PIRE: Taming Water in Ethiopia

Lake Level Estimation using Machine Learning and Physically-based Approaches in Lake Tana, Ethiopia

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Civil and Environmental Engineering
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Presentation and Research Outline

Estimation of monthly water levels of Lake Tana, Ethiopia

Physically-based model

January 2001 – December 2012

Data-driven model - SVR

Comparative analysis under various SVR scenarios

Errors, applicability, ease of use and computational speed

Summary and Conclusions

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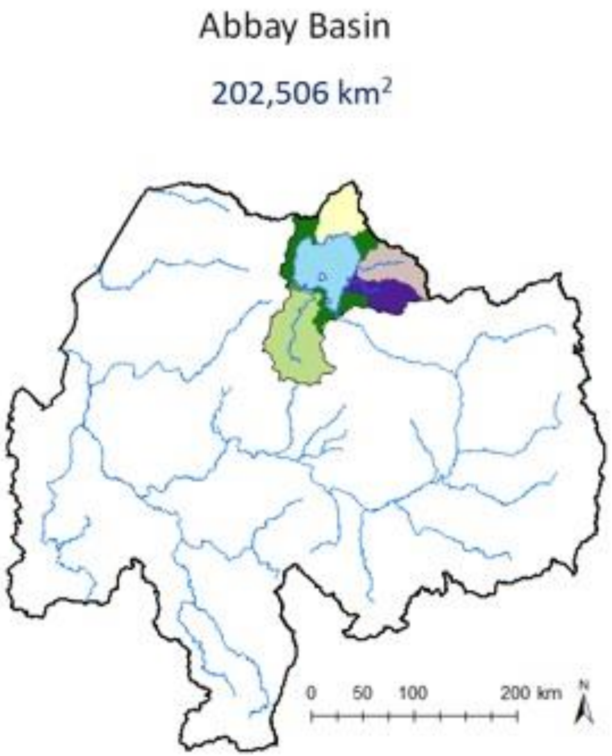
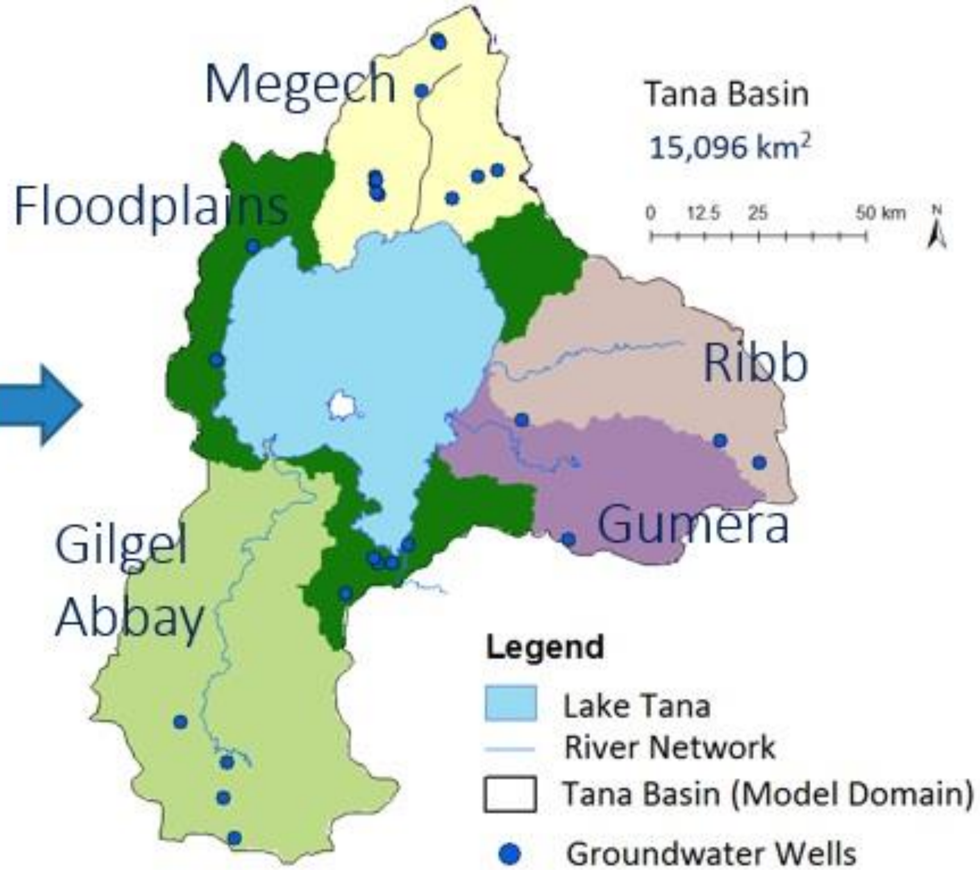
Location of Blue Nile and Lake Tana





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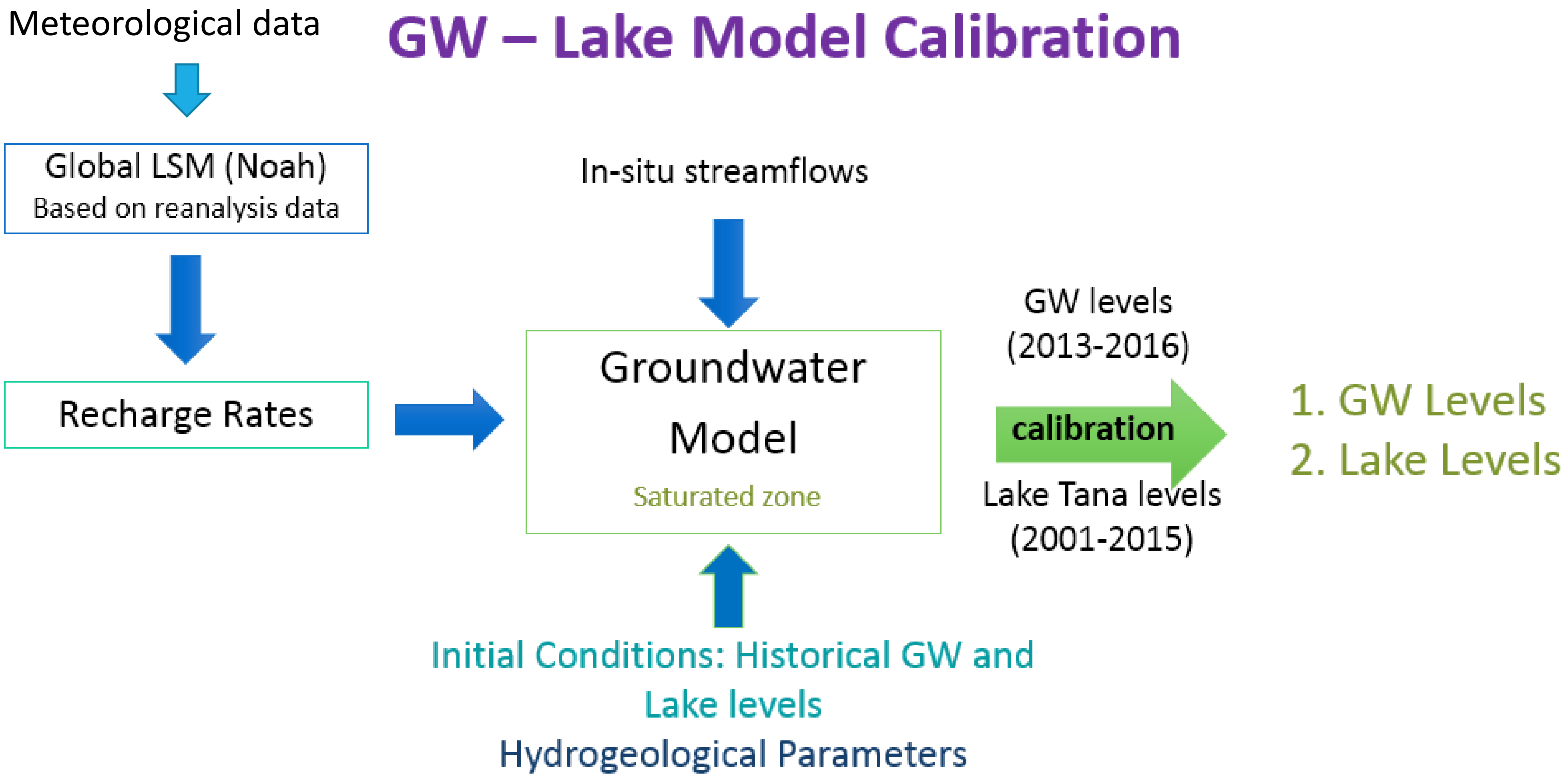
Modeling Framework: Physically-based Model



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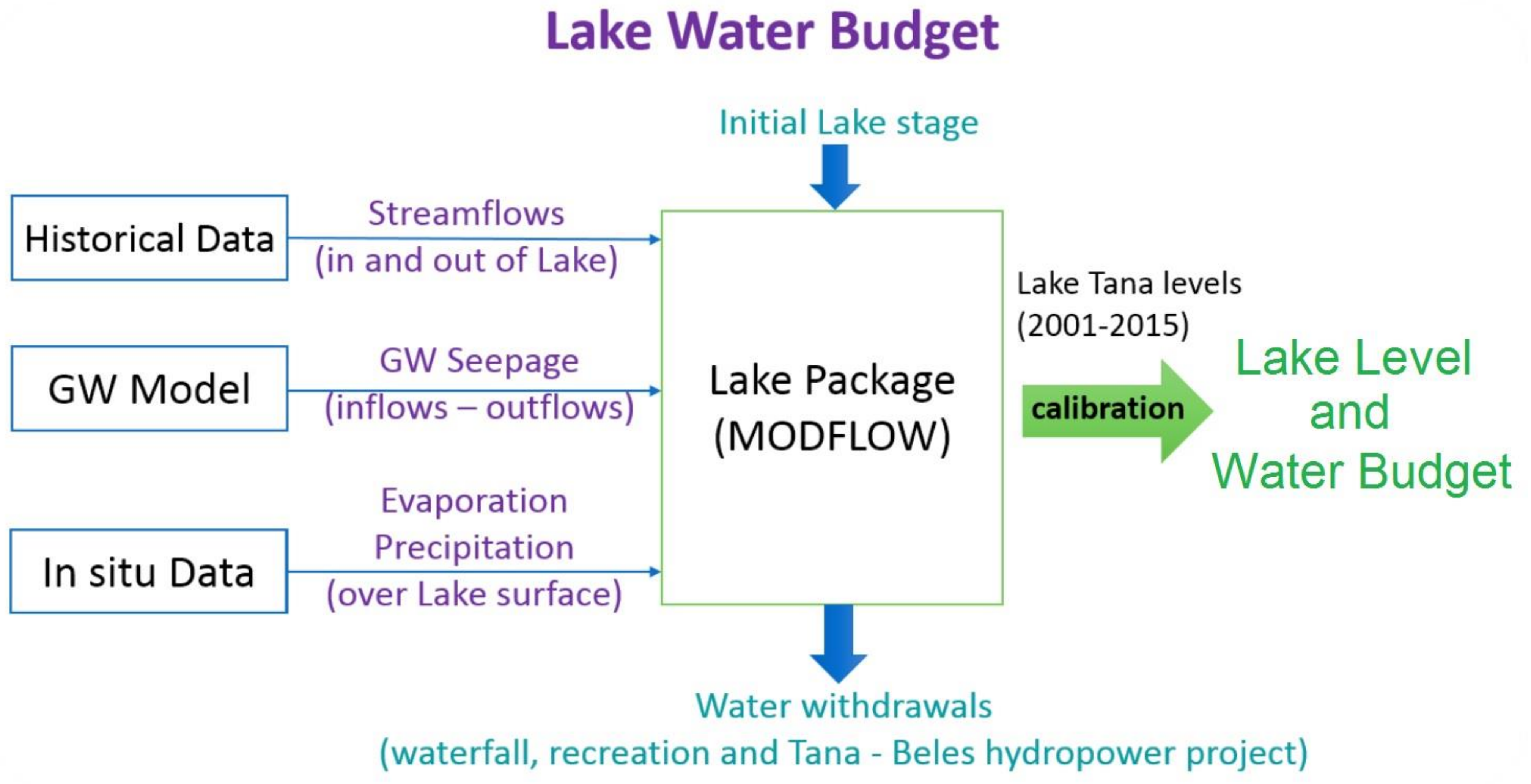
Modeling Framework: Physically-based Model



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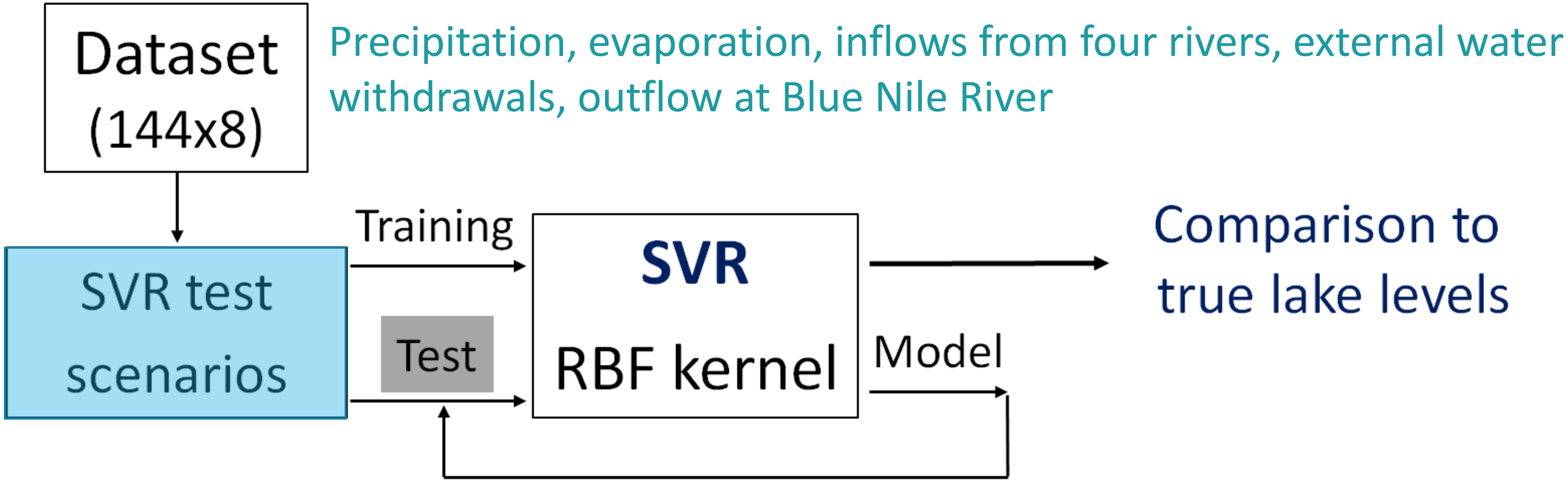
Modeling framework: Data-driven model

Support Vector Regression (SVR)



Radial basis function (RBF) kernel:

$$K\left(\boldsymbol{x}_i, \boldsymbol{x}_j\right) = \exp\left(-\gamma \left\|\boldsymbol{x}_i - \boldsymbol{x}_j\right\|^2\right)$$

$$\gamma = \frac{1}{2\sigma^2}$$

γ = {0.001, 0.005, 0.01, 0.05, 0.1, 0.15, 0.2}

C = {0.01, $1\cdot10^i$, $2\cdot10^i$, $5\cdot10^i$}, i = 0,1,…,4 (regularization parameter)

LIBSVM toolbox v3.22

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SVR Test Scenarios

10-fold cross-validation (permuted)

↓

12-fold cross-validation (un-permuted, each year is a test set)

↓

¼ Hold out (Test years: 2004, 2006, 2010)

↓

12 1/12 Hold out algorithms (each year is a test year)

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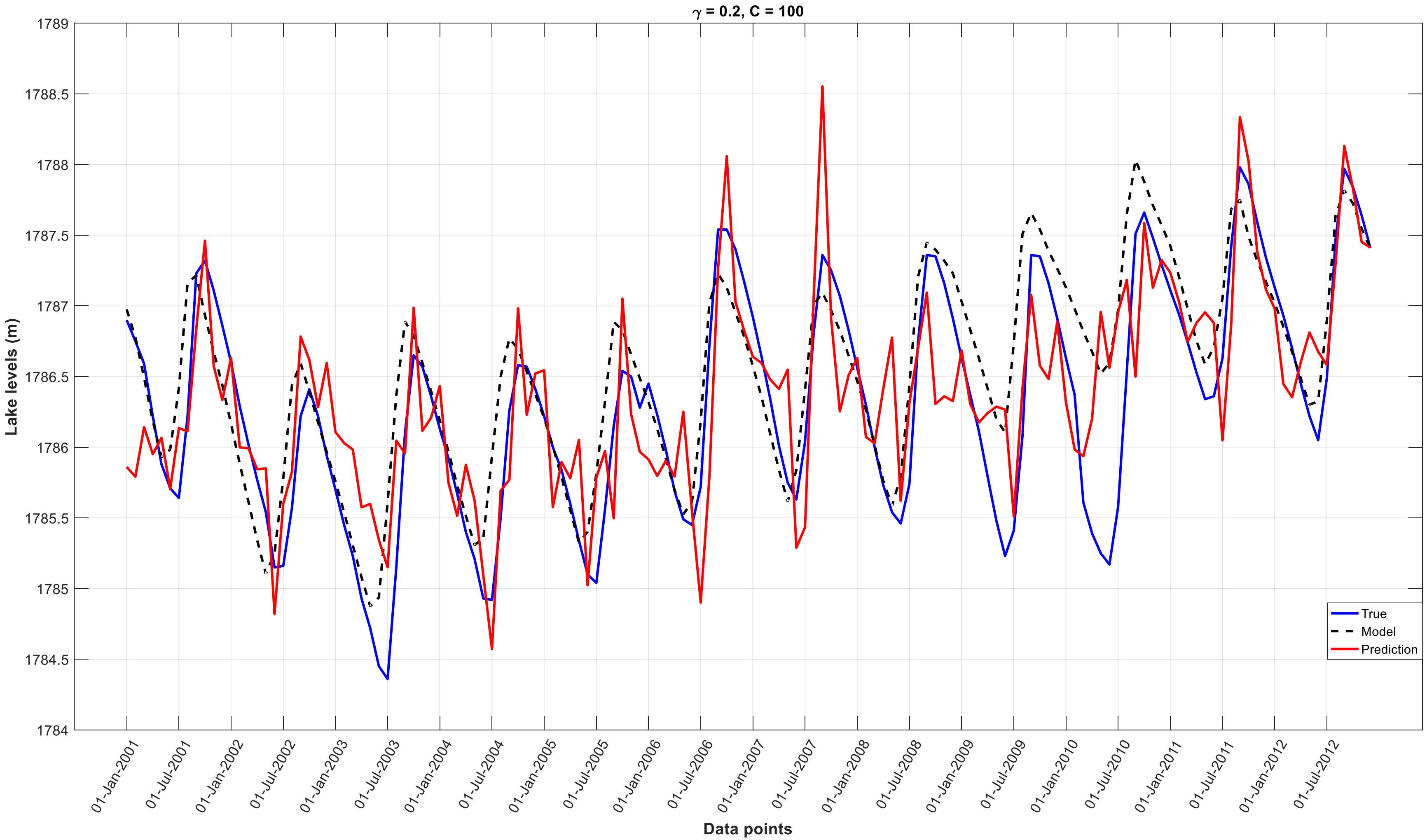
Scenario 1: 10-fold cross-validation



	MSE (m^2)	RMSE (m)	NRMSE	Mean error (m)	r	Bias (m)
γ = 0.2, C = 100	0.2788	0.5280	0.0296	0.4161	0.7636	0.065
Model	0.2376	0.4875	0.0273	0.3438	0.8376	0.212

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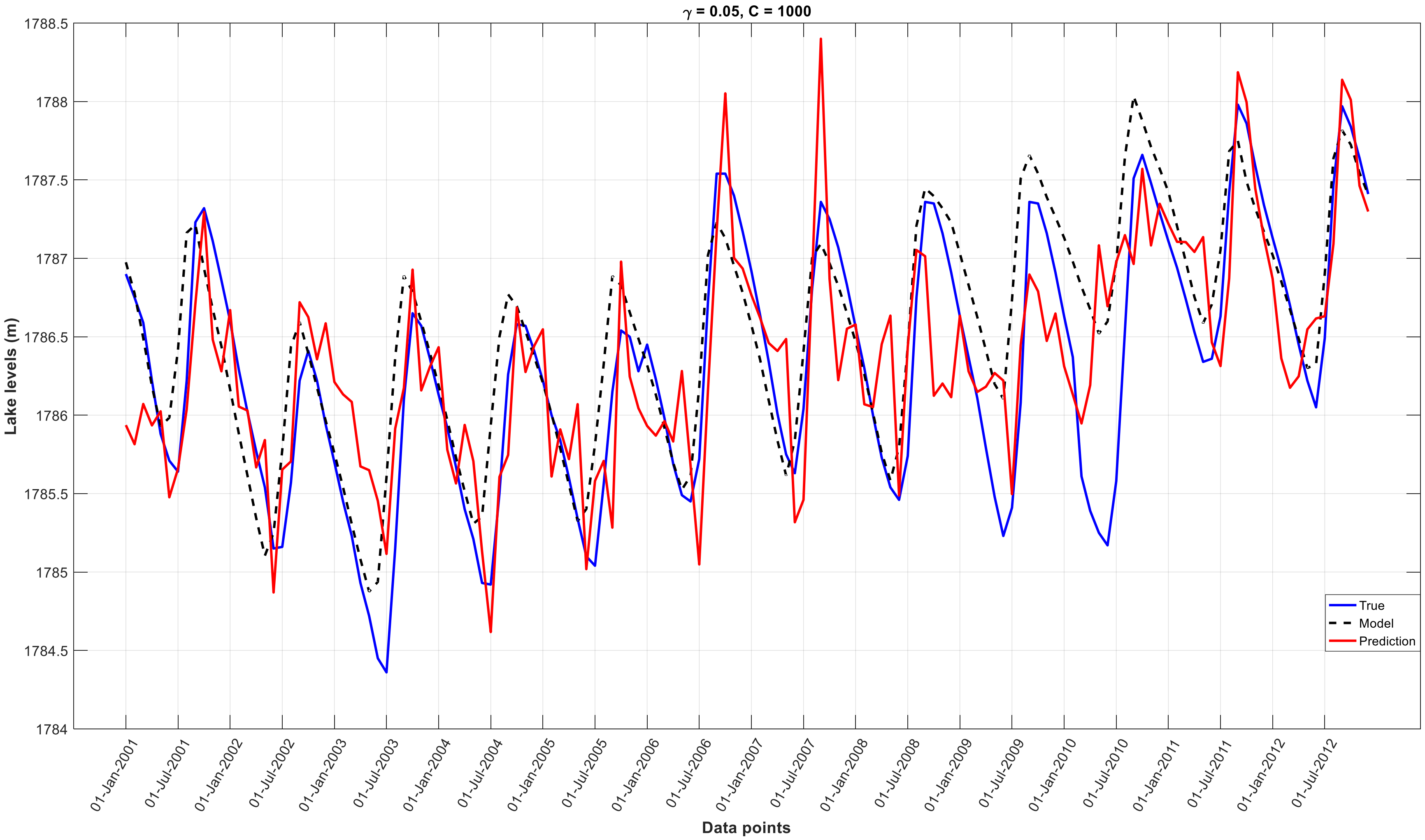
Scenario 2: 12-fold cross-validation



	MSE (m^2)	RMSE (m)	NRMSE	Mean error (m)	r	Bias (m)
γ = 0.05, C = 1000	0.2759	0.5252	0.0294	0.4089	0.7639	0.055
Model	0.2376	0.4875	0.0273	0.3438	0.8376	0.212

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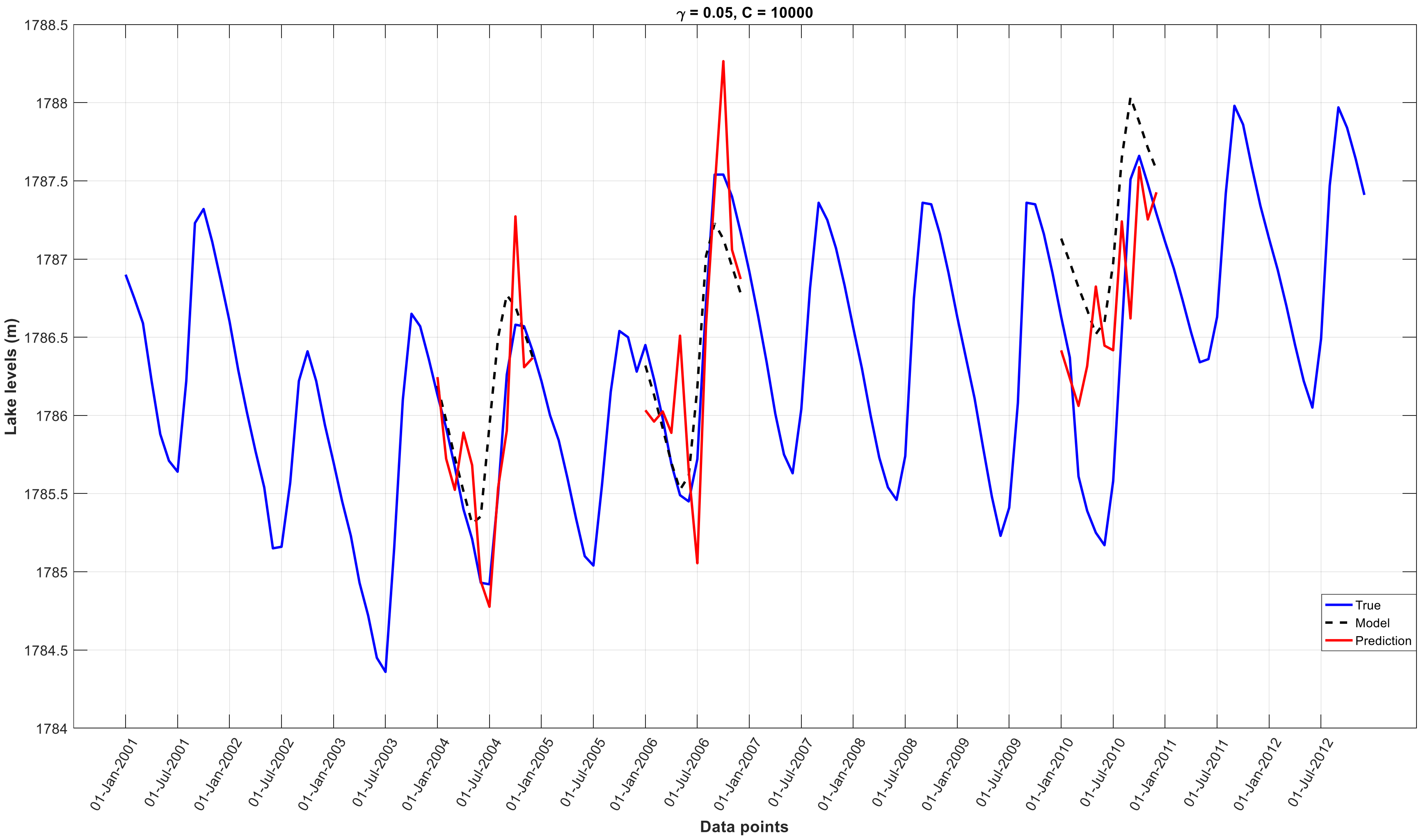
Scenario 3: ¼ Hold out (Test years: 2004, 2006, 2010)



	MSE (m²)	RMSE (m)	NRMSE	Mean error (m)	r	Bias (m)
γ = 0.05, C = 10000	0.3082	0.5552	0.0311	0.4115	0.7730	0.139
Model	0.4030	0.6349	0.0355	0.4554	0.7709	0.348

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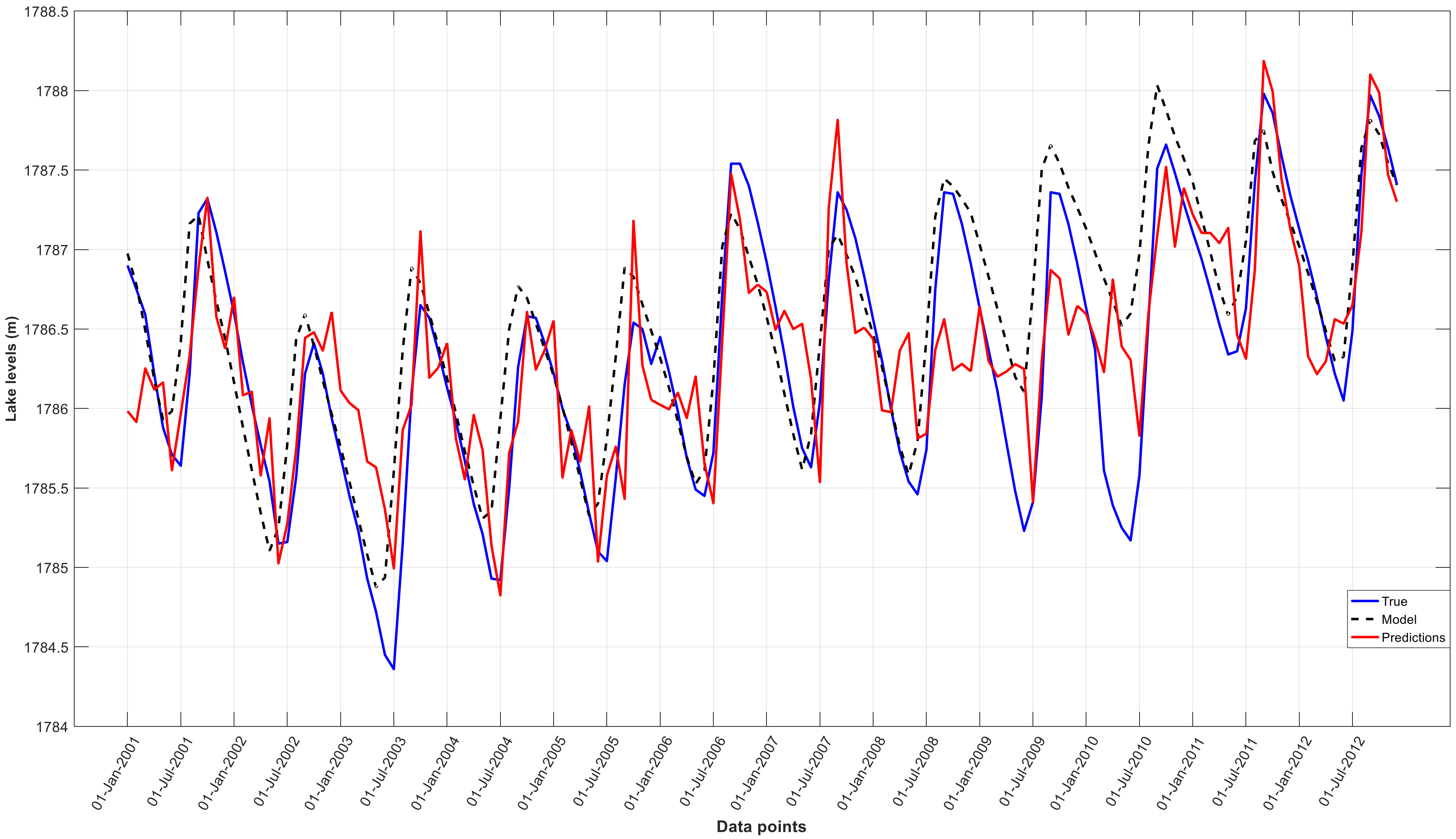
Scenario 4: 12 1/12 Hold out algorithms



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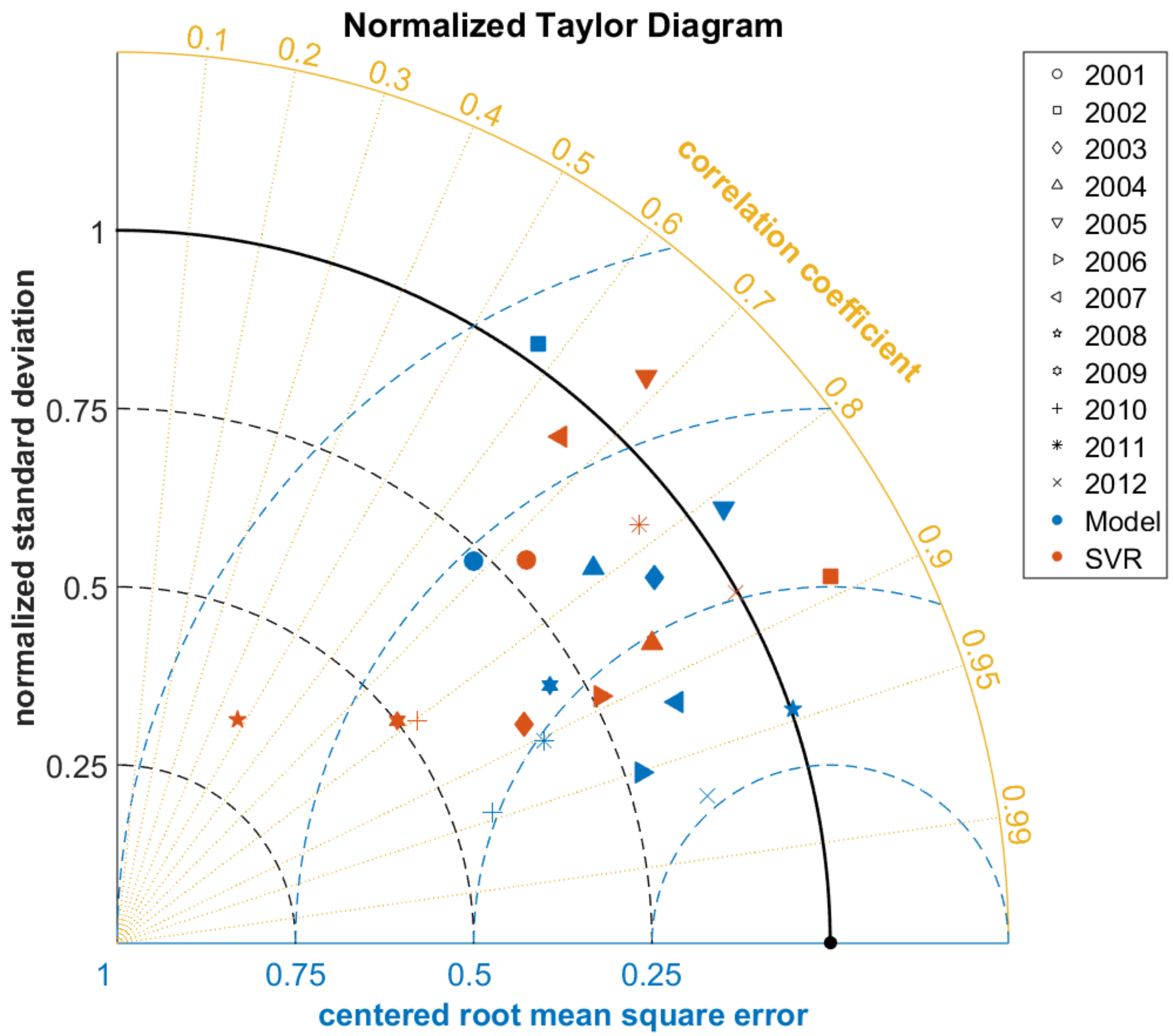
Scenario 4: 12 1/12 Hold out algorithms



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Summary and Conclusions

- The levels of Lake Tana were estimated using two approaches:
  - a physically-based groundwater model, coupled with a lake and streamflow modules
  - a data-driven algorithm which uses support vector regression with RBF kernel
- Both techniques achieved satisfactory results in estimating the lake levels in terms of various statistical metrics.
- The physically-based model outperformed the data-driven model in all but the bias metric.
- The data-driven model has multiple competitive advantages:
  - reduced computational effort,
  - shorter training/calibration time,
  - requires the selection of fewer model parameters
- Next step: explore forecasting capabilities of the data-driven model using incremental SVR

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THANK YOU
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