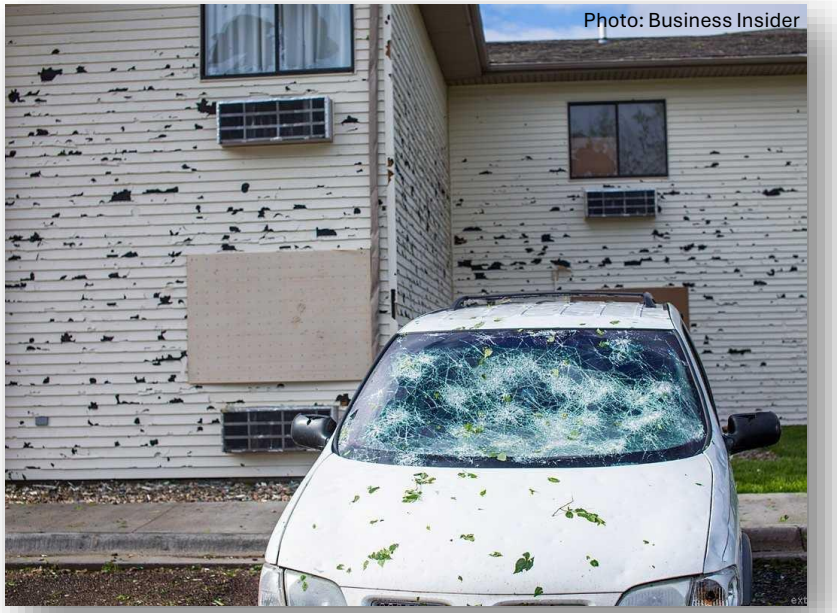
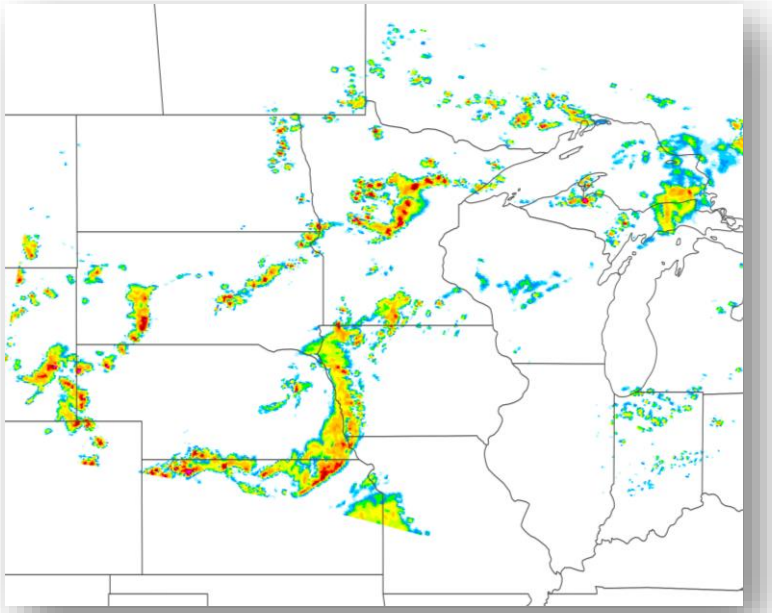
A Dynamics-Informed Open-Source Hail Stochastic Event Set





Lead PI: Daniel Wright, Civil and Environmental Engineering

Collaborators: Matthias Katzfuss, Statistics; Aaron Alexander, Civil and Environmental Engineering

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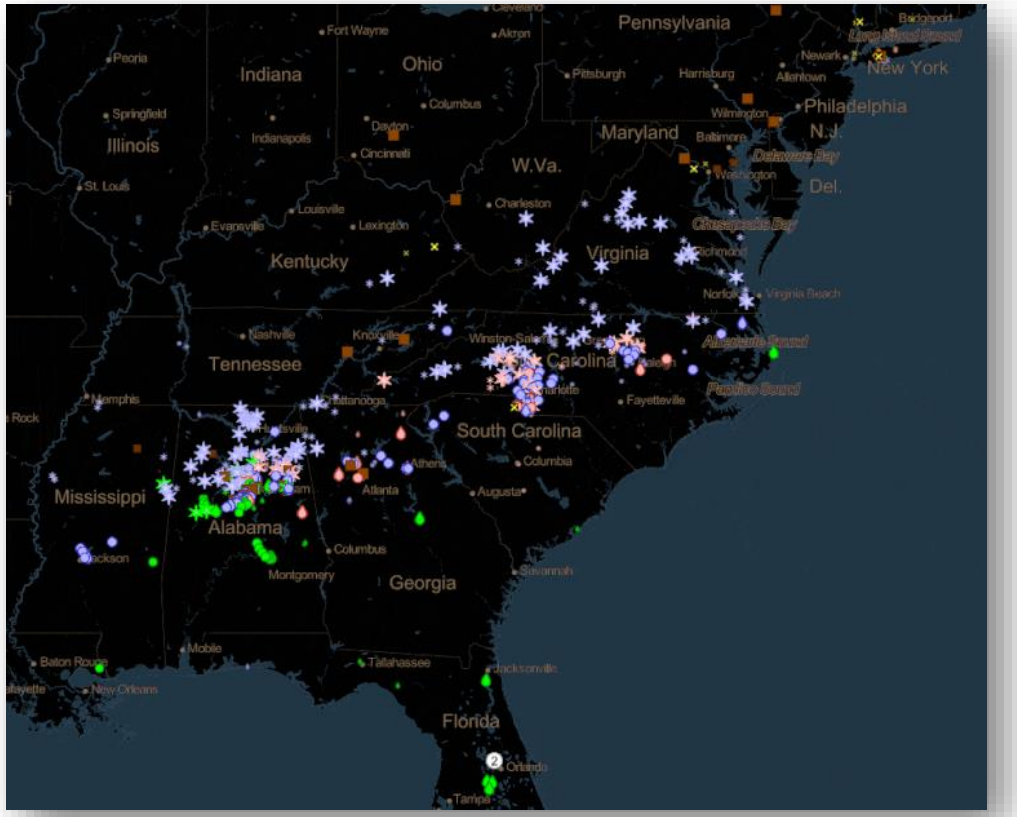
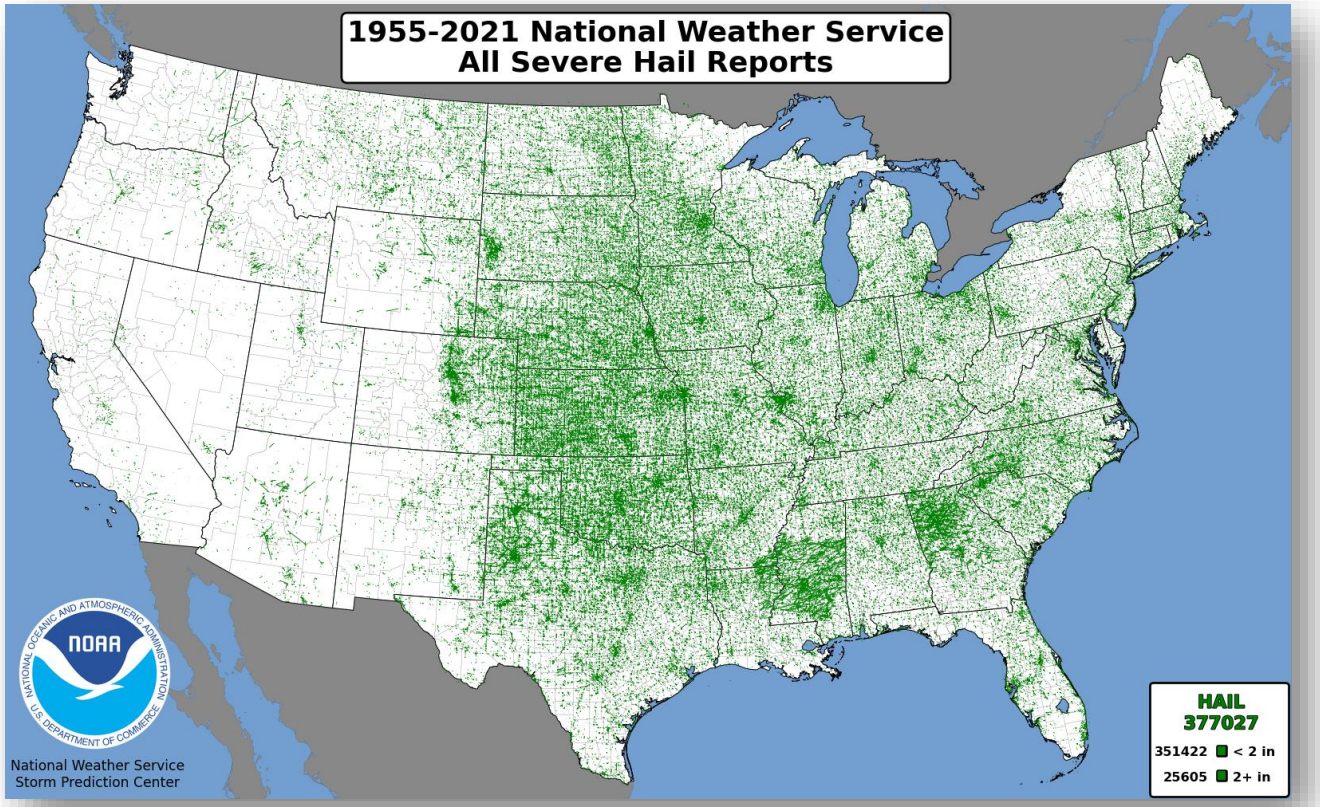
What's the problem?

- We can't accurately quantify hail extent and probability, particularly in forward-looking applications such as catastrophe modeling

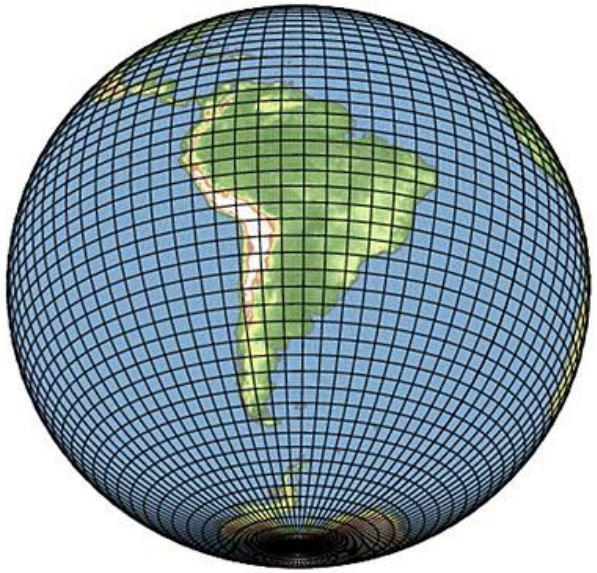


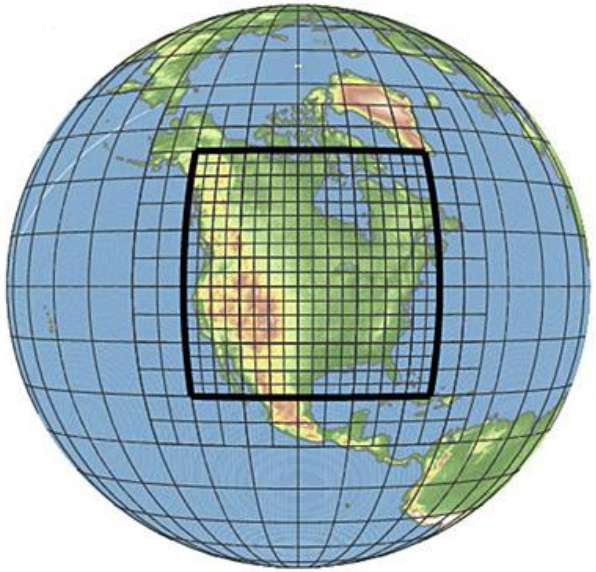


Need and Industrial Relevance

Peril	Insured losses H1 2024	Insured losses H1 2023
Severe convective storms	$42bn	$37bn
Flooding	$8bn	$3bn
Winter weather	$4bn	$3bn
Wildfire	$2bn	n/d
European windstorm	$1bn	n/d
Earthquakes	n/d	$6bn
Drought	n/d	$1bn
Tropical cyclone	n/d	$1bn

Source: Aon





Changes in built environment & climate are driving up hail losses

- Pricing risk based on historical experience is becoming problematic
- Hail observations are too incomplete & vague (geographical reporting bias, “golf-ball sized”) to estimate return periods
- Atmospheric models can in theory fill those gaps, but both regional and global models have specific shortcomings

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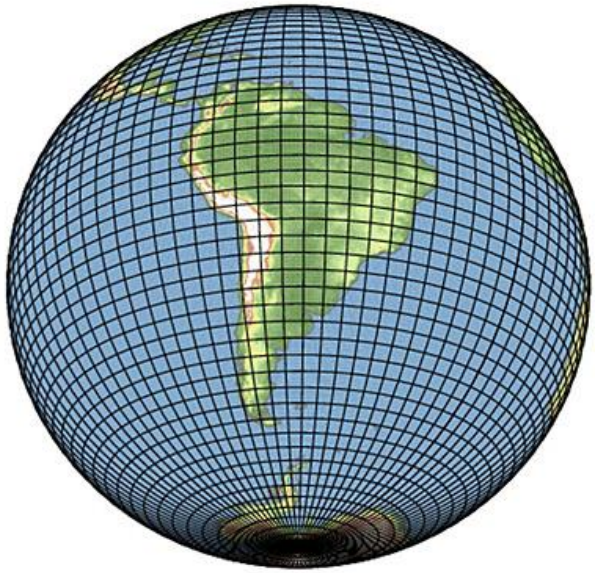
Project Vision / Impact

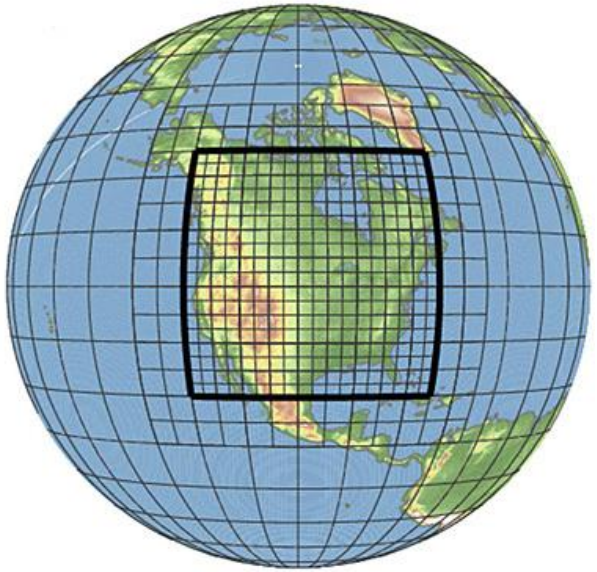
- This project will generate a large (~1,000,000) set of realistic hailstorms, leveraging existing high-resolution regional and global climate model simulations

- Supports prediction of hail return periods and impacts (for cat modeling, etc.) under past, present, and future conditions

Global Models: Computationally fast (many decades of simulations/ scenarios), coarse resolution



Regional Models: High resolution, computationally expensive (limited simulation periods and scenarios), likely biased



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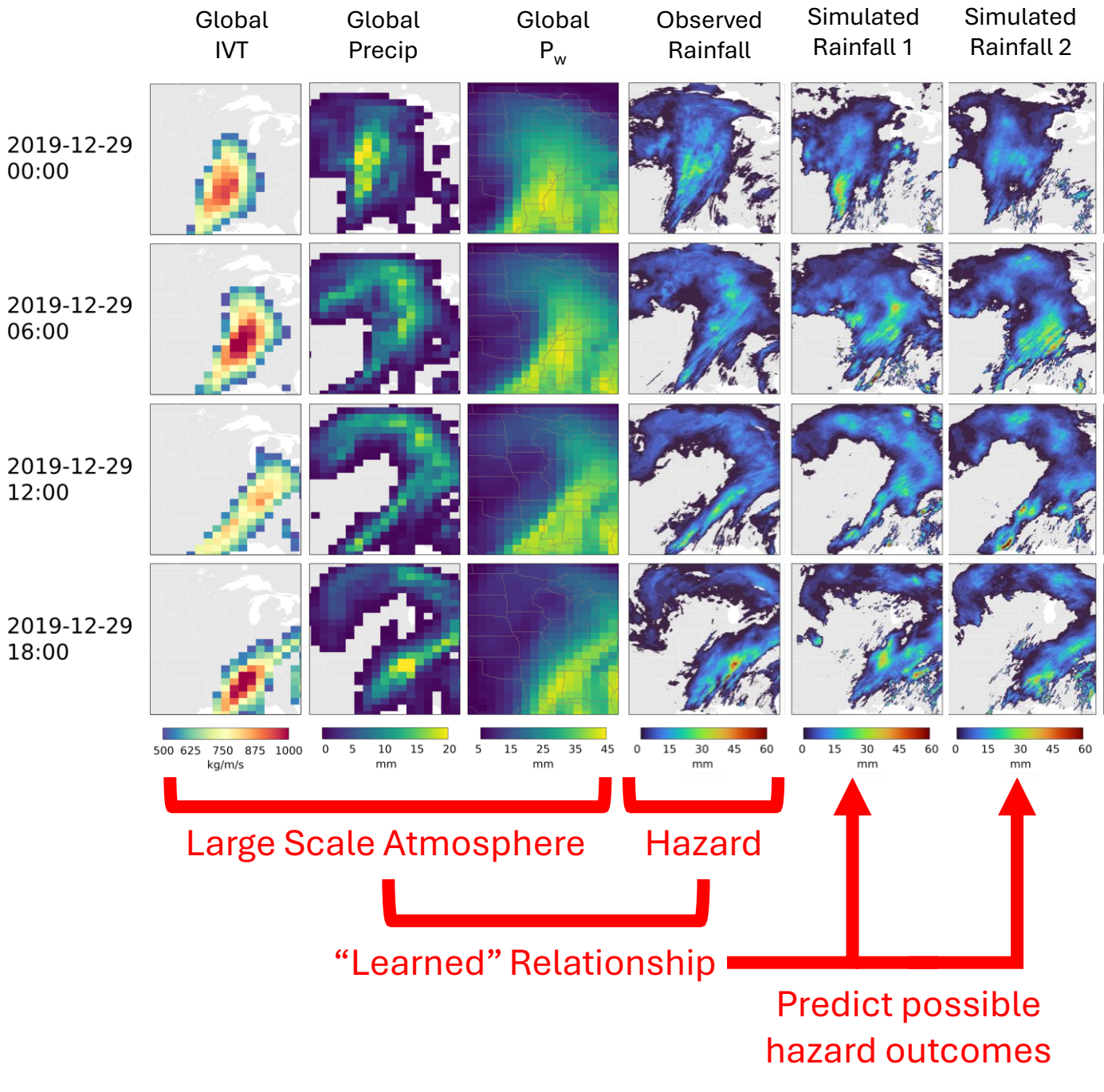
Approach

Key point: SCS are fine-scale phenomena embedded in large-scale atmosphere

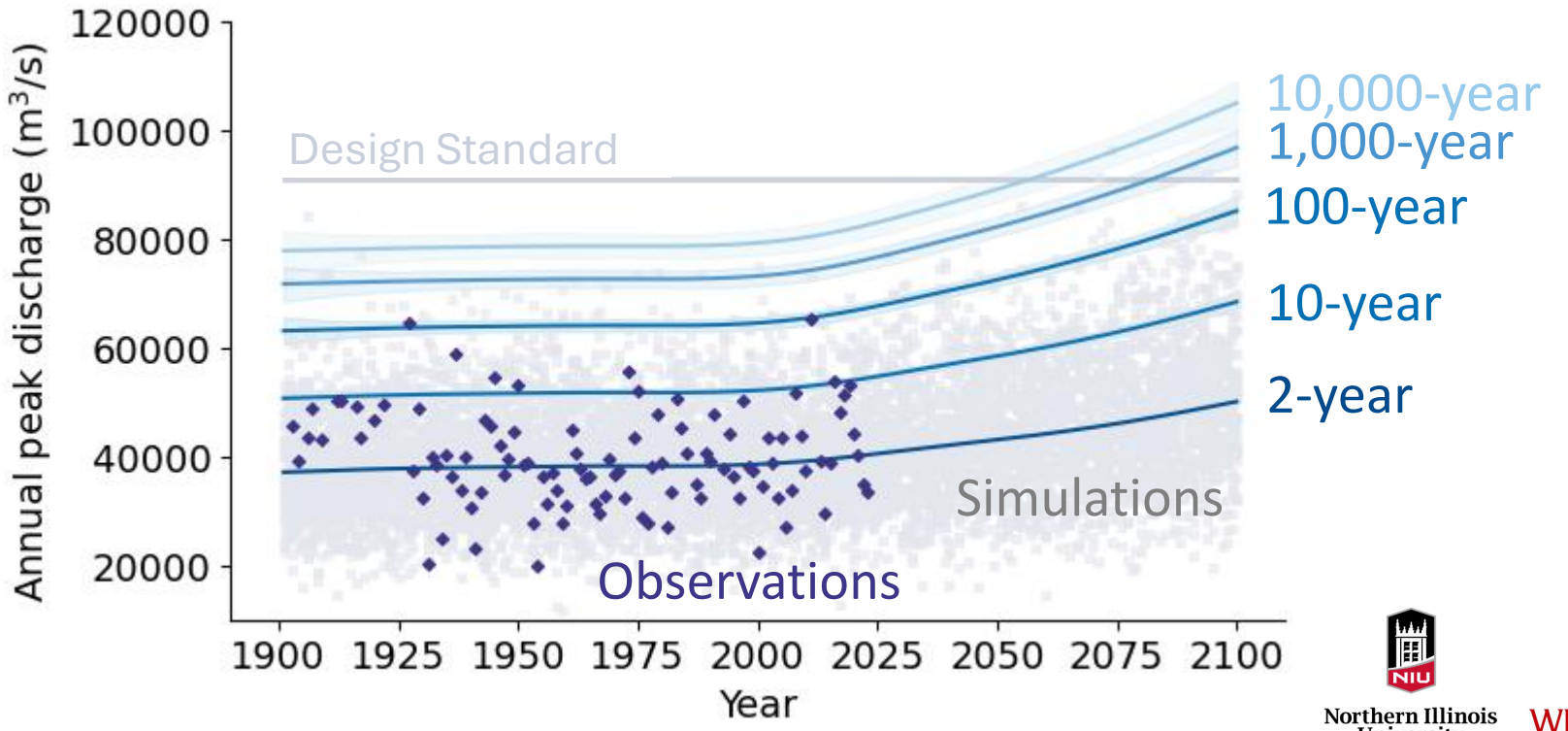
- Large scale provides important but insufficient info on hail outcomes
- Multiple SCS outcomes are possible for a given large-scale condition
- By “learning” what is possible, we can **quickly simulate many plausible hazard possibilities** based on large-scale model predictions
- Will adapt existing open-source StormLab software
  - Liu et al. (2024)
  - https://github.com/lorenliu13/StormLab



Approach

Recent work: Calculating past/present/future rainfall and flood return periods for Lower Mississippi River based on a large archive of climate model projections (Liu et al., 2024, 2025)

Ongoing work: hail proof-of-concept (thanks to AmFam!)



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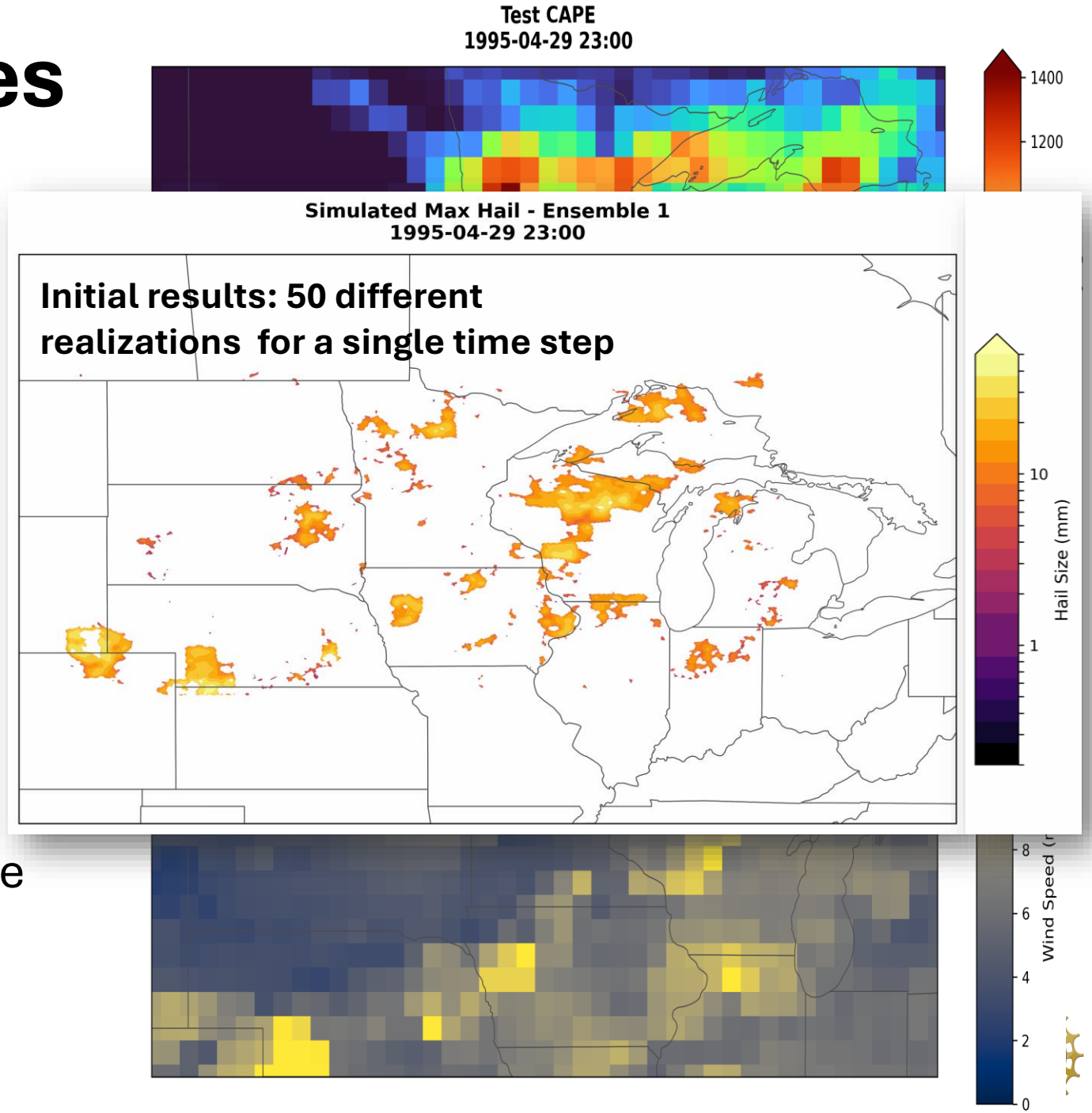
Outcomes/Deliverables

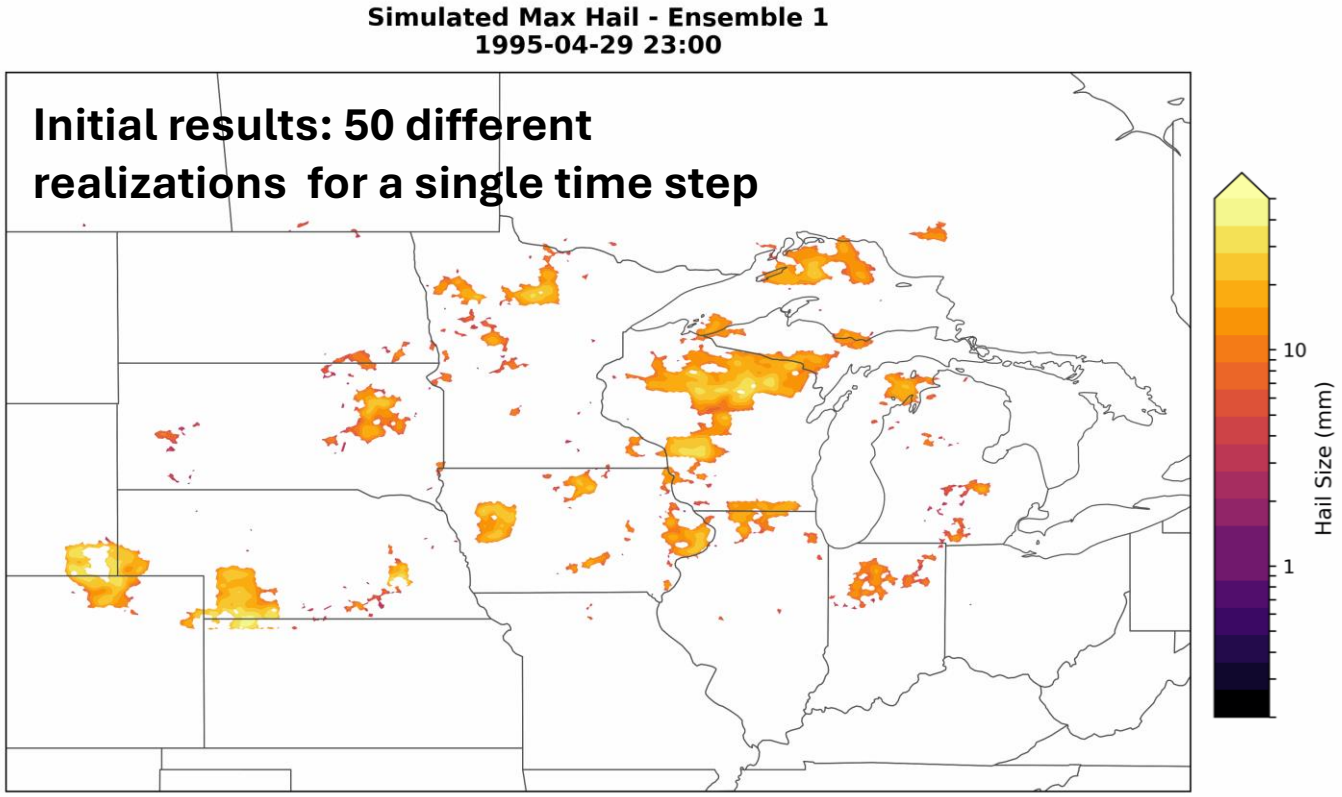
1. **Large hail event set for current/near future**
   - →Available to CIRCS members
   - →Flexible format/resolution
2. **Open-source codebase with examples & documentation**
   - →Members and CIRCS PIs can apply in new contexts
3. **Role/value within CIRCS**
   - →Rowe and L'Ecuyer, Bundy & Gensini: hail observations
   - →Pittman etc.: high-resolution climate attribution
   - →Strader and Ashley: hail impact modeling



Impact and Future Opportunities

1. **New data & methods for hail risk assessment**
   - Estimated hail return periods and storm maps
   - Applicable to other hazards (rainfall, wind)
   - Insights into the value of regional & global models to understand hail risks

2. **Long-Term Vision (Year 2+):**
   - Examine year-to-year and long-term variability in hail distributions
   - Validate against hail observations and explore model-data fusion
   - Leverage emerging model simulations



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Project Timeline

- Staffing: now-February 2027

Task	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Data procurement & preprocessing	Data											
Finalize processing algorithms			Algorithm									
Run StormLab on entire dataset						Run StormLab						
Finalize event set and write paper										Finalize Dataset		

Develop follow-on research plan

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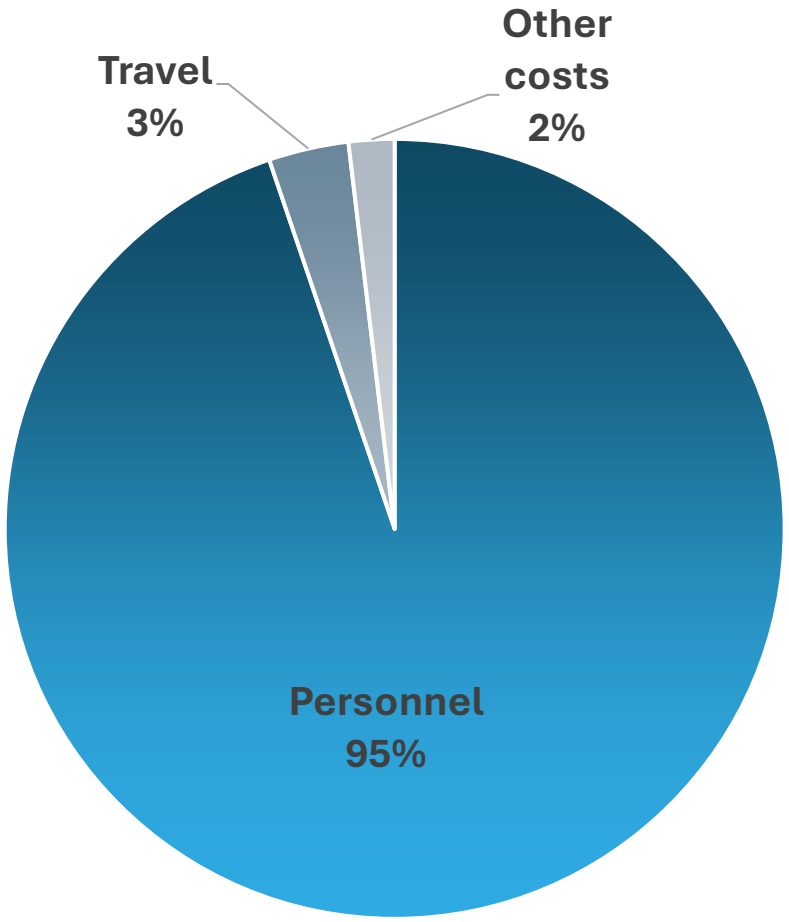
Project Budget

- **Personnel: $103k**
  - PI Wright (2 weeks)
  - Postdoctoral Researcher (12 months)
  - Graduate Student stipend + tuition (4 months)
- **Travel: $4k**
  - Travel to CIRCS annual meeting
  - Conference attendance and presentation (AGU 2026 or AMS 2027)
- **Other: $2k**
  - Open-access publication fee
- **<u>Total: $109,000</u>**



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