

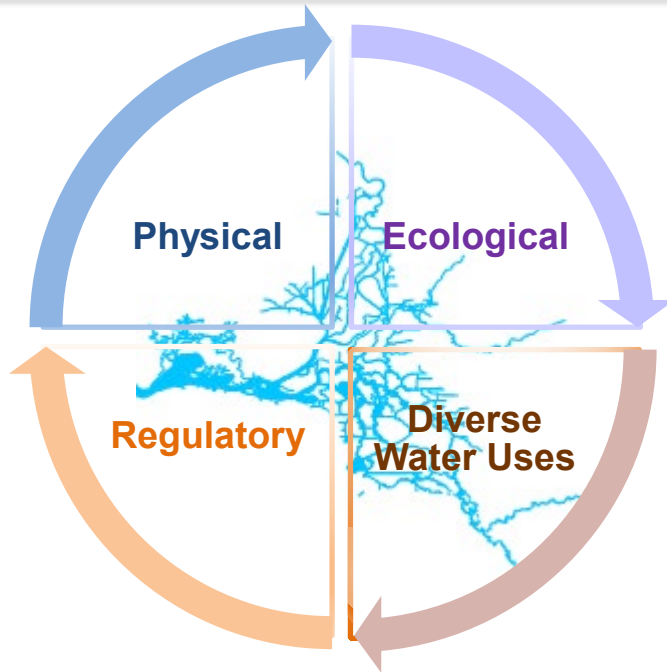
Machine Learning in the Delta: A 30-Year Retrospective and Future Prospects

32nd CWEMF Annual Meeting, April 22, 2026

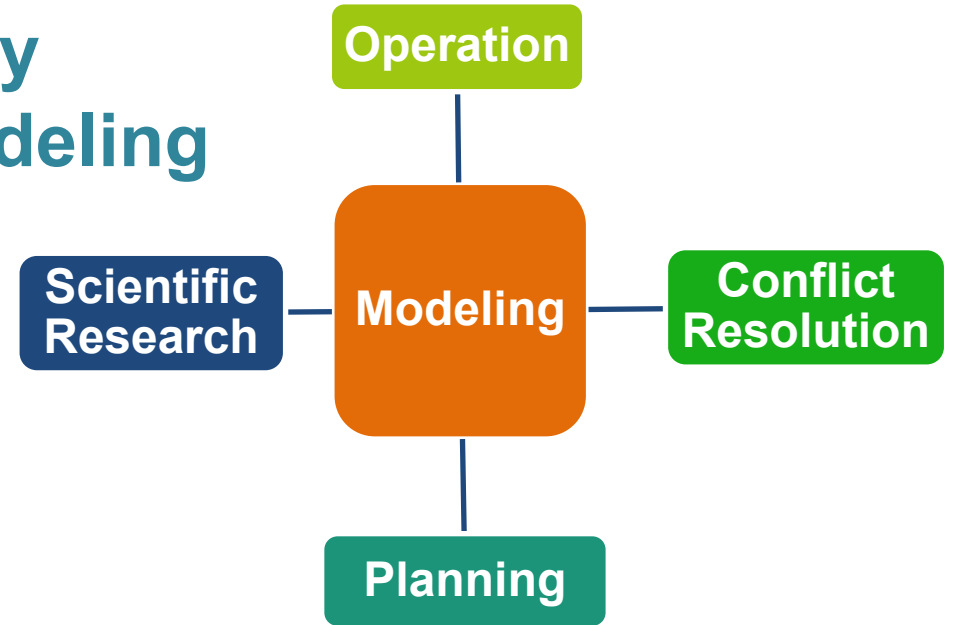


Background

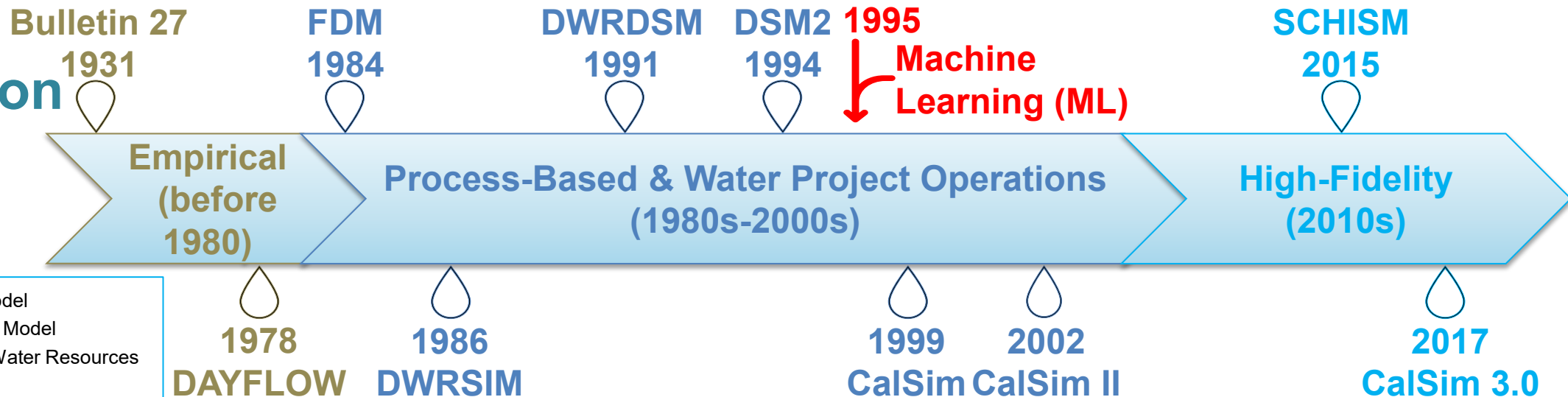
➤ Delta: A Complex System



➤ Why Modeling

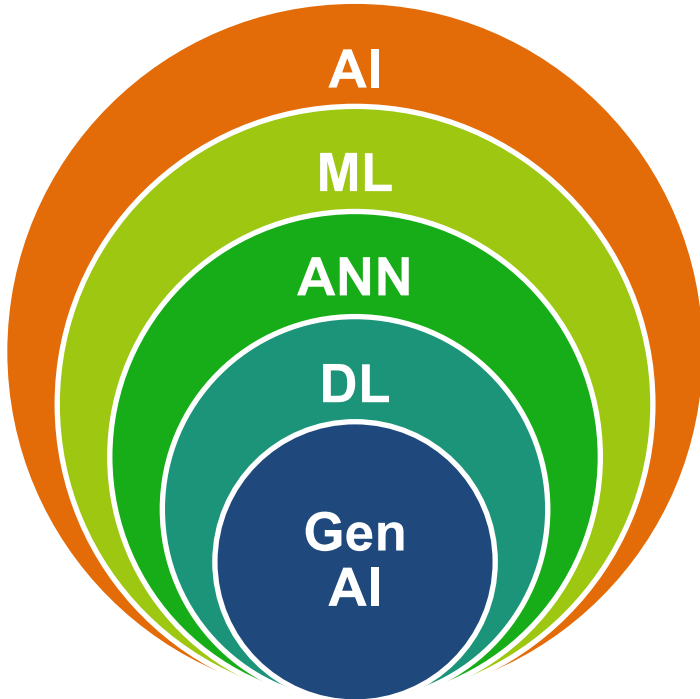


➤ Model Evolution



Background

➤ AI Terminologies



AI: Artificial Intelligence
ML: Machine Learning
ANN: Artificial Neural Network
DL: Deep Learning
GenAI*: Generative AI

➤ Conventional Delta Models vs. ML Models

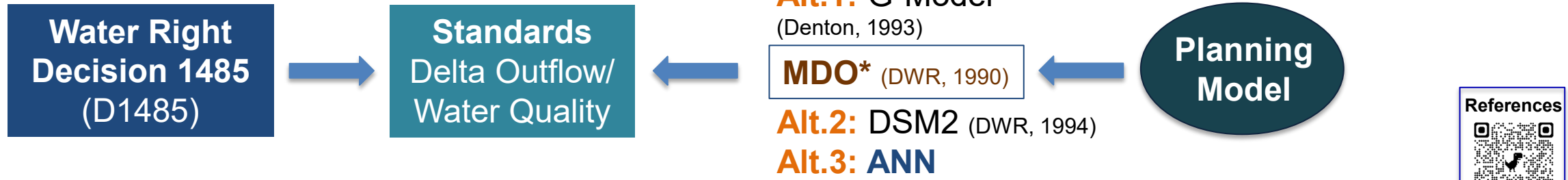
	SCHISM* 3-D Model	DSM2* 1-D Model	ML
 Approach	Physically-Based	Simplified Physics	Data-Driven
 Structure	Rigidly Structured	Structured	Flexible
 Runtime	Days	Hours	Seconds
 Interpretability	"White Box"	"Grey Box"	"Black Box"

***SCHISM**: Semi-implicit Cross-scale Hydrosience Integrated System Model **DSM2**: Delta Simulation Model II

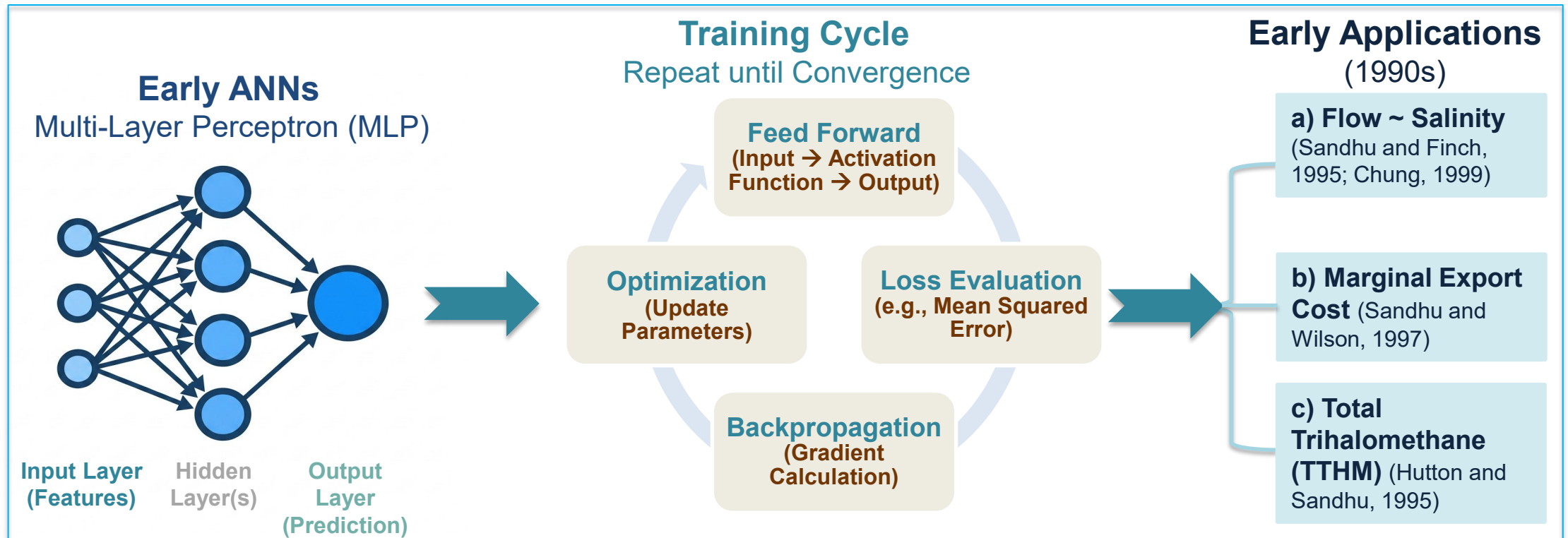
***GenAI** tools were used to create selected icons and images in this presentation

Retrospective: Foundational Development (1990s)

➤ Motivation



➤ Pilot Efforts: Feasibility & Viability



Retrospective: Refinement & Implementation (2000s)

➤ Refinements: Reliability & Stability

Input

- Perturbed inputs¹
- Varying input combinations²
- Tide influences³

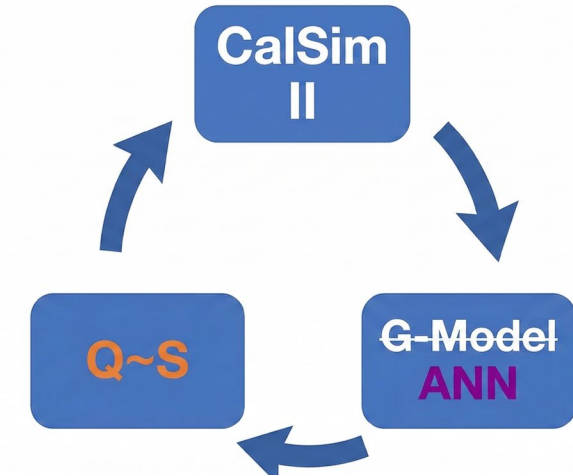
Model

- Different node structures¹
- Various train-test splits²
- Input data normalization²

Script

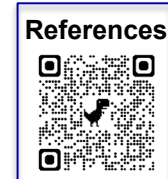
- Python, Awk, C-Shell → Python¹

➤ Implementation

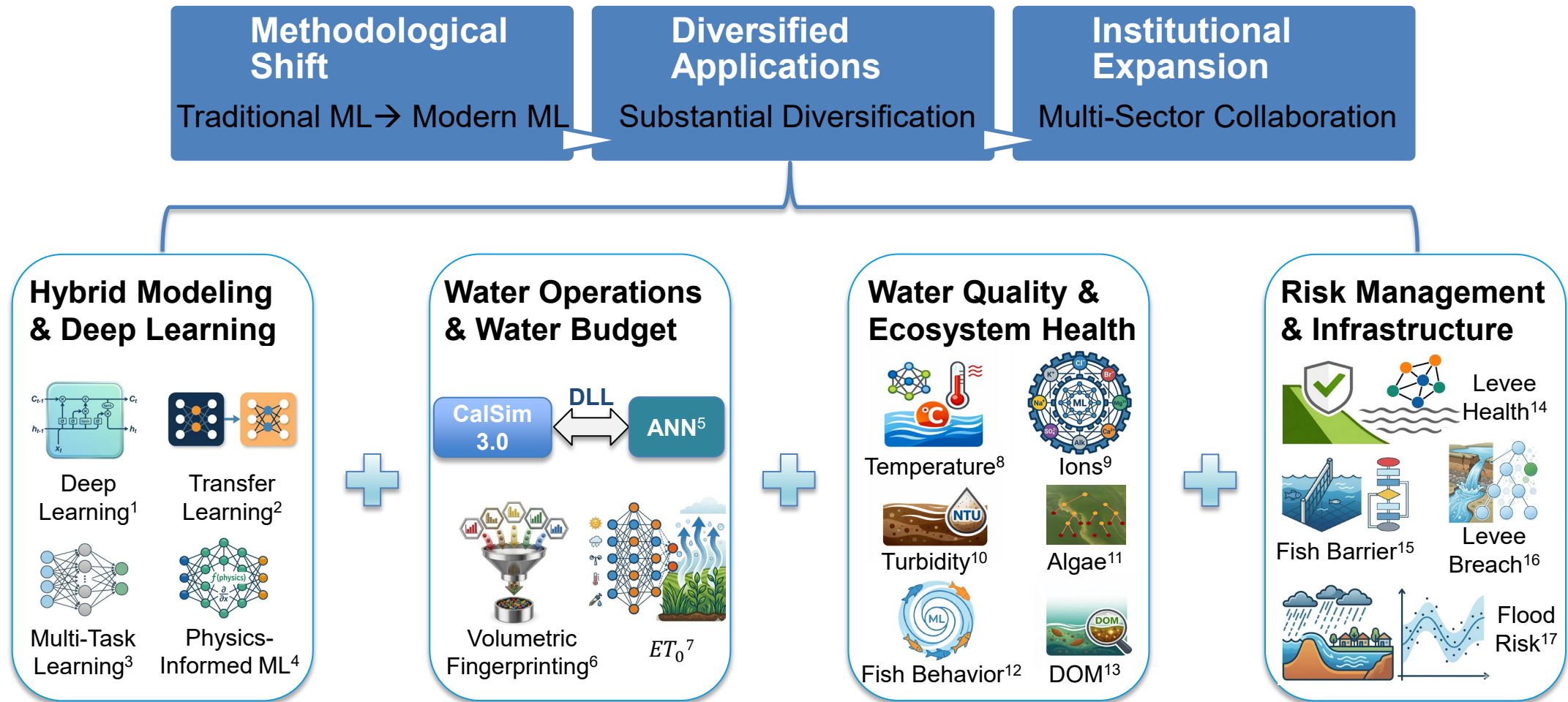


- CalSim II → G-Model → flow ~ salinity (**Q~S**) relationship
- **ANN** tested against G-Model^{4,5}
- **ANN** replaced G-Model

1: Pranger, 2000; 2: Seneviratne (2002);
3: Seneviratne and Wu (2007); 4: Wilbur
and Munevar (2021); 5: Mierzwa (2002)



Retrospective: Expansion & Diversification (2010~)



1: He *et al.* (2010); 2: Qi *et al.* (2023); 3: Qi *et al.* (2021); 4: Roh *et al.* (2023); 5: Jayasundara *et al.* (2020); 6: Chen *et al.* (2018); 7: Ahmadi *et al.* (2025); 8: He *et al.* (2022); 9: Namadi *et al.* (2023); 10: Kim *et al.* (2022); 11: Saha *et al.* (2024); 12: Olivetti *et al.* (2021); 13: Avouris *et al.* (2025); 14: Russo and Athanasopoulos-Zekkos (2024); 15: Swyers *et al.* (2023); 16: RMA (2021) 17: Wang *et al.* (2025)

References



Retrospective: Milestones & Critical Gaps

➤ Milestones

ML Emulator of: DWRSIM-MDO* CalSim II-G-Model* CalSim II-DSM2* CalSim 3-DSM2*

Timeline:

1995

2001/2002

2007

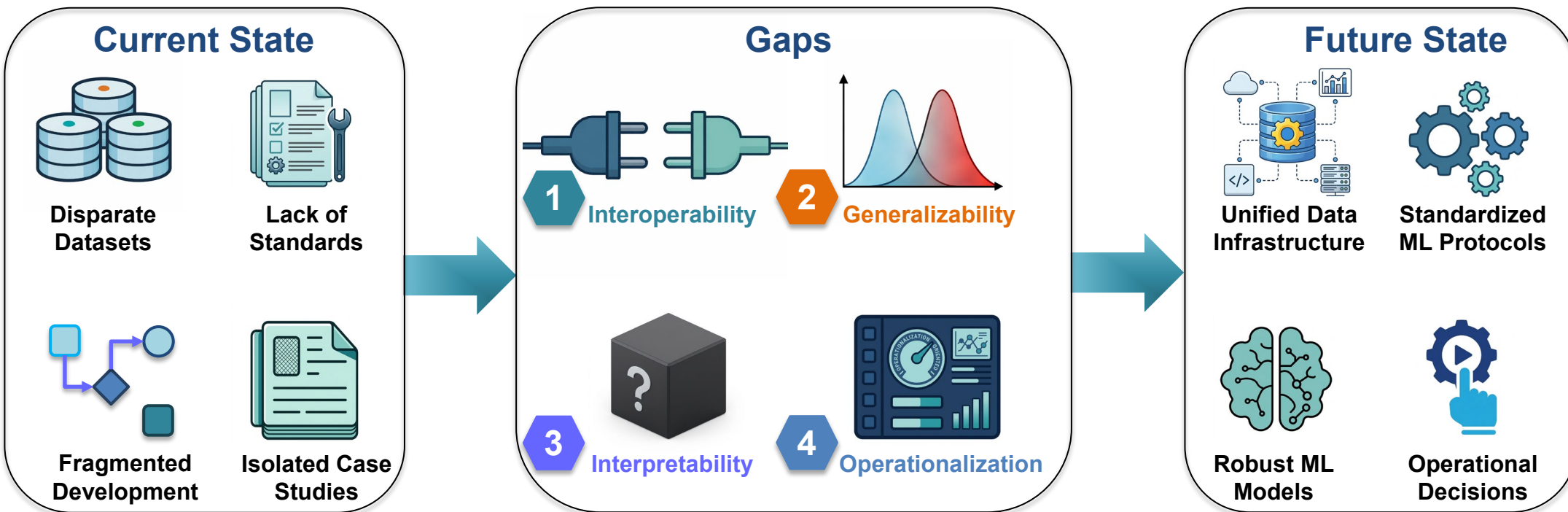
2020

* MDO: Minimum Delta Outflow

G-Model: Salinity Gradient Model

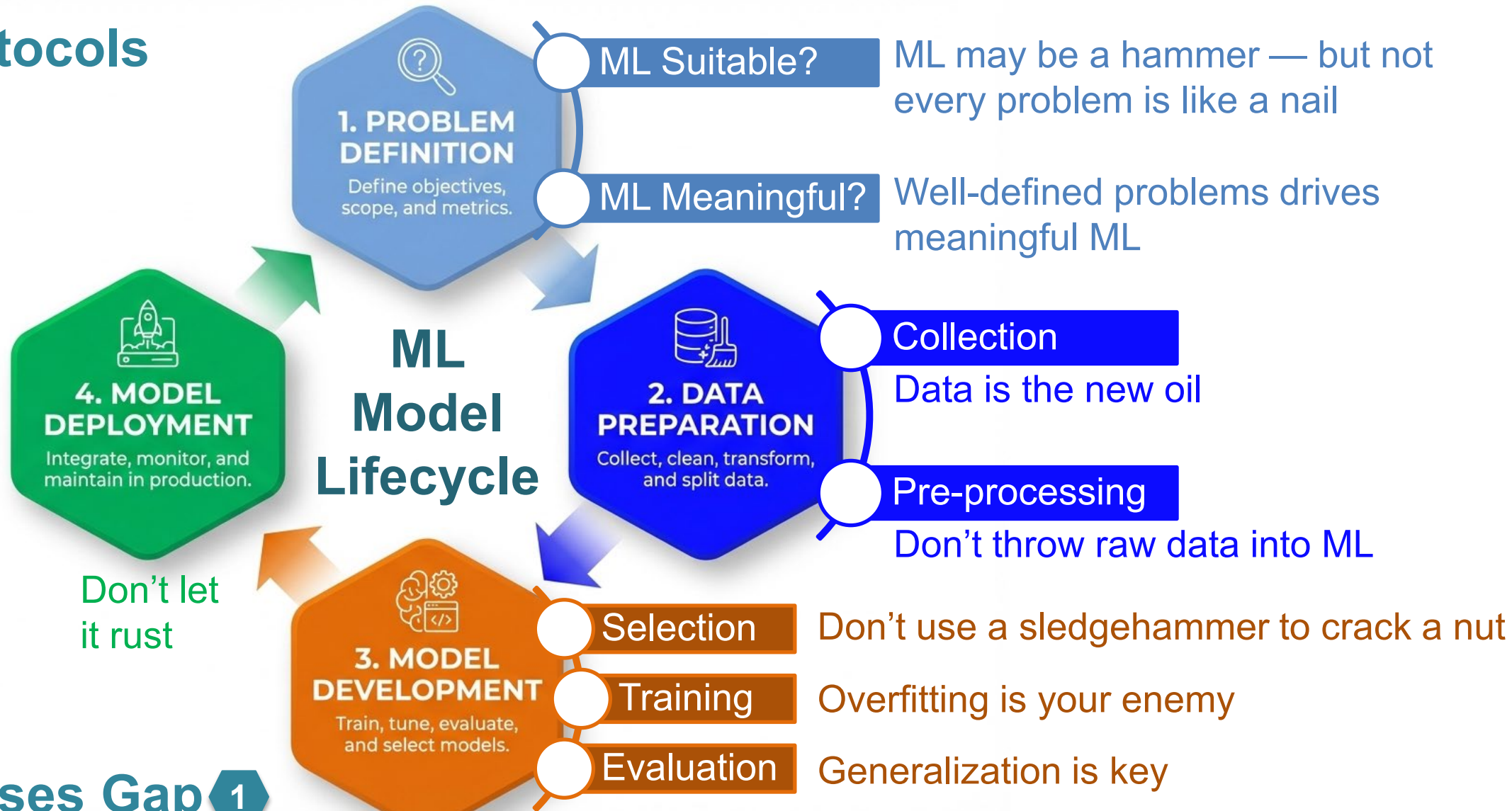
DSM2: Delta Simulation Model II

➤ Gaps



Prospects*: Implementing ML Protocols

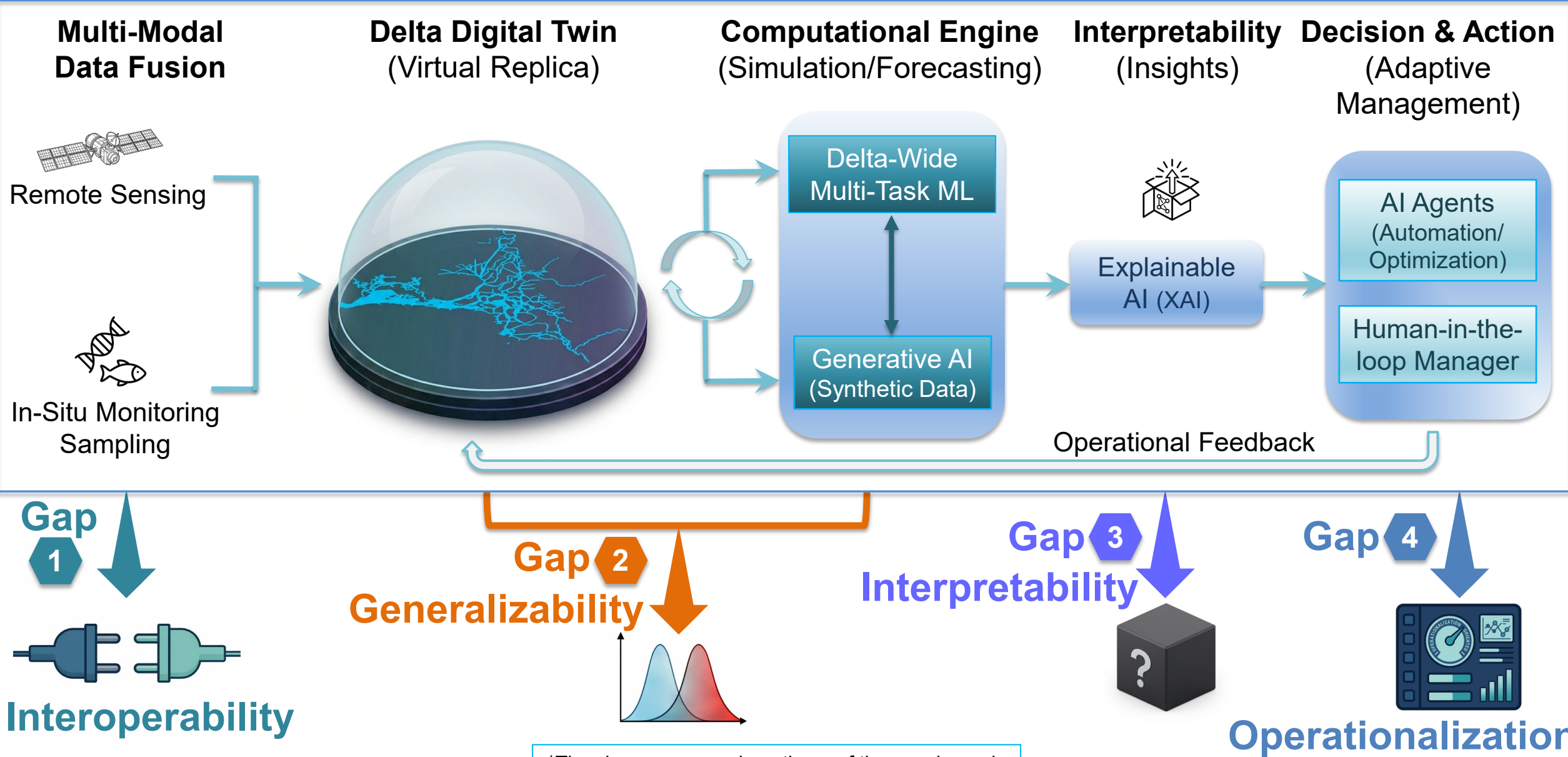
➤ ML Protocols



➤ Addresses Gap **1** - Interoperability

*The views expressed are those of the speaker only

Prospects*:Multi-Modal Data & Emerging Technologies



*The views expressed are those of the speaker only

Machine Learning in the Delta

“This present
moment
used to be
unimaginable
future”

1960s

SWP Construction;
Delta → Highly
Managed System

Contact:
kevin.he@water.ca.gov



Infancy

1995

1st
CWEMF
Annual
Meeting



Adolescence

2026

32nd
CWEMF
Annual
Meeting



Maturity?

2055

61st
CWEMF
Annual
Meeting

