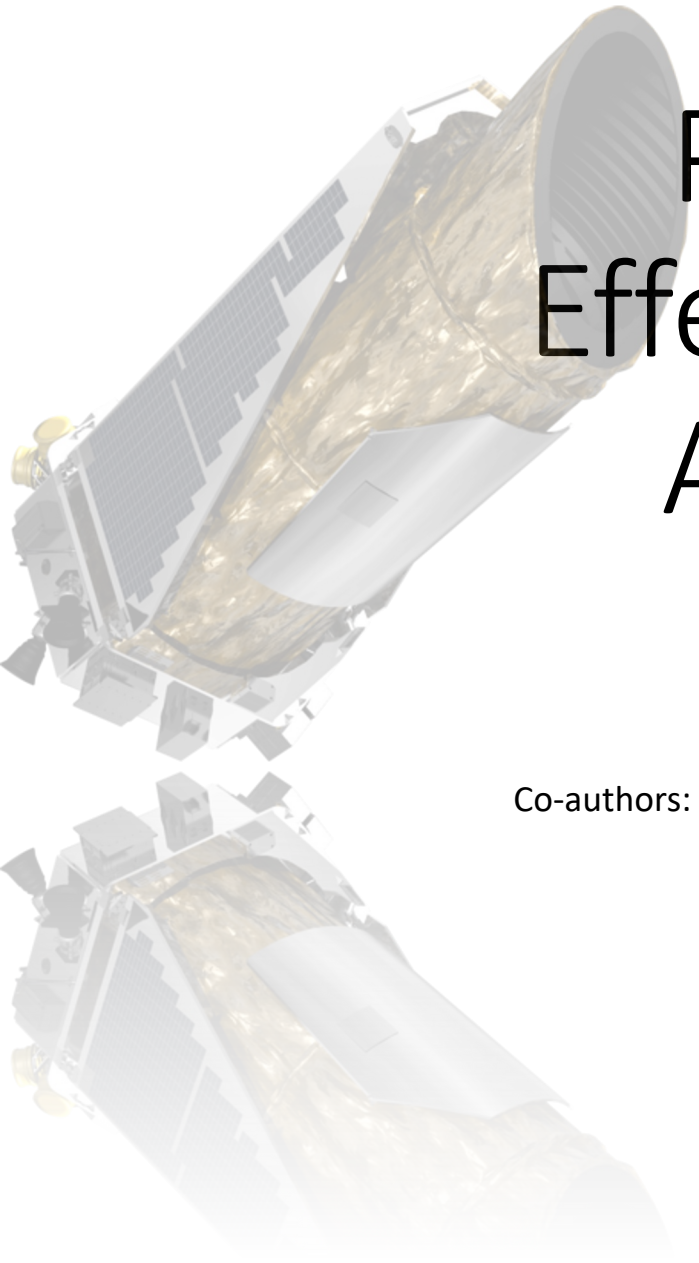

Probing ExoMiner for Effectiveness against False Alarms in Kepler Data

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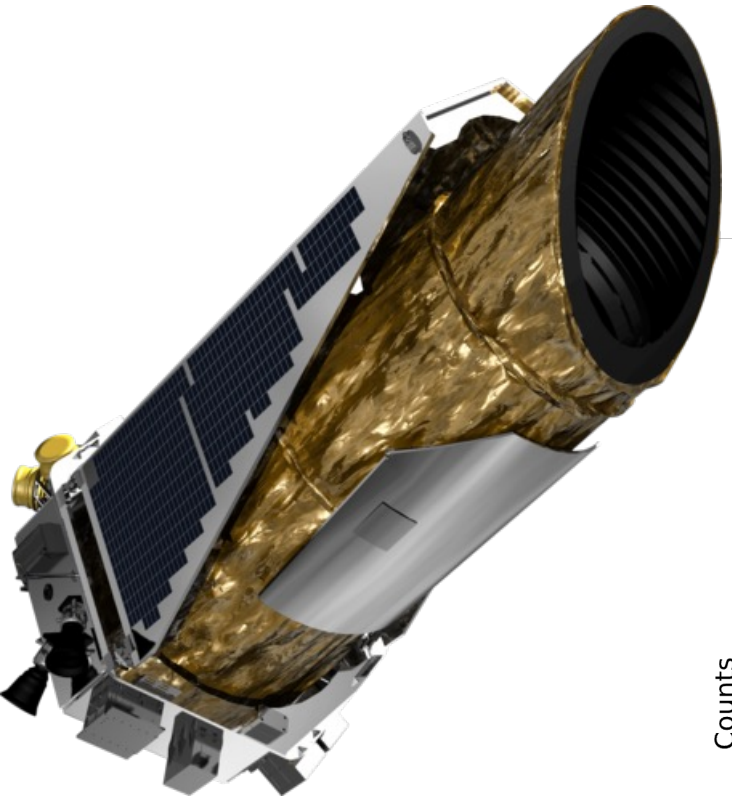
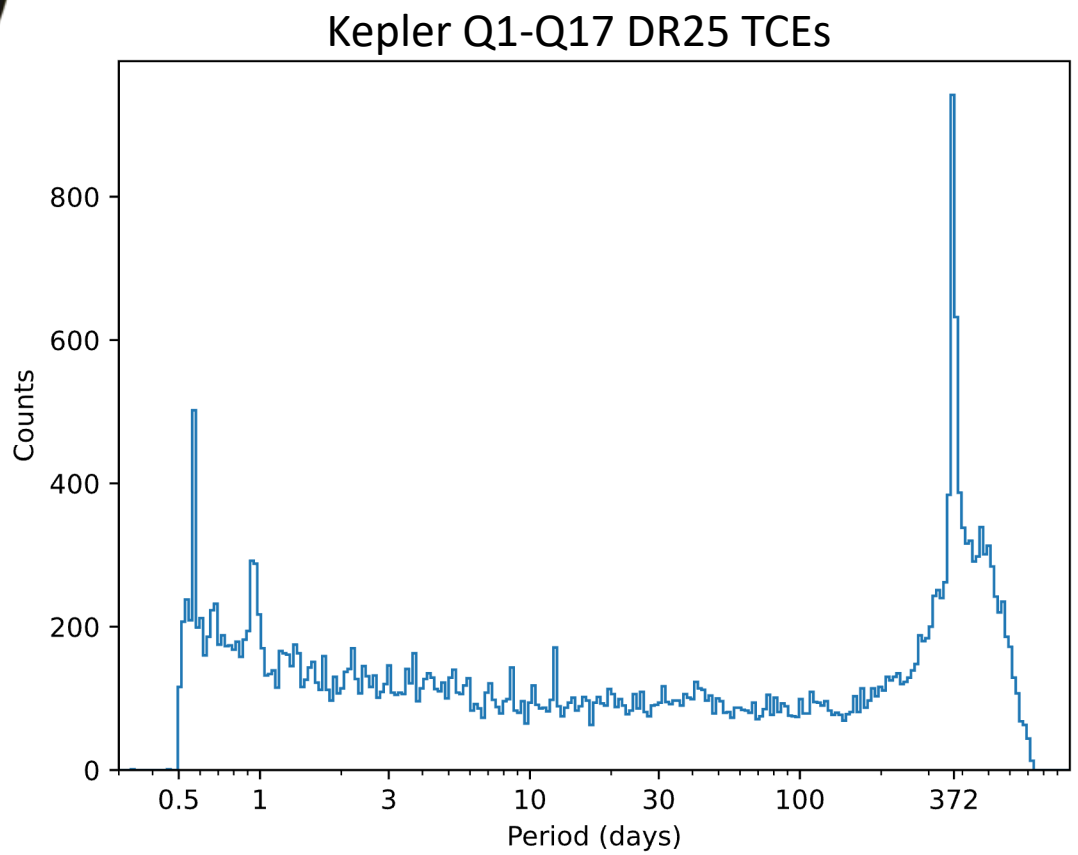
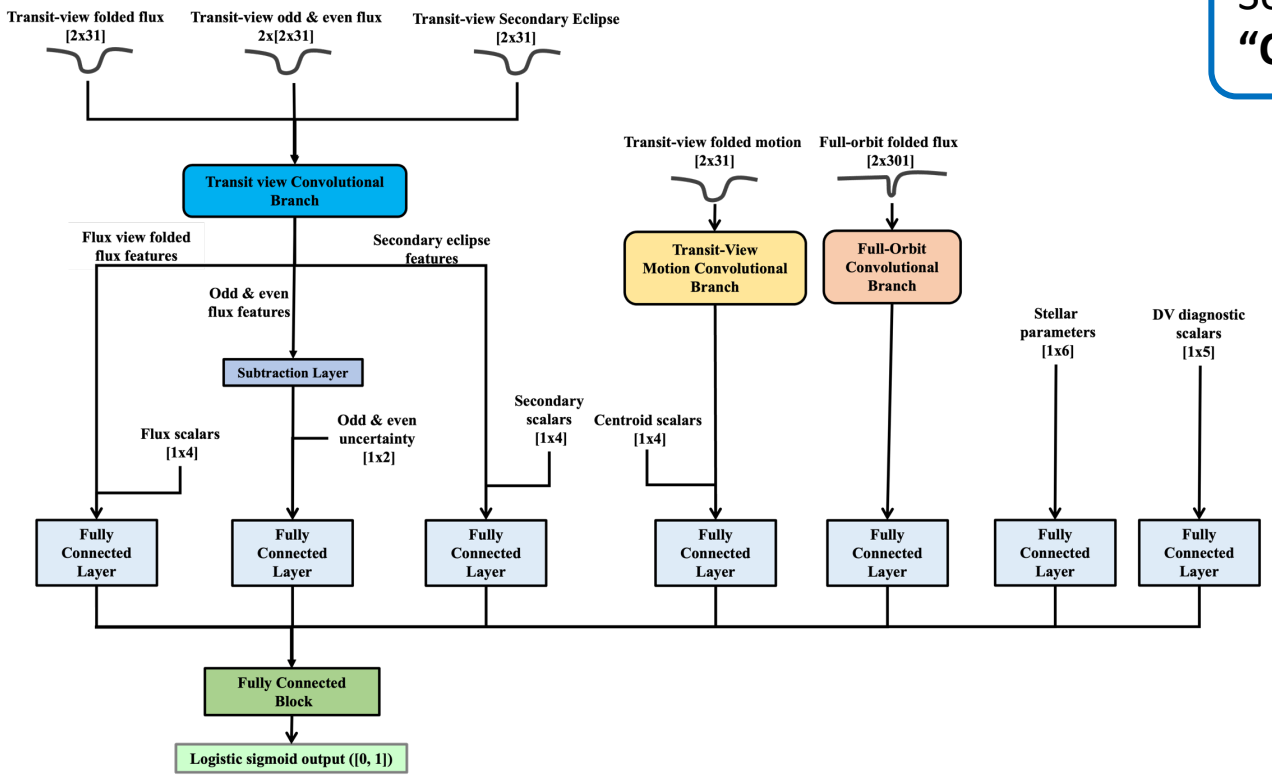
Co-authors: Hamed Valizadegan[1,2], Jon Jenkins[1], Steve Bryson[1], Douglas Caldwell[1,3], Joseph Twicken[1,3]

[1] NASA Ames Research Center
[2] Universities Space Research Association
[3] SETI




Kepler Q1-Q17 DR25 TCEs
Counts
800
600
400
200
0
0.5
1
3
10
30
100
372
Period (days)

ExoMiner



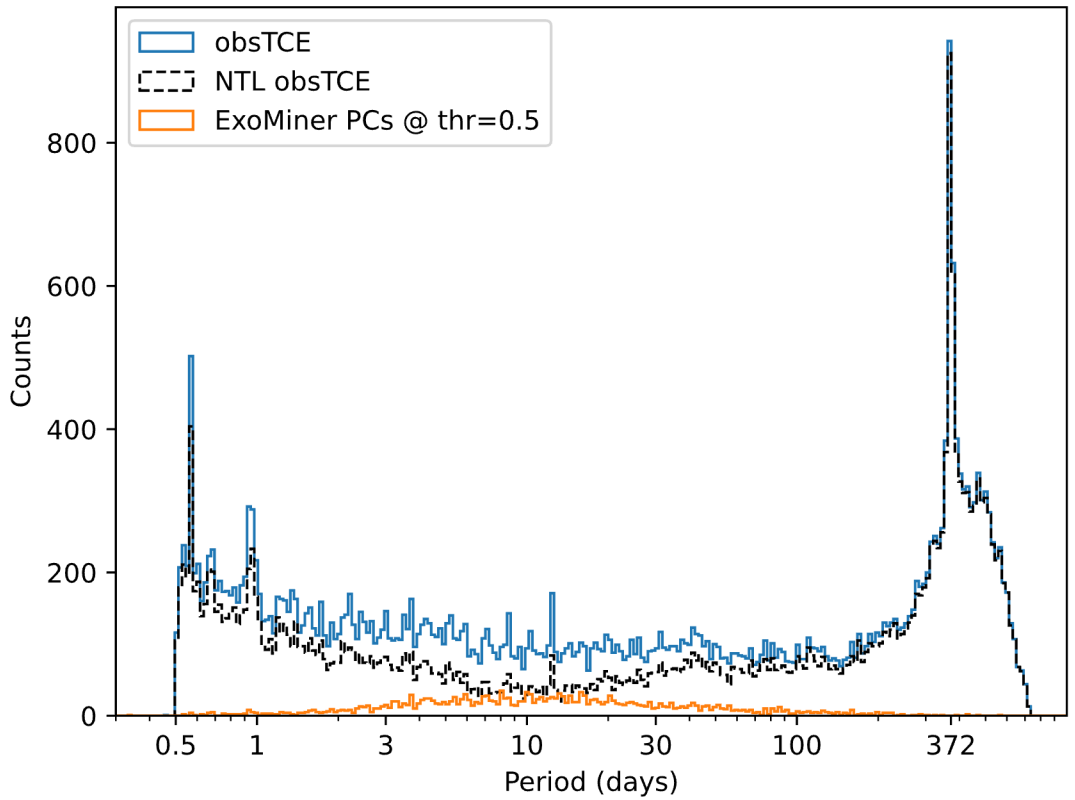
See talk by Hamed Valizadegan in this session for the **"Classification of TESS TCEs Using ExoMiner++"**

- Valizadegan, Hamed, et al. "**ExoMiner: A highly accurate and explainable deep learning classifier that validates 301 new exoplanets.**" *The Astrophysical Journal* 926.2 (2022): 120.

- Valizadegan, Hamed, et al. "**Multiplicity Boost of Transit Signal Classifiers: Validation of 69 New Exoplanets using the Multiplicity Boost of ExoMiner.**" *The Astronomical Journal* 166.1 (2023): 28.

We're releasing ExoMiner on NASA GitHub soon! (hopefully in the next months)

TCEs = Planets + Astrophysical False Positives (AFPs) + NTLs



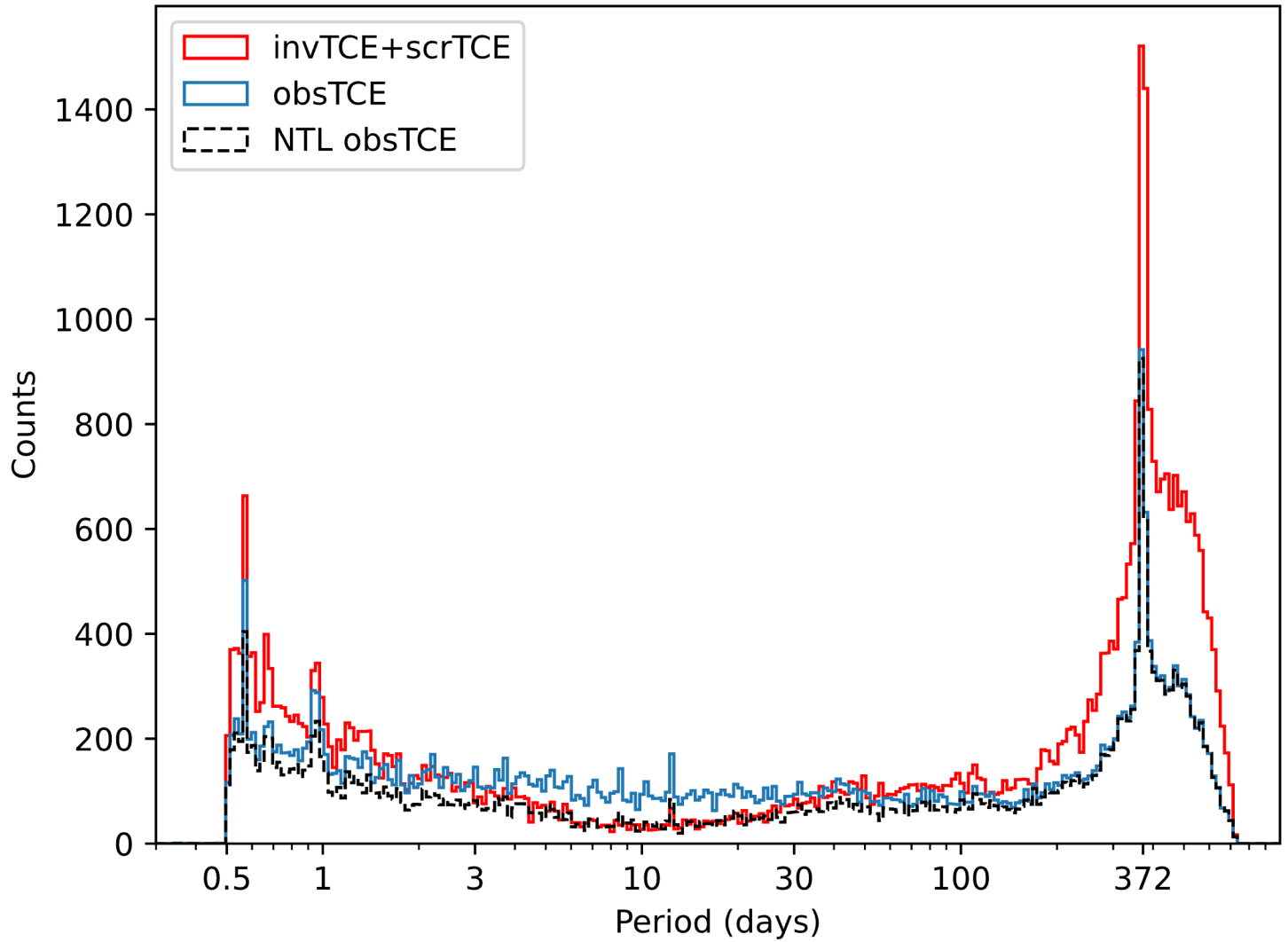
Goal: Comprehensive study of ExoMiner's capacity to **veto not-transit-like (NTL) signals** in **Kepler** data.

Which Catalog to Use?

Kepler DR25 Simulated Data

- **Inversion (INV):** DR25 light curves inverted before conducting the transit search to create **not-transit-like** TCEs
  - Test system's effectiveness against **quasi-sinusoidal false positive signals**.
- **Scrambling (SCR):** DR25 light curves were scrambled by switching order of quarters before conducting the transit search to create **not-transit-like** TCEs
  - Test system's effectiveness against false positives due to SPSDs and other **non-invertible phenomena**.

"Effectiveness" in "Planetary Candidates Observed by Kepler. VIII. A Fully Automated Catalog with Measured Completeness and Reliability Based on Data Release 25" (Thompson et al, 2017)


invTCE+scrTCE
obsTCE
NTL obsTCE
Counts
0
200
400
600
800
1000
1200
1400
0.5
1
3
10
30
100
372
Period (days)

Experiment

1. Trained ExoMiner model on Kepler **DR25 observed TCEs**

Disposition	**Planet**	**Planet%**	**AFP**	**AFP%**	**NTL**	**NTL%**
Counts/%	2,654	8.57	3,539	11.43	24,778	80.00

Recall[*]: fraction of false positives classified as false positives by the system – in our case we focus **on NTLs, not astrophysical false positives**

Disposition	**Planet**	**AFP**	**NTL**
Test Set Recall (thr=0.5)	0.993	0.983	1.000

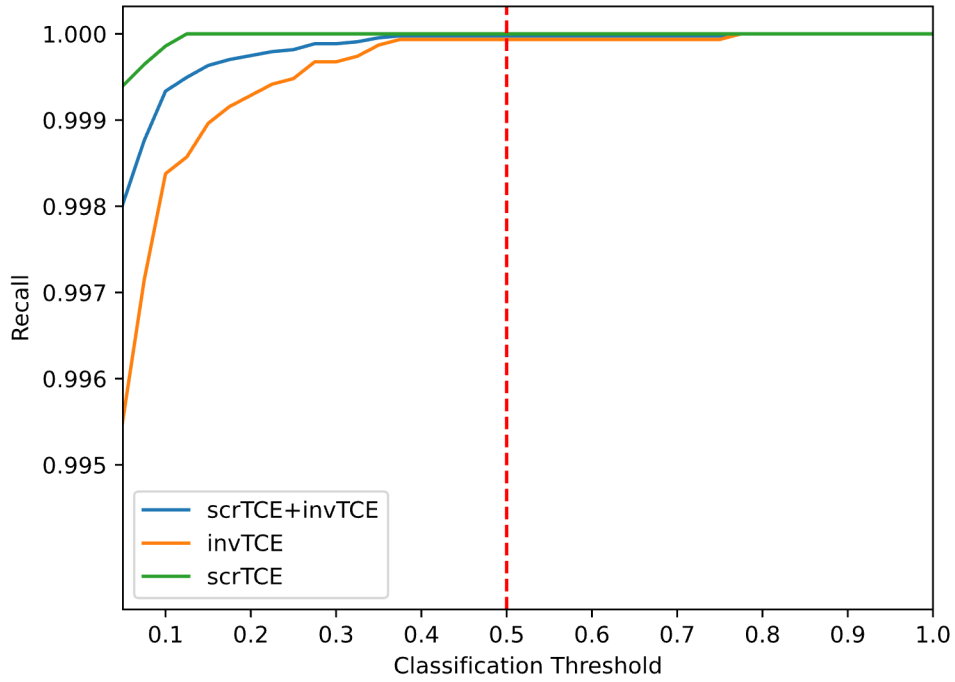
[*]Also described as “Effectiveness” in “Planetary Candidates Observed by Kepler. VIII. A Fully Automated Catalog with Measured Completeness and Reliability Based on Data Release 25” (Thompson et al, 2017)

Experiment

2. Evaluated trained ExoMiner model on **DR25 inverted and scrambled TCEs**

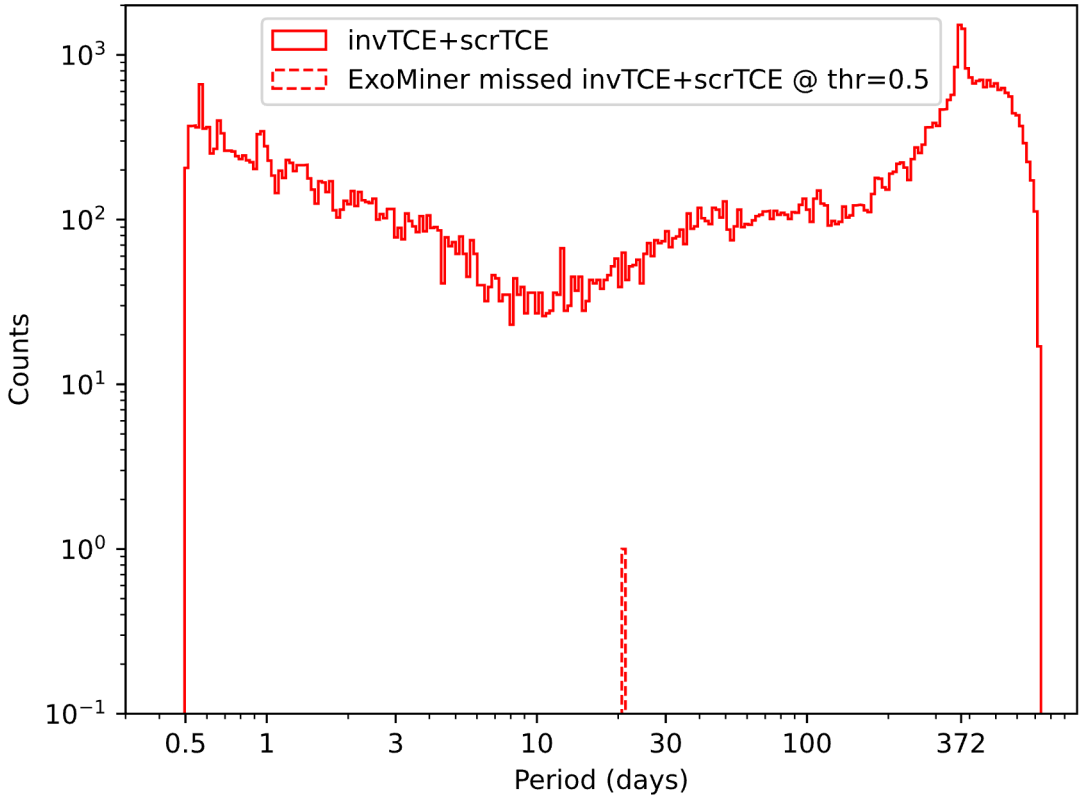
Data Set	**INV**	**SCR**	**INV+SCR**
Counts	15,411	28,216	43,627
%	35.32	64.68	100.00

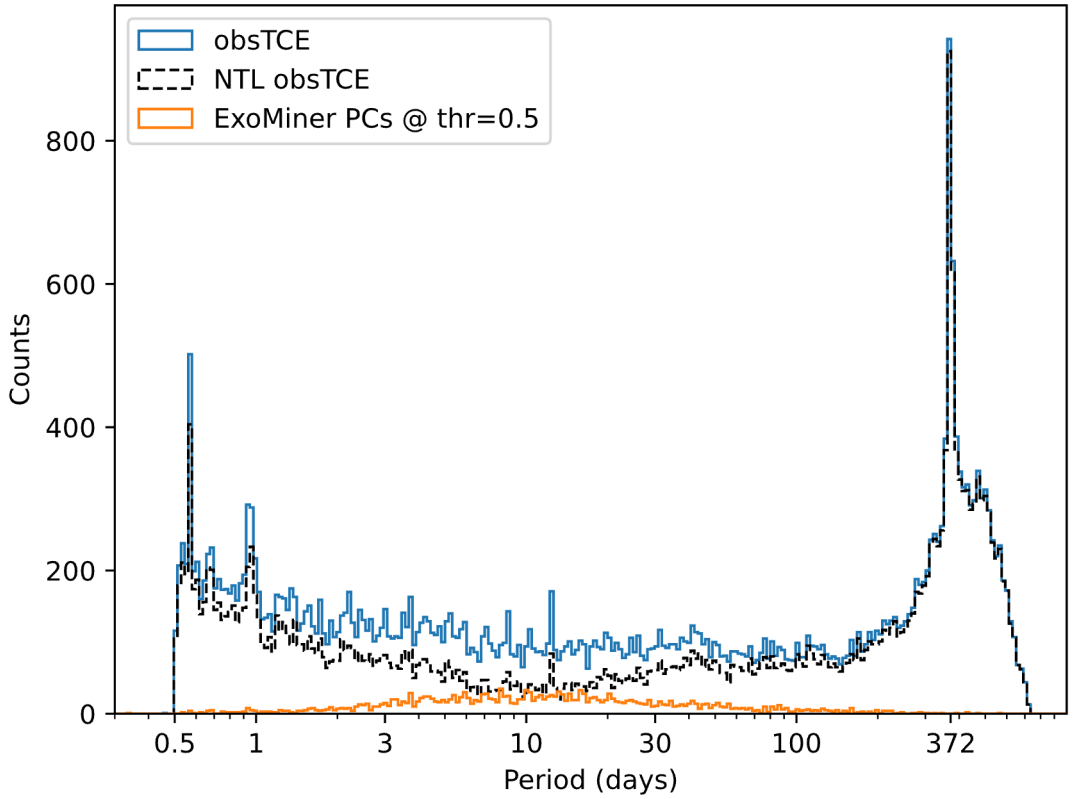
Group	**INV**	**SCR**	**INV+SCR**
Recall (thr=0.5)	1.000	1.000	1.000
Number of Misclassified TCEs	1	0	0



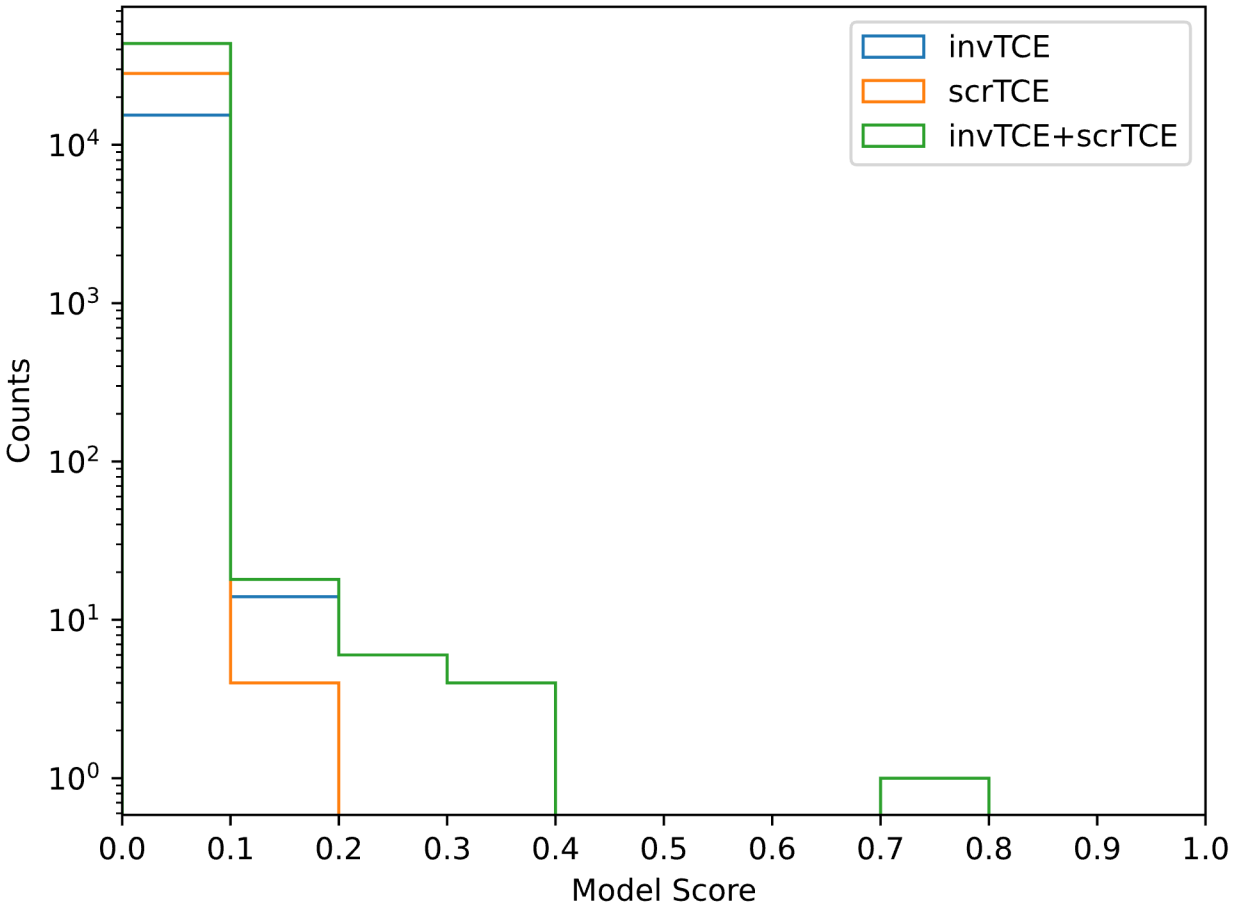
Conclusions

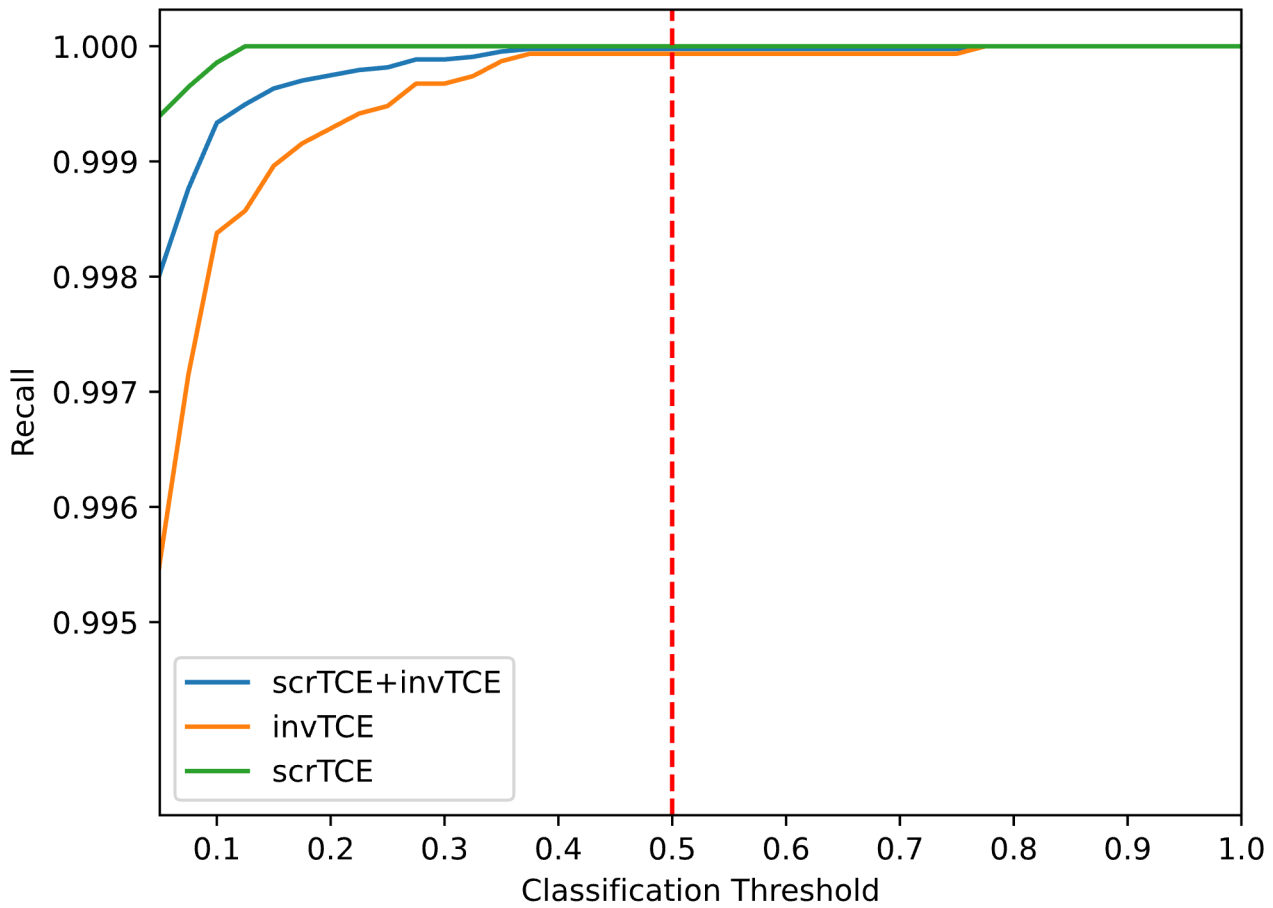
Future Work: Measure ExoMiner's performance on DR25 transit injection data.





Contact me for any question or potential collaboration! miguel.martinho@nasa.gov; or AAS 243 Slack @ miguelmartinho


invTCE
scrTCE
invTCE+scrTCE
Counts
10^4
10^3
10^2
10^1
10^0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Model Score


Recall
1.000
0.999
0.998
0.997
0.996
0.995
scrTCE+invTCE
invTCE
scrTCE
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Classification Threshold

Robovetter Performance

Results obtained from “Planetary Candidates Observed by Kepler. VIII. A Fully Automated Catalog with Measured Completeness and Reliability Based on Data Release 25”

Disposition	INV+SCR
Recall*	0.996

*After tuning Robovetter for a desired completeness value in DR25 simulated data and partial set of DR25 observed data

Data Set Split

Data Set	Planet	Planet%	AFP	AFP%	NTL	NTL%
Training	2,146	8.66	2,821	11.38	19,823	79.97
Validation	233	7.57	362	11.77	2,481	80.66
Test	275	8.85	356	11.46	2,474	79.68
Total	2,654	8.57	3,539	11.43	24,778	80.00

Evaluated trained model on **DR25 inverted and scrambled TCEs (with TCEs from KICs with KOIs)**

Data Set	INV	SCR1
Counts	19,536	48,435
%	28.74	71.08

Disposition	INV	SCR	INV+SCR
Recall (thr=0.5)	1.000	0.999	0.999
Misclassified	5	67	72