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Seasonal Structure and Multi-Decadal Stability of Cloud Cover over the Lagos Lagoon, Nigeria, 2000–2025: A Landsat-Based Assessment

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12:00 – 12:20 pm (WAT) | Online presentation

Theme: Innovations for Sustainable Development and Resilient Infrastructure



OUTLINE

Presentation Outline

01 Introduction and background

02 Problem statement, aim and objectives

03 Data, study area and methods

04 Results: trend, season and image availability

05 Conclusions and recommendations

06 References and acknowledgements

INTRODUCTION

Background to the Study

- Cloud governs the energy and water budget of the tropical coast and is the principal obstacle to optical Earth observation (Flores-Anderson et al., 2023)
- The Lagos Lagoon is both a moisture source and a thermal regulator for the Lagos megacity, reshaped by four decades of climate forcing and urbanisation (Omosanya et al., 2025)
- Persistent low-level cloud over southern West Africa is poorly represented in climate models (Kniffka et al., 2019)
- Cloud availability decides when optical survey, land-cover mapping and flood monitoring over the lagoon are possible at all

THE KNOWLEDGE GAP

The long-term behaviour of cloud over the Lagos Lagoon itself has rarely been quantified from the satellite archive, although it determines whether optical imagery of the lagoon can be acquired at all, and when.

This study supplies that record for 2000–2025 and converts it into acquisition guidance for the Lagos coastal zone.

INTRODUCTION

Problem Statement, Aim and Objectives

PROBLEM STATEMENT

Optical monitoring of the Lagos Lagoon is routinely frustrated by cloud, yet no study has quantified how cloudy the lagoon is, whether that has changed over time, or when usable imagery can be expected.

AIM

The aim of this study is to characterise the rate and pattern of cloud cover over the Lagos Lagoon between 2000 and 2025.

OBJECTIVES

1. To compile a 26-year, two-season record of Landsat scene cloud cover
2. To test for era change (2000–2012 vs 2013–2025) and for a monotonic trend
3. To test and quantify the dry-season / rainy-season contrast
4. To translate the record into optical image acquisition guidance

METHODOLOGY

Study Area, Materials and Methods

1 Data acquisition

52 Landsat 7 ETM+ and 8 OLI Collection 2 Level-2 scenes, path 191 / row 055; one dry and one rainy scene each year

2 Processing

Layer stacking and reprojection to WGS 84 / UTM 31N in ERDAS Imagine; lagoon area-of-interest subset

3 Analysis

t-tests, least-squares regression and the Mann–Kendall test on annual two-scene means

4 Outputs

Cloud climatology, ISODATA cloud maps for selected years and acquisition guidance

STATISTICAL ANALYSIS

Annual index: two-scene mean of the dry and rainy values

Era comparison: Student's and Welch's t-tests

Seasonal contrast: independent and paired t-tests, Cohen's d

Trend: least-squares regression and Mann–Kendall ($\alpha = 0.05$)

KEY SPECIFICATIONS

Lagos Lagoon, about 630 km², 2000–2025

52 scenes: 26 dry season, 26 rainy season

ERDAS Imagine; Microsoft Excel and Python (SciPy)

Scene cloud cover from CFMask product metadata

RESULTS

Cloud Cover Shows No Significant Change in 26 Years

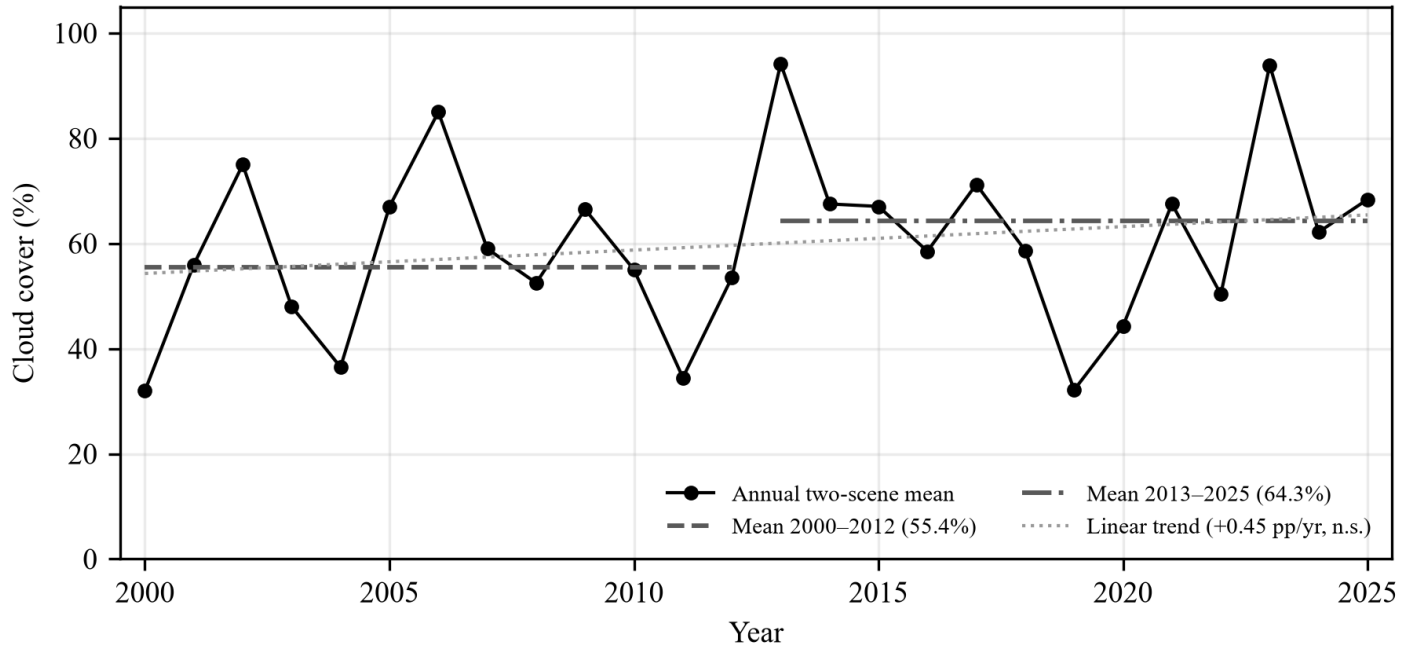


Figure 1: Annual two-scene mean cloud cover over the Lagos Lagoon, 2000–2025, with era means and the fitted linear trend.

KEY FINDING

59.9%

mean annual cloud cover over the 26-year record (SD = 16.8 pp; range 32.0–94.2%)

- No monotonic trend: Kendall's τ = 0.157, $p = 0.273$
- Eras do not differ: 55.4% against 64.3%, $t(24) = -1.376$, $p = 0.181$

RESULTS

The Rainy Season Is 47 pp Cloudier than the Dry Season

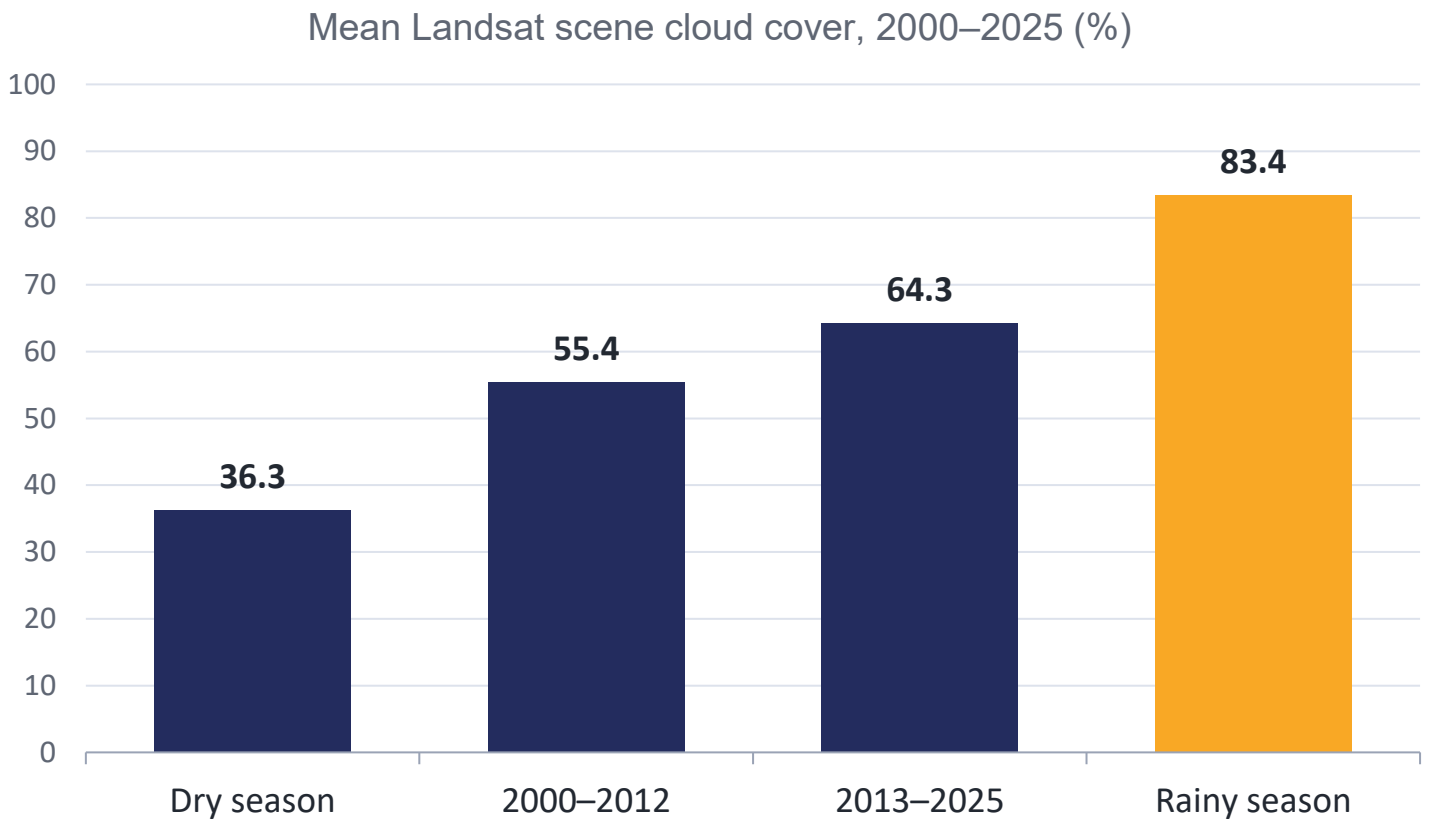


Figure 2: Mean Landsat scene cloud cover by season and by era over the Lagos Lagoon (%), 2000–2025.

KEY FINDING

47.2 pp

difference between rainy-season (83.4%) and dry-season (36.3%) scene cloud cover

- Highly significant, very large effect: $t(50) = -7.62$, $p < 0.001$; Cohen's $d = 2.11$
- The two seasons move independently ($r = 0.13$); dry-season anomalies in 2013 and 2023

RESULTS

Usable Optical Imagery Is Scarce, and Absent in the Rains

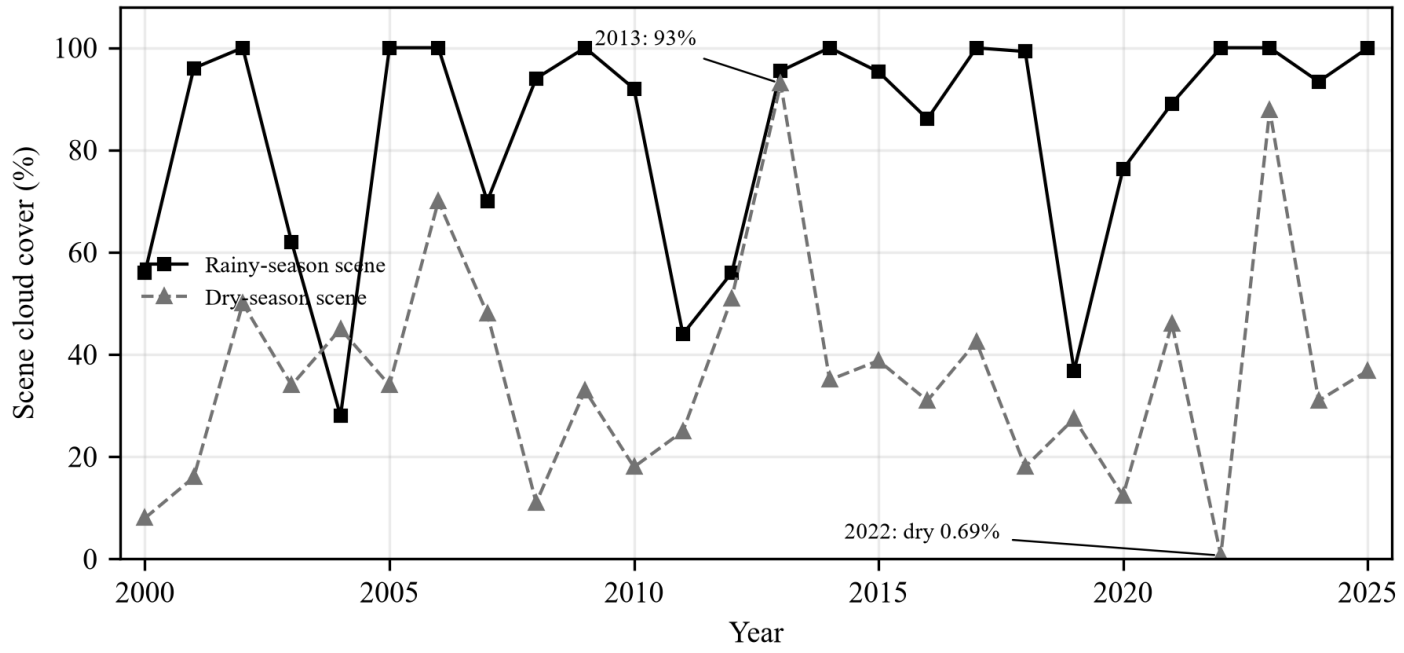


Figure 3: Dry-season and rainy-season scene cloud cover over the Lagos Lagoon, 2000–2025.

KEY FINDING

0 of 26

rainy-season scenes had less than 20% cloud cover over the 26 years

- Only 7 of 26 dry-season scenes fell below 20% cloud
- Only 3 rainy-season scenes fell below 50% cloud

DISCUSSION

Discussion of Findings

A This study

- Cloud over the lagoon is statistically stable at the multi-decadal scale
- The 47 pp seasonal contrast is the dominant signal, with episodic anomalies in 2013, 2022 and 2023
- Two scenes a year, and scene-level rather than lagoon-only values, cannot isolate local urban effects

B Previous studies

- Consistent with the persistent monsoon low-level cloud of southern West Africa (Kniffka et al., 2019)
- Matches the low optical image availability reported across the humid tropics (Flores-Anderson et al., 2023)
- Supplies the lagoon-scale cloud record that studies of lagoon change (Omosanya et al., 2025) do not provide

IMPLICATIONS

Plan optical acquisitions for the dry season, accept longer revisit gaps, and combine optical data with cloud-penetrating synthetic aperture radar for rainy-season monitoring. Cloud metadata should be screened and reported explicitly in every multi-year coastal analysis, because it biases derived products.

Conclusions and Recommendations

C Conclusions

1. No significant era difference (55.4% against 64.3%; $p = 0.181$) and no monotonic trend ($\tau = 0.157$; $p = 0.273$)
2. Rainy-season cloud (83.4%) far exceeds dry-season cloud (36.3%): $p < 0.001$, Cohen's $d = 2.11$
3. Optical image availability is low all year and negligible in the rainy season

R Recommendations

1. Schedule Lagos coastal optical acquisitions for the dry season
2. Integrate radar data for rainy-season monitoring and flood mapping
3. Compute lagoon-boundary cloud fractions from denser Landsat 8/9 and Sentinel-2 series

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Thank You

Questions and discussion

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