US Hurricane Death and Destruction 1900-2006

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Emanuel Cycle

Heat Gained = Work + Heat Exhausted

MPJ = \frac{T_c - T_o}{T_o}

Heat Gained

Heat Exhausted

Thus a hurricane can get stronger with a warmer ocean and a colder outflow temperature

Saffir-Simpson Scale

<table>
<thead>
<tr>
<th>Cat.</th>
<th>Winds</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>74-95 mph</td>
<td>No real damage to building structures</td>
</tr>
<tr>
<td>Two</td>
<td>96-110 mph</td>
<td>Some roofing material, doors, and window damage to buildings. Considerable damage to vegetation, mobile homes, and piers</td>
</tr>
<tr>
<td>Three</td>
<td>111-130 mph</td>
<td>Some structural damage to small residences and utility buildings with a minor amount of curtainwall failures. Mobile homes are destroyed</td>
</tr>
<tr>
<td>Four</td>
<td>131-155 mph</td>
<td>More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach. Major damage to lower floors of structures near the shore</td>
</tr>
<tr>
<td>Five</td>
<td>&gt; 155 mph</td>
<td>Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away</td>
</tr>
</tbody>
</table>

*Major hurricanes, CAT 3-5, cause 80% of US damage*
Track Forecasting

- Based upon "guidance" from numerical models
- Evaluated in terms of "vector error" distance from forecast position to actual
- Forecasts cast in terms of:
  - Watches: Hurricane-force winds expected within 36 h
  - Warnings: Hurricane-force winds expected within 24 h
- Trigger evacuation and other preparations under direction of local authorities
- Cost of warnings can be $200-400M

IMAPCTS

US Hurricane Landfalls, 1900-2006

Deaths, 1900-2006
Storm Surge

Evacuation keeps people from drowning in situations like this.

Drowning in fresh water floods accounted for 60% of hurricane related deaths 1970-2004

Inflation Adjusted Damage, 1900-2006

Normalized Hurricane Damage

- Pielke & Landsea (1998, 2008)
- Corrects for:
  - Inflation
  - Population increase
  - Greater personal wealth
- What would historical hurricanes cost with 2005 population and development?
- Constant at ~$10B per year, based upon updated 1900-2006 data

Everybody wants a view like this
The exponential trends and large dynamic range suggest a logarithmic transformation. Common logs are easier to interpret. We choose not to use decibel notation, dB(Deaths) or dB(MJ).
**Conclusions**

- Respite from impacts 1970-2003
- 2004 & 2005 are outliers
  - Mean damage increased to ~10B
  - First loss of more than 100 lives since Agnes in 1972
- Large dynamic range in D&D suggest logarithmic transformation
- Probability of > 0 impact has increased 1900-2006
  - Deaths 53% → 97%
  - Damage 33% → 99%
- Deaths decreased exponentially with halving time 27 years (18.2 in 1900-2000)
- Inflation-adjusted damage increased with doubling time 15 years (17.5 in 1900-2000)
- Damage normalized for population and individual wealth as well as inflation shows no discernable change
More Conclusions

• Years in which at least one major hurricane made landfall generally lie above the exponential trend lines and those with primarily nonmajor hurricane landfalls below.
• Stratifying by major (MJ) and nonmajor (HH) landfall seasons
  – The decrease in deaths is due to prevention of large mortality in MJ years
  – No appreciable change in HH years
  – HH property loss appeared to decrease during the 20th Century
  – Due to promotion of zero impact seasons
  – Effect saturated near the turn of the 21st Century
• Bimodal (Common) Log-Normal distributions OK
• Statistics are different for 1900-2000 and 1900-2006
• The 2004 & 2005 seasons lie on the tails of the statistical distributions
• BUT DO NOT INDICATE A TREND
• Large impact probabilities
  – Deaths > 1000 once a century
  – Damage > $1000B three times a century