

Puerto Rico African Dust and Clouds Study (PRADACS) – Overview and Plans for Summer 2011

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Outline



- ▶ Participants
- ▶ Scientific Question
- ▶ Hypotheses
- ▶ Location (stations)
- ▶ Instrumentation to be deployed July 2011
- ▶ Sampling Strategy
- ▶ PRADACS and ICE-T
- ▶ Education and Outreach
- ▶ Needs

List of Participants (2010-2011)

- ▶ PI: O. L. Mayol-Bracero - UPR-RP ITES
- ▶ CoPI: E. Andrews - UC Boulder and NOAA ESRL,
- ▶ CoPI: K. Prather, E. Fitzgerald, M. Zauscher - UCSD and Scripps
- ▶ F. Zurcher, A. McFadden – ITES, UPR-RP
- ▶ C. Valle, P. Vallejo, G. Santos, A. Carrion, J. Morales, H. Rivera – UPR-RP students (ITES, Chemistry, Physics)
- ▶ S. Raizada, C. Tepley – Arecibo Observatory, PR
- ▶ I. Matos – NWS San Juan, PR
- ▶ P. Diaz, M. Rosario – USGS, PR
- ▶ R. Morales – UPR-RP
- ▶ J. Collett, L. Taehyoung - CSU, Colorado
- ▶ D. Rosenfeld -Hebrew University, Israel
- ▶ B. McDowell – Univ of New Hampshire
- ▶ W. Eugster, J. Spiegel – ETH, Switzerland
- ▶ M. Scholl – USGS, Virginia
- ▶ P. Formenti – LISA University of Paris 12, France
- ▶ S. Borrmann, J. Schneider -Max Planck Institute for Chemistry – Germany
- ▶ A. Heymsfield – NCAR, Colorado
- ▶ D. Baumgardner – UNAM, Mexico
- ▶ S. Mertes – Institute for Tropospheric Research – Germany
- ▶ F. Scatena – UPenn
- ▶ A. Lugo, T. Heartsill – IITF, PR
- ▶ G. Roberts – Meteo-France, Scripps?
- ▶ B. Stevens – MPI-Hamburg?

PRADACS Scientific Question

- ▶ *How the physico-chemical properties of long-range transported African dust (LRTAD) aerosols influence Caribbean cloud properties and precipitation levels in a unique Puerto Rican tropical montane cloud forest (TMCF)?*

Hypotheses

- ▶ H1: Cloud properties in the TMCF are different during intense LRTAD periods.
- ▶ H2: LRTAD has unique chemical and physical properties which influence cloud properties and precipitation processes.

Why the Caribbean (Puerto Rico) is so Attractive for These Studies?

- ▶ Located in the subtropics, 18'15 N, 66'30 W
- ▶ Heavily influenced by the trade winds, by hurricane storm tracks, and by long-range transported African dust (LRTAD) (also volcanic ash)
- ▶ Key convergence zone between 2 continental landmasses, thus, plays a role in hemispheric climate
- ▶ Undersampled/understudied region
- ▶ Highly vulnerable to the Earth's climate change
- ▶ Presence of tropical montane cloud forests
- ▶ Two ideal sampling locations: the natural reserve of Cabezas de San Juan, Fajardo (CSJ) and El Yunque National Forest (East Peak, cloud forest - 1051 m)
- ▶ Large university research center (UPR-RP) within ~60 min drive.
- ▶ RICO-PRACS project during 2004-2005 (winter time)

Caribbean

o Mar Beach Resort & Spa Rio Grande (Puerto Rico)

del Caribe - El Yunque El Yunque Rain Forest

San Juan

Charlotte Amalie

Anguilla

Saint Martin

Puerto Rico

Saint Croix

Saba Island

Barbuda

Saint Eustatius

Saint Kitts and Nevis

Antigua

Antigua and Barbuda

Montserrat

Plymouth

Guadeloupe

Basse Terre

Marie Galante

Dominica

Roseau

Martinique

Fort de France

Saint Lucia

Saint Vincent and the Grenadines

Kingstown

Barbados

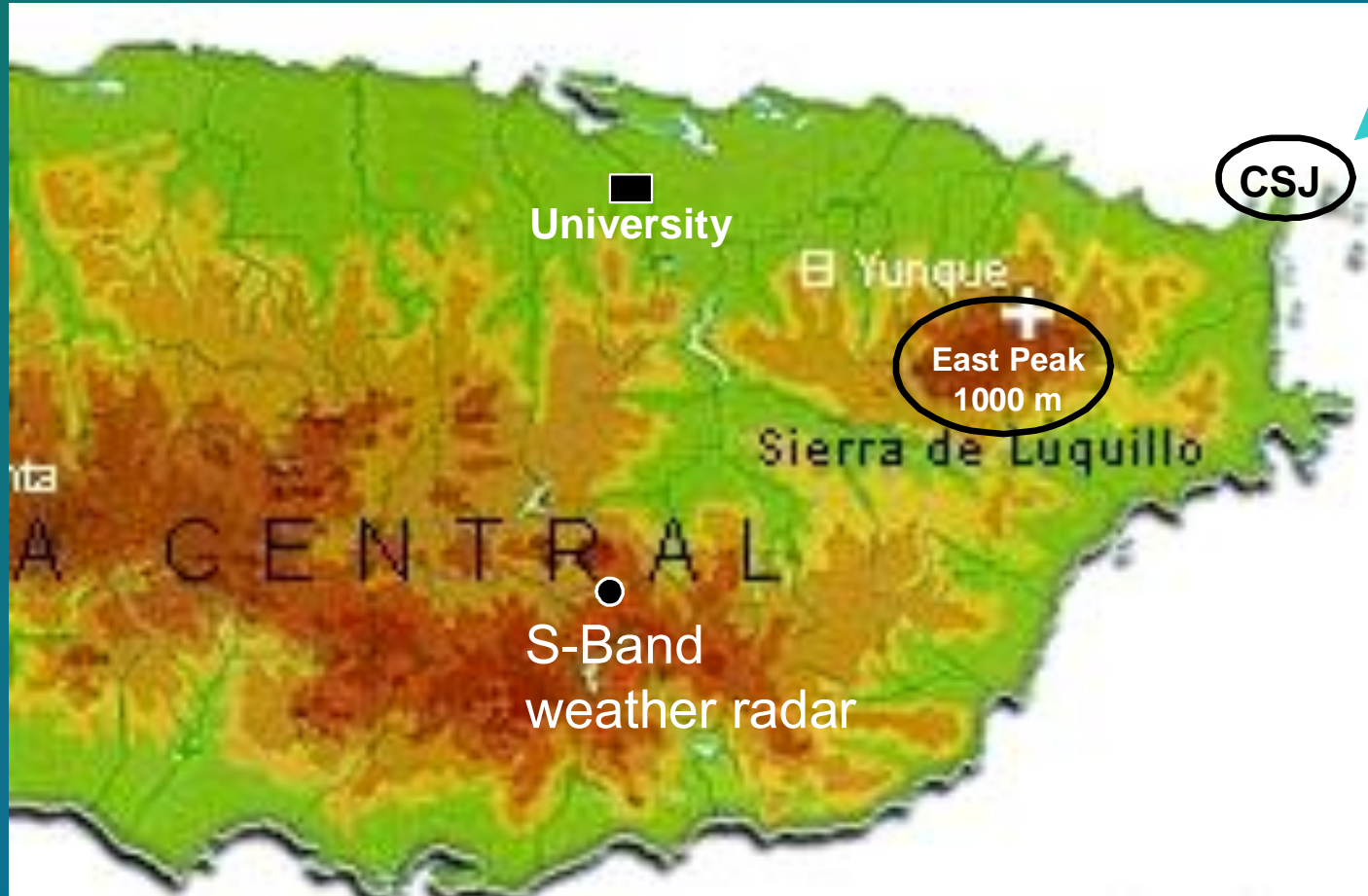
Bridgetown

Mopion Island

Grenada

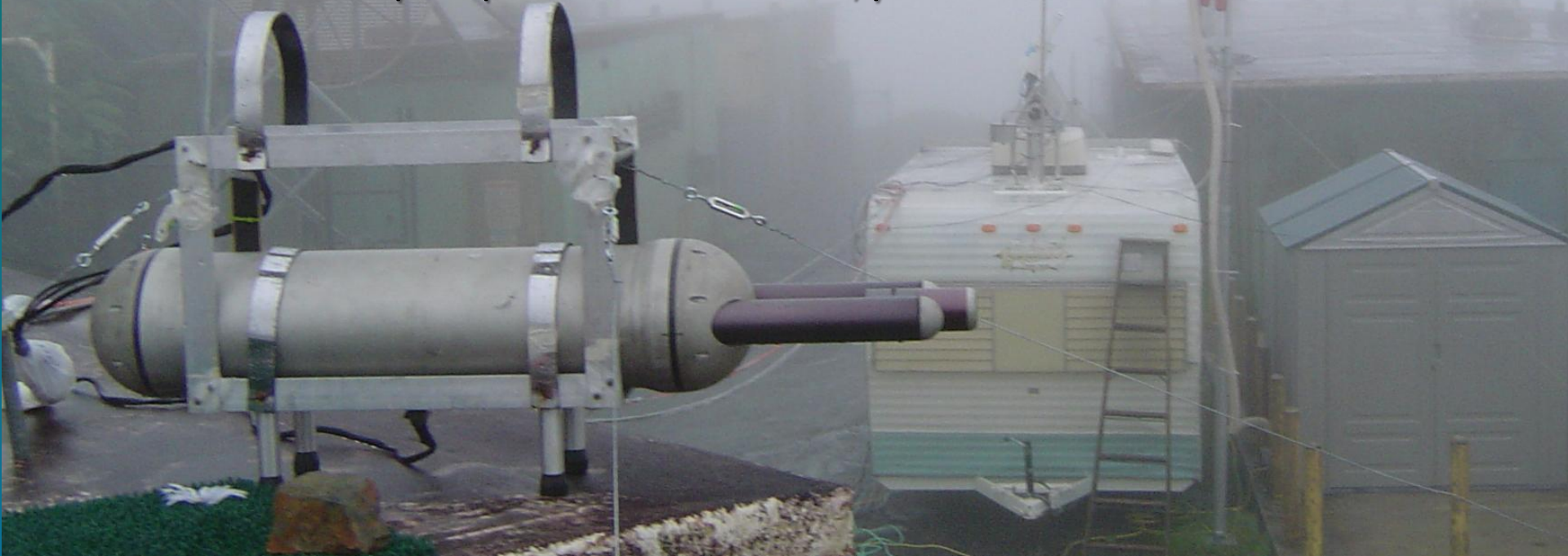
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Main Sampling Locations in Puerto Rico



Pico del Este (PE) station

- Tropical montane cloud forest (TMCF) located in the Luquillo Experimental Forest (part of El Yunque National Forest), Rio Grande, Puerto Rico
- $18^{\circ} 16' \text{ N}$, $65^{\circ} 45' \text{ W}$
- elevation - 1051 m amsl
- sits above the cloud condensation level thus facilitating the study of clouds without the need for aircraft and the related complexity and costs.
- mean annual precipitation - $> 5000 \text{ mm/yr}$



Some photos from RICO-PRACS - 2004



View looking upwind to CSJ, pointed to by the arrow.



Darrel Baumgardner (UNAM) and Stephan Borrmann (MPIC)



Old Trailer



Cloud water collector



Kim Prather and her family (2009)

Pico del Este (East Peak) during PRADACS 2011



Instrumentation at PE (June-July 2011)

-Clouds

- **Cloud water** - Caltech Active Strand Cloud Water Collector (CASCC) and size fractionating CASCC – UPRRP – CSU
- Liquid water content [PVM(CSU), LWC-100 (UPR)]
- Cloud residual chemistry [CVI-UCSD+Scripps]
- Frequency and occurrence of clouds [Belfort visibility sensor (UPR-RP, USGS)]
- Fog and cloud droplets sizes (D_p 2 to 50 μm) – [FM-100 (ETH, CSU)]
- **Cloud base height??**

-Rainwater

- **Bottle and funnel (UPR-RP)**
- **USGS sequential Sampler (UPRRP,UCSD, USGS)**
- **NADP data – EVFS (UPR-RP)**
- **Size of rain drops (Disdrometer) - ???**

-Aerosols

- **Samplers** – Stacked-filter units, low-pressure impactors (DLPI, MOUDI) [UPR-RP]
- Online instruments: UCSD-Scripps (CN counter, SMPS, APS, aethalometer, ATOFMS), UNAM or Univ Manchester (APSD), **CCN counter (G. Roberts, Scripps +MeteoFrance)**

-Trace Gas Analyzers (SO_2 , NO_x , CO , O_3) – UCSD + Scripps

-Meteorological data – UPR-RP

-Daily Aerosol Optical Thickness Satellite Images from NOAA / NESDIS, SAL,... - UPR-RP

-Air Mass Backward Trajectories

- NOAA ARL HYSPLIT model (HYbrid Single-Particle Lagrangian Integrated Trajectory)

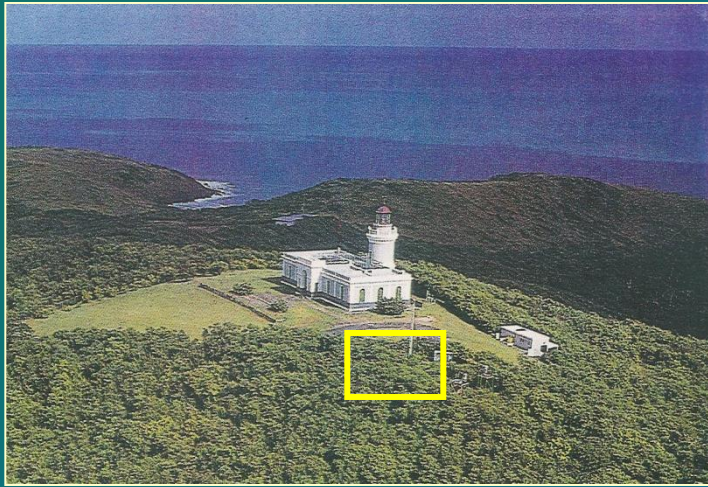
Analyses to be performed on aerosol, cloudwater and/or rainwater samples for both PE and CSJ

- ▶ Gravimetric
- ▶ Thermal/optical analysis (TC, OC, EC)
- ▶ Total Organic Carbon and Total Nitrogen Analyzer (TOC, DOC, TN)
- ▶ Ion Chromatography (Na⁺, NH₄⁺, Ca²⁺, K⁺, Mg²⁺, Cl⁻, NO₃⁻, SO₄²⁻, acetate, formate, oxalate, and MSA)
- ▶ ICP (P, K, Mn, Fe, Ca, Mg, Na, Al)
- ▶ SEM-EDS, TEM
- ▶ H-NMR
- ▶ pH, cloud and rain water volumes

Cape San Juan (CSJ) station (also known as CPR)

- ▶ Located at the natural reserve of Cabezas de San Juan, Fajardo, Puerto Rico
- ▶ 18° 15 N, 66° 30 W
- ▶ 60 m amsl and about 20 km upwind from PE
- ▶ It is within the subtropical dry forest zone.
- ▶ It has good exposure to the easterly trades (and hence AD), and is free of major land masses upwind, minimizing the effects of anthropogenic aerosol sources.
- ▶ CSJ measurements are supported by NOAA/ESRL, the station is part of the NASA AEROSOL ROBOTIC NETWORK (AERONET), and it recently became one of the regional stations of the Global Atmosphere Watch (GAW) program.
- ▶ CSJ's location allows the direct assessment of off-shore aerosol inputs before potential anthropogenic additions from the city of Fajardo, the sampling of aerosol properties below cloud, and the sampling of clear sky aerosol optical properties, difficult to get at PE since it is mostly in clouds.

CSJ, Puerto Rico



Instrumentation at CSJ (June-July 2011)

-Aerosols

- **Samplers** – Stacked-filter units, low-pressure impactors (DLPI, MOUDI) [UPR-RP]
- Online instruments: UPR-RP (CN counter, SMPS, OPC, aethalometer, nephelometer, CIMEL sunphotometer, PSAP, AMS or ATOFMS??), nephelometer with humidification system (UC-Boulder, NOAA ESRL), portable radiometers (AO), **CCN counter (G. Roberts, Scripps +MeteoFrance)**

-Meteorological data

-Daily Aerosol Optical Thickness Satellite Images from NOAA / NESDIS, SAL,...

-Air Mass Backward Trajectories

- NOAA ARL HYSPLIT model (HYbrid Single-Particle Lagrangian Integrated Trajectory)

-Rainwater

Bottle and funnel [UPR-RP]

Instrumentation at other locations

LIDAR – Arecibo Observatory

Sampling Strategy

- ▶ (ITES) at UPRRP has an ongoing aerosol sampling program at CSJ and performs monthly cloud/rain water measurements (weather- dependent) at PE.
- ▶ Column and in-situ aerosol measurements and meteorological data, including rainfall, will be collected, in the presence and absence of AD, at both sampling stations throughout the project, but more frequently during the Intensive field phase (IFP) periods.
- ▶ Cloud water measurements will occur only at PE.
- ▶ There will be a strong emphasis on chemical characterization with online and offline techniques, exceeding the *Rain in Cumulus over the Ocean* (RICO) and the *Puerto Rico Aerosol and Cloud Study* (PRACS) efforts (Frank et al. 2005; Mayol-Bracero et al. 2005; Raga et al. 2005; Rauber et al. 2007a, 2007b; Allan et al. 2008; Gioda et al. 2008a, Gioda et al. 2011) that were focused on wintertime clean marine organic aerosols.

Sampling Strategy (Last year – Test period)

Year 1 (Oct 2009 to Sept 2010) –

- ▶ Test, calibration, and diagnosis year that will allow to begin developing procedures for data analysis and archiving of combined data sets without distractions of a full blown intensive field campaign.
- ▶ Sampling logistics (e.g., shipping, transport, power, and installations).
- ▶ Running things side by side to find out the right sampling times, if we need other measurements,...
- ▶ Train students and technician
- ▶ Short intensive field period (end of July 2010) to test and fine tune instruments and methods
 - ▶ ATOFMS, nephelometers with the humidification system, new SMPS, OPC, CPC (see attached table of instruments to be deployed).
- ▶ In summary, Y1 was a test run that allowed us to be able to run a much stronger large intensive field period in Y2, ensuring the success of the **intensive field phase** and of the project.

Sampling Strategy (This year)

Year 2 (Oct 2010 – Sept 2011)

- ▶ The summer **intensive field phase** (IFP) of the project is taking place **this year**.
- ▶ June-September (dust period) and Oct-Nov from Y3 (non-dust period) sampling periods.

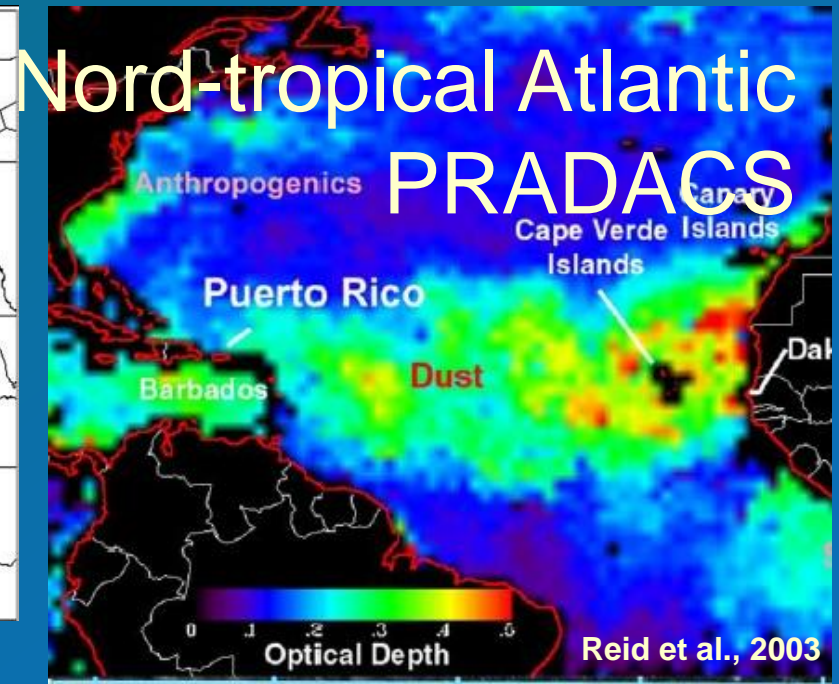
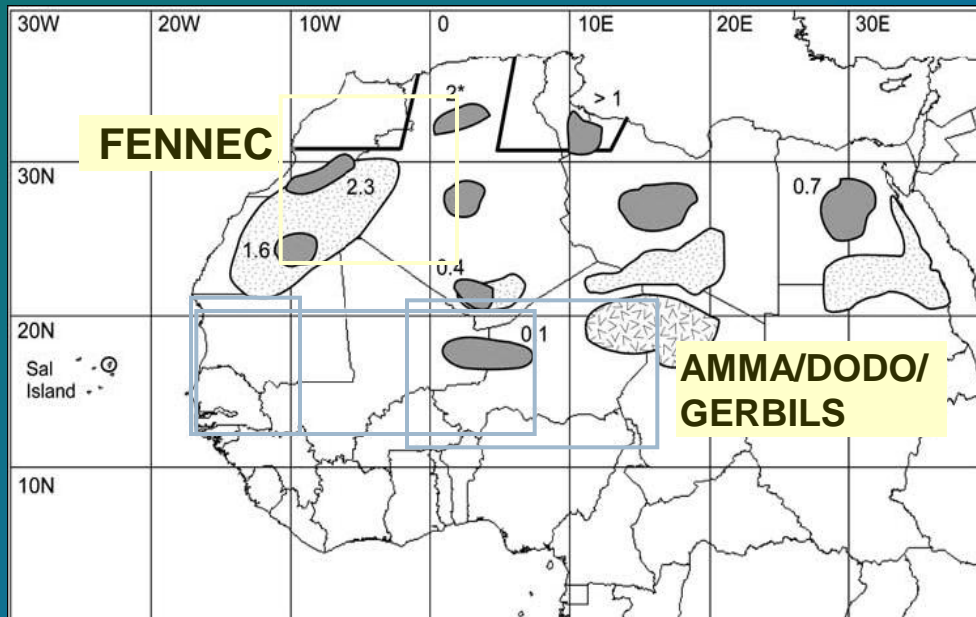
Collaboration with Other Simultaneous Projects

- ▶ *“The FENNEC project: Dust processes and the Western Sahara ‘heat low’”* – Paola Formenti – LISA Univ of Paris 7 and 12 (JUNE)
- ▶ ICE-T (*“The Ice in Clouds Experiment. - Tropical Field Campaign”*) - Andy Heymsfield (aircraft measurements from the C-130) – NCAR (JULY)

Looking at modifications of dust physico-chemical and optical properties due to aging as part of PRADACS and FENNEC and in Collaboration with P. Formenti –LISA (Univ of Paris 7 &12)

► Observations close to source and at a receptor site

- Source regions: data from previous campaigns (AMMA/DODO/GERBILS) + FENNEC (June 2011) – aircraft and surface sampling
- Receptor site: Puerto Rico during PRADACS (June-July 2011)



The FENNEC Project

- ▶ Joint French-British initiative, funded by French CNRS, ANR and British NERC.
- ▶ In collaboration with the Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA, Université Paris 7 & 12).
- ▶ The project will include aircraft observations by the UK FAAM BAe-146 and the FR F20 based in Morocco, and ground based observations in Mauritania, to determine the aerosol composition, size distribution, morphology and optical properties.
- ▶ Simultaneous aerosol measurements at PR and Mauritania (Africa, close to the AD source) to probe the chemical and physical properties of LRTAD and of freshly emitted AD.

Connection of PRADACS to ICE-T

One of ICE-T Objectives is to characterize the aerosol as CCN and IN and investigate the dependence on temperature, size and aging (special interest in dust and biological material).

- ▶ What put us together is our interest in aerosol-cloud interactions, particularly in dust (African dust transport)-cloud interactions
- ▶ Ground-based measurements (PRADACS) vs aircraft measurement (ICE-T) = excellent opportunity to collaborate!
- ▶ PE (PRADACS) will likely have detailed chemistry and size distribution and CCN spectra important in understanding cloud formation and may be useful to ICE-T.

PRADACS and ICE-T

- ▶ It would be great to have flights over PE and CSJ:
 - ▶ For intercomparison purposes – e.g., comparison between what we find with our CVI measurements compared to what is found on the C-130 CVI measurements will be very useful, as well as any upwind information on aerosol properties
 - ▶ Along wind direction
 - ▶ Providing vertical profiles upwind of PR
- ▶ It would be great to have the C-130 at least for a day in PR for outreach (education) purposes – Sonia Lasher
- ▶ What does ICE-T need from us (PRADACS team)?

PRADACS Education and Outreach

- ▶ PISCAS program – university students
 - ▶ Short Course at UPR-RP in May 2011 – *Chemistry of Precipitation, Clouds, and Aerosols* – Prof. Jeff Collett, CSU
- ▶ GK-12
- ▶ Birch Aquarium (Scripps) – general public
- ▶ C-130 visiting PR - high school and university students, general public (Sonia Lasher)
- ▶ REU students in St Croix (Sonia Lasher)

PRADACS Instrumental/Scientific Needs

1. Disdrometer - It would be good to have two, one at CSJ and the other at PE. If there is only one should go to CSJ.
2. CCN Counter (G. Frank will not be able to participate, G. Roberts might join the team!)
3. Cloud base height info (e.g., ceilometer, web cam?) **Will the C-130 have cloud-base info available?**
4. AMS and ATOFMS so that we can cover both stations
5. Rawinsondes (2 daily on a regular basis, NOAA NWS local office can provide up to 5 at no cost)

Announcement

- ▶ First Symposium on *Transport, Evolution and Impacts of African Dust into the Western Hemisphere*, sponsored by IGAC (International Global Atmosphere Chemistry)
 - ▶ Date: October 3-7, 2011 (together with the SSC IGAC Meeting)
 - ▶ Location: San Juan, Puerto Rico
- ▶ Mark this date in your calendar so that you can attend.
- ▶ More details in the near future.

For more information:

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Thanks for listening!