Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)
The physical dimension of changing risks:

- Climate Extremes
- Coastal Flooding

The human dimension of changing risks:

- Exposure: Spatial Population Distribution
The physical dimension of changing risks:

• Climate Extremes
• Coastal Flooding

The human dimension of changing risks:

• Exposure: Spatial Population Distribution
Aspen temperatures

From Weather Underground’s Aspen webpage
Mechanisms responsible for changes in climate extremes

1) INCREASE IN MEAN

- Previous climate
  - Less cold weather
  - More hot weather
- New climate
  - More record hot weather

PROBABILITY OF OCCURRENCE

COLD  AVERAGE  HOT
Mechanisms responsible for changes in climate extremes

2) INCREASE IN VARIANCE

- Previous Climate
  - More Cold Weather
  - More Record Cold Weather

- New Climate

- More Hot Weather
  - More Record Hot Weather

- Probability of Occurrence

- Cold
- Average
- Hot
Mechanisms responsible for changes in climate extremes

3) INCREASE IN MEAN AND VARIANCE

- Previous climate
  - Less change for cold weather
- New climate
  - Much more hot weather
  - More record hot weather

Probability of occurrence

Cold | Average | Hot
When the shift in mean explains the most:
Heat extremes: Ratio of the number of record highs vs. the number of record lows

Meehl et al., 2009: Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S. GRL
When the shift in mean explains the most:
Heat extremes: Ratio of the number of record highs vs. the number of record lows

Meehl et al., 2009: Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S. *GRL*
When the shift in mean explains the most:

Heat extremes: Ratio of the number of record highs vs. the number of record lows

Meehl et al., 2009: Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S. GRL
When the shift in mean explains the most:
Heat extremes: Ratio of the number of record highs vs. the number of record lows

Meehl et al., 2009: Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S. GRL
You remember last year…


US as a whole: 7.6
Recent simulation results:
NCAR’s Climate Model (CCSM4) under different scenarios
Changes in average temperature during the warmest three nights of the year (degrees C) by the end of the century

Meehl et al., 2012: Climate System Response to External Forcings and Climate Change Projections in CCSM4. *J. of Climate*
The physical dimension of changing risks:

- Climate Extremes
- Coastal Flooding

The human dimension of changing risks:

- Exposure: Spatial Population Distribution
The Battery, NY: Storm Surges (meters above Mean High Water)
The Battery, NY: Storm Surges (meters above Mean High Water)

The 100-yr event becomes the 15-yr event by 2050.
Changes in risk of coastal floods from storm surges as an effect of mean sea level rise

Current 100-year events

Changes in risk of coastal floods from storm surges as an effect of mean sea level rise

Current Sea Level Rise (1959-2008)

-2 – 0                  0 – 2                 2 – 4               4 – 6                 6 – 6.5
mm/year
Future extremes’ changed frequencies

Every how many years will today’s 100-year event recur, by 2050?
By at most the end of the century 2 meter (6 ft) surges will be happening on average every other year, or more frequently.

Strauss et al., 2012: Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States. *Envir. Res. Letters*
Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)
The physical dimension of changing risks:

• Climate Extremes
• Coastal Flooding

The human dimension of changing risks:

• Exposure: Spatial Population Distribution
Spatial Population Projection: Florida

Physical Impact

Terrain inundated by 6 ft surges

Population Exposure

Population Change

- < 0
- 0 - 10,000
- 10,000 - 25,000
- 25,000 - 50,000
- 50,000 - 100,000
- > 100,000

2100

Spatial Population Projection: Florida

Population by Distance to the Coast
Florida, 2100
High Pop. Growth

- EPA model
- NCAR model
- IIASA model
- Current

Population ( Millions ) vs. Distance from coast ( km )

Spatial Population Projection: Hurricane Sandy Landfall Area
Spatial Population Projection: National

State of the art, 2007

Shortcomings:

- Topography
- Protected areas
- Borders
- Calibration

Gruebler et al., 2007.
Spatial Population Projection: National

NCAR Projection, 2100

Existing Projection, 2100

Same national total population in 2100!


Gruebler et al., 2007.
Spatial Population Projection: Global

Projected Heat Extremes

Projected Population Distribution

Gruebler et al., 2007.
Current exposure to extreme heat: days above 35°C (95°F)

Exposure analysis from B. Jones, B. O’Neill, L. McDaniel (NCAR)
Current exposure to extreme heat: days above 35 C (95 F)
Total national 2050 exposure to extreme heat

- NCAR High Pop.
- NCAR Med. Pop.
- EPA High Pop.
- IIASA High Pop.

Exposure (person-days, millions)
Summary

Projecting changes in both physical and human systems is necessary for anticipating future risks from climate change.

Progress requires closer integration of research on climate science and human systems.
Acknowledgments

NCAR Integrated Science Program

DOE Cooperative Agreement DE-FC02-97ER62402

DOE Integrated Assessment Research Program

G. Meehl, G. Strand (NCAR); J. Arblaster (NCAR and CSIRO); B. Strauss, D. Adams-Smith, R. Ziemelinski (Climate Central); Chris Zervas (NOAA);

Bryan Jones, Larry McDaniel (NCAR).
Excluding chart like last one but % pop growth and % exposure growth

<table>
<thead>
<tr>
<th>Model</th>
<th>Exposure (millions of person days)</th>
<th>% Change</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2050</td>
<td>Change</td>
</tr>
<tr>
<td>NCAR A2-South</td>
<td>17,251.603</td>
<td>29,151.028</td>
<td>11,899.425</td>
</tr>
<tr>
<td>NCAR A2-Divisional</td>
<td>17,251.603</td>
<td>29,267.352</td>
<td>12,015.749</td>
</tr>
<tr>
<td>NCAR B2-Divisional</td>
<td>17,251.603</td>
<td>25,760.148</td>
<td>8,508.545</td>
</tr>
<tr>
<td>EPA A2</td>
<td>17,251.603</td>
<td>39,748.560</td>
<td>22,496.956</td>
</tr>
<tr>
<td>IIASA A2</td>
<td>17,251.603</td>
<td>26,147.375</td>
<td>8,895.771</td>
</tr>
</tbody>
</table>
Caveats

Urban heat islands and local spatial distribution

Population size and distribution matter, but how much relative to climate change?

Other extremes (e.g., drought, coastal storms, other indexes of heat)

Other parts of the world

Exposure is not vulnerability
When the shift in variance is more relevant: Precipitation extremes

Green/Blue/Purple: Increase in precipitation amounts

Pink/Orange/Yellow/Brown: Decrease in precipitation amounts

Stippling: Model consensus
Recent simulation results:
CCSM4 under different scenarios
Change in Precipitation Intensity (mm/day) by the end of the century

Meehl et al., 2012: Climate System Response to External Forcings and Climate Change Projections in CCSM4. J. of Climate