

# North American Weather and Climate Extremes

Question V. What do we understand about future changes?

L. O. Mearns, NCAR

Aspen Global Change Institute  
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# Question 5 Subtopics

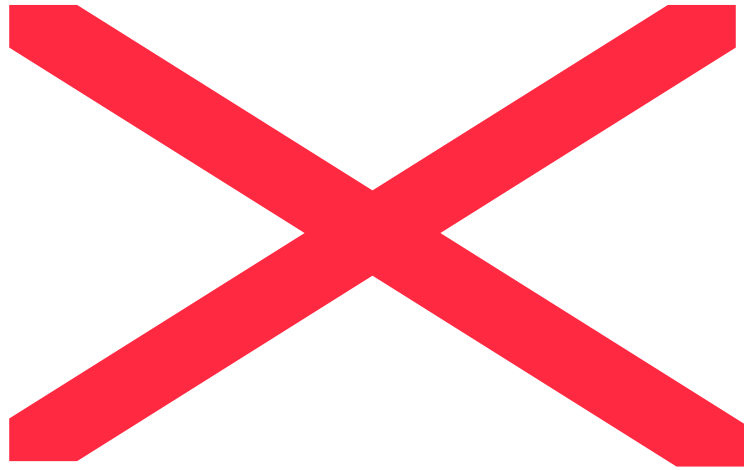
- How do models simulate observed extremes and how does this affect our confidence in extremes?
- How effective are models in answering questions for different spatial scales?
- How do model projections get tied back to aspects of socioeconomic impacts?
  - *How do we encourage further integrated research on extremes?*

# NCAR Program on Weather and Climate Impact Assessment Science

## Extreme Events

[www.assessment.ucar.edu](http://www.assessment.ucar.edu)

A Call for Help and we need it!



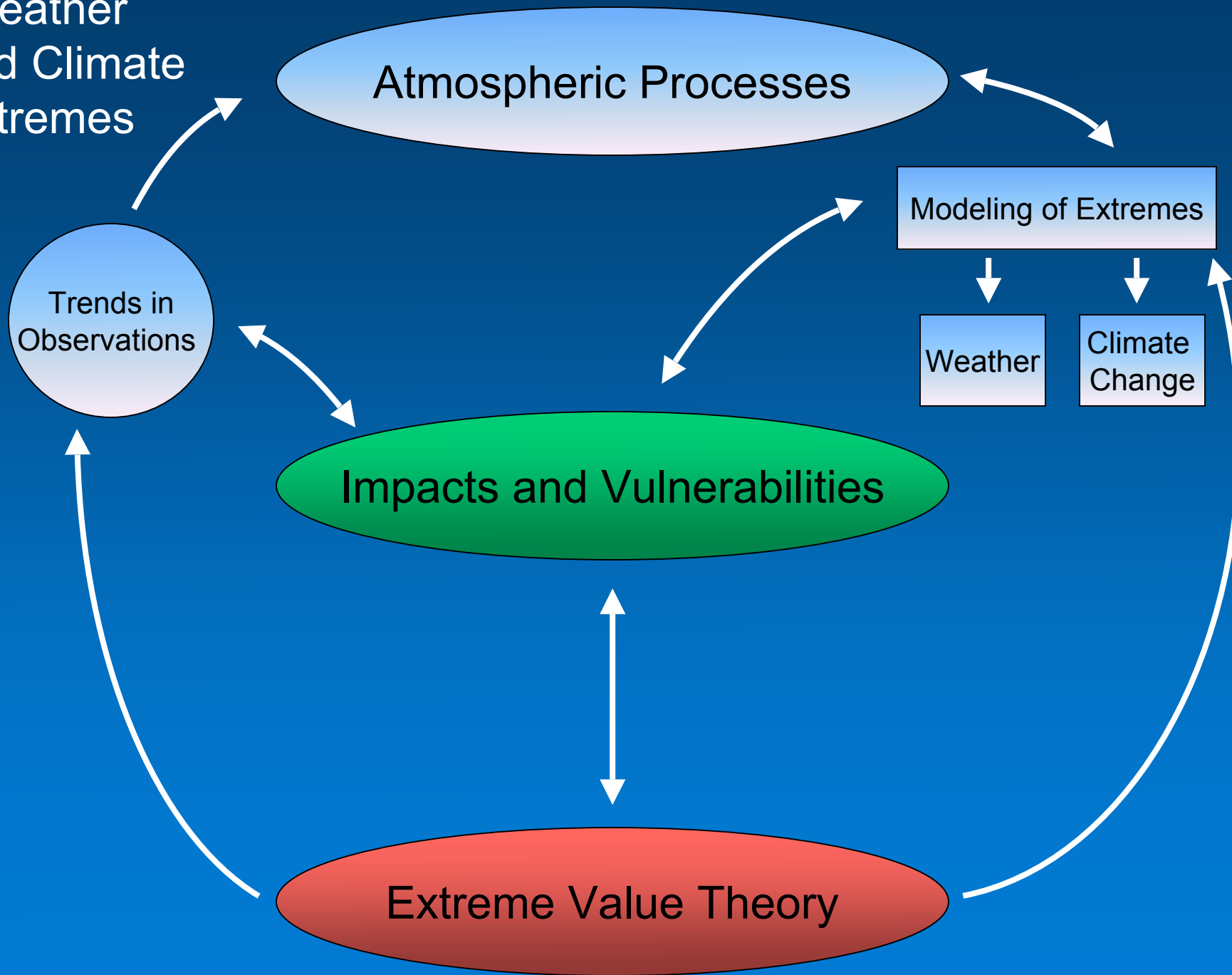
# Extreme Events

## Goal

Integrate different aspects of research in weather and climate extremes.

- Atmospheric science (processes and modeling)
- Statistical aspects of extremes
- Societal impacts and vulnerability

# Weather and Climate Extremes



# Extremes Projects

# Societal Impacts of and Vulnerability to Extremes

- Identification of extremes significant to society
- Modeling of impacts of extreme events
- Reducing societal vulnerability to extremes

Understanding vulnerability requires knowledge of the behavior and interactions of all systems involved in an extreme event.

E.g., town ↔ storm ↔ flood  
culture meteorology hydrology



# Extreme Events in Climate Models and Spatial Scaling

Detailed robust examination of the spatial scaling characteristics of extremes in observations and in climate models of different resolutions.

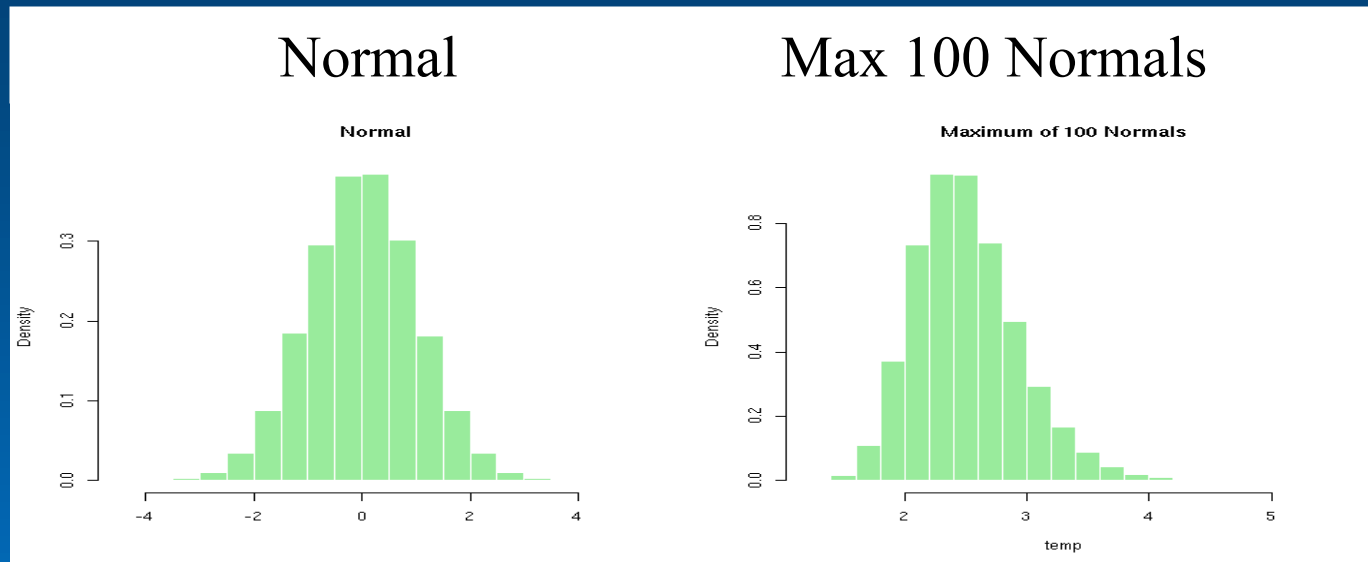
**NCAR Team:** R. Katz, J. Meehl, D. Nychka, R. Wagoner, J. Coen,  
R. Rasmussen, M. Moncrief, C. Tebaldi

**External Collaborators:** R. Smith, U. of N. Carolina, P. Naveau, U. of Colorado

# Spatial Scaling of Extremes

- How can we discuss how well climate models reproduce extremes if we don't understand how point extremes scale over space?
- Statements about how well climate models reproduce certain extremes (e.g. daily precip) should be viewed with caution

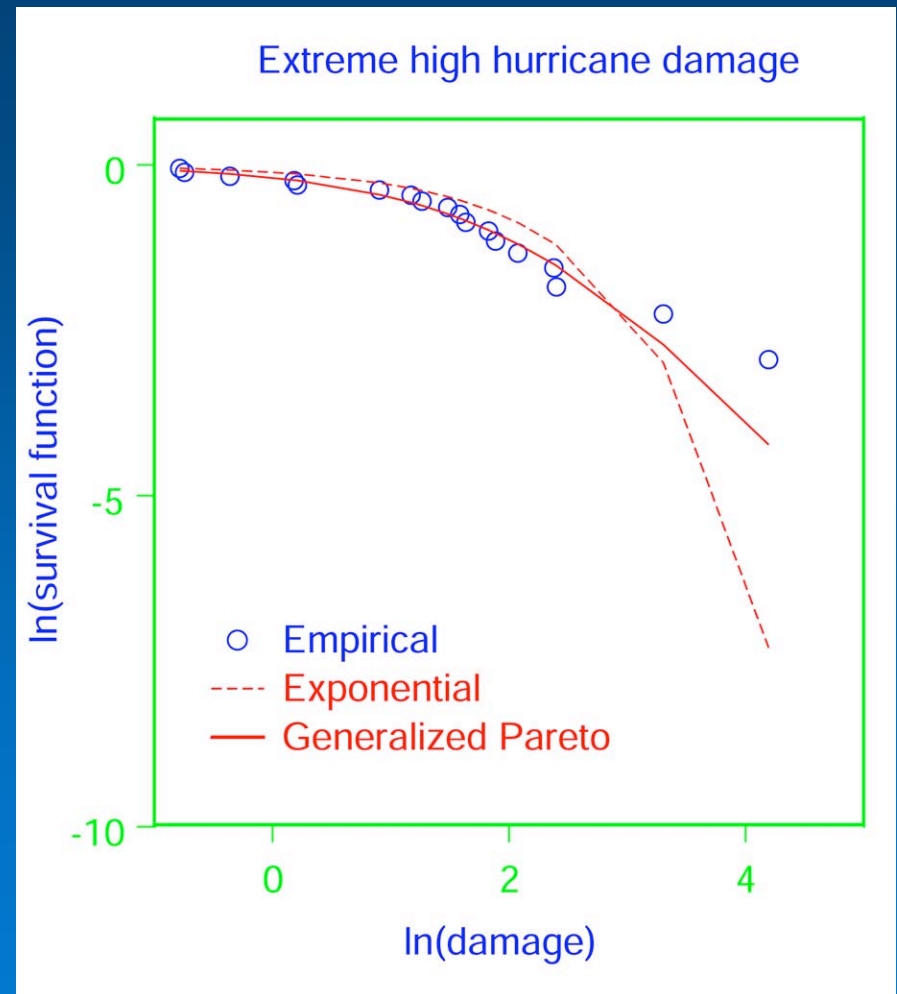
# Application of Extreme Value Methodology



- Analysis of weather and climate variables in terms of tail events and their properties at different spatial scales..

# Anticipating Hurricane Damages

This figure shows that the upper tail of the distribution of economic damage from hurricanes may be heavier than commonly assumed (i.e., storms with high damage are not as unusual as conventional analyses would indicate).



# Extremes Toolkit

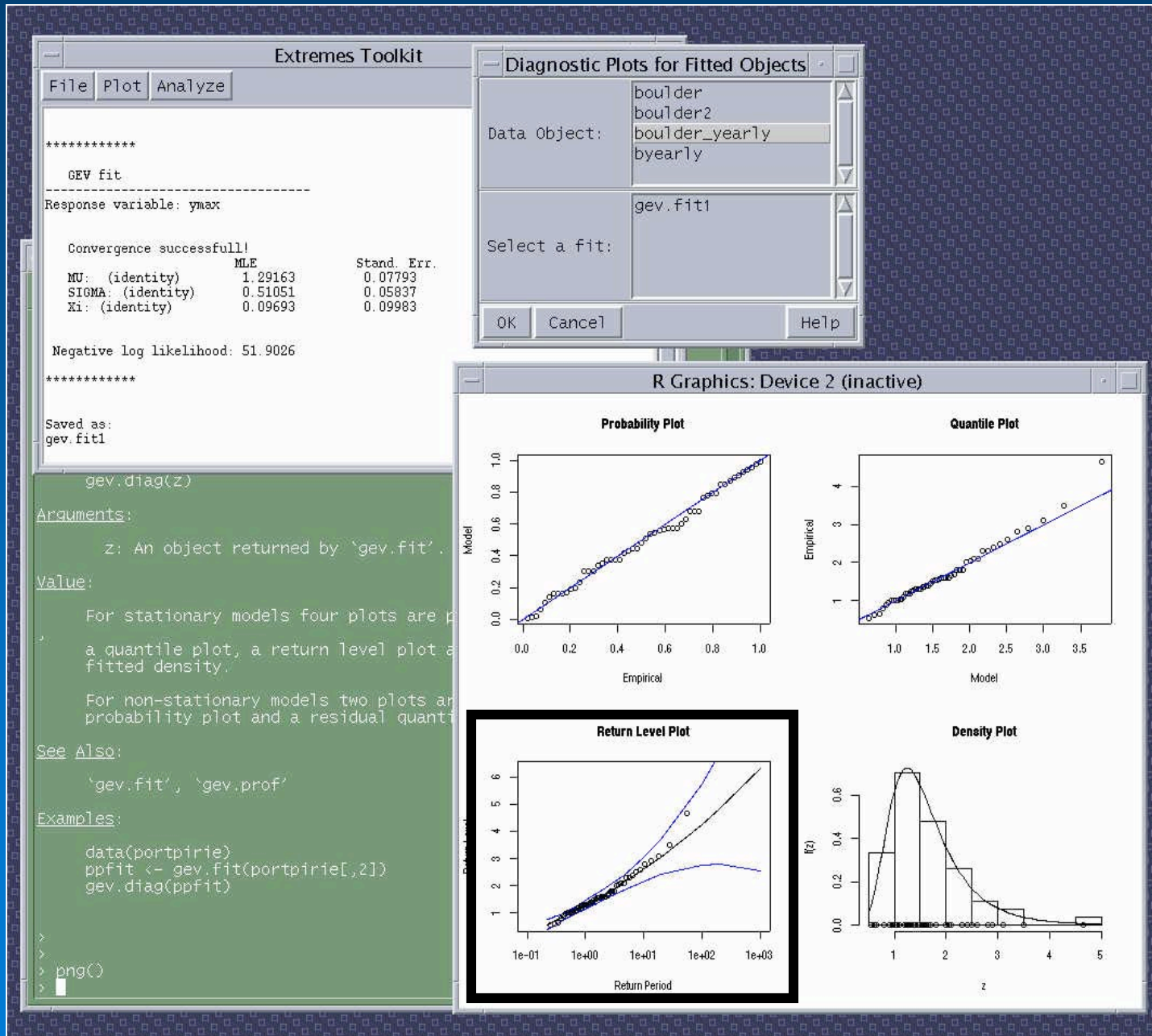
....designed to facilitate the use of extreme value theory in applications in weather and climate problems – oriented toward the nonexpert

- Tutorial document including examples
- GUI based - programming not required
- Fits data to extreme value distributions
- Estimates return values with uncertainty measures
- Allows for trends, annual cycles, etc.
- [www.esig.ucar.edu/extremevalues/extreme.html](http://www.esig.ucar.edu/extremevalues/extreme.html)

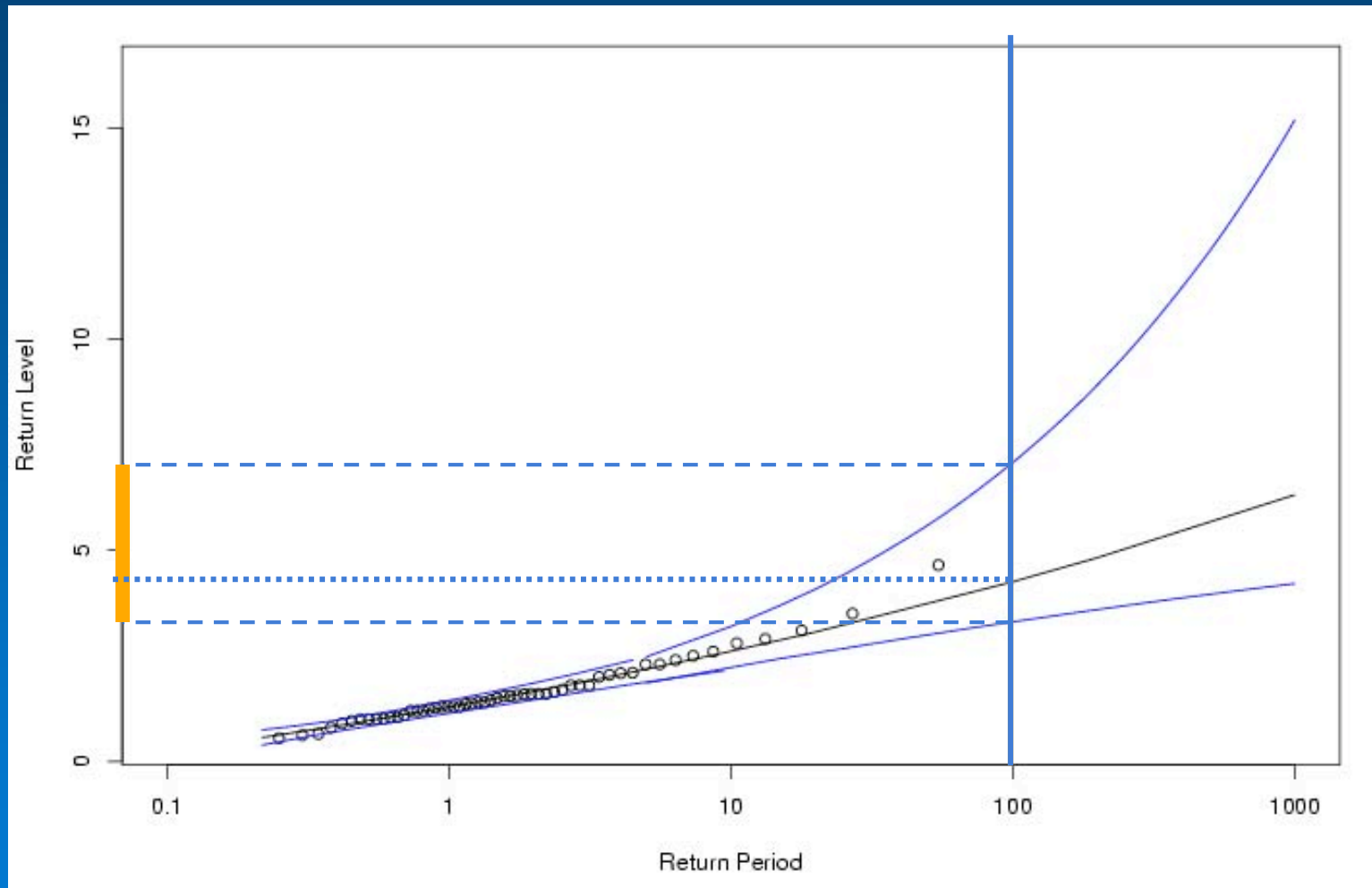
**NCAR Team:** R. Katz, E. Gilleland, G. Young, D. Nychka

**Acknowledgments:** S. Coles

# Analysis Using *Extremes Toolkit*



# Inference for the 100 Year Return Level for Boulder



# Downscaling of Extreme Weather/Climate Phenomenon

...to downscale severe thunderstorms (those containing large hail, strong wind, or tornadoes) using upper air variables from reanalysis, regional models, and global models.

**NCAR Team:** R. Katz, M. Pocerich, E. Gilleland

**External Collaborators:** H. Brooks, NOAA/NSSL



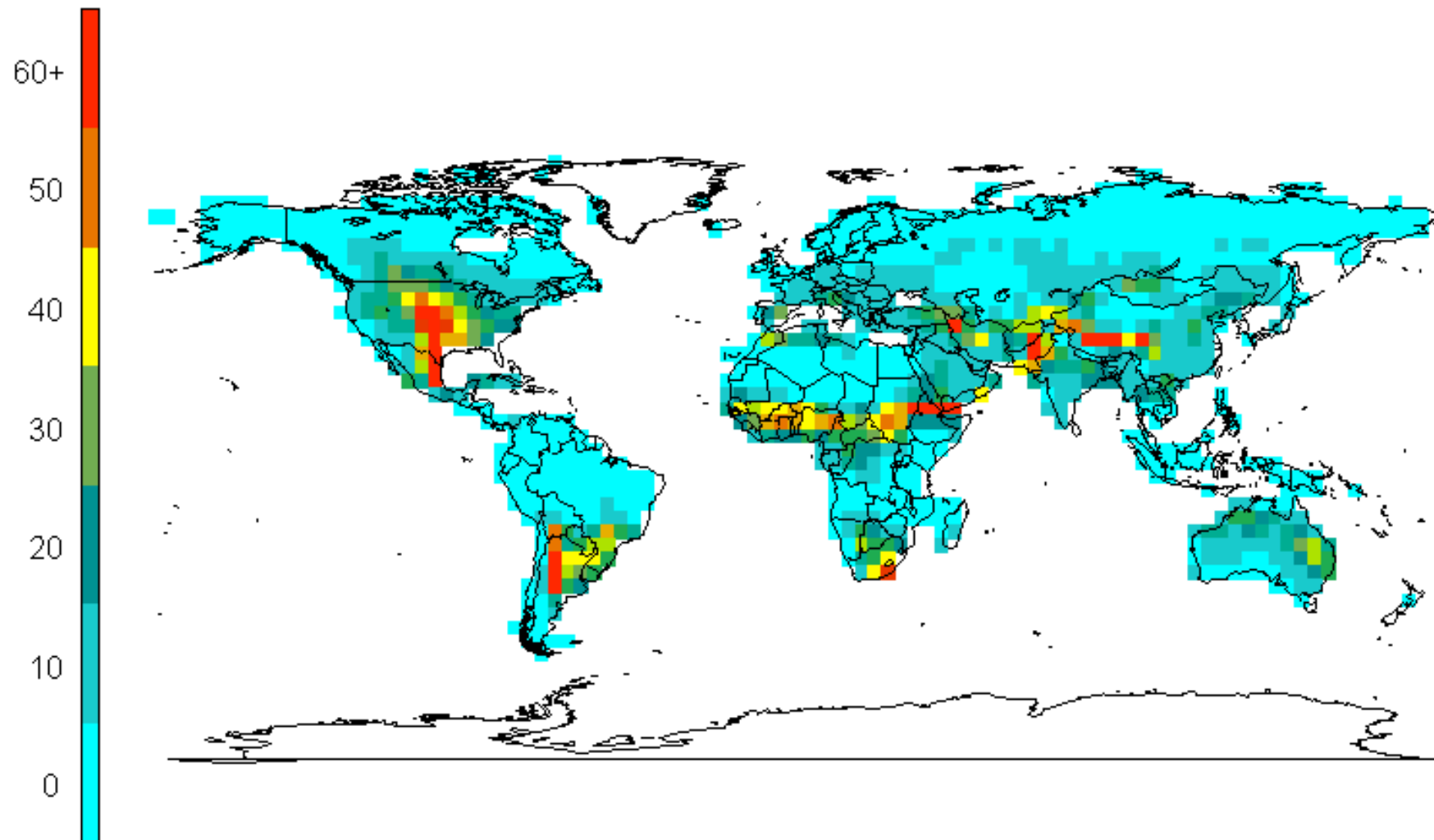
# Estimating Severe Thunderstorm and Tornado Climatology

- Relationships between observed weather and observed and reanalysis soundings from US, east of Rocky Mountains
- Apply results to global NCAR/NCEP reanalysis
  - Every other grid point over non-water, non-ice locations, one time per day
  - 1997-1999
  - Uses sounding time closest to late afternoon

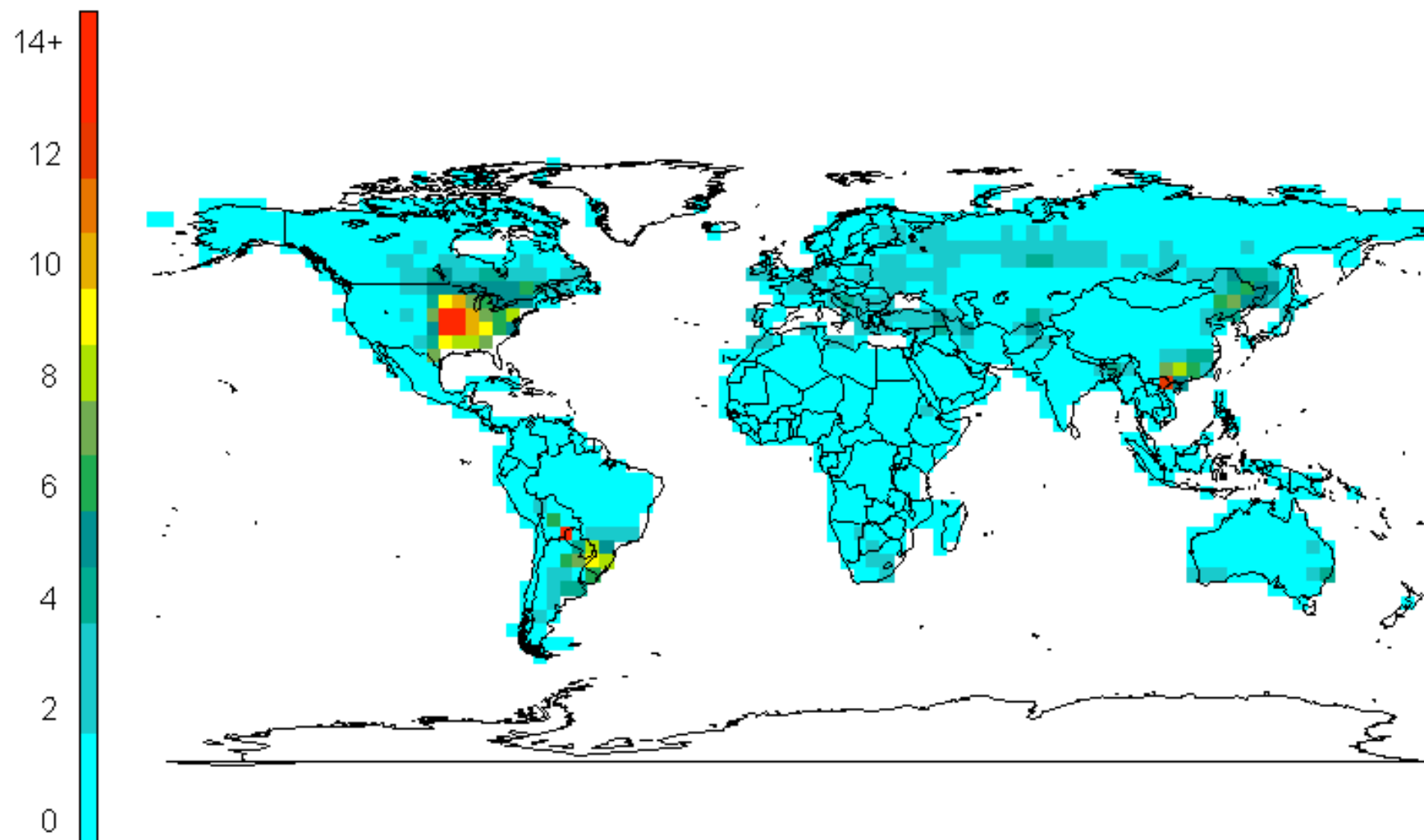
# Estimating Severe Thunderstorm and Tornado Climatology

- Severe thunderstorms with at least 5 cm hail, 120 km/h wind gusts or F2 or greater tornado (~10% biggest events in US)
- Severe occurrence related to Sfc-6 km vertical shear of horizontal winds and convective available potential energy (cape)
- Tornado occurrence (conditional on severe occurrence) based on Sfc-1 km vertical wind shear and lifted condensation level

## Days per Year with Favorable Severe Parameters



## Days per Year with Favorable Tornado Parameters



# Need for Integration of Research in Extremes

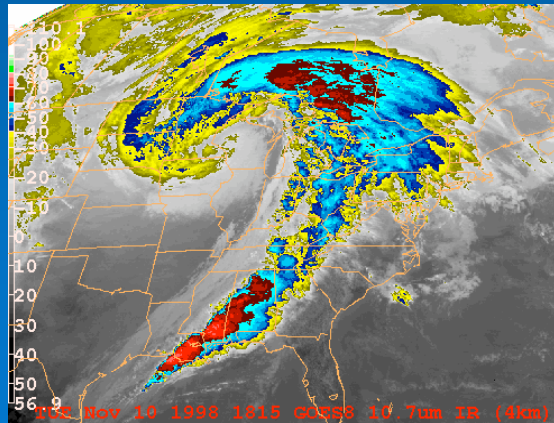
Example from the IPCC TAR  
'Dueling Extremes Tables'



## IPCC WG 1

High  
uncertainty:  
Unwilling to list  
probability in  
summary table

Frequency of  
mid-latitude  
storms in the  
future??



## IPCC WG 2

High uncertainty, but  
also high impact:  
Included in  
summary table even  
with high uncertainty



# WGI

**Table 1:** Estimates of confidence in observed and projected changes in extreme weather and climate events.

| Confidence in observed changes<br>(latter half of the 20th century)                  | Changes in Phenomenon  | Confidence in projected changes<br>(during the 21st century)  |
|--|--|---|
| Likely <sup>7</sup>  | Higher maximum temperatures and more hot days over nearly all land areas               | Very likely <sup>7</sup>  |
| Very likely <sup>7</sup>   | Higher minimum temperatures, fewer cold days and frost days over nearly all land areas | Very likely <sup>7</sup>  |
| Very likely <sup>7</sup>   | Reduced diurnal temperature range over most land areas                                 | Very likely <sup>7</sup>  |
| Likely <sup>7</sup> , over many areas  | Increase of heat index <sup>12</sup> over land areas                                   | Very likely <sup>7</sup> , over most areas  |
| Likely <sup>7</sup> , over many Northern Hemisphere mid- to high latitude land areas | More intense precipitation events <sup>b</sup>   | Very likely <sup>7</sup> , over many areas  |
| Likely <sup>7</sup> , in a few areas   | Increased summer continental drying and associated risk of drought                     | Likely <sup>7</sup> , over most mid-latitude continental interiors. (Lack of consistent projections in other areas) |
| Not observed in the few analyses available   | Increase in tropical cyclone peak wind intensities <sup>c</sup>                        | Likely <sup>7</sup> , over some areas   |
| Insufficient data for assessment   | Increase in tropical cyclone mean and peak precipitation intensities <sup>c</sup>      | Likely <sup>7</sup> , over some areas   |

<sup>a</sup> For more details see Chapter 2 (observations) and Chapter 9, 10 (projections).

<sup>b</sup> For other areas, there are either insufficient data or conflicting analyses.

<sup>c</sup> Past and future changes in tropical cyclone location and frequency are uncertain.



# WGII

*Table SPM-1: Examples of impacts resulting from projected changes in extreme climate events.*

| Projected Changes during the 21 <sup>st</sup> Century in Extreme Climate Phenomena and their Likelihood <sup>a</sup>  | Representative Examples of Projected Impacts <sup>b</sup><br>(all high confidence of occurrence in some areas <sup>c</sup> )  |
|---|---|
| Increased summer drying over most mid-latitude continental interiors and associated risk of drought ( <i>likely</i> <sup>a</sup> )  | <ul style="list-style-type: none"> <li>• Decreased crop yields [4.2]</li> <li>• Increased damage to building foundations caused by ground shrinkage [Table TS-4]</li> <li>• Decreased water resource quantity and quality [4.1 and 4.5]</li> <li>• Increased risk of forest fire [5.4.2]</li> </ul>   |
| Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities ( <i>likely</i> <sup>a</sup> over some areas) <sup>e</sup>                                | <ul style="list-style-type: none"> <li>• Increased risks to human life, risk of infectious disease epidemics, and many other risks [4.7]</li> <li>• Increased coastal erosion and damage to coastal buildings and infrastructure [4.5 and 7.2.4]</li> <li>• Increased damage to coastal ecosystems such as coral reefs and mangroves [4.4]</li> </ul> |
| Intensified droughts and floods associated with El Niño events in many different regions ( <i>likely</i> <sup>a</sup> )<br>(see also under droughts and intense precipitation events) | <ul style="list-style-type: none"> <li>• Decreased agricultural and rangeland productivity in drought- and flood-prone regions [4.3]</li> <li>• Decreased hydro-power potential in drought-prone regions [5.1.1 and Figure TS-7]</li> </ul>   |
| Increased Asian summer monsoon precipitation variability ( <i>likely</i> <sup>a</sup> )   | <ul style="list-style-type: none"> <li>• Increased flood and drought magnitude and damages in temperate and tropical Asia [5.2.4]</li> </ul>  |
| Increased intensity of mid-latitude storms (little agreement between current models) <sup>d</sup>   | <ul style="list-style-type: none"> <li>• Increased risks to human life and health [4.7]</li> <li>• Increased property and infrastructure losses [Table TS-4]</li> <li>• Increased damage to coastal ecosystems [4.4]</li> </ul>   |

<sup>a</sup>Likelihood refers to judgmental estimates of confidence used by TAR WGI: *very likely* (90-99% chance); *likely* (66-90% chance). Unless otherwise stated, information on climate phenomena is taken from the Summary for Policymakers, TAR WGI.

<sup>b</sup>These impacts can be lessened by appropriate response measures.

<sup>c</sup>High confidence refers to probabilities between 67 and 95% as described in Footnote 6.

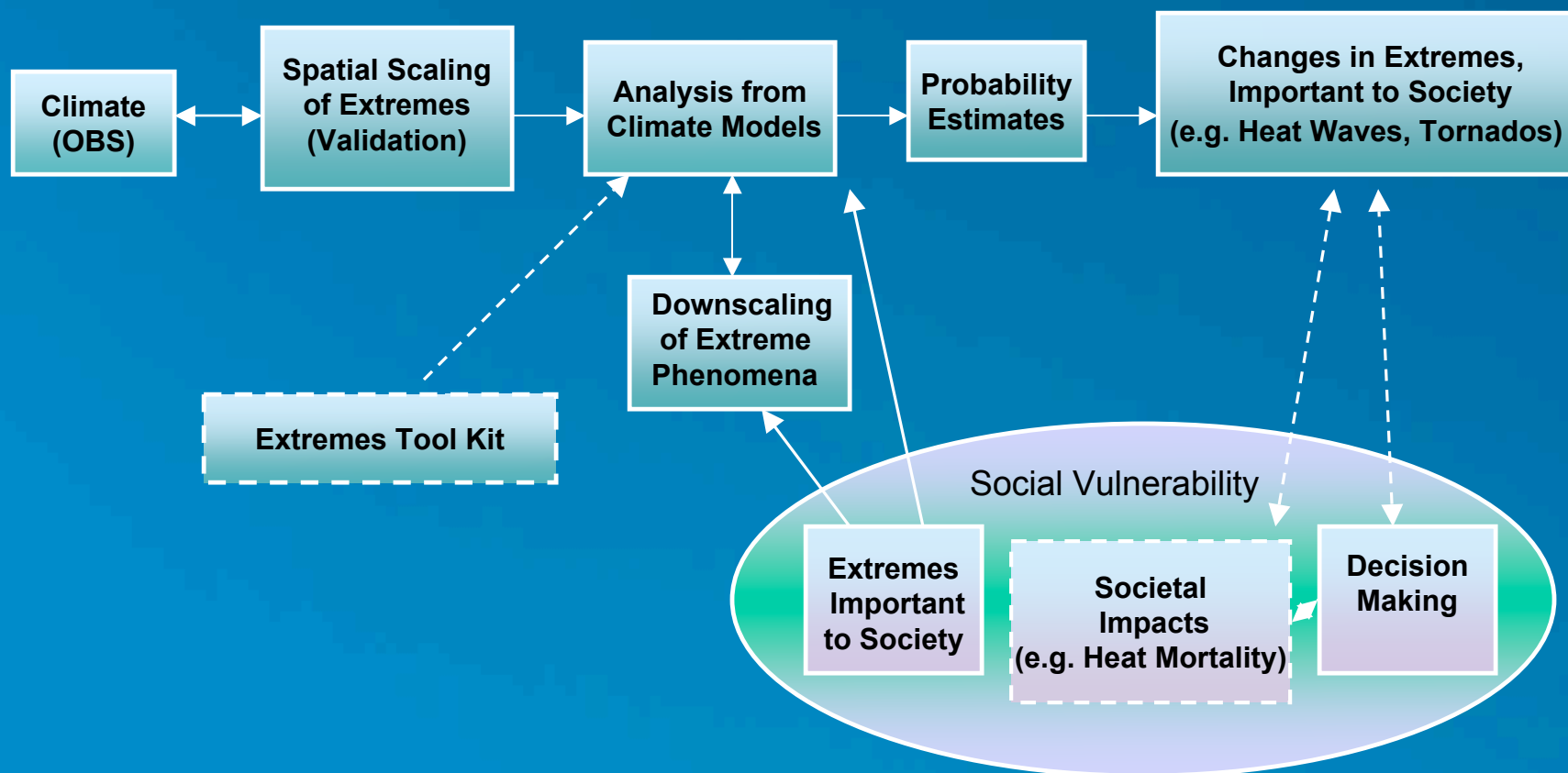
<sup>d</sup>Information from TAR WGI, Technical Summary, Section F.5.

<sup>e</sup>Changes in regional distribution of tropical cyclones are possible but have not been established.

Note  
inclusion of  
high impact  
but no  
information



## Examples of Linkages Among Extremes Projects

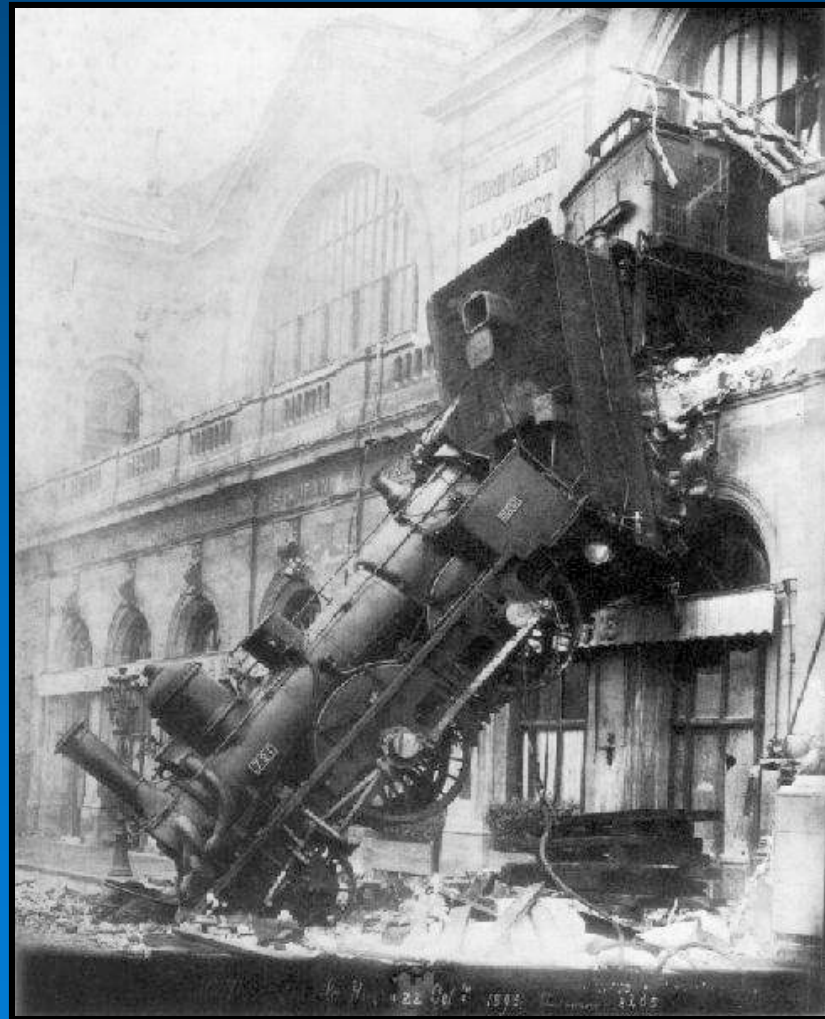




# Extreme Events

“Man can believe  
the impossible.  
But man can  
never believe the  
improbable.”

- Oscar Wilde





NCAR

# NCAR Initiative on Weather and Climate Impact Assessment Science

Linda O. Mearns

Doug Nychka and Jerry Meehl  
(acting co-directors)

<http://www.esig.ucar.edu/assessment>

National Center for Atmospheric Research