RACORO

R outine
A RM Aerial Facility (AAF)
C louds with Low Optical Water Depths (CLOWD)
O ptical
R adiative
O bservations

Website
http://acrf-campaign.arm.gov/racoro/

Objectives

- Conduct long-term, systematic flights in boundary layer, liquid-water cloud fields at the SGP measuring:
  - Microphysical properties
  - Optical properties and radiative fluxes
  - Aerosol properties & Atmospheric state

- The data needed to:
  1. Investigate Aerosol-Cloud Interactions
  2. Improve Cloud Simulations in Climate Models
  3. Validate ACRF Remotely-Sensed Cloud Properties

“Cast of Thousands"

Steering Committee

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IOP Archive

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Operations

- CIRPAS Twin Otter, based near SGP
  - 24 January to 29 June 2009
  - Long-term observations good for statistics (incl. seasonal var.)
  - Needed simplified operation paradigm, compared to an IOP
    - Standardized flight patterns (Cloud triangles w/ spirals over SGP)
  - 1st long-term aircraft *in situ* sampling of cloud
- 59 Research flights (259 hrs)
  - 31 cloud flights
  - 46 over SGP
  - 46 with EOS overpass
- "Non-Cloud" Flights
  - Aerosol and CCN characterization
  - Boundary layer turbulence
  - Surface albedo mapping
  - Radiometer tilt characterization
- King Air collaborative flights 2-26 June (HSRL, RSP)
  - 15 flights (11 cloud flights; 8 of which over SGP)

Photo by Jason Tomlinson

Comprehensive Payload

CATEGORY	MEASUREMENT	INSTRUMENT	PRINCIPAL INVESTIGATOR
CLOUD MICROPHYSICS	Liquid-Water Content	Particle Volume Monitor-100A (Gerber Probe)	Haf Jonsson
		SEA Liquid-Water Content Probe	Haf Jonsson
	Drop Size Distribution	Forward Scattering Spectrometer Probe-100 (FSSP)	Haf Jonsson
		Cloud, Aerosol Precipitation Spectrometer (CAPS)	Haf Jonsson
		2D Cloud Imaging Probe (2D CIP)	Greg McFarquhar
		2D Stereo Probe (2D-S)	Paul Lawson
	Cloud Extinction	Cloud Integrating Nephelometer (CIN)	Hermann Gerber
RADIATION	Broadband Irradiances	↑↓ Shortwave Kipp & Zonen (a modified CM22)	Anthony Bucholtz & Chuck Long
		↑↓ Longwave Kipp & Zonen (a modified CG4)	Anthony Bucholtz & Chuck Long
		↑ Sunshine Pyranometer (SPN1)	Anthony Bucholtz & Chuck Long
	Spectral Irradiances	↑↓ Multi-filter Radiometer (MFR)	Anthony Bucholtz & Chuck Long
		↑↓ HydroRad-3 Hyperspectral Radiometer	Anthony Bucholtz & Chuck Long
	Spectral Radiances	↑ or ↓ HydroRad-3 Hyperspectral Radiometer	Anthony Bucholtz & Chuck Long
		↑↓ Infrared Thermometer (IRT)	Haf Jonsson
AEROSOL	Cloud Condensation Nuclei	Dual-Column CCN Spectrometer (0.2% supersaturation [SS], Scan 0.8-0.2% SS)	Roy Woods
	Number Concentration	Ultrafine Particle Counter	Haf Jonsson
		2 Condensation Particle Counters (CPCs)	Haf Jonsson
	Size Distribution	Scanning Differential Mobility Analyzer (DMA)	Don Collins
		Passive Cavity Aerosol Spectrometer Probe (PCASP)	Haf Jonsson
METEOROLOGY	Temperature	Rosemount Probe	Haf Jonsson
		Vaisala Probe	Haf Jonsson
	Water vapor	2 Chilled Mirror Hygrometer (EdgeTech, CR2)	Haf Jonsson
		Diode Laser Hygrometer (DLH)	Glenn Diskin
	Wind turbulence and Updraft velocity	Gust probe	Haf Jonsson
	Conditions	Flight video	Haf Jonsson

- Interdisciplinary
- Some redundancy
- Some new things
- Pair a slow accurate measurement w/ a fast precise one

Enhanced Datasets - Current

SUMMARY/MERGED DATA	
Haf Jonsson	CIRPAS Cabin & CIRPAS Basic Parameters; 1& 10 Hz
Jennifer Comstock and Chaomei Lo	Merged Data (multiple instruments); 1 Hz
CLOUD MICROPHYSICS	
Lawson, Paul	Merged CAS and 2D-S Particle Size Distributions; 1 Hz
RADIATION	
Long, Chuck	Tilt-Corrected Radiation and MFR Calibrated Files; 10 Hz
MODELING	
Shaocheng Xie	Constrained Variational Objective Analysis Data
Shaocheng Xie	Cloud Modeling Best Estimate- Cloud and Radiation

Documentation

- Data Guide (Operations, Instrumentation, Data)
- Flight Details (Pilot notes, Flight images, Quicklooks)

Enhanced Datasets – In Progress

CLOUD MICROPHYSICS	
Greg McFarquhar and Hee-Jung Yang	**Best Estimate Cloud Microphysics Parameters** **Based on all aircraft cloud microphysics observations**
AEROSOL	
Betsy Andrews and John Ogren	**Enhanced Aerosol Data** • CCN corrections (Nenes algorithm) • "Splash" flagging • Standardization of CCN spectra from SGP and Twin Otter to 0.2% SS • Mapping aircraft data for spatial variability studies • Calculate light scattering from size distribution data

Research Progress

Completed Investigations

- Broadband radiometer tilt-correction technique [Long et al., 2010]
- Objective forecasting technique for field programs [Small/Verlinde]

Ongoing Investigations

- Cloud-aerosol relationships [McFarquhar & Yang]
- Turbulence Profile Retrievals via Raman Lidar [Turner et al.]
- Cloud Tomography Validation [Huang et al.]
- Surface Spectral Albedo Mapping [Long et al.]
- RACORO *BAMS* [Vogelmann et al.]

Planned Research

- Cloud Optical Depth Mapping [Marshak, Barker et al.]
- O2 A-Band Cloud Retrievals [Min, Vogelmann et al.]

A View of Boundary Layer Clouds

Must improve boundary layer clouds, since climate simulations are very sensitive to the small guys (e.g., Bony & Dufresne, 2006):

- **Climate sensitivity**
- **Climate prediction**

Clouds have biggest impact on the model radiative uncertainty, not the indirect effect

- **Yes, aerosol indirect effect is a “forcing” (as defined) but is secondary to uncertainty in model cloudiness**

Thus, need to get the small guys right:

- **e.g., PDFs of cloud-scale properties**

Opportunities for CAPI Research

1. How do aerosols affect the microphysical and macrophysical properties of boundary layer cloud fields?
2. Can the large sampling statistics from a long-term project isolate aerosol effects from meteorological effects on clouds?
3. How well do boundary layer models simulate the properties of an ensemble of clouds (i.e., their PDFs) and aerosol effects on the ensemble?
4. To what extent can high-resolution models simulate the seasonal variation of these PDFs?
5. Can parcel models represent the aerosol activation observed in real clouds?
6. Can surface CCN measurements serve as a proxy for CCN at cloud base and, if so, under what conditions?
7. What level of aerosol compositional complexity is required to achieve closure on drop number concentration?
8. Given the observed dynamics and turbulence, how dependent are model simulations of cloud variability to differing complexities in aerosol representation?

Thank you

Questions?

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