National Risk Index Data Version and Update Documentation

To provide a consistent and accurate baseline risk assessment, the National Risk Index must periodically review and update source data and methods. Many changes have been made over subsequent releases of the Risk Index. These changes incorporate new or improved data sources and enhanced the methodology to improve the quality of the risk calculation.

The National Risk Index is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards. It was designed and built by the Federal Emergency Management Agency (FEMA) in close collaboration with various stakeholders and partners in academia; local, state, and federal government; and private industry.

In the Risk Index, risk is defined as the potential for negative impacts as a result of a natural hazard. The risk equation behind the Risk Index includes three components: *Expected Annual Loss (EAL), Social Vulnerability (SV)*, and *Community Resilience (CR)*. EAL represents the average economic loss in dollars resulting from natural hazards each year, and it is calculated using a multiplicative equation that includes three factors:

- **Annualized Frequency** represents the expected frequency or probability of a natural hazard occurrence per year.
- **Exposure** is the representative value of population (Pop), buildings (Bld), or agriculture (Ag) potentially exposed to a natural hazard occurrence.
- **Historic Loss Ratio (HLR)** represents the estimated percentage of the exposed population, building value, or agriculture value expected to be lost due to a natural hazard occurrence.

Many subject matter experts representing 91 entities contributed to the development of the National Risk Index by reviewing, providing data, or supporting collaborative working groups to identify the best available and reputable data sources. All data supporting the components of the Risk Index are nationwide in scope and able to be measured at minimum the Census tract level.

FEMA

Data Version v.1.17.0 (October 2020)

The Phase 1 release of the National Risk Index contained the initial *Risk Index*, *EAL*, *SV,* and *CR* results for each county and Census tract in the 50 states and the District of Columbia.

Data Version v.1.18.0 (August 2021)

The National Risk Index development team regularly meets with experts in specific hazard types, responds to user feedback, and keeps track of new or enhanced data sources to continually improve the product. Version v.1.18.0, which was publicly released on August 16, 2021, had significant enhancements in seven areas over the initial version v.1.17.0. Table 1 illustrates the scope of the seven enhancement areas (numbered) by the hazard types and risk factors impacted by the change. The number corresponds to the section below that provides further details on the enhancement.

Table 1: National Risk Index v.1.18.0 Enhancement Summary by Hazard Type and Risk Factor

Hazard Type	*Frequency*	*Exposure Pop*	*Exposure Bldg*	*Exposure Ag*	*HLR Pop*	*HLR Bldg*	*HLR Ag*	*SV*	*CR*
Avalanche	1			N/A	6	6	N/A		
Coastal Flooding	2				6	6	N/A		
Cold Wave					6	6	6		
Drought		N/A	N/A		N/A	N/A	6		
Earthquake				N/A	6	6	N/A		
Hail					6	6	6		
Heat Wave				7	6	6	6, 7		
Hurricane				7	6	6	6, 7		
Ice Storm				N/A	6	6	N/A		
Landslide	3			N/A	6	6	N/A		
Lightning				N/A	6	6	N/A		
Riverine Flooding	4				6	6	6		
Strong Wind					6	6	6		
Tornado	5	5	5	5, 7	5, 6, 7	5, 6, 7	5, 6, 7		
Tsunami				N/A	6	6	N/A		
Volcanic Activity				N/A	6	6	N/A		
Wildfire				7	6	6	6, 7		
Winter Weather				7	6	6	6, 7		

1. Avalanche

The frequency factor for the Avalanche hazard type was updated to include three additional years from the source dataset, Arizona State University's (ASU) Spatial Hazard Events & Losses Database for the United States (SHELDUS). The period of record went from 1/1/1960 to 12/31/2016 in v.1.17.0 to 1/1/1960 to 12/31/2019 in v.1.18.0. Thus, the period of record went from 57 to 60 years.

2. Coastal Flooding

EAL estimation for the Coastal Flooding hazard type is modeled in four subtypes: (1) sea level rise and high tide flooding, (2) 1% annual chance of flooding area, (3) 0.2% annual chance of flooding area, and (4) Sea, Lake and Overland Surges from Hurricanes (SLOSH) hurricane surge. For v.1.18.0, the frequency factor of the sea level rise and high tide flooding subtype was updated. The previous approach used a simple national estimate of three flooding events per year for all areas susceptible to sea level rise and high tide flooding. This was refined in v.1.18.0 to derive *regional* frequency estimates by calculating average flood frequencies for each region from high tide flooding recurrence intervals for 146 National Oceanic and Atmospheric Administration (NOAA) tidal gauges distributed throughout the continental U.S. and Hawaii. These regional frequencies are adapted from NOAA research on high tide frequency patterns.[1]

The methodology was also updated to adjust sea level rise and high tide flooding frequencies for areas designated by the source data as being protected by levees. These areas received a sea level rise and high tide flooding frequency of 0.2% annual chance of flooding rather than the average frequency for its region.

3. Landslide

The frequency factor for the Landslide hazard type was updated to utilize a new source dataset: National Aeronautics and Space Administration's Cooperative Open Online Landslide Repository (COOLR). v.1.17.0 used a predecessor of COOLR with a period of record from 1/1/2010 and 11/20/2018. v.1.18.0 uses COOLR data with a period of record from 1/1/2010 and 12/31/2019. Thus, the period of record went from 8.9 to 10 years.

4. Riverine Flooding

The frequency factor for the Riverine Flooding hazard type was updated to include three additional years from the source dataset, the National Centers for Environmental Information's (NCEI) Storm Events Database. The period of record went from 1/1/1995 to 12/31/2016 in v.1.17.0 to 1/1/1996 to 12/31/2019 in v.1.18.0. Thus, the period of record went from 22 to 24 years.

5. Tornado

There was a major overhaul of the modeling approach for the Tornado hazard type that impacted all EAL factors. Foundationally, the methodology expanded from modeling all tornadoes of different magnitudes in the same way to

[1] Sweet, V.W., Dusek, G., Obeysekera, J., and Marra, J.J. (2018). *Patterns and projections of high tide flooding along the U.S. coastline using a common impact threshold*. NOAA Technical Report NOS CO-OPS 086. Retrieved from https://tidesandcurrents.noaa.gov/publications/techrpt86_PaP_of_HTFlooding.pdf (accessed December 4, 2021).

modeling tornadoes for three subtypes based on the Enhanced Fujita (EF) scale: (1) EF- 0 and 1; (2) EF- 2 and 3; and (3) EF- 4 and 5.

The exposure and frequency factors for the Tornado hazard type were updated to include two additional years from the source dataset, the Storm Prediction Center's Severe Weather Database Files, compiled by the National Weather Service (NWS). The period of record went from 1/1/1986 to 12/31/2017 in v.1.17.0 to 1/1/1986 to 12/31/2019 in v.1.18.0. Thus, the period of record went from 32 to 34 years.

Modeling tornado frequency for communities is a challenge because tornadoes can happen almost anywhere but generally impact very small geographic areas. For instance, EF-0 and 1 tornadoes impact less than 1 km^2 on average. The v.1.17.0 methodology made very conservative frequency assumptions where both counties and Census tracts inherited frequencies by an approach that counted historic tornado occurrences where paths were buffered by 80 kilometers (regardless of EF-scale) for each cell they intersected in a national 49-by-49-km fishnet grid. This method effectively increased the influence of past tornado occurrence on nearby communities even if those areas had not been impacted by past tornadoes. After discussions with tornado experts, the National Risk Index team updated the frequency approach to be less conservative by calculating subtype frequencies, scaling tornado counts by subtype nationally, and area-apportioning subtype frequencies to counties and Census tracts. This resulted in a major reduction and more accurate estimate of tornado occurrence rates.

For the exposure factor, representative damage areas were developed for each subtype based on the average areas impacted by historical tornadoes within the subtype. The v.1.17.0 methodology utilized a single representative damage area of 2.0 km^2 that was applied to a county or Census tract average consequence value density. The v.1.18.0 methodology uses these representative areas: 0.78 km^2 for subtype 1, 13 km^2 for subtype 2, and 79 km^2 for subtype 3.

In v.1.17.0, the loss ratio per basis exposure calculation was based on historic tornado paths occurring in each county during the year-month in which SHELDUS-documented loss occurred. In v.1.18.0, HLRs were enhanced by matching historical tornado paths from NWS with the SHELDUS loss events for event-specific loss ratios. Subtype specific HLRs were generated.

The three EAL factors were modeled separately for each subtype. EAL was calculated for each subtype and then summed up for the Tornado EAL.

These enhancements significantly changed the Tornado risk profile. In particular, tornado risk was reduced in high population density counties where severe tornadoes are rare, particularly in the Northeast and Great Lakes states.

6. Historic Loss Ratio

The Historic Loss Ratios (HLRs) for all hazard types were updated to include three additional years (2017-2019) from the source datasets:

- **Cold Wave:** NCEI's Storm Events Database
- **All Other Hazards:** ASU's SHELDUS

Thus, the period of record went from 21 to 24 years.

In addition, the National Risk Index team was granted access to SHELDUS's individual peril event loss records to develop v.1.18.0 HLR estimates. The v.1.17.0 version used summarized hazard county-month loss records. Access to the more granular data enabled development of more accurate loss ratio per basis estimates. These enhancements impacted the risk profile for all hazard types for all counties and Census tracts.

7. Expanded Agriculture Consequences to Five Additional Hazard Types

Within the National Risk Index, losses are estimated for three consequence types: building, population, and agriculture (crop and livestock). Each hazard type is modeled to have losses in one or more of these consequence types. Impacts to buildings and population were estimated for all hazard types except Drought, which only estimated agriculture losses. In v.1.17.0, agriculture losses were also estimated for those hazard types where historically agriculture losses contributed greater than 10% of the total reported losses.

In v.1.18.0, the loss contribution threshold was reduced to 1% resulting in agriculture loss estimation for five additional hazard types: Heat Wave, Hurricane, Tornado, Wildfire, and Winter Weather. This change resulted in a $292M increase of EAL nationally, a 7% increase in agriculture losses. The most significant impacts were from hurricanes in communities in the Southeast.

Data Version v.1.18.1 (November 2021)

Version v.1.18.1, which was publicly released on November 18, 2021, had one change from Version v.1.18.0, which was released in August 2021. Table 2 illustrates the scope of the enhancement area by the hazard type and risk factors impacted by the change. The number corresponds to the section below that provides further details on the enhancement.

Table 2: National Risk Index v.1.18.1 Enhancement Summary by Hazard Type and Risk Factor

Hazard Type	*Frequency*	*Exposure Pop*	*Exposure Bldg*	*Exposure Ag*	*HLR Pop*	*HLR Bldg*	*HLR Ag*	*SV*	*CR*
Hurricane					1	1	1		

1. Corrected Hurricane HLR Calculations

In v.1.18.1, the HLR calculation process for the Hurricane hazard type was updated to correct a defect that was identified after the v.1.18.0 data were released.

HLRs are hazard-specific, county-specific estimates of the percentage of the exposed consequence type expected to be lost in a single hazard occurrence. A county's HLR could be the simple average of a county's loss ratios (losses divided by exposure) from past hazard occurrences. However, because there are often wide variances in loss ratios or not enough hazard occurrences for a statistically significant average, the National Risk Index methodology employs a Bayesian credibility approach that considers multiple geographic levels. Specifically, averages and variances of the individual hazard occurrence loss ratios are calculated for each consequence type for up to four levels depending on the hazard type: (1) county, (2) surrounding area (196-by-196-km grid), (3) regional, and (4) national.

The intent for the Hurricane hazard type in the v.1.18.0 release was to utilize county, surrounding area, and regional levels in the calculation of the Bayesian-adjusted HLR values; however, a defect was identified that the county, surrounding area, and national levels were used instead. In v.1.18.1, this was corrected to the original intent.

This correction resulted in new Hurricane building, population, and agriculture HLR values that affect the Hurricane and composite EAL values and scores and risk scores for all counties and Census tracts where Hurricanes are deemed possible. The impact of this correction is most noticeable in inland counties, particularly in the Midwest and Southwest where hurricanes are deemed possible due to historic tracks but have not had many loss causing events in the 24-year period of record. As part of the update, these counties now receive contribution from the regional level, which for inland areas, is generally lower than the national average that includes loss ratios from coastal counties where loss ratios are generally much higher.

Data Version v.1.19.0 (March 2023)

Version v.1.19.0, which was publicly released on March 23, 2023, had significant enhancements in 10 areas over the previous version v.1.18.1, released in November 2021. Table 3 illustrates the scope of the 10 enhancement areas (numbered) by the hazard types and risk factors impacted by the change. The number corresponds to the section below that provides further details on the enhancement.

In addition, with version 1.1.19.0, EAL scores and ratings were generated for the territories of American Samoa, Commonwealth of the Northern Mariana Islands, Guam, Puerto Rico, and the U.S. Virgin Islands.

Table 3: National Risk Index v.1.19.0 Enhancement Summary by Hazard Type and Risk Factor

Hazard Type	*Frequency*	*Exposure Pop*	*Exposure Bldg*	*Exposure Ag*	*HLR Pop*	*HLR Bldg*	*HLR Ag*	*SV*	*CR*	*Risk*
Avalanche		4	4	N/A	4	4	N/A	8	9	10
Coastal Flooding	1	1, 4	1, 4	N/A	4	4	N/A	8	9	10
Cold Wave	2	4	4		4, 6	4, 6		8	9	10
Drought	2, 5	N/A	N/A	5	N/A	N/A	5	8	9	10
Earthquake	3	3	3	N/A	3	3	N/A	8	9	10
Hail	2	4	4		4, 6	4, 6		8	9	10
Heat Wave	2	4	4		4, 6	4, 6		8	9	10
Hurricane	2	4	4		4,7	4,7	7	8	9	10
Ice Storm		4	4	N/A	4, 6	4, 6	N/A	8	9	10
Landslide	2	4	4	N/A	4	4	N/A	8	9	10
Lightning		4	4	N/A	4, 6	4, 6	N/A	8	9	10
Riverine Flooding		4	4		4, 6	4, 6		8	9	10
Strong Wind	2	4	4		4, 6	4, 6		8	9	10
Tornado	2	4	4		4	4		8	9	10
Tsunami	2	4	4	N/A	4	4	N/A	8	9	10
Volcanic Activity	2	4	4	N/A	4	4	N/A	8	9	10
Wildfire	2	4	4		4, 6	4, 6		8	9	10
Winter Weather	2	4	4		4, 6	4, 6		8	9	10

1. Coastal Flooding Data and Methodology

There was a major overhaul of the modeling approach for Coastal Flooding. Previously, Coastal Flooding was modeled in four unique sub-types:

- Sea level rise and high tide flooding
- 1% annual chance of flooding
- 0.2% annual chance of flooding
- SLOSH hurricane surge.

The following sections describe the enhancements made to each of the sub-types for the v.1.19.0 release.

SEA LEVEL RISE AND HIGH TIDE FLOODING SUB-TYPE UPDATES

As described in the Data Version v.1.18.0 (August 2021), the sea level rise and high tide flooding sub-type frequency is based on simplified *regional* frequency estimates. In v.1.19.0, frequency and exposure estimates were updated to leverage newly available data generated in support of the NOAA Global and Regional Sea Level Rise Scenarios for the United States report.[2] These data provide estimates of the probability of coastal flooding events due to high tides for U.S. coastal regions. The data categorize flooding event frequencies and exposures across three severity levels: (1) Minor flooding events (50-100% annual chance flooding events), (2) Moderate flooding events (10-50% annual chance flooding event), and (3) Major flooding events (1% annual chance flooding event). For each severity level, there is a GeoTIFF raster layer where each raster cell contains information about the probability of high tide flooding at a given location. Frequencies for each NOAA high tide flooding subtype are calculated by intersecting their respective high tide flood raster layer and data with Census block developed area shapes and multiplied by HLRs to generate EAL estimates.

1% ANNUAL CHANCE AND 0.2% ANNUAL CHANCE FLOOD AREA SUB-TYPE UPDATES

The methodology to model the 1% annual chance of flooding and 0.2% annual chance of flooding sub-types remain unchanged in the v.1.1.19.0 version. The National Flood Hazard Layer[3] source dataset, which is used to define exposure for these sub-types, was updated from the 2018 to 2021 version. The National Risk Index team evaluated and refined coastal vs. riverine flooding designations in all coastal geographic areas to estimate exposure more accurately for the hazard types.

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[2] Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf
3 National Flood Insurance Program, Federal Emergency Management Agency. (2021). National Flood Hazard Layer [online dataset]. Retrieved from https://www.fema.gov/national-flood-hazard-layer-nfhl

SLOSH HURRICANE SURGE SUB-TYPE UPDATES

This sub-type was removed from the v.1.19.0 version as those scenarios are addressed in the new NOAA flood probability data used for the sea level rise and high tide flooding subtype updates.

2. Frequency Updates for Several Hazard Types

The period of record was updated for several hazard types to include additional years from the source datasets since the previous data release v.1.18.1. End dates vary across hazards based on availability and dates when the data was accessed by the National Risk Index team.

Table 4: Hazard Type Period of Record Updates for v.1.19.0

Hazard Type	*v.1.18.1 Period of Record*	*v.1.19.0 Period of Record*
Cold Wave	11/12/2005 to 12/31/2017	11/12/2005 to **10/06/2022**
Drought	1/1/2000 to 12/31/2017	1/1/2000 to **11/09/2021**
Hail	1/1/1986 to 12/31/2017	1/1/1986 to **12/31/2019**
Heat Wave	11/12/2005 to 12/31/2017	11/12/2005 to **10/06/2022**
Hurricane	1/1/1851 to 12/31/2017	1/1/1851 to **11/18/2020**
Landslide	1/1/2010 to 12/31/2019	1/1/2010 to **10/2/2021**
Strong Wind	1/1/1986 to 12/31/2017	1/1/1986 to **12/31/2019**
Tornado	1/1/1986 to 12/31/2019	**1/1/1950** to 12/31/2019
Tsunami	1/1/1800 to 10/25/2018	1/1/1800 to **9/8/2021**
Volcano	9310 BCE-12/18/2018	9310 BCE to **12/19/2022**
Winter Weather	11/12/2005 to 12/31/2017	11/12/2005 to **10/06/2022**

Additionally, the probabilistic modeling and susceptible area source data[4] for the Wildfire hazard type were updated to the 2020 version.

[4] Short, Karen C.; Finney, Mark A.; Vogler, Kevin C.; Scott, Joe H.; Gilbertson-Day, Julie W.; Grenfell, Isaac C. 2020. Spatial datasets of probabilistic wildfire risk components for the United States (270m). 2nd Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0034-2

3. Earthquake

The National Risk Index directly applies EAL data from the FEMA P-366 Estimated Annualized Earthquake Losses for the United States study.[5] This study uses FEMA's Hazus tool for a uniform engineering-based approach to measure damages, casualties and economic losses from earthquakes throughout the U.S. at both the Census tract and county levels. Rather than recreate the work of Hazus, the Census tract- and county-level exposure and EAL data produced by this study were loaded into the National Risk Index's database as a reference table.

For the v.1.19.0 release, the previous 2017 version of the P-366 data, which was generated by Hazus 3.0, was replaced by the latest 2023 version of the P-366 data, which was generated by Hazus 6.0.

4. Updated Census Data

For the v.1.19.0 release, the county and Census tract boundaries were updated based on the U.S. Census Bureau's 2021 TIGER/Line Shapefiles and Geodatabases.[6] This change, which migrated tract definitions from the 2010 to 2020 decennial Census, resulted in major changes to Census tract boundaries.

In addition, building and population exposure values were updated for all communities using Hazus 6.0 data,[7] which provides January 2022 valuations for buildings. The previous version (v.1.18.1) used Hazus 4.2 data, which provided 2018 valuations for buildings.

5. Drought

According to the United States Department of Agriculture's Farm Service Agency Guidelines for the Livestock Indemnity Program, drought is not considered a primary cause of livestock death in the United States.[8] In v.1.19.0, agriculture exposure for the Drought hazard type was updated to only consider the crop portion of agriculture. For this release, all crop exposure values were derived from USDA 2017 Census of Agriculture[9] (same as v.1.18.1) and updated 2020 CropScape[10] data using the "Cultivated Crops" agriculture land classification.

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[5] Federal Emergency Management Agency. (2017). *Hazus estimated annualized earthquake losses for the United States.* Washington, DC: Federal Emergency Management Agency, Department of Homeland Security. Retrieved from https://www.fema.gov/sites/default/files/2020-07/fema_earthquakes_hazus-estimated-annualized-earthquake-losses-for-the-united-states_20170401.pdf.

[6] U.S. Census Bureau. (2021). TIGER/Line Shapefiles and Geodatabases [cartographic dataset]. Retrieved from https://www.census.gov/programs-surveys/geography/geographies/mapping-files.2021.List_230945507.html

[7] Federal Emergency Management Agency (FEMA). (2022). Hazus 6.0 Release. Retrieved from https://msc.fema.gov/portal/resources/hazus

[8] US Department of Agriculture (USDA), Farm Service Agency (FSA). (2022). Livestock Indemnity Program Fact Sheet. Retrieved from https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2022/fsa_lip_livestockimdemnityprogram_factsheet_2022.pdf

[9] U.S. Department of Agriculture. (2017). 2017 Census of Agriculture. Retrieved from https://www.nass.usda.gov/Publications/AgCensus/2017/index.php.

[10] US Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). (2020). Published crop-specific data layer [online dataset]. Retrieved from https://nassgeodata.gmu.edu/CropScape/

6. Separation for Urban and Non-Urban Counties for HLR Estimation

The Bayesian credibility used to generate HLRs for most hazard types blends a combination of county, surrounding area, regional, and national loss ratios to balance regional variation and reduce statistical noise. However, problems can arise when blending loss ratios across communities with vastly different exposures. For instance, a credible regional/surrounding area average loss ratio could be driven by small outlier loss events in rural areas with low exposure. These outlier events can then increase the HLR of a neighboring extremely urban area with very high exposure leading to significant overestimation of EAL.

In v.1.19.0, this concern was addressed by separating all counties in the Bayesian credibility process for select hazard types into two groups: (1) large central metropolitan areas (LCMAs), as defined by the National Center for Health Statistics' (NCHS) *2013 NCHS Urban-Rural Classification Scheme for Counties,*[11] and (2) all other counties (non-LCMAs). This means that loss ratios from non-LCMAs cannot influence the HLR estimates of LCMAs and vice versa. This approach is applied to building and population HLRs for the following hazard types: Cold Wave, Hail, Heat Wave, Ice Storm, Lightning, Riverine Flooding, Strong Wind, Wildfire (population only), and Winter Weather.

7. Regression Model for Hurricane HLRs

In v.1.19.0, the previous Bayesian credibility approach to estimate HLRs for Hurricanes was replaced with a regression model to significantly smooth HLR estimations from previous releases. The model regresses county-level factors on county-level average loss ratios, and fitted values are assigned to each county for which a Hurricane is deemed possible. Specifically, county-level average loss ratios and event counts are computed and used as inputs into a frequency- weighted Generalized Linear Model with a logit link function. The model generates HLR estimates for each county, conditional on (1) their distance from the Gulf/Atlantic coast, (2) their NCHS Urban-Rural Classification, and (3) the Hurricane HLR region in which they reside.

8. Change of Social Vulnerability Source Data

In v.1.19.0, the Risk Index transitioned away from using the Social Vulnerability Index (SoVI) from the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) to represent the SV component. In this version, the Risk Index began using the Centers for Disease Control (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI).

SVI is a community-specific assessment of social vulnerability that utilizes 16 socioeconomic variables deemed to contribute to a community's reduced ability to prepare for, respond to, and recover from hazards.[12] This change has a major impact on the National Risk Index profile as the methodology and data differ significantly from the previous data source.

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[11] National Center for Health Statistics. (2013). 2013 NCHS Urban-Rural Classification Scheme for Counties. Retrieved from https://www.cdc.gov/nchs/data/series/sr_02/sr02_166.pdf

[12] Flanagan, B.E., Gregory, E.W., Hallisey, E.J., Heitgerd, J.L., & Lewis, B. (2011). A Social Vulnerability Index for Disaster Management. Journal of Homeland Security and Emergency Management, 8(1).Retrieved from https://doi.org/10.2202/1547-7355.1792

9. Updated Community Resilience Data

The University of South Carolina's Hazards and Vulnerability Research Institute (HVRI) Baseline Resilience Indicators for Communities (BRIC) index is used to represent the CR component of the National Risk Index. For v.1.19.0, the index was refreshed with 2020 data. The previous version was based on 2015 data.

10. Updated Risk Calculation, Values, Scores, and Ratings

The basic risk equation was updated in v.1.19.0 while maintaining the three basic components of: (1) EAL (natural hazards risk component), (2) Social Vulnerability (consequence enhancing component), and (3) Community Resilience (consequence reduction component). Equation 1 provides the generalized risk equation used in v.1.18.1 while Equation 2 provides the updated risk equation for v.1.19.0.

Equation 1: v.1.18.1 National Risk Index Risk Equation

$$Risk\ Score = EAL\ Score \times Social\ Vulnerability\ Score \times \frac{1}{Community\ Resilience\ Score}$$

Equation 2: v.1.19.0 National Risk Index Risk Equation

$$Risk\ Value = EAL\ Value \times Community\ Risk\ Factor$$

$$where\ Community\ Risk\ Factor = f\left(\frac{Social\ Vulnerability\ Value}{Community\ Resilience\ Value}\right)$$

$$where\quad f(\cdot) \rightarrow \tau(a = 0.5, b = 2, c = 1)$$

Where:

$\tau(\cdot)$ is a triangular distribution with minimum 0.5, maximum 2, and mode 1.

The Risk Index values form a more absolute basis for measuring risk within the National Risk Index. They are used to generate all Risk Index scores, values, and ratings. As described in Equation 1 above, Risk Index values are determined by multiplying EAL values by the new Community Risk Factor (CRF), which is a scaling factor unique to each Census tract, that varies as a function of the community's Social Vulnerability and Community Resilience values. All Risk Index values are calculated at the Census tract level, with county level values being determined by the sum of values from their tracts.

The function, $f(\cdot)$ is a transformation that maps the ratio between Social Vulnerability and Community Resilience to CRF values. This mapping is constructed so that higher social vulnerability and lower community resilience, relative to all other communities at the same level (county or Census tract), result in higher Risk Index values for a given level of EAL.

The National Risk Index provides three different types of results for risk and each component used to derive risk: EAL, Social Vulnerability, and Community Resilience. The following introduces the result types and discusses the changes from previous versions.

VALUES

Values for Risk and EAL are in units of dollars, representing the community's average economic loss from natural hazards each year. For Social Vulnerability and Community Resilience, values are the index values for the community provided by the source data sets. In previous versions, risk values were not available in the National Risk Index. They have been added in v.1.19.0.

SCORES

Scores in v.1.19.0 represent the national percentile ranking of the community's component value compared to all other communities at the same level (county or Census tract). To achieve this range, scores for each component are determined by the given value's percentile ranking in the national distribution (rounded to the nearest hundredth). In previous versions, scores were unitless index scores ranging from 0 to 100 that depicted a community's score relative to all other communities at the same level. Scores in the previous version were relative scores, not national percentiles.

RATINGS

Ratings are provided in one of five qualitative categories describing the community's component value in comparison to all other communities at the same level. Rating categories range from "Very Low" to "Very High." In previous versions, a machine learning technique known as k-means clustering or natural breaks was applied to scores for each component. For v.1.19.0, k-means is still used for risk and EAL, but Social Vulnerability and Community Resilience are divided into quintiles (e.g., Very Low represents 0^{th} to 20^{th} percentiles).