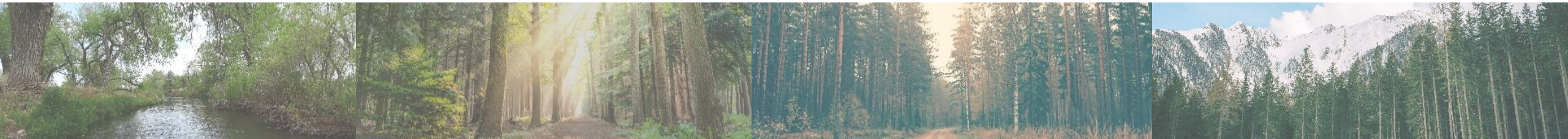


How will climate change affect Colorado's watersheds, and why should we care?

Adam N. Wlostowski, PhD

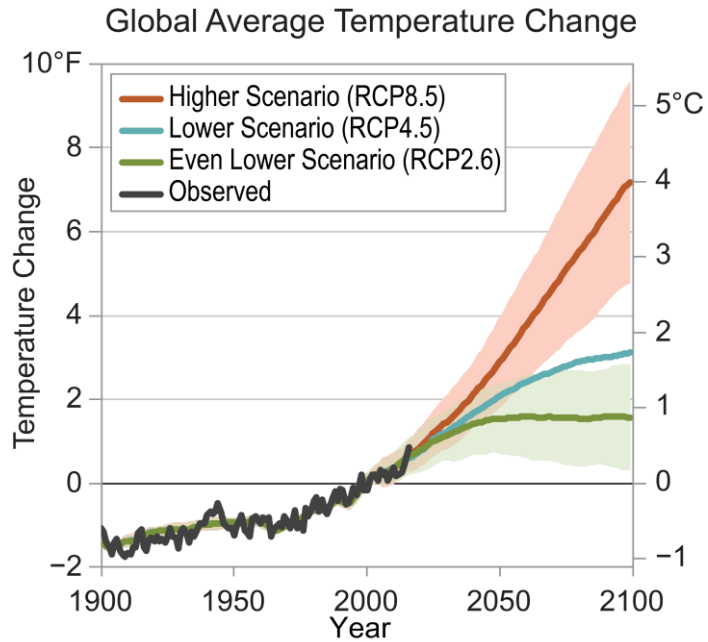
Graeme Aggett, PhD

Lynker Technologies, Boulder Colorado

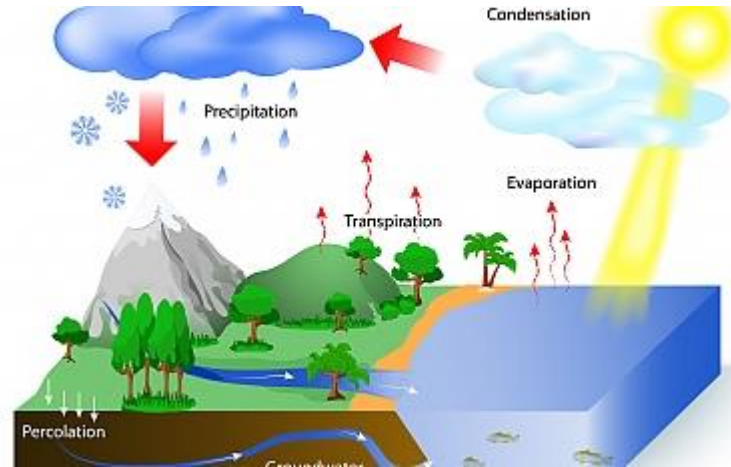


The Big Idea: Addressing the risk of climate change and hydrologic non-stationarity

Climate Change



Hydrologic Change



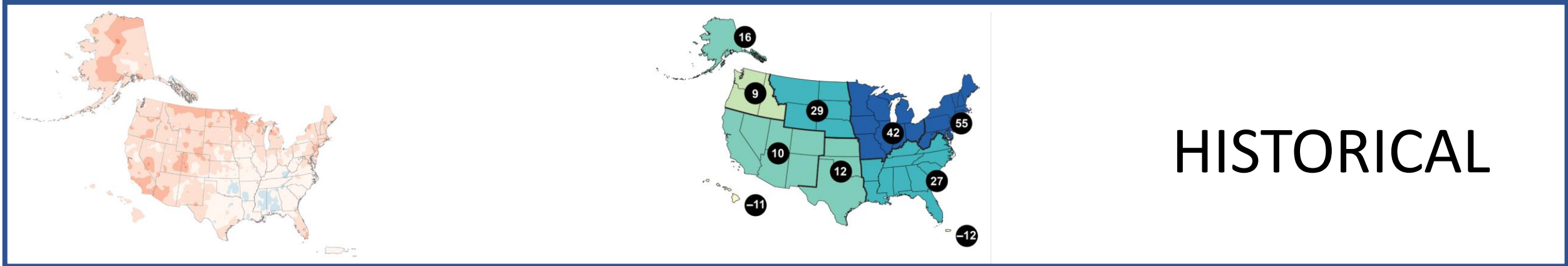
Asset Impacts (public & private)



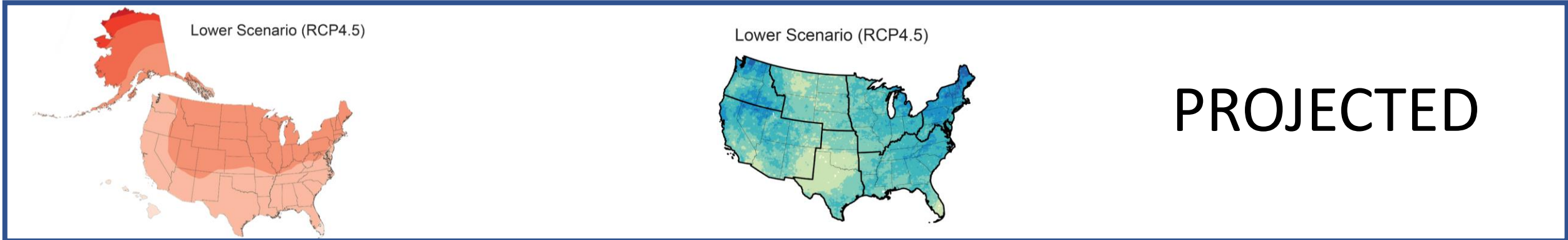
Historical and projected changes in Earth's climate

Increasing average temperatures

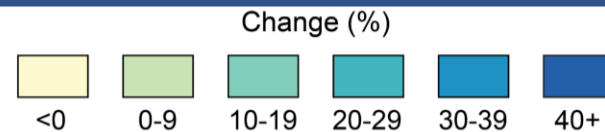
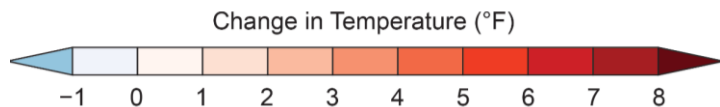
Increasing frequency of extreme precipitation events



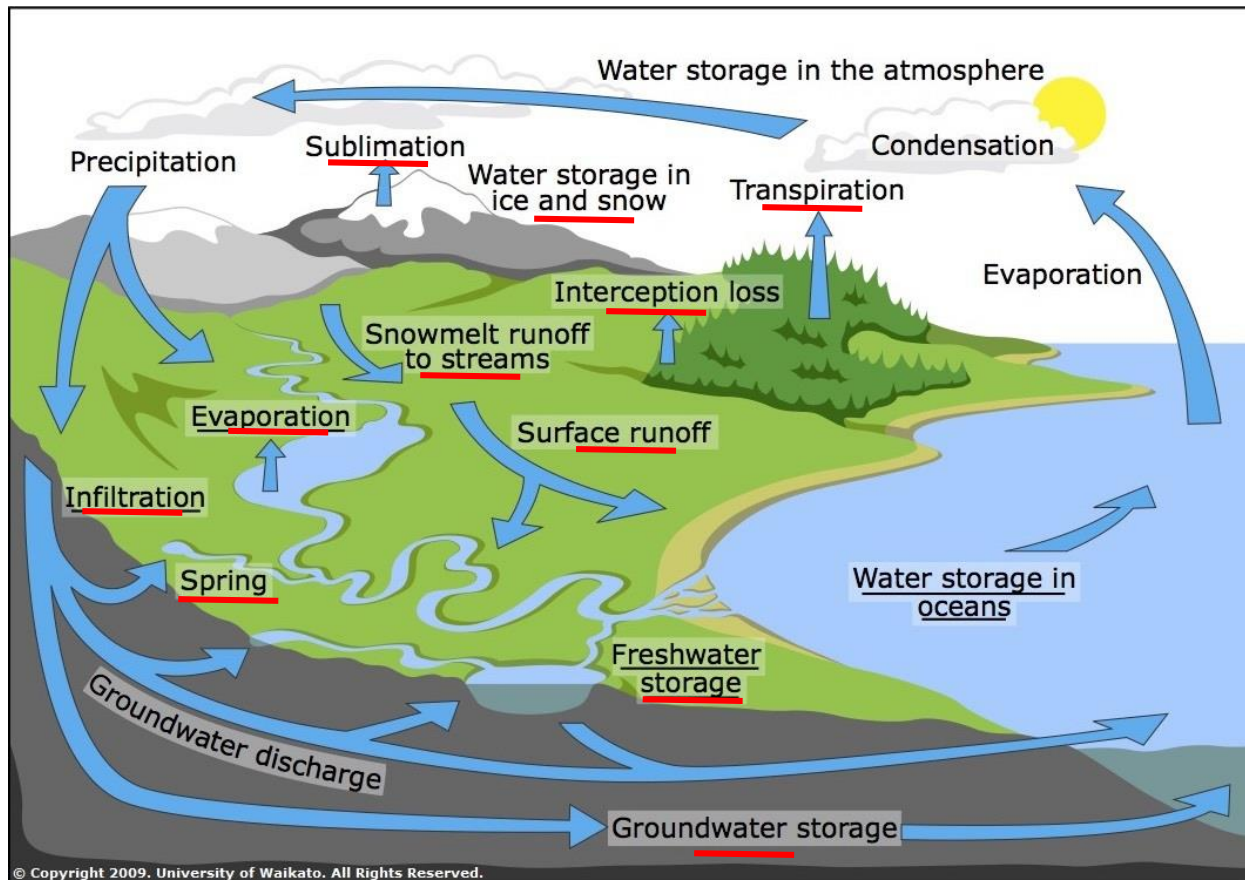
HISTORICAL



PROJECTED



Climate is the upper boundary of the terrestrial hydrologic system



Climate change affects how water is stored and partitioned in the landscape

Public and private assets are vulnerable to hydrologic hazards (changes in storage and transmission)

Agriculture



Infrastructure



Recreation & Tourism



So What?

Pretend like nothing is happening



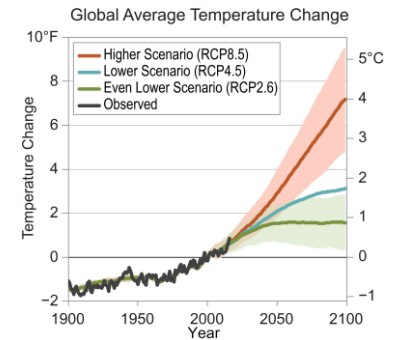
Data-driven tools based on the best available science



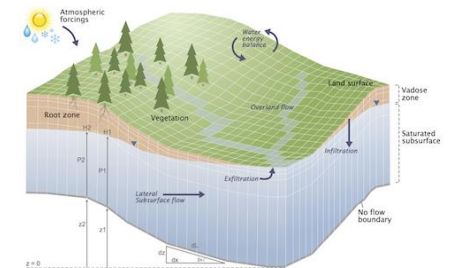
Observation networks



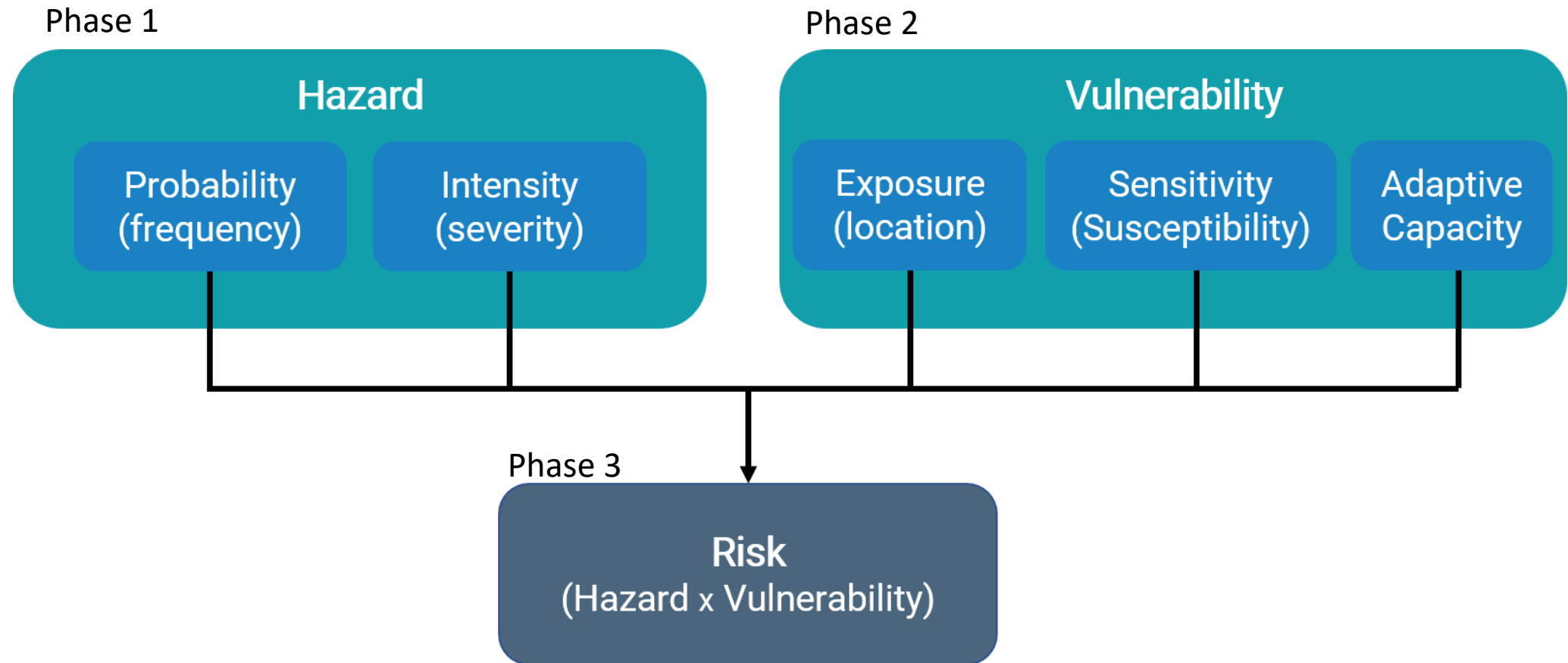
climate models



Hydrologic models

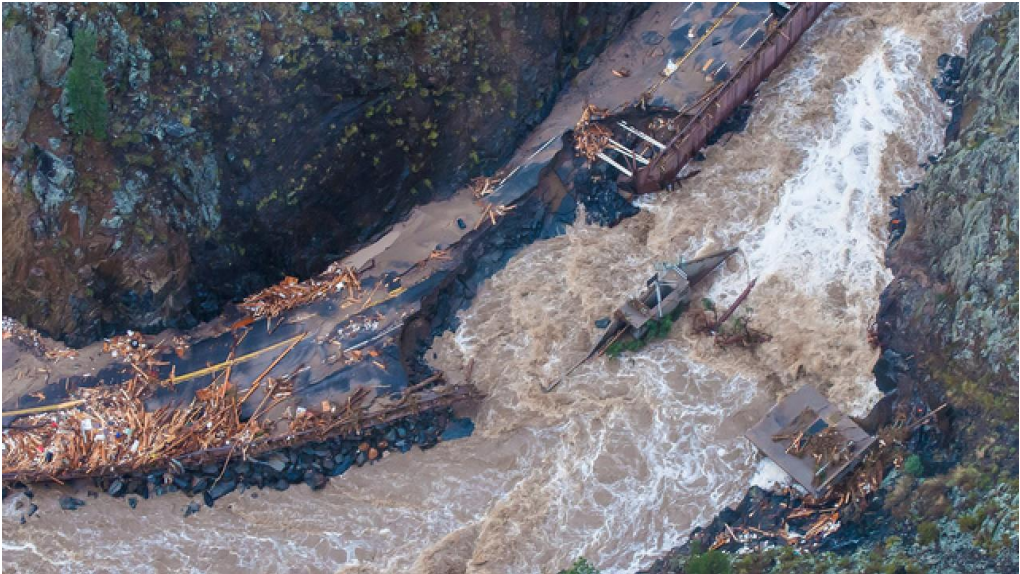
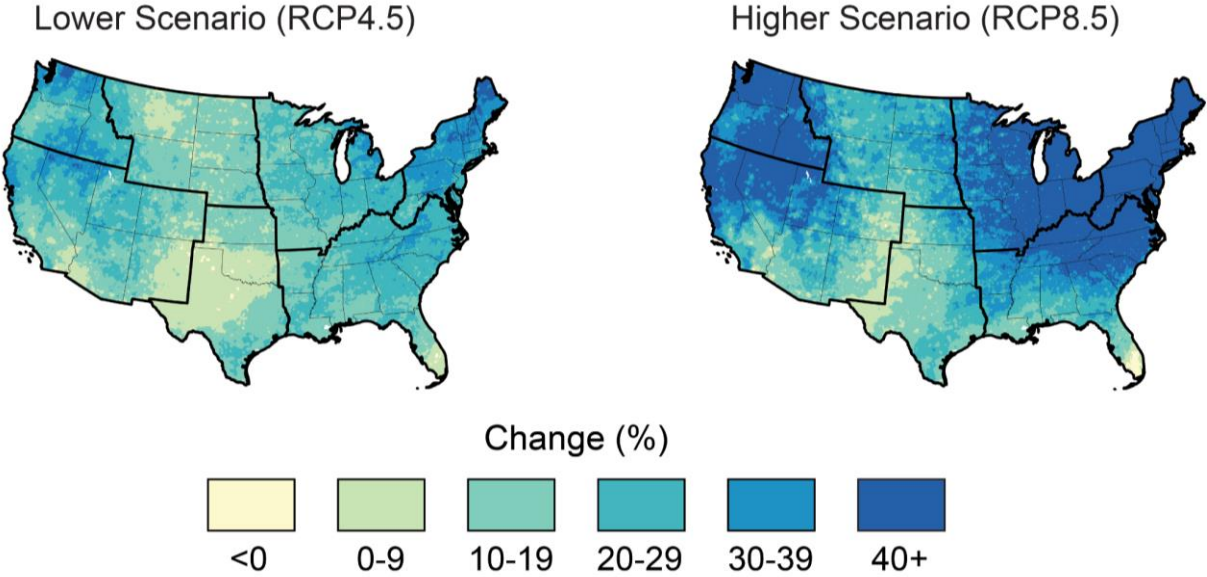


Risk = Hazard x Vulnerability

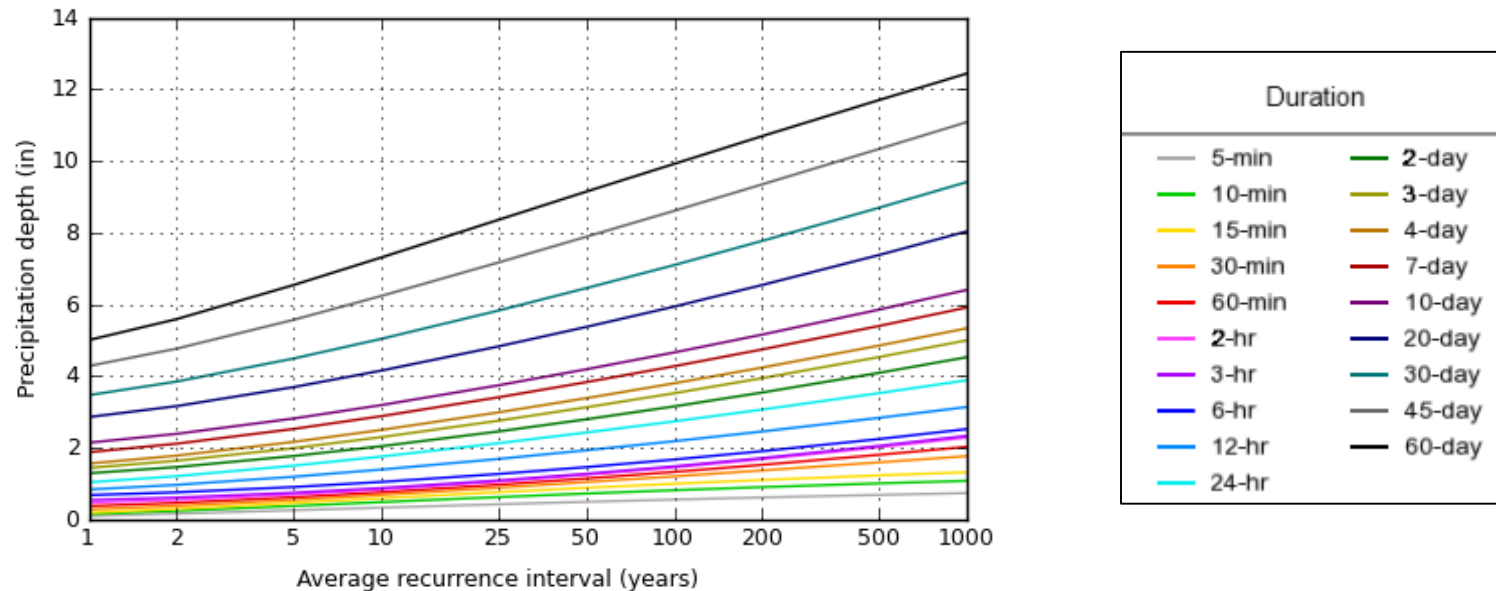


Infrastructure is at risk to increasing frequency and severity of extreme precipitation events

% change in the frequency of extreme precipitation



Intensity-duration-frequency curves: A tool for characterizing precipitation event likelihood

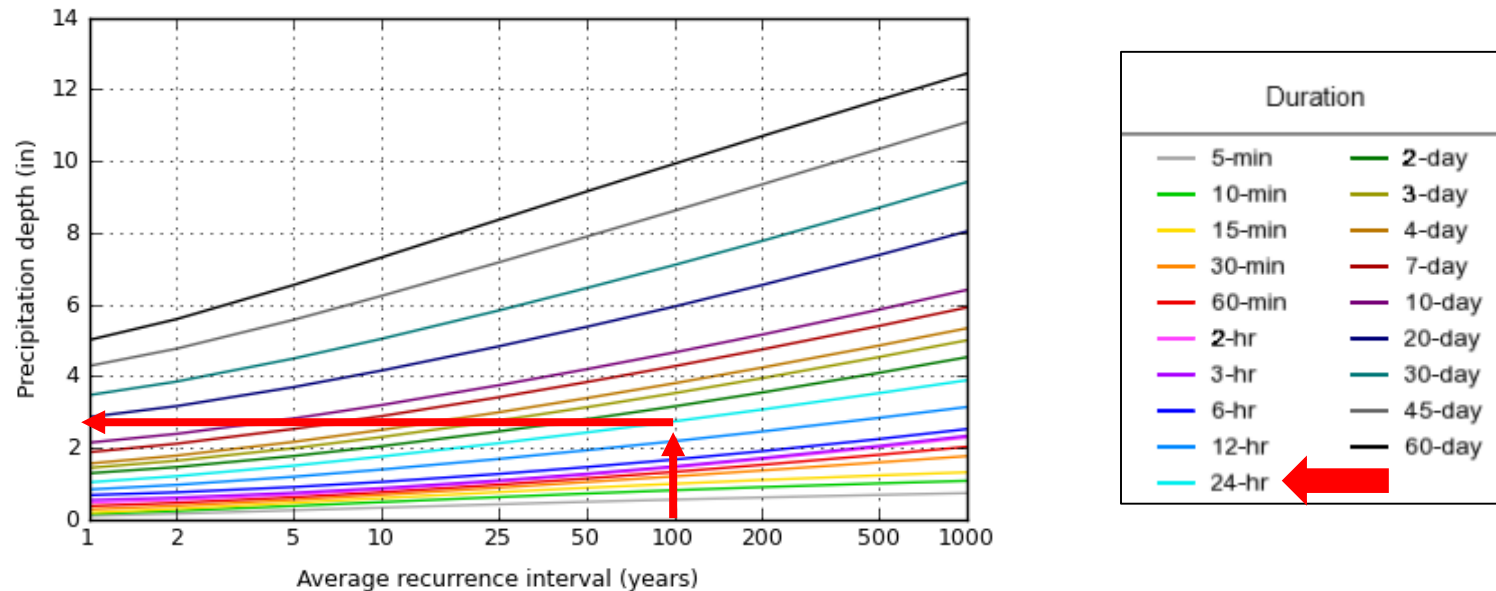


NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Sun Oct 6 19:33:37 2019

Intensity-duration-frequency curves: A tool for characterizing precipitation event likelihood

How much rain falls over 24 hours during the 100-year event in Avon Colorado?



NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Sun Oct 6 19:33:37 2019

Intensity-duration-frequency curves: Cornerstone of infrastructure design and decision making

How much precipitation?

• IDF Curves

How much runoff?

• Hydrological Modeling

Inundated extent/duration & geomorphic change

• Hydraulic & Geomorphic modeling

Intensity-duration-frequency curves: Cornerstone of infrastructure design and decision making

How much precipitation?

• IDF Curves

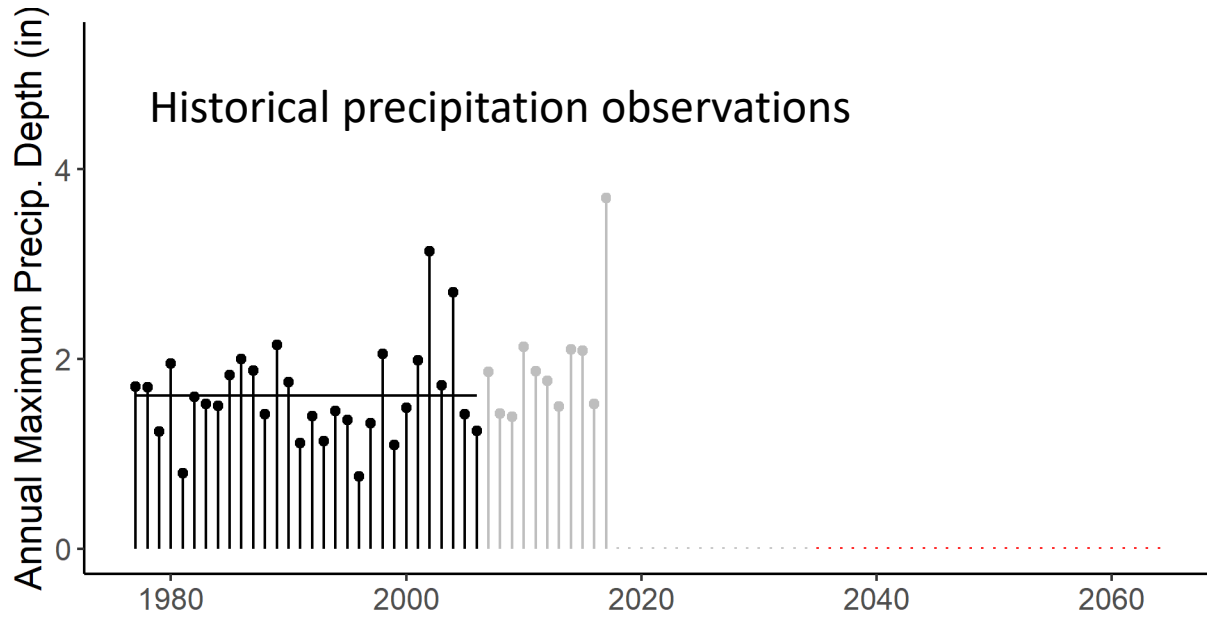
How much runoff?

• Hydrological Modeling

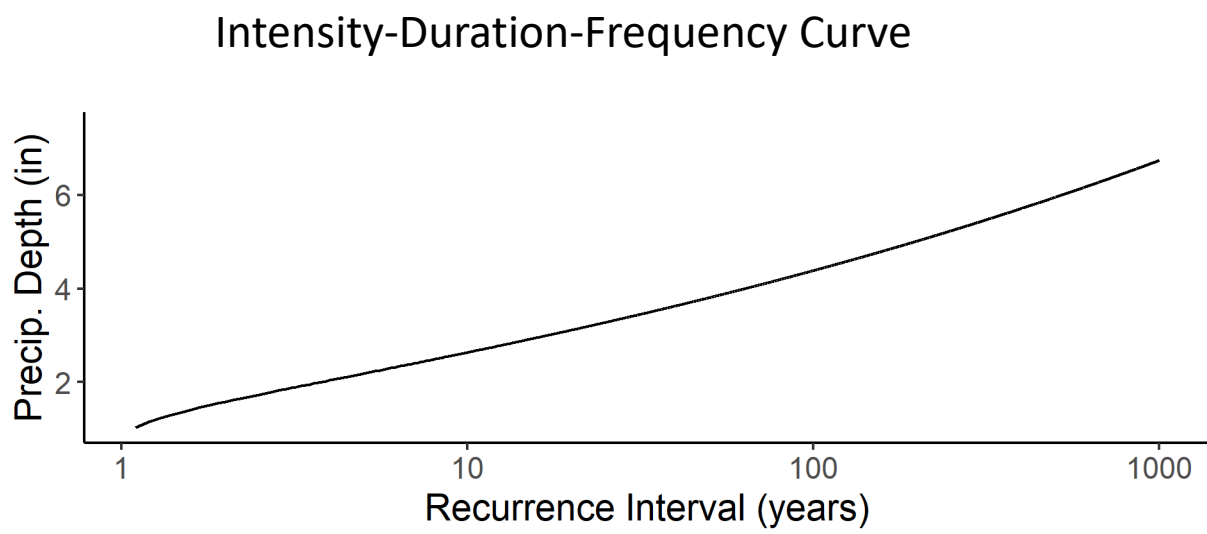
Inundated extent/duration & geomorphic change

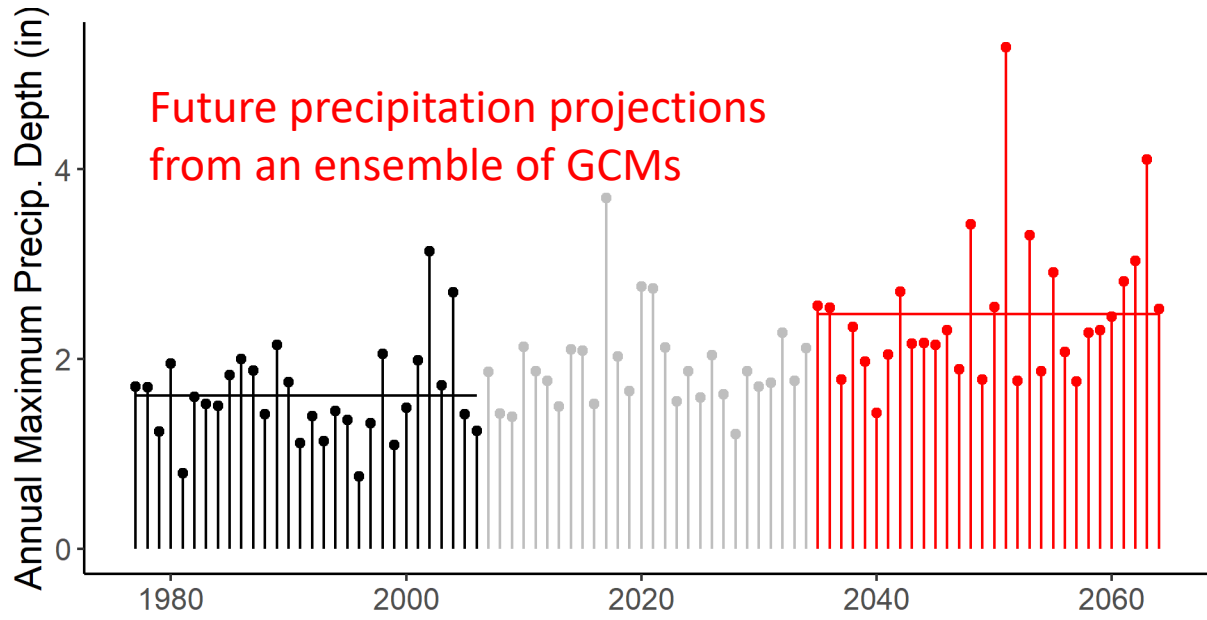
• Hydraulic & Geomorphic modeling





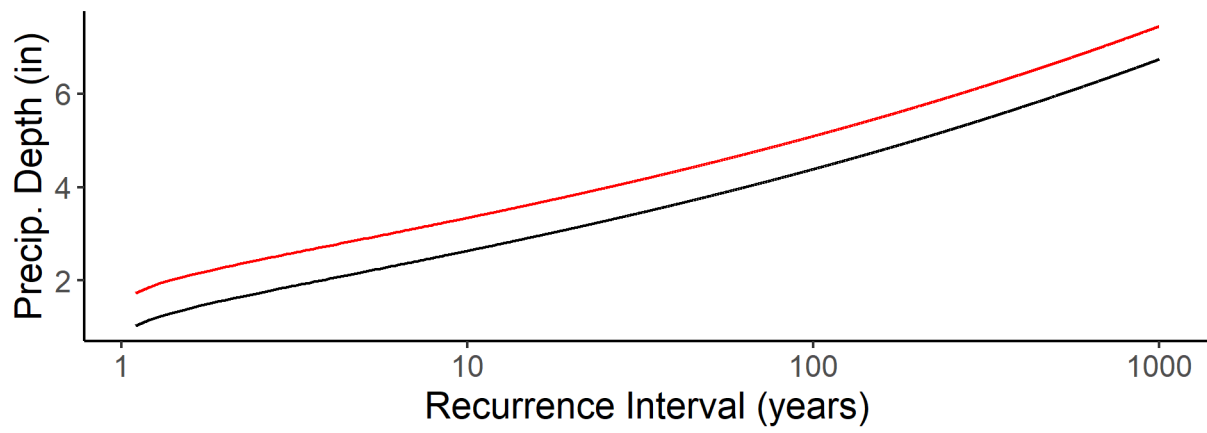
IDF curves are based on historical observations



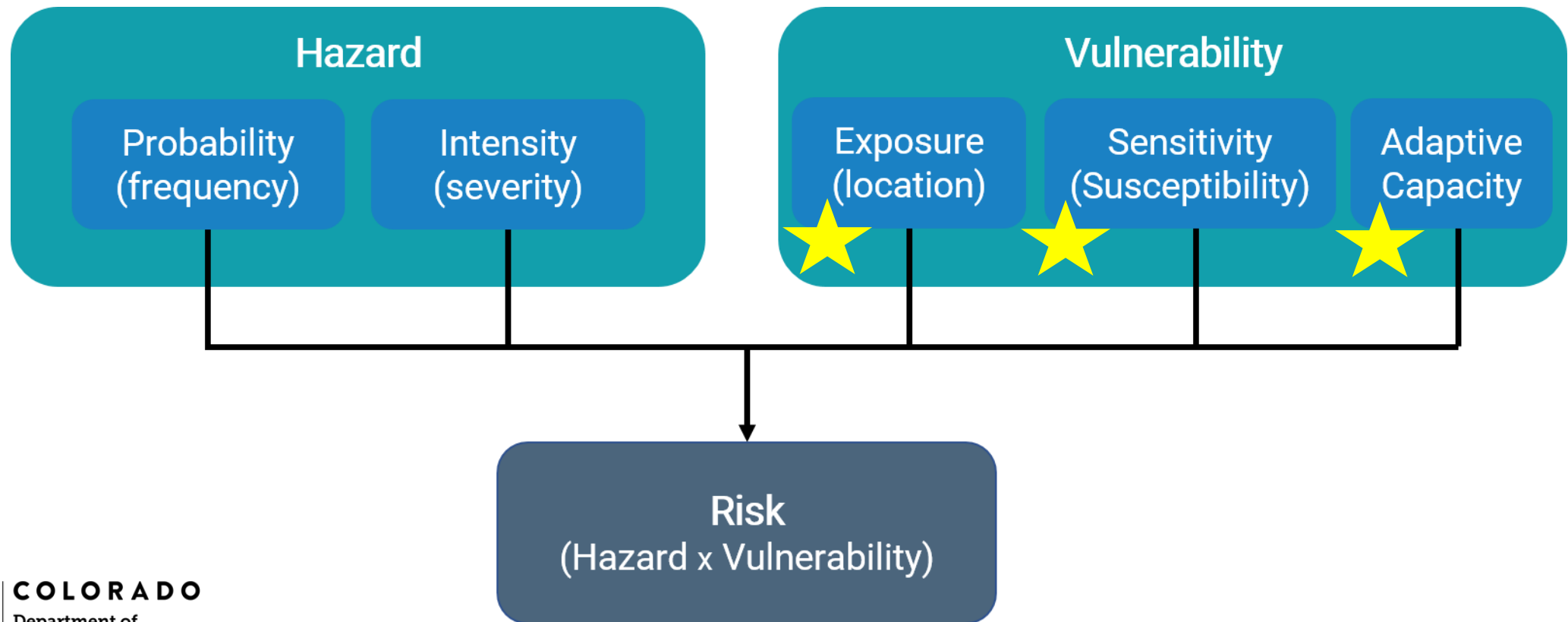


Using Global Climate Model data to predict future IDF

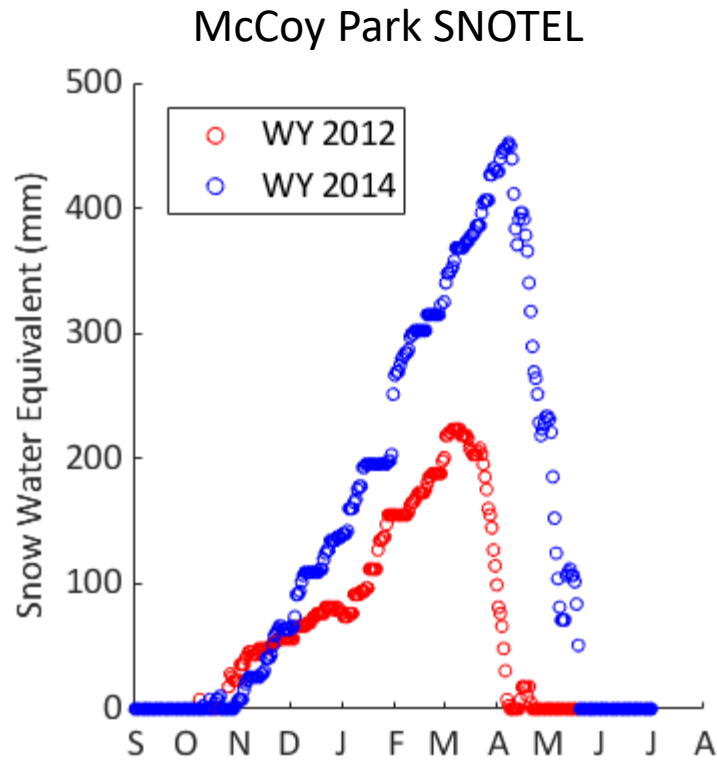
Upward shift of IDF curve: n -year event becomes more intense



Next steps: Asset-level vulnerability assessment



Colorado's snowpack is at risk to climate change. The outdoor recreation industry is vulnerable.



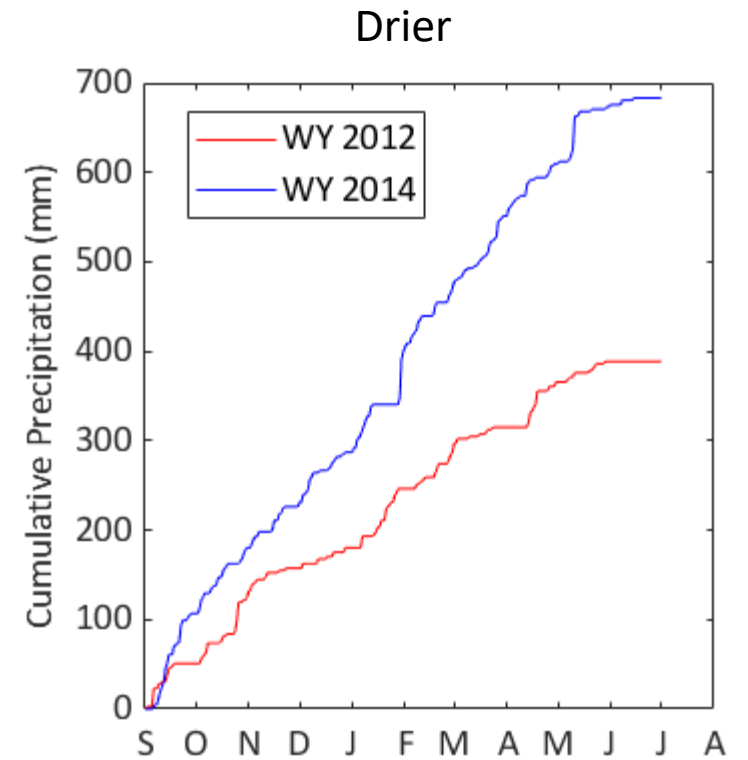
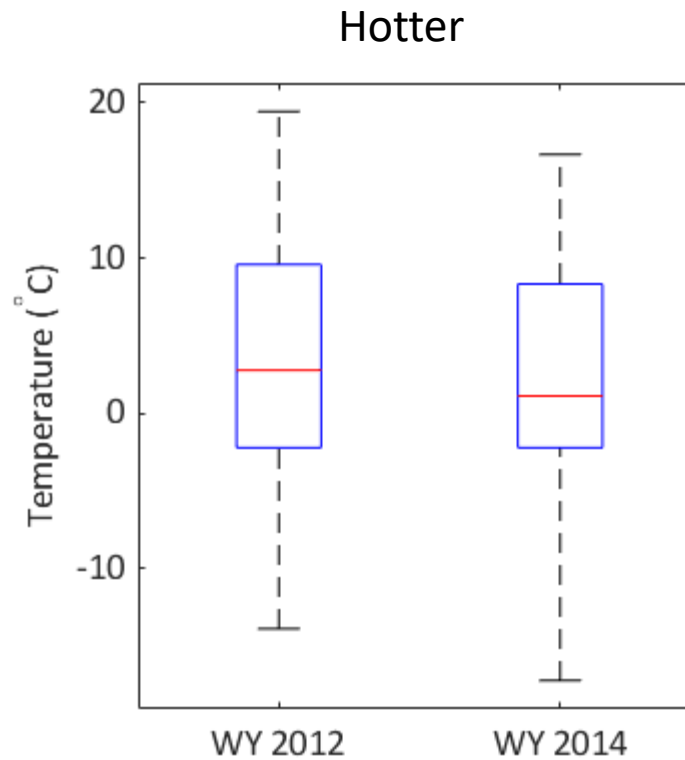
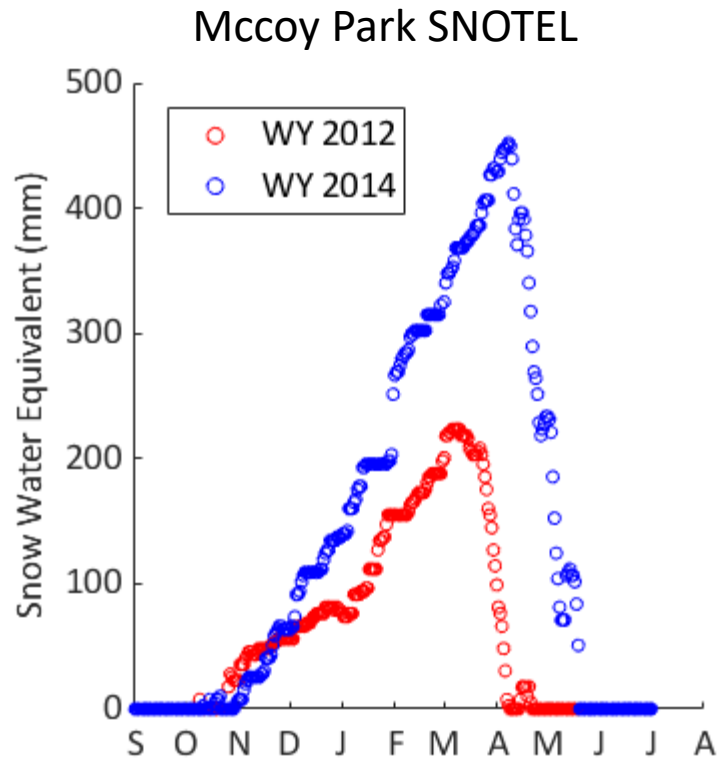
2012



2014



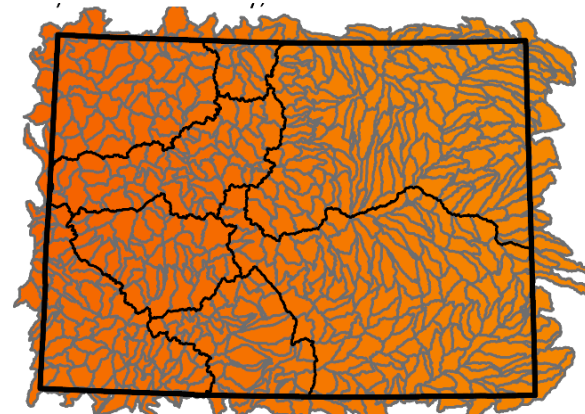
Colorado's snowpack is at risk to climate change



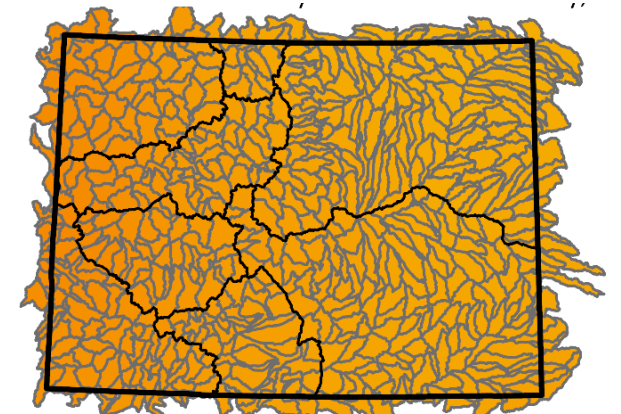
Modeling baseline and future snowpack under climate scenarios adopted by Colorado Water Plan

Scenario	Temperature Change	Precipitation Change
Hot and Dry	+2.3°C ↑	-1 - 3% ↓
Between 20 th Century Observed and Hot and Dry	+2.1°C ↑	+ 2 - 5% ↑

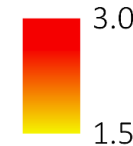
Hot & Dry



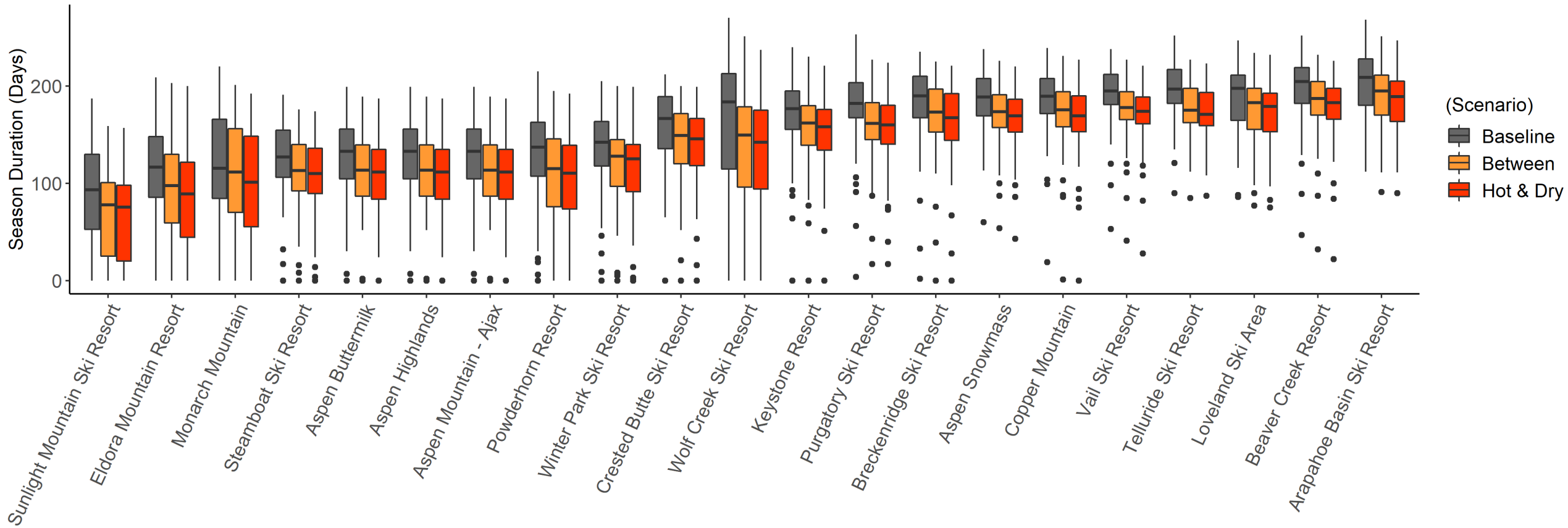
In-between
... 20th century observed and hot & dry



Annual average temperature offset (C)



Preliminary results indicate an 8 – 25 % reduction in ski season length

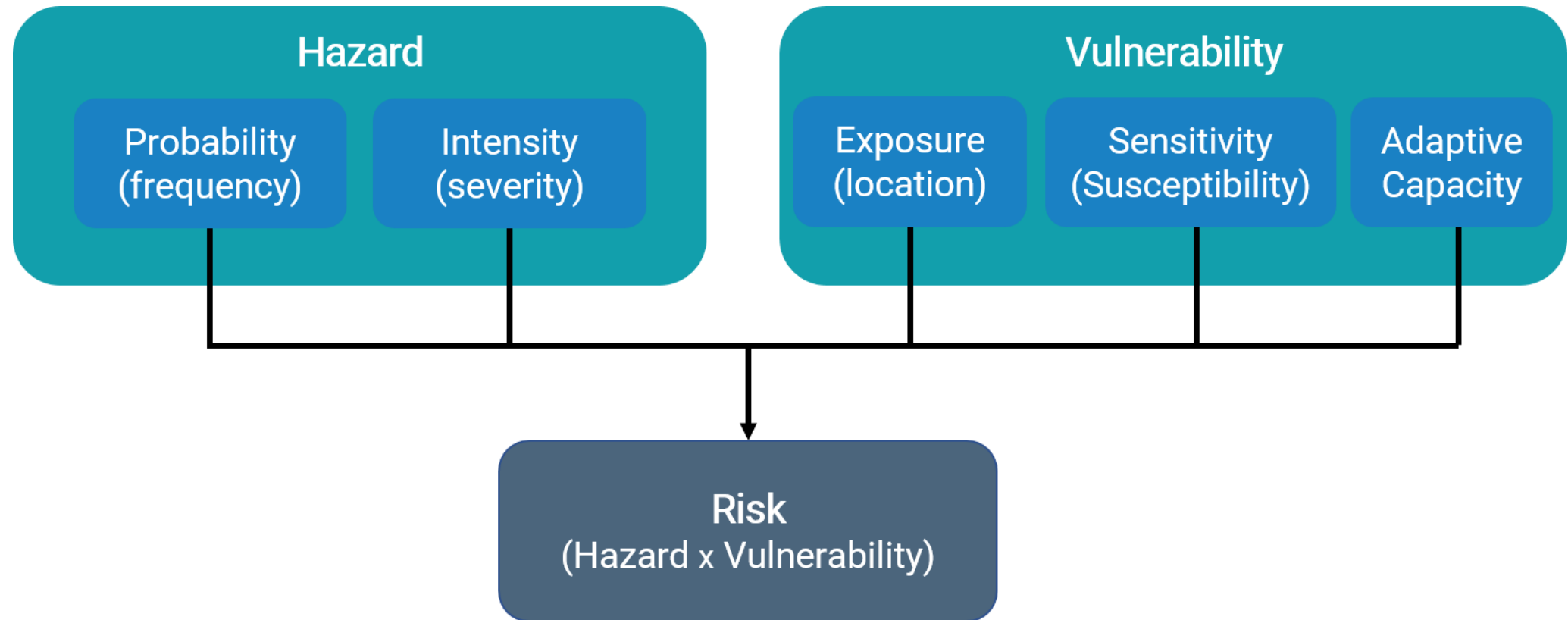


Next steps: Evaluating historical and future economic impact of snow drought

Winter sports contribute
~\$5 Billion to Colorado's
economy

What is the economic
consequence of warmer
and drier climatic
conditions?

Risk analysis framework is flexible and suitable to a range of client needs



So What?

Pretend like nothing is happening



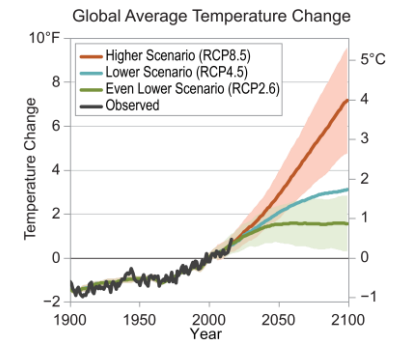
Data-driven tools based on the best available science



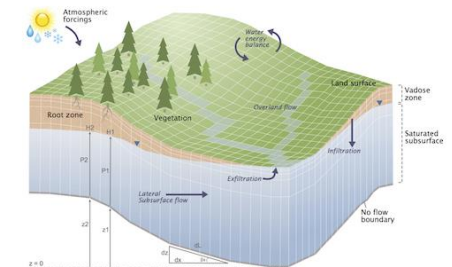
Observation networks



climate models



Hydrologic models



Thank you for your time



Funding for this work was graciously provided by:



Colorado Water Conservation Board

We can if...