A sink-to-source reverse approach to identify dust source regions within the Sahara based on PM_{10} levels measured on the West African coast

Marie Madeleine Atome BASSENE, Aloys BORY, Moctar CAMARA, Yevgeny DERIMIAN
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Laurine VERFAILLE, Dioncounda YOCK, Fodé SAMBOU, Thierno NDIAYE, Aboubacry DIALLO
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QR code Abstract

This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

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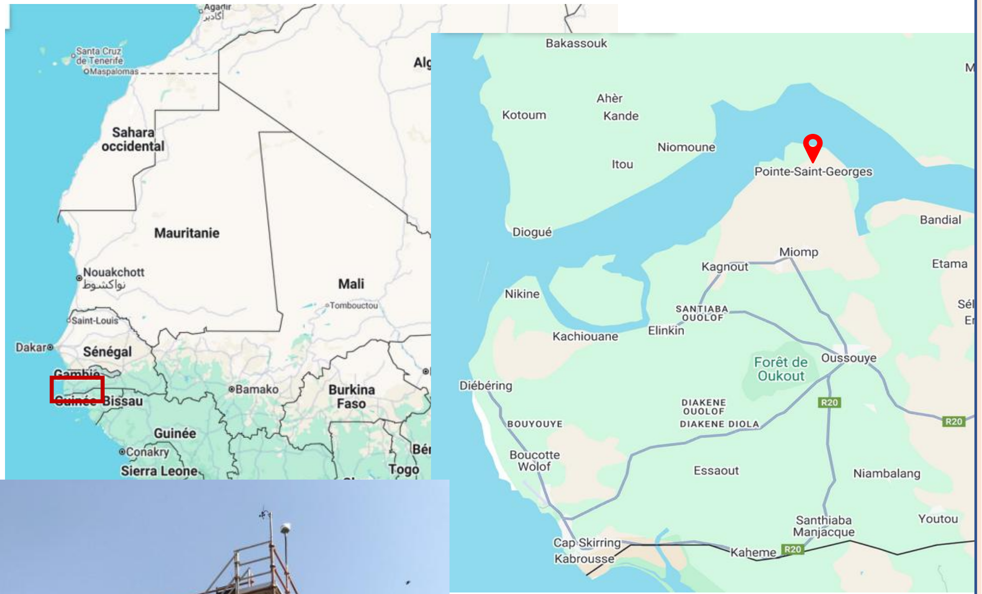
Laboratoire d'Océanologie et de Géosciences

AS3.5 | Aeolian dust : initiator, player, recorder, of environnemental change

CONTEXT & METHODOLOGY

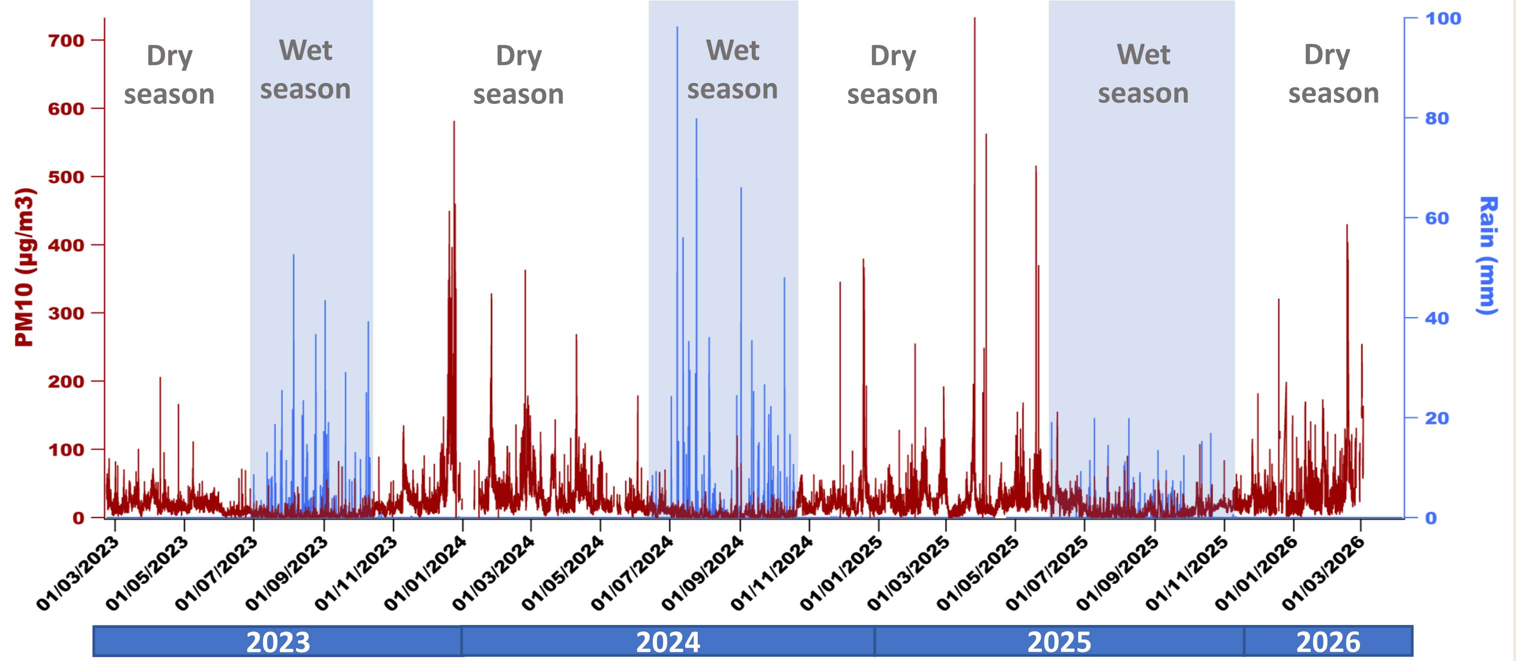
Saharan dust strongly impacts air quality and climate in West Africa. However, the source regions contributing dust to the West African margin (Senegal) remain poorly constrained.



Low-cost PurpleAir Sensor

PM$_{10}$ concentrations

- Rural site – minimal local influence
- 3 years time - series (2023-2026)

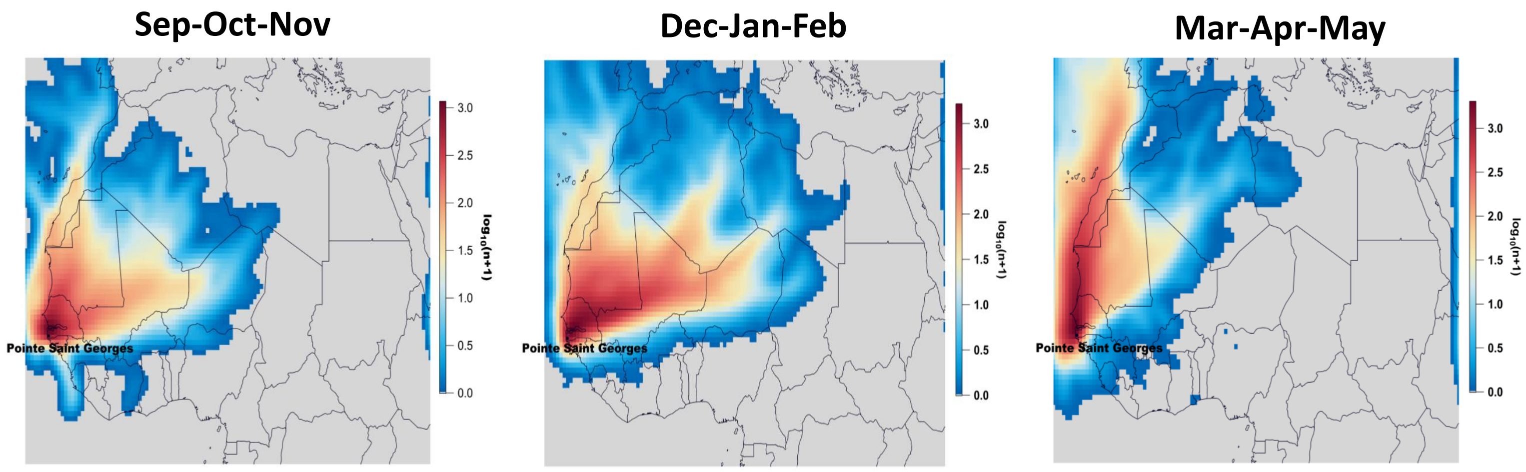


HYSPLIT
Back trajectories
Air mass pathways

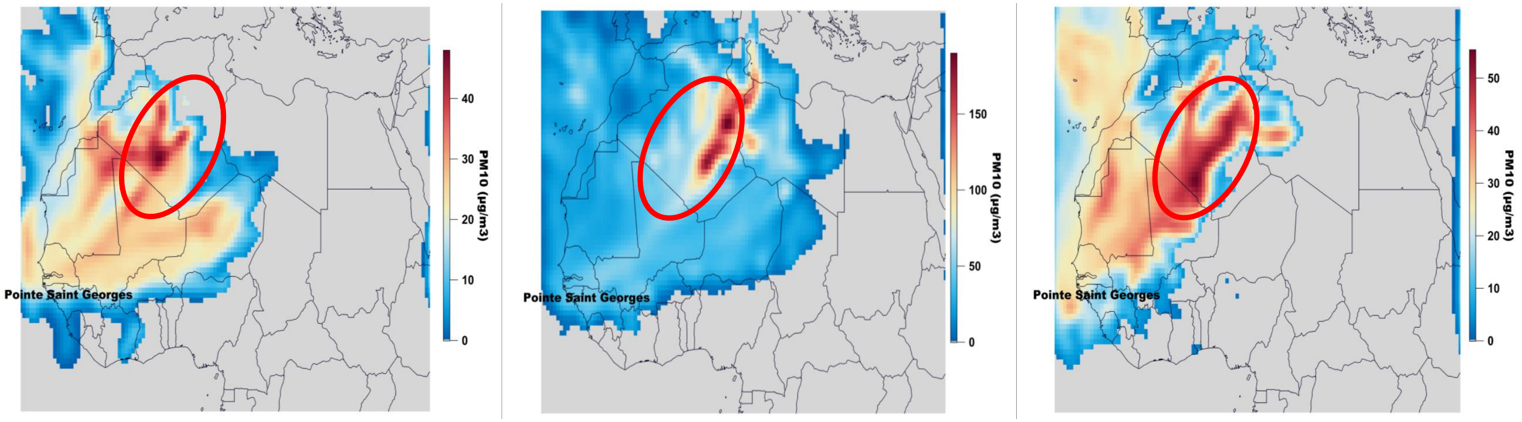
→

ZEFIR software
Origin of particle-laden air masses

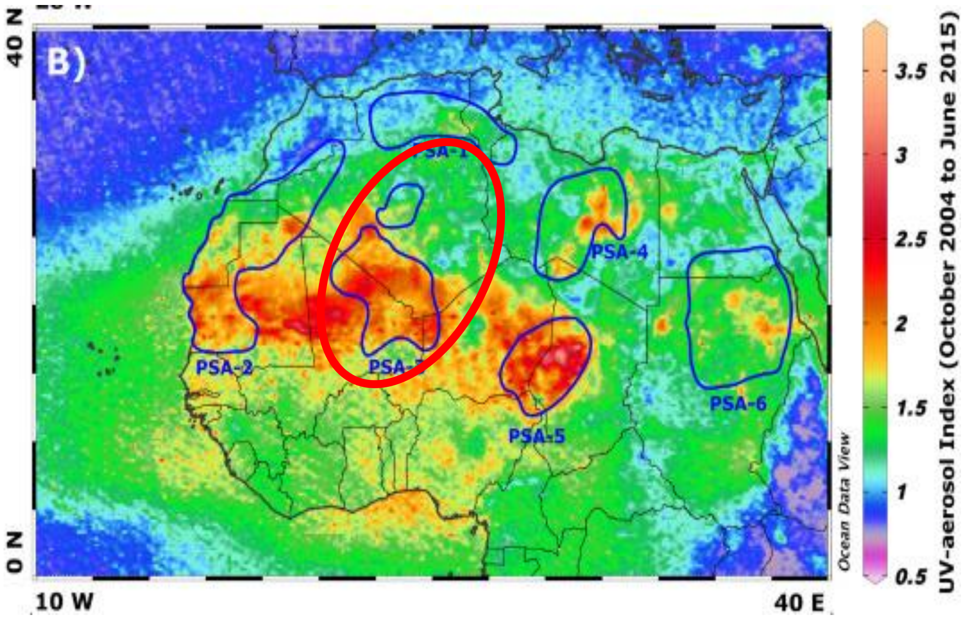
RESULTS & CONCLUSIONS



TRAJECTORIES (WINDS)



RECONSTRUCTED DUST PROVENANCE AREAS



UV-aerosol index (PSAs from Formenti et al., 2011; adapted from Guinoiseau et al., 2022)

- **Main source: PSA-3 (Algerian-Malian sector) dominant in all 3 seasons**
- **Secondary: Mauritania, Western Sahara, Sahel**
- **Bodele Depression: minor contributor**

We start from what we breathe to find where the dust comes from.
A low-cost, replicable and powerful tool to better constrain Saharan dust sources for a specific sink region.

Interactive session – Detailed presentation

A sink-to-source reverse approach to identify dust source regions within the Sahara based on PM_{10} levels measured on the West African coast

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Jean-Eudes PETIT[4], Jean-Louis RAJOT[5,6], Béatrice MARTICORENA[6]
Laurine VERFAILLE[2], Dioncounda YOCK[1], Fodé SAMBOU[7], Thierno NDIAYE[8], Aboubacry DIALLO[8]
and Viviane ROUMAZEILLES[2]**

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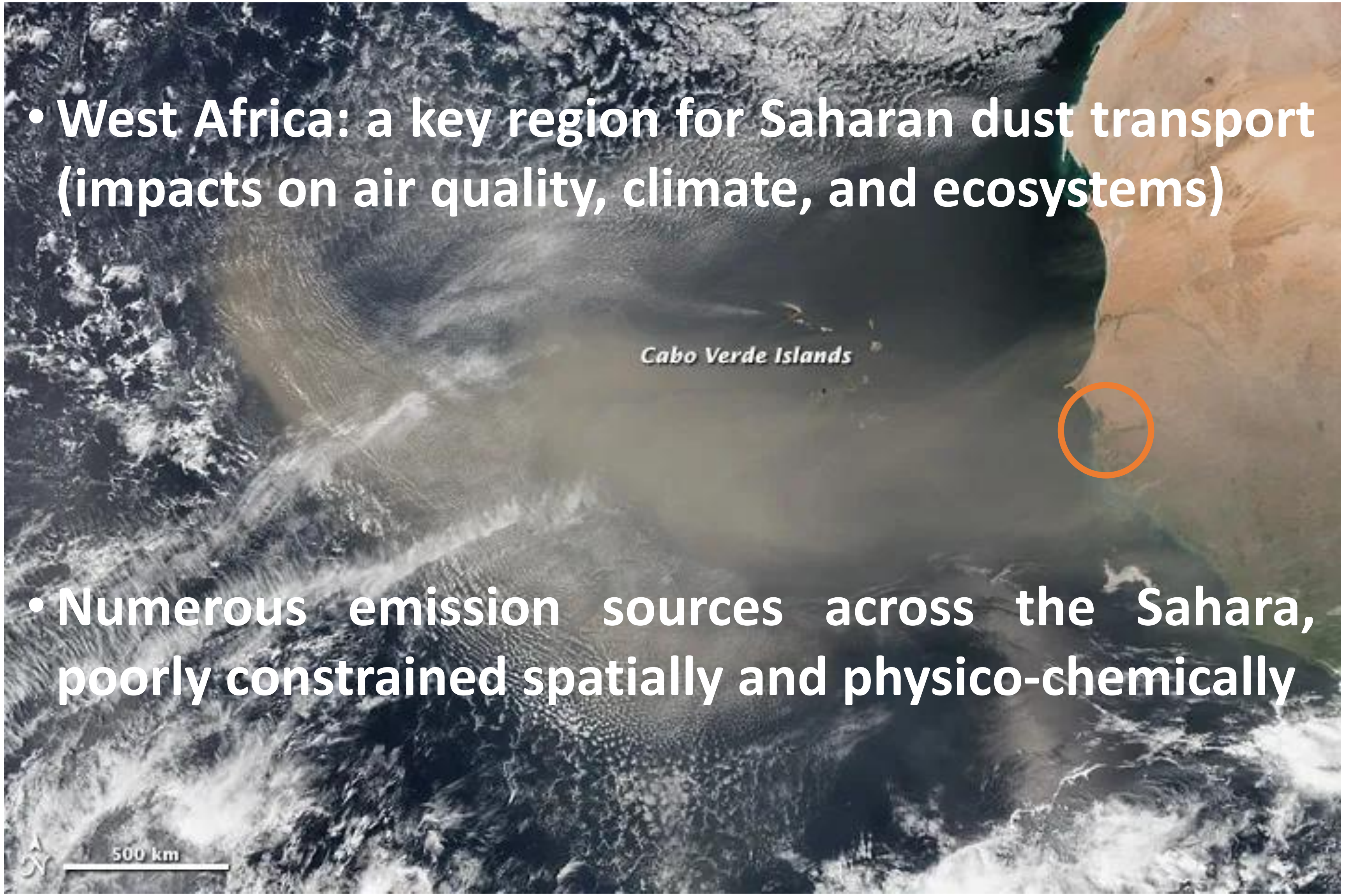
CONTEXT

- **West Africa: a key region for Saharan dust transport (impacts on air quality, climate, and ecosystems)**
- **Numerous emission sources across the Sahara, poorly constrained spatially and physico-chemically**



Saharan dust transport towards the Atlantic (NASA/MODIS)

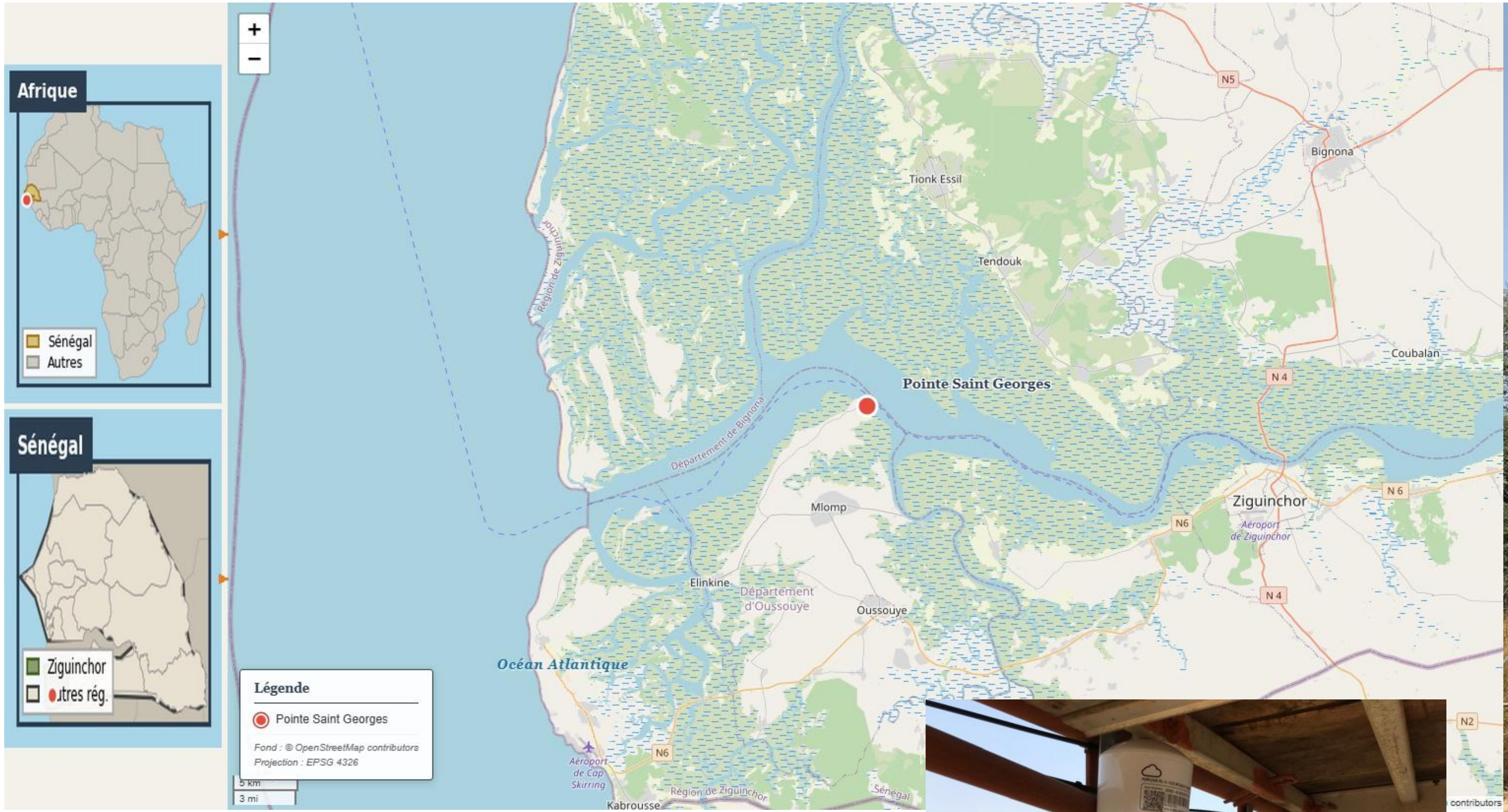
Research question

Existing emission maps do not allow the evaluation of the relative contribution of source areas **for a given receptor site (ex. Senegal),** which might be critical to better assess dust events dynamic and their impacts.

Method

Sink-to-source reverse approach: coupling PM_{10} measurements (proxies for Saharan dust) with air mass back-trajectories (HYSPLIT).

STUDY SITE AND INSTRUMENTS



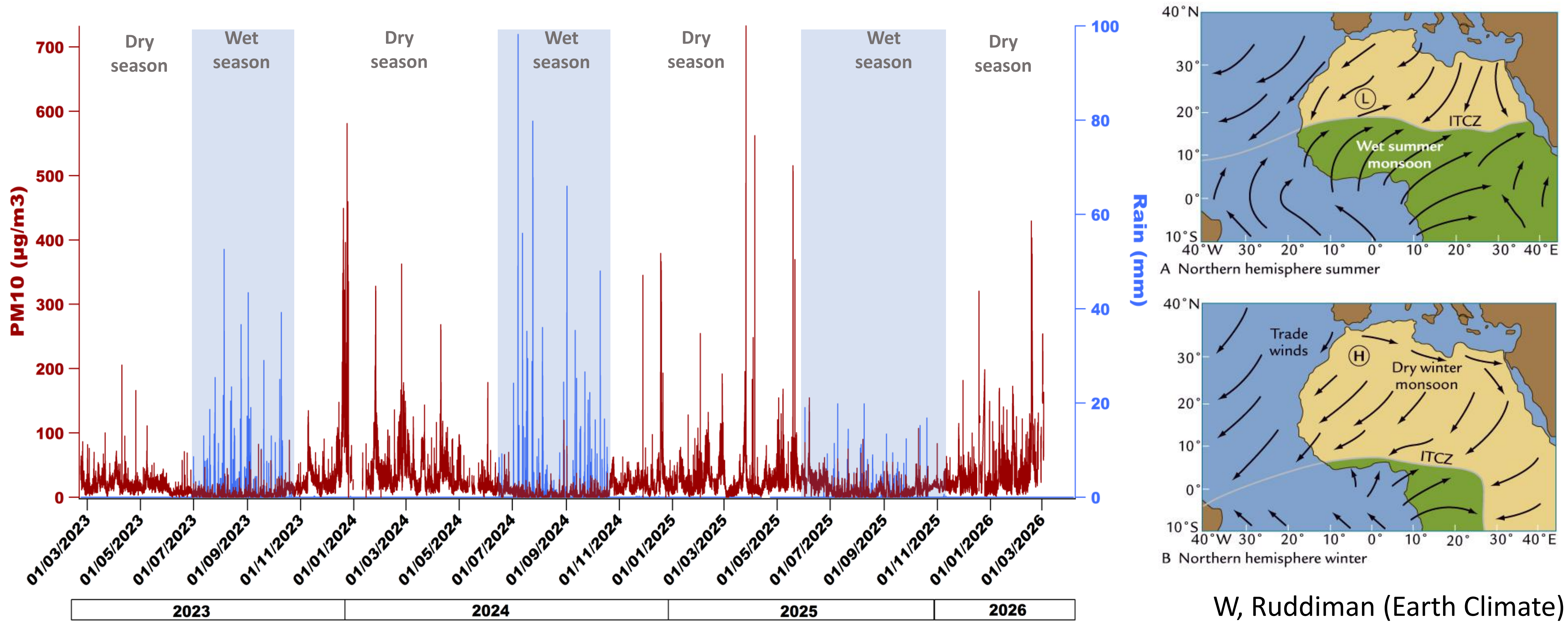
Site characteristics :

- Permanent vegetation cover throughout the year
- Low population density (a few hundred people)
- Ideal environment for measuring the Saharan background signal

Capteur PurpleAir Low-cost

Measurement tower at Pointe Saint Georges

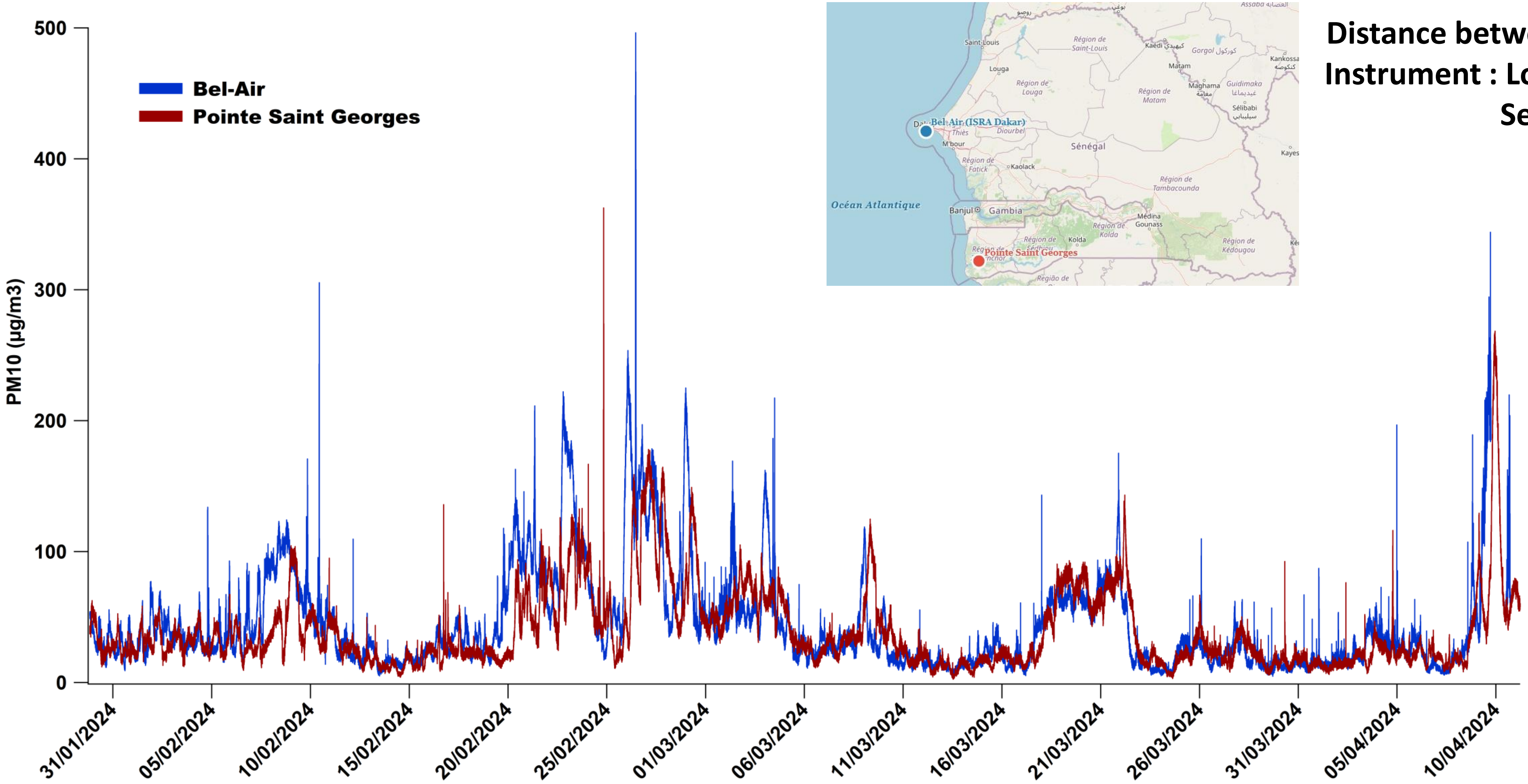
PM10 TIME SERIES AT POINTE SAINT GEORGES



W, Ruddiman (Earth Climate)

- **Dry season : continental trade winds (Harmattan), ~10 major dust events per year**
- **Wet season : summer monsoon circulation**

COMPARISON BEL-AIR AND POINTE SAINT GEORGES



Distance between sites: 250 km
Instrument : Low-cost PurpleAir Sensor

- **Similar signal recorded at both sites**

- **PM10 data measured at Pointe Saint Georges reflect large-scale dust events**
- **Confidence in PurpleAir sensor measurements**

METHODOLOGY : Back-trajectory & ZeFir

Data

- **PM10 concentrations (February 2023 to December 2025)**
- **Wind data (GDAS1, NOAA)**

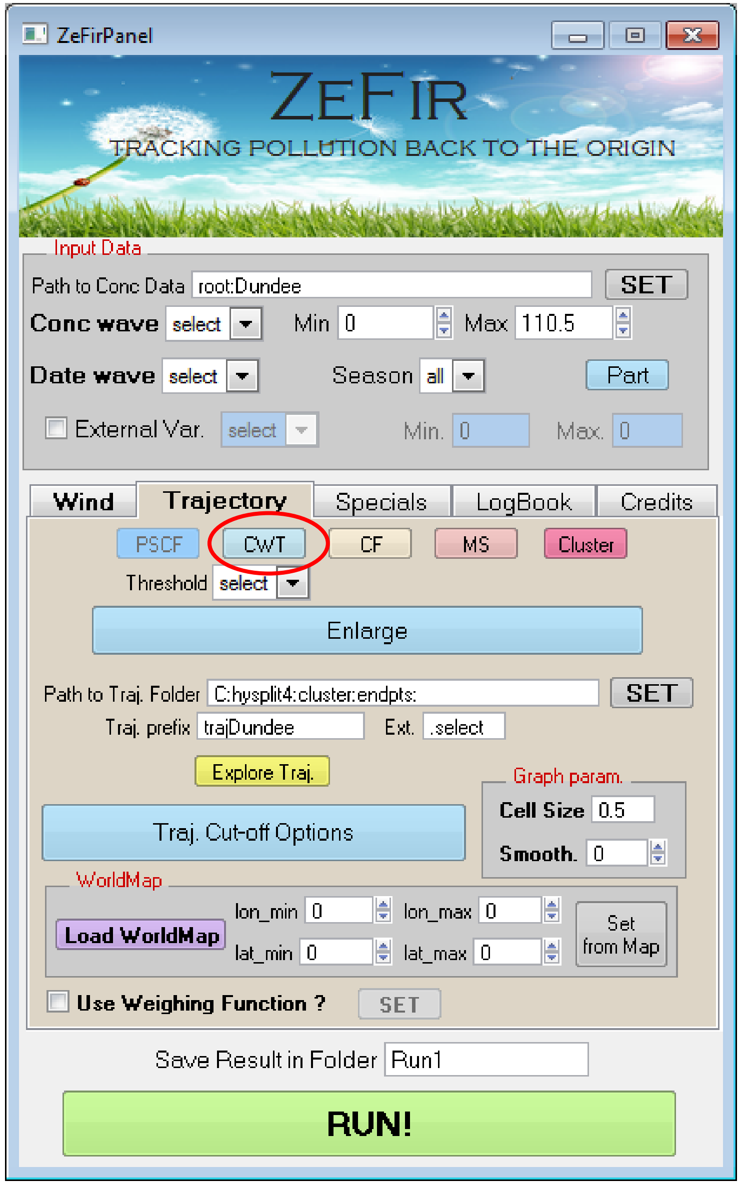
Methodology

- **Back-trajectories computed over 5 days at 500 m (HYSPLIT)**
- **Coupling with PM10 concentrations (ZeFir package for Igor, developed by Petit et al., 2017)**

CWT function (Concentration-Weighted Trajectory)

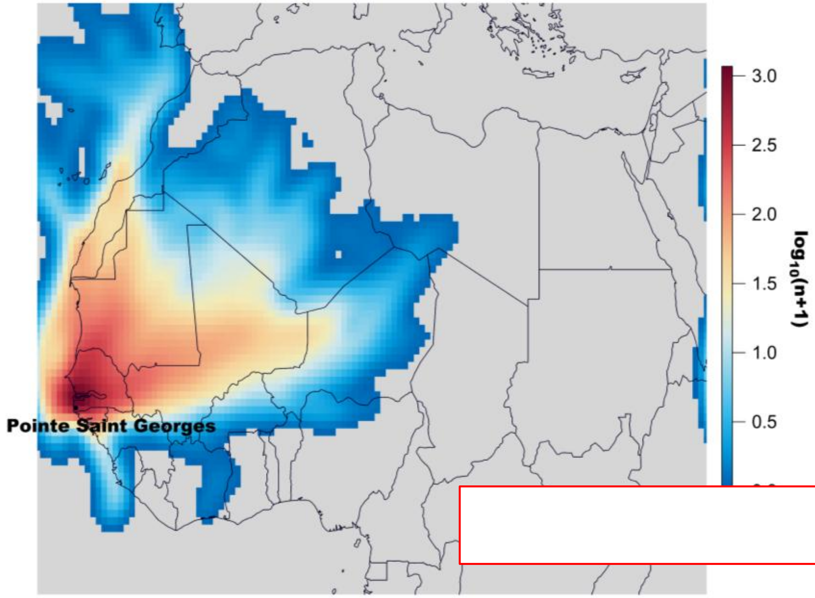
$$\bar{C}_{ij} = \frac{1}{\tau_{ijk}} \cdot \sum_{k=1}^{N} C_k \cdot \tau_{ijk}$$

ZeFir package interface (Igor Pro)

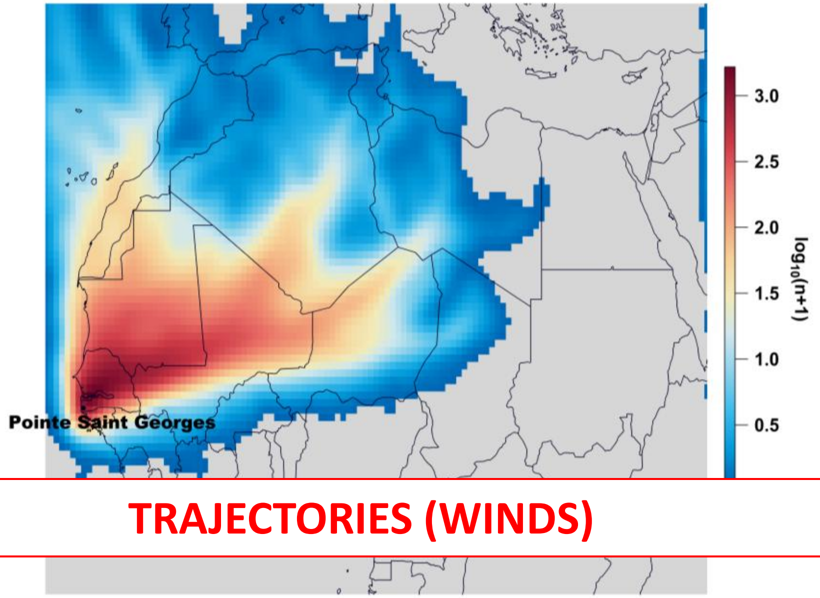


RESULTS: SEASONAL VARIABILITY

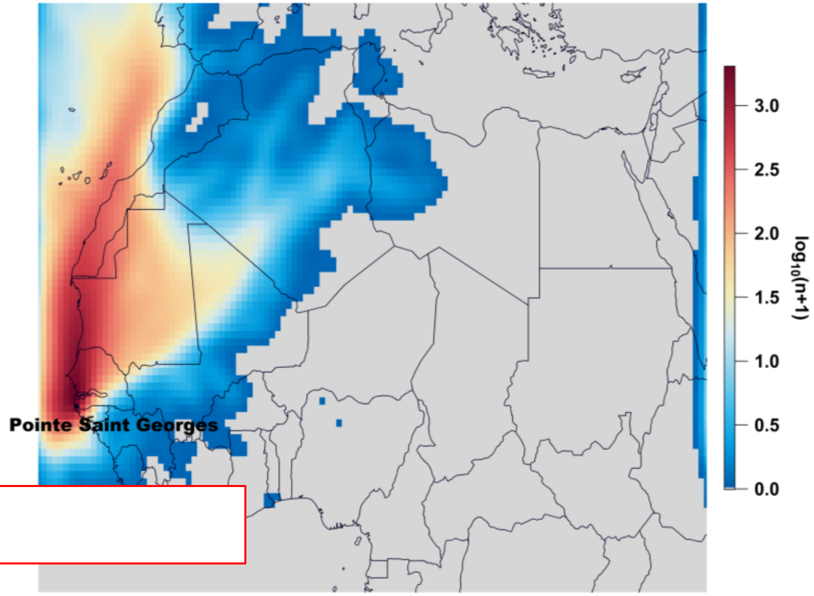
September-October-November



December–January-February



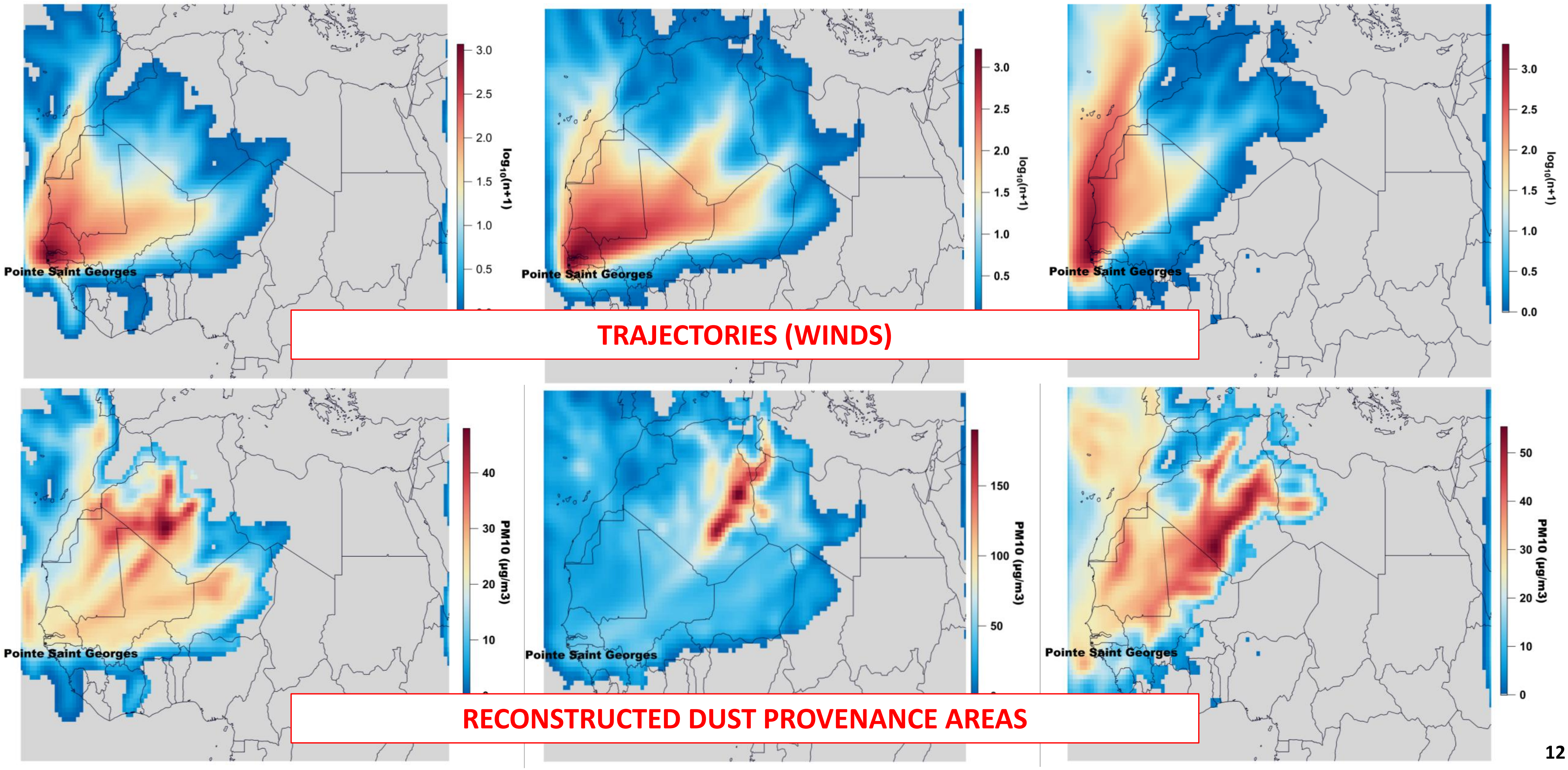
March-April-May



TRAJECTORIES (WINDS)

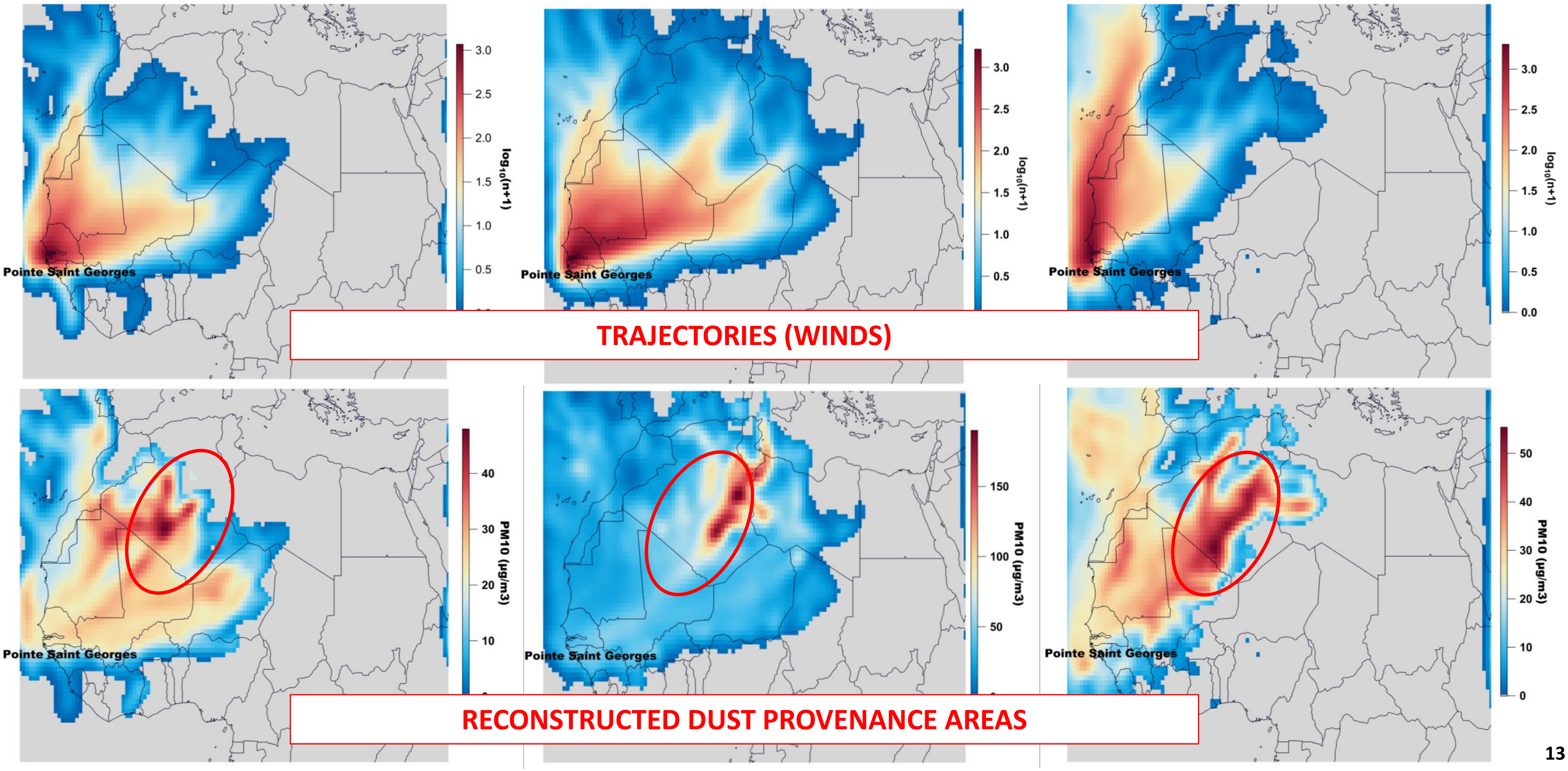
RESULTS: SEASONAL VARIABILITY

September-October-November **December–January-February** **March-April-May**



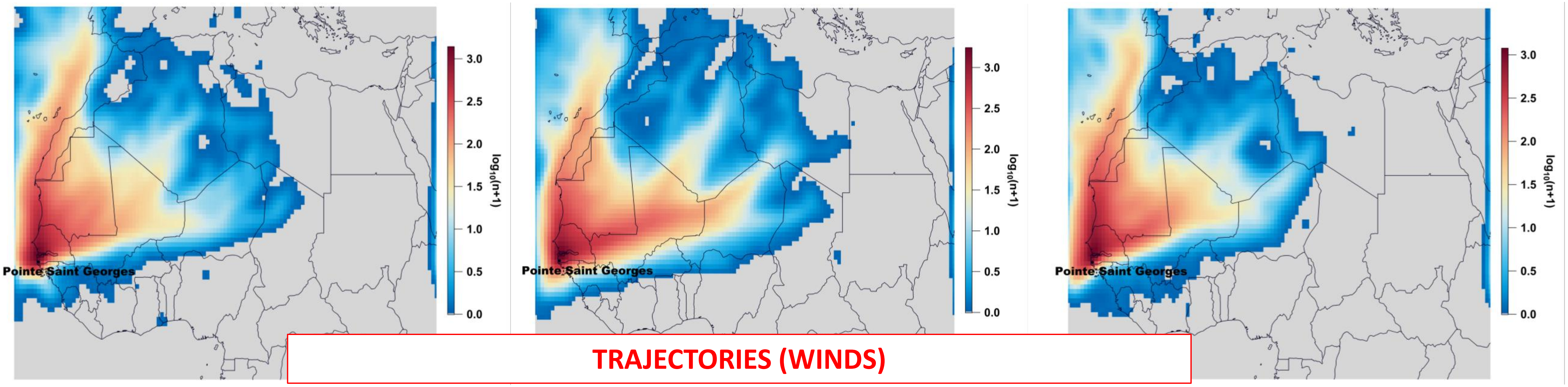
RESULTS: SEASONAL VARIABILITY

September-October-November | **December–January-February** | **March-April-May**

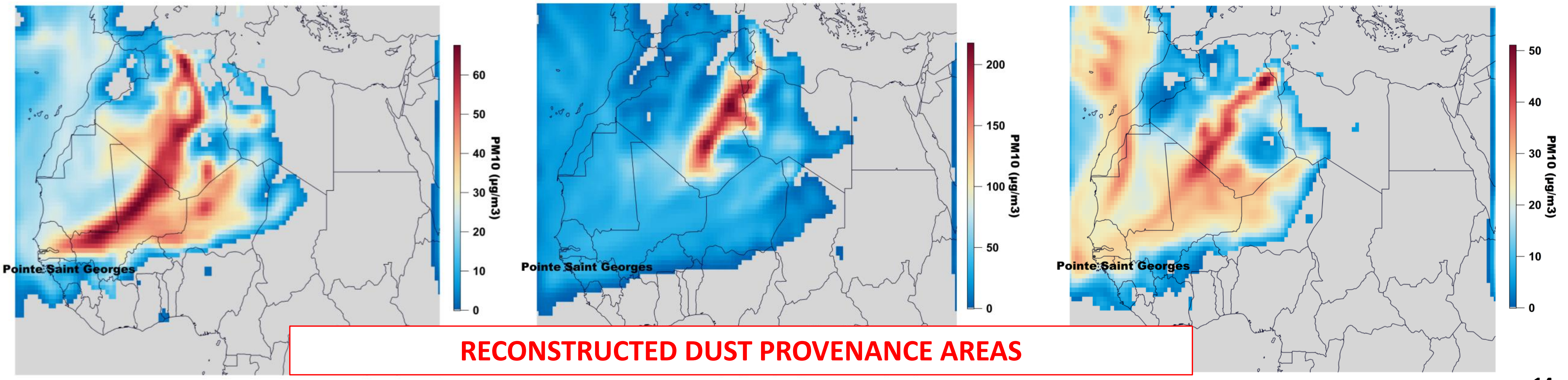


RESULTS: INTERANNUAL VARIABILITY

2023 | **2024** | **2025**



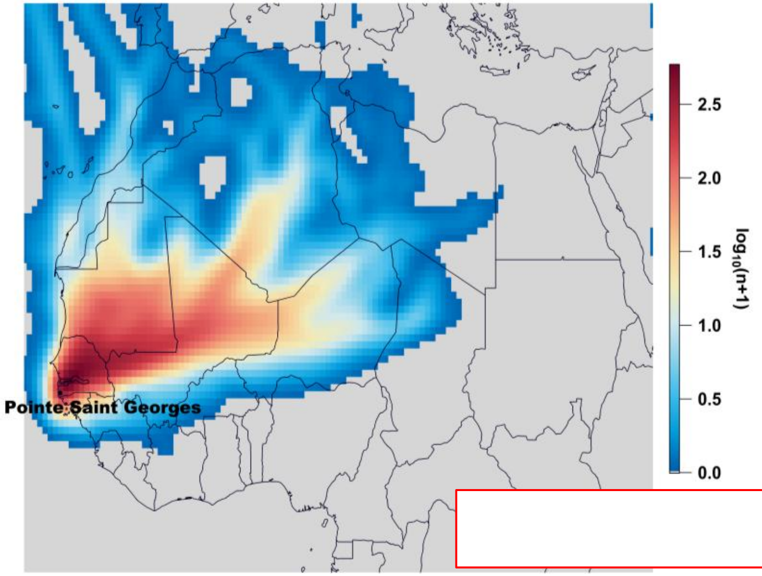
TRAJECTORIES (WINDS)

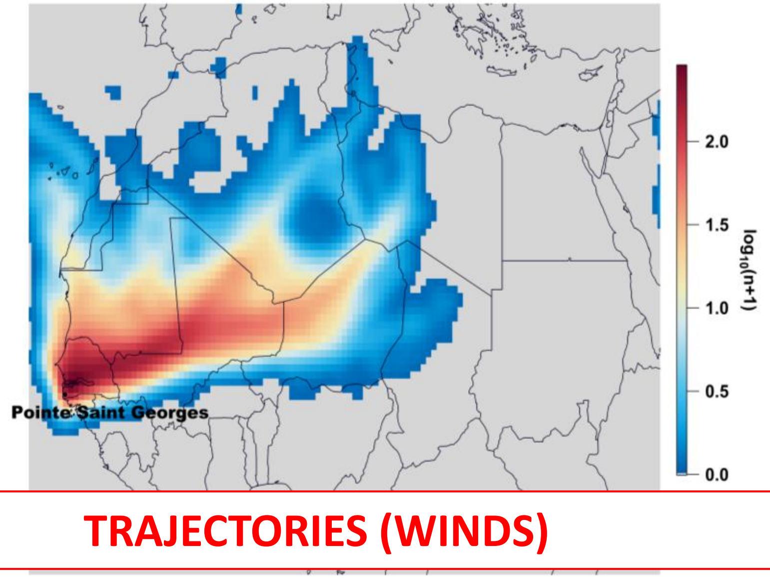


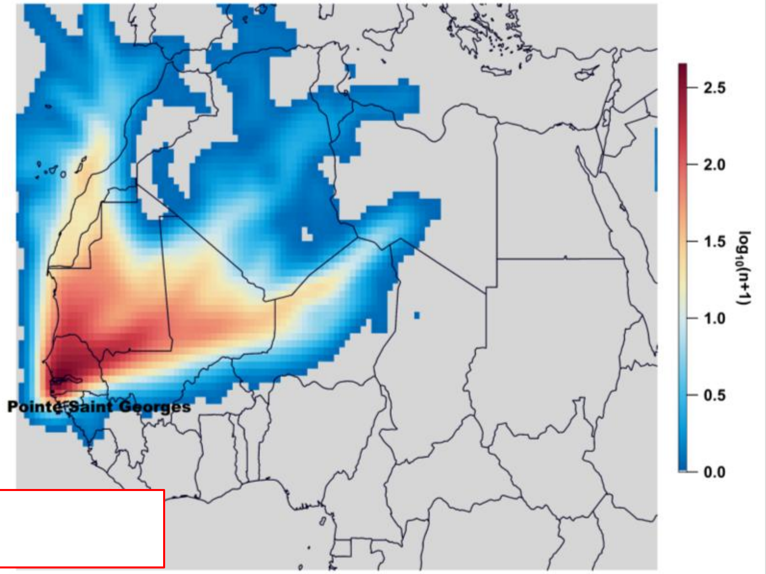
RECONSTRUCTED DUST PROVENANCE AREAS

RESULTS: MONTHLY MEAN

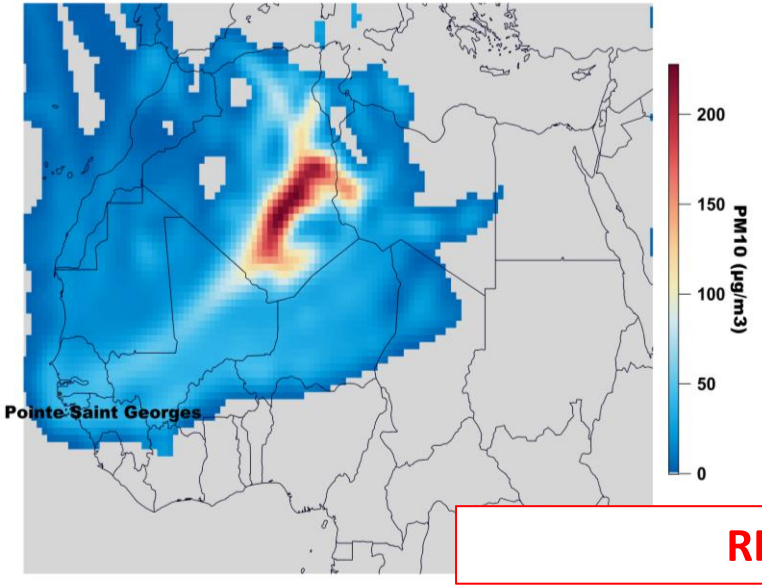
December | **January** | **February**

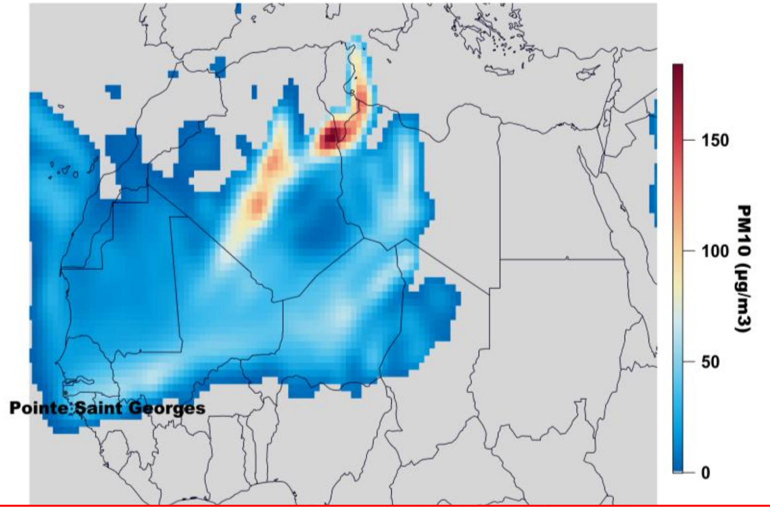


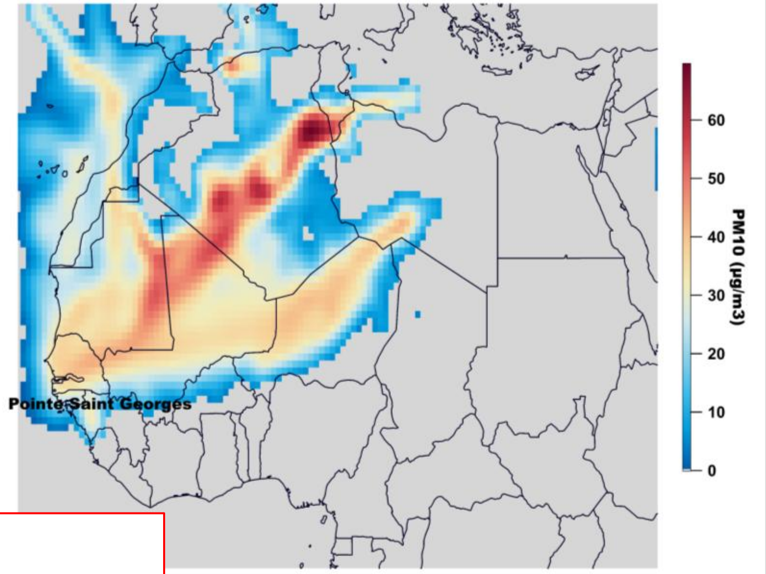




TRAJECTORIES (WINDS)





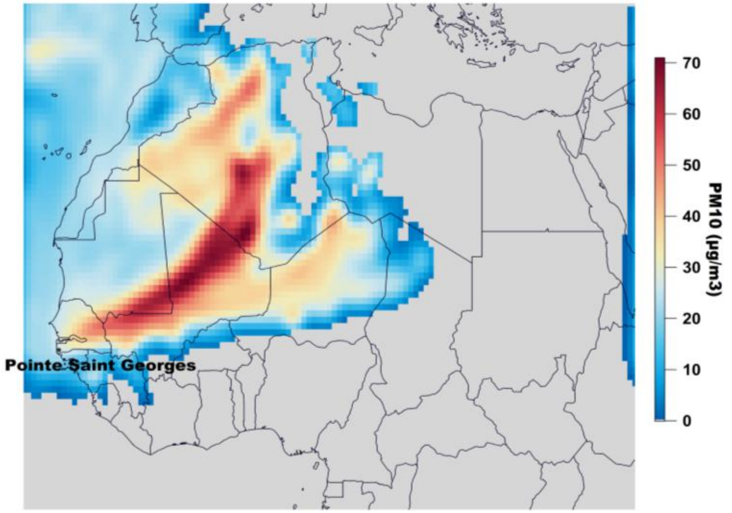


RECONSTRUCTED DUST PROVENANCE AREAS

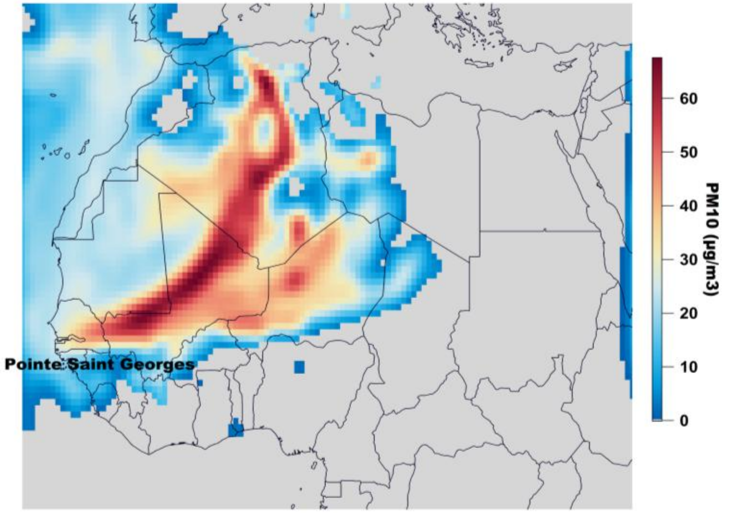
ZEFIR SENSITIVITY TESTS

Different altitudes

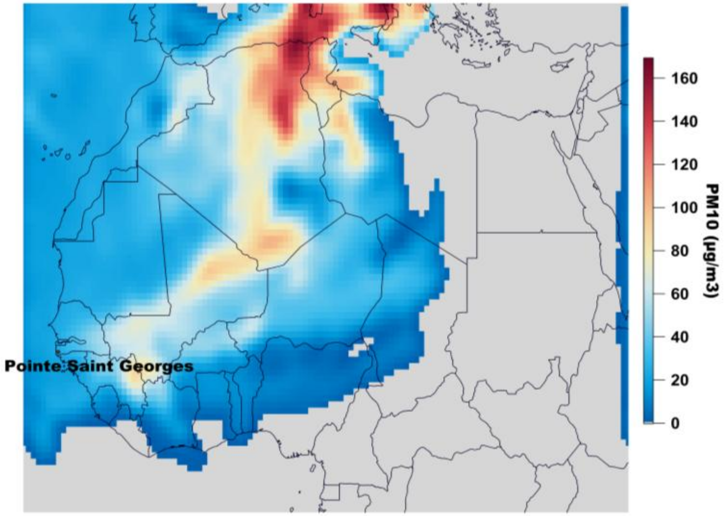
250 m



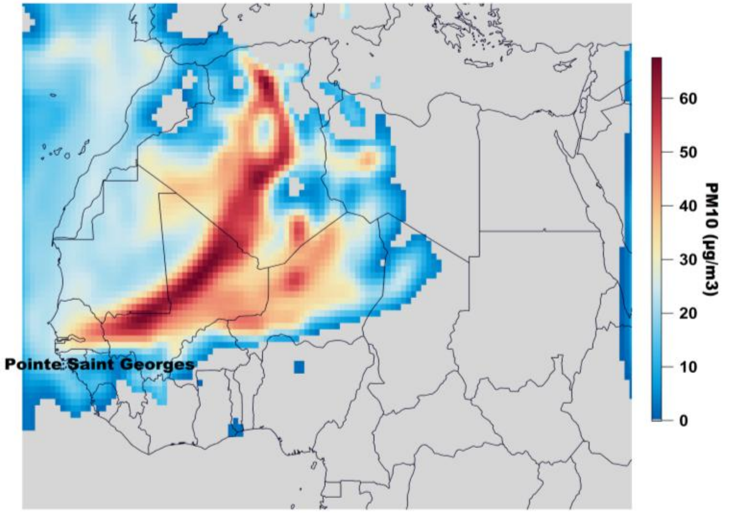
500 m



Same altitude but no cutoff to back-trajectories

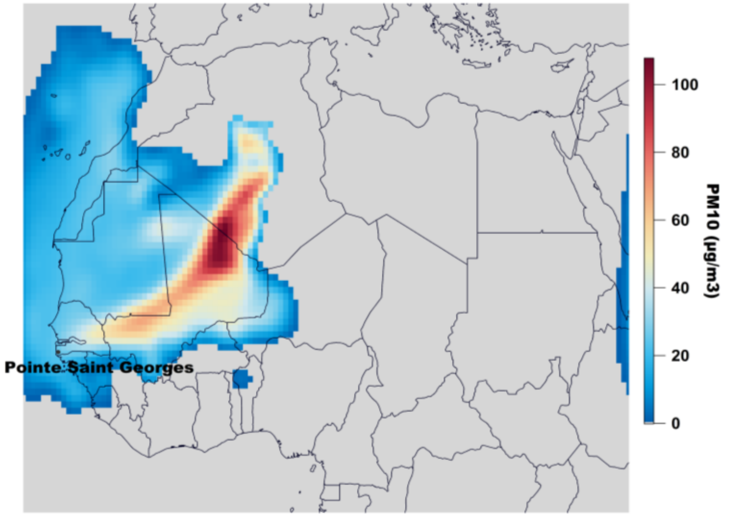


1000 m cutoff applied to back-trajectories

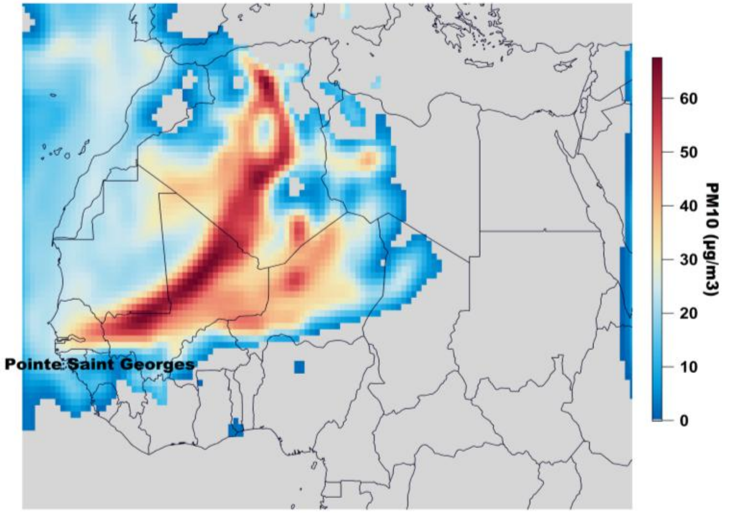


Different back-trajectory durations

3 days



5 days



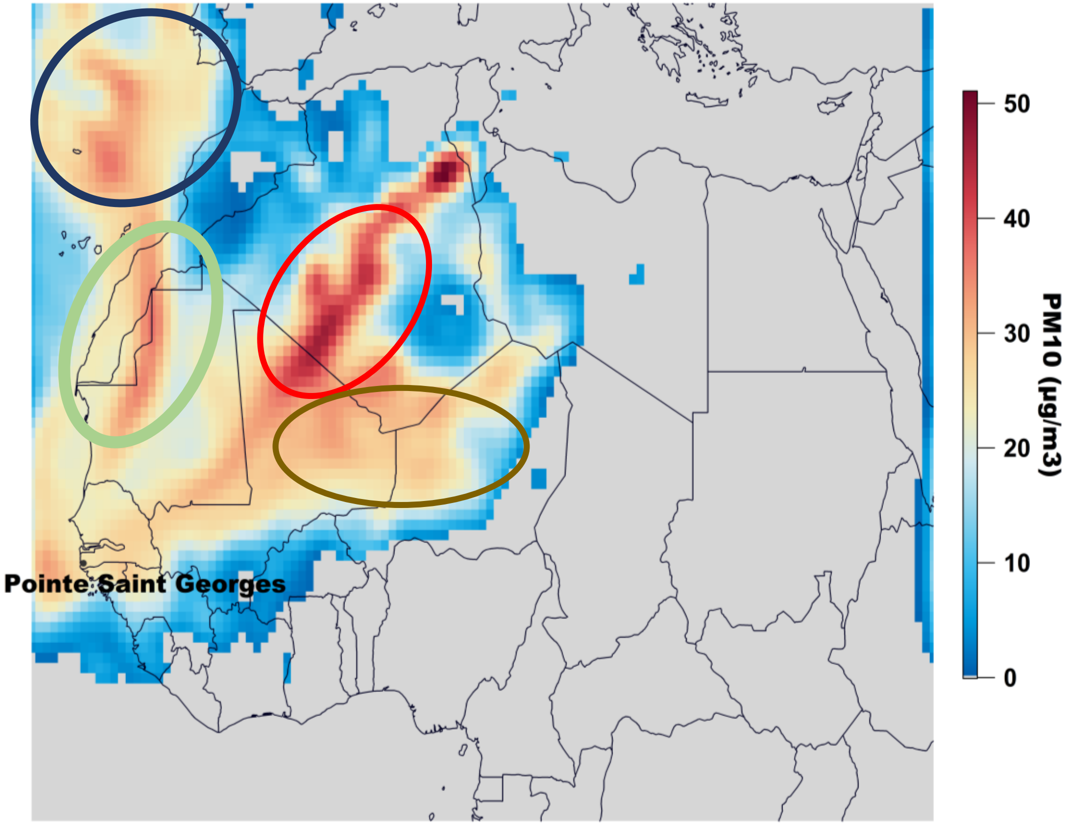
DISCUSSION

Identified provenance regions:

- **Algerian-Malian sector**
- **Sahelian sector (Mali-Niger-Chad?)**
- **Mauritania-Western Sahara**

Corresponding to the three main wind corridors reaching Senegal

Main source: Algerian-Malian sector

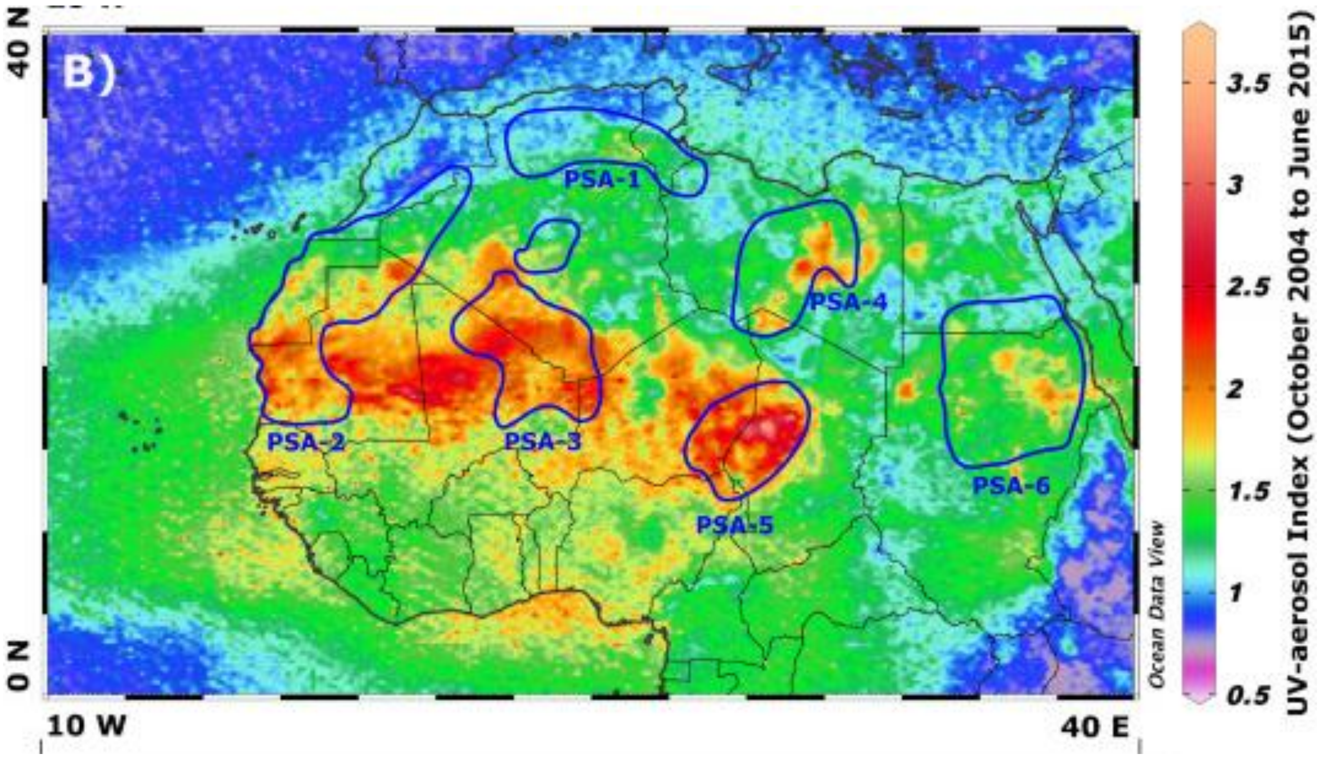


Limitations of ZeFir:

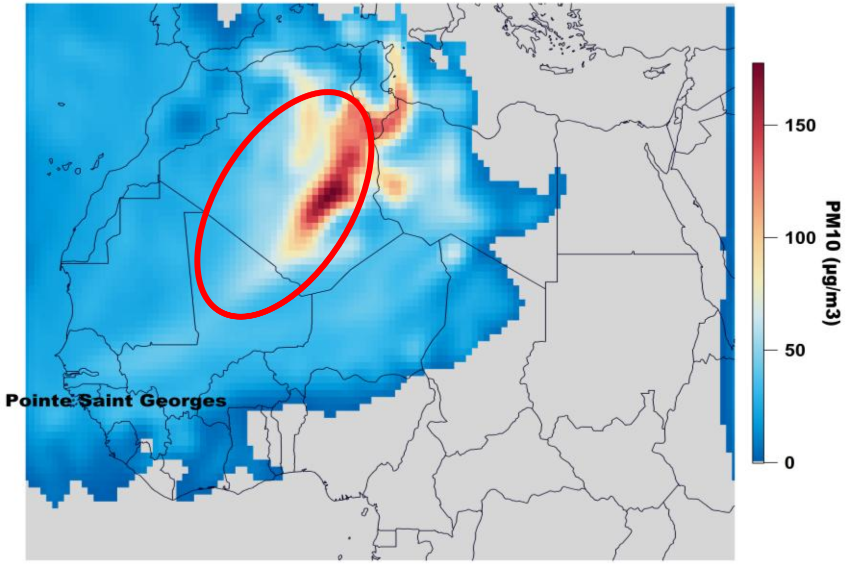
- **False positives (ex. signal observed in 2025 over the ocean)**
- **Since Saharan dust transport corridors are recurrent, ZeFir identifies a preferred transport axis rather than the precise emission source**

CONCLUSIONS & PERSPECTIVE

- **PM10 measured at Pointe Saint Georges (Casamance, southern Senegal) originate from distant sources**
- **The Algerian-Malian sector is the main region contributing desert dust to our study site**
- **Based on existing literature data, the main source for dust reaching Senegal is likely PSA-3 as defined by Formenti et al. (2011)**



Map of main Saharan and Sahelian dust source regions. PSAs (Potential Source Areas) defined by Formenti et al. (2011). Figure adapted from Guinoiseau et al. (2022).



RECONSTRUCTED DUST PROVENANCE AREAS: 2023 to 2025

To overcome ZeFir limitations, provenance sectors identified with Zefir must be combined with other data (satellite products, model outcome) in order to identify contributing dust source regions.

Over our study period (2023–2025), we intend to use IDDI (Infrared Difference Dust Index) satellite product from METEOSAT (LOA), which detects desert dust plumes using thermal infrared brightness temperature differences (Legrand et al., 2001, 2010) .