EOSC 112: Lecture Summary: Friday, September 21

Text Coverage: Feedback loops/Daisy World continued, pp. 26-31

Review:

Last lecture we looked at positive and negative feedback, as described in Chapter 2. Some key concepts:

- Systems consists of *components* (reservoirs, attributes, subsystems) linked by positive or negative couplings.
- In a positive coupling, a change in one component leads to a change in the same direction (up or down) in another component. vice versa for negative coupling.
- *Feedback* involves the action *and* reaction of coupled components.
- Sign of the feedback depends on the product of the signs of the couplings.
- Systems can be characterized by *equilibrium states*, which don't change unless they are disturbed.
- Disturbances can be either *perturbations* (short time) or *forcings* (long time).

  Question: What are some example climate perturbations?

  - Volcanos
  - Meteor impact
  - Nuclear winter
  - Kuwait oil fires

  Question: What are some example climate forcings:

  - Solar luminosity
  - Orbital variations
  - Pollution – fossil CO_2, CFCs, sulphate aerosols, jet contrails

  Note that none of these forcings and perturbations depend on temperature.

- Negative feedback loops can produce *stable* equilibria, while positive feedback loops produce unstable equilibria. A single system can have multiple equilibria, positive and negative.

Daisyworld–demonstration of stable and unstable equilibria:

- Daisyworld is characterized by two couplings:
  - The dependence of T_{sfc} on daisy coverage, which can be calculated by a slightly modified version of the lab1b spreadsheet. The actual (optional) spreadsheet can be downloaded from here , a pdf image of the page is here

  - Figure 2-7 just shows what we found in the lab – as the albedo goes up, less sunlight is absorbed, and T_{sfc} goes down.
  - The second coupling is biological – this is the dependence of daisy coverage on T_{sfc} and is shown in Figure 2-9.

- The equilibrium points are determined by the values of (T_{sfc}, daisy coverage) that satisfy both these coupling equations – i.e. the intersection points of the two curves.
- To determine the stability of these equilibria, do a *perturbation analysis* i.e. – pull up a bunch of daisies, or plant some, and see how the system responds. (Figure 2-11).
- You could also goose the surface temperature, but it's more realistic to increase T_{sfc} by increasing the luminosity, which moves the daisy-T_{sfc} coupling curve – see Figure 2-13.
- Question: Why would the dependence of daisies on temperature shift over time?
- Many climate modeling studies report the *feedback factor* for various processes, given by:

$$f = \frac{\text{temperature change with feedback}}{\text{temperature change without feedback}} = \frac{\Delta T_{eq}}{\Delta T_0} \tag{1}$$

- In the lab this week you found ΔT_0 for a 4 $\mathrm{W\,m^{-2}}$ radiative forcing with no feedbacks, As explained on p. 51, most models give $\Delta T_0 \approx 1.2$ °C for a 4 $\mathrm{W\,m^{-2}}$ radiative forcing. When feedbacks are turned on, these same models give $\Delta T_{eq} \approx 3 - 5$ °C, so f for these models is about 3-5.
- Chapter 3, p. 51 lists four large feedbacks:
  - Water vapor – positive (Lindzen disagrees)
  - Infrared flux – negative – this is what's keeping us near a comfortable equilibrium point.
  - Ice albedo feedback – positive – this is very important in climate simulations of northern latitudes, see the simulation results here.
  - Cloud feedback – high cloud, low cloud and cloud aerosol.

    cloud feedbacks these are all very uncertain – even the sign is in question.
  - There are other crucial feedbacks that involve the ocean, to be discussed in coming weeks.

Chapter 4: The Atmospheric Circulation – pp. 53-58.

The current world climate can be summarized in terms of a number of *climate regimes*, shown here.

They are the product of:

- Latitude and its influence on solar radiation received.
- Air mass influences.
- Location of global high and low pressure zones.

- Heat exchange from ocean currents.
- Distribution of mountain barriers.
- Pattern of prevailing winds.
- Distribution of land and sea.
- Altitude