Overview of Protocol and Flight Plans for the NASA King Air

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- The "basic" King Air pattern is designed to coordinate with the "basic" G-1 plume sampling strategy. The King Air will perform a series of coincident level legs transects above the locations of the G-1 transects to map out the aerosol and cloud distributions at various distances downwind of Oklahoma City. These transects, like the G-1 transects, will be oriented perpendicular to the mean flow (at 850 mb) and the Oklahoma City plume. The King Air transects will be slightly longer than G-1 transects in order to locate and sample the entire horizontal width of the plume as well as regions outside of the plume.

  While traveling en route to the anticipated location of the coordinated G-1 pattern, the King Air will perform a "zig-zag" pattern oriented roughly perpendicular to the expected location of the Oklahoma City plume. This pattern is designed to help define the exact location of the plume and to direct the G-1 to the optimal position to sample the plume.

- The King Air will perform a series of flights designed to validate the aerosol and cloud measurements acquired by the CALIOP instrument on board the CALIPSO satellite. This satellite is part of the NASA "A-train" constellation of satellites. These flights will be designed to acquire data along the ground track of the CALIOP lidar. The King Air flight tracks will be designed such that the HSRL will acquire data along the CALIOP ground track at least 15 minutes before and after the time of satellite overpass. These flights will target clear to partly cloudy conditions at the point of satellite coincidence to help reduce potential cloud interference of HSRL and CALIOP aerosol measurements. The King Air would also perform flights to acquire data coincident with the NASA MODIS (Terra and Aqua) and MISR (Terra) sensors to investigate algorithms that combined active (lidar) and passive (MODIS/MISR) measurements to retrieve aerosol parameters.

- As part of these flights, and/or during other dedicated flights, the King Air will fly over the ARM SGP CRF in order to acquire data coincident with the ARM SGP Raman lidar. These flights are designed to acquire combined HSRL/Raman lidar data sets suitable for testing advanced algorithms that use multi-wavelength lidar measurements to retrieve aerosol microphysical properties.

The King Air will also participate in joint flights with the CLASIC campaign aircraft to examine the variability of aerosols in the vicinity of clouds.

1. **Basic OKC Flight Plan: cloudy and clear conditions**
   a. **Motivation:** Investigate the spatial variability of aerosol optical properties over the southern Great Plains within the geographical domain to be sampled via *in situ* measurements from the G-1.
   b. **Conditions:** Since this flight plan will be coordinated with the G-1 pattern, this flight will be done under the same conditions as specified for the G-1 "Basic OKC Flight Plan", i.e. when the forecast mean 850hPa flow is between 135 and 225º [1]

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[1] Direction nomenclature based on flow from the north ('northerly') being 0º/360º and flow from the south being 180º

and FWC are forecast for late morning (depart Ponca City at 11AM) or early afternoon (depart 1PM). This pattern requires clear to scattered (1/3) mid-level (10 kft-25 kft) cloud coverage to avoid clouds interfering with HSRL sampling of the boundary layer region where the G-1 will sample.

  c. **Basic idea:** make constant altitude at ~ 28 kft above the G-1 transects upwind and at varying distances downwind of Oklahoma City.
  d. **Clear or Low Cumulus clouds present**
        i. Depart Ponca City (10AM or 12 PM depending on expected time of cloud formation). King Air likely to depart ~30-60 minutes prior to G-1 takeoff to perform scouting mission to locate OKC plume.
        ii. Flying between PNC and OKC, King Air to fly "zig-zag" pattern to locate horizontal extent of OKC plume. Plume location and boundary layer height communicated to G-1 pilots.
        iii. Upwind of OKC, perform single 60 nm transect above the G-1 transect. Cloud base and cloud top altitude relayed to G-1 pilots. Downwind of OKC, G-1 performs transects above the location of the G-1 transects; length of transects to be long enough to sample outside the OKC plume; minimum transect length to be 60 nm to coincide with the G-1 transects. Downwind transect locations chosen to coincide with the G-1 transects.
        iv. If sufficient fuel remains, the King Air will fly over the ARM SGP CRF site to acquire coincident measurements with the ARM SGP Raman lidar.
        v. Return to Ponca City

2. **CALIPSO/A train Validation:**
  a. **Motivation:** The HSRL is a primary instrument for evaluation/validation of the CALIPSO aerosol and cloud measurements.
  b. **Conditions:** Clear to mostly cloudy mid to high level clouds to minimize cloud interference of the satellite and HSRL measurements. Flights may be either during daytime (~17-21 UT) or nighttime (5-9 UT).
  c. **Basic Idea:** King Air flies over the CALIPSO ground track location so that the HSRL can acquire data at least 15 minute before and 15 minutes after the satellite overpass time. It is likely that, during some of these flights, the ER-2 (G-1) will also be flying along this same flight track, well above (below) the King Air, to also acquire CALIPSO/CloudSat validation data.

3. **Satellite Overpass:**
  a. **Motivation:** The NASA Terra and Aqua satellite platforms deploy instruments such as MISR (Terra) and MODIS (Terra and Aqua) that measure aerosol properties. Measurements from these instruments would be combined with the HSRL measurements to investigate advanced algorithms designed to combine active (lidar) and passive (MODIS/MISR) datasets to retrieve aerosol optical and microphysical retrievals.
  b. **Conditions:** Clear to partly cloudy mid to high level clouds to avoid interference of the satellite and HSRL measurements, and generally hazy conditions to allow sufficient aerosol signal to evaluate advanced retrieval algorithms.
  c. **Basic Idea:** King Air flies acquires data over the region sampled simultaneously by the MODIS and/or MISR sensors. Ideally, this region would be over the ARM SGP site, or in the location where other aircraft (e.g. G-1, DOE ARM IAP Cessna), are simultaneously measuring aerosol properties.

4. **ARM SGP Flight Plan:**
    a. **Motivation**: Acquire data over the ARM SGP CRF site data coincident with the ARM SGP Raman lidar and other ARM sensors. These flights are designed to acquire combined HSRL/Raman lidar data sets suitable for testing advanced algorithms that use multi-wavelength lidar measurements to retrieve aerosol microphysical properties.
    b. **Conditions**: Clear to partly cloudy mid to high level clouds to avoid interference of the satellite and HSRL measurements, and generally hazy conditions to allow sufficient aerosol signal to evaluate advanced retrieval algorithms.
    c. **Basic Idea:** Fly a series of transects above the ARM SGP site under hazy conditions to acquire combined data sets. Ideally, these flights would be coordinated with other aircraft (e.g. DOE ARM IAP Cessna) and/or coincident satellite measurements.

5. **CLASIC Sampling Flight Plan:**
    a. **Motivation**: Investigate aerosol/cloud variability to support CLASIC science objectives. For example, this may include investigating boundary layer variability associated with variations in soil moisture, variability of aerosols and clouds in CLASIC domain, variability of aerosol properties near clouds, etc.
    b. **Conditions**: Clear to partly cloud low to mid level clouds to permit HSRL sampling, and with close coordination of CLASIC airborne platforms (ER-2, Twin Otter, helicopter, etc.)
    c. **Basic Idea:** define airspace that the King Air can fly to and from Ponca City, and have flexibility to make high altitude transects over any of a number of locations within this airspace.

6. **Generic Sampling Flight Plan:**
    a. **Motivation**: to have a flight plan on file with DOE and FAA that will let us sample interesting phenomenon (e.g., other cloud formations, biomass burns, storm outflow) that arise during the campaign.
    b. **Conditions**: When the other flight plans have been exhausted or conditions warrant HSRL sampling.
    c. **Basic Idea:** define airspace that the King Air can fly to and from Ponca City, and have flexibility to make high altitude transects over any of a number of locations within this airspace.