IAHR AIRH

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39th IAHR WORLD CONGRESS

GRANADA, SPAIN 2022

From Snow to Sea

19-24 June 2022

#FromSnowToSea

Hydraulic structures engineering and research: why and where to?

22nd Arthur Ippen Award Lecture - Sébastien ERPICUM

Organized by:

IAHR AIRH International Association for Hydro-Environment Engineering and Research

Hosted by Spain Water and IWHR, China

UNIVERSIDAD DE GRANADA

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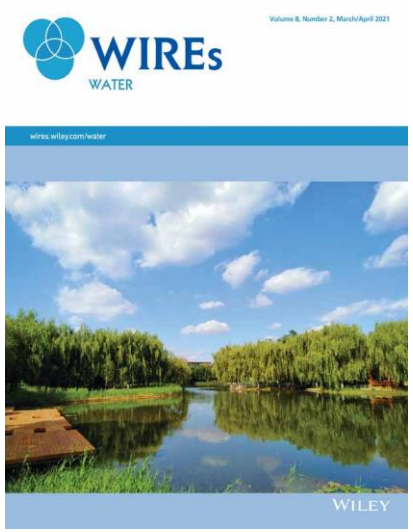
Baseground

- IAHR HSTC LT reflection on future of hydraulic structures engineering

  → Opinion paper (Erpicum, Crookston et al., 2020)

  → IAHR White Paper (Felder, Erpicum et al., 2021)



- Involvement in IAHR, ICOLD, PIANC…
- Great team at Liege University
- Great people and mentors met over the last 25 years

Hydraulic structures: structures interacting with water

Wyaralong Dam (Australia)

Paris sewers (France), with a sediment flushing boat

Weirs on Genil River in Granada (Spain)

Hydraulic structures: structures interacting with water

Block ramp fishway in the USA (courtesy L. Aadland)

New Romanche banks downstream of Gavet dam (France)

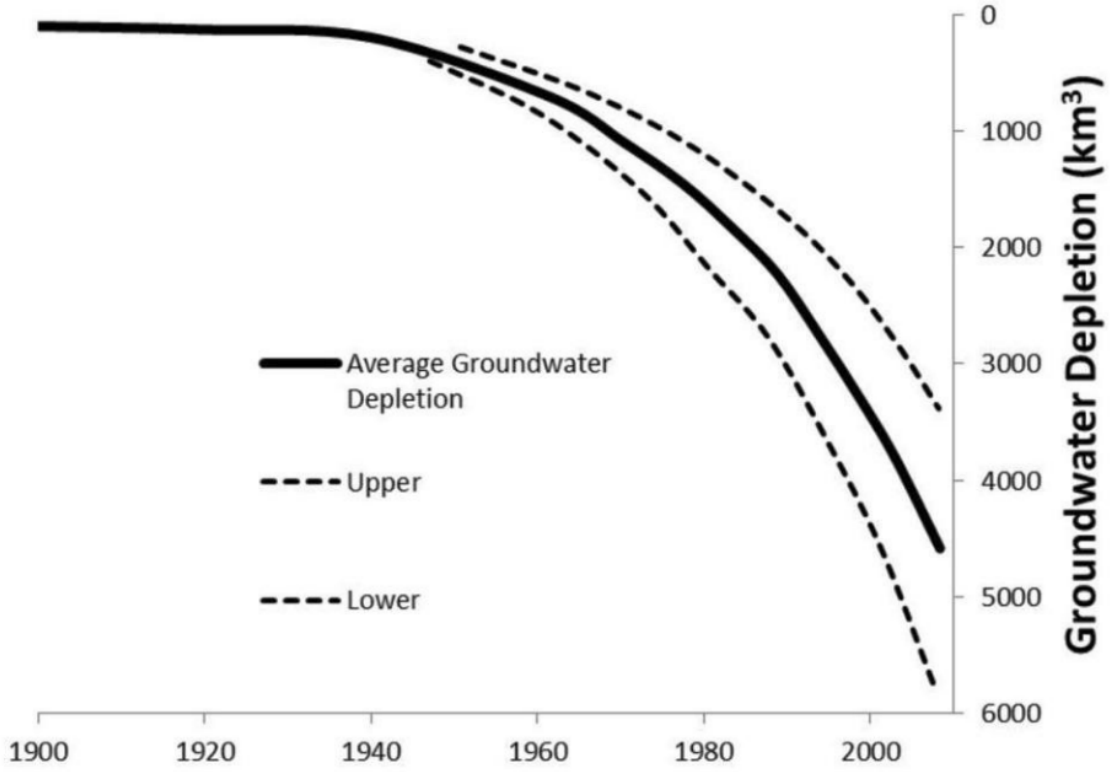
Pont du Gard (France)

Hydraulic structures engineering and research: all questions related to the understanding, planning, design, construction, operation, management, safety, and sustainability of hydraulic structures

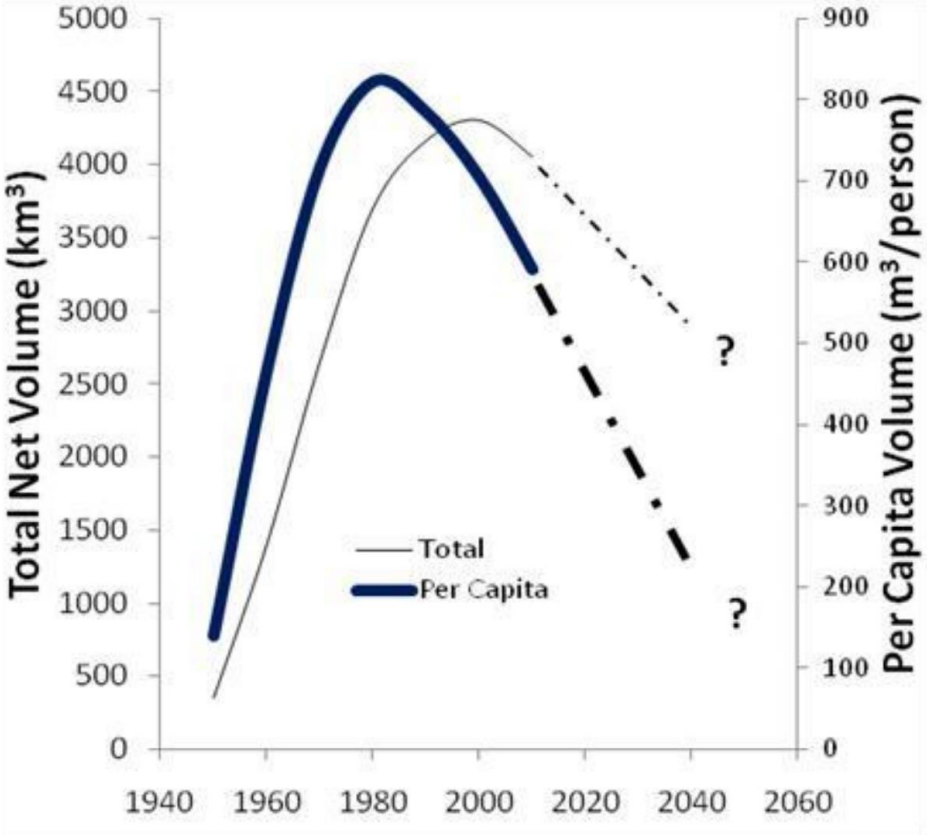
- Critical for water management
- As old as Civilization
- Support the development of human societies
- Evolve over time along with scientific understanding and society needs

Why do we (still) need hydraulic structures engineering and research?

Why? Population growth



Konikow, 2011
& ICOLD Bulletin 169, 2017



Annandale, 2013
& ICOLD Bulletin 169, 2017

Why? Global warming

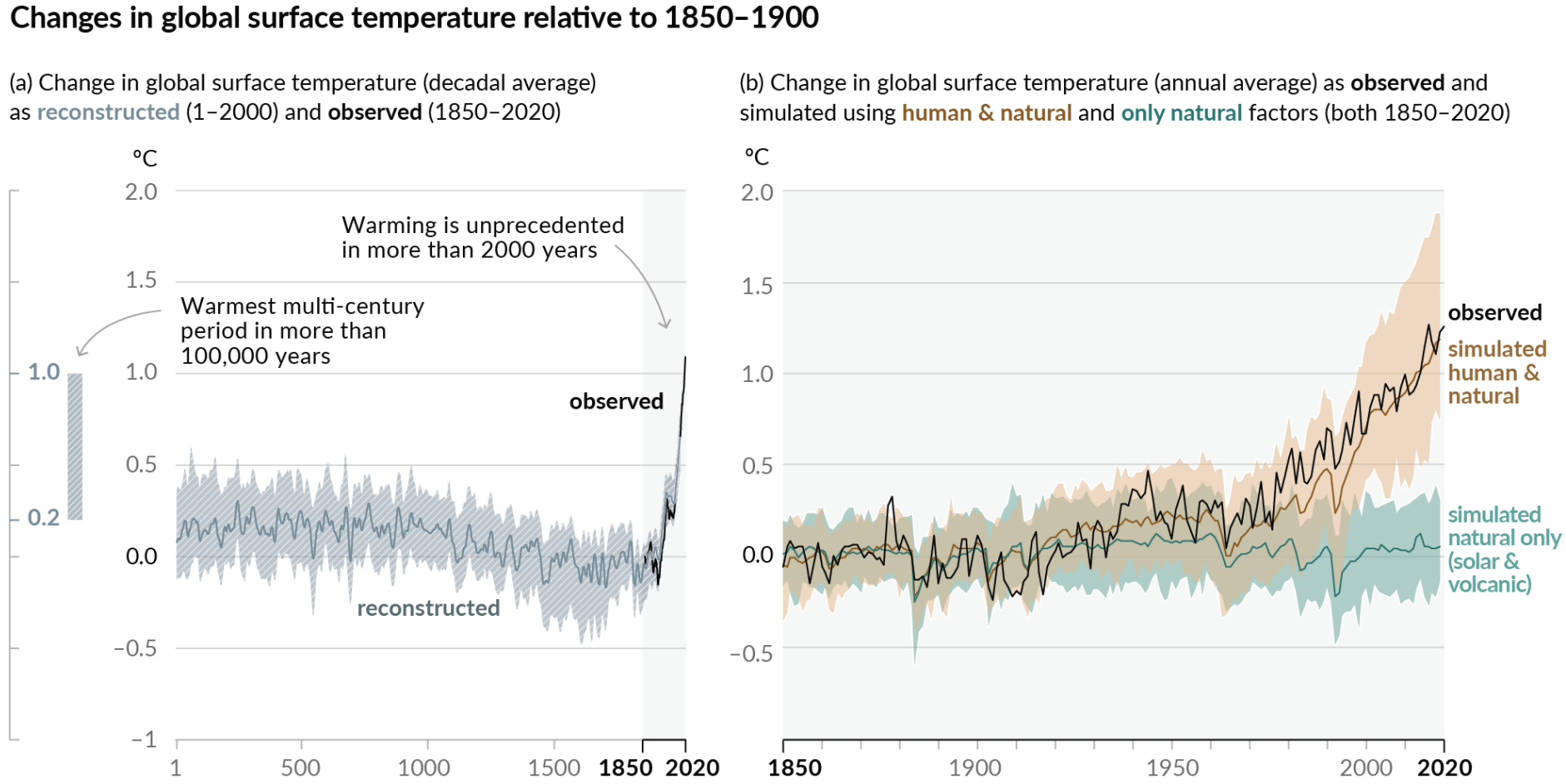


Figure SPM.1 in IPCC, 2021

Why? Climate change

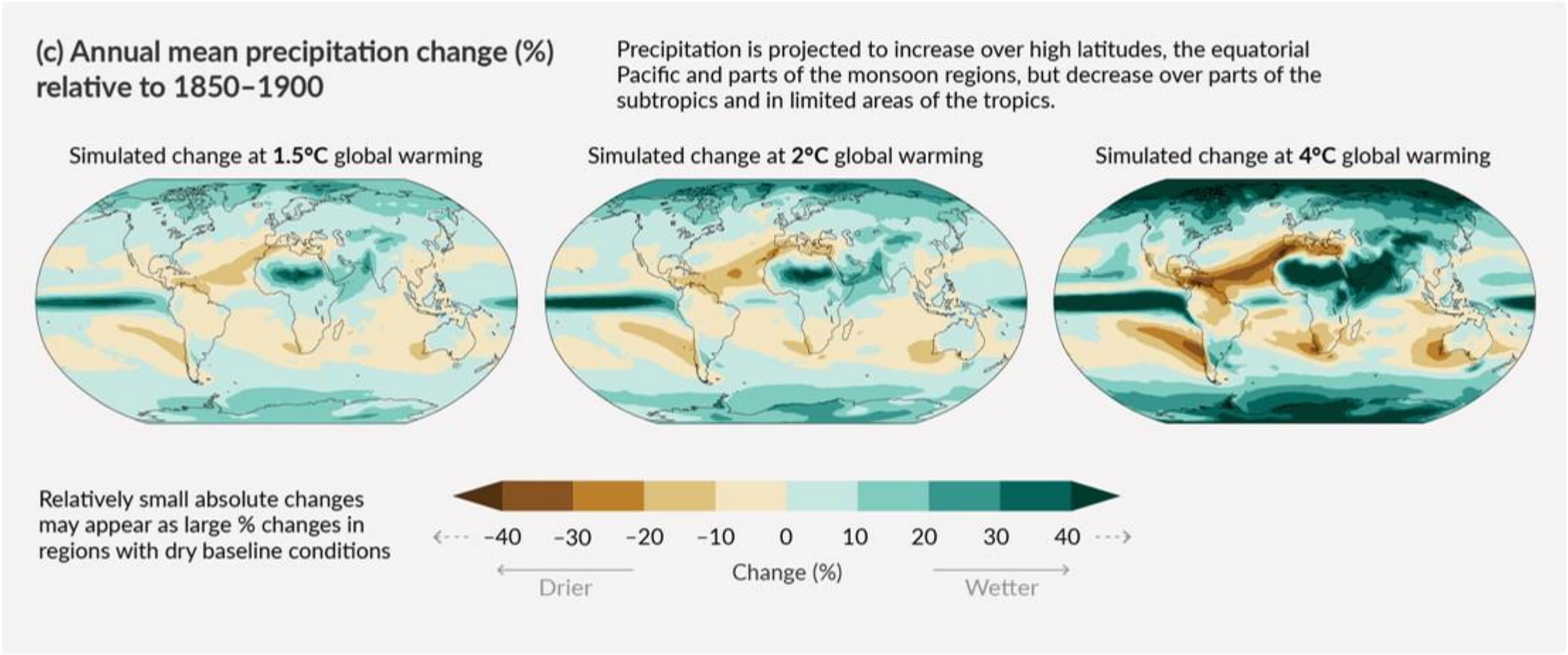


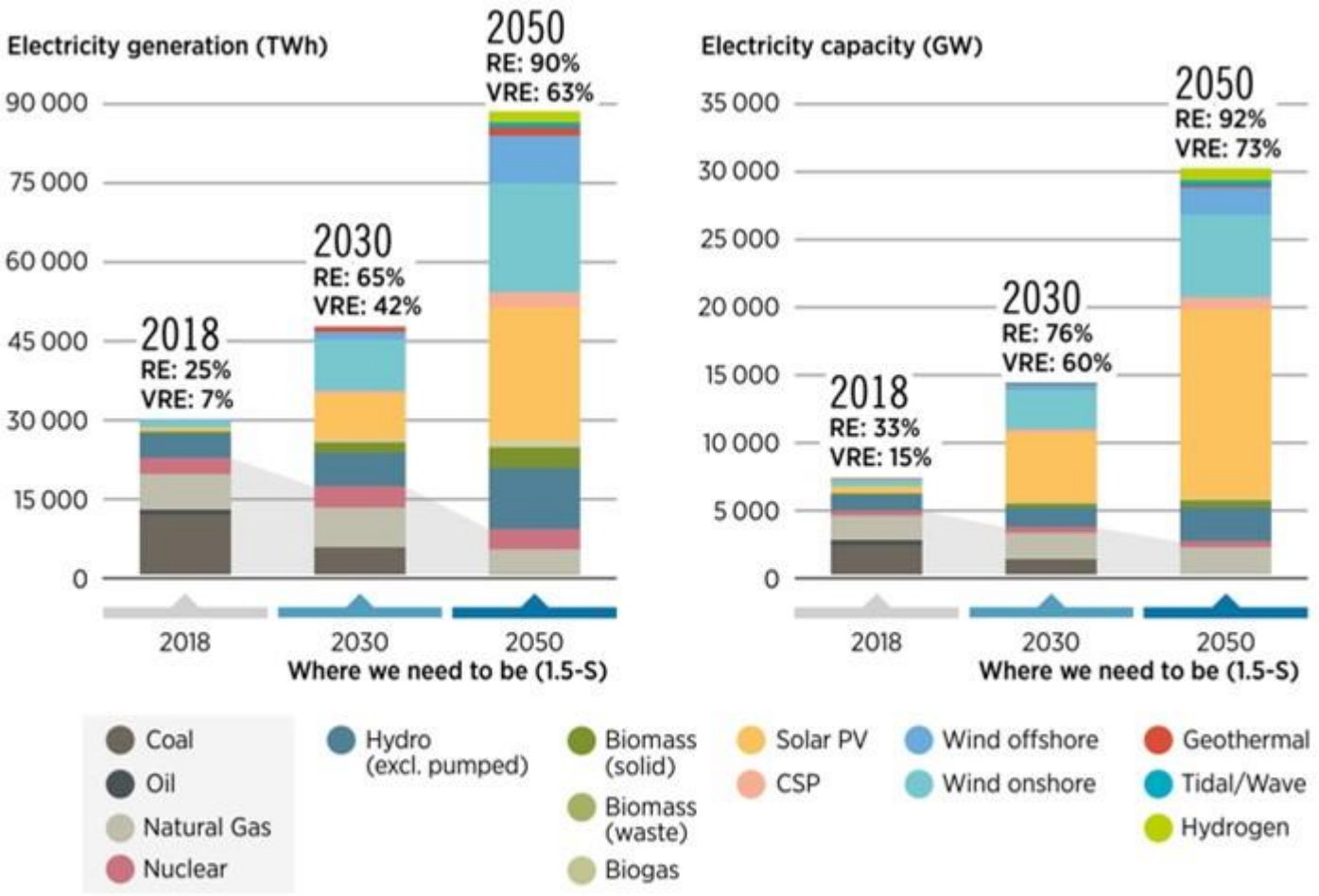
Figure SPM.5 in IPCC, 2021

Why? Energy transition

Median g CO2equ/kWh emission

Solar PV	48
Geothermy	38
Hydro	24
Nuclear	12
Wind	11

IPCC, 2014; Ubierna et al., 2022



IRENA, 2022

Note: 1.5-S = 1.5°C Scenario; CSP = concentrated solar power; GW = gigawatts; PV = photovoltaic; RE = renewable energy; TWh/yr = terawatt hours per year; VRE = variable renewable energy.

Why? Energy transition

"As our report highlights, ***hydropower is the forgotten giant of low-carbon electricity****;* ***it produces more of it than any other source worldwide****. And hydropower's critical contribution to clean energy transitions is not limited to the huge amounts of renewable electricity it produces – its capabilities for* ***providing flexibility and storage for electricity systems*** *are also unmatched, making it* ***a natural enabler for integrating greater amounts of wind and solar power****."*

Dr Fatih Birol, Executive Director, International Energy Agency

In Hydropower Special Market Report - Analysis and forecast to 2030 – IEA, July 2021

Why? Energy transition

*"And **all hydropower projects need to meet high standards for sustainability** to ensure the energy and climate benefits they can bring are not undermined by negative environmental and social side effects."*

Dr Fatih Birol, Executive Director, International Energy Agency

In Hydropower Special Market Report - Analysis and forecast to 2030 – IEA, July 2021

Why? Sustainability

Why do we (still) need hydraulic structures engineering and research?

- Population growth
- Climate change
- Energy transition
- Sustainability

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Long lasting structures (far over a career duration)

Fundamental roles of hydraulic structures remain, but solicitations and expectations are changing

Hydraulic structures engineering and research : where to?

Where to?

A sustainable perspective

"[We] have a moral and ethical obligation to act in the best interest of society..."

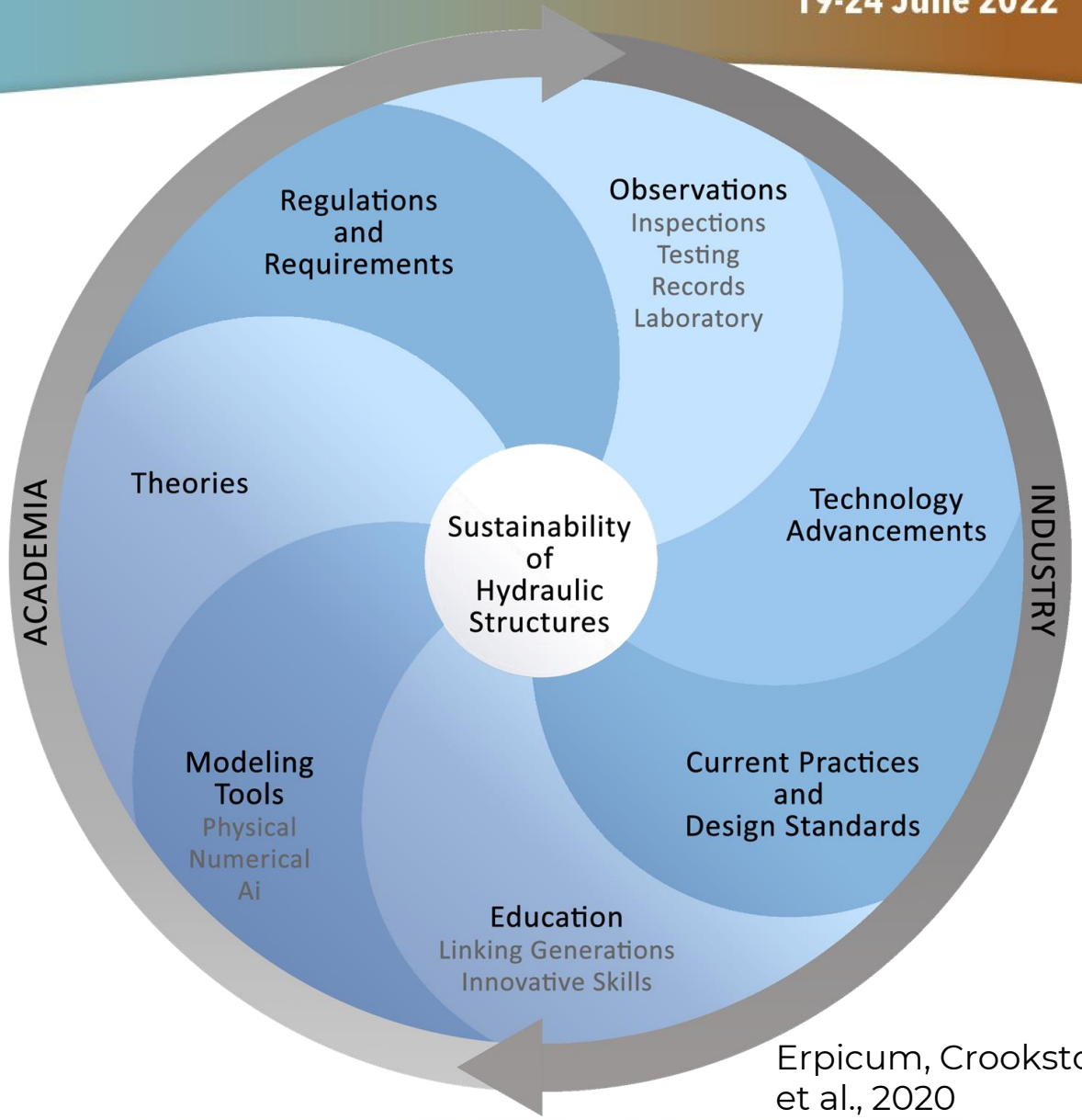
Felder, Erpicum et al., 2021

Erpicum, Crookston et al., 2020

Where to?

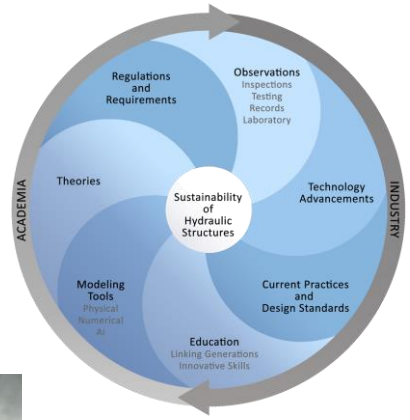
Hydraulic structures engineering and research are based on proven tools and methodologies …

… that need to continue to evolve to help us embracing a more sustainable perspective.



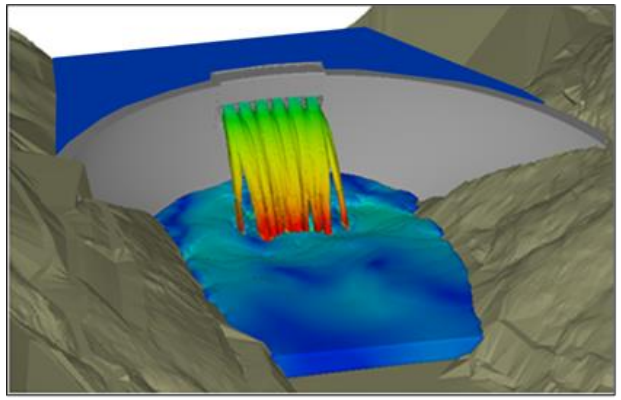
Erpicum, Crookston et al., 2020

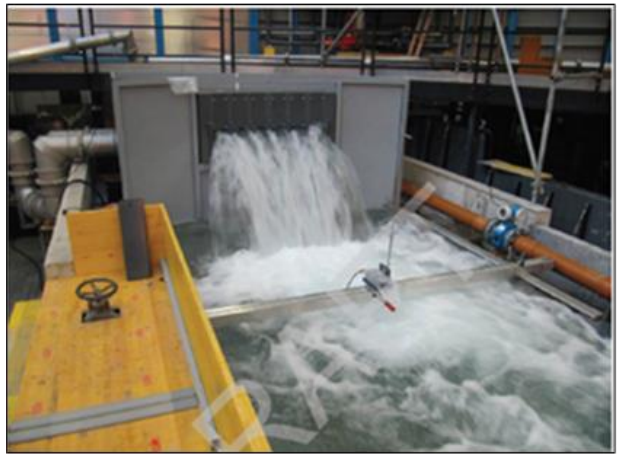
Where to? Field data are needed, and thus adapted instrumentation

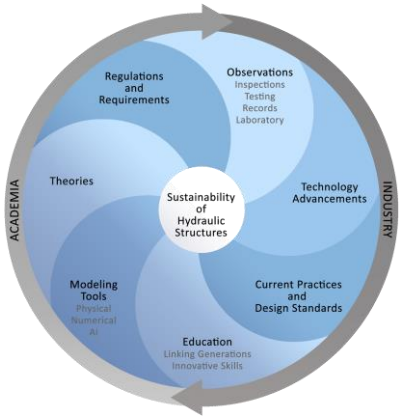


Sarrans Dam bottom outlet (France) – 1:35 scale model (left) and prototype (right) (Erpicum, Blancher et al., 2020)

Where to? Models must be questioned and developed

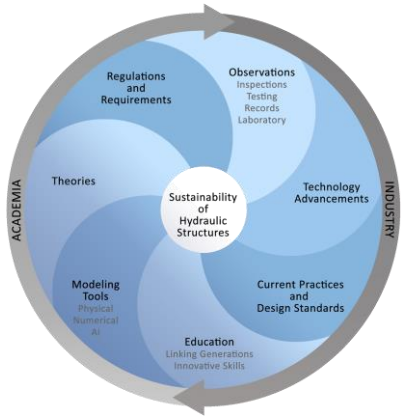






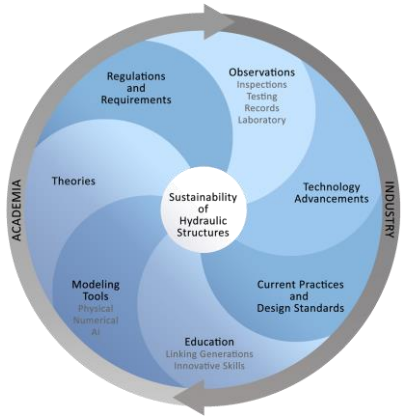
Kariba Dam (Zambia and Zimbabwe) – Numerical and physical model (left), prototype (right) (Daux et al., 2017)

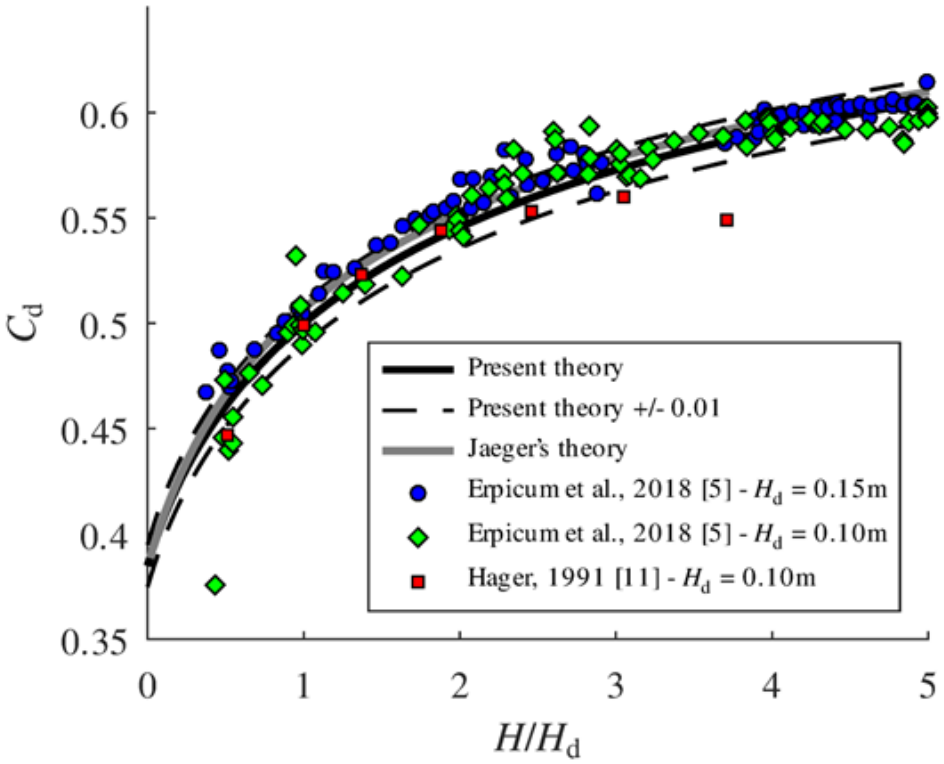
Where to? (Continuing) education should be encouraged

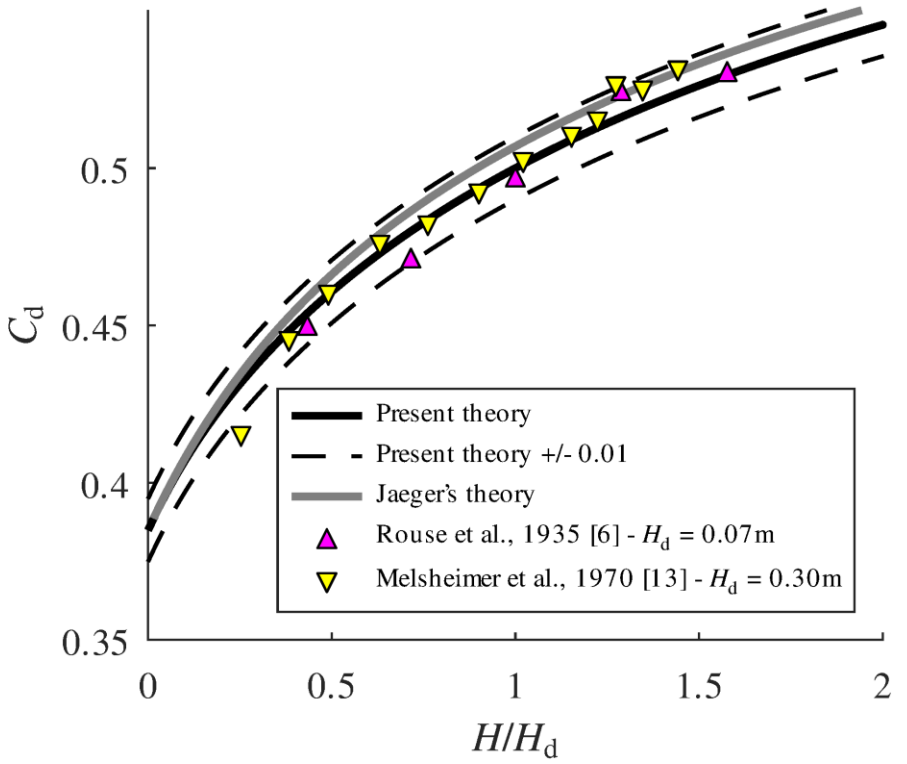


La Gileppe dam (Belgium) – Test of a bottom outlet during a students field trip

Where to? New theoretical developments are needed, to improve design criteria and physics understanding

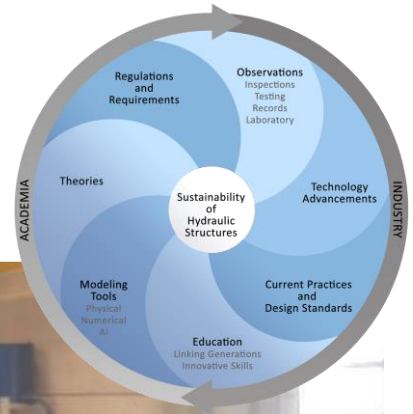






Theoretical evolution of ogee crest weir discharge coefficient (Stilmant, Erpicum et al., submitted)

Where to? Regulations and requirements must evolve to encompass sustainability



Re-oxygenation weir downstream of the Lom Pangar dam (Cameroun). Prototype and 1:1 physical model (Erpicum, Lodomez et al., 2016)

Where to? Collaboration between academia and industry should be strengthened and innovation promoted


Courtesy EDF-CIH

Malarce dam PKW (France)
Designed for 13.8 $m^3/s/m$
with a head of 1.50m

Van Phong dam (Vietnam)
Gates + PKW - 14,400m^3/s


Courtesy VNCold

Where to? Strengthen multidisciplinarity, diversity and collaboration

Tube fishway (https://www.wrl.unsw.edu.au/research/tube-fishway-project)

Where to? Improve communication

Eupen dam (Belgium) – Spillway in operation during flood on July 15, 2021

Where to go in hydraulic structures engineering and research?

- Update tools and methodologies
- Address the lack of detailed field data
- Promote innovation
- Strengthen multidisciplinarity and collaboration
- Improve communication

+

Shift the paradigm towards sustainability

How?

In fact, we all know.

It is mainly a matter of willingness and persuasion.

As hydraulic structures engineers and researchers, **we have the ability to create the required knowledge** and **we have the duty to make it available**.

It was the best hydropower projects; it was the worst hydropower projects: a tale of two dams. (Inspired from Barkdoll, 2022)

"Old" (left) and "new" (right) Poutès dam (France) on the Allier River (https://www.edf.fr/hydraulique-loire-ardeche/le-nouveau-poutes-un-projet-innovant-exemplaire/la-genese-et-lhistoire-du-nouveau-poutes & https://www.ern.org/fr/poutes-barrage/)

To conclude

Our civilization is facing tremendous changes

Water infrastructures are at the heart of our civilization and are directly affected by these changes

→ More than ever, hydraulic structures need sound engineering and research, based on proven but constantly evolving tools and methods

→ Multidisciplinarity, cooperation, innovation, (continuing) education, diversity and communication must be strengthened

→ We need to **shift the paradigm towards sustainability**

Thank you for your attention

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