SPANNING TIME AND SPATIAL SCALES: MODELING OUR PLANET’S CLIMATE

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• SIMILARITIES BTWN WEATHER MODELS & MULTI-DECADAL CLIMATE MODELS

► Physics is Physics!

• SOME KEY DIFFERENCES BTWN WEATHER MODELS & MULTI-DECADAL CLIMATE MODELS

► Initial Value vs. Boundary Value Problems
► Consideration of Spatial & Temporal Scales
► The Role of the Global Ocean

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Weather & Climate models serve as our “virtual Earths”. They are tools that provide a means to estimate how the planet’s weather and/or climate varies over time. Each successive generation improves, but is still incomplete.

Physics of Weather & Climate Models

* **Basics:** conservation of energy, equations of motion for a fluid on a rotating sphere, equations of state, latent heat, C-C, etc.

* **Parameterizations:** empirical formulae representing the effects of processes not resolved by the model grid.

Initial value problem

How does the system evolve from its starting point?

Seasonal-~1 yr Outlooks (Temperature, Precip, ENSO, Hurricane Outlooks)

How does the system respond to changes in ‘forcing agents’?

Daily Weather Forecasts
Initial value problem

Seasonal-
~1 yr Outlooks
(Temperature,
Precip, ENSO,
Hurricane Outlooks)

Decadal
Climate
Predictability

Multi-
Decade
to Century
Projections

How does the system evolve from its starting point?

How does the system respond to changes in ‘forcing agents’?

For more info, see “Weather Prediction, Climate Prediction. What’s the Diff?” by Bill Chameides on the PopSci web site…
Though weather and long term climate models are similar in many ways (physics is physics....) they are used to address different questions.

"An Initial Value Problem" vs. "A Boundary Value Problem"
1980s

40°N to 40°S

96 boxes east to west

Ocean grid
Atmospheric Model Resolution: Weather vs. Dec-Cen Climate Models

- The Limited Fine Mesh Model II (LFMII) grid points were \(~116\) km apart at 45° latitude (7 layers).
- The Nested Grid Model (NGM) had 3 grids. Its coarsest grid covered N. Hemisphere. The finest-mesh grid covered the east Pacific and N America with a resolution of \(84\) km at 45° (16 vertical layers).

GFDL CM2.1 (~2004) atmospheric grid resolution of \(\sim194\) km at 45° (24 vertical layers).

GFDL CM2.5 (2011) atmospheric grid resolution of 50 km (32 vertical layers).
On the Ocean’s Role…
Where has the additional heat energy gone? (1971-2010)
Most of it resides in the global ocean.

Heat Energy

- 93% Warm the Ocean
- 1% Warm the Air
- 3% Melt Ice
- 3% Warm Continents

Percentages are central estimates, adapted from the 2013 IPCC Working Group 1 Report’s Summary for Policymakers (Section B2)
http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf