Melting Layer Properties and Precipitation in Wintry Mix Storms

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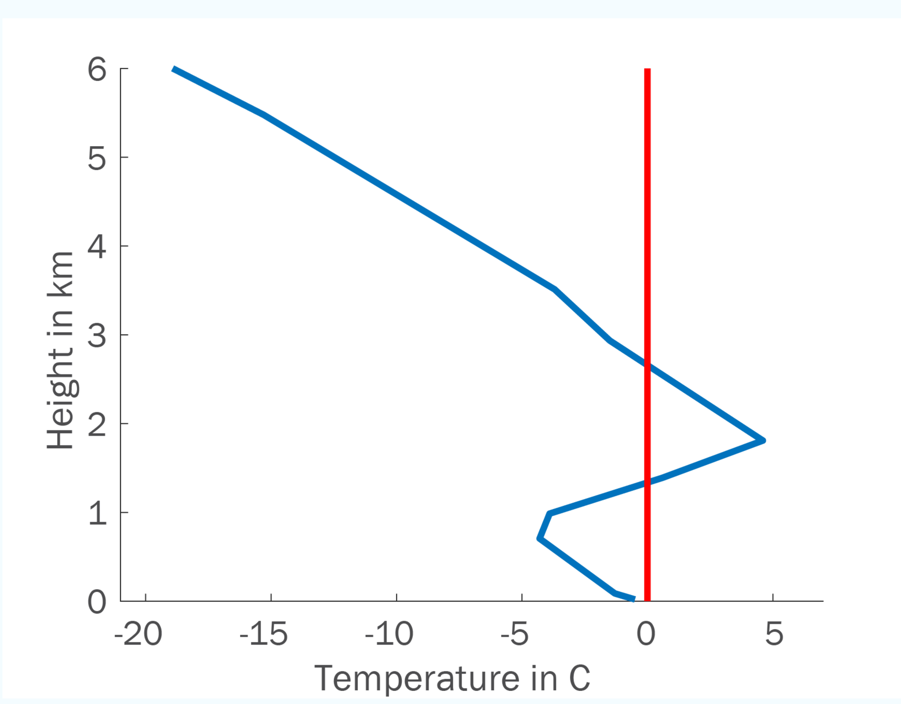
Introduction

Winter storms that produce mixed precipitation—combinations of snow, rain, sleet, freezing rain, and graupel—cause most winter weather in the eastern US. These storms represent a weather forecasting challenge with major economic and safety implications. Wintry mix storms possess one or more layers of above-freezing temperatures, usually called "warm noses," within an otherwise subfreezing atmosphere. Warm nose properties influence the surface precipitation type. For example, if precipitation remains frozen, then it reaches the ground as snow, but if it melts and refreezes, it arrives as sleet or freezing rain. We investigate melting layer properties and their influence on surface precipitation type.

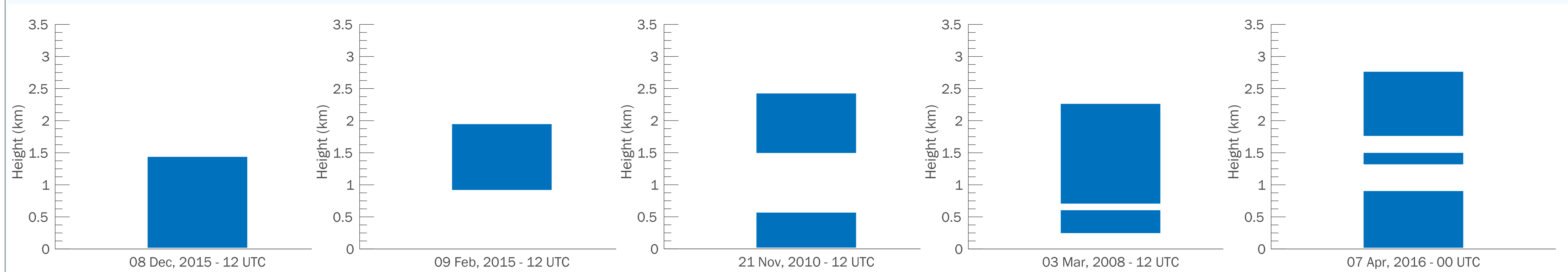


Example of a warm nose profile on a temperature-height graph. Upton, NY Mar 17, 2007 00:00 UTC

Methods

Weather balloon data from the Integrated Global Radiosonde Archive was used to find vertical temperature profiles for Upton, NY. Filtering the profiles to those with warm noses from January 2002 through April 2016 yielded 2937 observations. Each warm nose was plotted on a floating bar graph; we refer to these figures as "warm nose plots." Five different profile types were observed based on nose number and location. To see how changes in precipitation overlapped with warm noses, the warm nose plots were compared to MicroRainRadar (MRR) data; Multi-Angle Snowflake Camera images were used to supplement the MRR with direct observations. Since the MRR is located at Stony Brook University and soundings are launched from the Upton National Weather Service 22.5 km away, differences may exist between the sounding and the MRR location's actual profile.

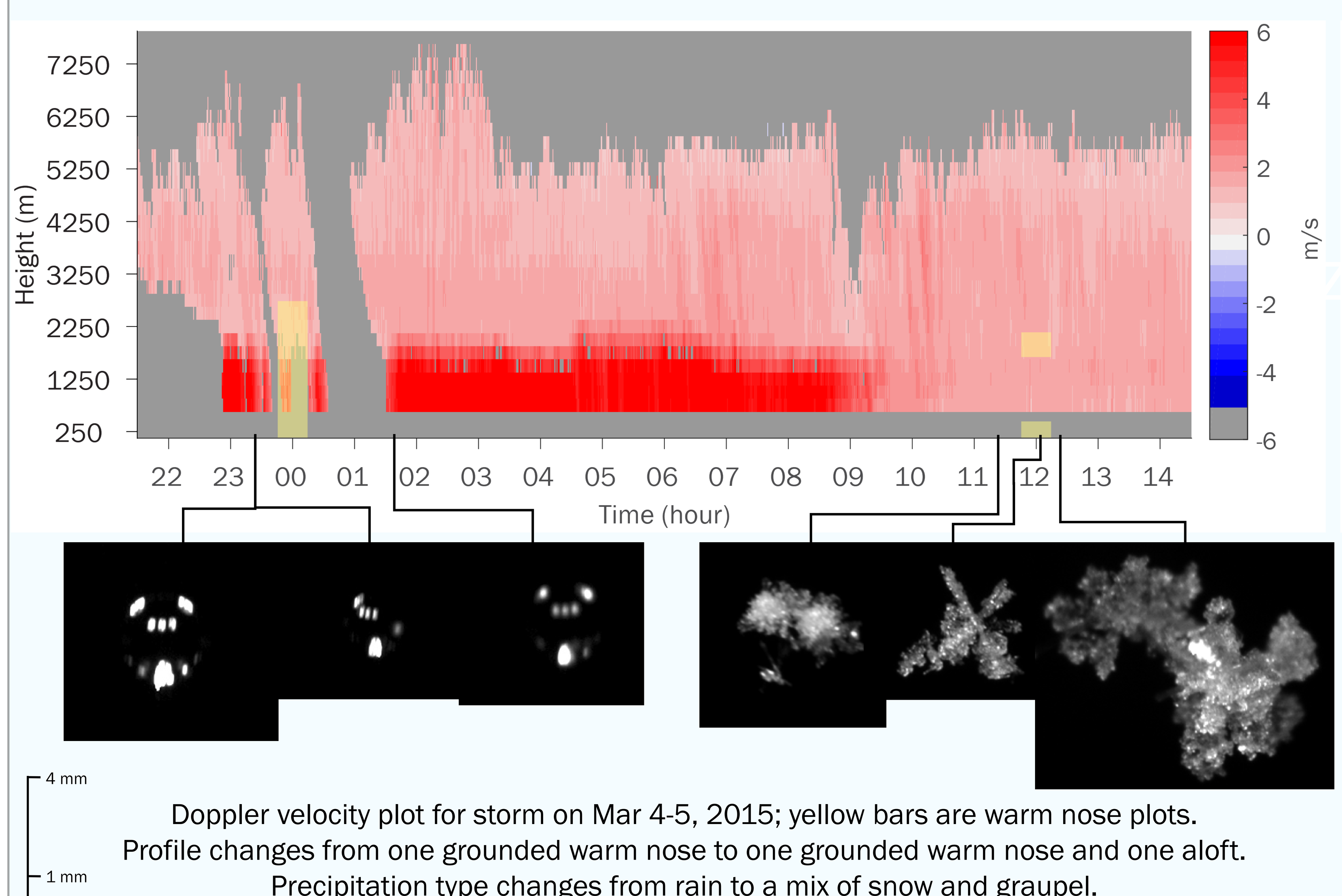
Warm Nose Profiles



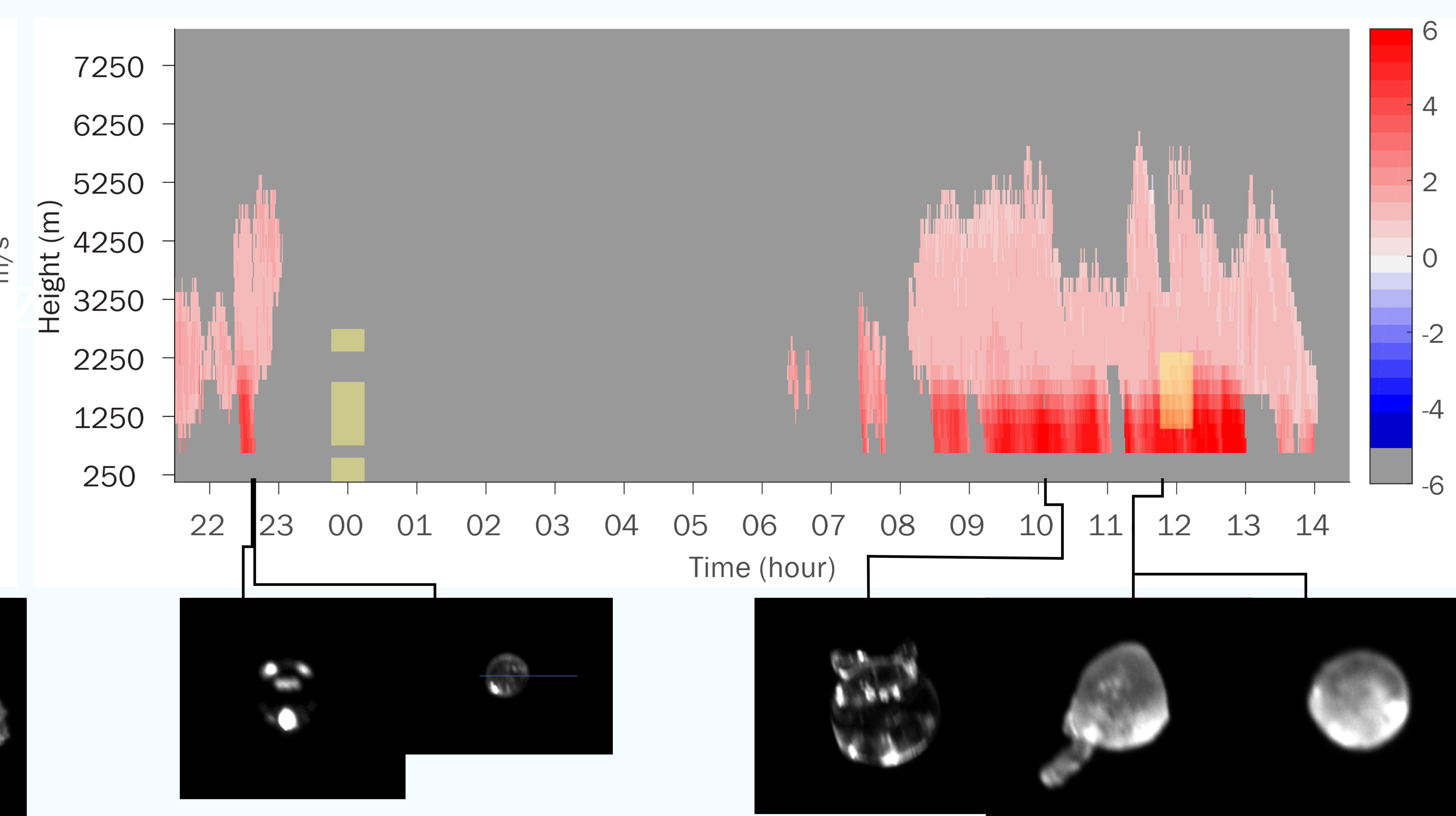
One grounded warm nose	One warm nose aloft	One grounded warm nose	Two warm noses aloft	One grounded warm nose
64% of profiles	17% of profiles	One warm nose aloft	4% of profiles	Two warm noses aloft
		13% of profiles		2% of profiles

MicroRainRadar and Warm Noses

When precipitation melting occurred, warm nose location matched with changes in precipitation type. The melting of icy precipitation within a warm nose causes fall speed to increase, which the MRR observes as an increase in Doppler velocity. Precipitation remained frozen in some winter storms with warm noses. Depth of the warm nose explains most of these cases, as precipitation has a shorter residence time in a shallow nose than a deep one, and thus a thin melting layer can be traversed without significant melting. However, precipitation types varied between some cases with similarly deep warm noses, indicating that depth does not explain precipitation type for every storm. Possible explanations include differences in average or maximum layer temperature; in addition, since the MRR and soundings are not co-located, the soundings may not always accurately portray the temperature profile at the MRR location.



Doppler velocity plot for storm on Mar 4-5, 2015; yellow bars are warm nose plots.
Profile changes from one grounded warm nose to one grounded warm nose and one aloft.
Precipitation type changes from rain to a mix of snow and graupel.



Doppler velocity plot for storm on Feb 8-9, 2015; yellow bars are warm nose plots.
Profile changes from one grounded warm nose and two aloft to one warm nose aloft.
Precipitation from 22:00-23:00 is rain, remains rain when it begins again, then changes to sleet.

Conclusions

- For cases in which precipitation melting occurs, warm nose locations match MRR observations of changes in precipitation type.
- Warm nose presence does not always affect precipitation type; melting layer depth on its own does not explain all of these cases.
- Future research will focus on the effects of melting layer temperature, structure, and depth on surface precipitation type.

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