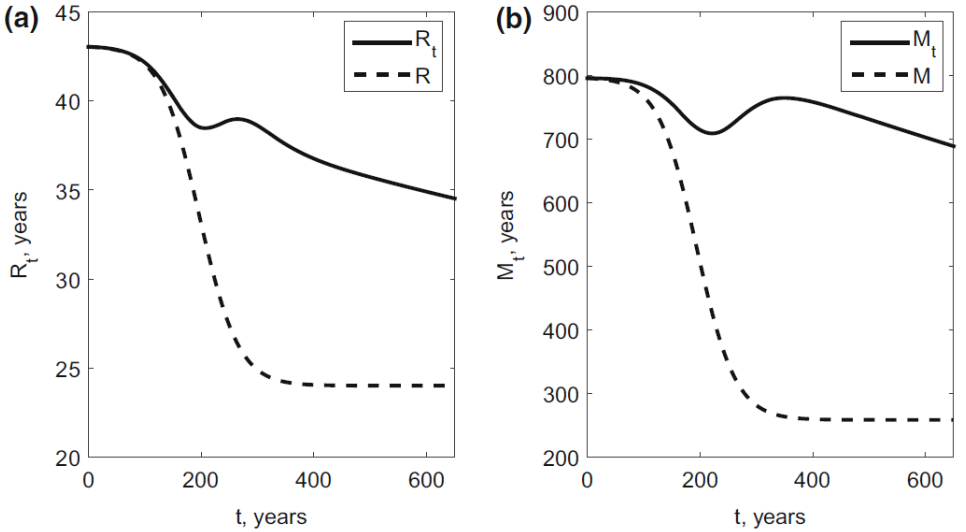
Modeling the Carbon Cycle as a Nonautonomous System

Objective:

To understand transit time and mean age dynamics of terrestrial carbon storage with time-dependent parameters and inputs.

Approach:

- We developed a theory for transit times and mean ages within nonautonomous compartmental systems.
- We employed the McKendrick-von Förster equation to show the mean age of mass in a compartmental system satisfies a linear nonautonomous ordinary differential equation that is exponentially stable.



Using our nonautonomous theory for representing a nine-pool terrestrial carbon cycle model, we showed an order of magnitude difference in the absolute values of mean transit time, R_t, and mean age, M_t. Moreover, significant differences were shown between these nonautonomous properties and the instantaneous quantities, *R* and *M,* which represent the autonomous model.

Results/Impacts:

- We applied the theory to a nine-dimensional terrestrial carbon cycle model.
- We demonstrated the nonautonomous versions of transit time and mean age differ significantly from the autonomous quantities when calculated for that model.
- Results indicated the average age of carbon stored on land is much larger than the average age of carbon leaving the land.

Rasmussen, M., A. Hastings, M. J. Smith, F. B. Agusto, B. M. Chen-Charpentier, **F. M. Hoffman**, J. Jiang, K. E. O. Todd-Brown, Y. Wang, Y.-P. Wang, and Y. Luo (2016), Transit times and mean ages for nonautonomous and autonomous compartmental systems, *J. Math. Biol.*, doi:10.1007/s00285-016-0990-8.