

# **Tropical Marine Aerosols in the Trade Winds: Towards a Better Understanding of the Role of Organic Aerosols in CCN**

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# **Puerto Rico Aerosol and Cloud Study as part of RICO (PRACS-RICO)**

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# Importance of Organic Aerosols

- Some aerosols with organic carbon (OC) content are CCN and contribute to the number and size of cloud droplets formed.
- The CCN activity of the OC is mainly the result its water-soluble organic component (WSOC) because it represents an important part of the water-soluble fraction and can influence the water tension of cloud droplets.
- Organic aerosols are produced from both natural and anthropogenic sources.
- A substantial fraction of measured aerosol concentrations cannot be explained by sulfate aerosol alone without taking into account nonsulfate aerosol species.
- Atmospheric concentrations of OC (average  $390 \text{ ng m}^{-3}$ ) in coastal and oceanic ground-based sites near, or in, Puerto Rico have been shown to exceed sulfate concentrations (average  $270 \text{ ng m}^{-3}$ ).

## Importance of Organic Aerosols (cont.)

- About 40% of the CCN number concentration can be accounted for by sulfate and the remaining 60% by the organic aerosol mass concentration demonstrating that background organic aerosols may significantly contribute to ambient CCN number concentrations in remote areas, including the tropics.
- **However, the exact role of OC and its WSOC in CCN activity and the specific species that make OC CCN active are still unknown.**

# Motivation for this Study

- If background organic aerosols make a significant contribution to marine background aerosols and to CCN population, this will suggest that they play an important role in CCN activation, therefore affecting cloud properties and having an impact on climate (affecting the estimates of indirect forcing by anthropogenic sulfate aerosols).

# Essential Information Needed

Improve knowledge of the chemical and physical properties of background OC aerosols in marine tropical environments.

## Limiting Factors

- Lack of measurements in the tropics.
- Scarcity of simultaneous measurements of CCN and aerosol chemical composition focusing on the organic fraction in marine environments.

**This project as part of RICO will sample aerosols and warm clouds in a tropical environment, providing ideal platforms to study organic aerosols and their impact on CCN activity.**

# RICO

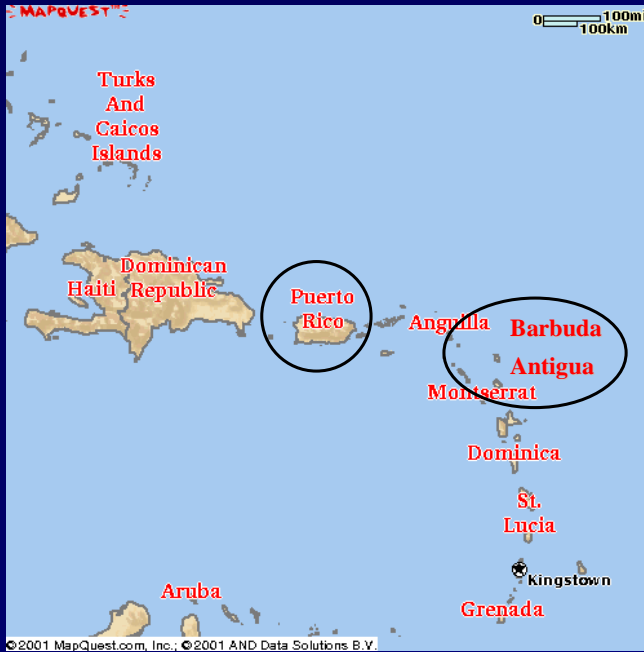
- The objective of the RICO experiment is to characterize and understand the properties of trade wind cumulus, with an emphasis on precipitation.
- Two fundamental questions are:
  - What is the spatial and temporal variability of aerosol chemical and physical properties in the trade wind environment?
  - How do aerosols impact the microphysics of trade wind cumuli?
- Our project will contribute to answering these questions by providing a better understanding of the role of tropical marine organic aerosols (organic carbon and its water-soluble fraction) as cloud condensation nuclei (CCN) by achieving the following scientific objectives...

# Scientific Objectives

- To determine for marine inorganic and organic aerosol (focusing on OC and WSOC) in the easterly trades:
  - their size, mass concentration and chemical composition.
  - their contribution to CCN.
  - their in-cloud scavenging efficiency.
  - the surface tension of WSOC fractions.
- Comparison of CCN measurements with predictions from aerosol chemistry and cloud droplet chemistry.



# Sampling Locations



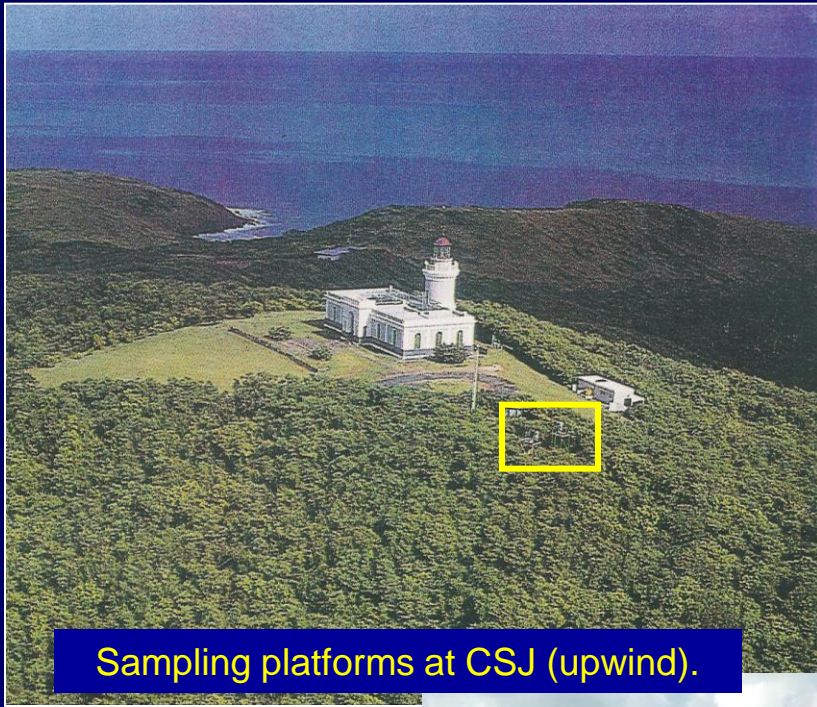
Cape San Juan (CSJ), Puerto Rico  
East Peak, Puerto Rico  
Barbuda



# Research Advantages of Puerto Rico Sites

- Located in the tropics, 18°15' N, 66°30' W
- Predominance of easterly trade winds with natural aerosols.
- Lighthouse, Fajardo (CSJ) – Good for the study of natural, marine aerosols.
- Caribbean National Forest (East Peak - 1000 m) – allows collection of cloud, fog, rainwater almost all year round.
- Large university research center (UPR-RP) within 50-60 min drive of the sampling sites (minimizes concerns about sample handling and preservation, greater reliability in the data,...).
- Natural laboratory for studies of frequent, predictable orographic clouds that can be measured with ground-based sensors.
- Possibility to make quasi-Lagrangian measurements of gas, aerosol and cloud properties.
- Site of long-term (since 1978) precipitation chemistry measurements (inorganic ions) as part of the National Atmospheric Deposition Program.
- Very supportive staff at NWS Station with radar coverage and rawinsondes (extra provided at no charge during project).

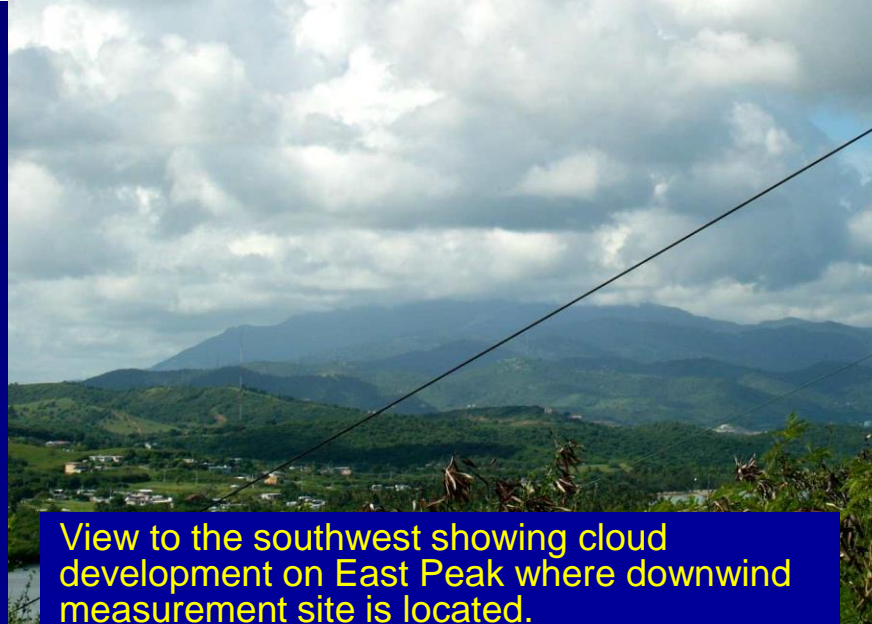
## Cape San Juan - Marine Site (clean)



Sampling platforms at CSJ (upwind).



View to the southeast showing early rain from shallow convection.



View to the southwest showing cloud development on East Peak where downwind measurement site is located.

## East Peak - Mountain Site



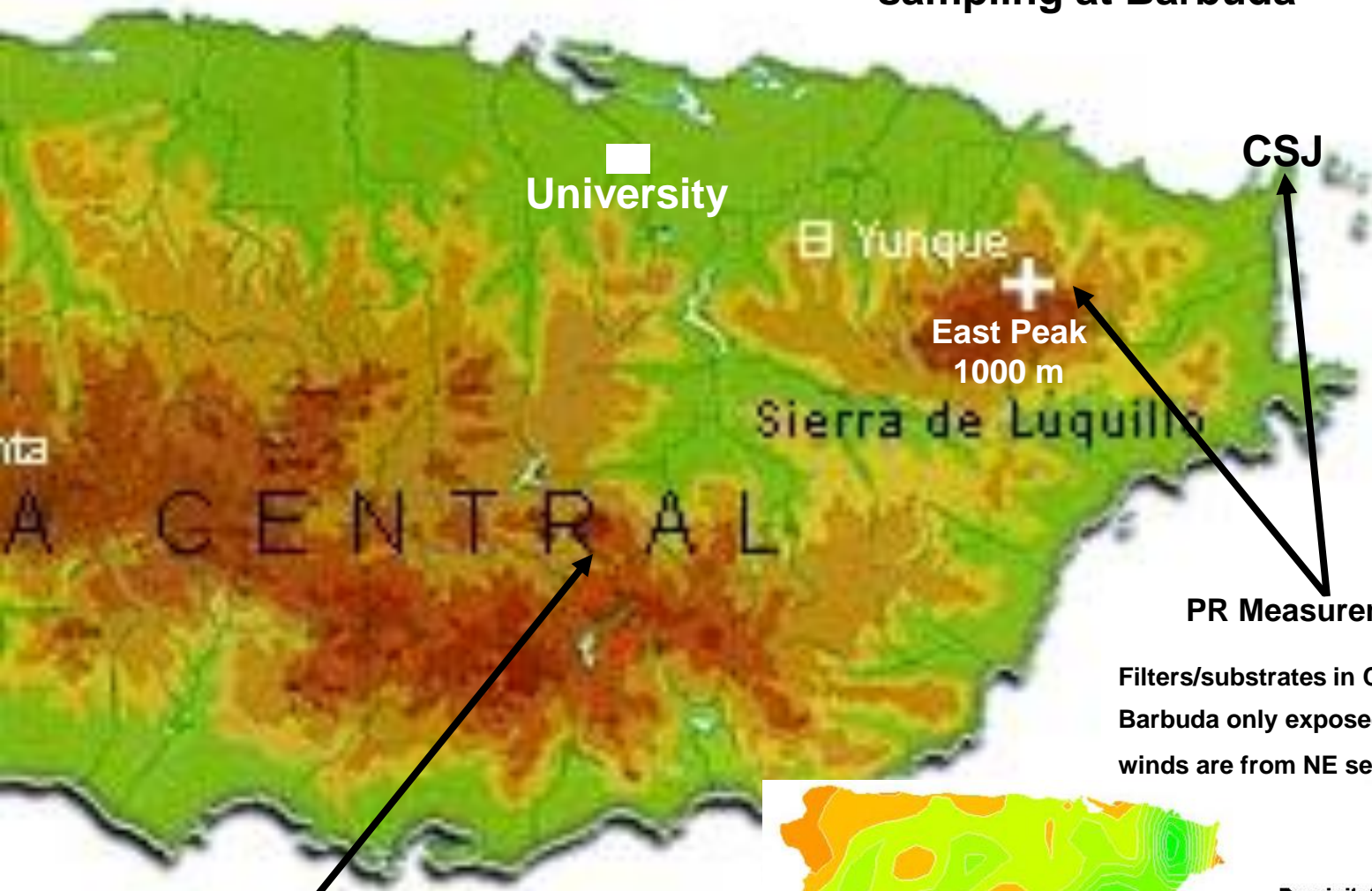
Mountain site at CNF-East Peak (downwind).



This is the view looking upwind to the lighthouse research site, pointed to by the arrow.

# Measurement Strategy

Simultaneous with  
sampling at Barbuda

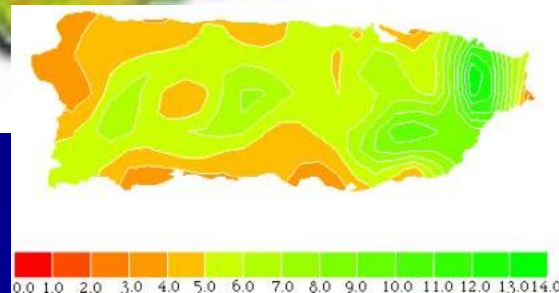


Prevailing  
Wind

PR Measurement Sites

Filters/substrates in CSJ, EP and Barbuda only exposed when prevailing winds are from NE sector.

S-Band Weather radar



Precipitation Climatology  
for November

units = inches of rainfall

# Instrumentation and Models (I)

University of Puerto Rico

UNAM

UMIST

NWS-PR\*

## Lighthouse Site (CSJ)

- Meteorology
- Low-pressure impactors (DLPI, MOUDI)
- Hi-Volume filter samplers (M.O. Andreae – MPIC, Germany)
- CCN counter (Wyoming/DMT)
- CN counter (TSI 3010)
- OPC (PMS LASAir 300)
- Aethalometer
- Nephelometer
- Sun Photometer (AERONET)
- Aerosol Mass Spectrometer

## Mountain Site (East Peak)

- Meteorology
- Low-pressure impactor (MOUDI)
- CN counter (TSI 3010)
- OPC (PMS LASAir 300)
- Soot Photometer
- Nephelometer
- Cloud Water Collector (Kasper & Puxbaum - Vienna Tech)
- Rainwater Collector
- PMS FSSP-100
- PMS 2D-C
- PMS 2D-P

# Instrumentation and Models (II)

University of Puerto Rico

UNAM

UMIST

NWS-PR\*

## Barbuda Site

- Low-pressure impactors (MOUDI)
- Hi-Volume filter samplers
- Meteorology??
- CCN counter??
- CN counter??
- Others??

\* is somebody doing these in Barbuda?

## Diagnostic and Prognostic Modeling

- Wind field predictions with MM5
- Wind field predictions with MM5, Cloud microphysics with ARPS
- Cloud development and chemical processing
- Diagnosis of aerosol fluxes and cloud development

\* NWS will launch higher frequency of rawinsondes during research period.

# Analyses (Filter/Impactor and Cloud/Fog Samples)

Technique	Species Determined	Institution that will Perform Analysis
Evolved Gas Analysis, EGA	Total carbon, organic carbon, elemental carbon (TC, OC, EC)	National University of México, UNAM
Thermo/optical analysis	TC, EC, OC	UPR-RP
Total Organic Carbon, TOC	Water-soluble organic carbon (WSOC)	UPR-RP and Institute of Atmospheric Sciences and Climate, ISAC, Bologna, Italy
<sup>1</sup> H-Nuclear Magnetic Resonance, <sup>1</sup> H-NMR	Chemical functional groups	ISAC, Bologna, Italy
High-Performance Liquid Chromatography, HPLC	Neutral compounds, mono- and dicarboxylic acids, polycarboxylic acids	ISAC, Bologna, Italy
Ion Chromatography, IC	Water-soluble ions	Vienna University of Technology, Austria

Gravimetric analyses of substrates - Vienna University of Technology  
Measurements of surface tension of water extracts – ISAC



# Why Should RICO Include Measurements in Puerto Rico?

- Premise of the RICO project is that the small cumulus that evolve in the region of RICO are representative of the general population of cumulus that evolve in the tropics from naturally produced aerosols. Therefore,
  - since measurements in Puerto Rico sites will be restricted to air coming off the ocean → natural sources of aerosols should be the same.
- Sampling times significantly longer than with aircraft allowing the characterization of the microphysical, chemical and optical properties of aerosols that form small, tropical cumulus clouds.
- Studies of the evolution of single clouds during their entire lifetime.
- Chemical analysis of cloud water to link cloud droplet formation and precipitation development to the aerosol source. Probably these are the only cloud/fog/rain measurements that are in RICO!?

For the objectives of RICO, this study will provide the size distribution, spatial variability and composition of the aerosol in the trade wind environment, contributing to improve our knowledge in terms of how aerosols, particularly organics, impact the microphysics of trade wind cumuli.



**Come visit us during the intensive-field phase of the project:  
November 1 - 30, 2004  
e-mail: [omayol@adam.uprr.pr](mailto:omayol@adam.uprr.pr)**