RACORO

Routine
Aerial Vehicle Program (AVP)
Clouds with Low Optical Water Depths (CLOWD)
Optical
Radiative
Observations

Steering Committee

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Scientific Motivation

- **CLOWDs**
  - **Common globally, ≥50% of liquid water clouds have LWP < 100 gm^{-2}**
  - **State-of-the-art LWP retrievals differ 50 to 100% (Turner et al., 2007)**
- **Boundary layer clouds constitute the largest uncertainty in climate models (IPCC, 2007)**
  - **Maritime boundary layer clouds**
    - **Cloud albedos poorly simulated (e.g., Zhang et al., 2005)**
    - **Main source of uncertainty in GCM tropical cloud feedbacks (Bony and Dufresne, 2005)**
  - **Continental boundary layer clouds**
    - **Poor agreement w/ observations (Lenderink et al., 2004)**
    - **Sub-grid scale to boot!**
- **Aerosol indirect effects**
  - **Thin, boundary layer clouds very sensitive to changes in aerosol loading**
  - **Aerosol effect on cloud albedo remains the dominant uncertainty in radiative forcing (IPCC, 2007).**

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**

- Statistics needed – these clouds are thin and/or broken, making retrievals uncertain
  - **Help develop & evaluate ARM retrievals (CLOWD-BBHRP)**
  - **Improve our understanding of boundary layer clouds and their interactions with aerosols & radiative fluxes**

The RACORO Steering Committee

Andy Vogelmann	**Science coordinator, CLOWD co-chair**
Greg McFarquhar	**AVP Chief Scientist, *In situ* cloud obs**
Dave Turner	**CLOWD Co-chair, Surface retrievals**
Jennifer Comstock	**CLOWD Translator, Lidar FG, BBHRP**
Graham Feingold	**Cloud-aerosol interactions**
Chuck Long	**Radiometer mentor, flux analyses**
John Ogren	***In situ* aerosol & cloud obs (7 yrs, 2x wk)**

RACORO Challenges

1. CLOWD Systems

- Low LWP/Cs
- Can be highly variable
- ➢ Need good statistics

2. "Routine"

- Operational logistics
- Instrumentation
  - Robust/reliable
  - Low maintenance
  - Simple/routine processing
  - Low weight & power

Prefer:

- Fast response
- Large sampling volumes

Approach:

- Pair a slow, accurate measurement with a fast, precise measurement

Thank you, Beat, Jason, Haf, Chuck!

Operations

CIRPAS Twin Otter

Speed: 55 m/s
Flight ceiling: 12,000 ft (no O_2)
Research Capacity: 1,500 lbs
Has needed AC & DC power

Schedule

Field period: 22 January to 30 June 2009
Frequency : 2-3 times a week (4-5 hrs each)
QC'd data in archive: 1 January 2010

Science & Operations Plan

In progress
Full draft by Thanksgiving (feedback), final by early December

Measurements

- **Cloud microphysics**
  - **Bulk LWC**
  - **Drop size distribution (0.3 μm – 1.5 mm)**
- **Radiometric quantities**
  - **↑↓ SW & LW BB fluxes**
  - **↑↓ SW spectral fluxes (surface albedo)**
  - **↓ SW spectral radiances (cloud optical depth retrievals)**
  - **Cloud extinction coefficient**
- **Atmospheric state parameters**
  - **Fast-response water vapor**
  - **Temperature**
  - **Vertical velocity & turbulence**
- **Aerosol properties**
  - **CCN**
  - **CN & Size distribution (D > 3 nm)**

(See me for further details)

Systematic Operations

Seasonal flight time partitioning

- **Time split evenly within the Jan-June period**

Flight timing

- **Sample diurnal cycle, including some nighttime flights**
- **Timing prefers satellite overpasses**
- **Fly Saturday, Monday, & Wednesday; roll to next day if no-go**

Flight patterns

- **Preset matrix of spirals & level legs**
- **Some pilot discretion for slightly modifying location of legs**

RACORO Modeling Considerations

- **Forcing Data & Fluxes**
  - Shaocheng variational analyses (RUC)
  - Possible mod. of wind profiler sampling to 5 min aves (vert. velocity)
- **Soundings**
  - Sonde every 6 hrs; Bookend the 4-5 hr flights
  - Consider aircraft profiling (P,T,RH) below cloud base to 150 m AGL
    - Beginning & end of level legs
    - In between, when quickly evolving boundary layer
- **Level-leg statistical sampling of cloud fields**
  - 100-200 m below cloud base (vert. vel., turbulence, vapor, aerosol)
  - 100-200 m above cloud top (top boundary condition)
  - Level-legs at multiple cloud heights (cloud props, lateral entrainment)
- **Spiral/Ramp/Parking-garage cloud profile sampling**
  - Beginning & end of flights
  - Mid-way flights (?); Time trade off w/ level legs (condition specific?)

RACORO Contact Information

- **Website: http://acrf-campaign.arm.gov/racoro/**
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- **RACORO e-mail list: debbie.ronfeld@pnl.gov**
- **Science & Operations Plan**
  - **Draft by Thanksgiving, Final by early December**

Questions?