

Characteristics of Thundersnow Associated with Heavy-Snowfall Observed with Next-Generation Satellite Sensors

Sebastian S. Harkema

The University of Alabama in Huntsville, NASA SPoRT

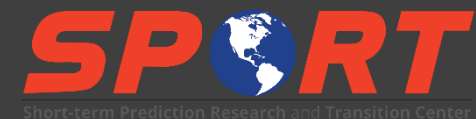
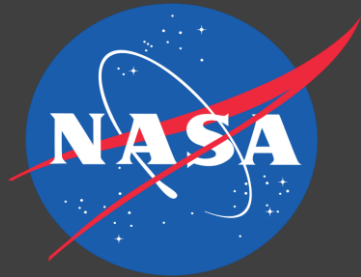
Emily B. Berndt, Christopher J. Schultz

NASA Marshall Space Flight Center, SPoRT

Geoffrey T. Stano¹, Stephanie M. Wingo²

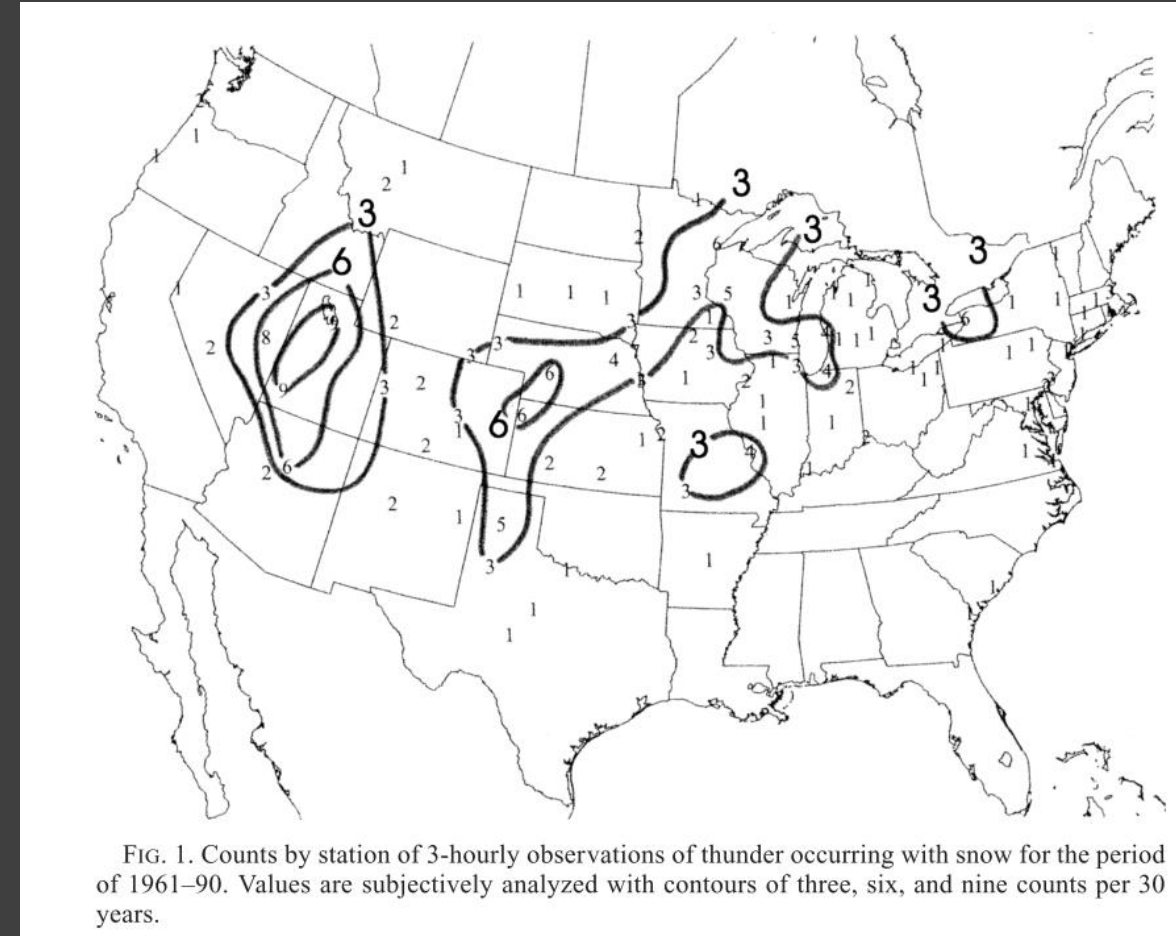
¹ENSCO, Inc., NASA SPoRT

²NASA Postdoctoral Program



Background

- Thundersnow (TSSN): Concurrent surface observations of snowfall and lightning
- TSSN has been statistically studied since the 1970s
 - Curran and Pearman 1971
- Often not co-located with heaviest snowfall rates and more frequent in leading edge of snowband
 - Market and Becker 2009
- With Geostationary Lightning Mapper (GLM) observations available for the first time this winter it presented an opportunity to characterize how GLM along with other satellite products can be used to detect TSSN and heavy snow



Market et al. 2002 (Fig. 1)

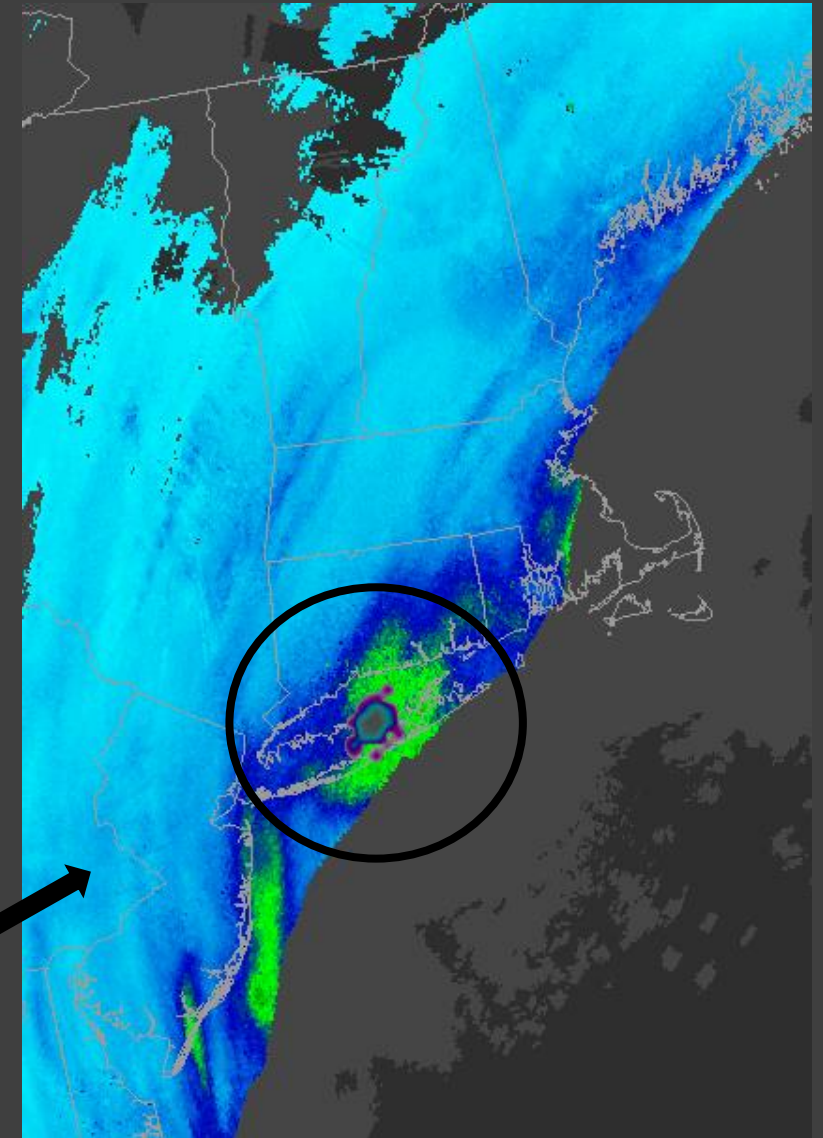
Objectives

- Identify heavy-snowfall cases from 2017/2018 winter
- Since heavy snow is typically forecast with a combination of model, radar, and observational datasets, determine how next-generation satellite data can be used to:
 - Identify TSSN
 - Characterize the environment
- Quantitatively analyze relationship between satellite data, derived products, and TSSN

Datasets

- Geostationary Lightning Mapper (GLM)
 - Horizontal, Temporal Resolutions: ~8km, 2ms
- NESDIS – merged snowfall rate (mSFR) Product
 - Horizontal, Temporal Resolutions: 1km, 10 min
 - Units: in/hr
- Global Precipitation Measurement (GPM)
 - Constellation of passive microwave sensors
 - Dual-frequency Precipitation Radar (DPR)
 - Ground Validation (GV) with radars

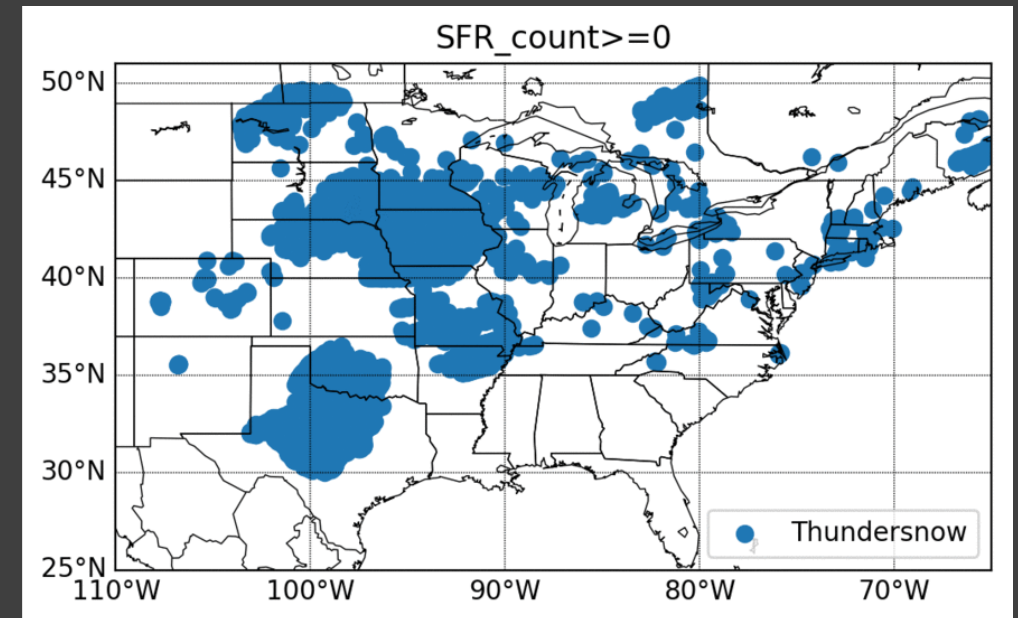
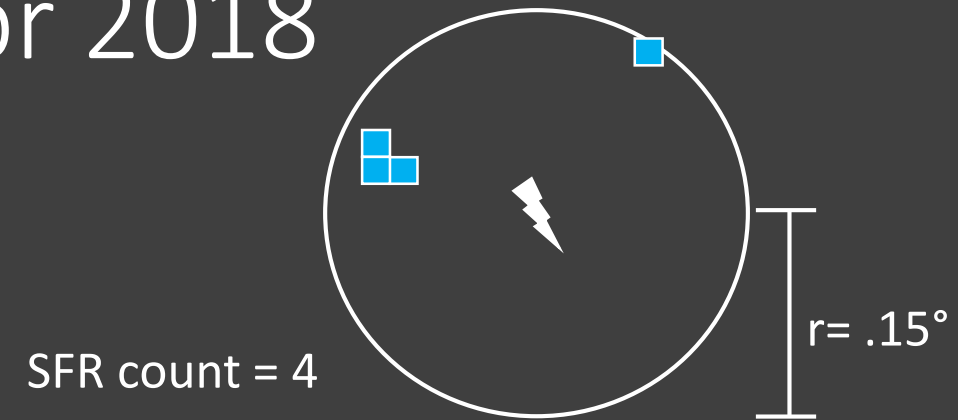
GLM data overlaid
on mSFR in AWIPS



2018-01-04 1410 UTC

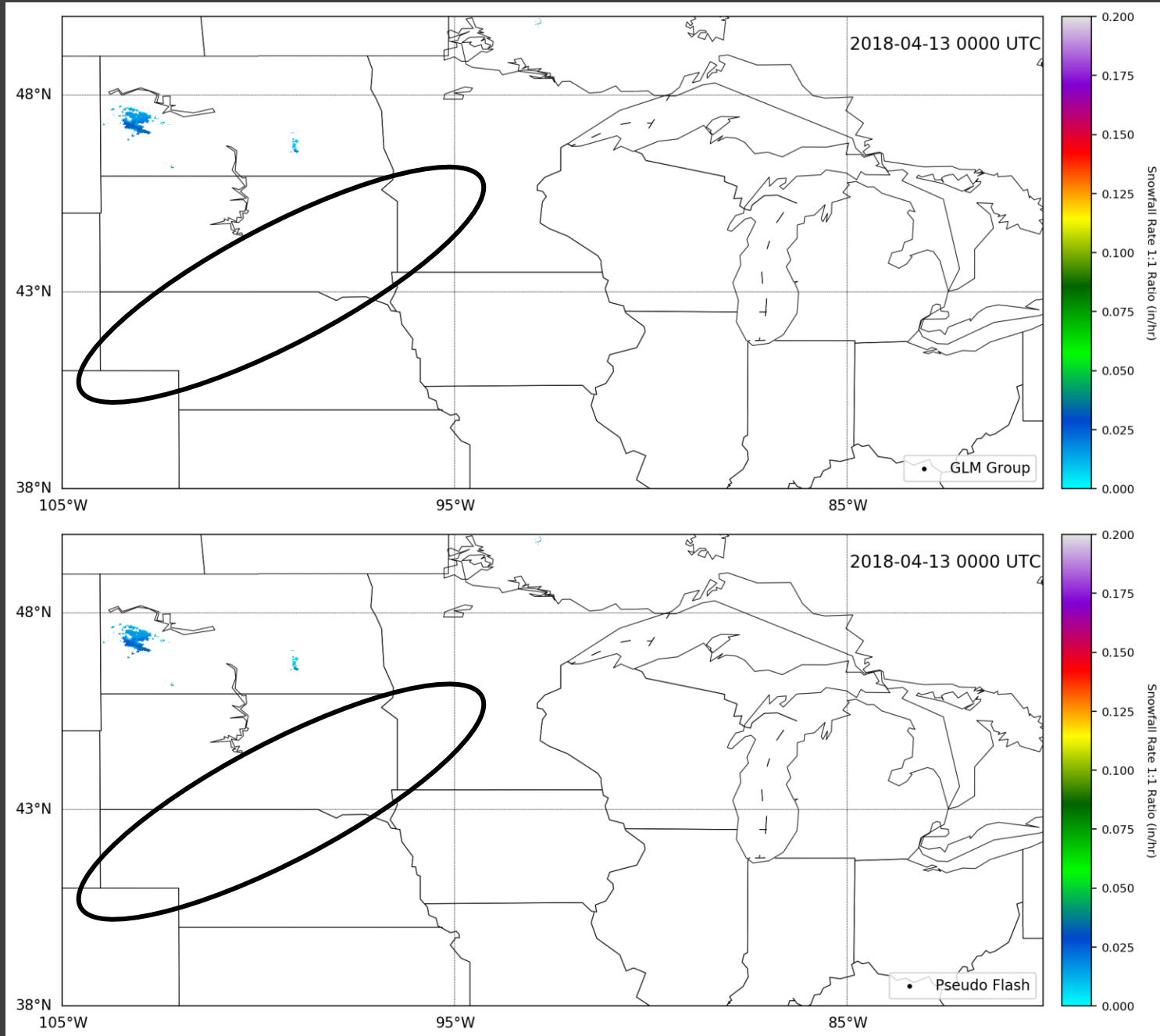
TSSN Identification for Jan-Apr 2018

- Overlap of mSFR product and GLM groups data using nearest neighbor
 - .15 degree (~15km) distance maximum threshold
- Count number of mSFR pixels within the distance threshold
 - More mSFR pixels, higher confidence of existence of TSSN
- Created TSSN “quasi” flashes
 - Aggregation of GLM groups based on Flash ID and mSFR temporal resolution
- Environments: Nor’easters, Heavy-banded snowfall, Convective snowfall



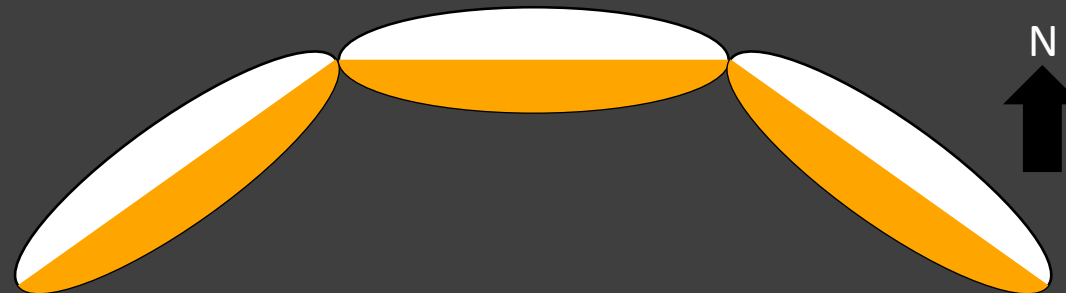
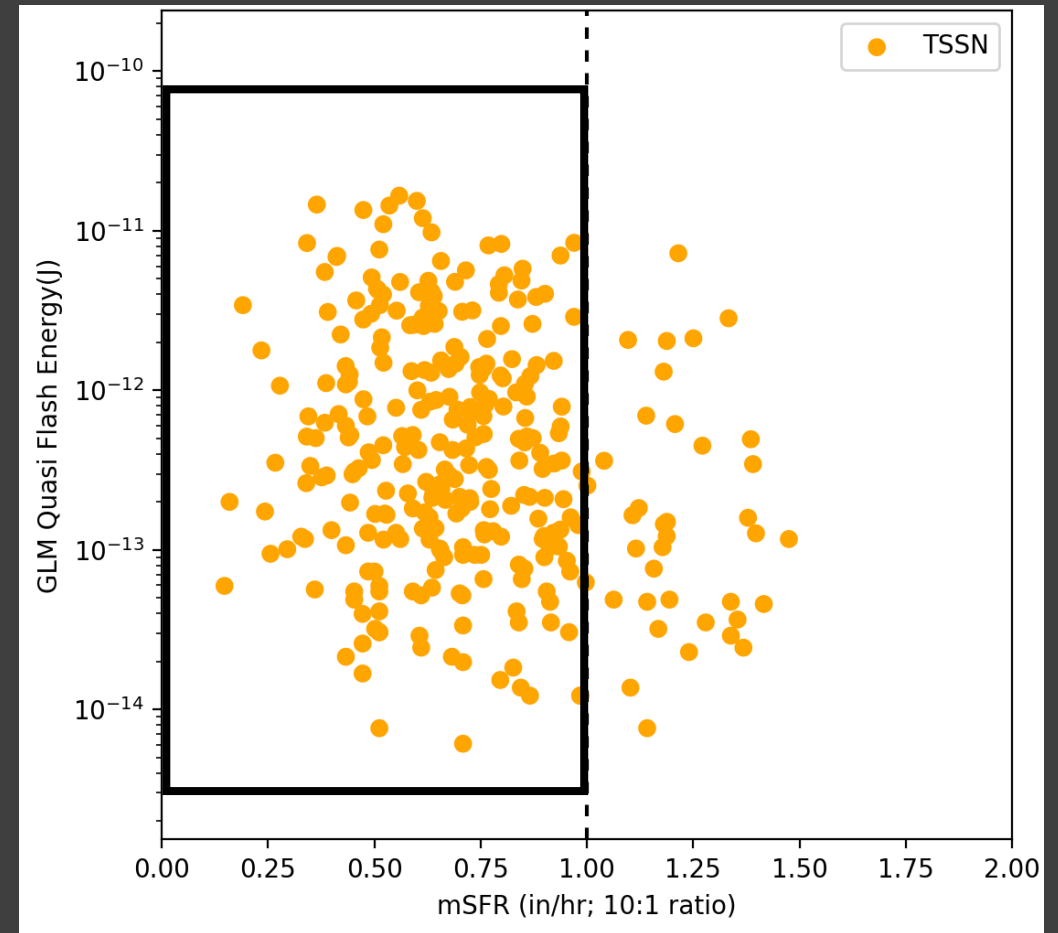
Identification Results

- 18 of 21 cases with TSSN
 - 14 with accumulation
 - 11 with ≥ 700 SFR count
- Midwest Blizzard
 - 2018 April 13
- Top: all GLM groups
- Bottom: TSSN quasi flash
 - Point size varying by SFR count



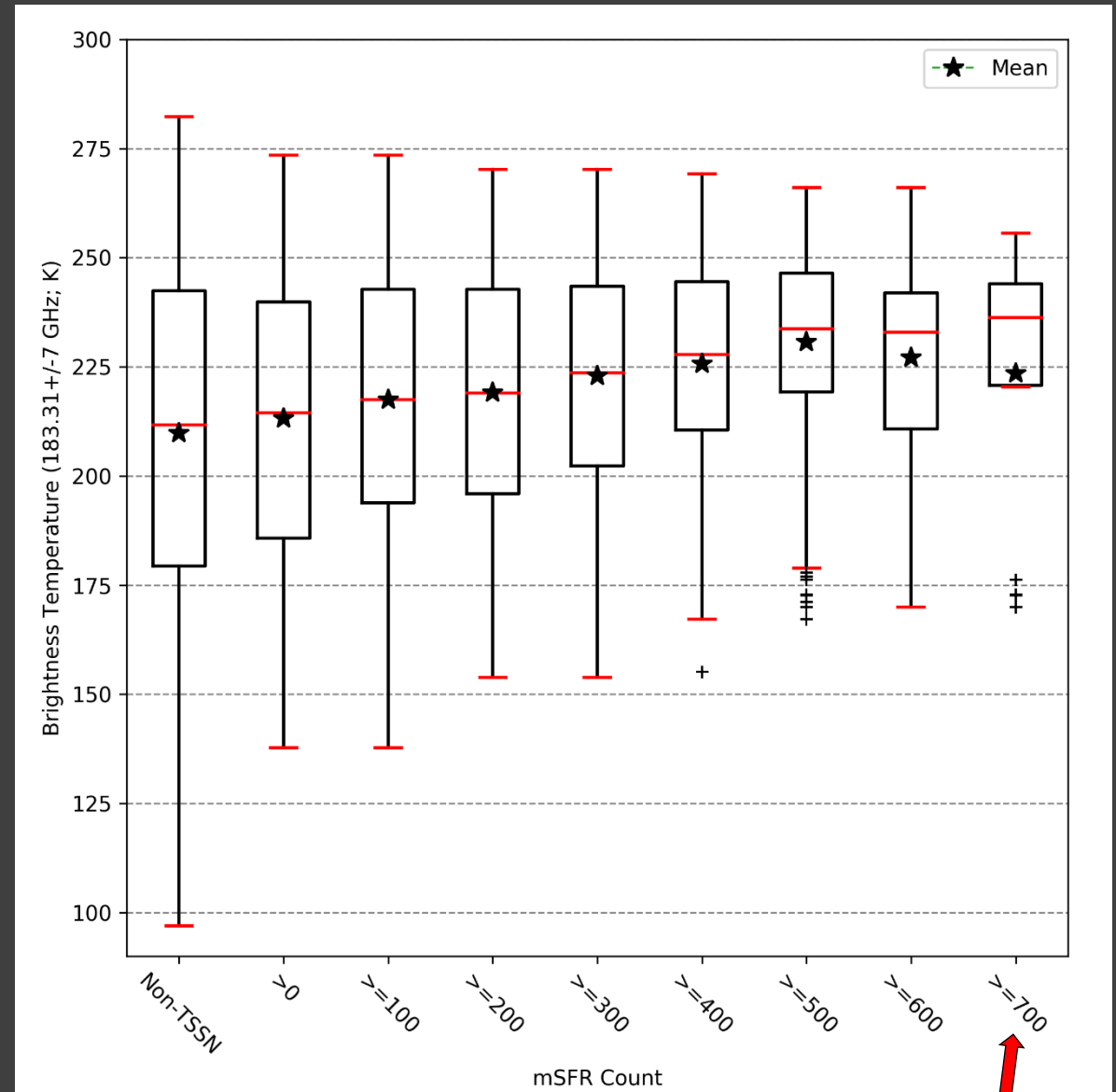
mSFR Characteristics

- 306 quasi flashes with highest confidence
 - SFR count ≥ 700
- More probable in lower mSFR values (< 1 in/hr; 10:1 ratio)
- Located in the southern facet of the major axis of heavy-banded snowfall regardless of band orientation



GPM Characteristics

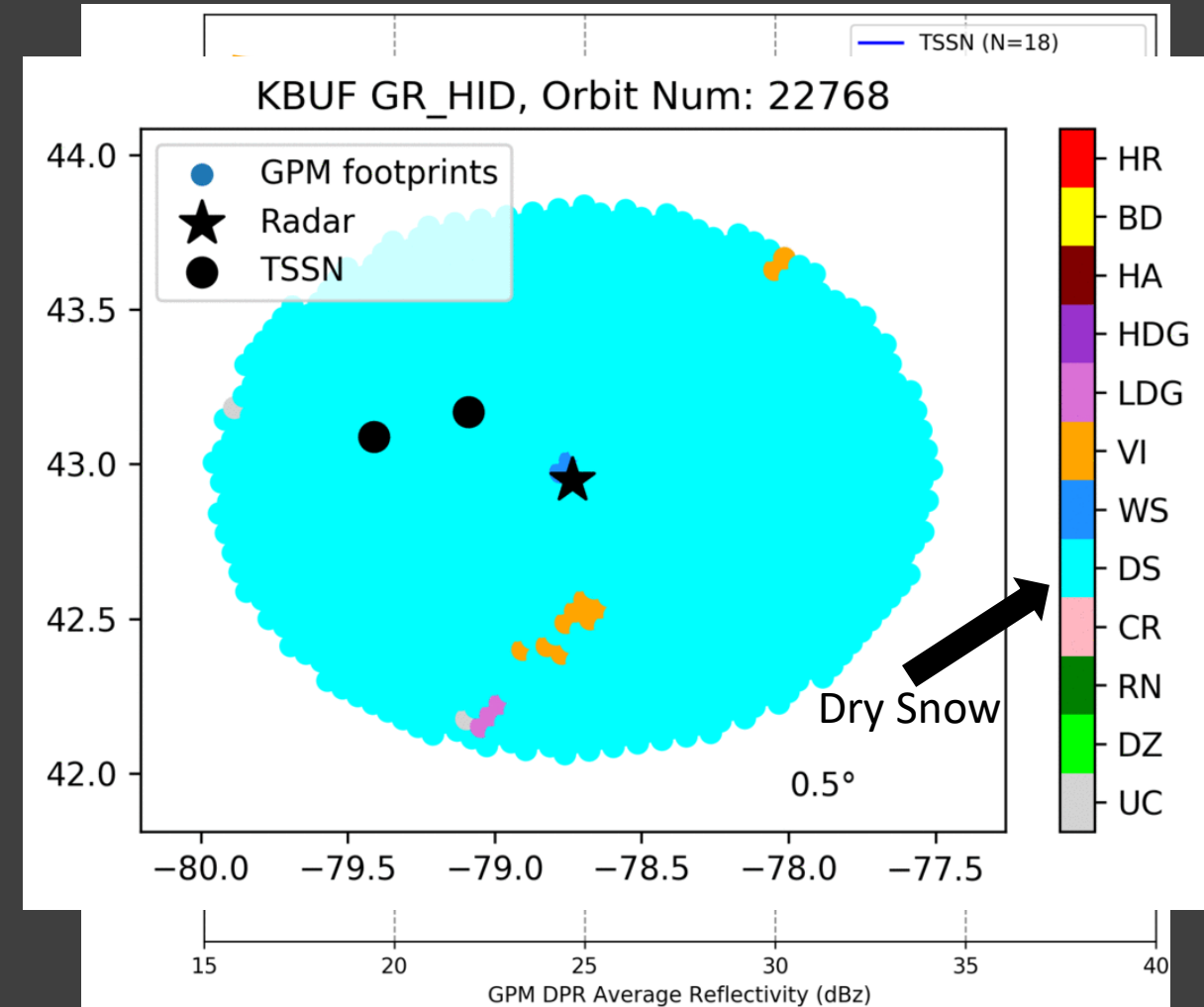
- 16.6% of quasi flashes occurred +/- 10 minutes of overpass
 - 11.1% when count ≥ 700
- GPM estimates some vertical integrated rain water ($< \sim 2 \text{ kg/m}^2$)
- TSSN occurs in regions of ice water path less than $\sim 3 \text{ kg/m}^2$
- Brightness Temperatures (T_b)
 - Range decreases as count increases
 - Means trend warmer as count increases for 183.31 GHz bands
- Inconclusive at highest confidence



Lack of data

GPM GV Characteristics

- Only three quasi TSSN flashes occurred during GPM GV
 - KBUF (02 Mar 2018 ~0422 UTC)
 - KMVX (05 Mar 2018 ~1256 UTC)
- GPM GV
 - Confirms snowing in region based on hydrometeor classification
 - Inconclusive by lack of data
- Average vertical reflectivity profiles from GPM DPR
 - 176 levels, 125m binsize
 - Never exceeds 26 dBz for TSSN



Conclusions

- GLM has capacity to identify TSSN in different environments
- Located in the southern facet of the major axis of heavy-banded snowfall regardless of band orientation
- TSSN quasi flashes more probable in snowfall rates less than 1 in/hr (10:1 ratio)
- T_b ranges decrease with higher confidence
 - Means trend warmer for 183 GHz bands
- Less vertically integrated ice and rain water than non-TSSN
- Vertical reflectivity profile max is less in magnitude (25 vs. 38 dBz) and lower in height (375 vs. 1125 m)
- Further GPM and TSSN overlap is needed to vindicate results

Acknowledgements

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 - Providing mSFR product files
- Dr. Phillip Bitzer
 - Providing additionally GLM knowledge and insight

References

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