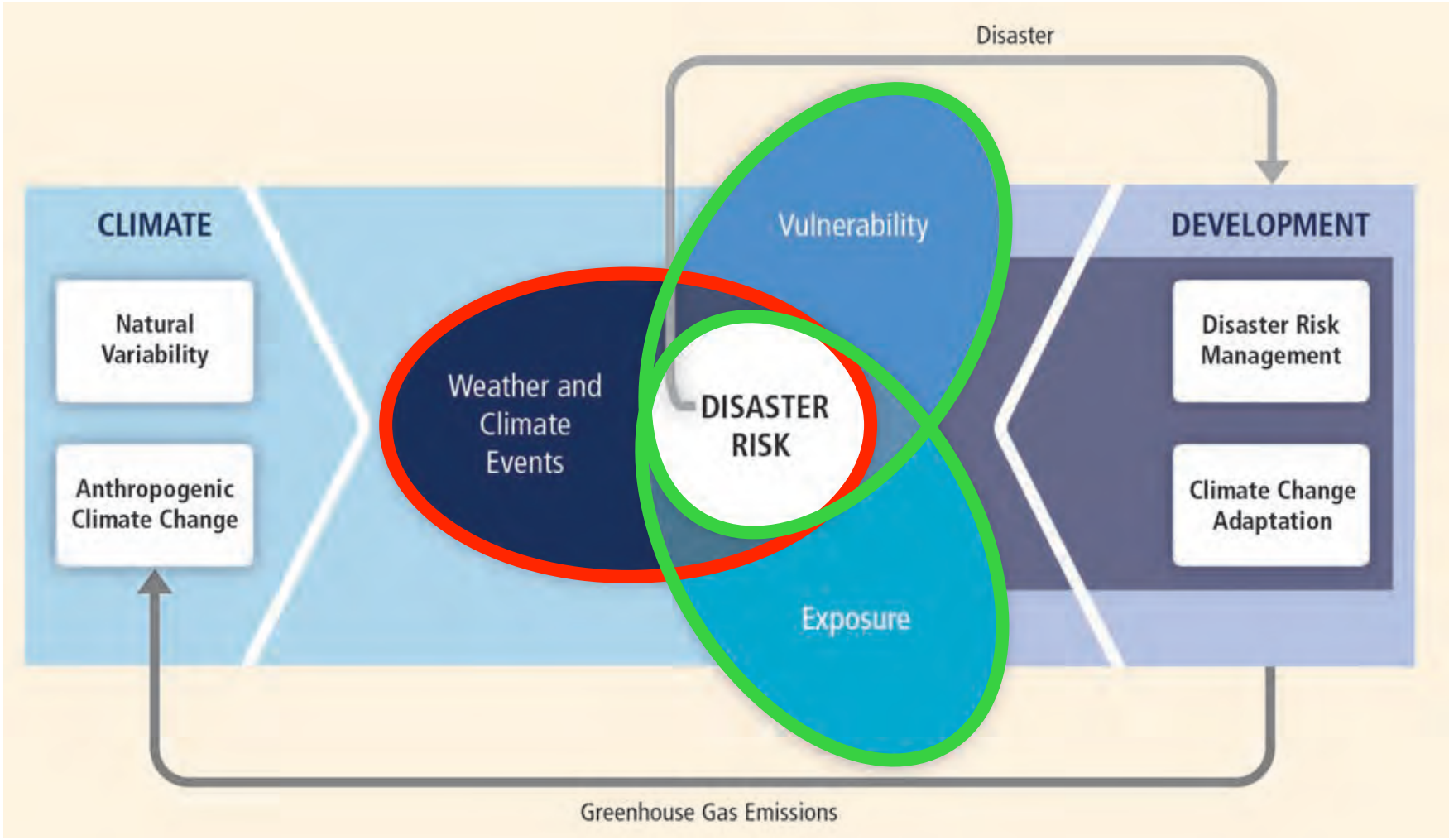
From IPCC *SREX* (2012) SUMMARY FOR POLICY MAKERS



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

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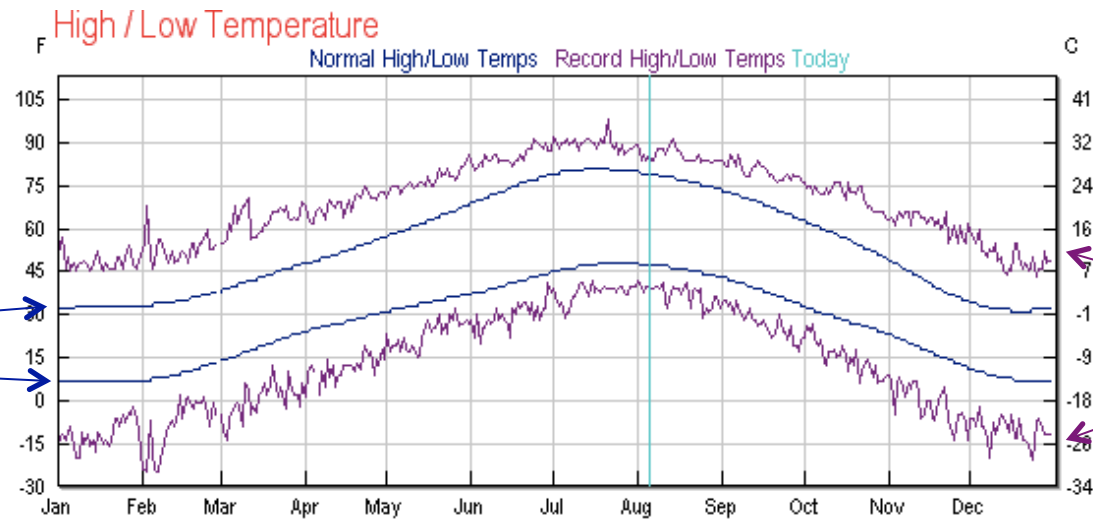
Aspen temperatures

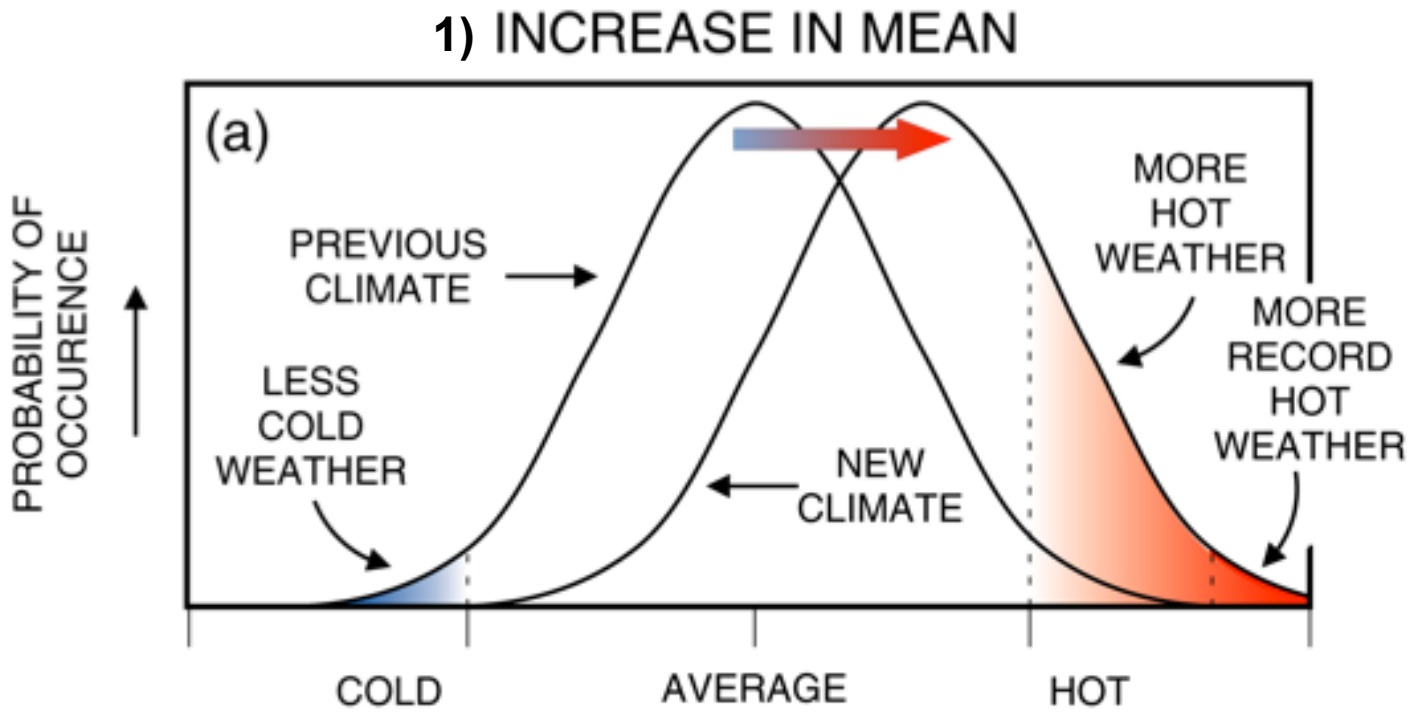


Daily Normals

Record highs/lows

From Weather Underground's Aspen webpage

Mechanisms responsible for changes in climate extremes



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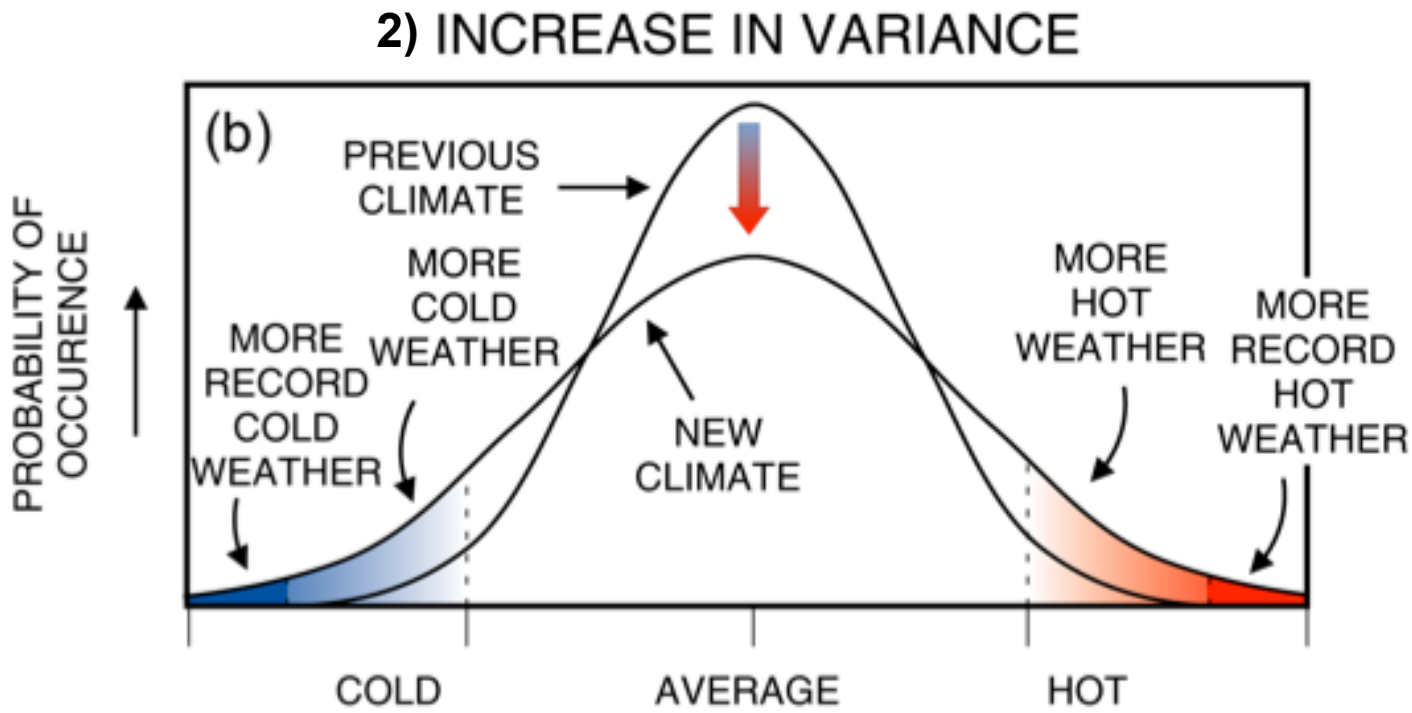

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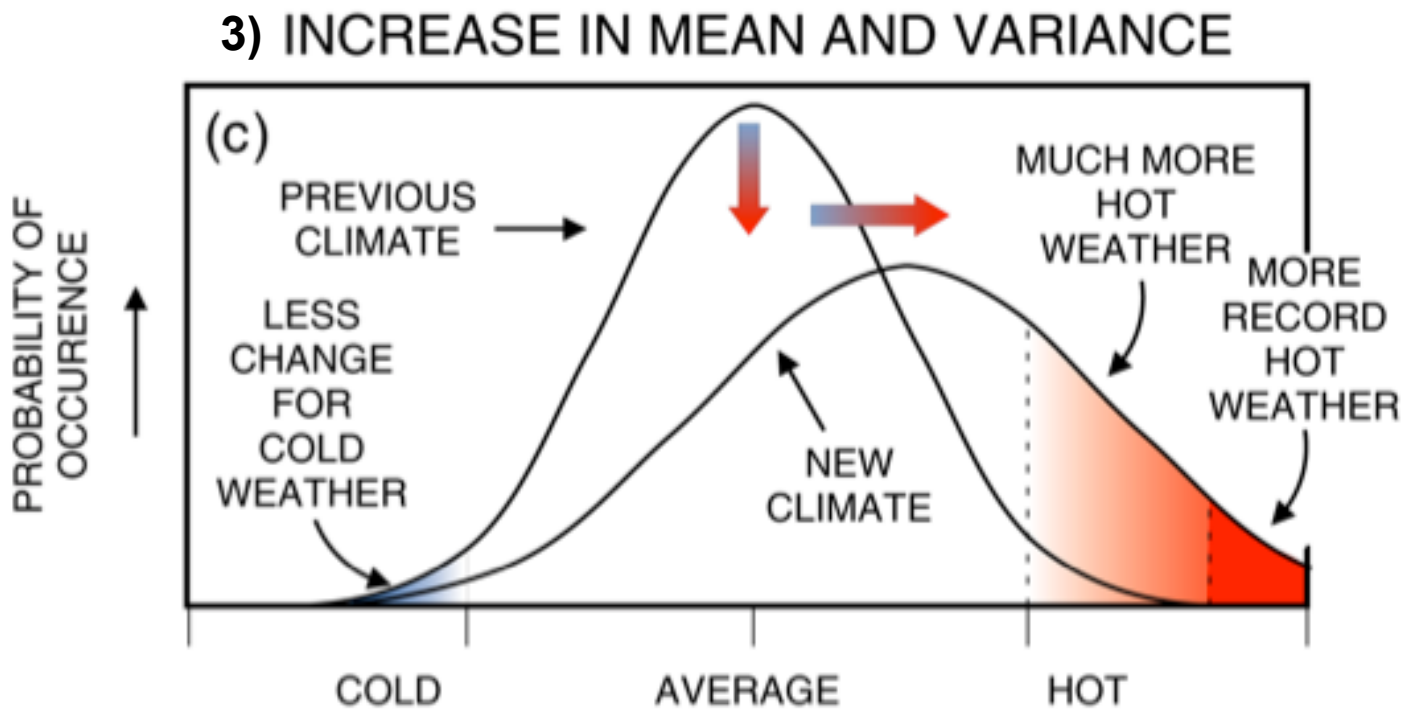
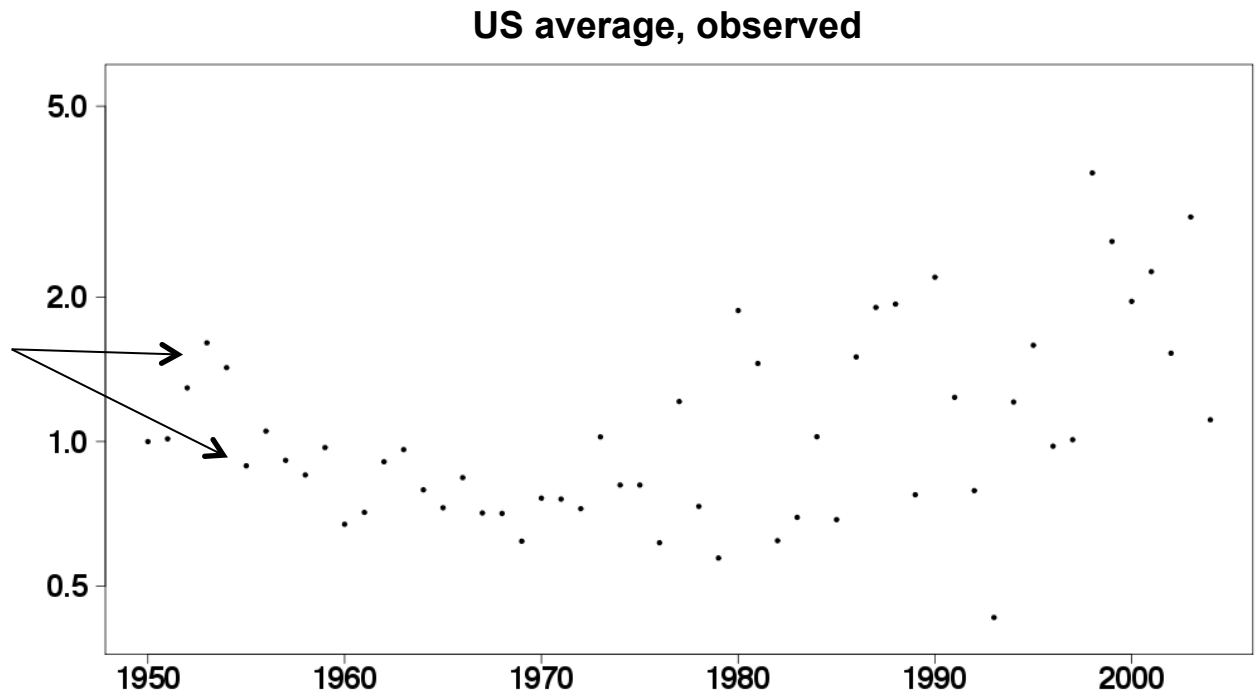


When the shift in mean explains the most:

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

Annual values of the ratio of # of record highs vs. # 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*

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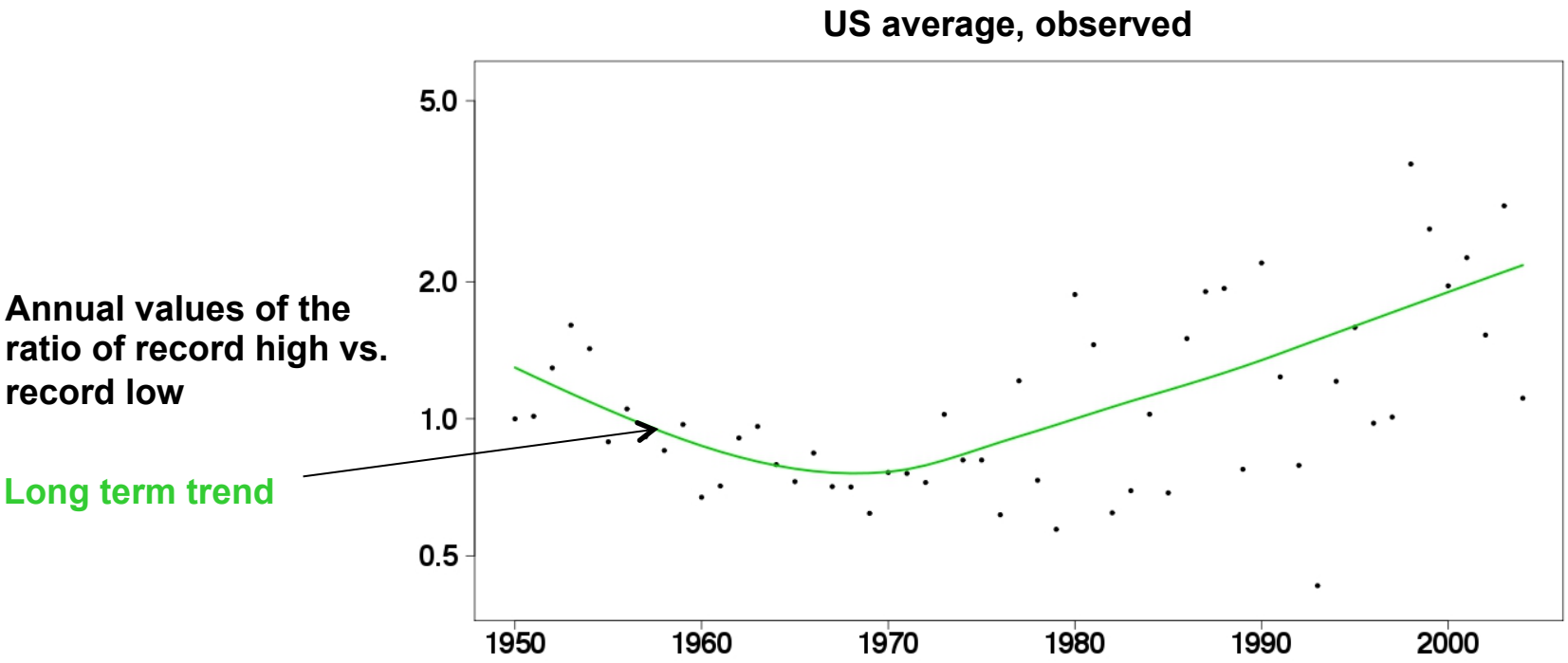

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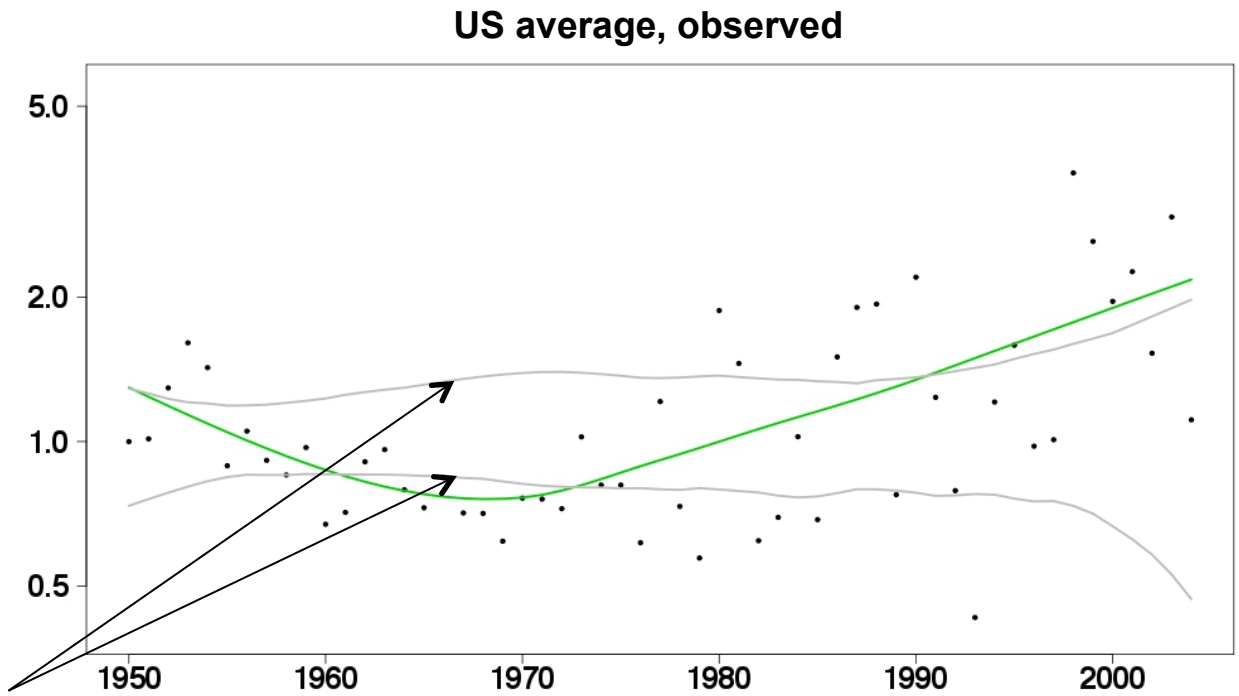
Annual values of the ratio of record high vs. record low

Long term trend

Confidence interval under the assumption of no long term trend



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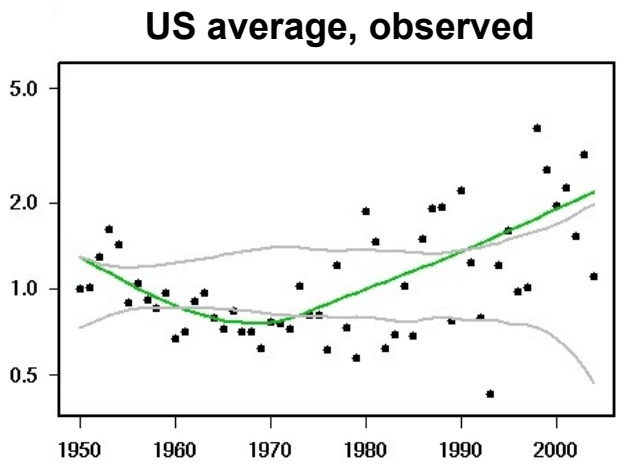
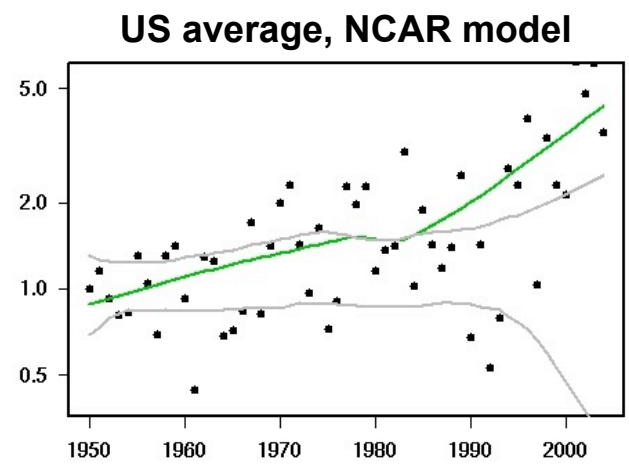
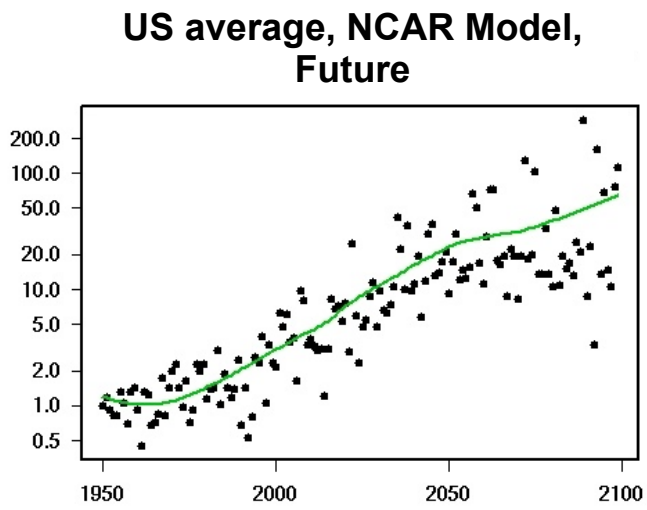
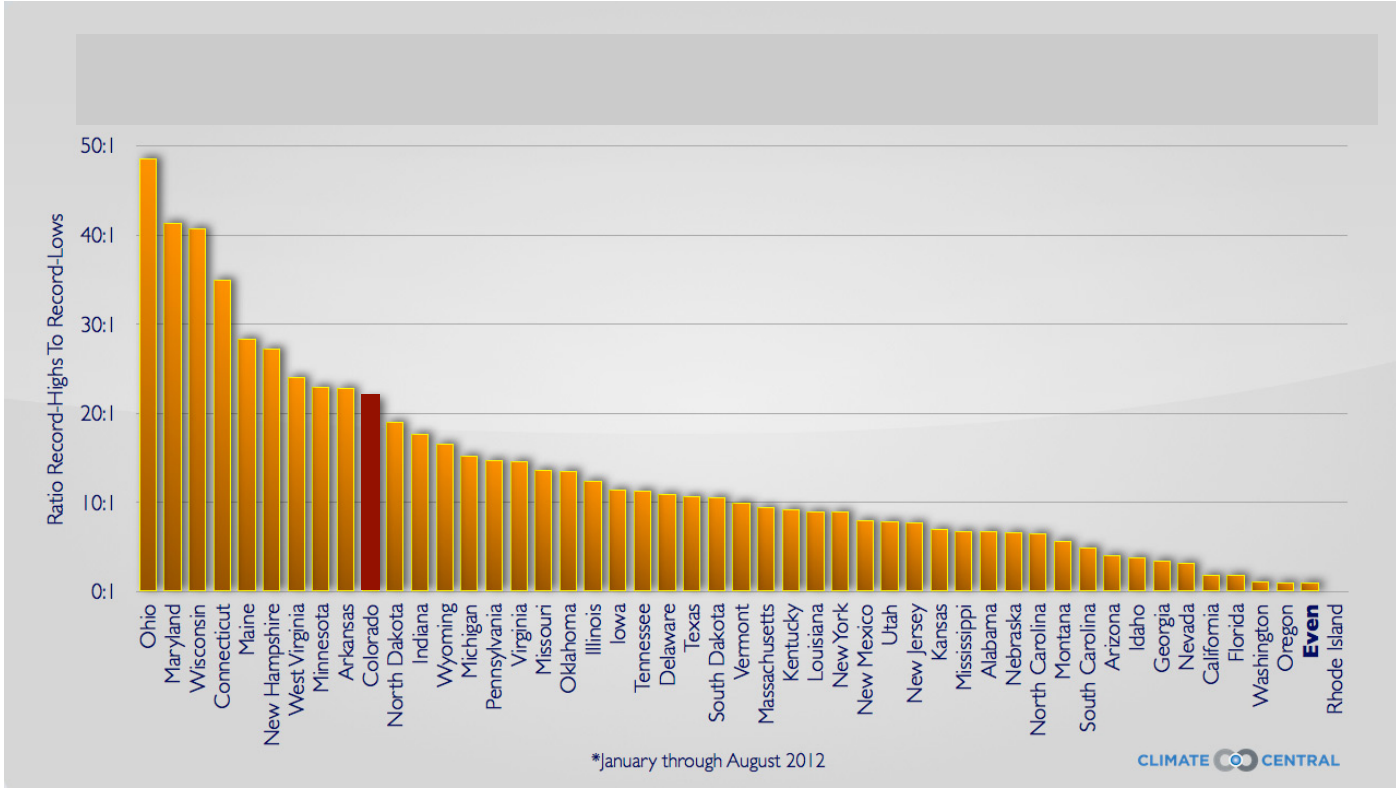






Meehl et al., 2009: Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S. *GRL*

You remember last year…

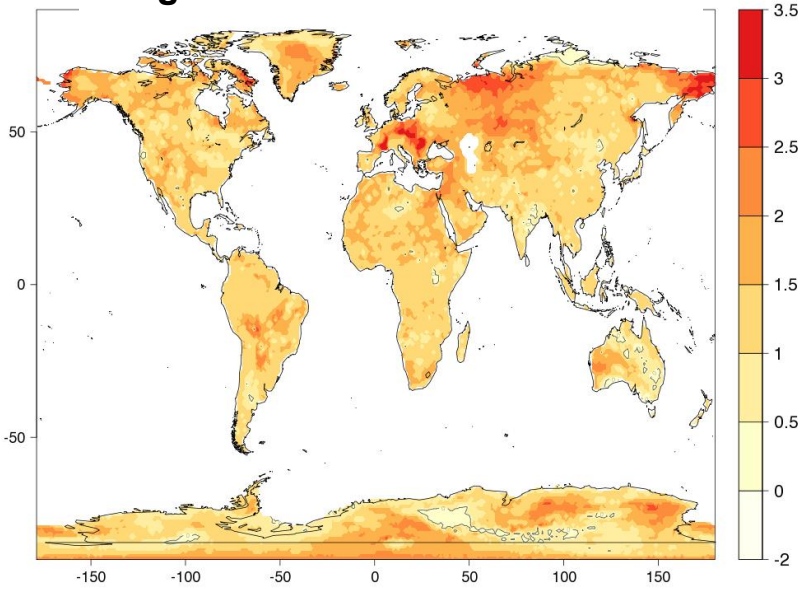


US as a whole: 7.6

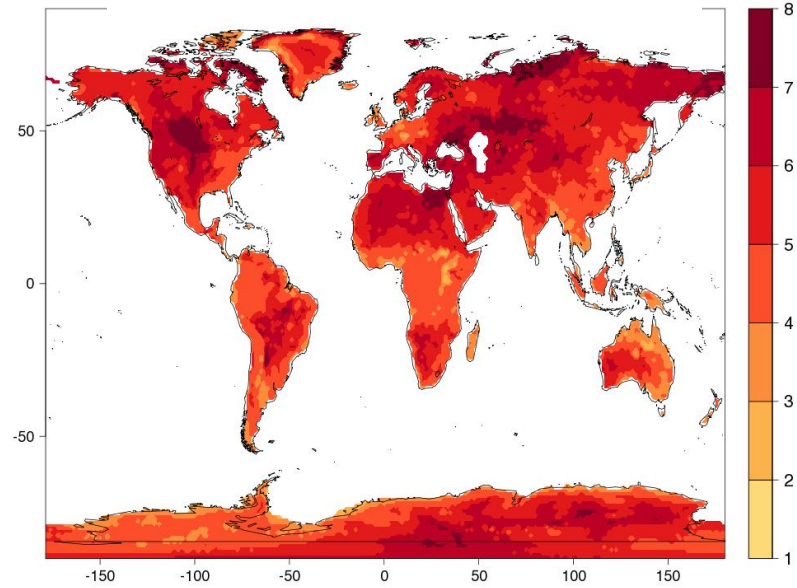
http://www.climatecentral.org/news/2012-record-temperatures-which-states-led-the-nation-14951

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

Large Emission Reductions



No Emission Reductions



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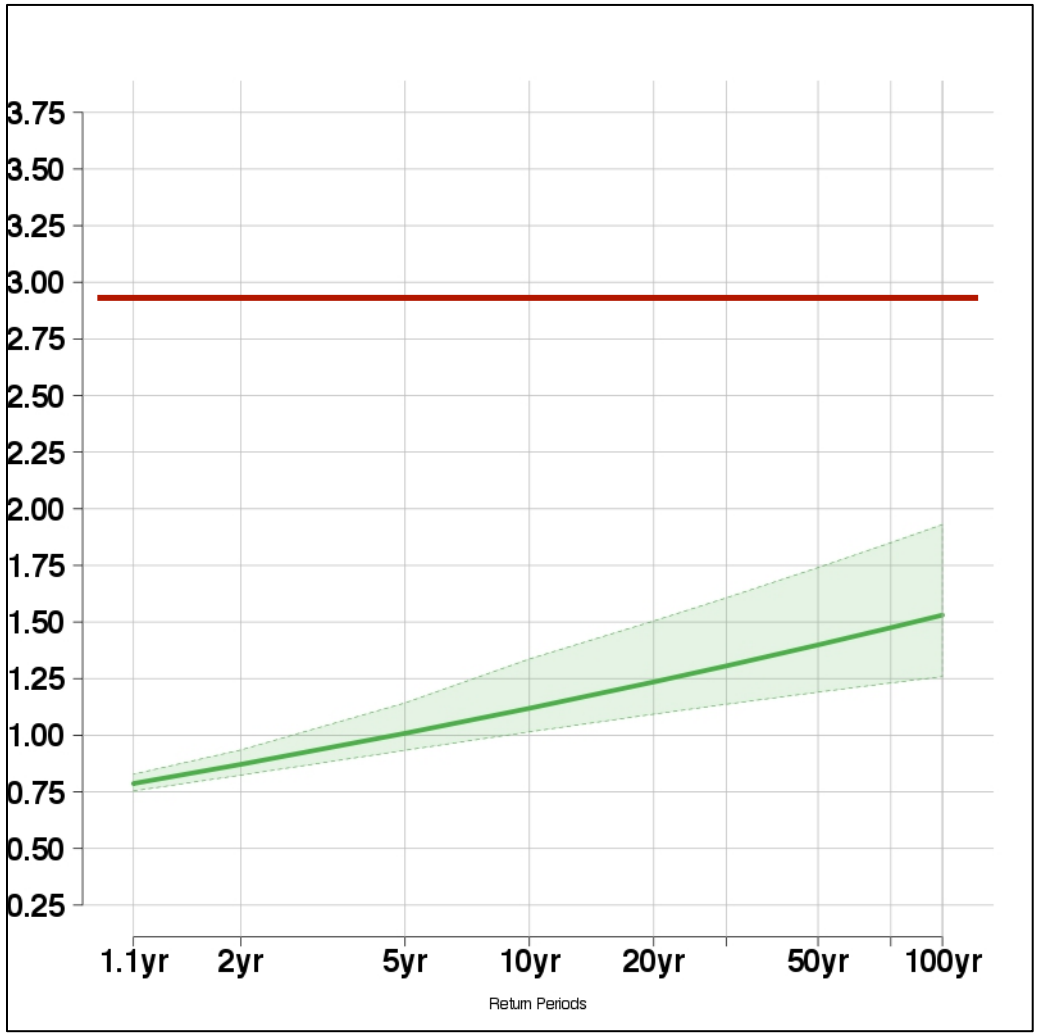
The Battery, NY: Storm Surges
(meters above Mean High Water)



Sandy's surge

The Battery, NY: Storm Surges
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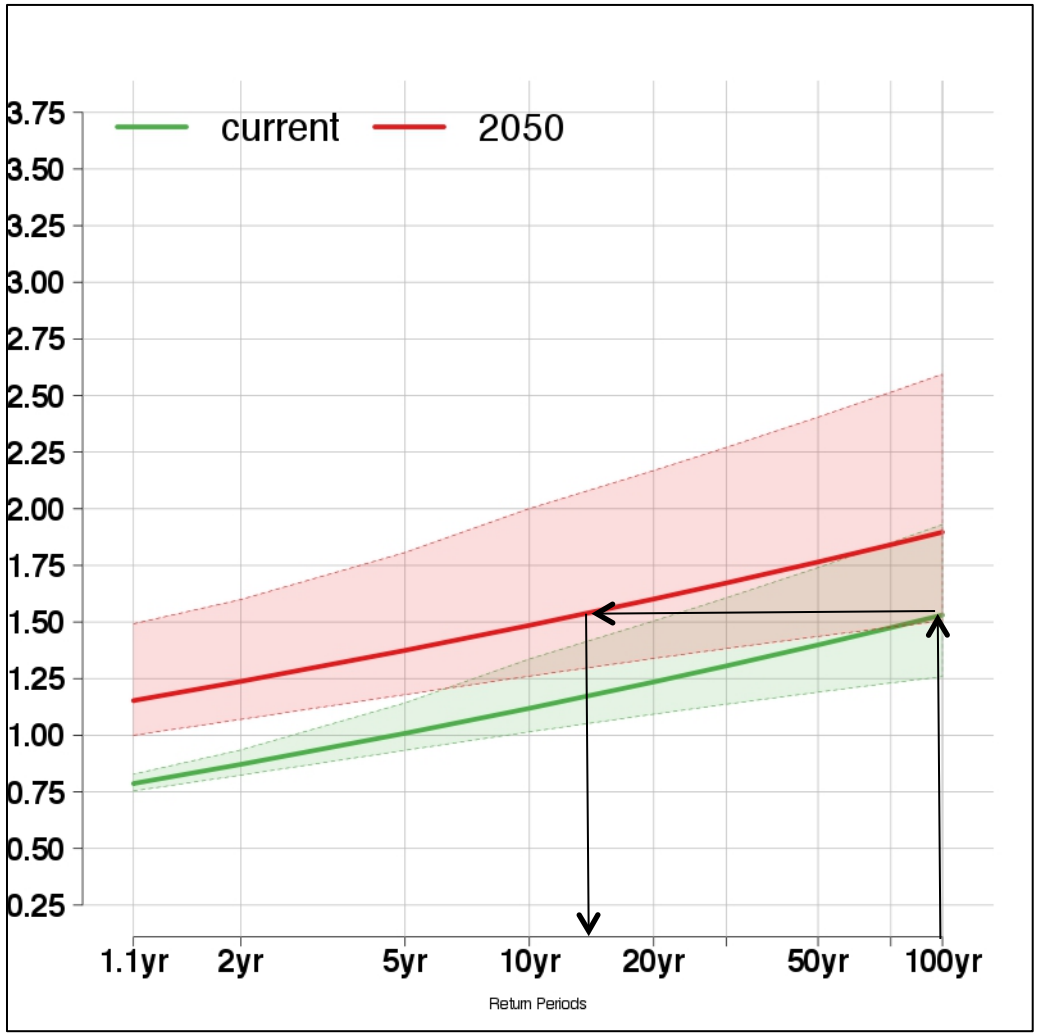
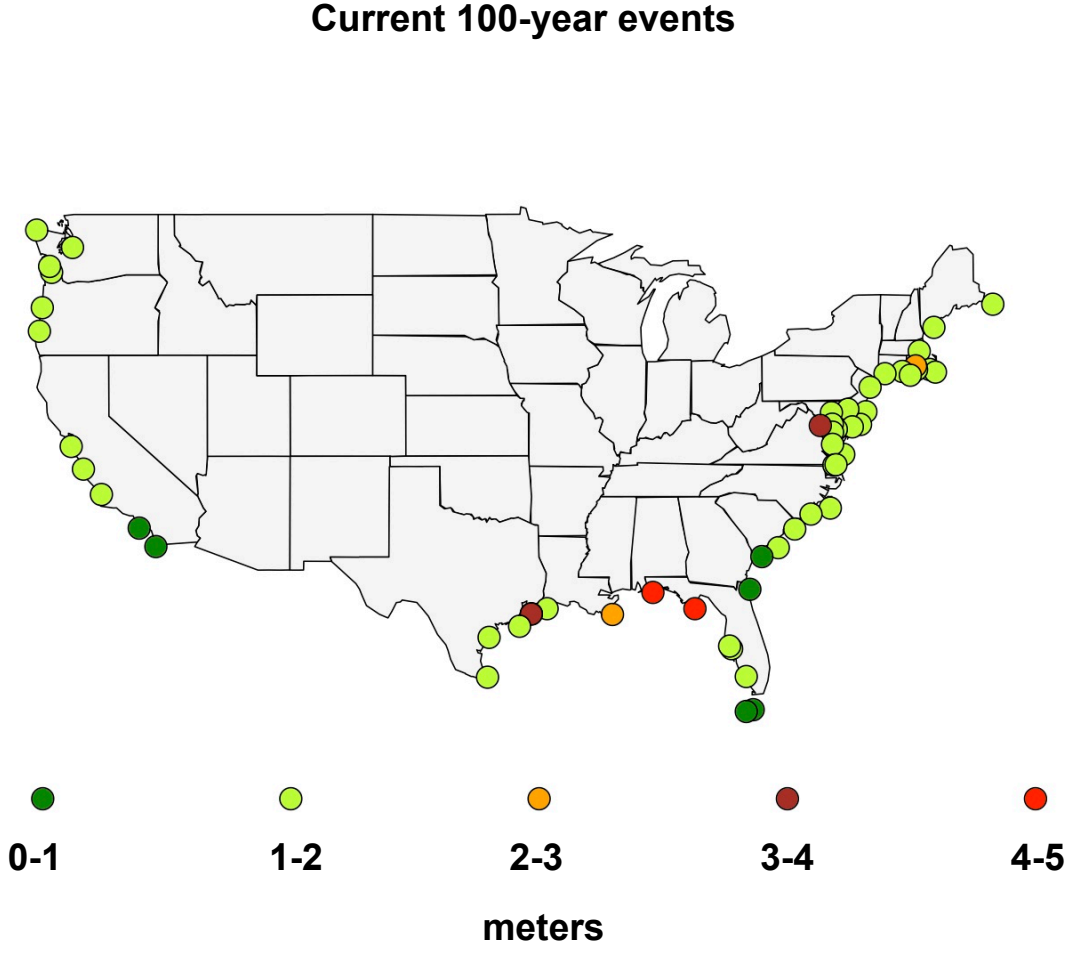


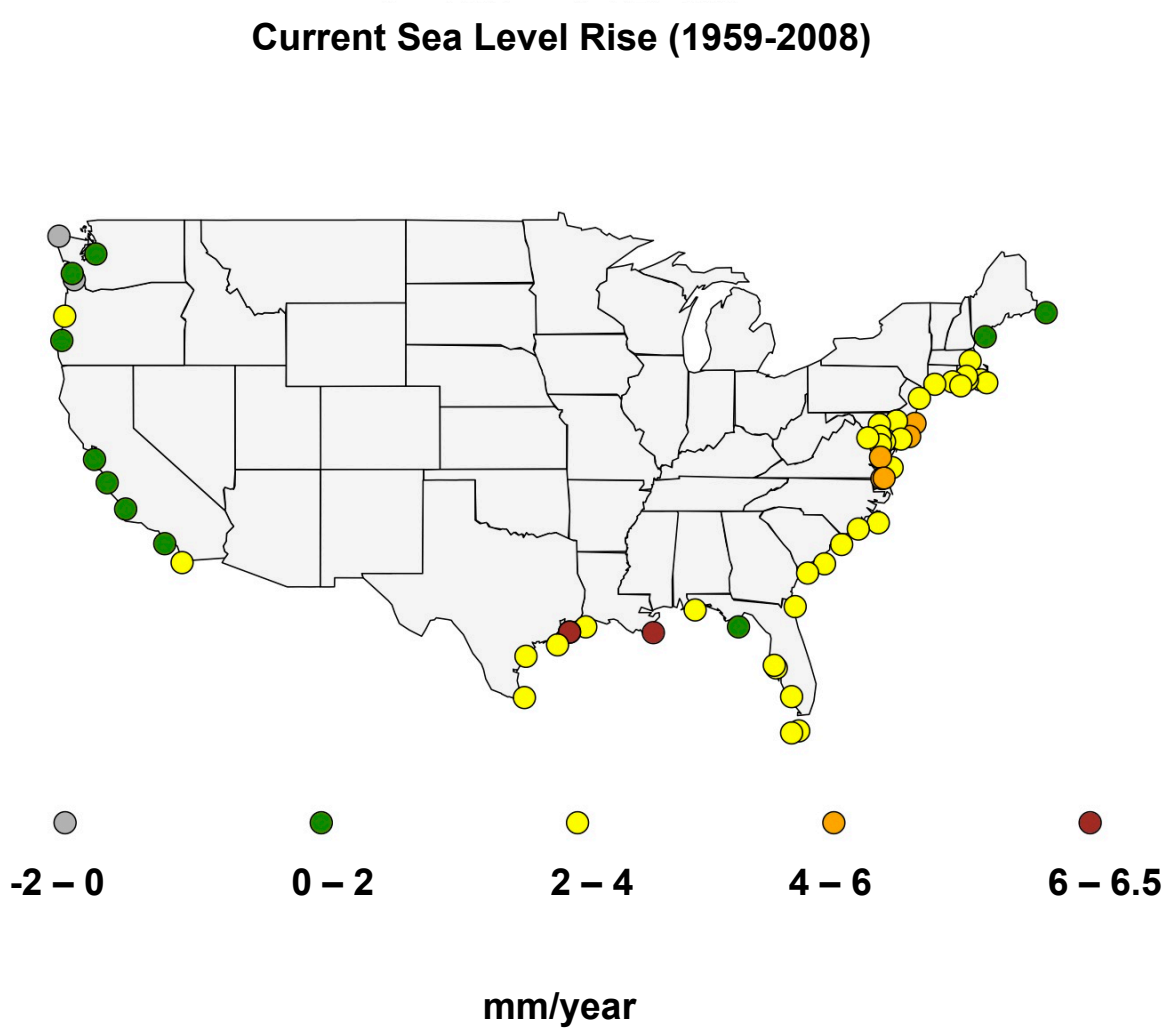
The 100-yr event becomes the 15-yr event by 2050

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

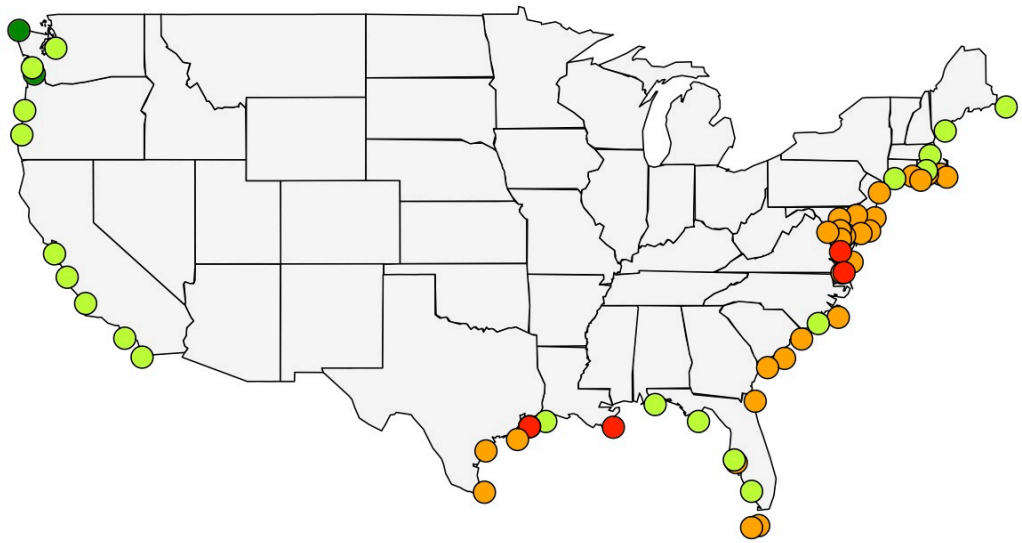


Tebaldi et al. 2012: Modelling sea level rise impacts on storm surges along US coasts. *Envir. Res. Letters*

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



Future (2008-2050)
Sea Level Rise

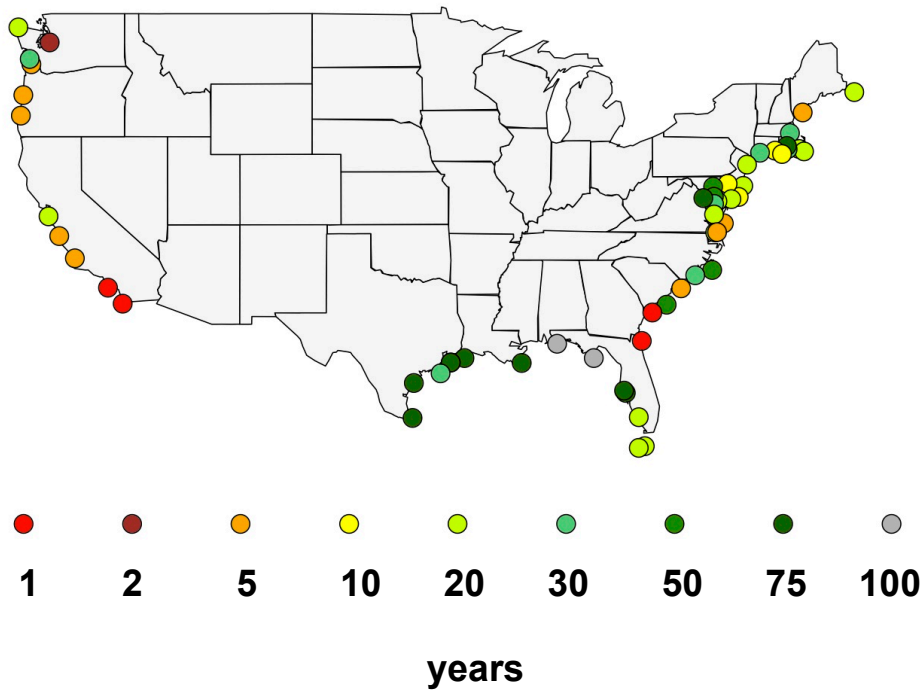


0.1-0.2 0.2-0.3 0.3-0.4 0.4-0.5

meters

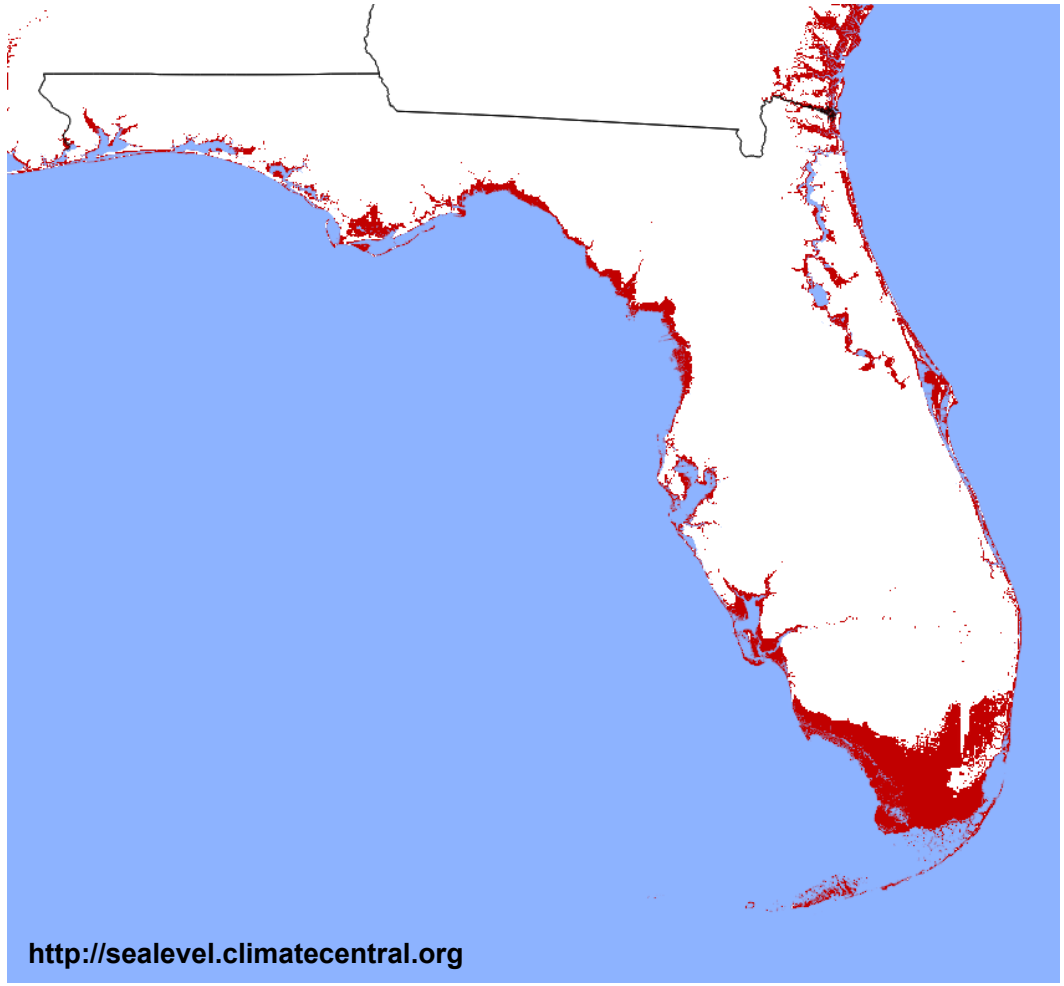
Future extremes' changed frequencies

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.

Terrain inundated by 2 meter surges



Strauss et al., 2012: Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States. *Envir. Res. Letters*

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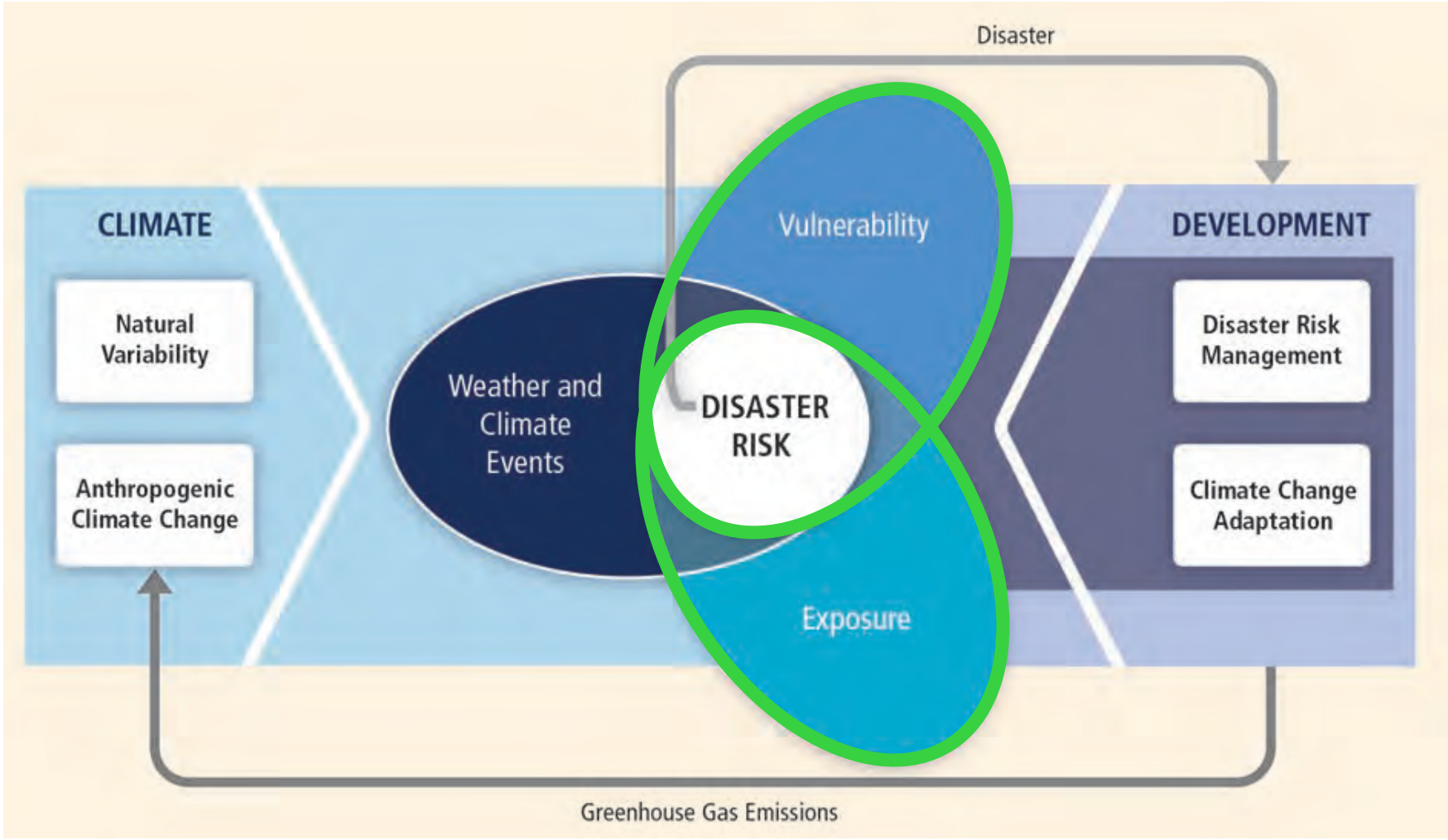

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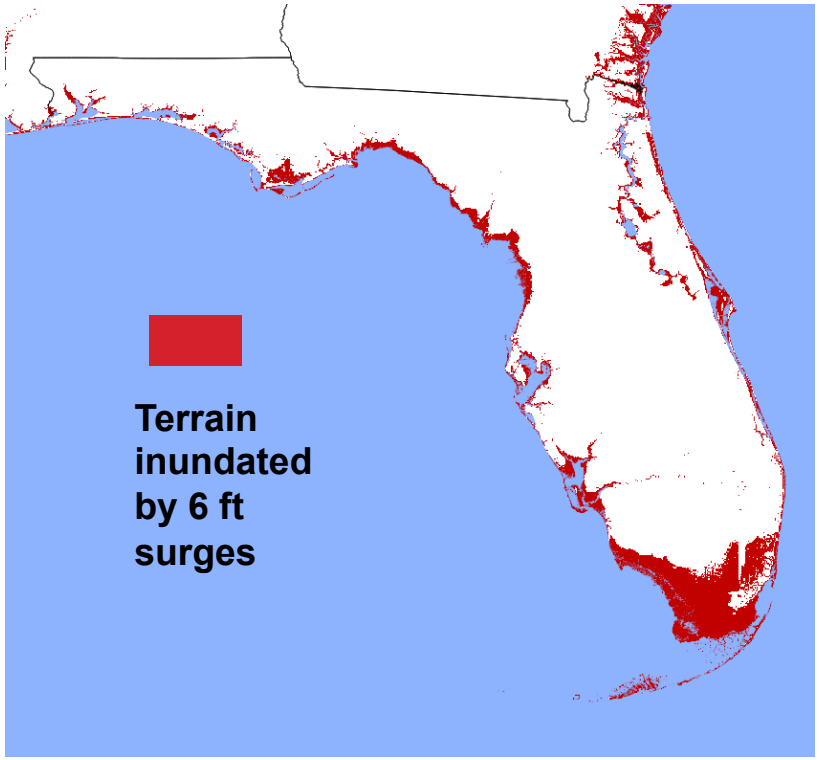
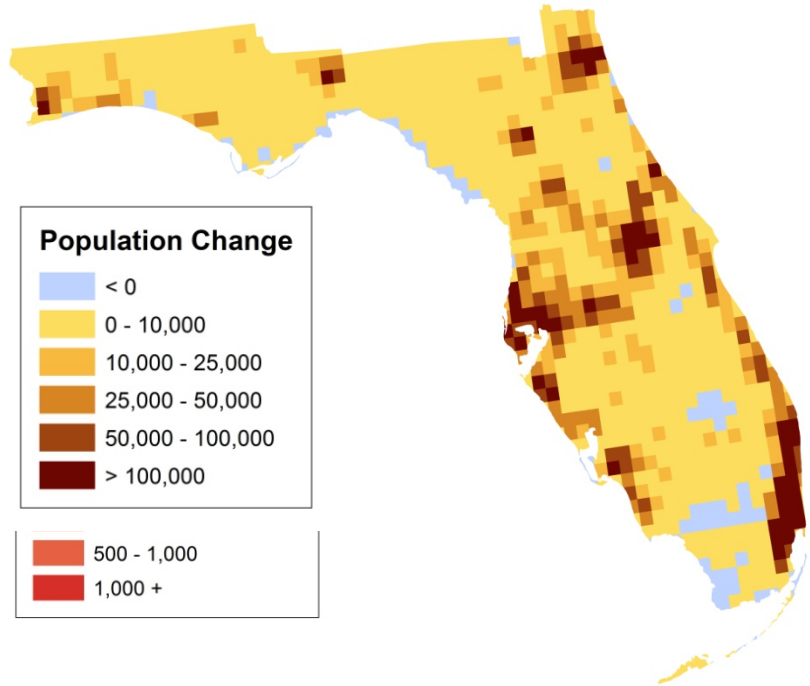
Spatial Population Projection: Florida

Physical Impact



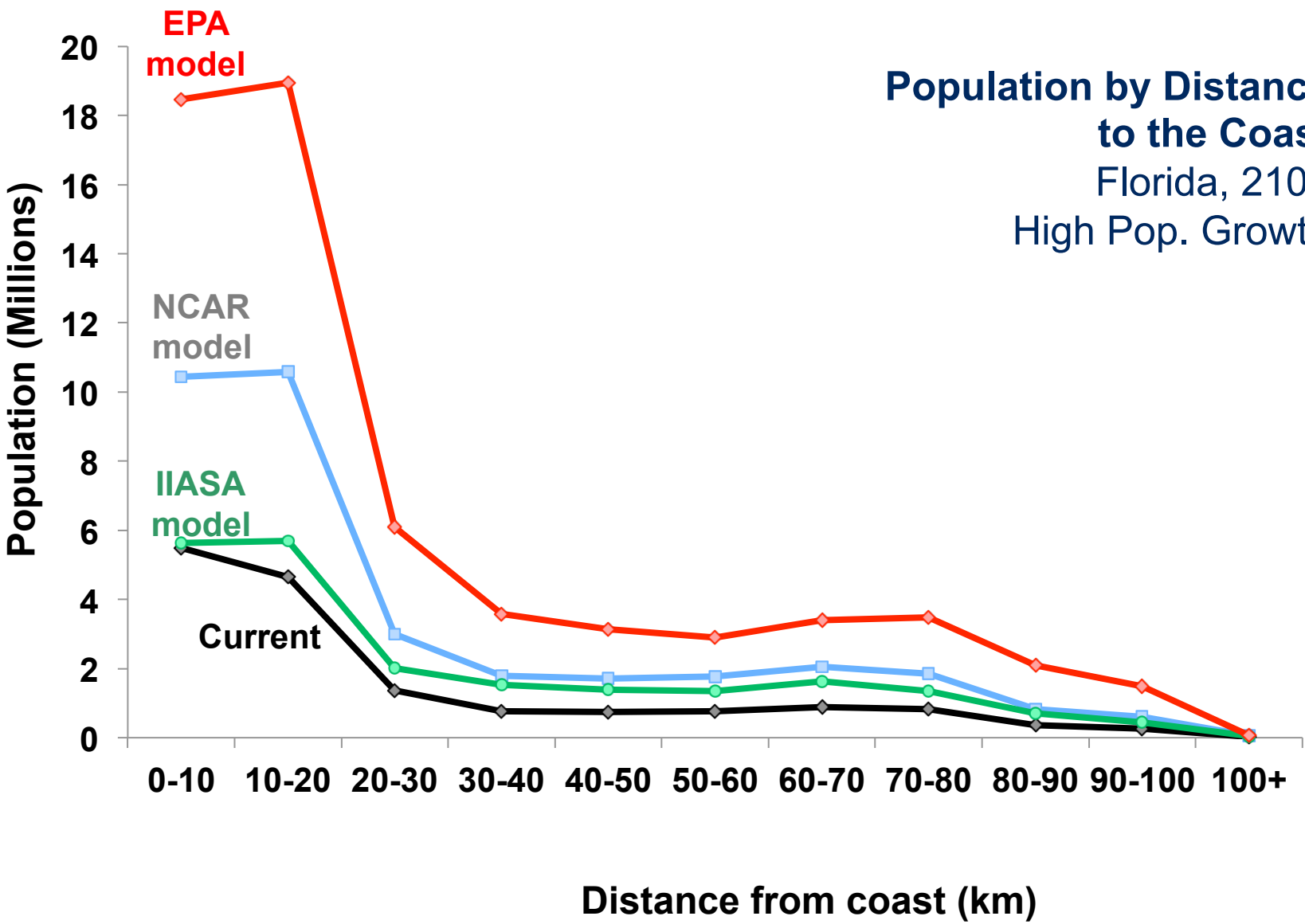
Population Exposure



2100

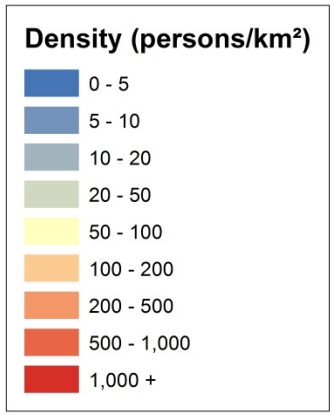
Jones & O'Neill, submitted.

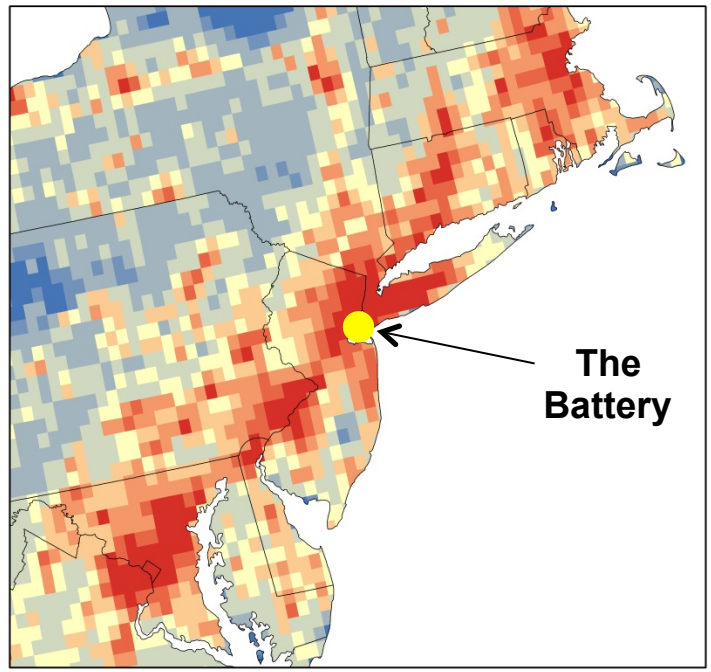
Spatial Population Projection: Florida



Jones & O'Neill, submitted.

Spatial Population Projection: Hurricane Sandy Landfall Area





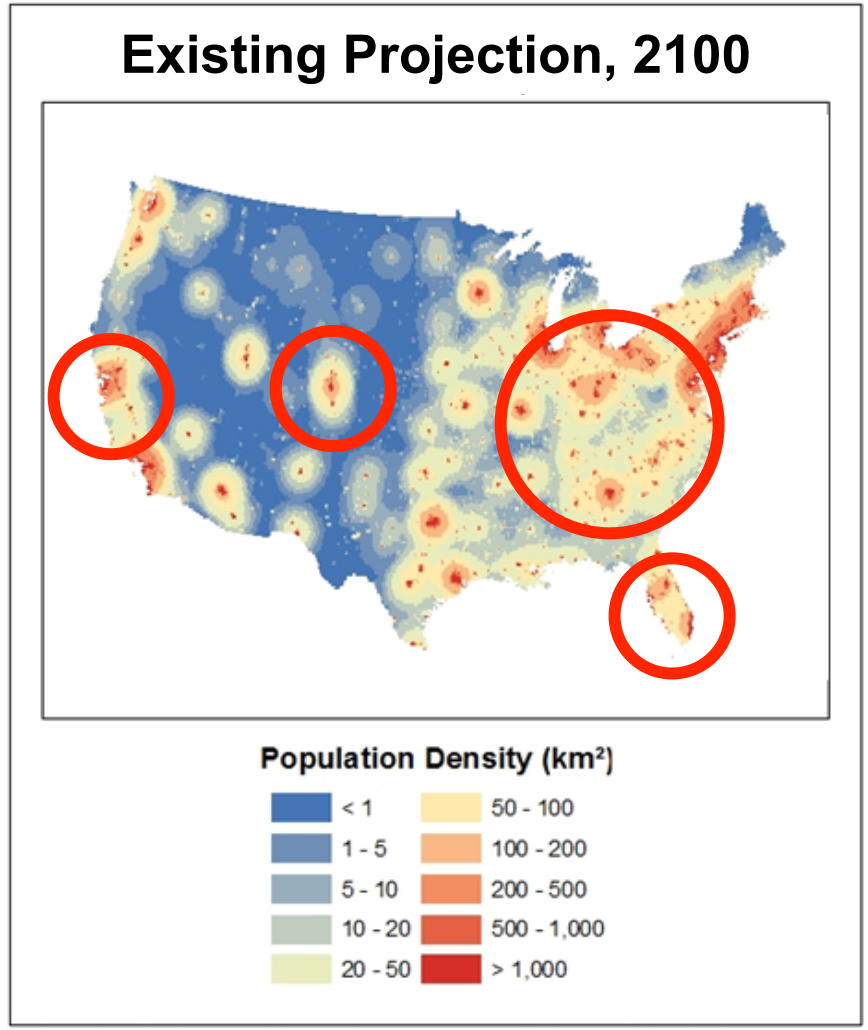
2100

Spatial Population Projection: National

State of the art, 2007

Shortcomings:

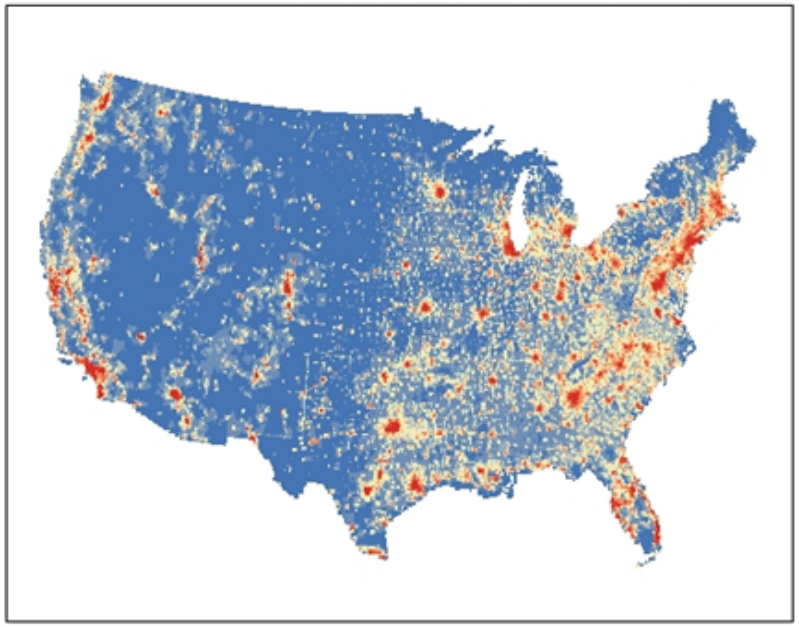
- Topography
- Protected areas
- Borders
- Calibration



Gruebler et al., 2007.

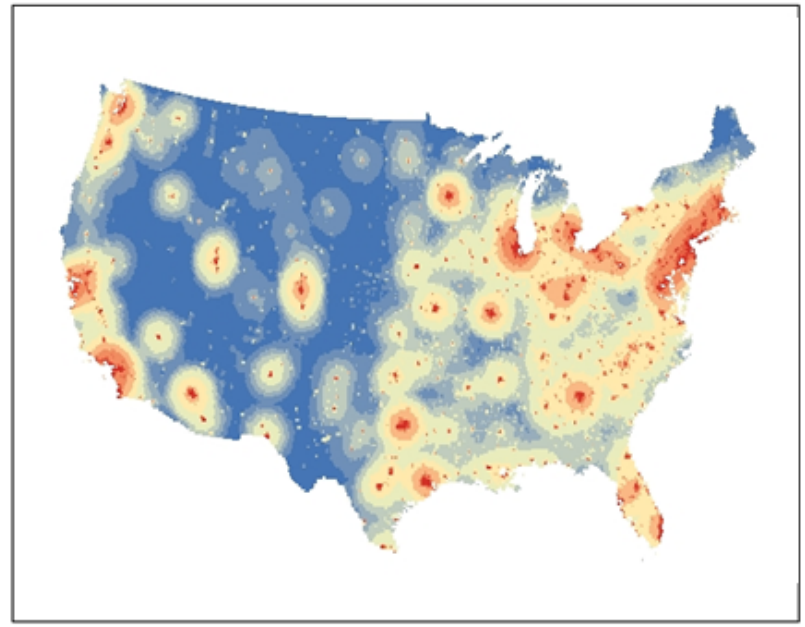
Spatial Population Projection: National

NCAR Projection, 2100



Jones & O'Neill, submitted.

Existing Projection, 2100

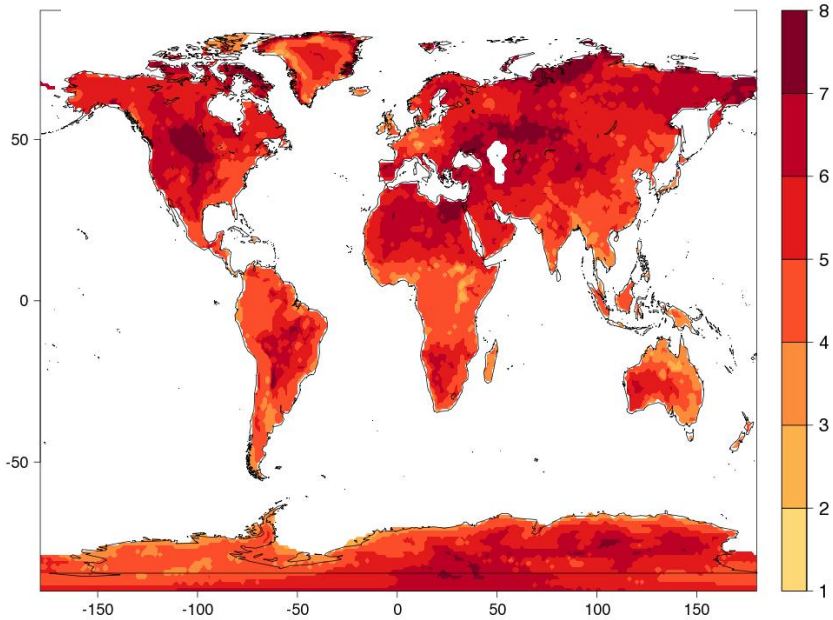


Gruebler et al., 2007.

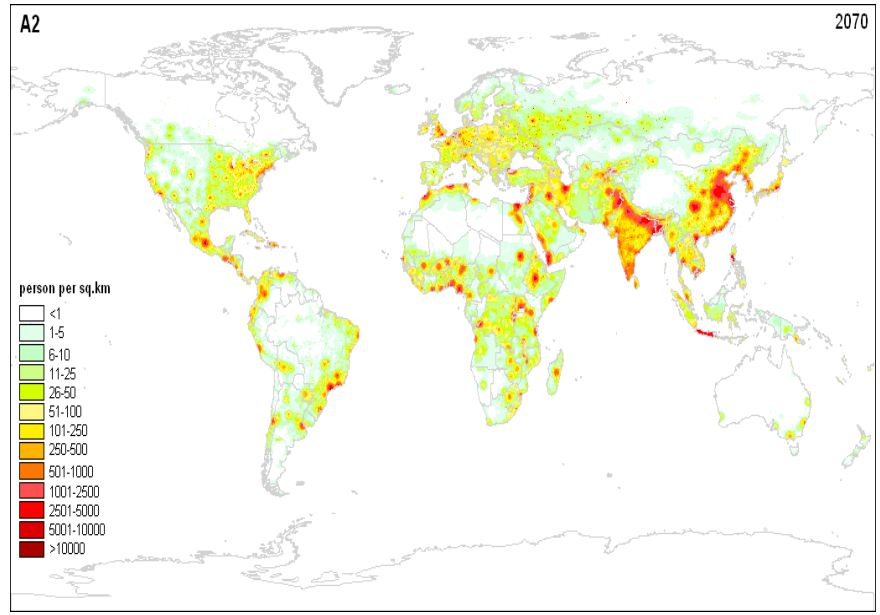
Same national total population in 2100!

Spatial Population Projection: Global

Projected Heat Extremes

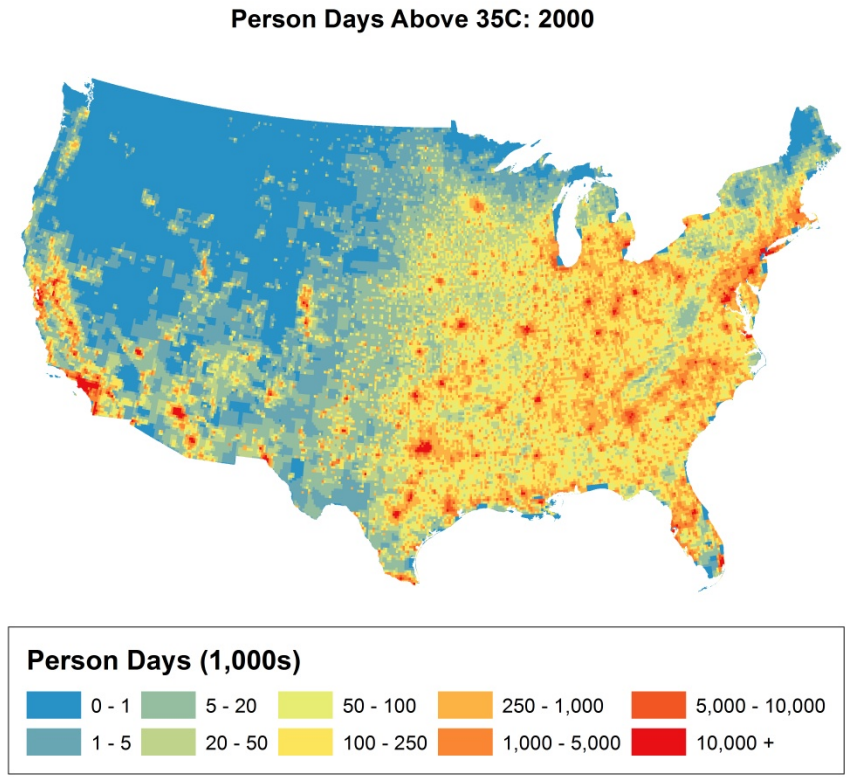


Projected Population Distribution



Gruebler et al., 2007.

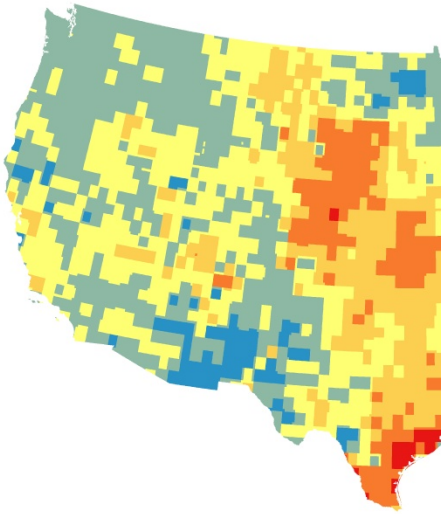
Current exposure to extreme heat: days above 35 C (95 F)



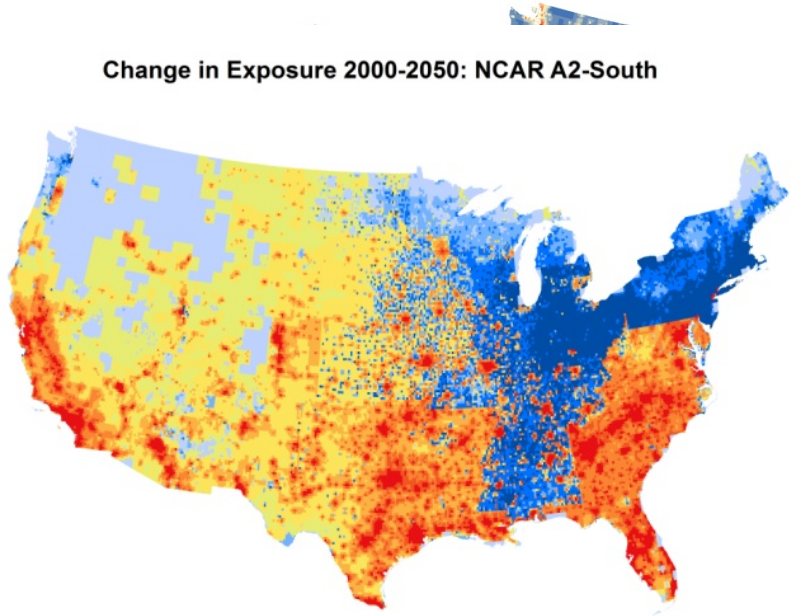
Exposure analysis from B. Jones, B. O'Neill, L. McDaniel (NCAR)

Current exposure to extreme heat: days above 35 C (95 F)

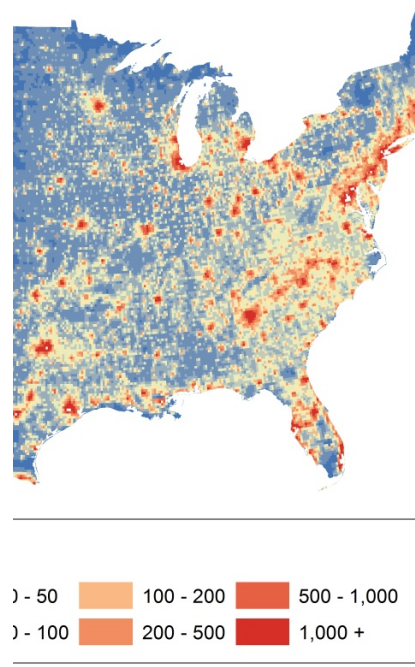
Change in days above 35C: 2000-2050



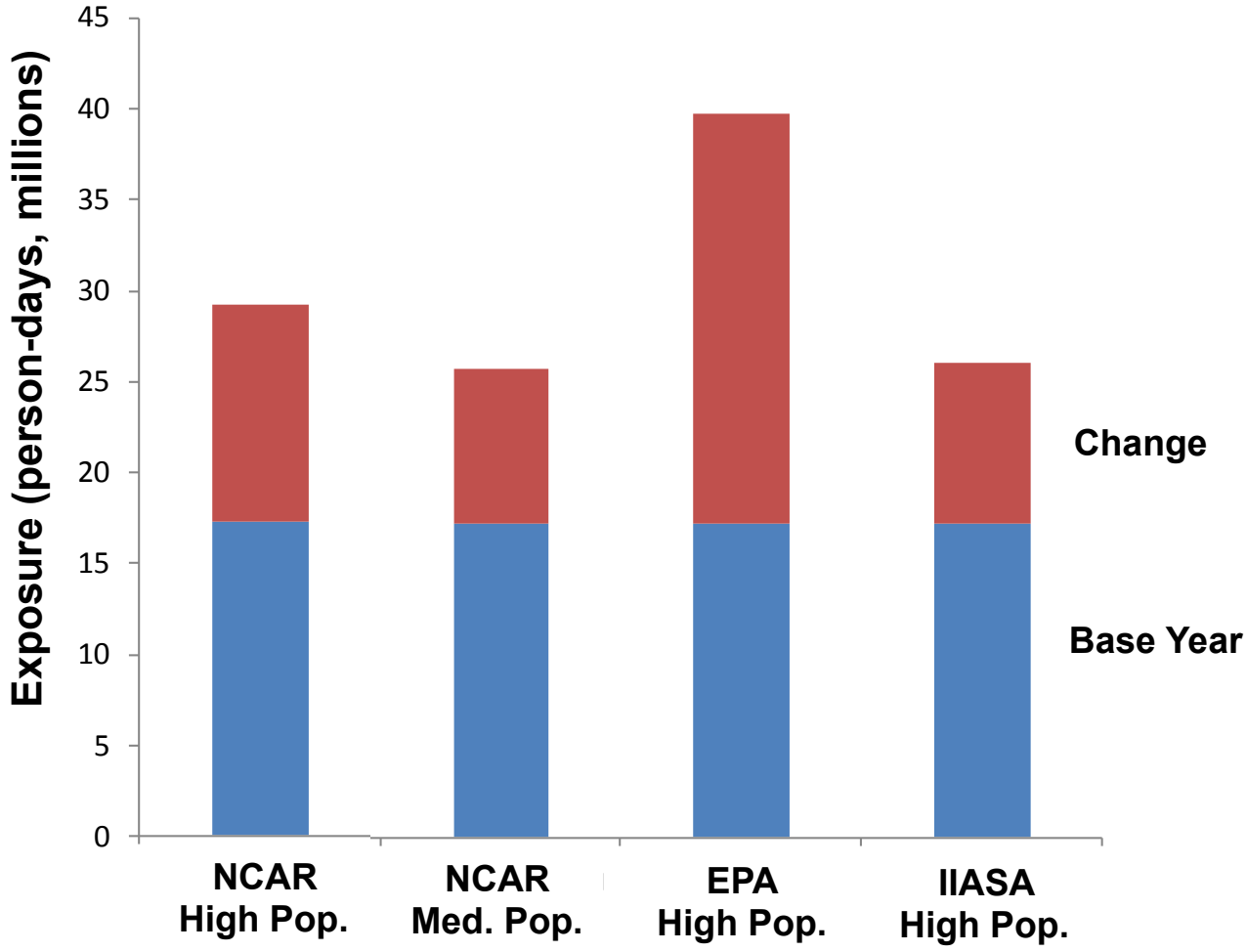
Change in Exposure 2000-2050: NCAR A2-South



Population Density, 2050: NCAR A2-South



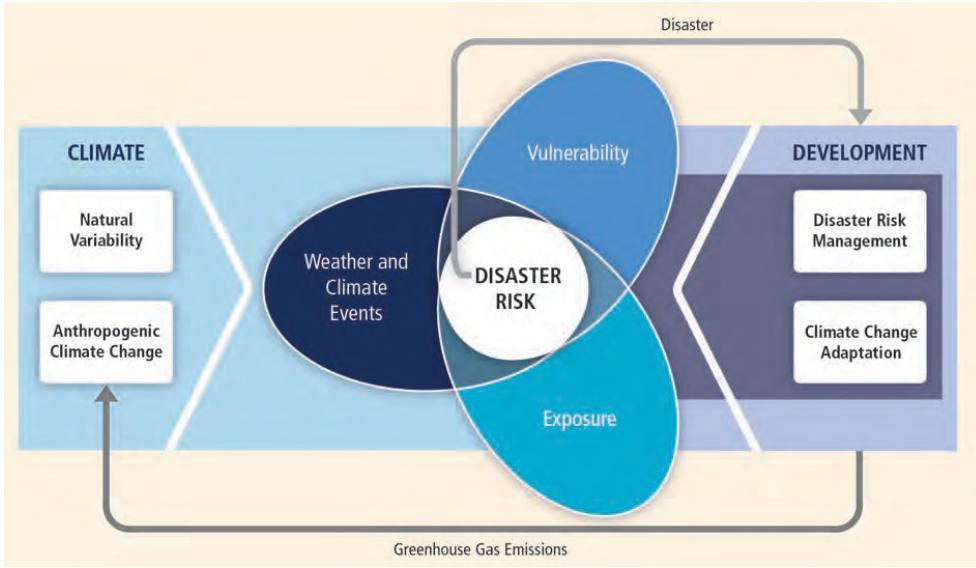
Total national 2050 exposure to extreme heat



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).

Excel chart like last one but % pop growth and % exposure growth

Model	Exposure (millions of person days)			% Change	% Change
	2000	2050	Change	Exposure	Population
NCAR A2-South	17,251.603	29,151.028	11,899.425	68.98%	33.73%
NCAR A2-Divisional	17,251.603	29,267.352	12,015.749	69.65%	33.73%
NCAR B2-Divisional	17,251.603	25,760.148	8,508.545	49.32%	17.78%
EPA A2	17,251.603	39,748.560	22,496.956	130.41%	79.85%
IIASA A2	17,251.603	26,147.375	8,895.771	51.56%	33.73%

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

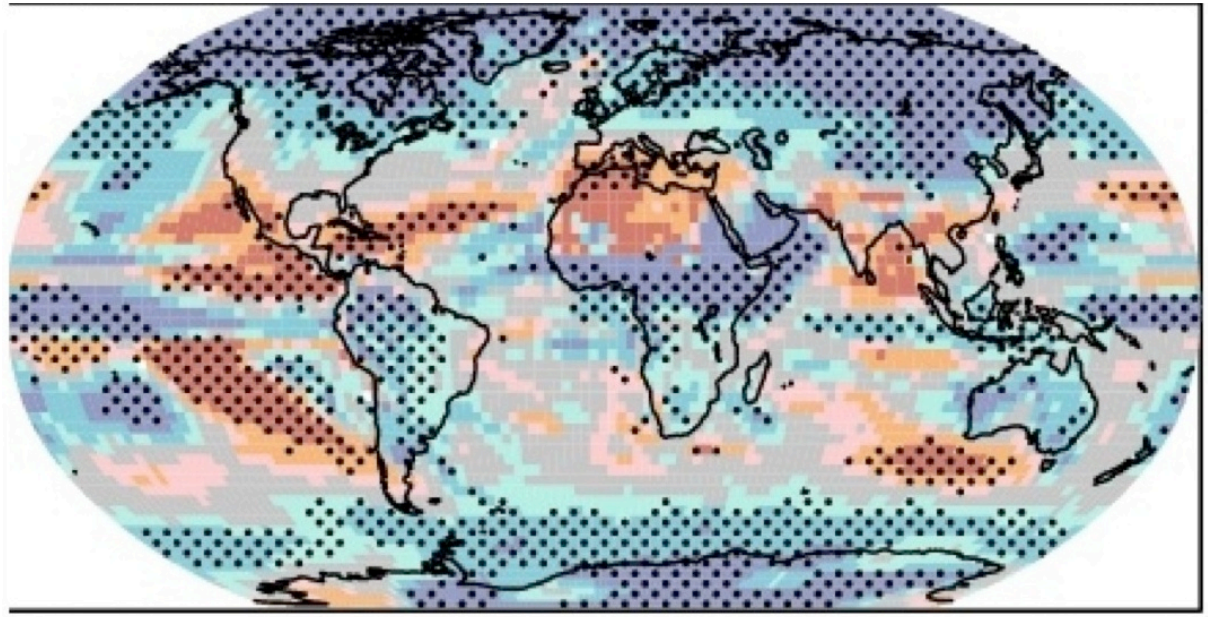
When the shift in variance is more relevant:
Precipitation extremes

Green/Blue/Purple: Increase in precipitation amounts

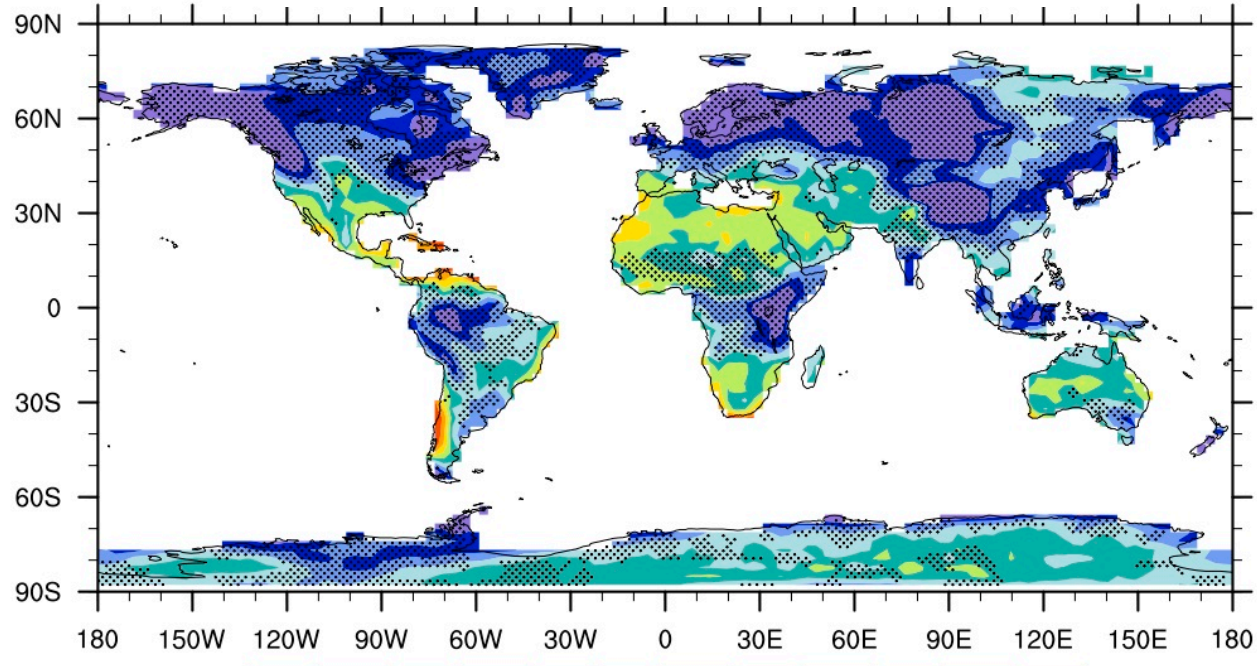
Pink/Orange/Yellow/Brown: Decrease in precipitation amounts

Stippling: Model consensus

Future Changes in Mean Precipitation



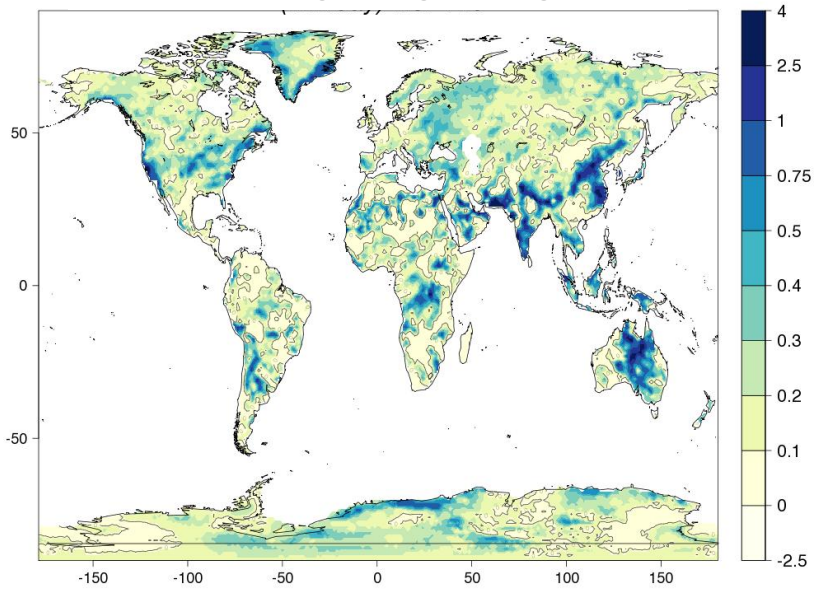
Future Changes in Precipitation Intensity



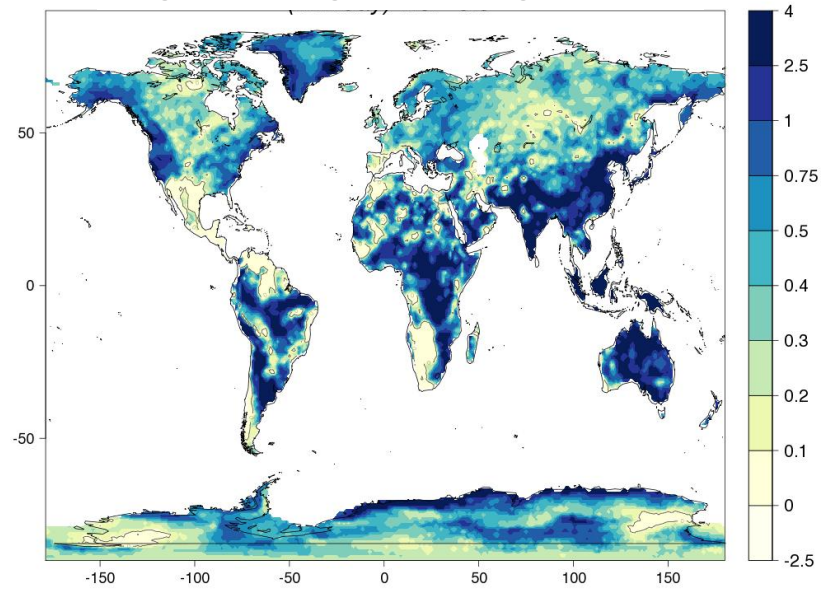
Meehl et al., 2005: Understanding future patterns of increased precipitation intensity in climate model simulations. *GRL*
Tebaldi et al., 2007: Going to the extremes. *Climatic Change*
Tebaldi et al., 2012: Mapping model agreement on future climate projections. *GRL*

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

Low Forcing – High Mitigation



High Forcing – No Mitigation



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