P4.29 Severe Storm Identification with the Advanced Microwave Sounding Unit (AMSU)

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I. Introduction

Previous work by Cecil (2009) and Cecil and Blankenship (2011) found a strong correlation between passive microwave measurements at 37 and 85 GHz and hail events over land; these studies used measurements from the TMI and AMSR-E sensors. They established climatologies of hail that appeared to agree well with ground based data.

The physical basis is that microwave energy is scattered by ice particles, thus greatly reducing the measurement brightness temperature (TB); "Mie" scattering occurs when the ice particles are of similar magnitude to the wavelength – ~ 1 cm at 37 GHz; ~3 mm at 89 GHz; ~ 1 mm at 150 GHz **(Figure 1).**

In this study, we attempt to extend this work to the Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sounder (MHS) on board the NOAA and EUMETSAT polar orbiting satellites. Why?

- AMSU/MHS operate on NOAA and EUMETSAT satellites and offer global, 4-hr sampling (since 2002) (Ferraro et al. 2010), so a better measure of diurnal variability of hail events can potentially be captured
- AMSU-B/MHS 150/157 and 183 GHz bands:
  - Offer greater sensitivity to ice AND vertical depth of ice **(Figures 2 - 4)**
  - Potentially eliminate false signatures of underlying surface when using lower frequency techniques

II. Methodology and Results

1. AMSU TB's extracted for CONUS for 2005 – 2010; mapped to a common 0.25 degree grid
2. Hail data from "Storm Reports" – data "averaged" in time/space from start to end period/location reported
3. Data matched – within 30 minutes and 100 km; only AMSU local zenith angle of ±30 deg; duplicate observations manually removed to ensure highest data integrity and coldest set of TB's used when multiple AMSU data was matched for same storm event. Data further stratified by >1" hail and <1" hail – results for 2005 (training) presented in **Figure 5.** Similar results seen in 2006 and 2007. Clear distinction between small and large ice cases.
4. Developed simple "thresholding algorithm" based on TB means at 150 and 183 GHz bands from 2005 data, hail larger than 1" and then applied to all available 2008 AMSU data
   - Results gridded to 2.5 degree; a single report within that grid constitutes a "hail day"
   - Total number of days for March – September 2008 computed **(Figure 6)** and compared with Storm Reports **(Figure 7)**
   - Relationships between both data agree extremely well (R=0.87)

III. Summary and Future Work

1. Our preliminary results indicate that the AMSU/MHS measurements are capable of detecting hailstorms of 1" sized hail or larger. The thresholds were consistent from year to year.
2. The 183 GHz channels are extremely valuable in detecting high altitude ice.
3. Future efforts will look at more sophisticated methods for classifying the hail events, POD and FAR.
4. MW measurements on a geostationary platform would be valuable for real-time monitoring of hail.

IV. References

Cecil, D.J., 2009: Passive microwave brightness temperatures as proxies for hailstorms. *J. Appl. Meteor. Clim*, **48**, 1281-1286.

Cecil, D.J. and C. B. Blankenship, 2011: Towards a global climatology of severe hailstorms as estimated by satellite passive microwave imagers. *In press, J. Climate.*

Ferraro, R.R., S. Kusselson, S. Kidder, L. Zhao and H. Meng, 2009: Application of AMSU-Based Products to Support NOAA's Mission. *In Press, National Weather Digest.*

FIGURE 1 – Hail Storm

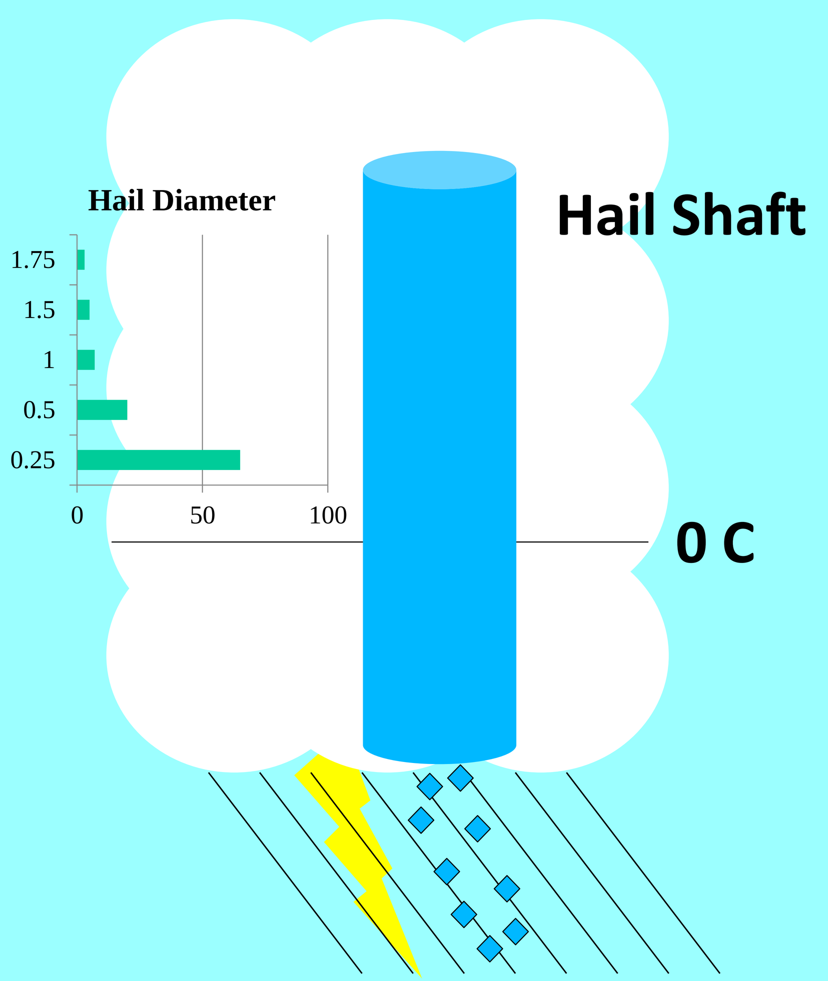


FIGURE 2 – AMSU Weighing Function

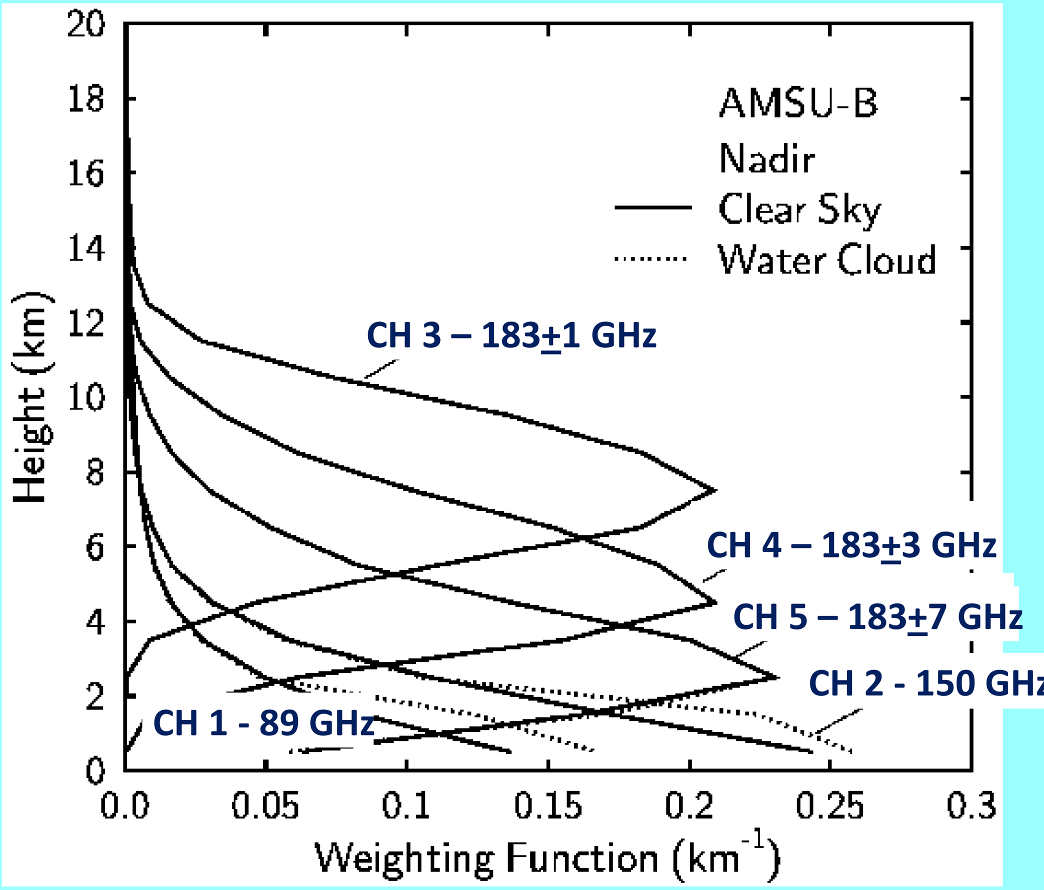


FIGURE 3 – Vivian, SD 2010

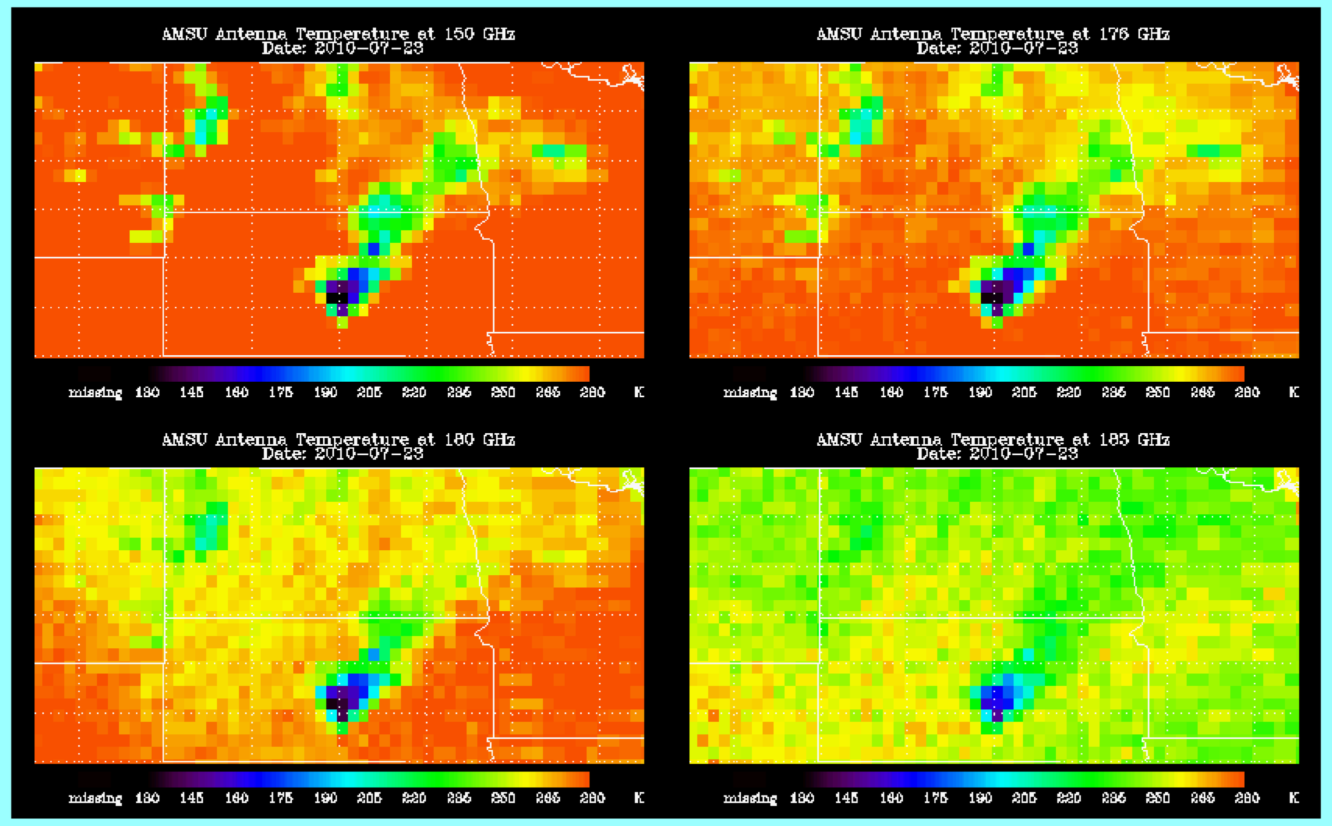
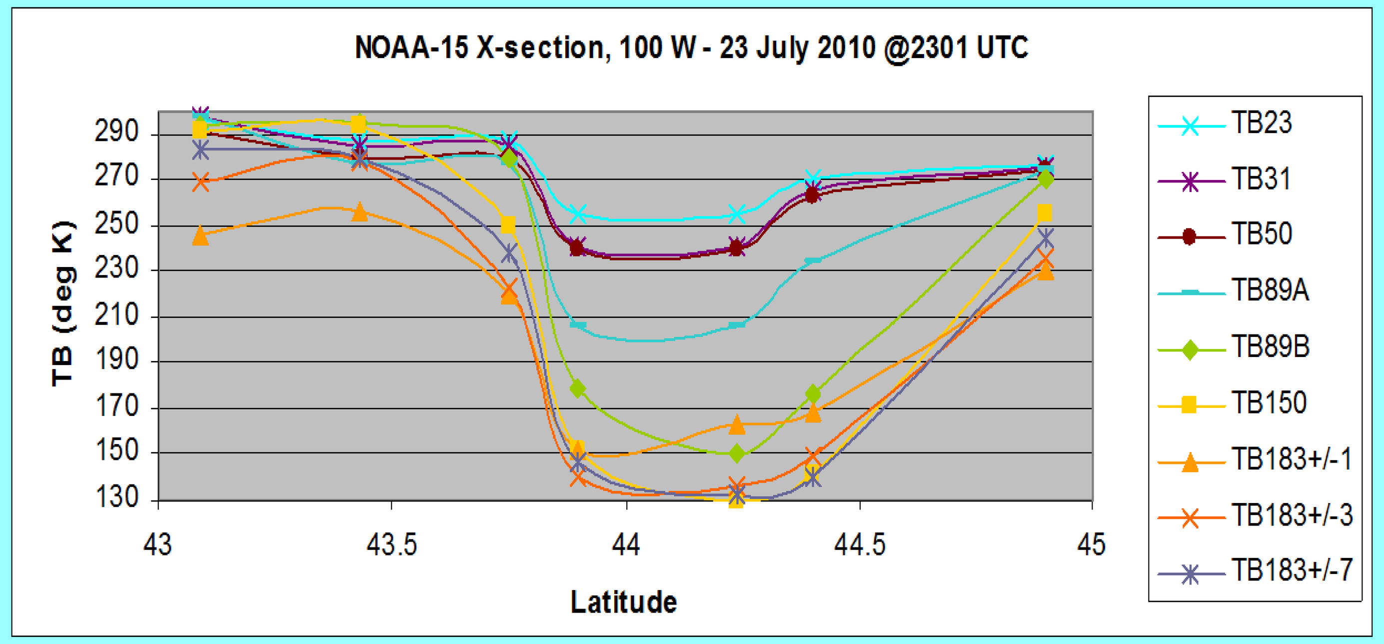
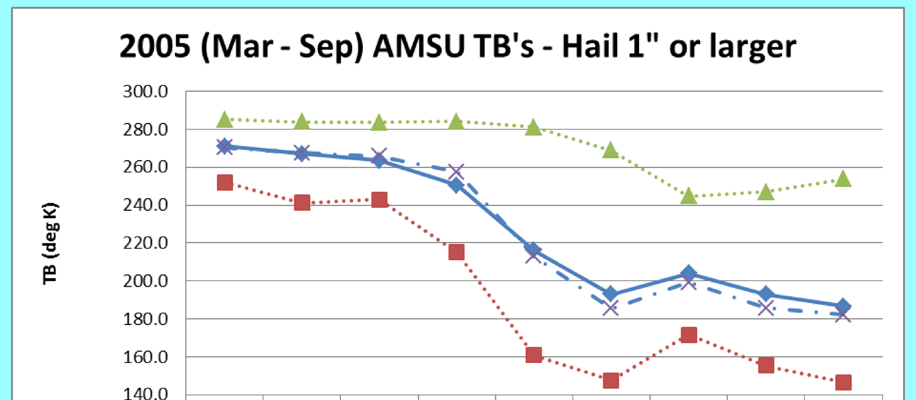


FIGURE 4 – Vivian X-section

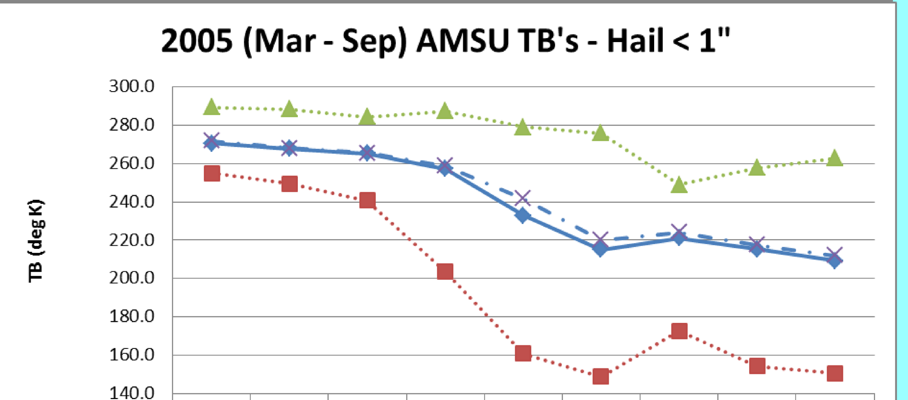


A typical hail storm has a shaft that occupies a relatively small fraction of the overall convective cell. The AMSU-B/MHS sensors have an FOV size of approximately 20 km which means it sees a mixture of hail and non-hail at any instance (in fact, the hail region probably represents a small fraction of the FOV). Also shown is that within the hail shaft, there is a ice particle distribution, with the largest ice likely having the least population of all of the ice in the rain layer. The Mie scattering will only affect the AMSU measurements if its of large enough volume (and its affect is highly non-linear). The AMSU/MHS channels have normal weighting functions that see mostly the surface (89 GHz) and then probe progressively higher in the atmosphere (183 GHz) – if the large ice is pulled high enough, the scattering will be seen at CH3 – 183±1 GHz. An excellent example was found in the 2010 Vivian, SD hail storm which produced an 8" hailstone! Shown is the AMSU overpass very close in time to this hailstorm, and large TB depressions are evident in the imagery **(Figure 3)** as well in the cross section through the strongest part of the storm **(Figure 4).** It is these properties that we are trying to examine and utilize in this study.

FIGURE 5 – AMSU & Storm Reports



	TB23	TB31	TB50	TB89A	TB89B	TB150	TB183	TB180	TB176
Average	271.2	267.0	263.4	250.5	216.1	192.8	204.0	193.0	186.8
Min	252.1	241.3	243.0	215.0	160.9	147.4	171.6	155.2	146.4
Max	285.2	283.8	283.6	284.1	281.2	268.8	244.6	247.0	253.8
Median	270.4	267.5	265.7	257.4	213.0	185.5	199.3	185.7	182.1
Std. Dev.	9.8	11.9	11.0	20.5	32.4	35.2	22.2	28.9	32.1



	TB23	TB31	TB50	TB89A	TB89B	TB150	TB183	TB180	TB176
Average	270.6	267.8	265.3	257.2	232.8	215.1	221.1	215.3	209.4
Min	255.0	249.4	240.6	203.5	160.9	148.7	172.7	154.4	150.6
Max	289.5	288.5	284.4	287.3	279.2	275.8	249.0	257.7	262.9
Median	271.8	268.1	265.6	258.7	241.6	220.2	224.1	217.6	212.1
Std. Dev.	9.0	10.2	10.3	21.1	31.0	35.2	18.2	27.1	32.8

FIGURE 6 – AMSU Hail 1" Days 2008

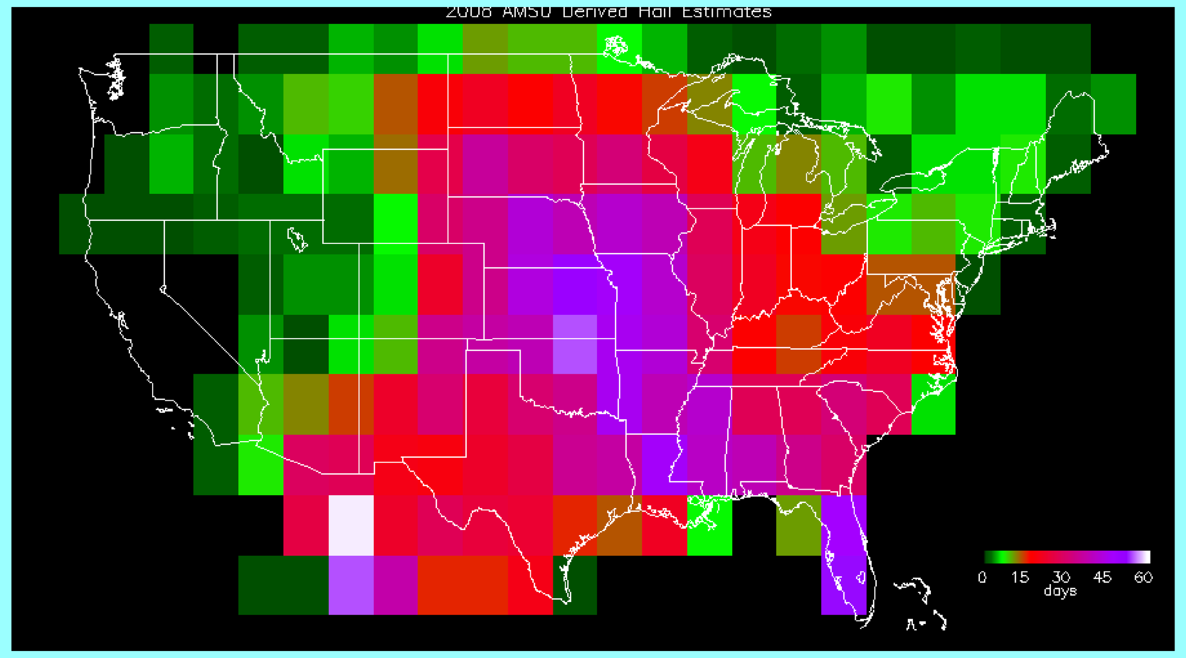
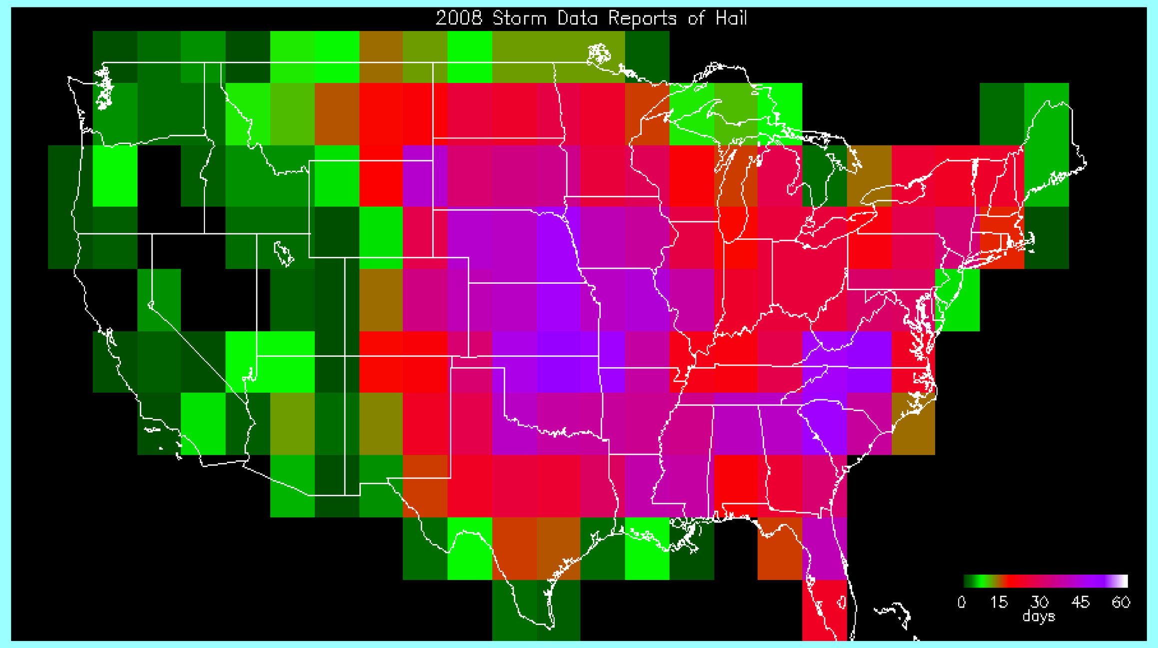


FIGURE 7 – Storm Report Hail 1" 2008



Stratifying the data by large (1" or greater) and small hail **(Figure 5)** revealed a reasonable separation in the magnitudes of the TB's at 89 GHz and higher. There is considerable spread amongst the data so that a unique classification of the largest hail may not be possible. Nonetheless, a simple "threshold algorithm" based on the mean TB values from the larger hail data was implemented and then used on AMSU data from 2008. The data were compiled for the months of March through September and then converted into 2.5 degree grids – any occurrence of hail for a day in that grid box was assigned a value of 1, and then all of the daily data for that time period was combined and is presented in **Figure 6.** A similar procedure was performed for the Storm Report data **(Figure 7).** As can be seen, the two data fields are highly correlated (R=0.87), thus indicating the utility of the AMSU/MHS data to detect hail storms. Further investigation is warranted.