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University of Applied Sciences

Climate Change Hydrology

African-Bavarian Academy: Climate Change Management

Kristian Förster

22 June 2023

Outline

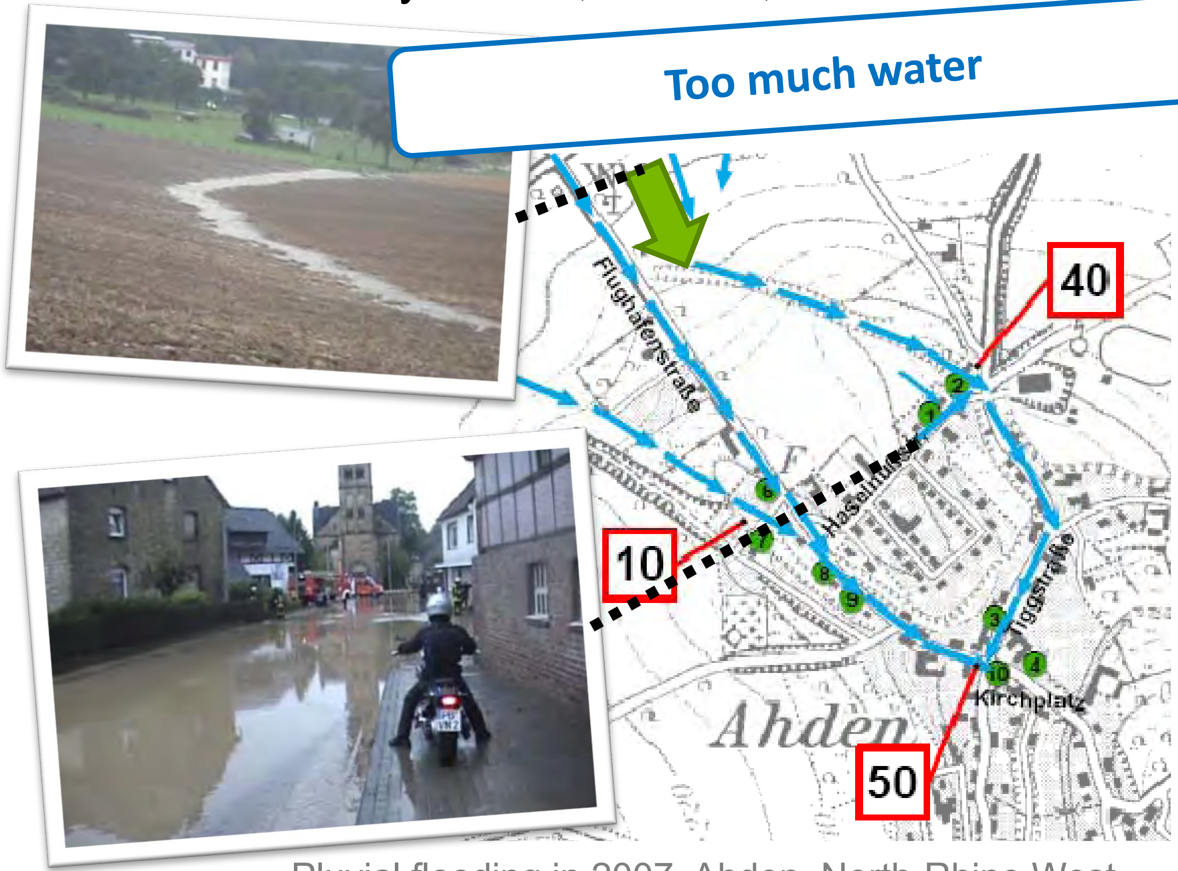
Image Source: WWAP (2018)

- Hydrological Extremes
- The relevance of hydrological storage
- Example 1: Green roofs
- Example 2: Water demand of urban green
- Synthesis

Hydrological extremes

Increase of heavy rainfall, erosion, floods:

Too much water



Pluvial flooding in 2007, Ahden, North-Rhine West-phalia, Germany, Stein et al. (2010)

Higher irrigation needs

Not enough water

Sprinkler irrigation in Ticino, Switzerland, 2018

→ Adaptation needed for the water balance at the landscape scale

Hydrological Extremes and Climate Change

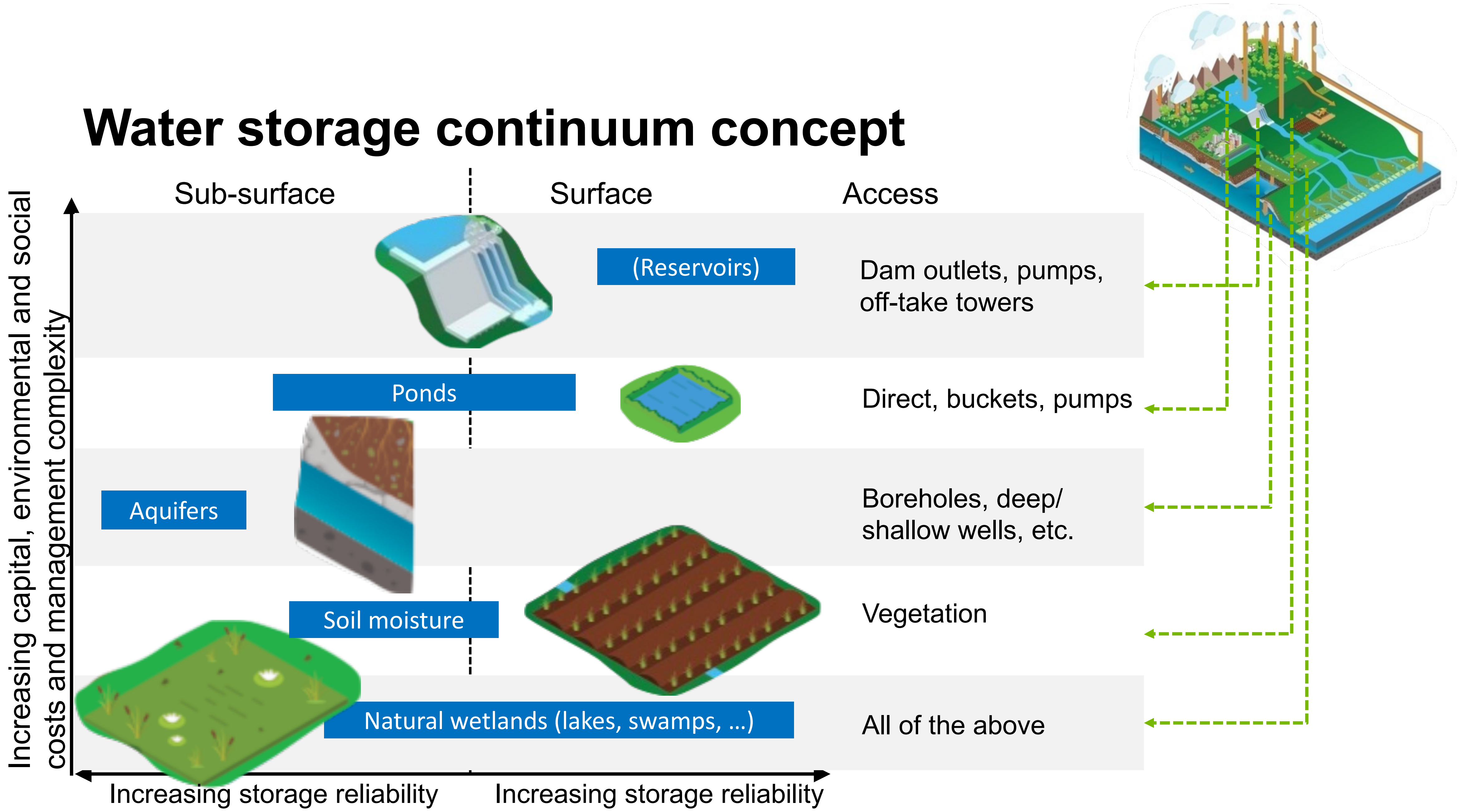
The Sixth Assessment Report (AR6) of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC)

Change in indicator	Observed (since 1950)	Attributed (since 1950)	Projected at GWL (°C) +1.5	+2	+4
Warm/hot extremes: Frequency or intensity	↑	✓ Main driver	↑	↑	↑
Cold extremes: Frequency or intensity	↓	✓ Main driver	↓	↓	↓
Heavy precipitation events: Frequency, intensity and/or amount	↑ Over majority of land regions with good observational coverage	✓ Main driver of the observed intensification of heavy precipitation in land regions	↑ in most land regions	↑	↑ in most land regions
Agricultural and ecological droughts: Intensity and/or duration	↑ for predominant fraction of land area	✓ for predominant fraction of land area	↑ for predominant fraction of land area	↑ for predominant fraction of land area	↑ for predominant fraction of land area
Precipitation associated with tropical cyclones	↑	✓	↑ Rate +11%	↑ Rate +14%	↑ Rate +28%
Tropical cyclones: Proportion of intense cyclones	↑	✓	↑ +10%	↑ +13%	↑ +20%
Compound events: co-occurrent heat waves and droughts	↑ (Frequency)	✓ (Frequency)	↑ (Frequency and intensity increases with warming)		
Marine heatwaves: Intensity & frequency	↑ (since 1900)	✓ (since 2006)	↑ Strongest in tropical and Arctic Ocean		
Extreme sea levels: Frequency	↑ (since 1960)	✓	↑ (Scenario-based assessment for 21st century)		

medium confidence	likely / high confidence	very likely	extremely likely	virtually certain

IPCC (2021)

Water storage continuum concept

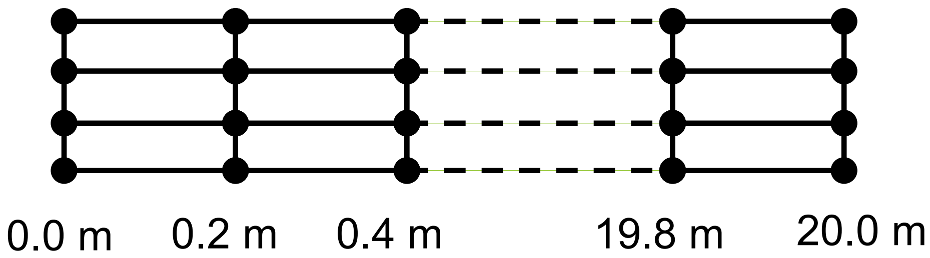


WWAP (2018)
McCartney & Smakhtin (2010)

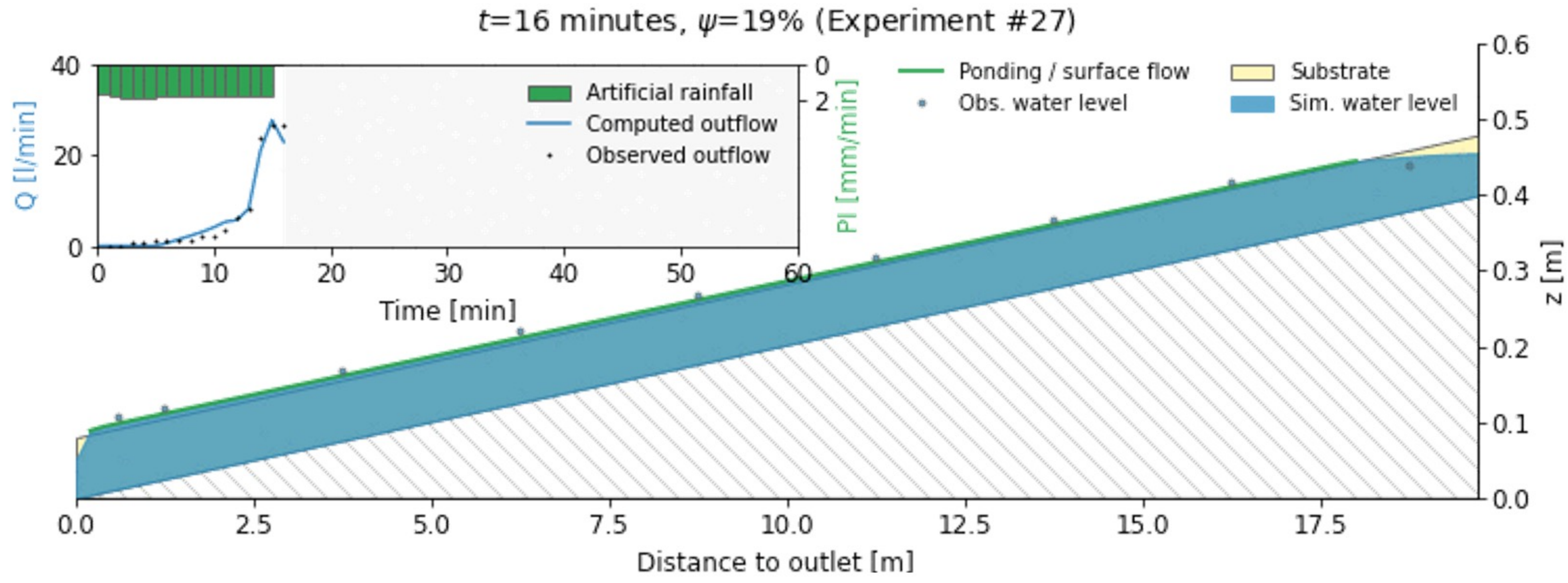
Physically-based representation of NbS in models

Artificial rainfall experiments

- Research question: Quantification of flow processes in green roofs with varying dimensions (44 setups in total)
- Methods: Physical model *and* numerical modelling, using CMF (Kraft et al., 2011):
  - Artificial rainfall: 27 mm/15min (~100 yrs. return period @ Hanover, Germany)
  - Darcy and Richards flow in a 2D numerical grid, diffusive wave surface flow



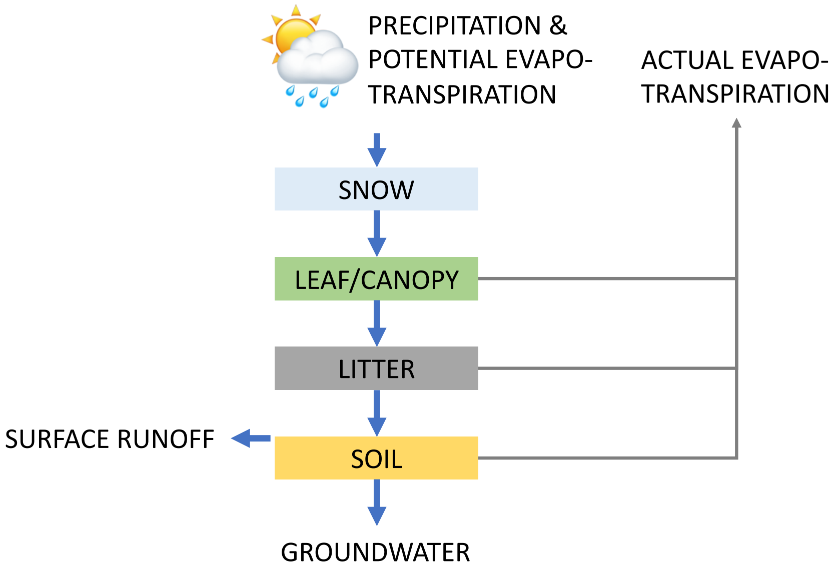
Physically-based representation of NbS in models



Numerical model of green roofs under extreme rainfall conditions (Förster et al. 2021)

Water demand of urban vegetation

- Research question: How to quantify the water demand (and irrigation demands) of urban green?
- Method: Detailed Evapotranspiration (ET) modelling coupled to a simple bucket soil water balance model
- Results: Comparison of actual ET and minimum requirement for various types of vegetation



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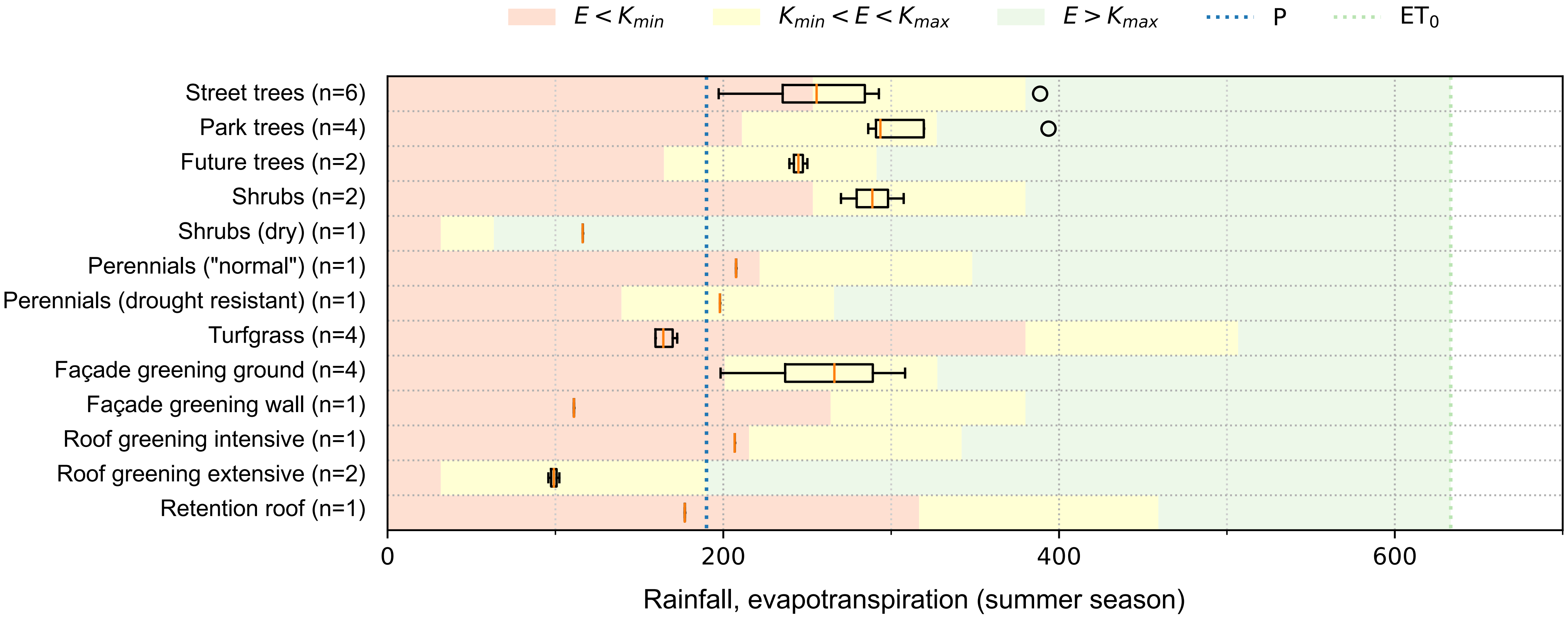
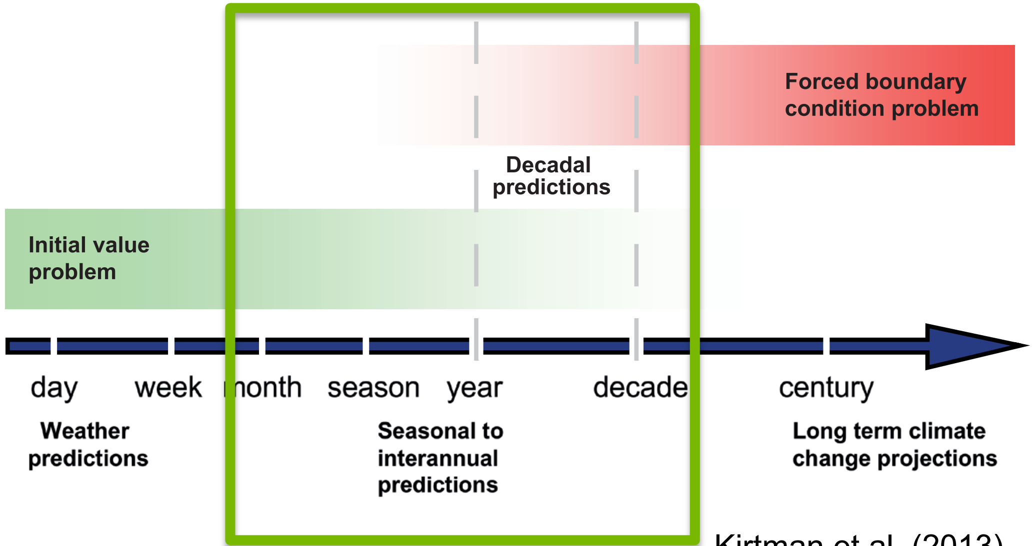
Water demand of urban vegetation

2018: dry year



Synthesis

- Very likely that hydrological extremes will become more intensive and more frequent due to climate change



Kirtman et al. (2013)

- NbS-based Hydrological storage is key for adaptation; models are good tools for planning but better quantification of fluxes, especially evapotranspiration needed

- Outlook: climate services with different lead time (from weather forecasts to projections) provide important information for water management and related policies

Towards near-term predictions

Still a gap between weather forecasts and climate projections as input to studies related to water availability

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EDITED BY
Julie Arblaster,
Monash University, Australia

REVIEWED BY
Jong-Seong Kug,
Pohang University of Science and Technology, Republic of Korea
Yong-Yub Kim,
Institute for Basic Science Center for Climate Physics (ICCP), Republic of Korea
Gerald Meehl,
National Center for Atmospheric Research (UCAR), United States

*CORRESPONDENCE
Terence J. O'Kane
terence.okane@csiro.au

†These authors share first authorship
‡These authors share senior authorship

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Recent applications and potential of near-term (interannual to decadal) climate predictions

Terence J. O'Kane[1*†], Adam A. Scaife[2,3†], Yochanan Kushnir[4‡], Anca Brookshaw[5‡], Carlo Buontempo[5‡], David Carlin[6‡], Richenda K. Connell[7‡], Francisco Doblas-Reyes[8,9‡], Nick Dunstone[2‡], Kristian Förster[10,11‡], Antonio Graça[12‡], Alistair J. Hobday[1‡], Vassili Kitsios[13‡], Larissa van der Laan[10‡], Julia Lockwood[2‡], William J. Merryfield[14‡], Andreas Paxian[15‡], Mark R. Payne[16‡], M. Catherine Reader[14‡], Geoffrey R. Saville[7,17‡], Doug Smith[2‡], Balakrishnan Solaraju-Murali[8‡], Nico Caltabiano[18‡], Jessie Carman[19‡], Ed Hawkins[20‡], Noel Keenlyside[21‡], Arun Kumar[22‡], Daniela Matei[23‡], Holger Pohlmann[15‡], Scott Power[24,25‡], Marilyn Raphael[26‡], Michael Sparrow[18‡] and Bo Wu[27‡]

[1]CSIRO Environment, Hobart, TAS, Australia, [2]Met Office Hadley Centre, Exeter, United Kingdom, [3]College of Engineering, Mathematics and Physical Sciences, Exeter University, Exeter, United Kingdom, [4]Lamont-Doherty Earth Observatory, Earth Institute, Columbia University, Palisades, NY, United States, [6]United Nations, [5]European Centre for Medium Range Weather Forecasting, Reading, United Kingdom, [8]Barcelona New York, NY, United States, [7]Willis Towers Watson, New York, NY, United States, Supercomputing Center, Barcelona, Spain, [9]Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Spain, [10]Institute for Hydrology and Water Resources Management, Leibniz University Hannover, Hannover, Germany, [11]Institute of Ecology and Landscape, Weihenstephan-Triesdorf University of Applied Sciences, Freising, Germany, [12]Sogrape Vinhos, Avintes, Portugal, [13]CSIRO ... [14]Canadian Centre for Climate Modelling and Analysis,

How you can reach me:
kristian.foerster@hswt.de

Thank you!

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