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Supporting Information for
Constraining nonlinear time series modeling with the metabolic theory of ecology

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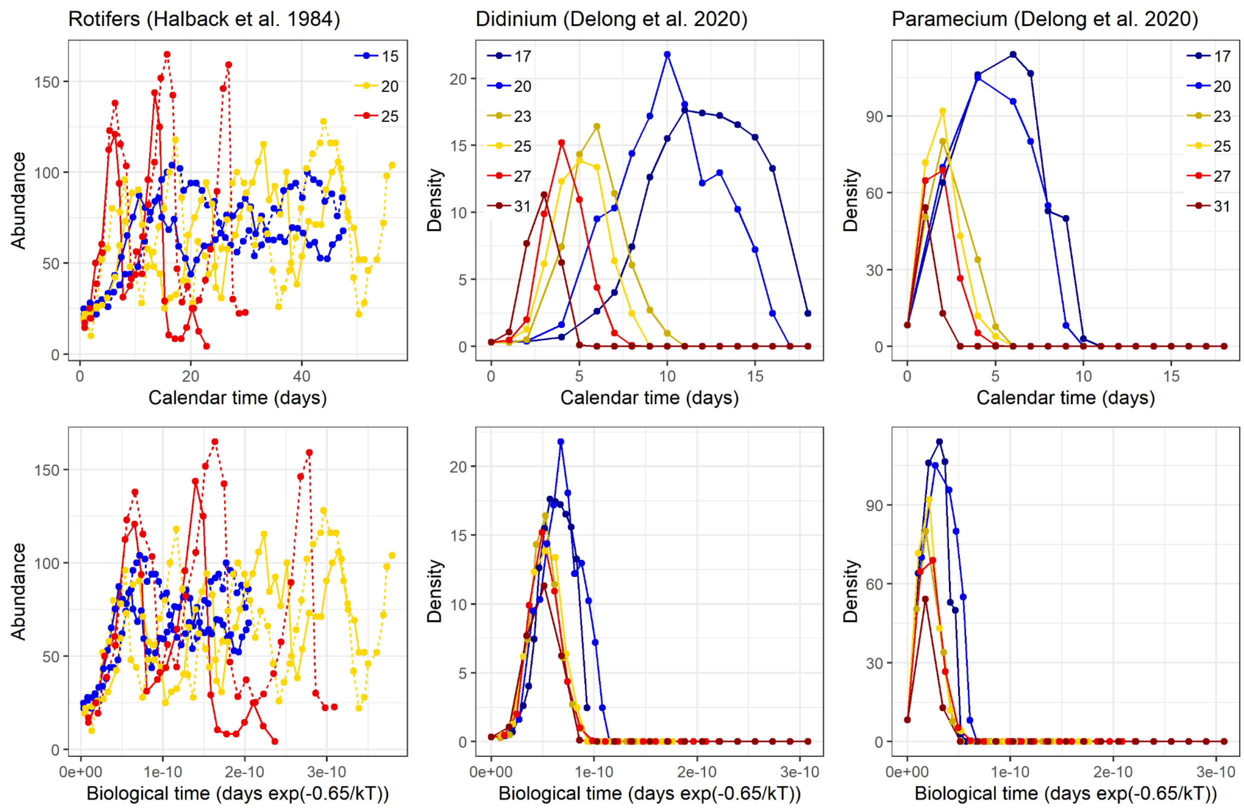

Figure S1. Time series from constant temperature laboratory experiments, plotted against calendar time and metabolic time.

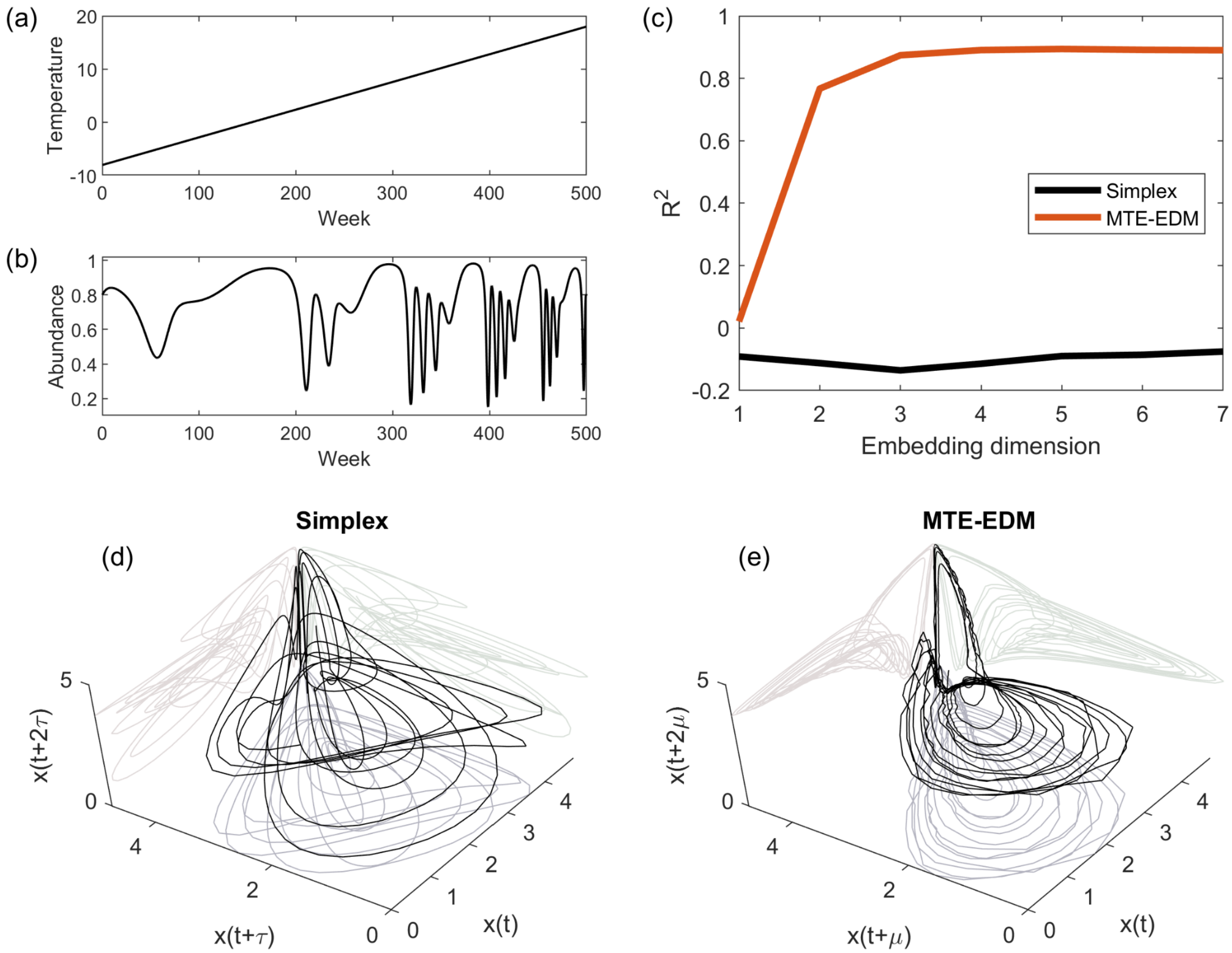

Figure S2. Simulated population dynamics with a linear temperature trend. Panel (a) shows temperature and (b) abundance time series. (c) Leave-one-out prediction R^2 for Simplex and MTE-EDM with different embedding dimensions. (d) Reconstructed attractor in delay-coordinate space using a fixed calendar timestep or (e) using a fixed metabolic timestep. The reconstructed attractor in delay-coordinate space using a fixed metabolic timestep (e) is much closer to the true attractor, permitting more accurate forecasts.

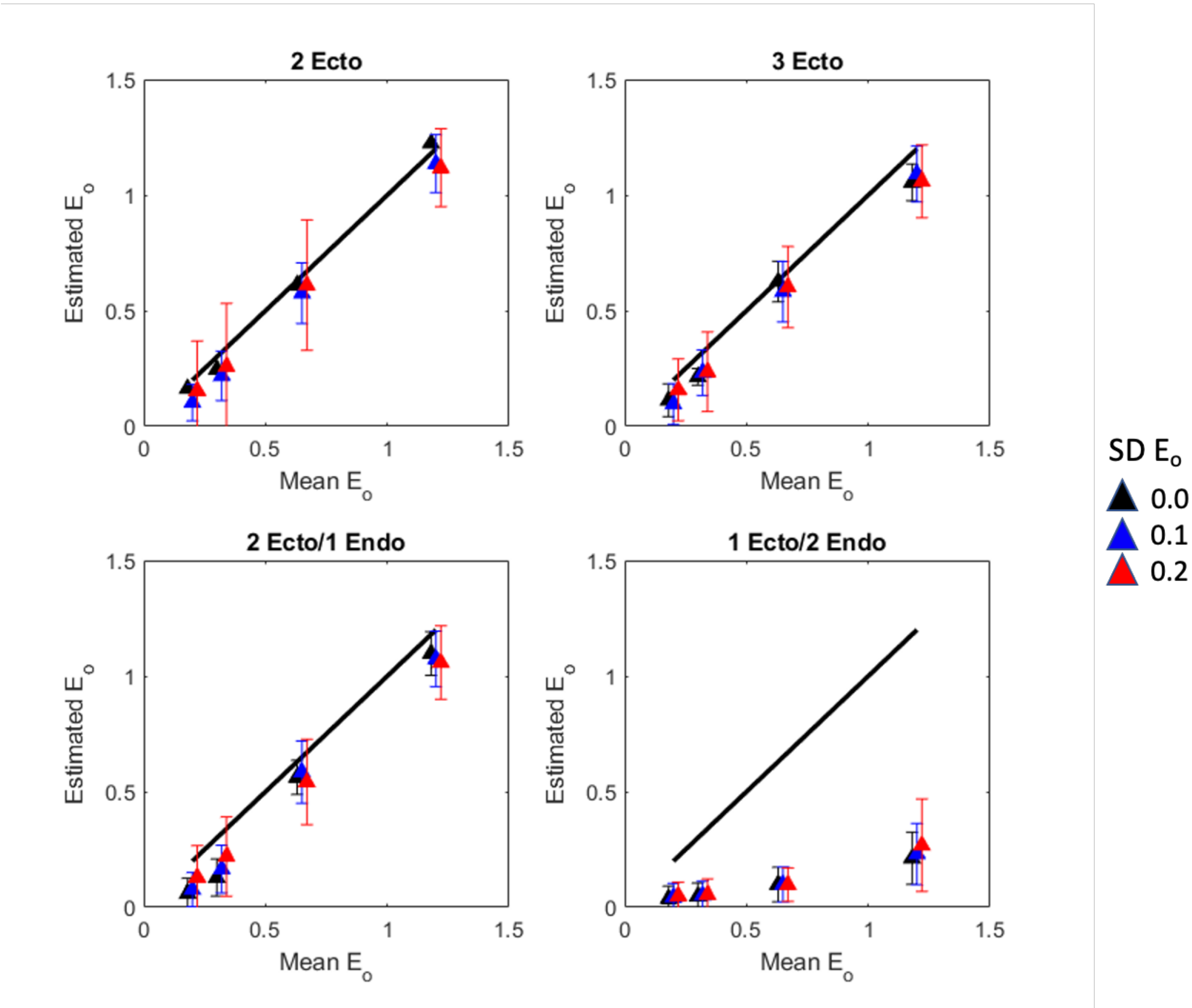

Figure S3: Estimated versus true activation energy across four scenarios of communities of ecto- and endotherms: 2 ectotherms, 3 ectotherms, 2 ectotherms and 1 endotherm, and 1 ectotherm and 2 endotherms. The estimated activation energy can be recovered despite different levels of the mean activation energy (E_0) and variation in E_0 (three levels of SD shown in black, blue and red). Only in the community dominated by endotherms, the estimated activation energy is biased low.

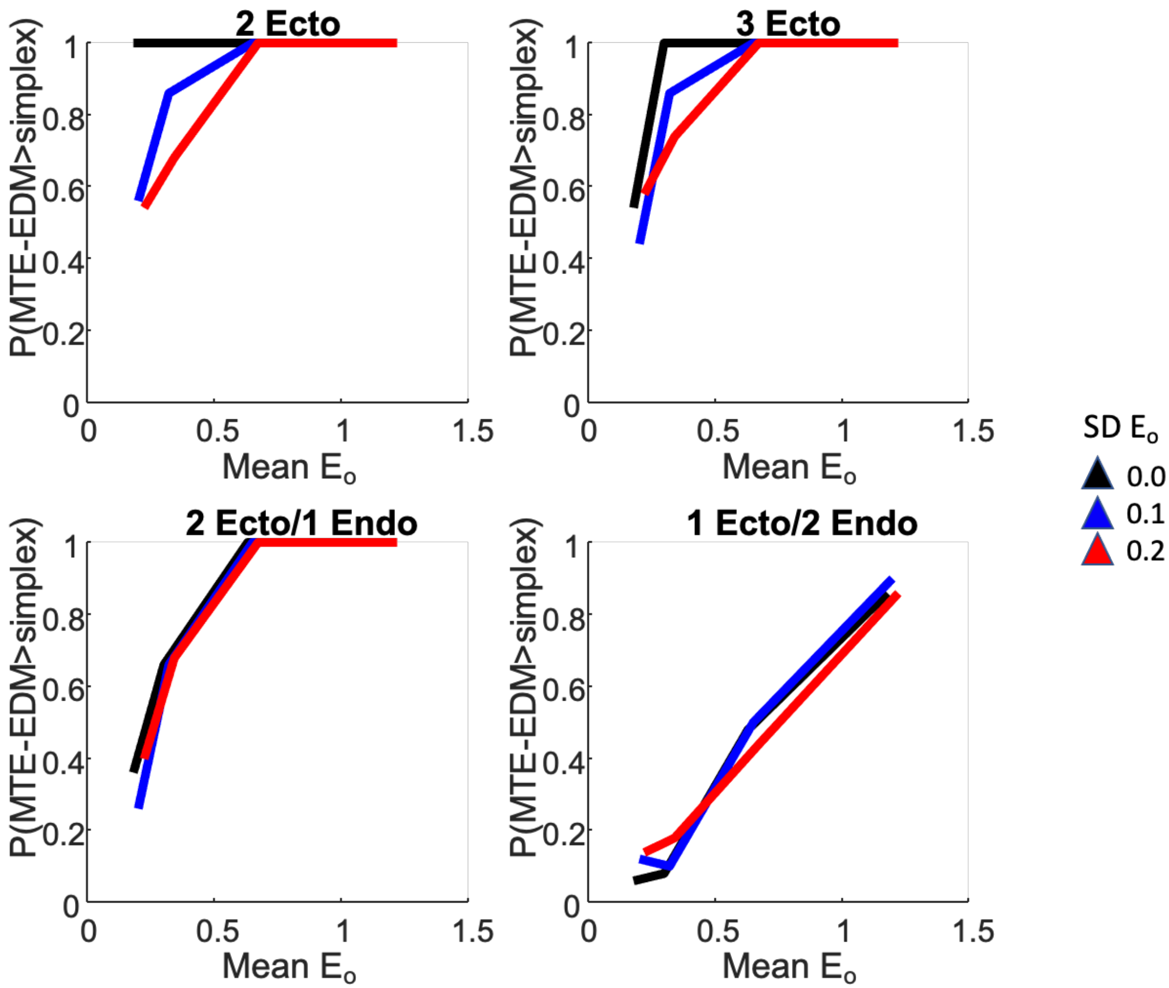

Figure S4: Probability that MTE-EDM outperforms Simplex across four scenarios of communities of ecto- and endotherms: 2 ectotherms, 3 ectotherms, 2 ectotherms and 1 endotherm, and 1ectotherm and 2 endotherms. When the community consists only of ectotherms (panels A-C), probability of significant improvement increases with the mean activation energy (i.e. greater sensitivity to temperature on average) and decreasing with variability among species. If the community is dominated by endotherms, the improvement probability increases only linearly with the mean activation energy.

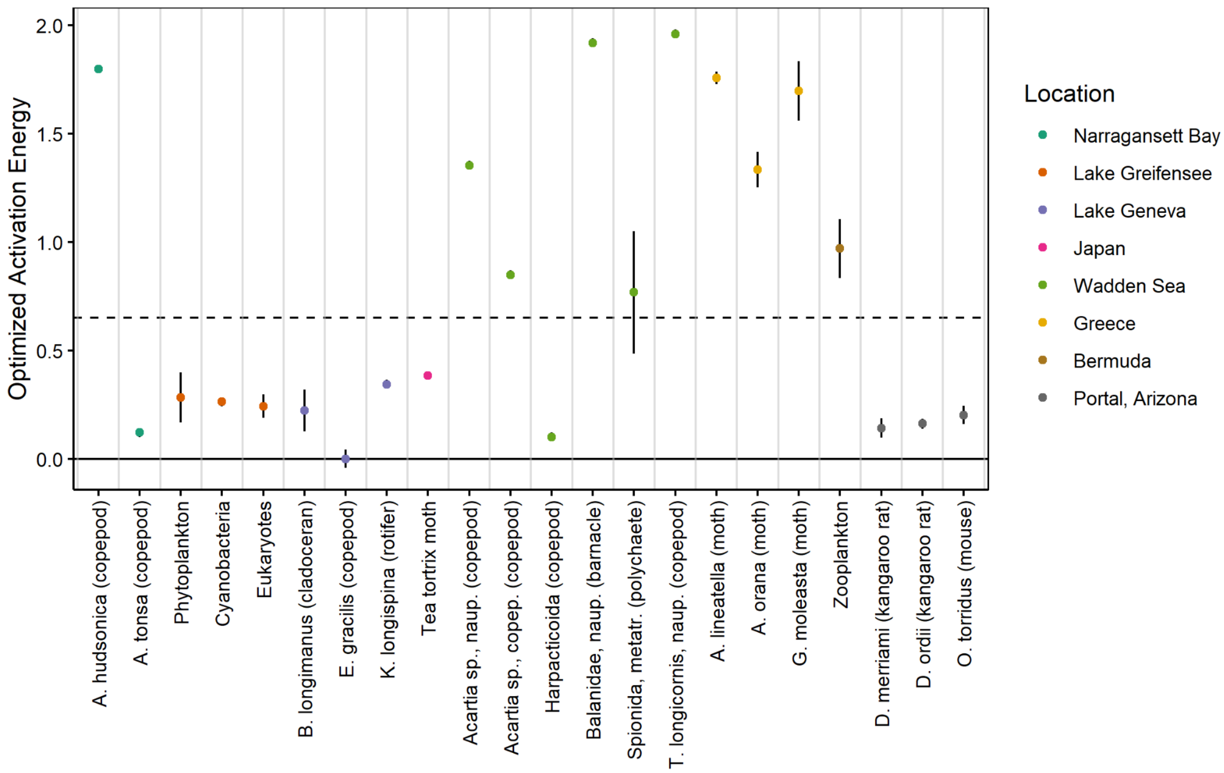

Figure S5. Optimized activation energies for each empirical time series. Error bars are approximate standard deviations. The horizontal dashed line is the UTD value (0.65). The Simplex model (no temperature dependence) corresponds to an activation energy of 0.

Table S1. Results of ordinary least squares regressions of natural log-transformed cycle period vs. Arrhenius temperature. P-values for parameters are given in square brackets, 95% confidence intervals in parentheses.

Study	Population	Slope (Activation Energy)	Intercept	R^2	N
Delong & Lyon (2020)	*Didinium*	0.68 [0.005]** (0.39,0.97)	-24.3 (-35.6,-12.9)	0.95	5
	Paramecium	0.67 [0.003]** (0.37,0.97)	-24.4 (-36.2,-12.7)	0.91	6
Halbach (1984)	*Brachionus calyciflorus*	0.57 [0.011]* (0.22,0.93)	-20.2 (-34.3,-6)	0.83	6
Fussman et al. (2014)	*T. pyriformis*	-0.76 [0.026]* (-1.4,-0.1)	31.8 (6.3,57.3)	0.40	12
	P. fluorescens	-0.39 [0.071] (-0.83, 0.04)	18.0 (0.98, 34.9)	0.21	16
Laughton & Knell (2019)	"Good" food	0.72 [0.42] (-1.28, 2.72)	-25.2 (-101.7, 51.2)	0.09	9
	"Bad" food	-0.66 [0.46] (-2.68, 1.35)	27.4 (-49.7, 104.6)	0.08	9

** p<0.01, * p<0.05

Table S2. Citations for empirical datasets

Dataset	Citation (abundance)	Citation (temperature)
Narragansett Bay	(1)	(1)
Lake Greifensee	(2)	(2)
Lake Geneva	(3)	(3)
Tea Tortrix Moth - Japan	(4)	(4)
Wadden Sea	(5-6)	(7)
Greece	(8)	(8)
Bermuda	(9)	(9)
Portal, Arizona	(10)	(10)

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