

# Overview of Ground-Based Aerosol Measurements during RICO: Antigua and Puerto Rico

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## Participants

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  - G. Frank, U. Dusek, S. Walter, J. Schneider, M. O. Andreae, S. Borrmann
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- **Institute of Atmospheric Sciences and Climate, Bologna, Italy**
  - M. C. Facchini, S. Decesari
- **UMIST, UK**
  - H. Coe, J. Allan, M. Gysel
- **University of Leeds, UK**
  - M. H. Smith, J. McQuaid
- **Meteo-France**
  - L. Gomes
- **University of Warsaw and SIO**
  - E. Grzeszczak, P. Flatau
- **Arizona State University**
  - J. Anderson

## Outline

- Introduction
- Measurements and Institutions Responsible
- Status of Data Processing and Analyses
- Preliminary Results
- Ongoing Activities
- Acknowledgements

## RICO

- Two fundamental questions are:
  - What are the size distribution, spatial variability, and composition of the aerosol in the trade wind environment?
  - How do aerosols impact the microphysics of trade wind cumuli?
- We expect that our participation in this project will contribute to answering these questions by providing a better understanding of the role of tropical marine aerosols (including organics) as cloud condensation nuclei (CCN).

## Stations for Ground-Based Aerosol and Cloud Sampling during RICO



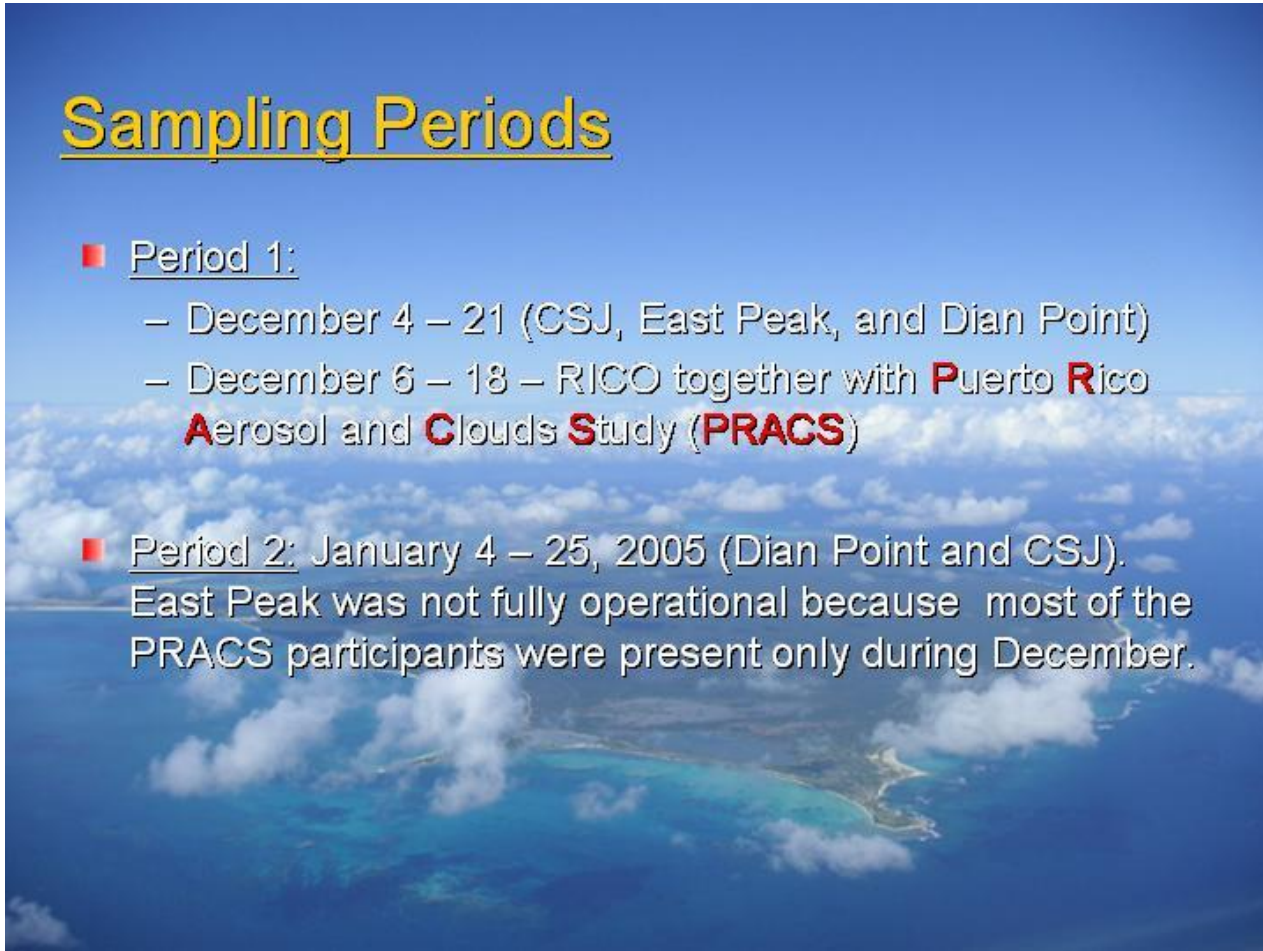
Dian Point



Cabezas de San Juan (CSJ)  
& East Peak

## Sampling Periods

- Period 1:
  - December 4 – 21 (CSJ, East Peak, and Dian Point)
  - December 6 – 18 – RICO together with **Puerto Rico Aerosol and Clouds Study (PRACS)**
  
- Period 2: January 4 – 25, 2005 (Dian Point and CSJ).  
East Peak was not fully operational because most of the PRACS participants were present only during December.



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## Dian Point (Marine Site), Antigua

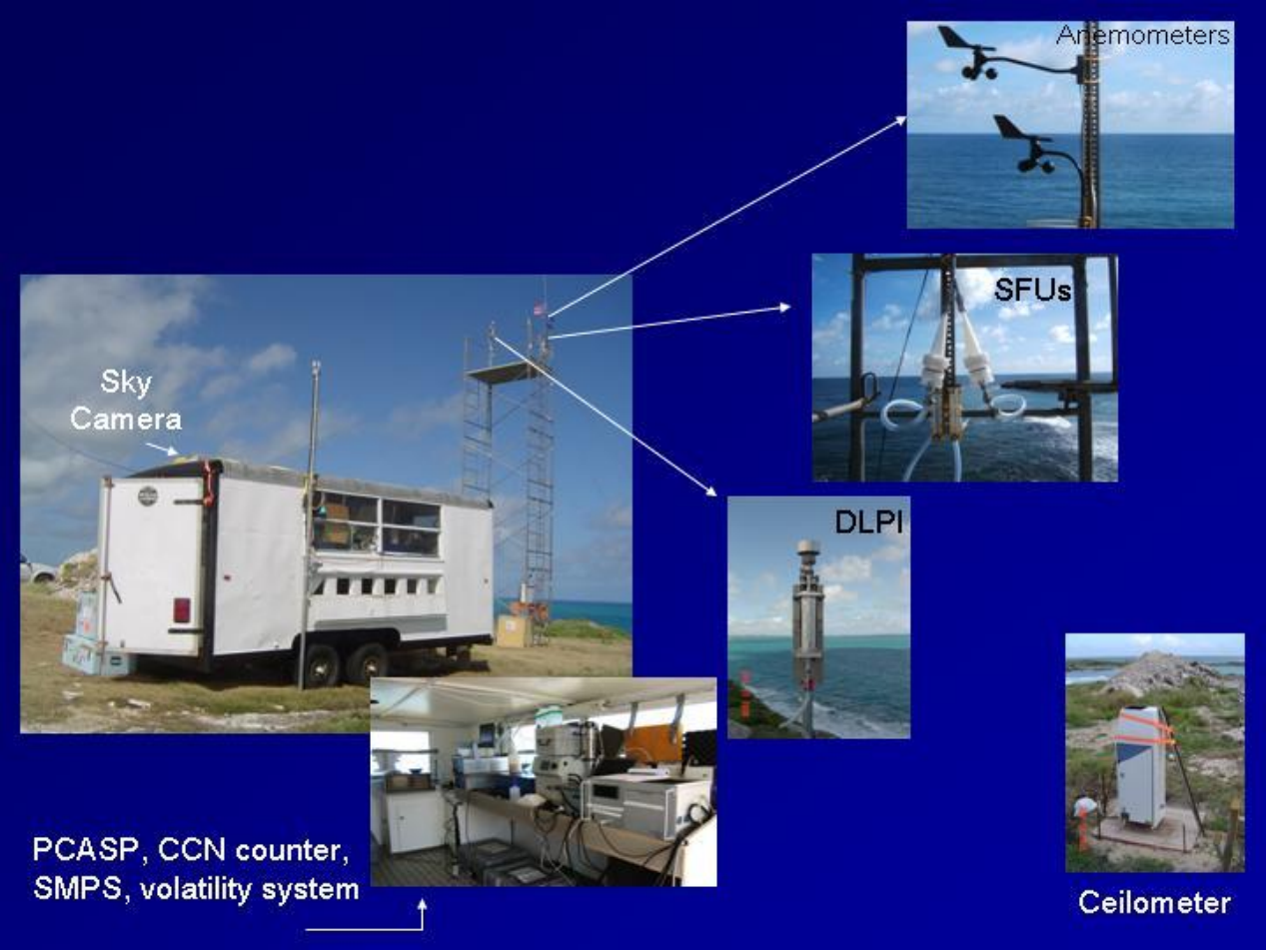




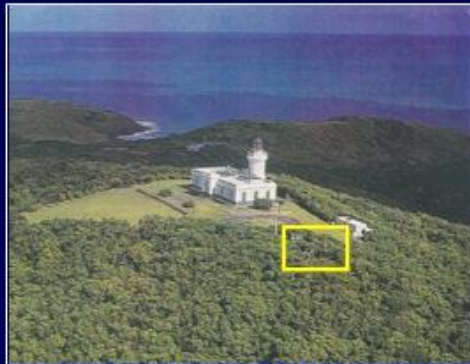
## Instruments at the Dian Point, Antigua

- UPR-RP
  - DLPI
  - SFUs
  - Weather Station
- Meteo-France
  - Condensation particle counter (CPC)
  - CCN counter
  - SMPS
- University of Leeds, UK
  - Volatility system
  - PCASP-X
- Warsaw University and Scripps Institute
  - Vaisala Ceilometer
  - Whole sky camera
- Arizona State University
  - Filter system (surface analysis)





## Cape San Juan - Marine Site, Puerto Rico



Sampling platform at CSJ (upwind)



Lab facilities for  
aerosol instruments



Aerosol inlet



## Instruments Deployed at CSJ

### ■ UPR-RP

- DLPI
- MOUDI
- SFUs
- High-volume sampler
- Aethalometer
- Nephelometer
- Condensation particle counter
- Weather Station

### ■ UNAM, Mexico

- OPC PMS LasAir

### ■ Max Planck Institute for Chemistry, Mainz, Germany

- CCN counters (2)
- SMPS

### ■ University of Manchester, UK

- Aerosol Mass Spectrometer
- HTDMA
- Condensation particle counter

## Lab facilities at CSJ

MPIC - CCN counters and SMPS



UMIST - HTDMA and  
aerosol mass  
spectrometer



UPR  
nephelometer,  
aethalometer,  
condensation  
particle counter



## East Peak - Mountain Site, Puerto Rico



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



Trailer and instruments for measurements of aerosol and clouds properties at the East Peak.

## Instruments Deployed at the East Peak

- UPR-RP
  - MOUDI's
  - SFUs
  - Cloud collector
- UNAM, Mexico
  - OPC PMS LasAir II
  - Condensation particle counter
  - CCN counter
  - FSSP-100, 2D-C, 2D-P
  - Nephelometer
  - Rain water collector
  - Weather Station
- Institute of Tropospheric Research, Leipzig, Germany
  - Condensation particle counter
  - PSAP
- Max Planck Institute for Chemistry, Mainz, Germany
  - Aerosol mass spectrometer

DEC 18 2004

## Instruments at the East Peak



Trailer



Darrel Baumgardner and Stephan Borrmann in action.



Cloud water collector



2D-C and 2D-P



Rain water collector



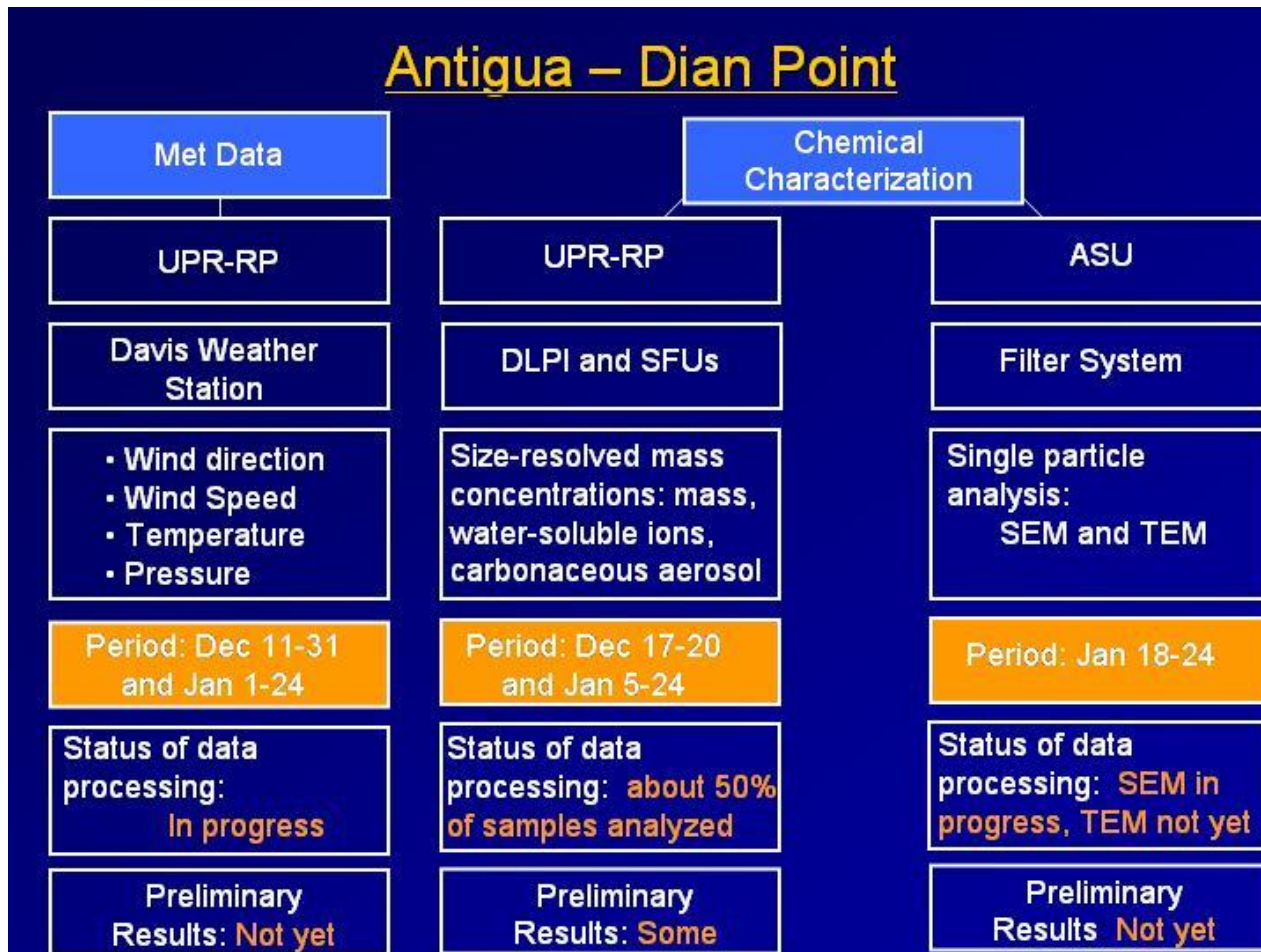
## C-130 Up Wind Flights

- Coordination was established between the NCAR C-130 and the three sampling stations for up wind flights during the ferry flights to Antigua (Dec 4) and on the way back to Colorado (Jan 26). Also during the student's flight (on the 18<sup>th</sup> of January) only over the Dian Point. This is to see if intercomparison with real-time measurements such as particle number, CCN, scattering and absorption coefficients can be performed.

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## Antigua – Dian Point



## Antigua – Dian Point

Only January  
Period!

Physical  
Characterization

Meteo-France

Univ. of Leeds

Univ. of Warsaw  
and Scripps

CN, CCN and  
SMPS

PCASP-X and  
Volatility

Ceilmeter and Sky  
Camera

Particle and CCN  
number concentration,  
& size distributions (10  
– 700 nm).

Number size  
distributions (0.1 to 10  
 $\mu\text{m}$ ) and volatility.

Cloud base & vertical  
distribution of particles  
(1-2 km), sky images of  
clouds (every 1 min).

Period: CN (7-23), CCN  
(11-21), SMPS (7-21)

Period: PCASP (14-24),  
volatility (some gaps)

Period: Jan 11- 21  
(some gaps)

Status of data  
processing:  
**In progress**

Status of data  
processing:  
**In progress**

Status of data  
processing:  
**In progress**

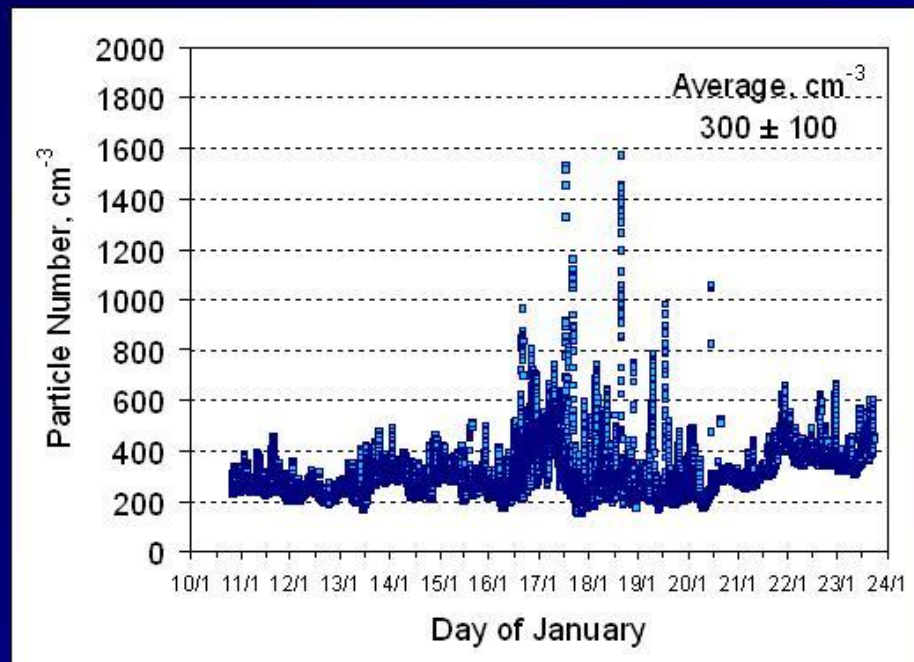
Preliminary  
Results: **Some**

Preliminary  
Results: **Some**

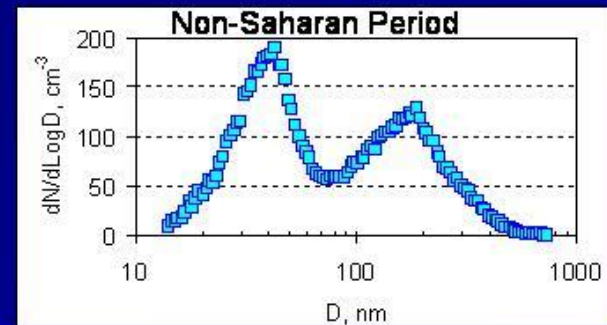
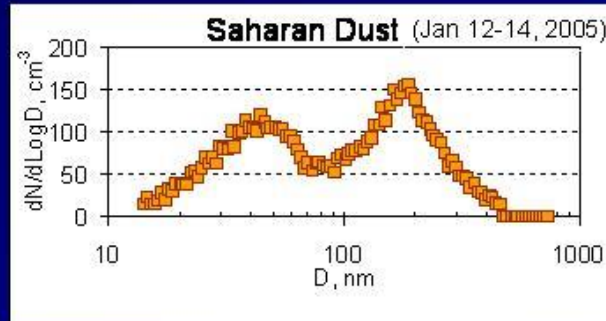
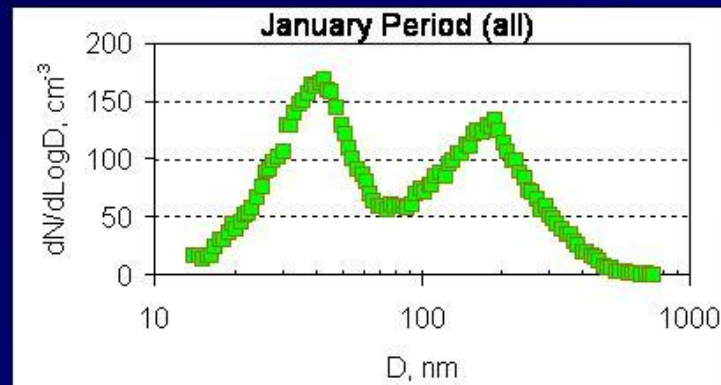
Preliminary  
Results: **Some**

## Preliminary Results: Physical Characterization

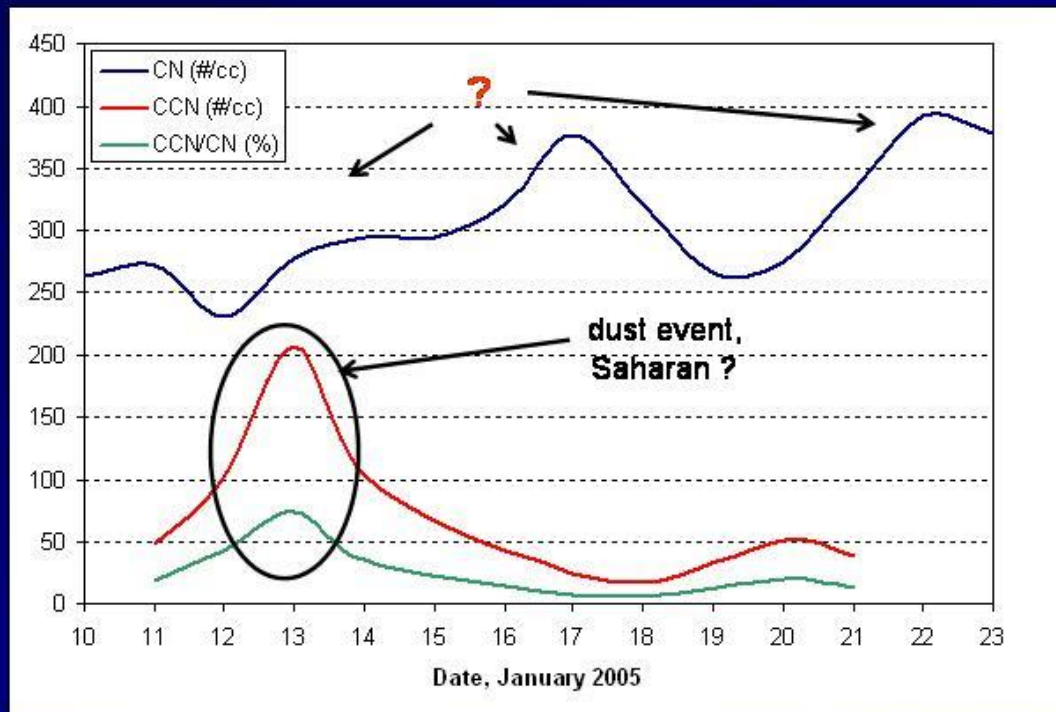
### Total CN Concentrations January Period, Dian Point



## SMPS Size Distributions, Dian Point

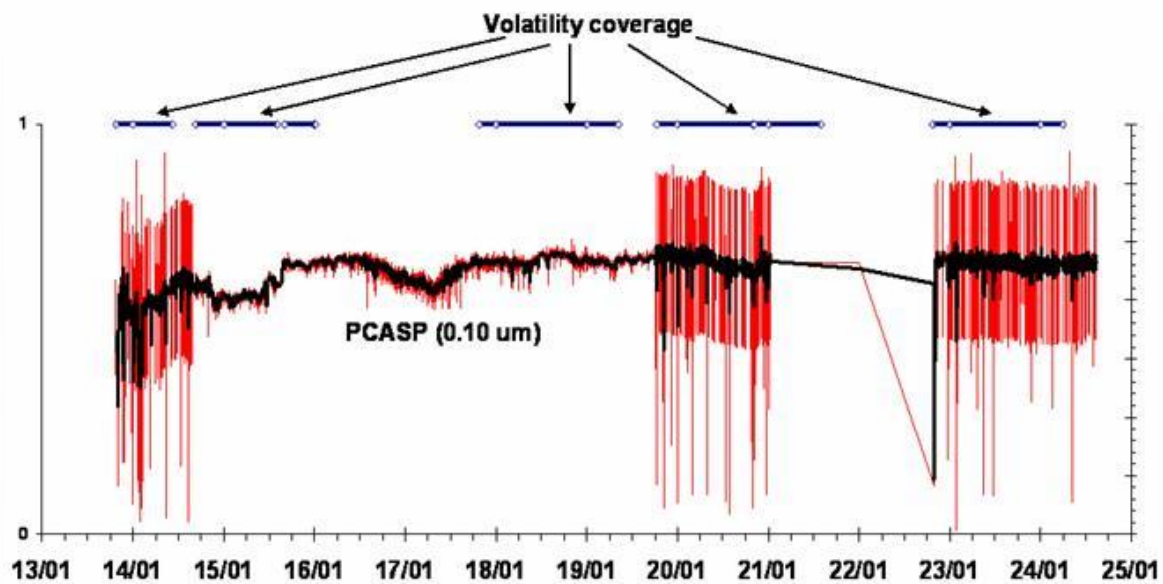


## Daily Average Concentrations of CN and CCN Dian Point (January)



## Leeds Data Coverage – PCASP & Volatility

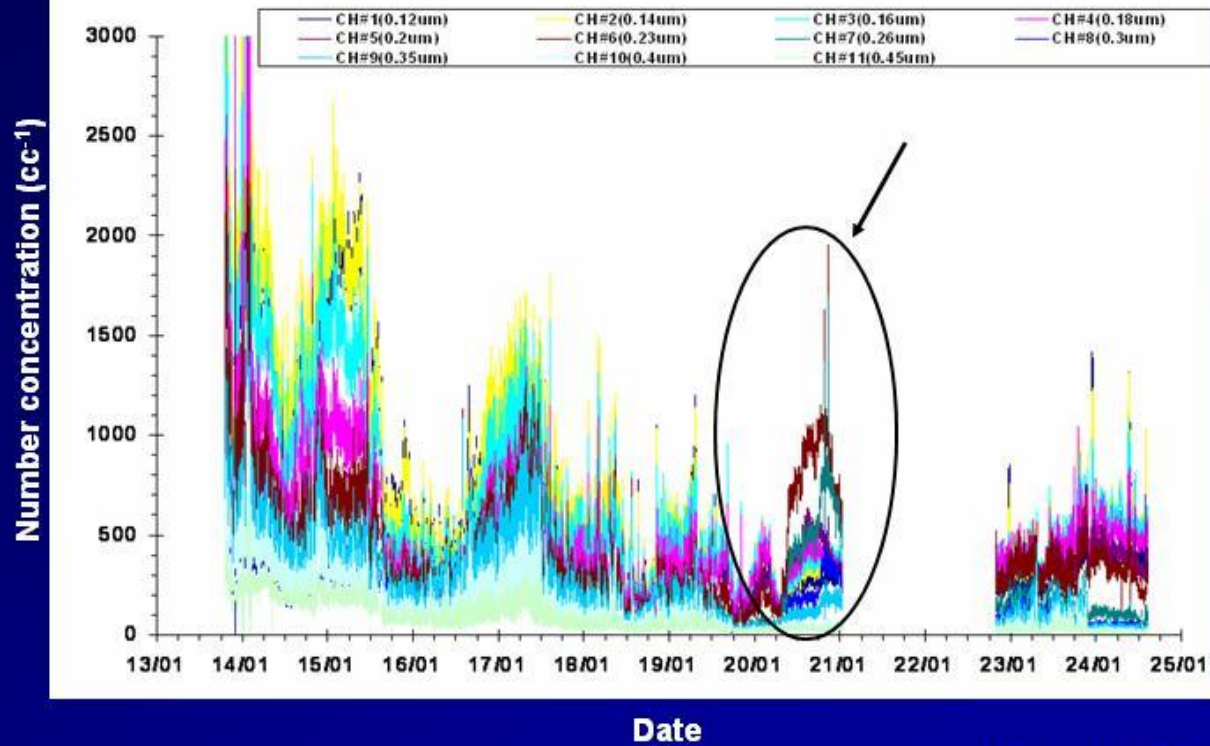
Dian Point





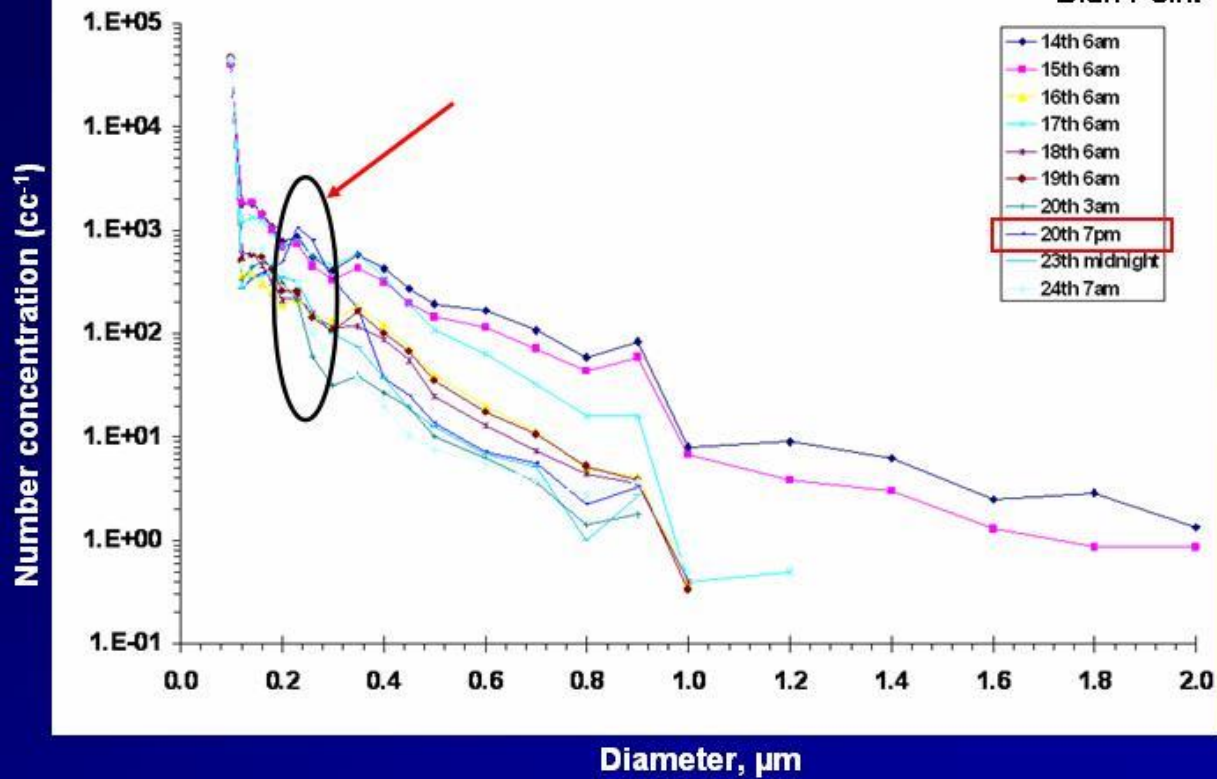
# PCASP - Smaller Sizes (0.12 - 0.45 micron diameter)

Dian Point



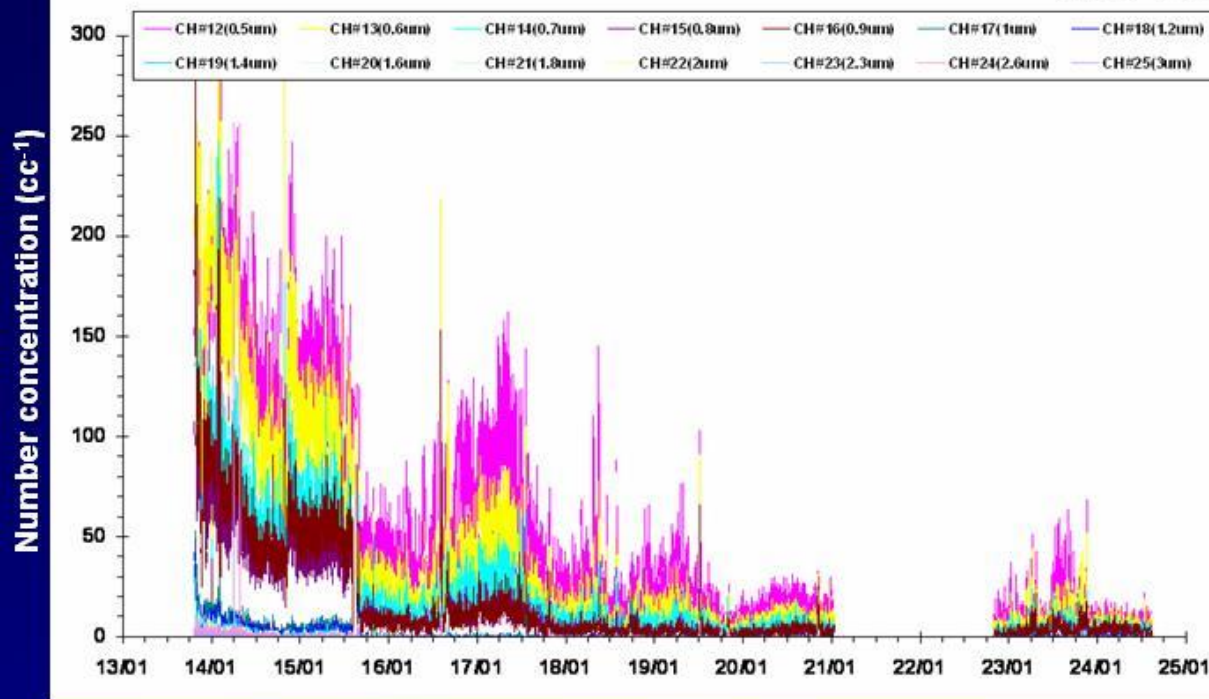
# PCASP Size Spectrum during RICO - January

Dian Point



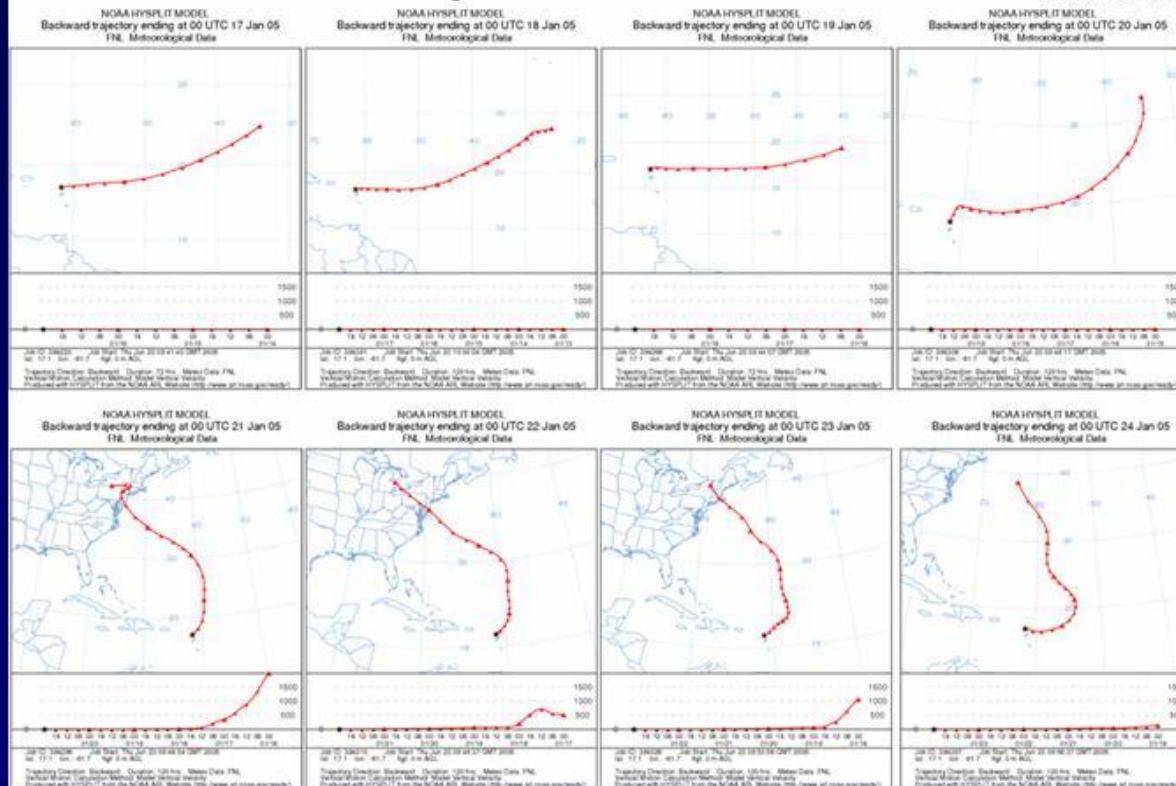
# PCASP - Larger Sizes (0.5 – 3 micron diameter)

Dian Point



# Back Trajectories – 17<sup>th</sup> → 24<sup>th</sup>

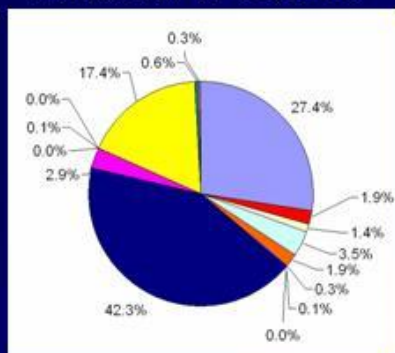
Dian Point



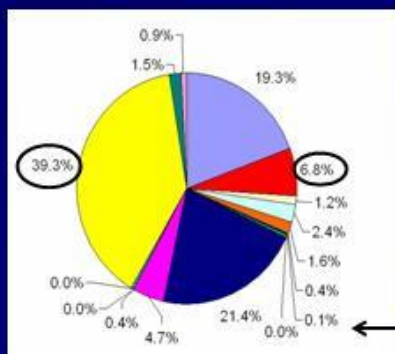
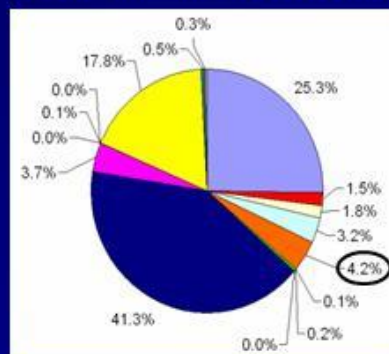
# Chemical Characterization, SFUs

## Water-Soluble Ions, Fine Fraction – Dian Point

Clean: Jan 16-18, 2004



Dust Event: Jan 11-14, 2004



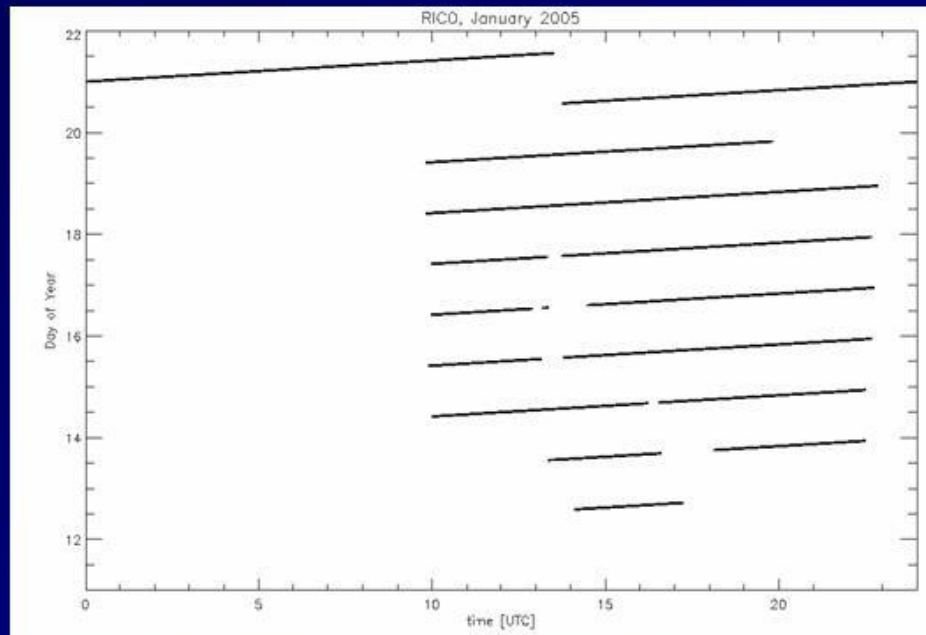
**40 (dust) – 70% (polluted) of the mass concentration has been identified with Ion Chromatography.**

- Na+
- NH4+
- K+
- Mg2+
- Ca2+
- Acetate
- Formate
- NO2-
- Cl-
- NO3-
- Malate
- Malonate
- Maleate
- SO4=
- Oxalate
- MSA

Pollution from US continent:  
Jan 21-24, 2004

O.L. Mayol-Bracero & F. Morales, UPR-RP

## Time Coverage of Sky Camera Data, Dian Point



Solid line indicates times when data were collected (Jan 11-21).  
Pictures were collected during daytime.

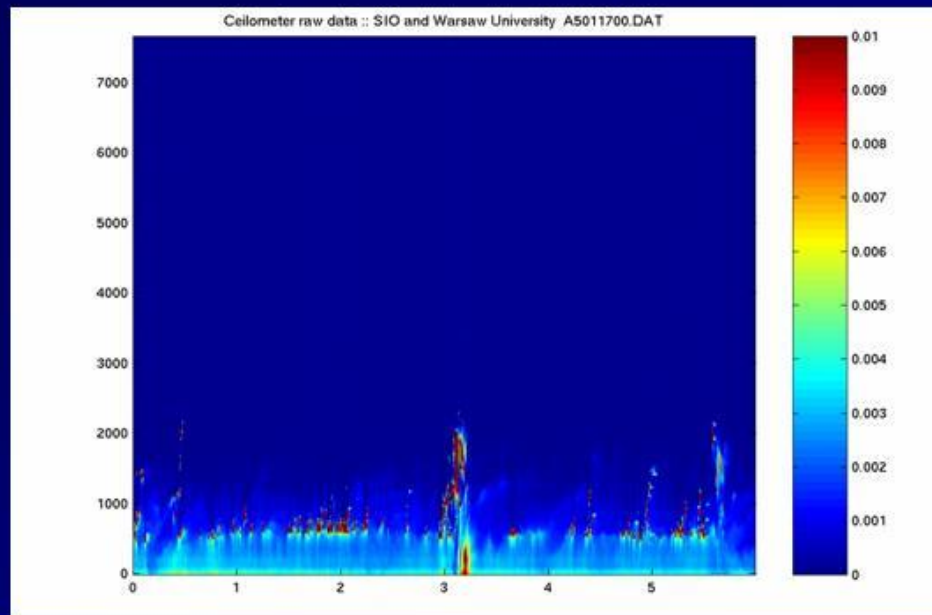
## Whole-Sky-Camera, January 21, 10:37:45 UT



**Sampling tower is visible on a whole sky image to the north-west and aerosol inlet was facing north-east. Pictures taken every 1 min, only during daytime.**

E. Grzeszczak, U. Warsaw and Scripps

## Raw Data from Ceilometer (Vaisala CT25K)



Two way attenuation coefficient measured [ $1/(\text{km srad})$ ] during January 17, 2005 from 0 to 6 UTC. Height is in meters. Cloud base is in red. Data collected every 15s. Vertical resolution is 30 m (signal termination at 7.6 km).

Warning: To obtain [ $1/(\text{srad km})$ ] one has to divide data values by  $10^6$ .



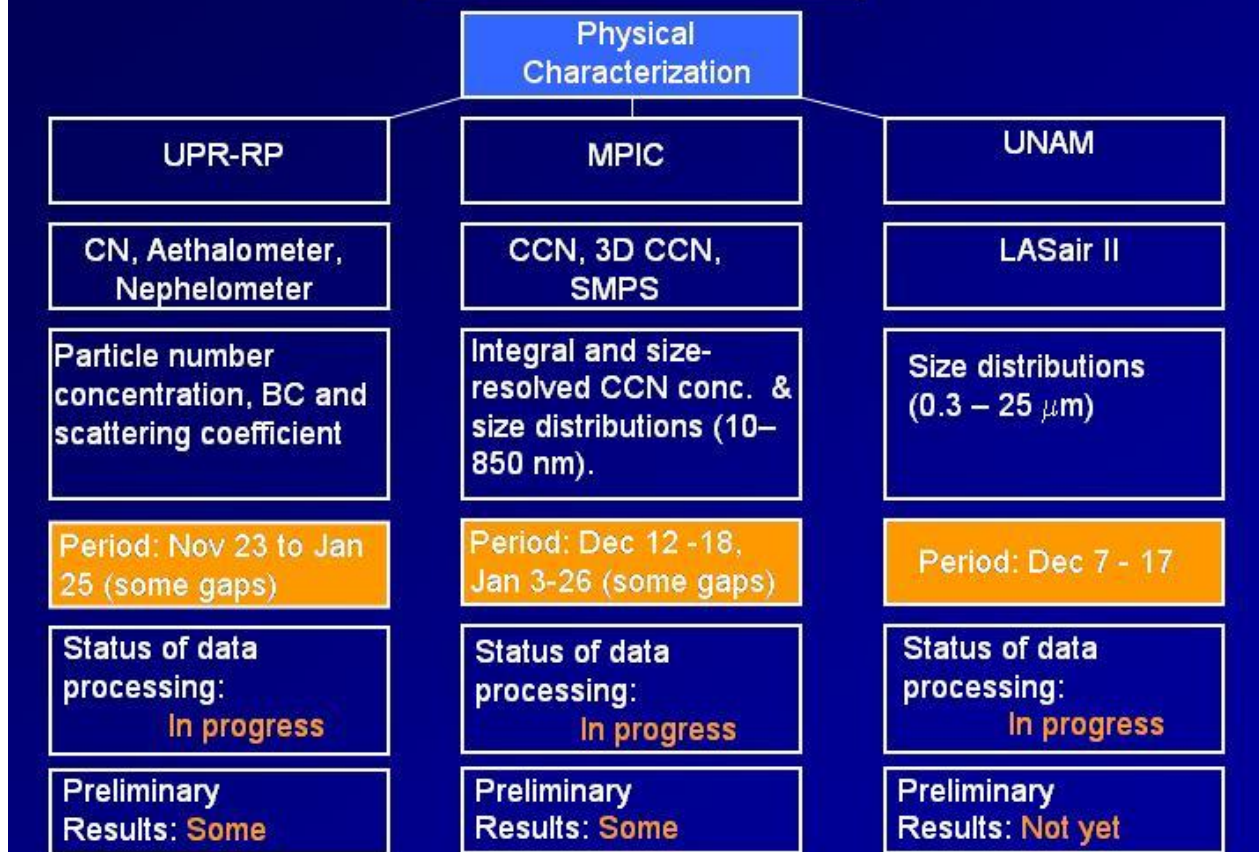
## Summary: Dian Point

- Power problems during December, therefore, most data available are only for the January period, only some chemistry and the Met data are also available for December.
- Possible interesting case studies:
  - Saharan dust – around Jan 12-14, 2005?
  - Pollution from US continent – around Jan 21-24, 2005?
- CN average:  $300 \text{ cm}^{-3}$
- Bimodal particle size distributions from SMPS (peaks around 40 and 200 nm)
- Particle loadings (fine fraction):  $0.4 - 2.9 \mu\text{g m}^{-3}$  ( $1.2 \mu\text{g m}^{-3}$  avg)
- Predominant water-soluble ions in the fine aerosol fraction are  $\text{Cl}^-$ ,  $\text{Na}^+$ ,  $\text{SO}_4^{2-}$ .

## Puerto Rico - CSJ

Met Data	Chemical Characterization	
UPR-RP	UPR-RP	Univ. of Manchester
Davis Weather Station	DLPI and SFUs	Aerosol Mass Spectrometer
Wind direction, Wind Speed, Temperature, Pressure, RH	Size-resolved mass concentrations: mass, water-soluble ions, carbonaceous aerosol	Chemical composition of individual particles
Period: Dec and Jan (some gaps)	Period: Dec 2-22 and Jan 1-26	Period: Dec 9-18
Status of data processing: <b>In progress</b>	Status of data processing: <b>In progress</b>	Status of data processing: <b>In progress</b>
Preliminary Results: <b>not yet</b>	Preliminary Results: <b>some</b>	Preliminary Results: <b>some</b>

## Puerto Rico - CSJ



## Puerto Rico - CSJ

Physical  
Characterization

Univ. of  
Manchester

HTDMA

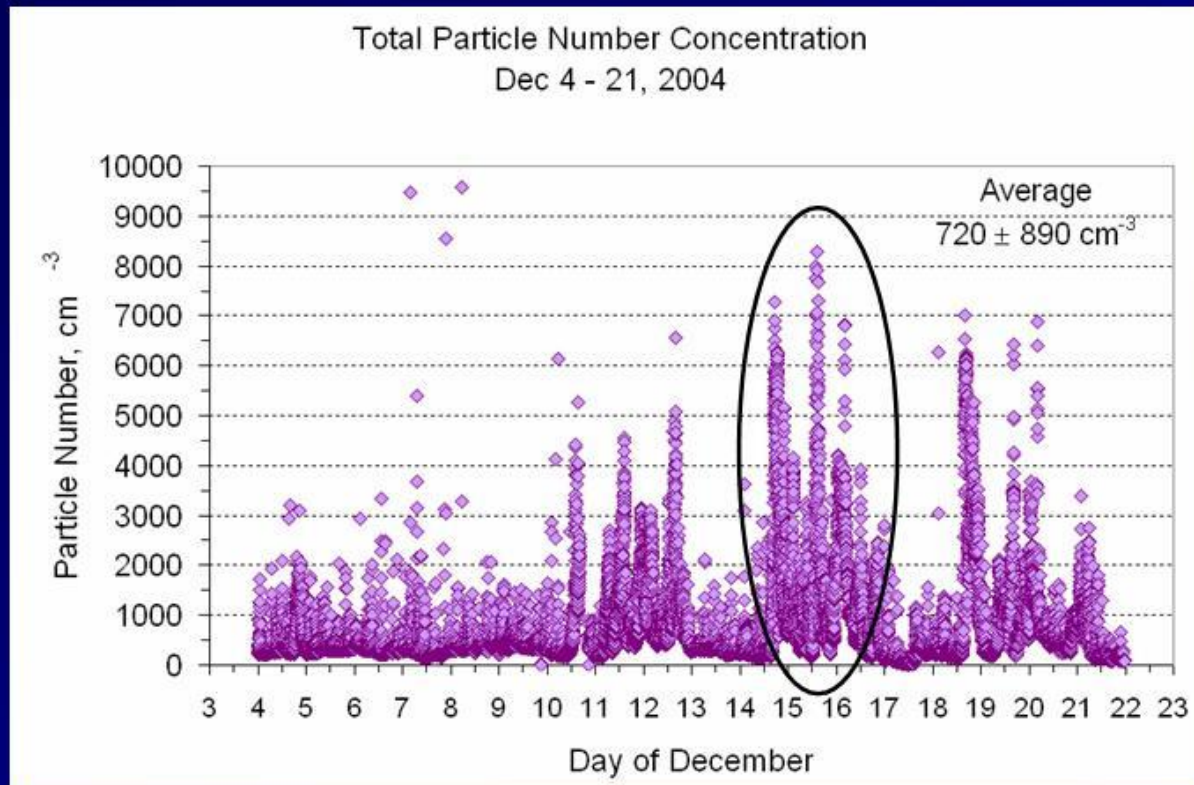
Particle Hygroscopicity

Period: Dec 9 -18

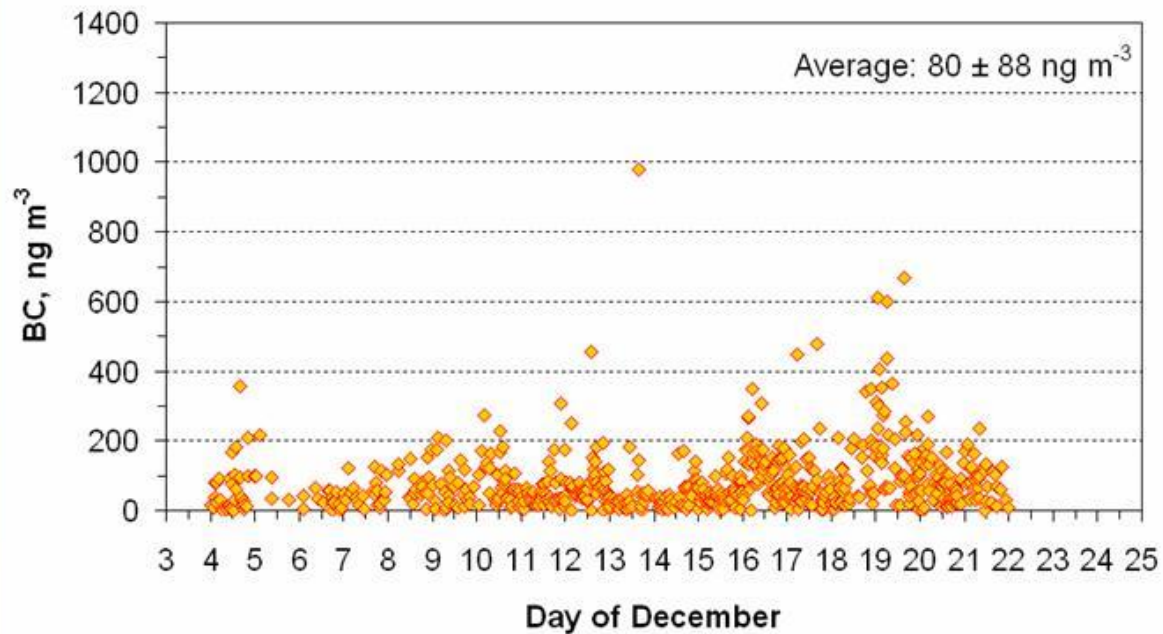
Status of data  
processing:  
**In progress**

Preliminary  
Results: **Some**

## Preliminary Results: Physical Characterization

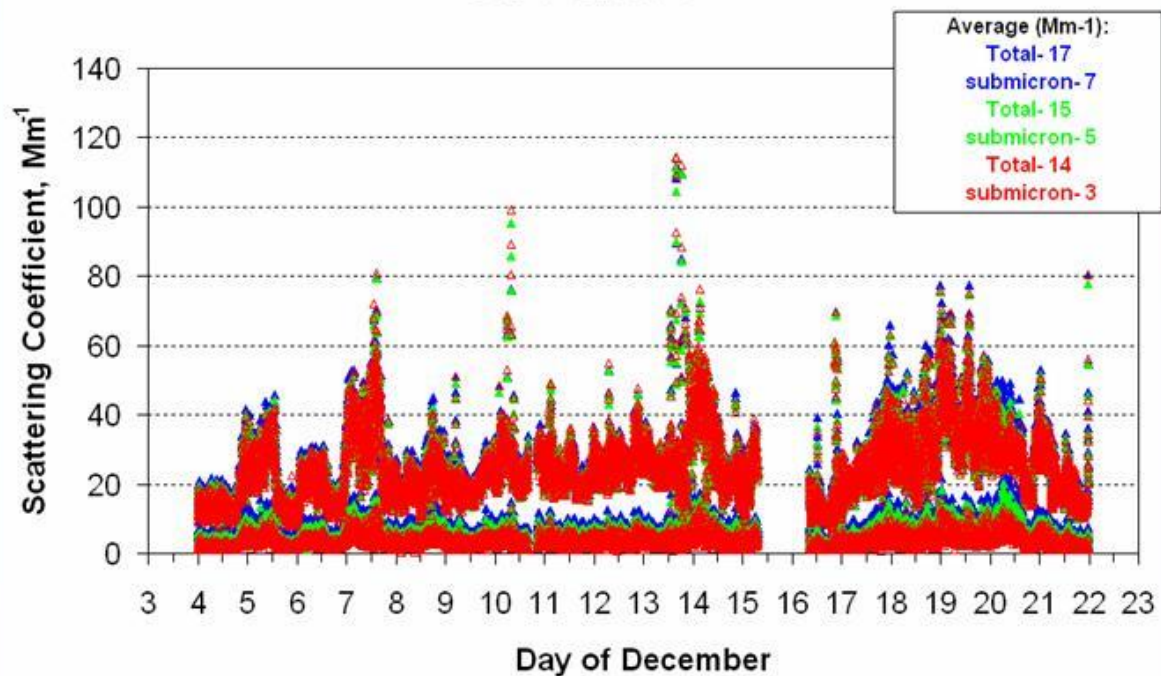


Preliminary BC Concentrations, CSJ  
Dic 4 -21, 2004



### Total and Submicron Scattering Coefficient (BGR)

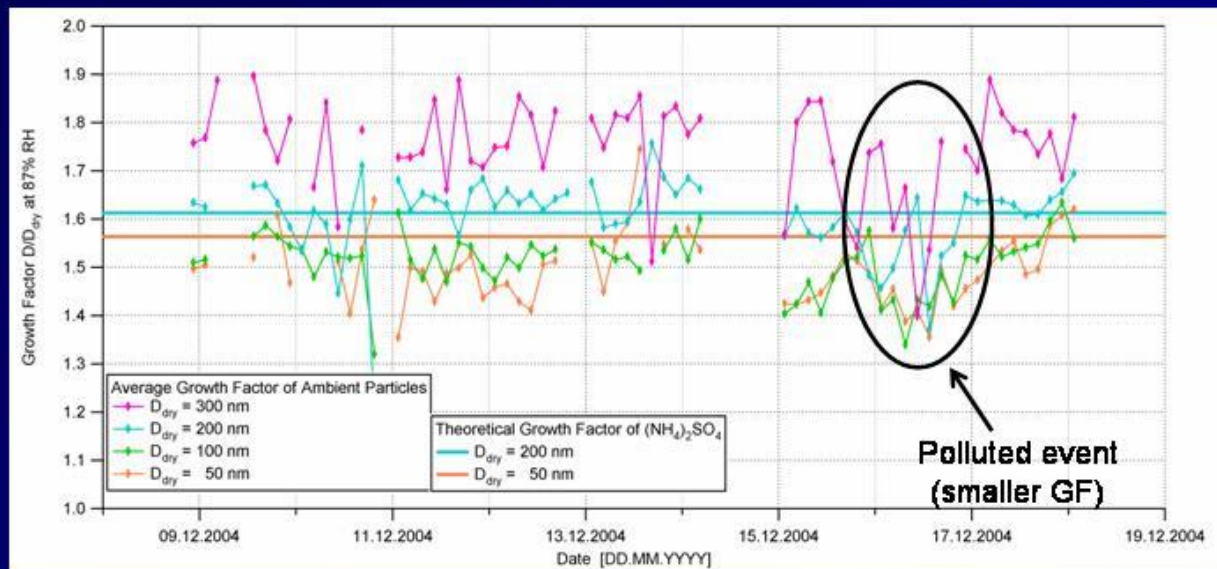
Dec 4-21, 2004



B (450nm), G (550nm), R (700nm)

O. L. Mayol-Bracero & D. Ortiz, UPR-RP

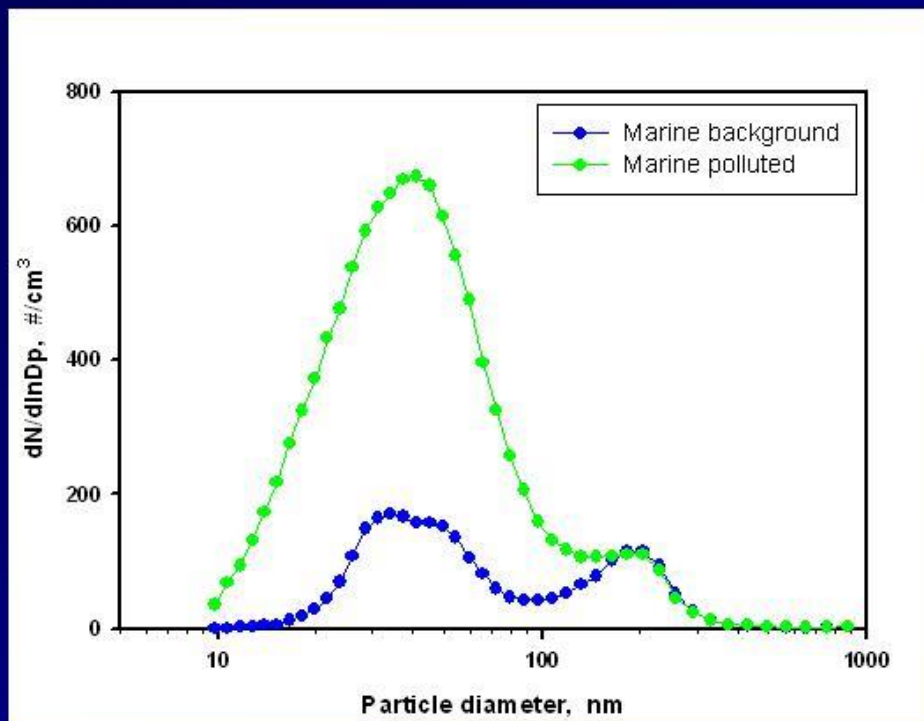
## HTDMA Average Growth Factor, CSJ



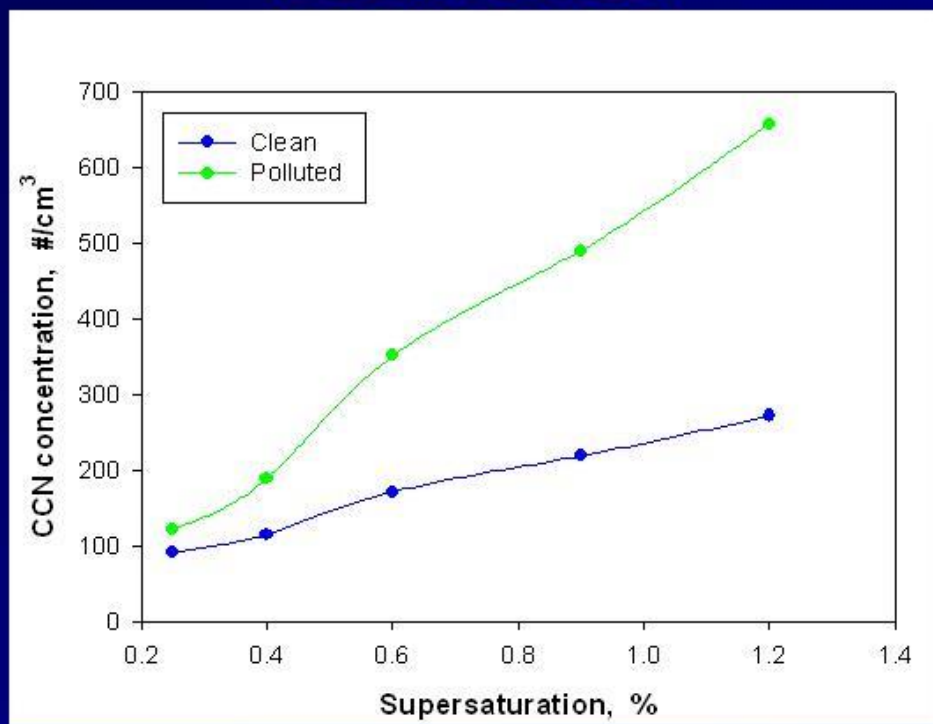
- Dominant growth mode at 300nm is above pure sulfate aerosol indicating internally mixed sea salt with sulfate (and possibly organics). There is also a minor fraction of externally "pure" sea salt particles.
- At 200nm - pure sulfate aerosol, which can be the result of either pure sulfate or internally mixed sulfate/sea salt/organic particles.
- At 100 and 50nm - mostly smaller than pure sulfate aerosol, indicating the presence of internally mixed organics in sulfate (+possibly sea salt) particles.



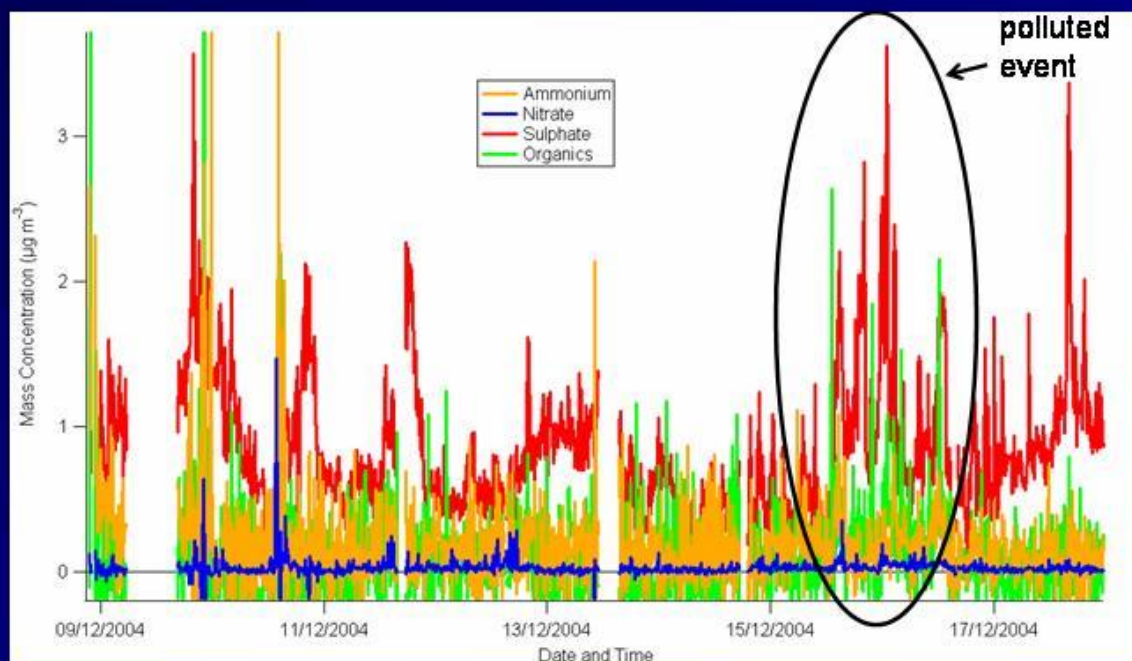
## Average Particle Size Distribution – CSJ Clean vs Polluted – December 2004



## Integral CCN Spectra, CSJ December 2004



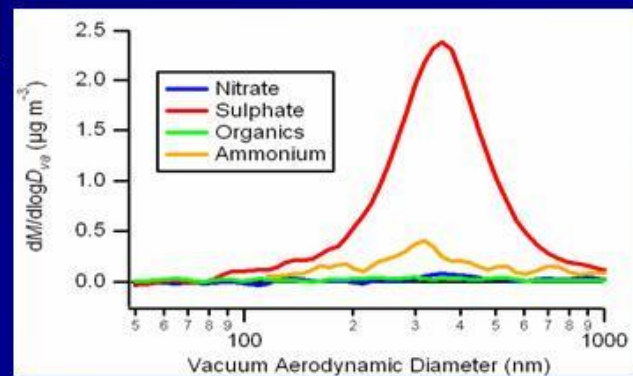
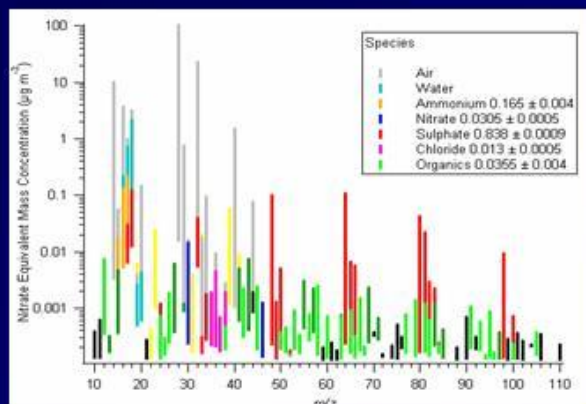
## Mass Concentrations from the AMS, CSJ



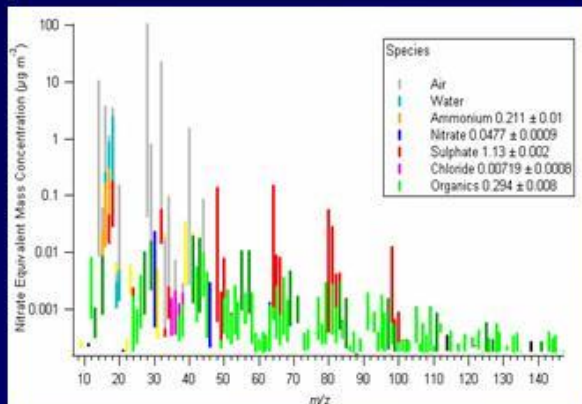
According to the AMS, the aerosol is dominated by sulfate. The GFs (HTDMA) show similar GF as for pure ammonium sulfate. However, for the 300 nm particles, the GF is even larger than for pure ammonium sulphate, and these particles probably also contain sodium chloride, which can not be measured by the AMS.

J. Allan, University of Manchester

## Overall MS and Size Distribution, CSJ December 9-18, 2004

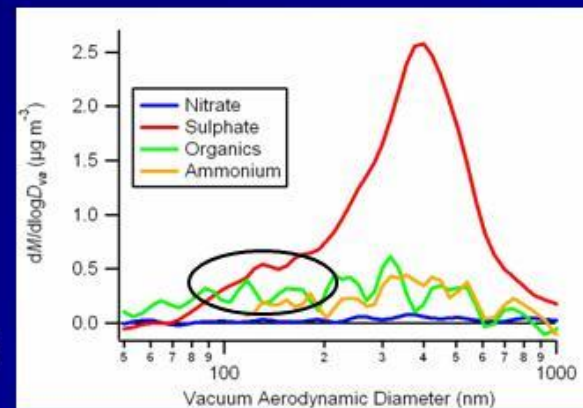


## Polluted MS and Size Distribution, CSJ December 15-17, 2004

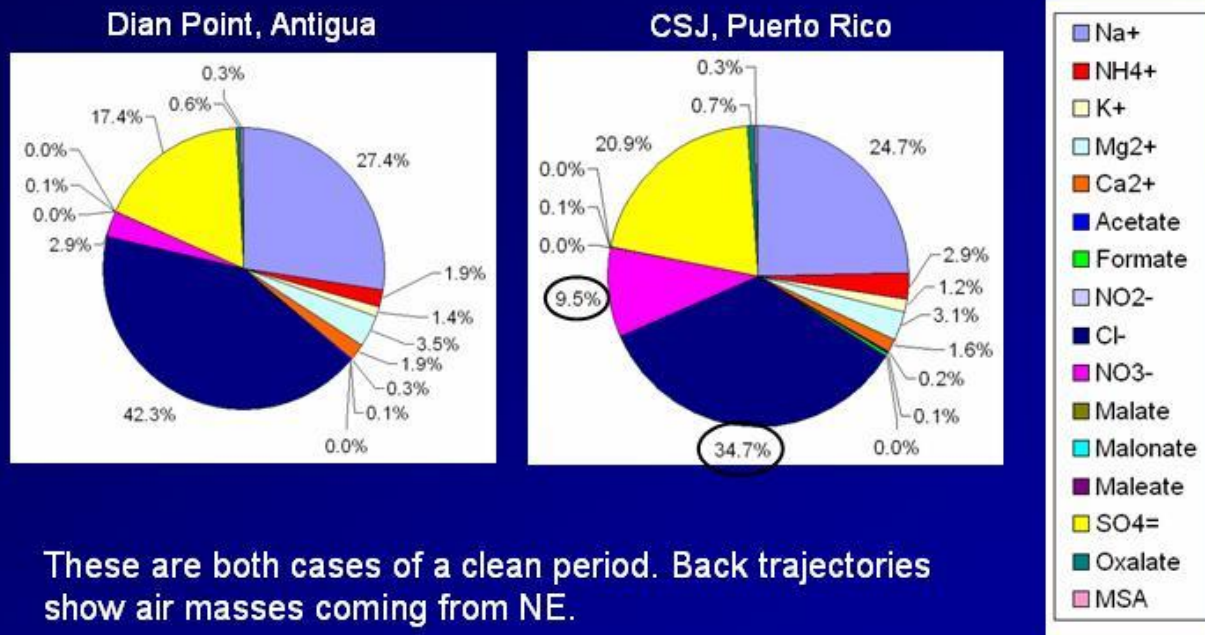


most activity in the organics

The pollution seems not to have a large influence on the mass distribution, although a shoulder at 150-200 nm can be seen in the polluted case.



## Chemical Characterization, SFUs Water-Soluble Ions, Fine Fraction, Jan 16-18, 2004



These are both cases of a clean period. Back trajectories show air masses coming from NE.

About 65% of the mass concentration has been identified with IC.

## Summary: CSJ

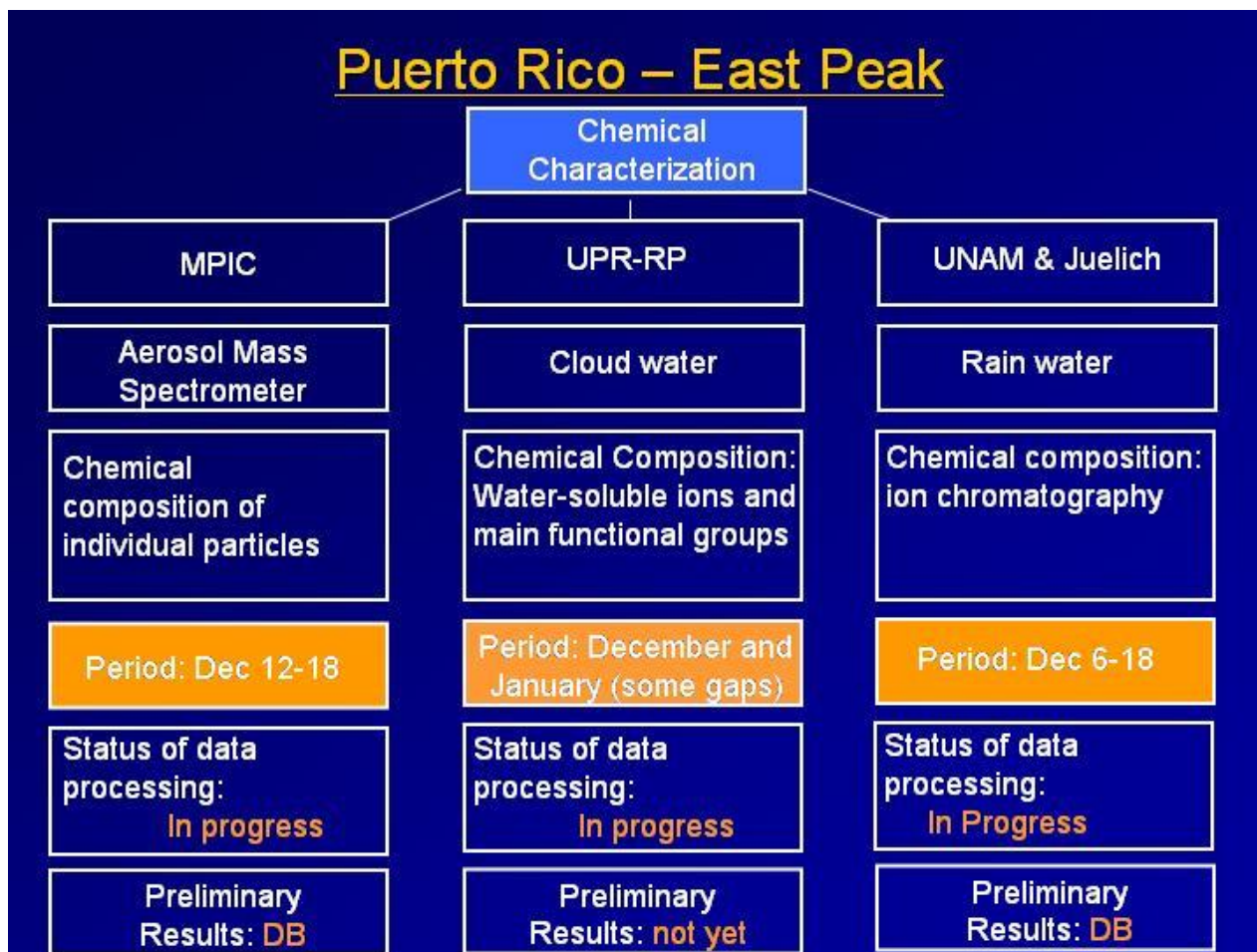
- During the December period, CSJ and East Peak stations were operating at full capacity. In the January period only CSJ station since most colleagues from UNAM, MPIC and U. Manchester were available only for the Dec period.
- Possible interesting case studies:
  - Polluted case – around Dec 15-17, 2004
  - Saharan dust?
  - Clean cases
- CN average:  $700 \text{ cm}^{-3}$  (December)
- Bimodal particle size distributions from SMPS (peaks around 40 and 200 nm)
- Particle loadings (fine fraction):  $0.8 - 2.9 \mu\text{g m}^{-3}$  ( $1.9 \mu\text{g m}^{-3}$  avg)
- Predominant water-soluble ions in the fine aerosol fraction are  $\text{Cl}^-$ ,  $\text{Na}^+$ ,  $\text{SO}_4^{2-}$ .

## Puerto Rico – East Peak

Met Data		Physical Characterization
UNAM	Inst. for Tropospheric Research	UNAM
Davis Weather Station	CN, PSAP, PVM	LASair, Neph, PSAP, CCN, FSSP, 2D-C, 2D-P
Wind direction, Wind Speed, Temperature, Pressure, RH	CN Total & absorption coefficient (INT, CVI), LWC, particle surface area & effective radius	Aerosol size distribution, scattering & absorption, CCN, droplet size distribution
Period: Dec 6-18	Period: Dec 12-18	Period: Dec 6-18
Status of data processing: Done	Status of data processing: In progress	Status of data processing: In progress
Preliminary Results: DB	Preliminary Results: DB	Preliminary Results: DB



## Puerto Rico – East Peak



## Status of Data Processing and Preliminary Results: East Peak

- See the following presentation from Darrel Baumgardner.

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## Ongoing General Activities

- Completing data processing.
- Merging of files to intercompare data of online instruments with high-time resolution.
- Completing analyses of filter and water samples (completing IC analysis and carbonaceous, WSOC, ...). Expecting detailed results on chemical characterization in the next weeks!
- Study of possible "case studies".
- C-130 flights over CSJ and Dian Point (Dec 4 and January 18 and 26) - Intercomparison
- REU student's projects

## Special Acknowledgements

- NOAA-CMDL - John Ogren, Pat Sheridan
- U. of Colorado, Fort Collins - Jeff Collett
- National Weather Service, San Juan, PR
- Fideicomiso de Conservación de Puerto Rico, Cabezas de San Juan (CSJ)
- Caribbean National Forest, PR (East Peak)
- Ms. M. Mikael, Steven and Mr. Errol – FBO, Antigua
- JOSS Personnel (D. Dirks, J. Moore)