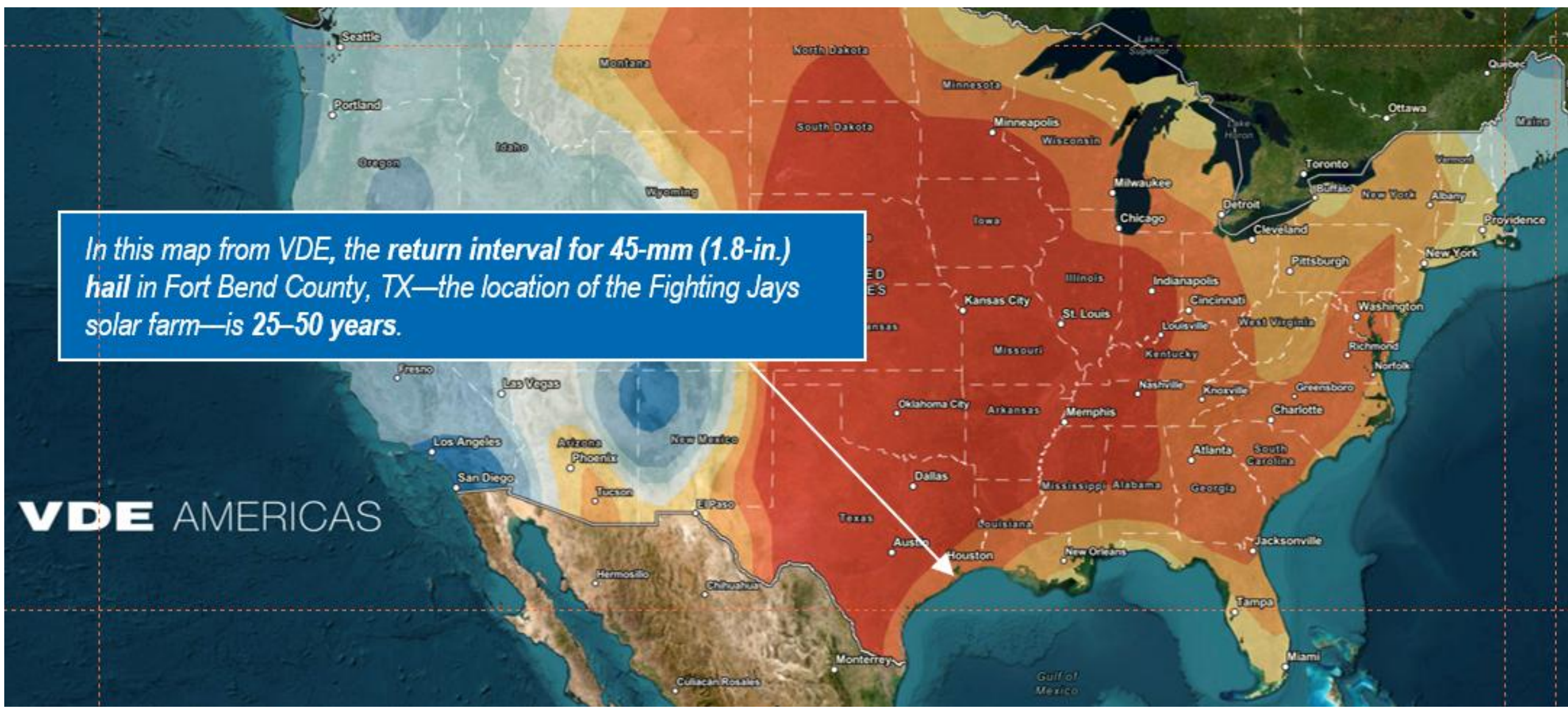
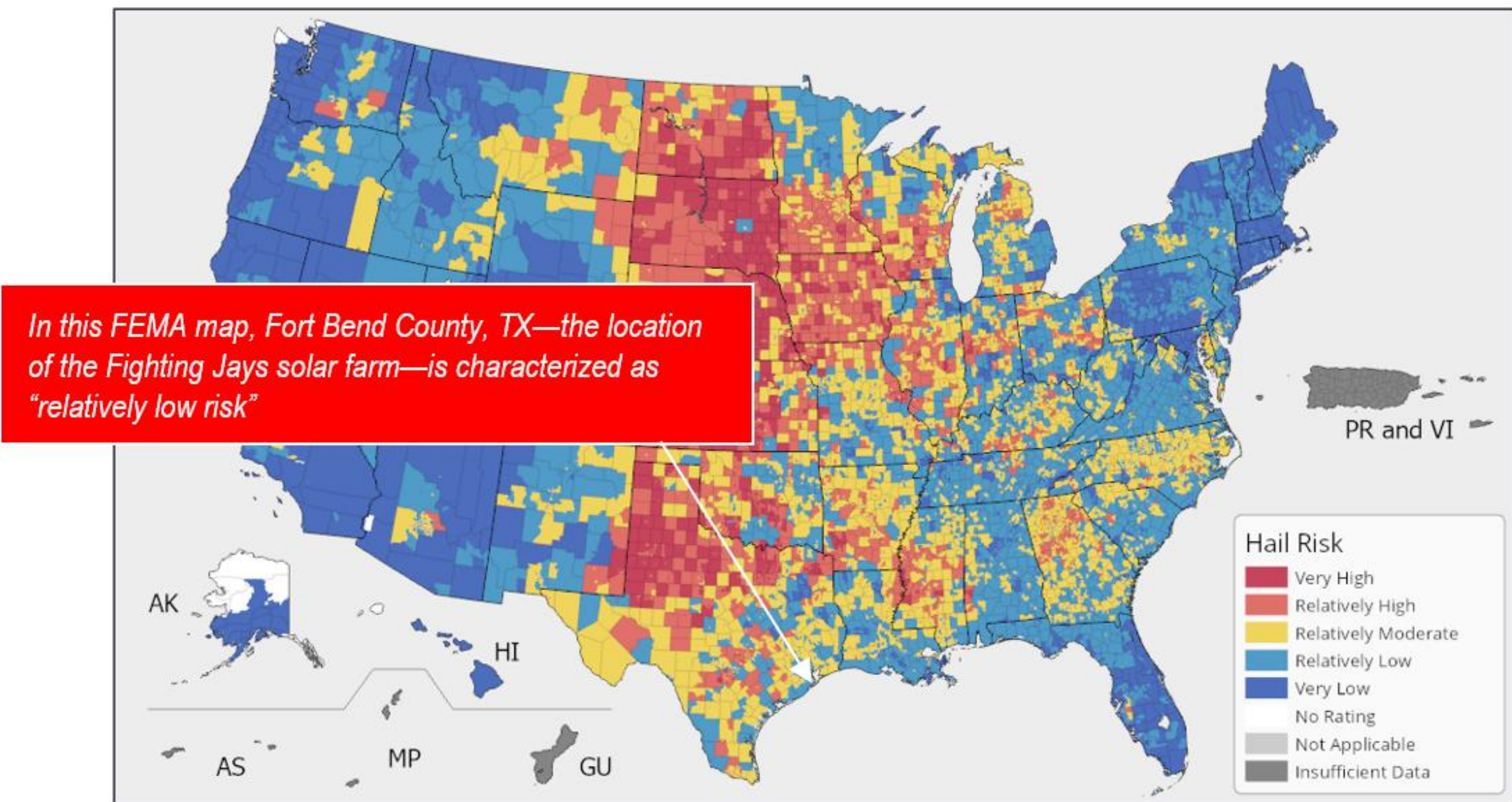


Advanced Hail Risk Modeling and Mapping for Solar PV Systems

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PV Performance Modeling Collaborative 2025

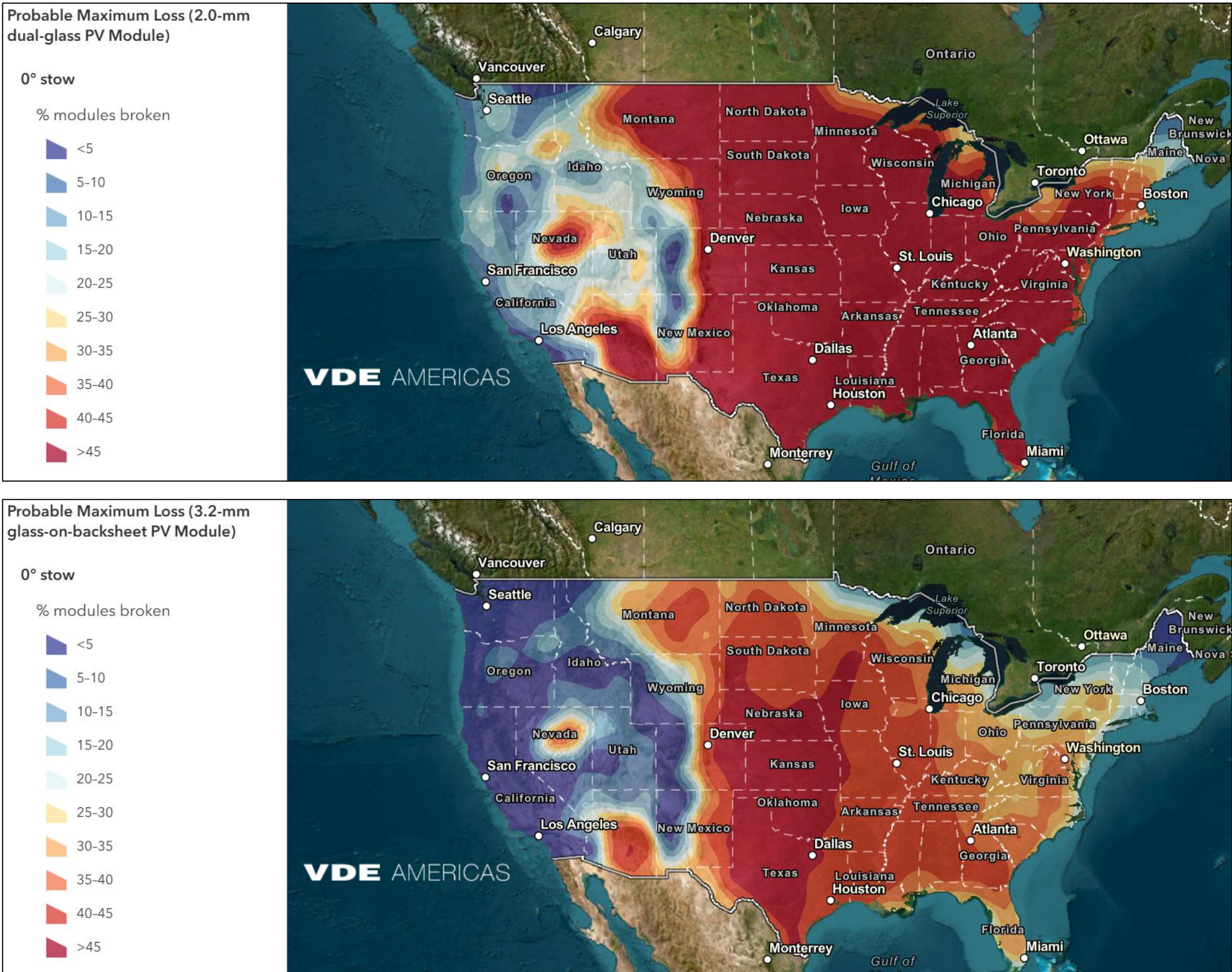
Introduction

- Traditional hail loss models used for utility scale PV projects typically fail to account for solar-specific equipment characteristics.
- Additionally, existing hail risk maps primarily utilize only ground observation information and claims, and therefore exhibit population bias
- Our approach to mapping hail risk across the CONUS accounts for both population bias in hail reporting, and PV module vulnerability based on module construction and tracker positions



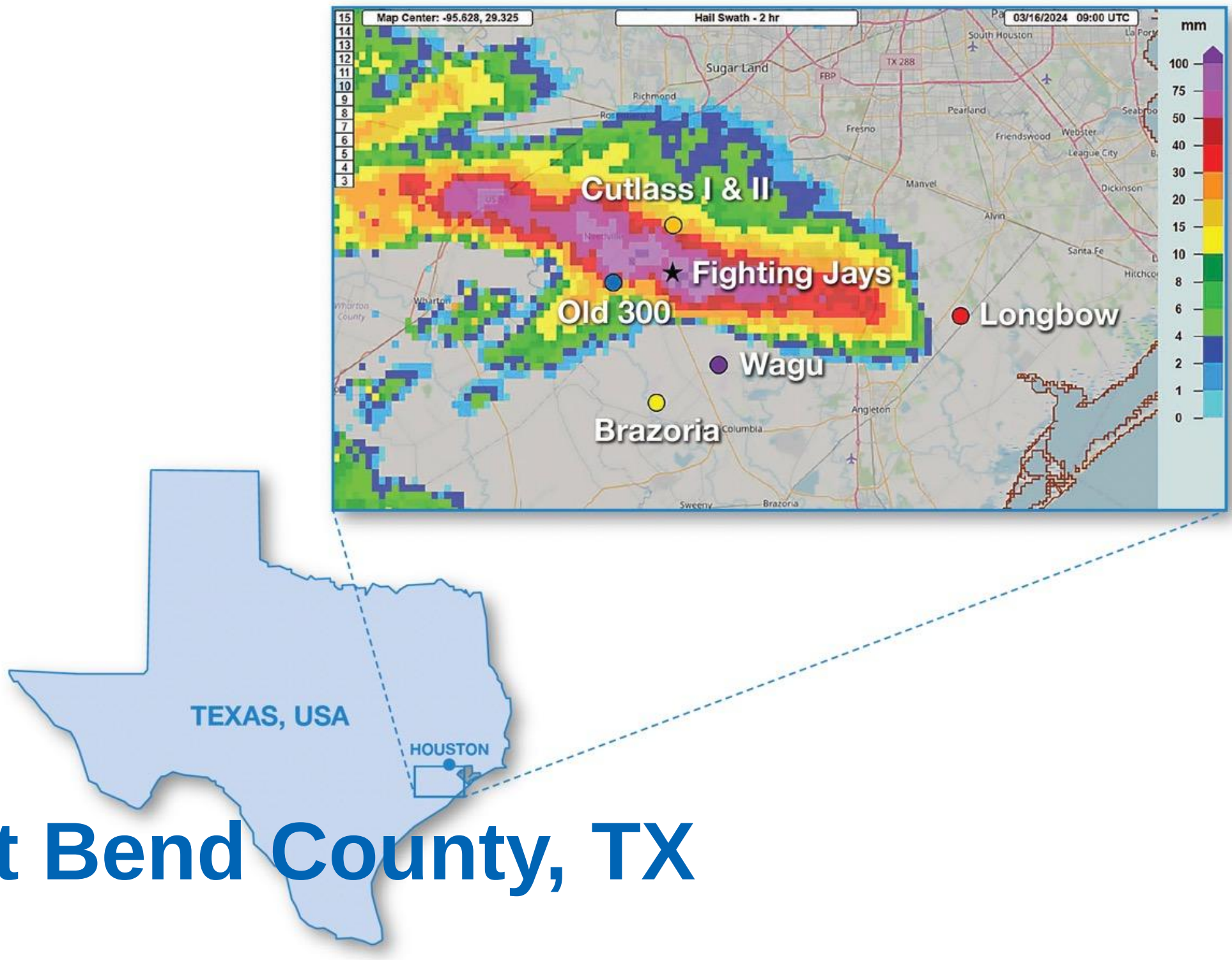
Hail Risk Map Generation

- Developed using location-specific values calculated on a non-standard grid covering the CONUS
- An initial set of grid points are selected using a 100 km x 100 km grid, and additional points are added at event-spaced intervals between adjacent grid points with greater than a 2x difference in values
- For each metric, use a linear spatial interpolation approach to estimate values between grid points, then utilize a Gaussian filter to smooth results and generate continuous risk surfaces



Location-Specific Data Generation

- In collaboration with Dr. John Allen (Allen Weather Risk, Central Michigan University), observed hail records (NOAA Storm Prediction Center) are combined with calibrated NEXRAD radar hail detection data (NOAA Severe Weather Data Inventory) from the period 2000-2024 to create a robust hail dataset capturing event frequency, severity, spatial variability, and temporal patterns
- To characterize the climatological hail environment at a particular location, we select historical hail events within a 100 km x 100 km regional grid (centered on the location of interest)
- Hail Return Intervals are calculated for discrete hail size bins by summing hail event frequency and inverting the mean annual rate
- A physics-based model estimates hailstone impacts per unit area for a given combination of hail event size and wind speed
- This data is combined with module resiliency characteristics to calculate the fraction of broken modules (damage probability) from each hail size event across a range of module tilt angles



Case Study: Fort Bend County, TX

Event Information:

		Old 300	Cutlass I	Cutlass II	Fighting Jays
3/15/2024 Storm (5:00–6:30 p.m. CDT)	Max hail size (per radar)	30–40 mm	40–50 mm	50–75 mm	50–75 mm
	Max wind speed at site	51 mph			
	Storm speed	23 mph			
3/16/2024 Storm (2:30–3:30 a.m. CDT)	Max hail size (per radar)	75–100 mm	50–75 mm	30–40 mm	>100 mm
	Max wind speed at site	31 mph	23 mph max gust (in vicinity)		
	Storm speed	30 mph			

Key Findings:

Fighting Jays

- Severe hail damage (no public details available)
- Stowed per protocol to nearest extreme angle
- Hail damage limited to ~40 modules on a non-stowed tracker (motor fault predated storm)
- <10 modules damaged due to wind-blown objects
- Oil gauge damaged on one MVT [medium-voltage transformer], causing inverter skid shutdown
- Tracker stow direction relative to wind direction unknown

Cutlass I

- No hail damage reported
- Stowed per protocol to nearest extreme angle
- Tracker stow direction relative to wind direction unknown

Cutlass II

- No hail damage reported
- Project under construction
- Trackers in hail stow per protocol
- Tracker stow direction relative to wind direction unknown

Lessons Learned:

- Demonstrates importance of reliable hail stow protocol, weather forecasting and early response times to trigger hail stow
- Highlights need for nighttime and construction hail stow protocols