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

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

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)

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

Proteus(F04, W06)

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
- Some 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

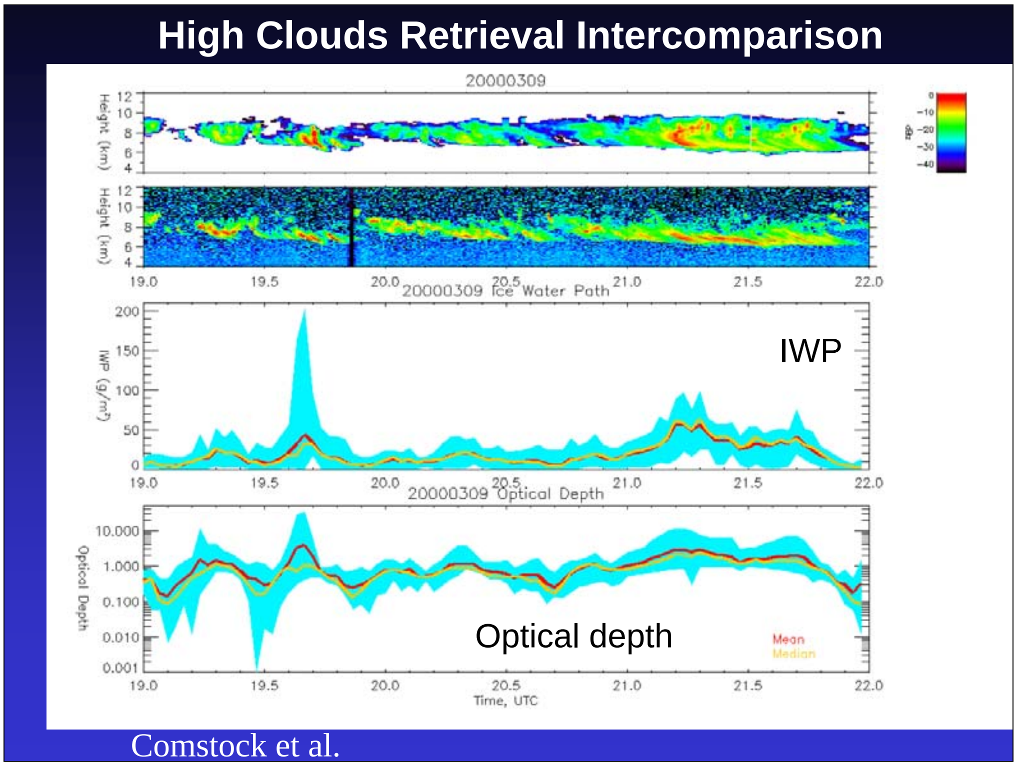
Three-Pronged Program

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

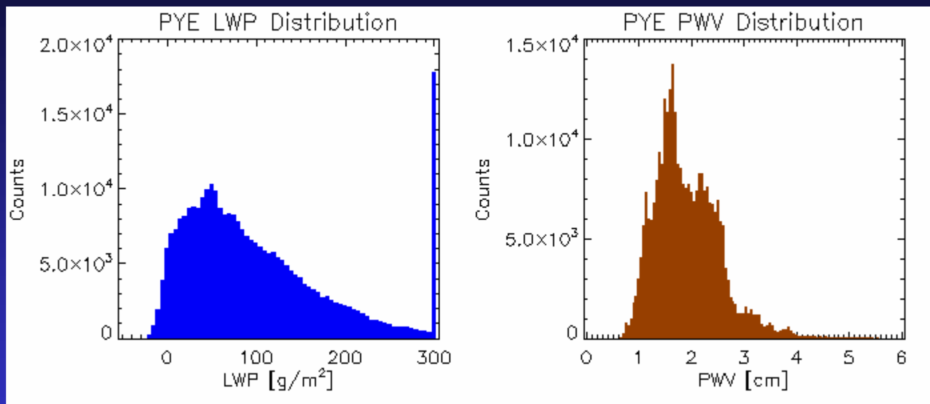
- Move concept of making routine observations of cloud properties into operation phase
  - ARM currently making twice-weekly observations of aerosols & carbon over SGP —this can serve as model
  - Start with observations of cloud microphysics over SGP
  - Extend to under-sampled regions (e.g., oceans 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 CLOWD, satellite and ground-based retrievals, etc.
  - Avoid dependence on the “case study” & big IOPs



This figure shows the spread of IWP and optical depth retrievals. There are 15 different retrievals with 5 different “classes” of retrievals: (1) lidar-radar, (2) radar only, (3) radar/lidar + IR radiometer (4) AERI and (5) Z-IWC regressions.

The top panel is radar (MMCR) reflectivity and the 2nd panel is MPL backscatter measured at the SGP on 9 March 2000 during the Cloud IOP.

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/m^2

Turner et al. 2005
CWG/IRF

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

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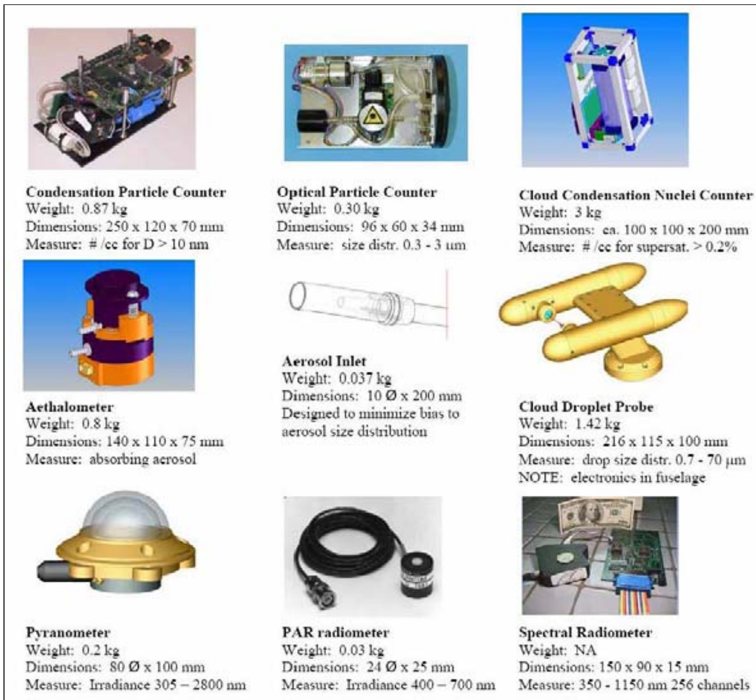

From Ramanathan et al.; example of instrument miniaturization

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, aerosondes)
  - Mid-range platform that has higher range and more payload but still can fly routine missions (Cessna 340/414)
  - Larger & more capable platform with flexibility where it can fly (ER-2, Proteus, B57)


E.g., of small platforms
N5278N


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 participation would come 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

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