ATM S 103

# Hurricanes and Thunderstorms

## Their Science and Impacts


Daytona Beach, FL prior to Hurricane Matthew

# Midterm 2: Wednesday May 22

- Bring a Scantron form
- Closed book, notes, electronics
- 30 multiple choice questions (similar to homework)
- Covers
  - Homeworks 4-6
  - Lectures from April 26 through today
  - Reading weeks 5-8
  - **No overlap with Midterm 1**

- **Clue review session:** Thursday (tomorrow) May 16, 6:30-8:00 PM in MGH 231

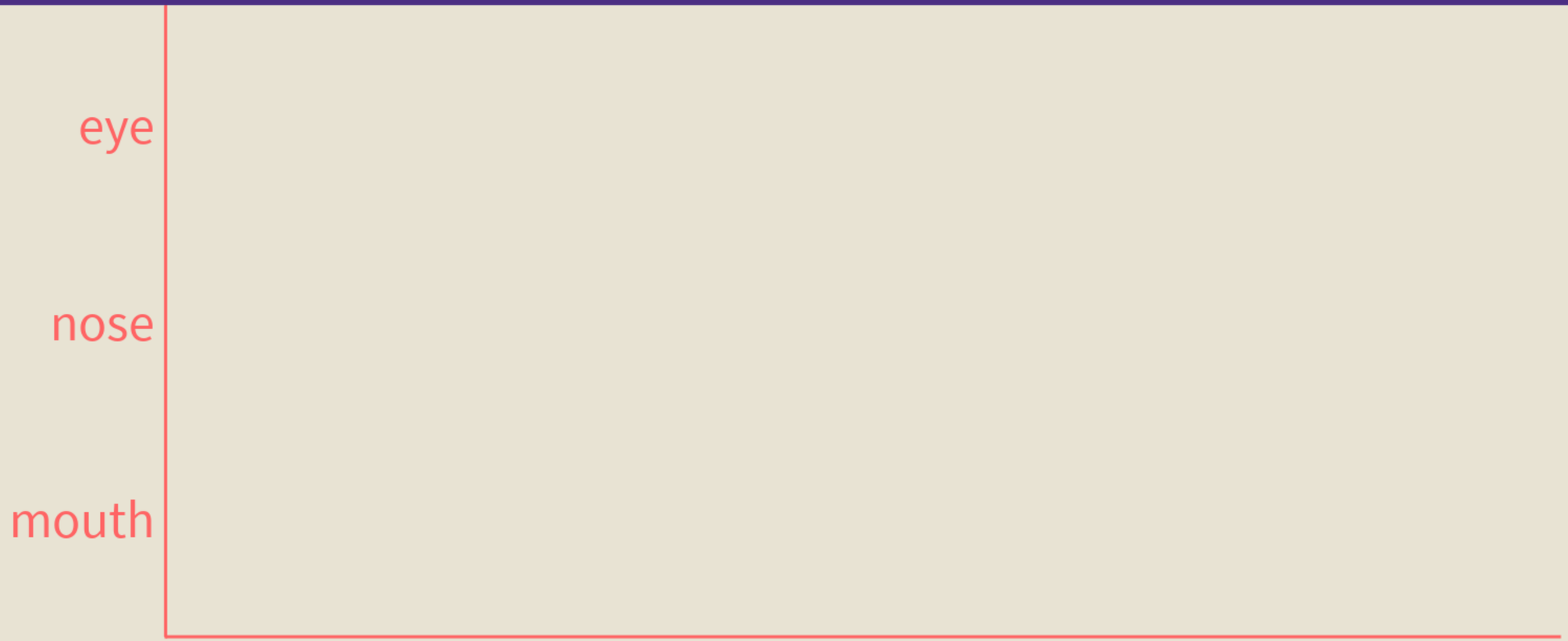
# Extra Credit Opportunity

- Make a sharable infographic with both of the following
  - A scientific fact about severe weather
  - A safety tip that you think people should know
- Make it succinct; don't put too much text on it
- Submit the infographic with a few paragraphs of text that describes the rationale of the information in the infographic (e.g., why do you think the information is important ?) — due 11:59PM on June 12
- Will be enough to offset a missed HW, or improve your midterm scores
- I'll post the best ones on social media

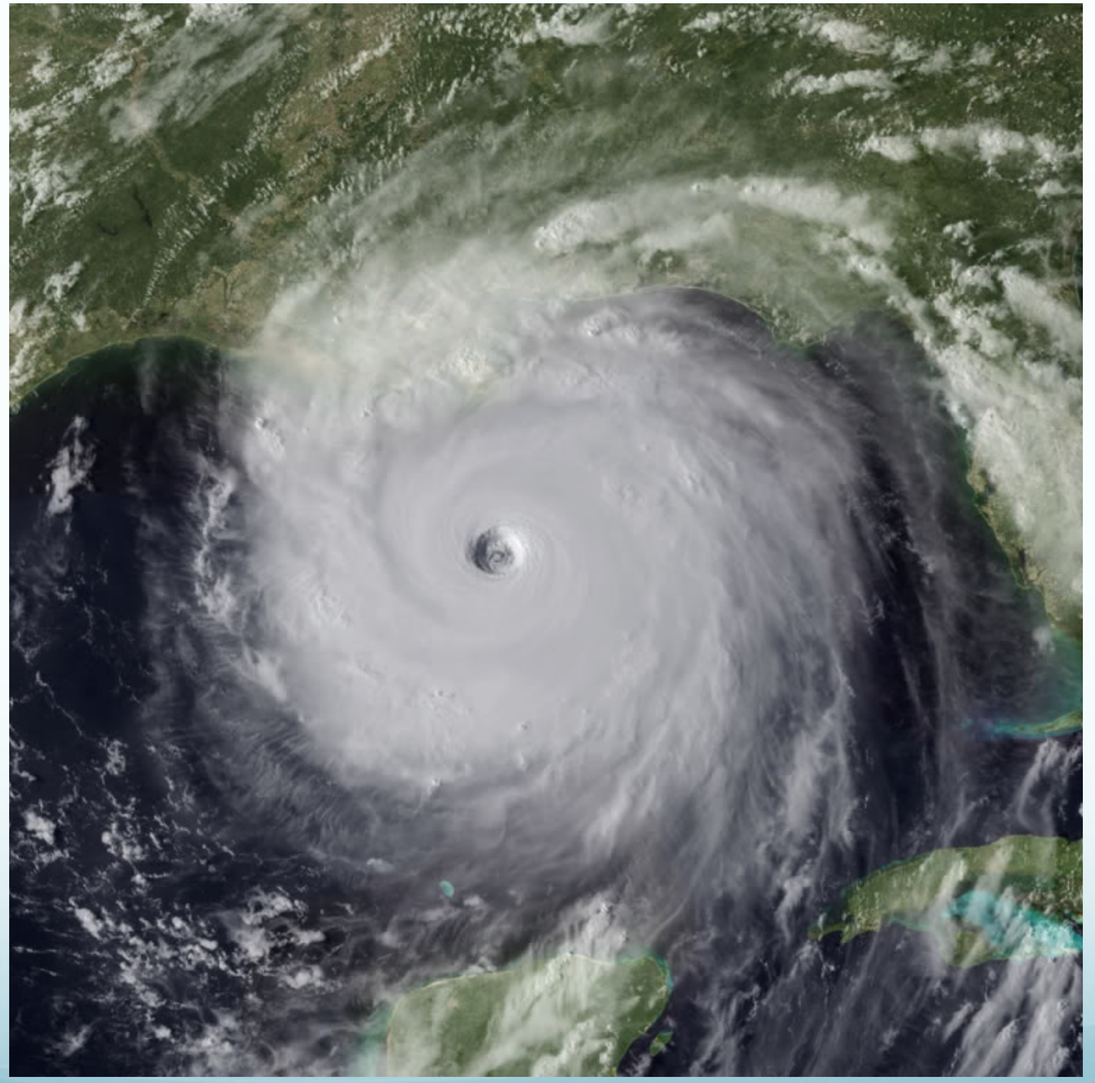
# Topics for today

- Basic hurricane structure
- The Coriolis force
- Tropical cyclone climatology
  - What does that tell us about necessary ingredients for these storms
- Tropical cyclone life cycle

# The central part of strong hurricanes in which thunderstorm activity is inhibited is often referred to as a (an)



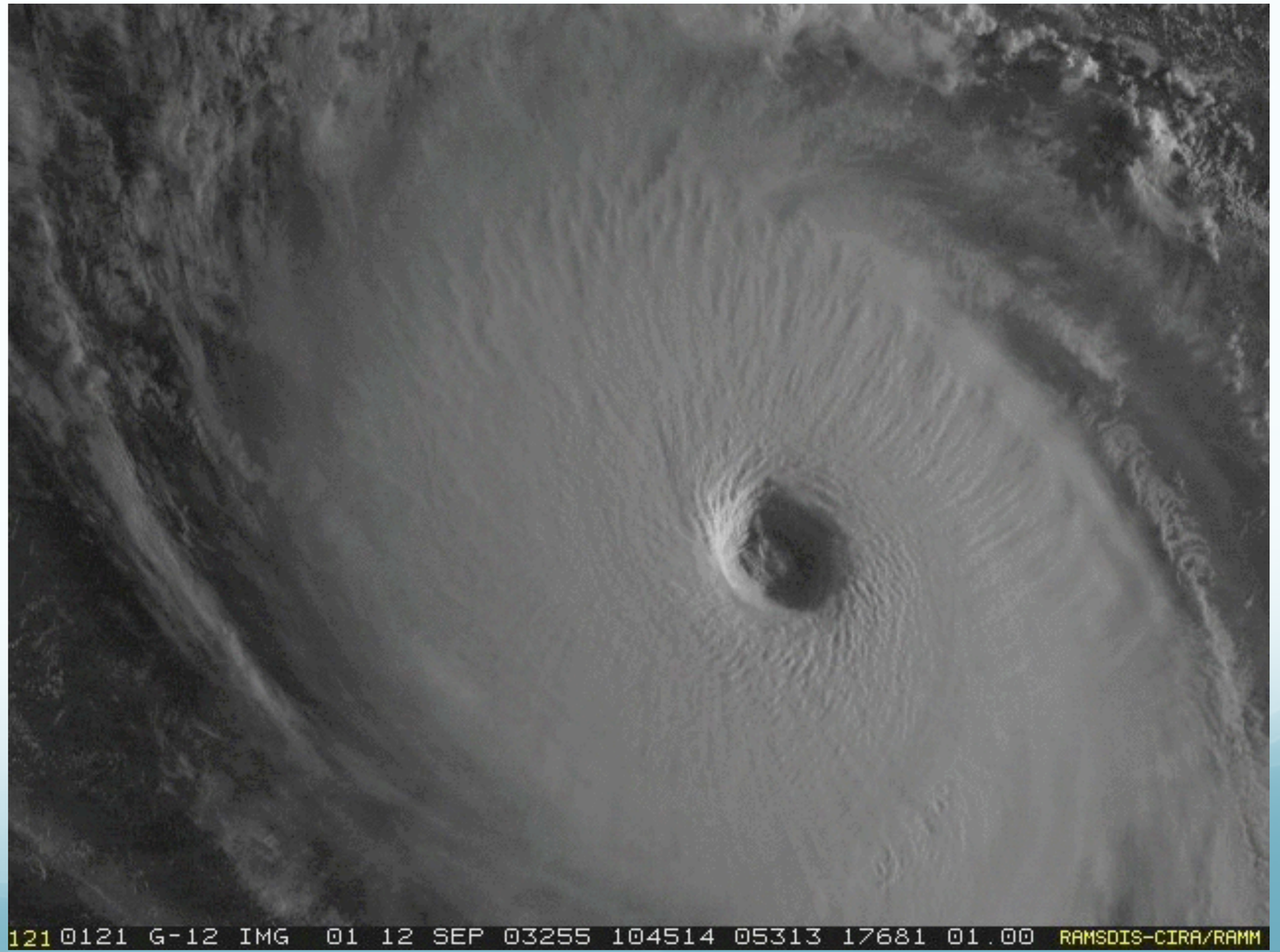
# Answer: eye



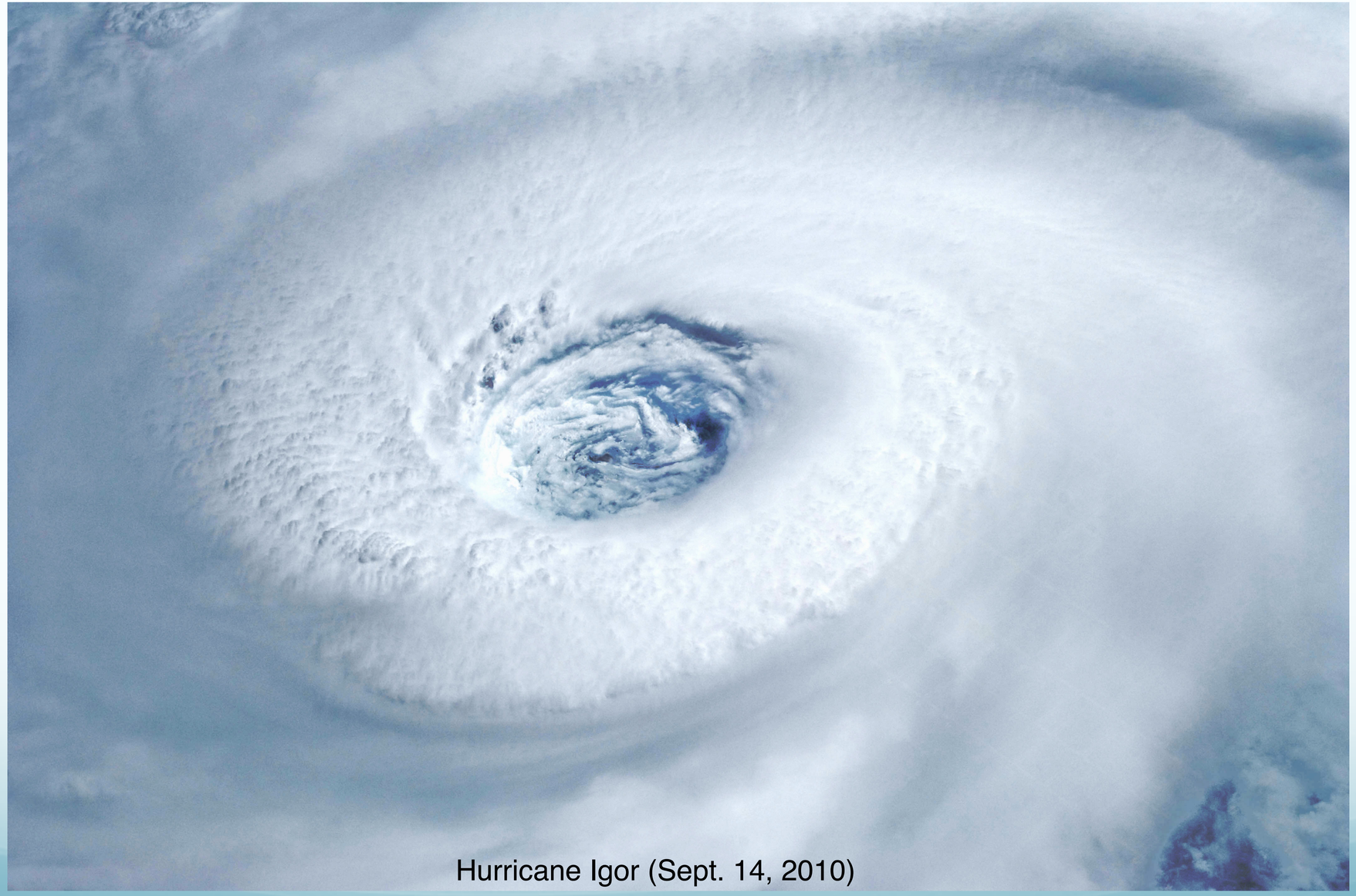
# Satellite Images of Hurricane Isabel

Some images here (during the slow parts) are shown 1 minute between frames

Note eyewall rotates very fast!
**High winds** there



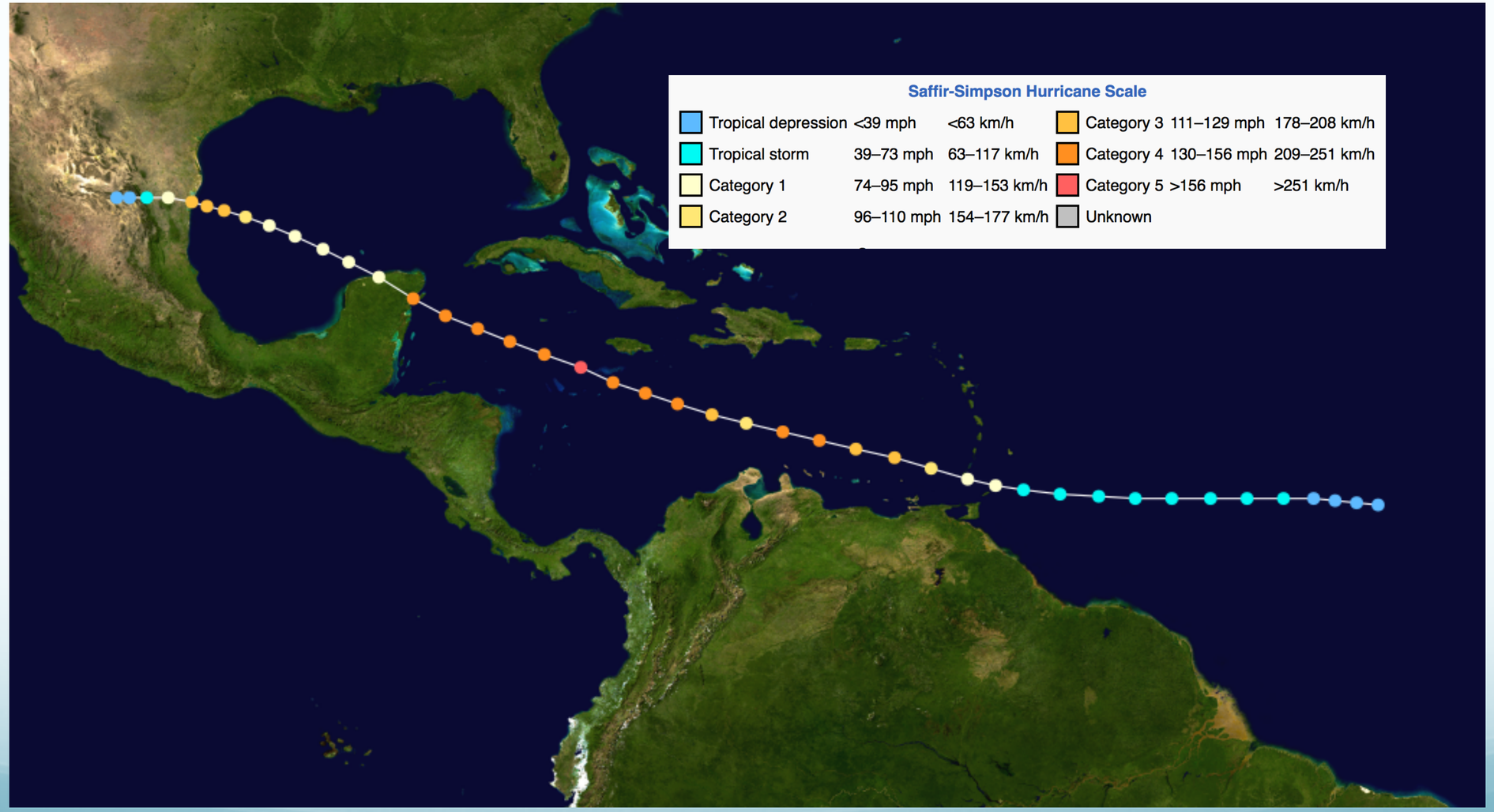
# Eye Is Not Always Clear



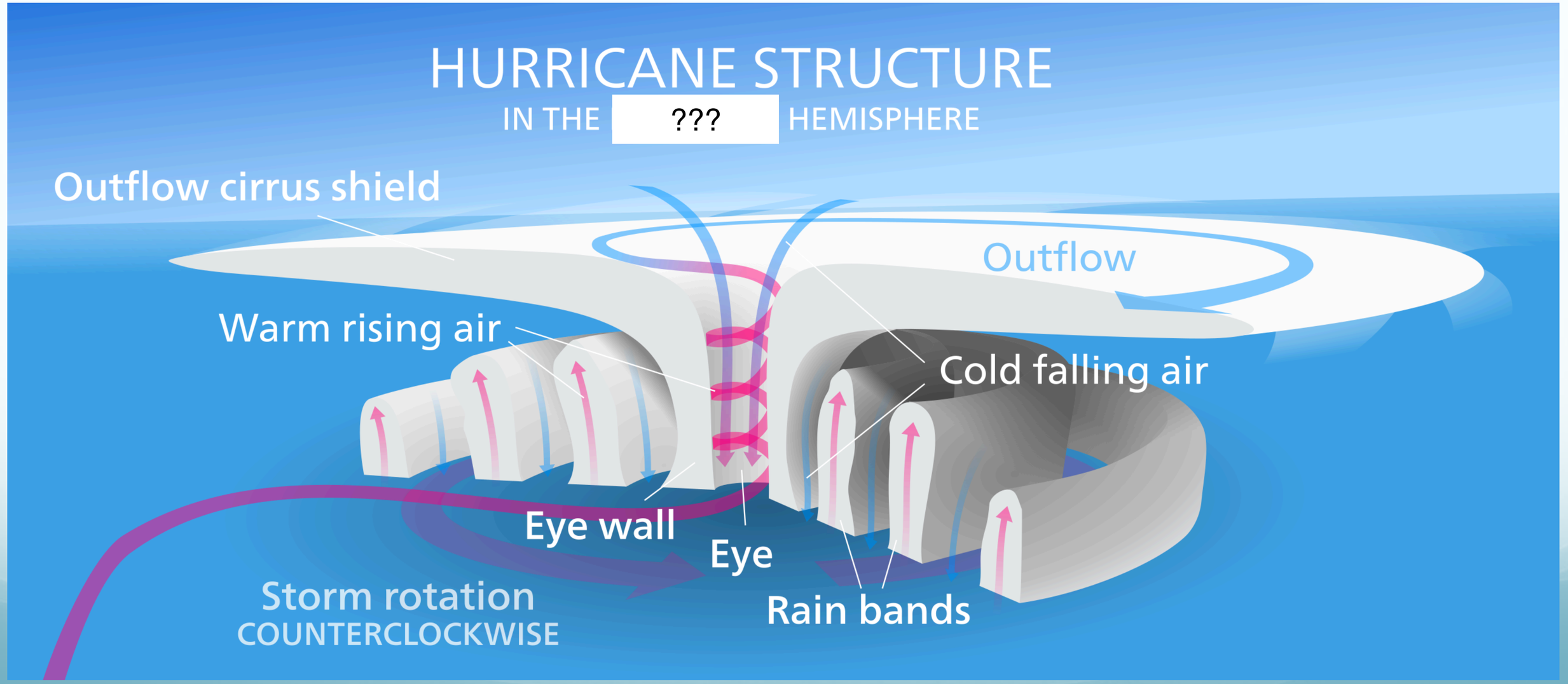
Hurricane Igor (Sept. 14, 2010)

# Hurricane Emily, July 2005

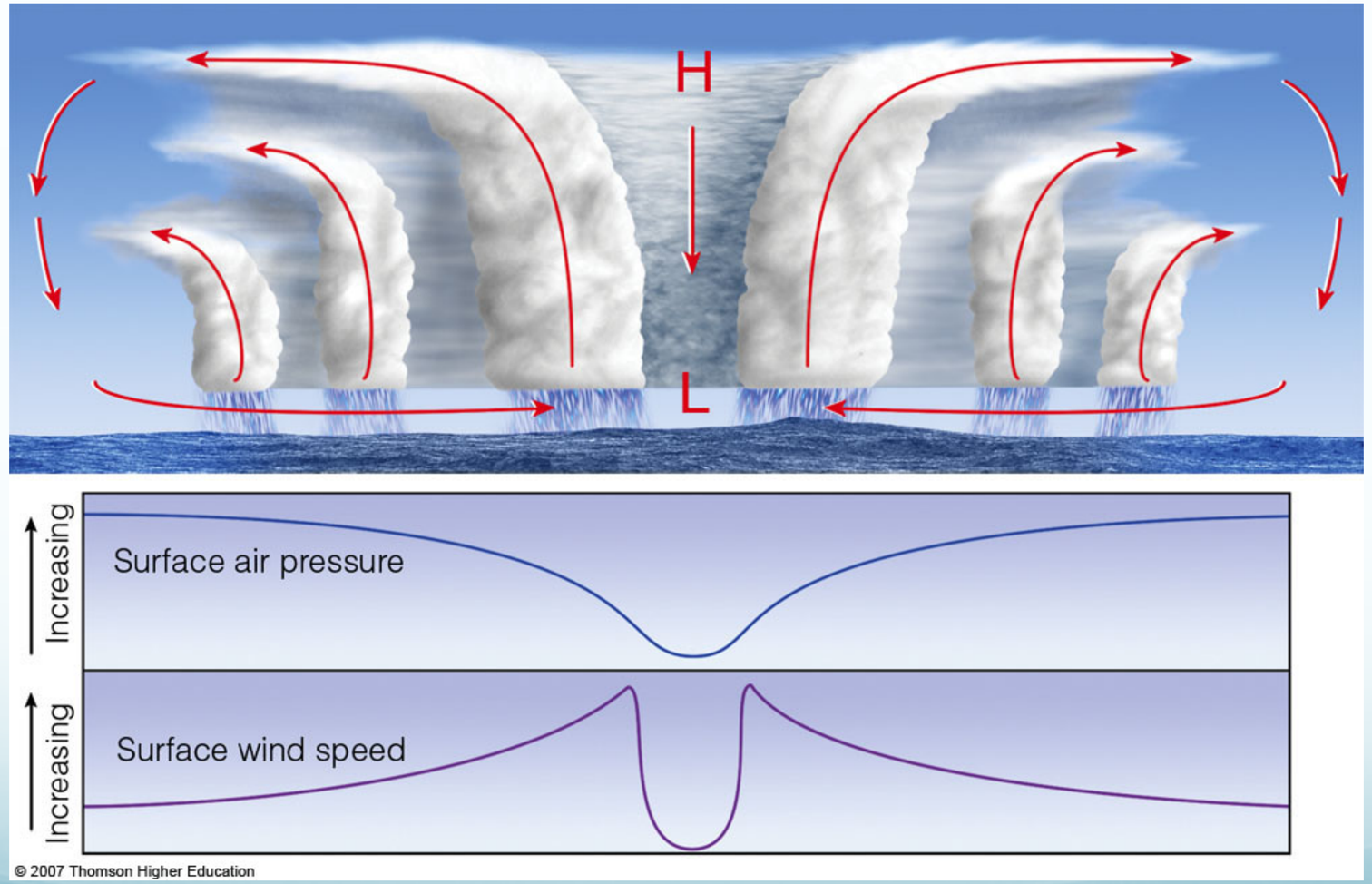
Flying into the eye



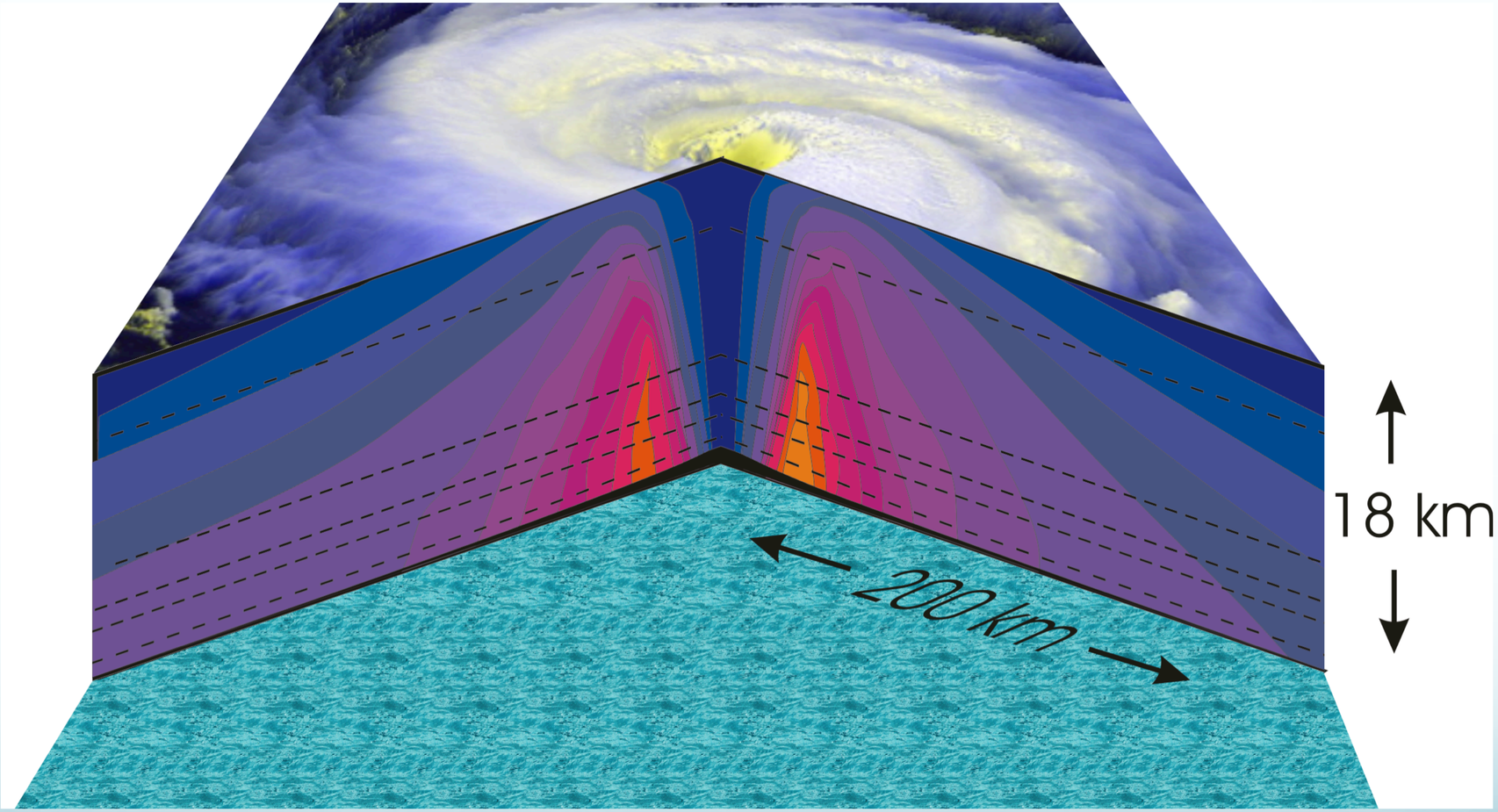
# The Structure



# Vertical Cross Section

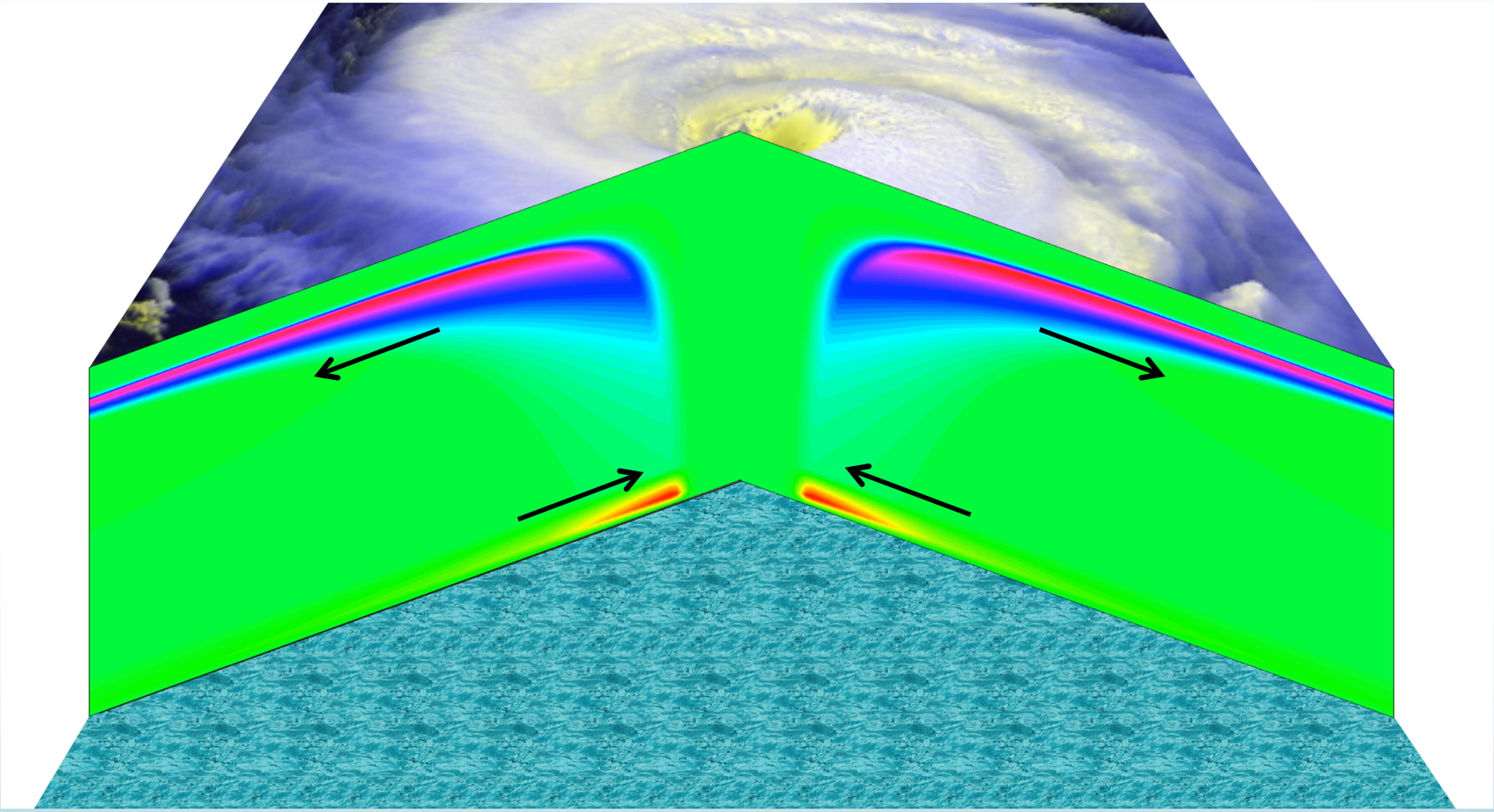


# Wind Speed Circling the Storm Center



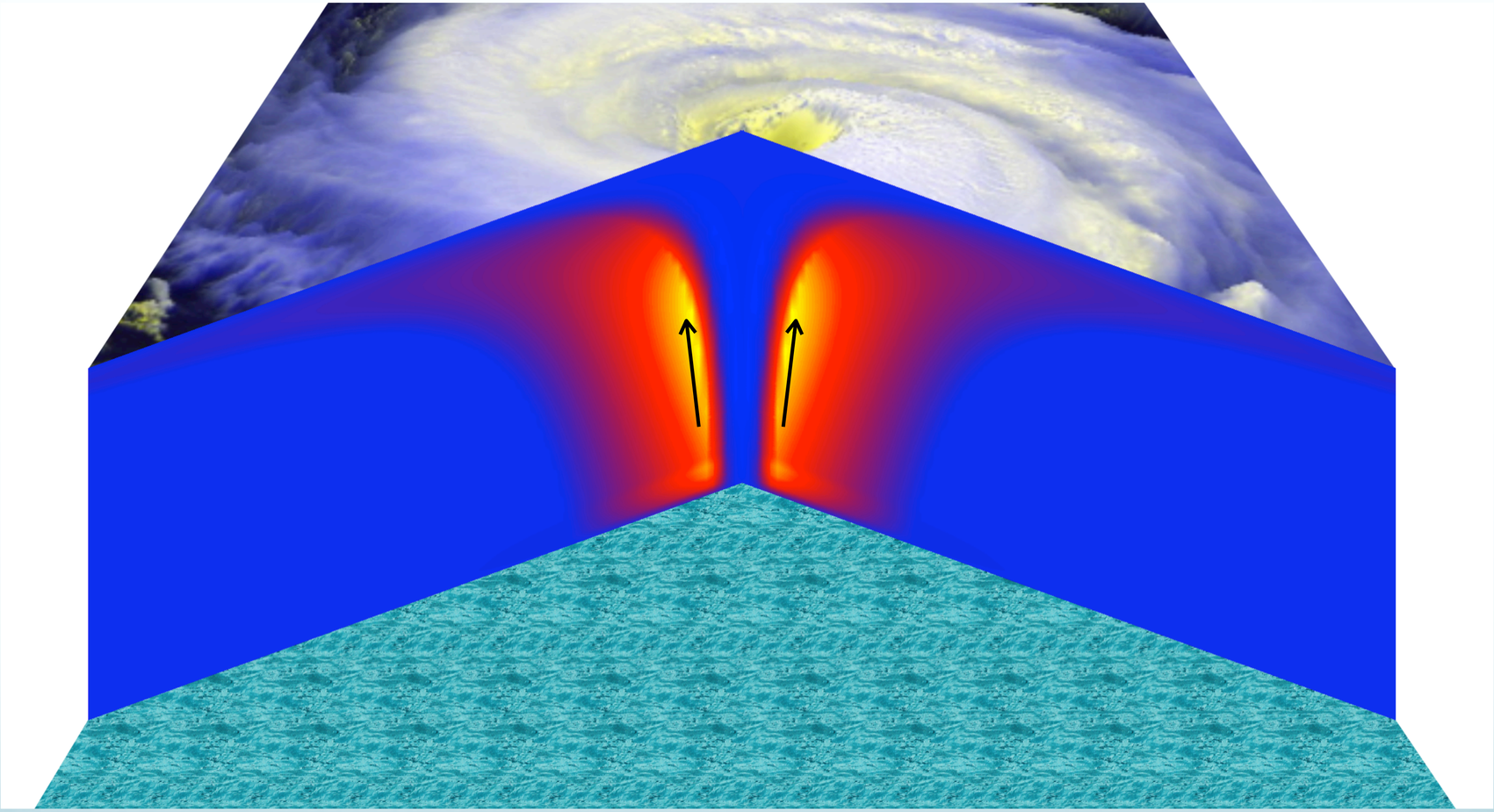
# Circularly Symmetric Radial Winds

Much weaker than the winds in the direction circling the eye.

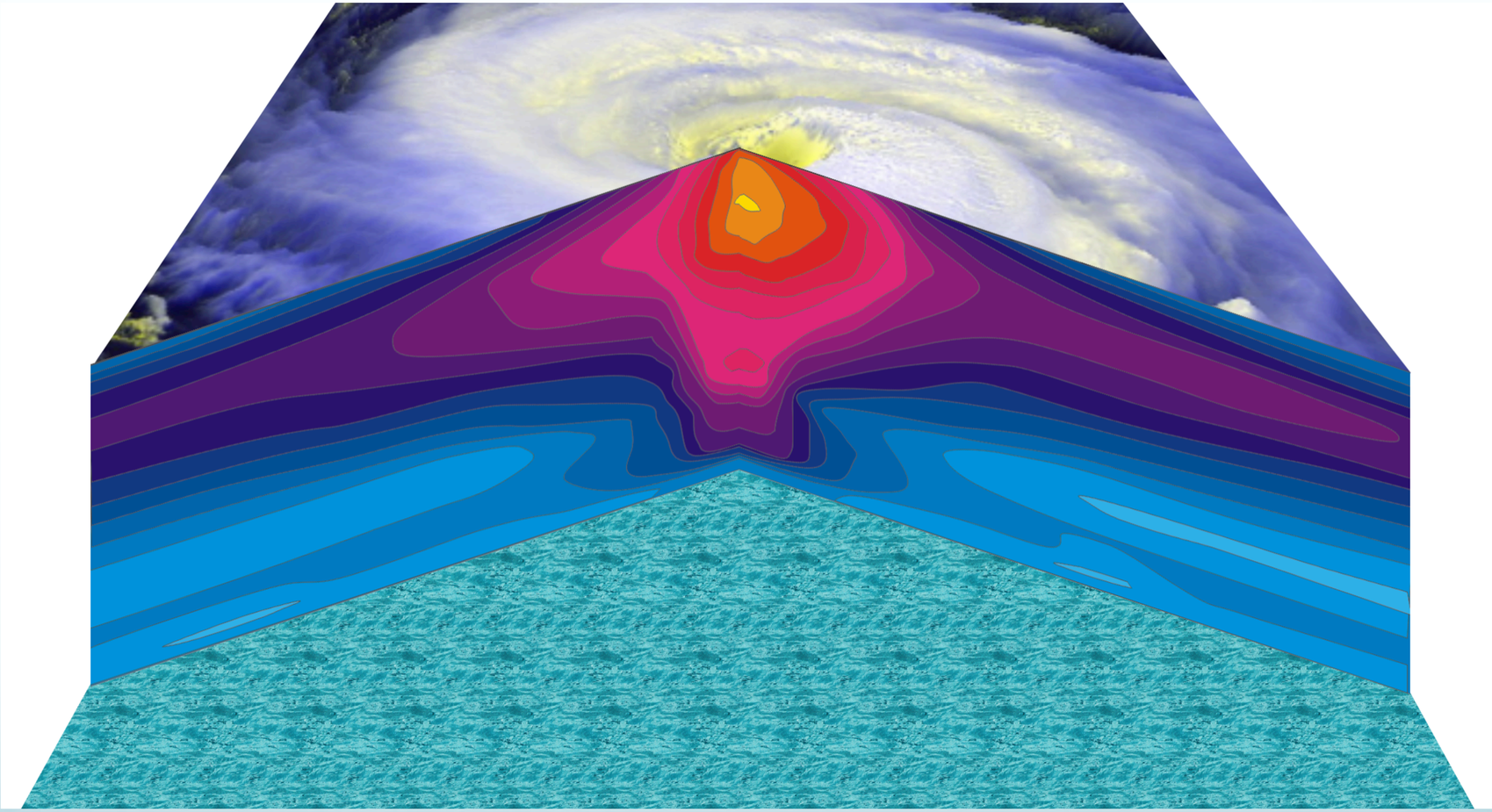


# Circularly Symmetric Vertical Winds

Updrafts in the eye wall

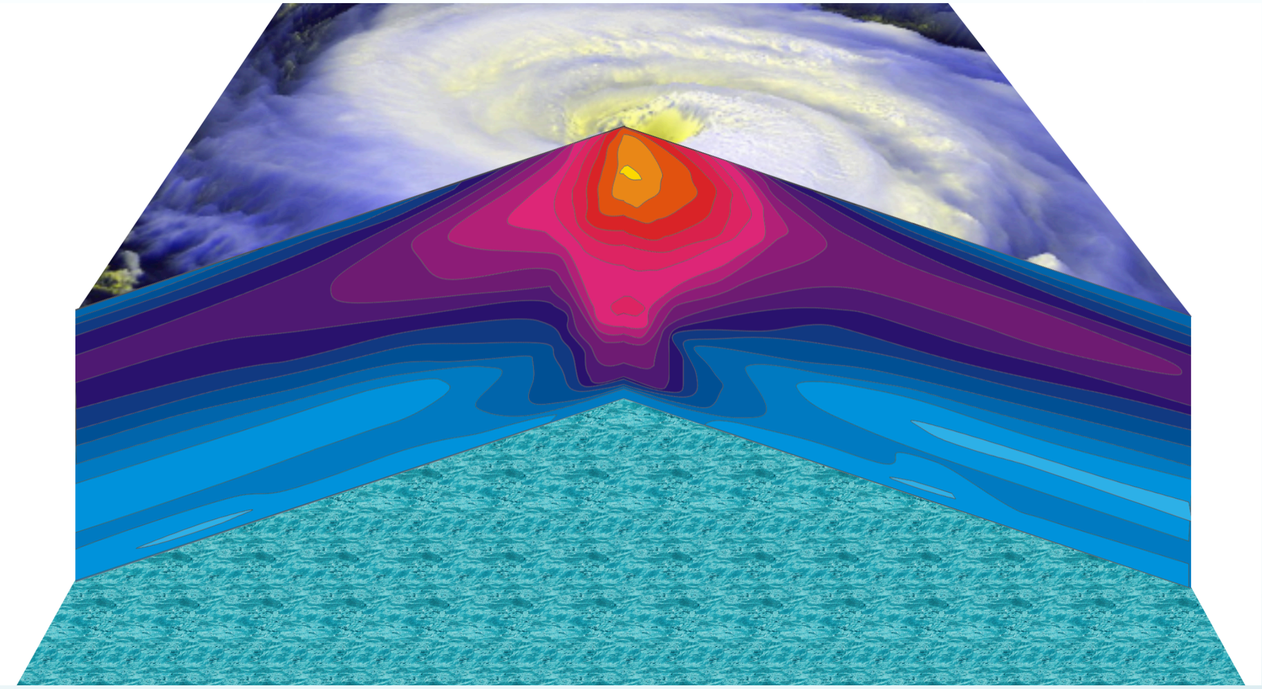


# Temperature Difference from the Environment at the Same Level

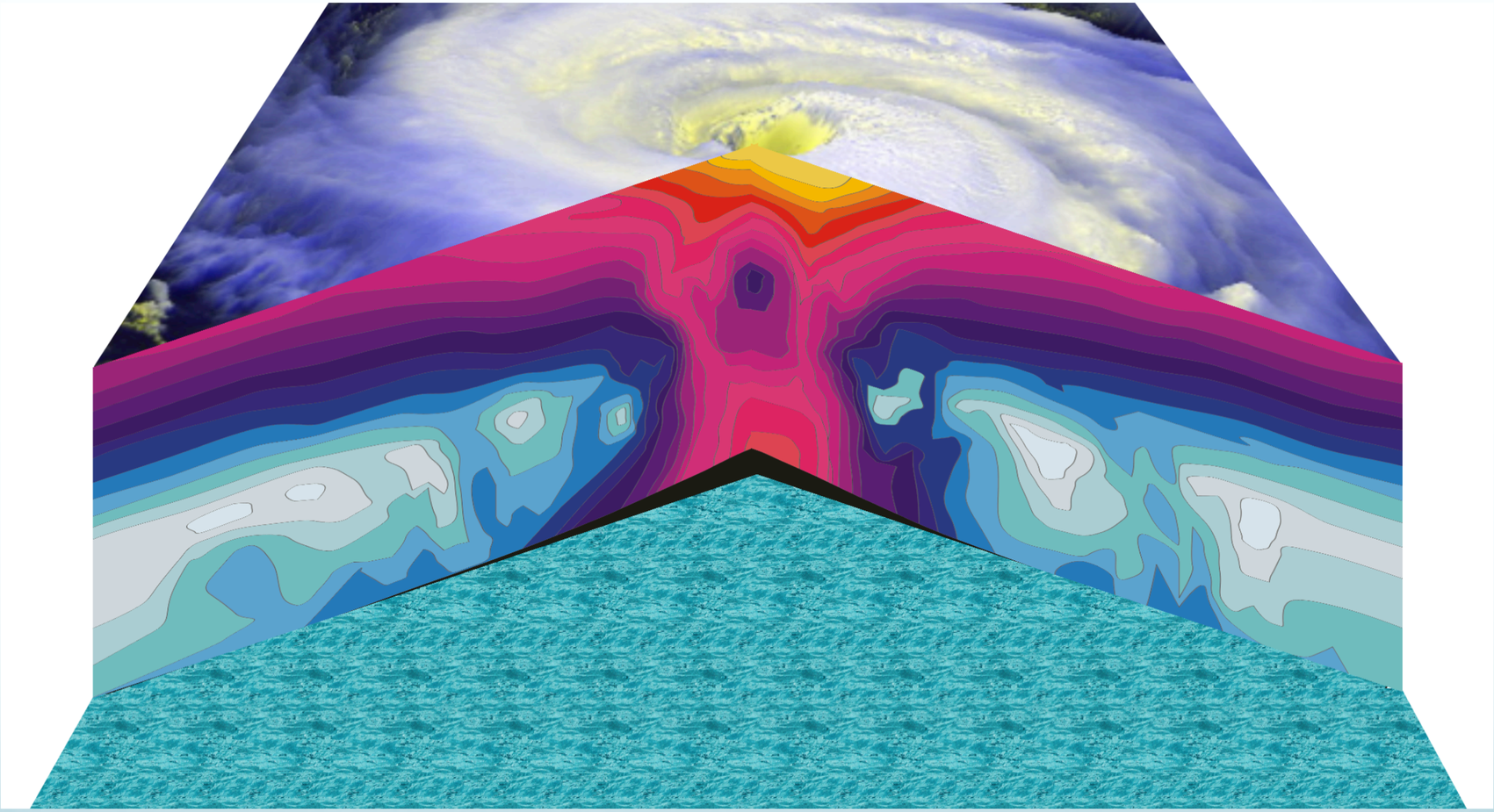


# Temperature Contrasts

- Over the eye, it is much warmer than in the far environment at the same level.
- Temperature at the surface remains similar to the environment.
- Heat transfers with the ocean help keep the surface temperature the same.



# Heat Added to the Air



# What is the major source of the heating within the tropical cyclones?

Upward turbulent transport of heat from the warm water

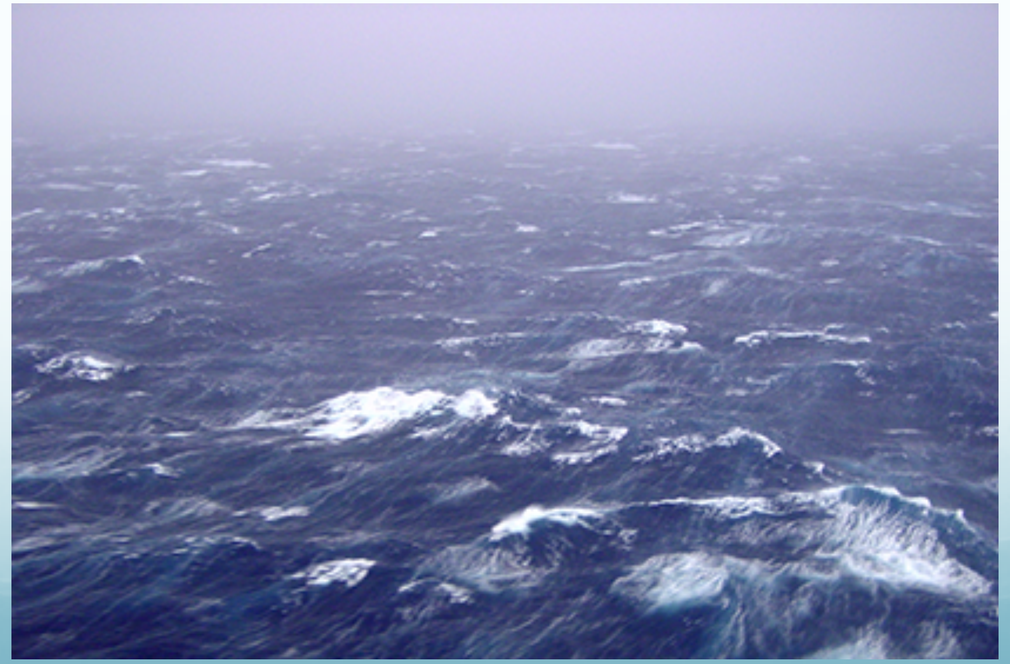
Absorption of sun lights in the eye region

Absorption of the radiation energy from the surface by clouds

Condensation and freezing of water vapor molecules in the eyewall and rainband clouds

# Answer: Condensation/Freezing within the clouds

- Tropical cyclones åre powered by LATENT HEAT
- The evaporation of water at the sea surface adds latent heat.
- High winds make this evaporation more efficient.
- Friction between the surface winds and the ocean also adds heat (small).



# Sea spray and large waves

# Why do hurricanes exist?

- They have a job to do.
- Hurricanes help keep the tropics from getting too warm as a result of the sun's heating.

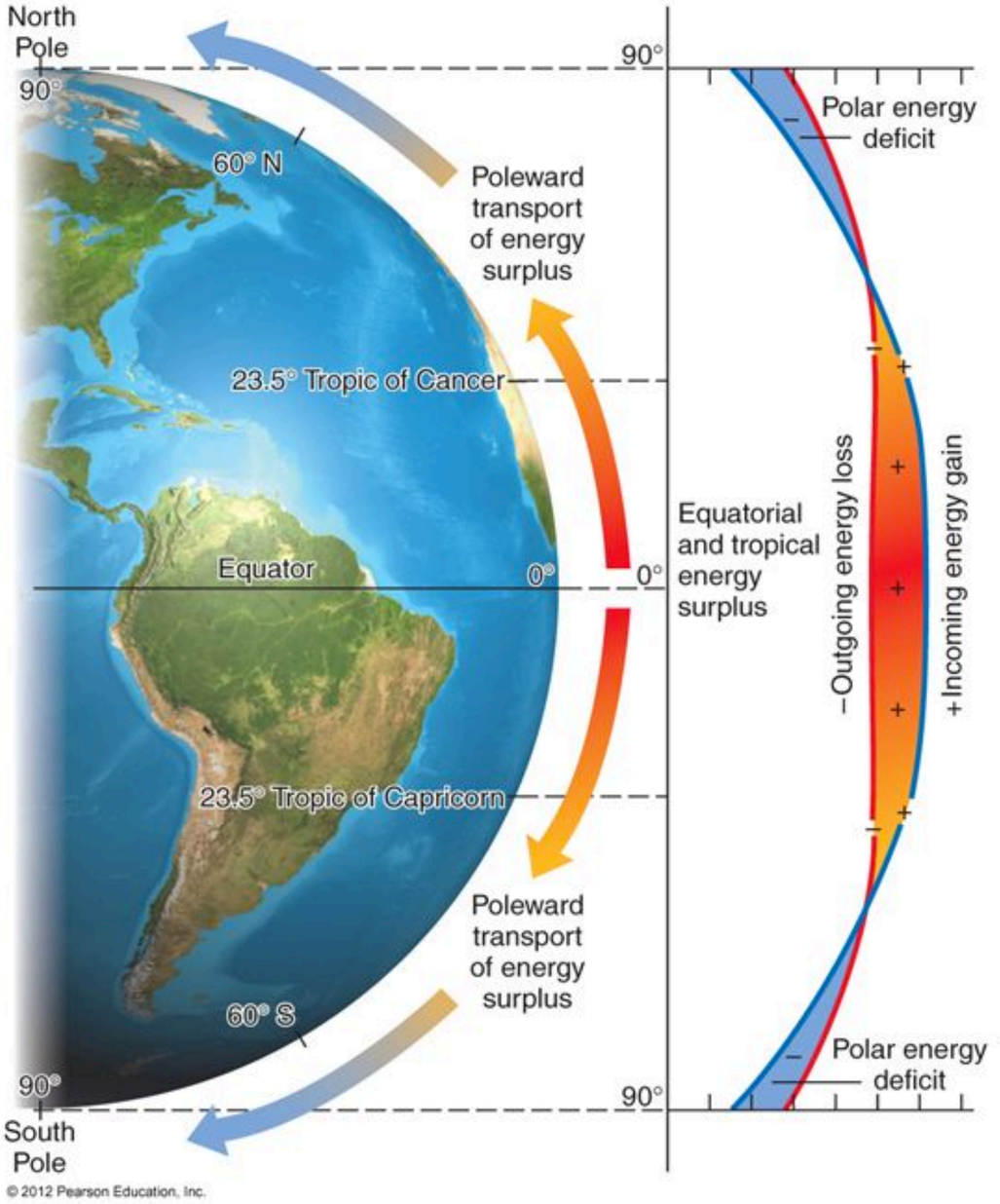





Figure 4.12

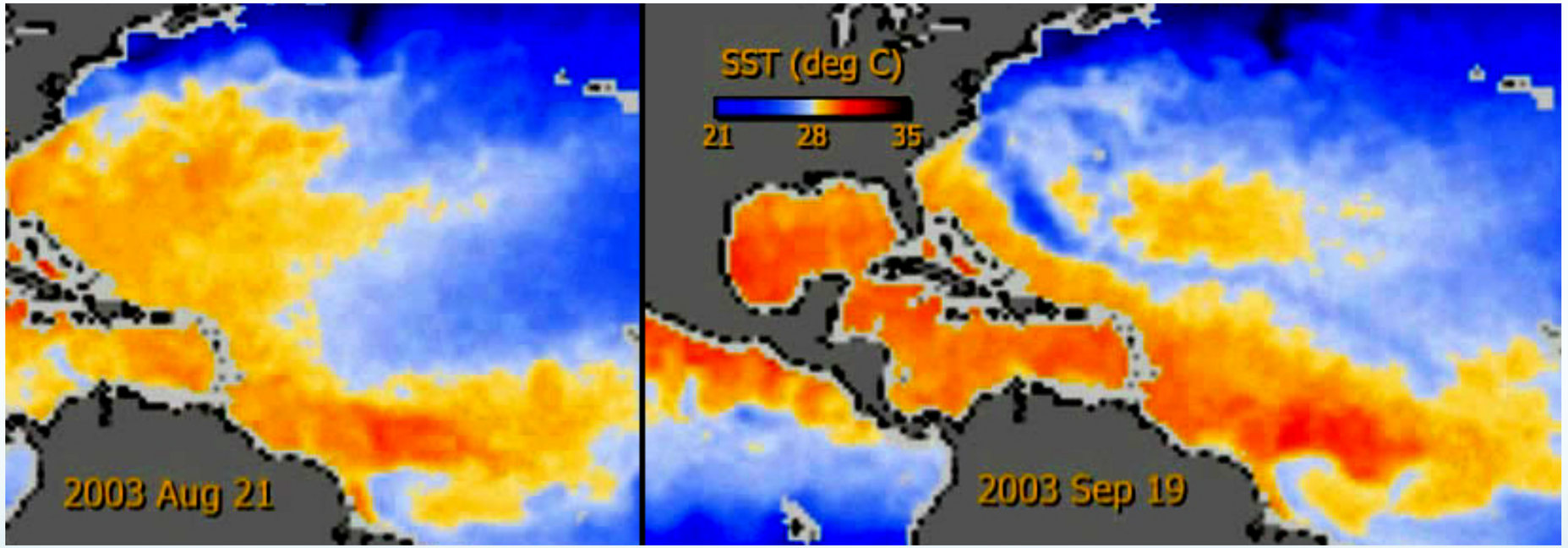
# Hurricanes Move Heat

- Hurricanes cool the tropics
  - by cooling tropical ocean surface via evaporation
  - The cooling is distributed through the top layers of the sea

Cold Wake Signatures from 2018 Hurricanes

# Cold Wake of Hurricane Isabel

Sea-surface temperatures (SST) measured by satellite.



# Hurricanes Move Heat

- Hurricanes cool the tropics
  - by cooling tropical ocean surface via evaporation
  - The cooling is distributed through the top layers of the sea.
- Hurricanes warm the extratropics
  - by releasing latent heat there
  - Heat is ultimately lost to space via thermal radiation

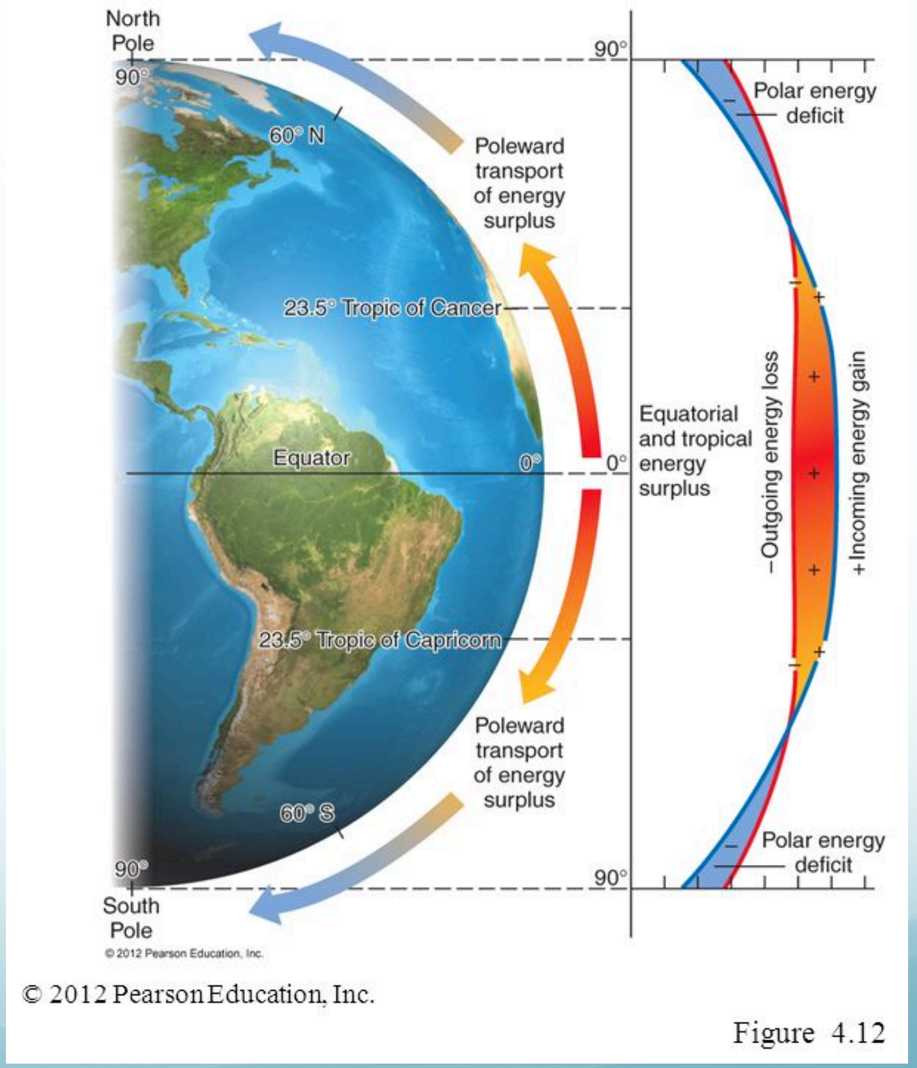
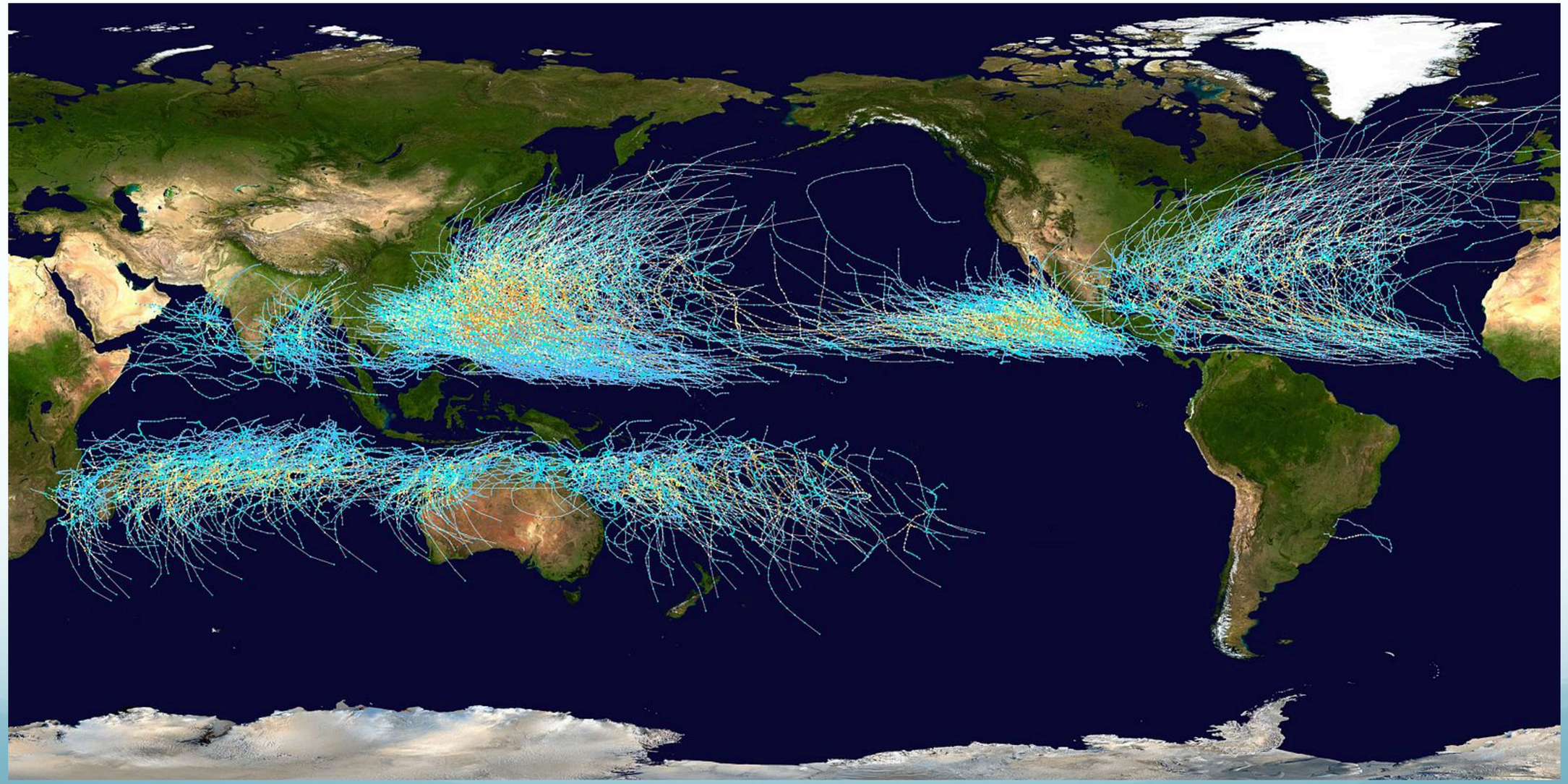


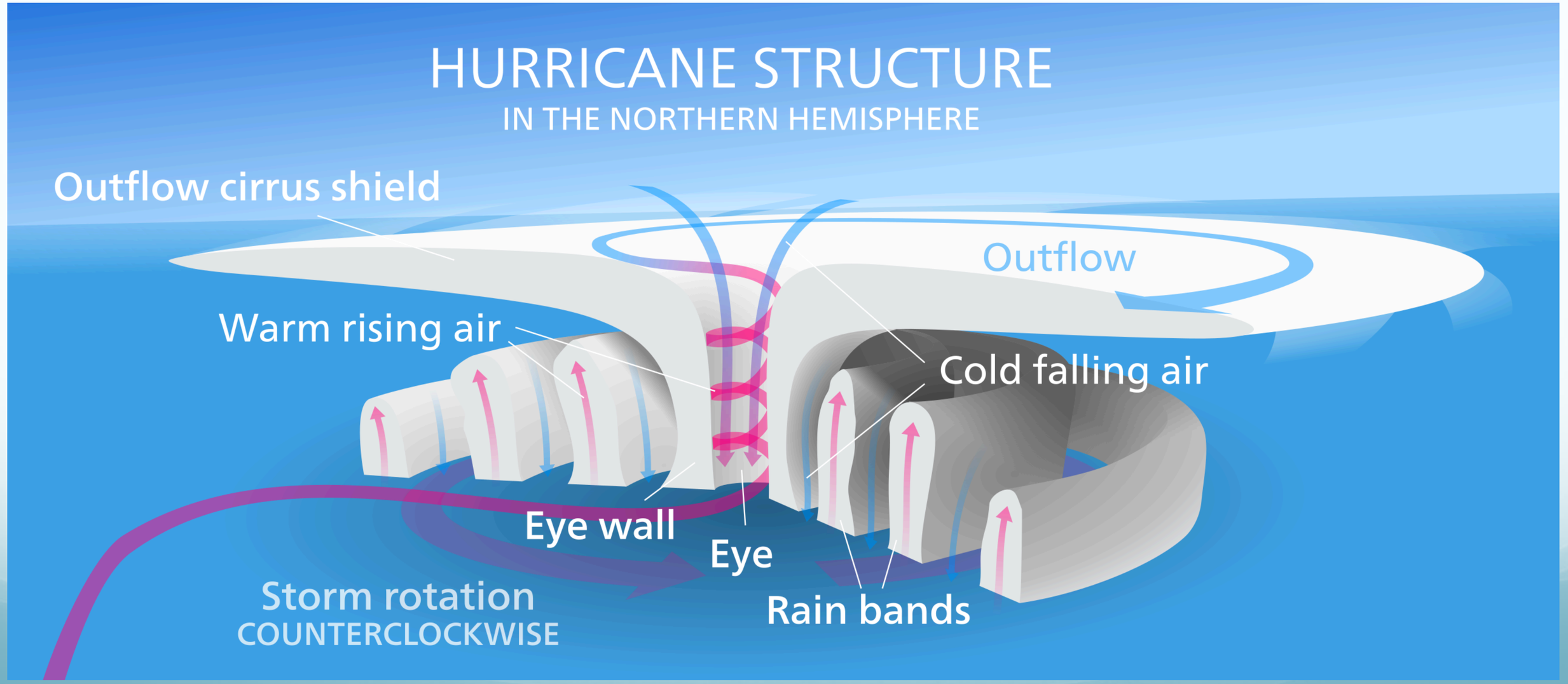



Figure 4.12

# Worldwide Tropical Storm Tracks

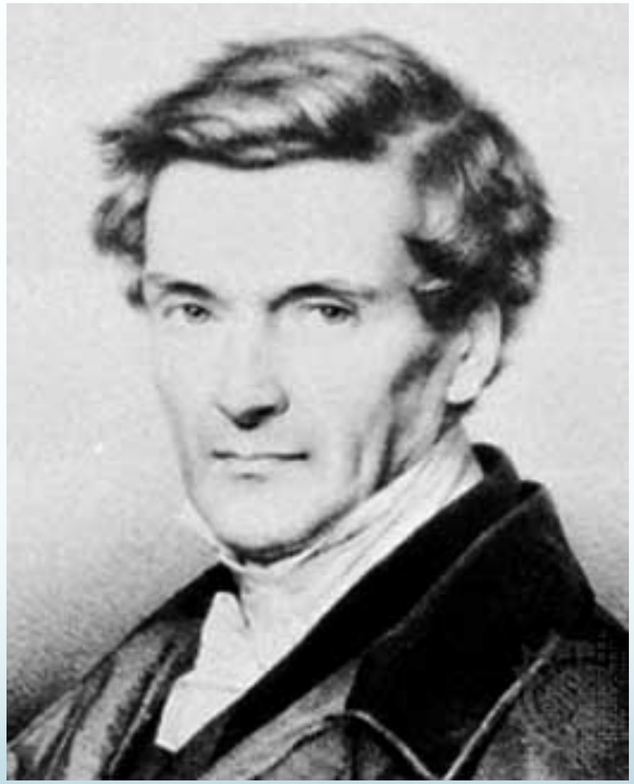


# The Structure



# The Coriolis Effect

The PBS take



Gaspard-Gustave de Coriolis

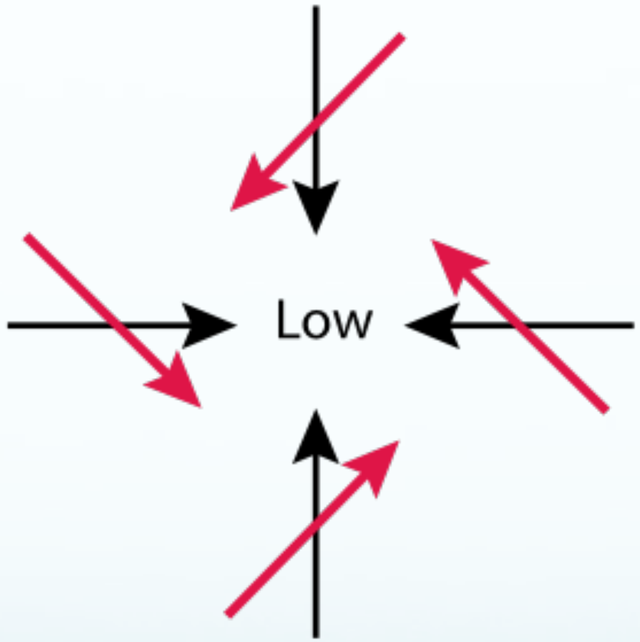
# Coriolis Force Summary: 1

- Arises because we are looking at motions in a rotating frame of reference.
- Turns winds to the right/left in the northern/southern hemisphere.

Throwing balls on a rotating platform

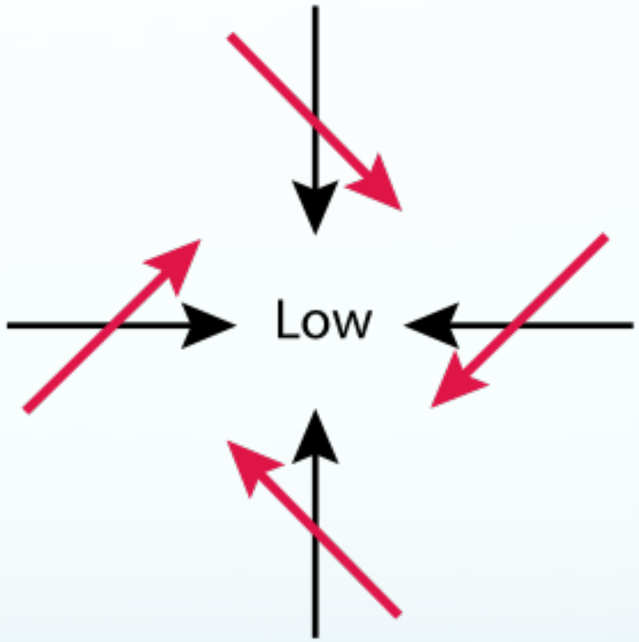
# Coriolis force deflects converging air heading into the eye's low pressure.

Northern Hemisphere



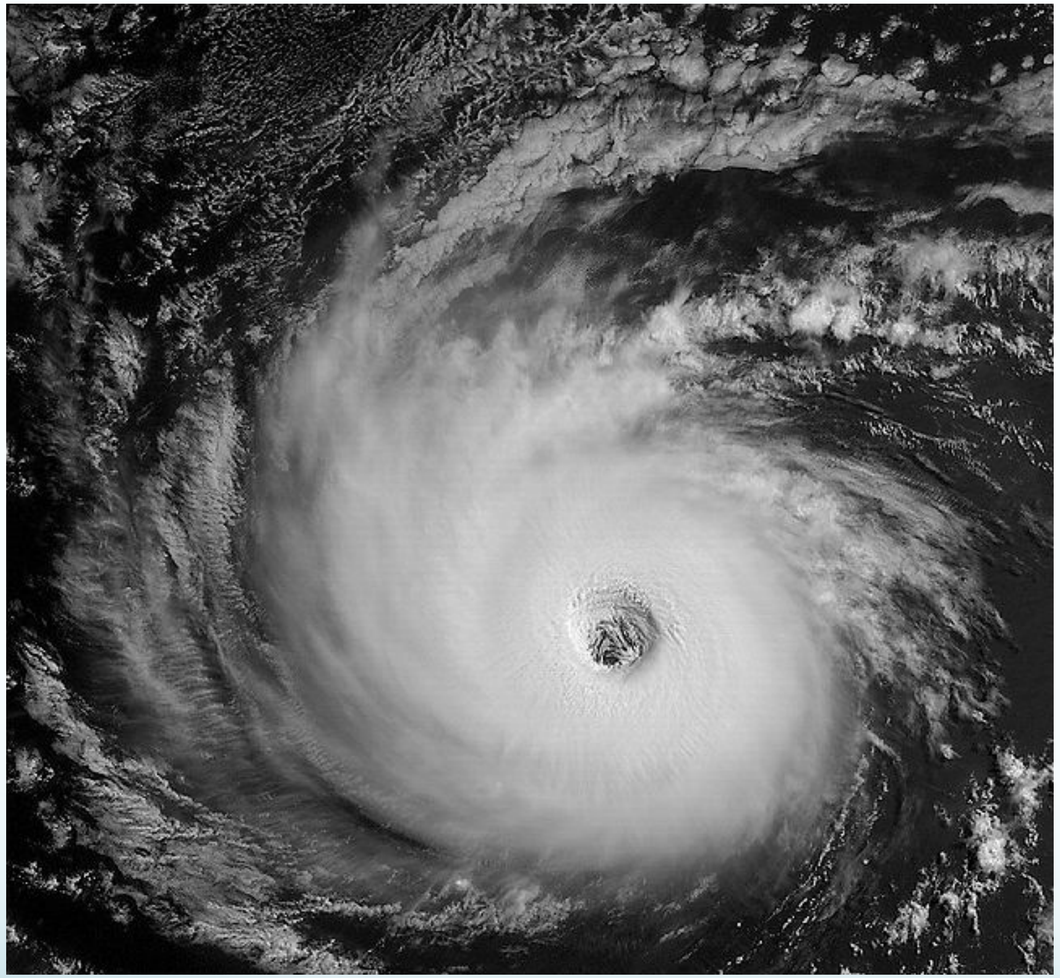

Winds turned to the right (red arrows).

Southern Hemisphere

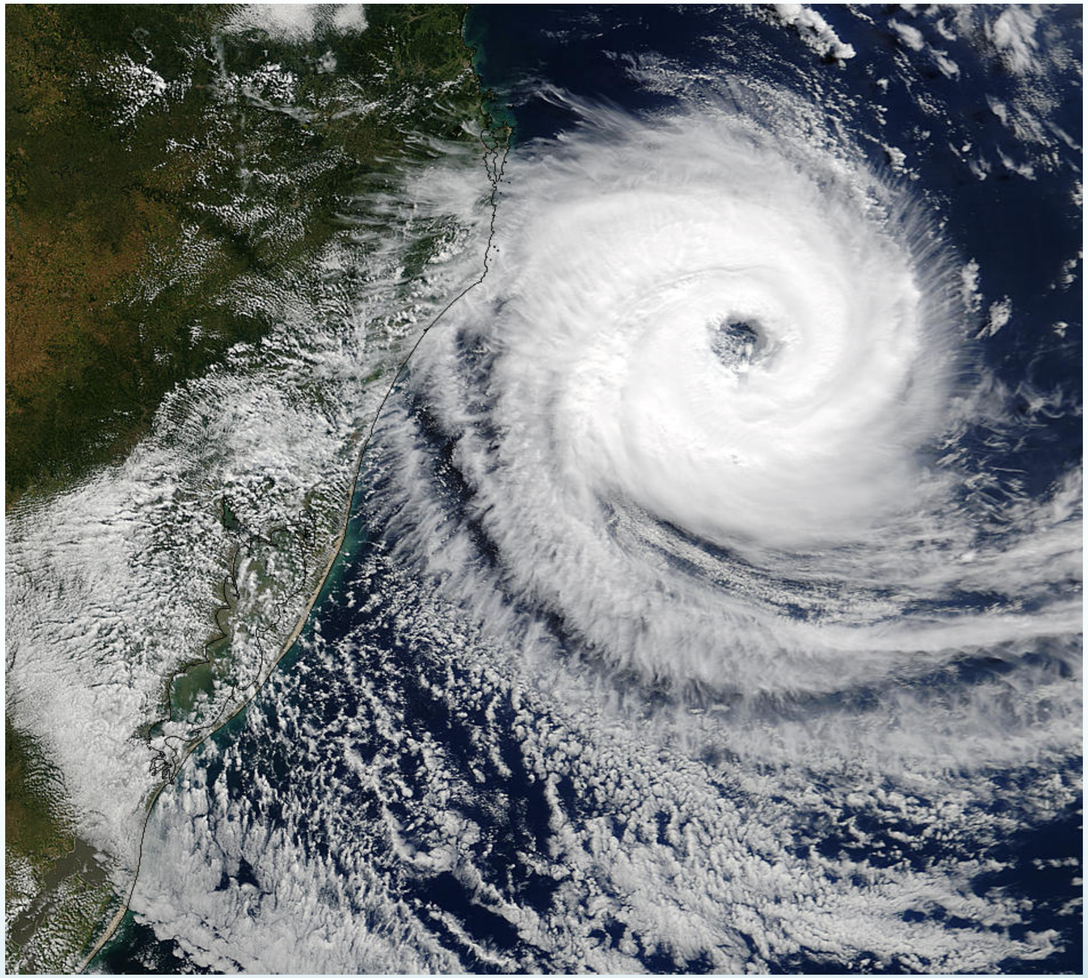



Winds turned to the left (red arrows).

# These are occurring on opposite sides of the equator



Northern Hemisphere
(Counterclockwise)



Southern Hemisphere
(Clockwise)

# Does the Coriolis force also regulate the direction of the swirl in a drain?

Down at the equator