Constructing an Extensive Hail Damage Swath Database Using Satellite Remote Sensing and Geographic Information Systems

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

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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
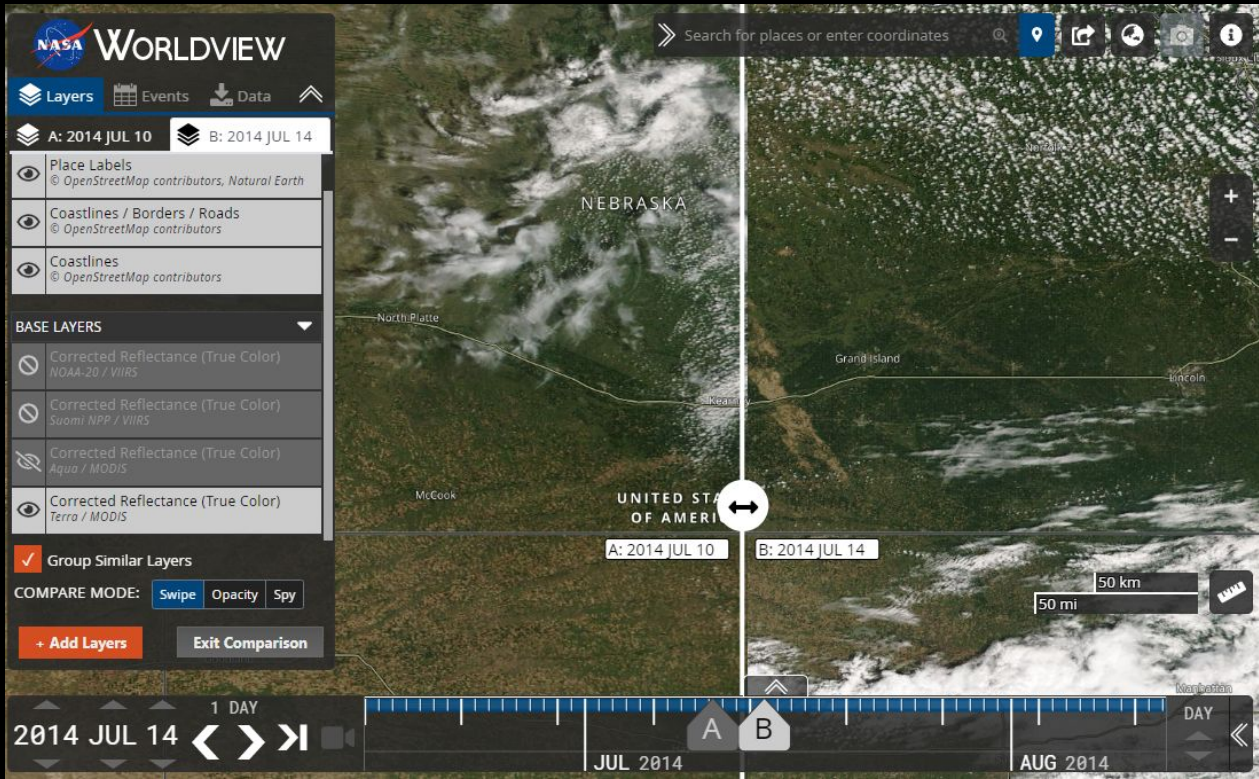
Nebraska, 07/09/2014
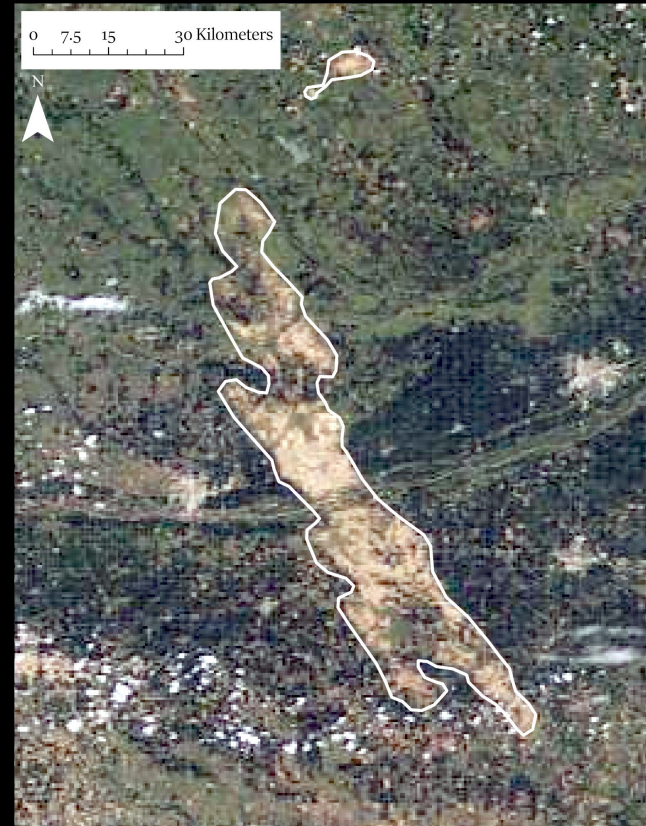
Methods – Archive Work

- Storm Prediction Center Storm Reports
  - 1 May to 15 September
  - 2000-2020

- Local Storm Reports (Hail) vs Maximum Estimated Size of Hail (MESH)
  - Only available 2012-2017
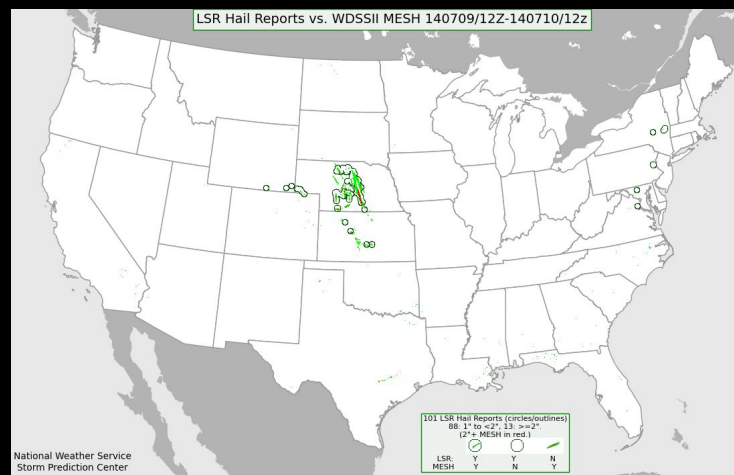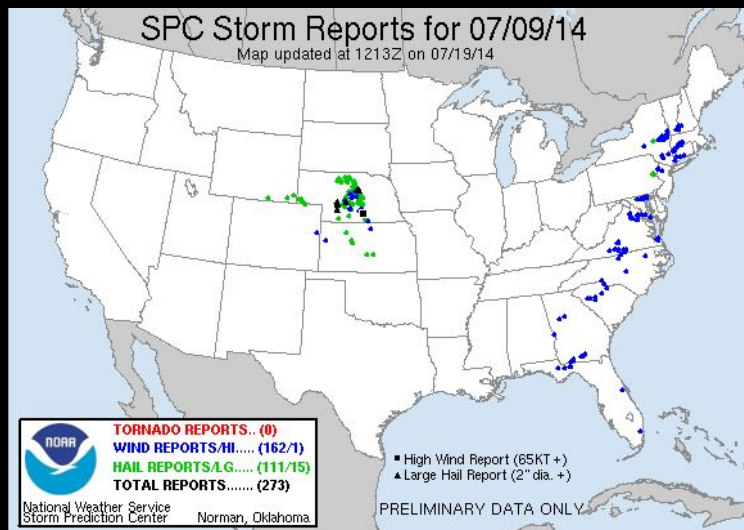
Methods – Archive Work

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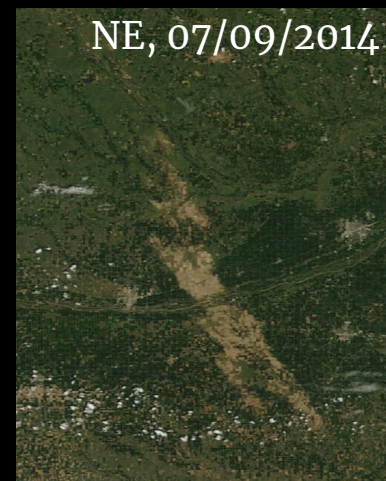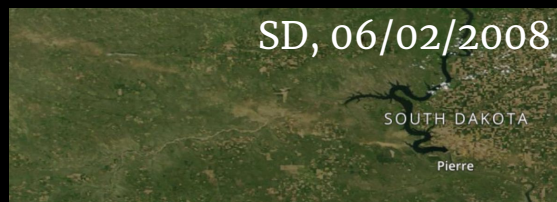
- Local Storm Reports (Hail) vs MESH

- NASA Worldview

NASA Worldview Portal

Diversity in Swaths

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

MN, 06/22/2013

SD, 06/02/2008

SOUTH DAKOTA

Pierre

NE, 07/09/2014

KS, 07/27/2018

CO, 06/27/2016

NE, 05/27/2019

MT, SD, WY, 07/19/2010

Pana

IL, 07/18/2003

ND, 06/24/2007

4

Methods – Archive Work

| | | | Analyst | | NASA Worldview | | | Best View | X-Ref | Additi |
Year	Location	States	Initials	Confid	Event Date	Worldview Link	First Appears	Best Date*	Sensor	(18-19) Only	# 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/3foLZXi					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/3kalDe3	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/3i6lk38	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

- Storm Prediction Center Storm Reports

- Local Storm Reports (Hail) vs MESH

- NASA Worldview

- Catalog events in Google Sheet

- 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

GeoTIFF Image from NASA Worldview

GIS

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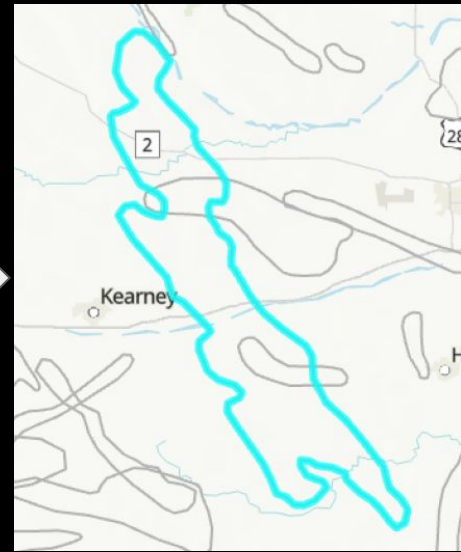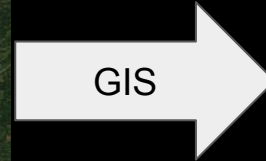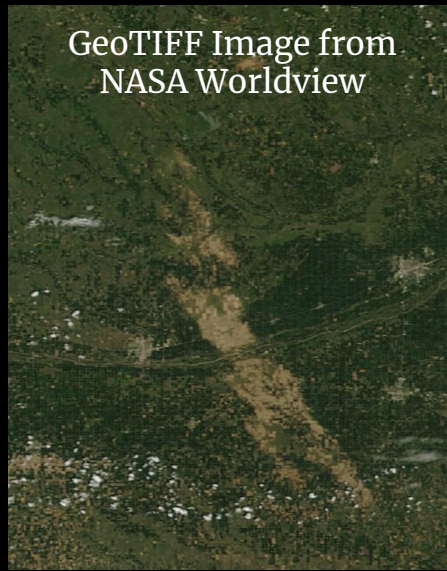
- For each confirmed event in Google Sheets
  - True color geotiffs from the "Best Date" were downloaded
  - Geotiffs were imported into desktop GIS software where analysts outline each swath into a shapefile
  - Metadata from Google Sheets were also entered into the shapefile.
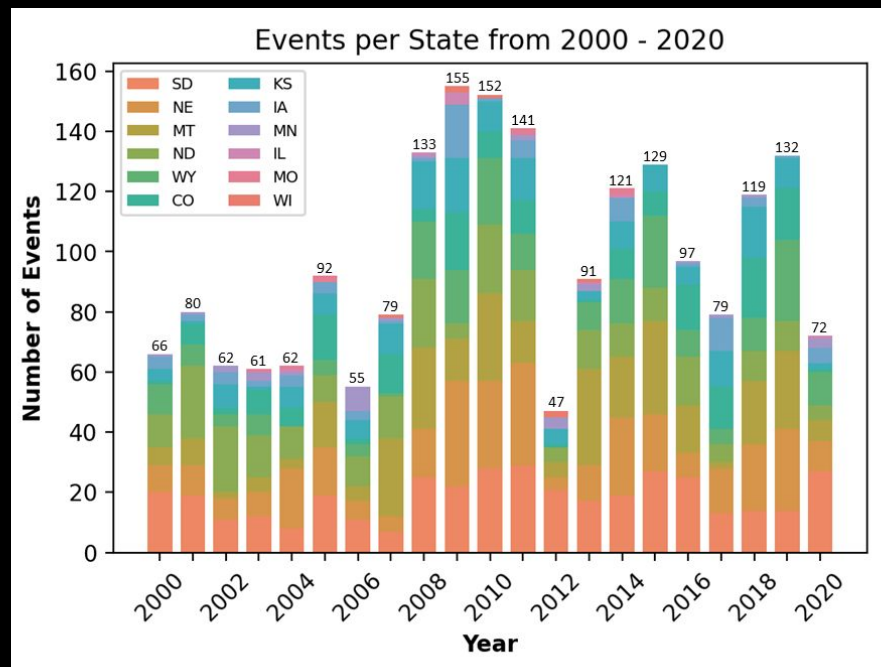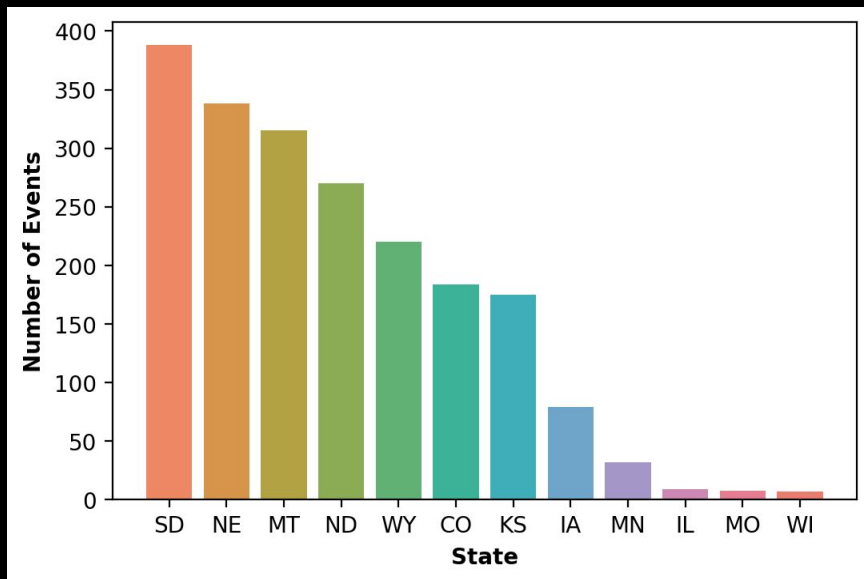
Results

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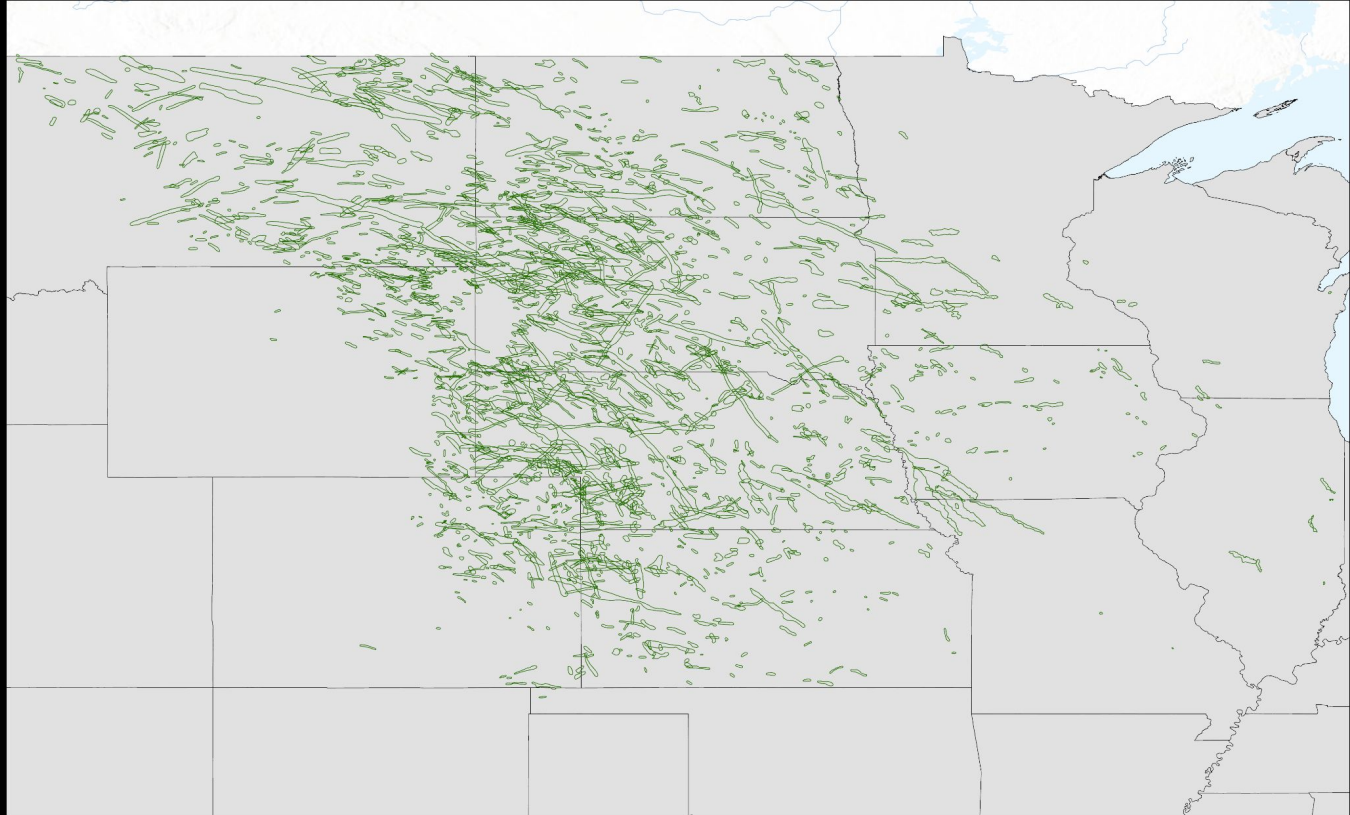
Results

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

Results

Hotspot Analysis
Magnitude Per-Unit-Area
High
Low
0   45   90   180 Miles
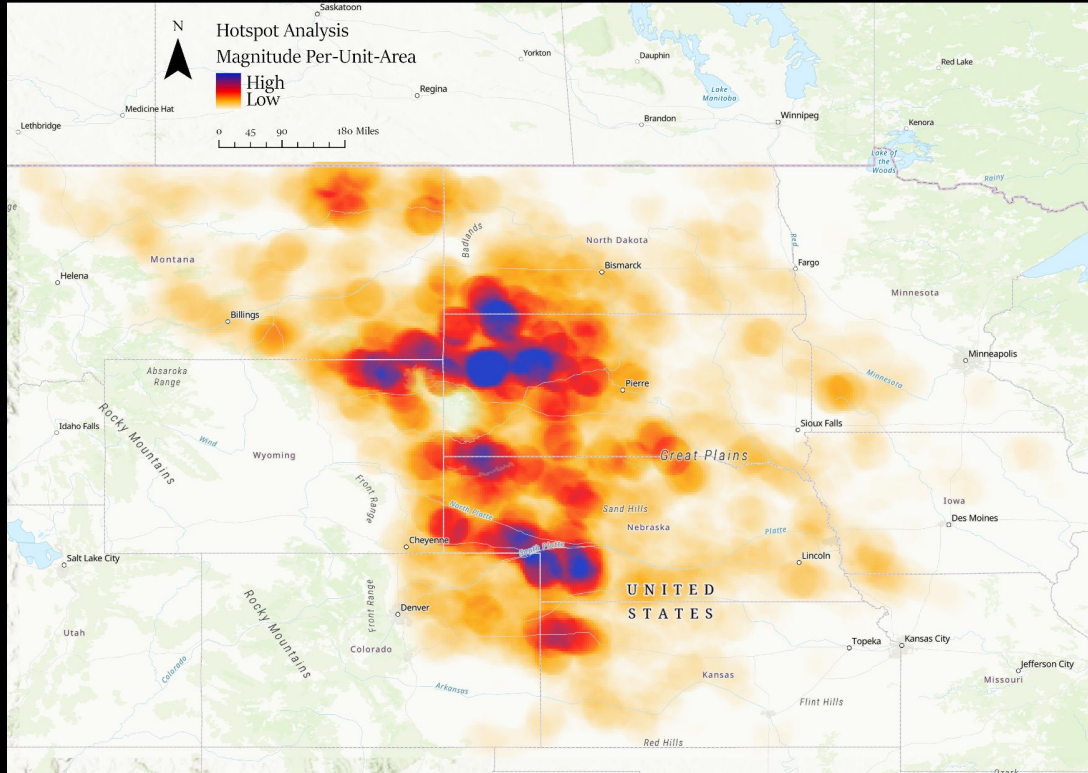
- Analysis visualizes hotspots for hail damage swaths based on the polygons drawn. Western ND, SD, and NE show the largest frequency of events occurring.
- Preparing manuscript that details methodology and impacts to agriculture - submitting Spring 2022.

Continuations of Applications

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

06/29/2018

06/26/2018

Two South Dakota swaths in 2018

Contact Information

Omaha, NE, 06/27/2008

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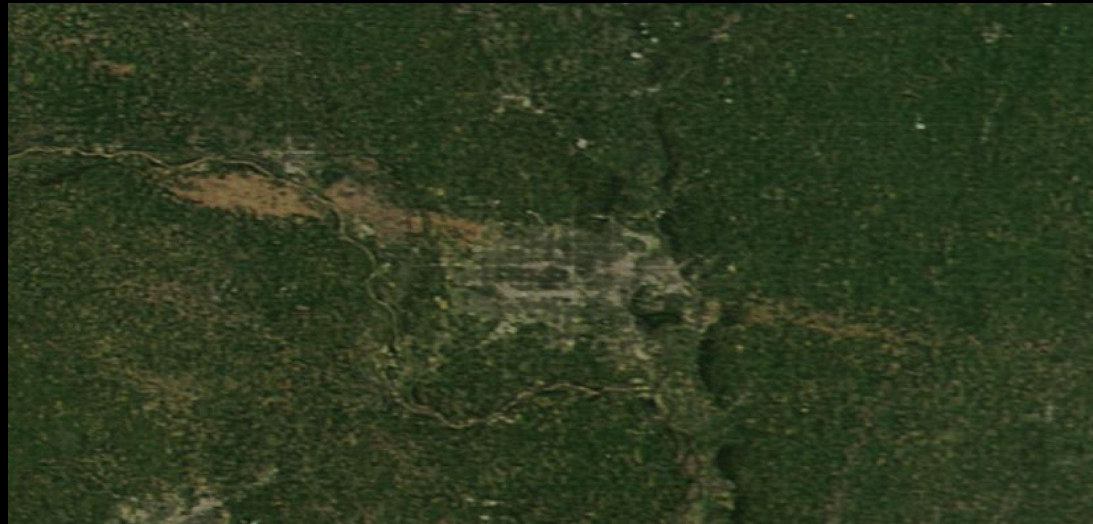
References

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	M	N	O	P
			Analyst			NASA Worldview			Best View Sensor				Additional Validation (Initials)		
Year	Location	States	Initials	Confid	Event Date	Worldview Link	First Appears	Best Date*		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
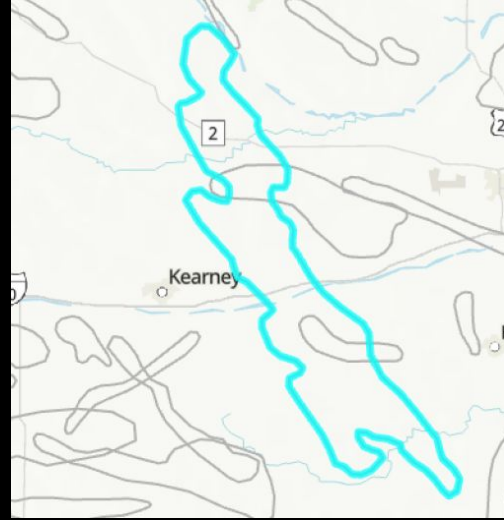
- Storm Prediction Center Storm Reports
  - LSR Hail vs. MESH Reports (2012 – 2017)
- NASA Worldview
- Google Drive Spreadsheet
- ArcGIS Pro Digitizing & Attribute Table

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