Phendulum: A first principles model of describing savanna phenology

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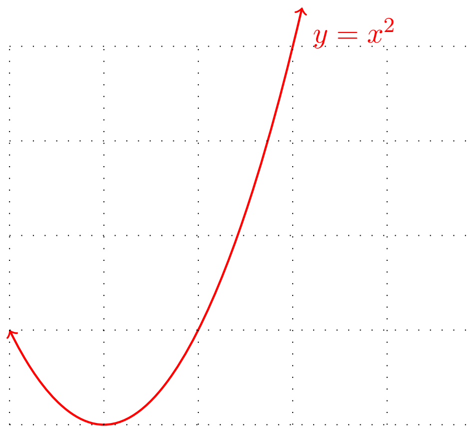
1 Introduction

The reasoning behind this idea is that global phenology, at a very basic (and possibly incorrect level), operates in simple harmonic motion. The underlying signal can be simply described as:

$$\Theta(t) = \Theta_0 \sin\left(\frac{t\pi}{T}\right) \tag{1}$$

where t is some arbitrary point in time, Θ_0 is the initial amplitude or angle from the perpendicular and T is the period (or frequency).



Tree and grass phenology can be represented by two pendulums, where both are coupled to one another via soil water status of the soil layers.

The amplitude of the pendulum changes at an annual time-step and is linked to the soil water content of the root zone and volume of incoming rainfall. For trees, that access deeper soil water stores, the amplitude of the signal is small, but for grasses, whose rooting zone is limited to the upper 0.5 m, their amplitude is much higher, such that $\Theta_g > \Theta_t$.

The period T of the signal is related to the growing season and has a relation to the length of the pendulum by $T = 2\pi\sqrt{(L/g)}$. At this point we assume mass plays no role in the motion of the pendulum (untrue as we could relate plant height), but we will get to that later.

We also ignore the effect of temperature on phenology (although this will be added in)

The key is then to translate this underlying signal into the way a model activates the plant it simulates and the allocation of leaf area to overall plant leaf area index.