Weather and Climate Prediction

ATM S 380

Course web site
http://www.atmos.washington.edu/academics/classes/2011Q1/380/

Instructor: Professor Cecilia Bitz, PhD in UW atmospheric sciences 1997

Lecture notes and/or ppt will be posted ASAP after class

Learning Goals/Objectives

- How weather and climate models are applied to solving problems in atmospheric sciences
- Use of models and visualization as resources for professional careers in the environmental sciences.
- Basics in numerical methods and high-performance computing
- Phenomenological approach to understanding complex problems
- Empower undergraduates with research skills for independent learning and to assist with university research projects

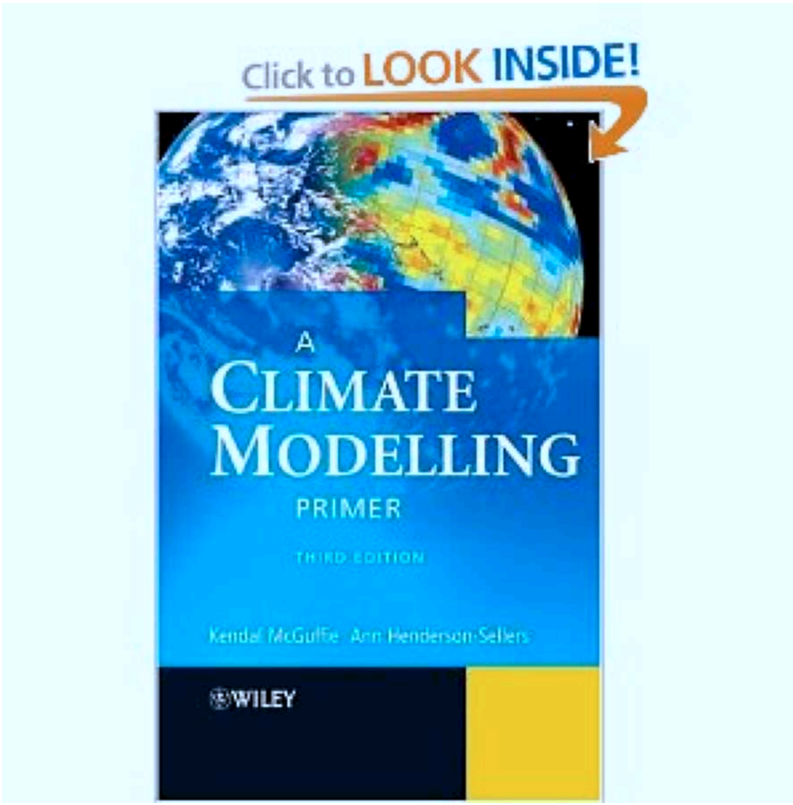
Grading

50% Homework

10% Participation

15% Midterm

25% Final

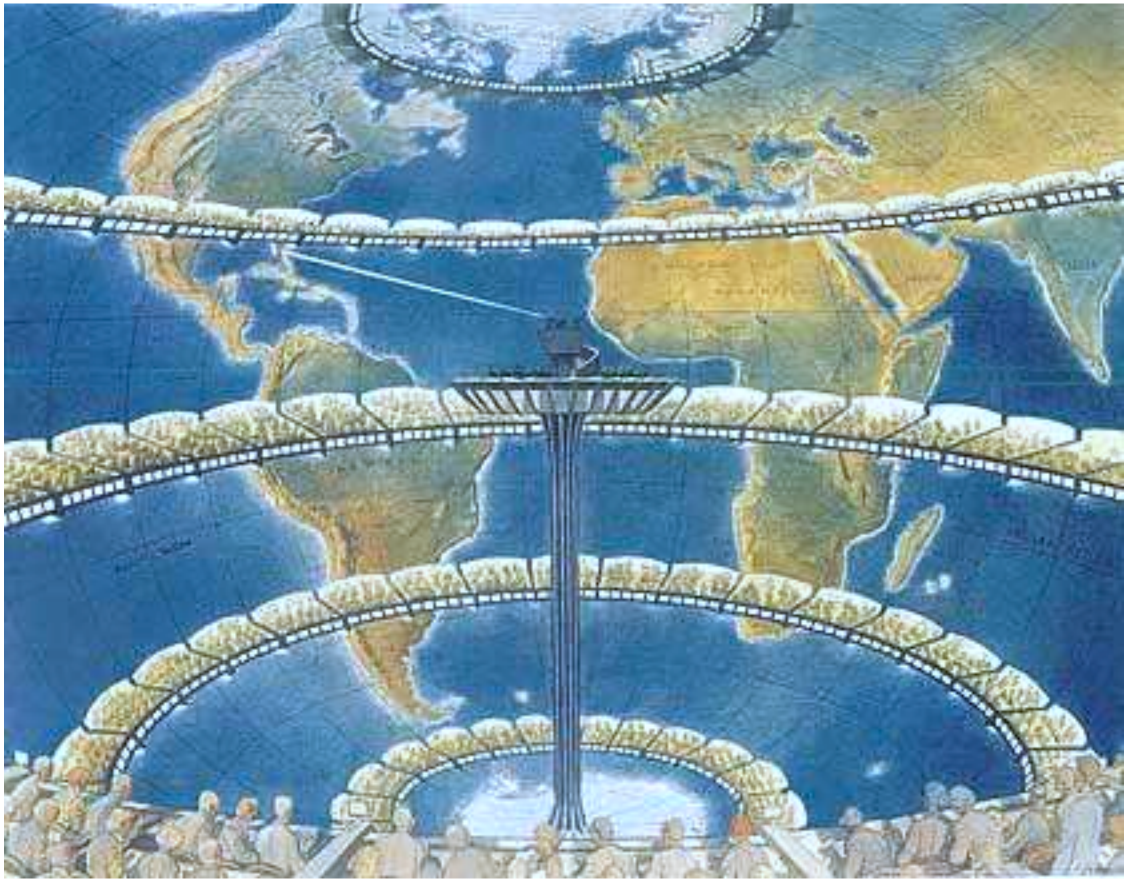


Textbook:

By Kendal McGuffie and
Ann Henderson-Sellers

Third Edition

Additional reading,
especially about weather



Lewis Fry Richardson 1881-1953

“Imagine a large hall like a theatre, except that the circles and galleries go right round through the space usually occupied by the stage. The walls of this chamber are painted to form a map of the globe....A myriad computers are at work upon the weather of the part of the map where each sits, but each computer attends only to one equation or part of an equation.... Numerous little "night signs" display the instantaneous values so that neighbouring computers can read them.” in his book titled *Weather Prediction by Numerical Process*,1922

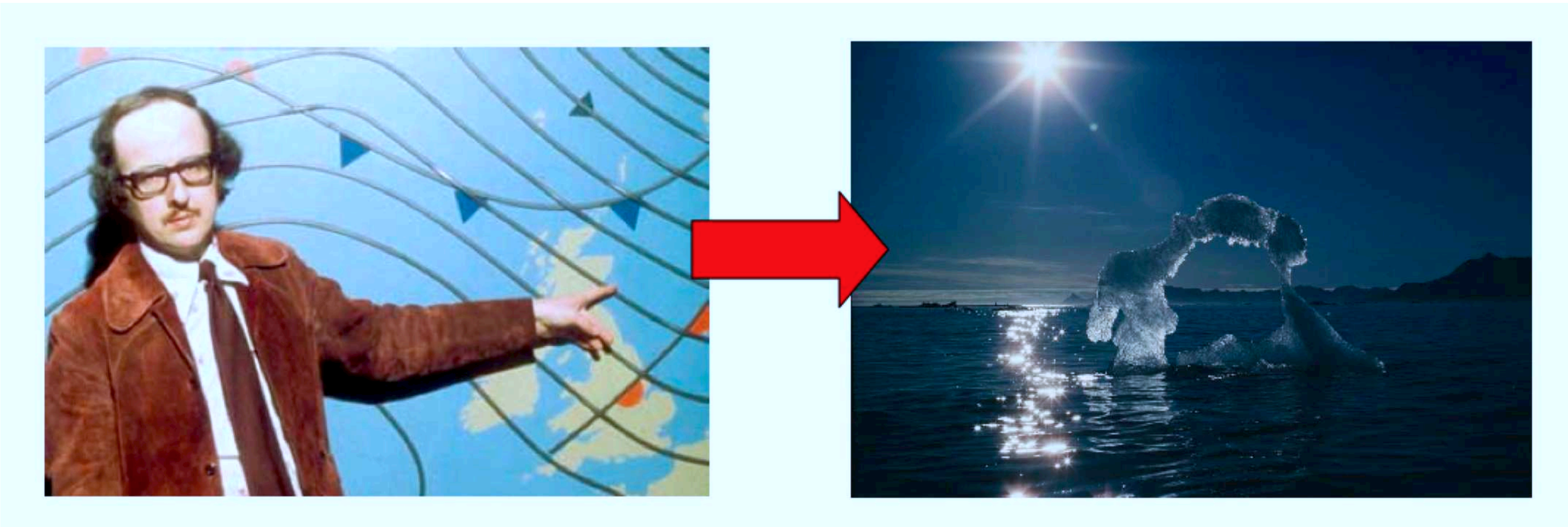
Lewis Fry Richardson 1881-1953

Attempted the first weather prediction, after the fact

It took 2 years and he found
ΔP = 145 hPa in 6 hours

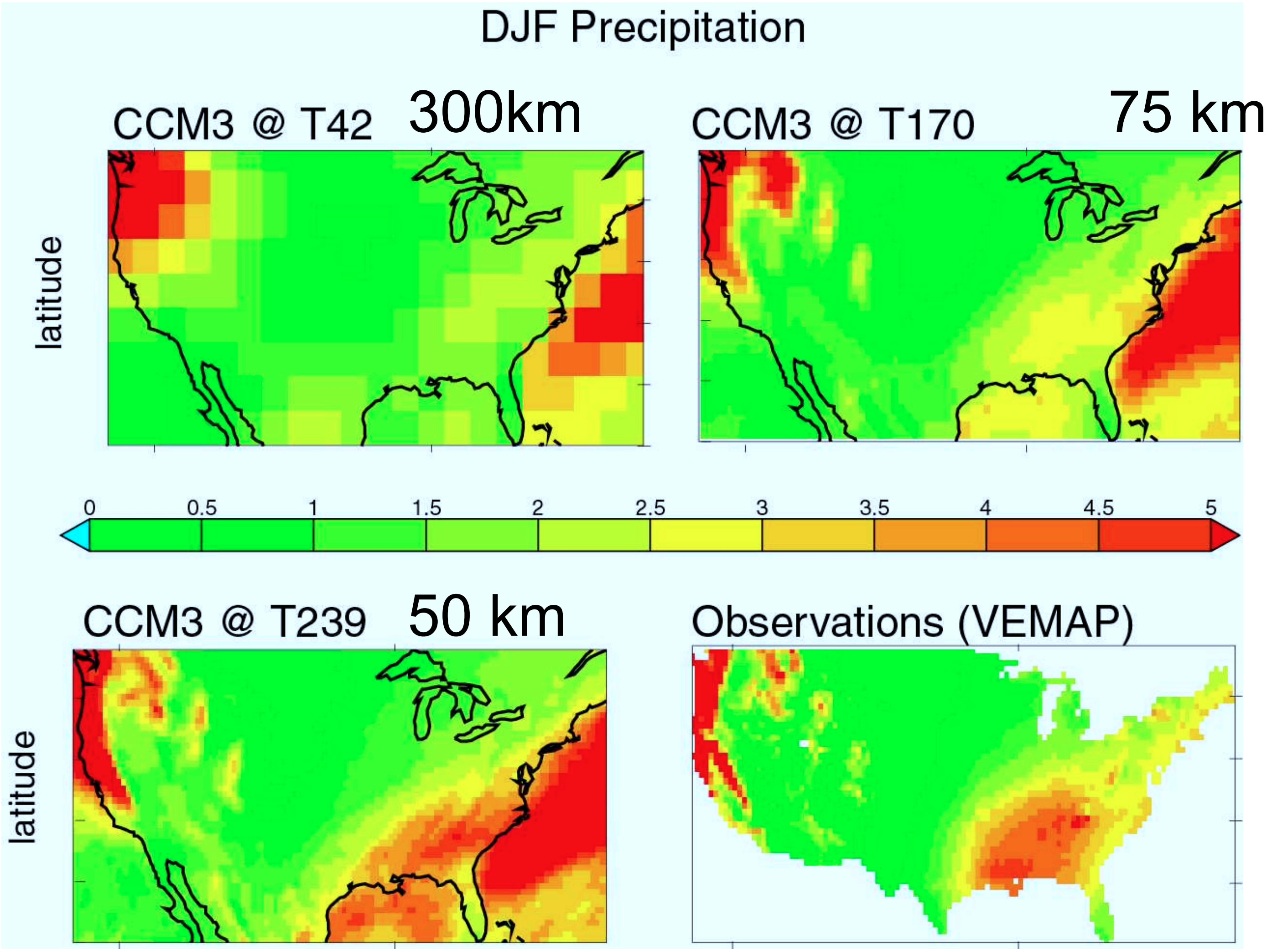
Wrong because he didn't filter the initial conditions to remove gravity waves and his prediction assumed the time derivative of the pressure field was accurate for too long (time step was too long)

Is there a difference between climate and weather?



Palmer, http://www.emetsoc.org/annual_meetings/documents/ems_palmer.pdf

Simulated precipitation as a function of resolution



Duffy, et al

Difference between climate and weather model?

(see two slides forward)

Is one a boundary value problem and one an initial value problem?

(This was the old paradigm. Boundary conditions include things like topography and if considering just the atmosphere the sea surface temperature is a boundary. However, “forcings” like atmospheric composition or solar variability are also frequently considered boundary conditions. We used to think climate depended on BCs while weather was mostly sensitive to ICs. Now we know that seasonal to annual climate prediction also depends on the state of El Nino (an IC to the climate) and weather can depend on sea surface temperature changes.)

How long is the weather predictable? (Storms are predictable for 1-2 weeks, with 2 weeks being rather optimistic in most cases.)

Is climate predictable? (Yes! But not in the same sense as weather. We predict the statics of weather and call that climate. Climate can be predictable as a result of the IC for a few months or years in places where El Nino has a strong influence, perhaps where the ocean overturning circulation has a strong influence (like western Europe), and perhaps where sea ice influences the atmosphere. However, it doesn't take very long in some places before the information from ICs is lost and the trend towards warming from rising greenhouse gases dominates. Greenhouse warming offers another kind of predictability. More about this later in the course.)

What is in a weather model?

Atmospheric general circulation model

- Dynamics
- Sub-grid scale parameterized physics processes

What else is in a climate model?

Oceanic general circulation model

- Dynamics (mostly)

Sea ice model

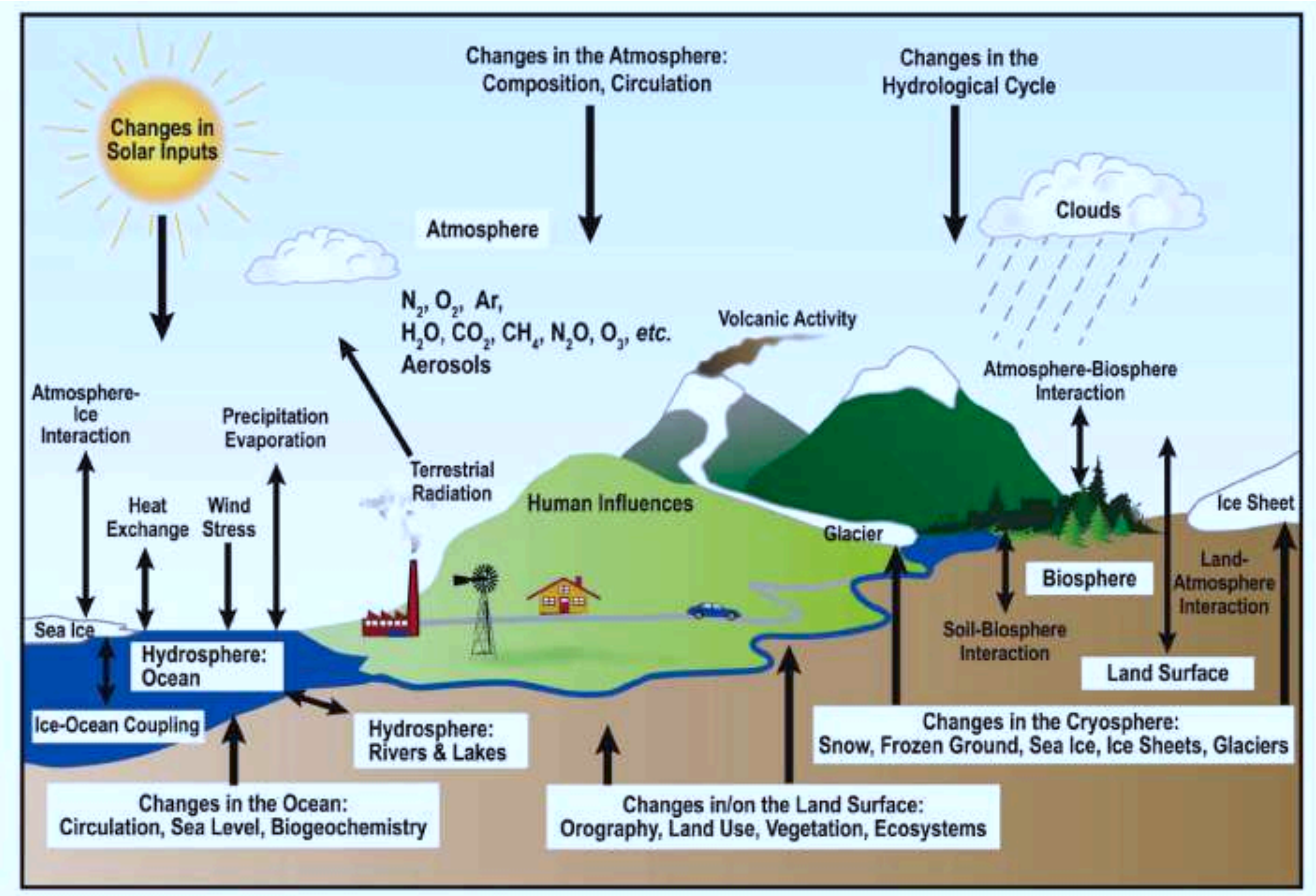
- Dynamics
- Thermodynamics

Land Model

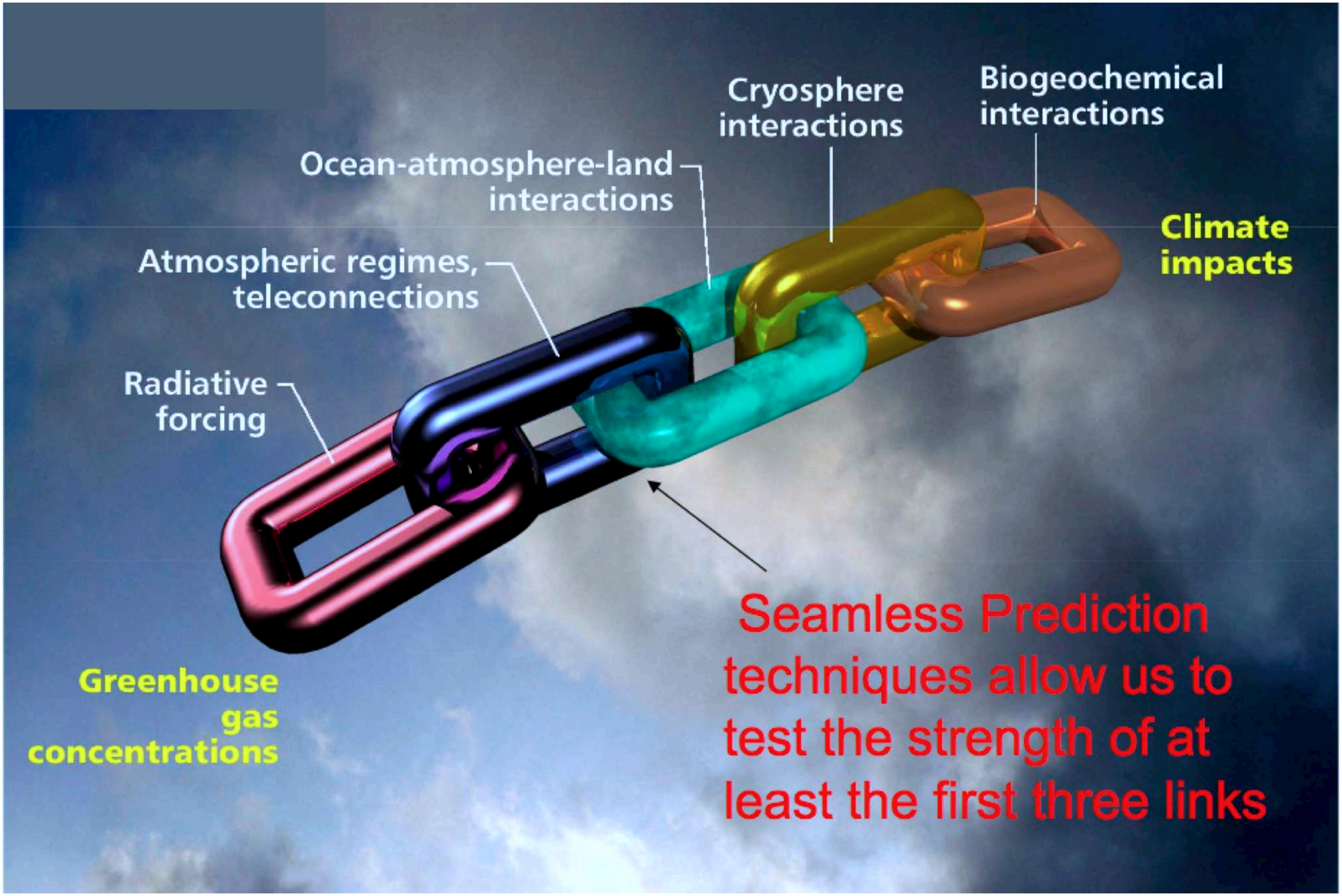
- Energy and moisture budgets
- Vegetation

Chemistry/Biogeochemistry

- Tracer advection and rate equations



FAQ1.2, Figure 1 from [IPCC (2007)]



TOWARD SEAMLESS PREDICTION Calibration of Climate Change Projections Using Seasonal Forecasts BY T. N. PALMER, F. J. DOBLAS-REYES, A. WEISHEIMER, AND M. J. RODWELL, 2008

Computational demands

Historically, models have been limited by computer power

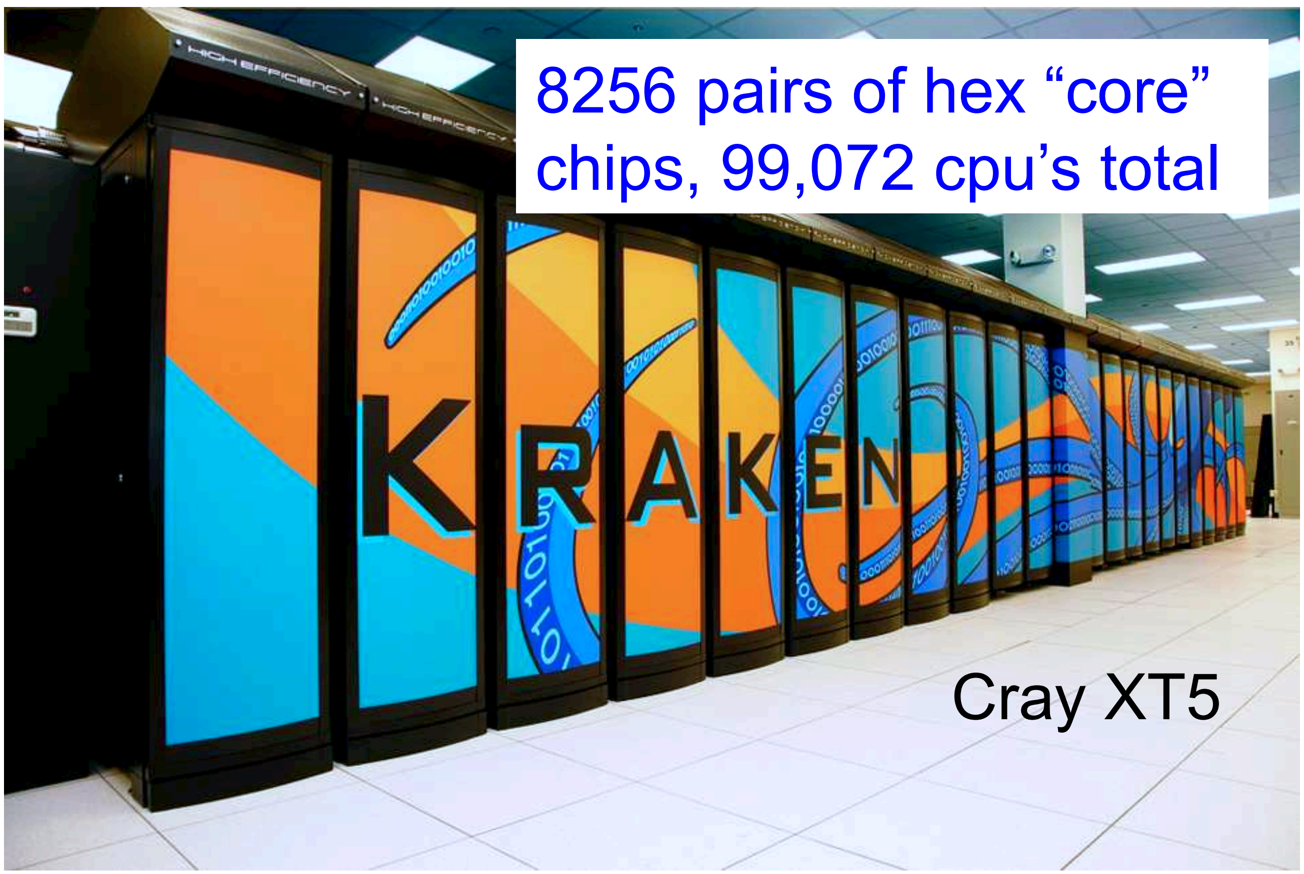
1990 Atmosphere Model Intercomparison Project (AMIP1): Many modeling groups required a calendar year to complete a 10 year integration. Typical grid resolution was ~5^o (64X32x10)

Now a fully coupled earth system model completes many simulated years per actual day

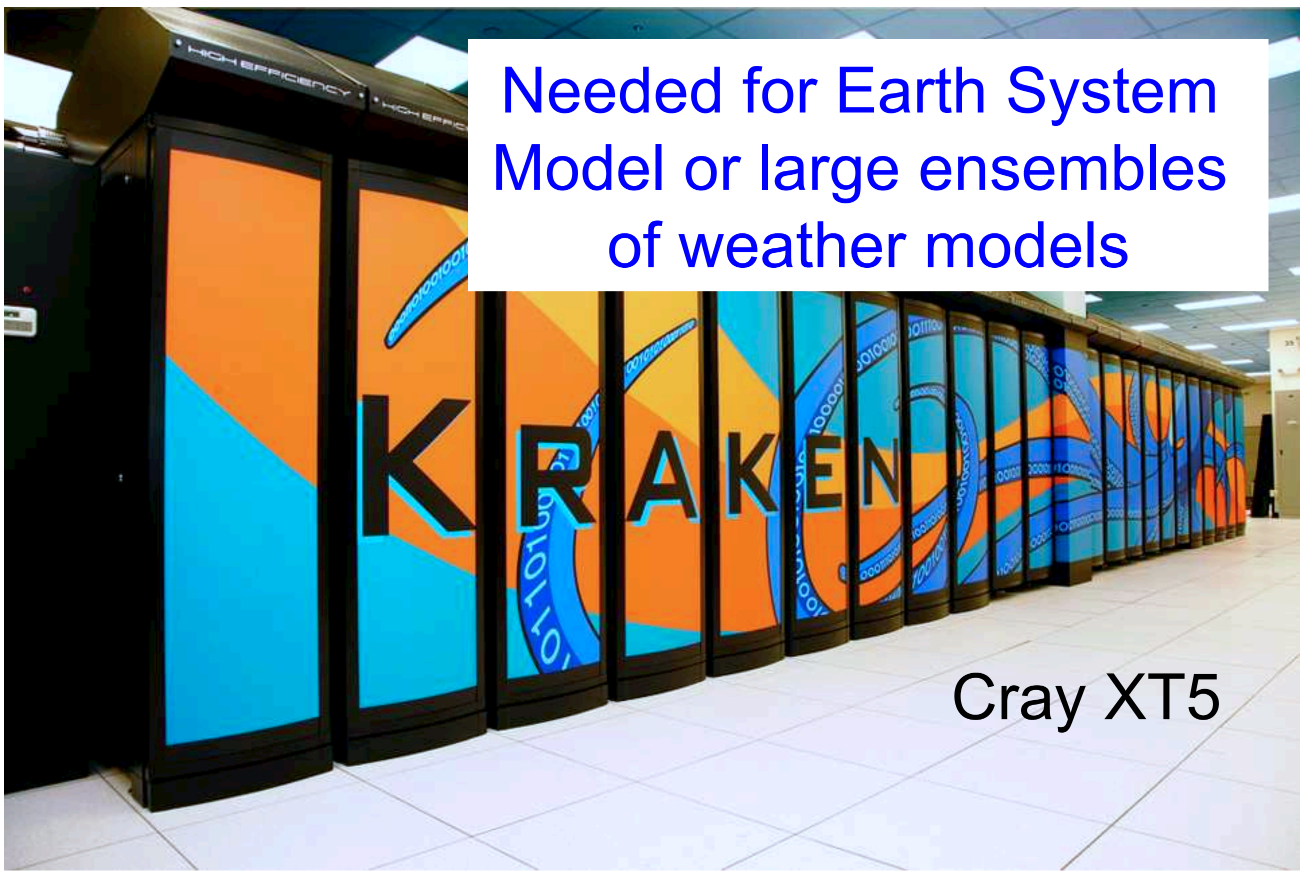
- Typical simulation is multi century.
- Atmosphere resolution is ~1^o (288X192x26)
- Ocean is ~1^o (384X320x80)
- Achieved by running on hundreds to thousands of processors or cpu's

Modern Computers:

Our cluster: 20 workstations
Each with a pair of quad "core" chips
160 cpu's total



We can run an atmosphere model with specified sea surface temperature (SST) or shallow “slab” ocean model (SOM)



Needed for Earth System Model or large ensembles of weather models

Cray XT5

The second assignment I will have you run the Community Atmosphere Model (CAM) at 1° resolution

A component of the Community Earth System Model (CESM), developed by the National Center for Atmospheric Research.

Also includes:

- Parallel Ocean Model (POP)
- Sea Ice Model (CICE)
- Community Land Model (CLM)
- Flux Coupler (CPL)

WRF THE WEATHER RESEARCH & FORECASTING MODEL

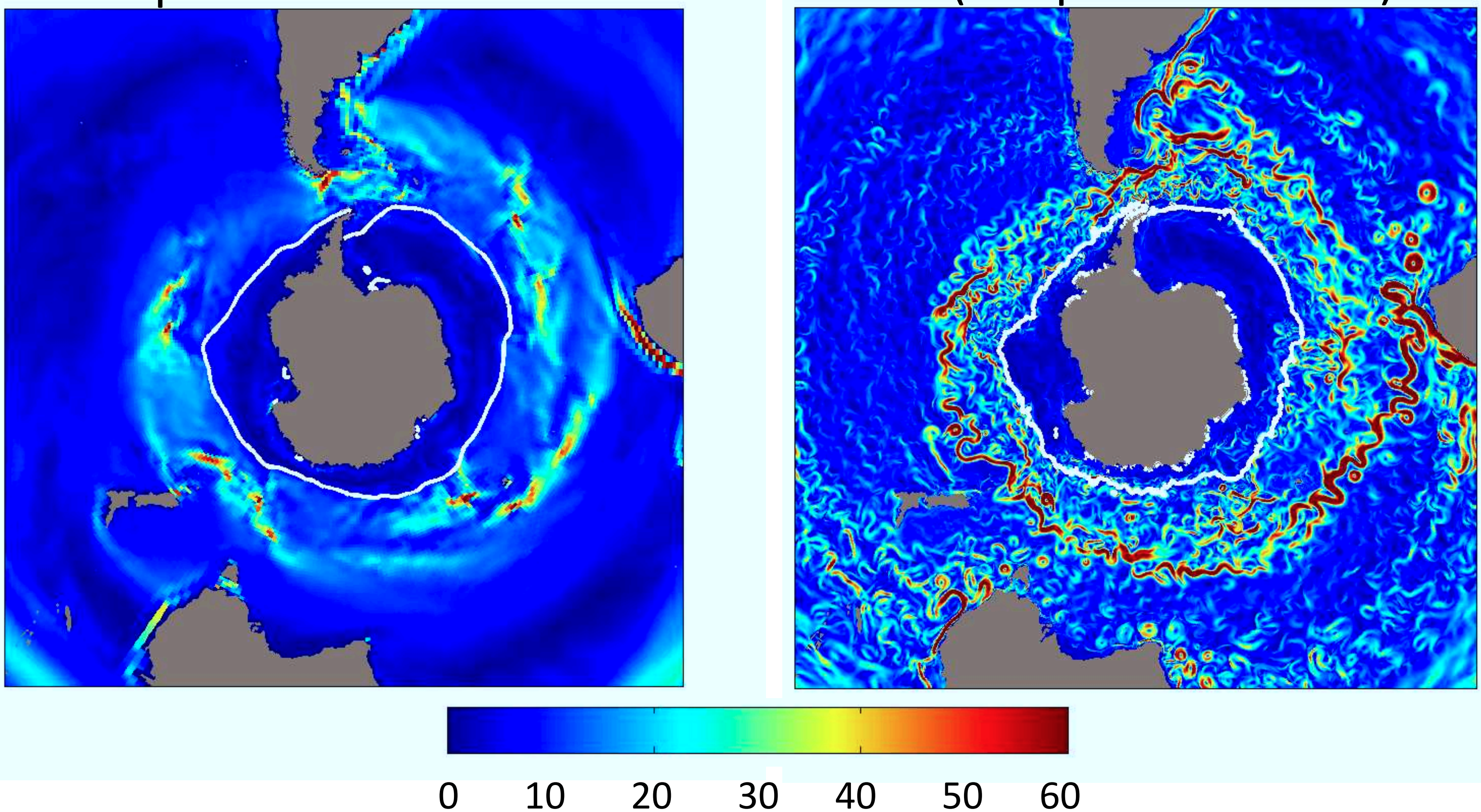
Why not WRF?

It is less general and less well engineered

What you learn about CESM translates well to WRF but not vice versa

1° Simulation
parameterized eddies

0.1° Simulation
resolved (not parameterized) eddies



Current Speed in cm/s for randomly chosen October