One Health and Vector-Borne Diseases Webinar Series (Webinar #5)

One Health Research Consortium

Project Title: **Enhancing One-health Surveillance and Control of Vector-borne Diseases related to Climate Change in the West Africa region**

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Prof Rosemary Audu

Senegal and Nigeria teams

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Background

- Climate change remains a major unrecognised threat in Africa.
- It has led to extinction of certain organisms, expansion of others, brought some animals closer to humans & increased risk of zoonotic diseases.
- Diseases transmitted to humans by vectors account for 17% of all infectious diseases.
- Studies demonstrate impact of climate change on the incidence of VBDs.
- Generating meteorological and biological data in hotspot areas are important.
- IPD & NIMR have an MOU and have significant experience in leading research on VBDs (arboviruses).

Study Goal

To jointly undertake a mixed retrospective-prospective research to determine the effect of climate change on VBD emergence, outbreaks and spread in our countries which can be extended to other parts of West Africa.

Objectives

- (a) To collate 10 years retrospective meteorological, climatic, disease prevalence and transmission data on mosquito-borne diseases in Nigeria and Senegal and overlay one with another (i.e. meteorological overlaid with biological data)

- (b) To conduct prospective research investigating the spatial temporal distribution of mosquito vectors and habitat characterization in relation to climate change in Nigeria and Senegal.

Secondary objective

- To strengthen the effective collaboration among our consortium, regional and national organizations to optimize VBD surveillance, prevention and response.

Methodology

- **Deliverable 1:** To conduct one joint applied research investigating the spatial distribution and habitat characterization of vectors in relation to climate change in Nigeria and Senegal applying a mix retrospective-prospective design.

- **Deliverable 2:** To strengthen effective collaboration among our consortium, regional and national organizations to optimize VBD surveillance, prevention and response.

Methodology (retrospective analysis)

- Collect 10-years (2012-2022) national retrospective data on disease prevalence, vector species and transmission dynamics and meteorological information.
- Data was obtained from Teranga in Senegal and DHIS-2 in Nigeria.
- Retrospective epidemiological, transmission and meteorological data collected from each country were analyzed
- Meteorological data: Weekly climate data (temperature, relative humidity, and rainfall)
- Access from available meteorological stations

Datasets	Full product name	Types Products	Period	Temporal resolution	Temporal resolution	References
ENACS (ANACIM)	Enhancing National Climate Services	Stations+Satellite	1970-2022	0.5° x 0.5°	Daily	Temporal resolution
WFDEI-CRU	WATCH Forcing Data ERAInterim (WFDEI) corrected using Climatic Research Unit (CRU)	Reanalysis	1979-2018	0.5° x 0.5°	3hours/day	Weedon et al. (2014)
ERA5	European Re-Analysis, 5th Generation	Reanalysis	1979-P	0.25° x 0.25°	4h/day	Hersbach et al. (2020)
CHIRPS v2.0	Climate Hazard group InfraRed Precipitation with Stations v2.0	Satellite	1981-P	0.05° x 0.05°	Daily	Funk et al. (2015)

Table 1: Characteristics of some climatic products.

Study sites

- Two sentinel sites Matam region (Bokidiawé and Agam-Siwal) were used.

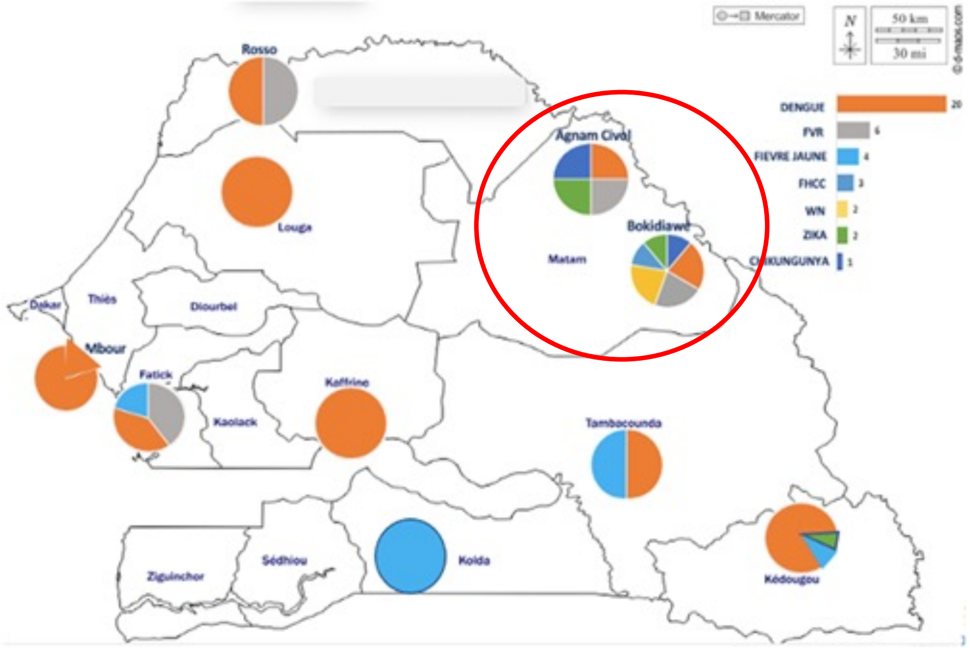


Figure 1: Senegal map with arboviruses detected

- In Nigeria, three health facilities in Ika North-East LGA, Delta State served as study sites.

Figure 2: Map of Ika North-East Local Government Area, Delta State, Nigeria

Study Team

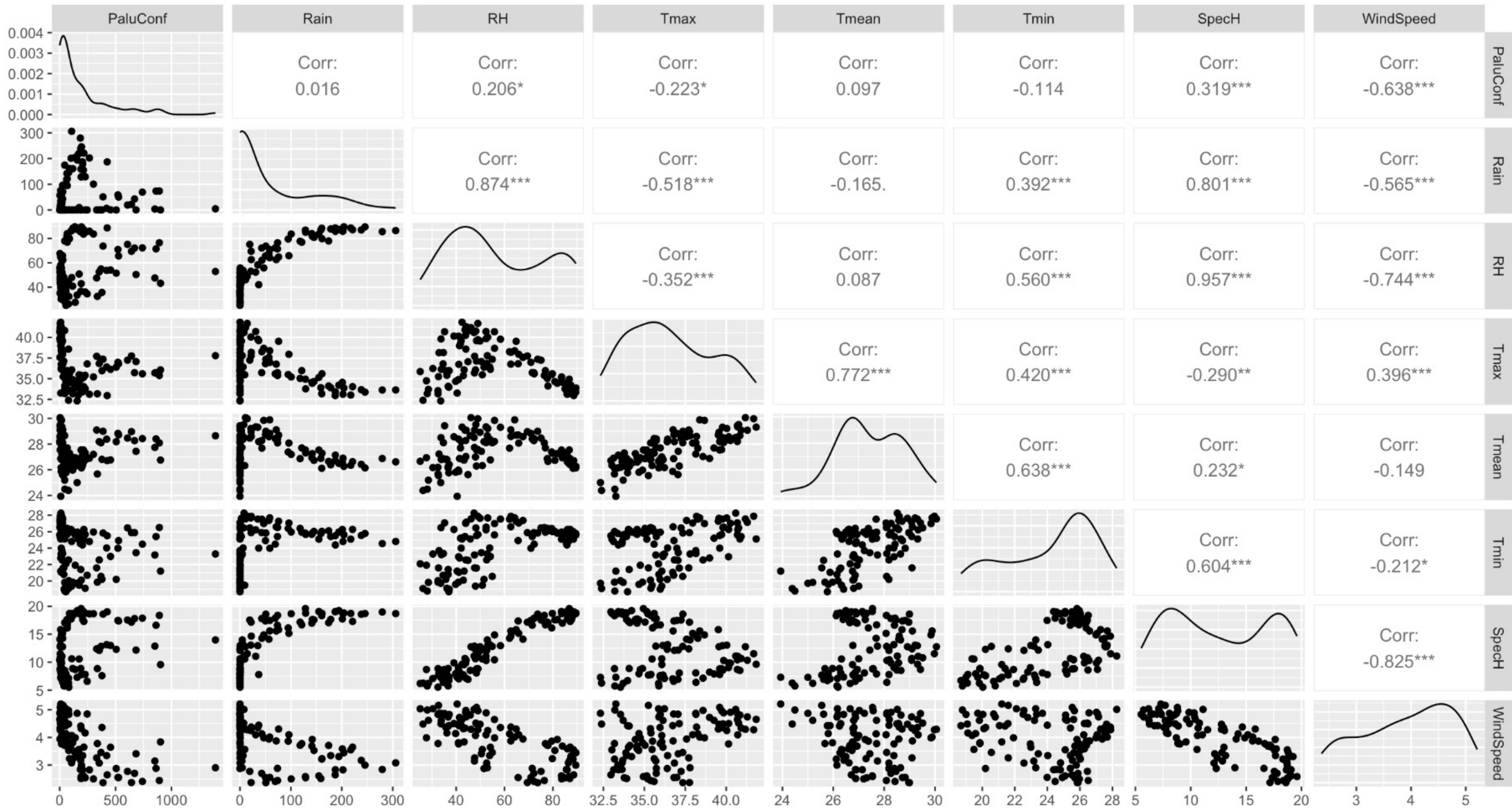
Senegal				
Dr Cheikh Talla	M	Institut Pasteur de Dakar	Statistics and data science	Principal Investigator (IPD)
Dr Cheikh Loucoubar	M	Institut Pasteur de Dakar	Statistics and data science	Co-Investigator
Dr Oumar Faye	M	Institut Pasteur de Dakar	Virology and diagnostics	Co-Investigator
Dr Mawlouth Diallo	M	Institut Pasteur de Dakar	Entomology	Co-Investigator
Dr Alioune Gaye	M	Institut Pasteur de Dakar	Entomology	Co-Investigator
Dr Ousmane Faye	M	Institut Pasteur de Dakar	Virology and diagnostics	Co-Investigator
Dr Martin Faye	M	Institut Pasteur de Dakar	Virology and diagnostics	Co-Investigator
Dr Ibrahima Diouf	M	Laboratory of Physics of Atmosphere and Ocean - Siméon Fongang (LPAO-SF) at the polytechnic Higher School	Climate Health	Co-Investigator

Nigeria				
Prof Rosemary Audu	W	Nigerian Institute of Medical Research	Medical Virology	Principal Investigator (NIMR)
Prof Ehimario Igumbor	M	Nigerian Institute of Medical Research	Epidemiology/Public Health	Co-Investigator
Ms Fehintola Ige	W	Nigerian Institute of Medical Research	Cell Biology and Genetics	Co-Investigator
Dr Adedapo Adeogun	M	Nigerian Institute of Medical Research	Entomology	Co-Investigator
Dr Olaide Kareem	W	Nigerian Institute of Medical Research	Veterinary Medicine	Co-Investigator
Dr Olufemi Amoo	M	Nigerian Institute of Medical Research	Cell Biology/Biochemistry	Co-Investigator
Shaibu Joseph	M	Nigerian Institute of Medical Research	Molecular Virology	Co-Investigator
Dr Azuka Okwuraiwe	M	Nigerian Institute of Medical Research	Biochemistry	Co-Investigator
Dr Babalola Ayodele	M	Nigerian Institute of Medical Research	Parasitology/Modelling	Co-Investigator
Qazeem Akinlotan	M	University of Lagos	Parasitology & Bioinformatics	PhD Student
Dr Henry Oshilonyah	M	University of Delta	Public Health Microbiology	Co-Investigator
Dr Gloria Patrick-Ferife	W	Delta State Ministry of Health	Public Health	Co-Investigator

MALARIA

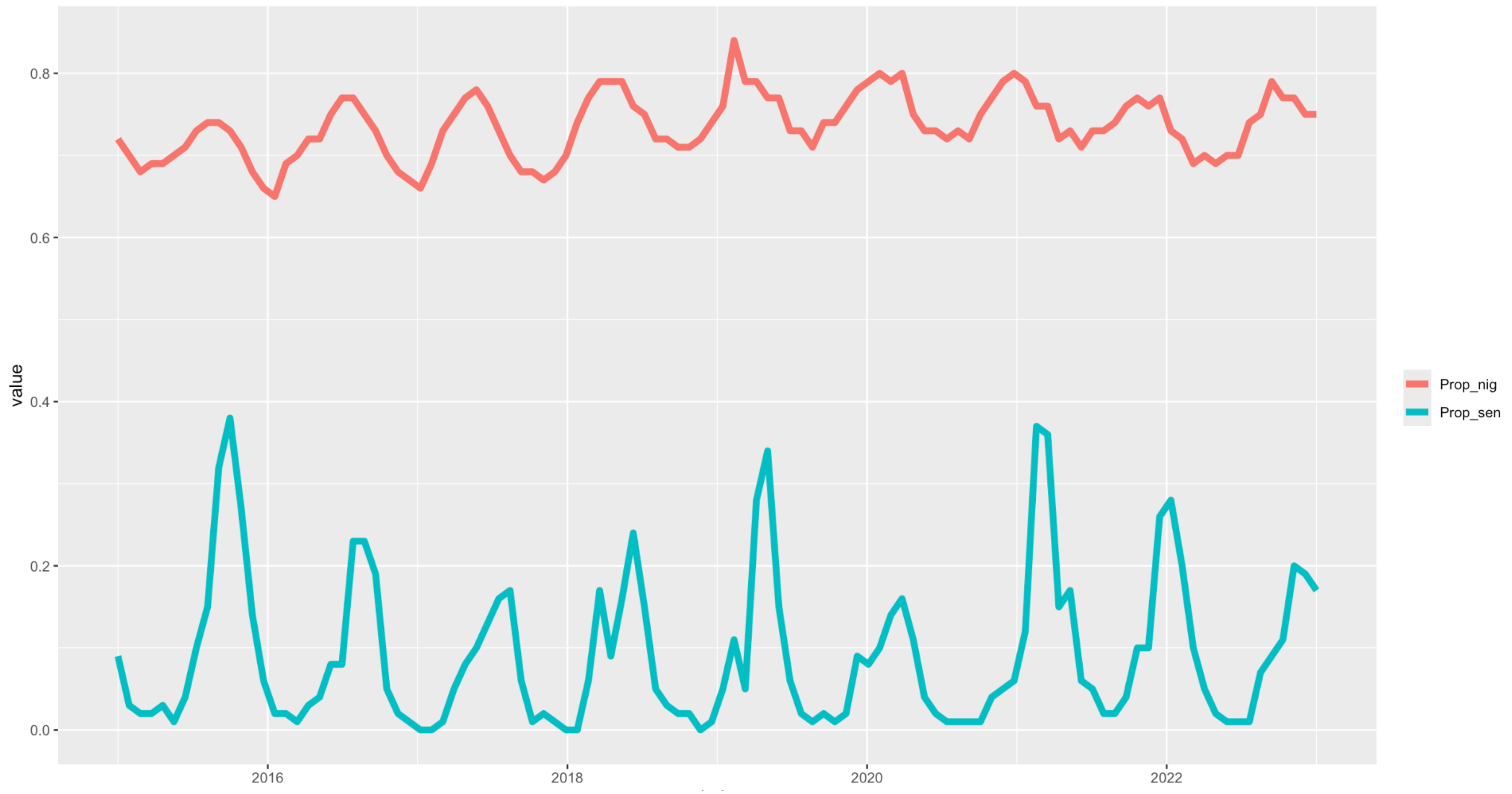
- SENEGAL - NIGERIA

Climate data (Monthly)



Malaria data (Monthly)

Proportion of malaria cases

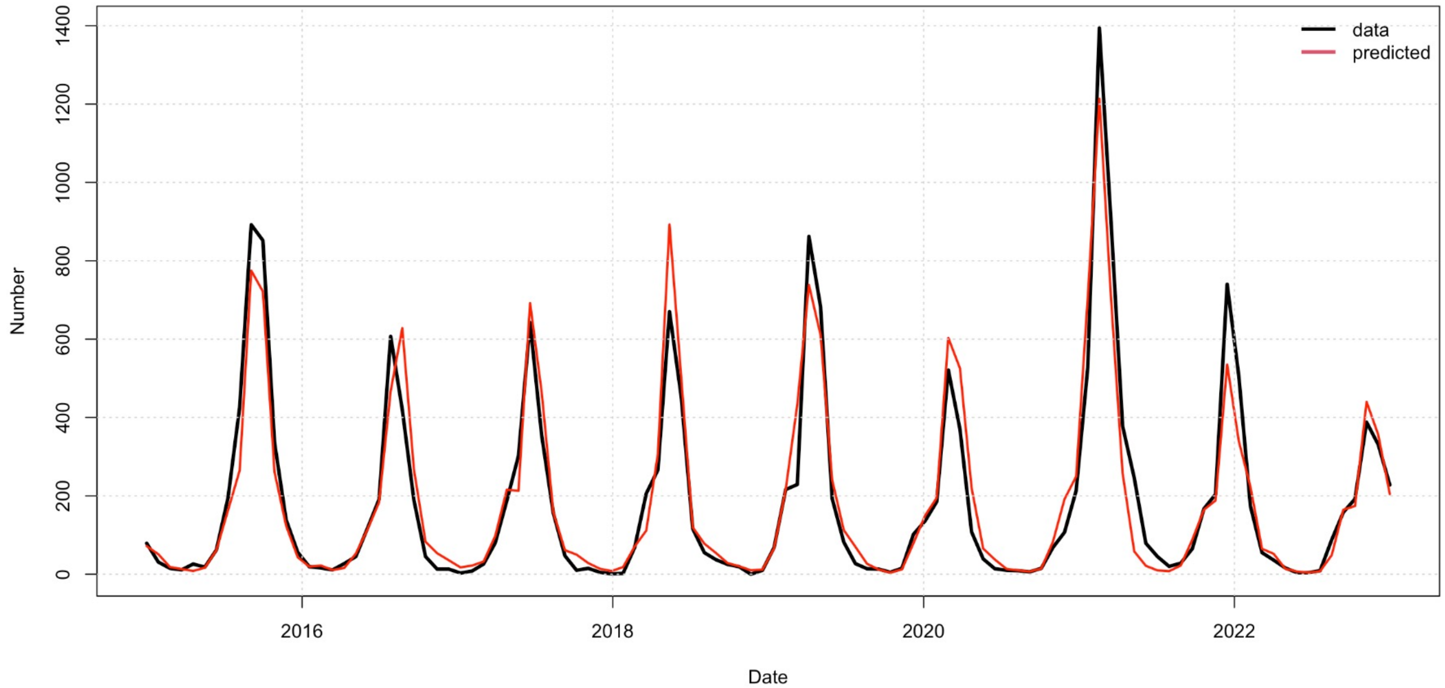


Mixed GLM model with Poisson distribution

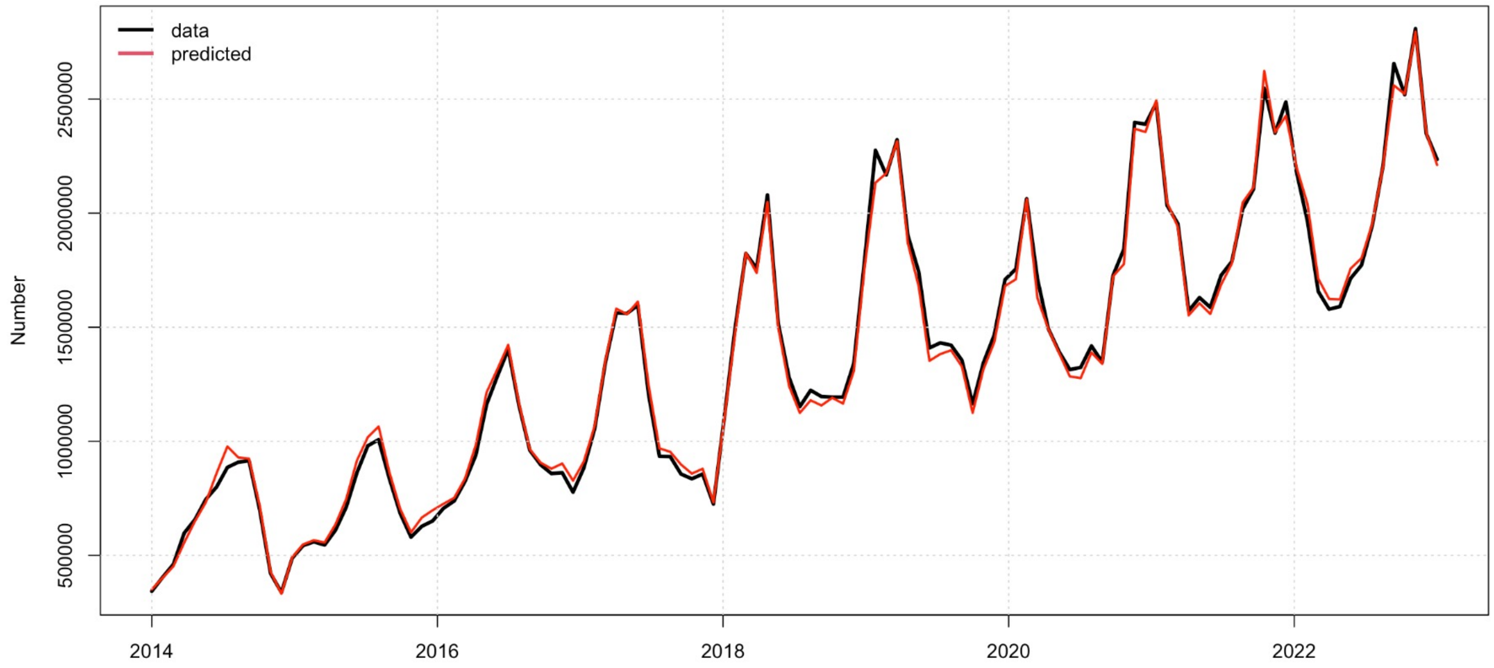
$$Y_{ij} \sim Poisson(\theta_{ij} \times E)$$

$$log(\theta_{ij}) = \beta_0 + \sum_j \beta_j \times Climatedata_{ij} + sin\left(\frac{W_i \times 2\pi}{12}\right) + cos\left(\frac{W_i \times 2\pi}{12}\right) + sin\left(\frac{W_i \times \pi}{12}\right) + cos\left(\frac{W_i \times \pi}{12}\right) + T_i$$

Model output GLM model with Poisson distribution



Model output GLM model with Poisson distribution



Model output GLM model with Poisson distribution

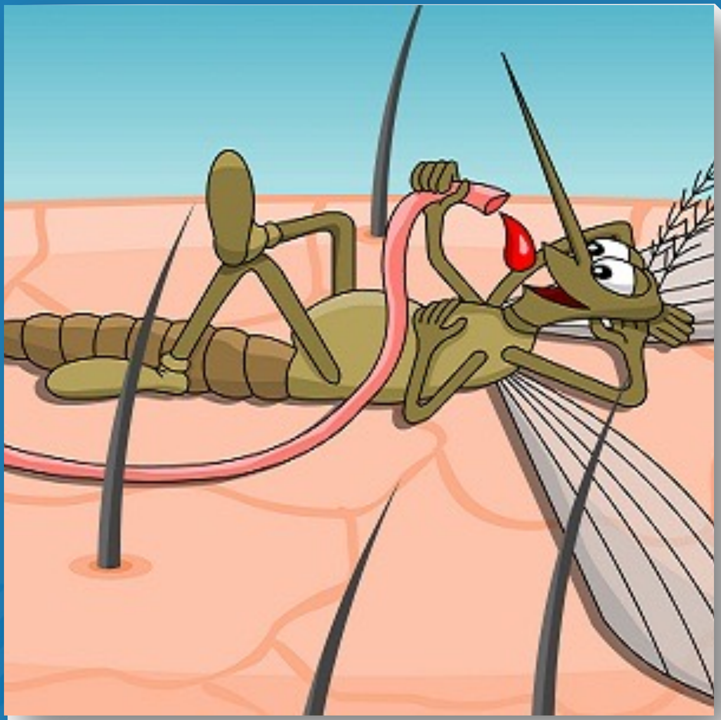
	Palu Conf		
Predictors	*Incidence Rate Ratios*	*CI*	*p*
(Intercept)	0.00	0.00 – 0.01	**<0.001**
Rain	1.00	1.00 – 1.00	**<0.001**
RH	1.02	1.02 – 1.03	**<0.001**
Tmax	0.93	0.91 – 0.95	**<0.001**
Tmin	1.19	1.17 – 1.21	**<0.001**
sin1	1.03	1.00 – 1.05	**0.017**
sin2	0.98	0.96 – 1.00	0.061
cos2	0.90	0.88 – 0.91	**<0.001**
cos1	1.14	1.12 – 1.17	**<0.001**
Random Effects			
σ^2	2.92		
$\tau_{00\ \text{Month}}$	2.16		
ICC	0.43		
N_{Month}	12		

	cases confirmed		
Predictors	*Incidence Rate Ratios*	*CI*	*p*
(Intercept)	0.53	0.51 – 0.54	**<0.001**
Rain	1.00	1.00 – 1.00	**<0.001**
RH	1.00	1.00 – 1.00	**<0.001**
Tmax	1.02	1.02 – 1.02	**<0.001**
Tmean	0.99	0.99 – 0.99	**<0.001**
Tmin	1.00	1.00 – 1.00	**<0.001**
Month	1.01	1.00 – 1.01	**<0.001**
sin1	1.00	1.00 – 1.00	**<0.001**
sin2	1.00	1.00 – 1.00	**<0.001**
cos2	1.00	1.00 – 1.00	**<0.001**
Random Effects			
σ^2	0.86		
$\tau_{00\ \text{Month}}$	0.00		
ICC	0.00		
N_{Month}	12		

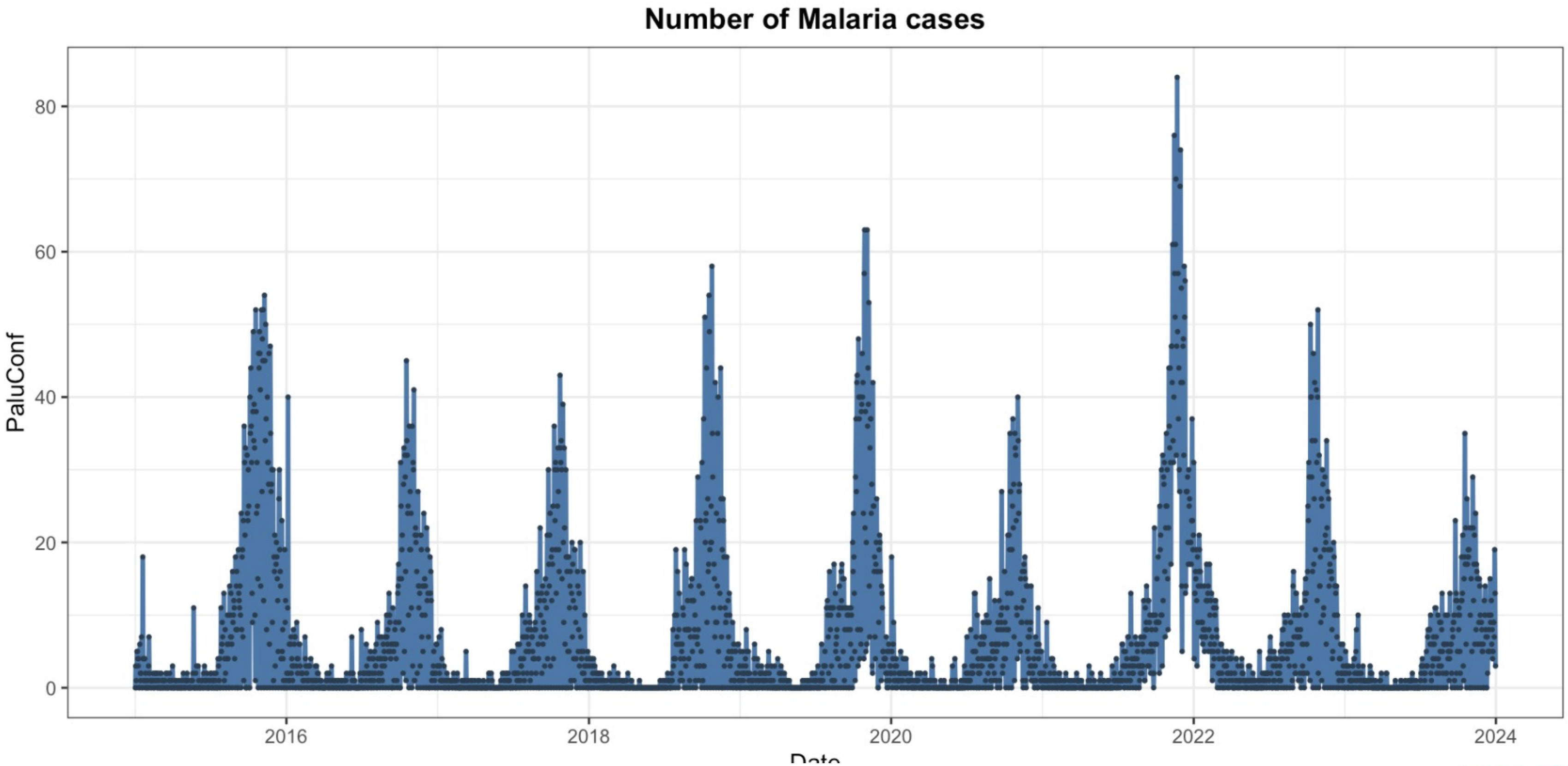
Discussions

- ✓ Climate affects the number of malaria cases
- ✓ The most important variable for Senegal is the minimum temperature
- ✓ In Nigeria, the variable with the greatest impact on the number of cases of malaria is the maximum temperature.

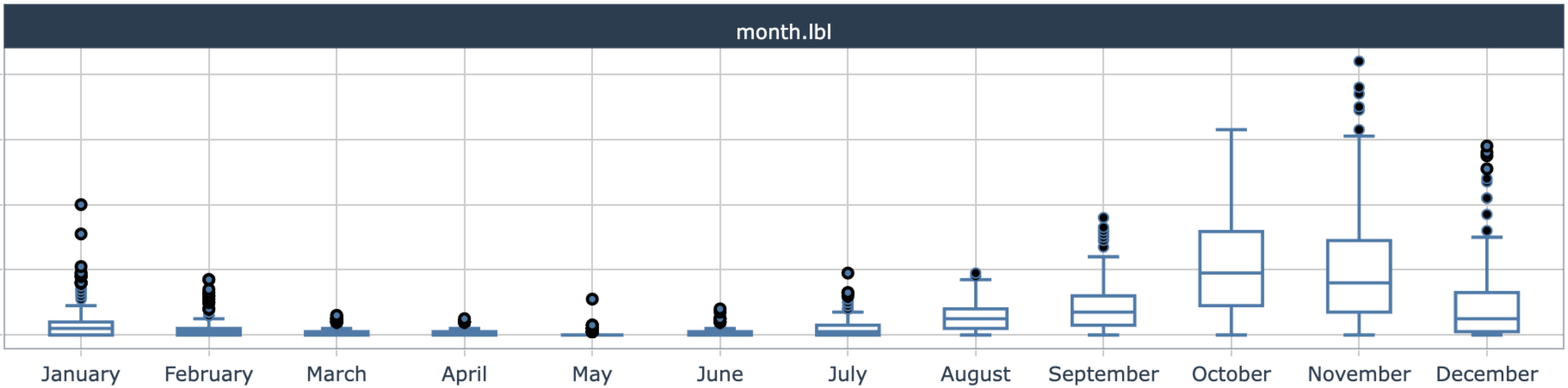
MALARIA



Malaria cases (Senegal)



Malaria trend (Senegal)



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Model output of the Distributed lag Linear model

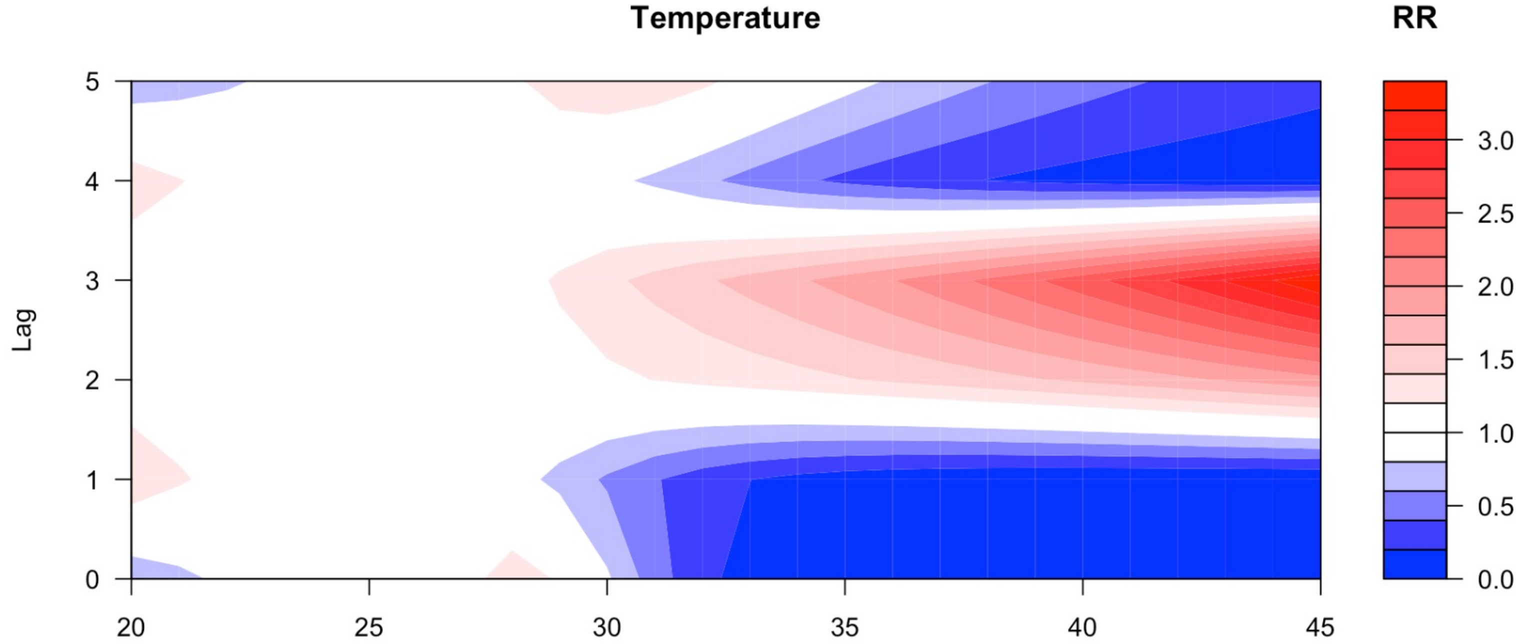
- Temperature has an impact on the number of cases of malaria, but this impact is delayed by between 2 and 4 days.

- The range of temperature values that have an impact on the number of cases is 30-45 degrees Celsius.

$$Y_i = \beta_0 + \sum_j^K \beta_j x_{t-l} + Climatedata_{ij} + \epsilon_i$$

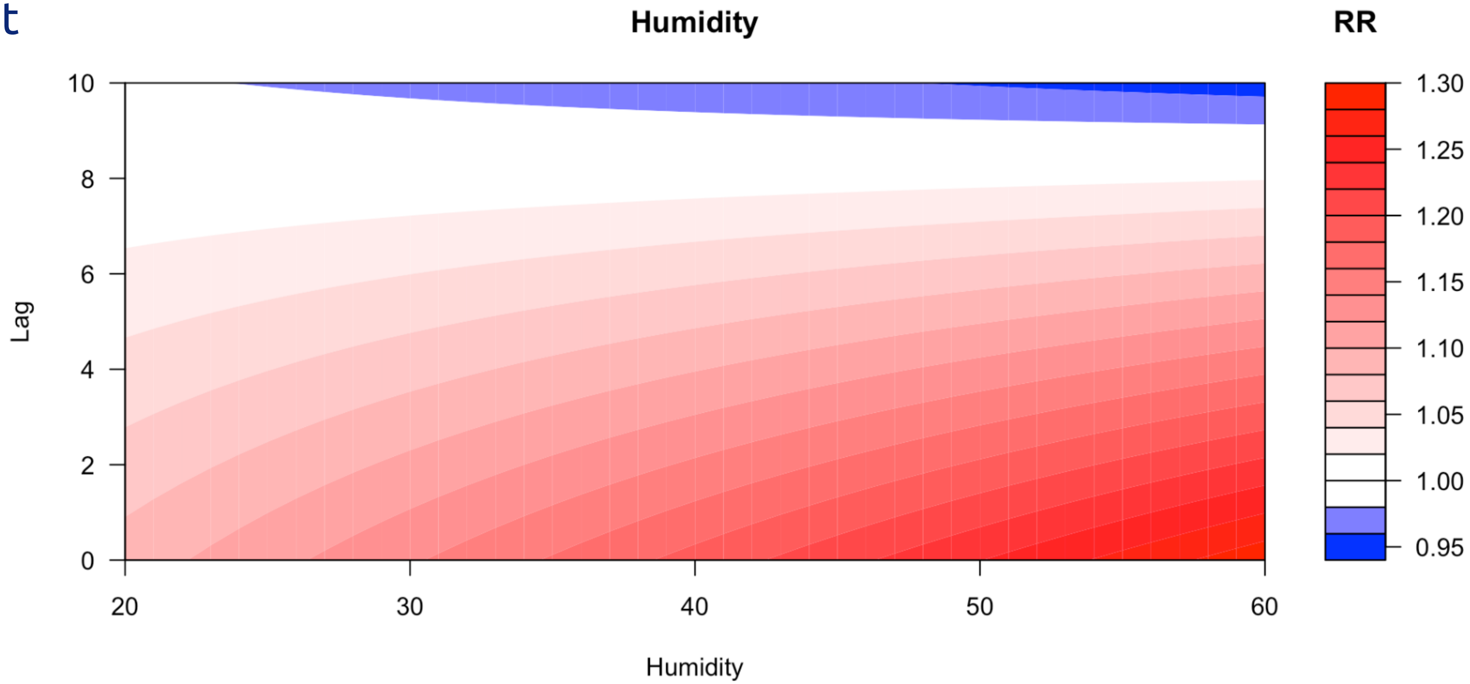
where K is the maximum lag and x is a predictor

$$log(\theta_{ij}) = \beta_0 + \sum_j \beta_j \times Climatedata_{ij} + ns(time, df)$$



Model results

Humidity impact is delayed by between 0 and 6 days and the range of important value is 20 – 60 mm



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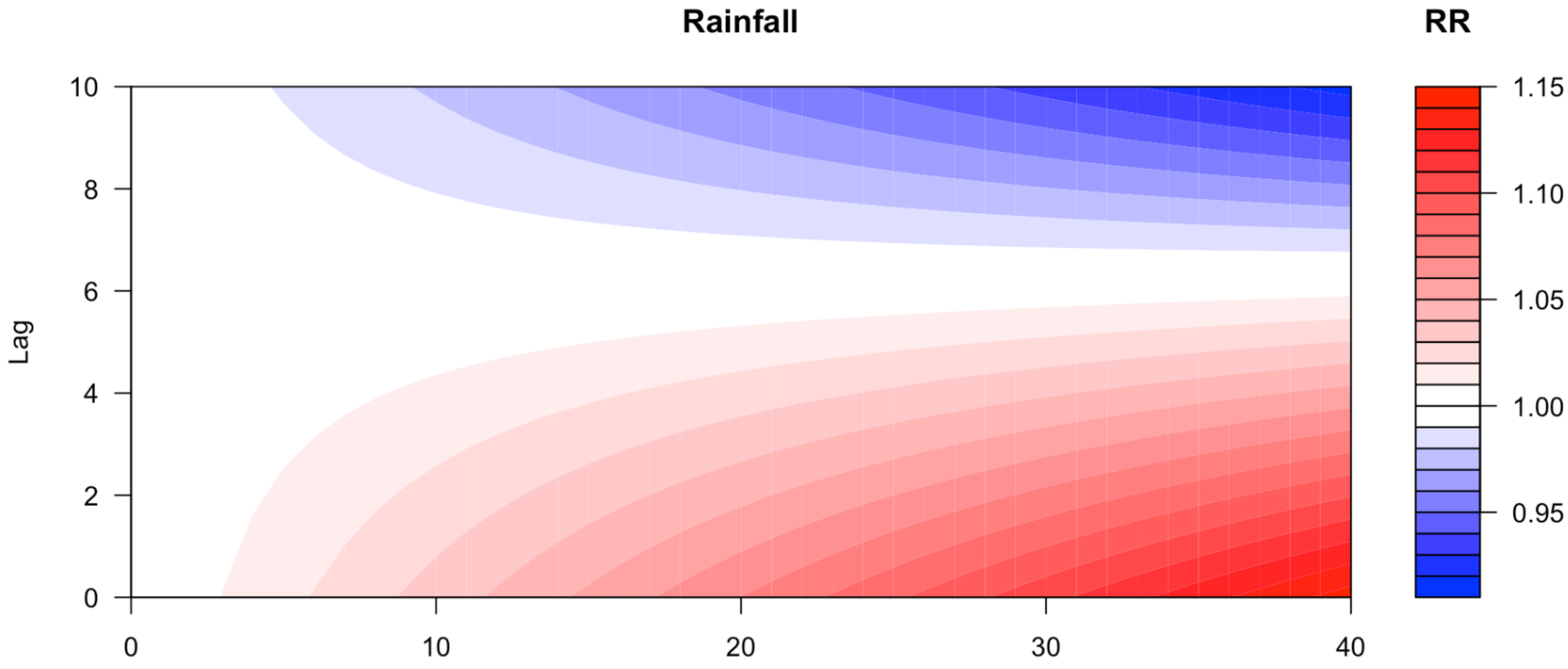
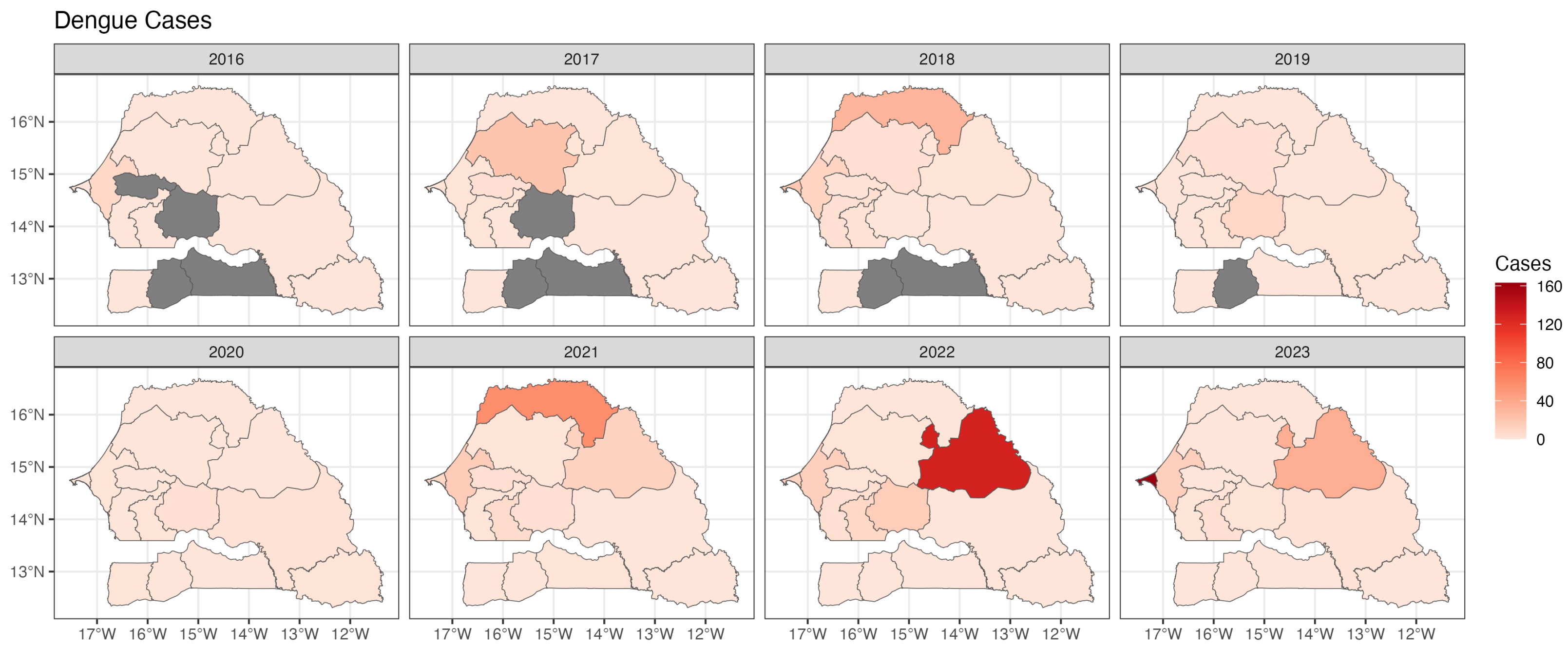
Model results

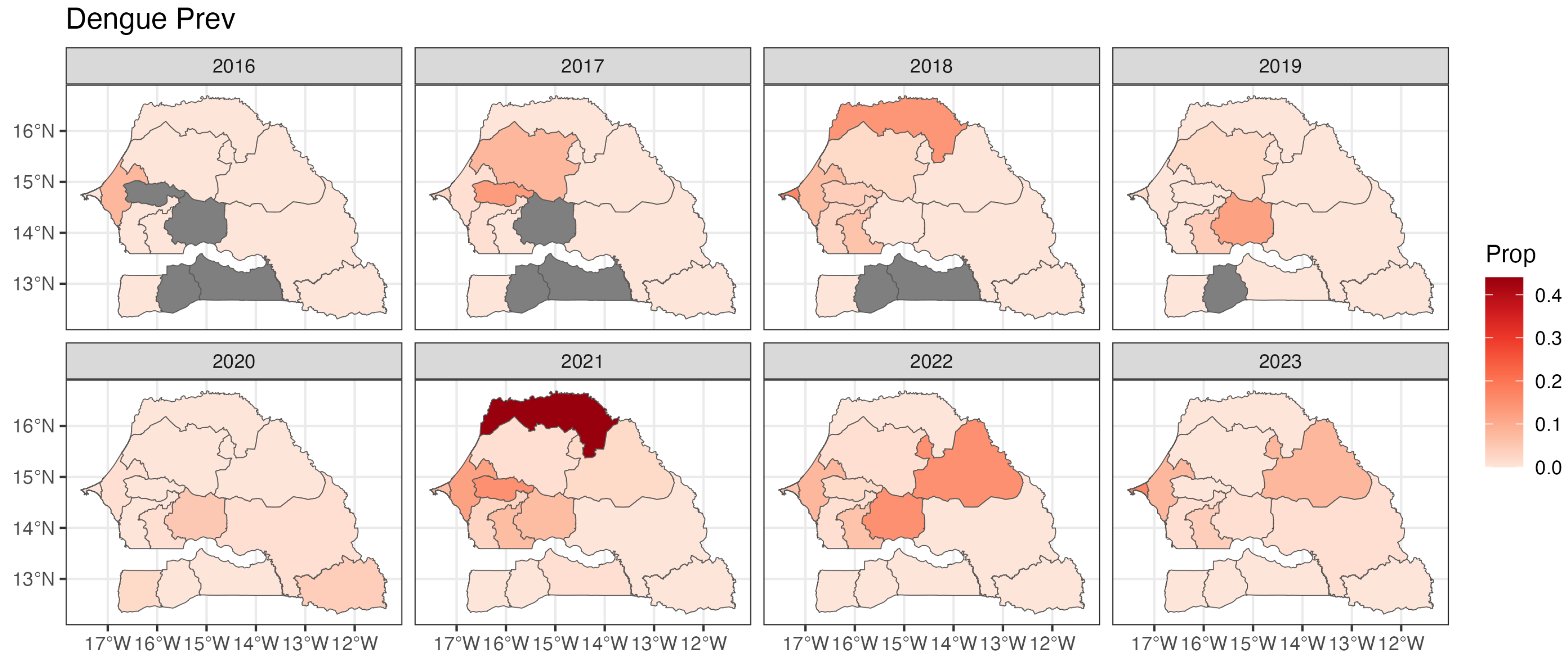


DENGUE

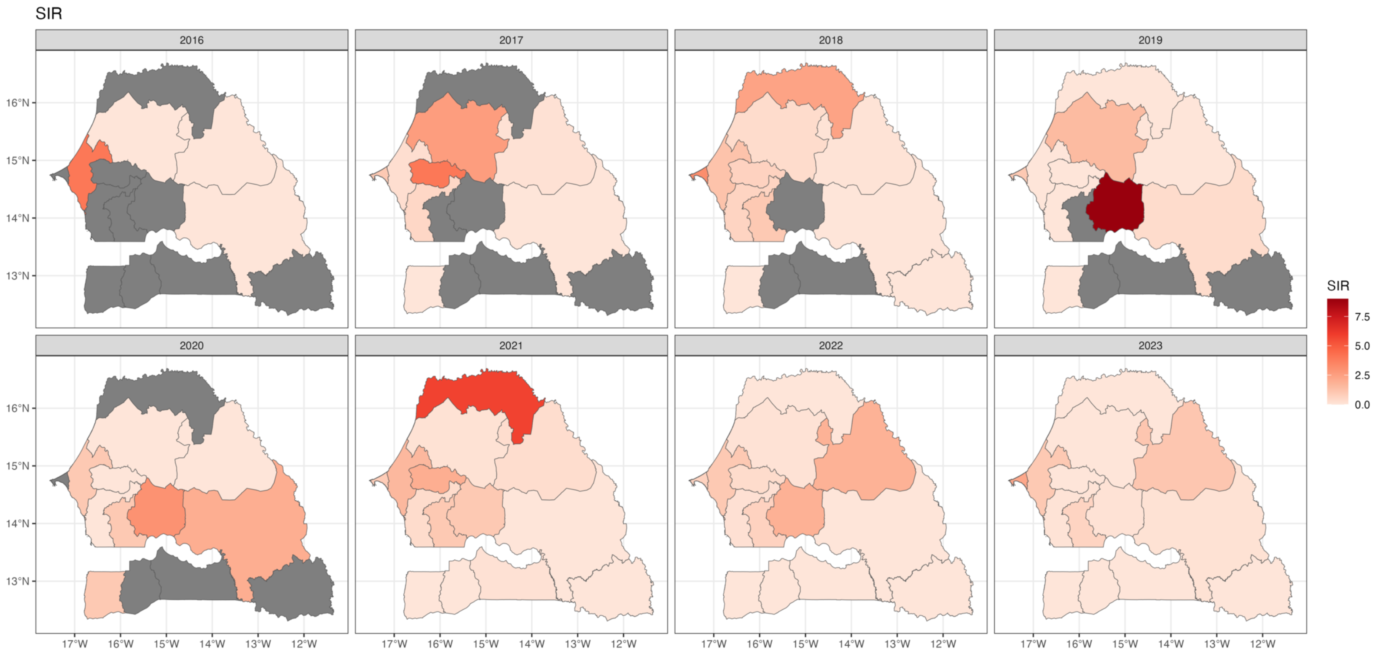
Dengue cases



Proportion of positive cases



Standardized Incidence Ratio (SIR)



The SIR is defined as the ratio of observed counts to the expected counts based on prevalence

$$SIR_i = Y_i / E_i$$

Model framework: INLA model with Poisson distribution

We estimate the relative risk of Dengue for each Sengalese region and year using the Bernardinelli model (Bernardinelli et al., 1995).

Observed count is Poisson distributed (y_i)

$$Y_i \sim Poisson(E_i \theta_i), i = 1, \ldots, n$$

With E_i is the expected count and θ_i is the relative risk in area i.

$$log(\theta_i) = \beta_0 + \sum_j \beta_j \times Climatedata_{ij} + u_i + v_i +$$

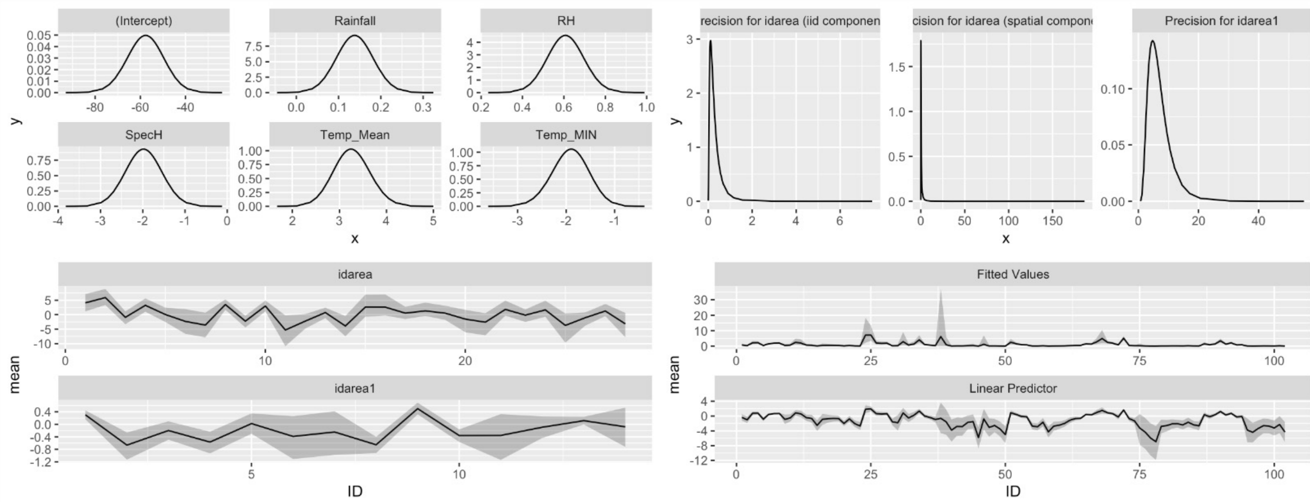
$$\mu | \mu_{-i} \sim N(\bar{u_{\delta_i}}, \frac{\sigma_u^2}{n_{\delta_i}})$$

$$v_i \sim N(0, \sigma_v^2)$$

Model output and diagnostic

	mean	sd	0.025quant	0.5quant	0.975quant	mode	kld
(Intercept)	-29.594	4.802	-39.195	-29.525	-20.375	-29.522	0
Temp_Mean	2.838	0.370	2.127	2.834	3.575	2.834	0
Temp_MIN	-2.832	0.340	-3.509	-2.828	-2.175	-2.828	0
Rainfall	0.138	0.041	0.057	0.138	0.220	0.138	0
RH	0.267	0.035	0.200	0.267	0.336	0.267	0
year	-0.439	0.167	-0.799	-0.430	-0.136	-0.404	0

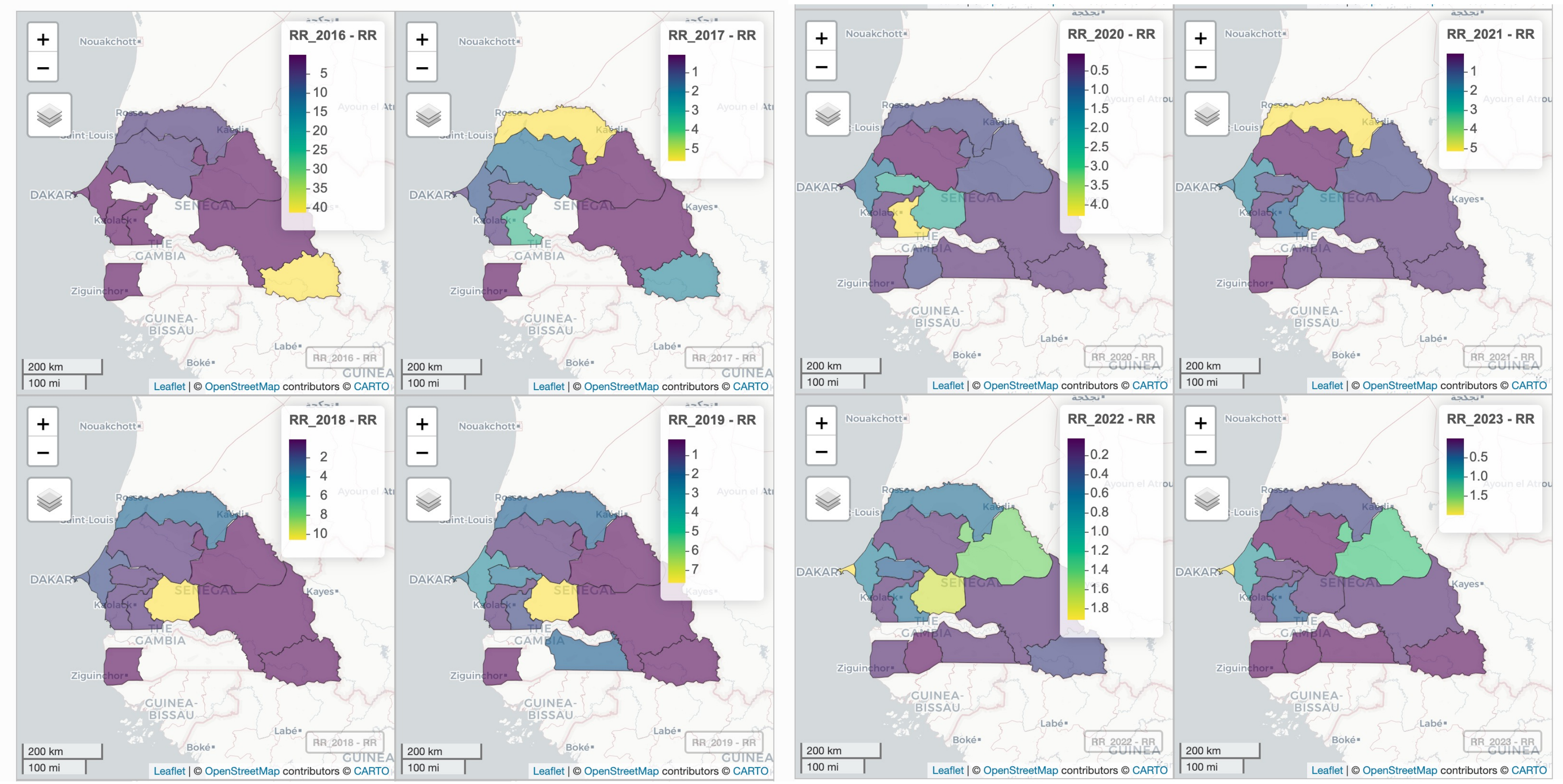
The most impacting variable on dengue cases



The model diagnostic

Relative Risk (RR) : Spatial and temporal distribution of relative risk

- The risk has been higher in the central and northern regions since 2018.



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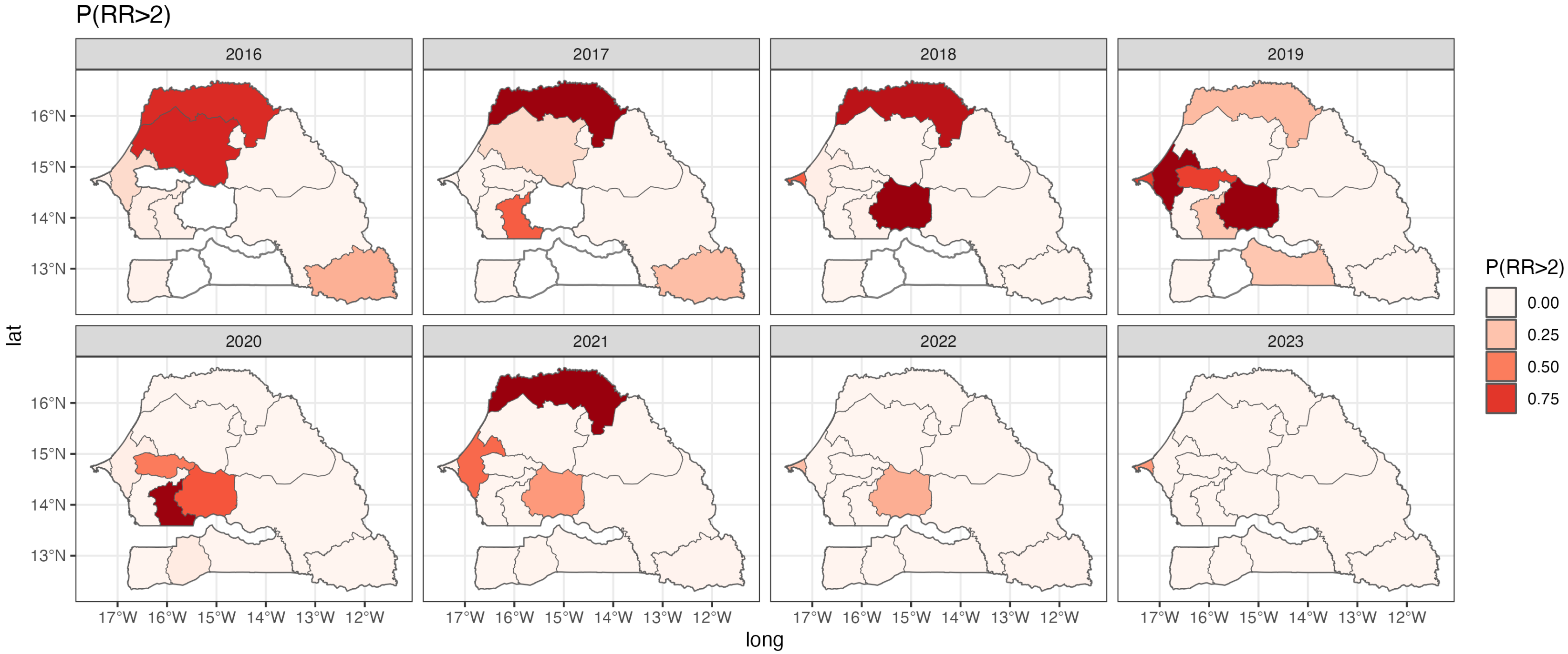
Map of the exceedance probabilities.



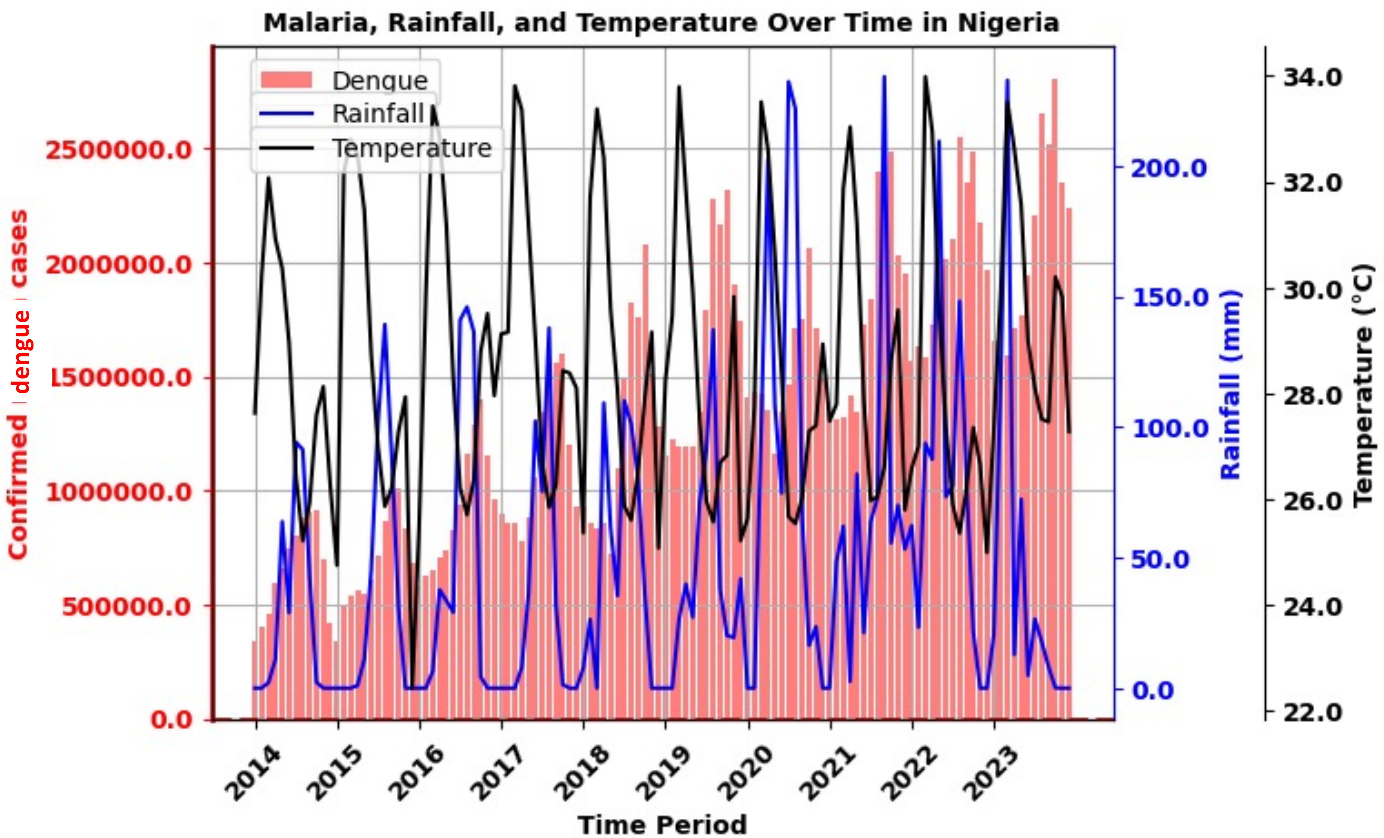
This map provides evidence of excess risk within individual areas. In areas with probabilities close to 1, it is very likely that the relative risk exceeds 2, and areas with probabilities close to 0 correspond to areas where it is very unlikely that the relative risk exceeds 2.

Discussion

- The covariates considered important in explaining the risk of dengue were The Min temperature, the average temp, the rainfall and relative humidity.

- Besides the climatic covariate's contribution to the model, temporal and spatial random effects are also important factors in modelling dengue behaviour because they provide temporal or spatial information which is not observable through the selected covariates.

Nigeria: dengue cases



Thank You for Listening