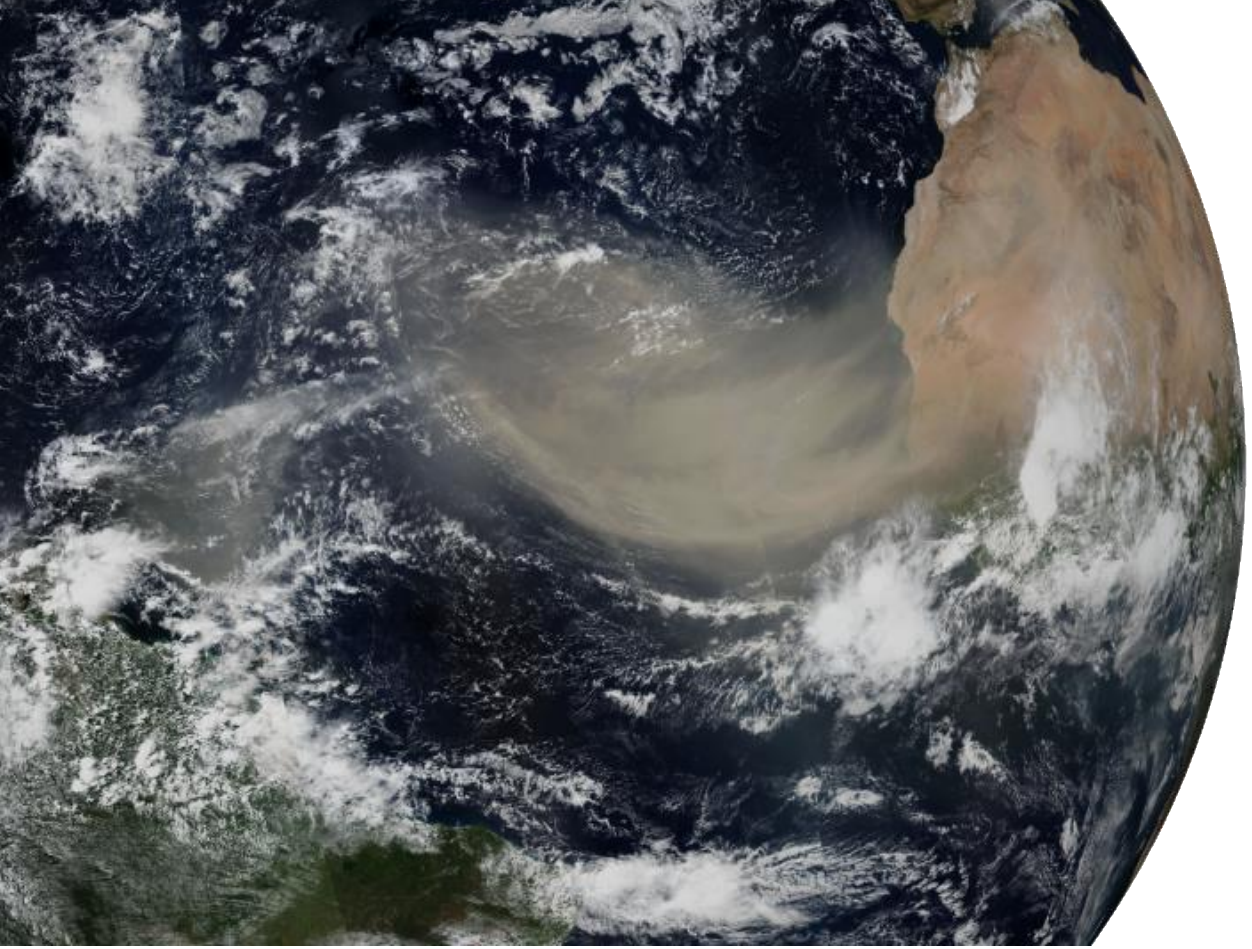
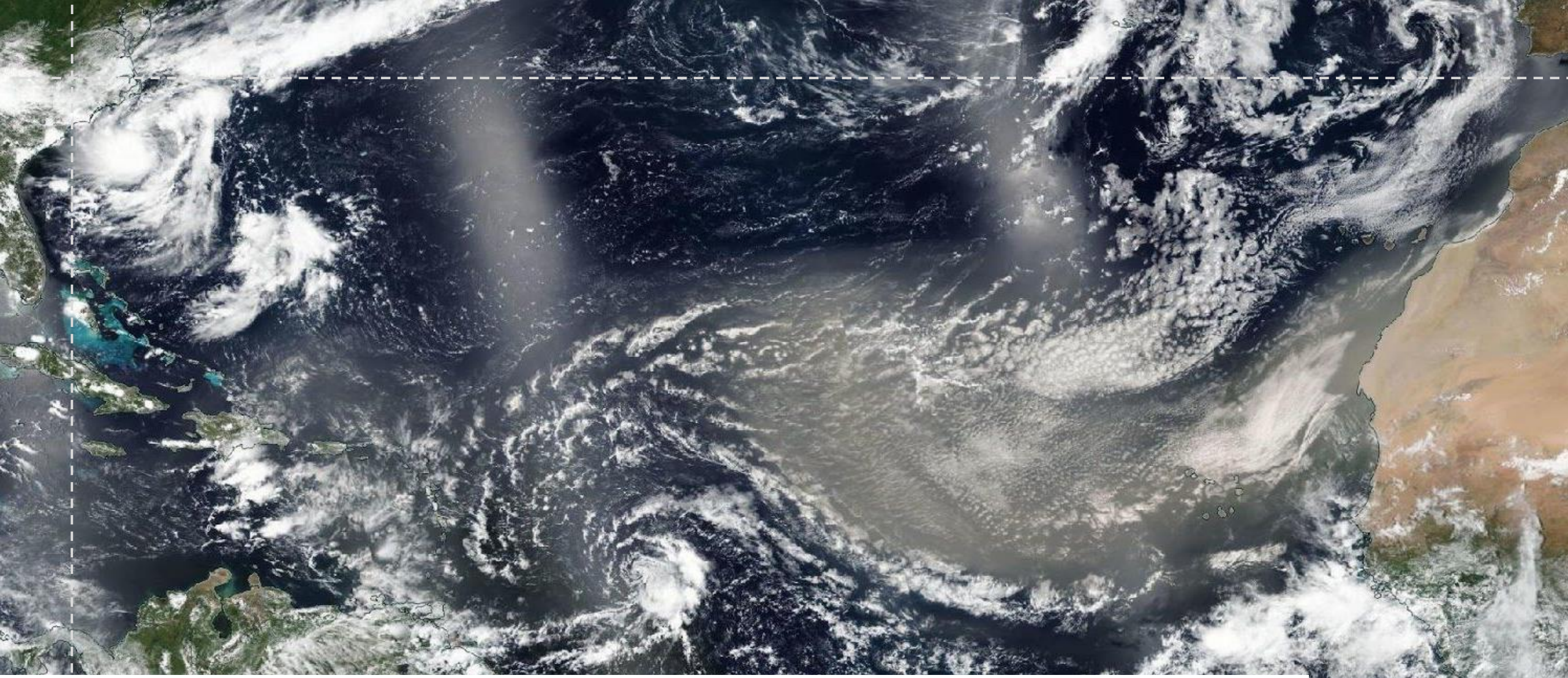


Multiscale Investigation of Microbial Biodiversity in Trans-Atlantic Dust Plumes

Hosein Foroutan, Virginia Tech

NASA Biodiversity and Ecological Forecasting Team Meeting, September 2022



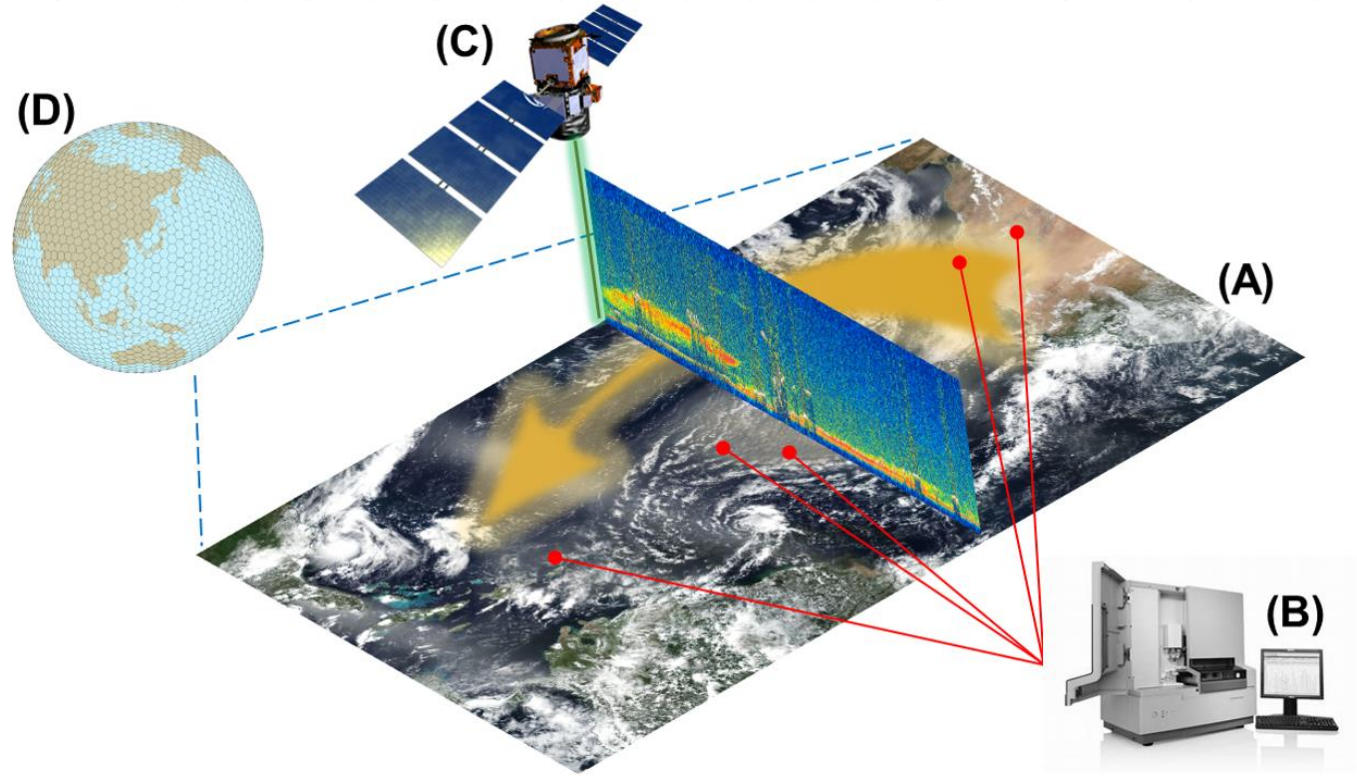
Trans-Atlantic Journey of dust and microbes

Dust particles can be a vehicle for microbes — viruses, bacteria, fungi can come across the Atlantic, as if hitchhiking on dust particles.

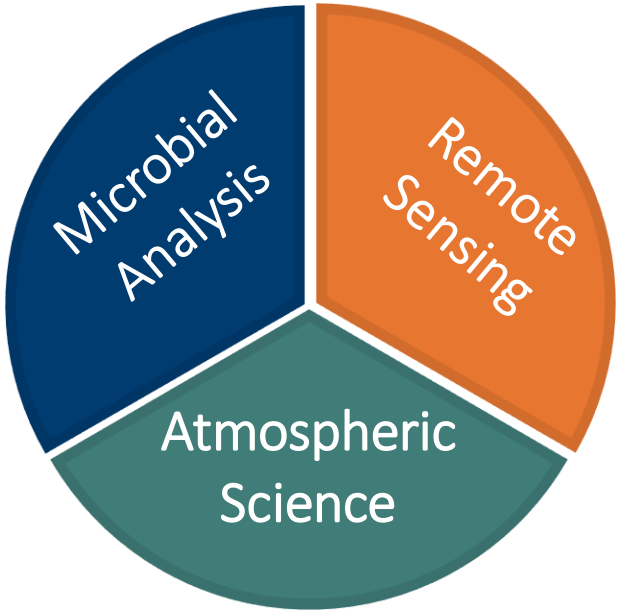
Project Overview

Overarching Goal: To improve our understanding of microbial long-range transport and survival in dust plumes.

Interdisciplinary Approach: Integrate multiplatform satellite observations, as well as multiscale reanalysis and atmospheric simulation data with microbiological tools to bridge dust aerosols transport and microbial biodiversity in the atmosphere.



NASA MITAD (Microbes In Trans-Atlantic Dust) Team



Hosein Foroutan, PI

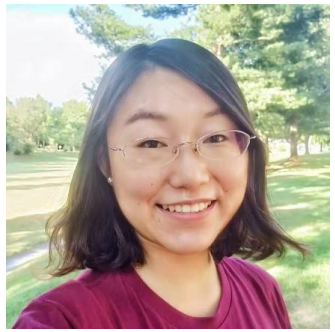
David Schmale, Co-I

Shane Ross, Co-I

Cristina Gonzalez-Martin, Co-I

Ali Hossein Mardi, Postdoc

Regina Hanlon, Research Associate

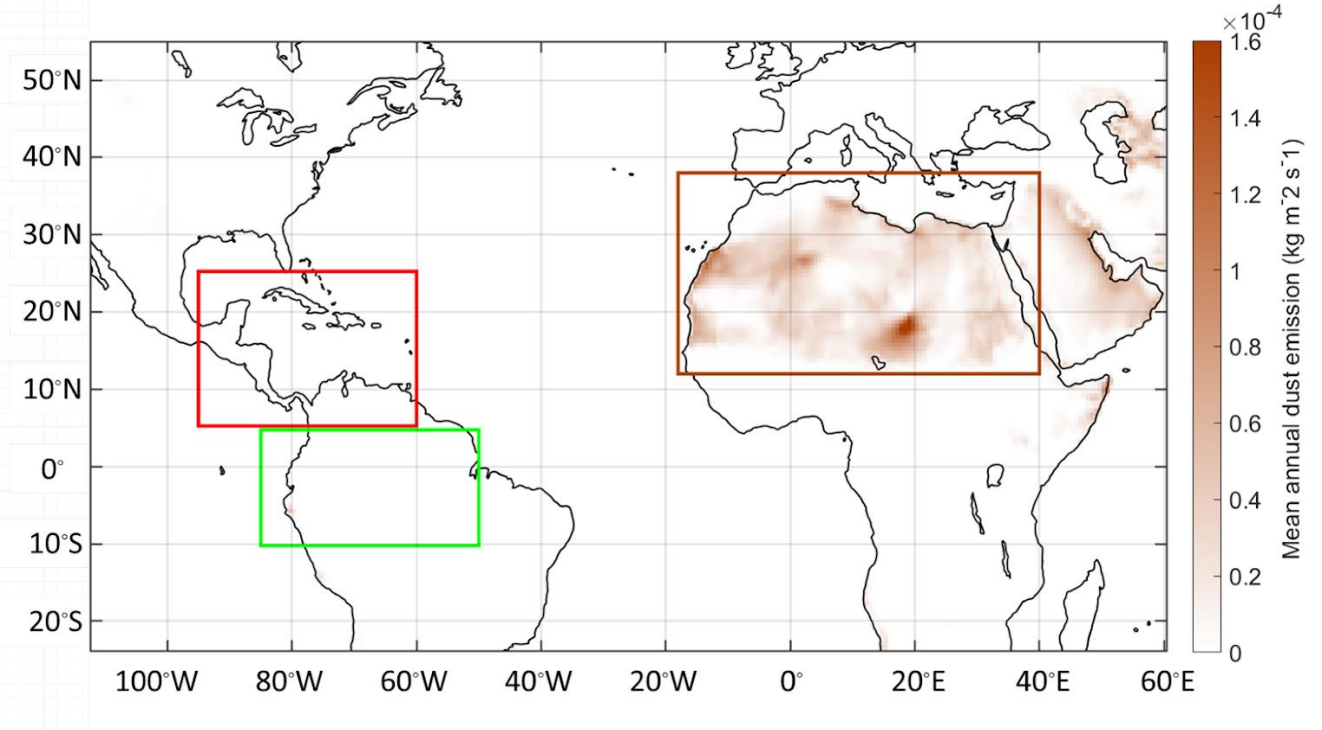


Xinyue Huang, PhD Student

Albert Jarvis, PhD Student

Multi-year Trans-Atlantic transport of Dust and Microorganisms: Source, Fate, and Environmental Conditions Along the Way

- Fourteen years (2008-2021)
- NASA MERRA-2* dust emission data
- NOAA HYSPLIT** forward trajectories



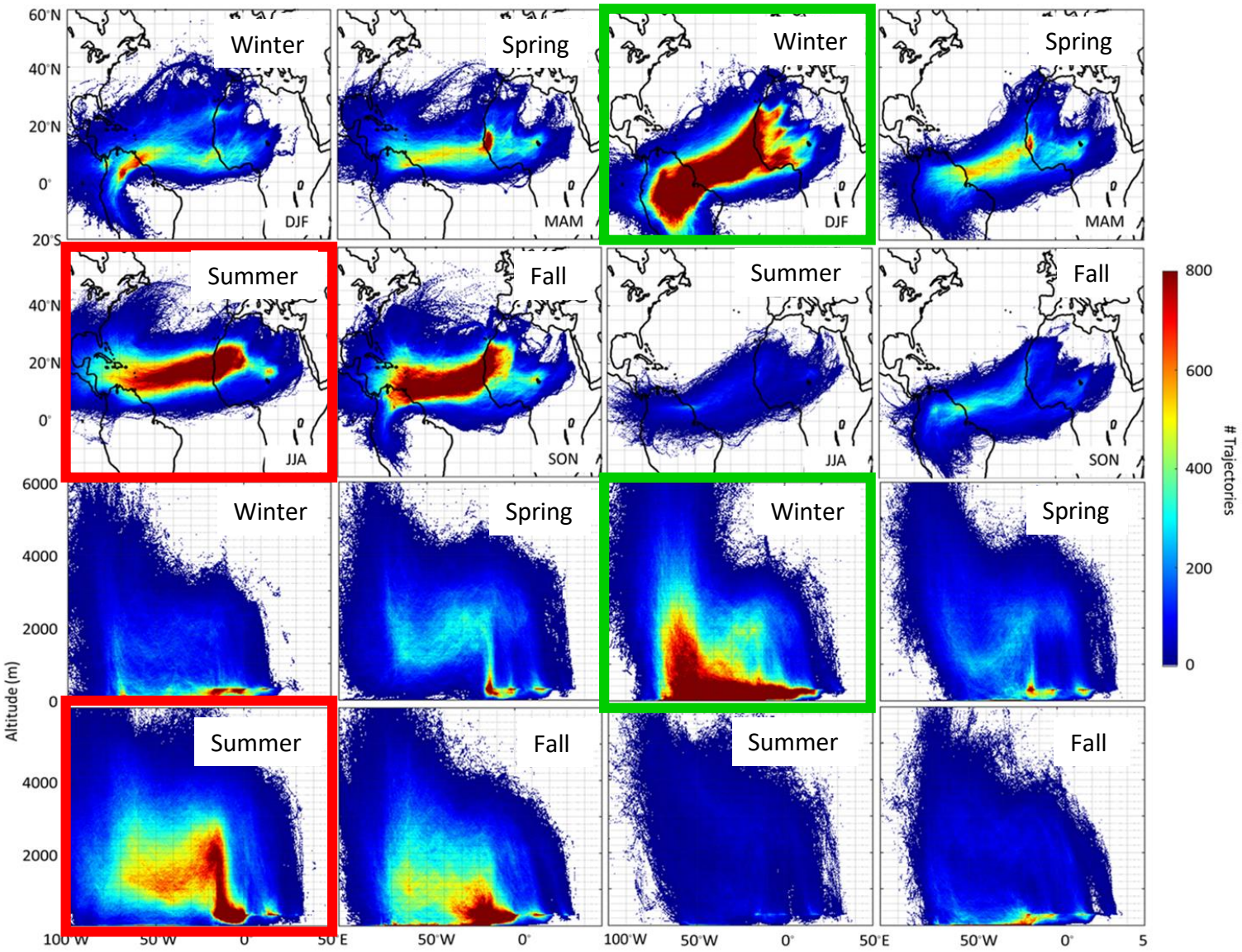
* Modern-Era Retrospective analysis for Research and Applications, Version 2

** Hybrid Single-Particle Lagrangian Integrated Trajectory model

Two Distinct Season/Region:
Winter/Amazon and Summer/U.S. Southeast and Caribbean

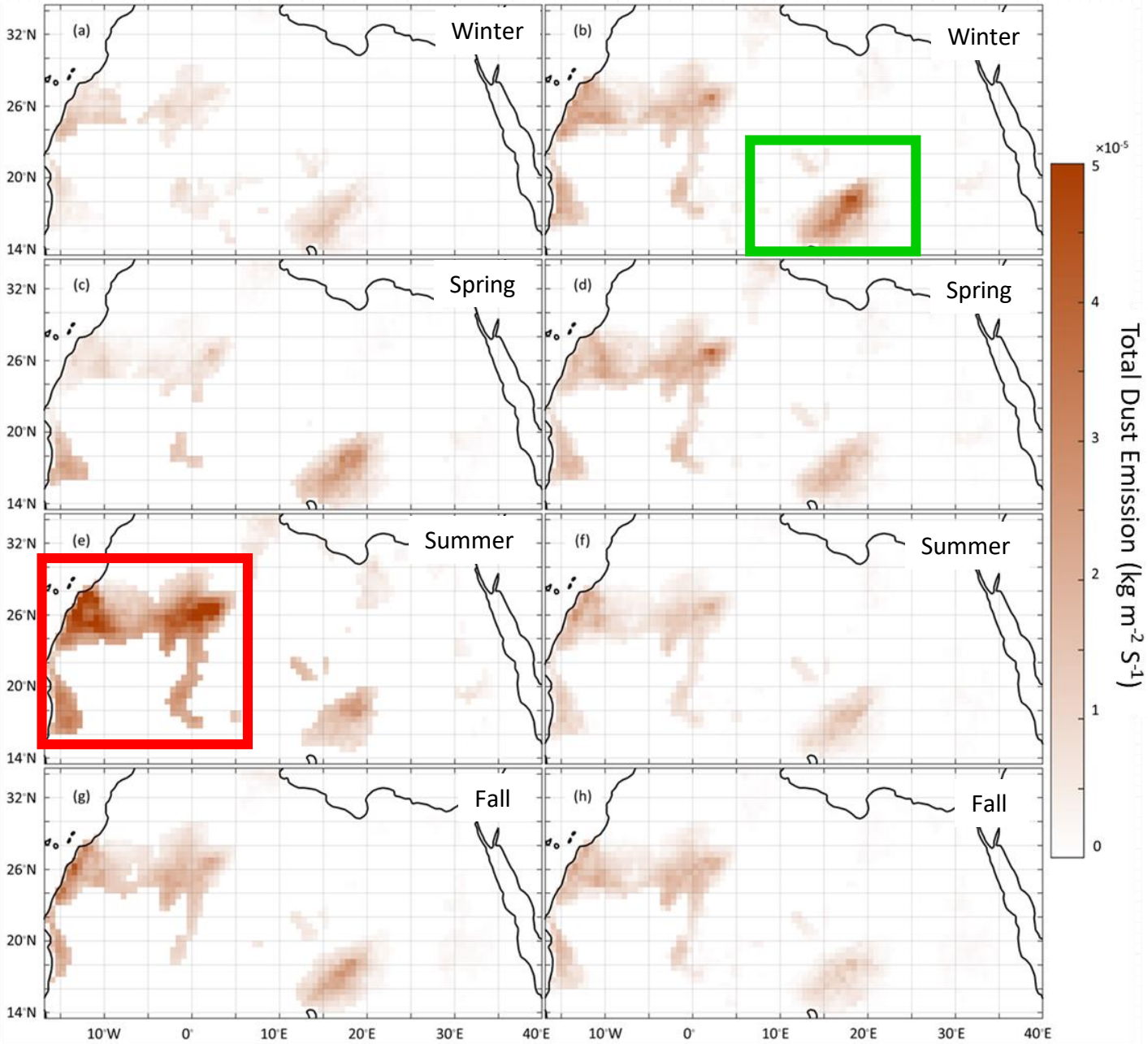
# Trajectories	Winter	Spring	Summer	Fall
US-CARIB	7839	9377	31826	19522
AMZN	32352	11883	3305	8573

Mean Altitude (m)	Winter	Spring	Summer	Fall
US-CARIB	850	1712	1639	1142
AMZN	663	1462	1940	1118



Trajectories enabled us to isolate seasonal dust emission sources contributing to each region

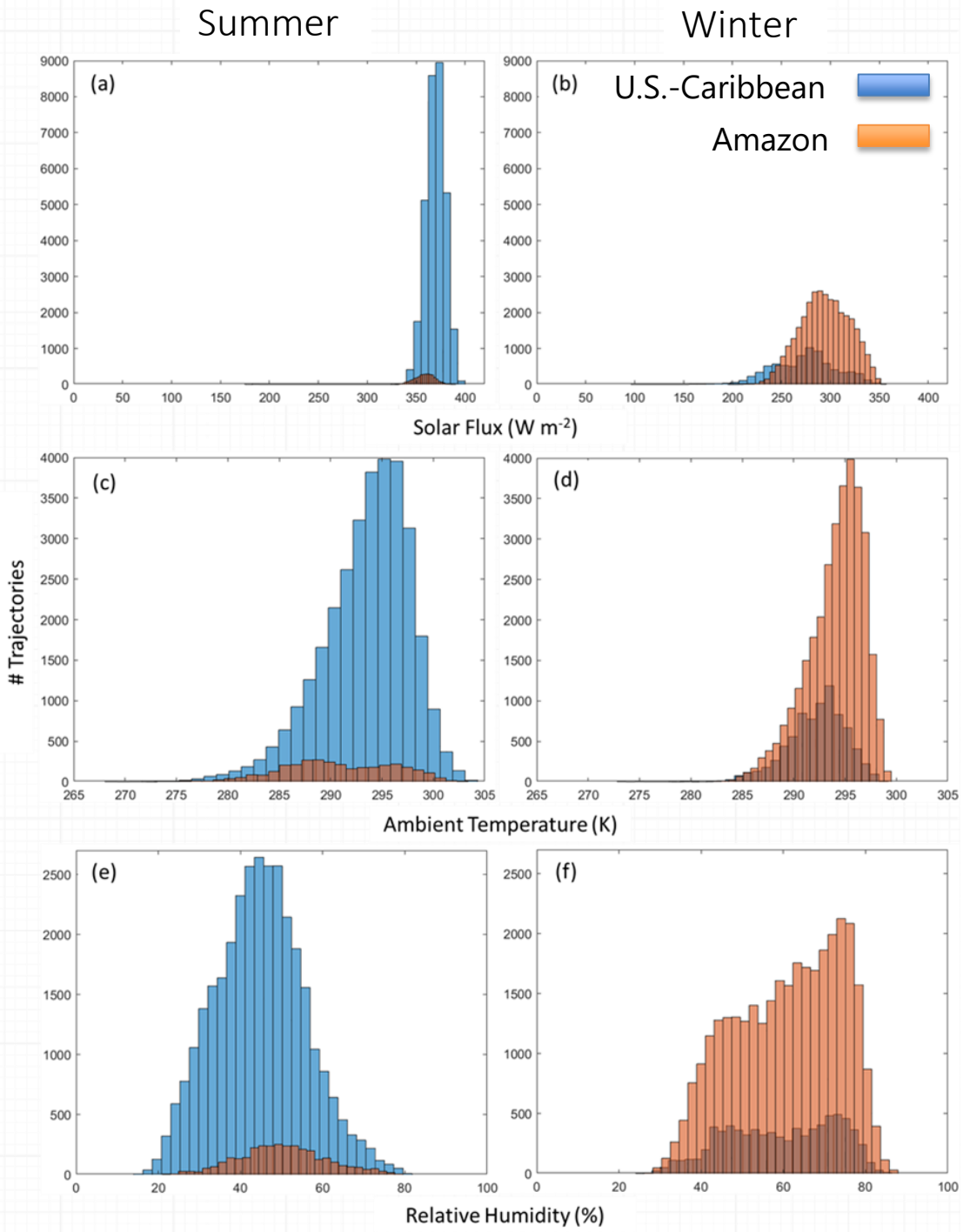
- During the Amazon peak season (December-February), Bodélé Depression plays a great role; however, emissions from western regions are also notable.
- During the U.S. Southeast and Caribbean peak season (June-August), the majority of dust emissions are sourced from the western regions.
- Different source regions suggest different taxa of microorganisms transported during each season.



U.S. Southeast and Caribbean **Amazon**

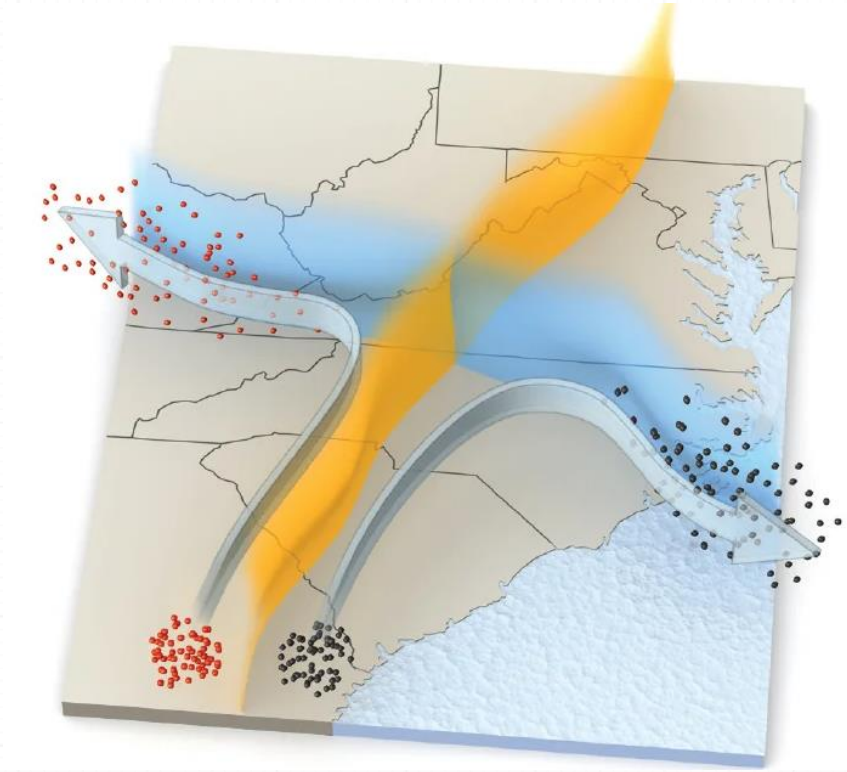
Trajectories of main peak seasons endure contrasting environmental conditions along the way

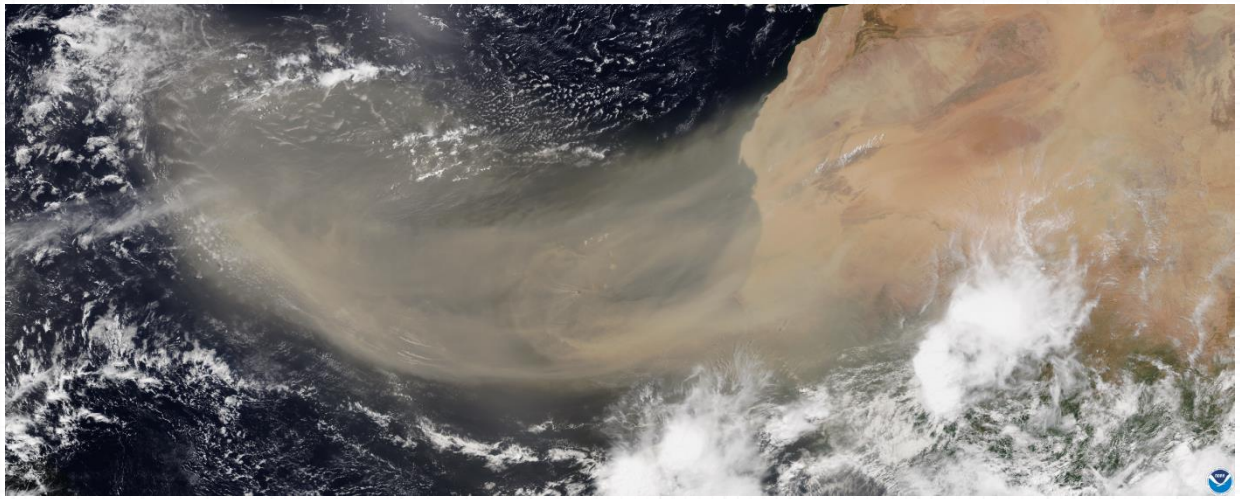
- Trajectories endure significantly higher and more uniform levels of mean UV radiation in U.S. Southeast-Caribbean peak season.
- Experienced mean ambient temperature is not significantly different between the two peak seasons.
- Endured mean relative humidity is more uniform yet lower on average for U.S. Southeast-Caribbean peak season and demonstrate a bimodal distribution for Amazon peak season.



Trans-Atlantic Dust Transport: Atmospheric Pathways

- The coherent structure analysis to reveal atmospheric pathways, or “air bridges”, of dust and microorganisms
- Godzilla dust storm of June 2020



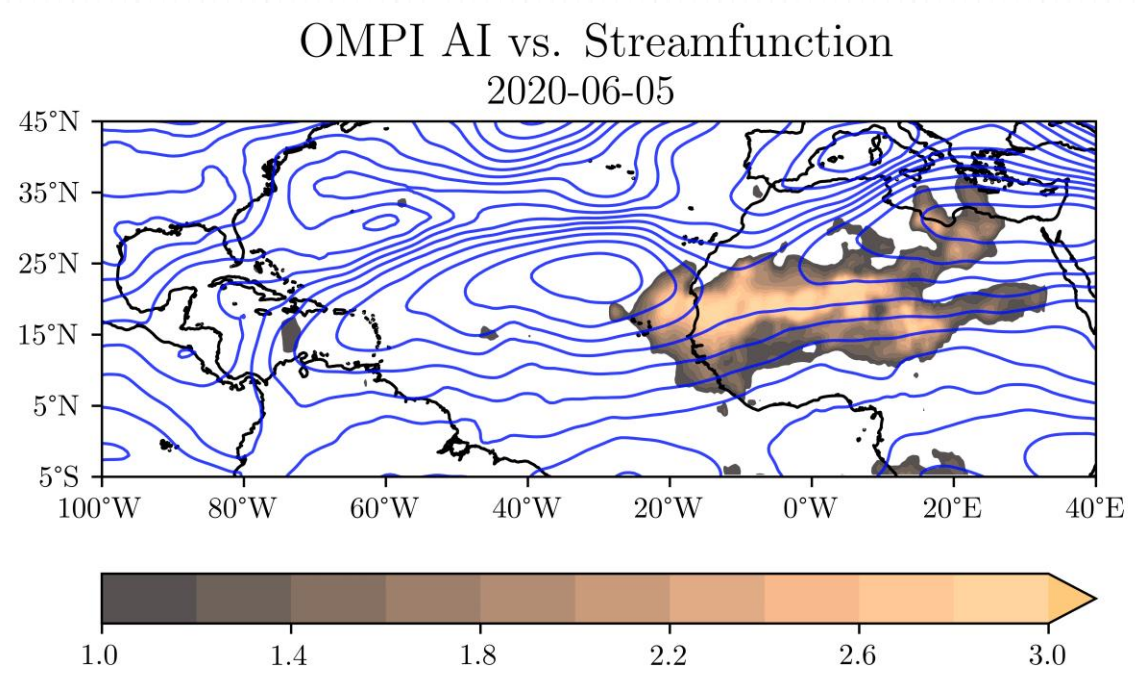


REUTERS World Business Markets Breakingviews Video More

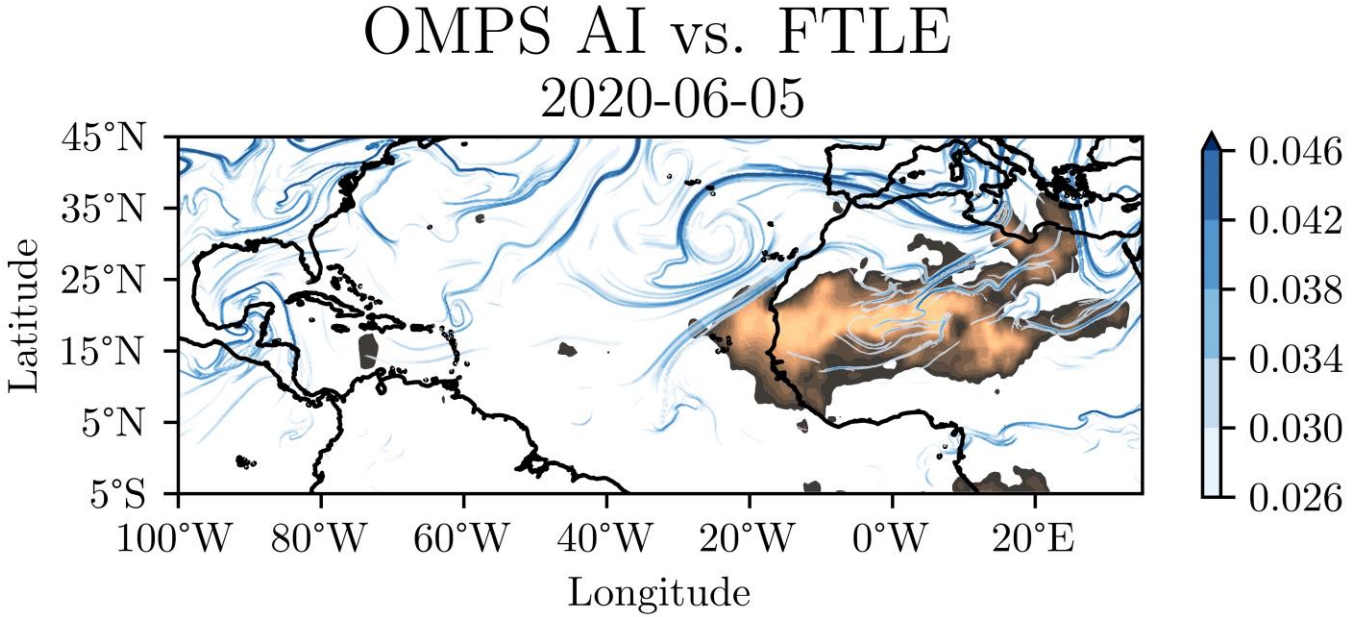
ENVIRONMENT JUNE 25, 2020 / 5:11 PM / UPDATED 2 YEARS AGO

'Godzilla dust cloud' drifts over U.S. Southeast, raising health concerns

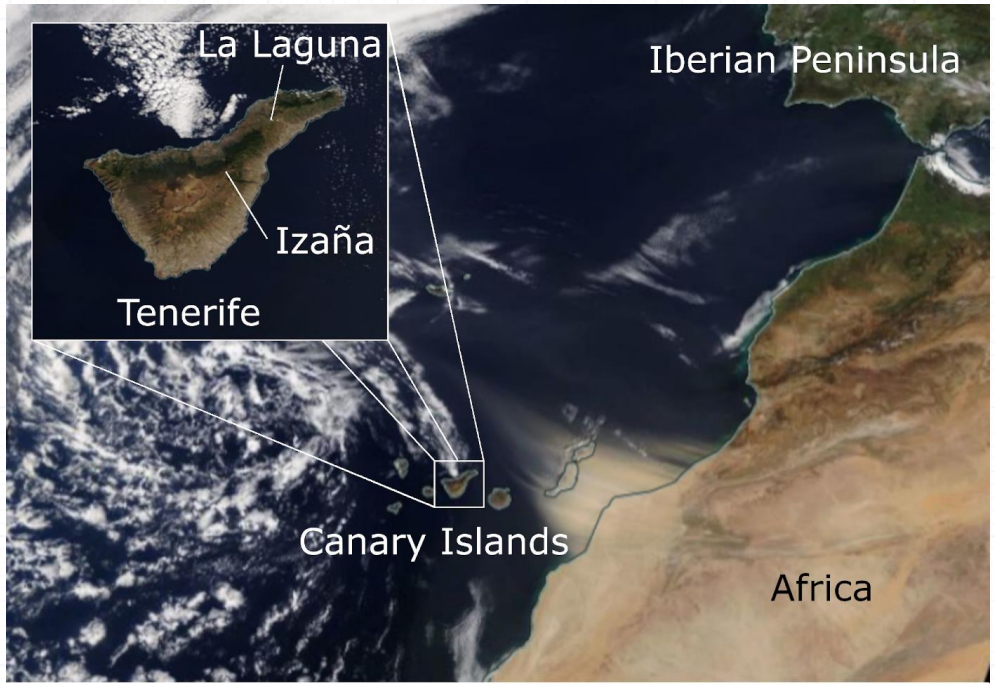
- We can compare the transport of the dust plume with **streamlines** (a conventional approach)
    - However, in time-varying flows, streamlines can be misleading and airborne material can cross them

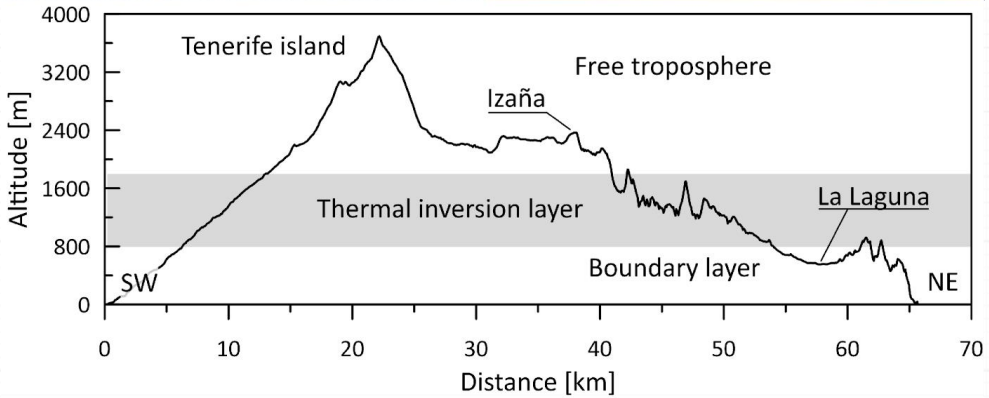


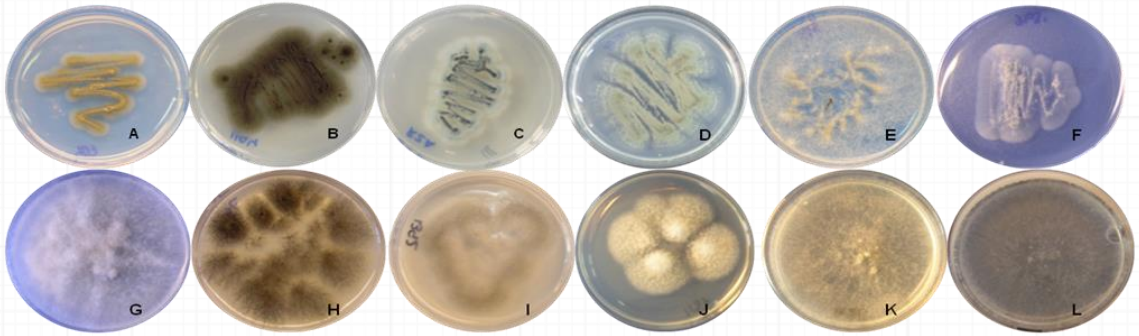
- Comparing with **attracting coherent structures** reveals more: they help shape and bound the plume as it develops across the Atlantic
    - Coherent structures move with the atmosphere, revealing transport pathways



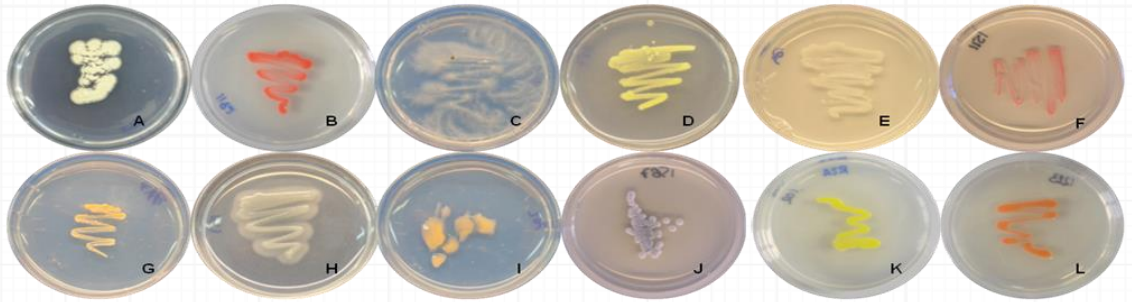
Sampling Dust and Microbes: Canary Islands







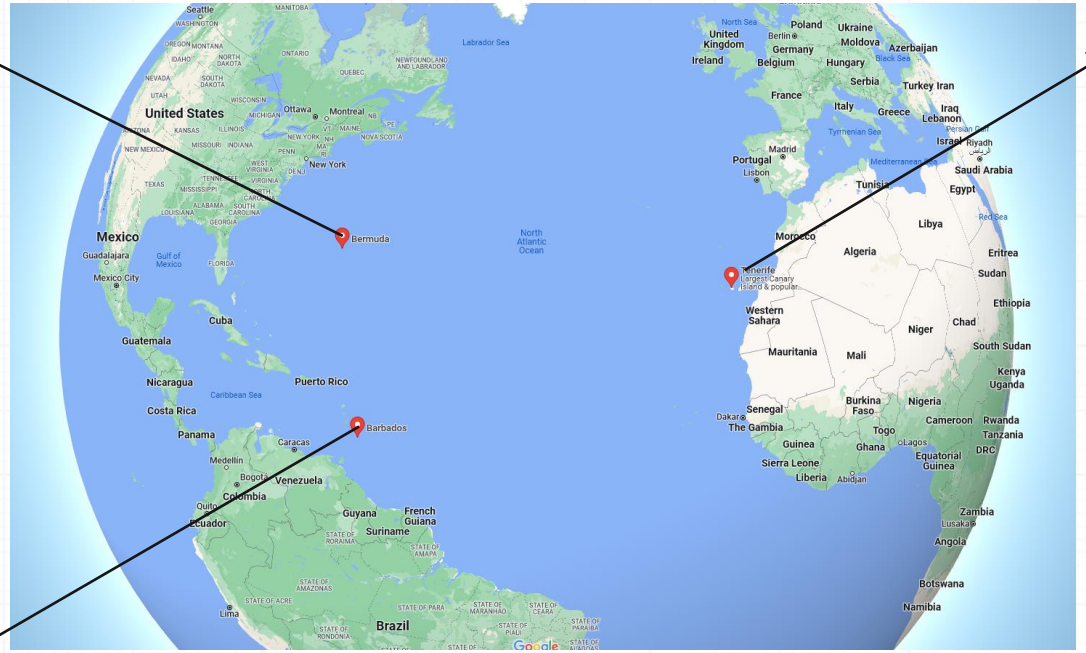
R2A Petri dishes with isolated airborne **FUNGI,** identified as: A and B: *Cladosporium* sp.; C and D: *Penicillium* sp.; E: *Rhizopus* sp.; F: *Aspergillus* sp.; G and H: *Alternaria* sp.; I: *Dendryphiella* sp.; J: *Leptosphaerulia* sp.; K: *Fusarium* sp.; L: *Botryotinia* sp. (Teigell-Pérez, 2015)



R2A Petri dished with isolated airborne **BACTERIA**, identified as: A and J: *Streptomyces* sp.; B; *Planococcus* sp.; C and D: *Bacillus* sp; E and F: *Arthrobacter* sp.; G: *Dietzia* sp.; H: *Pseudomonas* sp.; I: *Kocuria roseae*; K: *Microbacterium* sp.; L: *Staphylococcus* sp. (Teigell-Pérez, 2015)

Sampling Dust and Microbes: Coordinated Sampling

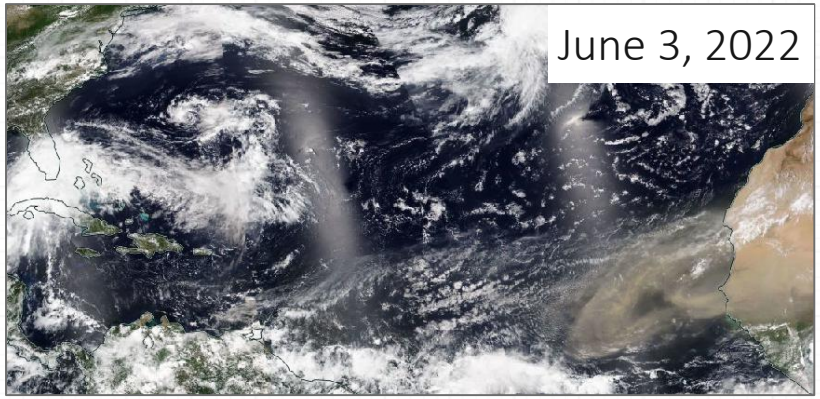
NASA ACTIVATE Campaign

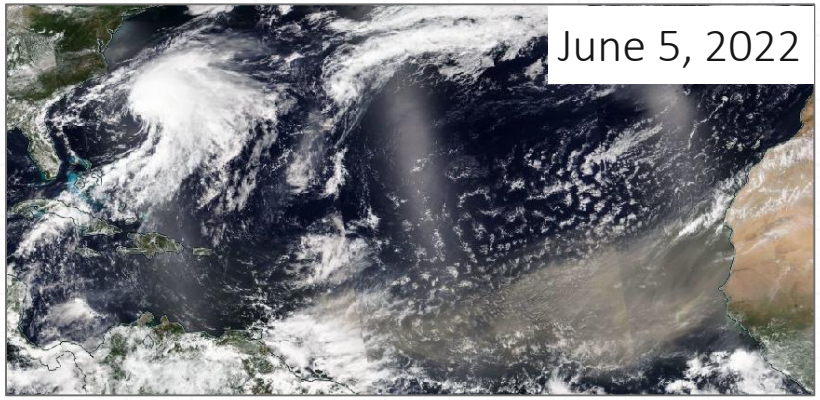


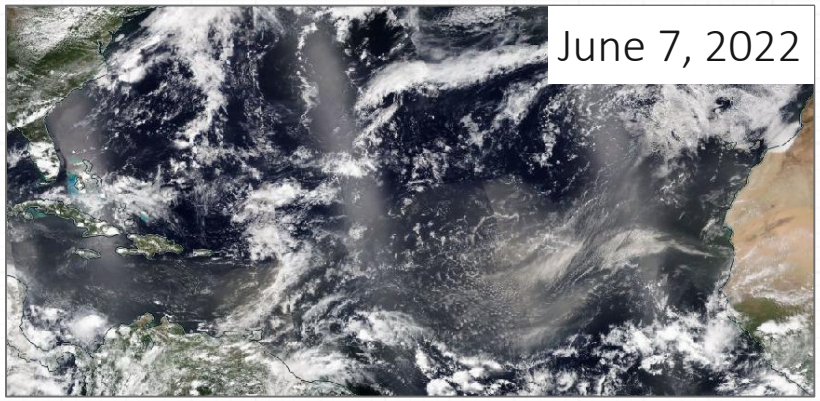
University of La Laguna, Tenerife

Barbados Atmospheric Chemistry Observatory, Univ. of Miami

Sampling Dust and Microbes: June & July, 2022



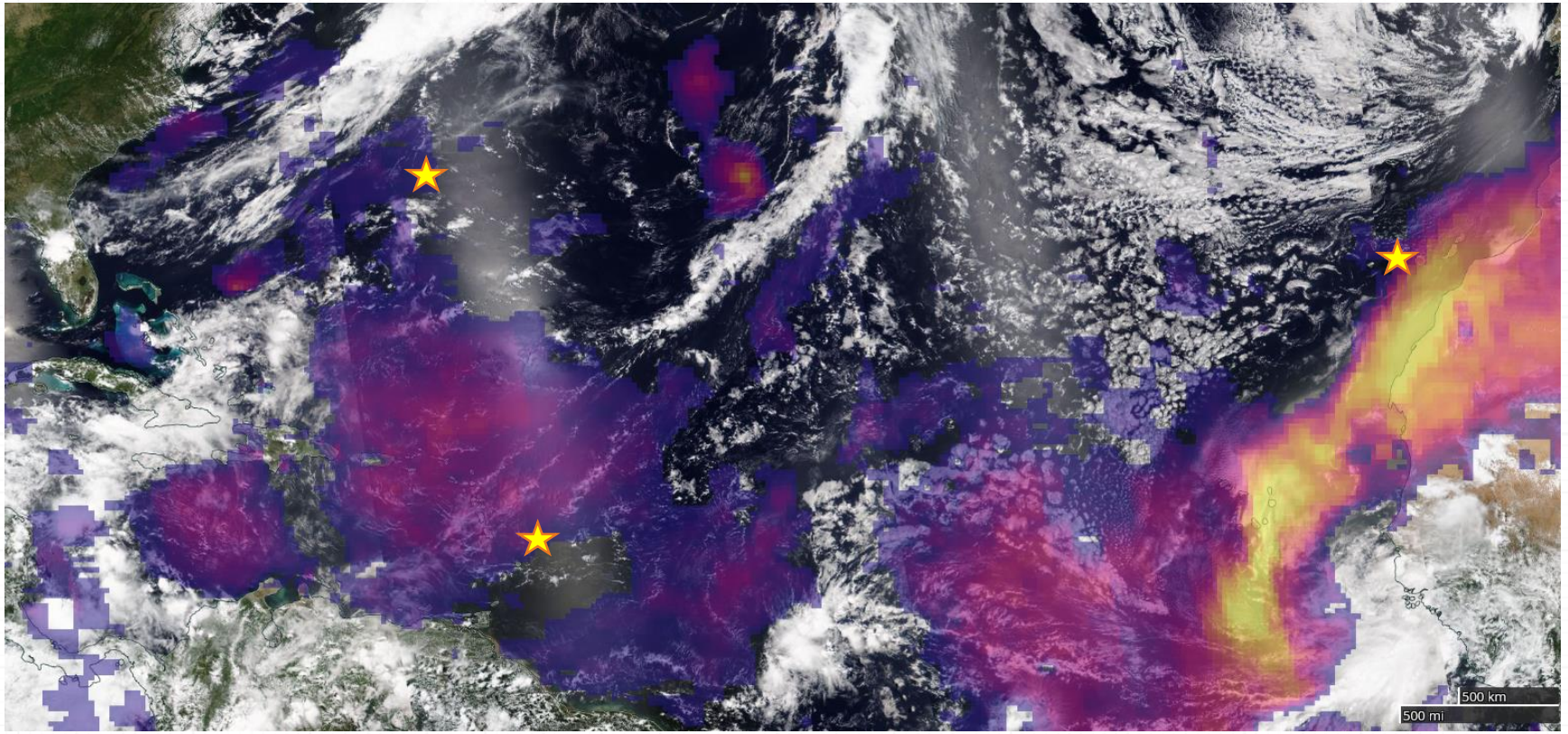




True Color / Suomi NPP / VIIRS

Sampling Dust and Microbes: June & July, 2022

Filters collected in Barbados



June 18, 2022

True Color / Suomi NPP / VIIRS
Aerosol Index / Suomi NPP/ OMPS

Ongoing Work

- Two manuscripts to be submitted soon:
  - *Mardi et al. on multi-year analysis of dust sources and pathways*
  - *Jarvis et al. on "air bridges" of dust and microbes*

- Analysis of purified DNA from samples collected in June & July 2022
  - *AGU 2022 presentation and a follow-up manuscript*

Fun Stuff

- NETFLIX Science Docuseries: "Connected: The hidden science of everything"
- Episode 3 : Dust - Featuring members of our team