# A new OH airglow imager at the Poker Flat Research Range for the study of gravity waves, instabilities and breaking

Jessica Berkheimer[1], Katrina Bossert[1], P. Dominque[2]
[1]School of Earth and Space Exploration, Arizona State University, [2]Center for Atmospheric Space Sciences, Utah State University

## Introduction

Gravity waves transport momentum throughout the atmosphere, cause drag on background mean winds and generate turbulence when breaking, and perturb densities, temperatures, and winds well into the thermosphere where satellites orbit. The momentum transport by gravity waves is of great importance to the atmospheric circulation, structure, and variability, especially in the middle atmosphere. Gravity waves are poorly resolved in many circulation models in the lower atmosphere and smaller horizontal scales are not accounted for at all in thermosphere models. Moreover, observations of gravity waves are critical for better constraining gravity wave drag parameterizations implemented in numerical weather prediction and climate models. This research aims to analyze and report on gravity wave events that take place over the Arctic region.

## Study Location

Poker Flat Research Range (PFRR) is a launch facility and rocket range for sounding rockets in the U.S. state of Alaska, located about 30 miles (50 km) northeast of Fairbanks and 1.5 degrees south of the Arctic Circle.


## Equipment

The study uses an OH airglow imager which views the near-infrared emission from 900 to 1700 nm, overlapping the OH Meinel bands. The imager resolves small-scale gravity waves, breaking, and instabilities near ~86km. The camera lens is equipped with a 185-degree field-of-view fisheye lens for whole-sky imaging. This imaging format has the advantage of viewing wave structure in mesospheric airglow emissions over a geographic region up to 1,000,000 $km^2$

## Methodology

Figure 1. 256 x 320-pixel resolution all-sky image showing short-period gravity wave structure in the OH Meinel Band airglow emission. The fisheye lens causes distortion moving away from zenith and the view becomes compressed towards the horizon.

Fig 1.

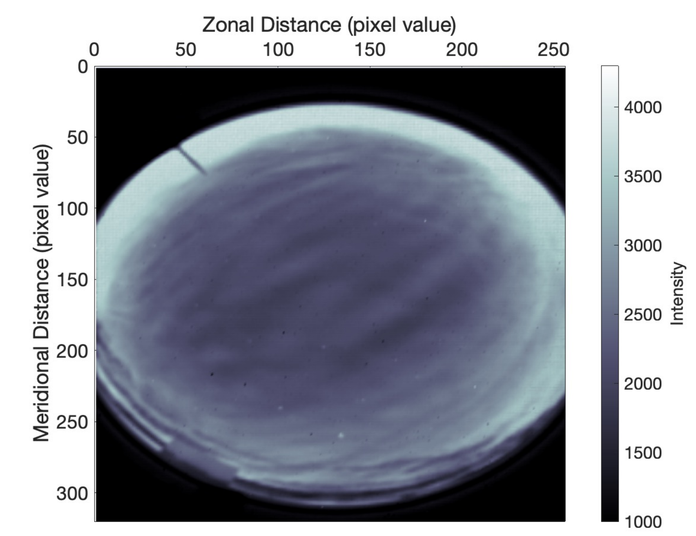



Figure 2. Following the methods of Garcia F. J. et al. 1997, we unwarp the image by interpolating pixel values onto a geographic grid.

Fig 2.

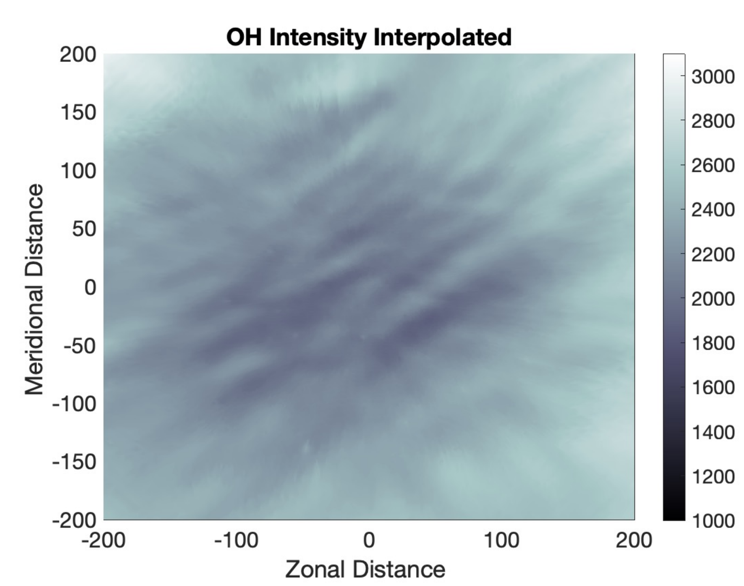
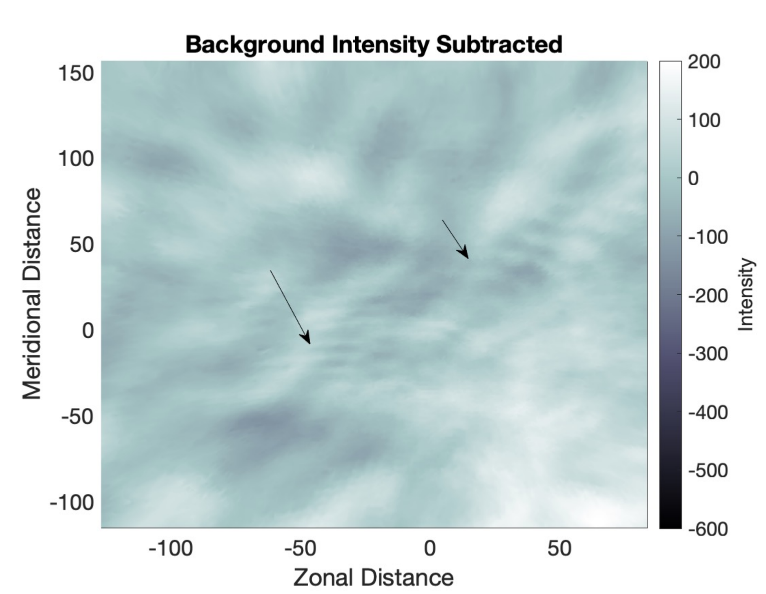



Figure 3. By averaging the background intensity of multiple images and then subtracting them, we identify features such as Kelvin-Helmholtz instabilities.

Fig 3.




## Results

Figure 4. We take a closer look at the events taking place on the night of February 2-3, 2022, and perform an analysis of dynamics in the OH Meinel Band airglow emission. Keograms from a sequence of individual images captured during the night yields periodic wave activity. We also can identify instabilities, and auroral activity. The keogram is created by extracting vertical pixel columns from individual all-sky images and plotting the columns side by side. The horizontal axis is the time, and the vertical axis is the geographical latitude.

Fig 4.

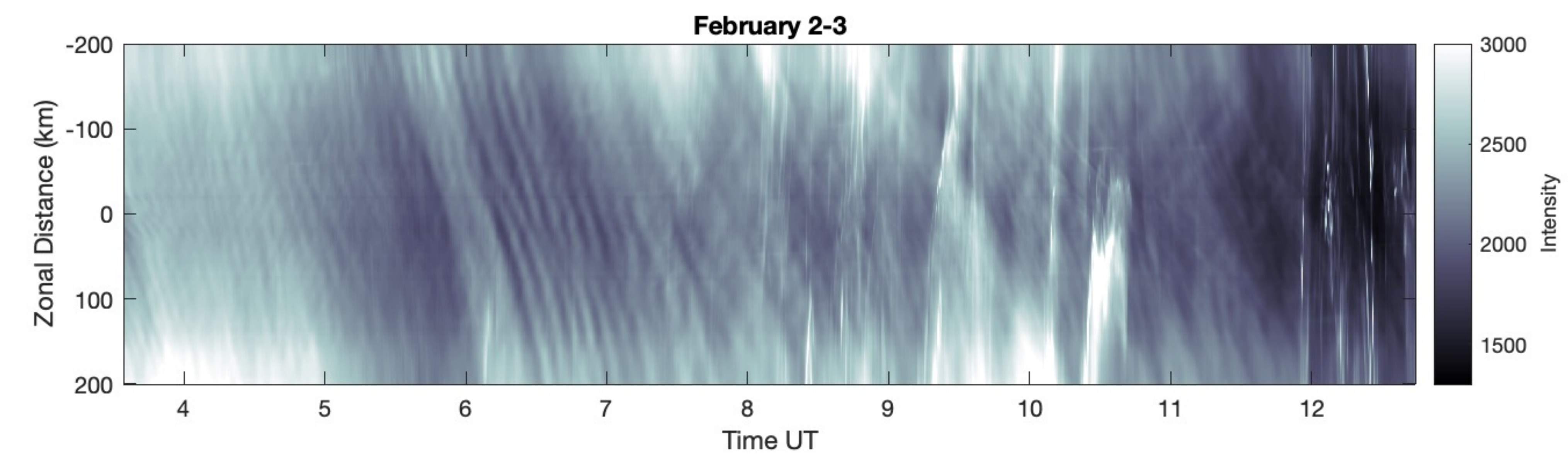
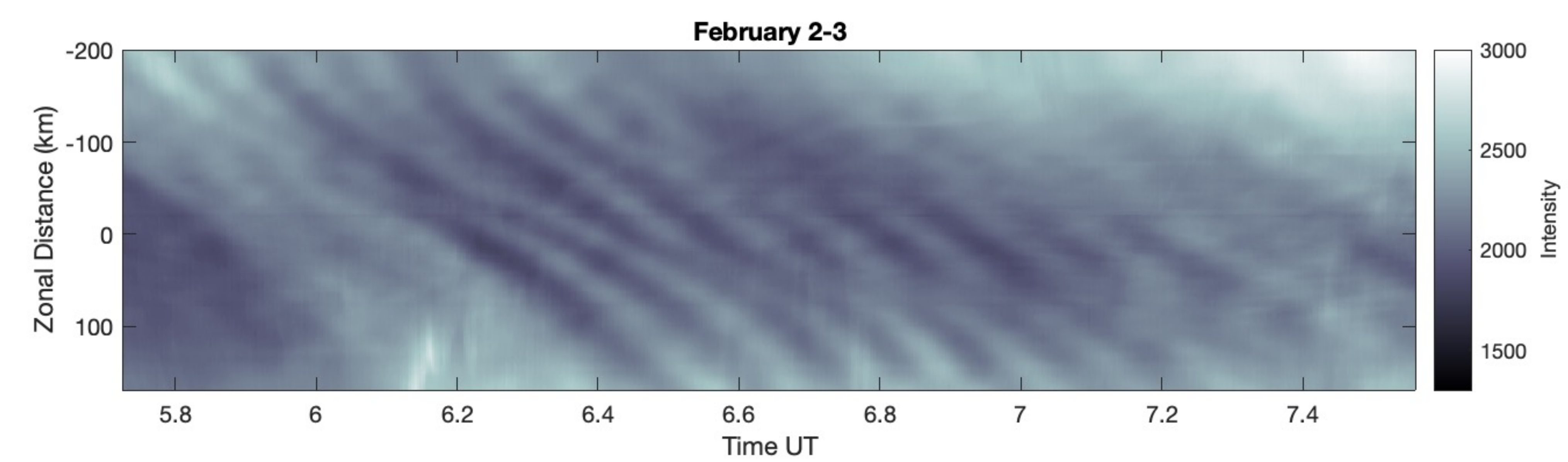



Figure 5. Gravity waves occurring at UT ~6.3472 - 7.4556 and propagating in the southeastward direction with a wave period approximately every 6 minutes.

Fig 5.




## Conclusion

There are many open questions regarding the fundamental dynamics of gravity waves, namely their genesis, maintenance, propagation and breaking, as well as the interaction of gravity waves with boundary layer processes, larger-scale waves and the mean flow. This study plans to use future OH Meinel Band airglow emission data with lidar data and RADAR data. We will compare sodium densities, winds, and temperatures to future analyze dynamics of waves and instabilities observed in the airglow.

## Acknowledgements

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## Contact Information

Jessica Berkheimer
Email: jberkhei@asu.edu