AOS 801: Advanced Tropical Meteorology
Lecture 1 Spring 2023
Overview

Ángel F. Adames Corraliza
angel.adamescorraliza@wisc.edu

This course

Advanced treatment of the fundamentals of tropical meteorology, including:

1. moist thermodynamics
2. tropical deep convection
3. quasi equilibrium
4. the weak temperature gradient approximation,
5. the mean tropical circulations
6. tropical weather systems
7. tropical cyclones.

What does advanced mean?: This is a high-level course in which the student is expected to learn much of the material independently through reading notes or assigned papers. Class lectures will supplement the readings. The pace of the class will be **fast**. It does not necessarily mean difficult if you stay up to date.

Canvas and lecture time

Canvas site
https://canvas.wisc.edu/courses/264500

- Syllabus
- Lectures
- Homework
- Reference materials and readings

Office hours

Which times work best for you all?

My preference: After Class

Weekend Policy

I will try to be prompt in responding to your emails (likely the same day)

However, I will not respond to emails sent during the weekend until the following Monday.

Your classmates may also follow a similar policy.

Be mindful of other people’s time.

Class Modality

This will be an in-person class, so most classes (>75%) are likely to be held in person.

Some lectures may be done remotely if I'm sick or if many students cannot attend in person lecture.

However, the class will be live streamed via *Zoom* for those that cannot attend. Accommodations will be made for class exercises.

Feeling Sick?

In the case that you feel sick, please **stay home.** Lectures will be live-streamed and much of the material will be uploaded to Canvas.

If your illness compromises your ability to complete homework, let me know so I can make proper accommodations.

You may also choose to attend the class virtually for other reasons. If you will attend many of these this way please let me know.

Mental Health

Your wellbeing is more important than the course.

If you are going through difficult times because of the course or other circumstances let me know so that you can get professional help.

The goal of the course is to **learn** and **appreciate.** It is not a hazing ritual nor a test of endurance.

Resources

Please let me know asap if you do not have a laptop and/or smartphone. I want everyone to have the resources to do well in this class and do the work efficiently.

Final Grade

There will be no midterms nor a final exam

Homework: Much of your grade will be based on 5 homework assignments.

You are encouraged discuss the problems with colleagues but final answers are yours. There is no redoing once you have submitted.

Paper assignments: Another large chunk of your final grade will be based on 5 paper assignments.

These are papers you will be requested to read. Several prompts will be given that will test your understanding of the paper and synthesize its contents.

Class work: The paper assignments will be discussed in class, and one or two students will be requested to lead and moderate the discussion.

Final Presentation: on a topic of your choice that is related to class.

Grading

Homework: 40%

Paper assignment: 35%

Paper discussion 15%

Final presentation 10%

Final grades will be given based on a standard curve:

A: > 92
AB: [88-92)
B: [82-88)
BC: [78-82)
C: [70-78)
D: [60-68)
F: < 60

No changes to this curve will be done!

Useful links

Some Links:

https://www.star.nesdis.noaa.gov/GOES/

www.windy.com

http://mag.ncep.noaa.gov/

earth.nullschool.net

https://www.tropicaltidbits.com/

http://weather.rap.ucar.edu/

http://rammb-slider.cira.colostate.edu/

Some homework problems will require you to look at weather maps or satellite data

More links

afadames.com/links

Links will also be posted on Canvas

Division of course topics

Introduction: Quick review of the equations of motion, scale analysis, a gentle introduction to the WTG approximation.

Tropical deep convection Review of moist thermodynamics, quasi-equilibrium principles, convection organization, instabilities.

Large-scale tropical circulations: The ITCZ and Hadley Cell, monsoons, ENSO, large-scale tropical waves, the MJO.

Tropical Cyclones: formation, steady state, intensification, movement, role in tropical circulation.

Learning goals

1. Recognize the many ways in which tropical deep convection is fundamental to tropical circulations.

2. Interpret the meaning and significance of the weak temperature gradient approximation.

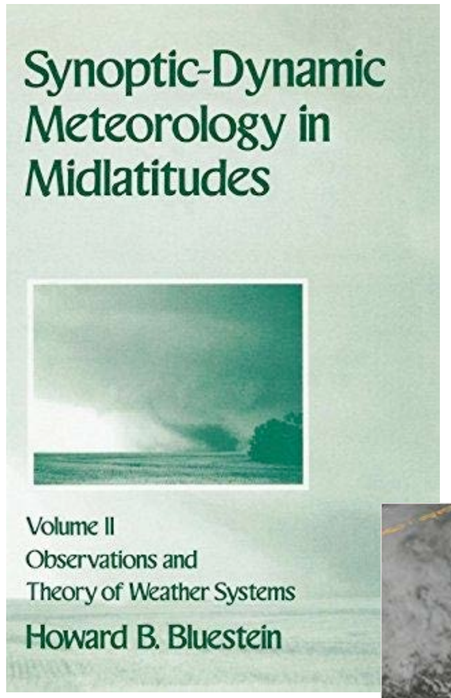
3. Recognize the fundamental role of water vapor has in tropics.

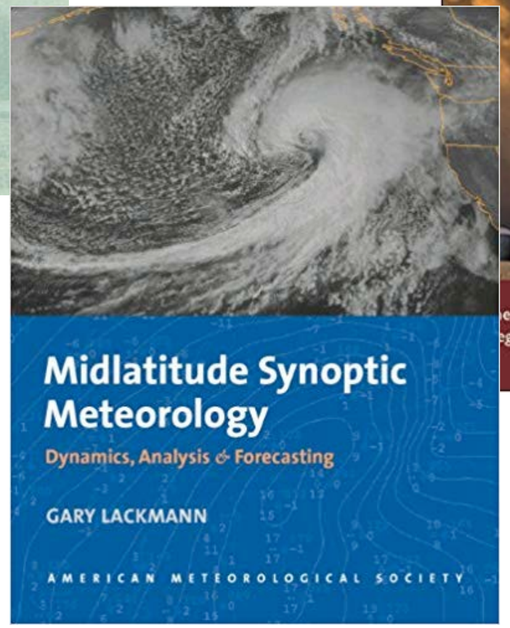
4. Be able to discuss the similarities and differences among different types of tropical motions.

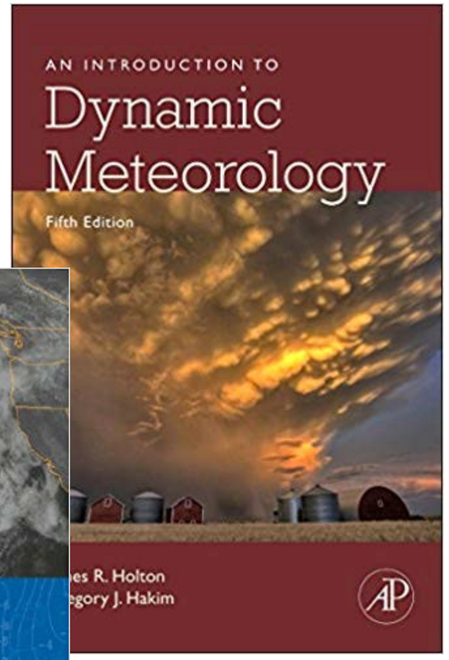
No time to waste,
let’s go!

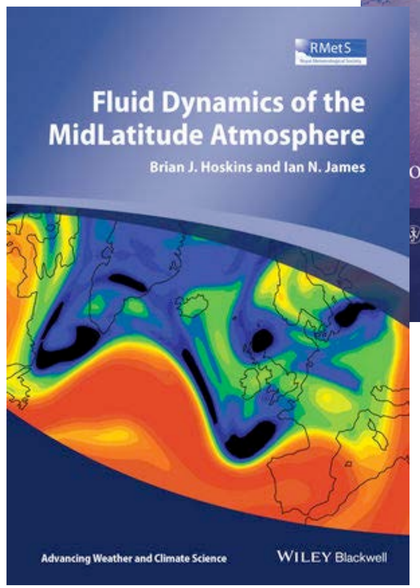
What your textbooks have taught you

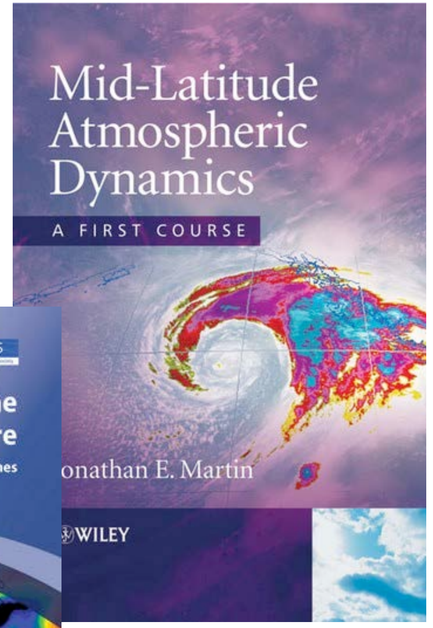
Has mostly focused on the midlatitudes

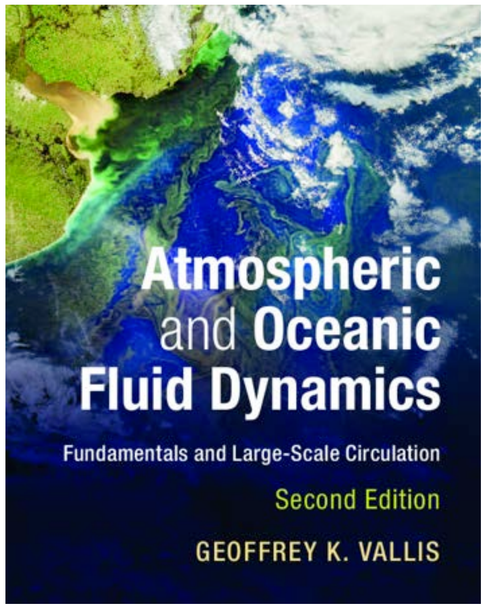












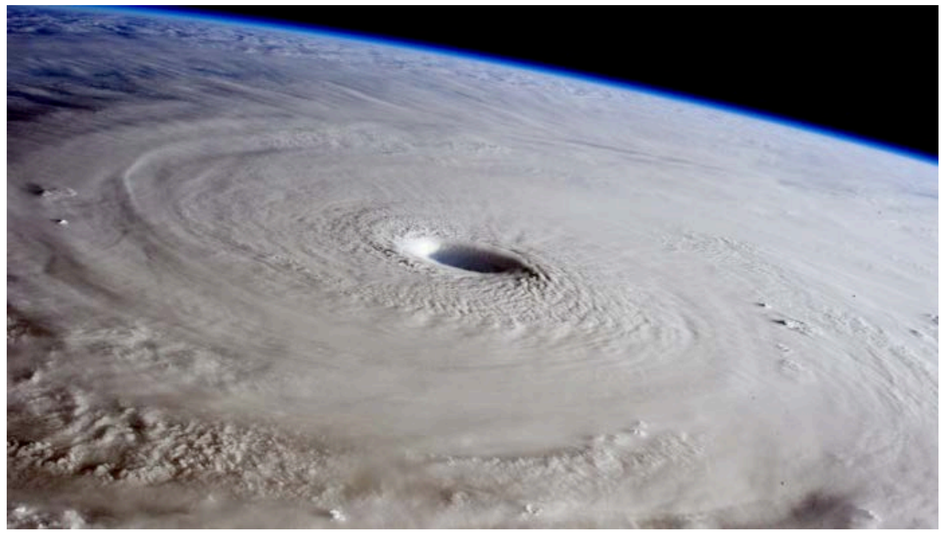
Have you had a class that uses a textbook that focuses on the tropics?

https://ahaslides.com/WXC82

Early thoughts on the tropics

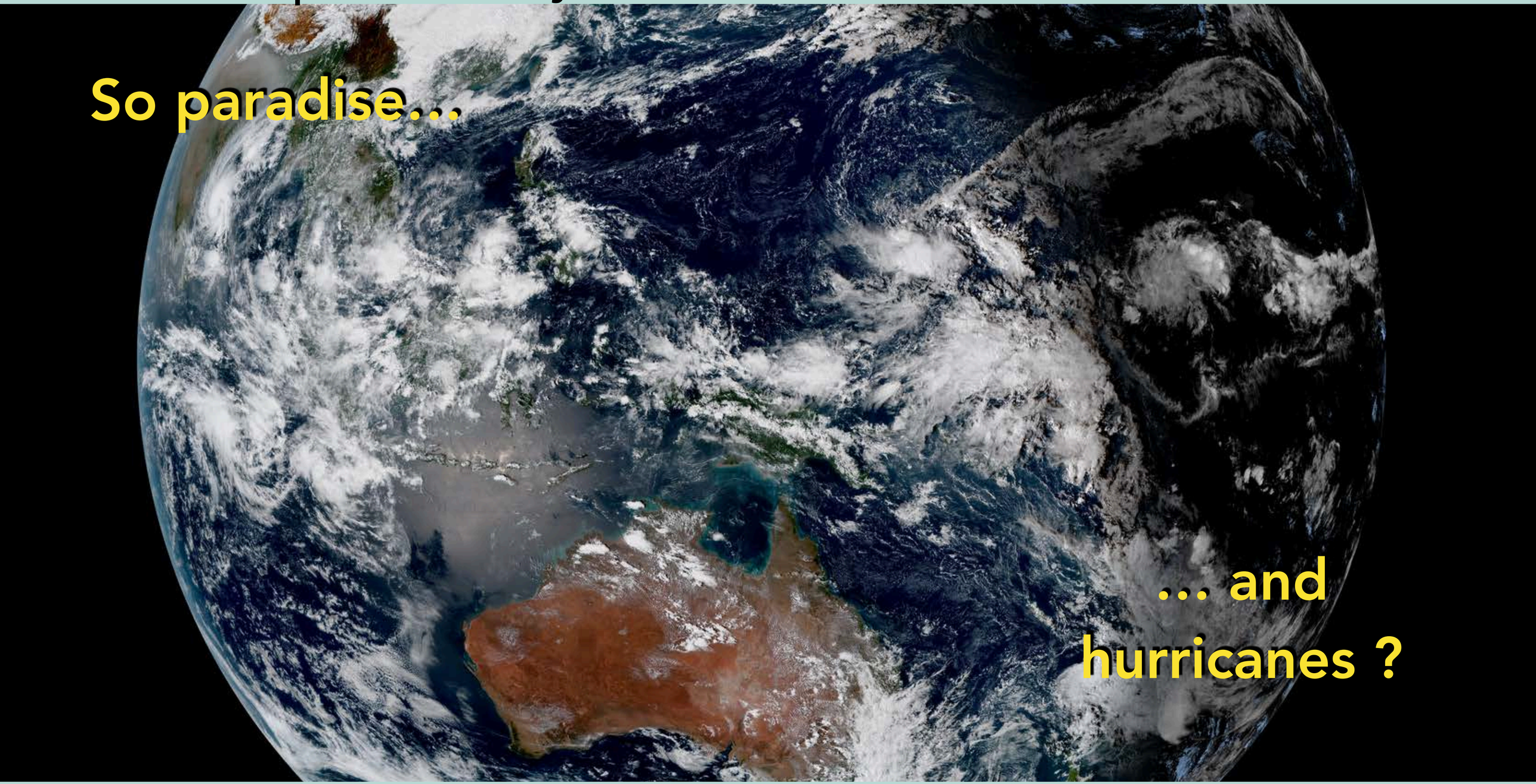
There and then the question arose: How is it with the other theories in so far as they concern the tropics? In the past, weather and circulation in low latitudes had been regarded as steady except for occasional hurricanes. The urgent demand of the U.S. Army Air Corps for research in tropical meteorology, which had provided the impetus for founding the institute, belied the old descriptions. Military forces conducting war in the tropics undeniably found that "weather" on a serious scale did occur in that part of the world. What brought it on, and how could it be predicted?

So paradise…

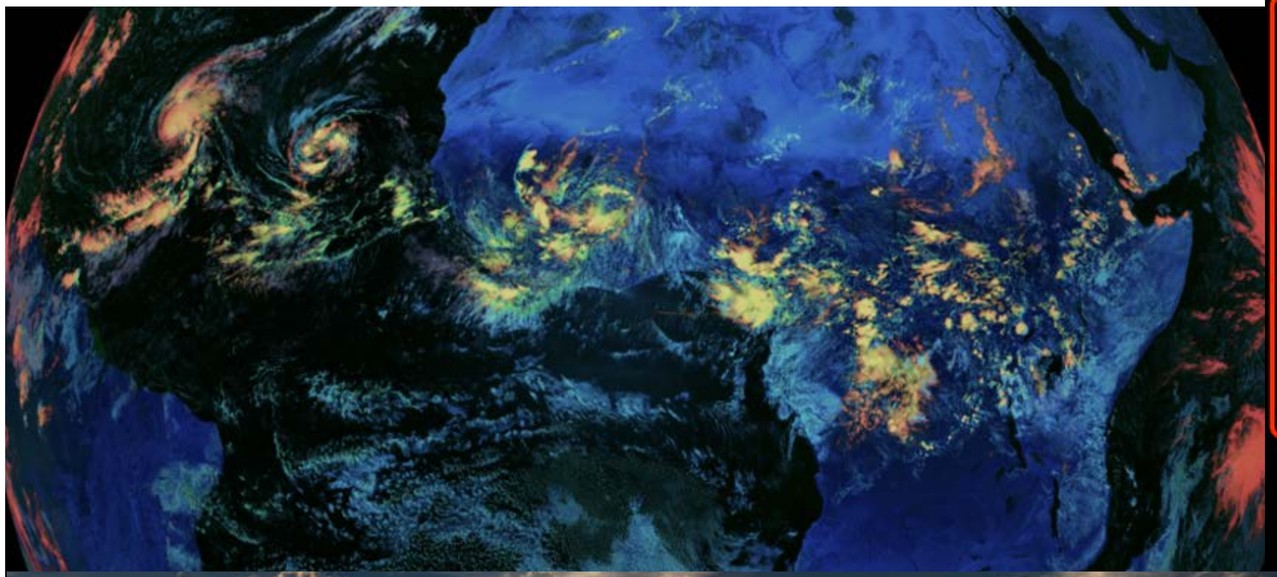


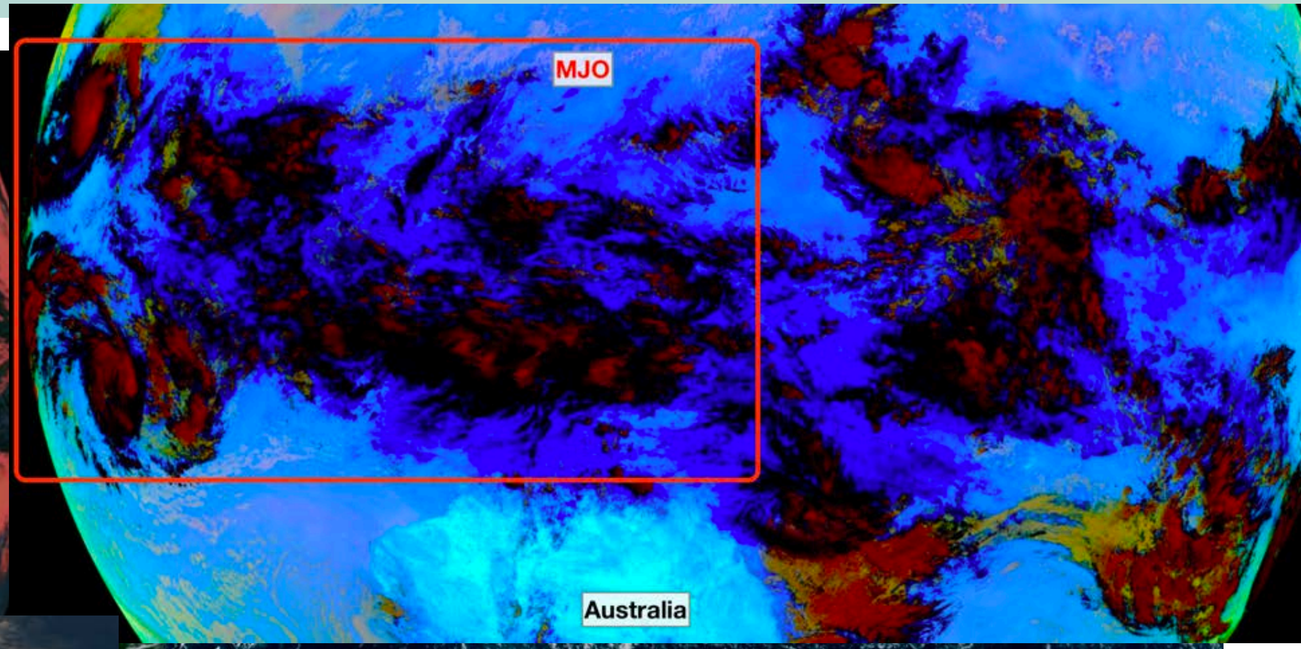
… and hurricanes ?

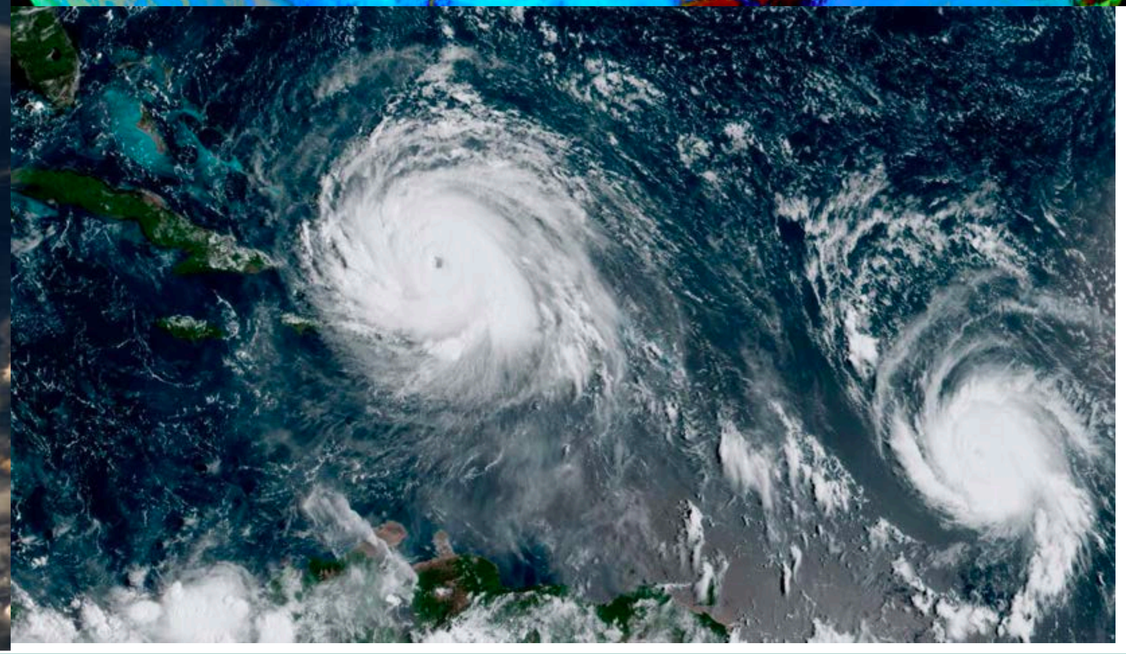
How the tropics actually look like



How the tropics actually look like





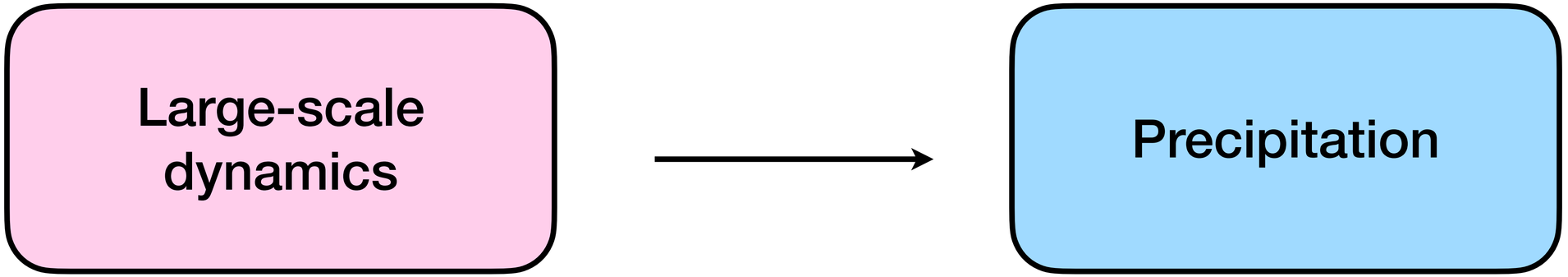


Early thoughts on the tropics

In the midlatitudes, deep convection is usually the result of large-scale forcing producing an unstable environment that triggers convection.

Early thoughts on the tropics

This view was translated into the tropics.



In this view, the atmosphere is conditionally unstable and convection responds to lifting by the large-scale flow. Convection is forced “externally”.

How did this idea stand up to scrutiny?

Not great

On large-scale circulations in convecting atmospheres

By KERRY A. EMANUEL[1]*, J. DAVID NEELIN[2] and CHRISTOPHER S. BRETHERTON[3]

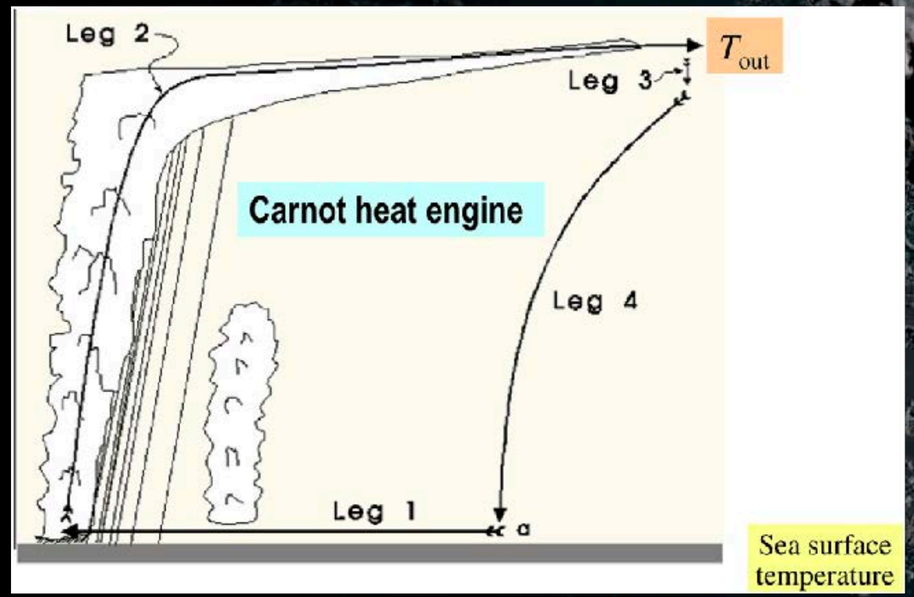
[1]*Massachusetts Institute of Technology, USA*
[2]*University of California at Los Angeles, USA*
[3]*University of Washington, USA*

(Received 6 January 1994; revised 15 March 1994)
(Symons Memorial Lecture: delivered by Kerry A. Emanuel on 19 May 1993)

Flaws in this 'external' view of moist convection became apparent by the early 1960s, when attempts to simulate the development of hurricanes in a conditionally unstable atmosphere met with failure. These simulations always showed development at the smallest scale …

… the representation of convection that was based on [this external view] , has been an influential and lengthy dead-end road in atmospheric science" Emanuel et al. (1994)

Nail in the coffin



One nail is not enough

Radiative–Convective Equilibrium with Explicit Two-Dimensional Moist Convection

ISAAC M. HELD AND RICHARD S. HEMLER

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, New Jersey

V. RAMASWAMY

Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, New Jersey

(Manuscript received 7 December 1992, in final form 29 April 1993)

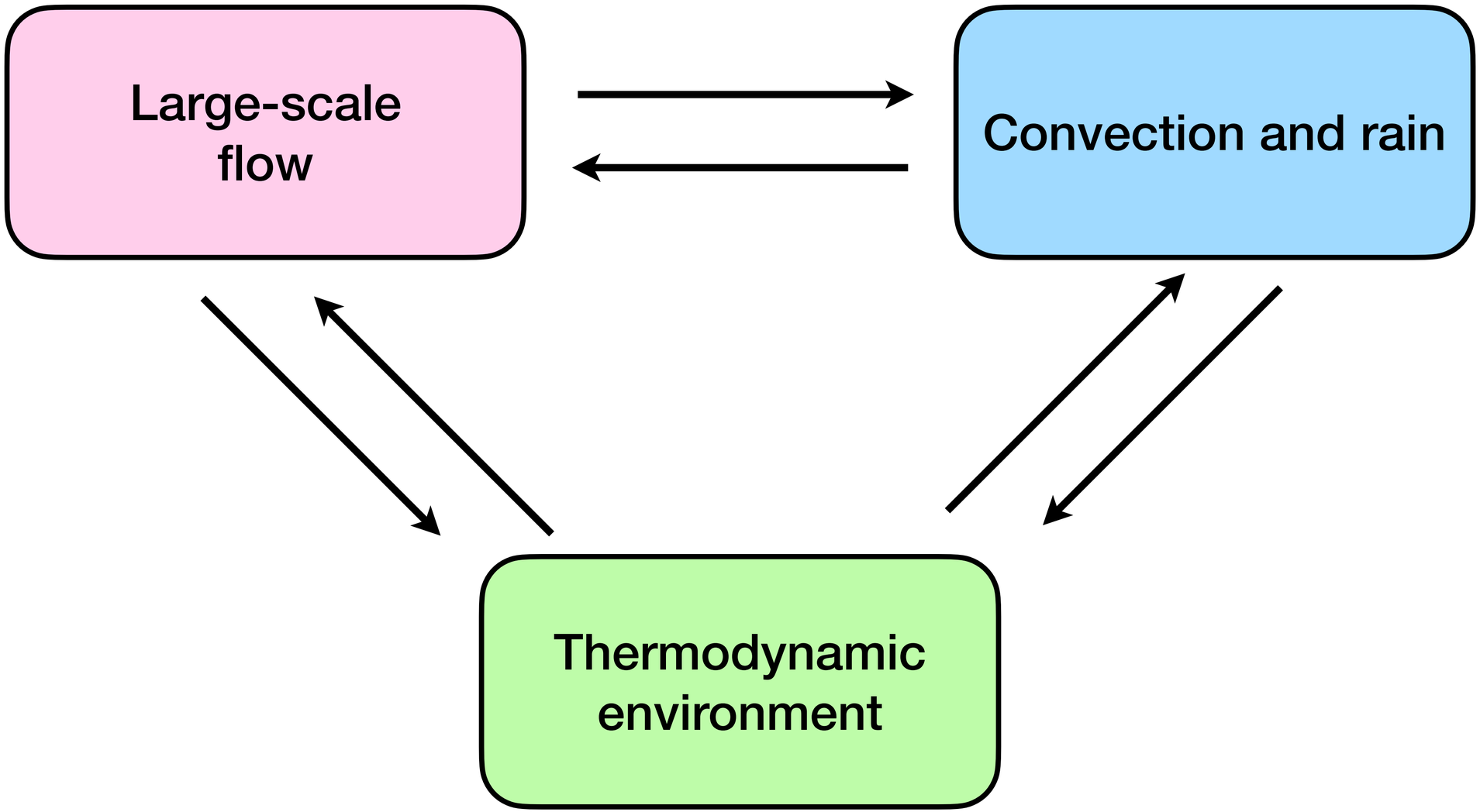
ABSTRACT

Radiative–convective statistical equilibria are obtained using a two-dimensional model in which radiative transfer is interactive with the predicted moisture and cloud fields. The domain is periodic in x, with a width of 640 km, and extends from the ground to 26 km. The lower boundary is a fixed-temperature water-saturated surface. The model produces a temperature profile resembling the mean profile observed in the tropics. A number of integrations of several months' duration are described in this preliminary examination of the model's qualitative behavior.

The model generates a QBO-like oscillation in the x-averaged winds with an apparent period of ~60 days. This oscillation extends into the troposphere and influences the convective organization. In order to avoid the associated large vertical wind shears, calculations are also performed in which the x-averaged winds are constrained to vanish. The convection then evolves into a pattern in which rain falls only within a small part of the domain. The moisture field appears to provide the memory that localizes the convection.

If the vertical shears are fixed at a modest nonzero value, this localization is avoided. Comparing calculations with surface temperatures of 25° and 30°C, the planetary albedo is found to decrease with increasing temperature, primarily due to a reduction in low-level cloudiness.

The story of this course

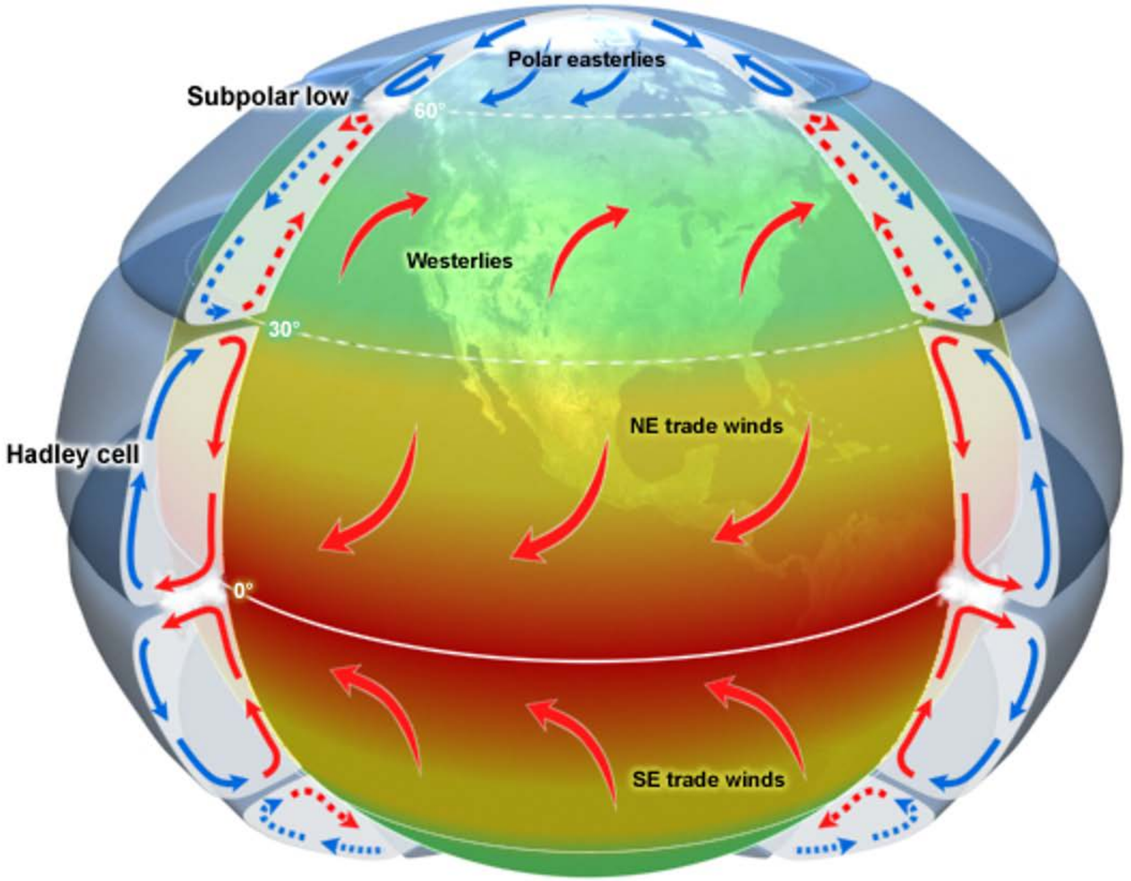


In order to understand the tropics, we need to discard the idea that large-scale dynamics are the only game in town and start all over.

The goal of this class is to do just that.

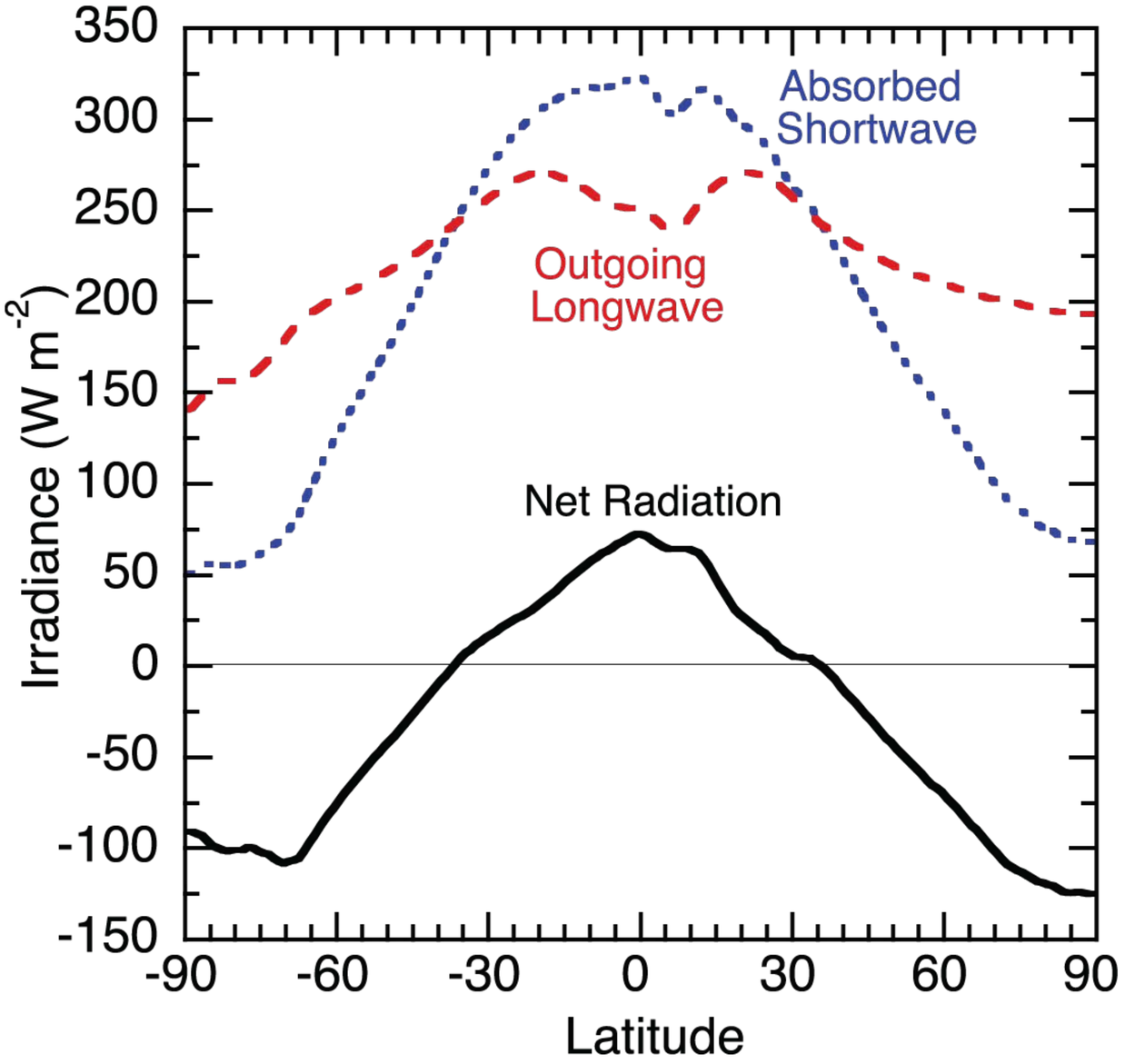
Planetary scale

Trade winds and a Hadley cell characterize the planetary scale features of the tropics.

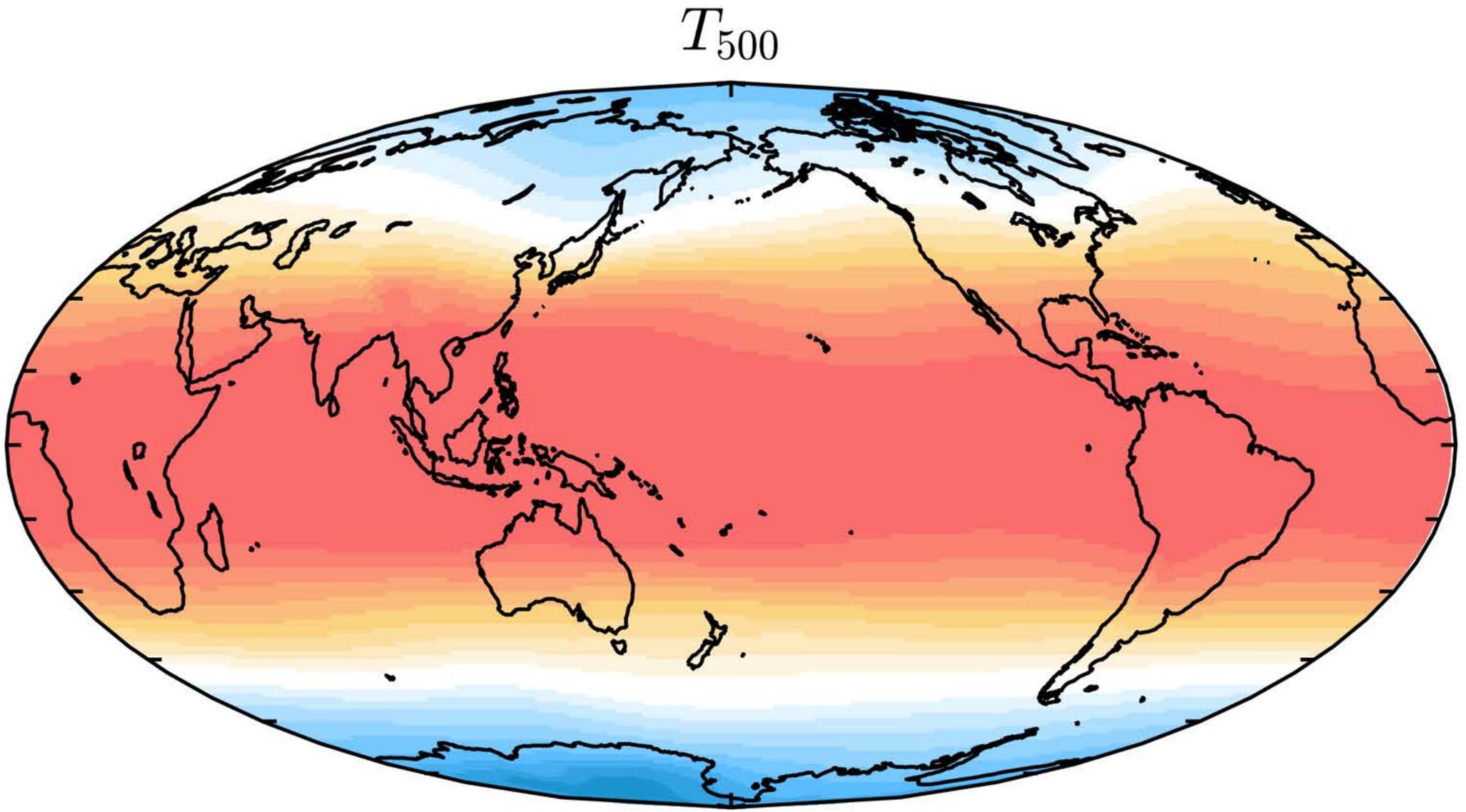


Net radiation

The tropics are also characterized by a surplus of energy, which gets transported to the midlatitudes.



Homogeneous temperatures



Lots of water vapor