FLORIDA TECH

FLORIDA'S STEM UNIVERSITY

Long-Term Exoplanet Habitability: How Chance Favors Prokaryotes

Joseph Evans (evansj2014@my.fit.edu)
Manasvi Lingam
Jeremy A. Riousset
Dept of Aerospace, Physics, & Space Science
Florida Institute of Technology, Melbourne, FL, USA

Overview & Definitions

- Definitions
- Motivation
- Hypotheses
- Methods
- Results
- Conclusion

FLORIDA TECH

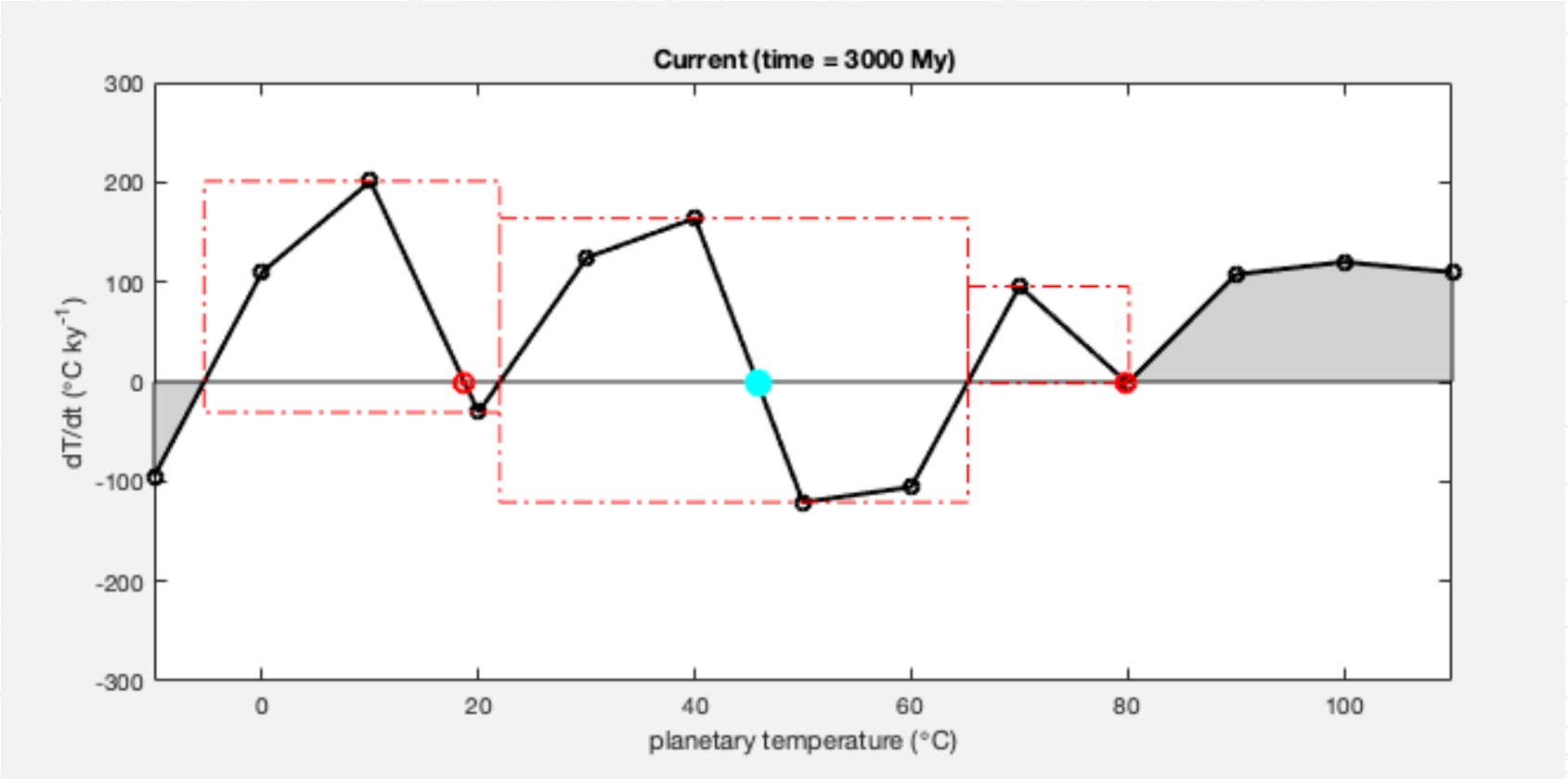
Motivation

Planets Model Code [Tyrrell 2020b]

$$\frac{dT}{dt} = f(T) + \phi$$

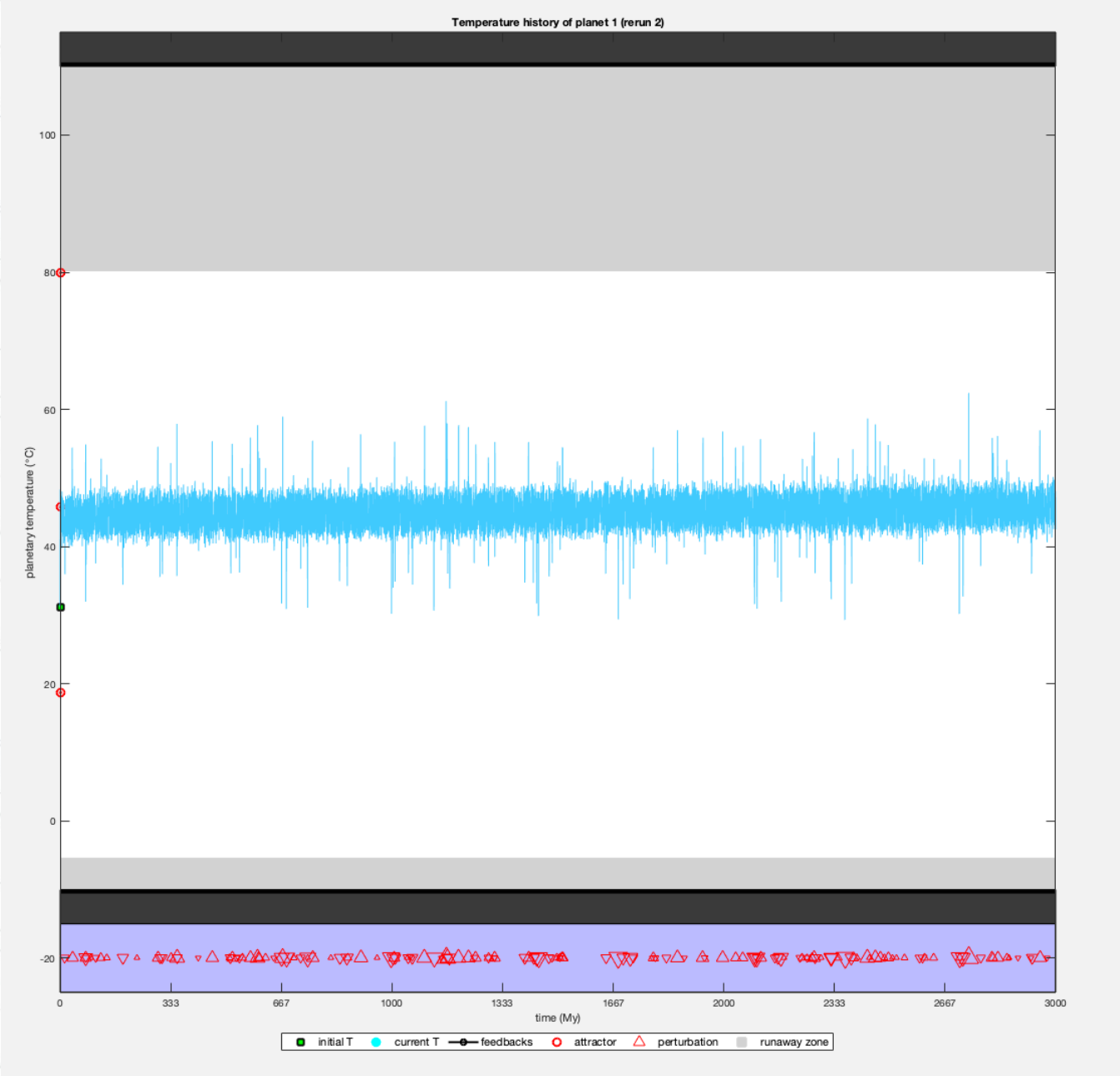
- Eukaryotic viable temperature: **-10°C to 50°C** [Tyrrell 2020a]
- Prokaryotic viable temperature: **-22°C to 122°C** [Lingam & Loeb 2021]

FLORIDA TECH



[Tyrrell 2020b]

FLORIDA TECH



[Tyrrell 2020b]

FLORIDA TECH

Hypothesis 1

Temperature Range (ΔT) Test

The chances of long-term survival of prokaryote-like life will increase in a non-linear fashion with an increase in viable temperature range.

FLORIDA TECH

Hypothesis 2

Time Interval (Δt) Test

The chance of complex multicellularity will increase in a non-linear fashion as the time interval requirement for the duration of eukaryote-like conditions is decreased.

FLORIDA TECH

Temp Interval (ΔT) Test Inputs:

Initial Experiment

Run #	Range °C	ΔT
1	-10 to 5	15
2	-10 to 20	30
3	-10 to 35	45
4	-10 to 50	60
5	-10 to 65	75
6	-10 to 80	90
7	-10 to 95	105
8	-10 to 110	120

- Each run consisted of 1,000 planets, each iterated twice.

Assumption Testing

Run #	Range °C	ΔT
1a	5 to 20	15
1b	50 to 65	15
1c	95 to 110	15
2a	35 to 65	30
2b	80 to 110	30
3	65 to 110	45
4	50 to 110	60
5	35 to 110	75
6	20 to 110	90
7	5 to 110	105
8	-10 to 110	120

FLORIDA TECH

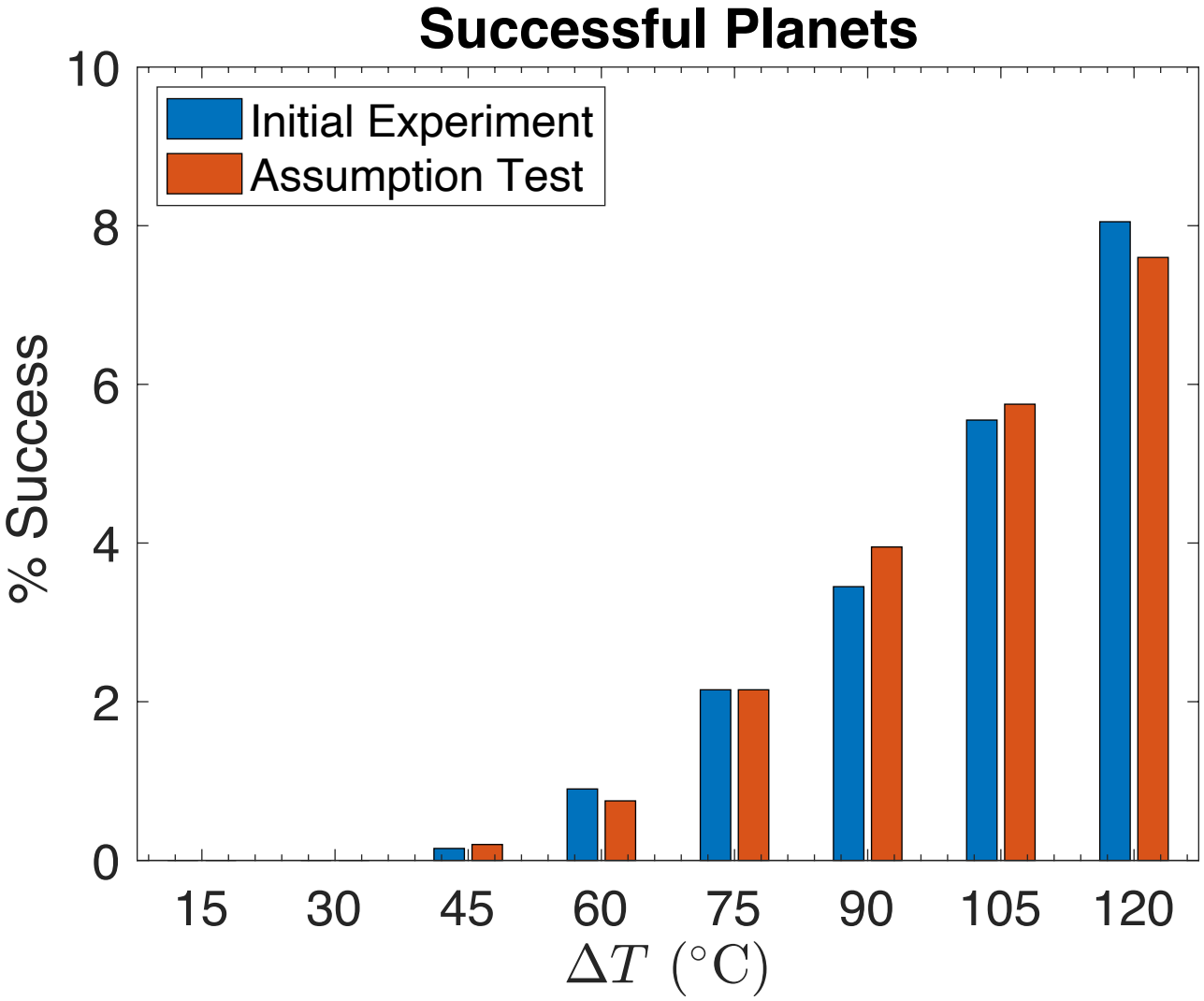
Time Interval (Δt) Test Inputs

Run #	ΔT_i °C	Δt (Ga)	ΔT_f °C
1	120	0.00	70
2		0.25	
3		0.50	
4		0.75	
5		1.00	
6		1.25	
7		1.50	
8		1.75	
9		2.00	
10		2.25	
11		2.50	
12		2.75	
13		3.00	

- Each run consisted of 1,000 planets, each iterated twice.

FLORIDA TECH

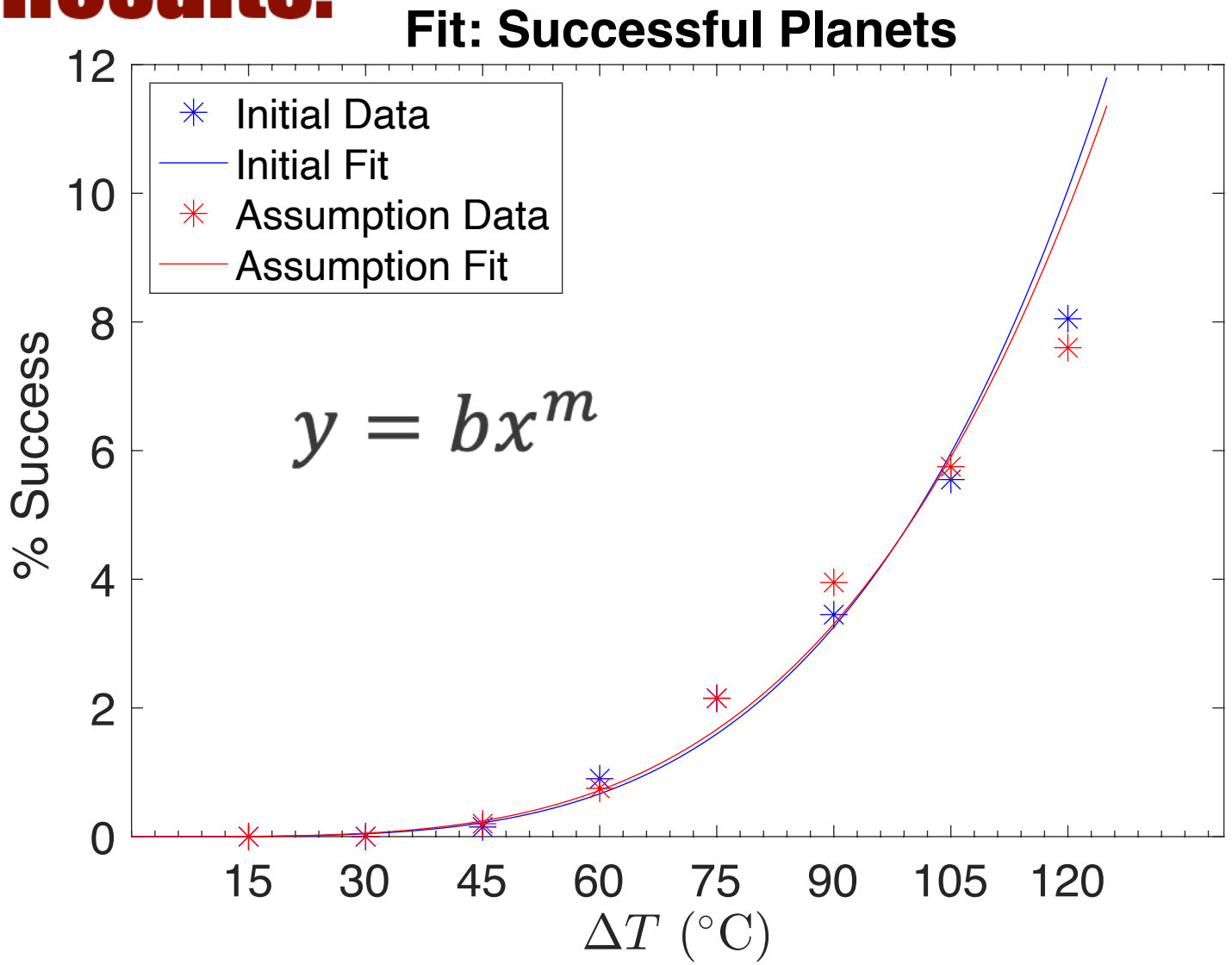
ΔT Results:



- Strong increase in long-term survival

FLORIDA TECH

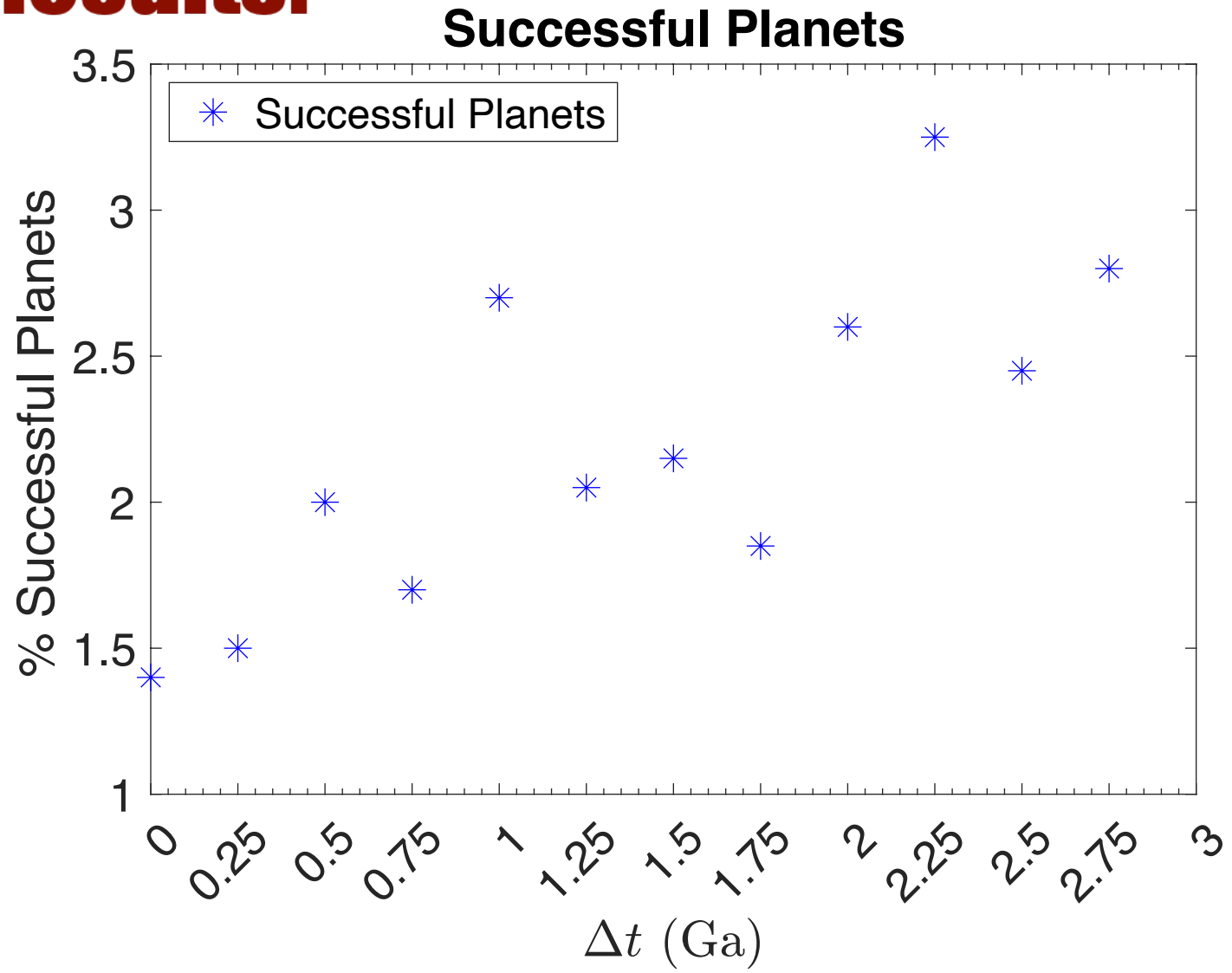
ΔT Results:



ID: m = 3.9 **AD: m = 3.8**

FLORIDA TECH

Δt Results:



- No significant increase in long-term survival

FLORIDA TECH

Conclusion

$$\% \text{ Survival} \propto \Delta T^{3.9}$$

- Long-term survival increases strongly as a power-law function of increased viable temperature range.
- The chance of complex multicellularity does not increase significantly with a reduced duration requirement for eukaryotic-like temperature limits.

FLORIDA TECH

Acknowledgements

- Dr. Tyrrell → Planets Model Code [2020]
  - Creative Commons Attribution 4.0 International License
    - https://creativecommons.org/licenses/by/4.0/legalcode
  - Adaptations:
    - Modified temperature ranges
    - Added ability to modify temperature ranges mid-simulation

- The authors acknowledge support from the National Science Foundation under grant 2047863 to Florida Institute of Technology.

FLORIDA TECH

References

- Lingam, M. and Loeb, A. *Life in the Cosmos,* Harvard University Press: 2021
- Tyrrell, T. *ComEE*, **1,** 61 (2020a)
- Tyrrell, T. *Planets Model Code,* Zenodo (2020b): *https://doi.org/10.5281/zenodo.4081451* (accessed 8 Oct 2021)

FLORIDA TECH