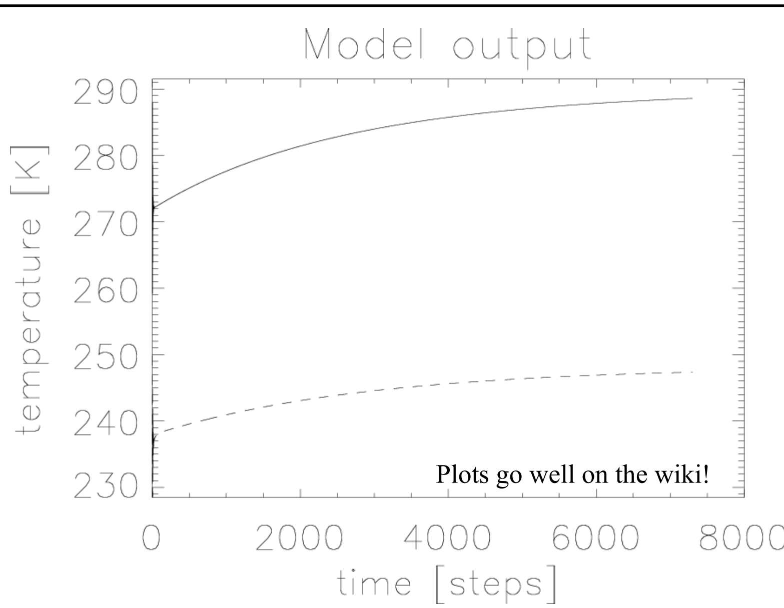
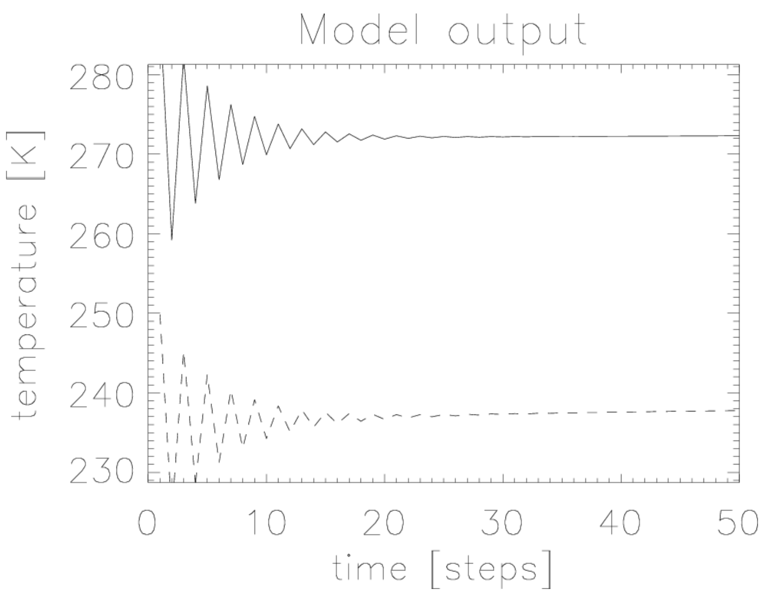
Model behavior

(predictability…)



See example Fortran and IDL plotting code in
~dcn/ATOC7500/week2 on atoc



See example Fortran and IDL plotting code in
~dcn/ATOC7500/week2 on atoc

Discussion

- How can we validate the model?
- How do we double check the model?
- What are 3 more ways to double check the model?
- On what criterion due you choose the drag coefficient k?
- What fraction of the temperature change is due to the water vapor feedback?

- Is the climate sensitivity the same for different epochs? (Today CO2=365 ppmv, preindustrial = 280 ppmv, Last Glacial Maximum CO2 = 200 ppmv)
- Is the water vapor feedback as important for all epochs?
- Is the water vapor feedback linear?
- Are you confident in your findings? Why?

- How does the model change if there is also an albedo feedback? (Is the water vapor feedback more or less important for "snowball Earth"?)
- Consider adding a second box so that there is both a "tropics" and a "polar region", with some meridional energy transport. How does this change the climate sensitivity? Which aspects are most crucial?

Points from greenhouse model

- Climate sensitivity depends on strength of feedbacks
- Non-linear feedbacks can amplify (or damp) variability (or changes in the mean climate)

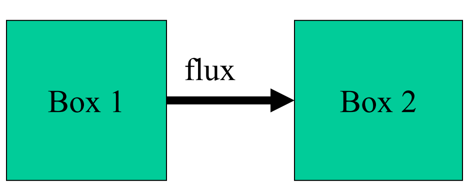
- Feedbacks and gain:

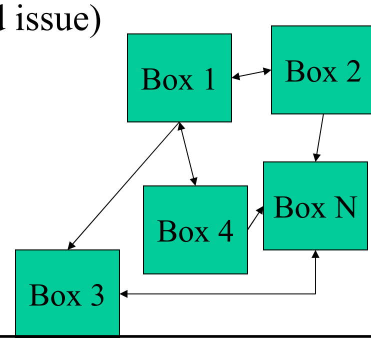
$$\Delta T = \Delta T_{forcing} + \Delta T_{feedback}$$

$$\Delta T = f\Delta T_{forcing}$$

Box models

- Quick, very general
- Can capture fundamental behavior even when governing laws are not well known (e.g., impact of national policies on climate)
- Quantify interactions (strength of feedbacks)
- Assess time scales (a related issue)





Examples…

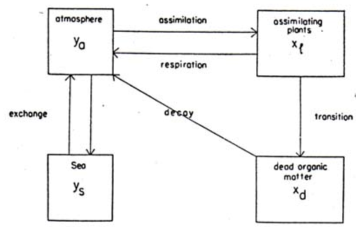
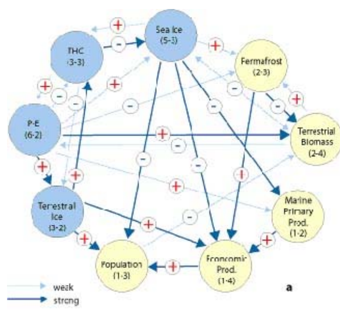
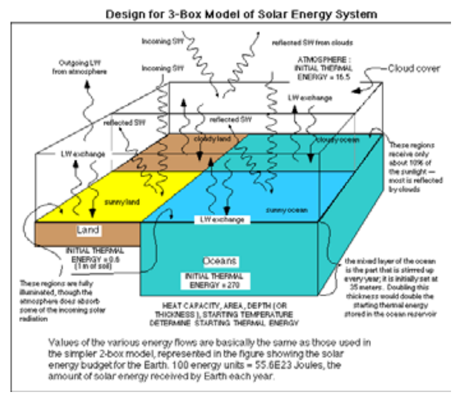
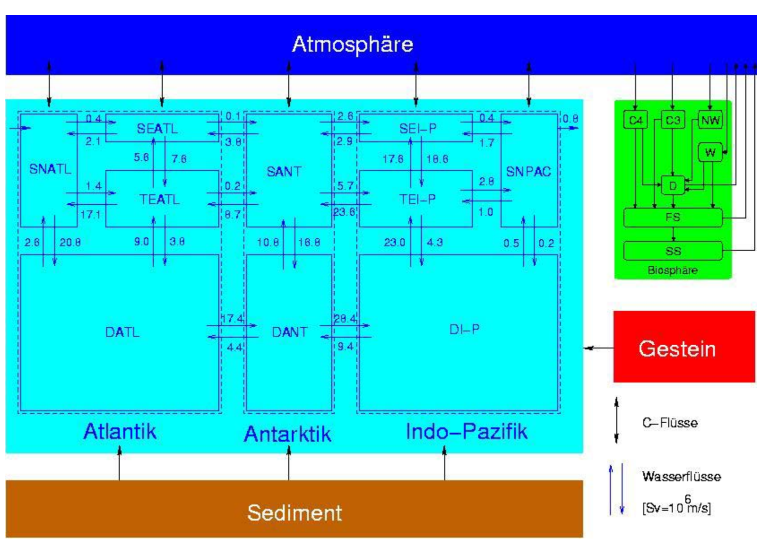


Fig. 1. Simple model of the carbon cycle in nature.





Global water balance/flux model



Dynamical models

(start with a "box model" approach)

Consider a one-layer atmosphere, with a tropical box and a polar box…

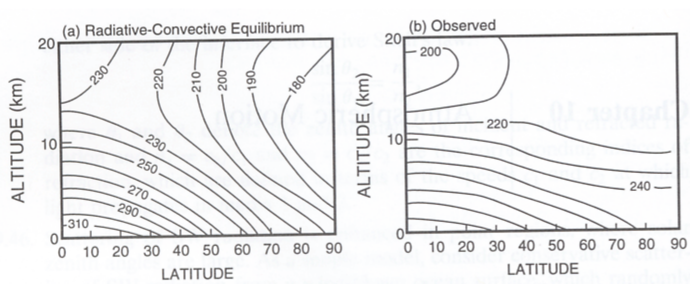


Figure 10.1 Zonal–mean temperature as a function of latitude and height (a) under radiative–convective equilibrium and (b) observed during northern winter. Without horizontal heat transfer, radiative–convective equilibrium establishes a meridional temperature gradient that is much stronger than observed. Sources: Liou (1990) and Fleming *et al.* (1988).

Radiation pushes atmosphere into a baroclinically unstable regime, which generates large scale turbulence (cyclones), that reduces the temperature gradient.

i.e., cyclones move heat.

Model of a mid-latitude cyclone

- Relaxation to radiative equilibrium at north and south boundaries
- Lateral mixing to zonal mean (recharge of air mass)
- Warm air advection to the east, cold air advection to the south
- Circulation change due to and frictional dissipation

Model basis

- Temperature to north, south, east and west
- Circulation (rotation rate/wind speed…)

- Equation for change in circulation
- 4x equations for temperature change
  advection plus mixing (E and W)
  or heating (N and S)

Model assignment

- Construct a model of a circulating midlatitude cyclone that transports heat poleward.
- Science question 2: Given uncertainty in the initial conditions, what is the useful range of a weather forecast?
- Science question 1: What is the difference between the radiative equilibrium equator to pole temperature difference and the “dynamic equilibrium” difference.

Important points:

1. Non-simple behavior exists in even simple models
2. Difference between statistical properties (say, mean, variance), versus a deterministic state
3. How to plot results

(check web site for PDF)