3B.1 POTENTIAL INSURANCE LOSSES FROM A MAJOR TORNADO OUTBREAK: THE 1974 SUPER OUTBREAK EXAMPLE

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1. Introduction

Insurance companies in the United States are exposed to many different natural hazards, such as earthquakes, hurricanes, floods, severe thunderstorms, Nor'easters/ice storms, and wildfires. Probabilistic models based on scientific, engineering, and actuarial research (e.g., Risk Management Solutions 2003) are often used by the insurance industry to gain perspective on the potential for future catastrophic losses, including severe thunderstorms. Severe thunderstorm catastrophe models are of growing use by insurance companies in applications such as asset allocation, annual budgeting, setting loss reserves, underwriting, and determining the contribution of the wind and hail hazards to fire policy premiums. Regional insurers focused on property in the Central Plains and Midwest also use such tools to cede that risk to other parties through reinsurance.

Insurance and reinsurance companies often use deterministic analysis to gain further insight into a company's probable maximum loss (PML) and to benchmark their potential loss against the industry. The Super Outbreak of tornadoes that occurred on 3-4 April 1974 (Figure 4) is a key benchmark for this form of scenario analysis. In total, this event produced 148 tornadoes spanning 13 states and producing about 900 square miles of tornado damage in less than 18 hours. Dating back to the late 1800s, no other single-day event has surpassed the Super Outbreak in terms of the number of tornadoes or the area they affected. The Super Outbreak is often viewed as one of the worst severe thunderstorm events that could impact the insurance industry. With the substantial economic growth that has taken place in the last 30 years, there is increasing interest to assess the impacts of this scale event on today's building stock. This report examines the property losses possible if this outbreak was to reoccur today.

A scenario model is built up from three key components: 1) a detailed mapping of the hazard footprint of the catastrophic event, 2) an assessment of the property at risk in the area affected by the event, and 3) an engineering model to relate the hazard severity to expected property damages. These aspects are presented in turn in sections 2-4. Some of the additional considerations regarding the potential insurance loss for a similar outbreak are discussed in section 5.

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2. Hazard Reconstruction

Following the Super Outbreak, the most extensive aerial tornado survey ever conducted was initiated by Dr. Ted Fujita and his colleagues. The aerial survey was complemented by the collection of vast amounts of engineering data on the performance of individual structures subject to wind and debris loads. It took Fujita's team nearly 10 months to confirm the characteristics of each of the tornadoes in the outbreak. This information was summarized in a highly detailed color map published by the University of Chicago, which included the shape of each damage path and the peak F-rating assigned by Fujita's team at regular intervals along each path. The tornado and downburst hazard has been reconstructed for this research from this original map of the outbreak.

Fujita's color map was digitized and each of the 148 tornado paths and downburst areas were georeferenced. Comparisons of the area affected by the tornadoes against those listed by Fujita (1975) indicated that the scale of tornado paths was increased in the map's original production to improve visibility. These adjustments appear to have been non-linear (Figure 1), with modification factors for tornado widths ranging from 1/10 to 1/100 for mean path widths of less than 0.1 mi and 1/2 to 1/7 for lengths less than 3 mi (length graph not shown). These relationships were used to reduce the scale of digitized tornado lengths and widths to yield the correct scale of each tornado (validated against Abbey and Fujita 1975), while preserving the irregular shape of each path as represented in Fujita's original color map.

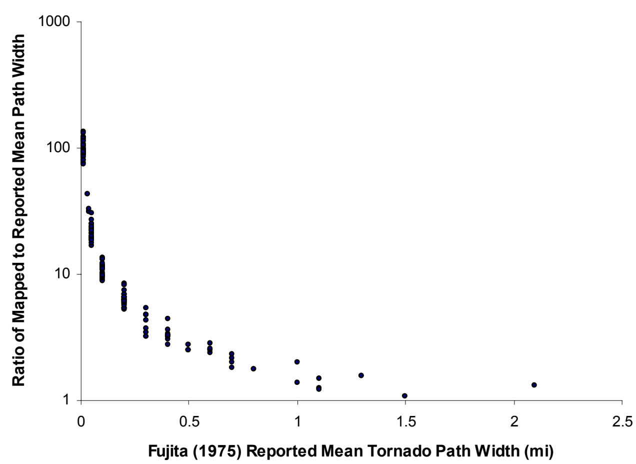

Figure 1: Calibration factor used to reduce the width of each tornado path digitized from Fujita's original color map.

Each tornado path was divided into segments at the approximate location of each F-rating label next to the path on Fujita's original color map (Figure 2).

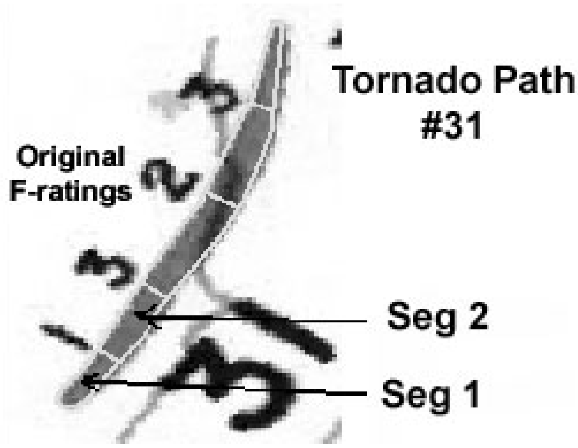

Figure 2: Example of the boundary of path #31 in Fujita's color map and the derived tornado segments.

The intensity distribution across each tornado path segment was determined using the empirical relationship

$$W_F = W_0 * 2.4^{-F}, \qquad (1)$$

which is based on the area/intensity relationships established by Fujita and his collaborators as a result of their extensive aerial survey after the 1974 Super Outbreak (Fujita 1978). An example of this calculation is provided in Table 1.

TABLE 1: INTENSITY WITHIN SEG 2 OF TORNADO 31

	SubSeg1	SubSeg2	Subseg 3	Total by F Area
Area F3	0.0%	0.0%	1.8%	1.8%
Area F2	0.0%	8.7%	2.5%	11.2%
Area F1	10.4%	12.2%	6.1%	28.6%
Area F0	14.6%	29.2%	14.6%	58.3%
Total by Seg	25.0%	50.0%	25.0%	

For simplicity, it was assumed that each tornado follows this mean relationship between the total path width and the width of each constituent intensity band.

3. PROPERTY EXPOSURE MODEL

The property exposure model used in this study is derived from a proprietary database of ZIP-code level estimates of values for insured buildings, contents, and time elements (i.e., business interruption and adjusted living expense) developed by Risk Management Solutions, Inc. This property database was disaggregated to a uniform grid of 300 m resolution using the method described by Beatty (2001).

4. INSURANCE LOSS ESTIMATE

In order to estimate property damages, each Fujita rating was related to a percent of property loss using an engineering model developed by Risk Management Solutions, Inc. This model describes the percent of damage expected to structures, their contents, and their resulting loss of use for 26 different classes of buildings and automobiles (varying by building material, occupancy, height, and year built). The model is similar to the data being elicited from experts as part of the Fujita Scale Enhancement Project (McDonald 2001), with additional calibration using actual insurance claims for recent tornado events. The calibration of a property vulnerability model with actual insurance data is essential, since F2 level damage to a wood frame residential home is essentially a total loss for an insurance company.

RMS' loss model suggests that a repeat of the 1974 Super Outbreak today would cause a record level of economic and insurance losses. The insurance losses from wind alone (tornadoes and downbursts) would exceed \$3.5 billion, surpassing the \$3.13 billion in insurance loss (PCS July 28, 2003) reported for the May 2-11, 2003 sequence of tornadoes that impacted 18 states. Approximately 2/3 of this loss would be to single family residential property, with commercial and industrial properties being the second largest contributor. Kentucky would incur 28% of the total loss, with 26% and 21% coming from Indiana and Ohio, respectively. Cumulative losses by latitude and longitude, shown in Figure 3, illustrate the breadth of the losses in this event. The outbreak was produced by three squall lines, oriented primarily in the north-south direction. Therefore, most of the insurance loss would occur over a ~100 mi wide corridor from Mississippi/Georgia to Indiana/Ohio.

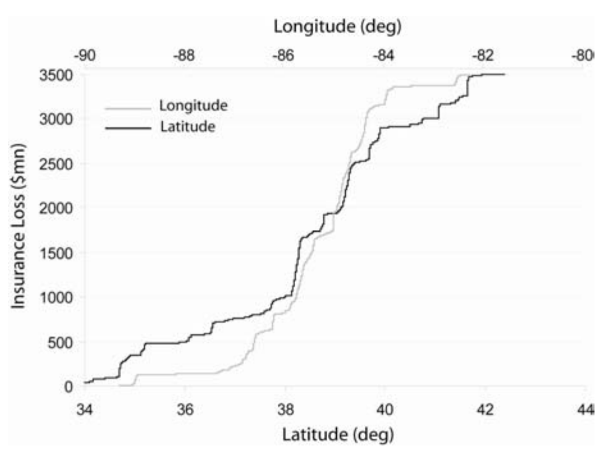

Figure 3: Cumulative distribution of modeled insurance loss by longitude and latitude.

Brooks and Doswell (2001) used trends in national wealth indices to adjust historic tornado damages to year 2000 levels of wealth. The modeled losses from those individual tornadoes studies by Brooks and Doswell were investigated and are provided in Table 2. In general, our analysis produces higher losses for these tornadoes than are suggested by adjustments using wealth statistics. The driver of this difference is not clear, but it is possible that local communities have experienced growth that has differed from the national average and that the intensity of individual tornadoes that affected these communities likely varied from the average values given by equation 1.

TABLE 2: COMPARISON OF TORNADO LOSS ESTIMATES

Tornado	Grazulis Damage (mn)	Nat'l Wealth Adj Damage (mn)	Insurance Loss Est. (mn)
Xenia, OH	$100	$326	$200
Monticello, IN	$50	$163	$287
Madison, IN	$35	$114	$216
Guin, AL (1)	$30	$98	$14
Northern AL	$17	$55	$26
Brandenburg, KY	$15	$49	$28
Guin, AL (2)	$15	$49	$147
Total	**$262**	**$528**	**$919**

5. DISCUSSION

The reinsurance industry generally considers a storm event to include the cumulative losses within a 72 hour period. Therefore, losses on the days prior to and following the Super Outbreak would also be considered part of the same "event", increasing the amount of loss that an individual insurance company could recover through their reinsurance. Also, additional losses would be incurred from hail damage, which have not been considered in this paper. Several $1 billion hail events have occurred in the past decade, which have demonstrated that this hazard is a non-negligible source of catastrophic insurance loss. The total losses from the recurrence of this outbreak, therefore, are more appropriately estimated at around $5 billion.

In many outbreaks, such as the 3 May 1999 tornadoes in Oklahoma, a single tornado that impacts a major urban area can account for >50% of the event's total insurance loss. In a recurrence of the Super Outbreak, tornado and downburst losses would be distributed over a large area, with over $500 million in insurance loss occurring separately in Ohio, Indiana, and Kentucky. Although this loss magnitude is substantial, it was fortunate that no major urban areas were severely impacted. It is conceivable that total insurance losses (wind and hail) could be substantially higher (e.g., in the $6-8 billion range) if one or more urban areas were directly impacted. This would place such an event in a loss range similar to a moderate U.S. hurricane catastrophe (e.g., Hurricane Charley in Florida in 2004).

6. ACKNOWLEDGEMENTS

I would like to thank Dr. Mohan Sharma for his review of this paper as well as other colleagues at RMS for their assistance in data processing and analysis.

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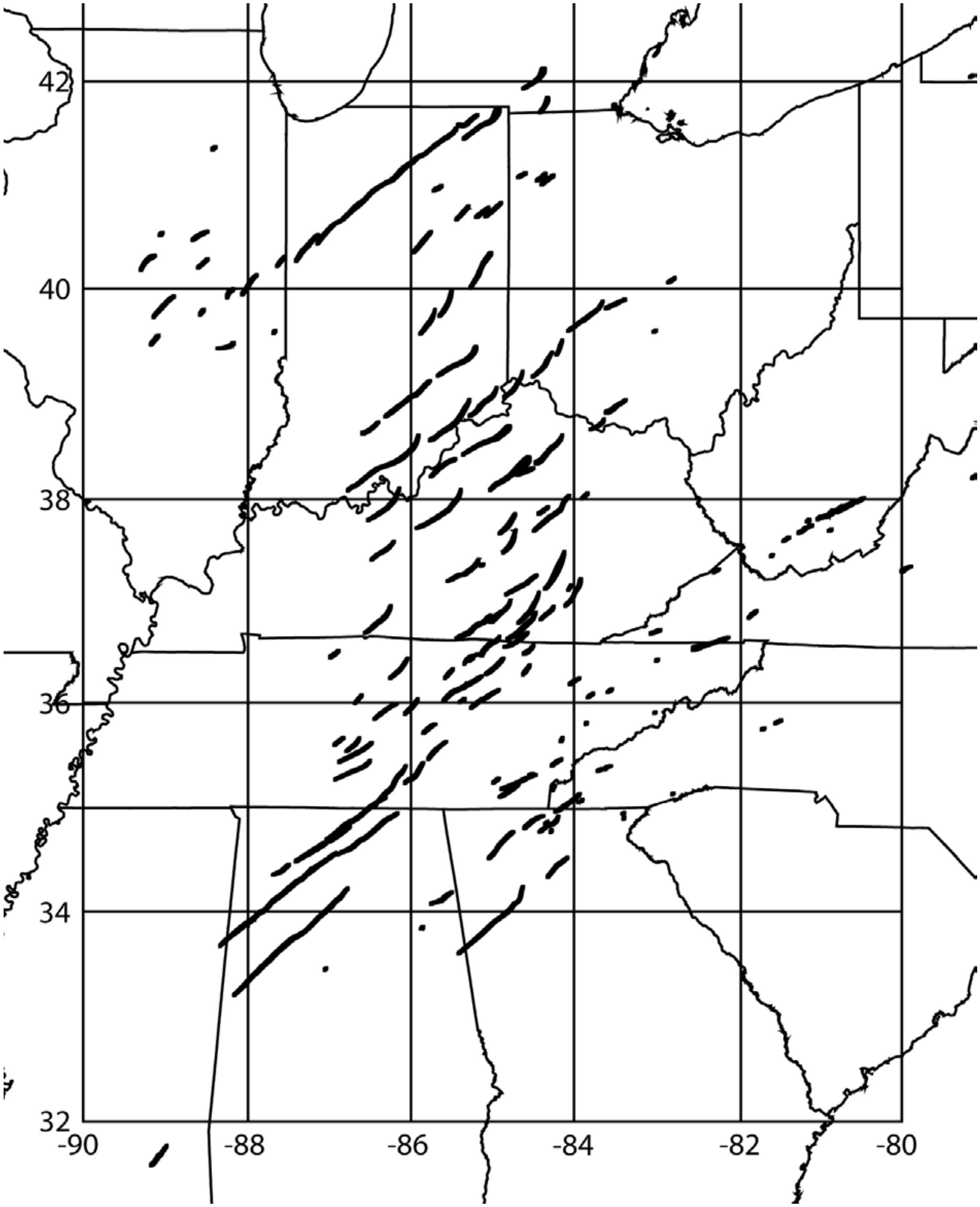

Figure 4: Map of the 1974 Tornado Super Outbreak