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COLLEGE OF SCIENCE
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TEMPO Spectrometer Satellite Validation using TOLNet Mobile RO3QET Lidar

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Introduction

The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument is a grating spectrometer, which is sensitive to visible and ultraviolet wavelengths of light (Zoogman et al., 2016). This instrument will be attached to a geostationary satellite in order to measure many different pollutants (NO_2 ,O_3 , SO_2 , HCHO, etc) in our atmosphere within the Field of Regard (North America, *Figure 1*). Validating the measurements of 0-2km tropospheric ozone precursors from space instrumentation, is vital for the future of air quality research. The RO3QET team validation plan is built off of many past campaigns by NASA and other air-quality research groups here in North America. These campaigns include OWLETS-1 and -2, LISTOS, BOEM, LMOS, CABOTS, SCOAPE, and FAST-LVOS, and DISCOVER-AQ. They will be the framework for our future campaigns.

Figure 1. The TEMPO Field of Regard (inside the green polygon) which is focused on North America. Credit: NASA/USGS/SAO

Methodology

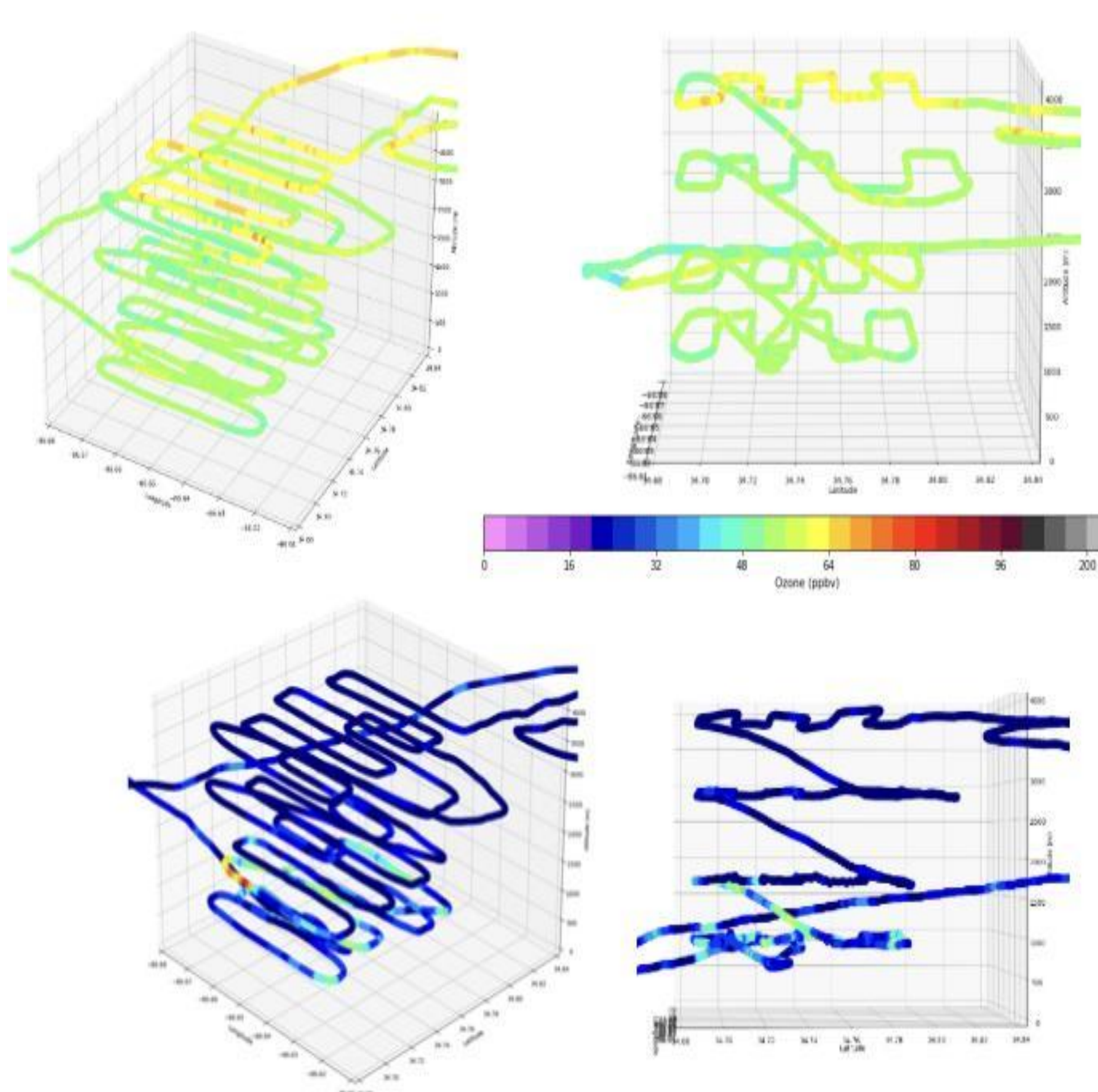

Figure 2. SeaRey 3D flight measurements over TEMPO pixels with Ozone and PM2.5 measurements . The top two figures show different perspectives of the ozone measurements from 1-4km. The bottom two panels display the PM measurements over the same grid. As the ozone measurements.

After TEMPO launch in May 2023, we will carry out the validation plan in the Summer of 2023 for 0-2 km ozone using Rocket-City Quality Evaluation in the Troposphere (RO3QET) lidar, one of the eight Tropospheric Ozone Lidar Network (TOLNet) lidars across the US (Johnson et al., 2018). This lidar is a Differential Absorption Lidar that derives ozone concentrations by analyzing the backscattered signals at two separate but closely-spaced wavelengths (Kuang et al, 2013). RO3QET's data has been used for various atmospheric research projects, such as ozone transport, biomass-burning smoke transport, and stratosphere-troposphere exchange (i.e., Dauphin Island campaign, SCOOP, launches in Huntsville, AL, etc).

A Progressive Aerodyne Searey amphibious aircraft and a UAV drone will be used by flying ozone-measurement instrumentation within a sequence of TEMPO pixels *(Figure 2).* The reasoning behind using aircraft/drone instrumentation for our validation is due to the spatial variability of ozone throughout our troposphere at different altitudes and locations. Ozonesondes will be released to measure the atmosphere at higher altitudes. Wind speed and direction will be monitored with mobile and non-mobile weather stations. With this variety of instrumentation that can monitor 0-2km ozone precursors accurately, the RO3QET team will carry out a campaign in order to validate TEMPO ozone hourly retrievals.

For the period of this RCEU, the RO3QET traveled to Dauphin Island, AL in July 2023 as a shakedown tour to exercise our ability to provide TEMPO validation measurement (*Figure 3).*

Conclusion

Validated geostationary TEMPO 0-2 km ozone and tropospheric-column aerosol measurements will provide a new paradigm to study air pollutants within North America. The RO3QET campaign at Dauphin Island, AL in July 2023 provided a shakedown tour to work on our validation plan. This allowed us to study ozone precursors, while also setting up how we will run future campaigns to validate TEMPO. This trip was from July 7th-11th, 2022 and the team successfully collected many forms of useful data. With this trip, we will be better prepared for our time validating TEMPO next summer.

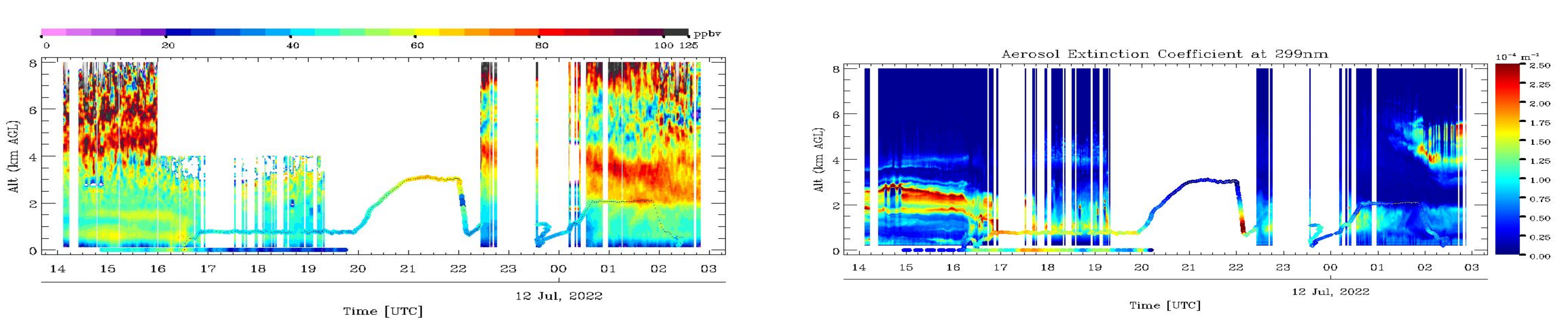

Figure 3. RO3QET Lidar ozone (left) and aerosol (right) curtains with Searey airborne in situ measurements (flight lines in both panels) from Dauphin Island, AL to Huntsville, AL on July 11th, 2022.

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