# Daisy world mini-project

The goal of this project to gain understanding:

* How a simulation works.
* Get a better understanding of positive and negative feedbacks.
* Understand the concept of hysteresis.
* Get familiar with programming.

The Daisyworld model was used by Watson and Lovelock to exemplify how the biosphere could foster ‘homeostasis’ (or equilibrium) within the Earth’s climate following the Gaia hypothesis. While we are not interested in the original idea in the Gaya hypothesis, suggesting that the biosphere behaves like a single super-organism aiming -intentionally- at obtaining a self- regulatory effect on the Earth’s environment. We recognize that the Daisyworld model is a nice example illustrating the potential role of the biosphere in controlling/ modifying local and global climate.

With the following equation you can write a code which is able to find the equilibrium temperature of the hypothetical planet exposed to a certain amount of solar radiation. The equilibrium temperature will depend and the planets albedo, which will change due to the birth and death of black and/or white daisies.

**Final goal:** find the equilibrium temperature for a range of radiations ().

# Daisy world equations:

Incoming solar radiation is given by,

where, L [-] can be interpreted as the brightness of the sun, called the luminosity. St is the solar constant [Wm-2].

where, is Stefan-Boltzmann constant ( Wm-2K-4). is the albedo of the Daisy World, defined as,

where, area and stand for the area in [m-2] and the albedo [-]. The subscripts *(g, b and w)* denote *(barren) ground, black daisies and white daisies*, respectively. The area barren ground () is defined as,

For simplification, the total area of the planet () is set to 1 m-2, such that the 3 types of area’s (barren, white daisies, black daisies), also match the ratio of the planet. For example, if , then 0.25 m-2 (and 25%) of the planet is covered with white daisies. The change in area of daisies is determined by the birth and death-rate, where we keep the death rate constant. The birthrate is depended on the local temperature,

where, [K] is the white daisy local temperature, [K] is the horizontal insulation, which is a measure of the heat advected across the white daisy area.

where, [K] is the black daisy local temperature. As said, the birth rate of daisies depends on the *state* variable (i.e. non-constant variables) temperature,

where, is the birth rate in [m-2t-1], [m-2T-1t-1] is the growth rate parameter, [K] is the optimal growing temperature of the white daisies. This birth rate is plugged into the equation for the change in area of white/black daisies [m2t-1], below given for the white daisies.

where, is the death rate [t-1]. The change in are is simply given by the simple forward Euler integration, i.e. . In our equation, setting the time step (*dt)* at 1 is sufficient to get stable results. Thus, the area after one time step is given by,

We now have all the formulae’s to perform the simulation. If the updated area () is different from , it will alter the albedo of the planet () and will lead to a different temperature ().

# Default settings

Please use the following variable names for the parameters, this will help me, help you!

|  |  |  |  |
| --- | --- | --- | --- |
| **Daisy parameters** | | | |
| **Equation symbol** | **Python variable name** | **Value** | **Unit** |
| q | hor\_ins | 20 | [-] |
| = | deathrate | 0.2 | [t-1] |
|  | WD\_albedo |  | [-] |
|  | BD\_albedo | 0.25 | [-] |
|  | opt\_temp\_W | + 273.15 | [K] |
|  | opt\_temp\_B | 22.5 + 273.15 | [K] |
|  | growth\_rate\_temp |  | [m-2T-1t-1] |
| **Initializing start values of daisies** | | | |
|  | WD\_area | 0.01 | m2 |
|  | BD\_area | 0.01 | m2 |
| **Global parameters** | | | |
|  | Stefan\_Boltzmann |  | Wm-2K-4 |
|  | barren\_albedo | 0.5 | [-] |
|  | DW\_area | 1 | [m2] |
| dt | Dt | 1 | [time] |
| St | solar\_constant | 1000 | Wm-2 |