The Midnight Temperature Maximum in the Mid-latitude NATION Network

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Introduction

The **North American Thermospheric Ionospheric Observing Network** (NATION) provides measurements of thermospheric winds, temperatures, and intensities over a mid-latitudinal region from 32 N to 42 N, which is about 1100 km in extent. It has five Fabry-Perot interferometers (FPI) operating since 2012 in the locations represented by stars in Figure 1/Table 1.

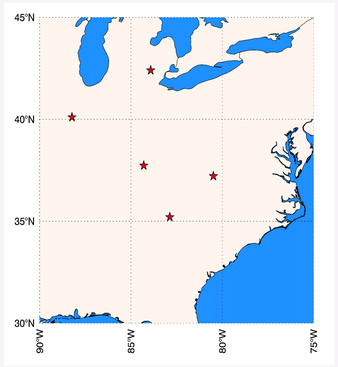

Figure 1: NATION sites.

Figure 3: FPI schematic.

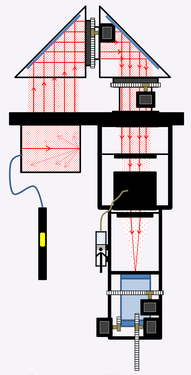

Figure 2: FPI laser calibration.

In this work we present a complete statistical view of the Midnight Temperature Maximum (MTM) over the NATION network as well as new techniques to analyze the MTM feature.

SITE		Latitude
PARI, NC	PAR	+35.2°
Virginia Tech, VI	VTI	+37.2°
Eastern KY Univ., KY	EKU	+37.8°
Urbana-Champaign, IL	UAO	+40.1°
Ann Arbor, MI	ANN	+42.3°

Table 1: NATION site name, abbreviation, plot color, and latitude, respectively.

The MTM Definition & BG Extraction

We define the MTM as an increase in the temperature (larger than 50 K as well as the measurements error) that starts after 1 UT and lasts longer than one hour, propagates northward and appears in at least 3 different positions.

To extract the thermal background we fit Equation 1 to the data without the MTM and subtract it from the data. The residual values are searched for the MTM peak.

$$T_{model}(LT) = a_0 + \sum_{k=1}^{3} a_i \cos\left[\frac{2\pi(LT - b_i)}{\tau_i}\right]; \tau_i[h] = [8,12,24]. \quad (1)$$

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Temperatures & Residuals

The temperature plots displayed in figures 4 and 5 illustrate results for the same night using two different approaches on determining the MTM peak amplitude.

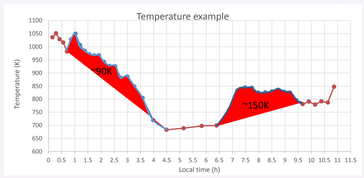

Figure 4: Typical MTM analysis.

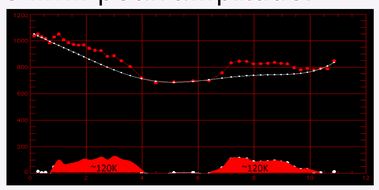

Figure 5: BG extraction.

Examples of Typical Behavior

QR1: Link to how to read Fig 6 & 7.

The following NATION plots represent examples of a typical MTM and NO MTM night. There is a clear displacement of the MTM peak from south to north and also seen is a significant variation with latitude in its amplitude.

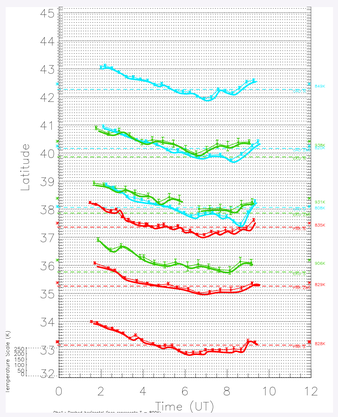

Figure 6: Typical NO MTM night (06/11/2013).

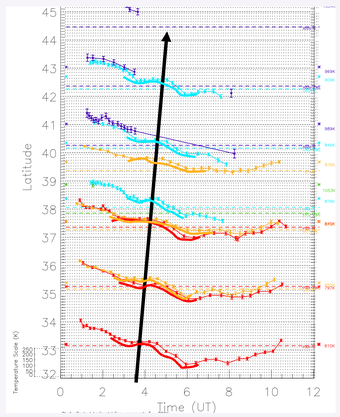

Figure 7: Typical MTM night (08/31/2013).

Figures 6 and 7 represent the typical NO MTM and MTM nights. The MTM night has a MTM peak with an amplitude of ~75K that is seen over 9 measurements from ~2.5 UT to ~4.5 UT.

MTM Statistics

Figures 8, 9 and 10 present results of a statistical analysis on the MTM amplitude and its seasonal variability.

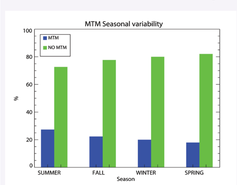

Figure 8: Seasonal variability.

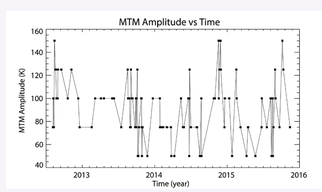

Figure 9: MTM Amplitude vs time.

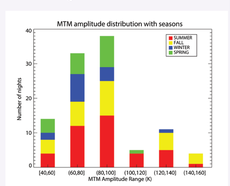

Figure 10: MTM amplitude distribution.

Tables 2 & 3 summarize the statistics with regard to the MTM start, end times, and the average amplitude.

AV START (LT)	AV END (LT)	AV # of AMP
2.8	7.4	90.6 K
STD START (LT)	STD END (LT)	STD OF AMP (K)
1.31	1.51	24.9

Table 2: MTM averages and standard deviations.

	MTM	NO MTM	MTM	NO MTM
SUMMER	41	109	27%	73%
FALL	29	101	22%	78%
WINTER	15	60	20%	80%
SPRING	21	96	18%	82%

Table 3: Number of MTM nights versus the season.

2D Temperature Interpolation

After the thermal background extraction we can spatially interpolate the residual temperature relative to the MTM peak. This requires the selection of a night with numerous measurements spread around the network observing region. The night of 2013/12/28 illustrates an example.

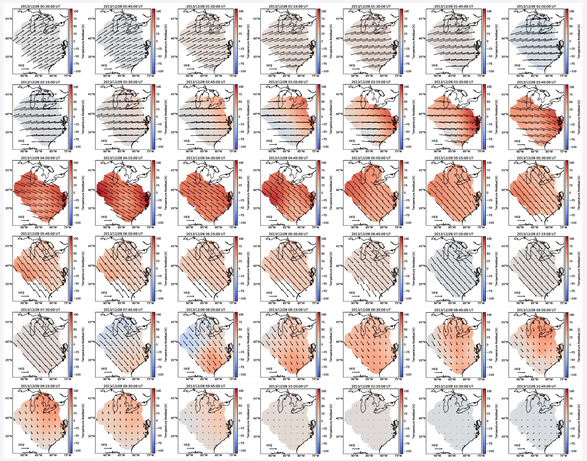

Figure 11: Evidence of the Double MTM peak in temperature

Conclusions

QR2: Link to *Akmaev* et al. *(2009)* double MTM in WAM.

- As shown by the results in figures 4 and 5, the algorithm is effective in detecting both MTM peaks [*Akmaev* et al. *(2009)*].
- The same figures also display different approaches with different results for the MTM amplitude.
- Figure 8 and table 3 show that MTM feature is more evident during the summer (27%) with its appearance less evident during the spring (18%).
- Even though the MTM appears more often during the summer, there is no strong relation between the seasonality and the MTM amplitude as shown by figures 9 and 10.
- Table 2 shows the average behavior of the MTM feature starting at 2.8UT and ending at 7.4UT showing an amplitude of 90.6K.
- Figure 11 shows the double MTM signature stronger early in the night.
- MTM structure is rather complicated for mid-latitude since the thermosphere winds are considerably influenced by the higher order components of the generating tidal forces from bellow.