# Unmanned Aerospace Vehicle Workshop

J. Vitko, Jr.
Sandia National Laboratories
Livermore, California

The Unmanned Aerospace Vehicle (UAV) Workshop concentrated on reviewing and refining the science experiments planned for the UAV Demonstration Flights (UDF) scheduled at the Oklahoma Cloud and Radiation Testbed (CART) in April 1994. These experiments are summarized below.

## UDF Experiments

**1. Clear sky, daylight**

*Scientific questions:* Do models and observations agree? Under varying conditions (low/high humidity, low/high aerosols)? How accurately can we measure fluxes? What is the impact of surface "patchiness" in the visible? In the IR? At what length scales does it average out?

*Flight profiles:* Minimum of 2 hrs centered on solar noon, clear sky, three altitude tiers, 10- to 20-km legs; 4+ hrs desirable for multiple profiles; several different atmospheric states (e.g., clear dry day, hazy humid day).

*Ancillary measurements:*

- soundings at the central facility every 3 hr for temperature and water vapor
- lidar measurements to verify that it is clear sky
- multi-filter rotating shadowband radiometer (MFRSR) measurements or equivalent for aerosol optical depth
- surface property measurements (could be a problem)
  - up- and down-looking pyranometers for reflectivity
  - downlooking pyrgeometer for surface brightness temperature
  - issues: spatial representativeness
- broadband solar and IR fluxes at the surface (up and down)
- satellite-derived top-of-the-atmosphere (TOA) fluxes

Because the surface reflectivity, and its variability, could potentially have a significant effect on the upwelling solar, the workshop suggested an additional experiment, which we have termed a diffuser experiment. In this experiment, heavy near-uniform overcast skies act as a diffuser for the incident solar radiation. Hence, any variability detected in the upwelling flux is due to variability in the surface albedo and not in solar zenith azimuth angle related effects.

**2. Clear sky, night-to-day transition**

*Scientific questions:* Can we accurately predict and measure the fluxes when the state of the atmosphere is rapidly changing? At low sun angles? The night-to-day transition, rather than the day-to-night transition, was chosen for two reasons: 1) it has the most pronounced effect on the surface and atmospheric temperature, and 2) the winds should be the most benign for the UAV at this time. One possible complication is the possibility of night-time surface condensate—e.g., dew and fog—which would complicate the interpretation. However, this does not appear to be a high likelihood for Oklahoma in April.

*Flight profiles:* Minimum of 2.5 hrs (6 desired) from a half hour before dawn to 2 hr after dawn. Perform the measurements at a single high altitude so that no other temporal dependences are introduced by cycling the altitudes. Center flights over central facility to take advantage of the radio acoustic sounding system (RASS) for continuous temperature soundings. Continuous water-vapor soundings for the first 2 to 3 km might be available from the Sandia Raman-lidar that is scheduled to be at CART for the cloud intensive observing period (IOP).

*Ancillary measurements:* same as for Experiment #1, plus

- RASS measurements for continuous soundings
- quasi-continuous surface temperature measurement is very important
- MFRSR important for optical depth at low elevation angles
- issue: IR data likely to be the most interpretable and, hence, are the primary objective. Solar data will be harder to interpret because of the low sun angles, but are still important because such low sun angles are characteristic of the Arctic.

**3. Clear sky; improve/validate the accuracy of radiative fluxes derived from satellite-based measurements.**

*Scientific questions:* Can UAV-based measurements of the broadband upwelling fluxes at the tropopause be used to improve/validate the accuracy of the corresponding fluxes derived from Geostationary Operational Environmental Satellite (GOES) measurements by P. Minnis? (Note: the Gnat cannot reach the tropopause and so does not fulfill the full measurement requirement; however, on a truly clear day, the atmospheric corrections above the maximum altitude of the Gnat [7 km] should be relatively small; hence, this can serve as a dry-run for the higher altitude flights of UIF-1.)

*Flight profiles:* 0.5 hr or more, mid-day, clear sky, at the highest altitude the Gnat can stably hold; flight pattern chosen to sample satellite footprint (8x8 km or 16x16, discuss with Minnis) while maximizing wings-level time. A large number of independent samples are preferred over a single long continuous measurement. Approximately 20 independent samplings over a variety of underlying sky conditions are desired to develop improved regressions for the satellite data.

*Ancillary measurements:* Same as for Experiment #1, plus

- climatic profiles for upper atmosphere (above 7 km) to estimate impact on measurements
- total direct diffuse radiometer (TDDR) data to characterize the optical depth above the UAV.

**4. Daylight, clouds of opportunity**

(Single cloud fills field-of-view—e.g. underfly alto- or cirro-stratus; fly close to cumulus)

*Scientific questions:* How does observed downwelling (or upwelling) flux compare with models? For thick clouds? For thin clouds? What is the spatial variability of the observed flux?

*Flight profile:* Underfly a relatively uniform extended cloud (or cloud layer) as close as comfortably possible —both an optically thick cloud and a thinner cloud seem desirable. Overflight also highly desirable if cloud conditions, geometry allow.

*Ancillary measurements:* Same as for Experiment #1, plus

- cloud optical depths from the TDDR (for thin cirrus)
- any cloud droplet phase or size information from ground-based remote sensing instruments at Remote Cloud Sensing IOP
- lidar or aircraft observations for cloud base height
- radar, aircraft observations, or lidar for cloud top height (lidar for thin clouds only).

**5. Daylight, broken clouds**

(Many clouds in field-of-view)

*Scientific questions:* How does spatial variability of cloud field map into the spatial variability of the radiation field? (Basic idea is to fly over a broken cumulus field at several different altitudes to measure the horizontal spatial variability in the upwelling fluxes.)

*Flight profiles:* Two hours, 2 to 3 tiers over a broken cumulus field, 10- to 20-km legs.

*Ancillary measurements:* Same as Experiment #4, plus

- whole sky imager data to provide cloud statistics.