# The Eastern Michigan University Eclipse Ballooning Missions

Rosalyn Friend, Hannah Popofski, David Pawlowski, Thomas Kovacs
Eastern Michigan University

## Introduction

The Eastern Michigan University Atmospheric Physics EXploration (EMU APEX) team recently launched high altitude weather balloons near Los Lunas, NM and Lima, OH during two recent solar eclipses as part of the Nationwide Eclipse Ballooning Project (NEBP). During the missions, one on October 14, 2023 and the other on April 8, 2024, a scientific payload was flown to an altitude of approximately 90,000 feet with the goals being to flight test new hardware, observe atmospheric dynamics during eclipses, and to attempt to detect atmospheric gravity waves. Ultimately, EMU APEX aims to be able to conduct repeatable ballooning missions with altitude and speed control using a modified version of the NEBP vent system so that the payload can be used to study atmospheric dynamics in difficult to observe regions.

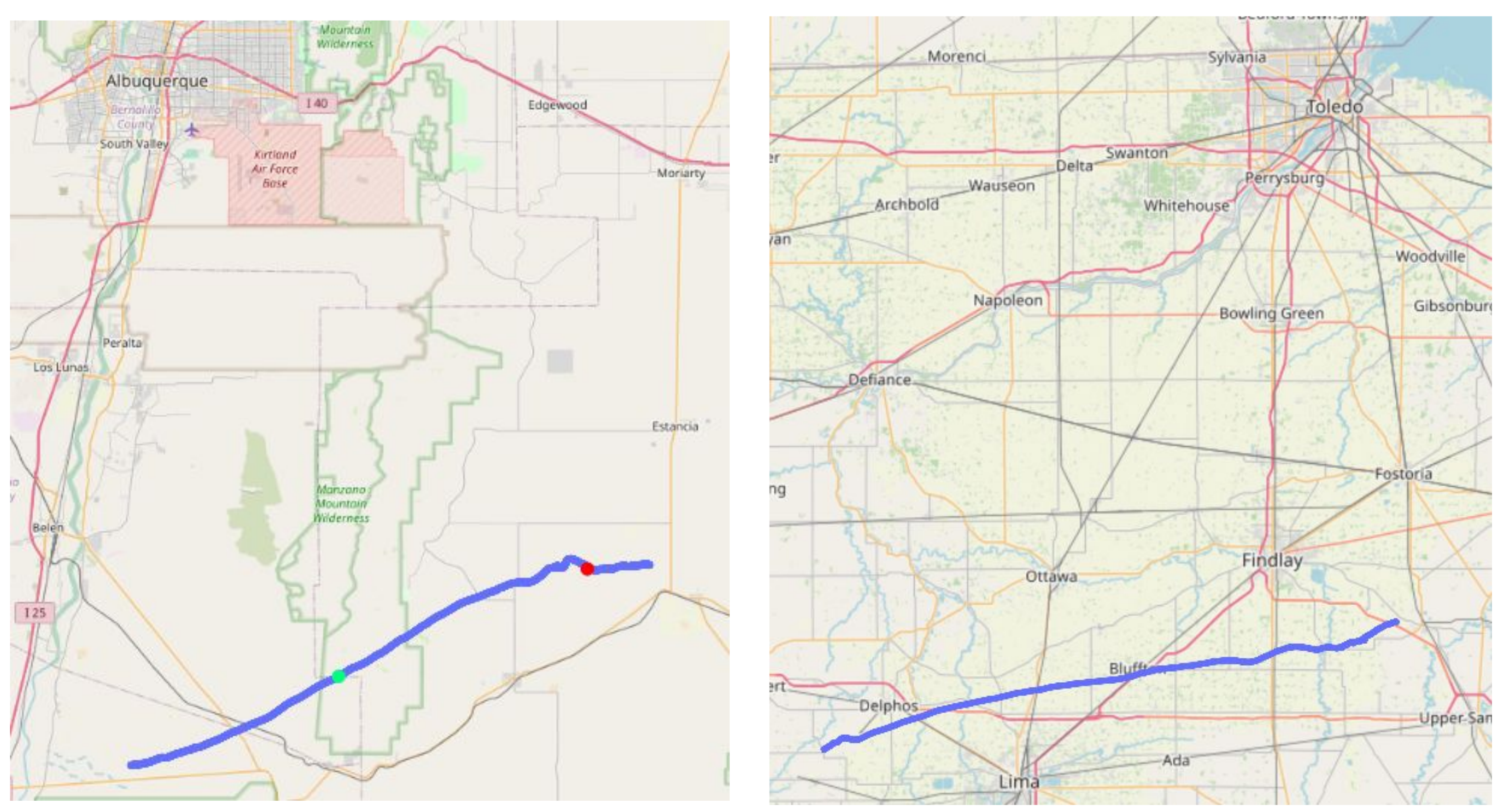

Figure 1. Ascent ground track for the October 14, 2023 launch (left) near Los Lunas, NM and April 8, 2024 launch (right) near Lima, OH. The green and red markers for the NM flight indicate the approximate start and end points of the observed intense vertical winds.

## Observations

Data was collected by several payload systems attached to the balloon. Temperature, pressure, and velocity data was collected by the PTERODACTYL Flight Computer and the RFD900 data logger. Additionally, a cosmic ray detector based off of the Cosmic Watch project was flown (http://www.cosmicwatch.lns.mit.edu/).

During the October 2023 launch, substantial vertical stratospheric winds were observed (Figure 1) due to upwelling caused by the topology associated with the mountain range east of Los Lunas, NM

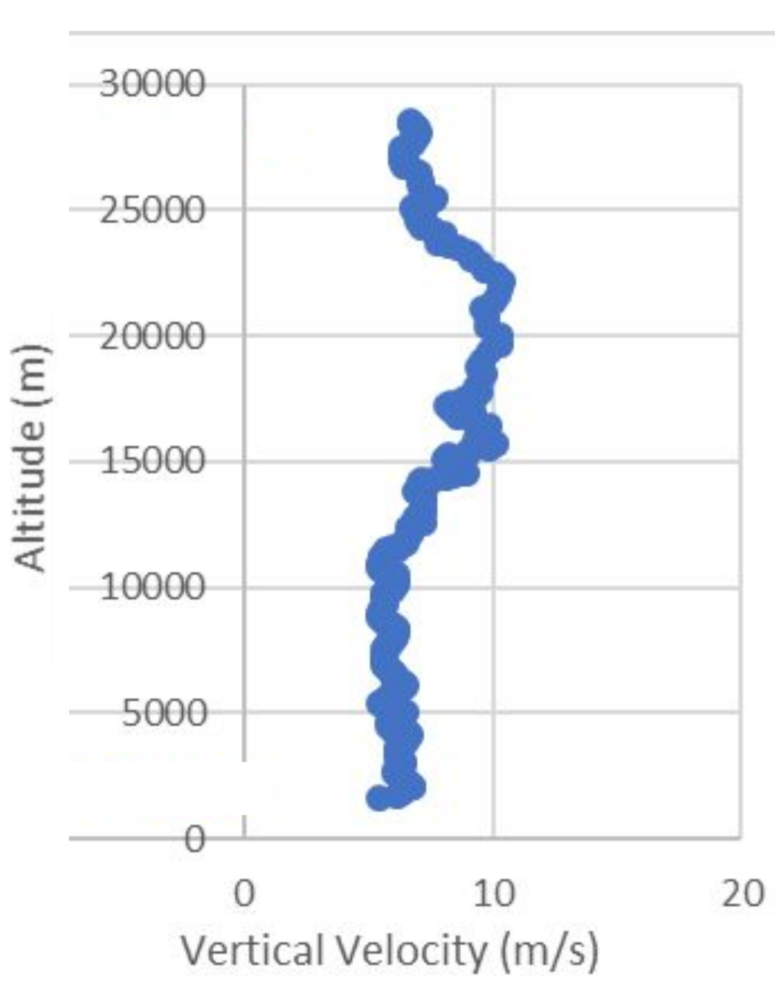


Figure 1. ~1 minute smoothed vertical velocities during the October 14, 2023 flight.

## The Vent

- The NEBP provided vent system attaches directly to the balloon and can receive commands from the ground station via the Iridium Satellite Network.
- It houses the Flight Termination Unit (FTU) which cuts the payload system free of the balloon when the cutdown command is sent or after 5 hours have passed since FTU power on.
- Houses a servo which opens and closes the plunger allowing the balloon to float at a target altitude.

## Vent Improvements

The vent was redesigned after the October 14th mission. In this new version of the vent, the base of the neck was beveled to increase its strength. Additionally, a flow meter was installed next to the vent plunger with flow rates stored to an independent SD card. EMU APEX plans to integrate the flow meter into the current vent design to collect additional data on the outflow rate during flight.

## Vent Performance

During the October 14th eclipse, the vent sheared at the base of the neck during the descent. This was potentially due to microfractures within the vent coupled with the cold stratospheric temperatures. The improved vent design was flown during the April 2024 event and was recovered in tact. However, the flow meter experienced power issues during the ascent and did not record valid data.

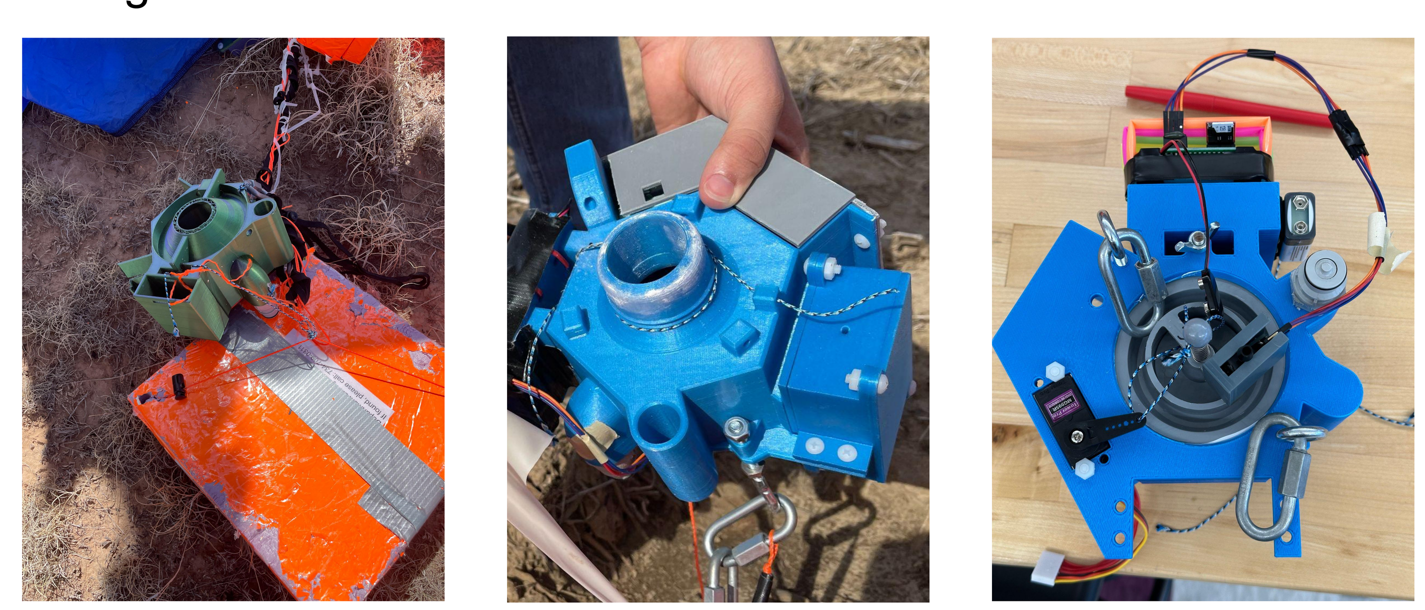

Figure 2. The original vent (left) is shown at the recovery site following the October 2023 flight. The neck has been sheared off at its base (and is missing). The EMU APEX modified design (middle and right) was flown during the April 2024 event. The flow meter housing can be seen partially obscuring the plunger in the right image with the electronics towards the top of the image.

Acknowledgements
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## Atmospheric Gravity Wave Observations

RFD and PTERODACTYL data from both the New Mexico and Ohio flights were analyzed for evidence of gravity waves. To do this, a polynomial fit was applied to the raw velocity observations in order to calculate the altitude-based velocity perturbations. A bandpass filter was then applied to filter out frequencies that are outside the known range of gravity waves. Then, other signals with known frequencies (e.g. Brunt–Väisälä) were also removed. Based on the filtered velocity perturbations, we found evidence of two gravity waves, one during each flight. The gravity wave that was observed during the 2023 annular eclipse in New Mexico is thought to have been caused by local topography. The origin of the Ohio observation is unclear.

New Mexico 2023 | Ohio 2024

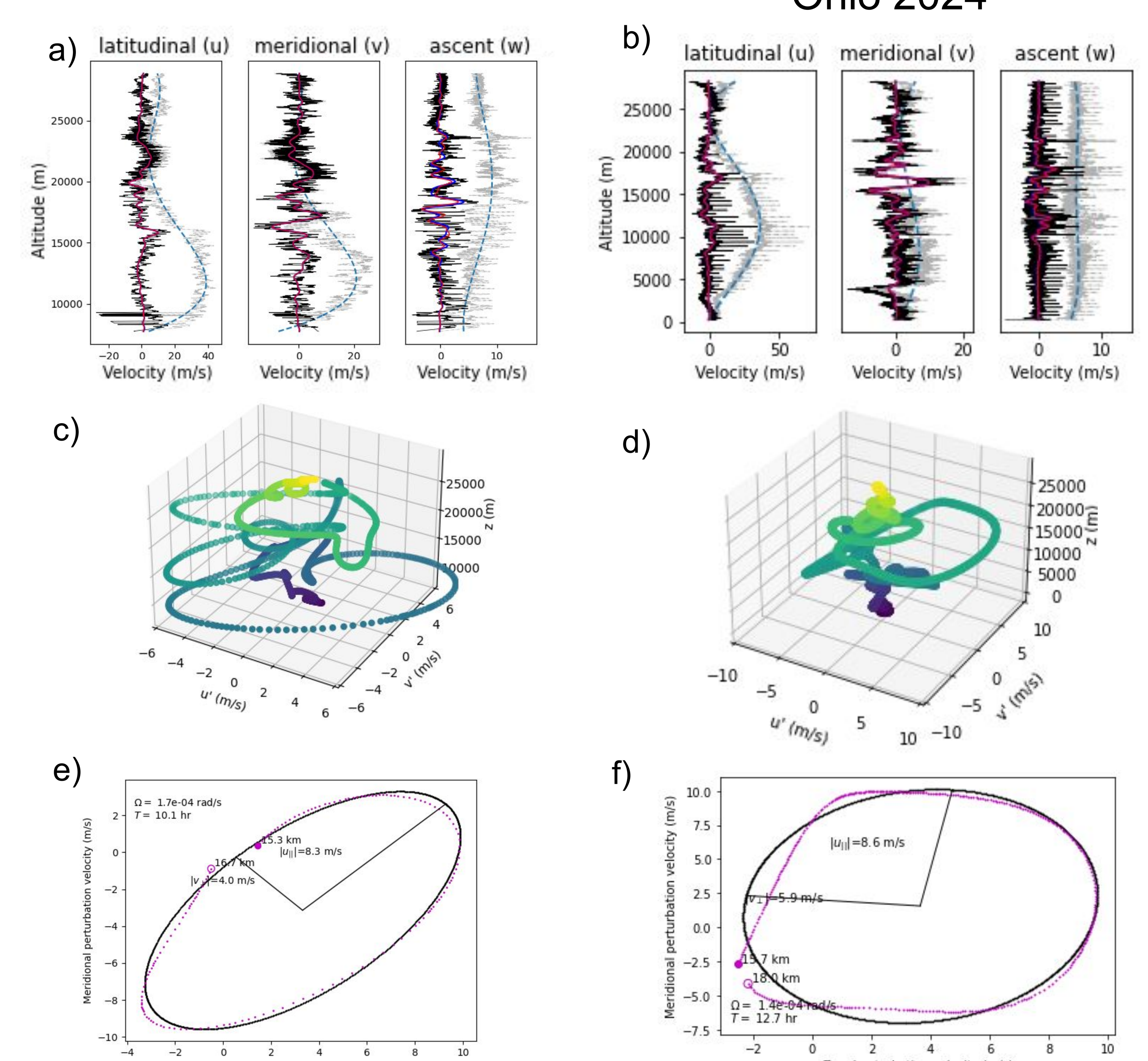


Figure 3. In a) and b), latitudinal, meridional, and ascent velocity are plotted as a function of altitude for the New Mexico and Ohio flights, respectively. The raw data (grey line), polynomial fit (blue dashed line), resulting velocity perturbations (black line) and filtered perturbations (red line) are all shown. In c) and d), the hodographs show where the largest elliptical velocity perturbations occurred for the New Mexico and Ohio flights, respectively. In e), a slice was taken of the largest velocity perturbations from the New Mexico flight (between 13 and 16 km) and fitted with an ellipse. The gravity wave corresponding to this ellipse has an intrinsic frequency of 0.00017 rad/s and a period of 10.1 hrs. In f), a slice was taken of the largest velocity perturbations from the Ohio flight (between 15.7 and 18 km) and fitted with an ellipse. The gravity wave corresponding to this ellipse has an intrinsic frequency of 0.00014 rad/s and a period of 12.7 hrs.