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Schweizerisches Tropen- und Public Health-Institut
Institut Tropical et de Santé Publique Suisse

Modeling of Large Geostatistical Data to Estimate Seasonal and Spatial Variation of Sporozoite Rate in Rufiji DSS

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INDEPTH 10th AGM and Conference

September 2010

Outline

- Introduction
- Data + Methods
- Application + Results
- Discussion + Conclusion

Introduction

- Seasonal behaviors of most factors (e.g. climate and environment)
  - Attribute to spatial and seasonal fluctuation on health outcome
    - Interfere with the ecological environment of vectors or their behaviors
- Malaria transmission has shown seasonal variations in many regions in the Sub Saharan Africa.
  - These change spatial-temporal distribution of the incidence of malaria
- Understanding the seasonal and geographical variation of malaria transmission is important:
  - targeted timely control strategy
  - disease dynamics
  - prediction of epidemics
  - better design and evaluation of control and intervention
  - relate patterns of transmission with other health outcome

Introduction

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- A number of entomological studies have looked at small area variations of the malaria transmission.

- Very few were based on entomological data
  - collected over a long period of time
  - with high temporal resolution

- No studies looking at spatial variation of seasonality using ento. data with high spatio-temporal scales.

  - **Difficult to draw general conclusion**

Data + Methods

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- The INDEPTH-Malaria Transmission Intensity and Mortality Burdens across Africa (MTIMBA) project (2001-2004)
  - initiated to study the relation between malaria transmission and mortality.
  - data were collected longitudinally
  - at a large number of locations every 2 weeks
  - in a systematic and standardized manner.
- Data are correlated in space and time
  - Leading to geostatistical models having large number of parameters.
  - Model fit is most appropriately done using Bayesian MCMC simulations.

Data + Methods

- Several methods have been proposed to estimate the spatial processes of large geostatistical data.

- This study develops the space-time model by further extend existing methodology which approximate the spatial process from a subset of locations and,

- Apply to analyze MTIMBA data from the Rufiji DSS.
  - Study the seasonality of the SR of the two species, *An. funestus* and *An. gambiae*.
  - Prediction of the SR for the whole DSS area using results obtained from the approximation methods.

Data + Methods

Outcome

- 16,325 (393 positive; SR=2.41%) *An. funestus* mosquitoes
- 10,610 (450 positive; SR=4.24%) *An. gambiae* mosquitoes
  - Data were summarized by locations and calendar months.
  - Repeated surveys (locations) within the same month were collapsed to a single observation.

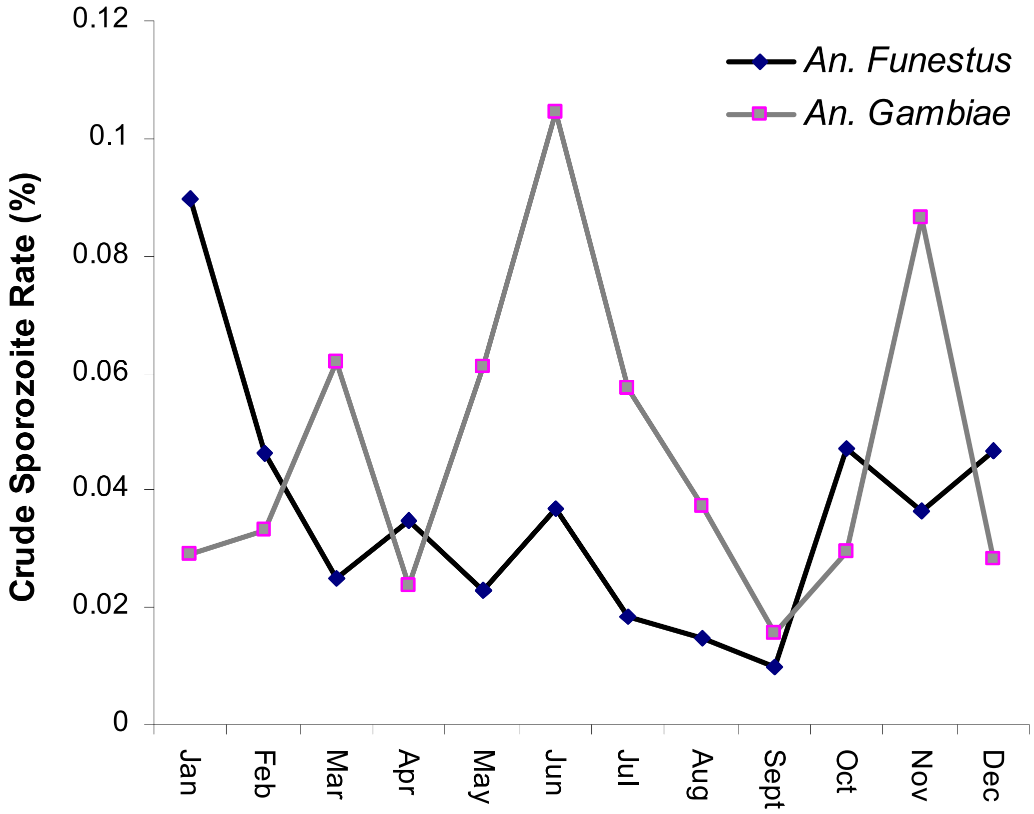
- 430 data points for *An. funestus* (415 unique locations).
- 670 data points for *An. gambiae* (639 unique locations).

Predictors

- normalized difference vegetation index (NDVI)
- Temperature (day)
- rainfall
- distance to water bodies.

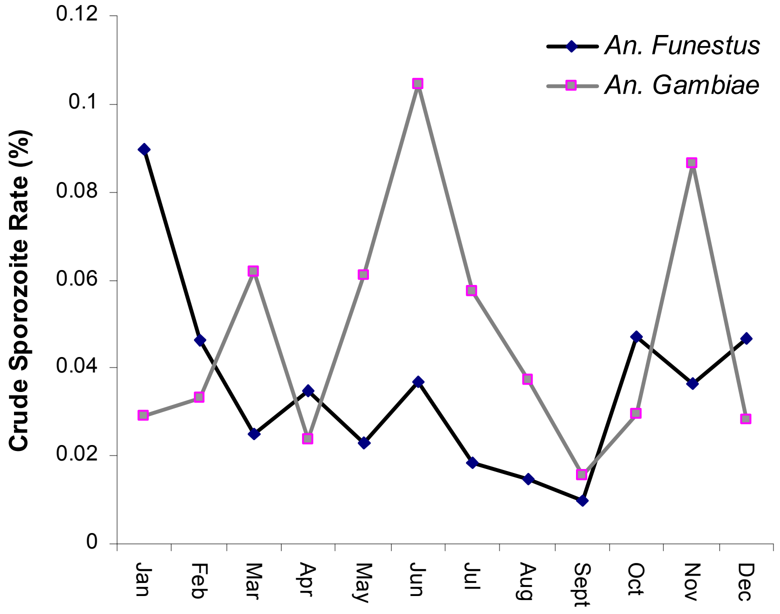
Data + Methods

Crude monthly sporozoite rate for *An. funestus* and *An. gambiae*

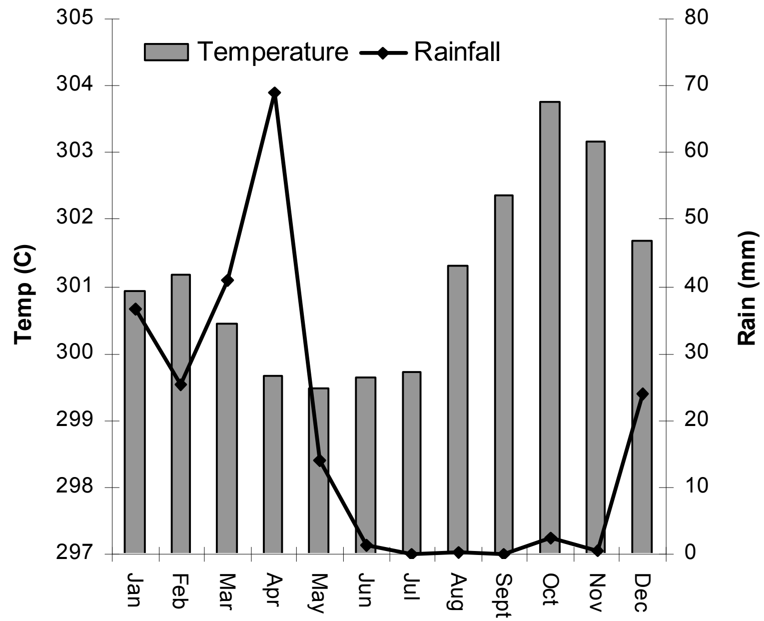


Data + Methods

Crude monthly sporozoite rate



Rain and Temperature



Application + Results

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Selection of knots (sub-locations)

- ❖ Use balance sampling procedure
- ❖ Preserve the variation of the outcome
  - ❖ 100 locations out of 415 for *An. Funestus*
  - ❖ 250 locations out of 639 for *An. Gambiae*

Capturing seasonality

- ❖ Use harmonic cycles of cosine function with a mixture of two periods, 6 and 12 months
- ❖ Programs implemented in FORTRAN

Application + Results

Maps of SR for both species

- Spatial and Seasonal differences

Overall trend of the SR (predicted)

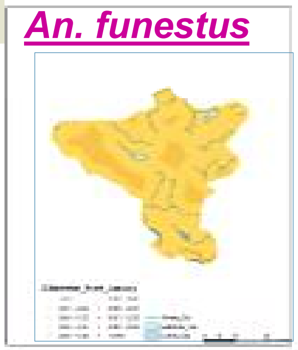
Monthly SR for *An. funestus* and *An. gambiae*

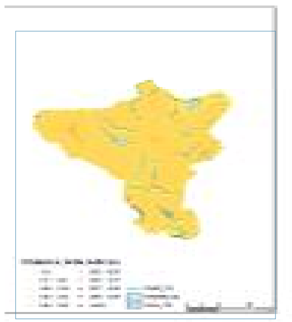
An. funestus

An. gambiae

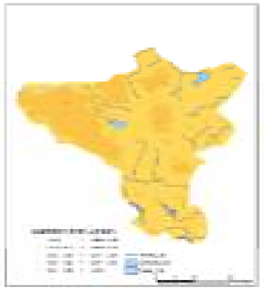
Monthly SR for *An. funestus* and *An. gambiae*

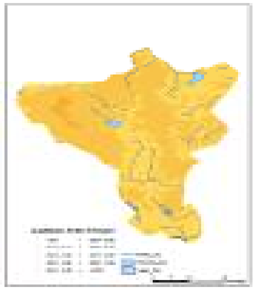
An. funestus





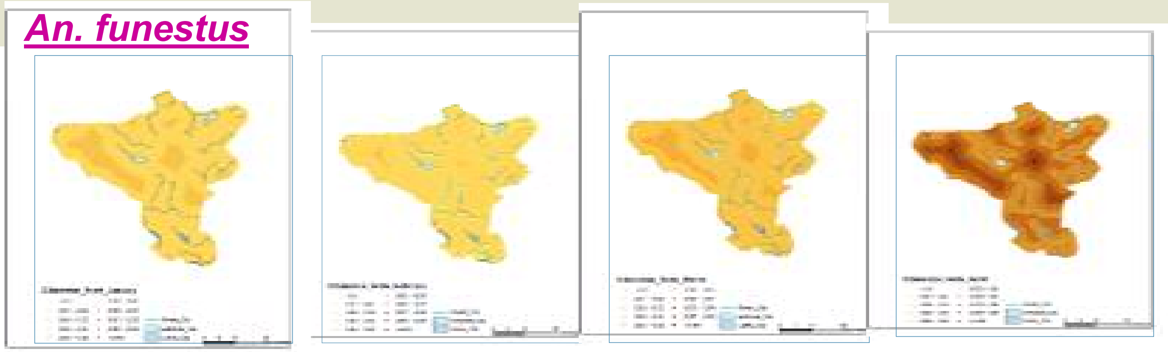
An. gambiae



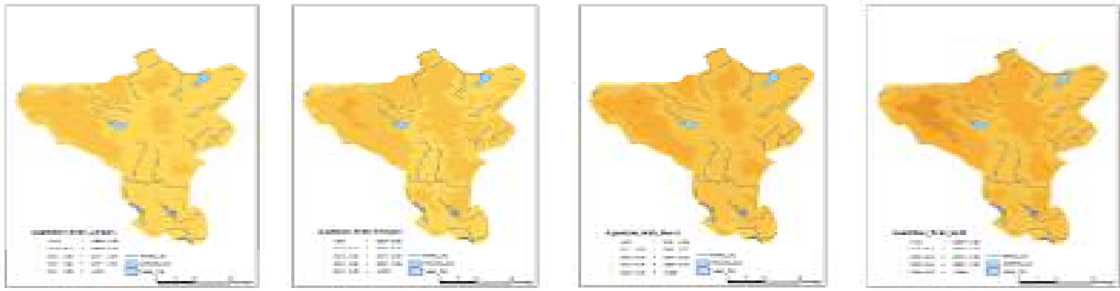


Monthly SR for *An. funestus* and *An. gambiae*

An. funestus

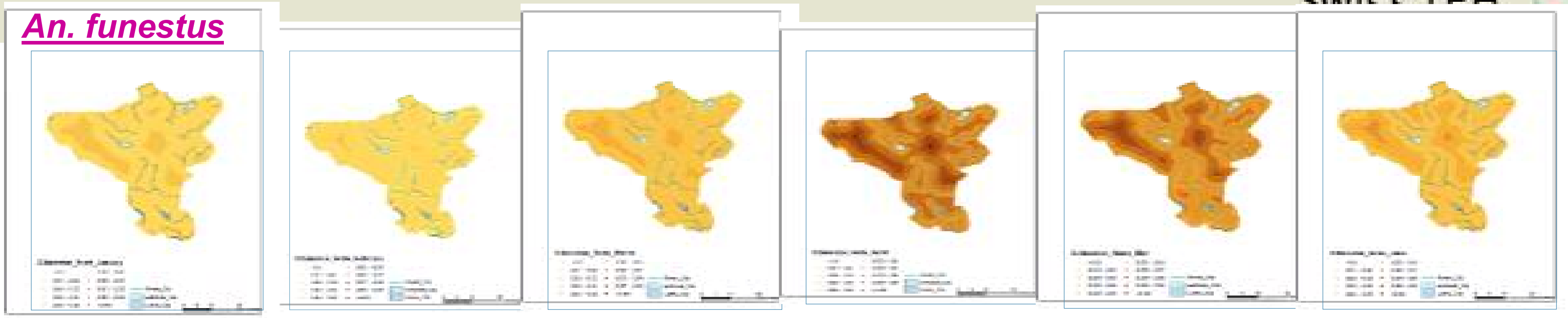


An. gambiae

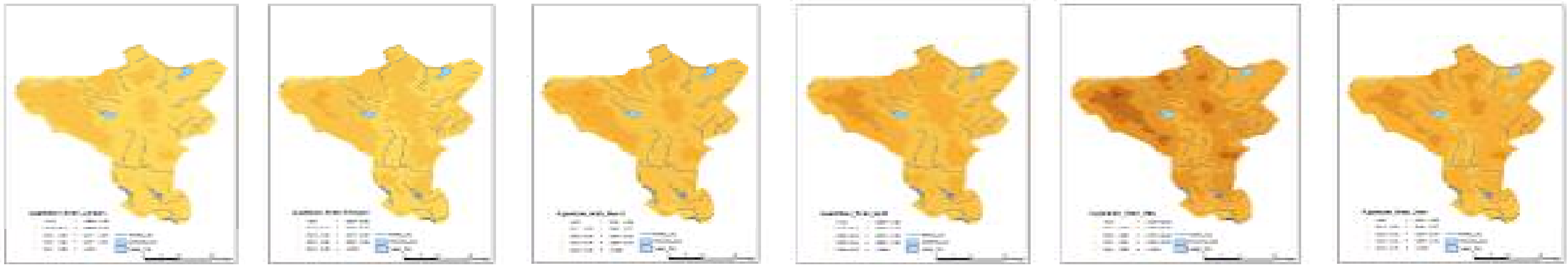


Monthly SR for *An. funestus* and *An. gambiae*

An. funestus

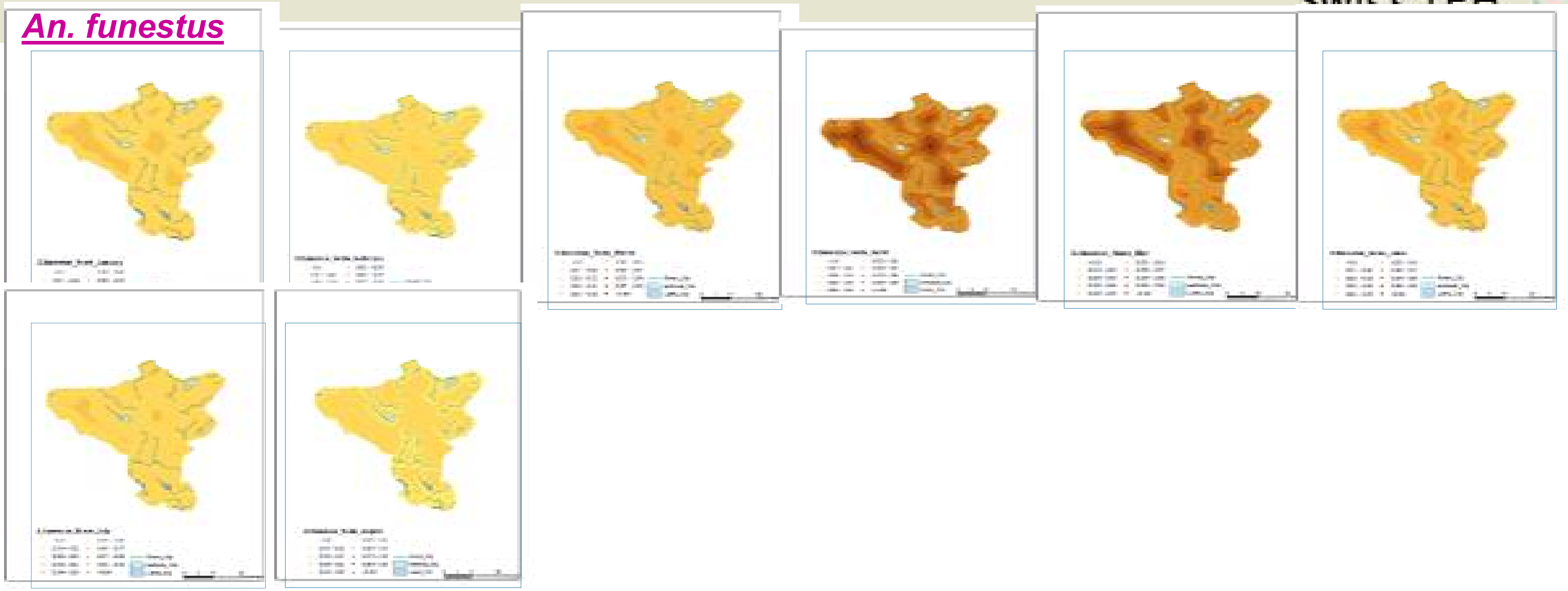


An. gambiae

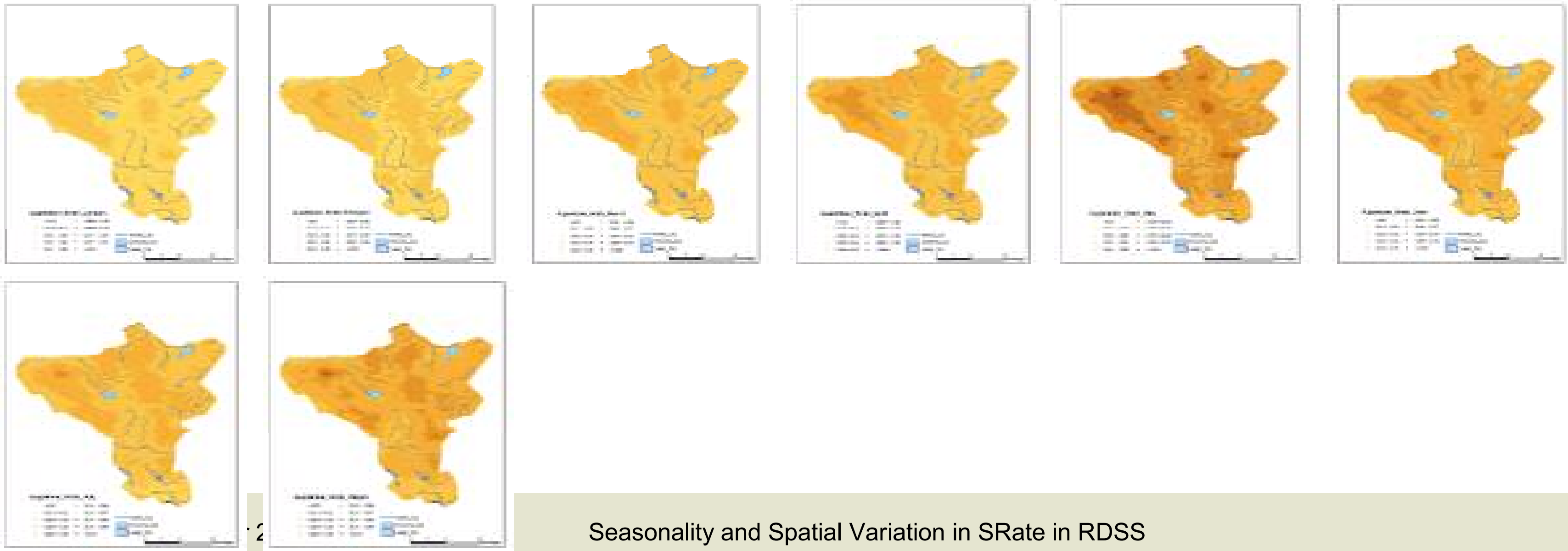


Monthly SR for *An. funestus* and *An. gambiae*

An. funestus

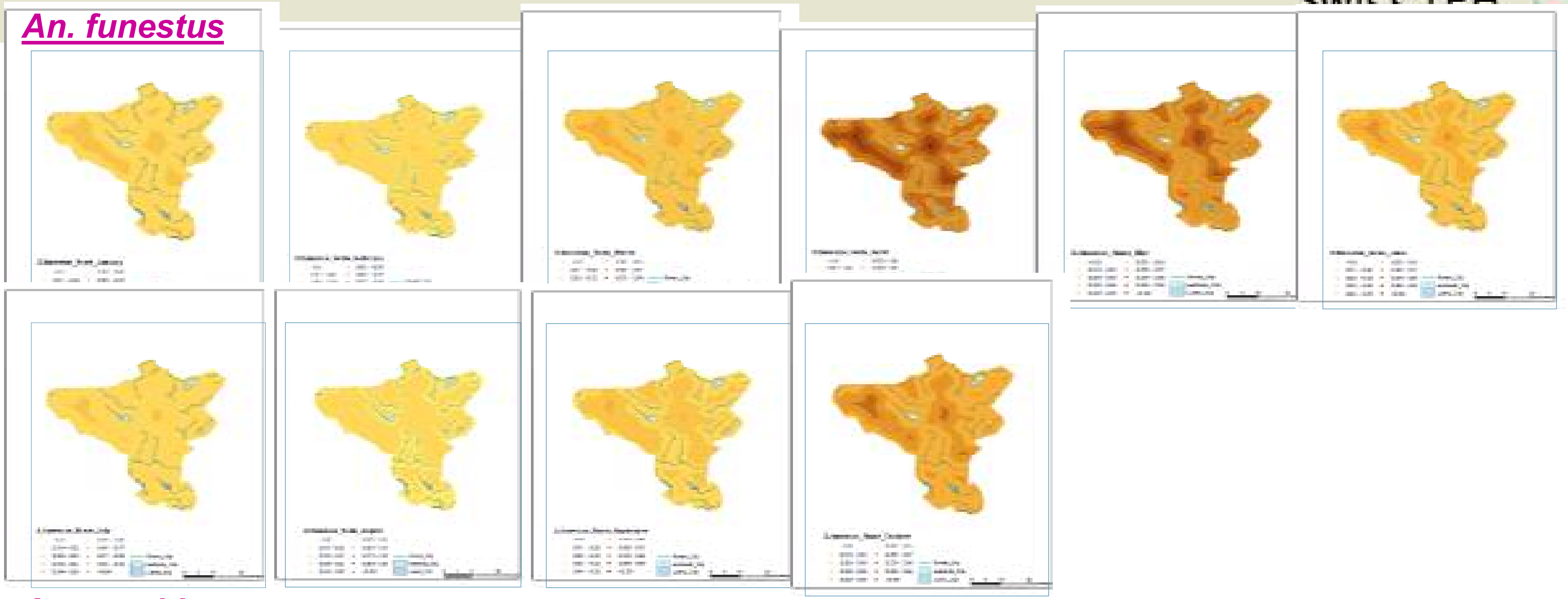


An. gambiae

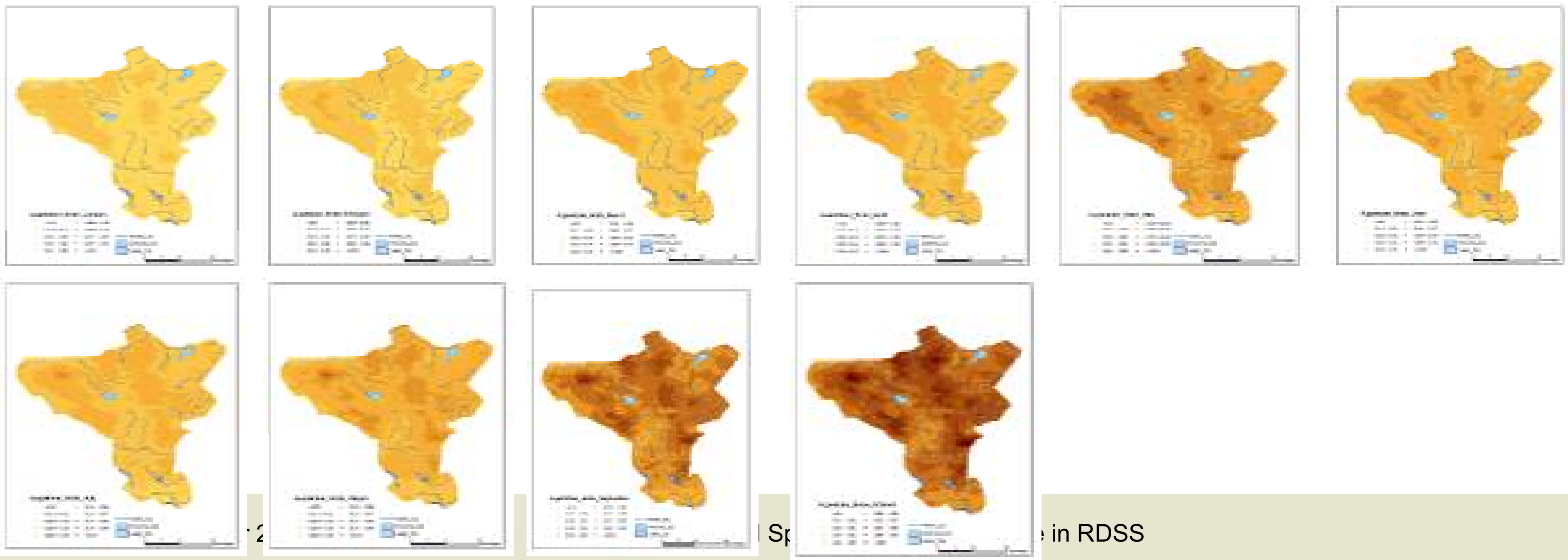


Monthly SR for *An. funestus* and *An. gambiae*

An. funestus

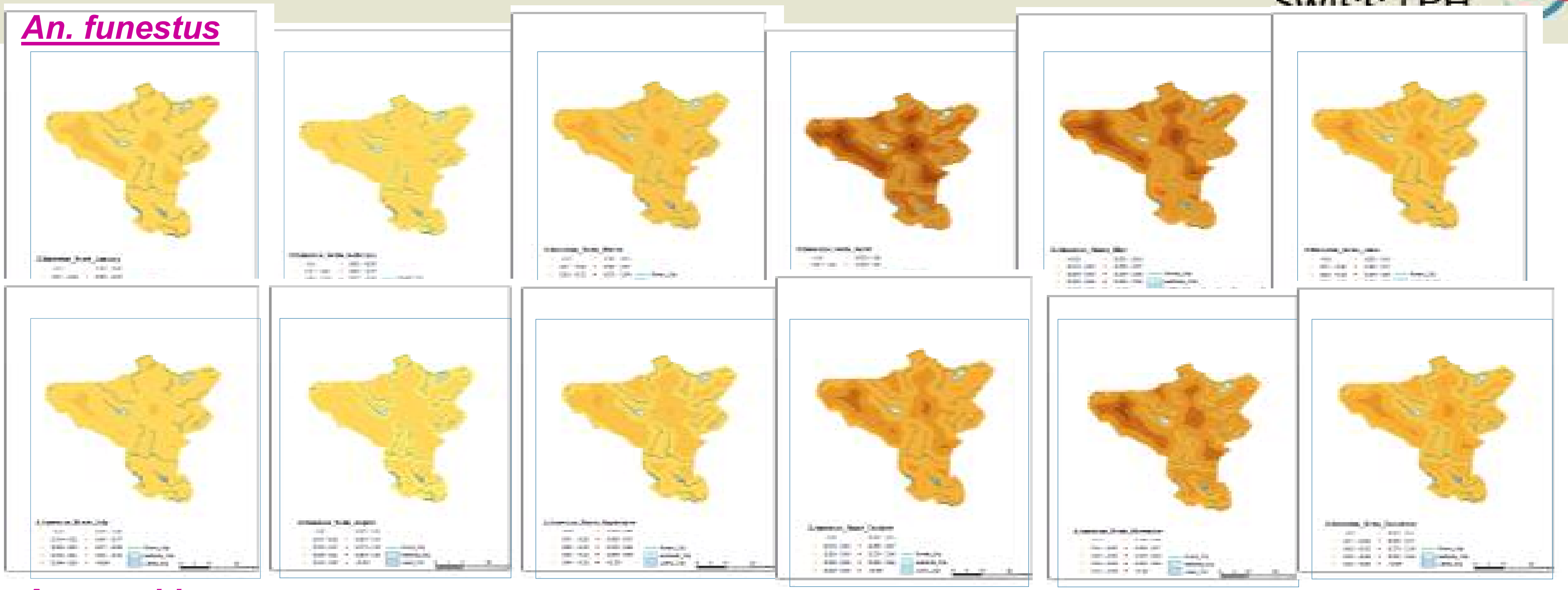


An. gambiae

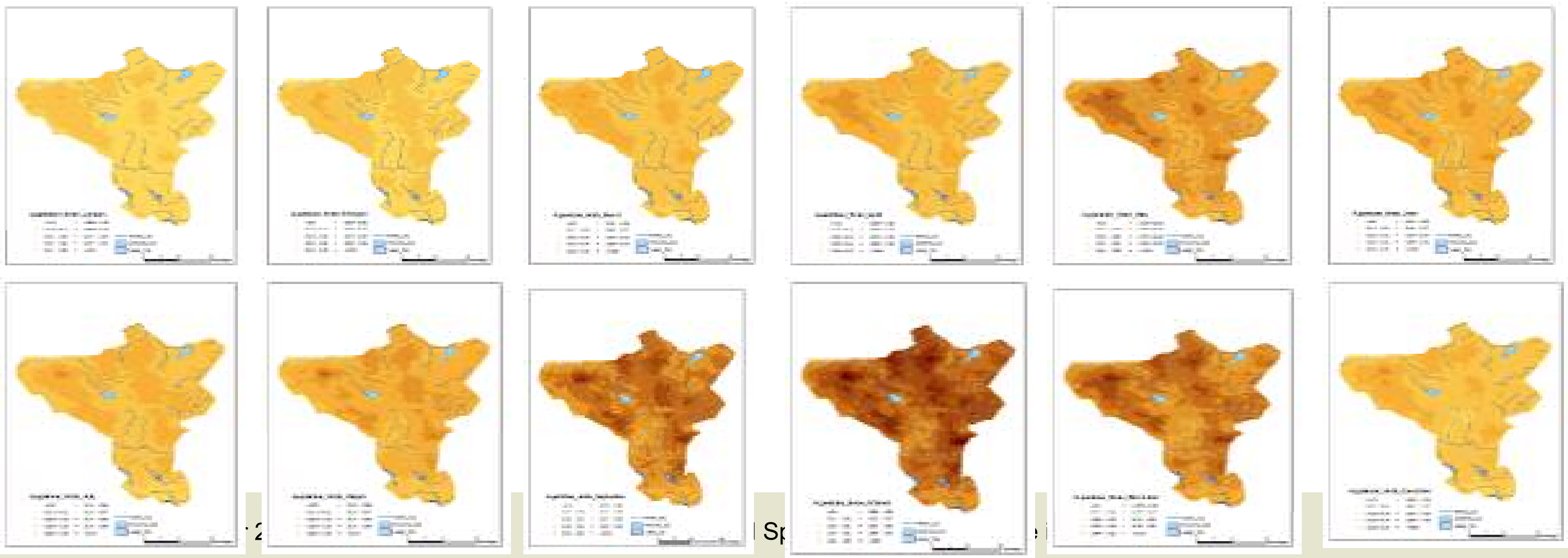


Monthly SR for *An. funestus* and *An. gambiae*

An. funestus



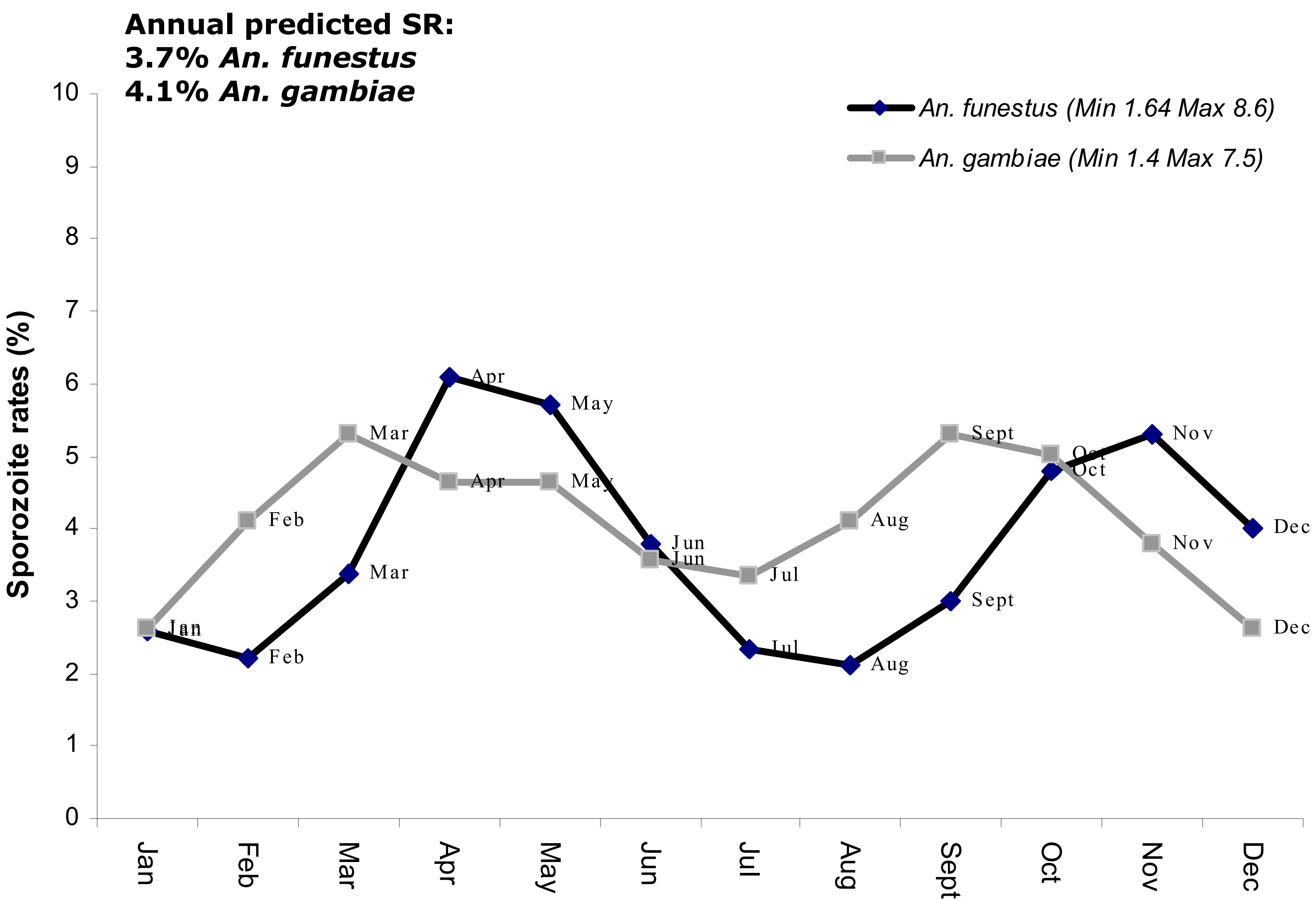
An. gambiae



Effect of Covariates and the Spatial Effect

- Significant negative effect of temperature and rainfall.
- The spatial correlation was still significant (more than 5%) till a distance of about 9km.
  - This means up to 9kms the SR within locations are still correlated.

Mean predicted sporozoite rates



Discussion and Conclusion

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- ❖ We demonstrates a need to generate spatial and temporal data on transmission intensity to guide targeted control of malaria operations
- ❖ As a part of the ongoing control and monitoring strategies:
  - ❖ Close follow up changes on climate and environment + occurrence and reoccurrence of breeding sites
  - ❖ Prioritize strategies to locations and periods where transmission peaks
- ❖ This methodology is not only applicable in entomological data but also in analysis of other spatial-temporal disease data with seasonal characteristics.

Acknowledgement

We would like to thank the following:

- INDEPTH Network team for facilitating the MTIMBA project
- The Ifakara Health Institute for the management of the project and data.
- All field workers, data managers and supervisors in the Rufiji DSS.
- Swiss National Science Foundation financial support

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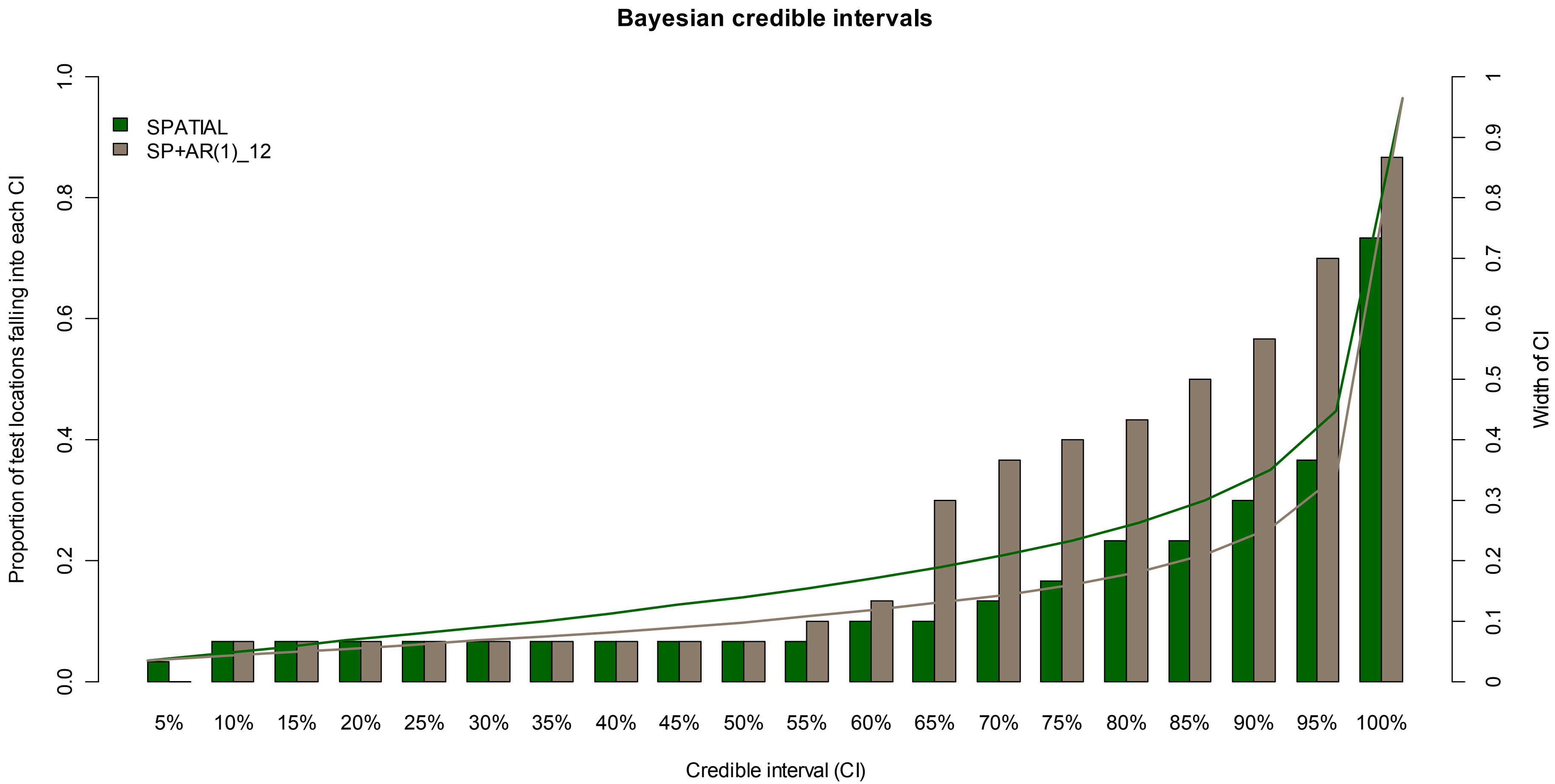
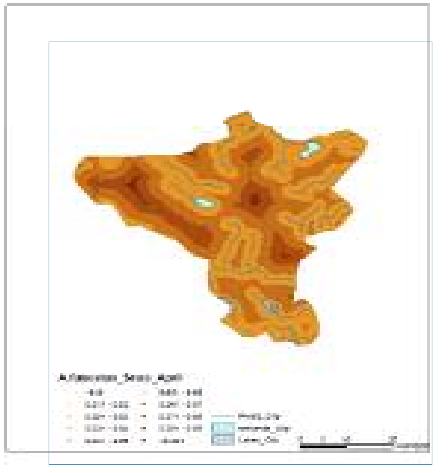
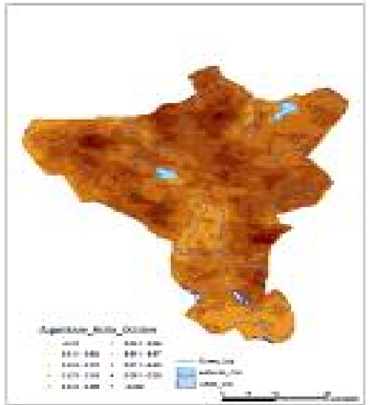
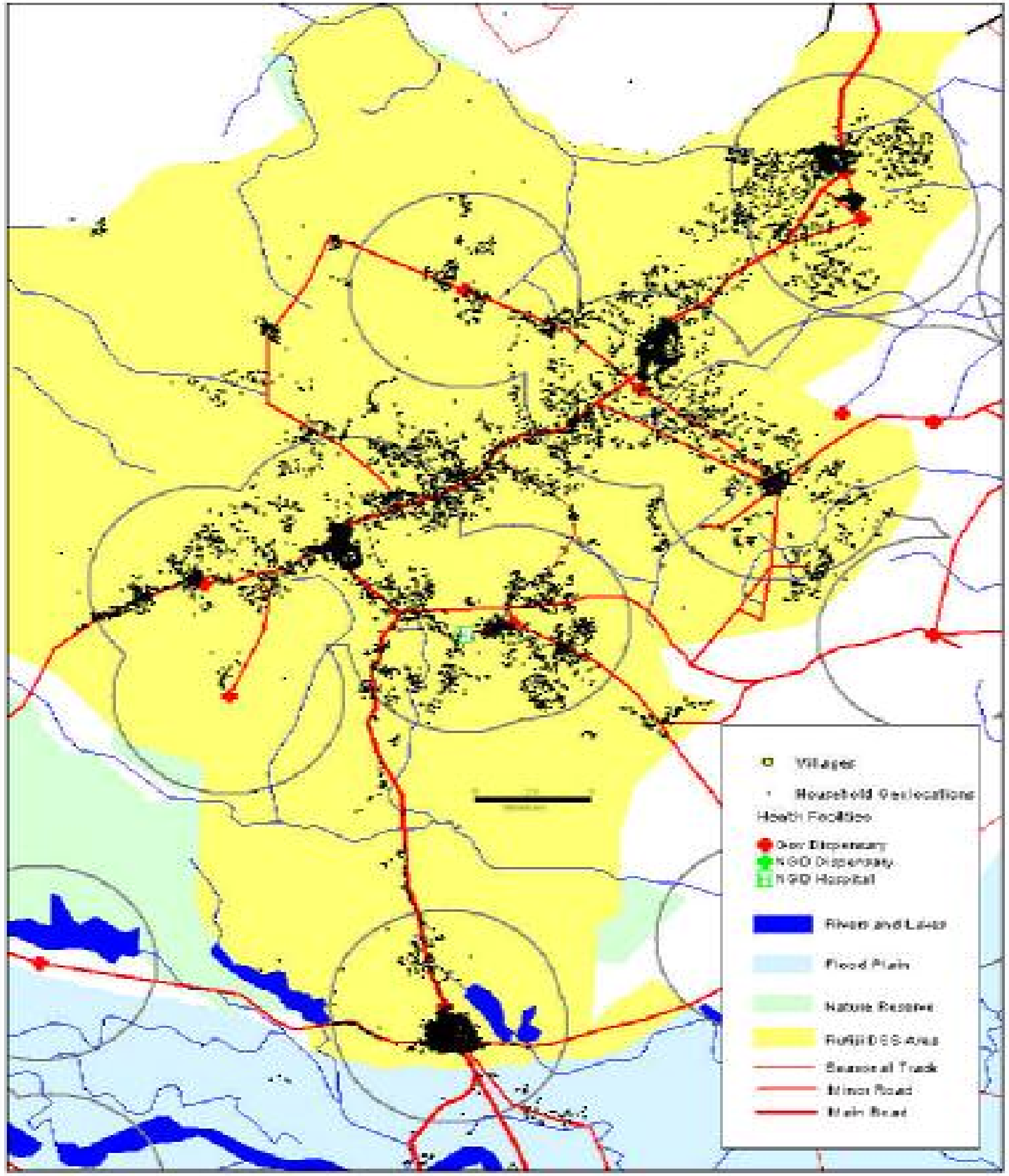
Model Validation







Rufiji DSS Area, Health Facility 5 km Catchments, Tanzania
14,516 Households Registered



Cartography by TEHIP / MOH, May, 2002

Discussion and Conclusion

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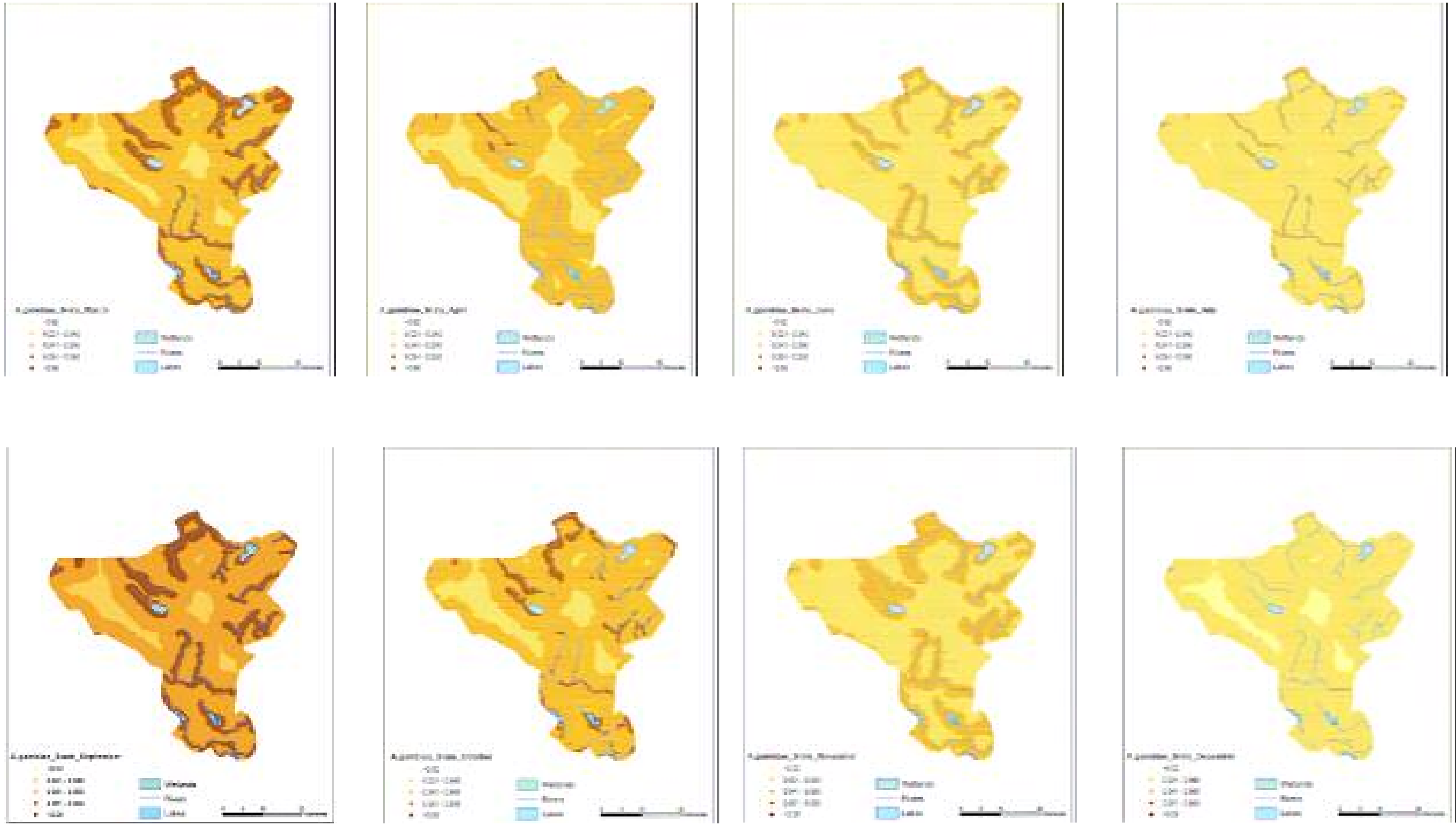
- As a part of the ongoing control and monitoring strategies:
  - Close follow up changes on climate and environment + occurrence and reoccurrence of breeding sites
  - Prioritize strategies to locations and periods where transmission peaks
- This methodology is not only applicable in entomological data but also in analysis of other spatial-temporal disease data with seasonal characteristics.

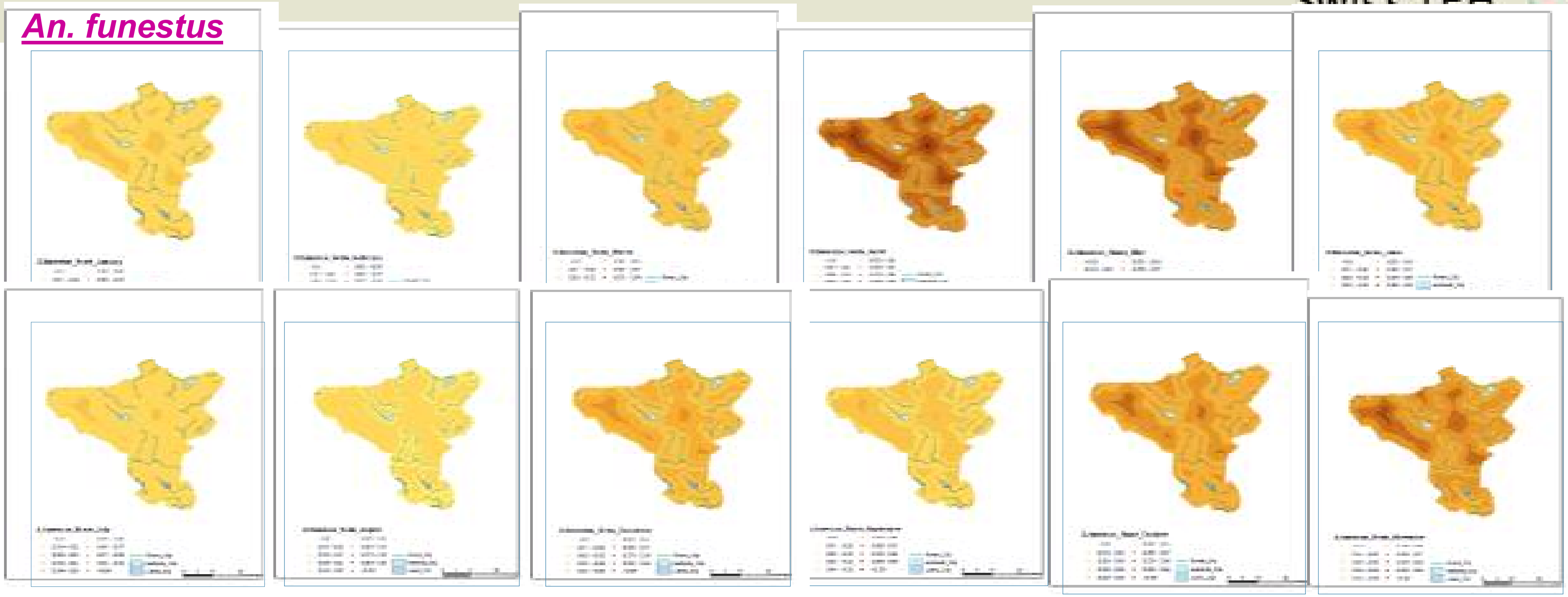
Application + Results



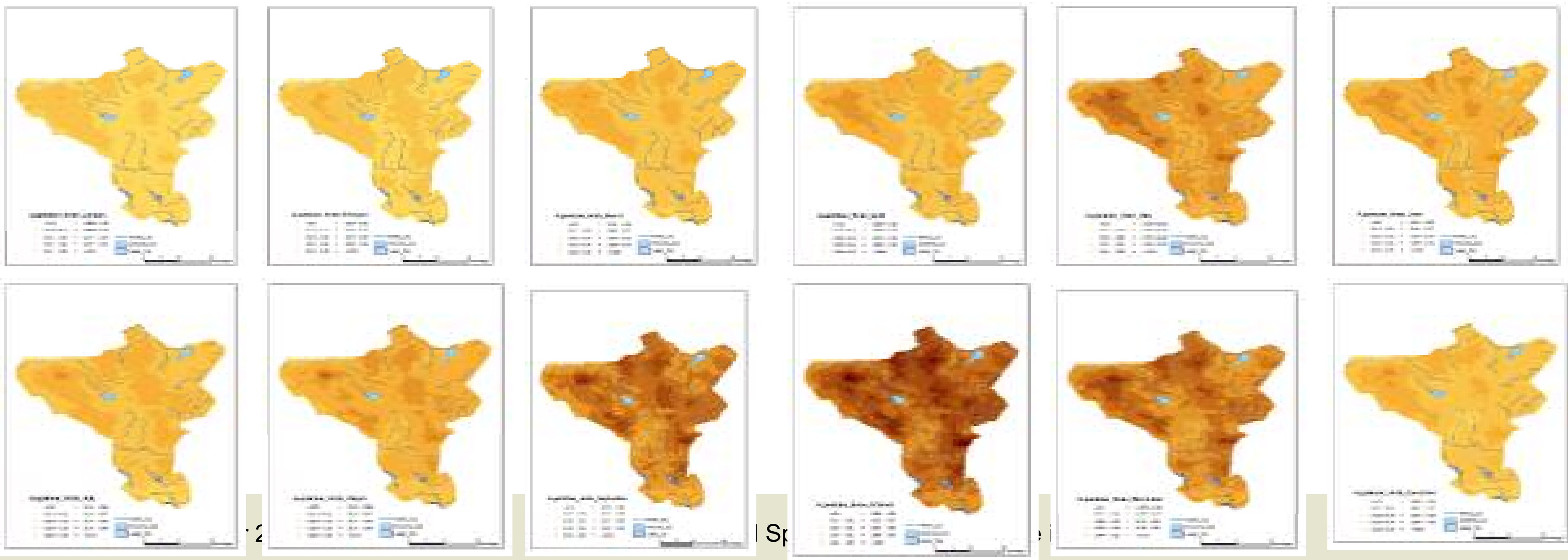
Peaks of transmission are observed during March and September.
The heavy and short rains are in March-April and September-October, respectively.

Monthly SR for *An. funestus* and *An. gambiae*

An. funestus



An. gambiae



Discussion and Conclusion

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- We have used and further develop methodology for modeling large geostatistical data by approximating the spatial process from a subset of locations.
- The model was able to assess spatial distribution and seasonal pattern of malaria transmission for both species
- We demonstrates a need to generate spatial and temporal data on transmission intensity on smaller scales to guide targeted control of malaria operations in semi-arid regions

Discussion and Conclusion

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How can this be done:

- As a part of the ongoing control and monitoring strategies:
    - Close follow up changes on rainfall, temperature and occurrence and reoccurrence of breeding sites
    - Give priority to locations and periods where transmission peaks to ensure success

- This methodology is not only applicable in entomological data but also in analysis of other spatial-temporal disease data with seasonal characteristics.

Objectives

Model Validation

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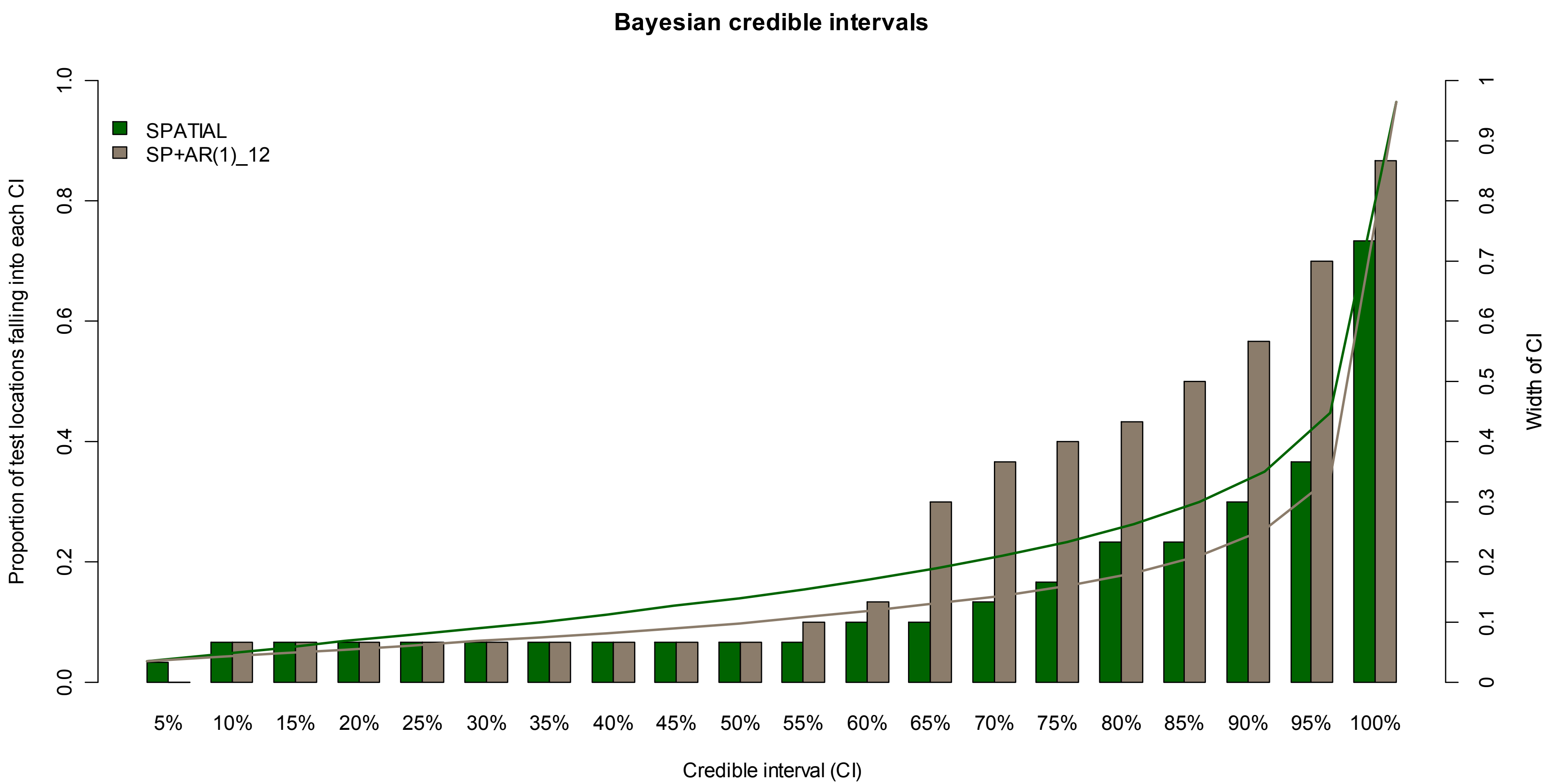

❖Development of the space-time model and approximate the spatial process using a subset of the locations

❖Application of the method (model)

- ❖ Study the seasonality of the SR of the two species, *An. funestus* and *An. gambiae*.
- ❖ Prediction of the SR for the whole DSS area using results obtained from the approximation methods.