EOSC 112: THE FLUID EARTH

INTRODUCTION TO EARTH SYSTEMS - SIMPLE CLIMATE SYSTEMS

Sys12
Read: Kump et al. Chap.2, p. 18-22, 26
Check: Key Terms, Rev. Questions, Problems 1, 2.

Objectives:

1. **To learn how to define the characteristics of a system**
2. **To learn how to build a simple climate system**
3. **To learn how to describe the behaviour of a simple climate system**

1. Definitions

- **System:** A **system** is an entity composed of parts called **components** that are linked and interact through **couplings**.
- **State:** The **state** of a system is the set of important attributes that characterise the system at a particular time.
- **Coupling (positive):** A **positive coupling** describes an interaction in which a change in one component leads to a change of the SAME direction in the linked component.
- **Coupling (negative):** A **negative coupling** describes an interaction in which a change in one component leads to a change of the OPPOSITE direction in the linked component.

- **Feedback:** **Feedback** is a self-perpetuating mechanism of change and response to that change. **Negative feedback loops** tend to diminish the effects of disturbances, while **positive feedback loops** amplify the effects of disturbances
- **Equilibrium:** If the attributes of a system are in equilibrium, the system is said to be in an **equilibrium state**. A **stable** equilibrium state is created by a NEGATIVE feedback loop. An **unstable** equilibrium state is created by a POSITIVE feedback loop
- **Disturbance:** A **perturbation** is a temporary disturbance of a system while a **forcing** is a more permanent disturbance of a system.

2. Build the climate system

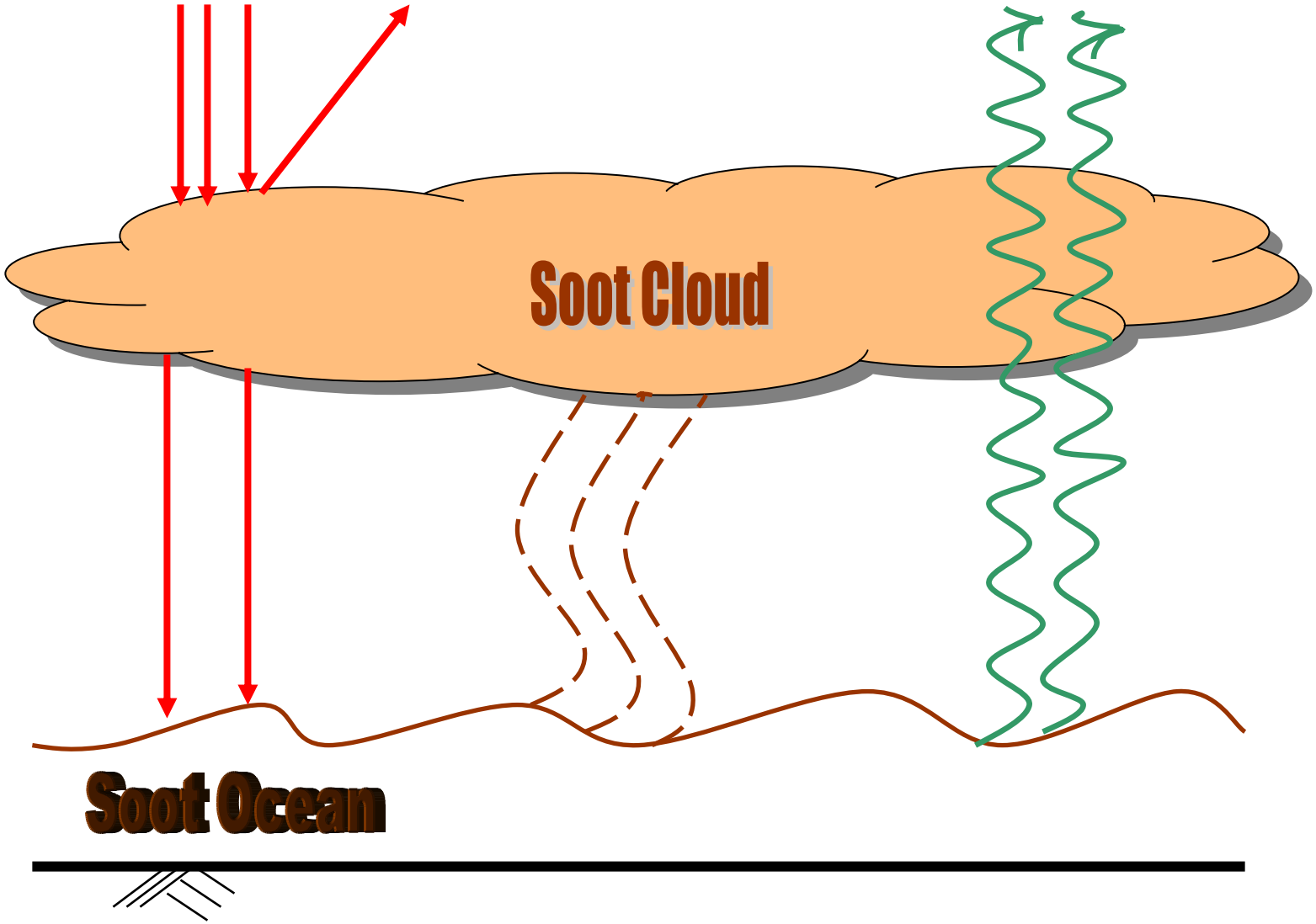
This is best done through examples.

Consider a "dirty planet":

This is a planet covered by an ocean composed of liquid soot. When heated, the liquid soot evaporates and forms clouds. The soot clouds partially reflect the sunlight coming from a nearby sun.

What would be the effect of a temporary change in the amount of sunlight reaching the planet?

Figure representing a “dirty planet”



First step:

Define the components of the system necessary to address the question:

Soot Ocean (O), Soot Cloud (C)

Second step:

Define the state attribute(s) for each component:

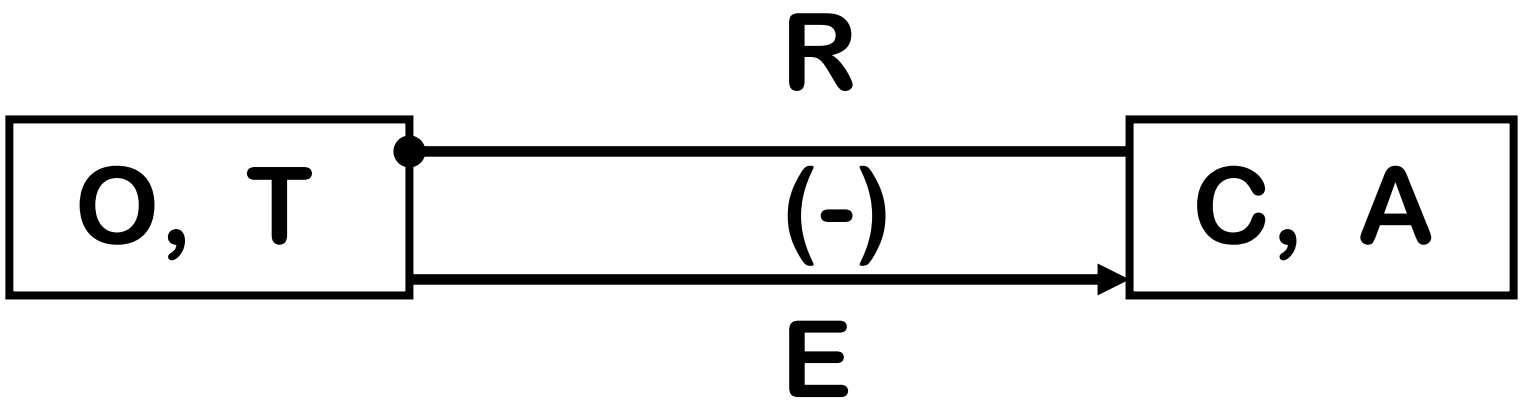
Ocean Temperature (T), Cloud Amount (A)

Third step:

Define the couplings between components:

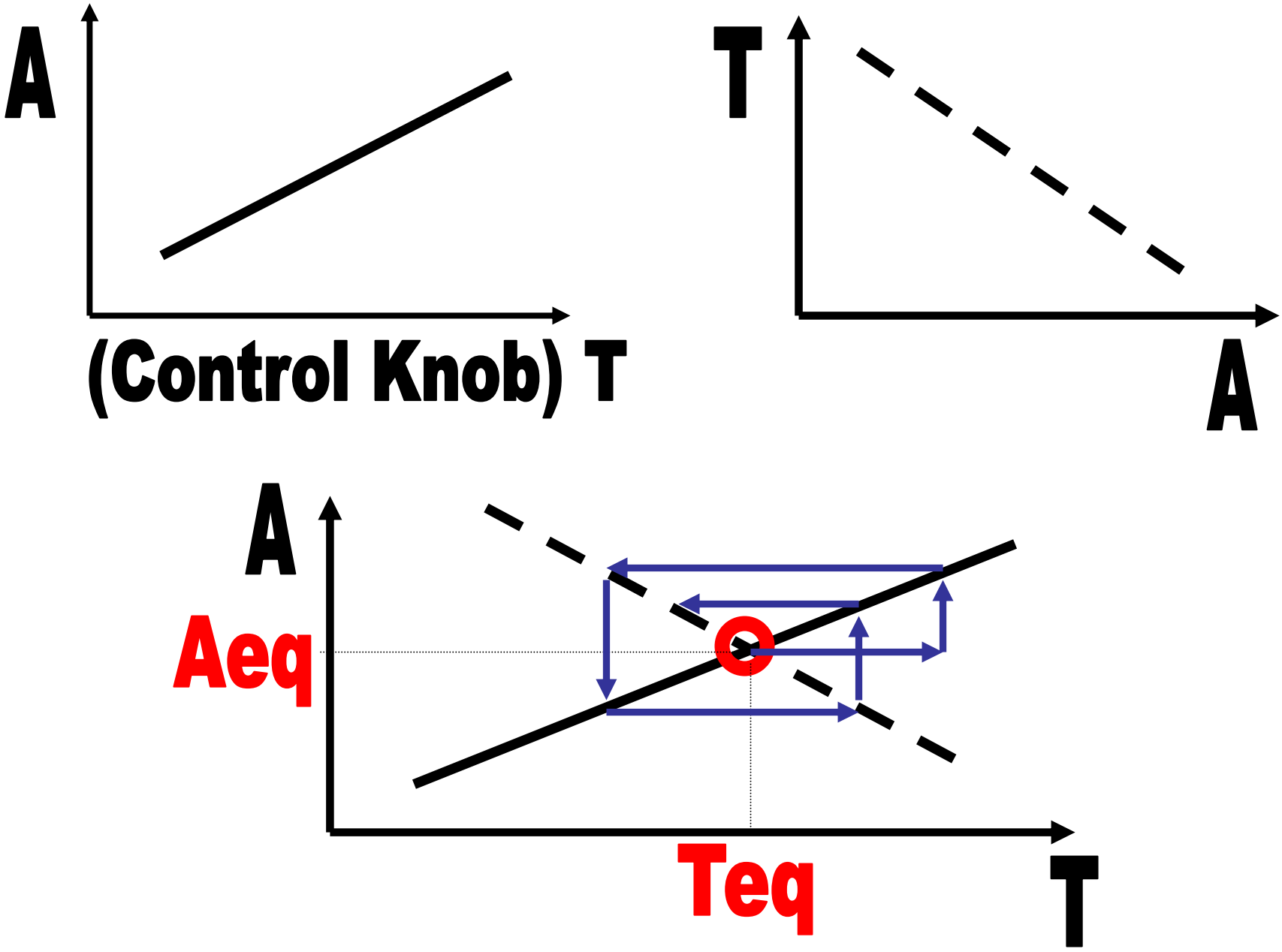
Evaporation (E), Reflection (R)

3. Describe the climate system



E generates a Positive Coupling
R generates a Negative Coupling

} Negative Feedback Loop


A
(Control Knob) T
T
A
A
Aeq
Teq
T

Other examples

Consider the previous example, but use different attributes to characterize the Soot ocean.

Amount of soot: No simple process can be found to link this amount to that of the clouds.

Color: Darkening > More heat absorbed > More E > More clouds > More reflection of sunlight > ???

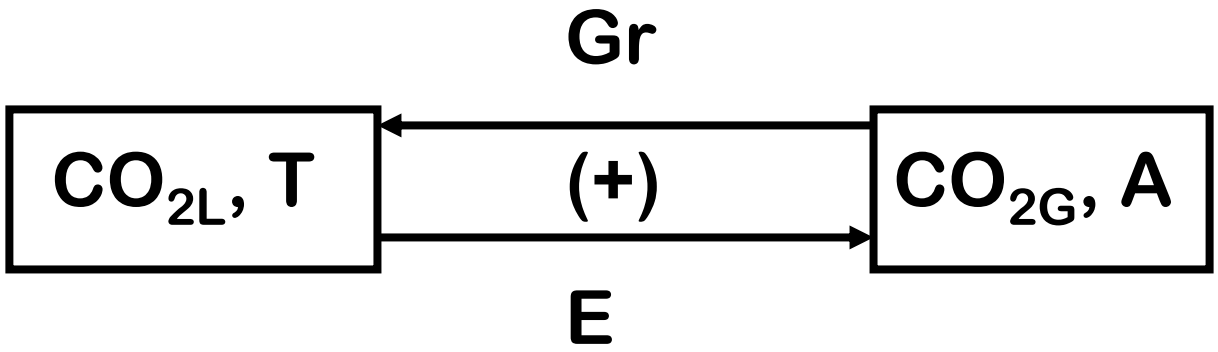
Heat content: determined by T!

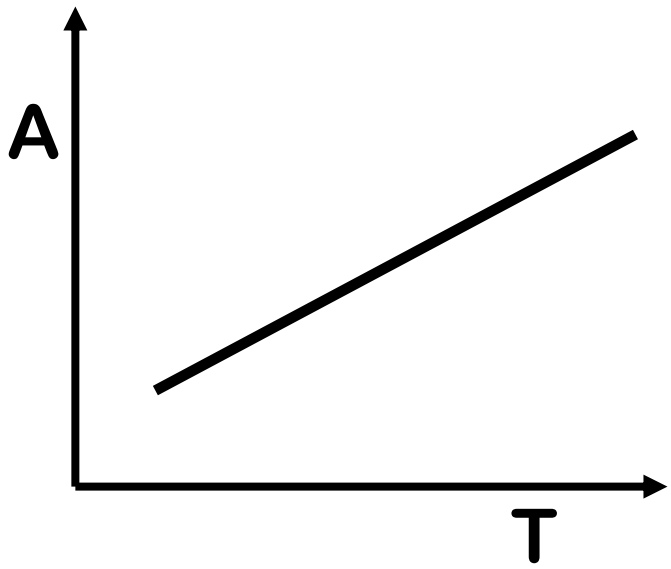
CO_2 example

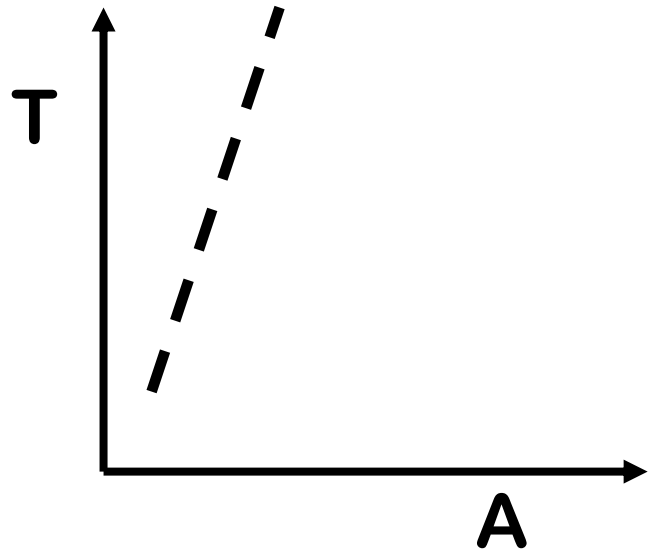
Consider the previous example, but replace the Soot with Carbon Dioxide.

Now, the difference resides in the fact that the thick layer of CO_2 absorbs all the radiation emitted by the ocean surface. The CO_2 cloud then re-emits the radiation (evenly) downward and upward.

What would be the effect of a temporary change in the amount of sunlight reaching this planet?







Description of the climate of the "Greenhouse Planet"