

## ATMS211 CLIMATE CHANGE

### Announcements:

- 1) The textbook for this class is now available on reserve at Odegaard Library (Ref: QH331 .K798).
- 2) **Bonus Credit Opportunity**  
TV Program re US Policy on Climate Change:  
"Now" with Bill Moyers  
9-10pm Friday 23<sup>rd</sup> Jan  
KCTS Seattle (PBS Stn, Channel 9)  
1 page description of the program

## Equilibrium

"A state of a system in which forces, influences, reactions, etc balance each other out so that there is no net change"

OR

State of a system from which there is no tendency to change unless subjected to an external forcing.

### FEEDBACK LOOP:

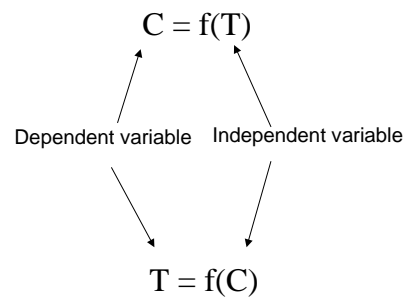
- count up the number of negative couplings
- **odd** means "**negative**"
- **even** or zero means "**positive**"

## Welcome to Daisyworld

- Planet same size as Earth
- No clouds
- No greenhouse gases
- 1 species of plant:  
White Daisies

## Functions and Variables

Daisy coverage (C) is a function of surface temperature (T)



Surface temperature (T) is a function of daisy coverage (C)

## Physical Relationships

Daisy coverage (C) is a function of surface temperature (T)

$$C = f(T)$$

Life responds to temperature.  
There is an optimal temperature for daisy growth.  
Daisy coverage increases as you get closer to that optimum. (and conversely...)

Surface temperature (T) is a function of daisy coverage (C)

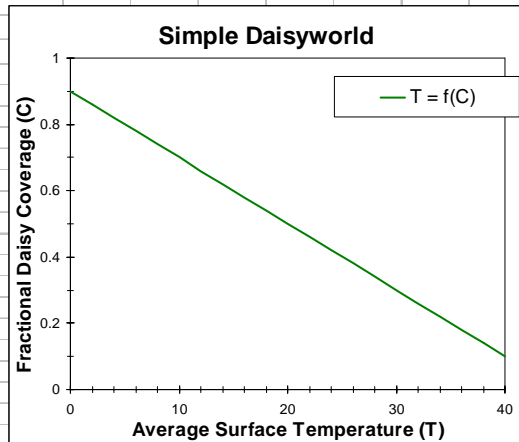
$$T = f(C)$$

Daisies are white, therefore reflect sunlight.  
Reflectivity (or "albedo") of planet responds to daisy coverage. Planetary temperature cools as more sunlight is reflected away. (and conversely...)

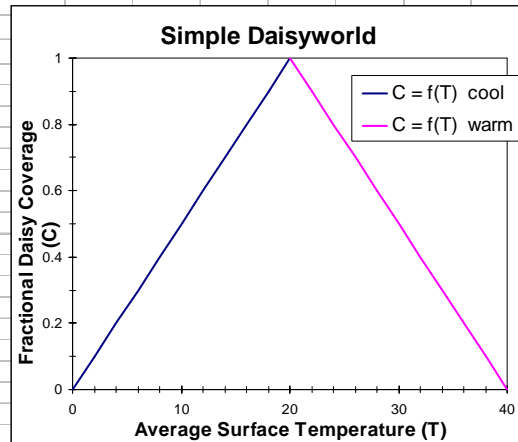
Effect of Daisy coverage on Temperature

C	T = f(C)
0.90	0
0.86	2
0.82	4
0.78	6
0.74	8
0.70	10
0.66	12
0.62	14
0.58	16
0.54	18
0.50	20
0.46	22
0.42	24
0.38	26
0.34	28
0.30	30
0.26	32
0.22	34
0.18	36
0.14	38
0.10	40

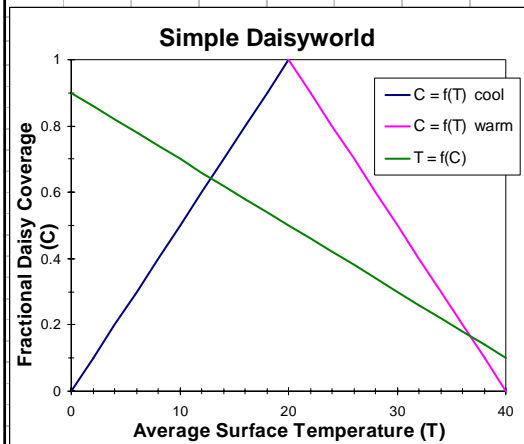
## Temperature as a function of Daisy Coverage



## Daisy Coverage as a function of Temperature



### Equilibrium Points



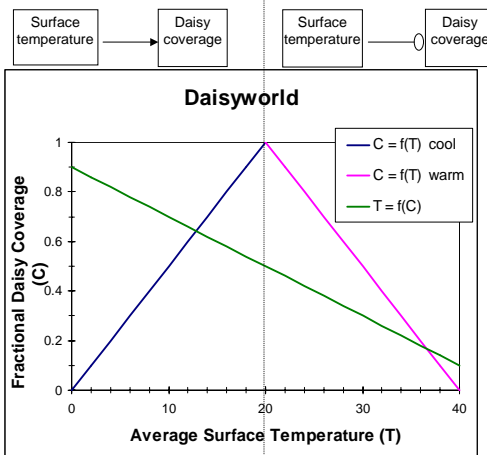
-- Equilibrium Points --

	T	C
cool	12.9	0.64
warm	36.7	0.17

### In-class activity

Cool Climate Regime

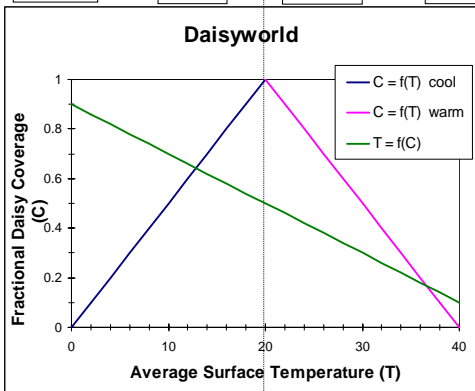
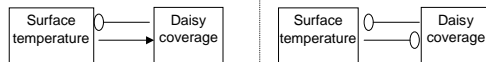
Warm Climate Regime



### In-class activity

Cool Climate Regime

Warm Climate Regime



1 negative coupling (odd)

2 negative couplings (even)

negative feedback loop

positive feedback loop

STABLE

UNSTABLE