Using Satellite Remote Sensing and Geographic Information Systems (GIS) to Create an Extensive Hail Damage Swath Database

Emily F. Wisinski[1], Jordan R. Bell[2], Emma Gilligan[3], Andrew L. Molthan[2], and Christopher J. Schultz[2]

[1]Department of Atmospheric and Earth Science, University of Alabama in Huntsville, Huntsville, Alabama
[2]Earth Science Branch, NASA/Marshall Space Flight Center, Huntsville, Alabama
[3]Geography and Environmental Systems, University of Maryland, Baltimore County, Baltimore, Maryland

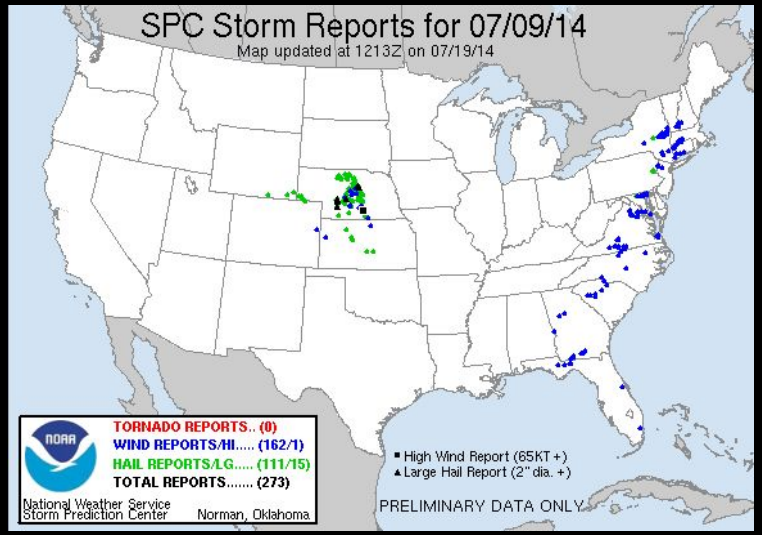
Background / Motivation

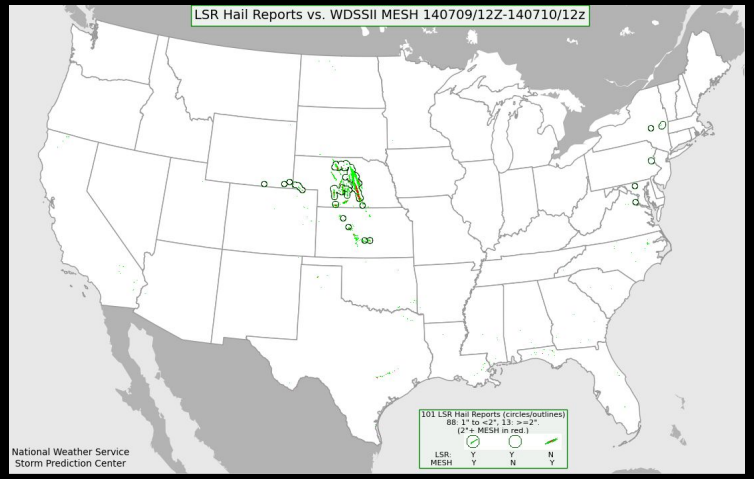
- Growing season overlaps severe & intense thunderstorms that bring damaging winds and large hail (Bell et al. 2020)
  - A number of these storms leave behind visible swaths of damage
- Create database of hail damage swaths events
  - Midwest and Great Plains
  - 2000 – 2020
  - Derived from daily NASA true color imagery
- Improve understanding of geospatial range and frequency

Nebraska, 07/09/2014

Methods – Archive Work

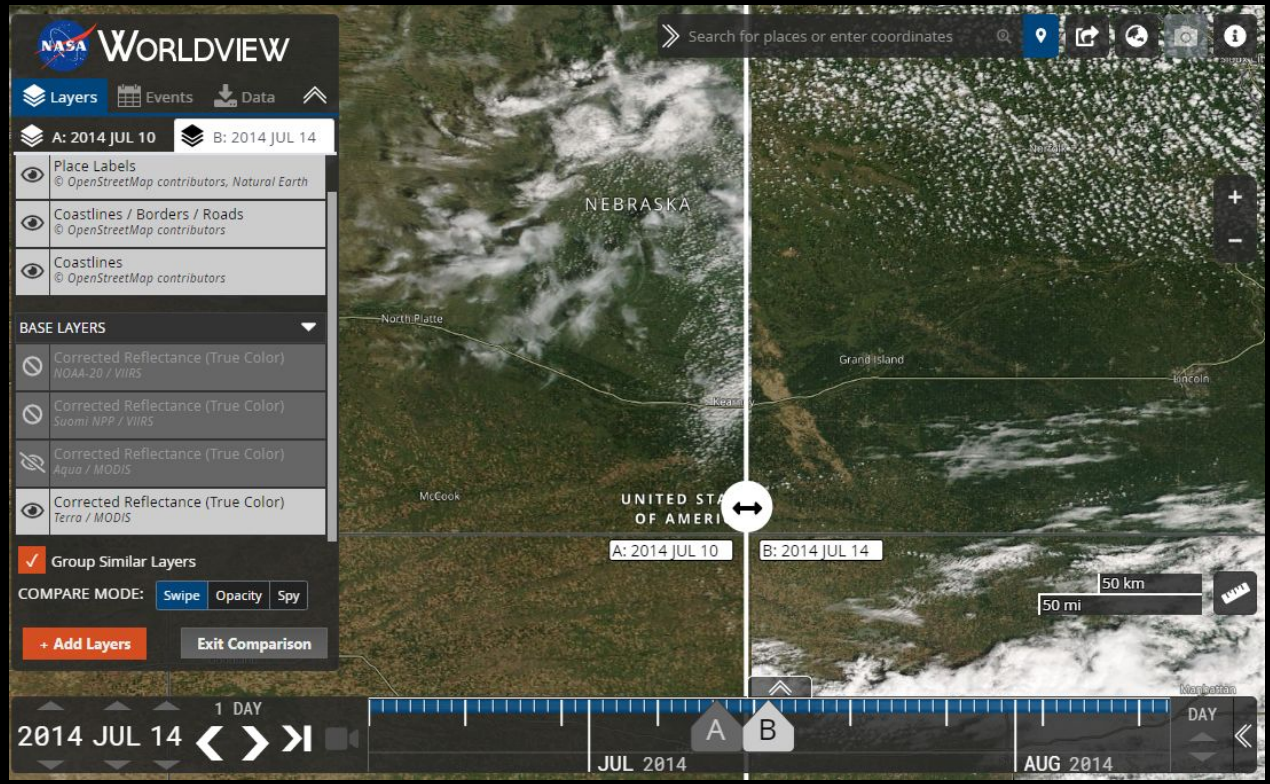
- Storm Prediction Center Storm Reports
  - 1 May to 15 September
- Local Storm Reports (Hail) vs Maximum Estimated Size of Hail (MESH)
  - 2012-2017





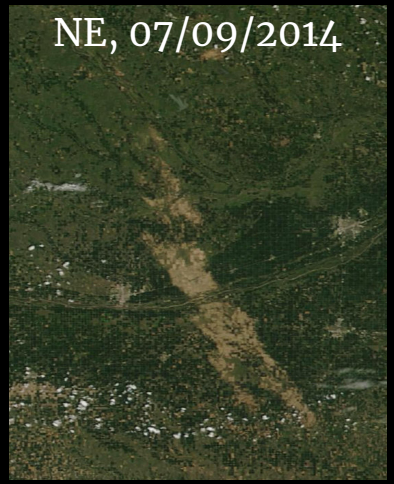
Methods – Archive Work

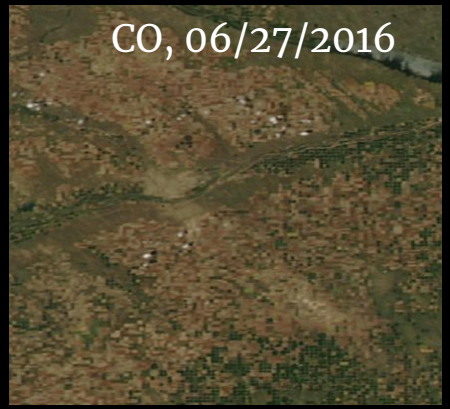
- Storm Prediction Center Storm Reports
- Local Storm Reports (Hail) vs MESH
- NASA Worldview



Diversity in Swaths

- Time of the growing season
- Background land cover
  - Ag vs grassland
- Size of swath





Methods - Archive Work

- Storm Prediction Center Storm Reports
- Local Storm Reports (Hail) vs MESH
- NASA Worldview
- Catalog events in Google Sheet

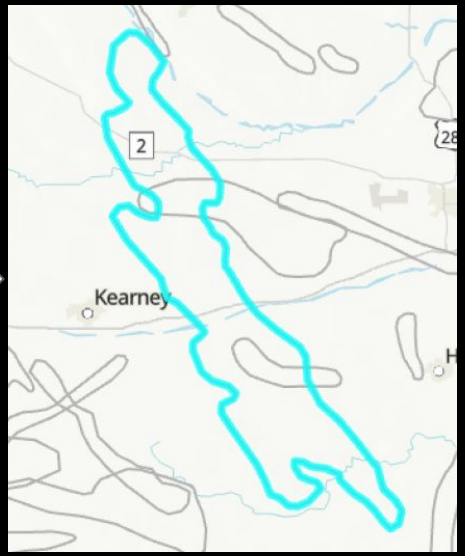
Year	Location	States	Analyst Initials	Analyst Confid	Event Date	NASA Worldview Worldview Link	NASA Worldview First Appears	NASA Worldview Best Date*	Best View Sensor	X-Ref (18-19) Only	Additi # 1
2020	East of Rapid City, SD (large event for May, lots of cloud cover so this may not be the entirety of the event)	SD	EW	10	05/03/2020	https://go.nasa.gov/39TwUvR	05/05/2020	05/21/2020	Terra		JB 10
	Northeast of Rapid City, SD	SD	EW	5	05/23/2020	https://go.nasa.gov/2BS38Lg	05/27/2020	06/01/2020	Both		JB 4
	West of Spearfish, SD	WY, SD	EW	10	06/04/2020	https://go.nasa.gov/2DyQAcs	06/11/2020	06/12/2020	Terra		JB 10
	Buffalo, SD to Dupree, SD	SD	EW	10	06/04/2020	https://go.nasa.gov/2DiuGdB	06/05/2020	06/12/2020	Terra		JB 10
	3 separate scars near White River, SD and Pierre, SD	SD, NE	EW	10	06/07/2020	https://go.nasa.gov/3fpUotx	06/08/2020	06/12/2020	Terra		JB 10
	Continuation of June 8th event in NE?	NE, SD	EW	3	06/08/2020	https://go.nasa.gov/3foLZXj					JB 3
	Southwest of Pierre, SD	SD	EW	10	06/21/2020	https://go.nasa.gov/3grgvkC	06/24/2020	06/24/2020	Both		JB 10
	Long scar beginning north of Spearfish, SD	SD	EW	10	06/28/2020	https://go.nasa.gov/30pWvcs	06/29/2020	07/03/2020	Both		JB 10
	East of Hot Springs, SD	SD	EW	6	07/02/2020	https://go.nasa.gov/3gqqJlo	07/03/2020	07/03/2020	Terra		JB 7
	East of Buffalo, SD	SD	EW	6	07/02/2020	https://go.nasa.gov/30mMwok	07/03/2020	07/03/2020	Terra		JB 7
	Southeast of Selby, SD	SD	EW	3	07/04/2020	https://go.nasa.gov/3kaIDe3	07/07/2020	07/12/2020			JB 3
	West of Buffalo, SD	SD	EW	10	07/05/2020	https://go.nasa.gov/3hX8Jzk	07/07/2020	07/08/2020	Both		JB 10
	Southeast of Pierre, SD	SD	EW	8	07/06/2020	https://go.nasa.gov/3i6Ik38	07/07/2020	07/07/2020	Terra		JB 8
	Yankton, SD	SD	EW	8	07/06/2020	https://go.nasa.gov/33qQTkf	07/07/2020	07/12/2020	Both		JB 7
	Near NE border	SD	EW	3	07/09/2020	https://go.nasa.gov/31g5Ym8	07/10/2020	07/10/2020			JB 4

- Collected additional metadata on each event
  - Metadata includes when the swath first appeared in imagery, which sensor saw it best, etc.
- Each event was assigned a confidence for identified swaths
  - Swaths that had high confidence did not require additional analysis for confirmation.
  - Swaths that had moderate confidence levels required additional input and analysis from experts involved to confirm.

Methods - Archive Work

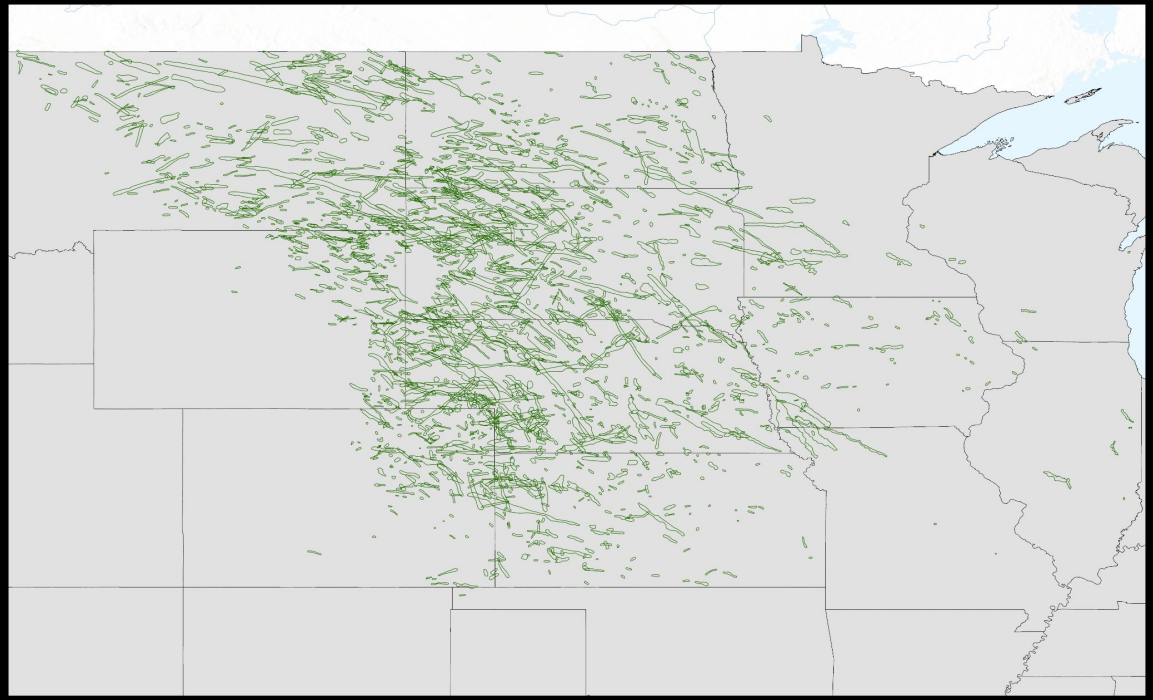
- Storm Prediction Center Storm Reports
- Local Storm Reports (Hail) vs MESH
- NASA Worldview
- Catalog events in Google Sheet
- Create GIS record of event database

GIS



- For each confirmed event in Google Sheets
  - True color geotiffs from the “Best Date” were downloaded
  - Geotiffs were imported into desktop GIS software where analysts outline each swath into a shapefile
  - Metadata from Google Sheets were also entered into the shapefile.

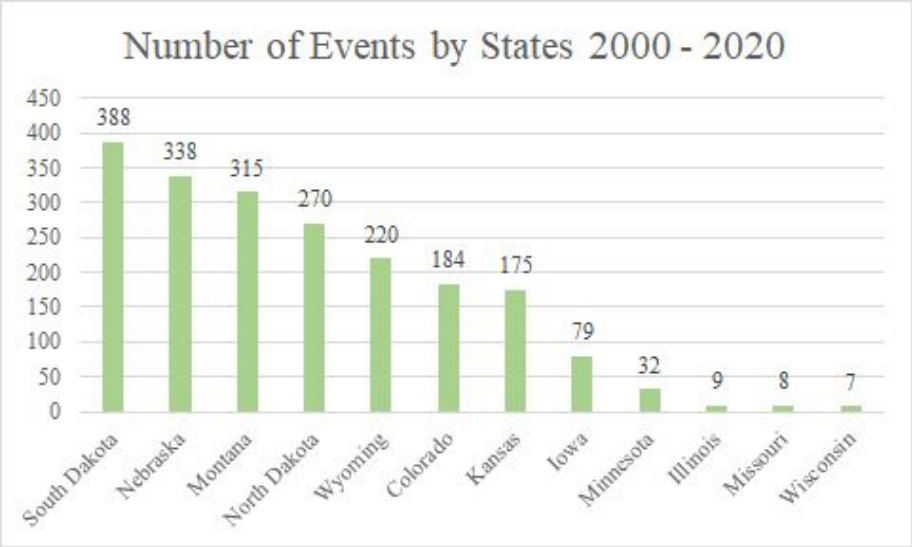
Results

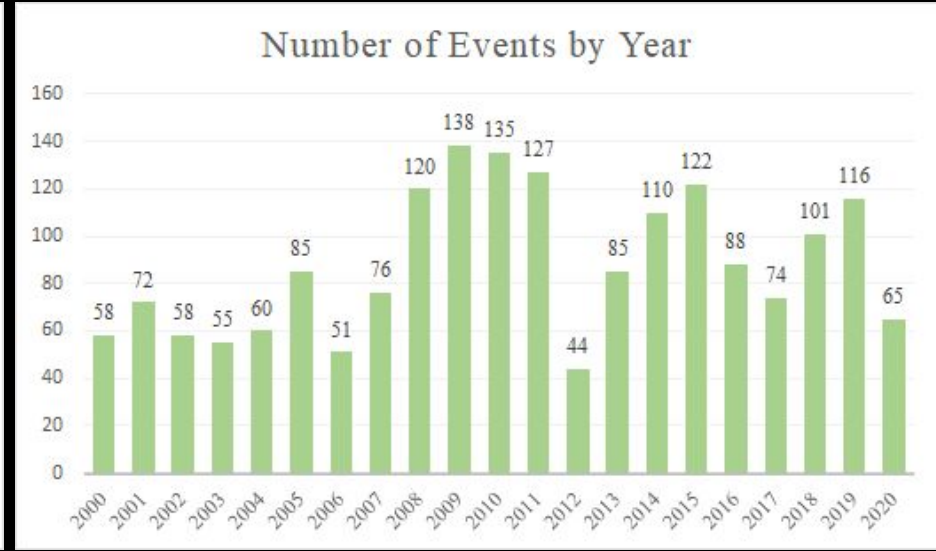


Full extent of the hail swath damage across the Midwest and Great Plains. Over 71,000,000 acres of land were affected by hail damage swaths from 2000 - 2020.

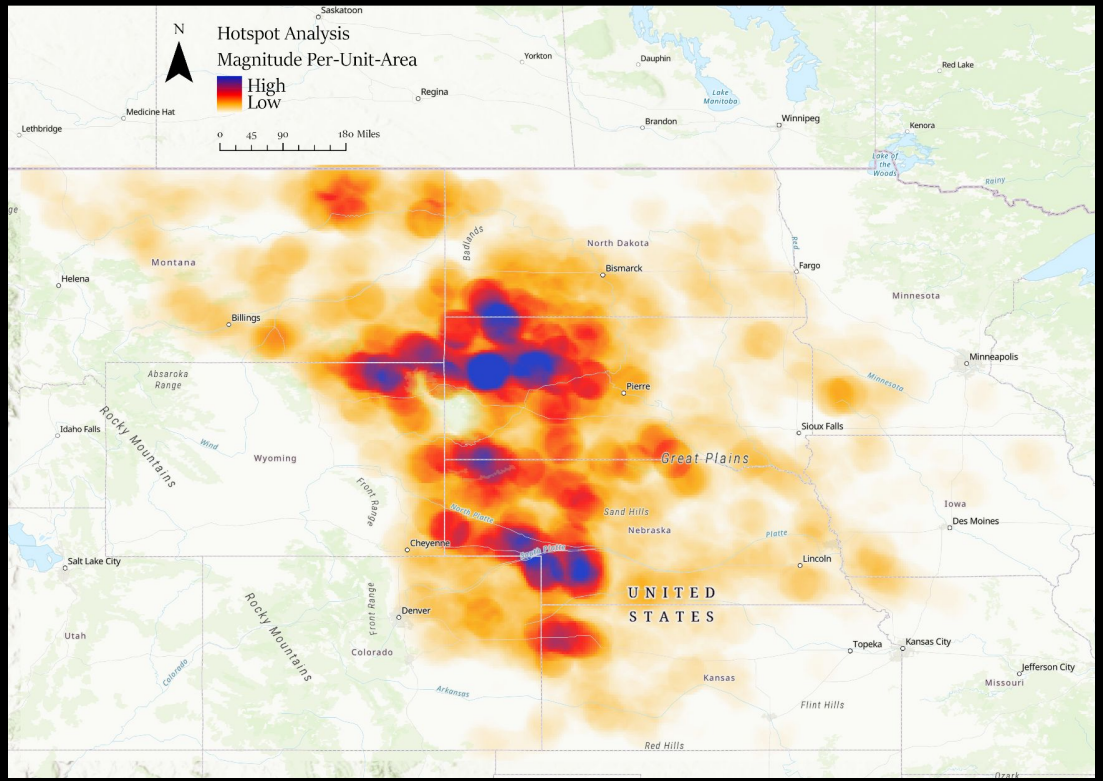
Results

- 1839 events occurred throughout 2000 - 2020
  - 2025 polygons drawn across 12 states





Results



- Analysis visualizes hotspots for hail damage swaths based on the polygons drawn. Western ND, SD, and NE show the largest frequency of events occurring.
- Preparing manuscript that details methodology and impacts to agriculture - submitting early 2022.

Continuations and Applications

- Develop machine learning technique to detect swaths through an automated process
  - Create databases in other locations where there is damaging hail events through this process
- Improve seasonal and subseasonal forecasting of active vs inactive years
- Investigate potential climatological teleconnections

Two South Dakota swaths in 2018

Contact Information

- Contact information:
  - Emily Wisinski, efw0003@uah.edu
  - Jordan Bell, jordan.r.bell@nasa.gov

References

Bell, J. R., Gebremichael, E., Molthan, A. L., Schultz, L. A., Meyer, F. J., Hain, C. R., Shrestha, S., & Payne, K. C. (2020). Complementing optical remote sensing. *American Meteorological Society*, *59*(4), 665-685. https://doi.org/10.1175/JAMC-D-19-0124.1

Metadata Fields Within Google Spreadsheet

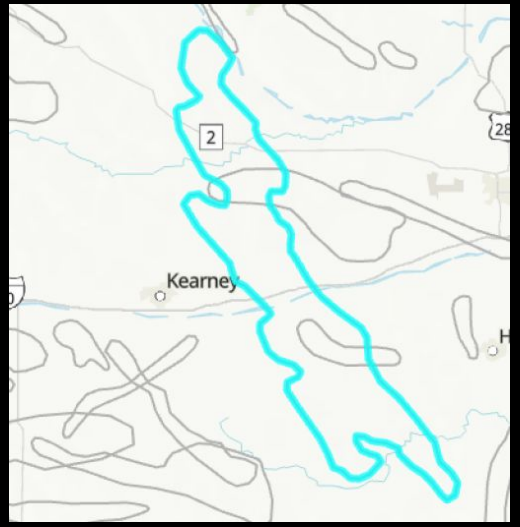
A	B	C	D	E	F	G	H	I	J	K	L	N	O	P
			Analyst			NASA Worldview						Additional Validation (Initials)		
Year	Location	States	Initials	Confid	Event Date	Worldview Link	First Appears	Best Date*	Best View Sensor	SPC Reports Link	Notes/Social Media/WFO Event Summaries	# 1	# 2	# 3
2020	Cheyenne, WY into CO	WY, CO	EW	10	06/26/2020	https://go.nasa.gov/3bsifdd	06/27/2020	07/01/2020	Terra	https://www.spc.noaa.gov/climo/reports/200626_rpts.html		JB 10		
		Individual State Swaths		0										
		Overlapping State Swaths		1										
		Total Swaths for the Year		1										

- Year
- Location
- States
- Analyst (Initials & Confidence)
- Event Date
- Worldview Link
- First Appears
- Best Date
- Best View Sensor
- SPC Reports Link
- Notes/Social Media/ WFO Event Summaries
- Additional Validations – 1, 2, 3 (if needed)

Investigator #1	Investigator #2	Investigator #3	Included or not Inlcuded in Database
7 or Higher	7 or Higher	Not Needed	Included in Database
7 or Higher	7 or Below	7 or Higher	If 2 of 3 Investigator Confidence Above 5, Included in Database
7 or Higher	5 or Below	5 or Below	If 2 of 3 Investigator Confidence Below 5, Not Included in Database

Methods - Archive Work

- Storm Prediction Center Storm Reports
  - LSR Hail vs. MESH Reports (2012 – 2017)
- NASA Worldview
- Google Drive Spreadsheet
- ArcGIS Pro Digitizing & Attribute Table



OBJECTID *	Shape *	swathYear	swathMonth	swathDay	swathDate	firstYear	firstMonth	firstDay	firstDate	bestYear	bestMonth	bestDay
300	Polygon Z	2000	7	21	2000-07-21	2000	7	25	2000-07-25	2000	7	25
301	Polygon Z	2000	7	21	2000-07-21	2000	7	25	2000-07-25	2000	7	25
302	Polygon Z	2000	7	19	2000-07-19	2000	7	21	2000-07-21	2000	7	21
303	Polygon Z	2000	7	10	2000-07-10	2000	7	11	2000-07-11	2000	7	14

bestDate	states_impacted	Sensor	SPC_Report	AREA	Shape_Area	Shape_Length
2000-07-25	NE	Terra	https://www.spc.noaa....	17057.73	0.007459	0.373866
2000-07-25	NE	Terra	https://www.spc.noaa....	4906.82	0.002134	0.281309
2000-07-21	NE	Terra	https://www.spc.noaa....	60002.13	0.025776	0.831265
2000-07-14	NE	Terra	https://www.spc.noaa....	22121.93	0.009852	0.487914
2000-06-30	NE	Terra	https://www.spc.noaa....	28652.92	0.012329	0.502367