National Aeronautics and Space Administration

FY24 Strategic Initiatives Research and Technology Development (SRTD)

Ozone and Trace Gases (4 of 5)

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Strategic Focus Area: Earth System Explorer – Science Definition and Technology Maturation | **Strategic Initiative Leader:** Sabrina M Feldman

1. Objectives

Our overall objective is to mature concepts that JPL could submit to future calls of the "Earth System Explorer" (ESE) program in the "Ozone and Trace Gas" category. Owing to budget reductions, objectives for FY24 (the final year of the project) were confined to:

Objective 1: Finalize the development and deployment of a ground-based ultraviolet (UV) spectro-polarimeter instrument (as a pathfinder for a future spaceborne instrument).

Objective 2: Quantify the ability of this instrument to measure vertically resolved ozone profiles. Specifically, quantify the additional information imparted by measuring (a) polarization information and (b) by viewing at multiple angles in the vertical.

2. Background

- Anthropogenic influences on atmospheric composition are the main drivers of global environmental change and have major impacts on human and ecosystem health.
- A major challenge in Earth System Science is to improve predictive capability for atmospheric composition on the timescales associated with climate forcings and feedbacks and those required for air quality forecasts.
- Atmospheric composition is affected by many processes, including surface emissions and deposition, horizontal and vertical transport, photochemistry, interactions with aerosols and clouds, impacts of lightning and solar/cosmic particles, transport between the various atmospheric layers, and transport/mixing and chemical processing within those layers.
- All these processes take place in different domains (boundary layer, free troposphere, upper troposphere, stratosphere), and no single measurement technique is capable of probing them all.
- A long-standing need for the atmospheric composition community has been to better measure ozone in the lowermost region of the atmosphere (the "Planetary Boundary Layer").
- The addition of polarimetry and multi-angle viewing to an orbiting UV imaging spectrometer has the potential to provide the needed improvements.

3. Approach and results

Objective 1: The instrument was completed, deployed, and now makes measurements at JPL's Table Mountain Facility every clear day (Fig. 1).

Objective 2: We developed a measurement simulation capability based on the state-of-the-art VLIDORT model and quantified the ability of the instrument to (a) measure vertically resolved ozone profiles (see one example in Fig. 2), and (b) the extent to which measurement of polarization and multi-angle viewing contributes additional information on ozone in the lowermost atmosphere (see Table 1).

Figure 1: *Multi-Angle UV Spectropolarimeter (MUGS2) installed and operating at Table Mountain.*

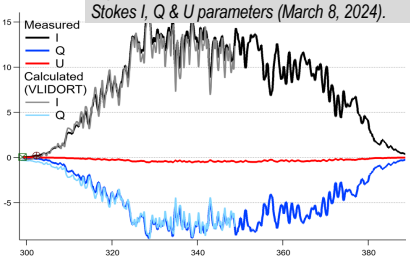

Figure 2: *Sample MUGS2 measurements of Stokes I, Q & U parameters (March 8, 2024).*

Table 1: *Ground-based multi-angle polarimetric measurements provide significantly greater information on ozone in the lowermost atmosphere than is obtained from non-polarimetric, single-angle viewing.*

	Degrees Of Freedom For Signal (larger is better)		**Ozone uncertainty (%)** (smaller is better)	
	Single-angle	Multi-angle	Single-angle	Multi-angle
No polarization	0.7	1.1	32	11
With polarization	0.9	1.5	23	6

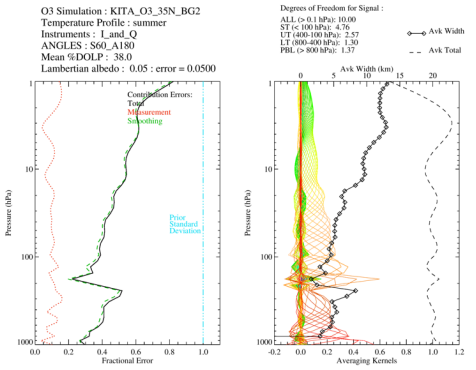

Figure 3: *Profiles of the fractional error (left) and "Averaging Kernel" (right, quantifies measurement performance) for ground-based ozone measurements for the MUGS2 instrument. This example is for polarimetric (I+Q) multi-angle viewing with a 60° solar zenith angle*

4. Significance and benefits to JPL

- The work lays the groundwork for future JPL-led or JPL-participating Earth System Explorer (ESE) proposals.
- It cements JPL's strong role in OTG-related observations by developing concepts for next-generation sounders that fill identified gaps in established knowledge and the expected observations from the Program of Record (PoR).
- Concepts developed may also be suitable for proposal to other opportunities, including the Earth Venture program.

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Publications:
None in this FY

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