Weather and Climate

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Contents

Reading:

Required Reading (everyone):

- Understanding the Forecast, Ch. 6.

Reading Notes:

Chaos

The layer model calculates the average surface temperature for the whole planet, but the MODTRAN radiative model and the RRTM full-spectrum radiative-convective model calculate the temperature only at a single location. Climate models do a much better job at calculating the average climate for the whole planet, but people live in different places, and their lives are affected by the details of how climate and weather change where they live.

We've also looked at the question of why scientists are confident that they can predict the climate 100 years in the future, even though weather forecasters can't predict what the weather will be a month from now with any confidence.

Both of these issues (predicting global averages versus local climate and predicting climate versus weather) have to do with the **chaotic** nature of the atmosphere.

Systems that obey **linear equations**, where the outcome is always proportional to the inputs, are easy to predict, but **nonlinear equations** can become difficult to predict and even **chaotic** (the behavior of chaotic systems cannot be predicted with any reasonable precision more than a short time into the future).

Temporal Patterns of Weather and Climate

Some things that contribute to the behavior of the weather have to do with the way that sunlight changes both during the day, and from season to season during the year. MODTRAN and RRTM models assume an average value of sunlight, but if the sunlight is changing during the day or from season to season, the temperature will also change.

Spatial Patterns of Weather and Climate

In Chapter 5, we looked at convection, which moves heat vertically, but winds and ocean currents that move heat horizontally are also important. Meteorologists use the term **convection** to refer to vertical transport of air and heat, and **advection** to refer to horizontal transport.

A very important aspect of winds and ocean currents is the **Coriolis effect**, which causes winds and currents to bend and follow somewhat circular paths instead of straight lines. The **Coriolis effect** is caused by the rotation of the Earth, and it's responsible for storm systems called **cyclones** that develop circular shapes.

Viscosity

If there were no friction in the air, winds would always follow perfectly circular paths, but friction (also called **viscosity**) interferes with the Coriolis effect and cause winds (and ocean current) to deviate from circular paths.

Big picture

The big picture of this chapter is to show us patterns in space and time of the way heat flows in the Earth system, and to introduce the idea of **chaos** to explain the difficulty of accurately predicting weather and the fine points of climate.

Climate models use the basic equations of physics (Newton's equations of motion and the thermodynamic equations of heat flow) to predict how the air and heat will move around the Earth system.

To make accurate predictions, we can't just average over the Earth because the equations are nonlinear. This means that to make accurate predictions, we have to calculate the equations at billions, even trillions of points all around the world. The more points we include in our models, the better their predictions, but the more computer power they need.

Right now, the most powerful supercomputers in the world are used to make weather and climate predictions, but even they are not powerful enough to answer a lot of questions scientists want to ask.