Synergistic Observations of Boundary-layer Ozone with Ground-based, Airborne, and Space-borne Instruments

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Sessions 4 | Gold Room

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S04_P19

The 30th International Laser Radar Conference (ILRC) virtual conference, June 26th – July 1st, 2022.

Objectives

Low-earth orbiting satellites have been observing the global distribution of air pollution for decades identifying pollution sources, temporal trends, and links to health effects and community disparities. However, historically, space-based observations have been **coarse in spatial and temporal resolution** resulting in challenges in data interpretation and product validation.

NASA's TEMPO (Tropospheric Emissions: Monitoring Pollution) satellite will create a revolutionary new dataset of atmospheric chemistry measurements from space. The instrument will resolve pollution levels to regions of several square miles—far better than existing limits of about 100 square miles.

TEMPO will be the first space-based instrument to monitor major **air pollutants** across the North American continent every daylight hour at high spatial resolution. The instrument, an ultraviolet and visible spectrometer was completed in 2019, will hitch a ride on a commercial satellite to a geostationary orbit (GEO) about 22,000 miles above Earth's equator.

This vantage point will enable **TEMPO** to monitor daily variations in ozone, nitrogen dioxide, and other key elements of air pollution from the Atlantic to the Pacific, and from Mexico City and the Yucatan Peninsula to the Canadian oil sands.

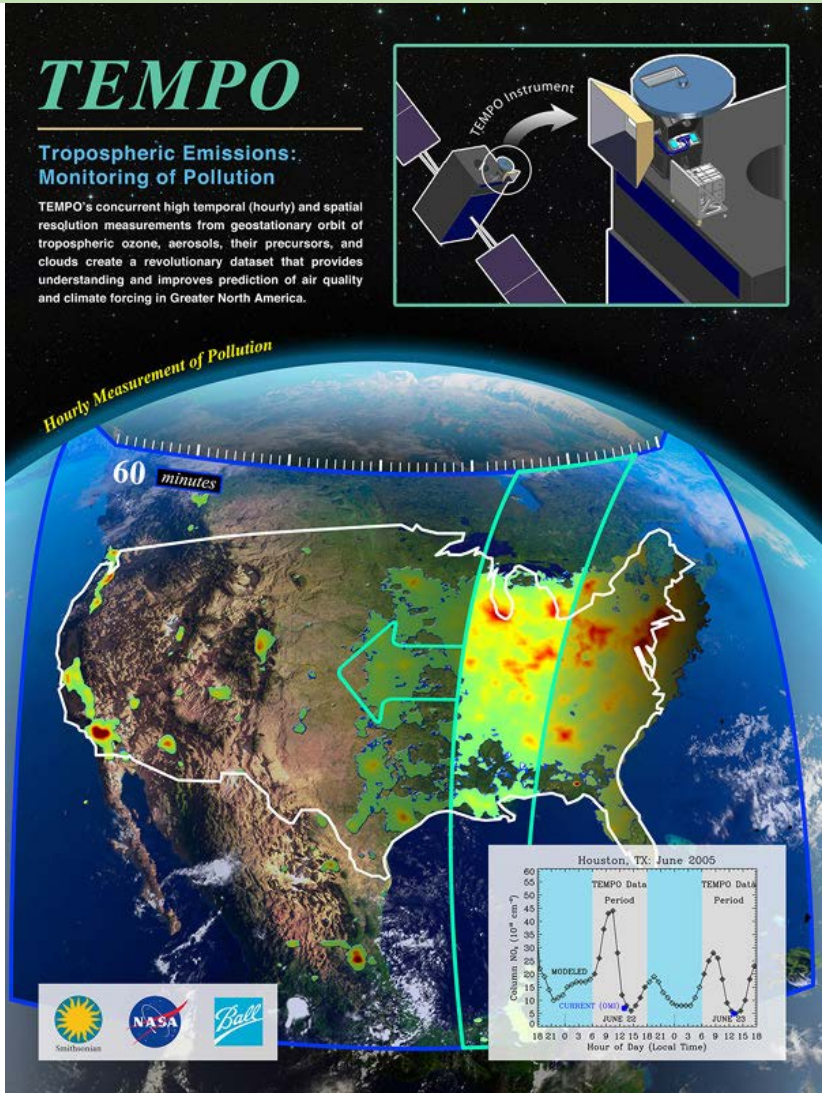


Figure 1: TEMPO concept of operations, via [NASA Langley Research Center (LaRC) TEMPO]

Objectives

Once **TEMPO** is operating, it is essential to perform *Green Paper Experiments* to validate TEMPO retrievals. **NASA's Tropospheric Ozone LiDAR Network (TOLNet)** is responsible for validating TEMPO's ozone retrieval product. TOLNet, using ozone LiDARs, aircraft, drones, profilers, and ground-based measurements, will provide time/height ozone measurements from near the surface to the top of the troposphere to describe in high-fidelity their spatio-temporal distribution. These high-fidelity measurements will provide the TEMPO science team with accurate representations of the PBL and FT ozone to assess retrieval performance.

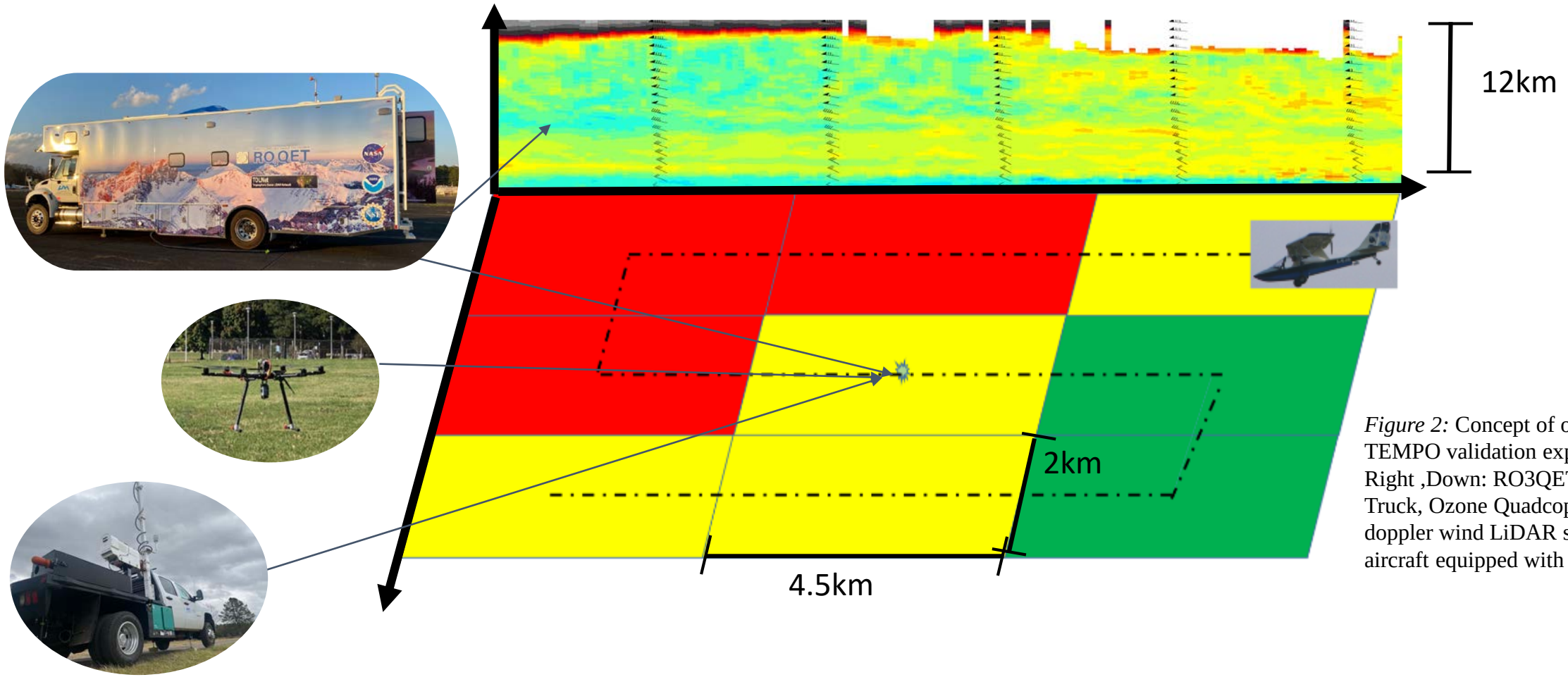
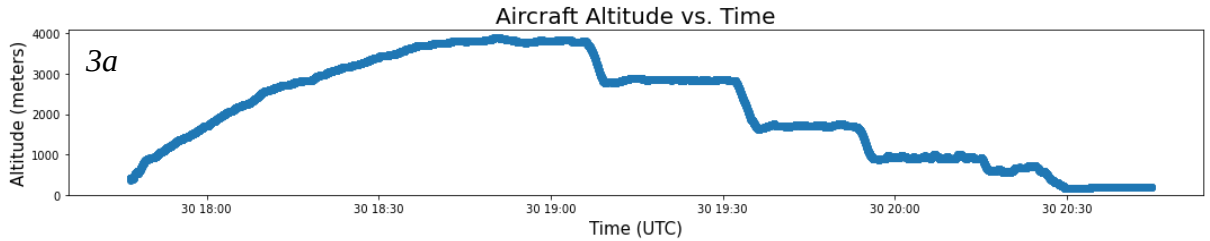


Figure 2: Concept of operations for a TEMPO validation experiment. Left to Right ,Down: RO3QET Ozone LiDAR Truck, Ozone Quadcopter drone, MODLS doppler wind LiDAR system, Searey aircraft equipped with air quality sensors.

Primary Experiments

Figure 3: Searey Aircraft with the RO3QET Ozone LiDAR.



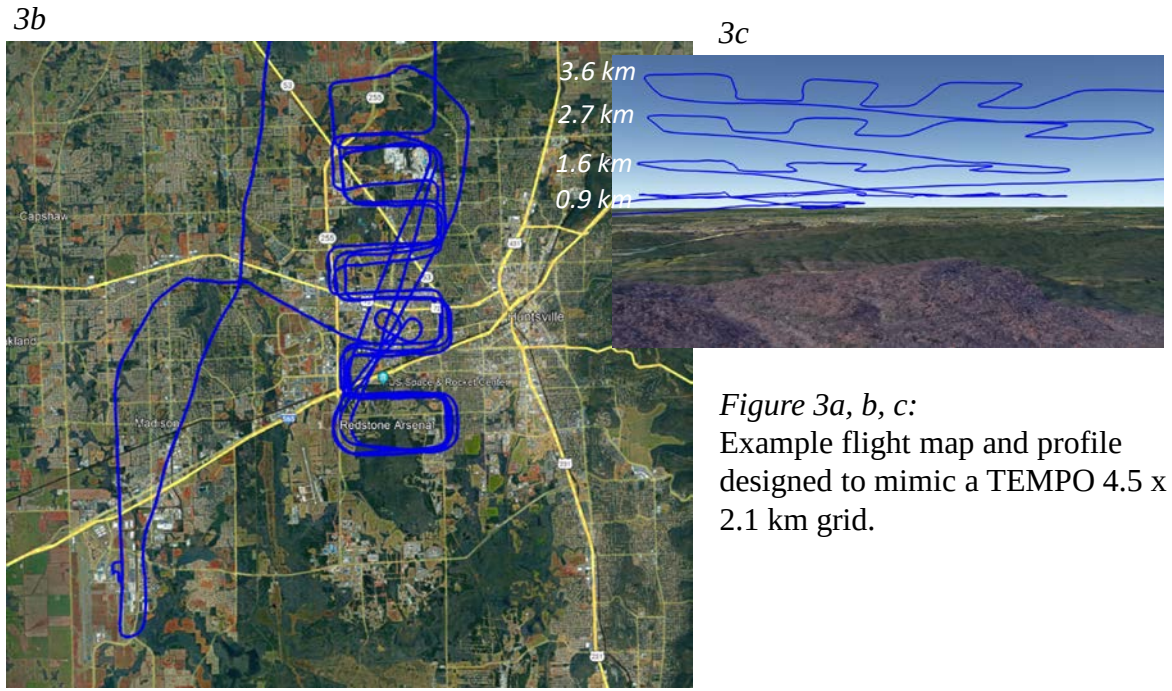


Figure 3a, b, c:
Example flight map and profile designed to mimic a TEMPO 4.5 x 2.1 km grid.

In conjunction with the **RO3QET Ozone LiDAR, airborne observations** are made to characterize ozone in the PBL (0 - 2 km). Judicious location of the flight pattern relative to the prevailing winds allow the time-altitude measurements of the lidar and aircraft to provide exquisite detail of the PBL ozone that will be observed by **TEMPO.**

Preliminary Results from 5/30/2022 Operations

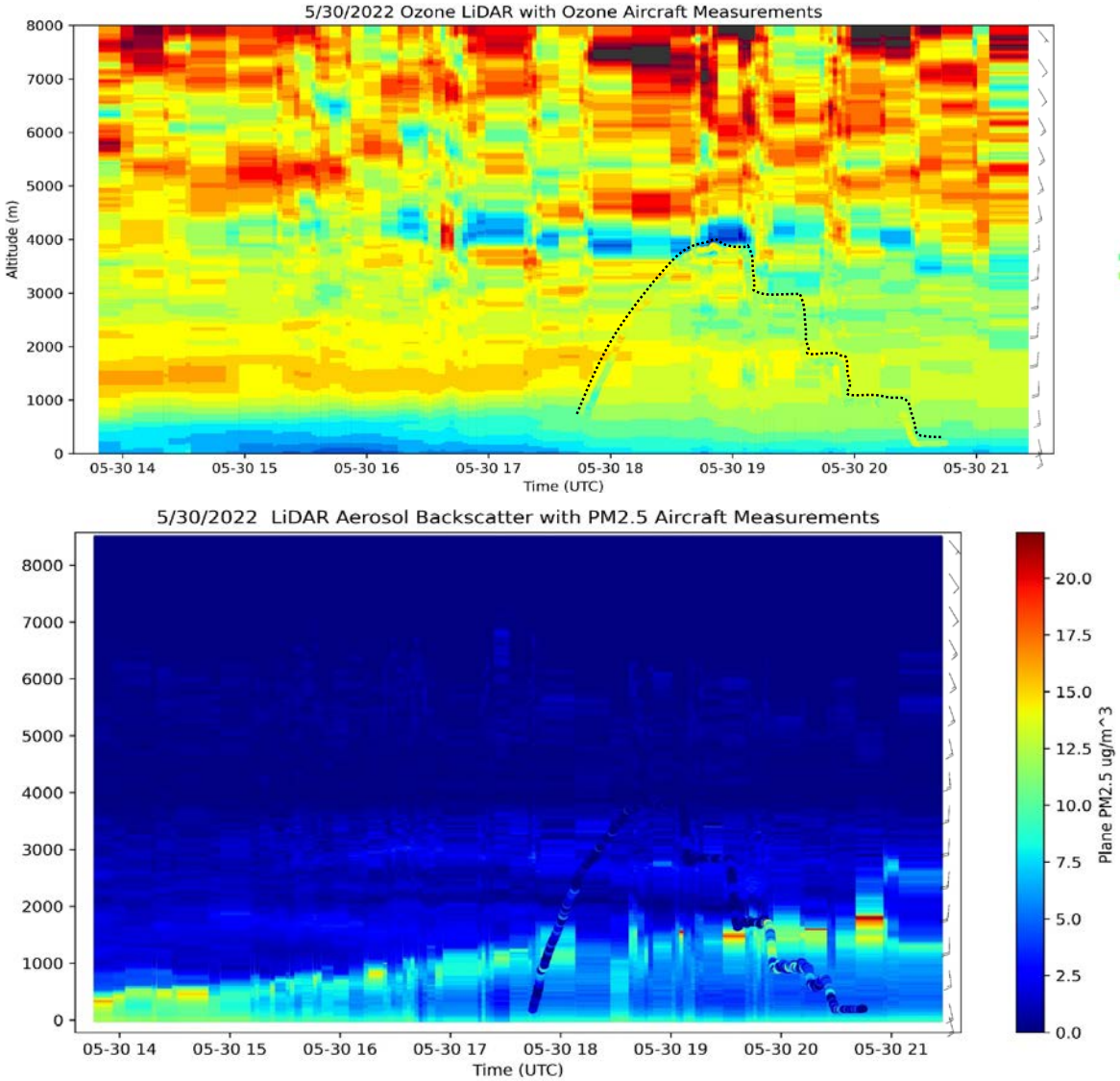
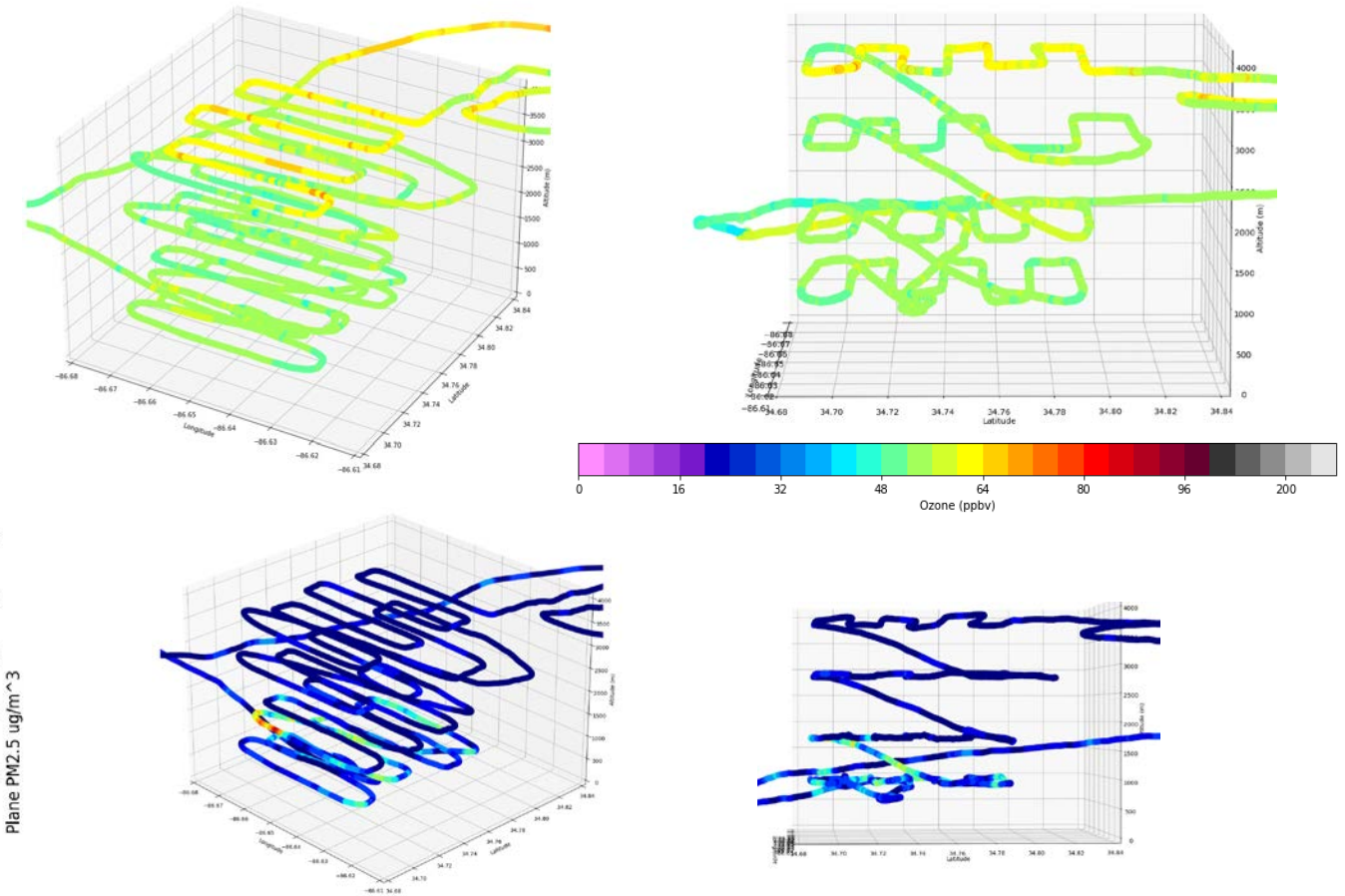


Figure 4: Altitude vs. time Ozone and Aerosol Backscatter LiDAR curtains. Flight data is plotted on top of curtain time series.



Visualizing 3D flight grids with **Ozone and PM2.5** measurements shows small scale **spatial/temporal gradients** present in both the lower and upper PBL. These types of observations will be used to characterize the accuracy and precision of TEMPO observations and if sub-pixel detail is captured.

Preliminary Results from 9/24/2021 Flight Operations

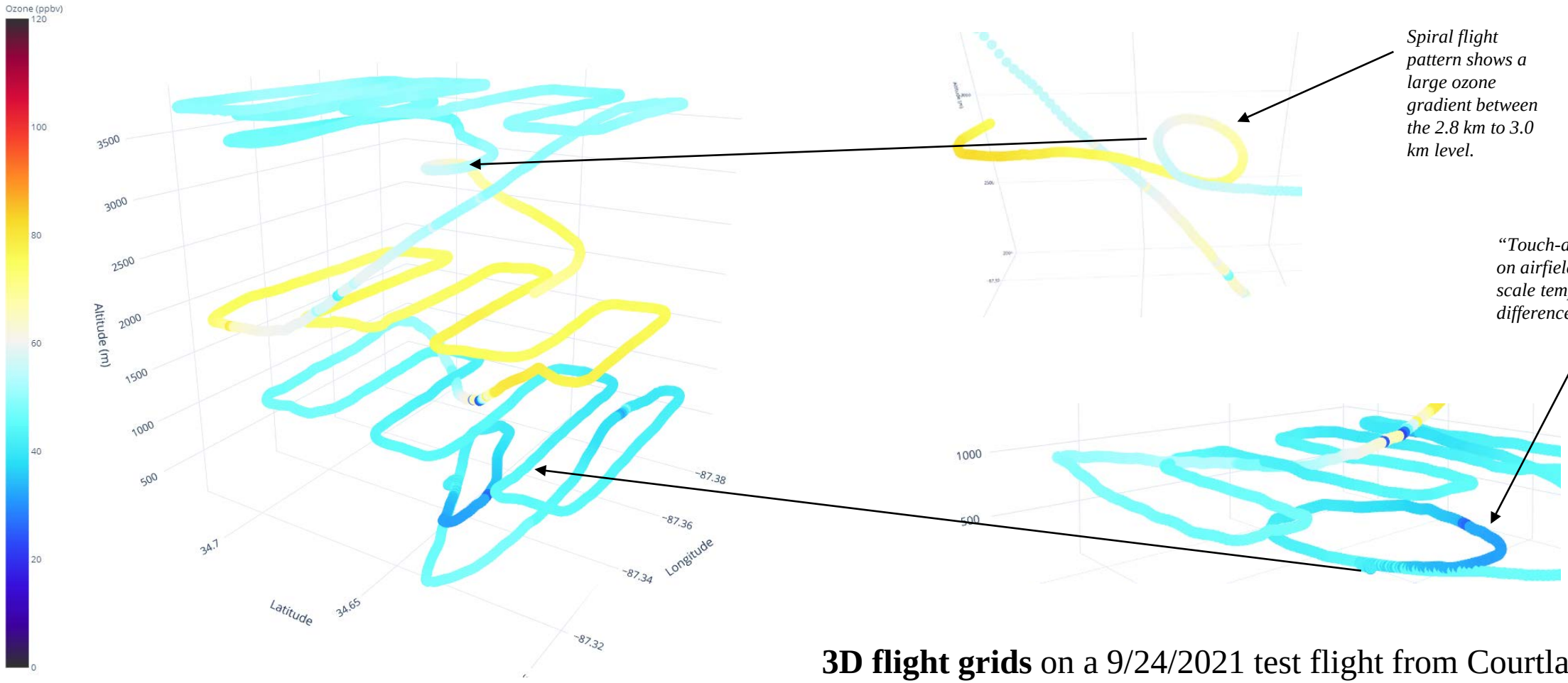


Figure 5: Test flight of the Searey Aircraft over Courtland, Alabama, with ozone data.

3D flight grids on a 9/24/2021 test flight from Courtland, Alabama, shows fine scale ozone structures between three separate1 km levels. Spiral and Touch-and-Go flight patterns reveal **unique surface and PBL ozone gradients.**

Preliminary Results from Drone Operations

Suburban Ozone - Drone Profiles below 100 meters AGL

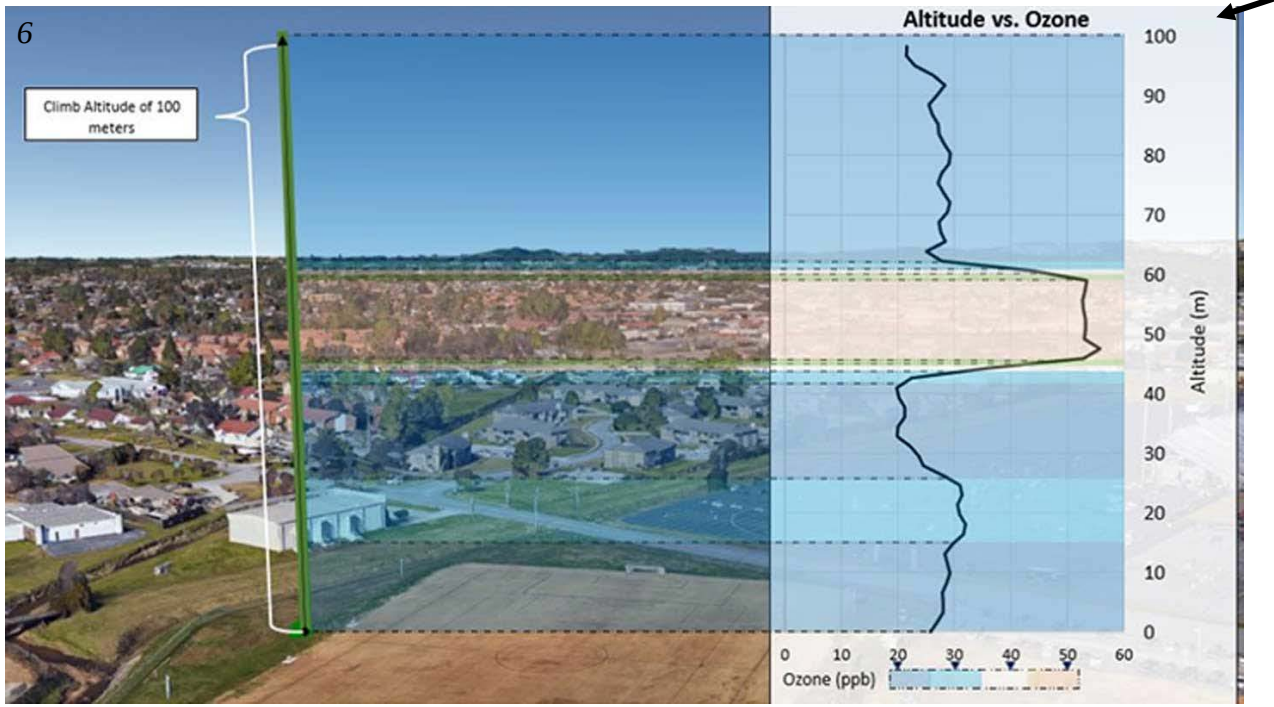


Figure 6: Test flight of the Deep Breath platform on February 23, 2021, shows fine scale PBL ozone 50 meters AGL in Huntsville, Alabama.

Figure 7a, 7b: a) Deep Breath performing it's first test flight at the University of Alabama in Huntsville. b) Casey Calamaio (yellow vest) provides Dr. Susan Alexander with drone operations and safety procedures.

The **Deep Breath drone platform** will produce measurements of boundary-layer ozone for future TEMPO validation and health impact studies. The drone can provide **both horizonal and vertical** profiles in the boundary-layer at 2 second measurement intervals. This platform will provide measurements of the PBL ozone where LiDAR and aircraft data collection is sparse.

Conclusions

TOLNet will continue to operate to support NASA/TEMPO/EPA/NOAA air-quality objectives, and will activity engage with the research community with the data obtained by **ozone and aerosol lidars.**