Smoke and mirrors in water modelling

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Smoke and mirrors in water modelling

something is being done or is true, when it is not

description that is not true or not complete and is used to hide the truth about a situation

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"Hydrology has a long tradition in UA/SA" (Reviewer #1)

→ **Hydrologists are well acquainted with uncertainties**

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- Overly confident explanatory language
- Simplified narratives about complex problems
- Overly precise statistics
- "Uncertainties will diminish with more refined models and datasets"

Smoke and mirrors in water modelling

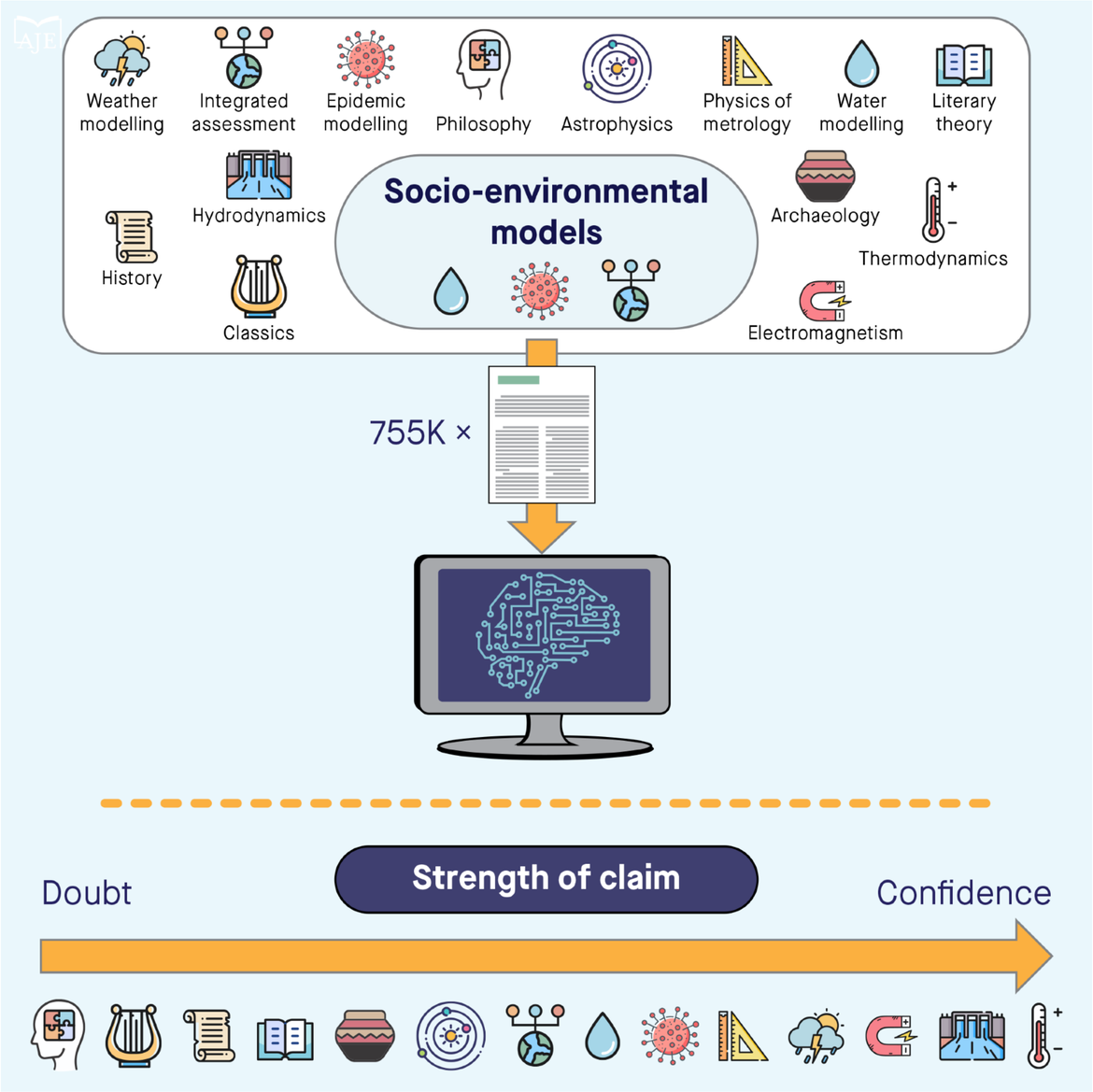
- Overly confident explanatory language
  - Water modelling is as assertive in knowledge claims as physics
- Simplified narratives about complex problems
  - “Humans have transgressed the freshwater planetary boundary”
- Overly precise statistics
  - “Irrigation withdraws 70% of all freshwater resources and produces 40% of all crops worldwide”
- “Uncertainties will diminish with more refined models and datasets”
  - Actually the opposite seems to be the case

Smoke and mirrors in water modelling

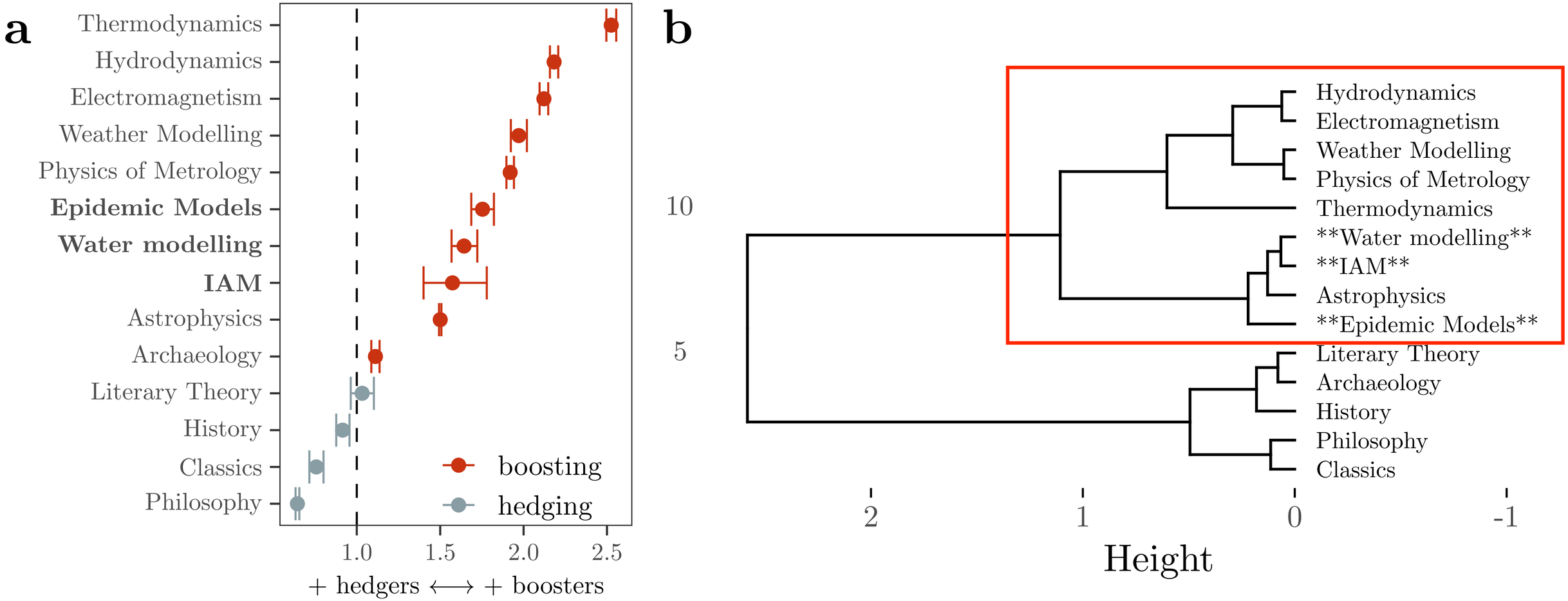
DAWN

Illuminating Deep Uncertainties in the Estimation of Irrigation Water Withdrawals

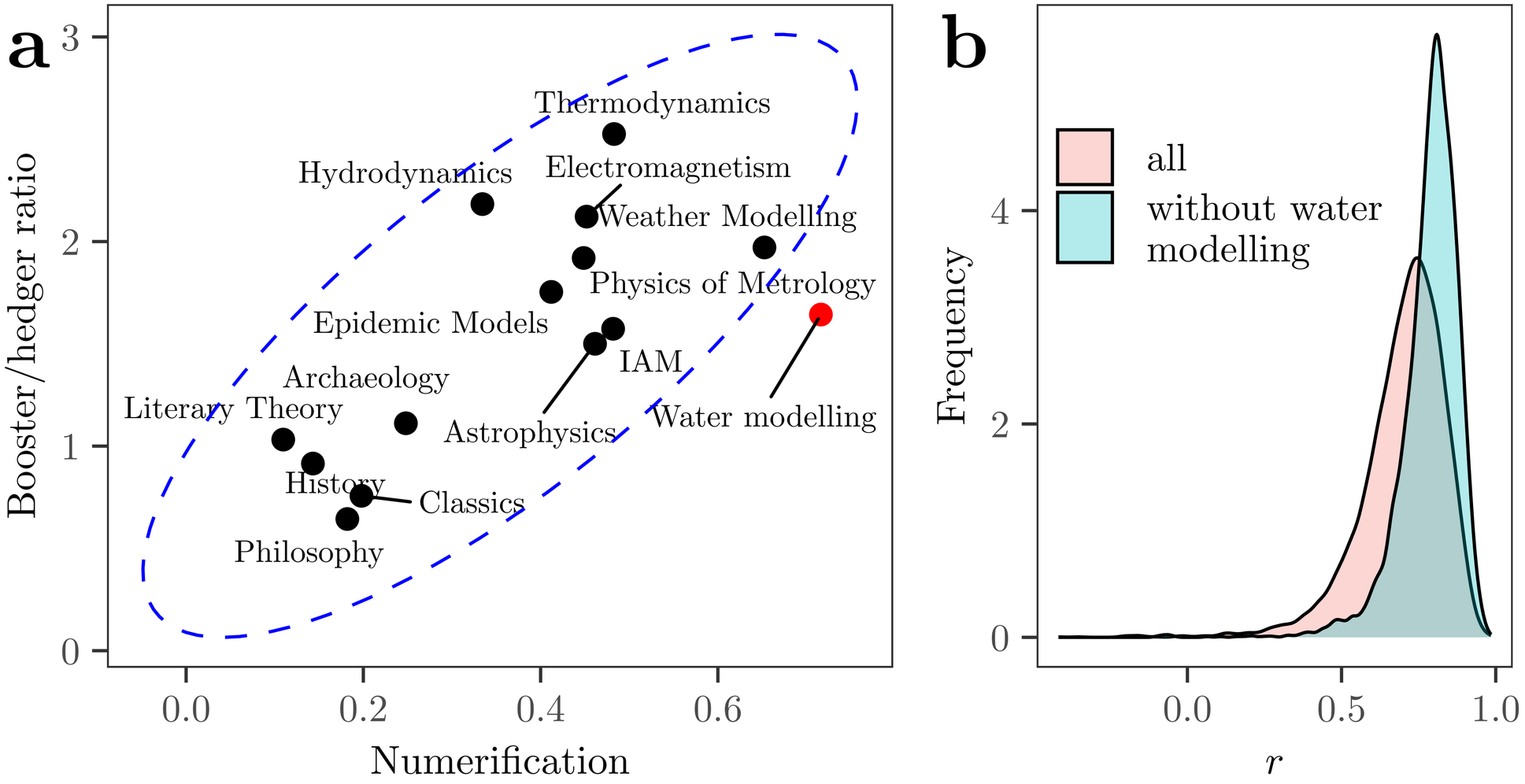
Water modelling is as assertive as physics



Water modelling is as assertive as physics



Water modelling **exceeds** physics in numerification



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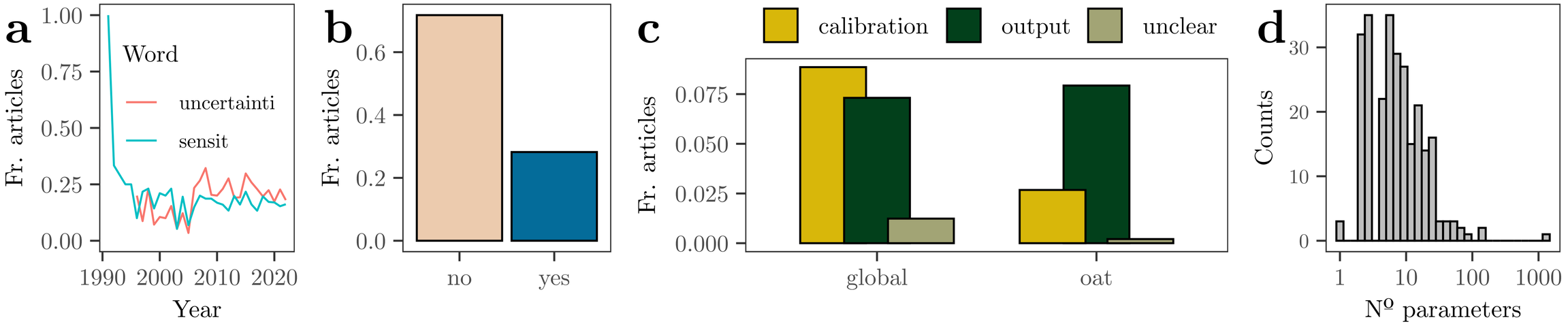

...but model-based numbers have not undergone UA/SA

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Socio-environmental modeling shows physics-like confidence with water modeling surpassing it in numerical claims

Arnald Puy [1,13] · Ethan Bacon [1] · Alba Carmona [2,3] · Samuel Flinders [1] · David Gefen [4] · Mohammad Khanjani [5] · Kai R. Larsen [6] · Alessio Lachi [7] · Seth N. Linga [1] · Samuele Lo Piano [8] · Lieke A. Melsen [9] · Emily Murray [1] · Razi Sheikholeslami [5] · Ariana Sobhani [10] · Nanxin Wei [1] · Andrea Saltelli [11,12] Show less

Affiliations & Notes Article Info

“We have exceeded the freshwater planetary boundary”

“We will fail on climate change if we do not solve water (…) **No person, place, economy or ecosystem will be spared**.”

We thus need a “**radical transformation**” of the economics of water”

GLOBAL COMMISSION on the ECONOMICS OF WATER

Mariana Mazzucato

Johan Rockström

“We have exceeded the freshwater planetary boundary”

Model

Global water consumption per year:

$$Y = PF_b W,$$

W is the estimated water required per person to sustain a 3000 kcal/day diet:

$$W = \frac{365\left(kF_m F_{m_w} + kF_v F_{v_w}\right)}{1000}$$

Model assumptions:

- F_b: need for eight digit precision (ratio green/blue water) = 0.1346154.
- k : Everybody consumes 3,000 kcal daily.
- k : No undernourished individuals in 2050.
- F_m, F_v : Diet: 80% vegetables, 20% meat.
- F_{m_w} : 1000 kcal meat = 4 m^3 of water.
- F_{v_w} : 1000 kcal vegs = 0.5 m^3 of water.

“We have exceeded the freshwater planetary boundary”

Model

Global water consumption per year:

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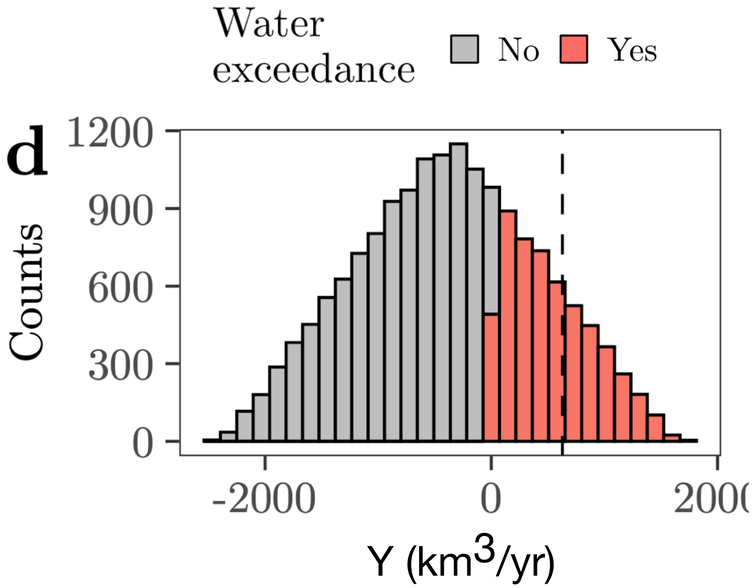

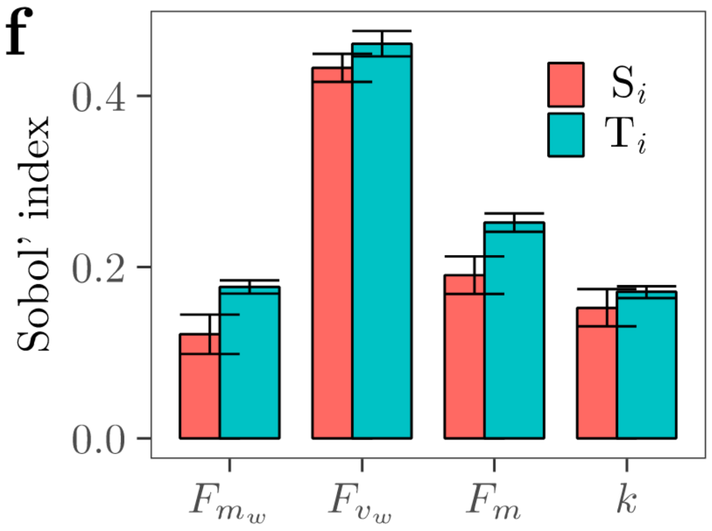

The Water Crisis by the Global Commission on the Economics of Water: A Totalising Narrative Built on Shaky Numbers

Arnald Puy

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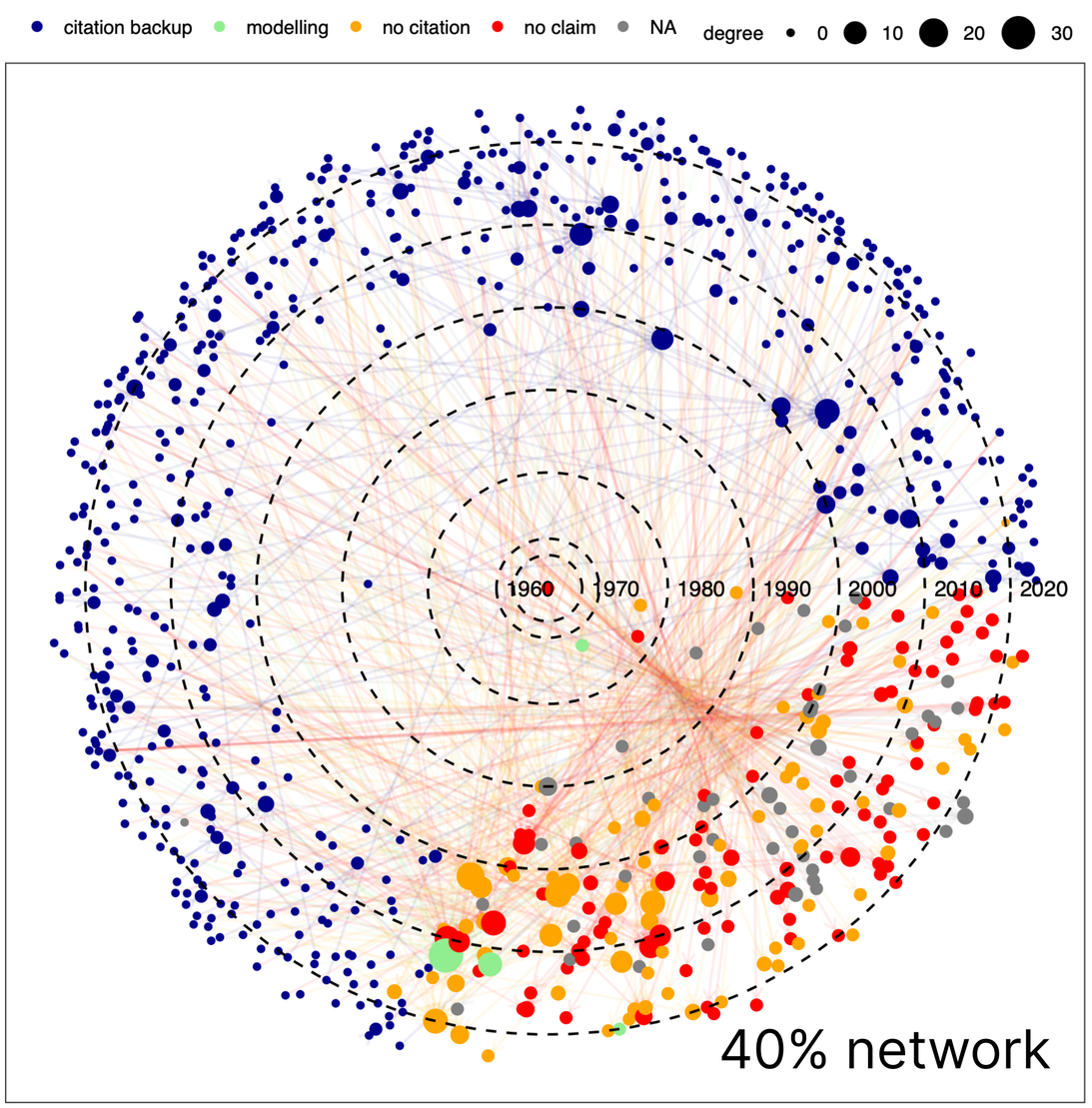
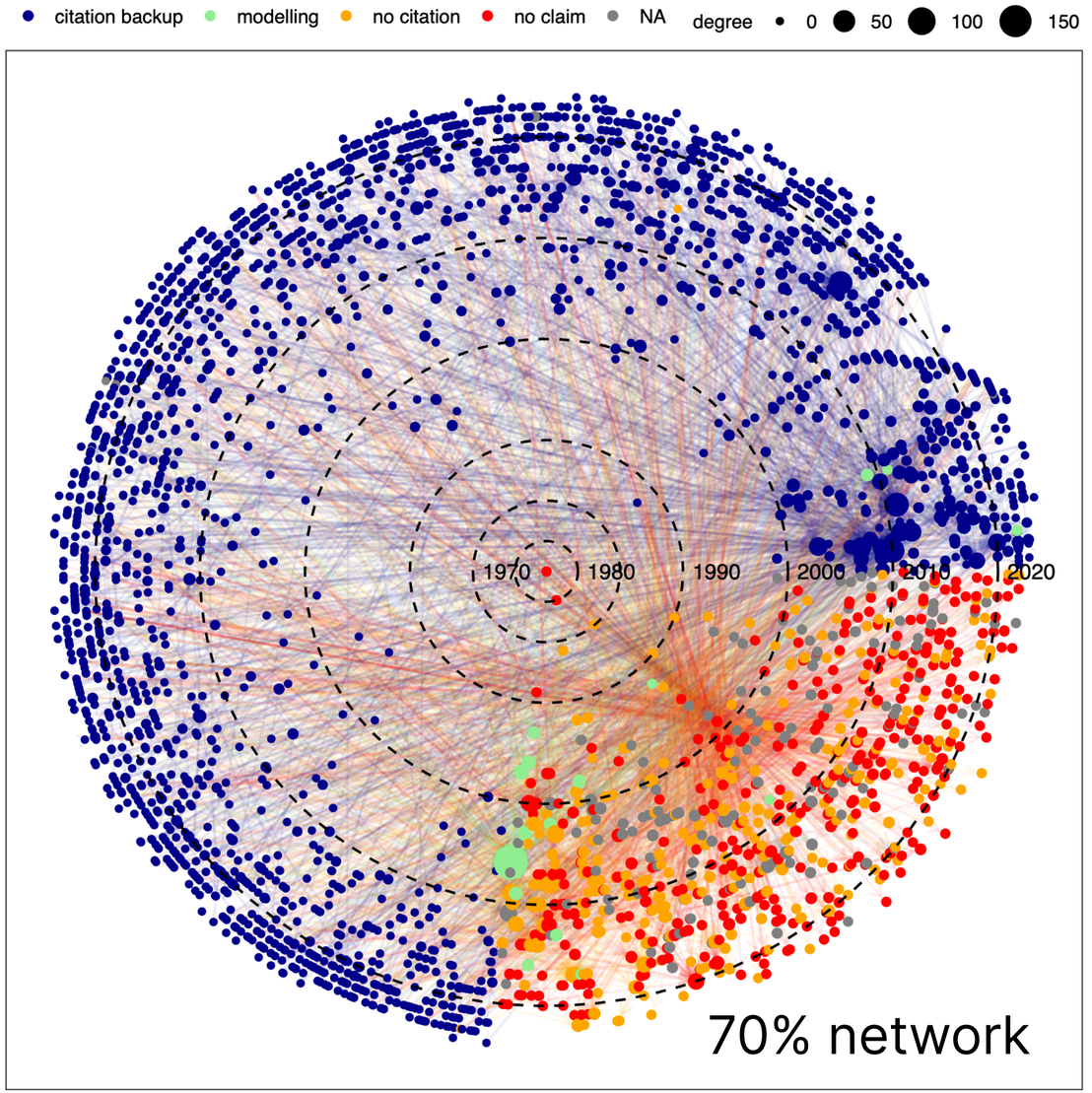
Bruce Lankford

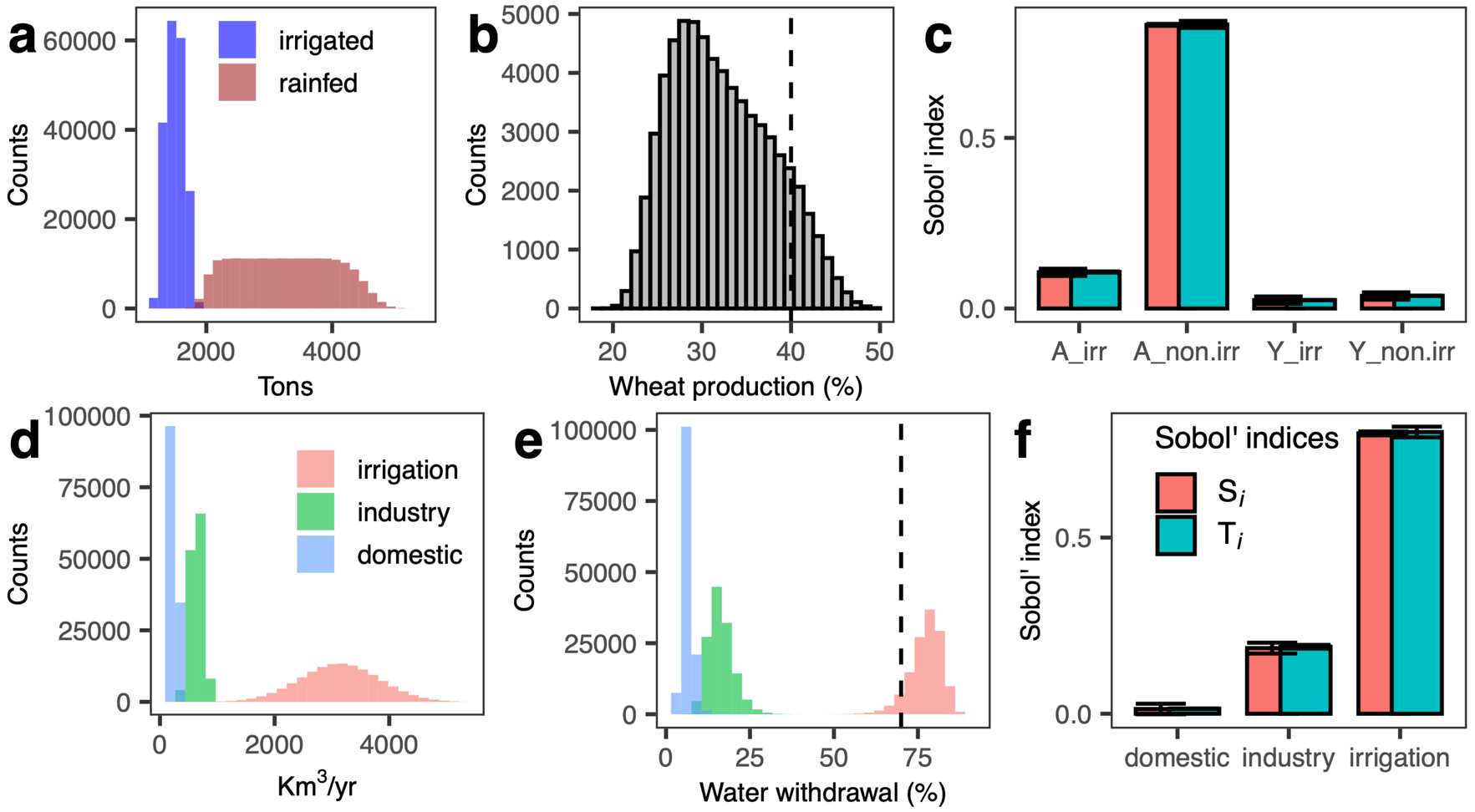
Emeritus Professor of Water and Irrigation Policy, University of East Anglia, Norwich, UK; b.lankford@uea.ac.uk

“Irrigation withdraws 70% of all freshwater withdrawals and produces 40% of all crops”





“Irrigation withdraws 70% of all freshwater withdrawals and produces 40% of all crops”



“Irrigation withdraws 70% of all freshwater withdrawals and produces 40% of all crops”

With current data:

“Irrigation withdraws 45-90% of all freshwater withdrawals and produces 18-50% of all crops”

AND THESE ARE LOWER BOUNDS

Low food, high water use
(18%) (90%)

Irrigation may be inefficient

High food, high water use
(50%) (90%)

Irrigation supports high use production at high water costs

Low food, low water use
(18%) (45%)

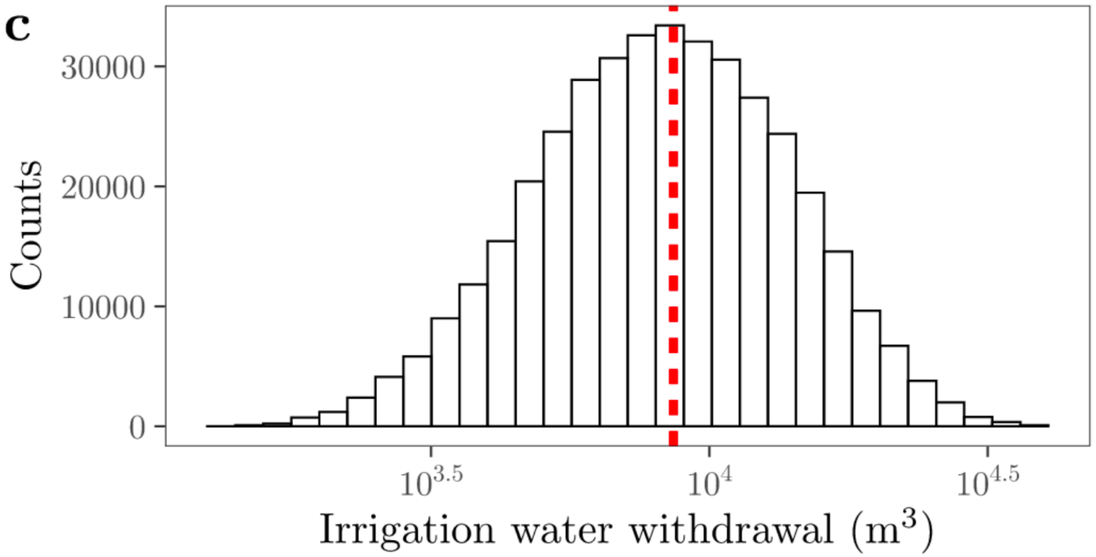
Irrigation has minor role in food production and water withdrawals

High food, low water use
(50%) (45%)

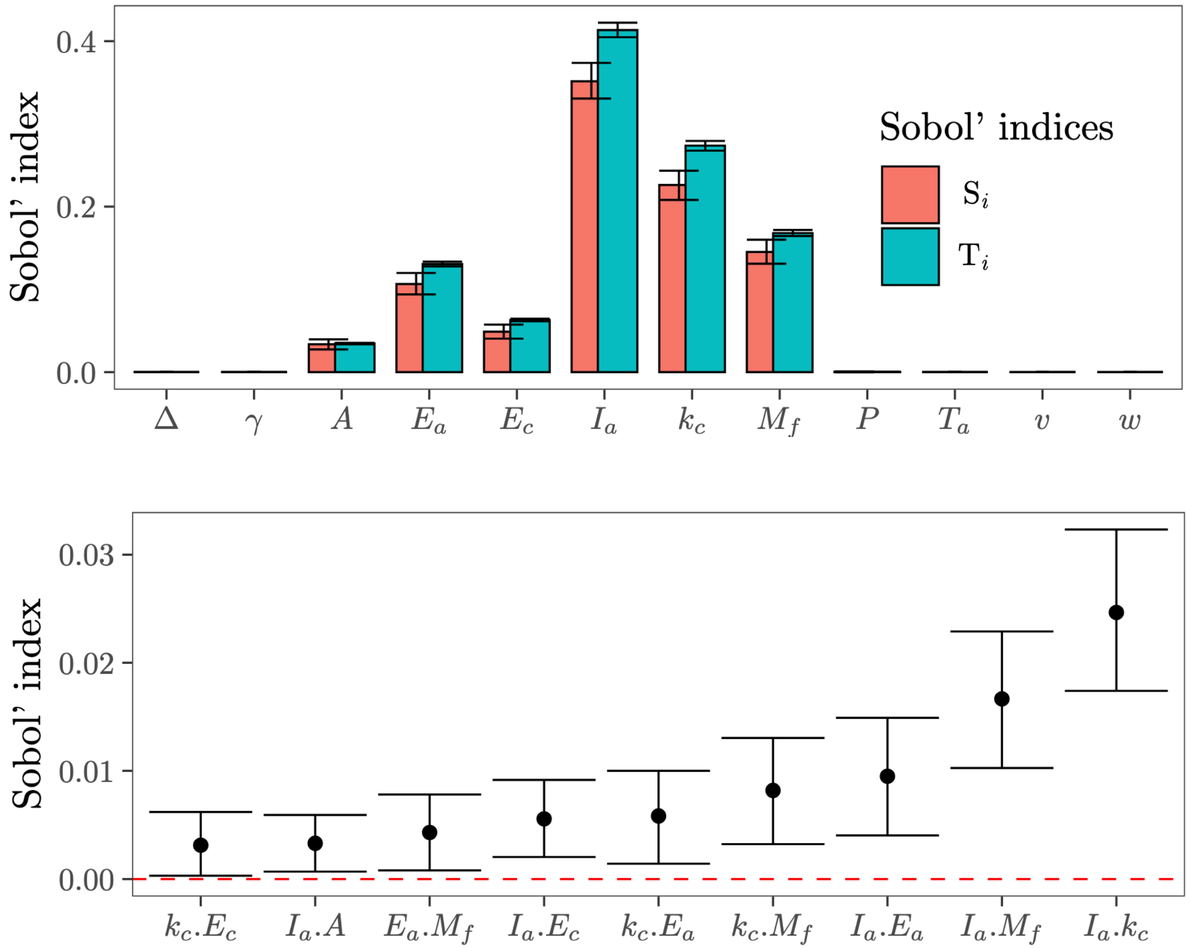
Irrigation is very efficient for global food and water security

Estimates of global irrigation water withdrawals are spuriously accurate

Global hydrological models: c. 200,000 grid cells



One single cell may hide uncertainties spanning two orders of magnitude



nature communications

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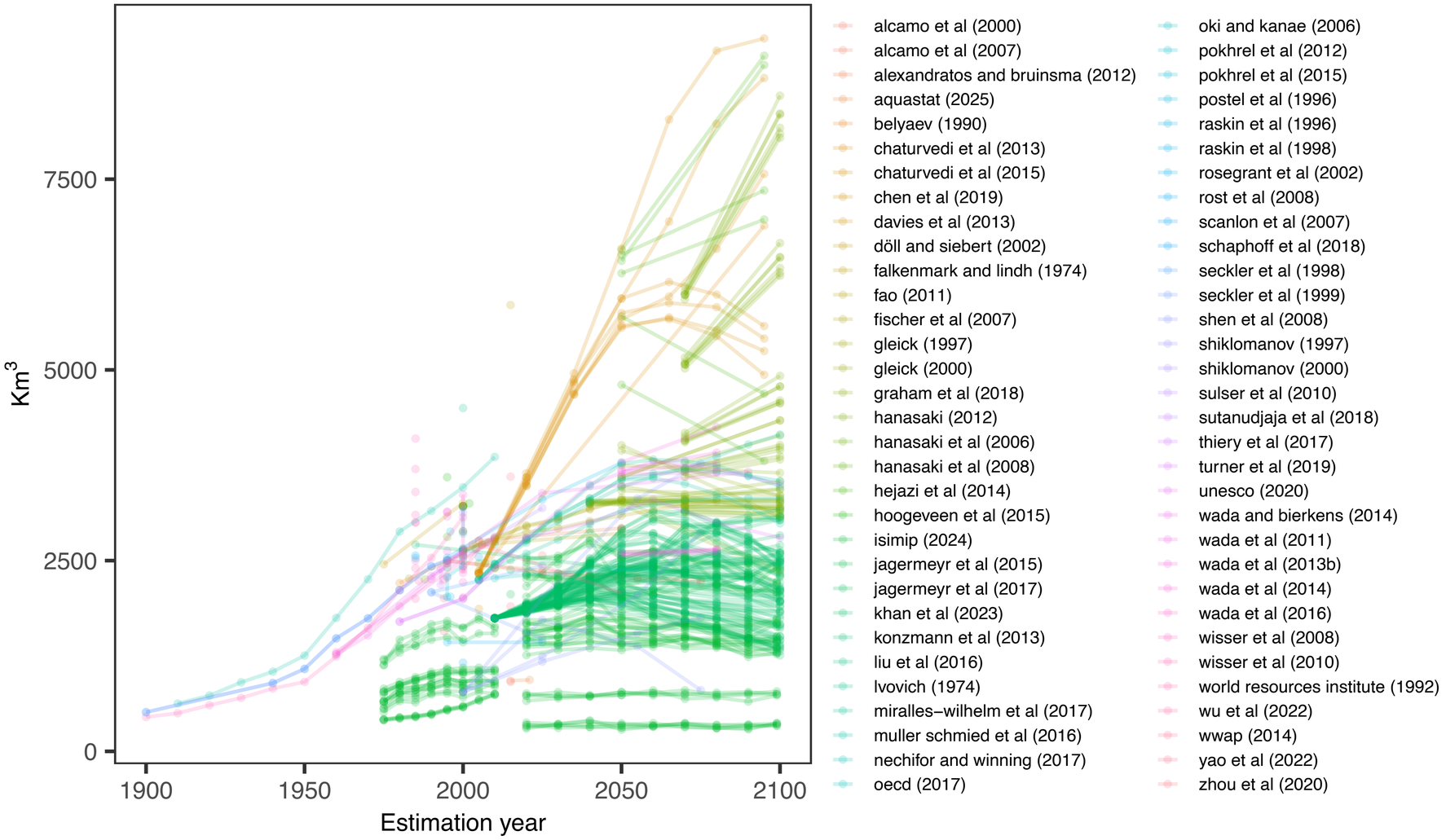
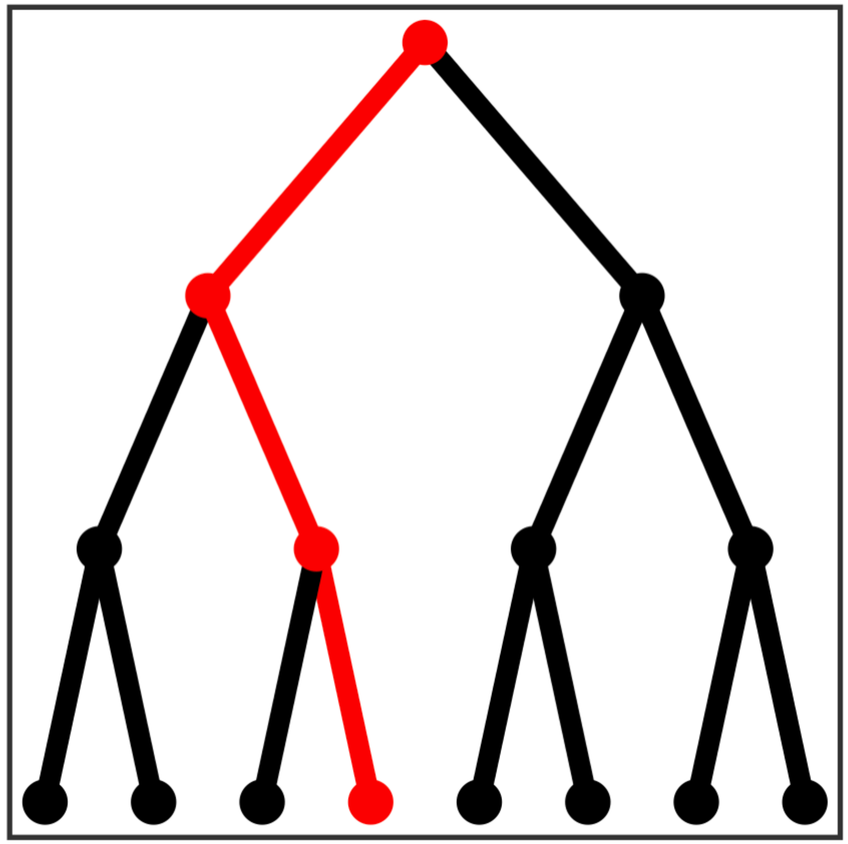
The delusive accuracy of global irrigation water withdrawal estimates

Arnald Puy, Razi Sheikholeslami, Hoshin V. Gupta, Jim W. Hall, Bruce Lankford, Samuele Lo Piano, Jonas Meier, Florian Pappenberger, Amilcare Porporato, Giulia Vico & Andrea Saltelli

1974-2025: “We have to refine datasets and models to reduce uncertainty in global irrigation water use”



Have 50 years of research reduced uncertainties?



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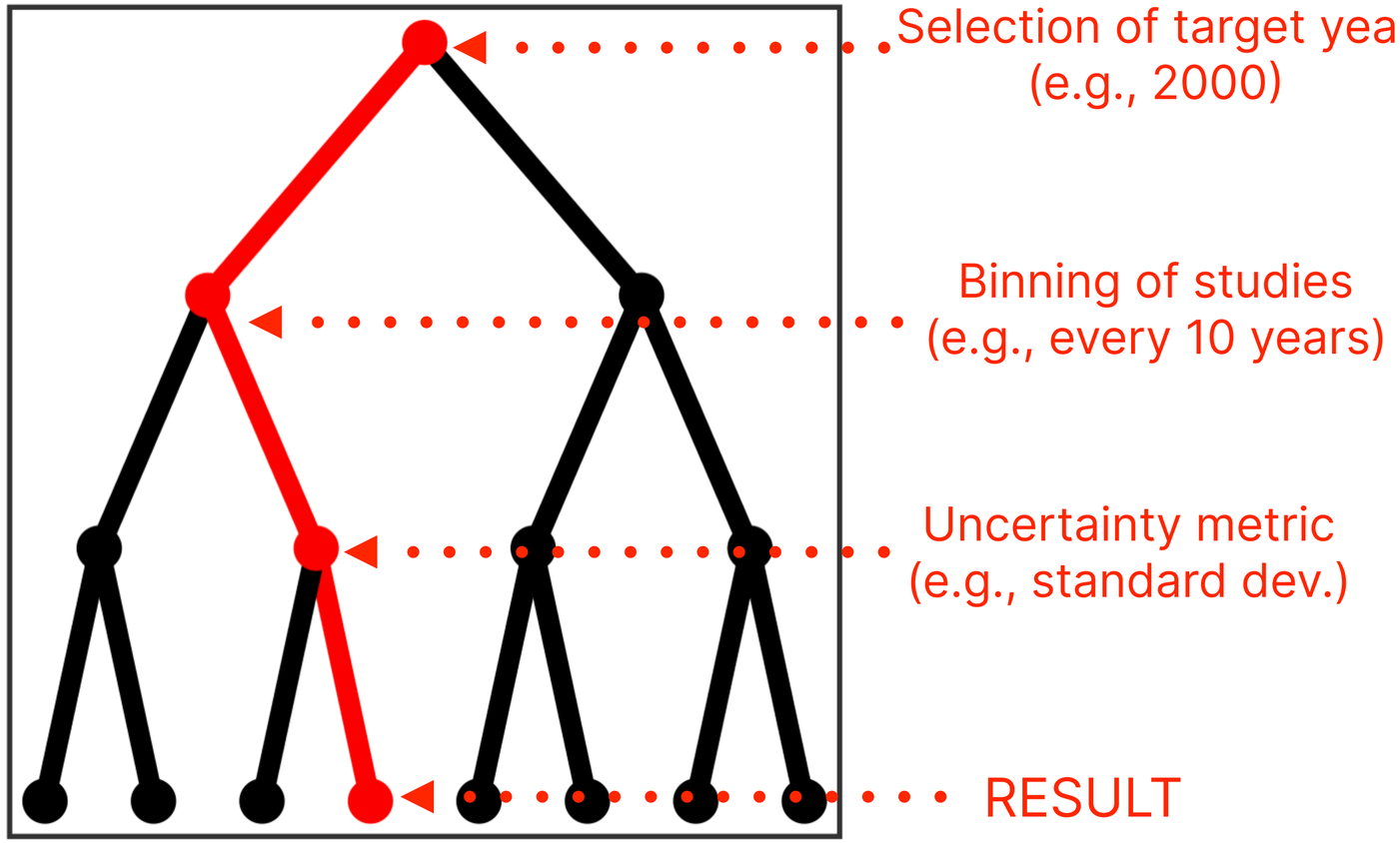

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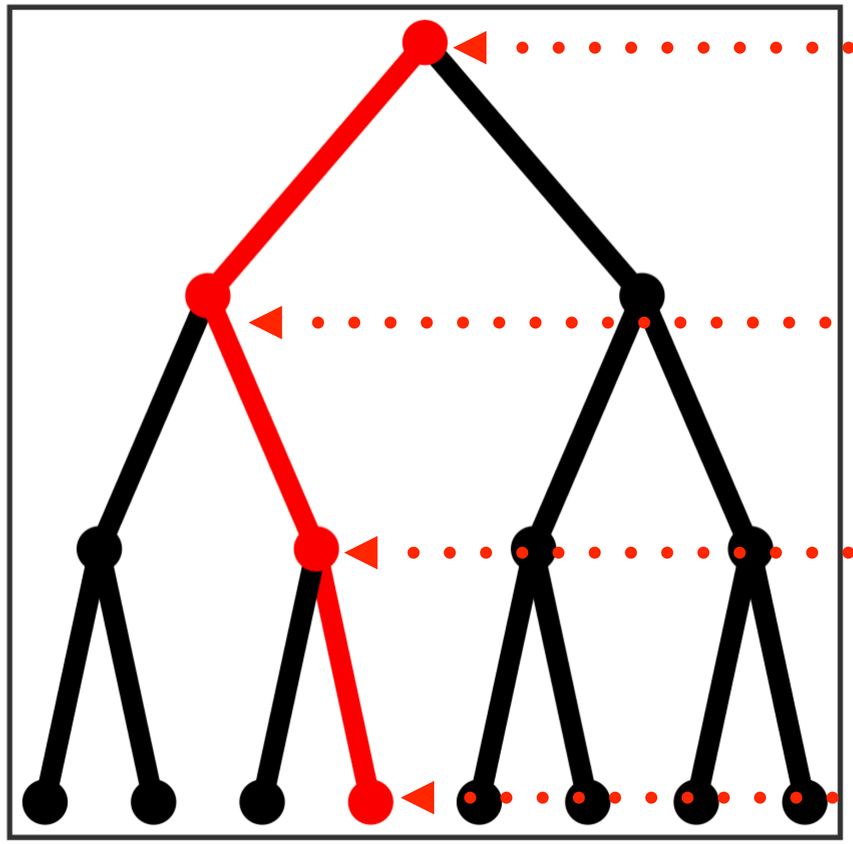
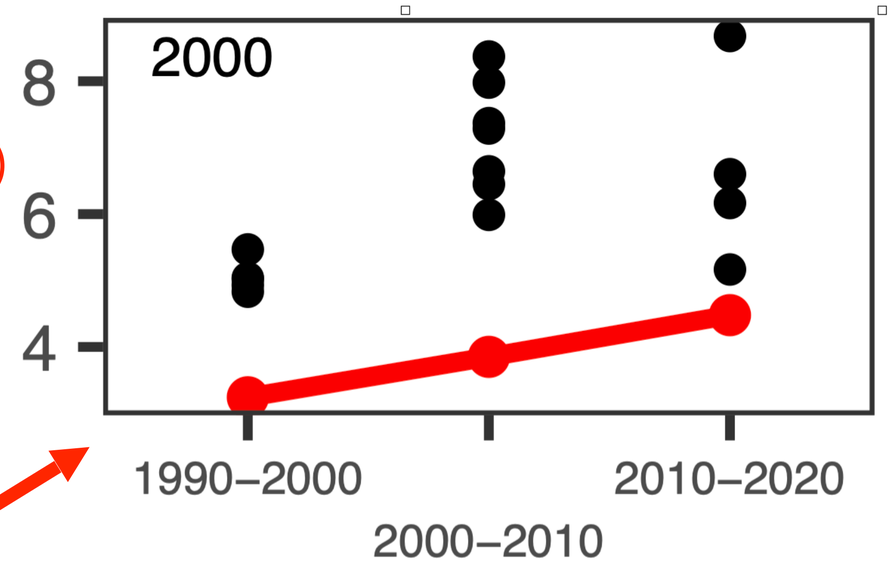


Selection of target year
(e.g., 2000)

Binning of studies
(e.g., every 10 years)

Uncertainty metric
(e.g., standard dev.)

RESULT



Uncertainty has actually increased

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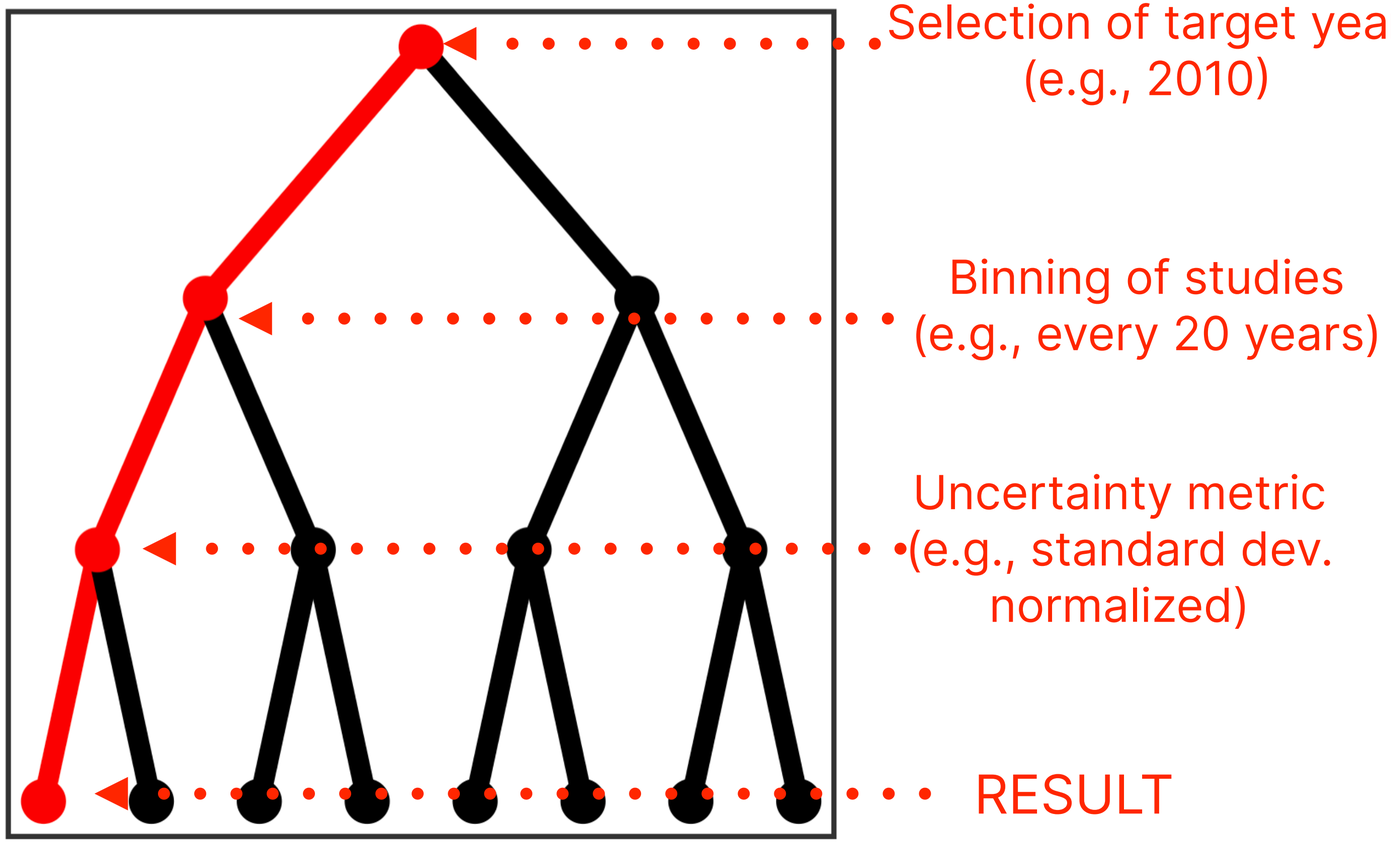

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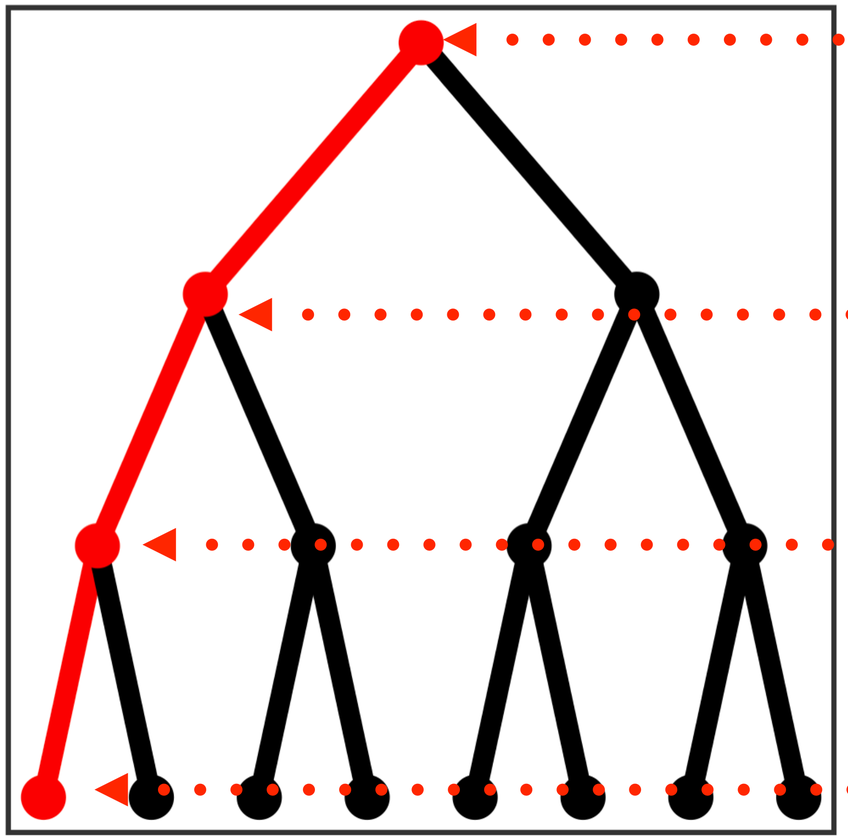
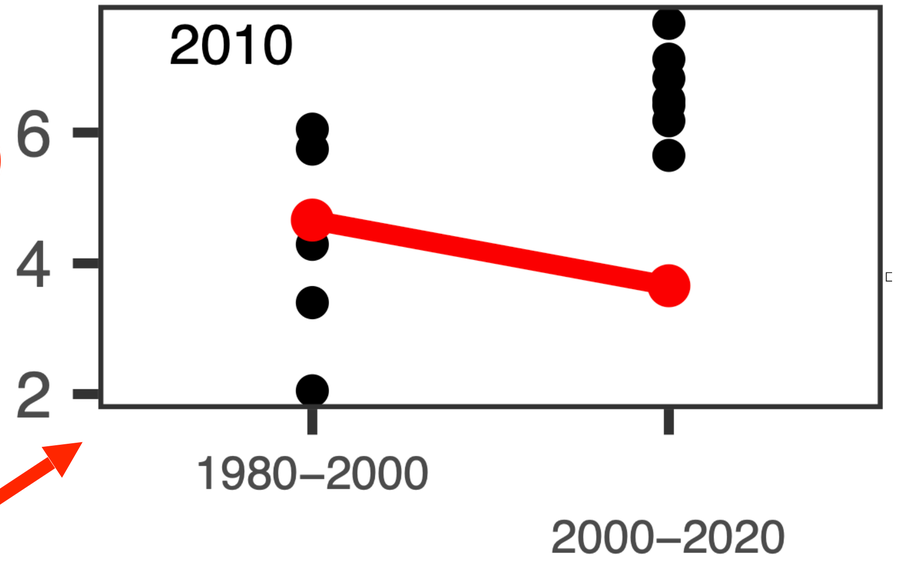


Selection of target year
(e.g., 2010)

Binning of studies
(e.g., every 20 years)

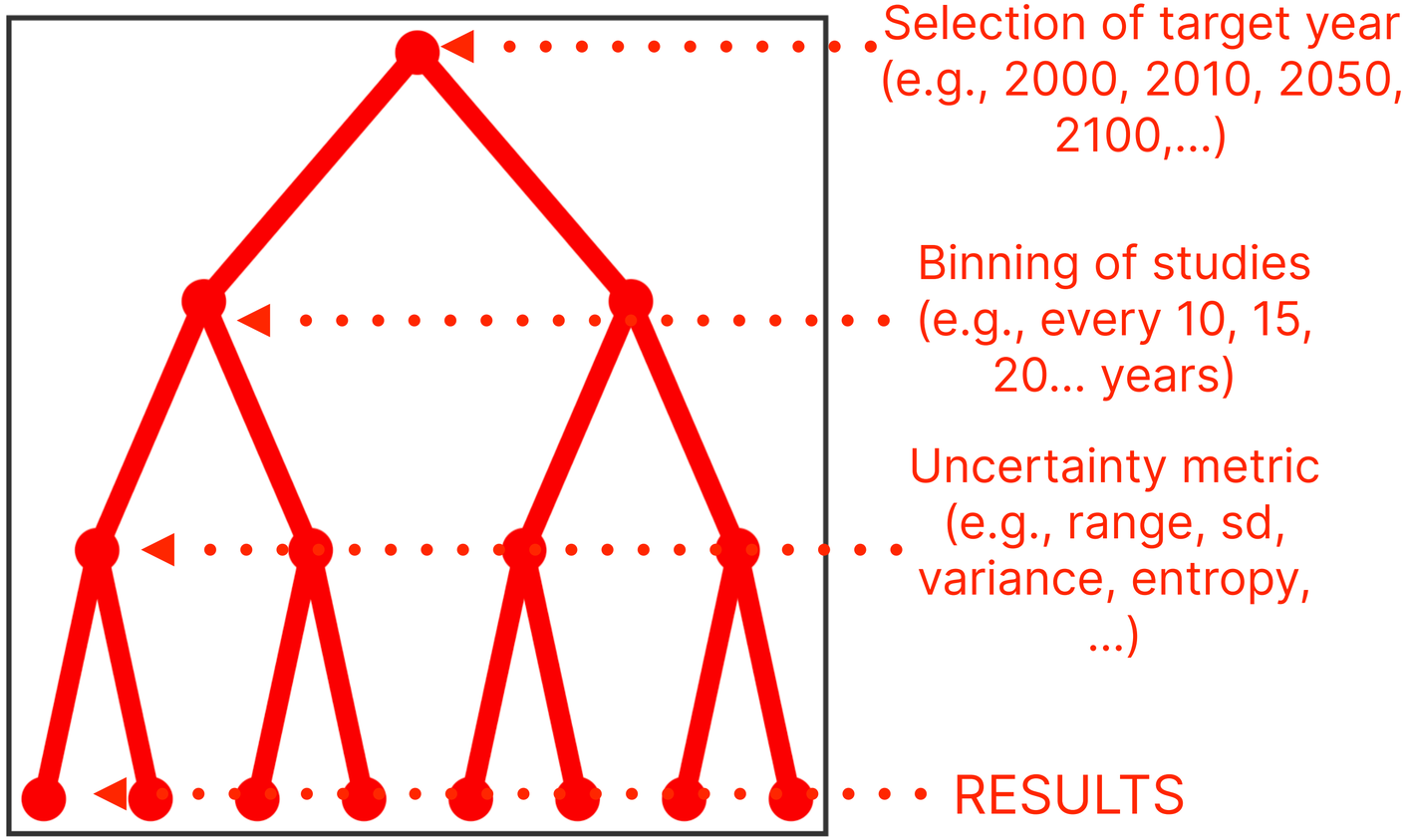
Uncertainty metric
(e.g., standard dev.
normalized)

RESULT



Uncertainty has actually decreased

Have 50 years of research reduced uncertainties?



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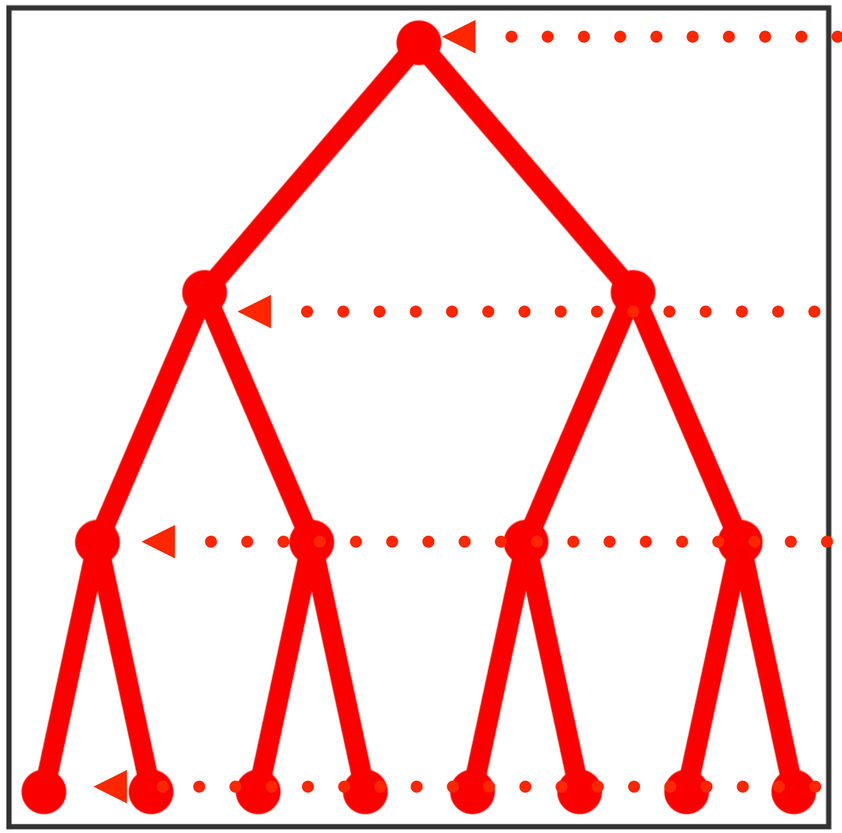
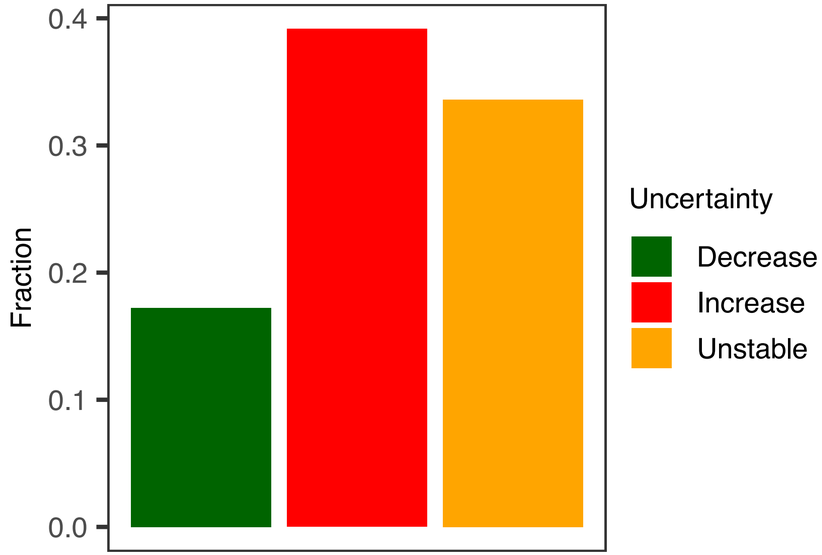


Selection of target year (e.g., 2000, 2010, 2050, 2100,...)

Binning of studies (e.g., every 10, 15, 20... years)

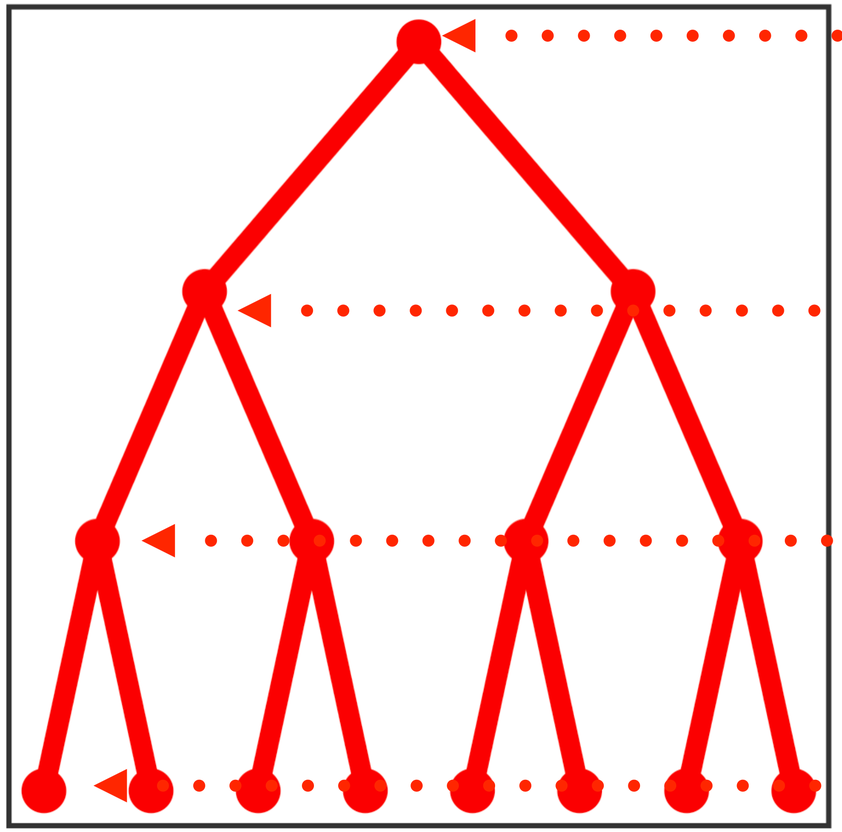
Uncertainty metric (e.g., range, sd, variance, entropy, ...)

RESULTS



The most robust answer seems to be **probably not**. More evidence for research having increased uncertainties.

Have 50 years of research reduced uncertainties?



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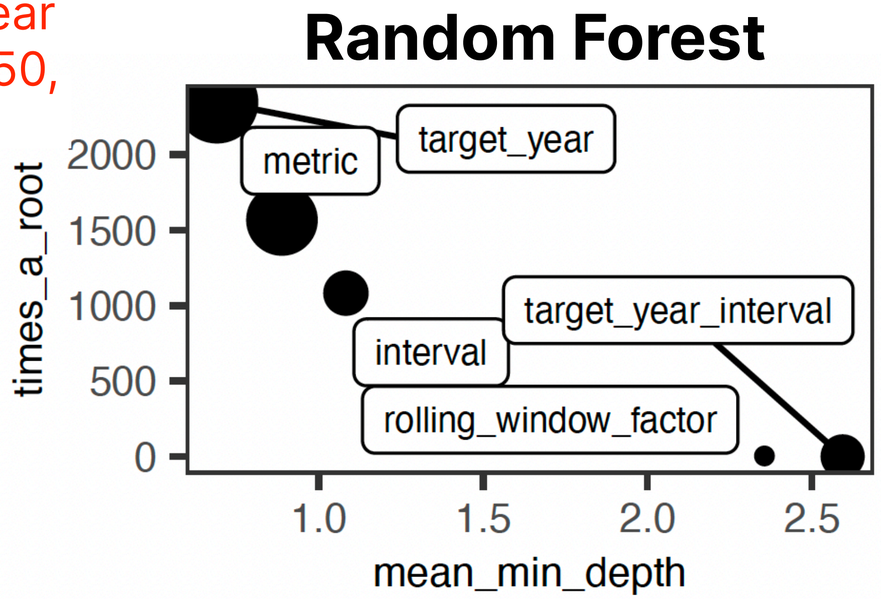
SENSITIVITIES



The most influential factors are the target year and the uncertainty metric

Conclusions

How to dispel smoke and mirrors in water modelling?

- Acknowledge we are still a long way off in handling uncertainties

- Progress ≠ accuracy. Maybe progress = higher uncertainties?

- If the latter, UA / SA have a key role in moving the field forward – but they can only do so much

- … and if uncertainties explode after embracing uncertainties, then models can excel at being formalized expressions of ignorance