Overview of the Simsphere Model Package

Welcome to Simsphere, a state-of-the-art Soil-Vegetation-Atmosphere Transfer (SVAT) model for use by the general scientific community. Simsphere is the product of 30 years of continuous use by myself (Toby Carlson) and my students at Penn State, so it has been thoroughly tested under many different conditions and almost never crashes when reasonable parameters are used as input.

Simsphere is a one-dimensional model that simulates the transfer of heat and moisture among plants, soil and atmosphere over a time period up to 24 hours specified by the user. The model demonstrates the evolution of the sensible, latent, radiative and other energy fluxes among a vegetated or bare soil surface, the soil and the atmosphere. Simsphere also describes the evolution of the atmospheric sounding, moisture, temperature and wind during the course of a day.

Three decades after its launch in the 1980s, Simsphere is still one of the best models of its kind. Feel free to use the model any way you please. You may download the Fortran 90 code, incorporate any or all of the components (subroutines), cannibalize them into new models, or simply use the present version. The package is tested and builds on Linux and Windows platforms; use in other compute environments may require some adaptation of the code.

You don't need to know much about meteorology, plant physiology or soil dynamics to use Simsphere. However, the underlying mathematical descriptions of these processes within the model are detailed and complex and include components that handle plant water storage, alternate stomatal resistance formulations, water content as a function of height in the soil, etc. The effects of these various model components on the runtime results can be explored by varying component settings available in the model configuration files. Follow the model input parameter links on the Simsphere website resources page for detailed descriptions of these configuration parameters.

The workbook is a Simsphere tutorial leading users on a step-by-step tour of increasing complexity through the model. Features such as the behavior of plants under stress, the creation of the turbulent mixing layer in the atmosphere, and the drying of soils are cover in the various chapters. The workbook provides a mathematical description of the model components and an extensive background description, including a discussion of the science behind the equations. Each chapter concludes with illustrative simulations for hands-on use by the student. Not all simulations provided in the workbook are fully tested due to their complexity. If one does not work properly, please contact me. A common reason for crashing the model is untenable initial parameters. Such a result can teach the student a valuable lesson about situations that are not possible in a real biosphere.

Finally, the "Archived Resources" link on the Simsphere "Resources" page includes a link to resources that are included for historical purposes to document certain stages of model development. Any codes referenced in the "archives" section may contain errors that have been fixed in the current operational version.

The user is free to download all the material on this site. To get started with the model, follow the "Quick Start Guide" on the simsphere website simsphere.ems.psu.edu. I welcome all who wish to contact me for help in understanding Simsphere. I once knew every line in the code and every equation in the model, but I may no longer remember every facet of Simsphere, including compilation procedures for the code. Although I might not be able to help you with machine or I/O problems, I urge you to contact me about the science or applications of Simsphere. My email is tnc@psu.edu and my office phone is 814-863-1582. Leave a message on my phone, as I am usually away from my desk.

Here are references to some published papers relevant to understanding Simsphere:

Carlson, T. N. and B. H. Lynn, 1991: The effects of plant water storage on transpiration and radiometric surface temperature. *Agricultural and Forest Meteorology*, **57**, 171-186.

Grantz, D. A., X. Zhang and T. N. Carlson, 1999: Observations and model simulations link stomatal inhibition to impaired stomatal conductance following ozone exposure in cotton. *Plant, Cell, and Environment*, **22,** 1201-1210.

Lynn, B. H. and T. N. Carlson, 1990: A stomatal resistance model illustrating plant vs. external control of transpiration. *Agricultural and Forest Meteorology*, **52**, 5-43.

Olioso A., T. N. Carlson T.N. and M. Bresson, 1996: Simulation of diurnal transpiration and photosynthesis of a water stressed soybean crop. *Agricultural and Forest Meteorology*, **81**, 41–59.

Petropoulos, G. P., M. R. North, G. Ireland, P. K. Srivastrava, and D. V. Randall, 2015: Quantifying the prediction accuracy of a 1-D SVAT model at a range of ecosystems in the USA and Australia: evidenced towards its use as a tool to study Earth's systems interactions. *Geosci. Model Dev.*, **8**, 3257-3284.

– Toby Carlson