Integrating Climate Impacts Into Groundwater-Surface Water Models:

A Pilot Study Using Existing Data and Open Source Models

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The Big Water Supply Shift

The Sustainable Groundwater Management Act

Undesirable results

- Chronic lowering of groundwater levels
- Reduction in groundwater storage
- Seawater intrusion
- Water quality degradation
- Land subsidence
- Depletions of interconnected surface waters

Measuring What Matters

Setting Measurable Objectives to Achieve Sustainable Groundwater Management in California

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Effective measurable objectives

- Define clear baselines;
- Set quantitative thresholds;
- Develop protective triggers that require action before reaching a threshold;
- Incorporate regular measurement and monitoring;
- Account for uncertainty; and
- Adapt to changing conditions and new information.

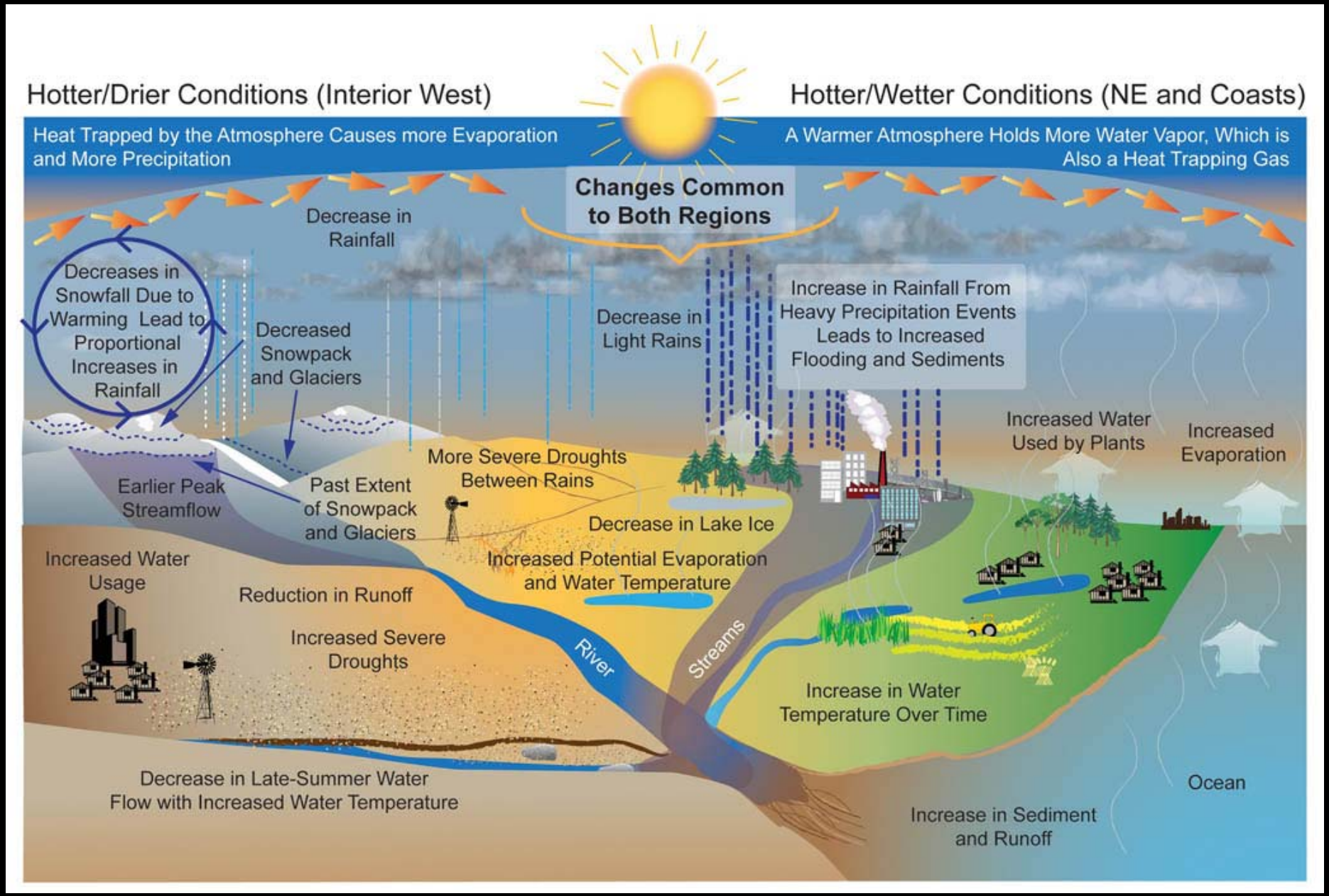
Groundwater Sustainability Plan Regulations

- Section 354.18 Water Budget

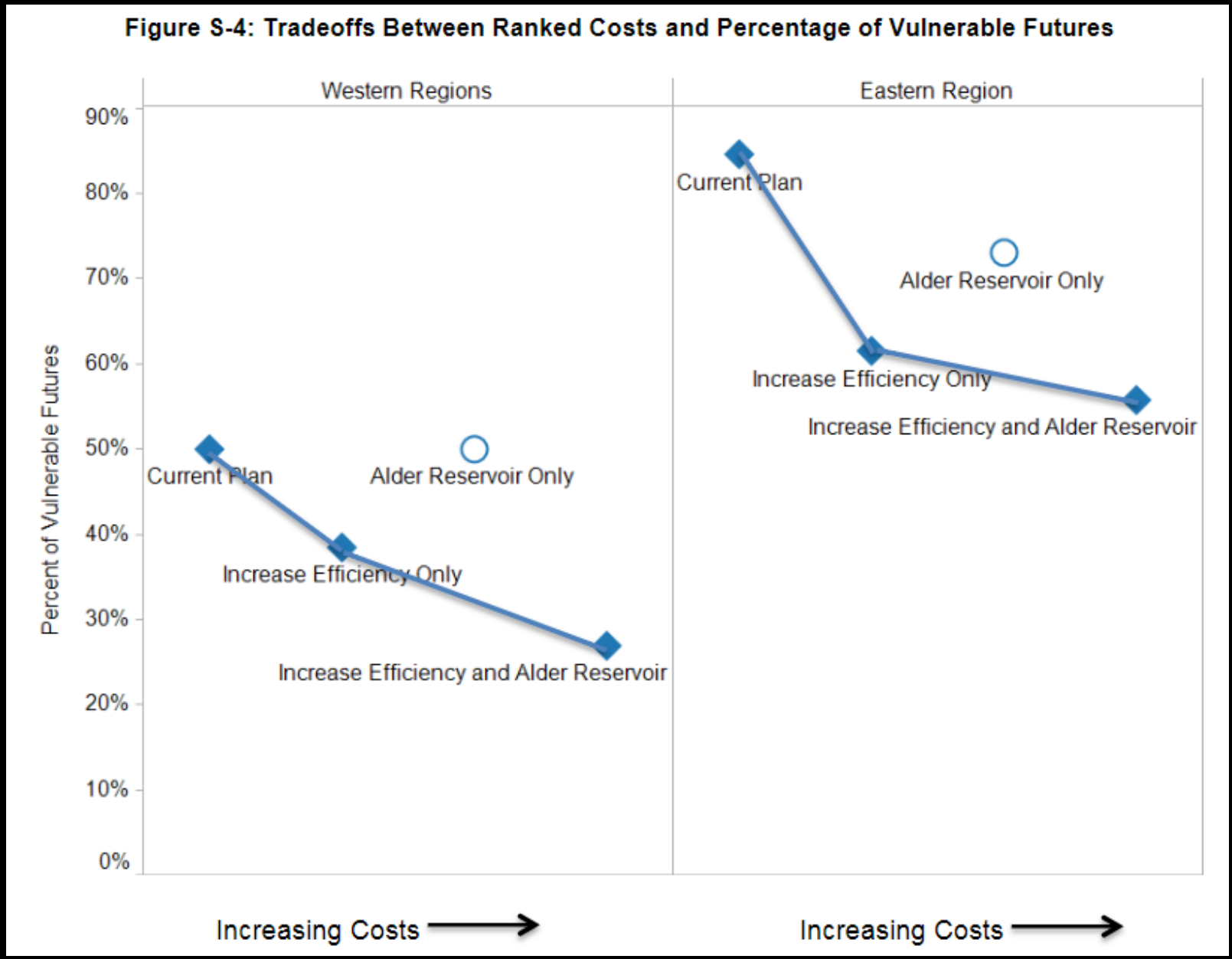
"Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise."

How *do we "evaluate future scenarios of hydrologic uncertainty?"*

Mostly Qualitative Analysis…



…Versus Quantitative Analyses



What can be accomplished using existing data, open source models, and a small budget?

What kind of data and open source models exist?

- Open source: publicly release the calculations and computer codes that drive model results. Do not require user licenses and, typically, can be downloaded by anyone with internet access
- *The Devil is in the Data: The Role of Science, Data, and Models in California's Historic Sustainable Groundwater Management Act (CJPP 2016)*

Article

The Basin Characterization Model Downscaled Climate and Hydrology Datasets

A sample comparison of historical and modeled future data.
Top: April snowpack. Bottom: Max temperature.

About the Datasets

The Basin Characterization Model (BCM) datasets provide historical and projected climate and hydrology data at a 270 meter resolution. These data have formed the basis for multiple research projects and vulnerability assessments applying climate change projections to conservation decision-making, providing a common base-layer and set of assumptions across these projects.

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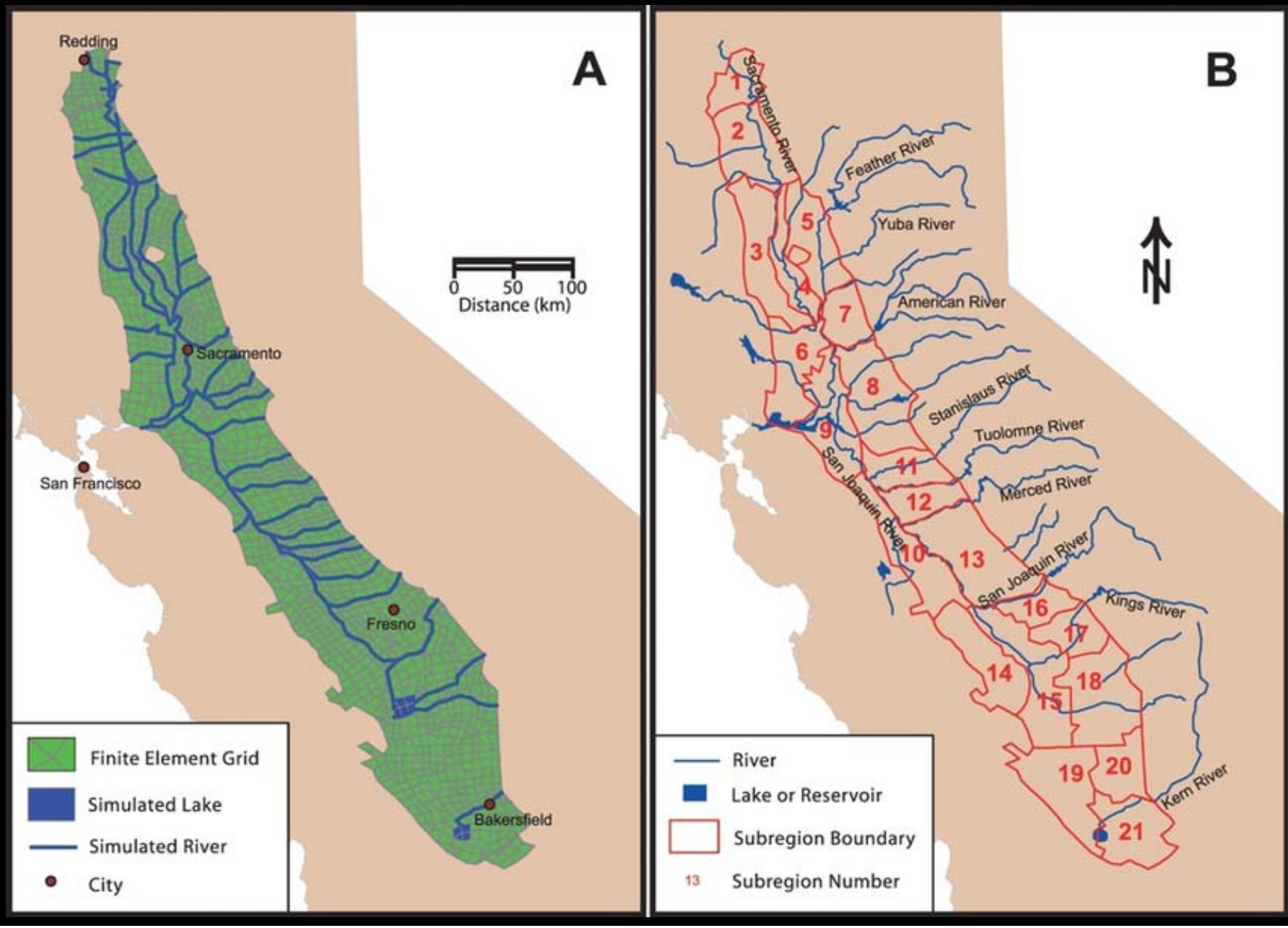
C2VSIM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River
Lake or Reservoir
Subregion Boundary
13 Subregion Number

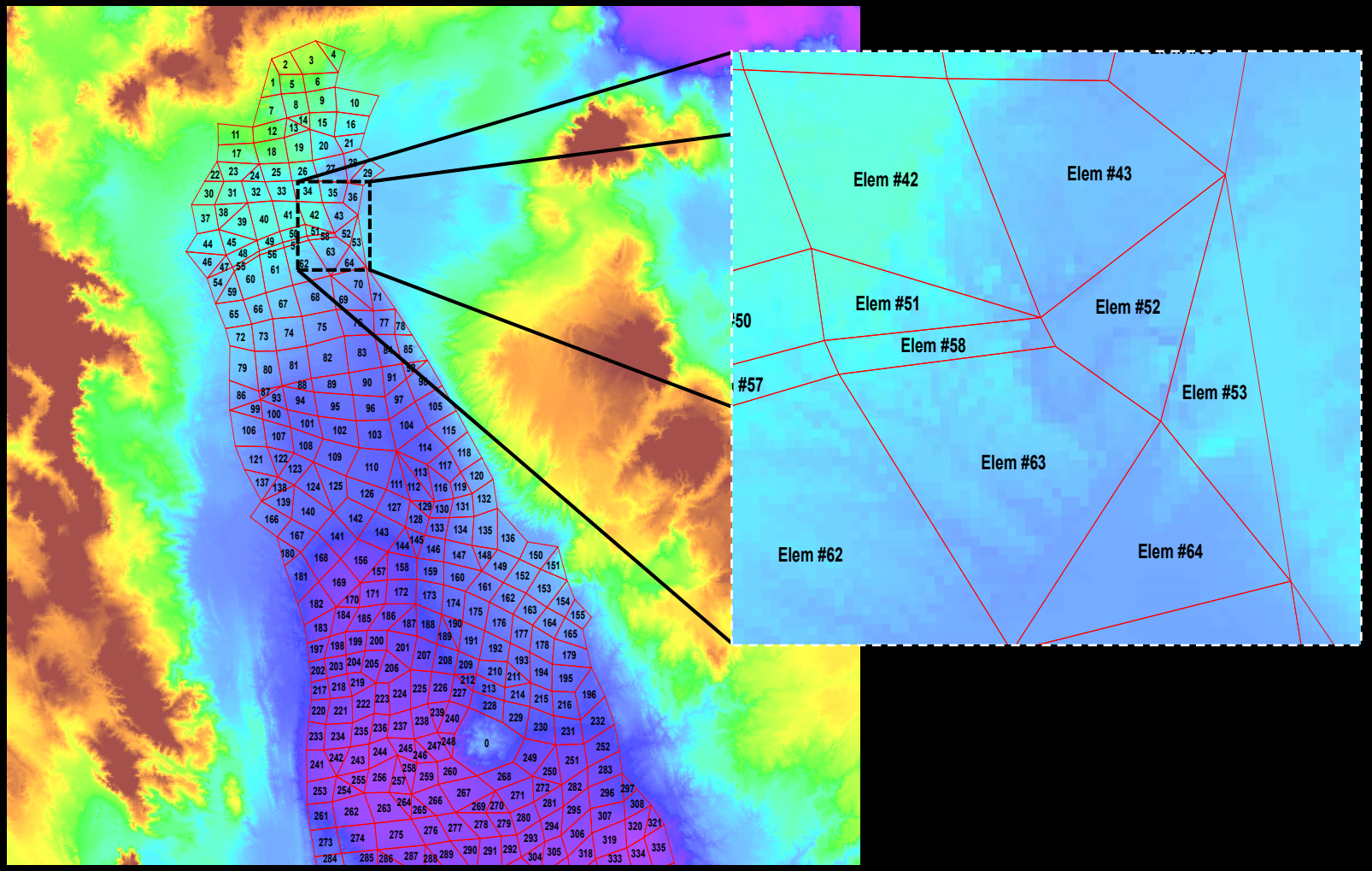
Pilot study focused on precipitation

- We applied bias corrected, downscaled precipitation datasets derived from global climate models (GCMs) for the BCM to the integrated groundwater-surface water model, C2VSIM
- We only looked at the wettest and driest scenarios to capture the range of possible futures
- Compared to a historic hydrology baseline

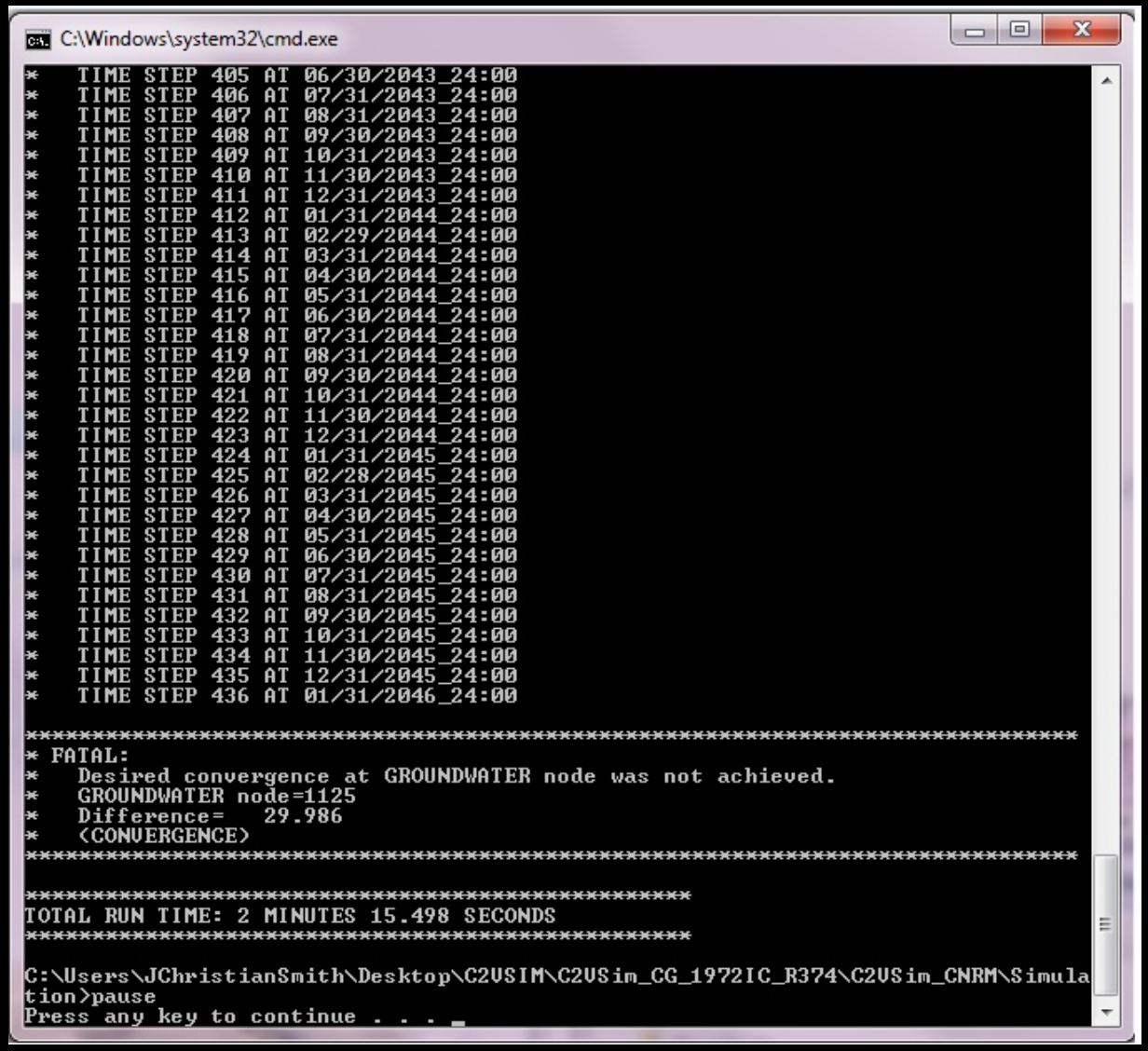
Pilot study's limitations

- Only analyzed sensitivity to precipitation, not reservoir outflows or evapotranspiration estimates
- Limited by the refinement of the C2VSIM grid
- As such, the pilot study represents a coarse-scale precipitation sensitivity analysis (the first step of a robust decision making analysis)

Aggregation of PRISM precipitation data for C2VSim elements



The actual process no one talks about…“FATAL ERROR”



Some key questions

- How are sensitive are these variables to precipitation?
  - groundwater storage
  - land subsidence
  - gain from streams
- Does precipitation matter?
- Which climate scenario is more likely?

Results

Scenario	Ending Storage (AF)	Gain from Streams (AF)	Cumulative Subsidence (AF)
BASE CASE	1,952,800,592	89,588	181,600,295
CNRM (wettest)	2,203,322,252	154,670	150,721,906
MIROC (driest)	1,772,125,777	42,051	198,211,693

Some key conclusions

- How are sensitive are these variables to precipitation?
  - groundwater storage (+/- 10%)
  - land subsidence (+/- 20%)
  - gain from streams (+/- > 50%)
- Do changes in precipitation matter? Yes, and it matters more for certain URs
- Which climate scenario is more likely? Climate scenarios are not probabilities, they are all equally likely to occur

Robust decision-making (RDM)

- RDM helps water managers iteratively evaluate robust strategies – those that perform well in terms of management objectives over a wide-range of plausible futures but may perform less well under an assumption that one future may be most likely to occur.
- Also called “stress testing” by DWR’s climate change TAG

Why *do we "evaluate future scenarios of hydrologic uncertainty?"*

Philosophical answer…

- Sustainability will be achieved in the future (sustainable yield to be achieved 2040)
- Unless you plan for future changes, sustainability may allude you
- Since the passage of SGMA, there are clear consequences for not achieving sustainability

Practical answer…

- Stop chronic lowering of groundwater levels at particular elevations
  - Develop management actions to keep groundwater above those elevations
  - Analyze under which conditions those management actions will fail to maintain elevations above the threshold
  - Reconsider management actions to avoid crossing thresholds

For more information

www.ucsusa.org/measuringwhatmatters

www.ucsusa.org/sustainablegroundwater

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