|  |
| --- |
| KhavrRF\_Micro\_modeltune\_Zn\_RS\_Landsat  Random Forest  47 samples  11 predictors  No pre-processing  Resampling: Bootstrapped (25 reps)  Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...  Resampling results across tuning parameters:  mtry RMSE Rsquared MAE  2 3.597980 0.12745223 2.717776  6 3.792184 0.09917229 2.838200  11 3.983301 0.07905903 2.974917  RMSE was used to select the optimal model using the smallest value.  The final value used for the model was mtry = 2. |
|  |
| |  | | --- | | > | |

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Landsat\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7579673 0.8034301 3.077099 1.754166 0.01589665

> # externalvalidation

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Landsat\_External , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.08830168 0.1804821 15.56083 3.944722 -0.9777843

> #training

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Landsat\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 48.7

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Landsat\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 1.092668

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Landsat\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 93.2

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Landsat\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 1.789454

KhavrRF\_Micro\_modeltune\_Zn\_RS\_Sentinel

Random Forest

47 samples

16 predictors

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.958327 0.05016826 2.959752

9 3.986626 0.07352347 2.897101

16 4.006232 0.08788820 2.838522

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 2.

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Sentinel\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7398738 0.7841892 3.307133 1.818552 -0.002340865

> # externalvalidation

> KhavrRF\_Micro\_Zn\_RS\_Sentinel\_External <- predict(KhavrRF\_Micro\_Zn\_RS\_Sentinel, newdata = RF\_Micro\_Scenario\_models\_dataset[-Training\_RF\_Micro\_scenario, ])

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Sentinel\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.0776099 0.1505231 15.74332 3.967785 -0.4804403

#training

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Sentinel\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 50.5

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Sentinel\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 1.131707

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Sentinel\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 93.7

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Sentinel\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 2.326728

KhavrRF\_Micro\_modeltune\_Zn\_RS\_Landsat\_Sentinel

Random Forest

47 samples

27 predictors

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.659520 0.08855394 2.850278

14 3.785571 0.08197421 2.853559

27 3.823901 0.09299839 2.798847

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 2.

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Landsat\_Sentinel\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7522181 0.7967322 3.150192 1.774878 0.07208952

> # externalvalidation

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Landsat\_Sentinel\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.1285582 0.1942595 14.87373 3.856648 -0.4596985

#training

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Landsat\_Sentinel\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 49.2

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Landsat\_Sentinel\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 1.1651

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Landsat\_Sentinel\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 91.1

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Landsat\_Sentinel\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 2.336982

KhavrRF\_Micro\_modeltune\_Zn\_RS\_Topographic

Random Forest

47 samples

34 predictors

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.661238 0.09655170 2.857348

18 3.779232 0.08009855 2.871660

34 3.824057 0.08576103 2.852267

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 2.

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Topographic\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7558152 0.7978489 3.10446 1.761948 0.02454157

> # externalvalidation

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Topographic\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.06239085 0.1397993 16.00307 4.000384 -0.6876829

#training

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 48.9

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 1.191227

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Topographic\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 94.5

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Topographic\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 2.176689

KhavrRF\_Micro\_modeltune\_Zn\_RS\_Topographic\_Climate

Random Forest

47 samples

38 predictors

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.555536 0.10540971 2.811924

20 3.750393 0.09368037 2.897239

38 3.816881 0.09509556 2.886388

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 2.

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7668325 0.8071009 2.964391 1.721741 0.0589963

> # externalvalidation

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.112856 0.1655811 15.14174 3.891239 -0.6171604

#training

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 47.8

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 1.194153

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 91.9

> MAPE(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 2.138941

KhavrRF\_Micro\_modeltune\_Zn\_RS\_Topographic\_Climate\_Soil

Random Forest

47 samples

41 predictors

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.317200 0.2226665 2.567616

21 3.264589 0.2560948 2.421953

41 3.286053 0.2597659 2.363063

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 21.

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Soil\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.8565628 0.8878199 1.823599 1.350407 0.1173056

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Soil\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.2636547 0.4353213 12.56791 3.545125 0.1480777

|  |
| --- |
| #training  > nrmse(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Soil\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])  [1] 37.5  > MAPE(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Soil\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])  [1] 0.909666  > ##testing  > nrmse(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Soil\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])  [1] 83.7  > MAPE(KhavrRF\_Micro\_Zn\_RS\_Topographic\_Climate\_Soil\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])  [1] 2.411902 |
|  |
| |  | | --- | | > | |

KhavrRF\_Micro\_modeltune\_Zn\_Topographic

Random Forest

47 samples

7 predictor

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.688464 0.08984911 2.728031

4 3.802312 0.08870621 2.772629

7 3.941767 0.09006476 2.808049

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 2.

|  |
| --- |
| goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Topographic\_Internal , plot.it = TRUE)  R2 concordance MSE RMSE bias  1 0.7075232 0.7641434 3.718424 1.928322 0.06802963  > # externalvalidation  > goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Topographic\_External, plot.it = TRUE)  R2 concordance MSE RMSE bias  1 0.0422064 0.1619918 16.34758 4.043214 -0.5067257  > #training  > nrmse(KhavrRF\_Micro\_Zn\_Topographic\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])  [1] 53.5  > MAPE(KhavrRF\_Micro\_Zn\_Topographic\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])  [1] 1.418822  > ##testing  > nrmse(KhavrRF\_Micro\_Zn\_Topographic\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])  [1] 95.5  > MAPE(KhavrRF\_Micro\_Zn\_Topographic\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])  [1] 2.06741 |
|  |
| |  | | --- | | > | |

KhavrRF\_Micro\_modeltune\_Zn\_Climate

Random Forest

47 samples

4 predictor

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results across tuning parameters:

mtry RMSE Rsquared MAE

2 3.464791 0.1973698 2.518450

3 3.533381 0.1775560 2.529355

4 3.626252 0.1529994 2.576142

RMSE was used to select the optimal model using the smallest value.

The final value used for the model was mtry = 2.

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Climate\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7710471 0.824796 2.910809 1.706109 0.004864339

> # externalvalidation

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Climate\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.211334 0.3030591 13.46092 3.668912 -0.3654877

#training

> nrmse(KhavrRF\_Micro\_Zn\_Climate\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 47.3

> MAPE(KhavrRF\_Micro\_Zn\_Climate\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 0.9420699

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_Climate\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 86.7

> MAPE(KhavrRF\_Micro\_Zn\_Climate\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 2.219542

|  |
| --- |
| KhavrRF\_Micro\_modeltune\_Zn\_Soil  Random Forest  47 samples  3 predictor  No pre-processing  Resampling: Bootstrapped (25 reps)  Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...  Resampling results across tuning parameters:  mtry RMSE Rsquared MAE  2 3.024978 0.3968178 2.036024  3 3.159794 0.3786140 2.094892  RMSE was used to select the optimal model using the smallest value.  The final value used for the model was mtry = 2. |
|  |
| |  | | --- | | > goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Soil\_Internal , plot.it = TRUE)  R2 concordance MSE RMSE bias  1 0.8665323 0.8990295 1.696851 1.302632 0.06099773  > goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Soil\_External, plot.it = TRUE)  R2 concordance MSE RMSE bias  1 0.3416357 0.5876113 11.23693 3.352154 0.5193329 | |

|  |
| --- |
| #training  > nrmse(KhavrRF\_Micro\_Zn\_Soil\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])  [1] 36.1  > MAPE(KhavrRF\_Micro\_Zn\_Soil\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])  [1] 0.6861783  > ##testing  > nrmse(KhavrRF\_Micro\_Zn\_Soil\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])  [1] 79.2  > MAPE(KhavrRF\_Micro\_Zn\_Soil\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])  [1] 2.23356 |
|  |
| |  | | --- | | > | |

KhavrRF\_Micro\_modeltune\_Zn\_Rec\_Fea\_Elimination

Random Forest

47 samples

2 predictor

No pre-processing

Resampling: Bootstrapped (25 reps)

Summary of sample sizes: 47, 47, 47, 47, 47, 47, ...

Resampling results:

RMSE Rsquared MAE

3.226802 0.3097875 2.132273

goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Rec\_Fea\_Elimination\_Internal , plot.it = TRUE)

R2 concordance MSE RMSE bias

1 0.7854608 0.8454547 2.72756 1.651533 0.01546401

> # externalvalidation

> goof(observed = RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario], predicted = KhavrRF\_Micro\_Zn\_Rec\_Fea\_Elimination\_External, plot.it = TRUE)

R2 concordance MSE RMSE bias

1 -0.04063625 0.3593492 17.76154 4.214444 0.8579326

nrmse(KhavrRF\_Micro\_Zn\_Rec\_Fea\_Elimination\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 45.8

> MAPE(KhavrRF\_Micro\_Zn\_Rec\_Fea\_Elimination\_Internal, RF\_Micro\_Scenario\_models\_dataset$Zn[Training\_RF\_Micro\_scenario])

[1] 0.8756545

> ##testing

> nrmse(KhavrRF\_Micro\_Zn\_Rec\_Fea\_Elimination\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 99.6

> MAPE(KhavrRF\_Micro\_Zn\_Rec\_Fea\_Elimination\_External, RF\_Micro\_Scenario\_models\_dataset$Zn[-Training\_RF\_Micro\_scenario])

[1] 3.049902