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# Advancing Hydrological Data Assimilation Frameworks with Machine Learning

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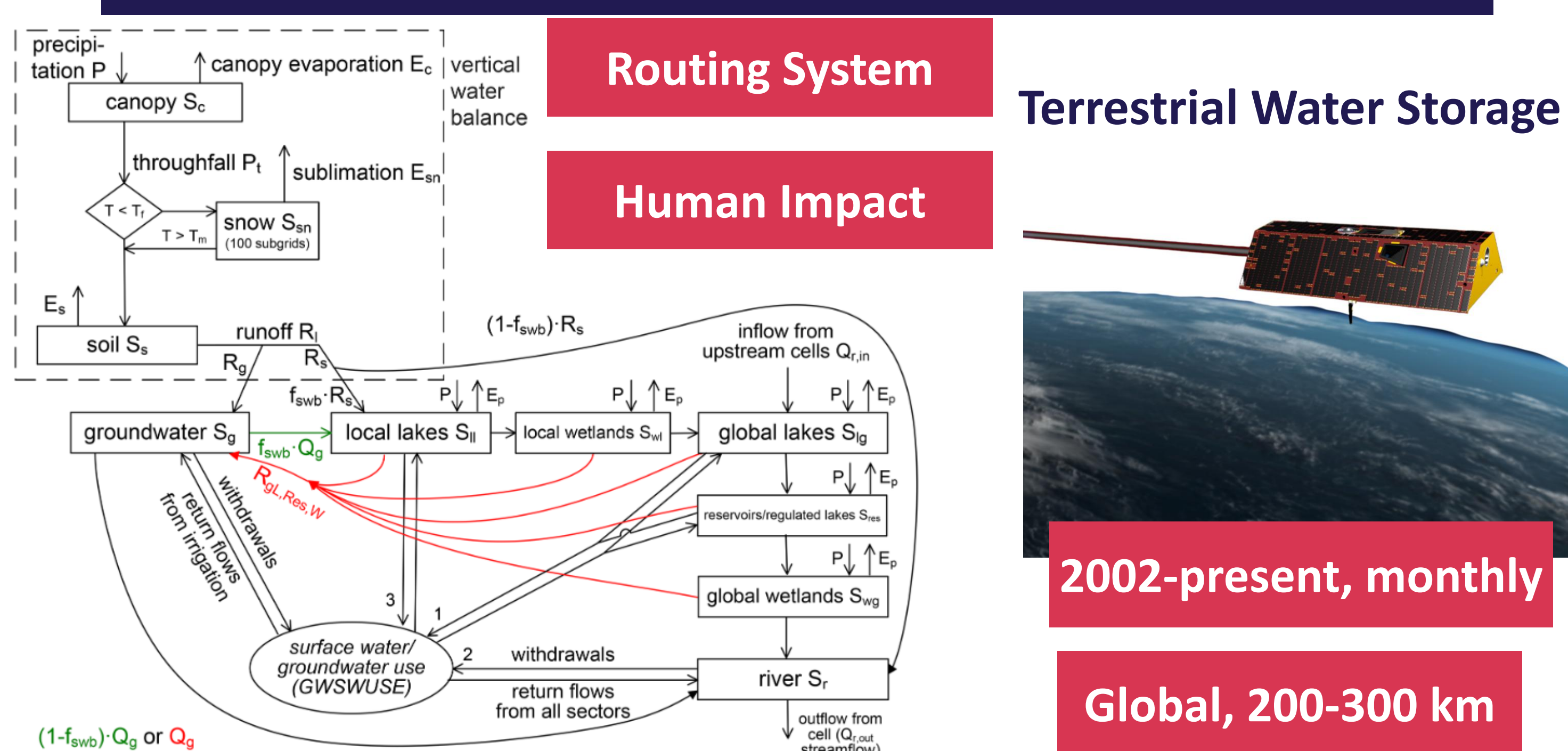
## Introduction

Accurate simulation of the water cycle is essential for **identifying extreme hydrological events**. As a baseline study, we introduce a data assimilation (DA) framework that leverages **Earth Observation (EO)** data, such as GRACE/FO terrestrial water storage (TWS). Initial results show promising improvements in the reliability of large-scale water cycle simulations. **Machine Learning (ML)** offers new opportunities to further enhance these frameworks by **synergizing physical-based and data-driven approaches**. Here we conceptualize how ML can be integrated into the existing DA framework of the **WaterGAP Global Hydrology Model (WGHM)** to improve water storage and flux estimates and deepen our understanding of hydrological variability in the era of climate change.

## Study Area

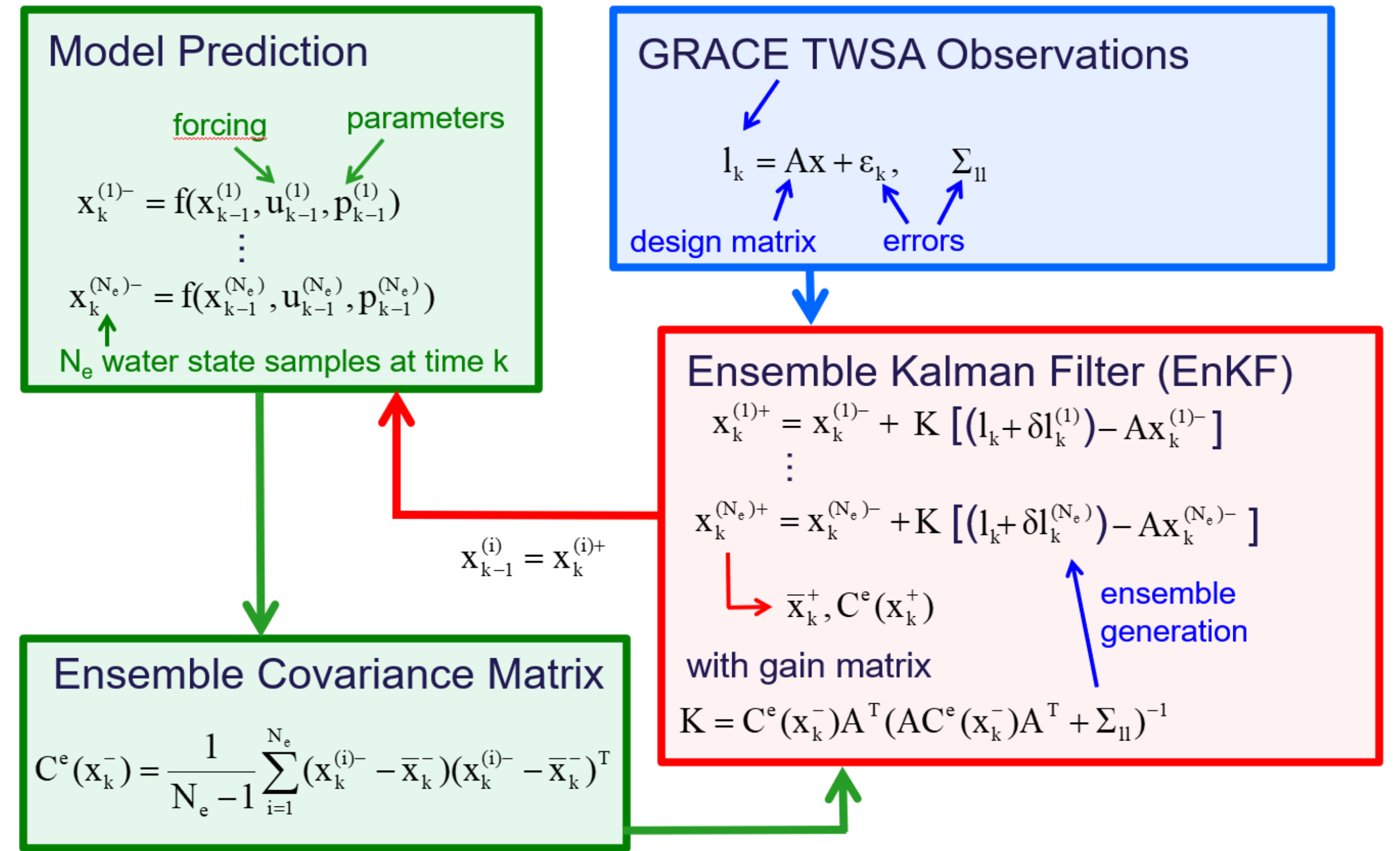


## Hydrological Model and Earth Observation

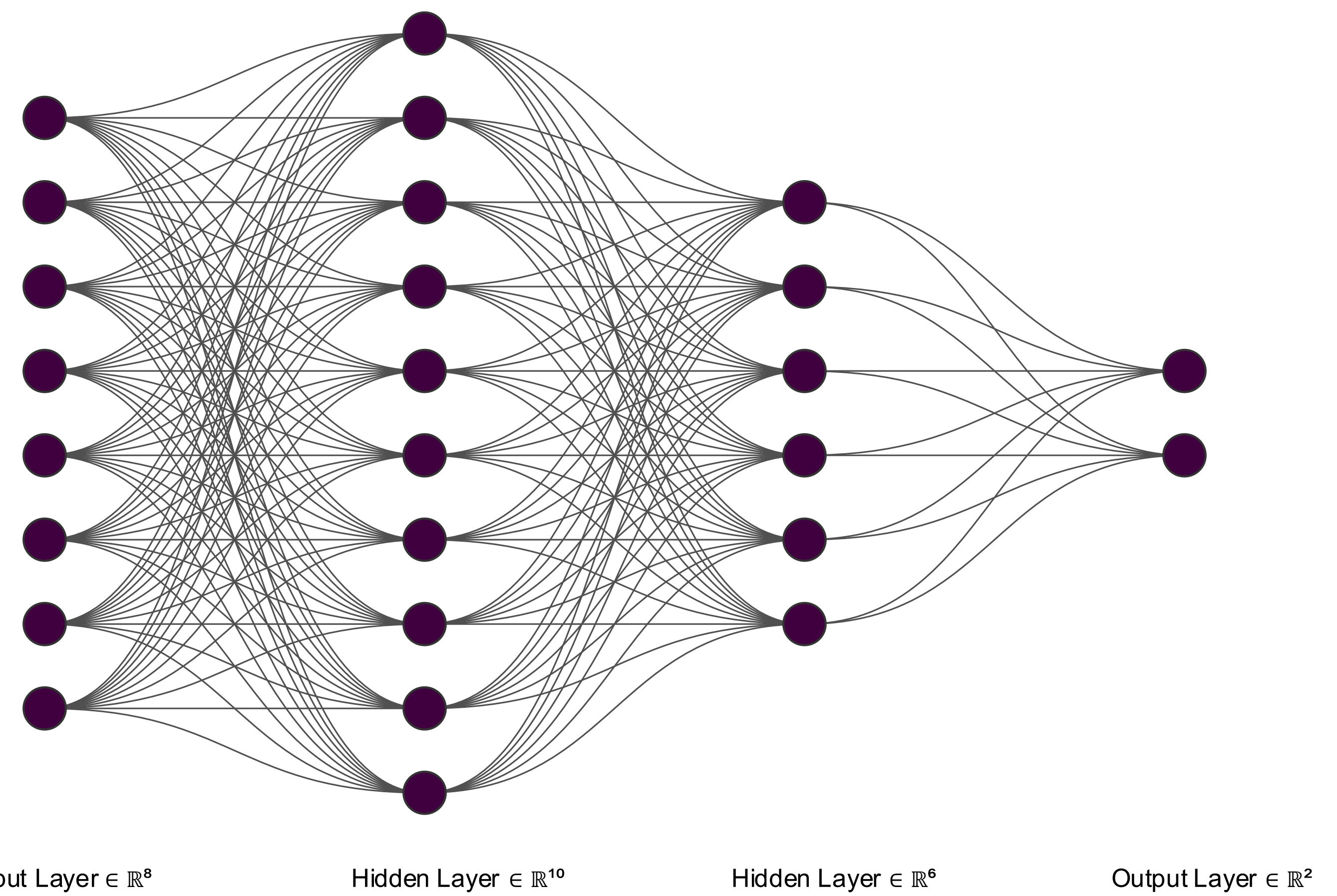


## Methodology

### Physical-based



### Data-driven



### Approaches

Replacing model components with a ML methods

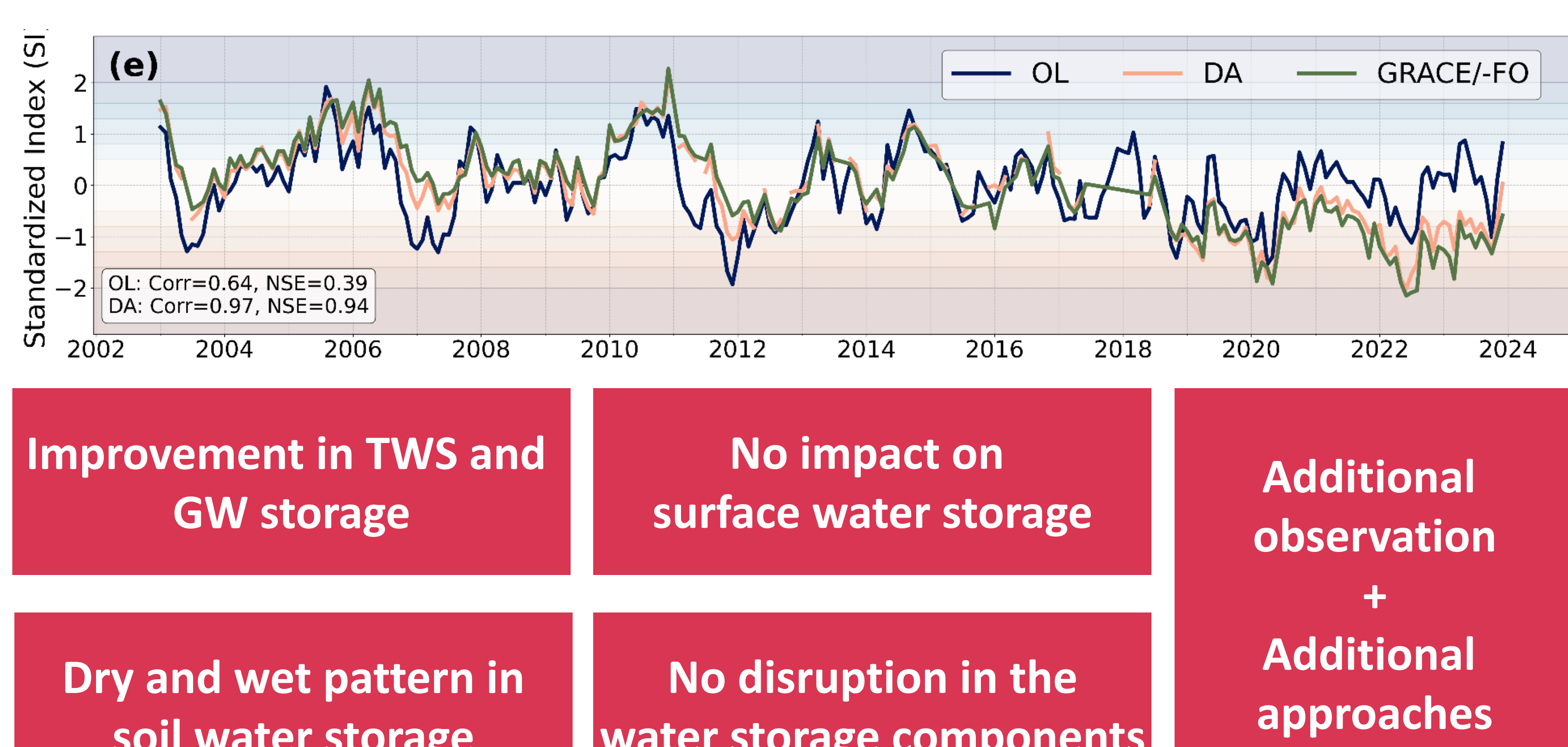
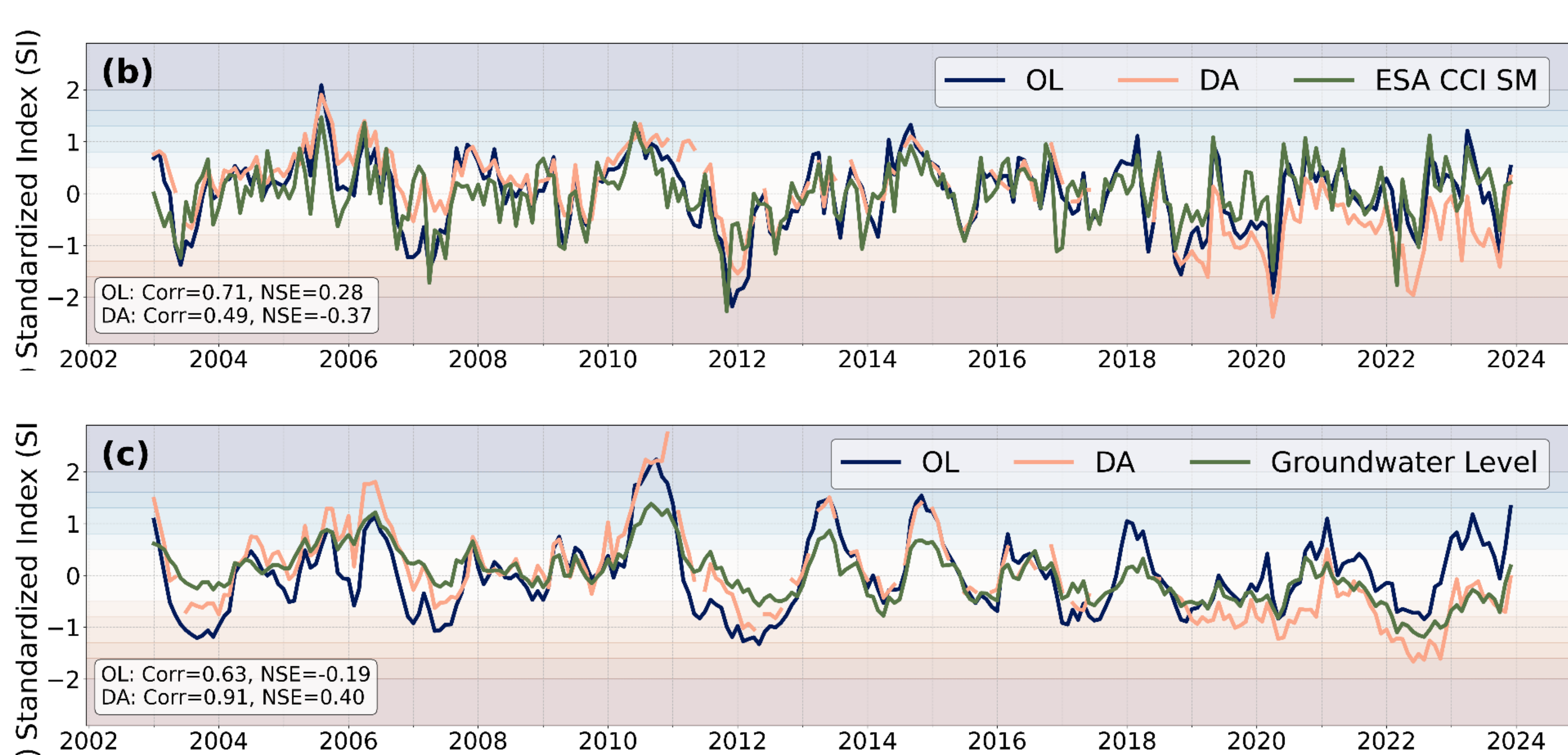
Combined DA-ML methods

LSTM

Graph NN

DL-EnKF

## Baseline Results



Improvement in TWS and GW storage

No impact on surface water storage

Additional observation + Additional approaches

Dry and wet pattern in soil water storage

No disruption in the water storage components