ENVIRONMENTAL INTELLIGENCE LAB

PUTTING HUMANS IN THE LOOP: COUPLING BEHAVIORAL MODELING WITH NATURAL SYSTEMS' MODELS

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POLITECNICO MILANO 1863

ACKNOWLEDGMENTS
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ACKNOWLEDGMENTS

EI/NRM LAB & PSU/CORNELL GROUP

ACKNOWLEDGMENTS
PROJECT COLLABORATIONS

THE HUMAN DIMENSION OF GLOBAL CHANGE

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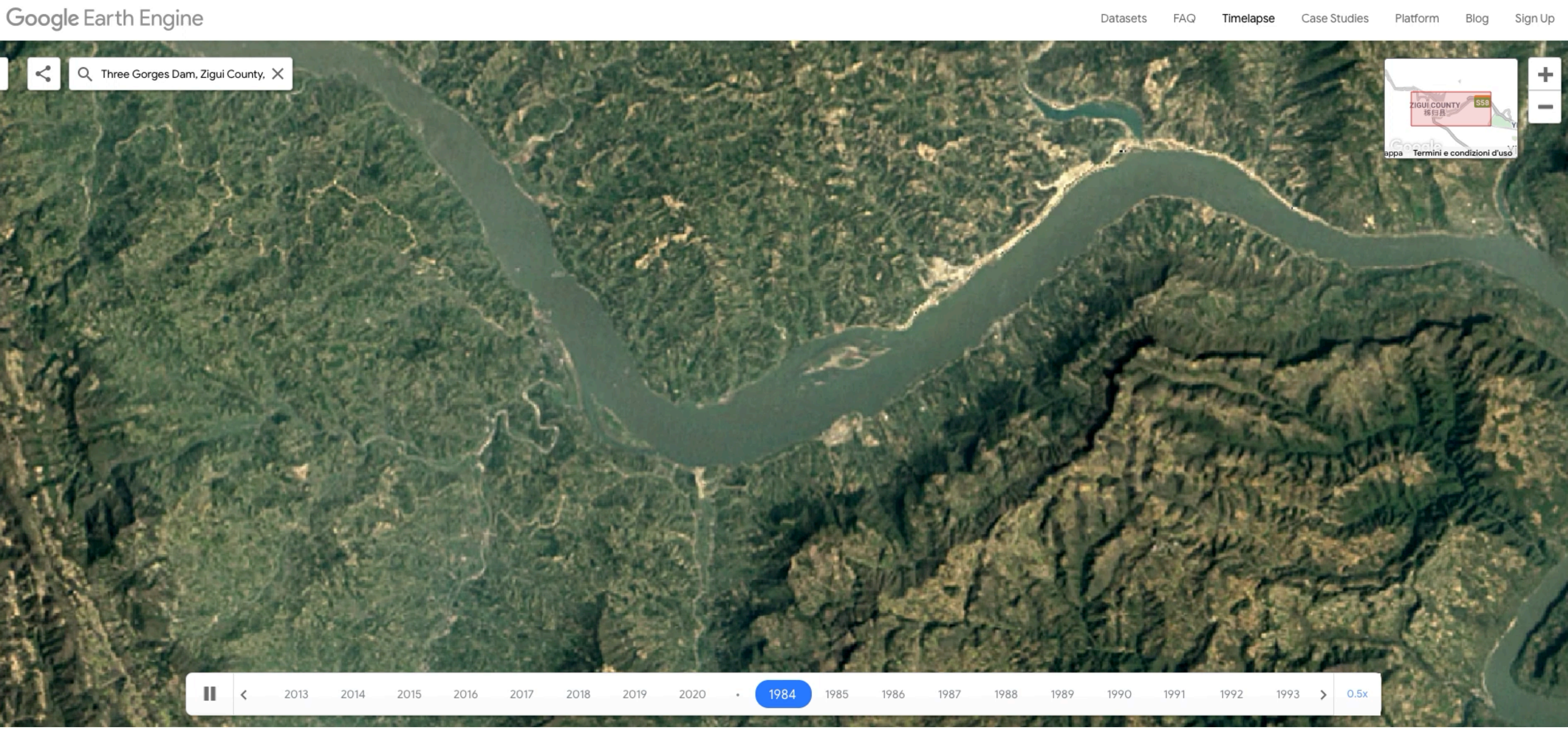

THE HUMAN DIMENSION OF GLOBAL CHANGE

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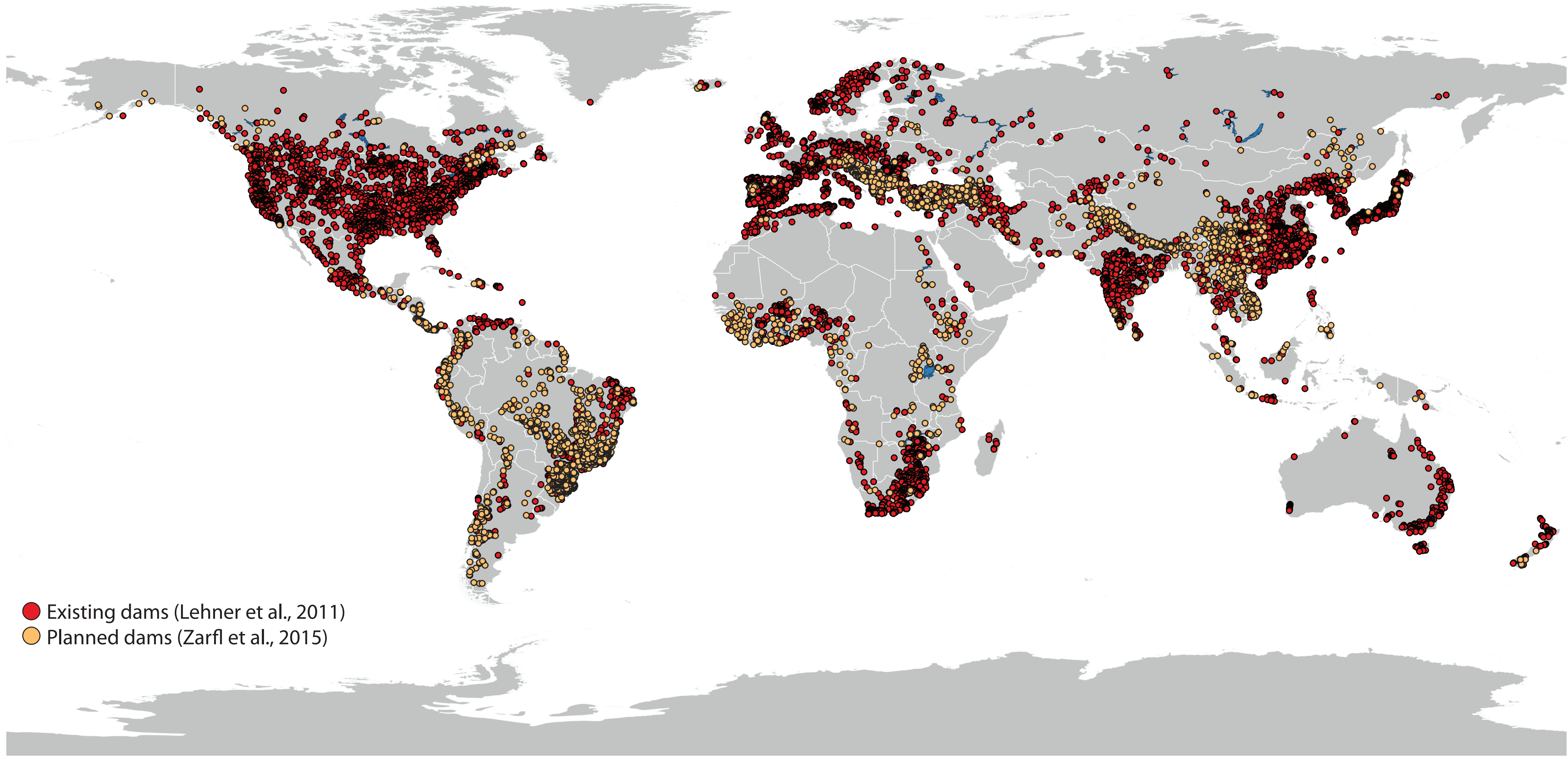


MODELS OF NATURAL SYSTEMS

A General Theory of the Unit Hydrograph

JAMES C. I. DOOGE

Civil Engineering Department
University College
Cork, Ireland

Abstract—By the single assumption that the reservoir action in a catchment can be separated from translation, the general equation of the unit hydrograph is shown to be

$$u(0, t) = \frac{V_0}{A} \int_0^{A(t)} \frac{\delta(t - \tau)}{\Pi(1 + K_i D)} \cdot i \cdot dA$$

JOURNAL OF GEOPHYSICAL RESEARCH   FEBRUARY, 1959

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A

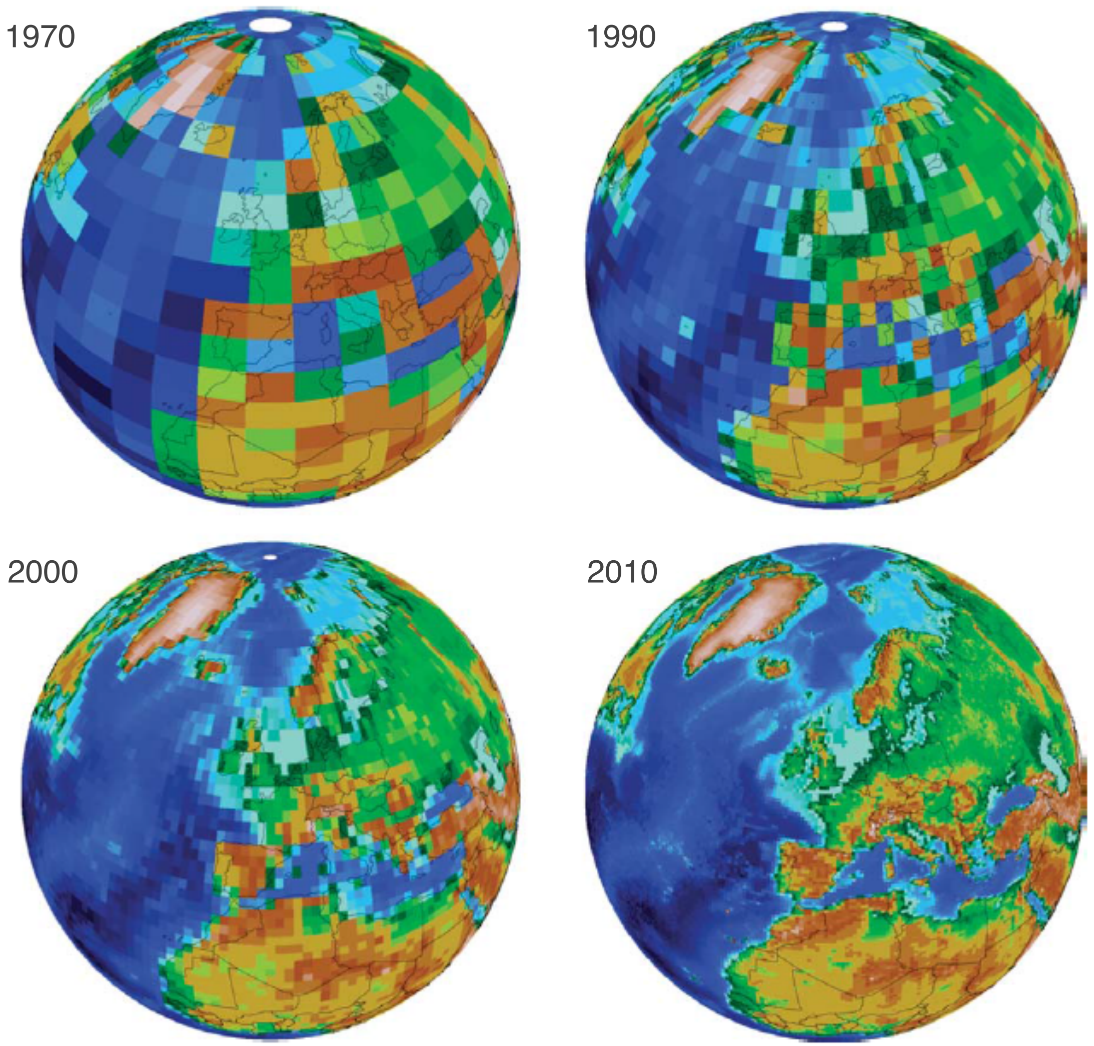
Phil. Trans. R. Soc. A
doi:10.1098/rsta.2008.0219

REVIEW

The computational future for climate and Earth system models: on the path to petaflop and beyond

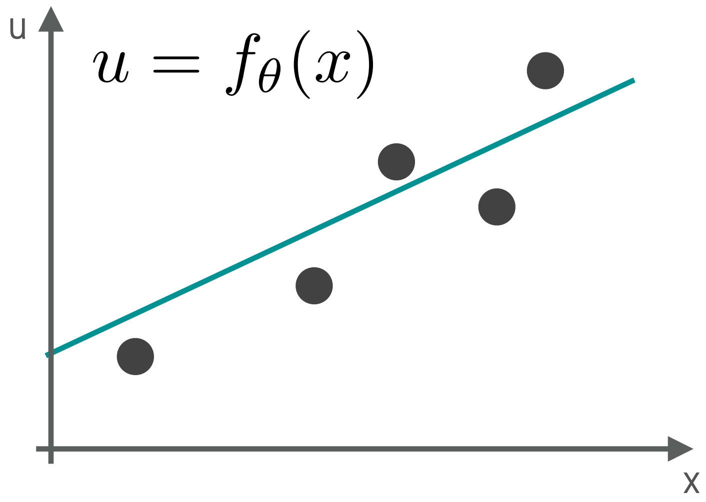
Q3 BY WARREN M. WASHINGTON*, LAWRENCE BUJA AND ANTHONY CRAIG

National Center for Atmospheric Research (NCAR), 1850 Table Mesa Drive, Boulder, CO 80305, USA



MODELS OF HUMAN BEHAVIORS

Descriptive models derive behavioral rules specifying observed human actions in response to external stimuli



- High structural uncertainty
- Low transferability to different decision contexts

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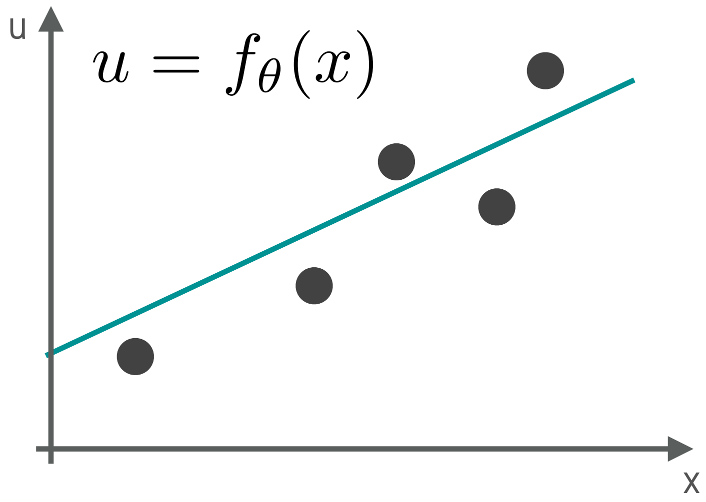

- High structural uncertainty
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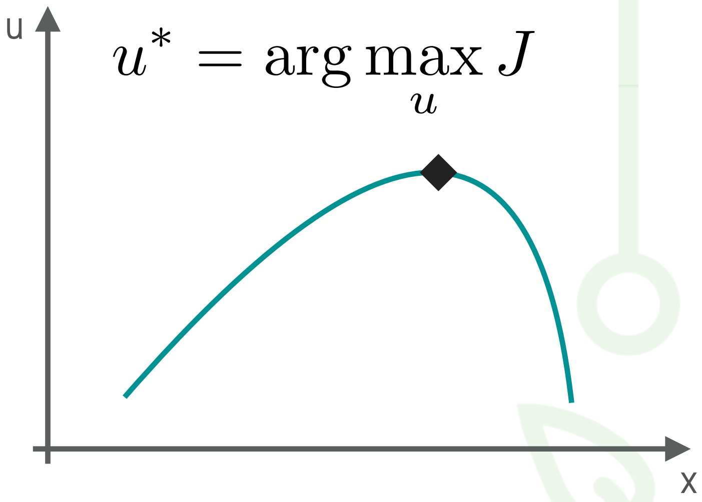
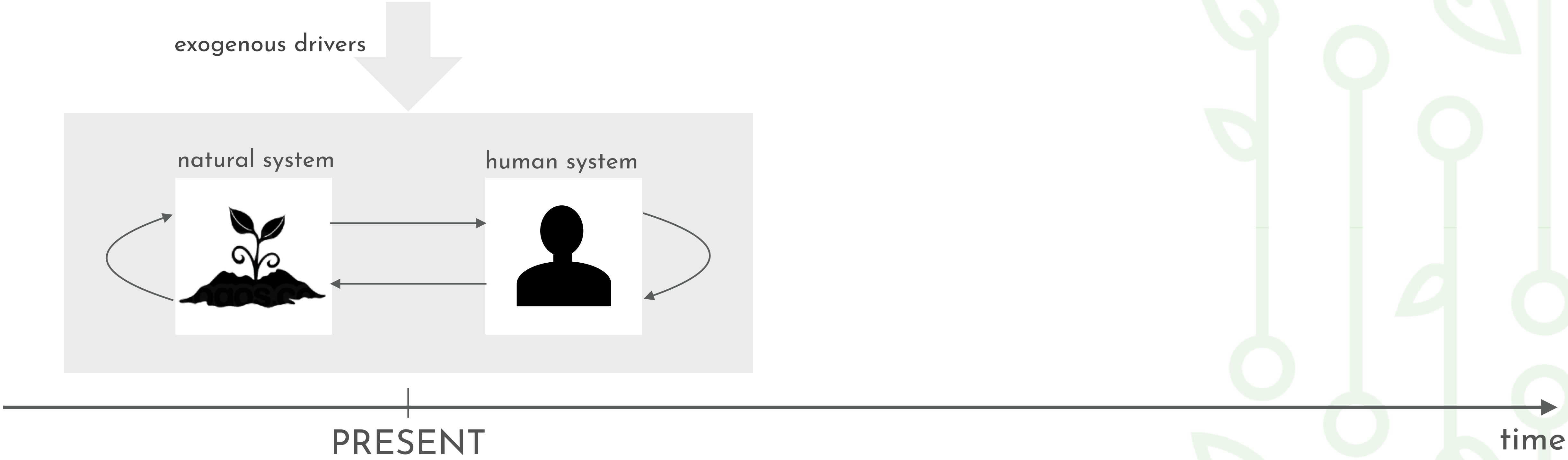
Normative models assume human decisions are designed to maximise a given utility function



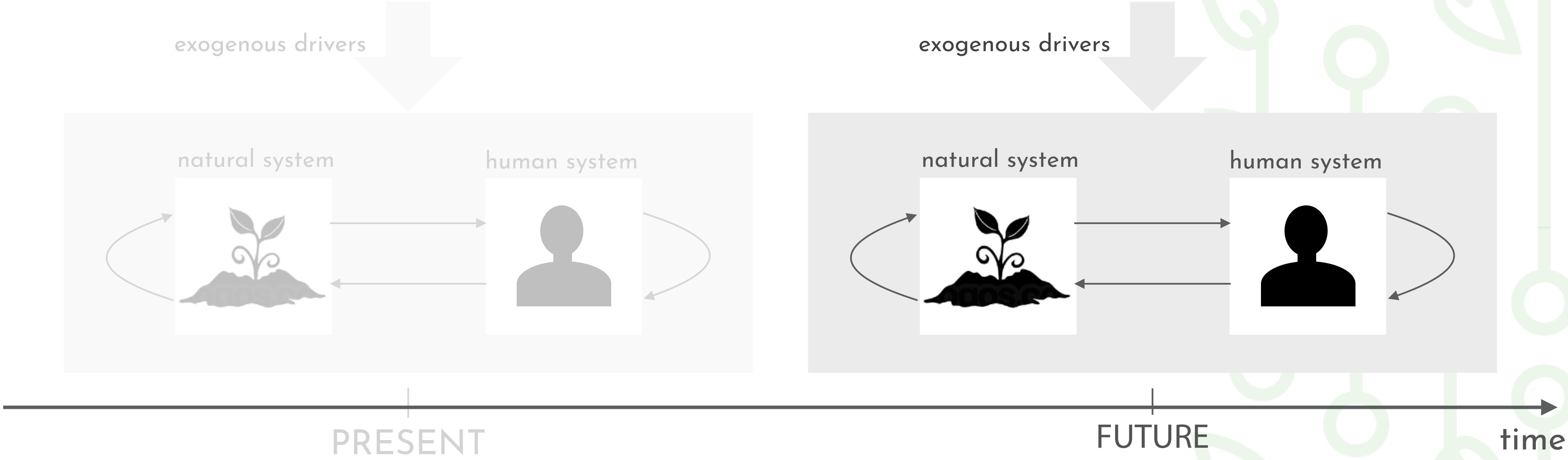
- Full rationality assumption
- Selection of tradeoff for balancing competing demands

TURNING NORMATIVE MODELS INTO DESCRIPTIVE TOOLS



GOAL: understand decision mechanism

TURNING NORMATIVE MODELS INTO DESCRIPTIVE TOOLS



GOAL: understand decision mechanism

GOAL: project the system coevolution

WATER RESOURCES SYSTEMS ANALYSIS

Annual count of WRR publications by AGU index terms

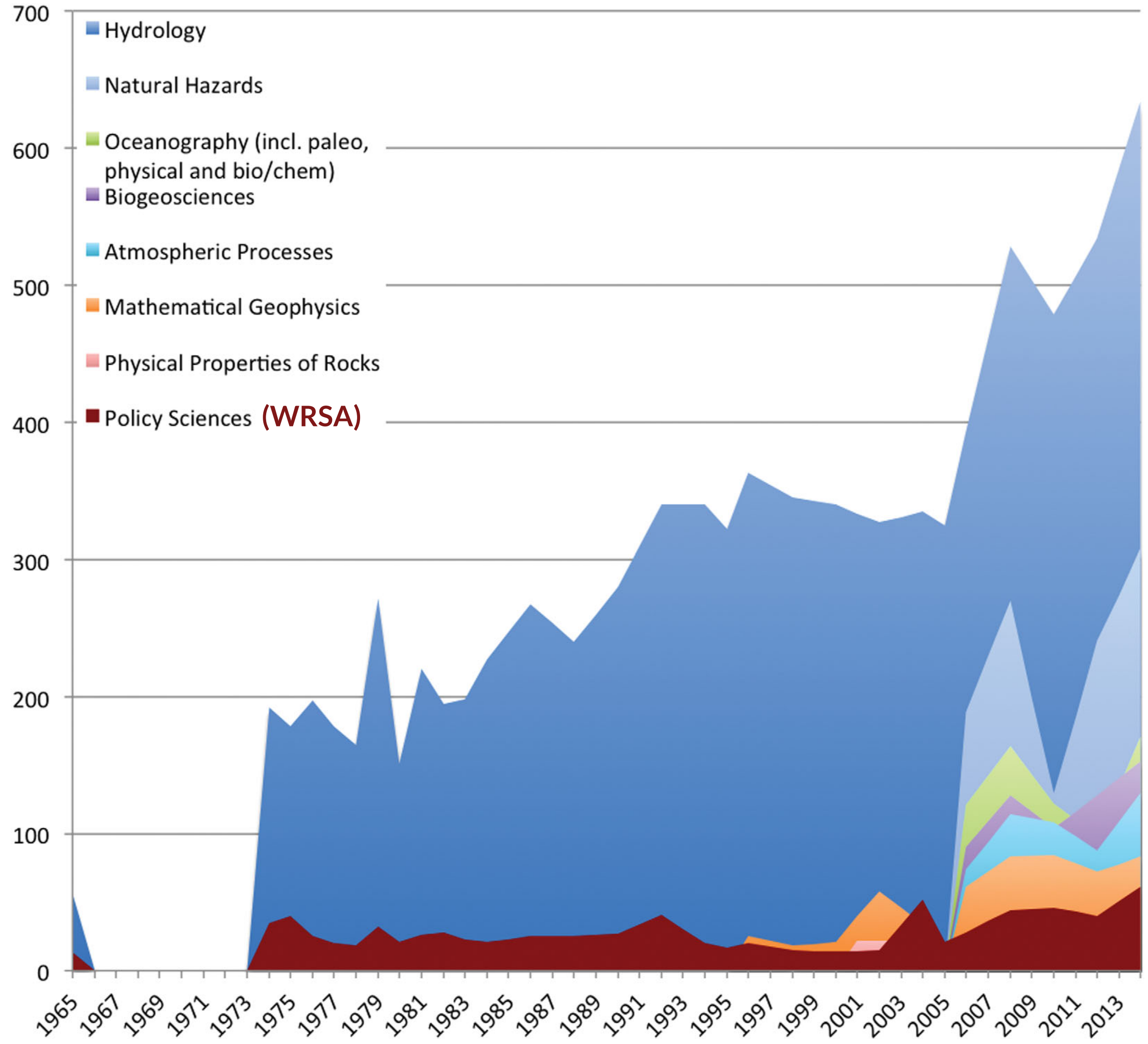
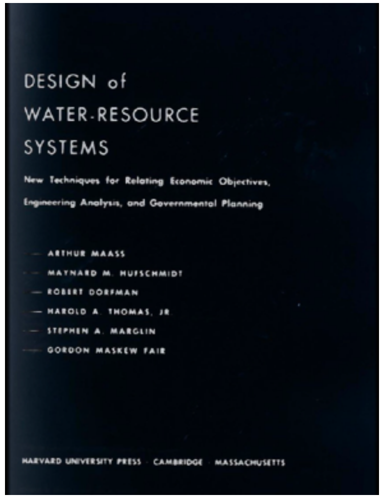
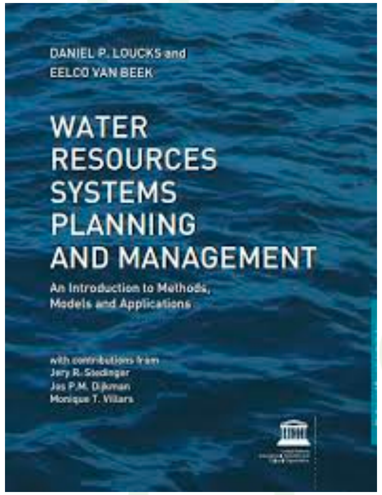


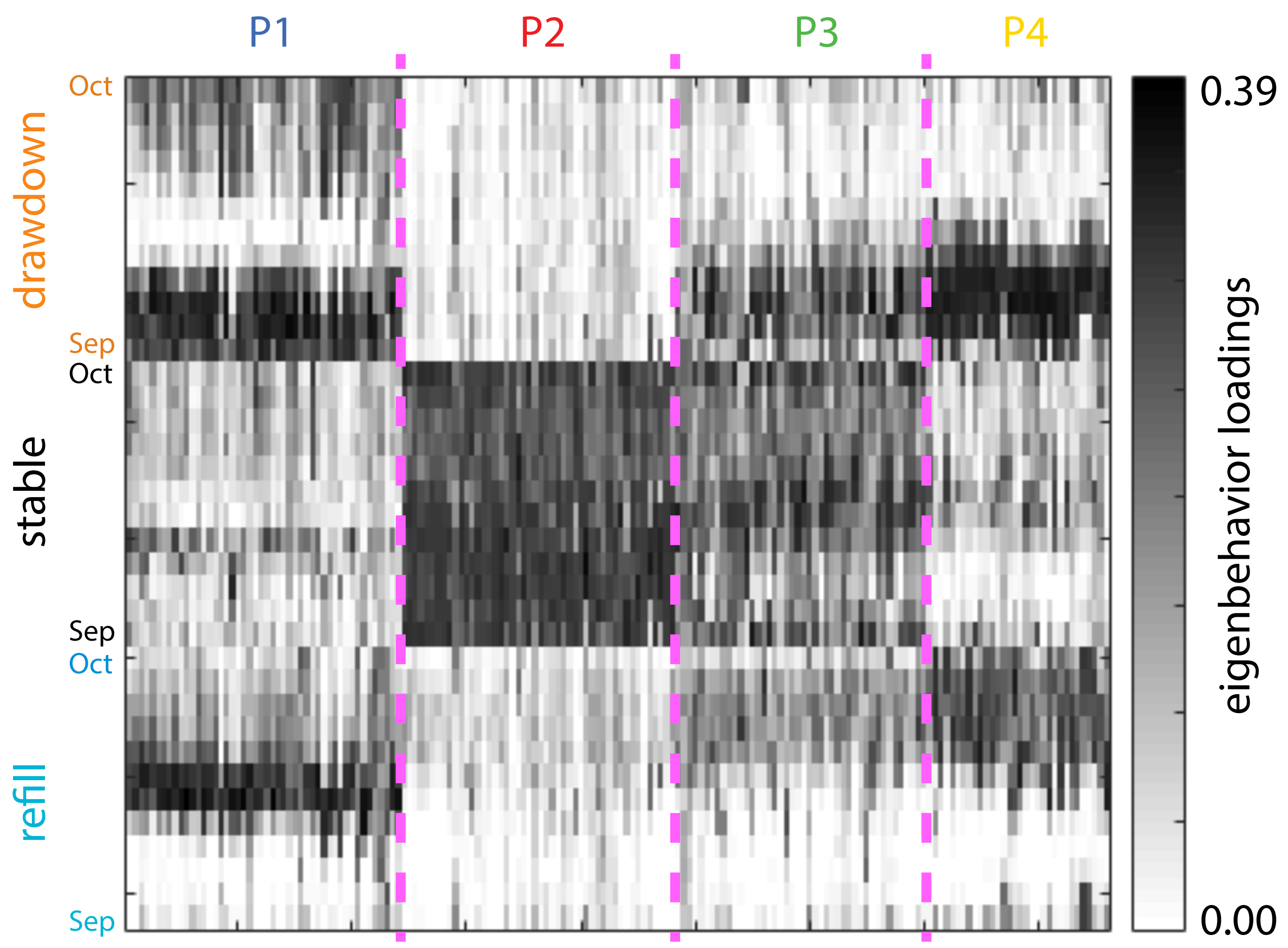
Figure from Brown et al., 2015, WRR

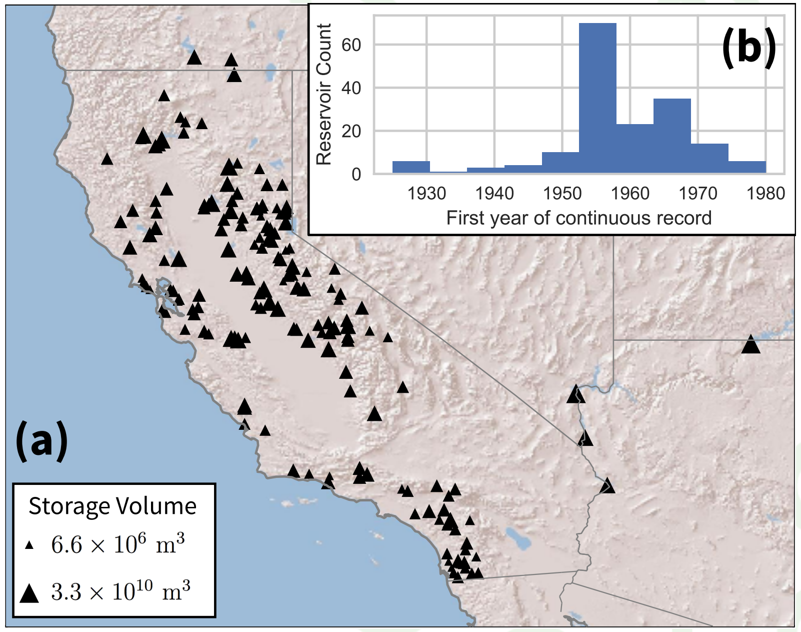




*The evolution of WRSA has produced… a field uniquely equipped **to describe and predict** the water resources future that government, industries, and people seek (Brown et al., 2015).*

BEHAVIORAL SEGMENTATION OF WATER RESERVOIRS OPERATORS IN CALIFORNIA



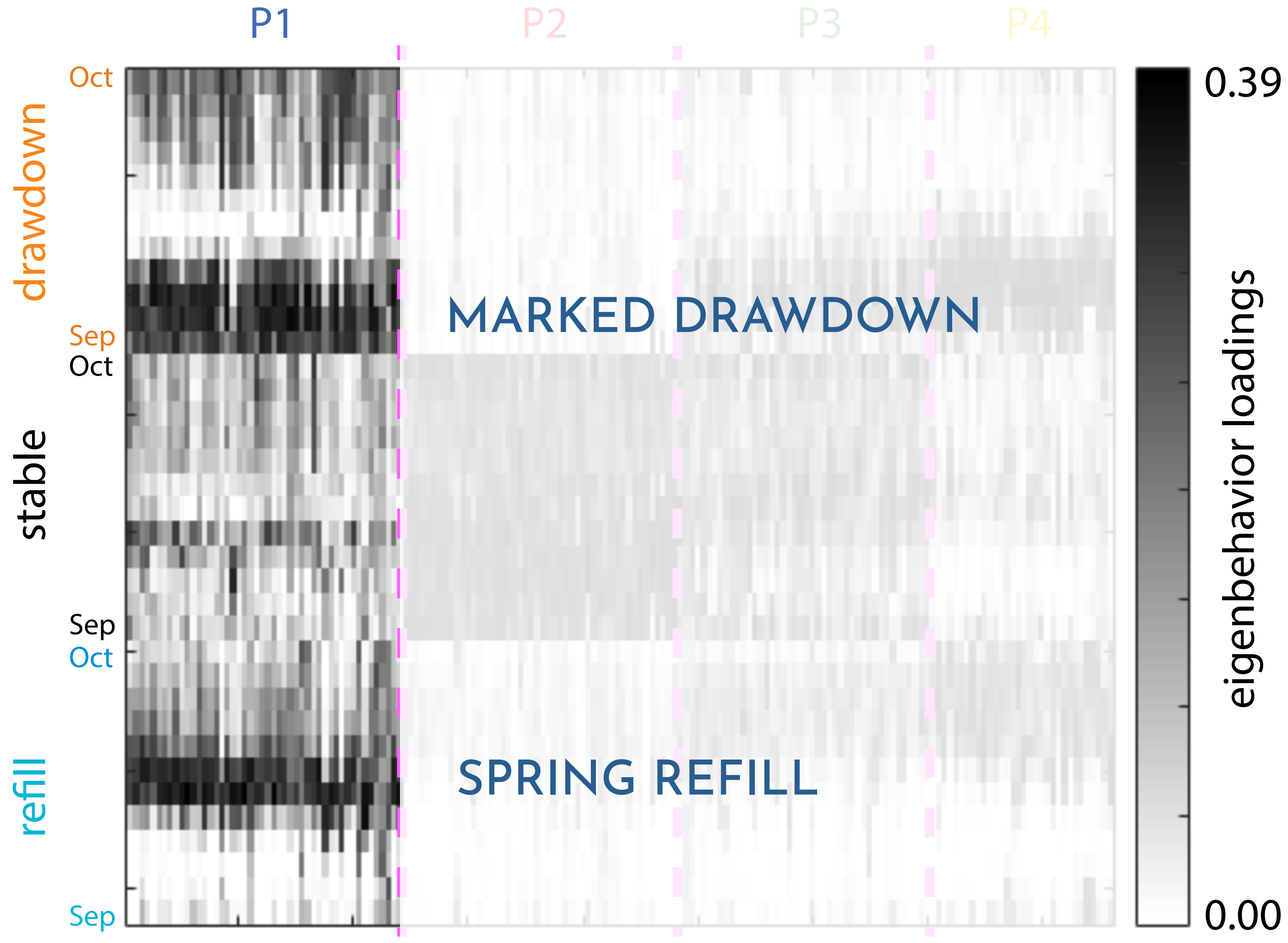


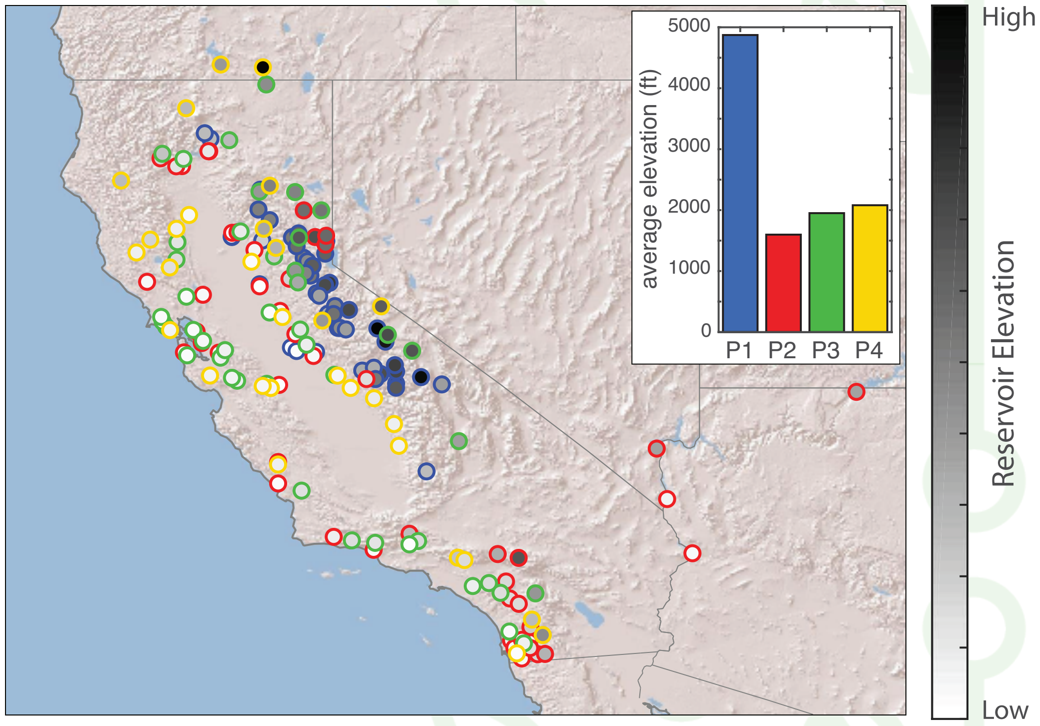
DATASET:

170 water reservoirs in California monthly storage trajectories observations over 1955-2016

Giuliani and Herman, 2018, ADWR

BEHAVIORAL PROFILES INTERPRETATION: RESERVOIR ELEVATION

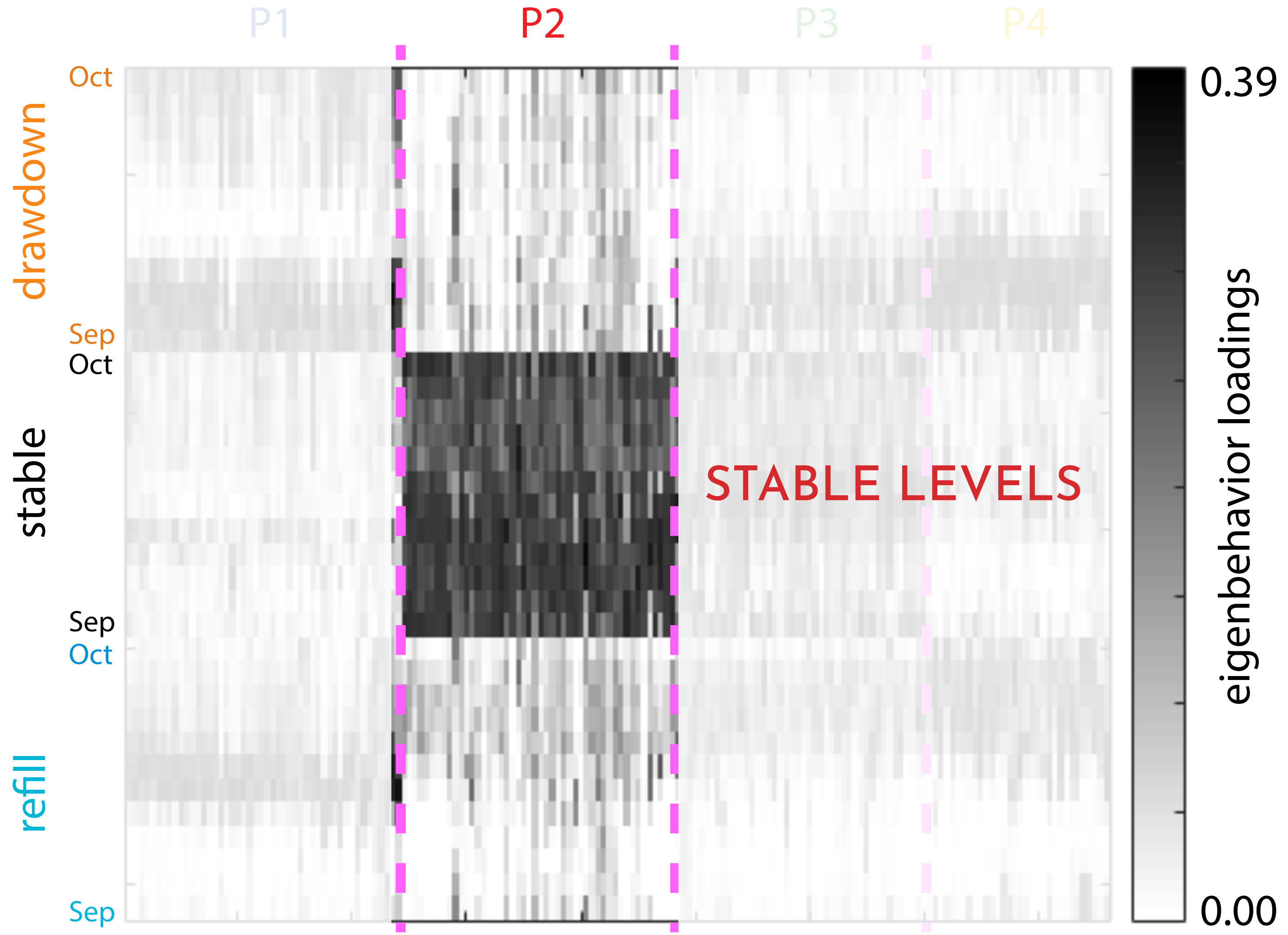


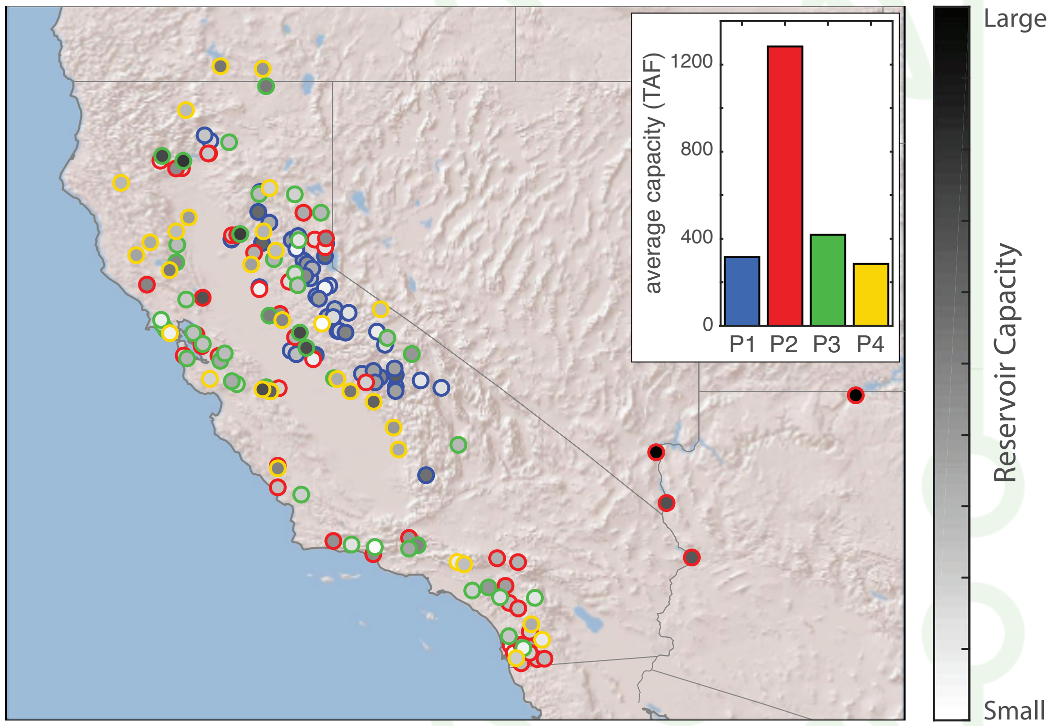


P1 reservoirs have highest elevation (Sierra Nevada mountains)

Giuliani and Herman, 2018, ADWR

BEHAVIORAL PROFILES INTERPRETATION: RESERVOIR CAPACITY

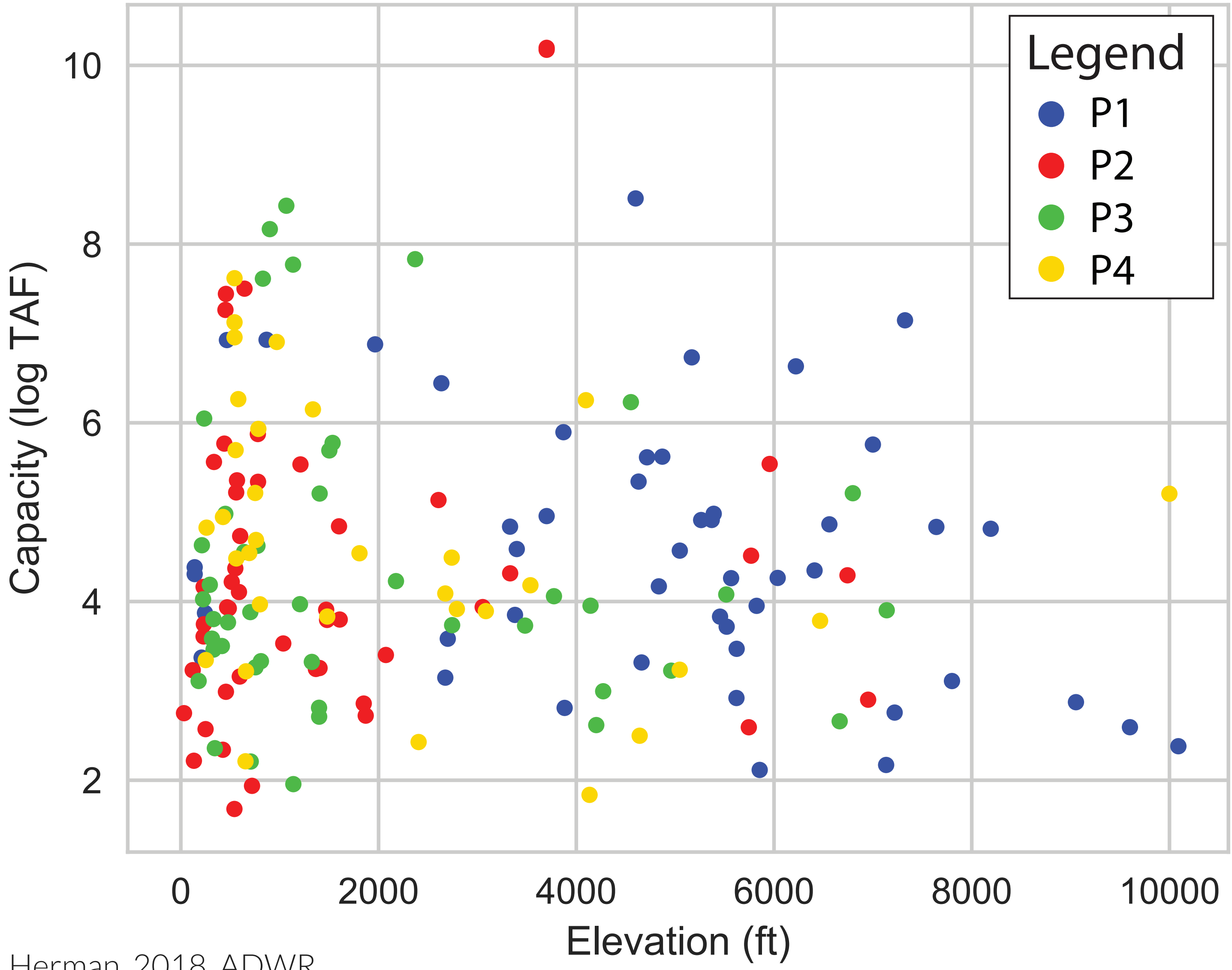




P2 reservoirs have largest capacity

Giuliani and Herman, 2018, ADWR

BEHAVIORAL FACTORS VS PHYSICAL RESERVOIR FEATURES



Giuliani and Herman, 2018, ADWR

EXELON OPERATION OF CONOWINGO RESERVOIR

Giuliani et al., 2014, WRR

EXELON OPERATION OF CONOWINGO RESERVOIR

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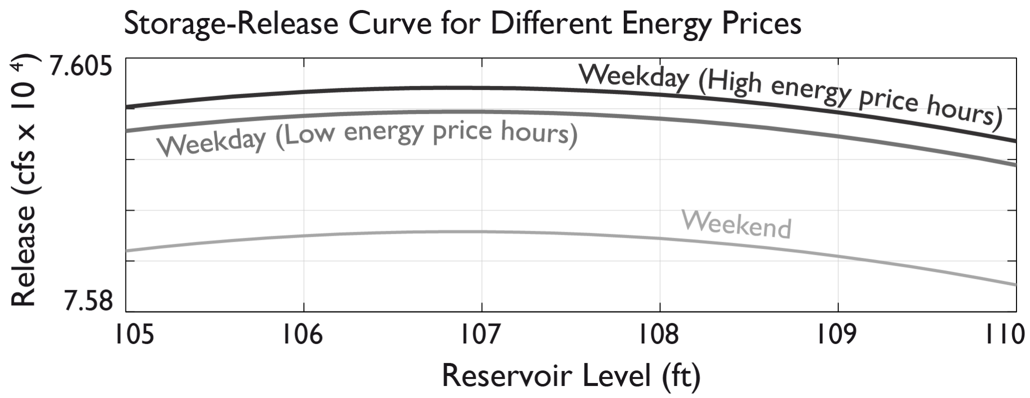
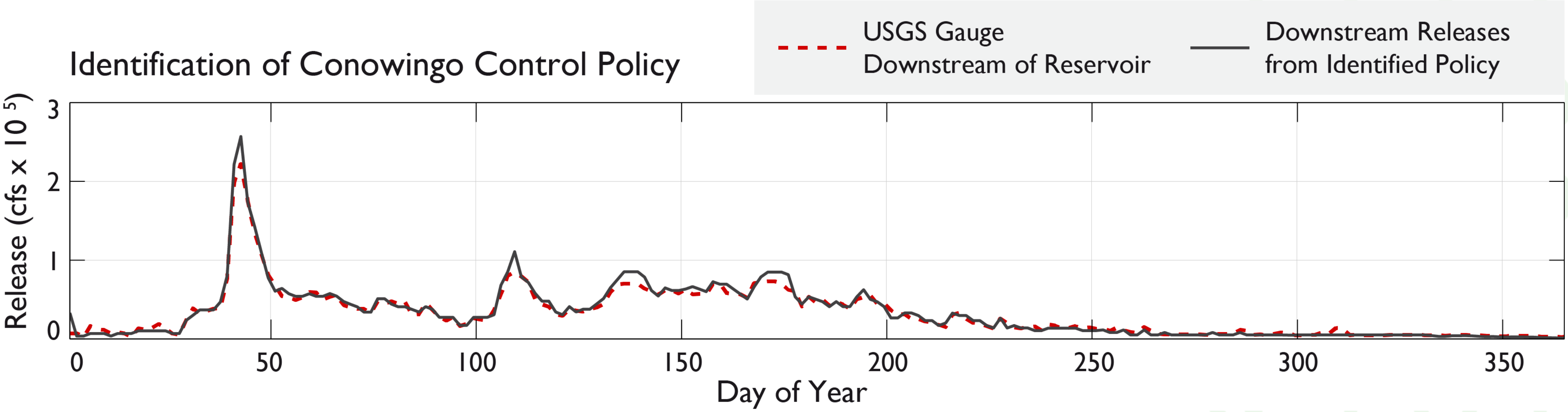
$$u_t = p^*_\theta(t, h_t)$$

$$p^*_\theta(t, h_t) = \arg\max_{p_\theta} J^{HP}$$





Giuliani et al., 2014, WRR

MODELING CHANGING PREFERENCES

THE LAKE COMO BASIN

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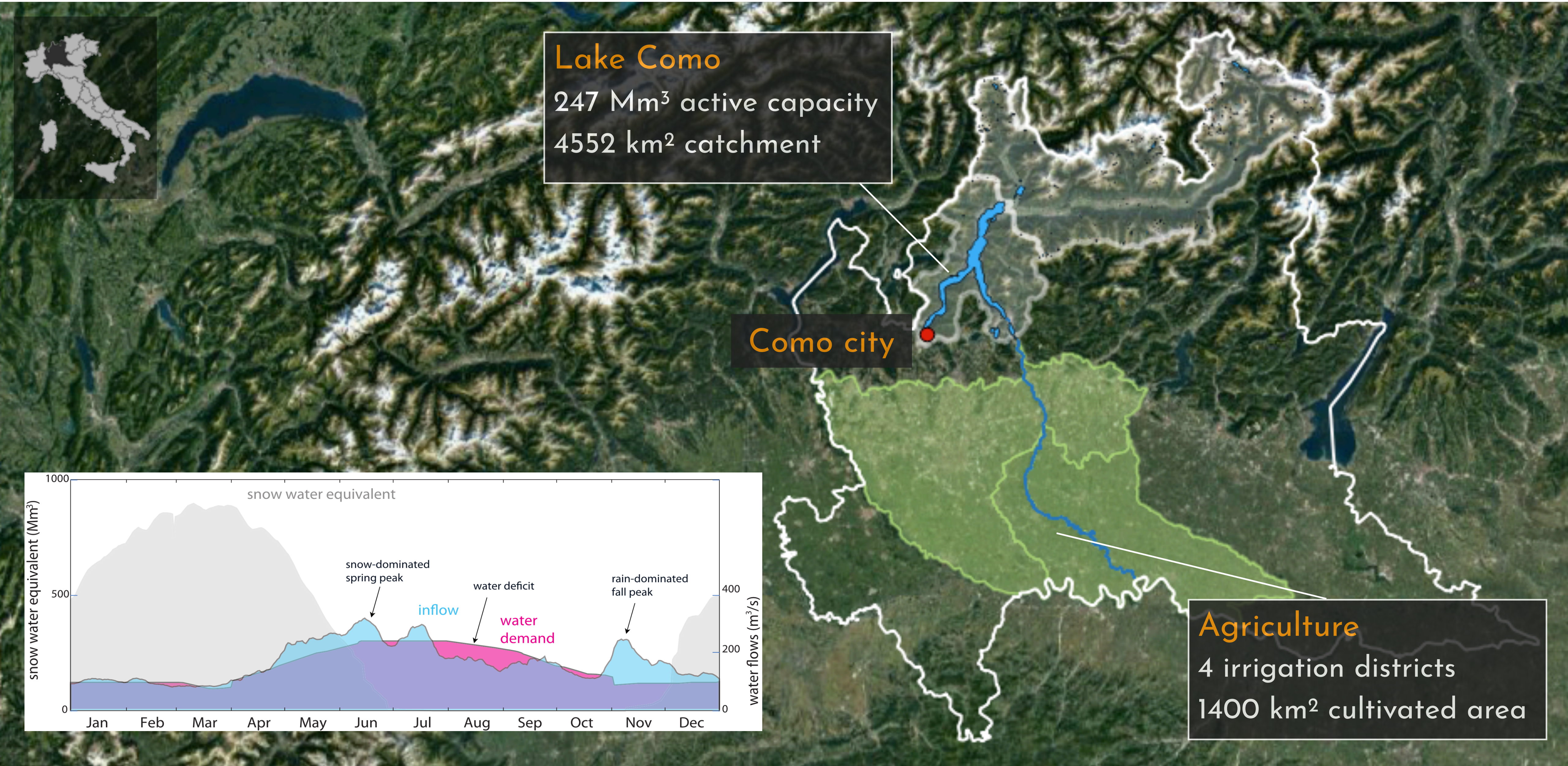

TRADEOFF CHANGE AFTER EXTREME EVENTS

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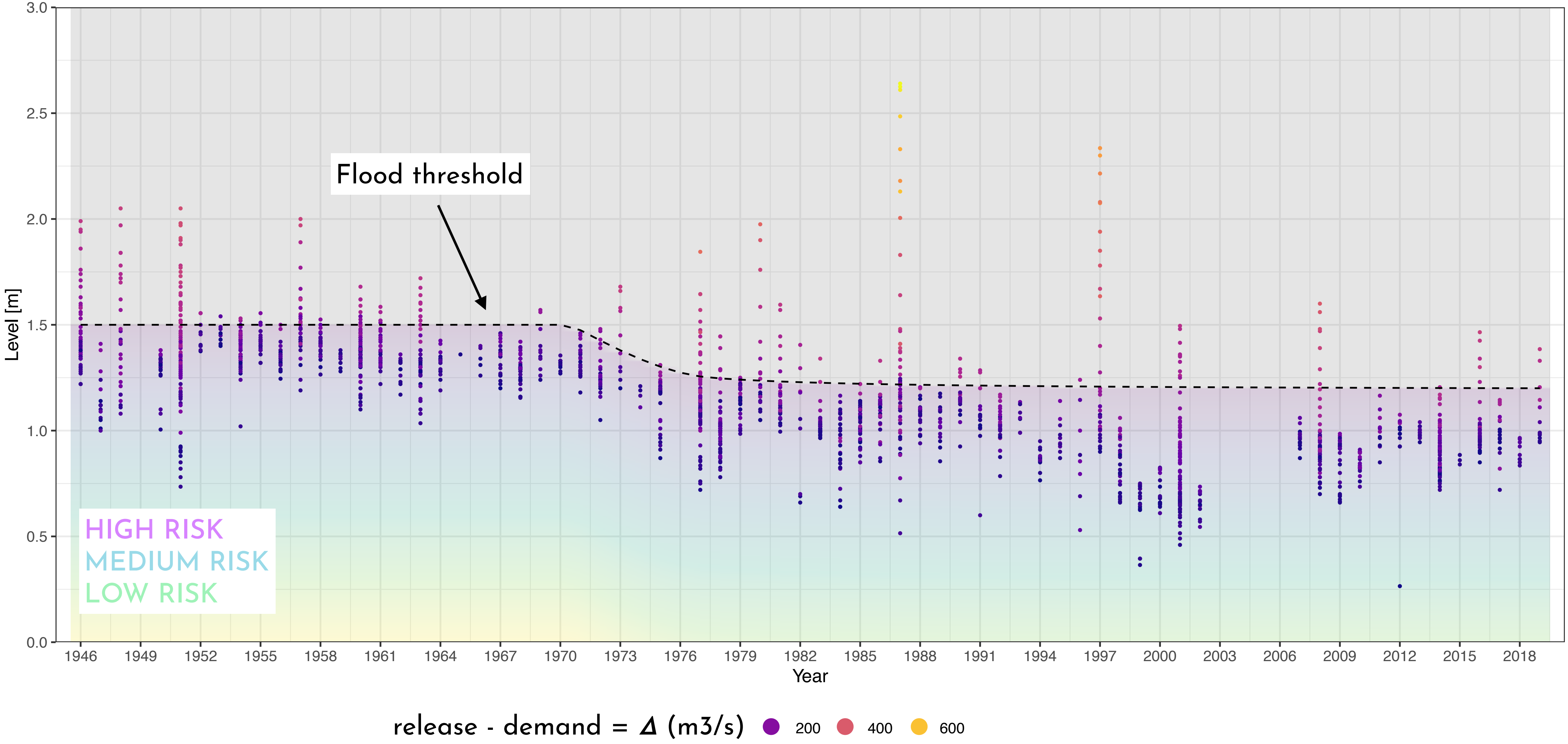

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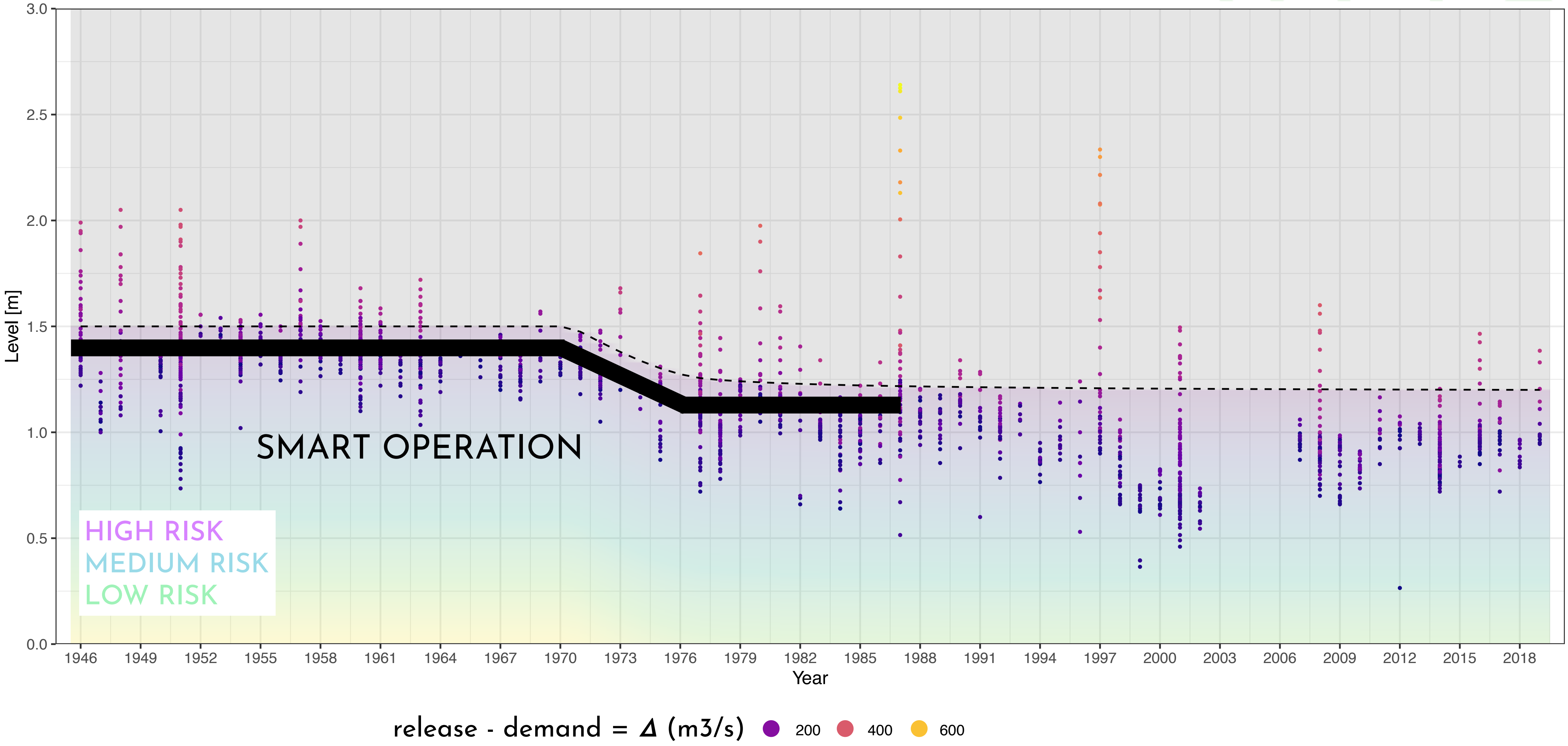

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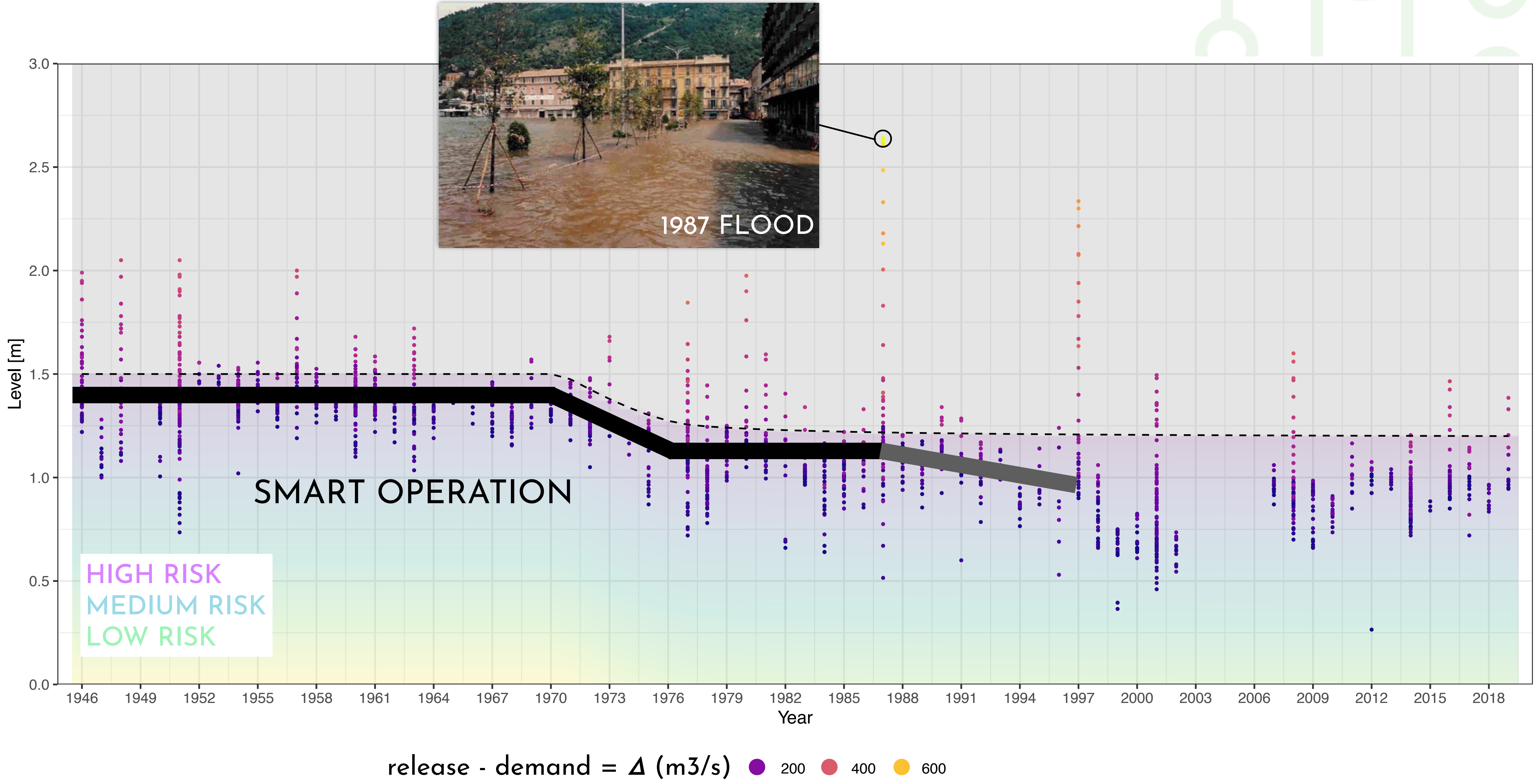

TRADEOFF CHANGE AFTER EXTREME E

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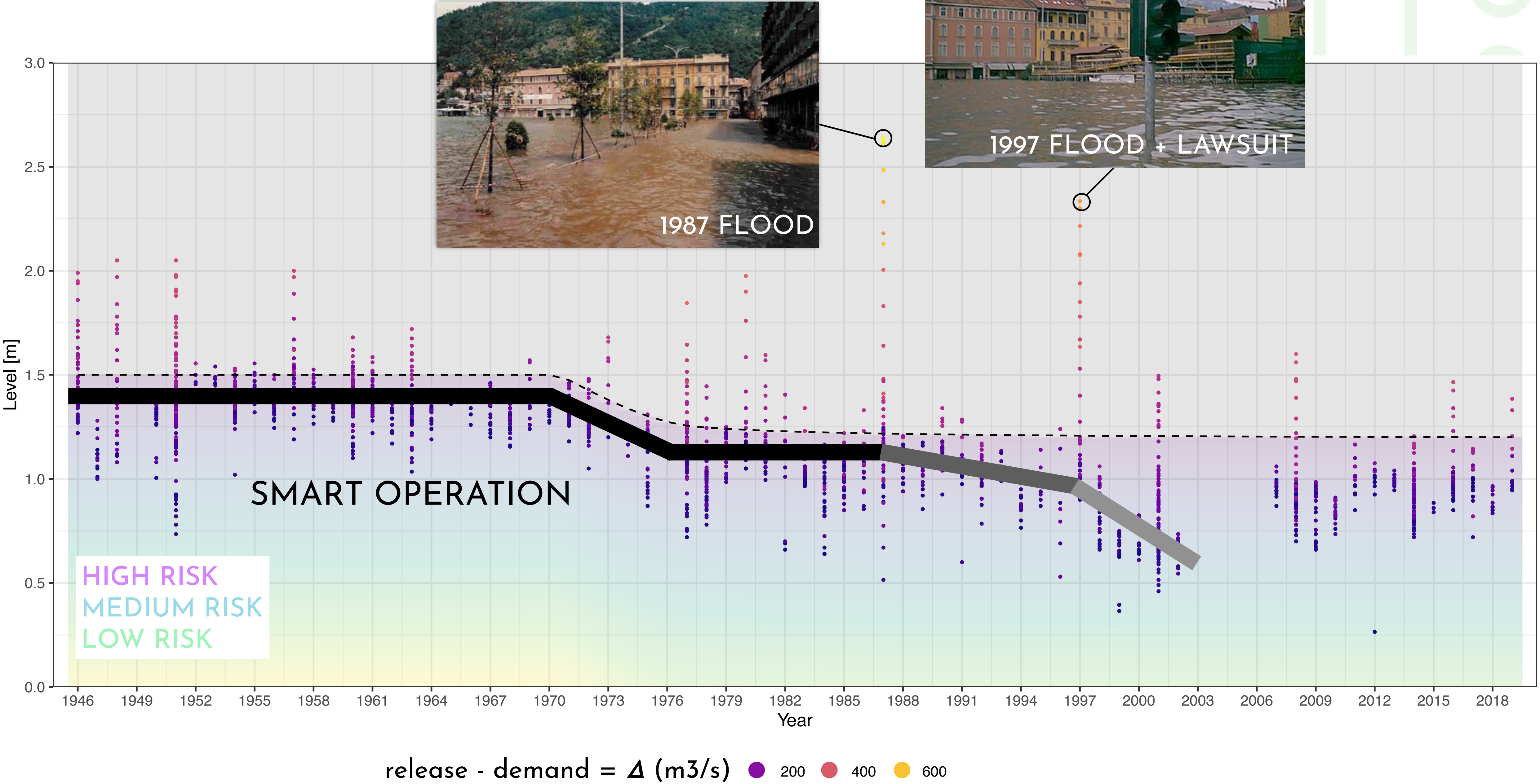
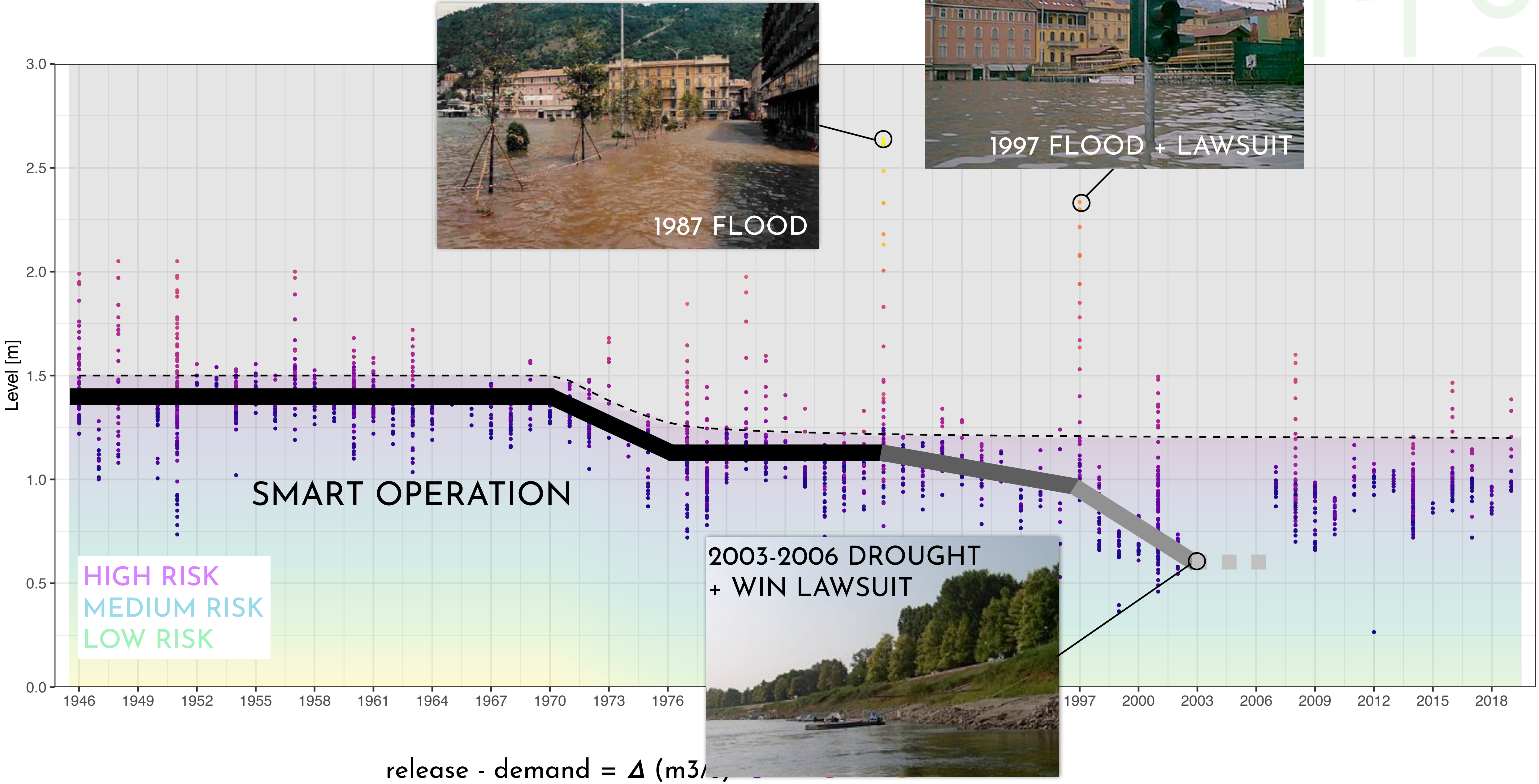


TRADEOFF CHANGE AFTER EXTREME E



TRADEOFF CHANGE AFTER EXTREME E

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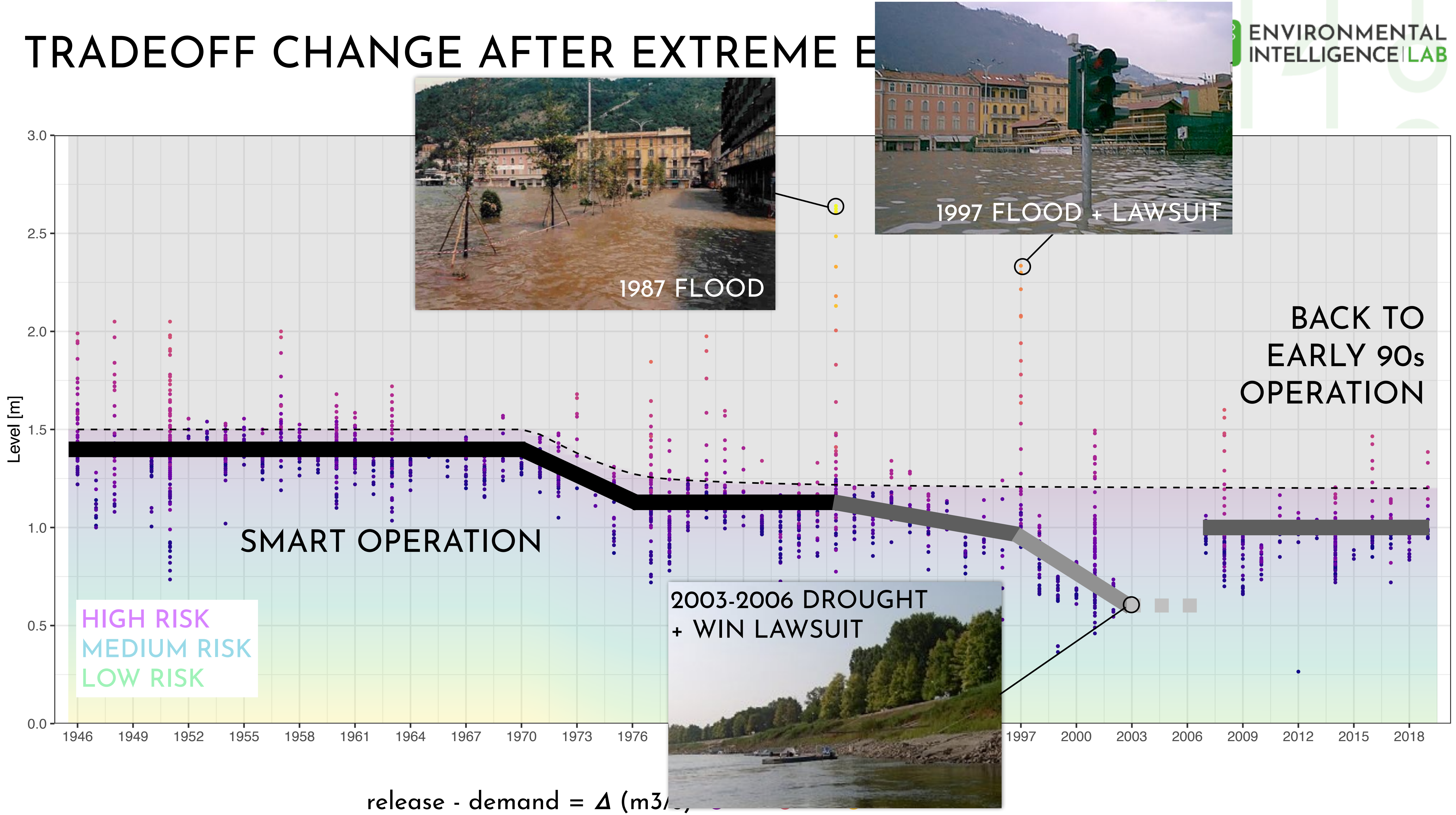


DYNAMIC PREFERENCES EVOLUTION

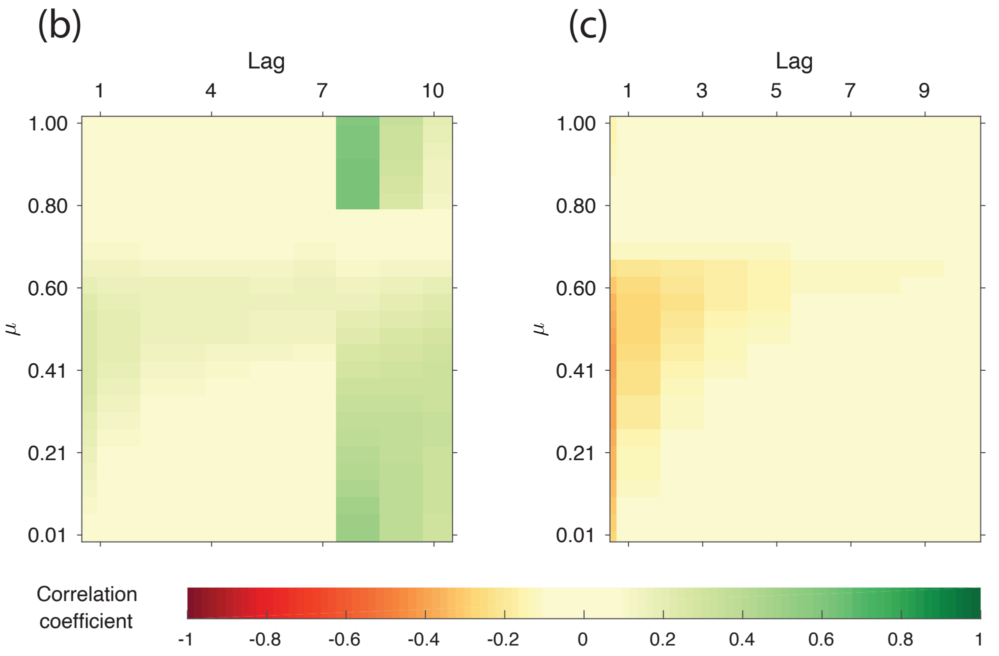
Autoregressive dynamic model implementing the availability bias:

$$\alpha_y^i = \mu\alpha_{y-1}^i + (1-\mu)\mathcal{R}_{y-1}^i$$

behavioral parameter

regret over the last time period

flood control preference positively correlated with inflow peak



water supply preference negatively correlated with average inflow

Mason et al., 2018, WRR

EXPLORING DECISIONS ACROSS SCALES

UNINTENDED CONSEQUENCES OF CLIMATE MITIGATION

ECOSYSTEM VULNERABILITY UNDER FUTURE SCENARIOS

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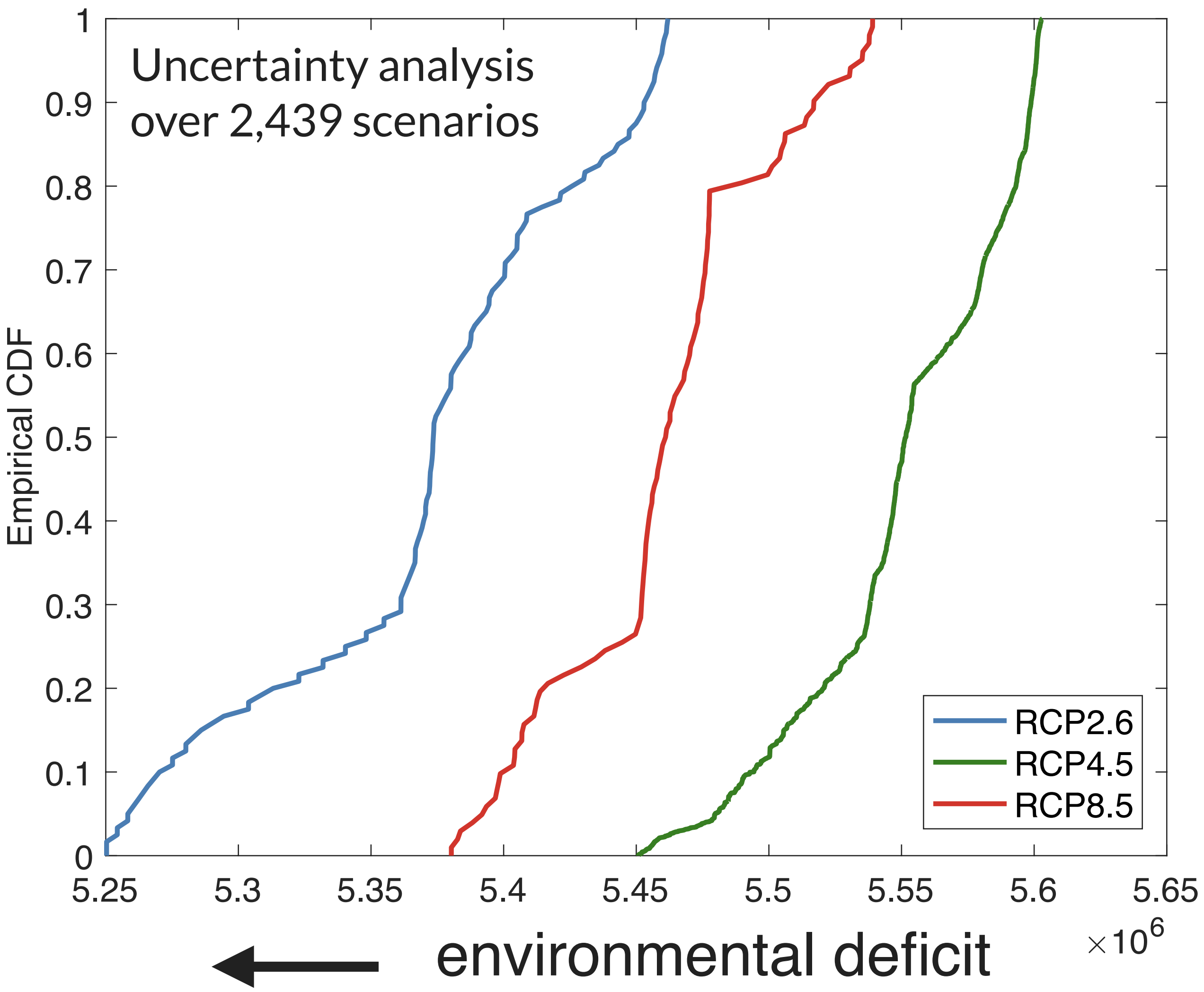
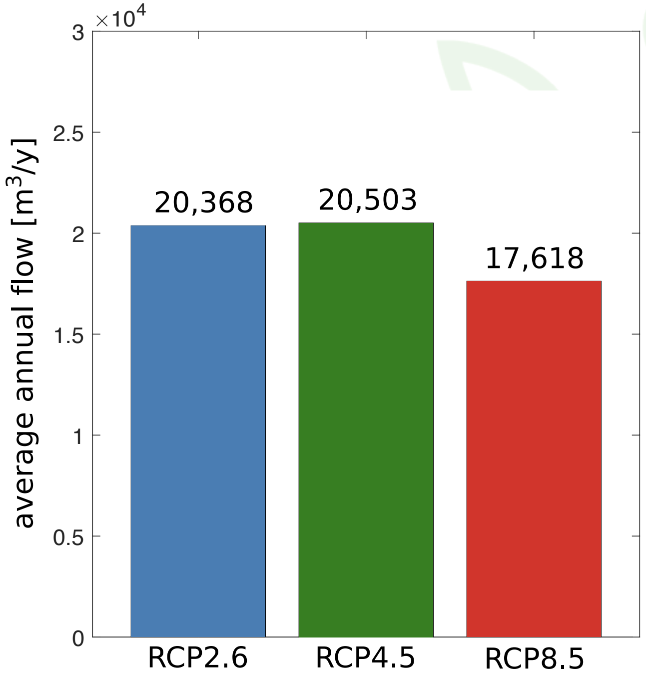
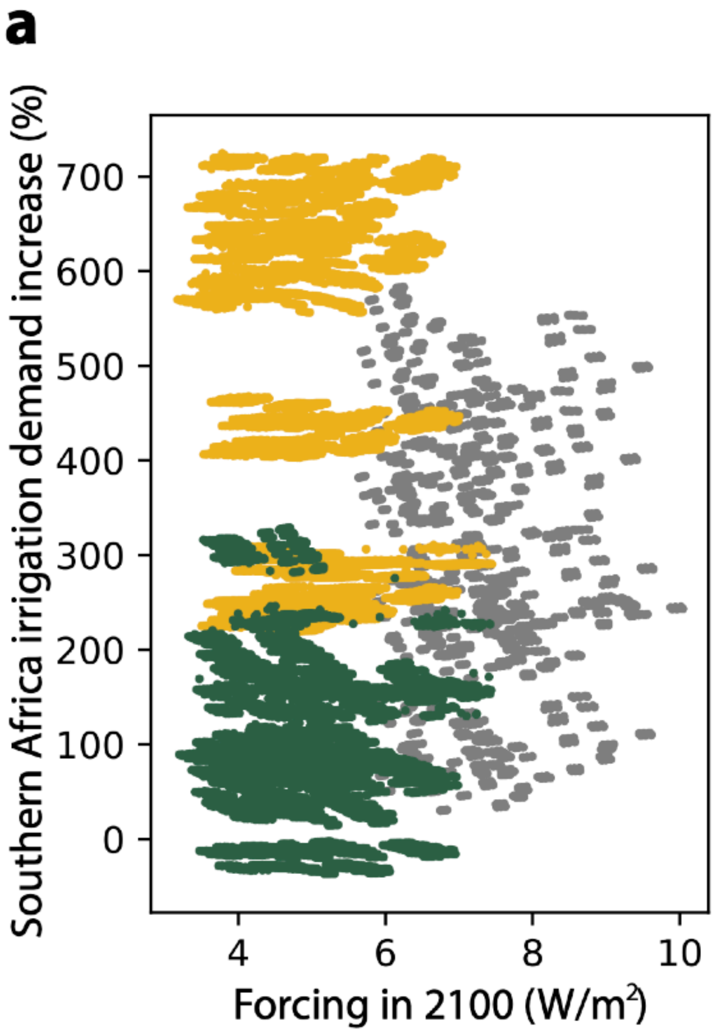




Why are the highest deficits obtained under the wettest scenario?

SIDE EFFECTS ON WATER DEMANDS



- No emission price
- Unified LUC price
- Fragmented LUC price

TAKEAWAYS

Describing the feedbacks between human and natural systems and predicting the coevolution of the coupled systems requires that we:

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- realize that humans are one of the largest drivers in every system

TAKEAWAYS

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TAKEAWAYS

Describing the feedbacks between human and natural systems and predicting the coevolution of the coupled systems requires that we:

- realize that humans are one of the largest drivers in every system
- take an adaptive systems approach to model how human behaviors shape pathways to alternative futures
- acknowledge the role of human preferences, multi-sectoral tradeoffs, interdependencies and feedbacks across spatial scales

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POLITECNICO DI MILANO

DEPT. of ELECTRONICS, INFORMATION,
and BIOENGINEERING

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