Climate Change Analysis in Planning

BACWA Collection Systems Committee

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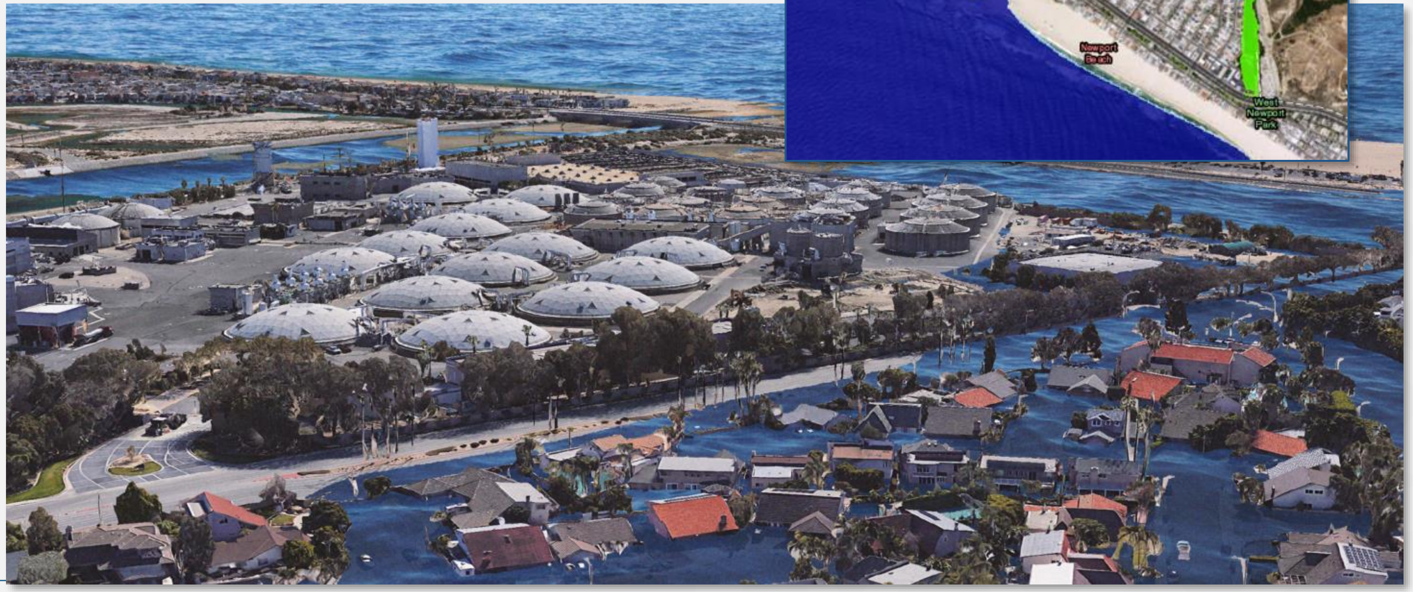
September 27, 2018

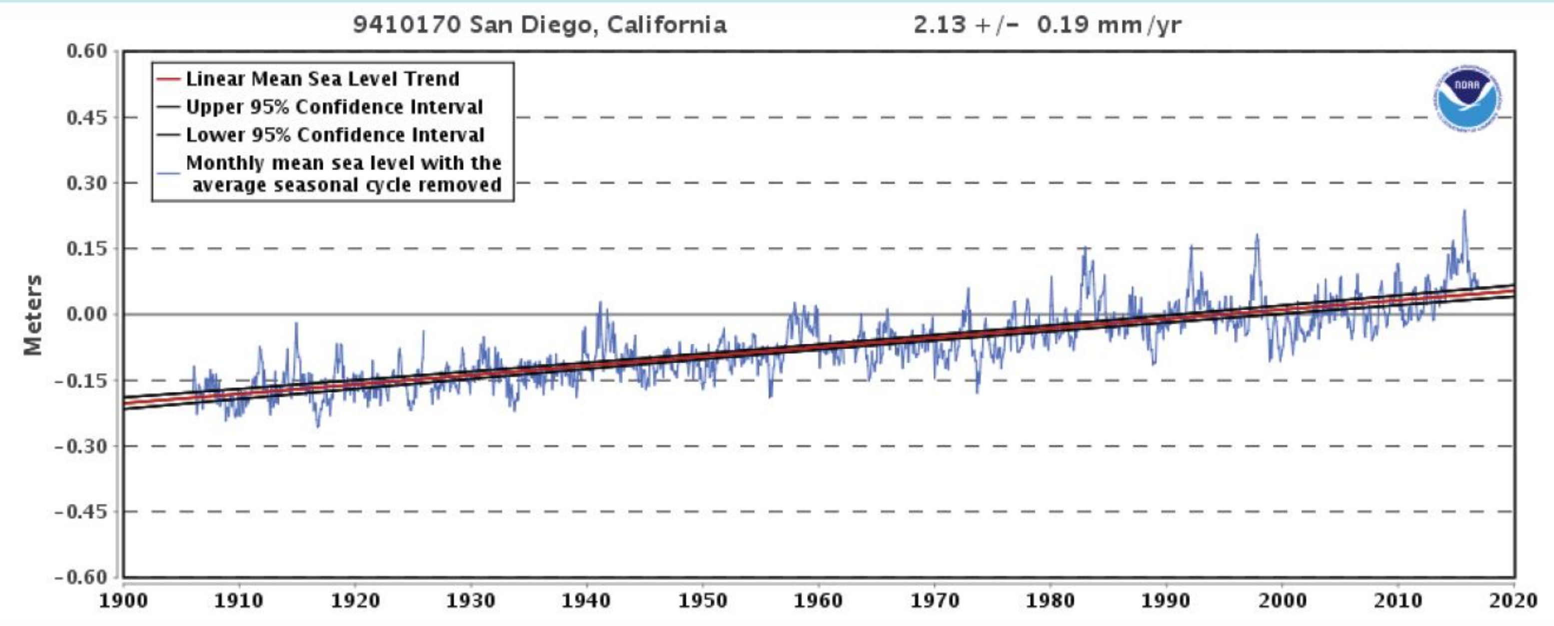
Presentation Topics

1. Background
2. Uncertainty
3. Methods to Manage Uncertainty
4. Assessing Vulnerability
5. How Can We Make Decisions?



Climate change analysis will be required

- Regulators in California adopting policy to mainstream analysis
- Rate payers -nationwide- expect agencies to be acting to address climate change (WRF Study – Stratus Consulting, 2014)
- Evidence of change and trends
- Sea level has already risen by 7 inches between 1900 and 2000



Griggs, G., et al. 2017. *Rising Seas in California: An Update on Sea-Level Rise Science. A Report by the California Ocean Protection Council's Science Advisory Team Working Group.* Ocean Science Trust

Potential effects on wastewater systems

Climate Change and Variability

- Temperature change
- Precipitation Change
- Accelerated sea level rise
- Increased storm surge and intensity
- Prolonged drought

→

Environmental Changes

- Increasing flood events
- Increasing drought events and low-flows in streams
- Changing runoff patterns and water quality
- Changing soil moisture

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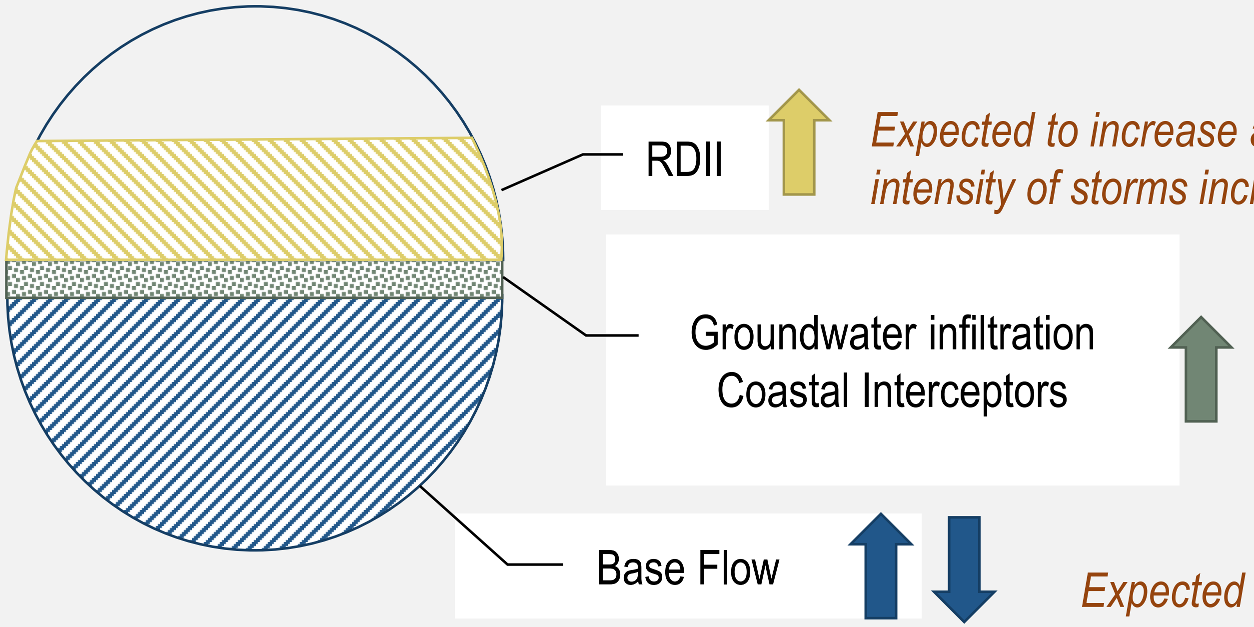
Sanitation Infrastructure Impacts

- Facility location
- Treatment process
- Design of collection infrastructure
- Inflow management
- Emergency response protocols

USAID, 2012

Forcing on wastewater flows



Expected to increase as intensity of storms increases

Expected to increase as sea level rises

Expected to increase with increase indoor water use triggered by higher temperatures

Expected to decrease with reduced indoor water use from water use efficiency measures

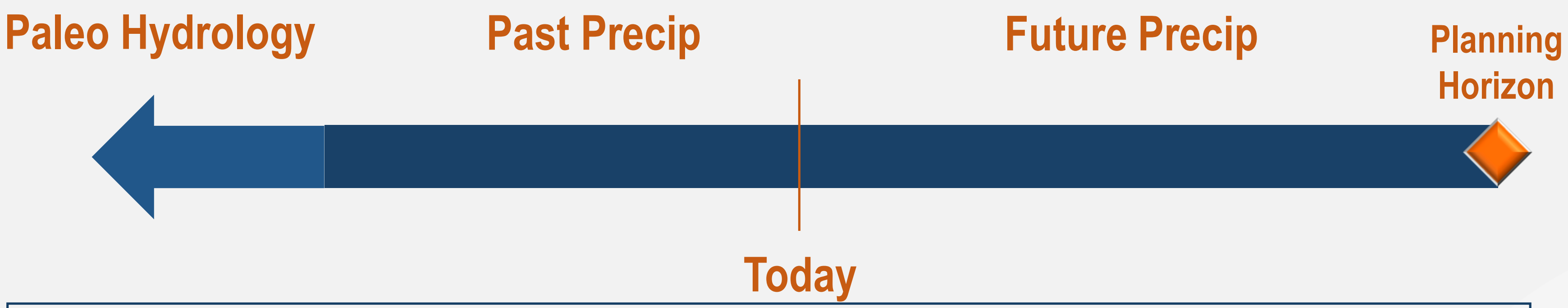
Baseflow Impacts

- Indoor demand variability to weather is much less significant than that of outdoor demand
  - Overall demand in Los Angeles County forecasted between 6% higher to 1% lower – with most of the change explained by outdoor
- Water use efficiency measures will continue into the future based on State mandates
  - AB1668 and SB606

But how do we quantify these?

Remember….we are forecasting

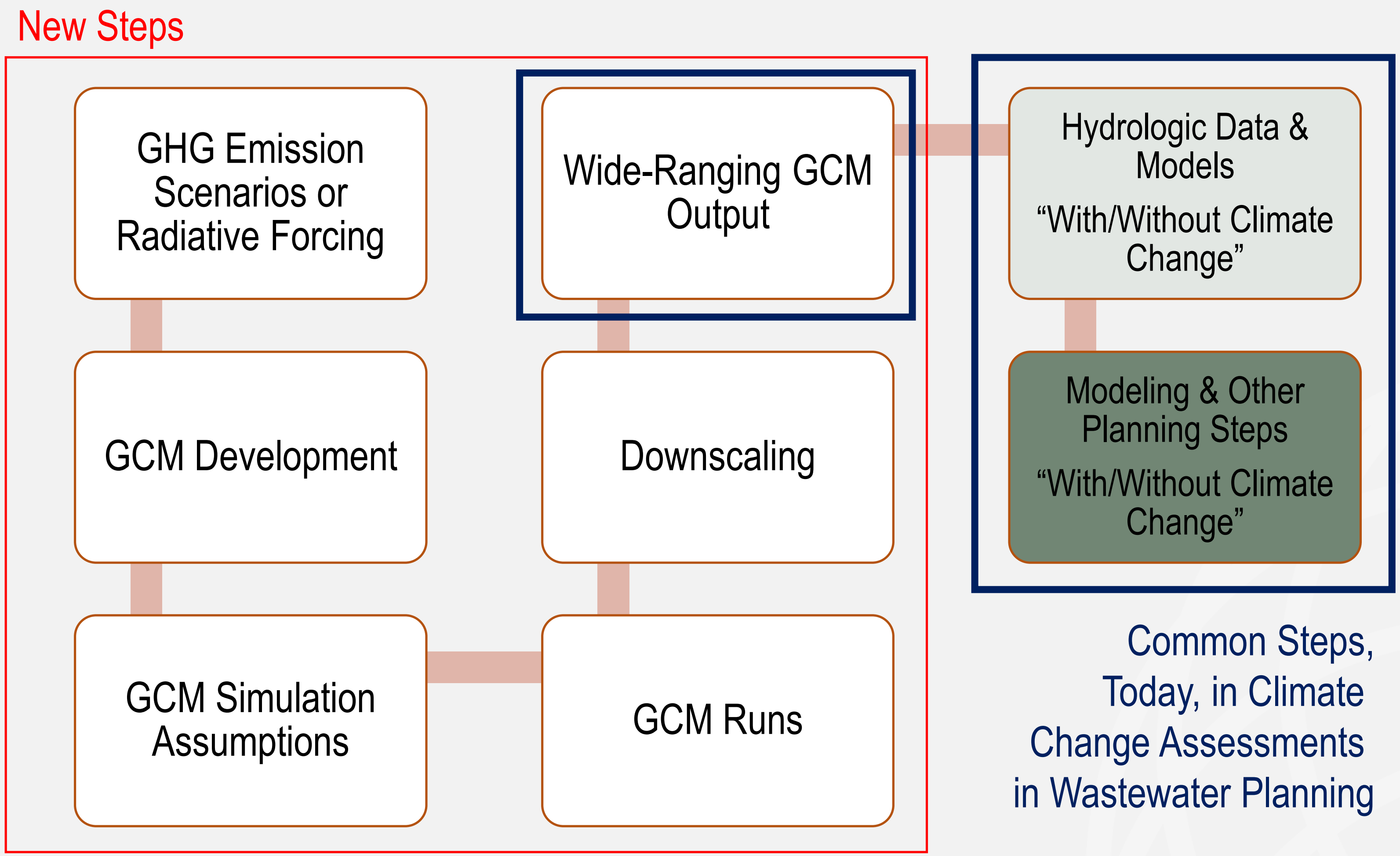
Past as future? (Stationarity)



	Records	Records	“Without CC”
	Records	GCM Forecasts	“With CC”
Paleo Records		Paleo Records	

Using hydrology of record as the basis of forecasts is common – “perturbed record”

An entire new “chain” of analysis feeding our professional practice



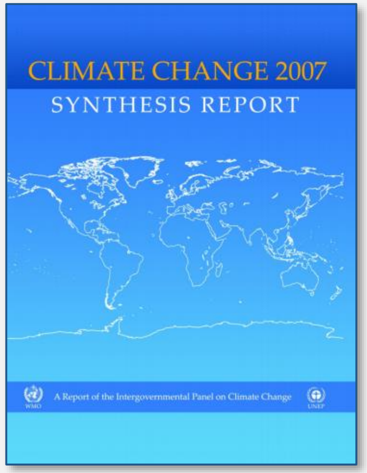
Common Steps, Today, in Climate Change Assessments in Wastewater Planning

"It is better to know nothing than to know what ain't so" [1]

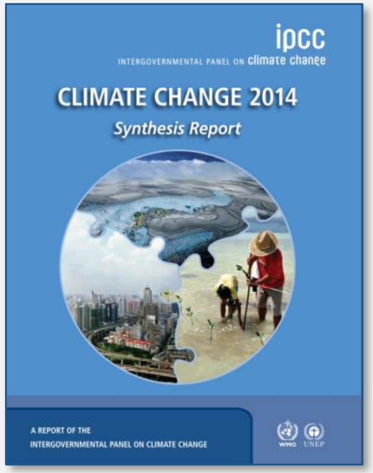
- Why talk about background elements?
- Context is critical to interpret forecasts
- A common roadblock in decision-making by utilities
  - Varying forecasts in different studies
  - Varying forecasts by different models

[1] Josh Billings

Background on Available Forecasts



Published in 2007

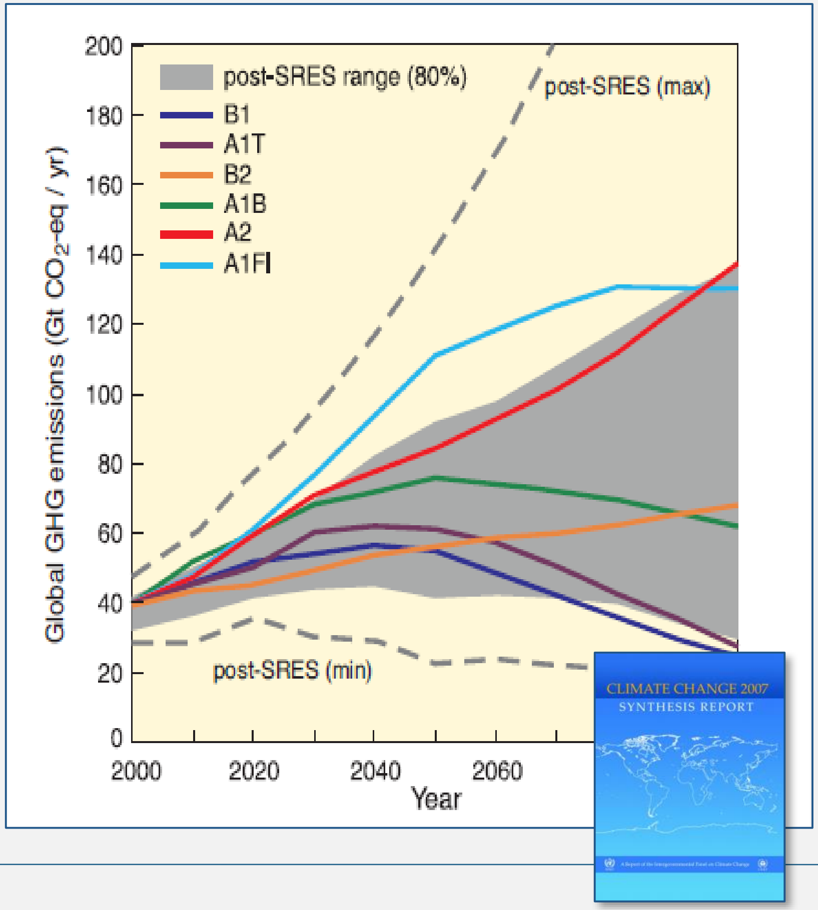


Published in 2014

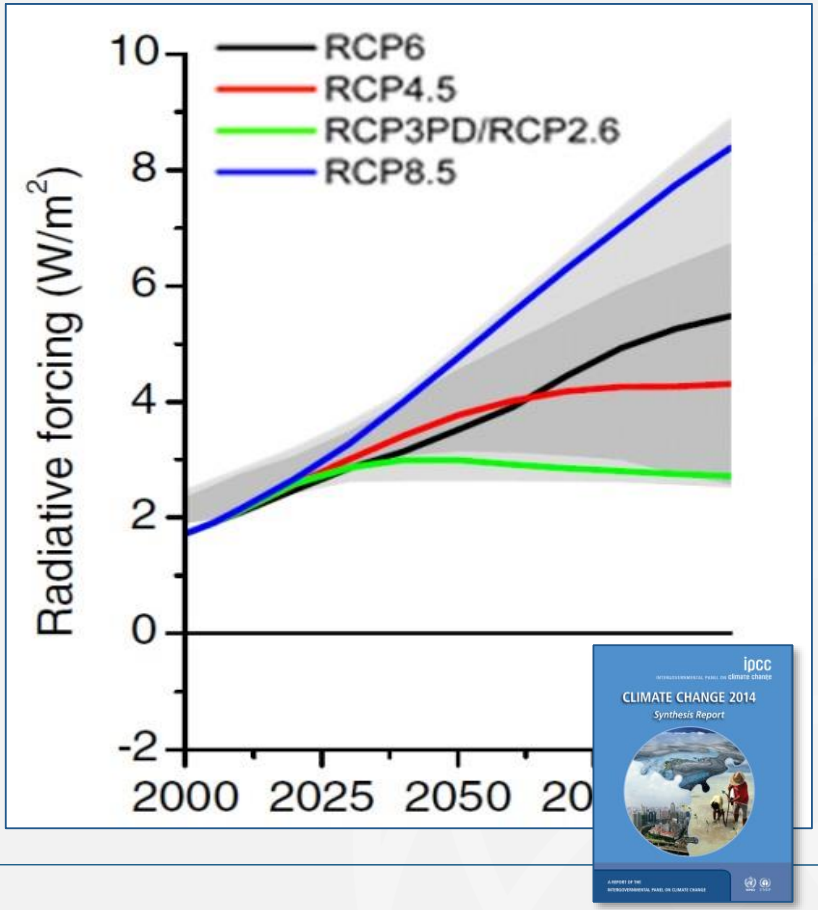
Greenhouse Gases Emission Scenarios (A1, A2, B1, etc.)	Reasonable Concentration Pathways (RCP4.5, RCP 8.5, etc.)	How much GHGs in the atmosphere
CMIP3	CMIP5	Modeling assumptions & protocols

Greenhouse gases (GHG) concentration in the atmosphere – Scenarios

- Called “emission scenarios” or “Reasonable Concentration Pathways”



2007



2014

General Circulation Models (GCMs)

- Forecast the weather globally in long-term transient simulations
- Some examples: (DWR recommended models for California)
  - ACCESS-1.0
  - CanESM2
  - CCSM4
  - CESM1-BGC
  - CMCC-CMS
  - CNRM-CM5
  - GFDL-CM3
  - HadGEM2-CC
  - HadGEM2-ES
  - MIROC5

Table 2-5 Change in Annual Temperature (°F) and Water Year Precipitation (inches) for Region East of Sacramento from Each of the 10 Selected GCMs

Model Name	Change in Annual Temperature (°F) 2070-2099 minus 1961-1990		Change in Precipitation (in.) WY 2070-2099 minus WY 1961-1990	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
ACCESS-1.0	6.0	9.5	-1.5	-5.6
CCSM4	4.7	7.8	1.3	1.3
CESM1-BGC	4.1	7.8	3.4	10.8
CMCC-CMS	5.1	9.1	3.3	-0.2
CNRM-CM5	6.7	10.3	7.9	9.9
CanESM2	6.4	10.5	3.7	7.9
GFDL-CM3	6.8	10.1	-2.0	-4.5
HadGEM2-CC	6.4	11.1	-0.2	-1.8
HadGEM2-ES	6.9	10.9	-0.4	0.5
MIROC5	6.1	8.3	-3.8	-1.0

Notes:

GCM = global climate model, RCP = Representative Concentration Pathway, WY = water year

Red shading indicates model simulations that show relatively high warming; olive shading indicates simulations that show drying. For GCM background information and affiliated research institutions, see the CMIP5 Coupled Model Intercomparison Project at http://cmip-pcmdi.llnl.gov/cmip5/availability.html.

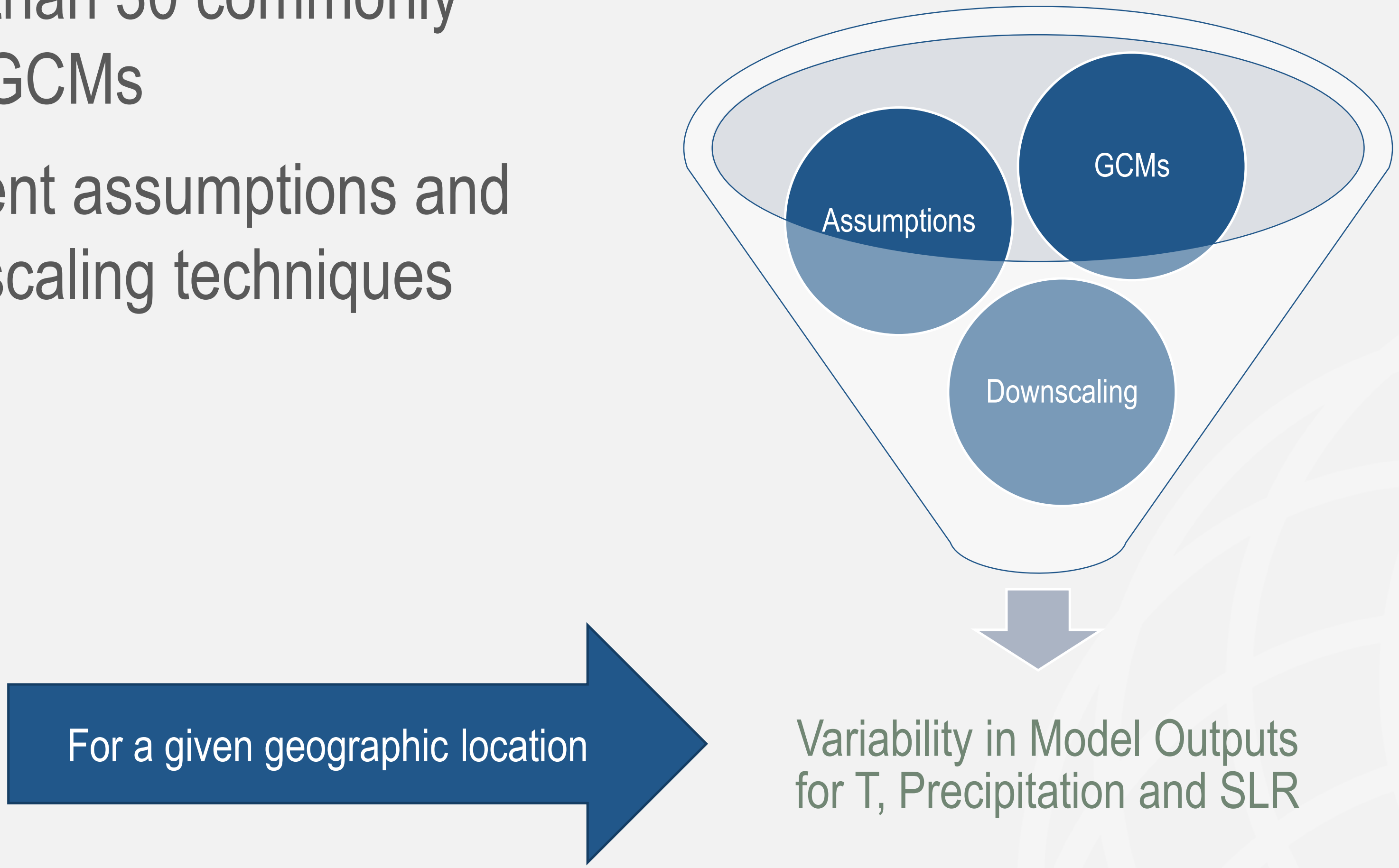
Uncertainty in Forecasts

As a result of

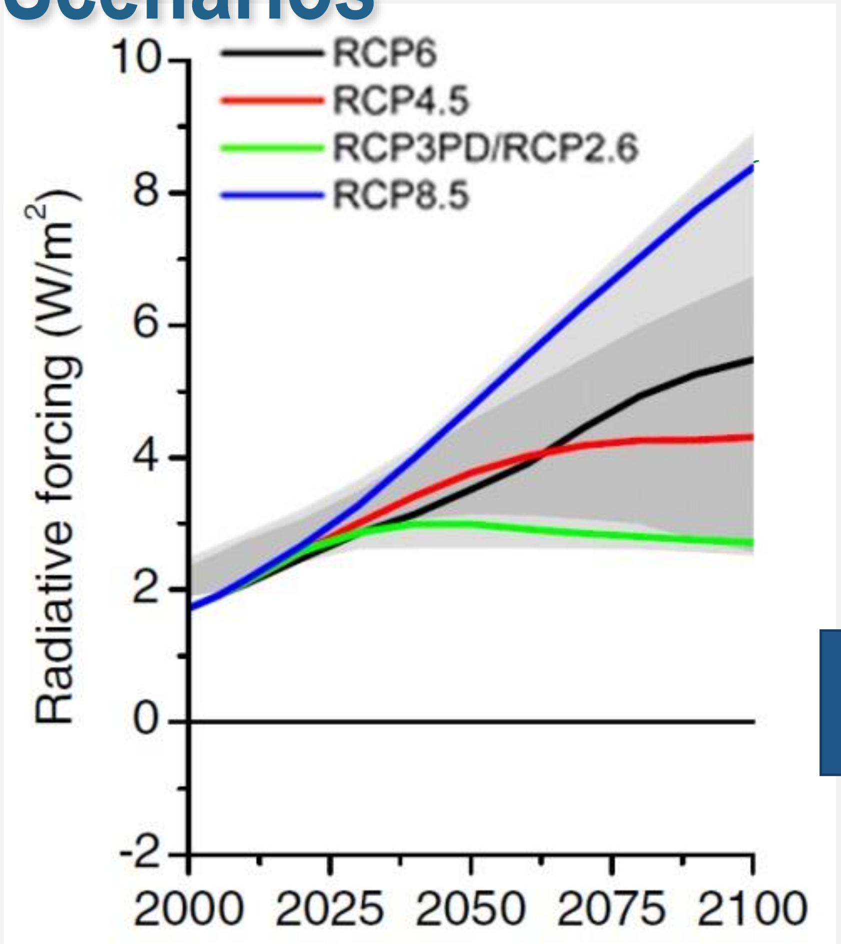
- Different greenhouse gas (GHG) emission scenarios
- Different Global Circulation Models (GCMs)
- Different set of conditions and assumptions - Couple Model Inter Comparison Project (CMIP)
- Different downscaling methods

Multiple Factors Create Variability

- More than 30 commonly used GCMs
- Different assumptions and downscaling techniques



A Given GCM Usually Runs Multiple GHG Emission Scenarios



IPCC, 2013

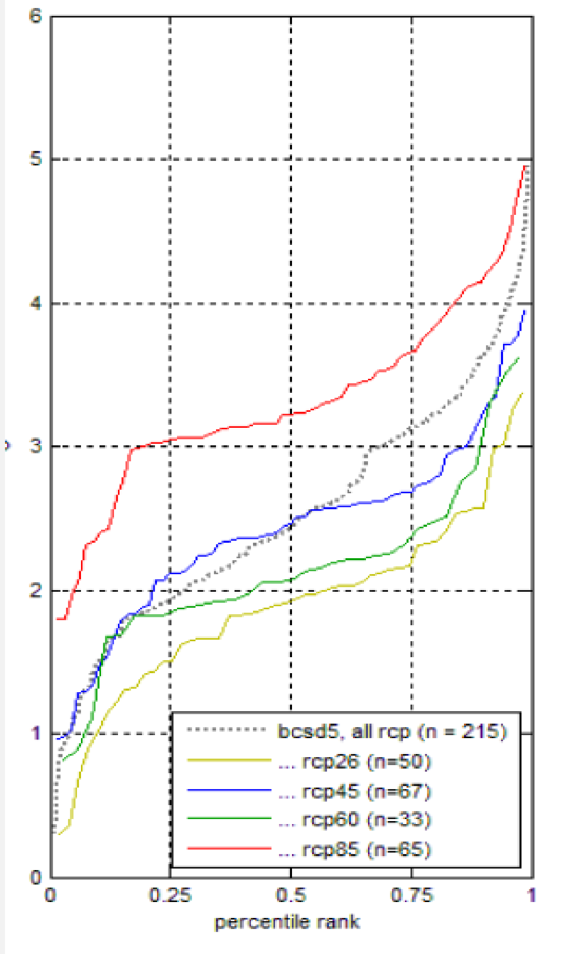
Potentially Hundreds of Forecasts Agencies Need to Formally Address Uncertainty

Multiple Hydrology Methods

Three Main Downscaling Methods

Multiple GCMs

Methods to deal with forecasts matter

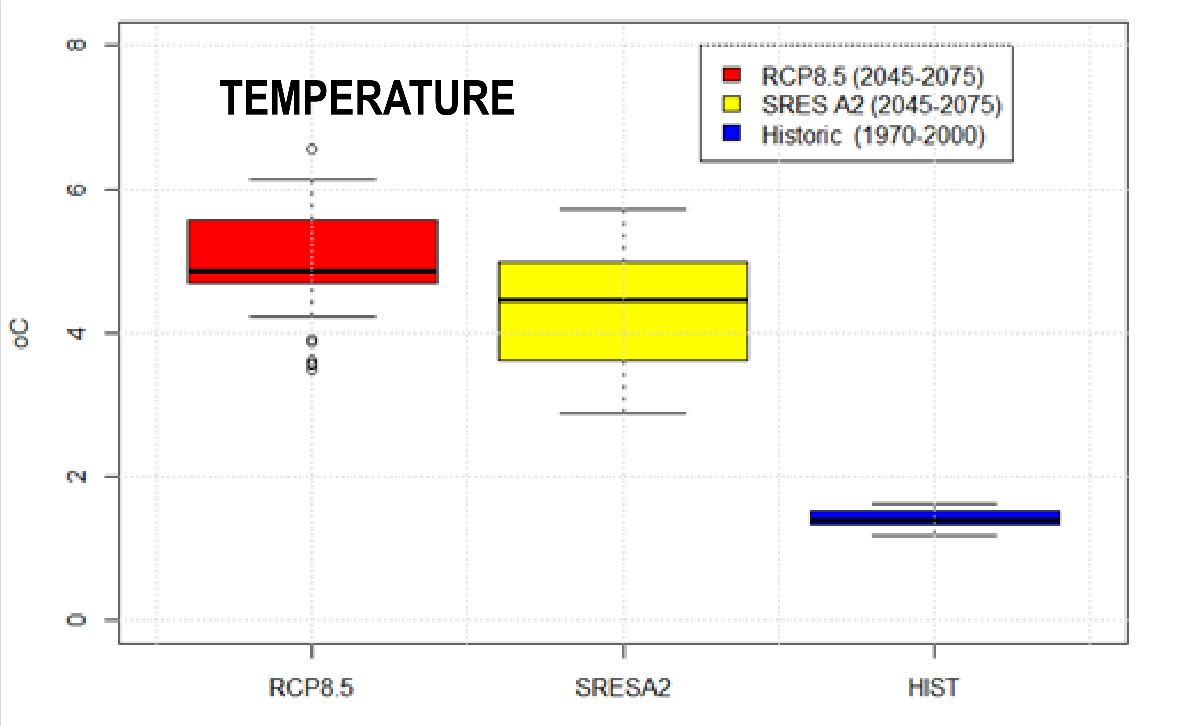


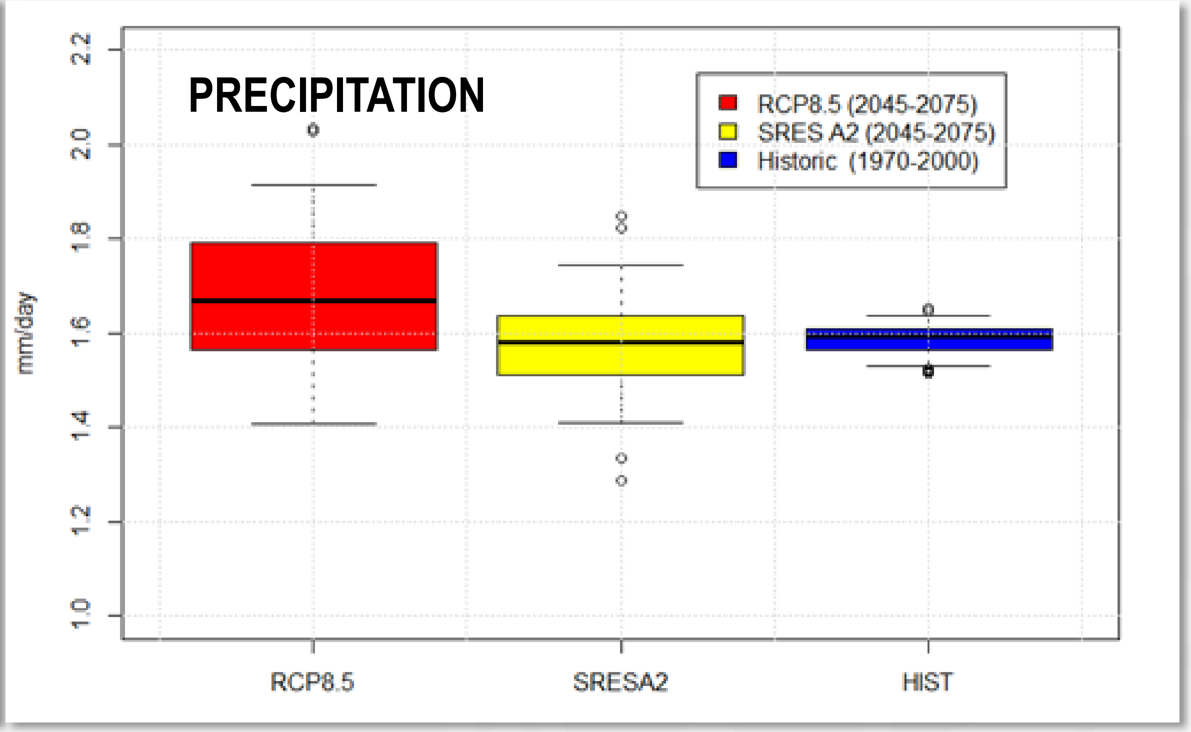
Bureau of Reclamation. 2013.

- Each scenario has its own distribution of forecasts
- An average would have a completely different exceedance curve
- Combined or “ensemble” output has a different distribution
  - Although it preserves min and max

Not all variables are predicted with the same uncertainty

Trends are in much closer agreement in temperature and sea level rise compared to precipitation

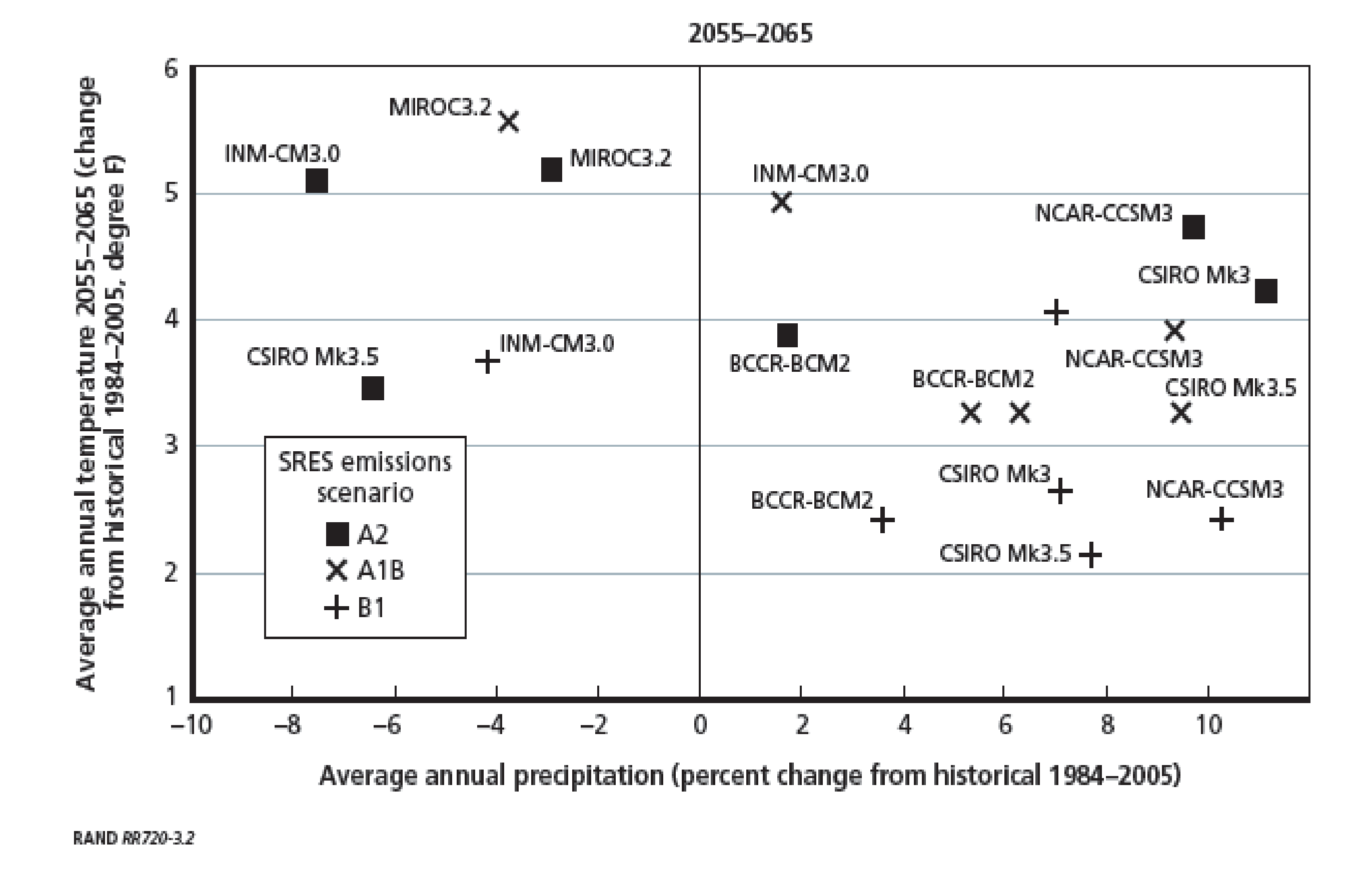




In Reviewing Multiple Predictions

Common and useful approach:

- How hot?
- How wet or dry?
- Quadrant of:
  - Hot/Dry
  - Hot/Wet
  - Warm/Dry
  - Warm/Wet



Ok, ….but how do we quantify impacts?

Methods we can apply

Summary of Researched Forecasts

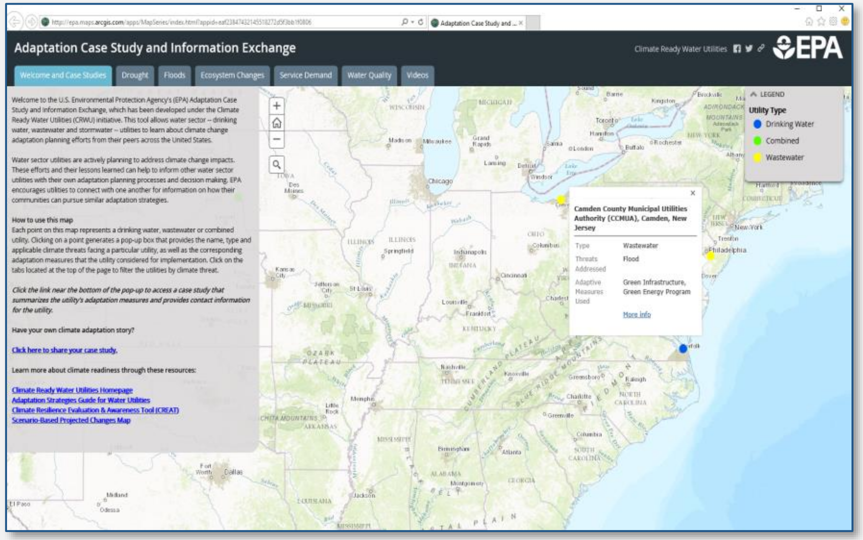
It's useful to start with researching prediction ranges (context)

Example: SoCal - Climate models general show:

- Temperatures will increase by approximately 3 to 9 °F
- Precipitation may decrease by 25% or increase by 30%
- In the Southern California Coast region, the magnitude and frequency of extreme precipitation events may increase
- SLR by 2100 forecasted to be 16 to 66 inches

Multiple agencies assessing vulnerability

Examples of adaptation efforts across the country "Adaptation Case Study and Information Exchange"



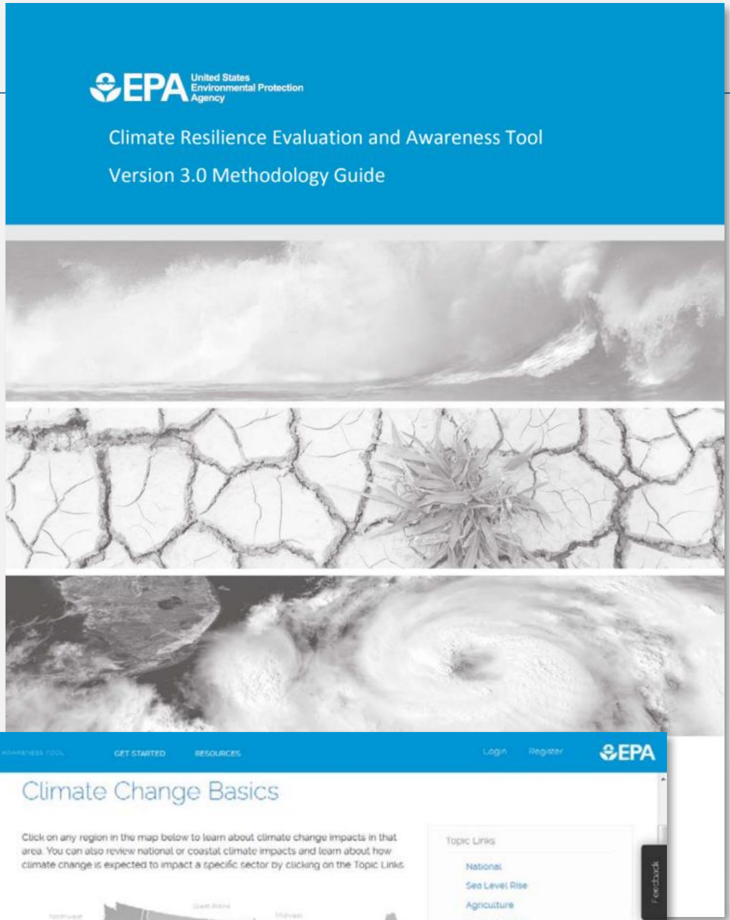
EPA's GeoPlatform

https://epa.maps.arcgis.com/home/item.html?id=eaf23847432145518272d5f3bb1f0806#overview

EPA CREAT (Climate Resilience Evaluation and Awareness Tool)

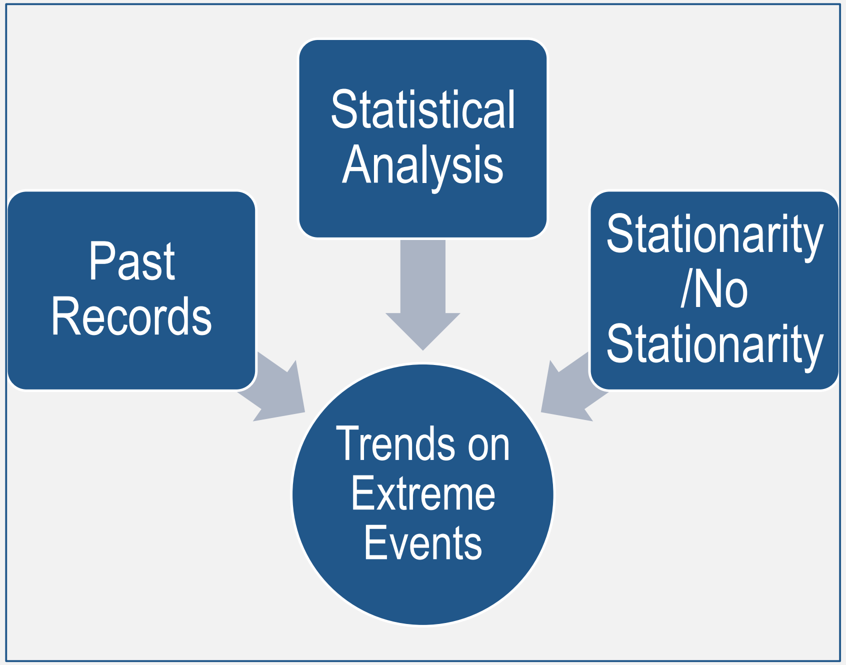
- Climate awareness
- Scenario development
- Consequences and assets
- Adaptation planning
- Risk assessment

Well documented and defensible but limited in terms of selection of different background information (scenarios)

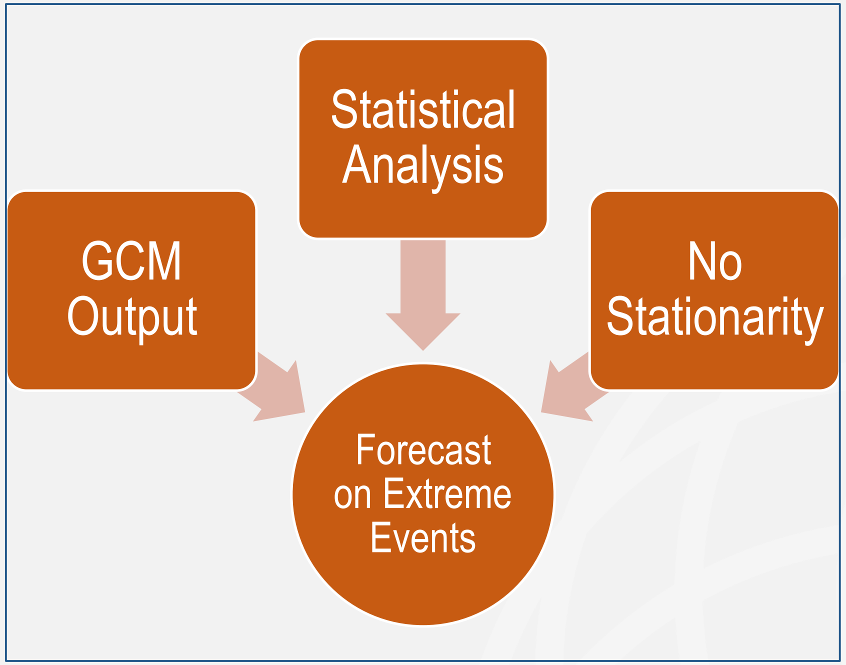


Two Clear Trends in the Industry

Option 1: Rainfall Data Analysis



Option 2: GCM Forecast Analysis



Data & Trend Analysis Example

Data Analysis

- Key Question:

  Can we identify a trend in events, related to frequency (for a given intensity), intensity (for a given return period), volume (for a given event type)

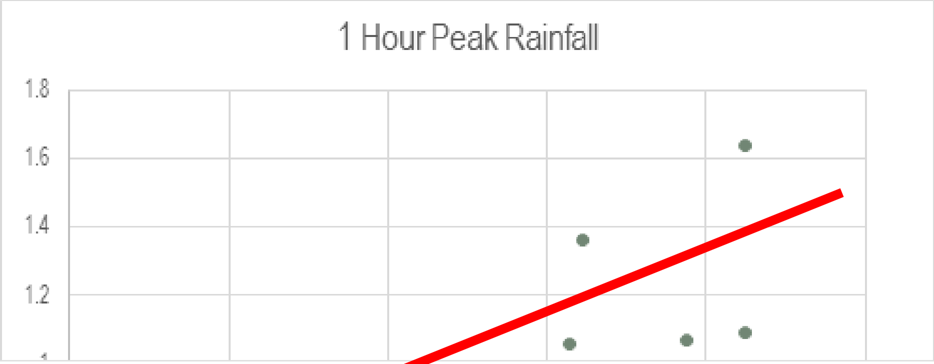
- Use conclusions on trend analysis to modify design storm

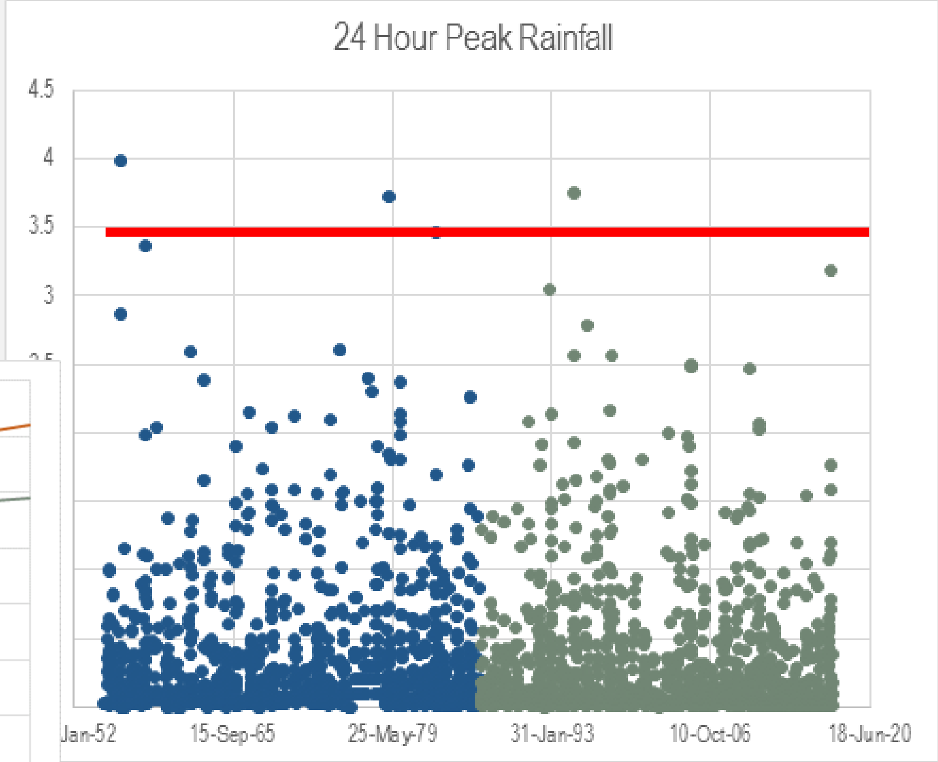
Simple Annual Maximum analysis

- Used local stations rain data from 1954 – 2017
- Aggregated peak cumulative rainfall at: 1-hr, 24-hr peaks
- AMS (only one maximum per year)
- Analyzed overall record, multiple recent intervals

Real example of precipitation analysis

- 1-hr Peak Seems to Trend Up with 24-hr Peak is Stationary





Statistical Significance Not Computed

Example of GCM forecasts for “perturbed” design storm

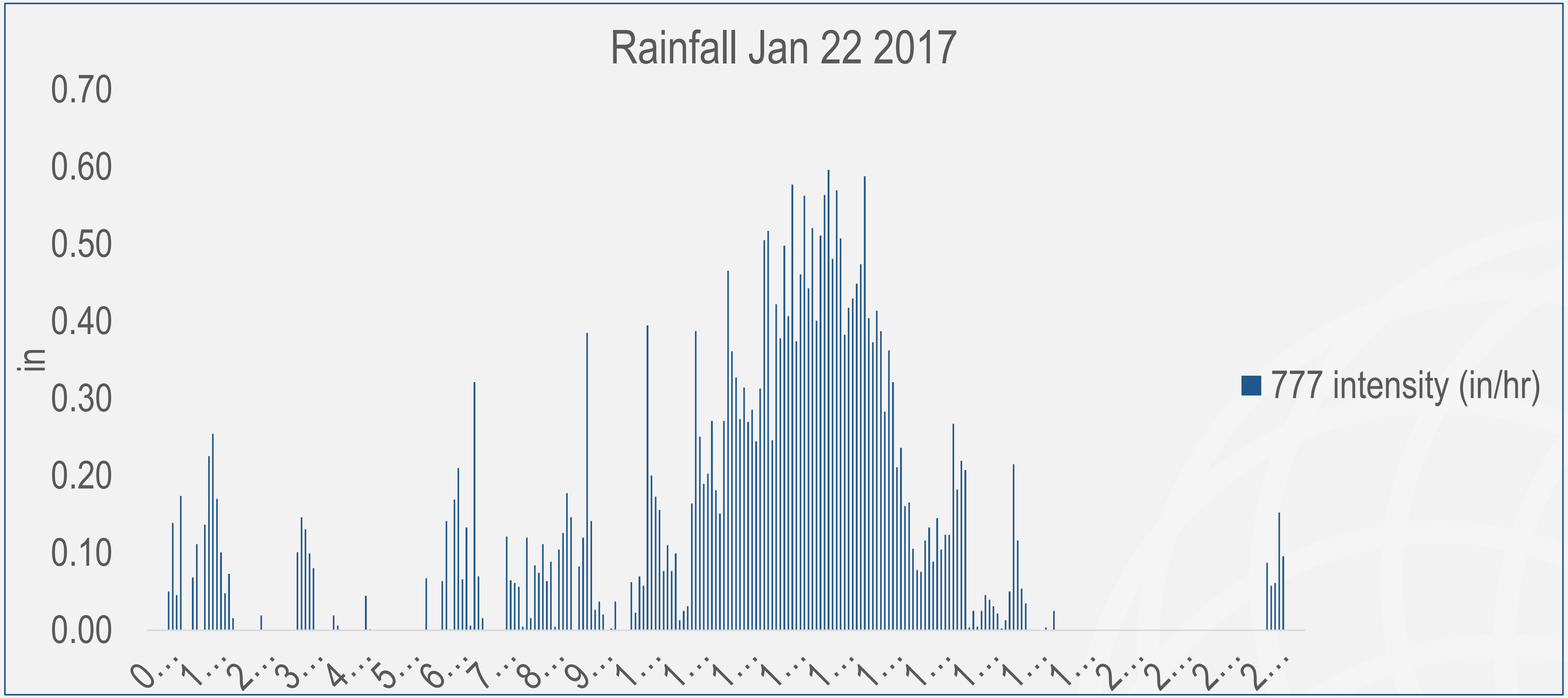
Used One Forecast Available from GCMs to Illustrate Mechanism to Perturb a Design Storm

Measurement	Value	Units	Source
Annual Change in temperature	2.88	Fahrenheit	CREAT
Annual Change in precipitation	11.16	%	CREAT
Number of Hot Days Over 100 F (Annual)	1.65	Days	CREAT
Change in 100-year Intense Precipitation Event	30.43	%	CREAT
Sea Level Rise by 2100	43.87	Inches	CREAT

Apply additional volume using methods available:

- Arithmetic – percent increase applied to each data point
- Quantile analysis – delta for each quantile based on two distributions
- “Manual” – usually selecting a specific part of the event for “manual” addition of volume

Start with historical event



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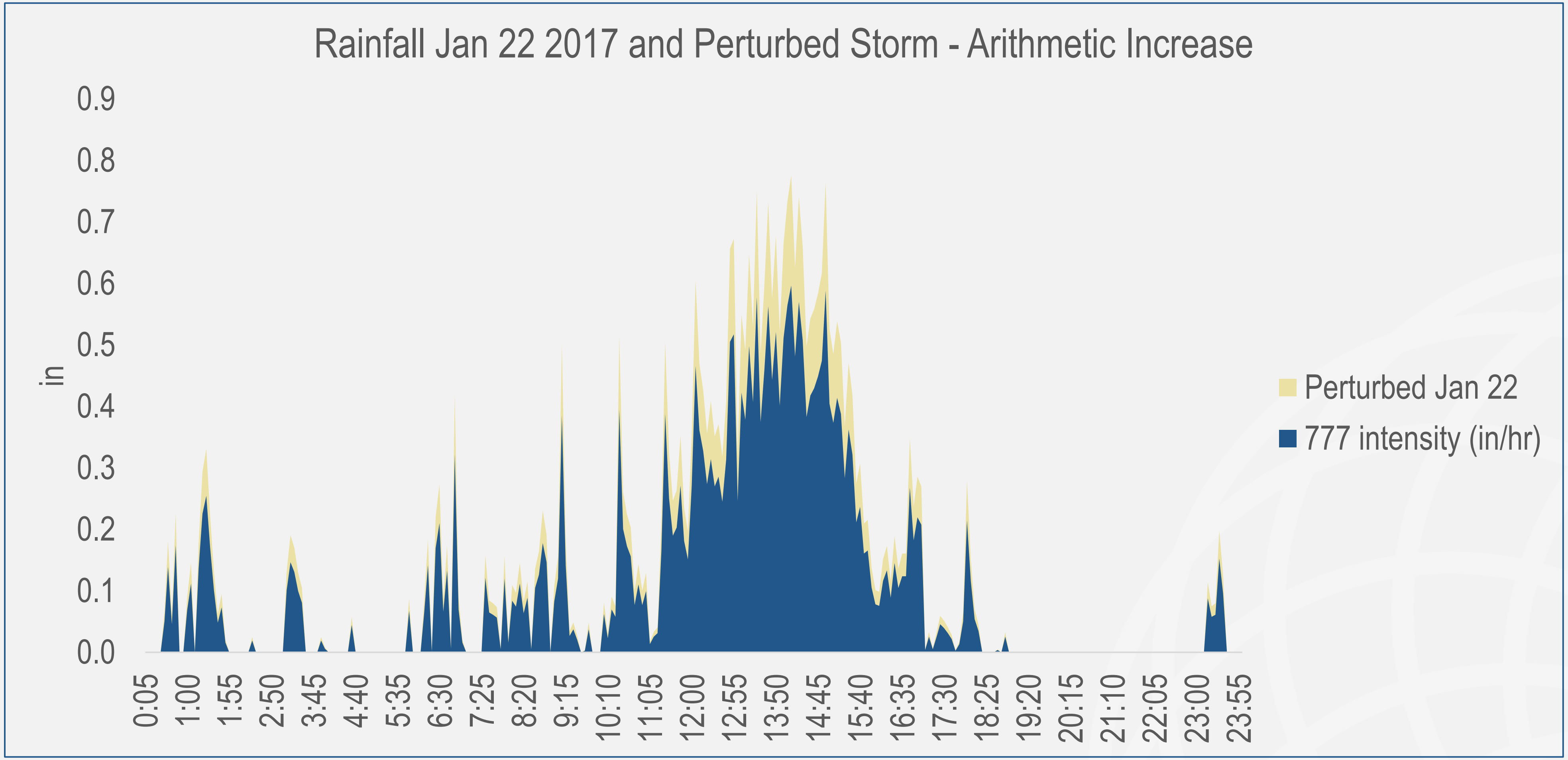
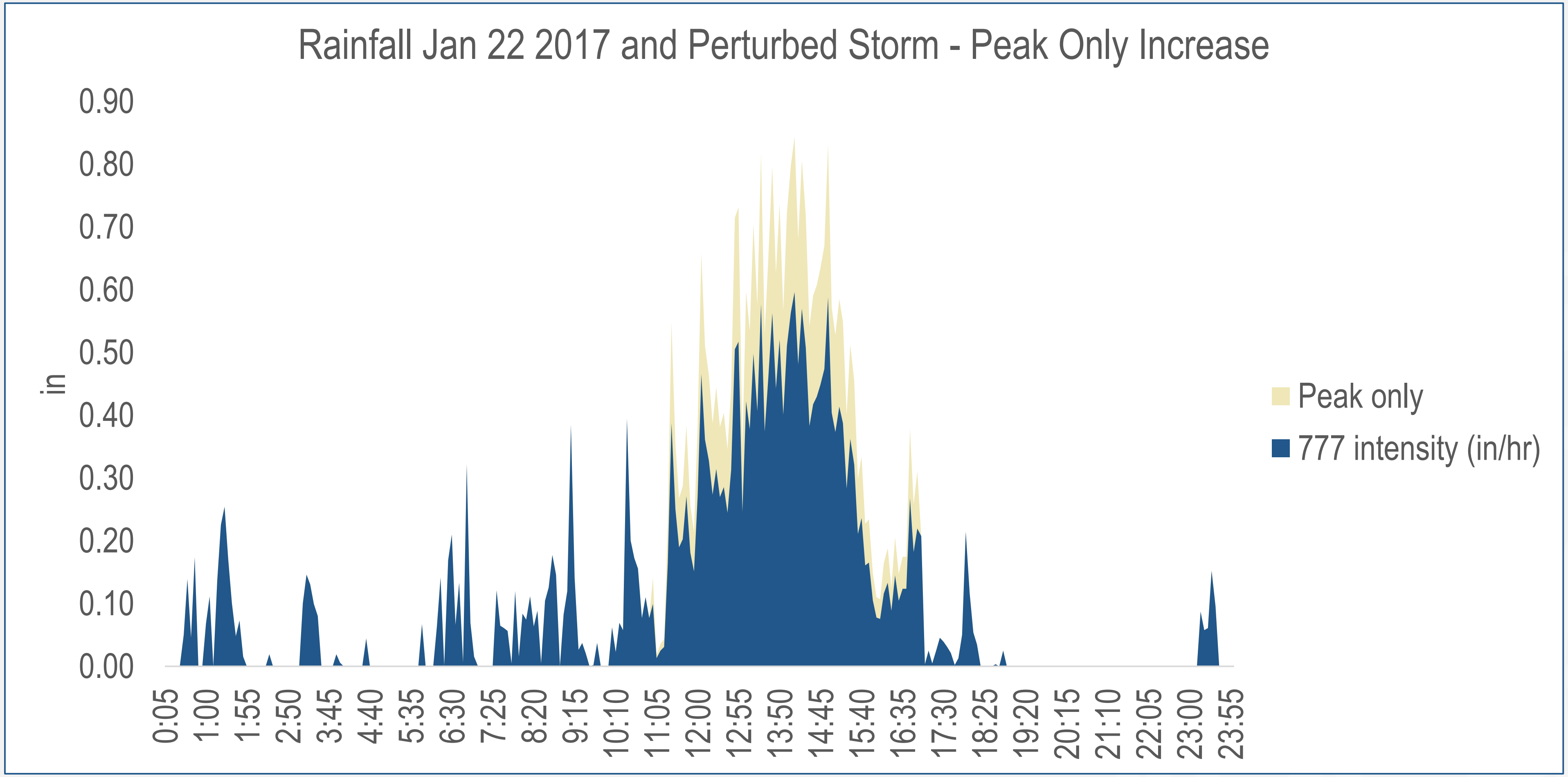
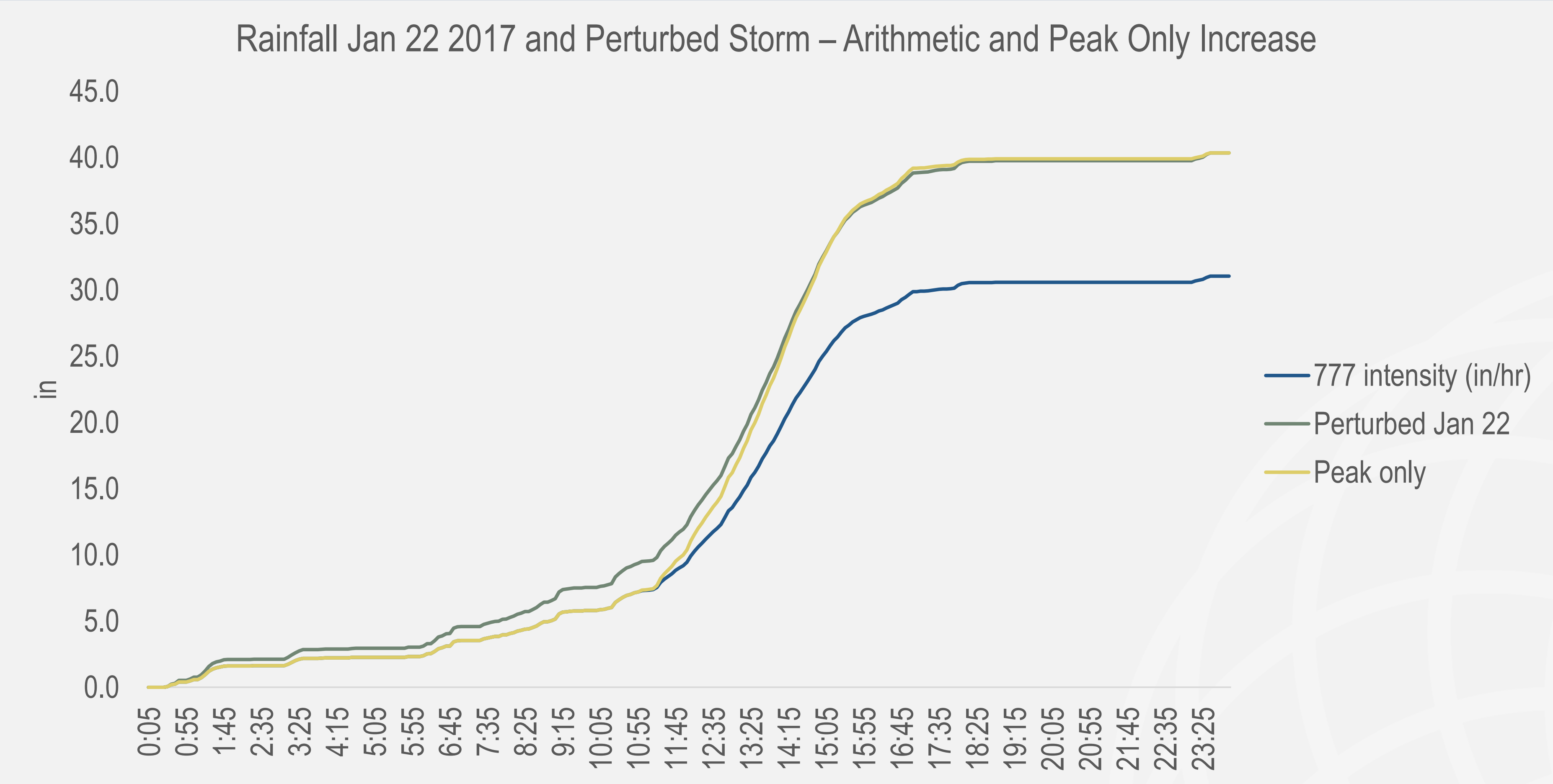
Methods: Arithmetic distributed increase



Methods: Arithmetic and Peak Only Increase



Methods: Arithmetic and Peak Only Increase



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Conclusions and recommendations

- Methods are established
- Uncertainty in forecasts is key
- Decisions about methods for PRE-processing of forecasts
- Understanding the science behind
- Not trivial

- Perform a task with multiple climate change scenarios and perturb design storm to define implications
- AND/OR: Define thresholds of system performance and find GCM predictions that would trigger events beyond that threshold

Questions

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Thank you!