Reliability-Targeted Design Ground Snow Loads in ASCE 7-22

2/23/2022

Presented by:

Marc Maguire, University of Nebraska

Brennan Bean, Utah State University

Polling Question

- Requirement to earn PDH credits
- Two questions will be asked during the duration of today's presentation
- The question will appear within the polling section of your GoToWebinar control panel to respond
- Please be sure that your pop-up blocker is disabled. If you're in full-screen mode, the GoToWebinar polling widget will appear behind the slides. You'll need to exit full screen to be able to access.

Disclaimer

The information presented herein is designed to be used by licensed professional engineers and architects who are competent to make a professional assessment of its accuracy, suitability and applicability. The information presented herein has been developed by the Steel Joist Institute and is produced in accordance with recognized engineering principles. The SJI and its committees have made a concerted effort to present accurate, reliable, and useful information on the design of steel joists and Joist Girders. The presentation of the material contained herein is not intended as a representation or warranty on the part of the Steel Joist Institute. Any person making use of this information does so at one's own risk and assumes all liability arising from such use.

Webinar Description

This webinar will cover the development and background of the forthcoming changes to ASCE 7-22. In this update, a new hazard tool will be available through ASCE making it easier to determine design ground snow loads; however, the basis for these changes may not be well known. The new loads are called reliability-targeted loads and provide a more uniform safety throughout the conterminous United States while at the same time nearly eliminating case study regions. By gathering data from throughout the country and performing site-specific reliability analyses at every measurement location, these loads use the best available information. The basis for the loads and use of the new tool will be discussed along with the subsequent changes to ASCE 7-22 Chapter 7.

Learning Objectives

- Understand the previous ground snow loads.
- Understand the process for developing reliability-targeted loads.
- Understand the general process for mapping reliability-targeted loads.
- Overview of changes to ASCE 7-22 Chapter 7 provisions caused by a shift to reliability-targeted loads.
- Learn how to use the ASCE hazard tool.

Introduction

Marc Maguire, PhD, Assistant Professor

– Research interests: Probabilistic methods, structural mechanics

COLLEGE OF ENGINEERING

The Durham School of Architectural Engineering and Construction

Introduction

Brennan Bean, PhD, Assistant Professor

- Research Interests: Applied Spatial Statistics

UtahStateUniversity

MATHEMATICS & STATISTICS

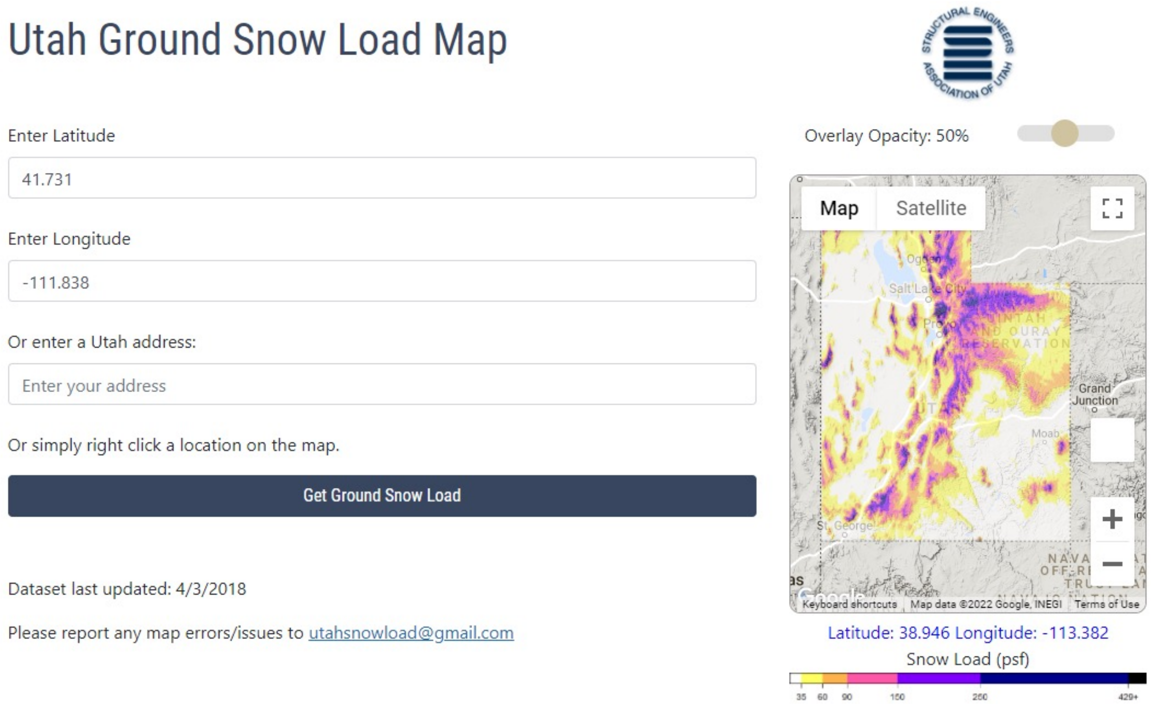
Previous Work

Formal western state snow studies

- Utah
- Washington

Informal studies

- Idaho
- Montana



Ground Snow Load Task Group

ASCE 7 R&SLSC Steering Committee

- Mike O'Rourke (RPI)
- Jim Harris (JR Harris)
- **Abbie Liel (Univ. of Colorado)**
- Jim Buska (CRREL)
- Jerry Stephens (Univ. of Montana)
- R. Nielson (Univ. of Idaho)
- D. Jared DeBock (Chico State)
- Johnn Judd (U. WY)
- David Thompson (KTA)
- Hossein Mostafaei, (FM Global)
- John Corless (SEAOC)
- John-Paul Cardin (AISI)
- Sean Homem (SGH)
- Gary Ehlrich (NAHB)
- Sterling Strait (SEAAK)
- Vince Sagan (MBMA)
- **Scott Russell (SJI/SDI)**
- Thomas DiBlasi (SEA)
- John Duntemann (WJE)

Need for the Ground Snow Load Update

Last significant update: 1995 Edition

- 30+ more years of data available

Significant 'case study' regions

- Challenging for practitioners
- Inconsistency in snow loads across state lines

Many states or municipalities have superseded ASCE 7 loads

Case Study Regions

In CS areas, site-specific Case Studies are required to establish ground snow loads. Extreme local variations in ground snow loads in these areas preclude mapping at this scale.

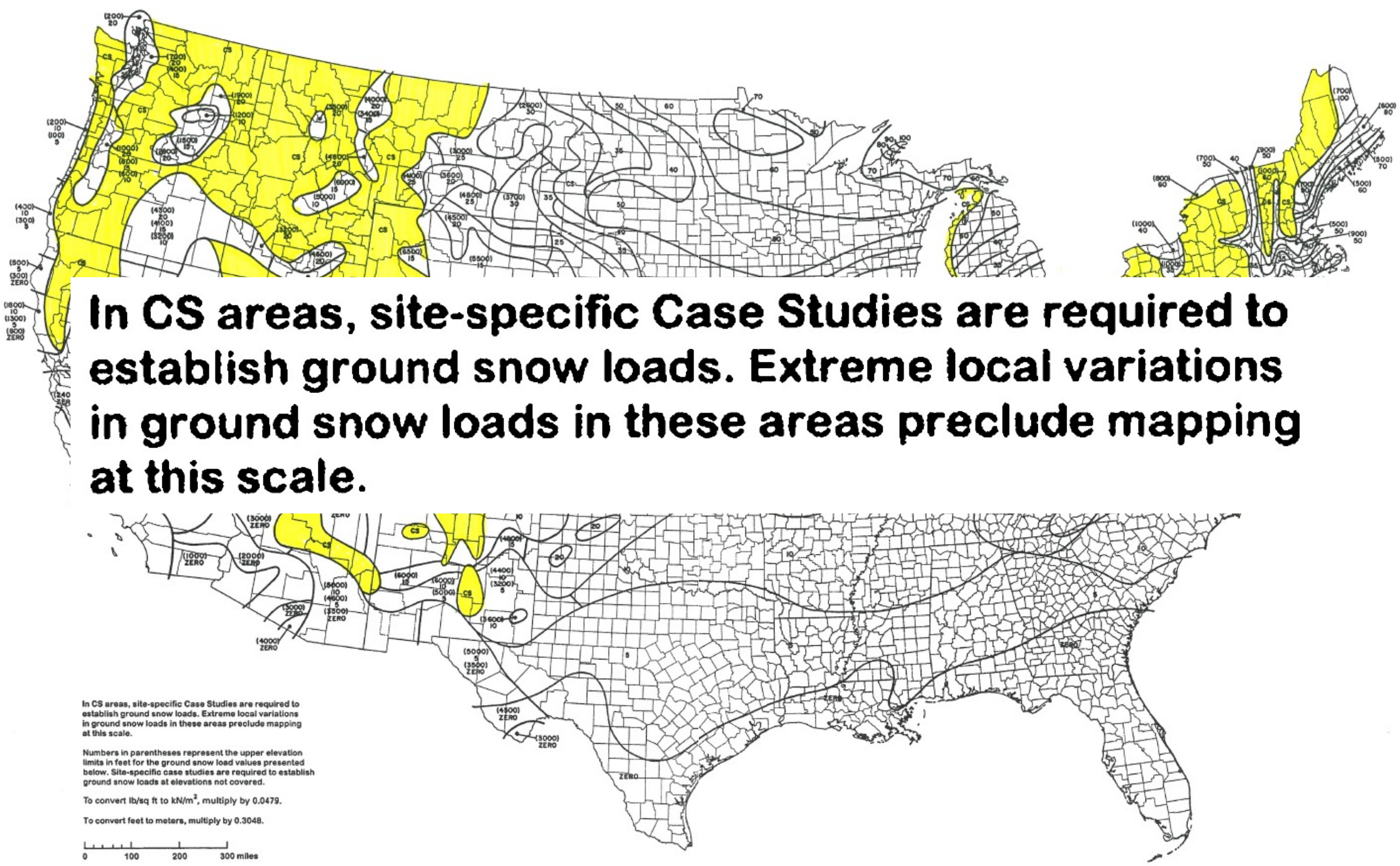


FIGURE 7-1 Ground Snow Loads, P_g, for the United States (Lb/Ft^2).

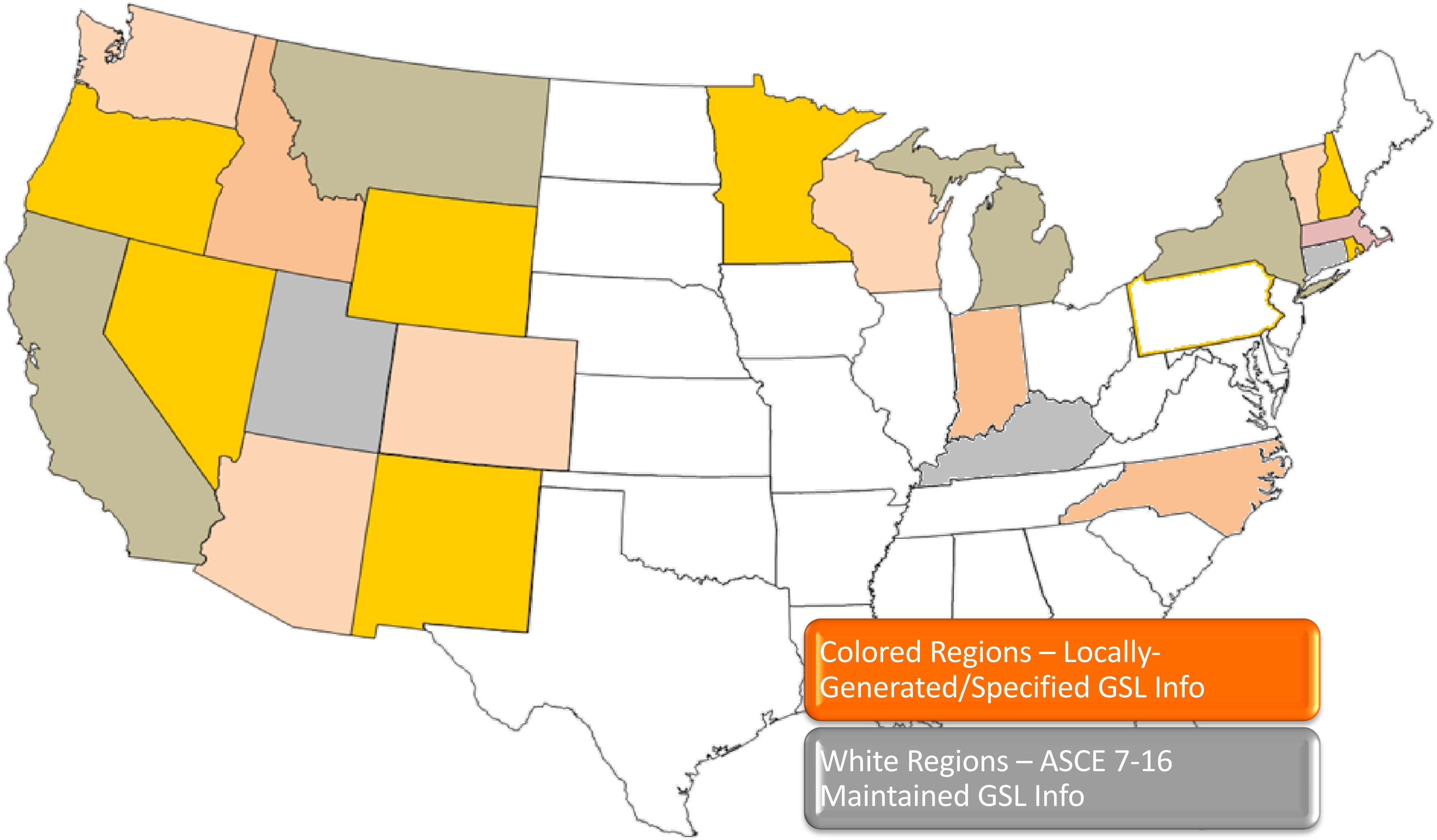
Need for the Ground Snow Load Update

Move to reliability-targeted basis

- 50-year ground snow load provides non-uniform reliability across the country
- 50-year ground snow load may not provide sufficient reliability against roof collapse in some parts of the country

Re-establish ASCE 7 as the National Standard for GSL

Current Ground Snow Load Situation



Colored Regions – Locally-Generated/Specified GSL Info

White Regions – ASCE 7-16 Maintained GSL Info

Previous ASCE 7 Maps

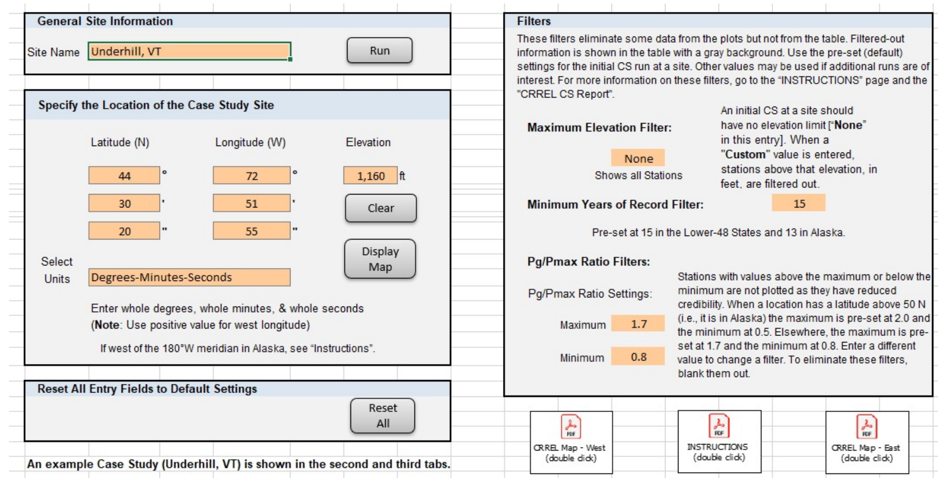
Created by researchers from US Army Cold Regions Research and Engineering Laboratory

- First iteration 1980
- Second update 1993
- Zone maps

Previous ASCE 7 Maps

CRREL Case Study

- CRREL provided case studies
- Spreadsheet
  - Identify nearby snow stations
  - Radius and elevation band of influence
  - Build linear relationship with snow and elevation
  - Predict at location of interest



Previous Safety Factor

Ellingwood et al. (1980)

The original calibration for the ANSI A58 and the later ASCE 7-88 related to snow load case has remained unchanged until the ASCE 7-22

$$1.2D_n + 1.6S_n = \phi R_n$$

Where:

- D_n is the nominal dead load.
- S_n is the nominal snow load.
- ϕR_n is the nominal factored resistance.

Previous Safety Factor

We wanted to target a similar scenario

- Open web joists and prefabricated wood truss make up a large number of roof systems
  - Limited available data to build statistical distributions similar to 1980 study
- Steel wide flange plastic sectional strength
  - $\phi R = 0.9 F_y Z_x$
- Target Scenario
  - $1.2 D_n + 1.0 S_n = 0.9 F_y Z_x$

Previous Safety Factor and Background

Ellingwood et al. (1980)

Material	Combination	Optimum Values		Optimum ϕ for
		ϕ	Y_L, Y_S	$Y_D = 1.2, Y_L = 1.6$
Steel Beam	$D + L$	0.96	2.10	0.78
$(\beta_0 = 3)$	$D + S$	1.05	2.32	0.79

Previous Safety Factor and Background

Bartlett et al. (2003) Most up-to-date material and geometry information on A992 W-Shapes

$$Bias = \frac{average\ material\ property}{specified\ material\ property}$$

Factor	Original Code (1980)		Bartlett et al (2003)	
	Bias	COV	Bias	COV
Geometry	1.00	0.05	1.00	0.034
Material	1.05	0.10	1.03	0.058

Previous Safety Factor and Background

Bartlett et al. (2003) Most up-to-date material and geometry information on A992 W-Shapes

$$Bias = \frac{average\ material\ property}{specified\ material\ property}$$

Factor	Original Code (1980)		Bartlett et al (2003)	
	Bias	COV	Bias	COV
Geometry	1.00	0.05	1.00	0.034
Material	1.05	0.10	1.03	0.058

Previous Safety Factor and Background

Bartlett et al. (2003) Most up-to-date material and geometry information on A992 W-Shapes

$$Bias = \frac{average\ material\ property}{specified\ material\ property}$$

Factor	Original Code (1980)		Bartlett et al (2003)	
	Bias	COV	Bias	COV
Geometry	1.00	0.05	1.00	0.034
Material	1.05	0.10	1.03	0.058

Today's material is closer to specified strength than in 1980, minor but quantifiable

Previous Safety Factor and Background

Ellingwood et al. (1980)

$$S = G_r G_l$$

Where:

- S is the random variable associated with roof snow loading
- G_r is the random variable associated with the ground-to-roof conversion factor.
- G_l is the random variable for ground snow load

Ground-to-Roof Conversion

Ellingwood et al. (1980)

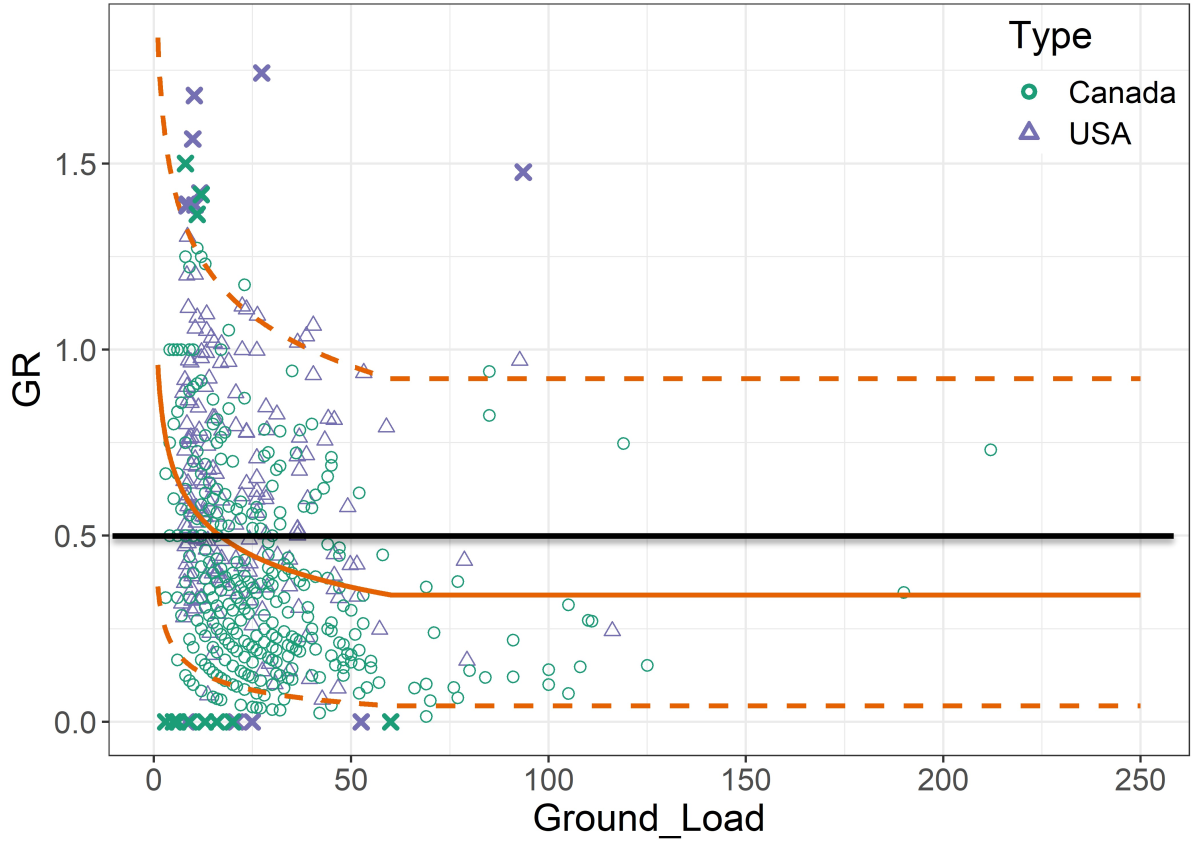
- *Ground-to-Roof Conversion* for flat roof snow load in ANSI A85.1 (1980) was 0.8.
- Shortly after it was changed to 0.7 in ASCE 7

$$p_f = 0.7 C_e C_t I_s p_g$$

- Based on the way safety factors are calculated, this should have decreased ϕ by 12% to maintain reliability

Ground-to-Roof Conversion

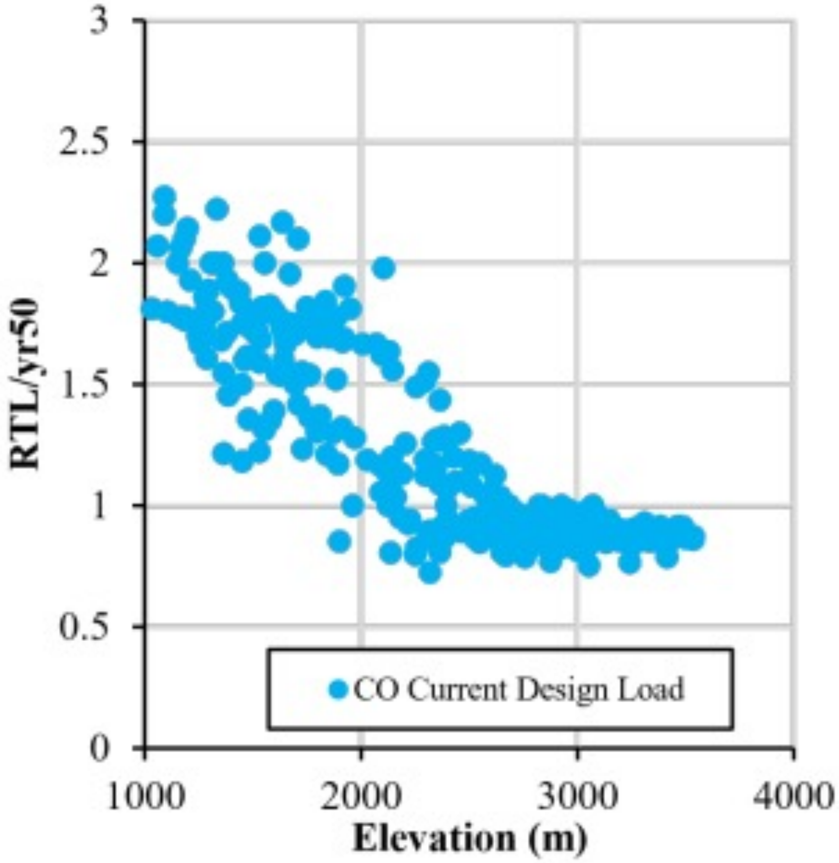
- *1980 – Not enough information available at the time to determine G_r (black line was the educated guess regarding statistics)*
- *2020 – Several international studies undertaken since 1980. We better understand that lower loads have higher G_r*



Previous Safety Factor and Background

Debock et al. (2016)

The Colorado Study: Reliability Targeted Loads, the first of its kind



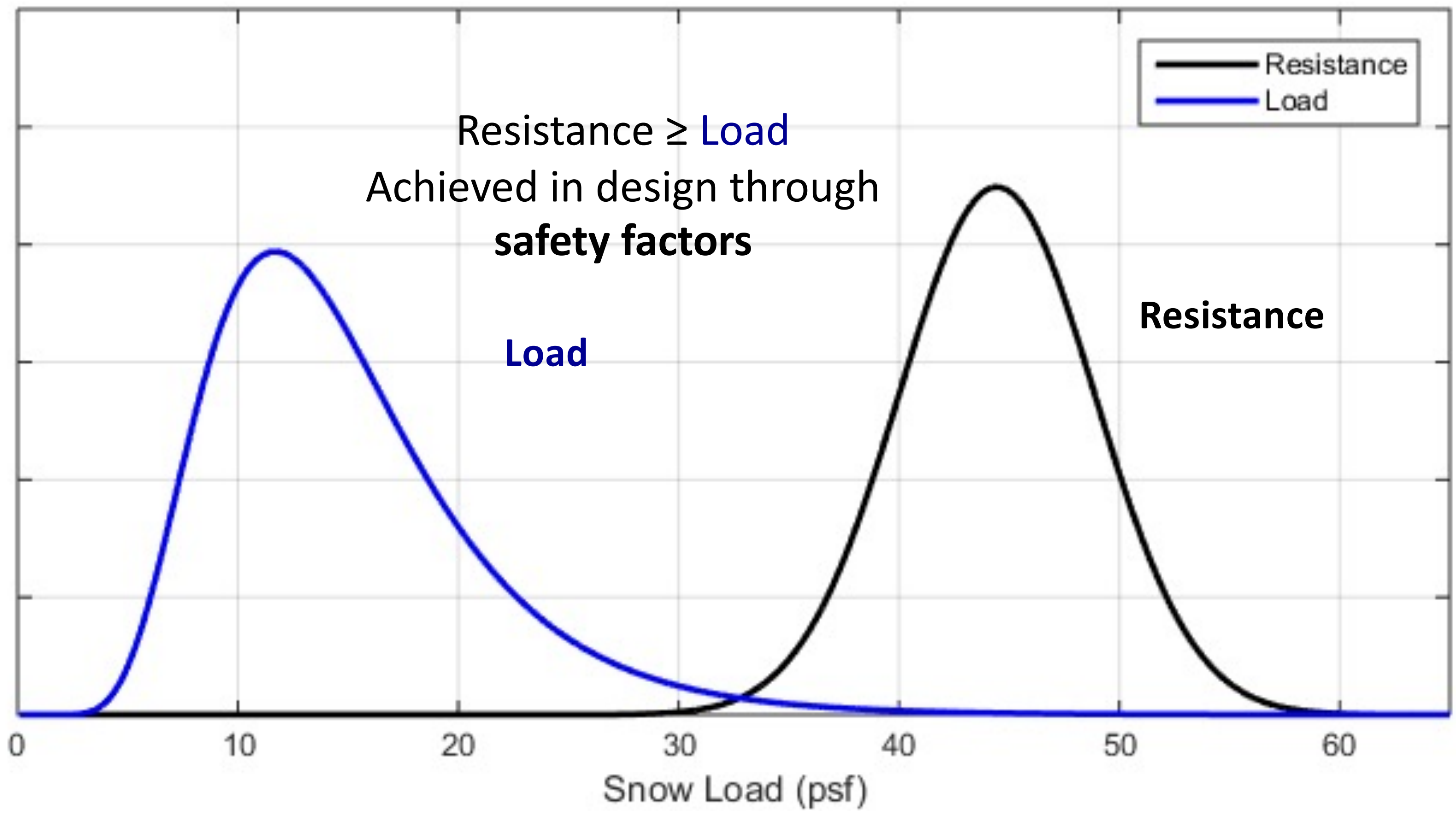
Reliability Targeted Loads

- Uniform hazard loading: loads that have a constant return interval
  - Snow was 50-year load, multiplied by 1.6 for strength design in ASCE 7-16 and prior.

Reliability Targeted Loads

- Uniform hazard loading: loads that have a constant return interval
  - Snow was 50-year load, multiplied by 1.6 for strength design in ASCE 7-16 and prior.
- Reliability targeted loads are not new
  - Seismic loadings moved to 1.0 safety factor
  - Risk targeted collapse at most locations
    - Some locations still deterministic in high seismic areas
  - Wind load moved to 1.0 safety factor
    - Reliability informed load

Reliability of Snow



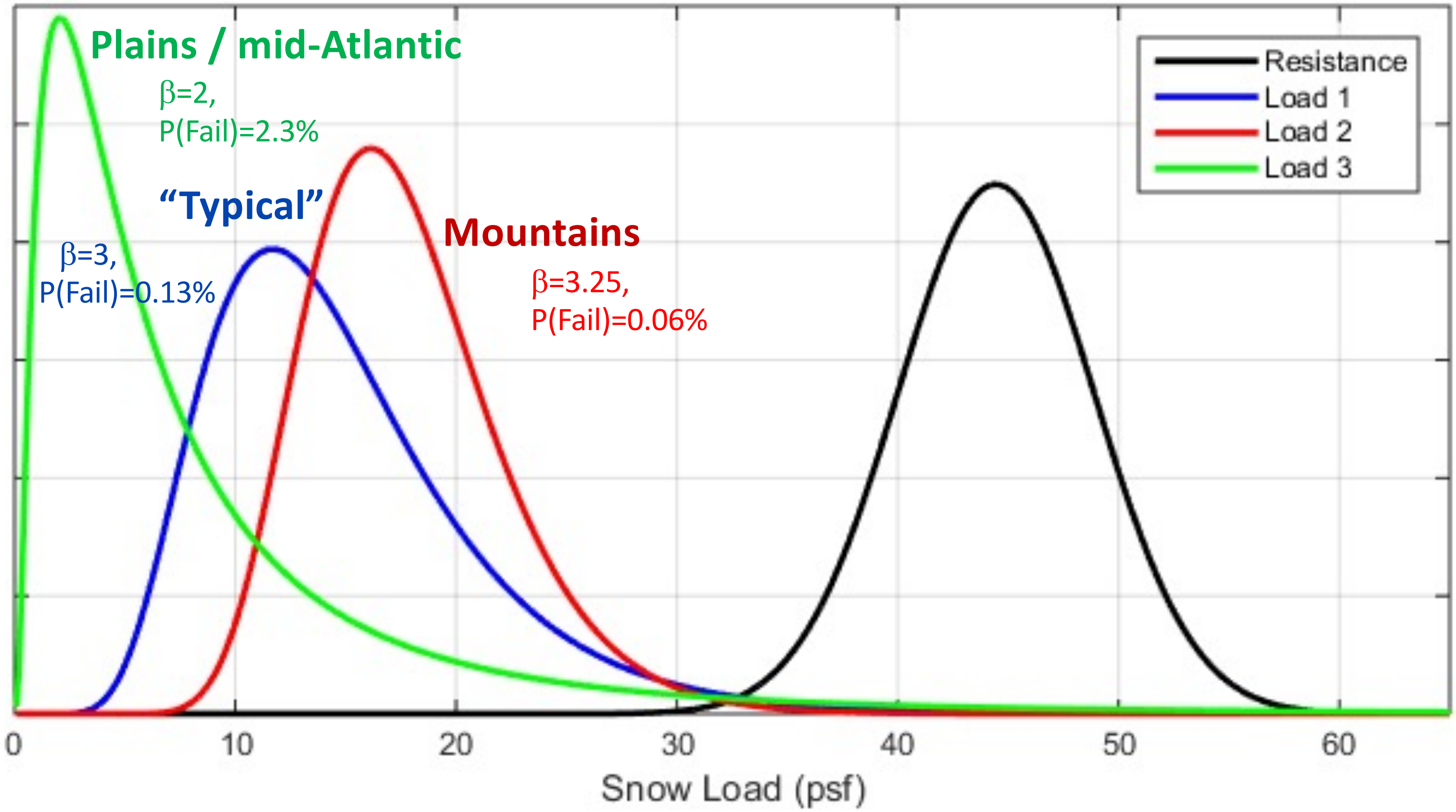
Reliability of Snow

Table 1.3-1 Target Reliability (Annual Probability of Failure, P_F) and Associated Reliability Indices (β)[1] for Load Conditions That Do Not Include Earthquake, Tsunami, or Extraordinary Events[2]

	Risk Category			
Basis	**I**	**II**	**III**	**IV**
Failure that is not sudden and does not lead to widespread progression of damage	$P_F = 1.25 \times 10^{-4}$/yr $\beta = 2.5$	$P_F = 3.0 \times 10^{-5}$/yr $\beta = 3.0$	$P_F = 1.25 \times 10^{-5}$/yr $\beta = 3.25$	$P_F = 5.0 \times 10^{-6}$/yr $\beta = 3.5$
Failure that is either sudden or leads to widespread progression of damage	$P_F = 3.0 \times 10^{-5}$/yr $\beta = 3.0$	$P_F = 5.0 \times 10^{-6}$/yr $\beta = 3.5$	$P_F = 2.0 \times 10^{-6}$/yr $\beta = 3.75$	$P_F = 7.0 \times 10^{-7}$/yr $\beta = 4.0$
Failure that is sudden and results in widespread progression of damage	$P_F = 5.0 \times 10^{-6}$/yr $\beta = 3.5$	$P_F = 7.0 \times 10^{-7}$/yr $\beta = 4.0$	$P_F = 2.5 \times 10^{-7}$/yr $\beta = 4.25$	$P_F = 1.0 \times 10^{-7}$/yr $\beta = 4.5$

[1]The target reliability indices are provided for a 50-year reference period, and the probabilities of failure have been annualized. The equations presented in Section 2.3.6 are based on reliability indices for 50 years because the load combination requirements in Section 2.3.2 are based on the maximum loads for the 50-year reference period.
[2]Commentary to Section 2.5 includes references to publications that describe the historic development of these target reliabilities.

Reliability-Targeted Loads



Polling Question 1

Reliability targeted loads account for:

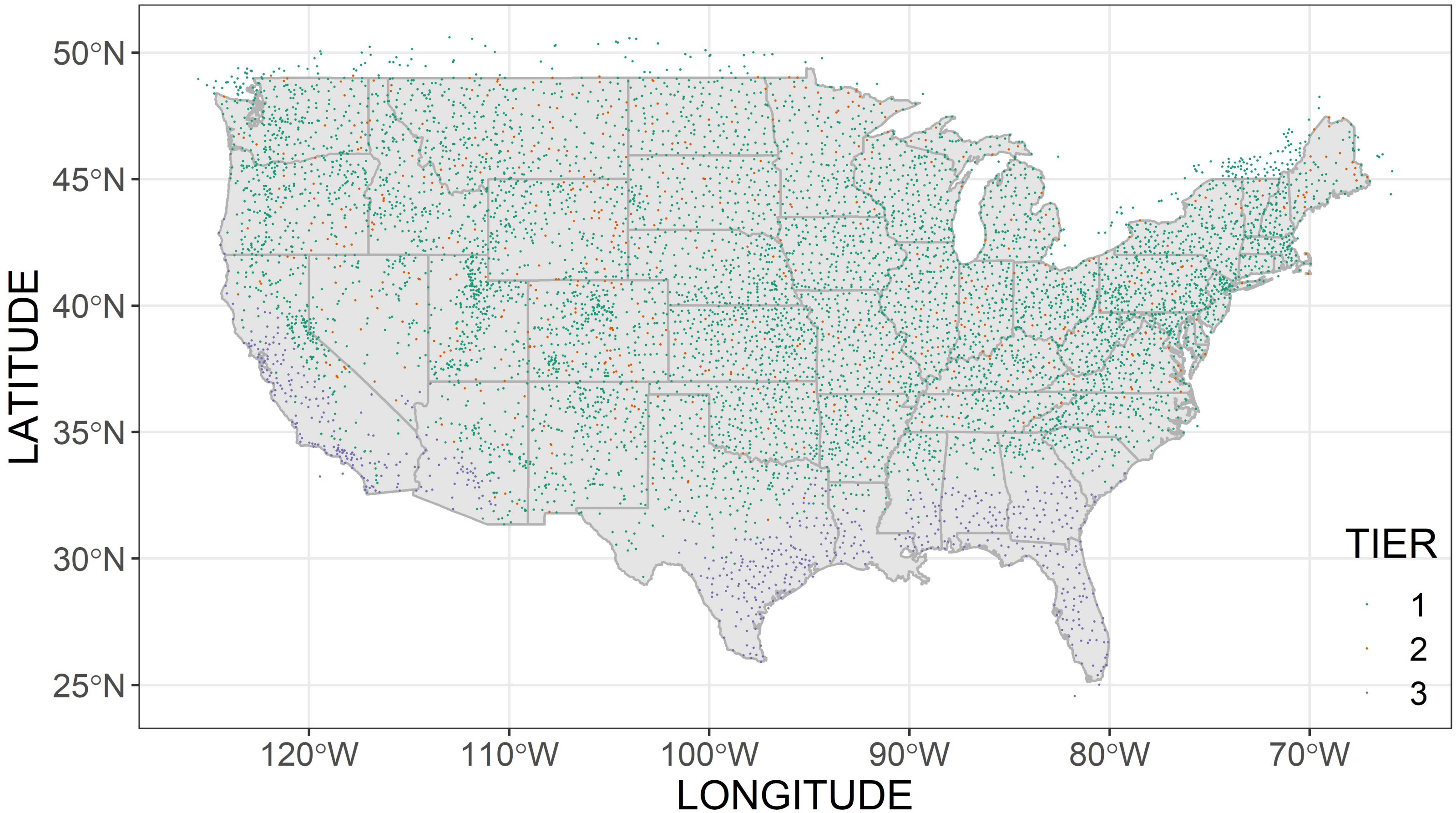
A. Variability in load

B. Variability in the structural system

C. All of the above

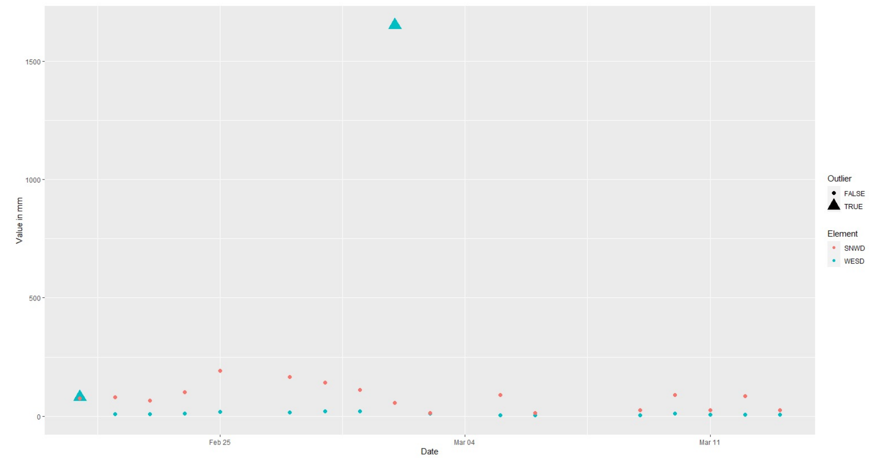
Data Availability

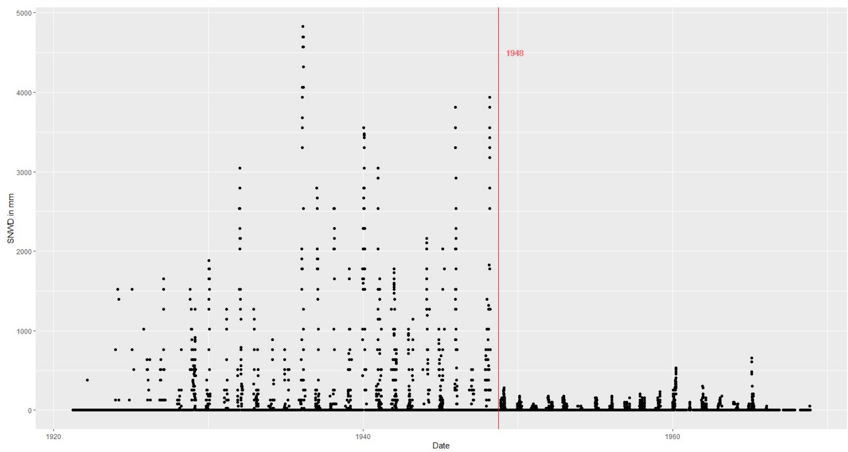
Considered more than half a million annual snow load maximums at more than 12,000 stations, retained stations based on years of record and spatial density.

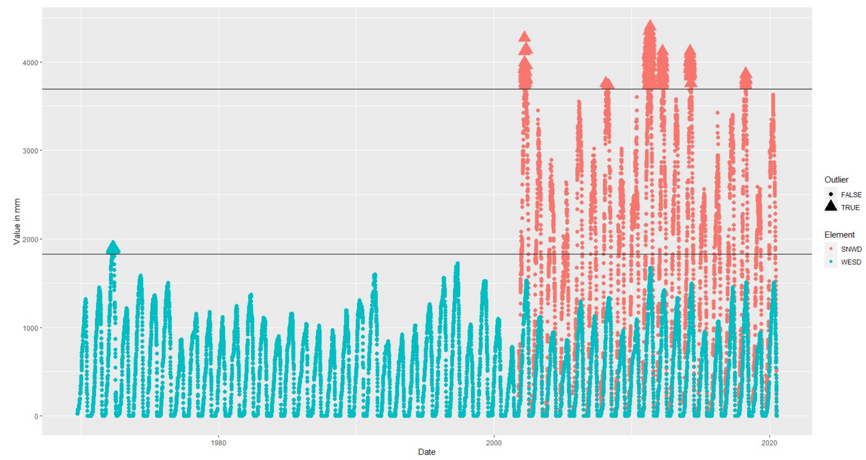


Data Cleaning

Rule #1 of data cleaning: If you can imagine a problem, then it already exists in your data.







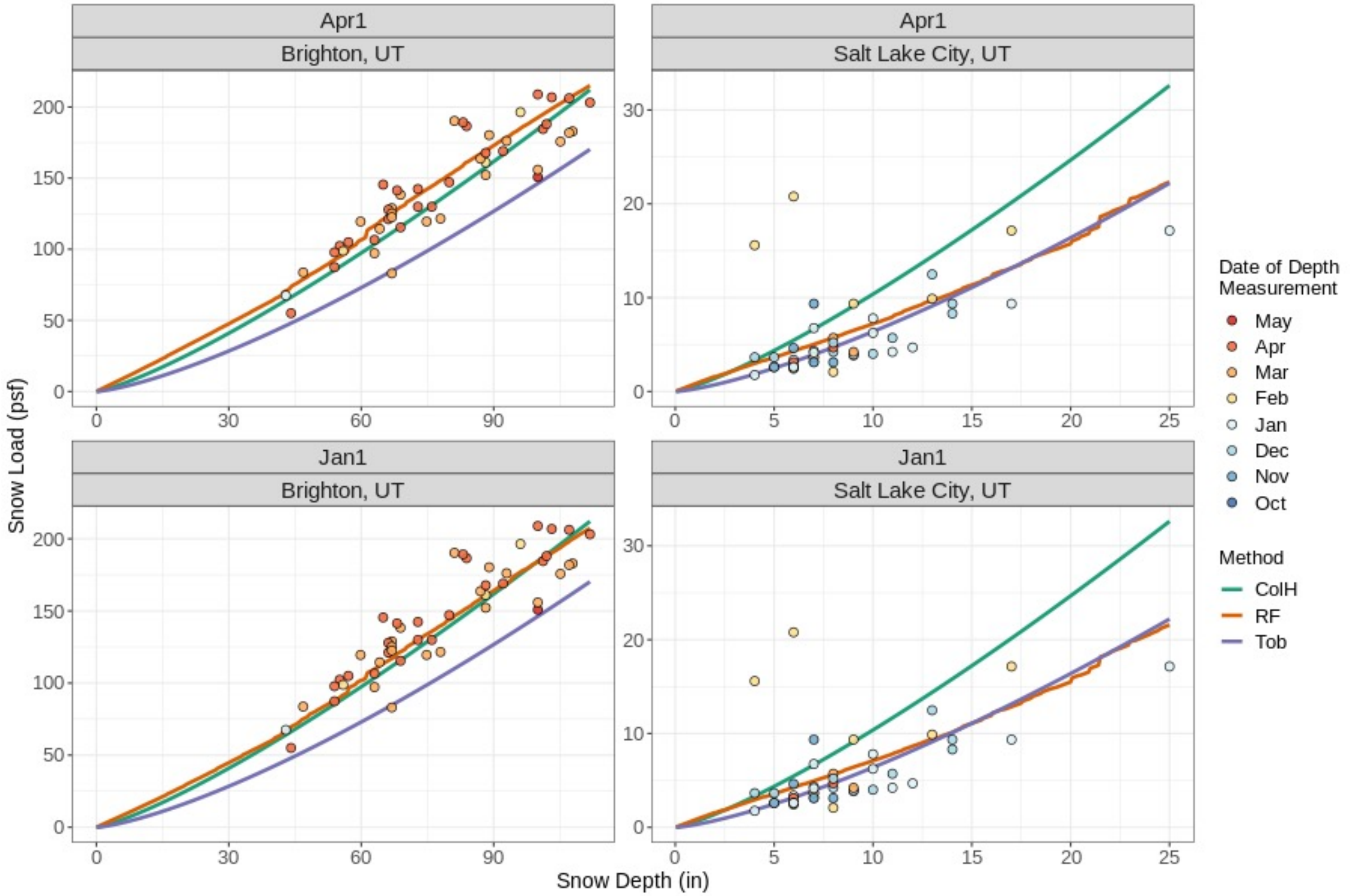
Data Cleaning

Final Approach Involved a Combination of Automatic and Manual Screening Methods

- Strategy:
  - Use automatic outlier detection approaches to flag suspect stations with outliers, then use manual inspection to confirm outlier observations.
  - Develop models and estimation techniques that are robust to the outliers that inevitably remain.

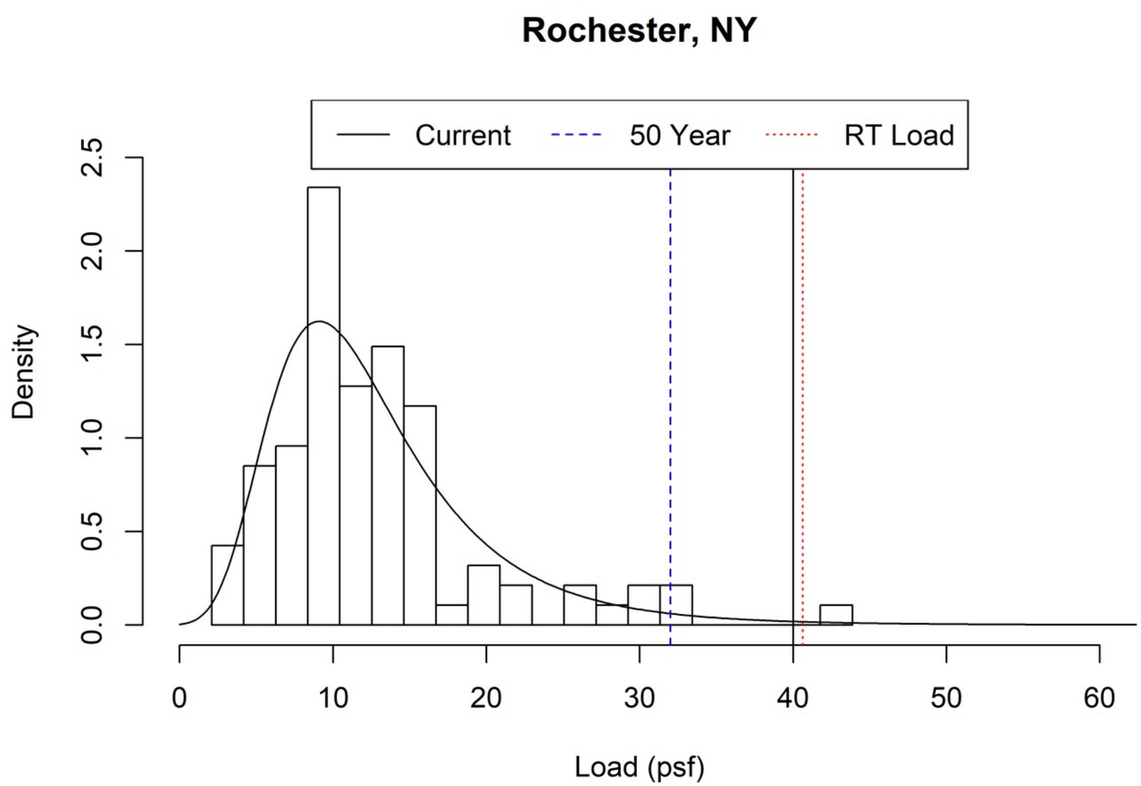
Depth to Load Conversions

Used information about the snow depth and the local climate conditions to create a universal approach for depth to load conversions.



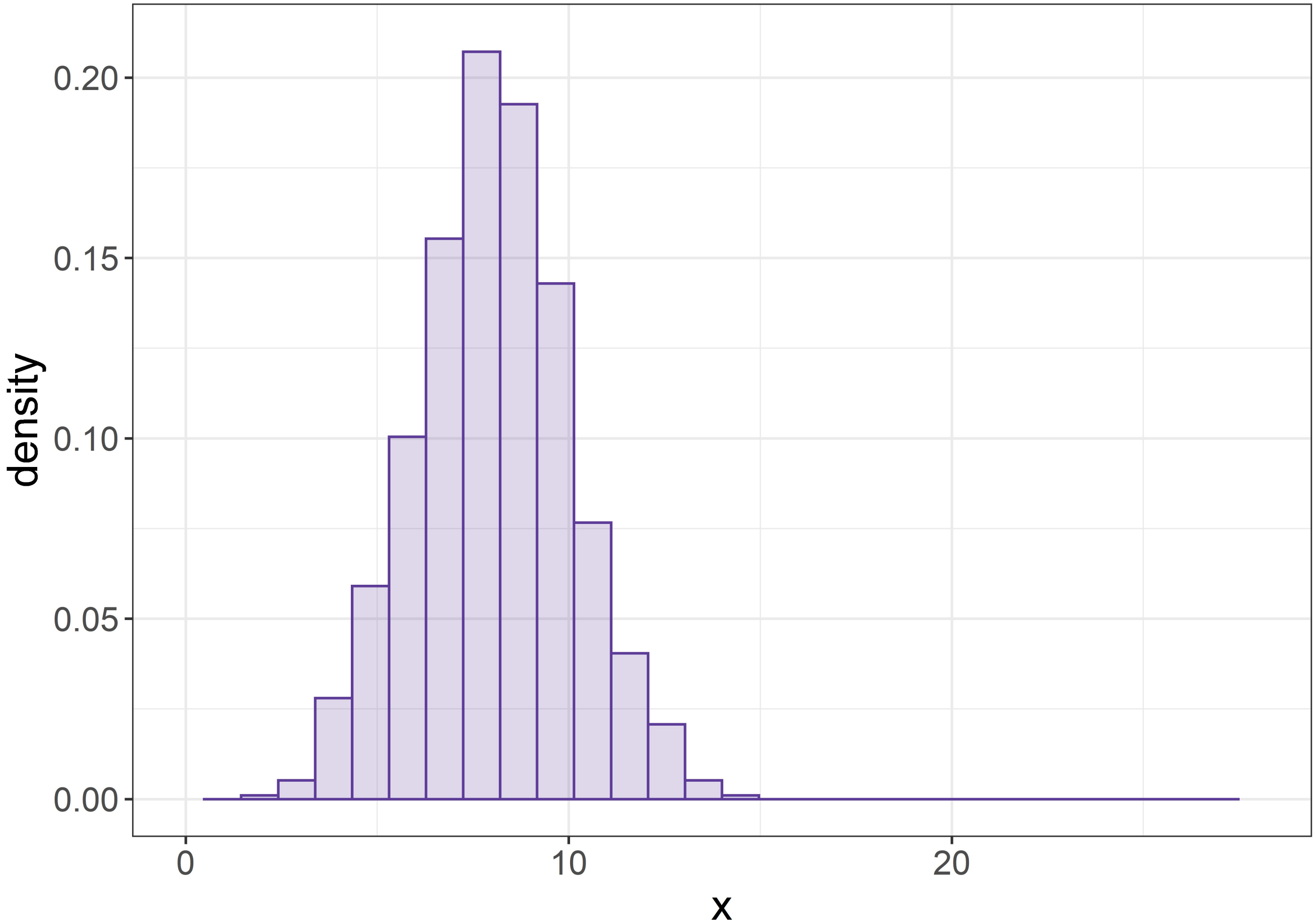
Distribution Fitting

A probability distribution is fit to the annual (October – June) maximum snow loads at each location.



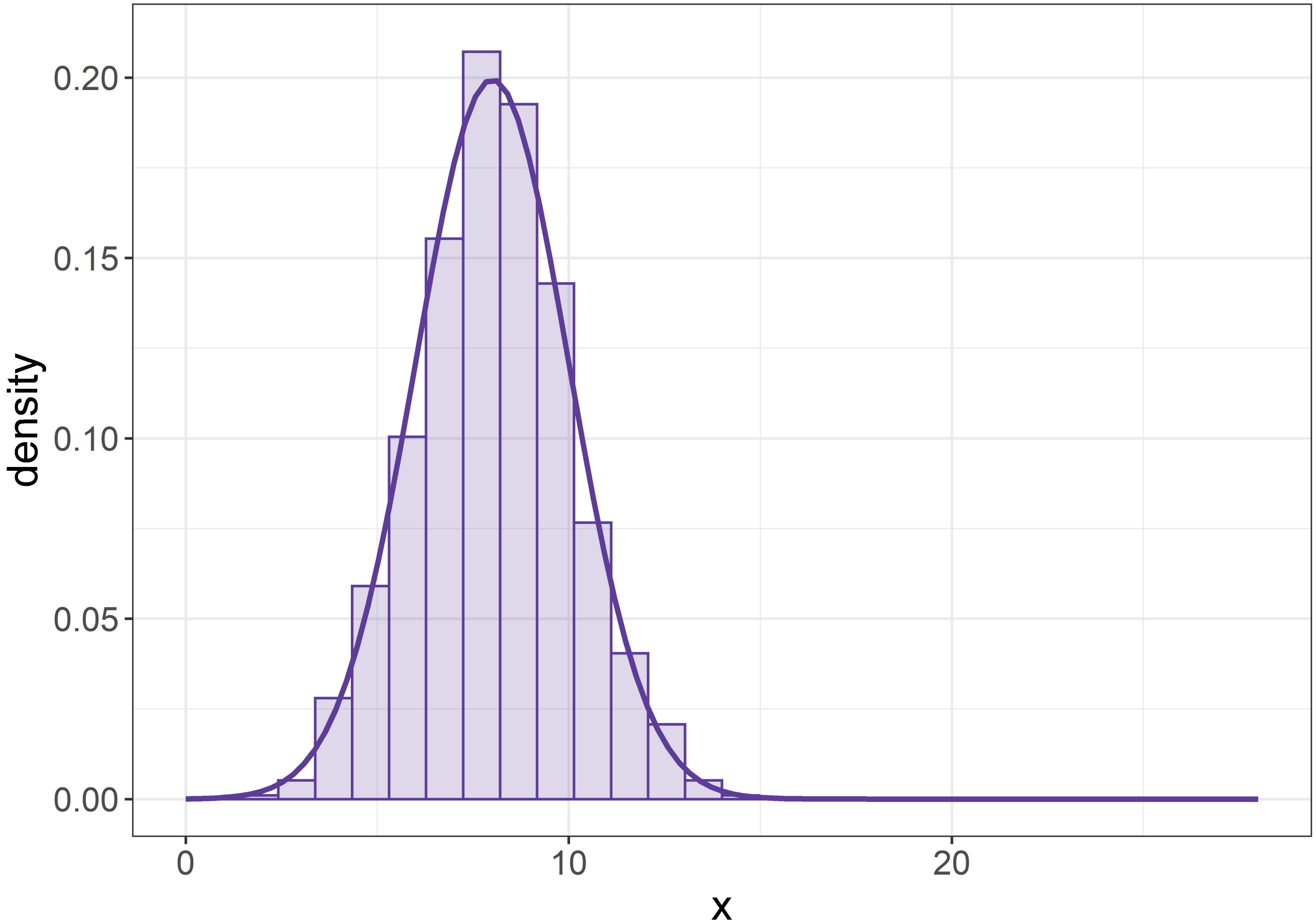
Distribution Fitting: Introduction

Histograms are commonly used to measure the number of observations within a given range. These can be scaled so that the area of the bins is equal to one.



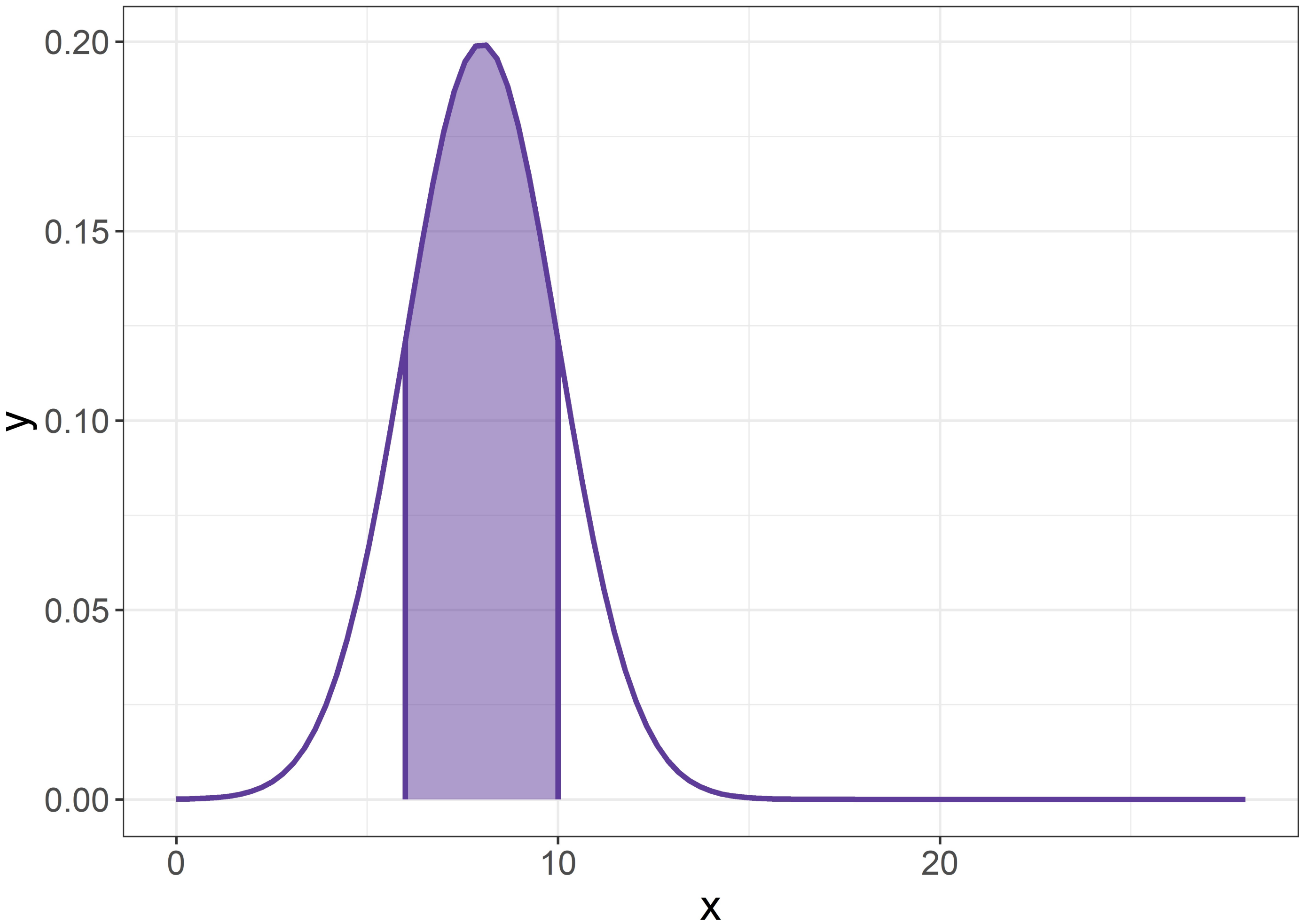
Distribution Fitting: Introduction

Probability distributions are like smooth histograms, where the height of the curve being proportional to bins of the histograms with the most observations.



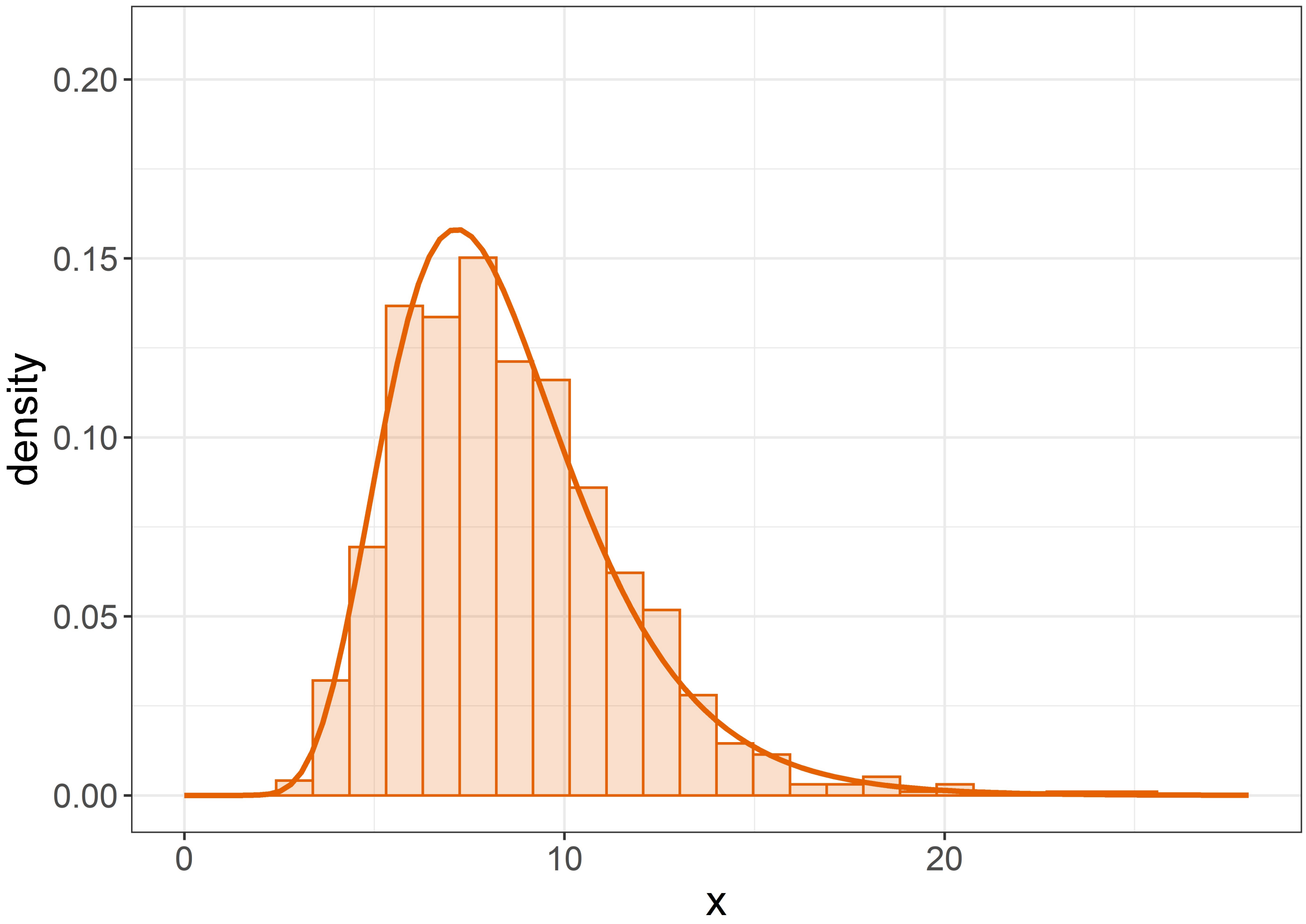
Distribution Fitting: Introduction

The probability of the “next” even occurring within some range is equal to the area under the curve (AUC) between two points.



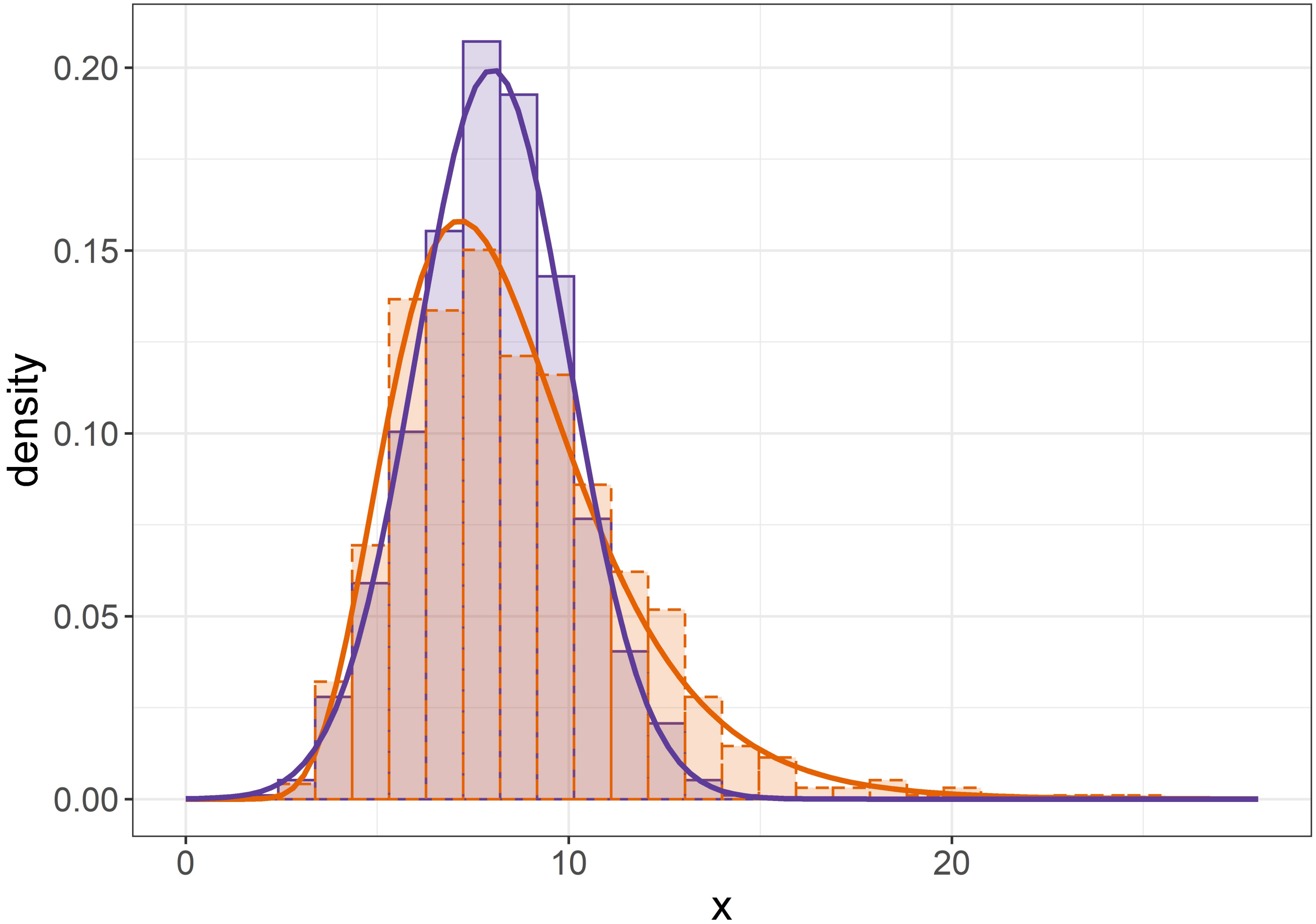
Distribution Fitting: Introduction

Different distribution types have different "shapes." In this example, this distribution gives greater likelihood to larger events than to smaller ones.



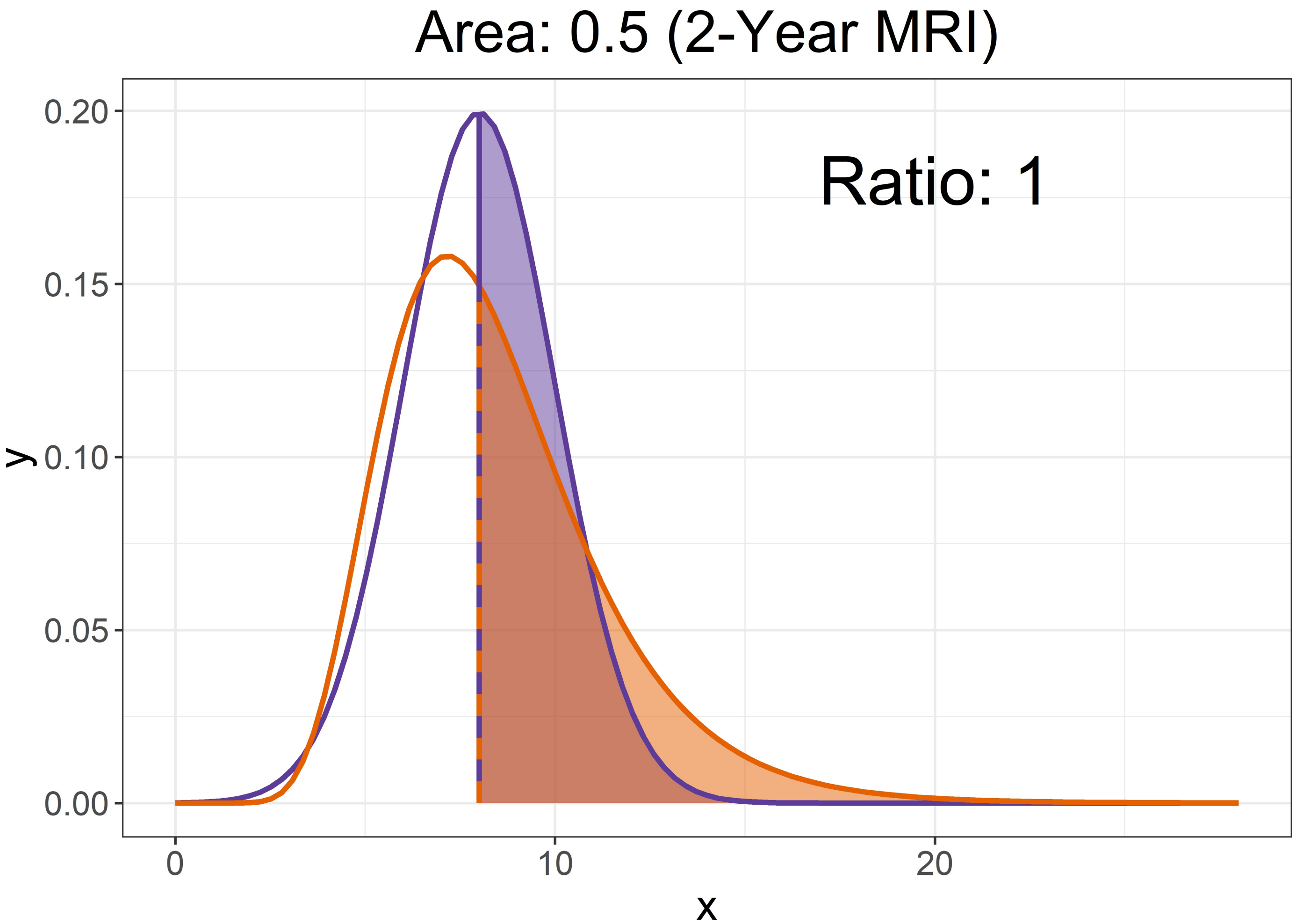
Distribution Fitting: Introduction

When modeling extreme events, we often refer to the “tail heaviness” of the distribution. In this example, the orange curve has a heavier tail than the purple one.



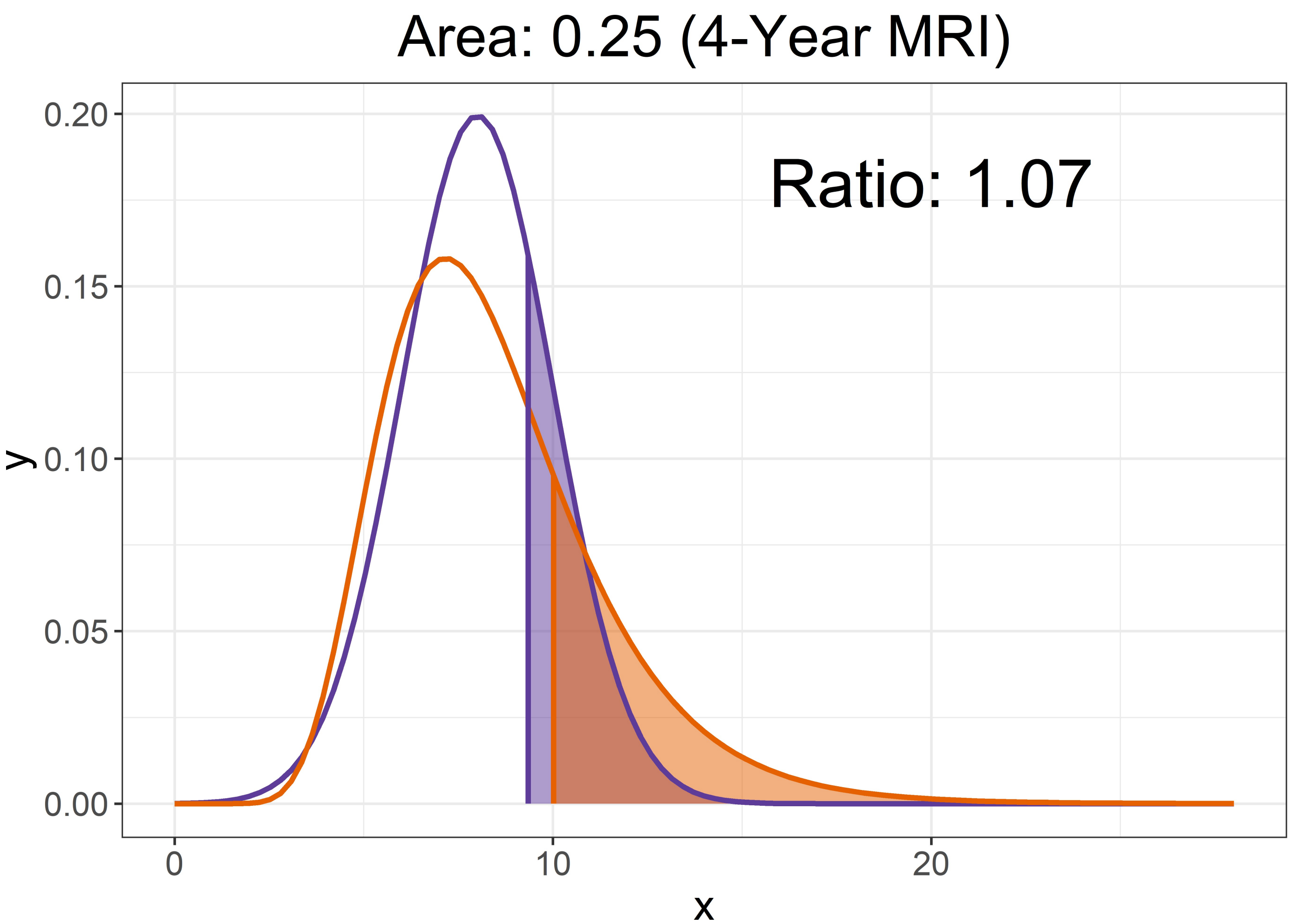
Distribution Fitting: Key Point

MRI events get larger at a faster pace for heavy tailed distributions than they do for regular ones.



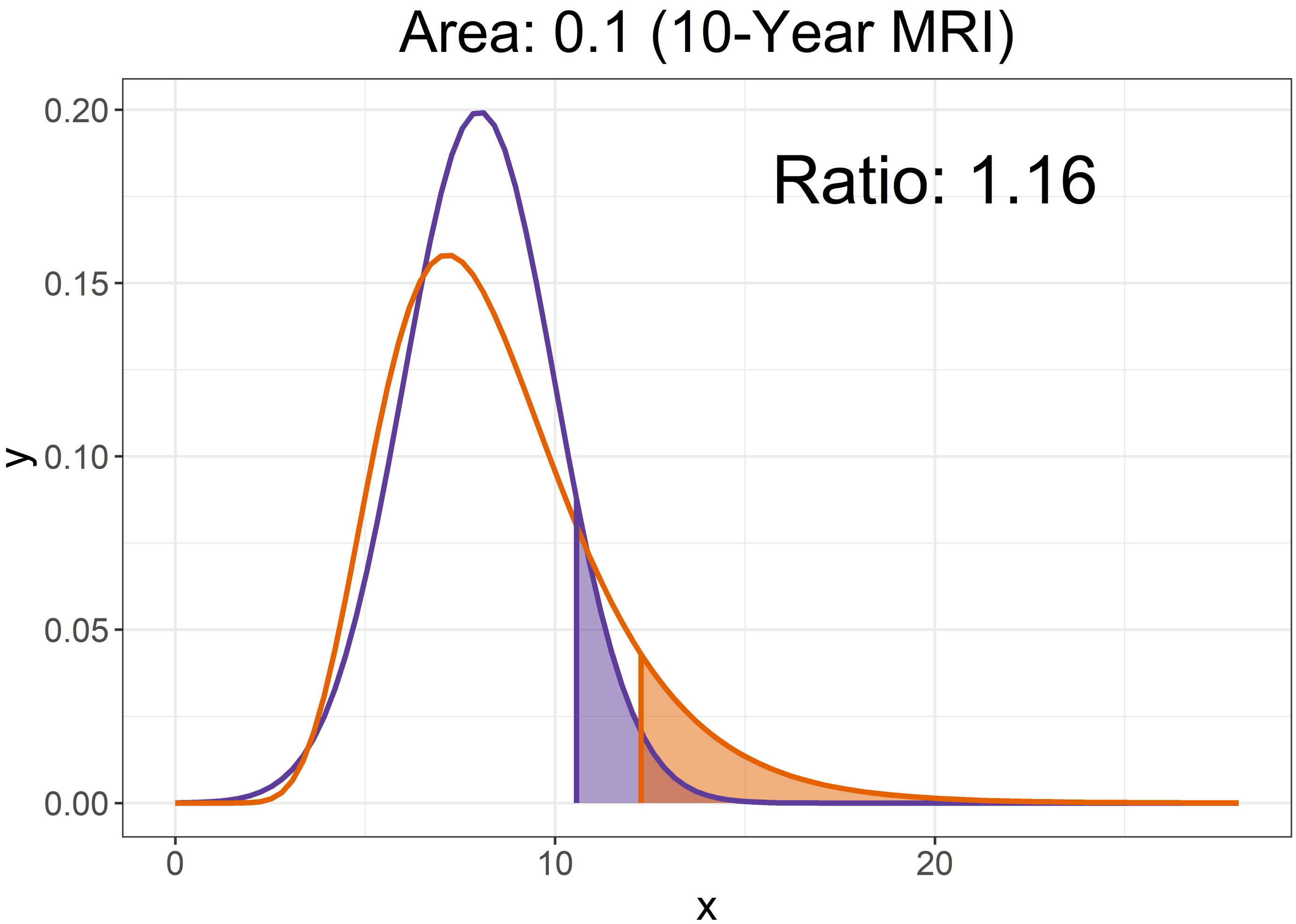
Distribution Fitting: Key Point

MRI events get larger at a faster pace for heavy tailed distributions than they do for regular ones.



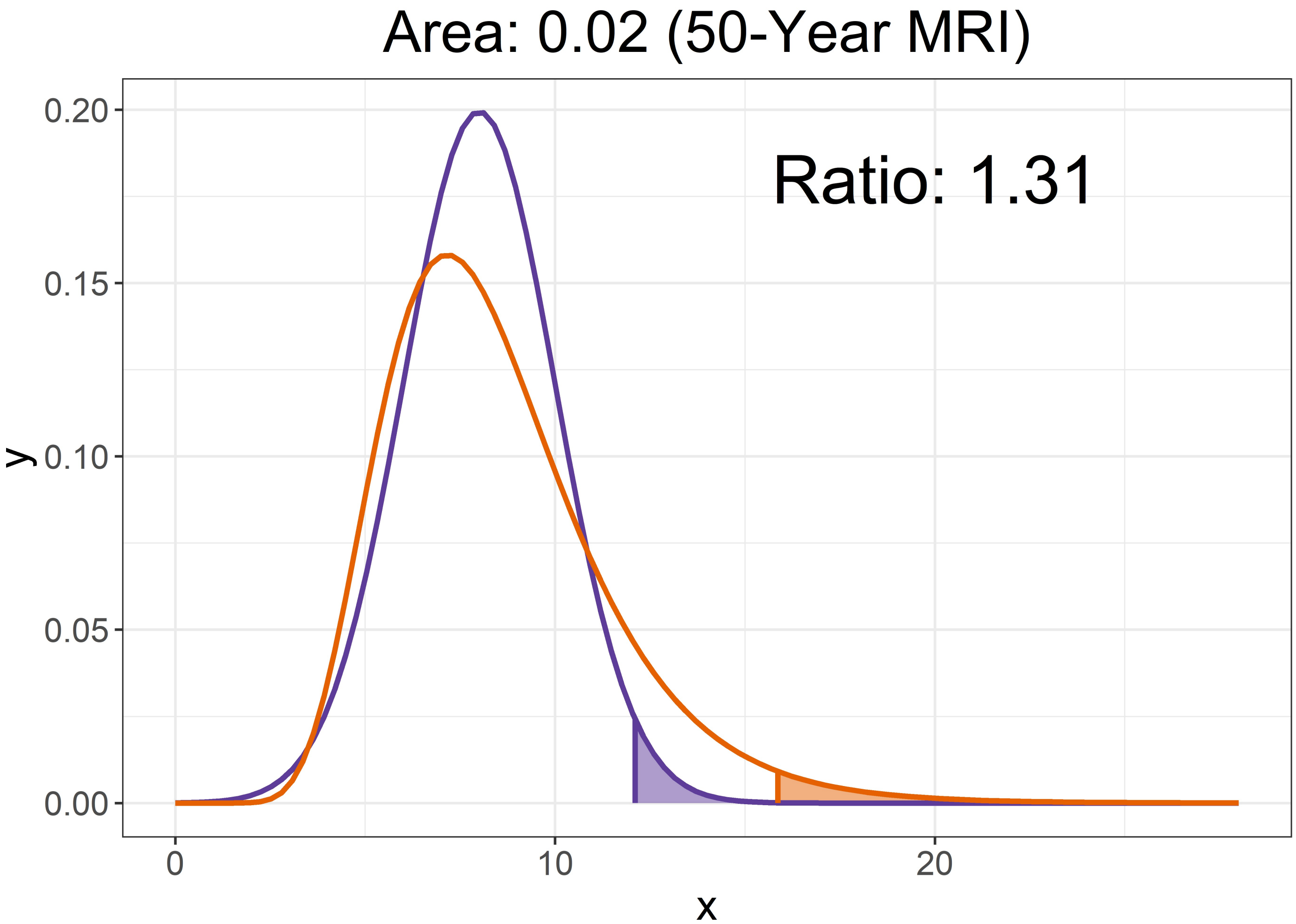
Distribution Fitting: Key Point

MRI events get larger at a faster pace for heavy tailed distributions than they do for regular ones.



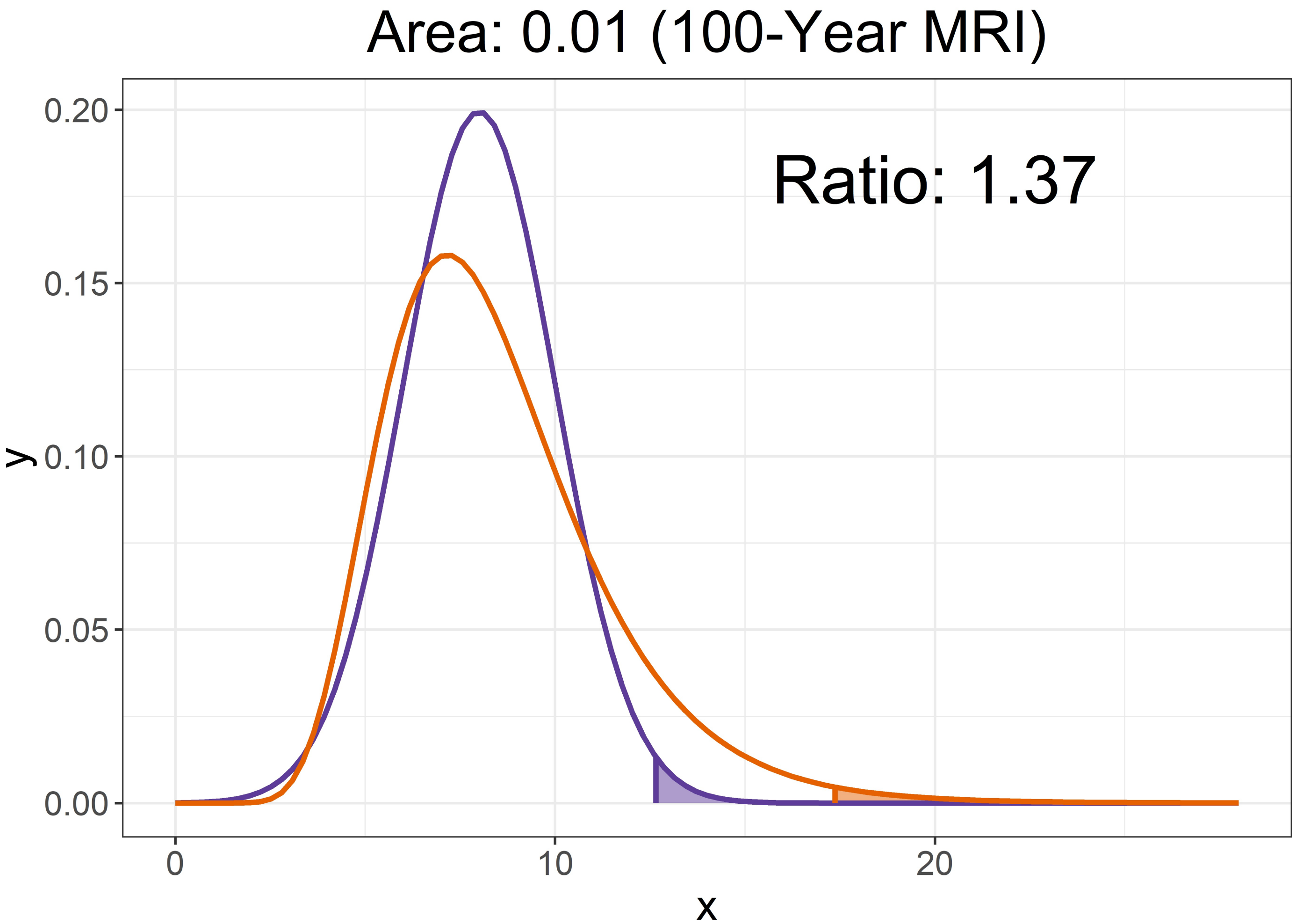
Distribution Fitting: Key Point

MRI events get larger at a faster pace for heavy tailed distributions than they do for regular ones.



Distribution Fitting: Key Point

MRI events get larger at a faster pace for heavy tailed distributions than they do for regular ones.



Distribution Fitting: Key Point

A 1.6 safety factor applied to a 50-year MRI does not account for differences in distribution shapes.

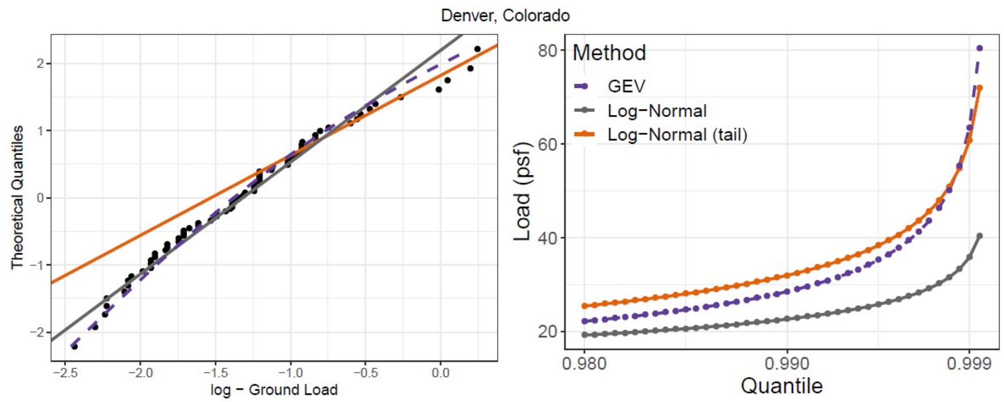


Fig. 1. Visualizations of the distribution fit and quantile estimates at annual maximums observed in Denver, Colorado.

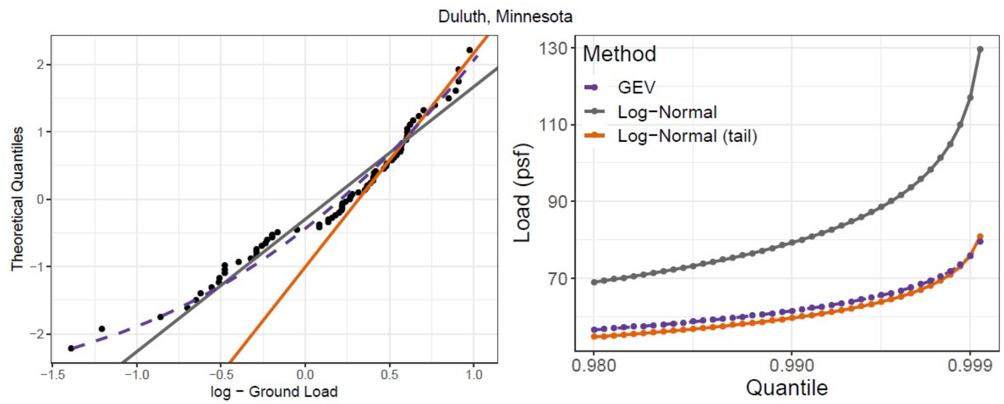
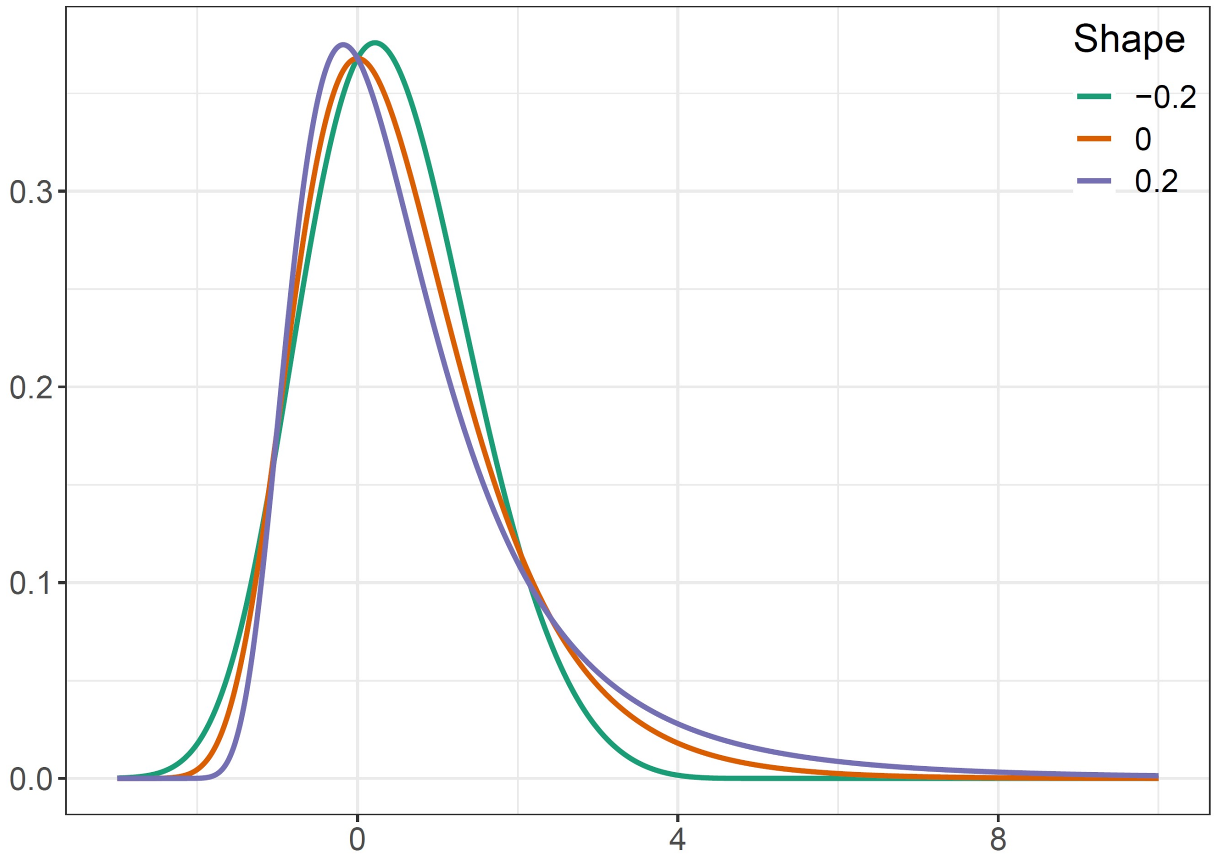


Fig. 2. Visualizations of the distribution fit and quantile estimates at annual maximums observed in Duluth, Minnesota.

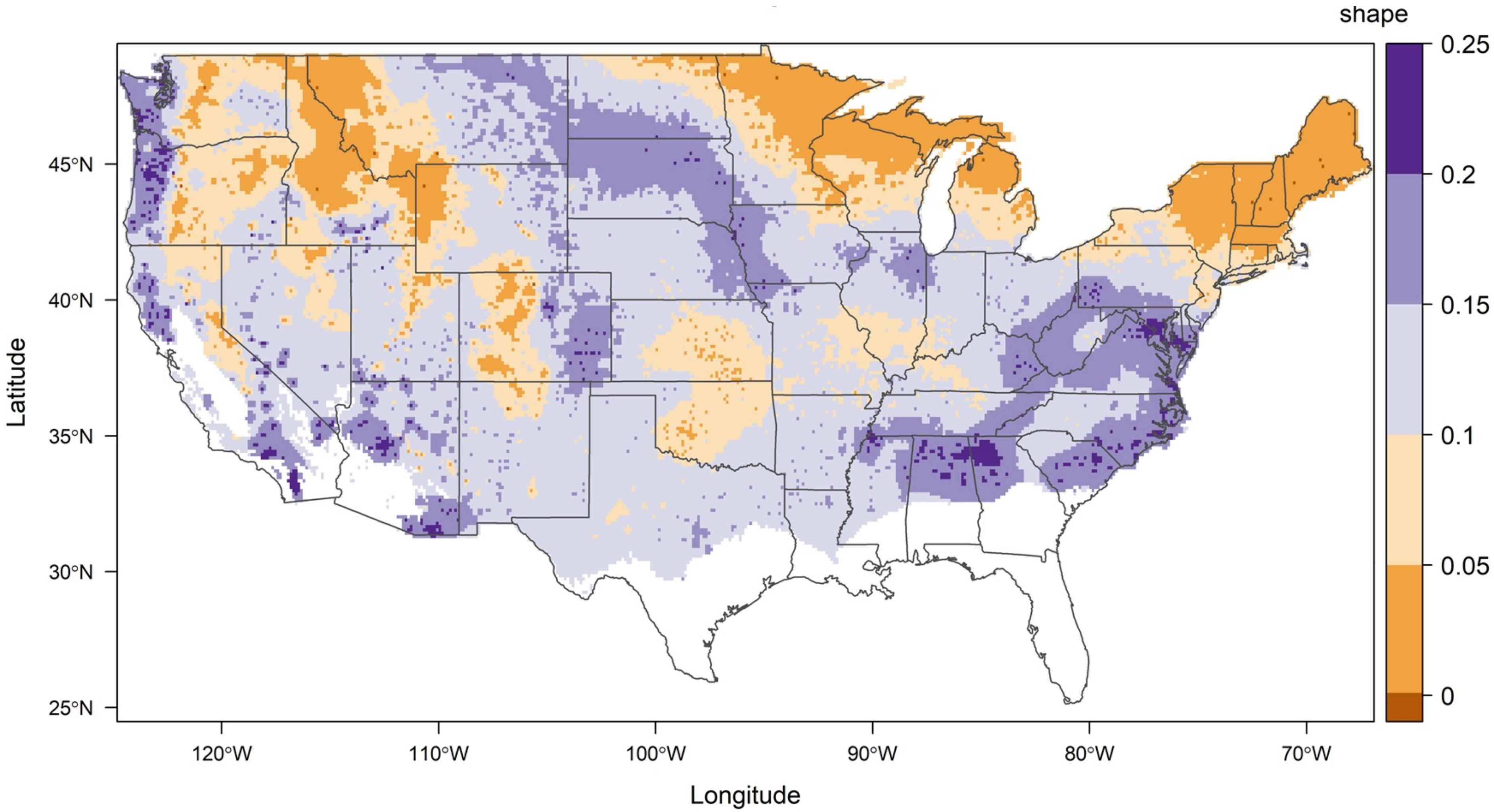
Distribution Fitting: Key Point

The generalized extreme value distribution has a third parameter that changes the shape of the distribution without changing the distribution type.



Distribution Fitting: Key Point

There are regional patterns in distribution shape



Distribution Fitting: Limitations

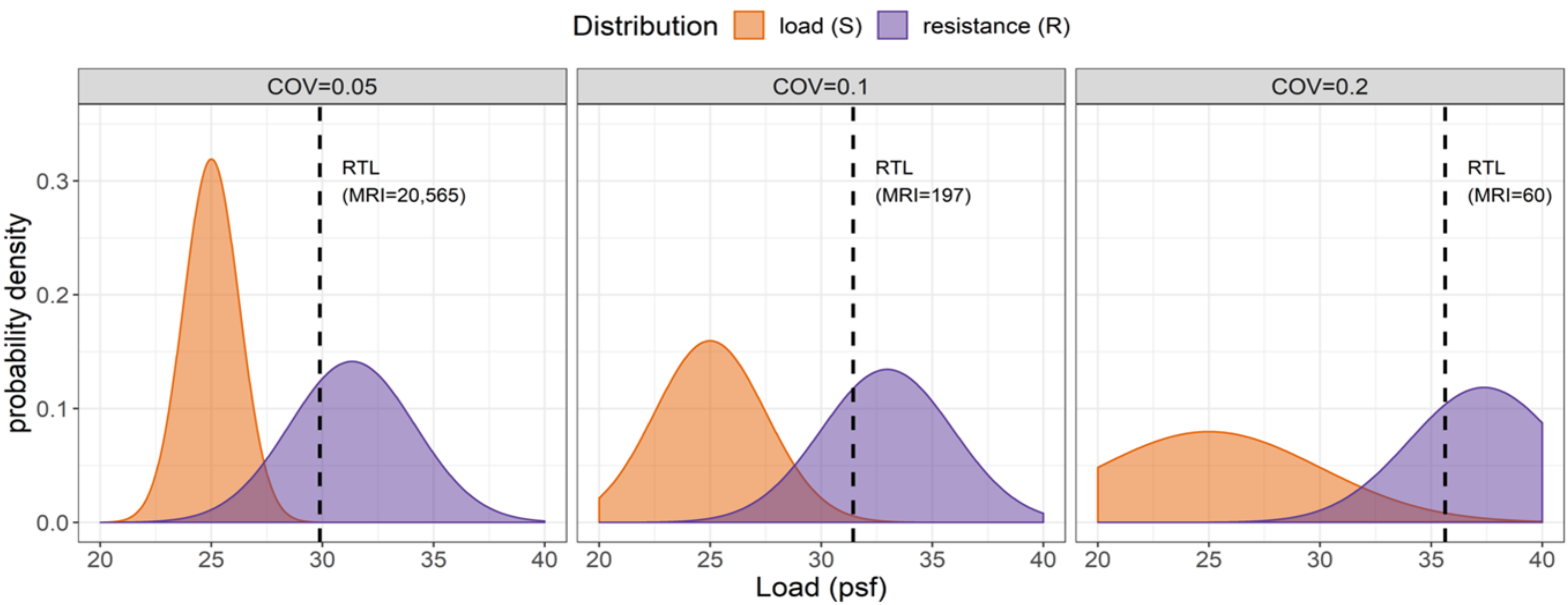
- Lots of stations have short histories, which leads to small sample sizes.
- Annual maximum snow load values are sensitive to misreported measurements and poor coverage of the snow season.
- Small changes in parameter estimates can lead to big differences in the characterization of extreme events.

National study used “consensus based” approaches to reduce the influence of outlier measurements when fitting distributions.

Simulation

While we have well-defined distributions for the load and resistance, we do not have a well-defined distribution for:

$$R - (G_l * G_r(g_l))$$



Because we do not know the best form for the *combined* distribution, we must estimate the probability of failure through simulations.

Simulation

Simulated values from the three distributions are combined to determine the P_g that satisfies the reliability-target for each risk category.

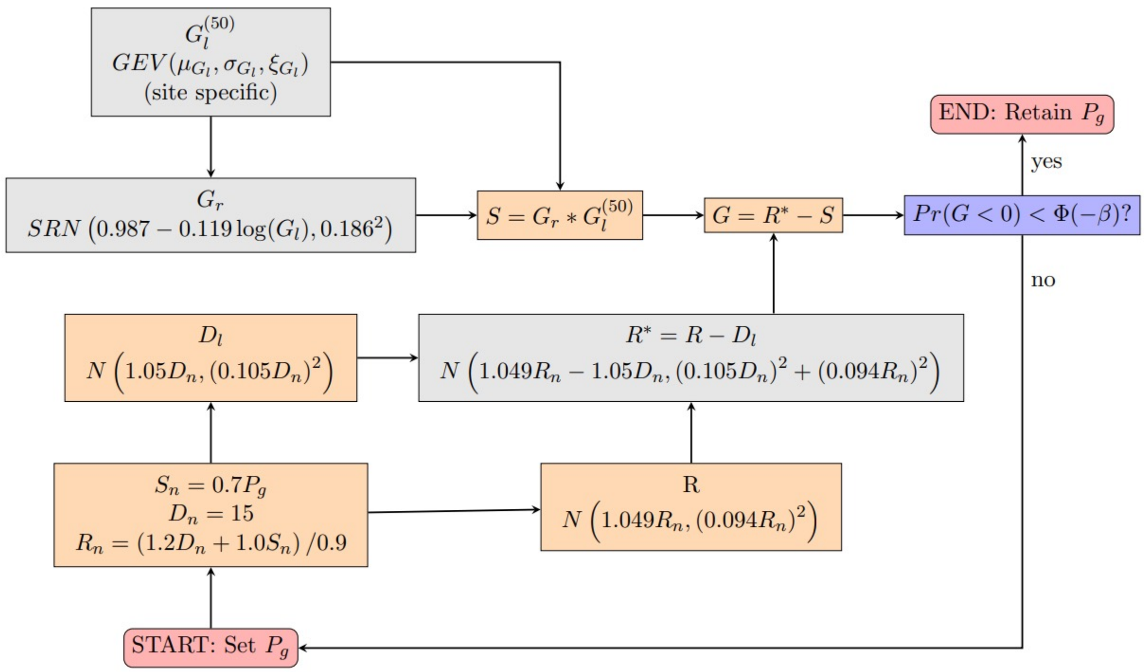


Figure 2.10: Flowchart summarizing the RTL estimation process. Grey squares indicate the distributions that are directly simulated from as part of the Monte-Carlo analysis. Orange squares indicate calculations. Distributions include generalized extreme value (GEV), Normal (N) and Square-Root Normal (SRN).

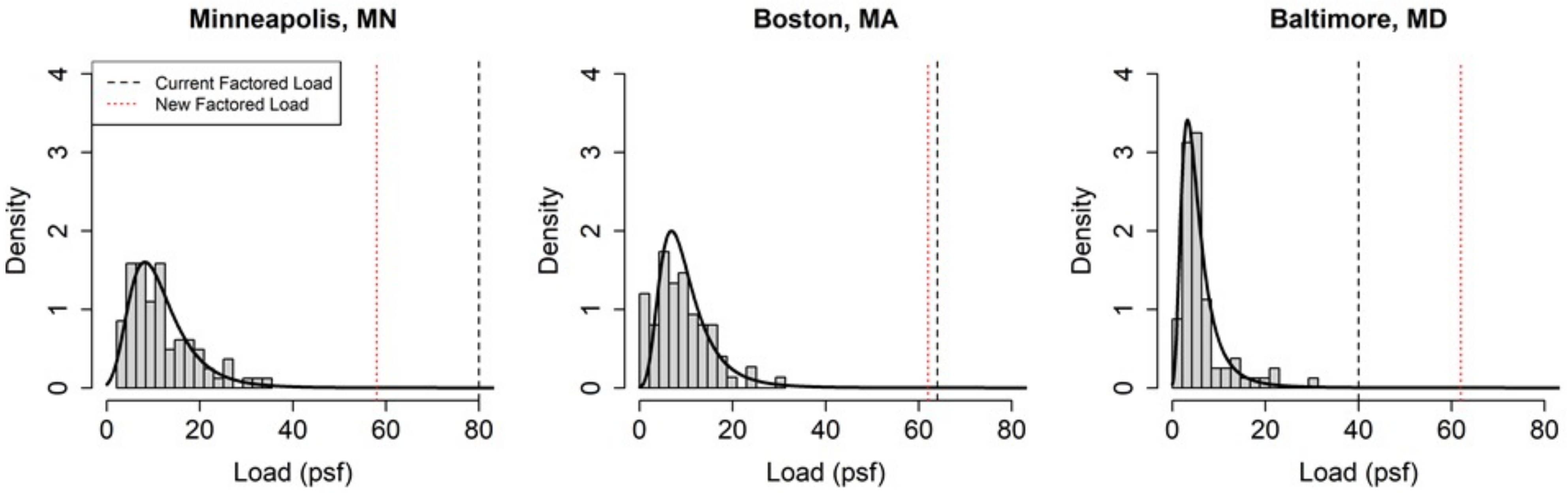
Simulation: Limitations

- **Computationally Intensive:** Requires simulation of millions of points to get a stable estimate of the probability of failure.

- **Extrapolation:** Must assume that the shape of the upper right tail of the distribution appropriately simulated events larger than have ever been observed.

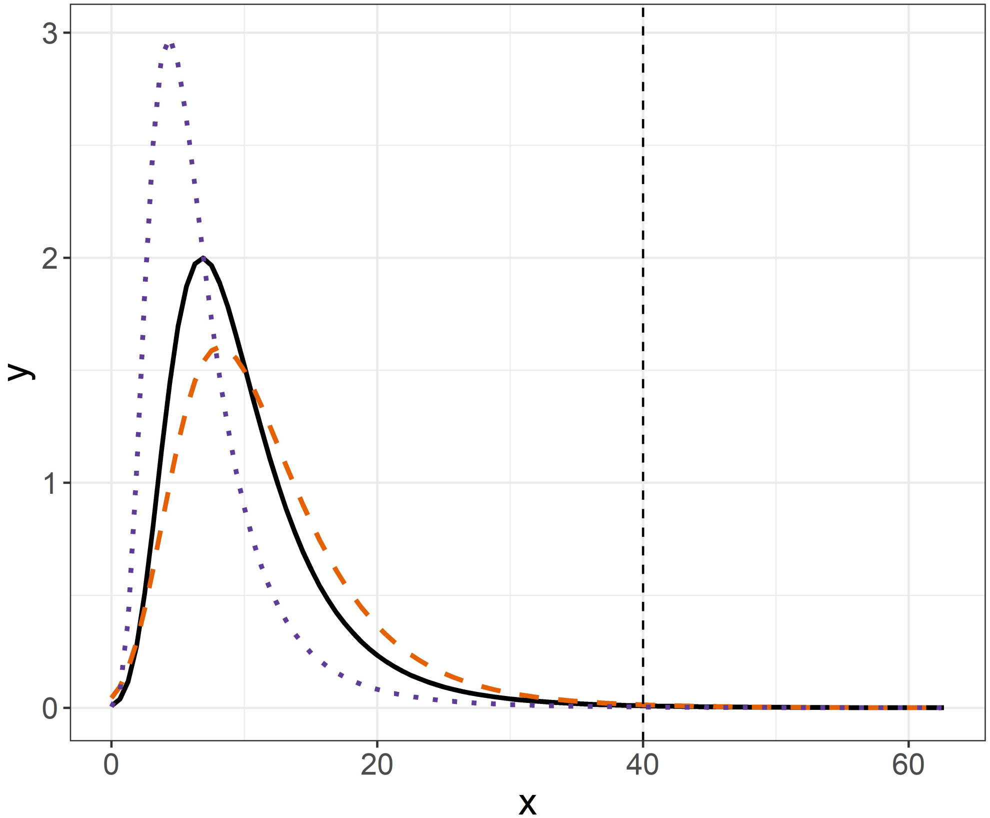
A "Tail" of Three Cities

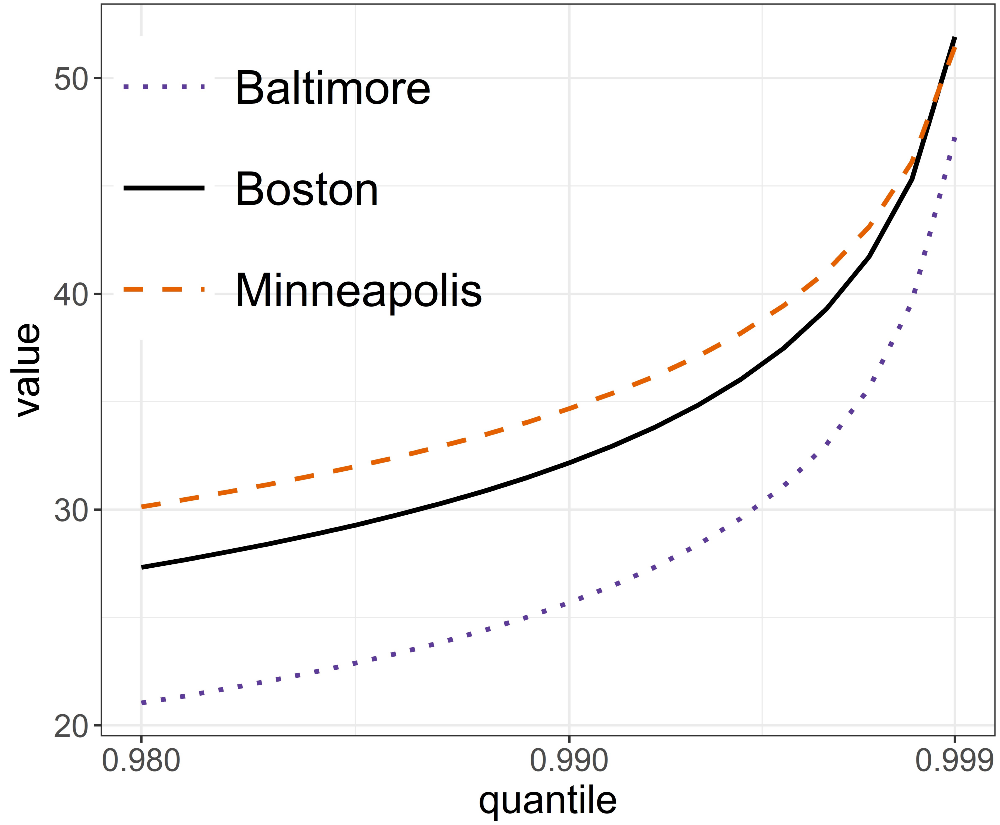
These three cities have different "typical" snow behavior, but similar "extreme" snow loads.



A "Tail" of Three Cities

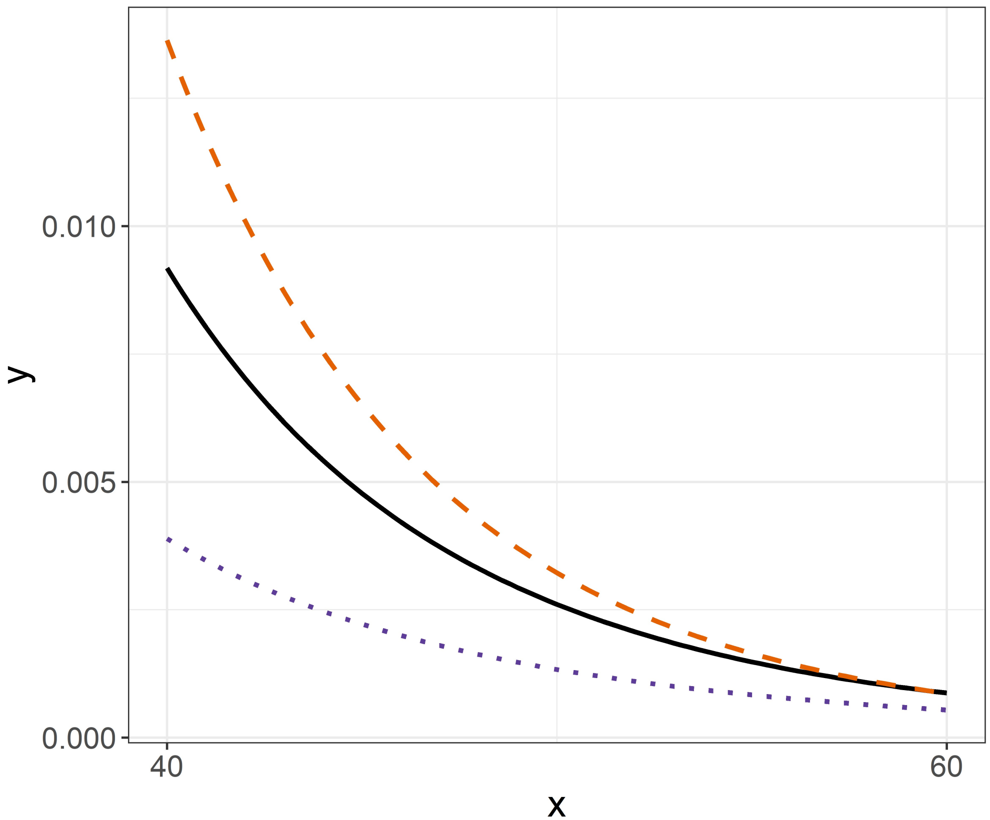
Closer inspection of the distribution tails shows similar estimates of super-extreme events.

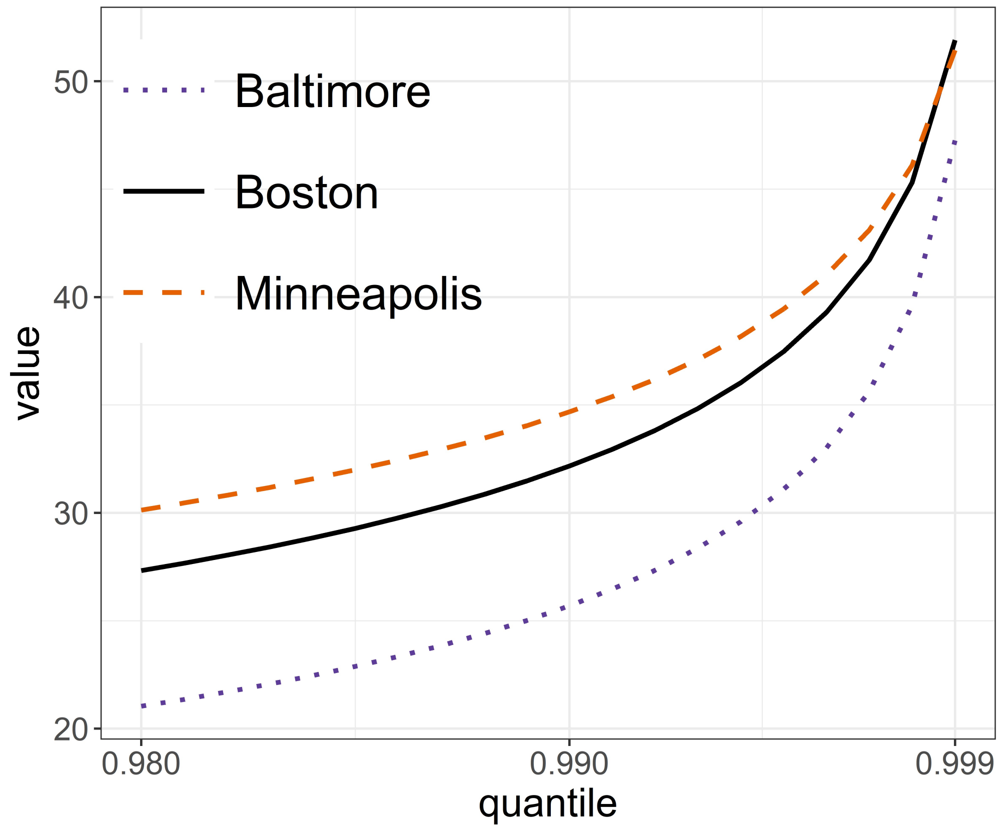




A “Tail” of Three Cities

Closer inspection of the distribution tails shows similar estimates of super-extreme events.





A “Tail” of Three Cities

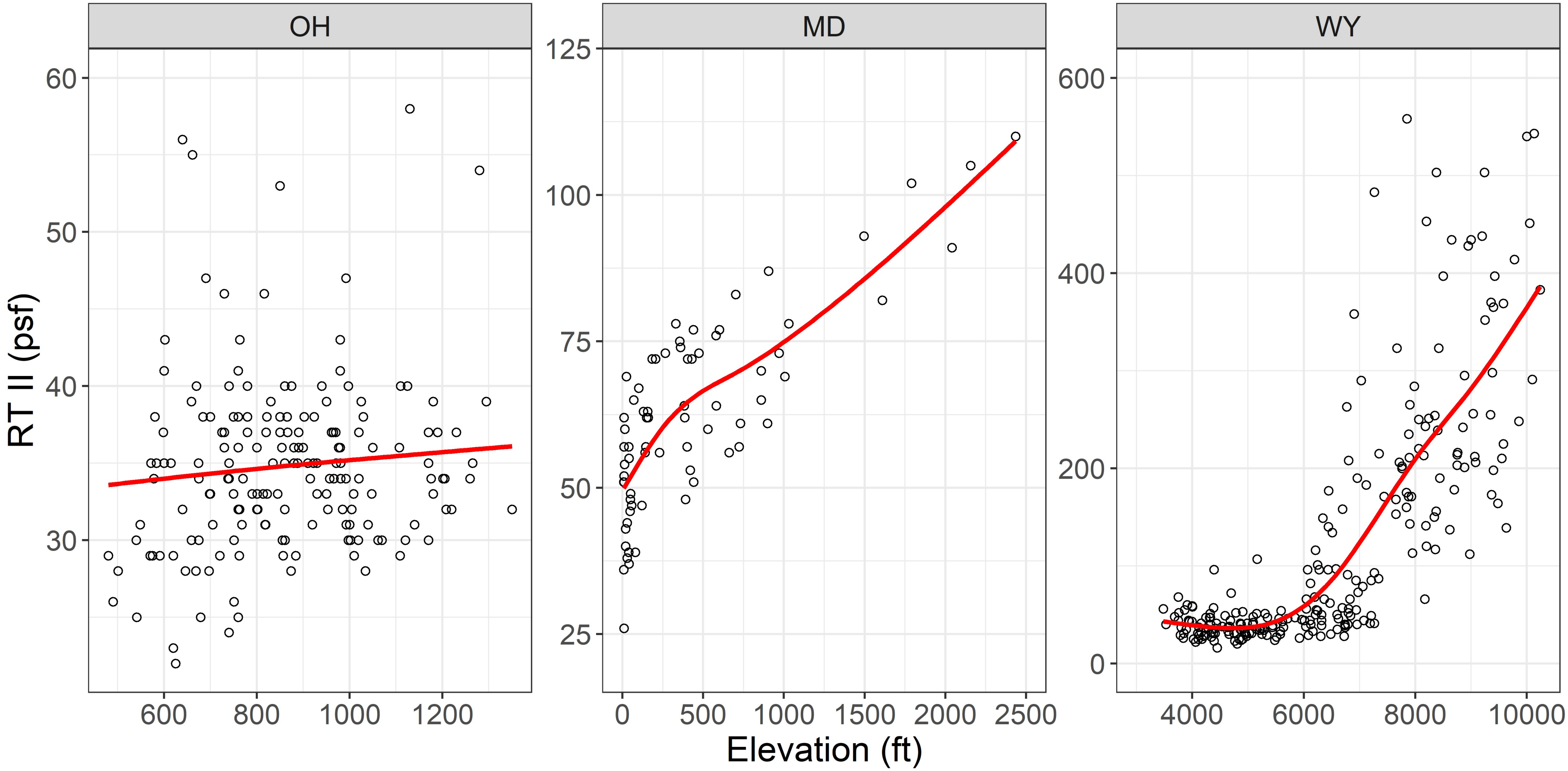
Key Point: A “typical” snow year may look very different than an “extreme” snow year, especially for places on the rain/snow boundary.

Table 2. Comparison of 1981-2010 Average Winter Precipitation and Coldest Month Temperatures (PRISM Climate Group 2015).

City	Winter Precipitation (Dec – Feb)	Coldest Month Temperature (ºF)
Baltimore	9.6	33.9
Boston	10.9	28.4
Minneapolis	2.9	15.9

Mapping

The influence of local terrain and climate on design snow loads changes drastically for different parts of the country.



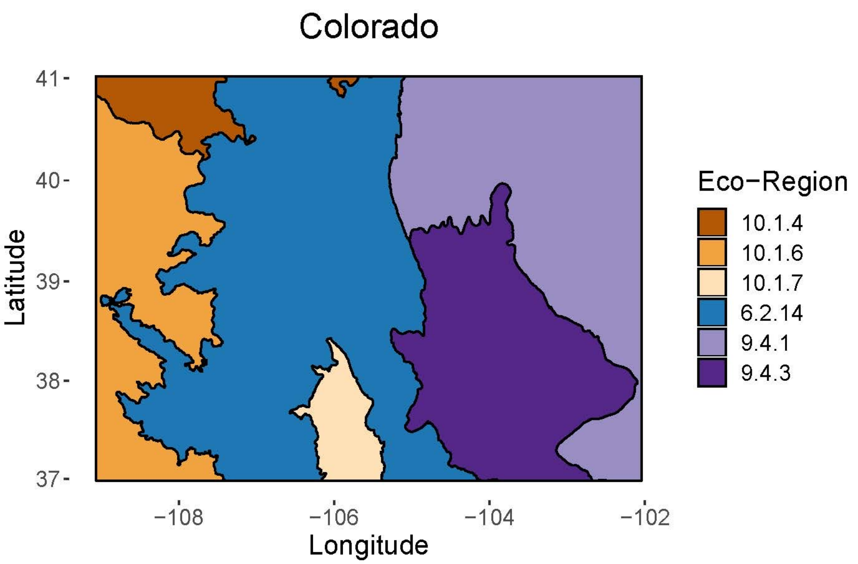
Mapping

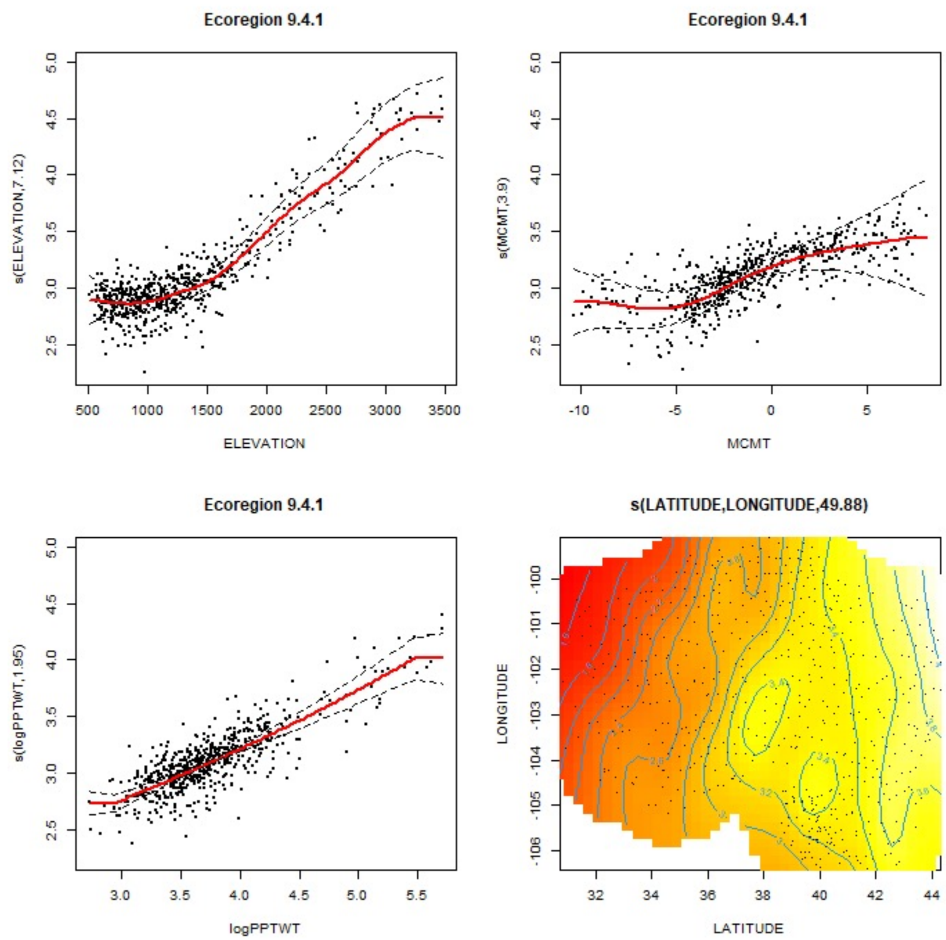
Used EPA Ecological Regions instead of states to partition the country. Fit regional models to each region.

Image taken from https://www.epa.gov/eco-research/ecoregions-north-america

Mapping

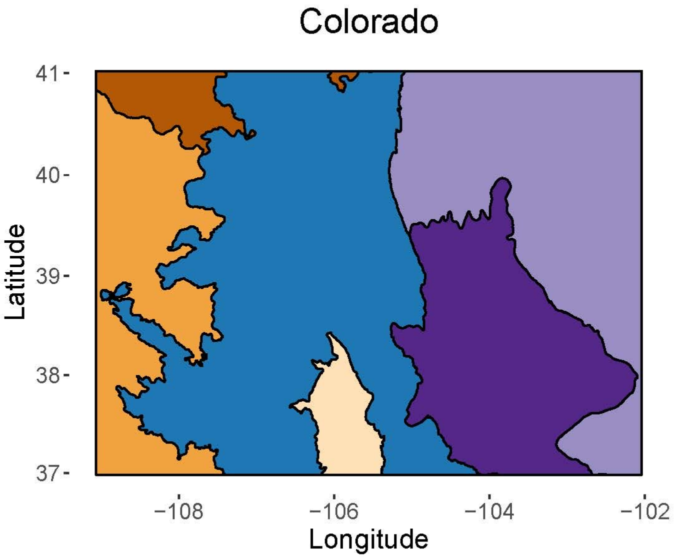
Generalized Additive Models (GAMS) flexibly model the changing relationship between snow and relevant climate variables in each region.

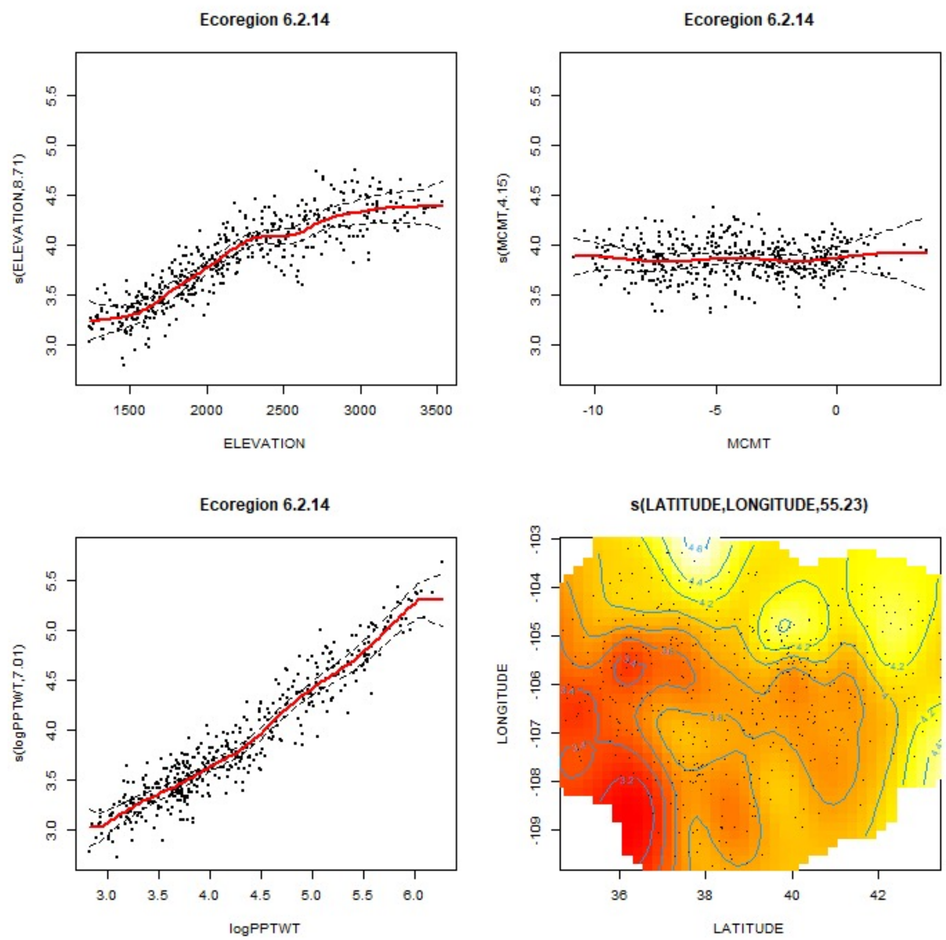




Mapping

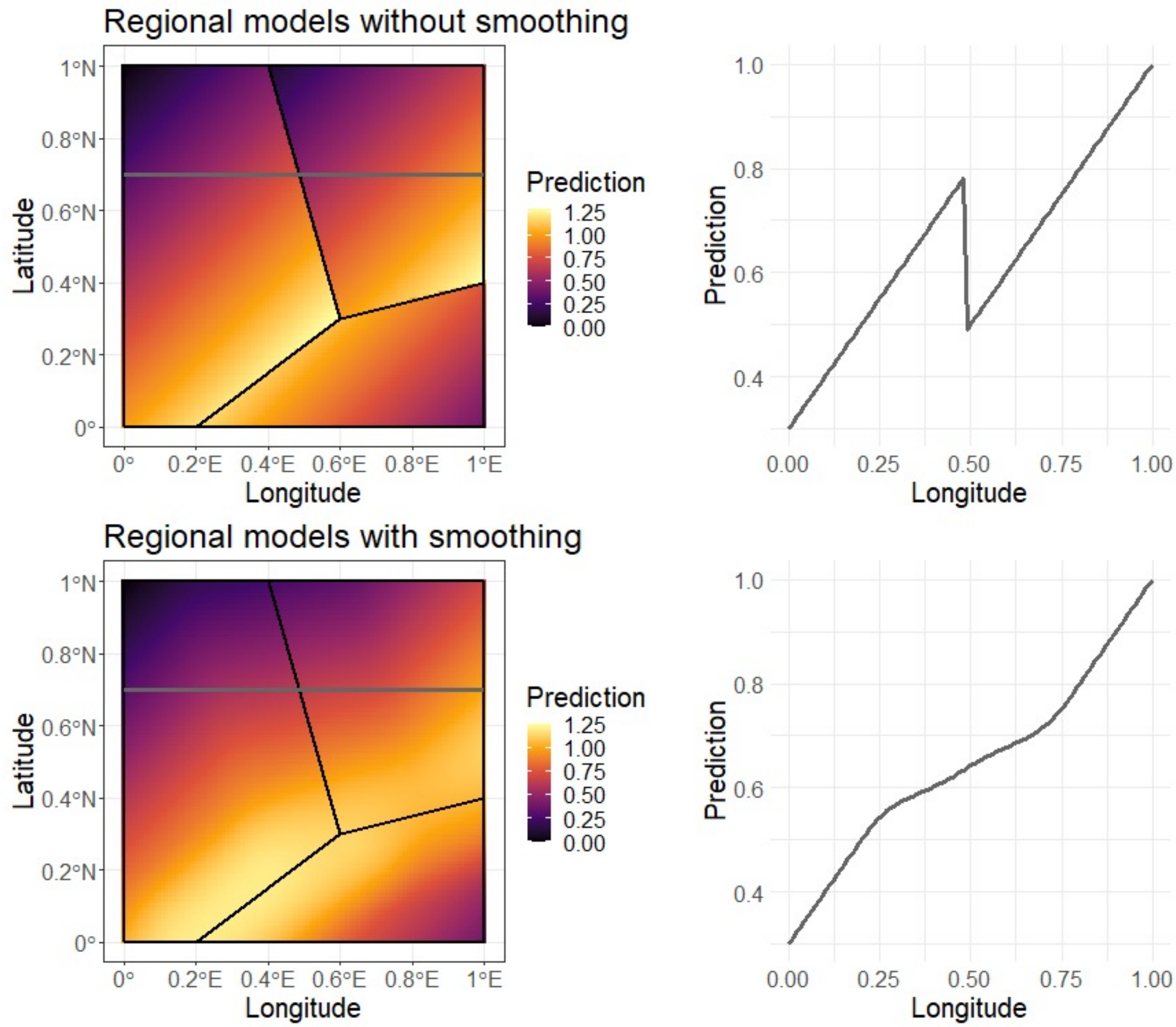
Generalized Additive Models (GAMS) flexibly model the changing relationship between snow and relevant climate variables in each region.





Mapping

Predictions “spill over” into neighboring regions and boundary transitions are smoothed using weighted averages.



Mapping

Key Point: GAMS intentionally avoid true interpolation in order to prevent any single poor prediction from unduly influencing the maps.

Table 7.1: Standard cross-validated results on RTL.

Model	Fitting Technique	MAE	MedAE	MSE
GAM	National Scale	8.51	3.2	504
GAM	**Locally Smoothed**	**6.43**	**2.35**	**235**
OLS	National Scale	16.8	6.53	1810
OLS	Locally Smoothed	8.44	3.35	361
Kriging	National Scale	15.3	5.74	1280
Kriging	Locally Smoothed	9.24	2.94	553
Prism	National Scale	8.33	3.12	518
Prism	Locally Smoothed	6.94	2.65	272
IDW	National Scale	28.9	15.6	2200
IDW	Locally Smoothed	18.3	6.3	1480

Still more accurate than true interpolation approaches.

Mapping: Limitations

- Difficult to pick up "microclimates" especially if local data availability is sparse.
- Site-specific terrain bias can be propagated in map predictions.
- GAMS were chosen because they provided a "stable" fit.

Mapping

Old maps focused on areas and elevations for which traditional mapping approaches worked best.

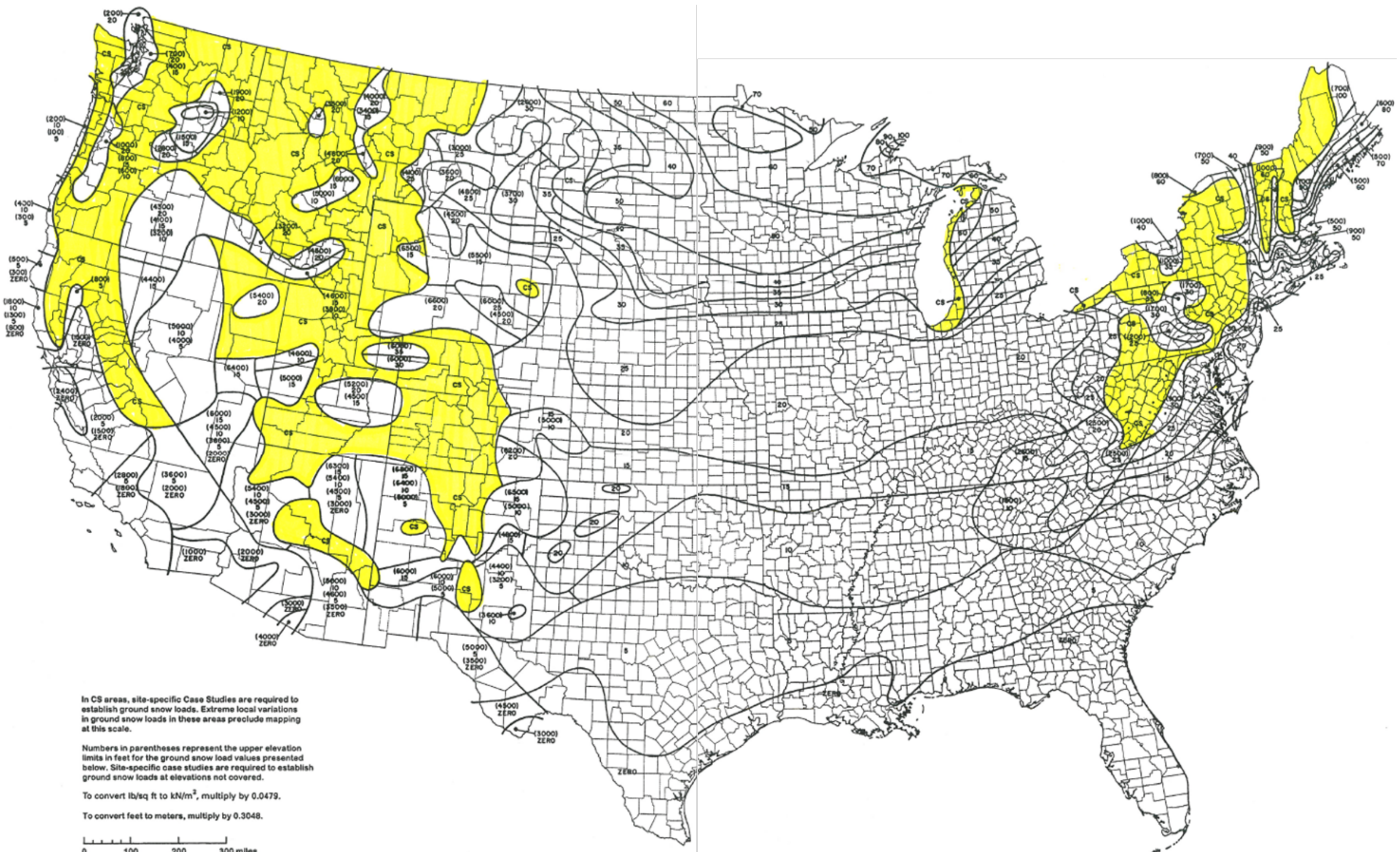
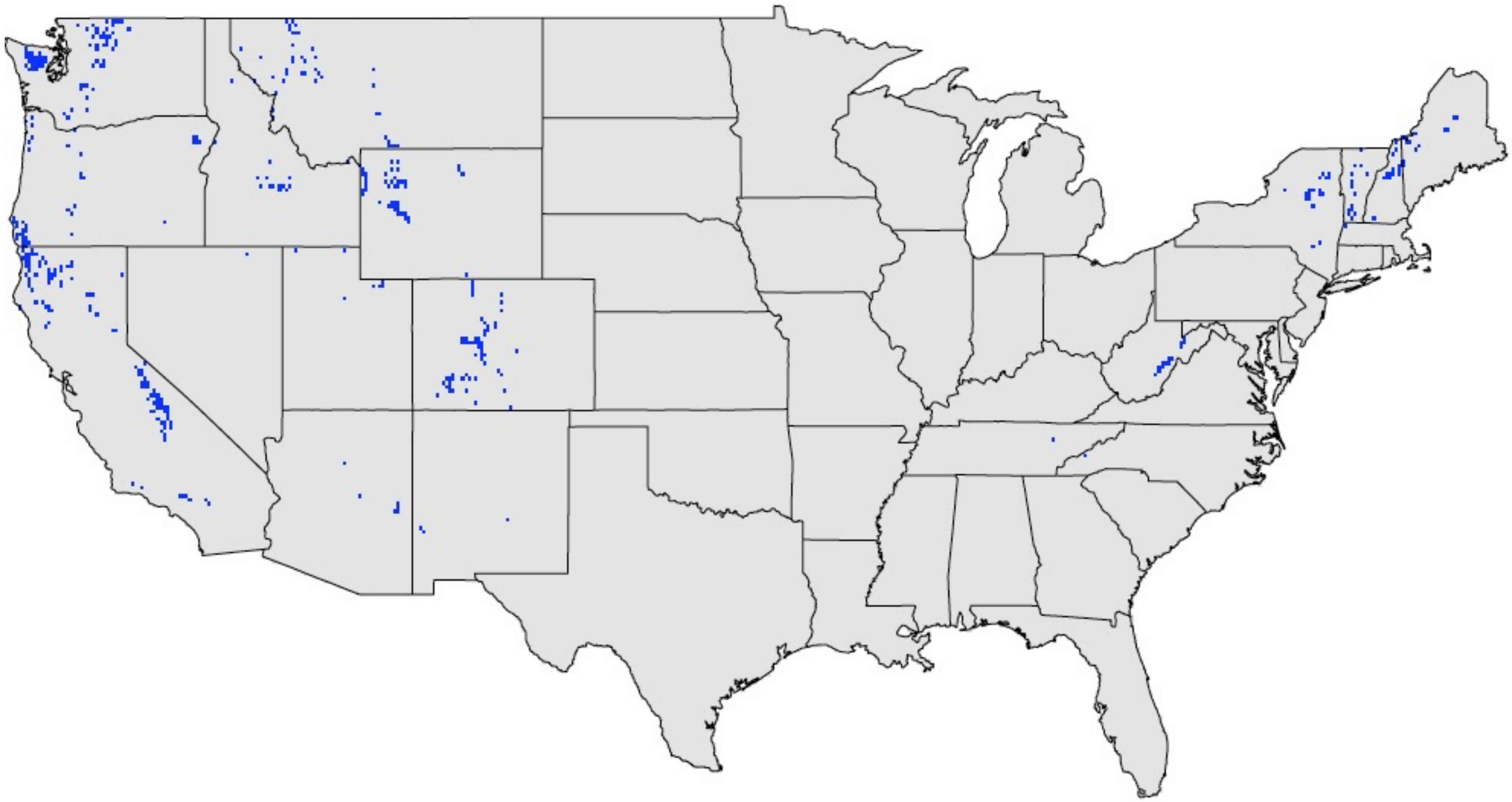


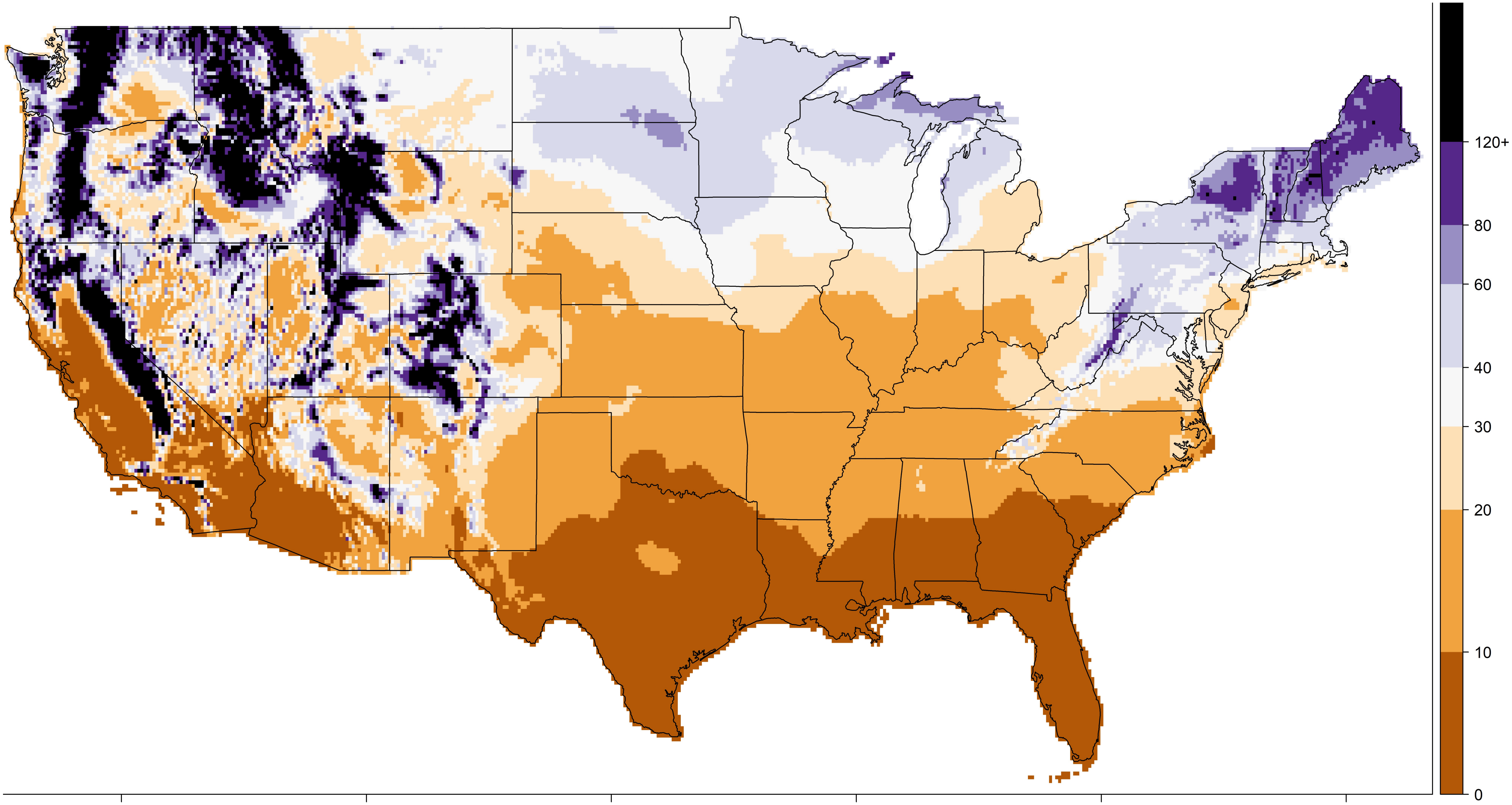
FIGURE 7-1 Ground Snow Loads, P_g, for the United States (Lb/Ft^2).

Mapping

The flexible modeling approach reduces case study regions by 91% from what they were in ASCE 7-16 and 96% of what they were in ASCE 7-2010.



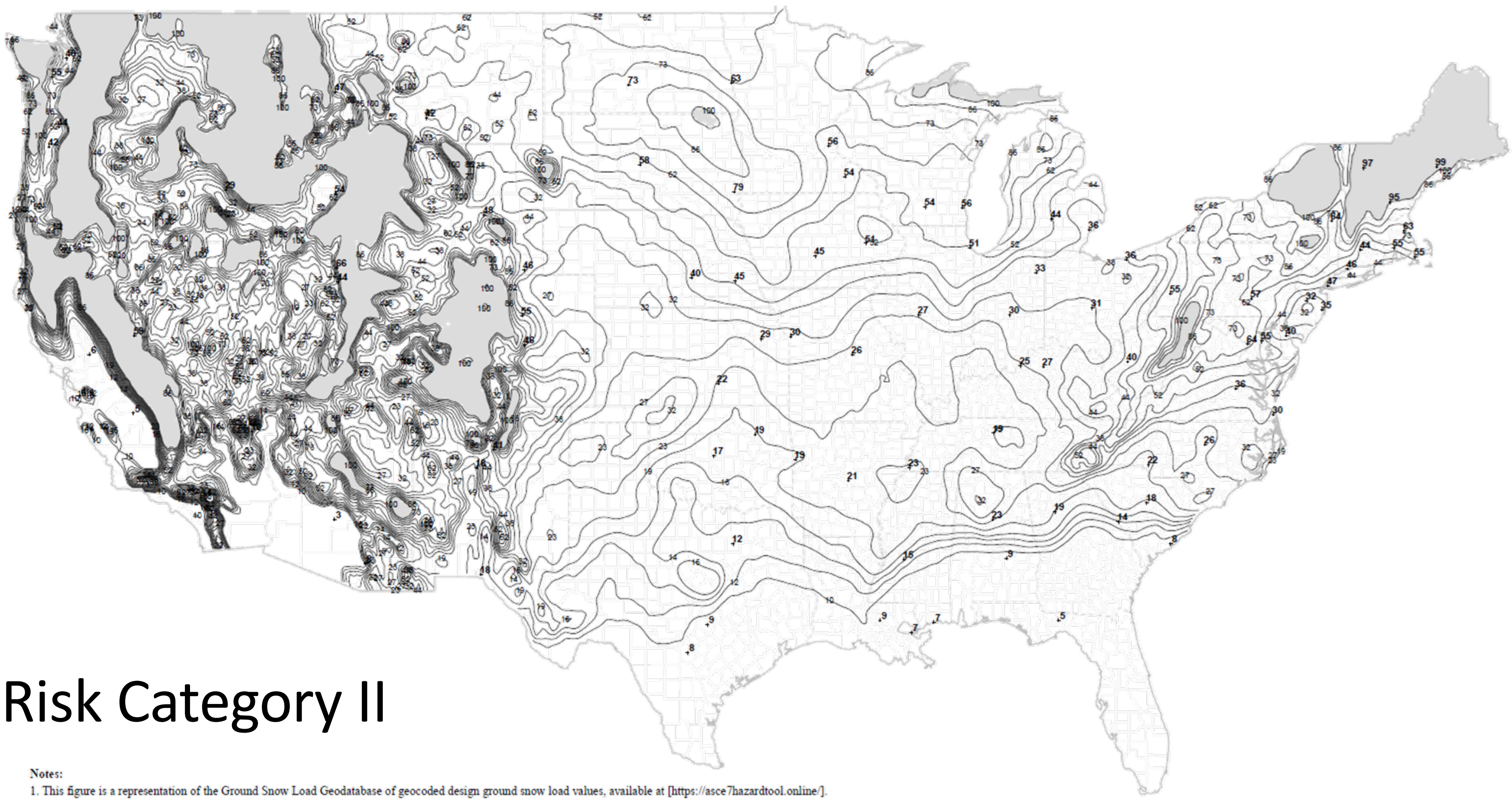
Final Maps



Risk Category II / 1.6

Final Maps

ASCE 7-22 includes contour maps. Gray areas are NOT case study regions, but locations whose values are only available in the online hazard tool.



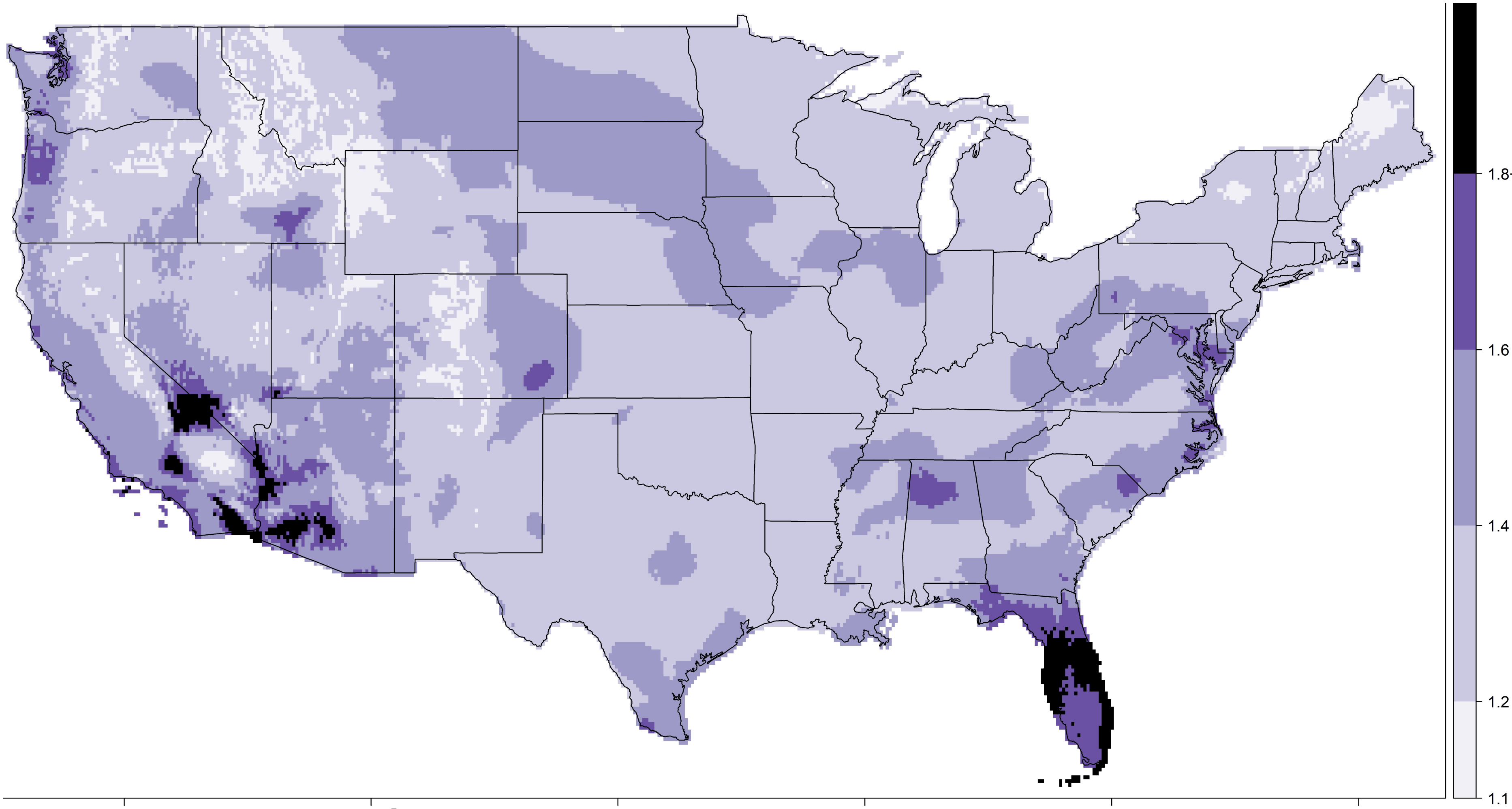
Risk Category II

Notes:

1. This figure is a representation of the Ground Snow Load Geodatabase of geocoded design ground snow load values, available at [https://asce7hazardtool.online/].
2. Values for specific locations can most-accurately be determined by accessing the Geodatabase at the website shown above.
3. Lines shown on the figure are contours with values of 10, 12, 14, 16, 19, 23, 27, 32, 38, 44, 52, 62, 73, 86, and 100 psf.
4. Areas shown in gray represent areas where the contours would be spaced too closely to be legible. Ground−snow−load values for these locations can be determined from the Geodatabase mentioned in Note 1.

More than one map…

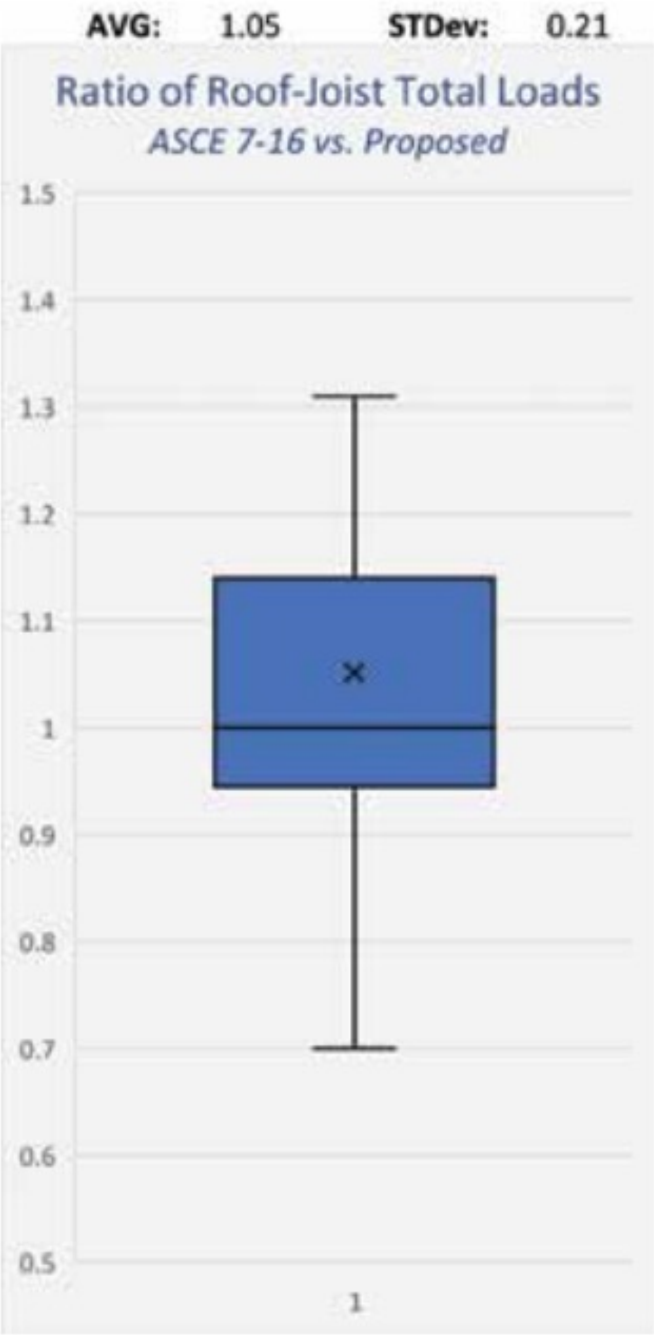
One map per risk category since constant importance factors don't achieve consistent reliability-targets.



Risk Category IV / Risk Category II

Cost Analysis

- The average load is increasing
  - Some loads go up, some down



Cost Analysis (NBS and Vulcraft)

Effects on Roof Loading

- Calculated Roof Total Load using
  - 1.2 D + 1.6 S (ASCE 7-16) vs.
  - 1.2 D + 1.0 S (Proposed)
  - D = 15 psf
- For 30' – 60' Roof Secondary Spans (Bay Dimensions)…
  - 5% average increase in demand
  - **5% increase** in weight of **roof** structure
  - **1-2% increase** in weight of **total** structure

Cost Analysis (NBS and Vulcraft)

- Site Selected: Baltimore, MD
  - One of the highest-impact locations on new GSL maps.
  - GSL (RT-II) = 60 psf
  - GSL (7-16, 50-yr MRI) = 25 psf (1.6*25 psf = 40psf)
  - After proper application of Load Factors (1.0 vs. 1.6), *Roof Total Load increases by 15%*
- Two Metal Buildings – configured to be highly affected by this change:

MB Structure	MB Weight Impact	MB Cost Impact	Total Cost Impact
70'w x 125'l x 15'h 2:12	+6.5%	+4.5%	+0.8%
200'w x 550'l x 18'h 3:12	+8.7%	+6.4%	+0.9%

ASCE 7 Provisions

2.3.1 Basic Combinations.

Structures, components, and foundations shall be … earthquake load effect E. Each relevant strength limit state shall be investigated.

1. $1.4D$
2. $1.2D + 1.6L +$ ~~0.5(L_r or S or R)~~ (0.3S or 0.5L_r or 0.5R)
3. $1.2D +$ ~~1.6(L_r or S or R)~~(1.0S or 1.6L_r or 1.6R) + (1.0L or 0.5W)
4. $1.2D + 1.0W + 1.0L +$ ~~0.5(L_r or S or R)~~ (0.3S or 0.5L_r or 0.5R)
5. $0.9D + 1.0W$

2.4 Load Combinations for Allowable Stress Design

2.4.1 Basic Combinations.

1. D
2. $D + L$
3. $D + (L_r$ or $0.7S$ or $R)$
4. $D + 0.75L + 0.75(L_r$ or 0.7S or $R)$
5. $D + (0.6W)$
6. $D + 0.75L + 0.75(0.6W) + 0.75\ (L_r$ or $0.7S$ or $R)$
7. $0.6D + 0.6W$

ASCE 7 Provisions

1.5.1 Risk Categorization.

Table 1.5-2 Importance Factors by Risk Category of Buildings and Other Structures for ~~Snow~~, Ice, and Earthquake Loads

Risk Category from Table 1.5-1	~~Snow Importance Factor, I_s~~	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	~~0.80~~	0.80	1.00	1.00
II	~~1.00~~	1.00	1.00	1.00
III	~~1.10~~	1.15	1.00	1.25
IV	~~1.20~~	1.25	1.00	1.50

ASCE 7 Provisions

- Adjust provisions which included I_s
  - Section 7.3 – removing from equations for p_f and p_m.
  - Specifically, p_m now selected from proposed new table per Risk Category

Where p_g is equal to or less than the value of the minimum snow load upper limit, $p_{m,max}$, shown in Table 7.3-3:

$$p_m = p_g$$

Where p_g is greater than the value of the minimum snow load upper limit, $p_{m,max}$, shown in Table 7.3-3:

$$p_m = p_{m,max}$$

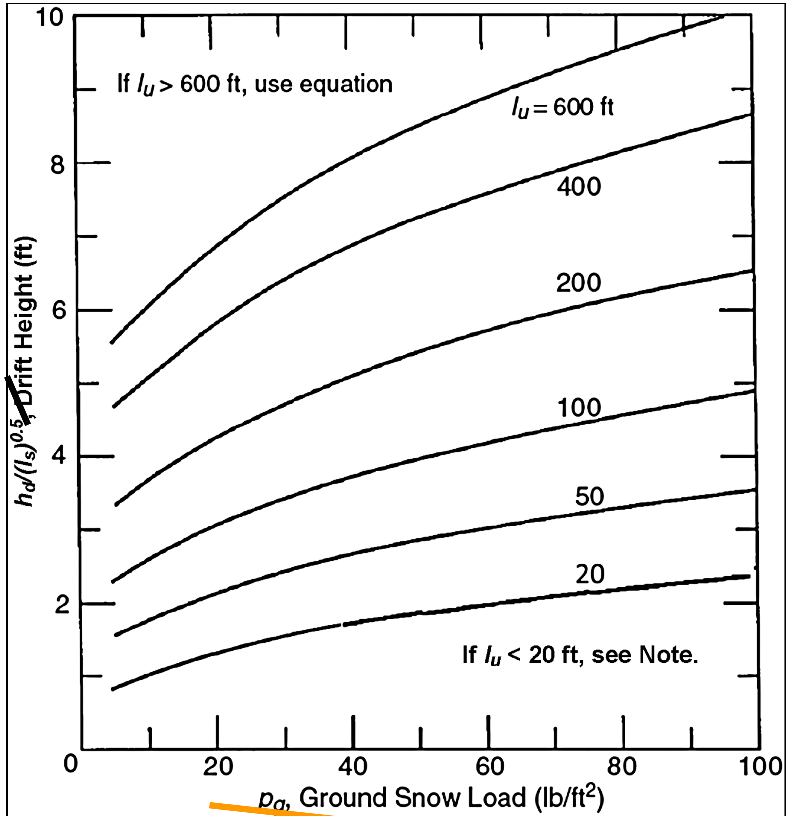
Table 7.3-3 – Minimum Snow Loads for Low-Slope Roofs

Risk Category*	$p_{m,max}$
I	25 lb/ft^2 (1.20 kN/m^2)
II	30 lb/ft^2 (1.44 kN/m^2)
III	35 lb/ft^2 (1.68 kN/m^2)
IV	40 lb/ft^2 (1.92 kN/m^2)

* For a description of the Risk Category, see Table 1.5-1

ASCE 7 Provisions

7.6.1 Unbalanced Snow Loads for Hip and Gable Roofs.



$$\frac{h_d}{\sqrt{l_s}} = \left(0.43\sqrt[3]{l_u}\,\sqrt[4]{p_g+10}\right) - 1.5$$

$$h_d = \left(0.52\sqrt[3]{l_u}\sqrt[4]{0.64p_g + 11}\right) - 1.9$$

ASCE 7 Provisions

Adjust Section 12.7.2, Effective Seismic Weight, W

4. Where the flat roof snow load, p_f, exceeds 4530 psf (2.161.44 kN/m2), 1520% of the uniform design snow load, regardless of actual roof slope.

ASCE 7 Provisions

Adjust Appendix CC – Serviceability Consideration

- Adjust suggested roof load combination (Eqn CC.2-1b) to be:

$$D + \sout{0.5S}\ S_{ser}$$

- S_{ser} = the roof snow load per Ch 7 Provisions using the 20-yr MRI GSL
- 20-yr MRI approximately 80% of the 50-yr MRI
- 20-yr MRI GSL Map now provided

Also new: Winter Wind Parameter

The new relation for the drift height, h_d, in ASCE 7-22 is

$$h_d = 1.5\sqrt{\frac{P_g^{0.74} l_u^{0.7} W_2^{1.7}}{\gamma}} \qquad Equation\ 7.6-1$$

Where:
γ = the snow density.
W2 = the winter wind parameter (Figure 3)

W2 is (typically small 0.25 to 0.45) for West of the Rockies and in the Southeast, while W2 is (typically large 0.45 to 0.65) Midwest and Northeast

Winter Wind Parameter

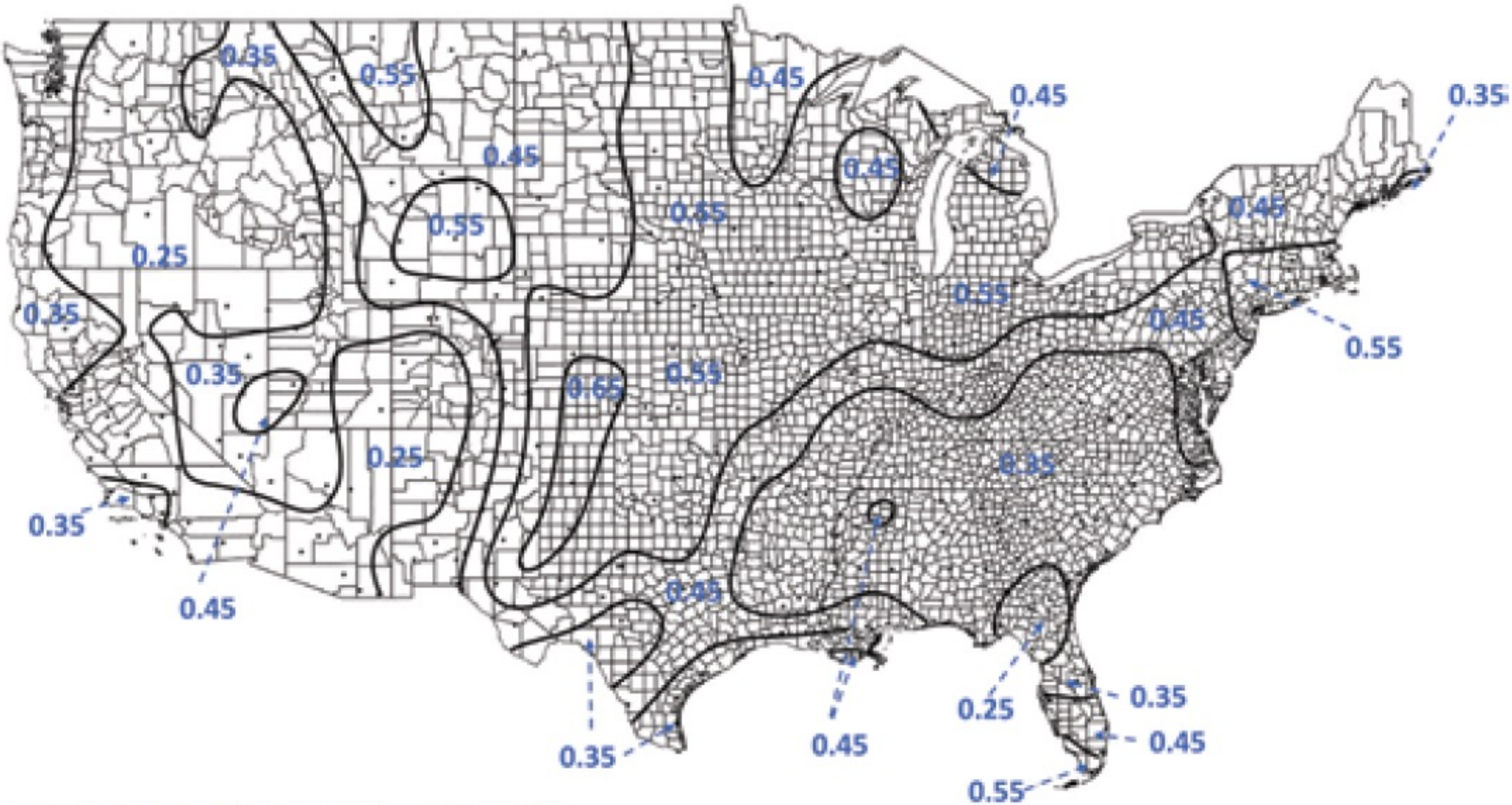


Figure 3. Map of winter wind parameter W_2.

Polling Question 2

How are the new provisions different with the updated reliability targeted ground snow load?

A. One must adjust all equations by the 1.6 safety factor

B. There were no changes to the provisions

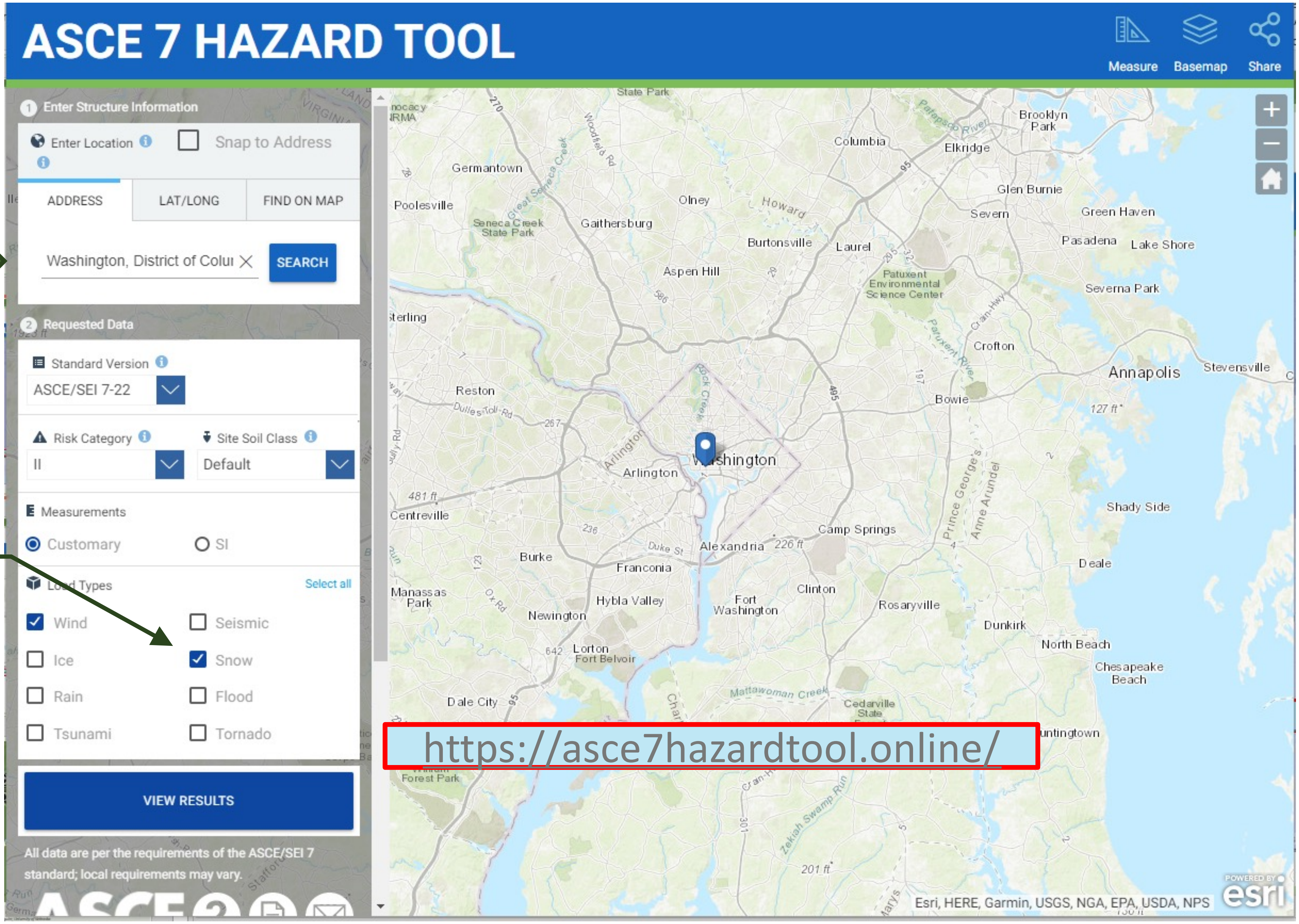
C. Multiply service snow by the new importance factor

D. All equations are now compatible with the new snow loads.

Web Demonstration

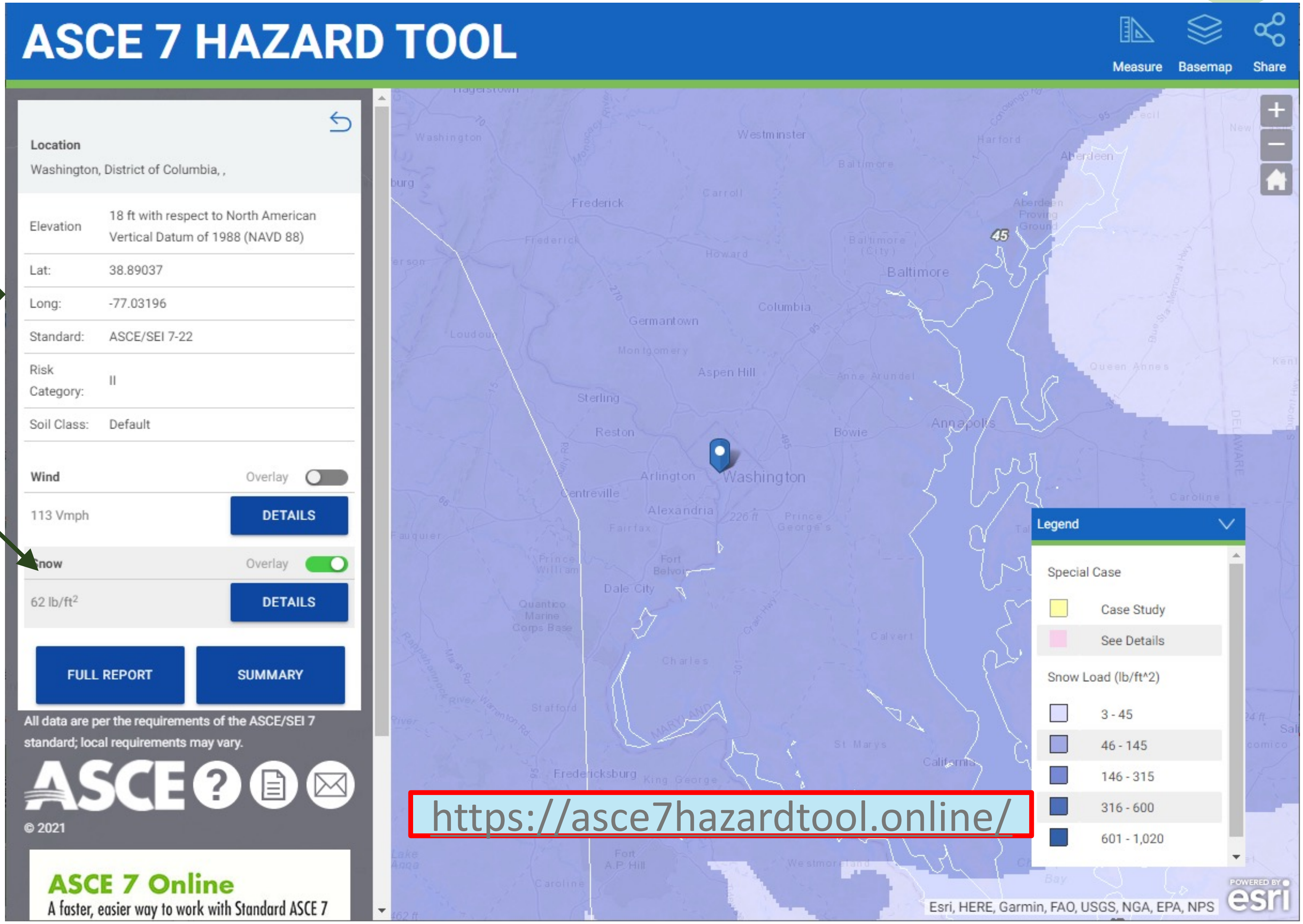
Inputs

Get this Turned On!



Outputs

Snow Results Here



Acknowledgments

Financially Supported By:

- **Steel Joist Institute**
- ASCE Struct. Engineering Institute
- Metal Building Mfr’s Assn
- Factory Mutual
- Steel Deck Institute
- Nat. Council of Struct. Eng. Assns
- Factory Mutual
- Simpson Gumpertz & Heger
- Wiss, Janney, Elstner Associates
- Nucor
- State of MT
- SEAMT

Acknowledgments

Technical Team

- Brennan Bean, PhD (Utah State)
- Marc Maguire, PhD (Univ. of NE)
- Yan Sun, PhD (Utah State)
- Jadon Wagstaff (Graduate Student, USU)
- Salam Al-Rubaye (Graduate Student, UN)
- Jesse Wheeler (Undergraduate Student, USU)
- Miranda Rogers (Undergraduate Student, USU)
- Scout Jarman (Undergraduate Student, USU)

Peer Review

- Bruce Ellingwood, PhD (Colo. State)
- Jeannette Torrents (JVA Engineers)
- Therese McAllister, PhD (NIST)

ASCE Staff

- Jennifer Goupil
- Laura Champion

Acknowledgments

The project was completed in the R statistical software language with the help of the following ancillary packages.

- **gstat:** For creating spatial estimation models.
- **maps:** For maps of the United States as used in visuals.
- **mgcv:** For generalized additive models.
- **randomforest:** For modeling depth to load conversions.
- **Rcpp:** For fast data simulation.
- **RColorBrewer:** For nice colors in figures.
- **rgdal:** For projecting geographic spatial data.
- **rgeos:** For spatial distance calculations.
- **sf:** For handling spatial data
- **sp:** For handling spatial data.
- **Tidyverse**: For basic data manipulations and visualizations

Questions?

Caribou-Targhee National Forest, Idaho

THANK YOU

Presented by:

Marc Maguire, University of Nebraska

Brennan Bean, Utah State University