

ARM Aerial Vehicle Program (AAVP): A New Direction for ARM UAV

Greg McFarquhar, University of Illinois

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Outline

- 1. Past Goals & Accomplishments of ARM UAV**
- 2. Three new goals for AAVP**
- 3. Routine Observations of Clouds, Aerosols & Radiation**
- 4. Participation in IOPs**
- 5. Instrument Development Program**

ARM UAV Program Objectives

The ARM-UAV Program was established by DOE to

- address the largest source of uncertainty in global warming:
the interaction of clouds and solar/thermal energy
- support the climate change community with valuable data sets
- develop measurement techniques and instruments suitable for use with the new class of high altitude, long endurance UAVs
- demonstrate these instruments and measurement techniques in field measurement campaigns



ARM-UAV conducted 12 major field campaigns

Field Campaigns to date:

- Fall 1993, Edwards AFB, CA
- Spring 1994, Northern OK
- Fall 1995, Northern OK
- Spring 1996, Northern OK
- Fall 1996, Northern OK
- Fall 1997, Northern OK
- Spring 1999, PMRF Kauai, HI
- Summer 1999, Monterey, CA
- Winter 2000, Northern OK
- Fall 2002, Northern OK
- Fall 2004, North Slope, AK
- Winter 2006, Darwin, Australia



GA-ASI "GNAT 750"
(F93, S94)



Grob "Egrett"
(F95, S96)



GA-ASI "Altus I" (F96, F97)



GA-ASI "Altus II"
(Su99)



Proteus(F04, W06)



Twin Otter
(F93, S94, F95, S96, F96,
F97, Sp99, Su99, W00)

Major Accomplishments of ARM UAV

- Used piloted & unpiloted aircraft for:
 - First science flight using UAV (1993)
 - Stacked flight of UAV & piloted aircraft for cloud absorption measurements (1995)
 - Use of unescorted UAV in general flight space (1996)
 - 26 hour flight of UAV over SGP (1996)
 - Compact instruments for UAVs used (1990s/2000s)
 - Instruments & payload operated from ground
 - Collected data enhanced understanding of clouds/aerosols/radiation in global change (2002 IOP, M-PACE 2004, TWP-ICE 2006)

Why Refocus Program Now?

- Maximize scientific return from program & make ARM leader in airborne research
- ARM UAV has reached mature state:
 - long-term goal of routine observations can now be pursued together with support of IOPs
- Emphasis on routine observations consistent with ARM philosophy of long-term measurements needed
 - Thus far, program has essentially focused on IOPs
 - Routine observations, especially of under-sampled regions (oceans, Arctic), could maximize scientific return
 - Miniaturized instruments & platforms increasingly available

Why Rename?

- Get a better description of what we are doing
 - Not exclusively using UAVs
- Rename **AAVP (ARM Aerial Vehicle Program)**
 - Will use piloted & unpiloted aircraft depending on platform suitability & availability

Three-Pronged Program

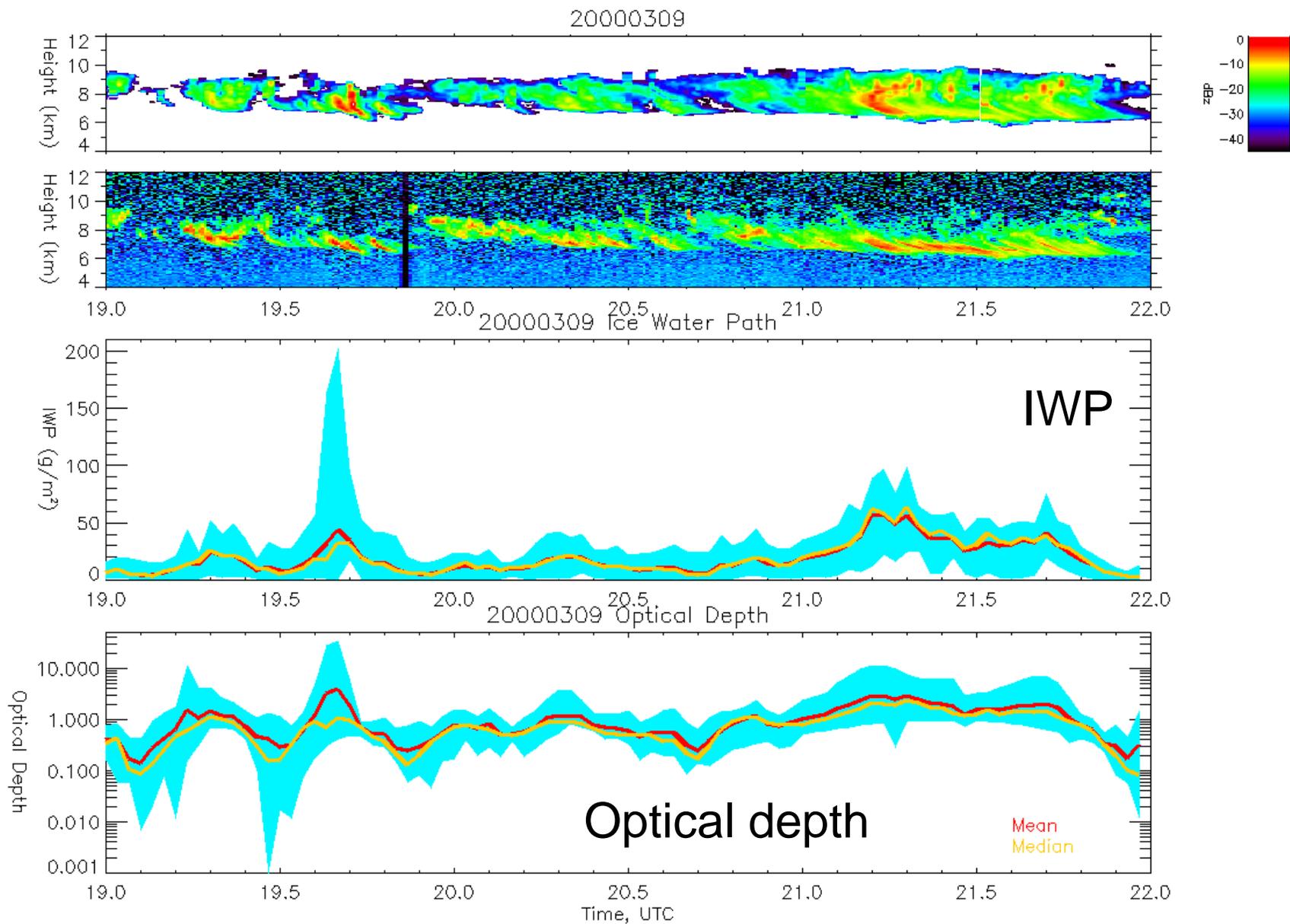
1. **Routine observations** of clouds, aerosols and radiative properties
2. **Participation in IOPs** designed to contribute to our fundamental understanding of clouds, radiation and aerosols and their effects on global change
3. **Foster instrument incubator program** where miniaturized in-situ and remote sensing instruments will be purchased or developed,
 - small size and modularity of instruments will make them amenable to UAVs and larger aircraft

Both piloted & unpiloted platforms will be used for these activities depending on platform suitability and availability

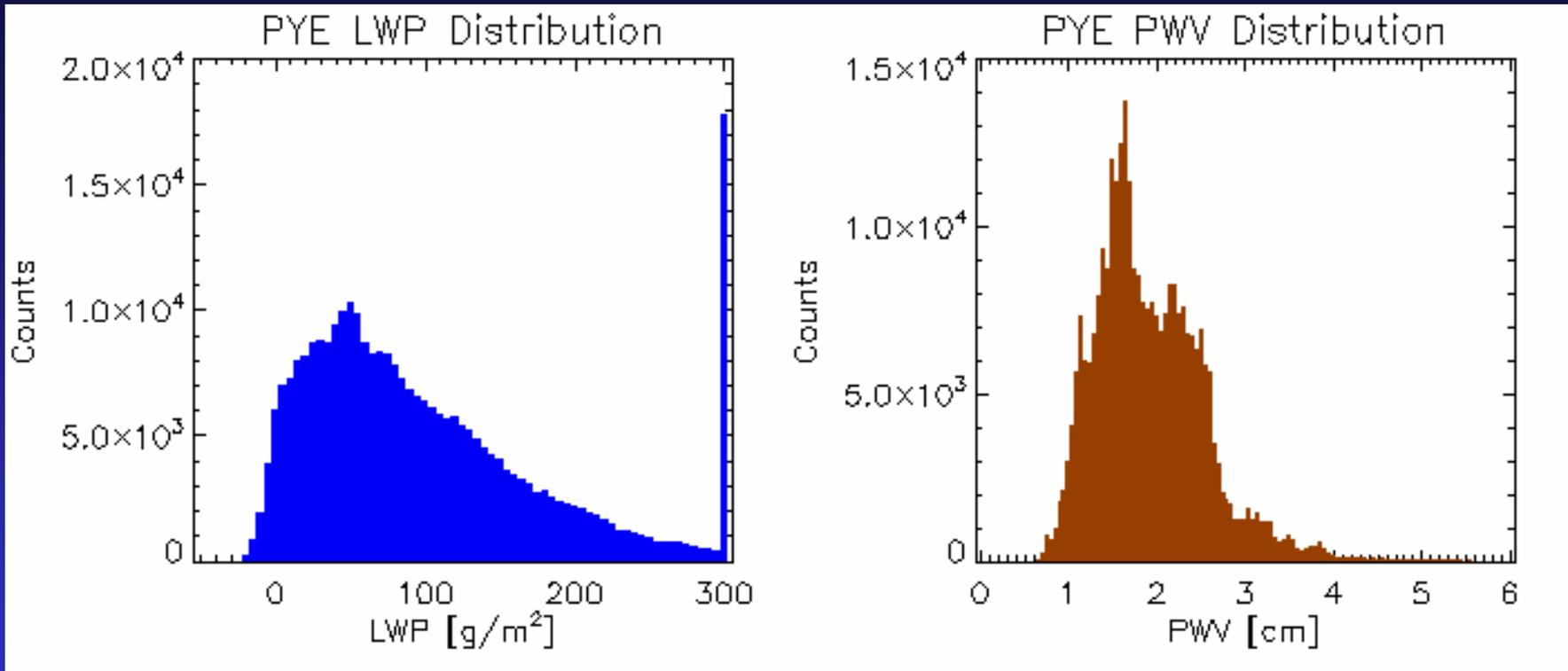
Routine Observations

- Move concept of making routine observations of cloud properties into operation phase
 - ARM currently making twice-weekly observations of aerosols & carbon over SGP —this can serve as model
 - Start with observations of cloud microphysics over NSA and then move to SGP
 - Extend to under-sampled regions (e.g., oceans off Barrow, Darwin, pristine oceans in S.H.)
 - Pseudo-randomized sampling of clouds (e.g., veer certain # of kms or certain angles from set paths)
 - More statistics on cloud properties, help with CLOUD, satellite and ground-based retrievals, etc.
 - Avoid dependence on the “case study” & big IOPs

High Clouds Retrieval Intercomparison



LWP / PWV Distribution at Pt. Reyes



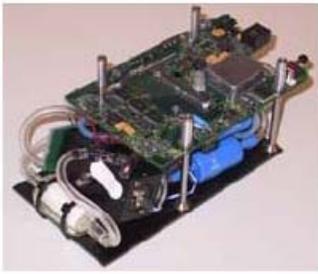
- Only include samples VCEIL indicated a cloud between surface and 1 km (~295,000 cases)
- 59% of these have LWP < 100 g/m²

Participation in IOPs

- Routine observations need to be supplemented by focused in-situ & remote sensing observations
 - IOPs focused on specific science questions still needed
 - Specialized data contribute to understanding of cloud & radiative effects on global environment (e.g., impacts of oceanic convection on environment, explaining longevity of mixed-phase Arctic clouds, etc.)
 - Working Groups make IOP proposals that require large & heavily instrumented aircraft not appropriate for routine observations
 - Ideally, integrate with routine observations (e.g., 2003 Aerosol IOP)

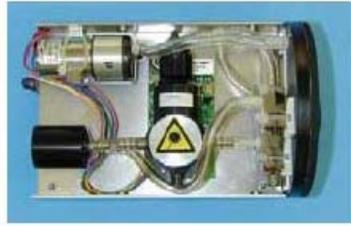
Instrument Development

- Routine observations & IOPs rely on continued integration of state-of-art instrumentation on aircraft platforms
 - Instruments should be miniaturized, platform independent and highly modular
 - Work on both slow/low and high/fast planes
 - In-situ mixed- and ice-phase cloud instruments & compact remote sensing devices needed
 - E.g., of specific instrument needs in white paper



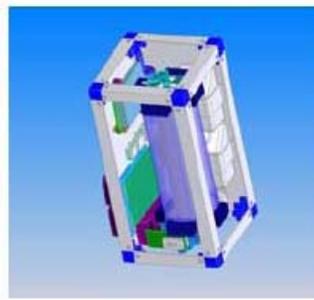
Condensation Particle Counter

Weight: 0.87 kg
Dimensions: 250 x 120 x 70 mm
Measure: #/cc for D > 10 nm



Optical Particle Counter

Weight: 0.30 kg
Dimensions: 96 x 60 x 34 mm
Measure: size distr. 0.3 - 3 μ m



Cloud Condensation Nuclei Counter

Weight: 3 kg
Dimensions: ca. 100 x 100 x 200 mm
Measure: #/cc for supersat. > 0.2%



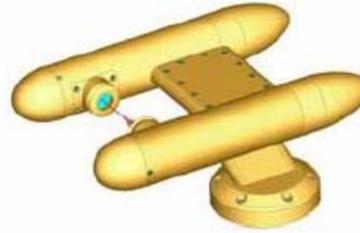
Aethalometer

Weight: 0.8 kg
Dimensions: 140 x 110 x 75 mm
Measure: absorbing aerosol



Aerosol Inlet

Weight: 0.037 kg
Dimensions: 10 \varnothing x 200 mm
Designed to minimize bias to aerosol size distribution



Cloud Droplet Probe

Weight: 1.42 kg
Dimensions: 216 x 115 x 100 mm
Measure: drop size distr. 0.7 - 70 μ m
NOTE: electronics in fuselage



Pyranometer

Weight: 0.2 kg
Dimensions: 80 \varnothing x 100 mm
Measure: Irradiance 305 - 2800 nm



PAR radiometer

Weight: 0.03 kg
Dimensions: 24 \varnothing x 25 mm
Measure: Irradiance 400 - 700 nm



Spectral Radiometer

Weight: NA
Dimensions: 150 x 90 x 15 mm
Measure: 350 - 1150 nm 256 channels

Aircraft Platforms

- Will not develop a platform, nor will we be restricted to use of a specific platform
- Envision variety of platforms depending on mission
 - Small, low-flying aircraft for routine warm cloud microphysics (Cessna 172/206, Caravan, aerosondes)
 - Mid-range platform that has higher range and more payload but still can fly routine missions (Cessna 340/414, Learjet, Falcon, Citation)
 - Larger & more capable platform with flexibility where it can fly (ER-2, Proteus, B57)



E.g., of small platforms





Mid-range aircraft

Larger aircraft with higher ceiling, more capability and large payload



Organization/Management

- Balance between 3 components deliberately flexible
 - Platform utilized can change from year to year
 - IOP/routine observation balance can shift from year-to-year, but *routine observations should not be eliminated at expense of large IOPs*
- Input from working groups will help prioritize instrument procurement in much same way instruments acquired for ARM
- Selection of IOP & routine observations comes from ACRF
- Chief Scientist will work with infrastructure & other interested parties to get routine observations initiated
- Examples of science issues that could be addressed in white paper

Input Sought

- Include AAVP in your IOP planning process
 - IOPs and routine observations
- Use AAVP data in your research
- Get involved in planning for routine observations
 - What types of instruments?
 - What flight profiles?
 - Send any thoughts/ideas to me

<http://www.atmos.uiuc.edu/~mcfarq/aavp.whitepaperoverview.pdf>

mcfarq@atmos.uiuc.edu