Possible Impact of climate change on meningitis in northwest Nigeria: an assessment using CMIP5 climate model simulations

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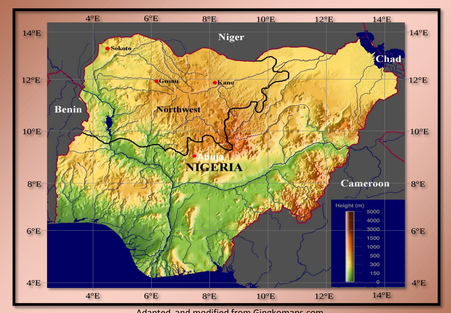
1. Introduction

Meningitis remains a major health burden throughout Sahelian Africa, especially in the heavily-populated northwest Nigeria. Cases exhibit strong sensitivity to intra- and inter-annual climate variability, peaking during the hot and dry boreal spring months, raising concern that future climate change may increase the incidence of meningitis in the region. The region is identified as "hotspot" of climate change (Diffenbaugh and Giorgi, 2012) and is projected to be disproportionately affected due to the vulnerability of the populations. Projecting the potential impact of climate change on meteorologically-sensitive infectious diseases is essential for regions where changes to disease distribution and seasonality may have adverse health impacts.

2. Study Area



Adapted and modified from Gingkomaps.com

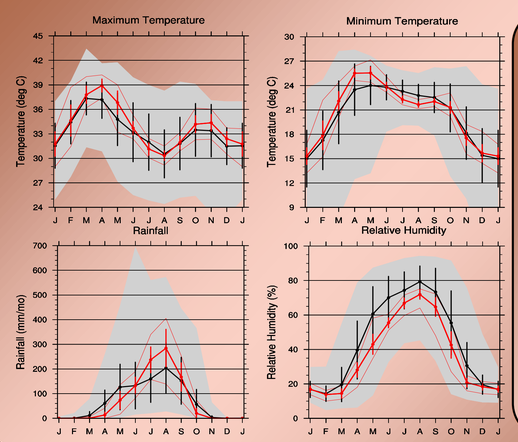
3. Data and method

The impact of future climate change on meningitis risk in northwest Nigeria is assessed by forcing an empirical model of meningitis (Abdussalam et al. 2013) with monthly simulations from an ensemble of thirteen statistically downscaled global climate model projections from the **CMIP5** for **RCPs 2.6, 6.0** and **8.5** scenarios, and for two 21st century periods: **2020-2035** and **2060-2075**. Seven AOGCM variables were statistically downscaled to each of the three cities (Kano, Sokoto and Gusau) used in the meningitis model development, using gamma method similar to that of Michelangeli et al. (2009), referred to as cumulative distribution function-transform (CDF-t).

4. List of climate models used

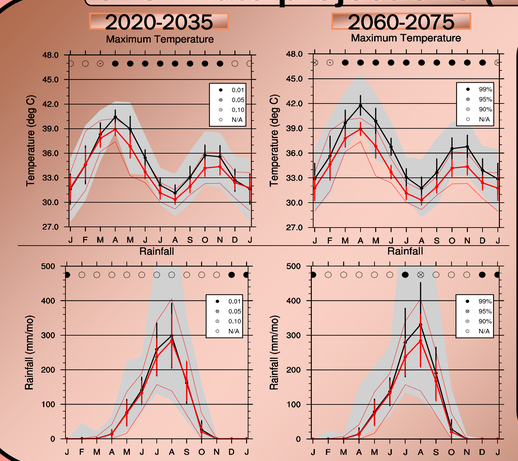
Model	Modeling centre	Institution
BCC-CSM1.1	BCC	Beijing Climate Center, China Meteorological Administration
CESM1-CAM5	NSF-DOE-NCAR	National Center for Atmospheric Research
CSIROMk3.6.0	CSIRO-QCCCE	Commonwealth Scientific and Industrial Research Organization in collaboration with the Queensland Climate Change Centre of Excellence.
GFDL-ESM2G	NOAA GFDL	Geophysical Fluid Dynamics Laboratory
GFDL-ESM2M	NOAA GFDL	Geophysical Fluid Dynamics Laboratory
GISS-E2-R	NASA GISS	NASA Goddard Institute for Space Studies
HadGEM2-ES	MOHC	Met Office Hadley Centre
IPSL-CM5ALR	IPSL	Institute Pierre-Simon Laplace
MIROC5	MIROC	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology
MIROC-ESM	MIROC	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
MIROC-ESMCHEM	MIROC	”
MRI-CGCM3	MRI	Meteorological Research Institute
NorESM1-M	NCC	Norwegian Climate Centre

5. Climate models evaluation



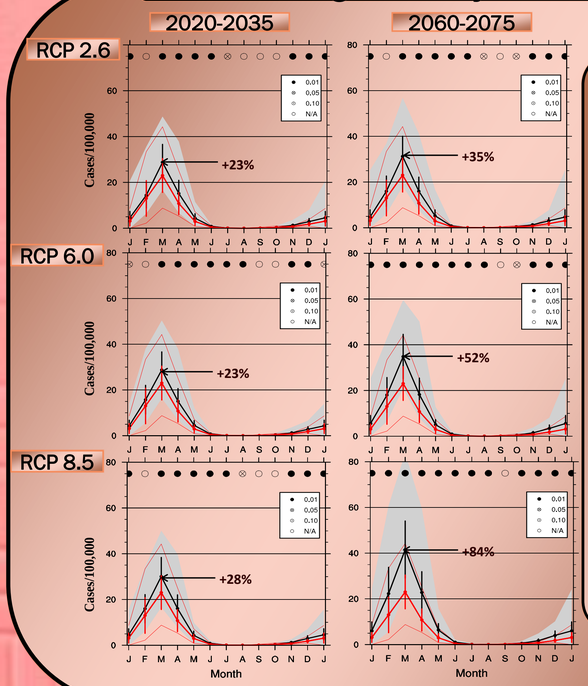
Annual cycle of the observed present day (1990-2005) maximum temperature (ºC), minimum temperature (ºC), monthly total rainfall (mm) and relative humidity (%) averaged for the three cities, in comparison with the ensemble of historical AOGCM simulations for the same 16-year period. **Red line:** Reference period **Black line:** The mean of the AOGCM simulations. **Vertical Lines:** +/- 1 standard deviation from means.

6. Climate projections (RCP6.0)



Annual cycle of the observed present day climate (1990-2005) in comparison with the ensemble of downscaled RCP6.0 AOGCM projections in 2020-2035 (left) and 2060-2075 (right). **Red line:** Reference period **Black line:** The mean of the AOGCM simulations **Vertical Lines:** +/- 1 standard deviation from means **Dots:** significance level

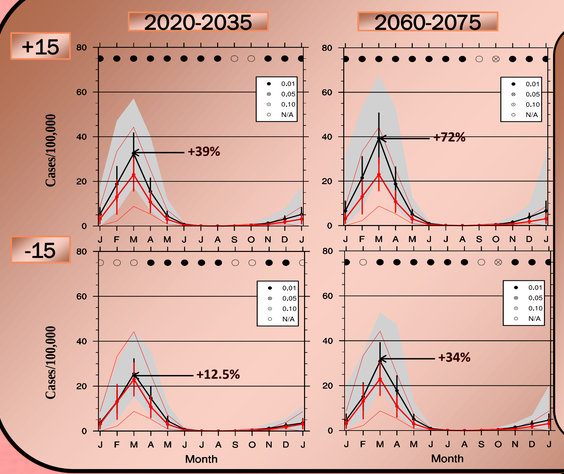
7. Meningitis Projections



The annual cycle of meningitis cases for present-day (1990-2005) compared with projected cases using the ensemble of thirteen downscaled AOGCM in 2020-2035 (left) and 2060-2075 (right) for the three different future scenarios.

Red line: Reference period **Black line:** The mean of the AOGCM simulations **Vertical Lines:** +/- 1 standard deviation from means **Dots:** Significance level

8. Sensitivity test for dust (RCP6.0)



Similar to the middle panels of figure 7 for the RCP6.0 projections of meningitis cases, but with the number of dusty days increased (top) and decreased (bottom) by 15%.

Red line: Reference period **Black line:** The mean of the AOGCM simulations. **Vertical Lines:** +/- 1 standard deviation from means. **Dots:** Significance level

9. Conclusions

- Temperature increases due to climate change has the potential to **significantly increase meningitis cases** in both the early and late 21st century, and to increase the length of the meningitis season in the late century.
- Annual incidence may increase by **47+/-8 %, 64+/-9 %, and 99+/-12%** for the RCP 2.6, 6.0 and 8.5 scenarios respectively in 2060-2075 with respect to 1990-2005.
- It is noteworthy that these results represent the *potential* for increased cases due to climate change, assuming current prevention and treatment strategies remain the same.

10. References

*__Abdussalam, A.F.__, A.J. Monaghan, V.M. Dukic, M.H. Hayden, T.M. Hopson, and G.C. Leckebusch, 2013: Climate influences on meningitis incidence in northwest Nigeria. *Wea. Clim. Soc.*, ***6***, 62-76. doi: 10.1175/wcas-d-13-00004.1.

*Diffenbaugh, N. S., and F. Giorgi, 2012: Climate change hotspots in the CMIP5 global climate model ensemble. *Climatic Change*, ***114***, 813-822. doi: 10.1007/s10584-012-0570-x.

*Michelangeli, P. A., Vrac, and H. Loukos, 2009: Probabilistic downscaling approaches: Application to wind cumulative distribution functions. *Geophys. Res. Lett.*, ***36***. doi: 10.1029/2009gl038401.

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