



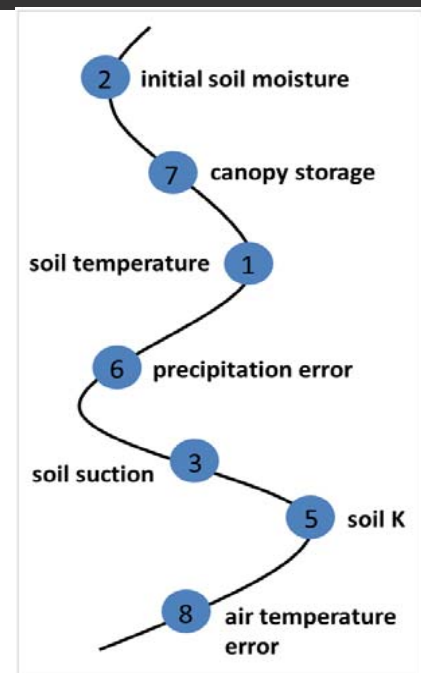
Preliminary Mapping of the Hydrologic Genome of CABLE for Soil Moisture Estimation



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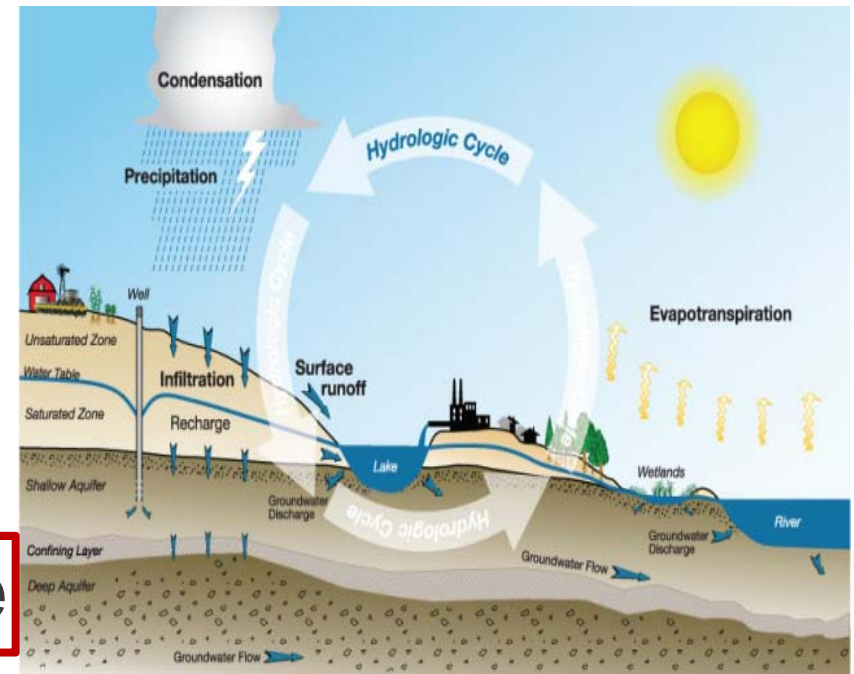
**CABLE Workshop
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Land Surface Model – Key Components

$$Y = M [X, \theta, U]$$

- Y = model output (e.g. soil moisture)
- M = model and its structure
- X = model states (e.g. storages)
- θ = model parameters (e.g. soil K)
- U = forcing data inputs (e.g. rainfall)



Diagnostic Model Evaluation

- The four model components – sources of uncertainty.
- Impact of model structure on **simulated output** is difficult to assess without knowledge about model parameters, states, and forcing data uncertainties.
- **Interaction** between uncertainty sources makes it difficult to assess the impact of individual errors.
- **Proposed approach**: quantify uncertainties linked to model parameters, states, and input forcing data.
- The proposed approach employs:
 - multi-objective evolutionary strategy
 - temporal updating from data assimilation

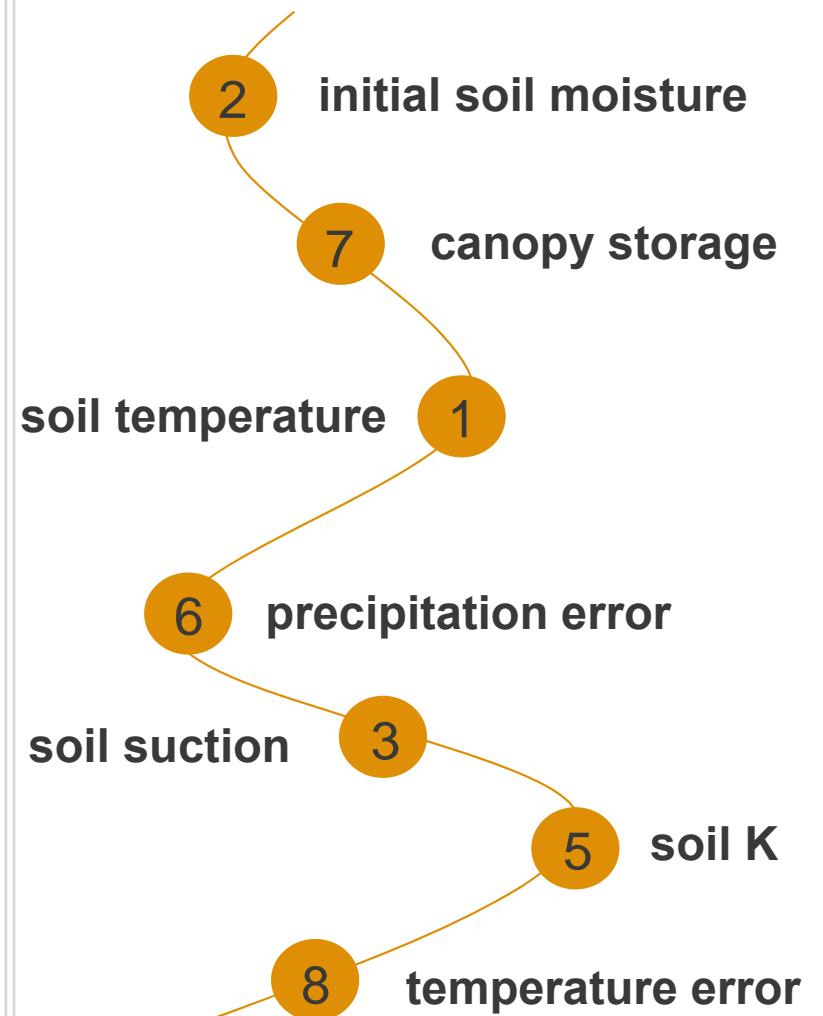
} **Evolutionary data assimilation (EDA)**

Evolutionary Algorithms (EAs)

EAs: population based search tool, use the concept of **evolution** and **natural selection**

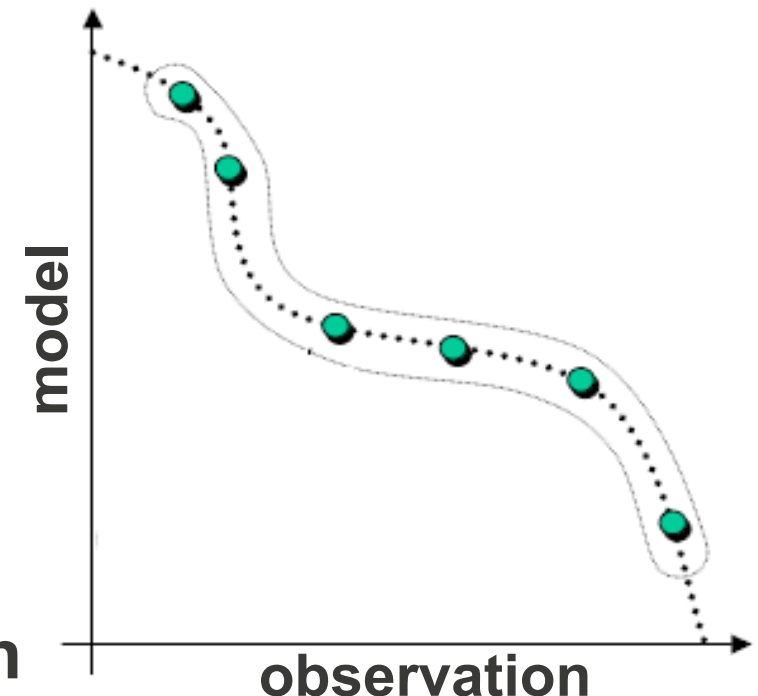
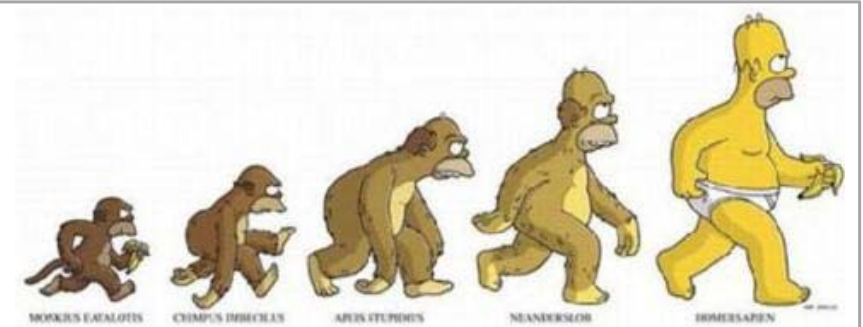
- **genotype**: genetic information (e.g. X , θ , U)
- **phenotype**: expressed behaviour (Y – soil moisture)
- **crossover**: **share** genotype among competitive members
- **mutation**: introduce changes to genotype to preserve **diversity**

Problem representation

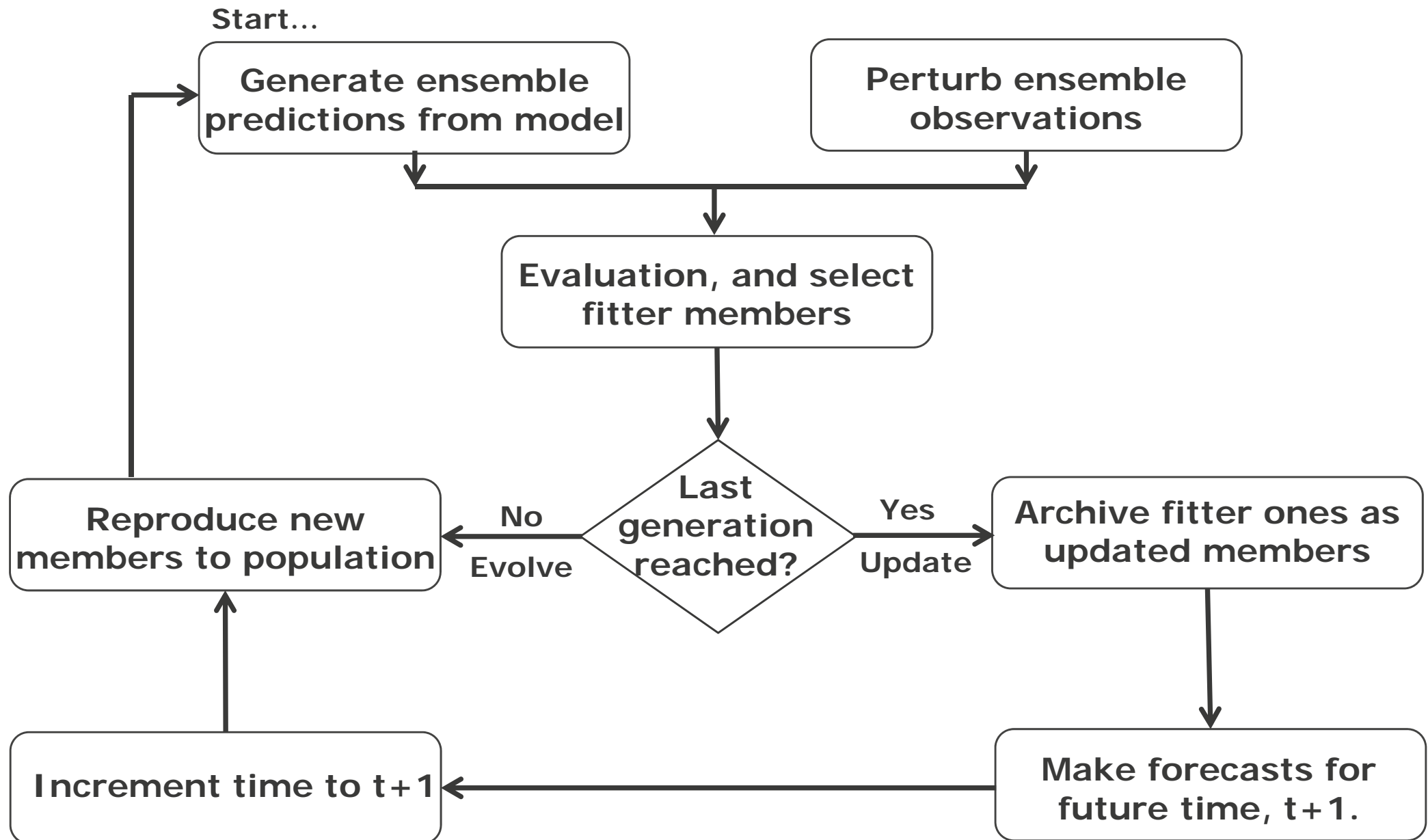


The Evolutionary Data Assimilation (EDA)

- EDA – combines Bayesian filtering with multi-objective evolutionary strategy
 - Natural selection – stochastic and population-based
 - Effective **use of memory**, and learning tool
 - Pareto dominance: 20–80 rule
 - An **improved compromise** between model and observation

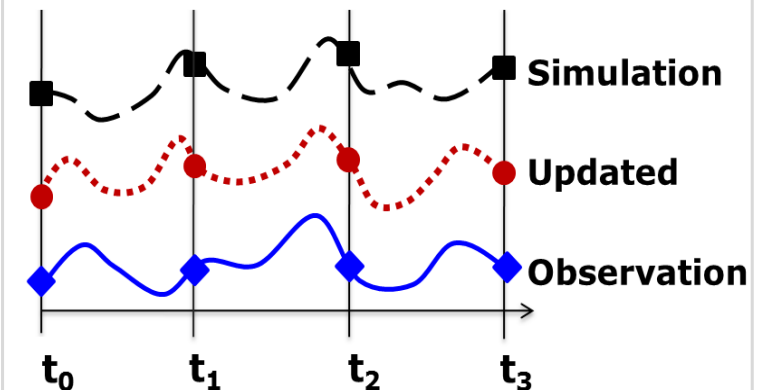
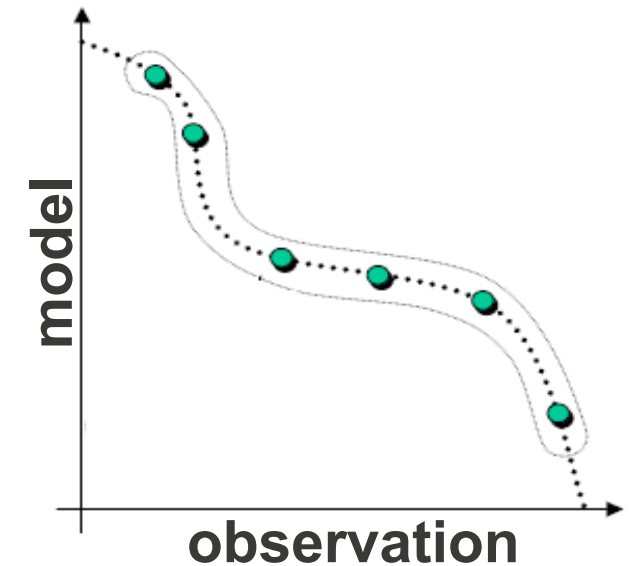


The EDA Procedure – Simplified



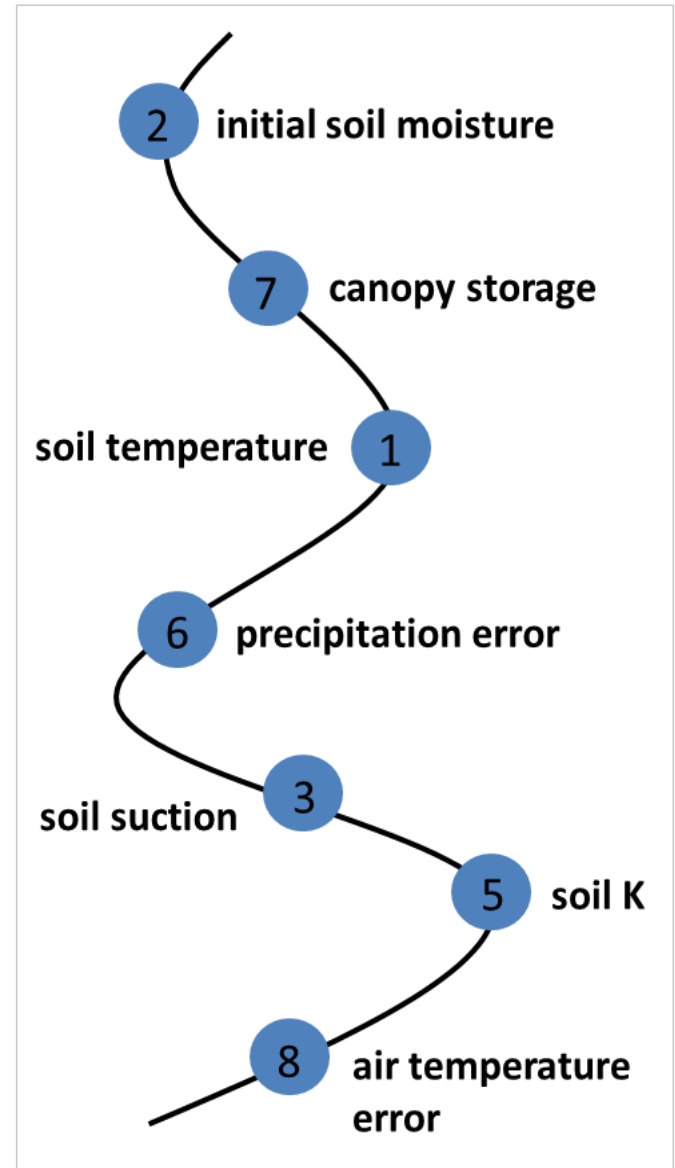
The Updated Ensemble Members

- Are equally competitive – **unique compromise** (or trade-off) btn. observation and prediction.
- Optimal values for model states, parameters, and forcing data uncertainty – provide both internal and temporal dynamics.
- Opportunity to study the **model behaviour**, the trade-offs, and the genotype through **time**.

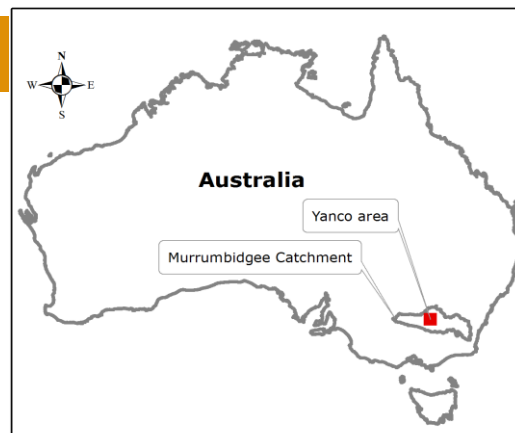


Hydrologic Genome – Proposed Mtd.

- **Proposed approach:**
equivalent to a **biological 'genome'**,
a string encoding the genetic **blueprint** that coordinates all
cellular **behaviour**.
- **Hydrologic genome:**
an ensemble string of values
encoding the **internal dynamics** of
the model, conditioned under
varied landscape properties, model
states, and weather conditions.
- **Mapping** the hydrologic genome

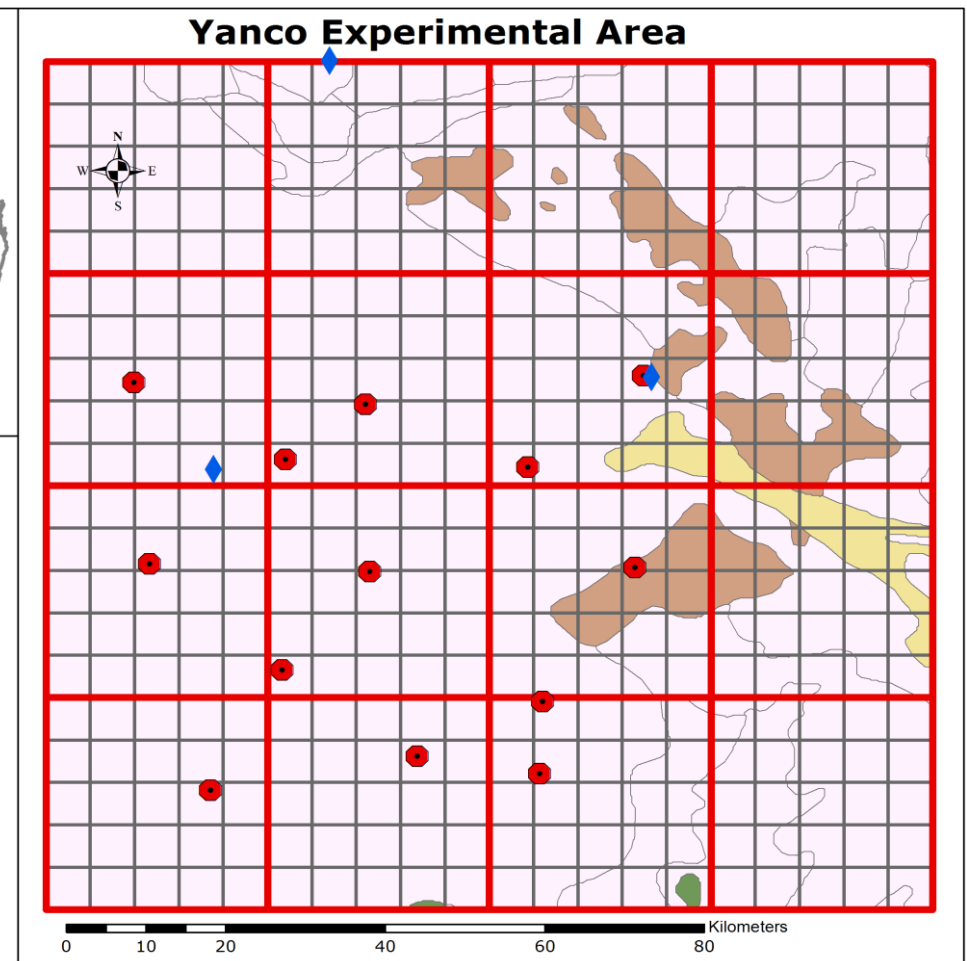


Experimental Area – the Yanco Area



Legend

- ◆ Forcing data stations
- In-situ OzNet stations
- AMSR-E Grid
- Model Grid - 5-km
- Soil Testure
- Sand
- Sandy loam
- Loam
- Clay loam



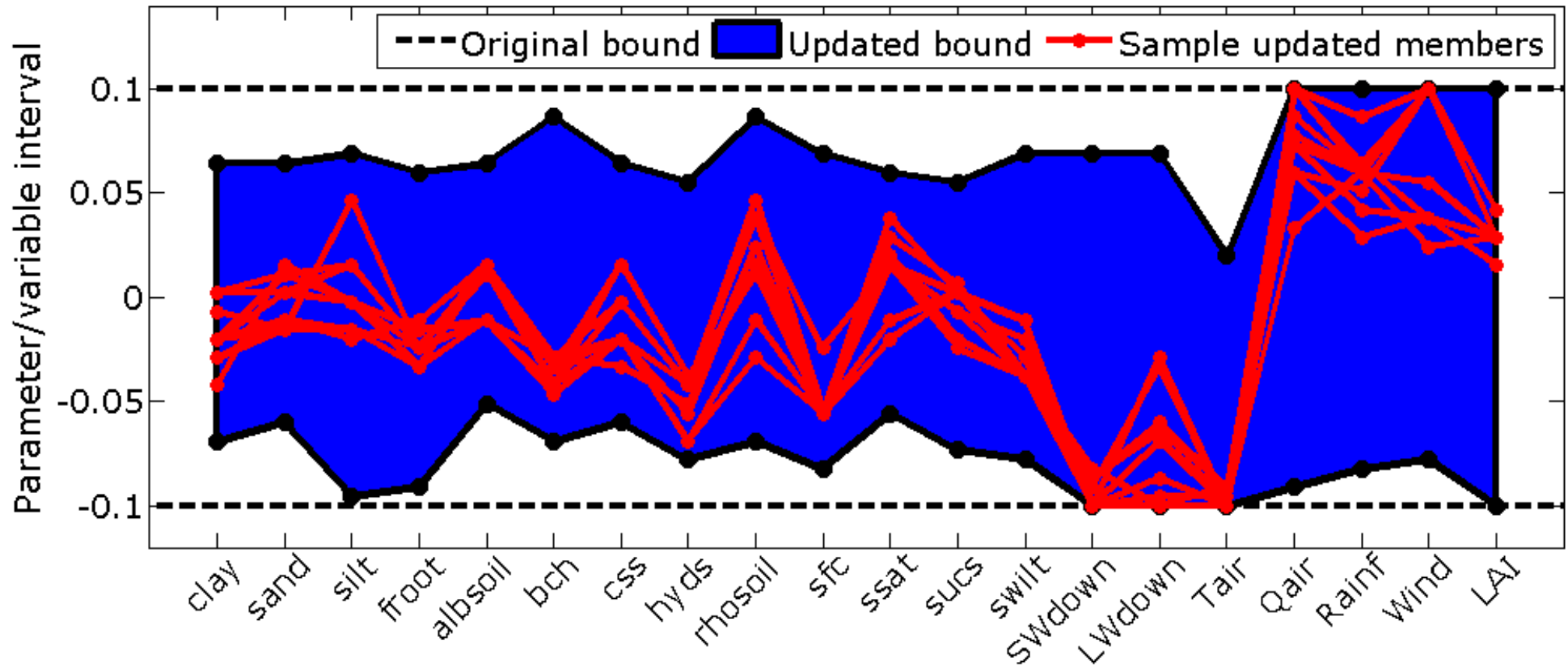
Data sets

- Forcing data: weathering monitoring stations (Griffith and Yanco)
- Soil data: Australian soil atlas
- Leaf area index (LAI): MODIS (MYD15A2)
- Observation data: the Microwave-Scanning Radiometer – Earth Observing System (AMSR-E)

Model and assimilation setup

- Modelling period: 2006 – 2007
- Ensemble size: 200
- Updated ensemble size: 20
- Evolutionary cycles: 5
- Model soil moisture depth: 2.2cm

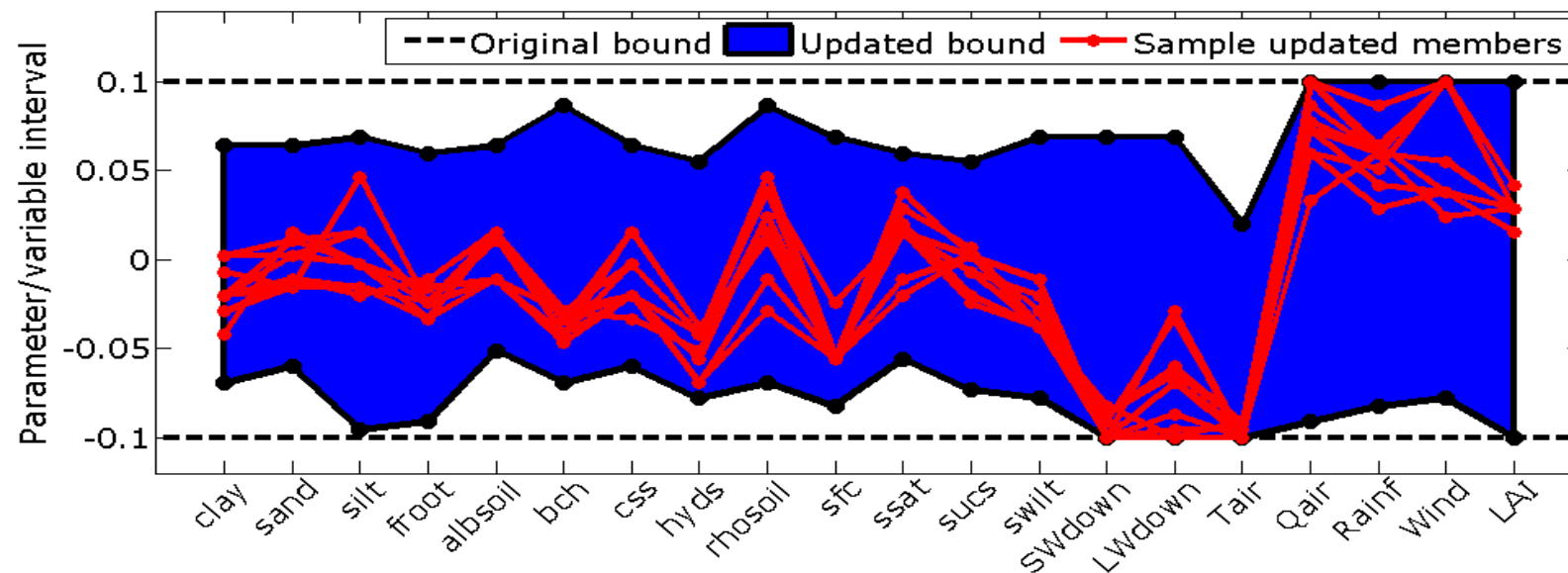
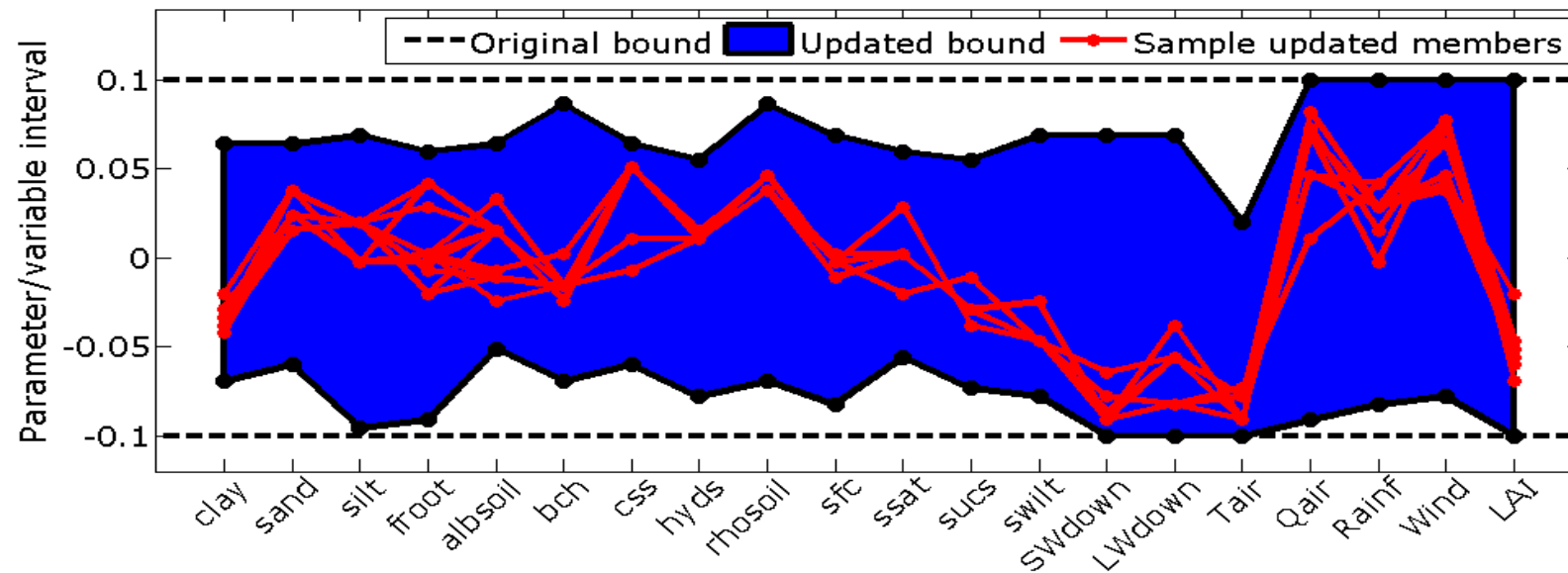
The Updated Genotype Space



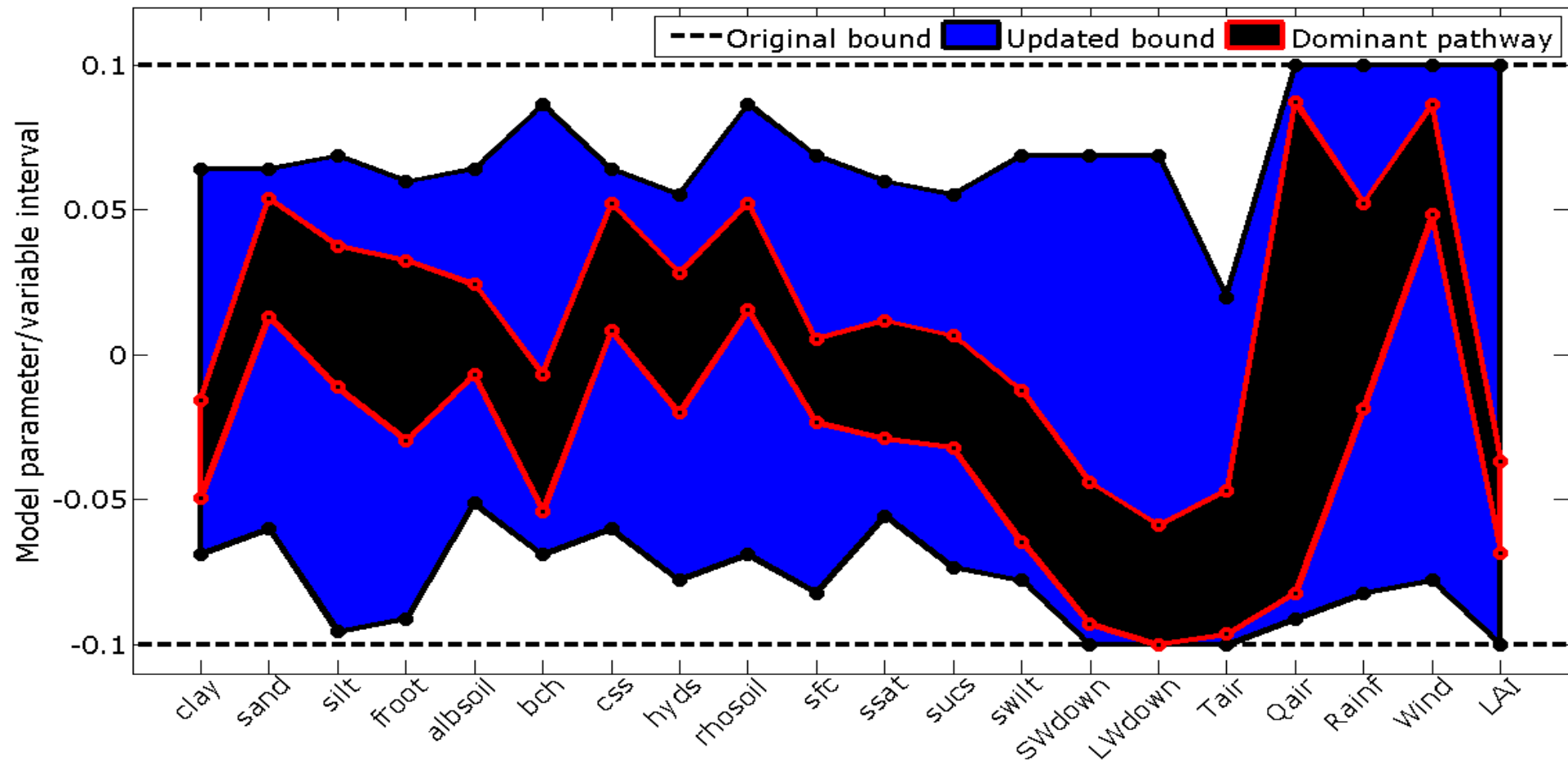
Overall reduction in search space:

- Updated bound as percentage of original bound: 75%

The Updated Space and Sample Members



The Dominant Pathway in Genotype



Clustering details:

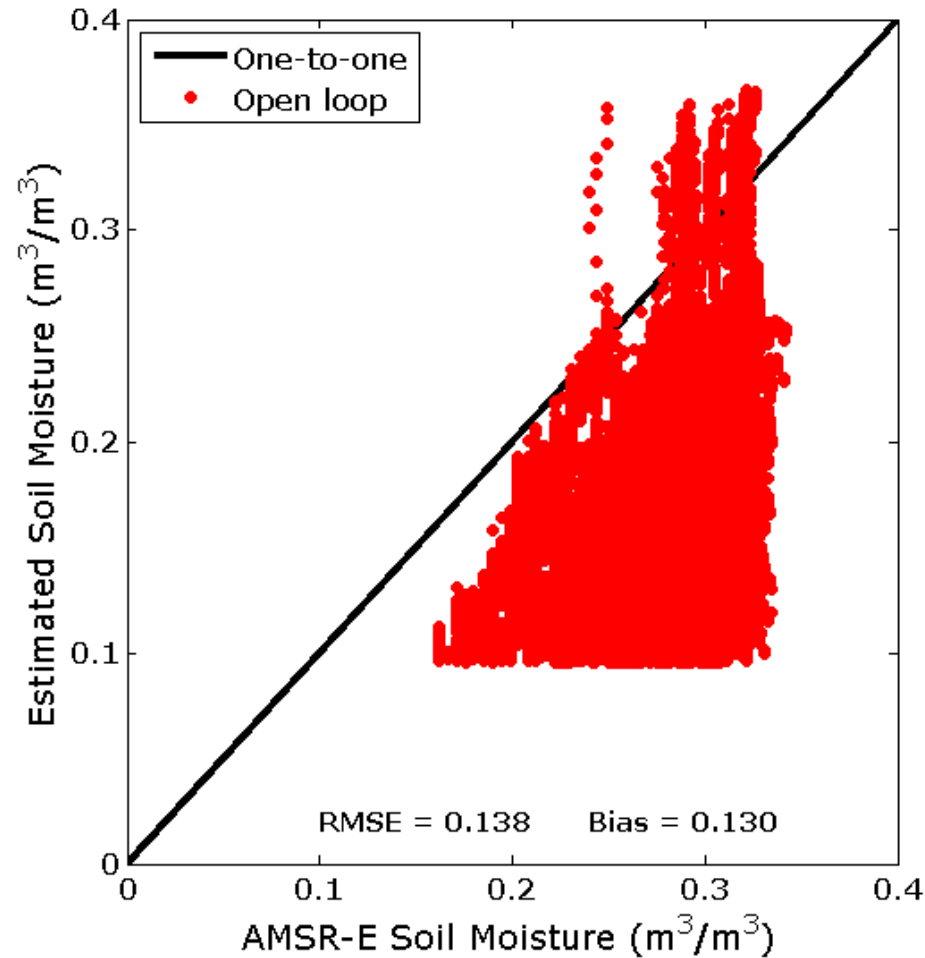
- Overall number of clusters: 8
- Overall coverage: 50%

Overall reduction in search space:

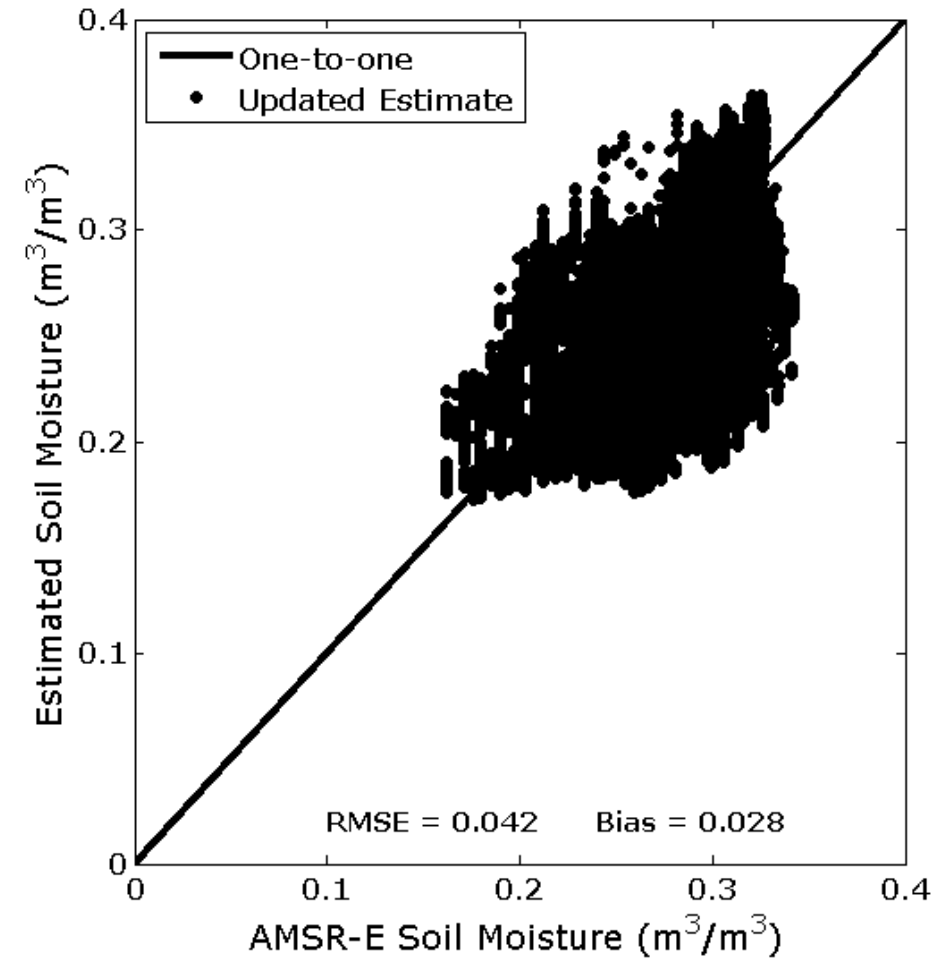
- Dominant pathway as percentage of original bound: 25%
- Dominant pathway as percentage of updated bound: 33%

Pre-Evaluation of Updated Estimates

Open loop soil moisture



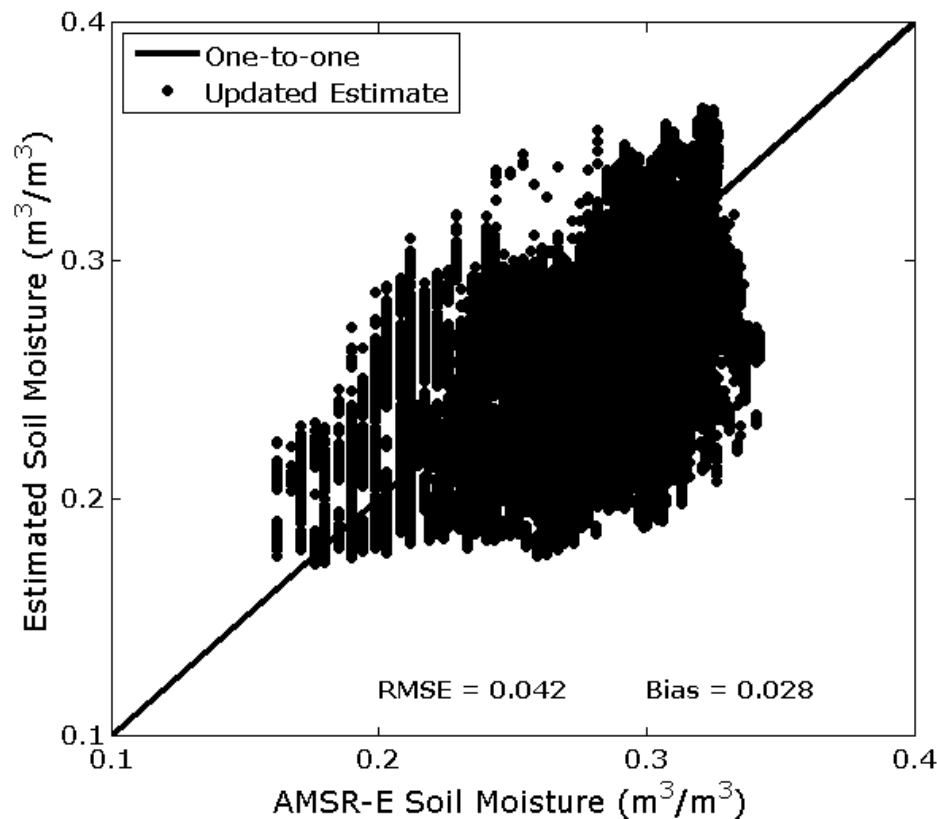
Updated soil moisture



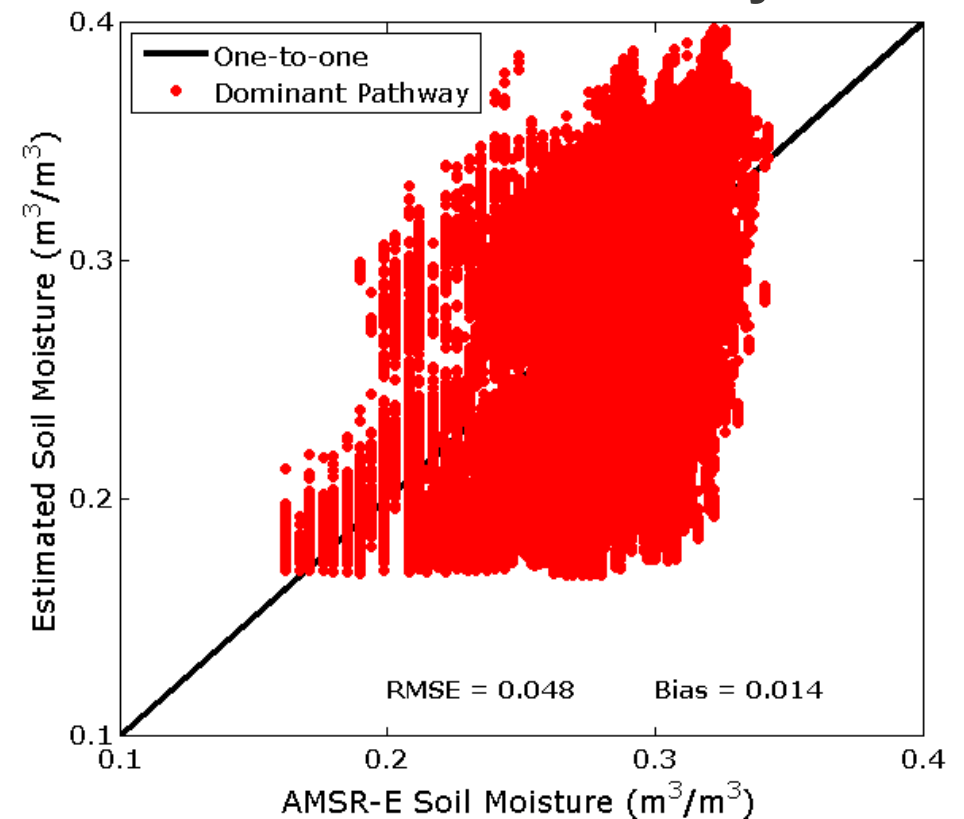
Overall accuracy increase $\approx 70\%$

Pre-Evaluation of Updated Estimates

Updated soil moisture



Estimate from Dominant Parameter Pathway



Overall RMSE decrease $\approx 14\%$ ($< 0.01 \text{ m}^3/\text{m}^3$)

Summary of Findings and Future Work

- Evolutionary data assimilation has been applied to update CABLE soil moisture.
- The EDA updated ensemble provide crucial information to **monitor model behaviour**.
- The assessment of updated members in genotype has both **diagnostic** and **predictive** potential.
- **Mapping** of the **hydrologic genome** puts the focus on evaluating the genotype, instead of only prediction & observation.

