ACRF Deployment in the Amazon Basin

Data and Opportunities in Cloud-Aerosol-Precipitation Interactions

Jiwen Fan

Pacific Northwest National Laboratory

March, 2011

ACRF 2014 Amazon Field Campaign

- **Deployment Time and Location:**
  - **AMF Operations: Jan - Dec 2014 (Manacapuru)**
  - **AAF Operations: Feb/Mar & Sep/Oct 2014 (Manaus)**

- **Requested Instrumentation**

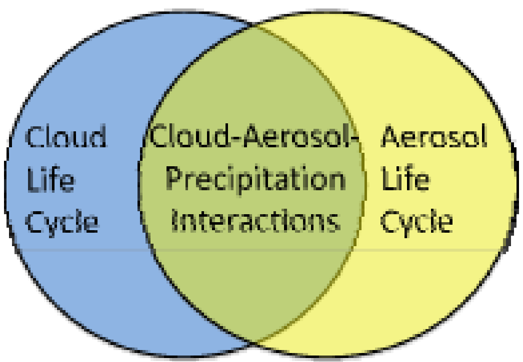
(1) the G-1 aircraft

(2) the Mobile Aerosol Observing System (MAOS)

(3) AMF #1

(4) The Brazil-based EMB-110B1 operated by INPE

- **Scientific Objectives**



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Important instruments and data

G-1 Aircraft

Integrated		
Fast - Forward Scattering Spectrometer Probe (F-FSSP)	SPEC	Size distribution 2.0 to 47.0 µm
Cloud Droplet Probe (CDP)	DMT	Size distribution 2 to 50 µm
Fast-CDP (F-CDP)	SPEC	Size distribution 2 to 50 µm
2 Dimensional Stereo Probe (2D-S)	SPEC	Size distribution 10 to 3,000 µm
High Volume Precipitation Spectrometer version 3 (HVPS-3)	SPEC	Size distribution 400 to 50,000 µm
Cloud Particle Imager (CPI) Version 2	SPEC	Images of cloud droplets and ice
Aerosol Properties		
Ultra-High Sensitivity Aerosol Spectrometer (UHSAS)	DMT	Size distribution 0.055 to 1 µm
Scanning Mobility Particle Sizer	BNL Build	Size distribution 0.015 to 0.450 µm
Dual Column Cloud Condensation Nuclei Counter (Dual-CONC.)	DMT	Concentration of CCN at a specified supersaturation
Single Particle Soot Photometer (SP2)	DMT	Soot spectrometry
Photo-Acoustic Soot Spectrometer, 3 wavelength (PASS-3)	DMT	Light absorption and scattering
Humidigraph	PNNL Build	f(RH)
Particle in Liquid System (PILS)	BNL Build	Particle ionic composition
Counterflow Virtual Impactor (CVI)	Brechtel/PNNL Build	Sampling of cloud droplets

MAOS and AMF1

Aerosol, CCN/IN:

Aerosol compositions, mixing states, and optical properties. CCN and IN. MPL: vertical distribution or particle entrained into cloud base

Radar/lidar measurements on clouds and precipitation:

Ka/W-band scanning cloud radar
MWR3C AND WACR
Ceilometer: CBH
MPL and new Doppler lidar

EMB-110B1 (Brazil-based aircraft)

Cloud microphysics and aqueous chemistry:
CAS, 2D-S. CIP and CSI.

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Science in Cloud-Aerosol-Precipitation Interactions

Typical Aerosol Scenarios

a) Pristine aerosols (clean and biogenic - wet season)

b) Biomass burning aerosols (polluted and high cabonaceous (soot) - dry season)

c) Manaus pollution plume (polluted and high-sulfate content)

d) African dust (when the ITCZ is south of the equator)

e) Interactions of a, b and c.

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Scientific Objectives

1. Process study with CRM and LES

Broadly…

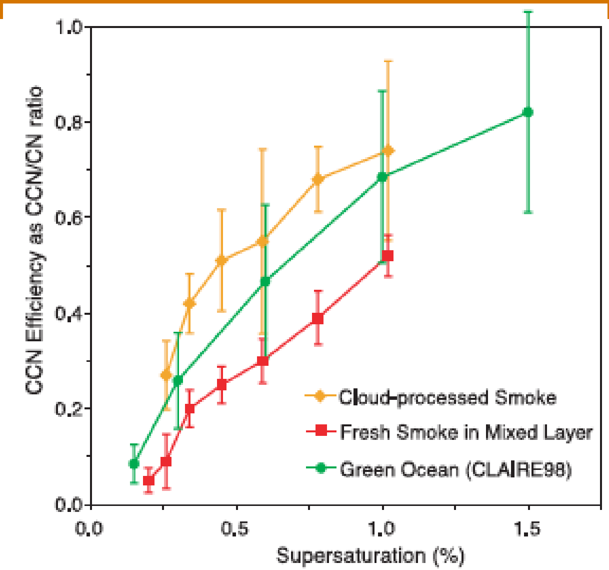
How different aerosol scenarios impact deep convective cloud microphysical (LWC/IWC, droplet/ice effective radius, etc) and macrophysical (cloud top/base height, cloud cover and lifetime, etc), precipitation (convective and stratiform), and lightning activity through aerosol radiative and microphysical effects.

Specifically…

(1) Nucleation abilities of aerosols (fresh, aged, or cloud-processed) as CCN or IN or both from the typical scenarios and the subsequent effects on deep convective cloud development …

Hypothesis:

- Biogenic particles in the wet season are good CCN and IN (Poschl et al., 2010, Science); Cloud processed smoke particles serve as good CCN (Andreae et al 2004).
- Dust is the major IN at colder T and biological particles dominate at warmer T (Prenni et al.,2009, Nature-Geo)

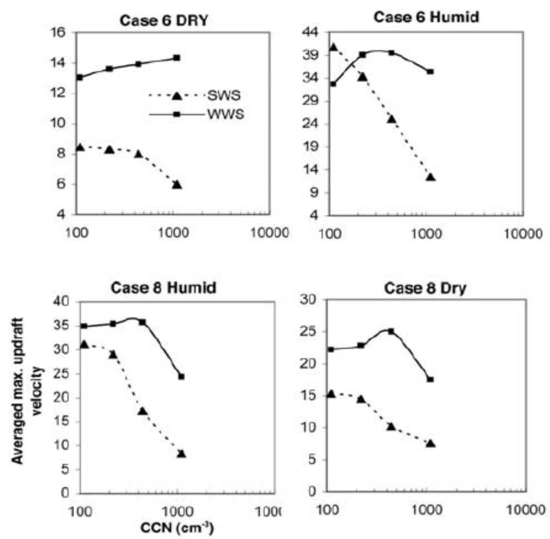


Andreae et al 2004, Science

(2) Aerosol impacts on convective strength, convective core and anvils, precipitation, radiation fluxes under different atmospheric states.

Hypotheses:

- Aerosols enhance convection under weak wind shear but perform oppositely under strong wind shear (Fan et al. 2009, JGR);
- Smoke increases precipitation (Andreae et al 2004; Lin et al. 2006)
- Strong warming produced by anvil changes induced by aerosols (Koren et al 2010); Aerosols increase cloud anvil cover and lifetime (Fan et al 2010, ERL)

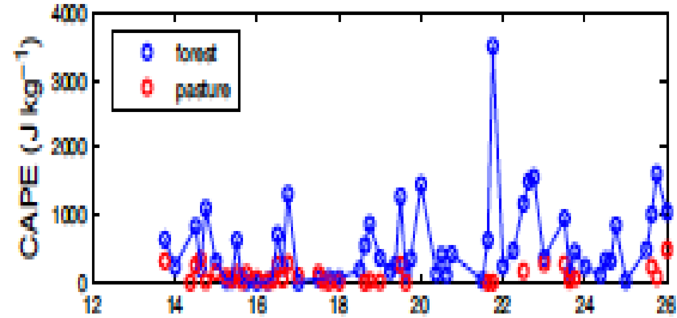


Fan et al. 2009, JGR

(3) Effects of deforestation on convection via changing aerosol properties and surface fluxes. Are these two factors are additive or cancel each other to some extent?

Hypotheses:

- PBL over the forested areas is more unstable due to greater humidity than the deforested area. More shallow convection over the deforested areas (Wang et al, 2009,PNAS)

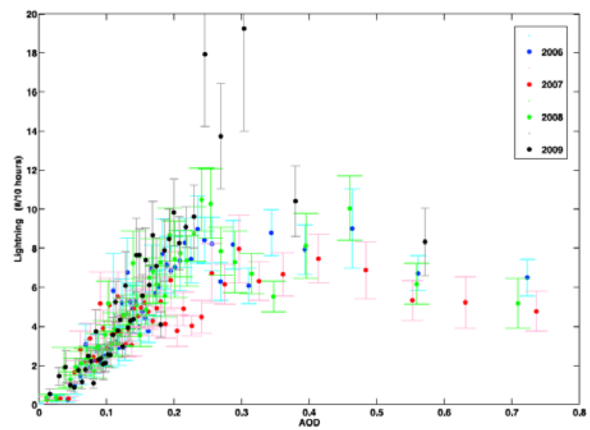


Wang et al, 2009,PNAS

(4) The CCN and IN induced changes of cloud electrification and lightning.

Hypotheses:

- Higher lightning rates experienced in the deforested area (R. Albrecht)
- Increased lightning activity response to Amazonian fires (Altaratz et al, 2010, GRL)



Altaratz et al, 2010, GRL

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2. Regional/global climate study

Broadly…

Contribution of aerosols to the change of the regional climate over the Amazon region (convection activity, rainfall, surface temperature, floods and droughts, and severe weather), and the atmospheric circulation such as the ITCZ.

Cloud parameterizations, e.g., (a) droplet/ice nucleation and (b) deep convection.

Specifically…

(1) **Contribution of aerosols to the transition from shallow to deep convection, the convection and precipitation anomalies over Amazon for different seasons** (wet/biomass burning season)**, and then the impact on the observed large variability of the tropical Atlantic ITCZ.**

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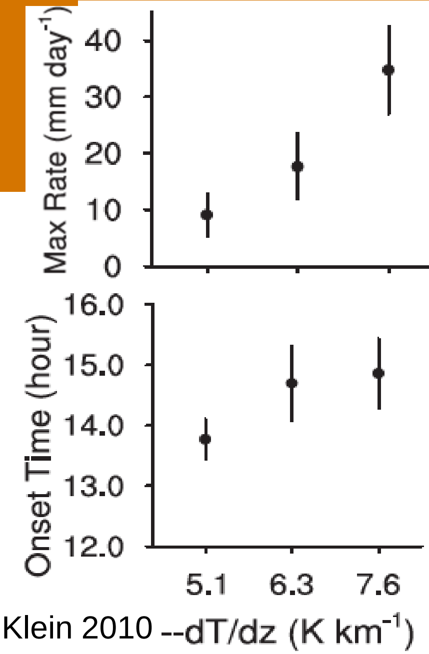
Hypotheses:

- The changes of Amazon convection could contribute to the large variability of the tropical Atlantic ITCZ (Wang and Fu, 2006)
- Large-scale models typically do a bad job with timing on the transition of shallow to deep convection. Instability in the 2–4 km layer above the surface are positively correlated to rainrate and onset time (Zhang and Klein 2010). Aerosols could affect the heating in the 2-4 km a lot, and what’s the role of aerosols in it?

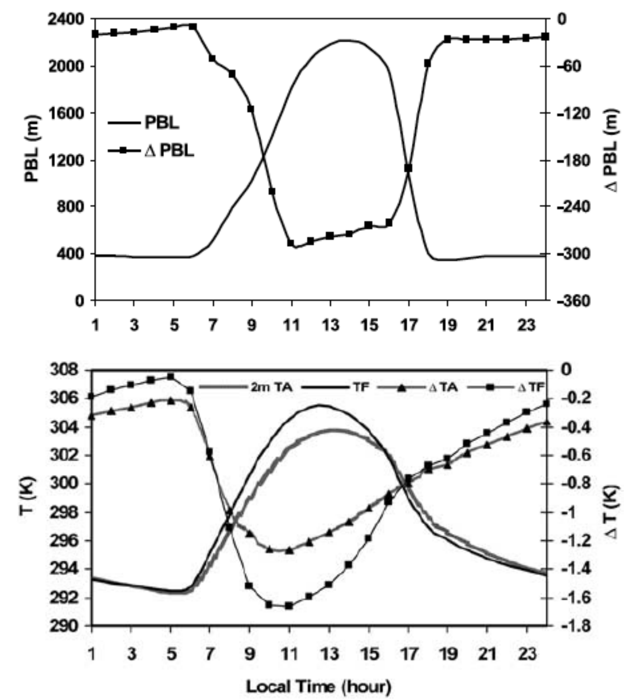


Zhang and Klein 2010

(2) How seasonally-different aerosol scenarios and long-term transport of dust modify (a) the heating profiles and its subsequent effects on cloud development, and (b) cloud properties and water vapor vertical transport, and (c) radiation fluxes, surface temperature, etc?

Hypotheses:

- Aerosol absorption stabilizes the lower troposphere, leading to anomalies of wind divergence in the southern and western Amazon (Zhang et al, 2008, JGR)

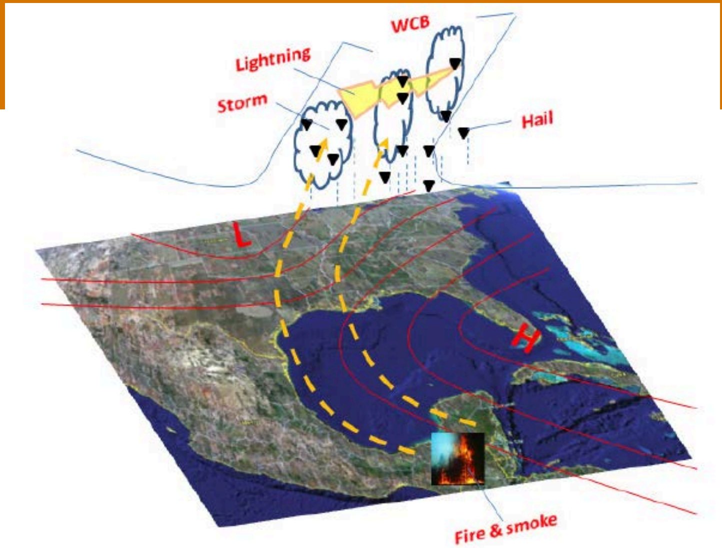


Zhang et al, 2008, JGR

(3) The contribution of biomass burning to the severe weather?

Hypotheses:

- Biomass burning aerosols invigorates updrafts and contribute to the formation of severe weather over the south central US (hail and lightning) (Wang et al 2009, ERL)



Wang et al 2009, ERL

(4) Develop and test cloud parameterizations considering aerosol-cloud interactions for large-scale models, e.g., a) deep convection parameterization with cloud microphysics and aerosol effects, and b) droplet and ice nucleation parameterizations.

Example studies:

- Song and Zhang 2011, JGR (deep convection)
- Barahona and Nenes 2007 (droplet nucleation)
- Prenni et al.,2009, Nature-Geo (ice nucleation)

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