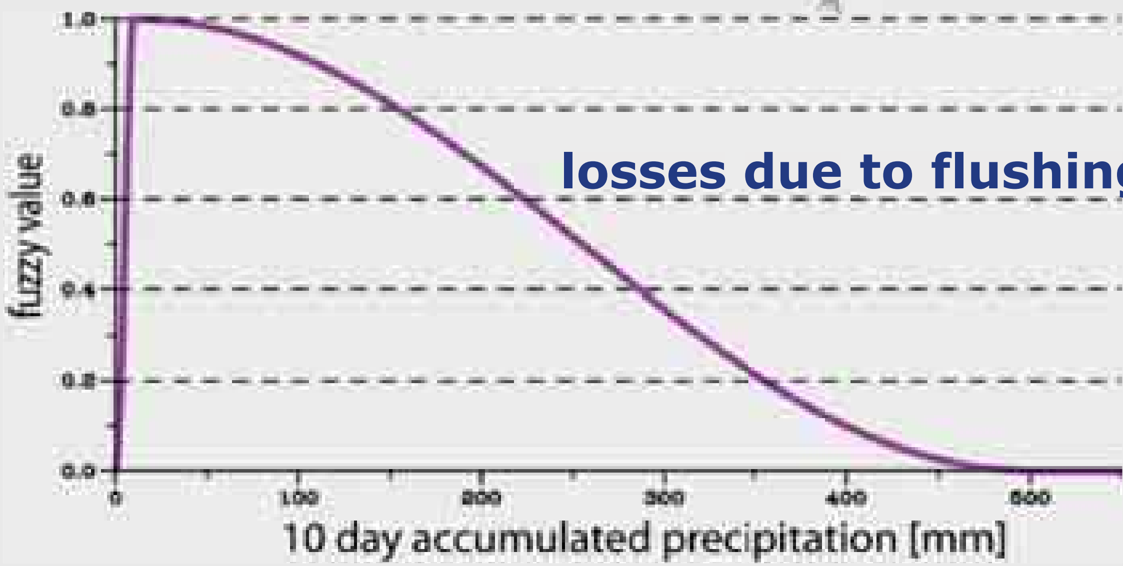
- **survival immature mosquitoes (S)**
  - max. 10% pass the egg, larval, and pupal stages ⇒ **S_{max}**
  - rainfall conditions ⇒ **fuzzification**



$E = E_p * VAL_{fuz}$

$S = S_{max} * VAL_{fuz}$

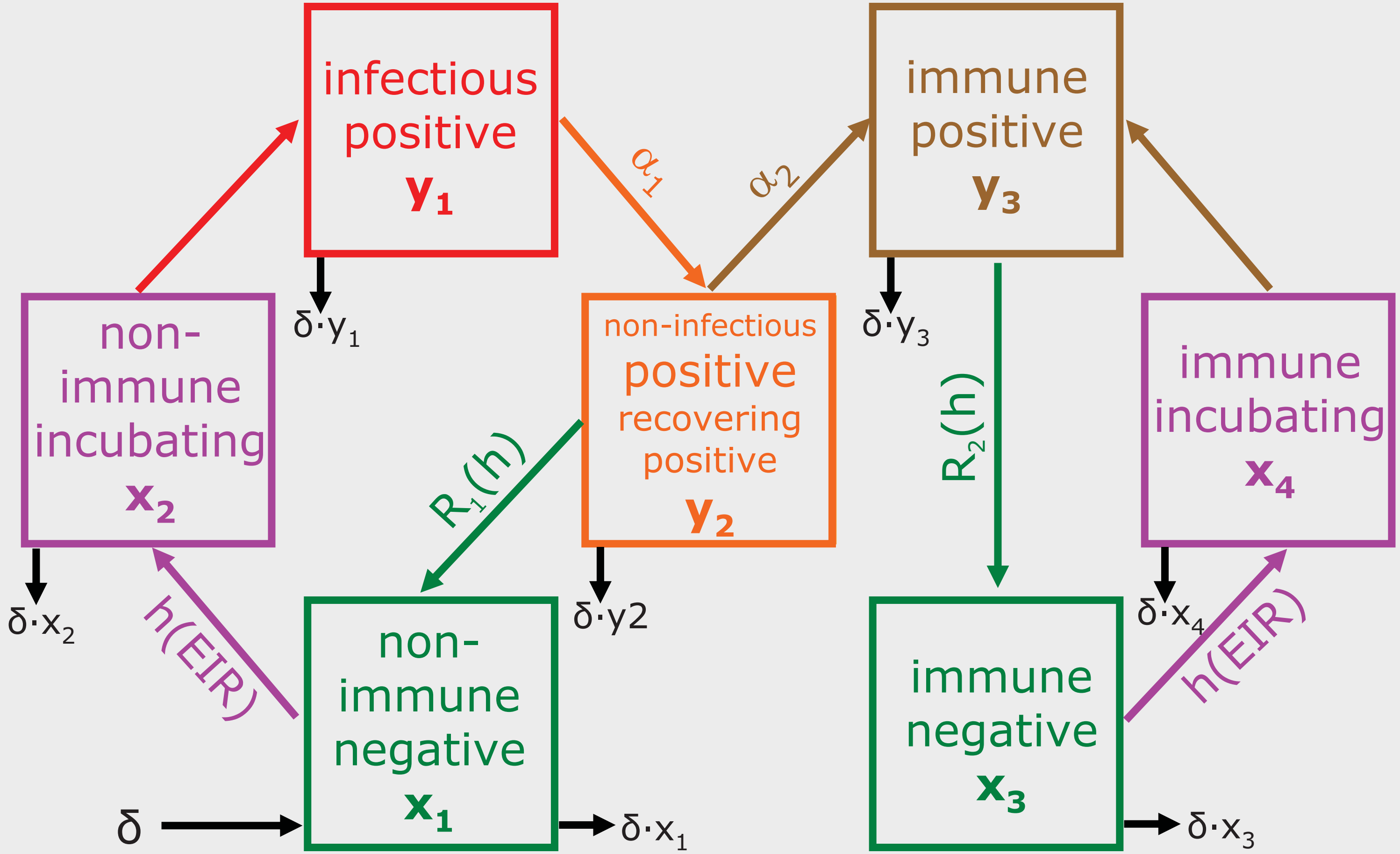
dry conditions



sigmoidal function

GARKI MODEL

- mathematical model of malaria transmission from the Garki project
- compartment model including immunity
- 7 coupled differential equations
- data input: e.g., **E**ntomological **I**noculation **R**ate (**EIR**) ← **LMM**
- simulates the **age-distribution** of the malaria prevalence



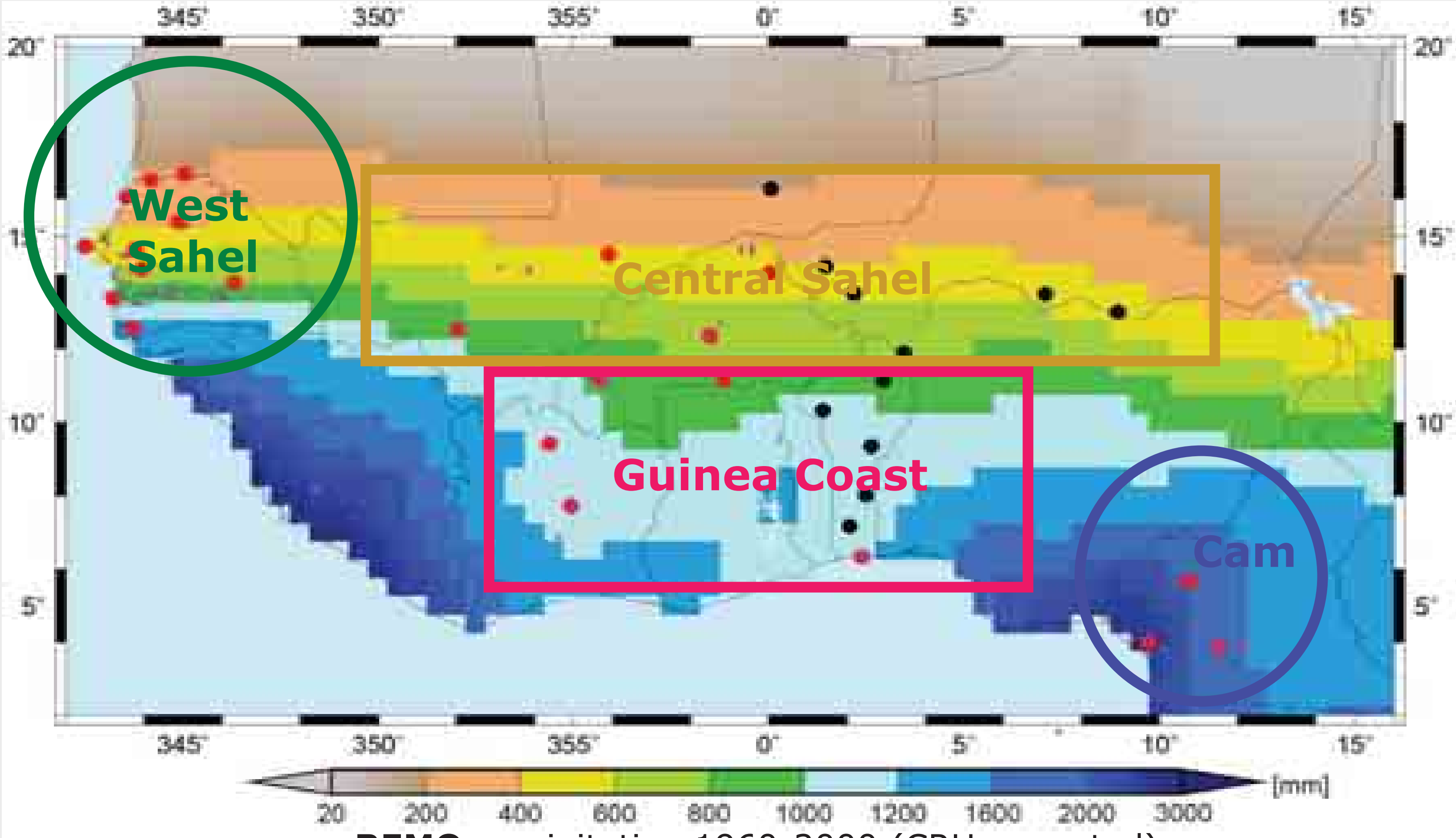
Dietz, Molineaux, & Thomas (1974) *Bull. WHO*, **50**, 347-357.

Performed LMM runs

period	*LMM input data*	*forcing*	*land use & land cover*	*ensemble*
1973-2006	station observations	–	–	–
1960-2000	REgional climate MOdel  0.5° resolution	increasing GHGs	constant (early 1990s)	1 2 3
2001-2050		A1B	stochastic changes in line with FAO	1 2 3
2001-2050		B1	weaker changes	1 2 3

The LMM is forced by:
- daily mean temperature
- daily precipitation

LMM VALIDATION in West Africa (1973-2006)



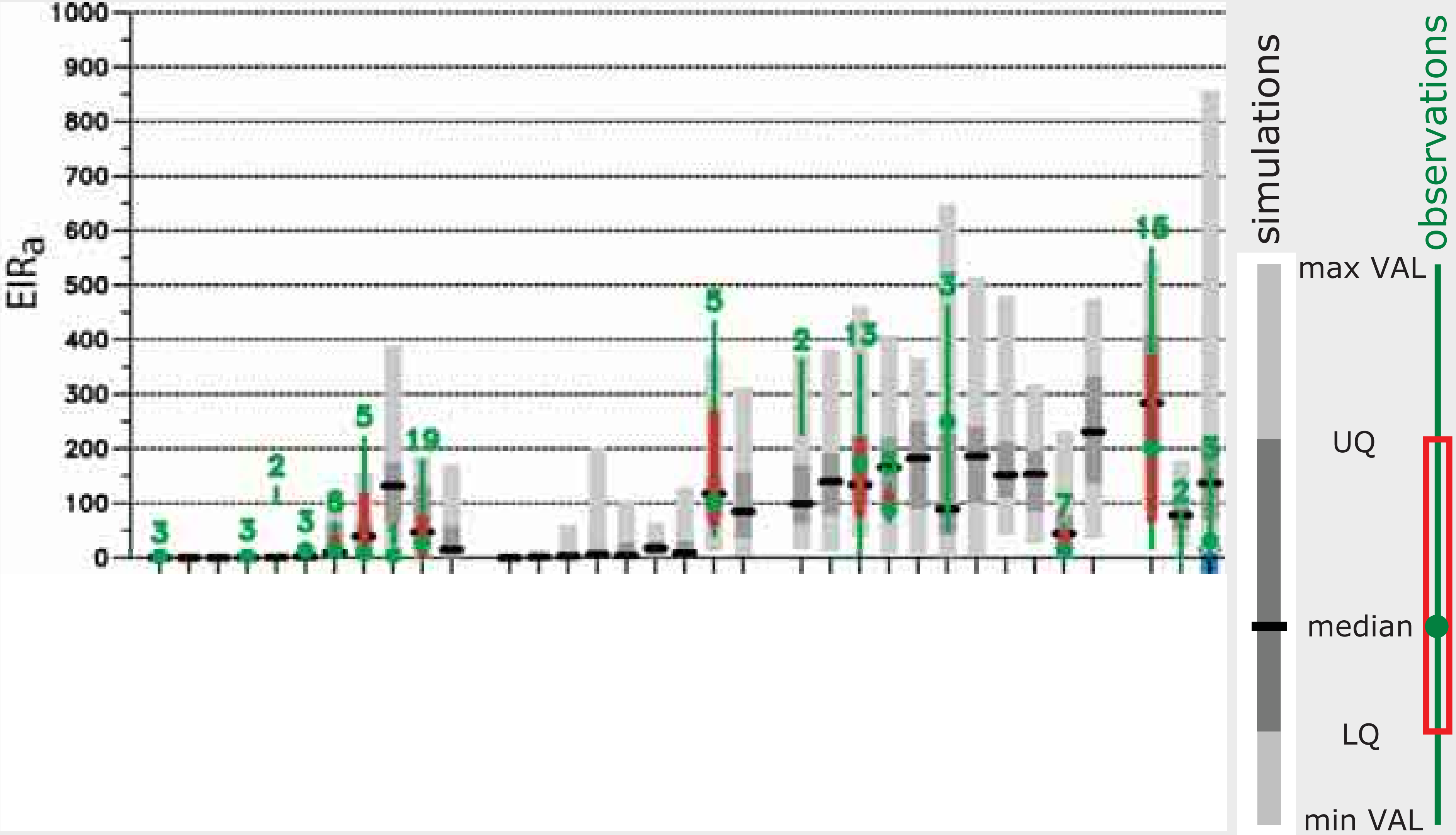
REMO precipitation 1960-2000 (CRU corrected)

- meteorological data
- malaria & meteorological data
- rural field sites of malaria studies

LMM VALIDATION in West Africa (1973-2006)

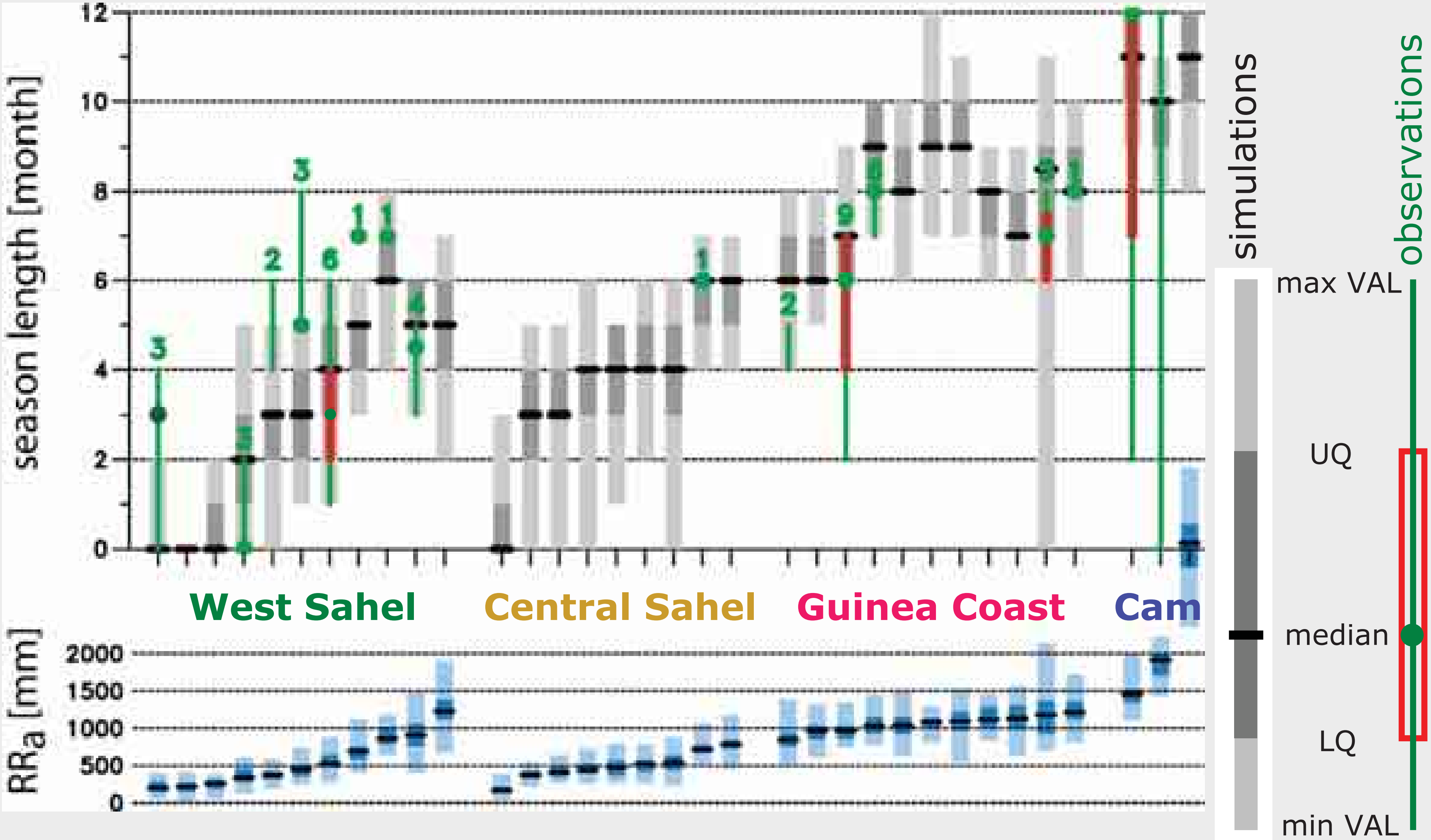
EIR_a: **a**nnual **E**ntomological **I**noculation **R**ate,

i.e. the number of infectious mosquito bites per human per year



LMM VALIDATION in West Africa (1973-2006)

Seasonality: length of the malaria season



Temperature and precipitation changes projected by **REMO**

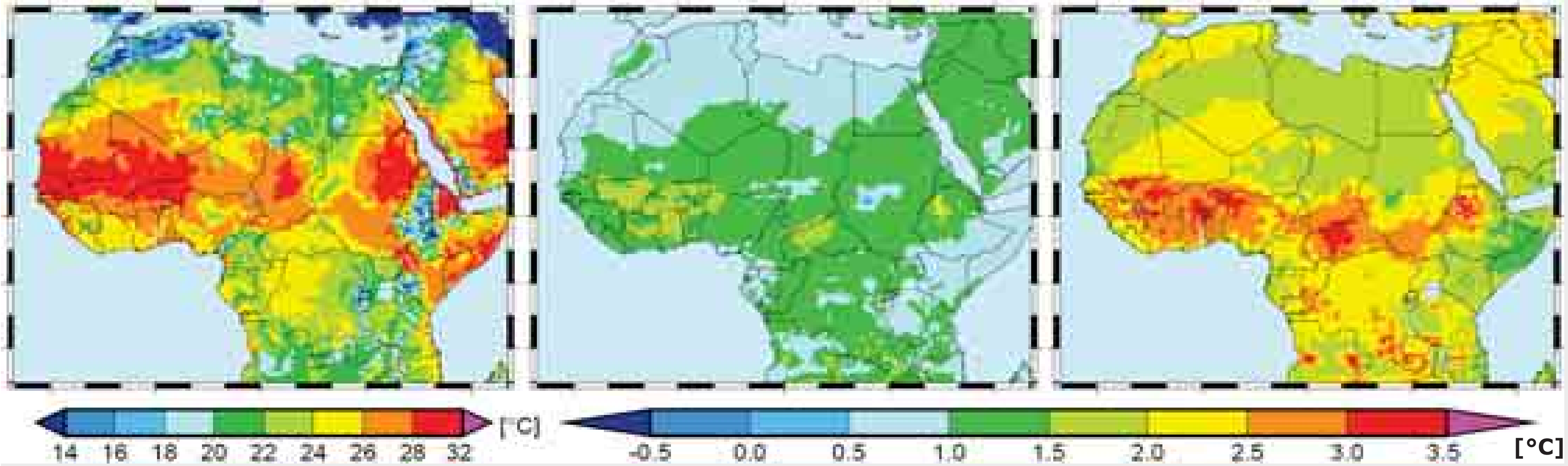
(data input of the LMM)

Paeth et al. (2009) Regional climate change in tropical and northern Africa due to greenhouse forcing and land-use changes. *Journal of Climate, 22, 114-132.*

REMO: temperature (T) and temperature change (ΔT)

A1B

T: 1960-2000 **ΔT: 2021-2030** **ΔT: 2041-2050**



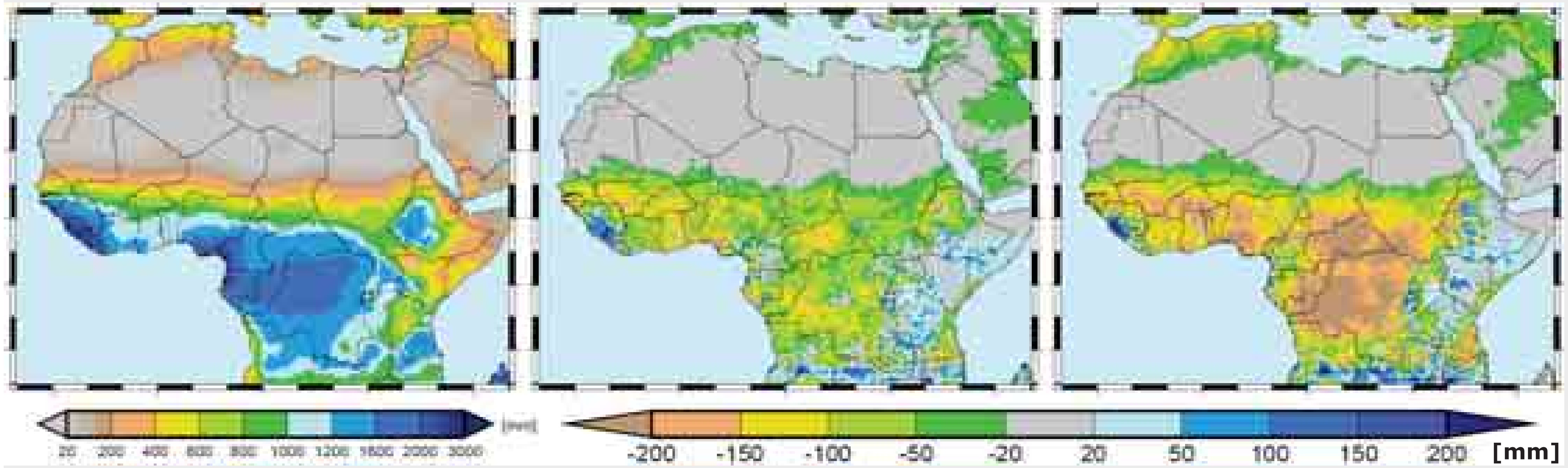
corrected by ERA-40 data

- temperature is increasing
- mostly pronounced around 10°N

REMO: precipitation (RR) and change of precipitation (ΔRR)

A1B

RR: 1960-2000 | **ΔRR: 2021-2030** | **ΔRR: 2041-2050**



corrected by CRU data

- precipitation decreases in West Africa and Central Africa
- precipitation is increasing around the Guinean Mountains and East Africa

Changes in the modelled

annual **E**ntomological **I**noculation **R**ate

projected by **LMM**

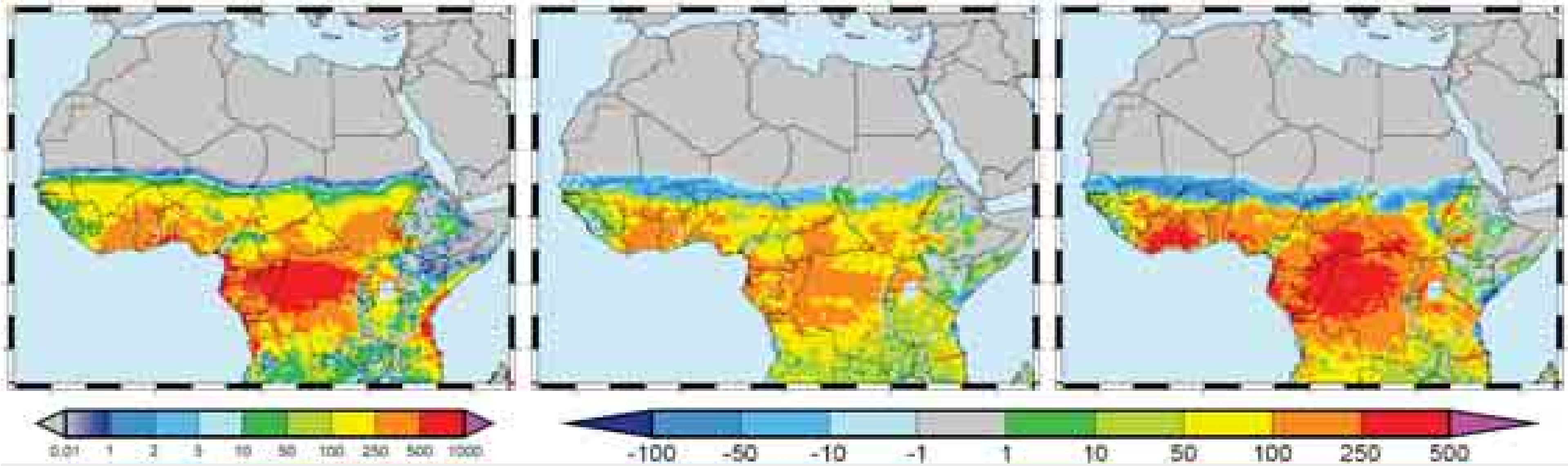
based on **REMO** data

LMM: annual EIR (EIR_a) and its change (ΔEIR_a)

↳ i.e. the number of infectious mosquito bites per human per year

A1B

EIR_a: 1960-2000 | ΔEIR_a: 2021-2030 | ΔEIR_a: 2041-2050



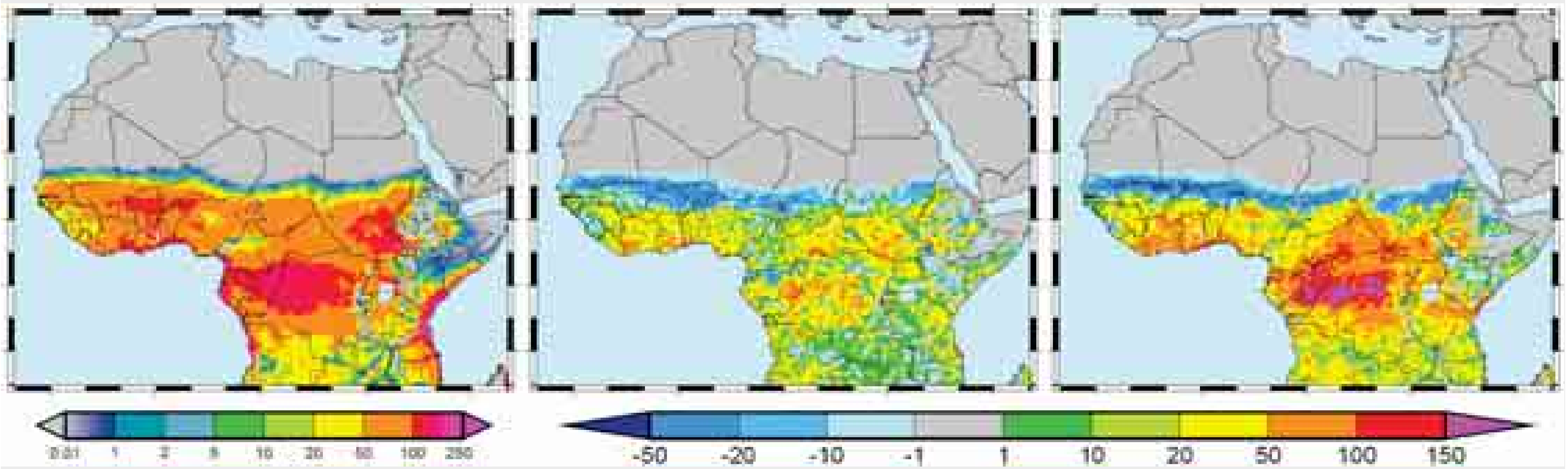
- malaria transmission is decreasing in the Sahelian & Sudanian zone
- EIR increases in most parts of Equatorial Africa

LMM: σ of annual EIR ($\sigma(EIR_a)$) and its change ($\Delta\sigma(EIR_a)$)

↳ standard deviation ⇒ interannual variability

A1B

$\sigma(EIR_a)$: **1960-2000** $\Delta\sigma(EIR_a)$: **2021-2030** $\Delta\sigma(EIR_a)$: **2041-2050**



- malaria transmission is decreasing in the Sahelian zone
- EIR increases in most parts of Equatorial Africa

Changes in the simulated

malaria **prevalence**

projected by the **Garki model**

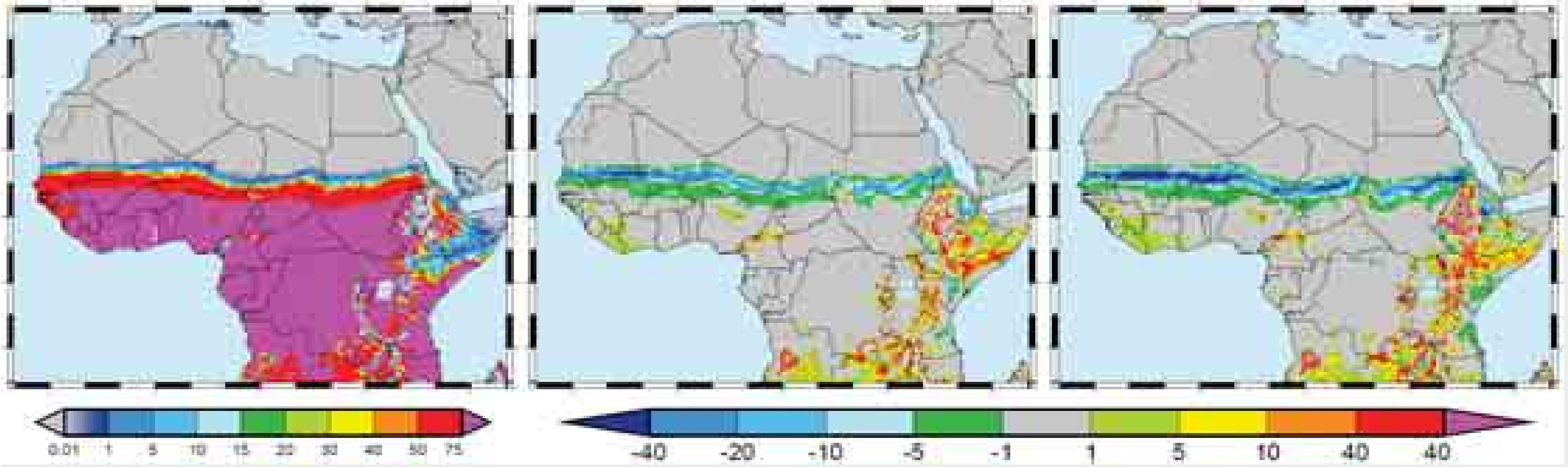
based on **LMM** data

Garki model: child prevalence (PR_{2-10}) and its change (ΔPR_{2-10})

→ i.e. the proportion of children (2-10 years) that are carrier of the malaria parasite

A1B

PR_{2-10}: 1960-2000 **ΔPR_{2-10}: 2021-2030** **ΔPR_{2-10}: 2041-2050**



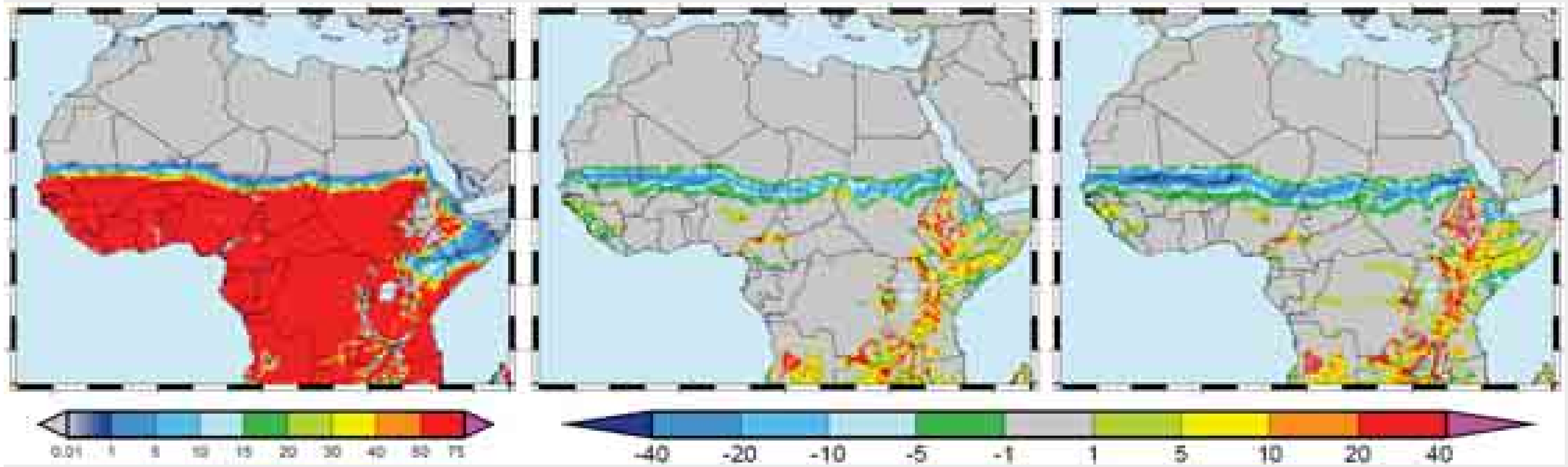
- **PR_{2-10}** decreases in the Sahel
- **PR_{2-10}** increases in East Africa

Garki model: prevalence max. (PR_{max}) and its change (ΔPR_{max})

i.e. the proportion of the population that is carrier of the malaria parasite

A1B

PR_{max}: **1960-2000** | ΔPR_{max}: **2021-2030** | ΔPR_{max}: **2041-2050**



- PR_{max} decreases in Sahelian zone
- PR_{max} it increases in Eastern Africa

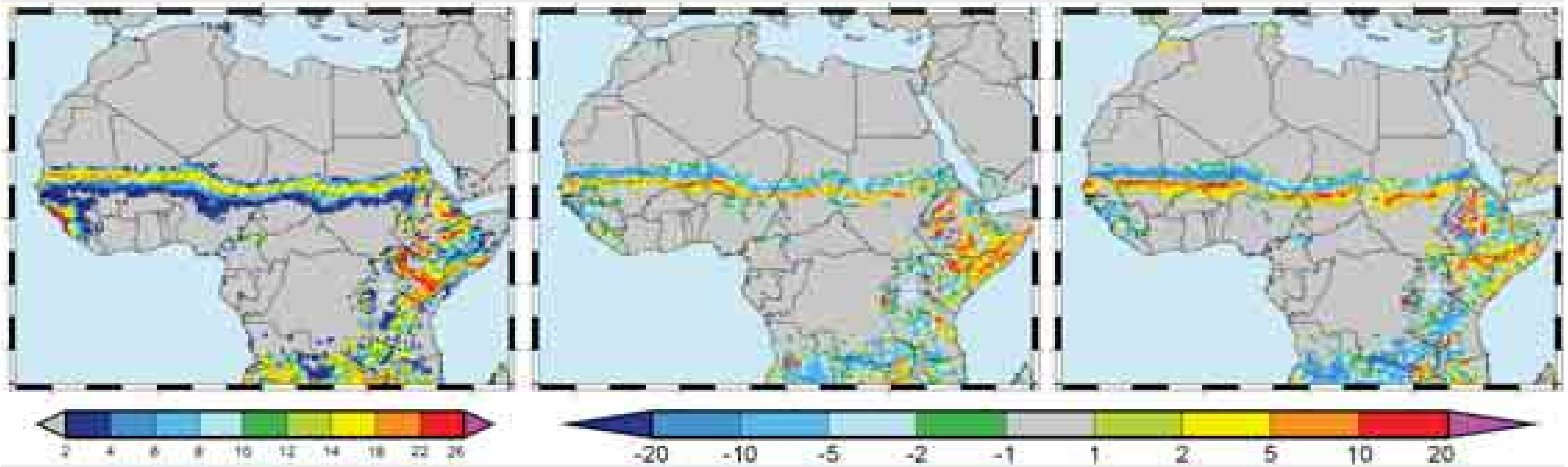
Garki: σ of **prevalence max.** ($\sigma(PR_{max})$) and its change ($\Delta\sigma(PR_{max})$)

↳ standard deviation

⇒ interannual variability of malaria transmission ⇒ epidemics

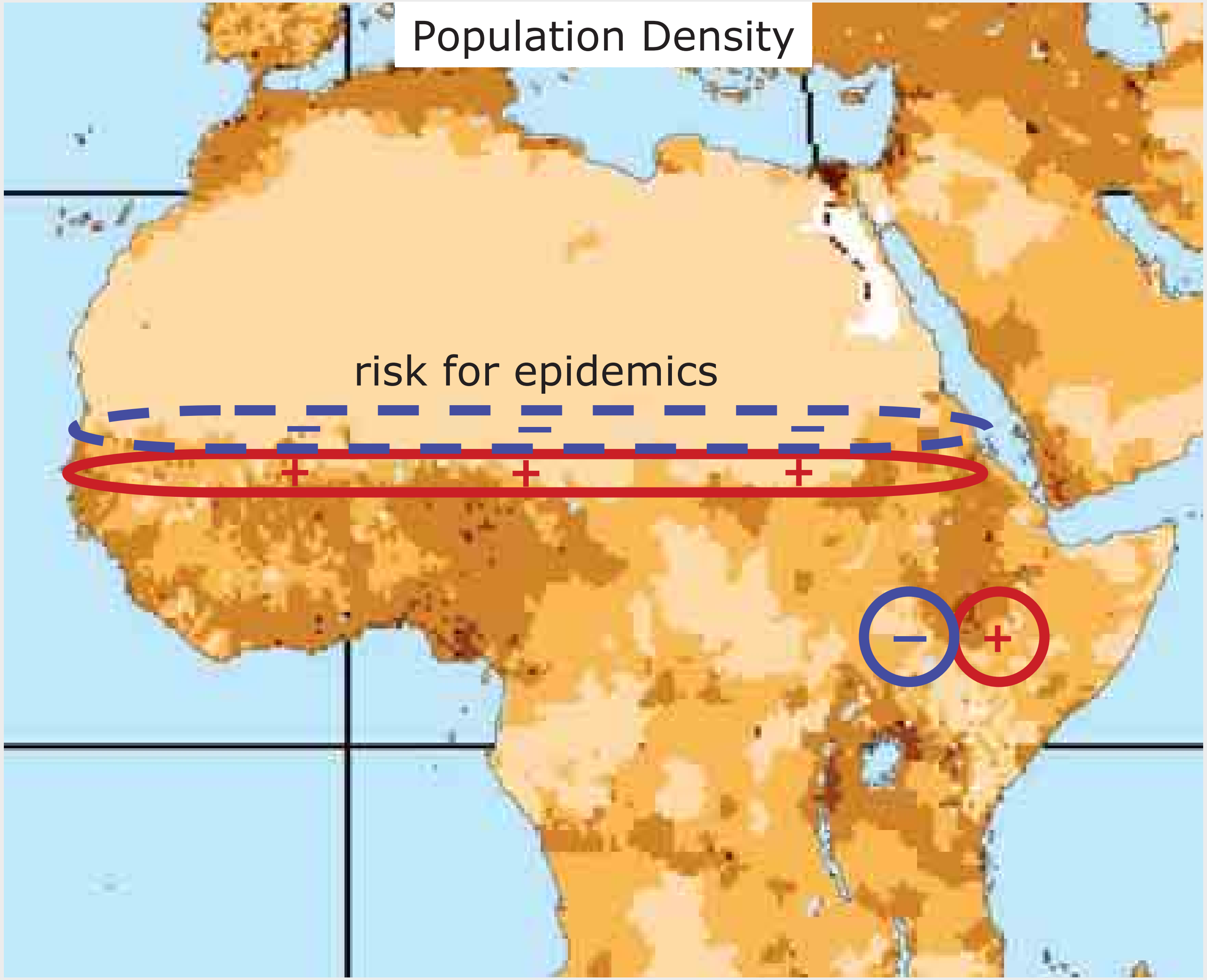
A1B

$\sigma(PR_{max})$: **1960-2000** $\Delta\sigma(PR_{max})$: **2021-2030** $\Delta\sigma(PR_{max})$: **2041-2050**



- σ decreases (increases) in the N(S)-Sahelian zone and in parts of East Africa
  - ➢ risk for malaria epidemics changes

MALARIA EPIDEMICS



source: CIESIN Columbia University; **gridded population of the world** (GPW),version 3

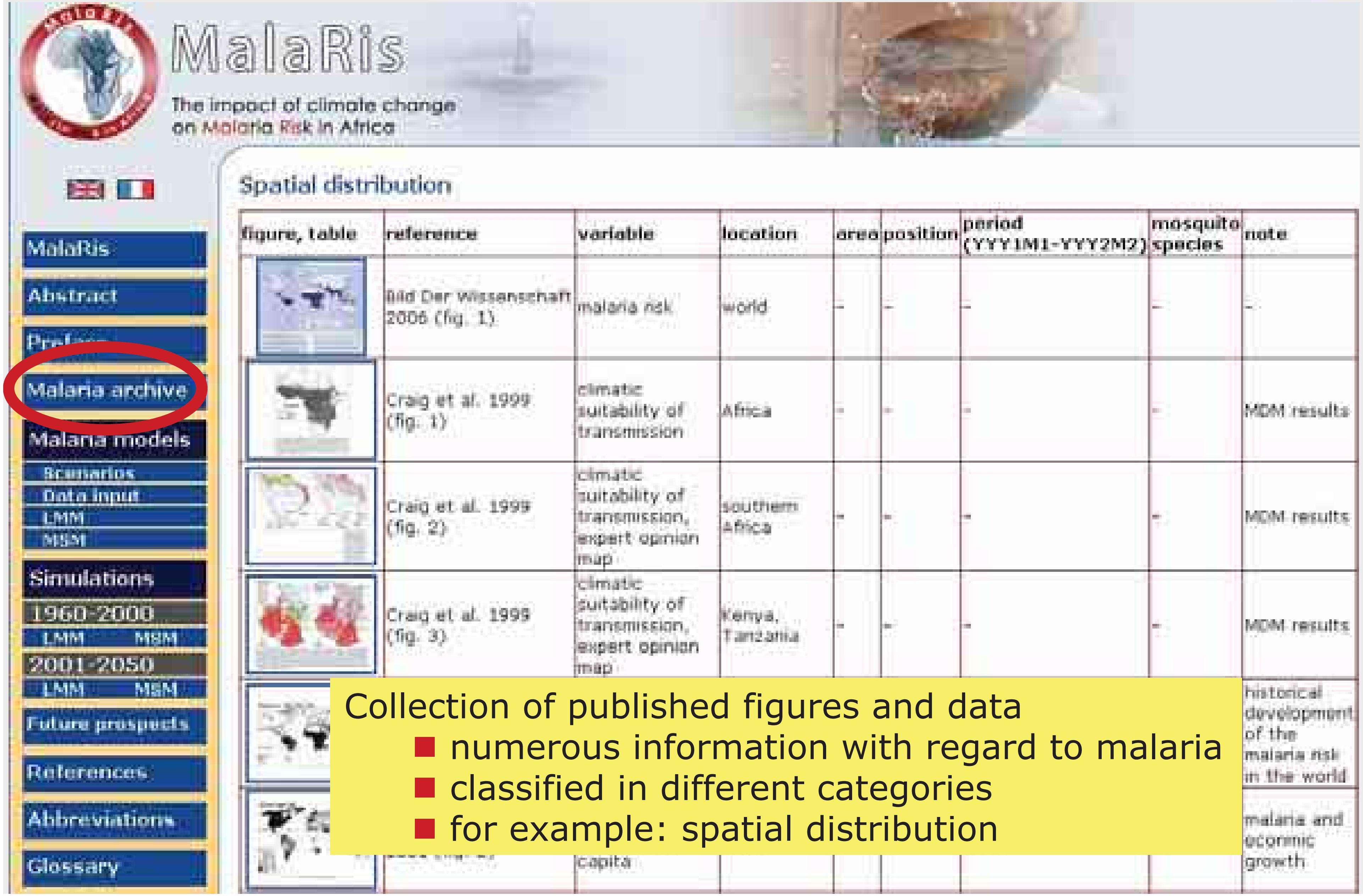
FUTURE PROSPECTS

- Changes in the **malaria season**
  - LMM vs. MARA Seasonality model
- Update of **MalaRis**
  - Title: The impact of climate change on malaria risk
  - HTML based
  - archive (figures of malaria studies)
  - WHO & public health authorities

http://www.impetus.uni-koeln.de/malaris


MalaRis
The impact of climate change
on Malaria Risk in Africa
MalaRis - Information System -
MalaRis
Abstract
Preface
Malaria archive
Malaria models
Scenarios
Data input
LMM
MSM
Simulations
1960-2000
LMM MSM
2001-2050
LMM MSM
Future prospects
References
Abbreviations
Glossary
Disclaimer
The impact of climate change on Malaria Risk in Africa
The simulation of the spread of malaria in Africa by the Liverpool Malaria Model enables the malaria risk assessment during the observed and projected climate change.
MalaRis
Malaria Risk in Africa

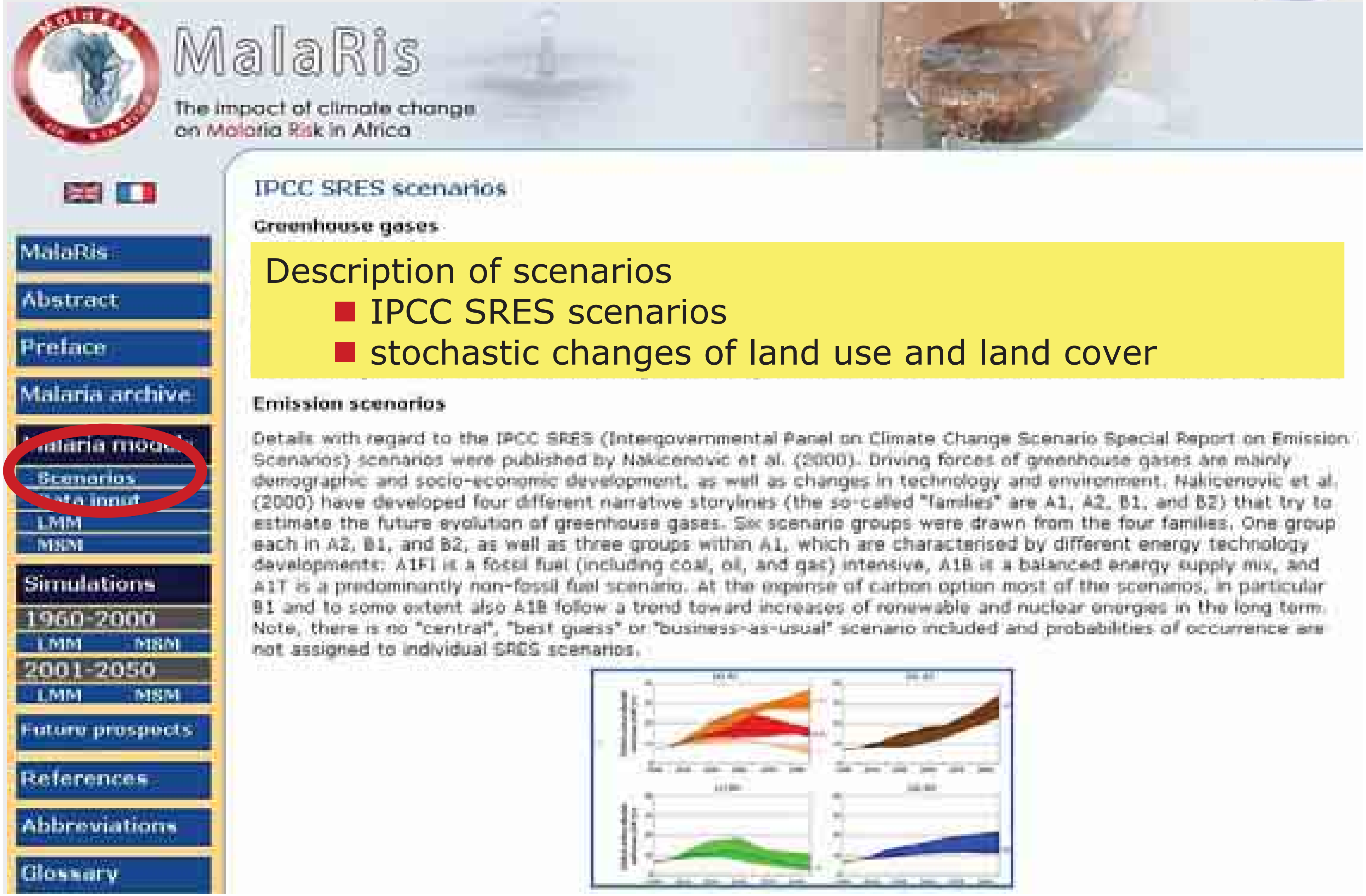
Malaria Archive



Collection of published figures and data

- numerous information with regard to malaria
- classified in different categories
- for example: spatial distribution

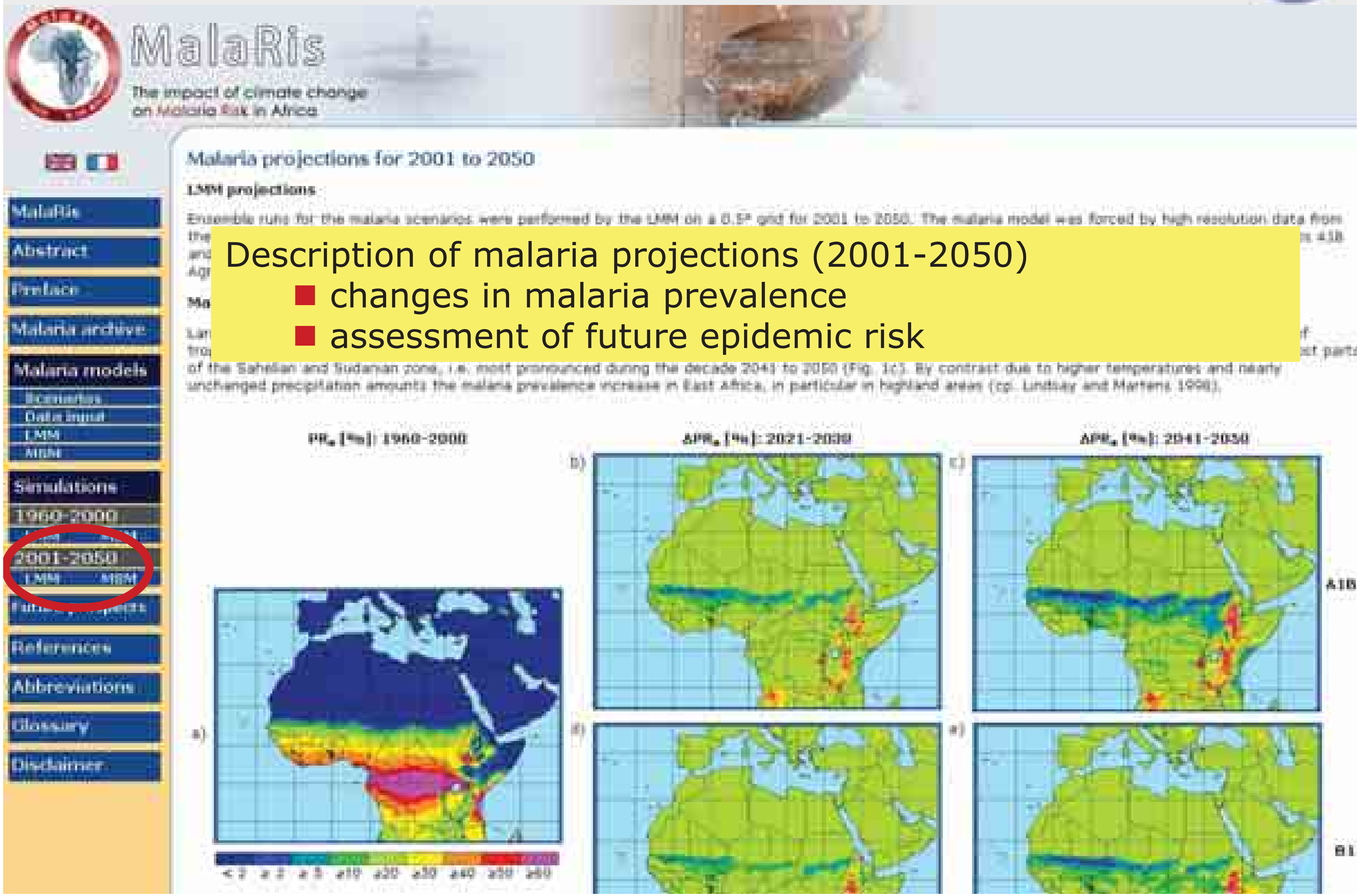
Scenarios



Description of scenarios

- IPCC SRES scenarios
- stochastic changes of land use and land cover

Malaria projections

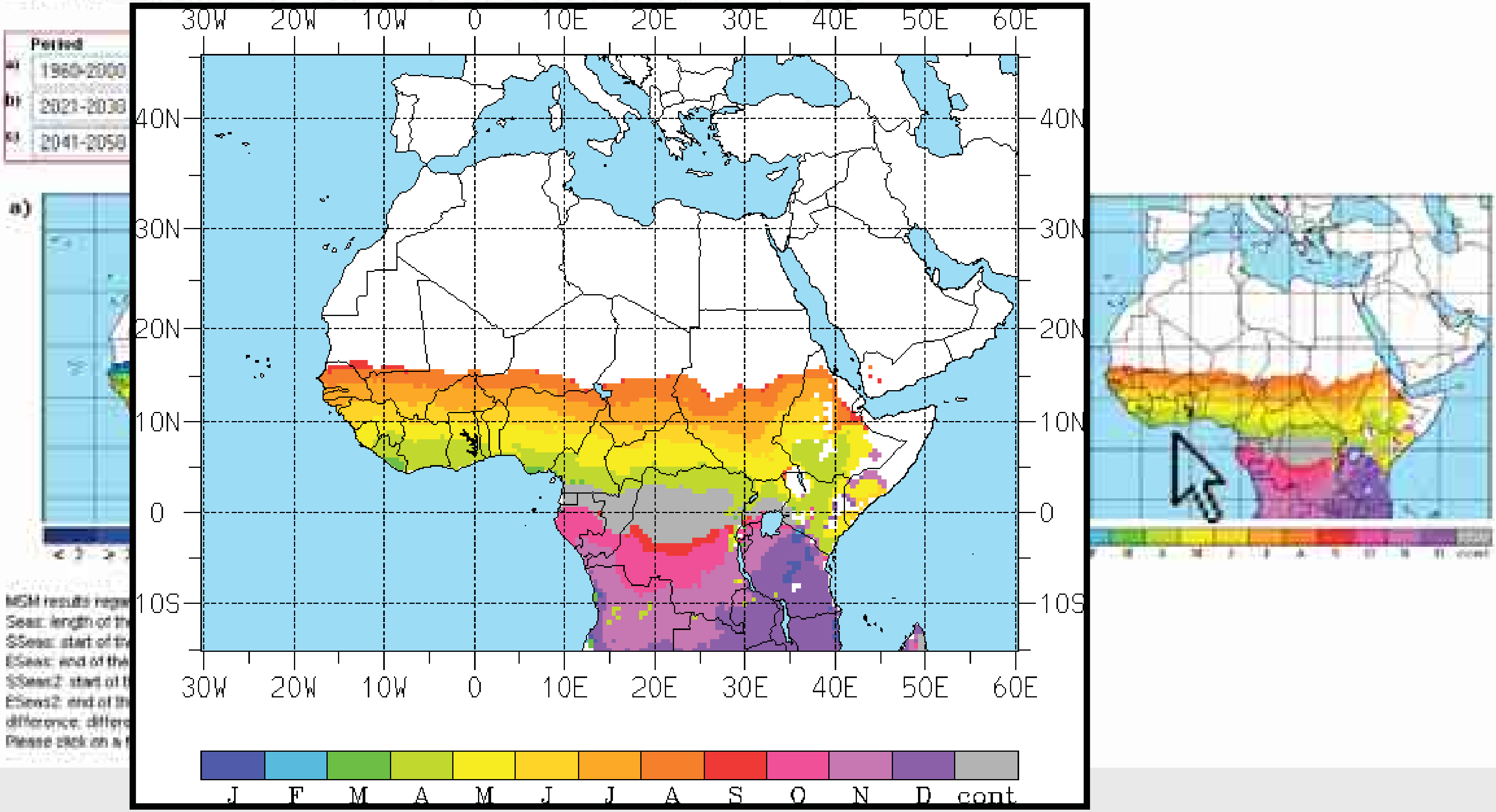


Description of malaria projections (2001-2050)

- changes in malaria prevalence
- assessment of future epidemic risk

Analysis of Malaria Seasonality

Dynamical MSM results according to different periods and scenarios



Thank you for your attention!

vermert@meteo.uni-koeln.de

http://www.impetus.uni-koeln.de/malaris