

Climate models

Reminder – NCAR field trip

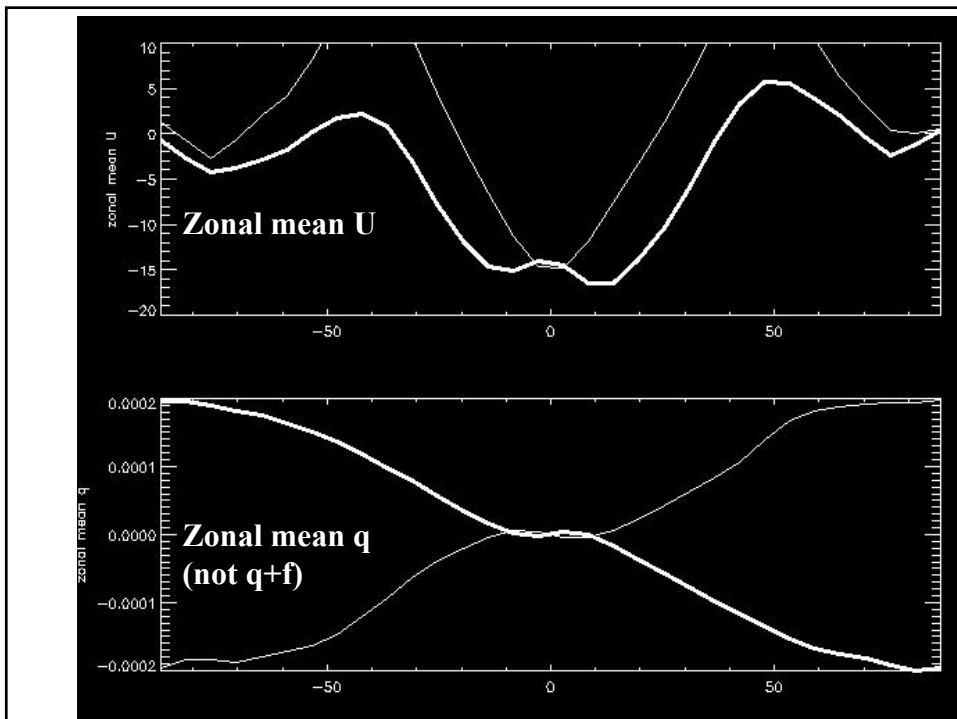
- Meet at NCAR Mesa lab 2:30-3:30
(check out displays in lobby)
- Presentations by Phil Rasch and Bill Collins
from 3:00-400pm in Chapman meeting
room

Carpools:

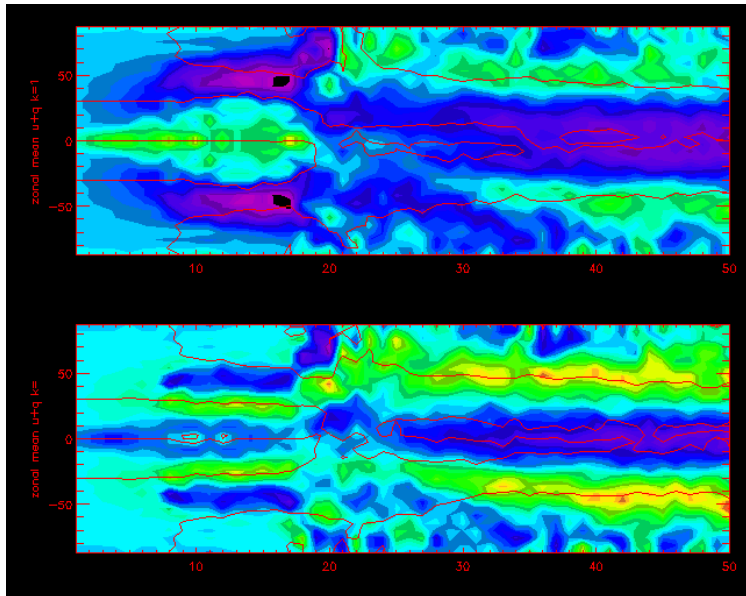
- David N (0/4)
- Dave K (1+3/4)
- Scott ONE WAY (1+0/3)

L2 QG model for general circulation

- How do you define the climatology?
- In what way does the simulation look like the real general circulation? In what ways does it not?
- How do you determine if the model is “spun up”?
- How does the behavior change with “tunable” parameters? (Rossby radius, diabatic heating rate, drag coefficient)
- How can you include topography: how does this change the simulation?
- What are some ways to better choose the forcing?
- How would you expand this model to be a fully fledged "climate" model?



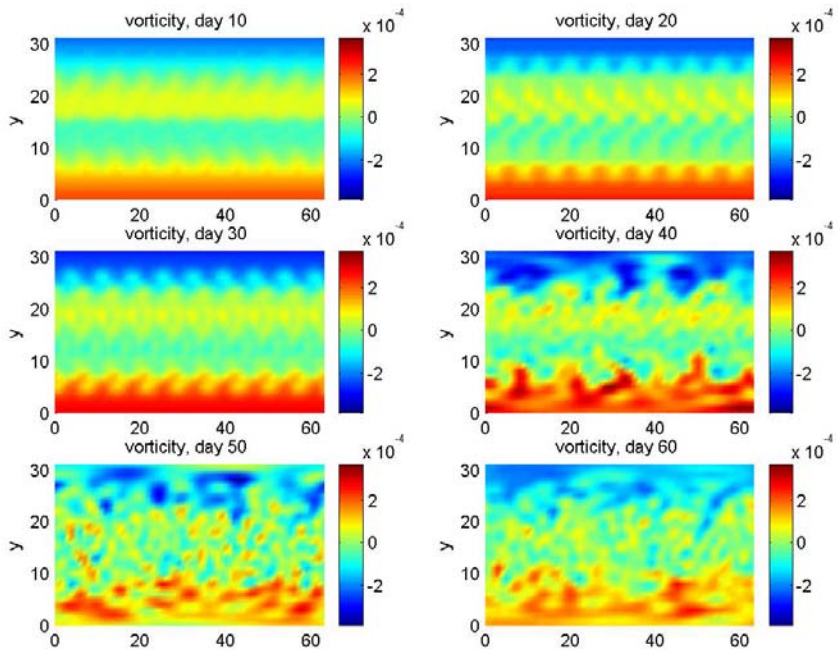
Zonal mean zonal wind



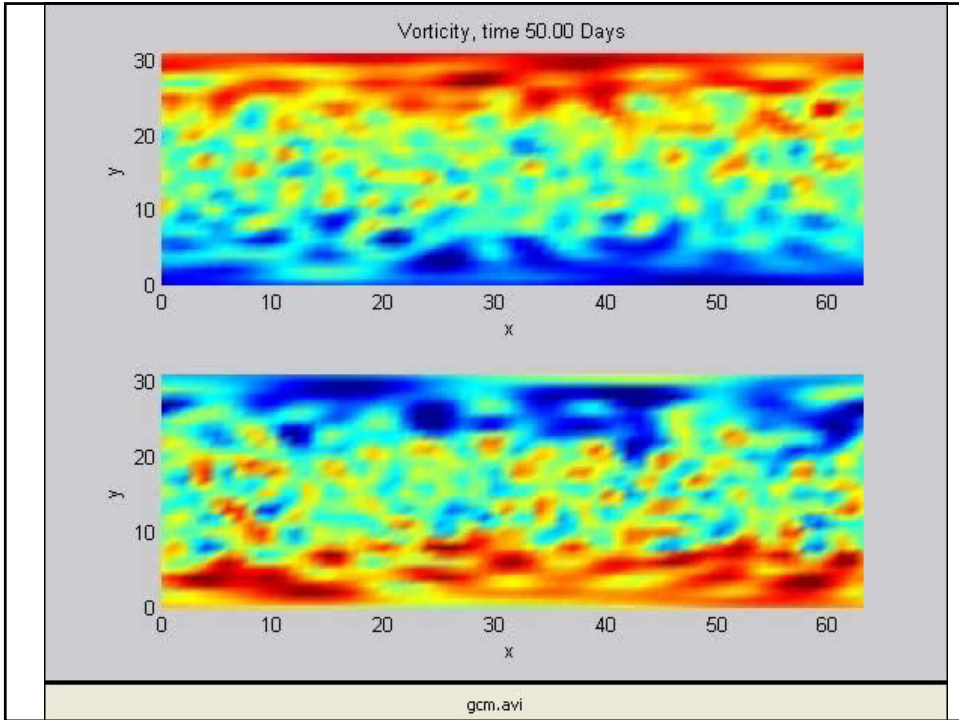
upper

days

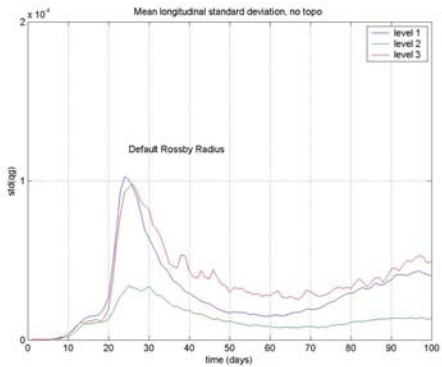
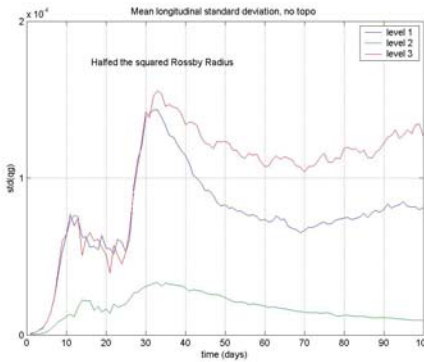
lower



Lower layer



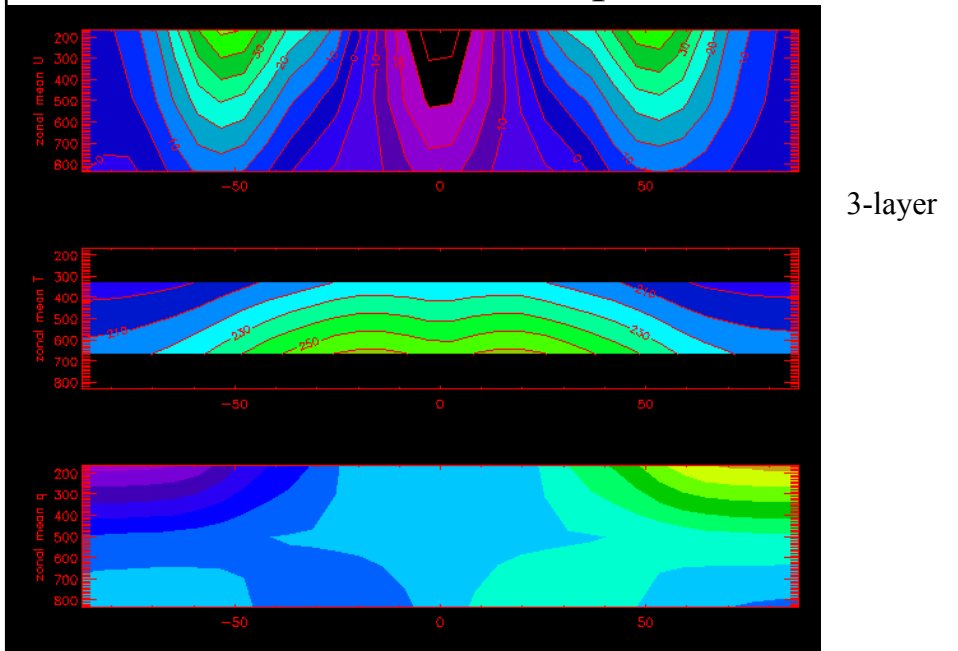
Rossby radius

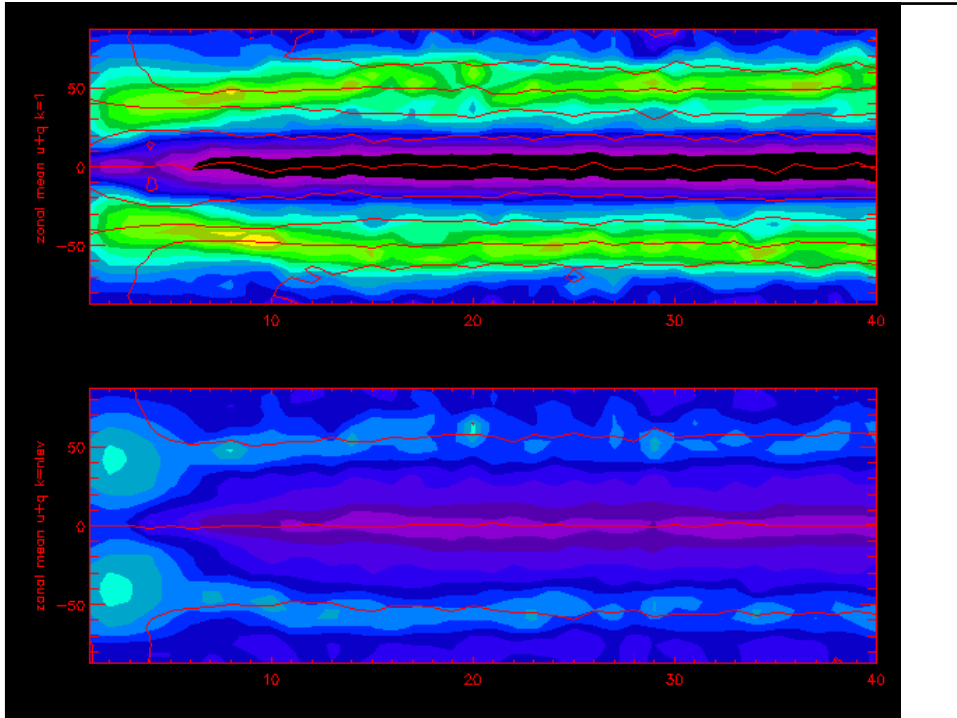


N-layers (e.g., n=3)

- Radiative equilibrium
- $dT/dt = K(T_{eq} - T)$
- T_{eq} , radiative equilibrium profile gives jet which is baroclinically unstable.
- Thus heating pushes atmosphere unstable, while dynamics tries to return to isothermal case
- Circulation is competition and balance between the two.
- Simple profile give by Held and Suarez (1993)
- N=3 means temperature at 2 layers

Relaxation to radiative equilibrium





Some limitations of QG dynamics

- Can not predict stability (recall $1/L^2 = f^2/\sigma(\delta p)^2$)
- So, can obtain spatial variation in temperature at each layer, but not mean temperature.
- This must be deduced from some other method (or use more complete equation)
- Model begins to fail in the tropics (including development of abnormally large tropical waves)
- Some of these aspects can be corrected by adding, for instance, strong damping/diffusion in the tropics.
- Also, note we are looking only at the non-divergent part of the flow field. QG also gives the divergent part associated with stretching and vertical velocity (i.e., the “omega” diagnostic equation)
- This would be needed to see the Hadley cells. Also needed for trace gas transport.

Projects

- Option 1) start with QG model
- Option 2) build specific model
- Option 3) **build** some part for another model

- The project is science driven.
- Modeling will be used to solve the problem, but is only a tool.
- **Bad example:** I will build a model of clouds.
- **Good example:** I will show test if cloud properties change surface energy balance (*by building a model of clouds*)

- Option 1) will need coordination for group success.

1. The effect of clouds on the regulation of the underlying SST over the tropic pacific (Lin)
2. Cirrus clouds (Chuck)
3. Effects of the ocean in the gcm, and the importance as a heat source to the atmosphere (Xylina)
4. Role of cloud properties in the mass balance of sea-ice or role of vertical motions in the partitioning of phases in clouds (with particular focus on mixed-phase cloud conditions) (Matt S)
5. Accessing changes in climate from changes in sea ice in the Arctic. Variability and mean state with ice loss. (Matt H)
6. By adding sea ice to an atmospheric model will increase atmospheric heat transport from the equator to the poles. This will occur due to a larger thermal gradient from equator to pole. (Dave)
7. Add a simple sea salt aerosol component to our gcm, and do some RT calculations on the aerosol column and do a quick comparison to aernet data (Lansing)
8. Parametric study of teleconnection between a tropical wavemaking anomaly and high southern latitude climate especially the southern annular mode. (Scott)

1. QG model on a beta plane with multi-grid methods (Jason)
2. QG GCM forecast model to forecast two significant regional weather events (2003 Blizzard and 2005 Hot Spell) starting 48 hours previous and ascertain model performance. Which event is best forecasted, why physics is important? (Darren)
3. Converting the quasi-geostrophic GCM to a Mars GCM to compare how the circulation on Mars is different from Earth (Elizabeth)
4. Antarctic isotopes and millennial-scale sea surface temperature variations during the last glacial period (~30-70 kyr ago). Are moisture source regions in phase or out of phase (or neither) with Antarctic temperature change, sea ice and ENSO (Annie)
5. Does a 10% decrease in relative humidity increase soil evaporation enough to where atmospheric temperature is on average higher than soil temperature? (Nik)
6. Humidity isotopic model of the Amazon Region using the boundary conditions from NCEP data with a model of surface and atmospheric fluxes of moisture and isotopes using Rayleigh theory and simple condensation/evaporation equation (Derek)

QG model

$$\frac{\partial q}{\partial t} = -V \cdot \nabla(q + f) + K \nabla^2 q - D\zeta + H$$

Forcing (H) is a strong control on climate

(i.e., governs equator-pole energy imbalance)

Model is conservation of energy, momentum and mass

Determines how the flow can resolve the imbalance

(i.e., make weather to transport heat – which we see as PV)

Additional components for GCM

- land/sea mask
- topography (possibly gravity waves)
- hydrologic cycle
(convection, clouds, rain/latent heating)
- radiative transfer
(atmosphere and surface? GHGs and aerosols)
- Land surface exchange
(drag, latent and sensible heating)
- Ocean
(slab EBM, advection, upwelling, dynamics)
- Sea ice

Coordination

- Dynamic core (adiabatic part)
- Interface for physics
(diabatic forcing terms)
- Number of levels
- How to couple with other components
- Interface subroutine
- E.g., each person would work on a subroutine, and adhere to the communication protocols
- Detailed time lines, since all work depends on other components.

Suggested timeline

4 April	Decide organization/infrastructure, etc
11 April	Implementing code
18 April	Finalizing code
25 April	Performing experiments
2 May	Finalizing experiments and write up
8 May	Project due