Medium-Scale Traveling Atmospheric Disturbances Observed Over Bear Lake, Utah

USU's Student Collaboration Team for NASA's Atmospheric Waves Experiment

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Introduction and Background

As a part of NASA's AWE (Atmospheric Waves Experiment) Mission, headquartered at Utah State University (USU) and the Space Dynamics Laboratory, the Student Collaboration team at USU operates an all-sky imager (Fig. 2), located at the Bear Lake Observatory (BLO) (Fig. 1).

By measuring the airglow of atomic oxygen, the imager can detect waves that travel at an altitude of 250 km named medium-scale traveling atmospheric disturbances (MSTADs, Hunsuker et al., 1982) (Fig. 3).

In this study, we analyzed clear nights from August 2024 through May 2026 and observed 23 distinct MSTAD events in that period.

Bear Lake Observatory

Fig. 1: USU's Bear Lake Observatory (BLO)

Methods

Raw images (Fig. 3) taken by the imager (Fig. 2) underwent processing to remove background stars, to correct for distortions due to the fish-eye lens, and to project images on a linear grid. The five central rows and columns of each image were collated to create North-South and East-West keograms (Fig. 4) that are used to measure the direction and period of the disturbances (Eather and Mende, 1981; Martinis et al., 2019).

To assist in visualizing the data, three rows were taken from each of the keograms (zenith and 250 km in each direction) and were plotted after undergoing filtering to remove noise. This produced the filtered cross-section plots used for analysis (Fig. 4).

Fig. 2: The all-sky imager is filtered around 630 nm to measure the nighttime atomic oxygen emission originating from 250 km altitude in the ionosphere.

Raw Image

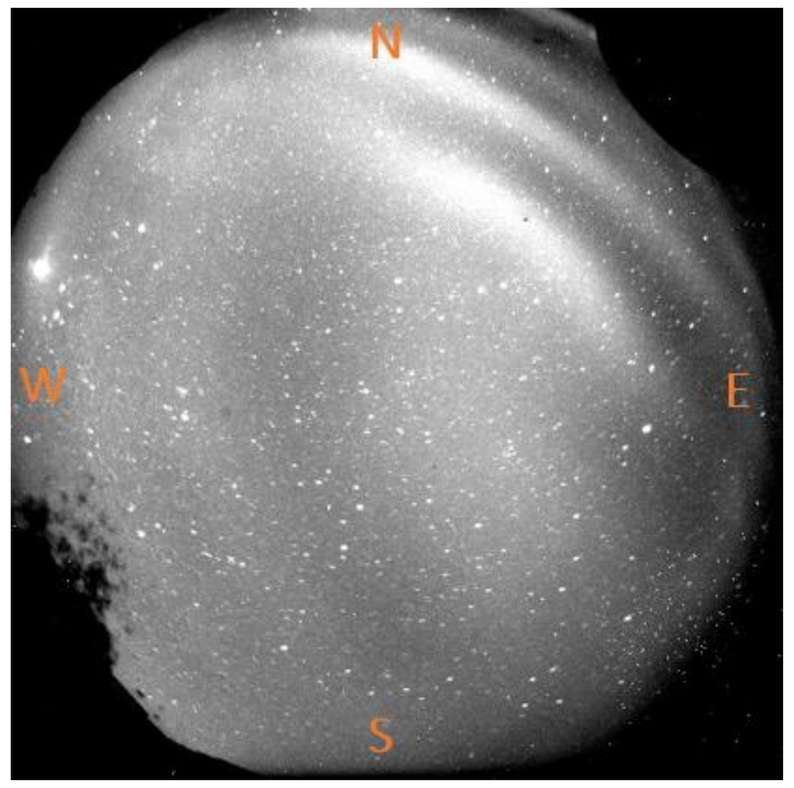

Fig. 3: Image of the night sky showing a MSTAD (top-right corner) captured at the Bear Lake Observatory, using the all-sky imager.

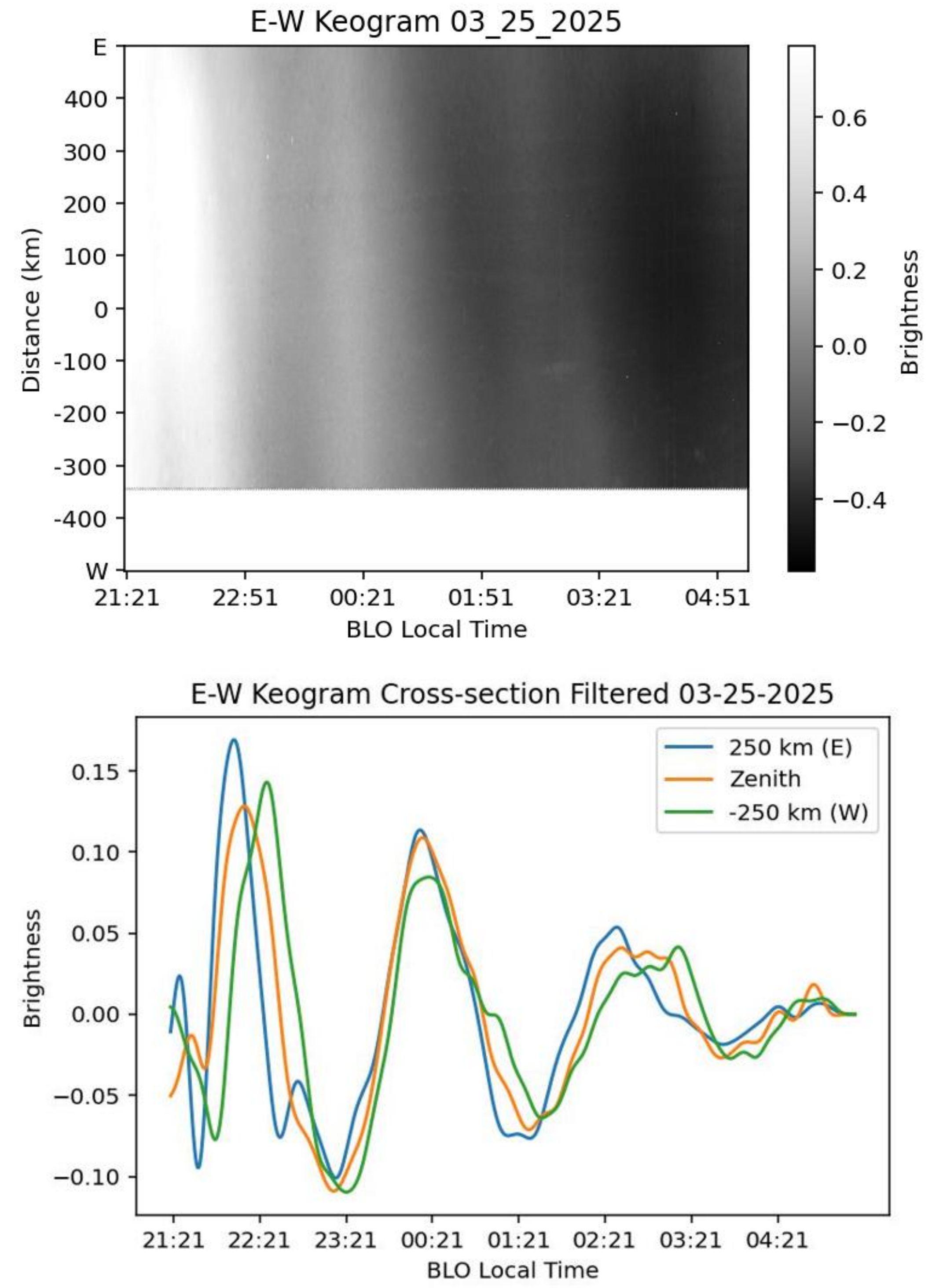

Fig. 4: East-West keogram and filtered cross-section plot for a MSTAD observed on March 25, 2025.

Results and Future Work

A total of 23 MSTADs were observed from August 2024 through May 2026. The properties of each of the 23 observed MSTADs are given in the table below. The average period of the MSTADs is about 1.5 hours. The directional distribution of the MSTADs is: 5 west, 16 northwest, 1 east, and 1 unclear. This shows a clear westward trend in the movement of the disturbances, with most of the events propagating in the West or Northwest direction. The seasonal distribution of the events over the 22-month period is: 12 Spring, 2 Summer, 7 Fall, and 2 Winter. Inclement weather severely limited the amount of good data that could be collected during the winter, and only one summer season is included in the dataset.

A geomagnetic storm is indicated by a KP-index of 5 or higher; however, none of the observed events occurred during a period when the average KP-index was greater than 5 (Matzka et al., 2021). These results indicate that most of the events were likely driven by processes other than solar activity.

This dataset is now ready for further comparisons with other datasets collected by different instruments. Future work will involve comparisons of these MSTAD observations with the AWE dataset in order to better understand the connection between mesospheric gravity waves at ~85 km and MSTADs at 250 km.

Summary of MSTAD Events

Date	Period (hours)	Direction	Average KP-Index
2024			
Aug 31-01	~2	W	2.444
Sep 04-05	~2	W	1
Sep 30-01	~1	E	1.333
Oct 01-02	~1.75	NW	1.556
Oct 06-07	~1.75	NW	4.333
Nov 03-04	~1.5	W	3.111
Nov 30-01	~2	NW	1.222
2025			
Mar 24-25	~2	NW	2.667
Mar 25-26	~2	NW	3.333
Apr 21-22	~1.5	NW	2.556
Apr 30-01	~1.5	NW	3.889
May 01-02	~1.5	NW	4.444

Date	Period (hours)	Direction	Average KP-Index
2025			
May 02-03	~0.75	NW	4.222
May 18-19	~1.5	NW	2
May 20-21	~1.25	W	3
Jul 05-06	~0.75	Unclear	3.778
Oct 27-28	~2	W	2.889
2026			
Jan 15-16	~1.5	NW	3.222
Jan 16-17	~1	NW	3.444
Mar 10-11	~1.5	NW	2.445
Mar 11-12	~1.5	NW	1.555
May 15-16	~0.75	NW	4.333
May 19-20	~1.5	NW	1.556

Table 1: Summary of the 23 observed MSTAD Events. KP-index is averaged over 3-12 UT time.

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