ARM Aerial Vehicle Program (AVP): Science Vision

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

Outline

1. **Objectives of AVP**
   a) **Routine Observations**
   b) **Participation in IOPs**
   c) **Instrument Incubator Program**
2. **Focus of Airborne Program**
   a) **In-situ Observations for Evaluating Retrievals**
   b) **Remote Sensing Observations as Link Between Ground/Satellite**
3. **What is role of UAVs?**
4. **Interagency Collaboration**

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Objectives of AVP

To acquire airborne observations to meet ARM science goals and that are needed to enhance observations obtained by ground-based sensors

- **Acquire airborne observations to answer science questions relative to clouds, climate, radiation and aerosols**
- **Key difference from former ARM UAV is more science-driven: technology development is pursued but must have impact on science pursued by ARM**
- **Observations can be obtained by any airborne platform, either piloted or UAV (look for platform to answer science question rather than vice-versa)**
- **Questions to be addressed are driven by proposals, but a science vision needed to identify the principal objectives of program**
- **Support development of instruments/technology so that ARM is positioned at leading edge of airborne technology**

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. **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

Broad Goals

- These objectives and possible use of airborne resources are very broad
  - To some extent, goals should be broad because use of ACRF resources is PI driven
  - At same time, program needs a vision/focus because AVP cannot offer open-ended airborne observations for any purpose
  - Vision/focus should maximize utility of program

What is AVP positioned to uniquely do?

- AVP can pursue unique goal of acquiring routine airborne observations of clouds, aerosols and radiation
  - routine observations are more consistent with ARM philosophy than IOPs focused on only a few weeks
  - Avoids dependence on case studies: data are more representative of conditions in general
  - Routine observations of under-sampled regions (Arctic, oceans in S.H.) can answer pressing science questions
- IOPs or more limited-time observations still needed
  - Focus of these campaigns should still be on how airborne observations can be used to evaluate/improve remote sensing observations that will still be crux of science investigations
  - Could be pilot programs that could lead into routine obsvns.

Science Vision for AVP

- **Emphasize observations that develop/evaluate/ answer questions that improve ability of ground-based observations to answer ARM's science goals**
- **Recommended focus:**
  - **In-situ observations over ARM sites**
    - **Profiles/point measurements to compare against retrievals (clouds, aerosols, BBHRP)**
    - **Data to assist in retrieval development (habits, m-D relations, IWC r_e in cirrus, mixed-phase clouds, clouds with low liquid water paths, how many small crystals in cirrus)**
  - **Observations that provide critical missing link in scaling between ground observations & those of climate models**
    - **Scales between fine time evolution ground observations at single point to satellite observations over limited time but extending to larger spatial scale (airborne remote sensing observations represent critical missing link in this scaling process)**
    - **How do we go between PI and PA products of MICROBASE, scale to GCM grid box**
- **Need STATISTICS: hence routine emphasis**

What are Routine Observations?

- Observations that extend over long-time period giving representative sample of conditions (similar to ground-based observations)
  - E.g., capture a transition season, get statistics on cirrus or clouds with low liquid water paths, etc.)
- Pseudo-randomized sampling of clouds (e.g., fly on specific days on relatively pre-determined flight plans: e.g., move for safety reasons or veer xx km to sample cloud)
- Key is to get more statistics on clouds to help with science issues (e.g., CLOWD, m-D relations in ice, habits etc.)

What Routine Observations are not

- An IOP that extends for 6 to 12 months:
  - must be done differently!! ($$ and stress on people)
  - Need some focus on mid-sized IOPs that do not involve biggest & most heavily instrumented aircraft
- Not tied to specific platform
  - Look for platform to answer science question rather than science question that can be answered with platform
- Will still need IOPs designed to answer focused questions on clouds, aerosols & radiation & their impacts on climate change
  - IOPs will be used when cost of making extended observations is prohibitive (TWP-ICE, CLASIC)
  - IOPs might identify instruments that are appropriate for making routine observations

Why Now for routine?

- Behavior of some airborne instruments increasingly well understood
- Miniaturized instruments/platforms suitable for routine observations increasingly available:
  - Some instruments more automated/reliable than others and are better candidates for use in routine observations
  - Focus on instruments for which processing relatively more defined/straightforward
- Strategy for airborne observations of other parameters successfully implemented
  - ARM has been making twice-weekly observations of aerosols & carbon over SGP for years
- Ideal linkage with marine AMF in under-sampled regions

Participation in IOPs

- **Science community still wants big IOPs → AVP will continue to support IOPs**
  - **IOPs can help focus on needs for routine observations**
  - **IOPs focused on specific science questions still needed to understand cloud & radiative effects on climate (e.g., impacts of oceanic convection on environment, explaining longevity of mixed-phase Arctic clouds, etc.)**
  - **Working Groups continue to make IOP proposals that require large & heavily instrumented aircraft not appropriate for routine observations**
  - **Ideally, IOPs should be integrated with routine observations (e.g., 2003 Aerosol IOP)**

Instrument Development

- **Easy to neglect when organizing IOPs/routine observations, but critical to future of program**
  - **Focused strategy allows instruments helpful for long-term goals to be pursued**
  - **Need to make use of SBIR process to meet identified instrument needs**
  - **University community/government, in addition to small business, also need support**
- **Should we fly IOPs/Routine Observations every third year to have money to support instrument incubator program?**
- **Future programs 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**
  - **Specific instrument needs in AVP white paper**

What is role of UAVs in AVP?

- Right now, they are not suitable for all goals ARM needs to pursue (especially over SGP, but also for heavily instrumented IOPs)
- However, they offer good long-term strategy for airborne observations, especially routine
- Can pursue their use when appropriate within goal of particular IOP/routine observation campaign
  - Ideal for campaign in coordination with marine AMF
  - Routine observations off coast of Darwin/Barrow?
  - Pursue interagency collaboration with NOAA and NASA

Aircraft/Instruments

- 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, Twin Otter, Caravan)
  - Larger & more capable platform with flexibility where it can fly (ER-2, Proteus, WB57)
- At same time, it is likely that both the instruments and platforms available cannot be limitless so may need to be refined

Outline for Session

- Process for requesting AVP resources (Mather)
- Interagency collaboration (Weatherhead)
- New instrumentation (Lawson)
- Uses of small UAVs (Ramana/Corrigan)
- Lots of opportunities for feedback on vision and mission of AVP