Rocket Plume Sampling using a Balloon Deployed Unmanned Aerial Vehicle

[1]Ronald Fevig, [1]David Delene, [2]Ismail Gultepe, [3]Nick Craine and [3]Gary Pundsack

[1]University of North Dakota; [2]Environment and Climate Change (ECCC) and Ontario Tech University, [3]Stratodynamics Aviation Inc.

Motivation

The steadily rising frequency of worldwide rocket launches has resulted in new concerns about potential environmental and climate impacts. Addressing these concerns requires in-situ observations in the upper troposphere and lower stratosphere to advance our scientific understanding. There are now proven platforms for deploying these miniaturized instruments, such as high-altitude balloons, unmanned aerial vehicles (UAVs), and stratospheric gliders that can deploy instruments up to 30 km.

Instruments

The weight and size of instruments has greatly reduced over the last decade, enabling deployment on smaller platforms.

Image showing Imet-XQ2 that measure temperature, relative humidity, pressure, and GPS position. The size is 3.25 x 2.25 x 0.875 inch and weight is 60 g.

Image showing Mini-OFS that visibility. The Mini0OFS has a size of 1.75 x 2.81 x 1.625 inch and weight of 170 g.

Image showing the Brechtel Miniature Optical Particle Counter (mOPC) that rapidly measures the aerosol number size distributions. The mOPC size is 9.4 x 11.9 x 15.2 cm and weight is 1.0 kg.

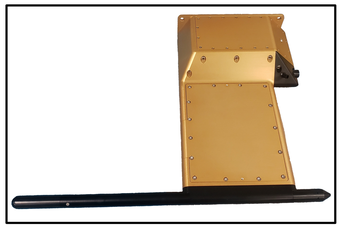
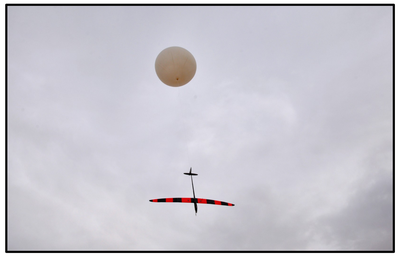
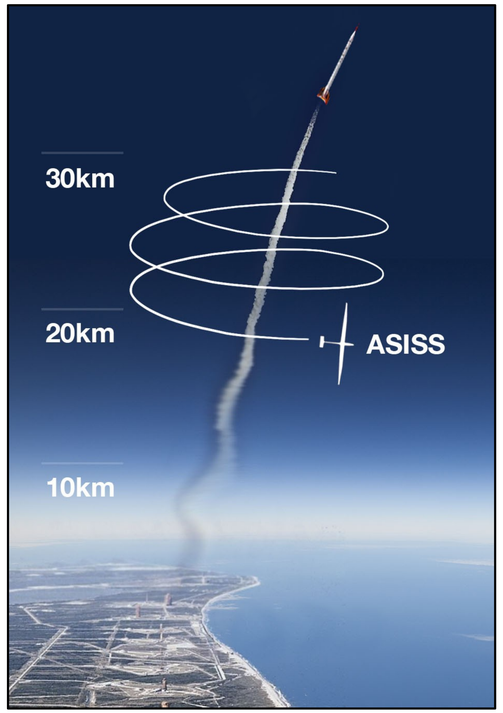


Image showing the Raindynamics 5 port gust probe system that measures atmospheric winds. The pitot tube is 39 cm, tip to tip. The housing is 27.3 x 7.6 cm and weigh is 1.4 kg.

Sampling Platform and Methodology

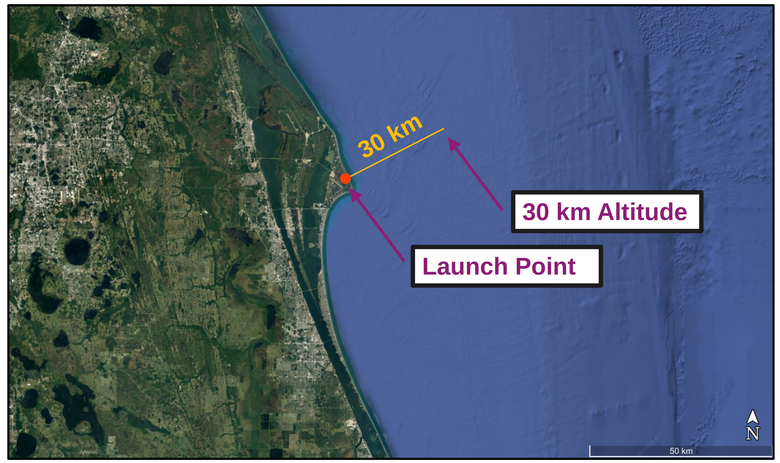
The UAV platform has proven effective at low (-60 °C) temperatures, in challenging (180 km/hr) wind conditions, and during high (9 G) maneuvering. A systems that combines the platforms with miniaturized instruments are able to conduct sampling up to 30 km. A field project is proposed to demonstrate that such an autonomous system can obtain stratospheric measurements of rocket plumes and measure meteorological conditions to evaluate pre- and post-rocket launch environments. An autonomous System for In-situ Stratospheric Sampling (ASISS) is a new, all-in-one instrument suite/platform for observing atmospheric state parameters, aerosols and ice particles.





Field Operations and Objectives

A field project is planned to demonstrate that an autonomous system can obtain stratospheric measurements of rocket plumes. The 3-week project is planned for Cape Canaveral with a 3-4 scientists, instrumentation personnel and a 3-person crew from the flight platform provider.



Conclusions and Future Work

- New observation methods and sensors are needed at extreme weather conditions to constrain models on environmental impacts; otherwise, regulatory agencies will continue to rely on limited model simulations, negatively impacting space commerce.
- The proposed campaign directly addresses these concerns offering a new data set that will enable responsible stewardship in the context of the high-volume rocket launch tempo of the new space economy.