Investigating Winter-time Mesospheric Gravity Waves Variations Observed at ALOMAR (69° N), Norway

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INTRODUCTION:

Atmospheric gravity waves propagate upwards, transporting energy and momentum from the troposphere into the mesosphere. This will effect the thermo-structure and general circulation of the mesosphere. The Advanced Mesospheric Temperature Mapper (AMTM), developed by Utah State University (USU), is designed to study the high latitude mesospheric dynamics by measuring the OH (3,1) band intensity and temperature. This project will use four years of mesospheric temperature measurements from ALOMAR (69°N) to investigate the intra-seasonal variations of temperature and gravity wave activities.

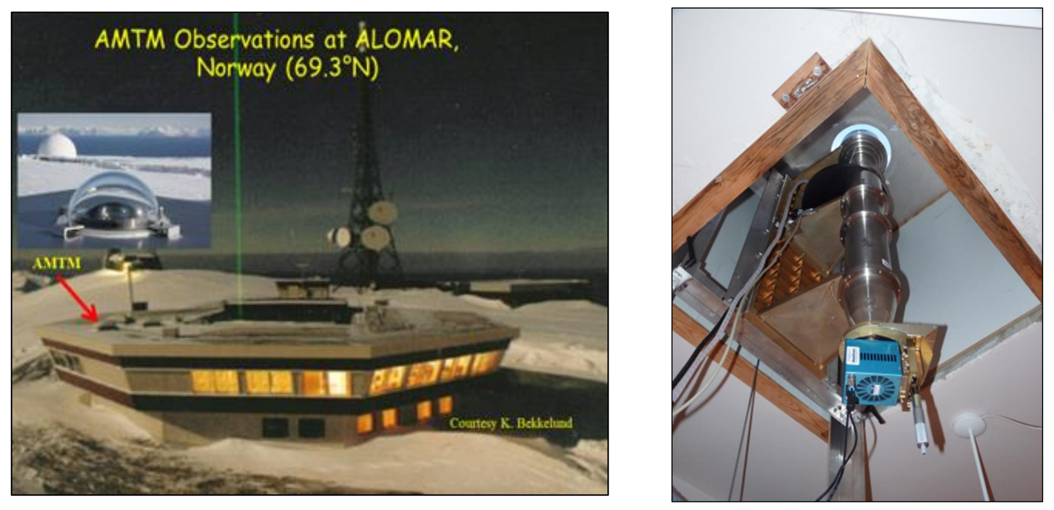

Figure 1: The Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR), Norway

USU AMTM:

- High performance, infrared digital imaging system designed for high latitude measurements, even in the presence of moonlight and aurora.
- Utilizes the OH(3,1) band emission to obtain high-precision (~1-2 K) temperature maps at ~87 km level every 36s over ~120° FOV (Pautet et al., 2014.)
- The 20x20 center pixels of the temperature maps are used to generate the "zenith" temperature time series data.
- In 2010, the USU AMTM was installed at ALOMAR observatory in Norway at 69°N.
- Eight years of winter-time operations (September-April) from 2010-2017.

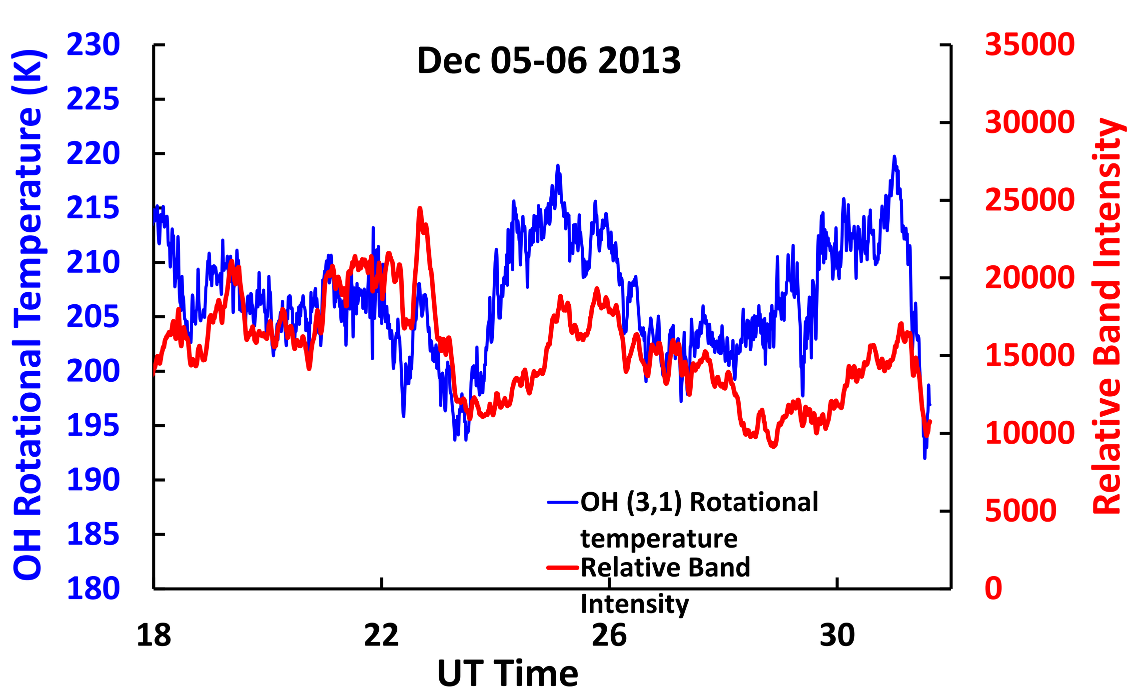

Figure 2: Example of nightly OH band intensity and temperature on Dec 5-6, 2013

METHODOLOGY:

- Cloudy nights were removed from this study.
- Least square fit was used to obtain tidal information.
- The temperature perturbation T' caused by gravity waves is given by
$$T' = T - T_{24} - T_{12} - \bar{T}$$
where T_{24} and T_{12} are the diurnal and semi-diurnal tides respectively.
- The temperature variance is calculated each night using the perturbation defined above.

CURRENT RESULTS:

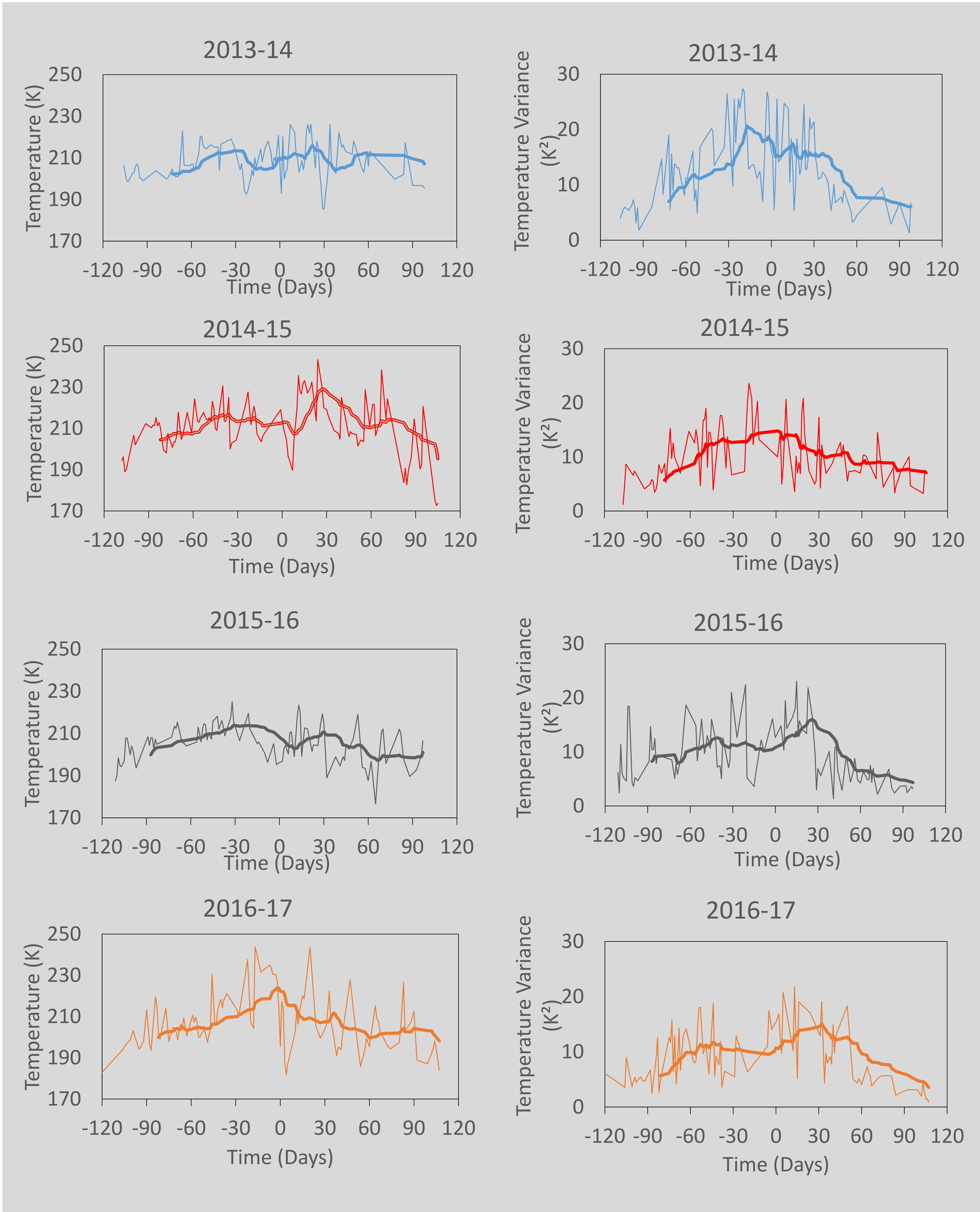

Figure 3: The nightly mean temperature and variances over four winter seasons.

Year	Average Temperature (K)	Year
2013-2014	208.1 ± 8.9	12.6 ± 6.8
2014-2015	211.2 ± 18.6	11.0 ± 6.2
2015-2016	205.0 ± 9.0	10.8 ± 6.9
2016-2017	211.0 ± 19.5	9.7 ± 6.3

Table 1: Summary of the average mesospheric temperature and variance for the four winter seasons.

SUMMARY OF RESULTS:

Four winters of data were analyzed to investigate mesospheric temperature and gravity wave variations during the high-latitude Artic winter season.

Intra-seasonal:

- The nightly mean temperature showed strong night-to-night variability.
- The gravity wave variance also showed strong night-to-night variability. At the start of the winter season, in September, the variance increased to a well defined maximum around December before gradually decreasing during the remaining winter season.

Inter-annual:

- The mean temperature for these four winter seasons was ~208 K. Two winter seasons(2014/15 and 2016/17) exhibited much larger variabilities within these two winters compared with the other two winter seasons.
- The mean variance for these four seasons was similar at ~11 K², with small year to year variabilities.
- Systematic decrease in mean variance over the four winters of observations (2013/14-2016/17).

FUTURE RESEARCH:

- To investigate the causes for inter-annual and intra-seasonal variabilities in the temperature and gravity wave activity, established in this study .
- Compare these results from this high altitude station in the northern hemisphere with other high latitude stations in the southern hemisphere over Antarctica (South Pole and McMurdo).

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Reference: Pautet, P.-D & J. Taylor, M & W.R., Jr, Pendleton, & Zhao, Yacon & Yuan, Tao & Esplin, Roy & McLain, D. (2014). Advanced mesospheric temperature mapper for high-latitude airglow studies. Applied Optics. 53. 10.1364/AO.53.005934.

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