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# Remote sensing data applications in assessing seasonality in land surface temperature in tropical cities

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# Outline

- Introduction
- My experience in Lagos, Nigeria
- Why this study?
- How can Remote sensing help?
- Results and Discussion
- Conclusions

# Introduction

- Rapid urban development is influenced by increasing demands for land by rapidly growing global population

- Little studies in Nigeria apply satellite data to monitor LST in urban areas
- So ??

# Why this study?

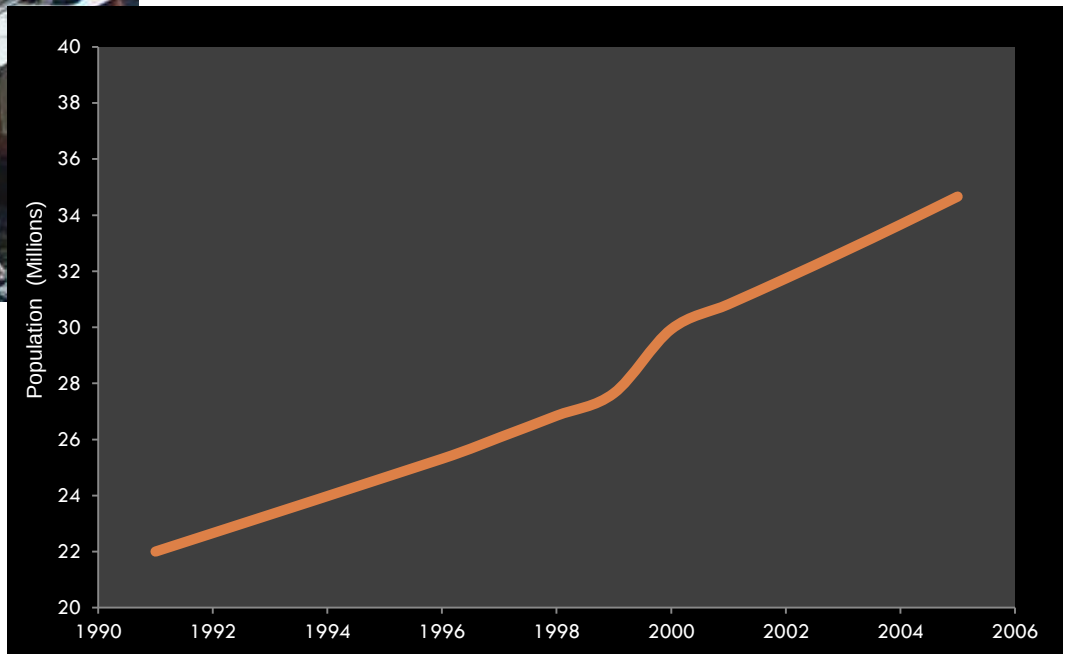
- Aims at using Moderate Resolution Imaging Spectroradiometer (MODIS) satellites data to:
- *assess seasonal variability in city LST, using Lagos metropolitan city as a case study*
- *examine spatial and temporal intensity of day/night time UHI*

Ayanlade A (2016) Seasonality in the daytime and night-time intensity of land surface temperature in a tropical city area. ***Science of The Total Environment*** **Vol.** 557: pp 415-424

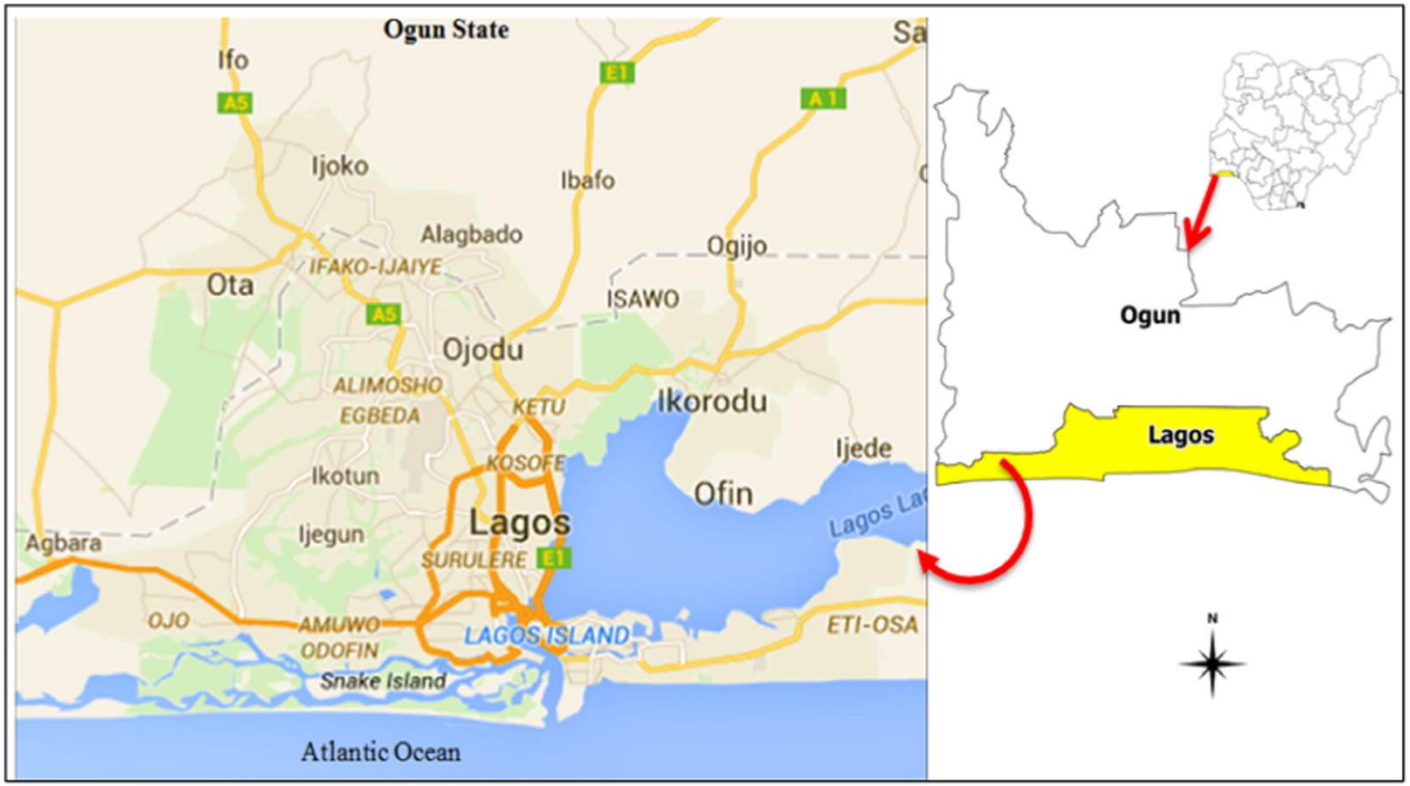
# My experience in Lagos, Nigeria

A rapidly growing Population due to:

- Rural-urban migration
- Increased birth rate



# Lagos, Nigeria



# MODIS satellites data

- The study utilizes satellite data from the MODIS data (Terra and Aqua).
- High temporal resolution and low spatial resolution (1 km)..
- MOD11A2 and MYD11A2, covering the period between 2002 and 2013
- split-window algorithm

# MODIS vs MET data

- comparing the LSTs derived from MODIS with air temperature from ground weather data.
- Landuse/Landcover change assessments
- The relationship between the Normalized Difference Vegetation Index (NDVI) and LST
- Landscapes contributions to UHI

# LST from MODIS

- LST was derived from MODIS data using two thermal infrared bands, as detailed in Wan *et al*. (2002).
- The split-window algorithm was used to derive thermal values are band 31 (10.78–11.28µm) and 32 (11.77–12.27µm)

Standardized split-window algorithm

$$LST = \alpha_0 + \alpha_1 T_i + \alpha_2 T_j$$

where $T$ represents the brightness temperatures of the two thermal infrared channels ($i$ and $j$), with coefficients, $\alpha_0$ , $\alpha_1$ and $\alpha_0$ chosen to reduce the error in the LST, the coefficients depending on the surface emissivity and the atmospheric state within the study area.

The coefficients account also for atmospheric conditions (related to spectral radiance and transmission).

# LST from MODIS

- LST contributions from sink (non-urban areas) and source (urban areas)

$$CI = D_t \times S$$

Where *CI* is the contribution index; $D_t$ is the difference in the temperature between the sink or source landscape and the entire region; *S* represents the proportion of the areas that were source landscape or sink landscape in the entire area

- Landscape index

$$LI = \left| {}^{CI_{sink}}/_{Ci_{source}} \right|$$

Where *LI* is landscape index; *CI* represents the contribution index of source and sink to Urban heat island

# Vegetal changes

- NDVI Model

$$\mathrm{NDVI} = \frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{red}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{red}}}$$

NDVI is calculated from surface reflectance in the near-infrared ρNIR and red ρred

- **NDVI Image Differencing**

$$\boldsymbol{DF = NDVI_{x_1} - NDVI_{x_2}}$$

Subtracting iNDVI mage of previous date ($X_1$) from later date ($X_2$),

# Landuse/Landcover Change

- Maximum likelihood classification Model

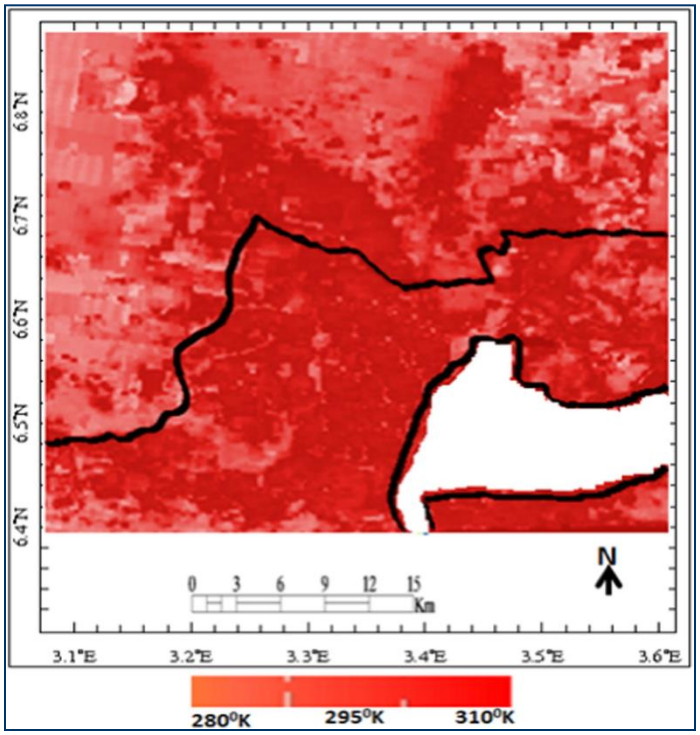
$$D = In_{(a_c)} - [0.5\, In_{(COV_C)}] - [0.5(X - M_C)T(COV_C - 1)(X - COV_C)]$$

- Post-classification comparisons

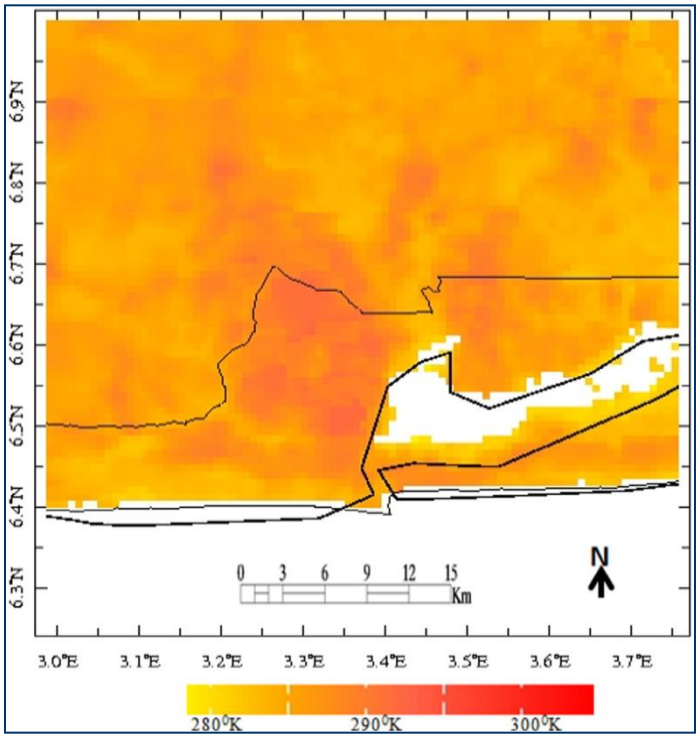
- $Int_{LUC} = [logC_{t1} - logC_{t0}]/(t_1 - t_0) \times 100$

- where $Int_{LUC}$ is the intra-annual land use change, $t_1$ is the final year, $t_0$ is an initial year and $C$ is the land use class percentage


# Results and Discussions




Daytime



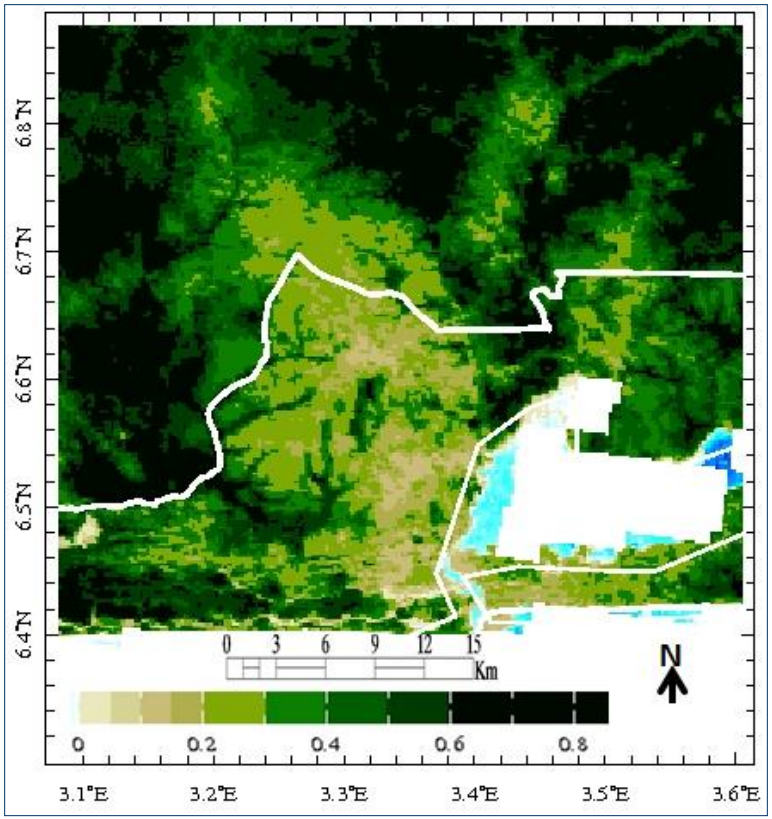

Nighttime

Overall pattern of UHI between 2002 and 2013

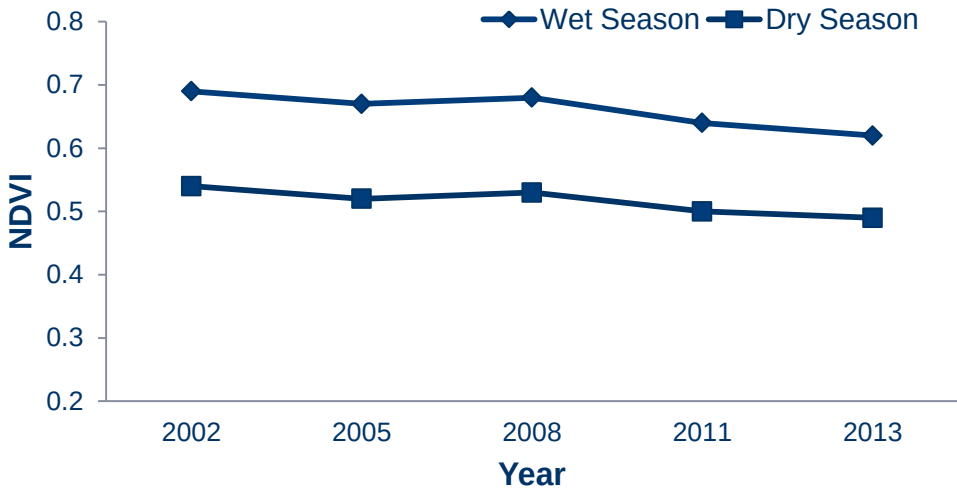
# Results and Discussions

| | | Wet season (°K) | | Dry season (°K) | |
|---|---|---|---|---|---|
| | | Day | Night | Day | Night |
| 2002 | Urban | 301.32 | 300.98 | 302.57 | 301.59 |
| | Non-urban | 298.43 | 297.61 | 300.29 | 299.56 |
| 2005 | Urban | 301.86 | 300.49 | 303.25 | 302.58 |
| | Non-urban | 300.78 | 298.65 | 300.67 | 299.31 |
| 2008 | Urban | 302.56 | 300.49 | 304.27 | 303.29 |
| | Non-urban | 298.54 | 297.35 | 301.26 | 300.18 |
| 2011 | Urban | 304.42 | 300.41 | 305.48 | 301.37 |
| | Non-urban | 300.78 | 299.39 | 300.64 | 299.29 |
| 2013 | Urban | 304.36 | 302.34 | 305.67 | 303.46 |
| | Non-urban | 300.45 | 299.81 | 301.56 | 299.63 |

# NDVI Results

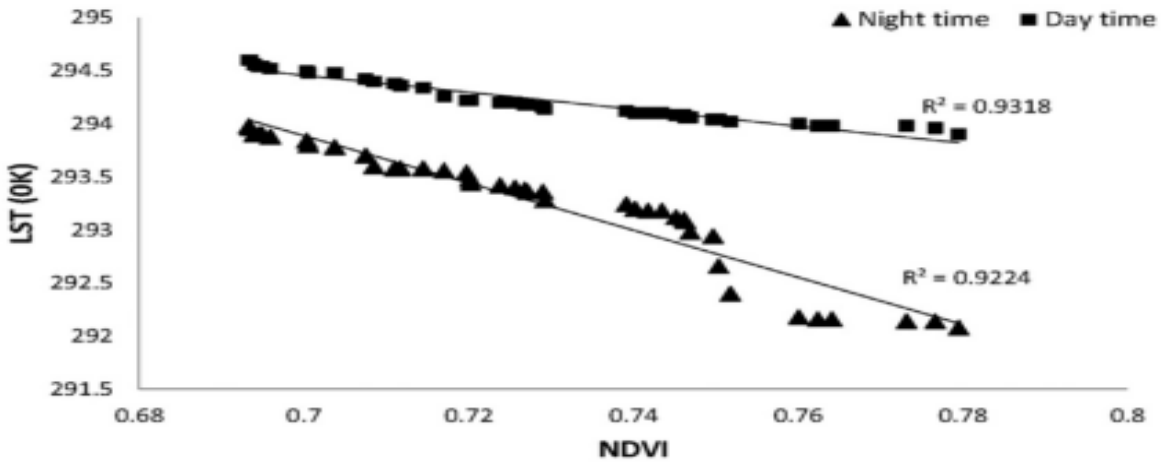

NDVI Image Differencing between 2002 and 2013




The seasonal changes in vegetation cover within the period of 2002 and 2013

# LST vs NDVI

| Time | Wet season | | Dry season | |
|---|---|---|---|---|
| | Daytime ($R^2$) | Night-time ($R^2$) | Daytime ($R^2$) | Night-time ($R^2$) |
| 2002 | 0.94 | 0.73 | 0.91 | 0.64 |
| 2005 | 0.91 | 0.68 | 0.87 | 0.65 |
| 2008 | 0.92 | 0.71 | 0.82 | 0.61 |
| 2011 | 0.90 | 0.63 | 0.79 | 0.59 |
| 2013 | 0.93 | 0.69 | 0.90 | 0.62 |




Negative correlation between NDVI and the LST for both day and night times

# LULCC

| | 2002 | 2008 | 2014 | Percentage change 2002-2014 |
|---|---|---|---|---|
| **Urban Centre** | 1014.68 | 1107.06 | 1206.96 | 15.93 |
| **Urban fringe** | 14.34 | 132.28 | 260.28 | 94.49 |
| **Wetland** | 45.27 | 33.45 | 23.98 | -8.31 |
| **Water body** | 642.79 | 631.76 | 622.34 | -3.28 |
| **Forest** | 2201.12 | 2013.65 | 1804.64 | -5.37 |
| **Total** | 3918.2 | 3918.2 | 3918.2 | |

# Landuse Vs LST

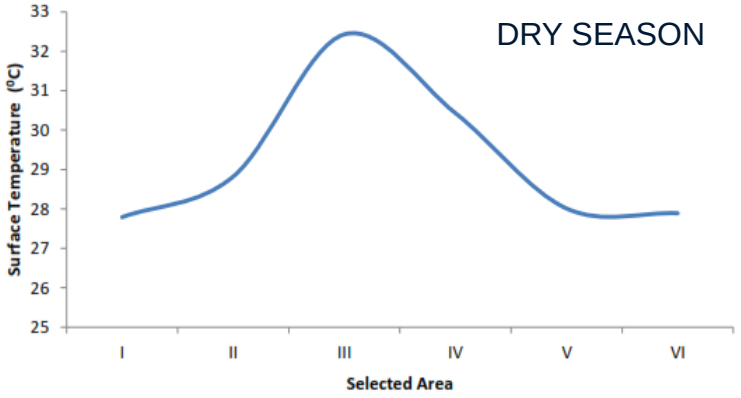
*Ayanlade (2016), Weather , in press*

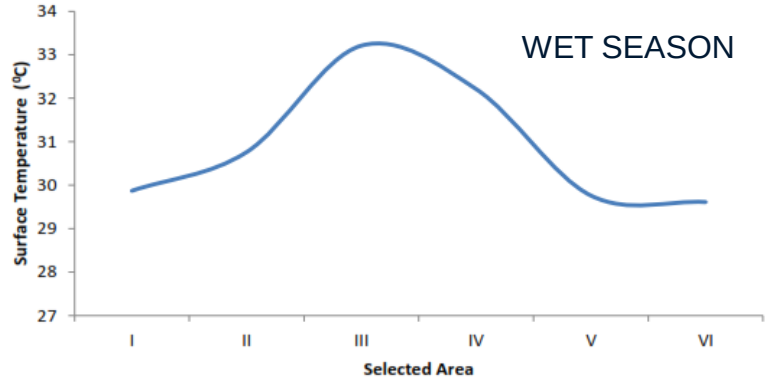
**Comparison of different landuse average Seasonal Land Surface Temperature (SLST) differentials by day and night between 2002 and 2014**

| | Wet Season ($^0$C) | | Dry season($^0$C) | |
|---|---|---|---|---|
| | Day | Night | Day | Night |
| Urban Centre | 33.25 | 25.65 | 34.21 | 27.24 |
| Urban fringe | 28.64 | 23.61 | 32.76 | 25.87 |
| Wetland | 27.18 | 24.65 | 28.23 | 25.45 |
| Water body | 26.78 | 23.67 | 27.71 | 24.12 |
| Forest | 27.87 | 24.98 | 29.87 | 24.02 |

# Selected site

| Selected Site | Description | Mean SLST Wet season | Mean SLST Dry season |
|---|---|---|---|
| I | This area is mainly farmland area, located around Ota community in Ogun state, Northwest of Lagos. | 27.7 | 29.8 |
| II | The zone is sub-urban residential areas, mainly along Alimosho community of Lagos, which consisting of urban fringe. | 28.8 | 30.7 |
| III | This site is mainly commercial and downtown area, consisting of Ikeja and Ilupeju of Lagos, which is the core urban part of the study area. | 32.4 | 33.2 |
| IV | This area consist of urban residential area, mainly the around Oshodi and Ijegun area. | 30.4 | 32.2 |
| V | This site is located around sub-urban residential area with some green cover, mainly around Isawo area. | 28.0 | 29.7 |
| VI | This is mainly rural area consist of vegetal cover and some houses, along Isiu community | 27.8 | 29.6 |



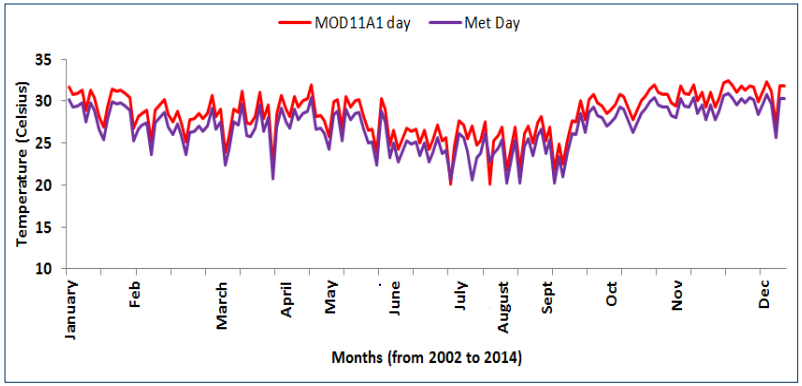



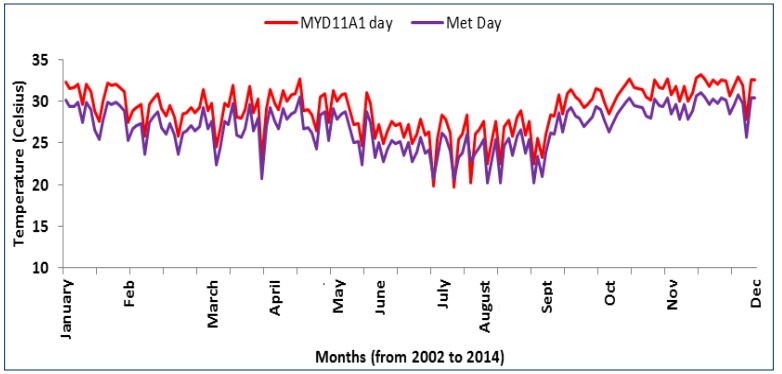

**Mean Seasonal Land Surface Temperature (SLST) from MODIS data between 2002 and 2014 for selected site.**

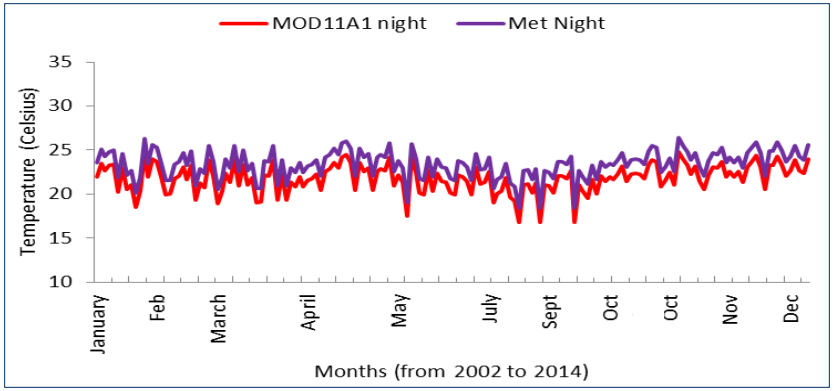
# MODIS and Meteo air temperature

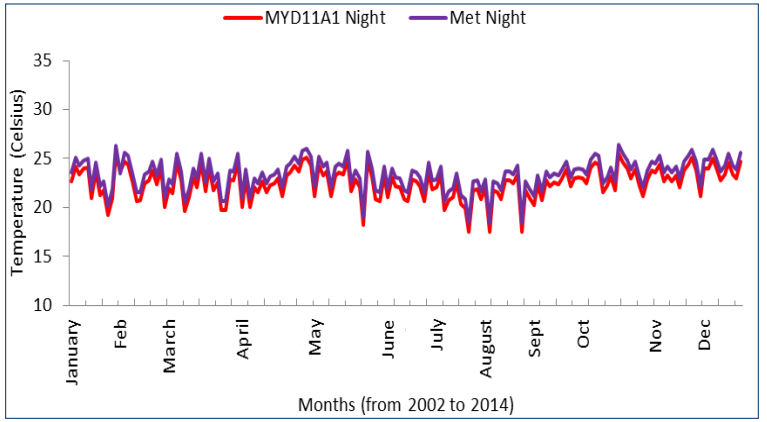
## LST observed between daytime and nighttime for both MOD11A2 and MYD11A2 values and that of maximum and minimum air temperature from in-situ data

- MODIS products hold potential benefits of good estimation of spatial and temporal LST
- MOD11A2 is a better proxy for daily maximum and minimum air temperature than MYD11A2



# Conclusion

- Remote sensing data offer possibility for measuring LST
- MOD11A2 is a better proxy for daily maximum and minimum air temperature than MYD11A2
- In all seasons, the average LST of urban areas is nearly 1.5 degC higher than the LST values for the surrounding rural areas.
- Reduction in vegetal cover in Lagos urban areas altered the terrestrial thermal and aerodynamic processes hence resulted in an intensification of UHI in the metropolitan city.

# *Thank you*