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CriticalEarth

Data-driven estimation of the committor function in an idealized AMOC model

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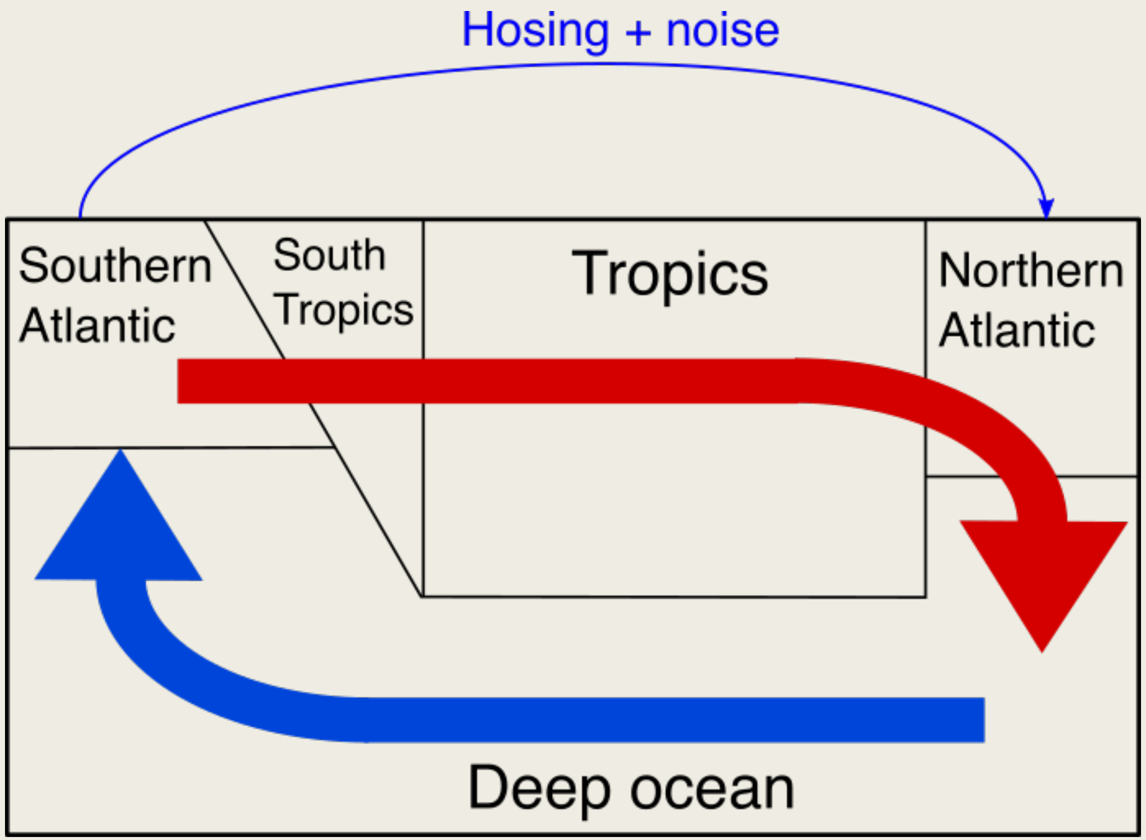
Introduction

- AMOC in a bi-stable state ?
  - On-state: current circulation
  - Off-state: no downwelling

- Collapse: rare event !
- Rare-event algorithm: TAMS
- TAMS requires a score function

Optimal score function ?



Cimatoribus Model

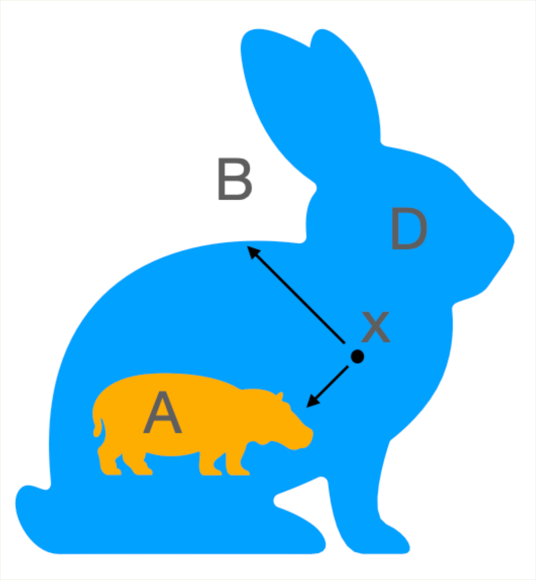
Cimatoribus, A. A., Drijfhout, S. S. & Dijkstra, H. A. Meridional Overturning Circulation: Stability and ocean feedbacks in a box model. *Clim. Dyn.* **42**, 311–328, https://doi.org/10.1007/s00382-012-1576-9 (2012).

Castellana, D., Baars, S., Wubs, F.W. *et al.* Transition Probabilities of Noise-induced Transitions of the Atlantic Ocean Circulation. *Sci Rep* **9,** 20284 (2019). https://doi.org/10.1038/s41598-019-56435-6

Committor function estimation

- **Optimal score function : committor function**
  - Objective: Data-driven estimation

$$\boxed{q(x) = \mathbb{P}[\mathrm{T_B(x)} < \mathrm{T_A(x)}]}$$



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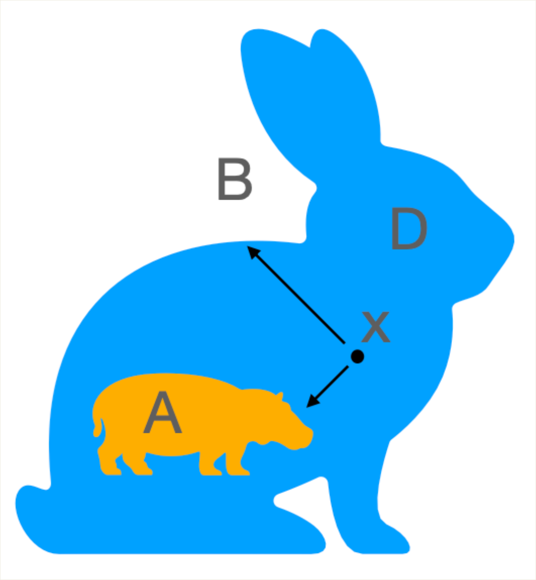
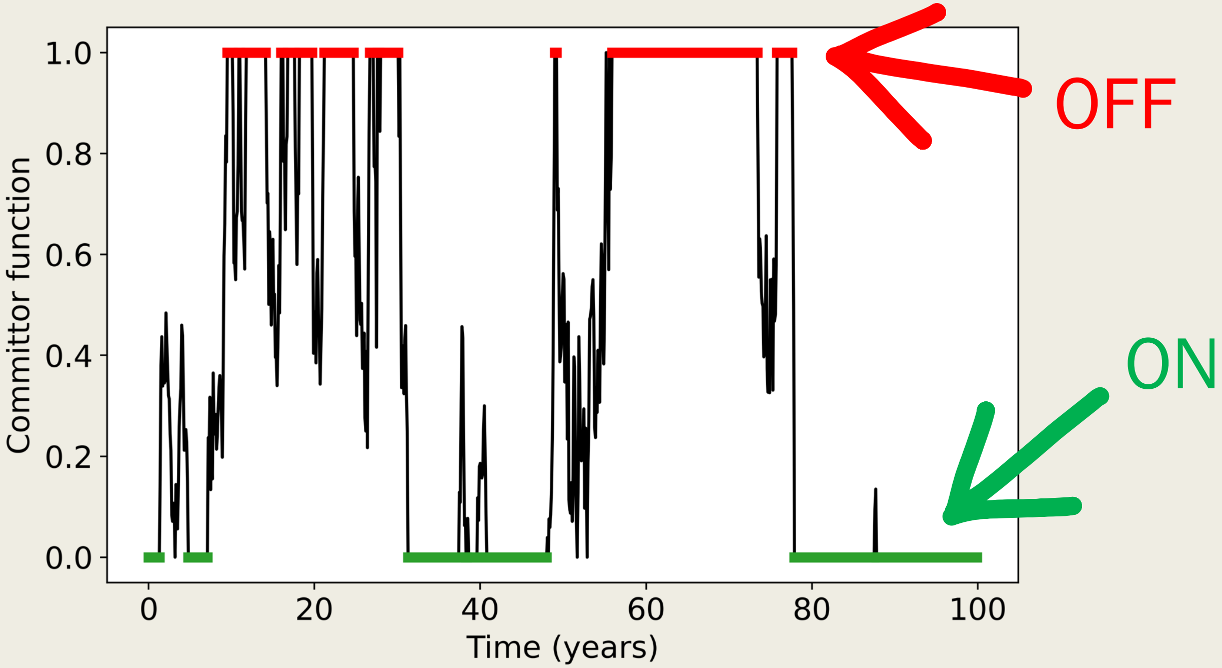
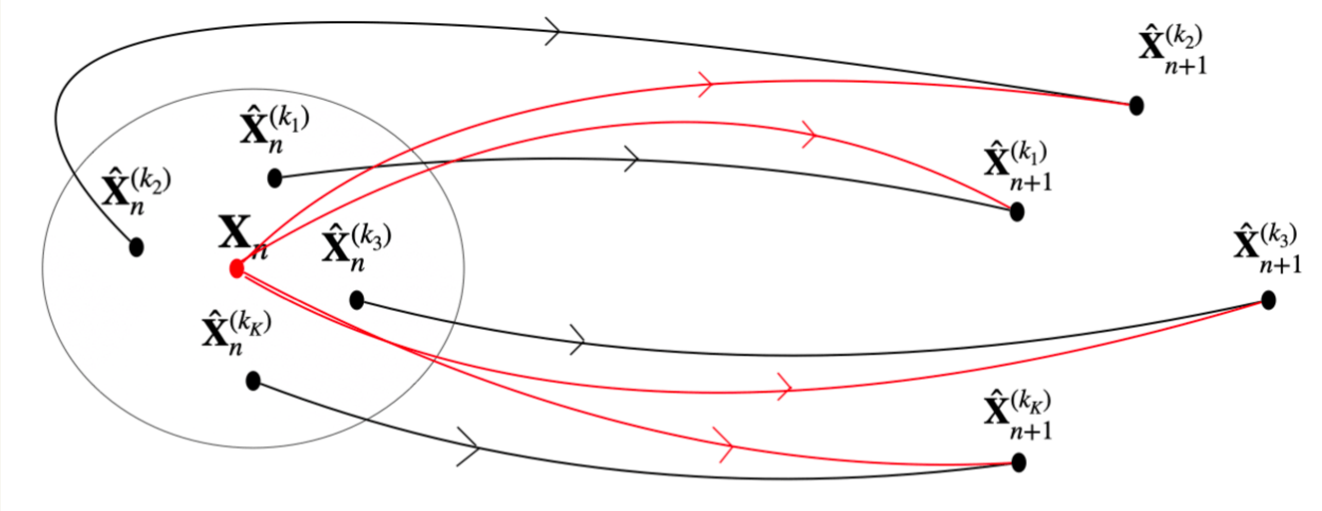




Analogues Markov Chain (AMC)

- Random transitions in long trajectory
- K analogues for each point
- Committor function from the transition matrix



D. Lucente, J. Rolland, C. Herbert, F. Bouchet, Coupling rare event algorithms with data-based learned committor functions using the analogue Markov chain
arXiv:2110.05050

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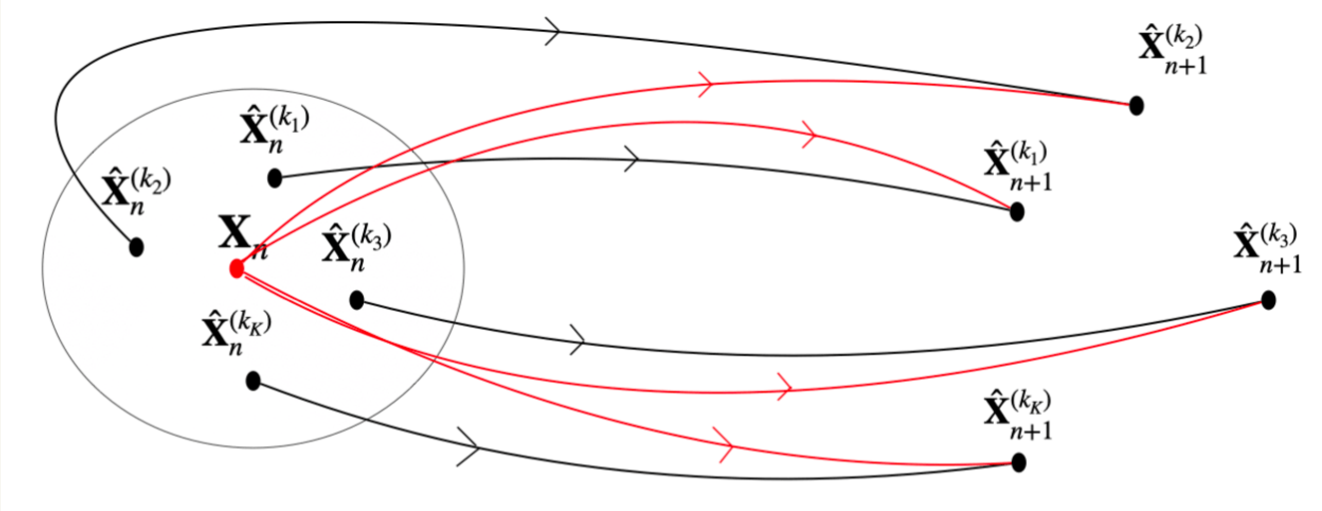

K-Nearest Neighbours (KNN)

- Requires training with AMC
- Compute the committor on any point
- Weighted average of nearest neighbours

$$q(x) = \frac{1}{K}\sum_{i=1}^{K} q(\tilde{x}_i)$$

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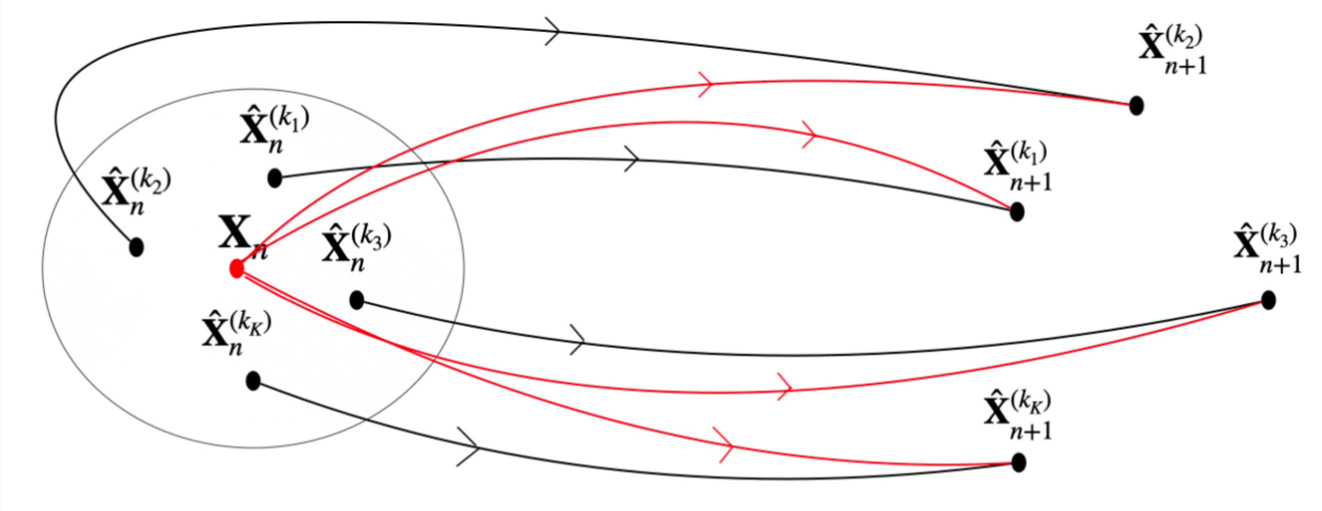

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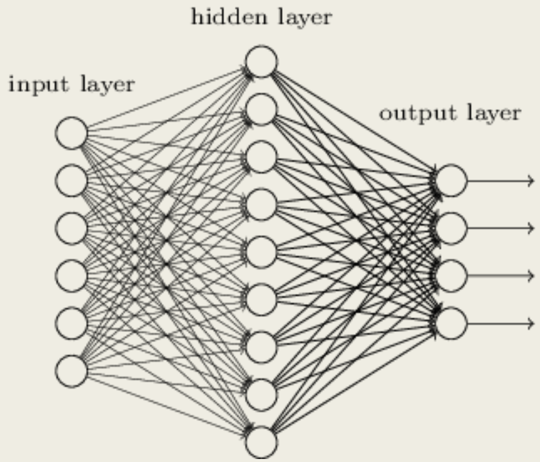
Dense Neural Networks



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Performance & Execution time

- AMC without training: best estimate
- AMC+KNN requires less data
- ML is the most time-efficient method

Perspectives

- Objective: extension to more complex dynamics and ICM
- AMC no longer tractable ?
- ML : promising solution