# Risk Assessment of Tornado-induced Property Damages in the United States

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# Objectives

For the reported tornado data in National Oceanic and Atmospheric Administration, we study:

1. Classification of tornado events taking property losses into account
2. Dependence between tornado variables
3. Prediction of the future property losses.

**Tornado Variables:**

- Path Length (in feet)
- Path Width (in feet)
- Property losses (in $ 2019)
- Enhanced Fujita scale $(0, 5)$ (measure of intensity)


Figure: Path of a tornado

# Tornado Property Loss Scale

We classify tornado events, $V_{n\times 3} = [\log(Length),\ \log(Width),\ \log(Loss)]$ using Non-negative Matrix Factorization (NMF):

$$V_{n\times 3} \approx W_{n\times r} H_{r\times 3}, \qquad W_{n\times r}, H_{r\times 3} \geq 0,\ r = 2. \tag{1}$$

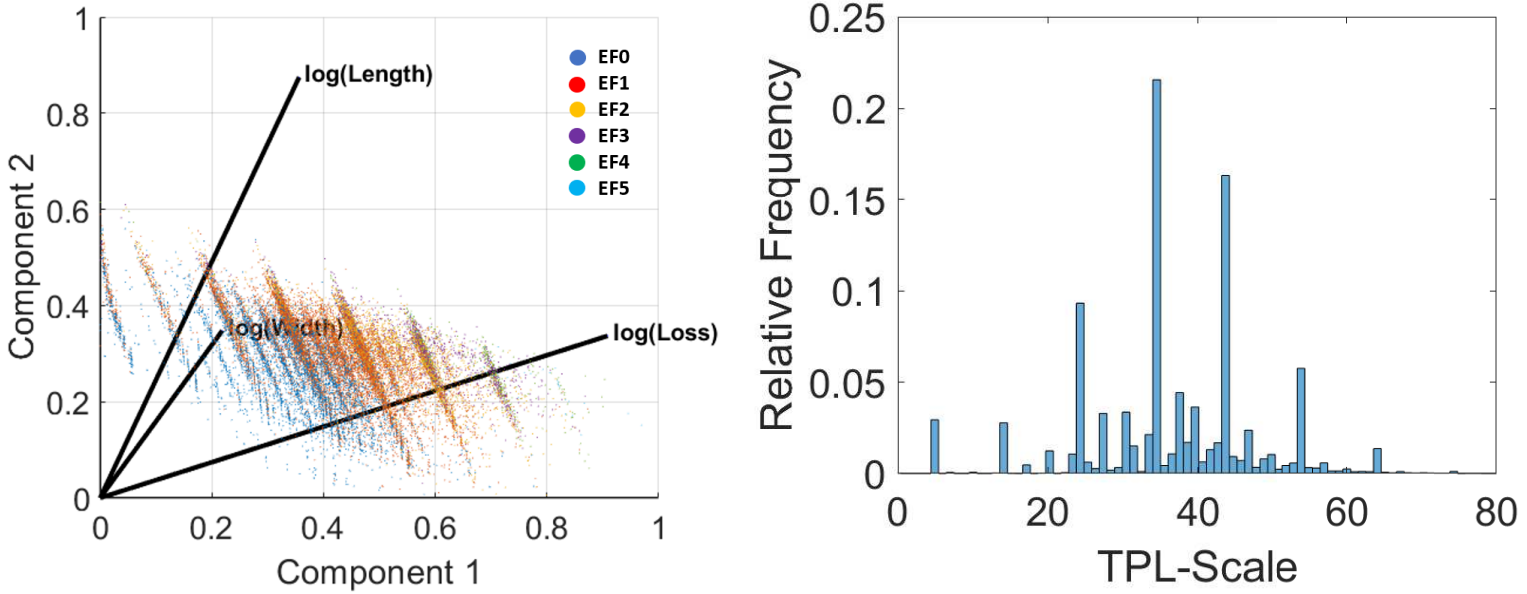


Figure: Visual representation of the NMF results (left), and Tornado Property Loss Scale: TPL-Scale $= 10\log_{10}\left(\frac{Loss}{10}\right)$ dB

# Dynamics of Tornado Variables

We examine a bivariate Gaussian copula with Gamma marginals to investigate the dependence structure of ln(*Area*) and ln(*Loss*). For all reported tornadoes, the copula (/dependence) parameter is 0.5356.

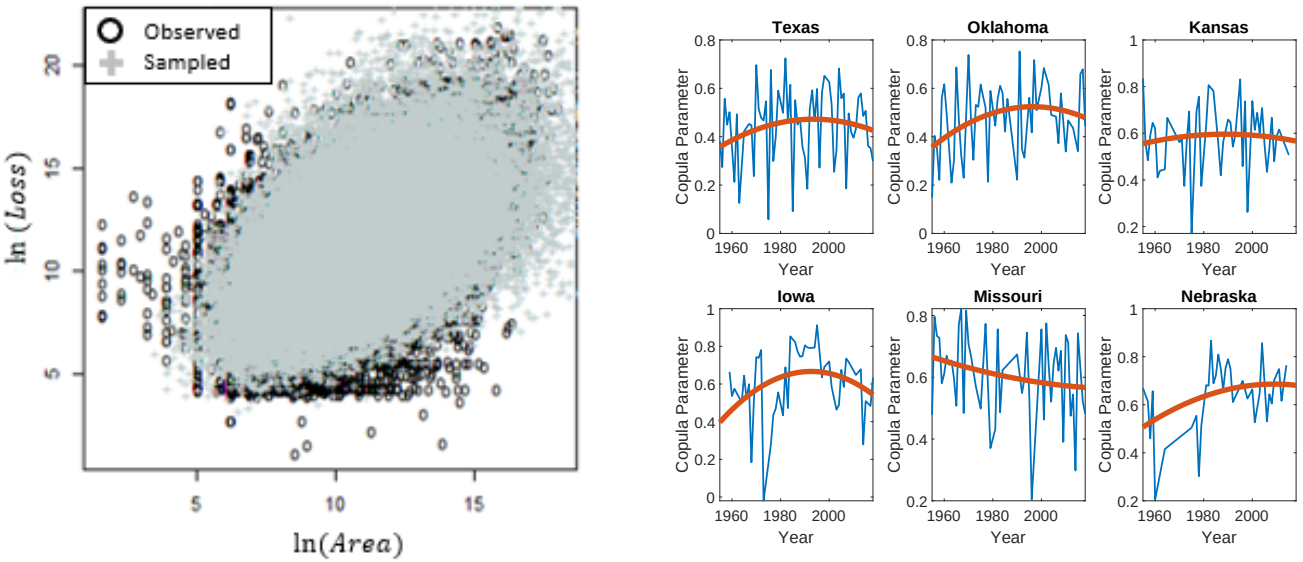


Figure: (a) A comparison of sampled and observed data (b) Gaussian copula parameters for annual tornado data in Tornado Alley states

The dynamics of Gaussian copula parameter is highly unstable, no general trends were observed.

# Predicting Property Losses

We apply a long short-term memory neural network composed of an input layer, a hidden layer of 500 units, and an output layer to predict future property losses during 2020-2025.

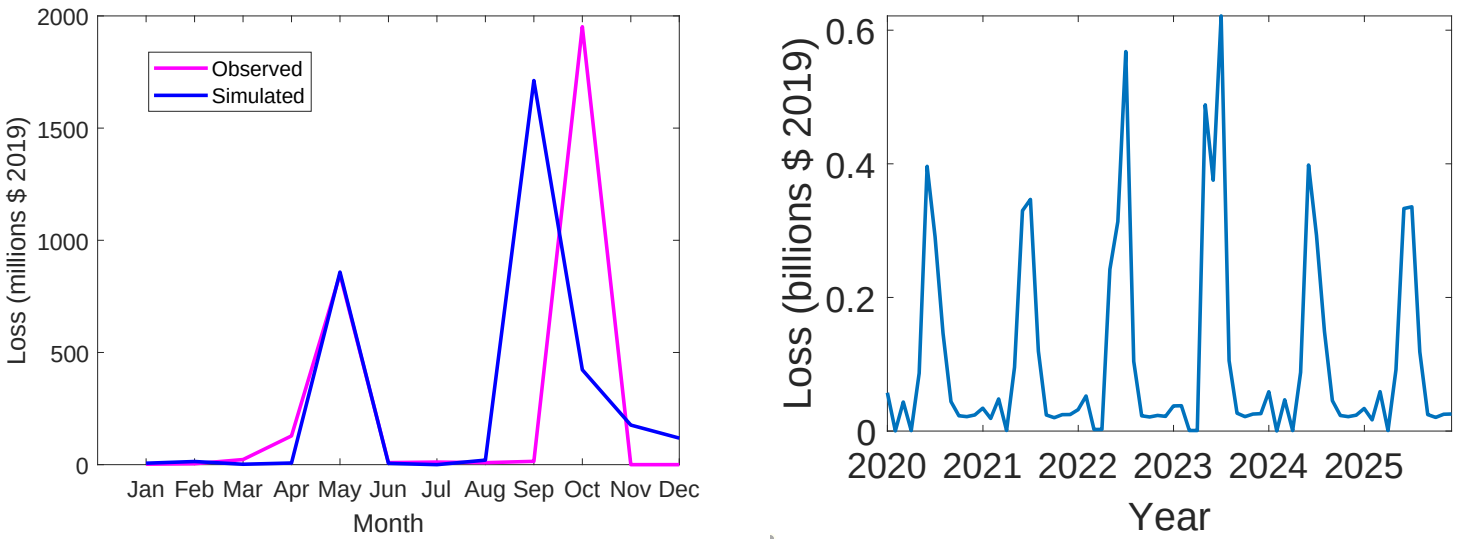


Figure: The predictions of monthly losses (a) in 2019 and (b) during 2020-2025

The higher losses could be reported from March to June (tornado season). The volume of property losses could amount up to 8 billion dollars in 2025.