Usability of Climate Model Outputs in Determining Future Rainfall Frequency in the Chicago Region

Momcilo Markus, Greg Byard, Jim Angel, Sally McConkey, Mary Richardson, Zoe Zaloudek, Chen Zhang, Ariel Wang
Illinois Stare Water Survey
University of Illinois

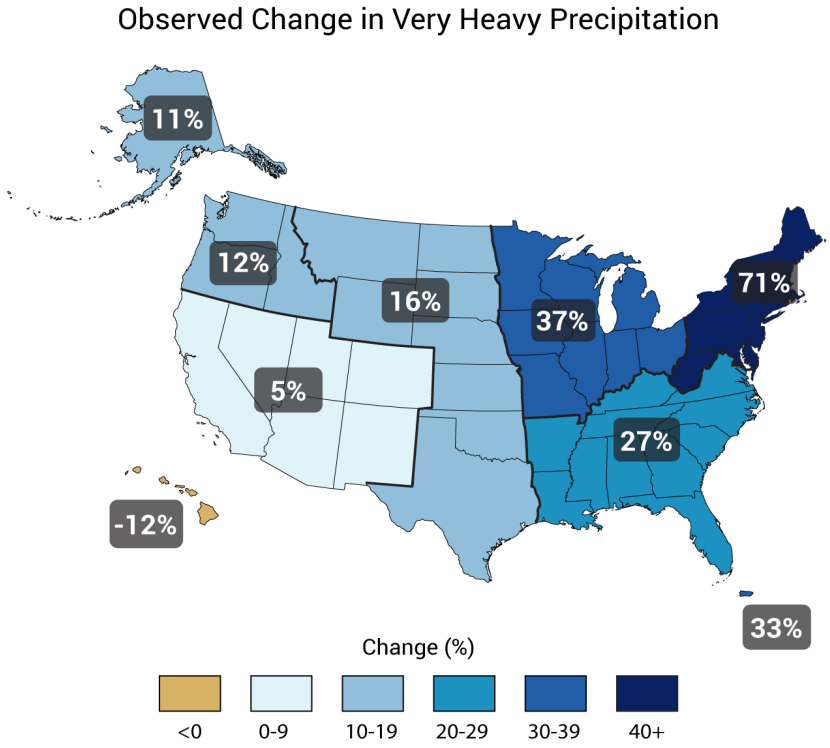
On average, over the past 20 years in the U.S., flooding has claimed over 90 lives annually

Courtesy of Clayton Ballerine, ISWS

Flooding is responsible for more fatalities than any other severe weather related phenomenon.

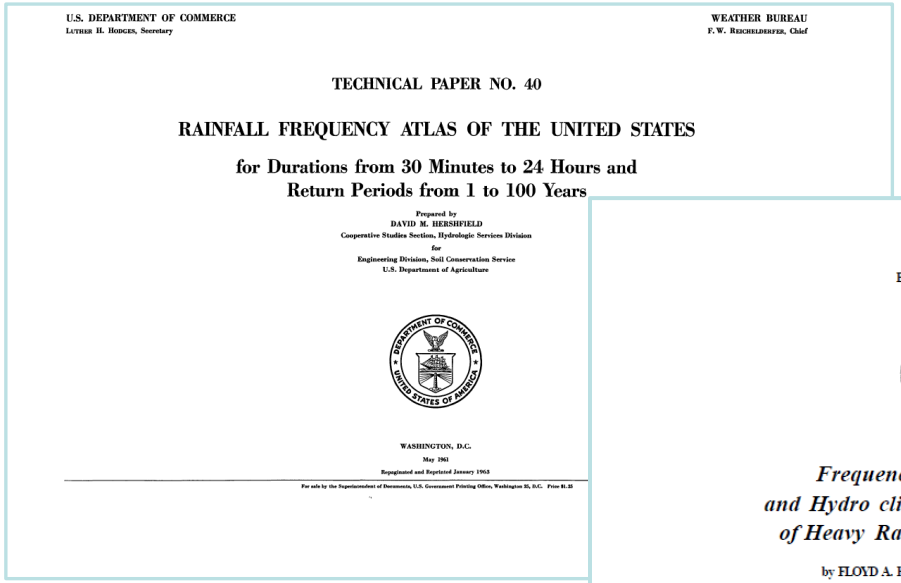
On average, over the past 20 years in the U.S., flooding has caused damages in excess of $7 billion annually

Observed change in the heaviest 1% rainfall events



Percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2007 for each region of the continental United States. The changes shown in this figure are calculated from the beginning and end points of the trends for 1958 to 2007. (Figure source: updated from Karl et al. 2009)

Rainfall frequency sources
TP-40, ISWS Bulletin 70/NOAA Atlas 14



U.S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

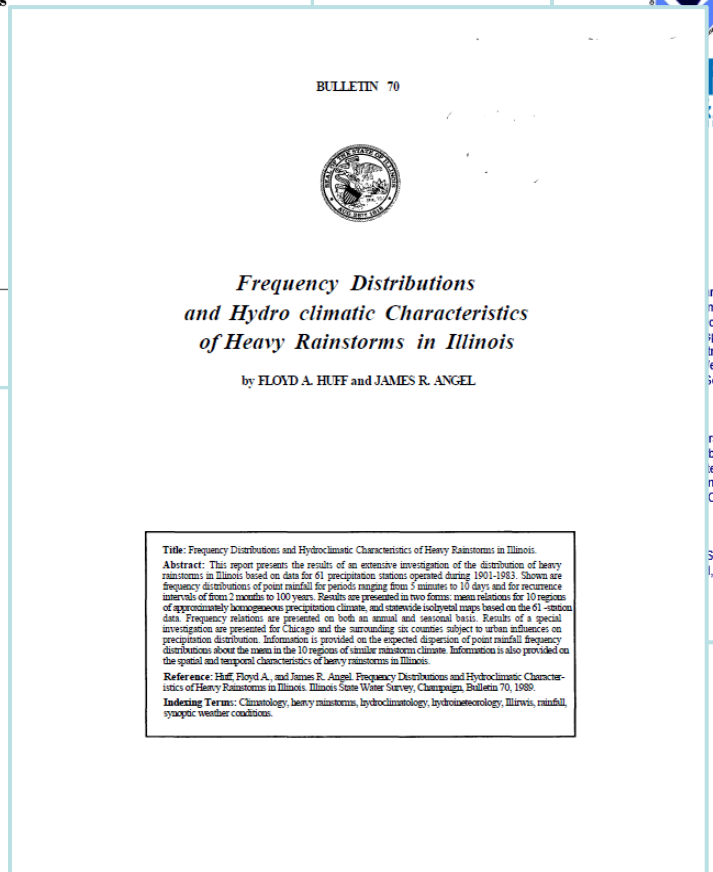
TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and
Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division
for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

WASHINGTON, D.C.
May 1961
Reprogrammed and Reprinted January 1963



BULLETIN 70

Frequency Distributions
and Hydro climatic Characteristics
of Heavy Rainstorms in Illinois

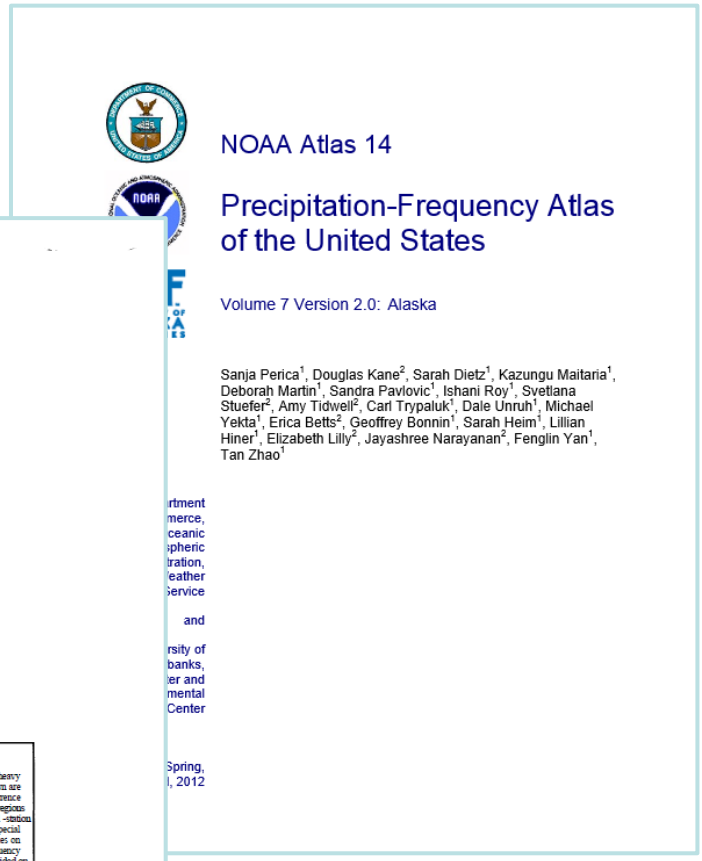
by FLOYD A. HUFF and JAMES R. ANGEL

Title: Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois.

Abstract: This report presents the results of an extensive investigation of the distribution of heavy rainstorms in Illinois based on data for 61 precipitation stations operated during 1901-1983. Shown are frequency distributions of point rainfall for periods ranging from 5 minutes to 10 days and for recurrence intervals of from 2 months to 100 years. Results are presented in two forms: mean relations for 10 regions of approximately homogeneous precipitation climate, and statewide isohyetal maps based on the 61 -station data. Frequency relations are presented on both an annual and seasonal basis. Results of a special investigation are presented for Chicago and the surrounding six counties subject to urban influences on precipitation distribution. Information is provided on the expected dispersion of point rainfall frequency distributions about the mean in the 10 regions of similar rainstorm climate. Information is also provided on the spatial and temporal characteristics of heavy rainstorms in Illinois.

Reference: Huff, Floyd A., and James R. Angel, Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois. Illinois State Water Survey, Champaign, Bulletin 70, 1989.

Indexing Terms: Climatology, heavy rainstorms, hydroclimatology, hydrometeorology, Illinois, rainfall, synoptic weather conditions.



NOAA Atlas 14

Precipitation-Frequency Atlas of the United States

Volume 7 Version 2.0: Alaska

Sanja Perica[1], Douglas Kane[2], Sarah Dietz[1], Kazungu Maitaria[1], Deborah Martin[1], Sandra Pavlovic[1], Ishani Roy[1], Svetlana Stuefer[2], Amy Tidwell[2], Carl Trypaluk[1], Dale Unruh[1], Michael Yekta[1], Erica Betts[2], Geoffrey Bonnin[1], Sarah Heim[1], Lillian Hiner[1], Elizabeth Lilly[2], Jayashree Narayanan[2], Fenglin Yan[1], Tan Zhao[1]

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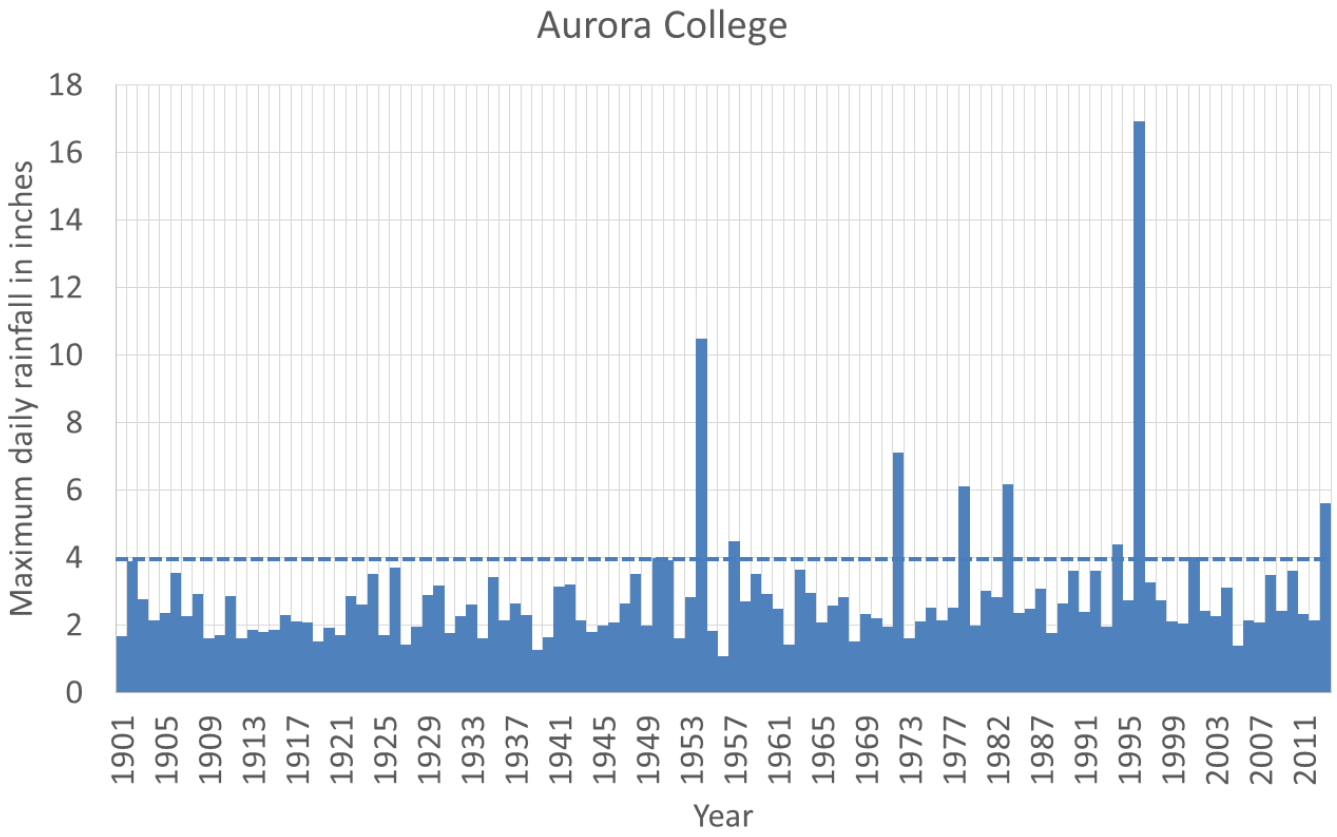
Spring,
, 2012

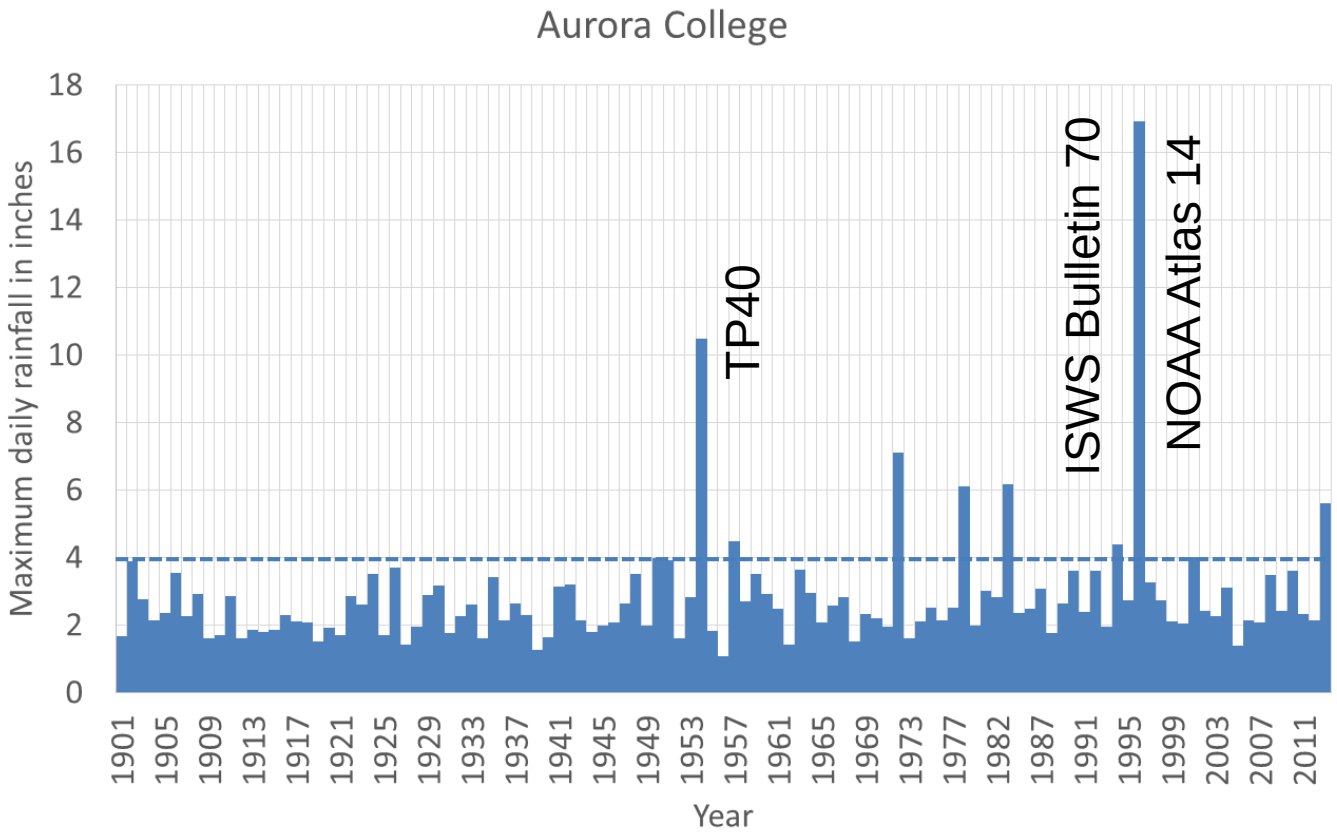
Annual Maximum Daily Rainfall

(none of the 10 largest values at Aurora College were observed prior to 1950)

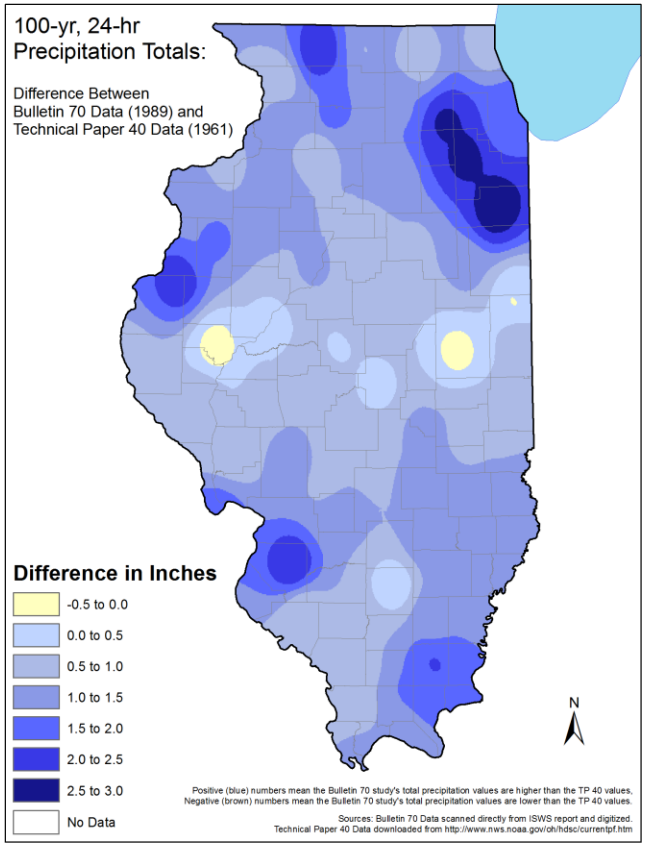


Annual Maximum Daily Rainfall

(none of the 10 largest values at Aurora College were observed prior to 1950)

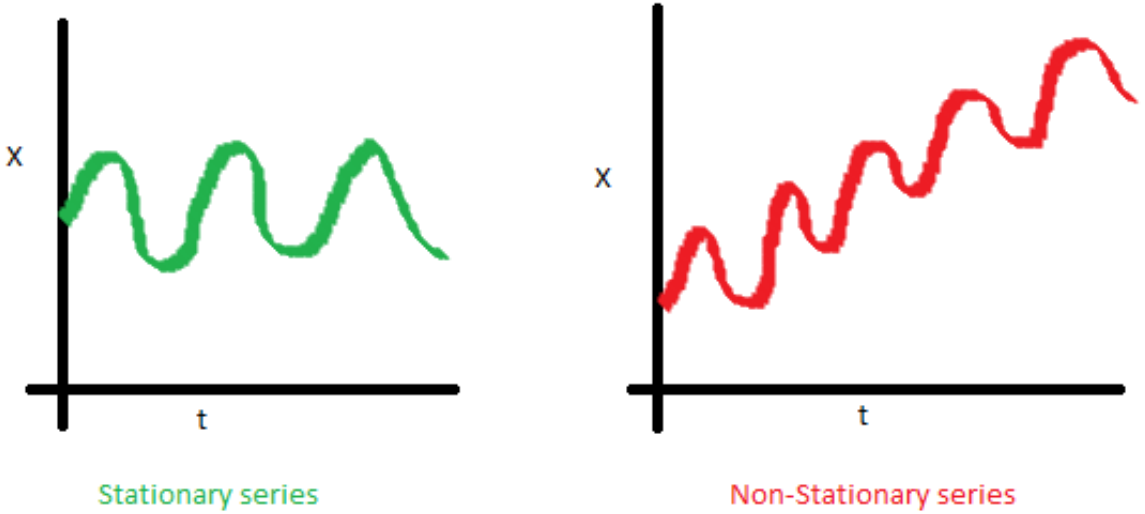


Difference between TP-40 and Bulletin 70



Stationarity of heavy rainfall

- Hydro-climatologists have used long-term rainfall records to estimate the probability of extreme events (e.g., the 100 year storm) occurring in the future, assuming that future variability will be like past variability.
- This assumption is called “stationarity.”



- In the light of climate change, that assumption now appears to be problematic.

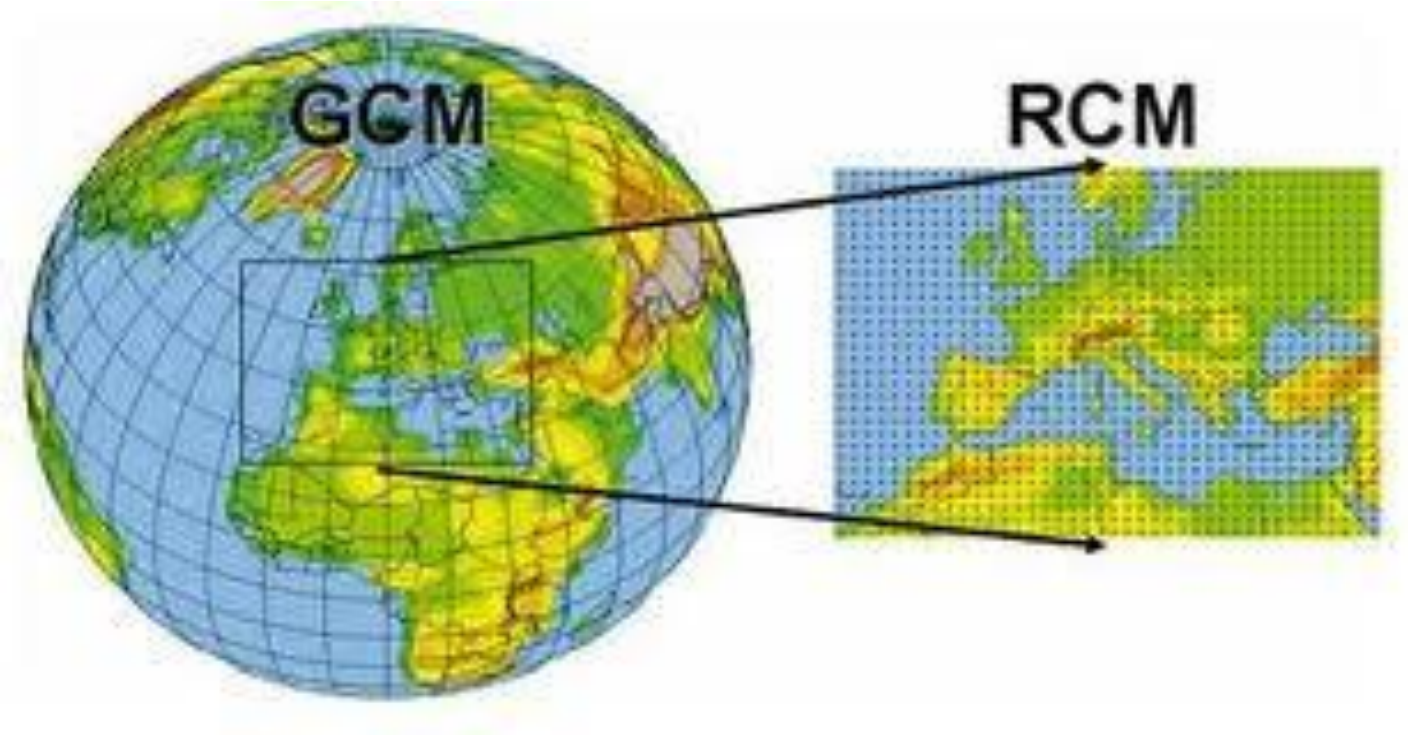
Climate modeling

A climate model = an atmosphere model, an ocean model, a land model, and a sea ice model.

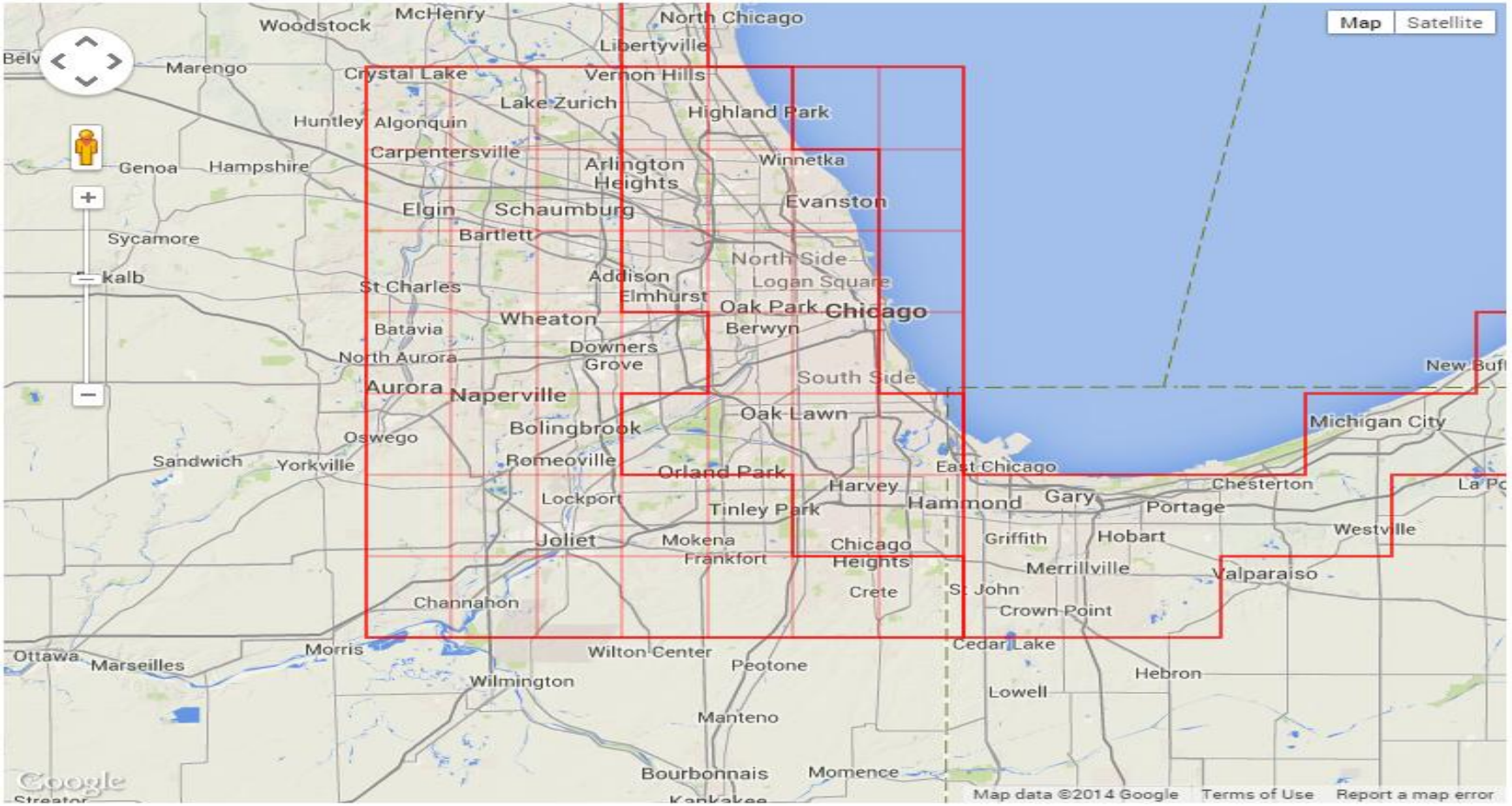
Inputs = the concentration of greenhouse gases, the intensity of sunlight, the amount of deforestation, and volcanoes that should erupt during the simulation.

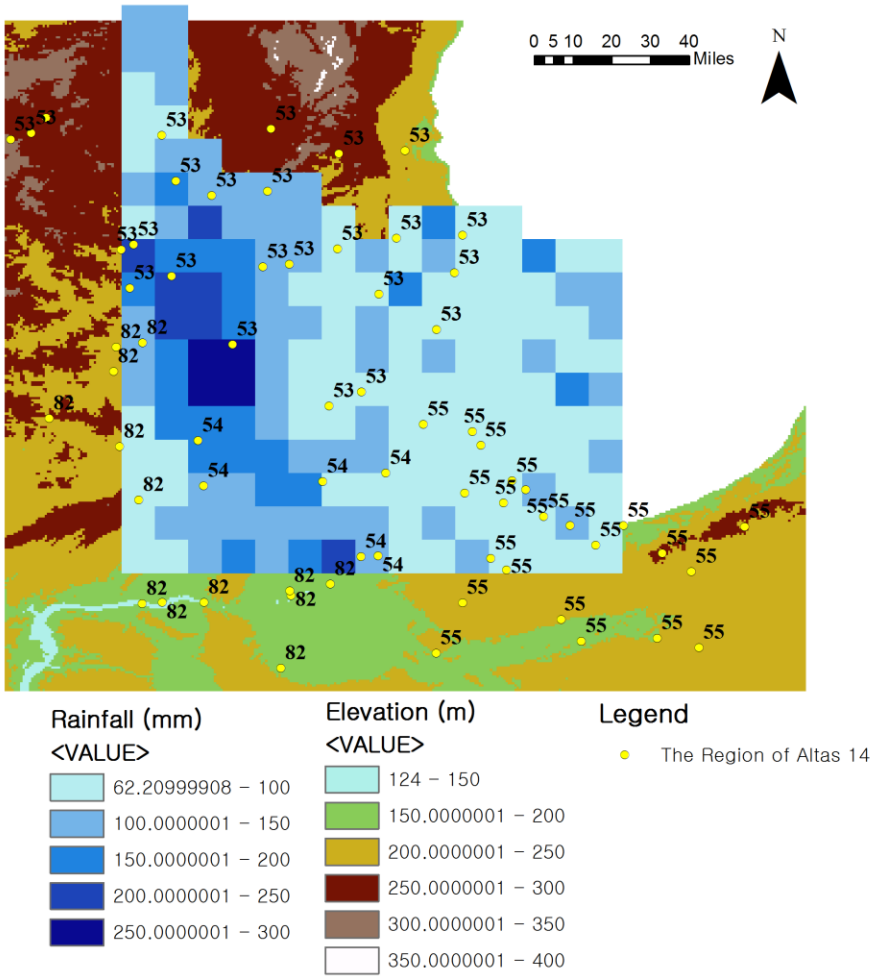
Outputs = atmospheric pressure, ocean salinity, forest cover, temperature, precipitation, clouds,…

Climate Downscaling



Climate Downscaling

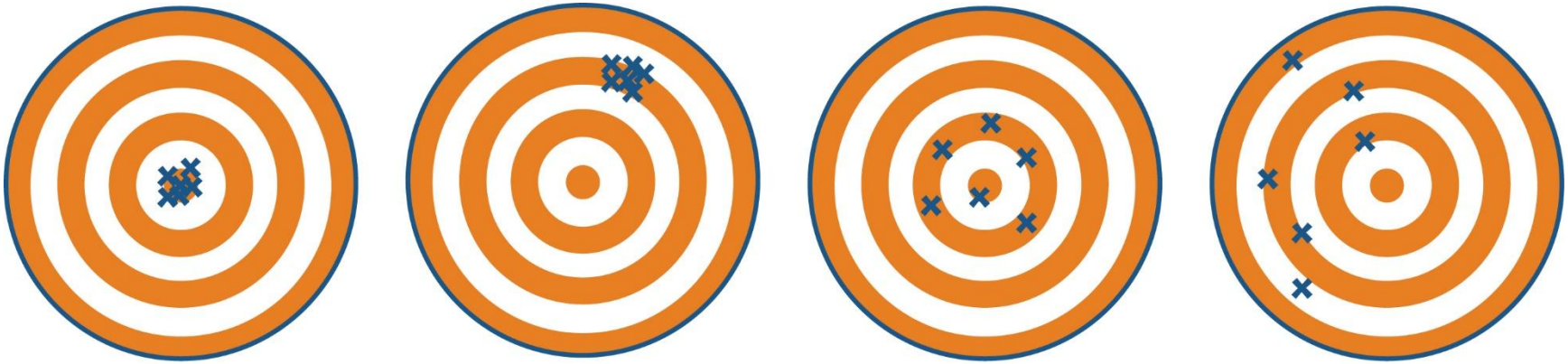



0 5 10 20 30 40
Miles
N
Rainfall (mm)
<VALUE>
62.20999908 - 100
100.0000001 - 150
150.0000001 - 200
200.0000001 - 250
250.0000001 - 300
Elevation (m)
<VALUE>
124 - 150
150.0000001 - 200
200.0000001 - 250
250.0000001 - 300
300.0000001 - 350
350.0000001 - 400
Legend
The Region of Altas 14

Observed or Projected Rainfall?

Method	Pros	Cons
Observed rainfall frequency	Simple Low uncertainty	Observed data may not be representative of future time horizons.
Extrapolated rainfall frequency	Simple. Future extrapolated data are used to design future structures.	Extrapolation may not be accurate for all time horizons.
Projected rainfall generated based on climate models	Projected data representing 2050 or 2100 are used to design future structures, providing more realistic outputs based on calibrated climate models.	Highly complex. Time consuming.

Modeling accuracy and precision



High Accuracy
High Precision

Low Accuracy
High Precision

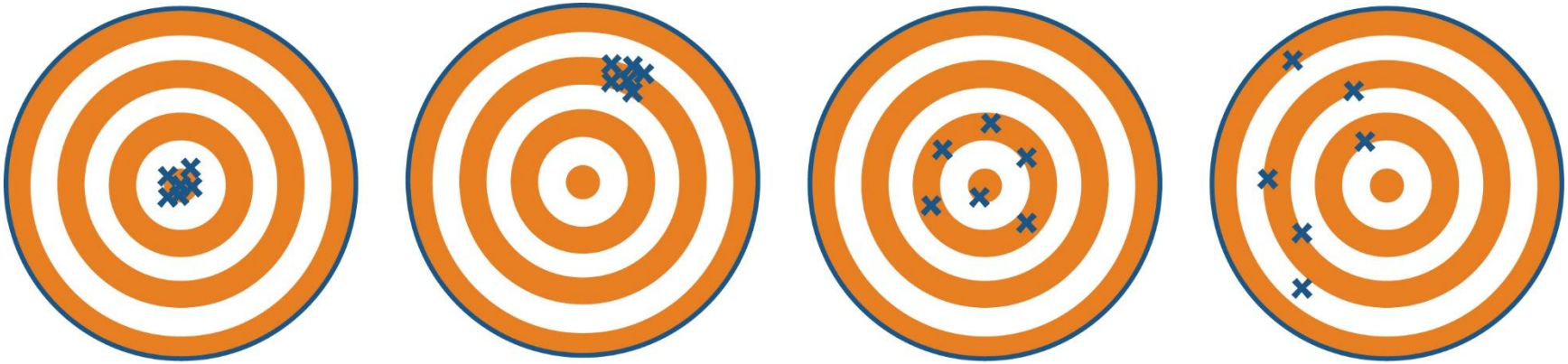
High Accuracy
Low Precision

Low Accuracy
Low Precision

Modeling accuracy and precision

STATISTICAL ANALYSIS OF OBSERVED DATA

STATISTICAL ANALYSIS OF CLIMATE MODEL-GENERATED DATA



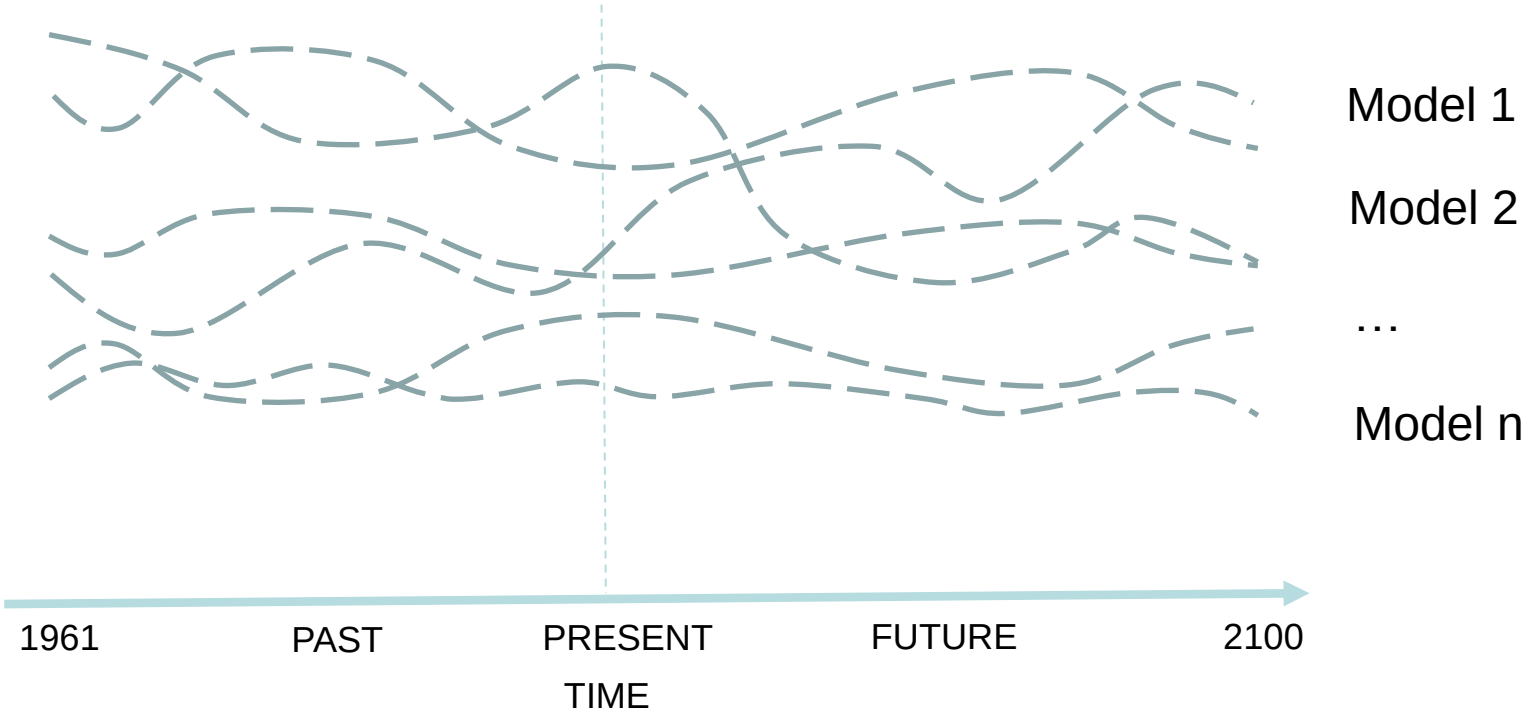
High Accuracy
High Precision

Low Accuracy
High Precision

High Accuracy
Low Precision

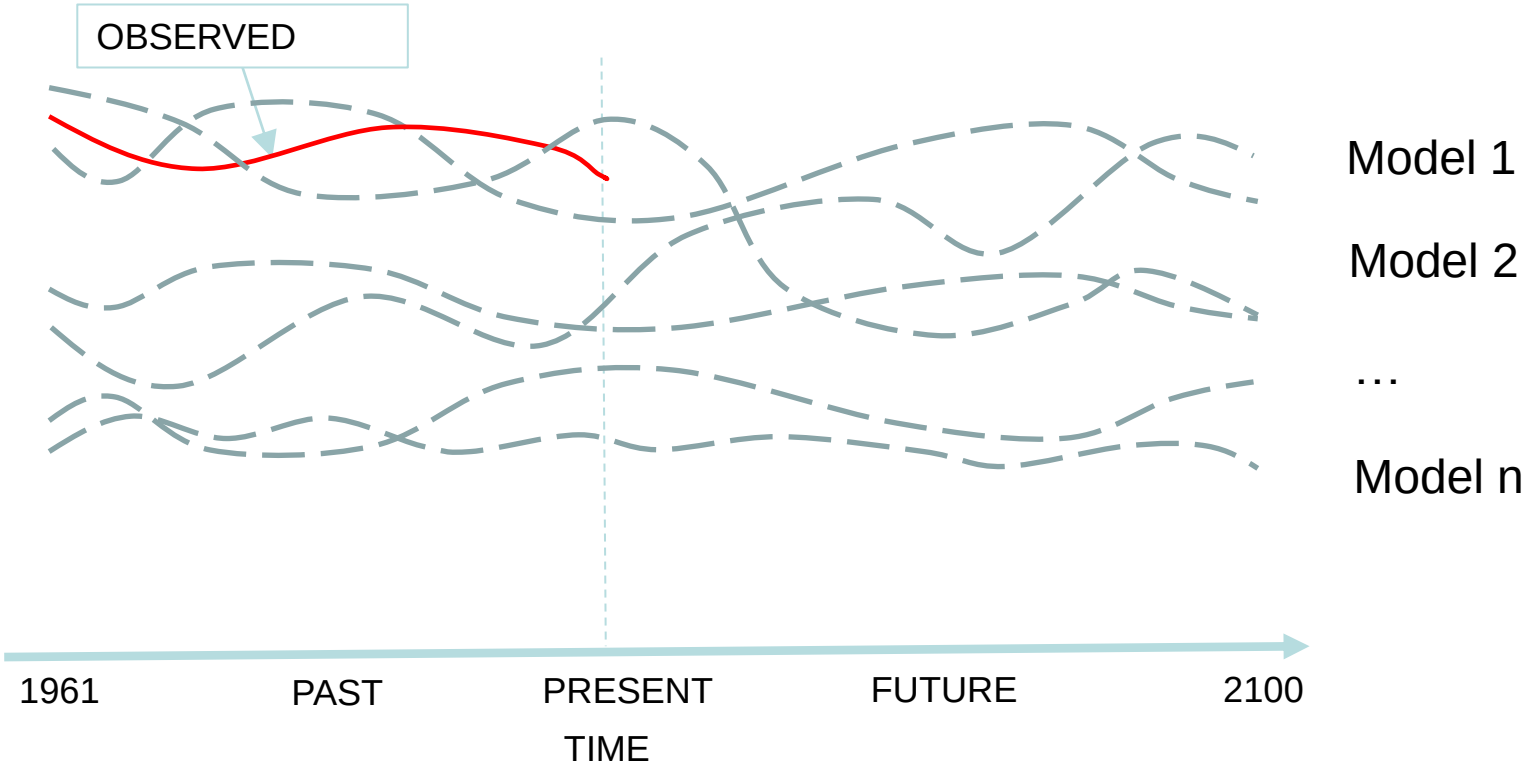
Low Accuracy
Low Precision

Schematic of climate model evaluation



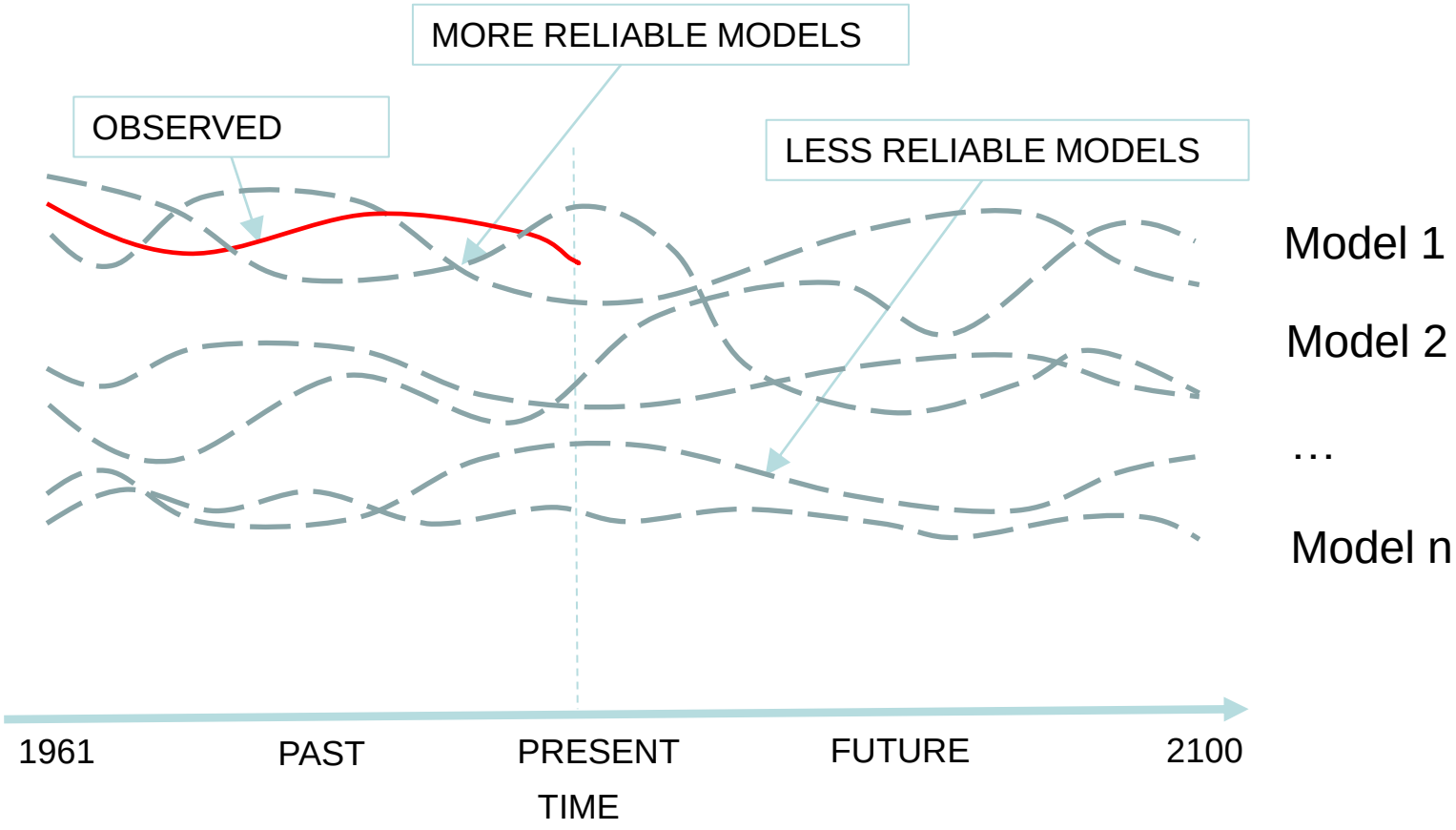
Markus, M., Angel, J., Byard, G., Chen, Z, Cai, X., and McConkey, S., 2016, "Communication of Climate Change Data for Community Assessment of Impacts of Severe Storms on Urban and Stormwater Infrastructure and Flood Risk in Cook County, Illinois", ISWS Contract report, funded by the National Oceanic and Atmospheric Administration.

Schematic of climate model evaluation



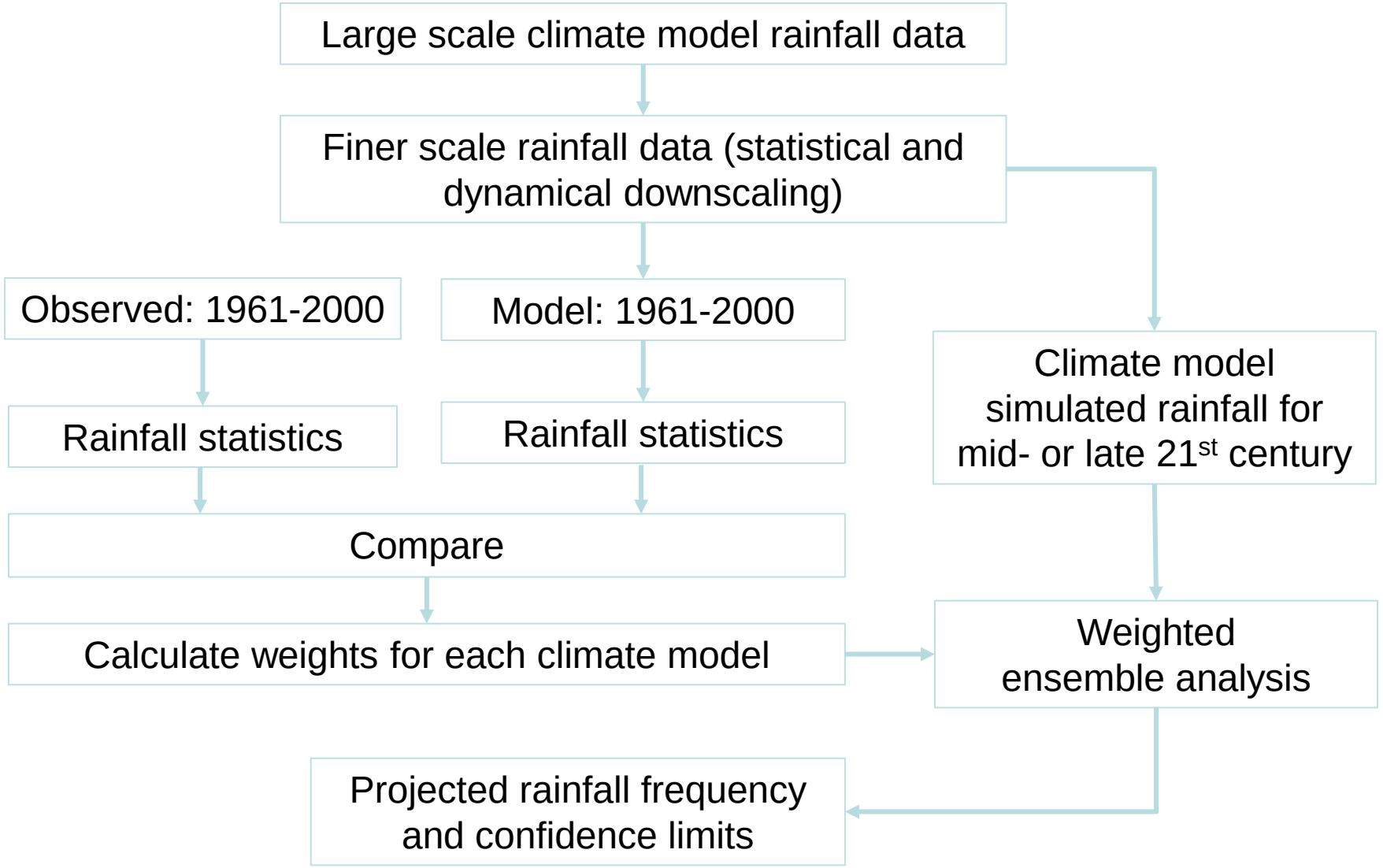
Markus, M., Angel, J., Byard, G., Chen, Z, Cai, X., and McConkey, S., 2016, "Communication of Climate Change Data for Community Assessment of Impacts of Severe Storms on Urban and Stormwater Infrastructure and Flood Risk in Cook County, Illinois", ISWS Contract report, funded by the National Oceanic and Atmospheric Administration.

Schematic of climate model evaluation

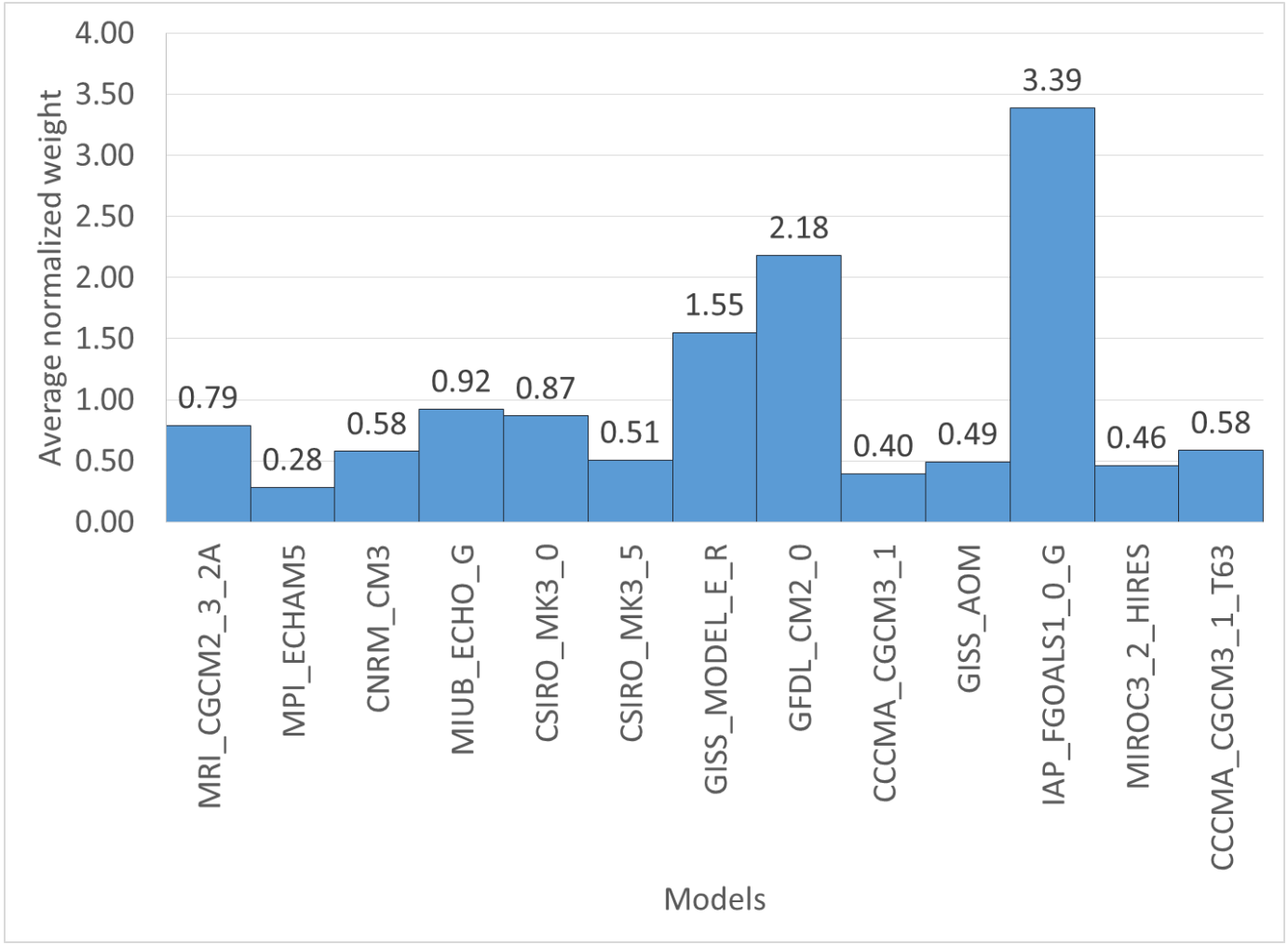


Markus, M., Angel, J., Byard, G., Chen, Z, Cai, X., and McConkey, S., 2016, "Communication of Climate Change Data for Community Assessment of Impacts of Severe Storms on Urban and Stormwater Infrastructure and Flood Risk in Cook County, Illinois", ISWS Contract report, funded by the National Oceanic and Atmospheric Administration.

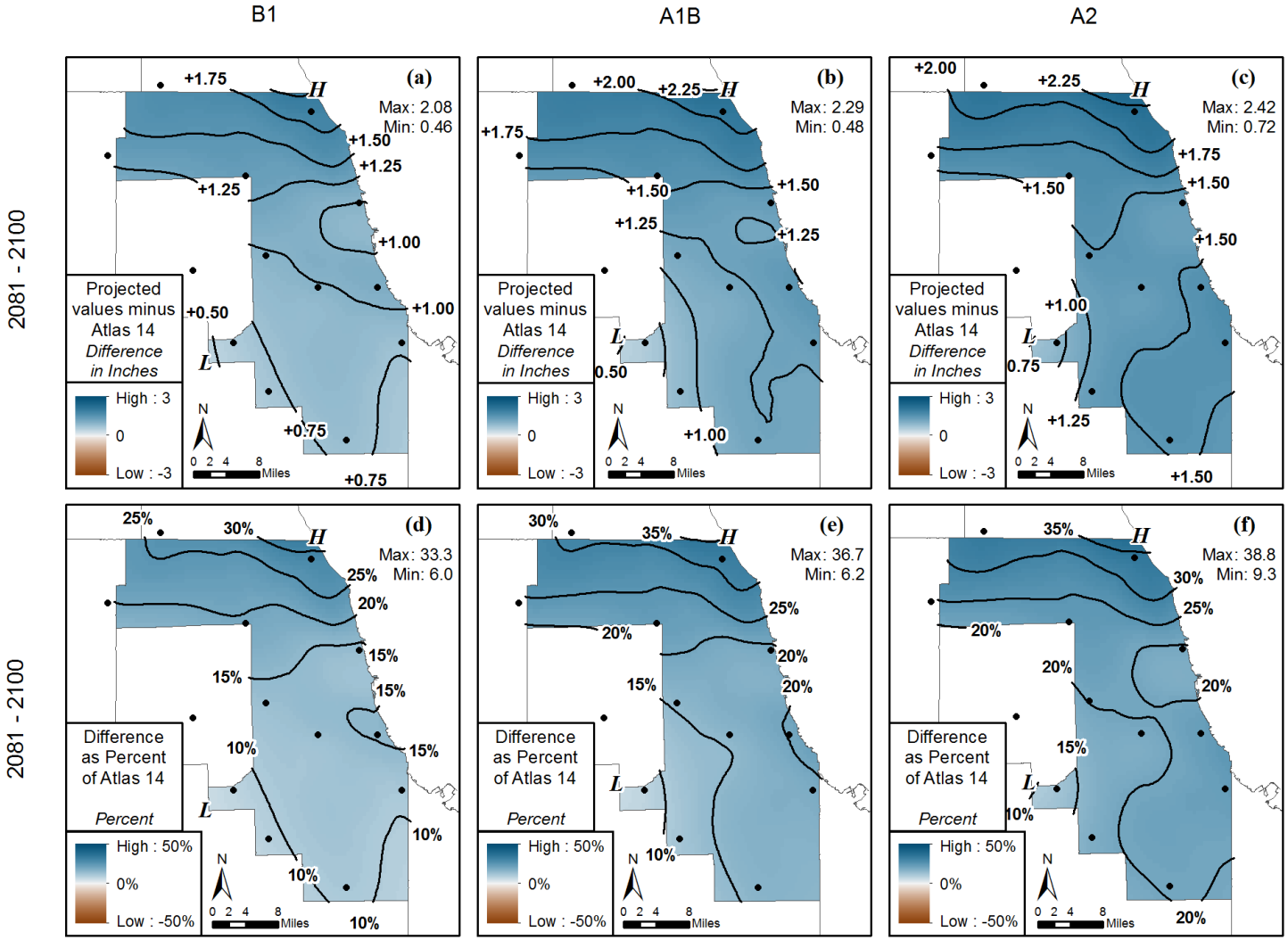
Weighted Ensemble Analysis for heavy rainfall



Model weights (example for NE Illinois)



Differences between projected 100-year, 24-hour isohyetals for late-21st century and those based on NOAA Atlas 14

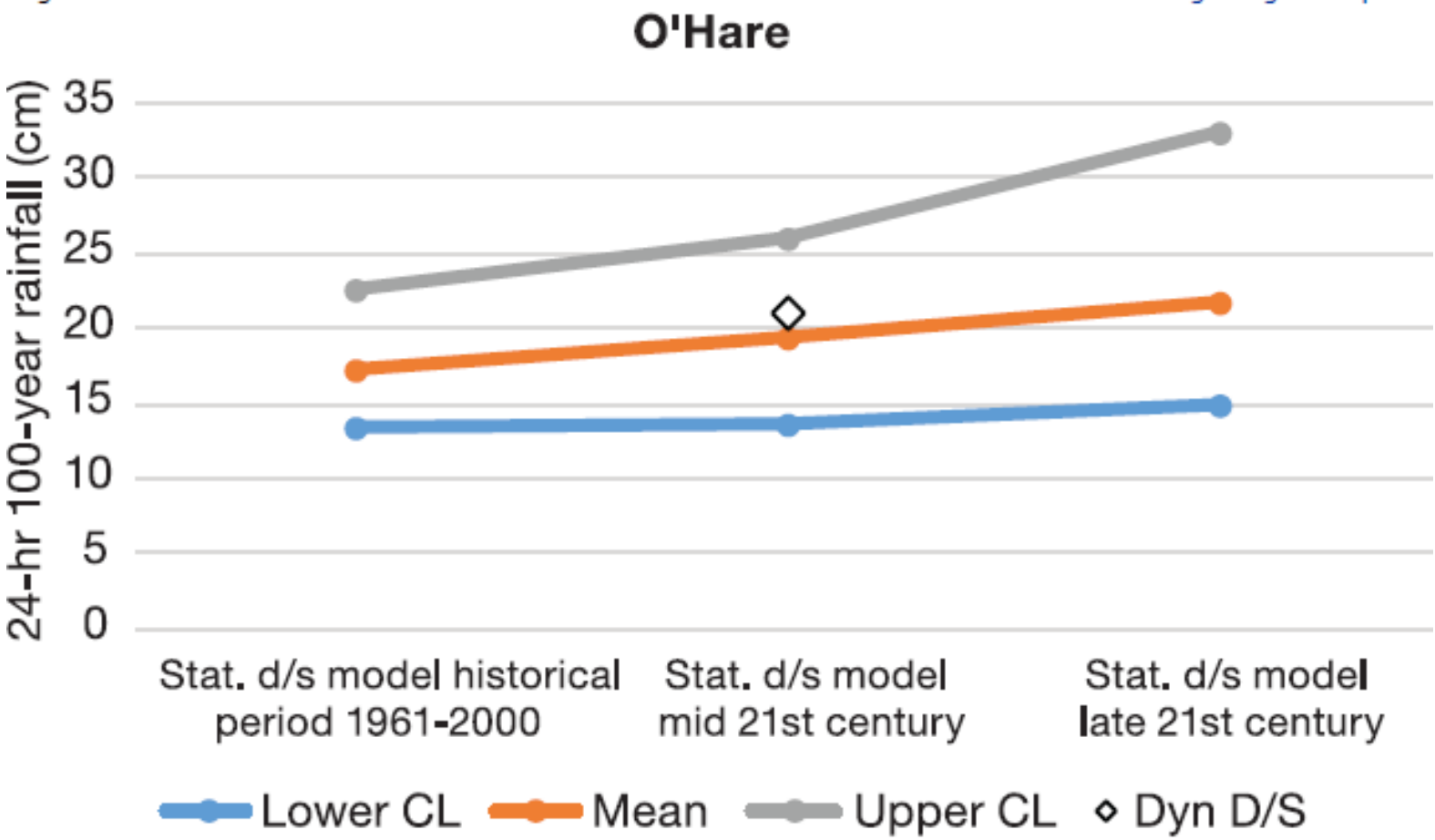


These results are not designed for operational use, nor do they replace the existing sources

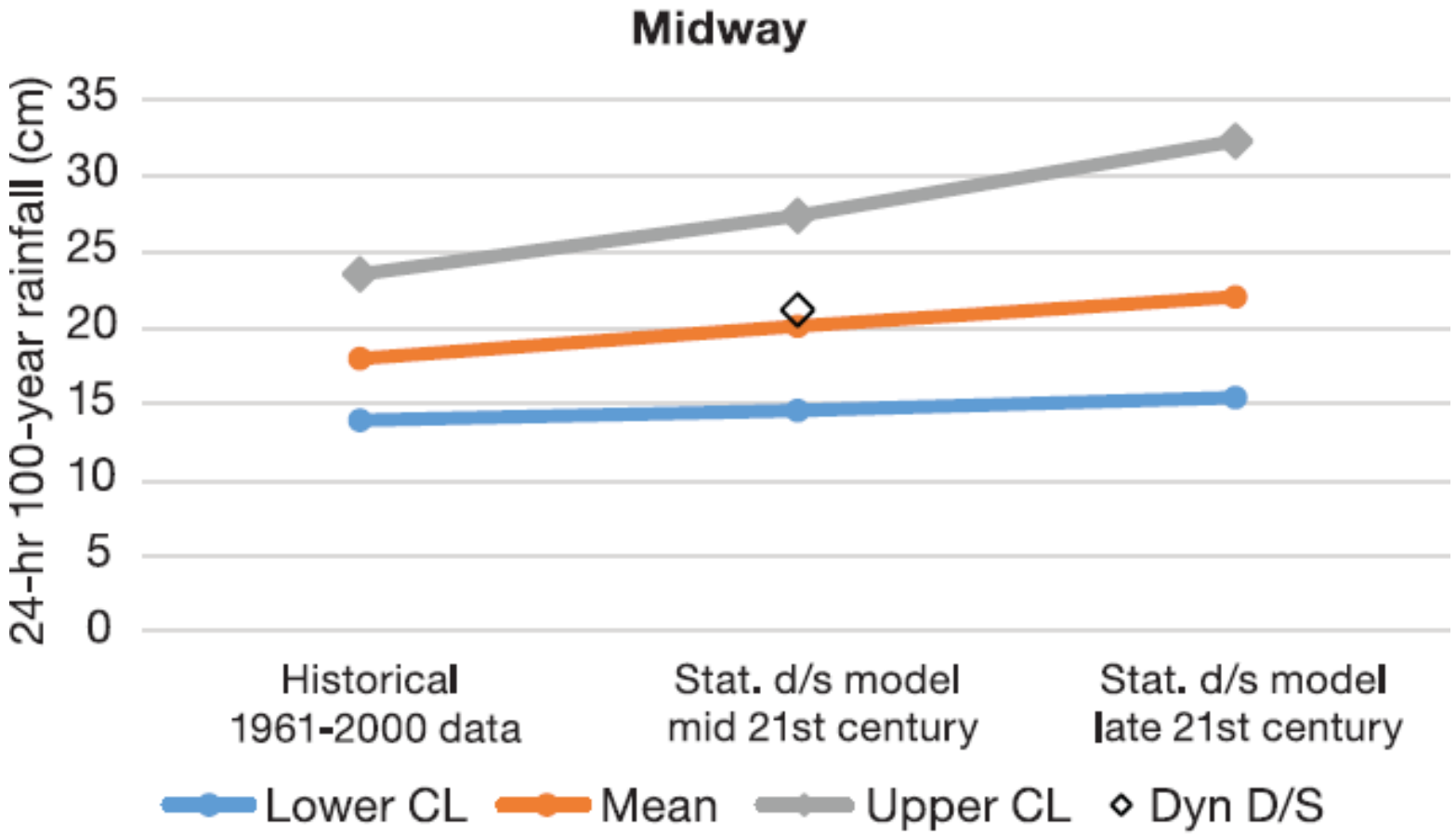
100-yr 24-hour rainfall
Consistency with other approaches

Figure 13

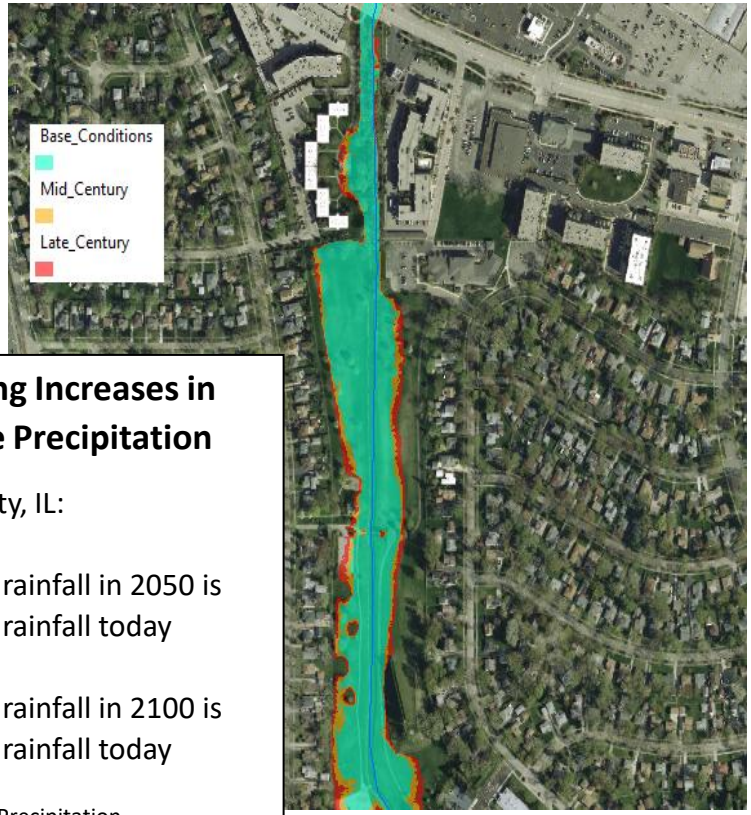
Click here to download Figure Figure 13.eps

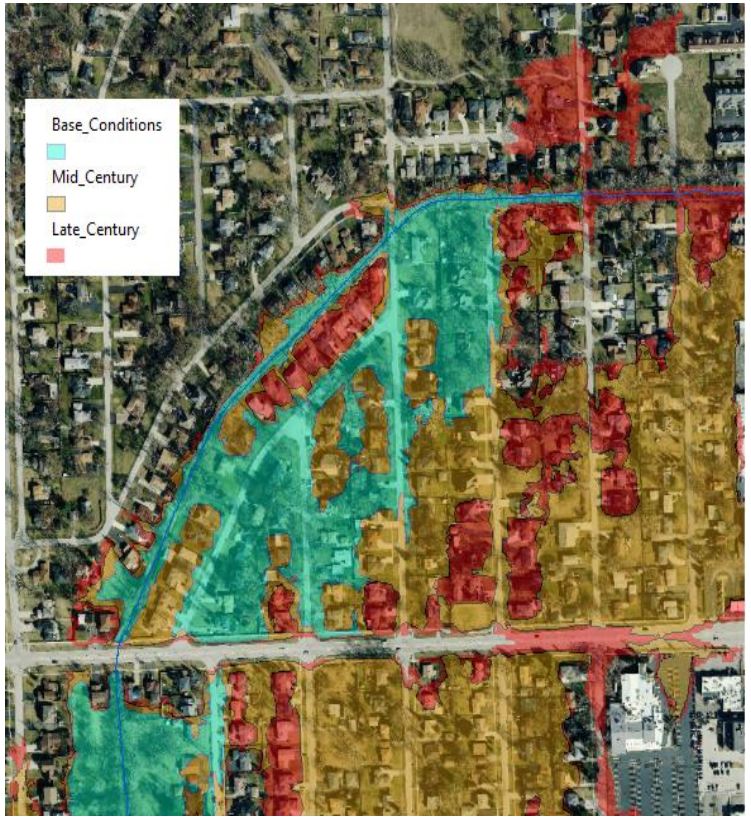


100-yr 24-hour rainfall
Consistency with other approaches



Projected flooding in Cook County, IL





Managing Increases in Extreme Precipitation

In Cook County, IL:

The 100-year rainfall in 2050 is
The 165-year rainfall today

The 100-year rainfall in 2100 is
The 250-year rainfall today

SRES A2. 24-hour Precipitation

The 1% Annual Chance (100-year) floodplains of Upper Salt Creek (left) and Stony Creek (right) respond very differently to changes in extreme precipitation, highlighting the need for climate modeling and mapping of impacts at a local scale. SRES A2 for Mid-Century (2046-2065) and to Late-Century (2081-2100).

Predicted flood level
(confidence limits missing)

Predicted river stage

FLOOD
PROTECTION
LEVEE

Predicted flood level

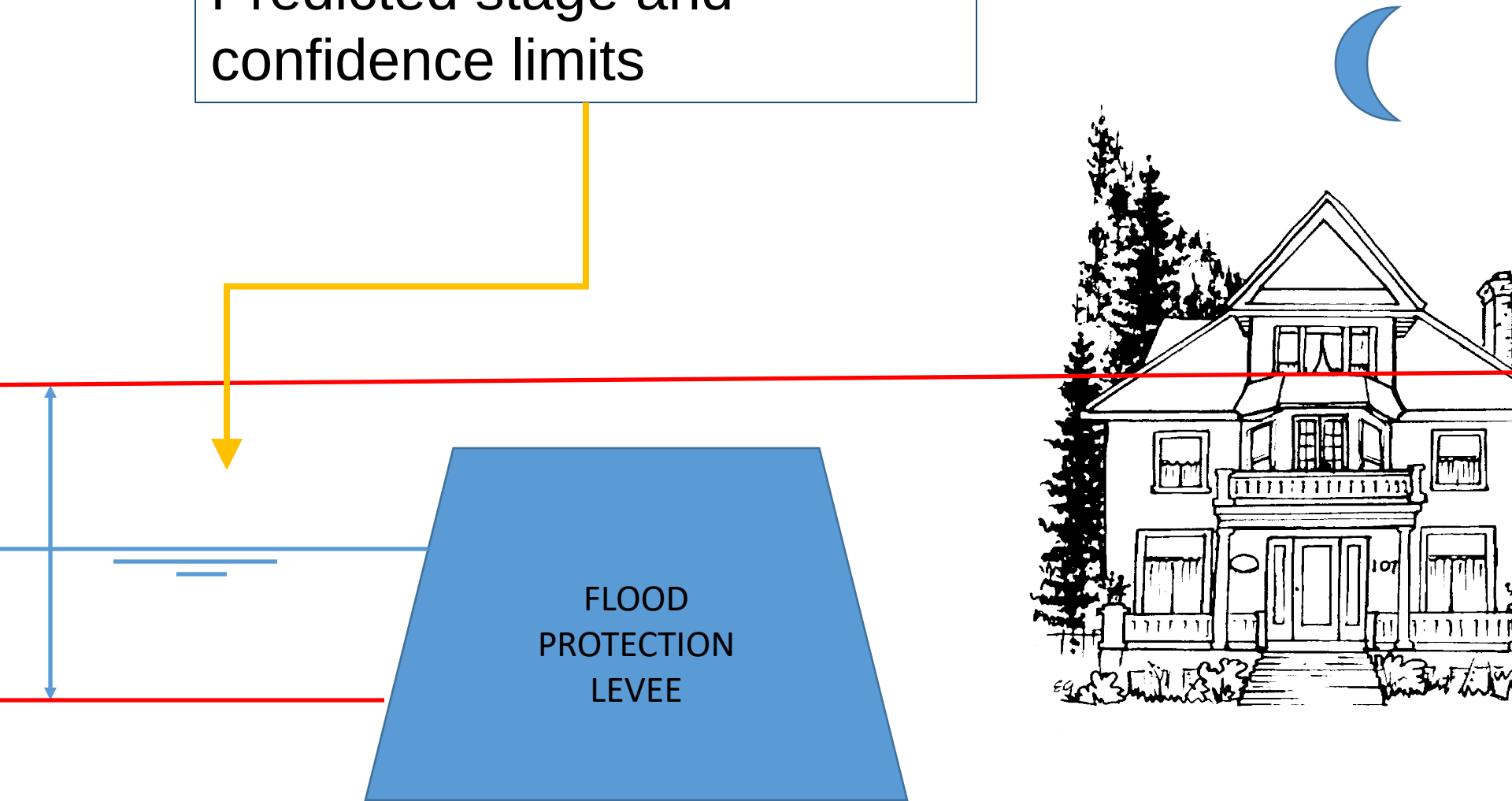
(smaller confidence interval)

Predicted stage and confidence limits

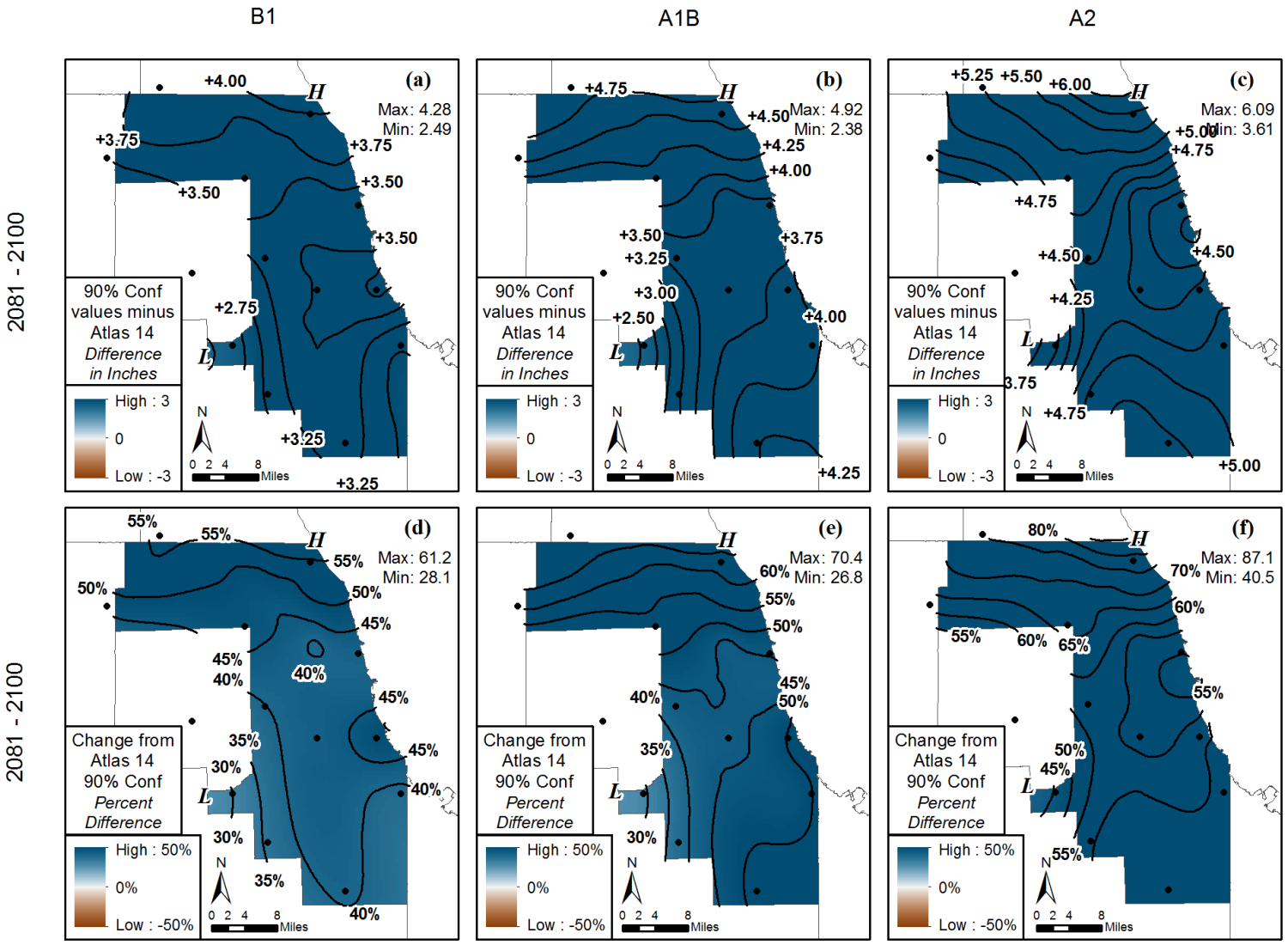
Predicted flood level

(larger confidence interval)

Predicted stage and confidence limits

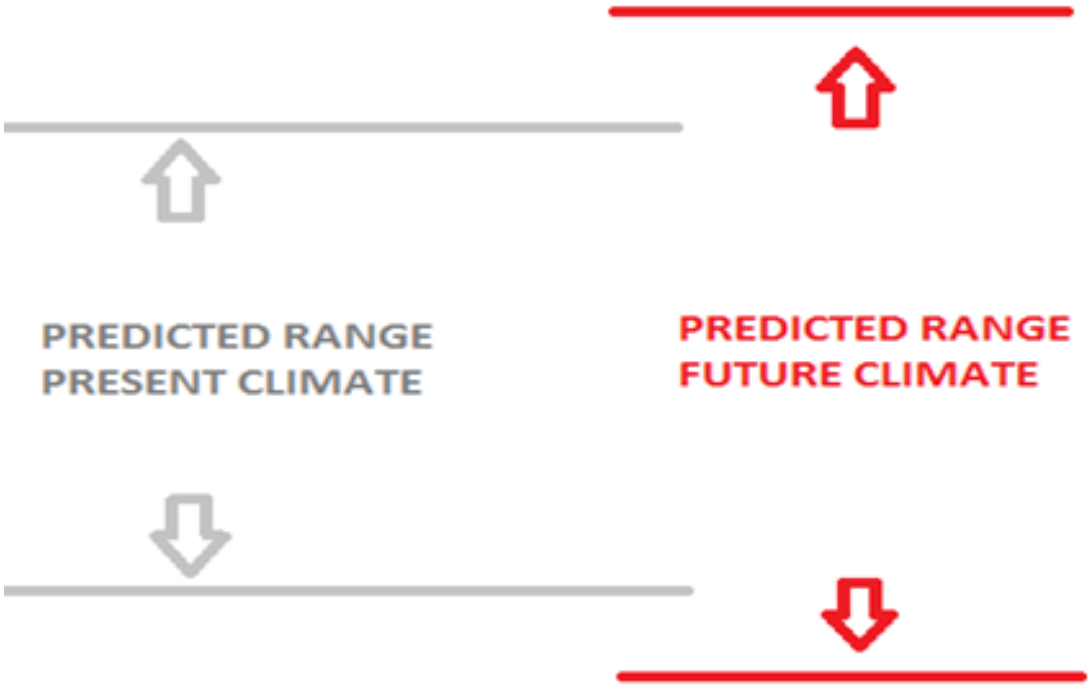


Differences between projected for late 21st century and Atlas 14 upper 90% confidence limits for 100-year, 24-hour isohyetals



These results are not designed for operational use, nor do they replace the existing sources

Uncertainty of future climate



- No change in expected rainfall can be dangerous

Summary

- More frequently assess the frequency of extreme events using observational and climate modeling data.
- These two approaches should be viewed as complementary approaches.


Questions?
217-333-0237
mmarkus@Illinois.edu
OUILMETTE