Predicting Disaster Declaration

Machine Learning & Predictive Analytics In Action

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What Bothered Us...

Thirty years of historical data shows that:

- On an average, it takes 20 days from the date a natural disaster occurs, to declare a ‘Presidential Disaster’
- Weather related disasters are by far the most common disaster type
- Severe and high-frequency weather alert activities correlate well with disaster activities

Bottom-line

- The sooner a disaster is declared, faster are the relief efforts to minimize losses and restore normalcy
Yes, future outcomes can be predicted

One of these bright ladies is a core developer of the Predictive Tool we’re going to discuss here

In Association with:
Big Data Analytics – What’s Big About It?

• A few years ago a business would have gathered information, run analytics and unearthed information that could be used for future decisions...
• Today that business can identify insights for immediate decisions.
• The ability to work faster – and stay agile – gives agencies/organizations a competitive edge they didn’t have before.
Machine Learning – Key Points

• Computers apply statistical learning ("normal distribution," "t-distribution," and "least squares regression") techniques to automatically identify patterns in data.

• These techniques can be used to make highly accurate predictions.

• Identifying boundaries in data using math is the essence of statistical learning.

• More data points we have, better the predictive model can be.
Delays in Disaster Relief

FEMA Disasters as of Jan 1 2018 – June 1, 2018

<table>
<thead>
<tr>
<th>FEMA Disaster #</th>
<th>Incident date</th>
<th>Declaration date</th>
<th>IA</th>
<th>PA</th>
<th>Lag time</th>
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<tbody>
<tr>
<td>DR-4370</td>
<td>2-Mar</td>
<td>8-Jun</td>
<td>No</td>
<td>No</td>
<td>98</td>
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<tr>
<td>DR-4371</td>
<td>13-Mar</td>
<td>8-Jun</td>
<td>No</td>
<td>No</td>
<td>87</td>
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<td>DR-4368</td>
<td>6-Mar</td>
<td>8-Jun</td>
<td>No</td>
<td>No</td>
<td>94</td>
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<td>DR-4367</td>
<td>2-Mar</td>
<td>30-May</td>
<td>No</td>
<td>No</td>
<td>89</td>
</tr>
<tr>
<td>DR-4364</td>
<td>15-Apr</td>
<td>8-May</td>
<td>Yes</td>
<td>No</td>
<td>23</td>
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<tr>
<td>DR-4363</td>
<td>14-Feb</td>
<td>4-May</td>
<td>Yes</td>
<td>No</td>
<td>79</td>
</tr>
<tr>
<td>DR-4362</td>
<td>19-Mar</td>
<td>26-Apr</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>DR-4361</td>
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<td>26-Apr</td>
<td>No</td>
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<tr>
<td>DR-4359</td>
<td>14-Feb</td>
<td>17-Apr</td>
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<td>17-Apr</td>
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<td>Dr-4358</td>
<td>9-Feb</td>
<td>12-Apr</td>
<td>No</td>
<td>No</td>
<td>62</td>
</tr>
</tbody>
</table>

June 15, 2018 – Ellicott City, MD, awaiting for Disaster Declaration. Actual flooding happened on May 26th.
Increase in Vulnerability

It’s more important now to be prepared for a disaster:

- Climate change – Record breaking weather phenomena occurs too frequently.

- Topography change – Increased urbanization (a.k.a concretization) causes changes or hinders water runoff patterns and absorption.

- Increasing population – the stakes are higher now.

- BTW: Flood is still the number one peril in the USA.
How Data Analytics Can Help

1. Significant amount of alert data comes in from multiple sources related to natural disasters (over 50,000 per month from NOAA/NWS) affecting the entire country.

2. A customized watch-area can be established by specifying the geographic location, alert type, severity and certainty. This pin-points the area to focus on, as the weather event unfolds.

3. NOAA’s incoming weather alerts (every 4 hrs.), can be analyzed and applied to a predictive modeling technique to indicate the probability of a disaster declaration and quantify the impacts of the disaster.

4. Near real time generation of disaster probabilities can reduce the lag time between the actual weather event and disaster declaration.
Step #1 – Input Data

• FEMA’s List of Declared Disasters (1986-present):
  o Contains event begin and end dates, declaration date, County FIPS6, program declared, disaster type, etc.
  o Declared on county/parish level
  o Each disaster is uniquely defined by ID and county FIPS6
  o Public Assistance (PA) and Individual Assistance (IA) program impacts

• NOAA’s Weather Alerts (1986-present):
  o Contains alert begin and end dates, alert type, alert level (warning, watch, advisory, outlook, statement), County FIPS6
  o Declared on county/parish level

• Census, Social Vulnerability Index, Geographic Vulnerability Index, Hazus decile ratings
Step #2: Identifying the right Impact Vectors
Our predictive model takes into account these impact vectors:

- **Dominant Alert** – The incoming raw data feed contains multiple alerts of different event types, resulting from a single weather phenomenon. Our algorithms eliminate white noise and establish dominant alerts at a given time and place.

- **Population and urbanization levels at zip code levels**, to evaluate the possible impact of a disaster.

- **Hazus Decile ratings** – Areas with high ratings have higher probability of disasters.

- **Social Vulnerability Index (SoVi)** – Areas with high SoVi ratings have higher probability of disasters.
1. **Real time raw weather data NOAA/NWS collected every 4 hours:**
   - NOAA weather alerts provide near-real time inputs on the weather as it happens.
   - We use this rich and reliable information as an important vector to predict a disaster map.

2. **Alerts processing:**
   - Raw data from NOAA weather alerts contains duplicates, blanks and expired alerts.
   - The ‘Data Clean up’ process removes duplicates, fixes missing data and tags the expired alerts.

3. **Establishing Alert Dominance:**
   - Our algorithm ranks the incoming alerts based on the severity, past occurrences and urgency to establish the most dominant alerts.

4. **Active Weather Alerts:**
   - The resulting data set, is a clean aggregated view of severe weather events happening in real time.
   - This data set can be refreshed right after NOAA releases the next set of alerts, roughly after 4 hours.
## Alert Viewer - Active NOAA Alerts

### States with Active Alerts (updated as of 9/5/2017)

![Map showing active alerts across states](image_url)

### Key Statistics

<table>
<thead>
<tr>
<th>Event Type</th>
<th>AK</th>
<th>AR</th>
<th>CA</th>
<th>FL</th>
<th>HI</th>
<th>ID</th>
<th>IN</th>
<th>KY</th>
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<tbody>
<tr>
<td>High Wind Watch</td>
<td>14</td>
<td>18</td>
<td></td>
<td>23</td>
<td>12</td>
<td></td>
<td>38</td>
<td>12</td>
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<tr>
<td>Special Weather Statement</td>
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<td>40</td>
<td></td>
<td>59</td>
<td>28</td>
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<td>50</td>
<td>38</td>
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<tr>
<td>Flood Warning</td>
<td></td>
<td></td>
<td>18</td>
<td></td>
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<td></td>
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<tr>
<td>Air Quality Alert</td>
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<td></td>
<td></td>
<td></td>
<td>310</td>
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<td></td>
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<tr>
<td>Dense Smoke Advisory</td>
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<tr>
<td>Flood Warning</td>
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<td>Air Quality Alert</td>
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<td></td>
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<tr>
<td>Red Flag Warning</td>
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<td></td>
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<tr>
<td>Beach Hazards Statement</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Special Weather Statement</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Effective from:

<table>
<thead>
<tr>
<th>State</th>
<th>Date and Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK</td>
<td>09/04/2017 22:49:00</td>
</tr>
<tr>
<td>AR</td>
<td>09/04/2017 19:49:00</td>
</tr>
<tr>
<td>CA</td>
<td>09/04/2017 20:43:00</td>
</tr>
<tr>
<td>FL</td>
<td>09/04/2017 22:00:00</td>
</tr>
<tr>
<td>HI</td>
<td>09/04/2017 15:28:00</td>
</tr>
<tr>
<td>ID</td>
<td>09/04/2017 14:14:00</td>
</tr>
<tr>
<td>IN</td>
<td>09/05/2017 04:41:00</td>
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<tr>
<td>KY</td>
<td>09/05/2017 04:34:00</td>
</tr>
<tr>
<td>LA</td>
<td>09/04/2017 21:49:00</td>
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<tr>
<td>MD</td>
<td>09/04/2017 20:07:00</td>
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<td>MI</td>
<td>09/05/2017 04:11:00</td>
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<tr>
<td>MT</td>
<td>09/04/2017 09:00:00</td>
</tr>
<tr>
<td>NY</td>
<td>09/04/2017 02:45:00</td>
</tr>
</tbody>
</table>

### Severity

- Severe
- Moderate
- Minor
- Unknown
Alert Viewer – Filter Criteria

Select Event:
- (All)
- Air Quality Alert
- Beach Hazards Statement
- Coastal Flood Advisory
- Dense Smoke Advisory
- Extreme Fire Danger
- Fire Weather Watch
- Flood Warning
- Heat Advisory
- High Wind Watch
- Hurricane Warning
- Red Flag Warning
- Rip Current Statement
- Special Weather Statement
- Wind Advisory

Select Urgency:
- (All)
- Expected
- Future
- Unknown

Select Certainty:
- (All)
- Likely
- Observed
- Possible
- Unknown

13
Alert Viewer – Alerts by Event Types

### Key Statistics

<table>
<thead>
<tr>
<th>County</th>
<th>Event Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calhoun County</td>
<td>Flood Warning</td>
<td>6</td>
</tr>
<tr>
<td>Chambers County</td>
<td>Flood Warning</td>
<td>10</td>
</tr>
<tr>
<td>Colorado County</td>
<td>Flood Warning</td>
<td>2</td>
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<tr>
<td>DeWitt County</td>
<td>Flood Warning</td>
<td>2</td>
</tr>
<tr>
<td>Fort Bend County</td>
<td>Flood Warning</td>
<td>26</td>
</tr>
<tr>
<td>Galveston County</td>
<td>Air Quality Alert</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Flood Warning</td>
<td>1</td>
</tr>
<tr>
<td>Goliad County</td>
<td>Flood Warning</td>
<td>1</td>
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<tr>
<td>Grimes County</td>
<td>Flood Warning</td>
<td>2</td>
</tr>
<tr>
<td>Hardin County</td>
<td>Flood Warning</td>
<td>11</td>
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<tr>
<td>Harris County</td>
<td>Flood Warning</td>
<td>128</td>
</tr>
<tr>
<td>Jackson County</td>
<td>Flood Warning</td>
<td>1</td>
</tr>
<tr>
<td>Jasper County</td>
<td>Flood Warning</td>
<td>7</td>
</tr>
</tbody>
</table>
4. Visualizations:

**Active Alerts:** The resulting active weather alerts dataset is visualized in an intuitive Tableau dashboard that displays all currently active alerts on a map. It offers a drill down view of the impacted counties, for the specific weather event selected. Users can set location preferences, weather event preferences and watchlist of high severity alerts.

**Predicted Disaster Map:** For all locations in the active alerts dataset, ‘probability of disaster’ is generated by our proprietary predictive analytics model. The predicted disaster map shows counties and their corresponding probability of being declared as IA, PA or NFIP disasters as influenced by the current weather conditions. Based on the magnitude of current probability, population impacted and volume of past payouts, an estimated payout amount is generated.
The Analytics core: Establishing the Disaster-Alert Correlation

Utilizing powerful R functions, we aggregated the ingested data and discovered correlations between weather alerts and disaster declarations.

- 100% of unique disaster IDs were matched with at least one alert.

- 85% of unique disaster IDs on county level were matched with at least one alert.
• When current weather alerts and user specified locations are input to the model, it generates forecasts/probability of disaster declarations.
• Applying more statistical modeling techniques to past relief efforts it was possible to quantify the estimated disaster relief funding amounts.
• The predicted disaster map shows counties and their corresponding probability of being declared as IA, PA or NFIP disasters as influenced by the current weather conditions.
• Based on the magnitude of current probability, population impacted and volume of past payouts, an estimated payout amount is generated.
How It Looks – IA/PA/ NFIP Probabilities
How It Looks – IA/PA/ NFIP Probabilities

State: TX
County Name: Montgomery County
Census 2010 Population: 455,746
Main PA Prob: 83.87%
IA Shelter Need: 835
IA Valid Registrations: 4,688
NFIP Gross Paid Out: 11,920,357
NFIP Locations: 19,838
PA Federal Share Obligated: 
Date of Update: 9/5/2017
How Our Tool Works

1. **Real time raw weather data NOAA/NWS API**
   Collected every 4 hours

2. **ALERTS PROCESSING**
   - Data Clean up
   - Establish Alert Dominance
   - Append GeoIDs

3. **Active Weather Alerts**

4. **VISUALIZATIONS**
   - User defined Locations
   - Probability of Disaster Declaration Estimates for PA, IA, NFIP assistance

5. **DATA AGGREGATION**
   - Evaluate Correlations
   - Establish Impact variables
   - Trend Analysis

6. **ANALYTICS CORE**
   - Predictive Model

7. **INGESTED DATA**
   - Archived NOAA/NWS weather alerts (Univ. of Iowa)
   - Public Assistance Data (FEMA)
   - Individual Assistance Data (FEMA)
   - Housing Assistance Data (FEMA)
   - NFIP exposure, claims, and annual payouts data (FEMA-NFIP)
   - Census, Social Vulnerability Index, Geographic Vulnerability Index (USGS, Census data etc.)

8. **USER INTERFACE**
   - Set location preferences, watchlist of high severity alerts
More Value Adds: Analytics & Machine Learning

• By incorporating continuous feedback of success rate of the model, it can be fine tuned to achieve higher accuracy.

• The probability patterns can be programmed into automated machine learning scripts that indicate disaster probabilities on ingestion of weather alerts, without user intervention.

• Additional data sources and loss estimation methodologies can be integrated with the model to generate what-if scenarios in domains like agriculture, supply chain logistics, impacts on public utilities and essential services.
Next Steps

• This is still in Pilot Stage.

• Working with DHS S&T, FEMA to scale it to Production Level.

• Work with State and Local Officials to enhance the tool further.
Thank You

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