Aura Validation Experiment (AVE)
White paper (version 1.0)

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Questions:
How will payloads actually be selected?
How will we determine the "science" questions for each deployment? Should we try and expand the timeline to include greater detail on science questions. We know those questions for the major campaigns, but the smaller campaigns are undetermined.
Should we lay out a management structure and assign project scientists for each deployment? Should we draw in Mike Craig et al. at this stage?
What about flight profile discussion? Do we need more detail?

ABSTRACT:

Aura instruments will make atmospheric observations under a wide variety of conditions. Currently planned NASA sponsored campaigns will not entirely meet the validation needs for Aura because they concentrate on single scientific environments. To provide a range of validation opportunities, the Aura mission will sponsor the Aura Validation Experiment (AVE): airborne payloads and flights targeting Aura validation needs and specific science questions. There will be approximately two AVE campaigns per year. These campaigns will be folded into the larger currently planned NASA sponsored field campaigns. Although AVE will mainly use a high altitude aircraft, the need for transects of ozone, aerosols and temperature by remote sensors (microwave and lidar) implies that a larger, medium altitude aircraft may also be needed for some deployments. Thus AVE deployments will include both aircraft or a single aircraft as the validation and science needs evolve. The AVE payload will have two configurations: 1) a base payload (chosen for Aura primary validation needs, and included on each deployment), and 2) an augmented payload which will be chosen based on the specific additional validation and/or scientific needs, cost and platform payload capacity. The augmented payload will vary from deployment to deployment.

Motivation:

The Aura satellite includes 4 instruments: the High Resolution Dynamics Limb Sounder (HIRDLS), the Microwave Limb Sounder (MLS), the Ozone Monitoring Instrument (OMI), and Tropospheric Emission Spectrometer (TES). The validation requirements for these instruments are extensively detailed at http://aura.gsfc.nasa.gov/mission/validation.html. The validation requirements not only detail measurements of particular trace gases (e.g., ozone, methane, etc.), but also require measurements over particular surface types and cloud regions in different seasons. This wide range of requirements encompasses the need for: 1) a number of instruments covering Aura constituents, 2) an altitude sampling that covers from the surface to the stratosphere, 3) sampling over various seasons, and 4) sampling over surfaces ranging from grasslands to ocean. These requirements therefore dictate a strategy based upon a relatively heavy lift aircraft with good altitude and range that is available for multi-week observational campaigns.

AVE platform requirements:

The Aura Validation Experiment has been developed to fulfill many of the broad range of requirements of Aura. The AVE platform requires a high-altitude capability that extends from the surface to the stratosphere. Both, the NASA WB-57F and the NASA ER-2 aircraft can carry in-situ instrument over an altitude range from the surface to the lower stratosphere. A medium-altitude, heavy lift capability is also necessary for extended range measurements. The NASA DC-8 can carry the relatively heavy remote sensing instruments such as ozone lidars that can sample from the surface to the upper stratosphere. The WB-57F has a range of approximately 3200 km with a full 3-ton payload, while the ER-2 has a range of about 4800 km with a full 1.3-ton payload. The NASA DC-8 has a range of approximately 10,000 km with a 15-ton payload.

AVE payload requirements:

The basic payload for AVE is determined by the top priority measurements of Aura (see Tables 1.1, 1.2, and 1.3 in the Aura validation pdf document). Table 1 of this document shows the measurement prioritization for the AVE deployments. The high altitude platform has a basic measurement set of temperature, pressure, winds, O_3, H_2O vapor and total water, CO, CH_4, N_2O, NO_2, HNO_3, a UV-vis spectrometer that yield measurements of O_3, NO_2, and BrO - HCHO column, and an IR nadir radiance spectrum measurement from 5-15μ with a 0.01cm^{-1} resolution. The medium altitude platform requires a similar basic payload to the high altitude platform, but with the addition of an ozone, aerosol, and temperature profiling capability.

Table 1. AVE Base Payload. Stars (*) indicate required for basic payload, while X indicates augmentation measurement.

Observation	**Platform**	
	HA	MA
Temperature, pressure, winds	*	*
O_3	*	*
H_2O vapor and total water	*	*
CO, CH_4, N_2O	*	*
NO_2		*
UV-vis spectrometer (O_3, NO_2, BrO - HCHO column)	*	*
IR Nadir radiance spectrum 5-15μ (0.01cm^{-1} res.)	*	
Clouds and Aerosol particle size	x	*
Cloud Particle habit and Aerosol Composition	x	
HNO_3	*	*
HCl	x	x

CFCs	x	x
BrO, ClO	x	x
$ClONO_2$	x	
O_3 profiles above and below the AC up to 40km		*
T profile	x	*
Aerosol profile	x	*

AVE Time Line:

It should be understood that the reality of satellite launches involves unexpected delays. Thus the timeline listed below represents an ideal situation under the assumption of an Aura launch by July 1, 2004. The attached time-line includes only the field deployment schedule, without the integration period.

2004: October – HA AVE from NASA JSC's Ellington Field facility. Objective: Radiance validation and in situ measurements in upper troposphere and lower stratosphere. Field deployment – 2 weeks (5 flights).

2005: January – **1)** MA AVE from NASA Dryden FRC. Objectives: Mid tropospheric lidar measurements of tropospheric and stratospheric ozone, aerosols and temperature across the subtropical edge and polar vortex boundaries. Field deployment – 2 weeks (5 flights). **2)** HA AVE from NASA JSC Ellington Field. Objectives: Objective: Radiance validation and in situ measurements in upper troposphere and lower stratosphere. Field deployment – 2 weeks. Field deployment – 2 weeks (5 flights).

2005: July – HA AVE, joint measurements with TCSP from San Jose, Costa Rica. Objectives: Water vapor and trace gas measurements in the tropical East Pacific near the tropopause, lidar measurements of ozone, aerosols and temperature in the troposphere and lower stratosphere. Field deployment – 4 weeks (10 flights).

2006: January – HA AVE, joint measurements with TC4 Winter Southern Hemisphere, and DoE TWP/ICE mission in Darwin, Australia. Objectives: Water vapor and trace gas measurements in the tropical East Pacific near the tropopause. Field deployment – 4 weeks (10 flights).

2006: April – Both **1)** HA AVE and **2)** MA AVE with INTEX NA-W from Dryden FRC. Objectives: Troposphere and lower stratosphere profiles and in situ measurements of tropospheric trace gases in polluted and unpolluted environments to assess inflow into the West Coast of the US. Field deployment – 4 weeks (10 flights).

2006: September - HA AVE from Ellington. Objective: Radiance validation and in situ measurements in polluted environments throughout the troposphere and lower stratosphere. Field deployment – two weeks (5 flights).

2007: January – HA AVE with TC4 Winter Northern Hemisphere from Guam. Objectives: Water vapor and trace gas measurements in the tropical East Pacific near the tropopause. Field deployment – four weeks (10 flights).

2007: June – HA AVE from Ellington. Radiance validation and in situ measurements in upper troposphere and lower stratosphere. May include joint flights with a UAV for mid troposphere in situ measurements. Field deployment – 2 weeks (5 flights).

2007: October – HQ AVE from Ellington. Radiance validation and in situ measurements in upper troposphere and lower stratosphere. Mid-latitude, high-resolution balloon profiles of stratospheric constituents. Field deployment – 2 weeks (5 flights).

Ozone and water vapor sonde launches would support the AVE campaigns and provide augmented measurements during satellite overpasses.

Flight Profiles:

The AVE flight profiles are primarily designed to be co-located with the Aura and A-train sub-orbital tracks. The Aura equator crossing time will be at approximately 1:45 PM local time, with about a 99 minute orbit period and approximately 14 orbits per day. The Aqua satellite will precede Aura by approximately 15 minutes. With this orbital period, the Aura satellite would pass over Ellington (or Dryden) at about 1:54 PM local time. Hence, AVE flights will likely be late morning to early afternoon takeoffs followed by collocated flight tracks with the satellite near 2 PM.

The flight profiles for AVE will typically be collocated with the nadir track at the time of the satellite overpass. The initial flights will target relatively benign flow conditions in clear air regions. As an example, Figure 1 displays a simulated flight track of the WB-57F flying from Houston for Sept. 13, 2003 (shown as the dark blue line). The colored map shows the continental United States surface land types, where desert is light brown, grassland is green, and agricultural use is shown in yellow. The Aura nadir track is simulated, and the MLS observation points from this simulation are shown as the magenta circles. Wind vectors at 300 hPa are superimposed in white, and show the jet curving out of Canada over the northern mid-west states. The initial track of the aircraft is from Houston to NE New Mexico. The aircraft flys from point 1 to 2, and then returns along the same track. Two MLS observation points are overlapped by the aircraft on this flight, and a spiral descent would be executed by the aircraft near point 1 from 60,000 feet to approximately 10,000 feet. The aircraft would fly straight and level legs from 1-2 at 50 kft, and then return from 2 to 1 at 60 kft on a second straight and level leg. This particular track was chosen because of: 1) the overlap with Aura, 2) the forecast cloud free conditions on this particular date, 3) the ranges of surface types, and 4) the presumably uniform trace gas distributions along the flow lines.

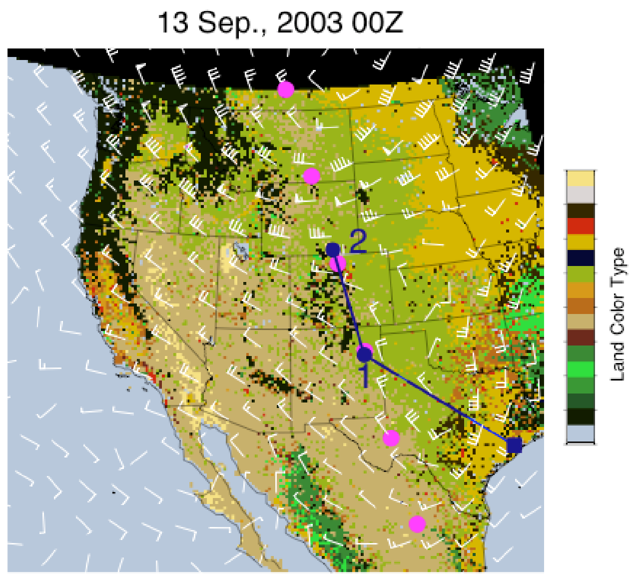

Figure 1. Simulated flight track of the WB-57F flying from Houston for Sept. 13, 2003 (shown as the dark blue line). The colored map shows the continental United States surface land types, where desert is light brown, grassland is green, and agricultural use is shown in yellow (see key). MLS observation points are the

Flight types:

A) Long distance following along nadir track flights, both over land and ocean.
B) Spiral descent flights at observation locations.
C) Overflights of ground observation sites (e.g., DOE ARM Southern Great Plains, JPL Table Mountain Facility, Gulf of Mexico oil platforms, Lake Tahoe) during various seasons.
D) Coincident flights with other platforms (e.g., balloon launches from Ft. Sumner, New Mexico).
E) Longitudinal aircraft profiles to compare: 1) satellite instrument “off nadir” side scan performance, and 2) instrument observations between orbits.